NIBCAS – Cloud Supported Novel IoT Based Health CAre System

M.Rajakumar[1], Dr.S.Thavamani[2]
[1] Ph.D. Scholar, [2] Associate Professor, Department of Computer Science & Applications
Sri Ramakrishna College of Arts and Science, Coimbatore-641 006, Tamil Nadu.

Abstract: *Pervasive healthcare monitoring system Body Area Network generate a vast amount of data using wearable sensors that need to be stored and managed for processing and future usage. Cloud computing combined with the Internet of Things (IoT) isa novel approach for efficient managing and processing of sensor data online. This paper presents NIBCAS system based on Cloud Computing for management of mobile and wearable healthcare sensors, demonstrating the IoT paradigm applied on pervasive healthcare.*

Keywords: Internet of Things (IoT), Cloud Computing, Patient Monitoring, Wearable Sensors.

I. INTRODUCTION

The new era of the ubiquitous healthcare paradigm has enabled the self-support living of elderly people, persons with permanent disabilities, children suffered with autism disorder and even people with sudden illness. The patients living in remote, isolated locations or villages are not capable of meetings their physicians periodically. In this perspective, advanced technically enhanced healthcare services are need to be made available anytime, anywhere and to everyone through the existing cloud network. A medical assistive setup on the other hand has to utilize these pervasive system for delivering the required services and assistances. Now-a-days a number of portable sensor equipped devices are available that can automatically detect the condition of patients such as pulse rate, blood pressure, breath alcohol level, and so on and convey them to the doctor's smart assistant devices.

The implementation of health management system through portable devices faces several challenges. The challenges include storing of large amount of data, accessing or retrieving the data, maintenance, privacy and security, permission control, and availability of heterogeneous resources.

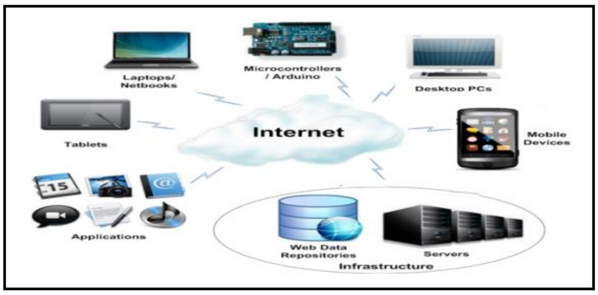

Fig 1. Cloud Computing Environment.

Most of these challenges can be easily conquered by cloud computing. Cloud computing paradigm offers the facility to access common infrastructure and shared resources in pervasive and transparent way, providing on demand services over the www and the capability of changing the functionality to meet the dynamic needs. Fig. 1 illustrates an example of cloud computing environment.In addition to the cloud computing, the advancement of Machine to Machine (M2M) communication enables the direct communication between the sensing devices and the Internet. This communication creates the new paradigm called the Internet of Things (IoT). The Internet Engineering Task Force (IETF) has created a new protocol called 6LoWPAN to enable the devices in IoT to use IPv6 for their communication. This makes the real time communication and computation process very simple and effective. IoT becomes an efficient infrastructure for health care monitoring systems with the help of sensor devices and the 6LoWPAN protocol [2], [3].

In this paper, we have proposed a cloud based system which manages various data collected from an IoT network. The IoT network referenced here uses different sensors, which are connected through a Body Area Network (BAN). In this system we have used several sensors in order to collect different data as mentioned in Table 1.

Sl. No.	Types of Sensors	Data collected
1	Wearable sensors fixed in cloths	Heart rate, pulse rate, ECG, Oxygen saturation and body Temperature
2	Accelerometers	Motion detection
3	Proximity Sensors	Location based information
4	Contextual Sensors	location, ambient temperature, activity status, etc.

Table 1. Types of Sensors and data collected.

The data can be forwarded to a smart phone and forwarded to the Cloud infrastructure using the existing network for IoT communication. The web based applications provide the necessary monitoring and management of the collected data. In this research work we proposed a prototype implementation, and the performance is evaluated using both wearable and mobile sensors that senses the patient data and forward them to the Cloud platform. The rest of the paper is organized as follows: Section 2 presentsthe literature survey; Section 3 discusses the context of Cloud computing and healthcare systems. In Section 4 we explain the proposed architecture and in Section 5 we present the performance evaluation ofthe system using mobile and wearable sensors. Finally, Section 6 concludes the paper.

II. LITERATURE REVIEW

There is a number of research works on pervasive healthcare systems. Most of the research work deal with management of data on the devices. Some of the works deal with the data management with intermediate nodes. Only a few works exist which illustrate the data storage and management in cloud environment.

In [1] Chen, Met al., proposed a Wearable 2.0 healthcare system to enhance the Quality of Experience (QoE) and the Quality of Service (QoS) of the next generation healthcare system. In the proposed system they have used the washable smart dresses, which are equipped with sensors, electrodes and wires, in order to collect the patients' body condition data and to receive the analysis results of the patients' health and psychological conditions provided by the cloud-based machine intelligence system.

In [4] Tong etal. proposed to build a mobile healthcare system with the help of the private cloud. They have proposed several features in this approach such as efficient key management, privacy preserving, data storage and retrieval at emergencies and auditability for mining the health data. It provides the encryption mechanism in order to encrypt the patients' health records and securely store in the third party server. Yuriyama M., Kushida T [5] proposed a cloud infrastructure with virtual sensor network. The proposed Sensor-Cloud infrastructure provides a platform with virtual sensors so that the users need not care about the real locations and the variations between multiple physical sensors. Pachube [6] is an on-line database service which enables developers to directly connect sensor data to theWeb. It is a real-time Cloud-based infrastructure platform, which supports the Internet of Things (IoT). Particularly it could be described as ascalable infrastructure that enables users to create IoT based products and services. Moreover this infrastructure is used to store and share real-timesensor and environment data from devices, objects & buildings around the world. The key features of this platform are: controlling and maintaining real time sensor and environment data, graphing, monitoring and controlling remote environments.

Furthermore there is unlimited number of interfaces available for building sensor or mobile-based applications for managing the data on the Cloud environment. Nimbits [7] is a Platform as a Service (PaaS) that we can use to develop software and hardware solutions that connect to the cloud and sensor data on the cloud.

It is a free, social and open source platform for the Internet of Things. It provides REST web services for logging and retrieving time and geo stamped data (such as a reading from a temperature sensor). Nimbits server runs on powerful cloud platforms like Google App Engine to the smallest Raspberry Pi device. Data points can be configured to carry out calculations, generate alerts, relay data to social networks and can be connected to SVG process control diagrams, spread sheets, web sites and more. Nimbits offers a data compression mechanism, an alert management mechanism, and data calculation on the received sensor data using simple mathematic formulas.

The iDigi system [8] is a machine-to-machine (M2M) platform-as-a-service. iDigi platform makes it easy to build scalable, secure economical solutions that can easily tie together with enterprise applications. Irrespective of the location of the sensor devices, iDigi platform manages the communication between the enterprise applications and remote sensor device networks. iDigiDia is the software included in the iDigi platform which is used to connect the devices which simplifies the connectivity and integration of the remote devices. It also helps in managing such as configure, upgrade, monitor, alarm, analyze of products including ZigBee nodes.

Another open source "Internet of Things" application and API is the ThingSpeak [9] which is used to store and retrieve data from things over the Internet via HTTP or via a Local Area Network. User of ThingSpeak, can create sensor-logging applications, location-tracking applications, and a social network of things with status updates. The ThingSpeak API allows numeric data processing such astime scaling, averaging, median, summing, and rounding in addition to storing and retrieving numeric and alphanumeric data.

In the research work [10] Richard J. Schuman defines "Health care computer system" which defines the hospital network in which communication is provided over a packet based communication network. Kanagaraj, G.Sumathi, A.C proposed an open-source Cloud computing system for exchanging medical images of a Hospital Information System [11] which can provide the essential details to the health care system in the cloud based platform. In [12] A.Tejaswi etal. proposed the "Efficient Use of Cloud Computing in Medical Science" which explored the redesign of medical system with the advent of cloud computing.

The presented approach is used to carry out the information of the patient details in sophisticated manner with less cost and minimum time. In [13] K.S. Aswathy, G. Venifa Mini presented an approach for personal health records, which uses the cloud storage for storing and exchanging patient health record between multiple caregivers.

Kavitha, Retal. [14] proposed an approach itstores all the history of the patient electronically with unique id. It enables the patient to avail the treatment wherever during a medical expert refers another medical expert. It also helps in another important thing that the medical tests once conducted need not be repeated again and again which is happening in the traditional system. This benefits the patients in reducing the treatment cost, standardized treatment procedure, diagnosis of the disease and maintains the history of the patient throughout the life time. V.Ramya, Dr.S.Thavamani [23] conducted an Extensive Study on the Secure Data Sharing Scheme for Electronics Health Care Record based time enabled Delegation mechanism is presented and it is analyzed against the guessing attack, keyword attack and cipher text attack. Hybrid constraint based re encryption (HCRE), multiple constraint such as user category, time and Specific intension of the user are taken as a key to re encrypt the data from security violation in order to impose the delegation rights to the data user. The HCRE can improve the performance in terms of security and computation cost.

III. PROPOSED SYSTEM

In this section we present the proposed system architecture, the hardware and software modules needed to implement and deploy the ubiquitous monitoring infrastructure of the IoT-Cloud based health monitoring system. We also exhibit the implementation of an initial prototype that demonstrates the functionality of the system.

A. Proposed System Architecture

This section explains the proposed NIBCAS – Cloud Supported Novel IoT Based Health CAre System architecture for gathering and managing sensor data on the Cloud platform.

The proposed architecture is depicted in Figure 2 which contains the following key components:

- The wearable sensors and mobile devices that acquire signals from the body of the patient and also motion and contextual information.

- The sensor gateway that gathers all the signals from various sensors and forwards them to the Internet. The gateway can be built using a smart phone or a microcontroller connected with the Internet.
- A web based application which manages which provides visualized report of the sensor data and important contextual information about the patient which includes the location, activity status, etc.

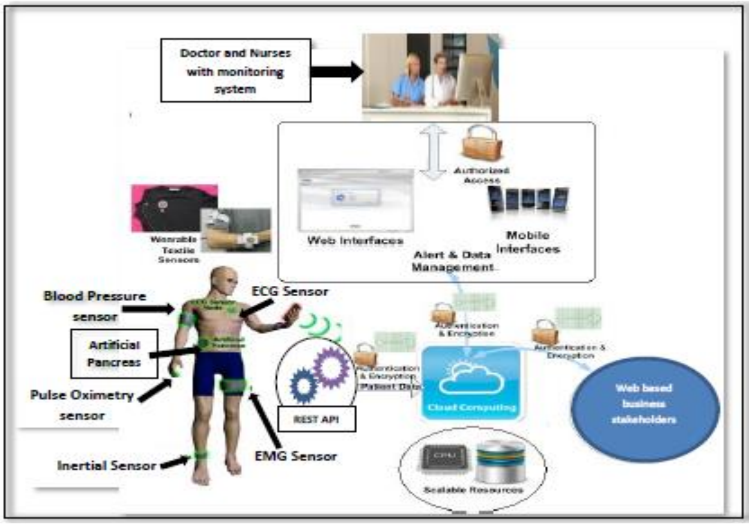

Fig 2. Proposed NIBCAS Architecture.

- The Application Programming Interfaces (APIs) provided by the cloud platform. These are lightweight interfaces which can be used by the sensor gateways for sending sensor data and retrieving information. The APIs can also be used by the external applications for data processing, alert management, billing, etc.
- The Cloud infrastructure which hosts the interfaces and the managing application. It provides the essential resources as PaaS services. This infrastructure includes CPU, storage and application servers for installing the web application and the interfaces.

The communication between the Cloud infrastructure and the other components is secure by applying suitable authentication and data encryption mechanisms. Sensors are given unique ID to identify and authenticate and symmetric encryption technique is used to secure the data [15]. Users and external entities are authenticated by using PKIand digital signatures [16].

The proposed architecture has many features like scalability, interoperability and light-weight access. It isscalable since it is working with Cloud infrastructure which provides resources dynamically based on usage and requirement.

The inter-operability with external applications can be provided by the web services based interfaces. The Representational State Transfer (REST) API is very light-weight and can be easily accessed and implemented by wireless sensor and mobile platforms. REST has also been proposed as a communication mechanism for IoT applications [17] [18] and is the basic interfacing technology behind established IoT platforms like Pachube, Nimbits and ThingSpeak.

B. Implementation

In order to evaluate the performance of the proposed architecture we have implemented a simple real time tele-monitoring system. The developed system consists of two main parts: (i) The IoT system consists of sensors and network interface that collect and transmit signals like temperature, motion and heartbeat data and (ii) Thecloud infrastructure for storing and monitoring the data.

The IoT system consists of two types of signal acquisition part: wearable and mobile. For the wearable sensors we have used textile accelerometers, temperature sensor and heartbeat chest strap by Polar [19]. The mobile sensors are connected to a textile version of the Arduino open hardware micro-controller platform [20] called LilyPad [21].

The Cloud infrastructure is built with a Java EE application which provides both the interface with IoT network and management graphical interface. The Jelastic platform has been selected as for creating cloud infrastructure. The Jelastic [22] is a PaaS Cloud provider that allows users to deploy Java-based applications providing all the essential components such as databases, application server instances, load balancers, etc. Jelastic provides encryption and authentication libraries by full access to theapplication server runtime environment.

We have designed several algorithms for diagnosing the disease in a patient. The algorithms are listed below. Algorithm 1(TT) is used to find out the temperature level of the patient, algorithm 2 (HBT) is used to check the heart beat and algorithm 3 (DD) is to diagnose the diseases based on the reading gathered by the IoT Sensors.

Algorithm 1 // Temp_Test (TT)

```
{
  Start
  Check User Id and PWD;
  Read temp;
  If temp = 98.4 then
          TmpResult = Normal
  Else if temp > 99 then
          TmpResult = Abnormal
  Else if temp < 98 then
          TmpResult = Subnormal
  End if
  Return TmpResult
Stop
}
```

Algorithm 2 // Heart_Beat_Test (HBT)

```
{
  Start
  Check User Id and PWD;
  Read syst;  //Systolic
  Read dias; //Diastolic
  If syst = 120 and dias = 80 then
          HBResult = Normal
  Else if syst between 130 to 140 or dias
between 80 to 90 then
          HBResult = "HP1" // High Pressure Stage 1
  Else if syst> 140 or dias> 90 then
          HBResult = "HP2" // High Pressure Stage 2
  Else if syst< 80 and dias< 60 then
          HBResult = "LP" // Low Pressure
  End if
Return HBResult
Stop
}
```

IV. EXPERIMENTAL SETUP

This section describes the performance analysis of the proposed NIBCAS system. The experiment setup is created in Contiki OS with the network simulator cooja. Contiki is an Open Source Operating System, which can be used to connect tiny, inexpensive, light weight microcontrollers to the Internet. For the simulation purpose, we used the emulated Tmote Sky nodes. The configuration setup is given in table 2.

Sl. No.	Contiki Layer Configuration	Protocol / Interface
1	Radio Interface	CC2420
2	Radio Duty Cycling (RDC)	ContikiMAC
3	MAC	CSMA
4	Network	IPv6
5	Routing	RPL
6	Transport	UDP
7	Physical	IEEE 802.15.4

Table 2. Contiki experimental setup.

Algorithm 3 // Diagnosis_Diseases (DD)

```
{
Start
Check User Id and PWD;
Read BMI
Read TMPResult
Read HBResult
If TMPResult = "Normal" and HBResult = "Normal" and BMI between 19 and 25
Then DiagResult = "Good Condition"
If TMPResult = "Abnormal" and HBResult = "HP1" and BMI between 25 and 30
Then DiagResult = "Hyperthermia"
If TMPResult = "Normal" and HBResult = "LP" and BMI < 17
Then DiagResult = "Weekness"
If TMPResult = "Normal" and HBResult = "HP1" and BMI > 25
Then DiagResult = "Diabetes"
Return DiagResult
Stop
}
```

IV. PERFORMANCE EVALUATION

The performance of the proposed system is analyzed on the existing methods. In the traditional method every patient is given an ID respect to the hospital and varies for every hospital. The patient needs to carry his / her reports whenever they need diagnosis if doctor needs. So it is difficult to access the details of the clinical data in the emergency situations since the patient details are not available globally.

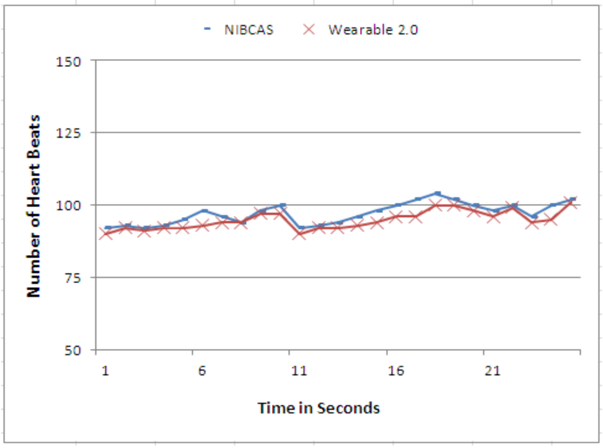

Fig 3. Patient Heartbeat data.

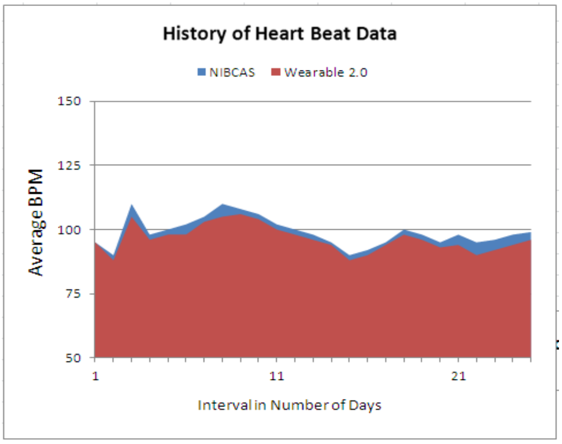

Fig 4. History of Patient heartbeat data.

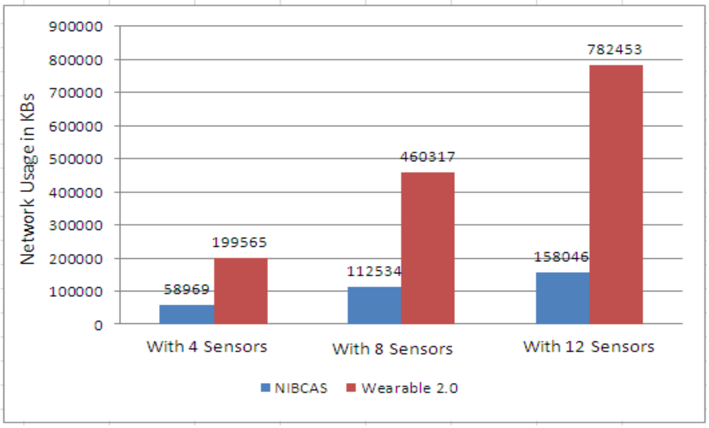

Fig 5.Comparing the network usage between NIBCAS and Wearable 2.0.

In this research work it we have developed a system which collects the data and stores in the cloud platform through the Internet. So that he/she will be able to undergo the treatment whenever required and during a doctor expert refers to another doctor. The performance results are shown in the figures fig 3, 4 and 5. Fig. 3 shows the heart beat rate of the patient during particular time duration. The accuracy of the result in NIBCAS is better than that of the existing wearable 2.0. Fig.4 depicts the average Beats per Minute (BPM) for 25 days. We can observe that our proposed system provides the more accurate result while comparing the result of the existing system. Fig. 5 shows the comparison of the existing wearable 2.0 with the proposed NIBCAS in terms of network usage. A drop packet rate of 20-30% has been detected during the initial experimentation. This is either due to the limited resources of Arduino for high rate sampling of sensors and transmitting the data at the same time, or due to the network congestion.

V. CONCLUSION

In this paper, we have reviewed the current state and projected future directions for integration of remote health monitoring technologies into the clinical practice of medicine. Wearable sensors, particularly those equipped with IoT intelligence, Pervasive healthcare applications generate a large amount of sensor data that need to be managed properly for further analysis and processing. Cloud computing through its elasticity and facility to access shared resources and common infrastructure in a ubiquitous and pervasive manner is a promising solution for efficient management of ubiquitous healthcare data. Cloud based health care system enables the experienced doctors to better diagnose the patients. Cloud computing solution offers major practical advantages such as reduced construction, maintenance and up gradation cost. The security risk can be removed by deploying hybrid cloud model.

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AUTHORS:

M. Rajakumar, MCA., M.Phil., M.Teh. and a Ph.D. (PT) Scholar under the supervision of Dr.S.Thavamani, M.Sc., M.Phil., Ph.D., Associate Professor, Department of Computer Applications, Sri Ramakrishna College of Arts and Science [Autonomous] (Formerly SNR Sons College), Coimbatore, Tamil Nadu, India. He has published 5-research papers in International Journals and presented 2-papers in National Conferences. He has 14+ years of Teaching experience in various Institutions (Arts and Engineering) in India and Abroad. Presently serving as a Head, Department of Computer Applications, Srinivasan College of Arts and Science, Perambalur, Tamil Nadu. And he is a Life member of ISTE professional body. His specialization areas are: Cloud Computing, Distributed Computing, Computer Networks.

Dr. S.Thavamani, M.Sc., M.Phil., Ph.D., Associate Professor in Department of Computer Applications, Sri Ramakrishna College of Arts and Science [Autonomous], Coimbatore, Tamil Nadu, India. She has completed Ph.D. degree in SNR Sons College under Bharathiar University, Coimbatore. She has 19 years of Teaching experience in the field of Computer Science. Her area of specialization is Distributed Computing, P2P Networks. She has published 12 research papers in various International Journals and presented more than 20 papers in various National and International Conferences. Also she has *Authored two books* (Introduction to Data Structures and Introduction to Assembly of Computer Architecture). She Organized Various National Workshops and Seminars. She Received *"THE BEST PAPER AWARD",* for her research paper and *"BEST FACULTY AWARD"* in the Year 2017. She is a Research Supervisor for M.Phil. and Ph.D. of various Universities in India.