Remote Health Monitoring through an Integration of Wireless Sensor Networks, Mobile Phones & Cloud Computing Technologies

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Abstract—Wireless sensor networks have several applications of direct and indirect benefit to humanity. These applications can be further enhanced by integrating local wireless sensor networks, internet and cloud technology for storing sensors' data. Our proposed application is based on the same concept. The existing processes of collection and analysis of patients' information requires a lot of effort and additionally they are prone to errors and unnecessary delays in real time information accessibility. These issues limit monitoring and diagnostic capabilities to clinics and hospital only. Wireless sensors provide the capability of information exchange among interconnected on-hand health monitoring equipments. The introduction of this concept is based on wireless sensor networks and utility computing. The information can be stored on "cloud" which will be accessible to medical staff. The proof-of-concept aim is to integrate commodity computing to predecessor medical devices, which should ensure simple integration and cost effectiveness into introduction of a system for health monitoring in remote areas for the best benefit of humanity.

Keywords- Cloud computing, Cloud educational operating System, Computing Model, remote health monitoring.

I. INTRODUCTION

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Wireless Sensor Network (WSN) consists of distributed nodes with the capability of sensing, computing and wireless communications. The nodes are connected in ad-hoc fashion, operating independently of each other. There are various factors associated with the performance of WSN such as power management, data dissemination and routing of information. A lot of work is undergoing in these areas where energy awareness of essential design; routing and data dissemination is application dependent. WSN architecture could be either centralized or distributed. Centralized architecture is prone to the collapse of the whole system if the central node fails. However, distributed architecture provides failure resistant sensor network [1].

Cloud computing offers the ascendable processing power and a variety of connectable services and/or devices. Cloud computing and wireless sensor networks share many common characteristics and are very much compatible with each other. Wireless sensor networks are composed of numerous nodes that are less expensive, have lesser processing burdens and lower battery power consumptions since the number of operational nodes depends upon the rout of connectivity. On the other hand cloud computing has abundant of processing and the power is not an issue either, and is therefore well suited for long-term interpretations and analysis. Large amount of data, which a sensor network delivers, demands a powerful, scalable storage and processing infrastructure. The current manual system of data collection, distribution and processing of the patient information is slow and requires more effort and human resources involvement. The proposed system automates the process of collection, processing and distribution of patients' information with an additional capability of remote access. The patients' data is collected through sensor nodes of the WSN from legacy medical devices. This data is stored, processed and encoded at cloud and then distributed through communication channels. This data can also be stored for further use and analysis. An intermediate way can be used which may involve both remote and local capabilities, known as exchange service. The exchange service can collect data from network nodes and pass it on to suitable storage services on cloud. The amalgamation of cloud computing with wireless sensor networks [1] provides the following benefits:

- Integrate sensor network platforms from different vendors.
- Scalability of data storage and processing power for various kind of analysis.
- Worldwide Web Based access to processing and storage infrastructure.
- Well Resource Optimization.

Tiny DB [2] provides the services of data aggregations in limited power and in wireless scattered environment. All sensor nodes have Tiny DB and run over TinyOS operation system [3], Tiny DB have very simple GUI along with java API for queries declaration and execution in acquisitioned query language identical to SQL. Tiny DB is very easy to use and utilize available processing resources efficiently. SPINE [4] is a TinyOS software used for body sensor signal processing

applications. It consists of signal processing components for nodes running TinyOS [2], environment along java module for the management of nodes from central node. Such kind of framework provides sensor data classified services which operates in scattered mode on individual nodes and base station. This approach does not consider aspects like scalability and data security.

II. WSN IN T-MEDICATION

In traditional health systems, data is taken manually and records are updated in a database with unique IDs for each patient. Figure-1 depicts the traditional manual process adapted in hospitals or healthcare centers [5].
Steps involved are:

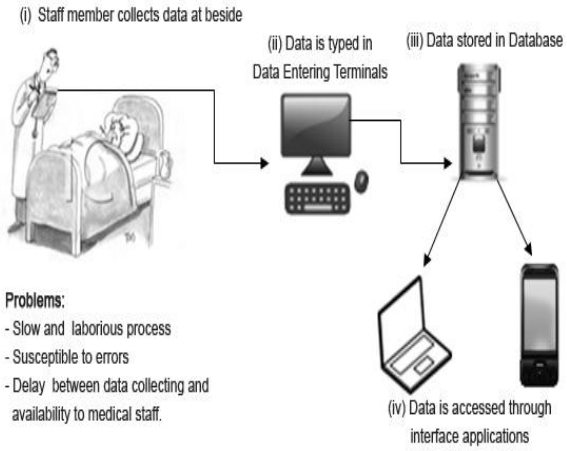

Figure 1: Current Scenario for Patient's Data

- Nurse notes down the patient's data on a piece of paper purely manual
- This manual data is fed into terminals
- This data is stored into a database server (centralized)
- Data is available in a shared view across the network to all the intended audience (medical staff)

III. EXISTING WORK

Initiatives have been taken in the integrated services of WSN and cloud computing. But this work is only in initial stages and facing challenges of the real world. We have studied the existing models and work to conclude some real tough challenges for in area of Wireless sensors networks. WSNs have been deployed in various application domains, including health care system that monitor human health and provide life care services. Current system is based on the central server i.e. all the monitoring and respective services are stored and processed centrally. This leads to couple of high risk factors associated with it such as low performance, prone to failure, high maintenance cost and limited services. For example, *Korea u-Care System for a Solitary Senior Citizen (SSC)* provides 24/7 monitoring and safety and emergency connection services at home. This paper proposes a *Secured WSN-integrated cloud computing for u-life care (SC^3)*. The system not only provides secured services but it also provides low-cost, high-quality services. The author proposed architecture is breakdown into two phases, where the first phase concentrated on the integration of WSN with cloud services. It also includes implementation of activity recognition algorithm, access control protocol and services for Alzheimer's disease patients. Figure 2 shows this functional architecture. At first, all the data captured through devices or camera is transferred to the cloud gateway which further classifies the data i.e. embodied or video and stores it locally. The filtering module is responsible for filtering the noise or redundant data in order to reduce the communication overhead. Query/response manager is responsible to fetch the data on request from the local database and send it to the appropriate user. Activity Recognition Engine resides in cloud and is responsible for predicting the activity of the monitored user. Ontology Engine is responsible for inferring complex activities. It requires activity and context as input for further processing. Doctors and nurses should authenticate themselves to access the data. On successful authentication Access Control Module gives respective access control privileges, and then the data is forwarded to authentic user.

The functional architecture has implemented sample scenario for Alzheimer's disease patient. SC^3 monitors the patient's health conditions and daily activities such as taking medicine, exercise, reading book and watching TV. Doctors and nurses have access to their respective patient's data on the cloud through web 2.0 interface. The implementation results have shown that it took at maximum of two seconds to respond to patient's actions. Activity recognition accuracy varies from 76% to 99.23%. The accuracy can further be improved with the development of different activity recognition techniques. The second phase will answer such enhancements. The following are the services that SC3 has deployed for u-life care:

Safety Monitoring Services for Home Users

The proposed system can be deployed at home where the sensed data is uploaded on the cloud and various life care services can be used such as emergency services.

Information Sharing Services

The patient data can be accessed globally and can be shared with a group of hospitals in order to diagnose it properly. SC3 can provide flexible platform for public-health departments to upload real-time health data and for the early identification and tracking of diseases outbreaks.

Emergency Connection Services

The system can be deployed for emergency connection services at real time such as alarm system connects user, u-119 police department for emergency situation alert.

Users can Monitor their Home anywhere anytime with any device

SC3 allows the user to monitor their environment with any device connected to the internet such as cell phone, laptop, computer, PDA etc.

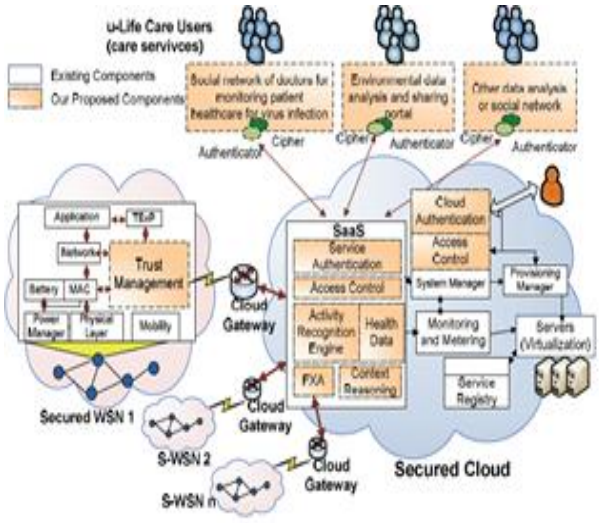

Figure 2: Abstract Architecture of SC3

Absence of Dynamic Collaboration between Clouds Provider

The use of Cloud services starts from the user agreement, this agreement is service level agreement, and if Cloud services provider fails to provide the services to the end user to satisfactory level, it can cause service level agreement violation. This violation may result in costing money to the cloud services provider. This problem will not arise if the service provider is in collaboration with other service providers. So a lot of the issues can be solved if the Cloud services providers' collaboration is practiced.

No infrastructure to support WSN integration to Cloud

This technology is relatively new so infrastructure is one the problems. As wireless sensor network is weak in processing and power so they need to be utilized properly. One cannot extend its range to communicate, because in doing so, one may put an extra burden on sign strength that could possibly eat up enough power of the specific node. So stepping into this technology needs a verification that the network works smoothly and accurately. Too many parameters can be obstacle in doing so. One example could be electric interference, so one should make sure that how to make it happen.

Weak Privacy Support

One of the greatest threats to the healthcare services is the weak privacy support. One of the US largest health care insurance companies the WellPoint, reported that about 130,000 of customer's records have lost the privacy and are now publically available on the internet. Getting any patient data publically while it is requested to be kept private is one of the issues. That may happen due to the weaker administration qualities or lack of technical skills to handle the technology. Privacy is the major concern of the people now a days and they are not ready to share their private data to anyone they don't know. Worst, it is available to anyone on the internet. This can damage the image of the technology and make the common man away from the use of Cloud services.

IV. PROBLEM STATEMENT

Traditional healthcare systems are paper oriented manual system by collecting notes and updating to computer to maintain records. Such kinds of processes are considered error prone and time consuming. Since doctors have to make decisions about the health and cure of the patients based on this data, the error factors make these data very sensitive.

Objective of our research is to propose a system based on integration of WSN and Cloud Computing technologies that will remotely monitor the patients' health without physical visit to the health care centers. This will also ensure the fast and accurate collection of patients' health statistics for the medical professionals to make the right decisions regarding treatment. It will also ensure security of patients' data from unwanted access. The system is equally useful for remote monitoring of indoor and outdoor patients. Additionally the proposed system will be capable of identifying emergency situations quickly and thus help making timely arrangements for avoiding life risks.

V. PROBLEM IN EXISTING WORK

Integration of WSN with Cloud Computing is not that simple, as the model or the framework that support this integration is not yet available. Although a few giants organizations like Google, Microsoft have already stepped into the run but this technology is still much new to adopt. People are still talking about the security in using this technology, as the data is available on global network. In few occasions it did happen that the private data got publically exposed and the privacy rules were violated. Devices connect to the Cloud Network though internet and sometimes internet response may not be quick and prone to disconnection. Continuously reconnecting process may not assign the same Internet Protocol address all the time. So the communication may be refused by the Cloud network because of change in IP Address. That may cause in failure of using data transmission.

VII. PROPOSED SOLUTION

We have proposed an architecture which integrates wireless sensor networks running on smart phones, with cloud computing. The health data obtained from the healthcare apps running on the

smart phones needs to processed and based on abnormality of the data, necessary actions needs to be taken. A copy of the sensor data is sent to the cloud from where the hospital accesses it. The proposed architecture integrating the smart phones and cloud solves the problem using the proposed filter system. If there is any abnormality in the health parameter, the smart phone sends an alert SMS to the healthcare organization. HIPAA [6] defines a set of rules on who has access to the patient's health records. Therefore, only authorized medical personnel should receive the alert SMS sent by the smart phones. The proposed key search and priority ranking algorithm solves this problem by finding the highest weighted list of medical personnel to whom the alert SMS needs to be sent.

VIII. TECHNICAL & APPLICATION ANALYSIS

All the sources of wireless sensor networks are heterogeneous. In order to process the data it is necessary to enforce standard abstraction on information on all sources. Moreover, data is communicated among intermediate nodes in path to reach the destination. This may lead to a security flaw, and in security applications it becomes necessary to control the flow of information. Thus, there has to be data centric access control to ensure the forwarding of critical data only. Besides, context aware attribute of the system allows the user access to data anywhere and anytime. Network Programing Management System (NPMS) can benefit from the integration of Wireless sensor networks.

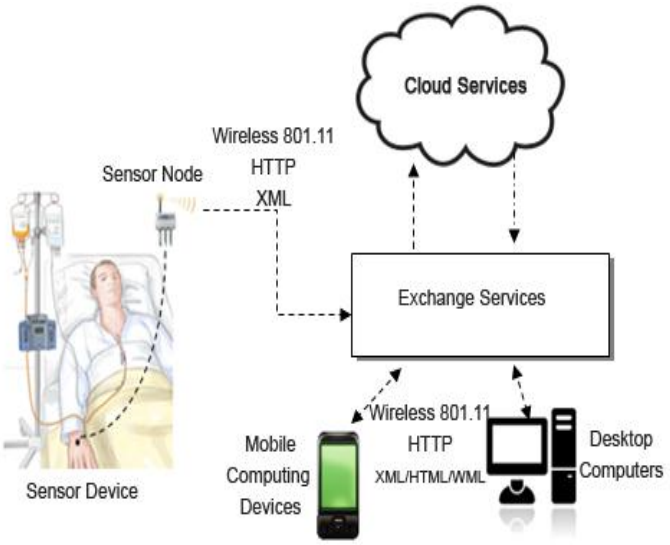

Figure 3: Architecture of the Proposed Solution

VIII.CONCLUSION

Both Wireless Sensor Networks and Cloud Computing technologies along with their applications in remote health monitoring for the benefit of humanity are discussed in this paper. This research article provides an overview of architectural extension of WSN. Application of cloud computing to enhance the reliability and availability of wireless sensor networks is discussed with special emphasis on its application for remote health monitoring. The proposed system is based on ideas taken from an in depth study and support of various technologies. The proposed system has its useful applications and important role in medical sciences field. It is supposed to help in efficient cure of Strokes and Parkinson. However the security issues involved in the integration process are of key importance and need critical focus. We used the advantages of Wireless Sensor network and cloud computing and merge them to make them work together.

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