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WBAN oriented for Smart Health

WBAN orientado para Smart Health

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Abstract

The wireless body area network, WBAN (Wireless Body Area Network) is defined as a wireless communication between the devices used on the human body. These devices are low-power sensors to control the vital parameters of the patient. The objective of these networks is the medical care and continuous monitoring of the vital parameters of patients suffering from chronic diseases and are continuously monitored. Therefore, this project focuses on the evaluation of a Level 1 WBAN to offer Smart Health (s-health) through its implementation with the IEEE 802.15.4 standard. The sensors to be used are: the AD8232, the pulse and the temperature. Data collection and data processing are performed on the Intel Galileo Gen2 development card, which is also configured as an HTTP server to display a graphical interface that represents the values of the heart rate and the patient's body temperature.

WBAN, Smart Health, 802.15.4

Resumen

La red inalámbrica de área corporal, WBAN (Wireless Body Area Network) se define como una comunicación inalámbrica entre dispositivos utilizados sobre el cuerpo humano. Estos dispositivos formados por sensores de baja potencia controlan los parámetros vitales del paciente. Estas redes surgen con el objetivo primordial de la asistencia médica y la vigilancia continua de los parámetros vitales de los pacientes que padecen enfermedades crónicas y necesitan ser monitoreados continuamente. Por lo anterior, este proyecto se enfoca en la evaluación de una WBAN a Nivel 1 para ofrecer Smart Health (s-health) a través de su implementación con el estándar IEEE 802.15.4. Los sensores a utilizar son: el AD8232, el de pulso y el de temperatura. La recolección de los datos y el procesamiento de éstos se realizan en la tarjeta de desarrollo Intel Galileo Gen2, la cual también se configuró como servidor HTTP para mostrar una interfaz graphic que representa los valores de la frecuencia cardiaca y la temperatura corporal del paciente.

WBAN, Smart Health, 802.15.4

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Introduction

The prosperity of a nation is measured by the quality of health services offered to its citizens. The quarters of public health hospitals and doctors' offices are populated with patients, and in addition to this, the lack of medical personnel means that a lot of time is lost and patient care becomes more expensive. Therefore, there is an active need to improve the provision of health services for patients [1].

Smart Health (s-health) defines the integration of portable devices, wireless communications and Big Data so that biomedical data are collected, processed and analyzed in real time to provide a diagnosis to the patient [2]. In this way s-health provides an opportunity for the accurate and efficient prevention of various diseases and accidents. However, s-health is still in its early stages and many of the concerns remain to be solved for practical applications [3].

Within this s-health concept, in [4] IEEE 802.15 defines the WBAN as "a standard communication optimized for low power devices and operation around the human body (but not limited to humans) to serve a variety of applications, including medical, consumer electronics, personal entertainment and others ". The main objective of this technology is to reduce the burden on hospitals and provide efficient sanitary facilities remotely through the medical implant communication system (MICS) and the wireless medical telemetry system (WMTS). Controlling patients in their natural environments is not practical when devices or sensors are connected through a cable. In this way the use of the WBAN carry out the daily activities discreetly, economically, easily and quickly [5].

There are works that address the idea of a distance communication to provide health services, such as E. Dolatabadi and S. Primak 6, which present a remote monitoring system for patients under the scheme of a WBAN, where the personal server developed in MATLAB is responsible for providing the storage and analysis in real time of the vital signs of the patient. M. Roşu and S. Paşca [7], present a focus on the healthcare solution.

Based on WBAN with ZigBee technology, for the transmission of a real-time ECG signal for long-term monitoring. WSN technology is applied in this system to transmit the ECG data wirelessly at a short distance, from the patient's body to a Central Control Unit (CCU) placed in an accessible location. On the other hand, L. Wang et al. [8], perform the detailed descriptions of the design of an integrated circuit for the acquisition of data from an ECG and the measurements of the results based on the IEEE 802.15.4 standard, thus defining the system-on-a-chip.

This work will provide an analysis of the performance of the Intel Galileo Gen2 card for s-health through the implementation of a WBAN level 1 network, considering only a point-to-point connection to know the scope and limitations of the card for the storage of data in real time. The information collected from this sensor network will be stored in a database configured on the same Galileo card, which represents the server and in other jobs can be used in the cloud computing so that those in charge of these areas can consult its due.

Architecture of a WBAN

The WBANs are a new technology for wireless communication, they have the ability to solve a variety of problems, especially for s-health [9]. The communication of a WBAN is based on a series of stages that go from the acquisition of the information to the management of the data. The architecture of the WBANs is classified as Level 1: Intra-WBAN Communication, Level 2: Inter-WBAN Communication and Level 3 Beyond-WBAN Communication. In Figure 1 you can see these levels of the WBAN [10].

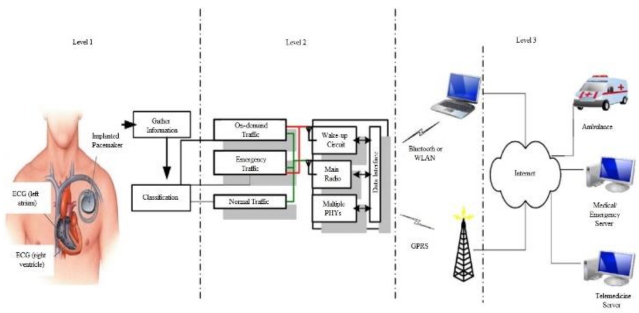

Figure 1 Architecture of a WBAN
Source U. Sana, et al., A Comprehensive Survey of Wireless Body Area Networks, Journal of Medical Systems, vol. 36, Issue 3, pp 1065–1094, 2012. https://doi.org/10.1007/s10916-010-9571-3

1. **Intra-WBAN**

In [11] the term "Intra-WBAN Communications" is presented in reference to radio communications of approximately 2 meters around the human body. It is made up of devices attached or implanted to the human body or devices around it. This type of devices are the sensors, actuators and the control device (BDU, Body Gateway, PD or PS). The data that is collected at this level is subsequently sent to level 2 of the architecture.

2. **IEEE Standard 802.15.4**

The most important requirements of the WBANs are the energy efficiency of the system, the quality of service (QoS) and the reliable transmission of data. The control layer (MAC) is the most appropriate level to address energy efficiency and effective data transmission while preserving QoS as it is responsible for node access to the shared wireless medium [12]. Therefore, we must look for the technology that covers the appropriate characteristics to carry out this series of requirements that make the WBAN implemented efficient.

IEEE defines the PHY layer and the MAC layer for low-rate wireless personal area networks, which is why a WBAN is a type of a personal area network (WPAN). The standard that supports the WBANs is the IEEE 802.15 TG6 group. IEEE 802.15.6 is a standard for short range, low power and high reliability in wireless communication. The IEEE 802.15.4 technology is currently the most relevant for the implementation of the physical layer (PHY) and the Medium Access layer (MAC) in the implemented motes. IEEE 802.15.4 has been widely used in applications that include industrial automation, home control and wireless sensor networks. Compared to the IEEE 802.11 and 802.15.1 standards, the 802.15.4 standard offers low complexity and low power consumption that makes it suitable for implementation in a WBAN.

Methodology for the Design of the WBAN

The implemented scheme was based on the level 1 that corresponds to the Intra-WBAN communication.

Figure 2 shows the complete set of the network implemented, the connections with the different devices and the way in which they are communicated in order to take the information obtained to the end user.

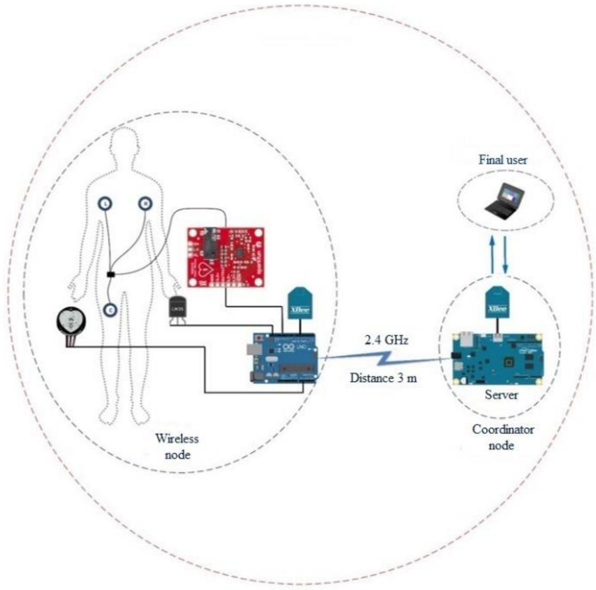

Figure 2 Implementation outline for INTRA-WBAN

As can be seen in Figure 2, an AD8232 sensor, a pulse sensor and an LM35 sensor were used for the implementation. For the calculation of vital signs an Arduino UNO was used and for the wireless transmission a pair of motes XBee PRO of the series one of Digi. The Galileo Gen 2 card, whose functions are that of a server with HTTP in the Linux operating system, and that of a personal server where data collection, processing and storage tasks are executed.

Description of the Methodology

In this work, the WBAN was implemented using a point-to-point topology where the sensors obtain the signals of the body in the form of voltage, electrical pulses, etc. according to the type of sensor and they are collected by the BCU that coordinates the operation of the sensors and later they are sent to the personal server, that is to say to the Intel Galileo Gen 2 card for later consultation by the end user. Figure 3 shows the block diagram of the methodology used to implement this work.

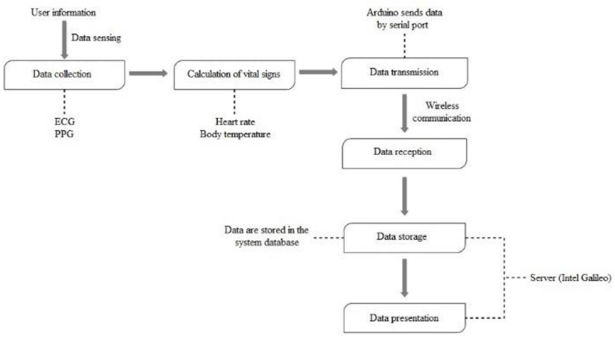

Figure 3 Block diagram for the WBAN

Analysis of results

An important feature in the development of this project is that the information will be evaluated in real time, so that the physical characteristics of the network that can influence the results are presented below.

The module to implement the network in the IEEE 802.15.4 standard, transmits data at a speed of 250 Kbps with a power of 18 dBm and have a reception sensitivity of -100 dBm which allows transmitting at maximum distances ranging from 10 at 300 m. The calculation of the end-to-end delay (End-to-End Delay, E2ED) was carried out according to Eq. one:

$$E2ED = T_R - T_S \quad (1)$$

Where T_R is the time at which the packet is received at the receiver and T_s the time at which the packet is sent from the transmitter. In table 1, the results obtained from the tests are shown. In this implementation the distance in which the data was transmitted was 3 meters and the average calculation of the delay was 22.6 s.

Test	T_R(s)	T_S(s)	E2ED (s)
1	108	73	35
2	98	77	21
3	61	42	19
4	52	33	19
5	46	27	19

Table 1 Delay in the transmission of data in the WBAN

The tests were conducted in an indoor environment where there was presence of other devices working in the same band as a modem in IEEE 802.11n which caused interference. A factor in the delay was the processing of the received information, which caused the buffer to saturate and result in a waiting time, which caused the delay to increase.

For the 2.4 GHz band, the latency is 4.25 ms for most of the monitoring applications, for this reason a waiting time of 1 second was programmed to receive the information of the final node and thus better process the information at the moment.

For the development of this work it was fundamental the analysis of the frame received in the Intel card, because this frame was decapsulated and thus the data of the sensors was obtained. In this way the data was sorted in the database in the corresponding column for analysis as shown in Figure 4.

ID	Name	Age	PPG	Temperature	Fc	Date
1	Lucero	24	483	35.16	84.27	2018-05-13
1	Lucero	24	370	35.16	84.27	2018-05-13
1	Lucero	24	360	35.16	84.27	2018-05-13
1	Lucero	24	394	35.16	84.27	2018-05-13
1	Lucero	24	431	35.16	84.27	2018-05-13
1	Lucero	24	460	35.16	84.27	2018-05-13
1	Lucero	24	476	35.16	84.27	2018-05-13
1	Lucero	24	482	35.16	84.27	2018-05-13
1	Lucero	24	480	35.16	84.27	2018-05-13
1	Lucero	24	473	35.16	84.27	2018-05-13
1	Lucero	24	459	35.16	84.27	2018-05-13
1	Lucero	24	446	35.16	84.27	2018-05-13
1	Lucero	24	432	35.16	84.27	2018-05-13
1	Lucero	24	420	35.16	84.27	2018-05-13
1	Lucero	24	410	35.16	84.27	2018-05-13
1	Lucero	24	404	35.16	84.27	2018-05-13

Figure 4 Estructura de la base de datos para el sensor de pulso

The size of the database varied according to the amount of data that was stored. The amount of information to be stored depends on the execution time, that is, if the system monitors the user's vital signs around 3 minutes, the average size of the database is 495 KB, so if the size of the database is monitored in a shorter time the BD is decremented.

A woman of 24 years of age was considered for the tests, so we will refer to her as u1. The tests were performed in a resting state and without prior physical activity.

Figures 5 and 6 show the graphic interface of the values measured in the patient by means of the AD8232 sensor and the pulse sensor respectively, in both tests the body temperature was also measured. Based on the reading of the data from each sensor is how the electrocardiogram or ECG and the photoplethysmogram or PPG were generated.

Figure 5 Graphic ECG interface and temperature measured with AD8232 and LM35 sensors

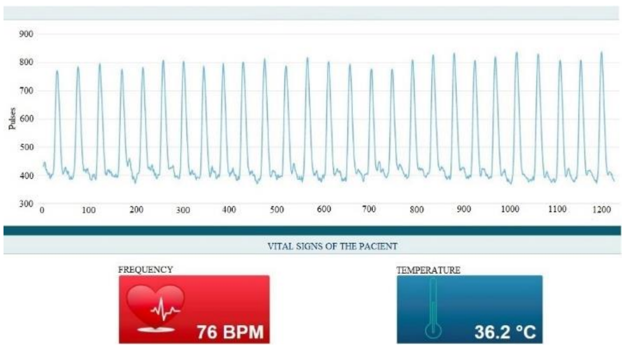

Figure 6 Graphic PPG interface and temperature measured with the pulse sensor and LM35

In Figure 5, a heart rate of 81 BPM is shown, which is in the normal range because the beats per minute of an adult range from 60 to 100 BPM. With respect to the body temperature, a value of 36.8 ° C is obtained, being acpetable because in adults the normal value goes from 36 ° C to 37 ° C. According to Figure 6, a frequency of 76 BPM and a body temperature of 36.2 ° C were measured, resulting in acceptable values.

Conclusions

The development of this work served to define potential applications in the area of health and thus perform a non-invasive and remote monitoring of the patient's vital signs. It also highlights the use of a database for the storage and processing of data, which when configured on the Intel Galileo Gen 2 card was applicable only for projects that do not require extensive use of resources for real time, for this Dedicated storage servers can be used.

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