Cloud Care: A Remote Health Monitoring System

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Abstract- Wireless technology has completely transformed the way we live, but health care is yet to enter the digital age at least at remote areas. By harnessing innovation in the wireless space along with cloud computing and pervasive technologies such as ubiquitous sensing and data analytics we can fundamentally shift the paradigm in health care delivery and dramatically improve the health care services at rural areas. Ultimately, we have the opportunity to create a new *"infrastructure-independence"* model of health care, which translates into the right care, at the right time, wherever people need it. Also putting cloud computing with it makes the health data to be monitored at any comfortable places or devices. Wireless health encompasses end-to-end solutions that facilitate continuous access to health care information, expert advice, or therapeutic intervention enabled by remote sensing, ubiquitous telecommunications networks, and smart systems and platforms.

Keywords: Remote Health Monitoring, Ubiquitous Computing, Pervasive computing, Body Area Network, Cloud Computing

1 Introduction

Wireless technology, in the long run has completely transformed the way we live, but health care of people at remote areas is yet another critical thing that ought to enter the digital age for the complete technological development in the wireless field. The main goal of our project is to make room for quicker and quality health assistance to patients at locations that are physically too remote to the well-equipped hospitals consisting of doctors (specialists) in every medical domain using modernized communication. By exposing the human body to biosensors (Wearable sensors), we can measure any physiological parameters blood pressure level, ECG, EEG and EMG; From the sensors, outputs are read to a local server, which is kept in a particular remote area, using the zig-bee gateway. From the measured data, received by the local server are sent to Cloud wherein the data analytics are done. The values are then sent as reports to the doctors' (of their specialists) smart phones that are connected to the Internet from the Cloud. That means we will have a panoramic, high-definition, relatively comprehensive view of a patient that can be used by the physicians at remote place to assess and manage the patients' diseases. That is the essence of digitizing a human being. In medical field, it is getting all the essential data (parameters) and generating a brief report in lightning speed which is the scope of radical transformation of the future of medicine evenly. Doctors are all essentially connected to smart phones and it is quite effective and easier form of connecting to them.

Pervasive computing technologies have seen significant advances in the last few years. This has resulted in design and development of sensors, wearable technologies, smart places and homes, and wireless and mobile networks. Driven by technology advances in low-power networked systems and medical sensors, we have witnessed in recent years the emergence of wireless sensor networks (WSNs) in healthcare. Specifically, unlike applications in other domains, healthcare applications impose stringent requirements on system reliability, quality of service, and particularly privacy and security. In this system we expand on these challenges and provide examples of initial attempts to confront them. These examples include: (1) network systems for vital sign monitoring that show that it is possible to achieve highly reliable data delivery over multi-hop wireless networks deployed in clinical environments, (2) Systems that overcome energy and bandwidth limitations by intelligent pre-processing of measurements collected by high data rate medical applications, (3) An analysis of privacy and security challenges and potential solutions in assisted living environments, and (4) Technologies for dealing with the large scale and inherent data quality challenges associated with in-field studies. The system also helps the government in identifying outspread of a disease and take immediate recovery mechanism or action plan by the click of a mouse.

The fundamental aim is to provide prompt and proper treatment of casualties, in some cases prevent additional casualties. A healthcare monitoring system prototype for remote areas using Pervasive computing technologies is designed. The system aims to measure various vital physiological health parameters like ECG, body temperature, EEG, Fall Detection and Blood Pressure etc., of in real-time and transfer his/her health parameters wirelessly using Zigbee, to a remote base station referred as Local Processing Unit[LPU]. Wearable are deployed and a pervasive computing model is deployed to implement the same. Wireless Body Area Network (WBAN) is setup using intelligent devices implanted in the bodies which are capable of transmitting the sensed (medical data's) wirelessly to a Local Processing Unit (LPU), which in turn communicates to the Cloud using the established gateway.

2.1 Scope of problem

1) There are fewer physicians, with the exception of family practitioners and general practitioners, in rural areas in all four regions of the nation.

2) Health manpower shortages and recruitment and retention of primary care providers were identified as major rural health concerns among state offices of rural health. Access to quality health services was the most often nominated rural health priority by state and local rural health readers across the nation.

3) 15% of adults in the US according to estimate, do not have preferred doctor's office, clinic or any other place in which they receive care.

4) In 2006, for every 10 000 population there were 2 nurses, 0.1 pharmacists and 6.3 community health workers.

5) There are 57 countries with a critical shortage of healthcare workers, a deficit of 2.4 million doctors and nurses. Africa has 2.3 healthcare workers per 1000 population, compared with the Americas, which have 24.8 healthcare workers per 1000 population. Only 1.3% of the world's health workers care for people who experience 25% of the global disease burden.

Table 1 Types of Urban Health Posts in India

Type	No	Population covered(in thousands)	Staffing Pattern
A	65	<5	1 Auxiliary nurse midwife
B	76	5-10	1 Auxiliary nurse midwife 1 Multiple worker(male)
C	165	10-25	2 Auxiliary nurse midwife 2 Multiple worker(male)
D	565	25-50	1 Lady medical officer, 1 Public health nurse, 3-4 auxiliary nurse midwives, 3-4 multiple workers(male), 1 class IV woman

2.2 Literature Review

At earlier stages a real-time patient monitoring system prototypes have been designed to obtain various physical parameters. But there were several constraints like security of the patient, Interference due to mass deployment. Also added to these were design constraints like battery power consumption and sensor calibration to different working conditions and controllers.

Secondly Biotelemetry (or Medical Telemetry) involves the application of telemetry in the medical field to remotely monitor various vital signs of ambulatory patients. Biotelemetry is the remote detection and measurement of a condition, activity or function relating to physical activities. But this goes with cost of deploying a high-end equipment at every remote centers which makes it little tedious to proceed.

Thirdly there were high-end systems in Military to remotely monitor the soldier's physical parameters. The Army Knowledge Online critical care Tele-consultation system is a web based service used to perform consultation on patients being treated in the field. Med Web provides a web based Tele-Radiology service which allows clinicians to transmit X-ray, CT MRI and Ultrasound datasets from patient in the field to be analyzed by radiologists around the world.

Fourthly the "long-distance home health care service" has become one of the key emerging businesses in Taiwan. A mobile health management system is presented which is the first one integrating a wearable ring-type pulse monitoring sensor with a smart phone. All physiological measurements are transmitted to the smart phone through Bluetooth. In some projects, handwritten medical documents are scanned and uploaded to the database as images to bridge the gap of typing and computer literacy in remote workers. In some cases optical character recognition technology has been tried to scan and index specific sections of the image based on their character based section-headings. However, the survey could not find any examples of adoption of character recognition technology equipped with medical vocabulary to digitize the handwritten content input from the images.

The Health wear service is based on the Wealthy prototype system. A new design has been made to increase comfort in wearing of the system during daily patient activities. The cloth is connected to a patient portable electronic unit (PPU) that acquires and elaborates the signals from the sensors. The PPU transmits the signal to a central processing site through the use of GPRS wireless technology. This service is applied to three distinct clinical contexts: rehabilitation of cardiac patients, following an acute event; early discharge program in chronic respiration patients; promotion of physical activity in ambulatory stable cardio-respiratory patients.

The design approaches for generating stealthy probes and describe various possible mechanisms that can be used for such a design. These approaches are evaluated according to the design criteria and we identify what may be feasible solutions for stealthy probing in battlefield ad-hoc wireless networks.

2.3 Methodology for proposed system

By exposing the human body to biosensors (Wearable sensors), we can measure any physiological parameters—blood pressure level, glucose level, oxygen concentration in the blood. The sensors are directly connected to low power microcontrollers. These microcontrollers in turn connected to Radio Frequency module. Whenever there is change in human parameter the sensor will sense the parameter and accordingly gives the analog signal, Microcontroller which itself has

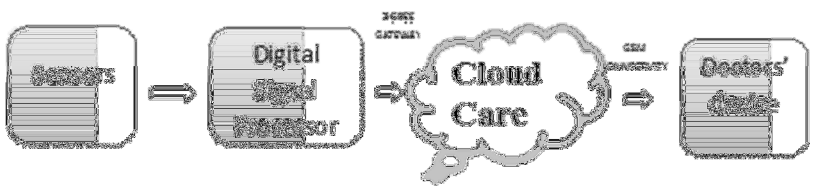

Fig.1 Flow Diagram for Cloud Care

inbuilt ADC will convert analog signal from sensor to equivalent digital value and it is calibrated to its unit scale and transmitted wirelessly to server using RF module if server is located not far away from its RF range . If server in Remote location ,then there occurs multi-hopping technique where the sensor transmit the value to the nearby sensor device which is present within the range, the sensor which receives the packet from nearby sensor module and again forward the same to the nearby sensor module . This hopping happens until the packet reaches the server.

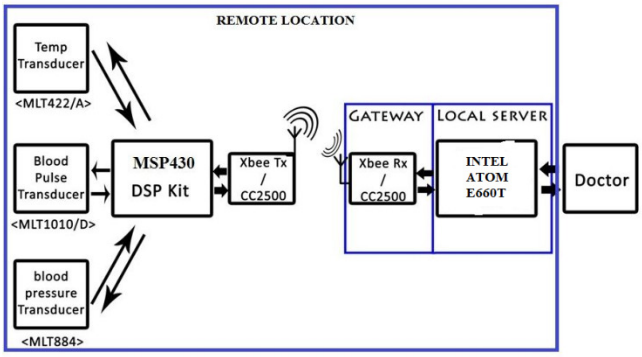

Fig.2 Working Model of Remote Health Monitoring System

Physiological sensors measure core body temperature, ambulatory blood pressure, blood oxygen etc. As the accurate measure of core body temperature is highly preferred in numerous medical applications, intra-body biosensor is required. The main challenge is the construction of a novel intra-body biosensor for intra-vaginal temperature monitoring.

3.1 LOCAL PROCESSING UNIT

The MSP430 series of microcontrollers are ideal in applications where battery life is critical. These microcontrollers require only 0.1µA of current in low-power RAM retention mode; In this mode the microcontroller must have power to retain volatile memory. For many portable-power applications, the power consumed during shutdown mode is more critical than power consumed while active. This is particularly true for portable monitoring equipment such as digital thermometers, blood glucose meters, or battery-powered blood pressure monitors.

This platform has a Measuring unit which is Texas Instruments MSP430 CPU (8MHz), an IEEE 802.15.4 Xbee wireless transceiver (2.4GHz), and a local server which is Intel Atom Embedded Board (E6xx).

3.2 BAN UNITS

3.2.1 Temperature

Wireless communications seems to be more realistic than other wired alternatives, taking into account patients comfort and operation simplicity by medical staff. In order to get temperature readings, a temperature sensor MA100 thermistor from GE

Industrial Sensing is used. Its sensitivity ranges from 0 to 50 degree Celsius, size is 0.762 x 9.52 mm, and is created for biomedical applications. SaO2 is defined as the ratio of the level oxygenated Haemoglobin over the total Haemoglobin level (oxygenated and depleted):

$$\text{SaO2} = \frac{\text{HbO2}}{\text{Total Hemoglobin}}$$

Body tissue absorbs different amounts of light depending on the oxygenation level of blood that is passing through it. This characteristic is non-linear.

Two different wavelengths of light are used; each is turned on and measured alternately. By using two different wavelengths, the mathematical complexity of measurement can be reduced.

$$\text{R}' = \frac{\log(\text{lac})\lambda 1}{\log(\text{lac})\lambda 2}$$

Where λ1 and λ2 represents the two different wavelengths of light used. There are a DC and an AC component in the measurements. It is assumed that the DC component is a result of the absorption by the body tissue and veins. The AC component is the result of the absorption by the arteries.

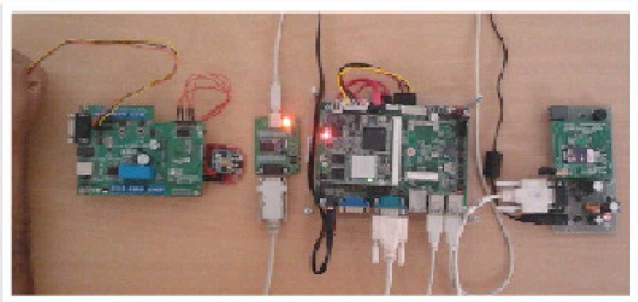

Fig. 3 Reading Temperature using Wireless BAN

Because both LEDs are pulsed, traditional analog signal processing has to be abandoned in favor of digital signal processing. The signal samples are low pass filtered to remove the 50/60 Hz noise. For each wavelength of light, the DC value is removed from the signal leaving the AC part of the signal, which reflects the arterial oxygenation level. The RMS value is calculated by averaging the square of the signal over a number of heart beat cycles.

3.2.2 Heart Rate Monitoring

The electrocardiogram (ECG) or elektrokardiogramm (EKG) is a medical standard for testing the human heart for defects and diseases. Fig. 4 shows the waveform of the

ECG signal. The ECG waveform can be used for extrapolation of data such as the number of heart beats per minute (BPM) and the values can range from 30 to 200 BPM or 0.5 to 4 Hz. The typical amplitude of the R wave component of the EKG signal is approximately 1 mV. This peak is located within a group of peaks known as the QRS complex and represents the electrical pulse flowing through the ventricles. As this pulse travels via the blood stream, it can be detected at various points on the body. The extremities and the chest have become the standard locations for placing electrodes for acquiring the ECG signal. In this application, the subject's finger tips act as the differential point of contact with conductive pads to detect the ECG signal. A resistor divider scheme is implemented to detect contact of the subject's finger tips with the conductive pads.

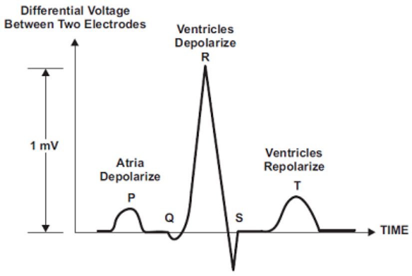

Fig. 4 ECG Waveform

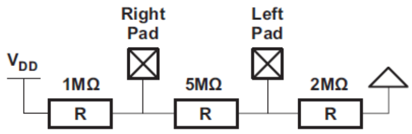

Fig. 5 Hand Detection Circuit Diagram

The premise of this scheme is that the resistance of the human body between the finger tips is in the 100 kΩ to 300 kΩ range, and the resistance placed between the conductive pads is significantly greater than this range, as shown in Fig 5. When contact is made, the current flows through the path of least resistance (the human body) causing the voltage at the left conductive pad to change. This voltage is sampled by an analog-to-digital converter (ADC) channel and the digital conversion result is compared against a set of thresholds to determine good, bad, or no contact. Power and ground are supplied from the microcontroller pins and can be disconnected to minimize supply current consumption in sleep mode.

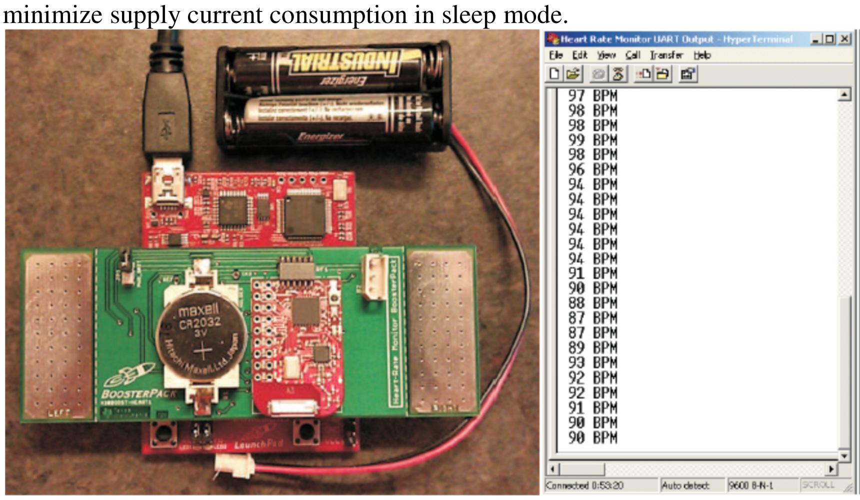

Fig. 6 ECG Circuit Illustrating the Wireless BAN unit and its corresponding reading

3.3 Future design and Conclusion

It is planned to add features like fall detection for elders, neural activities of patients and similar parameters in order to incorporate this into Remote Monitoring System. The fall is a risky event in the elderly people's daily living, especially the independent living, it often cause serious injury both in physiology and psychology. Wearable sensor based fall detection system had been proved in many experiments for its feasibility and effectiveness, but there remain some crucial problems, include: the people maybe forget to wear the clothes with micro sensors, which device standard should be selected between medical device standard and mass market standard, and how to control the false alarm probability to fit the individualized requirements. We propose to develop miniature telemetry systems that capture neural, EMG, and acceleration signals from a soldier and transmit the data wirelessly to a remote station. The systems are based on a customized low-power IC that will amplify, filter, and digitize essential four bio-potential signals using low-noise circuits. The user's physiological state is monitored using an onboard bio-amplifier implemented using an instrumentation amplifier with a signal conditioning circuit. The bio amplifier could be used for electromyogram (EMG) or electrocardiogram (ECG) monitoring. The output of the signal conditioning circuit is connected to the local processing unit; using the AD converter on the micro controller board and a higher resolution processer we sample and process the signal to remote station through the transceiver. This configuration gives flexibility of utilizing either microcontroller to process physiological signals.

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