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An Efficient Data reduction Technique in IoT Health Care System

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Abstract

Internet of Things (IoT) is a system of interrelated devices or things that communicate among themselves the device may be Electrical, Mechanical, Chemical or anything. IoT is used in almost all the field, one of the important field is health care, in remote patient monitoring system patient health data are needed to be monitored continuously, so it is unavoidable in such systems to generate unprecedented data, all the data acquired are processed in cloud, consequently it overloads the cloud and hence latency, congestion and memory requirement increases , In the Proposed system all the data are validated at the edge or fog node itself rather than the cloud, and also only the data which are more important are uploaded to the cloud for further broadcast here the non-critical data are redundant, hence a large number of data being transmitted to the cloud platform is averted. The data filtering method is used at fog node near the IoT gateway is used in the proposed work. Only Unsafe Health data is filtered out from the raw data used at Fog Layer, Fog computing is an architecture that permits applications to processed on the edge device rather in IoT cloud computing platform. Utilizing the concept of Fog computing here off load the cloud by restricting the raw data to be uploaded in to the cloud and also increase the effectiveness of the system.

Index numbers-*internet of things (iot), fog Computing, cloud computing, event triggering, data redundancy*

I. INTRODUCTION

According to Cisco the term fog node is any device which has the network, storage, processing capability, It permits applications to be executed on the edge node itself and not on cloud platform. Cloud computing systems are inter connected computers or networks. The word “Cloud” refers to the cloud symbol in the IT world which is used to describe the internet network or internet cloud. Cloud services offer variety of services, PaaS, IaaS, SaaS, FaaS. It is mostly used in businesses and helps to achieve the reduced investment cost and get confined to the intended functionality . Unlike generic cloud, IoT cloud has to handle huge amount of data , data problem arises as it gets data from all the things which have been incorporated with sensors[1].

There are few disadvantages of risk of data confidentiality, it rely on network connectivity, security level, compliance, vulnerability in the event of attack, data mobility and many more. In the existing methodology the vast amount of data collected is directly sent to the cloud which consists of repeated data which causes redundancy and storage consumption[3][4] .

To overcome these disadvantages computation and validation at fog node is proposed which performs the computation, data collection and networking services between end device and IoT Servers. It filters out the critical data at the edge node instead of sending a large number of data to the IoT Server [1][2]. The problems like edge location, latency issues, accuracy and transferring data to the best node for processing

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are worked out by fog node. [1] Fog based IoT systems has the following Devices, Data acquisition Device, Fog Intermediate Device, and IoT Cloud Platform . The fog layer filters the critical health parameters and only upload to the cloud, in case of any abnormal data generation. Fog layer does decision making and analysis of the real time data.

It predicts the event range in real time and then upload the critical data to the cloud for storage and broadcasting. Fog servers minimize [4]the bandwidth requirement and reduce the redundancy[3] present in the raw data.

The objective of our paper are i) monitor the patient using certain health attributes. ii) triggering the event if the patient is in an abnormal condition. iii) removing the superfluous data in order to save the storage space and decrease the bandwidth[3].

This paper is partitioned in to different parts. In part II information about fog and IoT based systems are provided. The proposed work and its layers are explained in Part-III. Part-IV discusses about the performance measurement of the proposed system. Atlast, Part V concludes the paper.

II. RELATED WORK

The ever-growing IoT devices produce and send enormous amounts[3] of irrelevant and data of less importance [4] to the cloud leads to congestion, overloading and degradation in the performance of IoT Cloud or server . Network edge based data reduction[3] is an option to address those problems. In reference [1], the authors proposed a data filtration techniques to overcome the issues like data accommodation , Input Output generation rate and cloud storage. They introduced NECtar which is capable of switching among various data reduction [4] algorithms such as selective forwarding, piecewise approximation, Perceptually Important Points (PIP) algorithm and data change detection based on the data type. According to Feng et al. who introduced a method to overcome the energy utilization[4] issues of IoT devices and the reduced data storage at cloud, the method works on a data reduction structure that operates on two terminology , IoT gateway and Edge Node. These Methods utilizes the PIP algorithm on continuous incoming data. The authors integrated the PIP algorithm with several other methods like restricting the updation interval, dynamic caching etc. At the Next level, they introduced a data mixing technique with the help of the data library. Other authors introduced a method that utilizes the benefits of edge devices to improve the data redundancy removal process [3] and to compensate for the errors of IoT gateways. The authors used PIP algorithm in their work to improve the performance of data minimization and used level1 and level2 IoT gateways without any synchronization between them and without transferring the repeated data. The concept is that the dataset is divided into two namely odd and even datasets and processed by level1 and level2 IoT gateways, respectively. Even though PIP algorithm takes the required points for keeping the overall shape of data, it gets affected from processing complexity as it requires more time for running to know the important points that forms the overall shape of continuous serial data in each loop.

III. PROPOSED SYSTEM

In a smart communication mechanism, the edge layer can access the necessary data of the patient from the cloud layer[2]. On the other side, in traditional communication, the information connected to fog node processing are transmitted to the cloud with patient other information for remedial treatments. In the Proposed work we have performed the required actions in the fog layer[1][7] instead working in the cloud

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layers. By combining different IoT devices, Bio medical sensors, and other computational units the health data from the patients are retrieved. The ultimate goal of this work is to supervise the state of the patients who need critical care using certain sensors and also to reduce the amount[3] of patient medical data being sent to the cloud. The term “Fog” and “Edge” are often referred to the edge layer[8]. The proposed system has the following layers: i) Sensor & Data Gathering Layer (DAL) ii) Severity detection and event classification Layer. These layers come under the Edge computing and Fog computing respectively.

BLOCK DIAGRAM :

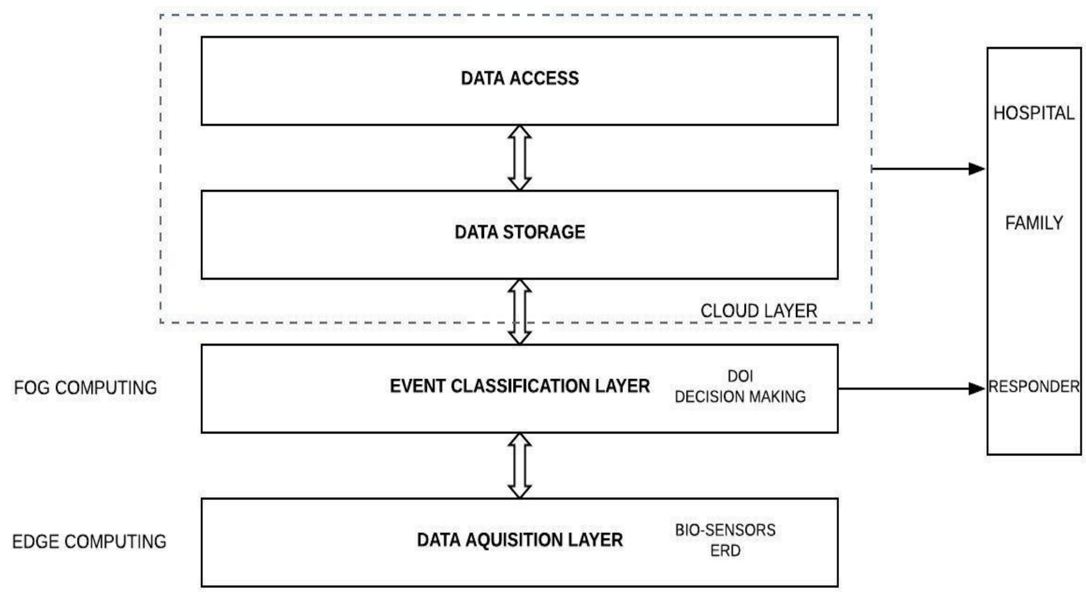

Fig 1.layered architecture of proposed system

EDGE LAYER :

Edge is normally associated with the nodes at which data are generated, edge and fog layers are combined and off load the cloud layer and hence reduced congestion, improved bandwidth and minimized latency can be achieved[3]. Any computational unit with the provision for interfacing sensors can be used at the edge node. Instead of overloading[2][8] all the generated data to cloud for computation and validation, Edge and fog can reduce the load[2] by doing the computation by itself and hence a large amount of data literally depleted by the edge and fog , it makes the computation ease for the cloud[8] , moreover the data generated can be checked for redundancy[3] if redundant data is present that can be filtered out in the edge itself that helps not only to reduce the memory requirement at the cloud but also improve the bandwidth abd decrease the congestion in the network. Sensor and Data Acquisition Layer comes under the edge layer.

Sensor and Data Gathering Layer (SDGL):

Sensor and Data Gathering Layer collects health parameters from the patient, Health parameters includes Body Temperature of the patient, Heart Beat Rate , and ECG Parameters P,Q,R,S,T amplitude

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and durations, and also environmental parameters of the location of the patient[1]. Data is obtained from various wired/wireless devices placed at various points at home or the Treatment centers and from the sensing point of the patient. In the work proposed only one patient data has been considered, Any controller having the capability of getting interfaced with these biomedical sensors can be used at the edge computation

The values from the different bio sensors are collected and converted into a definite format before analysis refer table4. Based on the data set normal and abnormal classes are derived refer table5. Abnormal event is said to be created when the medical parameters exceeds or fall short of the specified typical. Whenever there is an abnormality in the acquired value inferences from that is obtained , A notable event indicates that the sampled data of a feature is not in the typical range. Abnormal body temperature, hypertension and abnormal electrical activities of the heart i.e. ECG waveform are some of the critical event refer fig2 and fig3.

PQRST WAVE :

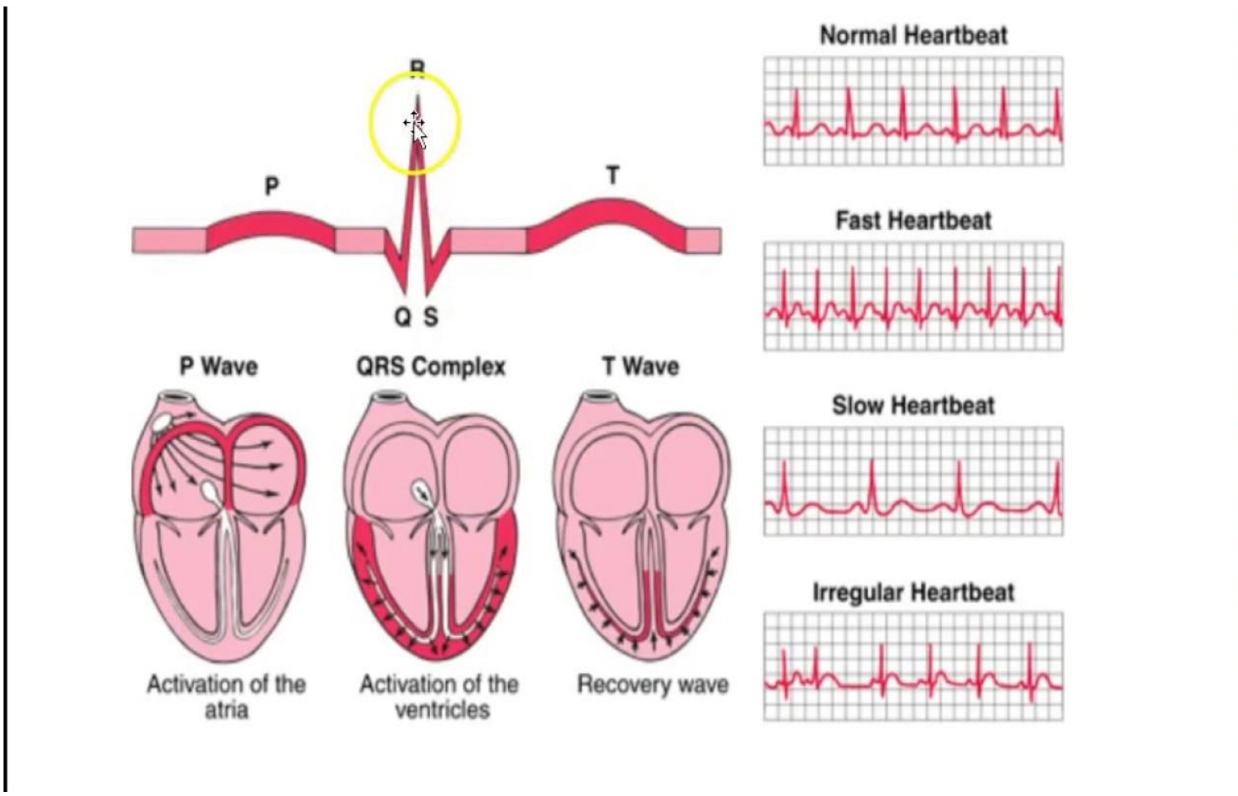

Fig 2. PQRST wave

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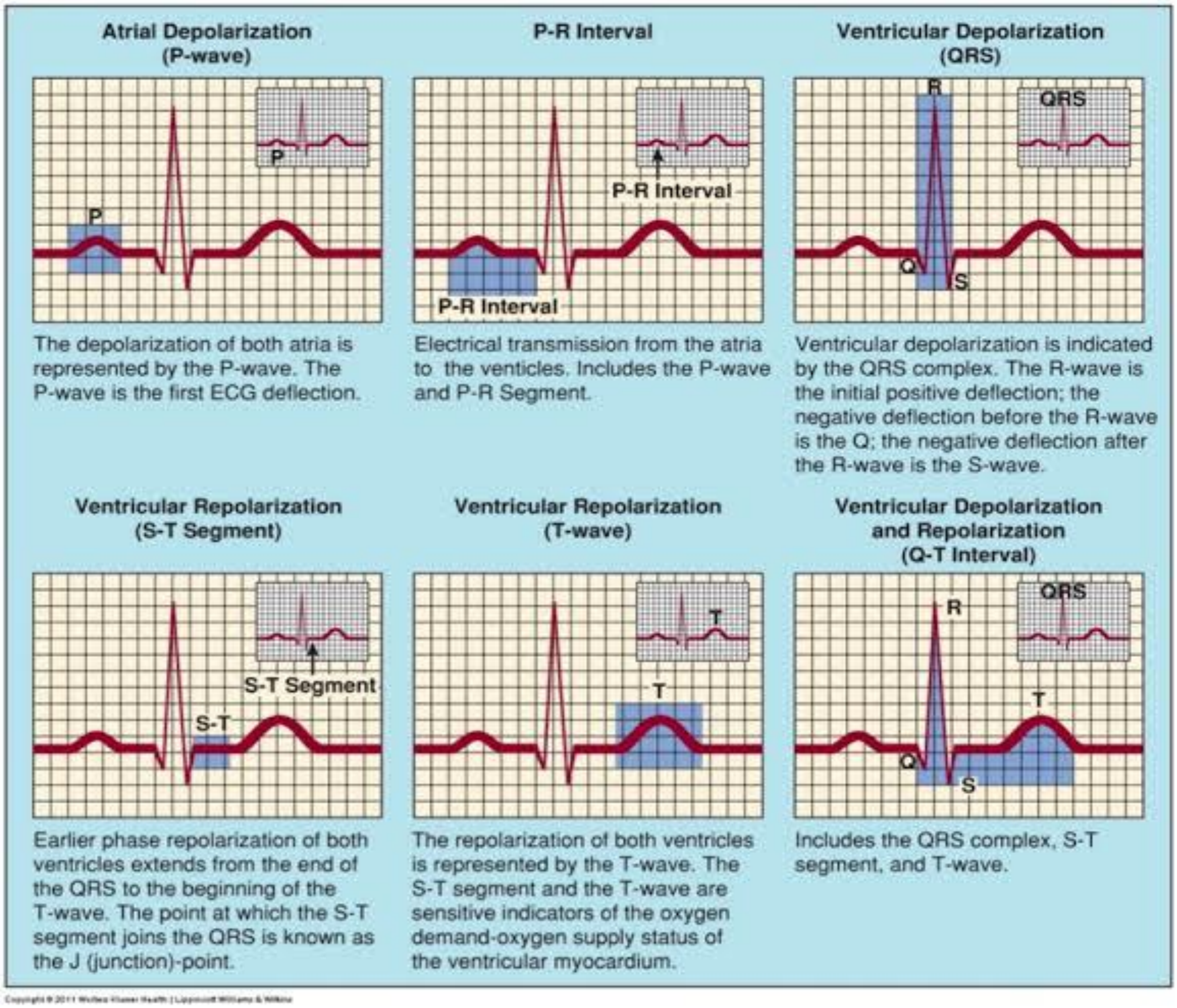

Fig 3.PQRST wave complexes in ecg waveforms

Severity Detection and Event Classification Layer (SECL):

The significant event is defined as the event value which can classify whether an event generated is normal or abnormal. Whenever an abnormal event happened, All the related parameters along with the time stamp is send to the Fog layer[7][8] for further processing refer algorithm1.

To segregate the events as normal or abnormal, A look up table in the form of pre-defined data set[5] is inserted in to the fog node[2] code enables the system to classify the event occurred and also mark it as safe or unsafe , when abnormal event occurs it will not be marked as unsafe at that instant , but wait for another set of data then if the data set remains same then it is marked as unsafe , only data which are finalized as unsafe data are sent to the cloud platform refer algorithm 2.

Categorization of the events needs the environmental factors[1] and a patient's medical history, as some of the parameters are subjective to medical history and environmental parameters. It has a very great

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impact and that might affect the patient health significantly. Many health researches have also proven it. These environmental features[5] may include room temperature, humidity, noise, air quality, etc refer to table 5.

Table 1. Body temperature sensor predictions

BODY TEMP	**FEVER**
37°C	37.8°C

Table 2. BPM sensor predictions

BPM	**PALPITATIONS**
60-100	Less than 60 Greater than 100

Table 3. ECG sensor predictions

P Wave	Atrial depolarization
QRS Complex	Ventricle Contraction
T Wave	Ventricular Expansion
PR Interval	Starts at the P-wave and ends at the beginning of the QRS complex.
ST Segment	Ventricular repolarization

Table 4. Normal and abnormal predictions[11]

WAVE	**AMPLITUDE VARIATION (mV)**	**DURATION (s)**	**AMPLITUDE VARIATION (ms)**	**DURATION (s)**
P WAVE	0.15	0.09	0.10	0.03
PQ INTERVAL		0.15		0.05

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Q WAVE	0.25	0.02	0.10	0.01
R WAVE	1.30	0.04	0.30	0.02
S WAVE	0.35	0.03	0.10	0.01
QRS INTERVAL		0.09		0.04
T WAVE	0.30	0.21	0.15	0.05
QT INTERVAL		0.40		0.10

Table 5. Parameters and its Inferences[1]

S.No	**Parameters**	**Type**	**Inference**
Environmental Attributes			
1.	Room temperature	Integer	Patient room temperature reading
Medical Record Past			
3.	Chronic Diseases	True/False	Whether patient is having any chronic disease
4.	Diabetes	True/False	Whether patient is suffering from diabetes
Health Parameters			
5.	Fever	Integer	Body temperature readings

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6.	Heart Rate	Integer	Beats per Minute
7.	ECG signals	Float	Articular /Ventricular Repolarization & Depolarization

Table 6. List of Parameters and Sensors used

S.NO	DataSet	Parameters	IoT Technology	Events
1.	Health related datasets(HRD)	Heart rate,body temperature,ecg	BPM sensor,body temperature sensor,Ecg sensor	High heart rate,high fever,high respiratory rate
2.	Environmental related datasets(ERD)	Air quality, temperature	Humidity sensor,temperature sensor	High room temperature,high humidity

Algorithm 1 Safe and unsafe classification

Step 1: Acquire the health parameters of the patient. (ECG, BPM, Temperature)

Step 2: Compare the acquired data with the predefined normal values.

Step 3: If there is any deviation from the normal range, mark as unsafe else mark as safe.

Fog Layer:

Fog Node is present in between edge node and cloud node it is a distribusted network environment. Fog computing[9] creates low latency connections between devices, off loads the cloud, It can also be used in scenarios where there are large no of edge nodes and the cloud alone cannot handle[2].

[9]Using Fog node in this work has several advantages includes dissemination of processing, increased speed, and good modularity, In this work separate controller for data acquisition and gate way is deployed

After classifying the event and alerting the responder, it is important to send only the required data to the cloud layer instead of transmitting all the values. This is done so as to decrease the bandwidth and also to increase the storage space in the cloud space. Therefore we use a data redundancy algorithm to reduce

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the number of data being sent to the IoT Server or cloud. This is where the primary prospect of the paper lies.

ALGORITHM 2 Event triggering algorithm / Decision making algorithm

Step 1 : Acquire the safe and unsafe data and calculate the Degree Of Impact (DOI).

Step 2 : If the Degree Of Impact is greater than the threshold, upload the values to the cloud.

Step 3 : Else, wait for the next set of parameters.

CLOUD LAYER:

Once the data had been marked as unsafe then it will be sent to the cloud , here in this work there is no computation at the cloud layer only it stores the data sent, and will be broadcasted to the end terminals or users, So many third party cloud services are in existence[10], once such cloud is used in this work as there is no computations at this level[2].

The Parameters that can be seen in the dashboards are Patient's Body temperature , Heart beat (Bpm)[6], ECG values inferences P,Q,R,S,T amplitudes and Two separate dashboards for no of data uploaded with and with out using the triggering model[10].

Experimental Setup and Analysis

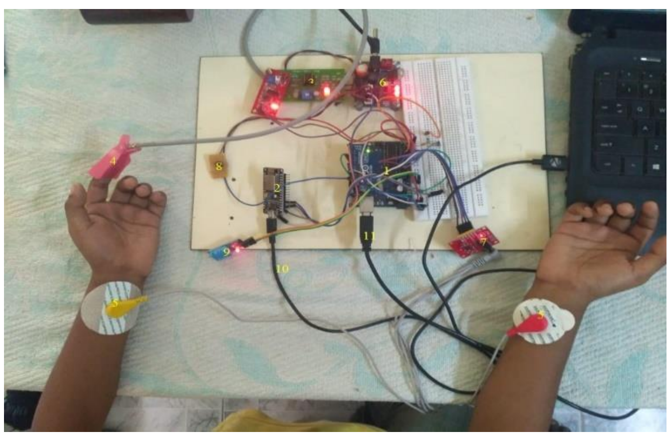

Fig 4 Experimental setup with labels

1. Edge Computational Unit
2. IoT gateway /Fog Node
3. Heart rate sensor module
4. Heart rate sensor
5. ECG Electrodes
6. Power supply unit
7. ECG Module
8. Body Temperature Sensor
9. Environmental Temperature Sensor
10. Serial cable/Programming line

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11. Serial cable/Programming line (ESP)

Hardware setup of the proposed work is spitted into 3 parts.

i) Sensor interfacing units.

ii) Fog Computing with gate way .s

iii) Cloud for storage and end terminals.

This work is meant for continuous remote monitoring of the data of several patients at the same time for that several edge nodes are needed , for simplicity only one node is deployed and but parameters are acquired from different patients

i) Sensor Interfacing Units

Body temperature Sensor, Heart beat rate [6], and ECG Sensors are used to acquire the parameters of the patient and add in addition Environmental Parameters are also acquired.

ii) Fog Computing with gateway

A wireless module incorporated controller with networking capability is uesd here as the fog node, it does the partial computing and upload the stream of dat a to the cloud ESP series controllers have been deployed for this purpise un this work

iii) Cloud for storage and end terminals.

Thing speak Iot cloud platform is used here to store all the important data from here the data is sent to the concern authorities for further attention.

ECG SENSOR OUTPUT

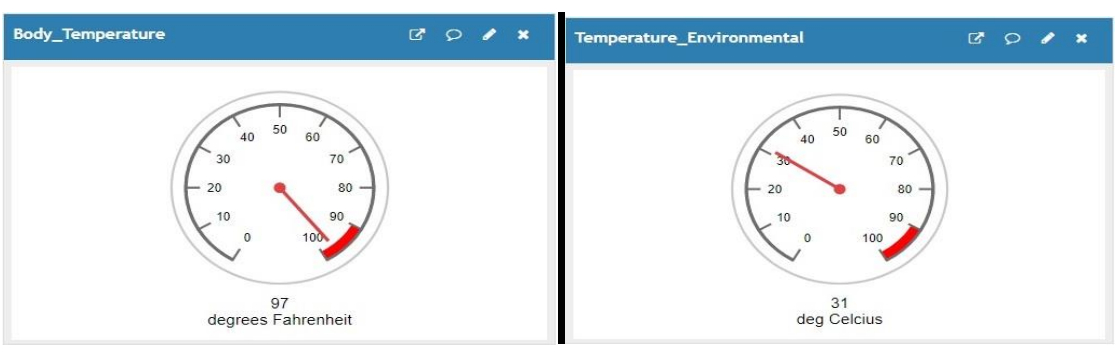

Fig 5 Body Temperature & Environmental Temperature Dashboard

Body temperature of the patient is indicated in Fahrenheit, Typical value of body temperature is 98.6◦F,Deviation is allowed in the ranges between 97◦F and 99◦F. Environmental Temperature has a very big impact on the health status of the patient, Separate dash board for the temperature is provided and it shows the temperature in degree Celsius.

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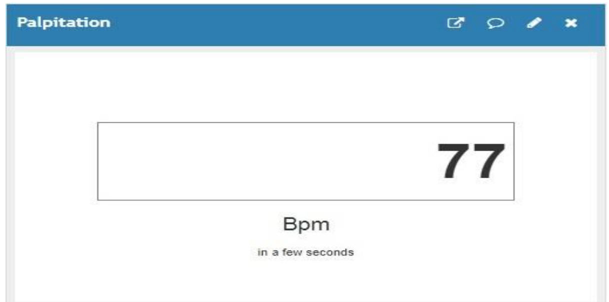

Fig 6 Palpitation rate Dash board

Palpitation and the low heart beat rate of the patient can be found out by the heart rate sensors and the same will be displayed in the separate dash board, Heart rate is subjective it depends up on the age group and also varies from athletes and normal person, although here we assume the normal range from 70 to 74 bpm.

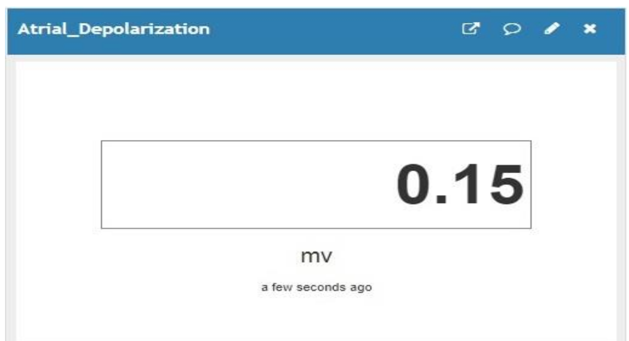

Figure 7 Atrial Depolarization Dashboard

Atrial Depolarization happens when the atria contract, the pressure within the chamber increases, this can be seen as the electrical activities through the ECG Sensors, the typical amplitude is 0.15 mV and allowable deviation is ±0.10 mV.

Figure 8 Ventricular Depolarization & Depolarization Dashboard

The dash board for ventricular depolarization and depolarization are depicted the typical amplitude when ventricular deploarization happens is 1.35mV and allowable deviation is ±0.30mV , Typical value for Ventricular repolarization is 0.35mV and permissible deviation is ±0.10 mV

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Fig 9 Un Redundant and Redundant count entry

To register the no of data uploaded two different dashboards are maintained, they are redundant count and un redundant count dashboards, events are said to be occurred when there is an unsafe data, consequently all the parameters will be uploaded at that moment that data will be counted under the un redundant field, whereas in redundant field all the data generated will be counted. With the help of this the performance (How much amount of data has been filtered out and memory consumption) of the system can be measured

IV. CONCLUSION

It is evident from the work that large amount of storage space can be reduced in the cloud, when unwanted , non-critical and redundant data are stopped from being uploaded to the cloud platform, health care is one of the important domain for IoT applications , in all the other domains also data reduction or redundancy removal can be done. It's necessary to process and filter the data before sending that to the cloud. Instead of simply setting the threshold limit for the parameters, By taking more inferences with the relative medical parameters further reductions are also possible.

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