2012 International Conference on Advances in Mobile Network, Communication and Its Applications

Mobile Software Platform for Rural Health Enhancement

Maneesha V Ramesh, Sruthy Anand, Rekha P
Amrita Centre for Wireless Networks and Applications
Amrita Vishwa Vidyapeetham, Amritapuri
Kerala,India
maneesha@am.amrita.edu, mesruthy@gmail.com, rekhap@am.amrita.edu

***Abstract*—The patients in rural areas lose their lives due to the unavailability of proper healthcare at the right time. This research work aims to develop a system suitable for continuous and real-time monitoring of rural patients to enhance healthcare facilities. The proposed system integrates existing and freely available mobile technology with wearable wireless sensors for patient monitoring. This research work has designed and developed a mobile software platform for continuous and real-time monitoring of rural patients. The prototype platform has been enhanced by integrating power optimizing and risk based data collection and transmitting methodologies. The system also provides an emergency warning message to the doctor's mobile phone. This proposed system collects the patient's health related sensor details in mobile phone, performs a first level analysis of the collected data, and transmits it to a central server for further processing. The system also enables the doctor to receive and view patient's ECG reports to a mobile phone. This paper introduces a dynamic algorithm to increase the battery life of a health monitoring mobile phone.**

***Keywords*— smartphones, mobile phone, energy optimization, health monitoring**

I. Introduction

The aging population has increased the prevalence of chronic diseases such as low blood pressure, hyponatremia, various heart diseases. Such patients need long term health monitoring. Most people prefer to stay at home rather than in hospitals. Mobile phones play a major role in a human's day to day life and miniaturized body sensors are also available. So we can use this technology to develop a low cost mobile software platform for monitoring the patients staying in their own homes.

Traditional health monitoring for chronic diseases are not resource friendly. Resources are drained by long stays in hospital or frequent trips to the hospital. Smartphone based health monitoring has the potential to save a considerable amount of health resources. Health resources such as cost, energy and the skilled time of patients and healthcare professionals can be better used. The objective of this research work is to develop a mobile platform that has the capability to collect sensor data from heterogeneous wearable sensors, process the data, analyze the data and trigger the warning messages to doctors, relatives etc. The system will provide the capability to visualize the signal in doctors mobile. Doctors will be able to assign the risk level of the patients, increasing the accuracy of the system. This system also proposes developing dynamic algorithms for reduced power consumption during real time continuous monitoring of the patients. This research helps to provide high quality healthcare to the rural population at a low cost.

Intensive research work is happening in the areas of E-Health and Wireless Sensor Networks (WSNs) to improve the quality of healthcare [1][2]. WSNs consist of sensor nodes that are able to sense and collect physical parameters from the environment, perform simple data processing and transmit data to a sink node. Using WSNs the health related information can be monitored intelligently [3]. The doctors can give instructions to patients and their relatives remotely by an e-mail or SMS. The doctors will get an opportunity to monitor the patients' health changes more frequently. This will be useful for the treatment and medication. This system also helps the relatives, if physically they are not able to take care of the patient's health condition, and the patient can live their life freely in their own home and this will help them to feel more safe and secure.

The paper is structured as follows. Section II presents the related work in the mobile platform development, health care systems and energy estimation of mobile power. Section III describes the System Architecture. Section IV deals with the algorithm designed to support the system for energy optimization. Finally, conclusions are drawn in section V.

II. Related Work

Our system is proposed based on the review of some previous work in the body sensor network area and the use of mobile phones in health monitoring. Yang et al [4] concluded that a single smartphone is not enough for the health monitoring and smartphone functionality. They went further to propose the use of separate hardware device, called PHM-Gate, placed between the smartphone and the human body sensors. However carrying and buying this PHM-Gate is inconvenient and not cost effective. Our research endeavors to make smartphone enough for reliable health monitoring.

978-0-7695-4720-6/12 $26.00 © 2012 IEEE
DOI 10.1109/MNCApps.2012.34

Heming Pang et al [6] proposed a monitoring scheme based on an android smartphone. Heming Pang et al proposed to collect sensor data from the temperature sensor, humidity sensor, infrared sensor and CO2 sensor, they then process the data at a server, and send the data to smartphone terminal via the socket to display. Our research is to collect the sensor data directly to the smartphone and to do the initial level of processing in the smartphone itself and transfer the data only later to the server.

Wanhong Wu et al [7] proposed a health monitoring system that uses small wearable sensors for collecting the real-time vital signals continuously. The sensor data is transmitted using Bluetooth to the mobile phone. The mobile phone does some processing in phone itself. The user's health status is sent periodically, using GSM, to the healthcare centers. During emergency situations alerts are automatically issued for medical aids. Our research improves on Wanhong Wu et al [7] work by considering the mobile phone power needed for developing this health monitoring application. Our research works to individually tailor the service to the patient's needs. Instead periodical transmission, we transmit data based on the risk levels of each individual patient.

Shye et al [8] studied 25 real user activities were studied for six months to elicit the high level characteristics of smart phone usage. There was a significant variation in usage behavior. Phones were used until the battery is as low as 20% and then recharged on a daily basis. Shye et al [8] studied the various components in phone that cause battery drain and the user's characteristics that cause battery drain. Falaki et al [10] experimented on the diversity in Smartphone Usage and energy estimation. 255 smartphone users were studied. Energy drain was found to depend on user interactions, applications, platform hardware and software. User behaviors were demonstrated to predict future energy drain on the smartphone.

Pathak et al [9] proposed a detailed design of a new, system-call-based, power modeling scheme and presented a detailed design of a power modeling scheme and its implementation on Android and Windows Mobile. They estimate the energy consumption of mobile applications but did not consider the energy estimation and energy optimization. In our application, we calculate the battery energy balance and concentrates on energy optimizing functionality in smartphone so that the phone will run long time before the next battery recharge.

III. SYSTEM ARCHITECTURE

The system is able to collect the sensor data to monitor the basic vital parameters such as ECG, EEG, EMG, EOG from the wireless body sensors to the patient's Smartphone using high speed Bluetooth technology. In this proposed system, SQLite database has been chosen to temporarily buffer the data in the mobile, due to its data security aspect. Confidentiality is major issue in patient's personal health information. The data can be analyzed in the phone itself to find the warning level. If the result is above a threshold a warning message will be send to the doctor and caregivers. The warning message and the stored data will be transmitted to the central database situated in the hospital. A web server is used, between the patient's mobile phone and the centralized database server. This web server helps to save the data, to the database server located in the hospital. The system also enables the doctor to view the ECG reports in his or her smartphone. System Architecture is shown in the Fig 1.

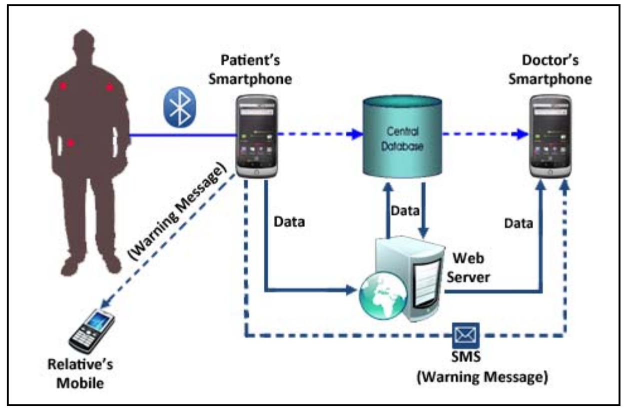

Figure 1. System Architecture

The major tasks performed by this system are as follows: reception of sensor data, processing the data, transmitting data to the central server, and transmitting data to the doctor's phone from the central database. First part of the system is the reception of sensor data to the mobile. The sensor data is received via Bluetooth. For the reception Bluetooth is chosen because of its low power consumption in Android phones[11]. After receiving the raw sensor data, it will be stored in an SQLite database or files in the phone. The data retrieved from the database is analyzed and if there is any abnormality in the patient's health the system will automatically generate a SMS warning message for the doctor and caregivers.

If the patient's condition is more stable, the frequency of data collection will be less, therefore power reductions can be considered. In this case, transmission to the central server will only occur if a warning level is reached or when the buffer becomes full. In order to reduce power consumption for the mobile phone, highly prioritized relevant data will be transmitted to the central database server for further processing and analysis and less prioritized data will be cleared from the database in phone. If the patient's condition is more serious, the frequency of data collection will be more and the data in its entirety will be transmitted to the central database. When the doctor wants to view a patient's ECG report on a mobile phone, a request can be sent to the central database server through the web server. When the web server receives the doctor's request, it will retrieve the data from the central server database and transmit it to the doctor's mobile phone. The main advantage of using a web server is its ability to transfer a large amount of data in single transmission, which reduces power consumption.

IV. ENERGY ESTIMATION AND OPTIMIZATION

Other energy consuming applications and functionalities, apart from the health monitoring application, also consume a smartphone's energy. A smartphone's energy can be

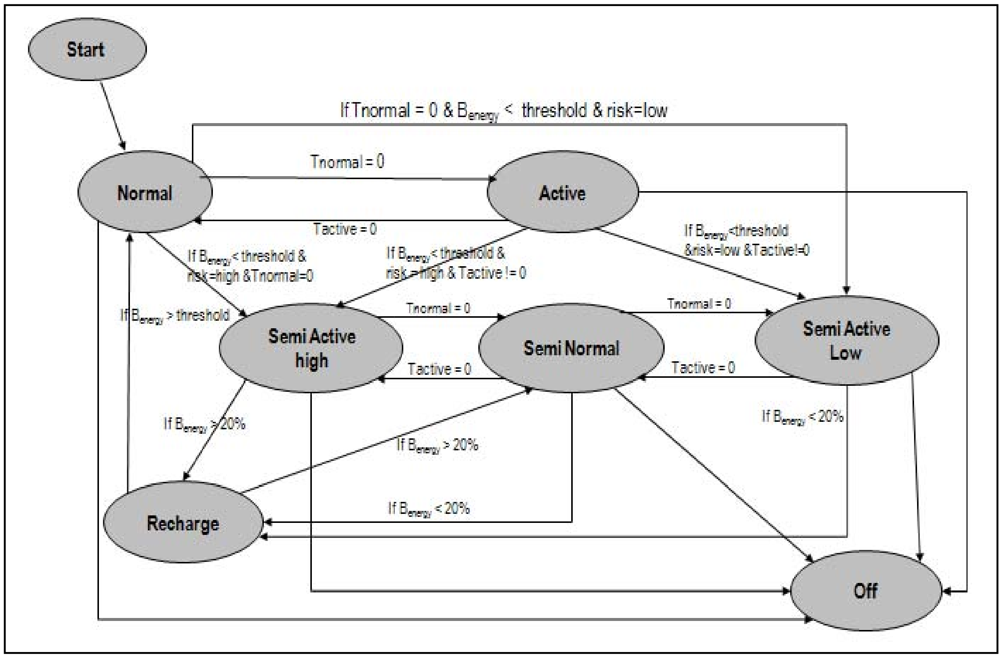

Figure 2. State Transition Diagram for Energy Optimization Algorithm

consumed by the brightness of the screen, adobe flash, and widget updates, entertainment applications (i.e. games), unused networks (i.e.: Wi-Fi, GSM, Bluetooth), and other web applications (i.e.:skype, facebook, gmail, twitter etc.).

For the purpose of the energy optimization, it is assumed that: the maximum energy available in a smartphone corresponds to a fully charged battery. The risk levels of the patients are classified as high risk patients and low risk patients. For high risk patients, the reception of the data from the sensor is more frequent than the low risk patients. T_{active} (application active time) and T_{normal} (application inactive time) will be based on the risk level of the patients. $T_{active/normal}$ will vary depending on the risk levels. The available power for the phone is calculated by reducing the total energy consumed by the phone from the maximum available energy (fully charged battery). When the balance energy B_{energy} reaches the threshold level $E_{threshold}$ then we have to execute energy optimization. This energy reduction method for both high and low risk patients includes: reducing the brightness of the phone, switching off unused networks (WiFi and GSM), adjusting widget updates timing, disabling adobe flash, and disabling applications that are not used. If the patient's condition is more stable, the frequency of data collection will be less, therefore power reductions can be considered. So, instead of processing the entire buffered data, we process only minimum samples of data. Also, transmission to the central server will only occur if a warning level is reached or when the buffer becomes full. In order to reduce power consumption for the mobile phone, highly prioritized relevant data will be transmitted to the central database server for further processing and analysis and less prioritized data will be cleared from the database in phone.

The state transition diagram of the Energy optimization algorithm is in the Fig 2. The algorithm is based on the different transition which is depicted in the diagram. The different states in the state transition are Start, Normal, Active, Semi Active High, Semi active low, Semi Normal, Recharge and Off State. In the normal state, the normal smartphone functionalities are there and in the active state along with the normal smartphone functionality the healthcare application also running. In Semi Normal some of the smartphone functionalities are disabled to reduce the energy consumption. The initial state of the state transition is the Start state. After the start the system will go in to the Normal state. The transition from Normal to Active happens when the T_{normal} time interval reaches zero and the balance energy exceeds threshold.

In Active State reception of data will happen and save the received data temporarily in phone itself. If the risk is high the data is transmitted to the central database. If the risk is low transmission to the central database happens when the buffer gets full. If a warning level is reached, energy consumption will depend on the transmission to the centralized database server and the number of emergency numbers for that particular patient. The transition from Normal to Semi Active Low happens when the T_{normal} time interval reaches zero, the balance energy comes below the threshold and the risk of the patient is low. The transition from Normal to Semi Active High happens when the T_{normal} time interval reaches zero, the balance energy comes below the threshold and the risk of the patient is high. The transition from the Semi Active High to Semi Normal happens when the T_{normal} reaches zero. Similarly the transition from the Semi Active Low to Semi Normal also happens when the T_{normal} reaches zero. The transition from the Semi Active High, Semi Active Low and Semi Normal to the Recharge will happen if the balance energy reaches below 20%. The transition from the Semi Normal to Semi Active High happens when the T_{normal} reaches zero and the risk is high. Similarly the transition from the Semi Normal to Semi

Active Low happens when the T_{normal} reaches zero and the risk is low. Except the Recharge state all other states can go to the Off state.

A. Experimentation and Results

'HTC Google Nexus One' was chosen for the algorithm implementation [12]. According to research [8] [10], a smartphone with normal usage has a maximum battery life of 24 hours. The company specifies that the talk time available, before recharge is required, is 10 hours over 2G and 7 hours over 3G[12]. However, the battery life of the 'HTC Google Nexus One' smartphone, used for this experiment was found to be only 20-24 hours, with normal usage. Fig 3 shows the energy drain comparison, of the smartphone battery life period, for a high risk patient, with health monitoring application, a low risk patient with this health monitoring application, a normal user when there is no optimization, a high risk patient with optimization by disabling the group of applications and for low risk patients with optimization. When there is no optimization the phone battery power will last for a maximum of 24 hours for a normal user, maximum up to 20 hours for a high risk patient and maximum up to 22 hours for a low risk patient. The results showed that even for a high risk patient the optimization algorithm extended battery life by 6 hours more. For a low risk patient by optimization algorithm extended battery life by 8 hours more.

V. CONCLUSION

The proposed system enables any android smartphone to be used for collecting and temporarily storing patient's health monitoring data. The system performs the first level analysis the patient's phone. If any monitoring abnormality occurs, a warning message can be automatically sent to the doctor. The system also provides a Graphical User Interface for the doctor's mobile phone. This research introduces an energy optimization algorithm to increase the battery life of smartphone 8 hours for a low risk patient and 6 hours for high risk patients.

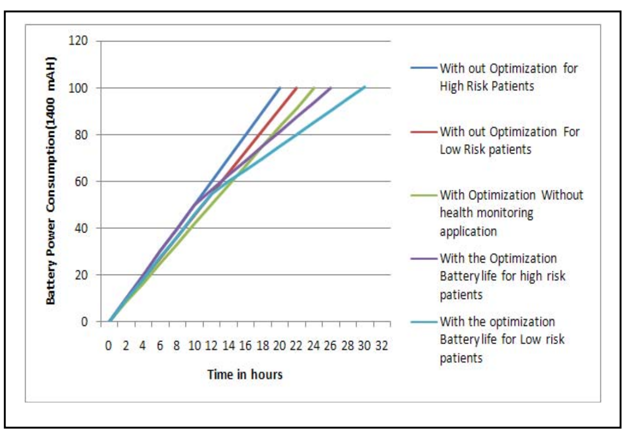

Figure 3. Energy Saving graph for energy optimization algorithm

As a future work we can integrate this system with an existing Hospital Information System. Security issues will also be considered in the future work. Also the integration of other health monitoring systems such as EMG, EEG, diabetes etc. could be added.

ACKNOWLEDGMENT

We would like to express our immense gratitude to our beloved Chancellor Sri. Mata Amritanandamayi Devi for providing motivation and inspiration for doing this research work. We also thank Thapasya Seingh for her valuable advices and help.

REFERENCES

[1] Y. X. H. Y. S. M. Hongwei Huo, Hongke Zhang, "An elderly health care system using wireless sensor network at home," Third International Conference on Sensor Techonologies and applications, pp. 158 – 163,2009.

[2] H. H. Y. X. Yaoming Chen, Wei Shen, "A smart gateway for health care system using wireless sensor network," 2010 Fourth International Conference on Sensor Technologies and Applications, pp. 545 – 550,2010.

[3] W. G. A. E. S. Md Abdur Rahman, Mohammed F.Alhamid, "An ambient intelligent body sensor network for e-health applications," IEEE International Workshop on Medical Measurements and Applications, pp. 22 – 25, 2009.

[4] M. G. Sungwon Yang, "Personal gateway in mobile health monitoring,"Smart Environments to Enhance Health Care, pp. 636 – 641, 2011.

[5] S. B. John Whipple, William Arensman Marian, "A public safety application of gps-enabled smartphones and the android operating system,"Proceedings of the 2009 IEEE International Conference on systems,Man and Cybernetics, pp. 2059 – 2061, October 2009.

[6] L. Y. K. Y. Heming Pang, Linying Jiang, "Research of android smart phone surveillance system," Proceedings of the 2010 International Conference On Computer Design And Applications, vol. 2, pp. 373 – 376, 2010.

[7] Y. Z. Y.-P. Z. Wanhong Wu, Jiannong Cao, "Waiter: A wearable personal healthcare and emergency aid system," Proceedings of Sixth Annual IEEE International Conference on Pervasive Computing and Communications, pp. 680 – 684, 2008.

[8] G. M. P. A. D. Alex Shye, Benjamin Scholbrock, "Characterizing and modeling user activity on smartphones: Summary," Proceedings of the 2010 ACM, June 2010.

[9] M. Z. P. B. Y.-M. W. Abhinav Pathak, Y. Charlie Hu, "Fine-grained power modeling for smartphones using system call tracing," Proceedingsof the 2011 ACM, April 2011.

[10] S. K. D. L. R. G.-D. E. Hossein Falaki, Ratul Mahajan, "Diversity in smartphone usage," Proceedings of 2010 ACM, pp. 179 – 194, June 2010.

[11] "Android Architecture," http://developer .android. com/what-is-android.html, 2010, [16-January-2012].

[12] "Google Nexus One"http://www.gsmarena.com/ htc _ google_ nexus _ one-3069.php

[13] "Nexus One Battery Life" http://www. technoon. com/ how-to-improve-nexus-one-battery-life.html