Sensor-Based Environmental Monitoring for Ambient Assisted Living

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Abstract. Home automation technologies have emerged more than four decades ago, but are undeniably a current subject of interest. Existing systems are usually highly customized, therefore expensive or very sophisticated and complicated, most of which requiring dedicated network cabling. The present paper presents a system for monitoring and control of an ordinary house in a simple and inexpensive manner. The ZigBee protocol is chosen so as to provide a reliable and secure wireless communication without additional cabling required. The data is transmitted to a computer that records and monitors any eventual threshold crossings. The control part is represented by simple means of acting upon an LED, based on data collected from the sensor network and processed accordingly.

Keywords: Arduino · Home automation · Sensor network · WEB applications · Zigbee

1 Introduction

Home automation technologies have emerged more than four decades ago, but are currently a major subject of interest. Existing systems are usually either highly customized, therefore expensive, or very sophisticated and complicated. Most of them require dedicated network cabling, often adding to the cost price. Furthermore, this solution is approachable only during the house's construction phase [1, 2].

The purpose of this paper is to develop a system for monitoring and control of an ordinary house in a simple and inexpensive manner. A centralized system will be created, in which most of the intelligence is managed via a server and network nodes' design to be kept to a minimum.

Sensor networks are ideal for any form of environmental monitoring. Due to the sensors' small size, low energy consumption and, in particular, their moderate cost, sensors can be installed in locations of interest and provide accurate reports. They will need another component to read the data and send them to a control system for processing. To achieve this, we will make use of the Arduino platform. The ZigBee protocol is chosen so as to provide a reliable and secure wireless communication without additional cable

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required [3]. Responsibilities related to basic security functions are assigned to a server. Its role is to monitor the system's current status and provide a user interface.

This paper is directed towards such a system, using Digi XBee communication modules, database management systems and tools for creating dynamic WEB pages, in order to achieve a sensor-based environmental monitoring system for Ambient Assisted Living, through WEB applications.

The paper is organized as follows. Section 2 describes how the environmental monitoring system is implemented. Next, Sect. 3 shows the results and discusses them, while Sect. 4 concludes the paper and outlines future work.

2 Hardware and Software Implementation

Our work aims the ambient monitoring of a typical room, therefore the desired parameters to be supervised were selected among those of interest for a human observer, i.e. temperature, humidity and illuminance levels.

The data collected from the sensors is assembled into a packet to be wirelessly transmitted from one XBee radio module to the other.

The block diagram for the environmental monitoring system is depicted in Fig. 1.

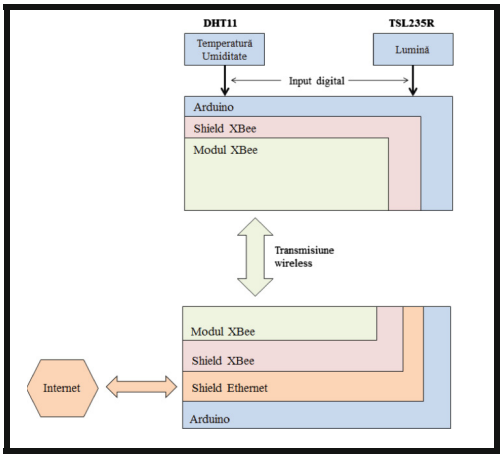

Fig. 1. Block scheme of monitoring system

2.1 Transmitting Module

The ensemble Arduino [4] - XBee shield and XBee module - sensors (Fig. 2) form the acquisition and transmission module. Clearly, their role is to monitor the room, assemble the acquired results and transmit data for further processing, while receiving control commands in reverse.

The sensors used were DHT11 [5] for temperature and humidity, respectively TSL235R [6] for illuminance. After acquiring the 3 parameters, we will proceed to assemble the package.

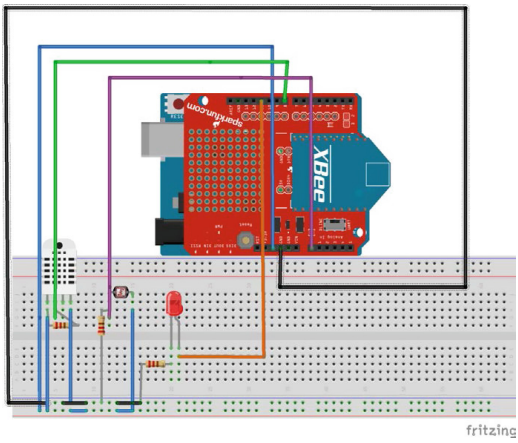

Fig. 2. XBee acquisition and transmitting module

The XBee module, accompanying the transmission module, is configured as a router, hence it fulfills the following: it expands the network, it monitors the two digital inputs, it manages packet transmissions and control commands receptions.

2.2 Receiving Module

At the reception side, the Arduino - XBee shield with the XBee module set as coordinator - Ethernet [7] shield ensemble was used. It is designed to receive and carry out the received packet decoding logic, restoring the monitored parameter values. Using the Ethernet shield, which connects the Arduino platform to the Internet, the database population is achieved, process intertwined with the WEB application's data "feeding".

The procedure for checking the reception of a packet is as follows: incoming data is checked, followed by the packet type identifier inspection (to decide on the appropriate decoding scheme, according to the predictable frame structure associated). The source address is afterwards tested, concluding with data decoding, in accordance with the known structure of the transmission.

2.3 Populating the Database

Populating the database was done in the following steps:

C.1. Create a Local Server - where databases and files allowing the WEB application to run properly will be stored; XAMPP was used for this purpose [8]. A MySQL database was likewise created.

C.2. Connect Arduino to the Internet – the Ethernet Shield [8] allows connection to an IP network; attaching this shield, Arduino can be converted into one of the two Ethernet devices, client or server. Client conversion will allow server connections and request data from the server, which is also what it is intended.

C.3. Initializing Server Connections - Effective connection to the server will be based on the server's IP address, to which to send the request, and the TCP port, in this case 80. If a successful connection is established, it performs an HTTP GET request to the server, in order to transmit the values of the three parameters, and further process them [6].
C.4. Development of PHP Scripts, in order to make changes to the database built in the previous steps (addition, deletion of data, etc.)
C.5. Building the WEB Application - PHP is capable of creating dynamic WEB pages (that can change their appearance contextually) [8]. The data was displayed in a table-fashioned manner. The table and user interface was created based on HTML, while data "fed" the application via PHP scripts, the nesting of these methods proving the claim made earlier in the paragraph.

At this point, the WEB application will display in real time (by refreshing the page) the results gathered from the acquisition node, wirelessly transmitted to the receiving node, decoded and stored in the database.

2.4 Control Interface

Monitoring the ambient parameters is fulfilled through providing qualitative and quantitative information on the environment in which the sensor network is installed. Usually, however, it is desired to act upon these parameters, therefore creating an automation system that can be easily and remotely controlled. Displaying the temperature, humidity and illuminance parameters using a WEB application allows their continuous supervision, but this can be supplemented with enabling interactive control of devices, adjustable according to a criterion of interest. The range of facilities mediated by such an approach is extremely varied: the control of a central heating system, a ventilation system, an array of switches, etc.

To emulate this concept, it was proposed to act upon an LED, having the role of an end device among those mentioned earlier, the principle being valid for any electronic device, as follows.

Acting upon a set of graphical buttons will be synonymous with the user's intention of sending a command. In this case, a file will be created that will include a value of "0", symbolizing the absence of control - because this is the prevailing state of the system, or overwrite it with an "1", indicating that a command was initialized. Arduino will query the server by opening the file, will read the value, will pack it and send it to the monitoring module installed in the room, which will decode it and act correspondingly upon the LED: will take a decision on its on- (when an "1" is decoded) or off- ("0") state.

Because, once the intended command is completed (for instance, the temperature reached the desired value, being time to stop the central heating adjustment), we proposed that, when acted upon the control button, the user is redirected to a waiting window, returning to the main application after the command's completion.

3 Results

The evolution of all 3 parameters was studied, during both daytime and nighttime, inside a laboratory environment. Figure 3 depicts data acquired from the TX module that corresponds to the particular situation of nighttime and, thus, sensors are tested in extreme conditions: the absence of light sources and proximity to a heat source.

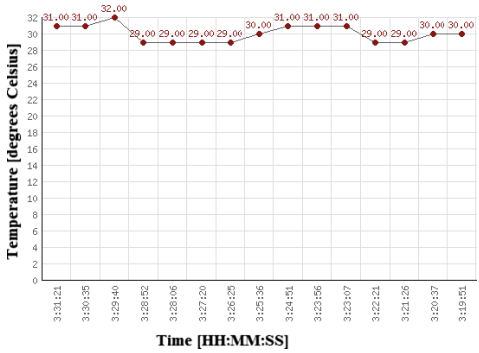

Fig. 3. Parameters'(temperature) graphical evolution over a 12 min window

At the end of the sequence described by steps C.1¬ C.5, in the database stored locally, the changes in values for the 3 parameters, along with their timestamps are stored.

The developed WEB application is used to display and control the parameters. The tools provided by the WEB application are:

- Periodical statistics,
- Graphical representation of the measured values,
- Possibility to send backward commands, in order to act upon electronic devices, which could lead to the monitored parameters adjustment.

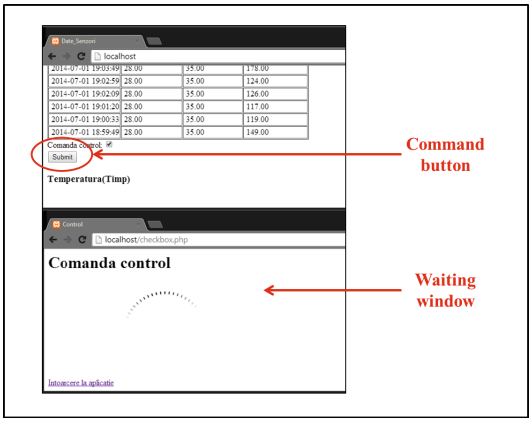

Fig. 4. Submitting a command and redirection to a waiting window

Figure 3 presents the variation of the measured values, in a 12 min window. The graphs are displayed via the developed WEB application in a WEB browser.

Intensive validation was carried out and the data from our system was compared with off-the-shelf products, such as home thermometers and lux meters. The results showed us that the system can very easily be compared in terms of accuracy and accessibility of the data.

As far as the initiating commands part is regarded, the graphical button, waiting window and results reflected upon the LED can be seen in Figs. 4 and 5. By not decoding packets of no interest for the system's proper functioning, precious time is thus saved, so the delay between the command's transmission and reception can be kept to a minimum (in our solution, the maximum delay achieved was 2 s).

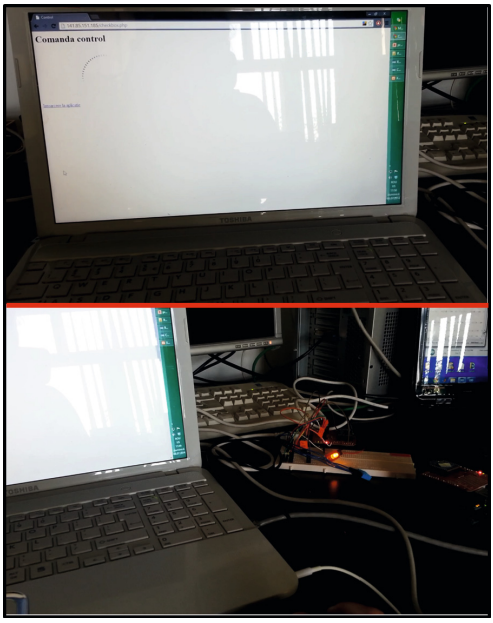

Fig. 5. Submitting a command in the web app (top) and the result of the command – led on (bottom)

4 Conclusions

The present paper presented a sensor network, designed to monitor a typical room in terms of ambient parameters, through regular reporting of the temperature, humidity and illuminance level values. The data was processed, and sent to a simple WEB application, which allowed an interactive view upon the results, and the prospective of adjusting the monitored parameters through a series of electronic devices, remotely, concept emulated by an LED. The system thus created proved to be extremely mobile and could be easily tested in various scenarios.

Future work might include the WEB application's customizing (in this project, a basic HTML code was used in order to design it), setting up 2 to more such modules to simultaneously send data to the same coordinator, replace the LED with an actual device in order to address a real-life situation.

Such a solution may find its applicability in home automation projects, for instance, Ambient Assisted Living, given the possibility to permanently monitor and adjust the indoor climate, therefore promoting a better, healthier lifestyle for people at risk.

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