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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. 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.

***Index Terms*—Remote Health Monitoring, Ubiquitous Computing, Pervasive computing, Body Area Network, Cloud Computing.**

I. 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 zigbee 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

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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 and intractable devices 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.

II. SCOPE OF A 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.

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TABLE I. 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

III. 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. Telemedicine is the tele-presence of medical experts with the ability to act and interact in an offsite environment by making use of virtual reality technology. Telemedicine reduces the cost of medical practice and brings expertise into remote areas.

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Telemetry is a technology that allows data measurements to be made at a distance. But this goes with cost of deploying a high-end equipment at every remote centers which makes it little tedious to proceed.

Many modern telemetry systems take advantage of the low cost and ubiquity of GSM networks by using SMS to receive and transmit telemetry data. Telemedicine programme is an innovative process of synergizing benefits of Satellite communication technology and information technology with Biomedical Engineering and Medical Sciences to deliver the health care services to the remote, distant and underserved regions of the country.

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. The clinician in the field is provided a window to communicate to specialists around the world who can answer for the solution within hours. 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. The user can monitor her/his pulse and temperature from the smart phone. Then these data are transmitted to a remote server through the mobile communication of the smart phone, such as HSDPA, Wi-Fi, GPRS, etc. The build-in GPS further provides the position information of the monitored person. The remote server not only collects physiological measurements but also tracks the position of the monitored person in real time.

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. Although the image files would require a lot more storage and bandwidth than text entry, this cuts time and learning curve for the medical personnel, and so it works out. 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. The integrated wireless CDMA based ubiquitous healthcare monitoring system for disease and chronic management and better patient care in the hospital, home or travel environments with extended standalone simple electrocardiogram (ECG) diagnosis algorithm at cell phone. This system utilizes a wireless dongles prototype as the intermediary devices to remotely monitor the physiological signs of patient's from a tiny wireless sensor to transmit directly to medical center monitoring/PDA wirelessly within 802.15.4 wireless LAN or using cell phone to relay the medical data through CDMA network when outside the coverage LAN. The external standalone ECG diagnosis was implemented to enable continuous monitoring and evaluation of the ECG signal locally before any medical data could be sent to the medical center.

IV. PROPOSED SYSTEM

The implemented model consists of low noise front-end amplifier (AFE) with tunable bandwidth and an asynchronous clock less analog-to-digital converter (ADC). Front-end amplifiers perform the essential conditioning for the vital physiological signals such as body temperature, pressure, pulse, ECG, EMG that complements downstream digital processing, which in turn refines the measurement and communicates with

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other systems. The, analog signals is measured from with the multichannel ADC unit of the MSP430F processors; this information is transferred to a remote server with an aid of ZigBee. With this system, signals obtained from the patients can be monitored simultaneously.

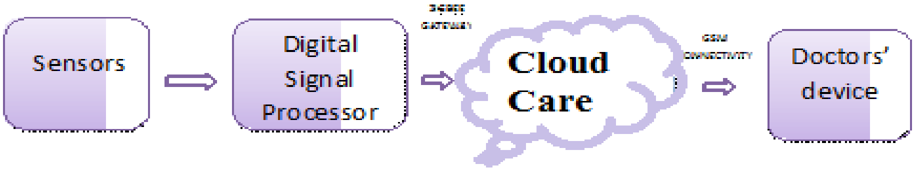

Fig.1 Flow Diagram for Cloud

V. METHODOLOGY

After 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 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.

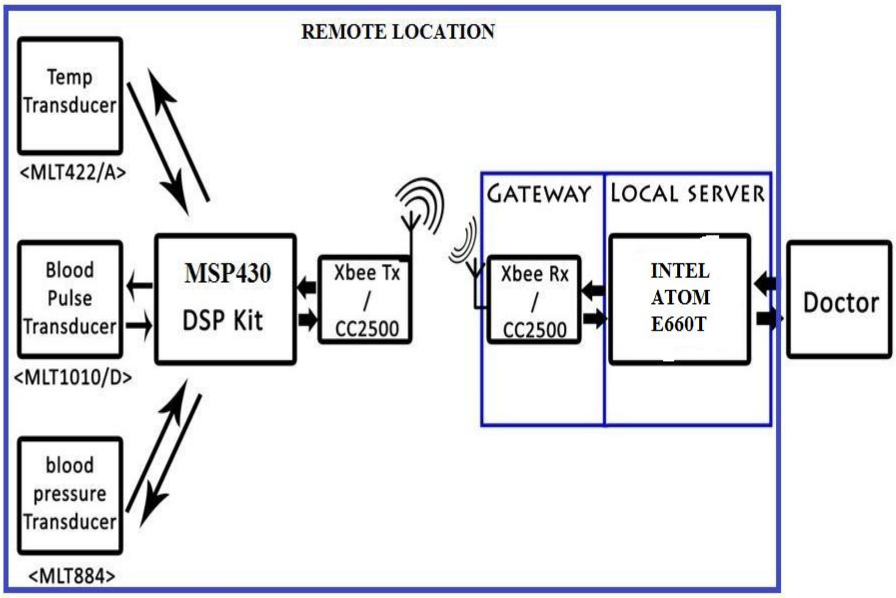

Fig.2 Working Model of Remote Health Monitoring System

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.

A. 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).

B. BAN UNITS

Blood Pressure, 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 Hemoglobin over the total Hemoglobin level (oxygenated and depleted):

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

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.

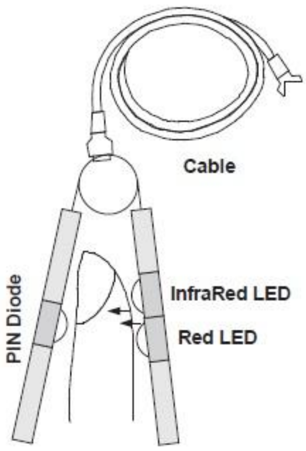

Fig.3 Pulse rate Monitor

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

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.

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.

The heart beat is measure by counting the number of samples in 3 beats, since the sampling rate is 500 sps. The heart beat per minute is calculated by:

$$\text{Heart beats per minute} = \frac{500x60}{\text{Samples Count}/3}$$

This is done by software, running in local processing unit in continuous mode which will commands over a Zigbee connection. Once a command is arrived, measuring unit analyzes it and proceeds in accordance. Various commands are start collecting the temperature values in memory of local processing unit, stop collecting

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programming the interval between temperature readings and send all data recorded in the memory of local processing unit to a remote doctor by using GSM network and to distant server using a gateway. Likewise various data collected from different places are put together and forms a cloud.

We developed a non-invasive continuous measurement of blood pressure and temperature of the soldier. This device is a small battery powered embedded system which measures a blood pressure, ECG and Temperature during a long time period and sends this information to remote station. Out of these signals we acquired the ECG of the soldier using miniature wearable chest equipment termed Wireless ECG Transmitter (WET).

1. These signals are amplified, conditioned and transmitted to the Local Processing Unit which is wirelessly enabled.

2. The in-built ECG analyzer processes the ECG signal and calculates the heart rate of the patient in beats per minute (bpm).

3. This output in bpm is fed to MSP430F. The ECG analyzer declares panic situation in any of the following cases:

- The beat per minute value is not between 60 and 100.
- Relatively fluctuating bpm for every heartbeat.

The R-amplitude falls below the minimum required by a healthy heart.

VI. WORKING MODEL

The working model of the system is presented here to read the Temperature and Blood pressure and also detect the fall of elderly people. The screenshot provides an overview of incorporating wireless wearable sensors to the body to read the medical parameters to cloud and sent as records of the format required to the mobile of the respective doctors of their specialization. The measured parameters are also monitored on cloud, so that doctors and as well as patients can access the data from anywhere and anytime.

Fig.4 Wearable TShirt with sensors fit

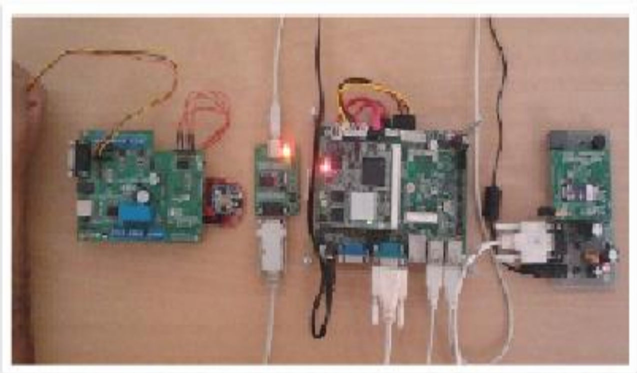

Fig.5 Reading Temperature using Wireless BAN

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VII. FUTURE DESIGN

It is planned to add features like body Fat Analyzer that can measure multiple fat-related parameters and send them to the central monitoring station wirelessly - this helps the health-conscious patients monitor their daily food habits and gradual changes in their health. An emergency button can be implemented that connects to call center for immediate assistance during emergency. Primary contacts will be notified during emergency by SMS or call with ability to receive and relay health results to central server. Also Track patient location and provide assistance with ability to remotely configure tasks from self-service portal.

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