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Versatile Aspects of IoT in Medical Science

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ABSTRACT: *With the advanced world, the technological benefits are increasing rapidly day by day. Internet of thing is an invention of modern world which is making our life easier and quicker in many aspects. Internet of thing has tremendous impact on education, healthcare, security, society and everywhere of our day to day life. In medical science its versatile impact is changing our life in a better way to save valuable time and ensure accuracy in health care. In this paper we will discuss many good and a little bit bad impact of IoT in medical science in details. Through this paper we could gather the knowledge and overall idea of IoT impact in hospitals as well as in healthcare, the over view of versatility of IoT in medical science.*
KEYWORD:*RFID, M2M, RFT, CGM, MDD, BAA.*

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I. INTRODUCTION

In 1995, only 1% people of world population used internet. But today 47% of the world population hasan internet connection. Usage of internet is increasing rapidly.With the rising percentage of internet usage, number of smart devices in the market also is increasing and researchers estimate that by 2020, the number of active connected smart devices will exceed 40 billion. The term Internet of Things abbreviated as IoT first coined by British researcher Kevin Ashton in 1999:

"*I could be wrong, but I'm fairly sure the phrase "Internet of Things" started life as the title of a presentation I made at Procter & Gamble (P&G) in 1999. Linking the new idea of RFID in P&G's supply chain to the then-red-hot topic of the Internet was more than just a good way to get executive attention. It summed up an important insight which is still often misunderstood.*"

While speaking at Fortune's Global Forum last monthKevin Ashton predicted that, 500 billion devices would be connected to the internet by 2025. (This prediction massively exceeds other predictions estimated by various stakeholders.)Take BI Intelligence,for example, which estimates that the number of IoT devices will hit 34 billion by 2020. Tech research firm, Gartner, which conservatively pegs it at 21 billion devices.So 500 billion is a particularly headline-grabbing number. Well, whether it's 21 billion, 34 billion, or 500 billion, it doesn't matter. (For instance if we take Business Intelligence as an example, it estimates IoT device will reach34 billion and Gartner (tech research firm) argues that the number will be 21 billion devices. Irrespective of thenumber to be reached all the stakeholders predict a rise in the IoT connected devices.The Internet of Things is going to increase exponentially as more devices get smarter and more consumers' gettech savvy.Gartner predicts that, by 2020, the IoT market will be comprised of 20.8 billion things—up from 6.4billion connected things in 2016.Experts estimate that the IoT will consist of about 30 billion objects by2020.[1]

In the United States alone, there are about 256,363 manufacturing firms. That's a lot of products being engineered and manufactured. With the Internet of Things, those products (and the machines that make them) can communicate with you, their surroundings, and each other. Products are finding their voices, and it turns out they have a lot to say. Smart products can do the following things: Sense their environment by collecting data about their surroundings, Analyze big data and perform computations through software, Exchange data and commands with other things, The Internet of Things is constructing a future with an infrastructure of billions of smart, connected products – products that leverage data and communicate with each other to operate with

increased productivity and efficiency.IoT is an industry buzzword, loosely, the Internet of Things references the growing network of smart, connected products. This network is impacting top industries and changing how things are designed, made, and used.IoT devices have several unique features that set them apart from non-connected products. [2]

II. ARCHITECTURE OF SMART HOSPITAL [3]

Many researchers have carried out relevant research on networking architecture, and there are three kinds: the architecture based on EPC Global, on the basis of RFID technology, the application architecture based on sensor network, mainly referring to WSN, the application architecture based on M2M (machine-to-machine), having the most extensive application scope and including partial content of EPC Global and WSN. In the medical field, though there are no literatures to directly mention the architecture of smart hospital, some related articles have appeared, for example a model of sensing hospital having no boundaries, a model of digital surround intelligent hospital etc. In view of the current existing research foundation and the actual environmental characteristics of hospital, smart hospital composed of perception layer, network layer and application layer, as shown in figure 1.

2.1 Perception Layer

Perception layer is divided into two sub layers, which are respectively data collection layer and access layer. Data acquisition layer is to identify hospital networking nodes, perceiving and acquiring related data, such as identity information about doctor and nurse, identity information and medical information about patient, basic information and location information about pharmaceuticals, medical equipment and medical waste, physiological information and location information about inpatient, the environment information around hospital and so on. Access layer is to transmit the data acquired from sub layer and access it to the backbone network, namely global object-conjunction network. There is a variety of access ways, such as by mobile network, by wireless network, by fixed network, by cable TV network and so on, where the access by mobile network will become the main way to access to smart hospital because of its wide coverage, low construction cost, convenience deployment and mobility characteristics. In practice, it needs to be determined by concrete conditions, for example, system with fixed using location, like outpatient management system and medical technical management system, is suitable to adopt access by fixed network, and hospitalization management system is suitable to adopt access by mobile network or wireless network, using wireless medical with unfixed workstation for physician and nurse.

2.2Network Layer

Network layer is divided into two sub layers, which is respectively network transmission platform and application platform. Network transmission platform is the backbone of hospital network, having real- time, barrier-free and high- reliable transmission of information perceived by perception layer, using technology of Ethernet, mobile communication, M2M and so on. Application platform is to implement the integration of various data, including description of unified data, unified data warehouse, technology of data middleware, and on this basis to constitute a service platform to provide an open interface for the various services of application layer, so that the third party can develop various applications on this platform for medical staff, patients and other related personnel to use.

2.3 Application Layer

Application layer includes two parts, which is respectively hospital informatization application and management decision and application. Hospital informatization application includes informatization of outpatient management, hospital management, medical technology (inspection, examination, radiology, pathology, physical therapy and so on) management, drug management, equipment and material management, medical management, financial management and so on. Management decision and application is the senior application, such as disease analysis (onset time, geographical distribution and treatment cost of various diseases), patients analysis (regional distribution, age distribution, proportion of free medical service and visiting time of patients), clinic analysis (outpatients visits , inpatients visits and doctor visits in each time quantum), drug analysis (amount, quantity of consumption and profits of various drugs) , department analysis (cost for diagnosis and treatment of every department in different periods) and so on.

The architecture of a smart hospital is given bellow with application layer, Network layer, perception layer and all necessary data within it.

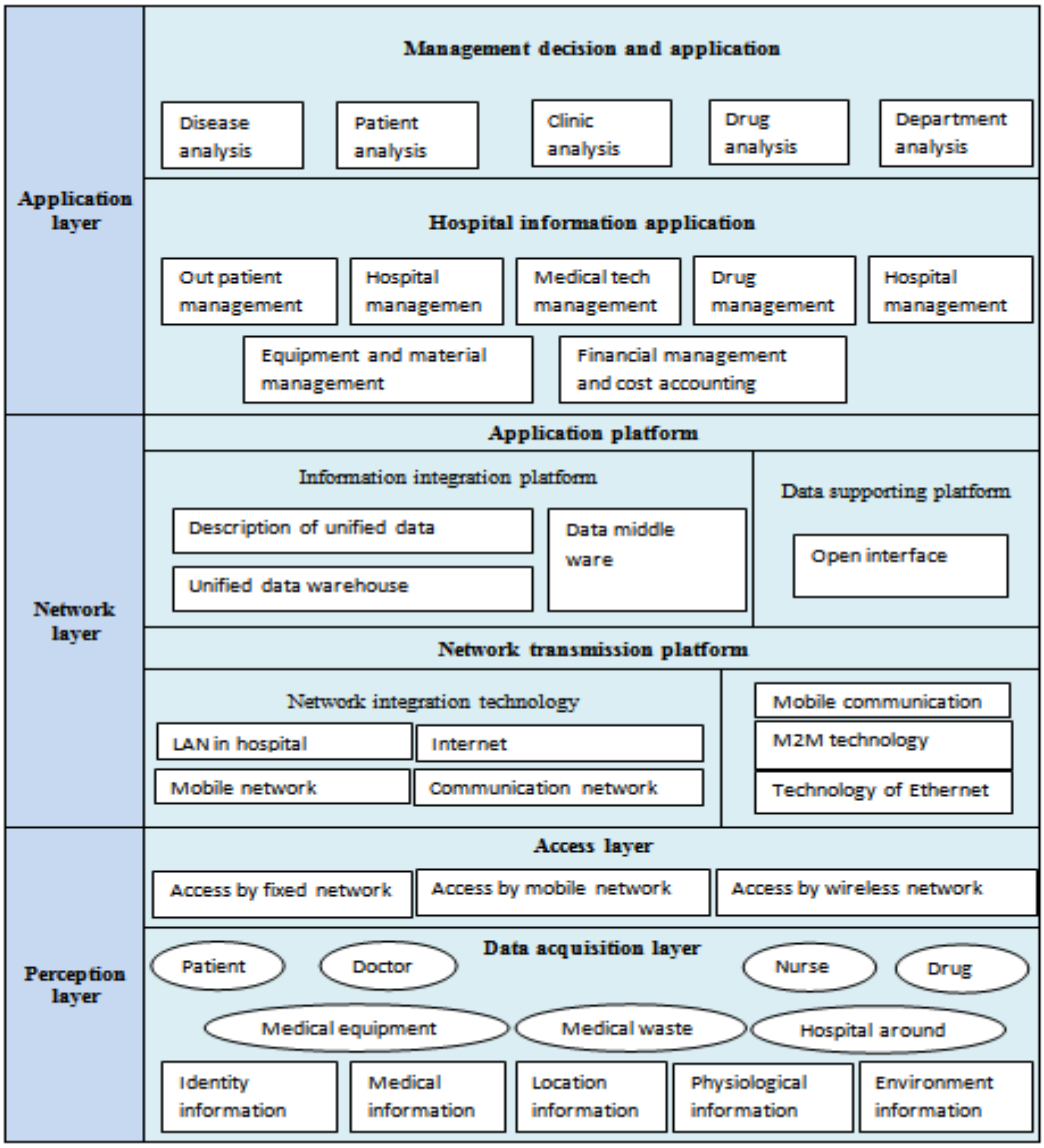

Figure 1: Architecture of smart hospital

III. VERSATILE EFFECT OF IOT IN MEDICAL SCIENCE:

Medical science is developing day by day,IoT is another thing that is affecting medical science in a versatile manner. In many aspects of IoT directly helping medical science now days. Versatile aspects of IoT in medical science are discussed below:

3.1 TopIoTTechs for hospitals: [4]

Internets of Things (IoT) technologies are now starting to make an impact in healthcare. Central to these technologies are goals to improve patients' experiences in hospitals, and to make electronic health data and insights more readily available across the care continuum to enable a holistic patient diagnosis.

A. **Virtual patient observation:** Healthcare providers need to have the ability to provide round-the-clock observation of patients. Especially for patients at risk of injuries such as falls or pulling out tubes. The expense of using patient-sitters is crippling – not only for the healthcare provider, but also for the patient's family.HD video and two-way communication is a new way of providing virtual patient observation. Trained staff monitors multiple patients from a central location. Staffs are notified just as quickly as if they were present with the patient.Virtual patient observation solutions can also be of immense value in the neonatal intensive care unit, where babies' conditions change by the minute. Physicians can remotely monitor babies and even evaluate them with the assistance of a bedside clinician.

B. **Patient presence sensors:** Major strides in IoT tech are being made in fall monitors. Traditional fall monitors mean that patients sit on a pad and an alarm is raised when dangerous movement occurs. The new patient presence sensors on the market continuously provide data to administrators and turn it into valuable information. Administrators are alerted even before a patient is at risk of a fall. Best of all, patients aren't connected to any wires or attached to any sensors.

C. **Wearable technologies:** Abductions of babies from hospitals are a grim reality, and it can happen in different areas: from the nursery to the maternity ward. Mother and infant ID bracelets are subject to human error, and even the best-trained staff can lose track of patients' movements. Modern infant and mothers' tags are linked to the hospital's Wi-Fi infrastructure and can locate the infant or mother anywhere within range.Wearable staff badges can also improve the safety of hospital staff. Badges for hospital staff linked to the facility's Wi-fi can instantly alert security of their exact location if they're under duress. For example, psychiatrists could alert security if they need help. When an alarm is raised, the badges use the hospital's existing Wi-Fi network to identify both the sender's identity and exact location.

D. **Asset tracking:** Hospitals often face the frustration of looking for available wheelchairs or hospital beds. By placing RFT tags on assets – from high-value medical equipment to low-cost items such as linen – hospitals can easily track and locate critical assets. The RFT tags are linked to the hospital's Wi-Fi network and personnel can analyze historical usage patterns so that assets can be deployed where they are typically needed most.

E. **Sensors to monitor temperature and humidity:** Monitoring temperature-controlled tissue and blood products, vaccines and other vital medications are critical in a healthcare facility. Failure to detect unforeseen events can lead to monetary loss, or worse, administration of comprised medicines to patients.Hospitals are obligated under compliance regulations and federal medication management standards, specifically The Joint Commission (TJC), to monitor refrigerators, freezers, and other temperature-controlled storage areas.Today's intelligent solutions provide fully wireless monitoring and alerts for temperature and humidity. Administrators are immediately notified of a temperature deviation and can attempt to rectify the issue and prevent losses.

3.2. Functions of IoT hospital integration [5]

A. Understand the location of various high value equipment used in the hospital
B. Map the usage of medical equipment used in various hospital departments
C. Monitor the temperature, humidity and operating environment of operation theatre and sterile rooms
D. Understand the usage patterns of medical equipment for maintenance department
E. Alert on movement and usage of equipment at odd hours – abuse, theft etc
F. Know the workflow of in-patients and specialty out patients
G. Track para medical and emergency staff
H. Schedule preventive maintenance activities based on usage
I. Energy management solutions for hospitals to understand current consumption

3.3. Advantages of IoT hospital solutions [5]

A. Integration of high autonomy (10 year battery life) sensors
B. Choice of sensors to deploy – asset tracking, monitoring, temperature, humidity etc
C. Easy to deploy noninvasive sensor devices
D. CE and other international certification
E. Best in class sensor technology procured from Netherlands & France
F. Monitor the operating environment and equipment location from anywhere in the world

3.4. The major facilities of IoT in healthcare: [6]

A. **Decreased Costs**–When healthcare providers take advantage of the connectivity of the healthcare solutions, patient monitoring can be done on a real time basis, thus significantly cutting down on unnecessary visits by doctors. In particular, home care facilities that are advanced are guaranteed to cut down on hospital stays and re-admissions.

B. **Improved Outcomes of Treatment** – Connectivity of health care solutions through cloud computing or other virtual infrastructure gives caregivers the ability to access real time information that enables them to make informed decisions as well as offer treatment that is evidence based. This ensures health care provision is timely and treatment outcomes are improved.

C. **Improved Disease Management** – When patients are monitored on a continuous basis and health care providers are able to access real time data, diseases are treated before they get out of hand.

D. **Reduced Errors** – Accurate collection of data, automated workflows combined with data driven decisions are an excellent way of cutting down on waste, reducing system costs and most importantly minimizing on errors.

E. **Enhanced Patient Experience**–The connectivity of the health care system through the internet of things, places emphasis on the needs of the patient. That is, proactive treatments, improved accuracy when it comes to diagnosis, timely intervention by physicians and enhanced treatment outcomes result in accountable care that is highly trusted among patients.

F. **Enhanced Management of Drugs** –Creation as well as management of drugs is a major expense in the healthcare industry. Even then, with IoT processes and devices, it is possible to manage these costs better.

3.5. Privileges of IoT in patient care [7]

A. **WearableDevices:** The use of wearable devices for fitness is the fastest growing sector of health-tech. You have heard of the Fit-Bit but maybe haven't considered how measuring steps can affect healthcare. The data obtained from wearable is often more than meets the eye, and can be a valuable source of information for clinicians. Their health condition specific wearable available too. The Gym Watch is a tool that allows physical therapists to monitor patient self-rehab. It measures things like muscle contraction, joint ROM and allows for real-time feedback to correct bad form. Hexo-skin takes wearable to the next obvious level of fashion. These tank-tops have sensors woven into the fabric that measure, heart rate, respiration, lung capacity, metabolism and even sleep.

B. **Remote Real-time Monitoring:** This takes wearable to a new level. Patients with sleep apnea can be monitored in real-time while they sleep and alerts sent or alarms activated if breathing stops or heart arrhythmia occurs. Infant monitoring is important to a lot of parents. The implications for infants at risk for SIDS is the greatest, as parents and healthcare providers can be alerted to a variety of symptoms that could prevent death. In all, this could decrease the number of hospitalizations thereby reducing costs.

C. **Real-time Communication:** Having data available in real-time is good, but the ability to provide feedback directly through the device is a revolutionary tool for physicians and practitioners. Machine to machine communication is another feature of the IoT. An early example of this is the patient with a continuous glucose monitoring device which sends data to a monitoring site that can in turn; regulate the insulin pump remotely based on the data received.

D. **Billing and Medical Records:** The nature of the billing and medical records makes it a prime benefactor of the IoT in healthcare. Because of the increase in the interconnectedness of M2M communications, billing will be affected in a positive way. Because everything is being tracked, fewer errors will be made. In addition, M2M verification with insurance companies in real-time can reduce many headaches. IoT-enabled billing will maintain accuracy with continuous audit checks verifications, and even fraud management. Additionally, billing companies that have the capability to provide services to collect, maintain, and analyze various medical data collected through many other connected devices, will be poised to differentiate their services from competitors.

E. **Medication Compliance:** Medication compliance is an issue that concerns every practice. Non-adherence increases healthcare expenses and costs countless lives. It is estimated that only 50% of medications are taken on schedule and as prescribed. One example of how the IoT can impact this area is the Smart Pill Bottle. This pill holder is unlike traditional organizers, in that it can track the patient's habits and compliance. Reminders can be sent to various devices if a dose is missed. This can include notifying family or caregivers if desired. Another feature is that it monitors the number of pills removed from the bottle which could significantly reduce the number of accidental overdoses.

F. **Hospital Workflow:** Patient and staff tracking within a hospital, lab or diagnostic center is a win-win. It allows for a more natural and reliable flow of work. Ultimately, this improves patient satisfaction and decreases the stress of staff members. An example of this is that a patient undergoing multiple tests is tracked through the facility as each test is complete the next department is notified, as well as transport staff. Of course, this doesn't ensure perfectly choreographed fluidity, but it does allow for planning and staging.

G. **Facility Management:** Real-time monitoring and tracking of the massive inventory of devices, supplies, and even staff are already in use in many hospitals. This is important from a cost management aspect as lost and misplaced equipment alone is a huge factor in the rising cost of healthcare. Monitoring also increases awareness and promotes stewardship and personal responsibility.

3.6. Benefits of IoT in hospitals [8]

A. Reduce response time. Most times d times between early symptoms and medical response is basic to patient recovery.

B. Improve hospital management: notifying in real time if the patient is discharged or the bed is empty.

C. Up-to-date and real-time information. However, one must know how to select which information is important and which is not important, since each patient needs to know what data the device should collect and how often.

3.7. IoT is Impacting Medical science: [9]

A. **Real Time Remote Monitoring**: WithIoT, multiple monitoring devices can be connected thus enabling real-time monitoring of patients. Along with this, these devices can transmit signals from home also thus, reducing the time needed for patient care in the hospitals. This can reduce the need for doctor's attention and can improve the level of care provided at the same time. This will also provide real time information which will help in providing evidence based medications.

B. **Smart Pills:**WuXiPharmaTech, Proteus Digital Health, and TruTag are some of the pharmacy companies who are developing edible IoT, "smart" pills that will aid monitoring of health issues, adherence and medication controls. These pills will dissolve in the stomach and transmit a signal to the sensor worn on the body. That signal will then be transferred to mobile phones for easy access to the patients. Smart pills will not only help drug companies to reduce their risks but also ensure that patients are able to monitor their medications and take prompt medication.

C. **Diabetes Management:** Dana Lewis along with her husband Scott hacked Dana's CGM (continuous glucose monitor) and her insulin pump. A Raspberry Pi computer deciphers the data transmitted from the CGM and controls the pump to put the required amount of insulin in the blood. This was presented at the OSCon 2016, held in Austin, where it was reported that 59 people were using this solution. In 2016, Roche acquired distribution rights to an implantable long-term continuous glucose monitoring (CGM) system. This system uses a 90-day sensor which is placed below the patient's skin. By using a smart transmitter it monitors and sends signals about the blood glucose levels to the mobile.

D. **Blood Pressure Monitoring:** In 2016, Roche also launched a Bluetooth enabled coagulation system to monitor the pace of blood coagulation for ant coagulated patients. Similarly, sensor based intelligent system can be used to monitor blood pressure levels in patients suffering from hypertension. Medications can be taken in accordance with the need thus there will not be a need for guess work. These monitoring devices can also lower the risk of cardiac arrests in critical cases.

E. **Smart Watches taking on Depressions:**Takeda is creating a test case on 30 patients suffering from major depressive disorder (MDD). For this purpose, they have developed an Apple Watch App which can monitor and assess people's mood and report data to the server. Along with this, there are apps developed to monitor sleep cycles and fitness activities. These apps are still in testing phase and present a huge potential for growth in future.

3.8. Positive aspects of IoT in smart hospitals: [10]

A. **Remote patient monitoring system:** Remote patient monitoring is one of the major innovation in IoT healthcare industry. By this, medical professionals like doctors, physicians, nurses and patient guardians can easily know the real-time health status of patients.Singapore has already implemented a sensor-based Elderly Monitoring System that helps office working family members to receive alerts when the health condition of their home living elderly parents or dependents deteriorates or exhibits abnormal behaviors.

B. **Smart bed:** In recent days, multi-specialty hospitals have started utilizing smart beds to sense the movements of patients and automatically adjust bed's position to the correct angle without need for a nurse to help.

C. **Connected contact lenses:** These lenses measure the glucose level of diabetes patients via their tears and store the information on their smartphones.

D. **Fitness Tracker:** Effortlessly track any activity including run, and provide detailed performance report.

3.9. Gain of IoT inhealth care: [11]

A. A leading cardiac rhythm management company is building a platform to ingest and analyze patient-generated cardiac data. The vast data will be used for real-time patient monitoring and will enable doctors to prevent episodes of care.

B. A leading renal care device manufacturer is enabling care teams to remotely monitor patients that carry out dialysis in the comfort of patients' homes.

C. A leading cancer treatment device company is increasing customer satisfaction by remotely monitoring IoT-enabled devices and by providing proactive support to their customers.

D. A leading device manufacturer is aiding providers in preventing hospital-acquired infections by creating a closed-loop feedback mechanism for sterilizations of surgical equipment.

3.10. IoT hazards in hospitals [8]

A. The integrity of the devices: not all measure with the same reliability.

B. The manipulation of the devices: patients have access and can manipulate the device, how does this affect data collection?

C. Risks of cyber-attack: Hospitals must take security measures for the network.

3.11. The Challenges [11]

A. **Wielding great power**. IoT has undoubtedly started to change the fabric of healthcare delivery. It provides access to previously unavailable data and insights – but with great power comes great responsibility. As confidential patient data leaves the four walls of a hospital, it's up to technology and service providers to ensure strong data protection and privacy. Having a "Cloud First" approach is critical to the success of IoT. The industry is already witnessing cloud service providers such as Amazon and Microsoft entering into HIPAA Business Associate Agreements (BAAs) to ensure patient data protection and privacy. However, to truly ensure patient data in encrypted throughout the healthcare continuum, one must engage with niche consulting-companies.

B. **Making sense of the data**. The healthcare industry faces an intimidating challenge – handlingvast amounts data. As the delivery model shifts to patient-centric care, it will be critical to create a single source of truth to build meaningful and correct analytics. Big data technology allows for structured and unstructured data sets to be stored and parsed. This technology will drive the evolution of analytics.

C. **The need for interoperability**. The adoption of analytics in healthcare relies on the ability of organizations to integrate data sources to leverage for smarter decision-making. As the number of medical-related IoT devices grows, the challenge lies in ensuring the data is read into big data platforms and is easily integrated into analytics solutions.

D. **Slower adoption rate**. The healthcare industry has historically been a slow and cautious adopter of technology. As a lack of standardization, security protocols and interoperability continue to pose a threat, CIOs will remain wary of IoT adoption. However, with some of the largest healthcare systems and device manufacturers leading the change, IoT will continue to observe wide adoption rates.

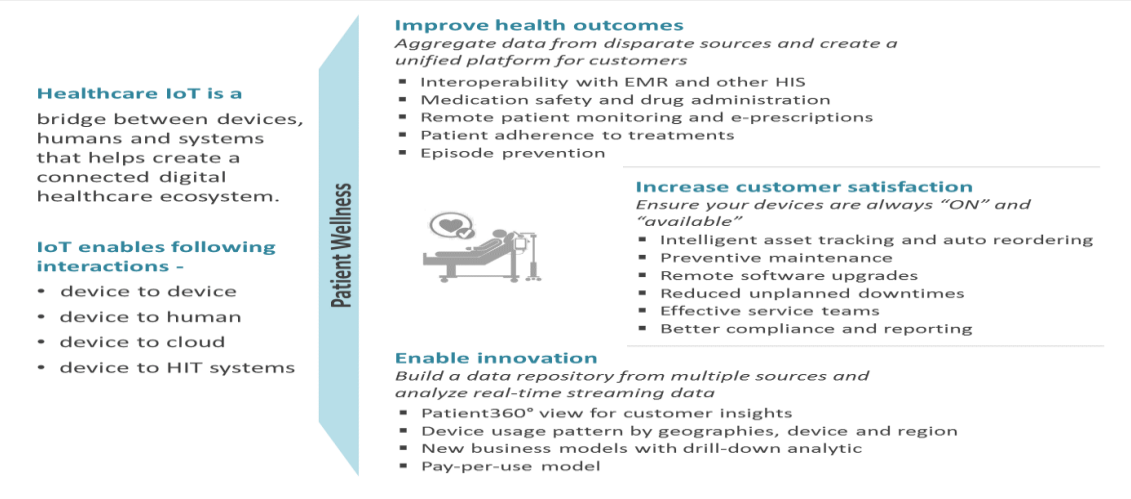

Figure 2: IoT Point of View

IV. CONCLUSION

IoThas proven its potentiality so many times and future of IoT impact on healthcare is unpredictably good but the success depends on how hospitals will afford to give support correctly to run all equipment and devices for IoT process in hospital. Security issue is another important concern here, where all necessary data and records should be safe and secured. Internet of medical thing is really a common phenomenon in developed world and its versatile impact proves patients satisfaction. That day is not so far that the IoT will act like a complete nurse in hospitals and an assistant of a doctor.

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