A MUTISENSOR GPRS-BASED SECURITY SYSTEM FOR INTELLIGENT BUILDING

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Abstract in this work we present a security system collecting data from detectors for carbon monoxide, flammable gas, smoke, radon and from an access control system based on fingerprint recognition, and sending warnings through a GPRS link. The warnings are sent over the Internet is the concentration of toxic gases or smoke increases over a certain level or an unauthorized access is repeated several times. The transmitted data contains information about the type of danger situation and the location of the system determined by a GPS receiver.

Key words: *Intelligent building, GPRS transmission, embedded system, Radon detector*

I. INTRODUCTION

Living and working places are more and more integrated into intelligent buildings. The security of these spaces as in controlling access to them and warnings of any danger situation are a major concern of all personnel involved in designing and maintaining these buildings.

We consider that the definition of intelligent environments as a place in which various intelligent devices work continuously to make the activity / relaxation of inhabitants as comfortable as it can given by Cook and Sajal in [1], lacks a serious aspect: the intelligent environment must ensure the safety of inhabitants in the first place.

There is commercially available a large number of different safety systems with wired or wireless sensors which have a warning capability by dialing a phone number. However this warning sometimes can be unsatisfactory.

We propose a system which is sending the warning messages (together with the geographic position of the building) through the GPRS (General Packet Radio Services) link over the Internet using an original set of sensors.

II. GENERAL ASPECTS

This work presents a system for detecting several danger situations for inhabitants and transmitting warnings to a remote server:

- Access control based on fingerprint recognition and detecting unauthorized access
- Detecting carbon monoxide concentration in air above safety limits
- Detecting the presence of flammable gas in air
- Detecting radon levels in air above recommended limits
- Detecting smoke

The warning about these events can be transmitted to a central computer in the building, but in this case there is the possibility that a warning may go unnoticed by the inhabitants. To solve this we added a secondary communication path used only for the transmission of warnings. The system uses both paths of communication with the possibility to choose only one of them according to local conditions. The two paths are:

- Transmission through a GPRS modem (if GSM coverage permits)
- Transmission through a phone line modem (cheaper solution)

The system currently tested in the Research Laboratories of the Electronics & Computers Department, Transilvania University of Braşov. Sensors used include:

- Safety Siren Pro3 Radon Detector based on detection chamber;
- Safety Siren Carbon Monoxide and Combustible Gas Detector;
- MDFP200 fingerprint authentication module.

For data transmission a Telit EZ10-GPS GPRS modem and an US Robotics 56kbps modem is used.

To ensure the continuous work of the system, periodic monitoring of all the sensor values is implemented together with a confirmation message sent to the remote server. The messages are sent exactly every hour, for which an GPS time is used. The GPS subsystem is also used for determining actual position which is also sent to the server. This way multiple buildings can be monitored based on their geographic location.

The block diagram of the system is presented on figure 1.

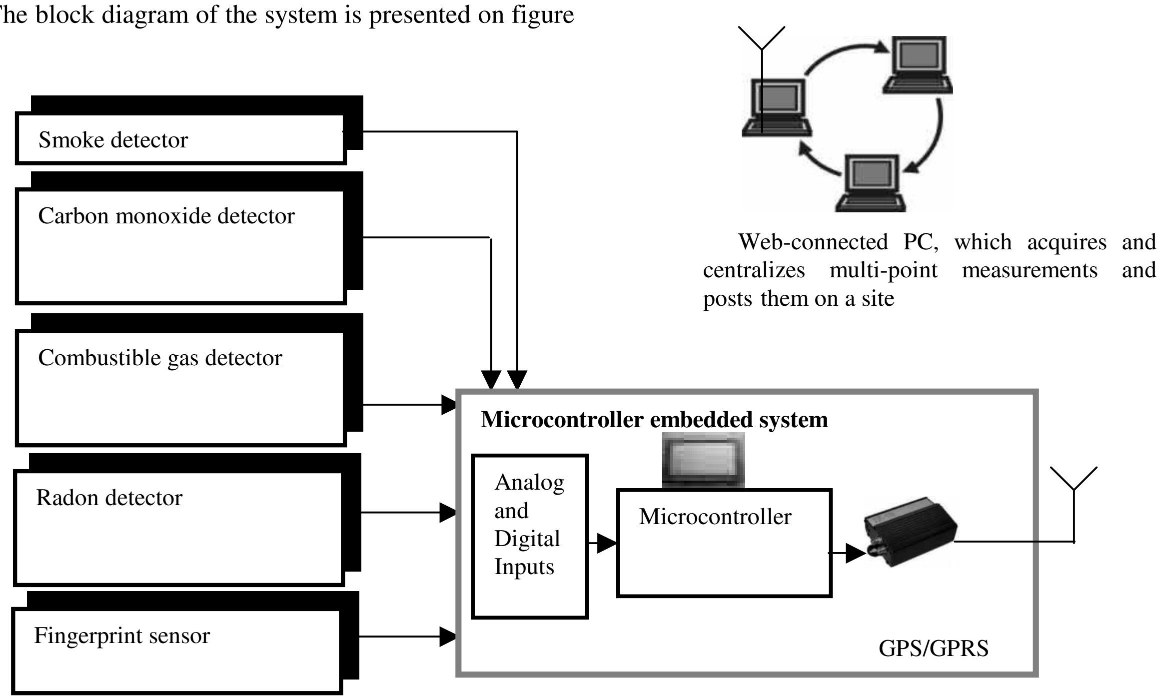

Figure 1. Block diagram of the security system.

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Similar solutions are presented in [2] where 4 blocks of detection is employed for fire detection, unauthorized access detection, environment paramters and power issues. Another similar work [3] shows an application where a smoke detector sends warning signal thorugh GPRS to the fire department along with the GPS coordinates. Some theoretical aspects of GSM based distributed security system is presented in [4].

II. THE CENTRAL PROCESSING UNIT

Built around the ATmega16 microcontroller it is responsible for data aquisitioin and data transmission through serial link.

The ATmega16 microcontroller has the following features used by this system:

- 16kB of flash – used almost entirely for storing the software
- 1kB SRAM
- 512B EEPROM – used for storing short term radon data
- 3 timers – one of them is used for the base timing of the system, the other two are used for counting pulses from the radon detector
- UART – used for communication with the GPRS modem
- 32 IO pins – 15 is used for the LCD display, the others are used by internal peripherals like UART and timers

The main functions of the software in the microcontroller are the acquisition, the displaying routines and the communication with the GPRS modem.

For displaying the messages a 128x64 pixel graphic LCD is used. The display has its own controller (KS107-108 type) which communicates through a 8 bit parallel port and 6 control lines.

The display is configured in 2 segments of 64x64 pixels each of 8 lines by 64 columns of groups of eight pixels placed vertically. This gives the option of having an 8 lines by 21 columns text display of standard 7x5 characters (although this characters have to defined in a look-up table in the microcontroller. The microcontroller implements software routines for displaying text strings.

For transmitting the messages a EZ10-GPRS type modem is used. This modem has a SIM card slot where a SIM which enables GPRS communication must be inserted.

The modem implements the Easy GPRS standard which involves internal TCP/IP stack and connection handling. This enables a simple connection to a server PC by using standard AT commands. The AT commands used include:

- a command for setting GPRS properties of all connections – issued once at powerup
- a command for setting authentication data (like username and password) – also issued once at powerup
- a command for setting connection parameters (like IP and port number) – also issued once
- a command for start dialing and connecting to the server – issued whenever a new transmission is necessary and the connection no longer exists

If the connection is established the messages sent over the UART is embedded into a TCP/IP packet and sent to the server.

The message is a simple HTTP POST command containing the environment values. An example of such command is:

```
POST /ibsec_g.php HTTP/1.1
Host: example.com
Content-Type: application/x-www-form-urlencoded
Content-Length: 19
radon=37.2&CO=no&FG=no&access=no
```

Other parameters can be added to the end in the URL encoded style.

After the sending of this data the connection is terminated with the sending of a predefined AT command.

Connecting the microcontroller to the modem is done through a RS232 cable. This involves using a MAX232 at the microcontroller to convert to RS232 levels.

The use of external modem also avoid interference issues with the radon detector which is very sensitive and must be placed as far from RF emitting electronic devices as possible.

III. RADON DETECTOR

Radon 222 (half-life 3.8 days), is a radioactive gas produced by decay of the uranium found in the earth's crust. Indoor exposure to radon is associated with high health risks: at around 3000 cancer affections/year this is the second cause for lung cancer after smoking.

In the outside air, concentration depends on soil, air currents etc. and varies between 7-26Bq/m^3. Health risks are very low. High concentrations are found near uranium mines. Inside buildings higher concentrations were measured in the basement and the ground floor depending mainly on soil, construction materials and insulation from soil.

For detecting radon we used a SafetySiren Pro3 Radon Detector (figure 2).

Figure 2: Safety Siren Pro3 radon detector

This model measures radon concentration between 0.0 and 999.9 pCi/l displayed on a 7 segment LED display. The sensor employed is an ionization chamber in which an electrostatic field directs alpha particles emitted by radon decay into a photodetector, giving an electronic pulse for every particle. Numbering this pulses gives the effective number of radon particles inside the ionization chamber. The detector includes a high gain analog amplifier for converting the pulses on the photo detector to logic level signals and a microcontroller to display the averaged radon concentration on the display. The averaging is done for 7 days (short term measurement) and for 5 years (long term measurement). Updating of the display is done every hour.

For reading the value from this detector two methods can be used:

- reading directly from the 7 segment display (which is more accurate as the system was calibrated)
- counting directly the pulses on the analog – digital interface of the detector.

The former method has the disadvantage of needing a large number of signals (8 from the segments and 4 from the multiplexing lines) which also presents some electromagnetic issues.

IV. CARBON MONOXIDE AND FLAMMABLE GAS DETECTOR

For detecting carbon monoxide and flammable gas we used a SafetySiren HS80004 (SM-TT-203) detector (figure 3).

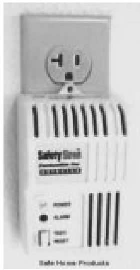

Figure 3 : SafetySiren CO and flammable gas detector

The apparatus is equipped with two SnO_2 based transducers one detecting carbon monoxide and the other detecting methane and propane concentration. The CO detector gives a warning when concentration above 200ppm (defined by the UL-2034 standard) is reached. The flammable gas detector gives warning when the concentration corresponding to 25% of LEL (Lower Explosive Limit) is reached (stated by the standard UL 1484). Warning conditions are signalled as:

- red LED is turned on and continuous sound on the buzzer is generated for dangerous CO levels
- red LED is turned on and intermittent sound on the buzzer is generated for flammable gases.

Collecting data from this sensor can be done by continuously reading the LED status (by connecting to an external interrupt of the microcontroller) and choosing the correct source by analyzing the signal on the buzzer.

V. SMOKE DETECTOR

The AHS-871 smoke sensor employs the following method: the smoke enters slowly inside the sensor through small holes. Inside the sensor an infrared emitter and a photodiode is used. The light emmited is refracting in the presence of smoke directly to the photodiode generating the alarm conditions. The holes are covered by a metallic net to keep out insects. The sensors is presented on figure 4.

Figure 4: AHS-871 smoke detector

Collecting data from this sensor is under development.

VI. ACCESS CONTROL

Controlling the access into the building is accomplished by a fingerprint recognition system.

The MDFP200 module employs a MBF200 solid-state capacitive fingerprint sensor with 256x300 pixel resolution (figure 5).

Figure 5: MDFP200 fingerprint recognition module

This module contains besides the fingerprint sensor a MB91F302 microcontroller, 8MB SDRAM, 2MB flash memory and 2 UART interfaces.

The microcontroller is preprogrammed with fingerprint recognition software. This software acts as a library containing 3 functions for fingerprint acquisition, enrollment and matching. The use of this function is left on the designer’s choice. The easiest way is assigning the acquisition function to the external interrupt coming from the sensor (which is generated when a fingertip is detected on its surface), and calling the enrollment and matching functions from a separate task started by the interrupt function, but managed by an operating system.

The whole recognition process takes only less than a second to complete.

The module sends out messages of accepted or rejected matching on a UART interface.

These messages are read by the central microcontroller and if multiple rejections are detected a warning is sent to the remote server.

VII EXPERIMENTAL RESULTS

A picture of the experimental apparatus is presented on figure 6.

Figure 6: prototype apparatus

The front panel together with the LCD display is presented on figure 7:

Figure 7: front panel

The inside of the prototype is presented on figure 8.

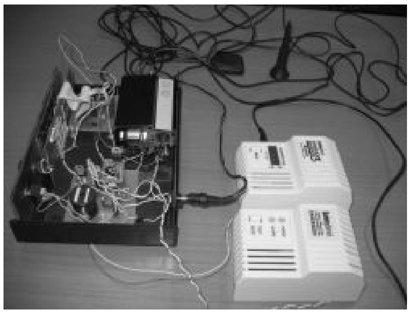

Figure 8: inside of the apparatus

VIII CONCLUSIONS

A prototype system was built and tested with several situations simulated on the acquisition systems and on the GPRS transmissions.

The system can successfully used for centralizing existing or new security systems into a single remotely managed system.

We are currently working on connecting other sensors to the system. Also we are studying the possibility of connecting the sensors to the central processing unit wireless.

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