IOT Based Applications in Healthcare Devices

Architecture and Protocol

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IOT in Heathcare Devices

Introduction

In recent years, the healthcare industry has shown rapid growth and has been a major contributor to revenue and employment. A few years ago, the diagnosis of diseases and abnormality in the human body was only being possible after having a physical analysis in the hospital. Most of the patients had to stay in the hospital throughout their treatment period. It has resulted in an increased healthcare cost and also strained the healthcare facility at rural and remote locations. Positive technological advancement that has been achieved through these years has now allowed the diagnosis of various diseases and health monitoring using miniaturized devices like smartwatches. Moreover, technology has transformed a hospital-centric healthcare system into a patient-centric system.

The use of such communication services in conjunction with the rapidly growing technologies eg.IOT,mobile computing,machine learning,cloud computing etc has improved the accessibility of the healthcare facilities. In healthcare applications, the sensors, either embedded or wearable on the human body, are used to collect physiological information such as temperature, pressure rate, electrocardiograph (ECG), electroencephalograph (EEG), and so on from the patient's body. Additionally, environmental information such as temperature, humidity, date, and time can also be recorded. These data help in making meaningful and precise inferences on the health conditions of the patients.

The success of the IoT system depends on how it is satisfying the requirements of healthcare providers. Since each disease needs a complex procedure of healthcare activities, the topology must follow the medical rules and steps in the diagnosis procedure.

Architecture of IOT Healthcare Applications

Certain healthcare applications need the immediate attention of medical personnel like in diseases related to the heart or while providing healthcare for patients met with life-threatening accidents. Such situations need a real-time and critical response with significantly less latency. In a general cloud environment, the latency for data to be transmitted to the cloud, processing in the cloud, and getting a response involves significant latency, which is not acceptable. To overcome or limit the latency issues, we can use fog computing, which brings the computing and storage resources to the edge of the network, i.e., closer to the sensors. Most of the existing healthcare solutions use a cloud environment for decision making. In recent years, more and more solutions being proposed are considering fog computing for time-critical healthcare applications. Some of the existing architectural solutions are discussed here.

Cerina proposed a multi-level architecture leveraging fog computing and context awareness. The authors used the Field-Programmable Gate Array (FPGA) as a fog node. The architecture consists of four layers, namely, i) interaction layer, ii) mesh layer, iii) fog layer, and iv) cloud layer. The authors suggested the removal of the mesh layer in the case of time-critical healthcare applications.Verma proposed a five-layer fog-based architecture for remote patient health monitoring. The layers are i) data acquisition layer, ii) event classification layer, iii) information mining layer, iv) decision making layer, and v) cloud storage layer.Azimi proposed a hierarchical fog assisted computing architecture that consists of three layers, namely, i) sensor layer, fog layer, and cloud layer for IoT-based health monitoring systems. The authors extended and implemented Microsoft's MAPE-K computation model into their hierarchical architecture. Some of the data analytics tasks are offloaded onto fog nodes.Kumar proposed architecture for healthcare applications using IoT. The architecture consists of different sensors for measuring health vitals, which transmit the data to the Intel Qurie hardware platform. The author didn't explicitly mention any layers and whether the computing is performed at the fog or cloud.

Debauche presented an IoT based health monitoring system that employs fog, which contains a smart gateway for storing data locally and cloud for processing the data and storing it. Their architecture consists of three layers, namely, i) sensors layer, ii) fog layer, and iii) cloud layer. A smart gateway is placed at the fog layer, which performs data acquisition and visualization. Abdelmoneemet proposed a cloud-fog based architecture that supports multiple types of healthcare applications. Their proposed architecture consists of four layers, namely, i) things layer, ii) sink layer, iii) fog layer, and iv) cloud layer. The fog layer contains complex functionality, and the sink layer adds to the latency of data.

Here a minimal and simple fog-based architecture for Iot-based healthcare application has been proposed . The proposed architecture addresses the latency issues present in cloud-based solutions. The architecture contains three layers, as shown in the below figure namely, i) sensing layer, ii) fog layer, and iii) cloud layer. This architecture supports both time-critical healthcare applications like applications that require an emergency response, mobile ambulance healthcare applications as well as applications that are not hard on deadlines. The sensing layer contains different sensors for monitoring the health vitals of patients and elderly people. These sensors transmit the data to nearby application devices or hardware platforms like mobiles, Arduino, Raspberry Pi, etc.

The use of IoT as a technology in the healthcare domain is still in its nascent stage. As such, many challenges need to be addressed by the research communities and the industry.

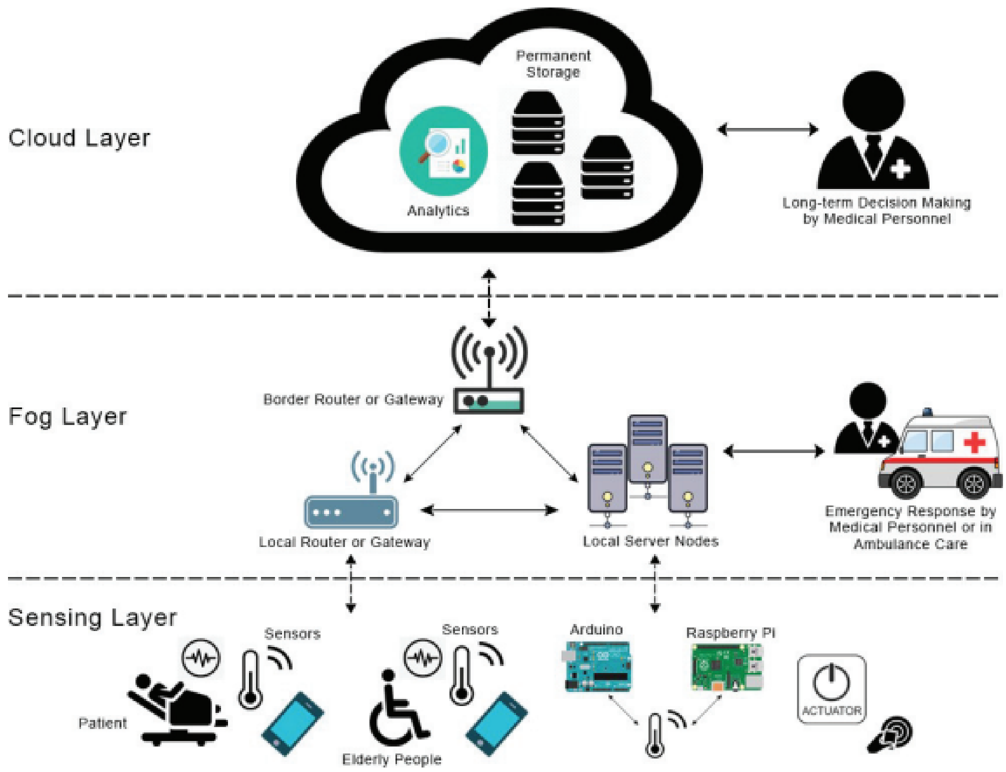

Figure 1: Architecture

Protocols

There are numerous application layer protocols available such as MQTT, HTPP, WebSocket, RESTful, SMQTT, DDS, COAP, etc. The suitable protocol is selected based on its application and requirements. Some of these protocols are defined below.

- Message Queue Telemetry Transport (MQTT) :- MQTT is broadly used as it is lightweight, simple and convenient to use. It supports many to one or many to many communication often called as multi-cast communication.

- Constrained Application Protocol (CoAP) :- CoAP got first outlined by Internet Engineering Task Force (IETF) that mainly works for Device to Device (D2D), Sensor to Device(S2D) or Sensor to Sensor(S2S) applications; and the interconnection and interaction of medical devices.
- Hypertext Transfer Protocol (HTTP) :- Hypertext Transfer Protocol (HTTP) is one of predominant stateless application layered protocol over the internet [6] which comprises of two main components as clients and servers. A request that is sent to the HTTP server with a URL by the HTTP client is processed and returned as a response to the client.
- Extensible Messaging and Presence Protocol (XMPP) :- XMPP is the most extensively used application layer protocol which facilitates the efficient communication of data between the sensors and its networks. It allows both bidirectional and multidimensional communication via the client/server model.
- Advanced Message Queuing Protocol (AMQP) :- AMQP was approved by OASIS. Likewise MQTT, AMQP is also publisher/subscriber model which works with TCP as transport layer protocol that makes the transfer of processed data on the device end highly convenient and reliable.
- Data Distribution Service (DDS) :- DDS protocol of the application layer has a vast scope for research and modifications. The framework of DDS was given by the Object Management Group (OMG) that supported varied applications in IoT and efficient D2D(Device to Device) communication for data exchange between devices for example, in IoHT, several devices like ECG, EMG, BP, HR etc. are connected to each other and other devices that can store and process the big data collected on the daily basis .

Conclusion

IoT is being incorporated into many healthcare applications and services at a moderate pace. Though IoT has many applications in the healthcare domain, many healthcare organizations are still hesitating to fully deploy it in their operations as IoT is still in a nascent stage and is not fully standardized. In this paper,an overview of the IoT technology in the healthcare domain was provided. First, enabling technologies like sensors, cloud computing,fog computing,and WBANs for smart healthcare were described briefly. A specific focus was given to wearable sensors as they are non-intrusive and due to their popularity among people. Wearable sensors like pulse sensors, respiratory rate sensors,body temperature sensors,blood oxygen sensors, and pulse oximeter sensors were discussed. Second, some of the key healthcare applications utilizing IoT were discussed like real-time monitoring and alerts, telemedicine, chronic disease detection and prevention, and home and elderly healthcare. Then, a minimal and simple threelayer architecture for IoT-based healthcare applications, which leverages the benefits of fog computing was spoken about. Finally, some of the important challenges of IoT in healthcare like fault tolerance, latency, energy efficiency, interoperability, and availability, along with current solutions in the literature, were presented. Another key challenge for IoT in general and IoT in healthcare is security. In the future, a comprehensive study of security in IoT healthcare applications will be carried out, and the proposed architecture will be implemented and analyzed.