Development of a Communication Platform for IEEE 802.15.4 based Wireless Sensor Networks

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***Abstract*— In this paper, the design and development of a communication platform for the deployment of IEEE 802.15.4 based wireless sensor networks, is presented. The communication platform will be able to establish a link between multiple devices using radiofrequency signals to simultaneously send and receive data frames, allowing the identification and authentication of each device. For this purpose, base functions and definitions from IEEE 802.15.4 protocol stack will be used.**

***Index Terms*—Wireless Sensor networks, IEEE 802.15.4, Communication Protocol.**

I. INTRODUCTION

Nowadays, the study and development of new technologies and wireless transmission methods are constantly moving forward, including the registering and reviewing of most popular communication protocols. Specifically, one of the areas that have been experiencing most attention on the research discipline the last years is the Wireless Personal Area Networks (WPAN).

Currently, there are several solutions for developing structures that uses local area networks as basis, being Bluetooth®, Zigbee® and 6LoWPAN® the most popular [1]. However, none of the present solutions fully satisfies the requirements for simple development of a wireless sensor network, including robustness, accessibility, scalability and easy deployment [3] [4].

Due to this, a communication platform was developed to integrate most of the typical properties of a WPAN device. For achieving that purpose, this Final Master Thesis was focused on the implementation of a complete and functional communication platform supporting wireless communications between devices, in order to ease the development of flexible wireless applications.

II. SENSOR NETWORKS

A sensor network is a network that is composed by several similar devices, called nodes. Each one of these nodes collaborates in a common task, so each one has a defined functionality. However, most of these sensors don't have enough capacity to process and analyze the acquired data, having the only function of capturing information from the environment and send it to a central node, where the processing task will take place.

To send the information, these nodes must be able to organize themselves, in addition to wirelessly interface with other peers, creating what is known as Wireless Sensor Network (WSN), which usually has the typical structure shown in Figure 1.

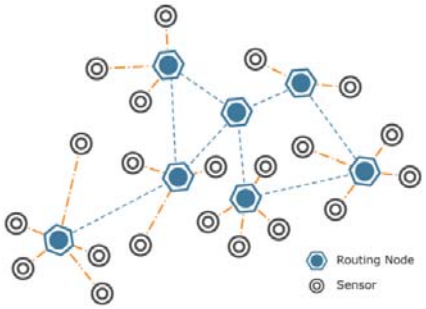

Figure 1. Wireless sensor network structure

Therefore, it can be said that sensor networks consist of a group of nodes that communicate with each other wirelessly, making it possible to create ad-hoc networks without the need of early deployment of physical infrastructure, or a central administration in charge of organizing the nodes. Some of the highlights of the wireless sensor networks are [4]:

- Dynamic topology.
- Channel variability capabilities.
- Fault tolerance with no predefined network infrastructure.
- Low power consumption due to hardware limitations.
- Low production costs per node.

III. IEEE 802.15.4 STANDARD

The IEEE 802.15.4 communication standard defines and regulates the PHYsical layer (PHY) and Medium Access Control layer (MAC) in wireless personal area networks oriented to wireless transmission between devices with low data rate and low power consumption [2] [3].

As indicated above, this communication standard just defines the PHYsical and Medium Access Control layers, so any application must be either developed over this standard according to its requirements, or imported by using any of the existing protocols based on the IEEE 802.15.4 standard.

IV. PROPOSED COMMUNICATION PLATFORM

The proposed communication platform is intended to be used in the deployment of wireless sensor networks based on the IEEE 802.15.4 communication standard. It has been designed with the aim of try to optimize resources and power consumption, achieve high scalability, and provide to the system with functional flexibility of platforms used in the deployment of WSN.

The developed platform has been based on the use of two functional types of devices defined in IEEE 802.15.4 standard, which, according to their functionality, can be *Full Function Devices (FFD) –coordinator nodes–* and *Reduced Function Devices (RFD) –sensor nodes–*. Also, a *star* architecture was decided to be used as the network topology.

For the development and functional verification of the proposed communication platform, a communication module was selected which includes an AT86RF212 radio transceiver and an AT90CAN128 microcontroller, both from Atmel manufacturer. In addition, the system is equipped with additional features, like hardware UART-to-USB and microSD memory card socket, where required information is stored.

In order to satisfy the different requirements of the communication protocol, it was necessary to develop several libraries in ANSI-C including firmware functionalities for allowing the system to establish a WSN able to exchange data frames between sensor nodes and the coordinator node, as well as making possible the communication between the coordinator node and the external system which the network is connected to.

The functional diagram of the developed communication platform is shown in Figure 2.

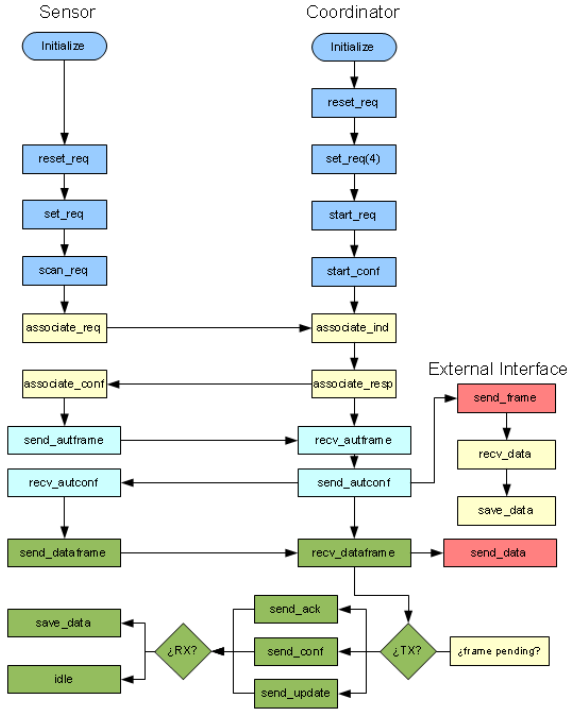

Figure 2. Functional diagram of the communication platform

In the proposed protocol, each sensor node performs a reset of its configuration, and sets the required parameters that allow the association to any coordinator node available on its cover range. After associating to a coordinator node, an authentication frame is sent in order to be validated by the coordinator, allowing it to send data frames. Once the sensor device is validated by receiving an authentication acknowledge frame from the coordinator node, the sensor proceeds to send each frame stored on its transmission buffer. For each data frame sent, the coordinator responds with another data frame that can be, a *configuration frame*, an *update frame*, or a simple *acknowledgment frame*, indicating in all cases that the data sent was successfully received. On the other hand, the coordinator node, after reset, set its parameters to establish a network with the desired *PANId*. Once the network is established, the coordinator node waits for incoming association requests in order to allow associating devices. After being associated, the coordinator waits to receive the authentication frame, checks the frame content and proceeds to send the authentication confirmation to the device. At this point, each sensor frame being received is stored on the external transmission buffer in order to be transmitted out of the network. Each received device frame is answered with a confirmation frame, that can be of one of the three types described above, depending if there is any configuration data available to send to the sensor device.

V. SIMULATION AND RESULTS

For the simulation and functional verification, it was necessary to operate using at least one device of each type, in order to reach and establish a communication link between them and verify the correct exchange of data frames and other operations realized in the establishment of the wireless communication.

To perform the functional verification system, debug modes of the compiler tool and programmer-debugger were used.

VI. CONCLUSION

With the completion of this Final Master Thesis, a communication platform have been successfully designed, tested and validated, for being used in the deployment of IEEE 802.15.4 based wireless sensor networks. In this way, sensor networks for different applications can be easily and cost-adjusted developed, allowing the implementation of networks without the requirement of developing a complex protocol or paying for the rights to use available commercial protocols.

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