J.Thirunavukkarasu, Dr.N.Kumaratharan / IOSR Journal of Engineering (IOSRJEN)
www.iosrjen.org ISSN : 2250-3021
Vol. 2 Issue 2, Feb.2012, pp.247-252

Sensors Enabled Patient Monitoring System Using Cloud Computing Concepts

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***Abstract*- This paper presents an integrated framework consists of sensor nodes which are used to monitor human health and activities using cloud computing technology. Sensors such as gyroscope and accelerometer are used to sense the activities of the patient. Human activities are monitored using sensors and these sensed data are uploaded to the cloud. The sensed data are then accessed by doctors, care-takers, clinics and pharmacies to provide an emergency aid.**

I. INTRODUCTION

Cloud computing is an internet-based computing, whereby shared resources, software and information are provided to computers and other devices on demand, like the electricity grid. Cloud computing is a paradigm shift following the shift from the mainframe to client-server in the early 1980s. Sensors enabled patient monitoring [1] system using cloud computing concepts monitor human health and provide life care services. Wireless Sensor Networks (WSNs) are deployed in home environments for monitoring and collecting raw data. The software architecture is built to gain data efficiently and precisely. Sensed data is uploaded to cloud using a fast and scalable mechanism. In the cloud, this sensed data is either health data or can be used to detect human activities. For human activity recognition embodied sensor-based and video-based activity recognition are used. To access data on the cloud, the user must authenticate and granted access permissions. In sensor-based approach, a gyroscope and accelerometer sensors are attached to the human body. By using gyroscope and accelerometer data, an activity is predicted based on semi markov conditional random fields. Detected activities could be simple (e.g. sitting, standing, and falling down) or more complicated (e.g. eating, reading, brushing teeth and exercising). In the video-based activity recognition approach, activities are detected by collecting images from cameras, extracting the background to get body shapes and comparing to predefined patents. It can detect basic activities like walking, seating, and falling down. Ontology engine is designed to deduce high-level activities and make decisions [2] according to user profile and performed activities. A voice enhanced service using voice over internet protocol (VoIP) is provided in order to communicate with the patients to, better diagnose their problems and to provide better aid. Once the data from sensor nodes are collected they are then uploaded to the cloud gateway, the gateway classifies data into health data, gyroscope and accelerometer data, and imaging data and finally store in a local database. The filtering module filters redundant and noise data to reduce communication overhead before sending to the cloud. The filtered data is also updated to the local database. Activity [3] and context are forwarded to the ontology engine for representation and inference higher level activities and context. To access data on the cloud, the user must authenticate and granted access permissions. An image-based authentication and activity-based access control are proposed to enhance security and flexibility of user's access.

II. RELATED WORK

Cloud computing [4] is a general term for anything that involves delivering hosted services over the internet. These services are broadly divided into three categories: software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS). The name cloud computing was inspired by the cloud symbol that's often used to represent the internet in flow charts and diagrams. A cloud service has three distinct characteristics that differentiate it from traditional hosting. It is sold on demand, typically by the minute or the hour; it is elastic -- a user can have as much or as little of a service as they want at any given time; and the service is fully managed by the provider. Significant innovations in virtualization and distributed computing, as well as improved access to high- speed internet and a weak economy, have accelerated interest in cloud computing. A cloud can be private or public. A public cloud sells services to anyone on the Internet (currently, amazon web services is the largest public cloud provider). A private cloud is a proprietary network or a data center that supplies hosted services to a limited number of people. When a service provider uses public cloud resources to create their private cloud, the result is called a virtual private cloud. Private or public, the goal of cloud computing is to provide easy, scalable access to computing resources and IT services. Cloud application services or "SaaS" delivers software as a service over the internet, eliminating the need to install and run the application on the customer's own computers and simplifying maintenance and support. Key characteristics include: n/w- based access to maintenance and support. Key characteristics include: network- based access to and

management of, commercially available software activities that are managed from central locations rather than at each customer's site, enabling customers to access applications remotely via the web application delivery that typically is closer to a one-to-many model (single instance, multi-tenant architecture) than to a one-to-one model, including architecture, pricing, partnering and management characteristics centralized feature updating, which obviates the need for downloadable patches and upgrades. Cloud platform services or "PaaS" delivers a computing platform and/or solution stack as a service, often consuming cloud infrastructure and sustaining cloud applications. It facilitates deployment of applications without the cost and complexity of buying and managing the underlying hardware and software layers. Sensors enabled patient monitoring system using cloud computing concepts monitors human health, activities [5] and shares information among doctors, care-takers, clinics, and pharmacies in the cloud and it incorporates various technologies with novel ideas including; sensor networks, cloud computing and activity recognition. Existing patient monitoring system monitors, [6] human health using sensors such as gyroscope and accelerometer. The collected data by the sensor nodes are uploaded to the cloud. The data in the cloud are then accessed by doctors, nurses, care-takers and also by other hospitals, by this way patients can have better care at low cost. In the existing system no voice enhanced services were used to know the health condition of the patients, so the doctors were not able to provide an immediate aid to the patients.

In this paper, EyeOS- an open source web desktop tool that acts as the cloud where all the sensor data are stored, rather than storing it in the local machine. The process of uploading the sensor data to the cloud is done through SaaS, a service provided by cloud to reduce the complexity of storing data in the local machine. All human activity data captured from sensors and cameras are transmitted to the cloud Gateway. The gateway classifies data into health data, gyroscope and accelerometer data and imaging data, and stores in a database. The filtering module filters the redundant and noise data to reduce communication overhead before sending to the cloud. The filtered data are then updated to the cloud database. The data in the cloud are then accessed by doctors, nurses, care-takers and also by other hospitals, by this way patients can have better care at low cost. In the existing system no voice enhanced services were used to know the health condition of the patients, so the doctors were not able to provide immediate aid to the patients.

III. PROPOSED ARCHITECTURE DESIGN

In the proposed patient monitoring system a voice enhanced service [7] is used to provide better aid to the patients. Fig. 1 shows the architecture of the proposed system, this service is provided using a protocol called VoIP. This helps the doctors to communicate with the patients to better diagnose their problems. The different modules of the proposed system are addressed in the following sub topics.

A. Cloud architecture

Cloud computing has computational and sociological implications. In computational terms cloud computing is described as a subset of grid computing concerned with the use of special shared computing [8] resources. For this reason it is described as a hybrid model exploiting computer networks resources, chiefly internet, enhancing the features of the client/server scheme. From a sociological standpoint on the other hand, by delocalizing hardware and software resources cloud computing changes the way the user works as he/she has to interact with the "clouds" on-line, instead of in the traditional stand-alone mode.

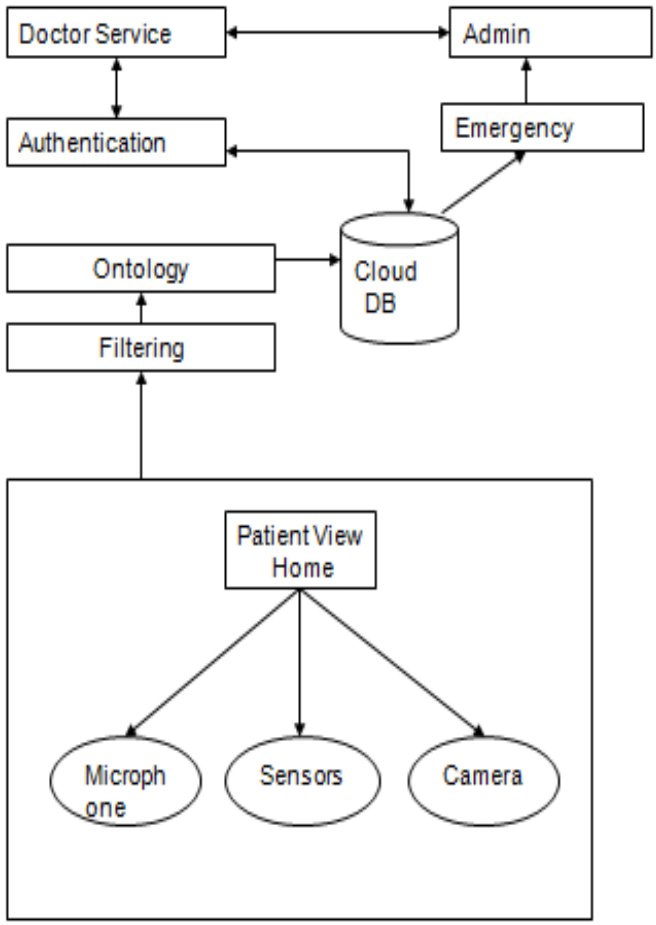

Fig. 1. Architecture diagram

B. Activity recognition

All human activity data is captured from sensors and cameras, then being transmitted to the cloud gateway. The gateway classifies data into health data, gyroscope and accelerometer data and imaging data, and store in a local database. The filtering module filtered redundant and noise data to reduce communication overhead before sending to the

cloud. The filtered data is also updated to the local database. Query requested from a service/application, the query/response manager fetches data from the local database and sends it to the requester. Data is transmitted to the cloud so that the activity recognition engine in the cloud can infer user activities. Activity and context are forwarded to the ontology engine for representation and inference higher level activities and context.

C. Service authentication

To access data on the cloud [9], the user must authenticate and granted access permissions. When doctors, nurses want to access data, they must authenticate themselves first. After successful authentication, the access control module makes decision whether his/her access permission is allowed or not. If yes, it allows him/her to access to the cloud data. Data is forwarded to authentic nurses and doctors.

IV. METHODOLOGY

Sensors enabled patient monitoring system using cloud computing monitors human health activities and shares information among doctor's care- givers, clinics and pharmacies in the cloud and it incorporates various technologies with novel ideas including sensor networks, cloud computing security, and activities recognition. WSNs have been employed to monitor human health and provide life care services. WSNs are deployed in home environments for monitoring and collecting raw data. Sensed data is uploaded to cloud using a fast and scalable sensor data dissemination mechanism. In the cloud, this sensed data is either health data or can be used to detect human activities. For human activity recognition, two novel approaches such as embodied sensor-based and video-based activity recognition are used. To access data on the cloud, the user must authenticate and granted access permissions.

Cloud Architectures [10] are designs of software applications that use Internet-accessible on-demand services. Applications built on cloud architectures are such that the underlying computing infrastructure is used only when it is needed, draw the necessary resources on-demand, perform a specific job, then relinquish the unneeded resources and often dispose them after the job is done. In patient monitoring system using cloud, EyeOS designed cloud [11] is used to integrate and store data from various sensors. EyeOS desktop serves as the central server from where the data are accessed by doctors and patients. EyeOS is an open source PHP based application that runs in Apache. It is a web based workload that allows you to manage your documents and files from anywhere an internet connection is available. The goal is to simulate as many virtual workstations as possible. Human activity data is captured from sensors and cameras, then being transmitted to the cloud gateway. The gateway classifies data into health data, gyroscope and accelerometer data and imaging data, and store in a local database. The filtering module filters redundant noise data to reduce communication overhead before sending to the cloud. The filtered data is also updated to the local database. If there is a query requested from a service/application; the query/response manager fetches data from the local database and sends it to the requester. Data is transmitted to the cloud so that the activity recognition engine in the cloud [12] can infer user activities. Ontology engine is used to make decision to respond to different Situations. Ontology is generally an iterative process and provides the representation and inference of the higher level activities and context.

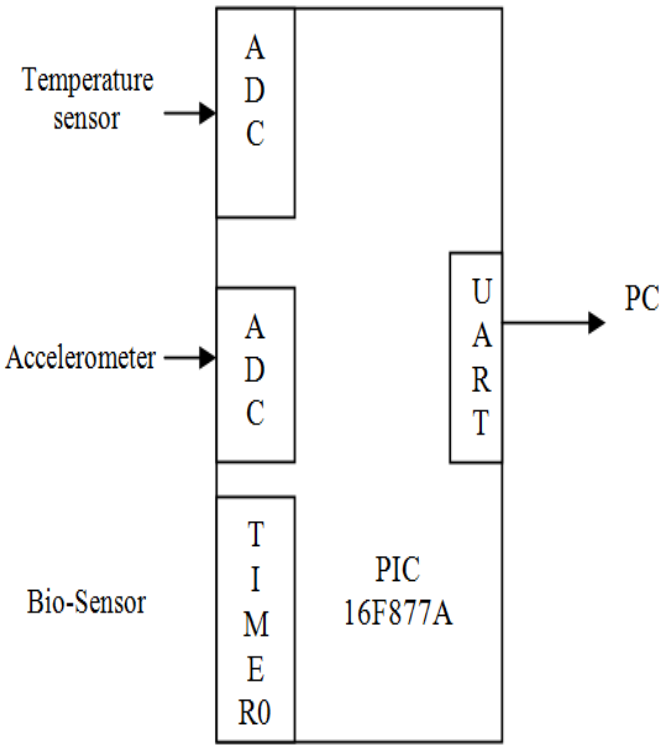

Fig. 2. Peripheral Interface Controller

Peripheral interface controller (PIC) 16F877A is used as the sensor board to which sensors such as temperature sensor LM35, accelerometer sensor ADXL 335, bio-sensors LM358 and 74LS14 are connected. Figure.2 shows the microprocessor kit used in the proposed system. The output from the temperature and accelerometer sensors are given to an analog to digital converter to obtain the digital output, then the output from bio-sensors is given to a TIMER0 interrupt to show and monitor the pulse rate of the patients. The output of these entire sensor devices are then given to a universal asynchronous receiver transmitter (UART), then the final output from the interface controller is given to the computer through RS232 cable, these data are then uploaded to the cloud database. To access data on the cloud, the user must authenticate and grant access permissions. An image-based authentication and activity- based access control are used to enhance security and flexibility of user's access.

V. SYSTEM IMPLEMENTATION

The various modules of the system have been implemented. The implementation results are discussed in the following sub topics.

A. Administrator login

Fig. 3 shows the administrator login page. In order to provide access to the cloud the administrator must login to the cloud and only the administrator must login to the cloud and only the administrator can grant access to the doctor/ patient to register in the cloud and to access the data on the cloud. Cloud administrator provides a dedicated link between the doctor and the patients in case of emergency.

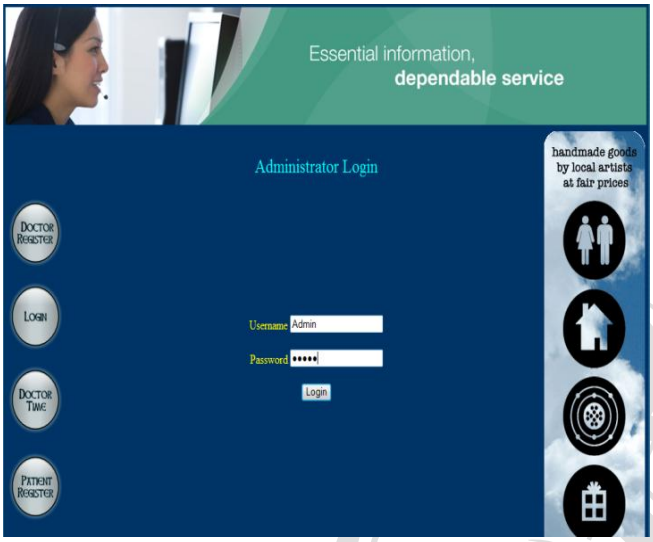

Fig. 3. Administrator login page

B. Doctor/patient registration page

Fig. 4 shows the registration of doctors and patients with all their detailed information. Each successful entry is updated to the database, after successful registration the doctors and patients are assigned a unique identification code based on which the doctors are assigned to monitor the condition of patients, once the doctor is assigned to a specific patient. The following doctor/patient registration page has been implemented using java and jsp. This registration page helps the doctor and patient to communicate with them. Hence the doctors can easily able to better diagnose their problems of patients. The docor registration page contains the specialist id to which he/ she is specialist to it. For example, if the doctor is an eye specialist, he/ she will give treatment for the patient who is suffering from eye problems.

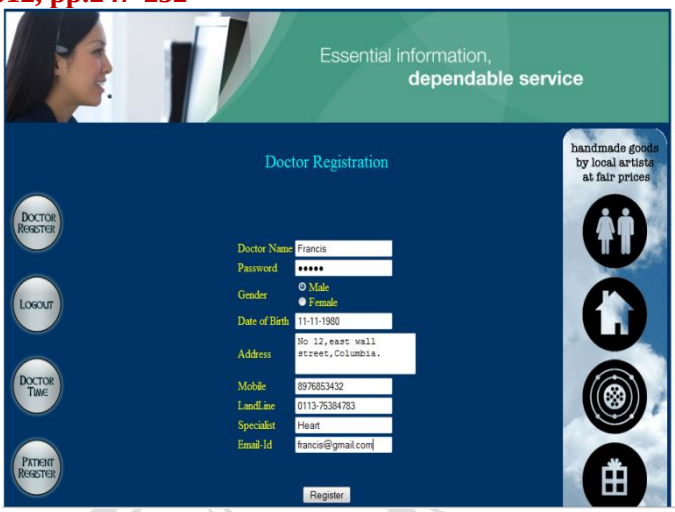

Fig. 4. Doctor/ patient registration page

C. Doctor time management

In the doctor time management, the doctors are allotted specific shifts such as first, second and night. This shift is assigned by assigning the doctor id with the patient id. Fig. 5 shows the doctor timing management process.

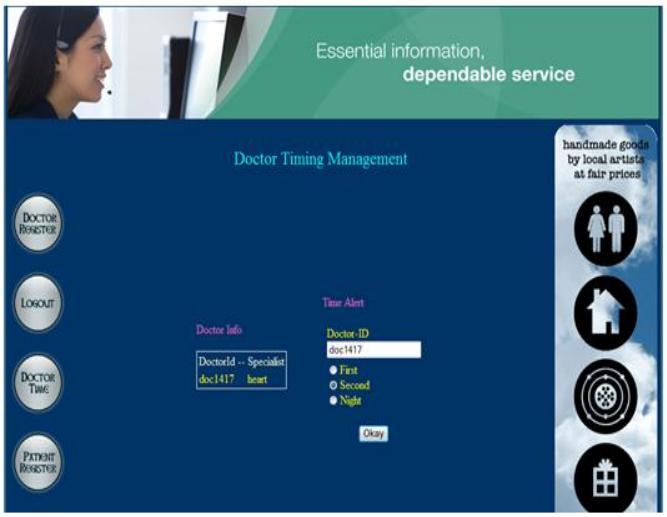

Fig. 5. Doctor time management

D. EyeOS cloud

In order to run EyeOS in a local machine a server called XamPP server is installed in the system and the EyeOS files are copied to the server. To open the EyeOS cloud operating system we should type the following address in the web browser http://localhost/eyeOS/index.php and the below page will be displayed. Fig.6, Fig.7 shows the EyeOS cloud implementation.

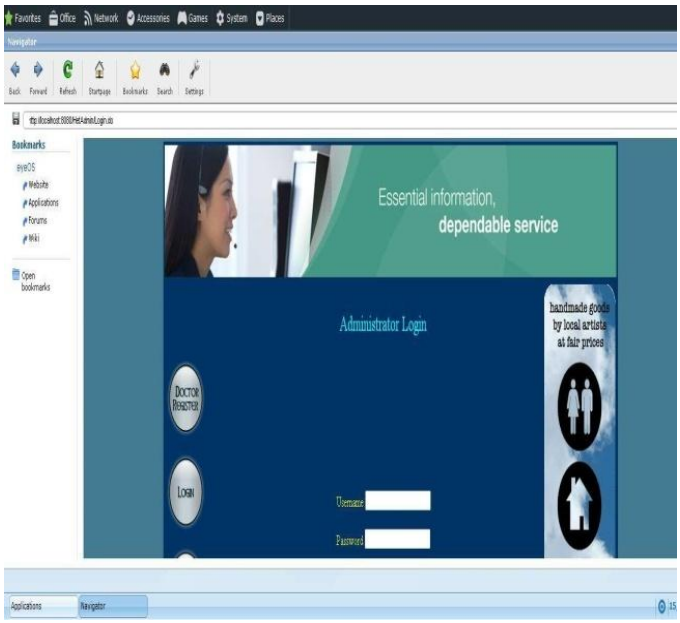

Fig. 6. Xampp server home page

EyeOS, an open source web desktop tool that acts as the cloud where all the sensor data are stored, rather than storing it in the local machine.

Fig. 7. EyeOS cloud screen

E. Sharing data's in the cloud.

By using software as a service a suitable interface to the cloud is developed through which the doctor and patients can access the cloud and all the sensor data are uploaded directly to the cloud thereby reducing the complexity of storing them in their local system. Fig. 8 and Fig. 9 show the EyeOS cloud access.

Fig. 8. Cloud EyeOS

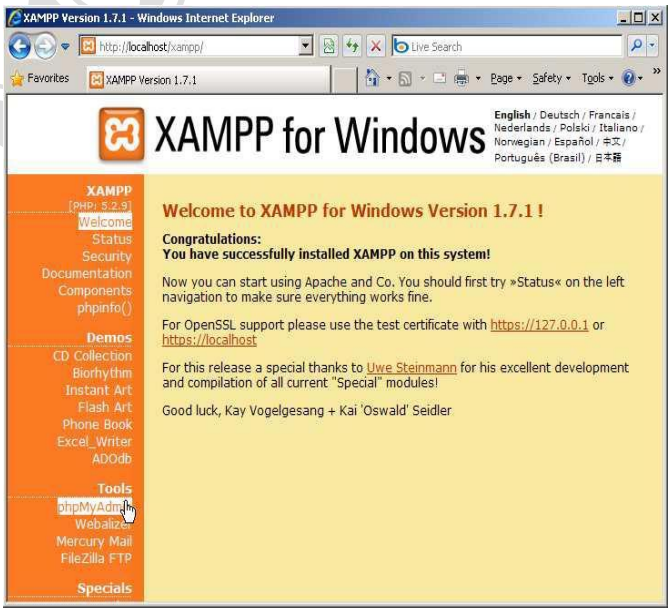

Fig. 9. Accessing data in the cloud

VI. EVALUATION RESULT

Table 1 shows the comparison of the proposed patient monitoring system with the existing system. The proposed system has several advantages when compared to the existing system as shown below.

S. NO	FEATURES	EXISITING SYSTEM	PROPOSED SYSTEM
1.	GYROSCOPE	YES	YES
2.	ACCELEROMETER	YES	YES
3.	FILTERING MODULE	YES	YES
4.	VOIP	NO	YES
5.	TEMPERATURE SENSOR	NO	YES
6.	EYEOS CLOUD	NO	YES
7.	PIC16F877A KIT	NO	YES

Table 1. Evaluation result

VII. ADVANTAGES OF THE SYSTEM

Sensors enabled patient monitoring system using cloud computing has the following advantages compared to the existing system, such as the use of *VoIP* through which the patients can communicate with the doctor in case of emergency, this helps the doctor to better diagnose the health condition of the patients. A temperature sensor is fixed in patient living room to monitor the room temperature of the room and an alarm is raised when the temperature exceeds or drops low than the normal room temperature. The use of EyeOS cloud environment enables efficient access to the cloud and managing the patient health data is effective compared to the existing system, this provides easy access to the cloud from anywhere in the globe. Proposed system uses 16F877A KIT through which various sensor devices are connected; this reduces the complexity [14] for the patient to go to the hospital to check their heart beat rate and health condition.

VIII. CONCLUSION AND FUTURE WORK

Sensors enabled patient monitoring system using cloud computing monitor human health [15] and share this information among doctors, care-takers, clinics, and pharmacies from the Cloud to provide low-cost and high-quality care to users. WSNs are deployed in home environments for monitoring and collecting raw data. The proposed work is focused on providing a voice enhanced service using *VoIP* to provide immediate aid to the patient and it improves the performance of existing system which uses bio-sensors and cloud architecture alone. Future enhancements such as latest sensor devices and several other sensor devices can be deployed using a much more efficient microprocessor kit, and cloud security can be increased consistently.

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