Practical experience for designing power saving systems in portable applications

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ABSTRACT

As known, the power consumption is a critical point in nowadays mixed signal design, being this parameter of particular relevance in portable applications. This work tries to familiarize students with general design methodologies for reducing power consumption introducing a real, specific and attractive application: the development of a battery supplied Wireless Sensor Network (WSN) System for habitat monitoring.

1. INTRODUCTION

Wireless Sensor Networks (WSN) are becoming an emerging technology, with applications in a wide variety of domains such as industry, home, computing, agriculture or environment [1, 2]. Design of a WSN represents, therefore, a promising and broad research topic which offers powerful opportunities both in the academic and industry sectors, existing at present an increasing demand of professionals well formed in this area. In addition, to obtain a complete and successful WSN implementation, interdisciplinary work from different education disciplines must converge. It is therefore an attractive example for students that closely match the industry field, where commonly a multidisciplinary team has to work together to meet the needs of customer, role played here by the teacher.

In response to the above, this paper presents a student project consisting on the development and implementation of a five-node wireless sensor network for habitat monitoring, using the battery supplied Atmel AVR Z-Link ATAVRRZ200 Demo Kit [3] shown in Fig. 1. The work described in this paper is focused on the sensor node electronics aspects, with the main purpose of testing power saving techniques; the student was required basically to: (i) select the set of sensors, complying the low-voltage low-power requirement, which measure the relevant parameters determined by the teacher; (ii) reprogram the existing node microcontroller to fit the present application; and (iii) develop a graphical user interface (GUI) to monitor the information in real-time. To guarantee a successful conclusion of this project, it is required from the student previous knowledge in C language programming and advanced knowledge in Digital Electronic Systems. On the other hand, the reprogramming of the microcontroller communication is beyond the scope of this work, though it will be proposed also as a student project in the near future.

2. WSN DESCRIPTION

To develop the WSN targeting habitat monitoring, the student has available the Atmel AVR Z-Link ATAVRRZ200 Kit, which consists of five radio control boards (RCB) and a board display (as shown in Fig. 1). This kit uses a radio frequency (RF) technology based on LR-WPAN (Low Rate Wireless Personal Area Network) IEEE 802.15.4 Communication Standard [4], suitable for applications that do not need high data throughput or constant updating and which considers power consumption as an important parameter.

3. RADIO CONTROL BOARDS

Each RCB or mote contains an AT86RF230 radio transceiver, a PCB antenna, an Atmega1281 microcontroller, board display connectors, two AAA batteries, a power switch and the corresponding sensors.

AT86RF230 is a low-power transceiver with high sensitivity (-101dBm) and a line-of-site about 30 meters using the built-in PCB antenna. It operates in the 2.4 GHz Industrial-Scientific-Medical (ISM) free radio frequency band, with 16 channels. The ATmega1281 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced Reduced Instruction Set Computer (RISC) architecture. Its main features are 128 Kbytes Flash, 4 Kbytes EEPROM, 8 Kbytes SRAM, 32 general purpose working registers, Real Time Counter (RTC), six Timer/Counters, 4 USARTs, a byte oriented 2-wire Serial Interface (TWI), 10-bit ADC with optional differential input stage and programmable gain, a Serial Peripheral Interface (SPI) port, an IEEE std. 1149.1 compliant JTAG test interface, also used for accessing the On-chip Debug system and programming, and six software selectable low-power sleep modes which allow power saving.

The board display allows monitoring the WSN, when it is not possible to use a computer, by means of an Atmega128 microcontroller with a LCD, two buttons, a joystick and the radio control board connectors. ATmega128 has only 4 Kbytes of SRAM, suitable for LCD control tasks.

Figure 2 shows a schematic image of the measure system hardware. One of the five RCBs is connected to the board display via SPI and by means of RS-232 bus to the computer taking the role of the PAN coordinator of the communication. The other RCBs are end-devices. This configuration is known as star topology.

4. SENSORS

The sensor nodes have a set of sensors which allow the measurement of four physical magnitudes previously determined as relevant: temperature, pressure, relative humidity and soil moisture. Results are transmitted to the LR-WPAN coordinator, then to a host PC and finally through the Internet to a local PC where the user monitors the WSN by a graphical user interface (GUI).

The corresponding sensors have to be selected so as to be compliant with the low-voltage low-power (LVLP) requirement. With this constraint, the following sensors were chosen by the student for the measurement of temperature: An NTC resistance in a Wheatstone bridge to monitor the mote internal temperature; the SHT10 relative humidity sensor from Sensirion [5] and the MS5540B pressure sensor from Intersema [6], both digital; and an analog Decagon EC-5 dielectric soil moisture probe [7]. All sensors are suitable for 3 V supply voltage.

For the analog sensors, the student has deepen into the signal conditioning and afterwards A/D conversion from the microcontroller, while for the digital sensors spotlight is on the synchronous communication needed for the initialization, control and data collecting.

5. SYSTEM PROGRAMMING

Project is developed using the free AVRstudio4 and WinAVR microcontroller programming tools, and Matlab2006b [8] for the graphical user interface (GUI).

The microcontroller programming is oriented to the optimization of the RCB resources in order to obtain an efficient implementation:

- An interrupt-based application must be developed, so that the microcontroller is in sleep mode and sensors are switched off to save energy whereas no interrupts occur. If an interrupt takes place, the associated interrupt function is executed.
- The student has to consider different kinds of interrupts. In the case of an end-node, the interrupt occurs when there is a data reception from the transceiver in order to start the measurement process or to change node settings, or, alternatively, when a timer overflow happens. This allows measuring periodically without coordinator requests (each 30 seconds). If the node is the coordinator, the sleep mode is also interrupted by board display communication or by serial communication through a request in the case of a PC-connected coordinator.
- Data processing and storing is carried out by the PC, to minimize source code size on Flash. The coordinator has a data table where saves the last measures.

The final user can monitor in real-time the environmental conditions through a graphical user interface from a host PC RS-232 connected to the LR-WPAN coordinator, or even in a remote way by using this host PC as server, sharing the serial port with any PC configured as client by using the free Agilent I/O Control application [9].

6. CONCLUSIONS

The project has been planned with the aim of providing to the student a complete training in wireless sensor network technology –with the learning of the programming techniques and the philosophy of optimization of resources– through a specific and attractive application.

The results of the work have been positive. Based on a commercial demo kit, last year was proposed a Master Thesis Project consisting on developing a WSN for habitat monitoring. The students main efforts have been focused, first, on the selection of low-voltage low-power sensors to fit in our application and secondly, on the programming of the node microcontroller to carry out the desired task with an optimum power consumption, as an appropriate energy handling is essential to achieve a long battery life. Power consumption depends on the kind of radio transceiver, sensors, and software design. Therefore, it was made use of sleep modes for the microcontroller and interrupt-based communications; moreover, sensors are normally switched off, unless they are measuring. Finally, it was been developed a graphical user interface to facilitate the monitoring of parameters.

7. ACKNOWLEDGMENT

This work has been partially supported by the Diputación General de Aragón (DGA-PM027/2006 and PM014/2007), the Aragón Institute for Engineering Research (I3A) and University of Zaragoza (UZ2006-TEC-02).

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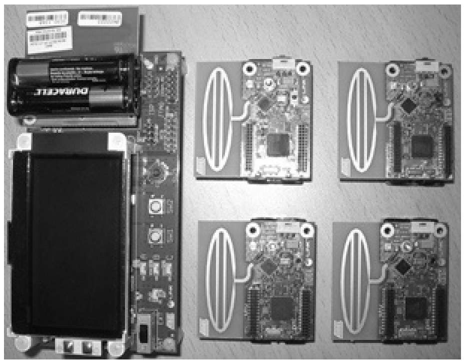

Figure 1: ATAVRRZ200 kit

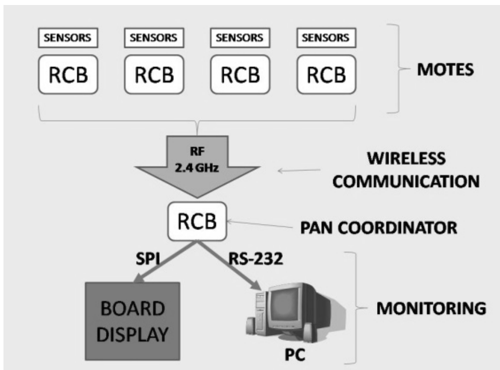

Figure 2: Hardware scheme

Figure 3: Sensors used in our WSN project