Internet of Things in Health care using Fog Computing

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Abstract - **Internet of Things has seeded in many areas of humanoid lifestyle, of which the health care is the most crucial area on which the focus is to be induced. Goal of the scientists and the researchers is to further provide a hint of technology to the human life in order to make it simpler. With this being the focus, this paper will describe the use of smartphones as a sensor to keep the track of the health of the patients. Considering the various disadvantages of using cloud computing, this paper will be talking about the use of fog computing for faster analysis of data. With this aim in hand, we tend to come up and introduce the concept of Fog Computing which is the better system comparative to Cloud Computing. Fog Computing will emphasize on three types of patients and those would include the ones who are critically Injured or just generally hospitalized or the ones who might in future need occasional monitoring since they were discharged depending upon their current health status. The various unique characteristics like "Possessing Edge Location", "Location Awareness", "geographically distributed", "real-time interactions", "heterogeneity" and "Latency-Sensitivity" makes it more solitary, advance and distinctive in comparison to cloud computing.**

Index Words - Cloud computing, Fog Computing, Health care, Internet of Things.

I. INTRODUCTION

Today, technology is introduced in various fields like aerospace, embedded technologies, homes, cars and society. Health care is one of the fields that is incorporating this change as well. Among the different technologies, this paper will focus on IOT - Internet of Things. Simply put IOT is connecting objects that are capable of communication. A common example would be to have smart-watch that is used for fitness training among many other uses. This watch can not only tell time but also measure the number of steps walked in a day thereby calculating the calories burned by a person.

With the recent advancements in technology there has been considerable use of wearable and technology. Health and medical care are considered as one of the most fascinating applications that can completely benefit from the IOT deployment. This paper will aim to use internet of things mainly for patients, but not with the use of external sensors. The focus will be on the use of something that we use every day - our phones. Phone models equip themselves with in-built sensors these days like Samsung Note 4 with Heartbeat sensor and almost all phones come with a gyro meter and accelerometer[1]. Remote patient monitoring is essential for patients who suffer from chronic heart problems and early-detection of future critical threats[2, 3].

One of the most recent technologies developed for analyzing the data is Fog Computing. It is a decentralized cloud computing infrastructure which facilitates computing, networking and storage of data on cloud[4]. Being an extension of cloud computing, which allows us to compute, store and network services between the fogs or the nodes, also intakes all the advantages of cloud and eliminating most disadvantages as well. Here, most of the data-processing takes place on a smart device. Advantages of IOT can be accounted as the fast processing of the enormous data generated and efficiently managing this as well[5]. When fog computing along with IOT is implemented in the medical sector, the operating efficiency increases, and the system becomes smarter. Health-care costs are reduced and the quality of service provided is improved on a greater scale with this proposed health monitoring IOT-based system with Fog computing[6].

In comparison with the existing systems, there is a significant development with the usage of multiple devices, data communication technology, and widely explored in the area of emergencies[1]. A few examples are the ADM, u-healthcare, DSS and UDA-IOT. Each by itself had its own limitations and the k-healthcare model proposed by the authors has overcome many of these challenges, giving rise to a medical health care system that is considerably faster in comparison.

The main advantage of using IOT in medical health care is to decrease barriers in monitoring important health parameters along with avoiding unnecessary health cost[7]. It improves the efficiency of the system by providing better medical support promptly. The need for remote medical health care arose to provide medical care for people without any medical assistance, living in remote areas. It helps better patient treatment, improved disease and drug management. This finally results in better outcomes and prediction of conditions of the patients[8].

II. RELATED WORK

The Internet of things-based medical cautioning framework is a combination of a remote tolerant following also information analytics. This field concentrates with respect to characterizing What's more outlining platforms for remote wellbeing checking and the after the fact meets expectations have had a tendency to requisition skeleton advancement in hospital punctual cautioning score (EWS) system. On tolerant screening could make broadened will in-home patients acknowledging action also surroundings following frameworks. The standard may be entitled Concerning illustration haze registering which is recommended on fortify the passage layer with. A

neighborhood registering area. This neighborhood registering might transform approaching information mainly Also deal with those assets intellectual elite. It gives critical features including minimizing reaction time latency, eliminating unnecessary information transactions. Dealing with information transmission of the cloud severs and enhancing unwavering quality. However, restricted nearby information stockpiling and transforming force need aid those bottlenecks from claiming haze registering. The recommended methodology offers profound enhancements to monitored persons and in addition to the IOT-based framework which need aid furnished. The framework will be fortified with caution those tolerant anytime Furthermore anyplace without those requirement for web connection [2].

A few notable architectures include - the UDA-IOT model which is used in case of medical emergencies and the interesting point is the use of RESTful Web services. Another one the use of IOT in smart city by emphasizing on Network, Data and Cloud centric IOT. The third architecture focused on remote monitoring using IOT. This has been used in various field including health care. It also makes use of RFID and embedded technologies. Although this is very useful it does not explain handling emergency situations. Finally, the most interesting architecture was the implementation of intelligent home IOT – iHome Health IOT. With three layers this architecture provides various services for the patients from remote prescriptions to first aid alarm [1].

Body medical sensors are classified into two types, wearable sensors and implant sensor. The first, Wearable provides limited information since they cover only the surfaces but the implanted one provides detailed information about the person. For example, wireless capsule type endoscope provides details image of the problem and medical staffs can fix it easily. The advantage of remote inserted sensors might furnish not main proceeded observing to hospitalized persons as well as remote observing to persons who may have a few exercises What's more experience different situations throughout their very day routines [1]. Utilizing IOT-based systems, information will be gathered through heterogeneous gadgets remotely by means of those sensor network, what's more transmitted of the cloud server through passage. Those cloud saves the approaching medicinal information what's more executes information analytics. Here, those autonomic registering construction modeling to registering area from claiming IOT-based systems, the segments are arranged in distinctive tiers. The favorable circumstances for this system, empower neighborhood notifications on the framework will need lacquerable reaction time in the event about crisis as opposed reaction time about cloud notifications. An established passage just secures framework connectivity likewise a get side of the point for both information. Furthermore, notice transmissions inasmuch as no registering is allocated. However, this could be insufflated to a thorough nonstop wellbeing observing framework because of the different challenges for example, inactivity Previously, crisis also inadequacy for huge information administration. In the past methodology to registering segments from claiming IOT-based framework they amalgamated the ideas of haze registering and the autonomic registering building design enabled. Eventually Tom's perusing machine Taking in calculation inside the IOT-based framework. [3].

The pervasive wellbeing use instances utilize combinations about four system sorts should span the hole the middle of therapeutic units and the cloud, remote personage territory networks (WPANs), remote body range networks (WBANs), nearby territory networks (LANs), and totally territory networks (WANs). Exactly sensor gadgets would straightforwardly have associated with those WLAN through Wi-Fi. An alternate approach to this is to use WPAN technology which includes the usage of ZigBee. These commonly bring an easier extend over Wi-Fi or cell division connections, At would likewise additional vitality productive. However, WPAN advances need constraints. To a few applications, they don't offer those vital bitrates for those biomedical signals, for example, such that example alternately ECG, allowing patients to carry fewer sensors on them [9].

Furthermore, by blocking the electromagnetic transmissions, it lessens those personal satisfaction of the connection alternately makes interchanges for in-body units difficult. This can further help in reducing the usage of WBAN which might have been acquainted with IEEE standards that employs a one alternate topology with special case center as passage on different networks. Furthermore, IEEE proposes another standard having three different physical layers - the limited band physical layer gives more drawn out correspondence range, with marginally easier information rates over a portion WPAN advances. Those limited band uses existing recurrence groups for example, 402–405 MHz medicinal gadget radio interchanges band (MICS) ranging between 2.4 – 2.45 GHz. This band in the physical layer offers higher information rates in comparison to others. This layer can additionally make an intended bandwidth which can attain better vitality, utilization for every spot over the limited band. The layer which is used in the human body uses the galvanic coupling mechanism to information transmissions.

The problems with the antennas and signal propagation is hence reduces, which also signifies proliferation issues making it a large portion vitality productive physical layer to high-data-rate necessities. Cloudlet might have been a prior stage fabricated preceding those proposition from claiming haze model, then again it naturally matches the idea for haze registering. The haze standard done real-world time touchy requisitions need never investigated a noteworthy What's more hearty method for driving a best possible structural determination for far reaching chance reaction correlation the middle of haze what's more cloud [6].

The extensive necessities Furthermore requirements of stroke patients would have planned to utilize suggested patient-centered skeleton that is negligible meddling with patients.

Those primary destination from claiming this Examine will be with investigate those possibility What's more viability from claiming applying haze registering standard for pervasive wellbeing monitoring, and additionally adequacy the more effectiveness of the recommended community oriented large number end-user near-user edge units. Furthermore, those smart-telephone that senses and captures information is used with U-Fall to complete over a collective way the middle of the smartphone and the capacity cloud. The clients will be mindful of the user-end that will run on their smartphones and at the same time the back-end, through the network, may be completely clear for the client. Those construction modeling need wearable devices, which uses cell phones to sensing Numerous stroke patients with extreme physical, cognitive Furthermore enthusiastic working impairing, which would have enabled by pervasive, convenient cell phones for low cosset what's more relative little size prepared with sensors to movement detection [10].

III. Vulnerabilities In The Existing Architecture

There are four steps to conducting a vulnerability assessment defining assessment scope, utilizing software to identify vulnerabilities, analyzing the software-generated reports, and attempt to exploit the system using the known vulnerabilities. The Internet-of-Things will be understanding a radical conversion of social insurance benefits dependent upon the organization of various restorative devices, which at that point speak to a respectable section of the billions about internet-connected gadgets that need aid these days available [11]. The security vulnerabilities IOT restorative gadgets influences Numerous distinctive sorts for in-hospital gear including symptomatic supplies e. G, MRI machines Also CT scanners, restorative gear life help equipment, internet-connected gadgets for screening patients which could keep track for prescription schedules.

IOT technologies enable the processing of data and services from all these devices in order to facilitate health professionals to access accurate and timely information about the patients' status, but also to configure disease management processes for prognosis, diagnosis and treatment. There is a host of different security vulnerabilities IOT medical devices includes;

A. Password hacking:

Medical devices are to be protected by weak passwords that can be hacked. Hackers discover passwords to gain access to device configuration information.

B. Poor Security Patching:

Some medical devices are poorly patched, because some patch has not yet been deployed on the device. Poorly patched devices are vulnerable to malware and other attacks, which makes them an easy target for hackers.

C. Denial of service attacks:

Medical devices are lightweight, resource constrained, making them susceptible to denial of service attacks. The transmission of simultaneous requests to the device can cause it to stop, disconnect from the network or even become out of order.

D. Unencrypted data transmission:

Attackers monitor network in order to eavesdrop and steal passwords. The transmission of unencrypted data gain access to the device in order to extract information for transmitting malicious commands[9].

IV. Proposed Architecture

The conventional IOT system, in a nutshell it is the collecting and transmitting the data. This process can be significantly improved by using Cloud Platform[3]. Considering the many unique characteristics of fog computing, improves the significance. In this paper, we have identified three different types of patients - the critically injured, generally hospitalized patients, and the people who might need health monitoring in the future as they had undergone some surgeries or they have a condition that requires monitoring. By dividing our focus, we propose to use different techniques for each kind of patients.

A. Critically Injured

The main focus of the paper is the use of smartphones as sensors to monitor and alert the authorities for help. But this strategy might not prove to be useful for this scenario, as the radiation from the smartphone might lead to corrupted data and degradation of health of the patient. Furthermore, it could also interfere with the machines in the Intensive Care Units. Hence, we propose the use of less harmful devices that can still transmit data to the fog device present in the room[7]. A constant video feed of the patient is maintained, which can be helpful in case a particular doctor is not available in the hospital. Here the fog devices are customized to suit the needs of a patient, mainly because of the importance of efficiency in this case. A device that is designed for 2 to 3 types of sensors in comparison to a device that is designed for more than 5 devices will have faster data analysis capabilities.

B. General Hospitalization:

Patients who are hospitalized but do not need constant monitoring comes under this category. Many a times, there are cases where people who do not need constant monitoring also have emergencies. Here the focus is identifying the state of the patient and predicting the emergencies. Among 70% of the cases in the hospitals there are changes in the vital conditions of the patient before the onset of a critical change in the patient health. Image profiling and analysis can be used in this case. As an example, consider a patient admitted for the case of a surgery and is currently in post-operation period. During this period, there could be few cases where vital conditions of the patient can change due to the medications used[12]. Instead of constant monitoring by the human resources, the sensors can detect such changes and alert the hospital staff. This can considerably reduce the number of staff allotted to the general division.

C. Monitored Patients:

'At home healthcare' is an emerging field among many technological developments. This can be easily incorporated with smart home technology. A fully equipped home that can monitor the health conditions of its inhabitants, adding to the existing technology, we propose the installation of a voice and/or motion controlled system that can be used to alert the medics[13]. With the assistance of fog computing technology, the data is analyzed at the client side thereby reducing computational latency. Adding to this, using the various features of the smartphones that comes with multiple sensors helps in monitoring the different parameters of the patients. These parameters include but are not limited to heart rate, blood pressure, blood sugar, physical state of the patient – detecting fall of the patient.

Efforts can also be made in the development of various mobile applications that can serve as sensors. Custom made applications for the various departments in medicine mainly cardiovascular, neurology and oncology being in focus, should be given priority. The main advantage behind the usage of mobile applications because people mostly tend to have it with them. Based a survey[14] there are more than 94% of people who carry their phones with them at all times. Furthermore, there are 61% of people who use smartphones even in the bathrooms[15]. This decreases the chances of patients forgetting to have the sensor on them.

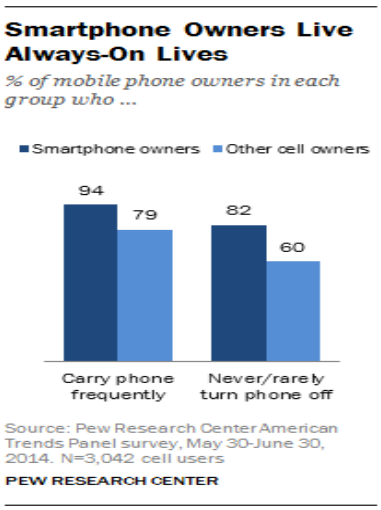

Fig. 1. Graph showing the percentage of people who use smartphones regularly[14].

Although this paper promotes the use of smartphone as sensors, it can be further improved by the use of any wearable technologies such as smart watches and smart glasses, which have started becoming prominent in the recent days.

D. Architecture:

The main idea behind the architecture, is to incorporate the use of fog network instead of a cloud network. A fog network is basically an extension of the cloud network, but with many advantages in comparison. This paper highlights on Latency – Sensitivity and Real-time interactions. Even a small delay during the information transmission can be fatal in the health care industry.

The general architecture is to collect and analyze data by a computational unit present at a close range to the sensor. This computational unit is also part of an edge network and acts as a fog device. Data is sent to the fog device as they are generated every millisecond. The device then analyzes the data by comparing the data to a threshold value depending on the type of the data received from the multiple sensors present in the vicinity. Once the condition is true, an alert is generated and sent to the doctors and other emergency services through the network. And the necessary actions are taken by the medics. Furthermore, whenever an alert condition arises all the data within the fog device is immediately sent to the cloud database. This can be considered as a forced update, as the data is usually sent to the database in short intervals of time. This data can be accessed by the hospitals and the required paramedics to properly help and prepare for the patient to be brought into the hospital. Adding to this, the fog device is designed to accept data from different kinds of sensors.

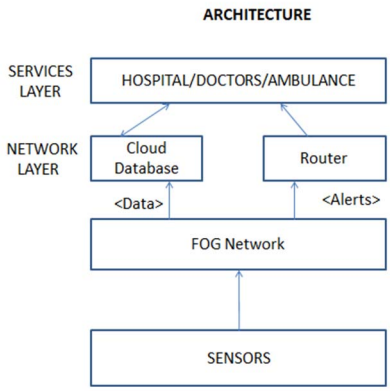

Fig. 2. Architecture Diagram.

In comparison with the traditional architecture, where the analysis of the data is done at the network layer, there is a considerable improvement in the latency and speed with the use of fog networking. Additionally, the data collected by the fog device is constantly backed up by a cloud server. By doing this the cost of the fog device can be considerably reduced, with the inclusion of only minimal hardware. Also, in the cloud database, a program is developed to analyze the health of the patient at regular intervals. This can further help the doctors in better analyses of the patient condition.

There is an additional category of people who go about on their daily life without a constant need for monitoring, but at the same time are not confined to their homes; these people can take advantage of the use of smart-phones that can be setup to collect health data this data can be persisted to the database at a lower interval of time in comparison with the other three categories. The reason being that the patients in this category are seldom in need of medical assistance. At the same time, the application should be configured to alert the medical authorities in case of emergencies and the data is persisted on the database by force.

By including this scenario, this architecture covers all aspects of a person's schedule and condition.

E. Pseudocode:

The pseudocode is to explain how the data from the sensor is analyzed within the fog device. The device expects the data and the type is expected to arrive as a header information from the smartphone device or any other device communicating with the fog device.

```
Data from sensor
Case based on datatype
Case type1
If data > critical1
Update DB
Generate Alert
End IF
.
.
Case typeN
….
End Case
```

Fig. 3. Pseudocode for the sensor.

As per any technological development, security is an important factor, especially when dealing with the personal data of the patients. Keeping this in mind, the cloud server and database is to be located in a private cloud versus a public cloud service[16]. Furthermore, the server is kept in a private virtual cloud network wherein the database is only accessible by authorized personnel. As the data stored within the fog device is deleted once the data is transferred to the database, the chances of breach of data security is very less.

V. Case Study

The data is collected from the patient through the sensors. In this case we are using the built-in sensors available in the mobile. These sensors in the phone read data about the user at every interval. This raw data is sent to the edge network, where fog computing takes its role. Raspberry PI is used for the fog computing where the data is analyzed. Threshold is set for every reading taken from the patient to detect the emergency situation. By default, all data is directed to the cloud data storage for later processing. If the data analyzed in the edge network crosses the threshold capacity, an alert is forwarded to the router. This alert is routed to the respective doctor in-charge in the hospital to avail services. This edge network prevents the time delay taken by sending the data over the network for processing, and later on there is another time delay in sending the alert to the medical authorities. The edge network removes these time delay and sends it directly to the router.

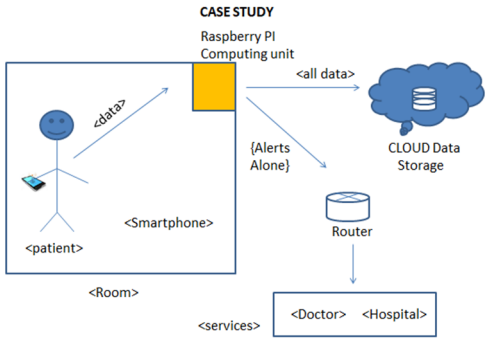

Fig. 4. Case Study Scenario Representation

A. Network Diagram for a single Sensor:

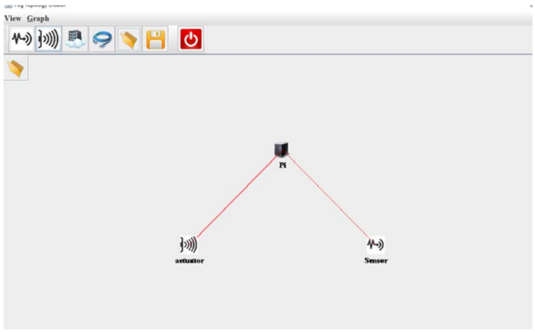

Fig. 5. Sample Network Diagram representing one sensor.

This case study involves the use of a Raspberry Pi as a fog device, on the edge network and a sensor that detects the fall which is inbuilt in all smartphones.

B. Results:

We created this architecture virtually in net beans using Java and checked its performance. The CPU utilization was negligibly 0% and the heap size utilization was 34144KB which is bearable by the Raspberry PI. This proves that this architecture is practically possible and will the processing speed.

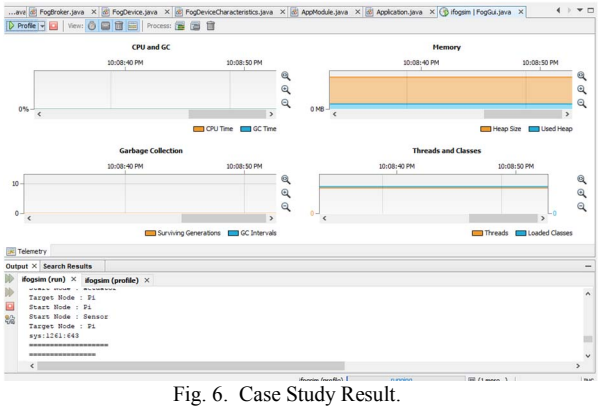

Fig. 6. Case Study Result.

VI. Advantages And Disadvantages

The architecture proposed in this paper replaces the cloud computing by fog computing eventually reducing the costs and efforts put in. The main objective of adopting the Internet of things in Healthcare is to make healthcare smarter by eliminating the barriers of monitoring the parameters related to

healthcare, which is achieved by adding sensors, that adds more functionality. This helps respond better in the shortest time possible. The latency of the system is reduced in Fog computing as compared to that in cloud computing in the proposed architecture since it's a real-time system that needs an instantaneous response with less latency. The sensors that are included in this system improves the efficiency of interaction of the system with the current environment. This is achieved by integrating the data from the sensors[7]. Fog Computing in comparison to cloud computing, offers new features such as Distributed analytics and Edge Intelligence. Being a dynamically high level programming model used in architectures that are bound for time sensitive, geo-spatially distributed, large scale and latency-sensitive, proves the impact this architecture has on our model[8]. The proposed model in this paper achieves accuracy in data and data consistency which is pivotal in medical data applications[6]. Hosting in the fog architecture is also simple and easy. Resulting in fog computing having an upper hand in performance, mostly because it has lower latency and has a much better decision-making model in critical scenarios for time-bound applications.

Fog computing provides access to all the data in the system and this violates the system privacy. It might lead to misusage of confidential system data. Fog computing has to focus on scalability, decrease in latency and bandwidth consumption and this becomes a tedious task to complete. Holistic solutions are required to solve the problems of extremely large data transfer between the interconnected nodes of the network[17]. The above mentioned aspects have to be taken care of long with reducing the cost of care and potential increase in the patient outcomes[18].

VII. CONCLUSION

With the widespread use of IOT, there's a sense in picking the most optimal solution from a set of concrete IOT projects considering all the parameters that affect the outcome of the corresponding applications. Using the examples discussed in this paper, we can say that IOT infrastructure for healthcare is revolutionizing new technologies and is in progress. With the help of new and upcoming developments in the IOT world, we can find out new use cases for the same to cater to the need of accessible and affordable healthcare[19]. Concurrently, there's a constant development in the IOT automation and machine-to-machine communication, which is an integral contribution to the betterment of any new device-to-device processing and connectivity solutions for healthcare that is driven by Internet of things[20]. Hence it is vital to have a well-defined Engineering Methodology for designing decision processes for health IOT systems.

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