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OGUNDUYILE O. OLUWAGBENGA
Department of Computer Science, Tshwane University of Technology, Pretoria, South Africa, ooluwagbenga@gmail.com

KGOETE S. FRANS
Department of Computer Science, Tshwane University of Technology, Pretoria, South Africa, kgoetesfrans@gmail.com

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IMPLEMENTATION OF SERVICE ORIENTED WEARABLE SYSTEM FOR PREVENTIVE HEALTHCARE

OGUNDUYILE O. OLUWAGBENGA[1], KGOETE S. FRANS[2]

[1,2]Department of Computer Science, Tshwane University of Technology, Pretoria, South Africa

Abstract- as an emerging state-of-art technology, wearable systems have been applied to various real life situations and healthcare is one of such important areas. This study reports the implementation of a prototype Service Oriented Wearable System (SOWS). After detailed analysis of healthcare requirements, a system based on Service Oriented Architecture (SOA), wearable devices and sensor networks is implemented to provide continuous remote monitoring, diagnosis, immediate response and treatment for the purpose of preventive healthcare. Technologies based on SOA and sensor networks can support cost effective ubiquitous access to healthcare services, real time service provisioning and processing of heterogeneous data for various wearable devices such as ECG, accelerometer, SpO_2 and location sensors. Wearable devices collect and transmit bio signal data to a wearable computer through IEEE/Wi-Fi network. Bio signal data is then uploaded to a Health Server PC (HS-PC) for analysis and storage where it will be accessed by doctors, paramedics or any other authorized personnel.

***Keywords**- Bio signals, Healthcare, PDA, Preventive, SOA, Wearable*

I. INTRODUCTION

With the pace of life in today's world growing faster, people are experiencing more physical and psychological pressures, this increases potential risks of many chronic health conditions such as high blood pressure, coronary disease etc [1]. A survey shows that, the incidence of "sub-health" (health status between health and illness) has increased in recent years especially among those engaged in white-collar jobs and are often under high mental stress[1]. Recent improvement in people's standard of living, their changing life styles as well as the acceptance of education has resulted in people being more aware of the importance of healthcare and desire to get timely preventive health examination. Therefore, there is an increase in demand for healthcare service systems that are capable of providing personal healthcare monitoring and early warning of diseases. Advancement in information and telecommunication technology, has led to the development of miniaturized healthcare devices and wireless networks that can be integrated to develop applications for monitoring, collecting and analyzing bio signals data. These applications can provide a way to prevent the prevalence of chronic diseases among people by enabling continuous monitoring of their health and providing an early warning mechanism. To effectively monitor and provide an early warning mechanism, they must ensure interoperability among existing heterogeneous data, have high computational power to process data and allow cost effective ubiquitous access service varieties. When fully implemented they serve as a system for preventive healthcare.

A preventive healthcare system holds the promise of maintaining wellness, support for independent living, prevention and early treatment, along with emergency intervention as and when needed. Moreover, applications that support preventive healthcare can be implemented to function ubiquitously i.e., anywhere anytime. To enhance the ubiquitousness of these applications, they are developed into wearable systems with the ability to monitor different bio signals [2-5], aiming at providing easy-to-use and affordable solutions for serving users/patients. Wearable systems involve the deployment of biomedical sensors around human body to proactively collect bio signals and transmit them wirelessly to a base node for processing [4]. These wearable systems continuously interact with neighbouring network nodes and can access services from the web/cloud/grid environment at runtime [5]. However, ensuring effective preventive healthcare mechanisms continues to remain a challenge using wearable system. By preventive healthcare mechanism we refer to providing affordable, easy accessible services, real-time monitoring, analysis, diagnosis, early detection and warning mechanism.

The prototype Service Oriented Wearable System (SOWS) reported in this study is an effective service provisioning tool for preventive healthcare. It implements both analysis of bio signal data and early warning mechanism for diseases using biomedical sensors and sensor networks. Biomedical sensors (hereafter referred to as wearable sensor systems) include a chest sensor band with 2 electrodes, an accelerometer, and pulse oximeter implemented on a fio node. The 2 electrodes and accelerometer acquire ECG and activity signals respectively while pulse oximeter to acquire oxygen saturation value and heart-rate. The wearable sensor system continuously

[1]World Health Statistics (2010)

collects bio signal data from body of a patient and transmits data to a base station (hereafter referred to as wearable computer) for analysis. Analysed information is uploaded to HS-PC via internet for further analysis and storage. Results from data analysis can give feedback instantly and make suggestions to patient. Meanwhile, doctors can get their patients' healthcare information from internet and give suggestions/recommendations on daily dietary, exercise and medication. If patient's information indicates an abnormal condition after analysis, the HS-PC would send out warning information to the patient as well as send a message to their family members and doctor. All events and processes are implemented as services and communicated through Wi-Fi wireless network and internet. This gives our prototype advantages of interoperability, scalability, reuse and flexibility. The wireless network provides real time monitoring. This current study was aimed at implementing a service oriented wearable system that functions as an early detection and warning mechanism for preventive health.

II. RELATED WORKS

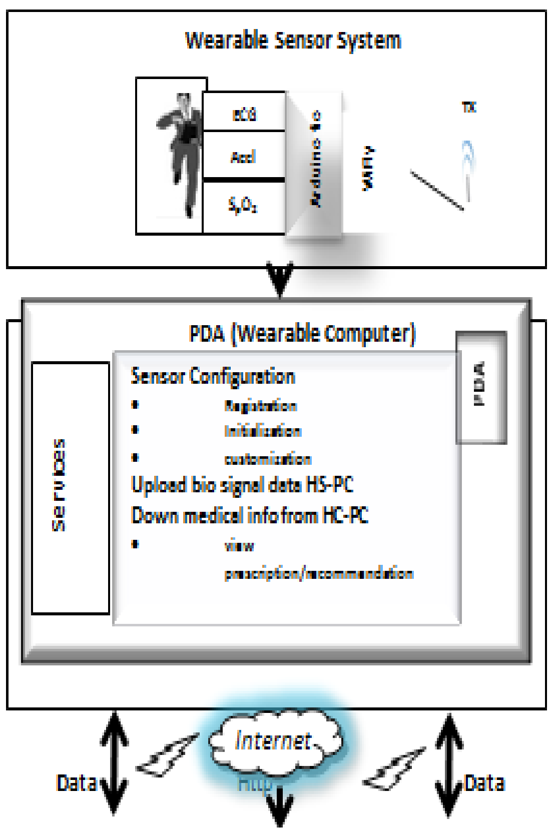
There are many promising systems implementing certain selected function or complex monitoring of a patient to prevent chronic health conditions. One of the first approaches proposed a wearable patient monitoring system, which integrates current personal digital assistant (PDA) technology and wireless local area network (WLAN) technology [6]. A wireless PDA-based monitor is used to continuously acquire the patient's vital signs. The patient's vital data are transmitted in real-time through the WLAN to a remote central management unit. A wearable patient monitoring system, facilitating early detection of Alzheimer's disease was proposed in [7]. The location and movement of a patient is tracked and reported to a local database with via wireless sensor communication. The collected data is then transmitted via the Internet to a decision engine (on a remote site). In another approach a mobile phone was proposed as a client-side part that communicates with the central device by GSM network [8].

An alert management mechanism has been included in back-end healthcare center to enable various strategies for emergency alerts triggered by automatically recognized situations. [9] developed a comprehensive physiological and environmental information processing platform on the basis of wearable sensors for services to counter lifestyle diseases. Their work aimed at developing a preventive healthcare system to improve quality of life of individuals. [10] proposed a personalized healthcare preventive system to maintain the health of individuals as well as receive evidence of feedbacks. Their proposed system introduced general medical check-ups, ubiquitous sensing, and plasma amino acid analysis as system core components. [11] presented a laboratory development of a wearable system, which makes use of unconventional techniques for physiologic monitoring. With its integrated textile electrocardiogram (ECG) electrodes, intelligent finger-ring photoplethysmogram (PPG) sensor, miniaturized optical fibre-based temperature sensor, eye dynamics monitor, global positioning system (GPS) module, and wireless capability, their work demonstrates a feasible solution for preventive health system.

This current study improves on these existing preventive healthcare systems using wearable devices, sensor and service oriented architecture. It designs and implements a system that does not only effectively monitor a patient's health but through integration of various technologies supports preventive health, it also provides patients with various important services to manage their healthcare needs more effectively.

III. SYSTEM ARCHITECTURE

Fig. 1 shows the overall SOWS architecture which consists of Wearable sensors systems, the wearable computer and HS-PC. The wearable sensor system consists of a chest band (2 electrodes and an accelerometer) and pulse oximeter. It collects bio signal data to make features like pulsation, activity monitoring and oxygen saturation level.



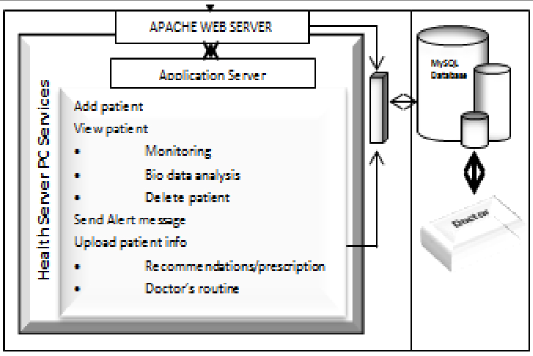


Figure 1. SOWS Architecture

The wearable sensor system is implemented on a fio board with a WiFly radio attached to it. Our wearable system is designed to be of minimum weight, greatly reduced form factor and low power consumption

WiFly radio is used to transmit bio signals data from wearable sensor system to wearable computer through WiFi. The architecture uses a PDA with 400MHz X-Scale processor, 64Mb RAM and IEEE 802.11/WiFi LAN capability as wearable computer. PDA allows for real time data processing and higher processing power. Integrating PDA with our wearable sensor system accelerometer gives our system the capability to determine location.

The architecture is designed to provide two types of services, wearable computer services and the HS-PC services. The operational code for a wearable computer service is executed in the wearable computer and downloaded through the Wide Area Network (WAN) from the healthcare service providers. Events are processed by the wearable computer, and a healthcare service is provided according to the events. These events enables configuration of the wearable sensor systems, in terms of: registration, initialization and customisation. Some events also enable patients upload bio signal data to HS-PC, download information (recommendations/ prescriptions) from the HS-PC.

The HS-PC services are provided in remote healthcare servers operated by a medical center or healthcare service providers. Services are located in remote healthcare service servers. The events should be transferred via the WAN, which are needed for the remote service.

IV. SYSTEM IMPLEMENTATION

Fig. 2 shows the SOWS data transmission process. The chest band with conductive fabric electrodes linking to the ECG and accelerometer is designed with a two-layered fio board. The fio board is placed on top while sensors board with the ECG and accelerometer is placed below with a button connecting both together.

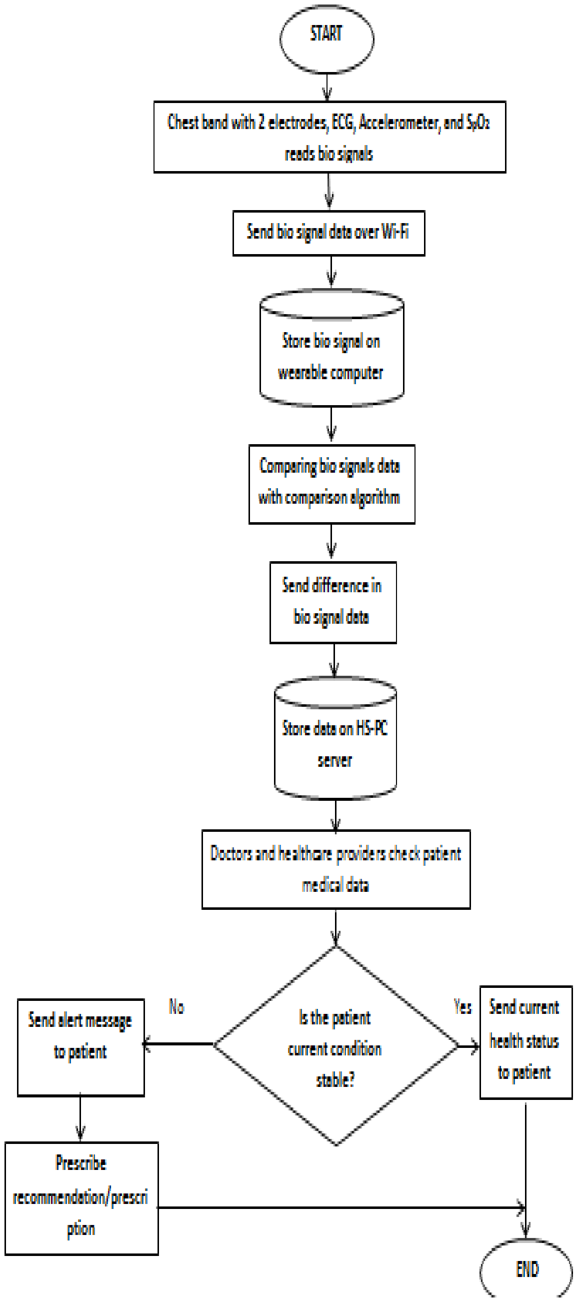


Figure 2. Prototype SOWS data transmission process

When sensor system is turned on chest band with conductive electrode collects both ECG and accelerometer bio data signals. The accelerometer monitors the patient's movement on the X, Y and Z axis. These movements are translated into motion states which correspond to the activities of the patient with the following states existing; resting (A_1), walking (A_2), running (A_3) and falling (A_4). Motion measurement is obtained by using the maximum recorded values from the accelerometer within a 1-second cycling period and based on these values, the respective states were determined. During measurement tests ECG and accelerometer signals were monitored continuously and recorded each minutes for 9 minutes. ECG signals showed record of events occurring as heartbeats while accelerometer showed patient's activity in terms of movement. Fig 3-5 shows measurement results of ECG, accelerometer and SpO_2 when a patient performs the following activities; resting (A_1), walking (A_2) and running (A_3).

Measurement for SpO_2 is based on Lambert Beer's law of spectral analysis which relates the concentration of absorbent in solution to amount of light transmitted through the solution [12]. Blood is circulated from the heart to other parts of the body systematically. The blood vessels blood volume undulates when the heart contracts and relaxes in every cardiac cycle. When a beam of light irradiates fingertip (or ear lobe), absorbed and transmitted light intensities changes periodically. This continuous change in light intensities is recorded as Photoplethysmogram (PPG). Knowing the intensity, the path length and extinction co-efficient of a substance (here, oxygenated hemoglobin (HbO_2) or deoxygenated hemoglobin (Hb)) at a particular wavelength, we determine oxygen saturation by measuring light transmitted at two different wave lengths through the fingertip. Light spectrum at the red region around 660nm reduced hemoglobin (Hb) has higher extinction co-efficient compared to HbO_2. While at the near-infrared region of the light spectrum around 940nm, the extinction co-efficient of Hb is low compared to HbO_2. Using differences in extinction co-efficient we get a value for oxygen saturation. By measuring elapsed time between peaks of infrared light signal we get a value for heart rate. The pulse oximeter test calculations report hearts rates in the range of 30 – 245bpm and SpO_2 values from 0-97%.

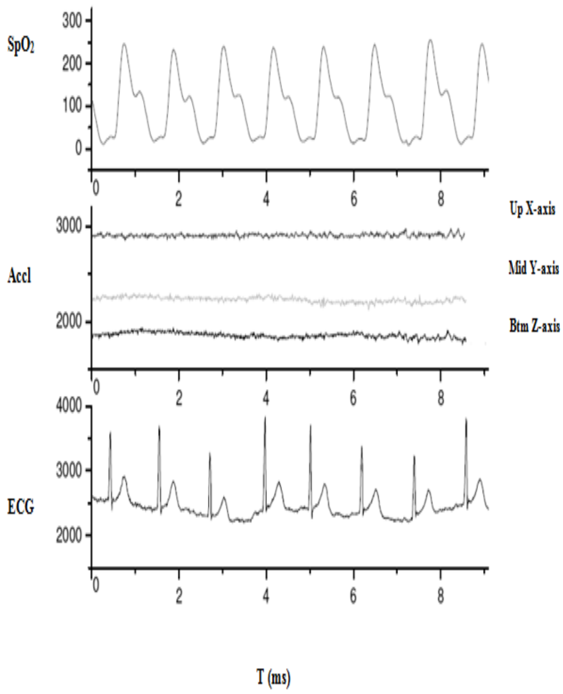


Figure 3. User resting (A_1)

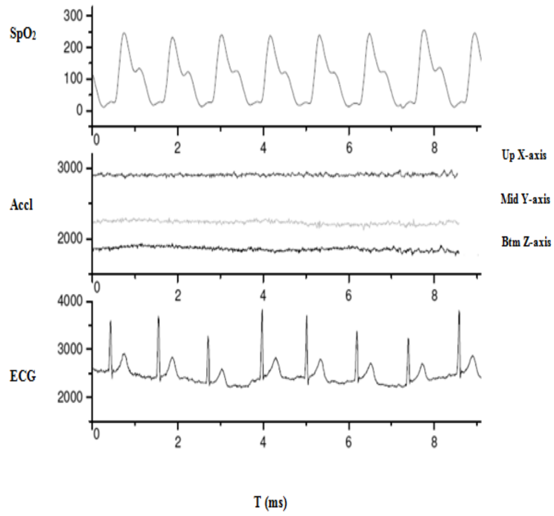


Figure 4. User walking (A_2)

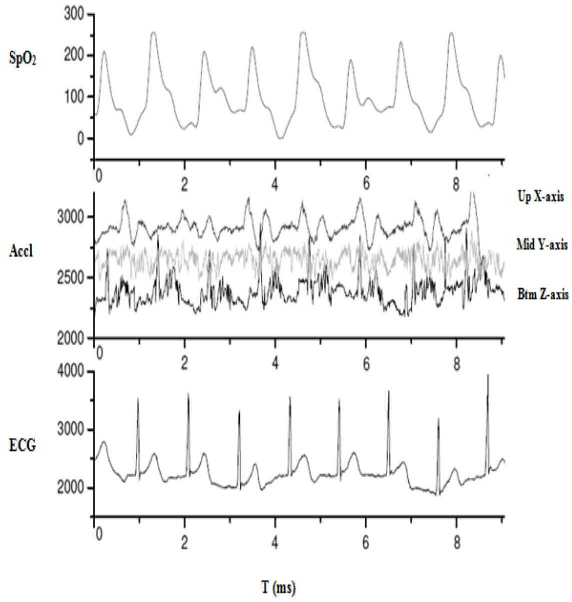


Figure 5. User running (A_3)

A python application is developed to run on the PDA to collect bio signal data from the wearable sensor systems. The python APIs (Application Program Interfaces) manage the AP's processes such as setting up wireless connections to both wearable sensor system sensors and HS-PC. On receiving data from the wearable sensor system biomedical sensors, sends data to the HS-PC. A web application server runs on the HS-PC, this server mines data received and determines health risks using logistic regression. Functionality on the web application server is implemented in HTML/PHP.

The medical doctors and health service providers can view the patient's ECG, activities and SpO_2 health status in real time through a web application over a web browser. An abnormal condition triggers the alert signal, which is received by both patient and medical doctors and in high risk situations the GPRS on the android can be used to determine the patient's location. The implementation of various off-the-shelf components and open source software (Python, PHP, MySQL and Apache Tomcat) helps to reduce the overall cost of SOWS

V. CONCLUSION

The paper reports the implementation of a service oriented wearable system for preventive healthcare. The system proactively monitors a patient's bio signal data to get information on the patient health status and recommend diagnostic services. This prototype is one of the first that successfully integrates service oriented technologies with biomedical sensors to monitor bio signal data. The SOWS ensures interoperability between heterogeneous devices and technologies, data representations, scalability and reuse. It allows remote health monitoring, through activity information such as ECG analysis, body positions and SpO_2 parameters, to know a patient's health status. However future study is required on different medical conditions in clinical and ambulatory settings to improve on providing tools for preventive health.

REFERENCES

[1]. F. Xiaomao, H Chenguang and L Ye, "A Novel Application- Oriented Cloud Platform for Preventive Healthcare". 4th International Conference on Cloud Computing Technology and Science 2012. pp. 705-710.

[2]. S Sneha, L. Virginia and M. Bick. "Ubiquitous and Pervasive Computing in Healthcare". 15th Americas Conference on Information Systems. San Francisco, California (2010).

[3]. O.O Olugbara, S.O. Ojo and M.O. Adigun. "A Grid enabled framework for ubiquitous healthcare service provisioning", Advances in Grid Computing. Zoran Constantinescu (Ed.), InTech, Croatia, 2011. pp. 229-252.

[4]. H. Wang, H. Choi and N. Agoulmine., M.J. Deen and J.W. Hong. "Information-based sensor tasking wireless body area networks in U-health systems". CNSM 2010. pp. 517-522.

[5]. O.O Ogunduyile, O.O Olugbara, and M Lall. "Healthcare Monitoring System Using a Collection of Sensor Nodes". International Journal of Emerging Technology and Advanced Engineering (IJETAE). 2013 3(2), pp. 632-639.

[6]. U. Anliker, J. A. Ward, P. Lukowicz, G. Tr · · oster, F. Dolveck, M. Baer, F. Keita, E. B. Schenker, F. Catarsi, L. Coluccini, A. Belardinelli, D. Shklarski, M. Alon, E. Hirt, R. Schmid, and M. Vuskovic, "AMON: a wearable multiparameter medical monitoring and alert system," IEEE Trans. Inf. Technol. Biomed., vol. 8, no. 4, , December 2004, pp. 415–427.

[7]. H.-T. Cheng, W. Zhuang, "Bluetooth-Enabled In-Home Patient Monitoring System: Early Detection Of Alzheimer`s Disease", IEEE Wireless Communications, Fetbuary 2010, pp. 64-69

[8]. Lee D-S, S. Bhardwaj and W-Y Chung. "New Concept of Healthcare Parameter Analysis on Sensor Node for Ubiquitous Healthcare System. Convergence Information Technology", International Conference, 21-23 Nov. 2007. pp. 1775-1780

[9]. I.Yamada, G and Lopez. "Wearable sensing systems for healthcare monitoring," VLSI Technology (VLSIT), 2012 Symposium on , vol., no., pp.5,10, 12-14 June 2012

[10]. M. Kuroda and O. Tochikubo. "Tailor-made preventive medicine integrating amino acid check-up and its application toward disaster-stricken areas," Engineering in Medicine and Biology Society (EMBC), 2012 Annual International Conference of the IEEE , vol., no., pp.2116,2119, Aug. 28 2012-Sept. 1 2012

[11]. K. Hung, C.C Lee, W.M Chan, Choy S-O and P. Kwok. "Development of a wearable system integrated with novel biomedical sensors for ubiquitous healthcare". Engineering in Medicine and Biology Society (EMBC), 2012 Annual International Conference of the IEEE, pp. 5802-5805.

[12]. M. Mendelson, R.J Duckworth and G.Comtois. "A Wearable Reflectance Pulse Oximeter for Remote Physiological Monitoring.". 2006 International Conference of the IEEE Engineering in Medicine and Biology Society (2006), pp. 912 – 915

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