# ZigBee Wireless Network Based Monitoring Systems

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**Abstract:** Applications that transfer data wirelessly tend to be more complex than wired ones. Wireless protocols make stringent demands on frequencies, data formats and timing of data transfers, security and other issues. Application development has to consider the requirements of the wireless network in addition to the product functionality and user interfaces. Using wireless networks in Mechatronics can be very useful and challenging in order to improve the general performance. The authors studied the opportunity of setting up Monitoring Systems based on a ZigBee Wireless Network Standard. The proposed systems were set up, tested and the minimal Hardware and Software requirements for them were determined.

*Keywords:* wireless network, ZigBee, monitoring system, mechatronics, $I^2C$ communication, microcontroller, humidity and temperature, vending machines.

## 1. INTRODUCTION

In the last years, Information Technology provided for rich connectivity and thus made the world highly interconnected. Sensor networks grew at a tremendous pace in the last decade, integrating humans and sensor devices seamlessly (LiYing et al. 2010). With wireless microcontrollers based on ZigBee Standard and suitable sensors and actuators, we are able to build wireless networks for a large area of mechatronics' applications (Sztojanov et al. 2006).

Wireless networks are very suitable for monitoring parameters or activities in a certain area by using integrated sensors and the RF communication facilities. For many applications the existent ZigBee Standard represents the most suitable solution because of the 2.4 GHz free global band, low cost, easy installation and use. To build up and to test a certain system we can use standard circuits in order to assess the necessary hardware and software requirements. The PICDEM Z Evaluation Board is specially designed for easy programming and testing wireless applications for ZigBee Standard.

We used this Demonstration/Evaluation Board in order to develop and test two monitoring applications: one using a combined humidity and temperature integrated sensor for vegetation supervision in a hot house and the second one for optimization of the refilling of vending machines from a certain area.

## 2. THE ZIGBEEE STANDARD

ZigBee is hardware and software standard built on the IEEE 802.15.4 standard and represent a standardized wireless protocol for personal area networking WPAN.

The main characteristics of the protocol are: global, unlicensed band operation at 2.4 GHz, RF penetration through walls and ceilings (demonstrated 30 m indoors and 70 m outdoors), automatic or semiautomatic installation, low cost and low data rate (10 Kbs to 115 Kbs). The standard supports the following device type: Reduced Function Device (RFD), Full Function Device (FFD) and network Coordinator with the typical network models presented in Fig 1.

The ZigBee Standard is tailor-made for monitoring and controlling applications.

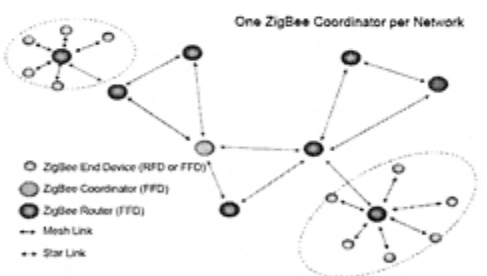


Fig. 1. Typical ZigBee network models.

## 3. TEMPERATURE AND HUMIDITY MONITORING

For monitoring purposes in a certain area, we need to build a wireless network with sensors connected to ZigBee End Devices, a ZigBee Coordinator and, in the case of large areas, some ZigBee routers have to be included too. The

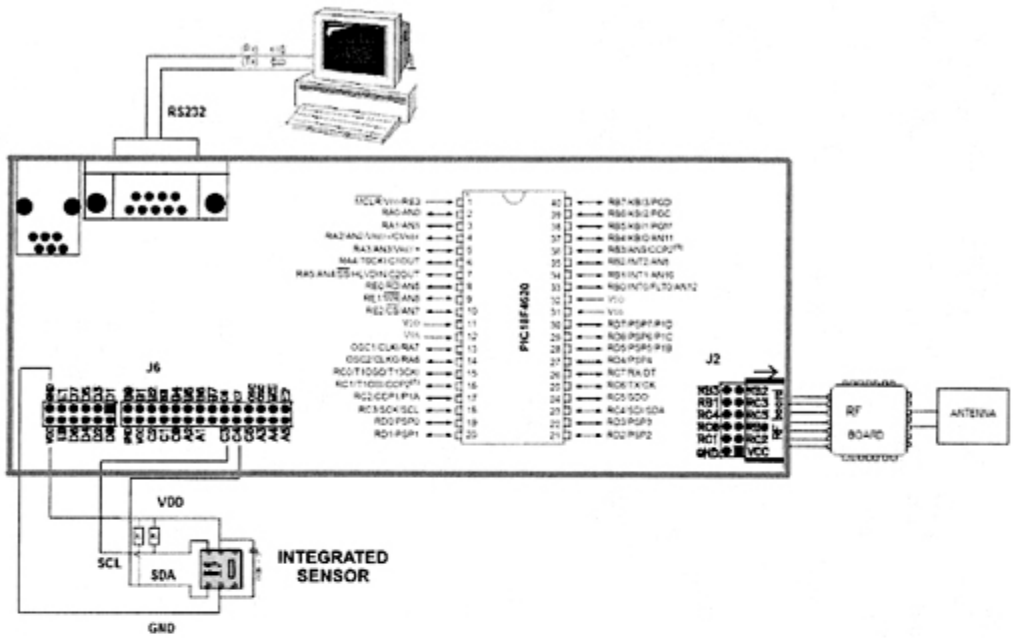


Fig. 3. A Reduced Function Device with the sensor and the RF module.

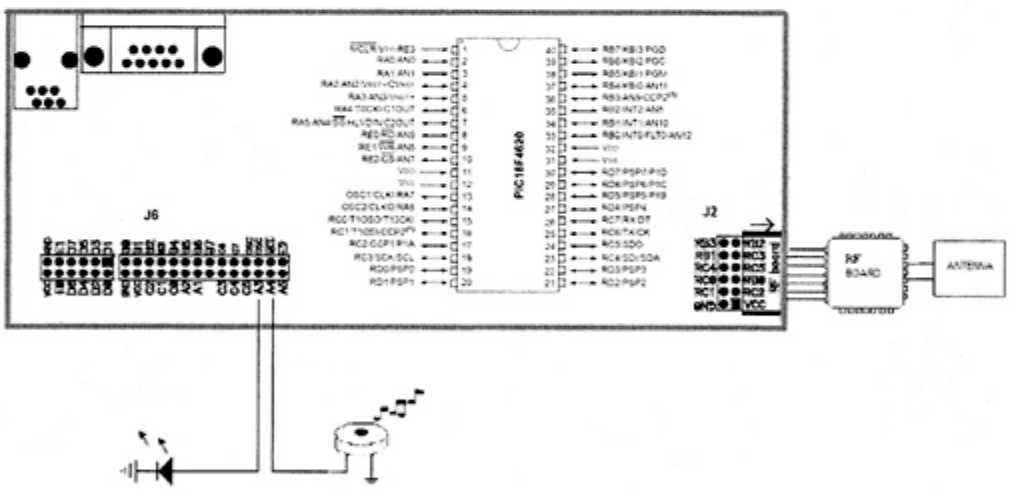


Fig. 4. A Full Function Device as network Coordinator.

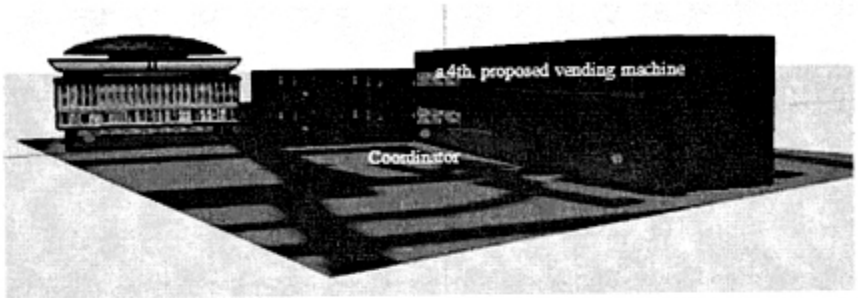


Fig. 5. Proposed placement of Vending Machines in the Politehnica Main Building.

The aforementioned vending machines are classical mechatronic systems, which only fulfill functions such as offering a selection of products, and making them available for the buyer in exchange of a certain amount of money.

The authors suggest the reconfiguration of the vending machines by means of new generation microcontrollers, specially designed for Wireless communications. These microcontrollers include RF-devices able to work according to the ZigBee standard in the free 2.4 GHz band. In the UPB-area a wireless star-network can be created, where the end points would be vending machines equipped with microcontrollers programmed as RFD. In the centre of the network, a microcontroller used as FFD would fulfill the role of network coordinator. By means of serial communication, it would also be connected to the computer in the headquarters. The data thus collected would provide the coordinator with an account of the available products at any time and enable it to make decisions for the optimal re-filling of the stock.

Once the network is built, additional functions can be introduced at minimal cost, such as: account of the number of passers-by, of the number of people stopping in front of the machine and, last but not least, of the number of buyers. These data are very useful for marketing studies (Basten et al. 2006).

The vending machines can be placed on the campus according to Fig. 5 in order to be connected in a star wireless network but wireless Router Devices are necessary in order to cover the large building area properly. The network coordinator will be serially linked to a computer used for monitoring the parameters of the vending machines in the network. The built network will allow an optimal refilling and also enable the transmission of commands to the endpoints (the vending machines), such as changing the prices of the products. The experiments have been built on a PICDEM Z development board.

We designed a Finity State Machine (Sztojanov et al. 2008) for controlling the Vending Machine. The designed FSM was programmed in C, set up and tested on a PIC18F4620 microcontroller as part of the PICDEM Z Development Board. The propagation properties of the application were tested in the Building of our University in a star network.

## 4. CONCLUSION

The built and tested systems allow us to draw some conclusions regarding the necessary hardware and software. For both applications, the ZigBee Standard is very suitable. From the hardware point of view, for the temperature and humidity monitoring application, instead of using standard wireless microcontrollers for the Reduced Function Device, we would require low cost, low energy consumption special designed Application Specific Circuit. In the case of smart vending machines, a standard wireless microcontroller appears to be the best solution. This new controller can replace the old one in the case of existing vending machines and with a new software program we can extend the fulfilled functions in order to build a smart mechatronic system for a new type of intelligent ambient.

## REFERENCES

Basten, T., Geilen, M. and de Groot, H. (2003). *Ambient Intelligence: Impact on Embedded System Design*. Kluwer Academic Publishers, Boston.

LiYing, C., Soundar, K. and Reka, A. (2010). Complex Networks: An Engineering View. *IEEE Circuits and Systems*, vol 10 (Number 3), pp 10 – 25.

Sztojanov, I., Paşca, S., Buzoianu, E. and Soran, I.F. (2006). Perspectives about the Hardware Structure of the Sensors used in Wireless Systems. *Revista Mecatronică*, nr.1, pp 4 – 7.

Sztojanov, I., Paşca, S. and Tomescu, N. (2008). *Electronică Digitală*. Editura Albastră, Cluj.