IoT in Healthcare comparison of Architectures

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Abstract:

Various countries have dedicated huge amount of their resources to explore the various technologies like IT to comprehend with the current healthcare system and strengthen their abilities to provide for their respective subjects. In particular Internet of Things (IoT) has been widely used to connect to various medical devices remotely in order to provide service to elderly and people with Chronic illness. A detailed comparison of the present contrivance is shown with different types of architecture and the usage of those architecture based on the situation encountered.

1. Introduction:

An IoT biological system comprises of web-empowered smart gadgets that makes utilization of embedded frameworks, for example, processors, sensors and correspondence equipment, to gather, send and follow up on information they gain from their surroundings. With the growth if the population new challenges arise in the medical field to take care of the outpatient emergencies and to cope up with them new architectural patterns are designed and followed. IoT gadgets share the sensor information they gather by associating with an IoT environment. The sensors will record flags consistently, they are then corresponded with the fundamental physiological parameters and conveyed over the remote system. Utilizing the accessible information records and choice emotionally supportive networks, the doctor can do a superior forecast so that to recommend early treatment. Various architectures are present for applying IoT for healthcare and these architectures vary depending on the conveyance of the end user the situation of its utilization and the region in which it should be implemented. A detailed study of these architectures is done, compared and best use of the architecture depending on situation is exhibited.

2. Background:

2.1 The IoT meaning:

Internet of Things (IoT) is a technology that makes use of various sensors to piggyback the censor values in order to store, maintain, utilize and analyze the data and convert it to meaningful information. The meaning of IoT is not just restricted to a particular domain but instead it is a vast area of study under industrial automation era presently Industry 4.0.

2.2 Implementing IoT in Healthcare

This framework comprises of four-convention layers, namely, the physical layer, system layer, middleware layer and application layer.

To begin with, the physical layer comprises of gadgets installed with sensors and transmitters. The system or data link layer is mindful of transmitting signals from sensors to the Cloudlets while the Middleware layer accomplish crafted by putting away the information into the cloud and make it accessible to the individuals who are concerned. At last, in the application layer, examination and finding process are performed.

Data Collection and Transmission:

Patients will be given with the fundamental wearable sensors fit for estimating Electrocardiography (ECG), Temperature, Electromyography (EMG) muscle action, respiratory rate, perspiring and blood glucose level. Utilizing these gadgets, infections, for example, arrhythmia, fever, neuromuscular irregularity, pulse, heftiness and diabetes. The sensors utilized these days can be effortlessly positioned in contact with the skin in various body parts are profoundly best so that to acquire exact measures.

From the conservative sensors inserted inside the patient's body, physiological information is gathered comprising of different essential physiological parameters. At that point a little equipment equipped for preprocessing the procured information and a correspondence programming to transmit that information. The sensors must be little, lightweight and not upsetting the patient's portability and developments. Those sensors must work on little, vitality proficient batteries. The batteries are required to be working ceaselessly without charging and substitution.

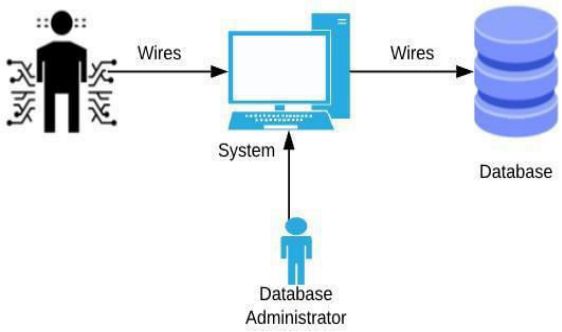
3. IoT Healthcare Architectures:

Depending upon the utilization and situation IoT architectures can be broadly categorized into 4 different types these types have evolved proportionately with time.

- Traditional System Architecture
- Cluster Network Model
- Close Range Systems
- Cloud Based service Architecture

3.1 Traditional System Architecture

In the beginning of the IoT era this was the utilized contrivance. In this architecture the IoT hardware devices basically sensors are connected to the computer systems directly and the sensor values piggyback directly to the system and stored these values are used to just determine the medication that can be prescribed for the data values obtained. But this prescription is done manually by the doctor by studying the various values.



The Figure 3.1: describes how the traditional system architecture works with the Healthcare system.

The values obtained by the sensors are sent to the systems by physical means like wires and that data is stored inside a database which are later analyzed by the doctors and suitable prescriptions are prescribed.

Advantages:

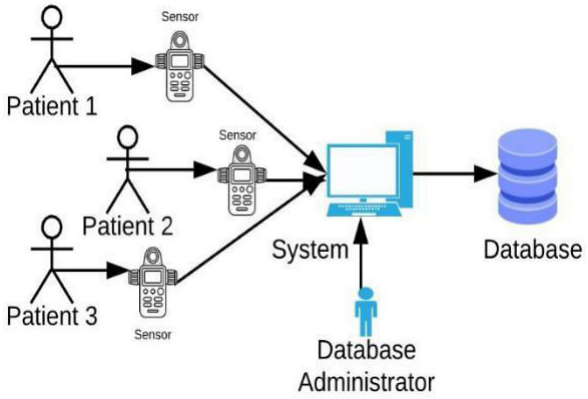
- The Physical data transfer means to eliminate data theft and manipulation from external resources.
- The Data is manually evaluated by medical personnel so the errors in prescription can be said to be greatly reduced as the doctor themselves analyze the patient.

Disadvantages:

- The Data is limited to a particular system only and it has to be manually sent over the network in order for an outside analysis.
- The human error in case of analyzing the patient may vary depending on the treating Doctor.

3.2 Cluster Network Model

This model is based upon the traditional System architecture but instead of limiting the data to a particular system the data is inside a particular organization which is connected by an INTRANET where the data can be values of many sensors to a single storage or a database.



The Figure 3.2: describes how the Cluster network model works inside a particular healthcare organization.

The piggyback data from different sensors or a similar but multiple sensors from multiple locations inside the organization will be sent to a database along with the sensor identifier number which has to be maintained by a physical administrator personnel or a Database Administrator who is responsible for allocating the patient details for the sensor values to know the data belongs to which patient.

Advantages:

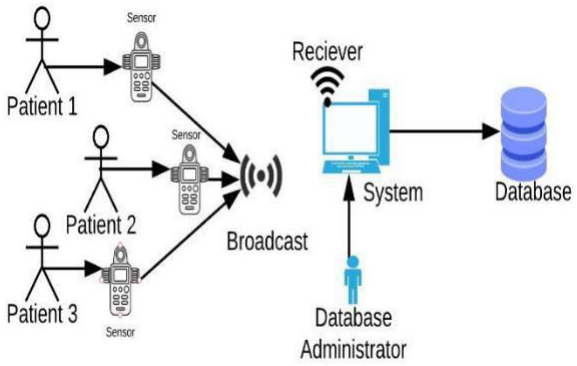
- This Architecture can do multiple operations or helps to treat multiple patients from different places of the Hospital/ Organization.
- Because many patients can be analyzed simultaneously the time taken for examination is reduced hence the waiting time for the other patients will be greatly reduced.

Disadvantages:

- The Database Administrator (DBA) is mainly responsible for maintaining the data so any error from DBA will cause the entire system to fail or may cause in the wrong diagnostics of the patient which is a huge threat for any medical organization.
- The Physical connection from sensors to database increases physical space and cost depending on the complexity of the network.

3.3 Close Range Systems

The innovation of wireless technology greatly advanced IoT and networks. The Bluetooth and Wi-Fi technology eliminated the bewilderment of the physical connectors like wires. This assists in the minimization of resource utilization and space utilization along with the time taken to configure new sensory networks.



The Figure 3.3: describes the Architecture of close-proximity systems.

The Bluetooth ranges from 10 meters (Bluetooth 1.0) to 240 meters (Bluetooth Low Energy) with the speed varying from 125 kbps to 2Mbps this helps in the wireless transfer of data from the sensor to the system and accordingly to a proper storage.

The Wi-Fi Wireless Fidelity allows the sensor to transfer directly to a database with a higher range and bandwidth than Bluetooth sensors.

With the implementation of Bluetooth and Wi-Fi wireless technology sensors the time taken to piggyback the data is greatly reduced and the switches cost for the network implementation is reduced greatly.

Advantages:

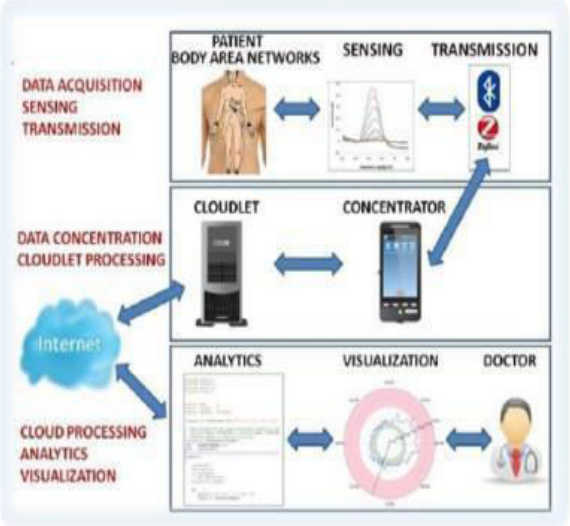
- The wireless contrivances help to eliminate the space issue and complex connectivity issues.
- It also reduces the time taken to install the system or add additional system to an existing system.

Disadvantages:

- This Architecture only eliminates the complexity of the system installation and resource management but nevertheless if there is an error from the Database Administrator (DBA) the system still fails.

3.4 Cloud based Architecture

Unlike the other Architecture which are Intranet based. This can belong to Intranet or an Internet Architecture the Piggyback values from the sensors are sent to a cloud server this will hold all the data of the System. The identifier sensors like RFID (Radio Frequency Identification), Bar and QR codes can be used to identify the patients and scan them accordingly the scanned data will be sent to the cloud servers. This will eliminate the middlemen that is the DBA and the error rate is reduced likewise.



The Figure 3.4: shows the cloud-based architecture with various sensory devices attached.

With the invention of various smart devices like Smartphones and Fit bands it is easy to keep track of the health record of any person. The data from the sensors are directly sent to cloud and is converted into useful information through means of Analysis and Algorithms which can predict the future problems that might occur in a patient and the present health issues that persists. Using technologies like Artificial Intelligence (AI), Machine Learning (ML) and Data Analytics the data is analyzed and based on the critical level the medicines are also prescribed by the analysis itself. The analysis data is verified approved by the Suitable personnel and is received as a notification or a message by the patient.

Advantages:

- This eliminates the physical presence of the patient in the hospital itself as well as the work taken by the doctors to analyze and memorize the details of each patient.
- The infectious illness can be treated remotely containing the infection itself.

- The work to the medical personnel is reduced massively by implementing these technologies.
- The patients in a farthest remote area or a rural area where there is a lack of hospitals, can be treated without either Doctor or Patient travelling.
- Data analysis can be used to predict illness in different patients with similar symptoms.

Disadvantages:

- If there persists the network issue in the patient's geographical location, then it will be difficult to diagnose the patient.
- The data analysis done by the system cannot be always accurate. There might be slight errors in calculation hence a Doctor is needed to verify the diagnosis before a patient is subject to any kind of prescription.

4. Comparison of Architectures

Different architectures can be utilized depending on the type of situation and the type of requirement by the medical organization.

If the medical organization is particular about their data being on a cloud system, one of the other architectures may be used for Privacy. Although the level of privacy has seemingly increased in the wireless technologies and the internet. The cloud-based systems provide its own set of security and protocols however the cost to set up a cloud might vary depending on the type of chosen cloud facility.

Table 4.1 Demonstrates the comparison of the mentioned architectures.

Architecture	Technology used		Services	
	Bluetooth	Wi-fi	Connectivity	Interoperability
Traditional	No	No	Physical Wires	No
Cluster	No	No	Physical Wires	Within Organization
Close Range	Yes	Yes	Bluetooth and wi-fi	Within Organization
Cloud	Yes	Yes	Hybrid Systems	Yes, using Internet

The table demonstrates the services and technology of different architectures whereas the initial architectures are wired the Close-Range Systems range up to 500 meters the cloud architecture does not have any range it is a widespread and can be used from any place with a device and a network.

Compared to other architectures cloud-based architecture is well advanced it can be used for data analytics, Patient Management and Remote Monitoring. Whilst the cloud provides all these features there are certain set of security risks and data exposure to public.

The close-range systems can help in achieving the inter organizational security however the infiltration of the organization might lead to data leakage. The inter organizational close-range systems can be implemented with cost efficiency.

The Cluster Range systems and Traditional architecture is only used by the organization which are unable to cope up with the current trend however it can be upgraded without disturbing the existing system. That is by using a Hybrid System.

A Hybrid system can be the implementation of a combination of any of the mentioned architecture with any other. Upgrading an architecture like Traditional and cluster network in a running system might be a problem because of its existing complexity and might cause the underlying system to breakdown hence new architecture can be implemented upon the existing one by using some of the network topology methodologies.

5. Conclusion

Internet of things is required to run the world in different fields, yet more advantage would be in the field of social insurance or Healthcare. Thus, present work is to think about the 4 structures out of which Cloud based Architecture is progressively solid design which uses cutting edge innovations like cloudlet, Wi-Fi, information investigation and perception. These strategies facilitate the examinations of the assembled information and encourage the clinician to settle on the proper choice. Use of cloudlet increases the portability and security to significant levels.

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