An internet of things-based smart homes and healthcare monitoring and management system: Review

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Abstract. Since the term of a smart city was proposed, Internet of Things (IoT) has been considered as the infrastructure's key in a smart city. Huge research consideration is an emphasis on remote wellbeing observing system dependent on IoT technology. IoT is the internetwork of physical objects or "things" that are embedded with software and sensors to collect and send data between them and central servers with minimum human intervention. This term can assist decline with constraining on medical clinic system and healthcare suppliers, decrease insurance costs, and improve healthcare. In the modern healthcare environment, IoT is being used in various medical areas like real-time monitoring, patient information management, medical emergency management and blood information management. Over these years a number of advanced applications based on IoT have been proposed for convenience of patients, doctors and caregivers in the healthcare sector. Therefore, the current study describes the applications of IoT technologies in medical and healthcare field. Moreover, the it highlights the huge potential of this process and future directions for further research.

1. Introduction

In the 21st century, the world's population is increasing rapidly. Cities that accommodate more residents face tremendous pressure from city life [1]. Although medical resources and facilities in the city are expanded every day, the level of adequacy has not yet been reached. Massive pressure on health service management in cities has triggered technological advances to produce appropriate solutions to develop problems rapidly. For example, the post-stroke rehabilitation services for the old individuals are new challenges, which require a long-term commitment from medical and human resources [2].

Therapeutic rehabilitation is considered as a new issue and plays a crucial role in keeping health service for people, particularly the old individual or those who suffer from incessant infections to improve the quality of life. However, the promotion of medical rehabilitation to a wider scope of applications faces several obstacles. First, most rehabilitation treatments require long-term and intensive therapy. Second, additional assistance facilities are needed to give patients easy access to rehabilitation services. Third, the availability of rehabilitation resources is relatively scarce due to the increasing population, especially the elderly in the community at this time [3].

The Internet of Things (IoT) is a synonym for a world that is fully interconnected and offers increased technology to reach the next level of health care [4]. "Objects" in IoT can be in the form of cars with built-in sensors or humans with heart monitors, that is, once an object is assigned an IP address and the object can collect and transfer data with little or no human intervention. The Internet of Things (IoT) additionally speaks to new, energizing open doors for pretty much every aspect of our life [5, 6].

Earlier research endeavors in the field of IoT in healthcare started with the initial research and development activities based on wireless sensor networks (WSNs) [7]. This tool ensures that devices are affordable, inexpensive, reliable, and practical to carry or put together with patients, thus enabling a seamless network between patients, medical devices and doctors [2]. The objective of this paper is to describe the application of IoT technology in medical and healthcare field for human health and to play out an assortment of tasks and things present in the environment to be connected to cooperate and conduct with the future commands for additional research "anytime, anyplace, with anything and anyone".

2. Smart healthcare concepts

Intelligent healthcare is a wellbeing administration system that utilizes innovation, for example, wearable gadgets, IoT, and versatile web to progressively get data, associate individuals, materials and foundations identified with healthcare services, and afterward effectively oversee and react to therapeutic environment needs in an insightful way. Intelligent healthcare can advance interaction between all gatherings in the healthcare field, guarantee that members get the administrations and services they need, assistance the gatherings settle on educated choices, and encourage the sane designation of assets. To put it plainly, intelligent healthcare is a higher phase of data development in the therapeutic field [8]. An intelligent healthcare services framework must give a consideration to individuals in remote areas and monitoring system to deliver a continuous data stream for better decisions and contingent upon the prerequisites [9]. An intelligent healthcare services system might be operated at the home, inside a network, or even be utilized widely in the world [3].

2.1. The requirement for personalized healthcare

S. K. Datta, *et.al*. 2015 [10], the details requirement of architecture component are: the availability and integration of a data generation subsystem from where the physical parameters will be collected, overall architecture system requires a processing and storage subsystem, the processing and storage subsystem should be able to access the data generation subsystem regardless of communication technologies, the architecture requires a consumer subsystem, the consumer subsystem should support resource discovery to discover M2M devices present at data generation subsystem and select appropriate ones for data collection. Machine to Machine (M2M) communication and mobile technologies are the current revolution of the internet. It is the leading phase towards the IoT [11]. Beside that point, a device management framework is necessary to keep track of the registered devices and their configurations, the processing and storage subsystem must incorporate mechanisms for generating high level abstraction from raw data, the interaction between the mentioned subsystems should occur in a stateless manner using RESTful principles, proper access control policies should be enforced to allow authorized users avail the personalized healthcare solutions. And the overall system should be able to provide subscription service for occurrence of a list of events, the architecture should allow the consumer to react to the smart home environment based on the received push notification, the architecture must ensure low latency, high QoS, easy user interface and social network integration, recovery from errors and timely feedback for AAL based systems [10].

2.2. The layer of IoT in healthcare

IoT applications are highly dependent on the middleware layer for information processing. Some IoT applications are smart health, smart grid, smart city, smart home, smart agriculture, intelligent transportation, etc. The fundamental IoT layer framed is below [5, 12]:

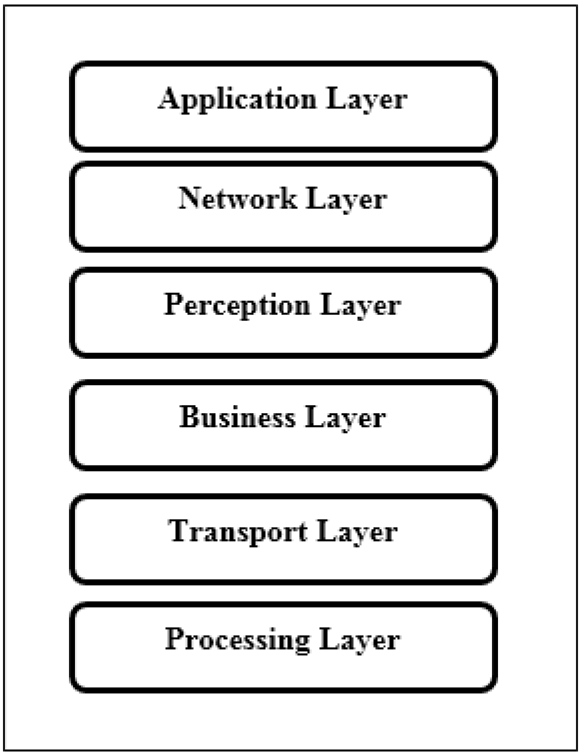

Figure 1. Architecture of IoT in healthcare.

The early stages for architecture IoT have three layers, namely perception, network and application layers. A perception layer describes about the sensor devices and physical objects to identify others smart objects in the environment and senses the object in some physicals parameters such as information about temperature, motion, orientation, humidity, location, acceleration, etc. Actually, this layer is composed of generation and actuation subsystem as a first step towards a smarter and personalized healthcare. Sensor and actuators are deployed to smart home with the purposes of (i) procuring deeper understanding of the person's environment as well as (ii) facilitating home automation. In [13], perception layer technologies are follows as passive, semi passive and active layer. Passive devices have the short radio coverage therefore they do not have on-board power supplies and rely on readers in close proximity for their energy supply. In the semi passive devices have batteries that power tags while receiving signals from a reader and in the active devices often have the extended range because they have larger batteries or are attached to power supplies that enable them to transmit and receive data.

The network layer is responsible for connecting to other smart things, network devices and servers. It is usually used for transmitting and processing sensor data. The application layer is the significant role of this layer to deliver application-oriented services to the end users. It defines various applications in which IoT can be deployed, like smart homes, smart cities and smart health [10], [12], [14]. The outline function of other layers is the transport layer, transfers the sensor data from perception layer to the processing layer and vice through networks such as infrared, wireless, LAN, RFID, Bluetooth, ZigBee, Wi-Fi, UMTS, and 3G. The processing layer or the middleware layer can store and analyses the large amount of information received. It can manage and provide a diverse set of services to the lower layers and can connect with big data, cloud computing, and databases for processing the huge amount of data.

Journal of Physics: Conference Series **1450** (2020) 012079 doi:10.1088/1742-6596/1450/1/012079

The business layer manages the whole IoT systems, including applications, business, profit models and user's privacy [12].

Another architecture proposed by [15], the layers of processing in the human brain. It is inspired by the intelligence and ability of human being to think, feel, remember, make decisions and react the physical environment and divided into three parts. First, the human brain is analogous to processing and unit or the data centre. Next part is the spinal cord, is analogous to distributed network of data processing nodes and smart gateway. The last part is the network of nerves as corresponds to the networking components and sensors.

2.3. Problem on medical practices in healthcare system

An increasing trend of an aging population throughout the society in recent decades was caused intricate health problems, involving an increment in incessant infections and an increase in clinical and hospital service expenditure. Health monitoring plays a significant role in keeping health for people, particularly for the old people infected with chronic diseases because of reduce ability of hospitalization and improve life quality because monitoring conventional health module is time-consuming and troublesome for all included [1], [16]. List a portion of the issues and boundaries looked by emergency clinic driven restorative practices [17], for example:

- Limited time and forthcoming: expanding populace with ailments and inabilities confines the doctors do not have the planned of patient's everyday schedule, for example, physical action, diet, rest, and public activity, these qualities are similarly significant during diagnosis operation and treatment.
- Adherence observing doctors are worse prepared to check if their patients are sticking to recommended treatment that may incorporate meds, recovery activities, and some preventive exercises, for example, staying away from some eating regimen.
- Aging populace: old populace will look for more offices and assets for restorative consideration.
- Urbanization: suggests that large urban communities will request more healthcare foundation to serve rising populace. Also, huge urban areas will turn into a focal point of pandemic upheavals of infectious sicknesses that will spread effectively crosswise over thick populaces.
- Shortage of medicinal healthcare workforce similarly builds the interest in healthcare laborers including doctors, specialists, dental specialists, nursing staff, nurture collaborators, proficient guardians, and lab staff who could upgrade the healthcare biological system in urban and country territories.
- Rising medicinal cost: expanding cost for the healthcare.

3. IoT Infrastructure in healthcare

The constituent segments of the healthcare IoT foundation are cloud, gadget (with a peruse, likewise frequently called as a "base station"), medicinal or healthcare suppliers and communication channels (among gadget and cloud). healthcare and therapeutic gadgets can be named [6], [18] customer items for wellbeing checking, wearable (external restorative gadgets), inside inserted medicinal gadgets and stationary medicinal gadgets. Such gadgets detect electrical, thermal, chemical, and different sign from the client's body. They straightforwardly detect and gather biomedical sign, that is, data about the physical and mental condition of human's wellbeing. For proposed in Parkinson's disease detection system, the framework comprises several components with a smart home equipped with sensors, the smart city, the cloud, the doctors, and the clients. The client resides in a smart home, which has many sensors, but we are interested in those that can capture voice signals, including smart phones, voice recorders, and portable computers or tablets. First, the client registered with the service provider through a web application. Second, after successfully registering, the client records a voice signal and uploads the signal for processing in the cloud. After processing, the results are sent to a doctor, who prescribes medication to the client via the cloud. The smart city controls vehicles and traffic to provide the client with the service as smoothly and early as possible [19]. For correspondence with the Cloud, gadgets much of the time utilize external gadgets that are alluded as the peruses (for example PCs, cell phones, and so forth.). In this way, the information can be sent to the Cloud straightforwardly or in a roundabout way (through the peruse). It surely understood and utilized, for example, Wi-Fi, Bluetooth, ZigBee and 2G/3G/4G Cellular.

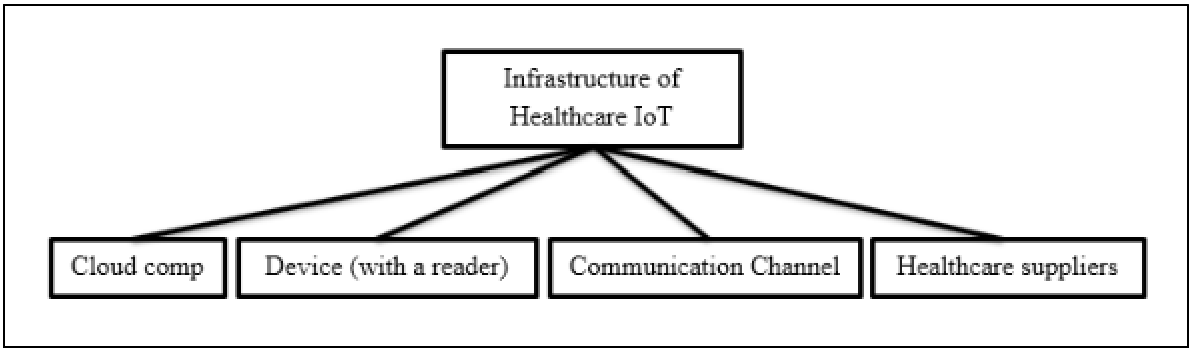

Figure 2. IoT Infrastructure of healthcare components [6].

4. Component of IoT in healthcare

There are 5 parts making the IoT in healthcare services to serve intelligent medicinal services and it shapes a round system. The system begins with the sensor to gather information. The gathered information goes to the following stage, which is a smart network to interact the system. The sent information through this network is saved at the cloud computing which is the third part of the healthcare system. When the information is saved, the information must be investigated and analysed for appropriate choice in the fourth part of big data analysis. Subsequent to choosing appropriate decision of information, refined information is sent to a smart medical clinic to illuminate the outcome to medicinal services experts. The smart clinic takes activities for fitting diagnoses and treatment. Despite the fact that the smart clinic is the last part of IoT healthcare services system keeps proceeding to gather information to affirm that the framework has fixed analysis and treatment. Henceforth, the system again goes to the first part to maintain the circularity of the system shown in Figure 3 [9]:

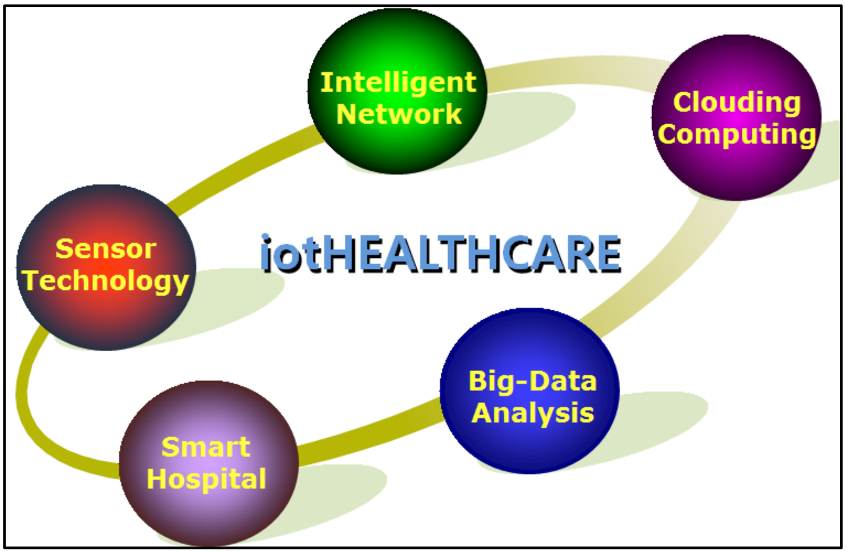

Figure 3. Component of IoT healthcare [9].

IoT healthcare is new paradigm which delivers the services and clinical information connected even remote locations. IoT technologies divided into remote patient monitoring, tracking health monitoring and telehealth, sensor technologies to monitor hand wash, RFID monitor activities and interaction. It provides the better assessment, rendering diagnose, and treat the patients effectively. Kumar [20] collects the data using IoT assist to health monitoring system include personalised alerts to patients and health provider. Smart Healthcare provides the awareness and medical education about Health status by providing information from time to time. IoT enabled healthcare technologies has more significance for process the healthcare information to service providers, research and development in medical field and government, service community and targeted group. IoT ensures monitoring and engagement and activities of elderly people in hospital and nursing homes and also track the wandering patients to monitor the chronic conditions as well as predictive analysis of patients with the usage of wearable and other devices at home and hospital.

In [21], other technologies that can be applied to IoT based on healthcare system are cloud computing to provide facilities with ubiquitous access to shared resources, offering services upon request over the network and executing operations to meet various needs; grid computing as the non-invasive sensing and low-power wireless communication technologies namely small wearable devices like capable of continuously monitoring vital signs such as blood pressure, temperature, Electrocardiogram (ECG), Electromyogram (EMG), oxygen saturation; big data provided by medical sensor in the healthcare environment to increase the efficiency of relevant health diagnosis and monitoring methods and stages; networks to support the physical infrastructure on the IoT-based healthcare must be defined for short-range communications, such as WPANs, WBANs, WLANs, 6LoWPANs and WSNs to long-range communications and ambient intelligence as an important part of IoT based healthcare because end users, clients and customers in a healthcare network are patients or health-conscious individuals.

5. System management in healthcare

Management is the purposeful and effective use of resources as work force, materials and finances for fulfilling a pre-determined objective. It consists of planning what is to be done, organizing how things are to be done, motivating people to do the work and checking to make sure that the work is progressing satisfactorily [22].

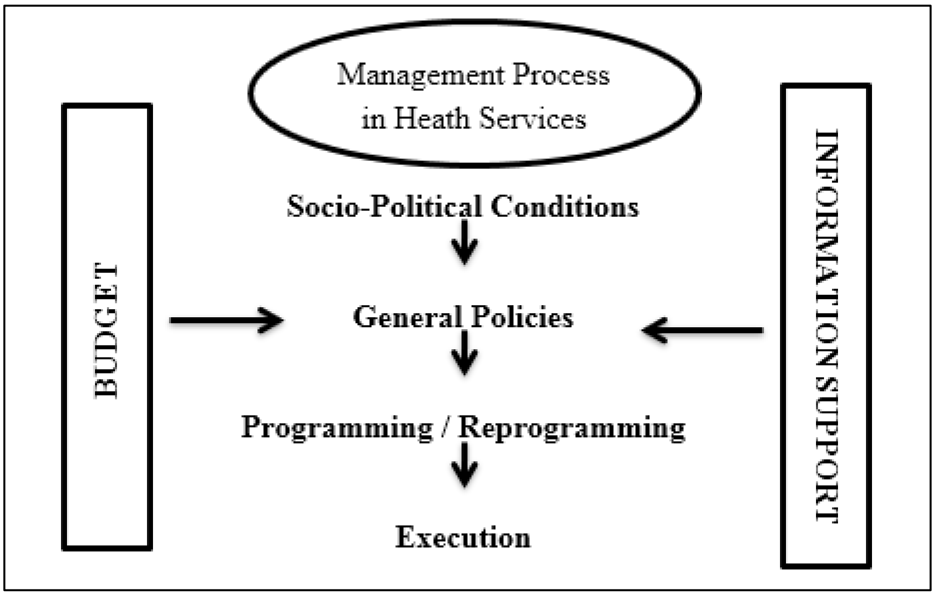

Figure 4. Management Process in healthcare service [22].

Performance management was applied in different economic sectors [23]. he concept is centred around three fundamental goals: improving health, enhancing responsiveness to the expectations of the population, and assuring fairness of financial contribution as process of assessing progress toward achieving predetermined goals, the relevant communication and action on the progress achieved and the instruments of performance management can be considered under broad headings of guidance, monitoring, and response [23, 24].

Smart healthcare helps to assures quality work force and also helps to evaluate their service thereby they can develop and improve the service. In [20], the system management consist of three part: assessment, assurance and service development. The assessment is divided into monitor the health, diagnose and investigation. The assurances connect and provide care, assure quality work force and evaluate the service. And for service development is divided into awareness and educate, quality treatment and develop the service policies.

6. Data collection and transmission

Fundamental function to gather information from intelligent sensors is shown in table 1 [9]:

Table 1. Fundamental function.

Function	Description
Accept Sensor Device (device)	Accept a new sensor device into IoT Healthcare
Drop Sensor Device (device)	Cancel the usage of the device from IoT Healthcare
Reset Device (device)	Reset the device to erase buffered data
Enable Device (device)	Enable a device after accepting the device
Disable Device (device)	Disable the device to quit a usage
Get Data (device)	Get signals from the device
Put Data (device, NetID)	Send signal data from the device for network ID
Check Signal (device, NetID)	Check the signal from the device going on network ID
Skip Signal (device, NetID)	Skip/Ignore the signal from the device going on network ID

The ideal case scenario for the conduct of the research would have consisted of an environment where a healthcare system was already benefitting from the use of IoT-based healthcare services [25]. In [9], the information assortment comprises of IoT-driver sensors to gather the ongoing monitoring from intelligent sensors innovation, for example, to deal with information in bio optic sensor, ECG sensors, EEG biotelemetry, heart bit rate sensor for monitoring of blood pressure, glucose tracking, virus infection monitoring and healthcare observe. The embedded gateway configuration (EGC) service is an architectural service that connects network nodes (to which patients are directly connected), the internet (to which required servers and clients are directly connected), and other medical equipment [26]. IoT-based ECG monitoring system composed of a portable wireless acquisition transmitter and a wireless receiving processor. The system integrates a search automation method to detect abnormal data such that cardiac function can be identified on a real-time basis as an innovation by [27].

Patients will be provided with a usable sensor that is able to measure muscle activity Electrocardiography (ECG), Temperature, Electromyography (EMG), respiratory rate, sweat and blood glucose levels that can be easily placed in several parts of the body to get accurate measurements to find out the type of diseases such as arrhythmia, fever, neuromuscular disorders, blood pressure, obesity, and diabetes. From compact sensors embedded in the patient's body, physiological data is collected which consists of various physiological parameters that are needed. Then a small piece of hardware capable of reprocessing the data obtained and communication software to transmit that data. The sensor must be small, lightweight and not interfere with the patient's mobility and movement. The sensors must operate on small batteries that are energy efficient. The battery is expected to work continuously without charging and replacing it [2].

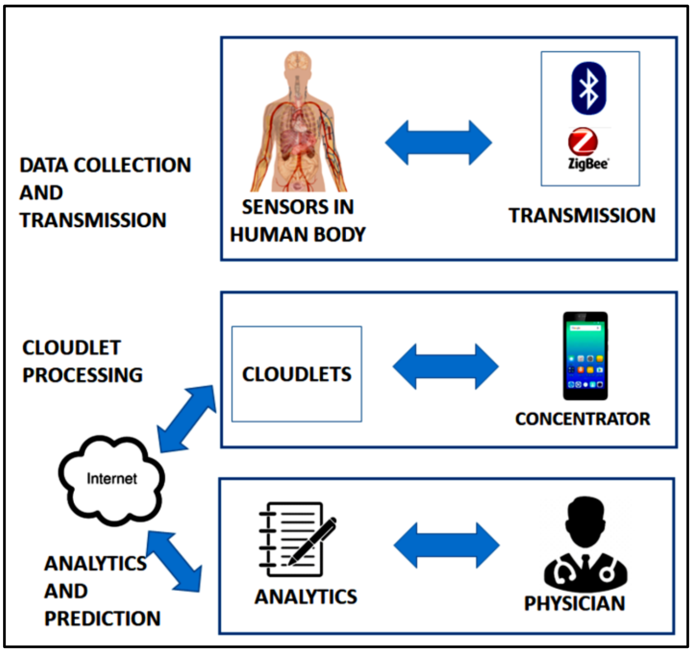

Figure 5. The Systems component [2].

The system components responsible for data transmission must be able to convert recordings of the patient from any of their location to the health centre with accuracy and security. For transmission, short range low-power digital radio ZigBee or Bluetooth can be used. Further, the acquired data can be relayed to health centre through Internet for storage. The sensors involved in the IoT system can be operated through the Internet via the concentrator which can even be a smartphone.

7. Application in the field of medical and healthcare

In the field of medical and health care, major applications of the Internet of Things include [28]:

7.1. Medical equipment and medication control

Monitor the whole process of production, delivery, anti- counterfeit and tracing of medical equipment and medication to safeguard public medical safety. The following aspects are:

- The Anti-counterfeiting of therapeutic equipment and medicine to recognize in RFID tags placed on the product is unique and hard to recreate. For instance, if the medicine data has been stored into the open database, patients or emergency clinics can check the labels as per the record set in the open database and distinguish the fake meds effectively.
- Robust real-time monitoring that ensures medicine delivery and storage environment.
- Medical refuse information management can track the medical refuse during the whole process of transport from hospitals to refuse processing plants and avoid illegal disposals of medical refuse.

7.2. Medical information management

Medical information management is an explicit applications include the accompanying a few viewpoints:

- Patient Information Management and Status Monitoring, in [29], a patient's electronic wellbeing profile incorporates therapeutic history, restorative assessments, treatment records and medication sensitivities may give some consultant and nurses to screen the patient's indispensable signs and do the test and treatment to keep away from the event of utilizing incorrectly prescriptions or giving injections. Depending on the specific pathology, different pieces of information on the patient's status may need to be collected (movement characteristics, heart beat, breath, proximity to other patients, etc.), it must be continuously available on medical / nursing staff [30].

- Patient Location and Tracking, it is a valuable asset, since it enables prompt reaction in case urgent assistance is needed. This is specialized in pathologies, including cognitive and/or perceptual disorders, Down's syndrome, epilepsy, neurodegenerative disease like Alzheimer and Parkinson's [30].
- Chronic Patient Healthcare Monitoring, continuous monitoring of vital signs of patients helps to reduce re-hospitalizations by detecting anomaly early, allowing appropriate and timely interventions [31]. IoT plays an important role in connecting medical devices with video-oculography with the goal of analysing the brain's functional structures and activity. The presence of oculomotor alterations in Parkinson's disease is well known with the integrated process with intelligent machine [32, 33]. Fall prevention and fall detection are emergency applications because falls are serious health problems with older adults. Fall detection can be classified into three types: wearable device based, ambient sensor based, and vision based [34, 35] proposed a real-time fall detection system based on wearable sensors to detect the motion and location of the body with 15 activities including ten intentional falls and 5 activities of daily lives.
- Medical Emergency Management help dependable and productive data stockpiling and review strategies for RFID innovation [28].
- Medication Storage Management, RFID can be applied in the storage, utilizing and review of medicine and made drug review considerably more helpful, in this manner to maintain a strategic distance from the perplexity of comparative prescription names, dosage forms, reinforce drug management and defend convenient supplies of medicine [36].
- Management of Blood data, can adequately maintain a strategic distance from the little limit downside of bar tags and acknowledge non-contact recognizable proof to lessen blood pollution, realize multi-target ID and increment the effectiveness of information assortment [28].
- Mechanism of Error Prevention during Pharmaceutical Preparations, [28], Through the development of mechanism of error prevention during getting drug and administering drug and the data management of pharmaceutical arrangements during the prescription, dose, prescription dissemination, prescription taking, drug impact trace, medicine stock control medicine buy and storing life and condition.
- Medical Equipment and Medication Tracking, the precise records of therapeutic Equipment and drug, incorporates the essential data of item use, the particular data of the item associated with the unfavourable occasion, the origin of the item with quality issues, the patients who have utilized the item with quality issues and the districts where the item with quality issues has not been utilized. IoT based on smart bundling technique for medication boxes can be utilized for drug management. This bundling technique have controlled fixing which depends on delaminating materials and that is constrained by remote communications [2, 37].
- Information Sharing, utilizing this system, approved specialists may investigate restorative records, therapeutic accounts, medicinal medications and health insurance of patients, in the mean time, patients can likewise openly pick or change their primary care consultants or clinics [28].
- Neonatal Anti-theft system combine the management of identification, anti-theft of neonatal and pathway access to avoid the random coming and going of strangers to give a workable and robust protection for new-born babies [28].
- Alarm System, the ongoing tracking and monitoring of clinic therapeutic apparatus and patients, the alert framework can assist patients with sending the crisis trouble signal.

7.3. Telemedicine and mobile medical care

Telemedicine [38], is a type of advance medical help that integrate multi technologies such as computer, communication, multimedia and medical. The objective is to improve the analysis and therapeutic level, diminish medicinal services costs, meet with the wellbeing prerequisite of individuals and build a patient focused assistance framework to complete remote counsel and persistent checking of basically patients. [39], progress of the remote technology to effectively communicate within the Body Sensor Network of patients. And telemedicine also monitoring gradually providing life-saving information and timely exchange of medical program [40]. Features of telemedicine are [41], remotely diagnose, prescription-based diagnostics, personalized website for patient, appointment management-patient, doctor dashboard, inbuilt billing feature, biosensors and seamless video-conference-multiple camera options.

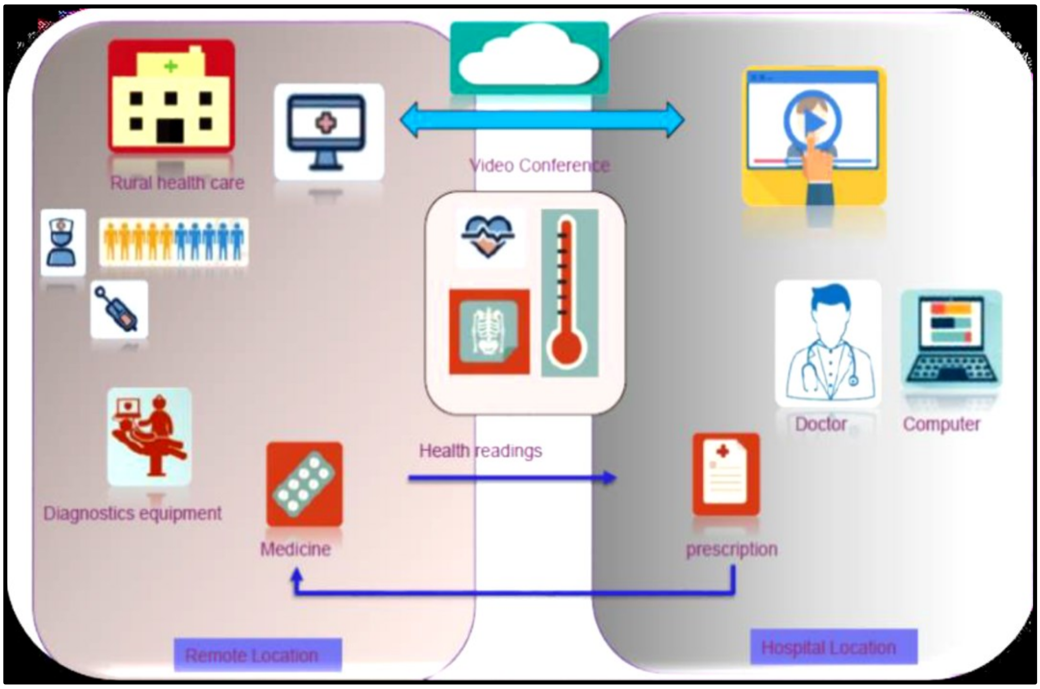

Figure 6. Telemedicine architecture.

There are six major explanations behind restricting the advancement of telemedicine [42]. First, media communications transmission quality isn't high. The data transmission and bandwidth are the greatest bottleneck. Second, the telemedicine systems communication standard is as yet not consistent with the nearby clinic, there is no uniform standard. Third, it is hard to process generous medicinal pictures. Fourth, there is a security issue for long-separation transmission which is powerless against be assaulted by virus and hackers. Fifth, telemedicine infiltration is still low. Sixth, the system development cost imperatives the notoriety of remote discussion centre. The genuine telemedicine can accomplish a uniform standard. It tends to be top notch, perfect, open and securely and whenever, wherever, any switching of medicinal staff.

7.4. Health management

A procedure and techniques, whose intention is to avert and control the appearance and advancement of disease, minimise therapeutic expenses, and enhance the life satisfaction because incessant infections have a long course of malady [38, 43]. The new wellbeing management model under intelligent healthcare gives more consideration to understanding self-administration. It accentuates continuous self-observing of patients, prompt input of wellbeing information, and auspicious intercession of medicinal conduct. The rise of implantable/wearable savvy gadgets, smart homes, and intelligent wellbeing data stages associated by IoT innovation gives an answer for this circumstance. Third-age wearable/implantable gadgets can join propelled sensors, chip, and remote modules to constantly detect and screen different physiological pointers of patients in a savvy way, while decreasing power utilization, improving solace, and enabling the information to be joined with wellbeing data from different channels. This methodology includes a jump from situation observing to consistent discernment and incorporated consideration. It further lessens the related dangers brought about by the sickness while making it simpler for medicinal establishments to track the guess of the infection [44].

8. Implementation strategies and methodologies of IoT healthcare

A rehabilitation system is established by WiFi and radio frequency identification (RFID) based short distance radio communication technologies, global positioning system (GPS) based location technology, unique identifier (UID) based identification technology, and service-oriented architecture (SOA) based architecture technology and enabled the IoT of rehabilitation system [45–48]. Viable techniques and strategies assume a focal job in IoT based healthcare services system for enhancement the ability and viability of the system. The centre issues incorporate the quick response capacity and hazard maintaining a strategic distance from insight that is firmly identified with recovery quality [3], [48].

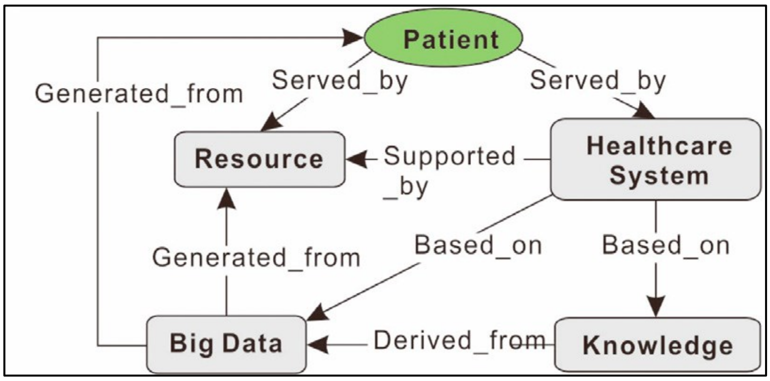

Figure 6. The semantic relations among the key methodologies in IoT based rehabilitation system [48].

The entail rehabilitation system is supported by medical resource. During rehabilitation, large amount of data is the raw material for analysis. Derived from it, the medical knowledge accumulates continually. The big data and knowledge act as the basis for recover treatment and system operation. In the field of chronic disease, especially in Parkinson's disease monitoring it focuses on the assessment of the motor status of Parkinson's patients and in the development of a wearable system to objectively quantify the severity of the motor disturbances using motion sensors based on the study of various parameters of motor behaviour from the selected sensors, usually accelerometers and gyroscope to use electromyogram (EMG) or voice analysis [49-51].

8.1. Resource management

Resource Management includes the issues of tracking, sensing, identification and authentication.

- Tracking, to solve the lack of "visibility" on the locations, the conditions of patients, physicians, medical equipment or other assistive resources. A real time asset tracking system for a hospital's clinical setting by attached Wi-Fi tags [52].
- Detecting, sensing, technologies are patient-situated, and operate as both enabling and key technologies in IoT based healthcare service systems. The devices are innovated to monitor and diagnose patient status and give real-time data for health indicator of patients [53].
- Identification & Authentication, indispensable to reduce the possibility of harmful mistakes to patients, such as wrong drug, dose, timing, or procedure.

8.2. Knowledge management

the acquisition, development, accumulation and reuse of healthcare knowledge in the expert system is crucial to the rehabilitation efficacy. The knowledge base of the system is featured with global disease ontology, which indicates cases and the corresponding treatment. The medical resources ontology covers doctors, nurses, rehabilitation devices, ambulances, and other medical resources. The classes and sub-classes in the ontologies are selected according to doctors' suggestion with the consideration of information integrity, nonredundancy, and legibility to ensure that the automated process is efficient and accurate [48, 54].

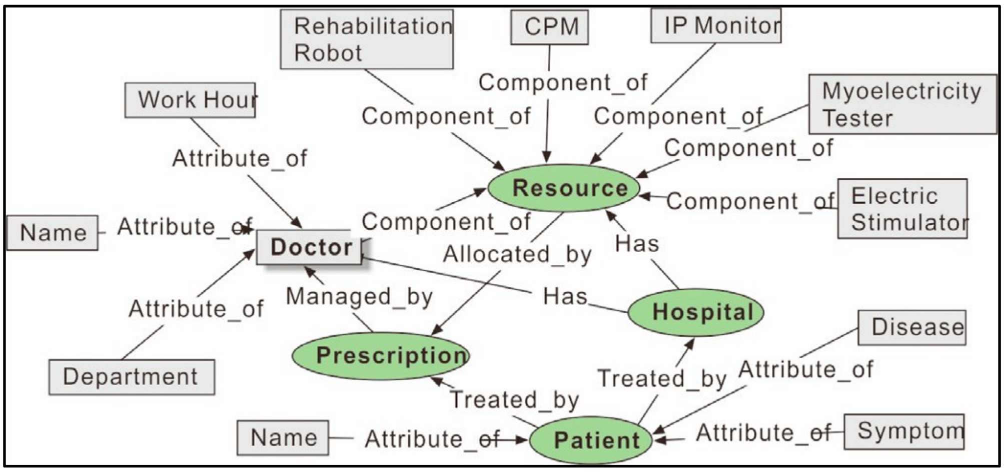

Figure 7. Ontology of smart rehabilitation system and its sematic network [3].

The fundamental semantic system of the cosmology of smart recovery system with four primary sub-classes, in particular asset, medicine, emergency clinic, and patient [3], therapeutic assets incorporate the treatment hardware, for example, continuous passive movement (CPM), restoration robot, IP screen and specialists. The gadgets, for example, IP screens with the goal that the real data can be gotten and checked by specialists, observe patients situated in clinics while taking the restoration treatment. The medicine is turned out by specialists and aides tolerant what treatment to take and how the asset ought to be overseen. In [48], cosmology fills two needs. To begin with, ontological information structure empowers increasingly effective and exact thinking. Second, cosmology gives well-organized space information on restoration designing, empowering simple information sharing and reusing. The asset cosmology formalizes medicinal assets including both human asset and material asset, for example, CPM, and restoration robot, and so on. It encourages the system to pick suitable assets rapidly as indicated by the treatment necessities determined by the disease cosmology.

8.3. Big data management

IoT sensors typically collect a huge amount of data. It is necessary to analyse all of this data in great detail. As a result, a lot of big data algorithms are used to analyse IoT data. Moreover, it is possible that due to the flimsy nature of the network some of the data collected might be incomplete. It is necessary to take this into account and extrapolate data by using sophisticated machine learning algorithms. In light of information gathered from medical clinics, recovery centres, networks and homes. The information from things are refreshed continuously and the information exchanges may happen at the same time among hundreds or thousands of things [12]. Health big data based on mobile health cloud has the following features [42]:

- Heterogeneity reflected into two aspects. The different parts of the body, different categories of different organizations and different countries and regions store health data with different standards of medical standard and complicated storage format with structured relational data and semi-structured data [55]. On the other hand, [56] with the development of technology and the advance of information technology, the same kinds of data may also be changed in the structure.

- High correlation. In [42], medical health data including the body's vital signs have closely linked. Alone or a small portion of the data, does not accurately describe the function of the body. Its causes may be acute infection, tissue injury, hepatitis, and leukaemia. However, if the white blood cell in urine is detected to be high at the meantime, can preliminarily estimate that it is suffering from renal disease.

In addition, mobile medical big data has the following three characteristics [42]:

- Real-time: Due to the special nature of health care, the data must be real-time detected. At sudden event, it also needs for timely treatment.
- Time and space association: Healthcare makes some huge memories and space trademark which is chiefly showed in two perspectives: First, the various areas' kin have a few contrasts. For instance, the measure of haemoglobin of the individuals at high elevation is commonly higher than the plains. Likewise, the equivalent physiological parameters of the human body at various occasions will have a few changes.
- Low extent of substantial data: Mobile smart gadgets and regular detecting gadgets can't give exact test outcomes like proficient restorative gadgets. It will produce a great of noise while transferring.

The generated big data continues to increase as the IoT collects extra data. The most efficient action plan for addressing continuously increasing data is to process them in actual time streaming [57]. Actual time processing enables up-to-date analytics that reflect recent modifications of the data and conserves storage. In this context, machine learning can also utilize Big data to make accurate predictions. Besides, parallel computing can be employed using some IoT nodes to process data in parallel with backend servers for superior performance and load balancing [13].

9. Conclusions

Medical rehabilitation is a relatively new subject and plays a significant role in keeping health for people, particularly for the old people infected with chronic diseases to improve the life quality. The Internet of Things (IoT) grows at unimaginable speeds, involving cultural and technological changes for organizations, businesses, and companies, as they are immersed in a transformation toward a more intelligent model, taking into account environmental care and responsibility social. There are important and beneficial benefits of implementing IoT in the health monitoring systems such as medical equipment and medication control, medical information management, telemedicine and mobile medical care, and the implementation strategies and methodologies including the entail of the rehabilitation system.

10. References

[1] Nguyen H H, Mirza F, Naeem M A and Nguyen M 2017 *Computer Science* 257–262
[2] Sathya K J M and Madhan S 2018 *International Journal of Engineering & Technology* **7** 175–178
[3] Yin Y, Zeng Y, Chen X and Fan Y 2016 *Journal of Industrial Information Integration* **1** 3–13
[4] Sunitha C, Asha P B and Lavanya S 2019 *International Journal of Trend in Scientific Research and Development (IJTSRD)* **3** 218–222
[5] Poongodi T, Balamurugan, Sanjeevikumar P, Holm-Nielsen J B 2019 *IEEE India Info* **14**
[6] Strielkina A, Uzun D and Kharchenko V 2017 *Proc. 2017 IEEE 6th International Conference on Intelligent Data Acquisition and Advanced Computing Systems IDAACS* **2** 849–852
[7] Albesher A A *IJCSNS International Journal of Computer Science and Network Security* **19** 181–186
[8] Tian S *et al*. 2019 *Journal of Global Health* 0–3
[9] Jeong J, Han O and You Y 2016 *Indian Journal of Science and Technology* **9**
[10] Datta S K, Bonnet C, Gyrard A, Ferreira Da Costa R P and Boudaoud K 2015 *24th Wireless and*

Optical Communication Conference WOCC 164–169
[11] Khan S A, Farhad A, Ibrar M and Arif M 2016 *International Journal of Computer Science and Information Security* **14** 94–99
[12] Sethi P and Sarangi S R 2017 *Journal of Electrical and Computer Engineering* **2017**
[13] Perwej Y, Ahmed M, Kerim B and Ali H 2019 *Communications on Applied Electronics* **7** 8–22
[14] Poongodi T, Balamurugan, Sanjeevikumar P 2019 *International Journal of Engineering and Technology* **14** 143
[15] Ning H and Wang Z 2011 *IEEE Communications Letters* **15** 461–463
[16] Karthikeyan S, Devi K V and Valarmathi K 2015 *International Conference on Green Engineering and Technologies (IC-GET)*
[17] Farahani B, Firouzi F, Chang V, Badaroglu M, Constant N and Mankodiya K 2018 *Future Generation Computer Systems* **78** 659–676
[18] Council A, Healey J, Pollard N and Woods B 2015 *The Health Care Internet of Things Rewards And Risks* (Washington, DC: Atlantic Council) pp 1-18
[19] Alhussein M 2017 *IEEE Access* **5** 19835–19841
[20] Kumar S M, Mahalakshmi K and Xavier P 2019 *International Journal of Mechanical Engineering and Technology* **10** 1007–1013
[21] Carnaz G and Nogueira V B 2016 *Actas das 6as Jornadas Informática Univ. Évora* 1–12
[22] Taguri A E 2008 *Libyan Journal of Medicine* 148–155
[23] Smith P C 2002 *Health Affairs* **21** 103–115
[24] Murray C and Frenk A 2000 *Bulletin of the World Health Organization* **78** 717–731
[25] Martínez-Caro E, Cegarra-Navarro J G, García-Pérez A and Fait M 2018 *Technological Forecasting and Social Change* **136** 268–276
[26] Islam S M R, Kwak D, Kabir M H, Hossain M and Kwak K S 2015 *IEEE Access* **3** 678–708
[27] Zhang B 2012 *et al. Mediators of Inflammation*
[28] Hu F, Xie D and Shen S 2013 *IEEE International Conference* on *Green Computing* and *Communications* 2053–2058
[29] Paul J, Dario V and Walls T A 2016 *Pers Ubiquitous Computing*
[30] Redondi A, Chirico M, Borsani L, Cesana M and Tagliasacchi M 2013 *Ad Hoc Networks* **11** 39–53
[31] Fanucci L *et al.* 2013 *IEEE Instrumentation and Measurement* **62** 553–569
[32] Cipparrone L, Ginanneschi A, Degl'Innocenti F, Porzio P, Pagnini P and Marini P 1988 *Acta Neurologica Scandinavica* **77** 6-11
[33] Romero L E, Chatterjee P and Armentano R L 2016 *Health and Technology* **6** 167–172
[34] Liu J and Lockhart T E 2014 *IEEE Transactions on Biomedical Engineering* **61** 2135–2140
[35] Cheng Y, Jiang C and Shi J 2016 *Conference: 2015 International Conference on Mechanical Science and Engineering*
[36] Jara A J, Belchi F J, Alcolea A F, Santa J, Zamora-izquierdo M A and Gmez-skarmeta A F 2010 *IEEE International Conference on Pervasive Computing and Communications Work* 809–812
[37] Pang Z, Tian J and Chen Q 2014 *Int. Conf. Adv. Commun. Technol. (ICACT)* 352–360
[38] Churcher G E *et al.* 2008 *3rd International Symposium on Wireless Pervasive Computing* 138–142
[39] Chen M, Gonzalez S, Vasilakos A, Cao H and Leung V C M 2011 *Mobile Networks and Applications* 171–193
[40] Luo J, Chen Y and Tang K 2009 *Future BioMedical Information Engineering, FBIE, International Seminar on* 482–485
[41] Kulkarni A and Sathe S 2016) *International Journal of Computer Science and Information Technologies* **5** 6229-6232
[42] Ma Y, Wang Y, Yang J, Miao Y and Li W 2017 *IEEE Access* **5** 7885–7897
[43] Merck S F 2017 *Nursing Forum* **52** 298–305
[44] Andreu-Perez J, Leff D R, Ip H M D and Yang G Z 2015 *IEEE Transactions on Biomedical*

Engineering **62** 2750–2762
[45] Li S, Xu L D and Wang X 2013 *IEEE Transactions on Industrial Informatics* **9** 2177–2186
[46] Xu L D 2011 *Int. J. Prod. Res.* **49** 183–198
[47] Wang L, Xu L D, Bi Z and Xu Y 2014 *IEEE Transactions on Industrial Informatics* **10** 408–418
[48] Fan Y J, Yin Y H, Xu L D, Member S, Zeng Y and Wu F 2014 *IEEE Transactions on Industrial Informatics* **10** 1568–1577
[49] Bonato P, Sherrill D M, Standaert D G, Salles S S and Akay M 2004 *Annual International Conference of the IEEE Engineering in Medicine and Biology.* **26** 4766–4769
[50] Skodda S, Grönheit W, Mancinelli N and Schlegel U 2013 *Parkinson's disease*
[51] Rahimi F *et al.* 2011 *Annual International Conference of the IEEE*
[52] Youn J, Ali H, Sharif H, Deogun J, Uher J and Hinrichs S H 2007 *Third IEEE International Conference on Wireless and Mobile Computing, Networking and Communications*
[53] Alemdar H and Ersoy C 2010 *Computer Networks* **54** 2688–2710
[54] Yin Y H, Fan Y J and Xu, L D 2012 *IEEE transactions on information technology in biomedicine* **16** 542–549
[55] Qiu M, Ming Z, Li J, Gai K and Zong Z 2015 *IEEE Transactions on Computers* **64** 3528–3540
[56] Qiu M and Sha E H M 2009 *ACM Transactions on Design Automation of Electronic Systems* **14**
[57] Akhtar N, Parwej F and Perwej Y 2017 *International Transaction of Electrical and Computer Engineers System* **4** 26–38