An Implementation of Raspberry-Pi Based Health Monitoring System Using Mobile Devices

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Abstract* - Healthcare and wellness management is one of the most promising applications of information technology. The telemedical system focuses on the measurement and evaluation of vital parameters, e.g. ECG, heart rate, heart rate variability, pulse oximetry, plethysmography and fall detection. The proposed system presents a personal healthcare system that is both flexible and scalable. Employing embedded wearable low-power sensors, the system measures health parameters dynamically. For wireless transmission, these sensors are connected to a sensor node through IEEE 802.15.4/ZigBee or bluetooth. Raspberry-Pi is used as a sensor node. Because of some advantages and the features of the Raspberry-Pi can be used as a controller not just as sensor node. To assess the physical health of an individual, the system uses heart rate variability analysis in time and frequency domains. Acquired data are first stored, analyze and visualize on a server. Results of the analysis are then automatically sent to mobile devices carried by the individual or appointed healthcare providers or other mobile devices through e-mail. In this way, mobile techniques are used to support remote health monitoring services.

***Keywords* – Raspberry-pi, heath condition, heath application.**

1. INTRODUCTION

Information and communications technologies are transforming our social interactions, our lifestyle and our workplaces. One of the most promising applications of information technology is healthcare and wellness management. Healthcare is moving from reactive responses to acute conditions to a proactive approach characterized by early detection, prevention and long-term healthcare management. In this framework, health condition monitoring and wellness management are seen as significant contributors to individual healthcare and wellbeing. This is particularly important in developed countries with a significant aging population, where information technology can be employed to significantly improve the management of chronic conditions and, thereby, overall quality of life [1].

Continuous or even occasional recording of biomedical signals is particularly critical for the diagnosis and treatment of cardiovascular diseases. For example, continuous recording of an electrocardiogram (ECG) or photoplethysmogram (PPG) by a wearable sensor provides a realistic view of a patient’s heart condition by tracking such factors as high blood pressure, stress, anxiety, diabetes and depression, during normal daily routines.

Further, automated analysis of such recorded biomedical signals supports doctors in their daily work and allows the development of warning systems. This brings several benefits, such as decreased healthcare costs, by increasing health observability, collaboration among doctors and doctor-to-patient efficiency [4]. Moreover, continuous monitoring serves to increase early detection of abnormal health conditions and diseases, offering a way of improving patient’s quality of life.

Nowadays, more attention is focused on the prevention and early detection of diseases as well as on optimal management of chronic conditions. These functions are often augmented by new location-independent technologies. In order to fully realize a pervasive or ubiquitous environment, personal area networks (PAN) must be connected to internet protocol (IP)-based networks.

Such integration enables resource sharing within networks, maximizing the utilization of available resources. In addition, communication with the individual nodes in a network requires an efficient addressing mechanism.

In addition, new generation mobile phones have an important impact on the development of such healthcare systems, as they seamlessly integrate a wide variety of networks (3G, Bluetooth, wireless LAN and GSM) through access points (APs), thereby providing an opportunity to transmit recorded biomedical signals to a central server in a hospital. As a result, continuous monitoring of biomedical signals will no longer be restricted to the home environment.

2. SYSTEM MODEL

Mobile communication devices can now provide efficient and convenient services, such as remote information interchange and resource access through mobile devices, allowing users to work ubiquitously. With the astronomical growth of the cell phone ownership rate, mobile healthcare supported by mobile and wireless technologies emerges as a cost-effective care solution with a better overall health outcome. A feasible mobile device for ubiquitous healthcare must be cheap to produce, ultra-compact, lightweight and its power consumption must be low. In addition to broad communication capabilities, it must support such functions as health condition monitoring and display of biomedical signals. It is now possible to draw inferences in real-time from a range of behavioral data made available via mobile phones. Feedback can then be offered relating to these behaviors, enabling people to make better everyday lifestyle choices and, ultimately, to better manage their health.

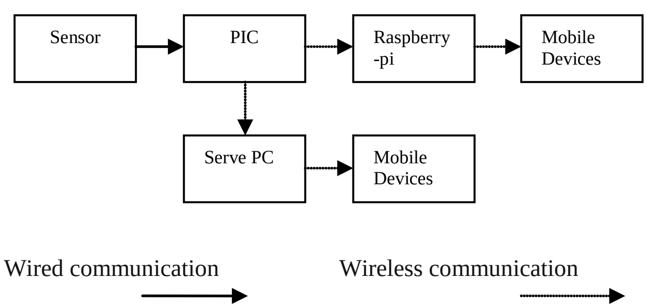

Fig.1. Block Diagram of System

Fig. 1 shows a block diagram of a healthcare system for health condition monitoring in a global environment enabled by the flexibility and scalability of Raspberry-Pi and mobile communication.

3. PREVIOUS WORK

A. Wireless sensor network for a healthcare system

WSN is one of the fastest growing technologies in ubiquitous networking today. Standardization efforts, such as IEEE 802.15.4 [3], are geared to reduce costs, provide device customizability for diverse applications and create standards for interoperability. The IEEE 802.15.4 standard was developed to address a demand for low-power and low-cost in low-rate wireless personal area networks (LR-WPAN). Dealing with low data rates, IEEE 802.15.4 offers very long battery life (months or even years) and very low complexity. The IEEE standard 802.15.4 defines the physical layer (PHY) and medium access control (MAC) sub-layer specifications for LR-WPAN in the 2.4 GHz and 868/915 MHz bands. A free license to use the industrial, scientific and medical (ISM) 2.4 GHz band is available worldwide, while the ISM 868 MHz and 915 MHz bands are only available in Europe and North America, respectively. A total of 27 channels with three different data rates are allocated in IEEE 802.15.4, including 16 channels with a data rate of 250 Kbps

in the 2.4 GHz band, 10 channels with a data rate of 40 Kb/s in the 915 MHz band and 1 channel with a data rate of 20 Kb/s in the 868 MHz band. Channel sharing is achieved using carrier-sense multiple access (CSMA), and acknowledgments are provided for reliability. Addressing modes for 64-bit (long) and 16-bit (short) addresses are provided with unicast and broadcast capabilities. The main characteristics of WSN devices are small physical size, low-power consumption, limited processing power, short-range communication capability and small storage capacity.

A number of studies and projects have focused on novel ubiquitous healthcare systems utilizing WSN technology to simplify methods of monitoring and treating patients. A case in point is the MobiHealth project, which developed a system for ambulant patient monitoring over public wireless networks based on a body area network (BAN). Another example is the Ubiquitous Monitoring Environment for Wearable and Implantable Sensors project (UbiMon) at Imperial College London, which aims to provide a continuous and unobtrusive monitoring system for patients to capture transient, but life-threatening events. CodeBlue was designed to operate across a wide range of devices, including low-power motes, PDAs and PCs, and it addresses the special robustness and security requirements of medical care settings.

A wireless sensor network (WSN) is composed of spatially distributed nodes equipped with sensing devices to monitor and to measure characteristics of the physical environment at different locations. WSNs are designed and deployed for different purposes by various organizations. WSN based monitoring applications range from simple data gathering, to complex Internet-based information systems. In other words, the observations obtained from sensor networks may be helpful in many software applications like environmental, industrial and meteorological monitoring, building and home automation, medicine, urban sensor networks, intelligent transportation, security, military defense, etc.

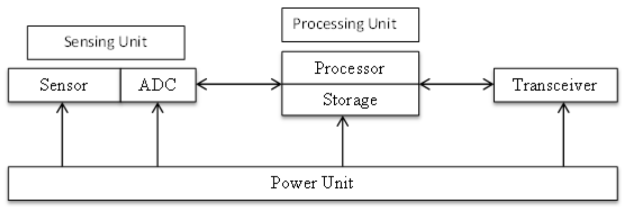

Fig.2. Sensor Node Architecture

Sensor nodes, as building blocks of WSN, are consisted of four basic elements shown in Fig. 2: the sensor unit, processing unit, communication and power units.

B. Raspberry-Pi

It is a small, powerful, cheap, hackable and education-oriented computer board introduced in 2012 (Fig.3). This credit card-sized computer with many performances and affordable for 25-35$ is perfect platform for interfacing with many devices [2].

Fig.3. Raspberry-Pi

The Raspberry Pi board contains a processor and graphics chip, program memory (RAM) and various interfaces and connectors for external devices. Some of these devices are essential, others are optional but all Raspberry Pi models have the same CPU named BCM2835 which is cheap, powerful, and it does not consume a lot of power. Raspberry Pi operates in the same way as a standard PC,

requiring a keyboard for command entry, a display unit and a power supply. SD Flash memory card normally used in digital cameras is configured in such a way to 'look like' a hard drive to Raspberry Pi's processor. The unit is powered via the micro USB connector. Internet connectivity may be via an Ethernet/LAN cable or via an USB dongle (Wi-Fi connectivity).

Like any other computer, the Raspberry Pi also uses an operating system and the "stock" OS is a flavor of Linux called Raspbian. Linux, as a free and open source program, is a great match for Raspberry Pi. On one hand, it keeps the price of the platform low, and on the other, it makes it more hackable. There are also a few non-Linux OS options available. The additional hardware and software requirements can be achieved by already existing hardware modules and open source software. One of the great things about the Raspberry Pi is that it has a wide range of usage.

Based on the comparison of Raspberry Pi's key elements and performances with presented current existing wireless sensor nodes it is possible to summarize Raspberry Pi's processing power, memory, connectivity, multipurpose usage (USB), power consumption. Raspberry Pi is ultracheap-yet-serviceable computer board with compare to the other wireless sensor node. With support for a large number of input and output peripherals, and network communication it makes the perfect platform for interfacing with many different devices and using in wide range of applications. By coupling it with Wi-Fi it can communicate remotely what the Raspberry Pi makes very suitable for the construction of wireless sensor nodes and SensorWeb nodes. Moreover, Raspberry Pi can be used as processing node in WSN networks, not just as sensor node but also as controller. In addition, data processing and decision making can be based on artificial intelligence.

Further, The Linux operating system usage provides additional advantages of using Raspberry Pi as a SensorWeb node. Programming in high-level languages such as C, C++, Python, or Java, solution implementation is quite simple and it is enabled to a large number of users, opposed to micro controller programming which usually depends of development kit.

By installing the Web Server on the unit and providing access to the Internet, Raspberry Pi becomes complete and ideal system (hardware and software) for building SensorWeb nodes. One of the possible Raspberry Pi usage scenarios, which are already implemented, is creation of hardware device that has implemented sensor units and communicate with Raspberry Pi via peripheral devices or via GPIO (I2C) interface. The developed Raspberry Pi prototype SensorWeb node is based on Restful services and created in order to build the infrastructure that supports fast critical event signaling and remote access to sensor data via the Internet (the detection of critical events is performed using fuzzy logic).

4. CONCLUSION

A wireless healthcare monitoring system using the Android mobile devices can be implemented in a global network with the help of the Raspberry-Pi. In the highly developing era, where directly or indirectly, everything is dependent on computation and information technology, Raspberry Pi proves to be a smart, economic and efficient platform for implementing the health monitoring system. This report provides an application of healthcare monitoring using Raspberry Pi which can be easily implemented and used efficiently. With the use of comfortable wearable sensors in global areas, the proposed healthcare system promises to improve the flexibility and scalability of healthcare applications. We can also conclude that with the evolution of network integration and the management of embedded devices operating multimodal tasks, a more precise and universal healthcare service scheme can be realized.

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