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Wireless Monitoring of Patient's Vital Signs

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1. Introduction

With all the technological advances and current devices available, large and good projects are not only restricted to the invention of new technologies and concepts but also, and mainly, to the merging of existing technologies resulting in new ideas and devices that address problems not yet solved.

Mobile computing and portable devices, for example, are changing the relationships between human and computers, and are introducing a new approach of communication based on context. According to Figueiredo (Figueiredo & Nakamura, 2003) this new approach of communication allows people to interact seamlessly with objects, computers, environments, etc. Such technological advances are a significant departure from the existing computational paradigm in which users need to interact explicitly with the systems in order to achieve the expected results.

This new paradigm, known as Ubiquitous Computing, named by Weiser (Weiser, 1991), has the ability to foster a different computer vision, focusing on people's daily life (and daily tasks). Its current applications and future possibilities can be utilized in an almost invisible way, allowing the user to communicate with technology without even realizing it. Thus, the processes occur for the user, as the services and interfaces are hiding the complexity of the system.

The medical field, in its constant pursuit for finding new methods of healing and improving patients' quality of life, has been, and will continue to be, a major beneficiary of Ubiquitous Computing. Although not a substitute for the direct contact between physician and patient, is increasingly becoming an essential and indispensable factor for physician's decision-making. The current telemedicine systems provide global integration, which enables the sharing of data, images and voice from different sources and applications.

This chapter proposal describes how wireless technologies can be used in medicine, offering many benefits to doctors and patients including new methods of surgery, appointments or monitoring. It presents a review of the current medical situation and how it can be improved using new technologies.

Patient monitoring is indispensible to any hospital. Any Intensive Care Unit (ICU) or hospital beds are surrounded by electrical devices monitoring the patient and these devices are often responsible for saving a patient life. Due to the importance of these devices, there are many studies in how to improve the monitoring and they are focused specially in three questions: What, where and when should it be monitored? The obvious answer would be: everything, everywhere, every time, but in many cases that is not possible.

Studies show that a good way to have an overview of the patient health is through the vital signs (Lima, 2002), and not only patients admitted to the ICU require continuous follow-up of those signs. There are many patients with chronic or debilitating diseases who do not need to remain in the hospital but, nonetheless, need constant monitoring of their vitals to assist in early detection of dangerous situations(Kochar & Woods, 1990) (Mion et. al, 2004). At the same time that more developed countries are thriving with all these technological advancements, third world countries have been struggling with insufficient ICU beds. In Brazil, for example, the number of ICU beds has been increasing at a significantly lower rate than the one recommended by the WHO (World Health Organization). (OMS, 2009) Thus, there has been a significant increase in the number of homecare systems offered around the world. However, while they provide an interesting alternative to communities facing health care challenges, most of those solutions still have important limitations, in particular for patients facing more debilitating conditions, such as Alzheimer, Parkinson, and physical disabilities. Those patients need a new way of care monitoring that can bring increased comfort and security for themselves and their families.

Given this problem, this chapter proposes a wireless monitoring of patient's vital signs, presenting a new telemedicine software using GPRS (General Packet Radio Service) and Bluetooth technologies that adds the idea of ubiquity to the medical area, innovating the relation between doctor and patient through wireless communication and bringing security and confidence to a patient being monitored in homecare.

2. Ubiquitous computing

Ubiquitous computing aims to make human-computer interaction invisible, i.e., integrating computing with personal actions and behavior. (Sousa, 2002). Ubiquitous computing is roughly the opposite of virtual reality. Where virtual reality puts people inside a computer-generated world, ubiquitous computing forces the computer to live out here in the world with people. Virtual reality is primarily a horse power problem; ubiquitous computing is a very difficult integration of human factors, computer science, engineering, and social sciences.

The last 50 years of computing can be divided into two major trends: the mainframe, with many people sharing a computer, and computers with a personal computer for each user (Fig 1) . Since 1984 the number of people using PCs is greater than the number of people sharing computers. The next era would be of Ubiquitous Computing (Ubicomp also called), with many computers, embedded in walls, furniture, clothes and cars, sharing each one of us.

Ubiquitous computing (Fig 2) is defined as the junction of two other concepts that are: Mobile Computing, where a computing device and its services can be relocated while they are connected in a network or the Internet. The other is the Pervasive Computing, in which computing devices are distributed in the environment in a seamlessly way (Weiser, 1996).

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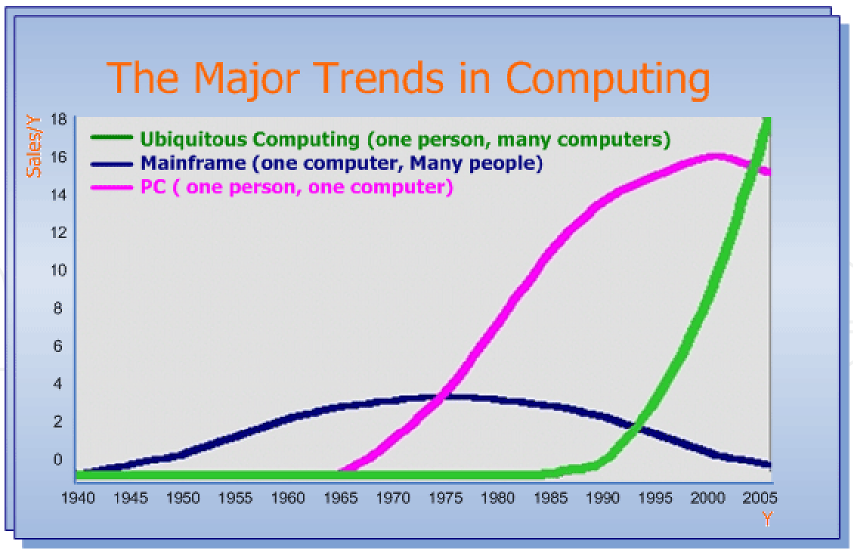

Fig. 1. Trends in computing.

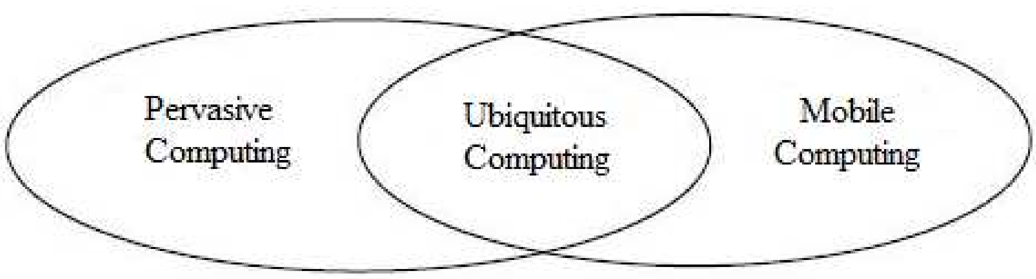

Fig. 2. Ubiquitous computing.

Pervasive computing: This concept states that media will be distributed in the working environment for users in a noticeable or perceptible way (Hess,2002). Through this concept, it is assumed that the computer would be distributed in the environment, and it would be only one machine on the table. Equipped with sensors, the computer would be able to detect and extract data and environmental variations, automatically generating computer models controlling, configuring and tuning applications as the needs of users and other devices. As this interaction, each member of the set would be able to detect the mutual presence of both users of other devices, and automatically interact among them building a intelligent framework for better usability (Fig 3).

Mobile computing: It is the ability of a computing device and the services associated with it are mobile, allowing it to be loaded or transported staying connected to the network or the Internet.

It is verified this concept today in the use of wireless networks, Internet access via mobile devices or even via the phone itself. We can also check the growth of Bluetooth applications through headphones, wireless photo printers or wireless mice.

Thus, as shown in Fig 2, ubiquitous computing benefits from the technological advances of both branches of research. Therefore, ubiquity is the integration between mobility and

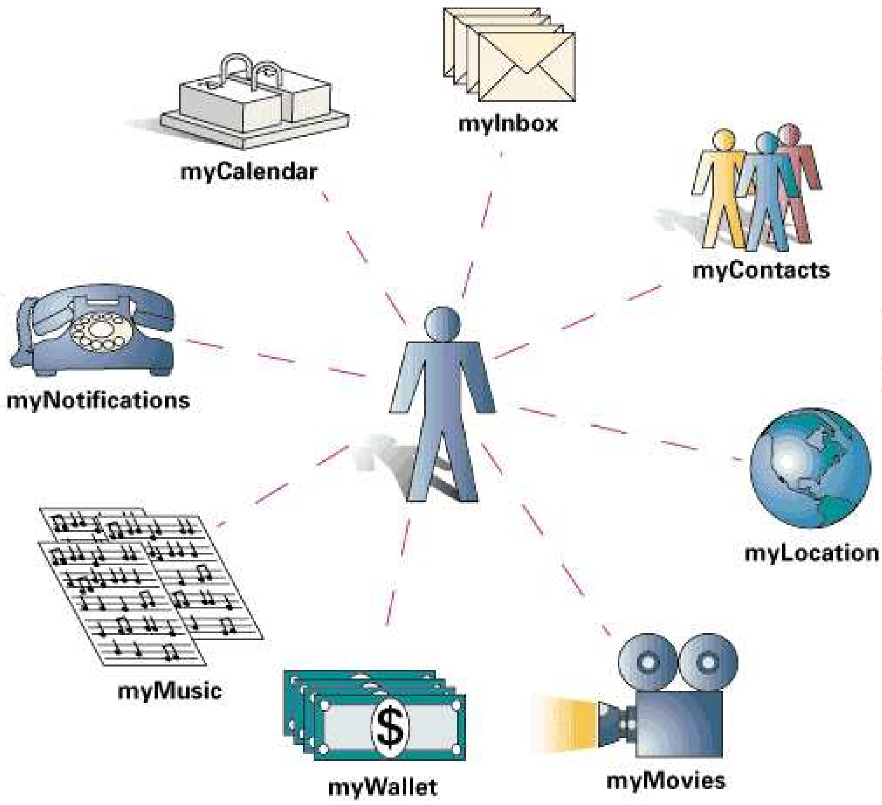

Fig. 3. Pervasive computing.

presence systems with distributed, largely invisible, intelligent and highly integrated computers and their applications for the benefit of users. This junction arise the concepts of:

- Disaggregated Computing: dynamic reconfiguration of the interface devices. Example: the ability to make your presentation move to any screen in the room. The "computer" is a diverse group of connected devices, which are actually attached to different computers on the network.
- Position Sensitive Computing: interaction with computers changes as people move. Example: Auto tour guide in a museum, automatically move your desktop to the closest display, as you walk around the room.
- Augmented Reality: Combine Wearable computers with information from position sensors, the user's relevant information can be superimposed in real vision of the world. This view can be displayed over helmets coupled with displays or even through special glasses, allowing the user to have access to an Augmented Reality. Unlike Virtual Reality (VR), where only the information generated by computer is displayed, Augmented Reality is a combination of VR with the actual image. For practical purposes this technology could be employed, for example, military sights on long-range weapons or civilly in identification, displaying or enhancing the user information out of the reach of his normal vision.
- Sensitive Object Interfaces: physical objects associated to some information. Example: to associate an object to the web page of your manufacturer. Perhaps the technology closer to reality, been used in some supermarkets in the U.S. and Europe and some production lines through RFID systems (Radio Frequency Identification).

"The deepest and most enduring technologies are those that disappear. They dissipate in the things of everyday life until they become indistinguishable."(Weiser, 1991)

Mark Weiser (Weiser, 1996) proposal is becoming a reality, through technologies such as PDAs, smart-phones, and the consolidation of wireless networking standards such as Bluetooth (Bluetooth.org 2004) and IEEE 802.11 (IEEE 2005). With ubiquitous computing, the relationship between users and computing devices changes compared to personal computers, what it was one to one, happens to be one to many (one user to multiple devices).

In addition to mobility, ubiquitous systems support interoperability, scalability, among other things to ensure that users have access when they want (Fig 4). According to Saha and Mukherjee (Saja & Mukherjee 2003), advances in technology necessary to build a ubiquitous computing environment are: devices, interconnection network, middleware, and applications.

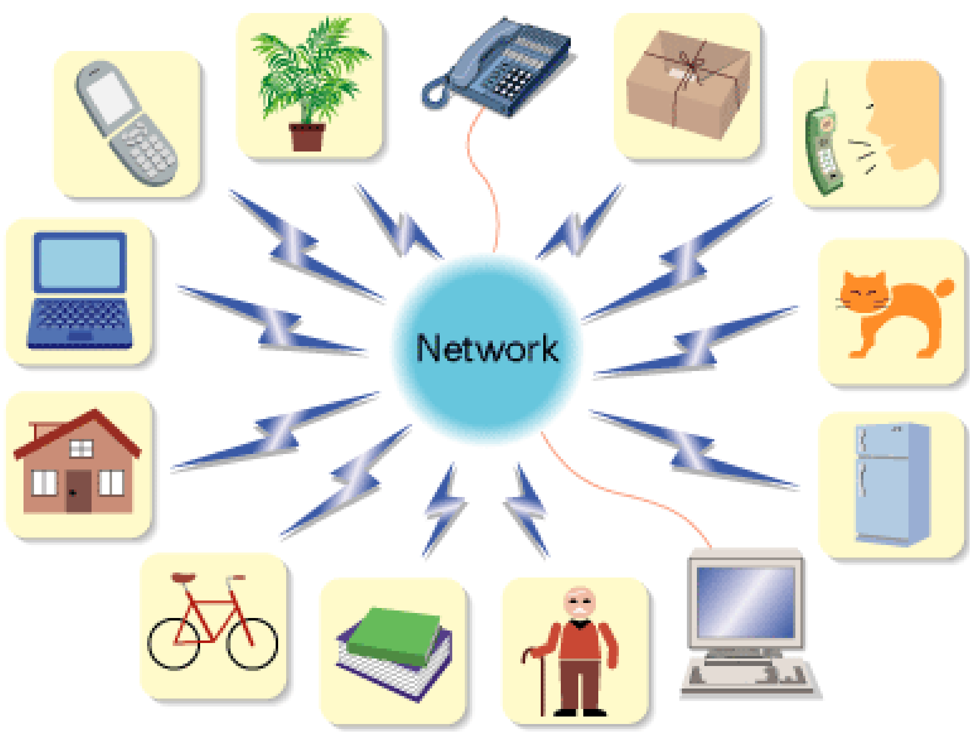

Fig. 4. Ubiquitous Computing , access everywhere.

2.1 Ubiquitous medicine

The development of technologies for health care are becoming a recurring term in the research field, whether the field of Engineering, Exact Sciences, Health or Human Sciences. This aspect characterizes the development of technology in health as a transversal element, or even transdisciplinary, for whose purpose is to study innovation in health usually permeate the border areas of knowledge, a factor that almost require interdisciplinary or transdisciplinary (Guimarães, 2004).

Health care seems to be an ideal application field for ubiquitous computing. Where else is the paradigm of "getting the right information at the right time at the right place of greater importance than in health care? Scenarios for application of ubiquitous computing are home care and monitoring, assistance for health professionals, and the self organization of health

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care institutions. Wearable systems and especially new man-machine interfaces are key technologies of ubiquitous computing in health care . Another key technology, namely RFID chips (Radio Frequency Identification) (Stanford, 2003), useful for realizing context awareness of ubiquitous computing solutions is already available and in use in several domains. These miniaturized chips allow the wireless transfer of data within a limited area around a special RFID reader and can be used to identify nearby people and objects.

Ubiquitous medical environments are those in which technological advances such as mobile devices and wireless networks bring new opportunities for access and interaction of its users, such as access of patient information. This information makes up the so-called Electronic Patient Record (EPR), allowing data about tests, facts and situations concerning the health of a patient to be accessed through multiple devices and heterogeneous networks. Ubiquitous in medicine can be made to EPRs access to consolidated information on patients from anywhere in the network, allowing also cooperation between professionals regardless the time and space. In particular, medical ubiquitous environments must support the mobility of its employees, given that mobility is inherent in the medical profession. In addition to this nomadic nature of the doctor, it is important to consider that the medical activity is highly fragmented, i.e., shall be subject to interruptions during execution, as doctors spend little time at each location or activity. Thus, mechanisms that facilitate the professional’s activities tend to improve their productivity. The importance of ubiquitous computing occurs not only when the main actor is the doctor, it can also be applied in the "world" of the patient, optimizing, for example, their monitoring system. Therefore the proposal shown in this chapter is not only a EPR system modernized but also the implementation of a unique module for tracking and monitoring patients.

2.2 Patient monitoring

Patient monitoring systems comprise sensors, data communication, storage, processing, and presentation of medical data. These functions are performed both near the patient, in local surgery, or remotely at a health care infrastructure, e.g., a medical centre or a hospital. Patient monitoring systems can be used in a variety of health care scenarios ranging from paramedic, diagnostic, surgical, post-operative, and home surveillance situations. The systems must meet a high demand of flexibility since data may be produced outside a health care enterprise (Maghsudi et. Al, 199) ((Raffloer & Wiggens, 1997). This requires specific measures in order to fulfill security, availability, privacy, and Quality of Service (QoS) demands. The properties are: a) mobility; b) outside hospital infrastructure; c) biomedical sensor networks in use; d) wireless channel.

2.2.1 Home care monitoring

Among the factors that drive the advancement of home care are: advanced treatments for many diseases and scientific technology resulting in rising costs of hospital care, increased the incidence of chronic degenerative and mental diseases determining the need for continued assistance; risks of cross infection, highly competitive world market; early hospital discharge with short periods of hospital stay.

There are three forms of service at home. The first is to domiciliary hospitalization, i.e., a patient transferred from hospital to home. In this type of assistance, it requires continuous monitoring, and sometimes, uninterrupted, 24, 12, 8 or 6 hours of nursing care. It is essential the continued support with a call center solution for emergencies, 24 hours, with doctors and nurses available to guide and fulfill the needs of the patient (e.g., patient dependent on mechanical ventilation, intravenous therapy and total dependence on nursing care).

The second type assists patients not totally dependent, who constitute the large majority. These patients require relatively complex procedures, with up to 3 hours of care provided at his home by a professional team. It is generally directed to patients unable to attend to medical treatment because they are bedridden and dependent on oxygen therapy, and other pathologies. Many of them only require specific care such as daily dressings, intramuscularly or intravenously medication. For these services the frequency of home visits is determined by the professional team.

The third method is the monitoring of patients with chronic diseases such as diabetes mellitus, hypertension, among others, through the implementation of health education, beyond the control and guidance. Thus it avoids re-hospitalizations or aggravations of health status, and provides safety and comfort for patients and their families.

The increase in life expectancy in recent years has led to the world an increasingly aging population. The problem is not aging, but aging with no quality of life. The overcrowding of health services is consequential, as well as the social security problems. The home care comes to help treat chronic and stable patients, and one of the goals is to take the patient to the hospital and treat him at home. It is less expensive for the public service and less cumbersome for the patient, who could spend months or years in a hospital since his illness is chronic and / or degenerative. The home care reduces exposure to risk of hospital infections, reduces costs and encourages the rotation of beds in hospitals, especially cases of chronic-degenerative or extensive postoperative. In addition, in most cases the availability of beds in hospitals is small. The home care also offers the possibility of a treatment with appropriate technology, highly trained professionals and family environment. (Krupinski et. al. ,2002)

3. Wireless communication systems

One of the biggest challenges of patient monitoring outside the hospital is their mobility, since the incumbent technology requires them to be connected to machines within a room. Nowadays, this issue can be addressed with the use of cell phones.

According to the Brazilian Telecommunication Agency (Anatel, 2011), Brazil has 175.6 million mobile phones and the teledensity (number of phone lines per 100 inhabitants) has reached 91.33 in February 2010. Mobile phones are used not only to make and receive calls, but also to send and receive data, having become an option for Internet access Furthermore, with the advent of wireless technologies, such as Bluetooth, mobile devices can communicate with other devices and computers. The trend is that the mobile phone will replace several technologies currently on the market (Fig 5).

That makes the cell phone an excellent option for patient monitoring: it allows for the desired patient mobility with full access to the internet (central sever). For the full mobility, the monitor and sensors must also be mobile (e.g. wearable for continuous monitoring).

Fig. 5. Technologies convergence.

3.1 GPRS (General Packet Radio Service)

The GPRS (General Packet Radio) is a technology that increases data transfer rates on existing GSM networks. This allows the transport of packet data (packet switching). Thus, the GPRS provides a data transfer rate much higher than previous technologies, which used circuit switching, which were around 12Kbps. Since the GPRS, in ideal situations, exceed the mark of 170kbps. However in practice this rate is around 40 kbps (Comtech M2M, 2011).

Unlike circuit switching technology, the GPRS service is "always on", i.e. it is a mode in which resources are only assigned to a user when necessary to send or receive data. This enables operators to provide access to the GPRS mobile internet at high speed and at reasonable cost, because the charge is the amount of data packets transmitted and not for connect time on the network. Because it uses packet switching, GPRS phones do not require dedicated circuits allocated to itself. Dynamically a physical channel is established, it remains while data is being transmitted and can be assigned to another user so that the transmission is completed, making more efficient use of network. The Fig 6 shows that we can transmit the data to the internet through a mobile phone by using a GPRS.

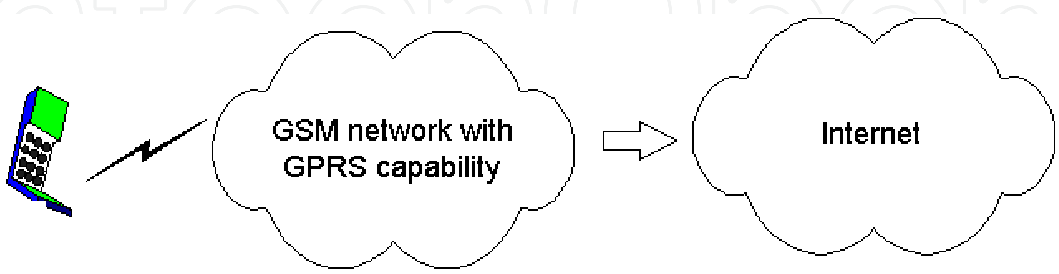

Fig. 6. Transmitting data to the internet through GPRS capability.

3.2 Bluetooth

Bluetooth is a global standard for wireless communication and low power consumption that allows data transmission between compatible devices with the technology. For this, a data combination of hardware and software is used to allow this communication to occur between the most different types of devices. Data transmission is done through radio frequency, allowing a device to detect the other regardless of their positions, since they remain within the limit of proximity. To be able to meet all kinds of devices, Bluetooth's maximum range was divided into three classes (Bluetooth, 2011):

Class 1: maximum power of 100 mW, range up to 100 meters;
Class 2: maximum power of 2.5 mW, range up to 10 meters;
Class 3: maximum power of 1 mW, range up to 1 meter.

This means that a device with Bluetooth class 3 will only be able to communicate with another if the distance between them is less than 1 meter, for example. In this case, the distance may seem useless, but it is enough to connect a headset to a mobile phone hanging on the waist of one person. It is worth noting, however, that different classes of devices can communicate without any problem, by simply respecting the limit of the one that has a smaller range. The speed of data transmission in Bluetooth is low: up to version 1.2, the rate can reach up to 1 Mbps. In version 2.0, this value increased to up to 3 Mbps. Although these rates are short, are sufficient for a data successful connection between most of the devices. However, the search for higher speeds is constant, as evidenced by the arrival of version 3.0, capable of rates up to 24 Mbps (Diane,2002).

Bluetooth is a technology designed to work around the world, which is why it was necessary to adopt one open radio frequency, which is standard anywhere in the world. The ISM band (Industrial, Scientific, Medical), that operates at a frequency of 2.45 GHz, it is the closest of this necessity and is used in several countries, with variations ranging from 2.4 to 2.5 GHz. As a device communicating via Bluetooth can both receive and transmit data (full-duplex mode), the transmission switches between transmit and receive slots, a scheme known as FH / TDD (Frequency Hopping / Time-Division Duplex). These channels are divided into slots of 625 ms periods (microseconds). Each frequency should be filled by a slot, so in one second, has 1,600 jumps.

The goal of Bluetooth is to allow intercommunication of nearby devices using the lowest possible power consumption (especially because many of these devices are powered by batteries) and a low implementation cost.

3.3 J2ME (Java Micro Edition)

Java Micro Edition is a set of APIs (Application Programming Interface) for developing Java application for mobile phones, J2ME is supported at least by most brands of mobile phones such as Motorola, Nokia, Panasonic and others.

The main components of the Java 2 Platform, Micro Edition (J2ME platform) is the CDC (Connected Device Configurations, connected devices), the CLDC (Connected Limited Device Configurations, for devices with limited connection), the MIDP (Mobile Information Device Profiles Profiles of information from mobile devices), plus many other tools and technologies that bring solutions to consumer markets in Java and embedded devices. There are three types of virtual machine for Java (Fig 7):

- JVM (for desktop computers);

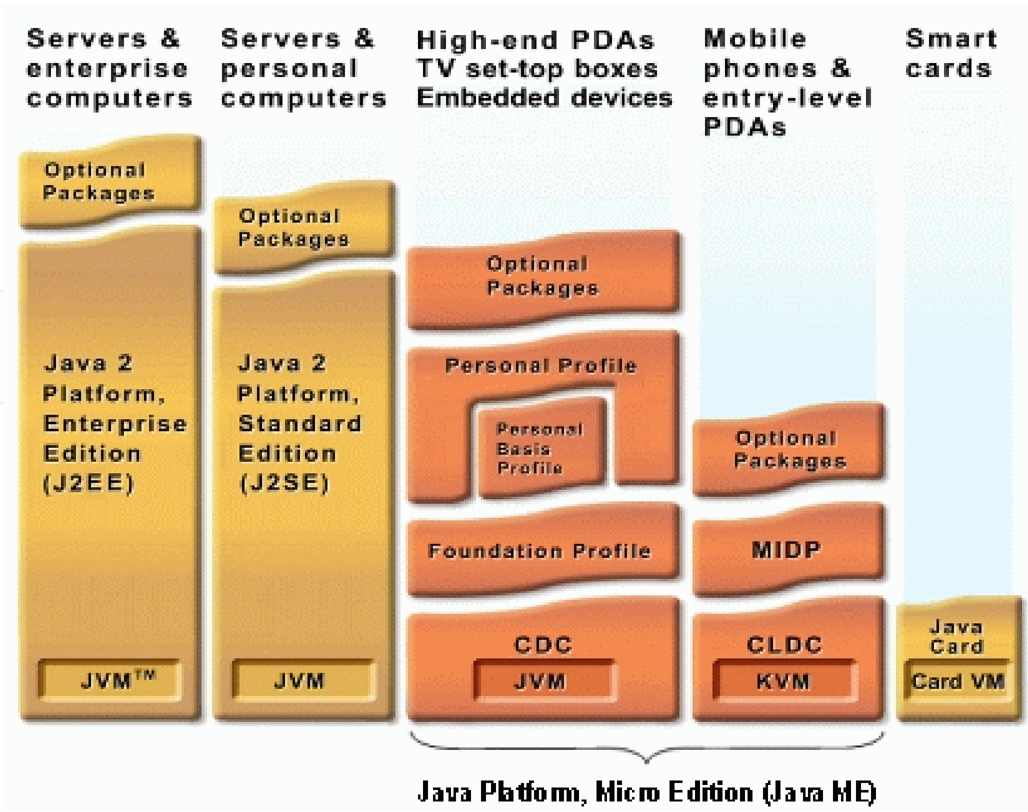

Fig. 7. Java hierarchy. (Java, 2011)

- KVM (for mobile phones and PDA's);
- and JavaCard VM (for Smartcards).

The program made in Java (J2ME) is called a MIDlet. MIDlet is a Java application for mobile devices, more specifically the J2ME virtual machine. In general applications are to run on phones, such as games and others. MIDlets will (should) run on any device that implements J2ME MIDP. Like all Java programs, MIDlets are fully portable and made to run on any platform. To write a MIDlet, you can get the Sun's Wireless Toolkit Java site, which is available for multiple platforms and is free.

A MIDlet has the following requirements to run on a mobile phone:

- The main class must be subclass of javax.microedition.midlet.MIDlet;
- A MIDlet must be packaged in a arquivo.jar (eg using the jar-tool)
- The. Jar file needs to be pre-checked.

4. Angel care mobile system

This section presents a software development that meets the needs mentioned above and aims to improve physician and patient lives through better homecare and web monitoring.

4.1 System architecture

The *AngelCare* solution (Ribeiro et. al. , 2010) was developed in Java ME (Java Micro Edition) for mobile devices and it is responsible for monitoring biomedical signals of a patient in homecare and for sending patient information to a web server on a regular basis. The web server plays the role of a supervisor, storing patient information for online access and sending alerts about the patient’s status whenever appropriate.

The system architecture is shown in Fig 8 which describes two scenarios: the patient at home (Communication via Bluetooth) and patient in the hospital (communication via Ethernet).

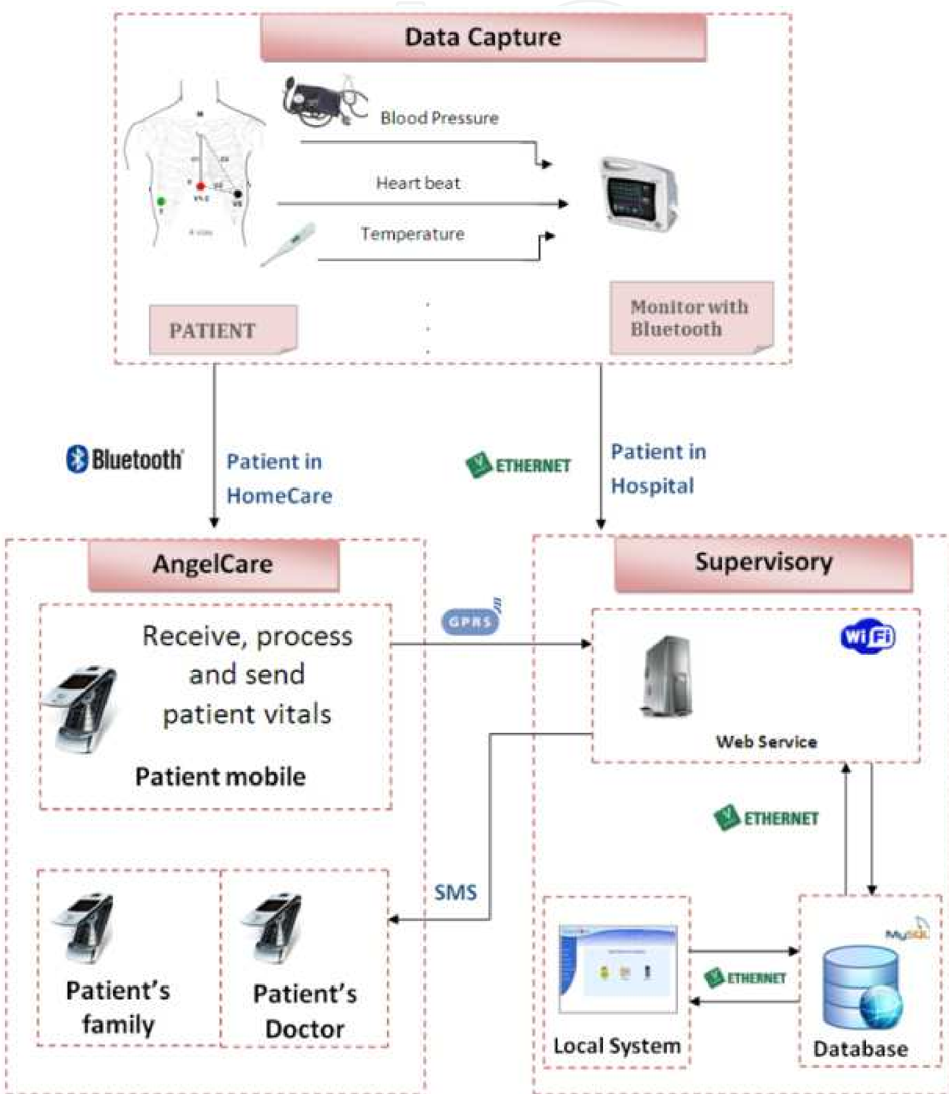

Fig. 8. System Architecture.

If the patient is in hospital, the communication between devices takes place via the local network through the IEEE 802.3 for wired LAN or IEEE 802.11 for wireless communications (Wi-Fi). If the patient is out of the hospital, the monitoring is done by the AngelCare system using Bluetooth and GPRS (General Packet Radio Service).

The architecture illustrated in Fig 8 shows the following components:

- Data Capture: signal transmission with Bluetooth output and Ethernet (IEEE 802.3), responsible for signals capture and transmission;
- AngelCare system with cell phones using Bluetooth and GPRS;

- The supervisory system including the central server that manages all hospital systems, and the system of medical records, on local system, to store information and query the database.

4.2 System modules

The system has three main modules: (i) signal processing and transmission; (ii) alert dispatch; and (iii) database management, as shown in Fig 9.

Fig. 9. System modules.

The first module, **signal processing**, the biomedical device connected to the patient communicates with his/her cell phone via Bluetooth technology and sends the data (vital signs) to the phone. It's important to note that each signal has its transmission period because some signals as heart rate needs to be monitored more frequently than body temperature, for example, as the temperature takes more time to change than the heart beat. So, if the device is monitoring signals with different time samples there are 2 solutions, either send them separately or send them together repeating the measure for those that has bigger sample time. In this case, we are sending all together with 3 minutes interval.

When the patient's vital signs reach the cell phone, they are evaluated and compared with the patient's baseline, which had been previously registered in the system, as each patient has different pattern of measurement, so it is necessary to have a previously knowledge about the patient healthy and data.

The purpose of this comparison is to detect potential abnormalities, such as arrhythmia, high/low blood pressure, and abnormal oxygen saturation as shown in Fig 11. If a problem is detected, the data is sent immediately to the web server (supervisor) via GPRS. If there is no abnormality in the patient's signs, the data is packaged in the cellular buffer and sent to the server every six hours, allowing all biomedical signals to be stored for future reference. Once the abnormality is founded not only the actual data is sent, but also, the data saved on the buffer until the present moment (Fig 10).

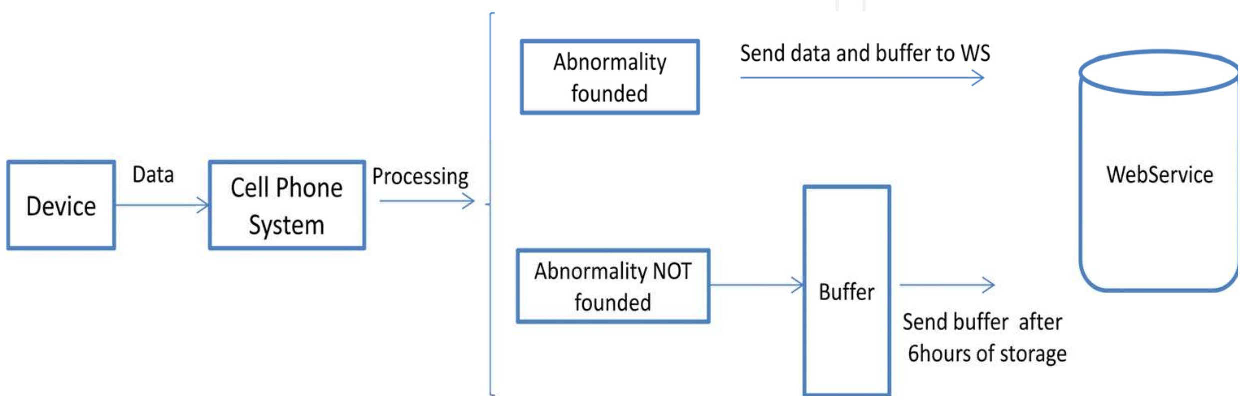

Fig. 10. Event diagram of sending data from the mobile to the web service.

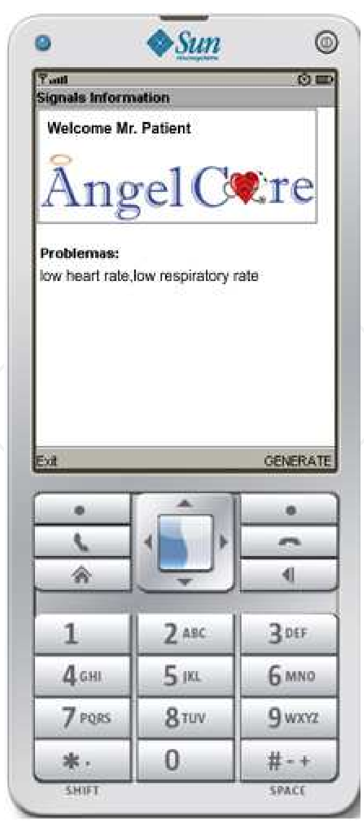

Fig. 11. System showing the patient's abnormalities.

It is important to note that one of the critical enablers of AngelCare's success is the use of GPRS technology, since it allows for sending and receiving information through a mobile telephone network, Global System for Mobile Communications (GSM), with great availability and extended coverage.

The second module, alert dispatch, is triggered whenever the data sent by AngelCare (cell phone) reaches the web server. The monitoring central or health insurance central receives a warning coming from the patient's mobile phone, containing data with the last vitals captured. At that time, the operator should decide on the most appropriated response, such as sending an ambulance to the patient's house or calling the patient's doctor. The server also sends alerts via SMS (Short Message Service) to the patient's family and doctor whenever necessary as the Fig 12 shows.

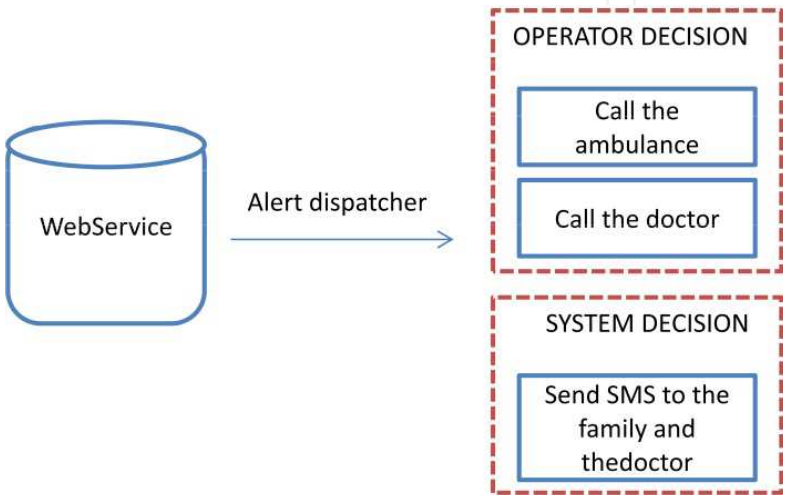

Fig. 12. Alert dispatcher schema.

The third module, database management, deals with storing and retrieving the patient's medical history, including appointments, exams, visits to the emergency room, hospitalizations, etc. All that information is stored in the database and can be accessed through an online platform provided by the system. Fig 13 shows one screen of the online system.

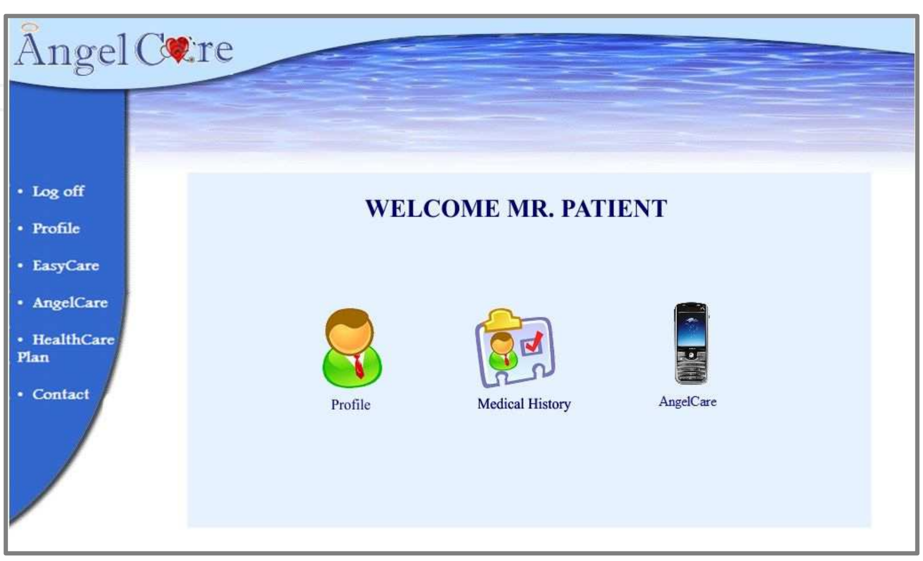

Fig. 13. Online system. Profile Screen.

With the online system the doctor and the patient can access medical history from previous appointments and exams and medical history from the AngelCare monitoring system in case the patient has this feature. The mainly benefit is to access these information anytime and anywhere.

5. Tests and results

This section shows some tests performed with the system and its results. It is focused on the constraints that must be obeyed when it comes to patient monitoring such as time consuming.

There are several reasons to use the mobile phone to process and send the biomedical data. First, it is necessary that the system is self-sufficient and independent from communications network that can fail. A mobile phone is a technology that allows the call center to be constantly updated on the status of the patient, anytime, anywhere.

Secondly, the cellular network also avoids problems related to hospital data traffic, since transmission infrastructure is estimated according to what is being requested .This is a critical point because it is necessary to ensure that the data flow time do not exceed the restrictions imposed by the processes of patients monitoring.

In this context, to prove the viability of the system, some tests analyzing the timing/duration of data transmission were performed.

The data packet generated by the patient's vital signs has 30 bytes. To be on the safe side, all tests were performed with 64 bytes packets, more than double the actual. The timing tests were divided in three steps:

- Data transmission time via Bluetooth from the monitor to the cellular;
- Processing time on the cell phone (used to compare the patient's actual vital signs and its baseline) and;
- Data transmission time from the cellular to the server via GPRS.

Thus, it was possible to analyze the system performance, checking the time spent in each stage the process. To carry out the analysis, 100 tests were performed for each step.

5.1 Bluetooth transmission time

In order to obtain an estimative of the total time of transmission occurred during the transmission of the packet from the biomedical devices to the mobile phone via Bluetooth, it was used RTT (Round Trip Time), which corresponds to the time spent in a round-trip message travels through the network. Thus, through the equation 1 was possible to perform this calculation.

$$T_G = \frac{RTT}{2} \tag{1}$$

Thus, the transmission time spent (T_G) corresponds to RTT / 2. Through the results of this experiment, it was possible to obtain the data transmission average time from the biomedical devices to the mobile phone via Bluetooth.

The Fig 14 shows the RTT time spent on all 100 packets. With the RTT time, the T_G time can be calculated and it is shown on Table 1.

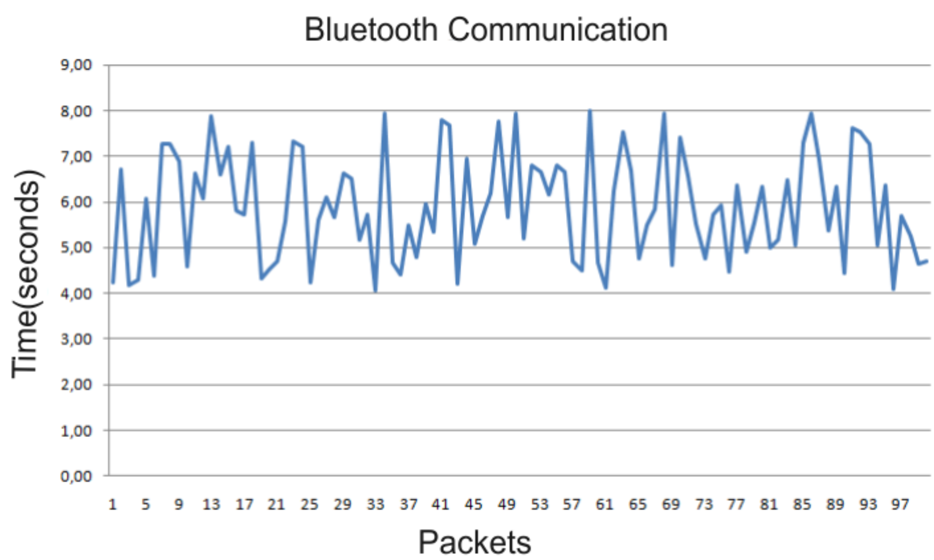

Fig. 14. Time spent on the Bluetooth transmission.

Round trip (RTT) average time	On way trip (T_G) average time
5,91 seconds	2,95 seconds

Table 1. Transmissions average time.

5.2 Cellular local processing

The processing time on the phone is the time taken to compare the current data received from the patient with data patterns previously registered on the device and detect whether or not there is abnormality in the received data.

As mention before, the system has to be previously configured with the patient patterns, as the data references can vary a lot among people.

The Fig 15 shows the time spent for local processing from the 100 packets tested, and the average time.

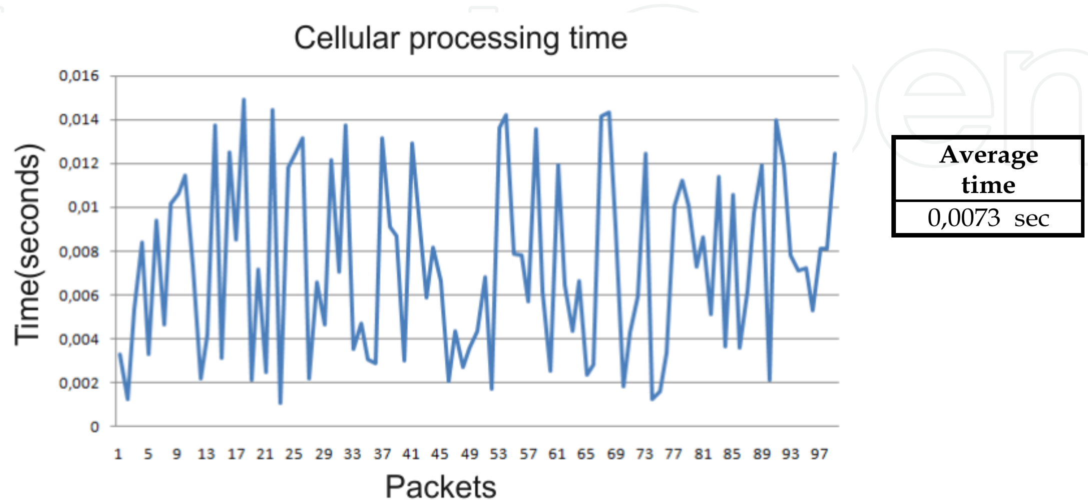

Fig. 15. Time spent on cellular local time processing.

5.3 GPRS transmission time

The GPRS transmission time is the time calculated from the data transmission from the cell until the arrival of the web server. The Fig 16 shows the time and average time spent on the transmission respectively.

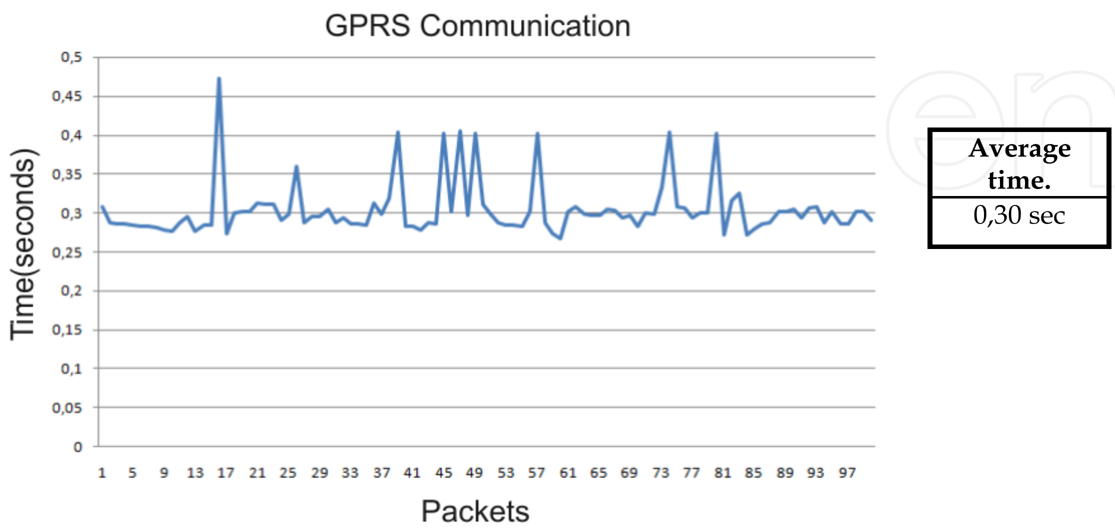

Fig. 16. GPRS transmission time.

5.4 Total transmission time

The total transmission time is summing the three averages presenting in

Table 2. Fig 17 shows the total time obtained along the 100 transmissions. Table 3 shows the average time and the standard deviation of the total time. The Bluetooth transmission is slower also because the synchronization time.

Technology	Time (seconds)
Bluetooth (Monitor to cellular)	2.95
Cellular local processing	0.0073
GPRS (cellular to server)	0.30

Table 2. Average time in the three communication steps.

Times	Time (seconds)
Total average time	3.26
Minimum time	2.32
Maximum time	4.28
Standard deviation	0.57

Table 3. Obtained Results.

The total average time of 3.26s validates the hypothesis that the total transmission time does not compromise the patient’s live. This can be confirmed with the standard deviation time which is much lower than the average time. Even the highest time obtained still would not

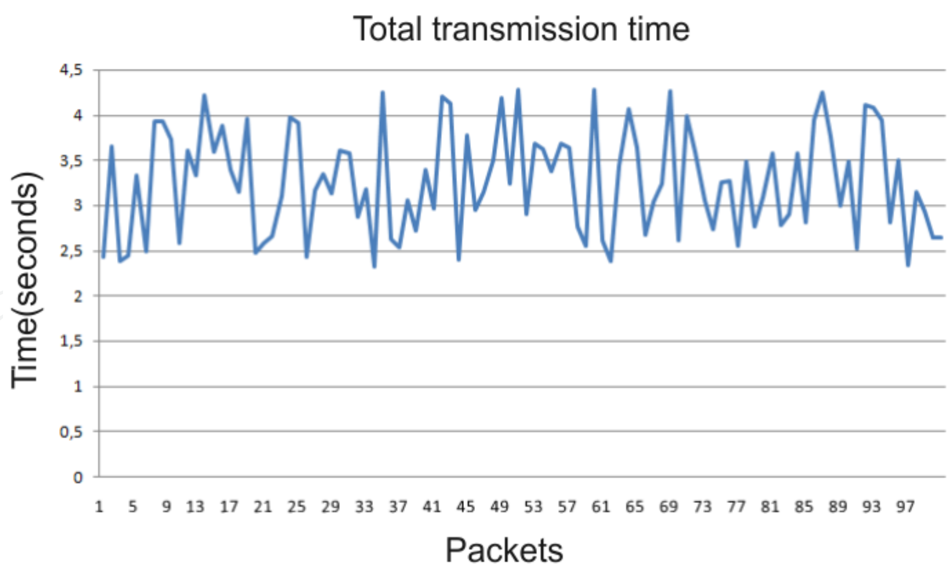

Fig. 17. Total transmission time.

compromise the patient's life. As without the AngelCare, the patient or the family would have to pick up the phone and call an ambulance, resulting in a time higher than 4.28 seconds.

5.5 Angel care advantages and disadvantages

Table 6 shows some advantages and disadvantages of the technology presented. It is important to note that some disadvantages do not come from the technology but from the homecare system itself. There are some points that can vary from each country, especially if we can compare 3rd world countries and 1st world countries. The points presented here are regardless the social class.

Advantages	Disadvantages
Mobility	
Portability	Network dependent
Safeness	Limited choices of medical equipments (homecare disadvantages)
Home environment	Financial (extra cost)
Comfort	
Privacy	

Table 4. AngelCare advantages and disadvantages.

6. Conclusions and future plans

The use of technological innovation in medicine has become extremely important for the scientific advances. This innovation brings the ability to exercise medical surgeries, examinations, consultations in a way never done before and we will all benefit from it. The future of medical technology, judging by their progress accelerated in recent years, leads us to predict that each day there will be new equipment and new diagnostics. The important thing is knowing when to use them and have a clear understanding of its indications, limitations, risks and cost-effective in each particular case.

Ubiquitous computing can be founded among almost all these innovations and allows the junction between the medical needs and the technological power, resulting and new methods and equipments in order to facilitate physician and patient's lives.

This chapter presented a system of remote monitoring for patients who are in homecare and proved to be extremely useful mainly for those who suffer from chronic diseases, or mental disability.

AngelCare is an effective remote monitoring solution for homecare patients. It offers as benefits more mobility, security, comfort and usability in an easy and cheap way and addresses many limitations of current applications

The major contribution of this research was not only the development of a medical system that allows patients monitoring and online access to the data, but it is also the performance analysis of communication and transmission of signals involved. This analysis allowed validating the proposed architecture for homecare patient monitoring. The results obtained in the performance analysis demonstrate the viability and safety of the system since the time between a patient present some abnormality and the arrival of this information in the central server is up to 4.2 seconds, small enough to ensure a fast and efficient care.

Above all, the AngelCare solution can offer a better quality of life to patients and their relatives.

In future plans, AngelCare can be used to monitor all kinds of patients and procedures, as long as the device has a Bluetooth transmission. This wireless and online monitoring has been tested to monitor patient's blood pressure in case of surgery or pos operatory recovering.

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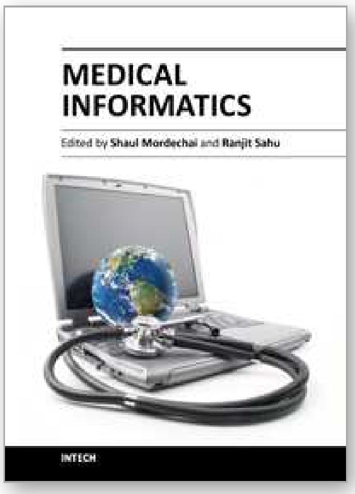

Medical Informatics

Edited by Prof. Shaul Mordechai

ISBN 978-953-51-0259-5
Hard cover, 156 pages
Publisher InTech
Published online 09, March, 2012
Published in print edition March, 2012

Information technology has been revolutionizing the everyday life of the common man, while medical science has been making rapid strides in understanding disease mechanisms, developing diagnostic techniques and effecting successful treatment regimen, even for those cases which would have been classified as a poor prognosis a decade earlier. The confluence of information technology and biomedicine has brought into its ambit additional dimensions of computerized databases for patient conditions, revolutionizing the way health care and patient information is recorded, processed, interpreted and utilized for improving the quality of life. This book consists of seven chapters dealing with the three primary issues of medical information acquisition from a patient's and health care professional's perspective, translational approaches from a researcher's point of view, and finally the application potential as required by the clinicians/physician. The book covers modern issues in Information Technology, Bioinformatics Methods and Clinical Applications. The chapters describe the basic process of acquisition of information in a health system, recent technological developments in biomedicine and the realistic evaluation of medical informatics.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Anna G. C. D. Ribeiro, André L. Maitelli, Ricardo A. M. Valentim, Cicília Raquel Maia Leite and Ana M. G. Guerreiro (2012). Wireless Monitoring of Patient's Vital Signs, Medical Informatics, Prof. Shaul Mordechai (Ed.), ISBN: 978-953-51-0259-5, InTech, Available from: http://www.intechopen.com/books/medical-informatics/wireless-monitoring-of-patient-s-vital-signs-

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