Use of IPv6 and Biosensors to Assist People with Heart Problems in Mauritius

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ABSTRACT

The rapid growth of multi-access devices inter-connected via Body Area Networks (also referred as Body Sensor Networks, BSN) has recently played a vital role in the healthcare sector. The different wireless technologies available today facilitate the co-existence of BSNs and mobile healthcare applications. In this paper, we review the use of biosensors to monitor or collect data, such as glucose levels and heart rate. The biosensors are connected to an android device which provides the necessary information to the patient. Moreover Cloud computing technology is also used to connect the biosensors and relay data and information to the medical centre. The Internet of Things (IoT) has been extensively researched on over the last decade and it has gained more attention and traction lately. The fundamental concept of IoT is the ability to use electronic devices that monitor or collect data, connected to a public or private cloud, allowing them to initiate certain events. For this scenario, each biosensor will have its own IPv6 address.

KEYWORDS

Body Area Networks, Biosensors, Cloud computing, Internet of Things, IPv6, emergency system.

1.0 INTRODUCTION

Currently, there are many cases of heart disease all around the world. Health Organization (WHO), an estimated 17.5 million (30%) of all global deaths in 2005 are associated with CVD (cardio vascular disease) and it is estimated that by 2015, CVD can be the leading cause of death in the developing countries [1]. According to the European cardiovascular disease statistics 2008, a staggering figure of over 4.3 million deaths in Europe are caused by CVD, and it is overall estimated to cost the EU economy €192 billion a year [2]. According to statistics Mauritius 2013 [3], there had been 713 surgery cases of cardio vascular disease in Mauritius. In 2006, the percentage of death caused by heart diseases was 8.2% in the male category and 7.4% in the female category. In 2013, the percentage of death in the male and female category is 18.2% and 17.1% respectively [3]. This shows that there has been a consequent increase of CVD not only in Mauritius but also around the world.

Today, with emerging technologies such as remote sensing networks, healthcare assistance is becoming much easier. Recently, the rapid growth of multi-access mobile devices interconnected with different wearable vital sensors via Body Area Network [4] (BAN, also referred to as a Body Sensor Network or BSN) plays an increasingly important role in healthcare and provide significant solutions for home healthcare, remote patient monitoring and real-time tele-consultation. The spreading of heterogeneous and overlapping wireless access technologies make possible to mobile healthcare applications to use the available network resources efficiently and call into being the ubiquitous Internet connection for these applications. The use of this wireless sensor technology in medical practice not only allows a supreme level of complexity in patient monitoring with regards to existing parameters (such as vital signs), but also offers the prospect of identifying new ways of diagnosing and preventing disease.

2.0 IPv6

IPv6 is the successor protocol to the currently used IPv4 which has an acute shortage of the available address space for allocation to the exponentially increasing number of devices both in the wired and wireless field.

2.1 Features of IPv6 that Makes It Promising to Be Used in Healthcare

IPv6 has been developed keeping in mind the increase in transition from the wired to the wireless technology and the increasing number of added nodes requiring specific network addresses. This makes IPv6 better suited to network devices over a wireless network such as the biosensors [5]. The points below elaborate some features of IPv6.

2.1.1 Enhanced Security Features

In IPv6, IP security (IPsec) is part of the protocol suite. IPsec is a set of security specifications originally written as part of the IPv6 specification. When the network is being used for medical purposes, it will carry large amount of confidential and sensitive information from the biosensors to the database every milli-second. Hence, security across the network becomes mandatory.

2.1.2 Optimized for Real-time Networks

IPv6 protocol is conceptualized for real-time wireless networks. This adapts very well with the network requirements of the biosensors used in the medical industry. As a matter of fact, IPv6 biosensors are better placed to provide all the real-time information requirements in the medical industry.

2.1.3 Optimized for High Data Transfer rate

The IPv6 protocol is tested to support communications over high-speed data networks (Gbps data networks). In order to transfer data from biosensors to the medical database, a relatively high speed is required and IPv6 provides this facility.

3.0 BIOSENSORS TO BE USED FOR DATA COLLECTION

In order to monitor the patients, collection of the necessary biomedical data is important and the biosensors which fit for this application are going to be explored in this section. And the biosensor which can be implemented in the concept is described below.
In this context, we consider 4 types of biosensors, namely the Samsung Gear Fit, the Jawbone Up3, the Fitbit Charge HR and the Zephyr Bio-patch. The four types of Biosensors are described below.

3.1 Samsung Gear Fit

The Samsung Gear Fit [6] is basically a smart-watch. Much like other smart-watches, it keeps us connected by allowing us to check up with emails, SMSs, incoming calls and third party applications. In addition, it is fitted with a hybrid fitness manager. Once personalized, this tracker will have the ability to monitor the patient's heart rate and daily exercise activities. By making use of a wearable device, which has sensors like an accelerometer and a gyroscope, the remote sensor allows data such as pedometer data, user activity events to be collected. The information gathered can be read from a host smart-phone to which the Gear Fit is connected. The Gear Fit establishes connection via Bluetooth 4.0 LE with the Android device. Bluetooth low energy is anticipated to provide reduced power consumption. It uses 2.4 GHz frequencies and the maximum data rate is 1 Mbits/s. An application package needs to be installed and configured on the android device. Moreover, due to Android permissions, the Gear Manager

must be installed first, followed by the remote sensor service and lastly the remote sensor application need to be installed. If the order is reversed, the remote sensor may not work properly. The remote sensor package is supported on Android 4.3 or above.

3.2 Jawbone Up3

The Jawbone Up3 [7] is the most recent fitness tracker from the Jawbone series which is commercially available. This fitness gadget is conceptualized and built by Jawbone, a leading software intelligence industry. The Jawbone Up3 has a sleek, power-efficient design and is embedded with bio-impedance sensors which measure heart rate count, hydration, respiration and temperature tracking. It is compatible with both IOS and Android systems. Moreover, the Jawbone application is currently one of the best in the healthcare sector. The application displays basic information about one's steps and sleep in a much elaborated chart. But, what Jawbone does with that information makes all the difference. Its smart coach feature monitors one's activity and makes useful suggestions.
However, fitness kit does not have a display to show progress and time. And it does not offer live heart rate reading.

3.3 Fitbit Charge HR

The Fitbit Charge HR [8] is a health tracker manufactured by the Fitbit Company which is known for its fitness products which help to improve one's health by keeping track of one's activity, exercise, food, weight and sleep. The Charge HR also makes use of the Bluetooth 4.0 LE technology to sync with devices. It has the ability to track 7 days of detailed motion data-minute by minute. Moreover it stores heart rate data at 1 second intervals during exercise tracking and at 5 seconds intervals at all other times. It is compatible with the IOS and the Android platform.
However, there is an issue of connecting this device to the cloud due to its restricted software and design. Also, this health tracker is not water proof. This may cause an inconvenience to monitor patients on a 24 hour basis.

3.4 Zephyr Bio-patch (BH3-M1)

The Zephyr bio-patch [9] is a sensor designed to make remote patient monitoring easy with its light-weight sensor that can be easily attached to the patients using standard Electrocardiography (ECG) electrodes. Like the Gear Fit, the Zephyr bio-patch uses Bluetooth technology to transmit data like heart rate, speed, distance, respiration, breathing rate, ECG and calorie levels towards Android devices. In this architecture, just as the Gear Fit, the system will forward the measured parameters to the medical centre. In order to pair with this sensor, we have to rely on the Android SDK's Bluetooth Device class. Also, there are dozens of applications available which are compatible with the BH3-M1. Additionally, the Zephyr SDK allows us to collect and process vital data easily on the host smart-phone. The Zephyr protocol and the HRSpeedDistPacketinfo classes are provided by the Zephyr SDK. And these classes enable communication and reception of the necessary information (heart rate, calorie levels, breathing rate).

Following the above details on the biosensors, the Samsung Gear Fit and the Zephyr Bio-patch are going to be used. The Gear Fit is being used because it offers the platform to personalize the device as per the system requirements. Also, Android wear is getting steadily better with advancing technologies. Compared to the other health trackers the Samsung Gear Fit gives more accurate results.
As for the Zephyr Bio-patch, it is manufactured by Zephyr Technology; a leading company specialized in designing and manufacturing healthcare devices. And its personalized SDK enables rapid implementation and synchronization with a smart phone and to the cloud.

4.0 SYSTEM DESIGN

This section elucidates the two different architectures that are set up in order to link the biosensors to the android device and to the private cloud.

4.1 System Architectures

Figure 1 shows the different layers that exist between the wearable device and the host device. It also shows how both devices are interconnected via Bluetooth.

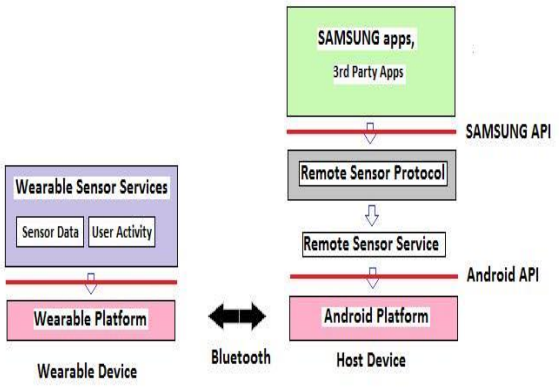

Figure 1. Architecture between the biosensor and the android device [10]

Figure 2[11] shows the overall structure, that is, how the wearable device is connected to the cloud and how information is relayed from the cloud to the healthcare assistance

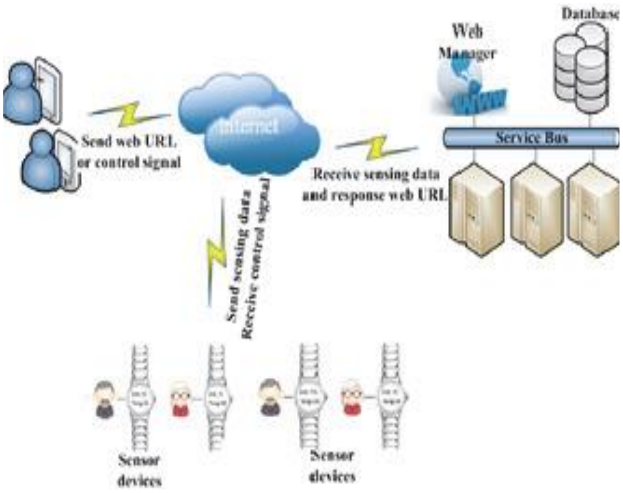

Figure 2. Architecture linking the biosensor to the private cloud

4.3 Healthcare on Cloud

The biosensors are linked to both the Android device and to the cloud for the sake of the patient's safety. In a worst case scenario, it can happen that a particular patient passes out. At that particular time, as the patient will not be able to use his Android device, the biosensors will automatically alert the closest healthcare assistance via the cloud connection.
With this system, a noise filtering algorithm along with a medical diagnosis system needs to be set up on the cloud platform. The noise filtering algorithm helps the medical diagnosis system to adjust and correct biological data sent by the biosensors.

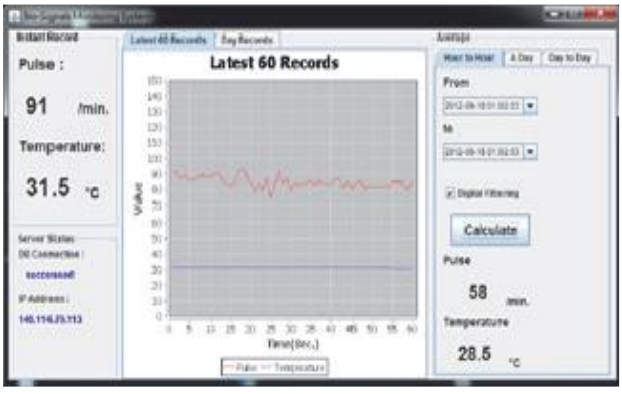

Figure3: The medical service on cloud platform. [11]

4.2 GPS Tracker

The wearable device equips a GPS module. Therefore, the medical system can send the location of the patient to the ambulance as soon as possible.

4.3 Application Design

A mobile Software Development Kit (SDK) is provided by Samsung which allows applications to be developed for the Gear Fit. There are 16 independent packages included in the SDK, one of which being the Remote Sensor Package. The application is implemented on an Android system. And, the different functions of the application include real-time blood glucose level, calories level, and the health condition of the patient as history view. Unfortunately, the SDK is currently in beta release state, due to which heart rate information cannot be collected with the Remote Sensor package as of now.

5.0 CLOUD REQUIREMENTS

For this particular system, a private cloud needs to be set up in order to receive all the necessary information from the biosensors. There are certain requirements concerning the cloud which needs to be met in order to have the system operational. The requirements are described in the subsections below. [12]

5.1 Heterogeneous Systems Support

The cloud management solutions should not only meet up along with the latest hardware, software solutions and virtualization, instead they should also support the existing infrastructure of the data centre. Additionally, cloud management providers must integrate with traditional IT systems in order to truly meet the requirements of a data centre.

5.2 Service Management

It is important that administrators have a simple tool to define and control the service offered in order to render the cloud computing infrastructure more productive. A service offering is a quantified set of services and applications that end users can consume through the provider — whether the cloud is private or public. Service offerings should include resource guarantees, metering rules, resource management and billing cycles.

5.3 Reliability, Availability and Security

Despite the fact that cloud computing changes the way that IT services are delivered and consumed, it is crucial that these new solutions support the same elements that end users have always prioritize. For the healthcare sector, it is of paramount importance that the cloud is fully reliable and available. For this to happen, the cloud needs to work while data remains intact regardless if a failure occurs in one or more components. Moreover, security is another prime aspect that should be integrated into every aspect of an operational architecture and process.

5.4 Visibility and Reporting

It is a requirement that data centers operations need to be visible and report on a real-time basis within the cloud environment. This ensures security, compliance, billing and charge backs along with other instruments which require high levels of granular visibility and reporting. Without strong visibility and reporting mechanisms the management of customer service levels, system performance, compliance and billing becomes increasingly difficult.

6.0 SYSTEM DEMONSTRATION

The user needs to wear the medical device so that the wearable device can save his/her life when he/she passes out and notify other people

around the patient by speaker module in the smart phone.

6.1 Health Monitor Platform

The figure 4 [12] below shows the health monitor platform. The wearable monitor device could detect the status of people's pulse, temperature and pressure. And the wearable device will sends the biological information of the user to the medical service platform and the healthcare application.

Figure 4. Health monitor platform of a patient

6.2 Health Care Application

Figure 6 [12] below shows a mobile application on Android system. Users can monitor real time EGC information in application and change the view of the history data list. The application also provides the configuration of the wearable device system. All of the information communication in the application is on the IPv6 network.

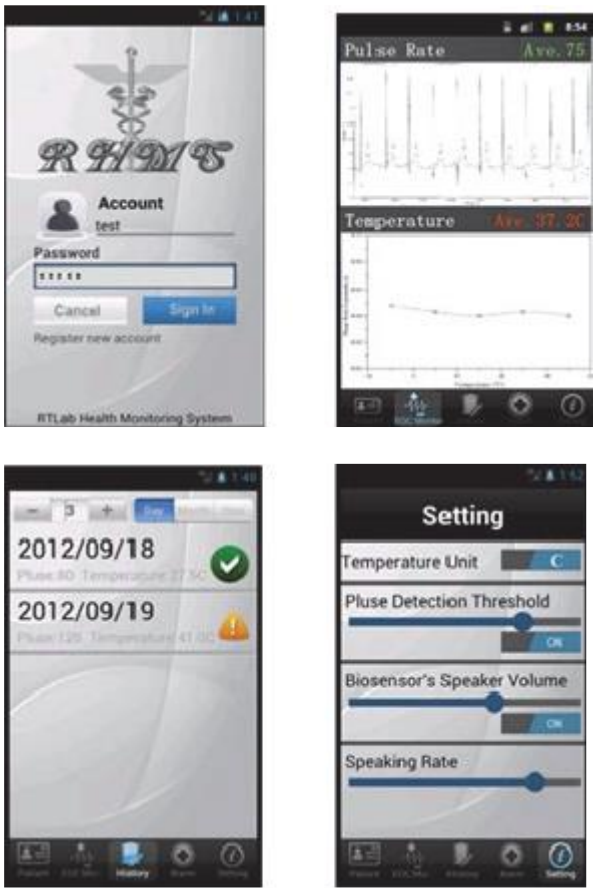

Figure 6: Healthcare application demonstration

7.0 FEEDBACK FROM PATIENTS

Some feedback of a conducted to patients using the wearable device are mentioned in the forthcoming subsections.

7.1 Promote Self-management of Chronic Disease Using Health Applications

28% of consumers said they have a healthcare, wellness, or medical app on their mobile device, up from 16% last year. Nearly 66% of physicians would prescribe an app to help patients manage chronic diseases such as diabetes, heart disease. [13]

7.2 Help Caregivers Work More As A Team

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79% of physicians and close to 50% of consumers believe using mobile devices can help physicians for better coordinate care. [13]

7.3 Put diagnostic testing of basic conditions into the hands of patients

Close to 42% of physicians is comfortable relying on at-home test results to prescribe medication. [13]

7.3 Increase patient-clinician interaction

Half of physicians said that e-visits could replace more than 10% of in-office patient visits, and nearly as many consumers indicated they would communicate with caregivers online. [13]

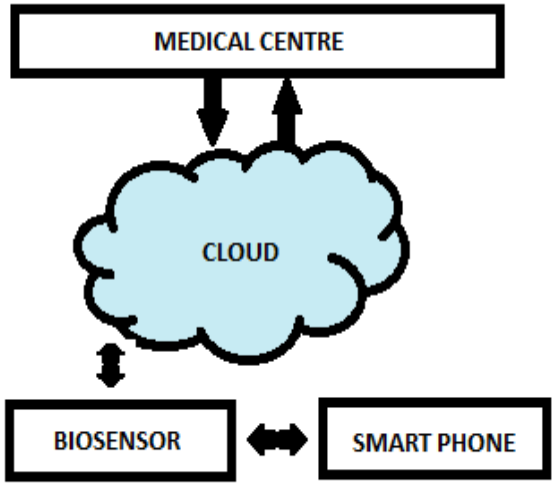
8.0 DEPLOYMENT OF THE SYSTEM IN MAURITIUS

8.1 Heart Diseases in Mauritius

Mortality rates from ischaemic heart disease in Mauritian male category are above the average of those found elsewhere. Moreover, ischaemic heart disease mortality in both sexes is among the highest recorded in the world.
The statistics mentioned in the introduction are quite alarming and this calls for a quick response to tackle this health issue.

8.2 Availability of Technology

The Samsung Gear Fit and the Zephyr Bio-patch are technologies that have already been in the market. The average price for the Samsung Gear Fit is around Rs (about 125 USD) [14] and the average price for the Zephyr Bio-patch is around Rs 2 960 (about 85 USD) [15].
Concerning the IPv6 technology, the local telecommunication service providers are already migrating towards it. The local service providers have also already made provision for cloud computing. Data centers have already been set up to support IPv6 addressing. Additionally, the 4G network will act as a background when data is transferred from the biosensors to the cloud. Currently, not much of the island's coverage area is connected to a 4G network, but eventually 4G networks will be deployed in most parts of the island. Until then the system will have to rely on 3G networks. The design below shows the block diagram of how will the system actually works.



The biosensor device connects with the smart phone via Bluetooth system. Then the smart phone is connected to the cloud system via the IPv6 network protocol where all data exchange from cloud to smart phone are stored in a database. The database is connected to the hospital, ambulance and patient relative. Figure above shows the system architecture of our emergency medical service system. We can see that our medical service system is composed of wearable health monitor device, medical service system in cloud platform and healthcare application on handheld device. The medical device system also integrates GPS module. The GPS module can locate the location of the monitored people. If the monitored people pass out, the medical service system will activate the GPS module on medical device immediately and the GPS module reports patient's location to medical service system. The medical service system will calculate a shortest path from

hospital to patient's location and find the hospital that is nearest to the patient. Then, the medical service system sends the calculated path to the hospital to save the time for picking up the patient.

8.2 Stakeholders Involved

The possible stakeholder for the project are the academia, Ministry of Health and Quality of Life, Ministry of Technology, Communication and Innovation and also Mauritius Research Council (MRC). The MRC acts a central body, advising the Government on Science and Technology issues and influencing technological innovation by funding research projects.

8.3 Cost Implications and piloting of the project.

This project can be launched on a pilot basis. At the start only a sample of volunteers (say about ten persons prone to heart disease) could be involved. Each participant would be equipped with a biosensor for close heart monitoring. These participants will of course be briefed about the system to be used and an appropriate disclaimer would be required, since health of the patients is of concern. The cloud system as well as the application will be developed according to the best practices in place. With feedback from the patients as well as doctors and other users of the system, the latter can then be upgraded to meet the needs of the patients while leveraging the best technologies available for the pilot, including the use of IPv6 and cloud computing.

9.0 CONCLUSION

In this paper we aimed to present a transparent and efficient way to monitor patients having heart diseases by using remote healthcare assistance. Each year the cause of death due to hear increasing. If necessary measures are not taken, the number of people victim of heart problems will attain an alarming number. The Healthcare sector has not been immune to the pace of innovative technologies. The mentioned biosensors can be used to monitor and save lives of patients. With all the necessary technologies available along with the local expertise, setting up of such a network infrastructure is a feasible task when considering the idea of saving lives.

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