# Design and simulation of prototype to get a soccer player's heart rate using a wireless network

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*Abstract*— The goal of this project is the implementation of a simulation that gets the vital information of a soccer player's body through Wireless Body Area Network (WBAN). With this objective in mind, several programming language environments are compared with each other. This simulation only has one sample to follow according to the proposal. Therefore, the challenge is to create a new simulation sample and other platforms to compare the accuracy and delay between communications. WBANs are not conceived to carry large amounts of data, according to the WSN (wireless sensor network) concept. This entails a problem when designing applications for this kind of networks. Lastly, in respects to the results that will be presented. The results will be about which one simulation is better or what differences lay between the different environments of development.

*Keywords*— *WBAN, Wireless Sensor Network, Zigbee*

## I. INTRODUCTION

With the development of science and technology, TICs has penetrated into all aspects of human life. One of this fields is the entertainment field which includes contact sports. This research will focus on soccer, which is one of the most popular sports, however it can be applied in any sports. The health care of players from any sport becomes very important for any personal and team's performance. The decision for this goal was made to help health and medical care in the main point to focus in the collection data aspect. This research is going to show the method to get information. For example, there is a device that can get continuously "sense heart rate" (HR).

In summary, the focus of this research is on how to enhance network topology on this area, communication among different technologies and a prototype that reaches all the expectations.

Hence, the proposal:

- Realize an enhance in the research of collecting data delays.
- Platform Comparison.
- Reduce the costs of acquisitions and implementation.
- Support the researches using simulators.
- Construct the interface design, data base and the communication with simulators.

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This research is going to show the method to get information. For example, there is a device that can get continuously "sense heart rate (HR), energy expenditure (EE) and body temperature (BT) and periodically broadcast the data to data collection nodes in the 920 MHz and 2.4 GHz bands at the same time, Performance evaluation of packet forwarding methods in real-time vital data collection for players during a football game [1, p. 2] .

Several years ago, some researches, such as [2], head already started with a big step, in which the target was the network topology and in the mobility model of the soccer players. Currently these studies have opened the business idea in many companies.

Nowadays, we found it commercially available devices "GPSports in 2006 [3]." and "VX Sport in 2008 [4], [5]. that is considers the best one, due your shape and size. All of them are projects that already done to validate this research.

In the case of this research, the decision was made to use sensors to monitor the heart rate (HR) for the collection data part, because currently we often see many athletes die around the world. The leading cause is cardiac arrest [6]. The lack of acquisition and implementations is due to high costs. Attracting both investors and software developers with another method of doing it, is relevant to this field of work. Here are some reasons:

1) Allow to make medical decisions, because of the BAN concept [7]. In contrast with the BAN concepts, the WBAN appear years ago as a solution for many problems that the BAN had [8].

2) Influence the decision making before, during, or after the match. Many concepts such as: [9], are part of the improvement in this technology that allows a coach to take quick decisions in the moment's notice. Another example of this is [10] and [11] mobility model for Body Area Networks of soccer players.

3) Enhance the weak research about the comparison among different platforms.

There is a lot of information about this technology, but not in-depth or any that can useful. Considering the initial results from the first samples to make a comparison with other platforms. Usually, the researchers before starting a research in a field, starts by choosing three platforms tools taking into consideration their skills. Hence, a weakness is given in one's background. Probably several samples were already tested in different platforms, however the results are unknown. The quick advancement in this technology can be the first applied responsibility towards the well-being of the player. This research can be an opportunity to address that important issue. In future, the researchers can have an idea about the specific point such as healthcare when they want to initiate a research in this field and take a preliminary decision.

## II. METODOLOGY

The prototype is presented in Figure 1. Called life cycle of an IS (Information Systems) development. More specifically is the prototyping model that essentially entails four different stages. In summary, this provides the model with much higher probabilities of success, as well as lower risks. Figure 2 shows this model.
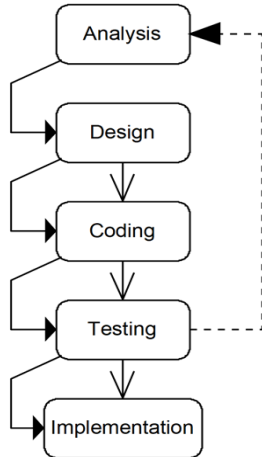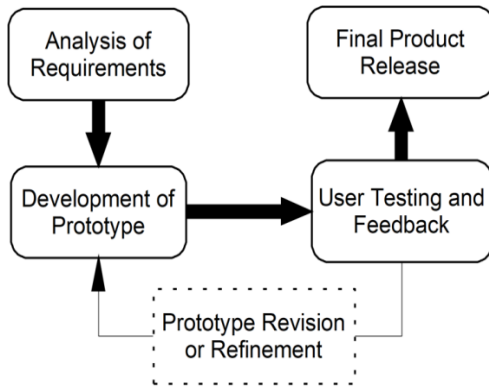


Fig. 1. Life cycle of an IS



Fig. 2. Prototype model

The instruments the system use are UML plugin, NetBeans IDE 8.2, MATLAB Simulink R2017b, VIRTUAL BOX, UBUNTU 2016, BONNMOTION, OPNET and SYSTEMS COMMUNICATION TOOLBOX.

## III. PROCEDURE

Below we present the three platforms that are the subject of study in this proposal.

### A. OPNET Simulator

The first one is focused on group-based topologies and mobility models, while the second part is focused on the research on biosensor systems for athletes or for any sportsman or sportswoman. In this last case, athletes, sportsmen or sportswomen become ad hoc network nodes that need to transmit and relay information from their sensors or from other players to sinks nodes.

The area inside a partial circle bounded by a radius r and an arc α is provided by equation 1. Where d is the circle radius and α is the angle (in degrees). Figure 1-3 shows the partial circle area covered by a football player.

$$Area = \frac{1}{2}d^2 \cdot (\pi \cdot \frac{\alpha}{180} - \sin \alpha) \qquad (1)$$

The Zone Model is the area that each player will move on the site within the location-dependent area. A two-dimension probability density function (PDF) position associated exists. We will call this function "the locator". Given a couple of coordinates x and y, a position locator returns the probability of finding the player associated to the position at that point. Equation 2 shows the PDF function.
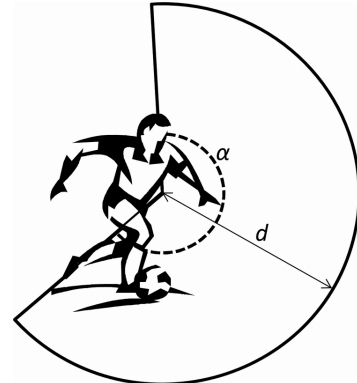


Fig. 3. Partial Circle area

$$P[a \leq X \leq b, c \leq Y \leq d] = \int_a^b \int_c^d f_{X,Y}(x,y)dxdy \quad (2)$$

The group mobility model is based on the Pursue Mobility Model. This model represents that the players track the goal: the ball. The target can have its own individual mobility model. In order to update location for each player, the model has a formula, which is shown in equation 3.

$$p_l = p_{ol} + acceleration(b_l - b_{ol}) + random\_vector \ (3)$$

A summary is made that currently this simulator is totally different, and your license is private.

### B. JAVA Animation

The first step about Java is to create a model of the class, which will be needed. When Java is work loading a project, these depend on what library the target needs. In this animation, in order to show plots, we have to add libraries that are fit to do that. For example: staxmate-with-stax2, substance.jar, wstx-lgpl-3.2.6.jar, jcommon-1.0.8.jar, jfreechart-1.0.4-demo.jar, jfreechart-1.0.5.jar and jfreechart-1.0.7.jar.

### C. MATLAB Simulation

WBANs networks can be developed by using MATLAB. The simulation simulated 11 players, with each player having four sensors that form a personal WBAN, moving around a soccer pitch according to a PURSUE mobility model. The PURSUE mobility model simulates a scenario where several nodes try to catch a node. In the model, one node that movies randomly on the pitch, whilst in all other models it moves randomly towards the desired nodes.

## IV.  ANALYSIS

The process in these technologies is to follow each stage, where all information is flowing until reaching its final intended destination. When the collection of information in beginning of project satisfies the criteria for the analysis stage, then it's possible to continue and design the wireless protocols. With the coding the development of every WBANS and his respective communication of devices such as Base stations and the sink, the challenge is later the implements and the search of the movement of model. The testing is last stage according with the prototypes, however the implementation is part of the analysis and conclusions. Such as OPNET, MATLAB and JAVA. As generalization this method reach all requirements in these kinds of simulations/animations projects. Otherwise the cost of devices, time of delivery in live and also the short duration to finish this proposal is not enough to reach the aims.

## V.  RESULTS

Given all results in the plot graphs, a general analysis is introduced according the research. First, every technology has their own tools, and these are completely different. For this reason, every platform has their own scenario and plots results about the delay and distance covered. The prototype network used in this research were the same, Zigbee, therefore both technologies are convenient to do in simulations. The results are product of the same movement model called pursue model. Except for JAVA technology where I will give the analysis itself, because is an animation.

### A.  OPNET

In this simulation, nodes communicate by using Zigbee in the 915 MHz frequency band. The traffic injected into the WSN follows an exponential distribution with an average packet size of 1024 bit and an inter-arrival time of 10 seconds. The use of an average of 10 seconds is appropriate because there is no need of monitoring these events with higher accuracy.

### B.  JAVA

Which follow a random forwarding of data, where the red line represents a delay performance and the blue line the Resource consumption, over the axis horizontal for a single machine in megahertz scale and the axis vertical the classification in milliseconds:

In the Figure 4 about Forwarding-based Schemes results, we have the same axis as the Figure 5.
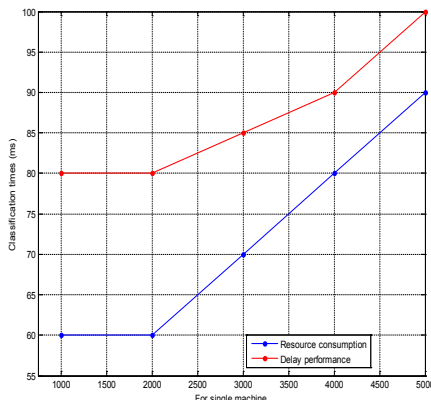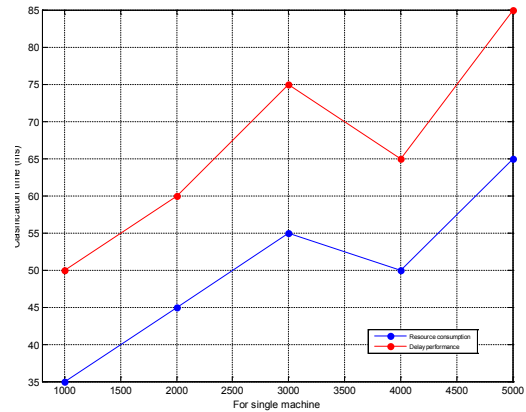
Fig. 4. Random forwarding



Fig. 5. Forwarding-based Schemes

### C.  MATLAB

The simulation was formulated to be realistic for a distance unit of meter and over a total simulated time of half an hour (one-time interval is about 3 mins).
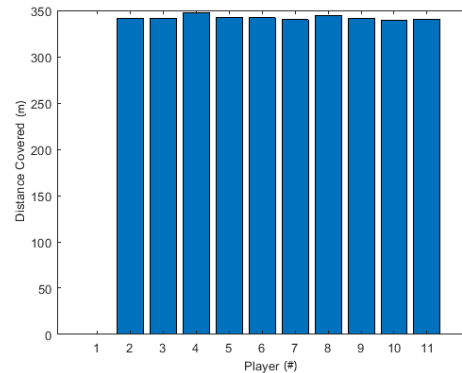


Fig. 6. Distance covered

MATLAB give this result, we have the distance travelled as we see in Figure 6, where almost all the football players in a simulation made in half an hour have about 340 to 350 meters travelled. Except for the goalkeeper who has no movement and is also our sinkhole in this protocol model. Therefore, the motion model works well, and the data generated on each node is clear to take the BMP data. It is appropriate to say that this distance is not very wide, with the certainty that the BPM will be normal, which we'll see later in the analysis of these results.

In the Figure 7, the result which one is the Delay Error Graph, which every WBAN or soccer player show his delay. In the horizontal axis is the player numbers and the vertical axis the Delay in milliseconds. The delay is between the sink node and every WBAN.
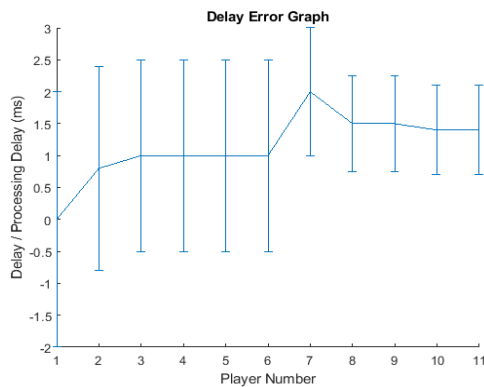
Fig. 7. Delay Error Graph

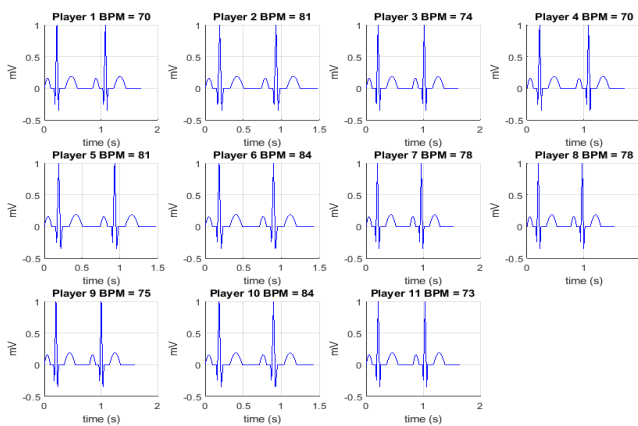At end the last result plotted is about BMP in every player means every WBAN.



Fig. 8. Beats per minute in every soccer player

In the Figure 8 the application simulates the heart-rate as being a baseline value of 70 plus an additional random number which is in proportion to the speed at which each player is going. Modelling heart rate in this manner allows the application to model heart rate in a very realistic way. The BPM is then mapped to an ECG curve by using a popular ECG reconstruction model.

## VI.    CONCLUSION

The delays in data collection in the simulation of MATLAB are about 2 milliseconds, in OPNET this can reach up to 4 seconds but throughout the system. Both use the same protocol "Zigbee" although different types of network, therefore, according to the research it was possible to introduce a new technology to improve or migrate.

In this research, three types of platforms were managed. One of which was already ready, and the other platforms have also been completed. Although JAVA is not a convenient platform in the simulation of communications.

The research allowed an animation to be coded that mimics real life. Which means that the animation is like a real scenario where this can be implemented with the suitable equipment. MATLAB along with its toolbox called Communication Systems was a successful simulation, achieved results with high reliability, therefore, it is correct

to say that developers already have two more platforms to do this type of projects.

In fact, the results show that the doors were previously opened to make new projects Time where the costs of acquisition and implementation are reduced. So, this research becomes the opportunity to start projects in wireless communication.

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