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Biosignal Monitoring Using Wireless Sensor Networks

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1. Introduction

The continuous search for people welfare through various mechanisms, has led medicine to seek synergy with other disciplines, especially engineering, among many other developments allowing the application of new techniques to monitor patients through their own body signals. The application of new developments in areas such as electronics, informatics and communications, aims to facilitate significantly the process of acquisition of biomedical signals, in order to achieve a correct approach when developing diagnostic or medical monitoring, to optimize the required care process and sometimes to reduce the cost of such processes.

In some specific situations it is desirable that the patient under monitoring does not lose his mobility by the wire connection to the device that captures any particular signal, since this state may interfere with the study. For example, in case you need to measure the heart effort of a person taking a walk or a sprint. It is in this type of environment where new ICT technologies such as Wireless Sensor Networks (WSN) can support the development of biomedical devices allowing the acquisition of various signals for subsequent monitoring and analysis in real time.

Telemedicine also called e-health is everything related to electronic health data for monitoring, diagnosis or analysis for the treatment of patients in remote locations. Usually this includes the use of medical supplies, advanced communications technology, including videoconferencing systems (Enginnering in Medicine & Biology, 2003).

Telemedicine systems can establish good and emerging technologies such as IEEE standards 802.11, 802.15 and 802.16, which these bases are characterized by the distribution networks for medical information, and provision for life-saving services. These systems have certain restrictions in the sense that when these wireless communications may be affected by a storm, or in conditions where the signal to transmit is not the most appropriate spots, then due to these problems, which solutions were sought resulted in great advances in wireless networking technologies providing vital routes for the restoration of services in telemedicine.

The efficiency of telemedicine systems are widely affected by the design of systems, such as standardization, which in this case would not only rapid deployment, but also easy access for maintenance and renewal future systems that support care services.

The constant study and monitoring of biomedical signals, has been an important tool in the development of new medical technology products. However, these over time begin to see that they are useful and important in industries that formerly had not been implemented

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but that scientific advances are essential. Over the years, monitoring of such signals have been putting more importance and trust in the medical corps, allowing them to exploit technological advances to benefit human care.

Within each wireless sensor network, sensors are one of the most important components of the network. There are several sensors based on the applications we want to use. An example is the temperature sensor, which is a component that is mostly composed of semiconductor materials that vary with temperature change. In the case of biomedical environments, it senses the temperature of the skin or skin temperature, which enables us to monitor it in the patient, allowing for immediate assistance.

We are not too far from the meaning stated above, to make a comparison, we found that both conditions vary only in the ability to sense, as this requires certain conditions of the system or agency is analysing nevertheless remains a fundamental part at the time to learn about processes that is "easy" observe or with our senses is impossible to understand.

However, biomedical sensors, should be chosen under certain parameters that are vital to the development and smooth operation of the same, they should be able to measure the signal in particular, but also to maintain a single precision and replacement capacity fast enough to monitor living organisms. Additionally, these sensors must be able to adapt to variations in the surface bioelectric be implemented (Bronzino, 1999).

This chapter is organized in the following sections. Section 2 shows the main characteristics of wireless sensor networks. We present the essential information about Body Sensor Networks as a WSN specialization in medical environments in Section 3. Section 4 shows our methodology for the development of applications of biomedical signals acquisition. We conclude this chapter with section V.

2. The wireless sensor networks

The wireless sensor networks are formed by small electronic devices called nodes, whose function is to obtain, convert, transmit and receive a specific signal, which is captured by specific sensors, chosen depending on the sensing environment. This technology, due to its low cost and power consumption is widely used in industrial process control, security in shopping malls, hotels, crop fields, areas prone to natural disasters, transport security and medical environments, among other fields.

A sensor network can be described as a group of nodes called "motes" that are coordinated to perform a specific application, this lead to more accurate measurement of tasks depending on how thick it is the deployment and are coordinated (Evans, 2007).

2.1 General features

In a wireless sensor network, devices that help the network to obtain, transmit and receive data from a specific environment, are classified according to their attributes or specific performance in the network (Cheekiralla & Engels, 2005).

A wireless sensor network consists of devices such as are micro-controllers, sensors and transmitter / receiver which the integration of these form a network with many other nodes, also called motes or sensors. Another item that is extremely important in any classification, is to know the processing capacity, due to its necessary because communication being the main consumer of energy, a system with distributed processing features, meant that some of the sensors need to communicate over long distances This leads us to deduce that higher

energy consumption needed. Hence the rationale for knowing when to be processed locally as much energy to minimize the number of bits transmitted (Gordillo & al., 2007).
A node usually consists of 4 subsystems (See Fig. 1):

- **Computing subsystem:** This is a micro controller unit, which is responsible for the control of sensors and the implementation of communication protocols. The micro controller is usually operated under different operating modes for power management purposes.
- **Communications subsystem:** Issues relating to standard protocols, which depending on your application variables is obtained as the operating frequency and types of standards to be used (ZigBee, Bluetooth, UWB, among others.) This subsystem consists of a short range radio which is used to communicate with other neighboring nodes and outside the network. The radio can operate in the mode of transmitter, receiver, standby, and sleep mode.
- **Sensing subsystem:** This is a group of sensors or actuators and link node outside the network. The power consumption can be determined using low energy components.
- **Energy storage subsystem:** One of the most important features in a wireless sensor network is related to energy efficiency which thanks to some research, this feature has been considered as a key metric. In the case of hardware developers in a WSN, it is to provide various techniques to reduce energy consumption. Due to this factor, power consumption of our network must be controlled by 2 modules: 1) power module (which computes the energy consumption of different components), 2) battery module (which uses this information to compute the discharge of the battery.)

When a network contains a large number of nodes, the battery replacement becomes very complex, in this case the energy used for wireless communications network is reduced by low energy multiple hops (multi-hop routing) rather than a transmission high-tech simple. This subsystem consists of a battery that holds the battery of a node. This should be seen as the amount of energy absorbed from a battery which is reviewed by the high current drawn from the battery for a long time (Qin & Yang, 2007).

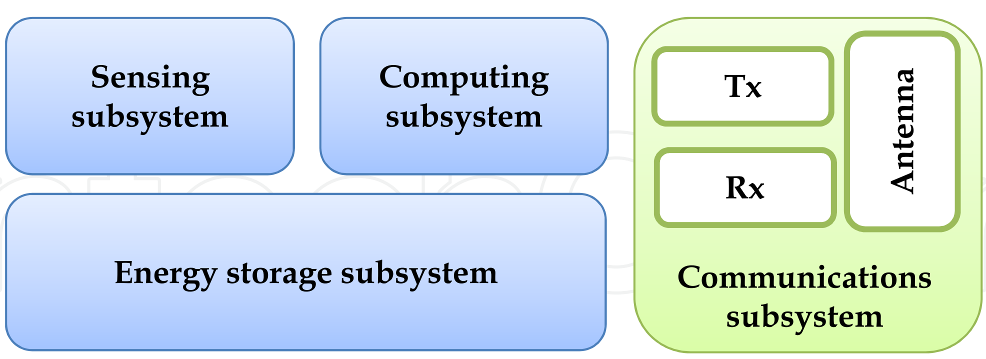

Fig. 1. Wireless Sensor Networks subsystems

2.2 WSN classification and operation mode

A wireless sensor network can be classified depending on their application and its programming, its functionality in the field sensing, among others. In the case of a WSN (Wireless Sensor Networks), is classified as follows:

- **Homogeneous**, refers when all nodes have the same hardware, otherwise it is called heterogeneous.

- **Autonomous** referenced when all nodes are able to perform self-configuration tasks without the intervention of a human.
- **Hierarchical** referenced when nodes are grouped for the purpose of communicating or otherwise shut down, in this classification is common to have a base station that works as a bridge to external entities.
- **Static**, referenced when nodes are static and dynamic otherwise.

A WSN can also be continuous, hybrid, reactive. In the case of the reactive mode, is when the sensor nodes send information about events occurring in the environment and both are scheduled when the information collected under defined conditions or specified for the application that want (Ruiz, Nogueira, & Loureiro, 2003).

A WSN is designed and developed according to the characteristics of the applications to which the design or the environment is implemented, then to which must take into account the following "working models" (Egea-Lopez, Vales-Alonso, Martinez-Sala, Pavon-Mario, & Garcia-Haro, 2006):

- **Flexibility**. In this item, the wireless environment is totally changed due to interference from other microwaves, or forms of materials in the environment, among other conditions, that is why most of the nodes can fail at any time, because should seek new path in real time, must reconfigure the network, and in turn re-calibrate the initial parameters.
- **Efficiency**. This item is very important due to the network to be implemented must be efficient to work in real time, must be reliable and robust to interference from the same nodes, or other signals from other devices. This item is in relation to that should be tightly integrated with the environment where it will work.
- **Scalability**. This item talk about when it comes to wireless sensor network is dynamic, due to its topology or application to use, being a dynamic sensor network, adding nodes is an important factor for the smooth operation of data storage.

2.3 WSN functional levels

WSN network are classified into 3 functional levels: The level of control, the level of Communications Network and the Field Level, as shown in Figure 1.

The field level consists of a sensors set and actuators that interact directly with the environment. The sensors are responsible for obtaining data either thermal, optical, acoustic, seismic, etc. The actuators on the other hand receive orders which are the result of processing the information gathered by the sensors so it can be run later. In the communication network establishing a communication link between the field level and the level of control. Nodes that are part of a communications subsystem WSN are grouped into 3 categories: Endpoints, Routers, and Gateways. Finally found the level of control consists of one or more control and/or monitoring centres, using information collected by the sensors to set tasks that require the performance of the actuators. This control is done through special software to manage network topologies and behaviour of our network in diverse environments (Rodríguez & Tellez, 2009).

One way to consider wireless sensor networks is to take the network to organize hierarchically the nodes of the upper level being the most complex and knowing his location through a transmission technique.

The challenges in hierarchically classify a sensor network is on: Finding relevant quantities monitor and collect data, access and evaluate information, among others. The information

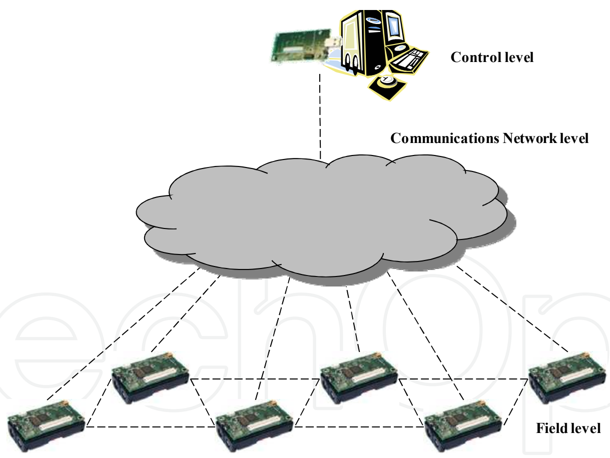

Fig. 2. Architecture of a WSN (Roldán, 2005)

needed for intelligent environments or whose variables are complex to obtain, is provided by a distributed network of wireless sensors which are responsible for detecting and for the early stages of the processing hierarchy (Cao & Zhang, 1999).

2.4 Communications protocols

At the National Institute of Standards and Technology (United States of America) was established as the main task in 2006, set standards that would allow both researchers and doctors to be clear about identifying the quality characteristics of the system to develop, creating an atmosphere of trust between medicine and engineering. Based on the principle of ubiquitous connectivity that seeks to facilitate the connection of different wireless communication standards to establish a wider range of possibilities when biomedical transmit a signal without being affected by the lack of coverage of a particular system (Rodríguez & Tellez, 2009).

In a wireless sensor network, the communication method varies depending on the application either at the medical, industrial or scientific. One of the most widely used communication protocols is the ZigBee protocol, which is a technology composed of a set of specifications designed for wireless sensor networks and controllers. This system is characterized by the type of communication conditional; it does not require a high volume of information (just over a few kilobits per second) and also have a limited walking distance (Roldán, 2005).

ZigBee was designed to provide a simple and easy low-cost wireless communication and also provide a connectivity solution for low data transmission applications such as low power consumption, such as home monitoring, automation, environmental monitoring, control of industries, and emerging applications in the area of wireless sensors. The IEEE 802.15.4 standard, as it is called ZigBee, can work at 3 different frequency bands. This protocol is divided into layers according to the OSI model, where each layer has a specific function depending on the application of our network. The physical layer and the medium access control (MAC) are standardized by the IEEE 802.15 (WPAN) which is a working group under the name of 802.15.4; where the higher layers are specified by ZigBee Alliance.

Some characteristics of the layers are given below:

- Physical Layer ZigBee / IEEE 802.15.4: The IEEE 802.15.4 physical layer supports unlicensed industrial, scientific and medical radio frequency bands including 868 MHz, 915 MHz and 2.4 GHz.

- MAC Layer ZigBee / IEEE 802.15.4: At the MAC layer, there are 2 options to access the medium: Beacon-based (based on orientation) and non-beacon (based on non-guidance). In a non-oriented, there is no time for synchronization between ZigBee devices. The Devices can assess to the channel using (CSMA / CA).
- Protocol to the network layer / IEEE 802.15.4: ZigBee got a multi-hop routing and help the capabilities designed as an integral part of the system. This function is implemented within the network layer.

2.5 Topology

The performance of a wireless sensor network is measured depending on the ability to manage energy consumption of all nodes and also the effectiveness in real-time transmission of data from the time of sensing to the display of such signs. Depending on the type of environment and resources in a network of wireless sensors, you can define multiple architectures, among the best known are Star, mesh and cluster tree network (See Fig. 2) (Tellez, Rodriguez, & Lozano, 2009). The nodes have no knowledge of the topology of the network must "discover".

A star topology network is characterized by a base station which can send and receive a Message to a number of router nodes. The advantage of this type of network for a WSN is the ease and ability to maintain energy consumption of a router node to a very low level. The disadvantage of this type of topology is the coordinator node (or base station), as it must be within transmission range of all nodes.

Mesh network topology or is characterized by allowing any node in the network, can transmit to any other node on the network that is within transmission range. This type of topology has an advantage which is the redundancy and scalability compared to a situation of failure. If the router node gets out of service, other nodes can communicate with each other without depending on the node unusable. The disadvantage of this type of network, power consumption for nodes that implement a multi-hop communication, which generally results in the life of the battery consumption, is too short.

Finally, a cluster tree network (union of a star and mesh topology), is one network that provides versatility to a communications network, while it maintains the ability to have low power consumption of wireless sensor nodes. This feature allows the power consumption of the entire network remains.

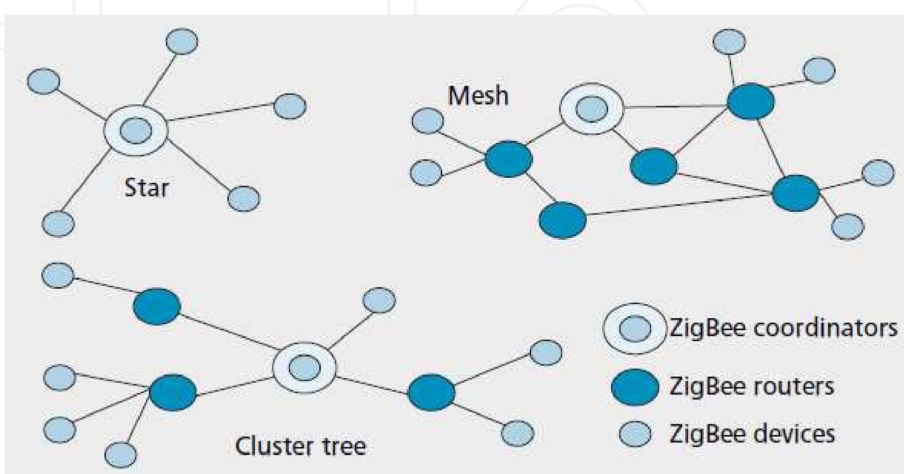

Fig. 3. Network Topology (W., Sohraby, Jana, J., & Daneshmand, 2008)

The position of the sensor nodes in a given area is not predetermined in some situations; this means that the protocols and algorithms used must be capable of self-organization (is the case of a changing field). Some designs have protocols for specific design features the main energy saving and management of the interference signal which is caused by the microwaves.
A wireless sensor network experience some interference in the setting of transmission and reception of data, depending on the type of technologies like the IEEE PAN / LAN / MAN, or some other technology that uses radio frequency. These technologies are deployed mainly in commercial and scientific aspects of WSN environments. They are currently showed a variety of wireless protocols, which focuses more innovation in the communications field.

2.6 Models for power consumption

A wireless sensor network functions depending on the energy consumption of total lifetime of the devices in the network of sensors, instead of relying only on the process of transmitting and receiving data. Energy consumption varies significantly from state to state on which the device is running. Some studies suggest 4 states to optimize our network, one of states or types most used and implemented are those that contain the following steps: transmitting, receiving, listening on hold, and idle. Due to the continued use of networks have been proposed or levels that contain more than 4 states, it is clear that this depends on the application you want to do, and our network energy dissipated.
Energy consumption is one of the most important factors in determining the life of a sensor network, because nodes are usually powered by a battery and because of that have few energy resources. This makes the optimization of energy becomes complex in a sensor network because not only involves the reduction of energy consumption, but also prolongs the life of a network (Raghunathan, Schurgers, Park, & Srivastava, 2002).

2.7 Simulators

Currently there are several simulators for sensor networks, which plays an key role in processing and in turn facilitate easy configuration of the network depending on the application to use. Among the most redeemable find (Bharathidasan & Sai Ponduru):

1. **NS-2**: It was one of the first simulations, which facilitates simulations carried out by both wireless and wired. It is written in C + + and oTCL (Information Sciences Institute).
2. **GloMoSim**: Your initials translate (Global Mobile Information Systems Simulator) is a scalable simulation device for network systems both wired and wireless. This simulator is written in C and Parsec. GloMoSom currently supports protocols for purely wireless network environment (Bajaj, Takai, Ahuja, Tang, Bagrodia, & Gerla, 1999).
3. **SensorSim**: This simulation framework provides channel sensing and sensor models, as models of battery, battery light wide protocols for wireless micro sensors (Park, Savvides, & Srivastava, 2000).

In many software projects are used to acquire data from a WSN by Tiny OS operating system and NESC. This software is well known in the sensor networks and more so in systems that use wireless sensors, is a system that does not use much energy and is small compared to other networking platforms. The system is very useful because its network operation is based on responses, more colloquial, the pot, as is known in Tiny OS; only works when you are authorized to make any transfer of rest is kept in standby.

2.8 Applications

The signal monitoring does not focus only on the medical area also find that developments in the search for home automation and control of enclosed spaces such applications are useful in projects such as houses or indoor intelligent, capable of having a autonomy. Another area of research that is taking shape every day, is the use of sensors in the automotive field, nationally the development of such projects is in its infancy, the development of a small network of sensors that seeks to solve small problems such as system capacity to meet their own needs and those of their neighbors in case of damage, and the ability to work with minimum energy expenditure without altering the quality of service or affect the information transmitted.

It consider finally found another area of application in monitoring signals applied real needs such as caring for the forests to preserve them; systems which can control all kinds of variables in this environment (Estrin, Govindan, Heidemann, & Kumar, 1999).

Sensor networks can have a wide variety of applications:

- Monitoring of habitat,
- Monitoring the environment, soil or water observation,
- The maintenance of certain physical conditions (temperature, light, pressure, etc.),
- Control parameter in agriculture,
- Detection of fires, earthquakes or floods,
- Traffic control,
- Civil or military assistance,
- Medical examination, among others.

3. Body Sensor Networks (BSN)

One of the most interesting areas for the implementation of the WSN is in the medical field because there are different challenges which are associated with monitoring the human body. The human body responds to its environment, as well as external conditions its live every day. Thus in order to monitor all these features, we apply the monitoring and sensor networks in order to get a really diagnose what gets the sensors on the body surface, as may be the frequency of monitoring (Yang, 2006). The name associated with this implementation is Body Sensor Networks (BSN).

The work in BSN has existed for several years and search provides guarantees and confidence to a mass deployment. This technology may offer the possibility of developing a detailed diagnosis of the patient, because the network would be able to monitor all vital signs and synthesize all relevant information for the more effectively patient care.

How Yang say in his book *"BSN patient monitoring systems will provide information that is likely to be as important, dramatic and revolutionary as those initial observations made by Hippocrates himself"* (Yang, 2006).

3.1 Differences between wide-scale WSN and WBSN

Practically the differences between the BSN and the WSN are very few, but it is very important to note that it is these small differences that allow BSN face the challenges posed in the medical field. Table 1 present a summary of the differences between WSN and BSN.

Challenges	WSN	BSN
Scale	As large as the environment being monitored (metres/kilometres)	As large as human body parts (millimetres/centimetres)
Node Number	Greater number of nodes required for accurate, wide area coverage	Fewer, more accurate sensors nodes required (limited by space)
Node Function	Multiple sensors, each perform dedicated tasks	Single sensors, each perform multiple tasks
Node Accuracy	Large node number compensates for accuracy and allows result validation	Limited node number with each required to be robust and accurate
Node Size	Small size preferable but not a major limitation in many cases	Pervasive monitoring and need for miniaturisation
Dynamics	Exposed to extremes in weather, noise, and asynchrony	Exposed to more predictable environment but motion artefacts is a challenge
Event Detection	Early adverse event detection desirable; failure often reversible	Early adverse events detection vital; human tissue failure irreversible
Variability	Much more likely to have a fixed or static structure	Biological variation and complexity means a more variable structure
Data Protection	Lower level wireless data transfer security required	High level wireless data transfer security required to protect patient information
Power Supply	Accessible and likely to be changed more easily and frequently	Inaccessible and difficult to replace in implantable setting
Power Demand	Likely to be greater as power is more easily supplied	Likely to be lower as energy is more difficult to supply
Energy Scavenging	Solar, and wind power are most likely candidates	Motion (vibration) and thermal (body heat) most likely candidates
Access	Sensors more easily replaceable or even disposable	Implantable sensor replacement difficult and requires biodegradability
Biocompatibility	Not a consideration in most applications	A must for implantable and some external sensors. Likely to increase cost
Context Awareness	Not so important with static sensors where environments are well defined	Very important because body physiology is very sensitive to context change
Wireless Technology	Bluetooth, Zigbee, GPRS, and wireless LAN, and RF already offer solutions	Low power wireless required, with signal detection more challenging
Data Transfer	Loss of data during wireless transfer is likely to be compensated by number of sensors used	Loss of data more significant, and may require additional measures to ensure QoS and real-time data interrogation capabilities

Table 1. Different challenges faced by WSN and BSN (Yang, 2006).

3.2 Topology of a BSN

The application design is based BSN regularly in the Star topology, this topology has the main advantage of optimizing the energy consumption of the network due to internal nodes called "slaves" only have the function of the coordinator will transmit information received by the sensors but as a great disadvantage has the high possibility of network failure due to the fall of the coordinator node.

3.3 Relevant applications, prototypes and projects

The importance of being able to identify the concept, functionality and applicability of the BSN, begins to identify the most important projects developed that gave rise to the medical applications. These projects are being used to develop a feedback process to strengthen knowledge and thus build a proposal that offers more input into health care.
Some of the most important research projects in this field include the technological development of the following fields: Miniaturization of hardware, systems integration, sensor integration to clothing, quality of service, information security, communication protocols and new biocompatible materials, amongst others. Here are some little bit references made to identify the progress and knowledge when deploying BSN in the medical field.

3.3.1 WearIT@work

The WearIT@work Project was set up by the European Commission as an Integrated Project to investigate "Wearable Computing" as a technology dealing with computer systems integrated in clothing (wearIT@work).
One of the possible applications of this project is the rapid availability of patient medical information at any time; this may mean an interesting reduction in medical examination fees, also the power to perform medical reviews in the daily circumstances of patients and in extreme cases could save the life of a patient.

3.3.2 SWAN: System for Wearable Audio Navigation

The department of psychology at Georgia Institute of Technology, specifically the Sonification Lab, researchers has created the SWAN project. This project is a practical device, portable whose characteristics are in navigation software for people with vision loss or even in places where the vision of the place is limited, and this emphasized the need for which to avoid obstacles or to obtain characteristics of the environment quickly, where they are using.
This device consists of a small computer, which contains various guidance devices such as GPS, inertial sensors, RFID antennas, RF sensors, among others. When all devices are synchronized and identify the exact location, SWAN through an audio device, sound guidance through the person using the device, which also indicate in real time the location of other characteristics of the sensing environment (GT Sonification Lab).

3.3.3 SESAME (SEnsing in Sport And Managed Exercise)

The SESAME project is development by a consortium of research groups. They base their work in creating several wireless sensor networks for high performance athletes from around the world. Among its features are that can sense both in idle mode and real time variables continued progress of the athlete.
The goals of the project lie in enhancing performance, improving coach education, and advancing sports science using a range of both hardware and software technologies to achieve this (Computer Laboratory & Engineering Dept. University of Cambridge).

3.3.4 Advanced Soldier Sensor Information System and Technology (ASSIST)

It is well known that any technological development is linked to advances in the military. Within these advances, we emphasize the ASSIST program, which is a program that integrates information on the battlefield (location, time, group activities, among others). Where the main tool of the program is based on the soldier to collect, disseminate and display key information, without risking the life or physical integrity (Information Processing Techniques Office). This project is funded by DARPA of the United States of America.

3.3.5 HeartCycle

A consortium with more than 18 entities between which we can highlight research groups, hospitals and industry. The research objective is to improve the quality of life of patients suffering from heart disease. This consortium focuses on developing devices which monitors and prescribes the history to the doctor to know which therapies or recommendations must follow the patient during treatment (Heartcycle).
The system will contain:

- A patient loop interacting directly with the patient to support the daily treatment. It will show the health development, including treatment adherence and effectiveness. Being motivated, compliance will increase, and health will improve.
- A professional loop involving medical professionals, e.g. alerting to revisit the care plan. The patient loop is connected with hospital information systems, to ensure optimal and personalised care.

4. Methodology for development of biomedical signals acquisition and monitoring using WSN

Taking into account the previous considerations, we propose a three phase methodology for the development of applications of biomedical signals acquisition (See Fig. 4). The first phase is the acquisition of biomedical signals, whose main objective is to establish a set of features for the proper selection of sensors that will accurately capture the required signal, and at the same time, allow the correct transduction of signals sent. The second stage concerns to the correct choice of communication protocol to use and to additional features to the network settings such as topology. Finally, we must determine the relevant elements to design the platform for visualization and monitoring of the sensed signals.

Fig. 4. Methodology for Development of Biomedical Signals Acquisition and Monitoring using WSN (Tellez, Rodriguez, & Lozano, 2009)

4.1 Signal acquisition

The monitoring of biomedical signals, requires mechanisms to strengthen, substantiate and legitimize the information captured by sensors, to try to understand these mechanisms, it should be noted that the acquisition of biomedical signals, you must meet certain

characteristics that do not interfere or alter the information gained, taking into account that the sensor components that are responsible for trapping that generate changes in the captured signals.
The concept of biomedical signals, focuses on the acquisition of data common phenomena of the human body, which can reach diagnoses and predicting diseases in the short and medium term, and a biomedical signal a signal becomes more complex and useful that capture a common signal, this allows to argue the importance of establishing and using elements that provide as much information for the analysis of the signal. Define and translate these signals, set parameters requires special handling and use of biomedical signals, as these because of their complexity and accuracy should have low error rates and sensors that have the ability to capture slight variations in depth to obtain the behaviour of the human body.
To acquiring a biomedical signal surface, such as the humidity or temperature, it should be noted that the structure has characteristics that do not alter sensor data collected by the sensors, may be the case limit or standard level moisture or temperature not met, may yield inaccurate data, or oxidation of the sensor to a more advanced level. However, as the environments are not extreme in relation to an industrial environment where sensors may be exposed to hostile areas, only know the following types of sensors and their respective form of measurement (See Fig. 5).

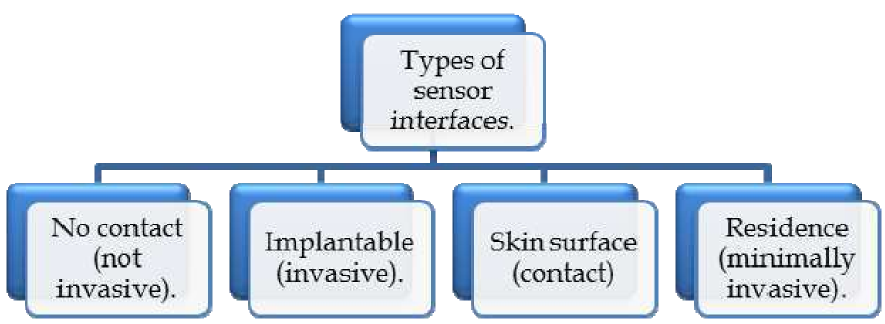

Fig. 5. Type of sensor interfaces (Bronzino, 1999)

The sensors can be used in diagnosis of medical diseases or for therapeutic purposes, which requires that the sensors respond positively to the demands of an analysis of diagnosis of this type are needed. Must also have high accuracy and in case of a touch sensor or implantable, alter the body (negatively affect the functioning of the body by the presence of an external agent as in this case a sensor).
If the sensor must be contact or implantable and this is closely affected by the presence of high humidity or temperature, is chosen for the design and implementation of protective sensor packages, these are intended to protect the sensor the presence of moisture or temperature at the points where the sensor can be affected, leaving only found the part where the sensor makes the sampling. This will protect both the information gathered as the prevention of possible damage to the body to place or deploy foreign agents in the body.
There are some kind of sensors that have direct contact with the body, there may be complications on the replacement of these components, although to deploy sensors should be a prior investigation and documentation on the reliability and accuracy of the sensor, is very complex to make changes or sensor calibration in real time or "in vivo", so you must design a protocol for internal sensor is at least the ability to calibrate itself, or rely on technology to which it is connected to maintain proper operation, all this must be properly

fulfilling predefined maximum quality standards taking into account that is not stopping the functioning of the body.

4.2 Processing & transmition

For optimum performance of a wireless sensor network, it must take certain variables or characteristics such as: Design the network topology sensing environment, energy consumption, distribution, formation of the network, which provide work a detailed selection of elements for optimum performance.

To get a sensing stability, we must be accurate when analysing signals, must turn to decipher and error-free data set give us a straight answer and correct what is a translation of a real situation. For this analysis, must take count that when handling and rely on signals, the noise and signals that alter our report as we may find situations where these noises are not important, as there spaces so. To overcome this obstacle, should be taken into account all types of filters that can regenerate the signal for the system to obtain an adequate response and follow the specifications with which the sensor reported the state of our system.

The next step is the routing of data, that we must consider how we get all this data, and network protocols that we use that are appropriate, including some that are feasible to use are the following: Internet, LAN, Bluetooth, RF, etc.

Can configure the data so that we know the environmental status according to the location of it and thus be able to see your progress. To have a comprehensive approach to what we see, we have three types of messages when creating a virtual environment that allows me to see the real situation. These three types of messages are control messages, which maintain stability in the system to monitor, we have messages of interest, which can give us an overall picture of what happens in reality and finally we have the data messages we give an independent report of the situation as external changes and variations as shown in control (Wassim & Zoubir, 2007).

The functionality of a wireless sensor network occurs in large part on the correct and accurate operation of the nodes that comprise it. For the acquisition of signals in a given environment using specific sensors, these sensors as was seen in the first objective, depending on the application and the environment in which you want sensing.

Based on the basic principles for designing a system for acquiring and processing of biomedical signals (Bronzino, 1999), the text provides 6 phases with which it must have the design of the data acquisition phase and later emphasizes the hardware design. The diagram is proposed as follows:

Fig. 6. General block diagram of a procedure analogue to digital (Bronzino, 1999)

The function of a node is to sense, process and communicate data from the signal for a more detailed study as the application that the network administrator requires. Depending on the topology of the network, each node has a specific function, is the case router node, which can only send or receive a message, but cannot send messages or data to other router nodes. On the other hand there is the coordinator node which has a dependency on other nodes for the complete management of a network, unlike router node; this node can send data to different nodes regardless of their classification.

The components that make up a sensor node, are mostly very small devices made by MEMS (Micro Electromechanical Systems), which each plays a vital role in the performance of each node in the network. Some of these components are:

1. Sensing unit and unit performance
2. Processing Unit
3. Communications Unit
4. Power Unit
5. Other

These hardware components should be organized to conduct a proper and effective work without generating any kind of conflict in support of specific applications for which they were designed. Each sensor node needs an operating system (OS) operating system operates between the application software and hardware and is regularly designed to be used in workstations and PCs.

In the market there are several manufacturers of nodes. Currently there are 3 companies that excel in developing this technology. These are: CROSSBOW, MOTEIV, Shockfish. In the Table 2 shows some characteristics of the nodes of the manufacturers of this technology (Serna, 2007).

	Micaz	**Mica2**	**Mica2dot**	**Tmote**	**TinyNode**
Distributed by	Crossbow			Moteiv	Shcokfish
Clock frequency	7.37 MHz		4 MHz	8 MHZ	8 MHz
RAM	4 KB			10 K bytes	10k bytes
Battery	2 AA Battery		Coin cell	2 AA Battery	Solar
Microcontroller	Atmel	Atmega	128 L	Texas Instruments	MSP430 microcontroller

Table 2. WSN Nodes characteristics

Among the key parts of the performance of a WSN, it should detail the minimum consumption for the network. So for the design of a wireless sensor network have focused on the biomedical field to consider the following items (Melodia, 2007):

1. The collisions should be avoided whenever possible, since the relay produces unnecessary energy consumption and other potential delays associated. Must find an optimal solution to avoid overloading the network and avoid the maximum power consumption.
2. The delay of transmission sent data packets is very important because you are working in a biomedical signal, it should be broadcasting continuous time and with the highest possible quality.
3. The receptor of our network must always be in constant operation (On), for it provides an ideal or hypothetical situation where our network only mode when you need to send or receive packets, and minimize the monitoring efforts of our spots.

4. There are points in the design of our wireless system such as: efficient use of bandwidth, delay, channel quality and power consumption.
5. The adaptability and mobility of our network.

4.2.1 Design coordinators and Router nodes

Some new technologies in the design and manufacturing of communications devices, smaller devices and better yields have been able to develop more complete nodes to the field of sensing, transmission and reception of signals obtained. Currently there are several devices that meet the requirements demanded for the development of a wireless sensor network.

The use of communication modules, have helped to design the networks, both in reducing devices included in a node, and the integration of several functions at a level both hardware and software (i. e. Security Protocols) in a single device.

On the other hand a form of management and efficient use for the acquisition of signals and their subsequent communication can be handled through the use of communication modules and modem devices. This solution is temporary and that the management and programming of micro-controller installed in the module, you can get a bit complex due to the type of software from the manufacturer and type of programming. The stage design software, you must set the proper display and lots of useful information necessary for a proper analysis of the situation and a diagnosis of what is sensed.

4.3 Acquisition & visualization

In order to develop a software application that allows the correct visualization of the acquired signals, it must take into account multiple factors to identify the basic features to implement it.

One of the first tasks is the selection of the platform for software development, the parameters to consider are:

- A platform that has the ability to receive a high volume of data
- A platform that allows easy synchronization between hardware and software.
- A platform with virtual instrumentation tools.

After selecting the development platform begins the design phase of the application. This stage should establish the visual and information to be submitted for a proper medical diagnosis. In order to visualize the acquired biomedical signals must be designed the following modules:

- **Acquisition Module**: This module is responsible for taking the BSN biomedical signals gateway.
- **Separation Module**: This module is responsible for recovering the received frame, the different signals transmitted (if more than one)
- **Processing Module**: This module each signal must translate the information received in units of voltage to the unit required by the signal such as temperature and relative humidity among others.
- **Display Module**: Determine the way in which the signal must be represented.
- **Graphical User Interface**: This module is integrated display modules to facilitate the analysis of information by the end user.

Finally completed the respective designs, the following steps are implementing the software and then testing to check its proper functioning (See Fig. 8).

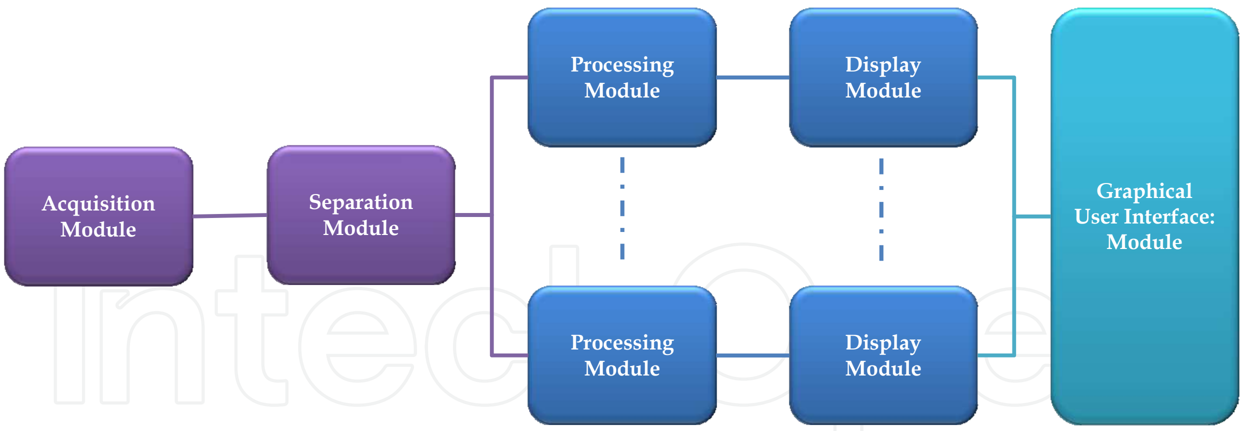

Fig. 7. General block diagram of biomedical signals visualization software

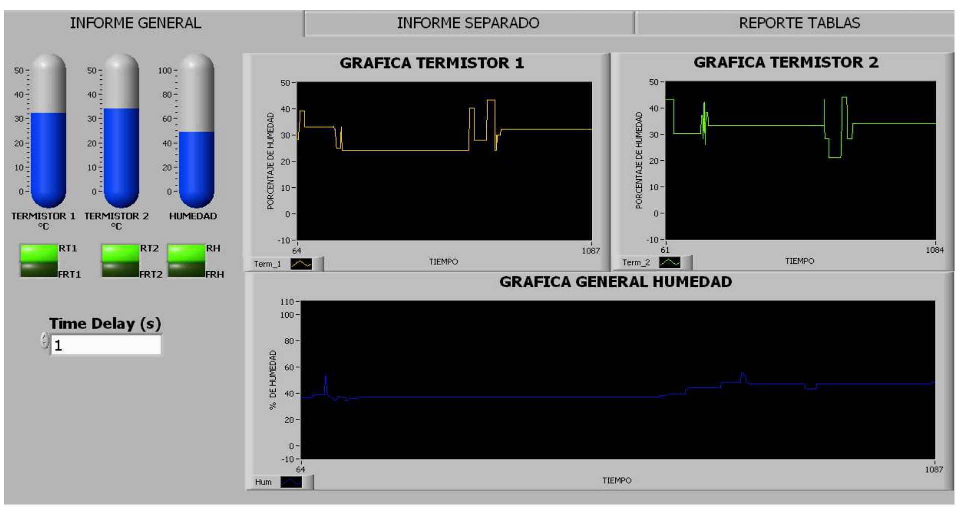

Fig. 8. Temperature and Humidity visualization software (Rodríguez & Tellez, 2009)

5. Conclusion

The impact generated by the use of wireless sensor networks in the quality of patient care is very high. The use of these devices in home care systems can reduce hospitalizations, health professionals timely interventions can extend patients life, and in some cases the use of biofeedback techniques in psychological treatments may overcome difficult phobias.

The development of such systems implies challenges to be faced in the area of engineering, such as minimizing energy consumption, since you want nodes lifetime in the network to be as long as possible. Another challenge is assuring the reliability of the information transmitted, since any slight variation may generate erroneous diagnosis. Finally, one of the biggest concerns is related to the potential impact of electromagnetic radiation to human bodies subject to the use of such devices.

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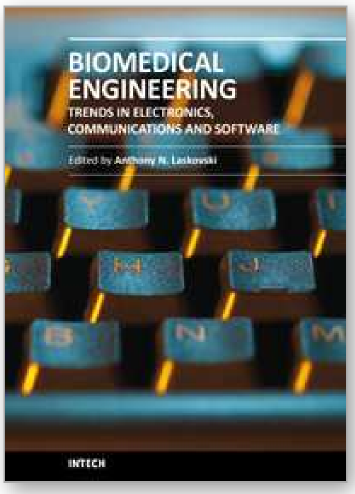

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Rapid technological developments in the last century have brought the field of biomedical engineering into a totally new realm. Breakthroughs in materials science, imaging, electronics and, more recently, the information age have improved our understanding of the human body. As a result, the field of biomedical engineering is thriving, with innovations that aim to improve the quality and reduce the cost of medical care. This book is the first in a series of three that will present recent trends in biomedical engineering, with a particular focus on applications in electronics and communications. More specifically: wireless monitoring, sensors, medical imaging and the management of medical information are covered, among other subjects.

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