A Prototype of IoT-Based Real Time Smart Street Parking System for Smart Cities

Pradeep Tomar, Gurjit Kaur and Prabhjot Singh

Abstract Smart city is a vision that aims to integrate multiple information and communication solutions to residents with essential services like smart parking inside the all streets. Today, the parking systems has been changed by new advances that are empowering urban communities to diminish levels of congestions altogether. Internet of Things (IoT) is also new advancement which helps in detection of vehicle occupancy and congestion by basic intelligence and computational capability to make a smart parking system. The main motivation of using IoT for parking is to collect the data easily for free parking slots. This work presents the prototype of IoT-based Real Time Smart Street Parking System (IoT-based RTSSPS) with accessibility of data to make it simpler for residents and drivers to locate a free parking slot at the streets. Firstly, this work presents the introduction of IoT for smart parking with technology backgrounds, challenges of accessing IoT and database. Secondly, this work presents the prototype design of IoT-based RTSSPS with architecture and algorithm. IoT-based RTSSPS architecture is divided into three parts IoT-based WSN centric smart street parking module, IoT-based data centric smart street parking module and IoT-based cloud centric smart street parking module with street parking algorithm, evaluation and future directions.

Keywords Internet of things · Smart cities · Sensors · Data-centric · Cloud-centric and WSN-centric

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1 Introduction

These days, one of the real outcomes of the vital advancement in the field of communications is the improvement of the parking systems. This is expected basically to current needs as far as accessibility and access to information whenever and from wherever. For sure, it means to make systems more secure, more effective, more solid and all the more ecologically well disposed without fundamentally having to physically modify existing foundation [1]. The unstable development of smart city makes numerous logical and designing difficulties that call for quick research endeavors from both scholarly community and industry, particularly for the advancement of proficient, adaptable, and solid smart city. IoT is perhaps the most widely discussed technology for landscape challenges in smart cities by using protocols, architectures, and IoT services. Ahmed and Anguluri [2] present the concept of smart city for the inclusive development of the cities to counter the issues of infrastructure, governance and make ourselves capable and competitive enough to address the issues of sustainable development and bring people together. It also includes industry and institutions from different parts of the country to make cities smart, eco-friendly, energy efficient and better place to live in through tailored innovative solutions. Smart cities are the foundation of smart things like smart education, smart health, smart parking inside the city. This work gives main focus on the smart parking through IoT due to the congestion of vehicles in the street. The main motivation of using IoT for parking is to collect the data easily for free parking slots. IoT objects will communicate with sensors, actuators, bluetooth associations, radio recurrence IDs, and so forth. Through IoT, this work can make this parking system even more real where objects can communicate with each other without human obstruction. Mechanized parking in the streets this is unrealistic.

These days, many vehicles are now guided by Global Positioning System (GPS) and sensors can be easily put in parking slots, so that monitoring of parking slot data can be done through drone and IoT to make a database for street. Sensors are best in light of the fact for vehicle detection. So this study identifies the availability of free slots in the streets and creates the database of streets. The extended Mobile Ad-hoc Network (MANET) are the most emerging research domains in contemporary decade. MANET can be visualized as a group of network nodes that can perform a collaborative task. In such case, the network nodes may be homogeneous or heterogeneous type where the different nodes may use the same or diverse network protocol or routing methodology. In addition, the network node can have different kind of nature based on the node movement. Based on the physical location of the network, the velocity of the nodes can be the same or different. Typically, the vehicular Ad-hoc network is a subset of MANET that has been deployed within a group of the ground vehicle. The majority of such network cases consist of a series of vehicles that can generate a connectivity to establish an Internet infrastructure [3].

The proposed prototype of IoT-based real time smart street parking system is combination of WSN-centric, cloud-centric and data-centric IoTs with the sensor

hubs. Sensor hubs installed nearby the roadside, each hub is placed at the center point of parking spot and card. At the point when a hub recognizes entry of a vehicle, it communicates with the client through switches. The switch advances the parcel to the main server and the main server gather the information from hubs and displays parking direction through display board.

1.1 Technology Background of IoT

In the context of Next Generation Internet (NGI) everyday devices are globally connected and managing an increasing number of devices requires scalable and efficient addressing mechanism. Due to the economics of scale in NGI, energy, ubiquitous access and secure interaction increases the complexity of operation. Distributed Address Assignment (DAA) proposed by the Zigbee Alliance does not ensure that the device may fail to access and available addresses from its neighbor which is referred as addressing failure. Mobility is another interesting challenge which needs to be addressed essentially in the context of NGI [4]. IoT are as of now the most prevalent information and communication innovation for smart cities. IoT is an idea that imagines all objects like advanced cells, tablets, computerized cameras, drone, sensors, and so forth. When every one of these objects is associated with each other, they empower increasingly keen procedures and administrations that bolster our fundamental needs, economies, environment and wellbeing. Such huge number of objects associated with web gives numerous sorts of administrations and creates gigantic measure of information and data. The IoT will enable connectivity for virtually any physical object that potentially offers a message, and will affect every aspect of life and business [5]. IoT furnishes us with loads of sensor information. Constant sensor information investigation and basic leadership is frequently done physically however to make it versatile, it is ideally computerized. Computerized reasoning gives us the system and instruments to go past unimportant continuous choice and robotization utilize instances of IoT. As per [6] the idea of the IoT originates from Massachusetts Institute of Technology, which is devoted to making the IoT by using radio frequency and sensor networks. As per Uckelmann et al. [7] IoT is an establishment for associating things, sensors, and other brilliant advances. Data and communication technologies can get data from anyplace by growing altogether new systems, which shapes the IoT. Radio-Frequency Identification (RFID) and related recognizable proof advances will be the foundation of the up and coming IoT. IoT advancements is possible because of 4G Long Term Evolution (LTE), Wi-Fi, ZigBee and Bluetooth Low Energy (BLE) technologies which are being utilized for most recent application to make a city smart.

Methodological perspectives adopted in the analysis of social implications of scientific and technical developments and in particular the current sociological debate involving monitoring technologies and social research. A particular attention is devoted to network analysis, an emergent area of research that focuses on the

relational implications of technologies in organizations, small groups and other contexts of participation. Using case studies and examples of technologies implementation, this study describes the advancements in this field of enquiry and highlights the main elements of the structure of interactions in virtual and technology mediated communications. It also pays attention to the implications of human interaction monitoring technologies such as IoT [8]. Things might be basic sensors (e.g. temperature sensor in a room), more perplexing sensors (e.g. electrical power measuring gadget), actuators (e.g. HVAC room controller, engine), or complex gadgets (e.g. mechanical electrical switch, PLC giving home, building or modern robotization). The IoT application may extend from a straightforward checking application, for example, gagging the temperature in a working, to an unpredictable application, for example, giving complete vitality mechanization of grounds. IoT correspondences might be required disconnected, where data is traded each day or on request, or internet taking into consideration ongoing control. Building control applications can give effective utilization of the vitality in a building while at the same time protecting solace (warm, power, and so on.) to building tenants. Customary arrangements are utilizing complex Building Administration Systems (BMS) interconnected with Programmable Intelligent Controllers (PLCs) that send requests to actuators in view of sensor information.

The system must consider numerous parameters, for example, climate figures or constant vitality costs. Substitute, developing IoT arrangements depend on sensors and actuators collaborating together in a self-sufficient way. So as to give the continuous building control locally (e.g. in a room, in a zone and so forth.), this nearby gathering of gadgets trades non ongoing data (e.g. temperature set focuses) with different gatherings and with larger amount administrations or applications to fabricate the worldwide building control application. This requires more wise gadgets (e.g. more insight in neighborhood actuators), however gives a similar application without the intricate structure of BMS and PLCs, interconnected with ongoing imperatives. Additionally, the neighborhood self-governance guarantees the system is stronger and dependable, while discharging the correspondence imperatives [9].

1.2 Architecture of IoT Layers

The architecture of IoT layers is dynamic in nature. The architecture of IoT has four layers i.e. sensors connectivity and network layer, gateway and network layer, management service layer and after that comes the application layer as shown in Fig. 1. This architecture provides communication stack for communication through IoT.

1.2.1 Sensors Connectivity and Network Layer

This layer has a group of smart devices and sensors as shown in Figs. 1 and 2 and grouped according to their purpose and data types such as environmental, magnetic,

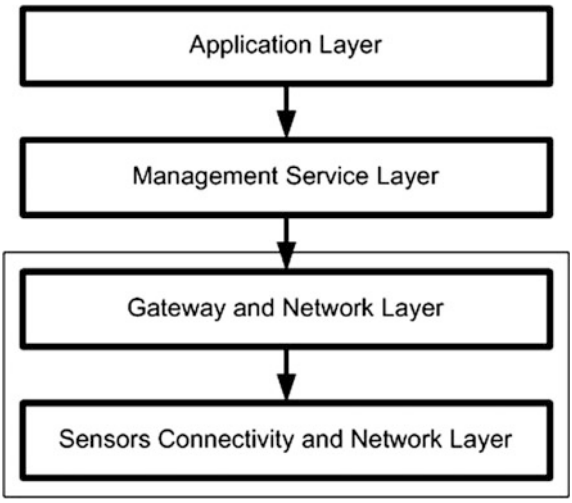

Fig. 1 Layers of IoT architecture

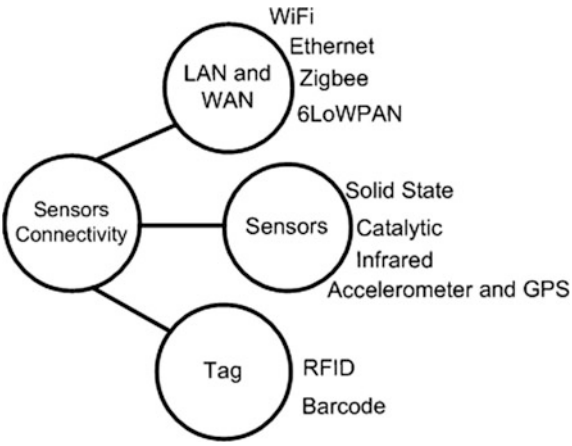

Fig. 2 Sensors connectivity and network layer

obstacle and surveillance sensors etc. WSN formation is made and the information is delivered to a targeted location for further processing. Real-time information is collected and processed to get a result or generate some output. The sensor network is then made to communicate with each other via sensor gateways. They can be connected using the Local Area Network (LAN) (ethernet or Wi-Fi), Personal Area Network (PAN) (6LoWPAN, Zigbee, bluetooth).

1.2.2 Gateway and Network Layer

Capacity of this layer is to bolster huge volume of database produced by sensor connectivity through gateway network layer as shown in Figs. 1 and 3. It requires a robust and reliable performance, regarding private and public network models. Network models are designed to support the communication, Quality of Service (QoS) necessities for inactivity, adaptability, transmission capacity, security while accomplishing large amounts of vitality effectiveness.

IoT sensors are amassed with different sorts of conventions and heterogeneous systems utilizing distinctive innovations. IoT systems should be versatile to productively serve an extensive variety of administrations and applications over vast scale systems.

1.2.3 Management Service Layer

Information analytics, security control, process modeling and device control are done by the management service layer. It is also responsible for an operational support system, security, business rule management, business process management. It has to provide service analytics platform such as statistical analytics, data mining, text mining, predictive analytics etc. The data management manages information flow and it is of two types: periodic and aperiodic. In periodic data management, IoT sensor data requires filtering because the data is collected periodically and some data may not be needed so this data needs to be filtered out. In aperiodic data management, the data is an event triggered IoT sensor data which may require immediate delivery and response e.g. medical emergency sensor data.

1.2.4 Application Layer

This layer at the highest point of the stack is incharge of conveyance of different applications to various clients in IoT as appeared in Fig. 4. This application layer

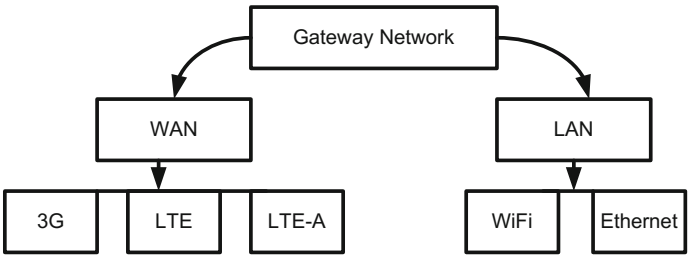

Fig. 3 Gateway and network layer

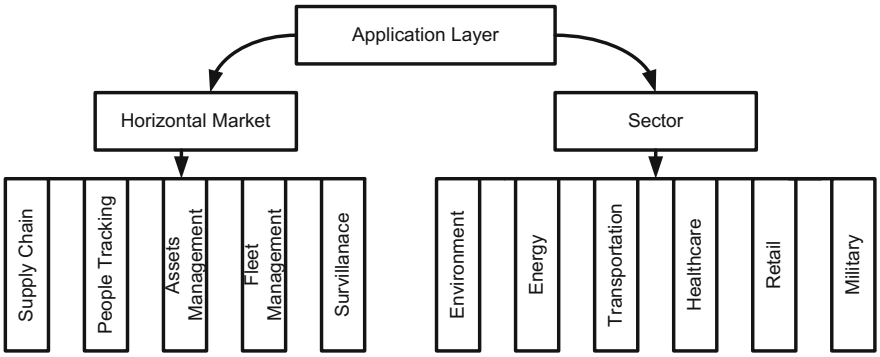

Fig. 4 Application layer

serves to the client of assembling, coordinations, retail, environment, open security, human services, nourishment, medication and so forth. Different applications from industry divisions can utilize IoT for administration improvement.

2 Parking Systems

The traditional parking system is unable to provide some real help to the residents and drivers in the streets. Parking congestion in cities is a major problem mainly in developing countries; to encounter this, many models of parking system have been proposed by different scholars. Different ways have been proposed to make the parking system smarter, reliable, and robust [10]. Smart parking systems are environments facilitated with technology that act in a protective and proactive function to assist an inhabitant in managing their daily lives specific to their individual needs. A typical smart parking implementation would include sensors and actuators to detect changes in status and to initiate beneficial interventions [11].

2.1 Vision Based Parking System

Vision based parking system have two classifications. First one is to search the quantity of empty spaces for parking of vehicles. The second one is to check the individual parking slots from the individual resident property.

2.2 Traditional and Multilevel Parking Systems

The infrastructural growth of cities is unable to cope up with the growing demand for the parking space. It becomes a major issue in old streets and near educational and religious institutions, near market area and also during fairs. A study conducted by the Central Road Research Institute (CRRI) clearly says, that the demand for efficient parking is quite higher than the parking supply offered. Though this work can find parking facilities close-by but the poor management and long waiting queues lead to driver's exasperation. Due to this, they are forced to park in front of someone's house or on streets adding to already existing chaos. People often park their cars in front of the house and shop, to buy things and get back to their vehicle aggravating the traffic congestion. Traditional parking facilities are typically an inefficient, aesthetically unappealing, and even environmentally unfriendly. Therefore resident require a smart parking system for their streets. The Centre for Science and Environment check the high rise building with multi-level parking facilities and according to them 20–40% of the capacity of the multilevel parking was in use, even as the surrounding area remained gridlocked with cars. Hence, it is clear that multilevel parking requires a large amount of capital but is unable to encourage the public to use the facility. The need of the hour is a low cost and an effective method of a parking facility that offers good benefits to the users because multiple parking is not possible in streets.

2.3 Intelligent and Smart Parking Systems

The intelligent and smart parking systems proposed till now are mostly based on webcam which are used to monitor the parking space. The system then uses image processing techniques to check the occupancy of that slot. Tang et al. [12] propose a WSN-based smart street parking system where remote sensors are put into a vehicle for parking slot, with every parking area furnished with one sensor hub, which recognizes and control the parking. The position of parking area is identified by sensor hubs and maintains data of parking through the remote sensor system. The data helps in parking through different administration functionality, for example, finding empty parking areas, vehicle-toll, security administration, and measurement report. They executed a model of the system utilizing crossbow bits. Kumar and Siddarth [13] presents the WSN-based smart parking system in light of remote sensor is used to observe and observing and oversee the person parking slots. It also gives giving computerized direction and booking ahead of time administrations too.

But every system have their own challenge like less information for drivers on parking availability and price is a big challenge for parking and drivers spend a lot of time in searching for a parking space. Inefficient use of existing parking capacity in street creates a big problem for users. Excessive use of automobile use in the small or large family is also a big issue. Automobile dependency imposes many

costs on society. Inconvenience parking spaces that are nearby residents and businesses create a problem due to less information and managed database. To overcome all the challenges this study proposes the IoT-based parking system by going through the following related work for parking systems.

3 Related Work for Smart Parking Systems

Deshpande et al. [14], proposes a webcam based parking system that uses IRIS infrastructure with different sensing and organizing component. Sensing components gather the information while organizing components gives offices to questioning later and verifiable sensor information. This system requires a lot of data transfer over a wireless network which consumes a lot of bandwidths. Lee et al. [15] presents the ultrasonic sensors for recognition and identification of vehicle at the beginning of parking. Identification of vehicles is based on their attributes like the shape and design. One could make a database of these qualities for every vehicle and make the identification calculation coordinate their examples, therefore, having the capacity to recognize and distinguish particular sorts of vehicles. Hsieh and Ozguner [16] proposed a parking algorithm gives a viable strategy for vehicle parking. No costly calculation is required, and demonstrated that the calculation can stop with any underlying positions and proper calculation of parking slots which can control an vehicle to stop in a restricted space. According to Kumar and Siddarth [13] Smart Parking Management System (SPMS) in light of WSN innovation which gives propelled highlights like remote parking checking, computerized direction, and parking reservation instrument. Initially, the system would ready to graphically show ongoing data and help client to save parking slot from remote area. So, this system helps clients to effectively find empty parking spots rapidly and securely. Chen and Chang [17] developed Parking Guidance Information System (PGIS) in which there are three sorts of hubs like screens hubs, directing hubs and sink hub. These hubs speak with the remote channel and self-arrange into a specially appointed system. Nawaz et al. [18] display ParkSense, a cell phone based system that identifies if a resident has removed the vehicle from parking space. ParkSense influences the universal Wi-Fi guides in urban ranges for detecting unparking occasions. It uses a vigorous Wi-Fi signature coordinating a way to deal with identifying driver's arrival to the stopped vehicle. Also, it utilizes another approach in view of the rate of progress of Wi-Fi guides to detect if the client has begun driving. They demonstrate that the rate of progress of the watched cases are much related with genuine client speed and is a decent pointer to whether a client is in a vehicle. Pereira et al. [19] presents an all-encompassing system engineering comprising of heterogeneous gadgets. According to Reddy et al. [20] a parking direction and data system that uses image processing technique to detects only car at a particular slot. If there is anything else than a car, it will not consider it as booked. They used ARM9 microcontroller, webcam, and global system for

mobile communication (GSM) to monitor parking space and a touch screen LCD to display the results. As mentioned earlier using webcam can create a lot of information which can be exceptionally hard to transfer over the WSN. According to Addo et al. [21] despite the fact that tending to key security and protection concerns comprehensively minimizes end-client selection obstructions, recognitions identified with the dependability of an IoT application hangs fundamentally on the execution of security and security best practices in the promptly noticeable IoT gadget. According to Barone et al. [22] parking is turning into a costly asset in any significant city on the planet, and its restricted accessibility is a simultaneous reason for urban activity clog, and air contamination. In old urban areas, the structure of the general population parking spot is unbendingly composed and frequently as on-road opens parking spaces. Lamentably, these open parking spaces can't be held in advance amid the pre-trip stage, and that regularly prompt to a weakness of the nature of urban portability. Tending to the issue of overseeing open parking spaces is in this manner essential to get naturally friendlier and more advantageous urban communities. Marquez et al. [23] show an open air parking model utilizing WSN as a conceivable answer for taking care of the issue of parking and can enhance the personal satisfaction in smart urban communities, on the grounds that the ideal opportunity for finding a free parking spot could be diminished, and also enhance vehicular activity. Rhodes et al. [24], used community wayfinding to enhance the effectiveness of smart parking system (SPS) and in this way lessen movement blockage in metropolitan situations, while expanding proficiency and gainfulness of parking structures. A huge bit of movement in urban zones is represented by drivers scanning for an accessible parking street. According to Sharma et al. [25] when the car goes into the parking zone, the stockpiling process begins, with the utilization of lifts vehicle gets stopped without getting hindered from different vehicles. They executed the capacity and recovery handle utilizing JAVA dialect. Utilizing A*, D* Lite, Unblocking calculations, it gets actualized. They can look for the utilized and unused spaces, utilizing D* Lite they arranged a way to retrieve the vehicle and utilizing unblocking calculations they put away and recovered vehicles without obstructing the way of another vehicle. They additionally utilized the Manhattan Distance to choose the closest way for the vehicle from the lift. According to Zhanlin et al. [26] cloud-based keen vehicle parking administrations in brilliant urban areas are imperative for IoT worldview. This sort of administrations will turn into a fundamental part of a non-specific IoT operational stage for keen urban areas because of its unadulterated business-situated components. Since the above related work and solutions are not IoT-based, this work aims to provide a smart solution based on IoT i.e. the next generation solution that will enable people to know before-hand about the availability of free parking space.

The IoT addresses the purchaser hardware showcase and also the B2B business. Contingent upon investigators, the estimation of IoT is evaluated to be from $300 B to near $2000 B in 2020 (contingent upon what is represented in IoT advertise). Gartner has a characterized concentrate on IoT included esteem. Ten billion IoT protest shipments are normal every year beginning in 2020, which will be utilized as a part of a wide assortment of uses. Associated LED lights are relied upon to be

the biggest by a wide margin. In term of innovations, Gartner states sensors will assume a basic part inside IoT engineering. However IoT design stays questionable; there won't be one single engineering for all business sectors portions. More than 80% of the $300 B incremental income evaluated for 2020 will be gotten from administrations.

The incremental cost of equipment and implanted programming is moderately little, though the administration and examination opportunity is substantially bigger. At first, a significant part of the provider center in the IoT markets will be on equipment and programming, as organizations attempt distinctive methodologies and capabilities with an end goal to construct consciousness of their items. As plans of action develop, in any case, the market will progressively be driven by administrations (counting information examination administrations). There will be administration openings related with organizing and dealing with the various things those common purchasers will communicate with in a normal day, both in their home and in their day by day ventures. For sure, the esteem chain for IoT gadgets and administrations will be multilayered, with use information utilized utilizing examination programming that is intended to haul out patterns helpful for further item and administration advertising activities. IoT creates "Enormous Data" that examination must deliver to change immense volumes of information into a little (promptly integrated by a human personality) amount of usable/noteworthy data [9].

4 IoT-Based Real Time Smart Street Parking System

The motivation behind this work is to give benefits to the citizens through smart street parking system using IoT because IoT can collect the data for free parking slots through drone. Drone images acquired by a UAV system which is the latest geo-spatial data acquisition technique are used in this project for mapping free parking features. This reduces the project cost and time substantially. Geo clipping video output of the drone are stored in a database and these data can be viewed together with the Google 2D map of the captured areas. Generated frames from the captured video which contain XY coordinates for individual frame are used to convert those raster into vector maps. Developed vector maps are stored in both ArcGIS server and specific map engine. Each individual free parking is stored with a unique ID. The government has been struggling very hard since last 15 years to reduce the parking problem in the unmanaged street. Vehicle population is eating up its street space at an alarming pace. The concept of multi-level parking failed in streets. The proposed prototype of IoT-based RTSSPS is divided into three modules in which each segment has the four layers as per architecture of IoT. A prototype of IoT-based RTSSPS is designed by using IR sensors on each parking slots to detect the vehicle by matching the token numbers. When a vehicle is in front entry gate of street, vehicle operator will generate a token with unique id and this unique id goes to the parking sensor server by using first module of architecture and takes database

from cloud module through the data centric module. The sensor readings are received and analyzed by Arduino UNO, the microcontroller. If the sensor reading will change from low to high for more than 5 s then the slot is considered as occupied and is its low than slot is vacant. It forwards the result to the application which displays the parking space. If a vacant parking slot is found the result is shown on the 16X2 LCD screen on the passageway of the parking facility. A motor controlled by an IC L283D opens the gate through which the car enters the parking street and with the help of token number.

4.1 IoT-Based Real Time Smart Street Parking System Architecture

IoT-based RTSSPS architecture is a better approach as it overcomes the disadvantages of other traditional and smart parking system. It basically involves sensors to detect the presence of vehicle on the street parking. The sensor data is transmitted to the management system which facilitates the administrators and managers with real-time information. In this IoT-based RTSSPS, sensor nodes, master nodes, sink nodes are used to set up their sensor and networking layer. IoT-based RTSSPS have focused on optimizing the sensor node placement so that least number of sensor hubs is utilized to get the greatest scope of the zone. Sensors are best to detect the vehicle, and place at the parking slots because vehicles have huge amount of metals, so this study can utilize a sensor for vehicles parking.

The IoT-based RTSSPS have two main things smart street parking architecture and smart street parking algorithm. Smart street parking architecture utilize WSN driven, cloud driven and information drove IoT with base stations, switches, sensor hubs, and a remote server. Sensor hubs are conveyed close by the roadside, every hub is planted in the center of a parking spot and one on parking card. Every sensor hub recognizes the world's attractive field, Wi-Fi, daylight and road light intermittently. At the point when a hub recognized a vehicle, it transfers the SMS to the portable of the client through the switch to main station. This main station gather the info from different hubs and transmits to the display board which can be mounting in the starting and leave purpose of the road, remote server furthermore on the portable of the considerable number of individuals living here.

To lessen the number of sensors and to give full scope, this study will attempt to utilize the street parking calculation through hereditary qualities or insatiable approach which helps in inquiry streamlining of sensors. IoT-based RTSSPS architecture is divided into three parts IoT-based WSN centric smart street parking module, IoT-based data centric smart street parking module and IoT-based cloud centric smart street parking module (Fig. 5).

Fig. 5 IoT-based real time smart street parking system architecture

4.1.1 IoT-Based WSN Centric Smart Street Parking Module

IoT-based WSN centric smart street parking module are a combination of the application layer, management service layer, gateway and network layer, sensors connectivity and network layer which officially portrayed in the design of IoT. WSN driven IoT helps in the simple establishment of sensor hubs. The parking slots are exhibited to clients through objects. In this architecture, application layer deals with the sensing and connectivity of vehicle when the driver wants to park into the parking slot and collect the data of free parking slots and owner information. Management service layer provides the QoS, information analytics, security control, process modeling and device control through big data analysis (Fig. 6).

Gateway and network layer and sensor connectivity layer must be able to support massive volume of IoT data preprocessing and interpretation produced by wireless sensors and smart devices through cloud computing and gateway network. This layer grouped with smart devices and sensors, according to their purpose and data types such as environmental, magnetic, obstacle and surveillance sensors etc. WSN centric IoT formation is made in this stack and the information is delivered to a targeted location for further processing. Real-time information is collected and processed to get a result or generate some output from data-centric IoT smart street parking architecture. WSN as a conceivable answer for take care of the issue of stopping and can enhance the personal satisfaction in smart urban communities, on the grounds that the ideal opportunity for finding a free parking spot could be diminished, and also decrease contamination and to enhance vehicular activity.

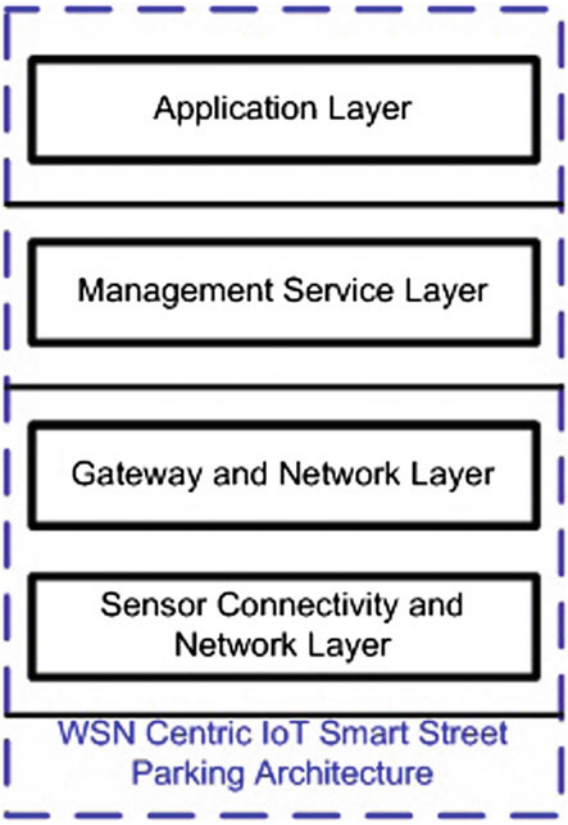

Fig. 6 IoT-based WSN centric smart street parking system module

4.1.2 IoT-Based Data Centric Smart Street Parking Module

From last consecutive years this study have seen an unrivalled explosion in the amount of data which is transmitted via many digital devices and for reducing the traffic, there is a need of strong communication technique so that large amount of data and information can be transmitted. The most principal issue in world today is the large amount of valuable big data that is flowing among various networks and swap information with more compression and security in both the time and space for data transmission for data storage [27]. A big amount of data will be collected and generated through data-centric IoT which emphasizes on data collection, processing, storage and visualization. A generalized system for data collection is required to effectively exploit spatial temporal characteristics of data which is prepared with the help of drone. Extraction of meaning full information from raw data is non trivial. It usually involve data pre-processing because in smart cities, adaptability and robustness of algorithm to compare data at large scales of time and

space is essential and for smart cities applications, visualization is important for data representation in users. The information gathered through application layer and WSN drove IoT, preprocessed and transmitted to the database system which is further utilized by the client through upper layer applications with LCD, LED and AMOLED (Fig. 7).

The data-centric IoT architecture maintains the following modules to communicate with the WSN and cloud-centric database:

- Parking management and data module which manage the free parking slots.
- Security management module through cloud computing which alerts the illegal parking.
- Sensor management module which manages the location and searches optimization through updated database.
- Server management module to control the servers which are linked with database and notify the situation through SMS.

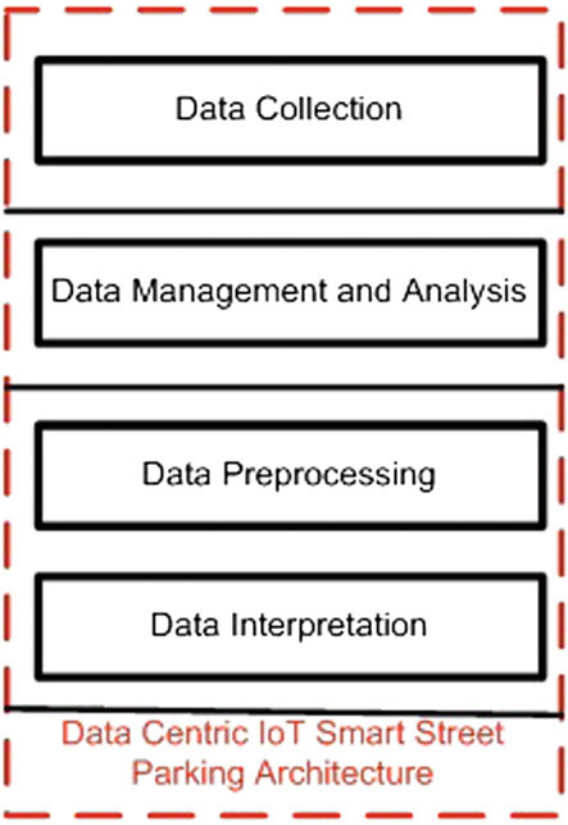

Fig. 7 IoT-based data centric smart street parking system module

4.1.3 IoT-Based Cloud Centric Smart Street Parking Module

IoT-based cloud-centric smart street parking module is the middle part of the whole architecture and makes communication between WSN centric IoT and data centric IoT through cloud database by using analytic tools. Cloud computing provides the software to collect the information of vehicle parking and to manage the system, services, and overall behaviors with changing physical environment of the street through proposed architecture (Fig. 8).

This cloud computing environment also helps in optimal parking space with the proposed algorithm according to the availability of space, and search and display the path to the parking space on the LED screen at the entrance. So that the drivers can enter the parking slots and spends less time for the parking space.

Fig. 8 IoT-based cloud centric smart street parking system module

4.2 IoT-Based Real Time Smart Street Parking System Algorithms

Numerous urban communities have embraced a parking direction and data system to attempt to reduce this activity clog. In our proposed system, this work creates the database of the streets by using drone and gives every resident an id number to their parking slots. When a resident or driver enters inside the street for parking, this system generates an id number which is combination of id number of parking slot, last two digit of car registration number and last two digit of resident house number. Suppose id of parking slot is 76A, owner car number is 1234 and house number is 1976 than unique id is 76A3476 and submits this unique id at the sensor location of real parking space. When a resident enter inside the street with nique id it automatically help to search the parking slot and help to park the vehicle. Reservation authority sends a sms to the user as soon as user reserves the parking space. At the parking slot host identifies the user by scanning the code with a parking ticket or IoT, generated by authority. But if the vehicle is not owner own vehicle than authority sent the car number to owner via sms and owner give permission for this number than authority generate the unique id number. This algorithm has been proposed for the car in the event and car out event to resolve the issue of street parking for outside and owner of parking. Sensor hubs have restricted figuring force and memory.

4.2.1 Implementation of Street Parking Algorithm

RTSSPS (PL, N)

Here RTSSPS is smart street parking system, PL is a linear array with N parking slots.

Input: S = C, CL, Db, PS, Dmin, Dmax, C_i, C_j, C_{next}

Here S denote the entry at Street Node. C denotes the Nodes and CL denote the current location of C and C_i denotes the next node, Dmin and Dmax denotes the maximum and minimum distance, PS denotes the parking slots and Db denotes the Database of streets.

Output: Signal for L293D

Step 1 **Initialize**: CL → Current Location of Car,
Car enters into parking street and search for empty parking space, authority generate the unique id for the resident or drivers

Step 2 **If** Parking Slot (PS) = 0, then L293D = 0 and
Car will not allow entering the street
Else if

If Parking Slot (PS) = 1 or more than 1, Than L293D = 1 or more than 1 Car will allow entering the street after getting the unique id

Step 3 **for** all C-nodes there is 2 neighbor tables of Ci do
Calculate the Dmin and Dmax for parking slot with IoT/Parking Ticket
Here w is weight/distance of the link between node Ci and node Cj
if w < Dmin for owner parking slot then

$$\text{Dmin} = \text{w}$$
$$\text{update} : C_{next} = \text{Cj}$$

end if
Else if w < Dmax for owner parking slot then

$$\text{Dmax} = \text{w}$$
$$\text{update} : C_{next} = \text{Cj}$$

end for
return C_{next}

Step 4 **Vehicle-In Event**

- *On arrival of the vehicle at the gate, the sensor will detect its presence and will report the same to the microcontroller.*
- *The microcontroller will check for the availability of the space in the parking lot.*
- *It communicates the result to the web application which displays it.*
- *If space is available, a parking ticket is issue with unique id, the gate opens and the vehicle enters.*
- *When the user parks the vehicle according to the ticket number, the sensor detects the presence and reports to the microcontroller.*
- *The microcontroller updates the database.*
- *If the parking space is not available then the gate will not open.*

Step 5 **Car-out Event**

- *At the point when the client escapes the parking spot, the sensor distinguishes the free opening and reports to the microcontroller.*
- *The microcontroller communicates the same to the web application. The database is updated. The slot status is now free from occupied.*
- *The result is displayed on the web application and user moves towards the gate.*
- *The entryway sensor matches the ticket number and gives the sms to the owner and is owner say yes than gate opens for vehicle.*

Step 6 **End**

5 Evaluation of IoT-Based RTSSPS

Performance evaluation: A prototype of the RTSSPS is built in order to test the working. The evaluation of the IoT-based RTSSPS was done based on the observations made while testing the prototype. It was watched that an ideal opportunity to look for a free parking space was lessened significantly when IoT-based RTSSPS was deployed. According to a survey conducted by the Telegraph, the average time taken by the drivers to find parking space is 20 min. Using IoT-based RTSSPS it was observed that this time was reduced to 1–2 min since the drivers will be able to locate a free parking spot using a smart token number. Hence, there is no need to wander around and time is only consumed in entering and parking the automobile in the parking facility.

The aim of the IoT-based RTSSPS is to help the drivers to easily spot a vacant parking space. The web application is able to fulfill this requirement. It shows real-time accessibility of the parking and facility which are authorized to manage the application. The clients can simply see the status and position for the parking space. The position of the parking opening is dictated by the accompanying condition:

$$\begin{aligned} &\text{If } ((\mathrm{S} = \text{ High}) \,\&\&\, (\mathrm{T} > 5)) \text{ then,} \\ &\quad \mathrm{P_N}! = \text{ EMPTY} \\ &\text{Else } \quad \mathrm{P_N} = \text{ EMPTY} \end{aligned}$$

where S is sensor signal, T is time and P_N is nth parking slot. When the sensor signal detects a presence it becomes High and when it remains High for 5 s then the spot is considered to be occupied else the status remains to be empty. Since the time to find a parking spot is reduced, the traffic congestion caused due to the drivers roaming around in search of free parking space will also be reduced. Hence, congestion density of various markets that use traditional parking system were compared against the IoT-based RTSSPS. Congestion density at a street place can be expressed as follows:

$$\text{Congestion Density } = \frac{(Tsearch + Tparking) * Naverage_{cars}}{ECs}$$

where ECS is equivalent car space which is a designated area for comfortable circulation space for vehicles and easy retrieval. ECS has been taken to be equal to 23 m^2.

6 Conclusion

The work presents review of the existing research done in field and tries to develop a IoT-Based RTSSPS suitable for developing countries, that improves performance by reducing the number of users that fail to find a parking space. This work presents

the prototype design of IoT-based RTSSPS with architecture and algorithm. IoT-based RTSSPS architecture is divided into three parts IoT-based WSN centric smart street parking module, IoT-based data centric smart street parking module and IoT-based cloud centric smart street parking module with street parking algorithm. Our proposed architecture and algorithm has been successfully implemented in a real situation by the proper communication of each module like IoT-based WSN centric smart street parking module, IoT-based data centric smart street parking module and IoT-based cloud centric smart street parking module. The sensors are to be fitted on the side of the street and connected to the controller at the intersection and communicate with the WSN centric IoT smart street parking module. These are some hectic jobs which are to be dealt before implementing the system, but once implemented, it will make our parking system more convenient and smarter. During implementation, this study finds that the algorithm significantly reduces the average waiting time of users to search the parking space. In our future work, this study considers the security aspects of our system as well as implements our proposed system in large scales in the real world.

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