Sensor network infrastructure for intelligent building monitoring and management system

R.VENKATESH, K.RADHA, M.GANTHIMATHI
2. Assistant Professor -CSE, Muthayammal Engineering College, Rasipuram.
3. Assistant Professor-CSE, Muthayammal Engineering College, Rasipuram.

ABSTRACT

The aim of this study was to present that it is possible to design and implement an efficient and functional intelligent building management system based on free tools, own project and self-realization of sensor network system which may be a low cost alternative to commercial ones. The paper presents the designed system consisting of implemented devices on the basis of sensor network technology and own hardware project in a building management system. At the application level there was designed and implemented the building management system which allows communication between the sensors, data exchange between the sensors and the database as well as the system parameters visualization panel used for intelligent building monitoring.

KEYWORDS

Wireless sensor networks, communication standards, energy management, building

I INTRODUCTION

With the increase in quality of life, people look for opportunities to improve the tasks of everyday life as well as its protection. Most of his time a man spends at home which should be a place where you can relax, spend a nice time and feel safe. In recent decades, the concept was to put up intelligent buildings that can take over household duties and tasks as well as people residing in them. In addition, a considerable amount of time we spend at work, so also the work environment, its functionality, security, etc. play an important role in this context. Intelligent buildings allow the integration of all existing systems in one complex system automatically implementing safety features, energy saving and comfort improvement. It designated a new idea to use sensors and network solutions [1, 2].

The wireless sensor network is a technology that changes the view on the economy and human life. The sensor network is composed of autonomous sensors distributed in space which are able to monitor physical parameters such as temperature, sound, vibration, pressure, motion, etc. Automated data collection and wireless transmission of theme to a central localization allow for permanent recording and monitoring of specific tasks and processes, as well as to respond to the occurred events. Sensors may be used for house protection against fire, burglary, flooding and ensuring the safety of the occupants. They also allow for building of the adaptive system which depending on time of day or the presence of a household can save thermal energy or electricity.

Low power transmission systems with low energy demand create a new area of systems for implementation in wireless sensor networks. The future is focused on the gradual replacement of wired systems by more comfortable wireless solutions. New technology is gaining recognition in any field of human activity. Wireless sensor networks offer great opportunities, but the threats that may affect solutions based on this technology must be known [3, 4]. Sensor networks gain a special advantage over large areas often inaccessible and allow easy deployment of sensors and communication between them. In their action they are also resistant to communication damage because nodes can change the information transmission route. Sensor network implementations can be found in other areas such as [5, 6]: mitigating the effects of forest fires and natural disasters, environment protection, traffic management, military, automation in building, etc.

Technologies and solutions that have arisen in recent years led to the creation of building management systems (intelligent buildings), both for private and
commercial implementations (e.g. office buildings, hotels, factories). In this paper we focus on presenting our complete project of the intelligent building monitoring and management system implementation based on our hardware sensor designs, sensor network infrastructure and web based management application.

II WIRELESS SENSOR NETWORKS TECHNOLOGY AND INTELLIGENT BUILDINGS

Wireless sensing in commercial and office buildings has lead to a greater awareness of the condition of buildings and their systems: As it provides information necessary for those in charge of building operation and maintenance to recognize limits and non-functioning equipment and systems and priorities building maintenance tasks etc. based on costs and other important factors (Brambly et al, 2005, Menzel et al, 2008).

The main benefits of this are:

- An increased lifespan for equipment/electric appliances;
- An improved building environment for occupants;
- Economies of scale gained from monitoring, tracking and responding to the status of multiple building assets from centralized or regional locations;
- The ability to detect impending faults and therefore minimize energy usage associated with facility assets and increase reliability while reducing costs;
- Lower energy and operating costs leading to an advantageous return on investment. For example energy management systems based on WSNs can save an average of 10 % in overall building energy consumption and the energy savings can be as high as 30% depending on occupancy (Lun-Wu Yeh et al, 2009).

III HARDWARE LAYER OF THE DESIGN SYSTEM - SENSOR NETWORK STRUCTURE SYSTEM

The intelligent building management system should have data gathering and control elements. In this paper we focus on presenting our complete project of the intelligent building monitoring and management system implementation based on our hardware sensors designs, sensor network infrastructure and web based management application. This paragraph is devoted to the hardware layer of our system presentation, especially the sensor architecture and the sensor network structure designs. The first step in achieving the objectives of the project is the construction of the measuring sensor node and the parent sensor node, acting as a sensor network gateway. The hardware implementation project includes the use of electronic devices available on the market. The diagram of the hardware sensor system project implementation presented in this
work, its basic elements, relationships, communication mode and software components (software drivers, communication, management and monitoring application) is shown in Fig. 2. For the construction of the measuring node and the sensor network gateway node in our design a microprocessor, executing calculations and programmed control functions was used. The role of microprocessors in the designed devices is played by Atmel AVR family chips. The AVR microcontrollers are a family of eight-bit, RISC architecture based on the principles of Harvard architecture processors [16, 17, 18]. A characteristic feature of the Harvard architecture is to separate memory address space of the program and data memory address space, obtained by using a separate address bus. The systems belonging to the RISC processors have a simplified list of commands and high computational efficiency (most commands are executed in one clock rate). In addition, the AVR microcontrollers have implemented many operating registers, which can simultaneously perform storage functions in arithmetic and logical operations processing. The result of this design is minimization of the internal inter register communication and thus increasing the speed of program execution. Combination of 8-bit RISC computing unit, high-level language programming techniques and reprogrammable flash memory on a single chip, allows the use of microcontrollers in a variety of functional solutions [16, 17, 18].

Sensor measuring node - the node acts as a measurement system that collects data, in the case of this project, the temperature of the surroundings. Our sensor node has an additional wireless remote light control function. The device transmits data or controls commands wirelessly to the parent node (sensor network gateway). The node is built based on the microprocessor ATmega16L, RFM12S transmitter and the temperature sensor DS18B20. In addition, the system is equipped with six-contact pushbuttons and the LED diode indicating correct sending of the information. Four buttons stand for the light control, one for a temperature measuring frequency change and one for a reset of the entire set [16, 17, 18, 19, 20].

Sensor network gateway node - Gateway is a device having the task of enabling communication between various elements of a building management system. The designed node architecture contains the following units: the microprocessor ATmega32, RFM12S transmitter/receiver, the temperature sensor DS18B20 and the converter FT232RS. Gateway acts as the parent node performing the receiving data from the remote measuring node. The data is then transmitted using the USART bus of the module FT232RS to a PC, updating the My SQL database. Another task of the device is to measure the temperature. The DS18B20 module is connected to the microprocessor’s PC port which functions as the 1-wire bus interface. In order to increase the functionality the DS18B20 is connected by a telephone cable of a length of 6 m (1-wire allows transmission for a distance up to 60 m) [16, 17, 18, 19, 20].

IV OVERVIEW OF SENSING AND SENSING PARAMETERS

The 6LoWPAN subsystem is formed by one server, two routers, and ten battery driven sensor nodes, see Fig. 1. The server, which stores both sensor data and network information, is connected to the Local Area Network (LAN) and provides a Web Interface, which displays data from the sensors and the network. Through this interface the user is able to manage and control the wireless network.

Access to the network from the server goes through the two parallel working routers. These routers manage the routing between the sensor nodes and the IP network connected to the server. Deploying two routers in the same network of sensor nodes will scale the throughput of the network. Each router is able to take over the other router’s tasks in cases of a non-operational router, which increases the redundancy and reliability of the network.
All the ten sensor nodes include integrated temperature, humidity and light sensors, and communicate with routers and each other using mesh routing protocols. The indoor operation range is approximately 50 meters. Built-in expansion ports make it possible to connect the sensor nodes to different external sensors, switches, and actuators. To utilize this range of use one of the 6LoWPAN sensors in the pilot network was connected to a device functioning as a relay controlling the mains to a desk lamp, as can be seen in Fig. 1. From the server’s Web interface the lamp was remotely switched on and off.

V THE FUNCTIONALITY OF THE INTELLIGENT BUILDING WIRELESS SENSOR MANAGEMENT SYSTEM

The functionality of the intelligent building management system requires communication between two platforms: hardware and software as presented in Fig. 3. Data transfer is realized from the gateway microprocessor to the database and vice versa. Created software application can receive and send data using a virtual serial port (COM). Application supporting PC communication with the parent sensor node (gate-way) is built based on the functional blocks and libraries of the serial port and functions connected to the database [16, 17, 18, 19, 20].

VI DATA COLLECTION

The buildings’ various temperature, humidity and light values sensed by the sensor nodes and the parameters measured by the energy meters (voltage, current, frequency, power consumption and load) are transmitted to the ZigBee gateway or 6LoWPAN routers and server. The server is also able to load data into a local or remote Post SQL database. The number of sensor nodes in the network, the number of enabled internal sensors in the nodes, and sampling period are important for the quantity of data collected by the WSN. The network information and sensor data stored at the 6LoWPAN server may also be exported in HTML and CSV formats for use in external Web based or other application reports.

VII RESULT

- Report the temperature, humidity and light, in the monitored area.
- Report the current, voltage, frequency, power use, and energy consumption of electrical appliances; Control the actuators/switches for energy consumption;
- Monitor in real time; Switch different electric appliances on or off; Self organize;
- Export sensor data for use with external applications.

- Home automation applications demand simple control and monitoring, and very low cost and low power solutions. Typical data rates are in the range of 1-250 kbps. The concept proposed can easily include 50-200 sensors/actuators and smart metering wireless nodes, that can be used for applications such as energy measurement, remote lighting control and remote heating control.
VIII CONCLUSION

Sensor networks represent a new approach using computer network solutions and wireless measurement technologies. Sensor networks deployed in space allow monitoring environmental parameters and response to physical factors operating. The integration of the individual components enables implementation of complex systems improving human performance in many areas. Additionally, sensor networks are characterized by low power consumption, fault tolerance and reliable communication which ensure an increasing interest in many implementations of wireless sensor networks. Sensing, processing, communication and self powering are the main elements whose combination in a small device causes an increasing number of applications providing endless opportunities.

In the future this work may provide a good basis for further expansion of the system by adding sensor nodes, as well as further functionality (e.g. integration of building control systems, alarm functions, SMS notification). Moreover, increasing the number of sensor nodes and adding routing nodes enabling data transfer between the sensors to the gateway nodes, is an interesting subject of further research.

IX REFERENCE


