New monitoring system based on wireless data acquisition devices

César Escusa Andrés, Telecommunication Engineer. Renaissance Project, 2010.

cescusa@unizar.es ; Tel. (+34) 976 762234

website: http://renaissance.unizar.es

http://www.renaissance-project.eu/?lang=en

Abstract For the last few years wireless technologies have grown up becoming one of the most important technological markets in the world. At the same time new phenomena started, it is called "The internet of things" [1]. This term has been used to show the possibility of monitoring every parameter of the environment, send this data wirelessly and have internet access to them. The University of Zaragoza's [2], Grupo de Energía y Edificación [3], through Renaissance Project [4] and Concerto [5], has been started on developing a new comfort monitoring system. This system will be installed on several districts of Zaragoza and will monitor some comfort parameters of the dwellings, storing this data and posting on the internet. Due to this technology several advises will be given to the tenant in order to improve the efficiency of the use they make of their dwelling, saving money in heating and air conditioning.

Introduction Grupo de Energía y Edificación is involved on Renaissance Project and has been studying the energy efficiency on the buildings for several years. Our work is to release recommendations to be introduced on refurbishment works and also on new buildings construction. To write these recommendations, a lot of deep studies have been done along this time, some of them are infiltrations measurement, thermo graphic studies and some other construction parameters. But after all this years researching, the Group realized that there is a main factor we passed through, the way the inhabitants use their dwellings can decrease the energetic efficiency of them.

To detect and solve this issue, the group started a monitoring program. The first phase included the installation of a monitoring system in some new bioclimatic dwellings in order to analyze the correct isolation, and the expected efficiency of these buildings. This system was setup using an optical fiber connection between sensing points. After this first step, the group could monitor the air quality and other parameters on several dwellings inside the bioclimatic district of Valdespartera [6], then we could determine if the inhabitants were using their dwellings correctly and we created a guidance of well behavior in using a bioclimatic dwelling.

After a successful first stage an additional foundation coming from Renaissance Project made an extension in the monitoring program. With this extension the Group decided to develop our own wireless monitoring system. This system is less invasive than the cable one and at the same time it is cheaper due to the savings in optical fiber and self developing system. For this system the Group selected a low consumption microcontroller, Waspmote [7], designed by Libelium Comunicaciones Distribuidas S.L. [8]. This device allows the creation of sensor networks that are able to transmit wirelessly the collected data from sensors towards a centralized server which store this data in order to be interpreted later on.

Implementation Waspmote device allows us complete sensor integration thanks to its multiple analog/digital inputs. This device has several characteristics that make it very versatile as will be shown later on. Apart from that this device has the capability of creating a wireless networks that gives a path to evacuate the data to a server. With all the data collected by these devices the Group can analyze the environmental variables in order to know what use the inhabitants do of their dwellings.

Figure 1. Waspmote device.

Within the wide sensing possibilities the Group decided to integrate some comfort sensors like temperature and humidity and leaving CO_2 concentration sensor and Energy consumption for further stages of the project. We elected low cost and low consumption sensors with moderate accuracy and very easy integration. The objective was to develop a very low cost and low consumption monitoring system with an acceptable accuracy.

-Temperature sensor **MCP9700A** [9] with a typical consumption of 6µA. and an accuracy of ±2ºC in full range [-40ºC, +125ºC] and ±1ºC around typical values ≈25ºC. This accuracy and consumption are enough for the system requirements.

Figure 2. Temperature sensor.

-Humidity Sensor **808H5V6** [10] with a typical consumption of 180 µA and an accuracy of ±4% of Relative Humidity. This sensor gives us a good response along the 0%-100% Relative Humidity range.

Figure 3. Humidity Sensor.

-Carbon dioxide (CO_2) Sensor **TGS4161** [11]. This sensor has high consumption 50 mA and need a long time to give an accurate value of CO_2 concentration but is probably the best choice in the market for being integrated on a low consumption device like Waspmote.

Figure 4. Carbon Dioxide Sensor.

-Electrical consumption split core sensor [12], this is a passive sensor which gives an output proportional to the power consumption of the cable you put it in. It is quite simple to install, just click over the main power cable, and very accurate, with a really linear output.

Figure 5. Power Consumption Sensor.

The integration of these sensors is quite simple due to the direct response of all of them. But when we started to develop the Printed Circuit Board we realize there is a scale cost issue. We really want to monitor Temperature and Humidity in hundreds of dwellings, but we only want to monitor CO_2 and power consumptions in around twenty. As it is know the cost of a PCB decreases with the quantity of them you need, so we decided to develop a dedicated Board just for Temperature, Humidity and Power consumption, and use a Libelium's Gases Sensor Board [13] for the previous plus CO_2 measurements. As we can see in Figure 6 this board is a very nonspecific board which can integrate several gases and using it only for CO_2, Temperature and Humidity seems to be a waste of possibilities, but is anyway can be the most economic option.

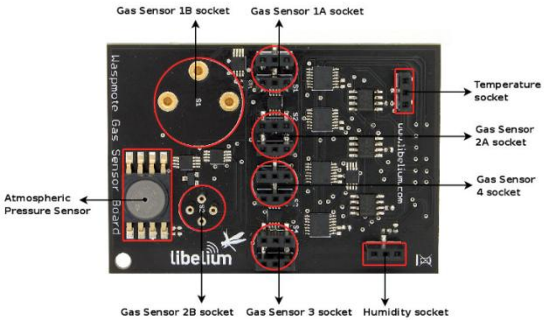

Figure 6. Libelium's Gases sensor board.

The cost of developing a board like this is quite difficult to calculate because we don't know how long could take the researching period for a board like this. As soon as we decided what kind of sensors we wanted to integrate, the design of the PCB started. It took more time the getting started with the Software period than the design of the board. The software that we used was EAGLE [14], and as we didn't know how to use it before, it took a little time to understand how it works. At the end in Figure 7 we can see the final PCB.

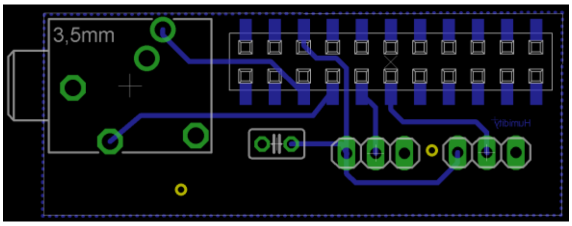

Figure 7. Resulting schematic PCB.

Economical study The final decision of choosing this system was determined by several points. These are cost, flexibility, interoperability, scalability, and self developing possibilities.

The main point is the cost of the Libelium's system compared with other systems. The price of the system is quite cheap; here is a pricing table of the complete sensing system.

Device	Price €
Temperature Sensor	0.19
Humidity Sensor	10.25
CO_2 Sensor	14
Power Consumption Sensor	7.2
Libelium Gases Board	105
Self Developed PCB	10

Table 1. Sensor device prices.

As Waspmote is a low cost device, for less than 200 € a self developed Temperature and Humidity equipped system, can be armed. And with the Libelium's Gases Board could be around 300 €.

Other point is that Waspmote has a complete freeware programming environment and a big community of programmers that share ideas and interests. Comparing with other proprietary systems, this could be an advantage because you can program your device for a particular behavior, and you can modify it on the way. In a proprietary system you need to call the supplier when you want to modify anything. As con, we can say that there is a learning period until you get use to the technology and the programming environment. This is a high cost, and it is difficult to take into account, but this is an investment in formation and is inherent to University Projects.

Another advantage is the scalability and interoperability of the system. The Wireless transmission protocol provides communication within every point in the network using a mesh network created over Digimesh [15] protocol. This protocol was developed by the company DIGI [16] international based on 802.15.4 [17] and provides data routing between every node inside the network. Using this protocol we can add sensing points or modify the position of them inside the network, just making sure that the maximum radius towards the last point of the network is not over passed.

Concluding this economical study we can say that the pros are definitely more than the cons in this system, is cheaper and it give us a lot of advantages for future decisions or changes.

Software This part talks about the software developed for this device and the tricks we use to save battery in order to maximize the battery life. First of all is necessary to know the main features of Waspmote's device in order to use them and take everything the device can give us.

This device has some low consumption modes or Sleeping modes in order to save battery when some functions are not necessary for a while or until an event happen. In Table 2 are shown different working modes of Waspmote.

Mode	Consumption	Micro	Time
ON	9mA	ON	-
Sleep	62µA	ON	32 msecs. - 8 secs.
Deep Sleep	62µA	ON	8 secs. - years
Hibernate	0.7µA	OFF	8 secs. - years

Table 2. Sleeping mode characteristics.

The difference between Hibernate mode and Sleep modes is the way they wake up. The Hibernate mode can only wakes up with the internal clock alarm and the Sleep modes can wake up with an input signal change which makes these modes really versatile. The idea of programming this device is to have a period of time to take data from the environment and then go to sleep for a pre-determined period of time minimizing the consumption during this period. If we only want to make the device sleep for a constant period of time the perfect mode could be Hibernate, but once you start programming there is not as simple decision, due to some requirements of the project. Using Hibernate mode you cannot have variables in use because after every sleeping period a reset happen and you lost all this data. On the other hand the power consumption is a hundred times lower than the Sleep or Deep Sleep modes. During the design period, two different programs where developed, one using Deep Sleep mode, and the other using Hibernate mode. With Deep Sleep mode we had more possibilities, as upload some data every hour or developing some complex programs, but the battery cost was very high. So we decide to develop a complex program using Hibernate mode to maximize the battery duration. The program only uploads data once a day, and takes data from the environment every 15 minutes, so we upload 96 values every day. At the beginning, we started taking data every 10 minutes because it was supposed to be the target, but we realize the objective was too ambitious; so at the end we decided sleep the device for longer periods in order to save battery and extend the time without changing the battery. The final program achieved our goal of staying more than two months without changing the battery of the system, and even more depending on the topology of the network and the distance between nodes.

Summary During the last few months we started an ambitious monitoring program. On the first stages the group browsed along the market looking for a solution for our monitoring system. As we only found closed and expensive systems which required maintenance from the suppliers we decided for a self developed system. With this idea we can monitor much more dwellings with the same investment and the researching we have done can be shared with all Renaissance project groups in order to minimize the costs.

We have dealt with the limited battery charge and the prospects of collecting as many data as possible. We have studied all possibilities in order to find out which one could maximize the life of the batteries, fulfilling our pretentions of collected data. Finally we found out the way to get equilibrium between data collected and battery duration.

Reference

[1]. http://www.theinternetofthings.eu/

[2]. http://unizar.es/

[3]. http://gee.unizar.es/

[4]. http://renaissance.unizar.es/ and http://www.renaissance-project.eu/?lang=en

[5]. http://concertoplus.eu/cms/index.php?option=com_content&view=frontpage

[6]. http://www.valdespartera.es/

[7]. http://www.libelium.com/products/waspmote

[8]. http://www.libelium.com

[9]. ww1.microchip.com/downloads/en/devicedoc/21942a.pdf

[10]. ftp://ftp.efo.ru/pub/sencera/pressure/808H5V6.pdf

[11]. www.figarosensor.com/products/4161pdf.pdf

[12]. http://www.seeedstudio.com/depot/noninvasive-ac-current-sensor-30a-max-p-519.html?cPath=84_91

[13]. http://www.libelium.com/documentation/waspmote/gases-sensor-board_eng.pdf
[14]. http://www.cadsoft.de/
[15]. http://www.digi.com/technology/digimesh/
[16]. http://www.digi.com/
[17]. http://en.wikipedia.org/wiki/IEEE_802.15.4-2006