An Inclusive Study on Substantial Need for Healthcare IoT Architecture: An Architectural Review

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Abstract— **In recent years Internet of Thing (IoT) devices have set a thrilling new trend in Modern Life Style. Also advances in wireless communication has led to an increased usage of IoT devices, particularly in healthcare field. IoT devices like sensors, wearable plays an important role in Healthcare IoT environment. Due to its benefit, an incredible number of IoT devices will be connected to the network and led to huge accumulation of data that makes complexity in data analysis and maintenance. To manage such an enormous number of IoT devices with an increased amount of multimodal data produced by them, an improved IoT Architecture is required. This paper mainly reviews some issues and significant needs for healthcare IoT architecture on the key considerations of Quality of Service (QoS), Big Data Technology, Analytic Techniques and Computing Level Paradigms in field of Health Informatics. Managing this role of data analytics and some computing architypes has turn out to be vital. Further, some Healthcare IoT based challenges and open issues are enumerated and outlined.**

Keywords- Internet of Things, Wearable Sensors, Wireless Communications, Health Informatics.

I. INTRODUCTION

Many organizations seek IoT due to its incredible performance in improving the standard of living. IoT is a concept of reflecting a connected set of anyone, anytime, anyplace, any service and any network [1]. IoT Architecture varies based upon the solution we need. Let us see the general architecture of IoT as shown in figure 1. [2] In general, IoT computing takes place at three levels: edge computing (i.e. lowest level) near a data/information source; fog computing (i.e. intermediate level) occurs in IoT Gateway or LAN; and cloud computing (i.e. highest level) which on the cloud server. In addition, Internet of Things architecture layers are distinguished in order to track the consistency of the system. This should also be taken into consideration before the IoT architecture process starts. Basically, IoT architecture has three layers.

Cloud Level: Nowadays there are many advancements in computing patterns that has developed from distributed level to Cloud level [24]. This Cloud Computing achieved a Centralized architecture with unlimited storage and computation power. But lacking in instant service, so that it is not suitable for real time applications. [3] It comprises three key service models: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). IaaS provides the virtualized resources, such as compute, storage, and networking. The PaaS provides software environments for the development, deployment, and management of applications. The SaaS provides software applications and composite ser-vices to end-users and other applications. In cloud computing, Long-Term sensor data analytics and Storage are per-formed on a remote cloud server.

Fog Level: In fog level Data Redundancy takes place in order to reduce the replication of data so that the cloud storage can be used efficiently. It is also known as Gateway Level which handles the communication standard interface to transmit the data from end user device to cloud level [22], [23]. In the context of healthcare situation typical Gateway interfaces used commonly are Zigbee, Zigbee Pro, RFID, Body Area Network (IEEE 802.15.6) etc. [2] In fog computing, a Gateway could collect, and/or de-noise and/or analyze sensors data and decide. Fog data mining is an important strategy for IoT in order to reduce the cloud storage requirement, the energy consumption, and package transformation across the wireless network. Each individual sensor or a set of sensors carries out sort of low-power processing on the acquired data to discover the novelty patterns.

Edge Level: In IoT, Edge level is where the data is produced and collected from IoT enabled devices like Sensors, Actuators etc., and it runs on single node. A node is the device we use to collect the data. The edge

computing devices are closer to the end user which can be implanted or worn by the user. Hence the edge computing devices are resource constrained and have less computation power, still the Quality of Service is achieved by providing quick response to the end users. Edge computing integrates edge computation nodes into the network through some communication standards and microcontroller which is embedded in IoT devices. The typical architecture of edge computing network is given in [4]. The structure of edge computing can be divided into three aspects, the front-end, near-end, and far-end. In Front-End, the end devices (e.g., sensors, actuators) are deployed at the front-end of the edge computing structure. The front-end environment can provide more interaction and better responsiveness for the end users. In edge computing, most of the data computation and storage will be migrated to this near-end environment to achieve a much better performance on data computing and storage. However, the cloud servers in the far-end environment can provide more computing power and more data storage.

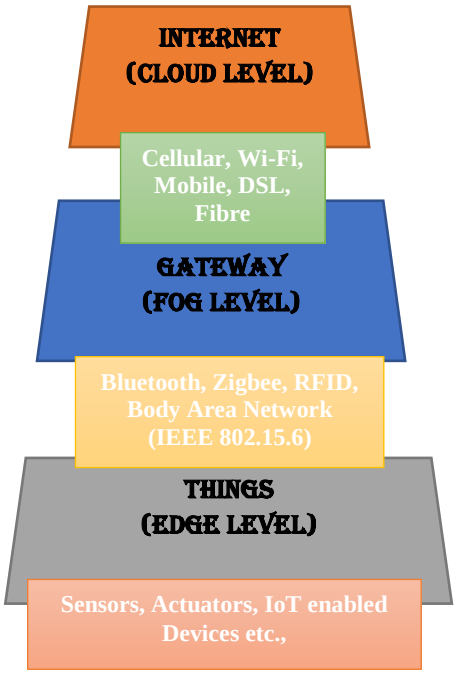

Fig. 1. General Architecture of IoT

1.1 Motivation

Sensor node which is enabled with internet technology are deployed to monitor an individual who are not only in clinics but also in the home or wherever they are i.e., patient monitoring system in healthcare filed. These benefits will be led to increase in number of IoT devices in future and these motivates to bring new IoT architecture which is adaptable for new growing devices.

According to the recent market survey, [5] Healthcare and life sciences are projected to increase from $520 billion in 2014 to $1.335 trillion in 2020. Healthcare will more than double in size with regards to IoT. Sensor companies, cybersecurity companies, wireless network companies and software companies are in a scramble to capture these markets. By 2025, the installed base of IoT devices will be over 75 billion devices — up from roughly 24 billion in 2018. [6] Data center and analytics will be the fastest growing IoT segment, reaching a 50% Compound Annual Growth Rate (CAGR) from 2017 to 2021.

II. REVIEW

Let us have a look on the review of this article which focus to build an efficient IoT Architecture enabled with certain Quality of Service, appropriate Big Data techniques, analytic solutions and some Computing Paradigms in respective of Healthcare IoT. In order to manage the huge number of IoT devices in the network, we need to consider some facts while developing IoT Architecture for healthcare solutions as given in Fig. 2.

QUALITY OF SERVICE (QoS): In Healthcare IoT environment QoS is improved by providing Mobility solution and prioritizing the service. [7] Mobile health could lead to a paradigm shift in healthcare and proved to be an asset in enhancing patient's knowledge and concerns about their health. It allows patient & their doctors to communicate with each other from any place and enables them to keep the track of their patient's health. With the help of the mobile device, now a days the doctors or physicians can easily diagnose or treat their patients

who live in a remote area or who are not able to visit their clinics periodically using remote health monitoring technique. Prioritizing the service could also improve the QoS by treating the emergency case. These priorities can be given by alert/warning indications that is sent through SMS to the physician in case of emergency.

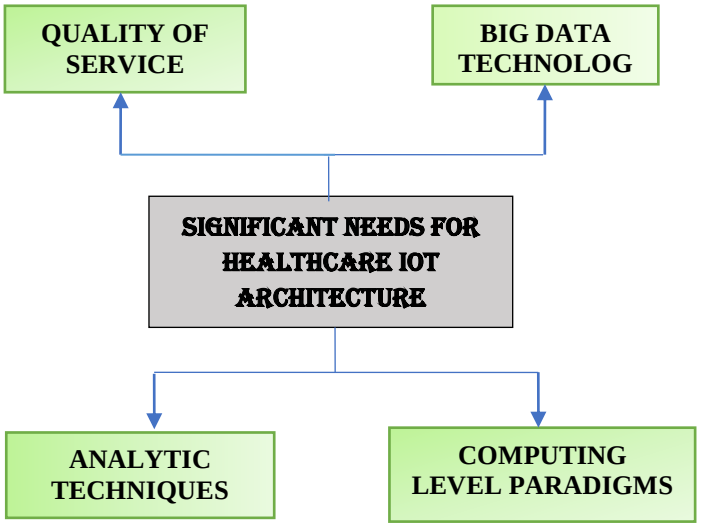

Fig. 2. Healthcare IoT Architecture

BIG DATA TECHNOLOGY: For IoT based environment, Big Data technology have three major transactions. First, managing data that is collected from various IoT devices like sensors, wearables etc., Second, solves the data complexity based on volume, variety and velocity. Third, some data analytic tools like Hadoop, MapReduce, MangoDB, and Kafka are used for analyzing the data. In the context of Healthcare IoT field, [8] bigdata mining methods like Clustering and Association Rules are used to fulfill analysis requirements. Because the category of the data may get varied based on the IoT devices used by particular application. The data format may be a text, image, video or signals that should be categorized accurately using these mining techniques.

ANALYTIC TECHNIQUES: In order to discover the valuable unknown information from the data, to predict the health status of the patient some analytic techniques are employed. [9], [10], [11] Machine Learning and [12] Deep Learning are the widespread algorithms for evaluating structured and unstructured data. But in the context of IoT environment, this mechanism is called as Fog computing and it should be a light weight process and fog level is suitable for that [26], [28]. Because the devices are resource constrained and miniaturized in nature. These devices have limited storage capacity to store the data. By considering these key points, lightweight process should be carried out for energy awareness.

COMPUTING LEVEL PARADIGMS: In the situation of Healthcare IoT environment, two modes of executions like online and offline are performed. Edge Level and Cloud level [27] computing are the two computing level paradigms that are achieved in IoT environment. Cloud and Edge levels have both merits and demerits. Processing sensor data i.e., data redundancy is carried out at the Edge level resulting in faster and efficient knowledge transfer to the cloud. Cloud provides centralized pool of storage and computing resources but not suitable for real time applications. Edge devices are light weight [30] that do not have sufficient storage but suitable for real time application. [13], [21], [25], [29] Employing Collaborative Edge-Cloud processing, some resources required for real time execution can be retrieved from Cloud storage.

III. OPEN RESEARCH ISSUES AND CHALLENGES

Light Weight Process: Most of computation takes place at node level in IoT field. Since every node or IoT devices namely sensors, wearables etc., used in healthcare field are resource constrained, Light Weight Process should be carried out. [14], [19] For example, if it is an encryption algorithm for securing the data, then the number of rounds or key size should be reduced. So that the energy could be saved, if it is a node-level process. But this light weight process will affect the particular function applied. If it's a security mechanism, then these light weight process may reduce the security level.

Motion Sensor: Actually, the situation is the data collected in healthcare IoT field is observed from Moving Objects or objects in motion. For instance, in sports field some sensors are implanted or worn by players in order to predict their performance while playing. Observing such kind of data from moving objects suffer from artifacts, the condition of alteration in observed data [20]. Up to my knowledge, so far in our studies, implementation with data from motion sensors are very rare.

Security: As this is a healthcare field, the data produced by these devices are very sensitive [15], [18]. It should be protected from unauthorized users. So, some security mechanisms should be employed at node level

or at cloud level. In fact, node level security may better than cloud level. The data should be encoded from the source itself before sending to the cloud level may protect the data from intruders. It is better to send the encoded form data from the source or sender. But this node level encryption may consume the energy.

Scalability: Considering the merits like mobility in IoT field, there is an addition of diverse application which may led to complexity for related operations. More over IoT devices also increases in number due to its benefits. [1] So, the IoT healthcare networks, applications, services and back-end databases should be scalable to meet the growing demands from both individuals and healthcare organizations. [16] Also, the IoT system should able to balance the load in case of redundant resource availability to utilize the resource efficiently.

Local on node processing: [17] On Node processing i.e., Node-Level process may reduce amount of data communicating wirelessly. So that the amount of radio power consumption is reduced. Also consider the system level energy saving while considering the trade-off between the radio power consumption for remote processing and digital signal processing power consumption for local processing.

IV. CONCLUSION

This paper surveys the Architecture of IoT framework for healthcare field. Sensors and wearables which are enabled with internet technology is a backbone of healthcare IoT environment. By considering this fact the implementation issues of these devices are discussed in open research challenges. As these IoT devices are battery relayed, system energy should be utilized efficiently by on-node processing at node-level with light weight mechanisms. Further this paper re-views the big data technology, data analytic techniques and computing paradigms in the context of Healthcare IoT. In order to achieve an efficient healthcare IoT architecture, IoT network should be flexible. Due to increasing demands, IoT field may take in a large number of nodes in future, the employed architectures and software services must be able scale to these numbers.

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