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Internet of Things and Its Applications

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Preface

Internet of Things (IoT) creates a new set of data sources. Industry can now better observe individuals' choices and test the effectiveness of different types of mechanisms to acquire and retain more customers. It may support policymakers to overcome one of the most frequent problems of policy design: the lack of personalized content. We argue that the IoT not only disrupts the way we track our actions and monitor our goals or objective, but also allows the identification of effective methods to alter our behavior. This is optimized by the combination of IoT, data analytics, and behavioral science. Specifically, one of the main contributions of behavioral science to the study of consumers is its empirical focus on observed behavior. Hence, behavioral specialists in the areas of marketing, economics, and public policy should be aware of the possibilities that innovative technologies/methods create for the analysis of consumer behavior.

Internet of Things – Behavioral Applications offers a holistic approach to the IoT model. The IoT refers to uniquely identifiable objects and their virtual representations in an Internet-like structure. Recently, there has been a rapid growth in research on IoT communications and networks, which confirms the scalability and broad reach of the core concepts. With contributions from a panel of international experts, the text offers insight into the ideas, technologies, and applications of this subject. The book will discuss recent developments in the field and the most current and emerging trends in IoT. In addition, the text is filled with examples of innovative applications and real-world case studies. *Internet of Things – Behavioral Applications* fills the need for an up-to-date volume on the topic. Some features of the book are as follows:

- Covers in great detail the core concepts, enabling technologies, and implications of the IoT
- Addresses the business, social, and legal aspects of the IoT
- Explores the critical topic of security and privacy challenges for both individuals and organizations, the IoT, and Internet of Services
- Contains contributions from an international group of experts in academia, industry, and research

Written for IoT researchers, industry professionals, and lifetime IT learners as well as academics and students, *Internet of Things – Behavioral Applications* provides a much-needed and comprehensive resource to this burgeoning field.

This book comprises a total of 29 chapters. Chapter 1 presents the various component of IoT like network architecture, various application, network topologies used, and protocol. Chapter 2 summarizes different IoT frameworks, architectures, platforms, and reference models to pave the way for businesses to be built on IoT. In Chap. 3, Raspberry Pi 3 has been used to implement a TensorFlow-based deep learning neural network model which tries to identify if a person is wearing a face mask or not using the Raspberry Pi camera module. Chapter 4 focuses on designing and implementing an IoT system to capture and monitor the environmental variables that influence a highly complex medical device (i.e., computerized axial tomography). Chapter 5 focuses on developing a smartphone-based wireless handheld unit that can be attached to the asthma inhaler for measuring the intensity of respiratory diseases and tracking the lung reaction to treatment. Chapter 6's ultimate goal is to use MRI images of the framed brain to create deep neural system models that can be isolated between different types of heart tumors. Chapter 7 narrates a voice controlled mechanized wheelchair that is structured and actualized with constant impediment shirking. Chapter 8 presents a brief overview about the present scenario and challenges of the application of IoT in biomedical engineering. Chapter 9 presents a study that was conducted using a lung cancer classification scheme by studying micrographs and classifying them into a deep neural network using machine learning framework. Chapter 10 presents a survey in the area of wireless body network infrastructure, research trends in WBANs, requirements of QoS (Quality of Service), QoS-based routing protocols, and optimization techniques. Chapter 11 encapsulates the basic concepts and definition of smart education with the incarnation of IOT devices. The system proposed in Chap. 12 represents a low-cost and efficient classroom system which controls appliances like lights and fans using NodeMcu module, relays, and adapters with the available LAN or Wi-Fi in a university, so that the devices can be remotely controlled using a Web application. Chapter 13 attempts to unfold the impact of smart banking on financial transactions of migrants. Chapter 14 aims to study and critically analyze the essence of the smart banking system and to define the variables affecting the accessibility of the smart banking system in India. Chapter 15 discusses solution of pest management which can be coupled with IoT system for enhanced performance. In Chap. 16, a smart plantation system is designed to observe the health status of plants/crops, and with the collected data, a specific action is triggered automatically and remotely. An automatic irrigation method is presented in Chap. 17, which will be helpful for its many benefits such as low-cost expenditure, and consumption of water is also minimized to a large level. Chapter 18 explains how modern technologies such as computing, machine learning, and data science help farmers in getting real-time data and knowledge of their corps. Chapter 19 presents a multidisciplinary perspective of smart agriculture advances along with future prospects. Chapter 20 discusses the concepts of layered IoT framework along with a novel quasi-based deployment of nodes. The chapter also suggests the need of localization of nodes and events so as to provide autonomous services using the IoT for post-disaster management. Chapter 21 discusses key criteria for the production of smart IoT-enabled garments and illustrates the possible effect of smart clothing on business models in the medium term. In Chap. 22, an emergency routing protocol for Vehicular Ad hoc Network (VANET) is proposed to quickly forward the current patient status information from the ambulance to the hospital to provide pre-medical treatment. The authors investigate the cloud services about VANETs and applications of VCC in Chap. 23. Chapter 24 focuses on the performance of SCMA in Rician fading channel which is predominant in indoor communication. Chapter 25 discusses all the methodology that is developed for the smart and efficient working of smart homes. In Chap. 26, a mobile application is being developed for the visually impaired to make them independent in the kitchen using IoT and deep learning. Chapter 27 proposes a novel, small, and energy-efficient location tracker called Nemo that can be used as a wearable by effectively combining the novel LoRa protocol of communication, geofencing, and Adaptive GPS Duty Cycling strategies. Chapter 28 conveys the challenges and issues created in this transformation, and provides various security mechanisms to address the issues faced by the IoT and IIoT domain. Chapter 29 discusses how IoT is being leveraged by organizations to make formidable changes in marketing and allied activities. Further, the chapter focuses on how AI and IoT can together enhance their individual capabilities, and synergize the potential benefits. The chapter also presents a case-let, discussing how a self-drive car rental company used IoT to enhance its services, and reaped benefits for itself and its customers.

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Odisha, India — Suneeta Satpathy

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Part I
IoT –Foundations, Architectures & Smart Services

Internet of Things: Basic Concepts and Decorum of Smart Services

Aradhana Behura, Suneeta Satpathy, Sachi Nandan Mohanty, and Jyotir Moy Chatterjee

1 Introduction

Internet of things (IoT) is a term used to describe an environment where billions of objects, constrained in terms of resources ("things"), are connected to the Internet and interacting autonomously. With so many objects connected in IoT solutions, the environment in which they are placed becomes smarter. A software, called middleware, plays a key role since it is responsible for most of the intelligence in IoT, integrating data from devices, allowing them to communicate and make decisions based on collected data. Then, considering requirements of IoT platforms, a reference architecture model for IoT middleware is analyzed, detailing the best operation approaches of each proposed module, as well as proposes basic security features for this type of software. This chapter elaborates on a systematic review of the related literature, exploring the differences between the current Internet and IoT-based systems, presenting a deep discussion of the challenges and future perspectives on IoT middleware. Finally, it highlights the difficulties for achieving and enforcing a universal standard. Thus, it is concluded that middleware plays a crucial role in IoT

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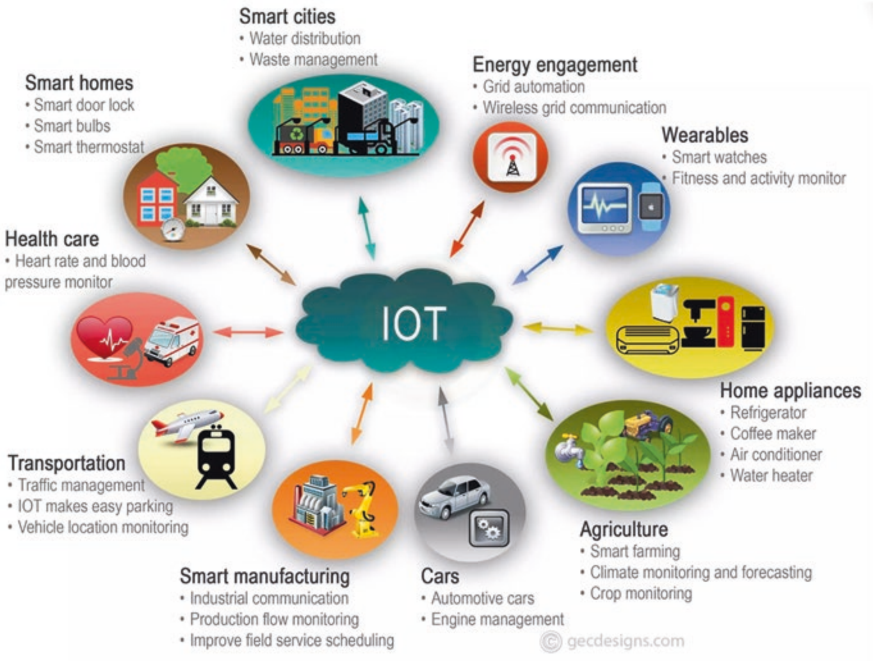


(a): Application Of IOT in modern age

Fig. 1 Application of IoT in modern age

solutions, and the proposed architectural approach can be used as a reference model for IoT middleware. Figs. 1 and 2 describe the IoT methodology.

- **Security and Surveillance**

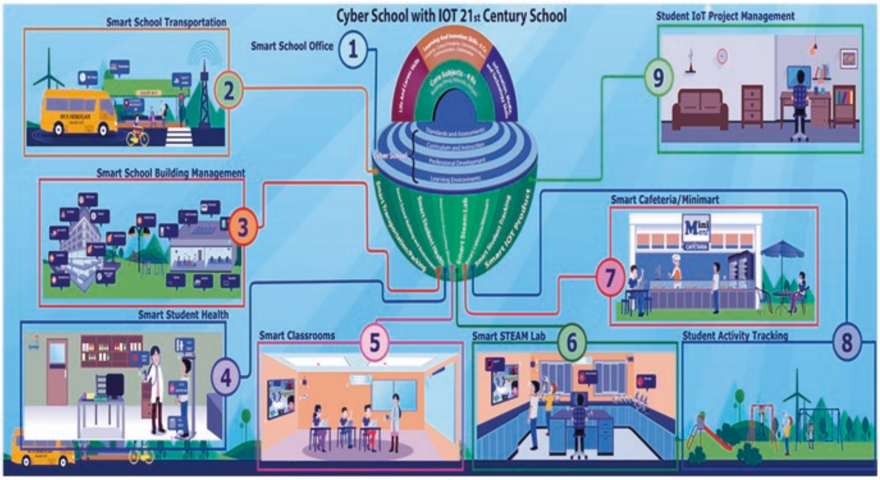
WSNs are essential components of military command and power, message passing, computing, intellect power, monitoring, attacking systems and observations. The sensor nodes and devices guarantee observation of enemy, battleground monitoring, conflict destruction evaluation, attacking, and nuclear, botanical, and enzymatic blast discovery techniques.

- **Environmental Monitoring**

Several WSN implementations in earth science research are covered by environmental sensor networks, associating sensing volcanoes, glaciers, forests, and oceans. To recognize slight soil movements and modifications, a landslide detection system utilizes WSN in several parameters that happen before or during landslides.

- **Health Applications**

To observe patient's physiological data and to trace and detect patients to manage drug administration and doctor's sensor networks are associated in modern health care centers. Different uses are found in glucose level detection, organ scanning, general health monitoring, and cancer detection. Inside a human body implanting



(b): Role of IOT in 21st Century

Fig. 2 Role of IoT in the twenty-first century

wireless biomedical sensors is promising though great challenges such as ultra-safety, security, and minimal maintainability of the system are associated.

- **Industrial Applications**

For machinery Condition-Based Maintenance (CBM) WSNs are enlarged as they guarantee high cost savings and allow new works. Through wireless sensors, earlier inaccessible locality, rotating machinery, dangerous or regulated regions, and mobile assets are reached.

- **Structural Monitoring**

Wireless sensors monitors moves inside premises, framework such as flyovers, cross over, tunnels and hills, monitor assets remotely, permitting engineering works without expensive site visits.

We learn various levels from Figs. 3, 4, 5, 6, 7 and 8.

Any technology available today has not reached its 100 % capability. It always has a gap to go. So, we can say that *Internet of things* has a significant technology in a world that can help other technologies reach their accuracy and complete 100 % capability as well.

Let's take a look over the major advantages and disadvantages of Internet of things.

Advantages of IoT

Internet of things facilitates several advantages in day-to-day life in the business sector. Some of its benefits are given below:

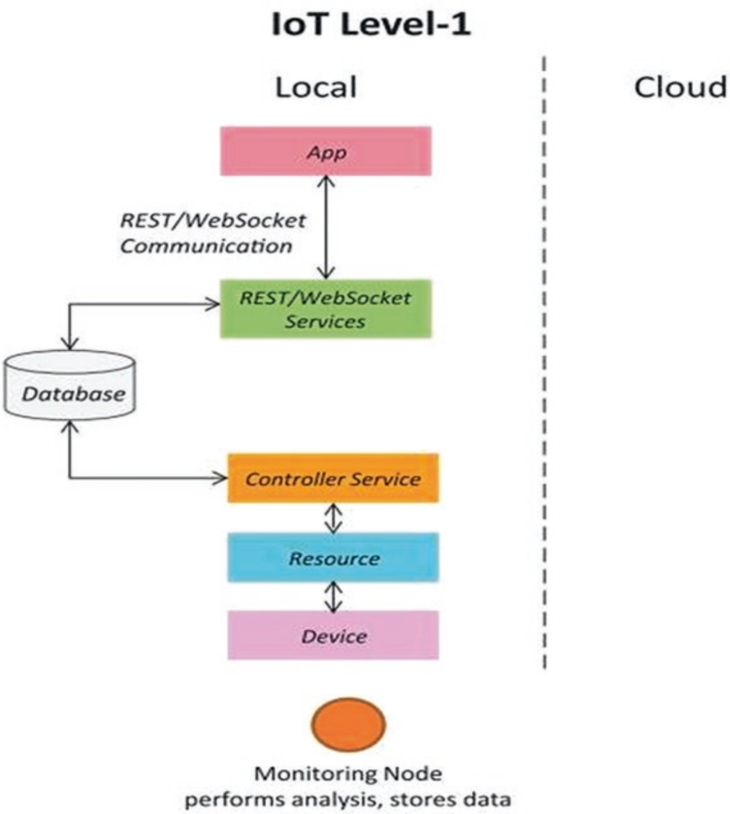


Fig. 3 Level 1 architecture of IoT

- **Efficient resource utilization:** If we know the functionality and the way how each device works, we definitely increase the efficient resource utilization as well as monitor natural resources.
- **Minimize human effort:** As devices of IoT interact and communicate with each other and do a lot of tasks for us, then they minimize human effort.
- **Save time:** As it reduces human effort, then it definitely saves out time. Time is the primary factor which can save through IoT platform.
- **Enhance data collection**
- **Improve security:** Now, if we have a system where all these things are interconnected, then we can make the system more secure and efficient.

Disadvantages of IoT

As the Internet of things facilitates a set of benefits, it also creates a significant set of challenges. Some of the IoT challenges are given below:

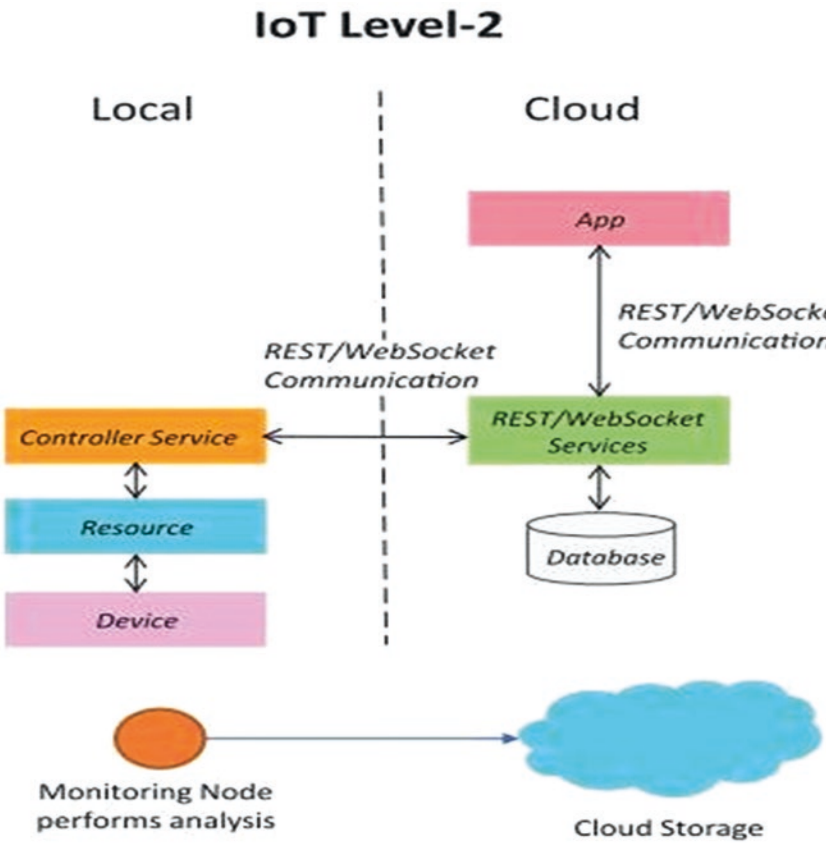


Fig. 4 IoT level-2 architecture

- **Security:** As IoT systems are interconnected and communicate over networks, the system offers little control despite any security measures, and it can lead to various kinds of network attacks.
- **Privacy:** Even without the active participation of the user, the IoT system provides substantial personal data in maximum detail.
- **Complexity:** The designing, developing, maintaining, and enabling of large technologies to IoT system are quite complicated.

1.1 Level of IoT

- The level-1 system of IoT has a single node/device that performs sensing and/or actuation, stores data, performs analysis, and hosts the application. These systems are suitable for modelling low-cost and low-complexity solutions where the

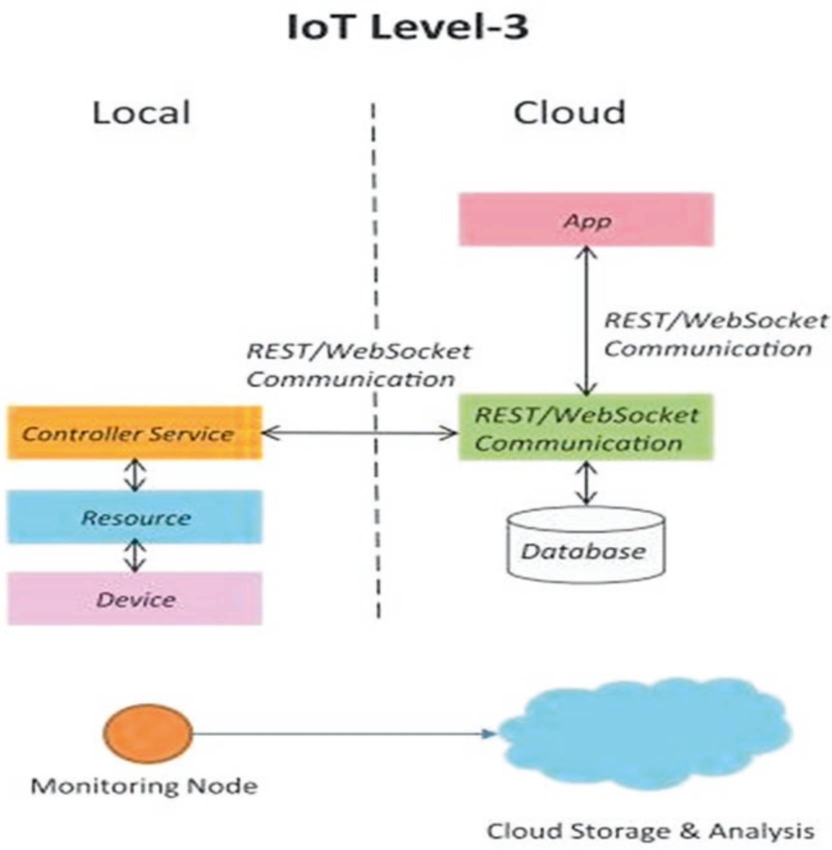


Fig. 5 IoT level-3 architecture

data involved is not big and the analysis requirements are not computationally intensive.

- A level-2 IoT system has a single node that performs sensing and/or actuation and local analysis.
- Data is stored in the cloud and application is usually cloud based.
- Level-2 IoT systems are suitable for solutions where the data involved is big; however, the primary analysis requirement is not computationally intensive and can be done locally itself.
- A level-3 IoT system has a single node. Data is stored and analyzed in the cloud, and application is cloud based.
- Level-3 IoT systems are suitable for solutions where the data involved is big and the analysis requirements are computationally intensive.
- Level-4 IoT system has multiple nodes that perform local analysis. Data is stored in the cloud and application is cloud based.

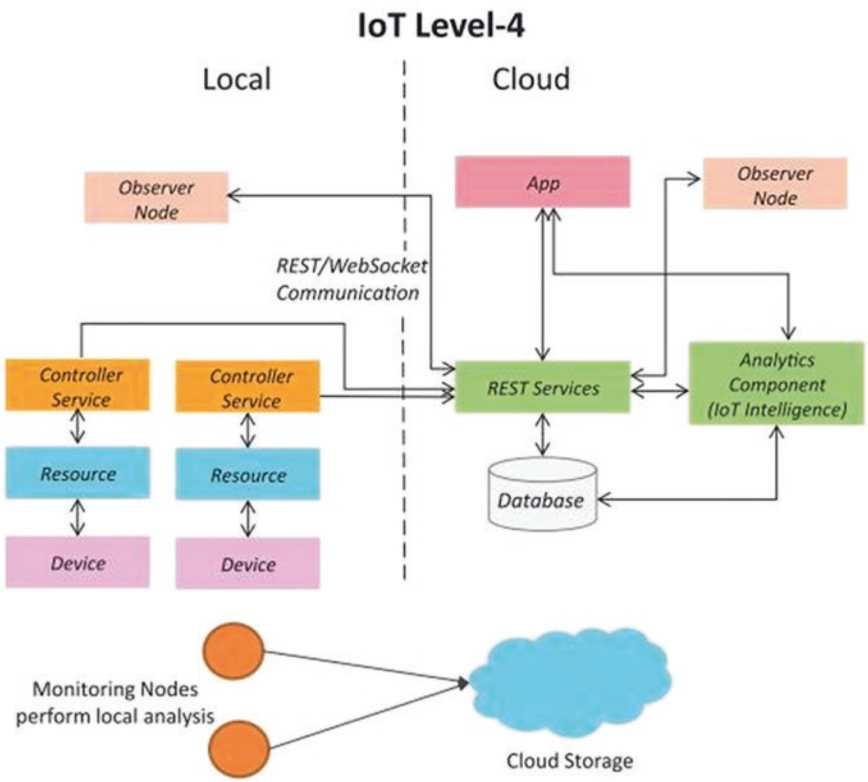


Fig. 6 IoT level-4 architecture

- This contains local and cloud-based observer nodes which can subscribe to and receive information collected in the cloud from IoT devices.
- These systems are suitable for solutions where multiple nodes are required, the data involved is big, and the analysis requirements are computationally intensive.
- A level-5 IoT system has multiple end nodes and one coordinator node.
- The end nodes perform sensing and/or actuation.
- Coordinator node collects data from the end nodes and sends to the cloud.
- Data is stored and analyzed in the cloud and application is cloud-based.
- Level-5 IoT systems are suitable for solutions based on wireless sensor networks, in which the data involved is big and the analysis requirements are computationally intensive.
- A level-6 IoT system has multiple independent end nodes that perform sensing and/or actuation and send data to the cloud.
- Data is stored in the cloud and application is cloud based.
- The analytics component analyzes the data and stores the results in the cloud database.
- The results are visualized with the cloud-based application.

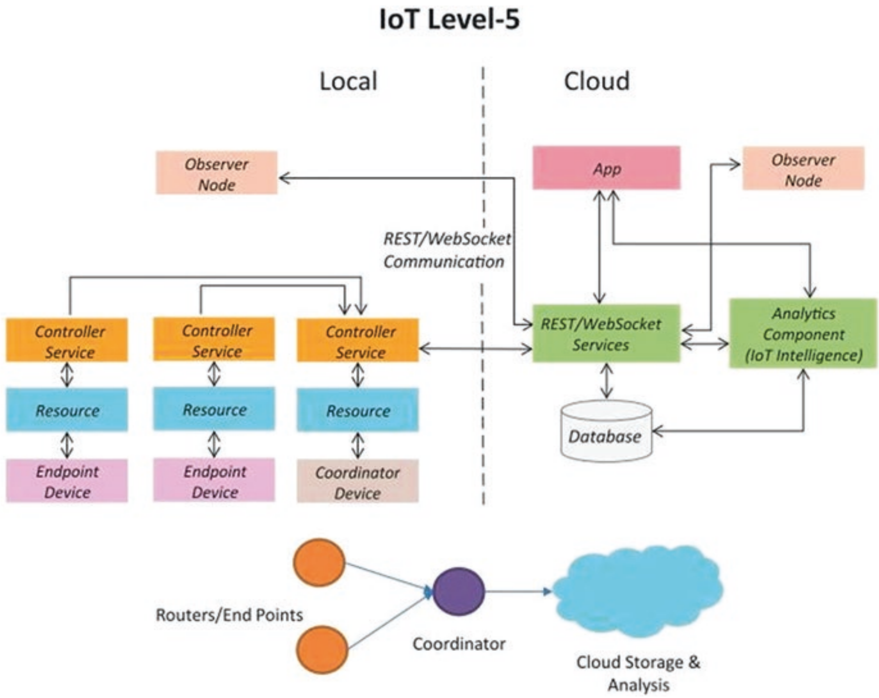


Fig. 7 IoT level-5 architecture

- The centralized controller is aware of the status of all the end nodes and sends control commands to the nodes.

A dynamic network infrastructure with self-configuring capabilities is based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network, often communicating data associated with users and their environments.

The "things" in IoT usually refer to IoT devices which have unique identities and can perform remote sensing, actuating, and monitoring capabilities.

- IoT devices can:
  - Exchange data with other connected devices and applications (directly or indirectly)
  - Collect data from other devices and process the data locally
  - Send the data to centralized servers or cloud-based application back ends for processing the data
  - Perform some tasks locally and other tasks within the IoT infrastructure, based on temporal and space constraints

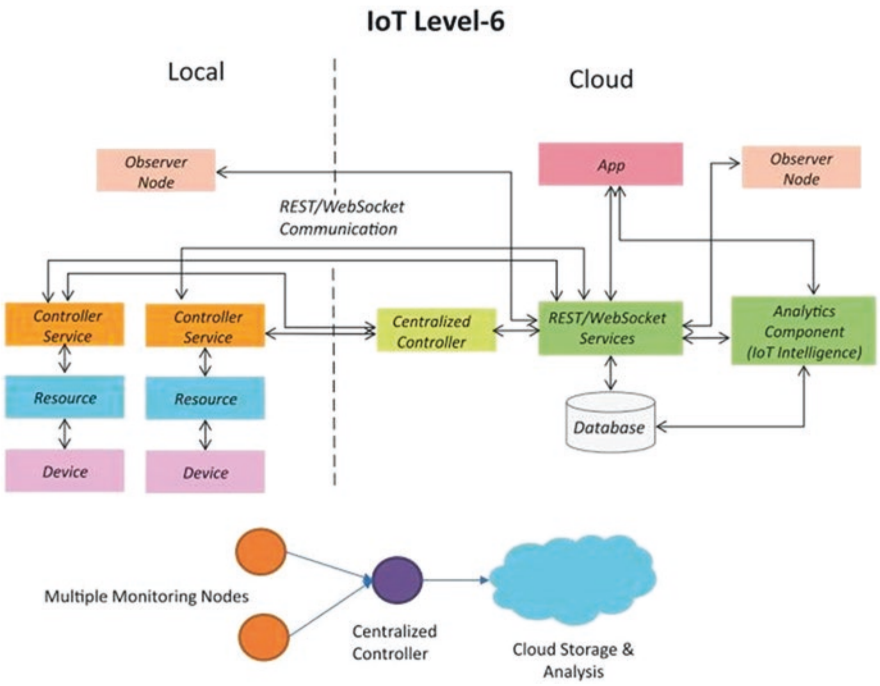


Fig. 8 IoT level-6 architecture

- Logical design of an IoT system refers to an abstract representation of entities and processes without going into the low-level specifics of the implementation.
- An IoT system comprises a number of functional blocks that provide the system the capabilities for identification, sensing, actuation, communication, and management (Fig. 9).

The policy of IoT-based smart farming made by different countries for standardization also has been discussed:

- Then the challenges that come to improve IoT-based smart farming

1.2 Discussion of Major Components for IoT-Based Smart Farming

Major components of IoT-based smart farming:

- Software used in AI
- Control unit connectivity
- Auto mode

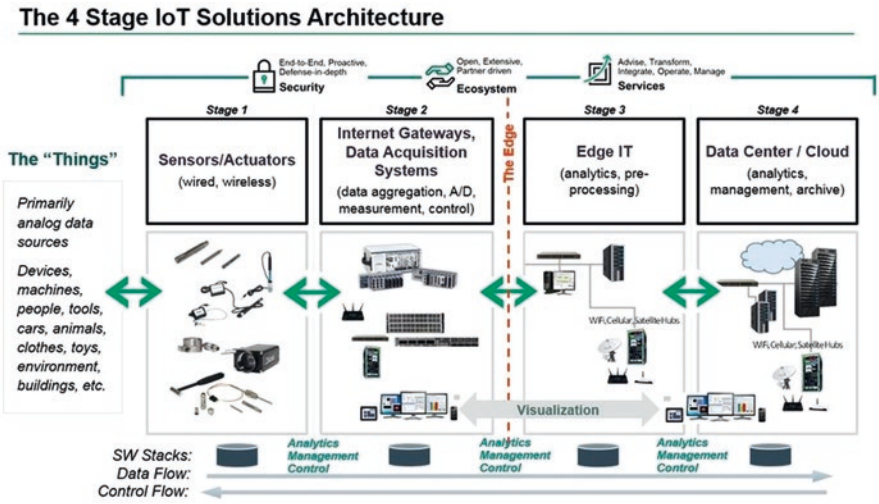


Fig. 9 IoT architecture

Automatically sprays the affected area with the help of four latitudes and longitudes

- Manual mode
  Manually instructs the sprayer (right, left, and both) to cover only the affected area
  Communication between device is too much fast.

  The driver gets full access to all the files with Bluetooth Low Energy (BLE) technology providing excellent communication between devices within close proximity.

2 IoT's Role in Application

For observing various environmental situations, a WSN includes numerous distributed sensors like motion, sound, pressure, temperature, and images. For further mandatory measures in WSNs, data sensation by this sensor is forwarded to the fusion center [8, 56, 9, 10]. Communication of data is endangered to various critical situations to the base station [21–24]. For example, when the sender transmits the data from source node to the destination node to a hacker, it won't be difficult to change the original message which the sensor node received; thus, WSN is not a closed system where there are rare reliability considerations such as wires configuration. Judgement considered in the ground of the message is not accurate when the fusion center gets in current data [12–20]. Nowadays, WSN is utilized as a process in business and industrial implementations [51–55].

Here we will discuss about various types of anomolies in the field of WSN. In this transmission, all nodes must link with different nodes and also attach with one sensor, each sensor network joining with faithful communication different ports situated in the network. It includes radio transceiver and intent antenna operations situated in the process application and this antenna managed by the process micro-controller inserted to that specific process transmission in wireless sensor network application process.

Basically, there are four main features and some optional elements in a wireless sensor node.

- Specific detecting part is inhabited by each sensor node that accommodates an A/D converter, and one and various sensors are employed for data acquisition.
- Memory is used for storing output where for another information every sensor node has a processor, more storage capacity, and a micro-controller.
- For transmission of data using wireless medium, an RF unit is utilized.
- A particular unit for supplying energy to detectors.
- Technique to locate the position conviction.

2.1 WSNs

By taking the help of MEMS, WSNs obtained worldwide attention which guaranteed smart sensor development. Smart sensors have realistic processing and computing resources [49, 48, 26].

Detector nodes detect, estimate, and collect message in surroundings. According to a local commitment process, they broadcast detected information. WSNs incorporate structured and unstructured types. An unstructured WSN has a heavy sensor node cluster and is utilized in an ad hoc manner [27–29, 47]. WSNs are recently utilized in below the earth and submarine. According to surroundings, detectors have varying problems with some restrictions. Some varieties of wireless sensor networks are multimedia, terrestrial, underground, mobile, and underwater. Whether in temporary or arranged earlier in temporary network, detectors fall in a target area arbitrarily. Many deployment models are optimal placement, grid placement and in two dimensional and three-dimensional view planes [30, 31].

In terrestrial WSNs, secure data transmission in heavy surrounding is very much essential. Terrestrial sensor nodes deliver data packet to the base station (BS) [46, 32, 33, 45, 34, 35]. Possessing little battery power and rare facility to recharge, such as solar cells, terrestrial sensor nodes have a secondary energy source. Sensor nodes must preserve energy. Through multi-hop optimal routing power for a terrestrial WSN is preserved, in-network data aggregation, decreasing delays, eliminating data concurrency, very small data communication range and utilizing very small duty-cycle operations [25, 50].

Underground WSNs have several sensor nodes to judge underground situations hiding underground or in caves or mines [44, 36, 37]. To send message from detector point to central station large number of sink point situated on the earth. Concerning utilization and conservation of appliances, a wireless sensor network is costlier than a terrestrial wireless sensor network. For secure transmission towards lands, stones, dilute substance and inorganic materials holds below earth detector points are more costly materials and it should prefer. Underground WSN utilize power, planning, and cost considerations such as terrestrial WSNs. For underground WSNs, efficiency is very much essential. Underground sensor nodes have very less battery energy as compared to terrestrial WSNs and when installed are very difficult to recharge or restore a battery. The important motive is to develop a network efficiency for preserving power that is feasible through secure data transmission protocols.

2.2 Characteristics of the Wireless Sensor Network

WSNs have various important features such as little energy, very small-scale sensor nodes, energy harvesting, node collapse, node portability, strong environment, recognized incidents versatility, node diversity, active network topology, large-scale deployment, and abandoned functions [38].

WSNs' important qualities are:

2.1.1.1. Utilizing batteries or energy harvesting energy utilization restrictions for nodes
2.1.1.2. Potentiality to control with the node collapses
2.1.1.3. Portability of nodes
2.1.1.4. Active configuration of a network
2.1.1.5. Transmission collapses
2.1.1.6. Diversity of position
2.1.1.7. Quality of resistance to a severe atmospheric situation
2.1.1.8. Very easily accessible
2.1.1.9. Abandoned functions
2.1.1.10. Energy utilization

2.3 Wireless Architecture

This architecture contains five layers which are described below:

Physical layer: Decreasing the path loss consequence and shading an enlarged authenticity is the goal of this layer. This layer enables link setup, bit transmission channel, encoding, frequency sensing, signal creation, and inflation.

Data link layer: This layer guarantees interoperability in inter-node connection. It can manage error recognition, multiplexing, continuous data delivery, and avoidance of packet loss.

Network layer: The finest route for secure routing is established by this layer. This is in control of forwarding a message from a particular point to base station,

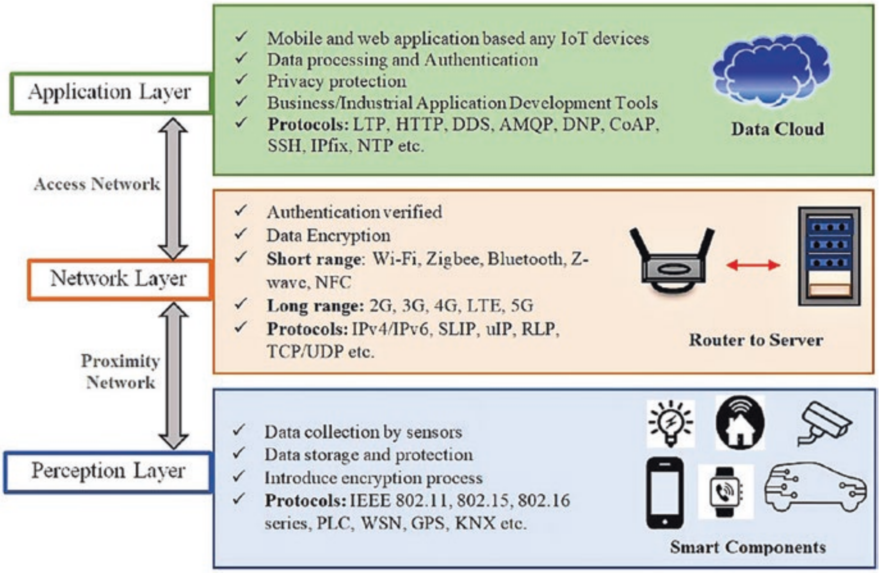


Fig. 10 IoT level [57]

point to point, point to the Cluster Head, point to sink, and reverse. LEACH and PEGASIS protocols relate the techniques to consume power and to increase sensor life. WSNs utilize identity-related protocols for routing, LEACH offers cluster-based data delivery, and PEGASIS is a chain protocol. To generate an efficient routing protocol, in WSN, a network node performs as a router, and it utilizes transmission mechanism. By encryption and decryption techniques, efficient routing is secured.

Transport layer: This layer links data transmission with outer networks that are interrelated to sensor network of the Internet. It is the one of the challenging tasks in WSN.

Application Layer: By securing data transmission to lower layers, this layer offers complete output. For the application software to receive efficient results, it is responsible for management and data cluster and transmission. Security protocols in sensor networks (SPINS) enable data integrity, replay conservation, low cost, and semantic security (Fig. 10).

Various implementations are encouraged by WSNs: a few are revolutionary, whereas various are virtually necessary. The latter's applications are unbelievable target tracking; environment monitoring; oil, water, and gas monitoring; accurate farming; providing chain management; systematic health monitoring; transport facility; active volcano monitoring; healthcare application [39, 40]; below-ground mining; and human job monitoring.

2.4 Network Topology Construction Phase with Efficient Processing

The procedure of the application in wireless sensor networks is stopped with sensible data process which includes a way of communication in data transmission [41–43]. Data communication obtained from warehouse repository with sensible data broadcast with compatible data relative with compatible executions in all sensor exist in the wireless sensor network real time application process management executions. In this situation of data communication, we reach our goal for construction in wireless sensor network application development. We retrieve resources of the wireless sensor networks, various types of protocols and algorithms were evolved with relative data delivery situated in every node termination [4, 5, 11] (Fig. 11).

For each sensor nodes exist in the process transmission wireless networks control topology. We transmit data transmission in commercial technical development, in data delivery of the wireless sensor networks exist in the process communication based on the quality of the service and other features exist in the processing application development. Topology will be modified its structure every time in all data delivery with sensible data delivery exist in the wireless sensor network application process. In general, secure data delivery can be possible in wireless sensor application development but in those data, exist in the delivery process message broadcasting creates a misbehaving nodes packet dropping in sensible data delivery process. In given application processes, successful application of packet dropping is an

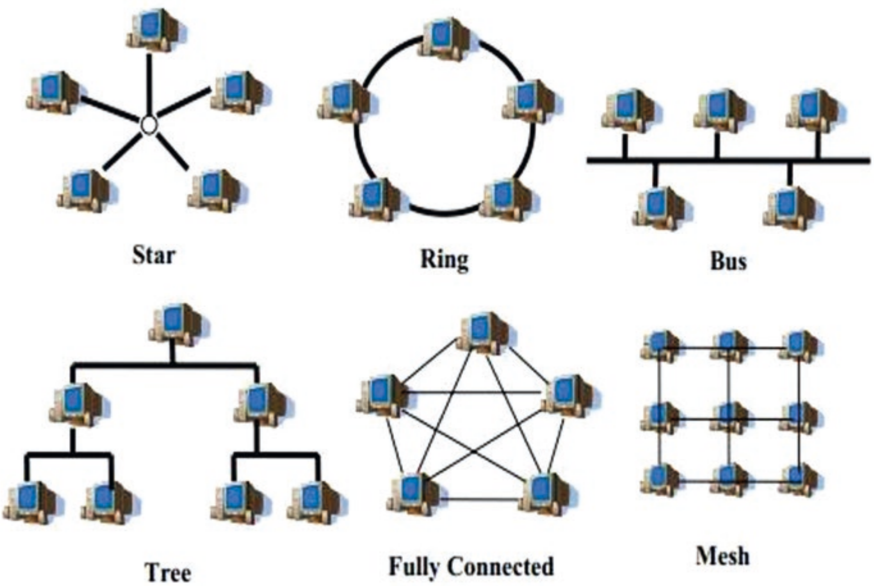


Fig. 11 Network topology construction phase with efficient processing

important issue. In this chapter, to recognize misbehaving nodes in wireless sensor network application processes, we suggest expansion of enhanced adaptive acknowledgement schema with sensible data delivery in process transmission of wireless sensor network application development processes. To protect the attacker from false acknowledgment packets, we enlarge this through digital signature.

2.5 *IoT Agricultural Network Architecture*

From the perspective of agricultural application architecture, it was found that current research are more concentrated on the gateway hardware, and the embedded gateway middleware application is relatively few on the one hand; on the other hand, the AIoT data sharing layer's research is seriously lacking; each application system usually sends the perceived data directly to the AIoT application layer; therefore, it is difficult to achieve the effect of further guiding to agricultural production for the lack of data mining and analysis. Finally, the chapter discussed on further research and application direction of the AIoT technology.

- **IoT Agricultural Platform**
  The IoT agriculture network includes both the analytics model and cloud model.
- **Big Data Analytics**
  Big data analytics largely involves collecting data from different sources, in a way that it becomes available to be consumed by analysts and deliver data products useful to IoT-based smart farming. The process of converting large amounts of unstructured raw data retrieved from different sources to a data product useful for smart farming forms the core of big data analytics. It also determines productivity and optimal cost analysis. IoT agricultural network platform is based on big data analytics. And this network consists of six components mainly:

- Farmer
- Farming experience
- Analysis of big data
- Monitoring and sensing
- Storage services
- Communication protocol and physical implementation

In IoT, this platform provides a backbone on information such as fertility, climate condition, how much moisture is present in the air, online crop monitoring, etc.

In recent years, we can say that agriculture is the backbone of India. Farmers select a large number of suitable crops, vegetables, and fruits. The plant plays a major role as main source of energy and livelihood. In this chapter, we discussed an IoT technology-assisted UAV (unmanned vehicle) procedure-based disease prediction system to identify the disease during its creation in the green ground. This system emphases on IoT with machine learning mechanisms to accomplish disease prediction process in green fields. Imagga cloud is used for the detection of affected leaf. The leaf can be detected by considering the highest confidence tag value as well as its threshold value. The IoT-supported UAV model is basically used to transfer many images to the Imagga cloud. This observes the ground at systematic time intervals by taking images from the field. In this chapter, a challenge has been prepared to display the affected leaf by taking the help of machine learning technique, so that the wastage of agricultural item can be minimized. The chapter prolonged to progress a computerized integrated system to monitor the rice during its production as well as its post-production activities in a better way. While some creature hosts may give their pathogens a steady scope of internal heat levels, plant pathogens are commonly significantly more presented to the components. Natural product infection will in general react to environmental change; however, various collaborations occur among host, pathogen, and potential vectors. At times, the activities of land administrators may likewise confuse elucidation of environmental change impacts. Some biological agents directly or indirectly affect the plant through plant diseases [34]. These biological agents are known as pathogens. Some common pathogens are viruses, bacteria, fungi, and nematodes. Besides these pathogens, some non-pathogenic disease may occur when pH, moisture, and climate are altered with respect to environment. From Fig. 18, we are able to know the role of UAV in agriculture.

3 Cloud and Fog Infrastructure for Data Security

Cloud computing infrastructure is composed up of many components such as storage, hardware, networking, and virtualization, each integrated with one another into a single architecture supporting various types of important operations. Proper security mechanism is required so that the intruder cannot alter any sensitive information (Fig. 12).

As cloud computing in agriculture continues to increase, so too will the number of questions about it.

Figure 1 describes a secure steganography-based fog as well as mobile edge computing environment. Basically, steganography consisted of two main processes, namely, embedding process and extracting process. At some point of the embedding method, watermark is embedded into the multimedia records (virtual records). The original digital data (multimedia content) will be slightly modified after embedding the watermark; this modified data is called watermarked data. At the same time as in extraction manner, this embedded watermark is extracted from the watermarked facts and recovers the original multimedia information. The extracted watermark is then compared with the authentic watermark; if the watermark is identical, it effects in authenticated data. During the transmission of the watermarked data over the public network through cloud or fog, attacker may tamper the data, and any modification in the data can be detected by comparing the extracted watermark with the original watermark. The proposed quantum steganography system ensures the authentication and security for fog cloud IoT users.

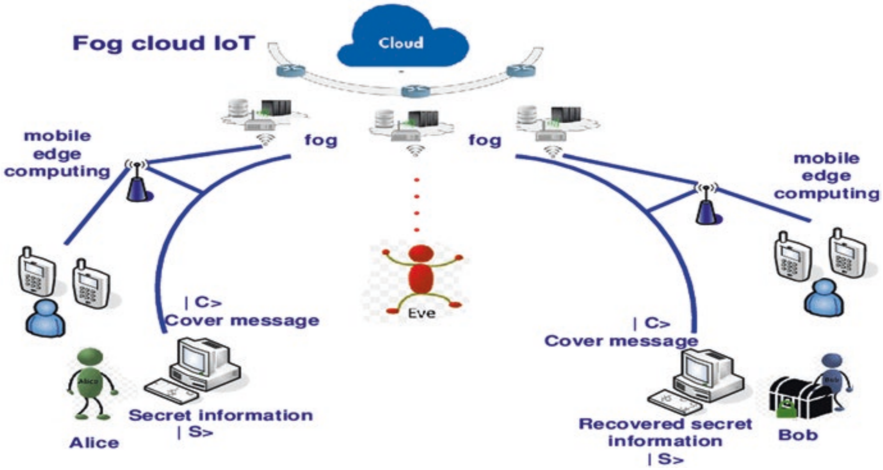


Fig. 12 Architecture of security system [2]

In this chapter, we discussed the role of Internet of things in smart healthcare through wireless body area network. There are many existing algorithms that prove better performance. Sensors (retina artificial arm chips) [6–8] inside the retina can be embedded to help one blind human being to see once more. For WBAN, the sufferers accompanied by heart disease [9], asthma, diabetes, Alzheimer's, Parkinson's, and so on can be performed. [10]. Inside conventional programs, there is a necessity for sufferers for staying inside hospital, yet WBAN confesses these sufferers for continuing through usual everyday schedule of them. It mitigates pharmaceutical work cost and also foundation cost. Biosensor nodes choose one route which has smallest distance towards sink node as well as absorbs small energy. We can integrate WBAN with cloud technology to improve efficiency, larger performances as well as utilities as well as greater reliability and so on, even so this will quiet inside its advance phase as well as might possess various oppositions as well as practical problems [22]. Thus, here we study dual sink technique utilizing clustering inside body area network. This is very important at improving duration of network with effectively using nodes battery lifetime. Here, we can get optimized result in terms of less collision, faster packet delivery rate, and less sensor node failure rate by using a nature-inspired algorithm. In the future, we can optimize [42, 43] by selecting efficient cluster head through the help of machine learning and Internet of things efficiently. We can learn about WBAN from Figs. 13, 14, 15, 16 and 17; Table 1)

- Efficient saturated information storing and retrieving: WSNs are visualized to give global sensation of data, reserve, and satisfy supplying facility in context with global computing. A growing saturated network saving information as well as recovery technique has been presented newly for the reason of secure data management. Therefore, large experimental attempts have been given in such a problem.

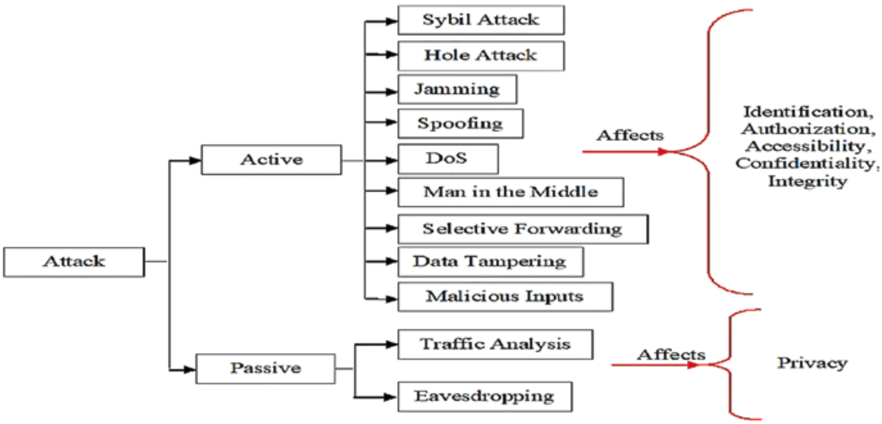


Fig. 13 Various types of attack

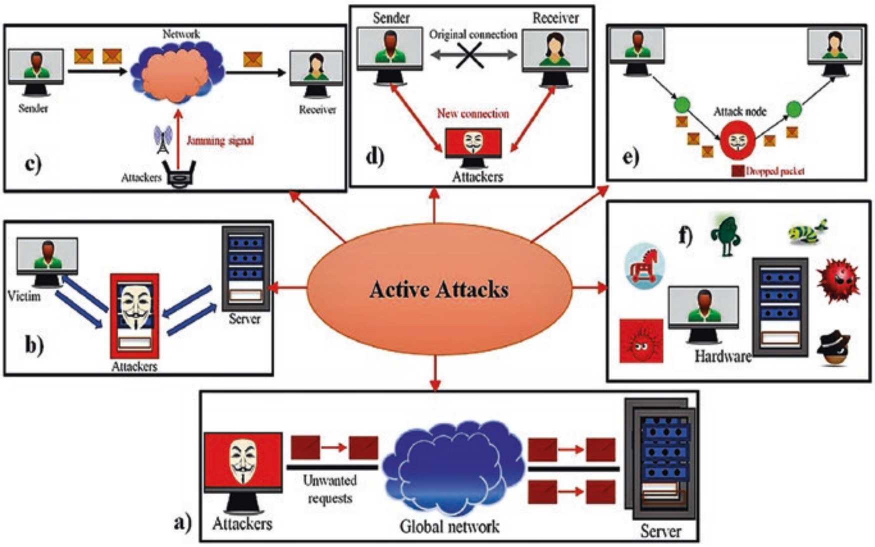


Fig. 14 Representation of various types of cyberattacks
a) Denial-of-Service attack
b) Spoofing and Sybil attacks
c) Jamming attack
d) Man-in-the-middle attack
e) Selective forwarding attack
f) Malicious input attack

- Secure data aggregation: In various applications, for the reason of deducting the transmission cost and efficiency expenditure in data collection, the raw data felt by each and every sensor should be combined. In this dissertation, we learned

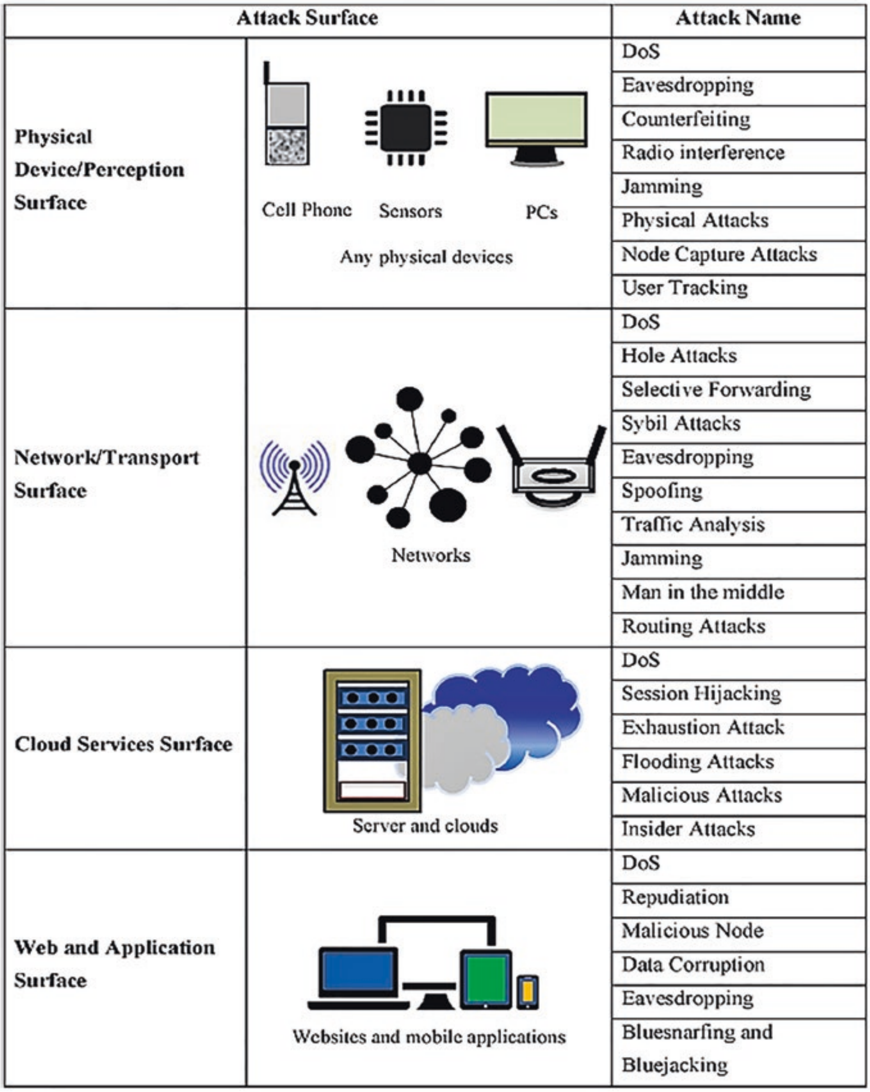


Fig. 15 Types of attack surface

about event boundary detection which is an important form of data collection. Therefore, as required by the given applications, data aggregation in WSNs can be of different forms. Each different type of data collection may need personalized efficient communication techniques. So, in order to deduct the complexity of the protocol stack, general techniques should also be grown. Various research should be created along this area.

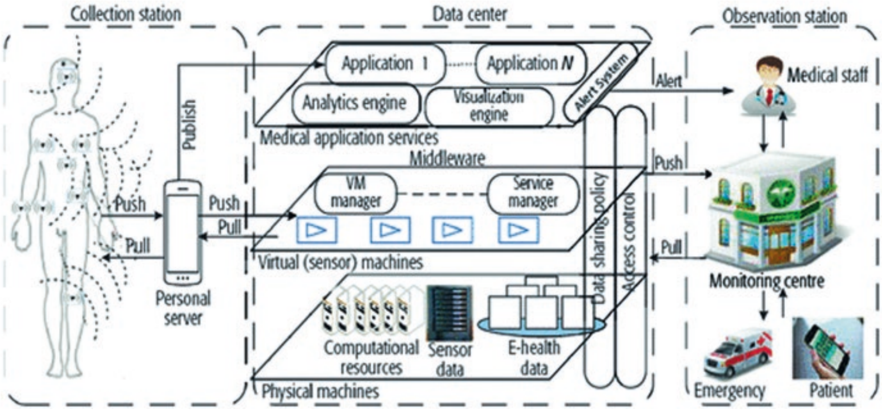


Fig. 16 IoT architecture for smart healthcare [1]

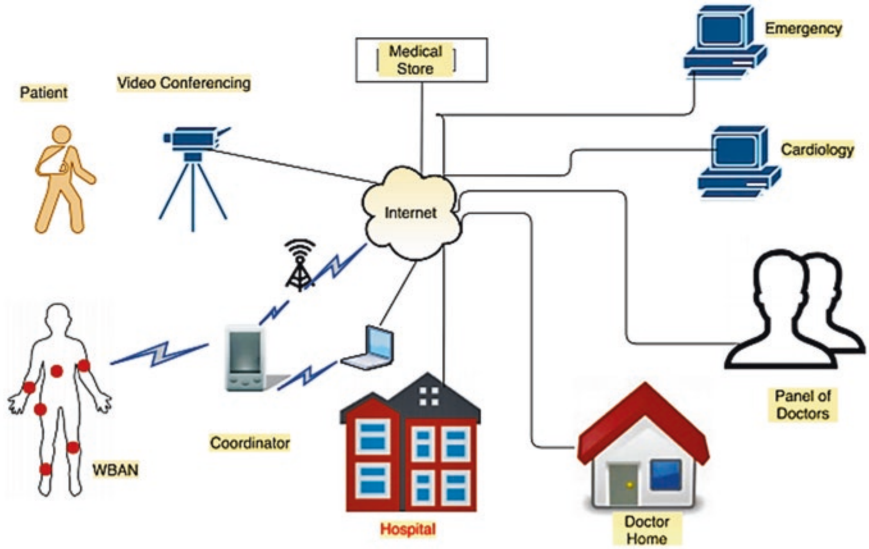


Fig. 17 WBAN architecture [55]

- Privacy-aware security services: Recent security research in WSNs seldomly judge privacy problem. Therefore, in various applications, information and network transmission confidentiality can be a large problem. Privacy-aware security services should be again enlarged as WSNs are visualized to become more and more extensive.

Here we will discuss about various types of anomolies in the field of WSN. These anomalies are elaborately classified below:

Table 1 Difference between IoT security and IoT forensics

IoT Security	*IoT Forensics*
Provides security insurance for both physical and logical security issues	Determines and reconstructs the chain of events by analyzing physical evidence and electronic data
Applies diverse security techniques to minimize the scope of the attack and prevent further damage	Applies investigative techniques to identify, extract, preserve, and analyze digital information
Real-time response: implements different techniques in order to confront the threats during a live incident	Post-mortem investigation: identifies deficits after the incident occurred or while the system is inactive (however, when applying live forensics techniques, forensics professionals acquire digital evidence during a real-time incident)
Generalized: looking for any possible harmful behavior	Case-centered: reconstructing a given criminal scenario
Continuous process: keeps alert 24 hours a day	Time-restricted process: after a crime is alleged to have occurred (notitia criminis)
Security training and awareness: applies a set of security procedures, processes and standards, in order to have a securely-ready system, and prevent future cyber-threats from happening	Forensics Readiness: meets the forensics requirements and applies forensics standards, in order to be ready to undertake an investigation; takes measurements to maximize the forensic value of the potential evidence, and minimize the amount of resources spent on the investigation
Specifies the judicial region and legal aspects in service legal agreements regarding the security	Specify the judicial region and legal aspects in service legal agreements regarding the forensics issues
Well-established computer science field	Young and unexplored branch of the Digital Forensics

Table 1 (continued)

IoT Security	*IoT Forensics*
Provides security insurance for both physical and logical security issues	Determines and reconstructs the chain of events by analyzing physical evidence and electronic data
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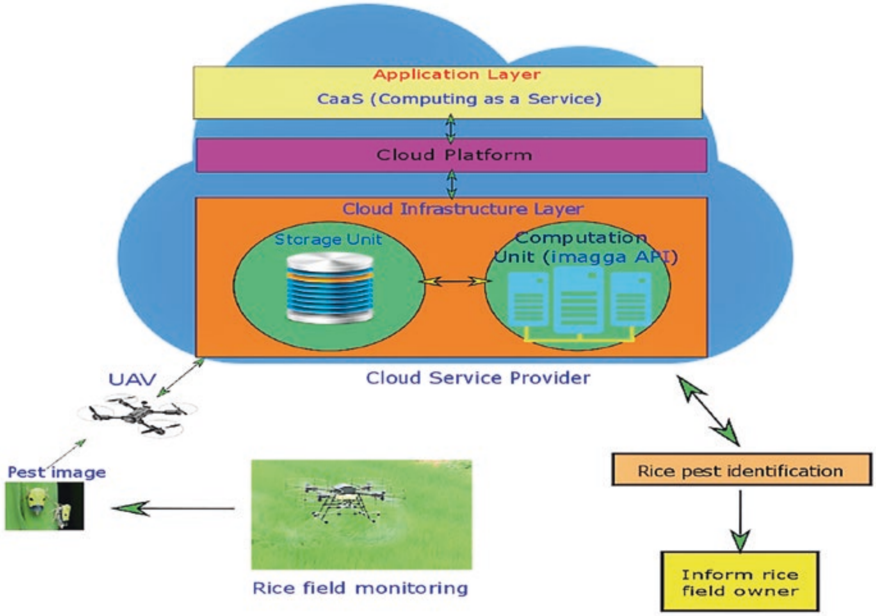

Fig. 18 Possible disease symptoms on plants with the help of UAV [59]

- Attacks on confidentiality and legitimacy: confidentiality and legitimacy of transmission paths should be secured by decryption methods from packet replay anomalies, eavesdropping, and changes of data packets.
- Attacks on network availability: Denial-of-service (DoS) attack are called attacks on availability. This chooses all layers of a sensor network.
- Stealthy attack against service integrity: the aim of the attacker in a stealthy attack is to create the network to receive an incorrect data value. For example, through the sensor node, a hacker encompasses detector point and inserts an incorrect message.

Having the detector network accessible for its deliberate work is necessary in these attacks. DoS attack is very dangerious for WSN should allow day today actual problem to our body and security of human being. Any effort to dispose, disturb, and ruin the networking system is generally known as denial-of-service. Moreover, incidents which eradicate system strength to carry out the involvement can be a DoS attack.

The network layer of WSNs is unsafe because of various types of attacks.

- **Transport Layer Attacks**

Transport layer attacks which can be launched in a wireless sensor network involves de-synchronization and flooding attacks.

- **Node Replication Attack**

A hacker or intruder appending it's connecting points with a survived wireless network in this type of attack by replicating identification number with existing survived point in networking. For a given sensor network, we would like to detect a node replication attack, i.e., an attempt by the adversary to add one or more nodes to the network that use the same ID as another node in the network. Ideally, we would like to detect this behavior without centralized monitoring, since centralized solutions suffer from several inherent drawbacks (see Section 3.1). The scheme should also revoke the replicated nodes, so that nonfaulty nodes in the network cease to communicate with any nodes injected in this fashion. We evaluate each protocol's security by examining the probability of detecting an attack given that the adversary inserts L replicas of a subverted node. The protocol must provide robust detection even if the adversary captures additional nodes. We also evaluate the efficiency of each protocol. In a sensor network, communication (both sending and receiving) requires at least an order of magnitude more power than any other operation [14], so our first priority must be minimizing communication, both for the network as a whole and for the individual nodes (since hotspots will quickly exhaust a node's power supply). Moreover, sensor nodes typically have a limited amount of memory, often on the order of a few kilobytes [14]. Thus, any protocol requiring a large amount of memory will be impractical [3].

- **Attacks on Privacy**

As spontaneous data assembling through systematic and deliberate deployment of sensors is feasible for WSNs, it is at risk to the abundant resources. In a WSN, secrecy maintenance of delicate data is an especially very tough challenge. However, to obtain sensitive data, a challenger may collect apparently safe data and finds for combining information gathered through various detector points.

(i) In mobile computing and wireless research methodology, WSN is attracting more interest over the last decade. Use of wireless network is abundant and is increasing a lot such as in strategic battlefield. Anyhow, these networks are unsafe to various security threats because of their saturated nature and implementation in rural areas, which can directly influence their result.

(ii) In Wireless Multimedia Sensor Networks (WMSNs), various components are responsible for the outline in networking system. It is permitted for the transmission of many streams of theory. The pattern of a WMSN is basically affected by various constituents, which are described in this part.

(iii) There are various necessities to the large area of implementations predicted on WMSNs. The availability of inexpensive hardware such as CMOS cameras and microphones that can ubiquitously capture multimedia content from the environment has fostered the development of Wireless Multimedia Sensor Networks (WMSNs) i.e., distributed systems of wirelessly networked devices deployed to retrieve video and audio streams, still images, and scalar sensor data. WMSNs will enable new applications such as multimedia surveillance, traffic enforcement and control systems, advanced health care delivery, structural health monitoring, and industrial process control. Many of these applications require the sensor network paradigm to be re-thought in view of the need to deliver multimedia content with predefined levels of quality of service (QoS).

QoS-compliant delivery of multimedia content in sensor networks is a challenging, and largely unexplored task. First, embedded sensors are constrained in terms of battery, memory, processing capability, and achievable overall rate, while delivery of multimedia flows may be a resource intensive task. Secondly, in multi-hop wireless networks the attainable capacity of each wireless link depends on the interference level perceived at the receiver. Hence, capacity and delay attainable at each link are location dependent, vary continuously, and may be bursty in nature, thus making QoS provisioning a challenging task. Lastly, functionalities handled at different layers of the communication protocol stack are inherently and strictly coupled due to the shared nature of the communication channel.

In our work, we look at cross layer design of WMSNs with the unique requirements of multimedia content in mind. In recent years, there has been intense research and considerable progress in solving numerous wireless sensor networking challenges. However, the key problem of enabling real-time quality-aware video streaming in large-scale multi-hop wireless networks of embedded devices is still open and largely unexplored. We look at a variety of ways to solve some of these problems. With a very lengthy period of time flowing, these data is created and need assisted message forwarding. Therefore, a powerful base is needed to carry out QoS and evaluate application-specific needs. Concerning a union of bounds on power utilization, accuracy, authenticity, delay, tampering, or network lifetime, these demands may exist to more domains and can be demonstrated with others.

(iv) Large data flow rate: Generally, video data needs data flow rate which is a magnitude greater and carried out with presently obtainable detector. Data rates such as one order of magnitude greater may be needed for high-end multimedia sensors, with equivalent energy consumption. So, it requires to be supported with a large amount of data with less energy utilization method. With regard to UWB (ultrawide band), delivery mechanism appears especially favorable for WMSNs.

(v) Power consumption: In WSNs, Power consumption is a basic involve in traditional wireless sensor networks. Multimedia applications generate large amounts of information, which need efficient data delivery powers with large computing.

(vi) Multiple media coverage: In specific video sensors, various multiple media detectors have greater sense power. Tiny wireless devices and the enormous growth of wireless communication technologies have already established the stage for large-scale deployment of wireless sensor networks (WSNs). A typical WSN consists of a large number of small, low-cost sensor nodes, which are distributed in the target area for collecting data of interest. Most of the time, WSN is used for monitoring, tracking and event management related applications. WSN is not a new topic as many inventions have been done and countless applications have been successfully implemented.

Normally, a multimedia sensor device includes a sensing unit, processing unit (CPU), communication module, co-ordination sub-system, storage unit and an optional mobility/actuation unit. Sensing units usually have two sub-units: sensors [digital micro cameras, microphones and/or scalar sensors (for example, temperature sensors, humidity sensors, fire sensors, pressure sensors and gas sensors)], and analogue to digital converters (ADCs). Most of the sensors generate analogue signals which should be converted into digital form by using ADCs as these are to be fed into the CPU. The CPU executes the system software in charge of coordinating sensing and communication tasks for signal processing, and it is interfaced with a storage unit. A communication Tx/Rx module interfaces the device to the network. In many applications, it has been observed that around 70 per cent of the battery is consumed for transceiver processes and the remaining 30 per cent consumption includes computational tasks, signal processing, co-ordination systems and sensor sub-units.

A coordination sub-system coordinates the operation of different network devices by performing various tasks, such as network synchronisation and location management. A mobility actuation unit can enable the movement or manipulation of objects, like motor, to track the object. The whole system is powered by a compact power unit that may be supported by an energy-scavenging unit, such as solar cells. Table II gives an overview of the features of hardware platforms for WMSNs.

(vii) Connecting other wireless technologies: By corelating regional "islands" of sensors through different Wi-Fi schemes, sensor networks must be added. Without giving up on the reliability of the performance, this is necessary to be secured within each and every individual technology. When the network is used for various mission-critical applications, this problem is very dangerous like that in a strategic battlefield. In real-life deployment scenarios, accidental collapse of nodes often occurs. Traditional security mechanisms with large overhead of computation and transmission are impossible in WSNs due to resource constraints in the sensor nodes (Table 2 and Figs. 16, 17 and 18).

- Irrigation Monitoring System

Older irrigation technologies led to a lot of water wastage, discouraging people to take up farming, particularly in a parched area like Dhanbad, despite owning lands and forcing them to migrate to other cities for employment. The project will help those with less farming skill in coming out with a more proficient way of irrigation with the sprinkler system. Temperature, moisture, and humidity readings are continuously monitored using sensors and are managed by the AgroPro app, which is available for download on the Google Play Store.

"The automatic soil monitoring and irrigation system will help farmers tackle water management issues and enhance the crop yield thereby generating means for their livelihood. We had conducted a survey last September and got to know about the problems faced by farmers. This helped us in developing the project to address their issues," said Ranjan. The basic setup costs around Rs 10, 000 for 21, 000 square feet of land. The solar-powered smart irrigation system aims to provide an

Table 2 Comparisons between cloud computing, edge computing, fog computing, and mist computing

	Cloud Computing	Fog Computing	Edge Computing	Mist Computing
Architecture	✧ Central processing based model ✧ Fulfils the need for large amounts of data to be accessed more quickly, this demand is ever-growing due to cloud agility ✧ Accessed through internet	✧ Coined by CISCO ✧ Extending cloud to the edge of the network ✧ Decentralized computing ✧ Any device with computing, storage, and network connectivity can be a fog node, can be put on railway track or oil rig. ✧ Fog computing shoves intelligence down to the local area network level of network architecture, processing data in a fog node or IoT gateway	✧ Fog computing usually work with cloud and Edge can work without cloud or fog. ✧ Edge is limited to smaller number of peripheral layers ✧ Edge computing pushes the intelligence, processing power and communication of an edge gateway or appliance directly into devices like programmable automation controllers (PACs)	✧ Middle ground between cloud and edge/fog ✧ Lightweight computing residing in the network fabric using micro-controllers and microchips ✧ Not a mandatory layer of fog computing
Pros	✧ Easy to scale ✧ Low cost storage ✧ Based on Internet driven global network on robust TCP/IP protocol	✧ Real time data analysis ✧ Take quick actions ✧ Sensitive data remains inside the network ✧ Cost saving on storage and network ✧ More scalable than edge computing ✧ Operations can be managed by IT/OT team	✧ Edge computing simplifies internal communication by means of physically wiring physical assets to intelligent PAC to collect, analysis and process data. ✧ PACs then use edge computing capabilities to determine what data should be stored locally or sent to the cloud for further analysis	✧ Local decision making data ✧ Works with fog computing and cloud platform
Cons	✧ Latency/Response time ✧ Bandwidth cost ✧ Security ✧ Power consumption ✧ No offline-mode ✧ Sending raw data over internet to the cloud could have privacy, security and legal issues	✧ Fog computing relies on many links to move data from physical asset chain to digital layer and this is a potential point of failure.	✧ Less scalable than fog computing ✧ Interconnected through proprietary networks with custom security and little interoperability. ✧ No cloud-aware ✧ Cannot do resource pooling ✧ Operations cannot be extended to IT/OT team	
Misc.		✧ Less sensitive and non-real-time data is sent to the cloud for further processing ✧ Fog node can be deployed in private, community, public or hybrid mode	✧ PACs (programmable automation controllers) then use edge computing capabilities to determine what data should be stored locally or sent to the cloud for further analysis ✧ intelligence is literally pushed to the network edge, where our physical assets are first connected together and where IoT data originates ✧ The current Edge Computing domain is a sub-set of Fog Computing domain.	✧ Architecture may not require Cloud

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IoT solution in automating the watering process using an Arduino-based microcontroller and sensors. It is an energy-efficient and eco-friendly system that generates electricity from photovoltaic cells to supply water to the plants from water pumps. The watering process is driven by the moisture content of the soil using sensors. Threshold limits are set for soil moisture sensor to ensure efficient and effective use of water resource. The main microcontroller unit controls the system whenever the sensor is across threshold value. Also, the system has built-in temperature and humidity sensors to monitor the climate condition on a specific environment. Another sensor is implemented to measure the water tank level which serves as storage capacity that supplies the water to the system. With the integration of IoT, automated irrigation can be easily accessed and remotely monitored over a mobile application through a wireless communication device. With these smart irrigation techniques, it replaces the traditional irrigation system that helps decrease manual intervention and mistakes.

4 COVID Handling Using IoT

To minimize the spread rate of the fatal COVID disease, scientists are trying and doing research to identify disease-affected persons. From Figs. 19, 20 and 21, we came to know about the architecture of the process, fog computing framework, and customer registration process. The number of infected as well as suspected people can be found by using this method nationwide. There are many terminologies used here, which we will discuss below:

- ARC: Automatic Risk Checker (ARC)
- CA: Cloud Application

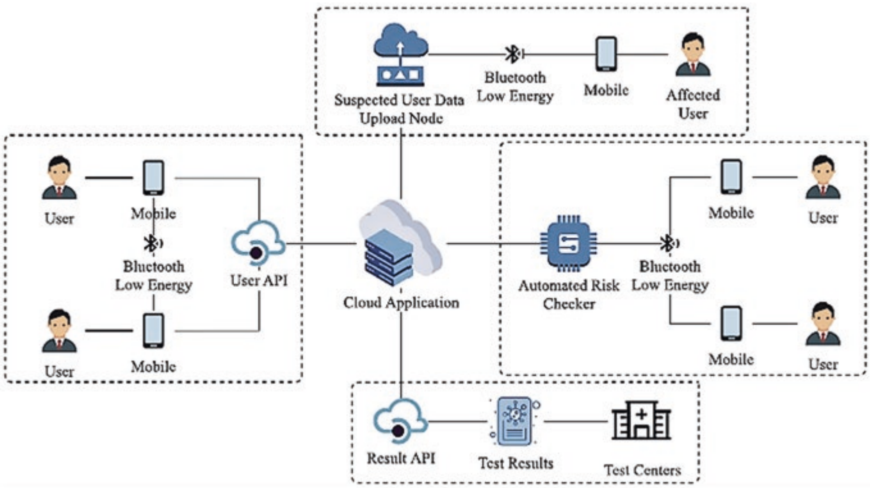

Fig. 19 Application of COVID system overview [58]

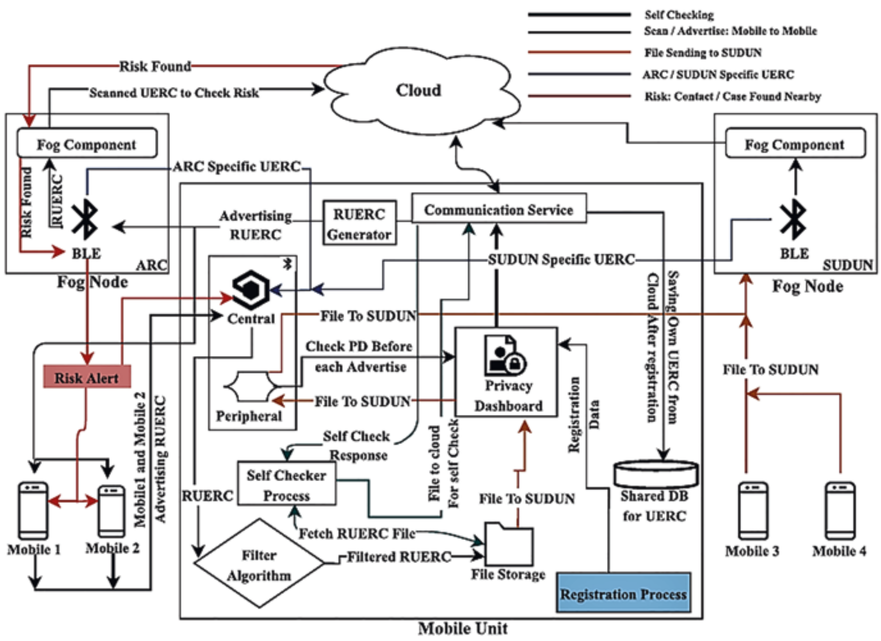

Fig. 20 Fog computing framework [58]

- SUDUN: Suspected User Data Uploader Node
- UERC: Unique Encrypted Reference Code
- RUERC: Rotational Unique Encrypted Reference Code
- BLE: Bluetooth Low Energy Technology

5 Conclusion

IoT is a technology that provides a platform where a network of devices can communicate, explore data, and practice information manually to cater to the needs of individuals or organizations. Enabling autonomous interaction between the interconnected devices and objects gives rise to another emerging interdisciplinary area as well as influencing new paradigms on the Internet. Among the other extension of IoT, Internet of behavior is the recent one and can be compiled under fields like technology, data analytics, and behavioral science.

This chapter's objective is to explore the concepts and applications related to Internet of things with the vision to identify and address its behavioral applications focusing into decisions, intensifications, and companionship while using the technology in healthcare solutions, agriculture and supply chain, industry, and other

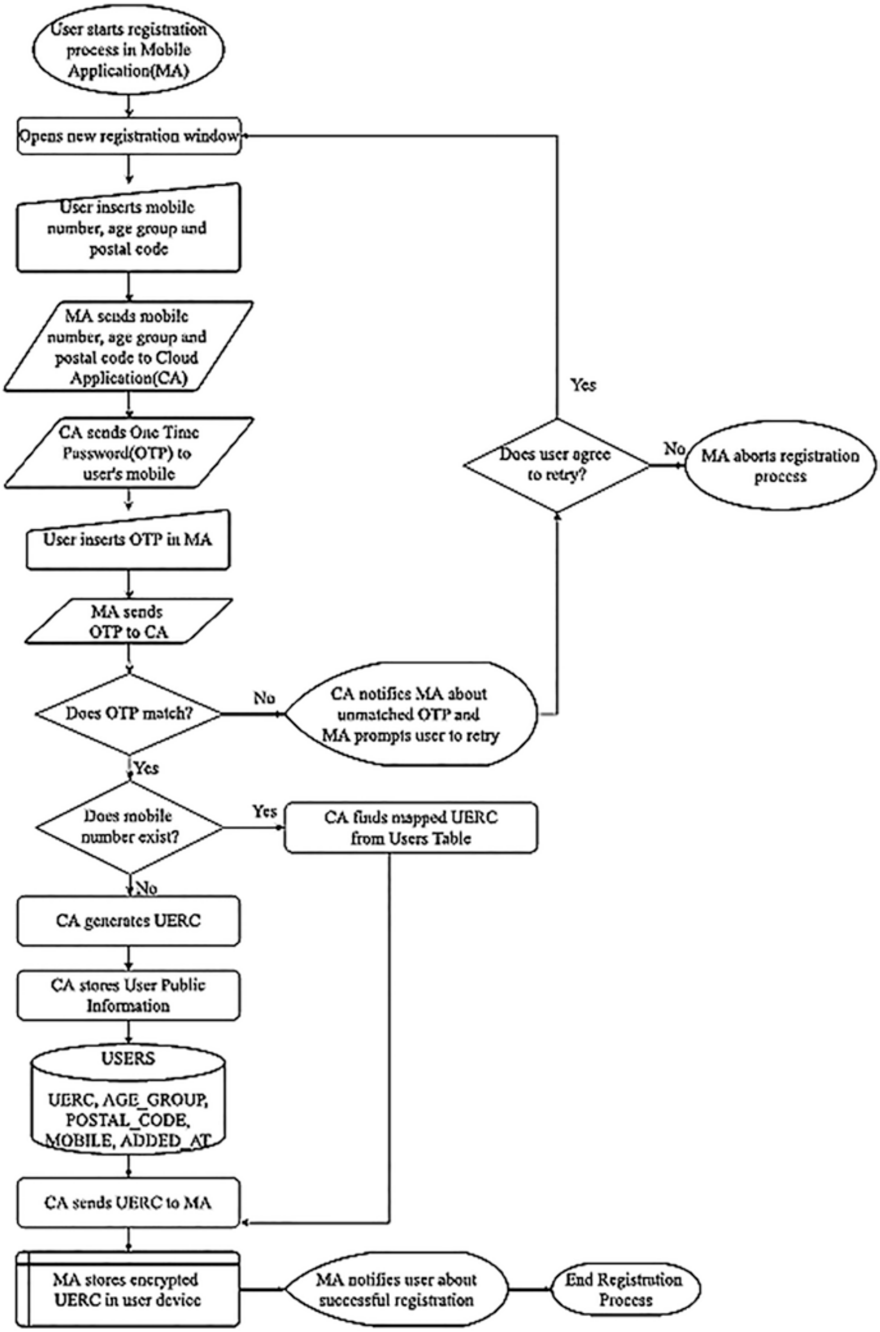

Fig. 21 Registration process of the user [58]

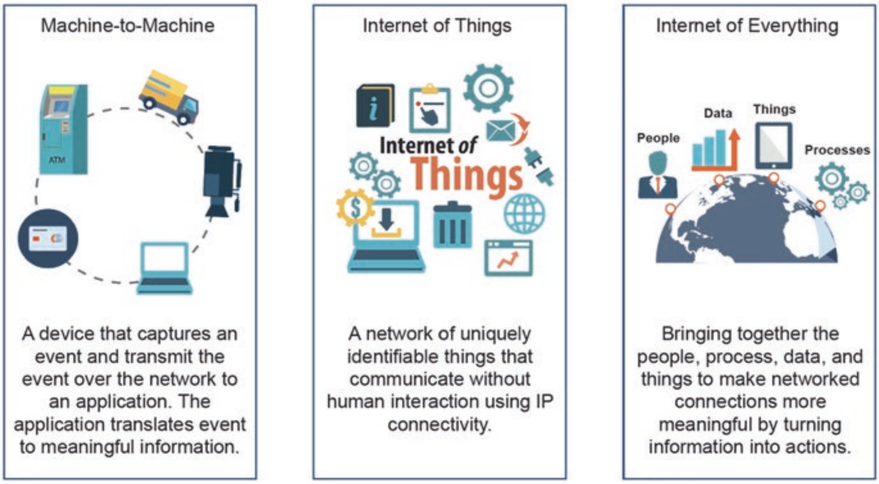

Fig. 22 Differences among M2M, IoT, and IOE

smart applications. Due to this all-in-one embedded nature of IoT and its behavioral applications, its architectural design, implementation, operational manageability, and maintenance are raising numerous prevalent concerns that serve as challenges for researchers and academicians (Fig. 22).

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IoT Framework, Architecture Services, Platforms, and Reference Models

S. Mahalakshmi and Kavitha Desai

1 Introduction

Internet of things (IoT) can be perceived as a platform where associated gadgets/things become brilliant, preparing gets clever, and correspondence is more important. Although the Internet of things is still trying to find ways, the effects it has created are causing waves in the connected world. The Internet of things is about seamlessly connecting devices for greater functionality and improved productivity. With all these advantages come the challenges as well. The lack of architecture standards, frameworks, and platforms is one of the greatest challenges IoT is facing.

A comprehensive reference architecture, platform, and framework are important to advance further and reap the benefits of IoT completely for its stakeholders. Cisco-authorized Forrester Consulting (2014) has demarcated IoT as the insolent associations of objects connected to the Internet that facilitates an altercation of accessible data and fetches user's information more safely. According to Forrester [3], IoT creates a smarter environment. It does this by making use of the information and communications technologies to create state-of-the-art infrastructure components and services. This makes things smarter, interactive, and efficient. Almost all the domains have benefitted from this. Perez, U.A. [4] has demarcated IoT as "the interconnectedness of interestingly recognizable implanted figuring gadgets inside the current Internet framework, offering progressed network of gadgets,

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frameworks, and administrations that go past machine-to-machine correspondences and covers an assortment of conventions, areas, and applications".

As indicated by Goldman Sachs IoT Primer (2014), the Internet of things associates gadgets, for example, everyday objects and industrial networks, enabling information gathering and management of these devices via software to increase efficiency, enable new services, or achieve other health, safety, or environmental benefits. As per the World Economic Forum, "The Global Information Technology Report 2012 – Living in a Hyper-Connected World," IoT incorporates equipment and programming to store, recover, and measure information and interchanges among people and gatherings. This converging of data and interchanges innovation is occurring at three layers of innovation advancement specifically the cloud, information, and correspondence of networks.

Contribution
As authors, we have made an honest effort to acquire IoT ideas. The part is planned so that it helps the pursuers and the IoT people group to comprehend the center ideas much better. The fundamental IoT definition, stages, and models are shrouded inside and out. This would give anyone a clear understanding of IoT and its application. In addition, both the creators have enthusiasm and openness to IoT and IoT-related exploration and have contributed similarly to this part.

Motivation
IoT is making another wave in the realm of associated gadgets. This field has incredible potential, and being essential for this spearheading field is an advantage. IoT has contacted practically all features of our lives. The associated world will be the new standard. As academicians and specialists, we might want to keep ourselves refreshed and comparable to the adjustments on the planet, and IoT guarantees that. Simultaneously, it's consistently an honor to be related with a diary-like springer where there is no trade-off with regard to quality.

1.1 Definitions

As indicated by Atzori et al. [1], the Internet of things can be fathomed in three standards, in particular, the middleware, the sensors, and the information. The "Bunch of European Research Projects on the Internet of Things" [2] depicts the things/gadgets that have a sensor installed in it collaborate and speak with different gadgets subsequently setting off activity without human intercession. These gadgets can detect its current circumstance and trade data.

Atzori et al. [1] clarify the Internet of things in three archetypes, to be specific, the web situated (center product), things arranged (sensors), and semantic situated (information). It further expresses that the adequacy of IoT can be procured distinctly in an application area where the three ideal models meet. Sundmaeker et al. [5] from the Cluster of European exploration projects on the Internet of things say that "Things" are dynamic individuals in the business cycle and are empowered to organize and impart among themselves and with the external climate by trading information and data detected about the climate continuously with insignificant or no human intercession while responding self-rulingly to the genuine/actual world occasions and affecting it by running cycles that trigger activities and make administrations with or without direct human mediation.

1. Belissent [3] on Forrester says by using ICTs (information and communications technologies), IoT improves the complex things that are more cognizant, interactive, and well organized like education, healthcare, etc. McKinsey [6] has demarcated IoT as the networking of physical objects through sensors, actuators, and other devices entrenched to it by amassing and conveying information about the object.

Though there is no standard definition for Internet of things, an appropriate definition would be as stated below: "The Internet of Things (IoT) is an arrangement of interconnected computing devices, machine-driven and digital machines, objects, animals or people that are provided with exclusive identifiers and the ability to transfer data over a grid without requiring human-to-human or human-to-computer interface." "An open and wide-ranging network of smart objects that can auto-organize, share information, data, and resources, reacting and acting in face of situations and changes in the environment" [12].

1.2 IoT Technologies

Oscillating from wearables to smart homes, healthcare to smart environments, to event logistics, supply chain, and retail, IoT is likely to practically infiltrate into almost all the facets of daily life. Though the existing IoT-enabling technologies are improving day by day, the heterogeneousness is a gigantic challenge that the IoT community must address. This section discusses various technologies that have enabled IoT.

1.2.1 Radio-Frequency Identification (RFID)

[7] RFID is the starter segment needed for the development of the Internet of things. It is essentially sorted into active RFID, passive RFID, and semi-passive RFID. It is fundamentally made out of a tag, a peruser, a receiving wire, an entrance regulator, a product, and a worker. It is monetary, compelling, and legitimate and subsequently can be effectively trusted upon [8]. RFIDWorld.ca (2012) in 2011 articulates the world exhausted and assessed $6.37 billion on RFID chips; however, that IoT piece of the overall industry is anticipated to blow up to more than $20 billion by 2014.

1.2.2 Internet Protocol (IP)

Internet Protocol (IP): Bicknell [9] states that there are two forms of Internet Protocol (IP) being used: IPv4 and IPv6. Every one of these unexpectedly characterizes IP addresses. As per rule, IP address ordinarily alludes to the tends to characterized by IPv4 just, which accommodates 4.3 billion locations while the IPv6 accommodates 128-bit (2128) addresses, along these lines permitting 3.4 × 1038 restrictive IP addresses.

1.2.3 Electronic Product Code (EPC)

It is an electronic code that is 64 bit/98 pieces signed on an RFID tag. It first evolved in the year 1999 at MIT's Auto-ID focus. "EPC Global" (2010) says it is answerable for alignment of Electronic Product Code (EPC) innovation, utilized for sharing RFID data. EPC code can store data about the kind of EPC, novel chronic number of items, its determinations, maker data, and so on.

1.2.4 Barcode

Barcode is simply an elective method of encoding letters and numbers utilizing bars and spaces of variable width in different blends. The *Bar Code Book* from Palmer [9] permits the substitute methodologies of information passage strategies. Standardized tags are optical machine-discernible marks appended to things that record data identified with the thing. Scanner tags are intended to be machine discernible. Laser scanners are ordinarily utilized for perusing, and in addition, it tends to be perused utilizing a camera.

1.2.5 Wireless Fidelity

Wireless Fidelity in short called Wi-Fi is a systems administration innovation that encourages correspondence among PCs and different gadgets through a remote sign. Wi-Fi essentially contains a WLAN item uphold on IEEE 802.11 joined with the double band, 802.11a, 802.11b, 802.11 g, and 802.11n. It's another standard these days that the whole urban communities are turning out to be Wi-Fi passages by these Wi-Fi applications.

1.2.6 Bluetooth

It is a remote innovation. This wipes out the requirement for cabling between gadgets like PCs, PDAs, scratchpads, cell phones, and so forth It works when the reach is of 10–100 meters utilizing the IEEE 802.15.1 standard particular in this way, making it reasonable.

1.2.7 Zigbee

This innovation has a data transmission of 250 kbps and a scope of around 100 meters and a. [10]. This convention was produced for additionally upgrading the remote sensor organizations. It is a remote organization convention based on the IEEE 802.15.4 norm and discovers its application in home robotization, brilliant agribusiness, modern computerization, clinical analysis, and so on.

1.2.8 Near Field Communication (NFC)

NFC is a bunch of short-range remote innovation that works at 13.56 MHz. It is broadly liked as NFC makes life less complex and advantageous for customers around the globe by making it easier for exchanges, trade of advanced data, and interfacing electronic gadgets. NFC's significant distance abilities that work at a range of 10 cm is comparable to Bluetooth and 802.11 conventions.

1.2.9 Wireless Sensor Networks (WSN)

This is a remote organization that comprises sole free gadgets appended with sensors. The sensors normally screen ecological conditions like sound, temperature, vibration, pressure, and so on. Arampatzis, T. et al. [11] say WSN contains an assorted number of gadgets that speak with one another and pass information starting with one and then onto the next. A remote sensor network is an imperative angle in the IoT worldview. IoT dependent on WSN has had an exceptional effect in territories in different zones like medical care, fabricating, line security, farming observing, backwoods fire and flood location, and so forth.

1.3 IoT Framework

IoT framework is a middleware layer underneath the IoT applications. It has a networking application that interfaces with the framework networks. Usually, frameworks support multiple communication technologies. IoT frameworks also play a vital role in exposing the security, applications, and framework nodes [19]. The IoT framework can be espoused by the IoT community that encompasses the users of the system, vendors, service providers, developers, integrators, business enterprises, and Governments themselves [13].

Interoperability is the capacity of different devices connected to IoT to exchange information and use it effectively. The basic function of IoT is to support connectivity and interoperability issues. The existing IoT initiatives provide petite scope for interoperability and connectivity thereby being redundant in terms of functionality, services, and visibility and limit the scope for coordination and reuse [14].

IoT devices upon interacting with other devices improve efficiency and ease of use and lead to economies of scale [15]. Poor interoperability and connectivity are mainly because of a lack of standardization for naming conventions leading to a lack of integration [16].

The absence of semantics and helpless context awareness as yet appears in the current IoT plan. Ongoing IoT frameworks struggle from insufficient setting familiarity with administrations due to uncouthly and unevenly disseminated semantics [17]. For a decent set of mindful information handling, a new technique ought to be applied to displaying and planning. Various IoT frameworks use the order of gadget administrations made on the gadget listing. This sort of traits to gadgets is dependent on the elite identifier of the two administrations and gadgets [18] (Fig. 1).

1.4 IoT Architecture

There is no widespread design or a typical concurrence on the engineering of IoT that is concurred commonly by organizations and specialists. Different structures have been proposed by specialists. Numerous structures are accessible however no normalization. Not many analysts uphold three-layered engineering; others uphold four-layered designs. Further progressions and the engineering of three layers and four layers can't satisfy the necessities of utilizations. In addition, with the disturbing test w.r.t protection and security, the five-layered design has likewise been proposed. It is viewed to satisfy the prerequisites of IoT concerning security and protection [20].

1.4.1 Four Stages of IoT Architecture

Four phases of IoT engineering are sensors and actuators, Internet doors and data acquisition systems, edge IT data processing datacenter, and cloud [33]. Connected devices (sensors/actuators): The sensors sense the data and process it for further analysis. The sensors are accompanied by the actuators which decide and take appropriate actions and gain necessary insights for future analysis. The sensors and actuators can be wired or wireless, for example, automatic opening and closing of a door. The second stage is aggregated and digitizes the data. The Data Acquisition System (DAS) aggregates the output connected to the sensor data, and the Internet

Fig. 1 10-layered IoT architecture with "IoT Industry and Solution" at the top and layer 1 "IoT Endpoint" at the bottom

Layers	Description
Layer 10 IoT industry solution	IoT industry area is the place where the IoT arrangement is essential for an enormous environment. The fundamental purpose of underscoring on IoT arrangements is to cling to the foundation, consistence, information protection and security, laws and guidelines, and so on for giving total IoT arrangements
Layer 9 IoT solution/service provider	Underlines the association and collaboration between the IoTSP and its stakeholders through its products/services
Layer 8 IoT user	A run of the mill IoT arrangement can have various sorts of clients with various uses and utilization designs. This layer features the clients, who are the principal recipients of the arrangement
Layer 7 IoT UI	Is the user interface design used by the end users to access the outcomes
Layer 6 application enablement	Application enablement is a broader part of the IoT platform and is a set of functions that includes the API gateway, data visualization, and device and database management
Layer 5 intelligence enablement	This enacts or empowers the application layer. This alludes to the utilization of (arising) advances, for example, big data and analytics, artificial intelligence (AI), machine learning (ML), and deep learning (DL) for assessing huge measure of constant information gathered from the IoT gadgets and other outer sources

(continued)

Layers	Description
Layer 4 connection management	Detecting and handling device connections and configurations on an IoT platform
Layer 3 connectivity	This layer is more concerned with the wide range of technologies used amid the sensors and fundamental IoT functions
Layer 2 IoT gateway	IoT gateway goes about as a convention passage that gathers information from sole sensors and together sends it to the unified IoT stage
Layer 1 IoT endpoint	Includes meek sensors to complex, standalone devices like smart meters, device trackers, device controllers, etc. to embedded devices in control systems, self-driven cars, etc.

gateways optimize the data collected from the previous layer for further processing. In this stage, data pre-processing and advanced analytical processing are performed. This stage enables the data thus captured at local sensors and sends them to remote locations. Stage 4 which is data visualization and analytics involves in-depth processing of data. Data from external sources might be gathered as well. This information thus obtained is used in predictive analytics [33] (Fig. 2).

1.4.2 Basic IoT Architecture

In basic architecture, we have the physical sensing layer which has sensors embedded into it that gathers the real-world data, and next is the gateway layer. The gateway layer sends the conventions to the associated gadgets which send the information detected to the web, while the center product layer encourages and deals with the correspondence among the application layer and true detected exercises (Fig. 3).

The IoT design has advanced from a three-layered engineering to a five-layered design. The three-layered engineering has the application layer, organization layer, and discernment layer. The four-layered engineering has a help layer notwithstanding the three layers found in the three-layered design. The five-layered engineering has a business, preparing, and transport separated from the application and discernment layer [25] (Fig. 4).

1.4.3 Three-Layered Architecture

The three-layered engineering was proposed in the beginning phases of the advancement of IoT. The fundamental IoT engineering is the three-layered architecture, and it has progressed further [30–32]. It has three layers in particular the insight, organization, and application layer as demonstrated in the figure beneath.

Perception layer: The perception layer is otherwise called a sensor layer. The discernment layer distinguishes the things and gathers data from them. In light of the applications, the sensors would be picked [26]. The sensors can gather data about movement, temperature, power observing, and so on. RFIDs, sensors, and

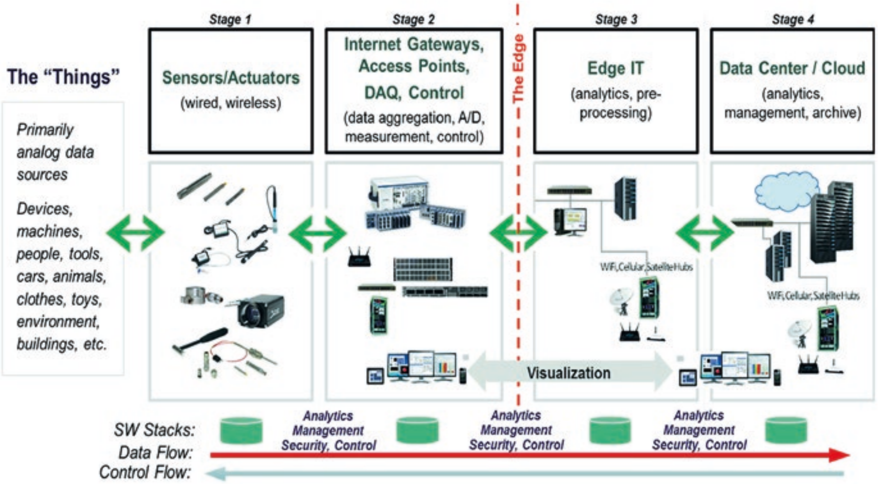

Fig. 2 Four stages of IoT architecture

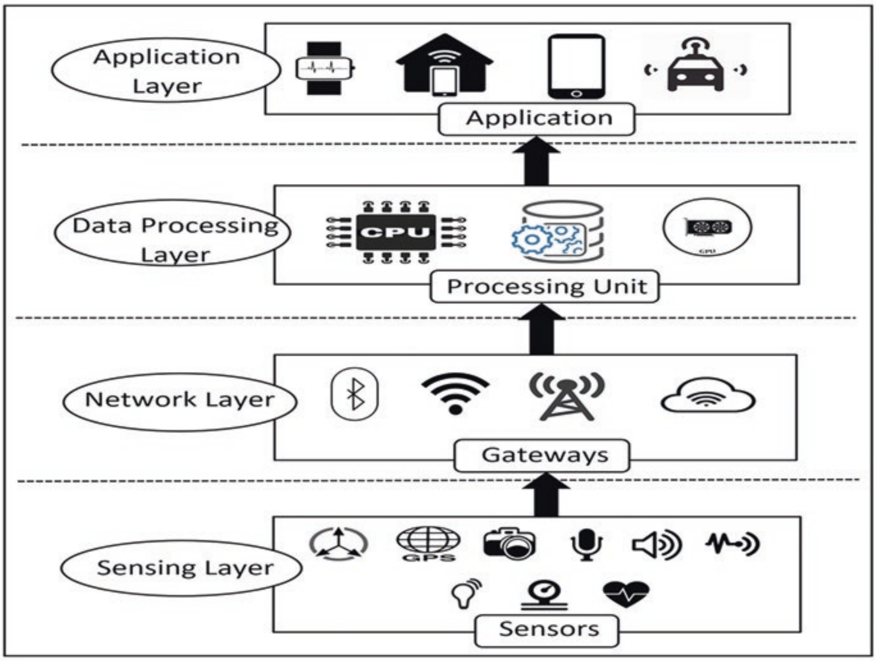

Fig. 3 Basic IoT architecture

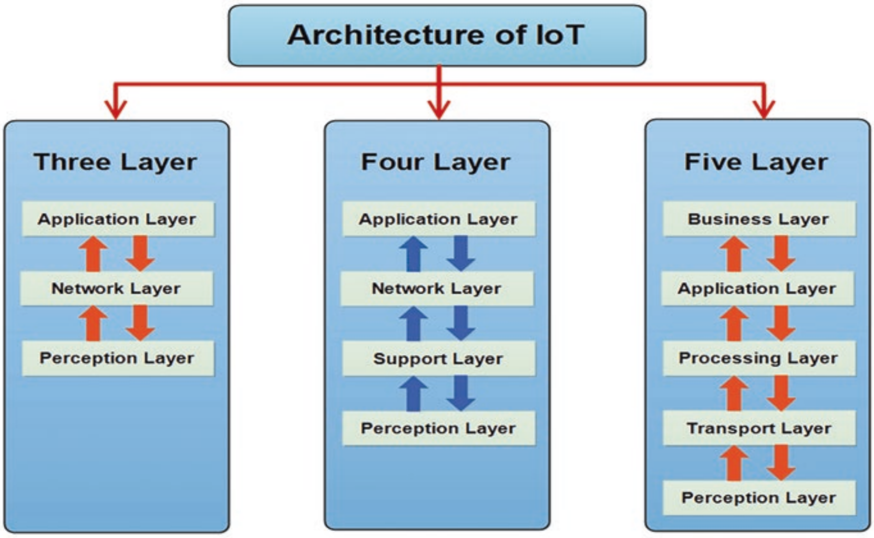

Fig. 4 Three-layered, four-layered, and five-layered IoT architectures

standardized tags are different sorts of sensors that gather information by being essential for the insight layer [21, 22]. The sensors are picked by the necessity of utilizations. Sensors are additionally generally defenseless as sensors can be supplanted and controlled effectively which is one of the greatest security dangers [27, 28].

Network layer: A network layer is additionally called the transmission layer. It sits between the discernment layer and the application layer. It associates the savvy things to the organizations. The method of transmission can be wired or remote. Essentially, it conveys and sends data gathered from the sensors appended to the actual article [20].

Application layer: The application layer offers types of assistance to every application dependent on the data that is gathered by the sensors. Every application may have an alternate assistance demand contingent upon the kind of data gathered by the sensors. For instance, the sensor data gathered for keen homes is finished not the same as the data gathered for keen well-being [20].

1.4.4 Four-Layered Architecture

The four-layered architecture has evolved from the three-layered architecture. The three-layered one was basic, and it was not able to accommodate the changing IoT paradigm. The four-layered architecture has all the levels present in a three-layered architecture, and in addition to that, it has another layer called the support layer [29]. The support layer focused on overcoming the security issues in the IoT architecture. The fourth layer of architecture was proposed primarily to overcome the flaws in the three-layered architecture. The support layer then sends the secured information to the network layer [20].

1.4.5 Five-Layered Architecture

The four-layered design assumed a noticeable part in the advancement of IoT engineering. However, the issues concerning capacity and security were not tended to totally. Thus, scientists proposed a five-layered design to address the capacity and security issue [30, 31]. The five-layered engineering shares three layers for all intents and purposes, to be specific, the application layer, transport layer, and discernment layer, notwithstanding that the recently proposed layers are the handling layer and business layer [32]. Preparing layer gathers data from the vehicle layer and measures it by eliminating the undesirable information and separating significant data. The business layer oversees and controls the applications and IoT models. This layer is capable of overseeing the expected conduct of the application and the whole framework [20].

1.4.6 European FP7 Research Project

This is created by Project accomplices of the European FP7 Research Project IoT-A. It is a proposition for an IoT engineering plan that utilizes the Architectural Reference Model (ARM). It was obtained from business contemplations, application-based necessities, and current innovations. The web acts as an empowering influence by interfacing interoperable IoT frameworks like medical care, retail, shrewd homes, and so forth through interoperable advancements like Bluetooth, RFID, ZigBee, and so on [34] (Fig. 5).

1.4.7 ITU Architecture and IoT Forum Architecture

The International Telecommunication Union (ITU) proposes a design much the same as the Open Systems Interconnection (OSI) reference model in organization and information correspondence for the Internet of things which comprises the detecting layer, the access layer, the network layer, the middleware layer, and the application layer. As per the IoT Forum, the Internet of things architecture is ordered into three sorts, which are applications, processors, and transportation [34].

1.4.8 Qian Xiao Cong, Zhang Jidong Architecture

As indicated by Qian Xiao Cong and Zhang Jidong (2012), the customary IoT is framed by three layers, to be specific, the insight layer, whose design is knowing and assembling data from gadgets. The middle of the road layer is the transportation

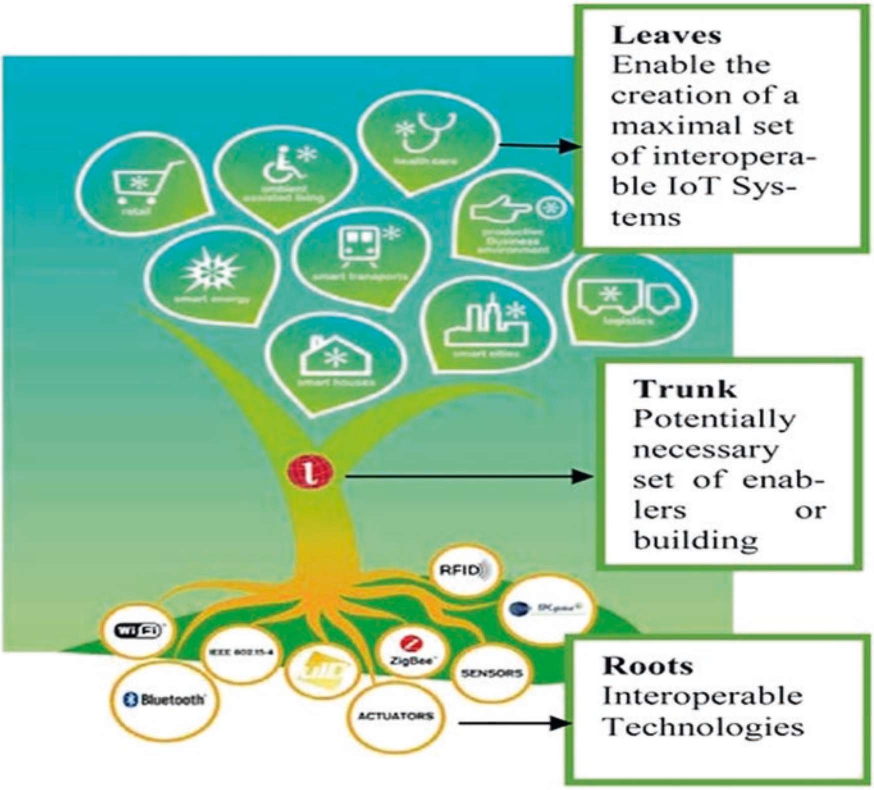

Fig. 5 European FP7 architecture

layer, which comprises optical-fiber cable, telecom organizations, and versatile and phone organizations. Also, finally, the top is the application layer, where an abundant number of utilizations run [34] (Fig. 6).

1.4.9 Cloud-Based Architectures

The information created by these IoT gadgets and their preparation is as yet an ambiguous idea. Distributed computing is versatile and adaptable which gives a centralised framework, stockpiling and a product for few models. The information handling on the cloud PCs do an enormous information gathering altogether. In such structures, the cloud is hitched between the applications that sit on it and the organization of brilliant things beneath it [35]. Also, devices, stages, and programming can be shared on the cloud as assistance (Figs. 7 and 8).

Off late, another design called mist registering is moving [35, 36]. Mist figuring is the place where the sensors and organization entryway layers do the information preparation and investigation. A haze engineering [37] presents a layered

Fig. 6 Qian Xiao Cong, Zhang Jidong architecture

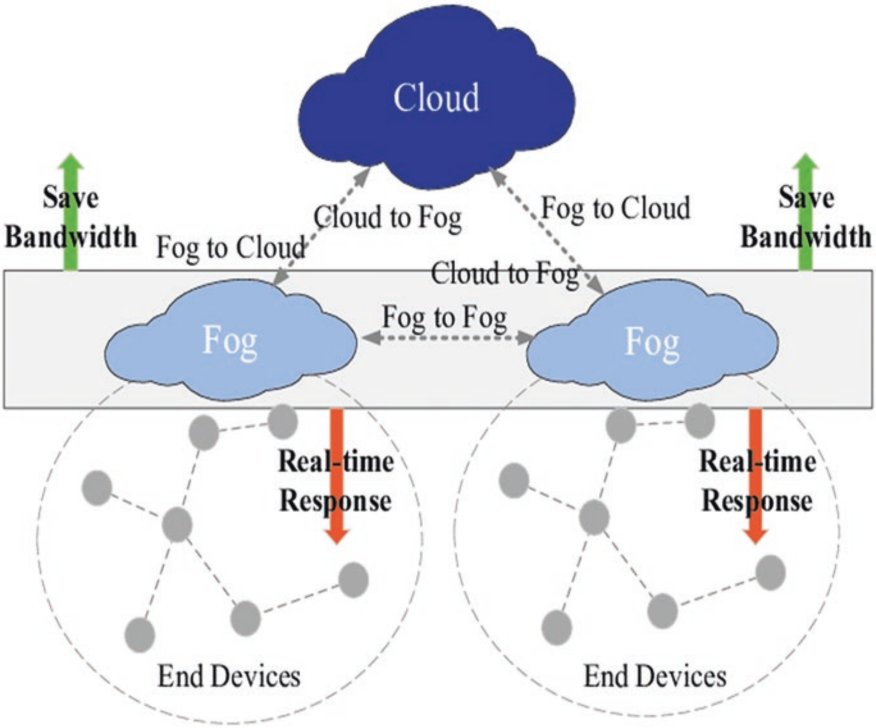

Fig. 7 Basic IoT cloud-based architecture

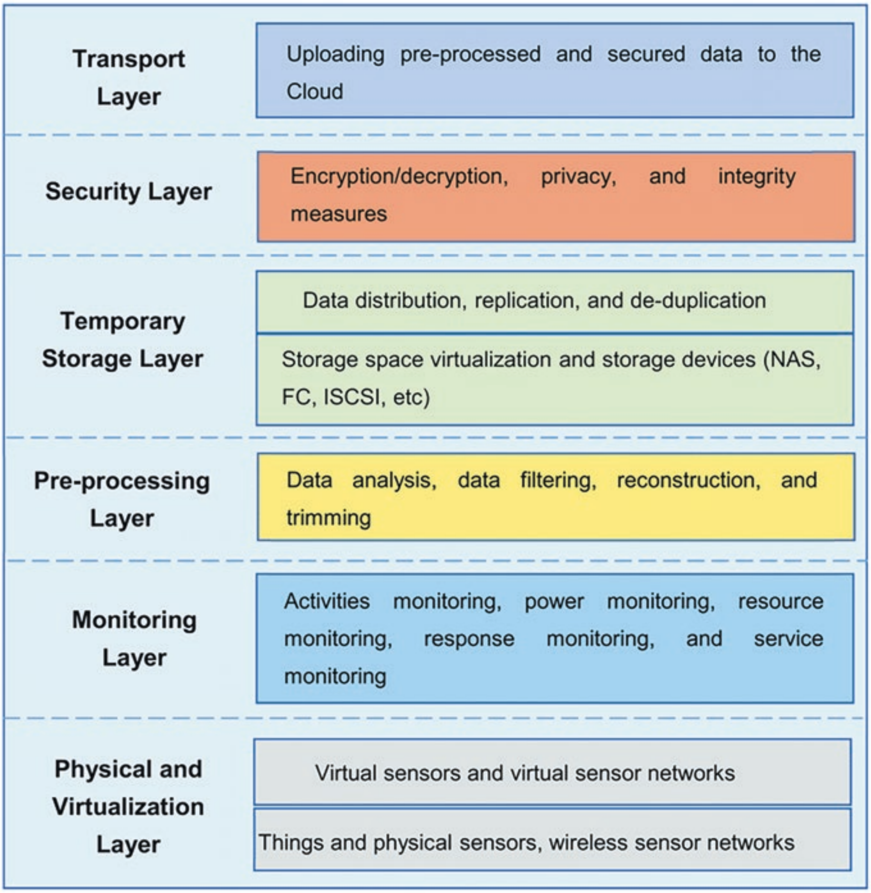

Fig. 8 Seven layers of IoT communication

methodology as demonstrated in the figure; this has the layers preprocessing, observing, stockpiling, and security layers hitched between the physical and transport layers. The actual layer has gadgets with sensors connected to it. The checking layer screens exercises, assets, force, reactions, and administrations. The preprocessing layer achieves the way toward separating, handling, and tangible information examination. The impermanent stockpiling layer obliges speculative capacity for functionalities like information stockpiling, replication, and appropriation. Ultimately, the security layer plays out the undertaking of information encryption/unscrambling for accomplishing information protection and afterward sends it to the cloud [38].

1.5 IoT Platform

IoT stages offer to its partners a framework that has inherent devices and capacities which makes IoT basic and monetary for organizations, designers, and clients. IoT stages likewise alluded to as the IoT application stages manage the cost of a comprehensive arrangement of functionalities that is utilized for building IoT applications. There is no equivocalness when there is a solitary correspondence interface and between gadgets that are of the same sort. Be that as it may, at that point in the event of correspondence between gadgets of shifted types, there exists a requirement for a typical standard application stage that hides the heterogeneousness of different gadgets and gives a typical workspace. Essentially, an IoT application stage is a virtual arrangement that sits on the cloud. Information drives business. There is consistently a gadget that communicates with another gadget in this way making/trading information. The IoT application stage through a cloud network interprets such gadget's information into valuable data along these lines empowering pay-per-use, prescient upkeep, ongoing information the board, and investigation. Subsequently, IoT application stages are those which give a total suite directly from application improvement to its arrangement including upkeep [37].

An IoT stage is planned to decrease improvement time for your IoT project by giving prepared to utilize and reusable applications. Aside from that, it causes one in approving their business case. It helps in dealing with various equipment and programming correspondence conventions. It additionally gives security and legitimacy to its clients and gadgets. The IoT stage regularly gathers, dissects, and imagines the information gathered by the sensors. These eventually coordinated with the business frameworks and web administrations.

Various cloud-based Internet of things (IoT) platforms.

[37] Though different IoT stages are accessible which can be utilized for building up an IoT arrangement, this part covers the famous IoT stages that are generally utilized for IoT arrangement building.

1.5.1 Google Cloud Platform

Google is undoubebtedly the most favored IoT stage in light of its worldwide wildlife organization, pay-as-you-use system, big data and investigation apparatus, and accessibility of different cloud administrations like BigQuery, Firebase, Wireless Solutions, Cassandra, Google Cloud Platform, and some more. Google foundation is constantly valued as it can assist engineers with coding and test and convey their applications easily. Google foundation is profoundly adaptable and solid. Besides, Google deals with issues for foundation, information stockpiling, and registering power. The special highlights of the Google cloud stage are it runs on the Google foundation; is climate-safe cloud, versatile, and solid; and gives both computational and capacity abilities that stick to Google grade security and consistency [37].

1.5.2 IBM BlueMix

IBM offers Bluemix through the stage as an assistance (PaaS) cloud. Coordinated DevOps lets engineers fabricate, test, run, and send just as oversee applications over IBM Bluemix cloud. Bluemix stage runs on the SoftLayer framework. The stage is fueled by IBM's after-driving items and administrations: IBM DataPower Gateway, IBM WebSphere Application Server Liberty Core, IBM Informix TimeSeries, IBM MessageSight, Cloudant, and SoftLayer. IBM Bluemix stage gives admittance to IoT information and gadgets. It underpins investigation applications, perception dashboards, and portable IoT applications. The stage protects API with your application. IBM IoT establishment is the center point where you can set up and deal with your associated gadgets. The key highlights are solid and adaptable availability, incredible dashboard, security, information stockpiling, backing, and help [37].

1.5.3 ThingWorx

ThingWorx is the first historically speaking programming stage for the associated world applications. It is basic and lessens the time, cost, and danger of building applications. The extraordinary component of this stage is it diminishes the sending time by weaving in the plan, improvement, and arrangement cycle. Aside from that, it underpins quicker organization, combination and cooperation, and adaptable availability. ThingWorx interfaces greatly with many gadgets that has IoT applications, not just the system administration incorporation layer present in ThingWorx likewise allows the application to collaborate with the ERP and CRM applications. The gigantic stockpiling motor empowers big data and analytics. Different representation strategies are utilized for information introduction [37].

1.5.4 Microsoft Azure Cloud

Microsoft Azure Intelligent System Service shapes a firm stage and administrations. By getting together, putting away, and preparing information, it constructs Internet of things frameworks and applications. The shrewd administrations that are based on Microsoft Azure encourage associations to produce important information out of it by safely interfacing, overseeing, catching, and changing. Applications like Power BI, Office 365, and HD knowledge are utilized to create significant experiences. The key highlights are information versatility, readiness, and network. In addition, it underpins heterogeneous frameworks with IoT availability. Through Microsoft's cloud computing, office highlights like distant access, observing, and arrangement of board offices for associated gadgets are given [37].

1.5.5 ThingSpeak

ThingSpeak is an open-source stage for IoT application advancement. It is equipped for coordinating your information with an assortment of outsider stages, frameworks, and innovations, including other driving IoT stages. This stage gathers and sends the gadget information gathered from the cloud for additional investigation. Post examination empowers the IoT framework and application. Later, the outcomes can be seen through the representation instruments. The remarkable highlights of ThingSpeak are the Electric Imp, which is a special stage with associated Wi-Fi gadgets with cloud administrations, Open API uphold, geolocation, information investigation, and representation utilizing MATLAB [37].

1.5.6 Digital Service Cloud

Advanced help cloud (DSC) is another open IoT stage. This stage enables IoT trailblazers to claim and deal with their clients by associating their items with 1,000,000 different gadgets in an organization. It has a fitting and plays dashboard that empowers one to assemble tweaked IoT arrangements. The novel highlights on DSC incorporate the UI-driven guidelines motor which doesn't need coding. Different highlights incorporate attachment and play, multi-channel uphold. This gives gadget and application improvement. It likewise underpins information examination and representation through a groundbreaking dashboard for end clients [37].

1.5.7 Zetta

Zetta is an open-source IoT stage created in Node.js made only for IoT workers that stumble into geo-disseminated workers and on a cloud. Zetta is an engineer well disposed, and it runs all over the place: on the cloud, on PCs, and on single-board PCs. Zetta has the force and capacity to transform any gadget into an API. The design is advanced for continuous applications that are information exceptional. Generally, IoT applications have an assortment of gadgets spread across various areas that run various applications created by various organizations. Zetta permits you to gather all the cloud and gadget applications together and work simultaneously. This permits observing gadgets through representation and gets bits of knowledge. The remarkable highlights of Zetta are it gives API to everything, is designer agreeable, underpins huge applications, across numerous areas or more, all these it runs wherever [37].

Nimbits
Nimbits is fundamentally a Platform-as-a-Service (PaaS) that can be downloaded from either Web Server, Raspberry Pi, Google App Engine, or Amazon EC2. This stage is utilized for creating both equipment and programming arrangements that interface each other along these lines recovering gigantic volumes of information

from actual gadgets and examination. This stage interfaces sensors, applications, and individuals to the cloud and with one another. It is based on information logging and rule-based innovation. The guidelines can be email cautions, a message pop-up, or any count. Key highlights are it is an open-source stage, sends alarms, and is time-stamped [37].

1.5.8 Yaler

Yaler is a compensation-as-you-use stage that is savvy and appropriate for big business applications. It is generally intended to give a consistent, secure, and superior execution climate for applications with sudden spikes in demand for Amazon EC2. The key highlights of Yaler are it tends to get to utilizing program or versatile and it gives attachment-and-play usefulness to end clients [37].

1.5.9 Amazon Web Services

AWS offers pay-more only as costs arise model for IoT applications. Amazon Web Services (AWS) licenses the Internet of things (IoT) by empowering administrations, security, and backing. It permits quick admittance to wanted to register power through Amazon Elastic Cloud Compute (EC2). AWS chains on interest framework for the IoT framework. It gives more stockpiling, process capacity, and worldwide assets. It underpins volumes of information and helps in performing huge information examinations. Amazon Kinesis ingests information from a large number of sensors and gathers high measures of information from gadgets. Further, it investigates and stores it on the cloud so applications can devour and help in producing brisk dynamics. It likewise gives adaptability regarding instruments, foundation, and information to the board. In particular, AWS offers types of assistance that decrease the endeavors in specific pieces of the application. Key highlights incorporate pay-more only as costs arise, high information stockpiling and information examination, adaptability, protection, and security [37].

1.5.10 Seven Levels of IoT Reference Model

Physical Devices and Controllers – This layer has gadgets, sensors, and regulators oversaw by the IoT and are called “things” in the IoT setting. Edge Intelligence, a significant IoT idea that takes into account more elevated levels of self-sufficiency and conveyed preparing, ought to be executed in this layer (Fig. 9).

Network/connectivity – The availability layer maps the field information to the consistent and actual advances. It is also used to interface with the cloud and the back-to-back layer, which is Edge Computing.

Edge Computing – Also known as “Cloud Edge”/”Cloud Gateway.” Needed to a degree in any IoT framework. The fundamental job is in information examination

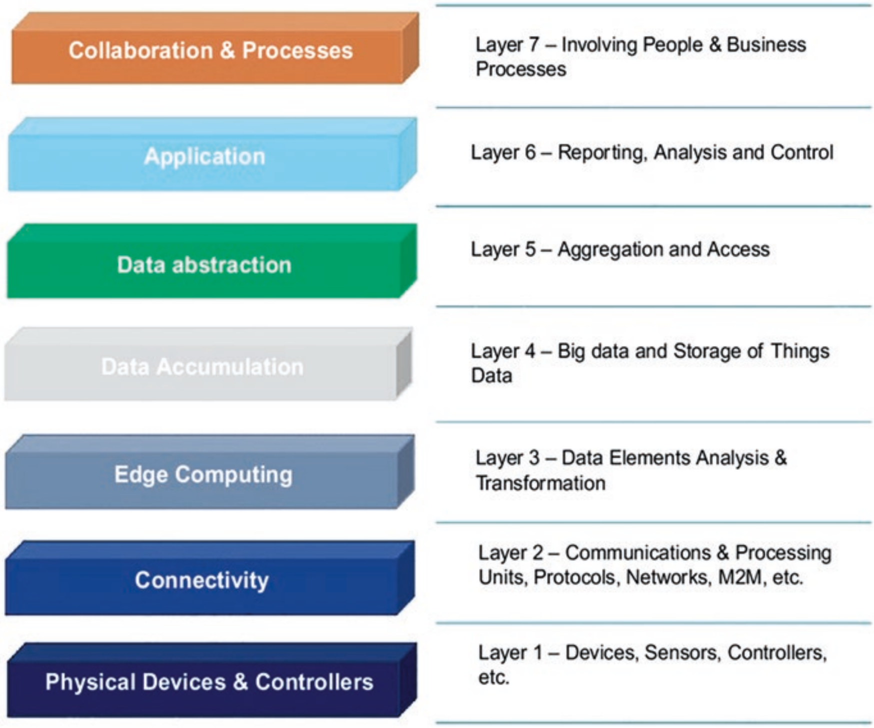

Fig. 9 Seven layers of the IoT reference model

and change. In change, the conventions are changed over into higher layer capacities. This layer accentuates on idleness dynamic through "quick way," likewise called a more limited guidance way.

Data Accumulation – The assortment, speed, and volume at which the information is gathered from the things prompt for a piece of extensive information stockpiling system for ensuing handling, reconciliation, and groundwork for forthcoming applications.

Data Abstraction – In this layer, we "bode well" out of the information gathered and "appreciate" the data from different IoT sensors or estimations, quicken high need traffic, and put together the approaching information for additional upstream handling.

Application Layer – This is the place where Monitoring, enhanced measurement, caution the executives, the factual examination would occur.

Collaboration and Processes – In the cooperation and cycles layer is the last layer and the layer where human communication with the wide range of various layers of IoT application occurs through perception apparatuses and user interface. The application preparation is introduced to clients, and information handled at lower layers is incorporated into business applications. There would be a worth expansion in particular if this layer is utilized and utilized.

1.6 Brief Introduction to IoT Analytics

Data that is gathered must be handled further so it gets important. Information in IoT is different and voluminous and comes at a high speed, making it hard to remove the commendable data. Information is ordinarily gathered by the sensor gadgets which thus will gather and send information to a brought-together worker. In like manner, the information is appropriated back to the gadgets also. IoT includes various heterogeneous components [33].

Huge data and IoT supplement one another. The essential assignment of IoT is gathering, preparing, overseeing, and removing data. Consequently, an adept insightful stage is needed to comprehend the information from IoT gadgets. It is imperative to deal with the immense volume of information and deduce from it. IoT information is constant. Applying constant examination is truly necessary. One can receive the rewards of IoT just when an examination is utilized on the continuous information. The upsides of IoT can be seen just when a constant examination is applied to the information put away [34].

1.7 Challenges of IoT

Even though IoT offers colossal advantages, it needs to address not many difficulties and obstacles. The following are not many key difficulties [23, 24, 35]:

- *Naming and Identity Management*: IPV6 gives 3.4 × 1038 interesting locations. The gadget distinguishing proof and the gadgets associated with it ought to be done progressively.
- *Interoperability and standardization*: This is the requirement for the hour. For the gadgets to be interoperable, normalization is a significant prerequisite.
- *Information privacy*: Security and protection concerns should be the most extreme concern. This whenever fizzled can be inconvenient to the whole framework [23, 24].
- *Object's well-being and security*: Another huge test is to ensure that the associated actual gadgets are free from any harm. There is a chance of actual harm to the appropriated gadgets.
- *Data privacy and encryption*: Since information is constant, at most consideration it should be taken to see that the information is scrambled and unscrambled and not abused.
- *Green IoT*: If there are no endeavors to limit the utilization, the utilization will be tremendous. We should limit the utilization to accomplish Green IoT.

1.8 Conclusion

Generally, this part "Prologue to IoT" begins with a concise prologue to the fundamental IoT ideas, definitions, and advancements utilized in IoT. It covers ten layers of IoT systems. Various IoT structures like the essential IoT architecture; the three-layered, four-layered, and five-layered designs; European FP7; and others are additionally talked about. The part likewise illuminates different cloud-based IoT stages and the IoT reference model. It likewise gives a sneak preview of IoT investigation and closes with the difficulties looked by IoT. Generally, this section causes one to comprehend IoT and ideas identified with IoT inside and out.

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Part II
Smart Healthcare & IoT

A Check on WHO Protocol Implementation for COVID-19 Using IoT

Abhinav Sharma, Jayant Dhingra, and Parul Dawar

1 Introduction

COVID-19, which is also known as coronavirus disease, causes a situation of emergency in all over the world from March 2020, and every country was under lockdown to control its rigorous spread. While other people are self-conscious about their looks, they hide their emotions from the public by hiding their faces. Scientists proved that wearing face masks works on impeding COVID-19 transmission [1]. Since the outbreak, the WHO suggested some measures to control the spread, and the governance bodies all over the world are adopting measures suggested by the WHO. The essential precautions that the World Health Organization suggested are to maintain personal hygiene and social distancing and to wear a face mask in public places. Wearing a mask in public areas is one of the most effective methods, and it actually reduces the growth rate of COVID-19 by 40%. However, wearing a mask for a very long time could be exhausting and frustrating, and this is the main reason that people do not follow it [2]. The lawmakers and the governments worldwide are facing a lot of difficulties in controlling the spread of this deadly virus [3]. To ensure that this protocol is followed, an IoT system is proposed, which will ensure a correct way to wear a face mask and thus can result in a controlled situation when it comes to the spread of the coronavirus pandemic.

The coronavirus epidemic has given rise to an extraordinary degree of worldwide scientific cooperation. Artificial intelligence (AI) based on machine learning and deep learning can help to fight COVID-19 in many ways [4]. The advancements in the area of machine learning and data analysis have allowed various researchers and

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scientists around the globe to assess extensive amounts of data to predict the dispensation of the novel coronavirus, which can be an early warning and help in damage control of this deadly virus.

Due to expeditious enhancements in machine learning techniques, various breakthroughs are obtained in deep learning. Really helpful information and attributes can be gathered by convolutional neural networks (CNN) when they are trained on various images. The convolutional neural network acquired its popularity due to its efficiency in detection and recognition of problems. The dataset on which the CNN was trained underwent three stages that included preprocessing, training, and, finally, testing. After completion of all the three stages, it gave an accuracy of 97.8% by taking account of overfitting and underfitting for the data.

The trained CNN was executed on a Raspberry Pi model 3B to capture the face of the person via the Pi camera and identify whether the person is wearing a face mask or not. The proposed model also noted the body temperature of the person via the MLX90614ESF contactless temperature sensor.

Raspberry Pi model 3B is a very compact sole and tiny computer that weighs only about 23 g. It utilizes a power rating of 5 Volts, 1.2A, and on top of that, it is cost-effective when compared to a traditional computer. There are various boards such as model A, model B, and a more advanced version model B+. The B model has 1 GB random access memory and runs on Quad Core 1.2 GHz Broadcom BCM2837 64 bit CPU. All kinds of monitors like projectors, LCD screens, and TVs can be connected using an HDMI port. Some additional features include the audio jack and the camera connector to interface the camera [5].

The camera module used in the proposed IoT system was a 5 megapixel Raspberry Pi 3 camera module Rev. 1.3 with a flex ribbon cable for attaching with Raspberry Pi 3 model B. This module is a custom add-on that is designed for the Raspberry Pi and is connected via the CSI port. The CSI bus that is used for data transfer is exceedingly efficient and carries pixel data flawlessly.

The MLX90614 is an infrared thermometer for contactless temperature measurements which was ideal for the proposed model.

Section 2 summarizes some of the previous works in the field of face mask detection and IoT studies related to it. Section 3 presents the proposed IoT model and its setup and explanation. Section 4 presents the algorithm behind the proposed IoT model. Section 5 summarizes all the conclusions and findings of this chapter.

2 Literature Survey

The spread of COVID-19 is a serious challenge for the governments to deal with. One of the most efficacious methods to control this outspread, which is even suggested by the World Health Organization, is to wear a face mask. A serious action must be taken to ensure that people wear a face mask when in public places. One of the solutions for this problem can be to automate the face mask check with the amalgamation of IoT. Many authors have contributed in the IoT domain to solve this problem. This section summarizes the literature available along with comparative accuracies and recognition rate.

Son Ngoc Truong proposed a low-cost artificial neural network using Raspberry Pi. The proposed algorithm used MNIST dataset to train, and testing showed a recognition rate of 94%. The proposed algorithm gave a recognition rate of 89% when tested for real-time objects, which is around 2.7 times faster than the conventional neural network for MNIST image recognition [6].

Brian H curtin et al. proposed a system to classify wildlife for their better study and which are inexpensive, unobtrusive, and optimal in remote environments. The proposed model uses TensorFlow library and Keras API to create the CNN that run on Raspberry Pi model 3B+. The proposed system successfully detected snow leopards with between 74% and 97% accuracy [7].

Abdel Magid et al. juxtaposed algorithms for image classification. The proposed algorithm collated mainly three algorithms, which were linear regression, Gaussian's process, and random forest. The results indicated that the random forest's performance outnumbered the other two algorithms with an R-squared value of 0.79 and 0.95 for two different datasets [8].

Marco Grassi et al. proposed a neural network system that helps in the recognition of the human face and various additional applications by introduction of a linear shaded elliptical mask centered over the face for preprocessing which was used in association with DCT, for feature extraction, and MPL and RBF neural network for classification [9].

Amirhosein Nabatchian offered a method that is very sturdy and is designed for face recognition and is automated. The proposed method can work with systems under differing conditions of noise levels and occlusion. The proposed technique uses reciprocated information and entropy of the pictures to produce varying weights for a group of ensemble classifiers based on the input image quality [10].

Loey et al. proposed a model that uses classical machine learning and some parts of deep learning for face mask recognition; the framework uses ResNet50 for feature extraction and algorithms like decision tree and various ensemble methods for classification process using RMFD, SMFD, and other datasets that are similar. The SVM classifier achieved 99.64% testing accuracy in RMFD. In SMFD, it achieved 99.49%, while in LFW, it achieved 100% testing accuracy.

Bosheng Qin and Dongxiao Li proposed a face mask wearing condition identification method in combination with image super-resolution with classification network (SRCNet). Identification was trained and tested on Medical Masks Dataset [11].

Ejaz et al. presented an implementation of PCA on face mask recognition. In this model, a statistical approach has been adopted on both masked and unmasked face recognition [12].

Park et al. put forward a unique method that helped in the detection of optical glasses on human face and gave the region occluded by the glasses. Furthermore, the model helped in bringing an intuitive perspective of the face without the glasses by recursive error compensation using PCA reconstruction, and the proposed method showed an effective solution [13].

Chong Li, Rong Wang Li, and Linyu Fei proposed face detection based on YOLOv3, which is a popular algorithm and is both fast and accurate. The model uses SoftMax as the loss function instead of the logistic classifier to maximize the difference of inter-class features and decrease the dimension of features on detecting layers to improve speed. The YOLOv3 model has obtained great performance on small face, speed, and accuracy for the face detection task [14].

Nizam Ud Din et al. proposed a GAN-based network for unmasking of masked faces. The objective was to remove mask objects in facial images and regenerate the image by creating the image by itself in the void that is created. The output of the proposed model is a complete face image that looks natural and realistic [15].

Nieto-Rodriguez et al. proposed a system to detect the presence or absence of mandatory medical masks in hospitals. The final objective of the model is to minimize the false-positive face detections. The model achieved an accuracy rate of 95% [16].

Maksimovic et al. presented a comparative analysis of Raspberry Pi with some of the current IoT prototype platforms like Arduino, and Raspberry Pi outperforms all its peers and remains an inexpensive computer with its very successful usage in a diverse range of research applications in IoT vision [17].

Cruz et al. developed a device that performs iris recognition using Daugman's algorithm on Raspberry Pi. The preprocessing of the image was based on the tests implemented like false acceptance rate (FAR) and false rejection rate (FRR) [18].

Shah et al. put forward a biometric system that was based on cloud technology; authentication node was implemented on Raspberry Pi. The proposed system can capture multimodal biometric traits such as fingerprints and send them to cloud service by end-to-end encryption [19].

Anoop Mishra and Arshita Dixit proposed embedded image capturing and digital converting process in which a camera module is interfaced with Raspberry Pi 2 model B and a defined digital image processing algorithm converts it into a gray image. The result is compared with Raspberry Pi 1 model B, and Raspberry Pi 2 model B outperforms the other [20].

Md. Maminul Islam et al. proposed Raspberry Pi and image processing-based electronic voting machine (EVM) in which the Raspberry Pi is used as host and it has the ability to do image processing and control a complete voting machine system. A camera was used to take pictures of a citizen's national ID card and identify the user [21].

Param Popat, Prasham Sheth, and Swati Jain proposed an animal as well as an object identification model that uses deep learning on Raspberry Pi where they have implemented convolutional neural network (CNN) to detect and classify an animal/object from an image by using it on Raspberry Pi, which has relatively low GPU and computational power. The model used a Python-based program with libraries like TensorFlow [22].

Durr et al. proposed a model that uses deep learning on Raspberry Pi for face recognition, and it is performed in real time where authors trained convolutional neural network (CNN) on a desktop PC and deployed on Raspberry Pi model B for classification procedure. OpenCV's results were outperformed, and an astounding accuracy of 97% was observed [23].

Khan et al. proposed a model in which there is an interactive removal of microphone from the images. The microphone is removed from images having faces, and the void created by the removal is filled with facial features already present in the photo. The interactive method used here is MRGAN in which the user roughly provides the microphone region, and for filling the holes, a generative adversarial network-based image-to-image translation approach was used [24].

Dr. Shaik Asif Hussain and Ahlam Salim Abdallah Al Balushi presented a real-time face emotion classification and detection using deep learning models. The facial features were captured in real time and processed using Haar cascade detection. The input image is analyzed using Keras convolutional neural network model [25].

2.1 Literature Survey Conclusion

A comparative analysis based on the literature review in the previous section, comprising various face mask and related techniques and methods with the proposed method, is shown in Table 1.

Table 1 Comparison of the proposed methods with literature

Reference number	Title	Technology used	Inference
Son Ngoc Truong [6]	Healthcare based on IoT using Raspberry Pi, International Conference on Green Computing and Internet of Things (ICGCIoT)	Artificial neural network using Raspberry Pi	Accuracy – 89%
Brian H. Curtin and Suzanne J. Matthews [7]	Deep learning for inexpensive image classification of wildlife on the Raspberry Pi	Convolutional neural network using Raspberry Pi 3B+	Accuracy varying from 74% to 97%
Abdel Magid et al. [8]	Image classification on IoT edge devices: Profiling and modeling	Linear regression, Gaussian process, and random forest	R-squared value of random forest – 0.95 and 0.79 for two different datasets
Nieto-Rodriguez et al. [16]	System for medical mask detection in the operating room through facial attributes	ADA boost along with a mixture of Gaussian techniques	Accuracy – 95%
Proposed method	A check on WHO protocol implementation for COVID-19 using IoT	Convolutional neural network using Raspberry Pi 3B+	Accuracy – 97.80%

This literature review adumbrates the trend and advancement in the methods and accuracies which ranges from 78% to 97%, and the method proposed in this chapter attained an accuracy of 97.80%.

3 Dataset

The dataset used in the model consists of real images of people, out of which 755 images are of people with a face mask and 754 images are of people without a face mask. The dataset is an amalgamation of the real-world masked face dataset (RMFD) and web scraped data with people wearing masks and people without masks. Figures 1 and 2 show some of the images from the dataset where people are wearing masks and people are without face masks, respectively.

4 Proposed System

The proposed face mask detection method is designed using deep learning and TensorFlow and implemented on a Raspberry Pi model 3B. According to the designed model, the face is captured via the Pi camera module, which is a 5MP camera module connected to the Raspberry Pi via the CSI port. The captured image is passed through the designed CNN architecture, which decides whether the person in front of the camera is wearing a face mask or not. Meanwhile, the MLX90614

Fig. 1 People wearing a face mask

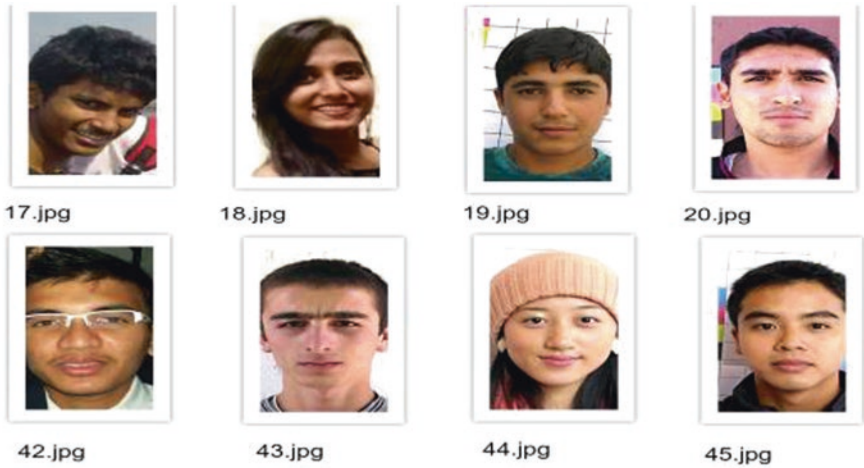

Fig. 2 People without a face mask

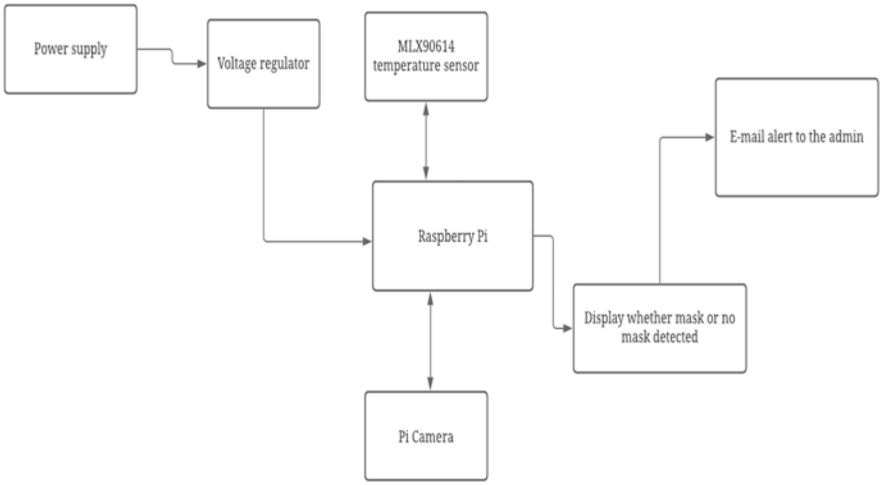

Fig. 3 Block diagram of the proposed system

notes the body temperature of the person in front of the sensor and returns the value of it. If the face mask is detected and the body temperature of the person is within the normal body temperature range, then an email is sent to the admin notifying that the person is safe and is allowed to enter the premises as shown in (Fig. 3).

4.1 Designed Convolutional Neural Network

Deep learning has many classes, out of which convolutional neural network (CNN) is one of the most liked classes. CNN is generally applied to examine visual images and related areas. In the proposed CNN model, TensorFlow was extensively used. TensorFlow is used in areas where the user needs a lot of numerical calculation needs to be done using the stream of data available. TensorFlow is an open-source library and is pretty common among data scientists. The designed model detects the face mask in three stages.

The first stage in face mask detection is the preprocessing phase. During the preprocessing phase, a cascade classifier is applied on the images; this cascade classifier provides area of the face after the images are resized to 100×100 pixels to provide similar inputs for the neural network. The images are also converted from RGB to gray because color is insignificant in recognition of a face mask. After the resized images are passed through the designed neural net, it gives the user probabilities. If no face mask is detected, 0 is given as the output and 1 if the mask is detected. The images are again resized to a 4D array as the CNN takes 4D inputs after which the images are converted into categorical labels. Any exceptions are also considered in (Fig. 4).

There is a 90% and 10% split in the training and testing data when the model is learning the data. Furthermore, the data is passed through two ConvNet layers. The first layer comprises 200 kernels of 3×3 size, and the second layer comprises 100 kernels of 3×3 size. In the end, the trained model's data is flattened and passed through a layer of neurons consisting of 50 neurons. Finally, the CNN model gives an accuracy of 97.8% on TensorFlow 2.0.0.

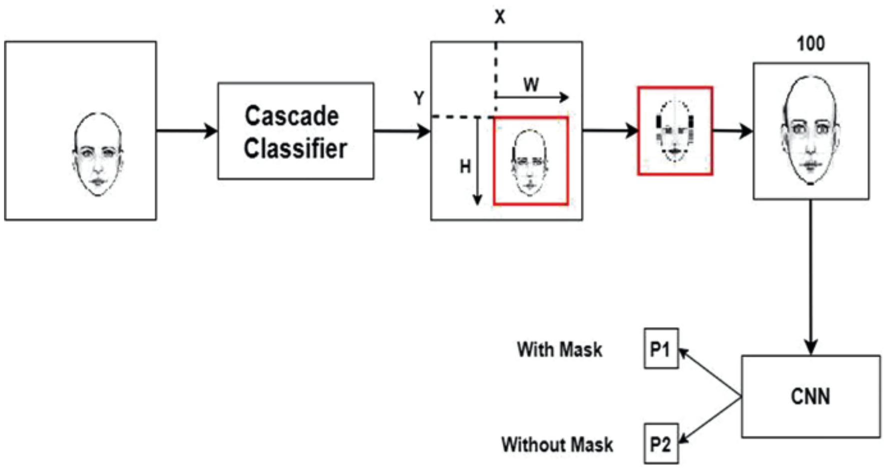

Fig. 4 Face mask detection model

4.2 Raspberry Pi's Setup

The Raspberry Pic used in the designed system was the Raspberry Pi 3 model B. It was used because of its compact form factor and its bang to the buck performance ratio. Size is an important aspect when you are trying to build a compact kiosk like this one. The Pi 3B delivers decent performance and is adequate for this face detection system. The MLX90614 sensor was connected to the Raspberry Pi via the GPIO pins. The MLX90614 has four connection pins, one for the VCC, one for the ground, one for the serial data line (SDL), and one for the serial clock line (SCL). The Pi camera module was connected to the Pi via the CSI port available on the Pi. Finally, the output was displayed on the LCD or LED display as shown in (Fig. 5).

4.2.1 Pi Camera

The camera module used in this system was the Raspberry Pi camera module Rev. 1.3, and it comes equipped with pliant cables that are attached to the Raspberry Pi's board via the CSI port. One of the main reasons this camera module was used in this system was because of its compact form factor and its high-definition camera that remits formidable photos. It is also extensively used in CCTV, drones etc. as shown in (Fig. 6)

The camera serial interface bus is capable of extremely high data rates, and it can also transport pixel data privately, making it perfect for our model.

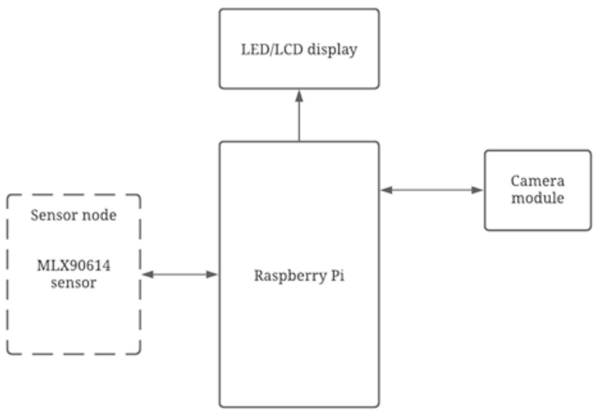

Fig. 5 Raspberry Pi setup

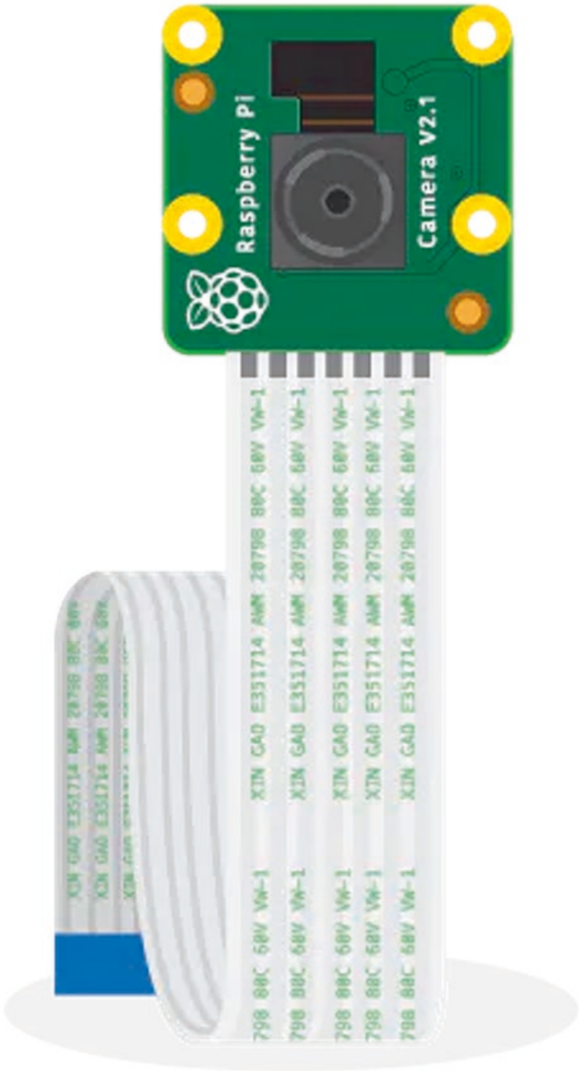

Fig. 6 Raspberry Pi camera module

4.2.2 MLX90614 Non-contact Temperature Sensor

The MLX90614ESF, which was used in our face mask detection system, is an infrared thermometer and is used for contactless temperature measurements. The MLX90614 GY-906 is a low-noise amplifier, and some of its key features are high-precision temperature measurements and livestock monitoring. The image of the sensor is shown in (Fig. 7).

The MLX90614 has an operational range of 3.3 volts to 5 volts input; also this module has a power regulator IC that is built inside the module. Some additional

Fig. 7 MLX90614 sensor module

features of the GY-906 like automotive blind angle detection and low voltage requirement make it ideal for the face mask and temperature detection model like ours.

5 Implementation

The implementation of this model is a pretty straightforward one as explained in Fig. 8. Initially, the dataset is loaded and then passed through the designed convolutional neural network where it is resized and passed through multiple layers of resizing and rescaling. After that, the model is trained and is ready to perform. The trained CNN model is tested and the Pi camera captures images and passes it through the designed neural net, and it tells whether the person is wearing a face mask or not. The mechanism of this CNN is explained in Sect. 5.1. The non-contact temperature sensor works alongside the camera to fetch the body temperature of the person in front of the IR sensor. After getting the results from the camera and the sensor, they are displayed on the LCD/LED display that is connected to the Raspberry Pi via the HDMI port, and an email is sent to the admin containing the person's picture and his/her body temperature. The setup is shown in (Fig. 9).

5.1 CNN Algorithm

Deep learning has been observed as a monumental growth in connecting humans and machines. The main motive of this field is to enable machines to view the world as humans do and discern the knowledge just like humans. The CNN architecture is shown in (Fig. 10).

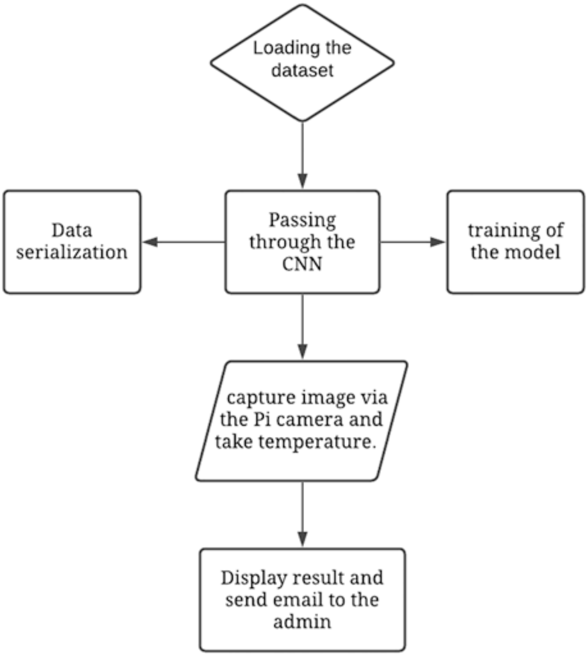

Fig. 8 Flowchart of the implementation of the model

Convolutional neural network is an integral part of deep learning that basically takes an input as an image and assigns various vital weights to different aspects in the image and is able to classify from others. The preprocessing power required in CNN is quite lower as compared to other classification algorithms that are suitable to use with Raspberry Pi. Convolutional neural network comprises various convolutional layers that are the major building block used in CNN, pooling layers, nonlinear layer (ReLU), fully connected layer, and classification layer. The initial layer works to draw out features from an input image in the convolution. This convolution further reads the input in a small square of inputs and saves the relationship between the pixels by which it remembers the image.

Nonlinearity (ReLU), which stands for Rectified Linear Unit, in convolutional neural network, is established by this ReLU layer. The matrix formed is flattened into a vector form and then fed into an FC layer or fully connected layer. Then this FC layer is concatenated to create a model.

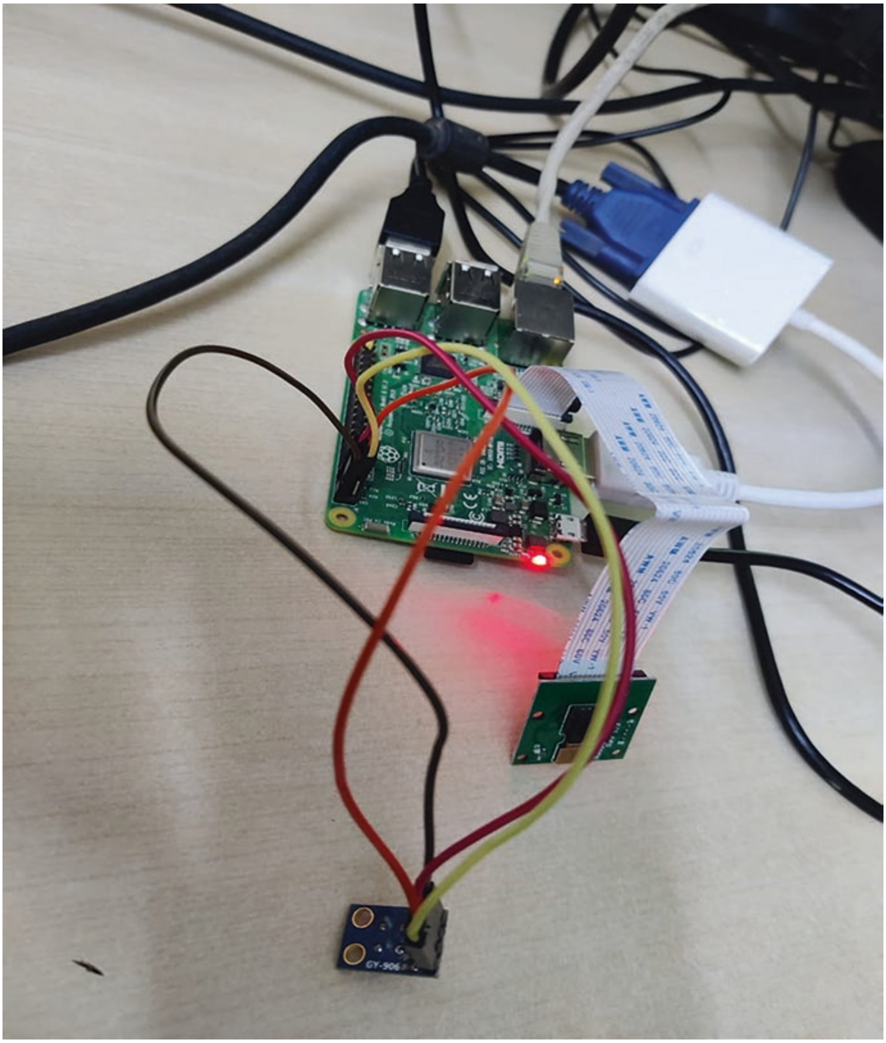

Fig. 9 Setup of the face mask and temperature detection system

6 Results

The proposed CNN model uses a TensorFlow library and detects whether a person is wearing a face mask or not and whether he/she is spreading or being affected by the coronavirus. The CNN is trained, passed through the designed neural net to finally give an accuracy of 97.80%. The results are depicted in Figs. 11 and 12.

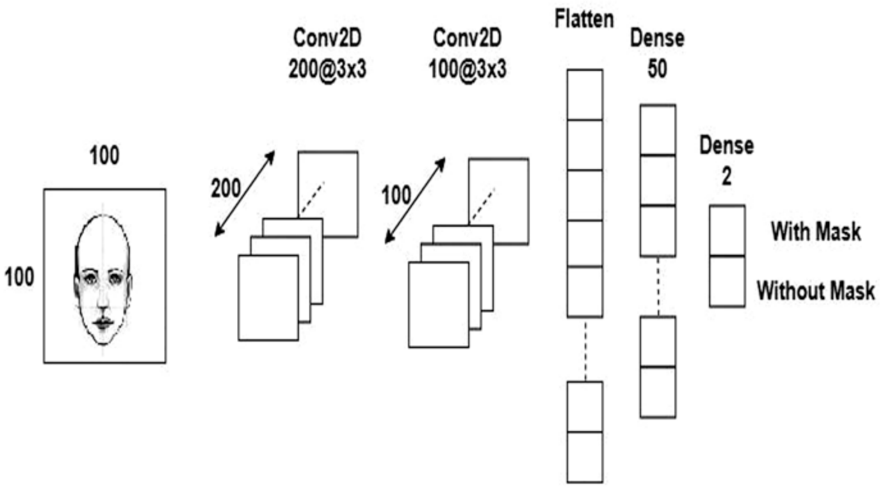

Fig. 10 CNN architecture

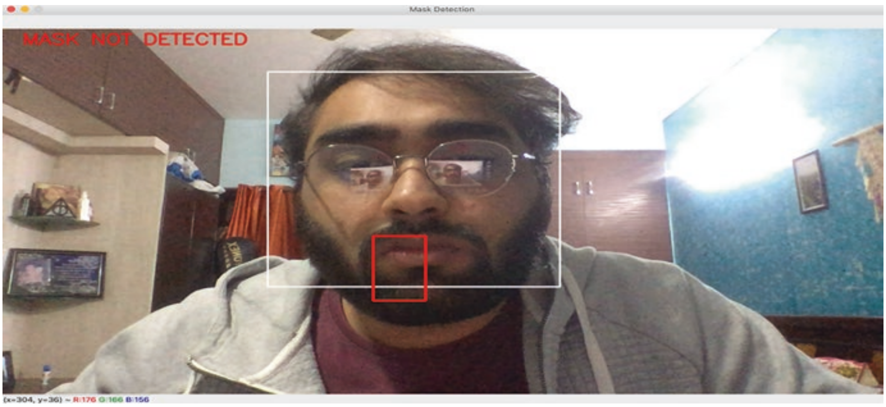

Fig. 11 Face mask not detected

Further, Figs. 13 and 14 represent the accuracy curve and loss curve, respectively.

It is quite evident in Figs. 13 and 14 that the model shows minimal signs of overfitting, but it is still pretty usable and robust. Pre-trained models like MobileNet can also be downloaded and used for tweaking the results.

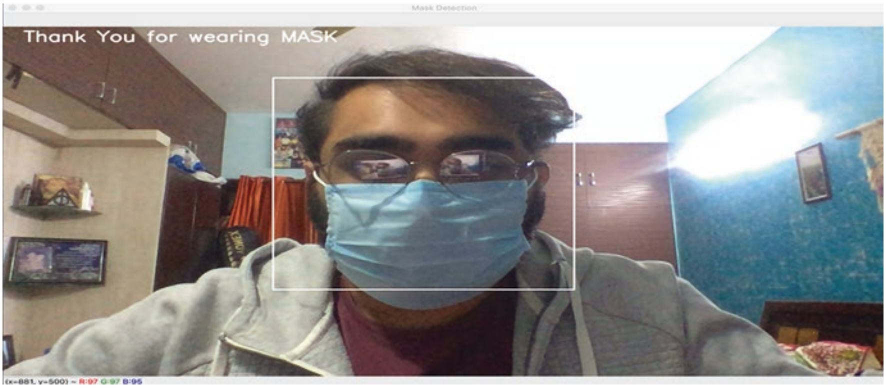

Fig. 12 Face mask detected

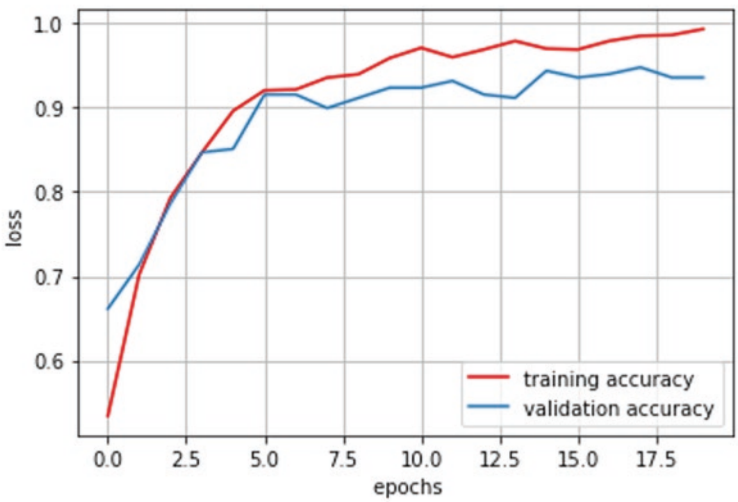

Fig. 13 Accuracy curve of the CNN

7 Conclusion

Tackling the COVID 19 pandemic is a real struggle for the world and is one of the toughest challenges that humanity has faced. Wearing a face mask can be a helpful method in controlling the outbreak of this fatal virus. In this chapter, a face mask and temperature detection IoT system was proposed. The designed CNN for the face mask detection was successfully trained and gave an accuracy of 97.80% when trained on TensorFlow 2.0.0 with minimal signs of overfitting and underfitting. The system captured the face mask's information and the body temperature of the person and sent it to the admin via email.

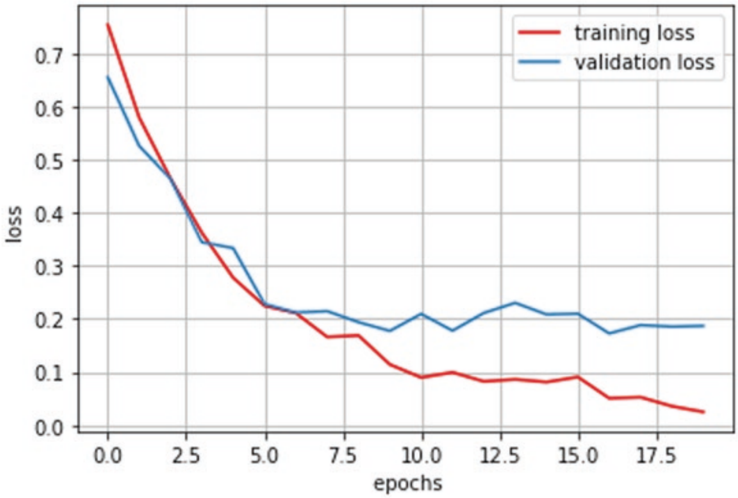

Fig. 14 Loss curve of the CNN

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Design and Implementation of an Internet of Things (IoT) Architecture for the Acquisition of Relevant Variables in the Study of Failures in Medical Equipment: A Case Study

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1 Introduction

Internet of Things (IoT), a term coined by Ashton in 1998 [1], is a recent technology integrating communication technologies, software, and sensors. The IoT is considered one of the most critical technologies of the fourth industrial revolution in developing emerging technologies, impacting economic development, social transformation, and the industrial field globally [2]. For example, the McKinsey Global Institute published a report to determine the impact of the multiple technologies interconnected with the IoT and how they can create real economic value [3]. The McKinsey Global Institute's report analyzed the application and impact of the IoT on 150 use cases, including devices (sensors and electronic systems) for monitoring people's healthcare, the maintenance of industrial equipment, and workers' occupational safety. The same report estimated that the IoT industry would have a total potential economic impact of $3.9 billion to $11.1 trillion annually by 2025. The IoT implementation can now be found in the factories (e.g., operations management and predictive maintenance), in public places (e.g., safety, health, traffic control, source management), in people (e.g., illnesses, welfare), in vehicles (e.g., maintenance based on the condition or use), in households (e.g., energy management, security), and in offices (e.g., time organization, job monitoring, training through

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augmented reality); that would be equivalent to around 11% of the world economy [3].

Therefore, the evolution of IoT has developed surprisingly in different fields, for example, the medical area in its various specialties and the medical technologies that support each one of the health services. The improvement in medical care and its management have been two significant challenges for decades. That is precisely where information technologies play an essential role in the challenges and opportunities associated with the supervision of the medical device's function. In this way, the Internet of medical things (IoMT) is changing the current provision of healthcare services under the scheme of information exchange and unification of communication in a multidirectional way between clinical systems, network operations sensors or devices, and the analysis within a hospital network, which gives infinite possibilities for the emergence of new processes in an integral and intelligent way that allows smart decision-making [4].

The continuous search for new technological alternatives that allow efficient management of different medical technologies in a clinical setting [5] has raised many research problems to offer promising solutions in the hospital environment. As a result, this trend raises some concerns about the economic viability of traditional health systems and new proposals, which undoubtedly need to be redesigned, generating innovative solutions focused on providing quality healthcare and healthcare services.

There is no doubt that the Internet of Things is transforming the way health services are provided by redefining applications, devices, and the fact that the different health professionals connect and interact with each other, making it possible to deliver solutions to the problems of the health area [6]. Consequently, the evolution of IoT satisfies the existing services, generating new opportunities to make the services more efficient; however, it is vital to contemplate some aspects that need to be considered, such as security and privacy. Being a solution to the constant challenges that arise in the health area.

IoT applications are used for home healthcare services, mobile health, electronic health, or hospital management in terms of healthcare. Still, they are not used in medical devices or for detecting failures in these devices [7]. However, there are different examples in the industry where IoT applications are used for detecting failures in wind turbines [8] or for monitoring energy consumption in industrial equipment [9]. Applications of IoT devoted to variables related to performance and maintenance of medical equipment are still scarce [7].

The aim of this study is to present an IoT architecture that is focused on capturing and monitoring the environmental variables that influence the performance of a highly complex medical device (i.e., computerized tomography) located in a real-context, high-complexity hospital in Bogotá, Colombia.

This chapter is organized as follows: Section 2 provides an overview of the related works about IoT application in failure detection in the healthcare industry and other industries. Section 3 describes the proposed architecture of the system. In Sect. 4, the results are presented. Section 5 presents the discussion of the results obtained. Sections 6 and 7 show the conclusion and suggestions for future work, respectively.

2 Related Works

The incursion of IoT in the health sector has allowed acquiring a large amount of data to be analyzed in real time, making safe decisions about different cases and technology use situations. Interoperability in heterogeneous environments allows constant learning and generates a reference model that covers the diverse characteristics of both security and privacy and scalability and interoperability. It seeks to give an identity to "things" by interconnecting them and integrating them into the network, assigning them a central function in the so-called Internet of the future, and allowing them to exchange information without the need for human interaction [10, 11].

Several attempts at predicting failures or monitoring devices from different industries have been reported in the literature. Some authors have used machine learning techniques to detect non-biomedical devices' failures [12], achieving positive results. However, the high consumption of hardware can be a drawback when these techniques are applied. Other smart algorithms have tried to predict medical device failures using predictive and corrective maintenance reports and the Monte Carlo estimation method [13], although this analysis was not performed in real time. On the other hand, conventional methods have been tried for predicting faults in medical devices using inductive techniques that allow the potential sources of failures to be determined and how these failures affect the performance of the equipment using the Failure Mode, Effects, and Criticality Analysis (FMECA) matrix [14]. In this way, it can be observed how industries are concerned about the state of their devices, as their non-supervision means damage and additional costs for their companies.

There are different examples of IoT applications for detecting failures. For example, Yamato et al. developed an IoT application based on lambda architecture to conduct predictive maintenance of industrial machines in Japanese factories [15]. Likewise, the IoT applications centered on monitoring relevant variables through sensor networks have been found in different industries. For example, IoT has been used in the performance monitoring of generators [16], turbines [17], power consumption in industrial equipment [9], transmission line in a smart grid system [18], and wind farms [8]. All the above-named applications have used machine learning techniques [19] to find failures or to make predictive maintenance in the industrial systems mentioned.

In healthcare, the literature shows that the main IoT applications are in-home healthcare services, mobile health, electronic health, and hospital management. Hospital management is based on preventing infections, educating patients, managing emergencies, and logistics systems [7]. However, to the best of our knowledge, there are no IoT applications for detecting medical devices' failures.

Thus, the difference between this research and the related works is to develop an architecture that permits environmental variable acquisition in real time (vibrations, current, temperature, relative humidity) through sensors aimed to detect and predict failures in medical devices, specifically in a computerized axial tomography (CAT) equipment.

3 Proposed Work

This work was developed and implemented in a real-context, high-complexity hospital in Bogotá, Colombia. The variable determination and technical specifications of the sensor's location were guided by the care personnel in charge of the service during the test development. Likewise, the hospital engineering team supervised the tests made up of biomedical engineers and diagnostic imaging technologists. In this way, it was possible to establish the location and variables to be measured according to the care personnel and hospital engineers' criteria.

3.1 System Architecture and Variables Measured

In this study, the captured and monitored variables were temperature, humidity, vibration, sound, and current of the powered node the CAT was plugged into. According to the manufacturer's recommendations in the manual and recommendations from the hospital's biomedical engineering team, these variables were selected.

In this study, a three-layer architecture based on service-oriented architecture (SOA) was implemented. This architecture has been widely used in IoT applications in healthcare environments [19]. The architecture of the proposed system is shown in Fig. 1. In this figure, three layers can be identified:

3.1.1 Sensing Layer

The sensing layer is also known as the perception layer in the computerized axial tomography like the electronic boards, which are made up of sensors and communication boards that allow for processing measurements and sending environmental variables.

The sensing layer or perception layer is made up of a development and communication single-board called the SparkFun® ESP8266 Thing board[1]. This SparkFun® ESP8266 Thing has an integrated low power 32-bit CPU and could be used as an processor and Wi-Fi communication module. In our case, we had five sensors

[1] https://www.sparkfun.com/products/13231

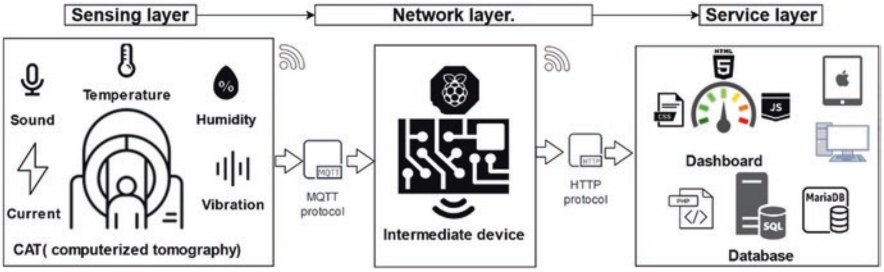

Fig. 1 The general architecture of the organized system in layers

Table 1 Description of ranges and sampling of sensors

Sensor	Range	Sampling rates
Temperature	0 °C to 50 °C	2 s
Humidity	20 a 90% RH	2 s
Sound	100 a 10 MHz	2 s
Vibration	1.1 V/g	2 s
Current	0 a 100 A	2 s

connected to a single-board measuring the environmental variables. To program this, this development board must use a USB programmer to serial or FTDI because it does not have one incorporated.

The references and more relevant characteristics are shown in Table 1. To measure temperature and humidity, a sensor DHT11 was used. This sensor allows temperatures between 0 and 50 °C and relative humidity (RH) between 20% and 90% to be measured. In the case of the current variable, a noninvasive current sensor SCT-013 was used; this sensor allows currents between 0 and 100 amperes to be measured. We was used the sensor KY-038 to measure noise level inside in the equipment; this sensor allows a minimal resolution to a noise of 58 Db to be measured. KY-038 has a frequency ranging between 100 and 10,000 Hz. To measure vibration variable, a sensor Minisense 100 was used; this sensor measures high sensitivity at low frequencies with a dynamic range in detecting vibrations or impacts. The sampling time of all sensors corresponds to the sending of the variables of the things to the intermediate device. This time is achieved with exactitude, thanks to the MQTT (MQ Telemetry Transport) protocol implemented in the machines.

In Fig. 2, the algorithm implemented in the ESP8266 can be detailed. It is presented in a flow diagram for a better understanding and can be replicated regardless of the programming language and programming environment with which the board is programmed.

In the case of the "GetSensor()" function, it does the reading of all the sensor variables, and later it is assigned the JSON (JavaScript Object Notation) format, which is currently a standard for the exchange and transfer of data over a network.

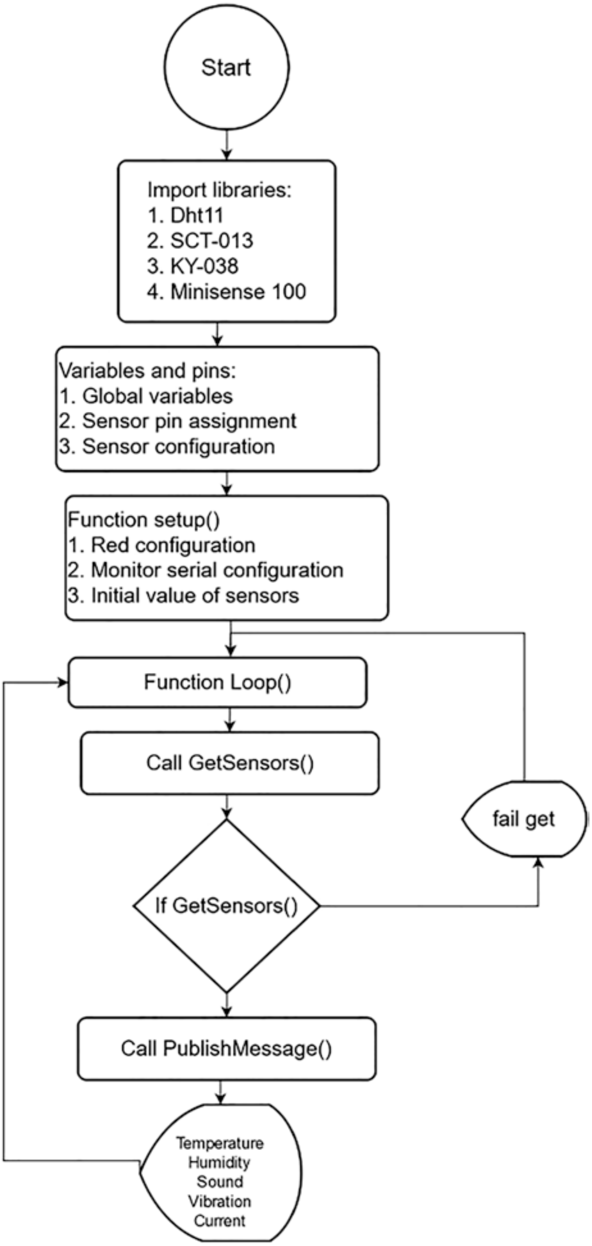

Fig. 2 Implemented algorithm flow diagram

The intermediate device analyzes this data block. After this, it is sent to the data display and storage services; therefore, a decoding process of the JSON format is carried out in these two services. An example of the JSON format sent from things to services is presented below.


```
{MAC: "5C:CF:7F:0B:98:D8",
Temperature: 23,
Humidity: 90,
Sound: 100,
Vibration: 5,
Current:12}
```


With the MAC address, the origin and security of the data in the intermediate device and the services are validated, making it one more step to validate the safety of the system in its entirety.

3.1.2 Network Layer

In this layer are the communication protocols that things use to send information. For this case, the MQTT communication protocol was implemented in the sensing layer. Likewise, the protocols for communication and request of services hosted on the server were implemented. A standard protocol was used, HTTP (Hypertext Transfer Protocol) with an SSL (Secure Sockets Layer) security certificate for this purpose. Similarly, this layer supports wireless communications between the sensors and the broker and communications broker to the web service. The network characteristics of this study were as follows: Wi-Fi network, 2.4 GHz, with upload and download speeds of 20Mbps and 40 Mbps, respectively.

Figure 3 shows communication between things, the server and the dashboard. The things were composed of SparkFun ESP8266 and all the sensors, i.e., the DHT11, the current sensors SCT-013, the sound sensor KY-038, and the Minisense 100 sensor. In the things was programmed the data capturing and sending data to sub-routines to be handled by the server.

The node is composed of Eclipse Mosquitto™, installed as a broker on the Raspberry Pi3 board. Mosquitto was used as a server. It was selected because it is one of the most-used MQTT servers in the IoT industry, and it is Open Source [20]. The Raspberry Pi3 board is a reduced plate with the characteristics of a computer; it is also at a low cost for the excellent hardware and connectivity potential that it represents [21].

The MQTT protocol was used to coordinate the communication between the sensor and network layers [22]. MQTT is a standardized push protocol of publishing/subscribing. IBM launched that in 1999. In MQTT, the editor publishes messages about topics that could be considered the subject of the message. The subscribers, therefore, subscribe to the topics to get specific messages. Subject subscriptions can be expressed to restrict the data collected on a particular topic [23].

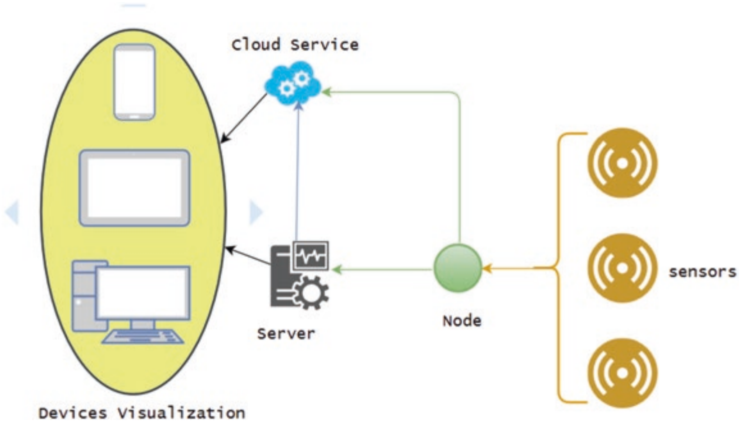

Fig. 3 Communication between things, server and dashboard

3.1.3 The Service Layer

This layer has two services hosted on the server: the first service is where the application dashboard is located and with which the user interacts with the system. It shows the visualization and graphical user interface and the data warehousing service delivered by the intermediate device using traditional data warehousing technologies such as relational databases.

The layer is composed of two elements. The first is the database, which stores the data received from the broker. In this application, a MySQL database was created and used in a web server hosted in Amazon Web Services to store the measured environmental variables. The web service designed for database management was developed using the PHP programming language and the protocol HTTPS.

An example of the code developed as a service for storing data in the relational database is presented below.

```
 $enlace = mysqli_connect("Server", "user", "pass",
"namedatabase");
  if (!$enlace) {
  echo "Error: Could not connect to MySQL. " . PHP_EOL;
  echo " debugging error: " . mysqli_connect_errno() . PHP_EOL;
  echo " debugging error: " . mysqli_connect_error() . PHP_EOL;
  exit;
  }
  echo " Success: A proper connection to MySQL was made! The my_bd
database is great. " . PHP_EOL;
  echo "Host info:" . mysqli_get_host_info($enlace) . PHP_EOL;
```

```
$chipid = $_POST ['chipid'];
$potencia = $_POST ['Potencia'];
$irms= $_POST ['Irms'];

mysqli_query($enlace,"INSERT INTO SensorCorriente(ID, chipid,
dateHour, power, imrs) VALUES (NULL, '$chipid', CURRENT_TIMESTAMP
, '$potencia', '$irms');");


mysqli_close($enlace);
```

Two storage layers were established: one is housed in the intermediate device, which, through an algorithm for detecting communication failures with the cloud, is activated by saving the records locally while the intermediate device is re-counted to the Internet. Once communication is established, it sends the records to the cloud, thus guaranteeing the traceability of the information registered on the platform.

For cloud storage, the MariaDB6 database manager was used together with an Apache server. This database manager was selected because it is one of the most popular and widely used database development environments for free software applications.

A relational database like MySQL was designed and developed to guarantee the safe storage of the implemented application information. Since it provides the basic methods and tools to ensure the data, it also controls and manages access permissions (users). It should be noted that the database is hosted on a server at the Universidad del Rosario, managed by the working group of the Internet of Things (IoT) subject.

Regarding the data, they were acquired with a sampling frequency of around 5 s and stored under the labels of temperature, humidity, sound, vibration, and current. Therefore, the structure of the message chain was determined with an identification number.

The second component is the dashboard or control panel. These objects are designed to show the measured environmental variables. The RESTful architecture-style services were used to develop web applications, which allows the use of standard methods of the Hypertext Transfer Protocol (HTTP) (e.g., GET, POST, DELETE, and UPDATE). The RESTful architecture provides data security and allows the representation of information in different formats. In this system, JavaScript Object Notation (JSON) was used with the Google chart API and Ajax to visualize the environmental variables measured in real time. Below is the code with which it is possible to graph the temperature and humidity in a chart-type graph using the Google API in real time.

```
 <!DOCTYPE html>
 <html lang="en">
 <head>
  <meta charset="UTF-8">
    <meta  name="viewport"  content="width=device-width,  initial-
scale=1. 0">
  <title>Document</title>
 </head>
 <body>

  <div id="monitor-chart"></div>


      <script   src="https://www.   gstatic.   com/charts/loader.
js"></script>


  <script>
  google. charts. load('current', {
  callback: function () {
   var  chart  =  new  google.  visualization.  LineChart(document.
getElementById('monitor-chart'));

  var options = {'title' : 'Temperature and Humidity',
  animation: {
  duration: 1000,
  easing: 'out',
  startup: true
  },
  hAxis: {
  title: 'Time'
  },
  vAxis: {
  title: 'Temperature and Humidity'
  },
  height: 400
  };

  var data = new google. visualization. DataTable();
  data. addColumn('datetime', 'Time');
  data. addColumn('number', 'Temperature');
  data. addColumn('number', 'Humidity');

  var formatDate = new google. visualization. DateFormat({pattern:
'hh:mm:ss'});
```

```
 var formatNumber = new google. visualization. NumberFormat ({pattern:
'#,##0. 0'});

  getTemp();
  setInterval(getTemp, 5000);
  function getTemp() {
  var temperature = (Math. random() * (35 - 30) + 30);
  var humidity = (Math. random() * (40 - 15) + 15);
  var timestamp = new Date();
  drawChart(timestamp, temperature, humidity);
  }

  function drawChart(timestamp, temperature, humidity) {
  data. addRow([timestamp, temperature, humidity]);

  formatDate. format(data, 0);
  formatNumber. format(data, 1);
  formatNumber. format(data, 2);

  chart. draw(data, options);
  }
  },
  packages:['corechart']
  });
  </script>
 </body>
 </html>
```

To execute the code above, the code must be copied and pasted into a notepad and save with the .html extension, for example, "realtime.html" The result should be like the one presented in Fig. 4. with the code in the "getTemp()" function; random values are used for the code to work. However, in the case presented in this chapter,

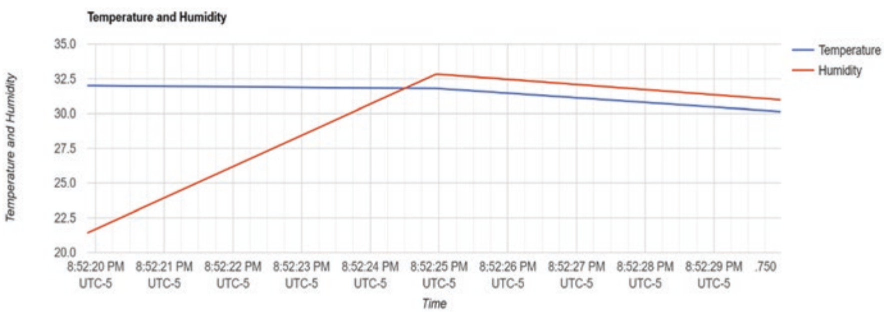

Fig. 4 Communication between things server, and dashboard

these functions are replaced by the values acquired through a service developed using the HTTPS protocol.

The interface layer is a dynamic web user interface designed for and adapted to all mobile devices to show the captured data. This layer uses Markup languages such as HyperText Markup Language (HTML) and style languages such as Cascading Style Sheets (CSS). To manage these languages, the Google Materialize framework was used to allow clients to interact with the interface layer, as shown in Fig. 7.

4 Results

4.1 System Architecture and Variables Measured

Figures 5 and 6 show a general view of the imaging service where the CAT is located and the installation of the different sensors in the device gantry. The sensors were installed in these locations following the original equipment manufacturer and biomedical engineers' recommendations from the hospital's maintenance department.

Figure 7 shows the electrical system of the hospital service, composed of three main power lines or phases, where energy is supplied to the isolation transformer, the intermediate system between the power supply of the equipment that serves as protection for the CAT. The current sensor was installed in one of the power lines, shown in Fig. 7.

Finally, the developed graphical interface or visualization layer is shown in Fig. 8. In this case, the temperature and humidity variables are shown. In the web service, the monitoring of the other variables with which the user can interact due to the dynamic controls offered by Google chart can be found.

Figure 8 shows an example of the interface components since all the measured have their chart-type graphics. The history of the last 20 data stored in the database is reported and continuously updated. This update is achieved with a method known as polling, which oversees always requesting an Internet service with which constant updates can be made in the graphics and data storage.

5 Discussion

The aim of this study was to design and implement a system with SOA and RESTful, which allows the continuous monitoring of environmental variables in medical equipment. The results show that it was possible to measure temperature, humidity, vibrations, sound, and current due to architecture. We could send information to the web service and see the variables on different platforms in real time. The SOA

Fig. 5 Computerized axial tomography (CAT)

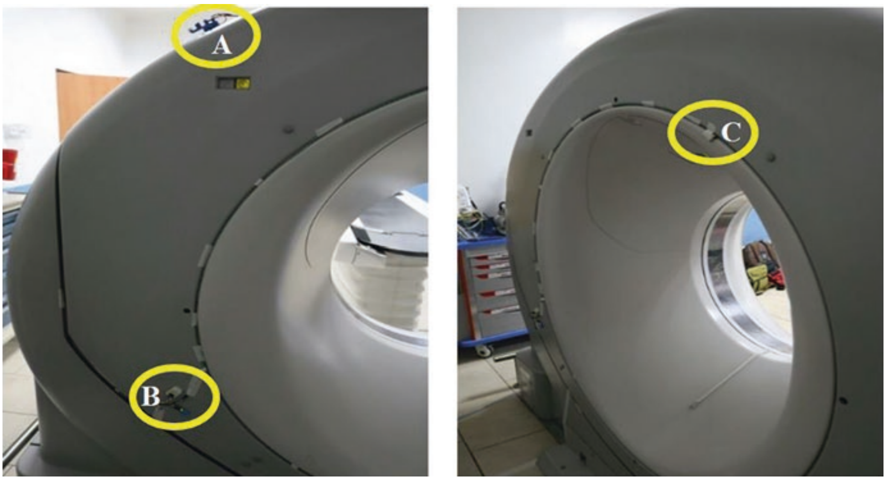

Fig. 6 Installation of the sensors; (**a**) sound sensor, (**b**) temperature and humidity sensor, (**c**) vibration sensor

Fig. 7 Installing the current sensor

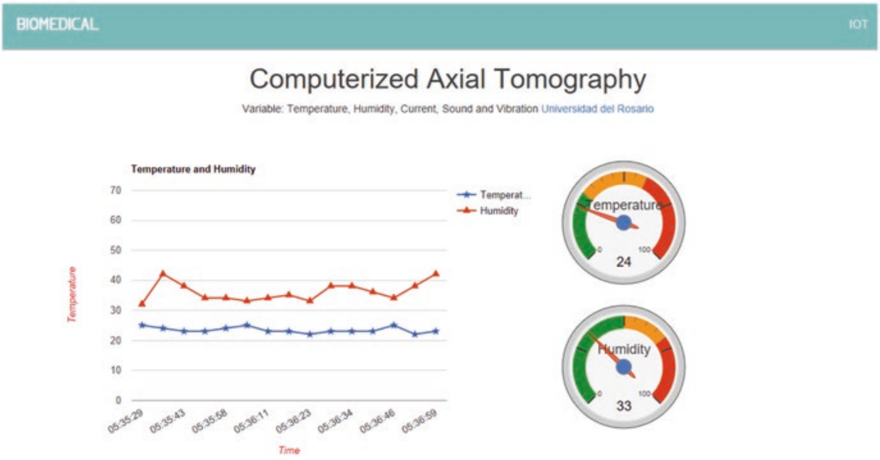

Fig. 8 The interface between the humidity and temperature variables

architecture has some disadvantages) for developing IoT applications, security being the main problem. Some authors claim that this architecture has some deficiencies in data security and access control [24]. This document presents an alternative by using the architecture style of the RESTful web application development. This architecture style has overgrown in popularity in recent years, especially regarding IoT applications [25]. Its principal features are facilitating the calling of application services through a URL, using the HTTP using standard verbs for safe navigation through the web, and being compatible with standard web data transmission formats such as JSON and XML.

To ensure privacy, in addition to using the Hypertext Transfer Protocol, the application also has an SSL (Secure Sockets Layer) certificate, which is a security protocol that transmits the IoT applications' data to the service layer integrally and securely. Thus, data transmission between the brokers and web clients in a bidirectional manner is fully encrypted, which guarantees security and privacy in data transmission [26].

This system is interoperable, as it can adapt to any sensor device or control board with Internet connectivity, either via a Wi-Fi connection or Ethernet. In the same way, one of the advantages of the implemented architecture is that different types of communication can be implemented, such as Bluetooth, RFID, NFC, and technologies widely used in IoT [27] from the sensors' control boards to the brokers. With the SOA architecture implementation, the platform allows this application to be implemented in different hospital services, thus allowing an easy and safe way of increasing the numbers of devices, sensors, and control boards, as well as creating several display boards for each area and complying with one of the main axes of IoT architecture, scalability [28].

Based on the above, IoT allows a new way of operating a "smart hospital" to improve health services; therefore, this new initiative is directly related to the growth in smart medical devices, their use, and accessibility health market. Essentially, the latest technologies are projected to be interconnected, allowing, on the one hand, the care personnel to monitor patients remotely, guaranteeing their health status, and the engineering staff to supervise the operation of different equipment with classic sensors under the wide range of IoT [29].

This study has the following limitations. Firstly, the system proposed does not perform online data analysis in real time since it is currently used to perform an exploratory data analysis. It is necessary to download and analyze them in a data analysis software such as R or Python. Secondly, the system was implemented using a WI-FI network, having limitations due to its coverage area. Although the system is easy to implement, having portable devices, and easy to move, this becomes a limitation to implement it in other hospital areas where the WI-FI network is not available.

The evidence in recognizing and exploring the imaging area was the fundamental reason for implementing the system to take environmental variables. The first one was that there is only one computerized axial tomography equipment in the institution, which has a reasonably high patient flow, so it is considered a critical service and needs technological alternatives to guarantee satisfactory operation times. The process was aligned with the protocols and requirements established by current regulations and according to the institution's policies.

The infrastructure characteristics made it possible to determine the assembly and installation conditions of the CAT. When we analized the different record data, It was possible to determined the proper functioning of the equipment. It was identified that of the five variables, temperature and current fluctuation, better known as current peaks, significantly affect the stability of the equipment. Initially, the equipment's temperature regulation is controlled with an air-conditioning system that regulates the room temperature where the equipment is located. However, it is not entirely reliable since, on several occasions, the wrong has been reported operation or lack of optimal refrigeration according to the work rate of the CAT, which sometimes works 24 hours in a row.

On the other hand, the current consumption of the CAT is relatively high, sometimes reaching 40–50 amps (adding its three phases), with peaks in the ranges of 30–62 amps. The above is due to the power system implemented in the institution for decades. Due to a lack of future planning, it is deficient in power and energy supply for imaging services.

In this sense, the developed system allows to know the behavior of each of the variables in real time and quickly make decisions that avoid damage or stoppage of equipment due to lack of supervision over it, since the technology that was built does not have a monitoring system. Thus, in this way, IoT technology would allow the optimization of resources and the promotion of predictive maintenance strategies that would lead to the saving of economic resources for the institution (corrective maintenance) and, on the other hand, to improve the provision of the services of health.

6 Conclusions

To conclude, the SOA architecture and RESTful architecture styles' implementation allows the environmental variables of medical equipment to be monitored in real time. In this case, it was possible to implement a network of sensors for the continuous monitoring of a computerized axial tomography through a web platform using visualization and data storage services.

The implemented system showed satisfactory results concerning the information acquisition time window since it was possible to obtain a reliable and secure record of the variables under study. Although there was no equipment failure during the information capture period with the implemented system, it was possible to guarantee the traceability of the variables for later analysis and control purposes by the institution's engineering group. The above will allow knowing the resonant behavior of the equipment and will provide solid tools to prevent possible equipment failure.

Therefore, different types of impacts could be covered according to the results obtained in this project. In the first place, the technological implications, derived from the interaction of the personnel of the biomedical engineering department and their concept about the functionality and benefits of implementing this type of technology in little-explored services, were recognized. A different kind of impact is reflected in the economic factor, given that the developed system can infer possible failures that would allow avoiding more significant damage to a medical team, in such a way that it is evidenced that different fully functional and practical technological alternatives could be generated that guarantee the operation of biomedical equipment or devices at a low cost, considering their development and functionality within the given hospital environment. Finally, there is the social sphere since it could increase safety and, incidentally, the quality in providing health services in front of users or patients who are intervened in a clinic or hospital services.

7 Future Work

The information acquired will be the basis for examining and advising health institutions in the near future about the importance of the precautionary measures needed to be taken by medical devices and how to predict abnormal functioning at any given time. Likewise, it is part of a new proposal by smart hospitals. Their interoperability allows new work and research scenarios that are the main objectives that this work contemplates in its initial stages by applying IoT architecture [30].

With current works, it was possible to have indications; then, different visualizations were made to analyze the potential relationships between the variables of temperature and current consumption as the main critical variables in the continuous operation of the CAT according to the behavior of the acquired data.

It was possible to identify the behavior of the data and the identification of the integrity and reliability of each of the tests, thus determining the average values of operation and anticipating whether the solution has a real value or not. In this way, it was identified if the captured values could be good deterioration indicators or malfunctioning of the equipment, allowing foreseeing failures.

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A Novel IoT-Based Solution for Respiratory Flow Diagnosis

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1 Introduction

Chronic obstructive pulmonary disease (COPD) is an unusual inflammatory lung reaction to unhealthy stimuli, mainly smoking. In developing countries, factors such as uncontrolled smoke and pollution in the atmosphere can cause COPD. Sometimes, exposures to harmful occupational environments can lead to COPD. The major symptoms of COPD are severe breathlessness, cough, and wheezing. Asthma is a disease that has similar symptoms to COPD. Asthma attacks and COPD can even lead to loss of lives. There is a rising need for early diagnosis as well as appropriate treatments for the diseases. It is difficult to diagnose COPD without spirometry.

Spirometry is the most usual technique used to determine the kind and degree of the lung defects by checking the blown-out air [1]. Spirometers are of various kinds which vary in size and performance. The modern spirometers are highly accurate in executing immense range of tests [2]. But they are very high priced and mostly found in well-established hospitals. These respiratory problems are frequent in densely populated and economically developing nations. As a result, there is a huge urge for precise inexpensive devices.

The proposal conveys the design of a low-cost mini handheld unit that measures the airflow rate and maximum volume of air breathed out using an ultrasonic transducer. Temperature, viscosity, and gas density have no influence on the results in ultrasonic-based measurements. Results obtained can be of greater accuracy compared to those of other spirometers. Ultrasonic-based estimations have more correctness and steadiness than other methods.

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Moreover, the measured values and the results are easily accessible to the patient and the physician or caretaker on a smartphone wirelessly. The physician can diagnose, suggest changes in medication, and track the health conditions of the patient through the mobile application developed. The data can be taken to a host computer, and further analysis can be made using a graphical user interface (GUI).

There are several atmospheric pollutants or vital parameters that adversely affect respiratory diseases [3]. The exposure to most of these can be reduced if the patient is aware of the presence of these asthma triggers. Monitoring of temperature, humidity, and harmful gas content of the atmosphere leads to provide warnings to the patient in case of bad conditions so that he/she can take precautions and control the disease.

2 Related Works

Tracking the respiratory activities of a patient imparts useful knowledge about his or her health condition. Numerous techniques for observing the activities have been introduced. There are different types of spirometer designs. Some spirometers are based on magnetostriction principle. Good quality ferromagnetic material is available for this type of spirometers. These are beneficial in those circumstances where the sensor needs to be replaced frequently. However, regular calibrations are required.

The sensor of the spirometer measures air velocity and air volume [2]. These sensors are categorized into different types based on their operation principle. Some of them are differential pressure sensors, turbine sensors, ultrasound sensors, and thermal sensors.

Body plethysmography is a well-established technique of lung function determination [4]. Types of plethysmographs include variable pressure plethysmograph, volume displacement plethysmograph, and flow plethysmograph. Arterial blood sampling is another technique to evaluate the function of the lungs [5]. Even though they perform fine in a lab environment, they fail to constantly track respiratory health with flexibility. Appropriate and correct design of respiratory inductive plethysmography (RIP) sensors leads to their increased sensitivity and linearity [6, 7]. Some sensors were introduced to monitor the strain of the ribcage, thereby measuring respiratory rate [8–10]. Optoelectronic plethysmography (OEP) is another method that uses camera [11, 12]. Some researchers have also focused on fast methods for measuring the capacity of the lungs using nanotechnology [13]. Developments were made for making acoustic-based sensors for monitoring the passage of air [14].

The measurement of temperature reduction in a hot metal that is produced as a result of heat exchange with the flowing air is the basic principle of thermal sensors [15]. Air velocity is in direct proportion to the drop in temperature [16]. It is incapable to measure airflow in both directions because of its design limitation. Additionally, these are vulnerable to atmospheric dust and pressure variations.

In turbine sensors, the velocity of air and flow rate linearly vary with the speed of the rotating turbine [17]. As a result, the total volume can be found out. The surrounding temperature, humidity, and pressure do not affect its working. Rotational inertia is the crucial drawback in these sensors. The main advantage is that it permits operation in both directions.

Differential pressure sensors operate based on Bernoulli's principle by computing the differential pressure across a tube [18]. But it is susceptible to temperature differences and vulnerable to blockages caused by small particles near the sensor.

An electronic device attached to the asthma inhaler containing an accelerometer to detect movements of the user is used in [19]. The wearable device in [20, 21] measures ozone concentration and ambient temperature. Concentrations of carbon monoxide in the atmosphere are measured and compared with standard Air Quality Index (AQI). The user is alerted by means of an email or a message [3]. Some studies were done to analyze the impact of air pollution [22] on respiratory diseases such as asthma.

3 Overview of Acquisition and Control Modules

The functional block diagram presented in Fig. 1 represents the system for measurement of airflow rate and relevant atmospheric parameters.

The device comprises the following units:

(a) Atmospheric vital parameter measurement unit
(b) Exhaled airflow rate measurement
(c) Microcontroller
(d) Bluetooth
(e) Mobile application and cloud connection

The functions of each module are described below.

(a) Atmospheric Vital Parameter Measurement Unit

The asthma triggers associated with the atmosphere such as temperature, humidity, and harmful gas content variations are measured. High-precision and low-cost sensors are used for the purpose. These environmental parameters give a clear picture of air quality variations to the patient. The patient can manage the respiratory problems such as asthma using these indications and take appropriate actions when necessary.

(b) Exhaled Airflow Rate Measurement Unit

The functionality of this unit is clearly described in Sect. 3.1.

(c) The Processing Unit

It comprises Raspberry Pi 3 which is a single board microcomputer having a 1.2 GHz quad core processor. This unit reads the data from the ADC and evaluates the air conditions based on the readings and the predefined threshold values.

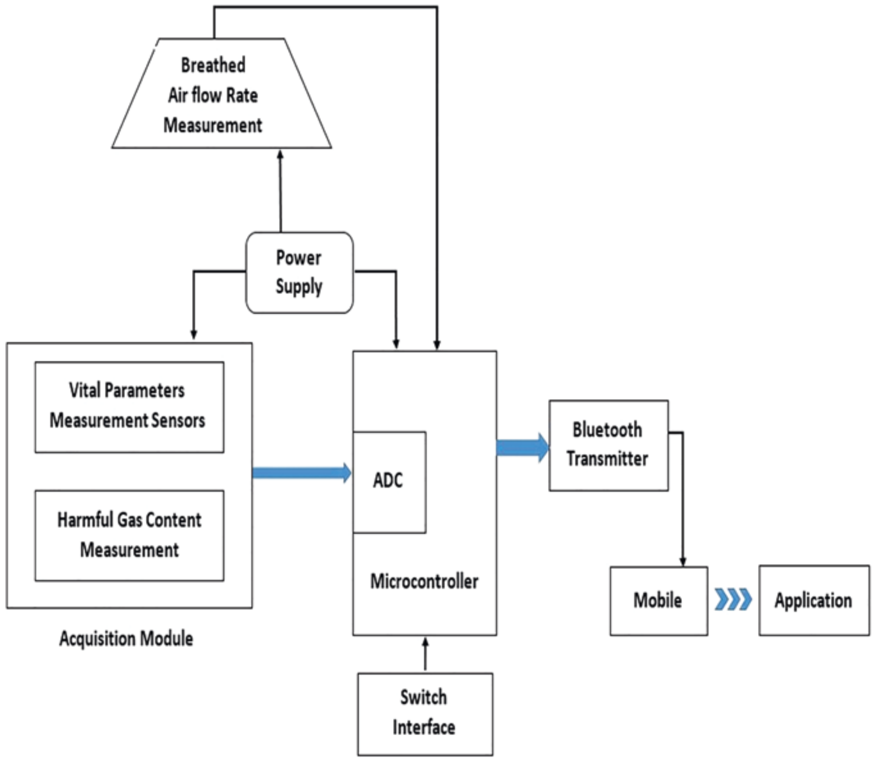


Fig. 1 Acquisition and control interfaces

(d) Bluetooth Interface

HC-05 is a popular Bluetooth module that uses serial communication protocol (USART) to communicate between devices. There are two operating modes for this module: one is command mode and the other is operating mode. The command mode is used for configuring the device settings of the module. The operating mode is used to send or receive data between devices. It works in 4–6 V range with about 30 mA current.

(e) Mobile Application

The air quality indications obtained using vital parameter and gas sensors, alerts on medicine usage, and recording of airflow rate measurements can be analyzed using an Android mobile application built on a smartphone. The system makes it easy to manage asthma in a controlled manner. This application can alert the patient about medicine usage and tells the balance medicine left in the inhaler.

The mobile application is developed using Android Studio. It is an Android IDE (Integrated Development Environment) that makes faster development of high-quality applications. Flexibility, smart code editor, and faster emulators make Android Studio more popular. Flutter SDK (Software Development Kit) makes high-quality applications for Android and iOS. Object-oriented concepts and Dart programming language are supported by Flutter.

3.1 Proposed System to Measure Exhaled Airflow Rate

This work presents the design details for developing a smart IoT device using an ultrasonic transducer for detecting the breathed airflow rate of the asthma patient. Using a Bluetooth interface, the system establishes connection with a smartphone and, through a mobile application developed using Android Studio, enables the doctor to access and analyze the patient details. The device can also be connected to a host computer using USB, and the information can be accessible using a GUI.

A. Breathing Tests

The breathing test computes the amount of air the patient can hold in the lungs. In addition, it estimates how strongly air can be blown out from the lungs [23]. The test is replicated three times and accepted only with less than 5% variation. The expiration must continue for as long as possible, without any slowing down. The patient should be ready with an inserted mouthpiece in the right way before the commencement of the test to confirm the smooth outflow of the air. It provides a measure of the intensity of asthma or COPD.

Parameters

The doctor needs to know certain parameters to establish if a patient has a respiratory illness or not. The most commonly measured indices are:

1. FEV_1 – Forced Expiratory Volume in 1 s: It is the volume of air expelled within 1 s [23].
2. FVC – Forced Vital Capacity: It is the volume of air expelled in one breath.
3. FEV_1/FVC – The ratio of exhaled air in 1 s to the vital capacity [23].

Variation in Parameters

1. Less FEV_1 and FEV_1/FVC ratio represent an obstructive disorder.
2. A low value of FVC and a high FEV_1/FVC ratio represent a restrictive pattern with reduced lung volume.
3. Small FVC and a less FEV_1/FVC ratio show a blended obstructive and restrictive pattern with decreased lung volume [23].

Volume of air expelled versus time can be plotted as shown in Fig. 2.

In this application, the principle behind the measurement of flow rate and volume of air is based on the transit time between ultrasonic transducers.

Paired ultrasound sensors, located on both sides of a mouthpiece tube, transmit and receive ultrasonic pulses [24]. The transit time of the waves varies according to the velocity of air. From this variation, the transit time of the pulses between transducers is computed. This is illustrated in Fig. 3.

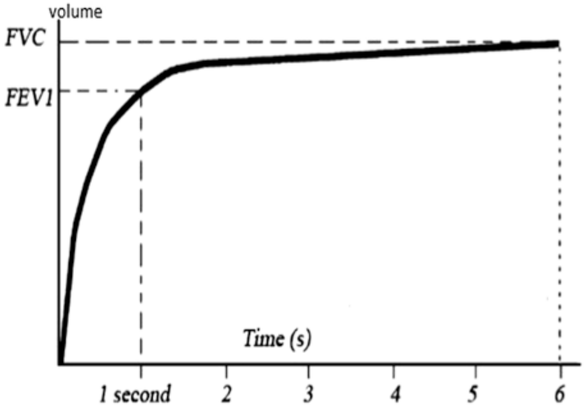


Fig. 2 Volume vs time graph that can be obtained in spirometry [23]

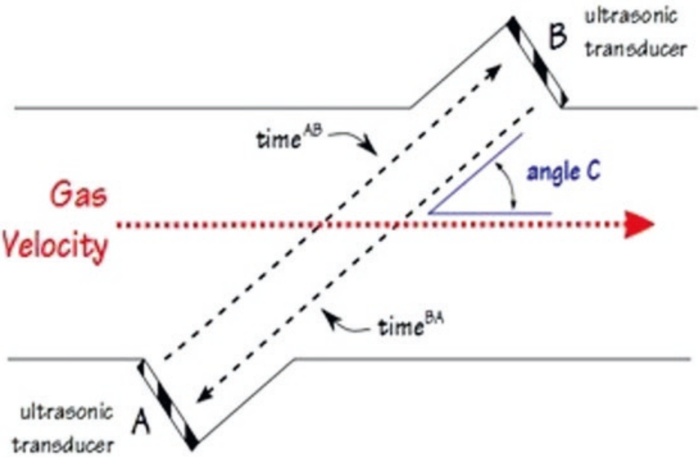


Fig. 3 Illustration of measurement of airflow rate and velocity [24]

The transit time relies on the space between the two transducers, the angle of the pulses, and the velocity of sound [24]. The transit time from A to B is determined using Eq. (1).

$$\text{Transit time} = \frac{D}{S + \left(V \times \cos\left(C\right)\right)} \tag{1}$$

Transit time from B to A is computed using Eq. (2) [24].

$$\text{Transit time} = \frac{D}{S - \left(V \times \cos\left(C\right)\right)} \tag{2}$$

D = distance between transducers
S = velocity of sound
V = velocity of gas
cos(C) = cosine of the angle between gas flow and pulses

Velocity of air flowing can be found out using Eq. (3) [24].

$$\text{Velocity} \cong \frac{D}{2\cos\left(C\right)} \times \frac{\Delta t}{t_{\text{avg}}^{2}} \tag{3}$$

Δt = transit time difference
t_{avg} = average transit time

The flow rate Q can be measured using $Q = VA$ where V is the velocity and A is the area of cross section [24]. The volume of air expelled can be measured by multiplying flow rate by time as shown in Eq. (4).

$$\text{Volume} = \text{Q} \times \text{Time} \tag{4}$$

B. System Design

The proposed system to measure exhaled airflow rate is represented as a block diagram as shown in Fig. 4.

The major blocks in the design are as follows.

(a) Flow Sensing Unit

It consists of an ultrasonic transducer for measuring the airflow rate. This unit calculates the voltage signal corresponding to the velocity and airflow rate. This transducer is mounted in a mouthpiece through which the patient exhales at a maximum rate. The signal from the unit is amplified using an instrumental amplifier and given to ADC of the microcontroller for further processing.

(b) Mouthpiece Assembly

It comprises a hollow pipe equipped with a mouthpiece for exhaling. Paired ultrasound transducers are placed at an angle of 40° with respect to the mouthpiece pipe to confirm maximum coverage. The assembly is packed inside another cylindrical pipe. When the patient blows air from the left end, it results in transit time variations between ultrasonic transducers. This gives measurement of flow rate and volume of air expelled as explained above.

(c) Signal Conversion and Processing Module

The amplified signal is sent to ADC of the microcontroller for analog-to-digital conversion. The data can be sent to a mobile phone using Bluetooth and then connected to the cloud so that the doctor can access the information through an

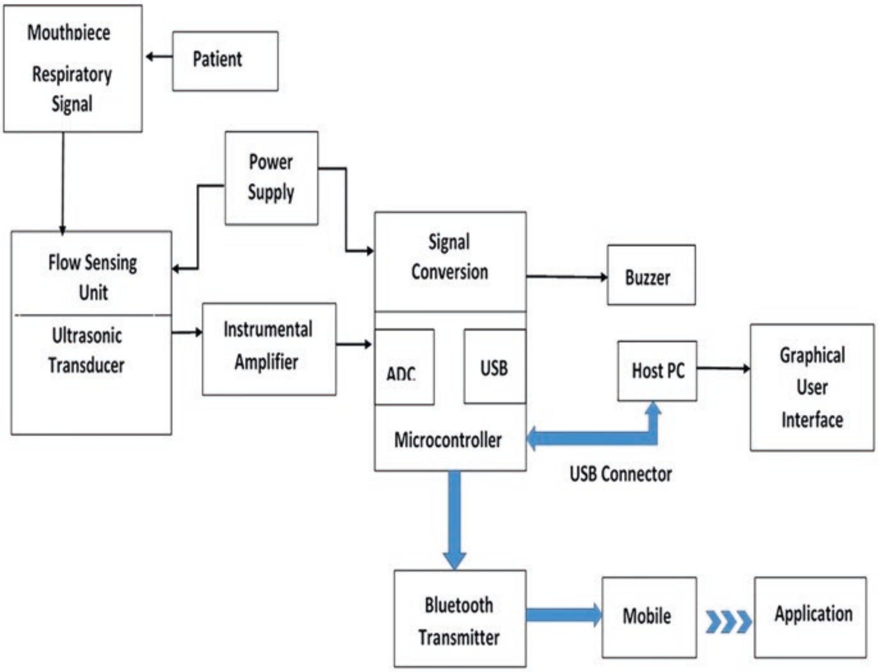


Fig. 4 Proposed system to measure the airflow rate of the patient

application designed for the purpose. For further analysis, the data can be sent to a host computer using USB connection. A buzzer is triggered upon identifying the passing of air inside the mouthpiece for a particular time that has been set for the test. This alerts the patient that the test has been started, and he/she should try to keep blowing until the buzzer stops.

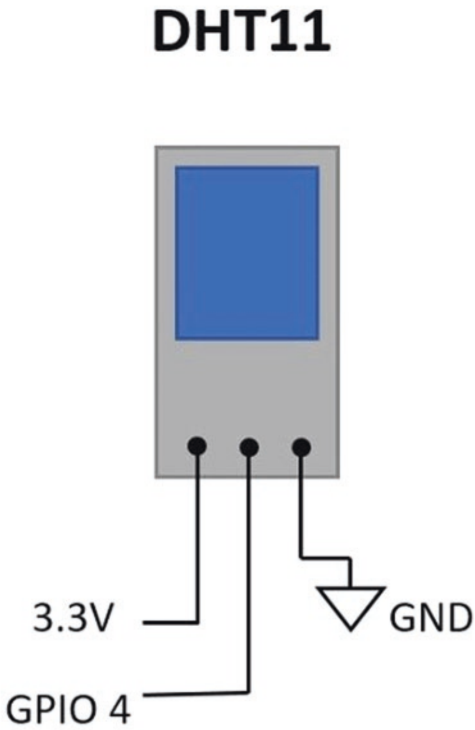
4 Design of Experiment

The different hardware modules used are described in this section. The hardware interfacing diagram is shown in Figs. 5 and 6.

A. Data Acquisition Units and Hardware Interface
Gas Sensor for Air Quality: MQ135 has fast response and high sensitivity. Its operating voltage is +5 V. It detects NH_3, NO_x, alcohol, benzene, smoke, CO_2, etc. It can be used as a digital or analog sensor.

Temperature and Humidity Sensor: The temperature and humidity sensor used is DHT11. It is a digital sensor that utilizes a thermistor and a capacitive humidity sensor for measurements. At most 2.5 mA current is used during

Fig. 5 DHT11 interfacing circuit diagram



translation. The humidity and temperature values are read with 5% and ± 2 °C accuracy, respectively.

Analog-to-Digital Converter (ADC): A 10-bit resolution ADC MCP3008 is used for getting better performance and reduced power consumption. MCP3008 is featured with successive approximation register (SAR) architecture. In addition, MCP3008 has got eight channels and an SPI interface. The maximum sample rate is 200 (ksamples/s).

B. Display and Switch Interfacing

Push-button switches are interfaced to Raspberry Pi in order to count the medicine usage of the inhaler. For the demonstration purpose, this information is shown on a 16 × 2 LCD screen. The interfacing of switches and LCD module is shown in Figs. 7 and 8, respectively.

5 Results and Discussion

The mobile application that we have developed using Android Studio for helping the asthma patient as well as the doctor to manage and monitor the asthma condition is shown in Fig. 9. Separate username and password are given to the patient and the

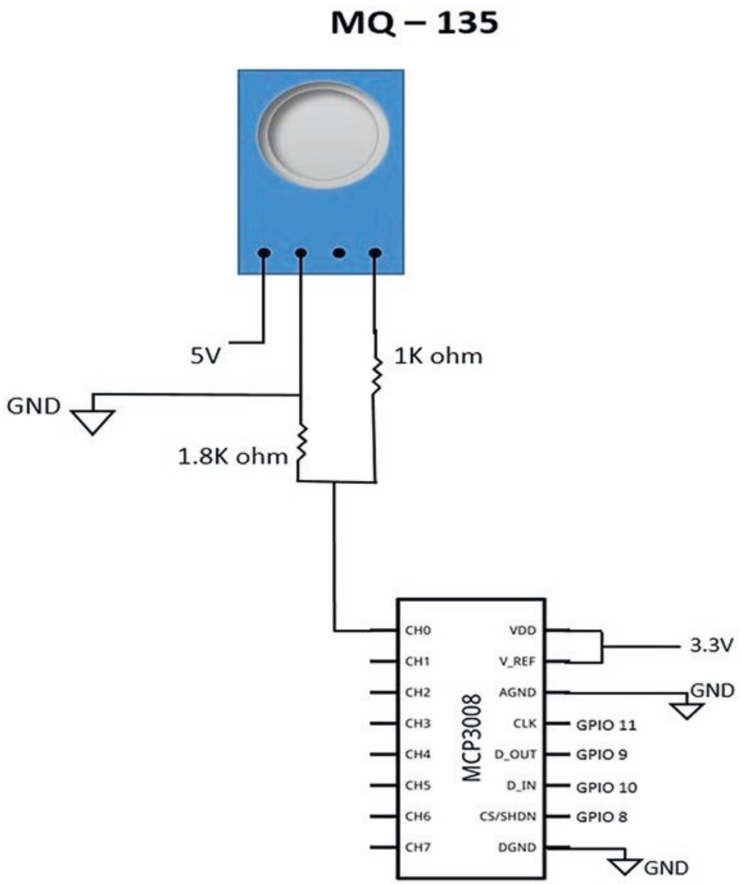


Fig. 6 MQ135 interfacing circuit diagram

doctor in order to log in to the app. Once the patient has made a login to the app, he will be able to access usage of the inhaler, medication details, air quality, and airflow rate through the airways.

Separate buttons are created for displaying the profile of the patient, airflow rate, instructions, air quality, usage, and medication as shown in Fig. 10. Medication gives the quantity of medicine remaining for use. This information is displayed on the LCD screen also.

The most relevant asthma triggers such as atmospheric temperature, humidity, and the presence of harmful gases are measured using the appropriate sensors, and the values obtained are compared with the threshold values. The threshold values taken are shown in Table 1.

If the sensor values cross the boundary values, alert or warning message is given to the asthma patient indicating that the surrounding atmospheric conditions are not favorable, so that the patient can change his location or act accordingly. The measured values obtained on mobile application with proper warning to the user are shown in Fig. 11.

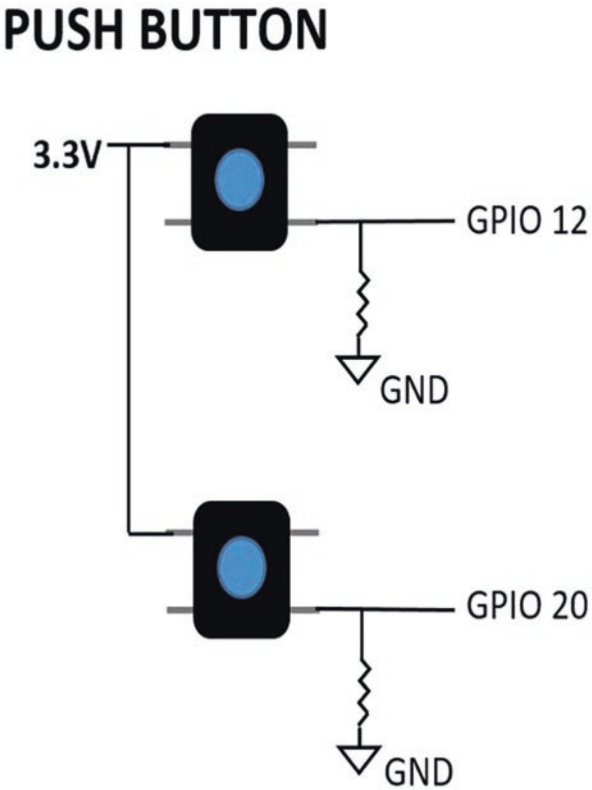


Fig. 7 Push-button interfacing circuit diagram

The patient needs to press the push button before using the inhaler so that the medicine left after every usage can be shown on the LCD screen as in Fig. 12. If the quantity of medicine left is very low, then it shows a warning or alert.

6 Conclusion

The research proposes the development of a mini hardware unit that can be attached to the inhaler for measuring the airflow rate through the airways of the asthma patient, thus helping the doctor to understand the severity of asthma and monitoring the response of the lungs to treatment. Respiratory diseases such as asthma and COPD are becoming a major concern in today's world due to factors such as changing environmental or climatic conditions, pollution, smoking, and so on. This forces a need for a low-cost portable unit that tracks the surrounding air conditions and warns the patient. The work focused on development of a unit that can be attached to the inhaler so that it will be comfortable for the user. High-precision sensors are

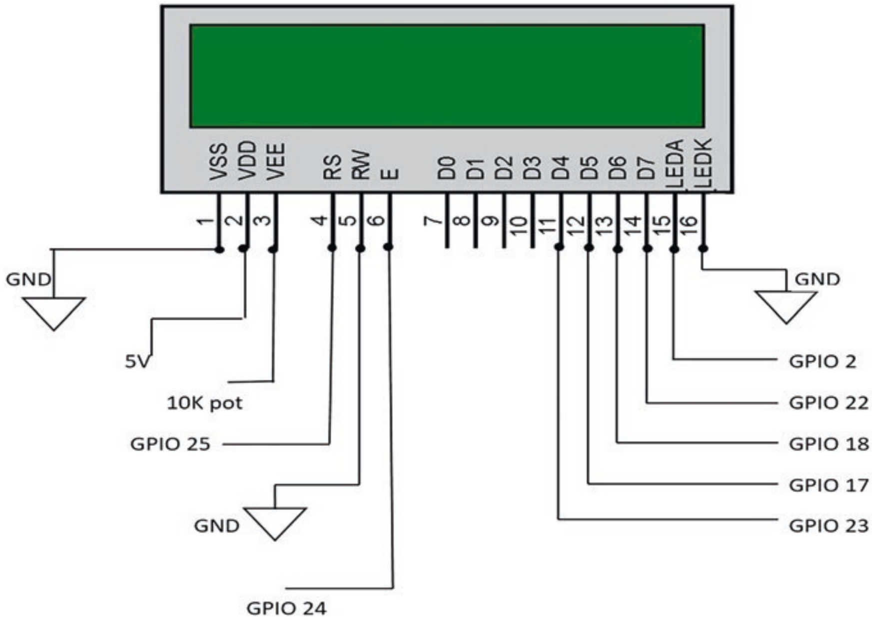


Fig. 8 LCD interfacing circuit diagram

Fig. 9 Login screen of the mobile application developed

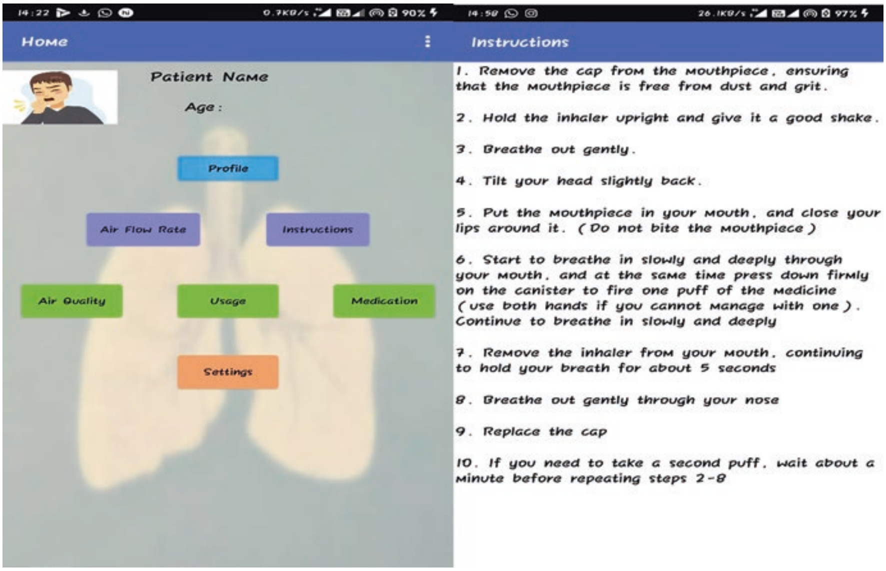


Fig. 10 First screen and instructions to the user displayed on mobile application

Fig. 11 Results obtained on Raspberry Pi output screen and mobile application

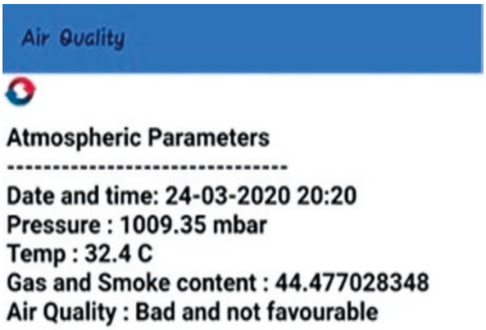


Table 1 Threshold values set for different sensors

Parameters	Threshold values set	Indication in mobile app
Temperature	29–33 °C	Air quality is favorable
	22–28 °C	Air quality is moderate
	Less than 22 °C	Air quality is poor and not favorable
Humidity	40–50%	Air quality is favorable
	Less than 40% and greater than 50%	Air quality is poor and not favorable
Gas content (measured by MQ135)	0–26	Air quality is favorable
	Greater than 26	Air quality is poor and not favorable

Fig. 12 Quantity of medicine left and alert message displayed on LCD

used to monitor the parameters, and a user-friendly mobile application is developed so that the patient as well as the doctor can access the necessary information.

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Deep Learning Application in Classification of Brain Metastases: Sensor Usage in Medical Diagnosis for Next Gen Healthcare

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1 Introduction

1.1 Brain Tumor

The human brain is naturally at the apex of the body and it is a very complicated part and it can function in collaboration with billions of cells. Brain tumors occur when ill and spurious cells replicate and grow in an uncontrolled manner. This dangerously increasing population of cells is capable of destroying healthy cells and also affects the normal functioning of the brain. Brain tumors are classified into two categories. The first one is "benign or low grade," and the second one is "malignant or high grade."

Since a benign tumor is nonprogressive (noncancerous), it is less vascular, and it grows more slowly, exhibiting the threat to brain. Also, other parts of the body are

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not affected by this tumor. But, on the other hand, the malignant tumor is cancerous or destructive and grows rapidly at unknown boundaries [1, 2].

1.2 Big Data Analytics in Health Informatics

Live computer programming element is the main difference between big data health and traditional health analysis. When we look toward traditional systems, for analyzing big data, the healthcare industry is totally dependent on other industries. Due to the significant impact of information technology, many healthcare professionals rely on it because the operating systems are functional and capable of processing data in standard formats [3, 4].

Currently, the rapid development of large amounts of healthcare data is becoming a major challenge for the healthcare industry. With the expanding and ingesting field of big data analytics, useful insights into healthcare systems can be provided. As mentioned above, most of the data generated by this system are stored and printed, as there may be a requirement to be digitized [4, 5].

1.3 Machine Learning in Healthcare

Data mining uses the concept of scanning two pieces of data which helps in identifying scanning patterns. This concept of data mining is quite similar to machine learning. Machine learning does not use data extraction programs such as data mining programs that are based on human understanding to extract data, but it uses these data in order to enhance the understanding of a program. Also, machine learning helps in recognizing data patterns and modifying the performance of programs accordingly [6].

1.4 Sensors for Internet of Things

A brand new model that facilitates our lives by connecting electronic devices and sensors through internal networks is termed Internet of things (IoT). The IoT uses smart devices and the Internet to provide innovative solutions to a variety of challenges and problems related to various commercial, public, and private industries around the world. IoT has become an important aspect of our lives that we can feel around us. In general, the IoT is an innovation that integrates various intelligent systems, frameworks, and smart devices and sensors. Also, it uses quantum and nanotechnology in terms of unimaginable memory, measurement, and processing speed. This can be seen as a prerequisite for creating an innovative business plan with security, reliability, and collaboration in mind [7–9].

Here are nine of the most popular IoT sensors:

1. Temperature
2. Moisture
3. Pressure
4. Adjacent
5. Surface
6. Accelerometer
7. Gyroscope
8. Gas
9. Infrared [7]

1.5 Let Us Look at Some Stats to See the Progress of IOT in Healthcare

Business Insider forecasts more than 161 million healthcare IoT devices by 2020 (Fig. 1).

1.6 Challenges and Critical Issues of IOT in Healthcare

Data security and privacy are the most important challenges of IoT. Smartphones or other smart devices like smart TVs, smart speakers, toys, wearables, etc., are equipped with real-time IoT recording data, but most of them are not compliant with

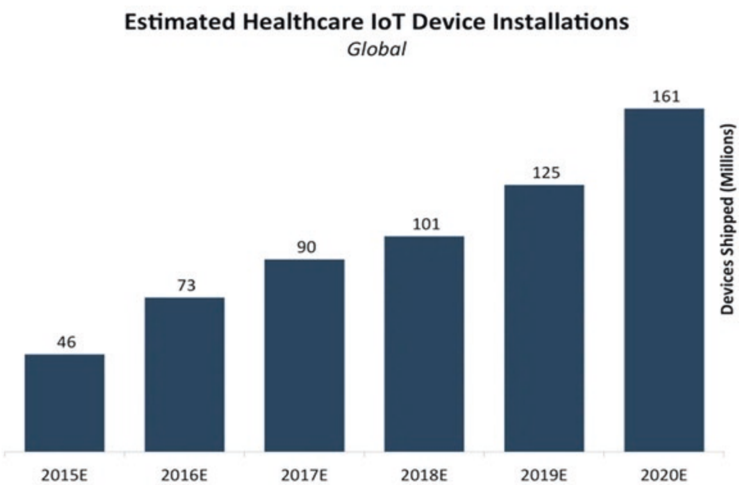

Fig. 1 Estimated healthcare IoT device installation [10]

data protocols and standards. There are many ambiguities in data ownership and organization. As a result, the data stored on IoT devices are at risk of data theft, and this data can be exposed to cybercrime and penetrate the system, compromising personal health information. Fake IDs for health fraud and drug trafficking claims are some of the examples where misuse of IoT data can be seen [10].

- Integration: multiple devices and protocols
- Data overload and accuracy
- Cost [10, 11]

1.7 Machine Learning and Artificial Intelligence (AI) for Health Informatics

In the 1970s, artificial intelligence (AI) appeared in healthcare. The first artificial intelligence system is essentially a knowledge-based decision support system, and the first machine learning method is used to approximate the classification rules of a label set. These first systems are working well. However, it is not commonly used in real patients. One of the reasons is that these systems are independent and have nothing to do with the patient's electronic medical records. Another reason is that the proficiency indicated in the knowledge field of these specialist systems expresses the non-acceptance of developed systems and that most systems are medically more academic practice [12].

After winning several championships, drug abuse has been transformed into a new mode of learning devices by improving an intensive artificial neural network, focusing on complex intensive learning. In May 2019, a team from New York University and Google reported that the accuracy can be improved by using deep learning models that are used in diagnosing lung cancer, and the study quickly covered magazine headlines and many newspapers [12, 13].

1.8 Health Sensor Data Management

A wide impact has been made on people's day-to-day lives by the latest technologies such as wearable sensor devices, cloud computing, and big data. These technologies have great future in the ecosystem based on Internet. Health Sensors require a mass data management and provide personal consumption and sharing. Through smart application of sensors, one can gather the information about the development of the health and welfare sector. Many new ways to collect information manually and automatically are provided by these tools. Numerous modern smartphones have multiple internal sensors, such as a microphone, camera, gyroscope, accelerometer, compass, proximity sensor, GPS, and ambient light [14].

Easily connect a new generation of new wearable medical sensors to smartphones and send measurement results directly. It will be a more effective and convenient set of personal health information such as blood oxygen saturation, blood pressure, pulse rate, blood sugar, electroencephalogram (EEG), and electrocardiogram (ECG or EKG) with all sensors and devices. In future, the process of collection and interpret health and activity data is not so far. The number of mobile phone sensor analysis and data collection is expanding rapidly. This graph of massive growth has created the ability to manage both data and challenge collaboration [14].

1.9 Multimodal Data Fusion for Healthcare

Healthcare is one of the areas of continuous improvement because of the proliferation of IoT technologies that are used to support the central functions of healthcare organizations. Thus, traditional hospitals have become the next generation of intelligent digital environments that use widely interconnected sensor systems and large-scale data acquisition and processing technologies. With the help of all of this scenario, smart health can be supported as a complex ecosystem of smart spaces such as ambulances, hospital wards, and pharmacies and backed by strong framework stacks such as sensor networks and edge devices. Smart healthcare also ensures the effective usage of innovative business models and rules industries [15].

1.10 Heterogeneous Data Fusion and Context-Aware Systems: A Context-Aware Data Fusion Approach for Health-IoT

Advances in low-cost sensor equipment and communications technologies are rapidly accelerating the evolution of smart homes and environments. The health industry is growing rapidly with the development of human body networks, big data technologies, and cloud computing. While using Internet of things (IoT), several challenges can be faced by an individual, such as text recognition, heterogeneous data mixing, reliability, complex query processing, and accuracy.

For more reliable, accurate, and complete results, collect personal data from your sensor source. In addition to the wearable sensor, an additional background sensor has been added to create the background. The IoT Health Program uses the potential benefits of combining knowledge data in this area. Background information can be used to tailor the behavior of the app to specific situations [16].

1.11 Role of Technology in Addressing the Problem of Integration of Healthcare System

Information and communications technology offers the opportunity to revolutionize healthcare. Technology-based healthcare coordination and care systems, including web, mobile, measurement, computing, and bioinformatics technologies, offer great potential to enable a whole new model of healthcare both at home and abroad. They provide a formal care system and have the opportunity to have a major impact on public health. Increasingly, decision support tools are being built to help people better understand, access, and make decisions about treatment [17].

The integration of behavioral health care into a care center that largely manages physical health has great expectations for improving care coordination, quality, and impact, but it also creates scenarios that physicians must now overcome. The limits may not feel the expertise, time, or resources that affect the client's behavioral health needs (e.g., substance use, mental health). In this way, technology reduces the quiet and dedicated care of illnesses and provides countless opportunities for tailors to monitor the behavior and provide intervention to each individual in response to therapeutic behavior that changes over time [17].

2 Literature Survey

Various strategies for segmenting, locating, and identifying images of brain tumors have been proposed from the late request to group MRI images.

Parveen and Amritpal Singh proposed a method for data extraction. The data grouping method is done in four stages: preprocessing, extraction, and highlight grouping. The main tissues improve speed and accuracy by improving and eradicating the skull. Conventional Fuzzy C-means (FCM) uses a portion of the grid in the dimension of the Dim dimension (GLRLM) to extract highlights in brain images. Sorting brain MRI images using the SVM method gives accurate results [1].

There are more than 120 types of brain tumors of different origin, location, size, and tissue characteristics, as per the reports of the World Health Organization. Articles on three types of malignancies are as follows:

Glioblastoma: An early malignant brain tumor consisting of astrocytes, which support nerve cells and are classified as tetraploids. It usually starts in the brain.

Sarcoma: The degree varies from 1 to 4 degrees and occurs in connective tissues such as blood vessels.

Metastatic bronchial cancer: A secondary malignant brain tumor that has spread from a lung tumor to a bronchial cancer [1].

Maoguo Gong [18], in his manuscript applying Fuzzy Algorithm with C-means (FCM) provides improved fuzzy image segmentation by introducing weight-lifting fuzzy factors and core metrics. The fuzzy weight factor in the exchange depends on the distance in the space of all adjacent pixels and the difference between their gray surfaces simultaneously. The new algorithm uses fast bandwidth selection rules to determine core parameters based on the distribution of distances from all points in the dataset. Also, both the business-based fuzzy weight factor and the core distance measurement are parameter-free. The results of experiments on artificial and real images manifest that the new algorithm is successful and systematic and relatively independent of this type of noise [18].

The paper is written by Rudie, J. D et al. titled "Emerging applications of artificial intelligence in neuro-oncology" [19]. They showed that artificial intelligence (AI) methods were developed to enhance the accuracy of medical and therapeutic diagnosis by increasing the computational algorithms. The field of radiology in neuroscience is now and perhaps at the forefront of this revolution. Advanced neuro-MRI data and the types of artificial intelligence techniques used in conventional tumors and permeability margins for glioma diffusion determine true progression assumptions and are used in routine clinics. Recurrence and survival are more predictable than what happens.

According to him, radiogenomics also facilitates understanding of cancer biology and enables high-resolution noninvasive sampling of the molecular environment, and providers understand the level of systems of heterogeneous cellular and molecular processes by making spatial and molecular heterogeneous markers in the body; these radiographs are based on artificial intelligence and classify patients using more accurate diagnostic and treatment methods. It also can better monitor dynamic therapy. Although the basic challenges remain, radiology is changing dramatically given the ever-increasing development and validation of artificial intelligence technologies for clinical use.

They revealed the purpose of this study that was to improve outcomes in patients with central nervous system neoplasms through advances in diagnostics and therapeutics. Tools of artificial intelligence that help in combined clinical, radiological, and genomic information with predictive models promise critical guidance and guidance on personal care. However, there are many challenges, and many things need to be done to keep promises.

Nevertheless, the use of artificial intelligence technology will dramatically change the progress of radiology, improving the accuracy and efficiency of radiologists. As these powerful tools will be integrated into daily practice in the coming years, radiologists should need to know and use these powerful tools [19].

According to Amin, Javeria and his team are diagnosing brain tumors, an active area for brain imaging research. This study proposes a methodology for presenting and classifying brain tumors using magnetic resonance imaging (MRI). In order to segment the tumor, an architecture-based deep neural network (DNN) is used [3].

The author team has given the proposed model, seven layers including three concealers, three ReLUs, and a softmax layer will be used for classification. The DNN determines the label based on the center pixel and performs the division. They described extensive experiments using eight large standard datasets including BRATS 2012 (image and artificial datasets), visual and artificial datasets, and ISLES (cerebral infarction, ischemic stroke).

According to Amin, the results are proved with accuracy (ACC), attribute (SP), sensitivity (SE), alopecia similarity coefficient (DSC), false-positive coefficient (FPR), true positive rate (TPR), and Jaccard similarity index (JSI) [3].

Gopal S. Tandel and his team member pointed out in a February 2018 World Health Organization (WHO) report that the death rate for central nervous system (CNS) or brain cancer is the highest in Asia. Early diagnosis of cancer is critical, as it can save many lives. Cancer grading is a necessary feature of targeted therapy [20].

According to him, the diagnosis of cancer is very aggressive, expensive, and time-consuming. There is an urgent need to describe and evaluate noninvasive, cost-effective, and effective brain cancer tools.

In this article, they tried to briefly describe the pathophysiology of brain cancer, a cancer treatment method, and an automatic computer method for describing brain cancer and deep learning of brain cancer patterns and equipment. It also aims to investigate issues with existing engineering methods and design future models. Besides, they emphasized the association of brain tumors with stroke, brain diseases (such as Alzheimer's, Parkinson's, and Wilson's), leukemia, and neurological diseases in other machine learning and deep learning paradigms. His main research areas are cancer pathway physiology, imaging technology, WHO's tumor classification guidelines, early detection methods, and existing computer algorithms that use deep equipment to classify brain cancer.

Finally, they contrasted brain tumors with other brain diseases. They made a conclusion that the ability to automatically extract DL-based methods is once again more common than traditional medical image classification methods. If cancer is evaluated and treated quickly and cost-effectively, many lives can be saved. Therefore, there is a need for a rapid, noninvasive, and cost-effective diagnostic method. The DL method can play an important role here. According to him, the use of DL technology and its full potential to evaluate automatic tumors has been completed, but the work is still very little, and no research has been carried out [20].

3 System Design and Methodology

3.1 System Design

A block diagram presented below shows the functional working of this manuscript in a step-by-step manner (as per Fig. 2).

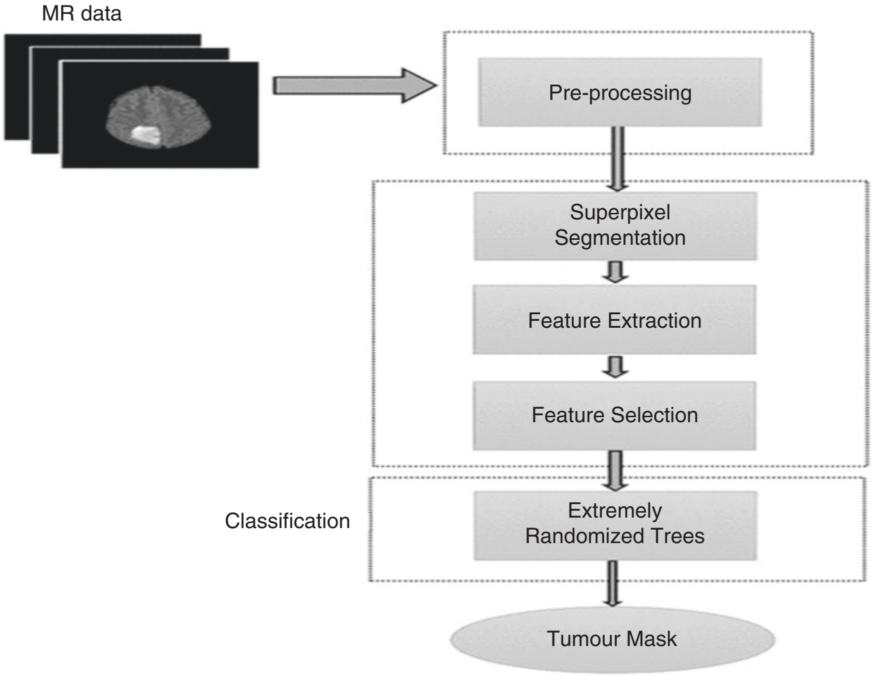

Fig. 2 System design flow chart

3.2 CNN Architecture

An evolutionary neural system (convolutional neural network (CNN) or ConvNet) is a profound neural system class, the most utilized in a visual examination. CNNs are multilayer perceptron regularization renditions. Multilayer perceptron for the most part alludes to completely associated systems, which implies that each neuron in one layer is associated with the following layer, everything being equal.

The CNNs, however, embrace another way to deal with regularization: they utilize the various leveled designs in the information and utilize littler and increasingly basic examples to collect complex examples. Therefore, CNNs are on the lower extraordinary on the size of the association and multifaceted nature.

Natural procedures motivated progressive systems by the way that the example of the network between neurons resembles the creature's visual cortex association. The open fields of the different neurons mostly cover the whole field of vision.

Contrasted with other picture characterization calculations, CNNs utilize moderately little pre-handling. This implies the system discovers that channels are produced by delivering customary calculations. This autonomy from past information and human exertion in the plan of highlights is a significant advantage.

Figure 3 is a representation of the CNN architecture and various layers.

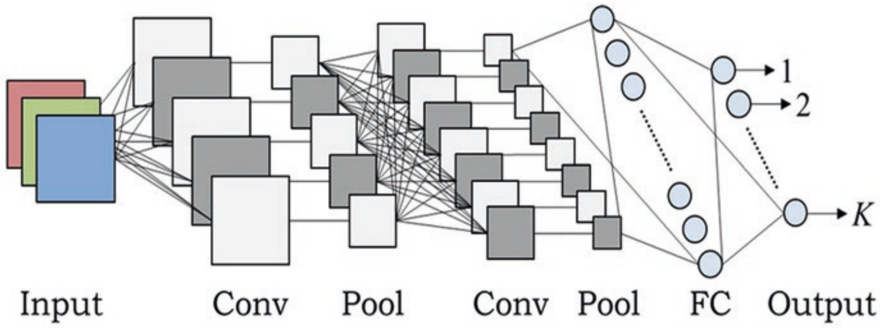

Fig. 3 CNN architecture

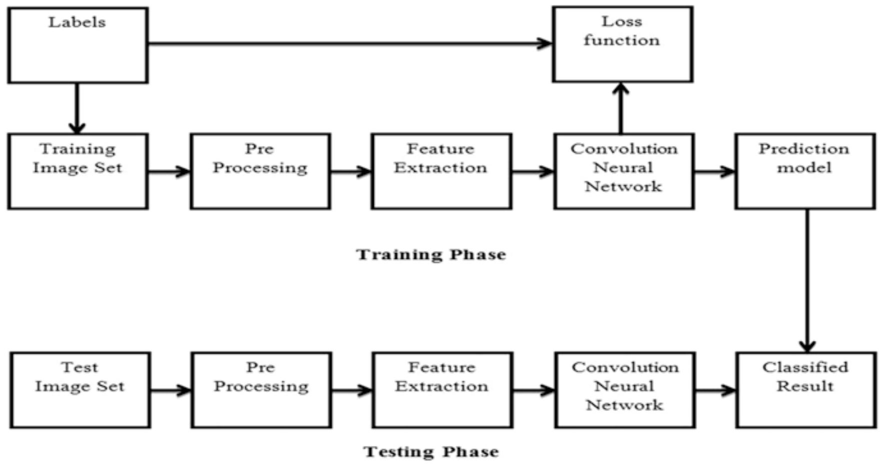

Fig. 4 Block diagram

3.3 Block Diagram

This picture represents the entire functioning of the project and how the CNN architecture is used to classify the type of tumor (as per Fig. 4).

3.4 Algorithm(s)

Gradient descent is a calculation of streamlining used to limit certain functionalities, moving to a lofty plummet toward the path characterized by the slope negative. We use the slope plunge in AI to refresh our model parameters. Parameters allude to straight relapse coefficients and neural system loads. According to our cost capacity, we can govern two parameters: *m* (weight) and *b* (inclination). One should consider fractional subsidiaries for the impact created on everyone that is taken as the last expectation. Concerning every parameter, the outcomes are stored in an inclination after we ascertain the halfway subordinates of the cost capacity.

The cost function is given as follows:

$$f\left(m,b\right)=\frac{1}{N}\sum_{i=1}^{n}\left(y_i-\left(mx_i+b\right)\right)^2$$

The gradient can be calculated as:

$$f'\left(m,b\right)=\begin{bmatrix}\frac{\mathrm{d}f}{\mathrm{d}m}\\ \frac{\mathrm{d}f}{\mathrm{d}b}\end{bmatrix}=\begin{cases}\frac{1}{N}\sum -2x_i\left(y_i-\left(mx_i+b\right)\right)\\ \frac{1}{N}\sum -2\left(y_i-\left(mx_i+b\right)\right)\end{cases}$$

To solve the gradient, we use our new m and b values to iterate through our data points and to calculate partial derivatives. This latest gradient expresses the slope of our cost function (current parameter values) to our current position and the direction to which we are to update our parameters. The learning rate controls the size of our update.

4 Our Experimental Results, Interpretation, and Discussion

4.1 Experimental Setup

Hardware Requirements

- 4 GB RAM
- Intel Core i3 or higher processor
- GPU (recommended)
- 2 GB available disk space

Software Requirements

- Python 3
- Spyder IDE
- TensorFlow and Keras
- Scikit-Learn
- Numpy and Pandas
- Linux or Windows OS

Constraints

- Data limitation
- Hardware limitation
- Accuracy limitation

4.2 Implementation Details

Deep learning expanded the structure of traditional neural networks (NNs) between input and output layers to add hidden layers to the network architecture, creating a more complex and non-causal relationship. In recent years, the reflectional neural network (CNN) is a popular architecture that allows you to carry out complex operations using concealed filters. A set of feedforward layers that implement loop filters and pool layers makes the typical CNN architecture. After the last layer, some fully connected layers are enhanced by CNN. Manipulate one-dimensional vectors for classification work with CNN. Get the results you need in four major steps. Data collection and preparation is the first step. We are going to collect labeled MRI images of tumor brains and prepare them so we can use them for training.

4.3 Snapshots of Interfaces

Below is the image showing the various classes of tumors our model can classify (as per Fig. 5).

Code snippet. Below is the screenshot of the code that we have used to train our CNN model (as per Fig. 6).

Welcome page. Below is the snapshot of the welcome page. This is the first page user will come across (as per Fig. 7).

MRI selection. Below is the snapshot of the page where the user can select and upload the MRI image (as per Fig. 8).

The result displayed. Below is the snapshot where the prediction result of the model is displayed (as per Fig. 9).

About section. The screenshot below is of the page of the about section where information about this project is displayed (as per Fig. 10).

Data source	Tumor type	No.of Images
REMBRANDT	Astrocytoma	21307
	Glioblastoma	17983
	Oligodendroglioma	12460
	Unidentified	13677
MIRIAD	Healthy brain	30688
BRAINS		556
Total		96115

Fig. 5 Various classes of tumors

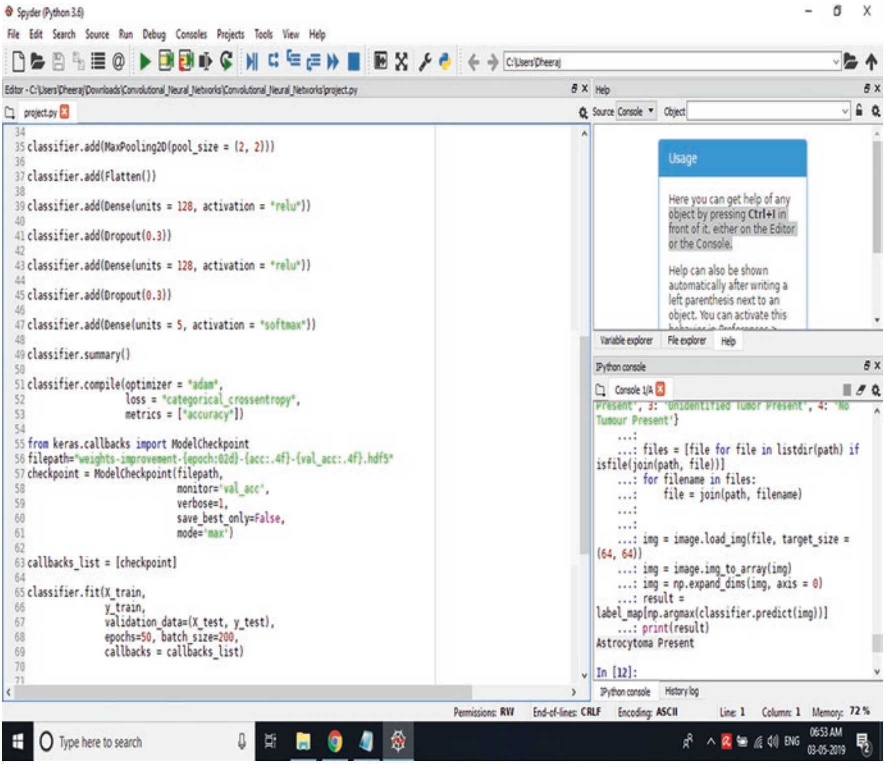

Fig. 6 The diagram above represents the snippet where the author team has tried to train their CNN model

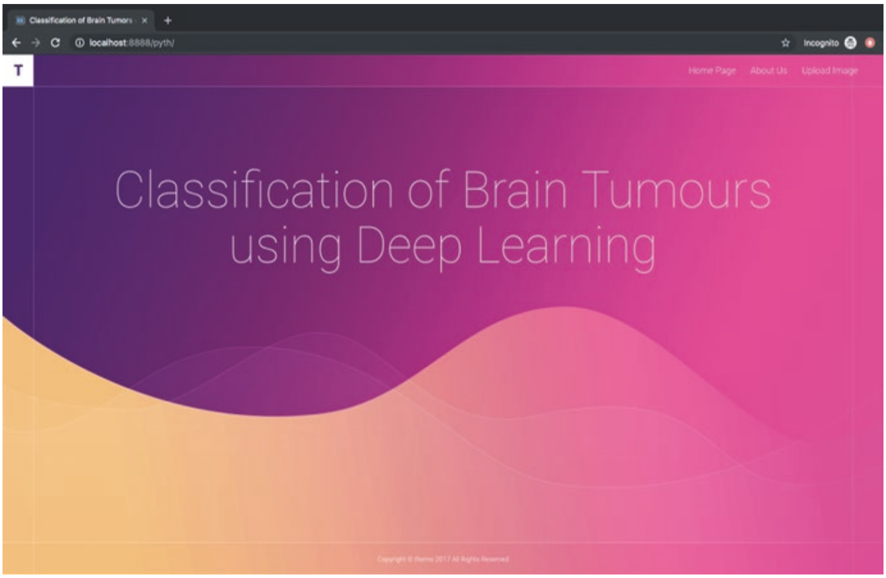

Fig. 7 Loading page

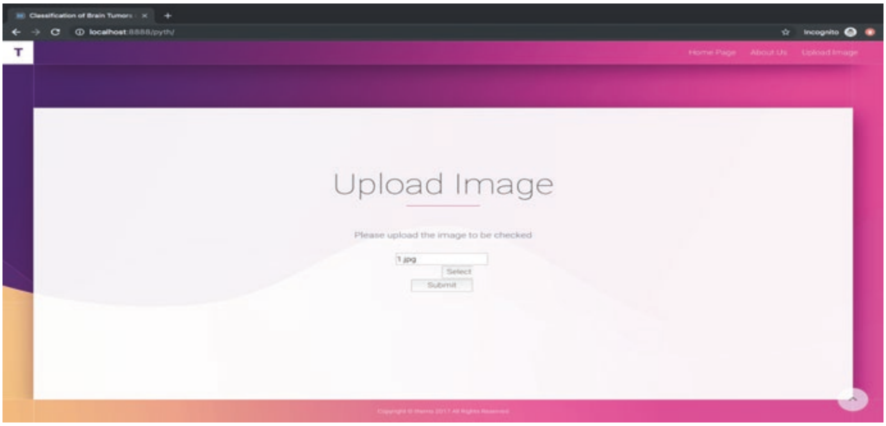

Fig. 8 MRI selection

Fig. 9 Result display section

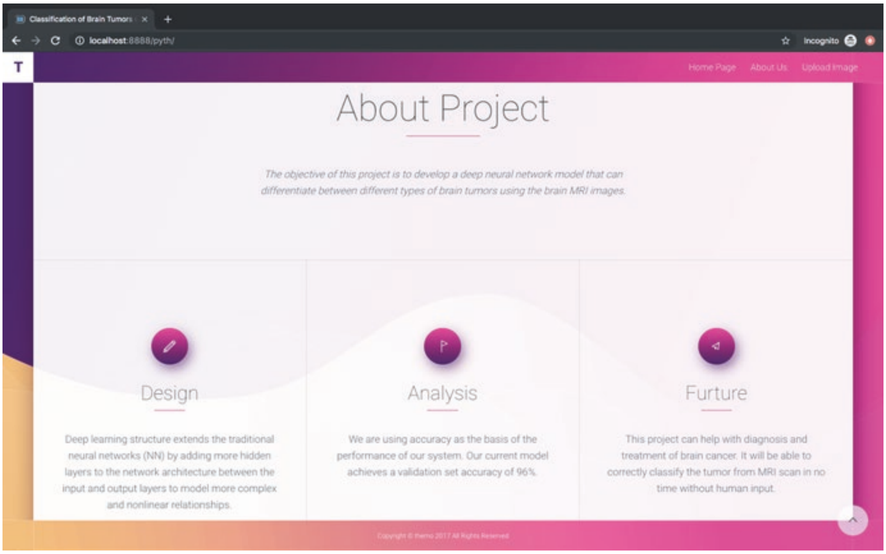

Fig. 10 About section

5 Novelty in Our Work

The DNN-based architecture and method will be the best method for most brain tumor classification contests. Many researchers are adding layers to CNNs to improve accuracy. This is a major aspect of scientist knowledge. Researchers and groups that work well with accurate learning methods and algorithms were able to do this using tools outside the grid, such as adding new data or implementing pre-processing techniques [21].

By adding a step before the normalization process, we improved the generalization capability of the network without changing the CNN architecture. We also tested the gradient descent algorithm for cost over-optimization, but these methods have not yet been implemented in the field of brain tumor classification.

6 Future Scope, Possible Applications, and Limitations

I have too much fat now. This could be improved by expanding the dataset and updating it to identify new types of tumors. Implementing deep learning techniques and algorithms for classifying brain tumor data poses a myriad of challenges.

The lack of large training datasets is a challenging barrier to deep learning techniques. The Health Label Structure Report is expected to facilitate future analysis, especially in the analysis of brain tumors. Especially in the area of brain tumor analysis, the use of non-textual and structural reports for network training is expected to grow rapidly in the future [22].

Deep learning techniques, which effectively learn from a limited number of classified data, are another major limitation of deep learning algorithms. However, it is not useful if the input field for image data from the entire network is small.

7 Recommendations and Consideration

Classification implementation in brain tumor analysis is a complex and rewarding task. This can be widely classified, processed, and post-processed. The above methods have many challenges and complicate the problem. So far, there are no ideal computer tools for adaptation, tumor grade, or aggression.

Therefore, rapid, noninvasive, and cost-effective diagnostic techniques are essential. DL techniques can play a big part here. To understand it better, the authors can submit that much less work have been done to classify automatic tumors using Max DL techniques and likely works are possible, but not yet studied in detail [23].

8 Conclusions

The main focus of data classification is brain cancer physiology, imaging techniques, tumor classification guidelines by the World Health Organization, early detection procedures, and existing computer algorithms for classifying brain cancer using devices.

9 Performance Evaluations

We are using accuracy as the basis of the performance of our system. Our current model achieves a validation set accuracy of 96.95% in the training set and 96.03% in the validation set.

Figure 11 shows the accuracy score of the validation set.

We also have made a webpage with options to upload the MRI and get results online. It has an upload button to choose an image from the system to check against the project.

9.1 Comparison with Other Algorithms

Comparison chart: This table shows the performance of our model in comparison to other conventional models (as per Table 1).

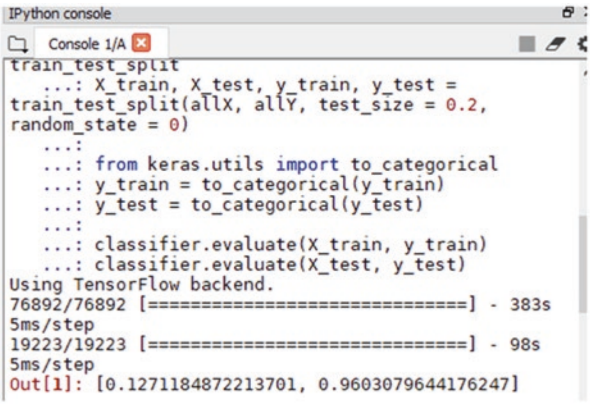

Fig. 11 Accuracy score

Table 1 Comparison chart

Algorithm	Classification rate (%)
DNN	96.97
KNN $K = 1$	95.45
KNN $K = 3$	86.36
LDA	95.45
SMO	93.94

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Annex

Key Terms and Definitions

Brain Tumors A brain tumor is a mass or an abnormal growth of cells in the brain. There are several types of brain tumors. Some brain tumors are noncancerous (benign), and some brain tumors are cancerous (malignant).

Healthcare 4.0 Healthcare 4.0 is a term that has recently emerged from Industry 4.0. Today, the healthcare sector is more digital than it has been for decades. For example, X-ray emission and magnetic resonance imaging to computer tomography, ultrasound scanning to electromedical recording.

Confusion Matrix A confusion matrix is a table that is often used to describe the performance of a classification model (or "classification") on an experimental dataset with known actual values. This allows you to visualize the performance of your algorithm.

Machine Learning Machine learning is an artificial intelligence (AI) application that provides systems with the ability to automatically learn and improve their experience without explicit programming. Machine learning focuses on developing computer programs that can access data and use it for your own learning.

Artificial Intelligence Artificial intelligence (AI) is a simulation of human intelligence on a machine that is programmed to think and mimic its behavior like a human. The term also applies to all machines that have functions related to the human mind, such as learning and problem-solving.

Deep Neural Network Deep neural network (DNN) is an artificial neural network (ANN) with several layers between the input and output layers. DNN finds the right mathematical operation to transform an input into an output, whether linear or nonlinear.

Big Data An extensive data set that can be analyzed by a computer to reveal patterns, trends, and relationships, especially in relation to human behavior and interactions.

Internet of Things The IoT is a system of interconnected computing devices of machines and digital machines that provides a unique identifier and the ability to send data over a network without the need for person-to-person or computer-to-computer interaction. It is equipped.

B. Additional Readings

- Brain Tumors-Types of Brain Tumors

  https://www.aans.org/Patients/Neurosurgical-Conditions-and-Treatments/Brain-Tumors

- 2016 WHO Classification of Tumors of the Central Nervous System

  https://braintumor.org/wp-content/assets/WHO-Central-Nervous-System-Tumor-Classification.pdf

- Tumor Types-Understanding Brain Tumors

  https://braintumor.org/brain-tumor-information/understanding-brain-tumors/tumor-types/

- Classification of Brain Tumors and Grade Using MRI Textures

  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2863141/

- Neurological Surgery-Types of Brain Tumors

  https://www.neurosurgery.pitt.edu/centers/neurosurgical-oncology/brain-and-brain-tumors/types

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Implementation of Smart Control of Wheelchair for a Disabled Person

N. Prakash, E. Udayakumar, and N. Kumareshan

1 Introduction

An embedded framework is intended to perform devoted capacity. For a complete gadget, a mix of equipment and programming plays out an installed piece. Since an embedded framework has a constrained scope of utilizations, plan engineers face no issue to streamline both size and cost or improve unwavering quality and nature of execution. Inserted systems are compelled by any event of one guideline planning focuses regularly either by microcontrollers or by digital signal processors (DSP). A specific assignment [1] which require shocking processors is being committed with the key attributes, regardless. For instance, flight authority structures may steadily be seen as installed, paying little heed to the way that they join united worker PCs and submitted provincial and public systems among air terminals and radar areas (every radar surely combines in any occasion one inserted game plan of its own).

Since the comfortable framework is being submitted with express undertaking plan, the specialists can revive it to lessen the size and cost of the thing and augmentation and the suffering quality of execution. Some presented frameworks are mass made, profiting by economies of scale. Truly, installed structure goes from valuable contraptions, for example, activated watches and MP3 players, to gigantic fixed establishments like traffic signals, managing plant controllers, or the frameworks controlling atomic force plants. Multifaceted nature changes from low, with a

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solitary microcontroller chip, to astoundingly high with different units, peripherals and structures mounted a colossal case or fenced in area [2].

With an immense augmentation in the measure of more arranged individuals and the individuals with certifiable troubles are the gigantic applications for the course help of clever wheelchairs. Because of debacles, oldness, or issues as cerebral loss of movement plus, spinal string wounds, the level of debilitated individuals is climbing and now tending to 1 billion people, which address 15% of the general individuals.

As per the Tunisian assessment concentrate from the Ministry of Social Affairs of Tunisia 2013 spread in an online source and the furthermore excess of 208,465 Tunisians experience the detestable effects of assortment insufficiencies, where they address 2% of the whole populace. They happen under various focuses like ataxia, spasticity and engine brokenness, which cause a nonattendance of muscle coordination required unforeseen developments of postponement in appearing at engine aptitudes, shaking, shiver, and the failure to control the upgrades particularly exact ones like piece. They will undeniably cause a nonattendance of free movability, conviction, and security that require the utilization of adaptable hardware, for example a manual wheelchair and an electric wheelchair or the assistance of a guard to do their bit-by-bit life works out. Individuals are notwithstanding those different moving challenges happen with them and experiencing the furthest point failure [3].

2 Related Work

This alignment framework depends on a man-made brainpower technique. In this manner, a neural organization calculation is at that point applied; it is at present utilized for both exploration and creation by various groups in numerous applications in medication, designing, etc. With an expansion of old and impaired individuals, driving a wheelchair in homegrown conditions is a troublesome assignment in any event, for an ordinary individual and furthermore turns out to be considerably more hard for individuals with arms or hands disabilities. When an individual turns out to be genuinely crippled, then he/she faces a great deal of issue while moving from one spot to another. They use wheel seat. Beforehand, wheel seats were controlled manually. For that sort of wheel seats, the individual should be sufficient to control that; in any case, someone else should be there to screen the development of the seat [4]. A few patients who cannot control the heading of the wheelchair with their arms because of an absence of power face serious issues, for example, direction, versatility, and so forth. Thus, this wheelchair is created to conquer the above issues permitting the end client to simply perform safe developments and achieve some everyday life significant errands.

Taking all in this in thought we have chosen to do a touchscreen and furthermore joystick worked wheelchair. As contact screen innovation is securing most elevated top in different logical just as financially creating items, its utilization in patient cordial gadgets like wheelchairs may bring about improved nature of administration. Contact screen innovation is the direct control type signal-based innovation. Joysticks were utilized in numerous applications like PC games, clinical gadgets, wheelchairs, mechanical technology, airplane, progressed vehicles, and different gadgets. Different instances of position detecting gadgets incorporate trackballs and computer-generated reality hardware, for example, protective caps, goggles, gloves, and foot pedals [5].

Joysticks were fundamentally a basic course of action of contact switches at four quadrants. Moving the joystick shaft away from its focused position shut one of the four switches, contingent upon the bearing of development [6]. At that point it is prepared through the regulator. Today, in market there are various wheelchairs available watching out anyway they are not inserted with sharp structures in the event that they are open, by then the expense is going from 3 lakhs to 4 lakhs, and this cost is not reasonable for a normal person [7]. With the revived movement of developing of the general population being represented in numerous post-present day countries, interest in Cartesian mechanical innovation, on which most customary approaches to manage canny progressed mechanics are based, followed by making game plans for the time of development progression and work step by step in complex genuine conditions with extended execution in productivity, security, and flexibility, and exceptionally diminished computational necessities.

The cerebrum wave starting late has gotten a subject of interest for controlling machines. To do thusly, electroencephalography (EEG) signal models should be described and accumulated into the proposed exercises. The customer ought to have incredible enthusiastic control and center for amazing control. This is a weight to the client despite the fact that this medium might be a decent other option for individuals with a completely incapacitated body. Looking input offers great data, for example head and eyes are the headings of control [8]. The fundamental thought is that a zone at which the client looks speaks to the expected bearing, which impersonates human physiological conduct during strolling or driving. While this medium appears to be a decent applicant, it is difficult to recognize between activities for guiding the wheelchair or essentially glancing around. Along these lines, the clients need to avoid seeing environmental factors and to focus on route during driving. Maybe the best answer for construing contribution from the client with extreme engine incapacities is depending on multi-client input approaches, so that various conceivable client's signals are examined prior to giving the ideal order. Utilizing this technique, we can relegate each controlling errand into the diverse client's info and henceforth will force less weight to the client contrasted with the case that exclusively depends on a solitary information [9].

While option in contrast to joystick mediums empowers the objective patient to move, the route trouble is still absolutely on the client. As indicated by among 200 rehearsing clinicians in the USA, 40% of their patients think that it is hard or difficult to control the wheelchair despite having such elective mediums [10]. Most as of late, it has likewise been accounted for in that most patients with engine hindrance can't direct the wheelchair for keeping away from deterrents and equal stopping. These clinical discoveries give knowledge to the significance for contriving a PC controlled stage to help the clients by decreasing their outstanding burden and expanding the well-being. In this structure, the client contribution alongside the ecological data will be flawlessly dissected for performing fundamental assistive undertakings. The measure of given help generally shifts relying upon how serious the clients' hindrances are. It performs transient course arranging, and the clients possibly mediate it when they wish to digress from the arrangement [11]. This implies that when an order is given, the clients can unwind while the PC is finishing the undertaking. In contrast to the self-sufficient control, the semi-self-governing control need not bother with a real guide of the climate; just a nearby well-being map dependent on sensor filtering is required. Henceforth, it can offer opportunity to the clients to move in new conditions [12].

Handicap is a problem that hampers the day-by-day life of the influenced individuals by restricting the individual's development, detects, capacity to think or act. Handicap can either be intrinsic or gained. Innate inabilities are generally acquired, while gained incapacities happen because of any mishap or sickness. As per the report of the Australian National University, handicaps can be of various kinds, for example, vision hindrance. Engine handicap is the halfway or on the other hand all out misfortune in strong elements of the body. These incapacities incorporate joint inflammation, cerebral paralysis, various sclerosis, strong dystrophy, procured spinal injury (paraplegia or quadriplegia), post-polio condition, and spina bifida [13]. All of these inabilities restrain the ordinary development of the influenced individuals. Almost 15% of the total populace comprises individuals having inabilities, and 2–4% of them have significant issues in working. One of the most widely recognized guides for development for the genuinely impeded individuals is the wheelchair; it is as yet insufficient to address the issues of a wide range of engine incapacities. Wheelchairs are basically intended to help individuals experiencing incapacities in the lower appendage region. Accordingly like quake, individuals who have issues in the upper appendage territory cannot use the wheelchair appropriately. Along with this problem, it is practically difficult for consistency [14].

As of now in market, sharp wheelchairs are accessible at any rate and are not resonable by typical people. They are controlled utilizing high-force battery by using super force engines, besides expands the expense of the thing is so tolerable. The seat accomodated with the advancement of such social requests require a part or an overseer with them [15]. Manual or standard wheelchair is a wheelchair that is generally utilized by a layman. An average individual cannot bear the cost of power wheelchair so they utilize the standard one.

3 System Design

PIC is a social affair of Harvard putting together microcontrollers made by Microchip Technology, got from the PIC1640. From the beginning Microelectronics division 1 is made by general instruments (Fig. 1)

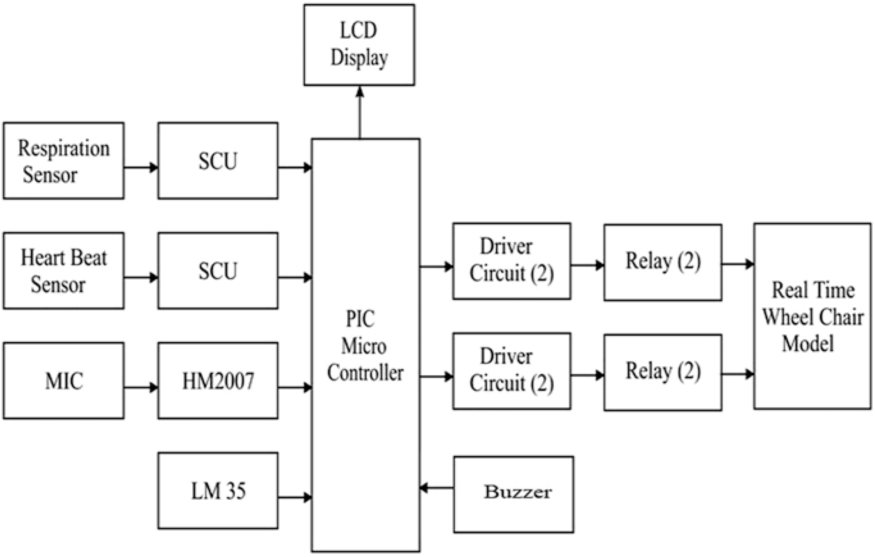

Fig. 1 Block diagram of the proposed system

(a) **Stacks**

PICs have an apparatus call stack, to bring address back were is utilized to spare. The ringing stack avaiable on prior gadgets is not modifying, yet this changed with the 18 arrangement contraptions. Equipment support for an inside and out accommodating boundary stack was deficient in early blueprint; at any rate, the phenomenally improved in 18 game plan making the 18 approach structuring considerably, increasingly, and neighborly to the basic level language compilers [16].

(b) **Instruction Set**

A PIC's headings change from around 35 standards for the PICs to more than 80 guidelines for first-in-class PICs. The bearing set reviews rules to play out an assortment of activities for registers, obviously the locater and a requesting reliable for finder finning [17]. A piece setting and testing, can be performed on any numbered register, regardless bi-operand math assignments constantly combine W (the force), making the result back to one or the other W or the other operand register. To stack a dependable very well, it might be moved into another register before it is fundamental to stack. On the more settled focuses, all register moves expected to experience W, yet this changed on the "most critical reason for the line" focuses.

(c) **Relay Driver**

A hand-off is an electro-attractive switch that is valuable on the off chance that you utilize a circuit to turn on and off a light (or whatever else) with the 220 V main source [18]. The graph beneath shows a run-of-the-mill hand-off (with "regularly open" contacts). The expected current is more than to work the hand-off curl, provided by most chips (operation, amps, and so forth), so a transistor is typically required.

(d) **Buzzer**

Buzzer is a sound hailing device, which may be mechanical or piezoelectric. Average business of ringers consolidate is a ready devices, tickers and attestation of customer data for instance, a mouse snap or keystroke. An electric sign uses a similar instrument to an interrupter toll, anyway without the full ringer. They are more settled than ringers, yet adequate for a notification tone over a little division, for instance, over a work zone [19].

(e) **LCD**

Liquid crystal displays (LCDs) are utilized in for all intents and purposes indistinguishable cases where light emitting diode (LEDs) are utilized. These solicitations are show of numeric and alphanumeric text styles in spot position and segmental highlights.

(f) **Liquid Crystal Cell**

The fluid disturbs the atomic arrangement and produces choppiness. At the point when the fluid is not initiated, it is straightforward. At the point when the fluid is initiated, the sub-atomic disturbance makes light be dissipated every which way, and the cell has all the earmarks of being splendid. This wonder is called dynamic dispersing. A liquid crystal display (LCD) is an electronically changed optical contraption merged into a petite, level board. It is as often as possible utilized in battery-energized electronic devices since it uses outstandingly constrained amounts of electric power [20].

(g) **Heartbeat Measurement**

The beat rate is an estimation of the beat, or the events the heart pounds each second. As the heart pushes blood through the passageways, the courses broaden and contract with the movement of the blood. Taking a heartbeat checks the beat and can exhibit the furthermore going with. The regular heartbeat sound for adult ranges from 60 to 100 beats per minute. The beat rate may change the addiction with work out, harm and emotions. Females ages 12 and progressively prepared, when in doubt, will by and large have faster heartbeats than do folks. Contenders, for instance, runners, who do a lot of cardiovascular embellishment, may have heartbeats right around 40 thumps for every second and experience [21].

(h) **Respiration Measurement**

Ordinary respiratory rate might be characterized as an individual's respiratory rate while resting. This rate changes with numerous elements, specifically age, sex, or ailments like asthma, seizures, bronchitis, untimely birth, indigestion malady, and so on. The rate ought to be estimated when an individual is resting and his/her feelings of anxiety are least. The most ideal path is to tally the breaths when the individual does not know about it being estimated [22]. This rate has a pattern of lowering down with age. Babies have a high typical respiratory rate, which lowers down as they develop.

Here's the age-wise range: The principle explation behind the occurence of age is ascend in limit of the lungs as an individual develops. Despite the fact that a grown-up breaths in less much of the time that a kid, the volume of air breathed in by a grown-up is ordinarily more than that breathed in by a kid [23]. This circuit is intended to quantify the breath. Right now thermistor is utilized for breath estimation, which is associated with the resistor connect arrange. The extension terminals are associated with modifying and non-transforming input terminals of the differential enhancer (Fig. 2).

The differential speaker is developed by the LM741 operational intensifier. Here, one thermistor is utilized for breath estimation. Another thermistor is utilized as reference, which gauges [22] the room temperature. The differential speaker gives the mistake voltage at its yield. At that point, the mistake voltage is sifted by the following phase of the operation amp. The yield voltage is changed over to +12 to −12 V square wave beat through the comparator. At that point, the square wave beat is changed over to 5 to 0 V TTL heartbeat through the transistor (BC 547). At that point, the last TTL beat is given to a microcontroller so as to screen the breath rate.

(i) **Temperature Sensor**

It is a precision-associated temperature sensor of centigrade circuits whose yield voltage is straightforwardly relative to the temperature of Celsius (centigrade). Accordingly, LM35 has a respectable circumstance over direct temperature sensors altered in Kelvin degree, as the client is not required to deduct a massive [24] consistent voltage from its thought to get incredible centigrade scaling. The sensor yield differs by 10 mV for every level of Celsius temperature rise.

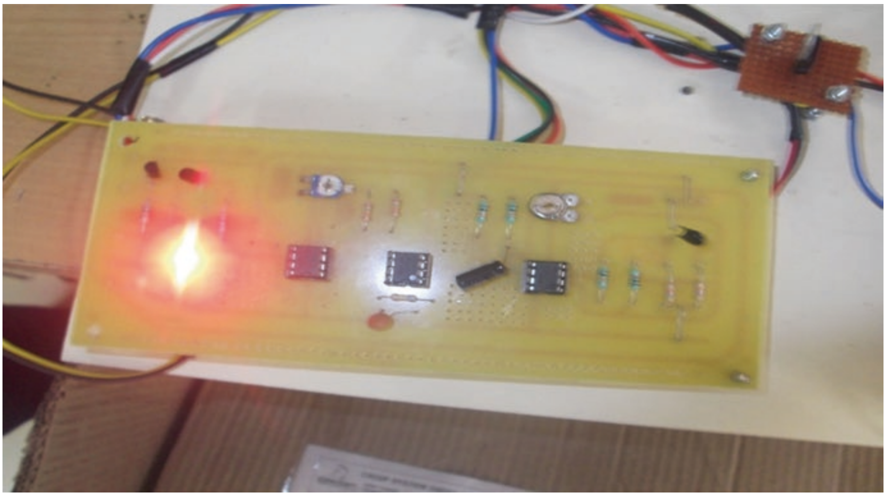

Fig. 2 Respiration measurement setup

(j) **Speech Recognition System**

The talk affirmation system is a completely accumulated and easy-to-use programmable talk affirmation circuit. Programmable, as in you train the words (or vocal enunciations) you need the circuit to see. This board grants you to investigate various roads in regard to various parts of talk affirmation development. It has eight piece data out which can be interfaced with any microcontroller for extra improvement. Some of interfacing applications that can be made are controlling home machines, applying self-governance advancements, speech-assisted developments, speech to content translation, and some more [25].

(k) **Homonyms**

Homonyms are words that sound the same. For example, the words feline, bat, sat, and fat sound the same. In light of their like sounding nature, they can befuddle the discourse acknowledgment circuit. When picking objective words for your framework, do not utilize homonyms.

(l) **Voice Security System**

This circuit is not intended for a voice security framework in a business application, yet that ought not keep anybody from trying different things with it for that reason. A typical methodology is to utilize three or four watchwords that must be spoken and perceived in grouping so as to open a bolt or permit section [26].

(m) **Aural Interfaces**

It has been discovered that blending visual and aural data is not compelling. Items that require visual affirmation of an aural direction horribly decrease effectiveness. To make a powerful AUI, items need to comprehend (perceive) directions given in an unstructured and proficient techniques. The manner by which individuals commonly convey verbally.

4 Results and Discussion

(a) **Heartbeat Output**

The heartbeat rate analyzed for 10 s is 04 the count is ($4 \times 6 = 24$); it is the abnormal heartbeat rate as shown in Fig. 3.

The heartbeat rate analyzed for 10 s is 15 the count is ($15 \times 6 = 90$); it is the normal heartbeat rate as shown in Fig. 4.

(b) **Respiratory Output**

The normal respiration rate for humans is between 12 and 20/min. Figure 5 shows the abnormal respiration rate as 30 counts/min. Figure 6 shows the normal respiration rate as 20 counts/min.

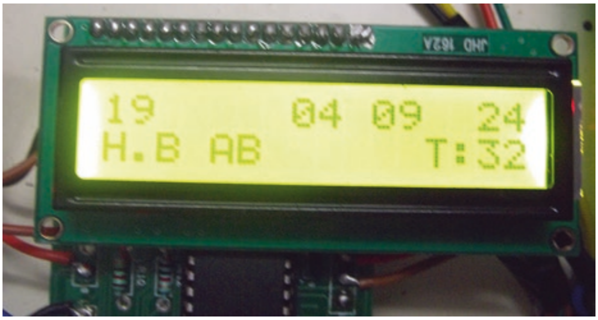

Fig. 3 Abnormal heart beat

Fig. 4 Normal heart beat rate

Fig. 5 Abnormal respiration rate as 30 count/min

Fig. 6 Normal respiration rate as 20 count/min

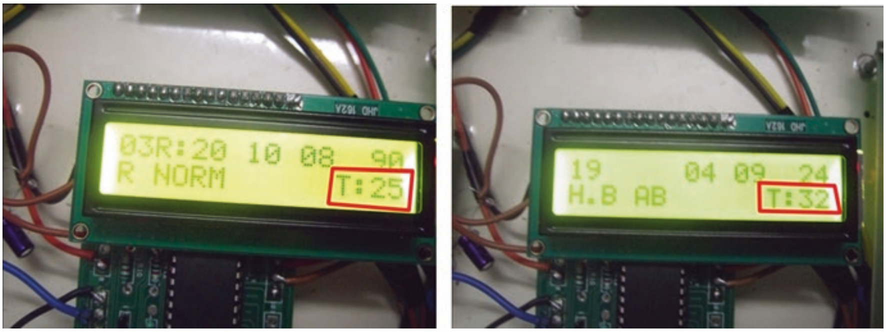

Fig. 7 Normal temperature rate of humans

(c) **Temperature Output**

The normal temperature rate for humans is between 35 and 40° C. Figure 7 shows the variations in temperatures.

(d) **HM2007 – Speech Recognition Output** (Figs. 8, 9, 10 and 11)

The locomotive control of the wheelchair is shown in Fig. 12.

(e) **Parameters in Wheelchair**

The voice-controlled wheelchair with heartbeat measurement, temperature measurement, and respiratory rate kit is shown in Fig. 13.

Fig. 8 Forward direction

Fig. 9 Reverse direction

Fig. 10 Right direction

Fig. 11 Left direction

Fig. 12 Stop

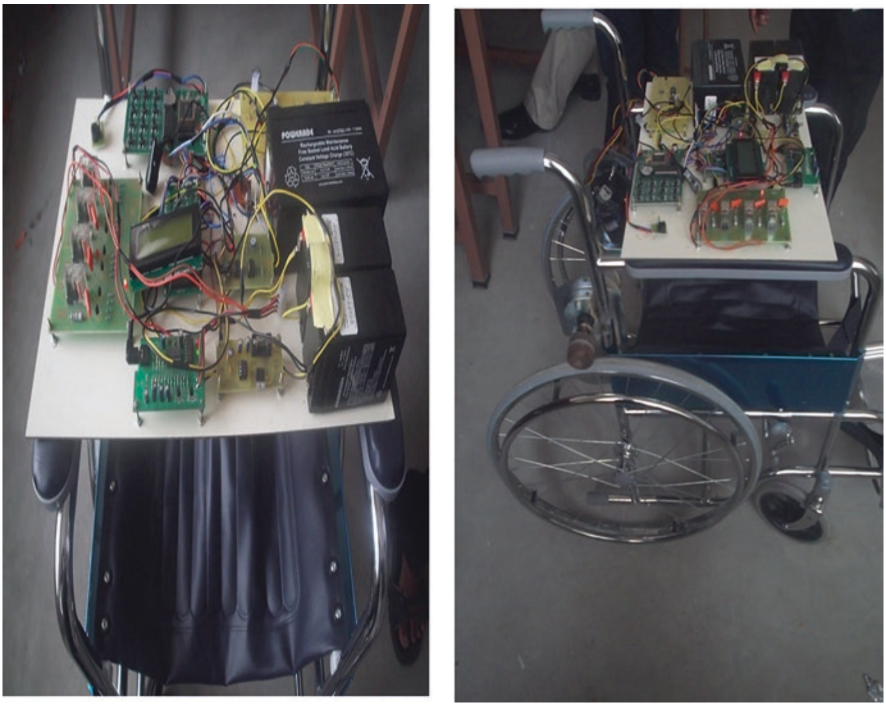

Fig. 13 Wheelchair with heartbeat measurement, temperature measurement, and respiratory rate kit

5 Conclusion

Quadriplegic persons are the main issue in the biomedical world. In which locomotive of their wheelchair by themselves is not possible. By using our paper, they can control their wheelchair through their voice. We have also implemented various physiological parameters for analyzing the heartbeat rate, respiratory rate, and temperature rate of a patient using the smart control wheelchair.

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Application of the Internet of Things (IoT) in Biomedical Engineering: Present Scenario and Challenges

Aradhana Behura and Sachi Nandan Mohanty

1 Introduction

Connecting everyday things embedded with electronics, software, and sensors to the Internet enabling to collect and exchange data without human interaction is called the Internet of things (IoT).

The term "things" in the Internet of things refers to anything and everything in day-to-day life that is accessed or connected through the Internet. IoT is an advanced automation and analytics system that deals with artificial intelligence, sensor, networking, electronic, cloud messaging, etc., to deliver complete systems for the product or services. The system created by IoT has greater transparency, control, and performance.

We have a platform such as a cloud that contains all the data through which we connect all the things around us, for example, a house, where we can connect our home appliances such as air conditioner and light through each other, and all these things are managed at the same platform. Since we have a platform, we can connect our car, track its fuel meter and speed level, and also track the location of the car. If there is a common platform where all these things can connect to one other, that would be great because based on my preference, I can set the room temperature. For example, if I love the room temperature to be set at 25 or 26 °C when I reach back home from my office, then according to my car location, my AC would start before 10 minutes I arrive at home. This can be done through the Internet of things (IoT).

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The most important features of IoT on which it works are connectivity, analyzing, integrating, active engagement, and many more. Some of them are listed below:

Connectivity: Connectivity means to establish a proper connection between all the things of IoT to IoT platform; it may be a server or a cloud. After connecting the IoT devices, it needs a high speed messaging between the devices and cloud to enable reliable, secure, and bidirectional communication.

Analyzing: After connecting all the relevant things, it comes to real-time analyzing the data collected and using them to build effective business intelligence. If we have a good insight into data gathered from all these things, then we can say our system has a smart system.

Integrating: IoT integrating the various models to improve the user experience as well.

Artificial Intelligence: IoT makes things smart and enhances life through the use of data. For example, if we have a coffee machine whose beans are running out, then the coffee machine itself orders the coffee beans of your choice from the retailer.

Sensing: The sensor devices used in IoT technologies detect and measure any change in the environment and report on their status. IoT technology brings passive networks to active networks. Without sensors, there could not hold an effective or true IoT environment.

Active Engagement: IOT helps to built smart connectivity among the various types of technology which helps to provide smart service.

Endpoint Management: It is important to have endpoint management of all the IoT system; otherwise, it results in the complete failure of the system. For example, if a coffee machine itself orders the coffee beans when it runs out, what happens when it orders the beans from a retailer and we are not present at home for a few days; it leads to the failure of the IoT system. So there must be a need for endpoint management.

The first step in IoT system design methodology is to define the purpose and requirements of the system. In this step, the system purpose, behavior, and various types of requirements (such as requirements, data analysis requirements, security requirements, user interface requirements, system management requirements, and data privacy and data collection) are apprehended. The second step describes the process specification. Here, the use cases of the IoT are properly described based on and derived from the various requirements as well as specifications of the model.

The third step describes the domain model (DM). This system defines the main concepts, entities, and objects in the domain of IoT system to be designed. This model defines the attributes of the objects and relationships between objects. It offers an abstract demonstration of the concepts, entities, and objects in the IoT domain, independent of any specific technology or platform. With the domain model, the IoT system designers can acquire an understanding of the IoT domain for which the system is to be designed. The fourth step describes the information model. This system defines the structure of all the information in the IoT system, for example, relations and attributes of virtual entities, etc. Information model does not describe how the information is stored or signified. To define the information model, we first list the virtual entities defined in the domain model. Information model adds more details to the virtual entities by defining their attributes and relations. The fifth step in the IoT design methodology is to define the service specifications. This model defines the services in the IoT system, service types, service inputs/output, service endpoints, service schedules, service preconditions, and service effects. The sixth step in the IoT design methodology is to define the IoT level for the system. The seventh step in the IoT design methodology is to define the functional view (FV). The FV defines the functions of the IoT systems grouped into various functional groups (FGs). Each FG either provides functionalities for interacting with instances of concepts defined in the model or provides information related to these concepts. The eighth step in the IoT design methodology is to define the operational view specifications. In this step, various options pertaining to the IoT system deployment and operation are defined, such as service hosting options, storage options, device options, and application hosting options. The ninth step in the IoT design methodology is the integration of the devices and components. The final step in the IoT design methodology is to develop the IoT application. Figure 7 is the pictorial representation of IOT methodology.

In today's world, wireless communication has a major application in sharing of information anywhere and at anytime. We can use wireless networks in the form of WLAN or WiFi in various fields such as education, healthcare, and industrial sector. As the technology is growing, the demands of users as well as the demand of ubiquitous networking is increasing. WBAN (Wireless Body Area Network) allows the user to move another without having the restriction of a cable for sharing information.

The term "Wireless Body Area Network" was coined in 2001 by Van Dam. It basically is a network containing sensor nodes which are attached to the human body, used to measure the bio signals (heart rate, blood pressure, brain signals, etc.) of humans. It has majority of applications in medical sector.

The communication in body sensor networks is of two types:

In-body communication
On-body communication

In-body communication is the communication between sensor nodes which are implanted inside human body. The MICS (Medical Implant Communication System) communication can be used only for in-body communication. On-body communication occurs between wearable devices which consist of sensor nodes. The ISM (Industrial Scientific and Medical) band and UWB (ultra-wide band) communication can be used only for on-body communication.

WBAN architecture:
The network architecture is divided into four sections-

WBAN part – It contains several number of cheap and low-power sensor nodes, which can be used for continuous monitoring of heart rate, ECG, blood pressure, etc. of a person. Being wireless in nature, this does not restrict the mobility of the person for continuous evaluation. Hence, WBAN is used in healthcare systems for patients monitoring.

CCU (Central Control Unit) – All sensor nodes provide their outputs to a central coordination node present in the CCU. CCU receives the signals from nodes and transmits it to the next section for monitoring the human body.

WBAN communication – Receives information from CCU and acts as gateway to transfer information to the destination. For example, mobile node is a gateway to remote station to send message to cellular network using GSM/3G/4G.

Control center – It is responsible for storing the information of user which can be used in the future or for monitoring purpose. It consists of end node devices like mobile phones (for messaging), computer systems (for monitoring), and server (for storing information in database).

WBAN applications:

These are various application:

1. Medical applications:

Remote healthcare monitoring—Sensors are put on patient's body to monitor heart rate, blood pressure, and ECG.

Telemedicine—Provides healthcare services over a long distance with the help of IT and communication.

2. Non-medical applications:

Sports—Sensors can be used to measure navigation, timer, distance, pulse rate, and body temperature.

Military—Can be used for communication between soldiers and sending information about attacking, retreating, or running to their base commander.

Lifestyle and entertainment—Wireless music player and making video calls.

WBAN is legal, affordable, and user friendly. It is an emerging technology and is expected to have a big impact on the society.

WBAN is a remote system administration innovation, in view of radio frequency (RF) that interconnects various little hubs with sensor or actuator capacities [1]. WBAN innovation is profoundly refreshing in the field of medicinal science and human social insurance [2–5]. Additionally, huge commitment is conveyed in the field of biomedical and other logical regions [6]. Also, its applications are broad in non-restorative territories like purchaser gadgets and individual diversion. The primary issues concentrated upon are size of system, result precision, hub thickness, control supply, versatility, information rate, vitality utilization, QoS, and real-time correspondence. WBAN hubs use scaled down batteries because of their little size. Thus, the system must work and perform in a power productive way with the goal that the existence term of intensity sources can be augmented. By and by, there are two distinct methodologies of MAC convention planning for sensor systems. Initial one is contention-based MAC convention plan. Case of this sort of MAC convention is Carrier Sense Multiple Access—Collision Avoidance (CSMA/CA). This structure has their hubs needs for channel access before transmitting information. The advantages of CSMA/CA-based conventions are no time synchronization limitations, simple flexibility to arrange varieties, and versatility. The other methodologies are scheduled-based MAC convention. Henceforth, various clients get isolated availabilities for information transmission. Schedule vacancy controller (TSC) is utilized for giving availabilities.

The advantages of this methodology are diminished inactive tuning in, overheading, and impact. TDMA-based methodology is utilized in vitality effective MAC convention [7, 8]. This convention is TDMA based and utilized for body sensor systems (BSNs). The work incorporates the use of heartbeat mood to perform time synchronization and consequently gives a vitality-proficient MAC layer by evading power utilization related with time synchronization reference point transmission. Utilizing a robot to revive batteries and exchange information can drastically build the life expectancy of a remote sensor arrange. In this, the way of the robot is constrained by waypoints, and the districts where every sensor can be adjusted are featured.

An auxiliary well-being remote sensor arrange (WSN) should keep going for quite a long time, yet conventional dispensable batteries cannot continue such a system. Vitality is the significant obstruction to supportability of WSNs. This chapter investigates how to misuse developing remote power exchange innovation by utilizing automated unmanned vehicles (UVs) to support the WSNs. These UVs slice information transmissions from long to short separations, gather detected data, and recharge WSN's vitality. Nowadays, it is very important to predict brain tumor and which category it belongs. It is a very crucial part that how can an illiterate person able to know whether he suffering from tumor or not. But it is possible in Internet of things (IOT). In present age, everyone can use a handheld device called mobile phone. By using IOT and with the proper technology, we can build an app. By using that application in mobile, a person can predict whether a person is suffering from tumor or not. It is a cost-effective and simple technique to predict cancer. The section at that point talks about the executed framework and how it functions with the assistance of test system and equipment stages.

2 Applications to Health Care

2.1 Health Monitoring System

Internet of things (IoT) is a well-known term that has gained massive encouragement over a few years. The future of the human race will be significantly influenced by the application of IoT over the coming years. IoT has not only the capacity to improve the standards of living by giving control over things but also the capacity to convert physical objects to intelligent or smart virtual devices. IoT is a diversified subject due to its varied meanings and perceptions and requires sound technical knowledge and understanding before its use. It will lead to the development of efficient mechanisms with high scalability and interoperability features among the things or objects. IoT is a reality that is progressing day by day, connecting billions of people and things to form a vast global network. IoT has applications in various domains like agriculture, industry, military, and personal spaces. There are potential research challenges and issues in IoT that act as a hurdle in the complete exploration of IoT in real-time implementation. Various organizations and enterprises have encouraged further research and study in IoT, which would prove essential in the global acceptance of IoT.

IOT has increased tremendous fame in the medical field because of its capacity to have applications for which the administrations can be conveyed to shoppers quickly at insignificant expense. An imperative application is the utilization of IOT and cloud innovations to help specialists in giving increasingly successful demonstrative procedures. Specifically, here, we examine electrocardiogram (ECG) information investigation utilizing IOT and the cloud. The slender improvement of Internet availability and its openness from any gadget whenever have made Internet of things an appealing alternative for creating well-being observing frameworks.

ECG information examination and observing comprise a situation that normally appropriates into such situation. ECG represents the important appearance of the contractile action of myocardium of the heart. Such action conveys an exact wave that is reiterated after some phase and that addresses the heart rate. The examination of the condition of the ECG signal is accustomed to perceive problems and is the most broadly perceived procedure to deal with distinguish coronary ailment. IOT advancement permits the remote checking of a patient's heart rate, information examination in immaterial time, and the notice of therapeutic guide workforce and experts should these data reveal possibly unsafe situations [1]. Meanwhile, experts and crisis treatment can immediately be informed with respect to cases that require their thought.

An illustration of the infrastructure and model for supporting remote ECG monitoring is shown in Fig. 1. Wearable computing devices equipped with ECG sensors constantly monitor the patient's heartbeat. Such information is transmitted to the patient's mobile device and will eventually be forwarded to the cloud-hosted web service for analysis.

Nation care and calamity reaction become progressively down to earth. Huge data has transformed into a marvelous test for some prosperity affiliations, and the cloud empowers providers to set aside some money by constraining in-house accumulating needs [2].

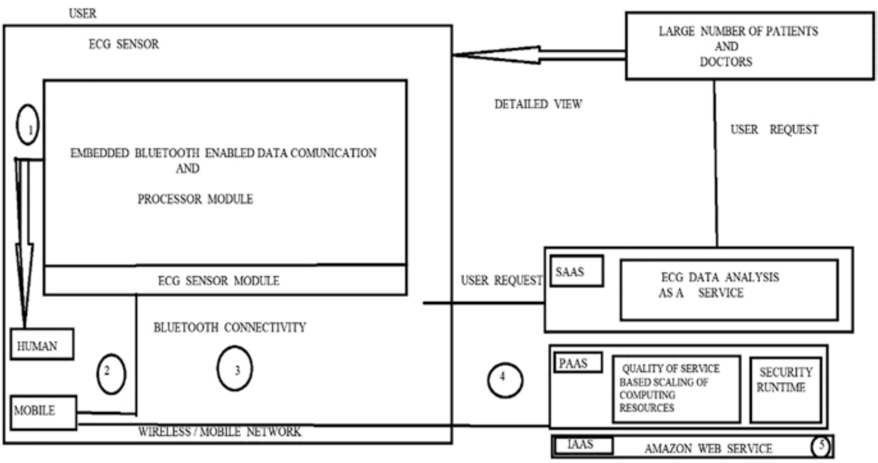

Fig. 1 ECG health monitoring system

Health care is an area where computer technology can be seen and as impacting a wide variety of items in our health: from offering help for business issues to helping in scientific growth. With recent technological developments such as cell phones and cloud computing, a range of services and devices are developed to provide health care. In the cloud system, medical data can be gathered and distributed automatically to medical practitioners anywhere in the world. From there, doctors in the field have the capability of returning input to specific patients [9, 6].

An ECG is just a visual image of a record of the electrical activity of the heart muscle as it varies over time, typically printed on paper for easier study. Similarly, like other muscles, the heart contracts in response to electrical depolarization caused in the muscle cells. When it is the time of day, it is the amount of the electrical activity, when amplified and registered for just a few seconds that we call a heart rhythm.

With ECG data collection and tracking, it is possible to test for chest pain, low-grade heart rhythm disturbances, arrhythmias, and more. An E-G (electrocardiogram) is the electrical expression of the contractile movement of the myocardium.

Due to the invention of the Internet or we can say due to the availability of the Internet, cloud computing has come into the picture and portray itself as an attractive choice for developing a health monitoring system. The study of the shape of the waveform is used to classify arrhythmias. It can be used as the most common way of detecting heart diseases. That way a patient who has a cardiac arrhythmia (or some other abnormal heart rate) can be continuously monitored through ECG tests. Since E-cigarettes allow for immediate notification for doctors and first-aid workers, at the same time such alerts do not slow down the movement of the patient. Cloud computing technologies allow the patient to have his/her heartbeat monitored remotely via the Internet.

The respective information will be sent to the patient's mobile device. Upon signing in, the mobile device sends information to the cloud-based services to review the results.

The online component of this platform that consists of three layers is internal to a cloud: the front end, the middle back-end, and the host server (i.e., "the cloud" for the IT service that supports this project).

Advantages

Since cloud computing systems are now readily available and deliver the services in less time, it has got the promise to be a massive disruptor to how the technology is distributed.

As a consequence, the doctor does not need to put a huge effort into computing, since there is a lot of software on which to run.

Cloud infrastructure is highly scalable; it can be maximized and minimized according to the needs of each user.

Cloud computing (or cloud computing) systems are now available and aim to provide reliable services to consumers with less time.

The doctor's office would not need to invest in a broad computer system.

2.2 Remote Steady ECG Checking

Connect the ECG banner to the area PC truly; by then the banner will get examined through the master therapeutic staff from crisis facility. This represents a strategy of instrument in restorative facility. With everything taken into account, the instrument is simply in the center since many patients cannot deal with the expense of the equipment [3]. Save the ECG banner to the area memory storing. The patients or their relatives take the memory storing to the restorative facility to be dissected by an expert. Such philosophy is employed for the flexible ECG player, yet the data may set aside such a long exertion to be sent to the crisis facility that the patients may miss the best time for treatment. Through the web, trade the ECG data to the remote checking center. Through remote frameworks, trade the data to the checking center [10].

2.3 Telemedicine Innovation

By virtue of the cloud, higher-tech devices, and convenient advancement, giving social protection from a partition has transformed into a reality. Models consolidate discourses, tele-therapeutic techniques, and checking patients without having them come in. Still dubious absolutely how to utilize the cloud for better execution? Need to get acquainted with the upsides of conveyed processing for social protection? Interface with one of our authorities to discuss what is possible or get some answers concerning other tech game plans that look good for affiliations like yours [11]. It wires answers for a couple of issues related with IoT and shows how they work in the realized structure for its particular stages.

The web of things (IoT) advancement is wrapping up dynamically normal in the human administration industry. The fundamental usage of IoT in the area of keen medication consolidates the view of the organization and digitization of restorative data and of the remedial methodology.

As per the Centers for Disease Control and Prevention (CDC), around 50% of Americans possess something like one incessant ailment, and their treatment expenditures represent more than 75% of the country's USD 2 trillion in restorative uses. Notwithstanding the mind-boggling expense of cutting edge treatment and medical procedure, specialists spend approximately billions of dollars on routine checks, research facility tests, and other observing administrations. With the progression of telemedicine innovation, refined sensors are utilized to screen patients with constant updates.

Moreover, the focal point of telemedicine observing has step by step moved from improving ways of life to rapidly giving lifesaving data and to medicinal projects concentrated on instructive trade. In viable applications, well-being data of inhabitants can be transmitted through the web, improving the nature of restorative administrations. This innovation likewise enables specialists to direct virtual counsels and give scholarly help to different medical clinics by specialists from a substantial

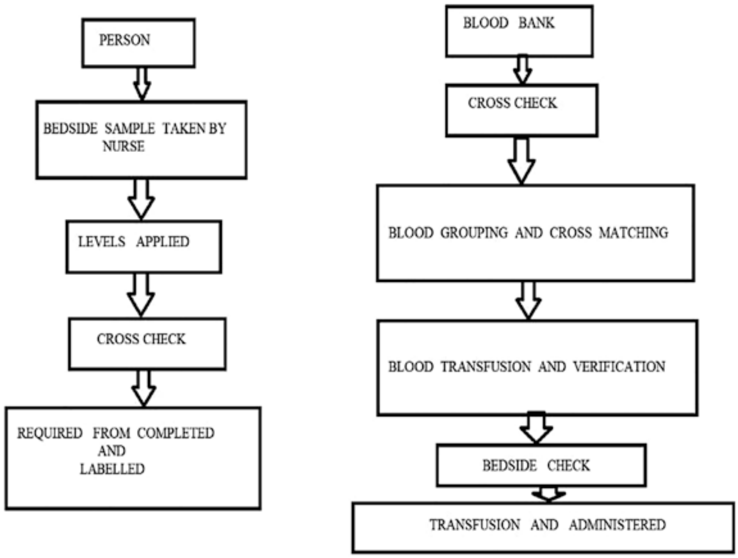

Fig. 2 Smart service

emergency clinic. This will stretch out astounding restorative assets to essential human services foundations, help build up a long haul, ceaseless instruction administration framework for clinical cases, and improve the nature of proceeding with training for essential social insurance laborers.

Utilizing the RFID innovation, the specialist can take the bedside test effectively. They can recognize the person's ID; if there are a few blunders, the alarm will call the specialist naturally [10]. Besides the RFID, there are numerous sensors in the patient's room that can catch the data of the sick and exchange the information to the specialist in the medical clinic. In this connection, Fig. 2 illustrates a scenario of smart service.

2.4 RFID Applications to Assist the Elderly to Live Independently

PC researchers at the University of Adelaide are driving an undertaking to grow new RFID sensor frameworks, which help more seasoned individuals with the goal that they can securely remain autonomous. Scientists utilized RFID and sensor innovation to distinguish and screen individuals' exercises consequently. This can assist with both routine consideration and crisis care on account of a mishap inside the home. Also, the framework includes low information costs and no necessities for escalated testing. Despite a maturing populace, this application has huge potential. Health observing is a critical part of the medicine industry [11].

The patients take the memory stockpiling to the emergency clinic to be analyzed by a specialist. This methodology is utilized for the compact ECG actor, yet the information may set aside such an extended effort to be sent to the emergency clinic which the patients may miss the best time for treatment. Through the web, exchange the ECG information to the remote checking focus. Along these lines, you should have the web, so this methodology constrained the extent of use. Through remote systems, exchange the information to the observing focus [12].

Remote zones of social insurance assume an important job [6].

2.5 Portable Medicine

This enables the patient to create convenient amendments to concerned eating regimen, encourages the age of auspicious customized therapeutic exhortation, and gives examined information to emergency clinics and research foundations [13].

2.6 Utilizations of RFID Wristbands

Soon every individual's phone will resemble a private specialist. While everybody absolutely has their own involvement with these issues, it is normal in China to see large queues of patients—hanging tight to take an enlistment number and see a specialist. Patients can be overpowered by visits, as emergency clinics are overflowed with thousands or a huge number of outpatients in a solitary day. All in all, how does this framework work? At the point when an individual turns out to be sick, the person in question needs to see a specialist. Thus, by what means can we proficiently support everybody? This should be possible correctly by empowering these sorts of changes as we enter what is to come [14].

Experience makes a specialist, and this experience is aggregated by watching information pointers identified with the patient's sickness [15]. At the point when the parameters in the database have achieved an adequate dimension, the database will almost certainly play out a programmed conclusion. At last, the database turns into a sort of "robot master."

For instance, on the off chance that we have the information markers for the cure of 10,000 instances of leukemia, at that point, the database holds 10,000 answers for treating leukemia. This sort of database will in the long run change into an inherent programming in our personal digital assistant (PDA), expanding the portability of medications [16]. In the event that the product is unfit to evaluate the circumstance proficiently, at that point, a human master will almost certainly regulate treatment over the web. In time, every one of us will have his or her own "private robot specialist" living on concerned telephones.

2.7 GPS Positioning Applications for Patients with Heart Disease

Every individual is required to construct their well-being database. On the off chance that a sufferer of coronary illness has made their advanced well-being record, at that point, when their heart starts to act strangely or represents an impending danger, the applicable information will be promptly passed to the framework that can utilize GPS situating to call the vital crisis administrations from the closest medical clinic [17]. This might be a basic IoT application; at the same time, later on, we may all have our own registration gadgets at home.

We should simply put our palm on the gadget that will at that point gather circulatory strain, pulse, heartbeat, and body temperature. Later on, it may even have the capacity to perform compound tests [18]. This information will be consequently passed to the emergency clinic's server farm, and if a specialist will request that we come into the medical clinic for further assessment or go to a nearby treatment focus to get treatment [19–22].

2.8 Prediction of Protein Structure

Cloud computing is an emerging technology that provides various computing services on demand. It provides convenient access to a shared pool of higher-level services and other system resources. Nowadays, cloud computing has a great significance in the fields of geology, biology, and other scientific research areas.

Protein structure prediction is the best example in research area that makes use of cloud applications for its computation and storage.

A protein is composed of long chains of amino acids joined together by peptide bonds. The various structures of protein help in the designing of new drugs, and the various sequences of proteins from its three-dimensional structure in predictive form is known as a protein structure prediction.

Firstly, primary structures of proteins are formed and then prediction of the secondary, tertiary, and quaternary structures are done from the primary one. In this way, predictions of protein structures are done. Protein structure prediction also makes use of various other technologies like artificial neural networks, artificial intelligence, machine learning, and probabilistic techniques and also holds great importance in fields like theoretical chemistry and bioinformatics.

There are various algorithms and tools that exist for protein structure prediction. CASP (Critical Assessment of Protein Structure Prediction) is a well-known tool that provides methods for automated web servers, and the results of research work are placed on clouds like CAMEO (Continuous Automated Model Evaluation) server. These servers can be accessed by anyone as per their requirements from any place. Some of the tools or servers used in protein structure prediction are Phobius, FoldX, LOMETS, Prime, Predict protein, SignalP, BBSP, EVfold, Biskit, HHpred, Phre, and ESyired3D. Using these tools, new structures are predicted, and the results are placed on the cloud-based servers.

Cloud processing gifts access to such limit on a compensation for each utilization premise. One anticipate that examines the utilization of cloud innovations for protein structure forecast is Jeeva—a coordinated web entryway that empowers researchers to offload the expectation errand to a processing cloud based on Aneka platform. The expectation task utilizes AI techniques (support vector machines) for deciding this optional structure of proteins [9].

These systems make an interpretation of the issue into one of example recognition, whereas arrangement must be characterized into one of three conceivable parts (E, H, and C). Despite the fact that these three stages must be computed in sequence, it is conceivable to exploit equivalent execution in the characterization stage, where various classifiers are executed parallel [23].

When this type of assignment is completed, the center product makes results accessible for perception done through the entryway. The upside of utilizing cloud technologies versus customary matrix frameworks is the capacity to use an adaptable registering foundation that can be developed and contracted on demand. This idea is particular of cloud advances and establishes a key favorable position when tenders are obtainable and conveyed as an administration. By analyzing Jeeva Portal, we can Predict Final Structure, Initial Phase, Classification Phase, Final Phase, Task Graph, and Aneka. The notation used in the below diagram Fig. 3 is depicted here.

Figure 4 describes the scalable nature of a classifier, and the dynamic platform, i.e., Aneka, provides a distinctive offer. Quality enunciation describing is the

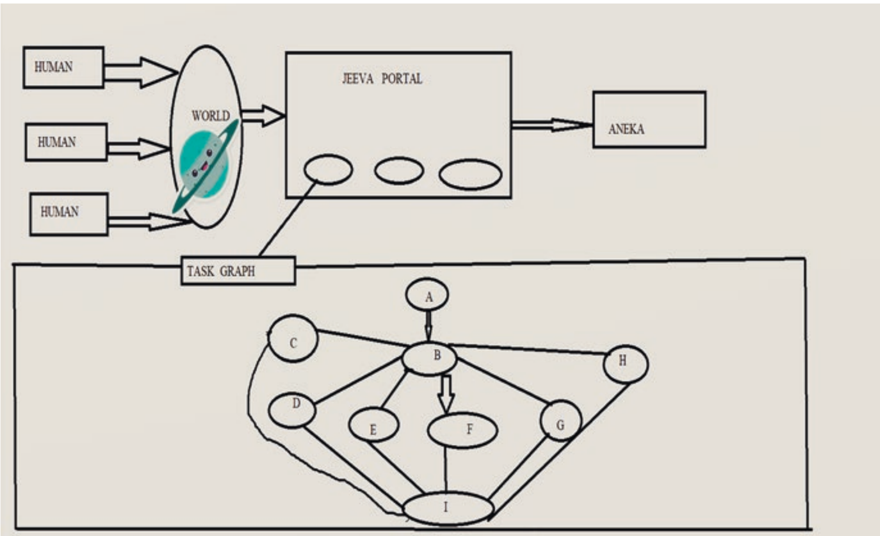

Fig. 3 Architecture and description of the Jeeva Portal
A **blast,** *B* **construct data vector,** *C* **HH classifier,** *D* **SS classifier,** *E* **TT classifier,** *F* **HS classifier,** *G* **ST classifier,** *H* **TH classifier,** *I* **predict final secondary structure**

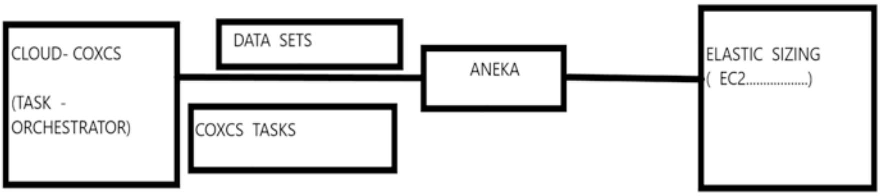

Fig. 4 Data processing on the cloud in cancer diagnosis

estimation of articulation measurements of qualities without a moment's delay. It is used to grasp the regular methodology that is initiated by therapeutic treatment at a cell level. Protein structure prediction activity is a key piece of medicine plan, since it empowers scientists to recognize the effects of a specific treatment. Another basic utilization of value enunciation profiling is malady assurance and treatment. Harmful development is an ailment depicted by uncontrolled cell advancement and proliferation. This thing directly occurs in light of the way that characteristics controlling the telephone improvement mutate. This infers that all the cancer-causing cells contain changed genes. In this context, gene verbalization profiling is utilized to give a logically accurate request of tumors. The game plan of value explanation data tests into specific classes is a challenging task. The dimensionality of ordinary quality enunciation datasets ranges from a couple of thousands to more than incalculable characteristics. However, simply little precedent sizes are routinely open for examination. The extended classifier system is adequately utilized for masterminding huge datasets in the bioinformatics and programming designing spaces. However, the reasonability of XCS, when went facing with high dimensional data (such as quality enunciation datasets), it has not been explored in point. An assortment of this computation, CoXCS [8], has ended up being effective in these conditions. CoXCS parcels the entire interest space into subdomains and uses the standard XCS estimation in each of these subdomains. Such a system is computationally raised anyway and can be successfully parallelized in light of the way that the portrayal issues on the subdomains can be handled simultaneously. Cloud CoXCS is a cloud-based implementation of CoXCS that leverages Aneka to solve the classification problem in parallel and compose their outcomes. The algorithm is controlled by strategies, which define the way in which the outcomes are composed together and whether the process needs to be iterated. Because of the dynamic nature of XCS, the number of required compute resources to execute it can vary over time. Therefore, the use of a scalable middleware such as Aneka offers a distinctive advantage. The RFID anklet is used for anti-kidnapping prevention system [24].

3 Specialized Problems Facing Medical IoT

In this medicinal area, despite everything, we have to report numerous specialized issues confronting Internet of things.

3.1 Node Versatility and Dynamic Large-Scale System: The Board in Enormous Scale Systems

At the point where there is a development of the observing framework to protect private networks, urban groups, or whole nations, the span of the system will overpower, and checking hubs will all must be portable somewhat. Along these lines, we need to plan a proper system topology the executive's structure and system portability the board strategies [25].

3.2 Information Completeness and Data Compression

In any case, conventional information pressure calculations are unreasonably exorbitant for sensor hubs. Moreover, pressure calculations cannot lose the first information. So it is very important to reduce power and carbon emission for a green environment [26].

From Fig. 5, we presume that server farms are costly to keep up yet additionally hostile to nature. Carbon discharge because of server farm is an overall issue. High vitality costs and gigantic carbon emissions are caused because of the monstrous measure of power expected to power and cool the various servers facilitated in this information center. Cloud specialist co-ops need to embrace measures to guarantee that their overall revenue is not significantly diminished because of high vitality costs [27].

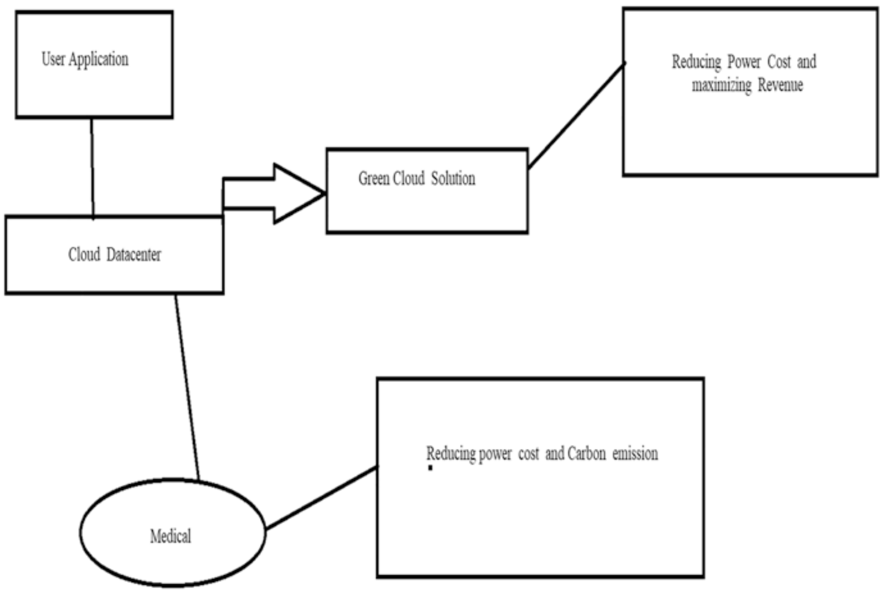

Fig. 5 Green technology scenario

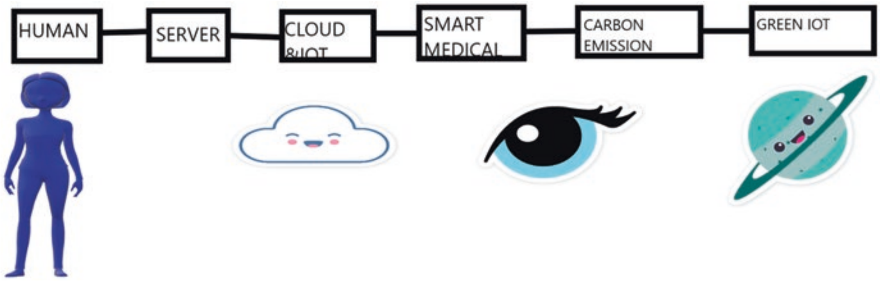

Fig. 6 Protocol of green environment scenario

Figure 6 shows that bringing down the vitality utilization of server farms is a difficult and complex issue as figuring applications and the information are developing so fast that bigger servers and plates are anticipated to process them quick enough inside the desired timeframe. This is fundamental for guaranteeing that the further enhancement of IOT is reasonable. IOT, with progressively unavoidable front-end customer gadgets, for example, iPhones associating with back-end information centers, will cause a colossal heightening of vitality utilization. To address this issue, server farm assets should be overseen in a vitality-productive way to drive Green IOT [28]. In particular, cloud assets should be apportioned not exclusively to fulfill QoS prerequisites determined by clients by means of administration level agreements (SLAs), yet in addition to lessen vitality usage.

3.3 Information Security

Remote sensors arrange hub structure, a self-composed system which is defenseless against assaults and is clearly dangerous when managing tolerant data that must be kept private. The processing intensity of a sensor hub is lacking. Subsequently, conventional protection and hiding innovation are not appropriate to this type of situations. The use of IoT is expanding step by step in each part of the medicinal services industry. In this article, we have investigated different utilizations of Internet of things in the therapeutic business.

3.4 Duplicate Medicine Detection

Duplicate medicine is very hazardous to our health. In this chapter, a solid technique used for fake expectation is analyzed. This strategy can be utilized by a client to foresee a fake product for their everyday prerequisite things accessible in the place of market. Currently, the development of a new bundle of the item dependably accompanies the danger of faking; now and again that could influence organization notoriety and the goodwill.

We should utilized the idea of undetectable and unmistakable watermarking technology present in a thing itself to give credibility to many products or items. This is an ease arrangement that enables endeavors and buyers to recognize the legitimacy of the item. Consumer-degree confirmation utilizing the present-day gear additionally will expand the consciousness of the issue of illegal exchange and is as of now utilized in different regions. In option, data created because of code assertion can be utilized by the item proprietor to examine areas wherein copy items are provided, which incorporates the likelihood of distinguishing resistant inventory network operators [29–33].

In this model, fixing ought to alleviate this risk. To be utilized as a method for copyright security, advanced watermark is implanting concealed measurements into the bundle that it cannot be changed and its acknowledgment to avow the privileges of upshots [24]. The mortal eye is capable to hit upon adjustments to lower regularities. Duplicate medicine is very risky to our health. “Divine Noni Gold” [28]. It assists to increase the human body’s self-healing mechanism [28].

Smart chair can be helpful for blind people. By taking the help of this type of chair, a blind person can know the direction or in which direction the vehicle is coming. We can also use GPS for anti-kidnapping of a newborn baby (Fig. 7).

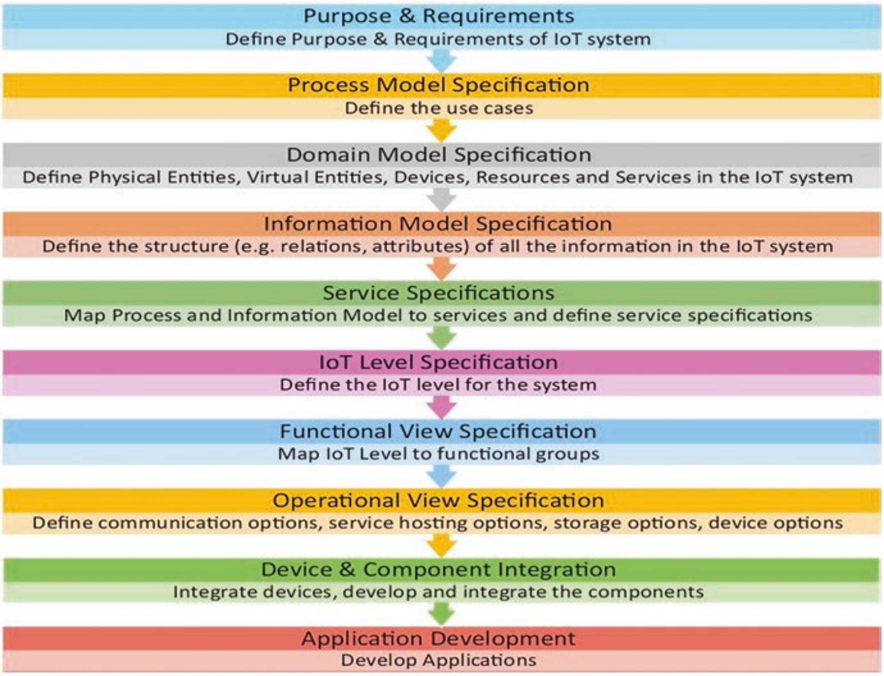

Fig. 7 Pictorial view of IOT design methodology

4 Conclusion

Here, we have investigated various uses of Internet of things in various uprights of the helpful business. Initiating from the drug watching and the administrators, digitization of facilities to telemedicine care, we examined each feasible region at which IoT advancement can improve the procedures. Compelling the quick elevating of human administration costs while extending restorative inclusion incorporation to all—the fundamental goals of therapeutic administrations change—will require essential upgrades in the introduction of our structure for social protection. This introduction fundamental is especially critical in light of the way that a bit of the components behind rising restorative administration utilizations, for instance, the developing of the people, is external to the social protection structure. The past zones of this record have given a broad structure to assessing whether and how novel change suggestions would look after these destinations. The parts of that structure—extending access to social protection, containing restorative administration costs, ensuring nature of thought, financing change, and improving the system for convincing change—all ought to be tended to if structure execution is really to be improved. A whole deal perspective is essential [34].

A framework for reviewing change, for instance, that we have suggested, will be useful both for the basic evaluation of recommendation and for the examination of progression after some time. The unconventionality of the restorative administration structure—and of prosperity itself—shows genuine troubles to change, and these challenges are increased by the various critical and every now and again engaging interests that have a stake in both the extensive ways and confounded nuances of course of action change. Change recommendation must demonstrate their general method to manage request, for instance, how social protection specialists are to be appropriately arranged and passed on, how superior information is to be arranged to progress implementation, and how nature of thought can be kept up and improved inside resource prerequisites. Finally, the difference in our therapeutic administration system should be grasped in a comparative soul of incessant improvement and reclamation that has so consistently been the foundation of achievement in America. To do that, we need incredible information and sound examinations of results, versatility and imagination in responding to that information and a withstanding base on the stresses of the all-inclusive community whose prosperity and success we hope to improve. It is hard to anticipate where IoT restorative devices are rushing toward straightaway—any way we are certain that with the rising in eagerness for IoT and the money being spent in social protection advancements, valuable things will without a doubt happen in this space.

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Risk Stratification for Subjects Suffering from Lung Carcinoma: Healthcare 4.0 Approach with Medical Diagnosis Using Computational Intelligence

Rohit Rastogi, D. K. Chaturvedi, Sheelu Sagar, Neeti Tandon, and Mukund Rastogi

1 Introduction

Non-small cell lung cancer (NSCLC) includes three types of cancer: squamous cell carcinoma, adenocarcinoma, and large cell carcinoma derived from the lung tissue. Adenocarcinoma is a slow-growing cancer that first appears in the outer region of the lung. Lung cancer is more common in smokers but the most well-known sort of lung cancer in nonsmokers. Squamous cell carcinoma is more normal in the focal point of the lung and all the more generally in smokers, but large cell carcinoma can be found anywhere in the lung tissue and grows faster than adenomas and lung cancer[1, 2].

According to Choi, H. and his team member's lung cancer risk classification models with gene expression function, the changes have been done on previous models based on individual symptomatic genes.

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They have revealed the aim to develop a risk classification model which was developed based on a novel level of gene expression network and it was performed using multiple microarrays of lung adenocarcinoma, and gene convergence network where investigation was carried out to recognize endurance networks. Genes representing these networks have been used to develop depth-based risk classification models. This model has been approved in two test sets. The efficiency of the model was strongly related to patient survival in the two sets of experiments and training. In multivariate analysis, this model was related with persistent anticipation, autonomous of other clinical and neurotic highlights.

They explained that this study provides a new perspective on the organization of gene expression networks in gene expression signatures and the clinical use of deep learning in genomic information science to foresee prediction [3].

1.1 Motivation to the Study

The medical services industry is confronted with the test of the quick improvement of a lot of medical services data. The field of big data investigation is extending—you can leverage your healthcare system to provide valuable insights. As mentioned above, most of the data produced by this system is digitally printed and stored.

The principal distinction between customary well-being analysis and big data well-being is the live programming component. In customary frameworks, the medical services industry depends on different ventures to examine big data. Many healthcare professionals rely on IT industry due to its huge impact. Their operating system is functional and capable of processing data in standard formats.

1.1.1 Problem Statements

A malignant lung tumor characterized by sporadic development of the lung tissue is known as lung cancer. Metastases can spread past the lungs to encompassing tissues and different pieces of the human body. Most cancers of the lung are called primary lung cancer, carcinoma. Small-cell lung cancer (SCLC), and non-small cell lung cancer (NSCLC) are the important types of lung cancer. The most common symptoms of pesticides (including coughing blood) are fatigue, emphysema, and angina (coronary thrombosis). NSCLC accounts and responsible for approximately 81%–86% of lung cancers. By this study, the author team is classifying the lung cancer cases as per their medical parameters. NSCLC accounts for approximately 81–86% of lung cancers. By this study, we are classifying the lung cancer cases as per their medical parameters.

1.1.2 Authors' Contributions

Mr. Rohit Rastogi was the team lead and executed the experiment. Dr. D.K. Chaturvedi created the design of the experiment. Ms. Sheelu and Ms. Neeti did the experiments. Mr. Mukund did the analysis. All contributed in manuscript formation.

1.1.3 Research Manuscript Organization

Chapter has been started with abstract and followed by Introduction which contains short literature review then motivation of study. After this, problem statement and definition have been introduced and then authors' contribution and chapter organization.

Literature survey contains latest relevant papers and is followed by proposed systems and experimental setup and analysis. Then results and discussions have been presented, which are succeeded by recommendations and considerations; then future research directions, limitations of our study, and conclusions have been established.

It is followed by acknowledgments and references. Finally, in annex, experimental data set images and experimental snapshots have been given for readers.

1.2 Definitions

Some important terminologies and key components are being explained here in light of our experimental work.

1.2.1 Computer-Aided Diagnosis System (CADe or CADx)

CADe or computer-aided diagnosis (CADx) is a type of system software that has been shown to be very helpful to physicians in the recent microscopic interpretation of medical images. X-ray diagnostics, magnetic resonance imaging (MRI), and ultrasound imaging technologies provide a wealth of information to help medical professionals to make comprehensive analyses and assessments in the short term. The CAD system processes the digital image to highlight the normal display or obvious areas such as possible illnesses and provide input to support a particular expert decision [4].

With the help of computers, all-slide imaging algorithms and machine learning have potential future plans for digital pathology. So far, the program has been limited to physical safety but is now being studied for standard spots. CAD is an interdisciplinary technology with artificial intelligence computer elements with radiation and pathological imaging. A common program is tumor diagnosis.

1.2.2 Sensors for the Internet of Things

The Internet of things (IoT) encourages our lives by associating electronic gadgets and sensors through interior networks. IoT utilizes smart gadgets and the Internet to give inventive answers for different difficulties and issues identified with different business, public, and private enterprises around the world. IoT has become a significant part of our daily life that one can look about. When all is said and done, IoT is an advancement that coordinates different savvy frameworks, systems, shrewd gadgets, and sensors. We also use quantum and nanotechnology in terms of memory, measurement, and unimaginable speeds. This can be seen as a prerequisite for creating an innovative business plan with security, reliability, and collaboration [5, 6].

Here are nine of the most popular IoT sensors:

1. Temperature
2. Moisture
3. Pressure
4. Adjacent
5. Surface
6. Accelerometer
7. Gyroscope
8. Gas
9. Infrared [5]

1.2.3 Wireless and Wearable Sensors for Health Informatics

IoT is a new concept that enables wearable devices to control healthcare. The IoT supports embedded technologies and is supported as a network of physical objects that connect data and sensors to communicate with the internal and external states of the object and its environment. Over the last decade, wearable sensors have attracted the attention of many researchers and industries and have become very popular recently [7, 8].

1.2.4 Remote Human's Health and Activity Monitoring

Remote monitoring of healthcare allows you to stay at home instead of visiting expensive medical centers like hospitals and nursing homes. Accordingly, it gives a proficient and practical option in contrast to clinical checking here. With a noninvasive, invisible, visible wearable sensor, such a system is an excellent diagnostic tool for healthcare professionals to diagnose physiologic critical conditions and real-time patient activity from remote centers. In this way, it is intelligible that handheld sensors assume a significant part in such observation frameworks. These reconnaissance frameworks have pulled in the consideration of numerous specialists, business visionaries, and goliath engineers [9].

Handheld sensor-based health monitoring systems include textile fibers, fabrics, elastic bands, or several kinds of adaptable sensors that can be straightforwardly associated to the human body. These sensors measure physiology such as electromyography, body temperature, electromy activity, arterial oxygen saturation, heart rate, blood pressure, electrocardiogram, and respiratory rate and can measure physical symptoms [10].

1.2.5 Decision-Making Systems for Sensor Data

Management decisions are very basic and are widely used in economics. They rely upon the information and experience of the administrator but increasingly more on target data. A variety of water quality sensors can provide real-time monitoring data for river and lake management [11, 12].

Until now, management has focused only on intuitive facts from checking data, for example, the overall status of water quality pointers and cases without accurate secondary analysis. For effective management and decision making, sensor based applications are frequently used [13, 14].

1.2.6 Artificial Intelligence (AI) and Machine Learning for Health Informatics

AI showed up in medical services during the 1970s. The main AI frameworks are basically information-based decision support systems, and the principal AI methods are utilized to foresee the classification standards of label sets. These first frameworks function admirably. Nevertheless, they are not commonly used in real patients. One of the reasons is that these systems are independent and have nothing to do with the patient's electronic medical records. Another reason is that the skill communicated in the information on these master frameworks shows that the created framework is not worthy here [15].

After winning several championships in focusing on artificial neural networks and improving complex learning, substance abuse became a new learning method. In May 2019, a team from Google and New York University announced that deep learning models used to analyze lung cancer could improve precision, and the investigation immediately covered numerous newspaper and magazine title texts.

1.2.7 Health Sensor Data Management

Trendsetting innovations, for example, cloud computing, wearable sensor gadgets, and big data, will affect individuals' day-to-day life and have extraordinary potential in Internet-based biological systems. Health Sensor data Management provides personal and shared consumption. Also it is useful for the information on the development of the health and welfare sector.

welfare sector. These apparatuses give numerous better approaches to gather data physically and consequently. Many modern smartphones have some internal sensors such as microphone, camera, gyroscope, accelerometer, compass, proximity sensor, GPS, and ambient light [16].

You can easily connect the new generation of wearable medical sensors to your smartphone and send the measurement results directly. This set is more effective and convenient than personal health information such as blood pressure, blood oxygen saturation, blood sugar, pulse rate, and electrocardiogram; by collecting and interpreting health and activity information, the future is not far off. The measure and number of sensor data assortment and analysis of versatile sensors are expanding quickly. This dramatic development enables both data management and collaboration [16].

1.2.8 Multimodal Data Fusion for Healthcare

Given the proliferation of IoT technologies used to support the core functions of healthcare organizations, healthcare is an area of continuous improvement. In this way, traditional hospitals with large-scale interconnected sensor systems and extensive data collection and collection technology have become the next generation of smart digital environments. From this point of view, intelligent health supports a complex ecosystem of intelligent spaces such as hospitals, ambulances, and pharmacies supported by powerful infrastructure stacks such as edge devices and sensor networks [17].

1.2.9 Heterogeneous Data Fusion and Context-Aware Systems: A Context-Aware Data Fusion Approach for Health-IoT

The improvement of inexpensive sensor gadgets and correspondence advancements is quickening the improvement of elegant homes and conditions. With the development of human body networks, wireless sensor networks, big data technologies, and cloud computing, the healthcare industry is growing rapidly. There are numerous difficulties, for example, heterogeneous data blending, text recognition, complex question preparing, unwavering quality, and exactness.

From this point of view, Intelligent Health supports a complex ecosystem of intelligent spaces such as hospitals, ambulances, and pharmacies supported by powerful infrastructure stacks such as edge devices and sensor networks. Use new business models and rules [18].

2 Literature Review

According to Timor Kadir and his team members, the machine-based lung cancer prediction model was developed to help undiagnosed lung nodules and assist physicians on-screen. Such systems can reduce the number of node classifications, improve decision-making, and ultimately reduce the number of benign nodules that are tracked or manipulated unnecessarily [1].

This article outlines the main approaches to lung cancer prediction to date and highlights some of the relative strengths and weaknesses. Some of the challenges of developing and validating such technologies, as well as clinical acceptance strategies, are discussed. The main approaches used to classify lymph nodes and predict lung cancer from CT imaging data are reviewed. In our experience, using the right training data and using a comprehensive CNN, achieving classification performance in regions is possible with low 90s AUC points and sufficient training data [1].

According to Choi H., Na KJ in their study, a gene correlation network, the author team has created a risk classification model for lung adenocarcinoma. An extension of future research is the use of this method in concurrent networks of cancer progression. Advances in technology change the DL design and the way toward choosing delegate qualities to improve expectation exactness. They found that net score was related with sex, status of smoking, phase, and sub-atomic subtype. In summary, a high net score trend in men, smokers, and KRAS mutants was delayed and observed to be positive [19].

Finally, they expected future clinical trials designed with all around controlled clinical and obsessive factors to help find clinical applications for their new danger grouping models.

Yin Li and his team members have predicted the risk of lung adenocarcinoma (LUAD) is important in determining subsequent treatment strategies. Molecular biomarkers may improve risk classification for LUAD [9].

Yin Li et al. analyzed the gene expression profile of LUAD patients by the cancer genome atlas (TCGA) and gene expression omnibus (GEO) analysis. They first evaluated the prognostic relationship for each gene using three separate algorithms: notable function, random forest, and Variable Coke Regression. Next, survival-related genes were included in the LASSO minimum and selection function models to create a LUAD risk prediction model [20].

They initially identified large dataset significant survival-related genes. A hybrid strategy was used to identify key genes associated with survival in large data sets. Enhancement analysis showed an association of these genes with tumor development and progression. A risk prediction model was created using the LASSO method. The risk model was approved with two outside sets and one free set. Patients in the high-hazard bunch had a lower danger of repeat (RFS) and in general endurance (OS) than patients at low risk. We also created a registry that predicts LUAD patient operating systems, including models and risk stages.

Hence, they conclude risk models may serve as a pragmatic and reliable predictor of LUAD and may provide new experiences into the atomic instruments of infection [9, 21].

The manuscript authored by Francisco as Azuaje titled "Artificial intelligence for precision oncology: beyond patient stratification" states the application of AI with precision based models [22].

Francisco Azuaje described axial data from medical conditions and treatment options as a key challenge for accurate oncology. Artificial intelligence (AI) offers an unparalleled opportunity to enhance such predictive capabilities in laboratories and clinics. Artificial intelligence, including machine learning, which is the most well-known area of research, has been able to accurately identify tumors beyond relatively well-known detection patterns such as single-source omics and supervised classification of imaging datasets.

According to Azuaje, this perspective is related to major developments based challenges in this regard. The authors argue that the scope and depth of artificial intelligence research should be expanded in order to achieve geological advances in accurate oncology [22].

According to Xu J [2], in a large era of data on cancer genetics, wide availability of genetic information is provided by next-generation sequencing techniques and rapid development of medical journals. Integrate artificial intelligence approaches such as machine learning, detailed learning, and natural language processing to challenge big data and high-dimensional scalability and use this method to process clinical data to handle big data. Bring the knowledge you have. It is bent using the base. It is bent using the base and one can see its open and lie down with real medicines.

In this mnuscript, the authors have reviewed the current status and future guideline for using artificial intelligence in cancer genomics in the field of workflow which is genomic analysis for accurate cancer treatment. Existing artificial intelligence solutions and their limitations in genetic testing for cancer and its diagnosis, including various contacts and interpretations, are being considered.

The tools or common algorithms available for the leading NLP technologies in literature extraction are reviewed and compared to evidence-based clinical recommendations.

According to him, this paper deals with data needs and algorithm transparency. The importance of preparing patients and physicians for real-time reproduction and assessment and modern digital healthcare is widely accepted now. They believe that artificial intelligence is the main factor in the evolution of healthcare into a precise drug but of the precedent that needs to be created to ensure safety and beneficial effects on healthcare [2].

3 Proposed Systems

Based on histopathological image inputs, the model design can be done on 2 steps.

There are two steps:

- Model building: The shape of this model is based on the extraction function.
- Model evaluation: Forms biological communication.

Modeling attempts to preserve the extracted shape by extracting shape-based features with full focus on the shape of the model. The fixed size is considered a constraint, and it focuses on all other faces found to achieve that form of the constraint, making it easy to extract the entire model.

3.1 Framework or Architecture of the Work

However, model evaluation includes some of the biological significance of the form, which requires the physician to have the precise and accurate information needed to evaluate the form.

3.2 Model Steps and Parameters

Here, we will focus more on size-based clinical models. There are several steps involved that help you to design your model in a very efficient way (as per Fig. 1).

Steps involved in this model are:

- Preprocessing
- Segmentation
- Feature extraction
- Dimension reduction
- Disease detection and classification
- Post-processing and assessment
- Sampling
- Smoothing
- De-noising
- Enhancement
- Thresholding
- Edge detection
- Active contour
- Disease diagnosis and classification, etc. (as per Fig. 1)

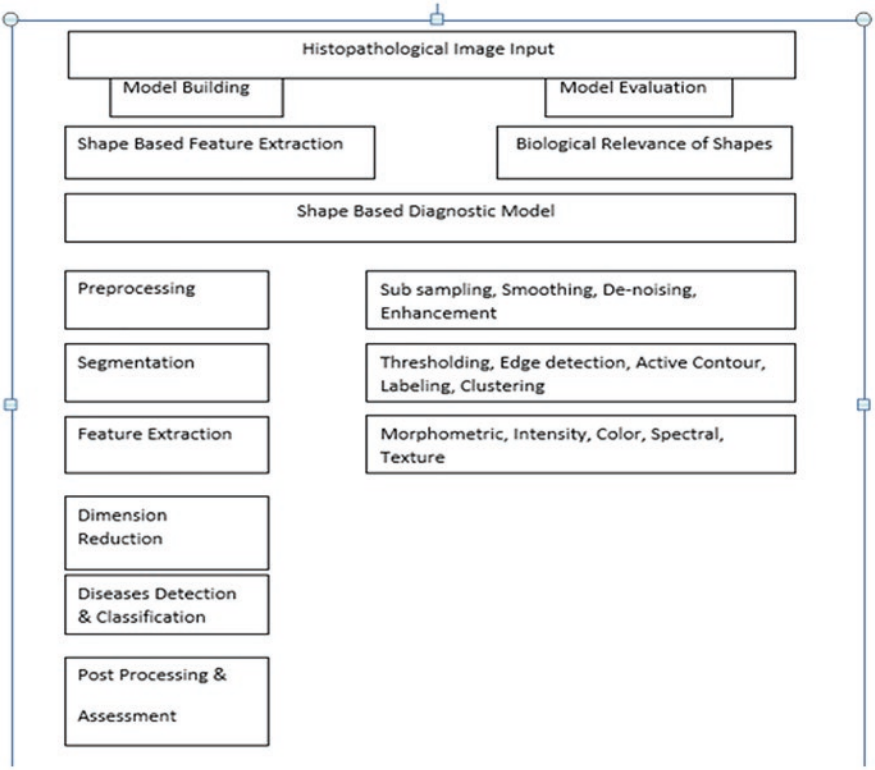

Fig. 1 Framework of the experimental study of lung cancer stratification

3.3 Discussions

Cancer has been the reason for casulaities globally for a very long time. Annals explain that less than 50% of the cancer happens in individuals and it was matured <=65 years. Lung cancer is one such driving force and it is termed in medical sciences as death-causing cancer. Young, middle-aged, and elderly patients, men who were heavy cigarette smokers, or women who didn't have a smoking history all have been casualties of this infection.

Thus, it is needed to separate lung cancer based on risk included and it can be classified as high risk and rising risk. This investigation depends on building up an arrangement conspire for lung cancers through examining minuscule images and ordering them utilizing deep convolutional neural network (DCNN), based on an AI (ML) structure model.

Microscopic images of tissues will be characterized on the basis of risk involved using deep convolutional neural network. Convolutional neural networks are deep artificial neural networks that are utilized fundamentally for ordering images, group them by likenesses (photograph search), and perform object recognition inside the scenes. They are the calculations that can recognize faces, tumors, people, road signs, and different parts of the graphic information.

The effectiveness of convolutional networks in image recognition is one of the main reasons why the world has woken up for the productivity of deep learning. They are fueling significant progress in computer vision (CV), which has clear applications for self-driving vehicles, mechanical technology, security, clinical judgments, and medicines for the outwardly impaired.

4 Experimental Results and Analysis

The term "tissue characteristics covers a wide range of meanings, from qualitative assessment to various scientific measurements. In the extensive literature available, we expand the definition of terms, show the relationship between tissue features and images, identify some relevant physical parameters, and briefly describe the subject's medical history. Excerpts are provided to explain how.

4.1 Tissue Characterization and Risk Stratification

According to an article titled "Automatic Classification of Lung Cancer from Cellular Images Using Deep Symmetric Neural Networks", the author team has evaluated three types of cancer and had trained their dataset for classification. However, pictures from the same sample belonged to the same group."

While executing cross validation algorithm in different sets of images, we found that in Set1, there are 28 items and respective cross validation score is 5280 for adenocarcinoma. There are 42 items and cross validation score is 5478 for squamous cell carcinoma. For small cell carcinoma, there are 26 images and cross validation score is 5070.

In Set2, there are 28 items and respective cross validation score is 5184 for adenocarcinoma. There are 37 items and cross validation score is 5220 for squamous cell carcinoma. For small cell carcinoma, there are 33 images and cross validation score is 5280.

In Set3, there are 26 items and respective cross validation score is 5040 for adenocarcinoma. There are 46 items and cross validation score is 5310 for squamous cell carcinoma. For small cell carcinoma, there are 32 images and cross validation score is 5214.

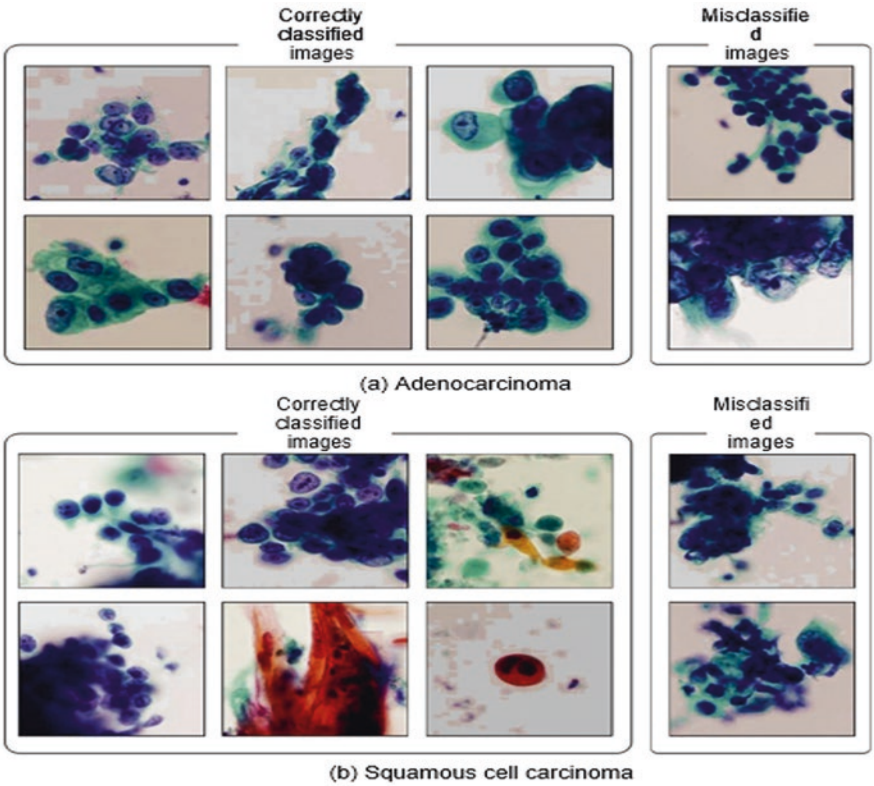

Fig. 2 Sample images of correctly classified and misclassified carcinoma. (**a**) Adenocarcinoma. (**b**) Squamous cell carcinoma. (**c**) Small cell carcinoma

4.2 Samples of Cancer Data and Analysis

The figures below (Figs. 2 and 3) show a sample of cancer types correctly classified and classified using the data amplification method. After successfully applying classification model in this dataset, the authors have to test the accuracy, precision, and recall of the model. So, the team observed the confusion matrix whose results are as follows, atual and predicted value of adenocarcinoma is 89% matched, and only 11% of the items are not predicted correctly.

After successfully applying classification model in this dataset, we have to test the accuracy, precision, and recall of the model. So we observed the confusion matrix whose results are as follows: actual and predicted value of adenocarcinoma is 89% matched, and only 11% of the items are not predicted correctly. Squamous cell carcinoma is predicted correctly 60%, which is less as compared to adenocarcinoma. Actual and predicted value of small cell carcinoma is 70% matched, and only 30% of the items are not predicted correctly.

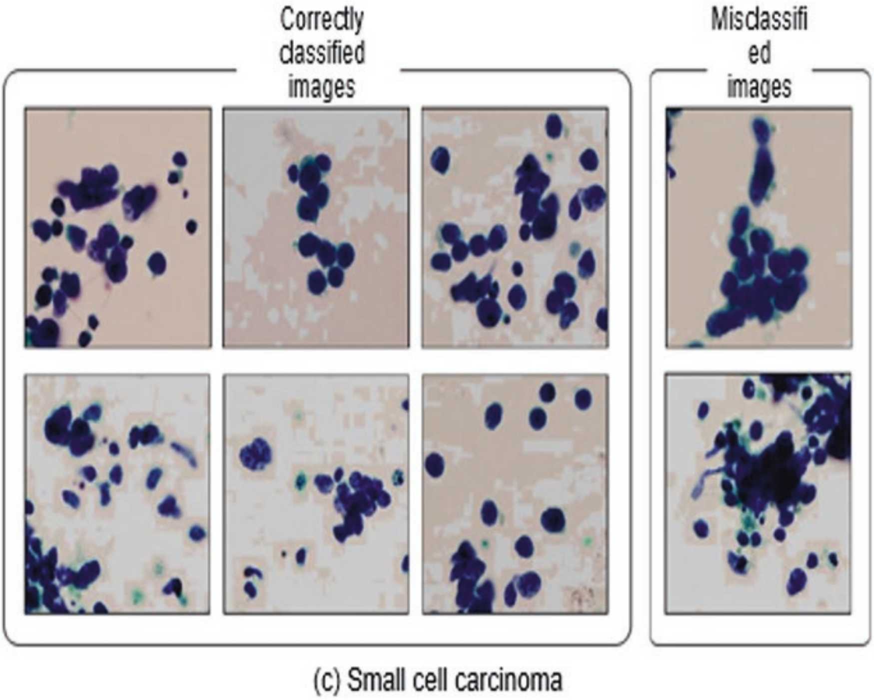

Fig. 3 More sample images of correctly classified and misclassified carcinoma

It shows the original image classification and the wide range of image accuracy. Results obtained using magnification images show that the classification accuracy for adenocarcinoma, squamous cell carcinoma, and small cell cancer is 89.0%, 60.0%, and 70.3%, respectively, and the overall corrected rate is 71.1%. In addition, apply plug-in to improve the classification.

Finally, we improved our classification model, and the accuracy score of trained set and augmented sets is given below:

Adenocarcinoma predicted 73% original images of lung cancer whereas 89% for augmented images. We found that 45% of the original images are correctly classified, and 60% of the augmented images are classified for squamous cell.

Carcinoma. Small cell carcinoma is classified correctly 75% for original images and 70% for augmented images.

In the three types of lung cancer, classification accuracy was highest for adenocarcinoma and lowest for squamous cell carcinoma. Squamous cell adenocarcinoma requires more images. DCNN helped to correctly classify 70% of lung cancer cells.

5 Novelties

Artificial intelligence will not only identify and predict at-risk patients but will also be a large data set available to hospitals and healthcare providers to identify changes in patient health and medical outcomes, as well as accurate diagnoses. The team has tried to represent the cases to use faster and personal support.

Treatment plans, especially for patients with chronic diseases are important to be dealt with. AI's information on infection states depend on learning calculations and the doctors experience in the treatment of patients with indications, signs, conclusions, medicines, and comparative results.

Most clinical data fall into a wide range of limited categories, although they are distant and may be limited by potential sampling, but future studies on the adoption of approved standards are not required. This allows artificial intelligence algorithms to learn information and enhance the creation of reinforcement learning loops.

6 Future Scopes, Limitations, and Possible Applications

The forthcoming examination is required to investigate how AI can customize treatment choices for singular patients to a clinician. The nature of data that AI gains is likewise significant and this is an expected boundary to the far-reaching selection of exactness medication. The size of data needed for deep learning is crucial and the variety of strategies are utilized to make it hard. The need is to obtain a way how precisely AI frameworks may function in genuine practice or how reproducible they might be in various clinical contexts.

Forthcoming exploration openings are necessary to address "social inclination" in AI calculations, and sufficient advances should be taken to abstain from compounding medical care differences when utilizing AI apparatuses to save patients. Tolerant security should be ensured and is more noteworthy straightforwardness into algorithmic process. Fairness is expected to guarantee acknowledgment of AI by suppliers and patients.

IoT solutions for healthcare that collect, transmit, and visualize data in complex intelligent systems via wearable and field sensor networks can facilitate analytics, activity detection, and decision-making. Artificial intelligence and machine learning technologies play a significant role in this transition, but their implementation requires computational power. It is often only available using cloud services.

In fact, with the increasing amount of data generated by sensors, the performance of ML-based cloud processing has several weaknesses for various reasons.

7 Recommendations and Considerations

Artificial intelligence in healthcare is ready to bring change and disrupt medical care. While not giving up marketing and profitability of drug addiction is the wisest guide, it balances artificial intelligence and the need for comprehensive healthcare to plan and manage and reduce potential unexpected consequences.

It is wise to take. For AI, the best solution is to start with a real healthcare issue, involving the relevant stakeholders, first-line users, patients, and their families (including artificial and non-artificial intelligence options). You need to find a solution and work on it. The presented manuscript is implemented, and extended by our five goals: better health, better care experience, doctor's health, lower cost, and common rights.

8 Conclusions

The nature of administration is significantly influenced by the nature of your Internet association, making it difficult to use. Healthcare providers require shorter response times to address potential health risks, especially when performance such as early detection, risk prevention, and activity diagnosis is guaranteed in real time.

Because of the huge measure of individual data that should be overseen, data stockpiling and security are additionally vital when managing medical care. For all of this, choosing purely local administration, especially for mobility, is not yet practical due to limited processing and storage capabilities.

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Annex

Key Terms and Definitions

Lung Cancer Cancer that begins in the lungs and most often occurs in people who smoke. Two major types of lung cancer are non-small cell lung cancer and small cell lung cancer. Causes of lung cancer include smoking, second-hand smoke, exposure to certain toxins, and family history.

Healthcare 4.0 Healthcare 4.0 is a term that has emerged recently and derived from Industry 4.0. Today, the healthcare sector is more digital than in past decades, for example, spreading from X-rays and magnetic resonance imaging to computed tomography and ultrasound scans to electronic medical records.
Machine Learning **Machine learning** is an application of **artificial intelligence** (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. **Machine learning** focuses on the development of computer programs that can access data and use it to learn for themselves.
Artificial Intelligence **Artificial intelligence** (AI) refers to the simulation of human **intelligence** in machines that are programmed to think like humans and mimic their actions. The term may also be applied to any machine that exhibits traits associated with a human mind such as learning and problem-solving.
Big Data Extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions.
Internet of Things The Internet of things is a system of interrelated computing devices, mechanical and digital machines provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
Cell Profiler CellProfiler is a free, open-source software designed to enable biologists without training in computer vision or programming to quantitatively measure phenotypes from thousands of images automatically.
CADe Computer-aided detection (CADe), or computer-aided diagnosis (CADx), is a type of system software that has been proven to be very helpful to doctors these days in the interpretation of the medical images microscopically.

Additional Readings (Addendum)

1. https://www.macadamian.com/learn/combining-ai-and-blockchain-in-healthare/
2. https://europepmc.org/article/pmc/pmc7217772
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6843531/

Data Set

The below set of pictures consist of various images that serve as a dataset to our tool and are processed under DCNN (from Figs. 4, 5, 6, 7, and 8).

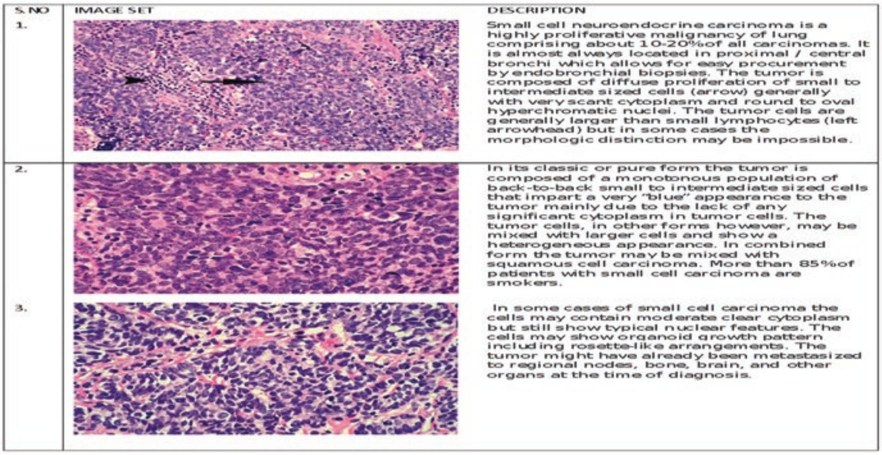


Fig. 4 Data set under considerations

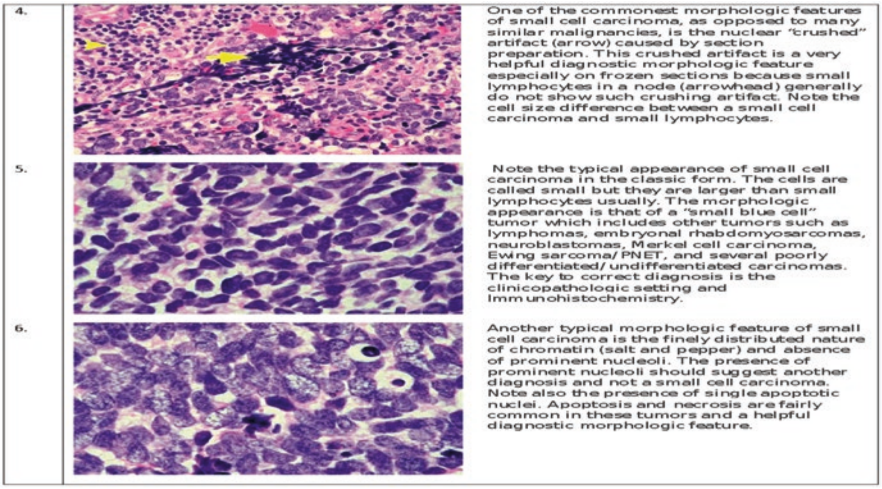


Fig. 5 Data set under considerations

Snapshots of the Implementation

The results are displayed under this section (Figs. 9, 10, 11, 12, 13, and 14).

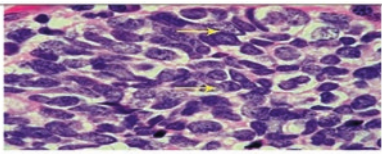
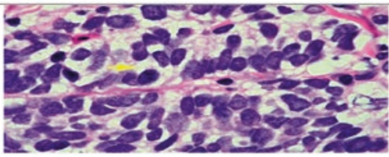
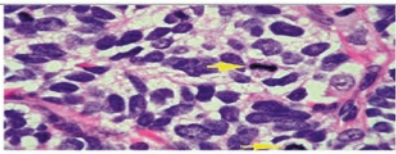
7.		Nuclear molding (arrows) is common and a very helpful diagnostic morphologic feature in sections and in cytologic preparations. This artifact is due to the flexible nuclear membranes. In nuclear molding the nucleus of one cell appears to be "bumping" into another one causing them to appear as pieces of jigsaw puzzle.
8.		In some cases the cells contain moderate clear cytoplasm as in this case and may erroneously suggest a diagnosis of carcinoid tumor. However, the invasive nature of the tumor and lack of completely organoid growth pattern favor small cell carcinoma. Note the oval nuclei with evenly distributed chromatin and lack of prominent nucleoli.
9.		Mitoses (arrows) are very common in small cell carcinoma and in fact a diagnosis of small cell carcinoma must not be made in the absence of mitoses. Mitoses are coupled with apoptosis and areas of necrosis.

Fig. 6 Data set under considerations

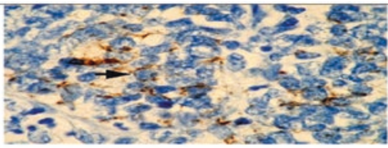
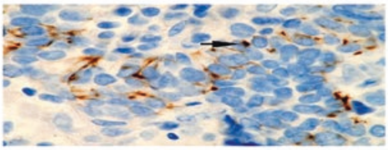
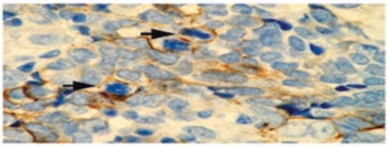
10.		The tumor cells generally show expression of low molecular weight cytokeratins including Cam 5.2. Cytokeratin 7 (CK-7) but not cytokeratin 20 (CK-20) is expressed which is in contrast to Merkel cell carcinoma of the skin which expresses CK-20 and not CK-7.
11.		The pan-cytokeratin AE1:AE3 generally shows focal dot-like paranuclear positive staining.
12.		The diagnosis depends on the expression of one or more neuroendocrine markers such as CD56 (shown), CD57, synaptophysin, Map-2, NSE, neurofilament and chromogranin.

Fig. 7 Data set under considerations

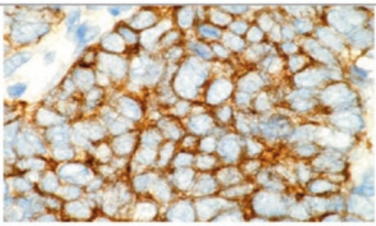
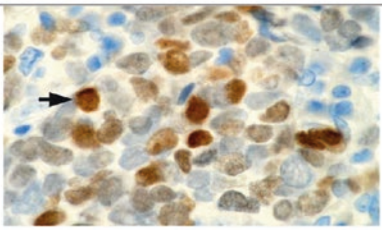
13.		Positive immunostaining for synaptophysin is seen in about 65% of all cases.
14.		Positive immunostaining for TTF1 is seen in about 85% of all cases and helps confirm pulmonary origin of a small cell carcinoma. However, certain extrapulmonary small cell carcinomas are also positive for TTF-1.

Fig. 8 Data set under considerations

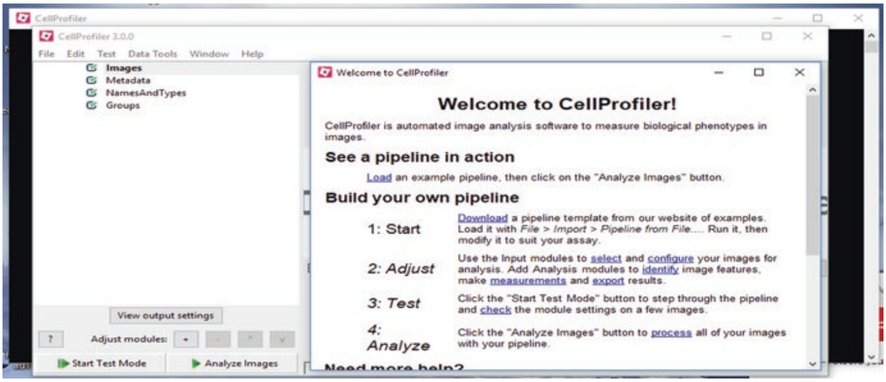


Fig. 9 CellProfiler

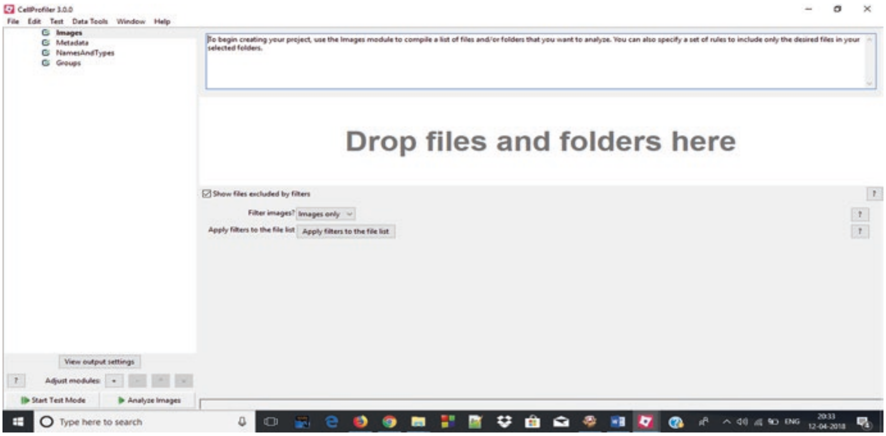


Fig. 10 Image modules

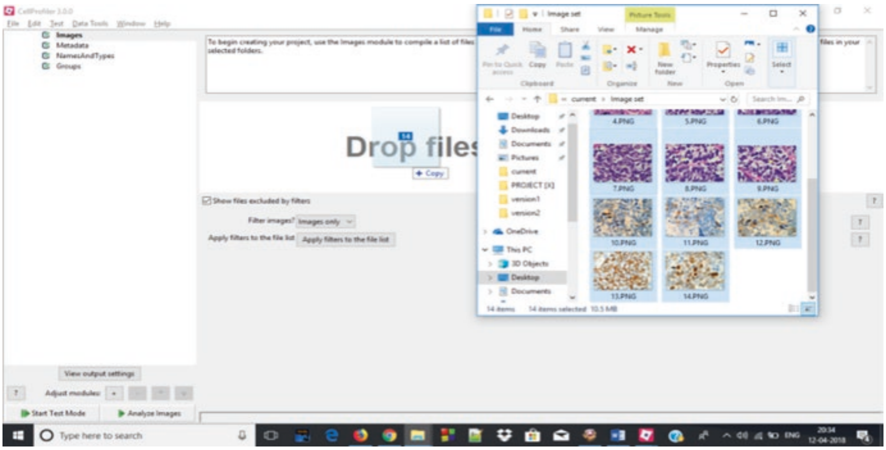


Fig. 11 Image set

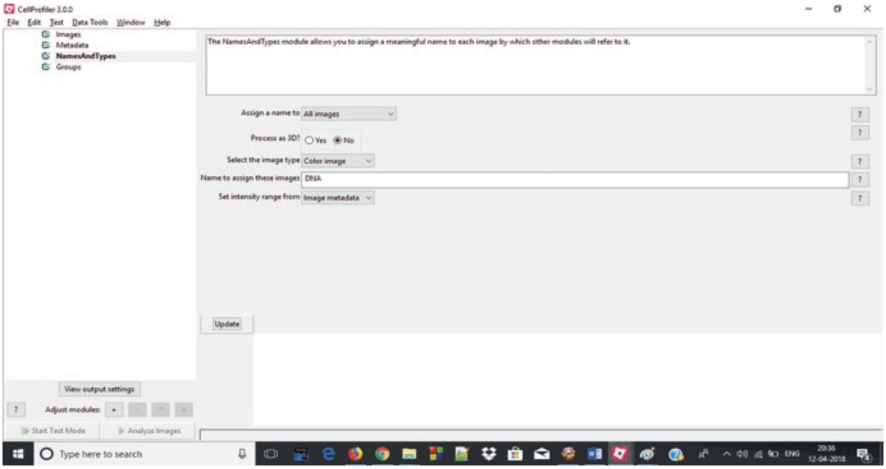


Fig. 12 Extraction of information from metadata modules

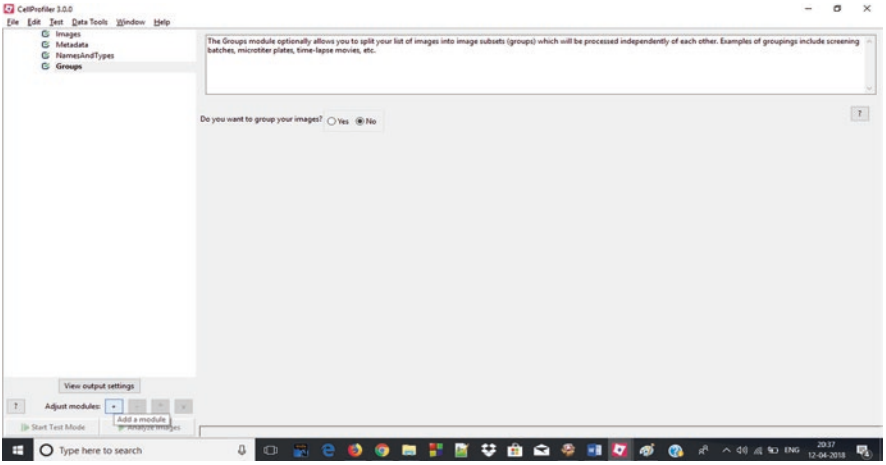


Fig. 13 CellProfiler 3.0

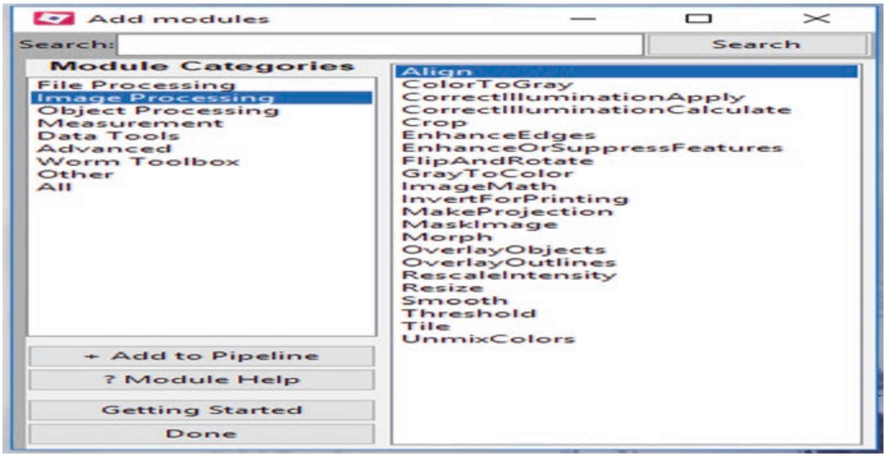


Fig. 14 Module categories

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The Fusion of IOT and Wireless Body Area Network

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1 Introduction

Recently, there is an emerging interest in wireless body area networks (WBANs) since they enable real-time and continuous monitoring in various fields including telemedicine, entertainment, sports, and military training. Specifically, it is one of the most convenient, cost-effective, and accurate technologies for health monitoring [1, 2]. In traditional healthcare systems, patients have to stay in hospitals, but WBANs free the patients from staying. They reduce medical labor cost and cost of infrastructure. In WBAN, sensors are placed in or on the human body to quantify the physiological signals of the patients [3]. The utilization of WBANs may enable remote diagnosis of diseases in an early stage. These systems provide uninterrupted health monitoring accommodations, sanctioning patients to perform everyday activities, which leads to the enhancement of the quality of life [4]. Sensors sense the signal to the sink which is further remitted to the medical server room where medical experts monitor the patient's activities. WBAN is a resource-constrained technology by their circumscribed battery life, bandwidth, recollection, energy consumption, etc. These are issues that have to be considered while designing an incipient protocol or algorithms for network [5]. Sundry authors proposed routing protocols or MAC protocols to increase the network lifetime of the network. The number of growing inhabitants increases within the whole universe and swells as each further day protection of health cost is enhancing [2, 3, 8, 10, 14]. The number of lonely human beings is increasing as well. Entirely these elements are motivating

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https://doi.org/10.1007/978-3-030-77528-5_10

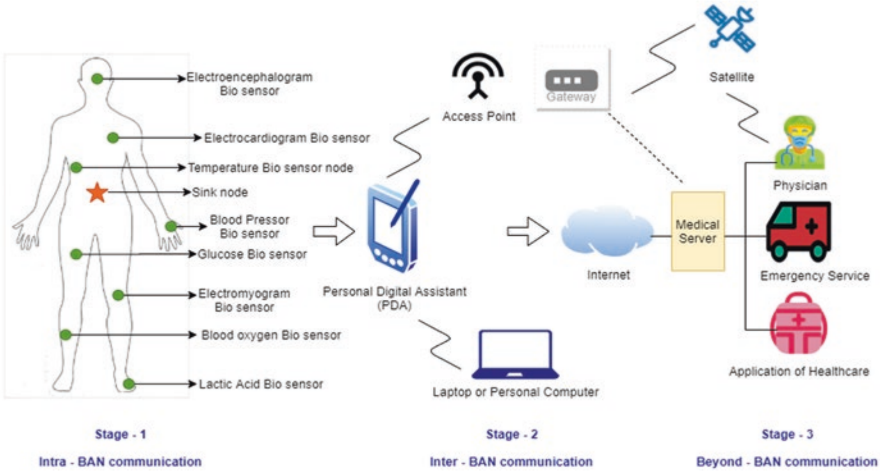

Fig. 1 Architectural model of wireless body area network

to introduce WBAN that helps enhance living wellness programs. M-health as well as telemedicine [6] gets many benefits from this concept [15–17] (Fig. 1). Routing is used to transmit message from one place to another.

Physical elements of the body observed with the use of sensors are respiratory rate, heart rate, blood pressure, movement of the body, levels of glucose, temperature of the body, and so on. By using such technique through Internet of things, remote tracking of disease detection, fitness monitoring, low collision rate, and faster message transmission occur sooner within this smart system.

Possibility may occur or not for sending anatomical signals whether sensor node dries up of battery power [18]. Because of resource limitation (processing power, memory, as well as battery power), low transmission reach, as well as path loss, one well-organized energy routing protocol is required in favor of maintenance of WBAN [19]. Stable Increased-throughput Multi-hop Protocol for Link Efficiency (SIMPLE) is a multi-hop routing protocol used inside WBANs [20]. By achieving efficient energy as well as high duration of network, this utilizes route as well as residual energy elements to choose the afterward hop. Even so, by using one sink, that disjoints problem abides equal. Inside DARE – Distance Aware Relaying Energy efficient routing protocol – patients in the hospital unit are observed in favor of various anatomical elements [21, 22, 11]. The on-body relay node has more energy compared with further sensor nodes. Those are duration of network addition, energy efficiency, classifications of anatomy, as well as management of position adjustment. Generally, duration of network addition should be regarded incorporating those classifications of anatomy for balanced performance as well as warranty of productive WBAN control. Additionally, WBANs' integration is accompanied by cloud computing shows within starting of recent cost effectual as well as data operated structure. It aids to boost this implicit hospital topic within future.

Thus, here we study dual sink technique utilizing clustering inside body area network (DSCB). This is very important at improving duration of network with effectively using nodes battery time duration. Additionally, connection of nodes toward forward nodes or sink is made certain as utilizing both sink nodes. Inside suggested protocol, we possessed the use of that dual sink accompanied by clustering technique. Utilizing clustering technique stabilizes the load of network at sink nodes. Calculation of SNR link occurs too as well as utilization inside searching power of transmission required as sensor node. Those elements make sure adeptly the use of nodes assets for improving capacity of network. Numerous demanding necessities inside WBAN are there like enhancing duration of network, end-to-end delay reduction, as well as path loss and achieving good communication. Though in WBAN health – care – data is critical type that requires to be redirected in the absence of whichever disruption as well as delay. Consequently, authors have suggested multiple routing protocols as well as algorithms for effective and fast data delivery. Few of them are studied and explored.

1.1 WBAN System Architecture

Millions of people die from chronic or fatal diseases every year. The most common reason of such fatal diseases is the lack of timely disease diagnostic services. The authors in [3] revealed that most of the diseases can be controlled if they are identified in their early stages. So there is a pressing need for proactive, affordable, and fast healthcare systems for continuous health monitoring and early detection of diseases. With the advancement of new wireless technologies, in WBANs, the system has different monitoring sensor nodes such as sensors and actuators. The sensor nodes are used to measure certain body parameters, whereas the actuators act on received data from other sensor nodes. In addition, personal devices act as a control unit to collect data from sensor nodes and transmit to the medical server using a wireless link [5].

A WBAN's systems architecture consists of several wireless devices and network components.

- **Sensors Nodes**

Sensor nodes measure the vital parameters of the human body and process the collected data and transmit to the control unit. Some types of these sensor nodes are heartbeat, temperature, humidity, DNA sensor, transmission plasmon biosensor, thermistor, magnetic biosensors, spirometer, blood glucose, pulse oximetry, motion, electrocardiogram (ECG), EEG, and EMG. The design of sensor nodes of WBANs is critical and should fulfill the main requirements such as wear ability, reliability, security, and interoperability. A sensor node consists of sensor hardware, processor, memory, power unit, and a transceiver.

- **Actuator Nodes**

This device acts according to the data received from the sensor node or through the interaction with the user. It consists of actuator hardware to administer medicine, processor, memory, power unit, and transmitter/transceiver.

1.2 Applications of WBANs

WBANs provide a wide range of monitoring applications in different fields such as ubiquitous healthcare, emergency, military, sports, interactive gaming, and many others [6]. In the section, we discuss the WBANs applications in the healthcare field. It provides continues health monitoring of patients and manages the necessary medication during their stay at home or elsewhere [7]. The in-body sensor nodes monitor patient's body organ functions such as pacemakers and implantable cardiac defibrillators, restoration of limb movement, and control of bladder function. On-body sensor nodes are used in medical applications to monitor blood pressure, heart rate, temperature, and respiration. Some of the WBAN applications are discussed in the following subsections.

1.2.1 Cardiovascular Application

This application is used to monitor cardiovascular disease which is one of the primary reasons of death. Healthcare service providers can prepare patient treatment in advance by any abnormal information from sensor nodes about heart rate or irregular heart functions [8].

1.2.2 Cancer Detection

Nowadays, cancer is one of the biggest threats for human life. It effects millions of people, and the number of effected people is increasing every year [9]. A set of small sensor nodes have capabilities to detect the nitric oxide which is usually produced by cancer cells. Sensor nodes can be placed in the patient's affected body part. This allows medical professionals to detect cancer tumors without any biopsy.

1.2.3 Blood Glucose Monitoring

Diabetes is one of the serious chronic diseases all over the world. According to the World Health Organization, diabetes has been gradually increasing over the years. More than 400 million adults are suffering from diabetes globally. If this disease is not treated properly, it can cause some other serious complicated diseases in the body like blindness, stroke, kidney disease, heart disease, and high blood pressure [10]. WBANs can provide effective treatment to diabetic patients by providing continuous and accurate blood glucose level monitoring. Currently, the typical way to measure blood glucose level is to prick the finger and place the blood drop on the test strip. This method can damage the tissues by constant pricking over the years. Wireless biomedical sensors can be implanted in the patient's body causing less invasion in monitoring glucose level several times a day. Through WBAN sensors, doctors also inject insulin in patients automatically using an actuator node whenever a glucose level is reached at a certain threshold [11, 12].

1.2.4 Stress Monitoring

Stress is a foremost cause of illness and different diseases. Chronic stress leads to production of psychological issues such as high depression and anxiety. It can also cause high coronary heart disease, morbidity, and mortality. WBANs can provide real-time stress monitoring in individuals and help their physicians provide proper treatment [13].

1.2.5 Artificial Retina

Retina prosthesis chips can be implanted in the human eye, which will help patients who are suffering from no vision or limited vision be able to see at an adequate level. In the Smart Sensors and Integrated Microsystems (SSIM) project by Wayne State University and Kresge Eye Institute, a retina test system was developed which consists of integrated circuits and array of sensors [11, 14].

1.2.6 General Health Monitoring

WBANs have also been proposed for general health monitoring. These types of applications help those patients which are out of the hospital; however, their health status is continuously monitored by these applications.

1.2.7 Non-medical Applications

WBANs also offer other non-medical applications such as public safety, monitoring battlefield activities, gaming, and entertainment applications.

2 Review of Existing Works

For WBAN, many authors suggested about the multi-hop routing protocol that functions effectively at consumption of energy, duration of network, as well as PDR, i.e., Packet Delivery Ratio [20]. Attached nodes are utilized within the network that's employed like relay nodes. Cost function is computed depending upon space by considering supervisor node, the residual energy, velocity vector of receiver, and transmission power of node for selecting promoter node. In WBAN, another routing protocol is used, i.e., Balanced Energy Consumption (BEC). In BEC, cost function for choosing relay node is dependent upon the distance of node from the sink. Relay nodes are being chosen for every stage for distributing uniform load. Whether that node is near to that sink, it transmits its information straightly, or else it's transferred to the closest relay node. In support of that protocol, Mobile-ATTEMPT (M-ATTEMPT) is being examined, and one enhanced technique is suggested. Such quality of proposed protocol is shown across different tests [13, 22]. The outcomes displayed obvious enhancements rather than before routing protocols with respect to duration of network, residual energy, and throughput. In diversified WBAN [23], NEW-ATTEMPT is an efficient energy routing protocol which attains an excessive throughput. For choice of relay node, by transferring its information to sink from node, a cost function is utilized. This is computed at residual energy, gap from data rate, as well as transmitter node's sink. Omar Smail et al. suggested efficient energy and genuine as well as secure routing protocol for Mobile WBANs [24, 25]. The routing protocol enhances duration of network with thoroughly utilizing the residual energy. Secure links and efficient energy are chosen for transmission utilizing the introduced model. Inside [26], those researchers suggested efficient energy on the basis of fuzzy adaptive routing protocol. This utilizes clustering method accompanied by straight transmission mode to sink node. This extracts the place as well as cruciality of sensor node toward the data forwarding conclusion also. In [27], the author's aim is to expand a strategy which assists a genuine data transmission for medical utilization of WBANs. RTT, i.e., Restricted Tree Topology protocol, utilizes dual-hop topology of network through transitional relays which are utilized as forwarder among sensor and sink nodes. RTT procedure expands that to a tree topology from star topology by limiting the number of hops. This method assists for solving issues like excessive loss of propagation, energy limitation, as well as reliability limitation. The standard of channels among variety of nodes is looked over utilizing RSSI, i.e., Received Signal Strength Indicator. RTT technique is capable of managing energy as well as reliability, by using opportunistic as well as dynamic relays. Even so, it utilizes a big number of relays that show discomfort in patients. Harsharan et al. talked about the use of WBAN accompanied by a variety of sensor nodes inside the healthcare environment [28]. Conversation of computation of residual energy as well as cost function is over. For choosing top forwarder node, utilization of cost function occurs. Here, the suggested protocol attains additional stability period of energy by comparing its counterpart as well as its cost-effectivity. The author in [29] proposed a strategy for naming WBANs, RE-ATTEMPT

(Reliability Enhanced Adaptive Threshold-based Thermal Unaware Energy Efficient Multi-Hop Protocol). On the basis of amount of energy, wireless sensor nodes are employed at determined locations. Urgent sensed information is straightly transmitted to that sink node although usual information is transmitted utilizing multi-hop transmission. The protocol utilizes less hop count like cost function for choice of route. Co-LAEEBA (cooperative Link Aware Energy Efficient protocol) routing strategies are introduced with the help of Sheeraz et al. [30]. For choice of probable route toward the sink node, the cost function is utilized. It's dependent on the distance of node from residual energy and the sink. After simulation, the outcomes display enhancement in execution of suggested protocol, by comparing with other chosen protocols utilizing described perimeter. In [21] the authors suggested one routing strategy for WBAN named DARE (Distance Aware Relaying Energy efficient). Inside such investigation, eight patients inside the hospital were supplied by seven sensor nodes, all being observed for multiple physiological variables. This study uses mobile sink node that is located at multiple locations of hospitals' quarter to create multiple topologies. By mitigating the consumption of energy, one on-body relay node located at the patient's chest is utilized to gain information from further nodes as well as transmission toward the sink. The on-body relay node holds greater energy by comparing with further sensor nodes. SIMPLE [20] with efficient power and reliable high-throughput routing strategy for WBAN is introduced by Q. Nadeem et al. With lengthy duration of network as well as minimum consumption of energy, multi-hops topology is being pursued. For selecting forwarder node and cost function on the basis of low distance toward more residual energy and sink is utilized. Even so, because of the utilization of one and only sink, the detached among sensor nodes located at foots as well as hands can occur.

3 Fusion of IoT with WBAN

The WBAN architectural model is classified into four surfaces [7] shown in Fig. 2. The first surface (Surface 1) called BAN surface combines various wireless sensor nodes employed within one restricted physiographic region, so making one WPAN – Wireless Personal Area Network. It depends upon owned style by positioning sensor nodes at human anatomy within mode of wearable sensors stitched inside fabrics, tiny marks (on-anatomy sensor) else placed inside anatomy of human (inside body sensor). SNR (signal-to-noise ratio), RNF (Receive-Noise-Figure), and BPL (body path loss) are three important components that turn on the sensor node's power transmission. SNR is based on standard of transmission link. RNF component is based on gadget. Different devices give different results by it. This receiver affects BPL within utilization as well as radioactivity system [31, 32]. Various customer interactivity with gadgets on Surface 2 are there (interactivity surface customer) that importantly performs like access point (AP). The sensor nodes sense information which is sent toward the treated server like pharmaceutical server located on hospital by such surface. With the basis of utilized wireless

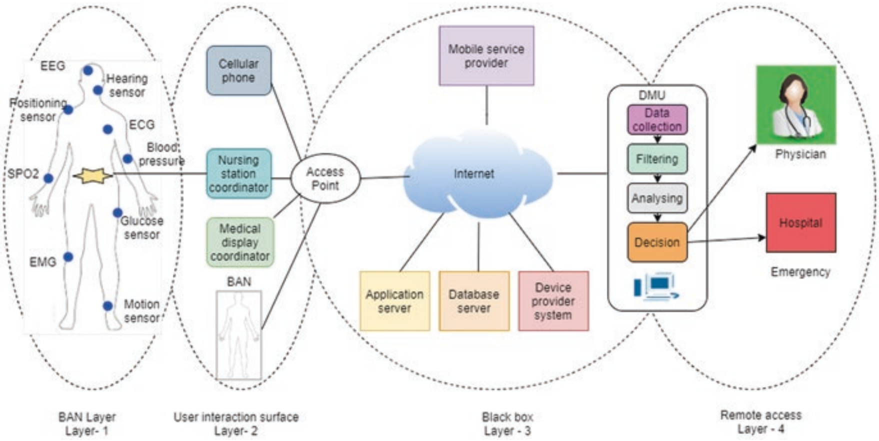

Fig. 2 Architecture of WBAN for e-health system

transmission protocol, surface 2 holds various gadgets like smart phones or PDAs which are based on Bluetooth. Those gadgets gain as well as send information toward surface 3. Due to observing of populous, by one AP equips various quarters inside home that is also attached with one wired else wireless network such as Wi-Fi [12]. Surface 3 carries the DMU – Decision Measuring Unit. This attaches with the back-end pharmaceutical server located inside the hospital by the World Wide Web. This consequently acts every main task of computation. The major task of the DMU is for collecting information, filtering, as well as analyzing to make decisions. Surface 4 is the end surface. This supplies medical management utilities toward staffs with monitoring. The processed information with the help of DMU is communicated with remote pharmaceutical server. Inside hospital it locates server, at which physician treated build correct conclusions at gained data. Such surface provides importantly dual various tasks called medical management services and urgent services.

Figure 3 describes about the DSBC routing protocol . The expanding duration of network focuses on DSBC protocol, enlarging throughput as well as association. Also, this stabilizes burden at a sink node. Afterwards, to sense information, every node sends this toward the sink node with straightly else by sender node. The sender node uses the CF (cost function) for selection. It is calculated for every nearer node calculates CF that is depended upon path from sink node, power of transmission as well as residual energy. By utilizing SNR, link standard is inspected too. The least CF of a nearer node is chosen for the sender. What we talk about in literature review, such larger part of suggested strategies utilize a sink node that gains information sensing from sensor nodes as well as sends this toward end server afterward accumulation. Moreover, nearly without protocol inside, WBAN utilizes clustering technology. For this, a few issues appear that don't possess awareness like:

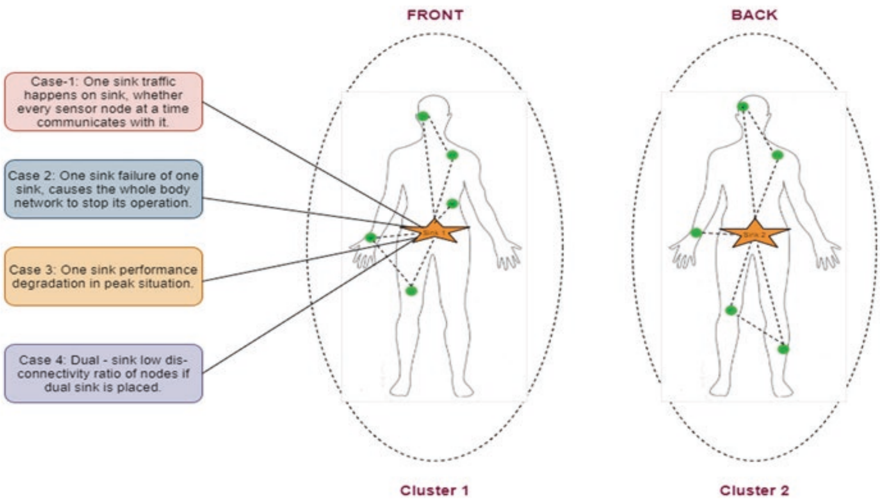

Fig. 3 Diagrammatic approach for DSBC protocol

- At first, there are many possibilities of traffic phenomenon on sink node while every sensor node forwards information at the same time, mostly on the condition of that censorious information.
- Secondly, WBAN' negligence of one sink node shows within absolute negligence while sink performs like the main hub.
- Third, degradation of action on sink node occurs while several sensor nodes forward information on time that shows for short transport ratio.
- Fourth, to maximize anatomy description, requirement of many sensor nodes occurs as well as whether a cluster proposal is utilized that may generate burden at one sink node.
- Fifth, LOS (Line of Sight) transmission is needed within several plots that can't be attained while anatomy is within movement.

Consequently, a routing strategy is presented by us known as DSCB that controls above-named lacks inside WBANs. Inside the DSCB protocol, path-loss consequences reduction, load of network leveling, as well as achievement of LOS transmission occurs.

The suggested routing strategy is presented by us in such part known as dual-sink software-defined networking proposal utilizing clustering inside BAN (DSCB) that improves WBAN execution by applying clustering strategy between both sinks. DSCB places both sinks nodes which are called S_1 and S_2 between ten sensor nodes at human anatomy. Sink nodes S_1 and S_2 are dissimilar with further distributed sensors at anatomy. The sink nodes possess superior assets by comparing with further sensor nodes like cell power, transmission power, memory, etc. Distribution of four sensor nodes occur at anterior part of human anatomy accompanied by S_1 like CH of them as well as four sensor nodes at behind of human anatomy accompanied by S_2 like CH of them. A node is located at right hand's anterior part when a node is

Table 1 Energy framework estimates

Parameters	Values
Initial energy ($E_{initial}$)	0.6 J
Minimum supply voltage	1.8 V
Frequency (f)	2.4 GHz
$E_{Tr\text{-}am}$	1.98nJ/bit
$E_{Tx\text{-}Cty}$	16.7nJ/bit
$E_{Re\text{-}Cty}$	36.3nJ/bit
DC current (Tr)	10.6 mA
DC current (re)	17 mA
Wavelength (λ)	0.138 m

located at behind of left hand. The waist locates S_1 as well as Lumbar S_2. With the movable part, these nodes which are connected toward the hands are attached to one of the two sink nodes utilizing LOS transmission. Figure 3 shows the suggested DSCB protocol's topology (Table 1 and 2).

3.1 *Starting Stage*

Inside such stage, two sink nodes (S_1 and S_2) telecasts packets i.e. "Hello" that carry IDs as well as places of them. On acceptance, every sensor node transmits "Reply" information that carries IDs, place as well as residual energy. With such procedure, every node plus two sink nodes gain data regarding every further node. To find nearer nodes this aids.

3.2 *Cluster Evolution*

Access point (AP) or cluster heads are used to receive messages from sensor nodes. Time period location follows cluster evolution toward every cluster participant, occurring with the help of CHs utilizing TDMA protocol.

3.3 *Sensed Information Stage*

Activation of sensor nodes occurs just within the assigned time period, or sensor nodes possess snooze way. As the sensor node turns agile, this initializes to sense information. That information sensing is inspected for cruciality firstly. Whether it is serious, it's transmitted straightly toward the sink node or sink node through multi-hop.

3.4 Choice of Forwarder Stage

DSCB calculates sender node with the help of link's SNR, distance (di) in distinction to sink, residual energy (E_{Rn}), as well as transmission power (T_{p}). The estimation of threshold considering SNR possesses default inside DSCB protocol that is same with "1". Whether one sensor node does sense little information as well as which isn't censorious, this chooses one node in distinction to its nearby table. After that, numerous hops to sink are added up for selecting nearby direct toward the sink. Whether numerous hops possess zero, such node is regarded by straightly attaching toward the sink, so this transmission occurs straightly with no sending node. Or SNR of link is computed whether less than 1, for becoming forwarder, it rejects such node as well as it records data of itself. Whether the SNR of link is greater than 1 after that node's Function of Cost (FC) be about is computed. To calculate the sensor node's residual energy (E_{Rn}), the following equation is used:

$$E_{\mathrm{Rn}} = E_{\mathrm{In}} - E_{\mathrm{Cn}} \tag{1}$$

where n indicates numerous nodes utilized, E_{Rn} as residual energy, E_{In} as initial energy, and E_{Cn} as energy consumption node that computes the equation below:

$$E_{\mathrm{Cn}} = E_{\mathrm{Tr}} + E_{Re} + E_{\mathrm{Cty}} \tag{2}$$

Here, E_{Tr} and E_{Re} are the amount of energy consumption with the help of node transceiver radio at the time of data transmission as well as reception. E_{Cty} is known as consumption of energy occurred with the help of electronic circuitry of node. The node n_j^i describes about the amount of energy absorbed at the time of setup period P_{su}, beginning on time 0 as well as consumption of energy which occurred in every round $E_{\mathrm{Rnd}}{}^i_j$ (ti):

$$E_{\mathrm{Rnd}}{}^i_j(\mathrm{ti}) = \int_{ti+P_{\mathrm{su}}}^{ti} E^i_{\mathrm{Cn}_j}(t)\,dt \tag{3}$$

$$= \int_{ti+P_{\mathrm{su}}}^{ti} \left(E^i_{\mathrm{Tr}_j}(t) + E^i_{Re_j}(t) + E^i_{\mathrm{Cty}_j}(t)\right)dt \tag{4}$$

where $E_{\mathrm{Rnd}}{}^i_j$ = energy needed with the help of node n_j^i at time of period P_{su} also in every cycle.

For finding energy value needed considering the transmission as well as reception, we use these equations:

$$E_{\mathrm{Tr}}(k,di) = E_{\mathrm{Tr-Cty}} * k + E_{\mathrm{Tr-am}}(k,di) \tag{5}$$

$$E_{\mathrm{Tr}}(k,di) = E_{\mathrm{Tr-Cty}} * k + \mathrm{T}_{\mathrm{am}} k di^2 \tag{6}$$

$$E_{Re}\left(k\right) = E_{Re-\mathrm{Cty}} * k \tag{7}$$

where “di” = entire distance among receiver Re as well as transmitter Tr. E_{Re} as well as E_{Tr} = consumption of energy fares for every packet with help of receiver as well as transmitter accordingly. $E_{\mathrm{Re\text{-}Cty}}$ and $E_{\mathrm{Tr\text{-}Cty}}$ = consumption of energy estimates for every bit considering receiver as well as transmitter circuitries of electronics accordingly. k = length of packet at which $\in_{\mathrm{am}}$ = radio amplifier kind. Loss of coefficient = l_o that is distinct inside the human anatomy by comparing with earthly networks; thus, Eq. (6) is written as l_o:

$$E_{\mathrm{Tr}}\left(k,di,l_o\right) = E_{\mathrm{Tr-Cty}}\ k + \in_{\mathrm{am}}\ nkdi^{lo} \tag{8}$$

$$P_n.T = \frac{\mathrm{SNR}}{\beta} \tag{9}$$

where $P_n.T$ = power of transmission as wireless signal and β the path-loss parameter. To find the entire distance di among some sensor node as well as nearby sensor node or sink node of itself, below equation is used:

$$di\left(n, D\mathrm{ts}\right) = \sqrt{\left(P_n - P_{D_{ts}}\right)^2 + \left(Q_n - Q_{D_{ts}}\right)^2} \tag{10}$$

$$Fn.C = \frac{di}{E_{Rn} * P_n.T} \tag{11}$$

where $F_n.C$ is function of cost of some node.

3.5 Consumed Energy as well as Routing Stage

An important edge with utilizing both sink nodes does which sink’s more nodes undergo straight transmission span. Packets data goes straightly bring of short delay at utilizing single-hop transmission. Inside DSCB, straight transmission happens within various instances. For few instances, this protocol chooses sender node considering routing motive. Consumption of energy with the help of sensor nodes inside multi-hop transmission indicates [18]:

$$E_{\mathrm{Tr-Mu(k,di)}} = n * \left(E_{\mathrm{Cty}} + E_{\mathrm{am}}\right) * k * L_{\mathrm{EN}} \tag{12}$$

$$E_{Re-\mathrm{Mu(k)}} = \left(n-1\right) * \left(E_{\mathrm{Cty}} + E_{\mathrm{am}}\right) * k \tag{13}$$

$$E_{\mathrm{Tot-Mu}} = E_{\mathrm{Tr-M}} + E_{Re-\mathrm{Mu}} \tag{14}$$

where E_{Tr-Mu} as well as E_{Re-Mu} represents energy needed considering transmission as well as reception with help of transmitter as well as receiver accordingly inside multi-hop transmission. k = bits dimensions, di = distance among sink node as well as sensor nodes, E_{Cty} = energy needed considering the transmitters as well as receiver's electronic circuit, E_{am} = for amplifying k numerous bits toward distance di for this energy needed, n = numerous nodes, and L_{EN} = energy loss at a time of communication by medium of transmission.

Straight communication's consumption of energy is [5]:

$$E_{Tr-di(k,di)} = \left(E_{Cty} + E_{am}\right) * k * L_{En} \tag{15}$$

$$E_{Tot-di} = E_{Tr-di} \tag{16}$$

where $E_{Tr-di\,(k,di)}$ = transmission energy of straight transmission.

3.6 Model of Network

Here we use eight biosensor nodes (S_1, S_2, S_3, …, S_8) in the human body. At the midpoint of the human body is located the sink node. Every biosensor node inside such strategy does various works. S1 is utilized for BP, S2 on temperature, S3 on EEG, S4 lactic acid, S5 EMG, S6 for blood oxygen, S7 for ECG, as well as S8 for glucose with respect to Fig. 1.

With the biosensor nodes distributed inside the human body, below suppositions are being studied:

(i) Every node is fixed as well as utilized that bi directional link inside WBAN.
(ii) Energy deployed for every biosensor node is the same.
(iii) Every biosensor node can be acquainted with its separation from nearer nodes with also from the sink.

3.6.1 Model of Energy

Every node inside WBAN is operative every time; thus, every node requires energy toward processing, transmitting, and sensing information. For this protocol's somatic awareness, a model of energy suggested is utilized. Consumption of energy within communicating information may be evaluated by making use of Eq. (1):

$$E_{trans=}\ E_{T\_elect} * Pc + E_{amp} * Pc * Di^2 \tag{1}$$

Consumption of energy by getting information is evaluated using Eq. (2):

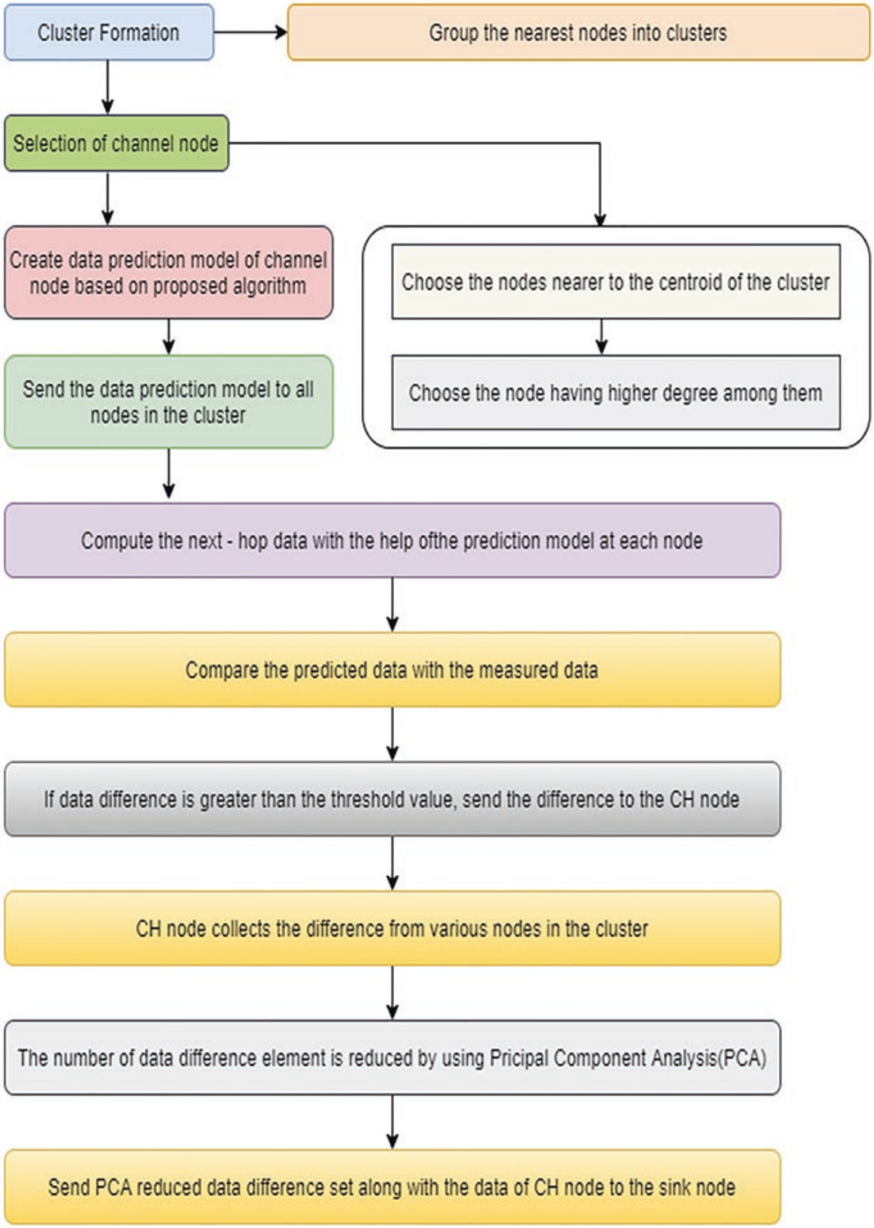

Fig. 4 Data transmission scheme in WBAN

$$E_{\text{recp}} = E_{\text{R\_elec}} * Pc \tag{2}$$

Inside WBAN, transmission of data occurs via the human anatomy, so few wastage may happen. So, overall consumption of energy for communicating the information later including path loss *m* can be evaluated by making use of Eq. (3) (Fig. 4):

$$E_{\text{trans}} = E_{\text{T\_elect}} * Pc + E_{\text{amp}} * m * Pc * Di^2 \tag{3}$$

where E_{trans} is transmission consumption of energy; E_{recp}, reception consumption of energy; $E_{\text{T\_elect}}$, energy needed by electronic transmitter circuitry; $E_{\text{R\_elec}}$, energy needed by the electronic receiver circuitry; E_{amp}, amplifier consumption of energy; Pc, size of packet; m, coefficient of path loss; and Di: distance to destination node from a source node (Fig. 2).

3.6.2 Model of Path Loss

This path loss turns on different elements like changeable opacity, attributive impedance, and constant dielectric of the human body. Such entire path loss throughout transmission of information is evaluated by making use of Eq. (4):

$$Ph_{\text{Loss}} = Ph_{\text{loss0}} + 10\log_{10}\left(Di_1 / Di_0\right) \tag{4}$$

where:

$$Ph_{\text{loss0}} = 10\log_{10}\left(4\pi Di_0 / \lambda\right) \tag{5}$$

Ph_{Loss} is the path loss, Di_1 distance of path, Di_0 distance of threshold (considered by 0.1) [20], and λ wavelength value (0.125 m) [16].

3.6.3 Particle Swarm Optimization Algorithm

James Kennedy and Russell Eberhart were introduced one metaheuristic on the basis of population optimization strategy called PSO, i.e., particle swarm optimization, in the year 1995. It's a much demanded metaheuristic optimization strategies which were persuaded from environment [34, 35]. Communal action of birds for hunting foodstuffs were prompted such optimization strategy. Inside the hunt area, every bird flaps toward that equal path. Below, we discuss about the PSO-based routing scheme.

Initialization

Firstly, along such hunt area, population being obtained candidly utilizing Eq. (6i) as well as starting speeds toward particles is allocated utilizing Eq. (6ii). Fitness value matches with place of particle inside hunt area that marks one feasible outcome toward issue. So direction as well as speed of particles is constituted with velocity as well as based at succeeding iteration also place is changed by particle.

$$Po^{0}{}_{j} = BL + rand(\ )x[BU - BL] \tag{6i}$$

$$vel^{0}{}_{j} = \text{zeros}(PN, N_o) \tag{6ii}$$

where $Po^{v}{}_{j}$ pertains to particle *j'* starting allotment; $vel^{0}{}_{j}$, particle *j'* starting velocity; *BU*, search variable' upper bound; *BL*, search variable' lower bound; *rand*(), random number across (0, 1); *PN*, population number (particles' size of population selected as 100); N_o, search space' total dimensions number; and x iterations chosen as 100.

Fitness Function's Evaluation

Each particle's fitness function can be found by using Eq. (7):

$$\text{Fit}_f : E_{\text{trans}} = E_{\text{T\_elect}} * Pc + E_{\text{amp}} * m * Pc * Di^2 \tag{7}$$

where Fit_f is fitness function and Fit_f ($\text{Loc}_\text{j}^\text{k}$) is fitness' estimate of particle *j* in *k*th iteration.

Hunting

Inside such hunting, hunt procedure carries where every particle hunts for their latest allocation as well as searches latest fitness estimate as per toward allocation. After that, particles are saved at the latest allocation.

Particles' Upgraded Velocity as well as Allocation

Each particle contains individual velocity as well as allocation. Every particle upgrades place as well as speed utilizing recent velocity as well as allocation of Pl_{bes} and Gl_{bes}. Here, these equations are used for upgrading velocity using Eq. 8 as well as allocation using Eq. 9:

$$Ve_{\text{j}}^{\text{k+1}} = \text{wt}Ve_{\text{j,k}} + \text{co}_1\text{rn}_1\left(Ps_{\text{j,k}}{}^{\text{loc}} - Ps_{\text{j,k}}{}^{\text{curr}}\right) + \text{co}_2\text{rn}_2\left(Ps_{\text{g,k}}{}^{\text{glob}} - Ps_{\text{j,k}}{}^{\text{curr}}\right) \tag{8}$$

$$Ps_{j,k+1}^{curr} = Ps_{j,k}^{curr} + wtVe_{j,k} \tag{9}$$

where $Ve_{j,k}$ is the *j-th* particle velocity at iteration *k-th*; $Ps_{j,k}^{curr}$, *j-th* particle's recent allocation at iteration *k-th*; $Ps_{j,k}^{loc}$ (Pl_{bes}), *j-th* particle's local finest allocation at iteration *k-th*; $Ps_{g,k}^{glob}$ (Gl_{bes}), *j-th* particle's global finest allocation at iteration *k-th*; co_1 and co_2, coefficients of acceleration of PSO technique; and rn_1 and rn_2, similarly diffused random numeral across (0, 1).

The coefficient of acceleration enhances probability for searching this global finest, at which one bigger coefficient of acceleration accelerates upward that crossway as well as make shorter calculation schedule, that aims PSO for effortlessly obtain confined toward local finest. By getting best results [40], puts co_1 as well as co_2 is determined as 2.0 estimates. Inside suggested protocol, estimates of elements co_1 as well as co_2 are 1.0 to achieve finest results.

This element weight be particles' weight of inertia as well as relies on below arithmetic correspondence:

$$wgt = wgt^{mx} - \frac{\left(wgt^{mx} - wgt^{mn}\right)itr}{itr_{mx}} \tag{10}$$

at which wgt^{mn} and wgt^{mx} are minimum as well as maximum estimates for weight of inertia. In this suggested technique, wgt^{mn} is 0.2, and wgt^{mx} is 0.9 [40].

Local Best as well as Global Best Upgrading

Here, we compare both local finest fitness estimate of particle and estimate of fitness searched as particle after iteration. The arithmetic representation of the equations are described below:

$$Ps_{j,k+1}^{loc} = \begin{cases} Ps_{j,k+1}^{curr}, Fit_f\left(Ps_{j,k+1}^{curr}\right) \le Fit_f\left(Ps_{j,k}^{loc}\right) \\ Ps_{j,k}^{loc}, Fit_f\left(Ps_{j,k+1}^{curr}\right) > Fit_f\left(Ps_{j,k}^{loc}\right) \end{cases} \tag{11}$$

$$Ps_{g,k+1}^{glob} = \begin{cases} Ps_{j,k+1}^{loc}, Fit_f\left(Ps_{j,k+1}^{loc}\right) \le Fit_f\left(Ps_{k}^{glob}\right) \\ Ps_{k}^{glob}, Fit_f\left(Ps_{j,k+1}^{loc}\right) > Fit_f\left(Ps_{k}^{glob}\right) \end{cases} \tag{12}$$

where $Ps_{j,k}^{loc}$ is the *j-th* particle's finest local location at *k-th* iteration; Ps_k^{glob}, finest global location at *k-th* iteration; $Ps_{g,k+1}^{glob}$, global finest location at *(k + 1)th* iteration; and $Ps_{j,k+1}^{loc}$, *j-th* particle's local finest location at (*k* + *1*)*th* iteration.

Algorithm (3.2.1) of Particle Swarm Optimization

Process i: Arrange those particles accompanied by arbitrary location Po_j^0 as well as velocity vel_j^0 by making use of Eqs. (6i) and (6ii).

Table 2 Distribution of biosensor nodes at the human body

Nodes	Position (X_1Y_1)
S_1	(0.55,1)
S_2	(0.25,1)
S_3	(0.28,0.2)
S_4	(0.48,0.25)
S_5	(0.3,0.5)
S_6	(0.5,0.5)
S_7	(0.45,0.13)
S_8	(0.35,0.9)
SINK	(0.4,1.1)

Process ii: Computation of fitness estimate utilizing function of fitness Fit ($Ps_{j,k}^{loc}$) by making use of Eq. (7) as well as search Ps_j^k local finest location as well as Ps_k^{glob} global finest location by making use of Eqs. (11) and (12).

Process iii: Searching of particle for recent position as well as velocity is upgraded utilizing Eqs. (8) and (9) with also recent location are stocked.

Process iv: Local finest as well as global finest fitness estimate as stated by finest outcome is upgraded.

Process v: Particles' recent location as well as velocity is upgraded.

3.7 Optimized Approaches

By developing WBAN, duration of network and consumption of energy are the most important factors. Each biosensor node transmits information toward the sink node by relay node. Biosensor nodes choose one route which has the smallest distance toward the sink node as well as absorbs small energy. The suggested task by us which has detected route to transfer information that's systematic as well as optimal. We are utilizing energy replicas for computing path loss as well as energy replicas for computing path loss within the chosen route. PSO technique is utilized to find the finest route for information transference inside WBAN. Such major procedures of suggested appeal for searching that finest route are found below. Inside Fig. 3. which is a flow chart of PSOBAN protocol also efficiency energy routing reveals.

3.7.1 System Model

Eight sensor nodes are used in the human body, and every node has the capability to sense as well as transmit information toward the sink to find the smallest path. Position of the biosensor nodes in the human body is listed in Table 2 (Fig. 5).

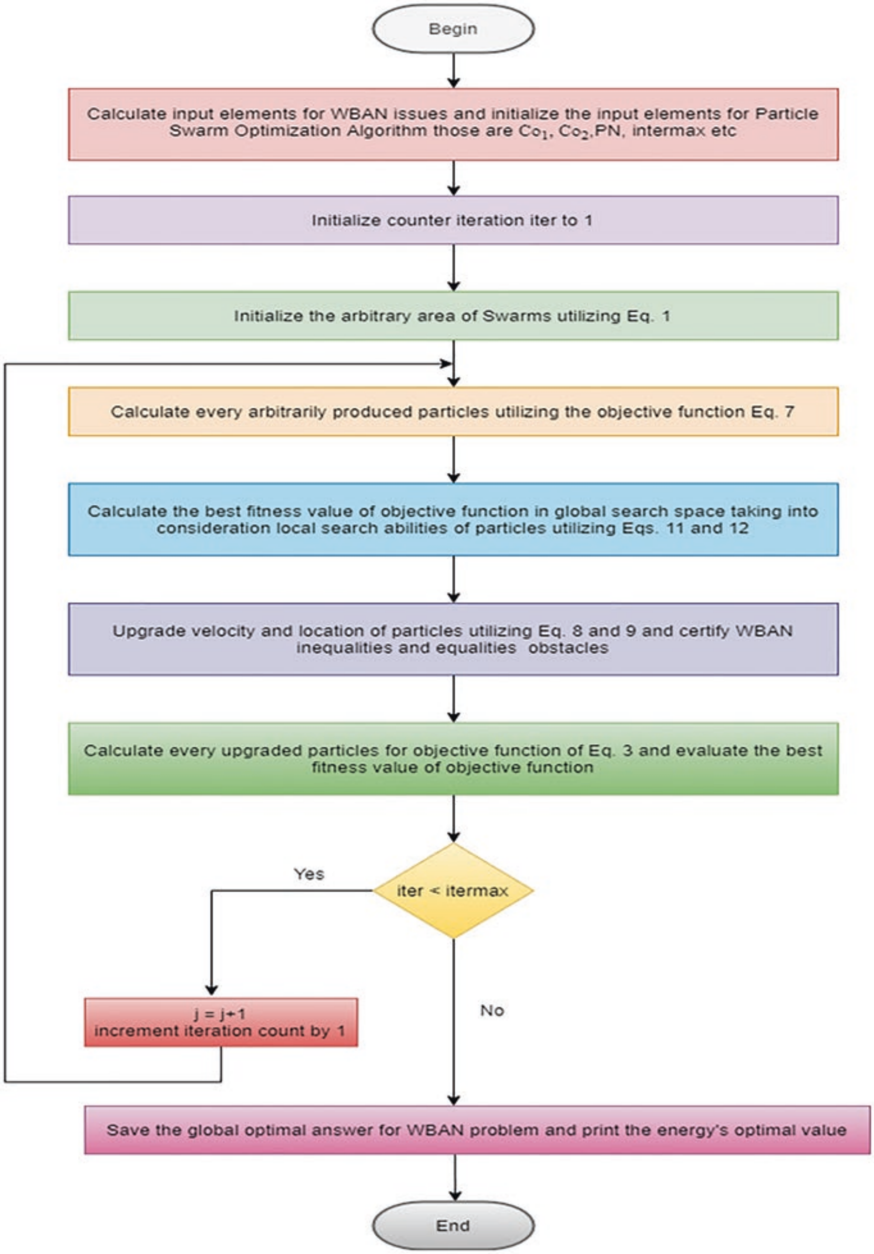

Fig. 5 Suggested PSOBAN protocol

3.7.2 Starting Stage

Inside suggested network for every biosensor nodes are distinctly set up. Preference 1 is put for S_1, S_2,…, S6 nodes, whereas preference 2 is put for S_7 and S_8 biosensor nodes. The important thing is to put various preferences toward S_7 as well as S_8 because of censorious information. Both nodes can transmit information straightly toward the sink node. Further nodes' preference 1 can forward information toward the sink node across the relay node. Here, S_3 node transmits information toward the sink; then information can be forwarded across 4, 5, as well as 6 nodes. Afterward, chosen protocol finds the finest path toward the sink from no. 3 node. Firstly, suggested protocol inspects of 3 no. node' residual energy. Calculation Stage

Within such stage, whether this chosen relay node is no. 5 node then utilized at most whether this has more abiding energy to transmit information. Let no. 5 node isn't one deceased node after that it is going to be chosen one relay node based on cost function that's computed with dividing that distance against no. 3 node accompanied by residual energy. Cost function (CF) is defined as the ratio of distance against the biosensor node toward the sink as well as sensor node's residual energy [20].

$$\mathrm{FC}(\mathrm{j}) = \frac{d(j)}{RE(j).}$$

Cost function estimation is computed with the use of PSO. Routing Stage

Afterward, such equal process is utilized to select the smallest route. In every stage, optimization protocol grants this optimum route within minimal interval. Then every stage matrix for cost function be given rise as well as upgraded as per abiding energy up to every node is announced deceased. These nodes that are chosen like relay nodes utilizing cost function will permit such smallest path. Furthermore, those characteristics of inducing routing protocols are matched by this suggested PSOBAN.

Transmission of Data Stage

At the last stage, transmission of data occurs from source node toward the sink by utilizing the smallest path chosen by the PSO. Every biosensor upon that path route accompanied by one minimal estimate of cost function is chosen to transmit data as computed by PSOBAN. The following flow chart (Fig. 4) is shown to handle different WBAN features inside PSOBAN. Such study suggests single efficient energy routing protocol being assorted WBAN on the basis of PSO Algorithm. This is obvious against name in which the protocol is conscious of path along the various biosensor nodes as well as is delicate toward biosensor nodes' energy. Those outcomes display which suggested protocol does well as regards residual energy. Such route

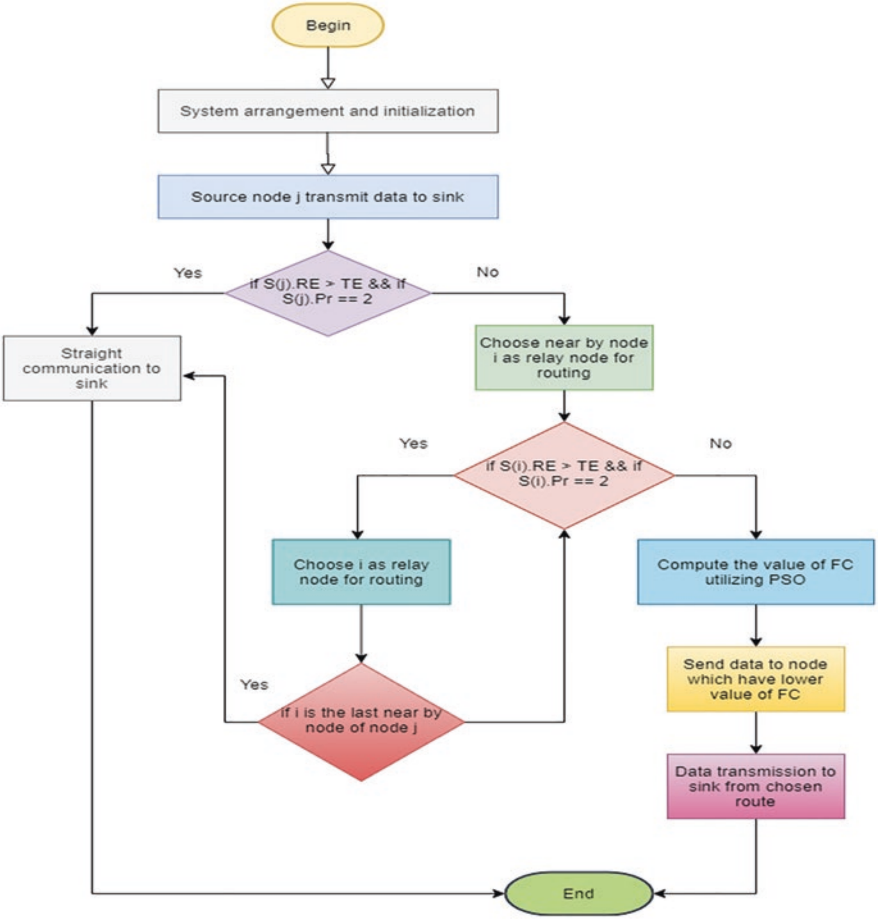

Fig. 6 Managing different WBAN obstacles

is chosen on the basis of numeral hops inside route as well as based on two important elements – distance and energy (Fig. 6).

4 MC-MAC Strategy for Interference Reduction Inside WBANs

In WBAN, sensor nodes are placed in or on the patient's body to monitor their vital signs. Figure 7 shows [42] the WBAN infrastructure for medical and non-medical applications. Personal server and medical server are the two main parts of the WBAN architecture. In WBAN, patient wears the sensor nodes on or inside the body that collect and transmit data to the personal server using communication

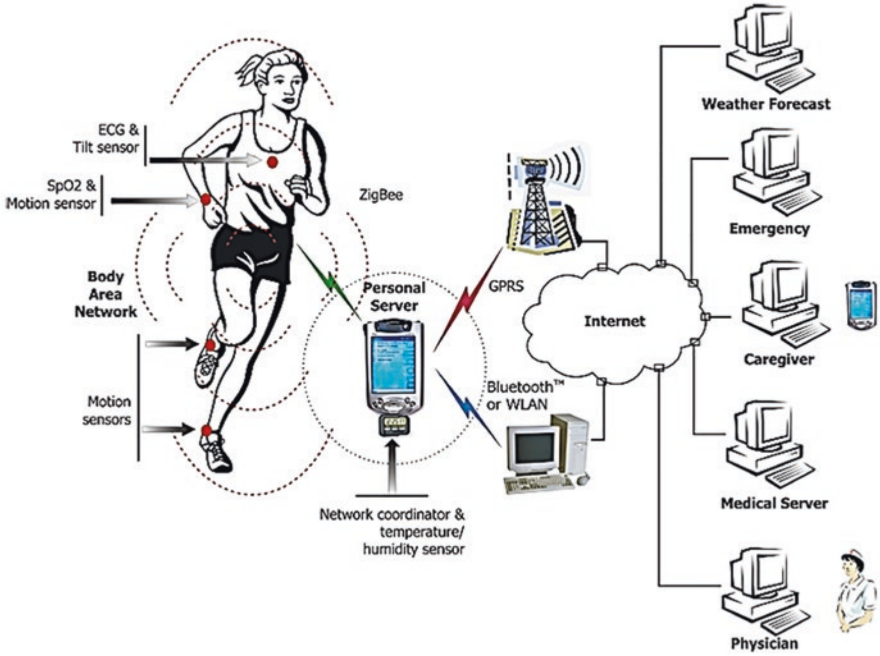

Fig. 7 WBAN architecture [42]

standards (Wi-Fi, Zigbee, etc.). Further data is transmitted to the medical server [41, 42]. The medical server then provides services to various users. The data is transmitted to the doctor from the medical server from where he can access the data from anywhere using the Internet. WBAN data is normally divided into three parts: normal data, emergency data, and on-demand data.

4.1 WBANs and Healthcare

Wireless body area network (WBAN) is a type of wireless sensor network (WSN) that has tremendous applications in the healthcare domain. Transmission of the critical health data must be prioritized over periodic ones to deliver it within the stipulated time. Further, as the spectrum is limited and fixed, there is a contention among users for its usage. The objective of this chapter is to maximize the system throughput by allocating the available bandwidth fairly based on the criticality of the data and mitigating inter-WBAN interference in a densely populated network by optimizing transmission power. We have mathematically modeled the problem as a Linear Programming Problem (LPP) and solved it using Particle Swarm Optimization (PSO). Simulation results show that the proposed solution converges quickly. It also outperforms 802.15.6 and other existing state-of-the-art algorithms in terms of throughput, packet delivery ratio, and retransmission of packets in high-mobility scenarios [2, 17]. Especially, defined from WSN, WBAN appears to be of much interest within these researchers [13–16]. The IEEE 802.15.6 standard gives a fast evolution of WBANs. WBANs constitute a broad scope of typologies of application accompanied by sensor nodes located on, near to, or inserted inside the body which calculate physiological symptoms. The developed small wireless sensors may help inhabitants as well as their stewards supply constant medical supervising, supervision of home applications, memory improvement, medical information retrieve, as well as urgent communication.

4.2 Protocols of Multi-channel

Various tasks inside productive protocols direct at featuring the issues of interference, huge traffic small utilization of channel, as well as inefficient energy, specifically in medical applications [18, 19]. To resolve issues, multiple access methods such as scheduling method or TDMA are introduced within particular modeled MAC protocols [20]. Even so, those are unsuitable for execution inside actual plot with proceeding within collisions at any time the WBAN topology replaces [33, 36–39]. Multi-channel perspective displays as a logical procedure to resolve the issues of interference as well as utilization of small channel. Also, within this outstanding evolution inside MEMS (micro-electromechanical systems) techniques and radio, sensor nodes are competent of accurately revolving their frequency above multiple channels. Generally, MC-MAC protocols are divided into four classifications at the basis of their concepts of action: common hopping [22], dedicated control channel [21], parallel rendezvous protocols, and split phase. SSCH (slotted seeded channel hopping) [20] is one protocol of scattered link layer Multi-channel Strategies Accurate for WBANs

After suggested MAC protocols observe one and only channel that emerges in interference issues, collision of channel and energy inefficiency. To solve these problems, various MAC protocols are raised inside WBANs. In [21], the author introduces an adaptive CSMA/CA MAC protocol for mitigating interference of inter-WBANs. The administrator begins an arbitrary back-off timer on the basis of its recognized interference level for mitigating collision probability. Viewing the multi-channel strategy is essential to reduce faults of one channel and suggests many MC-MAC protocols.

In [22], a multi-channel strategy is suggested for mitigation of coexistence for WBANs. This is reverse within small consumption of energy essential for sensors inside WBANs. [23] introduces one sole radio multi-channel TDMA MAC protocol in favor of WBANs utilizing one blend of mesh as well as star topology. Such actual sensor components prove that protocol may obtain a single small delay. The node accepts plenty of work. This will definitely speed up consumption of energy of nodes whose power is restricted as well as mitigate the entire network duration. According to the authors, the hub is accountable for coordinating those nodes that might be inculpated appropriately [25] explains a coherent method of management of multi-channel selected by one-to-one mapping among the beacon period as well as the data channel. Woefully, the channel allocation method is dull, and the access mechanism of coordination between the nodes is not supplied so far. In [26], Spectrum handoff strategy derived is for ignoring interference between concurrent WBAN with broadcasting as well as generating one table containing of nodes interfering. The dynamic resource assignment mechanism may certify the interference source for sustaining an interference tolerance level. Therefore, the strategy may reduce the interference of inter-tree, nodes on the basis of equal sub-tree have critical interference yet. In [27, 28], further multi-radio multi-channel mechanism introduces where each transmitting sensor node utilizes one specific channel whenever hub has multi-radio alliance. This enables for diminishing unusual loss of signal caused by immersion of electron beam waves inside interference, shadowing, fading and body fluid. Even so, this does not suggest some actual result for channel allocation scheme [33, 36, 39].

The faults regarding over-listening as well as restrictions of energy in CSMA/CA must be pulled inside deliberation. CSMA/CA is an allegation on the basis of MAC protocol. It attempts to mitigate collision; even so, it assists to problem of interminable inert hearing time as well as waste of energy [29]. The random access can propose a high detain whether load of traffic is long. Like the restriction of sensor battery capacity, more consumption of energy initiates an additional major problem.

5 Conclusion

Due to busy schedule, people do not have time to visit the doctor [41]. Sometimes, in case of emergency, doctors are not available. WBAN technology also helps the elderly population who are unable to visit the doctor regularly. An energy-efficient data routing protocol is of paramount importance for WBAN because biosensor nodes consume a considerable amount of assigned node energy for transmitting data to other nodes. A cluster-based protocol provides an energy-efficient data routing scheme with affordable data loss rates and network latency.

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Part III
Smart Education & IoT

Paradigms of Smart Education with IoT Approach

Dhirendra Pandey, Neha Singh, Virendra Singh, and Mohd Waris Khan

1 Introduction

The imparting and acquiring of knowledge through a holistic interaction between the teachers and the learners is perhaps the best way to define education, especially at the elementary level of education which begins in the school. There have been numerous changes in teaching-learning processes through generations. While the COVID-19 epidemic has ushered in a new era of online teaching and learning, the traditional method of learning was based on "Gurukul" pedagogy. The main ideology of Gurukuls was to transact subject knowledge along with instilling humane values for the overall development of the learner. The concept of Gurukul was followed where a teacher gives knowledge by reciting Vedas, culture, and behavior. Traditional education is the foundation of conveying knowledge using rudimentary tools. In schools and classrooms, teaching is done using preliminary equipment and tools like blackboard, chalk duster, textbooks, and assignments. In traditional education, the presence of the teacher in the classroom is compulsory, and students must enroll themselves. Taking physical attendance of the students daily was another key aspect for continuing the classes. No other source was available to gain knowledge. If students had not been able to attend the class, they would be deprived of basic education. This is the main reason many students do not get enough education. The classes in traditional education systems were instructed by a teacher who

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must also be present in a classroom to guide the students. The elementary goal of traditional education is to make capable the child so that they can fulfill their basic needs and survive in a society. In the conventional education system, students learn about culture, customs, and traditions of and how to live in a society. The pedagogical approach in traditional modes of teaching and learning was based on oral recitation with minimum written work and sessions mostly driven by teachers' lectures.

Then the education system transformed from traditional to modern. And the era of modern school has come with the introduction of smart technologies [1]. India has 130 Crores population, and with such a huge figure, lots of institutions are established regularly. However, despite the increasing number of institutions, literacy rate is still not that much achieved in many states. And this is all because of inefficient and less usage of technology. Hence, the effective use of technology is very important to convert schools into smart schools, and the exponential increase in population opens a prodigious room for smart education [6].

Before adding the concept of smart education, first it is important to understand the IoT in layman's term. IoT is an interconnected ecosystem with several interconnected computers equipped with sensors that sense the data of its environment of which it is stored, analyze, and then process in a device or a cloud. IoT gives the leverage to remotely controlled devices and monitor appliances. Today, the education that is provided schools is smart education, which is scientific and factual [3]. Modern education gives knowledge while also developing a student's skills in science, technology and medical. Digital and smart education uses a variety of tools like smartphones, smart boards, tablets, laptops, projectors, digital textbooks, etc. The presence of teacher is also not compulsory in a smart education system. Here, the focus is on smart audio and video tools. In a smart education system, the teacher is only a mentor who guides the students on digital tools, rears them to be independent for self-learning, and customizes the learning style according to students' preference [7]. Fig. 1 shows the difference between traditional and smart education.

Digital education learning system does not require the physical presence of the students in a classroom regularly. They can easily get equal knowledge from sitting anywhere in the world. Smart education gives flexibility to students, enabling them to learn from their own place. Besides the advantage of remote learning, students have the flexibility of repeating the lectures, learning at ease, and giving feedback as well as digitally connecting with the teacher-trainer at their convenient time. By this, they can easily create a suitable learning environment for them. Smart education is also less costly as compared to the hefty fee charged in schools. There is a large variety of courses available digitally that breaks the boundaries of the set syllabus that expands the learning range. Smart education gives multiple channels to communicate with the teacher instead of waiting for the teacher with their restricted schedule.

Smart education systems have numerous advantages over the traditional education system. And all the advantages can be implemented easily by using IoT technology. Technology has the power to transform the educational system as a whole. One such technology is IoT, i.e., Internet of things. The ecosystem of IoT consists of smart devices interconnected with sensors and communicated devices to share

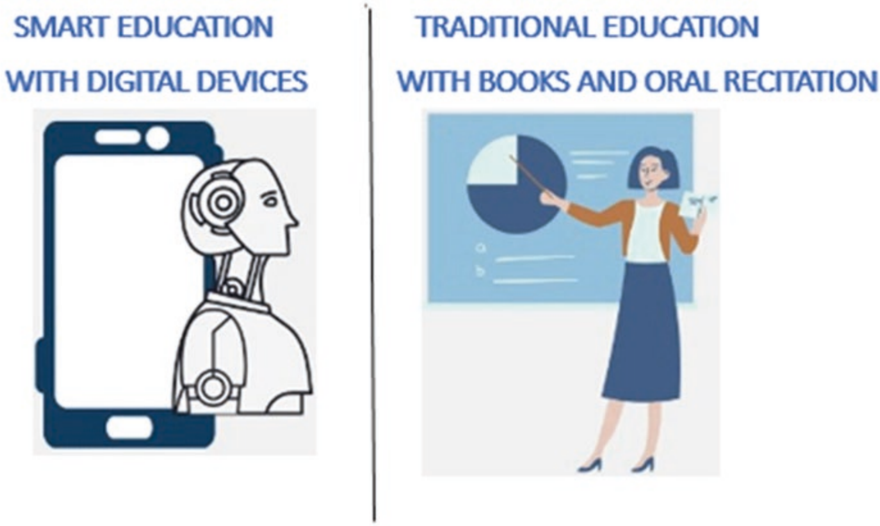

Fig. 1 Traditional education vs smart education

the stored conciliation data. IoT has the advantage of making work efficient and time-saving, enabling people to have full control over their lives [5].

Smart education when glancing from the lenses of IoT gives similar solution that increases learning and adds effectiveness. Classrooms can be remotely monitored and security of colleges and schools also increases. IoT helps track attendance and manage the strength of students in real time. Smart education is a set of technology-based resolution combined with several technologies such as artificial intelligence, cloud computing, machine learning, and other smart technologies with the excellence of engineering, making education affordable for all the students [4].

2 Meaning of “Smart” in Smart Education

Smart education is an expeditiously growing concept all over the world because of modern, smart, and unique technologies exponentially touching new standards. Technology makes education smart with interconnected and permeating intelligent designs. In recent years, with the advancement of technology, smart education has gained more attention. In education, the term “Smart” refers to intelligent, scalable, and engaging. The smart education system provides an intelligent learning environment and customized learning services which help students learn effectively and efficiently. There are many concepts behind the smart education that makes learning smart. Some of them are discussed below.

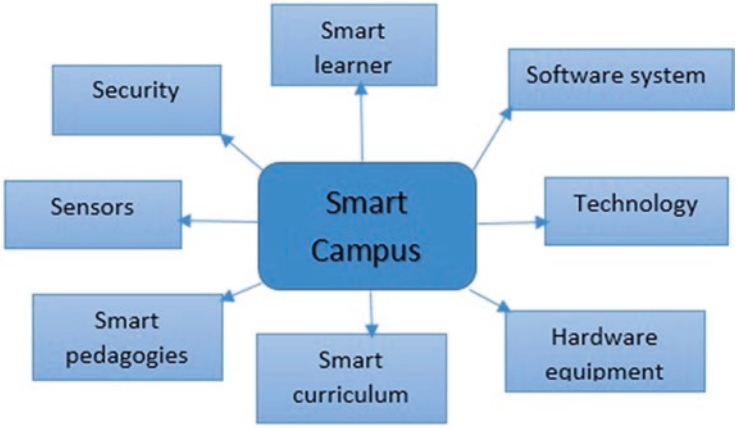

Fig. 2 Layout of a smart campus

2.1 Smart Campus

The smart campus is the result of two integrated technologies, i.e., Internet of things and cloud computing. Intelligent buildings are one of the major criteria that must be fulfilled to make a campus smart. Buildings that incorporate the best material, technology, Wi-Fi, health and fitness, safety, and security are called smart buildings. The incorporation of technology is the main backend network needed for both smart education and smart building systems. Massive sensors need to be installed all over the buildings to make it digitally enabled [2]. Pollution levels can also be controlled with sensors by measuring the correct amount of CO_2 present in buildings. The layout of smart campus is depicted in Fig. 2.

A complete monitoring of sensors will reduce human maintenance which automatically gives financial support to the entire organization. Interdependent collaboration is also needed in the campus for smooth flow of work [17]. For the building to be smart enough in communication and Internet connectivity, IoT provides many wireless devices that monitor and control the buildings automatically. IoT integrates artificial intelligence and big data. Big data handles the massive amount of data generated by the sensors. IoT provides digitization of assets to the whole building, and asset digitization influences the platform for real-time visualization in the cloud. Smart buildings are energy-efficient and use campus smart grids for solar and electrical power system. Water management and waste management are also featured in a smart campus [8].

2.2 Smart Learner

When the teacher uses smart and online devices to give knowledge to students and make learning smart by implementing IoT technology, it is called as smart learning. Smart learning is the process by which students learn with the help of online devices. In the traditional educational system, learning is defined as acquiring knowledge and understanding a topic. But as education moves toward smart education, the learning process has also changed into smart learning. Today, learning is not only confined to the understanding of the topic, but it is doing something skillfully in less time and by using less resources. The layout for IoT environment of smart learning process is shown in Fig. 3.

There are many organizations which separately run the skilled programs that meet the specific need of work. In-depth knowledge of the subject is a fundamental goal of smart learning. To do masters in any skill, first, the learning of core area is very important. Listening, reading, writing, art, etc. are the building blocks of smart learning. Smart learning includes the reasoning and comprehensive ability to think and solve critical problems that exist in the real world. The thinking pattern is changed in smart learning as it is more focused toward finding solution in minimum time [9]. Creative thinking and innovative ideas are given impetus and encourage students to build their world. Group studies done through digital learning become a means for fostering collective intelligence and collaboration with a diverse team.

2.3 Handheld Devices

Mobile and handheld devices are proven as a boon to students. By using these devices, IoT successfully senses data and provides topic-wise interests for students [10]. These handheld devices are used in numerous ways under the umbrella of IoT for smart education such as interactive smart boards, temperature sensors,

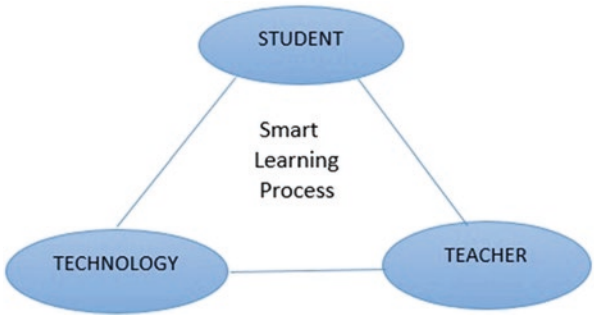

Fig. 3 IoT environment of smart learning

attendance tracking systems, security alarms for buildings, etc. These handheld devices relax the workload of teachers in different ways and increase efficiency.

2.4 Smart Tracking and Monitoring System

With the use of IoT, schools have implemented smart systems to track attendance of students and monitor their performance that offers the main benefit of reduction in redundancy [11]. The location of students can also be tracked with correct data. Biometric devices are very helpful in maintaining full attendance and strengthening security also. Final assessment also becomes very easy with digital records of students, thus saving time and physical workload of teachers and staff.

2.5 Smart Learning Environment

The traditional education system has been criticized for its rigid learning process and boring rules and regulations. But with the emergence of modern education and integration of technology, many fascinating phenomena come that enhance the environment of learning. IoT devices make the learning environment interactive and intelligent. The devices coordinate and communicate with each other without the need for people and give decisions based on their intelligence. Intelligent learning methods support institutions and students by making learning more personalized. An intelligent learning environment aims to monitor the progress of students and find their actual potential in individual fields. In a smart learning environment, many combinations of technologies are needed to build the whole system. In these systems, hardware and software are both integrated in a specified way. Hardware tools such as smart boards, mobile phones, smart devices, sensors, interactive boards, smart tables, etc. are used. Software tools such as online learning apps, video lectures, games, networking, visualization, etc. are used to build this model, i.e., IoT, machine learning, cloud computing, etc. With the combination of these technologies, the smart learning atmosphere creates a rich, soothing, customized, and best learning experience for students.

2.6 Smart Pedagogies

As the technology grows, strategies or pedagogies of using that technology also varies. In the education system, IoT implementation needs smart learning pedagogies to teach students with factual knowledge and in the particular domain. In traditional education, every student treats with the same content and learning atmosphere. But today, in the smart learning system, every student must consider with their background and their behavior and have different needs. Every student must give specific attention and specific strategies to make learning fast and effective. Classroom atmosphere is designed on the basis of the student's interest, learning level, and learning profile. Smart education focuses on smart learning and developing innovative thinking in students. So whether the education is given in a classroom or online, the learning atmosphere and pedagogy should be customized. The process of learning is modeled to cater to the needs of the individual students, their interests and background, etc. Hence, focusing on smart strategies is very important in the smart education system. Smart strategies must follow some of the basic learning stages. These include, first, class-based learning, where the teacher must define each student's task and lesson according to the student's interests; second, group-based learning, where two or more people, with similar interests, learn together; third, personalized learning, where each student must get content with their flexibility and motivation level; and last, mass-based learning, where students must handle real-world problems through their skills and problem-solving approach.

2.7 Increased Security

IoT and AI devices help the management and staff to maintain security of data and content of curriculum. Security is needed in all types of digital access such as attendance maintenance, exam paper, report cards, test series, content writing, teachers data, door locks, etc. In the smart education system, wireless network and Internet-connected devices are widely used [13]. So, security is the major concern for any institution. IoT provides security measures and protects wireless and Internet-connected data. With the automation and security protection IoT is no longer considered a futuristic technology. Today, automatic door lock systems and self-car parking facilities are becoming a common feasibility for any organization [18]. IoT critically examines the data and provides security, privacy, and safety all over the education system.

2.8 Smart Learning for Disable Students

Smart education and technology proved as a boon for disable students. Several devices are available, and research is ongoing to also expedite their learning. Hearing-impaired students can learn by converting audios and videos into written texts. The learning of sign language is also very easy with the help of IoT devices. IoT devices with the integration of artificial intelligence create a good atmosphere of learning for blind people. Smartphones with sensors and sensing apps can help the disabled know about their surroundings. There are many apps and devices that can be used to read facial expressions. In fact, the visually impaired can also be facilitated in their learning processes through such aids. Connected speakers and smartphone interfaces help the disabled in being self-dependent learners. Wearable IOT devices such as smart watches and smart bands translate signals into Braille. This allows students to learn fast and frequently. IOT devices have empowered the differently abled learners, to get educated in a smart atmosphere and smart environment in a speedy and effective way [19].

3 IoT in Smart Education

As the period changes, society moved from less data management to monitoring of big data. Technology day by day produces huge amount of data that is difficult to store and manage. So, before applying IOT in any application, first, it is important to develop a model for decision-making which handles big data generated by IOT [12]. IOT technology uses a large number of sensors that gather huge amounts of data. Thereafter, the data is segregated into two categories of good and bad data. The digitally connected world at present thrives on the utilities that are becoming smart. Information and communication technologies have changed the previous objects into smart objects. The education sector is also one of the booming sectors that utilize these technologies to enable fast communication between students and teachers. The IOT enhances education by introducing smart devices and personalized learning [14]. There are countless advantages of adding IOT in schools that encourage many institutions to add smart plans in their organizations; the concept of smart school by using IoT is shown in Fig. 4. IoT enhances the education system by using the following strips:

- Smart and digital boards.
- Handheld devices such as mobile phones, tablets, apps, etc.
- e-book,
- Sensors for analyzing temperature.

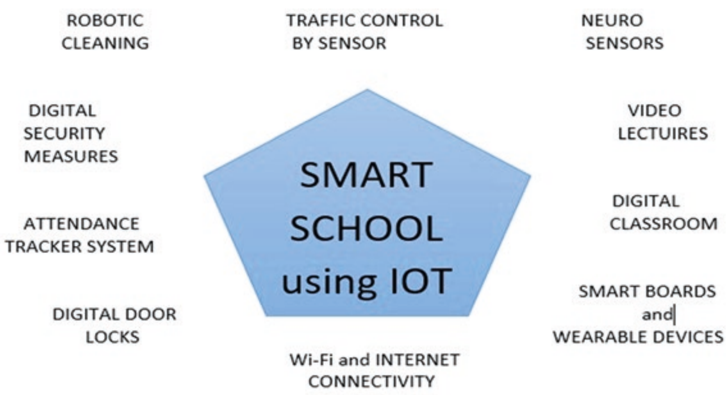

Fig. 4 Concept of smart school by using IoT

- Learning apps.
- Attendance tracking system.
- Communication between staff.
- Automatic door locks.
- Foster security system.

When applying IoT in schools, there are some important regions that should be considered:

- The design should be human-centered that helps students and teachers learn and teach in a smart environment. The requirements of students should be fulfilled by design.
- The methods used for learning should be personalized breaking down boundaries of specific learning, and students can choose course and subject by their own.
- Every school, university, and institution have a particular culture and working environment to follow. So implementation of IoT devices must consider about that.
- The foundation of smart education is its digital assistant and smart information technology. So exchange of data among students and teachers should be smart enough.
- Smart tools and devices should be modishly installed in the buildings.
- Security measures should be considered in a planned way because digital data has high risk about security.
- Reliable connection of Internet and wireless networks in the buildings.

The IoT will undoubtedly enhance the future of education. Students can learn effectively and efficiently. Similarly, teachers can also perform their work efficiently [15]. IoT devices are enjoyable for students creating an interest in subjects that previously look boring. Several IoT devices upgraded the process of learning by adding automatic tools and fantastic video lectures. An automatic attendance tracker can save time in class. The cleanliness and temperature of the classroom can be easily maintained [16]. The neuro-sensors can be used to sense the brain and IQ level of individual students that help teachers make the curriculum more personalized. Many wearable sensors are used for class and exam reminders and provide many health benefits also. Online tests and exams amplify the features of smart schools.

The introduction of IOT in education has been beneficial for students as well as teachers in many ways. The advantages include the following:

- All over the world, students can connect under one umbrella.
- With education anytime and anywhere, it cuts down the rate of transport and saves energy.
- A safe and secure environment will be provided to students.
- The process of learning will change from learners to creators.

4 Conclusion

Education systems are radically changed with the advent of the Internet and animations. The interactions of people on a virtual ground affect behavior and the learning process. The IOT has proven to be the best available technology for accomplishing the objective of skilled and effective remote learning, i.e., from anywhere to anyone. IOT aids can help in assessing and gauging the students' propensity, learning behavior, as well as abilities and needs. With a well-defined objective of catering to each student's requirements, learning modules can be planned, customized, and implemented in easy-to-use capsules in smart classrooms. Challenges such as cost-effectiveness, security measures, management control, physical presence of teachers and students, learning in physical classrooms only, etc. have also been contained effectively and gainfully by using IOT applications. IOT has a wide range of future applications in the education field. This chapter helps in understanding the basic concept of smart education and leads the way for more research to make a better environment for smart education system.

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Automated Electric Power Saving System in University Classrooms Using Internet of Things

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1 Introduction

The amount of energy consumed and wastage is expected to increase tenfold during the next years. Trying to reduce energy consumption may not be very successful; however, trying to control energy wastage can be. The idea behind this system is to control the appliances remotely hence allowing a valid user to save time by not having to access each switch physically and energy by using technology of the web application. Also, this application overcomes the problem where the user can themselves change the status of the appliance according to their will. Another thing is using the sensor which detects humans' presence and alerts users to switch off and on the devices (fans and lights) when signal reaches him while displaying in the web application about the room.

The basic understanding of the work here is the user is allowed to access the web application; once that is done, he is given the option of choosing one of the blocks of the college; once the user selects the block, there all the classrooms are identified; when the user chooses the desired classroom, all the statuses of lights and fans are displayed. Here the status displayed is whether it is being used or not, and the user is given the choice to change the status according to the presence of humans.

The objective of the work is to introduce a system in order to save power usage in the university. Another objective is saving power in the university by using

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effective and low-cost equipment which becomes highly demanding in a society where every individual can afford one. Another objective is to develop a web application to display information status about electronic devices in the university.

The purpose of designing a system is to save power usage in the university. Also, saving power in universities by using effective and low-cost equipment becomes highly demanding in society. The people responsible shall not physically go to each block and check each room to switch off the lights after the end of each class or end of the day. There is both software and hardware implementation used in development of the system which help control the appliances remotely using web application. A hardware connection is necessary which includes the use of sensor PIR (passive infrared sensor), NodeMcu, and relays, which reduces power usage; the cost of those equipment is less compared to other devices. This system can be very useful for schools, universities, and huge buildings including commercial offices and banks where excess of power consumption due to work negligence. Electricity is generated majorly by water and used in each part of the country. Water being a renewable source of energy is getting depleted day by day, and in the coming days, it may turn into a non-renewable source, making human existence difficult. Decrease in water production also decreases electricity generation, and as a result, the whole society suffers. Hence, reducing consumption of electricity as much as possible and switching off when not in use are very important points to follow. Even though people know this concept of scarcity of water and generation of water from it, still many people do not follow some basic ethics to reduce the consumption of power around them. Lack of accountability at present will affect the future generation and the environment. Therefore, this power-saving automation system development and usage in every huge building can save more than 75% of power daily, apart from small houses and offices.

2 Related Work

The Smart Home Automation System is designed to control various electronic devices of houses like washers/dryers, ovens or refrigerators/freezers, air coolers, and other devices [1]. IR, Bluetooth, GSM, and android were used. The appliances that need to be controlled are connected to a computer. The user must send a message to control switching on and off the device to the computer. The computer sends the command to the microcontroller, and the microcontroller controls the electronic devices. This system is practical, economical, and simple. Since the building has cement and concrete walls, the signal strength must be stronger to reach the appliances. So, the main drawback is that it requires equipment of higher cost and sometimes the wireless system would not be able to communicate properly. The computer that receives the signal should be turned on always, thus also wasting energy and would not serve any purpose.

A programmable logic controller that uses the Internet is used to control the temperature of water [2], recover heat from exhaust air, and control domestic appliances and other office appliances. This provides low-energy demand and security by using a firewall within the intranet to provide security. It is also scalable. The disadvantage is that high-level programming languages and automated testing are required. Since intranet and firewall are used, the cost for the implementation is very high.

Control of domestic devices like oven, refrigerators, heater, and computer remotely can be carried out by the use of telephones [3]. The system works as follows: any user with GSM and public phone can control the device. The user calls to the telephone, an opto-controller that is connected counts the number of rings, and the user enters a pin. If a valid pin is entered, the order provided by the user is carried out. This enables the user to control the appliances from any part of the world. The drawback of the system is that the pin check algorithm that is implemented needs a cable network; hence, the system is not wireless.

In [4], the author has developed a system to provide computerization and security by using Android ADK to the old individuals to help them control the home devices. It facilitates the old people who cannot move whenever required by helping them remotely control the devices.

In the proposed system [5] uses a Wi-Fi to connect various applications that come with easy installation, deployment, and coverage and also are scalable. And, those mobile devices can be used to control irrespective of the location of the device. The drawback is that the cost of implementation is more.

In [6], the author proposed a prototype which analyses body movements by inertial sensors worn on the human body. In this proposed model, predicts what activity the info information is from which sensor. The job of distinguishing persons in salvage tasks is hard for the automated specialist; however, it is direct for humans [7]. Compared to humans, a robot must be outfitted by a particular arrangement of sensors that give data about the person around. The robot-based framework will sense the radiation of person and condition the detected sign to convey to the control area of this robot. In view of the reacted directions, the robot will respond upon. The disadvantage of this system in its application in the university level is that robot maintenance is required by experts.

In [8], the author proposed a robotic system that detects human movements by moving in all direction, and it is automated to move in every direction when obstacle occurs. This robot uses the PIR sensor which detects heat produced by humans and notifies the user by the continuous buzz. This is used in homes to detect robbers and other frauds. This system cannot alone be used to detect and control the appliances.

Indirect detection of human presence using IOT devices and machine learning approach is designed which doesn't use sensors to actually detect humans, rather uses the interaction among the user and the devices to collect data, interpret the pattern using algorithms, and then provide the signal [9]. Precision recall accuracy methods are used in order to check whether detection is accurate. All these methods make the power-saving system complicated.

In indoor human presence detection, the method for device-free human presence (DFHP) [10] detection is carried out by reducing installation complexities by adding sensors to it. The strategy misuses the way that humans meddle with radio signs, affecting blurring and impacts of shadow.

In [11], the author designed a system for detection and tracking of humans using grid eye sensor. It is an infrared thermopile array sensor which detects humans in place. This sensor tries to overcome the limitation of PIR sensor which detects the human in motion. This design can be useful in applications where automation is used, providing full security, medical, etc. The sensor works on the temperature released by humans, and human tracking movement is done by Kalman filter.

In [12], author designed and implemented the real-time smart home automation system. There are two hardware components used such as PC associated with lab view platform, and another is Arduino board. All the devices are connected to it. Along with these devices, there are three sensors used like temperature, motion detector, and security camera for recording object action. This system uses many features, and all are not necessary for the power-saving system.

The author proposed a system that gives the role of smart homes in healthcare and intelligent home care units. The word smart home concept is used in healthcare in order to respond to and adapt their behavior among objects [13]. This system when used in old age care units will be very useful since the smart home concept will help elderly people interact with the objects sitting in one place. Also heath status can be closely observed if daily data is being collected and automated. The disadvantage of using this type of system in the university is not necessary because there is no need to study the behavior of each person in the room.

In [14], author proposed a home automation system that controls home attributes. The system uses a three-level household energy system to control the maximum use of energy resulting in human satisfaction. Using the scheduling algorithms, the set points of the equipment are noticed and solved. The mechanism makes the system more flexible in controlling the power. Each level has the equipment layer, protection layer, and expectation mechanism to set the points of the devices taking future requirements.

In [15], author designed a home automation architecture for comfort, security purposes, and resource saving at home. This model uses Zigbee and is designed to control four home attributes like light intensity, shutters, gas leakage detection, and irrigation. It has a brain which monitors the remote modules. The user interface is created using Visual C# so that the user can check the functionalities of the system. The results obtained here prooved the comfort level, the irrigation shutters and light intensity maintenance shows the saving of resource. The gas leakage detection proves its security function.

In the proposed system, [16] detects the facial expressions for automating home devices. The system used some of the facial expressions, and feature is extracted using some models to evaluate the performance. Then classification is done using the algorithm called SVM. After, the output will be connected to each appliance physically, and the special character according to the classified output is given to the microcontroller. Lastly, the device performs the necessary action.

In [17], the author designed a smart home using voice control over it. It used a voice xml-based approach. The system is intelligent to identify the voices from the user and then monitor the devices in the home. In [18], the author proposed a system that follows the process of mobile sensing for detecting user behavior without waiting for the user to actually give the commands. Two sensors have been used which are android sensors, for instance, accelerometer sensor and magnetic field sensor. The work depicts [19] the utilization of understood PC applications to empower keen home clients to screen and control their homes utilizing altered documents. Middleware written in AppleScript and Perl CGI was utilized to incorporate PC applications with the OpenWebNet convention utilized in home computerization. The occasions activated by the applications are effectively logged by web and mail servers to encourage analytic activities and authenticity.

The smart attachments [20] are progressing in a way to better deal with the highlights and accommodation offered by the current switchboards. Highlights like clocks which have equal effort in both modes like program and manual, security perspective using observation and facial acknowledgment, overburden, and utilization logging with the assistance of the present sensor are given. The information is likewise confirmed with the real signal reading device for precision. The information so assembled can likewise be utilized for expectation utilizing AI. Framework initially orders different sorts of simple meters.

In [21], the authors developed a system which is automated and saves power intelligently at the same time providing security to the home. The sensor used is passive infrared sensor. The system includes both resource saving and security purposes. The fundamental activity of the unit is that when an individual passes around the sensor, it identifies the radiation of the body produced by that person, and further actions continue. The activity change depends on the position of the switch. Then the alarm beeps for security purposes. The same device provides features which are multifunctional.

In [22], the authors work on home automation using DCS technology. This work introduces the home computerization prototype. The design has hubs that incorporate an alarm which beeps when smoke is detected, entryway sensor which detects people, entryway exit, many sensors for temperature detection, air cooler, movement identifier, caution board, shade control engine, light intensity controller, and hand-held controls. In this proposed work, additionally exhibits the product perspective which utilizes the NeuronC and how the hubs communicate each other by utilizing the creation of system variables.

Automated Object Detection and Tracking [23] apply an operator way to deal with remote sensor arrange to develop a circulated, computerized scene reconnaissance. A remote sensor organizes utilizing visual hubs as a structure for building up a scene understanding framework to perform keen reconnaissance. Current techniques for visual observation rely upon profoundly train staff to distinguish suspicious action. Be that as it may, the consideration of most people debases following 20 min of assessing screen screens. Subsequently present observation frameworks are brief to disappointment. In this work, a mechanized item discovery and the following was created to fabricate a solid visual observation framework.

In [24], the authors introduced a method that compares three camera-based methodologies for human discovery with regard to individuals tallying. Then exhibition is broken down with regard to various camera directions, thickness of individuals, lighting conditions, and impediments. Its exhibition within the sight of impediments is generally excellent and consequently makes it a decent possibility for such applications. Furthermore, utilizing a RBF improves the presentation than utilizing a straight kernel.

In [25] author proposed a model which does the positioning in the wireless sensor network for human sensing problem. This method uses wireless network based sensing the humans. Along with that crowd dynamics monitoring is analyzed for the humans. This method also considers the noisy data and processes the data. The physical principles of interaction between humans and sensor network.

In [26], the authors proposed a model that detects the activity in a smart home environment. It uses two approaches for detection of activity. The activities being checked for entry and exits from a room, can be utilized in applications which screen the prosperity of individuals (Surrounding Assisted Living applications, AAL), in HVAC (warming, ventilation and cooling) applications for checking and directing the temperature of the room, for guideline of lighting frameworks, and so on. The calculations were tried disconnected, on static informational index, and online progressively.

In [27], the authors developed a system which detects human pace using radars. This system approach uses a radar which is automated for following the objectives and a different Doppler radar which gives the extra data regarding the classes of the objectives. The arrangement of items for people depends on investigation of the Doppler range of focuses just as the speed of the objectives increased through the following procedure.

Human discovery expects to screen how individuals are moving in a territory of intrigue [28]. In this work, the authors propose to use Freesense, a novel Wi-Fi-based methodology for human identification. Not quite the same as past investigations that describe the variety of fleeting remote flags or ascertain the deviation of Channel State Information (CSIs) from an ordinary profile, it recognizes human developments by distinguishing whether there is any stage distinction between the sufficiency waveforms of various getting reception apparatuses. Furthermore, additional model is used for detecting inclusion for developments of various granularities in open space and propose a strategy to gauge the coverage range.

3 Proposed Methodology

In this section, the hardware components mentioned are connected as shown in the below block diagram. The block diagram in Fig. 1 will explain about the proposed system and connection between all the components used.

Figure 1 explains about the proposed model where there is NodeMcu, relay switches, power supply, relays connected to appliances, PIR sensor connected to NodeMcu, and PC to use the web application. The working status of appliances connected to relay is controlled using a webpage via Wi-Fi.

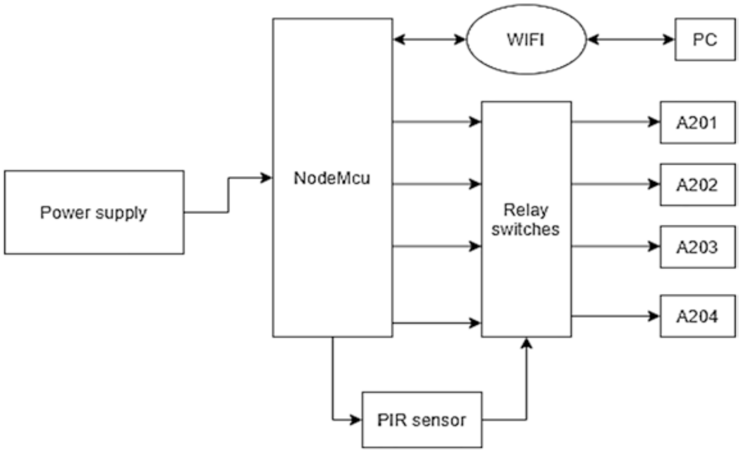

Fig. 1 Automated electricity power-saving system in the classroom

The proposed model of the classroom automation system is showcased in Fig. 1. The assumption made here is each bulb used in the hardware is considered as one room with lights. The blocks are named after the room numbers like A201, A202, A203, and A204 as shown in the figure. NodeMcu is used since there is a built-in Wi-Fi module. NodeMcu is connected to the power supply. The power supply can be a DC voltage or just a battery to implement the model.

The PIR sensor is connected to the NodeMcu, and the output goes into relay switches. Many relays with many channels used for different rooms or blocks can be used. The people will be detected, and the respective classroom signal notifies the user to switch off the lights by checking the notification on the webpage. During the point of entering an individual, it checked the locale, the infrared vitality came from the person engages by a focal point, covering a segment on the piece as shown in Fig. 2, which had recently been taking a look at a lot cooler purpose of the secured district. The part of the chip is currently a lot hotter than prior. When there is movement observed, the point on the outside also moves. The PIR sensor mechanism can also be understood by looking at Fig. 3, which is a flow chart that represents what actions should be taken when the sensors sense the classroom.

All communication and controls in the proposed system will pass through the node CU. Using Wi-Fi, a connection to PC and the hardware is made. The connection to the software is to display status of lights whether it is on or off on the web page.

3.1 Algorithm Used for Implementing the Model

- *Start*

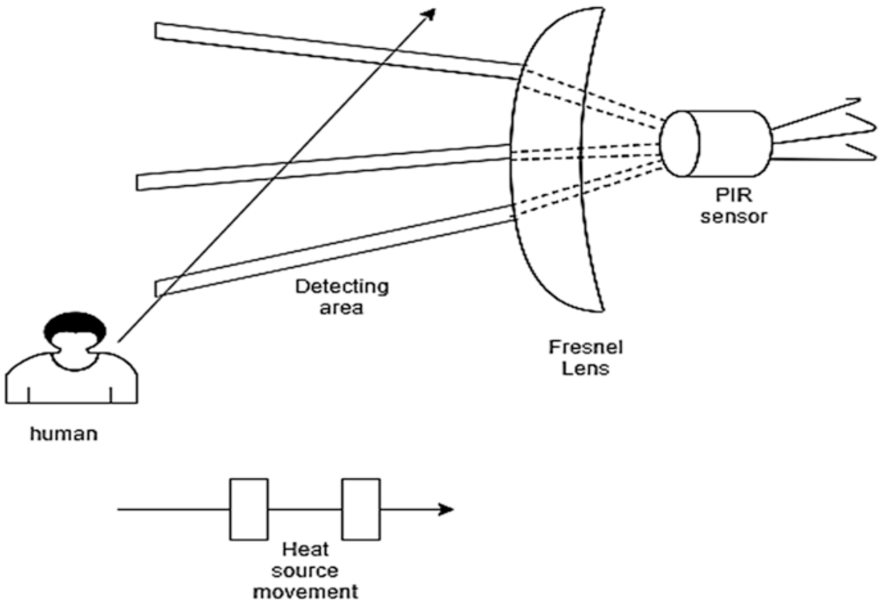

Fig. 2. Operation of PIR sensor

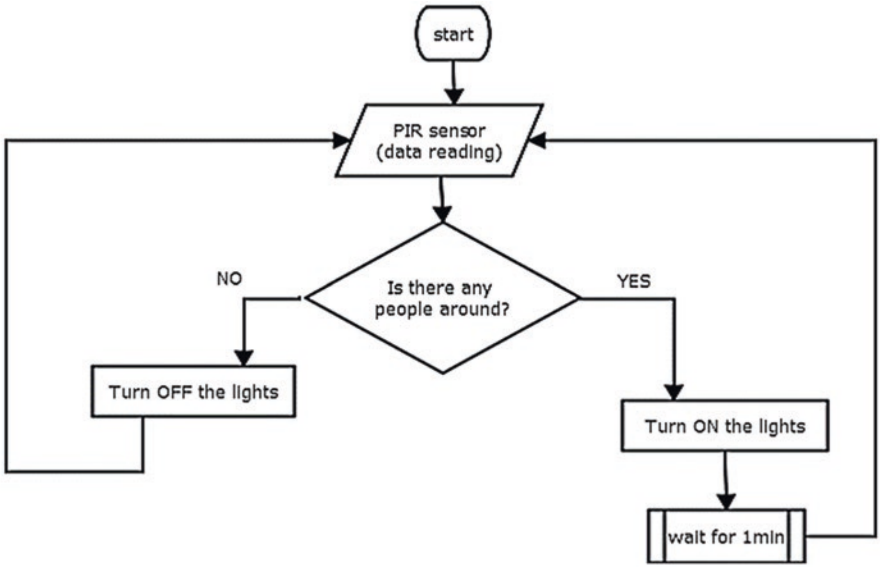

Fig. 3 Flow chart showing PIR sensor mechanism

- Initiate the model.
- Read the people as input to the sensor.

  For any number of people in the room, switch on the lights, and keep them on until there are people around.
  Wait for few seconds to switch off the lights when sensor has not read the data (people).
  Then the data must be updated in the web application which contains all the information about the rooms' appliances.
  User takes necessary action in operating the appliance.

- Repeat the process if necessary.

• *End*

4 Results and Effectiveness of Proposed Methodology

The system is highly efficient by "63%," and this can be proved here by comparing power consumption without using the power-saving automated system and with using the same system. The electricity units and calculation are done according to the taluk tariff [29].

A classroom considered in a university has ten tube lights with good wattage control that is of T12 type, which consumes 28 W per hour. And if the tube lights used are of type T8, they consume 38 W of power. In the esteemed educational institute like MSRIT, there is also goal of saving power, so efficient tube lights are used. Let the tube light of type T12 is used and the number of fans used are 5 consuming 75 W of power per fan.

The unit consumption and the rate fixed for those units according to Karnataka state are given in Table 1.

In Table 2, without using the system, power consumption and cost are observed per hour, per day, per month, and per year. 1unit = 1kWhr.

The power consumption and units used after the system has been implemented in the university can be observed in Table 3; whenever people are not in the classroom, at least 5 h' power will be used. This is said because, during the full-day timetable, people will come and go as usual, and there can be less usage and consumption of light when lights and fan are switched off.

Table 1 The tariffs according to Karnataka

Karnataka (tariff as of 30 May 2019)	Slab low	Slab high	Rate in rupees
	1	30	3.75
	31	100	5.2
	101	200	6.75
	201	Above	7.8

Table 2 Power consumption values without using the system

Appliance	Per hour power and units consumed	Per day (8–10 h) power and units consumed	Per month power and units consumed	Per year power and units consumed
1 tube light	28 W	224 W	6720 W	80,640 W
28 W	0.028 units	0.224 units	6.720 units	80.64 units
Fan 75 W in 1 room	75 W	600 W	18,000 W	216,000 W
	0.075 units	0.6 units	18 units	216 units

For 1 month, calculation of electricity cost would be:
Rupee per unit 3.75–5.2 rupees
6.720 units * 5.2 = 34.944 Rupees
For 10 bulbs in a room = 349.44 Rs
For 100 rooms in the university = 34,944 Rs

Table 3 Power consumption values using the system

Appliance	Per hour power and units consumed	Per day (5 h) power and Units consumed	Per month power and units consumed	Per year power and units consumed
1 tube light	28 W	140 W	4200 W	50,400 W
28 W	0.028 units	0.140 units	4.2 units	50.4 units
Fan 75 W in 1 room	75 W	375 W	11,250 W	135,000 W
	0.075 units	0.375 units	11.25 units	135 units

For 1 month, calculation of electricity cost would be:
Rupee per unit 3.75–5.2 rupees
4.2 units * 5.2 = 21.84 Rupees
For 10 bulbs in a room = 218.4 Rs
For 100 rooms in the university = 21,840 Rs

In the next section, the results are shown in terms of plots to identify the results with and without using the system in use.

Figures 4 and 5 show two different plots on how power consumption is deviated or reduced when the system is being used and without using the system per month of the tube light. In the comparison chart, we can observe the reduction of power consumption while using the system. The deviation is seen after the power consumption is raised to use after months while during the day and hourly consumption deviation or reduction is not much.

Figures 6 and 7 show how power consumption in units is deviated or reduced with the system being used and without using the system. In the comparison chart, we can observe the reduction of the power consumption while using the system. The deviation is seen after the power consumption is raised to use after months while during day and hourly consumption deviation or reduction is not much.

Therefore, there is approximately 63% reduction in power consumption and cost when the system is being used by the university. This could be even made possible when the people in the class take initiative to turn off the appliances whenever they leave the class.

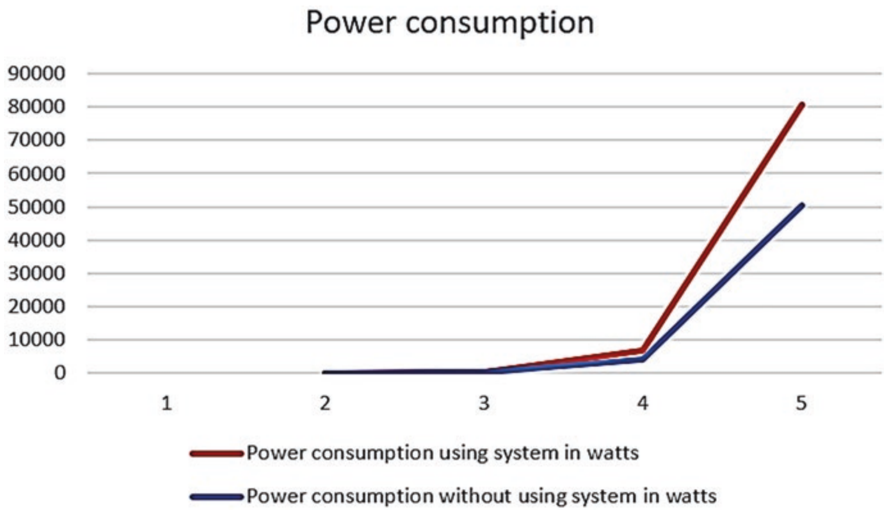

Fig. 4 Deviation of power consumption of tube light in terms of watts

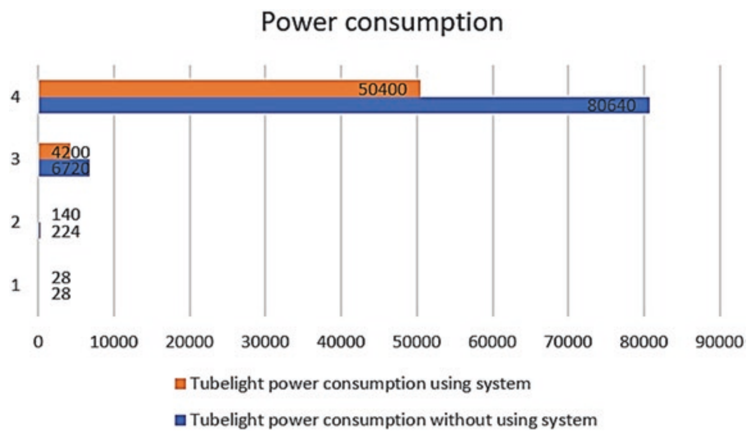

Fig. 5 Deviation of power consumption of tube light in terms of watts

5 Advantages, Disadvantages, and Applications of Using Proposed Methodology

Advantages

- The main purpose of the system is to save power in universities. It is energy efficient.
- This system works through a web application which will be easier for users.
- The application works remotely not needing the user to manually operate the devices in each room.

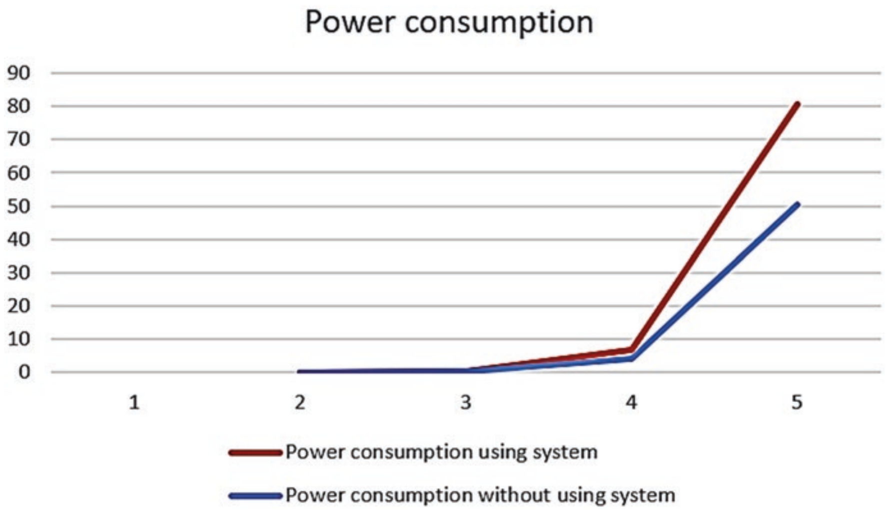

Fig. 6 Deviation of power consumption of tube light in terms of units

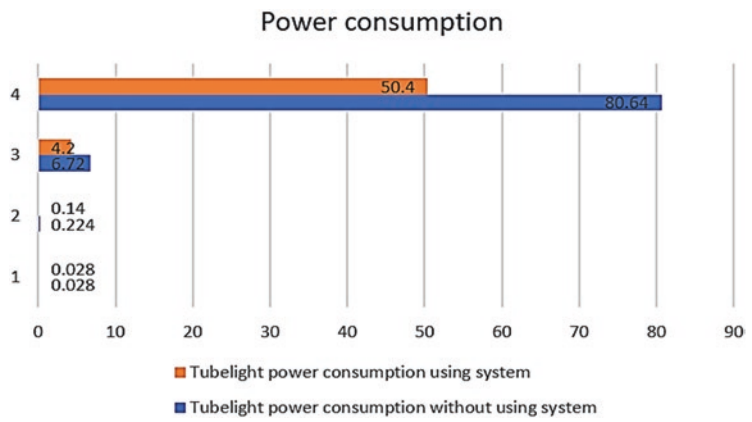

Fig. 7 Deviation of power consumption of tube light in terms of units

- The equipment used are easily available and cost-effective.
- A sensor is used which detects humans and sends signals to the user via the application.
- The system is automated, meaning the devices can be controlled from one place.
- The system is flexible for new devices in the rooms. That also includes replacing the faulty devices will not affect the operations of other devices.
- PIR sensor is small in terms of size, and it can be fixed effectively with any device.

Limitations

- The system can only switch on and off appliances but cannot control light intensity.

- The system cannot control the projectors in each room.
- The corridor lights are not controlled in this system.
- The system cannot be used to control PCs used in labs.

Applications

- Common restroom, for lights and exhaust fans: The system works through the PIR sensor which alerts the user when people are present, but there is simply wastage of electricity.
- Common staircases: the system switches on or switches off the lights when necessary. The switches may be somewhere present to make sure that the lights are *on* when necessary.
- In the parking area: the sensors could alert security and then the lights are switched *on* when someone enters the parking area. If the person is not the owner of the vehicle, then further actions can be taken.
- For garden lights: park lights are switched on and off automatically on schedule.
- For changing rooms in shops: the light switches on itself when a person enters the room and remains so even if someone has been locked inside, making it easier for security persons to check the rooms when necessary.
- For corridors: In malls or any corridor space, the system can be helpful in monitoring unnecessary use of electricity when people are not there, therefore, automatically switching them on in places where people use it more.
- Library and museums: here the system may not be so useful but in every portion of the room is installed it is very helpful for the users rather than the people in the area.
- Safety locker room in banks: the system can be used both to save energy and for security purposes. If any intruder enters the rooms, it alerts the user by switching on the lights during non-working time, alerting as well the security person to take further actions.

6 Conclusion and Future Directions

6.1 Conclusion

This section contains the summary of the system that has been implemented. The purpose of the system, how the proposed model was carried out, and the merits and improvements are being discussed. The system is developed to minimize the wastage of electricity in universities. The aim of the system was to develop a web application-based controller to monitor and control various electronic devices remotely. This model gives an idea of controlling electrical appliances like tube lights and fans remotely using the developed webpage. A literature survey was carried out by referring to conference papers about automation of homes and buildings to understand the implementation of the automation system.

The model consists of both the software and hardware. The software part consists of the webpage development and the code for the microcontroller – NodeMcu. The Arduino IDE 1.0 software was used to code for the microcontroller NodeMcu 1.0ESP 12E module. The hardware part consists of microcontroller NodeMcu 1.0ESP 12E module, 4-channel relay, bulbs, two-way switches, connecting wires, and adapter and jumper wires. These components were connected as per the constructed circuit diagram. The hardware and software components were integrated to obtain the final working system. The power consumption and cost are also calculated to get the absolute percentage to reduce with and without using the system.

6.2 Future Directions

The system can only switch on and off appliances and can be made to control light intensity. It can be made to control the projectors in each room as well as corridor lights. The system can be used to control PCs used in the labs. This work can be implemented in real time, and then the whole university can be controlled in an automated way. Not only in universities, but the work can also even be extended to residential buildings and government offices all over India, thus making it a less resource consumption country in the years to come.

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Part IV
Smart Banking & IoT

Smart Banking in Financial Transactions of Migrants: A Study on the In-Migrants of the Gajapati District of Odisha

Sanjaya Kumar Sahoo and Sukanta Chandra Swain

1 Introduction

Migration in India is ordinarily out of necessity. People do migrate for any or all of the following: to having a decent earning that will fetch them enough financial strength to maintain a reasonable living, to pay off past debts (if any) and to provide quality education to their children which they were unable to have. As people migrate, they start earning regularly and keep accumulating money for personal purposes. Hence, the role of banking system in the life of migrants comes into picture. After meeting the cosumption expenditure, if any surplus income is left out, migrated people save that surplus amount either with the bank or post office. In fact, savings may happen to become zero very often, owing to the pressure of sending money to family members or near ones staying in their native places. In conventional financial system, to deposit money, they were to go to bank branches and spend hours on queue. When it comes to sending money to dear ones at their native places, they either send cheque or draft or money order. However, all these modes are time-consuming, often resulting in frustration and hence preferring to carry cash upon return to their family during vacations. The advent of smart banking, i.e. an agile conceptualization meant to serve the customer in a virtual manner with the help of Kiosk branches or smartphone, has the potential to address all difficulties faced by migrant workers. It caters the opportunity to deposit, withdraw and transfer money at the customer's doorstep with self-service mode. However, it's to be ascertained whether migrants do have access to smart banking. Furthermore, it is also to be ensured whether migrants do avail the facilities embedded in smart banking and their experiences in availing the services of smart banking.

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People move from one place to another place to earn better income despite facing so many difficulties like loneliness, unhealthy atmosphere, eating substandard food, etc. Despite these difficulties, people earn income to provide for their families back home. They send remittance to their native place out of their earned income after meeting their own expenditure. Before sending the remittance, they generally save their income either at home, in the bank or in the post office. After keeping a lump sum amount, they send the saved money to their families through different modes like depositing in their bank account, remittance through friends and relatives, money order, Google pay, etc. Family members receive the money more or less in the same process and utilize it in various ways like paying past debts, allowance for special occasions, education of the children, etc. In this way, the banking sector plays a prominent role in financially linking migrants with their family members. In the modern era, the banking sector is revolutionized by developing smart banking to provide doorstep banking service. Smart banking is an intelligent approach to serve customers virtually with the help of Kiosk branches or smartphone. Now, with the help of smartphones, migrants and their family members can send and receive remittance in a fraction of a minute in the comfort of their homes. The Government of India has also initiated so many measures for financial inclusion of the marginalized section of the society like migrants. But different studies, observations, mass media and social media show that migrants are unable to fully utilize the advantage of smart banking. Still, there are some migrants and family members who do not own a generic mobile phone, let alone a smartphone. Further, smart banking will not be useful without proper Internet connection. Among different backward districts of Odisha, the Gajapati district is one where 55% people are tribal, 45.44% are literate and nearly 40% people are in-migrants for different purposes. Hence, this chapter tries to find whether migrants in the Gajapati district of Odisha really benefit out of smart banking.

2 Review of Literature

Mobile phones are being used by people to make use of banking facilities. M-banking/M-payment systems have immense potential to dominate the banking/payment industry. Three important aspects such as amplification vs. change, simultaneous causality and a multiple dimensional definition of trust urge for future research on M-banking/M-payment system [1]. Even though migrants are the pillars of growth, their mobility generally took place because of survival. They face problems of financial inclusion, social security, etc. Financial management practices of female migrants are precarious as they mostly depend on money lenders for loan. It is inferred that financial inclusion will benefit the female migrants a lot [2].

Remittance is the main source of external finance, but the cost of sending it is very high. It is identified that illiteracy is the main hindrance in the initiative for reducing this cost. It is also found that the different training programmes in this field do not bring significant fruitful results [3]. On the basis of a randomized experimental study conducted in Indonesia, it is found that the training programme to both migrants and family members has a large and significant impact on knowledge, behaviours and savings. Training only to family members has little effect, and training only to migrants has no impact on the family member [4].

It is found that women migrants use their social capital in supporting the family. Contribution of migrants increased family income of the male member from 12% to 98% and that of the female member from 7% to 82%. In the male migrating family, decision-making power is transferred to the female member [5]. Circular migration is found among the poor people of the society. It is found that because of the defect in policy implementation, migrant workers are suffering immensely [6]. As most of the migrants are unable to fill out the Know Your Customer (KYS) form, they are deprived of banking facilities. This leads to increasing cost of sending remittance. Further, they rely on informal ways of transferring money [7].

The study on the reaction of the household of migrating Filipinos to an economic shock finds that during the 1997 Asian financial crisis, countries experienced a sudden and heterogeneous change in their exchange rate. Migrant's currency appreciates against the Philippine peso, and hence their remittance status increased. This leads to enhancement in human capital accumulation and entrepreneurship in their native country. Further, education of the children increased in their native place and child labour declined. Self-employment of the household also increased [8].

On the basis of the study on how psychology guided information influence the borrowers for using high cost debt at a lower rate, it is found that people are borrowing less when the information makes the people think less regarding the finance cost [9]. The study analysing the experience of the migrant on immigrant incorporation shows that class and racial exclusion influence the immigrant incorporation negatively. Further, it shows that incorporation and transnational participation are interconnected. It concludes that gender plays an important role in immigrant incorporation. Even though men and women experience similar things in many things, they are affected differently in many ways [10].

Remittance helps for the accumulation of wealth and creation of asset by providing minimum consumption needs to the household. So, here, priority needs to be given on how remittance can be utilized in a more productive manner [11]. Latest research on migration, gender and remittance has a different behaviour which creates so many question. So the chapter suggests a complete theory by including the concepts of cultural dynamics. The study suggested for the measurement of network [12].

The effect of remittance on economic growth may be direct or indirect. It is found that an indirect effect of remittance on education is positive, and the direct effect of remittance on economic growth is negative [13].

A study on time series data from the year 1970–2005 finds that remittance has an impact on the growth of the Turkish economy. Regression analysis shows that even though remittance flow is meaningful in the country, it has a negative impact on economic growth. However, export and domestic investment have positive effects. But Foreign Direct Investment has no meaningful effect on economic growth [14].

On comparing wealth holding and financial literacy between two groups, i.e. planners and non-planners, the study finds that at the time of retirement, planners have more wealth and financial literacy as compared to non-planners [15]. As household behaviour is difficult to measure and constraints cannot be captured in a textbook model, household finance is challenging. Different evidence shows that maximum households invest effectively and very few make significant mistakes. These few people are more likely to be poor and uneducated. Further, a different study shows that people understand their mistakes and later rectify it [16]. A study on nearly 7000 retirement accounts from the period of April 1994 to August 1998 finds that most of the asset allocations are extreme and there is inertia in asset allocations. The study shows that equity allocations are more for two categories of investors, males and married investors, but less for older investors [17].

3 Objectives

The objectives of this chapter are as follows:

(i) To assess the availability and accessibility of smart banking facilities to migrant workers staying in the Gajapati district of Odisha.
(ii) To unfold the experiences of migrant workers staying in the Gajapati district of Odisha on smart banking.
(iii) To suggest how benefits of smart banking can be better utilized by migrant workers staying in the Gajapati district of Odisha.

4 Methodology

To achieve the above objectives, the methodology followed is mentioned below:

(i) To assess the availability and accessibility of smart banking facilities to migrant workers staying in the Gajapati district of Odisha, it is necessary to identify the migrants. Then a structured questionnaire is prepared about the mode of sending and receiving remittance at the originating and destination place, whether people are aware on the existence of smart banking, whether people own an operating smartphone, how they are enquiring their balance, how they are recharging their mobile, etc. After that, primary data are collected from 50 in-migrants staying in the district. Finally, the collected data are analysed through a statistical tool.
(ii) To unfold the experiences of migrant workers staying in the Gajapati district of Odisha on smart banking, it is necessary to identify the migrants. Then a structured questionnaire is prepared. After that, primary data are collected from 50 in-migrants staying in the district, and lastly, the collected data will be analysed through a statistical tool.

(iii) To suggest how the benefits of smart banking can be better utilized by migrant workers staying in the Gajapati district of Odisha can be opined on the basis of the primary data collected. Further opinion of the experts will be taken into consideration.

5 Availability and Accessibility of Smart Banking Facilities to Migrant Workers Staying in the Gajapati District of Odisha

To assess the availability and accessibility of smart banking facilities, samples have been collected near the Paralakhemundi area of Gajapati District of Odisha. Out of the 50 samples taken, 20 of them are government employees, 20 are private employees and 10 of them are working on daily wage basis in different informal sectors. All of them are in-migrants to the district. The following information is collected from them.

Figure 1 shows that out of the 50 samples considered for the study, 5 people earned less than Rs. 10,000. Similarly, the income range of 11 people are in between Rs. 10,000 and Rs. 15,000. Further income of 10 people, 12 people and 12 people are in between Rs. 15,000 and Rs.20000, Rs.20000 and Rs.25000 and Rs. 25,000 and more, respectively.

Figure 2 shows that out of the 50 people, 40 people are receiving their income through bank transfer, while 10 people are receiving through cash.

Table 1 shows that out of 50 respondents, 45 send their surplus income to their relatives, while 5 do not sending any income to anyone.

Figure 3 shows that out of 45 people, 2 send through bank transfer when they visit the branch, 34 transfer money through e-banking, 1 person send money through money order, another one send through any person who visits and 7 persons carry money when they go to the village.

Table 2 shows that all people taken for study save their surplus income.

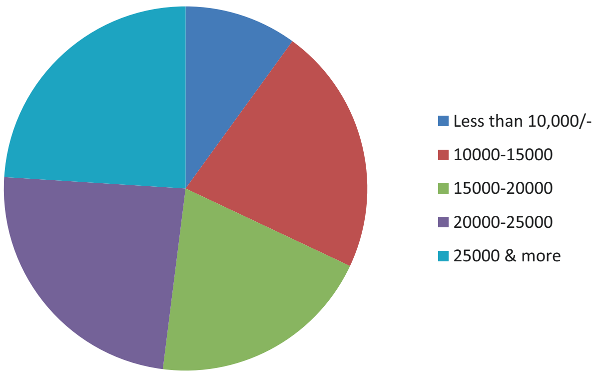

Fig. 1 Average monthly income of the sample

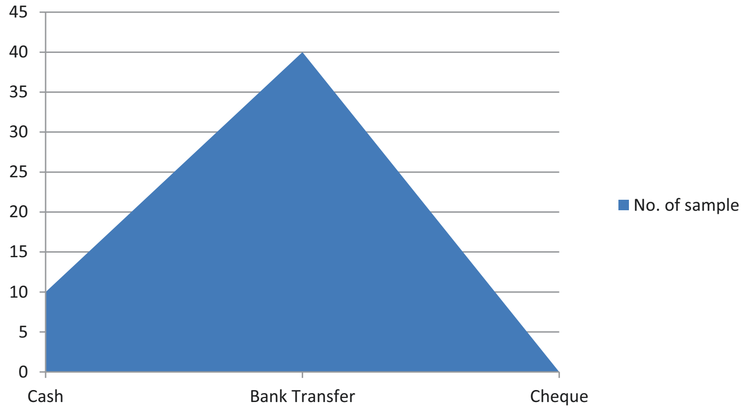

Fig. 2 Mode of receipt of income

Table 1 Send money to near and dear ones

Yes	45
No	05
Total	50

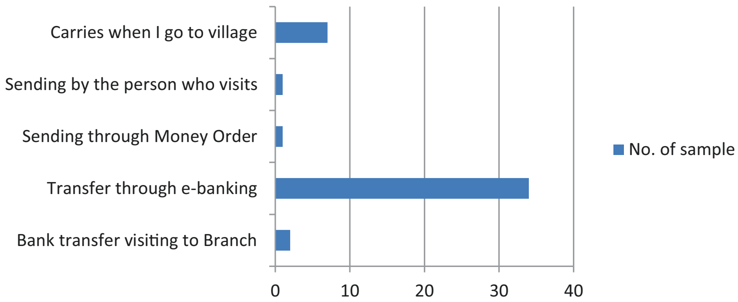

Fig. 3 Mode of sending money to near and dear ones

Table 2 Do you save money?

Do you save money	No. of sample
Yes	50
No	00

Figure 4 shows that 5 persons save at home, 43 save at the bank and 2 save at the post office.

Figure 5 shows that 30 respondents are staying within the distance of 1 kilometre from the bank and the post office, 15 respondents are staying at a distance between

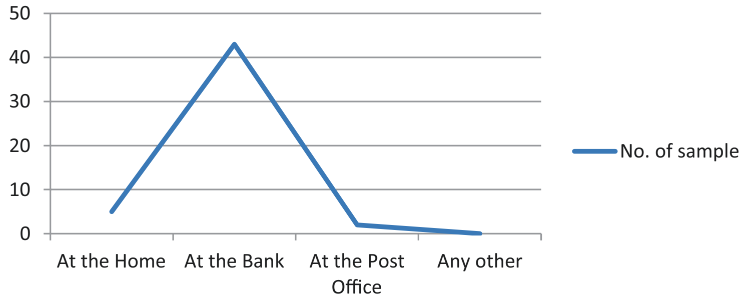

Fig. 4 Mode of saving

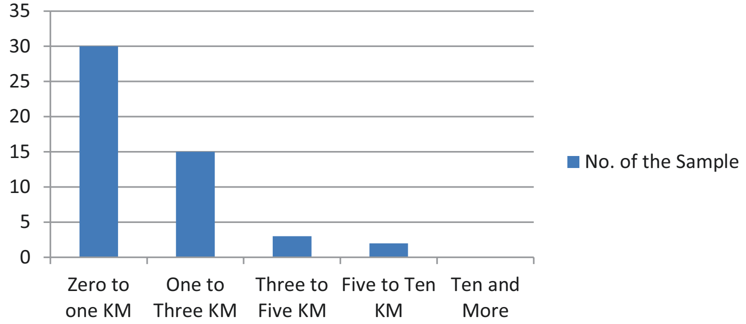

Fig. 5 Distance between the bank and post office

1 kilometre to 3 kilometres, 3 respondents are staying at a distance between 3 and 5 kilometres and 2 respondents are staying at a distance between 5 and 10 kilometres from the post office and bank.

Table 3 shows that almost all people have opened a bank account.

Table 4 shows that out of 50 people, 45 are aware about KYC, while 5 persons are not aware of it.

Figure 6 shows that 15 people visited a bank five times and less in a year, 20 people visited a bank five to ten times a year, 5 people visited a bank ten to fifteen times a year, 7 people are visiting banks fifteen to twenty times in a year and 3 people are visiting banks twenty and more times a year.

Figure 7 shows how much time people spend in the bank at one visit. Two people are waiting 1 h and less in the bank, 35 people are spending 1 to 2 h in the bank, eight people are spending 2 to 3 hours in the bank, four people are spending 3 to 4 h in the bank and one person spends 1 h and more in the bank.

Table 5 shows that 45 people are enquiring their account balance through online banking and 5 persons are enquiring their account balance by bank visit.

Table 6 shows that 30 people are recharging mobile phones using their own charger and 20 people are recharging their mobile by visiting a shop.

Table 7 shows that 35 people know about online banking activity through smartphones and 15 people have no knowledge about it.

Table 3 Opened a bank account?

Opened a bank account	No. of sample
Yes	50
No	00
Total	50

Table 4 Knows about KYC?

Knows about KYC	No. of sample
Yes	45
No	05
Total	50

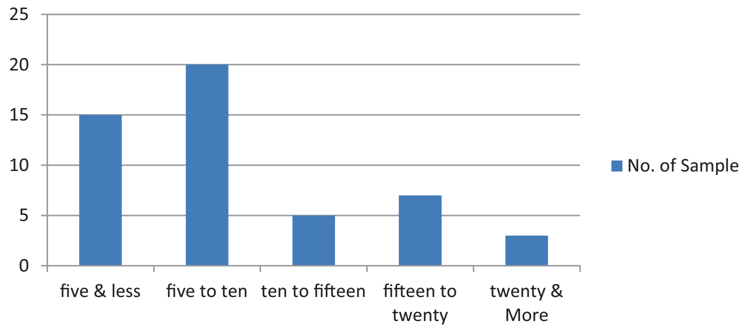

Fig. 6 Frequency of annual bank visit

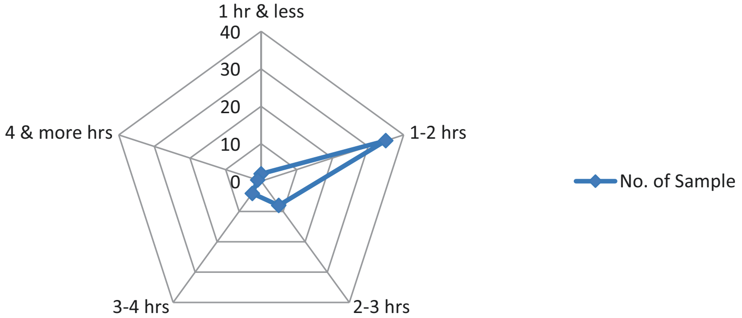

Fig. 7 Time spending in the bank

Table 5 Mode of enquiring account balance

Enquire account balance	No. of sample
Through online banking	45
Through bank visit	05
Total	50

Table 6 Mode of recharging mobile

Way of recharging mobile	No. of sample
Using mobile	30
Visiting shop	20
Total	50

Table 7 Knowledge about online banking activity through a smartphone

Know about online banking activity through a smartphone	No. of sample
Yes	35
No	15

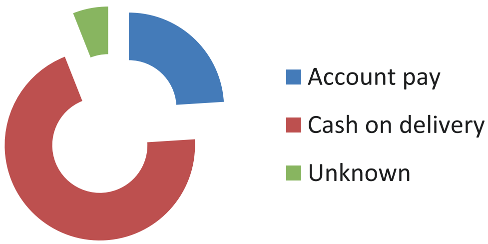

Fig. 8 Mode of payment while purchasing online

Figure 8 shows that at the time of purchase online, 12 respondents preferred account pay, 35 respondents chose cash on delivery and three respondents are unaware of purchasing through online mode.

Table 8 shows that 48 people have ATM cum debit card and two people have both ATM cum debit and credit card.

Table 9 shows that 20 people pay the utility bill online and 30 people pay it directly through cash.

Table 10 shows that almost all 50 fifty respondents are aware about digital payment.

As per the information collected from in-migrants, smart banking is easily available and accessible to them.

Table 8 Possession of ATM cum debit and credit card

	No. of sample
ATM cum debit card	48
ATM cum debit and credit card	02
Total	50

Table 9 Mode of paying the utility bill

Mode of paying the utility bill	No. of sample
Online	20
Cash	30
Total	50

Table 10 Aware about the digital payment

Aware about the digital payment	No. of sample
Yes	50
No	00
Total	50

6 Experiences of Migrant Workers Staying in Gajapati District of Odisha on Smart Banking

To find the experience of migrant workers staying in the district on smart banking, the following information collected from them are analysed and presented.

Figure 9 shows that three people are visiting a bank once or twice a week, five people visit fortnightly, 40 people visit monthly and two people are visiting rarely a bank. As per the data collected, 20 people are using cards once or twice a week, 20 people use it fortnightly, eight people use it once a month and two people are using it rarely. There are two people who use Internet banking every day, 35 use it once or twice a week, ten are using it fortnightly, one person uses it once in a month and two people never use it. Two people use telephone banking every day, 35 use it once or twice a week, ten use telephone banking once in a fortnight, one person uses it once in a month and two people never use it. As far as mobile wallet is concerned, one people use it once or twice a week, two people use it once in a fortnight, five people use it once in a month, 40 people never use it and two people rarely use it.

Figure 10 shows that cards are used by two people less than a year, three people in between 1 and 2 years, five people in between 2 and 3 years, seven people in between 3 and 4 years and 33 people use it more than 4 years.

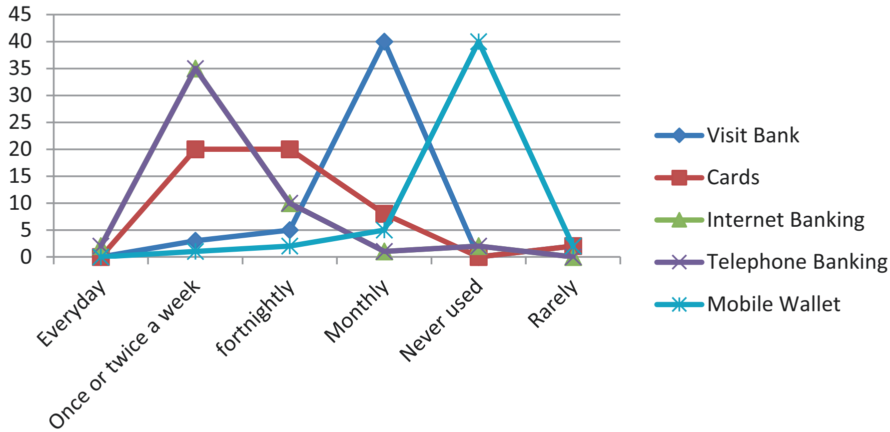

Fig. 9 Frequency of using the mentioned facilities

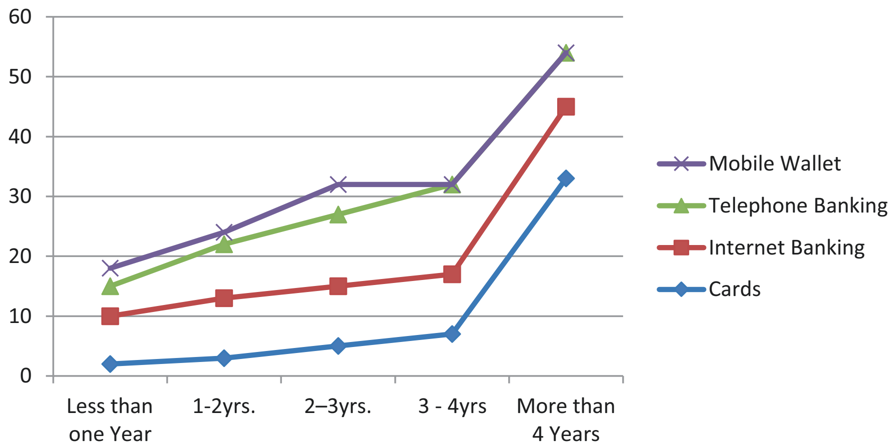

Fig. 10 Longevity of using the various services

Internet banking has been used by eight respondents for less than a year, ten respondents for 1–2 years, ten respondents for 2–3 years, ten respondents for 3–4 years and twelve respondents for more than 4 years.

Similarly, telephone banking has been used by five respondents for less than a year, nine respondents for 1–2 years, 12 respondents for 2–3 years, 15 respondents for 3–4 years and nine respondents for more than 4 years.

As far as mobile wallet is concerned, three people are using it for less than a year, two people are using it between 1 and 2 years and five people are using it between 2 and 3 years.

Table 11 shows that 48 people use ATM frequently for statement enquiry, bills payment, shopping/swiping in EDC machine, fund transfer and withdrawal/deposit.

Table 11 Use of ATM for various purposes

(a) Statement enquiry: 48	(b) Bills payment: 48
(c) Shopping/swiping in EDC machine: 48	(d) DD/pay order request: 5
(e) Funds transfer: 48	(f) Withdrawal/deposit: 48
(g) Cheque book request: 08	(h) Others

Similarly, eight people frequently use it for cheque book request, and five people use it for DD/pay order request.

Table 12 shows that 48 people use telephone banking frequently for statement enquiry, bills payment, fund transfer and online shopping. Only five persons use it frequently for DD/pay order request, and three people use it for cheque book request.

Table 13 shows that 48 people use Internet banking frequently for statement enquiry, bills payment, fund transfer and online shopping. Only five people use it frequently for DD/pay order request, and three people use it for cheque book request.

Table 14 shows that five people use mobile wallet frequently for statement enquiry, bills payment, fund transfer and online shopping. Only three people use it frequently for loan.

Table 15 shows that among people using ATM, 31 are highly satisfied, 25 are satisfied and 4 are so-so. Similarly 20 people are highly satisfied, 23 are satisfied and seven people are so-so among those who are using Internet banking. Further, 20 people are highly satisfied, 27 people are satisfied and three people are so-so among those who are using telephone banking.

6.1 Electronic Banking Service

To explore electronic banking services availed by the people, variables identified are:

- Convenience (V1)
- Comfortable (V2)
- Safe to use (V3)
- Saves time (V4)
- Cost-effective (V5)
- Better than human interface, i.e. bankers (V6)

Here V1, V2, V3, V4 and V5 are taken as independent variables and V6 as dependent variables. Data is collected from immigrants of the Gajapati district through a 5-point rating (Likert) scale, and regression technique is applied to know the significant influence of the independent variables on dependent variables. Since the

Table 12 Use of telephone banking for various purposes

(a) Statement enquiry: 48	(b) Bills payment: 48
(c) Loan: 3	(d) DD/pay order request: 5
(e) Funds transfer: 48	(f) Online shopping: 48
(g) Cheque book request: 3	(h) Others

Table 13 Use of Internet banking for various purposes

(a) Statement enquiry: 48	(b) Bills payment: 48
(c) Loan: 03	(d) DD/pay order request: 5
(e) Funds transfer: 48	(f) Online shopping: 48
(g) Cheque book request: 03	(h) Others

Table 14 Use of mobile wallet for various purposes

Statement enquiry: 5	Bills payment: 5
Loan: 3	Funds transfer: 5
Online shopping: 5	Others

Table 15 Satisfaction level of users on various digital modes

	Highly dissatisfied (1)	Dissatisfied (2)	So-so (3)	Satisfied (4)	Highly satisfied (5)
ATM	Nil	Nil	04	25	31
Internet Banking	Nil	Nil	07	23	20
Telephone Banking	Nil	Nil	03	27	20

Cronbach's alpha is 0.704 as mentioned in Table 16, the variables identified and data collected on them are reliable.

Null hypothesis: In-migrants do not find electronic banking better than human interface, i.e. bankers.

Table 17 shows that the level of significance is less than 0.05, and hence null hypothesis is rejected. So immigrants find electronic banking to be better than human interface, i.e. bankers, from the point of view of the in-migrants of the Gajapati district of Odisha.

Table 18 shows that out of the total five independent variables, the two variables, i.e. V4 and V5, significantly influence the dependent variable. Here the calculated significance value of v4 is .001, and V5 is .000 which is less than the presumed level of significance, i.e. 0.05. Other independent variables don't have significant influence on the dependent variable. So as per the statement of the in-migrants, electronic banking is better than human interface as it is cost-effective and saves time.

Table 16 Reliability statistics

Cronbach's alpha	No of items
.704	6

Table 17 ANOVA

Model		Sum of squares	Df	Mean square	F	Sig.
1	Regression	19.266	5	3.853	80.218	.000
	Residual	2.114	44	.048		
	Total	21.380	49			

Table 18 Regression coefficients

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
1	(Constant)	.612	.345		1.774	.083
	V1	.093	.071	.143	1.313	.196
	V2	−.055	.072	-.067	-.759	.452
	V3	.022	.082	.021	.263	.794
	V4	−.216	.059	−.286	−3.671	.001
	V5	.944	.055	.992	17.044	.000

6.2 ATM Service

To explore ATM services availed by the people, variables identified are:

- Convenience (V1)
- Comfortable (V2)
- Safe to use (V3)
- Saves time (V4)
- Cost-effective (V5)
- Better than human interface, i.e. bankers (V6)

Here V1, V2, V3, V4 and V5 are taken as independent variables and V6 as dependent variable. Data is collected from in-migrants of the Gajapati district through a 5-point rating (Likert) scale, and regression technique is applied to know the significant influence of independent variables on the dependent variable. Since the Cronbach's alpha is 0.715 as mentioned in Table 19, the variables identified and data collected on them are reliable.

Null hypothesis: In-migrants do not find ATM to be better than human interface, i.e. bankers.

Table 20 shows that the level of significance is less than 0.05, and hence null hypothesis is rejected. Thus, in-migrants find ATM to be better than human interface, i.e. bankers.

Table 19 Reliability statistics

Cronbach's alpha	No of items
.715	6

Table 20 ANOVA

Model		Sum of squares	Df	Mean square	F	Sig.
1	Regression	22.369	5	4.474	34.833	.000
	Residual	5.651	44	.128		
	Total	28.020	49			

Table 21 shows that out of the total five independent variables, the three variables, i.e.V1, V4 and V5, significantly influence the dependent variable. Here, the calculated significance values of V1, V4 and V5 are .008, .000 and .000, respectively, which are less than the presumed level of significance, i.e. 0.05. Other independent variables don't have a significant influence on the dependent variable. So as per the statement of the in-migrants, ATM is better than human interface as it is convenient and cost-effective and saves time.

6.3 Telebanking Service

To explore the service of telebanking, variables identified are:

- Convenience (V1)
- Comfortable (V2)
- Safe to use (V3)
- Saves time (V4)
- Cost-effective (V5)
- Better than human interface, i.e. bankers (V6)

Here V1, V2, V3, V4 and V5 are taken as independent variables and V6 as dependent variable. Data is collected from the in-migrants of the Gajapati district through a 5-point rating (Likert) scale, and regression technique is applied to know the significant influence of the independent variables on the dependent variable. The collected data were put in the SPSS to check the reliability, and we found the Cronbach's alpha to be 0.857 as mentioned in Table 22. So we accept the variables identified, and data collected are accepted as reliable for exploring the telebanking services used by in-migrants from the Gajapati District of Odisha.

Null hypothesis: For in-migrants, telebanking is not better than human interface, i.e. bankers.

Table 23 shows that the level of significance is less than 0.05, and hence null hypothesis is rejected. Thus, in-migrants find telebanking to be better than human interface, i.e. bankers.

Table 21 Regression coefficients

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
1	(Constant)	−.505	.465		–1.085	.284
	V1	.242	.087	.238	2.773	.008
	V2	.002	.098	.002	.024	.981
	V3	.084	.067	.087	1.253	.217
	V4	.475	.095	.455	5.007	.000
	V5	.353	.074	.401	4.802	.000

Table 22 Reliability statistics

Cronbach's alpha	No of items
.857	6

Table 23 ANOVA

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	21.520	5	4.304	45.521	.000
	Residual	4.160	44	.095		
	Total	25.680	49			

Table 24 shows that out of the total five independent variables, the three variables, i.e.V1, V4 and V5, significantly influence the dependent variable. Here, the calculated significance values of V1, V4 and V5 are .012, .000 and .005, respectively, which are less than the presumed level of significance, i.e. 0.05. Independent variables don't have a significant influence on the dependent variable. So as per the statement of in-migrants, telebanking is better than human interface as it is convenient and cost-effective and saves time.

As per the information collected from in-migrants of the Gajapati district of Odisha, smart banking is beneficial for them.

7 Suggestions for Better Utilization of Smart Banking by Migrant Workers Staying in the Gajapati District of Odisha

The benefits of smart banking can be better utilized by migrant workers, if the following points are taken into consideration, besides the existing practices:

- Proper network at every place is highly essential for effective use of smart banking.

Table 24 Coefficients

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
1	(Constant)	−.628	.413		−1.520	.136
	V1	.240	.092	.242	2.621	.012
	V2	.135	.104	.090	1.296	.202
	V3	.038	.073	.035	.523	.603
	V4	.495	.119	.447	4.161	.000
	V5	.287	.096	.289	2.991	.005

- Different people are unaware of the advantage of smart banking. So awareness programmes on smart banking is necessary.
- Effective toll-free number is to be given by which people can contact if they face any difficulty.
- Different policy needs are to be made in such a manner that if a customer cheated due to a technical problem, then it will be resolved soon.
- Stringent laws are to be made against cyberattack.
- Smart banking training programme is necessary for both in-migrants and their household.
- It is necessary to increase the saving habit of people so that they can use smart banking in an effective manner.
- Literacy rate in general and proper utilization of smart banking need to be enhanced through different programmes.
- A uniform portal needs to be developed on smart banking where all people can easily get all the information about it.

8 Conclusion

As migrants live away from their loved ones, they need to send a part of their earnings to them. Through smart banking, migrants are able to do transactions with utmost ease and comfort. However, migrants have mixed experience on this innovation. Being the easiest mode of transferring money, most migrants prefer to use smart banking. However, there are a few bad experiences of using smart banking that have created enough negative word of mouth propaganda to damage the potential benefits of it. Thus, some of the migrants are apprehensive of using it intensively. Considering the potential advantages that smart banking can offer, suggestions enlisted in the previous section may be implemented so that migrants can take best advantage of smart banking. As evidenced from the data analysed, it is found that in-migrants in the Gajapati district of Odisha get easy access of smart banking. Although their experience is encouraging, with little efforts, it can be made very attractive. Benefits from smart banking can be outreached and augmented; some more steps like awareness programmes, priority to increase literacy rate, training programmes, etc. need to be initiated.

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An Analysis of Consumer Expectations, Nature and Economic Implications of Smart Banking System in India

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1 Introduction

"Internet banking is convenient for me" is an expression people or customers sometimes use when expressing satisfaction with the way their financial transactions were conducted. Usually this expression is uttered almost admiringly and with a nod of approval in recognition of the technology innovation put to use in achieving successful financial transactions. In this, twenty-first-century smart banking is widely accepted because of the convenience that it offered. Years back before the introduction of smart banking, long queues with hundreds of customers milling around banking premises, struggling to gain entrance, are a situation that no one looks forward to. Digital evolution has actually provided an opportunity whereby there is virtually an app for almost everything including sealing a financial transaction in any part of the world from the comfort of our home. The lockdown imposed as a result of the outbreak of the COVID-19 pandemic did not really alter or change the spending or banking habits of a smart banking user as every single banking activity they desired was carried out. In addition, the health risk that goes with the push and shove in or around bank premises is avoided or visibly minimized. Amid these numerous benefits that smart banking users enjoy, there is increasing concern, however, over increasing cases of accessibility as a result of poor Internet network coverage and also the insensitivity of financial institutions who exploit their

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customers by passing the cost of banking to them in the form of unreasonable charges. This chapter seeks to address the challenges associated with smart banking and helps to bring clarity to those who are not yet convinced to explore the numerous benefits attached. Smart banking currently faces significant challenges with customer expectations continually shifting. It is an established fact that customers take their businesses to banks that have demonstrated that they can meet their expectations, but at the same time, they are also uncomfortable doing business with any bank that has no physical presence or structures on the ground.

The aim of this chapter is to analyze the role of customer expectations in determining how smart banking penetrates in the financial industry. The specific objectives are to discover the impact of smart banking on its users in the banking industry, examine the relationship between customers/devices and the quality of service offered by financial institutions, and evaluate financial transactions security.

This chapter consists of six sections. The introduction and objectives of this chapter are discussed in Sect. 1 followed by literature review in Sect. 2. Section 3 focuses on the advantages and disadvantages of smart banking from both customers and stakeholder's perspectives. Sections 4 and 5 discuss the findings of the online survey and conclusion of the study.

2 Literature Review

The invention and evolution of smart banking have enhanced businesses, enabling business owners and customers to conveniently undertake financial proceedings or dealings, thereby ensuring an efficient use of time and cost. Smart banking was introduced by banks as an additional medium aimed at improving the efficiency of banking transactions, thus providing a convenient and easily accessible service to their customers. The major objective is to heighten customers' engagement that will in turn boost customer retention. Results from an Internet banking survey revealed that the percentage of European Union nationals exploring e-banking services increased between 2009 and 2019. It is predicted that more and more customers will adopt the Internet banking platform with figures projected to exceed 3.6 billion by 2024. Further reports also claim that e-banking customers in Norway, Denmark, and major developed nations form a sizable amount of users of e-banking services across the world.

Like every other business, the banking sector all over the world and in India in particular witnessed a change that enhanced its productivity due to the introduction of Internet banking. The economic liberalization in India widely contributed to the socioeconomic changes witnessed in the banking sector. The financial industry in India is projected to rank fifth in the list of top financial industry rankings in the world by 2020, and it is expected to expand further to hit the third ranking by 2025 according to the KPMG-CII report. A study carried out by Bhelly and Sunil [3] revealed that a committee set up by the Reserve Bank of India to do a research on Internet banking and to make recommendations based on their findings split e-banking products in India into three types, namely, the information-only system, the electronic information transfer system that is a subsystem of equipment used in the creation and duplication of data and furnishes customers with a particular information like their accurate account balances and statement, and, finally, the fully electronic transactional system that was designed to aid in processing credit card payments and has the ability to function in two directions (usually opposite).

The modern world's increasing preference for online technology has sparked off intense competition among firms seeking to offer services that will be convenient for their customers. The banking industry evolved from an industry that functions and thrives on a thoroughly physical affair into one that is technology oriented. Smart banking ensures that users are able to conduct their transactions automatically and technologically through the use of Internet, thus avoiding the rigor of being physically present at the bank premises. Some of the smart banks are originally traditional banks that conduct financial transactions through the use of Internet, while others are purely smart banks with no physical presence at all. Technological advancement in the finance sector has resulted in the increase of financial products and services introduced by banks, thus ensuring that they meet the business needs and demands of their customers. Studies has been conducted on the expectations of users of smart banking in India over the years. However, only few focused on the economic implications of adopting smart banking. Most studies about customers' or users' comprehension or satisfaction toward the adoption of smart banking system in India and the world at large are based on questionnaires that focus and analyze a particular country or region. A study by Hammond et al. [6] examined the effect of e-banking service quality on customers' satisfaction in the Lebanese banking industry. The author gathered data by distributing about 280 samples of questionnaire among bank customers. Their findings revealed that reliability, efficiency, responsiveness, and communication all have a notable effect on customers' satisfaction, with reliability being the most influential factor. A similar study by Shin Ho and Yahya [7] investigated the impression of consumers on how e-banking has been explored and used so far in Malaysia with critical focus on how Internet accessibility, Internet quality, security and privacy, transaction benefit, and trust influences consumer's willingness to adapt, adopt, and engage in Internet banking services. Their findings revealed that the abovementioned variables have a noteworthy impact on the extent at which e-banking is being used stressing the fact that banks need to contemplate offering a wide range of e-banking products and services that can restore full confidence to its users. A similar study carried out by Zavarech et al. [14] revealed that a significant positive relationship exists between e-Service Quality (e-SQ) and e-Customer Satisfaction (e-CS) in Internet banking indicating that efficient and reliable services, fulfillment, security/trust, responsiveness, etc., all constitute e-SQ, which in turn influences e-CS positively. There are differing opinions on whether the demographic features of clients can influence the extent to which e-banking is adopted. While some researchers view demographic characteristics as a significant factor that can influence the adoption of Internet banking, other researchers differ on this claim. Some researchers, however, believe that not all demographic variables can influence the adoption rates of Internet banking. To understand the impact of demographic variables on smart banking system, a study carried out by Izogo et al. [8] examined the impact of six demographic variables, namely, gender, marital status, religion, income, age, and education level, on the adoption of Internet banking in Nigeria and revealed that while the influence of marital status, age, and education level on the adoption of Internet banking is significant, the reverse is the case with such demographic variables such as gender, religion, and income. To understand the impact of customers' expectations toward smart banking system in India, a study was conducted by Khare et al. [10] to investigate the attitudes of Indian bank customers toward Internet banking with results revealing that convenience and trust are the most influential factors that can easily have an impact at the rate at which Internet banking is embraced. Correspondingly, Goudarzi et al. [5] concluded that a positive relationship exists between trust and e-banking noting that trust has a major impact that determines the rate at which e-banking is adopted. Their research was based on the analysis and review of data on the subject, but a large part of the research was carried out in the context of smart banking. Their findings show that there are many components associated with trust in electronic services with discoveries that online trust is a crucial issue for customer retention in terms of Internet banking services. Almohaimeed [1] agreed with other existing studies that there are notable differences between users and non-users of e-banking, asserting that both classes of Internet banking are influenced by various elements. It was discovered that Internet banking users are more likely to be male who are in their prime and are technology driven with a need for convenience while non-users tend to be either younger or older and not open to change or innovation. Further discoveries revealed that educated customers tend to be more open to the idea of engaging in e-banking services because they are likely to be conversant with the use of computer and the Internet. Jayaram and Prasad [9] investigated if there is any association between the adoption of Internet banking and the bank's performance and risks with their findings revealing that there is no significant association between the adoption of Internet banking by banks and their performance. Suriyamurth and Karthik [13] carried out a research to prove the accuracy of the theoretical or philosophical way of the operation of e-banking. Their study revealed that education, gender, and income play a vital part that determines how Internet banking is used. In conclusion, their research supported the theoretical structure that states that there will be greater conviction by consumers to use Internet banking if their skills are upgraded. Ramanigopal et al. [11] in their assertion also affirmed that customer literacy level is a major influential factor that determines how Internet banking facility is accessed, pointing out further that factors such as transaction updating, account transfer, security, and easy access all contribute to the high level of satisfaction that users enjoy. They concluded by positing that attitude, commitment, and involvement of banks in addition to evolving technology determine the level of success that electronic banking will be able to attain which will in turn translates to how far the customers will reap the benefits. Smart banking (Internet banking and mobile banking) marked a major breakthrough in banking services, as banks understood that clients require a convenient and secure way to handle their funds, which can only be provided through smart banking. An empirical study carried out by Sohail and Shaikh [12] to examine the service quality of electronic banking services provided by financial institutions in Saudi Arabia revealed that there are components that have an impact on user's assessment of the service quality of Internet banking services. These factors are identified as efficiency and security, fulfillment, and responsiveness. Their findings will ensure that bank's management team has a better grasp of customer's awareness of the service quality of Internet banking while also providing a framework for banks to improve service quality. A study by Gerrard et al. [4] examined why consumers are resistant to using e-banking. The findings revealed that factors responsible include but not limited to perceptions about risk, lacking knowledge, inertia, human touch, inaccessibility, and research limitations/implications among others.

3 Advantages and Disadvantages of Smart Banking

3.1 From Stakeholder's Perspective

Cost savings and improving transaction efficiency have been identified as the main benefits that banks enjoy from Internet banking. Reducing the dependence on manual operation and physical structures enables banks to save cost. Aydin [2] posited that Internet banking enables banks to reap benefits especially in the area of cost reduction by allowing banks to reduce customer service staff, thereby providing a channel that enables banks to enjoy advantages such as retention of customers, reduction of density in bank branches, faster response to market demand, reduction of banking operation cost, provision of more effective customer service, strengthening the bank brand image, development of new products and services, ability to advertise and sell financial products and services via their website, increasing customer loyalty, acquisition of new customers, and increase of sales. Aydin [2] listed the benefits of e-banking from customers' perspectives: the cost of physical branch banking is reduced, the use of traditional branch banking is minimized, there is raised attainability and time-saving processing can be made round the clock, and bank customers can access and conduct financial transactions at any time without delays from the comfort of their homes, offices, or anywhere as a result of Internet banking that runs 24 h a day every single day. The cost of conducting financial transactions via Internet banking is relatively lower as bank customers save money that would have been spent travelling to and from physical banking locations. His study also pointed out some of the disadvantages:

Transactional Risk This is the present and potential risk to earnings and capital arising from fraud, error, etc. This risk may exist with Internet banking products especially if the lines of business are not sufficiently planned and executed.

Reputation Risk Reputation risk is the present and potential impact on earnings and capital arising from negative public opinion. A bank's esteem can be destroyed by e-banking services that are poorly executed. Engaging in marketing is one way to properly sensitize potential customers and help limit reputational risks.

Strategic Risk This is the present and potential risk to earnings and capital arising from adverse business decisions, inadequate execution of decisions, or lack of adaptability to industry changes. Banks must understand the risk associated with Internet banking before taking any decisive steps to develop a particular product.

Credit Risk This is the risk to earnings and capital arising from obligor's inability to meet the terms of any obligation with the bank.

Liquidity Risk Liquidity risk includes the failure to manage unplanned changes in funding sources. Increasing the flow of money and changes in deposits and loans may not be necessary depending on the volume of Internet account activities.

Foreign Exchange Risk This is present when a loan is financed by borrowings in another currency.

Price Risk This is the risk to earnings or capital arising from changes in the value of traded portfolios of financial instruments. Banks may be vulnerable to price risks if they create or expand loan sales as a result of e-banking activities.

Interest Rate Risk This is the risk to earnings and capital arising from the fluctuating interest rate.

3.2 From Customer's Perspectives

The existing disadvantages that users of Internet banking must keep in mind to avoid potential issues that could arise according to include the following:

Technology and Service Interruptions Temporary moments of instability are a scenario that every user of the Internet and Internet banking must experience. The ability to access accounts online will naturally be affected if your Internet service is running slowly or completely out for a period.

Security and Identity Theft Concerns Though banks continually put security protocols in place, accounts can still be hacked, resulting in identity theft via stolen login credentials. Users must be careful to avoid using networks that are not secure while accessing online banking.

Limitations on Deposits Business owners might find it difficult to make large deposits online as a result of limitations on deposits.

Lack of Personal Banker If a user does not have a personal relationship with a banker, it may be difficult to resolve concerns that emerge. So, even if a user handles their general banking needs on their own, they still require the assistance and counsel of a personal banker on spending.

A Limited Scope of Services There is a limit to the kind of service that a user can access though he/she can do quite a lot with an online bank account, such as making deposits, checking balances, and paying bills. Signing of forms, for example, and showing of identity documentation will still require a user to visit a bank branch.

4 Finding and Discussions

A well-structured scheduled questionnaire is intended to collect data from 74 respondents residing across India in both rural and urban areas. The aim of the online questionnaire was to understand consumer knowledge of the digital payment mode adoption and how smart banking is economically convenient and accessible to its users. Out of the 74 respondents, 48 were males and 26 were females. It is very clear that digitalization of India's banking system favors changing consumer behavior. The demographic dividend in India is well suited to push the Indian banking system toward digital conduct, with Indians with a median age of 27 years favoring maximum digitalization of the Indian banking system. However, smart banking connectivity is being properly introduced in urban areas, including metro cities and towns, and increased usage of smartphones and mobiles is likely to drive toward inclusive growth in the financial sectors, with mobile penetration of around 90% among young people and adults. Instead of waiting in long lines to make use of banking, digital payment strategies have become more casual and accessible among young people. Smartphones provide low-cost tools to expand the reach of banking and payments.

Digital payment methods, however, including Unified Payments Interface (UPI), Bharat Interface for Money (BHIM), Paytm (Pay through Mobile), and Net Banking, are very popular among young people and adults in both rural and urban areas. The usage and accessibility of the online payment mode are more observed among young people and adults from the age group of 15–30 years in both rural and urban areas during the lockdown period in India. However, when discussed with the respondents from the age group of 60–69 years, it has been observed that they are not much aware of the digital mode of payment. The reason would be lack of technical knowledge of payment, but a curiosity of learning the digital payment was observed among them.

From a gender perspective, the study also examined the availability and usability of smart banking. The survey reveals that female respondents are willing to learn how to incorporate new payment technology into the Indian banking system. As females are more mindful of their financial transactions, a sense of vulnerability was noted during their transaction. Female respondents in urban areas, however, are aware of and make regular use of the digital mode of payment. For them, using online payment methods made their household activities easier during the lockdown period in India, but a few of them were unaware of the digital payment mode when questioned personally through telephonic conversations. Thus, it is likely observed from our survey that still the accessibility and awareness of smart banking are lacking among females in rural areas of India. Though, on a general consideration, females are very keen to learn new technologies, it is observed that a proper channel of guidance and training is required.

In addition, it was also noticed during the survey that the main motivating force for allowing customers to use Internet banking was found to be customer convenience. The key reason for the lack of response towards e-banking, is a lack of computer literacy. Furthermore, our studies revealed that there is a group of customers that believe online banking is not not safe. They also claimed that private banks were influential in offering better facilities for e-banking than India's public banks.

5 Conclusion

India was known to have practiced a cash-intensive economy where every transaction and payments were made with cash, but the introduction of smart banking reversed that trend as more people adopted e-banking for their business transactions. Banking services recorded a major breakthrough with the introduction of smart banking as banks recognized the customer's preference for a convenient and secure way to conduct financial transactions. The factors that determine adaptability and the rate of adoption of smart banking in India were investigated in this study, with the results identifying convenience, age, and location as factors that influence the rate of adoption of smart banking in India.

Results from this study further revealed that the usage and accessibility of e-banking are more noticeable among young people and adults from the age group of 15–30 years in both rural and urban areas. Further discoveries further proved that educated customers are more willing to adopt and adapt to digital payment mode as a result of their being computer literate. This study was also designed to analyze the factors that influence customer's perception to the adoption and use of e-banking as well as the economic implication of adopting the digital mode of payment. It has been observed that the adoption of smart banking affords banks the opportunity to reap tremendous benefits especially in the area of cost reduction and transaction efficiency by reducing the dependence on manual operations. Convenience is the major motivating factor for customers to adopt smart banking, so banks should embark on a drive that exhibits convenience as a way of attracting and retaining customers. Financial stability, which is critical to any sustainable banking innovation, is a major concern of any major financial institution, and it is yet to be seen how new technologies like smart banking can mitigate any evolving financial crisis.

The ability of smart banking to conduct a faster transaction, saving time in the process, increases the speed of money which will in turn open new areas for scrutiny and regulation in the monetary system. This process will ensure financial stability and ultimately a robust economy.

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Part V
Smart Agriculture & IoT

Internet of Things and Smart Farming

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1 Introduction

As one of the well-known applications of IOT in agribusiness, cultivation accuracy deserves special consideration. On this circle, adoption of sensible technology includes using sensors, robots, frameworks of control, and self-governing vehicles. Further, the capability of IOT cultivation includes the ability to provide ranchers with earth-friendly pesticides. But, the incorporation of intelligent innovation into farming enables proper checking of the ordinary components, such as local weather substitute, soil organization, and surrounding gauge. According to this assessment, there are numerous cases of IOT bundles in horticulture. For example, there exists a complete harvest measurement affiliation that works with VRI (variable rate irrigation) enhancement, which implies the capability to enhance geography or soil fluctuation and improve skill ability and yield performance generally. In this circumstance, the IOT cultivation method improves accuracy information by training those who are familiar with the use of cloud programming software with an

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inordinate segment of customization that enhances water conservation and boosts profits. Secondly, ranchers widely make use of arable and Semios to exhibit their vegetation in the United States. On the one hand, arable allows producers to follow an investigation stage that gives a one-of-a-kind risk to amass each ecosystem and plant records and consolidate them without delay into a cloud. On the other hand, Semios is used in farming by employing a versatile stage for yield enhancement with real-time updates on the well-being of vegetation [1]. The IOT invention has recognized smart wearables and related contraptions and automated machines with driverless vehicles. As it is already known, in horticulture, a satisfactory impact has been introduced by IOT. Past archives discover that there will be 9.6 billion people on the planet by 2050. Furthermore, to care for this massive population, the farming commercial venture is constrained to get hold of the snare of things. Among the occasions like wonderful local atmospheric conditions, climate emergency, bionomical impact, IOT is destroying climate and asking for occasions and facilitate us to find the name for extra food. As a result, mechanical developments, such as tractors and collectors, came about and were taken into agribusiness activities in the previous late twentieth century. Furthermore, the farming challenge heavily relies upon innovative musings due to the persistently growing interest in food. The economic IOT has been an essential impetus behind increased agrarian introduction at a lower cost. Quite a while, the utilization of eager preparations is managed by IOT at the back of elevated horticultural introduction at a low cost. Within the next few years, the utilization of smart solutions powered by IOT will grow in horticulture activities. As a general rule, not many of the ongoing archive tells about the IOT device institution, which will witness a compound annual cost increase of 20% of core farming business. Also, the number of all related devices (agrarian) will increase from 13 million in 2014 to 225 million by 2024. In the absence of a constant and trustworthy dispatch foundation, an IOT service provider, as well as commercial enterprise exercise vendors, had defied utilization inquiring for instances in rural or outlying districts. In many cases, several community transporters provide a practical situation by implementing satellite availability as well as telephone systems [2].

2 IOT Making Agriculture Smarter

The Internet of things (IOT) has proven to be revolutionary ventures, and agriculture is no exception, with the related farming business center remaining at USD 1 until the end of 2018. With eight billion in total, the exchange has not halted nonetheless. It is expected to grow to USD 4.3 billion by 2023, at a compound annual growth rate (CAGR) of 19.3%. The innovation in the field of IOT has recognized the crafty wearables, connected devices, modernized machines, and driverless vehicles. Whatever the case may be, in farming, the IOT has bestowed the most effective impact. The most up-to-date data show that people all over the world are well-equipped to reach 9.6 billion by 2050 [3, 4]. What is needed now is compassion for these enormous number of people; the agriculture business is restricted to accepting the net of parts. Among the various challenges, such as uncertain atmospheric conditions, environmental conditions, and ecological impact, IOT is trying to overcome the challenges and serve the North American nation to satisfy the decision for additional food. Throughout the world, mechanical advancements, like tractors and reapers, were introduced and accepted into the husbandry activities in the late twentieth century. Furthermore, the husbandry business relies fully on gift day musings as a result of the steadily increasing demand for suppers. The IOT business has been a major impetus at the back of the improved rural production at a lower cost for quite a long time, whereas the employment of smart arrangements controlled by IOT can increase in the husbandry tasks. Indeed, several of the ongoing records show that the IOT appliance institution can see a compound yearly development charge of 200 in the farming business. Furthermore, the number of associated gadgets (farming) is expected to increase from 13 million in 2014 to 225 million by 2024 [5]. Because of the absence of a steady and reliable discussion organize framework, associate in Nursing IOT arrangements warrantor nonetheless the business endeavor proprietors had confronted usage requesting circumstances in distant less advanced districts. Nonetheless, several system merchants square measure, making it possible by providing satellite accessibility and utilizing cell systems. The trendy Internet of things (IOT) has recently disturbed various enterprises, and the agriculture business is no exception.

How has IOT in agriculture left its imprint? For a long time, sensors have been used in agricultural operations. However, the issue with the standard approach of utilizing device technology was that we were not able to get fresh data from the sensors. Along with these sensors, we used to record the statistics into their linked reminiscence and then make good use of it. With the introduction of business IOT in agriculture, a more extensive method of larger advanced sensors is being applied. The sensors at the moment are connected to the cloud through cellular/satellite network. This lets us to grasp the time period facts from the sensors, creating a more powerful cognitive process. The programs of IOT in the agriculture industry have helped farmers to divulge tank levels in real time, making the irrigation system more inexperienced [6]. The emergence of IOT science in agriculture tank ranges in time, making irrigation methods more cost-effective. The development of IOT science in agricultural operations has resulted in the utilization of sensors in each step of the farming method, like how much time and resources a seed requires to end up a fully grown green produce. Internet of things in agriculture has proven to be a second wave of revolution. The advantages that farmers gain by suggesting that IOT area units be adapted are twofold. This has supported the farmers in lowering costs and increasing growth yields while also increasing farmer's higher cognitive process with the right statistics [7].

3 Things to Recollect Before Increasing Your Good Cultivation Arrangement

As we will see, the applications for IOT in farming are nearly limitless. There numerous ways that good gadgets can help you develop your ranch's exhibition and deals. Regardless, improving garden IOT applications is not any easy enterprise. There are a number of certain requesting circumstances you ought to comprehend if you square measure pondering golf stroke into savvy cultivating:

1. The equipment: To develop an IOT-based commercial enterprise, you must choose sensors for your equipment. Your desire can be based on the realities you have gathered and therefore the rationalization of your answer in style. In any case, the quality of your sensors is imperative to the satisfaction of your item: it will have confidence the accuracy of the gathered data and its irresponsibility [8].
2. The mind: Insights examination wants to be at the middle of every smart agriculture order. The gathered knowledge is of very little help if you cannot realize it. Therefore, you must possess incredible measurement investigation abilities and observe discerning calculations and device learning in order to induce important experiences based entirely on the collected insights [9].
3. The support/the upkeep: The plan of your instrumentality is associate enterprise; this can be of essential significance for IOT things in farming, because the sensors are unremarkably utilized within the topic and may be harmed while not bother. Therefore, you would like to ensure that your instrument is long-lasting and easy to maintain. In another case, you will have to be compelled to take better care of your sensors than you would like.
4. The mobility: Smart farming applications ought to be tailored to the needs of the industry. Associate degree businessperson or ranch administrator ought to have the choice to induce section to the realities on the website page or remotely via a telephone or workstation. Furthermore, each connected device should run continuously and have much remote assortment to deal with totally different gadgets and send data to the central server [10].
5. The framework: To ensure that your smart cultivating programming works well (and does not disrupt the knowledge collection), you need a stable inward infrastructure. In addition, the interior design should be comfortable. Failure to properly confirm your gizmo simply increases the probability of someone entering it, stealing your data or in any information, or forwarding liabilities for your free tractors (Fig. 1).

Fig. 1 Internet of things based smart farming: A revolution on its way

4 The Importance of IOT in Agriculture

Shrewd farming may be a welcome school and winning contraption for doing agriculture and developing food in a very manageable manner. It is the proper use of actualizing related gadgets and dynamic enhancements along with agriculture. Smart agriculture considerably depends upon IOT, eliminating the need for herders and farmers to do actual work and consequently increasing the potency in every appropriate approach. With the most recent farming advancements relying on agriculture, the Internet of things has introduced vast endowments like productive proper use of water, improvement of sources of all information, and a lot more. What caused qualification to have been the massive benefits has recently returned to be an upsetting commercial enterprise. IOT-based sensible agriculture enhances overall agriculture convenience by reviewing the sector in real time. With the help of sensors and networks, the cyberspace of things in agriculture not only has saved the time of the ranchers but also has reduced the indulgent use of assets such as force and water. It pays off with varied elements like wetness, temperature, soil, and so on. Despite investigating and offers a gem clean real time proclamation.

5 Benefits of Embracing New Innovation: Internet of Things in Agriculture

The following are the benefits of instilling new innovation – Internet of Things in agriculture:

1. *Atmospheric Situations*: The atmosphere plays a fundamental role in cultivating. Also, having insufficient understanding concerning the atmosphere has a negative impact on the quantity and quality of crop production. IOT arrangements bestow you the ability to understand real-time environmental phenomena. Sensors are placed outside and at regular intervals across the farmland. They collect records from nature that are used to select the appropriate harvests that will grow and survive in the actual weather conditions. The entire IOT condition is made up of sensors that detect real-time atmospheric conditions like moisture, temperature, precipitation, and a lot more effectively. There are completely numerous sensors required to find the majority of those boundaries and style in such a way that your savvy cultivating stipulations are heard. These sensors reveal the case of the produce and therefore the atmosphere encompassing them. Within the event that any requesting atmospheric situations are resolved, associate degree alarm is transported. What gets expelled is the desire for physical closeness sooner or later of disconcerting weather conditions, which in the end expands the fruitfulness and facilitates ranchers to accomplish further farming-favorable circumstances.
2. *Exactitude Farming*: Exactitude agriculture/precision farming is one of the most well-liked bundles of IOT in agriculture. It makes the cultivating application more distinct and overseen by addressing discipline clarification, animal check, stock following, and vehicle following. The target of accurate cultivation is to look at the facts generated through sensors and to retort accordingly. Accurate farming encourages ranchers to provide realities with the assistance of sensors and look at those realities to require affordable and quick choices. There are numerous exactitude farming produces, like water system, domesticated animals, vehicle checking, and others that play an important role in increasing fertility and adequacy. With the assistance of precise cultivation, you will inspect soil conditions and distinct connected boundaries to develop operational potency. Not only that, but you may also notice the important custom-made operating time of the connected devices to unearth water and supplement level.
3. *Smart Greenhouse*: To make ourselves tech-savvy, IOT has scepters for ecological changes to consequently modify the climate circumstances according to a particular arrangement of pointers. Reception of IOT in greenhouses has expelled human mediation, therefore creating a cost-effective overall procedure and increasing exactitude on the indistinguishable time. As an example, solar-powered IOT sensors are used to manufacture bleeding edge and cheap nurseries. These sensors also collect and transmit real-time insights, allowing for extremely precise real-time monitoring of the nursery. The sensors help in water

utilization, and nurseries are often checked through message signals. Programmed and shrewd water system is completed with the help of IOT. These sensors make it easier to administer data under stress, mugginess and temperature and at low levels.

4. *Data Analytics*: Cloud-based reality repositing and a end-to-end IOT platform play a significant role within the crafty gardening framework. Those frameworks are anticipated to play an important role in ensuring that higher exercises are often finished. Within the IOT international, sensors are the most important source of information collection for a huge scope. Information is scaled down and converted to large amounts of data with the use of examination equipment. The investigation of records permits the assessment of ecological conditions, domesticated animal situations, and field circumstances. The realities must make use of mechanical advancements, consequently making better decisions. With the help of IOT gadgets and devices, you will understand the real-time status of the yields by capturing the information from the sensors. Using discerning examination, you can gain an understanding to make higher-level decisions connected with collection. The pattern assessment permits the cultivators to understand upcoming atmospheric conditions and collection of yields. IOT in agriculture has helped the ranchers in remaining at the top of the road in terms of yields and maturity of the land, thereby upgrading the quantity and rarity of the products.

6 Equipment Used

1. *Intellia INT G01-Soil Moisture Sensor*: The Intellia INT G01-Soil Moisture Sensor (Transmitter) is a soil moisture measuring device with high accuracy and sensitivity. This item is a metallic shell with a high compressive strength and desirable fixing execution; it uses an electromagnetic heartbeat statute to gauge the undeniable dielectric consistency of the dirt Snappy Specifications (Fig. 2 and Table 1).

2. Intellia Soil pH Sensor INT-PH1: The transmitter is widely used in soil pH discovery, waste material cure, and numerous exercises requiring pH observance. The three elements, such as vitality, acceptance, and yield, are completely detached. It is protected and trustworthy and, with its exquisite look, is simple to introduce.

Fig. 2 Intellia INT G 01 soil moisture sensor

Table 1 Details of Intellia INT G 01 soil moisture sensor equipment

Model no.	INT G01
Observing principle	FDR
Structure	4-pintype
Yield signal	4–20 mA
Force supply	DC12–24 V
Reaction time	<1 s

6.1 Brisk Specifications (Fig. 3 and Table 2) Figure 3 shows INT-PH1 and the corresponding specifications are provided in Table 2.

7 IOT Applications for Agriculture

Farming has seen a number of technological transformations in the last decades, becoming more industrialized and technology-driven. By using various smart agriculture gadgets, farmers have gained better control over the process of raising livestock and growing crops, making it more predictable and improving its efficiency.

Fig. 3 INT-PH1

This, along with the growing consumer demand for agriculture products, has contributed to the increased proliferation of smart farming technologies worldwide. In 2020, the market share for IoT in agriculture reached $5.6 billion.

8 Water System Management

The use of sensor measurements and investigation improve the way you discover and control water systems to stay aware of interest. Settle on more brilliant water choices: simultaneously, there are many factors that influence health, and a great collection of water is maybe one of the most basic. Water system control plays a critical role in ensuring that plants receive the appropriate amount of water at the best possible time. The Internet of things (IOT) is making it less difficult for ranchers to screen and manage water assets to satisfy the needs while reducing wastes and cutting operational costs.

Cultivation utilizes more water assets than any other undertaking or pastime. A high percentage of this water system's water is consumed as a result of the need for supervision and real-time monitoring, which can prompt dry spells and other guide issues. Smart water system frameworks assist ranchers by safeguarding more water after some time:

- Acquire real time water use insights through remote sensing innovations that help you to settle on more intelligent choices about water use.

Table 2 INT-PH1 Specifications

Model no.	INT-PH1
Force consumption	≤0.15 W(@12 V DC, 25 °C)
Estimating accuracy	±0.5 pH
Estimating range	0–14 pH
Working temperature	0–65 °C
Yield signal	RS485 (Modbus protocol)

- Trigger moves based on sensor data to exchange smelly water, contingent upon water system needs and phase of assets.
- Use bits of knowledge amassed from realities to avoid overuse and underuse of water resources.
- Quickly run over holes and faults in pipelines to address issues straight away and reduce water wastes.

8.1 Improve the Effectiveness of Your Harvest Yields

Since the human population continues to grow, the incorporation of vegetation is at a record-breaking high. Ultimately, growers have to generate the most significant sum, and only the highest quality of horticultural respects has the choice to satisfy this concern. A smart water system helps cultivators improve the productivity and consistency of their yield by enabling more astute water control:

- Stay on the zenith of changing conditions across horticultural situations by following temperature, precipitation, mugginess, and wind with smart sensors.
- Automatically trigger sprinkler structures to adapt to low dampness levels in soil to forestall crop damage or misfortune.
- Remotely measure and screen water dampness levels in soil to ensure that yields are becoming ideal water assets.
- Capture important realities to recommend inclinations and make gauges essentially enthusiastic about an extension of conditions to satisfy crop requests.

8.2 Increase Crop Yields and Reduce Water Waste

Smart water system arrangements permit cultivators to reduce water waste, save money, and improve normal harvest yields with the help of data-driven water systems. Collaborate with Telit to recommend the hardware and resources you will need to develop amazing, cost-effective IOT water systems.

9 Yield and Livestock Monitoring

Increase yield and wellness by performing constant checks that alerts you to the primary indication of disease.

9.1 Build Up a Measurement-Driven Procedure to Cultivation

As the world's population grows, there will be a greater need for suppers, necessitating the development of flood. With a decrease in the amount of land accessible for ranch use and an ever-increasing concern about water resources, ranchers must be sharp with their harvest and animals across the board if they want to reduce squander and typical expenses. The Internet of things (IOT) is making it possible for ranchers and producers to enhance their harvest yields and advance cow wellness through remote and data-driven dynamics.

9.2 Advance Harvest Yields with Bits of Knowledge

The Internet of things can possibly transform agriculture and food production by improving product quality, increasing crop efficiency, supporting in help protection, and helping ranchers in better cost control. Here are some methodologies of how ranchers utilize real-time records taken from agrarian IOT solutions to improve crop yields:

Accumulate data on soil, moisture levels, and weather conditions in order to effectively make preparations for improved harvesting.
Use atmospheric conjectures to improve efficiency and take deterrent measures to reduce the likelihood of harvest damage.
Reveal ecological boundaries and plant development to foresee bugs and adapt to any pending nuisance issues before they harm plants.
Analyze and manage crop water system prerequisites, and utilize accessible water assets wisely to reduce waste.

Improve the well-being of domesticated animals through constant checking: Consistently, farmers lose critical proportions of advantage due to animal maladies. There are various strategies that IOT-enabled livestock management courses of action permit farmers to sell more profitable animals.

9.3 Bolster Domesticated Animals Wellbeing Through Constant Checking

- Connected sensors in animal wearables allow farmers to monitor coronary heart rate, circulatory strain, respiratory rate, temperature, digestion, and other vitals.
- Realities spouted to the cloud straightforwardly from wearables enable farmers to perceive and oversee issues like affliction and address issues before they fundamentally sway the group's prosperity.
- Ranchers can use IOT solutions to indicate animals' regenerative cycles and also the calving strategy to sell progressively. IOT sensors are also used to detect a creature's location, which can be useful in locating sick creatures similarly as well as installing and optimizing grazing styles.
- Help agricultural prosperity while reducing operational expenses: IOT is helping farmers and cultivators improve the way they screen and control crop and livestock through rich data-driven encounters. Cooperate with the IOT specialists at Telit to induce your sharp yield and livestock management solutions to focus on business faster.

10 Recent Challenges and Future Expectations

As per the briefing declared in 2015 under the title "The 2030 Agenda for Property Development," the World Health Organization set an objective to eradicate hunger by 2030. In any case, recent figures released by the UN agency (World Health Organization) did not seem to be compelling enough to assist the arrangement, since in a population of more than 800 million people, 1 out of every 9 people is food insecure. Despite the fact that these figures are staggering on their own, what is additionally astounding is the nature of food. Aside from accessibility, the nature of food is becoming a major issue and considerably progressively basic. According to a study supported by the Bill & Melinda Gates Foundation published in *The Lancet*, either malnutrition or poor eating habits redirect 11 million people to an early grave yearly, making it far more dangerous than smoking. The investigation, which mirrored the impact of feeding routine on welfare, revealed 195 nations from 1990 to 2017 and inferred that 1 out of 5 deaths for every year could be avoided by providing more feeding routine. The report sums up that, all inclusive, a feeding regimen low in whole grains was the most widely known and leading cause of death. Aside from basic food needs, the per capital livelihoods of the majority of the nations in 2050 are expected to be significantly different when compared to current levels. Such an increase in pay can cause a lot of welfare-conscious public that expects food with some qualities that are abundant in fiber and completely different in minerals. Patterns, such as growing public everywhere in the world must pay attention of a lot of mouths with a high interest in important food, show that food requests continue to increase quickly. Due to this, general yield production must increase for food while also developing to satisfy the requests of business, like cotton and elastic, and, above all, increasing requests for biovitality, like ethyl alcohol.

10.1 Remote Sensors and Therefore the IOT

Remote sensors set deliberately around fields are increasingly providing ranchers with exceptional information, allowing them to regulate the thought that higher yields mean less waste. Remote device systems (WSNs) are also being utilized to inform ranchers regarding most viewpoints concerning their harvest development as well as the current condition of the homestead's equipment, hence, thereby preventing loss of yield while increasing the provision of the hardware that generates it (Fig. 4).

Figure 4 represents a preview of the serious difficulties that upcoming trends in agriculture are expected to bring in 2050. The above chart essentially displays three important issues: a way to watch out for around ten billion individuals while not utilizing a lot of land and by decreasing the outflow of nursery gasses over an hour. However, if we look closely, these three moves cause some new as well as minor rural work, such as systematically acquiring tillable land, water shortage, harsh climate conditions, and a few others. As the world moves toward urbanization, provincial populations mature quickly; consequently, less and younger producers have to be compelled to improve to assume the liability. Such awkwardness and age shifts will create real ramifications for the remainder of the workforce, as well as for creation examples and land residency. Besides, on one facet, tillable land is being acquired, whereas, among the remaining districts, several are simply affordable for express yields owing to limited geographic and natural constraints. Besides, the harsh atmosphere changes influence just about each part of harvest production. These progressions relied on to improve the capability of a substantial number of long-term ecological problems, just like dry seasons, floods, groundwater exhaustion, soil corruption, and so on. Throughout the twentieth century, in several areas, cultivators continued to use traditional cultivating methods while trying to meet the food requirements through a lot of distinguished manures and pesticides. Usage of such artificial compounds endeavors two issues: these will assist in increasing the production to merely a particular level, while the visually impaired use is causing irreversible ramifications for the world. Moreover, execution of either of the quality, like seed, water, composts, and pesticides, systematically over an entire field will not prevent the problem. Instead of managing every homestead and harvest in the

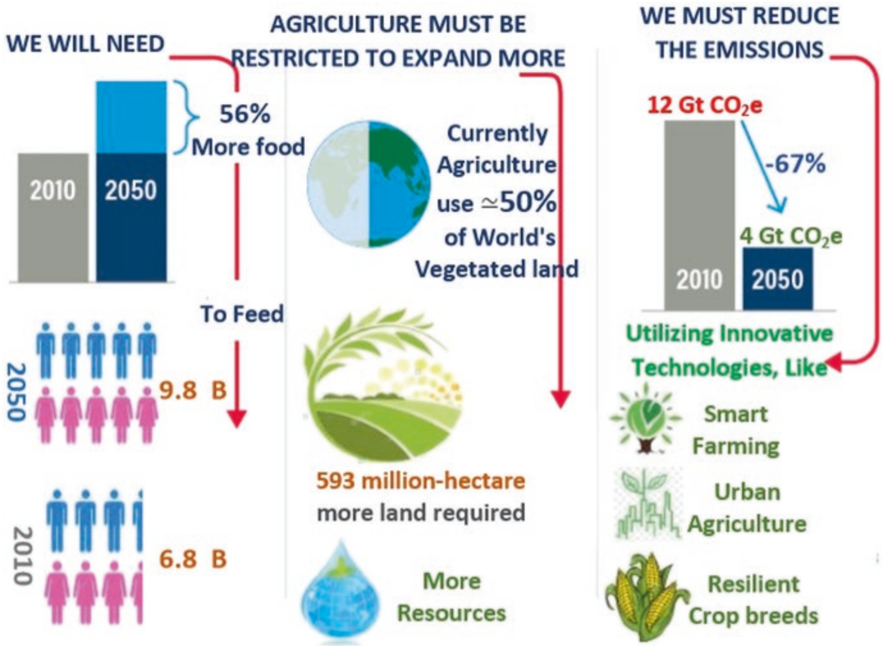

Fig. 4 Current Challenges

same manner, ranchers have to be compelled to utilize these assets as indicated by the needs of express territories, notwithstanding whether or not they must assume the requirement of every plant. Concentrating more on oral communication, one will feel that homesteads and necessary yield activities ought to be run unambiguously in contrast to old practices. One of the many reasons is advancements in innovation, such as sensors, specialized techniques, machines, and even robots. Actually, innovation has undeniably proven this as of now, as in most developing nations, over 1/2 of the people is involved in agriculture business in some way or another, yet they are long way behind in terms of quantity and quality when compared to developed nations, where less than two-thirds of the population is engaged in agriculture. The issue that matters is obvious, as nations like Australia, the United States, and therefore the majority of Europe utilize advanced instruments and techniques, duplicating harvest yields over the most recent five decades. These studies show that in-progress advances and propelled methods are making ranches that are both useful and safe for the environment. Considering this case, future farming is expected to advance as a cutting-edge business wherever interconnected frameworks can benefit from processed reasoning and massive knowledge offices. The resulting frameworks can be combined into a single unit where ranch hardware and executives, from seeding to production gauging, are consolidated. By combining leading innovations like big data, farming robots, and distributed computing with artificial reasoning in agriculture, a new super combination will be created. A few of the key advancements and techniques require the use of centering to accomplish sensible future agriculture

WSNs with GPS capability assist tractors in compensating for lopsided territory and enhancing land groundwork for developing harvests. Recent advancements in image recognition and computerized signal handling gave considerably a lot of abilities to WSN to precisely determine crop quality and eudemonia. Thus, on making business enterprise sufferable, the employment of IOT is going to be at the center and battlefront in husbandry activities. This incorporates everything, from water and force utilization to ranch hardware activity, crop transportation and maintenance alarms, and market price updates. The IOT has the capability to make these undertakings ironed out and more and more unsurprising by perceiving the yield's desires at all stages. Its simply incontestable accomplishment is going to alter the manner in which we have a tendency to take a goose at totally different gardening exercises by giving the sodbuster power over their property and resources in an unusual manner, thereby increasing their viability and productivity. Further, the ultimate fate of the IOT will be shaped by extraordinary advances in WSNs and therefore the fifth era (5G) of cell transportable correspondence advances to furnish ranchers with constant information whenever and wherever their property is. According to a recent accomplishment, it is estimated that more than 75 million IOT-based gadgets are going to be operating in the farming industry by 2020. Further, the conventional ranch hopes to gather 4.1 million information on a daily basis by 2050.

10.2 Correspondence

The genuine accomplishment of IOT in agribusiness to a great extent relies upon availability. From telecom's point of view, predominantly providing network and other value including administrations has enormous potential and can have a huge impact on the whole chain. The vast majority of the telecom administrators around the world offer availability administrations; however, such administrations speak to a minuscule portion of the whole savvy horticulture advertise. Thinking about its value, particularly in provincial regions, cell administrators bring to the table another scope of administrations focusing on the growers' demands. Given that a large portion of the network with a place in this industry are not profoundly educated and are generally unaware of new advancements, consequently, the administrator ought to give start-to-finish arrangements other than simply giving the availability. Assuming this is the case, at that point, it will surely assist in expanding a piece of the overall industry of portable and telecom administrators. Further, these administrators need organizations with speculators to give start-to-finish arrangements, which requests higher venture even before points of interest can be seen. The outcomes of progress while welcoming financial specialists rely upon the idea of the association and the included bodies, similar to gadget producers, arrangement suppliers, non-cell network specialist organizations, framework integrators, and so on. On the one hand, the result of this organization would assist administrators in entering further into the business, at last increasing their share of the pie. Simultaneously, this open door can form solid connections among the associations and ranchers to teach them about the advantages of savvy agribusiness. Cell innovation can only be achieved if specialist co-ops influence its genuine advantages, like compactness, adaptability, and extravagance of two path correspondences, to offer minimal effort yet modified arrangements. They should give what the rancher is out of luck for, at the spot they pick. Besides, to give quick infiltration in the horticulture industry, strategy changes are needed so as to give access to solid and quality sources of information. The examination, which considers 23 investigations, tha majority of which have a place with developing nations, presumes that cell administrations and advanced mobile phone innovation convey a promising and positive future for smallholder ranchers who are competent enough to improve their yields. Besides, authorized LPWA (low-power wide-area) innovation is required to be a distinct advantage for savvy farming. Because of its attributes and upheld administrations, including low force utilization and productive inclusion, it is appropriate to the topography and financial matters of agribusiness and is consequently expected to play a critical role in future smart cultivation. Thus, narrowband IOT (NB-IOT) gained widespread support from industries and turned into a viable worldwide standard for LPWA network. It may provide significant network possibilities in the farming industry after changing the observations in context to Internet capabilities. To ensure its future achievement, it is normal that driving cell administrators with strong IOT desire can generate noteworthy incomes by providing smart agribusiness administrations while working together with LPWA innovation suppliers. To make long-haul progress of these short-, mid-, and long-range correspondence advancements, essential strides for framework development are required toward achieving the innovation based horticulture.

10.3 AI and Analytics

AI and examination are utilized to dig information for patterns. In agriculture, AI is utilized, for instance, to anticipate which qualities are most appropriate for cultivation. It has been providing to cultivators all over the world the best seed assortments, those that are exceptionally reasonable to individual areas and atmospheric conditions. AI calculations, then again, have demonstrated which items are appealing and which are currently inaccessible in the market. In this way, for the rancher, this has given significant intimations for future cultivation. Recent advances in AI and investigation will enable ranchers to precisely arrange their items and remove less alluring harvests before they reach the clients.

10.4 UAVs and Other Robots

Automations are as a rule usually used by ranchers for crop development monitoring and as a means to combat hunger and other negative natural effects. Besides, they are being used to shower water and totally different pesticides effectively, pondering the extreme territories, particularly when the yields have varied statures. Automations have undeniable value in terms of splashing speed and accuracy when compared to conventional equipment of same reason. With recent advances in smart innovation and strategic management, gatherings of automatons equipped with heterogeneous sensors, as well as 3D cameras, will collaborate to furnish ranchers with far-reaching skills to affect their property. With the thought of UAVs in farming, ranchers will look up at the sky, but varied triggers ought to be considered so as to appreciate the real focal points of this innovation, particularly the incorporation of various advances and the way to utilize them in helpless climate conditions. Adjacent to drones, mechanical autonomy in farming has advanced fecundity and led to higher and snappier yields. Robots, like showering and weeding robots, are transferable down the agrochemical use chain. Sometimes, robots outfitted with optical devices and camera guidance are used to recognize and discharge weeds instead of human intervention. They explore between the lines of harvests on their own, eventually increasing the yield with labor cuts. Furthermore, plant transplanting and natural product selection robots are being developed to incorporate another degree of effectiveness to standard methods.

10.5 Yield Observation, Statement, and Harvest

Yield observant is that the element will not break down totally different viewpoints with reference to farming yield, such as grain mass flow, wetness content, and gathered produce quantity. It serves to exactly survey by archiving the harvest yield and wetness level to appraise how well the harvest performed and to do the recording. Yield observant is viewed as a fundamental piece of accurate cultivation not only at the time of reaping but also before that, as checking the yield quality assumes a necessary job. Yield quality depends upon a variety of factors, for instance, adequate fertilization with high-quality mud, which is notably important when anticipating seed yields under ever-changing ecological conditions. At present, after we progressively manage to open markets, purchasers around the world are becoming more and more specific regarding organic product quality; henceforward, powerful creation depends upon delivering the right natural product size to the right market at the right time. Yield decision could be a skill to anticipate the yield and creation before the collection happens. This decision helps the granger in the composition and dynamics of the not-too-distant future. Besides, breaking down the yield quality and its development is another basic issue that empowers the reassurance of the opportune time for gathering. This observant spreads totally different advancement

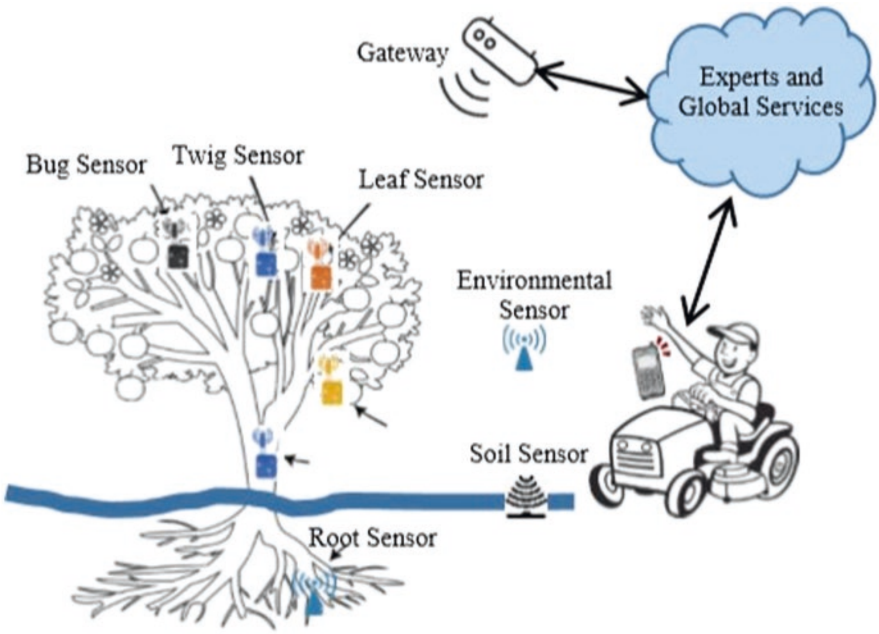

Fig. 5 An IoT based Farm Area Network (FAN)

stages and uses natural product conditions like shading, size, and so on. Anticipating the appropriate harvest time not only assists in augmenting the harvest quality and production but also offers an opportunity to change the administration procedure [11].

Despite the fact that gathering is the last part of this procedure, legitimate design will make a clear distinction. To induce the true benefits from crops, ranchers have to be compelled to understand when these yields are really ready to reap.

An IOT-Based Farm Area Network (FAN)
Figure 5 depicts a preview of a farm area network (FAN) that will illustrate the entire ranch to the granger more and more. A yield screen is often installed on any gatherer consolidate and connected with the mobile application FarmTRX, which shows live reap data and transfers it naturally to the producer's electronic stage. This application will manufacture wonderful yield guides and supply these guides with an expert, and therefore, the granger has the option to fare to alternative programming to interrupt them. To gauge the production and nature of yield accurately, the estimation of organic development is often exceptionally advantageous. This thought is employed in places where creators thought of the natural development to be the most essential and vital boundary to assess how well the harvest is advancing. Satellite photos are often an honest option to screen the yield of harvests with tremendous zones. This system is used when creators used Sentinel-1A Interferometric photos to set up the rice crop yield and power in an Asian nation. As we have

previously documented during this phase, organic product size systematically assumes a basic role in gauging its development, with reaping decisions and which specialize in the right market. For this reason, shading (RGB) profundity photos were used to follow various natural product conditions in mango ranches. Correspondingly, totally different optical sensors are used to monitor the harvest of papayas, notably throughout drying conditions [12].

10.6 Cloud Computing

Precise agriculture indicates its latent capability and benefits by expanding rural tasks through a higher information-driven dynamic. Furthermore, to proceed with this action, accurate factory farm needs not only higher innovation-associated instruments to process data effectively but also a reasonable cost so that the obtained information can be used to choose field options effectively. For this reason, ranchers will utilize cloud computing to gather information from discerning research foundations so that they can choose the best product accessible as per their explicit conditions. Distributed computing offers a position to ranchers to utilize information-based stores that contain a fortune of knowledge and encounters cultivation practice, as well as on equipment alternatives accessible in the market with the essential subtleties. Most of the time, this is combined with expert advice from wide range of hotspots (e.g., on cultivation and therefore the preparation of farming items). To make it more thriving, things may be expanded to include access to client databases, chains, and charging frameworks. While moving toward cloud-based administrations provides opportunities to analyze advancements, it also introduces new difficulties. Initially, an incredible scope of sensors is created and used in precision agriculture, each with its own information configuration and linguistics. Moreover, the overwhelming majority of the selections showing emotion corroborative networks are application-specific, whereas a granger may be in need of progressing to completely different frameworks for a selected application, e.g., soil observant. The Cloud-based alternative showing emotion corroborative network not simply must take care of the numerous style of info and their organizations nonetheless additionally should have the choice to style these arrangements for numerous applications associate open Cloud-based framework has been wind of by noble metal Junction that accumulates and scatters the knowledge on a structure from various precise agriculture controllers, prompting a decline in prices and natural effects. Moreover, Akisai cloud by Fujitsu centers on food and rural businesses and joins information correspondence innovation to increase food flexibility in the coming years. Correspondingly, supply trace technology is created and provides cloud-based mobile applications to present perceivability and relations among homesteads and markets, following the price chain at the supply, e.g., “eService Everywhere.” A major note regarding their applications is that, throughout the course of events, they thought of the farms’ remoteness and low transmission capability conditions.

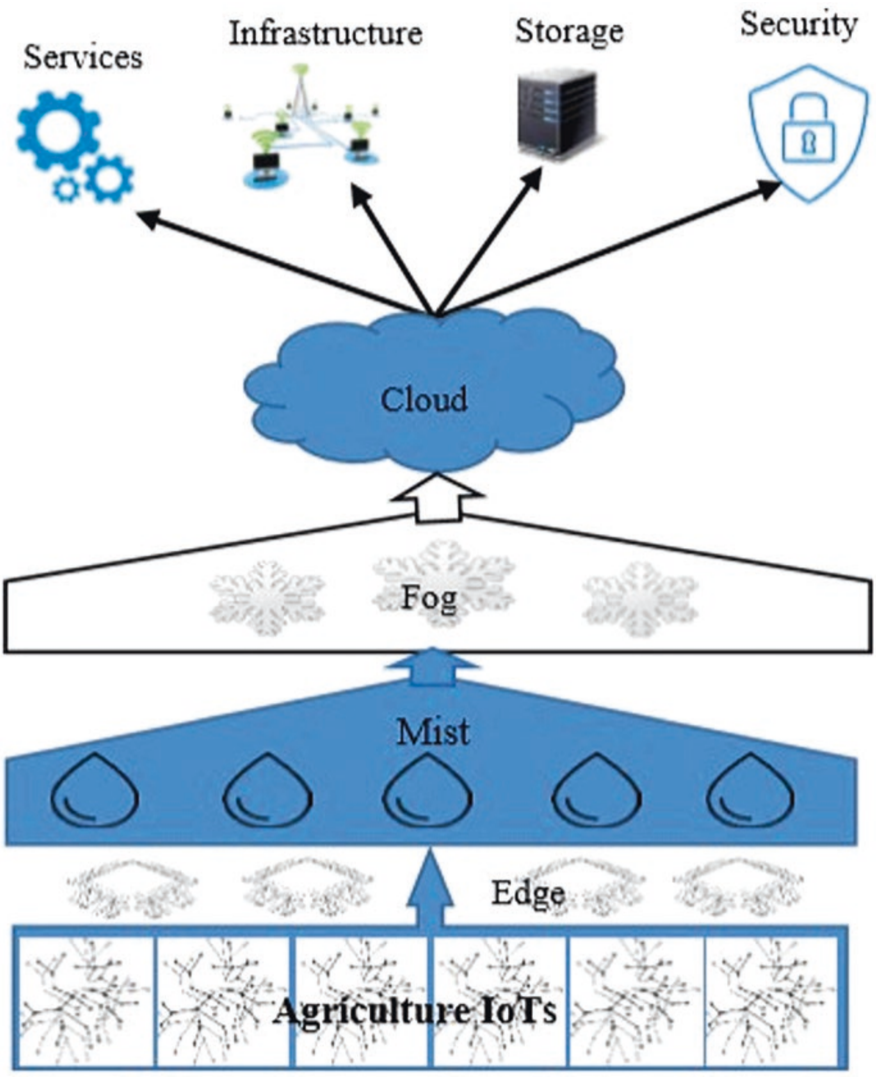

Fig. 6 IoT based smart agriculture

Figure 6 presents the conceivable foundation and relationship of fluid computing such as Edge, Mist, and Fog for keen agribusiness [13].

Fluid Computing Infrastructure for Smart Farming With the implementation of the Internet of Things, the agricultural domain has become data-driven, allowing for well-timed and cost-effective farm management while remaining environmentally sustainable. Thus, the incorporation of Internet of Things in the agricultural domain is the need of the hour for developing countries whose gross domestic product primarily depends on the farming sector.

11 Conclusion

The IOT horticultural projects are making it possible for farmers and ranchers to assemble huge statistics. Big landowners and little ranchers need to capture the capability of IOT commercial center for agribusiness by installing smart innovation to build seriousness and sustainability in their creations. With the population growing rapidly, the demand can be effectively met if farmers, as well as little ranchers, carry out horticultural IOT arrangements in a well-off manner.

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Implementation of Intelligent Plantation System Using Virtual IoT

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1 Introduction

Greenhouse cultivation has gained a growing attention as a significant method of contemporary farming. The key features of the modern greenhouse are incorporation of sensors, embedded and wireless communication technologies in the design of a greenhouse monitoring and control system [1]. Agriculture has been the primary occupation of our country for ages [2]. Presently, there is so much interference in the agriculture because of the immigration of people from villages to cities, resulting into the need of smart farming techniques using IoT to tackle this issue. IoT refers to a network of objects that make up a network to configure itself [3–6]. The smart plantation scheme conceived in this paper is based on the common platform Raspberry Pi and IoT. Virtual Raspberry Pi board is interfaced with the Ubidots platform using the Wi-Fi module. Ubidots is one of the smart and fully automated platforms of IoT. The system consists of Raspberry Pi microcontroller and sensors as major parts as they are responsible for controlling the field irrigation [7, 8]. Raspberry Pi is an advanced version of the microcontroller that forms the core of the system. Different sensors such as temperature sensor, humidity sensor, etc. are used to measure the different environmental constraints. The sensor parameter is

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demonstrated in terms of ppm at different levels and actions on the IoT device [9, 10]. Additionally, the sensor must be able to use the server via wireless communication in order to graphically achieve the real-time information so that data stored in the cloud can be transmitted to many users at any time [11]. Ubidots offers a quick and reliable mechanism for the real-time sending and receiving of data from and to IoT devices using the global cloud network [12]. Ubidots offers a firm forum for the hobbyists, enthusiasts, and professionals alike, allowing them to quickly retrieve and use the sensor data across the globe and making it useful. Ubidots platform is used to send the different sensor values or other data to the cloud, safely store them, and retrieve them whenever a person wants to use simple API calls.

As we know that there are so many plant monitoring projects developed to monitor the health status of plants [13]. Currently, there are so many manual approaches of plantation to monitor the parameters, in which manpower is used to detect the growth of plants [14]. The gardeners themselves examine the factors in their field [15]. Earlier only the sensors were used for accomplishing this task. The process may consume more time and a huge manpower. It is very difficult and hectic task to continuously monitor for the maintenance of the crops [16]. It is almost impossible to be always in the field and analyze as well as monitor the temperature [17], humidity, and moisture accurately. So, it may lead to the decrease in the quality of plants due to insufficient monitoring [18]. Previously, there was no source of information about the field status via SMS [19]. When any of the sensor value goes beyond the threshold value or some problem happens to the motor, he may know manually [20]. In order to avoid these circumstances, the authors have proposed a system in which the person can get information via SMS and e-mail immediately if any of the above sensors goes beyond the limit. The system is also required to do the needful operation, such as turning on or turning off the water pump whenever required by the user's instructions on the electronic device.

The main contributions of this research work are to propose a smart plantation system to monitor the health status of crops and thus increase the production of the crops, to implement a smart water management system, and to use the cloud computing resources to incorporate this framework. The purpose of this proposed system is to track the various parameters related to the plantation being observed electronically via wireless connectivity. The proposed system is of great benefit to the farmers as farming accounts to over 60 percent of our country's employment. The production of crops will also increase if the proposed system is used to gather the information about the irrigation outputs using IoT and different sensors. It provides security even to livestock. The farmers may also use remote technology to activate/deactivate the water pumps operated by renewable energy sources to keep the environment safe.

This article is systematized as follows. Section "Related work" deals with the related work on IoT and its potential agriculture applications. In section "System architecture and operation," the system architecture is represented along with the design. Section "Proposed methodology" refers to the proposed methodology with implementation. Section "Results and discussions" describes the results and discussion part. The conclusion is discussed in section "Conclusion and future scope."

2 Related Work

The authors in [21] have highlighted the potential of wireless sensors and IoT in agriculture as well as the challenges to be faced when this technique is combined with the conventional farming approaches. It investigates in depth IoT devices and communication methods related to the wireless sensors employed in the agricultural applications. The sensing technologies are required for specific agricultural operations, such as soil preparation, status of crop, irrigation, insect recognition, and pest identification. In [22], the real-time analysis of the data collected from sensors employed in crops is provided. It generates the results for farmers that are required to track the crop growth, hence reducing the farmer's time and resources. The data obtained from the fields are stored in the cloud and managed through the integration of IoT devices to promote the automation. The idea proposed in the paper can improve the crop productivity by reducing the wastage of agricultural field resources. The findings of the experiment show the field temperature, soil moisture, and humidity and carry out the decision-making analysis. A Cuckoo Search Algorithm is used in [23] that allows for the provision of water for farming under any circumstances. By integrating with the IoT network, equipped with related sensors and wireless communication systems, a variety of parameters such as temperature, turbidity, pH, moisture, etc. are calculated. Using ThingSpeak, the sensor data is accessed in the cloud environment on this IoT platform. Further, the authors in [24] suggested a technique that can generate the messages to alert the farmers through the various platforms. By obtaining live data (temperature, humidity, soil moisture, etc.) from the field, the product helps farmers to take the required actions to allow them to do the intelligent plantation that raises their crop yields to help them in the saving of resources (water, fertilizers). The authors in [25] presented a review to summarize the existing state-of-the-art irrigation systems. In irrigation systems, there are the parameters that are controlled in terms of water quantity and quality, soil characteristics, and weather conditions. The approach gives an outline of the nodes and wireless techniques that are mostly used. Finally, the problems and best practices to incorporate the irrigation systems based on sensors are addressed.

The authors in [26] proposed a variety of features such as GPS-based remote monitoring, moisture and temperature sensing, scarring intruders, safety, leaf wetness, and proper irrigation facilities. The system makes continuous use of wireless sensor networks to assess the soil properties and environmental factors. In [27], an IoT-based smart farm control system is proposed to help the farmers achieve the effective farming. The combination of the current environment and agricultural production with the farmer in a simple way through Arduino Mega and GSM modules is also explored. The suggested approach helps users to manage and control all the events required during agriculture.

3 System Architecture and Operation

The proposed system architecture is discussed briefly in this section (as shown in Fig. 1). The main aim of this model is to handle the harvests via remote mobile network and to initiate the certain orders. The flow of work is conferred with the help of various flowcharts and block diagrams. The key outline of this work is to design and implement a virtual IoT-based intelligent plantation system to monitor the electrical devices such as pumps (without any interference) depending on the atmospheric constraints such as soil moisture and temperature. The module design consists of two parts: hardware and software.

Hardware part consists of sensors while software part consists of middleware, communication part, and cloud part.

3.1 Sensor Part

This is the first layer of the structure suggested by the authors. The sensors are installed across the field for sensing or collecting the parameters. DHT11 sensor is employed to read the weather temperature and humidity of the field. The

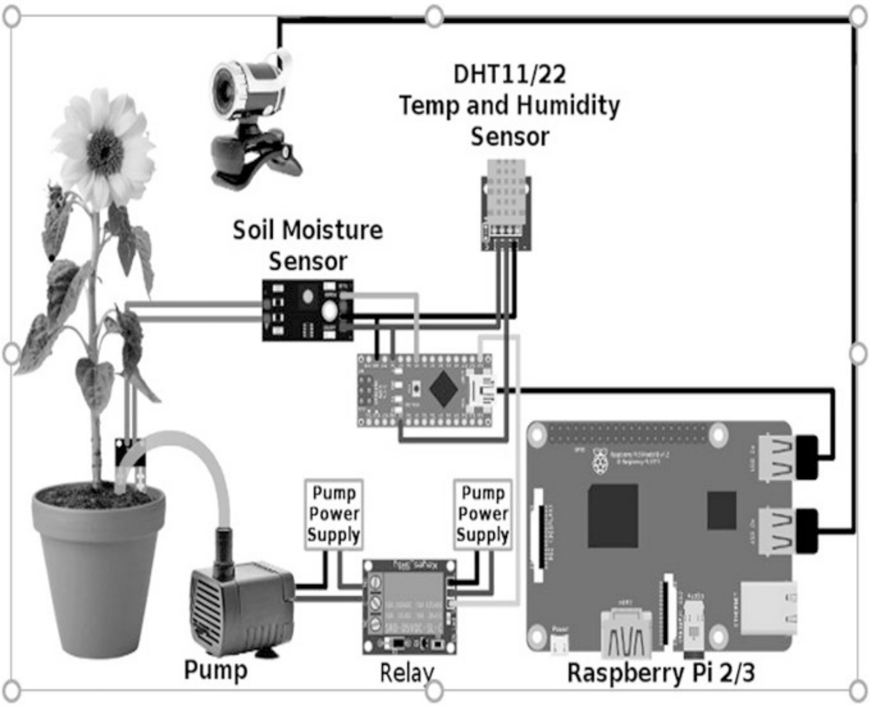

Fig. 1 Proposed system model

temperature ranges from 0 to 50 degrees centigrade, with the precision of 2 degrees. This sensor's humidity varies from 20 to 80 percent with a precision of 5 percent. It is ideal for the remote atmospheric stations, home environmental control systems, and residence or greenery walled in the area of observation structures. This sensor measures the relative clamminess [28].

The sensors for soil moisture measure the volumetric content of the soil water. The soil moisture sensor employed in this device to assess the quality of the soil to check whether it is good for crops or not [29].

The sensor used for the humidity is DHT-22. The humidity sensor (or hygrometer) detects the relative humidity in the air, calculates, and records. Therefore, it tests both humidity and temperature of the air. Relative humidity is the ratio of real humidity in the air to the maximum amount of humidity that can be maintained at that air temperature [30].

Raspberry Pi is a credit card-sized device for connecting the sensors and actuators in various models with General Purpose Input Output (GPIO) pins, so that it can play a major role in connection to the sensors. It is used to keep track of the data produced by the different sensors connected to the farming field and to send it to the web server which can be used for data analysis or data visualization purposes.

3.2 Middleware Part

Under this part, there comes a high-level general purpose programming language called Python and a free operating system (i.e., Raspbian) optimized for the Raspberry Pi hardware.

3.3 Communication Part

The communication protocol called Message Queuing Telemetry Transport (MQTT) protocol is the basis of the communication part.

3.4 Cloud Part

Cloud computing is an evolving platform that can be used efficiently in today's agriculture. The suggested model uses the cloud computing technology to record the data from different agricultural fields. The various channels are created in this layer, each corresponding to a particular constraint in the Ubidots cloud for storing the field data. The controller periodically sends the sensed data via communication protocol to the interface. Such types of data are designed in terms of time. In the

Ubidots web service, status of field (temperature, soil moisture) can be tracked as a graph [31].

The advantages of the proposed system are that it preserves the water used for plantation, senses the parameters accurately, has low maintenance cost, and provides the acknowledgment to the user about the field conditions.

The sensor module deals with the sensing where the sensors such as soil moisture sensor and temperature sensor are placed in contact with the soil to be grown. These sensors are linked through the wireless connections to the control unit. The decision is taken by the microcontroller, based on the sensed values. Initially, the controller program needs to be installed. The threshold values for each parameter have to be predefined before reading the analog inputs from the sensors. During the implementation of system, the moisture threshold is set at 91. The temperature tolerance value is 28 degrees centigrade. The sensors are wired to the Raspberry Pi pins that require encoding in Python language for the implementation of applications. After that, the reading of the moisture sensor is checked. If the humidity goes beyond 90, then the temperature test is performed. When the temperature is below the threshold value, this ensures that the plant will live for a few more days without water. If the threshold value is exceeded, the plant must be irrigated. In this work, user awareness is included as a module. This allows the user to become fully aware of the farming and agriculture. The system is designed particularly for the farmers who depend on the work to nurture the field. They don't need to stay near the field frequently. Instead, they can make use of this intelligent system and get worthwhile advices and field notifications. When there is low humidity and high temperature, the user receives the message about the plant's condition and irrigation requests. The text message also recommends the fertilizers for improving the soil nutrients when the temperature sensor value stretches beyond the range.

4 Proposed Methodology

An IoT-based smart plantation system intends to make use of the features of embedded system to make the agricultural science effortless. The system reads the soil moisture, temperature, and humidity in this sensor connected with Raspberry Pi, and then the sensed data are given to Raspberry Pi. The controller is considered to be the decision maker. It examines the moisture and temperature value. At first, the threshold values of moisture and temperature are defined.

Figure 2 shows that whenever the sensed value of temperature goes beyond the limit, the Raspberry Pi monitors the temperature value. If the sensed value of temperature is higher than the threshold value, then plantation is done and heater is turned off as explained in the flow diagram. On the other hand, if the temperature is mild, all crops can tolerate the moisture in the dry soil conditions.

As explained in Fig. 3, if the soil moisture is dry, it will check the water tank level. If water tank level is less than 15, the acknowledgment is given to the user and the relay will get opened automatically to provide the supply of water.

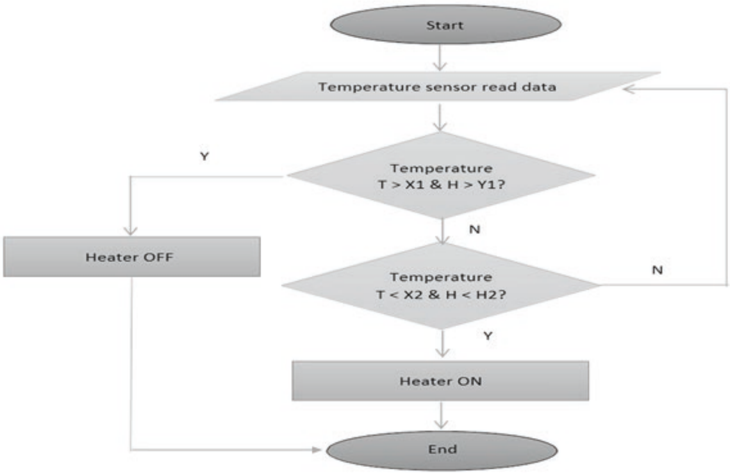

Fig. 2 Workflow of temperature sensor

4.1 Virtual IOT Implementation Using Ubidots

(a) *Importing library file into Raspberry Pi (set up Raspberry Pi)*

First step is to set up virtual Raspberry Pi. Integrated Development Environment (IDE) desktop version as well as online editor is used to upload the code to the board using various library modules.

```
Adafruit_DHT- For DHT11 sensor
RPi. GPIO-For LDR sensor
Adafruit_MCP3008- library to convert analog sensor data into digital
Time- For using function like delay
Adafruit_GPIO.SPI- To enable spi pins
```

(b) *Creating a device in Ubidots*

Next step is to create a device. Click on "Add New Device" and select "Blank Device" in Ubidots window. Next step is to create two variables – one to assign the value of button (1 and 0) and the other one to store the value of the text where acknowledgment from the Raspberry Pi is displayed. A note of the device label and variable labels of all the variables is made that is being used in the code. In order to create a dashboard by clicking "Add New Dashboard," click on "Add New Widget" and connect the Switch Widget to the Button.

(c) *Assigning authenticated values to the cloud*

Each packet demands a Token. Clicking on "API Credentials" under the profile tab is the fastest way to retrieve. API key is primarily an exclusive and immutable

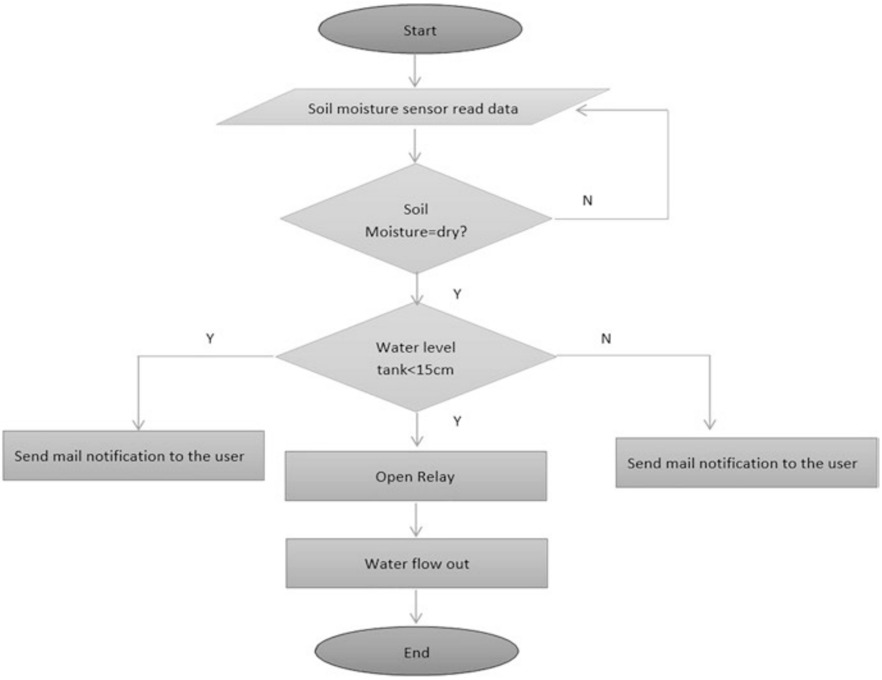

Fig. 3 Workflow of moisture sensor

key which is only used to generate the account tokens. Device Label, Device ID, Variable ID, and Token will be configured in the code.

(i) Defining server address and port no. of cloud

```
Server_Address = "mqtt.ubidots.com"
port = 1883
SPI_PORT = 0
SPI_DEVICE = 0
```

```
m                                c                                p
=
Adafruit_MCP3008.MCP3008(spi = SPI.SpiDev(SPI_PORT, SPI_DEVICE))
```

(ii) Assigning the value of channel ID, write API (application programming interface) key, and topic for writing the data in cloud.

```
Channel_id = 1101269 # from cloud
write_api_key = 'FMFCB72IVSU03247'
topic= channels/"+str(channel_id)+"/publish/"+write_api_key
Assigning the value of sensor type and related pin of sensor
sensor_type = DHT.DHT11 #DHT11, DHT22, DHT21
sensor_pin = 4
GPIO.setmode(GPIO.BOARD)
GPIO.setup(Moisture,GPIO.IN)
```

(d) *Assigning the value of sensor type and related pin of sensor*

```
sensor_type = DHT.DHT11 #DHT11, DHT22, DHT21
sensor_pin = 4
```

(e) *Creating client object for cloud and connecting from cloud server*

```
client = mqtt.Client()
client.connect(Server_Address,port)#connected to cloud
```

(f) *Writing the data of sensors into console and publishing in to cloud*

```
while True:
                  h    u    m    i    d    i    t    y    ,
temperature = DHT.read_retry(sensor_type,sensor_pin)
     print("Temperature : "+str(temperature))
     print("Humidity : "+str(humidity))
     Moisture_status = GPIO.input(Moisture)
        if(light_status <= 15):
        print("dry soil")
        else:
        print("wet soil")
     Publishing the data in cloud
     data="field1="+str(temperature)+"&field2="+
str(humidity)+"&field3="+str(Moisture)+"&field4="+str(Camera)
     client.publish(topic,data)
     print("Data sent to Cloud")
     time.sleep(15)
```

The callback function will be called when a new message is received in the subscribed topic. It will first display the received payload in the serial terminal. It then switches on or off the built-in LED of the Raspberry Pi and then publishes the state of LED through the pubTopic command. The serial monitor is started followed by opening up the browser and clicking on the button created in the Ubidots dashboard.

5 Results and Discussions

The results of the proposed system are simulated on virtual IOT and displayed on cloud platform Ubidots. The snapshots of the results are provided in this section. Ubidots helps to capture the data easily from sensors and convert data into useful information. Ubidots results are in the form of a graphic notation and are used for the administrative purposes to manage the system in an efficient manner. In this unit, the system findings are seen on the display screen.

Figure 4 represents the Ubidots cloud dashboard. Here, the Ubidots dashboard is created that consists of a button widget and a metric widget and three variables are assigned to it, i.e., temperature, pressure, and humidity. After pushing the button widget, command is sent to Raspberry Pi using MQTT protocol. MQTT protocol is used to send and receive the data from Ubidots cloud to the Raspberry Pi. When the data reaches Raspberry Pi, it sends back an acknowledgment signal to the Ubidots that will be displayed on the text widget. Firstly, an account in Ubidots needs to be set up followed by the configuration of the project on Ubidots so that Raspberry Pi can send the data. Dashboards are the human-machine interfaces where data are easily visualized. The project configuration is done with the help of Ubidots web interface.

After project configuration, the user can define the variables. One holds the temperature values, while the other holds the moisture and humidity values. The IDs of all these variables are used for the Raspberry Pi sketch. After configuring the variables, we can use them to send the data. After running the sketch of Raspberry Pi, it automatically starts sending data to the Ubidots. The user can create a simple

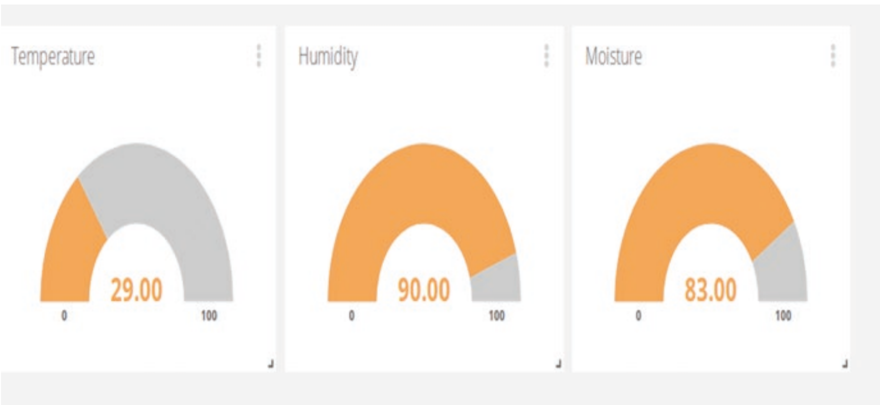

Fig. 4 Ubidots dashboard snapshot

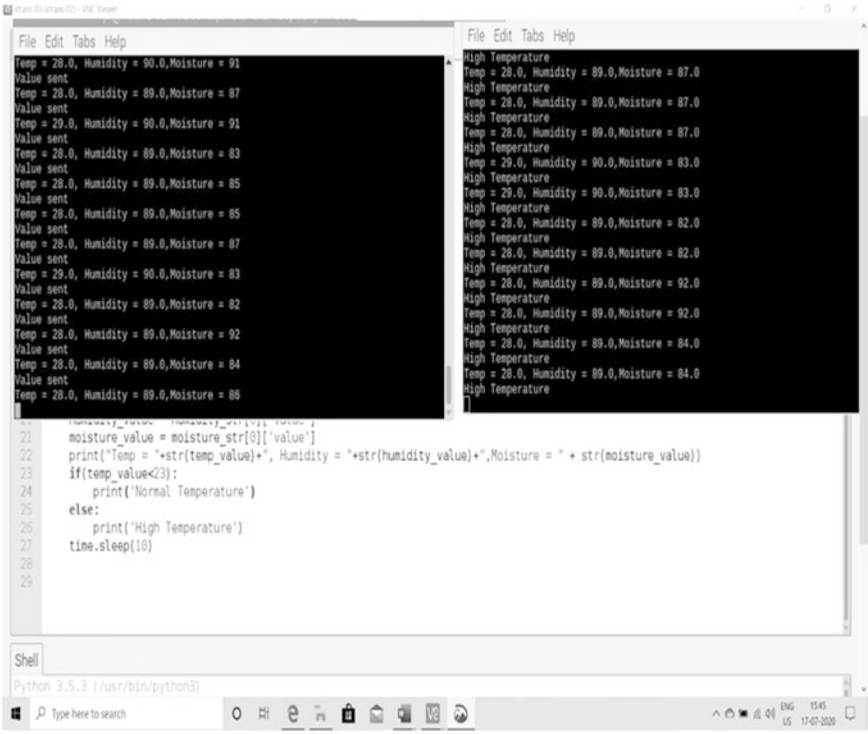

Fig. 5 Terminal snapshot: sending and receiving data from the cloud

dashboard to show the data sent by Raspberry and DHT11 and DHT22. Once the code has been uploaded to the virtual Raspberry Pi, the serial display button is clicked. As the board connects to Wi-Fi, the data is automatically transmitted to the cloud. Raspberry Pi receives the changed code in no time. Once the command is received and the LED is turned ON, it will send an acknowledgment back to the Ubidots server that will be displayed in the dashboard. Figure 5 shows the sending and retrieving data process of all three sensors from the cloud, and based on that data received, some action is to be initiated.

5.1 Analysis of Temperature Sensor

On the Ubidots website, a dashboard is created to provide the widgets to monitor and plot real-time graphs and sensor data. It is also used to trigger the alarm when the optimum value of a variable is exceeded. After the navigation to Ubidots dashboard, all the data sent from the sensor will be displayed in widgets.

The temperature, moisture, and humidity data are measured from the field where plantation is done. Ubidots technology provides the developers to easily capture the data of sensor and convert it into useful information. Figure 6 shows the analysis of temperature data in Ubidots server. Ubidots offers developers a platform that allows them to sense the data of sensor easily and transform it into graphical information. The result of this research is that the field temperature is successfully obtained. While the field is measured using a DHT sensor, the temperature results will be reflected on the board, and this data will be reached in real time as shown in Fig. 6. Figure 7 shows the readings of temperature sensed by sensor.

5.2 Analysis of Humidity Sensor

Figure 8 shows the analysis of humidity data in Ubidots server. Sensor data cloud storage is obtained in CSV format files, as shown in Fig. 9. GUI libraries provide the resources needed to create the various graphical interfaces. On the cloud, the agronomist will program events or alarms. Figure 8 shows the graphical interface, created with the Ubidots humidity cloud platform. Some alerts are also created if the moisture level exceeds a certain level and an alert is sent to our mobile phone via SMS.

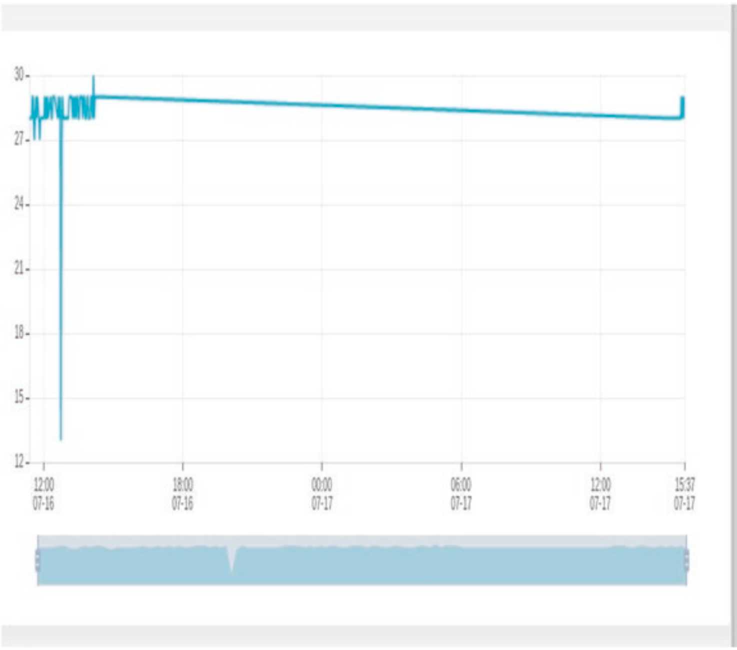

Fig. 6 Analysis of temperature using Raspberry Pi integration with Ubidots

Timestamp	Human readable date	temperature
1594980488054	17-07-2020 15:38	28
1594980459891	17-07-2020 15:37	28
1594980431637	17-07-2020 15:37	29
1594980388233	17-07-2020 15:36	28
1594980358903	17-07-2020 15:35	29
1594980265159	17-07-2020 15:34	28
1594980241783	17-07-2020 15:34	29
1594980217438	17-07-2020 15:33	28
1594980184151	17-07-2020 15:33	28
1594980155615	17-07-2020 15:32	29
1594980127323	17-07-2020 15:32	29
1594980103992	17-07-2020 15:31	28
1594980047174	17-07-2020 15:30	28
1594980011564	17-07-2020 15:30	29
1594979988116	17-07-2020 15:29	29
1594979941980	17-07-2020 15:29	29
1594979913844	17-07-2020 15:28	28
1594979883034	17-07-2020 15:28	28
1594979857538	17-07-2020 15:27	28

Fig. 7 Readings of temperature sensed by sensor

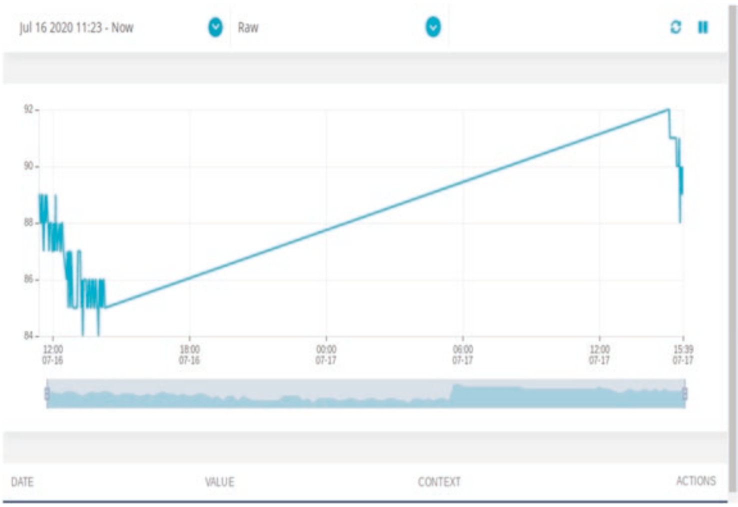

Fig. 8 Analysis of humidity using Raspberry Pi integration with Ubidots

Timestamp	Human readable date	humidity
1594980609614	17-07-2020 15:40	90
1594980583924	17-07-2020 15:39	89
1594980550566	17-07-2020 15:39	90
1594980517310	17-07-2020 15:38	89
1594980488980	17-07-2020 15:38	89
1594980460731	17-07-2020 15:37	89
1594980432450	17-07-2020 15:37	90
1594980389157	17-07-2020 15:36	89
1594980360367	17-07-2020 15:36	90
1594980266049	17-07-2020 15:34	89
1594980242983	17-07-2020 15:34	90
1594980219489	17-07-2020 15:33	89
1594980185025	17-07-2020 15:33	89
1594980156585	17-07-2020 15:32	90
1594980128259	17-07-2020 15:32	89
1594980104887	17-07-2020 15:31	88
1594980048475	17-07-2020 15:30	89
1594980012985	17-07-2020 15:30	90
1594979989222	17-07-2020 15:29	90

Fig. 9 Readings of humidity sensed by sensor

5.3 Analysis of Moisture Sensor

Figure 10 shows the graphical analysis of the moisture, which was previously viewed in the serial monitor. This happens because the value of different sensor reading is passed as a string and stored in a variable. Figure 11 illustrates the moisture sensor values sensed by the sensor.

Table 1 describes the deployed parameters range sensed by humidity sensor, temperature sensor, moisture sensor, and their respective threshold values.

6 Conclusion and Future Scope

A smart plantation system is designed to observe the health status of plants/crops, and with the collected data, a specific action is triggered automatically and remotely. A camera is used to monitor the live status of plants/crops. The proposed system can collect the data using parameters such as temperature, humidity, and moisture within the plantation field by integrating the features of all hardware components using virtual IoT. This design improves the real-time efficiency in changing the agricultural climate and hence contributes to the achievement of the unattended target resulting in the production of smart planting crops [32]. The proposed work is an achievement and will record a competent technique for the real-time readings. With this system, one can increase the production of crops and help farmers whose livelihood depends on the better quality crops.

Future opportunities can be on the basis of the data collected by the existing sensors. Using data analytics and machine learning, the favorable atmospheric conditions can be defined/predicted based on data of humidity, temperature, light intensity,

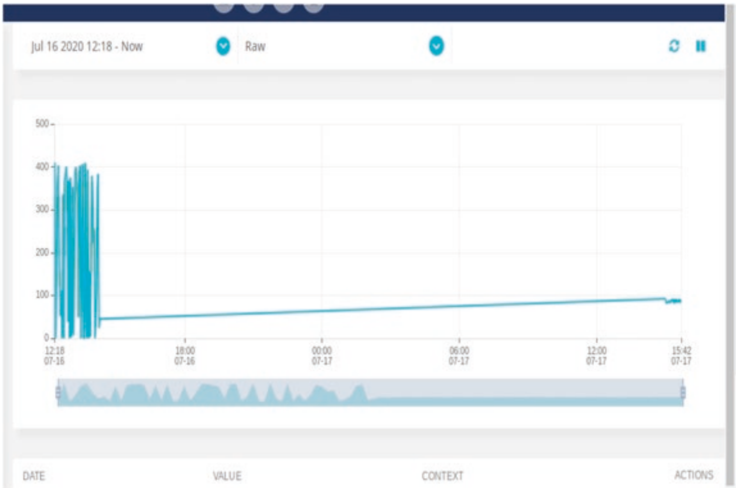

Fig. 10 Analysis of moisture using Raspberry Pi integration with Ubidots

Timestamp	Human readable date	moisture
1594980790062	17-07-2020 15:43	87
1594980764497	17-07-2020 15:42	85
1594980741537	17-07-2020 15:42	85
1594980707763	17-07-2020 15:41	83
1594980679582	17-07-2020 15:41	91
1594980646193	17-07-2020 15:40	87
1594980610516	17-07-2020 15:40	91
1594980584757	17-07-2020 15:39	89
1594980551513	17-07-2020 15:39	83
1594980518183	17-07-2020 15:38	91
1594980489940	17-07-2020 15:38	84
1594980461567	17-07-2020 15:37	90
1594980433370	17-07-2020 15:37	83
1594980389993	17-07-2020 15:36	83
1594980361697	17-07-2020 15:36	84
1594980327313	17-07-2020 15:35	85
1594980266892	17-07-2020 15:34	89
1594980243806	17-07-2020 15:34	85
1594980220356	17-07-2020 15:33	90

Fig. 11 Readings of moisture sensed by sensor

Table 1 Deployed parameters

Parameter	Range sense by sensors	Threshold value
Humidity sensor	88–90	90
Temperature sensor	28–29	29
Moisture sensor	83–91	91

etc. Images captured can be utilized after the image processing algorithms to identify the health conditions of leaves, fruits, and flowers, which can certainly be used to certify the quality of fruits/flowers. Based on motor triggering frequency, how much care a plant will require can be defined/predicted. If the accurate gas sensors can be developed to sense the exact amount of exhale/inhale of oxygen/carbon dioxide and other gases, then it will be great to categorize the plants as per our need in the different geographic locations. The sensors which can sense the vibrations around a plant can be used to open a new area of research to measure the energy level of different plants and their impact on surroundings. Additionally, sensors could be used to analyze the air pressure and altitude, and a web interface or data feed service could also be built directly to the Internet. This scheme may also be used in the future as a part of the advancement of remote control of the Internet of Things and may be extended to other areas of modern agriculture facilities.

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Smart Agriculture and Its Impact on Crop Production

M. Raj Kumar, P. B. Ahir, D. Mrinmoy, and K. N. Tiwari

1 Introduction

With the advancement in agriculture technology, population all around the globe has also increased. From last decades a huge drift has been observed in population growth, and without any halt, its rate is increasing with each passing year. Population growth is not confined to a specific country; it involves the entire world and with this, large-scale production of quality food arises. To fulfil this need, new methods and systems are developed including vertical farming, hydroponics and biotechnology which are applied on a large scale for greater production. However, for these advance methods, the establishment of systems for efficient use of water is also needed because of shortage in water supplies and it is one of the major results caused due to rising change in climate [15]. Traditional methods of irrigation are insufficient, less effective and inadequate to meet the need of the modern era. Hence, to optimize the usage of water, it is unavoidable to embrace automation along with data processing schemes in advanced agricultural irrigation methods [7]. For this purpose, researches are being done on estimation of water requirements by the crops and consequently the determination of optimum irrigation period. This estimation is done using sensors for soil moisture [8], sensors for drainage [12] and monitoring evaporation from the pan [11]. It is to be noted that a large number of automated irrigation method researches utilize data obtained from soil moisture sensor for the determination of the required amount of irrigation. [8] designed a

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system which comprises temperature and soil moisture sensors for the collection of data and for stimulating actuators a gateway unit and Internet for transmission of data along with web application to control and monitor the system.

Most recent advancement in agriculture is observed by the Internet of Things "IoT" which have made farmer capable enough to cope with daily challenges faced in the field. The main objective of new developments and inventions based upon the Internet of Things in agriculture is to find a most efficient solution against existing problems by enhancing the crop production factors such as quantity and quality of the crop, cost-effectiveness and sustainability. It has facilitated farmers to check and control the growth of plants and physical parameters such as temperature, soil moisture, atmospheric, humidity, etc. by the use of sensors which record current values in a certain instant to help in maintaining and controlling irrigation instruments and easy decision-making even from remote places [1]. A current problem faced by farmers is water scarcity; it is often dealt by managing water properly and crop production also can be enhanced by this way. Sensors used in large networks for advance irrigation system require Internet connectivity for communication and transmission of data, while some sensors can transmit data without Internet connectivity as well. Some of the efficient Internet-based irrigation systems which use sensors and transmit data with and without Internet connectivity are discussed.

To examine and check crop field and to automate the irrigation system, an Internet-based system by the utilization of the sensor is established where IInternet connection is enabled by GMS or GPRS module. Field data is transmitted from sensors to coordinator into database storage, and the transmission is wireless. Mobile applications and irrigation controllers are used to control the field. As this technique is developed to form irrigation system simpler, 90% efficiency in water usage is attained by this wireless sensor system as compared with the other conventional technique [16].

2 Basic Architecture of IoT-Based Automated Irrigation System

Sensors for soil moisture, humidity and temperature are used to monitor the field constantly and send the data to "NRF24LO1" transmitter as well as receiver to the web server along with the utilization of "Ethernet connection" present at receiving end. Web application is designed to evaluate and analyse the received data and threshold value of humidity, temperature and moisture. To automate the irrigation decision is taken by a server. The motor is switched "ON" if the value decreases from threshold value and switch "OFF" when value increases from the limit. The system architecture is shown in Fig. 1:

Each sensor is interfaced with "*Arduino micro-controller*" and programmed which is then kept in the field after placing in a box. Two probes of soil moisture sensor are used to pass current through the soil as a sensor is popped in the soil.

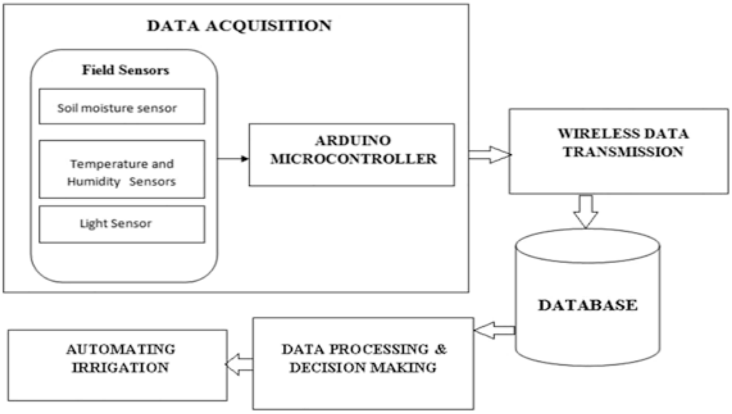

Fig. 1 System architecture [16]

More moisture in soil has low resistance within the current passage while dry soil resists its passage and fewer current is allowed to pass. This value of resistance is employed to detect the moisture. Moreover, for humidity and temperature, "DHT11" sensor is employed. Change in humidity and temperature happens before and after the irrigation. Humidity and temperature are relative to each other, and due to the increase in temperature, relative humidity increases and vice versa and their readings are notified to the user. For light detection "Light Dependent Resistor (LDR)" is employed during which resistance decreases when the intensity of light decreases and vice versa. This resistance is measured with "voltage divider circuit".

"NRF24L01 module" is utilized for wireless data transmission. It uses transceiver of 2.4GHz frequency using "Nordic semi-conductor", and the rate of data transfer is 256Kbps/1Mbps/2Mbps while voltage requirement is 1.9–3.6 V. This module is cheaper than other ones, and its receiver and transmitter modules are linked with "Arduino" boards where the transmitter is placed in field and receiver with in the system. Receiver in the system is linked to web server through Ethernet which is of IEEE-802.11 standard for local area networks in the computer. Data from the transmitter is received by the receiver, a request id is sent to web server as the Ethernet cable is connected to "*Arduino micro-controller*" and it consigns a specific IP address in network range and sends a request to the web server. As web server is established by PHP script for inserting value appropriately, it saves data within the database.

In the processing received sensor data is compared with threshold values and these values are different for various crops. They will also differ under climatic changes so all these conditions are kept under consideration while fixing threshold values. The motor automatically switches ON if the value of soil moisture decreases from threshold limit, or user also can switch it ON from phone or web application. Relays are used for the transfer of control from web app to electric switch. Relays are electric operation switches and solid-state relay is employed during this system. The scheme for automation is shown in Fig. 2.

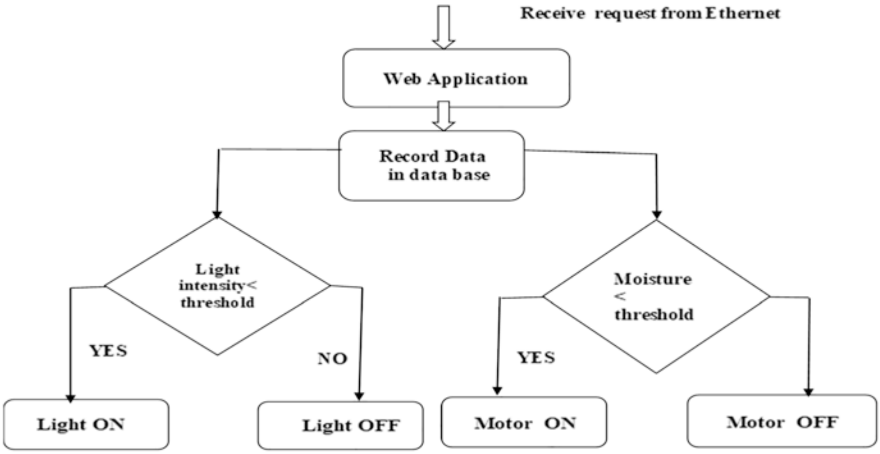

Fig. 2 Automation in the irrigation process [16]

Similarly, an automatic irrigation method based upon cloud server is established which works on the water-level measurements taken from a class-A evaporation pan. For Internet connection, GSM/GPRS module is used for transmitting data from sensors to cloud server. The user determines regularity in irrigation and therefore the opening of valves at a particular time, while the duration for irrigation is decided automatically with reference to water level with in the pan. To monitor the status of the system, mobile application is developed which updates the water-level information in cloud server also [3].

3 Construction of Cloud Server-Based Automatic Irrigation System

This irrigation system comprises four major segments which include “power and actuator, data gathering, control and internet connection and therefore the last one is monitoring”. The first segment which is power and actuator comprises transformer and solenoid valves which open only when the voltage of 24v alternating current is applied. Here, the role of the transformer is the reduction of high voltage which is 220v to the required 24v AC for valves. Relays are attached on the solenoid power cables and valves can be switched ON or OFF by transmitting a control signal from controller unit to relays. The second segment is data gathering unit which comprises water level and environmental sensors along with a transceiver module. All these constituents are linked to a micro-controller board which is based upon “ATmega328P (Atmel Corporation, San Jose, CA)”, while water-level sensor “PN-12110215TC-8 (Milone Technologies, Sewell, NJ)” is attached to evaporation pan for continuous values of water level. For the measurement of temperature, barometric pressure measurements and humidity, an environmental sensor “BME 280 (Bosch Sensortec GmbH, Germany)” is used. Moreover, the transceiver module “NRF24L01+ (Nordic Semiconductor, Trondheim)” is used which allows RF communication at the frequency of 2.4 GHz for the transmission of values from sensors to the control and Internet connection unit. For efficient use of the water-level sensor, an efficient process is required. The output of the sensor is estimated to be close to linear in sensor datasheet, but the lower test for error is accomplished through the utilization of a quadratic model instead of a linear model. Therefore, the output voltage must be noted at every 5 mm rise within the level of water while filling the empty evaporation pan of water. Then this purpose, “coefficients of second-order polynomial” to level-voltage pairs are determined by using the method of least square. Control and Internet connection unit is comprised of real-time clock-module “RTC” with transceiver module, and GSM/GPRS module for the Internet connection is installed in this unit.

Micro-controller board which is based upon “ATmega2560 (Atmel Corporation, San Jose, CA)” carries out the processing of data from modules and executes the given commands for processing. For the reading of immediate instantaneous time along with date, real-time clock module which is based on “DS 1302 (Maxim Integrated, Sunnyvale, CA)” is utilized as it is vital information which is important for the determination of certain time for the generation of the control signal. The control signal in this system initializes the process of irrigation. Recorded data is received when a transceiver module “NRF24L01+” alongside a communication setup which should be wireless and a data gathering unit are arranged. For Internet connectivity GSM/GPRS module “SIM900 (SIMCom, Shanghai, China)” is employed. As a SIM card is installed with this module, by the utilization of AT commands in series, data collected from sensors alongside data which is related to the status of the system including open or closed state of valves, time and date of last irrigation process all are sent to cloud server as shown in diagram Fig. 3.

Monitoring unit of this scheme comprises a mobile application which is developed by “MIT App inventor” [13]. The user of this application can check the instant system state and may also note the greenhouse environmental conditions. Moreover, information regarding water level also can be updated through the application as is shown in Fig. 4:

An important and useful wireless network developed for the automated irrigation and security system is wireless sensor network, “WSN”. It’s a sensory network which comprises several nodes. Sensor values are transmitted and communicated among these nodes from one node to a different node with a wireless connection. To monitor the soil factors, WSN is employed alongside the control of water flow to crops within the field. Moreover, by this method, farmer also can check the sensed factors affecting the field on his android mobile and laptop, and water flow towards crops also can be controlled from these gadgets without any need of physical visit to the fields [10].

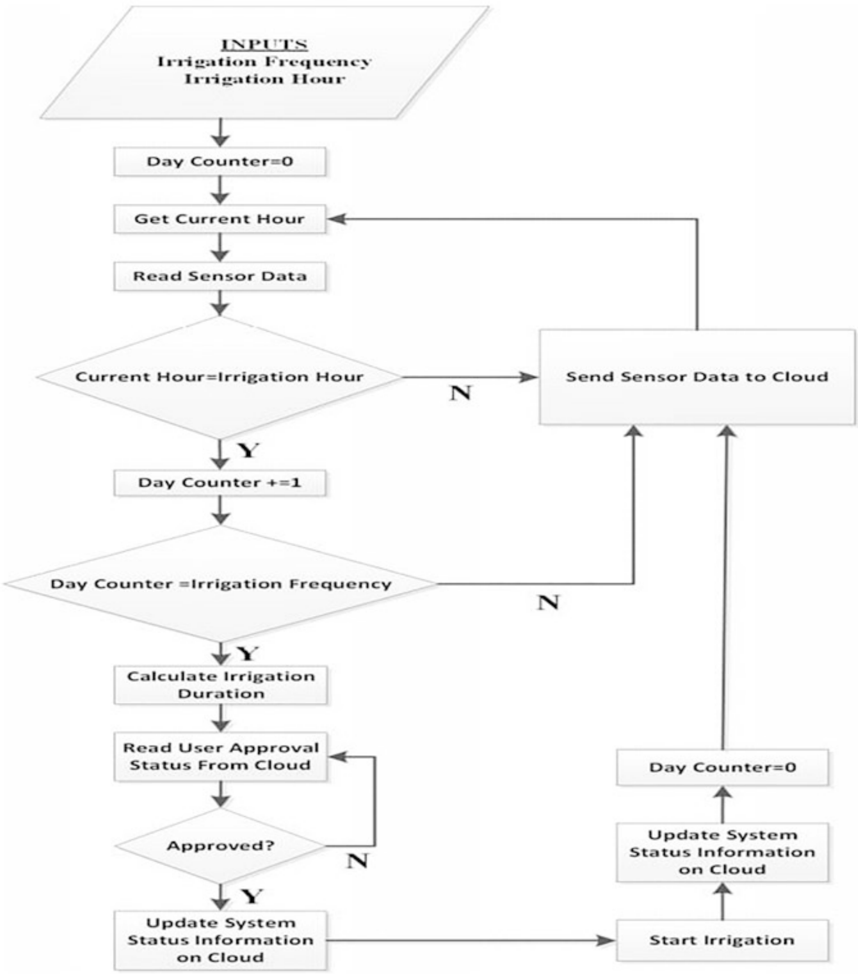

Fig. 3 Diagrammatical representation of scheme for automatic irrigation process [3]

4 Construction of the WSN Irrigation and Security System

Automatic irrigation method is developed by using WSN and by the use of the Raspberry Pi board security system is established for the crop field. Scheme of this system is shown in Fig. 5.

Each node within the hardware is comprised of "Arduino Uno" board which is interlinked to many sensors. These sensors include a temperature sensor, soil moisture sensor, passive infrared sensor alongside a transceiver "NRF24L01" for transmitting data to RPi and a buzzer. It's to be noted that Raspberry Pi web server is additionally used which acts as coordinator (CR) node. To detect any stray animal

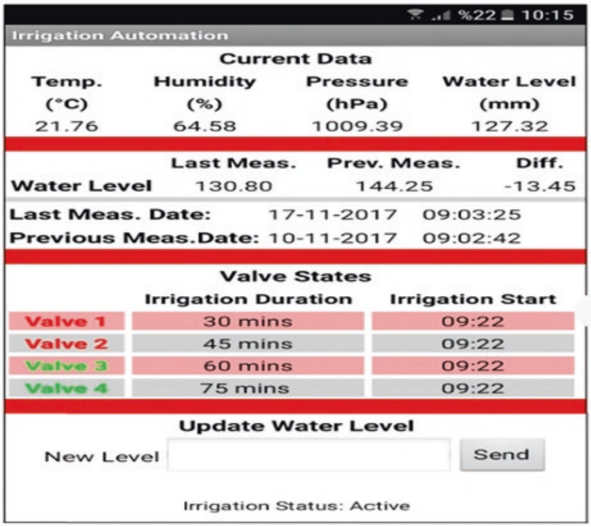

Fig. 4 Interface of the mobile app during the irrigation process [3]

like cattle in the field, a passive infrared sensor is installed within the field and a buzzer is also connected which automatically turns ON when the output of sensor increases and compels the cattle away. Data from interlinked nodes is received by Raspberry Pi which evaluates this received value relative to fixed threshold values and switch the pump ON or OFF accordingly. Status of pump alongside the sensed parameter like soil moisture, temperature and humidity is exhibited on the webpage and may easily be viewed on the cell phone and another Internet-connected gadget. Through this webpage, the pump is often controlled physically by the farmer.

A web-based intelligent irrigation method is established [18] where the farmer can control the water pump and check its status along with the level of water in well on a webpage. In this way, water can be distributed evenly to all parts of the field and crop production is boosted. Raspberry Pi is used for this web-based irrigation method.

5 Construction of Web-Based Irrigation System

This system is comprised of two distinct units, one is the transmitter part which transmits the collected data while the other is the receiver part which receives the data transmitted in web-based irrigation method by the use of Raspberry Pi. A schematic diagram for these parts is shown in Figs. 6 and 7, respectively.

"Arduino Uno" collects the data measured from the installed sensors in the field such as temperature, humidity and soil moisture sensors. This collected measured data is then transmitted to Raspberry Pi via "nRF24L01 module" designed in the

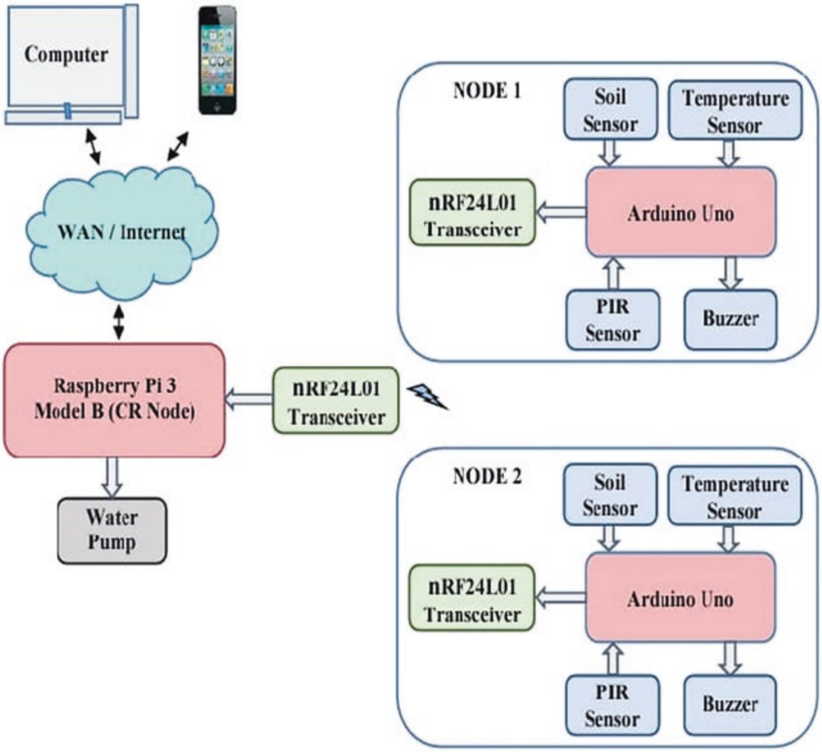

Fig. 5 Scheme of wireless sensor network and security system using the Raspberry Pi board [10]

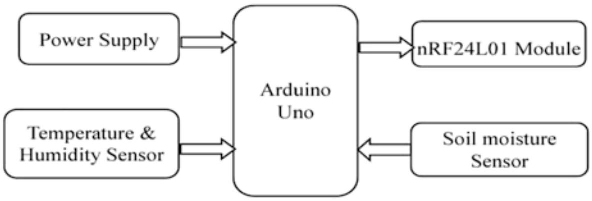

Fig. 6 Schematic diagram of transmitter part [18]

transmitter part of the system. Afterwards, this measured data is sent from raspberry to webpage of the receiver part. It is to be noted that the Raspberry Pi board used in this developed system is "Raspberry Pi Model B+ Board" which is a mini-computer with its size similar to a credit card. It uses chip SOC and is inspired from "BCM2835 (BCM Broadcom)" with storage of 512 MB. Other characteristics include "40 GPIO pins, one Ethernet port, 4 USB ports, HDMI port Audio jack". The processor is "700 MHz ARM1176JZFS". For communication purposes, transmit (Tx) and receive (Rx) pins and are used respectively.

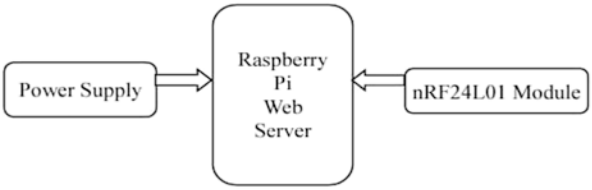

Fig. 7 Schematic diagram of the receiver part [18]

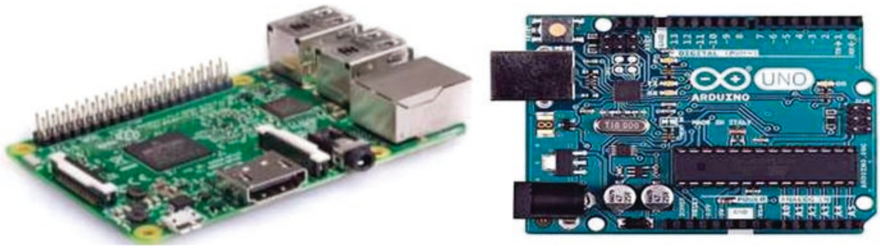

Fig. 8 “Raspberry Pi Model B+ Board” [17], “Arduino Uno” board [2]

“ATmega328P” micro-controller is employed in “Arduino Uno” board which is an independent source that is simpler and easier in use for both software and hardware. The installed micro-controller comprises 28 pins for configuration, and among these pins 14 are digital and other six are analogous pins. Moreover, its characteristics involve “16 MHz resonator, a USB connection, power jack and reset button” alongside “2 KB of SRAM, 32 KB of on-chip flash memory and 1 KB of EEPROM” [2] as shown in Fig. 8. An nRF24L01, 2.4 GHz wireless transceiver (Fig. 9) is an important instrument in the automated system of irrigation as it can transfer data of 2Mbps. It easily evaluates data sensed from sensors as well as from other several nodes at the same time due to its collision-detection mechanism and it is shown in Fig. 9 [14].

For temperature, humidity and change in weather, its current status is sensed by DHT11 sensor which comprises a resistive and negative-temp coefficient-type constituent to measure humidity and temperature, respectively. It has four pins which are VCC, GND, output data and NC which means no connection as the last pin. It is shown in Fig. 10.

For soil moisture measurements, a sensor is used which comprises double probes along with a comparator circuit and moisture percentage present in the soil is recorded. Comparator circuit compares the measured value of moisture with the threshold value. Water wastage is prevented by this method. In this automated irrigation method “nRF24L01 module” is interlinked with digital pins of micro-controller installed in the transmitter part, 5v of power to the module. Sensor for humidity and temperature is interlinked with five micro-controller digital pins. Data from soil moisture sensor is interlinked to analogous pin “A0”. Motor driver Ic “L293D” is interlinked with micro-controller while its output is linked with direct

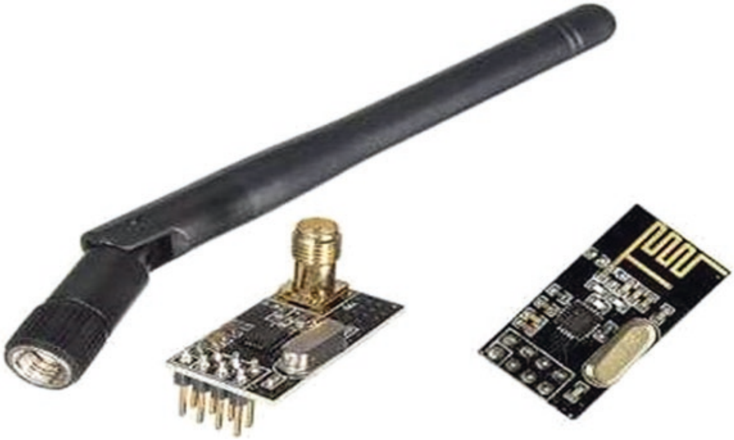

Fig. 9 nRF24L01 wireless transceiver [14]

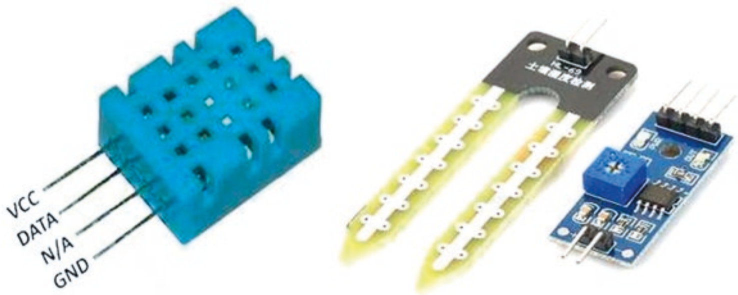

Fig. 10 DHT11 sensor and soil moisture sensor [5]

current motor. Moreover, one cable in the water-level indicator is linked with reference pin and dipped in well, while another cable is linked with upper level of well for the indication of water level. "nRF24L01 module" is linked with Raspberry Pi in receiver part. The following diagram represents the scheme of the system (Fig. 11).

The power supply is vital as "Arduino" checks for power; initially if it's OFF then no actions are going to be possible, and when if it's ON, the content of moisture within the soil is checked. If moisture is less than 600, then the soil is wet and no water supply is required in the field. If the value of moisture is more than 600, then the soil is dry and "Arduino" will determine the water level in well. If water is not present in the well, then the status of the motor will be OFF, and if the water is present, motor will be automatically switched ON. To automate the agricultural irrigation method, another IoT-based analysis of soil and automate irrigation method is established [1].

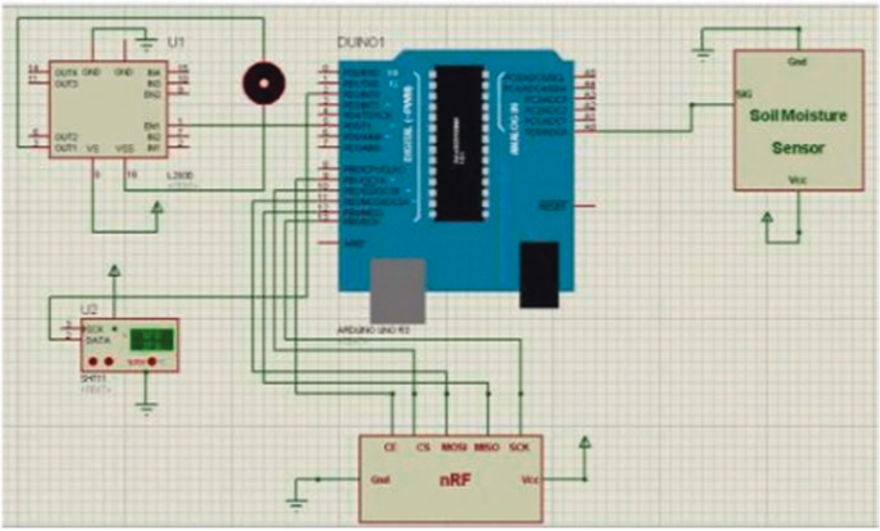

Fig. 11 Detailed procedure for automated irrigation method [18]

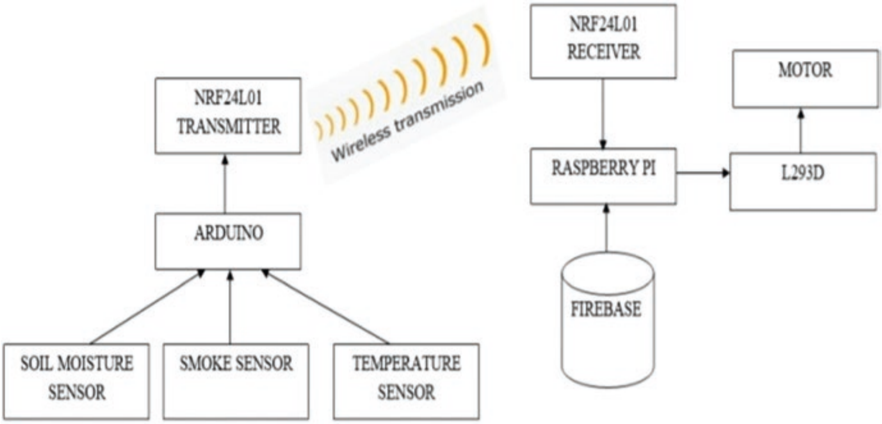

Fig. 12 The basic architecture of IoT-based system [1]

6 Basic Architecture of the System

The schematic diagram for this system is represented in the following diagram.

Figure 12 shows the system architecture of proposed architecture for the implementation of the Soil Analysis System using IoT. Three basic and influential field parameters are examined from the farm. Content of water in the soil is calculated initially, and it's the main measurement for the working of the motor because the motor is often switched on or off based upon this value. Measurement of water quantity is additionally taken from soil moisture sensor, and it's essential to take certain elements like rapid fire which destroyed crop as well as the field. Therefore, for a fire emergency, a smoke sensor is also installed in the field in this system. Fire is detected by this sensor in such a way that molecules of gas overpower and as a result value of sensor increases. For temperature check, a temperature sensor is also fixed, and this measured value is an additional value for the farmer as he can decide about the amount of water supply to crops based on this value. Sensed data is preceded to the subsequent phase by *Arduino micro-controller* as all the sensed data is sent and read by it. Arduino has a special and separate port to read sensed analogous data which confirm the precision of data. This data is transmitted to nRF24L01 transceiver for processing; therefore, transceiver plays the role of a transmitter during this step because it can send and receive data at the distance of one kilometre. Data is transmitted to a specific time duration of one second as the field is under check continuously and this data is stored in Raspberry Pi after reading from Arduino. This transmission is represented in the following diagram (Fig. 13).

Transmitted data is received at the nRF24L01 end and analysed at Raspberry Pi. Comparison is additionally done here, and if a value appears same on fixed threshold value, then the farmer is notified. This notification compels the farmer to make a decision whether to irrigate the field or not. Even if the farmer doesn't respond, Raspberry Pi takes control and switches the motor ON automatically. It shows that power control is automatic at this phase. It is shown in Fig. 14.

Moreover, irrigation is simple in this system as a farmer is notified by a message whenever water quantity is less in soil compared to a fixed value. By the use of cell phone application, motor can be switched ON by clicking the button. While in an emergency such as an instant fire in the field, the motor is automatically switched ON. Mechatronics is playing an important role in developing advanced agricultural techniques. Sensors and actuators are essential elements of mechatronics, and their role is prominent in the modern irrigation system of agriculture as well as in seeding, cleaning, cropping, fertilizing of field and observation of vegetation. Sensors are used to detect colour, level of light and level of alcohol to check the ripeness of

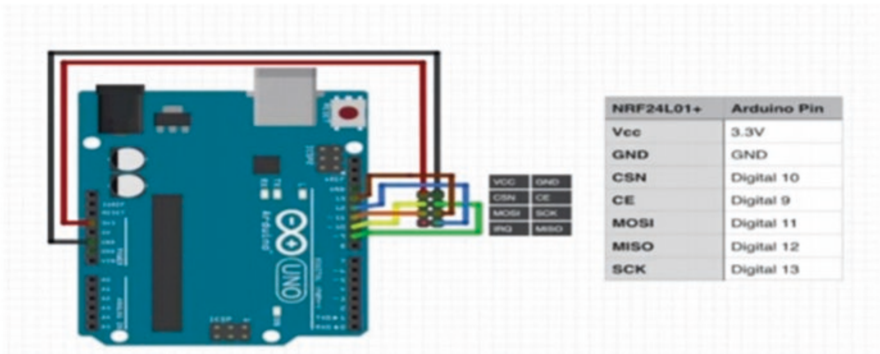

Fig. 13 Transmission of data [1]

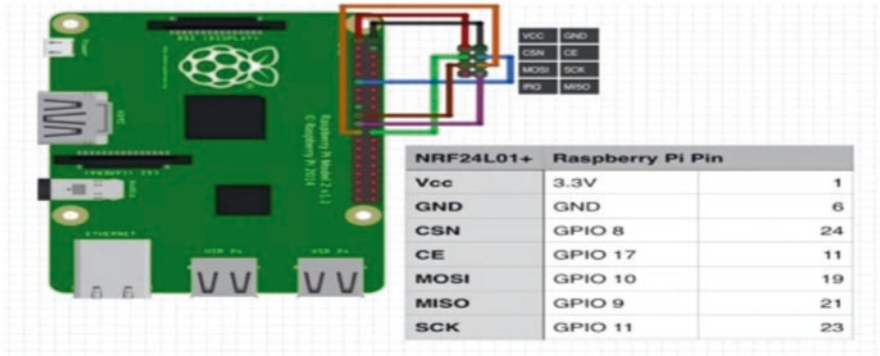

Fig. 14 Data reception [1]

fruit along with moisture content and risky level for chemicals including pesticides and insecticides. Various methods are also developed to facilitate agricultural systems, as to nurture the plant roots, robotic arms are developed and to seed, clean and collect fruit and soil regeneration, revolving machines are designed [9]. Several mechatronics and implanted systems as microcomputers and micro-controllers are used in agriculture. Precision agriculture is modern agriculture in which maximum crop production is the objective to be achieved by the use of advanced control systems [6]. Therefore a system is developed "Solar Powered Microcontroller-based Automated Irrigation System with Moisture Sensors" based upon the use of mechatronics elements [4].

This system comprises a sensing module, a communication module, control module and actuating by actuators. The following is the schematic diagram of this system (Fig. 15).

For the water source, a water tank with a capacity of 1000 litres installed on a raised platform, about 2 metres high from ground level, is used and water is stored in it and supplied when required. Water is supplied from this tank due to pressure and gravity for the drip irrigation system consistent with the need, and this requirement is decided by micro-controller's controlling valves. Four-meter-long main drip line is designed as piping and is interlinked with water tank. Three evenly distant drip sub-lines for further three crop ridges are also installed horizontal to the mainline and each comprises ten evenly spaced drippers for direct delivery of water to the roots of ten crops, and all this is controlled by *"Arduino" micro-controller*. A sensor box is also fixed along every drip sub-line and this box contains Arduino Uno micro-controller which reads analogous measured data regarding soil humidity from the sensors. For a sub-line, five sensors are fitted at equal distance from each other. Values are read and sent to micro-controller which calibrates them in a percentage along with the range of values from 0 to 100. During this way, the typical value for soil humidity is calculated which is then transferred to central master control Arduino Mega through a radio transmitter nRF24L01 after assigning a definite identity code, to differentiate between every Arduino from the other. After

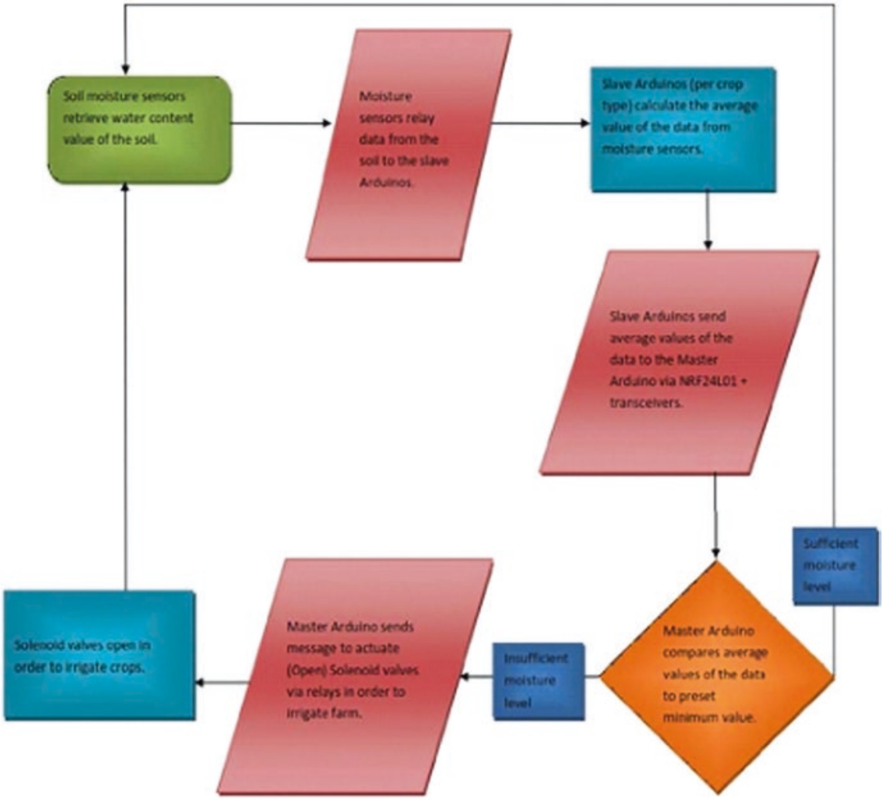

Fig. 15 Representation step by step of irrigation method [4]

reception of the value, master Arduino runs an algorithm which is exclusive to the crops and actuates the subsequent valve to open and permit water supply into sub-lines for irrigation of crops for a particular period and after this period valve closes automatically.

7 Conclusion

An automatic irrigation method has many benefits like low-cost expenditure and consumption of water is also minimized to an outsized level. Moreover, maintenance requirements also are minimum. Reduction in consumption of energy to a large extent is also a valuable advantage for the automated Internet-based irrigation system. It's beneficial in greenhouses as well as in areas with a shortage of water as the main issue. By this technique, production of crops enhances. In the same way, an automatic irrigation system with micro-controllers interlinked to a cloud server in a field is of valuable importance. In this system threshold, the water requirement is computed mechanically by the system. The decrease in the water level present in the evaporation pan determines this computation. Risks of drought stress and fungal as well as a bacterial infection in the crops are prevented by this system. The mobile application further facilitates the farmer to check the field status from a distance without physically visiting the field. Moreover, man or labour-related errors also are reduced and therefore the optimum water amount is taken into account for best quality of crop and modest water usage on the earth.

Another automatic Internet-based system developed for automatic irrigation is WSN and for the security may be Raspberry Pi-based security system. Field parameters especially soil moisture are checked by the utilization of data from the sensor at every node in the designed system, while water flow is also controlled by the user from any place by the use of any Internet-connected gadget. This system is quite efficient even at low cost because Internet access in rural areas is available at low rates nowadays. Therefore, a web-based irrigation method based on “Arduino Uno” and Raspberry Pi is the most applicable system. Various field parameters including humidity, temperature and soil moisture can be monitored from a webpage established by the use of “HTML and PHP”. An appropriate action is taken consistent with the displayed state of those parameters on a webpage.

In another Internet-based agriculture, the system has proved its usefulness as this system is sensitive to any animal intrusion in the field which is considered a serious cause for the reduction in crop production. Internet connectivity is required every time. An intelligent water-saving irrigation system is established by the combination of WSN with the fuzzy control system. This system effectively monitors and controls the field from remote places. For the power source, nodes in the board use solar energy and lithium battery devices by which the difficulty of limited power is also overcome as nodes can self-organize with low consumption of energy and consistency by the utilization of several hopping network protocols for communication. The control system has been made more scientific by the use of fuzzy logic toolbox for the development and evaluation of the system comprising of one output fuzzy for two inputs illustrating a connection between input and output of the system. The objective of water-saving irrigation system is achieved by this system as valves are open automatically when a threshold limit is reached. Therefore, it is an efficient, productive and water-saving system which prevents the waste of water resources.

8 Future Work

As the technology is progressing, more efficient and effective work is required which includes the automated prediction of water requirements for crops by the use of “data mining algorithms”, and it’s to be noted that developments are required in this area of research to achieve an economical system as prediction is beneficial to determine the right amount of water to be supplied. Moreover, the need for continuous Internet connection can also be overcome by establishing a system to inform the user directly by SMS on the cell phone by the use of "GSM module" rather than mobile applications which require Internet for updates. For a cloud server-based irrigation system, a statistical model is required which may approximate the total evaporation as all system information is stored in cloud server including values recorded by sensors, previous irrigation date and duration and total evaporation between successive irrigations. Moreover, the entire system is interlinked so if the power supply is cut off or a shortage occurs, the entire system is disturbed including recorded values from sensors and lost in Internet connectivity. Hence, future work includes the use of batteries which are charged from solar panels and the addition of more sensors including anemometer along with more efficient sensors for soil moisture.

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Developments in Agriculture Technology Using Internet of Things

G. Sucharitha and M. Mandeep Sai

1 Introduction to IoT

The internet of things will have the great impact on our way of life, from our reactions to our behaviour. The IoT is a network of interconnected devices ranging from air conditioners that can be controlled via your smartphone to smart cars and vehicles that provide the shortest route and the smart watch [1]. These devices gather and share data about usage and also the environment being operated.

In IoT network, sensors are playing a big roll. The sensors in the network will serve like controllers and data aquisition elements. Sensors are used in many places like mobiles, trackers, cars, shopping malss etc.. These sensors continuously collect data and end up in the operational state of devices [1, 2]. Here, the problem arises of storing and sharing of this information for various applications. To share the collected information from various IoT devices (Sensors, actuators etc), IoT network provides a platform in order to communicate among the devices.

Data is collected from different sensors and sent to an IoT security platform. The IoT architecture helps in integarating the data which is collected from various IoT devices and it also analyze the data for various applications of the data. The effect is shared with other devices for better user experience automation.

The in buit systems of the IoT devices has the capability of sensing the minute changes of the environmental parameters which helps to take the effective decisions to improve the farming [2]. IoT enables people to work smarter. Also, smart devices help in automating homes. IoT is also play a vital role in various sectors in monitoring the system work, performance verification, which helps in mass

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production. The IoT has increased agricultural production at a lower cost. For several years, the usage of smart solutions provided by IoT has increased agricultural operations. In fact, according to a recent report, IoT device installation will see a compound annual rate in the agriculture industry [1, 2]. And the number of connected devices will grow from 14 million in 2013 to 235 million by 2025.

A code is attached to each product before leaving the belt [3]. It contains the merchandise code, manufacturer details, etc. The manufacturer uses this data to look at where the merchandise was distributed and to track the retailer's inventory.

This is often one of a million scenarios. We have smart appliances, smart cars, smart homes, smart cities, etc.

As the world's population grows by 1.5 billon people every decade, the dependence on food increases. To feed the entire world population, the methods used now in agriculture to induce higher yield aren't beneficial. To promote sustainability in crop production, we would prefer to adopt new technological methods. In this chapter, there are only a few technological methods discussed. According to experts, this market will triple by 2025, with 75 million IoT systems deployed for agricultural purposes over the next few years, not to mention the number of innovative startups in this field. There are many agtech and food-tech venture capitals out there.

According to statistics, the world's population will reach 12 billion by 2045. And to feed this much population, few technological methods are known to increase crop production [2, 3]. In the face of many climatic conditions and changes, IoT could be a technology that helps in overcoming these challenges and supplying the food needed.

Smart farming is an efficient method of farming and crop production that is also environmentally friendly. The incorporation of connected devices and innovative technologies into agriculture majorly depends on IoT to reduce the necessity of human labour and thus increases productivity in every possible manner.

The IoT transforms the agricultural industry by empowering farmers and growers to overcome obstacles.

1.1 Advantages of IoT in Agriculture

- Water treatment is often spent efficiently using the IoT without the sensors for wasting water.
- The IoT allows problems to be solved and all matter that can occur during the farming processes to be directly eliminated.
- The IoT device tracks everything so that actions can be taken as soon as possible. It increases work efficiency, saves time and reduces the need for human labour.
- The amount of time saved could also be very significant as a result of the IoT program, and we can use more energy in the present.
- Crop monitoring is often done easily by using IoT to keep track of crop production [4, 5].

1.2 Disadvantages of IoT in Agriculture

- The IoT equipment allows the farmer to understand how to use technology. The most important challenge for large-scale implementation of smart agriculture farming is a large amount of capital.
- The security measures and the IoT system offer limited power and might cause various sorts of network attacks.
- It is very difficult to plan, manage and permit the broad technology to IoT framework.

2 Why IoT in Agriculture

IoT will create a new world in which all devices and objects are connected, as shown in Fig. 1, to the Internet and communicate with one another with minimum human intervention to optimize the use of resources, expand the standard services offered to people and reduce operational costs of services given to them [4, 5].

The IoT provides solutions for many problems encounterd to the farmers in terms of percentage of utilization of the fertilizers & pesticides, finiding soil fertility etc, which directs to get significant increase in the farming productivity.

The future of agriculture will have advanced technologies like robots, thermal and aerial images, GPS technology and moisture sensors. These types of advanced techniques and precision farming allow farmers to be more profitable, eco-friendly and efficient.

Fig. 1 Sample structure of agriculture IoT

2.1 Agriculture Evolution Using Technology

The evolution of agriculture, as shown in Fig. 2, through the use of technology began a few decades ago. Only a few simple hand tools were used in the beginning. Later, it gradually evolved into the mechanical equipment commonly available to the farmers today.

The development and evolution of IoT agriculture have resulted in simplified methods of doing things ranging from hand tools to machinery. The following points describe the revolution in the agriculture from hand tools to smart machinery:

(i) **Product:** Agriculture production systems are rarely isolated in different landscapes. Mainly in the past, the products were obtained only through basic machines, which require a longer time for production.
(ii) **Smart Product:** During this period of evolution, the system has also allowed data collection and analysis. To get a proper yield, data play an important role in examining the growth of the crops.
(iii) **Smart Connected Agriculture:** The purpose of the system is to develop compact monitoring and control for the agricultural land. This can be operated and managed from any location wirelessly by using a device.
(iv) **Product System:** From this system, the automation process has begun. The product is processed using advanced machinery, like remote-access tractors, planters and combine harvesters.
(v) **System of Systems:** This circle will define where we are today. There are so many aspects of automation involved in agriculture today. There are so many companies that are building excellent products and services for smart farming and allowing us to manage that farm through automated systems, like weather information system, farm equipment system, water irrigation system and seed optimization system.

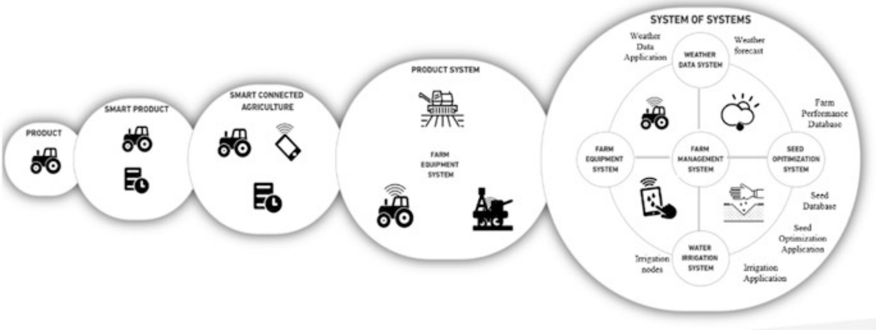

Fig. 2 Evolution in IoT agriculture

2.2 Modern Smart Farming Techniques

The IoT smart farming techniques address many problems to farmers due to the unexpected changes in the environment. The smart agriculture optimize the water requirements to the crops and also reduce the man power.

In IoT smart farming, a system is made only for monitoring (temperature, light, humidity, soil moisture, etc.) the crop field with the assistance of sensors from the irrigation system. Farmers can monitor the sphere conditions from any location [6]. IoT-based smart farming is the most efficient when it comes to quality output.

2.3 Precision Farming

Precision farming is an agricultural management approach centred on observing, measuring, and responding to crop variability between and within fields. Plant production is targeted towards identifiable land units that are determined not only by property lines or the predicted average crop output of a certain field, but also by local and ecological factors. Farmers may now manage their fields based on the regional variability of variables such as nutrient availability and predicted crop output, thanks to new technologies. Plant protection is now guided by the pressure to avoid harm and economic efficiency to a considerably higher extent than before. Small-scale soil cultivation, sowing, fertiliser, pesticide treatment, and other procedures are all part of the precision farming process. It improves productivity, quality and profitability in agriculture.

This method is employed to assess the potential capabilities of precision agriculture [6]. Precision agriculture is technology-enabled. It is enabled by specific technologies, so the potential to assess and manage is formed [6, 7].

Precision agriculture/precision farming is one of the most well-known applications of IoT in agriculture. It will improve the farming procedures like monitoring, tracking, observation and inventory monitoring [7]. The aim of precision farming is to analyse the data generated by sensors and to respond accordingly. Precision farming helps farmers to collect data using sensors and analyse that data to make intelligent and quick decisions. With the help of precision farming, we can analyse soil conditions and other required parameters to increase efficiency [9, 10].

- **GPS (Global Positioning System)**
- GPS is a global radio navigation, timing and site system with high precision that works in all weather conditions. It is a powerful and free source of spatial information for anyone, anywhere on the planet. GPS is employed to gather information about soil, seedlings, diseases, insects and weeds.
- **GIS (Geographic Information System)**
- GIS is a mature and widely used software platform used to store, analyse, threat and express geographical spatial attribute data.

- More effective utilization of inputs will result in higher crop yield and quality without polluting the environment and might lead to sustainable agriculture and development (Fig. 3).

The precision farming in the agriculture, farmers will come to know precisely what input is required, where it is needed, how much is needed and when it is needed. This needs collecting information from different sectors and parts of the arena on issues like the presence of pests and weeds, soil nutrients, the extent of the greenness of the plants, inputs applied and prognosis. Once collected, this data should be analysed to provide agronomic recommendations. As an example, given the developmental stage of a plant, its level of greenness may reveal its nutritional requirements. This information, combined with the characteristics of the soil in which the plant is found, and thus the forecast of the weather are used to determine what proportion of certain fertilizer should be applied to the plant the following day [6, 7].

Delivering agronomic recommendations, as shown in Fig. 4, on time to farmers and ensuring that they are able to apply these recommendations is significant.

Farmers must have all the desired inputs on hand and be able to translate the recommendations into actions within the field [8]. To resolve this problem, big farmers use sophisticated machinery that collects geo-referenced information on soil characteristics, yields and greenness of the plants. The machines are often connected to the web and send the knowledge automatically to big data firms, which analyse the information and send agronomic instructions back to the machines, which are able to automatically apply them within the fields.

For instance, robotic machines attached to GPS-guided tractors are used, as shown in Fig. 5. Therefore, solutions like these are also economically infeasible for medium- and small-scale farmers to implement. Sometimes, many of the mandatory

Fig. 3 GPS (global positioning system)

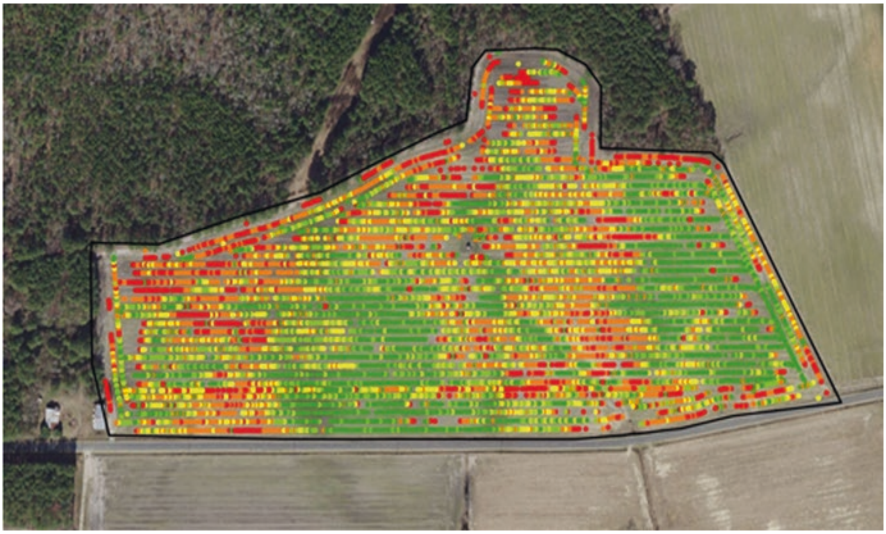

Fig. 4 Agronomic recommendations

Fig. 5 Robotic machines

compliments don't seem to be readily available, or there is no connection to the Internet, or there aren't sufficiently skilled workers [7, 8].

A number of solutions are being developed to address several of the issues that medium- and small-scale farmers face when trying to implement precision agriculture technologies. Easy-to-operate, economic sensors, as shown in Fig. 6, are used to measure soil humidity and nutrient content. Portable networks are used to transmit data collected by field sensors to a central location, as well as economic ways to connect to the Internet. Remote sensing is the use of satellite imagery to assess the

Fig. 6 Climate sensor

health status of plants in an economic way, without requiring producers to understand the way to control a device or to access complex data on the Internet [11].

Usage of Mobile Technology and Cameras In nurseries and greenhouses, camera-based technologies are used to automatically monitor and assess plant growth. Livestock breeding is another good example. Camera-based systems are being used to monitor and analyse automated operations, as well as to cut costs and improve efficiency. The installation of cameras with software helps in monitoring the farm all day and night.

Advantages of Precision Farming It will increase agricultural productivity and prevent soil degradation.

- It reduces excessive chemical usage in crop production.
- It is efficient in water utilization.

Disadvantages of Precision Farming Small landholdings limit the economic gains from currently available precision farming technology.

- The social, economic and demographic conditions.
- It requires huge capital for setting up this technology.

Data Collection The biggest application of cloud software in agriculture is for data collection and restoration. Cloud software has capability of storing large amounts of data from weather cycles, crop patterns, harvesting, soil quality and satellite imagery to provide perception with good accuracy and speed [12]. The information collected from the farm is stored in cloud software. For example, if the crops are infected with the identical symptoms or disease as they were 5 years ago, the information is used to find the answer used at that point.

Data Processing The database management within the cloud software helped to remember every sort of data available and helps in performing higher level of decision-making.

Data Storage Data storage is important for predictive analysis. Within the past, data storage was hardware-based, so hardware needed to be carefully maintained and stored. When hardware fails, the information is gone forever. Nowadays, the agriculture technology system is cloud-based, which is the simplest way where nobody has to invest in maintenance and hardware acquisition. All data will be monitored from PCs, mobile phones and tablets.

Irrigation Control Adopting technology improves control and efficiency, and irrigation is within the limits in the agriculture industry. Systems that ply status reports on pivot performance, soil moisture sensing, weather and other field data to mobile phones and computers are commonplace, providing end-users with on-the-go tools to make and implement irrigation management decisions [13].

2.4 Hydroponic Precision Agriculture System

Hydroponics is the art of growing plants without soil; it maximizes growth capabilities, reuses water and ensures clean and disease-free growth. Now, IoT comes into place to unravel this problem. Hydroponic systems are mostly developed in enclosed greenhouses. To avoid plant diseases, sensors are installed throughout the greenhouse to monitor the growth of plants. Producers and costumers enjoy the compact end-to-end IoT solution and the accelerated time to value. Wireless sensors, as shown in Fig. 7, transmit data to a centralized asset gateway [13].

Greenhouse is an agri-tech greenhouse organization and use technologies and IoT for providing services. The greenhouse state and water consumption can be supervised by these sensors by sending SMS alerts to the farmer via an Internet portal. It builds modern and affordable greenhouses by using IoT sensors that are solar-powered [13, 14].

The command gateway collects this data and transmits it to the cloud via IoT module and global IoT data concept for data analysis and delivery to user-facing applications. Rather than worrying about maintaining a baseline condition for the answer and clover, the focus is on optimizing conditions for improved growth. This information and data will be used to develop a {much better|higher|stronger| more robust|an improved} growth protocol that may yield much better product.

Advantages of Hydroponics It grows faster than soil-grown plants.

- It is easy to monitor the plants.

Fig. 7 Wireless sensors

- It consumes 90% less water than traditional farming.
- It also takes up less space as it grows.
- Without soil, we can prevent the plants from becoming deficient.
- The nutrients needed for plant growth is obtained from nutrient solution (contains macronutrients and micronutrients).
- To determine nutrient strength, electrical conductivity (EC) or conductivity factor must be measured.

2.5 Smart Drones for Agriculture

The use of technology has changed and bought major impacts in various sectors. Drones are extremely useful in the field of agriculture. Nowadays, agriculture is one of the most important aspects to consider when developing drones [15]. They have a tendency to enhance various practices within the field of agriculture. They are also used for crop health imaging, integrated GIS mapping, etc. The special drones, as shown in Fig. 8, have capabilities like thermal sensors that detect which portions of the sector are under-watered, allowing us to water only the areas that need to be watered, reducing water consumption and waste. They collect thermal, multispectral and visual as imagery during flight, allowing it to land within the same location from which it took off, saving time. It is also employed to spray pesticides and fertilizers without human contact and to cover the utmost area in less time. The main advantage of using drones is that it reduces the health issues faced by farmers. It consumes less time in spraying the fields [15].

Technological advancements have many agricultural operations, and the introduction of agricultural drones is a trending disruption. Aerial drones are used for the

Fig. 8 Aerial spraying drones

examination of crop health, crop monitoring, crop spraying and field analysis. The proper strategy of planning and implementation of the real -time data, the agriculture sector may reach in generating the high productivty, and with the help of drone technology even spread of ferilizers, pesticides, monitoring the seedlings is also possible with verl less man power. Thesmart drones have the thermal and multispectral sensors to identify the areas that requires changes in irregation. According to the results, there has been a significant reduction in chemicals reaching the groundwater.

Farmers through drones can enter the most points of the field they need to survey. Select an altitude or ground resolution from which to obtain data of the fields. From the data collected by the drone, useful insights are drawn on various factors, like plant counting and yield prediction, plant health indices, plant height measurement, nitrogen content in wheat, drainage mapping and so on.

Since drones collect thermal, visual and multispectral imagery during their flight, the information they gather helps in the number of plants and yield prediction.

Usage of drones is eco-friendly and not dangerous to the environment. Drone technology in the field of agriculture helps the farmers in avoiding health issues like respiratory and breathing problems.

With the help of drone technology, as shown in Fig. 9, we can monitor the fields at different stages, like weather, climate, soil moisture, etc. This technology can be assessed and monitored for phones and many wireless devices [16].

Various countries in the world utilize smart drones with specialized algorithms to analyse and collect vast amount of data within seconds.

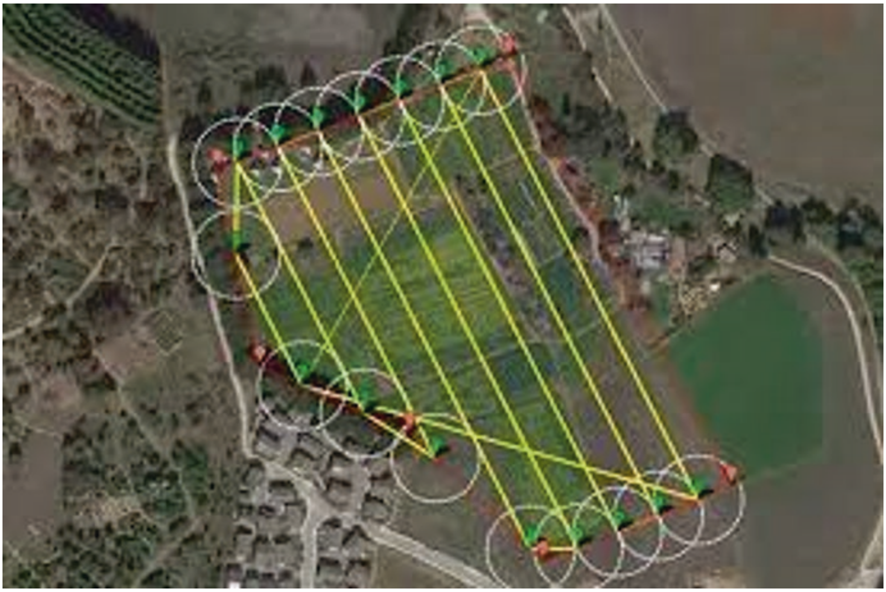

Fig. 9 Drone system

The data allows farmers to see how their crops are performing in a device. Drones not only help in analysing data but also help in indicating and measuring weather, soil moisture and many parameters.

2.5.1 Weather Monitoring and Tracking

The methods for monitoring and tracking weather are increasing rapidly. There are few weather services that focus mainly on agriculture, and then farmers can access these services via mobile apps [17]. This method will give farmers enough information about matters of the weather, etc.

2.5.2 Soil Sensors

Perhaps the equipment having the foremost immediate effect are soil and water sensors. These sensors are durable, unobtrusive and comparatively inexpensive. As an example, these sensors can detect moisture and nitrogen levels, and also the farm can use this information to figure out when to water and fertilize instead of depending upon a predetermined schedule. That finally winds up in more efficient use of resources and thus lower costs, but it also helps the farm be more environmentally friendly by conserving water, limiting erosion and reducing fertilizer levels in local rivers and lakes.

2.5.3 Vertical Farming

Vertical farming is the process of cultivating crops in layers that are piled vertically. It frequently integrates soilless farming techniques such as hydroponics, aquaponics, and aeroponics, as well as controlled-environment agriculture, which tries to optimise plant development. Buildings, shipping containers, tunnels, and abandoned mine shafts are some of the most frequent structures used to house vertical farming systems [18]. This offers many advantages. Farmers in all areas can use it to make better use of accessible land and to grow crops that would not normally be viable in those locations.

Indoor Vertical Farming This kind of vertical farming can increase crop yields, overcome limited acreage and even reduce farming's impact on the environment by lowering the distance travelled within the supply chain. This type of growth is usually associated with city and concrete farming due to its ability to thrive in limited space. Vertical farms are unique in that some setups do not require soil for plants to grow. Most are either hydroponic, where vegetables are grown in an exceedingly nutrient-dense bowl of water, or aeroponic, where the plant roots are systematically sprayed with water and nutrients.

2.6 Crops Connected with Wi-Fi

Modern farms usually have electronic sensors distributed within the sphere capable of monitoring various conditions; in some cases, gadgets send data to an on-the-farm server or cloud (network servers are widely used for computing and data processing) [17, 18].

It maximizes efficiency, periodically distributes the correct amount of water, prevents waste and reduces the amount of fertilizer water. Farmers can now access this data via tablet or smartphone, giving them real-time information that previously required a slow, manual-intensive soil testing process.

2.6.1 GIS-Based Technology

Since fields are location-based, GIS software becomes an incredibly useful gizmo in terms of precision farming. While using GIS software, farmers are able to map current and future changes in precipitation, temperature, crop yields, plant health and so on. It may also generate the employment on GPS based applications in line with smart machinery to optimize fertilizer and pesticide application; by not treating the whole field, but rather focusing on certain areas, farmers can save money, effort and time.

2.6.2 Role of Information Technology

The availability of those reasonable technologies is ensured through effective Internet tools and smart networks. To fulfil the task, the build-up of the full spectrum of application packages and databases is imperative. Agriculture is an amalgamation of plenty of little areas, necessitating an ocean of information inputs; amalgamating that information can be a strenuous task. Therefore, the sensible option is to make technological solutions for individual needs. It is recommended to limit the planning of the system only after perusing the task; we must deviate from the standard method of constructing the system first before inputs to induce practical results. A full system is barely possible after documenting the complete data to at least one platform.

2.7 Smart Machines for Agriculture

Robotic Labour Replacement of human labour in automation is an upcoming trend in the major industries. Many aspects of farming are exceptional, including lots of labour work.

We are already seeing various types of agricultural robots, as shown in Fig. 10, appearing in the fields and performing multiple tasks like planting, watering,

Fig. 10 Smart machinery

harvesting and sorting. Eventually, this gives various profits in providing higher-quality food and products.

Driverless Machinery Machinery plays plenty of roles within the field of crop production; various kinds of machinery are used for various purposes. Probably, auto-driving technologies are expected to become the first machines to be converted into smart vehicles [18].

Semiautomatic Robots Arm robots can identify and detect weeds and spray pesticides on the affected plants. It helps in saving the plants and spending capital on buying pesticides. These bots will be also employed in harvesting. This could operate for a remote-control device to perform tasks.

Farm Automation A large number of multinational companies are researching on innovation in developing drones, autonomous tractors and seeding robots. While this technology is new to the world, it is leading to an increase in the number of traditional agriculture companies, which can help in adopting the farms for technology.

New modern technologies, ranging from robotics and drones to computer vision software, have completely changed the way of contemporary technology. The primary goal of farm automation technology is to make agriculture more sustainable. Few major technologies utilized by farms include harvest automation, seeding and weeding and autonomous tractors. The advantages of automating traditional farming processes are labour shortages and also a reduction in the environmental footprint of farming [19].

Artificial Intelligence The development of digital agricultural has opened replacement job opportunities in many sectors. Technologies like sensors and satellites can help in gathering information 24 hrs each day throughout the entire field. Using these methods, we will keep track of plant health, soil moisture and temperature, etc. The information is revised using some AI algorithms and computer vision to induce accurate results for present and upcoming crops.

Farm Mechanization

India's massive agricultural potential is often best utilized by increasing productivity through timely and cost-effective field work. To make this possible, agricultural mechanization plays a principal role [20].

In light of this, the Government of India has introduced schemes like the Sub Mission on Agricultural Mechanization (SMAM). Under the SMAM programme, the government ensures that farm mechanization reaches every farmer within the country, including those within the regions where farm power is scarce. Furthermore, it creates hubs for high-tech and high-value farm equipment. It also raises awareness among the intended audience, i.e. the farmers, through demonstrations and technological displays.

Post-harvesting Technology Post-harvest could even be a significant element within the agriculture industry, posing a good requirement for low-cost technology. Being highly susceptible to natural calamities and external factors, the post-harvest space of the agriculture industry is extremely volatile. This is where post-harvest technology comes into play. To be more specific, post-harvest loss reduction technology reduces losses in packaging, handling, transportation and storage with modern infrastructure, latest machinery, thermal processing and low-cost preservation techniques.

2.8 Opportunities and Challenges in Smart Agriculture

Wireless technology, networking, mobile phones, etc. are being developed. The agricultural system must be monitored every day. The developed framework will be used to reduce waste by automating the entire agricultural system.

The major challenge identified within the present domain is the provision of the required information and timely assistance, and modern agriculture has many complex challenges [20].

The agricultural supply chain in India is unorganized, and there is no coordination among various stakeholders in India. It leads to great amount of agricultural waste. According to various researchers, the majority of food items likes cereals, fruits and vegetables are wasted each year. The pre- and post-harvest of crops should be traceable to spice up accountability. It promotes transparency in communication among all stakeholders within the agricultural supply chain, leading to less waste and increased consumer trust.

Farmer Objectives to Adopt the Modern Technologies Farmers will have several queries and questions, along with risk management, quality of life and environmental management. Aside from the majority of farmers who trust agricultural income, expected profitability is the sin qua non – they have to earn enough to stay in business.

In making a shot to supply profitably, farmers are constrained by restricted access to essential productive resources, such as land, labour, equipment, buildings and management knowledge. Profitable farming needs the exploitation of these resources up to the point where the worth of additional resource use is no longer stipendiary by the price of the resulting gain in output. The profitability attractiveness of VRA input management has been the potential to tailor input use of Internet site specifically, increasing it by expected yield gains or reducing inputs where costs exceed the expected benefits.

Problems Faced by Farmers in Adopting Smart Agriculture Climate change, soil erosion and biodiversity loss.

- Meeting the rising demand for more food of higher quality.
- Investing in farm productivity.

- Adopting and learning new technologies.
- Requiring huge investment to adopt the new technology.
- They need talented and well-employed people to practise such techniques.
- They need more employees to educate the users.

2.8.1 Difficulties of Technology in Agriculture

- **Low Agriculture Productivity**

- Indian agriculture has capability to increase farm productivity and yield. There has been a consistent adoption in hybrid crops, irrigation techniques and seed quality. Technologies used are sensors and GIS-based soil, climate and weather prediction, as well as water asset information.
- **Precise Predictions**
- The data from machines provide farmers with information that will help them grow a desirable and high-quality crop. This can help farmers utilize data to determine the best seeds and other agri products to use to achieve perfect outcomes. They can likewise use cutting-edge e-platforms to cut out middle people [20].
- **Drones**

- Drones help in increasing production by decreasing expenses in agricultural produce through supervision work. With the assistance of programmed and advanced sensors, the capability of digital imaging and image processing, soil investigation, crop monitoring and examination of the health of yields, including fungus infection, are all conceivable.

2.9 The Benefits of Smart Farming

IoT-based greenhouses and hydroponic systems result in short food supply chains, which may be ready to feed the society.

One way to develop agriculture in the future as the third engine of growth is through gaining knowledge on technologies. Among the ideology and techniques to develop the agriculture sector, attempts have been made to encourage technology adoption among farmers and in terms of activities such as agriculture-based websites. Agriculture-based websites are very helpful and contain lot of information [21].

Using connected systems, they are going to recreate the foremost effective conditions and increase the nutritional value of the products:

- To make our greenhouses smart, weather stations are activated by the IoT system to automatically change the climate conditions in accordance with a specific set of instructions. The implementation of the IoT method in greenhouses has reduced human interference while increasing precision.

- IoT approaches are geared toward maximizing the usage of resources like water, energy and land. By using a method similar to precision farming, the IoT system depends on data collected from various field sensors to help farmers precisely assign enough resources to plant.
- IoT within the agricultural industry has helped farmers sustain crop quality and soil fertility, thus increasing the quantity and price of the products.
- In agriculture, IoT device systems that do not integrate with automation, like demand-based irrigation and robot harvesting, are not common [20, 21].

In addition, robotic technologies give more definitive monitoring and management of natural resources, such as air and water quality. It also gives greater control over plant and animal production, as well as distribution and storage:

- Data collected by agricultural sensors help in predicting weather conditions and crop growth.
- Having good control over internal processes: the ability to get the output of the production allows us to plan in detail for product distribution.
- Capital management and waste reduction in production: it enables the detection of any problems in the crop growth.
- It results in increased yields by using minimum resources such as pesticides, fertilizers, seeds, etc.
- This method is cost-efficient.
- It results in high crop production.
- Using solar-powered pumps and machines saves a lot of electricity.

Farm Management Systems Farmers are considering farming as a business venture instead of an activity for producing food for domestic consumption. A bit like other businesses, farming is also faced with challenges like limited resources. But because of advanced technology, farmers can still increase their yields. Software vendors have come up with farm management software that helps farmers monitor farm yields with ease. The beauty of this software is that it can be used with any mobile device, such as an Android phone, etc.

Also, such systems have reporting, analytical and accounting features, making them essential for farmers. FarmLogs system offers all the mandatory features for analysing the complete situation on the farm, monitoring business process, making reports and helping with accounting [21].

For agribusinesses, management of crops, procurement, supply chain operations and daily farm routines can become a lot easier with the adoption of agri-tech innovations like farm management, or what we had high value to define as our farm management platform.

Farm management solution for businesses must be adaptable to agribusiness needs and requirements, which not only resolve key business problems but also act as a technology arm.

3 Conclusion

Farmers can benefit from IoT agricultural applications by enabling them to gather data on their crops. Implementation of such systems within the field increase the yield of the crops and overall production. In several stages of crop production, farmers face lots of problems economically and socially. Various challenges within the agricultural have been identified and mentioned above. With the world's population growing rapidly, food demand is reaching heights; to beat this issue, cutting-edge technology plays a major role in increasing crop yield. Precision farming employs IoT to collect data from diverse sensors within the sphere, which helps farmers to allocate only enough resources to a single plant.

The primary point that comes to everyone's mind when they think about it is land scarcity and population. By using vertical farming and hydroponic technique, we are able to produce more yield in the same and equal space utilized in traditional farming.

IoT in agriculture has helped in the implementation of modern technological solutions to time-tested knowledge. Data ingested by obtaining and importing information from the multiple sensors for real-time use in a very large database ensures swift action and fewer damage to the crops. With seamless end-to-end intelligent operations and improved business process execution, orders are processed faster and delivered to supermarkets within the fastest time possible.

Farmers must learn and adopt few essential techniques that are related to agriculture. Additionally, organized media bodies play an important role in advertising so as to encourage technology adoption among the farmers.

Role of Technological Companies in Agriculture AI-based sowing app has been developed by Microsoft. This low-cost app has the features like predicting the optimal date to sow without the installation of sensors on fields, etc., which don't incur any cost to farmers. To analyse commodity prices, it has also developed an agricultural commodity price forecasting model. Smart farm, by CropIn Technologies, provides a cloud-based platform with a mobile app to track the expansion of crops on diversified locations in India. Automated feeders which may well be controlled using mobile apps are arising within the market. We at Brill Infosystems are exploring the mobile apps which could give them more insights of the farm products' prices and updates and costs of pesticides and insecticides. Our apps will give all the information the farmer needs from best practices in agriculture, news, latest researches, prices and plans for Indian farmers.

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A Multidisciplinary Perspective in Smart Agriculture Advances and Its Future Prospects

Saurav Roy, Jyoti Prakash Panigrahi, Mrunmay Kumar Giri, and Satya Ranjan Dash

1 Introduction

The proper definition of the much-hyped word "Internet of Things (IoT)," at its core, is the idea of its literal meaning, i.e., the self-connectivity of physical electronic devices or "things" [14], i.e., stuff that consist of sensors, electronics, softwares, and network connection modules, etc. which enable these objects to gather and interchange data with the user and among themselves. To simplify, it is an object or group of objects which is controlled or sensed remotely through and across an existing network setup which permits the combination of physical and digital world together. This, in turn, improves their accuracy and efficiency reducing human intervention. Upon addition of sensors, actuators, and other complementing hardware [21], the technology becomes a class of IOT systems, which comes under the technologies of today and that of future, such as smart homes, smart grids, intelligent thermostable environment, smart transportation, and smart cities [5].

In recent years a trend has been observed in the integration of the IoT in almost all the industrial sector. In popular culture it is being called the industrial revolution 4.0 [24]. The agricultural industry is no exception. Monitoring, aiding production, safeguarding harvest, etc. are some of the areas that have been using IoT in recent

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times [22]. With developing threats like water scarcity, more animal intuition, reduced harvests, etc., it is the time to look into sustainable methods of agriculture. Sustainable technology approaches are quite different from traditional system of agriculture. It makes smart use of limited water, nutrients, and resources like power. Alternative energy (like solar, wind,etc.) is used to power the machines in agriculture field [8].

The technologies that are powering the backbone of the IoT are in existence since a long time, but the expansion of their combined uses in such a technological advanced manner is the industry of the future [29]. The Radio Frequency Identification (RFID), Wireless Sensor Networks (WSN), Internet Protocol (IP), Low-power wide-area network protocol (LoRa), and Wireless Fidelity (Wi-Fi) are some of the examples of such system [14]. To understand the chapter better, some important parts of the IOT systems and some basic hardware are discussed too before diving deep into their use in agriculture.

Hardware The backbone of IoT is the web of interconnected devices which are attached with sensors, actuators, relays, and various other transmission module that controls and senses the changes of physical world as data points. While using computer network for transmitting the data in real time, or after a certain temporal cycle, these devices need some basic processing, storage, and electrical proficiencies, provided by an integrated circuit, microcontroller, or a similar System on a Chip (SoC) or something like a field-programmable gate array (FPGA) [6].

Networking Network designing and management are vital within and across IoT systems. It is important mainly because of two reasons. Firstly, the volume of connected devices is quite large so it impacts the network design decisions. Proper connection enables devices to communicate better with devices present or connected to the same network. Secondly, the network designing also plays a key role with running applications and web services that control the devices. It is important to have real-time data streaming for the appropriate functioning of the Internet of Things (IoT) system. The web infrastructure is used for data processing, storage, and analysis and also for the implementation of IoT applications [15].

Programming Most of the IoT hardware are embedded devices. Often, they are prototyped using commercially available microcontroller platforms, i.e., Arduino, Raspberry Pi, etc. Prototyping an IoT system single-handedly requires circuit designing skills, microcontroller programming, and a complete understanding of hardware communication systems like serial, I2C, SPI, etc. They are traditionally programmed using C++ or C. However, in current years Python and other similar languages are becoming more popular for use in IoT devices.

Artificial Intelligence and Machine Learning To visualize and conclude important insight from the data that is produced by IoT devices, computer-aided approach such as AI and machine learning plays an important role in IoT development. To become a real-world usable system from a lab-based prototype, different techniques such as data mining, statistics, visualizations, machine learning, modeling, etc. along with AI implementation are essential. These methodologies are functional in real-time feed into sensor data streams to perform predictive analysis, which in turn will help in making decisions autonomously [1].

Analytics The amount of IoT devices increases on a daily basis. It is one of the issues for the development. The data accumulated needs to be analyzed, stored, and visualized for inferences and predictions. The vast amounts of data originating from these devices pose a problem for its use. Hence the use of analytics is also an important part for the same [19]. Also, it is seen that many IoT devices face latency in time-sensitive data. Thus, it is also needed to filter or reject irrelevant data.

2 Basic IoT Hardware Used in Agriculture

The use of IoT-based irrigation system has gained popularity in recent times; over the last few years, embedded system is used extensively to make agriculture automated and easy with little supervision. In scientific literature, some the following hardware are seen as a vital component for almost all embedded systems. The use of these hardware are seen in some of the studies which uses the IoT approach in sustainable and smart agriculture [19].

Raspberry Pi Embedded boards liked Raspberry Pi in Fig. 1 or Arduino in Fig. 2 are the vital components of the system. One could argue this as the brains of "the system." It works on the Raspbian operating system which is installed via a microSD card. The other sensors are connected to the board along with the power supply [2].

All the data that are collected through the different sensors are processed in the microprocessor of the main unit, and those values are sent to the web or phone via any Internet of Things application or by using an application programming interface (API). The data is sent using the HTTP and MQTT protocol over the Internet or via a Local Area Network. All the other programs related to the IoT are loaded into the microSD, and using the feeds from the different sensors the required action is implemented.

Temperature and Humidity Sensor The temperature and humidity sensors in Fig. 3 are both an important part of the system which measures the temperature and humidity of the soil. One of the most used sensors is the DHT11 Temperature and Humidity Sensor Module. It uses a capacitive sensor for humidity detection and a thermostat to measure the surrounding; it produces a digital signal on the data pin. Apart from this, the other sensors like the LM35 Temperature Sensor and DS18B20 Temperature Sensor Probe can also be used. For detection of soil humidity, Soil Hygrometer Humidity Detector can be used as a separate sensor.

Fig. 1 Raspberry Pi 4B

Fig. 2 Arduino Uno

Motor and Switch Motor in Fig. 4 can be used for supplying the water for irrigation, when water level is below a certain level. When the moisture content is less in the soil, this motor is used to turn on the sprinklers.

Camera/Arduino Camera Module The cameras in Fig. 5 are used for a variety of purposes, such as looking at the plant condition, security, and also for capturing animal intrusion in real time. An aiding system can be of the infrared (IR) sensor which can detect this and start an alarm while the camera records or streams so that the user can know what kind of animal is in the farm or field. This image/video can be processed by using libraries like OpenCV, SimpleCV, Mahotas, etc. Further

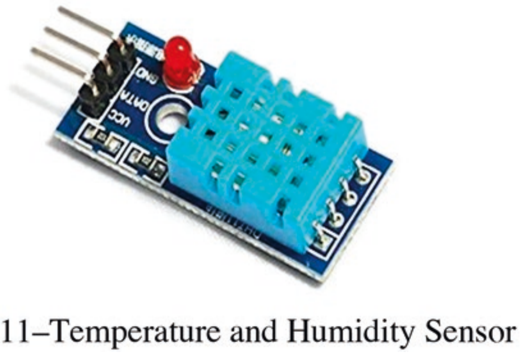

Fig. 3 DHT11 Temperature and Humidity Sensor

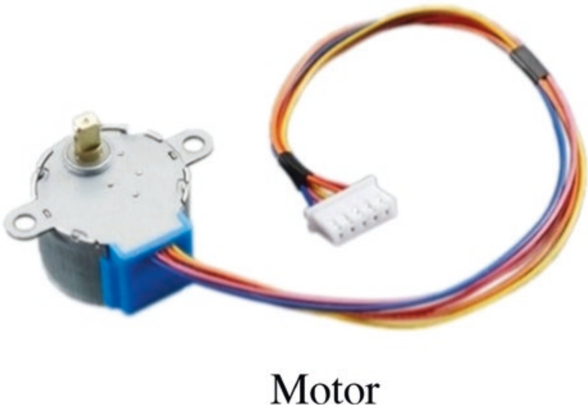

Fig. 4 Motor

classification can be done by using algorithm like Scikit-learn, convolutional neural network (CNN), support vector machine (SVM), etc. To find out the animal real time, a huge noise can be triggered to drive away the animal.

Infrared Sensor The purpose of this sensor in Fig. 6 is to detect movement of animals if they are inside the area. Such similar approach is seen in wildlife monitoring, which can be extrapolated and used into the agricultural protection; the only issue in this arrangement is that it will increase the cost. Further an alarm system can be made to send text/mail so that the user is alerted.

Rain Sensor The rain sensor in Fig. 7 is essential as it reduces the wastage of water. Upon rainfall, this sensor detects the droplets of the rain and switches off the sprinkler or the irrigation pump.

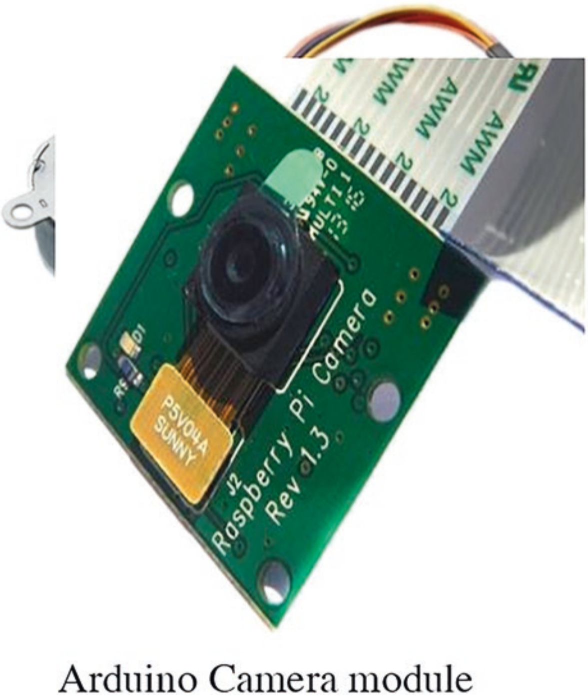

Fig. 5 Arduino camera module

Siren/Flashlights The siren or flashlights are an essential for the creation of a system grazing animal-proof system. Upon intrusion, movement can be detected by the IR sensors, and then the smart alarm system can be relayed to be activated based on that signal feed (Fig. 8).

3 Algorithms Used in IoT

Some of the prominent works in these fields have been done using simple components like Raspberry Pi 3, Arduino, and simple programmable embedding boards. Fully or even partially automated systems, however, make use of other sophisticated techniques like artificial intelligence (AI), machine learning (ML) techniques, etc. and algorithms, like principal component analysis (PCA), linear discriminant [28] analysis (LDA), convolutional neural network (CNN), regression modeling and fuzzy logic, etc.

Principal Component Analysis (PCA) PCA or principal component analysis can simply be explained as a perpendicular, linear transformation system that converts each of the new data to an improved, new, simplified coordinate system in such a

Fig. 6 HC-SR505 Mini Infrared PIR Motion Sensor Infrared Detector

Fig. 7 Raindrop sensor module

way that the greatest variance by the data clusters on each of the coordinate system [11]. In this way, the data corresponding to the very first coordinate (called the first principal component) has the most variation, second one has the second most, and so on. The components with the highest variation consist of most of the information regarding the classification task. Each of these components is influenced by all of the features of the system (feed data from various sensors), and the ones which influences the components the most are the most important ones which contributes to the classification. The orientation of the first PC is such that geometrically it causes greatest variance in the dataset, hence retaining the maximum classification information.

Linear Discriminant Analysis (LDA) LDA is also related to principal component analysis (PCA) and factor analysis, as in that algorithm, they both look for

Fig. 8 Siren/horn

combinations that are linear in nature, of variables which best explain the data. However, instead of just looking into the variation like PCA, LDA organizes a much simpler method to "fit" the required data points (variables) in such a way that there is maximum clear distinction based on the difference between the classes of data. LDA is best suited when the quantities made on independent variables for each observation are continuous quantities [28].

Convolutional Neural Network (CNN) Convolutional neural network has gained popularity for the analysis image data. It is currently one of the best algorithms for detecting image diagnostics or image embedded object. The IoT systems use the CNN algorithm to identify the pests like wild animals, so that one could be alerted when they approach the field. The model can be pre-trained using datasets of various animals so that upon requirement this model can fetch the identity of the pest and so the user can prepare accordingly. Upon detection of the trained animals, the model will clearly show the result. To improve this system, OpenCV can be used which has some elevated capabilities for better resolution processing, which will aid in this process. Works in this sector are quite limited as most model suffers from natural lighting issues which limits the proper functioning of the system.

Support Vector Clustering (SVC) The use of clustering is to divide and segment "scattered" or "unorganized" dataset into separate groups of similar parameters to organize the data into a more expressive form based on some criteria. In our case, all the sensor readings are fed to the microcontroller to perform the decision making. Once that is done, it moves to the next phase where the sensor values of humidity, temperature, and soil moisture sensor are uploaded to a web application or to some connected device. The training set and testing set (usually, 20% of data for testing set and 80% of data for training set) is implemented, depending upon the datasets formed by the continuous feed. The SVC model is able make predictions about the field parameters such as water requirements [13].

4 Application of IoT in Agriculure

Like many other industries, Internet of Things (IoT) has entered in agriculture and has flourished as well. Some of the important uses that are worth mentioning in are variable rate irrigation (VRI) optimization, automated evaluation crop health, monitoring of progress, irrigation, spraying harvest and pest and animal intrusion monitoring, etc. However, the extended discussion of all of those systems is quite lengthy and is loosely bound with respect to this chapter. Hence, we'll keep our discussions limited to the irrigation, crop pH, and animal intrusion management.

Over the last few years, a steady attention in this field has been observed. The table provided below is a short summery of some of the recent advancements of the use of computer-aided system in agriculture. The list is not all inclusive; efforts were made to keep the summery table relevant to the chapter objective, and any deviation that is perceived as important in IoT has been included as shown in Table 1.

Irrigation Irrigation is one of the essential commodities that directly affect the harvest. Water is essential for any form of crop production. The shortage of irrigatable water worldwide has created a need for its optimum utilization. Researchers are keenly looking into different approaches to solve the issue of sustainable water use in agriculture. It is estimated that 844 million people don't have access to clean drinking water [10]. Earlier, traditional methods were used to improve the water use in agriculture [20]. With the development of automation systems, methods like artificial intelligence, machine learning, and Internet of Things (IoT) came into play. IoT is built for using sensors' data acquisition and intelligent decision-making technology to integrate the digital and physical systems to provide result. Hence, system based on IoT can help in achieving optimum water use in smart agriculture. The development of smart system for the prediction of the irrigation must take the account of the various parameters like temperature, moisture, and weather conditions. The efficient use of water in an agricultural field is one of the major hurdles that IoT-based technologies are keen on achieving. To accomplish the efficient use of the water, agronomists, agrobiologists, and engineers rely on information from different sources (plant, soil, and atmosphere) to properly manage and mitigate the requirements of the crops.

This is generally done by using an automated system. The system, in its heart, has mainly three parts, a sensing node (sensor), an evaluative pre-programmed board (Raspberry Pi, Arduino, etc.), and a implementation (switch on/off) unit. The sensing nodes are involved in sensing the ground and environmental parameters (temperature, moisture, pH, etc.). This information is often expressed by a set of predefined variables, which are measured using the aforementioned sensors. Then, they are evaluated by programs to characterize the status of the matrix (soil in the case of regular farming or water in the case of aquaponics) to correctly obtain their water levels, nutrient requirements, or other physiological needs like total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), etc. While meteorological variables (moisture, temperature, light density, etc.) of an area are easily measured by a single sensor, or by a group of sensors for a vast area, the soil type and vegetation cover creates a large variability. Monitoring other variables, such as hydrodynamic factors like water drainage, terrain elevation, etc., might increase the chances of successful implementation of the models obtained by the system. Hence, the usage of sensors which detect the water status is an important complement to modulate the water requirements for the harvest. The systems developed have three core parts, namely, a detection unit, a decision unit, and a deployment unit (Fig. 9).

Animal Intuition Management Apart from the environmental factors, detection of small to large animals is important which causes problem to farmlands that share borders with forests or animal routes. Animals such as elephants, cows, deer, and monkeys are often seen feeding from easily available farmland or agricultural fields. The increase of non-regulated developmental activities such as construction of road, railways, and power projects is disrupting the natural environment and is contributing to the breakup of large forest covers. Moreover, clearing of forestland for agriculture and creation of human settlements, plantations, etc. often results in forests being divided into smaller patches. The wild animals present in these segmented forests are left with very little resources and often have no choice but to come to the human settlements for food and shelter leading to intrusion [7].

Researchers all over the world have tried to develop various methods of prevention of animal intrusion using methodologies like computer vision, infrared sensors, ultrasonic emitters, etc. The most common system that is suggested is that a sensor senses the entry of wild animals into the field and produces a noise or flash of light or ultrasonic waves to drive them away. The use of ultrasonic sound waves is beneficial as it is inaudible to humans [27].

pH Control Another important factor in agriculture is the pH of the soil. The water, which is being supplied to the field for irrigation, is often used as a means for providing fertilizers. Hence it is important to have a check and balance in the system so that the pH doesn't reach any extremes. We developed an automated pH control algorithm for using in IoT systems to keep the pH under control.

Table 1 Some of the notable development in application of IoT in agriculture

Sl. no.	Application	Components used	Experiment setup detail
1.	Irrigation	Soil sensor, pluviometer, meteorological data, etc.	In the model proposed by the authors, an expert agronomist performs the analysis by taking various sources of information (meteorological data, soil data) into account. Soil sensors that are present in crop fields aid in the system. It is used to formulate an irrigation report, indicating the need of water on a weekly basis [17]
2.	Irrigation	Moisture sensor, temperature sensor, ultrasonic sensor, Raspberry Pi, pump, etc.	The authors developed a system with instrumentation which can provide measurement of water level in tanks. The data uploaded real time to the cloud. The system also enables suggestions and control [25]
3.	Irrigation	Moisture sensor, temperature sensor, humidity sensor, raindrop sensor, Raspberry Pi, pump, etc.	All the parameters are checked beforehand; once the AC supply is in off position and the power unit goes to the Raspberry Pi, the sensor fed data is then analyzed in the pi and uploaded in web server to check, and once done it can perform the action [26]
4.	Animal monitoring	Camera, programmable chip, computer, etc.	In this paper, the authors proposed a new algorithm for recognizing wild animals. They claim the newly developed algorithms accomplished better accuracy on two standard datasets when compared to other already existing algorithms. The study was conducted on static images. The methodology can be further developed on recognizing animals from a video feed while working on the similar line of development [4]
5.	Irrigation	Moisture sensor, temperature sensor, humidity sensor, raindrop sensor, Arduino Uno, raspberry pi, pump, etc.	The algorithm proposed by the authors uses recent data of sensors and, after integrating it with the weather forecast data, gives a prediction of soil moisture. The predicted dats is accurate and error-free which helps in standardization of watering the field with lesser water wastage. The prediction further is integrated into a prototype when set into automated mode [9]
6.	Irrigation	Moisture sensor, temperature sensor, ultrasonic sensor, Raspberry Pi, MQTT dashboard pump, etc.	The authors in this literature presented an automatic farm monitoring and irrigation system. The system was seen to concatenate three modules together: unified sensor pole, low-cost and intelligent IoT-based module, and irrigation and sensor information unit. The system upon some initial monitoring goes into a continuous monitoring phase, where it senses data, uses it for neural network-based decision making, and performs ON/OFF water for the required zone [18]

(continued)

Table 1 (continued)

Sl. no.	Application	Components used	Experiment setup detail
7.	Irrigation	Moisture sensors, temperature sensor, Arduino Uno, breadboard, GSM/GPRS SIM900A modem, etc.	In the system an automated irrigation system has been proposed which uses unsupervised learning approaches. To validate this, a hardware implementation was done to validate the machine learning techniques. IoT sensors are used in the prototype to wirelessly transfer status of the plants. Taking things to the next level, a smart irrigation system is implemented based on the analysis of the data feed and environmental status of individual plants. The model also uses color change in leaf as a measure for requirement of water [2]
8.	Agriculture monitoring	None (Image dataset was used for development of the algorithm.)	The authors used a deep learning-based approach to construct and demonstrate a system of classification to classify rotten tomato and small creatures to analyze the accuracy. The captured image files were automatically analyzed using the classification which was sought appropriate by the system. The types and conditions were varied to look for discrepancies. Overall, they described the differences among correctly certified and non-certified data, with both quantitative and qualitative manner [12]
9.	Irrigation	Arduino board, moisture sensor, temperature sensor, GSM board, etc.	Using an Arduino board as microprocessor, the authors used different sensor-fed data which are compared to a standard. Depending on the deviation from standard, the system takes action accordingly. Simultaneously, the data is sent to the user's smartphone [16]
10	Irrigation	Soil moisture sensor, temperature sensor, humidity sensor, Arduino, water level sensor, Raspberry Pi, etc.	The regulation of soil moisture is done by the use of KNN algorithm. It is done to complement the shortcoming of other existing systems, with 93% accuracy; this system ensures a great harvest and a high yield. According to the author and their provided evidences, they proclaim "the use of KNN algorithm is one of the best suited algorithms for comparison of water allocated to agriculture" [1]
11.	Pest control	Microcontroller, driver circuit, sprinkling pump, solar, pesticide tank, IR sensor, GSM module, camera, etc.	The authors developed an agriculture robot vehicle, which is able to navigate between the crop-based user input using an Android application. This vehicle is low cost and effective. The user can control sprinkling device using IOT application to sprinkle pesticide, and an image feedback system is also added in the robot to aid the system [3]

(continued)

Table 1 (continued)

Sl. no.	Application	Components used	Experiment setup detail
12.	Animal monitoring	Temperature sensor, humidity sensor, camera module, Raspberry Pi, environmental sensors, etc.	The study showed an integrated implementation of environmental sensor and an imaging network. The system was used for automated insect monitoring. The authors claim the work being an improvement than only using wireless cameras alone. The key contribution of the work presented by the authors is development of an automated and integrated system for pest monitoring [23]

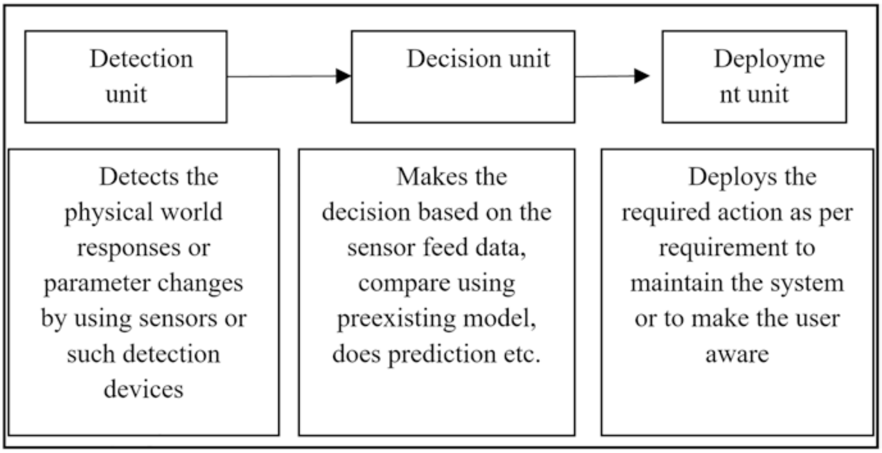

Fig. 9 As can be seen easily from the diagram, this is a simplified version of the usual IoT arrangements

Automated pH Control System Sodium hydroxide to increase the pH of acidic solutions or hydrochloric acid to decrease the pH of alkaline solutions is a widely used chemical for pH control. Make sure that you use goods for hydroponic systems that are formulated. You may add weak acids such as vinegar or citric acid for limited systems or short-term effects. Automatic pH controllers cost more than products with pH up or pH down, but they maintain pH at consistent levels. The treatment process of soda ash/sodium hydroxide injection is used if water is acidic. When injected into a water stream, soda ash (sodium carbonate) and sodium hydroxide boost the pH of water to near neutral.

In human body, by releasing carbon dioxide the, lungs regulate the pH balance of the body. Carbon dioxide is a compound that is slightly acidic. It's also a waste product that cells in the body generate when they use oxygen. It's released into the blood by the cells, and it's taken to the lungs. Using hydroxyl ion source in water-base mud to regulate pH is shown in Table 2.

Table 2 Hydroxyl ion source in water-base mud to regulate pH

Typical physical characteristics	
Appearance physical	White beads, pellets, flakes, or crystal
Particular gravity	2.13
About pH (1% solution)	13
86 degF solubility [30 degC]	119 g/100 mL water

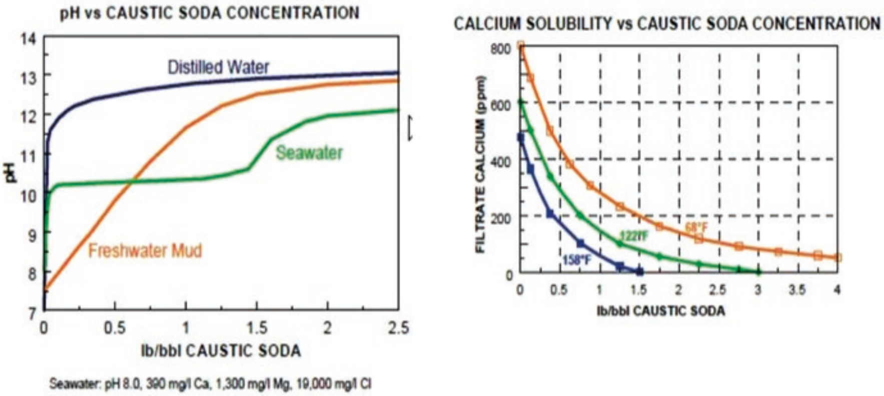

Fig 10 pH vs caustic soda concentration and calcium solubility vs caustic soda concentration

To preserve or raise pH, caustic soda is used. Increasing pH precipitates magnesium (Mg2+) with caustic soda and suppresses calcium (Ca2+) in high-hard waters such as seawater. It also decreases corrosion and neutralizes acid gases such as carbon dioxide (CO2) and hydrogen sulfide (H2S). Typical concentrations vary from 0.25 to 4 lbm/bbl [0.7 to 11.4 kg/m3] depending on water chemistry and drilling fluid type, with treatments. A higher concentration of caustic soda is required in marine water and waters containing buffering salts. To precipitate all magnesium, the Gulf of Mexico seawater takes 1.5 to 2 lbm/bbl [4.3 to 5.7 kg/m3] to transform the calcium to lime as shown in Fig. 10.

The appropriate pH is between 5.5 and 6.5 in the hydroponics method. This system requires manpower to maintain its equilibrium. If the user of the reservoir tests it periodically and adds acid or base accordingly, the eqileberium is easily maintained. In cases, where plants can be affected by a wrong pH level and its concentration, a nutrient lock is also triggered to protect such incidents from happening. Here we suggested an AI-based system that operates automatically on the prediction model and with few components to balance pH value. This technique is even less difficult and has a chip to execute.

Data Collection The main component is data for creating an AI-based application. We are preparing a system that has 20 liters of water capacity and set up with one cucumber and two tomato plants to collect the real-time pH data. The entire setup was DWC architecture and connected to an air stone that runs every 30 minutes for

10 minutes. We placed a pH electrode and an onboard computer (Raspberry Pi) to process the data to obtain the pH value. As the pH sensor comes in UART mode, jumpers are added to turn it into a Raspberry Pi-compliant i2c mode. In the method, the electronic computer was assembled with regular running routines that read and store the data in the device itself. The device runs for all three months to collect real-time data from five different stages of growth of the plant. We found that pH imbalance is not common during the running time, so we added some bases to get data read. We choose two small water pumps in the second portion, capable of pumping 50 ml of liquid in 5 seconds. To get the running time, both of them are linked to the Raspberry Pi kit and the trigger is fixed with a web service endpoint to start and stop. For pH level 7.2 to 6.5, we measure that 10 ml of acid is required to be added to 1 liter of water where 200 ml of acid is needed for 20 liters of reservoir. We also developed diluted base solutions in the case of the base to simplify the operation, where the 2nd pump is connected to the base solution.

The optimized machine runs with a pumping time of 0 seconds every day for reading and runs manually when we need to apply the acid or base to maintain the pH level in seconds with the right pump running time. We gathered data with the attribute pH value, pump A running time, and pump B running time after the complete growth period. To visualize the pH spike and pump running time, we use the data analysis process. Figure 11 shows the spikes and the Table includes the sample data we obtained (Table 3).

Study of Correlation We evaluated the association between the pH value and the running time of each pump here. We find that both running times are associated with a positive correlation of pump B running time and a negative correlation of pump A with pH value. Figure 12 is a demonstration of the configuration of the entire device.

Dataset The created dataset contains 90 collected data dates with three attributes such as pH value, pump A runtime, and pump B runtime. We split the dataset into two separate sections during the preprocessing section, with two columns holding the pH value and one pump running time in each sub-data set. Each subset contains 90 records where the independent variable is the pH value and the dependent variable is the pump operating time.

Model Generation We need to predict the running time of the pump here as the length of seconds, where a value is the predicted attribute. So we'll turn to the mechanism of regression. To implement the model with distinct algorithms, we used Python libraries. In this method, we introduced linear regression, support vector regression, and K-nearest neighbor regression according to the data attribute, where 90% of the prediction precision is provided by linear regression. And KNN has 73% and SVR has 60% of the precision of the model. It was seen in Chat in Fig.13.

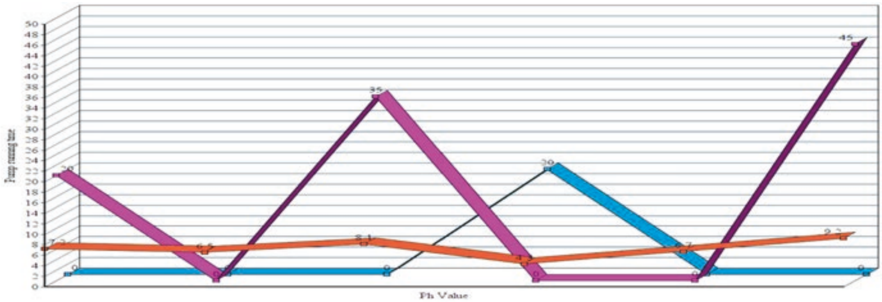

Fig. 11 Value of pH with pump time running

Final Installation We selected a linear regression model after testing the model to predict the running duration of the pump. We prepared two triggers for the pump to operate as both the model produced separately for both the pump. The Algorithm-1 is designed to deploy the model and other features, such as calculation, initialization of the input value, pump triggers, etc.

Algorithm-1: For Final Installation

Step-1:

Water contains in the liter ← Input

Step-2:

Load_model(model_A, model_B)
(where model_A is for pump_A and model_B is for pump_B)

Step-3:

pH_value ←- read from the sensor
predict _value for pump_A = model_A.predict(Ph_value)
predict _value for pump_B = model_B.predict(Ph_value)
(Here ph value is read in each day and then the duration of pump A and B is predicted from the ML model.)

Step-4:

predicted_value_A = total_amount_of_water*predict_A
predicted_value_A = total_amount_of_water*predict_A
(Here the duration of predicted value is for one letter so it's recalculated according to the amount of water input.)
Run_triger_with duration(predicted_value_A, pump_A)
Run_triger_with duration(predicted_value_B, pump_B)
(Here pump running method is called based on the predicted duration that is obtained.)

Table 3 pH dataset demonstration in real time

pH value	Pump A running time (s)	Pump B running time (s)
7.2	20 s	0 s
6.3	0 s	0 s
8.1	35 s	0 s
4.3	0 s	20 s

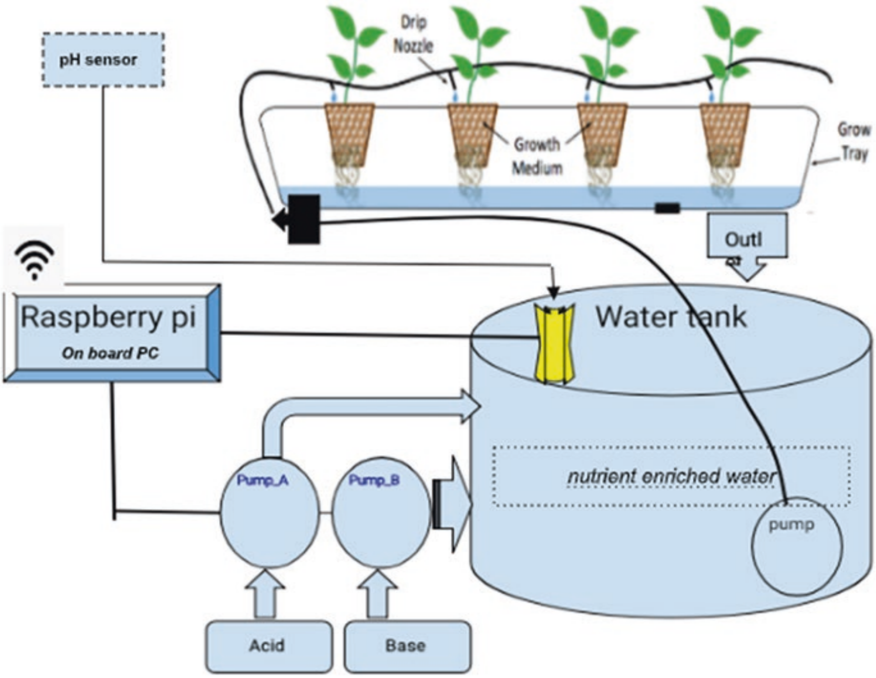

Fig. 12 Demonstration of the whole process

For the same test setup with the same plant where positive results are observed, this approach is used for the same setup. The greatest benefit of this method is its flexibility and lower cost. The device architecture is also compatible for any volume of water as the value is predicted to be set to 1 liter of the unit length. We have checked the method with rising greens where, with less effort, we find very good results. It can be flexible in large-scale applications by adjusting the volume of input water. It is absolutely reliant on the air stone in DWC, water in-out as a drip system, or NFT, as it does not have a diluting function. In Kratky's architecture, the mechanism would fail.

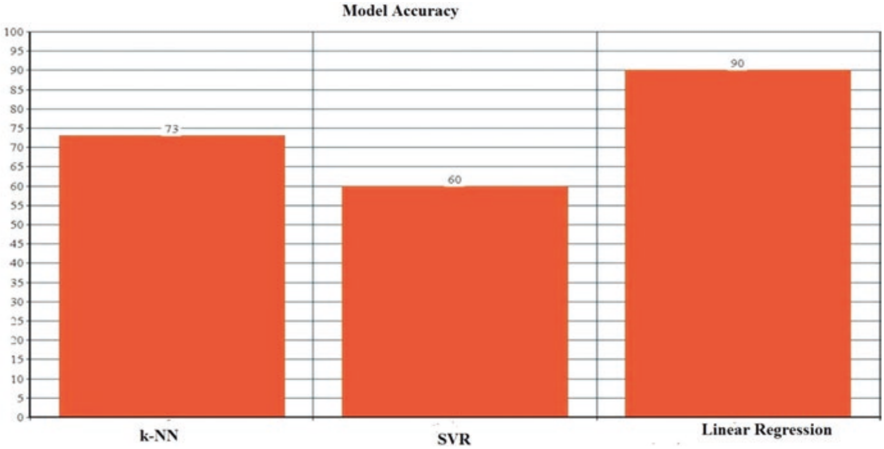

Fig. 13 Precision of the model

5 Result and Discussion

The study conducted based on the pH parameters of an agricultural system yielded us the required inference. The process was able to become a low-cost method of the regulation of pH. The system consisted of two pumps which, upon detection on the pH value to either too acidic or basic sides, switches itself on and maintains a somewhat neutral area. Our work was based on an aquaponics system. The results so obtained were satisfactory with respect to the time interval.

To sum up, use of IoT in agriculture is the new addition to agricultural system's ever-growing development. A lot of contributions to this field can be seen. It is assumed that a diverse plethora of individuals are being benefited by the technology, small farmers, high-tech agricultural fields, plantations, farms, greenhouses, hydroponics farmers, etc. are using IoT to their advantage. This chapter looks into the various methodologies that are used in irrigation and development of intrusion-proof farms. Our work in the area of pH management is in alignment with the previous systems that has been developed.

6 Conclusion and Future Work

The overall conclusion of the work done so far summarizes a smooth path for the development of IoT in agriculture. With the development of cheaper electronics, we hope that one day agriculture will be able to work as smooth as the other IoT technologies. With smart lighting, pH management, irrigation, and animal intrusion-proof systems, the yield is expected to increase in smart agriculture with lesser efforts and costs.

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Part VI
Multidisciplinary Behavioral Applications & IoT

Collaborative Processing Using the Internet of Things for Post-Disaster Management

Saurabh Kumar

1 Introduction

In recent years, the occurrence of disasters has caused a significant amount of loss to the different countries of the world. Disaster management agencies worldwide have categorized the disasters as either *natural* or *man-made* [1, 2]. A natural disaster is considered as the physical phenomena that occur naturally and are caused either by the rapid or slow occurrence of events that have significant impacts on the health of human beings, sometimes causing death and severe suffering among them. Natural disasters can be geophysical, hydrological, climatological, meteorological, and biological [3]. On the other hand, a man-made disaster is considered as an event that is the result of environmental or technological emergencies near human settlements and is caused by the daily life activities of human beings. Man-made disasters can be related to environmental degradation, pollution, and accidents in the industries, technological developments, transportation, etc. [4]. Moreover, there are certain complex combinations of natural and man-made disasters, which include, but are not limited to, food insecurity, epidemics, armed conflicts, and displaced population. According to the International Committee of the Red Cross (ICRC), the different complex emergencies can be characterized in terms of loss of life, extensive violence, widespread damage to the societies and economies of any country, and evolving risks for humanitarian relief workers in terms of their security [5, 6]. In the last three decades, the world has observed different pandemics such as Ebola, Zika, Avian flu, Cholera, Dengue fever, Malaria, Yellow fever, and Coronavirus Disease (COVID-19), which is the most recent one from among them all [6]. These

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pandemics have negatively affected the economic and social costs and resulted in an unexpected decrease in human manpower. According to the International Federation of Red Cross and Red Crescent Societies, a disaster results from a hazardous impact on vulnerable people worldwide [7]. Thus, there is a need to address the disaster management practices to prevent and mitigate such disaster cases in real time.

Disaster management focuses on prevention, preparedness, response, relief, and recovery operations [8]. There is a cyclic link between environmental management and disaster mitigation and adaptation. The practices carried for disaster mitigation and adaptation result in the management of the environment, whereas the management of the environment forms a pillar to prevent disasters from happening. The former is a part of post-disaster management [9], and the latter forms the basis of pre-disaster management [10]. The disaster management cycle consists of four phases: *response*, *recovery*, *mitigation*, and *preparedness* [1]. The pre-disaster management ethics is mostly based on human beings' education and forming a disciplined environment so that the unexpected vulnerabilities cannot be exploited unnecessarily. For instance, cutting off too much of the woods may result in deforestation, which again results in frequent floods in the area that affects the lives of human beings negatively. To perform effective management of the disaster, once it has occurred, one must understand and follow the practices related to post-disaster management.

In the case of post-disaster management, there are six tools used, namely, Environmental Risk Assessment (ERA), Environmental Management Systems (EMS), Strategic Environmental Assessment (SEA), Environmental vulnerability and hazard mapping, Rapid Environmental Assessment (REA), and Environmental Impact Assessment (EIA) [11]. Using the abovementioned tools, the assessment of a disaster can be done effectively, and relevant safety measures for its prevention and mitigation can be devised. In the past few years, it has been observed that the disaster management authorities have created and been working upon these tools efficiently to either prevent the disasters with early warning systems or prepare the concerned authorities to focus on the mitigation, response, and recovery operations once the disasters have occurred. However, there is a need to integrate the technologies and techniques utilized across the world to handle the disaster situations, as and when it happens, in a more profound manner. With the emergence of Information and Communication Technology (ICT) and ambient intelligence [12] around the world, there is a need to use these technologies to automate the post-disaster management activities all around the world. The use of technologies will help governments, businesses, and civil society to plan and reduce the impact of disasters by appropriate shaping of public policies and plans through integrated communication among the conscious entities participating in the post-disaster management operations.

Effective communication is one of the crucial aspects in performing the operations associated with post-disaster management. The invention of the Internet and its evolution in terms of connectivity, communication capability, and speed have helped build a concrete backbone infrastructure to support the ICT applications. Also, the emergence of the Internet of Things (IoT) [13] and the profound use of cyber-physical systems [14] provide a platform wherein different types of devices and human beings, irrespective of their ethnicity and languages, can be connected all across the world with the use of the Internet. It has helped emphasize five significant but continuing trends concerned with the world of computing, i.e., ubiquity, interconnection, intelligence, delegation, and human orientation [15]. These five trends are the basic building blocks of ambient intelligence and help perform intelligent distributed processing, even with the devices deployed in remote or inaccessible regions. It must be noted that there is a need to address the issue of disaster management on a global scale and in real time, wherein the autonomous operation plays a significant role. Since the post-disaster management operations require a significant amount of communication and computation to be performed in real time, the five continuing trends mentioned above with their features and efficient platforms are highly useful in planning and producing the strategies intended for effective post-disaster management operations. However, to address the challenges such as heterogeneity in devices, communication protocols and mechanisms, demand for heavy computation, processing power, and reliability, there is a need to understand and incorporate the collaborative processing among the devices in the network, as described in the following section.

2 Collaborative Data Processing

In the current real-world situations, the task of post-disaster management requires efficient connectivity and communication among the entities involved in the operations. In [16], J S Kumar et al. present a generic model for communication among the different entities involved in the post-disaster management operations. It is emphasized to use an Intelligent Information Network (IIN) for the IoT environment, wherein an information processing system acquires the information from the site of disaster using the cyber-physical network, which in turn will be utilized by the disaster management team and legislation authorities to understand the nature of the disaster and communicate this information to the media/citizens/non-governmental organizations. The information processing system performs its activities using the sensing and actuation operations in the region of interest. To deploy and manage such an information system is a critical challenge and requires a collaborative strategy of processing the data at different levels.

Collaborative data processing revolves around five key terminologies: *communication*, *cooperation*, *coordination*, *collaboration*, and *task* [17]. Communication is the exchange of ideas and information among the participating entities. Cooperation is to work with someone in the sense of enabling, i.e., provide the needed resources and information. Cooperation is achieved using the conscious and deliberate efforts of the participating entities. Similarly, coordination is identified by the actions of the users directed by a coordinator to accomplish a common goal. On the other hand, collaboration is defined as a collective effort of participating entities to achieve the desired goal with willingness. Finally, the task is a schedulable function or feature executed in temporal scope. A task may be periodic or aperiodic, sporadic, deadline-based, and precedence-based by its characteristics. Collaborative Data Processing (CDP) is the collection and management of data from one or more sources and distribution of information to the destination with the goal to control, process, evaluate, and report data and information activities [18]. To perform efficient collaborative data processing among the devices deployed in the network, there is a need to address the critical challenges associated with it.

Four critical issues are needed to be addressed for successful collaborative processing among the networked devices: dynamic determination of the level of sensing, entities of sensing, frequency of sensing, and entities involved in the computation [17]. Moreover, there are two technical issues with collaborative data processing. First is the degree of information sharing among the devices in the network. The second issue is to formulate the methods employed to fuse the information among the devices sensing it. Thus, collaborative data processing revolves around the concept of distributed information fusion.

Figure 1 depicts a simple scenario to understand the concept of collaboration and its significance using a tree-based network infrastructure [19]. As an event occurs in the region of interest, it is detected and sensed by the device, in the communication range of which the event has occurred. As shown in Fig. 1a, two devices sense the event. The sensed event is forwarded to the root node, which serves as the sink node in the network. Since two devices send the same data to the root node, the redundant data will be received by the root node. Also, forwarding of the same data will incur a significant amount of load on power-constrained devices, which must be avoided necessarily to maintain the lifetime of nodes and the network as well. This is an undesirable case and, thus, must be handled at the device level only. In this context, the devices sensing the event must collaborate among themselves to devise a strategy to forward the sensed information in such a way as to reduce the power consumption and redundancy in the network. This kind of scenario may further become more complicated in a network wherein the autonomous operation occurs among

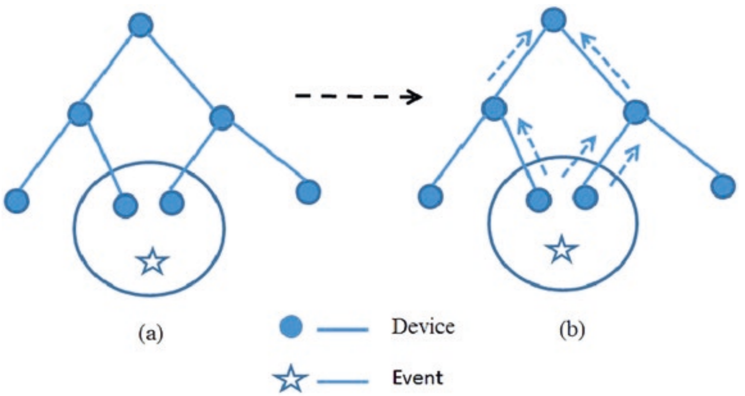

Fig. 1 (**a**) Two nodes detect an event; (**b**) event information is propagated to sink node [19]

heterogeneous devices. Thus, there is a need to outline the different challenges associated with collaboration by understanding the different research areas in CDP.

2.1 Research Areas

The research areas in CDP are based on the different characteristics affecting the operation of devices and key evaluation metrics used to measure the performance of these devices. The characteristics of these devices are outlined in terms of mobility of nodes, distributed processing demand of the applications, ability to cope with node failures which affect the reliability adversely, power consumption constraints of devices using batteries or other forms of energy harvesting, communication failure affecting the real-time response of the system, and high-scale data processing both at the local and global levels to process the tasks in the applications [20, 21]. On the basis of different characteristics discussed above, the key evaluation metrics may include the performances related to lifetime, connectivity and coverage, deployment cost and ease of operation, response time, effective sampling rate, and security [21]. The different research areas in CDP are shown in Fig. 2.

The research areas in CDP can be categorized into *network-based* and *Quality of Service (QoS)-based* [14, 18]. In the network-based category, the problems related to the creation and maintenance of the network are discussed, such as the

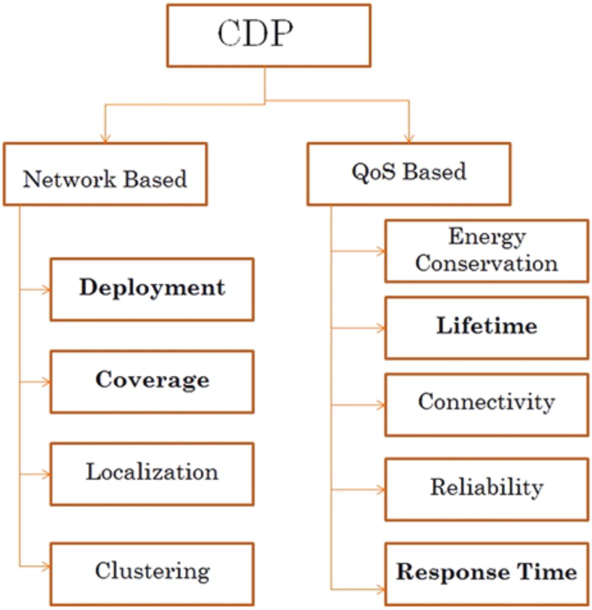

Fig. 2 Classification of research areas in the collaborative data processing [20, 21]

deployment of devices in the network, coverage of the network, localization of devices and events in the region of interest, and the clustering of deployed devices to support the operations related to the different applications [18]. Similarly, the QoS-based category discusses the problems related to maintenance of the performance of the network, such as energy conservation of the devices, lifetime, connectivity, reliability, and response time of the network to different services [14].

Furthermore, there is another category for the classification of research areas in CDP: *collaborative sensing*, *collaborative communication*, and *collaborative computing*. Collaborative sensing is governed by three factors, i.e., anomaly detection rate, quality of signal processing, and false alarm rate [19]. When an anomaly is detected, the signal is sampled and filtered, the process of threshold comparison is performed, information is fused, and, finally, the features are fused with neighbors to achieve accuracy and improvement in signal quality. The primary role of collaborative sensing is to gather information from the environment with robustness. Collaborative sensing takes care of the assignment of tasks to sensors, execution of the sequence of tasks on sensors, and creation of communication schedule among the sensors. The collaborative signal processing gets affected by attributes such as the size of the sensor, deployment methodology and mobility model utilized, the extent of sensing required, operating environment, underlying processing architecture, and availability of energy of the devices. Among all the above attributes, the processing architecture plays a significant role in efficiently sensing the events in the region of interest. A layered architecture for cooperative signal processing is discussed in [22], as shown in Fig. 3. It can be observed from the figure that the lower three layers execute operations autonomously, whereas the upper three layers perform the operations cooperatively. The lower layers focus more on

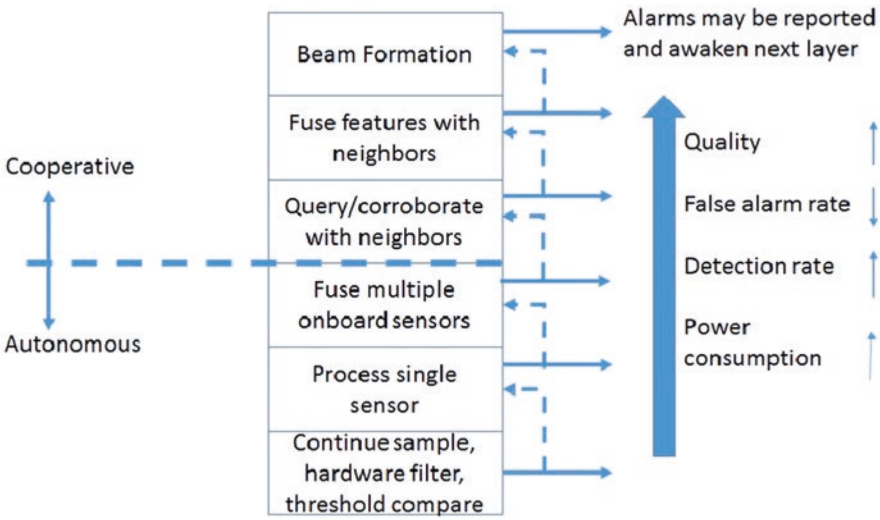

Fig. 3 Layered architecture for cooperative signal processing [22]

hardware-based processing, and the upper layers perform application-oriented functions. The quality, detection rate, and power consumption increase when moved from lower to upper layers, whereas the false alarm rate decreases considerably.

The success of collaborative communication depends on attributes such as optimized response time, maximum throughput, maximum average lifetime, minimum energy consumption, and maximum coverage of the network. The strength of the backbone ICT network plays a significant role in performing efficient communication. On the other hand, a computing model deals with dynamic network heuristics and distributed computing, wherein the computation needs to be performed at the node, local, and global levels. The computing model can be categorized into *centralized* and *distributed* schemes [23]. The centralized computing model uses the client-server model of computation, whereas the distributed model uses mobile agent-based computation. The centralized model suffers from higher energy consumption and storage requirements, has a longer processing time, suffers from disconnection of the network when the server goes down, and, thus, is suitable for small and sparse networks. The different challenges and issues related to collaborative data processing and their respective characteristics are summarized in Table 1.

On the other hand, in the case of distributed computing model, the energy consumption and storage requirements are comparatively lesser, and processing does not get affected, due to which, with increase in scalability, mobile agent bypasses the dead node, results into longer network latency with less dense networks, and, thus, is best suited with denser nodes in the network. The authors in [24] discuss a graph-based communication algorithm that utilizes two computing schemes to address the collaboration among the devices. The first scheme assumes that the number of nodes within a cluster is large and the number of cluster heads is small.

Table 1 Challenges and characteristics of research in the collaborative data processing

Challenges/issues	Characteristics
Device deployment	Uniform distribution of devices, optimal clustering, multiple wireless hops
Energy consumption	Accuracy in communication, strong dependence on battery lifetime, affected by re-routing
Date reporting model	Periodic, event-based, query-based, hybrid, depends on route stability
Node/link heterogeneity	Different rates of sensing and reporting of events, diverse QoS, multiple data reporting models
Fault tolerance	Multiple levels of redundancy, application dependent
Scalability	Routing scheme must support huge number of devices
Network dynamics	Issue of route stability, depends on application, reactive vs proactive reporting mode
Transmission media	Effect of fading, high error rate, multipath spread, other channel impairments
Connectivity	High device density, deployment strategy
Data aggregation	Reduction in number of transmissions, signal processing methods, beamforming
Quality of services	Bounded latency, energy dissipation of devices, lifetime improvement

In this case, computing within a cluster is performed using the distributed model, and computing among different clusters is performed using the centralized model. Similarly, the second scheme assumes that the number of nodes within a cluster is small and the number of cluster heads is large. In such a case, the process adopted is just the reverse of the former one, as discussed above.

In addition to collaborative processing, the post-disaster management activities require the exploration of ambient intelligence in the region of interest. It helps to achieve ubiquity, interconnection, and intelligence, which results in efficient communication among the entities involved in the operation. The advent of IoT serves as a strong pillar of ambient intelligence with profound communication capability among the heterogeneous devices deployed in the region of interest. In conjunction with collaborative data processing, the IoT environment provides a platform to use the cyber-physical systems to perform sensing and actuation on the environment and communicate the sensed information in real time. Thus, there is a need to explore the IoT technology to understand its utilization in post-disaster management activities, as discussed in the following section.

3 Internet of Things

Currently, there are over 4.5 billion people across the world who have access to the Internet. Every eight out of ten Internet users have smartphones, which has increased the information and data access in real time, and its demand is ever increasing. The evolution of ICT has attracted the world's attention toward the notion of a smart world [25]. The idea of an intelligent world includes a key component, i.e., device-to-device communication. It emphasizes the role of unified communication, which can be realized with integrated telecommunications, computers, enterprise software, robust middleware, storage, and audiovisual systems. This enables the users to access, store, transmit, and evaluate the information in real time. However, there are certain critical issues related to the usage of a unified communication platform, such as the gap between developed and developing nations, penetration of remote areas, availability of cellular coverage, electronic transmission speed, and efficient use of the backbone network. In this context, the Internet of Things environment plays a major role in realizing the vision of unified communication using the Internet.

The IoT environment offers the scope of connecting and communicating among the devices around the world using the Internet protocols. The use of the Internet is crucial and profitable for energy-constrained and limited computing powered devices. The IoT environment assumes the distribution of heterogeneous devices of various types, such as sensors, actuators, servers, mobile stations, etc. The term *heterogeneity* means that the devices use different mechanisms for manufacturing and different communication protocols having different sizes and shapes, adopt different computation techniques and different processing power, may exist in different types of networks, are short-ranged or long-ranged, and offer different QoS performances. In such a scenario, various issues are affecting the performance of the IoT networks. First, there is a need to address the efficient connectivity among the physical, Information Technology (IT), social, and business infrastructures by virtue of collective intelligence and QoS parameters affecting the communication in real time. Second, the issues of mobility, routing, and the requirement of an on-the-move configuration of devices pose a big challenge. Third, since the IoT environment assumes communication among many machines worldwide, the algorithms must support the scaling at the global level, robust communication, and self-organization capabilities. Fourth, the IoT network integrates different platforms, protocols, and technologies, and thus, interoperability must be addressed on a large scale. Finally, the underlying network architecture and system design must be prepared in such a way as to support the issues as discussed above with efficient processing of the application operating in the IoT environment. Thus, it is important to conceptualize the IoT on a global level.

The Internet of Things is a global networking interconnecting smart objects employing comprehensive Internet technologies to support a wide range of technologies necessary to realize the vision with the intent to develop applications and services using such technologies in the global business world. There are three conceptual pillars of IoT: be identifiable, have communication capability, and have collaboration among the objects or things [26]. These IoT objects or things are anything that can be seen around the world. It can range from your spectacles to the chair, table, bed, sofa, wall, wearables, and more complex computing machinery. It can be observed that the IoT tries to connect all the objects in the world using the Internet. However, it can also be observed that these objects are heterogeneous in their behaviors and characteristics. Thus, the devices in the IoT environment are categorized into two basic types: sensor device and IoT device.

The sensor device detects or measures a physical property or records and indicates or responds to it in real time. On the other hand, creating an IoT device is complex and challenging, yet not so difficult in the world where we live. To create an IoT device, choose any *thing* besides a computer, and add computational intelligence to make the *thing* a computationally intensive device. Further, add a network connection to the computationally intensive device to build an IoT device. An IoT device can be able to communicate using the Internet protocol stack. An example of the IoT device is shown in Fig. 4, wherein a simple cellular phone is added with intelligence using sensors, a camera, high-end display, wireless fidelity, and GPS. Then, it is connected with high-speed mobile broadband to make a smartphone, which can be utilized as an IoT device in the network. With the understanding of the different devices in the IoT environment, the way forward is to get acquainted with the different underlying architectures of IoT and their significance, as discussed in the following section.

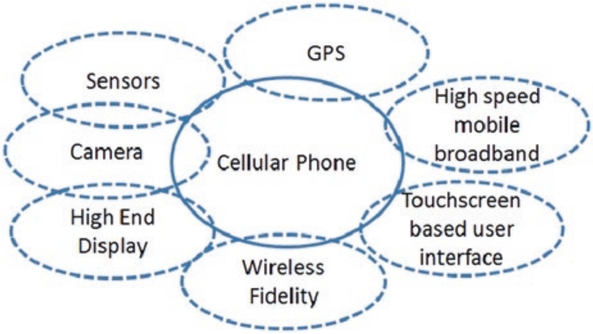

Fig. 4 Example of an IoT device

3.1 Issues and Challenges

The development of applications using the IoT environment must address five crucial points: deployment of devices in the network, use of smart agents, development of intelligent spaces, real-time pervasive computing, and system architecture. These five topics are also known as the building blocks of IoT. The deployment of devices must be performed in such a way that the mechanism provides ease of access to the broadband infrastructure. This helps improve the collective embedded intelligence of the region, which further provides a cohesive and integrated infrastructure of smart devices. However, the most crucial aspect of the IoT environment is to address the system architecture. This is because the different devices use various communication protocols, for which there is a need to develop an underlying architecture that integrates the functioning of these protocols at different layers of the operation.

Gubbi et al. [27] discuss the conceptual IoT framework with cloud computing serving as the middleware of network of things and applications. The critical aspects of the network of *things* include, but are not limited to, security, reconfigurability, QoS, communication protocols, location awareness, and compressive sensing. The middleware serves as a cloud platform supporting the visualization, computation, analytics, and storage services. This kind of framework is beneficial in the real-time processing environment. However, it does not address the distinction among the heterogeneous devices at the physical layer. Similar application-oriented architectural models are discussed concerning smart cities [28], healthcare [27], smart grid [29], and intelligent transport systems [30]. When these architectures are analyzed on a micro scale, it can be observed that the IoT architecture requires the physical layer, data accumulation layer, abstraction layer, and application layer for implementing the network layer functionality at the edge for routing and exploring the role of analytics and business processes.

Although there exist different applications in the IoT environment, the devices and edges can be considered as the heart of the complete architecture in a nutshell so that any business application can run on top of it. In this context, a layered IoT framework is proposed in [31]. It consists of two types of devices: sensor device and

IoT device forming two different layers, namely, *sensing layer* and *IoT layer*, respectively. Both the sensor and IoT devices are responsible for performing the data acquisition and data distribution operations. However, since the IoT devices are better than the sensor devices in terms of communication and computation capabilities and are connected using IP-based protocol, they are assigned to perform data distribution on a major scale and data acquisition on a minor scale. The responsibility of the devices at the sensing layer is just the opposite of that of devices in the IoT layer. The sensor devices are ID-enabled and short-ranged and have comparatively lower energy, whereas the IoT devices can be either IP-enabled or ID-enabled based on the requirement of the scenario in which it is operating. The devices at the IoT layer support IEEE 802.15.4, IEEE 802.15.4e, 6LoWPAN, and CoAP in the physical, MAC, network, and application layers, respectively [26, 27]. The layered IoT framework is shown in Fig. 5. It can be observed that the devices in the same layer are assumed to communicate in the local neighborhood. Similarly, the IoT devices can acquire the data from the sensing layer and, thus, assume to perform this operation in the global neighborhood. Even with the architectural framework of the IoT environment, there is a need to address the different issues and challenges associated with such a network.

The collaboration in the IoT environment embeds numerous heterogeneous devices and processes the information from them to improve the sensing and actuation capabilities. There are some issues and challenges which must be addressed for performing efficient communication among these devices, as shown in Fig. 6. These issues can be addressed for real-time service delivery by incorporating effective algorithms in the fields of deployment, localization, and clustering. The significance of these fields can be outlined by the fact that real-time service delivery requires the localization of devices in real time. The better location estimation results from better coverage of the terrain, hence resulting in the discussion of the deployment in the

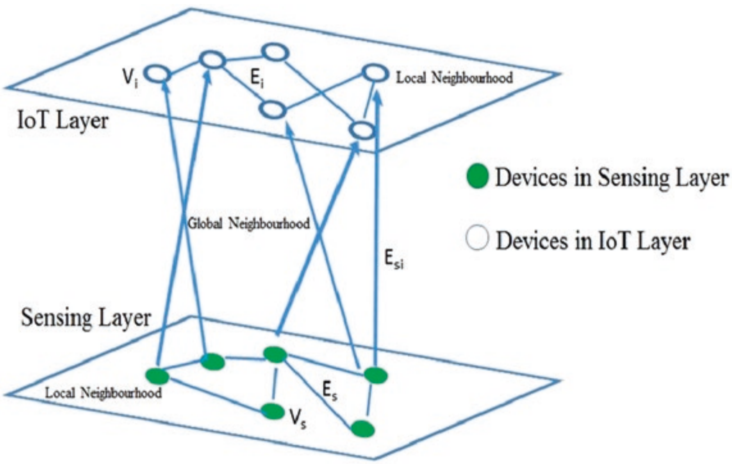

Fig. 5 Layered IoT framework [31]

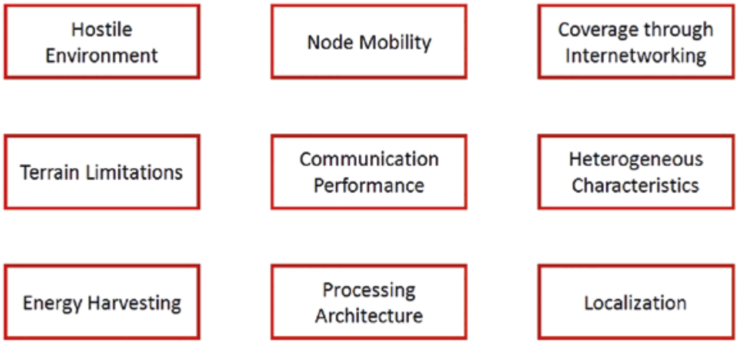

Fig. 6 Issues and challenges of operation in the IoT environment [27–29]

case of the IoT environment. Additionally, the sensing and acquisition by the deployed devices can be efficiently performed if these devices are logically clustered in terms of their context of the operation. These topics are discussed in the next few sections.

4 Deployment

The operations for post-disaster management using autonomous devices require that the devices must provide the services throughout the terrain. Specifically, the requirement is to cover the region of interest with an optimum number of devices. This is due to the reason that the devices are costly and their management and maintenance are associated with a high cost. In a broader sense, the deployment of devices provides efficient connectivity and coverage throughout the area. It results in more proficient communication among the devices to sense and forward the sensed information in real time. An efficient deployment strategy helps to achieve robustness in case of the failure of specific devices. The robust processing of the data strengthens the data acquisition capability of the devices in the terrain. This ensures a better distribution of devices with higher granularity, which further provides a better communication range with energy efficiency and reliability. Thus, deployment becomes one of the key issues for building a concrete infrastructure for post-disaster management.

The deployment strategy can be categorized into *pre-deployment*, *post-deployment*, and *re-deployment* phases [25]. In the pre-deployment phase, the algorithms are developed to deploy the devices for the first time in the terrain. This is essentially the initial phase of deployment, and thus, a lot of effort is required during this phase to provide better coverage of the area. It is because the deployment process also incurs a high cost, depending on whether it is performed manually or autonomously. During the pre-deployment phase, efforts are made to understand the coverage area of the terrain. The area of coverage may be either *known* or *unknown*.

With a known area of coverage, the placement of devices becomes comparatively easier than when it is unknown. For instance, the coverage area of a house is known and can be measured in square feet. In such a case, for sensing the earthquake tremors, it is easier to judge the minimum number of devices required to be deployed to serve the purpose. On the other hand, with an unknown area of coverage, it is comparatively difficult to decide the minimum number of devices that need to be deployed in the region, further resulting in the additional cost in its implementation. This becomes even more challenging in the presence of obstructions and non-line of sight conditions. Moreover, it can be inferred that the manual deployment can be done in regions with the known area of coverage. Still, it is quite difficult to adopt it in regions with unknown coverage areas. Thus, in such a scenario, the deployment can be performed using unmanned aerial vehicles.

It has been seen that there are certain possibilities of change in the network topology due to the non-availability of enough power, changing task dynamics, and non-reachability of the services. The post-deployment phase is carried out to perform the maintenance operations in such conditions. This phase is crucial as it improves the lifetime of individual devices and the overall lifetime of the network. Further, the re-deployment phase is carried out whenever it is observed that the deployed devices are either not functioning or stopped functioning due to unforeseen circumstances. These circumstances may vary based on the environmental conditions. Also, since the devices are battery-powered, they may get disconnected due to power issues or network connectivity. In such cases, either the devices are additionally deployed or re-deployed at the same location to serve the purpose of the dead device. Based on the requirements of the applications, there are different strategies of deployment, as discussed in the following section.

4.1 Types of Deployment Strategies

The disaster may occur at any place. The places where the disaster has occurred may have either regular or irregular terrain, line of sight (LoS), non-line of sight (NLoS), or obstructed line of sight (OLoS) conditions [32], the geographical region may be small or very large and require either less or huge number of devices to be deployed. Since it has already been discussed that the algorithms and strategies for deployment must be chosen by adhering to the respective cost constraints, there is a need to decide on the type of deployment strategies by considering the terrain parameters as discussed above.

In the literature, two basic types of deployment strategies are used, namely, *deterministic* and *random* deployments. These strategies are studied widely in the field of Wireless Sensor Networks (WSN) [33, 34]. The deterministic deployment is concerned with placing the devices in a well-organized manner in the terrain. Usually, it uses the concept of the geometrical distribution of the devices. The geometrical distribution may take the form of a square, circle, hexagon, ellipse, linear placement, etc. It gives better performance with a known area of coverage. The deterministic deployment has the advantage in terms of the fact that there is a certain level of control on the optimum number of devices used. However, when considering the real-time IoT environment with a huge number of devices and changing task dynamics for the cyber-physical systems, the deterministic scheme poses a certain level of limitations.

On the other hand, the random deployment scheme offers to solve the limitations of the deterministic deployment scheme by using two approaches: *random distribution* and *planned placement* [35]. The former approach employs algorithms based on mathematical computations to calculate the location of devices to be placed in the region of interest. Similarly, there are three categories of methods used for the planned placement approach. The first method, also known as the incremental approach, deploys the devices in different increments. This provides a well-planned strategy to deploy the optimum number of devices based on the requirement of the application. The second method uses the concept of airdropping. This approach must be carried out cautiously as the hardware is costly, and thus, some mechanism must be devised to handle such deployments by considering the cost. This method is also known as the virtual force-based approach. The random deployment strategy is better than the deterministic deployment strategy as it offers better coverage, even when the area of coverage is unknown. However, there are three major limitations associated with a random deployment scheme. First, it relies on multi-hop communication using relay nodes as the information must be carried to farther ends of the region. In such a case, if one of the relay nodes is dead, then the implementation algorithm gets affected severely. Second, a random deployment scheme produces coverage holes in the region, which results in the isolation of some devices in the region. Finally, randomness is a tangible concept, i.e., there is no concept of pure randomness in the universe. Thus, random algorithms utilized in the deployment use a certain level of determinism in its implementation. Moreover, the coverage holes may result in a greater number of signals getting exchanges among the devices, and thus, the random deployment scheme may suffer from inefficient utilization of energy and reduced lifetime of the network.

It is well known that the IoT environment assumes heterogeneity at various levels of operation. For example, the different areas may need different requirements of coverage, connectivity, and reliability based on the type of applications and services. In this regard, the authors in [25, 36] discuss a quasi-random deployment strategy that uses an amalgamated method of both the random and deterministic schemes. It uses the concept of the quasi-Monte Carlo method of numerical integration. It also uses the discrepancy theory to generate the locations of the devices to be deployed in the terrain. The discrepancy theory, in mathematics, can be described as the deviation of a situation from one state to another. It has fundamental roots in classical theory. It is the distribution of points in *s*-dimensional space using geometrically defined subsets to generate evenly spaced points in the space. The quasi-random deployment scheme is implemented using the low discrepancy sequences. There are four low discrepancy sequences as shown in Fig. 7, namely, Van der Corput, Halton, Faure, and Sobol [36]. The Van der Corput sequence works in

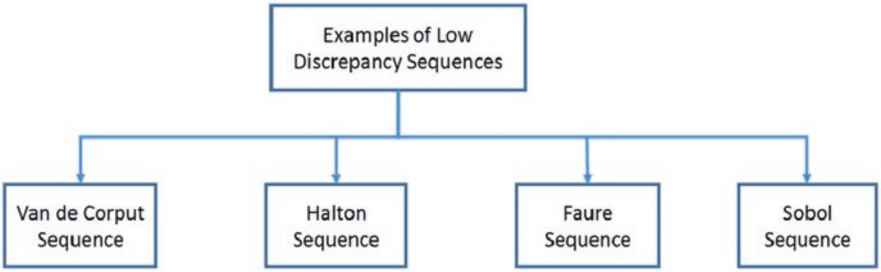

Fig. 7 Categories of low discrepancy sequences [25, 36]

one-dimensional terrain, Halton is best suited for two-dimensional terrain, and Faure and Sobol are algorithms meant to be implemented in multidimensional terrain.

4.2 Comparison of Deployment Strategies

In the IoT environment, there is a need to understand the advantages, limitations, and applications of all the deployment schemes to utilize them with respect to the different requirements. The authors in [25] compared the random, deterministic, and quasi-random deployment strategies. The grid-based deployment is considered as one of the deterministic schemes for comparison. The comparative evaluation is shown in Fig. 8. The comparison is performed by deploying 100 nodes on a 1000 × 1000 squared meters terrain. It is observed that the grid scheme provides better coverage in the terrain, as depicted in Fig. 8a. However, it is already discussed that the grid-based deployment does not have limited applications in a real-time environment where the area of coverage is unknown. As shown in Fig. 8b, random deployment has significant coverage holes in the region. However, this limitation of random deployment is eliminated with quasi-random deployment, as shown in Fig. 8c, wherein the distribution is more even compared to the random deployment.

It is well established that the quasi-random deployment provides better coverage. Also, it supports all three phases of deployment, i.e., pre-deployment, post-deployment, and re-deployment, which has limited scope in the case of random schemes of deployment. Once deployed, the next crucial task of the devices is to provide real-time service delivery. The service delivery in real time can only be achieved if the real-time locations of the devices are known. In this regard, there is a need to understand the fundamentals of localization and its applications in the IoT environment, which is discussed in the following section.

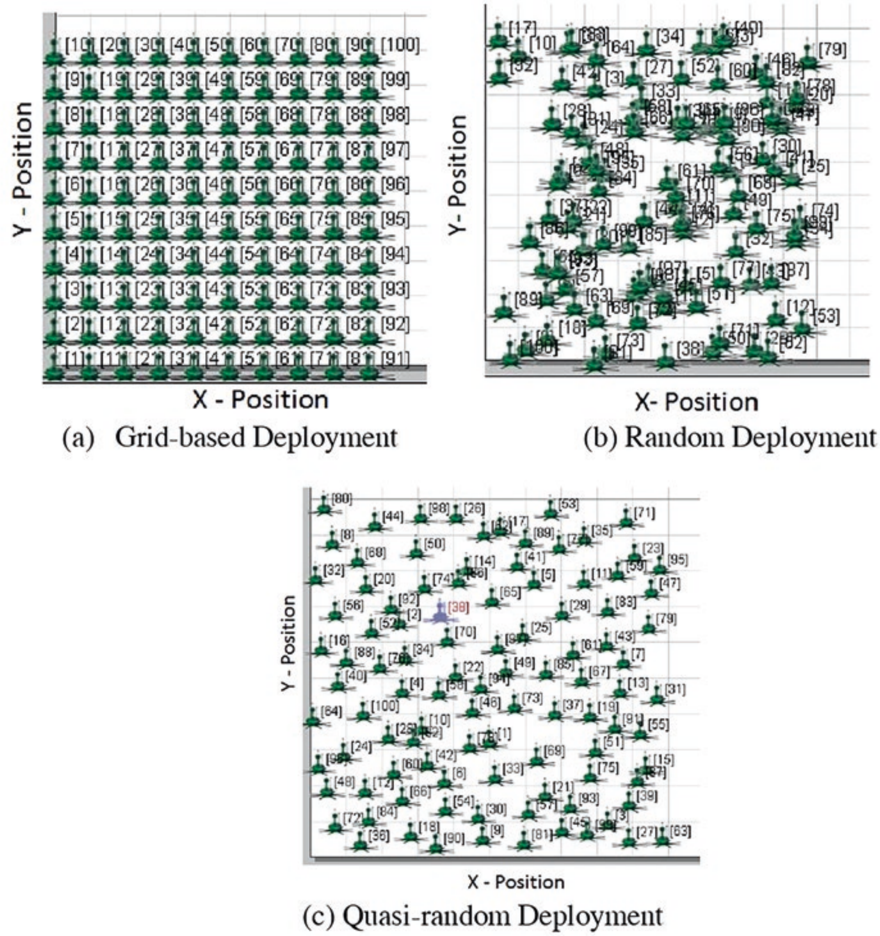

Fig. 8 Deployment of devices using grid-based, random, and quasi-random schemes [25]

5 Localization

The different relief operations to handle the disaster situations in real time require data and information about the situation in real time. The communication of these data and information may be periodic or sporadic based on the type of applications and their requisites. One of the crucial aspects of real-time service delivery is to know the location of the device from where the data need to be communicated. However, it is a challenging task due to several reasons. First, the installation of GPS is costly and, hence, cannot be implemented on all devices. Thus, one must devise a mechanism that can be used to find the location of the devices in the absence of GPS technology. Second, the deployed devices have heterogeneous characteristics, for which the mechanism must support a certain level of efficient mapping to find the location of the devices in real time. Finally, the capability of the deployed devices must be explored so as to map the signals transmitted and received among the devices. Thus, the challenges associated with the process of localization need to be formulated and understood for better development of the algorithm for the IoT environment.

The goal of localization is to estimate the position of the nodes placed in the region of interest. The localization algorithm is needed to satisfy the real-time delivery constraints for scalable applications that require data from a huge number of devices. The high accuracy positioning of devices depends on data processing in the spatial context. In this regard, the different underlying assumptions for localization are shown in Fig. 9. To devise an efficient localization algorithm, there is a need to develop an effective deployment scheme with a better area of coverage and connectivity in the region of interest. The processing architecture and network topology have significant contributions to the performance of the localization algorithm. This is due to the reason that the changes in topology are caused by either the sudden death of some of the nodes or heavy mobility in the network. Due to the mobile nodes in the network, the location of the devices changes frequently. The location estimation and communication of estimated location in real time need accuracy in signal processing, which further depends on the different parameters of the environment. Thus, the technologies used for building the cyber-physical systems must be efficient enough to work in such complex conditions of the environment to support the different applications and services in real time.

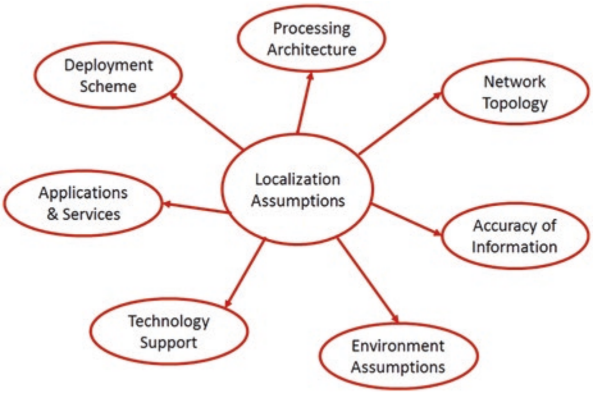

Fig. 9 Underlying assumptions for localization [31, 37]

5.1 Node Localization

In the case of disasters, the data and information about the situation of these disasters can be accessed if the location of devices deployed is known in real time. The localization problem can be categorized into proximity-based, range-based, and angle-based [25, 31], as depicted in Fig. 10. In proximity-based localization, the location is estimated using the signals received from the devices in the communication range of the device that is estimating the location. The range-based localization uses the distance information, and angle-based localization uses the angle at which the signals are received from multiple devices in the communication range. The localization algorithm is implemented in three phases: coordination phase, wherein the information in the form of signals is received from the other devices in the vicinity; measurement phase, in which the different forms of measurements are performed either in the form of distance or phase of the received signals; position estimation phase, in which the location is estimated using the information derived in the measurement phase [31].

Localization is a well-researched topic in the field of wireless sensor networks. The localization algorithms are categorized to be either *range measurement-based*, *infrastructure-based*, or *distributed/centralized* based on the mechanism of implementation used in the process [37]. The categories of localization algorithms are shown in Fig. 11. The range measurement technique includes algorithms based on either range-based or range-free mechanisms. The infrastructure-based technique uses either anchor-based or anchor-free localization methods. The distributed or centralized localization algorithm uses either former or latter way of network topology for the purpose of location estimation in the network.

When considering the IoT environment, the location information is crucial to perform different activities to satisfy the real-time service delivery constraints. A significant amount of research is done in the field of localization in the IoT environment. The localization algorithms in IoT can be categorized to address four critical issues: mobility of objects in groups, distribution of smart devices, environmental

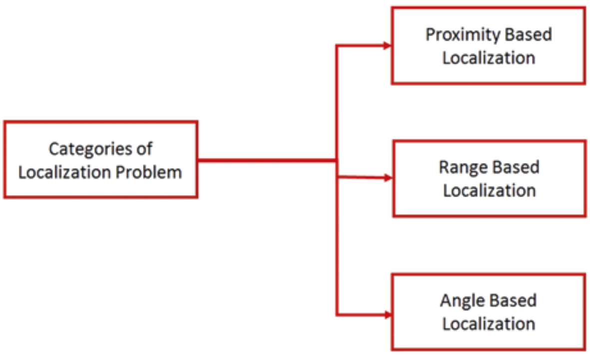

Fig. 10 Categories of localization problem [31]

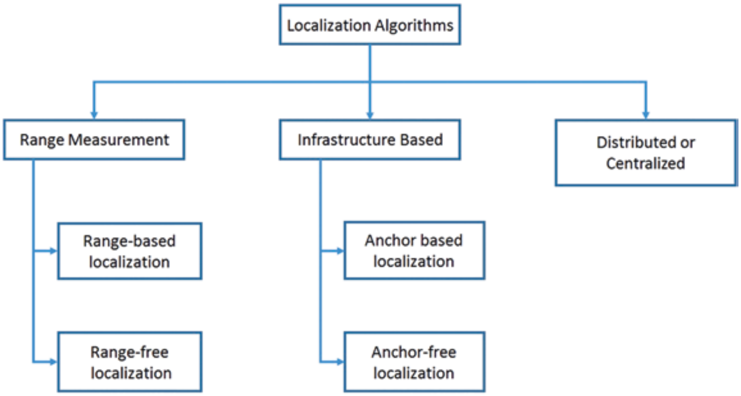

Fig. 11 Categories of localization algorithms [37]

conditions, and framework for the different services. Similarly, there are four crucial challenges associated with developing efficient localization algorithms for devices operating in the IoT environment: the amount of signaling overhead, localization accuracy, communication accuracy, and complexity in computing.

The authors in [25] discuss the localization of both the sensor and IoT devices operating in the IoT environment by implementing an across layer localization algorithm. It localizes the sensors using the known locations of IoT devices and vice versa. The authors emphasize that although the GPS is costly, it can be used for some of the IoT devices to localize them. In [38], the authors have discussed the use of Unmanned Aerial Vehicles (UAV) as IoT devices. The network is created in such a way that all the sensor devices are placed on the ground, and the UAVs serve as the IoT device. There are multiple UAVs that are communicating using IP protocol on the Internet. The sensor devices on the ground are clustered using the hierarchical clustering technique [39] to create clusters wherein one UAV is assigned as the cluster head. The sensors send the data sensed to the UAV, which further communicates the data to other UAVs in real time. The localization is performed in such a way that the location of one cluster is known to other clusters in the network and vice versa. Such a way of real-time data and information exchange based on the location information of the devices in the network is beneficial in handling post-disaster situations.

5.2 Event Localization

As and when the disaster occurs, the situation is identified on the basis of different types of events. An event may be defined in terms of any abnormality observed in the usual process. For instance, the fire may be considered as a disaster, wherein the situation can be identified on the basis of different events such as rise in temperature, pressure, and humidity in an abnormal way as compared to the normal conditions. Similarly, one can check the concentration of different gases to identify the occurrence of fire in the region. Also, the camera can be used to identify the fire situation in a building. Thus, by analyzing the different parameters as mentioned above, one can reach the conclusion that the fire has happened in a particular area in the city. Since the current scenario demands the autonomous operation to be carried out for post-disaster management, there is a need to localize such events in real time to provide effective response and relief supports as and when the disaster happens. The localization of events has prominent applications in industries where human lives are at stake during the shop floor activities and, thus, requires the real-time data of the abnormality, if any, to solve the issues as early as possible.

There are a lot of algorithms proposed in the literature to solve the event localization problem. The emphasis is given on understanding the intensity of events, deciding whether the events are occurring only once or multiple times, either at the same spatial location or different locations in the region of interest, and terrain limitations where the events are occurring. When considering the IoT environment, it is assumed that a huge number of devices sense the events in the region. Thus, there is a need to bridge the gap between IP-enabled devices and the short-range wireless devices deployed to serve the purpose. However, the major challenge is to address the LoS and NLoS situations in the terrain. In this context, the angle of arrival of signals can be explored for better location estimation of the events.

Since the deployed devices can send and receive signals in their vicinity, the Direction of Arrival (DoA) of signals from the events can be calculated to further find the location of these events. The algorithms of the DoA of signals calculate the angle of arrival and use the different parameters of the signals to calculate the location of the events [40]. The DoA estimation algorithms can be classified into two categories: non-parametric estimation and parametric high-resolution estimation [41]. The non-parametric estimation is categorized further into low- and high-resolution methods. Some of the famous low-resolution algorithms are periodogram, correlogram, and modified periodogram correlogram. Similarly, some of the high-resolution algorithms are the methods proposed by Capon and Borgiotti-Lagunas and methods based on maximum entropy. The parametric high-resolution estimation algorithms are classified as either AR/ARMA-based, model fitting-based, or subspace-based. The AR/ARMA algorithm uses the concept of maximum entropy to estimate the parameters of the signals. Similarly, some of the famous model fitting-based algorithms use the deterministic and stochastic machine learning and least square methods. On the other hand, MUSIC and min-norm methods are a few classic algorithms used for parameter estimation using the subspace-based methods. The classification of DoA estimation approaches is summarized in Fig. 12.

The IoT environment may have regular or irregular terrain, thus making it extremely difficult to map the signals getting exchanged among the devices operating in the region of interest. The authors in [32, 41, 42] discuss utilizing the DoA estimation technique for event localization using the quasi-random deployment of devices in the region of interest. The proposed algorithm utilizes a concentric circular array for mapping the signals from the devices in the terrain. The concentric

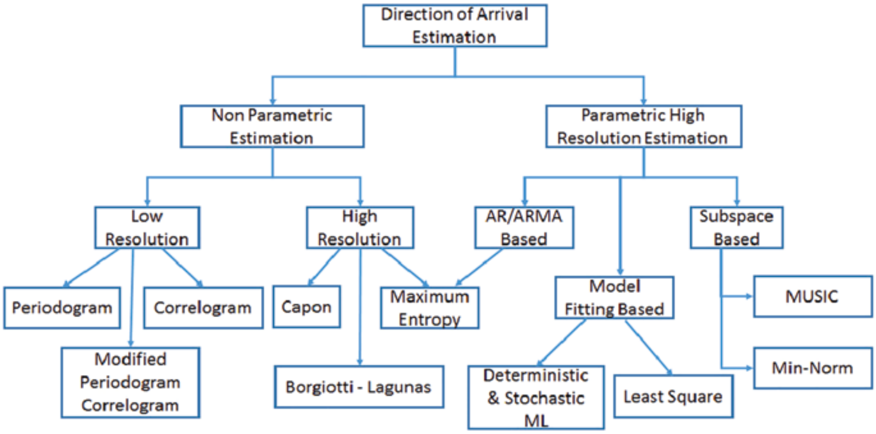

Fig. 12 Approaches for direction of arrival estimation [41]

circular array provides better coverage of the terrain as compared to the linear or uniform circular arrays. Thus, the signals are received with higher accuracy than that of the other two approaches. The event localization algorithm is further explored and implemented on a real testbed experimental setup using the cloud to acquire, store, and fetch the data in real time using the UAV-based communication in the IoT environment [43]. Such a type of communication environment is beneficial for real-life operations to be performed autonomously.

The localization is a very crucial activity to be initiated for the response and relief operations in case of the occurrence of disasters. For real-time service delivery in the IoT environment, where a massive number of devices operate in the terrain, the location estimation needs to be done for both the nodes and the events occurring in the region. This helps in processing the event information and understanding the places of origin of these events. It further helps in providing the services for disaster mitigation, as and when required.

6 Conclusion

The two crucial operations during disasters are response and recovery. Effective implementation of these operations requires the data and information to be accessed from the places of catastrophe in real time. One of the essential tasks during disaster situations is to save lives. Thus, employing human beings for relief operations is a dangerous initiative. The loss of human lives has been reported a lot during relief operations throughout the world. To save lives and create a robust infrastructure with which post-disaster management can be done efficiently is challenging. In this regard, the evolution of IoT has served a greater purpose by implementing a network where all the devices and things can get connected among themselves using the Internet. However, using an IoT environment to perform post-disaster management comes with a certain level of challenges. In this chapter, three critical challenges, namely, deployment, localization, and collaborative processing, to explore the benefits of IoT are discussed. For a successful post-disaster management operation, the relevant activities must be integrated on a platform for efficient management of resources and effective communication for real-time service delivery. This chapter focuses on the basic understanding of these topics with their significance and real-world applications.

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Revolution in IoT: Smart Wearable Technology

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1 Introduction to the Technology

What Is Technology?

The application of technology in scientific understanding to the practical purposes of human life or, as it is often said, the transformation and exploitation of the human world. The simplest form of technology is the development and use of basic tools. The prehistoric discovery of how to manipulate fire and the later Neolithic Revolution expanded the available food supplies, and the invention of the wheel allowed humans to move and manage their environment. Developments in historical times, including printing presses, telephones, and the Internet, have eliminated physical barriers to contact and made it possible for people to communicate openly on a global scale.

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1.1 Technology Related to IoT

The Internet of Things (IoT) has received extraordinary value in current years as it seeks to grant humans with innovative and smart technology and offerings in which all bodily objects around them are linked to the Internet and are capable to have interaction with each other. IoT products and services can be found from a range of sectors, including healthcare, hospitality, transport, infrastructure, education, and social services. Smart devices, frequently interconnected with cloud services, provide quick and international access and lead greater clients to take part in such technology. Figure 1 represents the logo of IoT [1].

The IoT system may be described as a set of interconnected smart units and objects that are supplied with special identifiers that are capable of interacting and transmitting records besides human or computing device intervention in order to reap the favored target. It covers a variety of technology, amenities, and standards. The IoT consists of individuals, objects, and information as primary agents. It is estimated that more than tens of billions of artifacts will be sections of this community by means of 2030. As shown in Fig. 2 we can apprehend the trust mannequin of IoT [2].

In order to monitor the room well and remotely, an IoT system, such as a shrewd home application, will use a couple of sensors and acquire information from very touchy and personal domains. This is, however, a digital contact where an energetic role is no longer performed by the individual. Security and, in specific, trust continues to be foremost challenges for clients and developers in this scenario.

History of Wearable Technology

Wearable technology can seem, at first glance, to be a latest improvement – we would possibly assume of the fictional spy devices of James Bond or the smart watches that are presently flooding the market. Despite this, wearable tech has been around for longer than we may assume and is helping shape the future of fashion.

Fig. 1 Model of Internet of Things

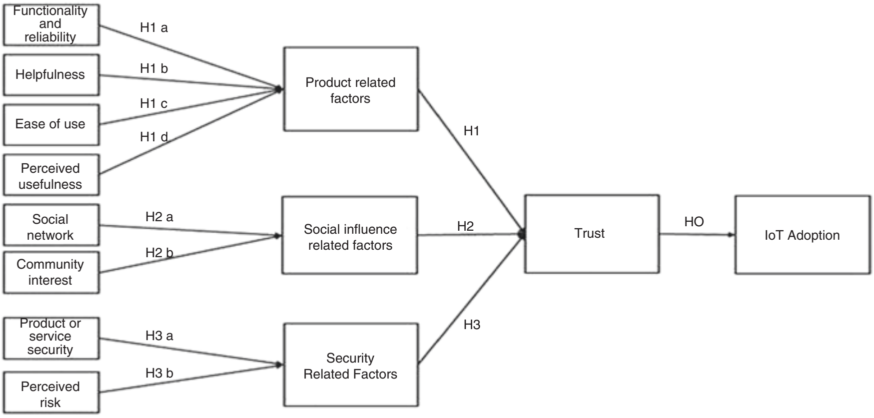

Fig. 2 IOT technology trust model

The pre-history of wearable devices begins with the watch, which was worn by individuals to tell time. The German inventor Peter Henlein produced tiny watches in 1500, which have been worn as collars. A century later, as the waistcoat grew to be a famous item, men commenced to put on their watches in their pockets, which led to the invention of pocket watches. In addition, wristwatches were produced in the late 1600s, however, had been generally worn as bracelets by women. The watch can get smaller and greater accurate with time. The use of the wristwatch used to be pioneered in 1904 by using the aviator Alberto Santos-Dumont as it allowed him to hold his hands unoccupied while piloting. This has demonstrated that the wrist is a cozy region to wear a watch and has prompted humans to start the use of wristwatches. People started out to boost wearable to be used for every event, from devices that assist them be successful in playing games, to finger rings used by retailers as a computer device, to digital hairbands used in theaters as a mask, and a wearable digital camera tied to a bird to take in-flight photos.

The wearable current technology is linked with both abundant computing and wearable arrangement's history and development. By incorporating it into day-by-day life, wearables make the technology ubiquitous. Developers have sought to raise or enlarge the affectivity of clothing via the records and enhancement of wearable computing or to produce wearable as accessories successful of granting surveillance of people, normally monitoring behavior through small wearable or compact non-public technology. The computed self-movement entails monitoring important points such as movement, moves, and coronary heart beat rate.

In both of these solutions to the imaginative and prescient of ubiquitous computing, the roots of contemporary wearable technology are impacted. The calculator watch, which used to be utilized in the 1980s, was one early piece of regularly adopted pre-modern wearable technology. The listening to useful resource was a portable system long before.

Let's see how wearable technology has evolved throughout the decades:

In the 1950s, wearable tech started in a very different way from today's recognizable devices, with Sony's first transistor radio making its debut in 1955. "The Sony TR-55 served as the template for portable devices we use today. Everything from the iPod to the Game Boy can trace its primary handheld plan to the TR-55's form factor."

A secret Bluetooth microphone used to be built-in into a pair of jewelry by Ilya Fridman in 2008.

In late 2010 Fitbit unveiled its first phase counter; Fitbit units have especially focused on health monitoring. Fitbit is now owned by Alphabet and is no longer an unbiased enterprise of wearable electronics.

Smart watches persisted to be delivered in the following years with the use of critical electronics groups as well as new startups. In September 2013, the Samsung Galaxy Gear used to be one of the first options. In April 2015, Apple followed with the Apple Watch more than a year later [3].

Oculus launched a kickstarter initiative in 2012 to begin sales of the first augmented reality headset for consumers. HTC launched a new age of VR headsets in 2016, permitting humans to stroll freely inside a virtual environment.

2 Technologies of IOT

The main technologies involved in IoT are categorized as follows:

- **Identification Technology**

This type of technology is used for position and observation purposes, as the name implies. Various representations of these technologies are given in Table 1. RFID, WSN, QR code, barcodes and intelligent sensors, etc. are examples. Linked RFID systems include a reader to collect the data and a transmitter to relay the data. Compared to similar solutions, RFID tags are pricey like WSN [4].

- **Communication Technology**

Table 1 Key technologies of IOT

Technologies of IOT	
Identification technologies	QR code RFID Barcode WSN
Communication technologies	Zigbee Li-Fi Z-Wave Wi-Fi MQTT NFC Bluetooth Powerline area network

Such data transfer can be followed. Zigbee, Z-Wave, MQTT, Bluetooth, Li-Fi, Wi-Fi, Near-Field Communication (NFC), HaLow, Powerline area network, and others are all examples.

- Zigbee: It is a short-range protocol used to create a small network, i.e., about 20 m. Generally, these are used in home automation.
- Z-Wave: It is a wireless protocol for a long range protocol, i.e., around 100 m. Every Z-Wave will have a fascinating ID called network ID, and there will be a node ID for each device in the Z-Wave network. In home automation, it is also put to use. It can interchange data at a high speed, unlike Wi-Fi.
- Bluetooth: Usually used in day-to-day applications, it is a short-range protocol. For example, we can retrieve the information on the paired device on our smartphone using Bluetooth.
- Li-Fi (light fidelity): This is also a wireless short-range protocol. Here, in the form of light, the transfer of data takes place.
- Wi-Fi: This is a medium-range network that is commonly used on a local area network. This has more versatility.
- Near-Field Communication (NFC): It is a protocol for very short-range networking, i.e., around 4 m. It provides point-to-point communication between devices. For instance, we can share the screen of our smartphone with a smart TV using NFC.
- HaLOW: Wi-Fi is close to this. The main difference is that this is a medium-range protocol and, relative to Wi-Fi, the data transmission rate is minimal.
- Powerline area network: It is a wired communication network with a long range. For data transmission, it utilizes power lines.

Voice User Interface (VUI) and Wearables

The design of VUI was once especially complicated in the past. The accumulation of difficulties is inherent in speech recognition, because of their transient and intangible nature, and VUIs are often rife with main contact obstacles.

In comparison to visual interfaces, they have gone after verbal commands and moves have been conveyed to the user. A visual performance in response to the vocal information, such as a smart watch as seen in Fig. 4 (e.g., Siri on an Apple Watch) [5], is one technique employed with modest results.

Even, the same difficulties and problems of the past are generated by developing the individual interface with these kinds of technologies. We can see the VUI smart speaker functionality here in Fig. 3.

A human consumer may also skip the natural comment loop of human-to-human interaction used to set up shared understanding while communicating with computers. They will try to give an order or inquire about something, hope that the machine will acknowledge what they say, and in return provide treasured information. Most modern voice AI is now not adequately advanced to draw on the conversation to achieve understanding and may even not be able to differentiate a new instruction from a previous explanation [6].

Moreover, speech as a means of human-computer interaction is still very inefficient. It would take too long, for instance, to deliver a menu of choices orally. Users

Fig. 3 Smart speaker VUI application

Fig. 4 Many smart watches, like the Apple Watch and the LG Sport, feature voice interface features

can't change the shape of the details visually, and they want to understand the direction to their target. Designers depend on Miller's Law when providing choices in a noticeable UI and normally have a maximum of seven options. The maximum decreases dramatically when a person is supposed to take note of an orally delivered list of picks (Fig. 4).

The challenges are real for VUI. However, a wise approach is to provide support for voice interplay to limit its usage to these areas where it is most useful, in any other case to increase it with interface frameworks that use the other senses. VUI will continue to evolve and is an excellent visually impaired mobility option. The two most positive approaches to incorporate a VUI into the ordinary user interface are to acknowledge verbal entry and impart visual remarks [7].

2.1 Applications of Iot Technology

This technology has a range of functions in a wide variety of fields. Then there are numerous viable locations where we can harness the strength of the Internet of Things (IoT) to clear up day-to-day problems. It could be put to a lot of uses, however.

- **Smart Society and Smart Home**
  Nowadays homes and offices have been using IoT technology. Various digital units and HVAC systems, such as lamps, microwave ovens, refrigerator heaters, and air conditioners, are blended with sensors and actuators for the appropriate use of energy; monitoring and regulating the amount of heating, cooling, and lighting; space lights; and human presence which switches on when you enter. Wireless smoke and carbon monoxide sensors, sound alarms when fire or smoke is detected at home, as well as phone or e-mail signals add greater relief to life, which in turn lowers charges and will increase energy conservation. The IoT can be used to remotely manage and customize your domestic appliances. It may also be beneficial to pick out and deter theft.

- **Smart City**
  IoT technology can be used on a wider scale to make cities more effective. The aim of smart cities is to use the IoT to enhance the lives of humans through enhancing traffic management, monitoring the availability of parking spaces, measuring air quality, and even supplying warnings when trash cans are filled.

- **Smart Traffic**
  Currently the traffic control is a large hassle in the metropolitan cities. Managing them manually has grown to be almost impossible. This trouble may also be conquered through enforcing IoT for traffic management. This smart traffic monitoring makes use of sensors to accumulate raw visitor's data, which offers traffic updates to the driver, which allows him to make the decision for touring better route. This moreover facilitates individuals to book a cab without phone call and be picked up and additionally suggests cabs close to and moreover their movement in true time.

- **Smart Parking**
  Sensors will be installed in parking areas to determine whether or not the parking area is available. Driver's park their vehicle searching via the utility that affords

details on the nearest reachable parking slots, the price of parking relying on the statistics collected and analyzed by way of smart sensors that assist them store time and power.

- **Smart Waste Management**
  A garbage bin with sensors capable of analyzing and alerting the authorities when it is complete and needs to be cleared.
- **Smart Street Light**
  Sensors which might also analyze the context like time, season, or climatic stipulations will be embedded among street lights which will routinely turn lights on or off and set the dimming range of person or crew of lights supporting the context.
- **Smart Water Supply**
  Smart cities have to alter the grant of water to make sure that residents and agencies have adequate access to water. Wireless sensor helps monitor their water pipe structures more successfully and detects water leakage and indicates water loss, which in turn additionally saves money and natural resources.
- **Smart Environment**
  Detection of emissions and natural disasters is a very huge application of IoT. In order to limit air pollution, we need to modify emissions from factories and vehicles. We can display the launch of poison chemical compounds and waste in rivers and the sea, thereby stopping water contamination. We can also maintain tabs on the quality of consuming water supplied. By detecting tremors, we can ship warnings about earthquakes and tsunamis. In order to be alert in the event of floods, we need to hold the water ranges of rivers and dams beneath surveillance.
- **Air Quality Monitoring**
  Sensors are integrated to seize contextual data such as carbon monoxide (CO) amount, airborne nitrogen dioxide (NO2), sound levels, temperature, ambient humidity levels, etc. This offers non-stop contextual awareness, which helps to take action as soon as it hits the ordinary level.
- **Smart Water Quality Monitoring**
  Sensors that can detect history, such as water quality, water movement, velocity, temperature, water pollution, and water content, are placed in or flowed into the water. This helps to assess and monitor the water sources available for use in real time.
- **Smart Sewage Water Management**
  Embedded sensors in the sewage reservoir assist to track the overflow of wastewater that flows into it, through continuous statistics on the quantity of wastewater that is contained. By means of these details, maintenance staff can prepare the water treatment technique to prevent overflow of sewage.

- **Natural Disaster Monitoring**
  Wireless monitoring sensors can be used to predict natural hazards, like earthquakes, landslides, forest fires, floods, etc. Such results enable the appropriate authorities to take measures before a tragedy happens [8].

- **Agriculture**
  Smart Farming: Sensors collect and analyze background information such as current temperature, soil moisture conditions, leaf moisture, and solar radiation, which in turn informs the owner of the water, chemicals, manure, or treatment needs for infected plants.

- **Healthcare and Health Tracking**
  In the healthcare sector, IoT is used to improve the quality of human existence by permitting humans to operate primary duties that have to be achieved by way of application. The sensors might also be hooked up on patient-used health monitoring devices. To improve the treatment and responsiveness, the statistics accrued from these sensors is made accessible on the Internet to doctors, household contributors, and other involved parties. In addition, IoT gadgets can be used to track modern medicines in an affected person and to examine the threat of new medicines in phrases of allergic reactions and negative reactions. Using the sensor and technology described above, we can manage the person's body temperature, heart rate, blood pressure, etc.

- **Pharmaceutical Products**
  The safety of the drug product is of utmost importance in the prevention of patient well-being. There are benefits attaching smart labels to medications and monitoring their status with sensors such as preserving storage conditions and expiry of medications that prevent patients from carrying expired drugs [1].

- **Food Sustainability**
  The packaged food we eat must go through various stages of the food cycle, such as production, harvesting, transport, and distribution. Sensors are used to detect contexts such as temperature, humidity, light, heat, etc., which accurately report variations and inform the persons concerned to prevent spoilage of food.

- **Supply Chains**
  The Internet of Things tracks each stage of the supply chain from packaging, production, distribution, storage, and product income to after-sales services, through the procurement of raw substances from manufacturers. This will assist to maintain the stock required for persisting sales, ensuring client pride and, in turn, elevated sales. Over the subsequent decade, IoT will generate $1.9 trillion in supply chain and logistics, according to Cisco's economic report. Using this, we can also diagnose if the devices need protection and repair. The Government of India has additionally determined to strengthen a hundred smart cities that will cover some of the above-stated IoT applications. In Fig. 5 we can examine the most popular IoT function rankings primarily based on net analytics [9].

2.2 Some Smart Wearables and Appliances

Smart wearables discovered in smart garb can be organized in accordance with a variety of criteria. There are various kinds of smart wearables as shown in Fig. 6. The IEC (International Electrotechnical Commission) TC (Technical Commission) 124, which strives to normalize the subject of wearable digital units and technologies, differentiates four special types of smart wearables [10].

- Wearable accessories: They are low-power devices that are tailored to the human body to be worn as add-ons such as smart watches, smart glasses, or health trackers.
- Textile/wearable fabric: They combine electronics with textiles for versatile fabrics. In 2011, the European Committee for Standardization categorized such wearables as practical fabric structures that interrelate with their surroundings (i.e., adapt or react to modifications in the environment).
- Wearable patches: They are skin patching units that are trendy and very thin.
- Wearable implantable: They are lightweight self-propelled wearables that are positioned into the human body besides any fitness issues.

Regulation concerned in the IOT smart clothing grant chain administration is shown in Fig. 7 Similarly, the IEC Standardization Group (SG) 10 on wearable smart units suggested that the previously listed kinds of wearables can be labeled in accordance to their position, close, on, or with a crew (e.g., the human body), distinguishing between:

- Wearable near body: They are supposed to be placed near the body, however, not directly in close proximity.
- Wearable on the body: They are set up on the body, in direct contact with the skin.
- Wearable in body: They're implanted inside the body.

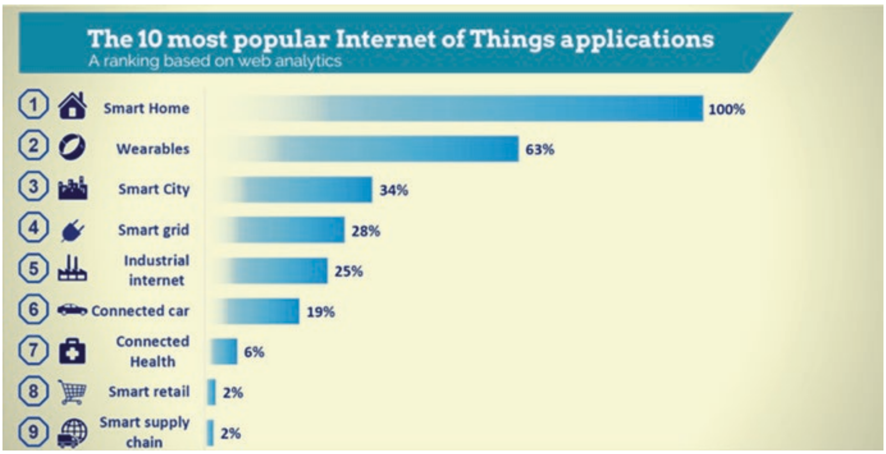

Fig. 5 Applications of Internet of Things

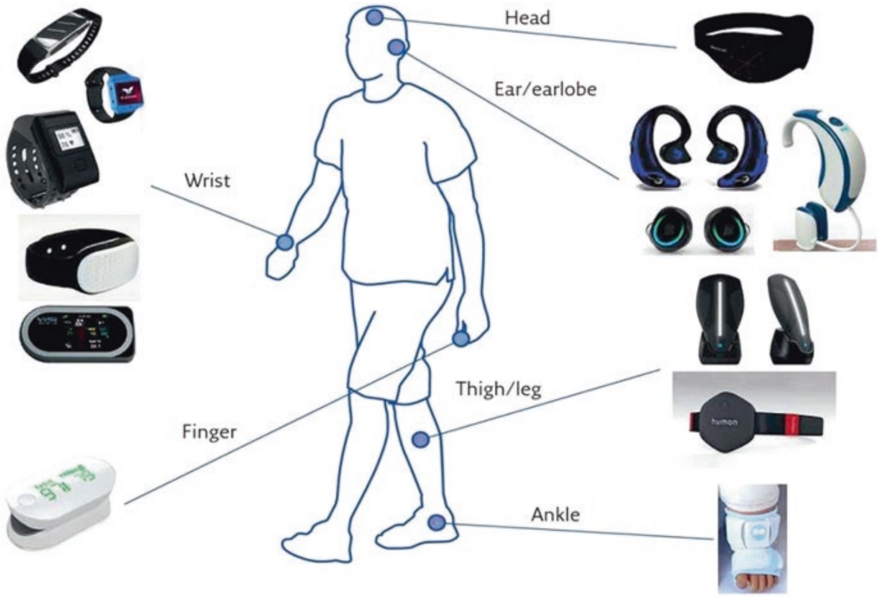

Fig. 6 Types of smart wearables

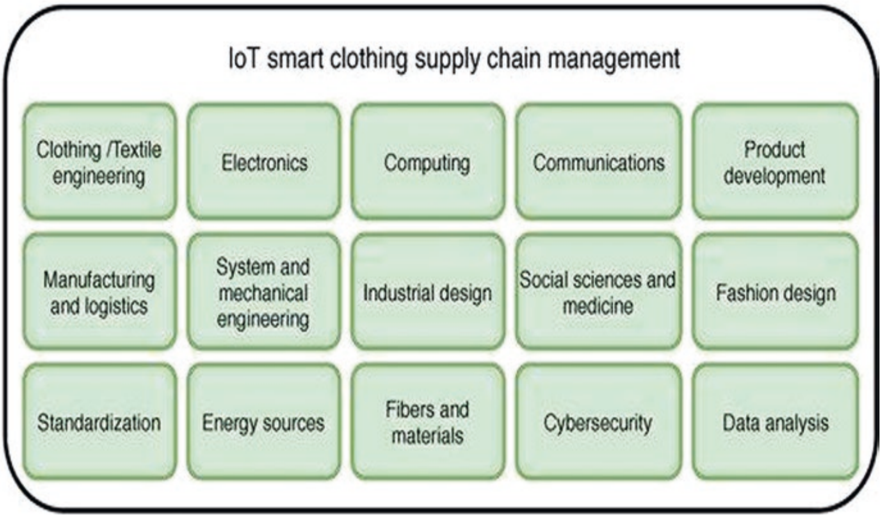

Fig. 7 IOT smart clothing supply chain management

- Electronic textiles: They use electronics and elements based totally on textiles [11].

Wearable Technology

Did you ever hear anyone point out that wearable technology wasn't quite sure what it meant, though? Simply placed, wearable technology is a typical concept for a collection of gadgets that are intended to be worn during the day, including fitness trackers and smart watches. In short, these items are sometimes referred to as wearables.

Wearable technology, wearables, fashion technology, smartwear, tech togs, skin electronics, and fashion electronics are smart electronic devices (electronic devices with microcontrollers) worn next to and/or on the skin surface where data such as body warnings, vital signs, and/or environmental data are sensed, processed, and transmitted, enabling instant bio data in some cases.

Wearable devices such as activity trackers are an example of the Internet of Things, since "things" such as hardware, apps, sensors, and networking are effectors that enable objects, with the manufacturer, user, and/or other associated devices, to alternate information (including data quality) over the Internet, with the exception of requiring human interaction.

Wearable technology has a number of features that are increasing as the market itself grows. The popularization of the smart watch and fitness tracker continues to be prevalent in consumer electronics [12]. In addition to commercial applications, wearable technology is used in navigation systems, specialized textiles, and healthcare. Figure 8 represents certain wearable technical technologies used in different styles.

Issues and Concerns of Wearable Technology

The FDA has created a low-threat device practice that recommends that private health wearables are common health devices if they only receive weight loss, physical exercise, rest or stress control, mental acuity, self-esteem, sleep management, or sexual function knowledge. This was due to the hazards of secrecy involving the machines. These devices will be able to tell whether a person is displaying any health issues and have a course of intervention when larger and more of the devices become used properly and elevated quickly enough. With the growth in these devices being fed, this instruction was drawn up by the FDA to minimize the danger to an infected user in the event that the app does not work properly. Due to the fact that they help monitor well-being and foster liberty, there is also an infringement of privacy that ensues to collect information, the ethics of it is claimed as right. This is due to the large volumes of data that must be transmitted, which should exacerbate difficulties for both the customer and the businesses if access to this information is accessed by a third party. There was a concern with the Google Glass that surgeons used to use to recognize vital signs of a patient where there were privacy concerns related to the use of non-consented information from third parties. When it comes to wearable devices, the question is approval as right and it allows the opportunity to report and it is a concern because permission is no longer required when an individual is being monitored.

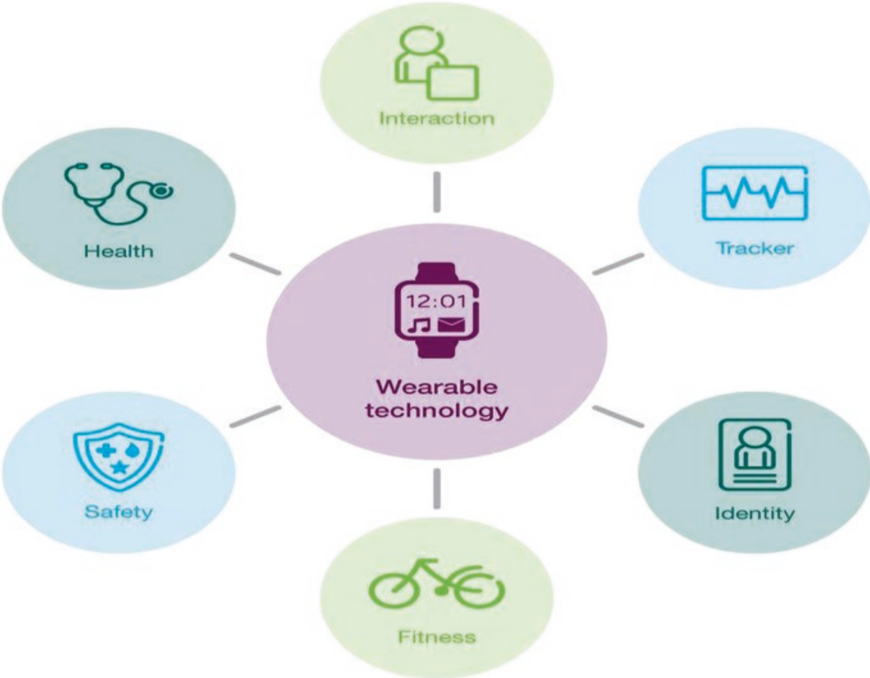

Fig. 8 Wearable technology

Wearable systems face numerous new reliability problems to smartphone designers and app developers as opposed to mobile phones. Restricted display space, limited processing capacity, limited volatile and non-volatile memory, unconventional system shape, proliferation of sensor information, diverse app conversation patterns, and constrained battery size can all lead to excellent software glitches and modes of failure. In addition, given that many of the wearable devices (either tracking or treatment) are used for health purposes, their accuracy and robustness issues can give rise to security concerns. In order to consider the reliability and safety properties of these wearable devices, some equipment has been produced. The early findings point to a weak wearable software spot where overloading of the devices can cause failures, such as an excessive UI operation [13].

3 Prototypes of Smart Wearables

Rosalind Picard and her students, Steve Mann and Jennifer Healey, created, developed, and demonstrated data collection and decision-making from "Smart Clothing," at the MIT Media Lab from 1991 to 1998, which tracked the wearer's ongoing physiological data. Smart clothing, "smart underwear," smart shoes, and smart jewelers collected and included details on the affective state.

In 2009 Sony Ericsson entered the London College of Fashion for a competition for digital textile design. The winner was a Bluetooth cocktail dress, which lights up when a call is made.

During a "Fashion Hacking" workshop at a New York City creative group, Zach "Hoeken" Smith of MakerBot fame made keyboard pants.

In Ireland, the Tyndall National Institute [17] has set up a "Remote Non-Intrusive Patient Monitoring" network to assess the quality of patient sensor information and how the technology can be used by end users.

More recently, CuteCircuit, a London-based design company, created costumes with LED lighting for singer Katy Perry so that the dresses would change color during stage shows and appearances on the red carpet, such as the dress Katy Perry wore at the 2010 MET Gala in NYC. As worn by singer Nicole Scherzinger in 2012, the CuteCircuit created the world's first dress to feature Tweets.

In 2014, Tisch School of Arts graduate students in New York designed a hoodie that sent pre-programmed text messages caused by gesture movements.

Designs began to appear for heads-up display (HUD) optical eyewear at about the same time.

Using a technique called holographic optics, the US military employs headgear with screens for soldiers.

In 2010, Google began designing prototypes of its Google Glass optical head-mounted display, which in March 2013 went into beta for customers [14].

3.1 Smart Wearables and HealthCare

To track the health of a person, wearable technology is also used. It can quickly capture data because such a computer is in direct contact with the user. It began as early as 1980, when the first wireless ECG was developed. It has seen rapid development in textile, tattoo, patch, and contact lens research over the past decades.

Wearables can also be used to gather the data on fitness of a person, which includes:

- Heartbeat
- No. of calories burned
- Steps walked
- Rate of blood pressure
- Dissipation of biochemical
- Exercising time
- Capture
- Physical shear [14]

These features, such as a fitness tracker or a smart watch like the Apple Watch Series 2 or Samsung Galaxy Gear Sport, are mostly packaged together in a single device. Apps such as these are used for athletic activity and basic physical well-being control, as well as notification of extreme medical problems such as seizures.

Other technologies are currently being studied within healthcare, such as:

- Predicting mood, fatigue, and health
- Calculating alcohol level in the blood
- Athletic efficiency measurement
- Monitoring if the consumer is sick
- Long-term surveillance, reported by electrocardiogram and self-moistening, of patients with cardiac and circulatory problems
- Applications for well-being risk management, including frailty steps and risks of age-dependent diseases

While wearables can capture data in aggregate form, the ability of most of them to analyze or draw closure based on this information is limited; thus, most of them are mostly used for health information. (Seizure-alerting wearables that continuously evaluate the wearer's data and make a decision to call for assistance are an exception; the data collected will also provide physicians with reliable information that they may find helpful in diagnosis.) Wearables can account for human variations, but mostly collect data and implement one-size-fits-all algorithms.

There is an increasing trend in the use of wearables today, not just for customer self-tracking but also within organizational health and well-being programs. Since wearables create a massive data trail that employers can repurpose for reasons other than exercise, more and more research has begun to explore the dark side of wearables. Asha Peta Thompson, which produces woven power banks and circuits that can be used in infantry e-uniforms, founded Intelligent Textiles Limited, Intelligent Textiles.

How Can Wearables Affect Our Lives?

Wearable hardware has gone from being non-existent to being everywhere in only a few short years. Wearables have the power to trade our lives and culture, for greater or worse, because of this unexpected surge in popularity. Since they are so recent, it is impossible to explain what outcomes they will bring, although we can guess on the basis of our existing knowledge about them.

Will They Help Improve Our Health?

Many wearables give the physical workout the chance to tune and store it at a later time for observation. This can be an outstanding asset, helping us to set short-term and long-term goals and monitor our progress toward them. Wearables can also serve as source of encouragement and motivation through receiving real-time updates of our actions, such as standing or exercise reminders.

On the other hand, there is no guarantee that, over time, people will continue to use wearables. At first, they are really new and exciting, but a survey has shown that about 30% of individuals have avoided using them because they have not considered them helpful or simply grew tired of them.

Furthermore, many wearables have embedded cardiac sensors that send you readings of real-time heart rate. Although there have been instances of this role helping to save lives, it must be remembered that they are not tools for healthcare and are no longer intended to diagnose or address any health problems. In addition, some have been shown to incorrectly measure heart rates, particularly during exercise.

Security of Information
Most wearables appear to have no safety precautions to keep their data secure. The fact that a lot of the information is unencrypted and that most of these machines relay information using Wi-Fi or Bluetooth links means cyber hackers can get their hands on it very quickly.

It's important to consider how this data turns into large information to be collected and used through organizations and governments. This means, whether you like it or not, that your tracked data could be used for advertising or fitness purposes. There are wonderful ways this information could be used; however, as with all huge information there is additionally a risk that it would be misused [15].

4 Advantages and Disadvantages of IoT

4.1 Advantages of IoT

The Internet of Things facilitates many benefits in daily life within the business sector.

The number of its edges is given below:

- **Communication**
  Since IoT has device-to-device compatibility where physical devices can stay attached, maximum transparency with less inefficiency and better quality is possible.
- **Automation and Control**
  Machines automate and monitor large amounts of information without human intervention, which leads to faster and more timely production.
- **Monitoring Saves Money and Time**
  Since IOT uses smart sensors to track various aspects of our everyday lives for different applications, it saves money and time.
- **Efficient Resource Utilization**
  If we understand the functionality and how each device operates, we will definitely increase the efficient use of resources and monitor natural resources.
- **Minimize Human Effort**
  As IoT devices communicate and connect with each other and do a lot of work for us, they reduce human effort.
- **Saves Time**
  Since it eliminates human effort, it certainly saves time. The primary factor that can be saved on the IoT platform is time.

- **Improve Security**
  Now, if we have a system that interconnects all of this stuff, then we can make the system more stable and effective.
- **Better Quality of Life**
  IoT-based technologies make our everyday lives more relaxed and better controlled, thereby enhancing the quality of life [16].

4.2 Disadvantages of IOT

As the Internet of Things enables a range of advantages, a number of challenges are also emerging. Some of the challenges facing IOT are set out below:

- **Compatibility**
  As IoT can interconnect products from various manufacturers, there is currently no international compatibility standard for labeling and monitoring equipment.
- **Complexity**
  The IoT is a dynamic and complex network. Any software or hardware failure or error will have significant repercussions. Also power failure can cause a lot of discomfort [17].
- **Privacy/Security**
  Many devices and innovations are involved in IOT and will be monitored by a variety of organizations. Since smart sensors relay a lot of context-related data, there is a high risk of losing private data.
- **Lesser Employment of Menial Staff**
  With the introduction of technology, everyday operations are simplified with less human interference using IoT, which in turn creates less human resource requirements. This is what causes the unemployment crisis in society [18].

4.3 Future Scope of IOT

The Internet of Things has risen as a global pioneer in science. In less time, it earned a great deal of praise. The advances in artificial intelligence and deep learning have also made it possible to automate IOT systems. Basically, to provide them with perfect automation, AI and ML implementations are blended with IOT systems. Because of this, IOT has also strengthened its utility area in a number of industries. Here, we will discuss the roles and potential reach of IoT in the sectors of healthcare, automotive, and agriculture in this segment.

New and advanced varieties of wearable science are being created by a number of industries, mainly in the healthcare zone where they are searching to take a step beyond health trackers and construct fitness care trackers. These may also be used to monitor things for diabetics, such as blood pressure, vital signs, or blood sugar levels. Also applied sciences such as smart hearing aids and eye output measuring glasses are becoming available to both clinical professionals and the ordinary public [19].

If the wearable gadget subject grows and matures, designers will have new opportunities to influence how the modern-day world communicates with individuals. When it blends with or enriches everyday human behavior, present-day science works better. This is true for any interface framework, not just wearables.

These gadgets are not designed to be dealt with in the same manner as a desktop or smartphone [20]. Manufacturers ought to understand how they are worn and how they can collect and convey knowledge to the wearer more discreetly and effectively. Some wearables also affect how other individuals respond to their responses.

In certain ways, the best wearable gadgets gracefully vanish into the background. Wearables shift technologies from the screen into real-world environments, providing creators with fresh and unique issues to consider as well as obstacles to address. Getting a chance to help shape the face of this technological revolution is thrilling.

Other accessories continue to evolve and gather momentum, such as pet trackers, smart jewelry, and AR/VR headsets. At the moment, there is a lot of scope for wearable devices. It would be interesting to see where things come from here and how they affect each of us individually and as a society [21].

5 Conclusion

Wearable technologies have evolved gradually in parallel with technological advancements like electronic chips, GPS systems, sensors, etc. The major applications of wearable technologies are in health industry, textile, and electronics industry. There are quite real wearable technologies. They are on the market and available for purchase and use in hospitals. However, now we have smart watches and smart glasses which have almost evolved throughout the world. The aim of the study is how these wearable devices became milestones for both ways of doing business for companies and for daily life of people. It may take some time for wearable technologies to become completely incorporated into healthcare; but for now, among the instruments we use to keep seniors safe, wearable technologies seem to be taking their place.

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Intelligent Automotive Sector with IoT (Internet of Things) and its Consequential Impact in Vehicular Ad Hoc Networks

Aradhana Behura

1 Introduction

Almost all important features of upcoming vehicle equipment contribute to the advancement of vehicular communications. The intelligent transportation system (ITS) plays a vital role in vehicular ad hoc networks. Recently, many people are using cars and other personal vehicles daily. Now, mortality rate increases due to accidents on the streets, which has become the major problem in recent years. For this, the costs as well as correlated risks have been identified as a vital problem that is being addressed by the modern community. Wireless communication between working vehicles is provided by VANETs (vehicular ad hoc network), which use a dedicated short-range communication (DSRC) (Fig. 1).

The DSRC technique was developed from the standard draft of IEEE 802.11P to improve driving safety and support for automotive drivers. Communication occurs when one vehicle directly communicates with another vehicle, i.e., vehicle to vehicle (V2V), or with a device mounted along a road, which is referred to as roadside unit (RSU), establishing infrastructure of vehicle-to-infrastructure (V2I) or vehicle-to-roadside communication (VRC). These kinds of communications permit vehicles to split distinct types of data like safety data for accident precaution, post-hazard inspection, or traffic jams (Fig. 2).

Traveller-associated data is reviewed as there is no safety information to supply well-being information to alert motorists regarding anticipated dangers to reduce the number of dangers as well as protect human lives or allow people to travel safely. Scientists are attracted to this field from multiple disciplines to expand VANET petitions/applications, simulation tools, and protocols. Developers and researchers are facing several challenges. Many articles and papers have attempted

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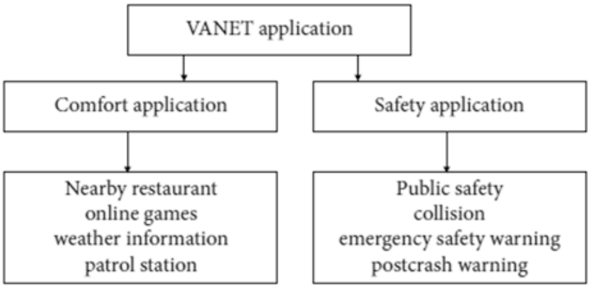

Fig. 1 Application of VANET

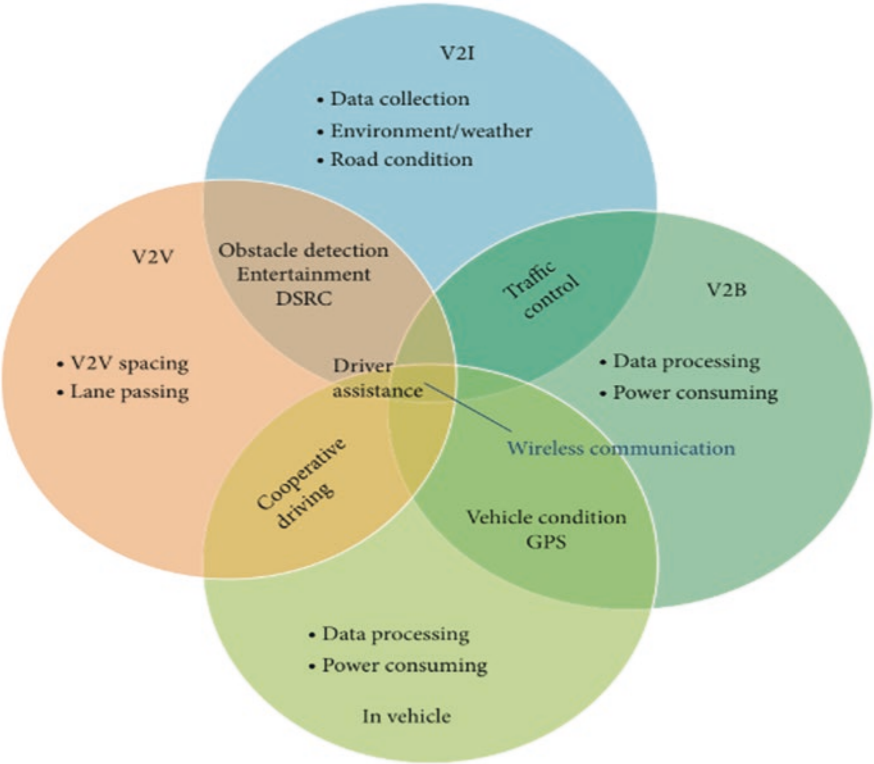

Fig. 2 Category of VANET system

to resolve these issues. Laberteaux and Hartenstein (2008) have looked over the networking and communication characteristics of the abovementioned technology and discussed privacy and security concerns. In that paper, we suggest a document key that can provide brief information to developers and researchers. To comprehend the major features and provocations linked to VANET, VANET encompasses a wide range of topics like applications, simulation tools, network construction, communication zones, and provocations. Figure 1 shows all-inclusive bandwidth, which is classified into seven channel frequencies. According to the figure, control CH is CH178, and it is utilized for the general well-being of the channel, which is applicable on petitions on that street. Another six channels are known as service channels (SCHs), which are used as non-safety facility applications to allow drivers to drive comfortably. WAVE, i.e., wireless access in vehicular environments, is designed with a frequency of 5.9GHz and an established family of IEEE 1609 and IEEE 802.11p. Standard 802.11 for VANETs that is reforming with current physical layer or MAC is researched by IEEE 802.11p, which operates on the physical layer category. On the physical layer, this includes an orthogonal frequency division with up to 27 Mb/s data rate, 10 MHz b/w, as well as a communication gap of 300–1000 m. The multichannel multi-access control conventional for VANETs is regarded by the standard draft of IEEE 1609.4. It describes the radio waves of wireless multichannel, which includes the interspersing action of SCHs and control CH, priority acquisition parameters, and another aspects of MAC and PHYs. Coordinated Universal Time (UTC) was developed by a globally accompanied channel coordinated scheme for efficiently acquiring coordinated channels. Figure 1 shows how the acquired time of the channel is divided into synchronization intervals mixed with 100 ms of affixed length containing SCH and CCH intervals. As per the coordinated strategy, every device has to observe CCH security as well as personal facility ads at CCH intervals. At SCH intervals, non-safety petitions are performed by SCHs where devices can shift information. The bounded length is impotent to supply enough bandwidth for control CH to carry a large number of control packets and safety packets. Adversely, if node substance is sporadic, periodic transmission will exhaust resource channel on control CH, as long as a few large bandwidth taking petitions, like map update and video download, cannot acquire abundant resource bandwidth at service CHs. Small latency with safety packets is necessary for multi-CH MAC protocol, which ensures genuine transmission and also supplies maximum throughput for non-safety applications in circulated mode. This paper proposes a variable CCH interval (VCI) multichannel access control system for increasing throughput saturation in VANETs of IEEE 1609.4. Some features of this method differ from existing methods, such as the fact that CCH interval is distributed into WAVE service announcement (WSA) interval and safety interval and that optimal CCH interval is distributed to the increasing throughput saturation of service CHs that certify safety data transmissions and personal advertising services on the control CH. The CoMP (coordinated multipoint transmission and reception) protocol is based on a cooperative strategy and ensures dynamic multipoint selection. This protocol not only helps to reduce interference but also provides better utilization on the network (Fig. 3).

This paper provides a brief overview of a recent study of MAC strategy in VANETs, with a focus on advancements in VCI multichannel MAC strategy. This protocol not only provides maximum throughput but also ensures safe transmission of data packets. The following important features of our research distinguish it from other existing protocol schemes:

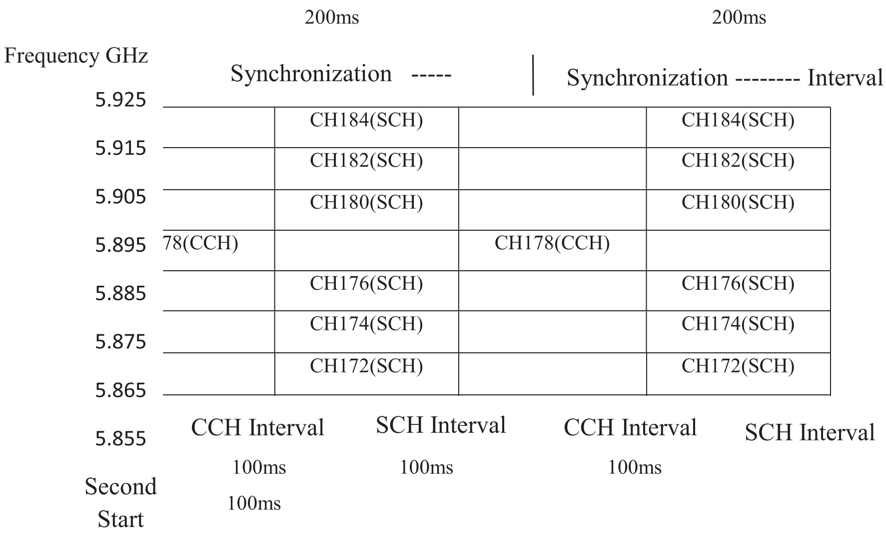

Fig. 3 Channel frequency design of a 5.9GHz instrument

- This paper focuses on a dynamic control channel interval-based multichannel system to enhance the quality of service parameters. It represents a conceptual inquiry on optimal VCI and ensures optimal control channel intervals.
- To deal with the dense traffic of the vehicular network as well as to reduce packet collision, we use the CoMP (coordinated multipoint transmission and reception) protocol, which is a multiuser service provider that reduces blocking probability and helps to ensure the quality of service and trunking efficiency.
- RSU (roadside unit) announced the control channel interval. The vehicular node selects a leader using an optimized donkey-smuggler and K-means clustering algorithm when no RSU is detected.

The research paper is organized as follows: Section II contains a literature review on vehicular ad hoc networks. Section III presents the multichannel MAC protocol. Section IV goes over the simulation results as well as the model validation scheme. Finally, Sect. V brings this paper to a close.

2 Related Works

The vehicular ad hoc network (VANET) provides information and entertainment to drivers to ensure safe and enjoyable driving. Wireless access in vehicular environments (WAVE) is a technology designed for VANET to provide services more efficiently. Since the control messages transmitted in WAVE are broadcast, the collision probability increases as the number of vehicle nodes increases. In this review paper, we propose a coordinated multichannel MAC protocol for VANET. The proposed

Table 1 DSRC standard

Features	Japan (ARIB)	Europe (CEN)	USA (ASTM)
Communication	Half-duplex (OBU)/ Full duplex (RSU)	Half-duplex	Half-duplex
Radio frequency	5.8 GHz band	5.8 GHz band	5.9 GHz band
Band	80 MHz bandwidth	20 MHz bandwidth	75 MHz bandwidth
Channels (Down-link/Up-link)	7/7	4/4	7/7
Channel separation	5 MHz	5 MHz	10 MHz
Data transmission rate	Down-link/Up-link 1 or 4 MBits/s	Down-link/500 Kbits/s Up-link/250 Kbits/s	Down-link/Up-link/3–27 Mbits/s
Coverage	30 m	15–20 m	1000 m (max)
Modulation	RSU: 2—ASK OBU: 4—PSK	RSU: 2—ASK OBU: 2—PSK	OFDM

ARIB Association of Radio Industries and Businesses
CEN European Committee for Standardization
ASTM American Society for Testing and Materials
OBU Onboard unit
RSU Road side unit
ASK Amplitude shift keying
PSK Phase shift keying
OFDM Orthogonal frequency division multiplexing

MAC protocol provides contention-free broadcasting of safety messages by coordinating roadside units (RSU) (Table 1 and Fig. 4).

An RSU schedules the broadcasting order of transmissions for safety messages. Contention-free broadcasting lowers the collision probability and reduces the required time for transmissions of safety messages. An RSU could harvest energy wirelessly and send it to coordinated VANET terminals, which act as gateways for Internet of things devices in the car. The contention interval for service channels is optimized to provide maximum throughput. The proposed MAC protocol is shown to enhance throughput and delay via analysis and simulation (Fig. 5).

Multihop ad hoc networks in terms of coordination strategy and channel assignment has been valuable to VANET [1]. Multichannel MAC protocols for wireless networks are divided into four groups based on channel coordination: general hopping, dedicated CCH, parallel protocols of rendezvous, and split phase. Almost all researchers of VANET choose split phase, which is easy to implement and consists of MAC protocol. In split-phase perspective, time is classified into fluctuating sequences of data exchange and control phases. The originators noted that the production of split phase is more diplomatic to variables like the time span of data and control phases. Here, the practicability of MAC protocols regarding VANET is discussed [7, 5]. Taking into consideration **the** contention formed by utilizing carrier-sense multiple access with collision avoidance, those originators terminated the IEEE 802.11 MAC protocols, which are not preferable regarding the actual duration of traffic jam as well as quality-of-service allocation. This model is proposed in

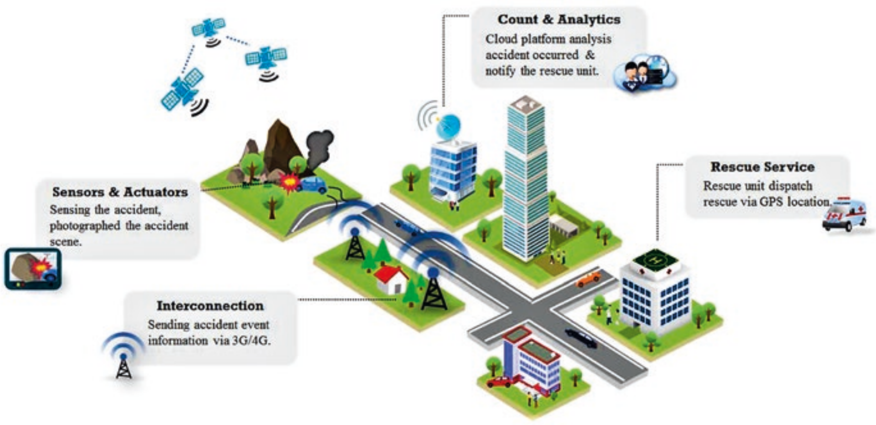

Fig. 4 Vehicular crash message transmission

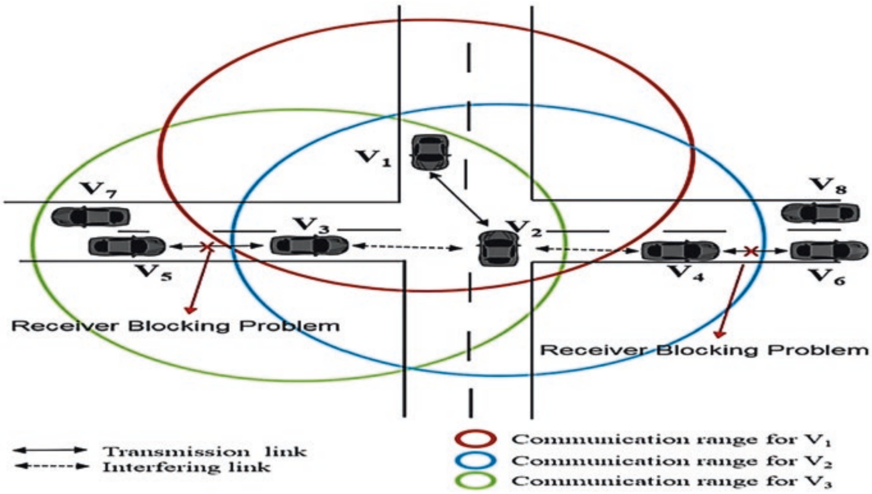

Fig. 5 Receiver blocking in vehicular network

which position the devices repeatedly shift to CCH and listen for packets that come from the closest. If no attention is paid to safety packet, those devices will revert to service CHs. Despite the fact that this method can increase SCH throughput, a few safety packets may be lost because the suggested replica cannot determine which devices are simultaneously holding on to the control CH. The authors suggested a vehicular MESH network (VMESH) MAC protocol with a scattered beaconing strategy and a skepticism formed through channel strategy to upgrade the usage of channel of service CHs. VMESH outperforms classic WAVE MAC strategies with regard to system throughput. Despite this, CCH is still only using a small portion of channel [6]. The task preferred a DSRC MAC protocol for supporting multichannel potency. The focus is on providing prospectively extreme bandwidth, whereas non-safety petitions are given by streetside configuration, in the absence of dealing with that safety transmission happening in another channel [9, 8, 10]. Their infrastructure aims to resolve the channel cooperation issue in the existence of a roadside unit (RSU). It approaches admirations as well as existing ad hoc strategies when there is lack of RSU. Even so, every device must be furnished as well as various protocols in both an ad hoc way and architectural manner in the network layers and MAC. As a result, the difficulty of device execution increases significantly. The investigation suggested a life-changing intermission substructure because of the WAVE system [2, 3, 4, 5]. This control channel interval is divided into three sections built in the form of various frames. This strategy can lower the communication interval of health-related information. Even so, these strategies are not fully utilized in the SCHs. The task in recent years has been to develop a dedicated multichannel MAC (DMMAC) protocol for VANETs. The DMMAC used a telecasting adaptive aspect to manage crash-unbound and crash-bounded communication delay for health-related traffic jams. By acquiring the length of change in CCH, this DMMAC can increase the transport ratio of well-being packets. Even so, no systematic replication was specified, and the vital conversion of no CCH interval was not reviewed.

3 Preliminary

3.1 VCI MAC Strategy

Following extensive industrial research and intellectual work on VANETs, the suggested MAC problems permit VANETs to perform excellently in several bounded schemas with careful utilization of channel. The paper suggests a multichannel MAC strategy for helping IEEE 1609.4 provide real-time well-being packets as well as indulge sensitive-throughput utilities within VANETs, along with utilizing a channel of multiple cooperation procedure as well as changeable intervening time about SCHs and CCH (Fig. 6).

IEEE 1609.4 inherits the duration of the synchronization of UTC process in MAC VCI. WAVE nodes transfer safety messages with WSA packets on CCH as well as execute calculation and figures for channel cooperation. The CCH interval is further subdivided into the *WSA interval* and the *safety interval*. Figure 3 shows a recently evolved CCH interval that begins with the *safety interval* and progresses through those WAVE nodes by transferring safety messages and telecasting the packets of VCI. Throughout the interval of WSA, supplier's service telecast packets of WSA and piggyback accompanied by a message of service as well as SCH specifications is utilized. The nodes that require that facility can optionally respond to WSA packets with an acknowledgment (ACK). Moreover, user services can dispatch a request-for-service (RFS) packet enterprise-wide to create uniformity accompanied by service suppliers. After the termination of CCH interval, the nodes

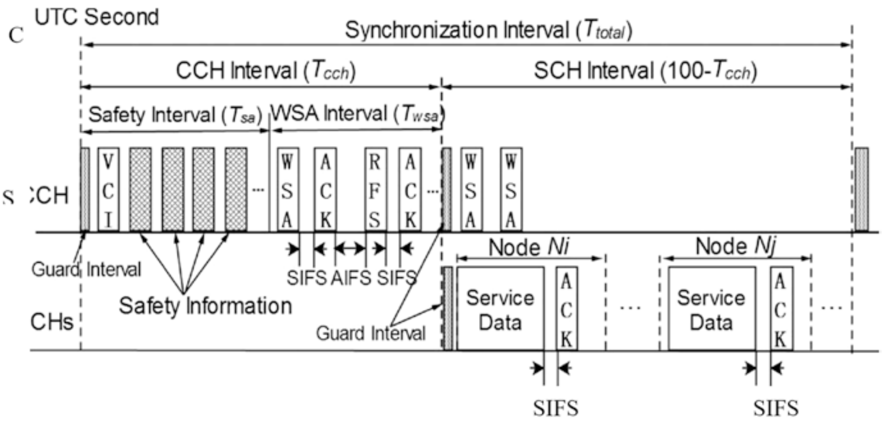

Fig. 6 MAC scheme of VCI multichannel

adjust to fixed SCHs to transfer service packets. Additionally, brief data regarding reservation channels and communication service data will be introduced in the next section.

3.1.1 VCI Scheme

Taking into consideration the cooperative accessed multichannel techniques defined in IEEE 1609.4, the ratio between the interval of service channel and the interval of CCH (control channel) is a stable variable (Fig. 7).

Even so, within the explosively variable traffic jam of vehicular situation, the confined intervals of SCH and CCH are incapable of supplying actual bandwidth for transmitting the two control/safety packets and application series. To resolve its issue, it suggests a VCI strategy that modifies the ratio between the interval of SCH and the interval of CCH based on the network state. Figure 6 shows that at the start of CCH interval, RSU telecasts the packet of VCI holding distance about interval of control CH to those nodes down its radio coverage range. Because of dependable dispatch, every VCI packet will be telecast at least twice. Due to the high volume of traffic, those packets of VCI can only be listened to by a few nodes. To address that problem, attach an area constituting the newest CCH interval message into WSA/RFS packets. Those nodes that acquired the newest interval of CCH about the recent cycle will pack that area while delivering RFS/WSA packets, whereas other nodes will pack that area accompanied by none. Moreover, more distance about the interval of CCH has to make certain successful transference of packets and also packets of WSA down this range coverage on RSU. By improving channel use on SCHs, this interval of CCH must be used best for attaining that perfect instance, which is the number of packets transferred on every SCH within the roadside unit dominions. The best used interval of CCH is computed from the number of roadside units required for gathering recent vehicle domain as well as the number of nodes within

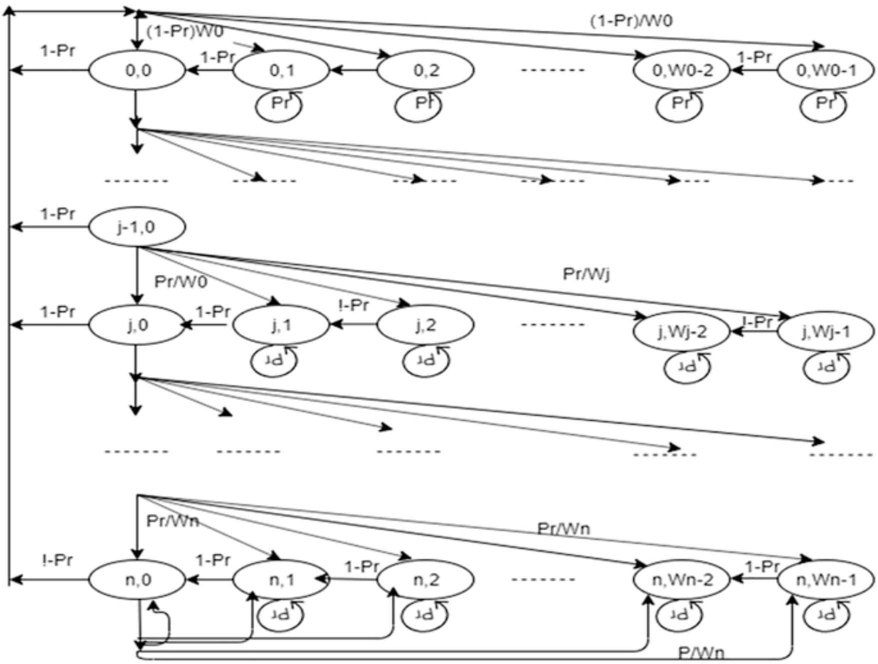

Fig. 7 Markov model analysis

the range of coverage. The analytical description of the interval of optimal coverage can be searched. Even so, the CCH intervals declared by multiple RSUs can be changed. Nodes that collect multiple values of the interval of control CH must embrace the highest interval of CCH to ensure communication about a well-being message. In another case, when a node wishes to communicate with another node within a RSU's neighbor that has multiple intervals of CCH, the dual of nodes must choose the higher interval of CCH. The process by which a node chooses its genuine interval of CCH is represented in Algorithm 1.

Furthermore, if no roadside unit (RSU) can be noticed, nodes within a single hop would select one head by performing VCI packet telecast by using K-means clustering. The shortest distance can be calculated by using the donkey-smuggler optimization algorithm. The shortest ID procedure is easy, but the virtual principal choice scheme is complex. On the other hand, single nodes which behave as supplier's service can telecast the VCI packet. While the packets of WSA telecasted by supplier's service through WSA interval hold the basic service set identifier (BSSID) message, the supplier's service accompanied by the lowest BSSID will transfer the VCI packet.

Additionally, when the roadside unit or the chosen node representing just as a RSU computes the actual CCH interval, it should decide how long the interval of safety should be. The interval of safety is related to the number of nodes as well as the recent vehicle domain. When the number of nodes increases, there is a greater

// *implemented by nodes by the starting of interval* of CCH

// *IC*curr: *interval of CCH of the recent-synchronizing cycle*

// *IC*prev: *interval of CCH of the earlier synchronizing cycle*

// *IC*wsa_rfs : *interval of CCH introduced in the frame/RFS/ WSA*

// *IC*vci_fr : *interval of CCH of introduced inside frame VCI*

// *Put standard interval* of CCH

if *IC*prev ` 0 then

*IC*curr = *IC*prev

else

*IC*curr = 100 ms

end if

// *Upgrade interval of CCH while getting frame VCI*

if get frame VCI then

if that initial timespan getting one frame VCI then

Upgrade the *IC*curr

else if *IC*curr < *IC*vci_fr then

*IC*curr = *IC*vci_fr

end if

end if

// *Upgrade interval of CCH while getting that* RFS/ WSA/ACK frame

if get a RFS/ WSA/ACK frame **then**

if even got one frame VCI then

Upgrade that *IC*curr

else if frame RFS/ WSA/ACK is taken away node will link to then

// *Inside distinct RSUs*

if *IC*curr < *IC*wsa_rfs then

*IC*curr = *IC*wsa_rfs

end if

end if

end if

Algorithm 1 Process of choosing the interval of CCH need for longer intervals of well-being, because when hazards happen or in arrival instances, the number of safety information that must be transferred also increases. According to paper, utilize the delivering frequency of safety information by indicating the number of times safety information is transferred because of hazards that have occurred as well as another arrival instances. The computation of the interval's safety is to be seen.

3.1.2 SCH Access Reservations

Unlike the actual contention-based IEEE 1609.4 MAC proposal, the MAC VCI strategy acquires the recent cooperation procedure to supply released contention SCHs along this channel scruple in CCH. Figure 6 gives a brief overview of channel scruple as well as information transmission service. At the start of the interval's WSA, the supplier's service telecasts WSA packets containing the specifications of the SCHs to be utilized as well as another message. Additional nodes that require the facility can take part in responding with an acknowledgment. The node that eminently delivers the response can build a concurrence accompanied by the supplier's service on message transference asset accompanied by certain Scheme ID and transference timing. Taking into consideration more suppliers' service may divide a SCH in a heavy node domain, every supplier's service can barely transfer a single service packet to affluent contention. Each node will reserve channels for SCHs in the committed traffic jam by observing the affluent reservations. Through the interval of WSA, nodes that serve as user service can gradually begin reservation. The user service sends an RFS packet accompanied by the ID of supplier's service as well as the kind of work. After that, the supplier's service will accept or deny the work appeal found in accordance with the conditions of the channel. As long as the service appeal is received, the acknowledgment packets from the service supplier will hold an ID about SCH, which will be used in the future of SCH. Supplier's service will choose a SCH, while they need the CCH for telecasting one packet of either response to petition of service. Based on the used SCH data, a supplier's service chooses a channel that adapts the slightest service message packets in the upcoming service CH interval. Whether or not various SCH are present, the supplier's service partially chooses the equal SCH utilized before service message communication. In the beginning of the interval of SCH, nodes that built preservations will shift to SCHs to do transference of service as stated by the preservation documentations in the repetitive traffic jam in a well-managed manner. The nodes that have not produced any preservation may be found in the CCH. From those nodes, the supplier's services can telecast WSA packets, and users' service can note the message carried in those packets of WSA so that users' service can connect the WAVE basic service set (WBSS) or moderately deliver RFS within the upcoming interval of WSA.

4 Model Analysis

Within the MAC VCI strategy, the ideal range of the CCH interval must be most salient by productive alliance about resource channel in SCHs as well as CCHs, especially in heavy traffic jams. To describe this ideal interval, first use a Markov chain replica to survey the performance of a single node and acquire the probability of the node transferring a RFS or WSA packet in every duration. After that, a submission replica is suggested to examine the mean time absorbed on CCH because of arbitrations of service packet transference. At last, it describes the optimized ratio between the SCH interval and the CCH interval.

4.1 RFS or WSA Probability of Transmission

A Markov chain model is suggested for determining the probability of stationary Φ in which one node transfers a RFS or WSA packet in random time duration. To take into account when a WBSS has N WAVE nodes, everyone can commune with them in only one hop. This assumes that a constant number of nodes providing service are always in a saturated traffic state, which means that all nodes are available of RFS or WSA packets behind a proper preservation throughout the *WSA interval*. Furthermore, the two SCHs and CCHs have the same rate of transmission. Assume $S(t)$ and $B(t)$ are processed stochastic functions that present the window backoff state and backoff size for a specified node with period time t, respectively. Assume M is the highest backoff stage, and Wj is the highest contention window (CW) of the jth stage backoff, where $Wj = 2^j W_0$ and $j \epsilon (0,M)$. The procedure of one node testing to deliver RFS or WSA packets simultaneously for the duration time onside state $S(t)$ is assumed to be self-made. Let Pr be the collision probability of various node transfers in a single span. Fig. 4 shows how the procedure of bidimensional $\{S(t), B(t)\}$ can be replicated while being accompanied by a distinct time Markov chain. The proposed Markov chain model differs from the other features.

At first, while a node finds a steady channel, the backoff counterclock in model will be "preserved" until the channel is noticed to be perfect once more. Second, during the phase of backoff, if one node surpasses the maximum value M, that node contains M till RFS or WSA packet is retransferred properly, or which is readjusted to 0.

Assume $B_{j,k} = \lim t \to \infty\{S(t) = j, B(t) = K\}$, $0 \le j \le M$, $0 \le K \le Wj - 1$ is the stationary distribution of Markov chain model, and we will obtain Theorem 1.

Theorem 1 The probability of a stationary Φ delivering a RFS or WSA packet in every time interval is $\Phi = B_{0,0}/(1 - P)$, and the probability of collision is

$$P = 1 - \left(1 - \Phi\right)^{N-1}.$$

Proof – In a replica of the Markov chain model, Fig. 4 shows only the null single-step probabilities of transition as follows:

$$\begin{aligned}
&\Pr\{0,l,K,l,j,l,0\} = (1-P)/W_0, 0 \le K \le W_{0-1}, 0 \le j \le M \\
&\Pr\{j,l,K,l,j-1,l,0\} = P/W_i, 0 \le K \le W_{j-1}, 1 \le j \le M \\
&\Pr\{j,l,k,l,j,l,K+1\} = 1-P, 0 \le K \le W_{j-2}, 0 \le j \le M \\
&\Pr\{j,l,K,l,i,l,K\} = P, 0 \le K \le W_{j-1}, 0 \le j \le M \\
&\Pr\{M,l,K,l,M,l,0\} = P/W_M, 0 \le k \le W_{M-1}.
\end{aligned} \tag{1}$$

Equation 1 constitutes five facts:

(i) After a proper transference of RFS and WSA packet, the stage of backoff caused by a current packet is set to 0.
(ii) A failed transference produces an extended backoff stage.
(iii) While the channel is clear, then the timer of backoff reduces.
(iv) While the channel is engaged, the timer of backoff lasts.
(v) At maximum backoff stage *M*, the contention window contains a timer for backoff that will be adjusted if the transference fails.

In contrast to the Markov chain model, it is straightforward that:

$$B_{j-1,0} \cdot P = B_{j,0} \to B_{i,0} = P^j \cdot B_{0,0,} 1 \le j \le M-1 \tag{2}$$

$$BM,0 = (BM-1,0 + BM,0) \cdot P \to Bm,0 = \frac{P}{1-P} Bm-1,0. \tag{3}$$

whereas the Markov chain model is uniform, taking into consideration the fact that: $\sum_{i=0}^{M} B_{i,0} = B_{0,0} / (1\text{-}P)$, then

$$Bj,K = \frac{Wj-K}{Wj} \frac{1}{1-P} Bj,0, 0 \le j \le M, 1 \le K \le Wj-1. \tag{4}$$

Consequently, by utilizing the normalization state for distribution of stationary, then:

$$1 = \sum_{j=0}^{M} \sum_{K=0}^{Wj} Bi,K = \sum_{j=0}^{M-1} B0,0 \cdot Pj + \sum_{j=0}^{M} \sum_{K=1}^{Wj-K} \frac{Wj-k}{Wj} \frac{1}{1-P} Bj,0 \tag{5}$$

Utilizing Eqs. (2), (3), and (5), I get:

$$B_{0,0} = \frac{2(1-P)^2 (1-2P)}{(1-P)^2 + W_0 \left[1-P-P(2P)^m\right]} \tag{6}$$

After that, the probability Φ of transferring one node and RFS or WSA packet in a random slotted time is prescribed as:

$$\Phi = \sum_{j=0}^{M} Bj,0 = \sum_{j=0}^{M-1} B0,0 \cdot \mathrm{Pj} + \frac{\mathrm{Pm}}{1-P}\mathrm{B0,0} = \frac{1}{1-P}\mathrm{B0,0} \tag{7}$$

whereas $B_{0,0}$ is given in (6).

Assuming that P is the probability of a collision while more than one node transfers in the same slotted time, then $P = 1 - (1-\Phi)^{N-1}$. (8).

Therefore, following Eqs. (6)–(8), values Φ and P are to be calculated using numeric methods in [16]. Consider 0 < P < 1 and that 0 < Φ < 1 (Fig. 8).

4.2 Analysis of Time for RFS or WSA Transference

Figure 5 shows one replica, called contention, that is suggested in the paper to examine the mean exclusive reservation time on CCH. Assume *X* is the time interval between the accessed CCH contention and the time when a proper reservation is formed. Let *N* nodes supply service every time WSA packets are presented. Furthermore, the below notations are utilized in the transference time evaluation:

(i) Each slotted time throughout the WSA interval, a concurrence will be properly produced accompanied by probability *p*suc, a collision channel occurs as well as probability *p*col, either the channel is supreme along probability *p*idle; and after that:

$$\mathrm{Pr}_{\mathrm{idle}} = (1-\Phi)^{\mathrm{N}}$$

$$\mathrm{Pr}_{\mathrm{busy}} = 1 - \mathrm{Pr}_{\mathrm{idle}} = 1-(1-\Phi)^{\mathrm{N}}$$

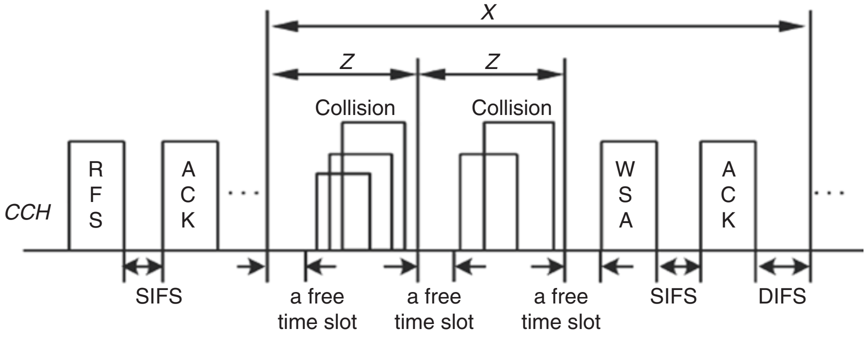

Fig. 8 Model of contention of forming reservations on CCH

$$\Pr_{suc} = N\Phi(1-\Phi)^{N-1}$$

$$\Pr_{col} = P_{busy} - P_{suc} = 1-(1-\Phi)^{N} - N\Phi(1-\Phi)^{N-1} \tag{9}$$

(ii) Assume t_{wsa}, t_{rfs}, and t_{ack} represent the time spent transferring a WSA, RFS, and ACK packet, respectively, and that $t_{wsa} = t_{rfs}$. Let t_{sifs} and t_{difs} be the SIFS time and the DIFS time, accordingly.

(iii) Assume t_{idle}, t_{col}, and t_{suc}, respectively, represent the time span of untied slotted time, the time span for collision transference, and the time span for proper reservation, accordingly. After that:

$$t_{idle=}\ \beta\text{timeslot}$$

$$t_{col=}\ t_{difs} + t_{wsa} \tag{10}$$

$$t_{suc=}\ t_{wsa+}\ t_{difs} + t_{sifs} + t_{ack}$$

Theorem 2 In the case of traffic saturation, the average of interval time x is specified by:

$$E[x] = t_{idle} / P_{suc} + Pcol \cdot t_{col} / P_{suc} + t_{suc}.$$

Proof: Assume interval z is in the middle of two continuous unbound slotted times prior to properly forming a reservation. For the procedure of backoff, either the continuous probability of packet collisions as a choice of continuous proper reservations is very small, which is taken into account. So, z can be demonstrated as follows:

$$z = t_{idle} + x$$

whereas the arbitrary value y is demonstrated as:

$$y = \begin{cases} 0, Pidle / (Pidle + Pcol) \\ tcol, Pcol / (Pidle + Pcol) \end{cases} \tag{12}$$

By following Eqs. (12) and (11), the average variable of z is noted as:

$$E[z] = \text{tidle} + \frac{Pcol}{P\text{idle} + P\text{col}} t\text{col}. \tag{13}$$

Moreover, the probability that K unbound slotted time manages throughout interval x based on common allocation is:

$$\Pr\{K = k\} = (1 - P_{suc})K - 1 \cdot P_{suc}, K = 1, 2, 3, \ldots. \tag{14}$$

Here is the proper scruple to the next K unbound slotted time. According to Fig. 5 and also utilizing Eqs. (14) and (13), the average variable derived from x can be shown as:

$$E[x] = (1/P_{\text{suc}})E[z] + t_{\text{idle}} + t_{\text{suc}} = t_{\text{idle}}/P_{\text{suc}} + P_{\text{col}} \cdot t_{\text{col}}/P_{\text{suc}} + t_{\text{suc}}. \quad (15)$$

4.3 Interval of CCH Optimization

To examine the optimal interval of CCH, the below inscriptions are described.

1. Assume N_{sch} denotes the number of SCHs presented in the VANET.
2. Assume t_{cch}, t_{sch}, t_{wsa}, and t_{sa} represent the intervals of SCH, WSA, and safety, respectively.

The interval of synchronization, which is the total SCH and CCH time, is denoted as $\mathbf{t_{total}}$; after that:

$$\begin{cases} \mathbf{tcch = twsa + tsa} \\ \mathbf{ttotal = twsa + tsa + tsch} \end{cases} \quad (16)$$

3. Assume α is the ratio between t_{wsa} and t_{sch}; then:

$$\begin{gathered} t_{\text{wsa}} = \alpha\, t_{\text{sch}} \\ \text{tsch} = (t_{\text{total}} - t_{\text{sa}})/(\alpha + 1). \end{gathered} \quad (17)$$

4. Assume $g1$ represents the number of scruples built onside CCH throughout the WSA interval, and $g2$ represents the number of service packets transferred at every n_{sch} SCH throughout the SCH interval.

Throughout the interval of CCH, more time should be allocated to well-being packet transference, that is:

$$\text{tsa} = \frac{\beta \cdot F \cdot N}{bcch} \times 103 \quad (18)$$

where n is the sum of nodes delivering safety packets, Bcch is the information rate about CCH, β is the predetermined element following for recent vehicle domain, and F is the frequency of delivering well-being information.

Whether the distance of the service packet is infinite, the time span for transferring a service packet onside SCH is shown as:

$$t_{\text{data}} = t_{\text{h}} + t_{\text{e}} + t_{\text{sifs}} + t_{\text{ack}} + t_{\text{difs}} \quad (19)$$

whereas *Th* is the value of MAC as well as PHY header that has been initialized with information service packet, $Te = v/B\text{sch}$, and *v* is the overload of service packet.

The ratio between the SCH interval and CCH interval is optimal when the number of reservations built onside CCH is the same as the number of service packet transferred onside every SCH, which is $g1 = g2$, and there is not much idle slotted time in the interval of *WSA* by making many scruples or interval of SCH by transferring additional service packets. Consequently, by following Eqs. (15), (17), and (19):

$$\alpha = \frac{\text{twsa}}{\text{tsch}} = \frac{E[x]\cdot g1]}{E[\text{tdata}]\cdot g2/\text{nsch}} = \frac{E[x]\cdot \text{nsch}}{E[\text{tdata}]} = \frac{\left(\frac{\text{tidle}}{\text{Psuc}} + \text{tcol}\cdot\frac{\text{Pco}}{\text{Psuc}} + \text{tsuc}\right)\cdot \text{nsch}}{\text{th} + \text{te} + \text{tsifs} + \text{tack} + \text{tdifs}} \tag{20}$$

By utilizing Eqs. (16) and (20), t_{wsa} and t_{sch} can be demonstrated as:

$$\text{twsa} = \frac{\left(\frac{1}{psuc}tidle + \frac{pcol}{psuc} + tsuc\cdot \text{nsch}\cdot(\text{ttotal} - \text{tsa}\right)}{\left(\frac{1}{psuc}tidle + \frac{pcol}{psuc}tcol + tsuc\right)\cdot \text{Nsch} + \text{tdata}} \tag{21}$$

At last, by following Eqs. (16), (18), and (21), the optimal CCH interval can be simply computed.

Furthermore, since $\mathbf{t_{wsa}}$ was obtained by using Eq. (21), we have:

$$g1 = \boldsymbol{t}_{\mathbf{wsa}} / E[x] \tag{22}$$

$$E\left[_{\mathbf{tcch\_delay}}\right] = \frac{1}{2}(g1+1)\cdot E[x] \tag{23}$$

$$E[\mathbf{tsch\_delay}] = \frac{[\frac{1}{2}\left[\frac{g1}{\text{nsch}}\right]\cdot \text{nsch} + (g1 \bmod \text{nsch})\cdot\left[\left[\frac{g1}{\text{nsch}}+1\right].E[\text{tdata}]\right]}{g1} \tag{24}$$

Assume $\boldsymbol{t}_{\mathbf{delay}}$ is the total delay for transferring a service packet, which includes the delay throughout the interval of CCH $\boldsymbol{t}_{\mathbf{cch\_delay}}$ as well as the interval of SCH $\boldsymbol{t}_{\mathbf{sch\_delay}}$.

Both portions may be derived by Eqs. (23) and (24), which are given further down the page. Thus, the mean transference interval of one service packet can be simply acquired.

Furthermore, as nodes do not want to participate in the transference of service packets provided by SCHs, the throughput saturation is demonstrated as:

$$\mathrm{ssch} = \frac{\mathrm{tsch}}{\mathrm{E}\left[\mathrm{tdata}\right]} \cdot \mathbf{nsch} \cdot \mathrm{v} \tag{25}$$

5 Quality of Service Evaluation (Figs. 9a, 9b, 10, 11, 12 and 14)

Figure 11 shows the transmission probability of safety messages in terms of the duration of safety interval. It can be observed that, with higher safety interval, the transmission of safety message is ensured. Figure 9 (a) shows the optimum CCH intervals and the corresponding WSA intervals in terms of the service packet length. Figure 9(b) shows the optimum intervals in terms of the number of nodes. The average service packet delay in terms of packet length is shown in Fig. 13. Throughput of the system decreases by increasing the number of nodes. The collision probability increases as the number of nodes increases as shown in Fig. 10. Figure 12 depicts that the delay increases as the number of node increases. The trust system among V2V-V2X-V2P-V2I is shown in Fig. 14. Further the picture depicts how to protect modification of information from intruder at the timing of sending the message. If a node detects that the channel is busy, the counter of the back off timer in the model will be frozen until the channel is detected to be idle as reflected in Fig. 8.

6 Conclusion and Future Work

There is a brief idea about VANET in the introduction for traffic conditions. To refine the implementation of IEEE 802.11p and 1609.4 following the WAVE system, multichannel MAC VCI scheme is introduced in this chapter [22]. A scientific

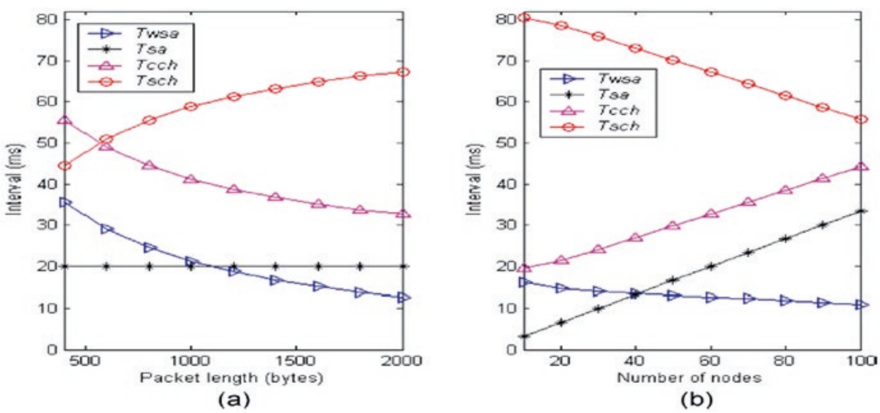

Fig. 9 Simulation result of control channel interval in the network

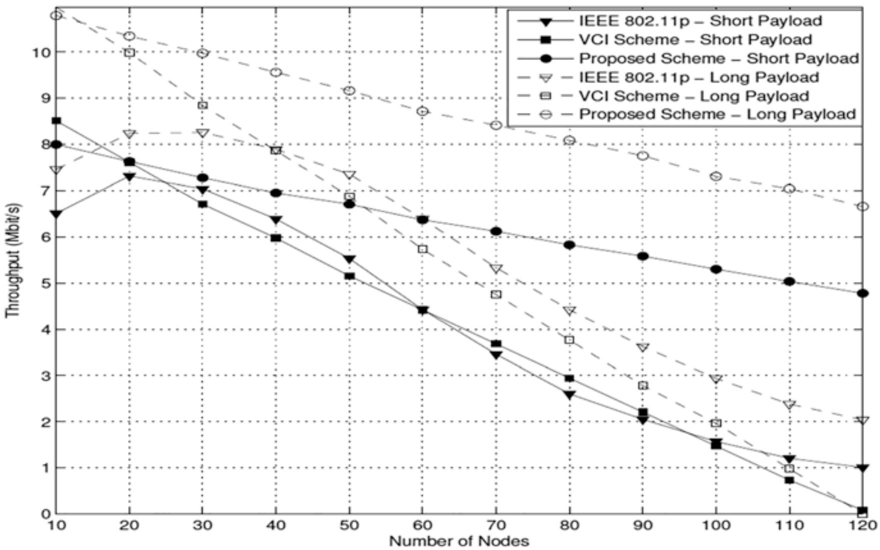

Fig. 10 Simulation result of throughput vs. total number of nodes

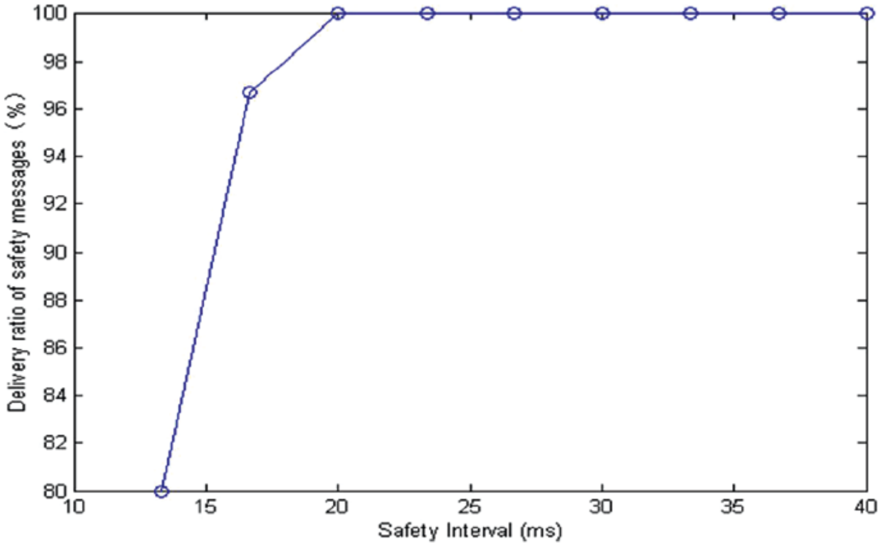

Fig. 11 Simulation result of safety message transmission

replica based on Markov chain model as well as stochastic procedure is presented for determining the optimal interval of CCH (Fig. 14).

The two logical outcomes and model modification investigations suggested that MAC VCI strategy is capable of supplying systematic channel utilization

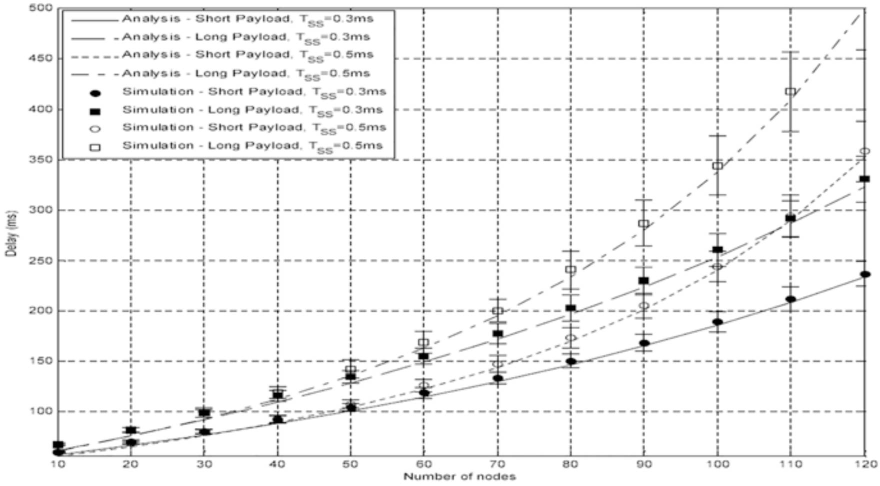

Fig. 12 Simulation result of transmission delay

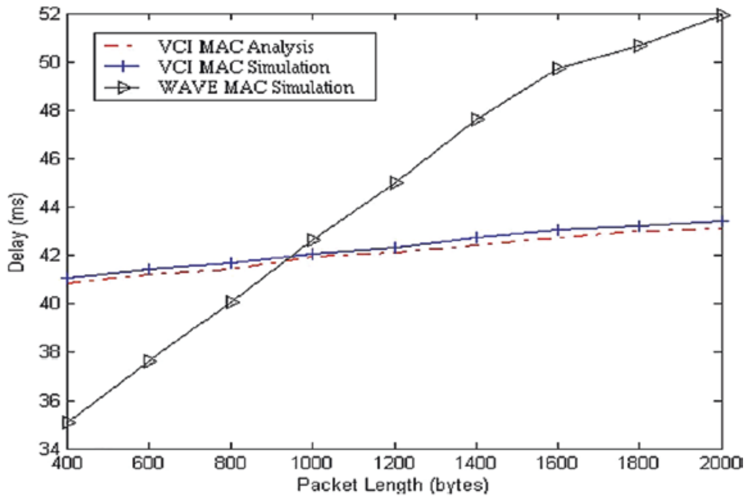

Fig. 13 Simulation result of transmission delay vs. packet length

accompanied by excessive saturated throughput as well as short service packet interval while transferring big service packets. In the upcoming work, we will try to expand the experiment to a multi-hop wireless domain accompanied by prospective concealed terminals. VANETs also apply various channels like service channels (SCHs) and control channels (CCHs) to supply unbarred general street safety facilities and better comfort as well as effectiveness of driving. Survival of a patient depends on effective data communication in the healthcare system. In this paper, an emergency routing protocol for vehicular ad hoc network (VANET) is proposed to

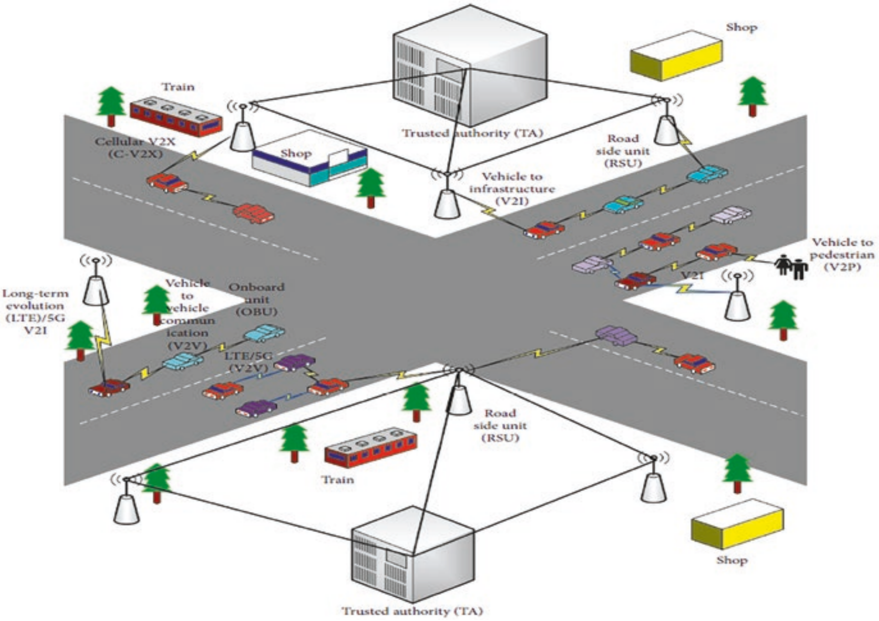

Fig. 14 Picture of VANET system

quickly forward current patient status information from the ambulance to the hospital to provide premedical treatment. As the ambulance takes time to reach the hospital, the ambulance doctor can provide immediate treatment to the patient in an emergency by sending patient status information to the hospital via vehicular communication. Secondly, the experienced doctors respond to the information by quickly sending treatment information to the ambulance. In this protocol, data is forwarded along the path that has less link breakage problem between the vehicles. This is done by calculating an intersection value for the neighboring intersections by using the current traffic information. Then, the data is forwarded through the intersection with the lowest value. In this chapter, we suggest a MAC (medium access control) VCI, or variable control CH interval, scheme, which reduces safety message transmission time and helps to minimize collision probability when the vehicle node increases in the road by using K-means and donkey-smuggler optimization algorithm. In the donkey-smuggler algorithm, the donkey follows the smuggler's instruction and helps them in transporting items to their proper destination by taking the shortest path possible. In an emergency medical situation, this concept will be very useful. The distance ratio between SCHs and CCHs can be effectively modified in the MAC scheme. The multichannel coordination mechanism is used to provide a variance-free approach to SCHs is established by that scheme. To improve intermissions based on traffic situation, a model called Markov chain model is used, and this process is known as a stochastic process. The conceptual analysis and simulation resulted to the recommended scheme capable of assisting IEEE 1609.4 and

IEEE 802.11p protocol. While retaining the methodized channeling of condemnatory safety data on control CH, the MAC scheme consequentially improves the higher saturated throughput and gives effective channel utilization of service CHs and minimizes transmission interval of service packets.

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Role of Cloud Computing in Vehicular NETs to Design Smart ITS

Priyanka Dadhich and Ekta Acharya

Abbreviations

4G	4th Generation
AWS	Amazon Web Services
CRM	Customer Relationship Management
GCE	Google Compute Engine
IOT	Internet of Things
IT	Information Technology
ITS	Intelligent Transportation Systems
VANET	Vehicular Ad hoc Networks
VCC	Vehicular Cloud Computing

1 Introduction

1.1 Introduction to Cloud Computing

The cloud computing is a new term. It is a technology that uses the Internet and central remote server to maintain data and various applications. It includes information, applications, and storage, and it also provides three primary facilities, such as software as a service, application as a service, and infrastructure as a service. Companies provide diverse clients with cloud computing applications through a virtualized software environment as a service model. Different software

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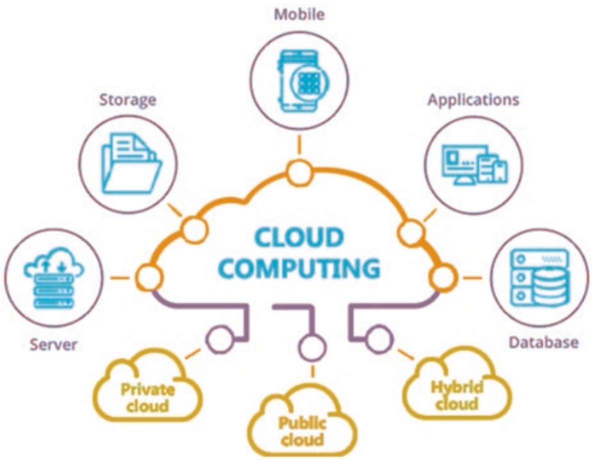

Fig. 1 Cloud computing services

development environments are provided, as a platform service, by the companies to the user so that their applications can be developed easily. As an infrastructure service, the user procedures the physical infrastructure like servers, hard disk of the cloud providers.

Fundamentally, the word cloud denotes a network or Internet service. We can also state that the cloud is somewhat permitted or authorized to use its remote location services and multiple users. Cloud services can be delivered via public and private networks. Cloud applications such as e-mail, web conferencing, and customer relationship management (CRM) can be run on the wide area network, local area network, and virtual private network (Fig. 1).

With the introduction and usage of cloud computing, the cost of working out, contented storage and distribution, and application introduction is reduced. It is a practical approach for direct cost benefits. Cloud computing has the prospective to renovate a data repository to a variable evaluated environment. The cloud computing concept is based on principle of “Reusability of IT capabilities.” By using this principle, we can use all the services of cloud from anywhere, anytime.

1.2 Introduction to VANET

Vehicular networks are a new type of ad hoc network that operates without the need of wires. Vehicular networks provide interconnection of vehicles. Drivers used their expressions, movements, signals, and interpretations of each other’s routes to attain their performance in previous days. Due to the increase of vehicles, there is difficulty in managing them, but in the first half of the twentieth century, transportation police procured custody of monitoring and running the traffic using hand gestures and colorful traffic lights and now car indicators were organized. Drivers cannot share information directly due to very less structure of roads. Nowadays drivers can easily exchange information about traffic using vehicular ad hoc networks; that's why VANET is going to be famous or popular in recent years. Many issues have been solved using this technique [11]. The issues which have been resolved through this technique are as follows: road traffic accidents, road jamming, fuel depletion, and pollution in environment. The traffic instances are common problems in our country or other developing countries which result in huge loss of people's life and property also. Overcome these issues and making the journey safer, important, and entertaining, a system named intelligent transportation system (ITS) is introduced by VANETs to generate a safer infrastructure for road transportation. Although VANETs is not a new subject, new research experiments and difficulties need to be continuously offered.

The objective of VANETs is to maintain a vehicle cluster. It provides arrangements for maintaining a connection between networks without using any essential base location or controller. Medical emergencies to save human lives are one of the other applications of VANETs. The VANETs are responsible for the connection between vehicles in a secure environment. In the last years, smoother vehicles and harmless and less demanding driving capabilities have been recognized. Currently, to inform the driver of all kinds of road safety environments and power-driven faults, everyday vehicles currently have panel computer policies and modified types of distinguishing devices, such as GPS, radio transceivers, small-balance accident radars, and cameras (Fig. 2).

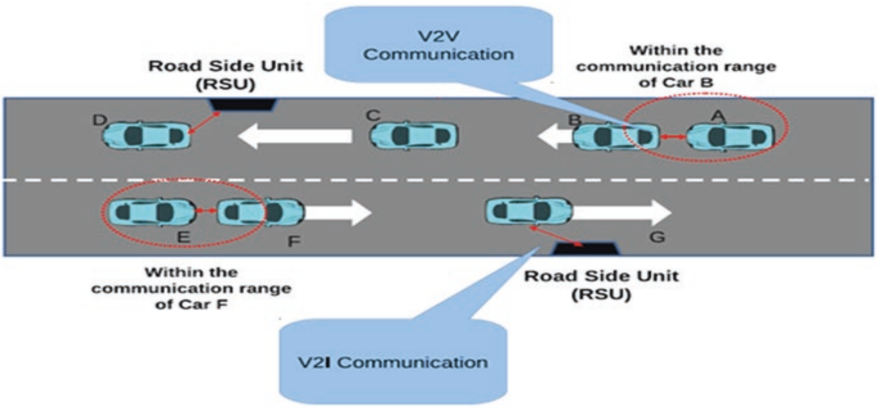

Fig. 2 A classic VANET development [1]

1.3 Introduction to VANET Clouds

With the regular growth of vehicular technology, it provides several resources like better computing power, fixed storage devices, perceptive radios, and sensor nodes. Driving safety and traffic efficiency can be upgraded using wireless sensor networks (WSNs), intelligent applications, and ITS. Vehicular cloud computing is a new technology which uses the advantages of cloud services to serve and operate the VANET. The main objective of vehicular cloud computing (VCC) is to make availability of several computational services to the drivers. These clouds are also used to minimize the stream of traffic flow congestion, accidents, transportable timing, and environmental pollution by ensuring and providing software, infrastructure, and platform as services.

Whaiduzzaman et al. [10] and Olariu et al. [12] defined the vehicular cloud computing as follows:

> A group of largely autonomous vehicles whose corporate computing, sensing, communication and physical resources can be coordinated and dynamically allocated to authorized users.

Vehicular clouds are cloud computing's lean-to, with unique features. All cars that utilise the VCC can interact with one another, as well as access network infrastructure and other vehicles' network communication. All vehicles which use the VCC can communicate with each other; they also can use network infrastructure and network communication of other vehicles. VCC provides a secure communication between the vehicles. Highways are overloaded with congestion of traffic in the current scenario, people are not altered by advance alert about the overcrowding. For several years, the ITS forum has planned and proposed various solutions to control congestion. One of the solutions was to increase the traffic lanes on highways and street, but this was not a long-term solution in the congestion and pollution levels. VCC services aid the drivers to make adequate decisions that could reduce the overcrowding and improve traffic at the same time enhance safety and help them save fuel and time. The VCC provides an innovative approach to resolve traffic hazards detection and monitoring the traffic system.

2 Architecture

2.1 Architecture of VANET

In principal, VANET does not follow a fixed architecture. A typical VANET, however, includes moving vehicles that communicate with each other as well as with certain nearby RSUs.

To considerate network architecture of VANET it is prerequisite to understand the complete prospective of vehicular communication. Most of the researchers [2, 3] have founded their studies by dividing VANET scenarios in three classes as: Urban, Rural and Freeway/Highway.

According to researchers in a sparse network like highways, the prime issue of vehicles that remains is low density at nighttimes. Unfluctuating conditions in some metropolitan areas, as well as a low saturation ratio and minimal activity at night, can cause significant network delays. One of the most important characteristics of mobile ad hoc wireless network is the movement connected with the different nodes. The highly movable environment of vehicles makes it very problematic to model the communication situation. Flexibility model for a VANET environment has to look deeper into key characteristics of vehicular mobility like acceleration, deceleration, changing lanes, and human driving designs. For this purpose, a huge amount of research is conducted [4–6]. In the architecture of VANET, it provides high mobility. In the VANET case, for error-free, effective packet transmission, the versatility model must involve the behavior of moving vehicles separately and in a cluster.

Architecture of Vehicular Clouds (Fig. 3)

In the above diagram the architecture of VCC is shown. The architecture is divided into three main layers. These layers are edge cloud layer, smart vehicular layer and cloud layer.

I. **Cloud Layer:** This layer is responsible for accomplishing the operations like data aggregation, data mining, optimizing of data, analyzing, storing, and batch processing of the data.

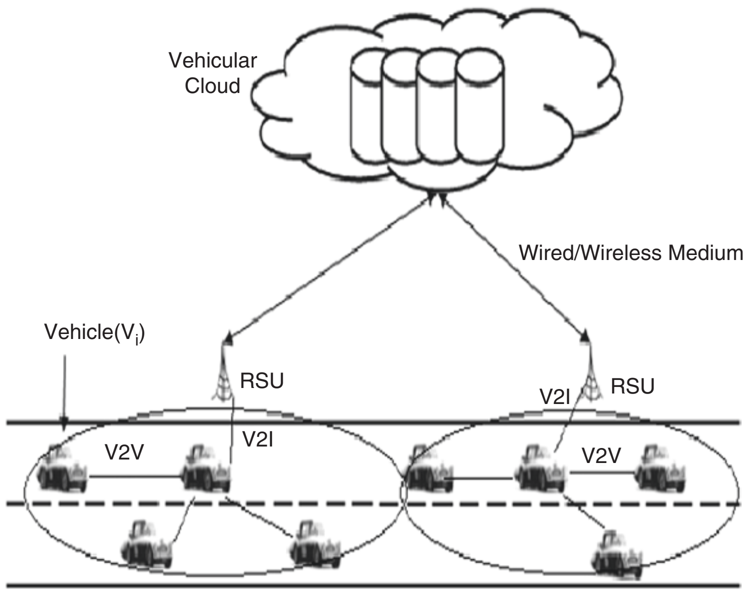

Fig. 3 Architecture of VCC [Source semanticscholar.org]

II. **Edge Cloud Layer:** This layer verifies that linking or connectivity between cloud layer and smart vehicle layer is properly maintained. To achieve the proper connectivity between the layers, the vehicles require Wi-Fi connectivity between the drivers and protocols such as 3G, 4G, 5G, LTE, etc.

III. **Smart Vehicular Layer:** This layer includes a group of smart vehicles having embedded sensor, GPS, camera, and radar.

Application and Services of VCC (Fig. 4)

Vehicular cloud computing has several applications, and some important applications are as follows:

1. **Data Center:** VCC is used as a huge repository of data. The details of vehicles moving around the highways and inside the cities are kept stored in VCC, so each vehicle is connected with each other by sharing network of common clouds and can share information about traffic faced, speed to be maintained, and information about milestones, fuel stations, food centers, etc.
2. **Traffic Management:** VCC acts as traffic managers in the situation of heavy traffic. VCC also helps the drivers to guide the best path with less traffic and time.
3. **Urban Surveillance:** With the use of vehicular clouds the surveillance to urban areas using CCTV has improved. The cloud services are connected with several IT resources and can be monitored simultaneously. Monitoring the traffic and streets activities became easy with the use of VCC.
4. **Emergency Management:** Management of accidental cases and emergency handling can be handled very promptly using the VCC.
5. **Internet of Vehicles:** This is used for traffic management. The Internet of Things, i.e., connectivity of resources through the Internet and smart devices, is limited to just cars using this technology.

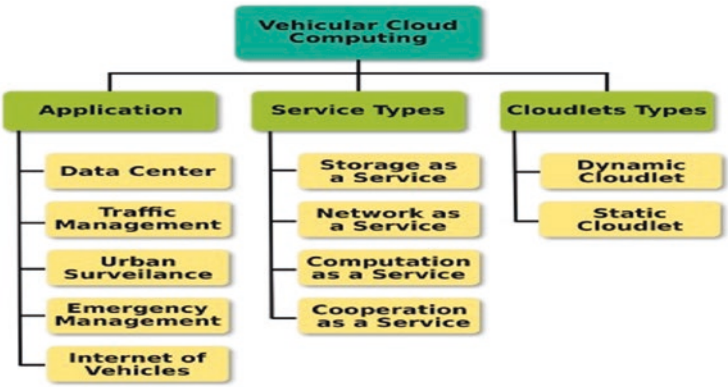

Fig. 4 VCC application and services

2.2 Architecture of Clouds (Fig. 5)

In small and large organizations, cloud computing infrastructure is used to preserve information in the cloud. Once again, it is reached via network and networking from anywhere at any time. The cloud computing architecture [14–17] is shaped by the combination of architecture-related services and event-driven architecture. The cloud computing architecture can be distributed in two parts:

- Front end
- Back end

Front End
Application which is used by the client is called the front end. User applications and interfaces are compulsory to admittance the cloud platforms are contained by Front End. It comprises web services (Internet Explorer, Chrome, Firefox, etc.).

Back End
Application which is used by the service provider is called back end. All the resources are managed by this end that required providing cloud computing services. It contains an enormous quantity of storage of data, safety and privacy, computer generation, deploying models, servers and traffic controller mechanisms, etc. (Fig. 6).

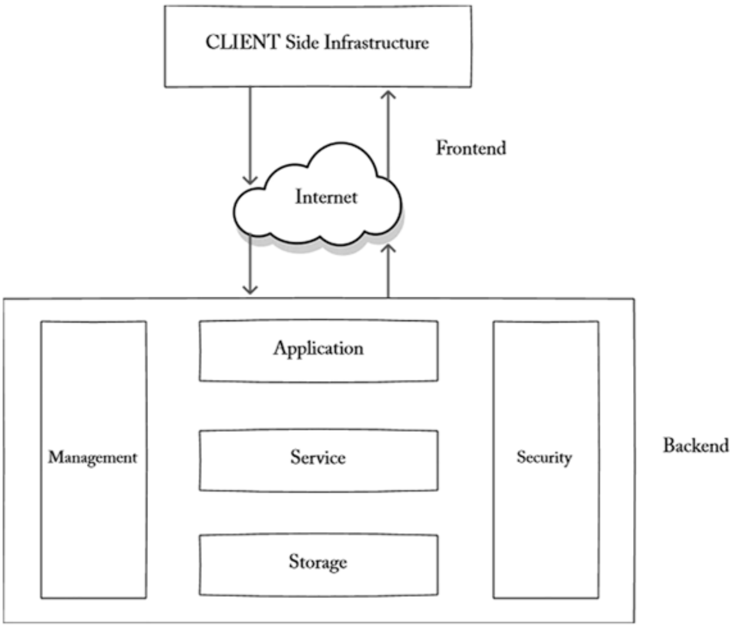

Fig. 5 Cloud architecture [Source W3schools.in]

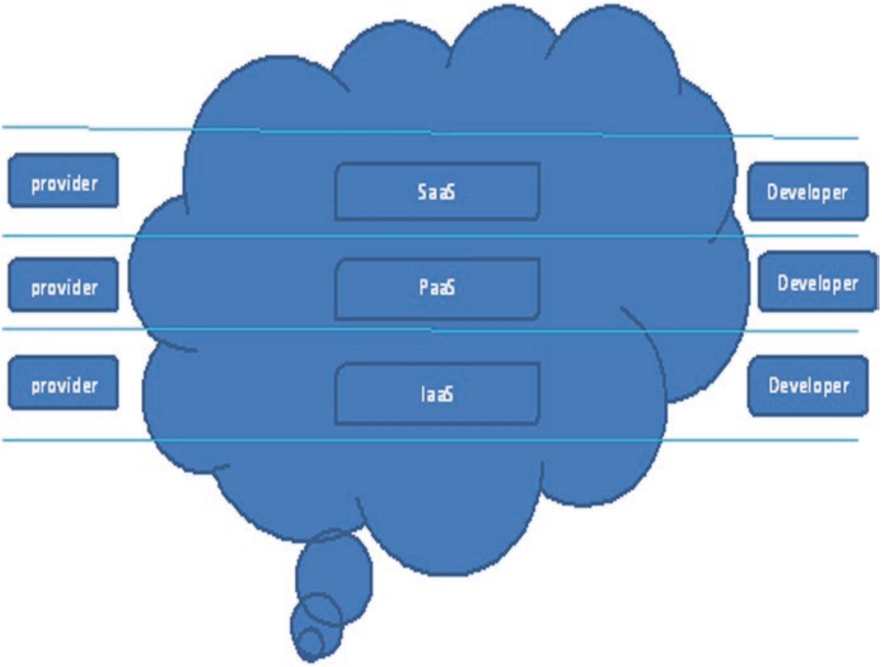

Fig. 6 Cloud computing architecture

Components Used in Cloud Architecture

1. **User Infrastructure**

   It offers graphical user interface (GUI) to interrelate with the cloud.

2. **Application**

   In this component part user can access any software or platform.

3. **Service**

It depends on the client's requirement as to which type of service one can access through the clouds.

Cloud computing services:

I. **Software as a Service** – It's also known as an application for cloud services. These applications directly run through the web browser, and we can access them without downloading and installing. Some significant example of SaaS is given below:

   Example: Google Applications, Cisco WebEx, Salesforce Dropbox, and Slack.

II. **Platform as a Service –** This service is also regarded as a provider for cloud platforms. This is fairly similar to SaaS, but the key difference is that it offers a base for software development.

    Example: Windows Azure and Commerce Cloud.

III. **Infrastructure as a Service –** This service is also known as an infrastructure services for clouds. It is responsible for handling runtime environments, data applications, and middleware.

    Example: Google Compute Engine (GCE) and Amazon Web Services (AWS) EC2.

4. **Runtime Cloud**

Virtual machines are provided the runtime environment and execution by using the runtime cloud.

5. **Storage**

The most important components is its capability to store the data as a repository for the data A huge amount of data can be stored on clouds, and it provides heavy storage capacity to the files and to manage the data.

6. **Infrastructure**

The cloud offers various facilities at host level, network level, and application level. It contains hardware components and software components such as servers, storage, network devices, virtualization software, and other storage resources.

7. **Administration/Management**

Management is the component which is used to manage various applications, storage, runtime cloud, infrastructure, service, and other issues related to security in the back end, and harmonization between front end and back end is established.

8. **Security**

It has built-in security mechanism to protect the data. The security mechanism is implemented in the back end.

9. **Internet**

To interact with front end and back end, the Internet is the only medium. Client can interact and communicate with each other with the Internet services only.

3 Application of VANET

Usually, applications in the automobile setting will improve road safety, increase traffic abilities, and make entertainment accessible to travellers. In order to provide road safety for drivers and passengers, vehicles are equipped with a road monitoring sensor to inspect national highways, such as risky, saturated regions. In most cases, two main curricula can be roughly designed for the use of VANETs: one is safety applications and the other is non-safety applications.

3.1 Safety Applications

The development of vehicular ad hoc networks will also reduce the accidents and increase the safety profile of the vehicle. The communication link between vehicle to vehicle and vehicle to infrastructure can also prevent vehicle crash with these applications [7]. Vehicles are now equipped with various sensors which are used for collection of data traffic and observe the environment continuously, and application like real-time traffic accommodate applications of vehicular safety with change in information. The exchange of information takes place between vehicle-to-driver infrastructure and vehicle-to-vehicle interaction to improve security for roads and avoid accidents.

In 2006, in many transport departments, the USA recognized eight safety applications that are intended to provide optimum benefits, i.e., traffic signal injury, curvature speed alert, alternate braking lights, pre-crash detecting, accident warning, left crack assist, warning of direction change, and stop sign assist [9].

These are some examples of safety application:

Traffic Protection for Roads – Reducing the number of roadside accidents by providing advance notice of hazards to drivers.

Traffic Efficiency – By reducing travel time and congestion, the performance of transport networks improves.

Road Travel Protection and Eminence – Comfort technologies such as “advanced traveller information systems” “electronic payment systems,” “variable message signs,” “electronic toll collection,” etc. are provided to visitors.

3.2 Non-safety Applications

Specific technologies suggested for a specific purpose which are non-safety applications can be classified into several subclasses, such as traffic synchronization and other productivity and entertainment applications. Since usability and performance applications can be available on a different basis, there is no need for control and collaboration between vehicles. In recent years, the growth of such applications and

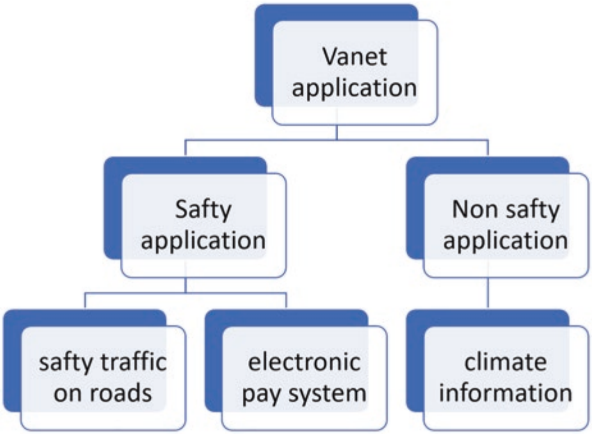

Fig. 7 Vehicular cloud computing applications

services in the industry has increased. On mobile gadgets these several network service packages can be also accessed [8]. Accessibility and reliability applications also have certain valuable data for travellers or drivers, such as environmental or traffic statistics and the location of nearby cafeterias or guesthouses [7]. Entertainment applications can offer services such as media downloading and online services. Games (Fig. 7).

4 Fields of Use of Vehicular Cloud Computing

The allocation of resources along with vehicular clouds has been rising day by day in recent years. According to these researchers, "Vehicular Cloud Computing" provides a broad variety of applications such as airports, train stations, bus stops, data centers, traffic control, management of road safety messages, Vehicular Cloud Computing of parking and real-time navigation services, car repairs, crossing mishap warnings, data cloud parking allowance, and emigration management, etc. Below are some applications described:

1. Road safety signals: Road safety signals are one of the most significant signs on the road. The VCC aims to ensure roadside protection for vehicles. Today's up-to-date population details high temperature and speed road safety signs can be operated, and they can be used to monitor the state of other cars and to alert drivers.
2. Management of traffic: If the number of cars increases day by day, traffic management plays an important role on the road in finding the right solution to the everyday problems faced by drivers and passengers, such as wasting the precious time and energy of people, risking citizens' well-being, and overcoming the

immense computing efforts. One of the reasons given for achieving road safety is that vehicular computing provides drivers with signals about traffic positions (e.g., congestion). Traffic control apps minimize regular overcrowding. Some drivers want to renovate the roads to overcome the overcrowding; this is dictated by the latest information on the vehicle networks and it provides the drivers with an effective solution.

3. Direction-finding in real time: This is a stationary terrestrial map for old-style network cars, but vehicle cloud computing has a "virtual reality technology" that can be moved freely without obstacles by drivers. 3D space has been used for interaction with this simulated world.
4. Parking management: It is hard for drivers to find a parking spot in heavily populated areas. The VCC enables drivers to book parking easily, offering close and appropriate space for all parking locations linked to information stored in the cloud.
5. Managing evacuation: The model used by the disaster authority for road safety and traffic monitoring carries out an evacuation. A advance warning of an imminent occurrence is then given, and evacuation incidents can be split into cases where they are pre-informed. In vehicular cloud computing, existing conditions are part of the evacuation phase for vehicles and vehicular clouds.
6. Data center configuration: People have been parking their cars in the mall, hospital, office, and airport for several hours or days. Vehicles throughout this time are unreliable tools. Building a data center will benefit people from parking. The vehicle receives part of the cloud via either cable or wireless media linked to the Internet. One of the main problems of the parking data center structure is complex in nature, owing to the unpredictable timing and time of arrival for spending per vehicle in parking.
7. Improving traffic signals: There is a high significance in allocating a signal period length and green phase lengths over traffic signals. Vehicular clouds can also improve signal system efficiency by using a vehicular network system dynamically.

5 Future Scope of VCC

The VCC plays an important role in people's lives. As it efficiently controls and accomplishes the traffic and provides safety and security [13], passengers and drivers feel trust and comfort; hence for researchers, it's called a rich setting. It is recognized as the basis for the growth and enhancement of the ITS (intelligent transportation systems), even though the phase of growth and enhancement is still constrained by various factors, such as vehicular cloud computing problems and issues. In the coming years, the future of VCC profits from underutilized resources and utilizes them to a full degree, such as computing advantages and storage capabilities possessed by new technology cars and wasted time in the car park. In order

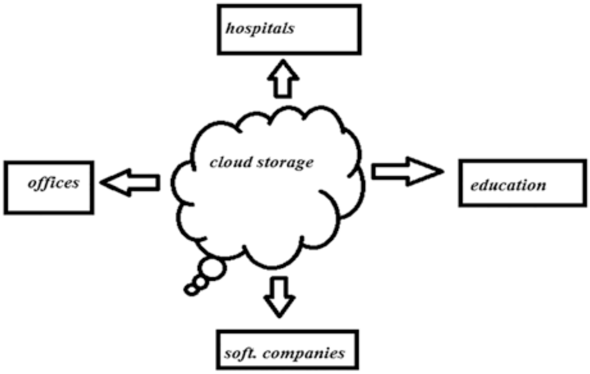

Fig. 8 Future scope of cloud storage

to perform any application or mission, some businesses are also thinking of renting resources from the parking lot (Fig. 8).

According to [17] cloud infrastructure market of the global public will grow from 40% to $130 billion in 2021. According to Forrester Research, the cloud storage remains to "proceed center phase" in the retrieval from the pandemic.

Better creativity assumption, cloud provider income, and business value will in 2021, according to "Predictions 2021." Before the pandemic, the dramatic transformation into the cloud was already underway at a rapid pace.

Forrester previously estimate the using of public cloud storage market would increase 30% to $115.1 billion following year.

According to [18] the ratio of IT costs in worldwide speedup continues in 2021. According to Gartner, the Stamford, and advisory firm spending public cloud by end user will grow 20% following year.

Today, we can numerically connect anything with cloud computing. It will provide us with a work repository, interactive software, enhanced facilities, and online platforms. In IT, we will understand the future of measuring cloud storage as a hybrid approach in a combination with cloud-based software products and on property computing.

The updated cloud, elastic and versatile, will offer security and power over the data centers. One of the integral parts of cloud computing will be the simplified approach and an easier way to manage data. The cloud has many characteristics in the IT market, making the future brighter.

Vehicular cloud computing is a modern research area aimed at educating mobile agents (people, vehicles, and robots) as the process, climate, and data circulate the results and more resources are normally exchanged as they interrelate and cooperate with common sense. Mobile agents act together as vehicles that use this technology to improvize the traffic system and ITS. It helps in environment displaying, content finding, collection of data and distribution, and other vehicular applications.

6 Conclusions

The chapter presents the architecture and applications of vehicular clouds. It also describes the overview of cloud computing and VANET. The authors also described the architecture of cloud and VANETs. The authors concluded that VCC is a very crucial and valuable area of research. Using VANET services, we can avoid the accidents due to heavy traffic; we can resolve the problem of the parking faced in metro cities.

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Sparse Code Multiple Access for Visible Light Communication and 5G and IoT Application

S. Murugaveni, B. Priyalakshmi, Mummidi Veera Sai Rahul, Shreya Vasudevan, and Raghunathan Varun

1 Introduction

Visible light communication is one of the new and emergent fields of optical wireless communication (OWC). Visible light provides a much safer, cleaner, and greener method for communication over the conventional microwave emitters in radio spectrum that are currently in use today [1]. The next generation of wireless communication aims to overcome spectral efficiency and minimize the latency so as to balance the extra data rate requirements. This will also help with the massive connectivity requirements of 5G and Internet of Things (IoT). Author utilise a distributed dynamic spectrum system in this article, in which both licenced and unlicensed users use spectrum at the same time opportunistically. To keep the interference they produce within the permitted interference temperature, channel gain estimations are first used to determine viable transmit powers for unlicensed users, such as device-to-device users [2]. The author suggested power strategy is a cross-layer power allocation method based on branch and bound that integrates the physical and data connection layers [3]. Bidirectional visible light propagation combined with non-orthogonal multiple access (NOMA) was used in the suggested technique, which is a promising strategy for fifth-generation wireless networks. With the same frequency and several power levels, the NOMA may assist several users at once [4].

The future of Non-Orthogonal Multiple Access (NOMA) is very promising. There are Power Domain-Non Orthogonal Multiple Access (PD-NOMA) and Sparse Code Multiple Access (SCMA) which use different parameters to serve

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multiple users based on resource availability. Single-carrier NOMA (PD-NOMA) employs successive interference cancellation (SIC) to eliminate interference in the decoder side, and power allocation is based on their Quality of Service (QoS). [5] Whereas Multi-Carrier NOMA (SCMA) uses turbo coding or convolution with iterations to spread the user messages and spread them using Multi-Dimensional Star-QAM and thereby using MPA (Message Parsing Algorithm) for message detection.

SCMA enables multi-access, meaning a single resource element can be shared between multiple users [6]. This gives the overloading access as greater than one. In VLC, we use light sources such as LED and laser in different environments which will give us optimum SNR even without the channel state information in the transceiver. In SCMA, each user has a unique codebook which is used to identify the user at the receiver's end [7].

The strict positive values in the codebook design require splitting and DC biasing in SCMA and in the detector end. The values from both the matrices are combined and computed.

We are going to look further into improvising the performance where multiple users can be served simultaneously employing codebooks. These are derived from the various data set acquired from phase rotation and decision boundary predictions from Star-QAM. Codebooks have specially optimized and unique code words which take parameters from user message and differ in the way messages are encoded for every user. Symmetric codebooks reduce complexity of the system. After the signals are received, the detector uses MPA for multicarrier detection. The detected signal is distributed to the respective users in the downlink model and also with the users in movement.

In our project, we consider indoor communication model for uplink and downlink using SCMA technique for six users using four channels in a Rician fading channel with accounting for various noise parameters such as AWGN and Flicker noise. The BER vs SNR plot is obtained for radio spectrum for VLC codebook in a Rician fading channel has the least BER.

This paper is properly structured into different sections. In Sect. II, we define the proposed system model. Section III talks about the performance evaluation with respect to reasoning out the selection of SCMA, section and the communication channel with appropriate encoding and decoding using the appropriate codebooks. In Sect. IV, we describe the obtained results. In Sect. V, we draw conclusion from the results of our simulation. Finally, in Sect. VI, we address the possible future work to enhance it outdoors.

2 System Model

An SCMA encoding procedure is defined as a mapping of m bits to K-dimensional complex codebook of size M. K-dimensional complex codewords consist of $N < K$ nonzero elements. Each user has a unique codebook from a set of J codebooks. J users (also called layers) can transmit information over K-orthogonal resources simultaneously. The overloading factor is given as λ = J /K. VLC codebooks use only real values, whereas radio spectrum codebook imaginary values.

The signal can be detected by maximum likelihood algorithm. However, it has very large complexity which increases exponentially as number of users increase and polynomially with the codebook size M. For many users and large codebook sizes, maximum likelihood detection is not feasible for real-time applications. Fortunately, there is an iterative algorithm with a lower computational complexity: message passing algorithm (MPA).

Data stream from each user is encoded by turbo encoder. In the receiver of base station, signals transmitted through six independent Rician flat fading channels are detected by SCMA decoder and then decoded by turbo decoders which forms an iterative procedure.

Rician flat fading channels are used since the communication in consideration is visible light communication which becomes the dominant signal and Rayleigh fading becomes Rician.

We have omitted the selection of interleaver because the choice of optimal interleaver is in itself a complex process which is beyond the scope of this paper. Turbo codes are error-correcting codes with performance closest to Shannon theoretical limit. The encoder is formed by a parallel joining of two convolutional codes kept apart by an interleaver [8]. An iterative process through two decoders is used to decode the data received from the channel. Each elementary decoder passes to each other soft probabilistic information about each bit of the sequence being decoded. This soft information also known as extrinsic information is updated at each iteration (Fig. 1).

After the transmitted matrix is obtained, there are various noises such as AWGN which is statistical, radio noise which is additive, and Gaussian spectrum. Flicker noise which is a 1/f or pink noise occurs at low frequencies. All these noises added

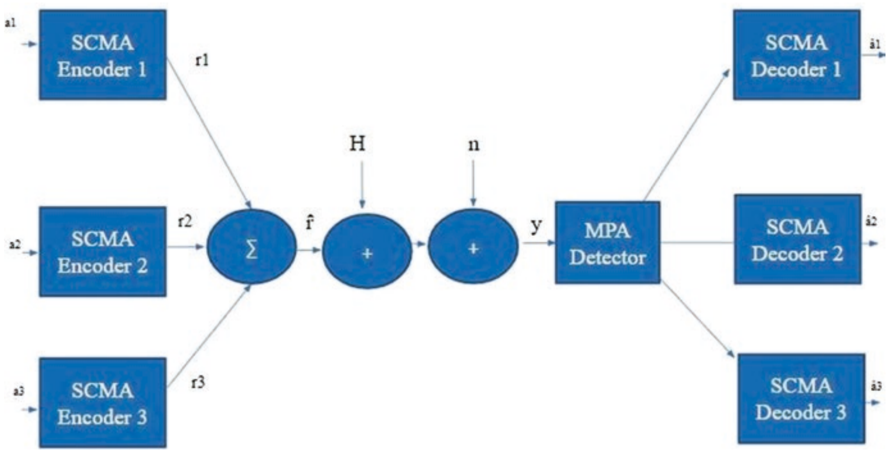

Fig. 1 System model

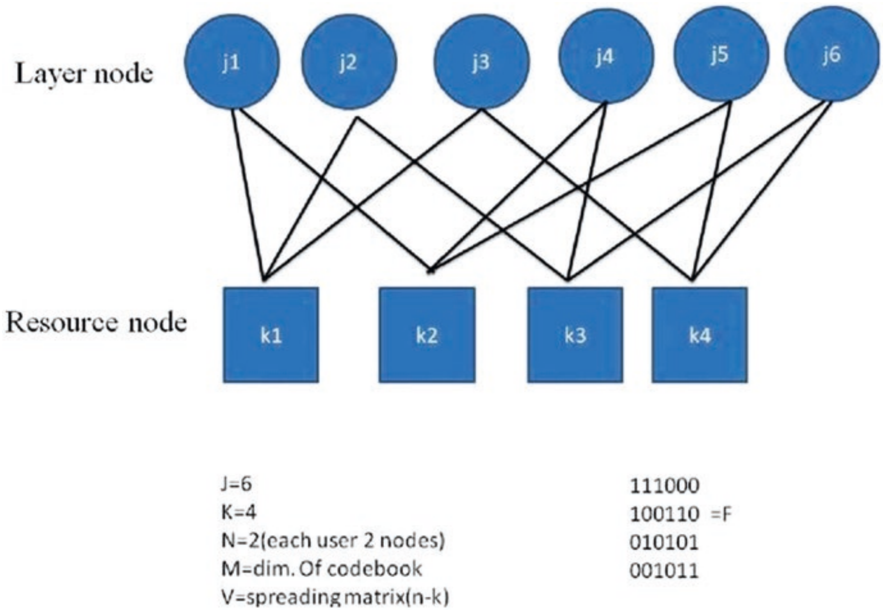

Fig. 2 Mapping matrix

and multiplied together causes major disruptions to the signal travelling in indoor environment. At the receiver side we insert two filters such as Golay and Gaussian filters to remove the hard noise components and bring the signal levels to desirable range. The multiuser detection at this point is done by iterative procedure by the MPA algorithm and the mapping matrix for layer node and resource node are shown in Fig. 2. The final signal is reshaped and then taken for computing the loss of message.

3 Encoding and Decoding of SCMA Signal

Given below is the steps followed to encode an SCMA signal:

1. Decide codebook dimensions; it is taken as 8x6 dimension matrix.
2. Eight resource elements (K) are shared between six users. Users are also referred to as layers.
3. There are six codebooks, one codebook for each user.
4. Generate bit symbols (random function is used) for mapping.
5. Generate SCMA encoded signal matrix (y) and initialize to 0; it is taken as a KxN dimensions, where N is the frame size.
6. Rician fading channel "h: is considered.
7. Perform SCMA encoding - y = y + CB*h.

8. Obtain an 8x100 dimension complex SCMA encoded matrix (Fig. 2).

Given below are the steps involved in decoding an SCMA signal through use of Message Parsing Algorithm (MPA):

1. Calculation of conditional probability.
   (a) Calculate probability of each functional node (user) given the channel and codeword.
   (b) Main loop running "k" times depending on number of resource elements.
   (c) Three internal loops, each resource element shared between three users.
   (d) Assumed probability of 1/M given to each user.
2. Iterative procedure.
   (a) Update functional node, which is the resource node.
   (b) Update variable node; this is the user node.
   (c) Run outer loop "k" times depending on number of resource elements.
   (d) Add the calculated probability to the conditional probability functional.
3. Log likelihood ratio calculation.
   (a) Find all nonzero matrix values in conditional probability function.
   (b) Chain product of all guesses from neighboring nodes.
   (c) Convert the log likelihood ratio to bits.
   (d) Calculate error percentage.

4 Results

The BER vs Eb/No curve has been plotted for the following: a VLC codebook in Rician channel (Fig. 3), VLC codebook in a Rayleigh channel (Fig. 3), radio communication codebook in a Rayleigh, and radio communication in a Rician channel (Tables 1 and 2) . The BER was found to be lowest for a VLC codebook in a Rician channel (Tables 3 and 4). Six codebooks are used for six users in a VLC codebook, and there are no imaginary values (Fig. 3).

Given below are the radio spectrum and visible light communication (Tables 1, 2, 3 and 4):

5 Conclusion

There is an increasing demand for bandwidth as the number of devices increases just as predicted by [9–13]. The onset of IOT promises interconnectivity like never before and expects all data transfer to take place in real time with very little latency. Visible light communication is a clean and green technology ensuring enhanced

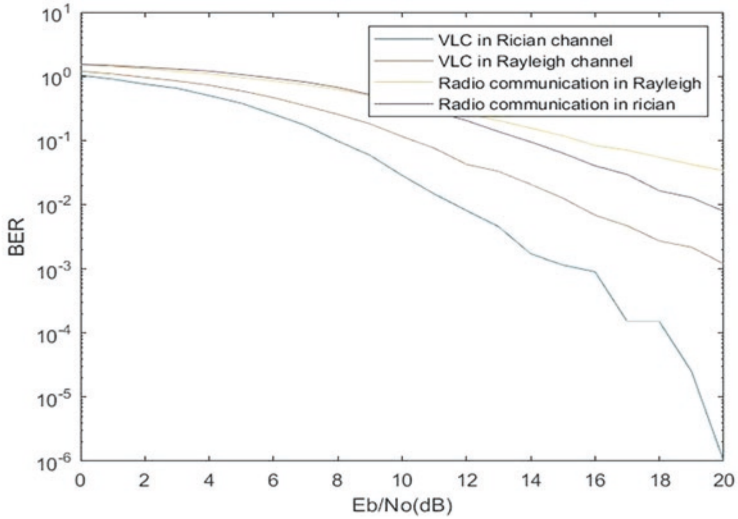

Fig. 3 Eb/N0 vs BER curve for CBs in Rayleigh and Rician channels

Table 1 BER for radio spectrum CB in Rayleigh

1.199 2	1.088	0.957 45	0.846 5	0.725 65	0.591 45	0.46 34
0.344 55	0.254 35	0.180 85	0.114 7	0.075 55	0.042 3	0.03 28
0.020 55	0.012 55	0.000 68	0.004 65	0.002 7	0.002 15	0.00 12

Table 2 BER for radio spectrum CB in Rician

1.03 55	0.900 45	0.75 66	0.649 2	0.499 05	0.379 2	0.25 57
0.17 09	0.097 1	0.05 84	0.028 35	0.014 6	0.008 05	0.00 45
0.00 17	0.001 15	0.00 09	0.000 15	0.000 15	2.5e-5	1.0e- 6

Table 3 BER for VLC CB in Rayleigh

1.512 4	1.4133 5	1.3047 5	1.1893 5	1.0934	0.9599 5	0.8448
0.736 4	0.6187	0.4978 5	0.4137 5	0.3196	0.2588 5	0.2033 5
0.155 6	0.1179 5	0.0835	0.0701 5	0.0546 5	0.042	0.0338 5

Table 4 BER for VLC CB in Rician

1.543	1.4725	1.3782 5	1.2935 5	1.2039	1.0637 5	0.9315 5
0.811 9	0.6684 5	0.5205 5	0.393	0.2808 5	0.2036 5	0.1368 5
0.094 4	0.0631 5	0.0401	0.0293	0.0163 5	0.0128	0.0078 5

security. Sparse Code Multiple Access is a promising method and also a challenge to increase the efficiency [9–13].

Future Work.

The usage of visible light spectrum comes with a lot of challenges due to its narrow bandwidth. Our encoding and decoding techniques can use many other techniques such as priori probability, Markov process for reducing the receiver complexity, and turbo coding for encoding to increase the simplicity.

Appendix

Codebook used for visible light communication:

CB1=	0.7071	0.7071	−0.7071	−0.7071;…
	0.0000	0.0000	0.0000	0.0000;…
	0	0	0	0;…
	0.3536	−0.3536	0.3536	−0.3536;…
	0.3536	−0.3536	0.3536	−0.3536;…
	0	0	0	0;…
	0	0	0	0;
CB2=	0.3536	0.3536	−0.3536	−0.3536;…
	0	0	0	0;…
	0.3536	0.3536	−0.3536	−0.3536;…
	0	0	0	0;…
	0.7071	−0.7071	0.7071	−0.7071;…
	0	0	0	0;…
	0.0000	0.0000	0.0000	0.0000;…
	0	0	0	0;…
	0	0	0	0;…
CB3=	0.0000	0.0000	0.0000	0.0000;…
	0	0	0	0;…
	0	0	0	0;
	0.5	0.5	−0.5	−0.5;…
	0.3536	−0.3536	0.3536	−0.3536;
	0	0	0	0;…

	0	0	0	0;…
	0.3536	−0.3536	0.3536	0.3536;
CB4=	0	0	0	0;
	0.3536	0.3536	−0.3536	0.3536;…
	0.3536	0.3536	−0.3536	−0.3536;…
	0	0	0	0;…
	0	0	0	0;…
	0.0000	0.0000	0.0000	0.0000;
	0.5	−0.5	0.5	−0.5;…
	0	0	0	0;…
CB5=	0	0	0	0;…
	0.6036	0.6036	−0.6036	−0.6036;…
	0	0	0	0;…
	0.2500	0.2500	−0.2500	−0.2500;..
	0	0	0	0;…
	0.7071	−0.7071	0.7071	−0.7071;…
	0	0	0	0;…
	0.0000	0.0000	0.0000	0.0000;
CB6=	0	0	0	0;…
	0	0	0	0;…
	0.7071	0.7071	−0.7071	−0.7071
	0.0000	0.0000	0.0000	0.0000;…
	0	0	0	0;…
	0	0	0	0;…
	0.2500	−0.2500	0.2500	−0.2500;…
	0.6036	−0.6036	−0.6036	−0.6036;

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IoT Enabled Smart Connected Homes and Its Social Graces

Baibhav Pathy and R. Sujatha

1 Introduction

Smart homes have a longer back history than we expect; they can be traced back from the year 1890 to 1900 when rich aristocratic families were finding a way for their comfort and convenience. And it all started with the introduction of electricity to create a home with a high degree of luxury, privileges, facilities, automation, leisure, and indulgence levels [1]. With the introduction of the bulb created by Sir Thomas Alva Edison (American inventor and businessman), there was a blossom of the new era of smart home technology which later on becomes an omnipotent field for the future generation.

Similarly, during the 1930s, the US rural electrification administration vigorously advocated a variety of "modern" electrical equipment going hand in hand with attempts to electrify rural farms [2]. A campaign was launched in 1956 as "Live Better Electrically" by General Electric and Westinghouse to award medals to those who converted their appliances to electricity. Since then, the definition of smart homes has different meanings in different eras of time. Perhaps the exact meaning cannot be determined by a single definition as the purpose of its usage varied vividly from time to time. Although the modern-day definition of smart homes refers to a home packed with smart technology aimed at supplying consumers with personalized services, it's not certain if this definition will be applied to the

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next decade of 2021–2030 with the development of new AI technology with computational data analysis. Automation is the ultimate goal of the smart home [3].

1.1 Smart Home Definitions

The following section provides the timeline for the definition of a smart home and its evolution over the decade. Let's discuss from 1992 to 2019 the influential concepts for smart home technology.

In 1992, by employing a common communication method, Lutolf stated the convergence of numerous resources within a household [4]. It guarantees that the home is run economically, securely, and comfortably and a high degree of intelligent mobility and flexibility is involved [44]. In 2003, Aldrich identified a computer and information technology residence that anticipates and responds to the needs of people, operating through in-home technology management and connectivity to the outside world to promote their convenience, security, safety, and entertainment [5].

In 2012, De Silva and researchers demarcated a homelike experience with ambient intellect and automated monitoring, which allows them with various facilities [6]. In 2014, with his fellow researchers, Balta-Ozkan said that a residence fitted with a communication network, connecting sensors, household appliances, and devices that can be tracked, activated, or managed remotely and that provides programs that meet the needs of its people [7].

Similarly, same year Saul-Rinaldi and the team were given an inclusive, two-way mode of contact between the building and its inhabitants [8].

A smart building was highly energy-efficient in 2017, Buildings Efficiency Institute Europe detailed, and covers to a great extent the relatively low electricity consumption is met by on-site or renewable electricity supplies powered by district system. Smart building (i) stabilizes and induces quicker power system decarbonization by power storage and resilience on the demand side, (ii) enables the consumer and occupants with energy flow control, and (iii) understands and reacts to requirement of users and occupants in terms of convenience, well-being, quality of indoor air, protection, and operational requirements [9]. Hargreaves and Wilson discussed that a smart home gathers and analyzes residential and local knowledge climate, provides consumers (and service providers) with information, and improves the capacity for various domestic systems to be handled (e.g., heating, illumination, entertainment) [10]. The home automation is described by Strangers and Nicholls and includes residential ICTs, wired and controlled domestic appliances, and the Internet of Things [11].

Shin and his researchers identified a smart environment in 2018 which can obtain and extend information about its occupants and their environment to adjust, in addition to achieve comfort and efficiency goals. Gram-Hanssen and Darby [1] described one where sensors, machinery, device controls, and other instruments are connected to a data network by a communications system which enables occupants and others

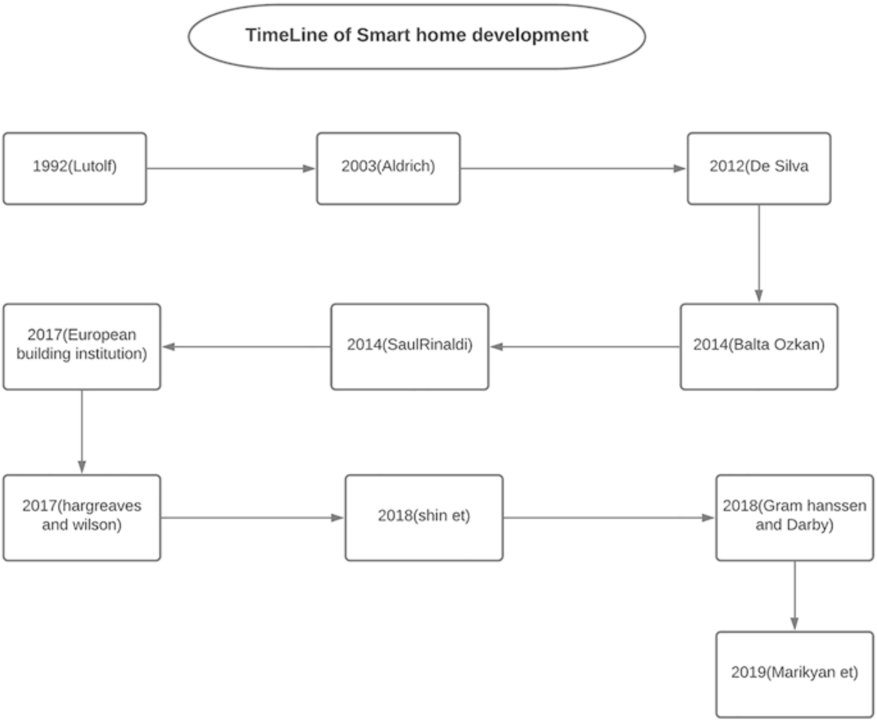

Fig. 1 Timeline of smart home development

to be monitored and managed remotely and to provide occupants electricity system with frequent and regular services. In 2019, Marikyan and his researchers defined it as a residence packed with intelligent technology aimed at supplying consumers with personalized services [12]. A brief idea of development of smart homes is given through Fig. 1.

There has been a boom in the creation of modern "smart" gadgets over the past decade that can attach to the Internet and be operated remotely using apps. The Internet of Things (IoT) [13] is the name of this network of computers and other objects equipped with sensors, circuitry, applications, and networking. This has contributed to a cloud-centric approach for smart home development focused on IoT, along with another modern cloud computing technology [14].

1.2 Smart Home Devices

Although it's not possible to categorize smart home because of its vast diversity still by using certain norms and criteria we were able to categorize smart into five levels.

In level zero the home has no smart technology, i.e., it is just a traditional home. These are the houses that go back to the eighteenth century. The house doesn't even have electricity so people used to lit candles during the night.

In level one, there are few simple smart technologies in the home, for example, a TV or micro oven or windmill device, and maybe basic input levels, but inhabitants also determine how to communicate in an analog way, and the technologies are not integrated and residing in storage facilities. Basically, all the features work on electricity and are operated manually by the user.

In level two there is a significant upgrade in technology, and here all the different types of electronic devices are bundled together so that they can integrate to provide better household services, such as air conditioner (e.g., it maintains the optimum room temperature and automatically gets on and off with respect to room temperature) or entertainment (such as a smart television intraconnected with an Internet router, computer, music system, and smartphone).

In level three the home may be configured to fulfill certain preferences for greater automation through various devices, with systems continuing to intraconnect and also predicting certain criteria, such as turning devices and modules for a few seconds before a human comes home. Most of these are operated by sensors linking all to each other's mobile gadgets.

In level four the home starts using machine learning to provide greater comfort to user. It starts to learn as well as adapt by themselves and provide supply of resources in background, i.e., whenever a storm arrives, switch the lights on or put them back off until the sun shines out. At this time, sensors and monitors can enable devices to understand and follow up the requirements of the household, and natural cycles can facilitate certain learning to become more independent and adapt to what users feel and want.

In level five they become almost fully automated and can do all the household tasks without any human assistance. Feedback and learning converge through several interconnected structures (combustion, illumination, gardening, mobility) at this stage, so that the house itself can deliver services seamlessly. Home like this would be using artificial intelligence which can respond back to any household request of the user. These houses will then be called full-fledged smart homes where no major upgradation can be brought to make it much more convenient.

There is level six also where all the single homes of smart neighborhoods both local and regional that would be composed of level-five smart homes gather together to form intraconnected smart home technologies. But this is beyond the imagination and may take a few decades to happen.

Even nowadays also new technology has come up by many tech giant companies with the smart speaker having artificial intelligence assistance like Google HomePod in Fig. 2 or Apple homepods or Amazon Echo Dots.

Fig. 2 Google Home Mini connected to the TV. (Source from user)

2 Home Automation Using IoT

With the increase in the capability of harnessing and computing large amounts of data available in the cloud home, automation has achieved another degree of evolution thus expanding the horizon of our civilization. There have been a large number of sensors used in our daily life that include IR sensor for our smart tv remote, touch sensor used in our smartphone, smoke sensor, and proximity sensor for the safety and security of our home.

2.1 Smart Home Energy Distribution

Energy demand will rise constantly with the projected growth of the world population. Modern power grids were installed generations earlier, and their ability to meet future demands is uncertain, even though they are regularly upgraded [15]. Existing fossil fuel reserves are restricted due to deficiency in quantity and emit toxic gas and sulfate aerosol, making it inevitable to have social and environmental consequences and impact. This present incarnation is the product of the transition from the conventional centralized system to a distributed hybrid power generation system which largely depends on renewable energy sources such as solar and wind [16], biomass, tidal energy, and fuel cells.

A new concept such as the smart grid that integrates information and communication technologies (ICT) with grid power systems has been adopted in recent studies achieving productive and sensible production and use of resources [17]. The idea behind this concept is to design a power grid in such a way that the load demand is distributed and decreases in critical situations to avoid grid failure or large-scale blackout [18]. If the demand of power supply for consumption is greater than the power generated, it will analyze and redistribute the power supply thus increasing power grid reliability, quality, and safety overall forming a connecting bridge to information and electricity.

Smart home has recently become a major interest in smart grid research and application. The use of ICT in home automation applies to the smart home, varying from appliance control to home feature automation (lighting, windows, etc.) [19]. The use of intelligent power scheduling algorithms is a vital element of the smart home, which will allow people the opportunity to make effective a priori decisions on how to extend power to reduce energy usage. The network model of such objects is under the framework of a rapid-growing phenomenon known as the Internet of Things (IoT).

This concept of integrating information technology along with different sensing device creates a variety of different techniques with different possibilities. New innovative concepts, such as omnipresent or omnipresent computing [20], where computation is rendered to exist everywhere and everywhere, have a tremendous potential for smart grid application [21].

2.2 Cloud Usage in Smart Home

A cloud is a storage house to a massive set of data from different sources (data from homes, measurements of sensors from transmission/distribution lines or manufacturing facilities, etc.) which is used as processing infrastructure for high computational data analysis which can be later used to give promising results. The whole system of smart homes depends on this cloud-centric framework as illustrated in Fig. 3.

The fog cloud is used to incorporate and analyze all data from multiple sources (sensors, actuators, devices, and other technologies). The major advantage of cloud computing is that data can be accessed anytime and anywhere which in turn helps in reading sensors, recording readings, and Internet tracking of home appliances. We use the Google App Engine [22] framework to create, launch, and manage our web applications in the deployment, since it is easy to use, highly performant to service requirements, and has an in-built data store and a modular GUI.

2.3 Blockchain for Privacy

The Internet of Things (IoT) comprises machines that generate, process, and exchange vast quantities of data vital to defence and security, as well as information vulnerable to privacy, and are thus attractive targets for numerous cyberattacks [23]. Most of the existing system works on one core system for making it a low-energy consumption device making the role of fostering protection and privacy in an inexpensive way very difficult.

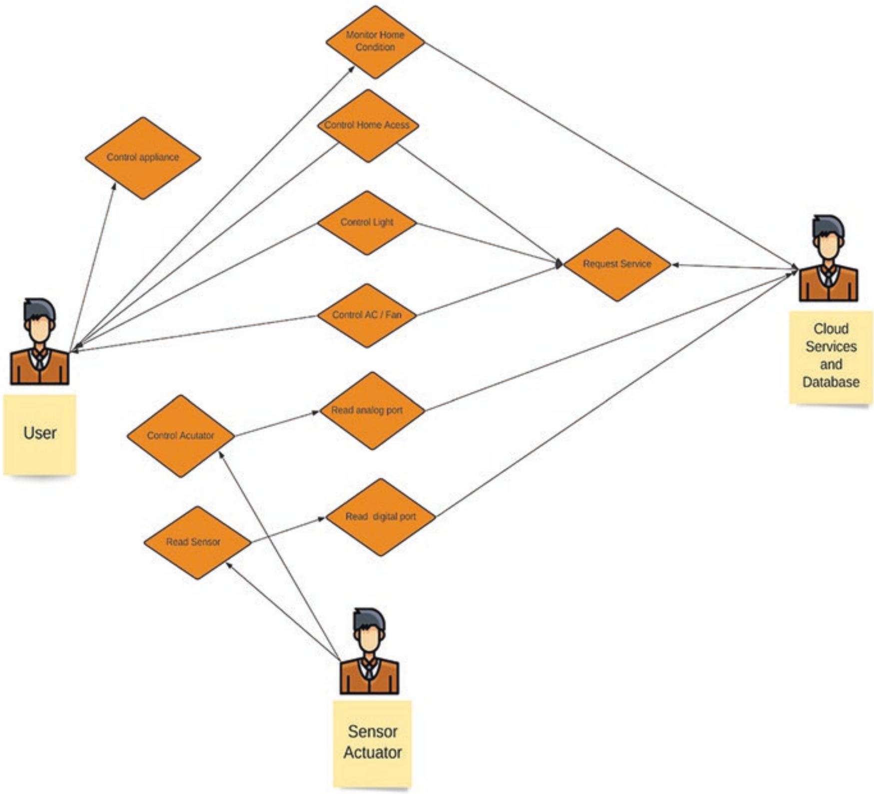

Fig. 3 Use case diagram

Older generation system tends to be pricey in terms of computational overhead and power consumption. In addition, all of the state-of-the-art security systems are heavily structured, and, owing to the sophistication in terms of size, many-to-one nature of the flow and single point of failure are thus not intrinsically well suited to IoT [24].

Modern approaches also either expose inaccurate data to protect user privacy, which could theoretically prohibit any IoT software through the availability of personalized services [25]. The IoT thus requires a portable security and privacy protection and, flexible and distributed services [26]. The BC technology that undergirds Bitcoin's first cryptocurrency system [27] has the ability to solve the challenges mentioned above in terms of its distributed, stable, and private design.

Here we use topological structure and distributed faith to preserve the stability and privacy of the blockchain (BC) while rendering it more suited for the unique IoT specification in smart homes. The design consists of three layers.

- Miner-type smart home.
- Cloud storage services.

- Implementation of overlay design.

Smart homes constitute a miner that centrally manages all the smart devices that are located within the home automation tier. It also consists of an overlay network together with a data provider, server, and personal computer servers. It is designed in such a way as to decrease network crowding overhead and lagging delay by grouping nodes in the cluster. The cluster head (elected from each cluster) maintains a public BC in connection with two other key lists.

- Requester key list: List of PKs of overlay users who can access the information for the smart homes associated with this cluster.
- Key list of requestee: Cloud storage is used to store and exchange data via the list of PKs of smart homes linked to this cluster that are authorized in order to be controlled.

To provide safe control configuration for the IoT smart devices and their data, a private and local BC is used. In addition, the BC creates an unchanging time-ordered transaction history that can be connected to other levels to provide relevant services as shown in Fig. 4. Build protection comes from different features, including design safety:

- Indirectly accessible devices.
- Numerous transaction systems in the overlay and smart home.

The main smart home components are:

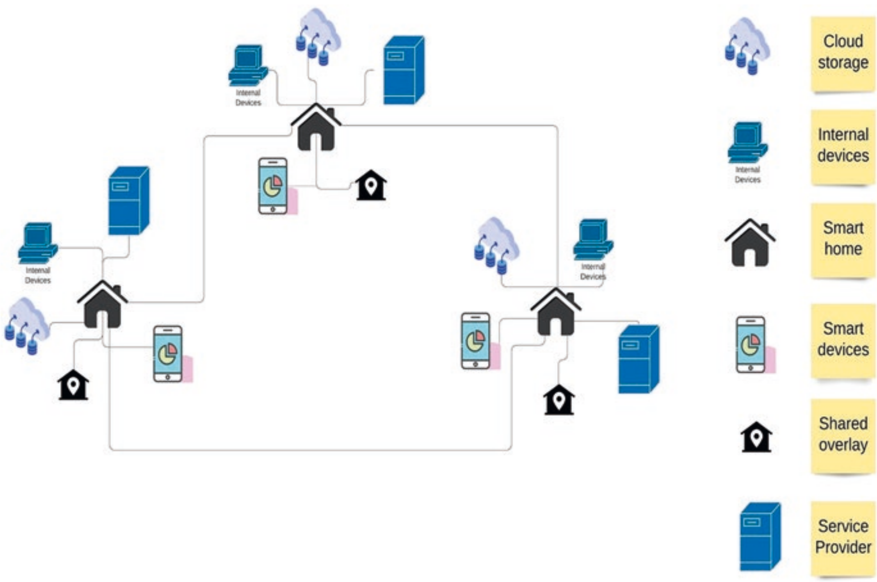

Fig. 4 Working of blockchain

- Transaction.
- Local BC.
- Home miner.
- Local storage.

2.3.1 Transaction

Transaction is local system communications between overlay nodes and intraconnected devices. In a blockchain (BC)-based smart home, there are different types of transactions each designed to perform a specific function.

The storage transaction is created by data storage devices. To access the cloud storage, an access transaction is created by an SP or the homeowner. A monitor transaction is created for periodic monitoring of system details by the homeowner or SPs. A past history of transaction is used to connect a new device to the smart home and a device is removed by a withdrawal transaction [26]. In a nearby private BC, all of the above transfers to or from the smart home are stored to use a shared key to secure the communication.

2.3.2 Local BC

The main work of local BC is to keep track of all the transactions as well as enforce any user policy for inbound and outbound network transactions. Each local BC has two headers, namely:

- Block header: used to keep the BC immutable, the hash from the corresponding block (unchanged).
- Policy header: used for authorization and enforcing the monitoring policies of the holder.

There is a different type of transaction that has to be stored, accessed, and monitored; thus the local BC helps in keeping these parameters and perform the requested action. The local BC is operated and maintained by a local miner.

2.3.3 Home Miner

A system that centrally deals with inbound and outbound transfers to and from the smart home is the smart home miner. The miner was able to integrate with the Internet portal of the home or a different unit that is stand-alone [26].

The function of the home miner is:

- Distributing and updating key.
- Authorizing and auditing transaction.
- Genesis transaction.

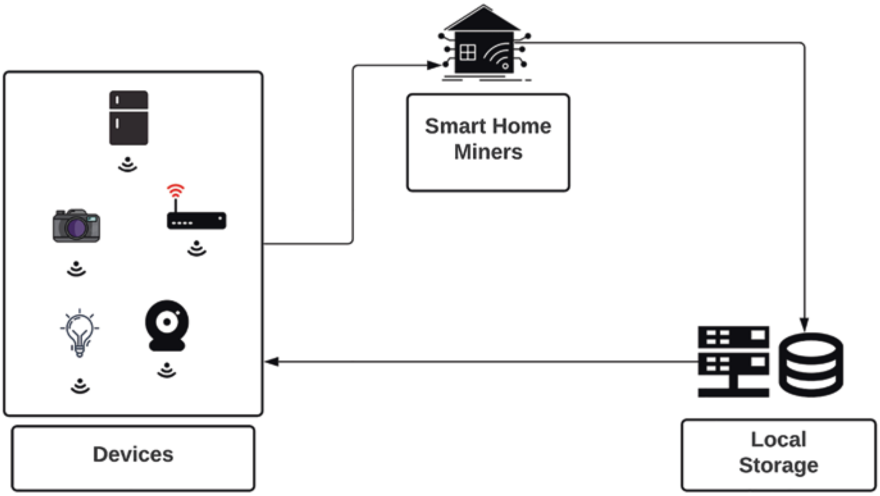

Fig. 5 Working of home miner diagram

- Changing transaction structure.
- Forming and managing cluster.

The miner manages local storage as well as collects transactions into a block, adding the entire block to the BC as represented in Fig. 5.

2.3.4 Local Storage

Local storage as the name suggests is a device used to store data locally which may or may not be part of the miner. A First-in-First-out (FIFO) storage system is used to store information and store the data of each smart device as a log intraconnected to the reference point of the device [26].

2.4 Smart Home Architecture

The architecture of a smart home should be in quite a way that it can measure home condition with the help of a microcontrolled enabled sensor, process instrumented data, and monitor home appliances in the front end by using microcontrolled actuators. For this, we use two concepts, namely:

- PaaS: Platform as service.
- SaaS: Software as a service.

The main function of the microcontrolled actuator is to perform certain tasks issued by the interaction between the microcontroller and cloud service. For data processing and simulation, all information from sensors allowed by microcontrollers and cloud resources is stored in the database. The database also acts as a command pool that is sent to actuators.

Between the back end and the front end, the server/API layer makes it easy to process and archive the information obtained from the sensors in the database. It also collects instructions to monitor the actuators from the web application client and stores the command lists in the database. For all the instructions in the database [28], the actuators make requests to call the registry. Using cloud services along with web applications, we can control, visualize, and monitor data and action from smartphones and smart speakers with in-built AI. There are several technologies and methodologies available to convert our home into a smart home. Arduino microcontrollers, ZigBee networking protocol, JSON for data sharing, and Google Cloud Platform for cloud computing are among these innovations.

In the following section, we will be discussing in detail this technology and also their feasibility and commercialization of these technologies.

2.4.1 Arduino Microcontroller for Smart Homes

Thanks to several microcontrollers and microcontroller platforms [29, 30], the IoT makes computation and networking omnipresent, handheld, and wearable. Arduino consists of an environment for programming and boards for Arduino. The Arduino programming environment allows programs to be managed, compiled, imported, and simulated by the creator. There are different types of Arduino with different parameters such as the number of digital and analog pin, speed of clock, and size of ram (flash memory). The main features of Arduino are:

- Open source.
- Cross-platform.
- Low cost.
- Simple programming.
- Extensible software and hardware.

As a microcontroller module, we use Arduino UNO to program different kinds of sensors/actuators so that it can act as a communicator technology such as RFID and ZigBee.

2.4.2 Networking Smart Home Using ZigBee

To share sensor outputs, triggers, status updates, etc., the Arduino-embedded devices (smart things) installed in the home need to communicate with each other. ZigBee is one of the most advanced digital communication technologies that is commonly used to create connectivity between items for home automation [31, 32].

ZigBee is a protocol based on IEEE 802.15.4 for radio-frequency (RF) communications. ZigBee network system has two parts, namely:

- ZigBee coordinator: It is responsible for network formation and management.
- ZigBee node: It's the appliance or device that needs to be controlled, e.g., washing machine, television, and lamp.

ZigBee coordinator controls and manages the ZigBee node as shown in Fig. 6.

It can communicate between a range of 100 meters to 1 Km with a speed of a maximum of 250 Kbps where 40 Kbps can meet the requirement of most of the system. The system consists of two Arduino UNO microcontroller boards where all the actuators are connected to the first board which acts as a central receiver linked over an Ethernet link to a network server on the Internet. The central transmitter that is linked to all the sensors in the device is the second board. For contact between ZigBee sensors/actuators and the central Arduino boards, ZigBee technology is used.

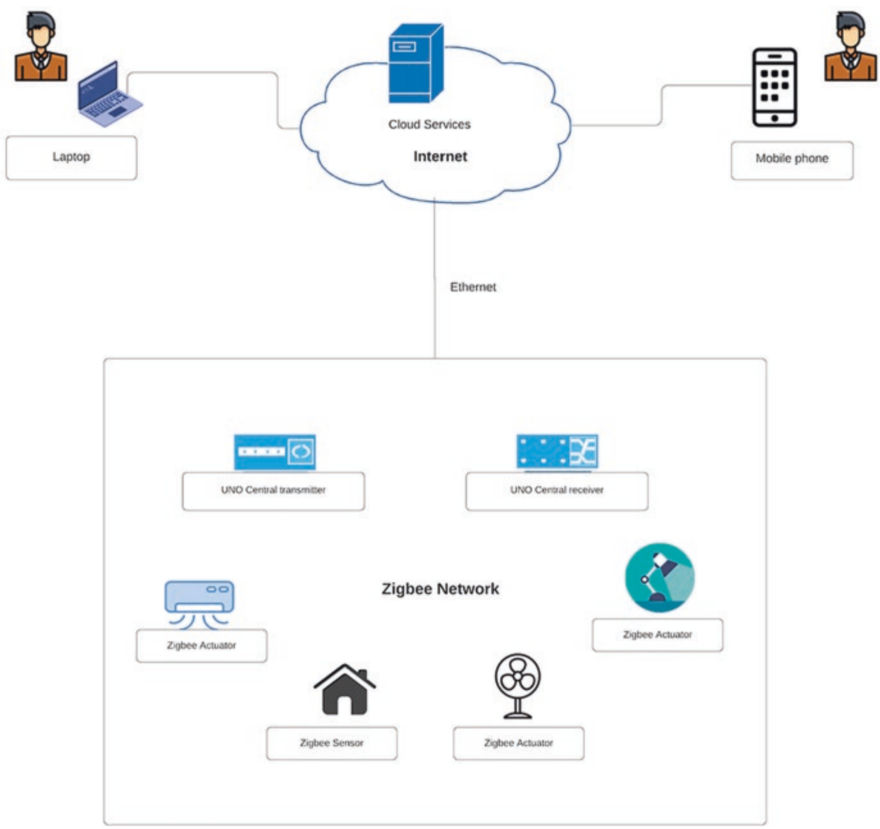

Fig. 6 Representation of ZigBee network

2.4.3 JSON Used for Data Exchange in Smart Home

The future of the smart home relies heavily on cloud connectivity that requires access to the Internet. The future smart home is expected to have a wide range of sensors, all of which are limited and have inadequate capacity for storage, memory space, and communication bandwidth. Full extensible mark-up language (XML) is popularly used in web-based heterogeneous architectures as a message serialization language. However, owing to their resource limitation, IoT nodes that are space constrained do not always manage to do full-fledged XML processing [33].

JSON is a lightweight syntax of data representation to store and share text information. It's a lot like XML, but it's smaller than XML, and decoding is faster and easier. JSON syntax is a syntax subclass for object notation. JSON data is entered as pairs of names/values. Building JSON into JavaScript offers it a separate advantage when operating with software partly written in JavaScript [34] over other serialization formats, such as XML.JSON which can be used for data representation and data sharing to decrease traffic load and bandwidth utilization. All the devices integrate together to provide seamless services as shown in Fig. 7.

3 Challenges to the Problem and its Solution

In this section, we will discuss the challenges and things to be considered in the phase of smart home construction.

3.1 Usage of Fog Computing in Smart Home

Fog computing is the data processing strategy at the data center connected to a remote server. The data is supposed to begin extraction as early as possible in this phase at the moment the data is identified, i.e., at the sensor side. There are several explanations for using this strategy, but energy conservation, reduction of data rate, and reduction of latency [15] are some of the most common ones. If their contact is not streamlined, each IoT object/entity will absorb a massive amount of energy.

A simple way of doing it is switching over local computation rather than operation. This can be done by developing a lightweight algorithm for local data processing. This method would minimize the amount of information and will stop submitting enormous amounts of unprocessed data. Instead, it can relay only metadata (information about the data). In this way, the huge figure of transactions between the IoT devices decreases thus reducing delay problems and cellular channel overload.

Different methods for data reduction can be used to minimize overhead contact. For data reduction, there are three major strategies used:

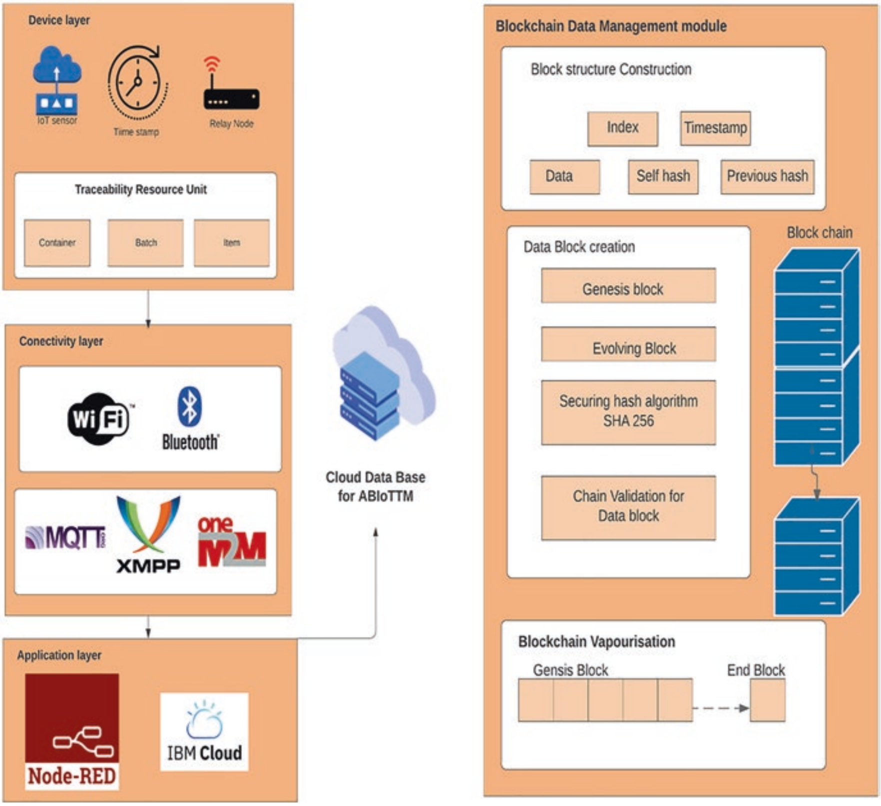

Fig. 7 Cloud database management

- Compression of data: when data is not needed in real time, sigma compression can be used.
- Data prediction: various filters, most of them are reliant on adaptive filtering. Methods, such as the moving average (MA), autoregressive moving average (ARMA), least mean square (LMS), autoregressive (AR) model, and variable step scale LMS, can be used for real-time sensor data estimation (LMS-VSS) [35].
- In-network data transmission: the process of processing information consecutively on the way to the target (endpoint). Some aggregation operations are carried out as data passes across intermediate nodes.

3.2 Big Data for Smart Home

A big amount of information is generated by these IoT devices as a variable in systemic terms (order); they frequently arrive in real time and can be of unknown origin. These volume, velocity, and variety (not to mention variable veracity) make it a very complex approach for storage and analytics that will produce valuable insights [36]. Traditional SQL-required relational database management systems (RDBMSs) are ineffective for the job, because of which big data technologies are required. The IoT cloud [37] will allow long-term storage and dynamic analysis as well as processing of this data. Although the total output approximately relates to the data's attributes of collection service [38], the task of managing big data is important.

There are various number tools involved to give service in this type of market like the open-source Hadoop collaborative data management framework from Apache, plus numerous NoSQL databases and a variety of tools for business analytics platforms.

Several vendors (data aggregation, data processing, key analytics, and data presentation) run in various areas of the analytics pipeline, as well as "full stack development" vendors such as IBM, Microsoft, Oracle, SAP, and Software AG. Alternative database architectures for big data are implemented by both proprietary and open-source solutions [39].

- Time serialization.
- Key-value detection.
- Stored document.
- Wide column storages.
- Graph and databases.

3.3 Smart Home Networking

There can be different types of data network protocol that can be set up in a smart device network and traditional network, designed primarily for high data rates. The protocols already developed in Wireless Sensor Networks and Machine-to-Machine (M2M) communications are supposed to be followed by smart home networking protocols, with no definite winner so far [40]. The implementation of several complex framework features raises the charges and lowers the simplicity of use. The creation of an attractive protocol is not a convenient job and is typically a trade-off between price and performance.

3.4 Interoperability

The cost related with incorporating smart home devices [41] is the key challenge associated in the upgrowth of the generic smart home solution. The key to opening up markets to competitive IoT technologies is interoperability [42]. Leading smart technology production firms around the world are working to achieve complete interoperability to ensure fast connectivity with the current Internet.

3.5 Security Privacy in Smart Home

Cybersecurity is the most important issue emerging both for wired and wireless machine sections. The smart grid, which is a vital issue for device builders, may be a target for cybercriminals. Because of how data is distributed, IoT is theoretically susceptible to some of the wireless network attacks that are common.

Alternative techniques should also be examined to provide protections for flexible crypto-primitives [43] and to provide authenticity (the system is not a malevolent object), credibility (the data sent is similar to the data received), and secrecy (the unreadability of the data to others) [44].

3.6 Machine Learning in Smart Home

Smart home is designed to optimize the user experience. It is therefore important for the system to be able to analyze and recognize the data/activity of the user. It is necessary that behavior detection is carried out in actual environments, so that the smart home can "respond" and "stimulate" automatically if necessary. This process of recognition and prediction of user activity can be done by an advanced machine learning algorithm by a two-step process. The first is the exploration of the operation, which is achieved with strategies of learning that are not supervised. Second, the identification and estimation of events using supervised learning techniques is enabled by the clustering of data collected in the preceding step [45].

The tracking and sensing of user activity for collecting data should be done in a nonintrusive and non-observable way so that the user does not become cautious that they are being tracked. For this reason, researchers at Massachusetts Institute of Technology (MIT) have developed new techniques of breath and pulse rate measurement using a radar system called frequency modulated continuous waves (FMCW). It can track an entity from up to 8 meters away, even behind a wall, with properly placed sensors; this is plenty of coverage for an average-sized home. Although these technologies are made currently for medical purposes, future development of these have the potential to revolutionize the field of smart home technology.

One more important point to focus on is development of new and more efficient algorithms to handle large amounts of continuously generated streams of data from motion detectors and cameras as well as identify new types of activities. Unmonitored learning approaches are ideally suited for finding correlations in vast volumes of data, which is what task exploration is about, to our best understanding. No single strategy will, however, act as a definitive approach, and multiple approaches must therefore be used together to produce better outcomes and create more dynamic intelligent hybrid systems [46]. Genetic algorithms (GA), for instance, and swarm intelligence approaches are a better idea for enhancing a system's machine learning and prediction capabilities.

All major tech giant companies are now working on creating their own home assistance. For example:

- Alphabet: Google Assistance.
- Apple: Siri.
- Amazon: Alexa.
- Microsoft: Cortana.

These assistants have the human intelligence of 3 years to 6 years and can do almost all the basic tasks ranging from switching off fans or lights to setting reminders or playing music. With the passage of time, we can see and predict more development and efficiency in these assistants which will indeed ease higher levels of comfort and convenience as well as recognize and predict which enables a smart environment to react according to user need.

4 Social Grace of Smart Home

The literal meaning of social grace is the impact that has been put in our life which has shaped us to what we are today. Over the years smart homes have deeply and drastically impacted individuals by uplifting interactive development of individual social and life skills. Several goodwills brought by smart homes are:

- Now parents who are working can monitor their child from the office while working at home.
- Smart home can make children learn etiquette like giving warning of switching off light and fans as well as giving information on amount of energy wasted or save toward environment.
- It can also inculcate good habits like sleeping early, waking up early, doing exercise, and fitness workout.
- By its efficient integration it can also save environment by saving energy.
- Smart home can also help individual security toward home while they are out of town for work.
- Smart homes save time because of automation of every device. So now people can have more family while sitting together.

- Smart home can save cost because of no labor cost work and its fully automated.
- Smart homes can get us connected to our relatives in real time, thus increasing connectivity and bonding with all.

5 Conclusion

This paper gives you a brief idea about smart home usage and advancement from an earlier age to this decade. In this paper, we discuss all the methodology that is developed for the smart and efficient working of the smart homes. In the end, we discussed the problem and issue faced by us during the transition from normal to smart home as well as solutions to get over the problem. We also discussed the contribution and future potential of machine learning in the development of smart homes. Also, we get to know of social grace and impact on society and future generations.

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Iris: A Novel Approach to Blind-Friendly Kitchen

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1 Introduction

Nearly 40 million people in India, including 1.6 million children, are blind or visually impaired. The human life is contingent on all five sensory organs and most important of it all is vision. To understand life without vision, we have to place ourselves in the shoes of visually impaired people. They do live a normal life similar to us but in their own way. In the United States, 1.1 million people are blind and about 50,000 lose their sight each year. These things can be avoided to a certain extent such as most of the cases of blindness are preventable. Visually impaired people also have a hard time in recognizing consumables and keeping track of quantities. The difficulties addressed by the people that are disabled in some way are vast.

The objective of our project is to create something that would make the life of visually impaired people a little better than it was used to be. The items that they consume have an expiry date which they might consume. This consumption of expired food is harmful. It might be the root cause of unknown diseases. They also need to keep track of the quantities around the house, and for that, Iris provides a simple and effective solution. As we have mentioned about the tribulations that visually impaired people face throughout their lives, our primary aim is to reduce the problems faced by them and to make their life much simpler due to the findings of new technology. The assistive technology helps in understanding what type of consumable is present within a container which is connected to Android application and provides the necessary information regarding the consumable. When the item

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has an expiry date, that information is also provided. All these things are integrated together and provide a complete solution to the visually impaired people.

In this project, we are developing a smart container integrated with a mobile application that helps visually impaired people recognize consumables in the container by just touching it. At that time, an audio output will produce in our mobile application giving the information of the contents in that container. Alert messages are also provided to give information on the expiry date of consumables and also for the low-quantity substances. This system is very helpful for people with dementia and also helps to avoid accidental consumption of medicines by visually impaired people. We are also providing a system that detects the leakage in gas cylinders, and the control of flame intensity is made possible through our mobile application. We are also providing object detection and product suggestions in our mobile application to help people in purchasing new and good products.

2 Related Works

In our system, we are using load cells for weighing substances in the container. After certain tests, the results show that the load cell has high accuracy and high stability under certain combined errors such as hot-cold temperature [1]. It is clear that the load cell will give accurate values for measuring fluids also [2]. Thus, the load cell is highly suitable for weighing different types of substances. The normally used touch sensor buttons can be replaced by a more cost-effective assembly that uses variation in amount of infrared radiations falling upon the photodiode to sense the proximity of human finger [3]. Raspberry Pi is used to configure, that is, it converts analogy values into digital value and passes this value into database. So, we chose Raspberry Pi in our system [4]. In our system, we used MQ-6 sensors for detecting gas leakages. Being a highly sensitive sensor, MQ-6 detects the presence of LPG in concentrations from 200 to 10,000 ppm. It has an outer membrane coated with tin dioxide (SnO2). Upon contact with the components propane and butane, in LPG, this coating reacts with them and results in an output which is converted into an electrical voltage [5].

So, it is clear that MQ-6 sensor is suitable for detecting the gas leakage. ROSmotic, a system for building smart homes operated by a smartphone app which is accessible for people with visual disabilities, is controlled through touch or voice commands, and a three-layer architecture was implemented to connect new clients without modifying the control system and the UI consists of a voice control and touch control system, but this application only works for iOS platform [6]. Typhlex describes the use of motion gestures to control mobile applications and mentions 91% of blind users use an iPhone, but in developing countries like India, mostly people depend on Android platforms so we decided to release our application in Android platform, and moreover this system is difficult to set up as it is an iterative procedure and a very cumbersome process. Typhlex was in its initial stage of development and seemed to help many visually impaired people adjust their design which is a very important and necessary procedure while designing gadgets and applications for visually impaired as most products may fail to achieve their desired efficiency [7]. Gablind is an electronic equipment which is connected to a smartphone application for obstacle detection for visually impaired people. The system was tested in Indonesia, and they succeeded in providing a Bluetooth connection to the application and system so that the use of the Internet is not required, but to enhance the productivity we decided to connect the system through Wi-Fi [8]. Gas leak detection could be achieved by means of various MQ series sensors, and through researching about those sensors, we decided to use the MQ5 sensors which could detect LPG gas, and we implemented a system to turn off gas immediately, and in case of leaks, a serial plotter plots those values continuously, and when the threshold gets broken, gas supply will be cut [9]. A screen reader is a very essential function in our application, and for the ease of use, a gesture control operation is also very useful for them, so by researching through this paper, we are trying to implement both voice and gesture control for our application so that visually impaired people could utilize the best UI interface [10]. As we have seen IoT is becoming an integral part of daily life.

There are multiple components that we have used for our project. So, as we can see, there are two types of architectures in IoT—three-layer and five-layer architecture. The first and basic architecture of IoT is three-layer architecture. It basically consists of three layers—perception layer, network layer, and application layer. Perception layer basically deals with sensing and actuation. The network layer is responsible for transmitting and processing the information [11]. The application layer gives a specific application to the user [12]. In five-layer architecture, two more layers are there to give more abstraction to the IoT architecture. The five layers are perception, transport, processing, middleware and application layer [11]. Transport layer is used for sending the values, and middleware acts as a medium between the flow of data, i.e. it controls the data flow.

Application layer presents the necessary application for the usage of the device. These layers of architectures are mainly used in all types of IoT devices. IoT devices are classified into three sections low, middle and high. We have used devices from all these sections such as IR sensor and NQ5 gas sensor, all falling into the category of low. ESP8266 falls under the category of middle and at the latter Raspberry Pi in the last category. Visually impaired have a hard time detecting objects in surroundings, so we can use object detection to detect objects. One of the used object detectors is YOLO [14]. YOLO has achieved the balance between performances and computational costs [13].

There we can also use Faster R-CNN [15] which is also a model. Faster R-CNN [15] still requires a large computational cost in testing phase. These models are well known for their detection performance and usage. But these models are worthwhile to mention, and for our usage, we are using mobilenetSSD which performs better in the case of mobile application. The load cell is highly suitable for weighing substances. The normally used touch sensor buttons can be replaced by a more cost-effective assembly that uses variation in amount of infrared radiations falling upon the photodiode to sense the proximity of human finger [16].

3 Experimental Works

Figure 1 shows the workflow of our proposed system as to how the connections are made and the flowchart of our proposed model.

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3.1 Sensor Attached Container

A load cell and IR sensor attached container is implemented to measure the amount of content present in that particular container. Here, we use load cell instead of ultrasonic sensor to produce an accurate result. Load cell will give accurate value for measuring fluids also [17].

3.2 Mobile Application

The application is designed in such a way that there are two log-in options, one for blind or visually impaired people and other for common people. After installing the application, user has to enter their basic details provided in it and have to choose the appropriate log-in option. After all the details are entered, the user can enter into the homepage in which four options are provided. They are:

- Add to The Container: To add details of the container.
- View Container: To view the container details.
- Quick Bucket List: To find low-quantity products.
- Usage Analytics: To analyse the usage of each month.
- Object Detection: To detect objects present in the nearby environment.

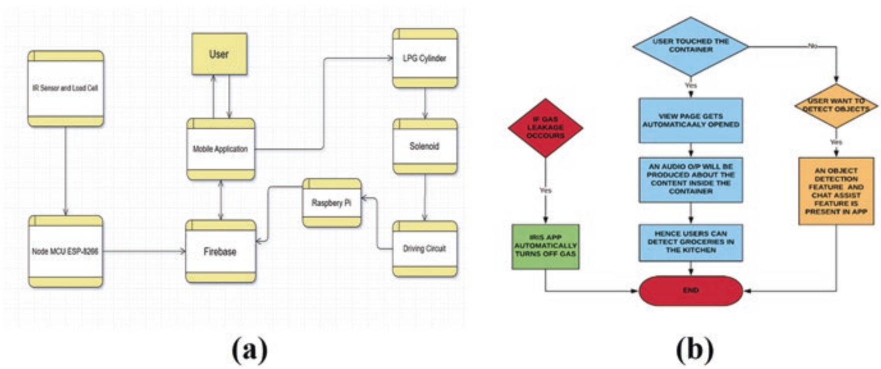

Fig. 1 Representation of (**a**) work flow diagram and (**b**) flow chart

- Gas Control: Controlling the intensity of gas.
- Iris Assist: Group chat-based assistance.

When we click on The Add to The Container button, a QR code scanner is opened. We have to scan the QR code pasted on the container. The QR code contains details about the container including container ID, maximum weight and so on. After submitting all the details, that corresponding container is ready to use. When we touch the container, the IR sensor attached to it will send a HIGH signal to the MCU to let it know that someone has touched the container. Then container parameters such as weight (calibrated to container level), expiry date, etc. read by MCU are sent via Wi-Fi to Firebase real-time database. From the database, the data is read by the mobile application. This idea makes blind people to be self-sufficient to a certain extent. It provides an easy text-to-speech mechanism for them. This product also helps people to keep an update about the items and their expiry date. It also prevents accidental consumption of medicines.

3.3 LPG Flame Intensity Controller and Gas Leak Detection

Visually impaired people find it very difficult in using LPG gas stove. To overcome their problems, we have devised a mechanism for controlling the LPG flame. A solenoid valve is used for this purpose to control the gas flow, and the solenoid valve is controlled by Raspberry Pi unit via a solenoid driver circuit. The gas tube is fitted via a solenoid valve which is connected to the main gas cylinder, and the smartphone application can send messages to the Raspberry Pi via the cloud Firebase. Based on the input from the user, the valve can be fully shut or fully open or anything in between. The solenoid driver is built using a TIP122 NPN transistor; TIP122 acts as a switch to control the voltage going through the solenoid valve, thereby controlling the gas flow through the valve.

A 1n4007 diode is used as a fly back diode to prevent the transistor/Raspberry Pi from overloading from reverse current. The solenoid driver is connected to a GPIO pin of the Raspberry Pi and PWM output can be used to simulate an analogue voltage value which then controls the valve.

By programmatically controlling the duty cycle of PWM, we can simulate an analogue voltage from Raspberry Pi. MQ-6, a sensor specialized in the detection of LPG and gases whose constituents are propane and butane, is used in the proposed system [18].

3.4 IRIS Assist

Iris Assist is a group chat feature that provides assistance to visually impaired people through sighted volunteers. The feature works similar to a WhatsApp group chat in which our volunteers give replies to the queries by the visually impaired people. Every day, sighted volunteers lend their eyes to solve tasks to help blind and low-vision people lead more independent lives. Visually impaired people may need help for distinguishing colours, distinguishing currencies, reading instructions, navigating new surroundings, etc. Our volunteers will guide them to solve all these problems.

3.5 Object Detection

Object detection is a computer technology related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class in digital images [19]. Recent advancements in the field of computer vision and deep learning have given rise to reliable methods of object detection [20]. We see the difficulties visually impaired people face in their day-to-day life. As they have hardships in recognizing objects, we plan to use deep learning technology that is blooming. With the help of that, the app can be used to identify the various objects in the real world. Once these objects are detected, an audio output is given as feedback so that the user can know what object is present in front of them.

This would be beneficial to them to identify objects near and help them have an intuition about their surroundings and the placement of items. Using TensorFlow, we can create a model that is trained on a COCO dataset which contains 40+ classes, and this will be more than enough to detect most of the common objects placed around a person. Now, the best detection model with the great accuracy would be YOLOv3 which has no supported version for mobile application. So, we are going to use YOLOv2 or SSD (single shot detector) mobilenet for the detection of objects. These models are converted from the original TensorFlow architecture into TensorFlow Lite which has the primary purpose of working in a mobile application. In the end we have found that SSD mobilenet works best for our project.

4 Result

Iris is capable of providing talk-back facility about the contents of the container once the proximity of the user is detected through the IR sensor. Moreover, the LPG gas stove can be controlled by using Iris mobile application to turn off the gas stove. In case of gas leaks, the solenoid valve automatically closes and an alert occurs in the application. The mobile application consists of two signs in functions including

Google and biometric log-in which leads to the homepage. The homepage navigates to the previously defined functionalities mentioned above. All the data from the hardware is stored and retrieved from the Firebase, and the same data is used for analysis purpose for getting the consumption insight so that the user can track the usage insights. The same principle using load cell platform used for measuring the quantity of contents in the container can be used to measure the LPG gas quantity present in the gas cylinder by using a bigger platform and a 20 kg load cell. Hence, a smart kitchen model can be implemented using our hardware and mobile application.

The above figures explain more the results we obtained through implementing the system. Figure 2a represents the platform made for placing the container in the kitchen, and we designed our own platform using two acrylic sheets and using spacers in between to hold the load cell. Figure 3a shows the load cell attached to the platform through which we measure the amount of substance placed on top of the platform and a HX711 unit along with ESP8266 NodeMCU which is used to retrieve and send those data to the Firebase. Figure 2b shows the container we use to store those various groceries in kitchen and the container is placed on top of the platform and two IR sensors are placed on top of the container, and upon detecting proximity, that is, when the user brings his/her hand towards the lid of the container, the IR sensor gets activated and the corresponding view page, and as shown in Fig. 3b, each container contains a separate QR code to identify the contents present inside the container.

The gas detection system contains these components:

Figure 4a shows the solenoid valve attached between the gas tube to regulate the gas flow and circuitry used; we used a Raspberry Pi 4 model b as the control unit for this system and the flame can be shut down through our mobile application as shown in Fig. 4b. The following are the screenshots of our mobile application:

Figure 5a describes our homepage UI and contains six different buttons. The first button 'Add To The Container' lets the user register a new container through scanning the QR code. Upon clicking this button, the user gets redirected to a page

(a) (b)

Fig. 2 Representation of (**a**) the platform and (**b**) the container

Fig. 3 Representation of (**a**) load cell and (**b**) QR code

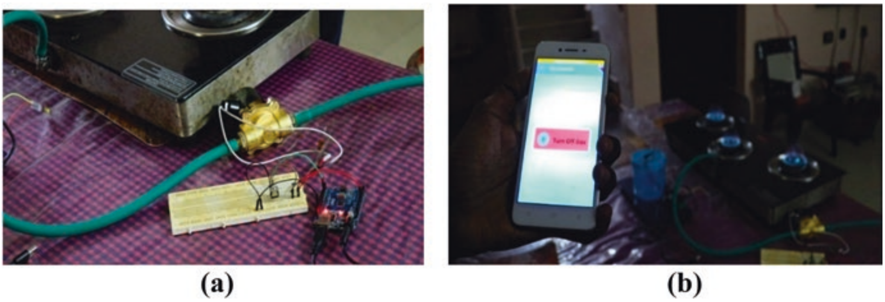

Fig. 4 Representation of (**a**) the solenoid valve (**b**) turn off button

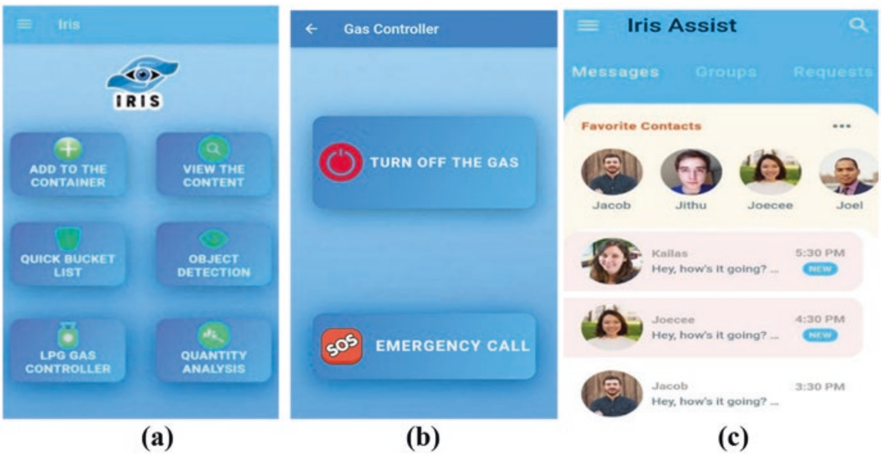

Fig. 5 Representation of (**a**) homepage, (**b**) gas controller and (**c**) Iris Assist

where the QR code can be scanned and to enter the relevant information regarding content and expiry date. Figure 5b shows the gas controller page where the user is provided with the feature to turn off gas remotely. In case of gas leaks, this button gets activated automatically. Moreover, an SOS button is also provided to tackle with emergency situations. Figure 5c shows a chat application where like-minded peers can engage in a conversation. These are the results we could obtain out of our work, and we are planning to include more features to our application such as to make a smart kitchen environment for both normal and visually impaired people.

We have made a small comparison of our work with two other works related to kitchen inventory management: We have taken two papers to compare with our system: one is called Sims system [21] and the other one is called ZigBee system [21] which is similar to the device we have made (Table 1).

5 Conclusion and Future Work

In this paper, IoT technology is mainly focused on along with deep learning. A mobile application is being developed for visually impaired to make them independent in the kitchen. A majority of visually impaired people, especially women, face many difficulties while cooking such as recognizing various groceries. They often forget to go to grocery shops, or about the grocery list, or how much grocery items

Table 1 Comparison with ZigBee and Sims system

Sl. no.	Iris system	Sims system	ZigBee system
1	Iris can be used by both normal people and visually impaired people	Sims system can only be used by normal people, and it is not blind-friendly	ZigBee system is also not blind-friendly
2	Iris uses less hardware components	Sims uses bulky hardware components and consumes more space in kitchen	ZigBee system uses many sensors and hence costlier and complex to implement
3	Iris provides security notifications like gas leak detection and SOS application	There are no security features present in Sims system	There are no security features present in ZigBee system
4	Iris assist provides live assistance to visually impaired people and aged people	There is no assistance feature present in Sims system	There is no assistance feature present in ZigBee system
5	Iris UI is designed in a manner so that people of all ages can use the system comfortably	Sims presents a very basic and old type UI	ZigBee UI is not friendly for aged people
6	Iris provides a feature for object detection	Object detection feature is not present	Object detection feature is not present
7	Iris provides a user insight on the usage of different commodities on weekly basis	There is no usage analysis feature present in Sims system	There is no usage analysis feature present in ZigBee system

are available in their home. From their testimonials, it was found that they also find difficulty in using LPG gas stove, and mostly gas leaks would occur which would lead to accidents. This system provides an out-of-the-box solution to all these problems in a user-friendly manner. The mobile application is designed in a manner for both visually impaired people and normal people for their inventory management in kitchen. By using this system, it becomes easier to shop for groceries even on a daily basis as well as to keep track of the groceries and also helps in object detection. The team behind Iris is planning to develop a smart spectacle-based system for object detection, navigation and facial recognition in the near future to make this product more effective and available for customer.

We are also planning to create a dual log-in feature for visually impaired and normal people so that normal people will be able to use a more visually appealing version of our application with improved user interface. Currently we developed a very basic UI intended mainly for visually impaired people [22–27].

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Part VII
IoT Future Research Trends & Challenges

Nemo: Energy Efficient Location Tracker for Dementia Patients Using LoRaWAN and Adaptive GPS Duty Cycling Strategies

Riboy Cheriyan, Joel Abraham, E. Sree Sankar, Sandeep Narayanan, and Reuben George Mathai

1 Introduction

Dementia is a set of chronic mental diseases in which there is a degradation of memory, thinking, calculation, comprehension, orientation, learning capacity, and other cognitive abilities [1]. Being one of the leading causes of disability and death among old people worldwide [2], dementia is expected to affect 132 million people worldwide and will account for 1.1% of the global GDP by 2050, thus posing a grave risk to global health, well-being, economy, and society in general [3].

Each patient is affected in different ways based on the impact of the disease and the physical and mental capability of the person. Apart from impairment of cognitive functions, wandering is a common symptom in much of the cases [4]. According to studies conducted by the Alzheimer's association, out of ten dementia patients, six will tend to wander posing a grave risk to the physical safety of the person and also a matter of great concern for the care givers.

2 Comparison of Existing Devices

Till date, no effective cure has been found for wandering associated with dementia. But, precautions can be taken by the caregivers to stop the dementia patients from wandering to greater distances and being lost. To aid the same, a myriad of location tracking devices specifically designed for such patients are available in the market [5].

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These devices in general consist of a small-sized battery-powered GPS module to receive a real-time geolocation along with a GSM module to relay the received coordinates to a personal device assistant or a central server. Some of them employ geofencing techniques so that an alarm is triggered only when the patient is out of a prescribed safe zone. Also, they are small, lightweight, and flexible enabling them to be easily carried by a patient. But the small and lightweight design significantly limits the size of the battery used in the device.

In general, these devices work in mainly two different modes: standby mode and a real-time tracking mode. Standby mode refers to the state of the device when it is powered on but is not receiving or transmitting GPS coordinates. The maximum battery life time experienced in this state is approximately 3 days. At the same time, if these devices work in live location tracking mode, receiving and transmitting GPS coordinates continuously such as in the case of geofence monitoring, the maximum battery life time drops to 12 hrs leading to a situation where the patient has to remove the device often to charge it.

On a closer look, one can find that the total power consumption of all these devices is heavily dependent on the GSM and the GPS modules only. In a typical location tracker, the GSM module for data transmission consumes 250 mA, the GPS module in tracking mode consumes 20 mA, and all the other peripheral devices combined consume only less than 10 mA. Thus, in a device that works on 250mAh battery, if both the GSM and GPS modules work together, i.e., at 100% duty cycle, the total battery life reduces significantly. Increasing the battery size to counter the same adversely affects the size of the device making it very difficult to be carried around.

3 Architecture of the Proposed GPS Tracker

Therefore, changes have to brought in the devices such that the most power-hungry components, GPS and GSM modules, are either replaced by power-efficient alternatives or used only when it is necessary.

3.1 Substitution of the GSM Module by Low-Power Wide Area Network (LPWAN) Alternatives like LoRaWAN

Similar to ZigBee and NB-IoT, LoRaWAN is a LPWAN communication protocol specifically designed for long-range, low-data, and low-power IoT applications [7]. Table 1 shows the comparison of existing mobile technologies with LoRa. While using a low transmission and reception current of 40 mA and 10 mA, respectively, the LoRaWAN can support a low data rate (0.3 kbps to 50kps) communication up to 6 km in urban areas and 20 km in less dense rural areas by leveraging the unlicensed

Table 1 Power consumption comparison of LoRa with mobile technologies [6]

Protocol	Transmit (mA)	Receive (mA)
LoRa	40	10
2G mobile	240	77
3G mobile	153	78
4G mobile	184	93

radio spectrum in the Industrial, Scientific, and Medical (ISM) band [8]. The network also consists of different gateways deployed in a star-of-stars topology to relay messages between end nodes and a central network server. The gateways are connected to the central network server via standard IP connections, and they act as a bridge that converts RF packets to IP packets and vice versa [9].

Currently, the existing location trackers employ GSM technology so as to obtain maximum coverage in a variety of environments. Table 1 shows the comparison of power consumption of GSM with LoRa protocol. Studies have shown that in 75% of the cases, the dementia patients tend to wander and stay within a radius of 3 km from their homes [10]. In such a case, it would be better to use low-power alternative like LoRa protocol that offers considerable range at comparatively lower power consumption.

3.2 Adaptive GPS Duty Cycling

Often dementia patients tend to be within a safe zone (e.g., their home), and one needs to worry about their current location when they are nearing or tend to cross their prescribed boundaries. Therefore, we can safely assume that frequent round-the-clock location updates are not required to ensure their safety, i.e., the GPS module can be kept in a sleep mode when they are within their safe limits and can be switched on to an active mode adaptively when they are nearing the boundary.

But at the same time, one must note that it is not advisable to keep the GPS module in sleep mode for a longer time because this will adversely impact the GPS lock time (t_{lock}), i.e., the time required by the module to calculate its current location from the location of the satellites and last known location of itself [11].

All of these can be achieved by a two-pronged methodology using a combination of geofencing, Adaptive GPS Duty Cycling and LoRa Received Signal Strength measurements as shown in Fig. 1.

1. Passive Tracking Phase: In this mode, the patient will be well within the safe zone or the geofence created. The same is ensured by measuring the Received Signal Strength of LoRa module and comparing it with a threshold value that is proportional to the radius of the geofence. For most of the time, the GPS module

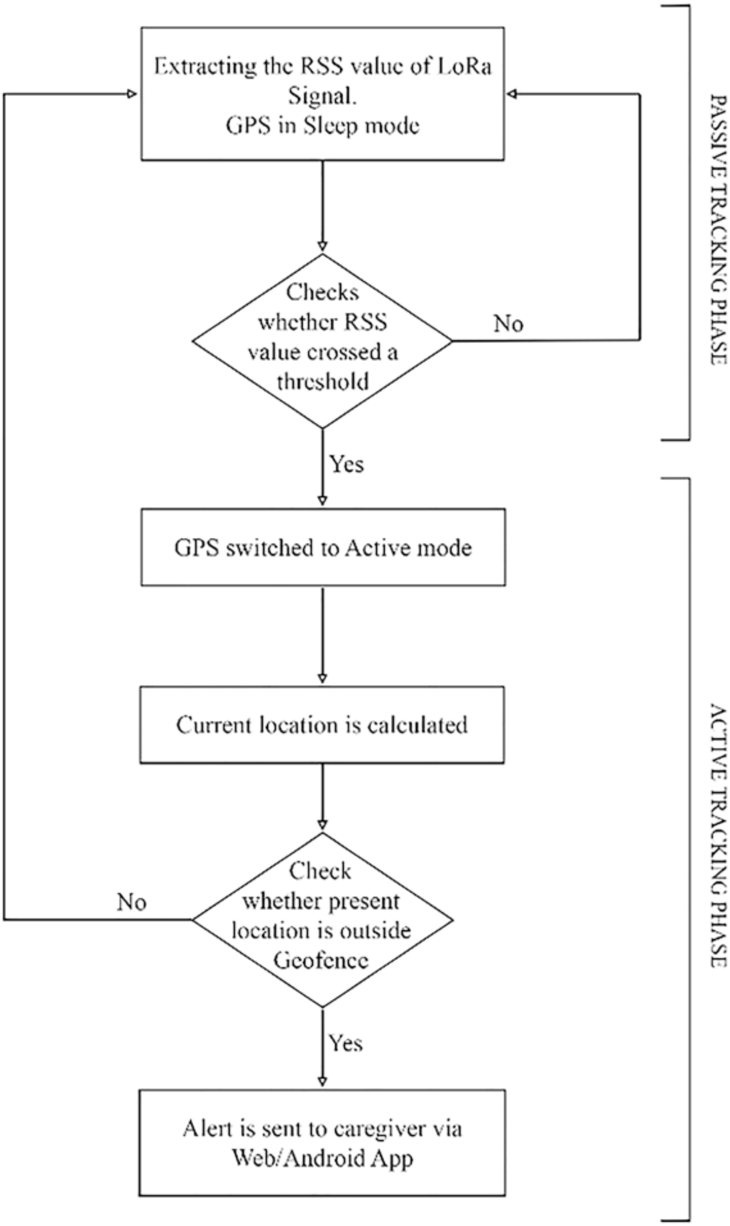

Fig. 1 The flowchart of the proposed location tracker for dementia patients

will be in a sleep mode and will be switched to active mode only periodically to update the current location.

2. Active Tracking Phase: When the patient nears the boundary of the geofence, a subsequent fall in RSS value of the LoRa device can be observed. When the RSS value crosses a preset threshold, the GPS module switches to the active mode automatically to send frequent location updates (say 20 secs) so as to enable real-time tracking of the patient.

4 System Design

Inspired by the previously mentioned observation, we propose a novel and energy-efficient LoRa GPS tracker that updates location data to a LoRaWAN server in real time. The tracker is designed compact and lightweight as a multipurpose module that can be used as a wristwatch or with a shoe.

Figures 2 and 3 show the implementation of the tracker and the LoRaWAN gateway used in our application. For prototyping purposes, we have used Arduino Microcontroller and Dragino LoRaWAN shield to develop the tracker. The shield is equipped with LoRa transceiver SX126/78 and an internally embedded GPS module that can be operated without the aid of an external antenna. The LoRa gateway that can be installed in patient's house is always connected to the Internet and is designed using Raspberry Pi and corresponding Dragino LoRaWAN Hat (Fig. 4).

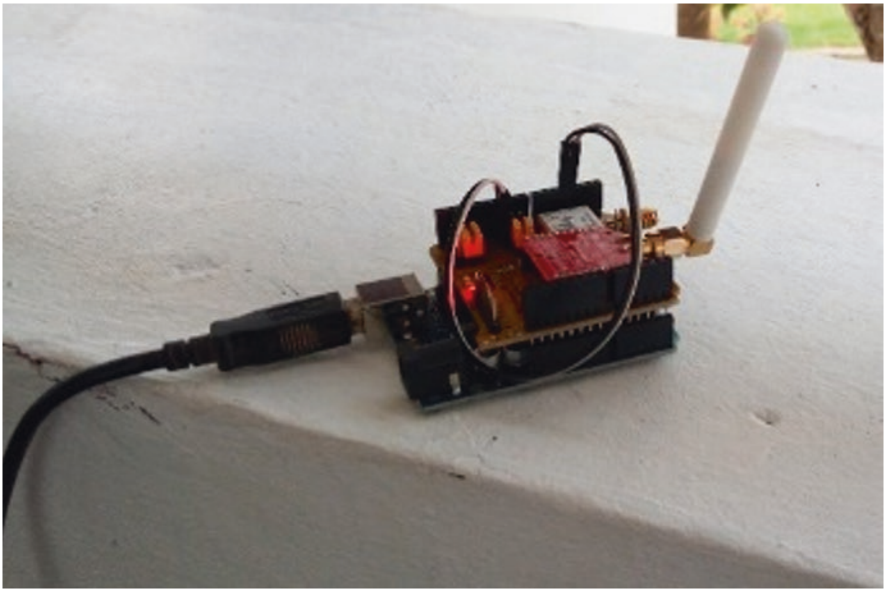

Fig. 2 The 3D model of the proposed tracker for dementia patients

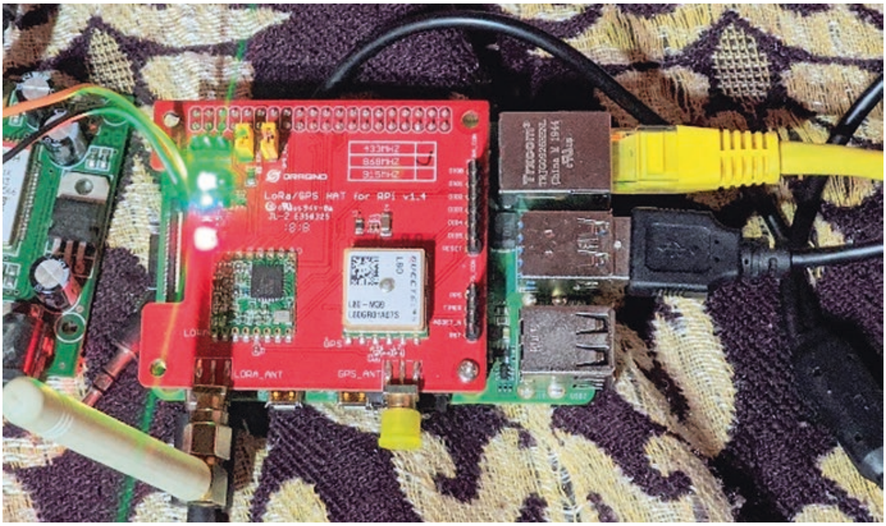

Fig. 3 The LoRaWAN gateway built using Raspberry Pi and Dragino LoRa shields

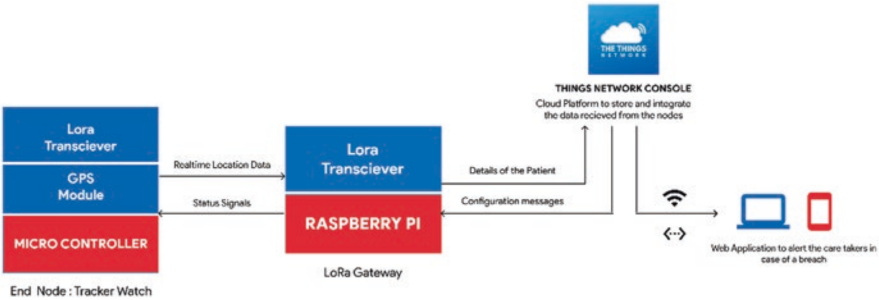

Fig. 4 Block diagram depicting the overall working of the system

An Android and web application as shown in Fig. 5 is also developed using Things Network API to give real-time notifications and alerts regarding the condition of the patient to the caregivers.

5 Range of Communication of LoRa

To assess the possible range of the tracker in a real-world environment, we tested the device at Thakazhi, Kerala, India, with a gateway placed at a location 9.XXX, 76. XXX. After setting the device to update to the base station every 5 seconds, we travelled in different directions to find out the maximum range of transmission around the base station (Fig. 6).

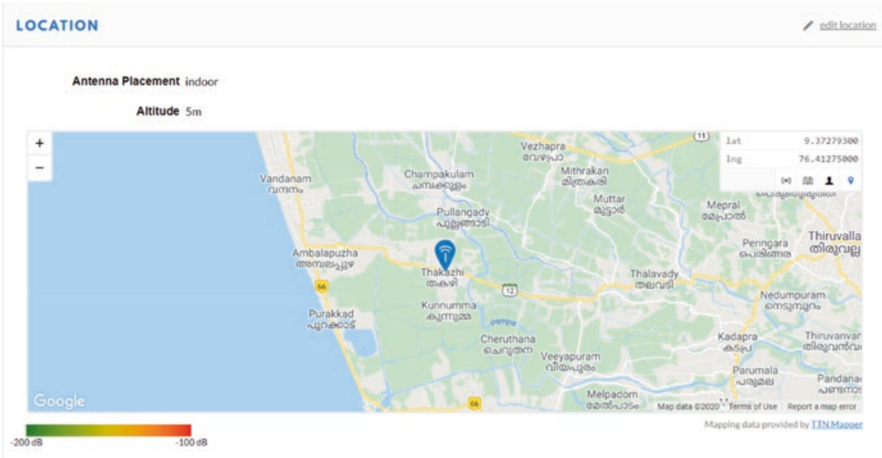

Fig. 5 Web application built using Things Network API used to track the node

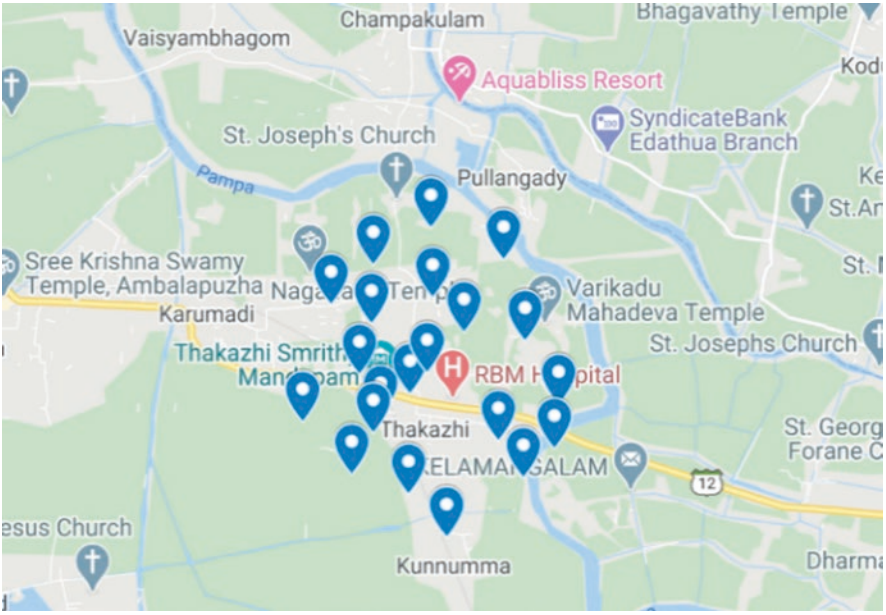

Fig. 6 Testing the communication range of LoRa device

Figure 5 is a map depicting our experimental results, with red markers portraying areas that can effectively report to the base station. Please note that in this experiment we are using a minimal gateway using Raspberry Pi and Dragino LoRa shield. In a more suburban region with a comparatively good antenna, the LoRa transmission and reception can be extended to more than 7 kms. In fact, this range of communication is more than enough for our application.

6 Sleep Interval and Energy Consumption in Adaptive GPS Duty Cycling Strategy

To maximize energy efficiency, Adaptive GPS Duty Cycling strategy is used. Let P denote the total power consumption of the wristband. If t_{sleep} and Ps are the GPS sleep (off) time and corresponding total power consumption, t_{lock} and Pl, the GPS lock time and corresponding total power consumption and Elora – the energy consumed by the device while transmitting data – we can obtain the total power consumption as:

$$P = \frac{P_s \times t_{s+} P_i \times t_i + E_{LoRa}}{t_{s+} t_i} \tag{1}$$

In order to find the relationship between lock time (t_{lock}) and sleep time (t_{sleep}), random experiments were conducted by varying t_{sleep} from 1 to 600 seconds and corresponding t_{lock} values were noted.

$$t_{\text{lock}} = 0.0017 t_{\text{sleep}} + 2.5723 \tag{2}$$

Figure 7 depicts the variation between {t_{sleep}, t_{lock}} pairs. As seen in the figure, there is a strong linear correlation between values of t_{sleep} and t_{lock} similar to observations in [6, 12].

Substituting t_{lock} with t_{sleep} in Eq. 1 and further simplifying, we obtain the total power consumption of the model as:

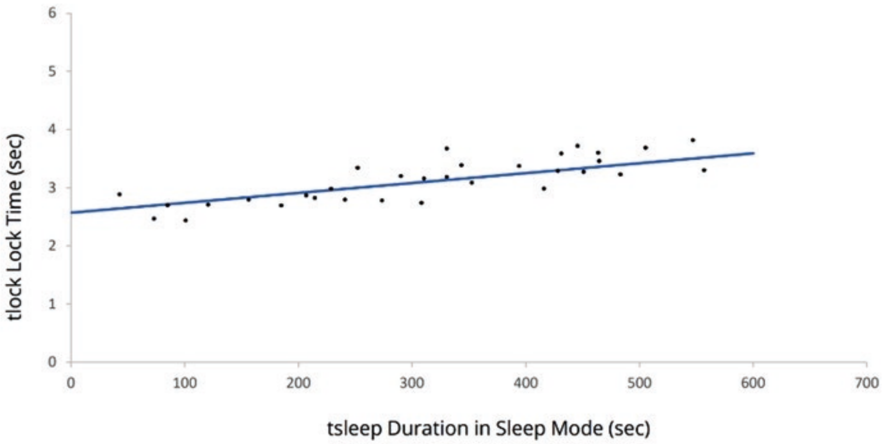

Fig. 7 Time to lock experiment results

$$\frac{1}{P-2.57} = at_{\text{sleep}} + b \tag{3}$$

Further, average power consumed at different t_{sleep} values was measured by programming the GPS module accordingly. The device was made to run in sleep mode for t_{sleep} seconds, switched to active mode to calculate and transmit the GPS coordinates, and then switched to sleep mode again for another t_{sleep} seconds and the process continues. Using the measured values, through linear regression analysis, we obtained the value of a = 0.005 and b = 0.035 (Fig. 8).

Assume S to be a strategy for duty cycling that includes a series of sleep intervals s_n, i.e.:

$$s = (s_n), n \in N \tag{4}$$

The overall device energy consumption E can be calculated as:

$$E = \sum h(s_n) * s_n \tag{5}$$

Based on the above observations, we chose two different sleep intervals based on requirements. Figure 9 shows the energy consumption pattern. In the initial passive tracking phase when the device is inside the safe zone, to conserve energy we chose a sleep interval t_{sleep} = 240 s. In the active tracking phase where the patient breaches the safe limits, the sleep interval is reduced to t_{sleep} = 20 s to send frequent updates. Thus accurate location updates can be provided at different scenarios while consuming comparatively lesser power.

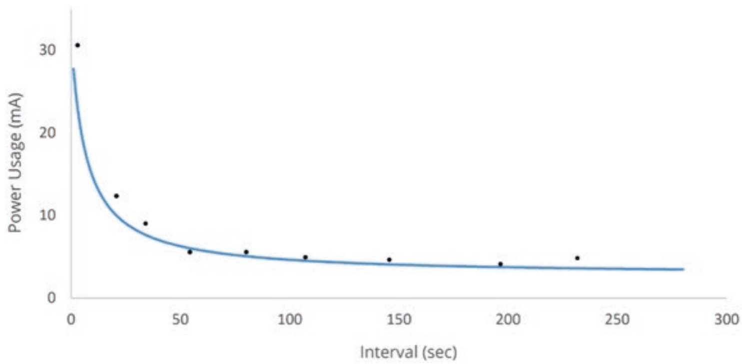

Fig. 8 Time to lock experiment results

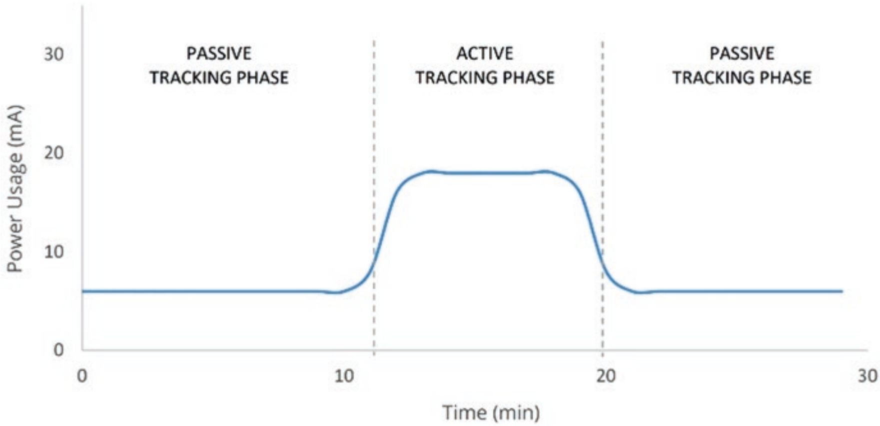

Fig. 9 Average energy consumption pattern

7 Conclusion

We have tried to demonstrate the possibility of developing an energy-efficient GPS tracker using LoRa protocol for dementia patients that has both long-range and low-energy consumption.

LoRa is just one among the numerous LPWAN (low-power wide area network) technologies used to interconnect sensors in a modern IoT (Internet of Things) environment. Since, they are the future of IoT communication, more and more base stations are incorporated [13] every now and then, and this will further improve the range of the tracker. Also, in such a case, the gateway timestamps from received packages can be leveraged to develop a GPS free geolocation, thus reducing the energy consumption further [14]. The prototype that we made is not of such a low profile due to the larger size of components, and in our future implementations we wish to reduce the size of our prototype further by integrating the LoRaWAN transceiver and the microcontroller on to a single chip.

We would also like to investigate the possibility of using onboard inertial measurement units to further track the movements of the patient and improve the efficiency of the device.

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Challenges, Security Mechanisms, and Research Areas in IoT and IioT

Deepu Job and Varghese Paul

1 Introduction

IoT is a revolutionary technology in science and technology where it has enabled automation of tasks without human intervention. IoT has emerged because of the advancement in communication technology, sensor, actuators, information technology, etc. IoT has made intercommunication of devices through the Internet or private network spreading across the cities to create smarter systems [36]. Smarter systems are built over the interconnection of everyday objects with aid of IoT devices where these devices could interact with each other and work intelligently without human intervention.

The industrial sector has adopted the potential of the Internet of Things (IoT) [1] creating the Industrial Internet of Things (IIoT) which makes it smarter, efficient, and profitable. The Industrial Internet of Things uses IoT technology to connect actuators, sensors, smart energy meters, power grids, medical equipment, manufacturing devices, robots, etc. to communicate and collect data [18]. Adoption of IoT into industry has triggered the creation of the fourth revolution of industry, Industry 4.0 [6]. In Industry 4.0 the machines, sensors, and other devices are interconnected wired or wirelessly and can communicate, act intelligently, and view the entire process production line [34].

Digitalization of the entire physical process happening in the industry will give great visualization of the entire production flow for the customers and business parties which has greatly resulted in the improvement of business in the industry sector

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[26]. The devices in the industry were already interconnected, monitored, and controlled using existing technologies like Supervisory Control and Data Acquisition (SCADA [10]) and Programmable Logic Controller (PLC [3]). Control center equipped with SCADA systems collected data from sensors and other industrial devices situated in remote locations for monitoring and proper management of industry. Integration of the Industrial Internet into SCADA has enabled interconnection of large industries.

Industrial IoT has transformed industries into smarter and profitable industries with integration of trending technologies like data analytics [24], artificial intelligence [14] and machine learning [23, 29]. Industries have to handle huge amounts of data segregated from IoT sensors and have to store this data in large cloud storage. Industries got intelligent with automation for cyberphysical systems using machine-to-machine interaction without human intervention. Interoperability, scalability, and automation were achieved with this adoption. With these benefits the industry has to face new challenges and security issues inherited from IoT. These security issues and challenges expose the industry to cyberattacks which may result in heavy losses during its operations. The research should focus on areas like data security, device authentication [35], key management, cyberphysical system security [2], etc. for Industrial Internet of Things. These challenges and issues were recently researched already in IoT over the past few years and need to address separately these issues similarly considering the requirements of IIoT.

This paper is organized into five sections. In section "Related works", the related survey works on security of IoT and IIoT are discussed. In section "IoT and IIoT's architecture", the basic architecture of IoT and IIoT is discussed. Section "Challenges and issues faced by IoT and industrial IoT" conveys the challenges and issues faced by IoT and Industrial IoT. Further section "Security mechanisms for IoT and IIoT" provides various security mechanisms involved in the IoT and IIoT domain. Finally section 6 discusses the open research security issues faced by IoT and IIoT networks.

2 Related Works

In recent years there are numerous related works discussing various aspects of IoT, and IIoT can be found in various research articles. We have primarily focused on different recent research works associated with security issues and solutions in IoT and IIoT. This section has been divided into three subsections: section "Existing survey on IoT security issues" has covered recent survey work in IoT security issues, section "Blockchain based security solutions for IoT" has covered research works proposing blockchain for addressing security issues in IoT, and section "Research work related to security issues in IIoT" has covered recent research work discussing security issues particularly in IIoT.

2.1 Existing Survey on IoT Security Issues

An extensive survey in 2019 [13] covering IoT security examines three perspectives: security threats, application area, and solution architectures. Further in the above work explains how the different upcoming technologies like blockchain, fog, edge, and machine learning could enhance the level of security in IoT. Another survey [39] analyzing the IoT platform security was found comparing different platforms provided by vendors such as Samsung, Amazon, Google, etc. IoT data security enhancing work by introduction of blockchain was proposed in another work [33]. A recent work in 2019 [19] discussed the security risks and vulnerabilities in real time. IoT devices were found and have pointed out the recent security weakness in commercially available IoT devices. In another work [16], a review of IoT security and blockchain solutions and its open challenges were discussed. Furthermore the authors have tabulated a map that contains existing attacks against solutions they have found in the literature.

2.2 Blockchain-Based Security Solutions for IoT

A recent work in 2019 proposes an efficient blockchain mechanism model for improving security and privacy of IoT, and authors have tried to implement blockchain in a smart home environment [21]. Another work discusses the use of blockchain technology and challenges in IoT [17] and further elaborates the component interactions in IoT while using distributed ledger in blockchain. A similar research article was found that discusses the possibilities of blockchain in relevant applications for IIoT and that paper further elaborates the attacks and issues faced in the Industrial IoT [32]. Another work discusses the possibility of edge computing-based design for IoT security [15] and proposed edge-centric IoT architecture. In another work, blockchain mechanism [20] for fixing the security issues in IoT was found and has elaborated briefly how the blockchain solution can be applied in various layers in IoT fixing the security issues.

2.3 Research Work Related to Security Issues in IIoT

A recent research work [25] that discussed the attacks and its countermeasures of security issues in IIoT was found. The IIoT architecture was examined in different layers, and attacks in each layer were elaborated in the work. An exclusive survey on [38] IIoT was found discussing the common security challenges and IIoT-specific security challenges. A very similar brief work [8] was found discussing recent challenges and opportunities and has suggested a cryptographic solution for the Industrial Internet of Things. Another work [7] suggests software-defined networking (SDN) to mitigate injection attacks in IIoT and has proposed a lightweight authentication scheme for solving identity among IoT devices. Another work [11] discussed the challenges found in the Industrial Internet of Things with aid of two use cases: factory metering system and natural gas metering system. A recent work [40] was found that discusses the security challenges in edge intelligent industrial IoT for storage, usage, search, and deletion of data.

All these recent research works found were unique, which have discussed the numerous security challenges and attacks in the IoT and IIoT. Furthermore few papers discussed the potential benefits of using blockchain technology in IoT and IIoT. In this work we discuss various challenges and issues faced in industrial IoT. Further we suggest various security mechanisms which are suitable for low-resource IoT devices and open up security-related research opportunities in this work.

3 IoT and IIoT's Architecture

IoT a is revolutionary technology that connects physical objects in the world to the Internet and makes these objects smart.

IoT architecture can be viewed in Fig. 1 where it has four layers: sensing layer, network layer, service layer, and interface layer. The lowest layer is the sensing layer where RFID tags, sensors, and other physical sensing devices are there to collect real-world data. Network layer is the layer that creates communication channels for sensing layers to upper layers. Service layer collects the data from the communication channel and processes it further and stores the data in the database. Application layer provides interface to end users.

IIoT architecture is slightly different from the IoT and is provided in Fig. 2. IIoT is divided into three layers: edge layer, platform layer, and cloud layer. Edge layer focuses on the collection of data from the sensors and to activate actuators accordingly. Platform layer is also known as the network layer that creates the communication channel for the above and below layers with wired and wireless technologies. Platform layer processes all the data obtained from the edge layer and then passes summarized data to the upper layer. Cloud layer is responsible for analyzing the data and planning further for the optimization of the entire process in the industry.

4 Challenges and Issues Faced by IoT and Industrial IoT

The main challenges and issues faced by the IoT and Industrial IoT are resource constraints, scalability, security issues, privacy concerns, data analytics, standardization, and interoperability.

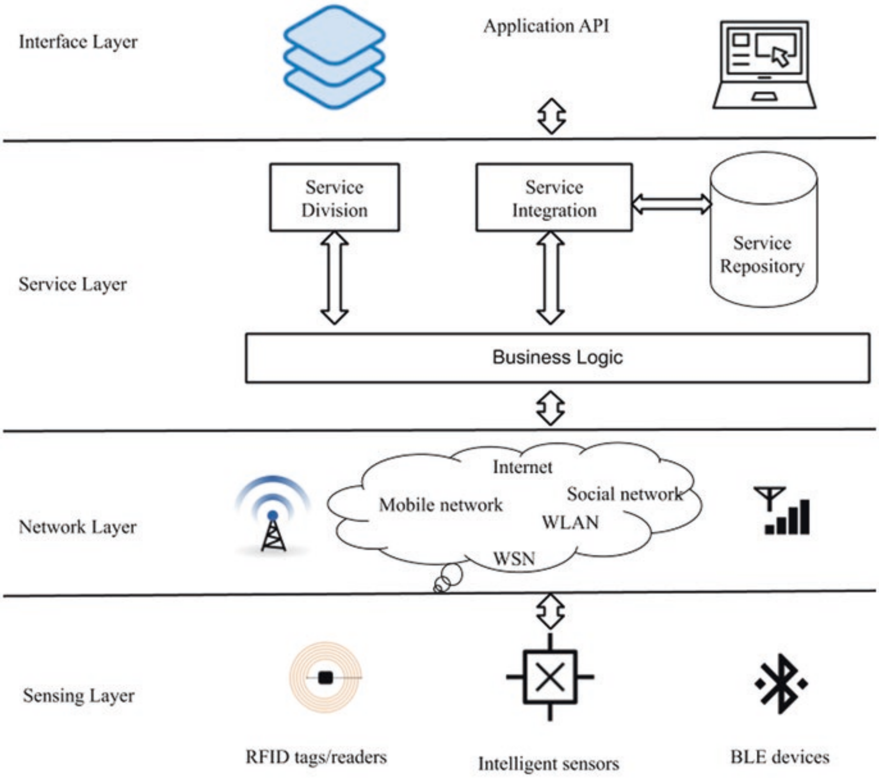

Fig. 1 Architecture of IoT and its layers: sensing layer, network layer, service layer, and interface layer

4.1 Resource Constraints

The IoT devices are built over low-resource devices with limited computational power, memory, and bandwidth and power backup [30]. The main reason for the resource constraints is to extend the battery life of the device. The manufacturers are competitive to produce low-cost devices to make maximum profit. These devices are manufactured aiming to attain minimum functionality and form factor. Inherently these devices may not have adequate fixtures to handle complicated security issues. These devices won't be able to run essential security services that we see in traditional systems. Because of these constraints, these devices won't be able to support existing network protocols and are in need of sophisticated lightweight network protocols.

The main challenge for manufacturers in developing IIoT devices is incorporating basic essential functionality sensing, controlling, and connectivity services into a small footprint even without an operating system. The other significant challenge is that IIoT devices should perform real time without any latency in their strict

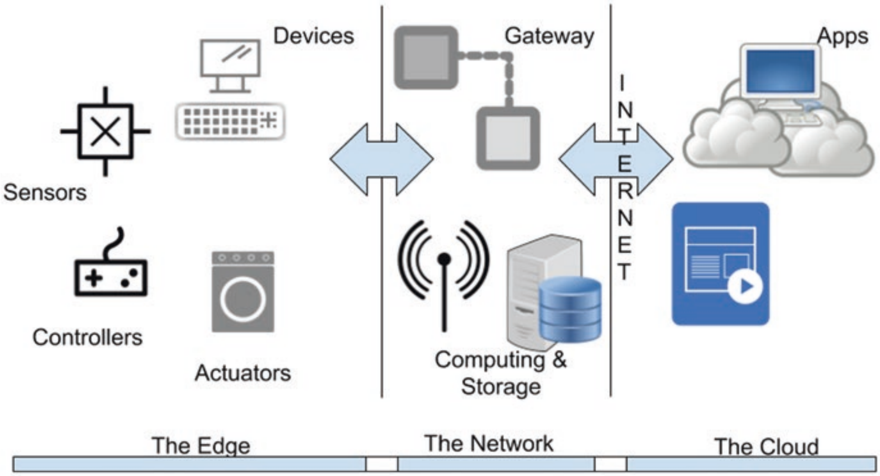

Fig. 2 Architecture of IIoT and its layers: edge layer, network layer, and cloud layer

resource constraints since most of the devices are deployed in critical industrial infrastructure. Demand and challenges for IIoT are different from IoT devices; these devices should be zero tolerance to failure and need 99% uptime. These IIoT devices need to react instantly according to events sensed by sensors, so time criticalness and reliability are yet another properties which are indispensable for IIoT devices.

4.2 Scalability

The number of IoT devices that are getting connected to the Internet is exponentially growing [27]. Cloud server architecture setup for the IoT devices is prone to central node failure, which may bring the entire network down. The scalability is a great issue, and when the number of devices getting connected increases, it will be difficult for centralized management of the entire device and network.

Scale is the most complex challenge faced by IIoT. The scale complexity handled by the IIoT devices in the industry has got multiple dimensions: the number of devices, the size of data, velocity of data, total volume of data, etc. Scale of data generated from multiple nodes in the industry is huge. Each node will be having different sensors creating data items from multiple instances. Potentially significant data should be filtered from huge data generated and need to be sent to right interested systems. Scalability factor is that many sensors are there in a node generating multiple data in each instance; the challenge is the difficulty in selecting significant data and sending it to multiple intended receivers in real time. IIoT devices and entire system architecture in the industry should be having data-centric design intelligence to manage data by actively filtering data and its delivery. The next challenge in scalability is that working on huge selected potential data items from various devices. Data needs to be monitored and analyzed thoroughly for the efficient operation of the industry.

4.3 Privacy Concerns

Privacy concerns are yet another major challenge faced by IoT devices [31], where these devices need to exchange data over existing networks which are vulnerable. The data that is being exchanged with the service provider creates yet another privacy issue. Service providers are third parties which handle these data and may get exploited or shared with other vendors for business opportunities. IIoT devices running in different locations record location-related information. The great privacy challenge faced by IIoT is that data needs to be analyzed in multiple locations preserving the data location information. Data privacy concerns are there for the data aggregated from different locations which may turn into sensitive information when analyzed.

Data generated from the multiple sources in an industry needs to be transferred, processed, analyzed, and assessed at different locations. With respect to all above stages the data has undergone, we need to preserve the privacy of the data. The privacy of data is significant in three different levels in IIoT architecture, machine level, system level, and user level and is shown in Fig. 3. In machine level data is sensed, stored, and transferred between devices. These activities and communication should not expose sensitive information and need to be secured. So as to improve the reliability and confidentiality, the machine-to-machine communication and device management need to be secure considering machine-level privacy concerns. At system level the data aggregated from machines are handled by data acquisition systems, edge IT, and cloud data center. Data acquisition system aggregates data, monitors, and controls industry. In edge IT data from the acquisition system are analyzed and preprocessed. In the cloud data center, main analytics and archive of information are done. Data in these multiple systems need to be secured and should have different privacy policies according to the accessibility needs in each. In user level, there are different categories of user, the worker, supervisor, analyst, corporate manager, researcher, etc. Proper data access level policy and user authentication techniques are required to address privacy concerns in the industry.

4.4 Security Issues

New security vulnerabilities and exploits are growing together with the number of IoT devices getting connected with the Internet [28]. Devices which are manufactured and programmed vulnerably could easily be compromised by hackers and could compromise the entire system. The manufacturers are competitive to reduce

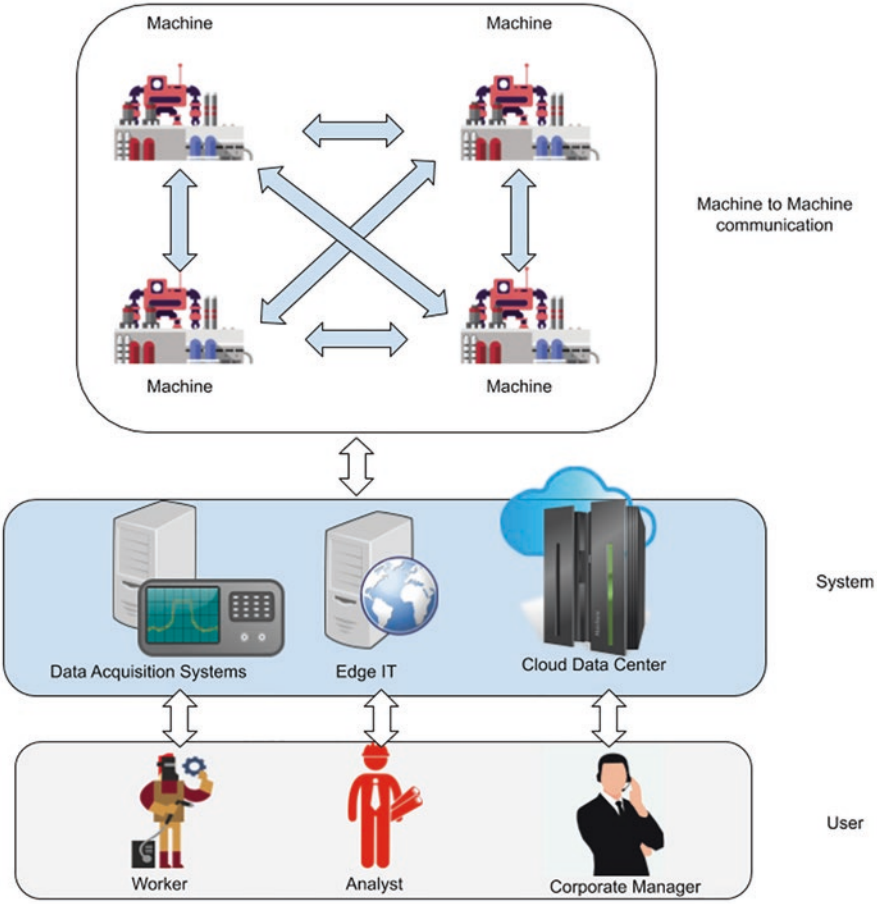

Fig. 3 Data privacy levels in IIoT architecture

the cost compromising the essential security requirements, and they go ahead with limited resource devices which could run the essential services. This in turn makes the device further difficult to maintain in the future. Security is so crucial in IIoT and needs to be integrated into the core architecture. To enhance the reliability of the IIoT devices, security is vital to mitigate attacks. The main security challenge for IIoT devices is the difficulty to implement proven security encryption techniques in resource-constrained environments. Hardware resources won't be able to run complex encryption and decryption techniques to send data securely.

Security issues have to be considered at multiple levels in IIoT as shown in Fig. 4. Security issues in physical devices, communication protocol, analysis, archiving, monitoring, and assessing levels are to be treated separately according to the requirements. Another security challenge in IIoT is the authorization and authentication of users and devices. Devices getting connected into the network should

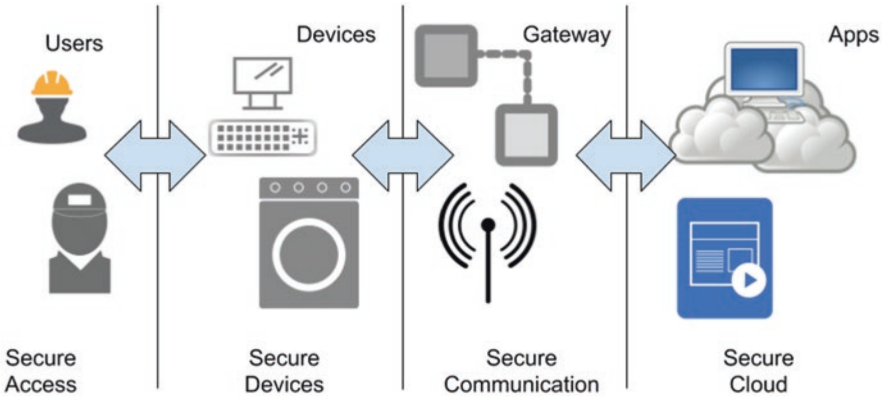

Fig. 4 Security issues at multiple levels in IIoT architecture

establish the identity using proper cryptographic mechanisms. Users accessing applications and other series must provide credentials to prove their identity. Each authentication should determine which services are being subscribed to access.

4.5 Standardization and Interoperability

Interoperability capability of IoT devices makes themselves sustainable to communicate among themselves [9]. The connected devices could communicate using mutually understandable protocols and encoding standards. Few manufacturers who are cunning are reluctant to manufacture interoperable IoT devices among other vendor devices seeing business advantages. These manufacturers create IoT devices which could work with the same brand only and makes consumers difficult to switch between vendors. Consumers are forced to lock in using single vendor products which are only interoperable among themselves. Industry has adopted IoT technology to work smarter and effectively. There are greater interoperability challenges in industry for the integration of IoT technology. In industry different sections would have been developed in different time periods and by different vendors. Making these sections to communicate and interact is a great challenge. The interfacing of these can be achieved by standardization of interfaces and communication protocols. Data communication at different levels depending upon the interaction type in IIoT is shown in Fig. 5.

Industries need to expand over time according to demands by adding devices from different vendors. These expansions will be costly if the industry doesn't have interoperable devices. Without much investment in the software and hardware changes in the industry, they need to grow with these adoption of new devices. Most of the time when new devices from different vendors get connected, there will be compatibility issues because of lack of standardization. Certain manufacturers

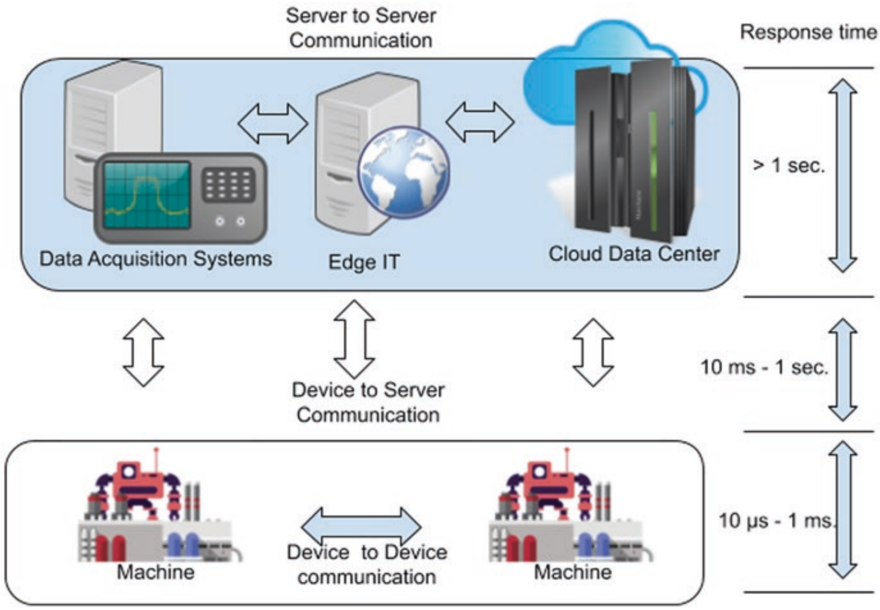

Fig. 5 Data communication at different levels depending upon the interaction type in IIoT

produce devices without need of industry standards so as to reduce the cost and for performance improvement. This creates a bottleneck for various industries later during the expansion.

In industry IoT the interoperability challenges shall be addressed in three different levels, namely, device level, network level, and data level. The low-resource device used in IIoT shall be able to interact with each other by incorporating all essential communication protocols. Various communication protocols exist in IoT devices at different levels depending upon the interaction type and are, namely, device to device, device to server, and server to server communication. MQTT, DDS, AMQP, OPC, etc. are such communication protocols that can be adopted for IIoT devices.

4.6 Data Analytics

There is a great challenge in analyzing that data generated by Industry IoT devices. The networks in the industry will be having heterogeneous devices working in various environments spread in different geographical locations sensing real-time data that needs to be analyzed and further need to take action accordingly. Data generated needs to be filtered dynamically and added to analyzed quickly for real-time response. There will be thousands or lakhs of devices with many sensors to generate huge volume of data values. The data inflow volume for analysis will be very large and the need to analyze those is a great challenge in industry.

Smartness and efficiency of the industry depend highly upon the valuable outcome obtained from the analysis of data procured from IIoT devices. Industry needs big data analytics techniques for the predictions and for the smart decisions. Working on big data needs huge computation horsepower and large storage volume requirements. Industry needs to store historical data as much as possible for most precise predictions in the future.

Effective analysis on data in the industry will lead to production efficiency. Real-time analysis of monitoring data reduces downtime and industry could mitigate critical failure. With proper analysis on data it will guide predictive maintenance of machines and devices in the industry. The three main concerns on analysis of data in industry are security of devices, volume of data,and malfunctioning of faulty devices.

5 Security Mechanisms for IoT and IIoT

This section provides various security mechanisms involved in the IoT and IIoT domain. The security mechanisms are very essential to provide essential security traits that are authorization, confidentiality, integrity, and trust in IoT and IIoT devices.

5.1 Authorization and Authentication Protocols

The devices involved in IoT and IIoT networks need to handle three kinds of authentication: user authentication, device authentication [37], and data authentication. Authentication can be achieved using cryptographic authentication techniques. There are many lightweight authorization protocols. A lightweight authentication protocol should have the following traits: minimal cost for communication, minimal computational power, minimum size for storage, and no trusted third-party devices.

5.2 Essential Encryption Standards Using Lightweight Cryptography

Encryption is the most essential security mechanism to ensure confidentiality and integrity of data sent over a network. Confidentiality is the preservation of secrecy of messages sent through the communication channel. Integrity of the messages ensures the message sent over the channel is unaltered at the receiver end. So as to

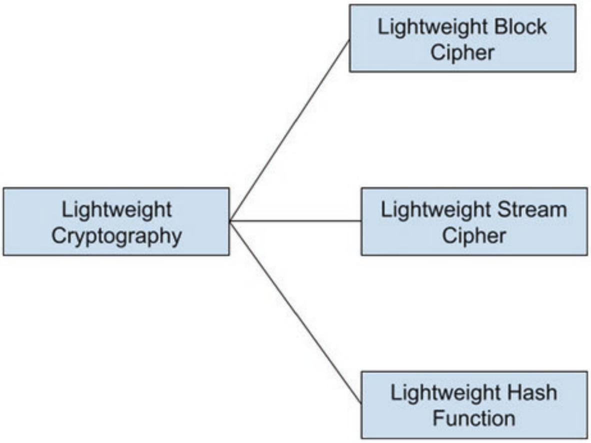

Fig. 6 Lightweight cryptography and its subdivisions: block cipher, stream cipher, and hash function

ensure the confidentiality of the message, it is converted to ciphertext using encryption algorithms either symmetric key or asymmetric key algorithms. Integrity of the messages is achieved by generating hash values using a hash function algorithm. Essential lightweight cryptography and its subdivisions required for IoT and IIOT are shown in Fig. 6.

Low-resource devices [22] are resource-constrained devices with limited computational power, small memory, and limiter power backup. So as to ensure data security in low-resource devices, data encryption is needed. Conventional ciphers are not suited for these devices and need lightweight ciphers designed for low-resource devices. The lightweight ciphers need only minimal computational power and memory size to provide adequate security. Ciphers that are involved in encryption are classified further into symmetric key and asymmetric key encryption. Asymmetric key encryption is encryption that uses different keys for encryption and decryption processes which are high in demanding computational power and are expensive in implementation. Symmetric key ciphers are best suited for low-resource devices that are again subdivided into block ciphers, stream ciphers, and hash functions.

5.3 Hardware Security

IoT devices that are deployed in the field will be in remote locations with low level of protection and are vulnerable to side channel attacks or further for physical tampering of the device or for spoofing. Security of those remotely deployed devices in the industry is very significant.

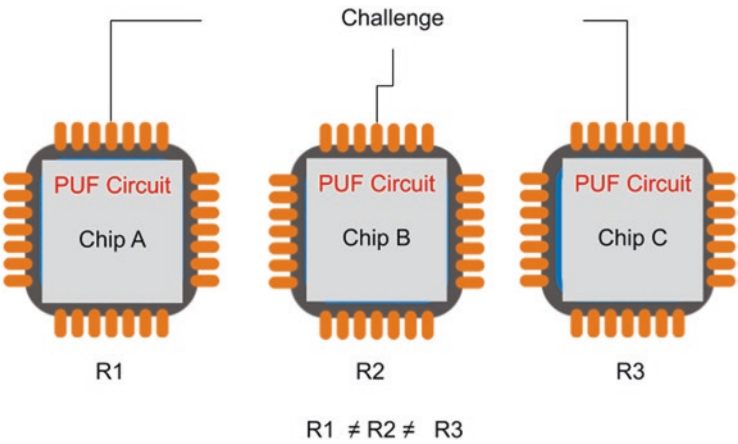

Fig. 7 Physical unclonable function concept

The physical tempering of the drives shall expose the digital key stored in the system at the time of deployment which is used for further communication of the devices. The device spoofing should be avoided using proper techniques such as physically unclonable functions (PUFs) [4]. Adoption of PUFs in the IoT devices will improve the hardware security significantly. PUF [5] function utilizes the unique physical properties of the device at time of fabrication of the chip which generates a unique signature for the device and is shown in Fig. 7.

So as to mitigate side channel attack in IoT devices, the service in IoT should include randomness in the instruction cycle. These randomness in instruction cycles are used in cryptographic algorithms to avoid side channel attacks.

6 Open Research Areas in Security of IoT and IIoT

This part discusses the open research security issues faced by IoT and IIoT networks where researchers have to give more importance to improve the security.

More focus has to be given to lightweight algorithms aiming efficient key deployment techniques in the low-resource IoT devices and key management techniques. The key should be loaded into the device at time of initial deployment, and it could be updated further during the working period. Lightweight key management techniques have to replace conventional systems.

Application-specific data control mechanisms have to be developed according to the requirements. In particular cases the data integrity and confidentiality is to be given more significance. In other cases such as healthcare system, data access control has to be given more importance while handling sensitive and personal data.

Novel cryptographic lightweight protocols have to be evolved addressing the vulnerabilities and specific attacks in IoT devices. Network scanning and routing loop attacks have to be mitigated by developing proper lightweight protocols. Denial of service and distributed denial of service attack have to be mitigated by proper development of attack monitoring and detection systems.

Devices that are compromised or attacked or malware affected have to be identified immediately and have to be powered down so as to avoid further propagation of compromising of devices in the network. These kinds of security schemes have to be developed so as to mitigate attacks by malware.

The need to develop security schemes emphasizes on secure fog [12]-based architecture which reduces the computational overburden for low-resource devices and in turn reduces the latency. In the above scheme the majority of data processing is to be done in secure intermediate fog systems rather from low-resource devices.

Developing industrial-level security standards is to be followed by the different vendors who supply IoT devices. Industrial-level security standards should maintain the high security and reliability of IoT systems while working in an industrial environment. Secure data handling techniques for the data communication with cloud systems. The cloud system interaction includes the communication and storage in the cloud and is to be secured. Develop systems that could avoid trust on the third-party cloud systems. Attack prevention systems have to be developed for application specific attacks on smart factories, smart power grids, and healthcare systems.

7 Conclusion

IoT technology has revolutionized and is rapidly getting accepted in a wide domain because of the business advantages and smartness it brings into the system where it gets integrated. Vulnerability is inherited into these domains which accept IoT technology and are prone to attacks which have attracted the security research community into it. Likewise IoT is greatly adopted in industries because of great usefulness making Industrial IoT.

In this work various challenges and issues faced by IoT and IIoT are discussed. Further it looks into the possible security mechanisms that can be used for enhancing the IoT and IIoT. At the end of the section the discussion opened up research areas in security of IoT and IIoT networks, where various latest technologies like blockchain, fog computing, and data analytics techniques could be used to resolve the issues.

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IOT in Marketing: Current Applications and Future Opportunities

Rishi Dwesar and Rachita Kashyap

1 Introduction

Internet of Things (IoT) is revolutionizing the world around us. A recent report from International Data Corporation (IDC) estimates that by 2025 there will be more than 40 billion IoT-based devices, or 'things', which will generate approximately 80 zettabytes (ZB) of data [1]. What makes IoT specifically exciting is that it brings intelligence to physical products, thereby making them interconnected and smart [2].

There are myriad applications of the IoT which ranges from wearables, consumer durables, smart homes, automobiles and industrial automation among others [3]. IoT can benefit numerous industries and society as a whole in myriad ways [4]. IoT is actively being applied in heart-monitoring implants, electricity distribution systems, automobiles, consumer electronics, biochip transponders on farm animals, in search and rescue devices and smart thermostat systems and washer/dryers that utilize Wi-Fi for remote monitoring [5, 6].

Though IoT has various promising applications, it is relatively novel and yet to usher the mainstream technology transformation across fields. In this chapter, we discuss some existing applications of IoT in marketing, how IoT can transform marketing in the future and possible untapped applications of IoT which may benefit by linking and leveraging other technologies and some of the challenges and pitfalls associated with IoT.

IoT is increasingly becoming essential for organizational innovation, adaptation and success, especially for firms with high amounts of connectivity, network and data [7, 8]. Organizations are gradually finding newer ways to adopt and leverage

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IoT across various marketing functions, particularly in the relationship-oriented activities that engage in customer relationship management (CRM), customer co-creation, automation and analytics. The developments in the field of IoT are changing the rules of marketing, and marketing is an inflection point in this new IoT era.

Many companies which have built IoT-led capabilities are now at the forefront of IoT revolution and increasingly launching IoT-driven marketing solutions and products. Many of such solutions involve interconnected smart things and inter-operation capabilities, focused on improving customer-firm relationships and enhancing integrated marketing systems.

2 IoT Definition and its Components

Osseiran et al. (2017, p.84) define Internet of Things as 'a system of interconnected devices, mechanical and digital machines, objects, animals, systems and services that rely on the autonomous communication of physical objects within the existing internet infrastructure. These devices have unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction' [9].

While more operationally, IoT can be defined as an advanced automation and analytics system which exploits networking, sensing, big data and artificial intelligence (AI) technology to deliver complete systems for a product or service. In other words, IoT is connecting everyday things embedded with electronics, software and sensors to the Internet, enabling them to collect and exchange data.

IoT consists of various components, some of which can vary depending on the application for which IoT is being used. Nevertheless, some of the components are necessary for the IoT to be considered IoT and not just another network, and this includes a physical device which has a *sensor* and a signal transducer and another device containing signal transducer with which the former device communicates. In reality, IoT applications are made up of numerous elements (including devices, network, software, user interface, etc.) which are designed and interconnected based on a specific architecture. Before we discuss a use case of IoT, let us understand some of the components that make up majority of IoT products (refer to Fig. 1).

1. **Sensors and Actuators:** These are the primary components which make up the IoT devices. Sensor is a device which detects or measures a physical property and records, indicates or otherwise responds to it. There are many different sensors which can be part of IoT applications, such as sensors measuring temperature, humidity, weight, light, noise and many others elements. Figure 2 lists some of the commonly found sensors in IoT devices. The sensor technology is quite developed today, with most of the sensors available at a low price, in miniature form, low on energy consumption and with high precision accuracy. While actuators are devices that make something move or operate, actuators are usually driven through electric or mechanical means and mostly controlled by a software.

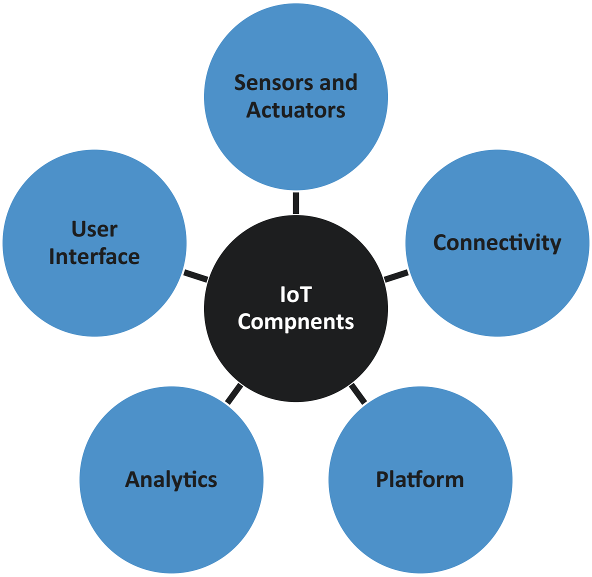

Fig. 1 Components present in common IoT applications

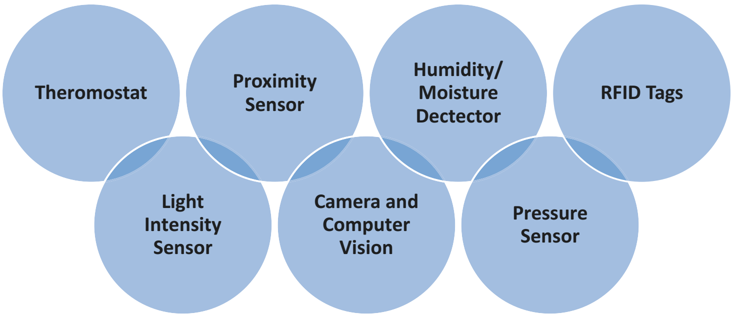

Fig. 2 Common sensors found in IoT devices

A simple example of an IoT-based firefighting device (see image above) explains how sensors, software (control centre) and actuator work in sync with each other.

2. **Connectivity:** The second vital component of IoT is reliable connectivity. IoT connectivity is largely driven by wireless connectivity, including cellular, broadband and optical technologies. A key role is played by low power Wi-Fi transmitter which is present widely in the IoT devices and has taken over initial ZigBee technology which was suitable only for short-range connections. Another important element in the connectivity grid is the unique identifiers (UIDs) which are allocated to specific elements and are the cornerstone of the connectivity.
3. **Platform:** The data collected through sensor(s) need to be stored and processed to make IoT useful. IoT predominantly uses cloud-based platforms, which pro-

vides interconnectivity to the IoT user and to the service provider (product or service) in majority of the applications. Platforms are also responsible to keep the data secure, organized as per predefined design, and process it as per the requirement. Usually the platform receives and sends the data through application program interface (APIs). There are many commercial platforms available today which are specifically designed for IoT applications.

4. **Analytics:** What makes IoT smart is the analytics capability which can be integrated into IoT devices and actions can be taken automatically based on that. The analytics capability of IoT is paramount and is increasingly becoming the main differentiator. It has added value and capabilities to the use of IoT across different applications and is one of the primary reasons for the growth of IoT usage in the recent years. However, even today the analytics capabilities of IoT systems vary largely, which ranges from ability to provide basic insights or statistics (e.g. daily average temperature at a remote location) to advanced problem-solving capabilities (e.g. facial recognition based entry, attendance and payroll management). IoT applications are increasingly leveraging on advanced AI and machine learning skills, computer vision and other advanced technologies. The analytics which makes IoT smart has made IoT applications synonymous to 'Smart Devices'.

5. **User Interface:** UI provides effortless access to information and allows the user to provide necessary instructions to the IoT systems. Also referred as front end, it usually comprises a touch display with some inbuilt operating system. Although IoT applications can have a standalone display and interface, they mostly use apps and web-portals accessible on mobile phones and computers to lower the cost and make the IoT applications easily accessible. However complex the IoT system might be, it is paramount that the user interface is easy to use, free of any bugs, and provides necessary functionality

To illustrate how IoT-based applications can transform life, the example below (see Fig. 3) illustrates a possible application of IoT which promises auto-replenishment refrigerator and groceries in the kitchen. The figure below showcases how a smart refrigerator and kitchen cabinets, fitted with a camera, Wi-Fi transmitter and other sensors, can detect the items in the refrigerator and give the user the option to auto order these items from the connected retailer. The connected retailer can then send these items at the time preferred by the customer, giving utmost convenient. Though not illustrated below, using AI the retailer can also keep track of the items usually ordered by the customer, frequency of consumption, etc. and suggest offers, products and brands based on the customer's consumption patterns. Similarly, a healthcare company can track the eating habits of customer and suggest healthier eating options which are low on calories and more nutritious.

In the next section we discuss some of the existing consumer, industrial products and marketing applications leveraging IoT.

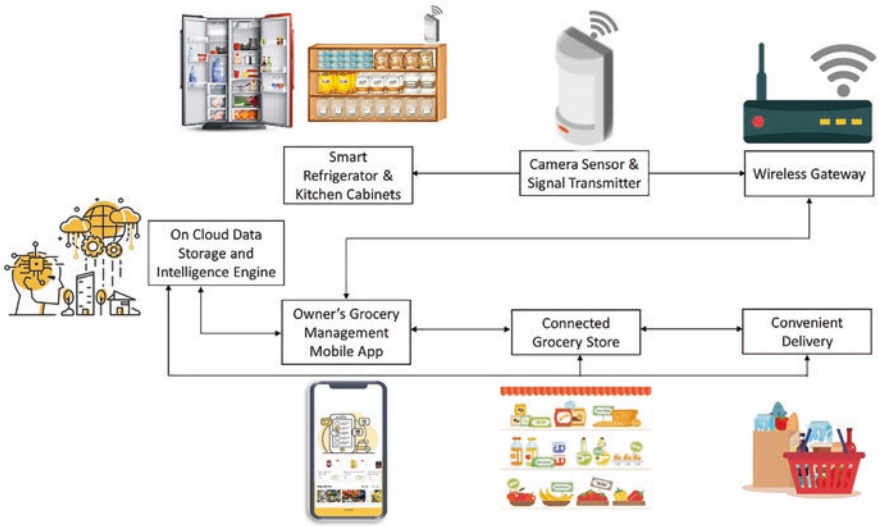

Fig. 3 Illustration of IoT enabled Auto Replenishing Refrigerator and Kitchen Cabinets. (Source: Created by Author)

3 Current Applications of IoT in Consumer Products and in Marketing

IoT provides endless opportunities to marketers. It enables marketers to provide product and service solutions which were untapped or difficult thus far and to brands to listen and respond to the needs of customers – with the right message, at the right time, on the right device and to device products which provides solutions. There are many consumer products already available in market and a myriad new products and services are being added every year. We first discuss some of the IoT-based products already present in the market and later present some of the possible applications of IoT, specifically for marketers.

1. **Smart Speakers, Personal Assistants and Smart Homes:** You got it Right! There are many smart speaker-based personal assistants widely present in the market like Google's Home, Amazon's Echo and many others. These devices are not only capable of acting as a personal assistant to you or play your favourite music but can also manage and control other connected IoT devices. Studies show that Nest, a personal assistant and home management IoT device, was able to save 10 percent on heating and 15 percent on cooling by controlling the devices based on the thermostat sensor [10].
2. **Home Appliances with IoT Capabilities:** From coffee makers and air conditioners to refrigerator, home appliances are increasingly being introduced with IoT capabilities. Although majority of IoT-based home appliances largely offer basic IoT functionality like ability to control the device remotely, scheduling and

basic integration with other IoT devices such as a personal assistant [11], nevertheless, marketers are eager to implement wider solution (such as auto-replenish fridge) as more consumers adapt technology and industries are ready for integration.

3. **IoT in Automobiles:** Automobile has been one of the most promising consumer products, when it comes to IoT capabilities. From IoT infused semi-autonomous cars to cars which can automatically update the dealership and owner about specific repair or maintenance well in time, premium and luxury automobiles have already introduced IoT in their various car brands. Moreover, all the software in the car are now mostly updated and fixed remotely 'over the air', another capability brought forward by IoT.
4. **IoT-Driven Customer Service:** Though nascent as compared to other IoT applications, use of IoT in customer service is increasing manifold. A recent survey by Harvard Business Review Analytic Services revealed that for 58 percent of business leaders, improving customer experience was the most important factor for adopting IoT [12]. From smart chat bots on websites and mobile apps to magic bands which can pay for food and unlock rooms, IoT in customer service is helping companies to deliver superior and seamless customer experience. The technology makes it possible to resolve many of the customer complaints automatically and gives companies opportunity to be available 24x7.
5. **Smart Medical Devices and Healthcare:** The medical and healthcare industry has been one of the early beneficiaries of IoT. Specifically, the remote monitoring capabilities of IoT have been a blessing for all: the patient, caregivers, physicians and hospitals. The ease of interaction and monitoring by doctors has increased patient engagement and led to more satisfaction. Remote monitoring has also led to reduction in the length of hospital stay, resulting in cost savings.

4 IoT and Associated Technologies

The transformation of IoT is associated with many other technologies which are either part of IoT or are related with it. The Gartner Hype Cycle (see Fig. 4) showcases some of these technologies, their current stage on the Hype Cycle and the duration in which they might reach to a plateau. As we can see, most of these technologies were at innovation trigger stage in 2016 and expected to stay for at least 5 to 10 years. New technologies primarily driven by IoT, like 'Things as Customers', are expected to further revolutionize and enhance the application of IoT. Simply put, things as customers is the ability of 'things' to behave like 'customers'. As IoT-based devices become smarter, they would be able to digitally transact (buy, sell or rent) on their own, at the discretion of the owner. Just imagine, a dishwasher being able to tell the manufacturer that it is due for service, based on the number of hours it has been used over the last year or the wear and tear it has undergone due to some heavy load it handled in the last month. Thus, things will become customers and act on the behalf of the actual customers.

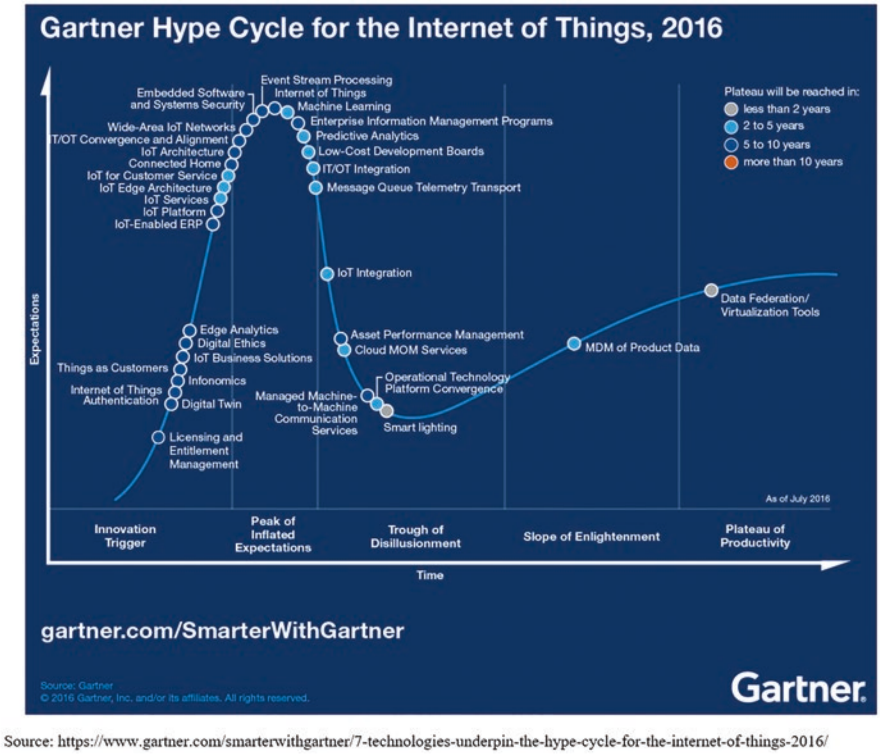

Fig. 4 Gartner Hype Cycle for Internet of Things, 2016. (Source: https://www.gartner.com/smarterwithgartner/7-technologies-underpin-the-hype-cycle-for-the-internet-of-things-2016/)

Similarly, through IoT-enabled devices, the companies will have the ability to collect a lot more specific data about the customer and look more closely to their day-to-day activities, such as purchase preferences, and they would be able to create a ‘digital twin’. A digital twin is a digital representation of a physical object or human, which can be used to run simulations very close the real-world scenarios. Thus, the digital twin can help companies to predict the types of purchases the customer is likely to make and suggest the same to the customer or the IoT device just at the right time. Both ‘things as customers’ and ‘digital twin’ are new innovation triggers and likely to become mainstream in a span of 5 to 10 years.

5 Relationship Between IoT and Artificial Intelligence with Specific Focus on Marketing Applications

IoT needs AI to unleash its full potential in marketing applications [13]. AI is defined as a system's ability to correctly interpret external data, to learn from such data and to use those learnings to achieve specific goals and tasks through flexible adaptation [14]. In other words, AI is group of systems and algorithms that think like and act rationally like humans. It is predicted that around 80 percent of industrial IoT projects will as well deploy AI capabilities by the year 2022, whereas the figure was mere 10 percent in 2017 [15].

A recent survey conducted by IBM [13] revealed that around 19 percent of high-performing CXOs (of 3000 CXOs which were part of the survey) are planning to leverage augmenting IOT and AI to achieve more benefits. Companies are increasingly using customer data and analysing competitors. They are capturing IoT sensor data and leveraging to innovate new and improved products and services. Many companies have realized that full potential of IoT can be realized by integrating it with AI and are using this opportunity to reinvent their business models. Moreover, there are many other triggers which indicate that IoT and AI will together influence our lives soon [16]. Some of these include increased venture capitalist funding of AI-focused IoT start-ups; IoT-based platform vendors such as Microsoft, Oracle, Cognizant, GE and IBM are expanding their AI capabilities.

The manner in which AI (with the help of machine learning) can swiftly bring in insights and support decision-making from data makes it a perfect companion of IoT. Machine learning algorithms can be used to create a lot more value from the data smart sensors (part of most IoT applications) generate. Using machine learning marketers can automate pattern identification and detect anomalies automatically. Just envision a water purifier with IoT capability, which can automatically sense the wear and tear of reverse osmosis cartridge and informs both the company and customer in advance, thus preventing unplanned downtime. Moreover, AI technologies such as speech recognition and computer vision can help to pass on instructions in a secure manner to IoT devices. Thus, the marriage of AI with IoT can increase operating efficiency sporadically and help companies to spawn new products and services. Below are some of the use cases of how IoT systems have leveraged the power of artificial intelligence:

1. **Improving and Enhancing Current Consumer Products:** Over the last decade, and specifically in the later part of it, many existing products have leapfrogged in their capabilities. Smart thermostats, connected coffee machines and intelligent cars are just among a few of hundreds of many products transformed by IoT.

2. **Commercial Fleet and Cold Chain Transport Management:** With the use of IoT and AI-enabled monitoring, commercial fleet and cold cargo becomes intelligent. The sensors provide oversight capabilities and can send timely alerts in case of any potential theft, damage to packaging, delay, increase/drop in

temperature, etc. Such applications largely depend on global positioning system, camera, proximity and tempering sensors and allow companies to monitor, locate and address any potential errors quickly [17]. Application of IoT in cold chain cargo management allows temperatures to be measured and maintained to exact degrees and controlled depending on the accepted norms for any given cargo. In case of any irregularity, such systems generate alerts, based on which the driver and other parties can take corrective action well on time. Thus, IoT and AI together are reinventing the manner in which fleet of planes, trains, trucks or automobiles is being managed. Companies such as Cloudera report that their IoT and AI powered fleet management solution 'Navistar' has cut downtime for fleet vehicles up to 40 percent [18].

3. **Enabling Predictive Maintenance:** With the help of IoT and analytics, companies can now predict equipment failure ahead of time and schedule orderly maintenance. This helps to reduce costs by reducing downtime and help in mitigating any possible losses which may arise due to overuse. Furthermore, it is now possible to identify patterns across data and predict possible machine failure well in advance using machine learning. In a recent study, Deloitte reported that with the help of predictive maintenance companies are able to reduce the maintenance time by 20–50 percent and increase equipment availability and uptime by 10–20 percent, leading to reduction in overall maintenance costs by 5–10 percent [19].
4. **Helps in Reducing Risk:** A number of organizations are reaping benefits by deploying applications pairing IoT with AI which enable them to better understand and predict various risks and take necessary corrective actions automatically. These applications are not only capable of reducing financial losses but can also prevent physical and human catastrophes. The applications range from cybersecurity, insurance and property management and agriculture to aviation and marines. For example, General Electric's latest locomotive uses around 250 sensors which can measure up to 150 thousand data points per minute. The data collected helps in enhancing on time performance, safety and locomotive uptime and increases overall longevity [20]. Some other use cases include detecting fraudulent behaviour in the banking and financial services sector, deriving insurance premiums based on driver's driving style and using data to know the condition and quality of the concrete as it cures in a moving concrete mixer.

5. **Enhancing Production and Operational Performance:** With the help of real-time data from interconnected devices and predictive analytics, it is not possible to speedily deploy lean manufacturing, leading to improved performance and reduction in costs. In words of Stefan Ferber, Vice President at Bosch, 'The Internet of Things allows for a new way of organizing industry production: by connecting machines, warehousing systems and goods, we can create smart production systems that basically control each other without requiring any manual intervention' [21]. With the help of IoT, manufacturers can accurately measure the time taken for a machinery to start, duration for which it is in operation and frequency (and often reason) of interruptions in the machinery. With the help of machine learning, this information can provide useful and pre-emptive insights

to plan production better and enhance operational efficiency. This often makes IoT enabled manufacturing superior, as large volume of multi-layered data is leveraged to detect patterns, otherwise difficult to gauge and invisible to the human eye.

6. **Reduces Unplanned Downtime:** As already discussed, IoT applications with AI capabilities are exceptionally useful in reducing unplanned downtime. These capabilities are specifically critical for remote manufacturing and installation such as offshore oil and gas extraction, solar and tidal power plants, etc. As unplanned downtime can lead to severe economic losses, such fields' use of IoT in this field can led to significant savings [22].
7. **Probes Counterintuitive Insights**: Interestingly, IoT-driven machine learning algorithms have revealed contradictory findings when compared to standard practices. For example, in case of a shipping company, contrary to the usual, machine learning revealed that cleaning ships' hulls more often was far beneficial in terms of cost savings [23]. The common practices were to do cleaning less often as it was an expensive process, leading to some downtime. The math however proved that cleaning hulls more frequently leads to smoother operations which decreased fuel consumption, enough to outweigh the increased cleaning costs.

The above practices clearly show how the capabilities of IoT can be substantially enhanced when they are integrated with AI. Thus, in the near future it is likely that all the IoT systems will be enabled with AI prowess and make IoT a lot more effective.

6 Various Conceptualizations of IoT as an Enabler of Marketing

Ng and Wakenshaw (2017) in their conceptual paper bring forth insightful conceptualizations about IoT with specific focus to marketing [24]. These are:

1. **IoT as Assemblage System:** As an assemblage system, IoT can be seen as an amalgamation of various elements including devices, sensors, communication network, etc. The basic premise of assemblage theory is that the 'whole' is more than 'the parts', and the objects jointly can do things which they can't do on their own [25].
2. **Digital Materiality:** This conceptualization of IoT focuses on the digital instead of physical properties of IoT systems. Different from physical materiality, i.e. the primary value provided by the product (e.g. shoes have physical materiality as they can be worn), the digital materiality relates to the digital or virtual value. This value is often flexible and can be modified as per use. For example, a physical speaker can be converted into a personal assistant, a security device, a translator or something else. Thus, IoT-based applications need to be designed with a

different process and not as suggested by traditional product development concepts.

3. **Liquefaction of Information:** The next conceptualization focuses on separation of information from the physical object. IoT systems collect plethora of information from various sensors, information about human interaction with the system and information about the system itself. In majority of the cases, it is this information and its analysis based on which the system acts which makes the IoT useful and not the physical device itself.
4. **IoT as Modules, Transactions and Service:** This conceptualization discusses the possibility and importance of disambiguation and customization of IoT system and services. As consumers may want to deploy IoT based on their personal preference, it is important that IoT is considered as modules, transactions and service rather than a product. Moreover, the IoT system should be able to customize itself or by minimal human effort.

7 Barriers to IoT Adoption

Nevertheless, there are some barriers which the industry needs to overcome (and is already working in that direction) before they can take full advantage of IoT:

1. **Data Interoperability**: One of the major barriers is in the terms of data inoperability. In most of the organizations, often the data is siloed within particular team, department or a functional unit. It has been observed that various departments like production, quality control, scheduling and supply chain, analytics, etc. are often not linked when it comes to data. It is estimated that up to 60 percent of value-added IoT systems can potentially bring loss due to these limitations. Nevertheless, organizations and their internal departments are increasingly acknowledging the multitude of advantages which can be brought in by standardizing data collection, storage,and its interoperability.
2. **IT Skillsets**: Despite a tremendous improvement in IT skills of workforce today, not everyone is skilled enough to use IoT-led technologies. This limits its operational efficiency and deployment. IoT is still a new and evolving technology, and many organizations have not upskilled their workforce to the required levels. This acts as a barrier to the adoption of such technologies.
3. **Security**: One of the major reasons because of which IoT adoption is often stunted across particular sectors and organizations is security. Many a times IoT applications are designed using open source programming (OSS), which, if not screened properly, is prone to security attacks and data breach. Moreover, miscreants are increasingly finding new ways to access and misuse data, leaving IoT systems and related data vulnerable. As this is a serious threat, that many a times risks customer data, various governments have stepped up and are planning to regulate such security concerns. Furthermore, vague laws and standards add to the confusion, which further limits the adoption.

4. **Data Privacy and Data Ownership:** As IoT applications generate and use data to function data privacy, security and ownership is a big concern. As most of the times the data is generated and consumed by different entities (often consumers, platforms and one or more service providers), who owns this data, how this data can be used, how much control a particular entity has on the data and data use become a big concern. It's the prerogative of companies at the forefront of IoT development to create clear polices for the parties involved, bring more transparency and control. Until such time, adoption of IoT may face some resistance from various stakeholders.

Though these barriers may indicate the gloom and doom IoT industry is in, there has been an enormous adoption. Moreover, the industry is coming with better technologies and standards which are strengthening the safety and other concerns which inhibit the growth of IoT. It is not the first time that such revolutions have faced such challenges. It is just a matter of time that IoT-based technologies will address these initial barriers and unleash its full potential. As it looks like, various stakeholders such as businesses, regulators, technology providers and end consumers are increasingly coming together to overcome these pitfalls, benefiting everyone of the IoT revolution.

IoT adoption is likely to gain a lot more traction as we increasingly get enchanted by the digital ecosystem. The market estimates also suggest the same, with industrial IoT market expected to reach $123.9 billion by 2021, possibly contribution $14 trillion to the global GDP by 2030 [26]. With many untapped application areas, emerging clarity on the role of various stakeholders, several opportunities and overcoming of challenges, IoT is likely to be on the centre stage of overall technology transformation. There are many areas where marketers can effectively embrace IoT and be on the forefront of this transformation.

We conclude this chapter with a case-let on Zoomcar from India and discuss how the company transformed its business using IoT.

Case-Let: How IoT and AI Enabled Zoomcar Owners to Save Costs and Reduce Accidents

In January 2017, India's most popular self-drive car rental company Zoomcar launched 'Cadabra'. A flagship and full -tack IoT application, Cadabra was set to transform the way drivers, owners and the company interacted with the car. Cadabra was equipped with Bluetooth, 4G cellular connectivity and various sensors (e.g. GPS) which allowed it to collect vital information. This included information on driver behaviour such as harsh braking, erratic acceleration, seatbelt usage and other vital car-related information such as fuel levels, clutch position, hand-brake position and other engine-related parameters. The device was installed under the car bonnet and did not require any modifications to the vehicle. The app was named Cadabra, as the company felt that the IoT-enabled app was poised to give its users a sense of magic and a wonderful experience.

Zoomcar was founded in 2013 and was one of the first companies to offer self-drive car rental service in India. Though initially Zoomcar owned the entire car inventory, the company soon moved to a marketplace model named Zoomcar Associate Program (ZAP) where others (associates) could list their personal cars on an hourly basis and earn money in return. One of the prime reasons to launch Cadabra was to give more confidence to the car owners about the whereabouts and usage condition of their car. Cadabra was deployed across all entire car inventory listed on the Zoomcar platform which included more than 2500 cars.

Cadabara seamlessly connected to the car's onboard diagnostics (OBD-II) chip and recorded vital information and showed this information on the Zoomcar mobile app. The company dubbed this as 'Internet of Moving Things' as they had used IoT technology on a moving object, a car. The real-time data collection made it possible to send automated notifications using AI in case anything unusual was detected. For example, if the hand brake was on during driving, driver drove above 125 KMPH or did anything unusual or car sensors and OBD-II chip reported any possible malfunction, the owner and the driver were instantly reported through an SMS and the mobile app. This made Zoomcar safer and much more efficient. Zoomcar worked with car manufacturers and insurance companies across the country and shared a common goal of car and driver safety. Moreover, in case of any accident or breakdown, the technology enabled the driver to connect with emergency services, which could tract the real-time location of the vehicle.

Post-successful implementation of Cadabra, Zoomcar also launched the keyless entry (KLE) feature. Driven by Cadabra, KLE allowed driver to unlock the car from their mobile phone when they were near the car. This exempted the need of human being to hand over the car keys and gave more control to driver while reducing the operation costs (Mallya, 2017). Once the driver had unlocked the car, he/she could use the keys placed inside the dashboard to start and use the car. The entire technology made the entire operations easy and automated.

Cadabra's intelligence has enabled Zoomcar and car owners listed on its platforms to significantly reduce maintenance and servicing costs while allowing drivers to avoid accidents and car breakdowns. The IoT platform is fully integrated into the customer focused Zoomcar app and the Zoomcar back-end analytics server [27]. It allows the company to automatically rate the trips, create and keep a track on cumulative driver score and also sends personalized real-time and post-trip notifications to improve driving. The company has realized that the more the data they can generate and integrate using these platforms (Cadabra, onboard GPS, OBD-II chip, driver mobile phone app and Zoomcar back-end analytics systems), the more responsive, accurate and useful the ecosystem can become [28]. The company is poised to even further enhance its IoT capabilities and create new benchmarks in the self-drive car industry.

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