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WSN INTEGRATED CLOUD FOR AUTOMATED TELEMEDICINE (ATM) BASED e-HEALTHCARE APPLICATIONS

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Abstract. Nowadays Healthcare applications become more attractive among researchers due to a demand on a high quality and low cost care services at anytime and anywhere. Most of the existing healthcare systems rely only on their own data centers to store and process sensory data. It brings high cost to maintain the system, yet the performance is not reliable and a limited number of services can be provided. Many works exploit sensor networks to monitor patient's health status and movements to provide care services to them. It requires sensory data to be transmitted and processed quickly so that physicians, clinics, and other caregivers can access conveniently via Internet. This paper presents our study and development of a Wireless Sensor Network (WSN) - integrated cloud computing for e-healthcare applications. WSNs can be deployed in hospitals or home environments. In this system sensor data is collected and sent to the clouds. Different users such as hospitals, clinics, researchers, or even patients themselves can access their data from the Clouds. Our architecture can provide cost efficient model for automating hospitals and other life care agencies, managing real-time data from various sensors, efficiently disseminating information to medical professionals, support privacy and strong authentication mechanism. Our versatile architecture makes it possible to launch web applications quickly and also upgrade e-healthcare applications easily as and when required. Our automated secure framework of community cloud would provide increasingly cheaper with the end-goal of better health outcomes in the future.

Keywords: Wireless Sensor Network, Cloud, e-healthcare Applications, Telemedicine

1. Introduction

Telemedicine plays a vital role around the world for remote diagnosis and monitoring patients. It is the largest, fast growing and most informative intensive area. Wireless Sensor Networks (WSN) plays a vital role in healthcare services in different environments [2]. A wireless sensor network (WSN) is a collection of wireless sensors (called motes) that form a certain network topology [3]. This technology helps in giving physicians, emergency department personnel and caregivers, a real-time universal access of patient's health record, clinical histories, treatments, medications, tests, lab results, etc. So it requires some mechanism to share the patient's information available in different hospital and home environment [7]. Cloud computing has evolved as a standard approach to give a powerful, flexible, and cost-effective infrastructure in providing life care to people anywhere at any time with increasing the coverage and the quality [1]. The cloud itself is a set of hardware, networks, storage, services, and interfaces that enable the delivery of computing as a service. Community cloud services include the delivery of software infrastructure, knowledge grid, and data over the Internet based on customer demand. Currently there is no proficient framework to support the integration of WSNs to cloud [8]. There are many challenges exist to enable this framework as the entire network is very dynamic. Our architecture designed to computerize this development from patient's bedside (data) to information sharing and distant access by medical professionals.

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Our solution is based on the concepts of wireless sensor networks and utility computing. Medical sensors are attached with existing medical instruments that are inter-connected to swap over services; these are integrated to the hospital's computing network infrastructure [4]. The information becomes accessible in the community cloud, from where it can be processed by the medical professionals for analysis.

2. Related Works

During last few years, many research works are focused on wearable systems for health monitoring. Researchers have developed a wearable system compatible with both custom and off-the-shelf sensors. The medical sensors, when equipped on patients in hospitals use adhoc networks to transmit patient's vital signs to healthcare givers [2].

Recently, research efforts are beginning to study the integration of WSNs and cloud system networks computing. Researchers in the UK are studying how sensors can be integrated into e-science cloud system networks computing applications. Research works was also focused in building a cloud networks-based structure for developing and deploying information based services to examine data collection from distributed sensors. The applications include life sciences, environmental monitoring, geo- hazard modeling and remote patient monitoring [5]. There was an argument that current Health IT systems offer only a fragment of patient's needs, emphasizing the need for a complete feedback loop including monitoring of patient status, patient self monitoring, individual treatment goals, and timely communications to the patient with tailored recommendations or advice. State that the inclusion of human interactions along with a more complete Health IT system will prove most effective, such as providing rapid and frequent communications from clinicians[12].

The current trend towards Telemedicine and Telecare evident in the UK has seen an explosion in the range of locations where advanced medical care needs to be delivered. E-medicine initiatives such as NHS Direct have illustrated the need to maximize the flexibility of delivery of healthcare. Existing trials in Telemedicine and Telecare such as those carried out by the Oxford centre for e-health, the Biomedical Informatics group at Nottingham University and the Glasgow Royal Infirmary and Glasgow University have demonstrated the feasibility of remotely monitoring patients as part of an overall care programme or as part of a clinical trial [6]. However, these efforts have tended to be small scale in nature and have typically required the development of bespoke sensors and purpose-built infrastructure for the logging of data for analysis [13]. The work in [9] proposes a structure design based on the services of cloud computing concepts, Knowledge grids and image toolkits to identify bowel cancer images. Finally, Xiao. Yunpeng team proposes a solution based on wireless web access, where mobile devices use processing power of cloud to parser HTML components of a web page [14]. This work shows how the services in cloud computing is preferred for processing depth solutions. Based on the examination above, we concluded that none of the analyzed solutions satisfy our requirements completely. Consequently, we identified this circumstance to develop an architectural solution that integrates the idea of wireless sensor networks and service of cloud computing to create a stage to support automated telemedicine environment.

3. Proposed Architecture

Recent scientific advances in medical sensors, low-power integrated circuits and wireless communications have enabled the design of low-cost, miniature, lightweight wireless sensor nodes [11]. These wireless sensor nodes are capable of sensing, processing and communicating one or more patient's vital signs, can be faultlessly integrated into wireless body networks for health monitoring. A wireless system could be set up throughout the hospital to sense physiological parameters such as ECG, heart rate, body temperature of patients. The mote kit receives information from the sensor and transmits it to the central server through USB gateway for analysis. We have designed architecture to share the wireless sensor network data resources of multiple patients monitored in three different hospitals. Figure 1 illustrates the architecture of a wireless sensor network integrated with community cloud, which comprises three different sites that are geographically distributed and belonging to different divisions of organizations. The dynamic updates in the hospital database shared between the clouds. This community cloud provides scalable processing power and several kinds of services. Community cloud enables medical professionals to store files and software remotely, rather than the system at respective hospitals.

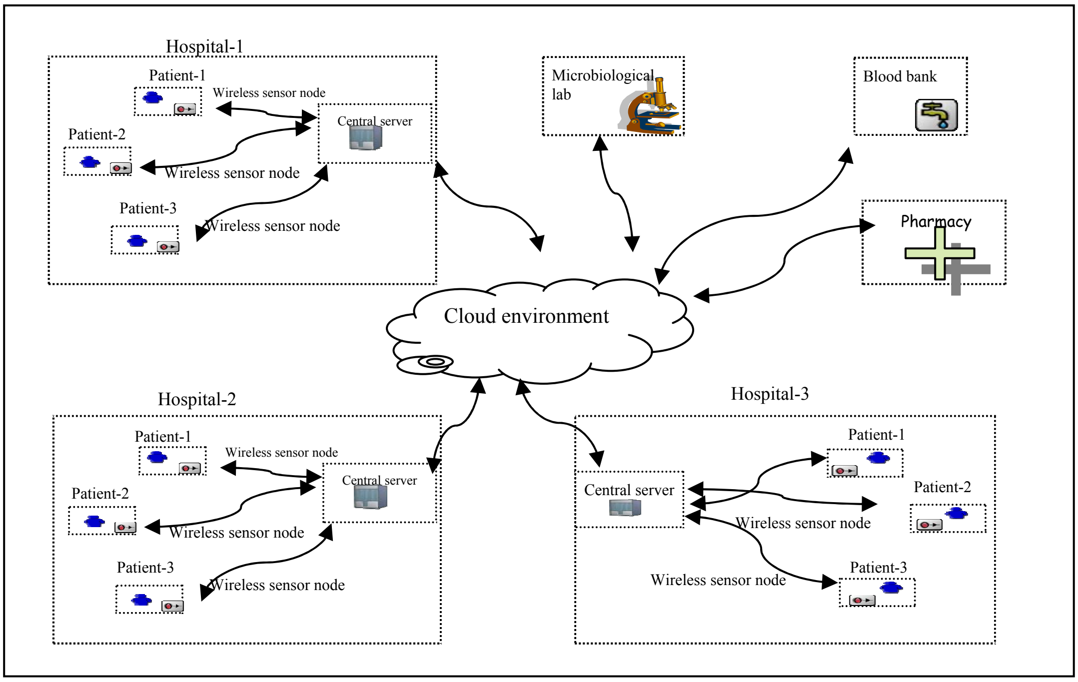

Fig. 1: WSN integrated with Cloud architecture for e-healthcare application

4. Implementation and Results

Our proposed architecture involves connecting Wireless sensor networks and community cloud together. All the experiments were carried with mote kits having transceivers operating at 2.4 GHz with a typical range of 750m. The test bed uses a medical server with 5 user nodes for medical specialist, caretakers and patients for monitoring and analyzing medical data's. The medical server contains dual AMD processor with 2.2 GHz with 2GB RAM while each user node contains Intel dual core processor with 1GB RAM. We have used PASCO CI-6539A ECG Sensor, PASCO CI 6543B Heart Rate Sensor and CI6605A temperature sensor interfaced with mote kits to monitor patient's physiological parameters such as ECG, heart rate and temperature [10]. The ECG Sensor measures cardiac electrical potential waveforms of the patient. The Heart Rate Sensor monitors the flow of blood through the part of a body, such as an ear lobe, by shining a light through it and monitoring the change in intensity. As the heart beats and forces blood through the blood vessels in the ear lobe, the light transmittance through the ear lobe changes. The stainless steel temperature sensor has a faster response time, wider range, and greater durability than other sensors and is fixed in the elderly patient's axilla to the temperature. Figure 2 shows how wireless sensor node is interfaced with the sensor and transmits signal to the central server of particular hospitals.

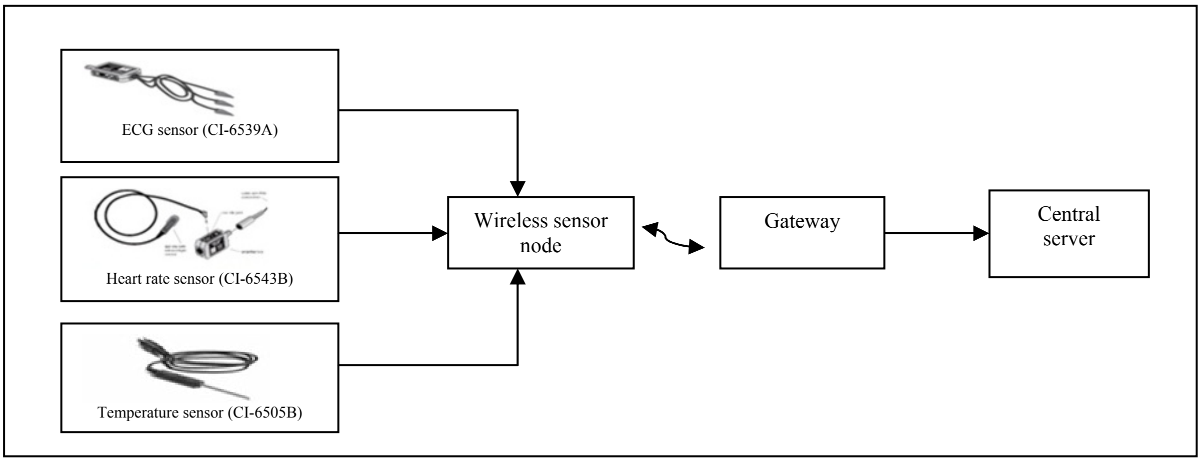

Fig 2: Wireless sensor node Interfaced with Physiological Sensors and the central server

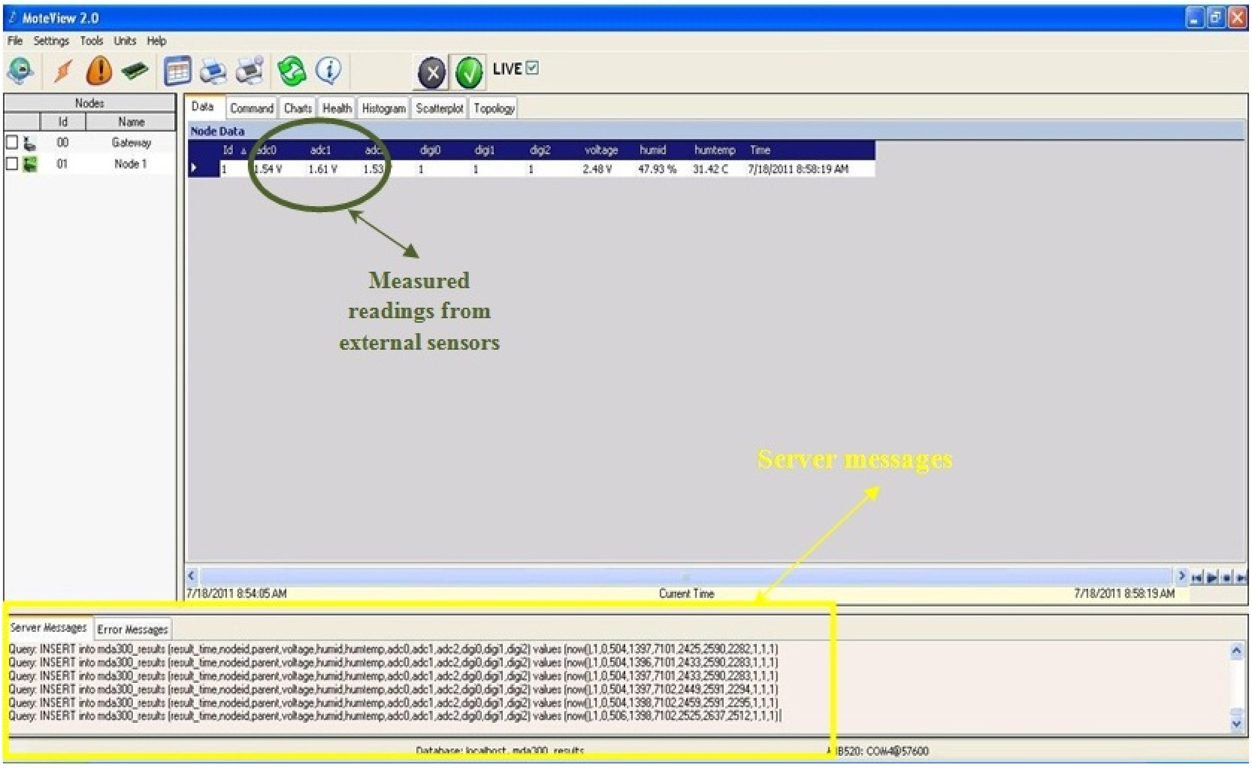

Fig 3: Screenshot of the MoteView's graphical user interface

The sensor consists of an amplifier box with DIN connectors for connecting to the wireless sensor kits. The ECG, heart rate, temperature sensors connected to the patients, measures the respective signals and produces analog outputs. The output terminals of the body sensors are connected to the analog input ports (A0, A1) of the data acquisition board (MDA300CA) attached to the mote kit. Mote kit transmits the physiological signals to the corresponding USB gateway (MIB520) through mesh networking. The gateway is attached with the central server, where the received data stored and viewed through MoteView for analysis. Figure 3 shows the screenshot of the MoteView's graphical user interface. The medical professionals can access the particular patient's data from any of the hospital server through front-end web service. Figure 4 shows the sample snapshot of a webpage displaying patients' information through doctor's login.

Fig 4: Doctor's view of particular patient

5. Conclusion and Future Works

In this paper, we have demonstrated the potential use of wireless sensor network integrated Cloud Computing for e-healthcare applications. It provides a number of featured components, including security and privacy control, WSN-Cloud integration mechanism, dynamic collaboration between Clouds to enable many e-healthcare services. We also present our primary result of development, and then discuss about its potentialities and benefits. Additionally, a cloud computing environment offers flexibility in building low-cost, scalable health record systems. Our system offers physicians, the capability to perform exploratory data analysis in order to maximize insight into the distributed databases, and uncover important events. As future works, we intend to create community cloud by any of the open source framework. In addition, we intend to validate this proposal in a real world setup to assess the benefits of the solution in large scale scenarios.

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