Wireless Monitoring Systems for Enhancing National Health Services in Developing Regions

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Abstract: Sensor based applications and Wireless Technologies introduce sophisticated health methods, especially for patients who need continuous monitoring. Wireless Body Area Networks (WBAN) applied in medical systems provide wireless wearable sensor's structured architecture, which uses elements of remotely observance and monitoring of home-based patient rehabilitation. The possibility of transmitting and receiving remotely and continuously signals leads to constant monitoring of patient's vital parameters and real-time exchange of information. Considering Republic of Kosovo as a developing country, this application is considered to provide many benefits. As thought, the system will offer constant monitoring, early detection and prevention of abnormal conditions which are caused from last war or even natural conditions. Current research will present thoroughly examined and observed WBAN related factors which are used for enhancing e-healthcare. Moreover, during our future research we plan to analyze all existing architectures in order to conclude on and propose a unique schema that can be applied on developing regions, like Kosovo, and be beneficial.

1 INTRODUCTION

Unlimited wireless network connectivity of devices within a geographic area nowadays is considered an essential need. The radio frequency signals are transmitted and received using antennas, which cover a limited geographic range and should consider various impairments and difficulties. Wireless Area Networks usually use mobile telecommunication technologies, like: Fourth generation standards: LTE, WiMAX; Third generation standards: UMTS, CDMA 2000; or even Second generation standards: GSM. These technologies are provided by a wireless service provider regionally, nationally or even globally.

The Institute of Electrical and Electronics Engineers (IEEE) 802 constitutes a body which specifies the computer networking standards. It includes several groups, including IEEE 802.15 Task Group 6: Body Area Networks. This standard includes low complexity, low power consumption and short-range networks which are designed (Chartier 2008, Kwak et al., 2011, Isikman et al., 2011) to operate in devices located around the human body. Body Area Networks represent emerging technologies with potential human care impact derived from continuous monitoring applications (Jovanov, 2005). This includes usage of small devices that can be part of human's everyday activities. Hence, Wireless Body Area Networks together with intelligent sensors, introduce modern health care technologies which can solve (Bults et al., 2004) many medical encountered problems while monitoring patient's everyday activities. This fact is apparent also considering the wide availability of wireless networks and their increased bandwidth in one hand; and the advancing miniaturization of sensor's dimensions in another hand. Consequently, remote medical advices, based on received parameters through wireless connection from a sensor activity, will make easier the medical care. Moreover, the application of Wireless Sensor Network in developing regions is followed by the lack of having medical specialists (Joshi et al., 2013). However, there exist a number of issues which should be considered, such as: limitation of sensor's weight and size, wireless connectivity, reliability of transmission, security or

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interoperability of platforms.

Application of Wireless Sensor Networks (WSN) in developing regions can provide many facilities for patients in general and healthcare centres, in particular. More specifically, considering Republic of Kosovo as a newly created and a developing country, this application will offer many benefits. Furthermore the number of people who need continuous monitoring and those who need constant remote observation is increasing, considering also that Kosovo is a country which recently has experienced war, though it has a high number of elderly people who live alone. Medical centers provide environments with limited space considering the country's population; and they use traditional health care mechanisms. Wireless Body Area Networks together with intelligent sensors, will help lower the number of hospitalized people, and provide new healthcare tools.

The generic aim of our research is the evaluation and critical analysis of currently used WBAN system architectures, and proposal of a general schema which will fulfil developing regions needs. While analysing proposed schemas of wireless body area networks, we will try to define a new system architecture which can be implemented in developing areas, like Republic of Kosovo, and suit their conditions and needs. Focus here is to present a new system architecture which can help people and facilitate their life by applying applications based on wireless sensor technology.

We intend to focus on the following objectives:

- Review in detail state-of-the-art WSN technologies.
- Analyze proposed health monitoring systems.
- Examine the telecommunications infrastructure in Republic of Kosovo.
- Research the health system policies and structure in Republic of Kosovo.
- Reveal opportunities for deploying country-wide health monitoring systems.
- Exhibit the benefits and perform a feasibility study.
- Develop architectures that adopt efficient approaches for the case of Republic of Kosovo.
- Evaluate proposed schemas.

Through this position paper we present a brief background about Wireless communication and Body Area Networks in section two. Related information about sensors and types of sensors, are summarized in section three. Section four, describes WBAN system architecture. Wireless Body Area Network challenges and important considerations are thoroughly analyzed in section five. In section six we present our approach to propose a WSN schema which can be applied in developing regions like Republic of Kosovo. The last section includes some conclusions based on the research done until this stage.

2 WIRELESS COMMUNICATIONS AND BODY AREA NETWORKS

Wireless communications enable data exchange between several parties connected in the same network. Most common devices which use wireless data exchange are: cordless telephones, fixed, mobile or portable applications, cellular phones, radios, personal digital assistants (PDA), global positioning systems (GPS), garage door openers, wireless computer mice or keyboard, headphones, satellite television and broadcast television.

The main idea of Body Area Networks in health applications is the collection of patient vital data in order to provide diagnosis, help in early detection of abnormal conditions, or prevent its consequences (Jovanov et al., 2005). With the usage of wireless communication the e-healthcare services are enabled (Li and Lou, 2010). This term includes the assembly of vital parameters from small wearable or implantable sensors through short-range wireless connection technologies. Some of the advantages of using WBAN include (Chen et al., 2010):

- Effectiveness and efficiency
- Flexibility
- Cost-effective

Wearable health-monitoring devices which use Wireless Body Area Networks can be integrated into human's clothes. In this way, they can monitor continuously a diagnostic procedure; supervise a chronic patient condition or different surgical procedures.

Current technologies provide unsuitable applications (Jovanov et al., 2005) for lengthy and continuous monitoring due to complex, power demanding and interference from other devices operating in the same frequency range (for example Bluetooth). Therefore, there is seen the need for a future wireless based technology, which will overcome mentioned issues.

3 SENSOR'S APPLICATION

Healthcare applications nowadays are seen as an emerging need especially when considering the aging population, chronic diseases, acute care, or the means of early diagnosis (Balakrishna et al., 2013). Consequently, taking into account the proportion of elderly people, which is closely doubling from 10% to 20% over next 50 years (Yang, 2007); and the increased number of people who live alone, the provision of e-health services constitutes a rising need.

Sensors detect physical phenomena, in this case patient movements, activities, blood flow, heart beats, or related measures, which are then converted into electrical signals. These signals are amplified, encoded, and transmitted using wireless connection. Advantages of sensor's usage are summarized in (Yang, 2007), as below:

- Continuous surveillance 24/7
- Timely diagnosis
- Preventing sequences
- Home care
- Improved quality of life

Taking into consideration the sensor's applications and the benefits they offer, the industry has managed to develop different types of sensors with various functionalities, respectively different sensing parameters. Existence of various types of sensors is based on sensor's function and working methodology. Below, are summarized some of the most used sensors based on (Chen et al., 2010).

– Accelerometer/ Gyroscope

Is used to observe body posture and maintain orientation. Examples of activities include: sitting, laying, kneeling, walking, or running.

– Blood Glucose (blood sugar) and pressure sensor

Represent the amount of glucose circulating in the blood. This includes the non-invasive glucose monitoring through infrared technologies and optical sensing. This sensor measures human blood pressure while using oscillometric technique.

– CO2 Gas Sensor

It senses the concentration of gaseous carbon dioxide and oxygen levels and monitors their changes during human respiration process.

– ECG Sensor

This sensor constitutes a graphic recorder of human heart electrical activity by using several electrodes attached at specific parts of body (usually arms or chest).

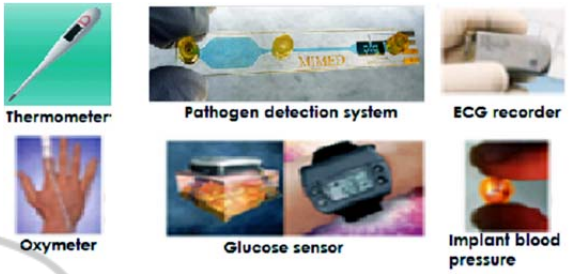

Figure 1: Applied sensor's in humans everyday lives (Li and Lou, 2010).

– EEG Sensor

The brain electrical activity is observed while using small electrodes. These electrodes forward the received signals, amplify and then transmit them.

– EMG Sensor

The electrical activity that muscles generate is recorded through EMG sensors.

In Figure 1 are presented some of the mentioned sensors that are applied in industry. Depending on each sensor's functionality and its sensing abilities some of them are wearable sensors, and the others implantable.

4 SYSTEM ARCHITECTURE

Seen the relevance of wireless sensor based applications in medical environments, one should consider the wearable and implantable sensor nodes. These nodes should sense biological information (Kwak et al., 2011), such as heart rate, ECG, blood pressure, or important environmental parameters like temperature or humidity.

Gathered information from human body are transmitted over a short-range distance using wireless connection to a device which may be a microcontroller.

Sensors have the ability to monitor readings, gather patient's related data and patient profile. These data are transmitted to one or more gateways. Respective gateways, which may be also local servers, should perform data processing (Li and Lou 2010).

After data processing, the patient related data from all wireless body area networks are sent to a centralized database for recording purposes.

In Figure 2, is presented a possible three layer system architecture of a wireless sensor based application. Hence, starting with the lowest level, we have the physiological sensors; the second layer is composed of personal servers (personal data collecting devices), such as cell phones, PDAs, home computers, laptops; while the third level encompasses the architecture of remote healthcare servers including the access of the user (in our case the doctor or nurse) in the collected data which are stored in the corresponding database.

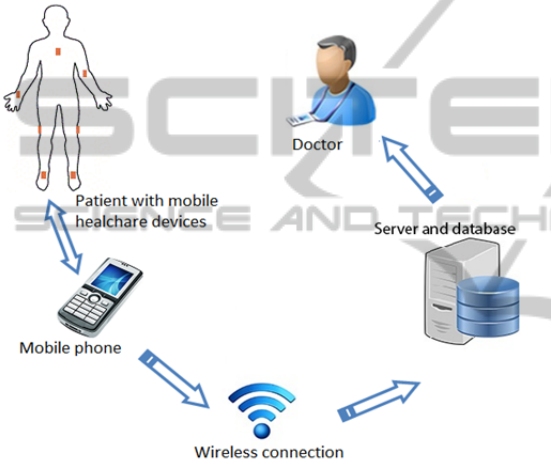

Figure 2: Possible system architecture of a wireless sensor based application.

The servers initialize, monitor, configure, and synchronize all WBAN nodes and process sensors' collected information. Personal data collecting devices should provide secure communication (Jovanov et al., 2005) with remote servers in the upper level while using wireless connection. The wireless links, including the access points, are used to transmit accumulated data from several nodes to the central storage equipments.

5 WIRELESS BODY AREA NETWORK CHALLENGES

Despite the benefits that Wireless Body Area Networks provide, there are also challenges and problems that need consideration. In the following subsections are presented separately some of the issues that a system designer should take care of.

5.1 User's Point of View

Based on continuous research in the field of Wireless Body Area Networks, its structure, components and application, there are also some limitations which are related to user's view of the system.

While applied in medical areas there is evident that sensors should adapt user's state. Furthermore, the sensor's size needs consideration when used as wearable device on human's body. Here are included for example the design and operating functionalities of a WBAN, in the sense that they should not affect the user's everyday life and activities.

5.2 Data Security

The transmission of data through several nodes should be carefully analyzed and considered. In this way, the data privacy and integrity need to be ensured, either when stored inside the wireless body area networks or during their transmission. Failure to receive correct, non-modified, or other patient data, may result in non-effective or even wrong treatments (Li and Loum 2010; Milenković et al., 2006). The error coding techniques, encryption and cryptographically data, can prevent these drawbacks. In this way data are securely stored and transmitted, and at the same time accessed by authorized people.

Moreover, the main challenges still remain the seamless connectivity, and secure and reliable communication (Jovanov, 2005).

5.3 Sensor's Considerations

Depending on the system application, a system designer should first decide the type of sensor the system needs. While choosing the sensor, its size and weight may be factors for sensor's application and whole system architecture. These factors determine sensor's placement.

Besides sensor's considerations, the power source is another system component which will play an important role for functioning of the whole application. Therefore, system designers should think carefully about power sources and power consumption, and their rechargeable capabilities. Usually this attribute is dominated by the operation of wireless chips and radio transmissions. This means that application engineers should choose a wireless platform which can provide low power consumption and has a minimum transmitting

power, meanwhile still operating in short-range frequency bands.

In general, low power consumption and small dimensions of sensors; provide two essential physical requirements that determine the lifetime and suitability to be wearable by patients (Yuce, 2010). However, these requirements are closely related with wireless communication's operating range, and transmission characteristics of used sensors.

6 OUR APPROACH TO PROPOSE A WBAN SCHEMA FOR DEVELOPING REGIONS

Referring to Wireless Body Area Networks operating logic, many applications are enabled, including health monitoring systems, emergency response systems, computer-assisted rehabilitation, or similar systems trying to facilitate people's lives. An example of WBAN in medical area is presented in (Bults et al., 2004). With the aim of analyzing and monitoring vital signals based on a Body Area Network, and UMTS and GPRS platforms, The MobiHealth project was presented. This system continuously transmits audio, images and positioning information of patients to health service providers. However, the observed biosignals are transmitted to the remote healthcare location using wireless telephony services; this fact may not be convenient considering WBAN challenges.

Another proceeding work is also the "MedVision" project (Lagkas and Eleftherakis, 2013). This project involves the development of a complete, automated, and flexible distributed system for monitoring health status, human activity, and/or environmental variables in different remote locations. This presents an ongoing project which is thought to provide a framework that involves different types of independent sensors, which would be able to provide autonomous services to any requesting entity. The main goal here is the integration of various smart sensors capable of supporting different applications without the limitations imposed by a centralized architecture. Among the latest WSN research issues that are taken into consideration in this project are ad hoc connectivity, network self-configuration, energy efficiency, resource requirements optimization, distributed service provision, and software agents' interaction-behaviour.

Aimed to analyze all existing WBAN architectures, we will try to conclude on and propose schemes that can be applied in developing regions. While critically evaluating existing applications and their system design, we will try to suggest an applicative architecture which may be beneficial for developing regions, respectively in our case, Republic of Kosovo.

While analyzing the mechanisms and infrastructure how this schema can be applied in developing regions, we came to some technical parts which are found in Kosovo market. For example, a simple system-architecture for efficient collection and dissemination of monitored health data using WBAN may consist of small scale components, such as: health field sensor, microcontroller, GPS-SIM900 chip, GPRS component, sensor's battery, and an electronic board where these components are assembled. This mainly includes the first layer presented in Figure 2. The corresponding sensor nodes may be connected wirelessly with a 'temporary' storage system, for example a PDA or a mobile phone. This device will forward the collected information to the permanent data storages where the users will have easier to receive data.

In any case, wireless connection obstacles should be thoroughly analyzed. The best solution to overcome wireless connection challenges would be the usage of fourth generation standards, which provide higher data rates, more reliable services, and a totally digital (all IP) platform which enables application of more sophisticated coding techniques for data security. These components, equipments and technologies present an existing infrastructure and opportunities to propose a WSN schema.

7 CONCLUSIONS

Taking into account advantages of wireless sensor networks while applied in practice and absence of these applications in Kosovo region, we believe in many benefits and facilitations for patients in this region. Medical centres will have easier to monitor patients in distance, provide better diagnosis, lower the number of hospitalized people, and prevent abnormal conditions. Moreover, as a developing country, Kosovo wireless infrastructure is improving day by day by implementation of new state of art antennas and fibre optic connections.

With provision of new technologies, people's interest to use them would be higher especially considering its advantages and market absence. This leads to conclusions that WSN applications will have positive impact in Kosovo people's lives.

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