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Body Sensor Network Using a Domotic System

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Abstract. In this paper is presented the design of a domotic system with a body sensor network (BSN) based on an internet of things (IoT) architecture. It is presented two phases of the project: 1) a BSN evaluation based on computing simulation and 2) a system that collects the information generated by the BSN simulation and send to a Cloud system, to process the data and applying different analysis. One of the goals of this research is to define an IoT architecture that works as a framework for future implementations focused on sensor networks. Summing up, it is described a domotic system that monitors different physiological signals (e.g., cardiac rhythm) these data are sent to a cloud system. In the cloud data is processed and if an event in the data is detected (e.g. accelerated heart rate) then an action is triggered (e.g., turn on relaxing music). The BSN was simulated computationally. Simulation is validated and general outline of the system is presented and the future work is discussed.

Keywords: BSN, IoT, domotic, cloud environment.

1 Introduction

As stated by several sources, IoT has evolved into a state where it’s not seen as an emerging technology by itself, but as a platform that evolves and can help other emerging technologies achieve their full potential [5]. However, the term itself involves many other technologies, most of them different from each other, and the definition can vary from author to author. As [4] mentions IoT has passed through three different stages, which can be characterized by the technologies involved in them. These stages mark different milestones that have improved the development of IoT systems, and that also have helped the definition of the term to become more concrete. However, the state-of-art systems that have been published in recent years don’t seem to incorporate these three stages and in most instances they seem to incorporate tools that make impossible the interaction between them. Because of this, it’s proposed the development of a simple IoT system that works as a guideline for future implementations that deal with similar technologies.

2 Methodology

The first two phases of this project are a simulated Body Sensor Network and a Cloud system to analyze the data generated by the BSN.

2.1 BSN Simulation

The simulation of BSN consists of the configuration required to many sensors acquire different data (physiological signs) from a person (or even many persons). The simulated BSN comprises a certain number of nodes that transmit physiological signs, extracted from a person. The communication and transferring data is through the use of the protocol Slotted ALOHA for medium access control. The binary data transmission is used to apply pattern recognition (identify an event into the signal, for example: accelerated heart rate). Fig. 1 shows a general outline of the system's structure.

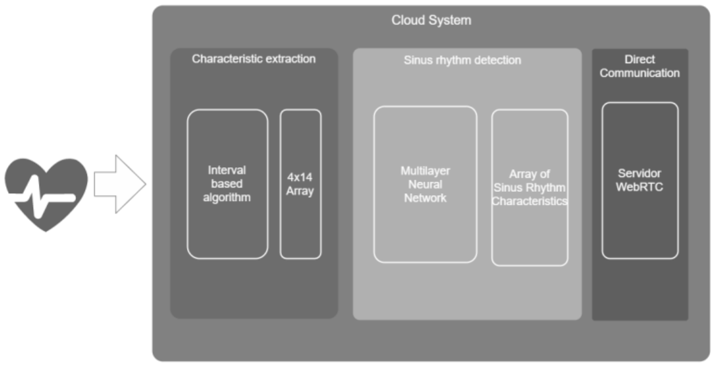

Fig 1. Outline of the system's structure. As can be seen, the cloud system will be comprised of three different modules.

2.2 Cloud System Communication with Energy Saving

The Cloud system receives the data of vital signals generated by the BSN simulation. These data are analyzed to identify or detect an event (e.g. characteristic extraction). The data is received through a gateway device that coordinates the data flow from the BSN to the Cloud. Here, one of the goals is save energy in the communication process. To achieve that, the BSN coordination is assigned to a device with higher capabilities within the BSN nodes. It ensured that the nodes save energy by only using it to communicate with the data sink and their own functionality needs.

The cloud system is envisioned as a series of web services that allow any kind of device that can implement the http protocol to make use of them through the use of an URL. In the tests done the cloud environment server is comprised by four web services that allow the BSN to send data to the Neural Network located on the server.

Fig. 2 shows a graph that displays the death times of the nodes in the BSN. Said test displays the result of the calls made to a web service by the simulated BSN.

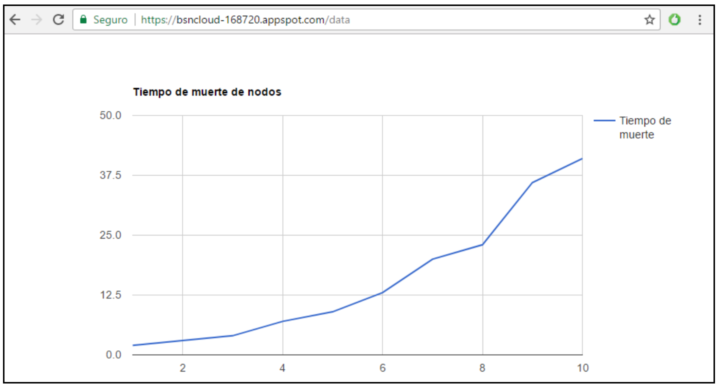

Fig 2. Transmission test from the BSN to the cloud environment with a graph showing death time for the net nodes.

2.3 Communication in BSN Simulation

The BSN was simulated as a set of nodes that transmit information to a sink under a Slotted Aloha protocol. Using a simulation proved to be easier to implement than a real testbed with nodes attached to real people since in order to determine de different operational parameters of the BSN or the nature of the obtained signal we can just simply change a few lines of code. The physiological signals used in this project were taken from The MIT-BIH Normal Sinus Rhythm Database which contains physiological signals from healthy and abnormal sinus rhythms [7]. In Fig. 3 the workflow of the simulation is shown.

The simulation's performance was validated using a Markov chain denoted by equation 1 and a comparison of the throughput obtained through the simulation and the Markov chain is shown on Fig. 4 and 5.

$$S = \sum_{i=0}^{N} \frac{1}{i\tau(1-\tau)^{i-1}} = \frac{1}{\tau} \sum_{i=0}^{N} \frac{1}{i(1-\tau)^{i-1}}, \quad (1)$$

where:

S = throughput

N = number of nodes

τ = transmission probability

It is shown that the throughput reaches its maximum value when the transmission probability is selected around 1x10-2 and it is proportional to the number of nodes in the BSN. It has also been proposed an energy aware transmission protocol. This protocol assigns each node a different transmission probability based on its energy left and based on the networks' residual energy, however, testing has shown that this leads to nodes not transmitting at all when energy levels are low.

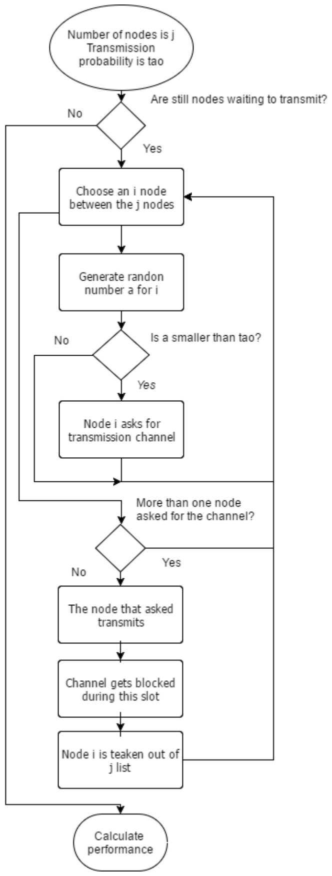

Fig. 3. Workflow of the BSN simulation.

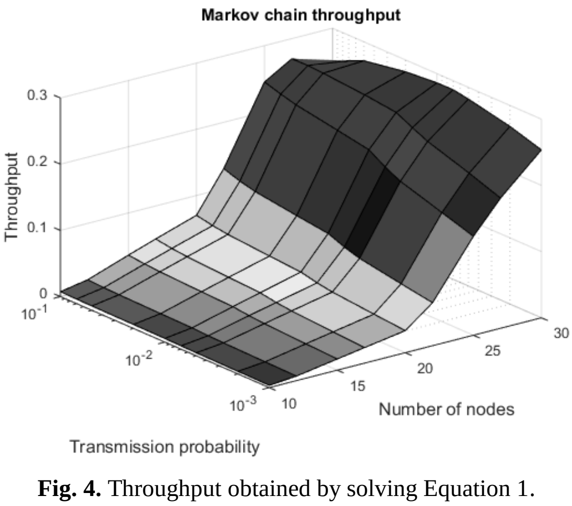

Fig. 4. Throughput obtained by solving Equation 1.

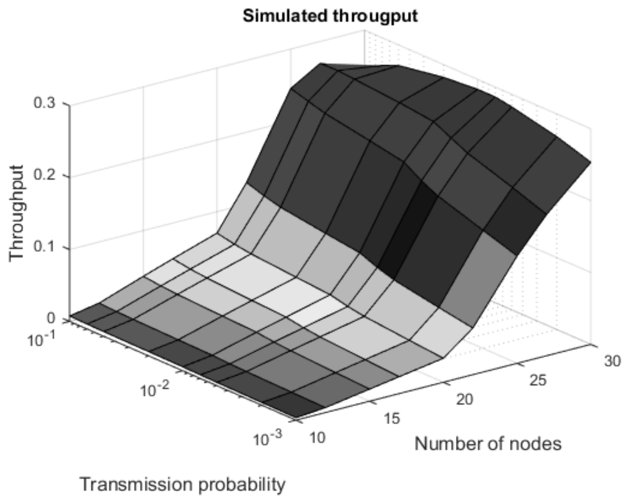

Fig. 5. Throughput obtained by the simulation.

The cloud system as for this stage, is comprised of four different Restful web services created with the Java library Jersey. These web services correspond the CRUD paradigm and serve as the only means to communicate with the server. They were accessed from the BSN through the use of the *curl* tool.

The characteristic extraction is based on [2], were the classification of the electrocardiogram signal is based on 13 different characteristics extracted from each heartbeat and the relation between heartbeats. The extracted characteristics can be classified under three categories: qrs complex characteristics, inter beat relations and time related characteristics. These characteristics are given as a 1x14 array input to a two layered neural network. Work is still being done on this module since its implementation relies heavily on WFDB Toolbox on Matlab [6,7].

3 Experiments

The test was an implementation of the character recognition exercise given by [3] for testing the connection between the BSN and the server. In said test an array of 37 different values are given to a neural network in order to be classified according to the letter they represent. Through the access to an URL, the BSN uploaded bipolar arrays that represent characters and the server classified them based on their similitude to the correct characters.

The web services are four, but for this test only one was used. The test was successful and given that the sole purpose of the test was to ensure the correct connectivity between the BSN and the server it is concluded that the system passed the test.

4 Future Work

In the first place, it has been stated that the pattern recognition method used for the tests so far, although it has proven to be successful, it is still not validated as the best method for this kind of implementations. Since detecting fluctuations on the normal sinus rhythm, is the main focus of this project more work is needed in order to get a more refined method of detection. Further testing is needed in order to get a higher percentage of detection.

Secondly, the tests done so far, involve only one simulated BSN. Further tests must involve more simulated BSNs in order to test the Cloud environment stability under a big number of BSNs sending data continuously. Also, the patterns transmitted from the BSN to the server must be physiological signals un future tests instead of bipolar arrays.

Finally, the BSN simulation is focused mainly on the transmission behavior of the net. In future tests the BSN must be modeled as close as possible to a real BSN.

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