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Healthcare Informatics and Monitoring System based on Fog Computing

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Abstract: ***Wireless sensor networks and internet of things are widely used in healthcare industry. In today's scenario wearable sensors become very popular devices to monitor patients at high risk. Patients who are suffering from long lasting sickness visits hospital at multiple time for their regular check-up. Treatment from this kind of system increases the expenditure in overall for the patients. However, with recent technological innovation such as cloud and fog computing, with minimal expense on storage and computing facilities these problems are overcome. In this paper, we provide an analysis of fog computing role over cloud computing to monitor patient's health to provide context aware services without delay to the end user when it required to patient and medical practitioner. Three layer architecture is proposed for real time domain data storage, processing and communication. This increase the capability of cloud computing with the integration to fog computing for current and future use application.***

Keyword: Wireless sensor high overcome. services without delay to the end user

I. INTRODUCTION

The world's population growth in today's scenarios is very high and numbers of chronic diseases for people have been a serious concern for medical agencies. Due to these the expenditures increases in healthcare. As a result, the usage of cloud computing in healthcare increased. Nowadays cloud computing isn't a providing a complete solution. The development in technology opens some new era of technological implementation in healthcare like Internet of Things(IOT), Fog Computing(FC) etc. The monitor of patient health through wireless sensor network has been playing a huge role in healthcare industry. The devices and wearable sensors are attached to patient and it generates a huge number of data and these data's are used for effective monitoring of patient. The huge number of patient data generated by wireless sensor networks. The different devices have been used to collect data those are connected to the network. Both useful and redundant data has been collected here. The huge amount of data can devastate the all system of data storage as well application of data analysis. Extracting out of undesired data has to be a context sensitive process. Actually the data collected by sensors have send to the computing devices, and computing devices computing these data for further processing.

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Generally in most of the cases, high numbers of sensors are required for each patient and it is very difficult and costly to create infrastructure for them. But Internet of Things (IOT) can be used as an alternate where common infrastructure can be used by sensor devices. Than these sensor devices collected data can be forwarded to cloud server.

In many healthcare applications, most of the hospital doesn't prefer to store the patient data outside the hospital. Due to any reason any loss in patient data put the patient on high risk, may be failure of data centre, power failure etc. The use of cloud only also creates delay in processing or transferring of data because sensors transferring the data to the cloud and cloud transferring the data to the hospitals.

In real time scenarios, we required emergency response system, where time plays an active important role, delays in time is not acceptable and the delay occurs due to transferring of data and processing of data over cloud and final outcome reached back to users.

In a number of cases, just a tiny delay or be short of application accessibility due to any reason like failure of power, disconnection of internet, failure of cloud etc may become life menacing. Security of data has an also imperative issue in cloud.

For rectify the above issues of cloud computing, Fog computing is an emerging computing paradigm introduced between cloud computing and IOT devices. Real time emergency situation where delay can be reduced by using fog gateways. For better outcome, edge devices can be integrated and broaden the exiting cloud infrastructure. Fog computing is useful for interactive environment to facilitate the edge devices to ingress the prerequisite data used in a cloud network. Fog computing is an extension of cloud computing paradigm at the edge of the network. The fundamental objectives of healthcare applications are to provide the regular command on the patient health. Fog layer Implementation provides the unbeaten fulfillment of the requirement. Fog computing entrust service delivery with consistency on time while conquer the difficulties allied with cloud computing such as delays, cost, infrastructure, maintenance. Enhancement is done in storage capacity, networking resources and computational due to its distributed flat architecture along the cloud computing. The accessibility is increased to the resources for healthcare such as storage and computing. In this paper, we reduced the challenges of present healthcare by implementing fog computing environment such as delay in care of patient and security of patient data. Only Cloud Computing isn't a proper and best solution. Its own limitations are like as low in real-time response, delay and security. Life is very precious and a small delay can destroy it so it needs to improve the healthcare services and applications.

So the fog computing comes with attention in healthcare. Fog computing entrust service on time delivery with high consistency while conquer at most all the difficulties related with cloud computing such as delay time, effective cost, infrastructure, maintenance. Improvement is done in the capacity of storage, networking resources and data computation due to distributed flat architecture along with the cloud computing. The accessibility is enhanced to the resources in healthcare such as computing of data and storage. Low latency, privacy and elasticity against cloud computing are the foremost advantages of fog computing. We discuss the assortment of computational task which are involved in healthcare and it will performed in fog layer. The security of the information passing through the system will increased due to the fact that the data doesn't travelling more in the network.

The remaining paper is arranged as follows. In Section 2, Related work are discussed. The proposed work is discussed in section 3. Heart disease monitoring by use of Electrocardiography (ECG) patient are discussed in Section 4 as a case study to support the proposed research. Open issues and research challenges are discussed in 5th section. Final section 6 is concluding the work.

1. 2. Related Works

Fog computing provides a medium for storage, computing and networking between the cloud and end devices. It is highly virtualized.[1] The large amount of data are processed and it has been proved that fog computing is very useful for real time application.[2] Real time domain processing having an important role in healthcare application. Processing of data was very fast and having very less time as possible as response time[3,4,5]. The IOT devices acceptance is growing at a very rapid rate to fulfill the requirement of current industry[6].Capabilities for high storage and high processing , cloud computing has an expansion of application system based on wearable medical sensor[7]. Smart gateways in fog computing are used to accomplish monitoring healthcare monitoring system of patient in order to put forward an urban and improvement technique[8]. Mohapatra et al. [9] proposed a healthcare monitoring hybrid framework that works for remote patient health monitoring through sensor cloud. The collection of data for patients in healthcare systems was proposed by C.O.Rolim et. al [10] where data of patients sends to the cloud by sensors are attached with medical devices for access. A health monitoring system that was based on Bluetooth interface for uploading the collected data to remote server and the sensing servers were used as a gateways in system. However, the proposed system was high in cost, less scalable, and very less efficient for application based on IoT[11].

II. PROPOSED RESEARCH

A Three layer architecture used in fog computing architecture (Fig 1). It will actually change the complete scenario of hospitals. Three main layer consist in this architecture: medical device integration layer (MDIL), fog layer (FL), cloud layer(CL). It provides an absolute solution from acquisition of data, processing of data and analytics of data to cloud environment.

III. MEDICAL DEVICE INTEGRATION LAYER (MDIL):

Traditional healthcare systems are disconnected. Here a large number of medical devices based on Internet of things (IOT), such as smart phones, smart watches, pacemaker and wearable or implanted sensors enhance the health monitoring system of patient in real era of time. The status of health of patient can be trace out by any computer or mobile phone and match it safely with cloud eHealth platform [13]. In this first layer of architecture patient data is captured by any of the smart phones, smart eyeglasses and smart-watches. All the information is required to reach fog gateways through a proper network connectivity using any suitable communication protocol. MDIL further divided into two sub groups 1). To digitally monitoring health of patient physical smart sensors are used. 2) To get the information about patient health and related data from surrounding. These are highly reliable and cost effective sensors. So these can be mostly distributed at different hospitals or clinic to watch the patient health status always. And very carefully the generated data required to be processed. Generated data sent to fog layer for further processing.

3.2 Fog Layer (FL):

Fog layer is receiving the data generated by MDIL for further processing of data. Various Fog nodes (FN) are available here with property of high performance and low powered. Every local group of medical devices is connected with different fog nodes. That covers processing of data on perfect time. Basically here fog layer is responsible all the challenges of cloud computing for processing of data in minimum time. Processing of critical data is main requirement of the healthcare and fog layer is fulfilling the requirement of healthcare, It took healthcare industry at another level. Here time sensitive data is analyzed and decision is done according to placement of fog nodes. Fog nodes are located in close proximity of smart medical devices. On the other hand the remaining data is directed to the cloud because cloud is the main storage. Fog layers has different characteristics to reduce the latency is as

- The fog nodes are dexterous to maintain reliable and completely secure connectivity between medical devices and intra & inter networks.
- The fog nodes provide bi-directional data flow and the route of data is from medical devices to cloud through fog layer. And data will be available to healthcare agencies or doctors, also for patient on request. On regular intervals the aggregated data sends to the cloud.
- Fog nodes perform aggregation, formatting and compressing of raw data received by medical devices.
- Fog layer provides multi layer security of data through access control and encryption-decryption.

3.3 Cloud Layer (CL):

Cloud layer is highest layers which have high data computing data centre as well provide centralized controlling and region wise monitoring. This layer consist cloud server to achieve dynamic decision. The cloud server is responsible for extra storage and aggregation of patient data received by fog nodes as center layer.

Patient or healthcare agencies or doctors can access these data for further processing such as billing or to make summery of report, etc. Current and old medical history can be checked or visualize by patients using any mobile application or any web interface which are compatible. It also contains some different internal layers:

- Connectivity Layer: The connection is established among different medical devices, Fog nodes and cloud. A communication channel and compatible hardware are used to maintain connectivity between fog nodes, cloud and medical smart devices.
- Data integration layer: The cloud data will be integrated to various sources. And data of patient can be access by medical agencies or patients anywhere at any time when it's required.
- Application layer: Different application services are provided in this layer such as data analytics, alarm notifications, trigger actions and events notifications. Cloud gateways are used to connect the with others.

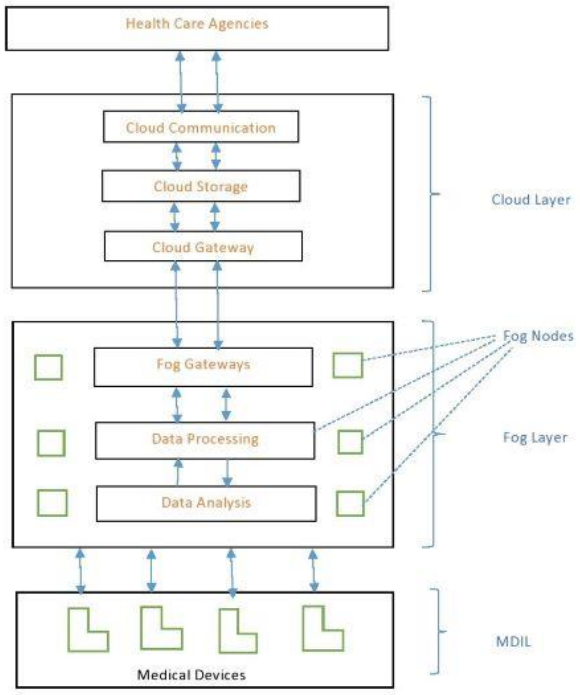

Fig.1 A Three layer architecture

IV. CASE STUDIES:

Electrocardiography (ECG) monitoring: Real time processing without any tiny delay is done by fog computing. It is well appropriate for Strewn data analytic and collection of data at node. The idea behind development of fog computing for using distributed storage at smart gateways, real time information and data mining at network edge to enhance the power of electronically monitoring system of health. ECG feature extraction has a very important role in diagnosis of different cardiac disease. In this case study different signal of ECG such as PR, QT, RR intervals, T wave, P wave are indentified. The searching of these signals are done by dynamic-time-warping (DTW) method. This method is used by different applications such as spoken word recognition, walking pattern recognition, automatic voice recognition, online signature recognition and different signal analysis for ECG. Dynamic-time-warping (DTW) can identify the similarities among the two different series with diverse phase difference and distinct signal length. A shortest path is discovered through the adjacency matrix. Fog layer receive the ECG dataset using internet. The most important goal is to discover the cardiac arrhythmic ECG beats through QRS complex and the measurements of RR interval. The QRS complexes are extracted from ECG signals using signal processing in real time domain. The data reduction or compression is completed on different fog nodes. The large number of sample of ECG signal around 3000 took 1 sec as a processing time from the proposed architecture on fog nodes. Hence the proposed architecture suits very well for the real time ECG monitoring. The time series of ECG data can be compressed by using GNU Gzip programs. After the compression, cloud received the compressed files. Fig 2., The ECG time sample pattern shown by DTW is sent to the cloud. The ECG compressed file also shows the percentage of compression. The executions of time files are reduced by the help of it. Further, an analysis is done with feature extraction including different heart beat, different waves in smart gateways. Fog computing provides very low latency in real time processing and achieved a great efficiency about more than 90 % of bandwidth[12]. It authenticates the architecture of fog computing for monitoring of ECG data in real time domain.

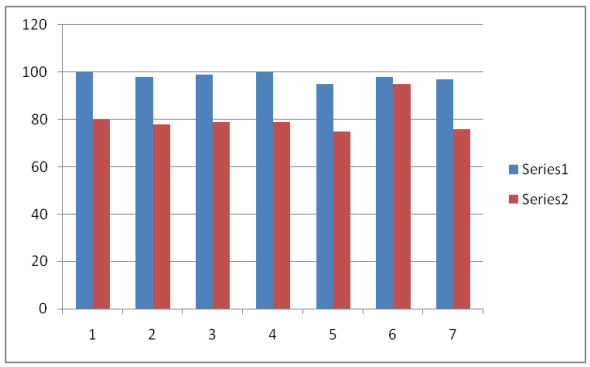

Fig 2. X-axis: ECG data file series, Y–axis: ECG data reduction,
Series 1: DTW, Series 2: Compression

V. OPEN ISSUES AND RESEARCH CHALLENGES:

There are several research issues and challenges in real world associated with the appropriate implementation of fog computing based medical facilities. These issues must be overcome before implementation.

- Real time data management: Huge amount data of patients received by medical devices. This is more associated with the capabilities of fog nodes to collect, store, routed to process and correspond to communicate. Data fluctuation can be visualize between the fog computing and cloud computing and it is necessary to monitored by establishing a system by administrative setup. There is a requirement of standard data format in fog layer, to handle the highly different data like as text format, image format etc.,

- these data are received by different source such as smart eyeglasses, smart mobile phones. Gateways needs to very careful and aware for urgent data routing and normal data routing.
- Scalability: Data collection is done either from medical devices and smart sensors. This facility must be scaled up to entire hospital positively so that each and every patient can avail this facility. And they can check their update status of health. It save time of patients who are waiting for appointment with doctor, results waiting time and provide a direct access to a certain level of medical assessment.
- Security, Privacy and fault tolerance: It is the primary concern. The information of end-users should not be accessed by any unauthorized person or agencies. Security and privacy of records are key concern in deployment and implementation. Hence protection is majorly required in all layer such as MDIL, fog layer and cloud layer. There must be an alternative plan for failure of any sensors, networks etc.
- Standardization: Today there is no standard mechanism or rules are available neither for protocol nor for interfaces. Standardization must consider a wider range of topics such as interface for devices, aggregation of data interfaces, protocol for communication and interface for gateways.
- Interoperability and federation: There must be translation of protocols at all internal layers such as data annotation layer, network layer and message layer of fog layer. A federation structure must be available for patient before the product make available in market.
- Power Consumption: Fog layer consists of many fog nodes and computation is distributed over them, so power consumption should be as low.
- User friendly interfaces: There must be a design team who provide the feedback on comfort and dislike on medical devices, so that comfortable medical devices can be constructed.

VI. CONCLUSIONS:

With increase of huge data generated in IOT is processed in the real time environment with efficiency. Fog computing having various challenges in healthcare environment such as real-time data management, security, privacy and fault tolerance, scalability, power consumption, user interface, interoperability and federation have been properly covered in this paper. We proposed a three layer architecture based on fog computing. This helps to properly monitor the health monitoring systems. Doctors can take quick decision in real time emergency cases. The proposed architecture can be used in developing patient concentric data based medical analysis system. A case study were discussed in the paper which verifying the proposed architecture effectiveness.

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