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A Zigbee Based Smart Sensing Platform for Environmental Monitoring

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Abstract: ***Wireless Sensor Networks have gained a tremendous attention in the last decade. The ability to monitor environmental conditions is crucial to research in fields ranging from climate variability to agriculture and zoology. Being able to document baseline and changing environmental parameters over time is increasingly essential important and researchers are relying more and more on unattended weather stations for this propose. A Zigbee Based Smart Sensing Platform for Monitoring Environmental Parameters have been designed and developed. The smart weather station consists of LPC 2138 controller based measuring units which collects the value of the temperature, wind speed, humidity and sunlight. These units send their data wirelessly to a Base station, which collects all the data and send to PC where incoming data stored and display in Graphical and in numeric form. The numeric value data is finally displayed on web page. The facility of adding a few more sensors and a few more stations has been provided.***

Keywords: Zigbee, Environmental monitoring, wireless sensor network, weather station, temperature measurement, wind measurement, humidity measurement and light measurement.

1. Introduction

Pervasive sensing systems have gained significant attention in the last decade in various areas. Continuous unobtrusive monitoring of the environment is usually performed by a Wireless Sensor Network (WSN). In Some WSN based Environmental Monitoring Systems, data is collected by SMS using GSM/GPRS technology [2].

WSN based environmental sensor station, where the environmental sensors interfaced directly to the Zigbee module [3] and data transmission takes place by using Zigbee module. There are several different procedures of weather stations, with all kind of sensors. These stations can be wireless or connected with a wire to a Server storing the data and make it possible to access them. These Stations can only be operated with the given software which makes it difficult to access the data and use them for different purposes; additionally these stations are very expensive. Therefore, this research motivates to develop a new weather station which is efficient, flexible. The present paper describes the development of a wireless environment monitoring station measuring temperature, humidity, wind speed and light intensity.

1.1 Present Work

The smart wireless environmental sensor station has started to exist in the real applications.Subsequently, there was also essential need for introducing a real-time alerting the variation of the environmental conditions with simultaneous monitoring. This is the main reason the market started to shift from wired manual environmental sensor stations to more advanced and controllable wireless sensor stations.

1.1.1 WubiNet

Wubi-net [2] is a wireless network designed for monitoring larger regions. Depending on the available infrastructure, the network can be operating for two years using only batteries, or its coordinator can be powered by solar cells to guarantee the transmission of the collected data by SMS using GSM/GPRS technology or satellite phones.The data is transmitted to base station located out of the node Tran's receiver and analyzed. Here, the base station is connected to GSM module by additional Telit module. All data generated by sensor node are received by coordinator node using standard 802.15.4 protocol and sends the measurement by SMS by means of specific GSM/GPRS module. In this work MPPT with low form factor solar panels were used to provide supply to coordinator node.

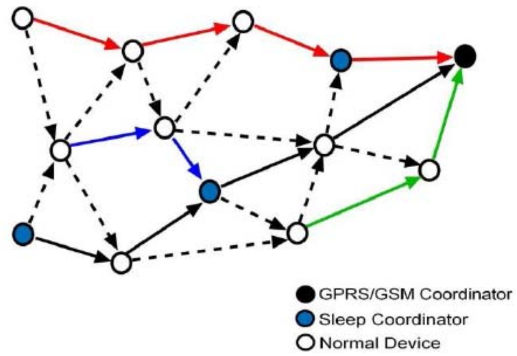


Figure 1. Mesh Network

The Use of SMS allows to transmitting data from sensor network with limited infra-structure to base stations located far away from WSN range. Previous work make use of SMS connecting GSM module to the sensor nodes Here, all the data generated by sensor node are received by coordinator node using standard 802.15.4 protocol and sends measurement by means of specific GSM module GM862, powered by 3.7 V and 6000mAh Li-Po battery.

1.1.2 Environmental Monitoring Based On tiny OS

A wireless sensor network in a greenhouse area environment monitoring system based on Tiny OS is designed. The design of the hardware and software of the monitoring system is based on the using of the MSP430 microcontroller and NesC language. And the control application program on PC is designed with Visual Basic, which realizes the remote control between the PC and the monitoring system. The design of the system is divided into hardware design and software design. A hardware platform, which is an ultra-low power wireless sensor node for WSN, is designed. And it uses the Tiny OS operating system for designing the program running on it. Energy concerns dominate sensor hardware and softwaredesign. Embedded Operating-System of WSN is the basalcore software on the nodes.

Tiny OS

Tiny OS is an open-source lightweight operating system specifically designed for low-power wireless sensors. Tiny OS differs from most other operating systems in that itsdesign focuses on ultra-low-power operation. Rather than afull-fledged processor, Tiny OS is designed for the small,low-power micro-controllers motes have. Further-more, Tiny OS has very aggressive systems and mechanisms forsaving power.It provides a set of services and abstractions,such as sensing, communication, storage, and timers

NesC Language

Tiny OS applications and systems, as well as the Operating-System itself, are written in language. NesC is a C dialect with features to reduce RAM and code size, enable significant optimizations, and help prevent low-level bugs like race conditions. With nesC, programmers can define new components using a C-like syntax, and connect together existing components to create other components or applications (the act of connecting together components is called wiring).Each component declares input and output functions, called commands and events, that are used in the wiring process. Commands and events are usually grouped into interfaces. Tiny OS is written in the nesC language. A nesC application consists of one or more components Assembled, or wired, to form an application executable. Components define two scopes: one for their specification which contains the names of their interfaces, and another scope for their implementation. A component provides and uses interfaces. The provided interfaces are intended to represent the functionality that the component provides to its user in its specification; the user interfaces represent the functionality the component needs to perform its job in its Implementation. There are two types of components in nes C: modules and configurations. Modules provide the implementation of one or more interfaces Configurations are used to assemble other components together, connecting interfaces used by components to interfaces provided by others, as shown in Figure 2. Every nesC application is described by a top-level configuration that wires together the components inside. With the study of these two systems, we developed a simple, efficient, new environmental Monitoring system.

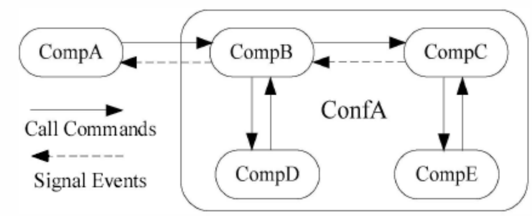


Figure 2: Modules and Configurations

2. Proposed Work

The main objective of this project is to introduce wireless environmental monitoring system. The characteristics of developed systems are as follows.

2.1 Characteristics

- Usage of low cost equipment.
- Flexible data-handling to use the data for different purpose.
- Sensors should be as accurate as possible.
- Wireless connection to get the data from different sensors and to make the set up as easy as possible.
- A possible number of at least 2 different stations per central station to make a comparison possible

The System architecture is as shown in fig.3.where the two nodes are connected to a coordinator gateway through wireless connection. This communication is Bidirectional. Coordinator gateway has a wired connection with PC on which data can be stored. Finally data is displayed on web-page. Here, Zigbee coordinator and PC have serial wired communication whereas Zigbee coordinator and Zigbee Transmitter have wireless communication.

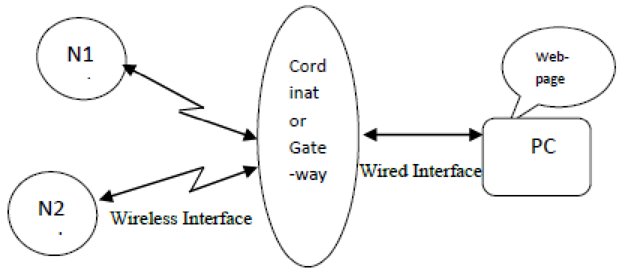


Figure 3: System Architecture

2.2 Block Diagram

The developed system is based on an ARM controller, communicating with a central station (Figure 4). The ARM is connected to different sensors, which gives analog voltage signals. These signals are measured and "translated" into the responding value. All of these values are send trough the ZigBee Module to a base station, which stores the data into an Access Database. The Values can then be displayed in the GUI running on a computer. The numeric value data is finally displayed on web-page.

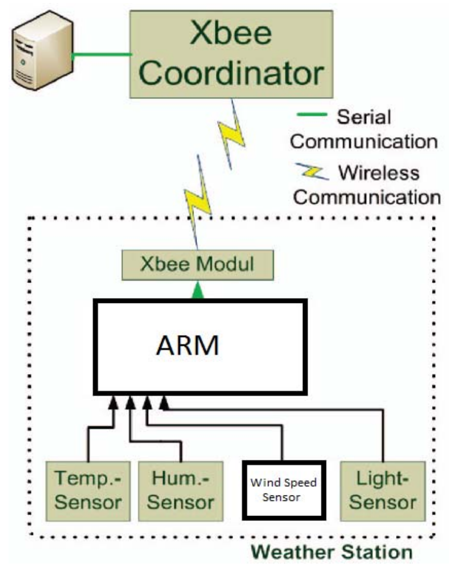


Figure 4: Block Diagram of Developed System

A. Transmitter system

Transmitter system which includes the different sensors related to the environmental physical parameters, ARM 2138, LCD display & Zigbee Module. The sensors are Temperature, Humidity, Wind Speed, and Light Intensity. They are interfaced with ARM 2138. LCD will display all the parameters value measured by sensors at the transmitter side. ARM is interfaced with Zigbee module, with the help of which the received parameters are transmitted. Zigbee module is a transreceiver i.e. It will transmit as well as receives the data The use of LPC 2138 ARM processor in our project is due to its following features. Features of LPC2138-

- 16/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 or HVQFN package.
- 8/16/32 kB of on-chip static RAM and 32/64/128/256/512 kB of on-chip flash program memory. 128-bit wide interface/accelerator enables high-speed 60 MHz operation.
- In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot loader software. Single flash sector or full chip erase in 400 ms and programming of 256 B in 1 ms.
- Embedded ICERT and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high-speed tracing of instruction execution
- One (LPC2131/32) or two (LPC2134/36/38) 8-channel 10-bit ADCs provide a total of up to 16 analog inputs, with conversion times as low as 2.44 ms per channel.
- Single 10-bit DAC provides variable analog output (LPC2132/34/36/38).
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
- Low power Real-time clock with independent power and dedicated 32 kHz clock input.

B. Receiver system

Receiver side also consist of a one Zigbee module. Here, Zigbee Module acts as Co-ordinator Gate-way which receives all the data from transmitter side. This coordinator gateway is interfaced with PC where the received data is stored in the form of GUI (Graphical User Interface) as well as in numeric.

C. Processing System

The processing system consists of PC where the data can be store. Here GUI system is used to store the data .Main purpose of design a GUI (Graphical user interface) is to analyze the received digital data of environmental data to the coordinator, so that we can observe these data either numerically or graphically.

D. Communication System

To save the data measured by the sensors it was necessary to build a network between the sensors and to set up a computer receiving and storing the values. For the communication ZigBee pro S2 modules were used. These provide a wide range and a couple of low power modes, which could be used to reduce the current consumption of the circuit. In addition the network-setup is easy and fast, so that an extension of new Stations is possible without problems.

Zigbee Module

For wireless communication we selected Zigbee S2 module. The ZigBee Series 2 OEM RF Modules were engineered to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within the ISM 2.4 GHz frequency band..

Figure 5: Zigbee S2 Module

Specifications:

- Indoor /Urban Range- up to 133 ft. (40 m)
- Outdoor RF line-of-sight Range- up to 400 ft. (120 m)
- Transmit Power Output (software selectable)- 2mW (+3dBm)
- RF Data Rate-250,000 bps
- Supply Voltage-2.8 – 3.4 V
- Operating Current (Transmit/Receive)- 40mA (@ 3.3 V)
- Operating Frequency Band- ISM 2.4 GHz

Comparison between these two modules is as shown in Table 1.

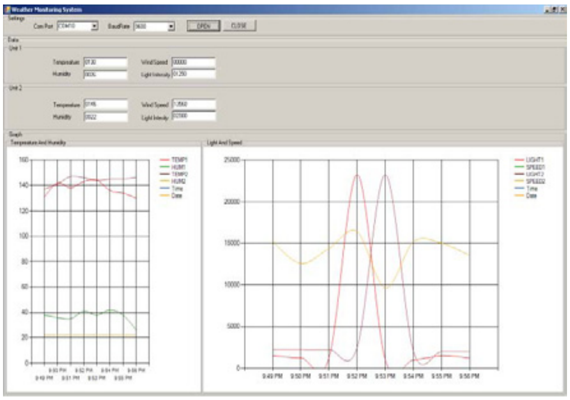
The sensors we are using are-

A. Temperature sensor (LM35)
B. Humidity (SYHS-200)
C. Light Intensity (LDR)
D. Wind Speed (developed by own)

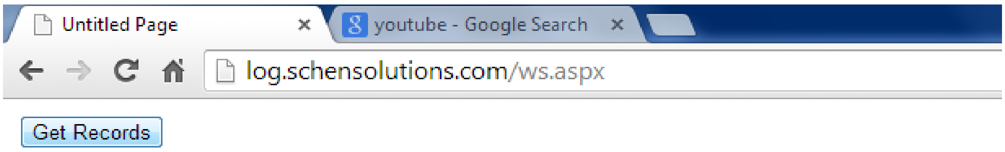
3. Results

3.1. Graphical User Interface (GUI)

The data coming from coordinator gateway is interfaced with PC, where this is represented in Graphical as well as in numeric form. The graphical results from two different nodes are shown in to two different charts. For better differentiation we used different color notations for different data.



The main advantage of our weather monitoring system is that everyone can see system recorded weather parameters on internet which is as shown below.



t1	h1	t2	h2	TIME	DATE	l1	s1	l2	s2	TIME1	DATE1
0131	0038	0137	0022	9:49 PM	12/10/2013	01500	00000	02250	15180	9:49 PM	12/10/2013
0142	0036	0141	0022	9:50 PM	12/10/2013	01250	00000	02250	12600	9:50 PM	12/10/2013
0138	0035	0147	0022	9:51 PM	12/10/2013	01250	00000	02250	14400	9:51 PM	12/10/2013
0143	0041	0146	0022	9:52 PM	12/10/2013	23250	00000	02500	16380	9:52 PM	12/10/2013
0144	0038	0144	0022	9:53 PM	12/10/2013	01000	00000	23250	09600	9:53 PM	12/10/2013
0136	0042	0145	0022	9:54 PM	12/10/2013	01000	00000	02000	15180	9:54 PM	12/10/2013

Figure 6: Result Displayed on web page

4. Conclusion and Future Work

In this paper we proposed an environmental monitoring system with a Star network structure controlled by a central station. The different stations are equipped with temperature, relative humidity, sunlight and Wind Speed sensors. Initial component testing of sensor performance has reflected good results in sensing and radio communication. The outcome provides a variable platform for different sensors to measure necessary values. In future we can add GSM module at coordinate side of developed system to get records on Mobile phones.

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