Smart City Technologies for Next Generation Healthcare

Tahmina Harun Faria, M. Shamim Kaiser, Chowdhury Akram Hossian, Mufti Mahmud, Shamim Al Mamun, and Chinmay Chakraborty

Abstract A smart city is a municipal area aimed at managing the expanding urbanization through a vast exchange of information using technologies. It is the concept of bringing technology, society, and government together to refine the quality of the living standards of their citizens. As the number of urban areas is increasing day by day and the citizens are becoming ambitious for a living style with a secured environment, the demand for a proper and safer healthcare system with tech connectivity is increasing rapidly. Therefore, the next-generation smarter healthcare receives considerable attention from academics, governments, businesses, and the health care sector through the growth of information and communication technology infrastructure. From the personal level to community level, information and communication technology driven healthcare is becoming the ultimate role player. In this study, we have briefly described the overview of a smart city and its components. Among all these components, smart healthcare is our target component for further studies. We presented current informative views regarding next-generation healthcare system modules such as data collection through mobile sensors and ambient sensors; usability of data processing using edge computing and cloud computing applications; privacy and security of data; and connectivity with other 'Smart City' services like smart infrastructure, medical waste management, health education. Finally, we discussed underlying opportunities and challenges so that a path towards the optimization of current healthcare technologies is disclosed.

T. H. Faria · M. Shamim Kaiser (✉) · S. Al Mamun
Institute of Information Technology, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh
e-mail: mskaiser@juniv.edu

C. A. Hossian
Department of EEE, American International University-Bangladesh, Dhaka 1229, Bangladesh

M. Mahmud
Department of Computer Science, Nottingham Trent University, Clifton, Nottingham NG11 8NS, UK

C. Chakraborty
Department of Electronics & Communication Engineering, Birla Institute of Technology, Ranchi, Jharkhand, India

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1 Introduction

With the increase of population growth and tremendous urbanization, a new track involving technologies is taking place into the construction of city services. This results into the creation of a new notion of "smart city". The rapid advancement and development in information and communication technologies (ICT) pave the way towards critical urban support for the communities and in-habitants of the city including energy system, security system, transportation, healthcare system, education, waste management, utilities management system and what not [12, 31]. These systems work layer by layer following some plans and policy designed by the decision makers and stakeholders. Together these layers comprise an ecosystem. The main target of this smart city ecosystem is to enhance the thought of living standard in the urban peoples' mind and also to increase economic growth by continuous connectivity with technology [21].

Healthcare system is one of the most crucial factors in raising the living standards of the citizens. Previously, this system was totally infrastructure and care-giver centric. Now with the chronological advancement, the smart city healthcare is being patient centric [15]. Various types of sensors and devices secured data exchange and processing have made this easier than the previous one. The values derived from these services provide a context that helps the system to decide faster and smarter [35]. Real time access to this information has led to a new era of the smart healthcare dimension. Smart healthcare system can respond rapidly to urgent needs and is able to make optimized decisions which consumes less time. The maturation and upgradation in the healthcare system result in promptness in services [18].

Personal health records (PHRs) and electronic health records (EHRs) came into limelight in the early 2000s. It has influenced many governmental policy designs and decisions on where to invest healthcare funds [3, 6, 16]. While doctors do not typically analyze real-time health, data received from streaming or data storage, researching with these records allows caregivers to examine conditions to understand the health trends that are commonly seen across entire subpopulations [23, 47]. About 55% of healthcare providers nowadays use PHR and EHR resources [17]. In 2006, a study from Istepanian et al. predicted the views on healthcare services regarding the potential impact of mobility [22]. Mobile devices and introduction of body area networks helps device owners in self-monitoring their physiological and related variables in real time using mobile sensors and ICT [9, 27]. Then care providers are able to use this information to conquer geographic barriers. It creates the opportunities to prescribe medical treatments and behavioral changes more effectively [38, 42]. Along with personal devices, sensors are also internally embedded into physical environments at present. In recent years, data collected from environments with ambient intelligence has been used to look for the pattern of changes in health status

[2, 29, 44]. These ambient assistive environments have to overcome challenges of monitoring several people at a time without the direct interaction with the users [30, 36].

This chapter is organized as follows: overview of a smart city, components and eco-system of smart city, studies of layer wise protocols of smart city concept, introduction to next generation healthcare, data collection through various components; data processing; study of data privacy and security. Then integration of smart city components with healthcare systems; open issues, challenges, and recommendation for futuristic research purpose and finally conclusion of the studies.

2 Smart City–An Overview

In the last few decades, the population of the world has been increasing significantly. With this large population, it has created excessive pressure on the amount of resources available. With the advancement of science and technologies, people tend to expect a much better living standard than before [26, 28, 33]. In eagerness for quality living styles, the citizens are moving to urban areas in a large number. As a result, the number of urbanites is increasing in full swing. Now it is predicted from various sources that around 75% of the population will start living in urban areas by the year 2050 [21]. These urban areas consume the maximum of the world's resources and thereby it can impose severe negative consequences on the environment. All these incidents have led to the concept of technology-based cities. The tremendous growth of ICT in the hardware and software developments has changed the views about lives in every aspect [5, 26]. These usefulness of ICT in various forms has impacts on urbanization too. These cities created with a large technological viewpoint, have been defined using many different terms like "digital city", "information city", "wired city", "cyber-ville", "smart city" and so on [42]. Among all the labels, smart city is the most fruitful and largest abstraction as it includes all other labels within its concept. But the "smart city" concept has no consistent and fixed definition. Rather it is a concept oriented to the effectiveness, flexibility, sustainability, and a system with much higher tech supports. The use of abrupt information with secured communication and network improvises the operational activities of different stakeholders such as the citizens, the society and the government. Though the cost management processes and policy design are very much crucial for the authority, after the establishment of a smart city, it becomes the never ending resource for tremendous development in the living standard of its inhabitants [29]. With the foundation of smart cities, the present challenges and issues formed by rapid urbanization and highly increasing population will be mitigated. In a comprehensive definition, it can be said that a smart city is the balanced combination of the physical and social infrastructure which uses secured transmission of information to increase operational efficiency and to improve quality of living standard, while keeping it in attention that it opens the opportunities for present and future in socio-economic and environmental aspects. Though the definition varies, the main aim of a smart city is

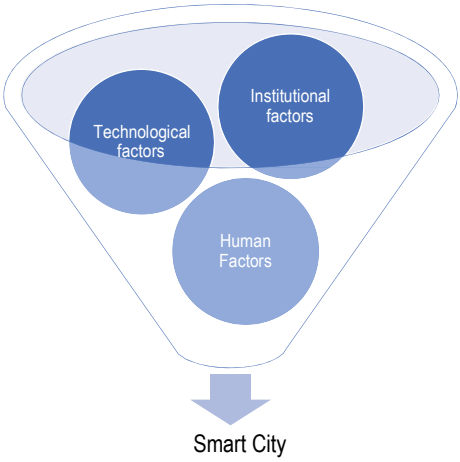

Fig. 1 Abstraction of Smart city from technological, institutional, and human factors is represented here

to optimize the traditional functionalities of urban areas and to smooth the economic growth. The decision-making factor toward a smart city remains in the usage of available technology, but not the stack technological resources [15]. A smart city may have the most trending technological structures available in the world nowadays, but if there is no inspiration in the stakeholders to optimize the results or if they do not have adequate knowledge regarding the technological aspects to maximize their targets, then the main goal of a smart city will be deteriorated. The performance of a smart city depends on the strong interactions among the stakeholders, from personal level to community level. These relationships are significant because the technological development and maintenance requires a trustworthy data-driven environment. To mention a city as a smart city, it is not needed that all the components of the city are handled on technological basis. Mainly it is the central infrastructure and decision-making components that needs to be smart in terms of both technology and viewpoints. Figure 1 shows smart city combined technological, institutional, and human factors.

2.1 Smart People

The most important part of a smart city is undoubtedly its citizens. Without the improvement of peoples' understanding, the technologically enabled smart city will not have the prosperity that it has aimed at. The thoughtful citizens are the main driving factor, they will be solemnly responsible for interpreting data provided by systems and designing policy factors. More precisely, smart people mean the individual or group citizens as well as corporate actors [10].

2.2 Smart Infrastructure

Smart infrastructure includes the smart buildings, parking system, utilities system, roads and all. Usually, these infrastructure systems can be built of traditional approach and then combined with technological supports and management [31].

2.3 Smart Economy

Smart economy includes systematic development for the industrial environment as well as urban farming, that means the activities related to economic growth and efficiency all are under the smart economy component [31].

2.4 Smart Mobility

Smart mobility means the ease of transportation system for both the citizens and resources necessary for life leading. It often overlaps with some subsystem components from smart infrastructure [26, 29].

2.5 Smart Environment

Environment is one of the important components in a smart city system. It was often ignored in traditional urbanization processes. But as the environment pollution is increasing day by day and greenhouse effect is showing its destructive impacts more often, it has shaken the mind setups of the policy and decision makers. So a smart environment is undeniably a must component for a smart city [19].

2.6 Smart Healthcare

Previously the healthcare system has been mostly infrastructure occupied. But with the tremendous impacts of information and communication technology, this view has been changed. Now it is more of a patient data driven system. Our main aim is to study the smart healthcare perspective in this article. So, it will be discussed in more thoroughly detail in the later parts of this article [5, 28].

2.7 Smart Education

Education is the key factor in making the citizens more aware of their rights. Because of the educational improvements, the citizens are vigorously working toward the high living standards [31]. Ongoing advancement in the ICT sector is the result of technological education. So the system related with smart education is also a main component in smart city components [30, 33].

2.8 Smart Governance

Finally, smart governance is the working factor to combine all these components together. The main concern of smart governance is to design policies appropriate for the smart city concept, decision making and overall the clarity and security in every component [46].

3 Layers of Smart City Ecosystem

Among all the subsystem or smart city components, the researchers have developed a plan and vision that leads to the construction and development of a smart city. From the views from Kehua, Li and Fu, the smart city is a concept built of three distinct, non-overlapping layers. These layers are: "Perception layer", in which layer data are collected through sensors and devices; second layer is known as "Network layer" which is used for transmitting data and mainly responsible for providing data to the final layer; and the final layer is "Application layer" which is responsible for analysis, processing and making decision [5]. All these layers work together to get the desired final outcome.

Figure 2 shows system components of a smart city, the same structural behavior is observed to meet the final goal. Various sensors and devices are instrumented in the objects and in the environment. They work as the never-ending source of data. A high-speed network infrastructure holds the whole system. Finally, management of these data and autonomous decision-making lead to the goal of providing smart services and applications in a smart city.

4 Smart City Ecosystem- Layer-Wise Protocols

The definition of smart city may vary depending upon the views of the stake-holders. From the view of solution providers, it is the activities that relate to do anything with technologies [8]. Again, the authority may term it as the ease and speediness

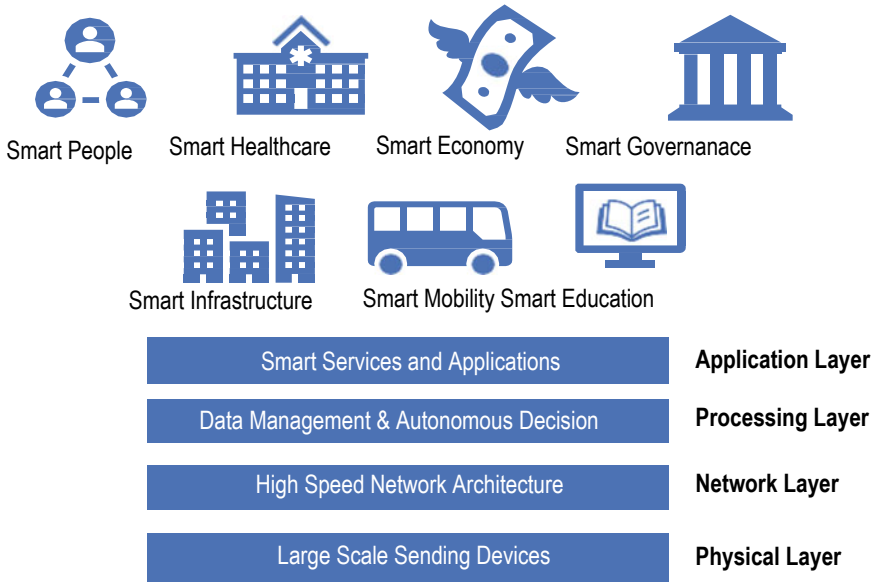

Fig. 2 Layer structure of the smart city architecture

of management systems that will reduce their time and efforts to maintain economic growth and development. From the perspective of the city inhabitants, the views may differ again. They may think a smart city is an opportunity and storage of resources that will prosper their daily lives. Whatever the views are, the main aim behind a smart city is to build a system where the technological advances do not suppress or change the thoughts of the society. The stakeholders can perform their activities easily and securely without thinking of the view whether the city they live in is a smart city or not.

A smart city ecosystem comprises mainly four types of value creators. They can be titled as the "smart city actors". They create values and with their interaction with the system, they increase the domain of opportunities in a smart city.

- The smart city service providing authority is one of the most value creating stakeholders in a smart city system [8]. They provide the services through operating municipal or governmental authorities. From the utilities service, societal security system, operating functionalities of the system etc. to design policy and calculate the upcoming outcome in near future—all these activities are operated and guided under the smart city authority [21]. It is also their job to balance and combine the other smart city stakeholders' commitments and activities to ensure the goal of the entire system.
- Outside the governmental system authorities, the private businesses and organizations that provide services on a personal demand basis—are another value creating medium. They build small component-based systems like personal mobility system services, traffic and commute planning services, food and resources

delivery services, healthcare at home services, online education providing system and many more [45]. These systems add a large value when it comes to smart city solutions and create outcomes for the users as well as the community.
– Communities within the smart cities work as a miniature smart city in the system. All kinds of infrastructure with distinguished goals add value in the smart city ecosystem. These are all types of educational institutions, offices, healthcare centers, business organizations, housing infrastructures and so on.
– Lastly, the individual citizens also work as a huge value creator in the smart city. They exchange the information on which the city paradigm is built. It is their direct activities that will decide the fruitfulness of the city's goal.

Figure 3 shows Inter-connectivity between smart city infrastructure with its services. There are four types of actors that participate in value generation in a smart city. A smart city platform is there to combine the smart city infrastructure and service providers. It exchanges the information and makes the opportunities for resource sharing. The citizens, communities, governmental and private service providers also take part in value creating. They access services from the applications and service providers. In return, they exchange information with the smart city platform.

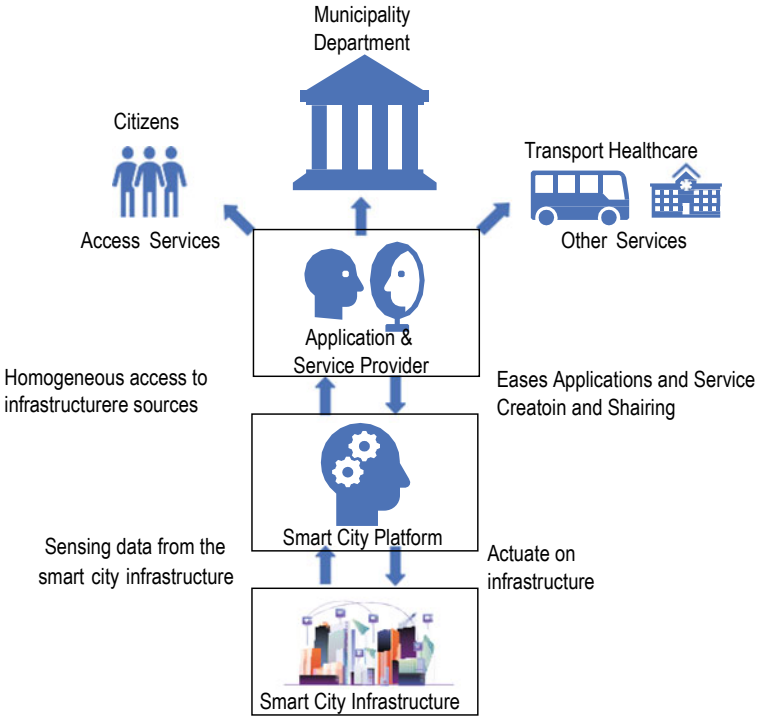

Fig. 3 Inter-connectivity between smart city infrastructure with its services

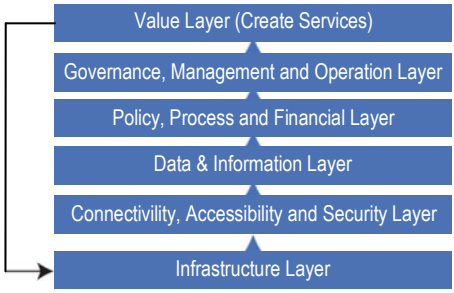

Fig. 4 A smart city system has multiple layers

A smart city comprises multiple layers. Each layer plays a distinct role in the smart city. However, the layers have no fixed definition, but these are the layers that must integrate and coordinate together in creating the final system outcome for a smart city (see Fig. 4).

Value Layer: Value layer is the most visible layer in the smart city framework. The value layer consists of the value created by four types of stakeholders explained before. The value creators offer inputs and consume outcomes at the same time.

Innovation Layer: To keep pace with the stakeholders' updated demand, it is very important to innovate the smart city services continuously. Therefore, the smart city facilitates innovation programs and updates plans in city system management. It may join with the educational and investor communities, and create new opportunities of skill development, training, workshops etc. so that it can stay relevant all the way.

Governance, Management and Operations Layer: A smart city creates the divergence through digital transformation and results in the upgradation of existing services. So, the management model must have to create the integration of a new co-ecosystem of the value creators. They have to work toward new business models and services to upgrade existing infrastructures and management to advance the outputs. And they also have to measure the performance of the outcomes with respect to the given inputs so that it can help the authority to update their policies simultaneously.

Policy and Financing Layer: A smart city is an outcome of a long-term plan. An entirely fresh set of rules, development policy design, financing source, models and decision maker minds are needed to build, operate, and sustain the smart city. It also requires a great bonding among the public and private organizations so that they can develop plans together.

Information and Data Layer: The main working unit in a smart city is the information. The smart city must create the system through which open data initiatives, analytical services, data marketplaces, monetization policies etc. can have the encouragement of data sharing. They must be ensured the privacy and security to protect data storage.

Connectivity, Accessibility and Security Layer: In a smart city, stakeholders, resources and the systems are interconnected. The ability to connect these three parts and run verification systems to check the connectivity is very significant. Again, the privacy and security of information is also very crucial. So, a well-built secured

seamless layer for trusted connectivity in all systems requires the highest priority in a smart city system.

Smart city Technology Infrastructure Layer: It is the technological aspect that combines the smart city layers with each other. Without this layer, traditional city and smart city concepts will have no difference. Therefore, smart cities must be supportive towards the value creators with technological resources [45].

5 Next Generation Healthcare and Internet of Healthcare Things (IoHT)

With the increasing growth in the living standard, the concept of smart city has come to another dimension of attention. As a smart healthcare system is a key component of a smart city, it also uses the trending generation of information technologies, such as the internet of health things (IoHT), blockchain, cloud computing, big data, machine learning, artificial intelligence, 5G/6G etc [5, 13, 28]. It is transforming the view of traditional healthcare approaches and increasing the capabilities of the healthcare system by making it more convenient, effective, and personalized. Smart healthcare is a concept that was born out of the concept of the "Smart Planet" concept proposed by IBM (Armonk, New York, USA) in 2009. "Simply put, Smart Planet is an intelligent infrastructure that uses sensors to perceive information, transmits information through the internet of things (IoT), and processes the information using supercomputers and cloud computing" [3, 16]. Smart Healthcare is a service providing system that requires technologies built as in wearable devices, software, mobile internet. It can connect people, institutions related to healthcare; shares the information and can respond to the medical needs based on the information processing. Thus it provides the scope to promote interaction between the stakeholders in the medical system so that it can promptly ensure the treatment in the shortest possible time. A smart healthcare system changes the traditional healthcare model from disease centered to patient centric model [14]. It shifts the information construction system into a regional medical information system. Altogether, it changes the paradigm from focusing on disease treatment to pay attention to preventive healthcare. Thus, individual needs of the citizens are met in a short span of time and also improves the system by enhancing the health service experiences. The healthcare system components like disease prevention, diagnosis, and treatment; decision making, healthcare infrastructure management and research—all combine together to provide a smart healthcare system with the trending technologies [32, 34].

The Internet of Health Thing (IoHT) plays a vital role in the field of smart healthcare systems. It integrates the physical and technological layers with a connected network in the healthcare area. It transforms raw data to improvised information based on which further decision making can be possible. Above all, it has created the baseline of a developed smart healthcare system by improving quality of care, enhancing consumer experience, and optimizing functional efficiency.

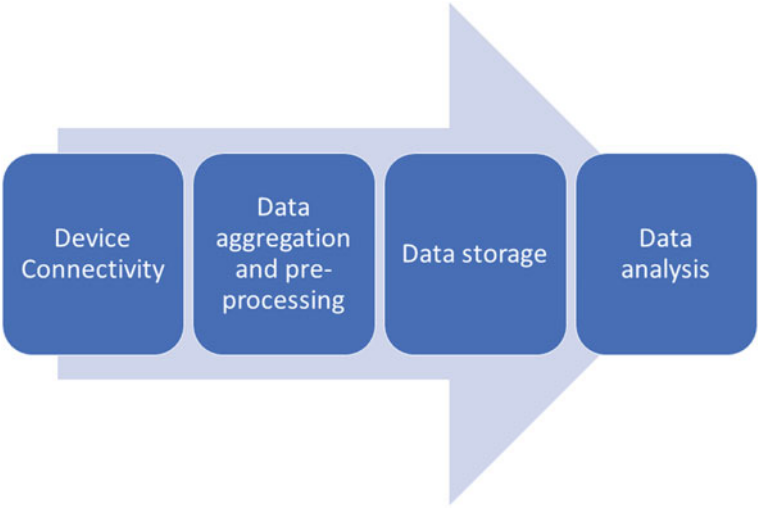

Fig. 5 Four system layers comprise the system structure for internet of health things

Internet of Health Thing (IoHT) has a four-step architecture. These layers or steps are connected to pass the information to the following step so that it can analyze and make a decision (see Fig. 5).

Step 1: The first step is the connectivity of the devices which collect data. These include sensors, monitors, detectors, image capturing camera etc. These devices are connected through a network with the next step.

Step 2: The second step is responsible for data aggregation and processing. The raw data is in analog form or maybe in a form that is not organized properly. This step converts the data and pass the information to data storage.

Step 3: In this step, the information is pre-processed and moved to data storage as in the data center or cloud.

Step 4: This is the final step. Here data is analyzed with advanced analytic processes and results in actionable insights for further decision making.

5.1 Device Connectivity

Device Connectivity is the key component in the field of internet of health thing (IoHT). They collect data in personalized manner for any individual and share these data through a secured network. Built in mobile sensors or body sensors play a prominent role in the organization of data collection. Nowadays, smartphones and various wearable smart devices are equipped with many sensors. These devices have sensors which can be termed as smart wearable sensors (SWS) [2, 11, 30]. The smart wearable sensors include a wide range of sensors like accelerometers, gyroscopes,

actuators, smart fabrics. This also includes the backend wireless network communication, power supply technologies and technology used in data capturing for further decision support [1]. Wearable devices lessen the restrictions in daily activities and keep monitoring the wearer in any environment. Some well-known and mostly used sensor accelerometers are electrochemical sensors. They measure acceleration of objects in motion with axial references [11, 40]. It is used because of the activity counting quantity assessment for physical activity. This may also come handy in the evaluation of velocity and displacement by merging the data. For monitoring vibrations in three dimensional planes, tri-axial accelerometers can be used to detect movement according to the magnitude of signal with respect to the axes. Another popular type of sensor is gyroscope which can measure 3-D orientation based on the idea of angular momentum. These sensors can detect the values of various variables like distance, steps taken, calories count, speed, floors climbed etc [4]. A Tri-axial accelerometer can be waist-mounted that can detect walking activities or posture if it is implemented real time. These sensors can be placed in a vest or shoe. Smart vest is a wearable monitoring system for measuring physiological parameters such as heart rate, body temperature, blood pressure (BP) and it is even able to perform electrocardiograms (ECG) [34, 37, 40]. All these sensors can be incorporated into a regular t-shirt rather than an expanded vest which is more convenient to the wearer [11, 41]. If the sensors are placed in shoes, it can be more comfortable for the user. "This can measure differences between mean foot extreme and gait stride time for healthy gait and those with physical disorders, as well as proved highly capable of detecting foot orientation and position" [37]. Besides these devices, many devices include cameras and microphones. Using these the state of the user and environment can be measured. A list of mostly used sensors are given in Table 1

The foremost step in the analysis of data collected from mobile sensors is to extract features. These features contribute a lot in the creation of a context with descriptive statistics. These features are extracted from a fixed length sequence of sensor data. Most of the sensors generate the values at a constant time increment. Again along with these mobile sensors, there are other sensors that can be embedded into the environment. It will create a pro-active living environment to support easier lives. For designing an interconnected, intelligent, dynamic and adaptable environment, Wireless Mesh Sensor Networks can be used. These structures can be incorporated into the objects of daily chores. These embedded sensors can be termed as "ambient sensors". Ambient sensors collect data from the environment to anticipate the needs of the citizens and thus maximizing the quality of living style. These sensors typically generate a reading if there is a change in state. WMSNs are built based on mesh networking topology in which each node serves as a relay for other nodes and capture and disseminate its own data [5, 29].

WMSNs are capable of behaving dynamically self-configured and self-organized. It can automatically establish and maintain mesh connectivity in the connected devices. WMSNs do not need centralized access points to arbitrate the wireless communication. They can suitably be used in dynamic and complex situations [1]. Table 2 shows a list of ambient sensors with their features.

Table 1 A list of mostly used mobile/body sensors

Sensors	Measurements
Accelerometer	Acceleration in x/y/z directions location
Location	Latitude, longitude, altitude
Gyroscope	Rotational velocity
App status	Use of applications, phone, text
Barometer	Atmospheric pressure
Thermal	Temperature
Camera	Image/video
Microphone	Surrounding audio
Biosensors (E[E/C/M/O]G) body activity	
Carbon dioxide (CO_2)	CO_2 concentration
Light	Ambient light level
Photodiodes	Heart rate
Force	Screen touch pressure
Pulse oximetry	Blood oxygen saturation
Glucometer	Blood sugar
Proximity	Nearness to external object
Galvanic Skin Response perspiration	
Compass	Orientation

Table 2 A list of ambient sensors with their features

Type	Measurement	Data rate
RFID/bluetooth	Object interaction	Low
PIR	Motion	Low
Power	Electricity consumption	High
Pressure	Pressure on object	Low
Temperature	Ambient temperature	High
Camera	Video, still image	Very high
Magnetic	Switch door/cabinet open/close	Low
Microphone	Audio	Very high
CO_2	CO_2 concentration	High
Light	Ambient light level	High
Water	Water consumption	High

5.2 Data Processing

In the internet of healthcare thing (IoHT) concept, distributed computing provides the optimum solution in data processing and data storage. Distributed computing refers to the studies of distributed systems. In brief, a distributed sys tem is a system with components located in different networked devices. These components interact together to produce the outcome toward a common vision.

We will be discussing two types of distributed computing systems and their contribution in respect to the smart healthcare system.

5.3 Cloud Computing

Cloud computing refers to the use of types of services like storage, servers and other software development through internet connectivity. It allows the option of deployment of clouds on demand and provides system maintenance to the users. It is a cost effective model and reliable storage for data. Cloud computing requires less security policies than edge computing.

There has been a large scale paradigm shift in the generation of the traditional manual entry based data storage. Not only generation, but also consumption, storage and exchange of healthcare data is changing due to digitalization of healthcare systems. Cloud computing has definitely added the large contribution in optimizing the traditional data management system. Healthcare sector has adapted cloud computing in a vast mode compared to other sectors [20]. This has been possible because of the continuous data storage on cloud architecture. Thus with the optimization of workflows and efficiencies, healthcare providers are able to offer personalization in care plans at reduced operating cost which ultimately results in improved outcome [16]. Cloud computing has proven to be a source of enormous advantages for both the patients and healthcare providers. It has become beneficiary for the business purposes too as high quality of personalized care is being provided with less expenses and with boosted interoperability than previous. The healthcare consumers are getting acquainted to the instantaneous delivery of services whenever they require emergency response. With the availability of cloud data storage, it amps up consumer engagement with the personalized healthcare outcome and plans by providing them healthcare data which results in improvised treatment gain. It also breaks down the location barriers between the patients and the caregivers [24]. This remote accessibility of data is the biggest advantage when it comes to the making of healthcare related plans such as providing telemedicine, virtual medication support and also in post hospitalization care plans. Access to healthcare services through telehealth adds a new dimension in caregiving management [24, 26]. Telemedicine upgrades the element of convenience to healthcare delivery along with patients' expectations. Easy sharing of healthcare data, proper accessibility, and supportive

healthcare coverage to the patient during the preventive or recovery phase reduce the health risk issues of the individual.

The data are collected from sources like sensors, wearable devices, and actuators. These personalized patient records and medical images can be archived and retrieved whenever needed from the cloud very quickly. Any individual can have control over his own health data which boosts the participation in opinion pertaining to own health. It also leads to the informative healthcare plan and acts as an awareness creating tool regarding health education. Though data security is a matter of concern, the provided reliability of cloud storage is higher. With an increase in system uptime, the issue of data redundancy also reduces which is notable. There is an automated backup option and also the location of complete data cannot be guessed, recovery becomes much easier if any problem occurs. These collected data, both structured as well as non-structured, is a large source. Data collected from various sources can be computed in the cloud with advanced computing power. Alongside with the help of applications of advanced algorithmic applications from big data analytics, artificial intelligence or deep learning based approach, the research opportunities get boosted. It paves the way for analytical formulation of personalized care planning. Thereby inter-operability between the system and consumer increased. It also creates higher interoperability among the different segments of the healthcare related industries like pharmaceuticals, insurance etc. Thus seamless transfer of healthcare data between the stakeholders accelerates care management procedures and improves the efficiency. Cloud computing also provides on demand availability of hardware and software resources. These can prove to be helpful for the healthcare institutions and providers from the need of purchase of resources which results in massive cost savings.

5.4 Edge Computing

Edge computing refers to the kind of distributed computing system where data storage is much nearer than cloud computing. This distribution requires less time than the cloud in processing. It enables the opportunity of real time processing. Applications are run as physically close as possible to the data generator instead of the centralized cloud, which is considered the ‘edge’ of the network. It has improved performance than cloud computing in terms of time [5].

Though cloud computing has established the idea of data storage through the internet, it cannot provide the information within the blink of eyes. Though it does not matter much in other sectors whether the availability of critical information and real time analysis is being occurred or not, it has a huge impact over the healthcare sector. For a patient with a life-threatening condition, it can quite literally mean the difference between life and death. In cloud computing, most of the computing activities happen in some fixed clouds. Here real time analysis faces many difficulties because of high latency, poor reliability and bandwidth congestion. These public networks can also present a threat to the potential security, privacy and accessibility issue. So to eradicate these challenges, edge computing introduces a new level of data

analysis by bringing it closer to the devices where the information is collected. This can be really handy in the situations where the analysis is required immediately like healthcare sectors. Though nowadays dependency on cloud computing is increasing, many of the healthcare facilities still prefer to store data in data centers. It creates the scope for more controlling ability over matters of security. As there is a reduction in need for wider connective status, the risk of downtime overcomes significantly. An infrastructure with edge computing options which is powered by a 5G/6G network provides the optimum solution in healthcare data processing [28]. It gives centralized control and security plans and saves data with safety so that potential threats can be detected earlier. Here in edge computing, there is no requirement for data being uploaded to the cloud storage. So, for real time analysis, data will be accessible in the possible shortest moment of time. For security at the hardware level, edge computing with the power of 5G/6G can play a vital role. With proper security measurement, certain services like viewing medical records can be accessed with permission. Thus, it can provide a greater range and improvised performance and latency. Another perspective to edge computing is, it can help to overcome the risk of storing and processing data in a tremendous amount. This results in faster, responsive and accessible infrastructure with the transportation of critical medical information immediately. Real time analysis with these data is also possible. Medical practitioners can have the support of advanced analytical results and then they can decide the best solution for their patient with more reliability. Unlike cloud computing, the barrier to time consumption and real time processing can be handled easily by processing through edge computing [25].

5.5 Security and Privacy of Healthcare Data

As a large amount of data is being stored and used regularly for the sake of proper healthcare management, it is really very important to pay attention in ensuring security and privacy of the data [16, 39]. Within the data stored in the cloud storage, the value of security is much higher. Therefore, encryption of data and use of proper security keys for accessing data must be prioritized. This can safeguard data from external threats. Concerns of breach exist in the online format of data. Unauthorized outsiders can frighten people by imposing virtual threats toward the data storage. Breach of personalized data can lead to identity theft which can further destroy the patient's reputation and finances. That is why elimination of the risk of breach is necessary [3].

Healthcare data security and privacy can be provided by following the solutions and norms:

- Enhancing administrative control by updating procedures and policies.
- By guiding stakeholders through privacy and security trainings.
- Monitoring physical and system access.

– Accessing the list of authorized users and by providing them proper validations for data access.
– Providing automated software shutdown processes.
– Having exigencies in place for prompt data recovery and backup.

6 Integration of Smart Healthcare with Other Smart City Components

Smart healthcare is one component under the smart city component domain. So, it requires to keep pace with other components too. We will share some perspective here regarding this.

6.1 Infrastructural Collaboration

Smart healthcare needs to collaborate with a proper combination of infrastructure. This infrastructure includes equipment, medical resources, healthcare technologies, healthcare providers, healthcare institutions etc. So, it requires the co-operation of smart people, smart governance, and smart structure to regulate healthcare outcomes.

6.2 Smart Education

Without a balanced combination of technological education and health education, people cannot be aware of their rights and participation in the healthcare system. And without stakeholders' participation, it is not possible to produce the optimum health care. The citizens need to be updated with advanced health planning so that they can use the findings in increasing smart healthcare benefits.

6.3 Medical Waste Management

Another related factor to smart healthcare is to manage the disposal of medical waste. If the medical waste is not handled and disposed properly, it can impose serious threat to public health. It will then hamper the process of smart environment establishment. So collaborating with medical waste management is another serious task bestowed upon the smart healthcare system.

6.4 Anytime, Anywhere Services

One of the biggest advantages of smart healthcare is that it can provide healthcare services on a personal need basis without having the location barriers and time constraints. So to avail this opportunity, smart healthcare systems need to get upgraded more frequently [43]. Smart economy and its outcomes can help smart healthcare systems to apply these visionary upgradations. Proper guidance from smart governance is also required in this matter.

7 Open Issues, Challenges and Recommendations

With any uprising ideas, come the challenges of maturing the concept and building up systems to smoothly turn the ideas into reality. Smart healthcare system is no different. Since the idea of it has arrived recently, exceptional systems have been formed. Yet, there is much room for development and challenges that need to be mitigated. With the changing world, new challenges are to be emerged every now and then. Only improving the technology accordingly will let it get the best possible results.

One of the current challenges is that smart healthcare lacks the proper macro direction and programmatic documentation. Hence, it does not have clear development goals. With vague goals, many resources are wasted. Smart healthcare does not only work on improving the quality of medical care, but also reduces the expenses of typical medical systems [43]. With the help of smart healthcare, service providers can study and cite enough scientific evidence to aid their diagnosis [5]. Along the way, they can also help physicians, researchers, suppliers of medical essentials, insurance companies and pretty much everyone working on the healthcare ecosystem. An obstacle on the way is that medical institutions among different regions and organizations do not maintain uniform standards. To ensure data integrity, many improvements are needed. There are large numbers of data which are quite complex. So naturally, data sharing and communication becomes a difficult process. Different platforms and devices also lack compatibility issues.

Smart healthcare does not have proper legal standards, which leads to patients not relying upon it. From a patient's perspective, this system is not secure enough and there are open risks of privacy violations. Since this is an advanced technology, people need to be educated enough to understand its proper usage. Some people find it too difficult to use it and accept the technological advancements. Also, some technologies of this field are still under experiment to maintain and upgrade these, a huge amount of funding is needed to work with all components and stakeholders of smart health system.

Only focusing on the technological aspects will not solve the mentioned problems. To solve those, we need to work on both technology and regulations. To advance the technology, we need to upgrade related technologies. This will accelerate the maturity

of the concept and make the system stable. Then, a unified standard between different devices and platforms need to be developed. It will assure maximum compatibility between them. This way, information exchange will become more effective and data integrity will also be improved. To integrate the business procedures between hospitals and medical information centres, a medical information integration platform needs to be set up. Between them, resources will be shared and information will be exchanged [7]. Cross-medical institutions will also be able to make online appointments and two-way referrals. In this way, the ideal residents' healthcare and medical treatment model will come to reality [9].

Next comes the ethical issues. The issues about data security simply cannot be ignored, since patients' reliability on smart healthcare depends on it. Smart medical care's development is unstoppable. To mitigate the anticipated ethical problems, developers and Government must work together to ensure the highest possible security to patients' data. Information disclosure may lead to people losing their jobs and getting into depressions which are uncorrectable, hence despite the advantages of smart medical care the system will not be accepted to the society.

Meanwhile, people need to abandon traditional medical services. Only the quality medical services should be existent and the quality of it should not be compromised at any cost. We need to keep in mind that smart medical care works on upgrading the overall medical services; but it does not intend on replacing the medical system completely. Considering the needs of patients in different groups and regions, improving the legal system is a key task that needs to be well taken care by the government. For developers and users, the states' law is the most powerful guarantee. If proper legal enforcement is not assured, it will cause serious damage to all the participants of the system. It is ideal for the smart healthcare system to be managed and monitored by the local government. Since the normal citizen trusts the government more than they trust the companies, all collected personal information should be kept by government-administered databases. Establishing this relationship will promote medical services and this way, a healthy ecosystem will be developed too.

To take data security and transmission stability a step further, applying advanced technologies will come to use. Combining these and government monitoring, data security will be ensured as much as possible. Finally, the development goals need to be defined to achieve the maximum results using the minimum resources. Professionals from relevant fields can come together to elucidate proper development goals of the industry. All and all, to make smart healthcare a more secure and reliable system, legislation must be ensured. This will guarantee the privacy and data security of relevant personnel and make this a more accepted system by general people.

8 Conclusion

The latest advancement in digital technology has facilitated formation of smart cities. Using different types of wearable devices and e-health sensors would create a pervasive potential for smart health care. For individual citizens, smart healthcare will

result in better personal care management in least time possible. Appropriate and adequate medical services can be accessed on a personal demand basis and with the updated data about any individual will help in prompt decision making for the health care-giver. For the healthcare institutions, acceptance of smart healthcare approaches will reduce operational cost, create less distraction and peaceful working style for the personnel, achieve unified management of resources and information etc. For the authority, a smart healthcare system will help in policy designing and decision making in the healthcare sector. It has already created a new dimension in the healthcare view. With further upgradation, it can improve current status of healthcare resource inequality. Promoting the implementation of prevention strategies can reduce the risks of spread in major health issues. Smart healthcare reduces cost for healthcare for both at the individual and authority level. Thus it will ensure the betterment for the other smart city components and smooth the economic growth. Although there are some underlying challenges to overcome to improvise the smart healthcare system foundation, development and maintenance. The solution to these barriers requires more emphasis on the collaborative efforts of health institutions, care-givers, technology companies, consumers and policy makers. With proper combination of technological efforts and collaboration of the stakeholders, a smart healthcare system can become a trusted resource and can leverage the smart city goal.

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