Implementation and Analysis of Temperature Sensor Based on PIC and Wireless Sensor Network Technology

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Abstract- ***This project presents the performance analysis of Wireless Sensor Network (WSN) used in the high-end applications such as weapons sensor ship, biomedical applications, habitat sensing and seismic monitoring. Recently WSN also focuses on national security applications and consumer applications. This project shall demonstrate the performance of WSN models, which have been developed using PIC. Temperature sensor nodes were deployed in the networks to create sensing phenomena. The results recorded that successful throughput from sensor node, strongly depends on the delay setting. This project were setting three second for displayed result and if very small for delay setting like 10ms, the system can't process the data. Therefore, the important factors and issues pertaining to the WSN performance will also be determined and describe briefly.***

I. INTRODUCTION

Wireless Sensor Network (WSN) are a trend of the last few years due to the advances made in the wireless communication, information technologies and electronics field [1]. The developments of low-cost, low-powered, multifunctional sensors have received increasing attention from various industries [2]. WSN is a wireless network composed of autonomous and compact devices called sensor nodes or *motes*. A sensor network is designed to detect desired phenomena, then collect, process the data and transmit this information to users. Sensor nodes or *motes* in WSNs are small sized and are capable of sensing, gathering and processing data while communicating with other connected nodes in the network, via radio frequency (RF) channel. The sensor nodes scattered in a sensor field where each sensor nodes collects data and route the data back through a multi-hop hybrid wireless communications. The design of the sensor network is influenced by factors including scalability, operating system, fault tolerance, sensor network topology, hardware constrains, transmission media, and power consumption [6]. The developments is low-cost, low-powered, multifunctional sensor have received increasing attention from various industries [2].

There are two kinds of sensor used in the network. One is the normal sensor node deployed to sense the phenomena. The other is a gateway node that interfaces sensor network to the external world. Sensor such as magnetometer, accelerometer, light and temperature are among the types of sensor being used depending on the application.

As represented in Fig.1, the system architecture of a sensor node consists of a radio transceiver or optical as the communication unit, microcontroller for the processing unit, sensor as the sensing unit and battery as the power unit. The hardware device in the sensing unit may consist up to several sensors. This device produces measurable response to change which acts as an interface between *motes* to the environment.

The processing unit or control unit (CU)is responsible for the collecting and processing of the captured signal from the sensor unit. These signals are then transmitted to the network. It determines both energy consumption as well as computational capabilities of the sensor node.

The power unit consisting of battery supplies power to the sensor node. It is important to choose the battery type since durability will affect the design of sensor node [3].

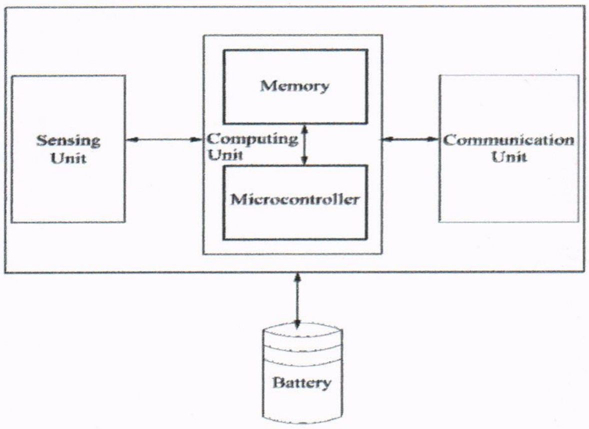

Fig.1. Sensor Node System Architecture [3]

WSNs has been used in high-end application such as radiation and nuclear-threat detection systems, weapons sensors for ships, biomedical applications, habitat sensing and seismic monitoring [4]. Measurable changes are vibration, temperature, sound, motion, pollutants or pressure in environmental conditions [3]. For ultra compact, high data-rate wireless sensor node is constructed using eCAM miniature camera, plugging a VGA video camera to an Eco node. The purpose is to show that high data-rate wireless capability and expandability of a platform can came in a miniature package. The camera module itself already performs compression in hardware thus represents an optimized subsystem in terms of its power consumption and bandwidth demand [8], [9].

II. METHODOLOGY

The main aim of this project is to use the wireless sensor network to compare the actual temperature at random section of an environment and obtain successful throughput of the data transferred by the sensor. The sensor is developed using Peripheral Interface Controller (PIC) while the transmitter utilizes Xbee technology. Information is sent by the temperature sensor will then be processed by the PIC controller before it is transmitted to the base station. The PIC has been program to send the data periodically to the base station through the Xbee module. Temperature results shall be displayed at the base station.

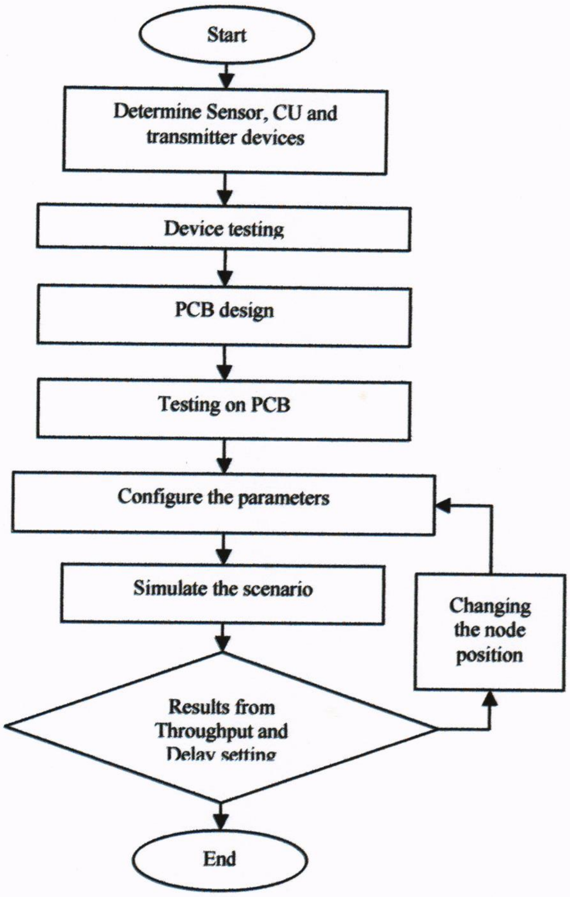

Fig.2. Flow chart of project implementation

Fig.2 represents the processes carried out to produce the total system while fig.3 is the total system block diagram consisting of 1 sensor, and a database of a system utilizing WSNs. One of the benefits of using Xbee is the distance between the sensor node and the base station can exceed 100m for outdoor implementation. Therefore, it is very suitable for applications that involved outdoor monitoring and control.

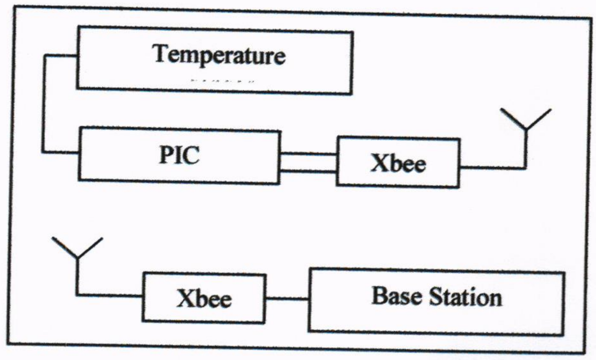

Figure 3: Block Diagram of Overall System.

A. Sensor

Hardware device producing measurable response to change in physical condition such as temperature or pressure. Sensor measures physical data by obtaining continual analog signal d directly from the environment. This signal is then digitized by an Analog-to-digital converter (ADC) and sent to the CU for further processing. Characteristics or requirements of sensor node are it should be small in size, consume extremely low energy, operate in high volumetric densities, autonomous, and adaptive to the environment. Strict requirements are due to hardware constrains since nodes are micro-electronic sensor device, only be equipped with a limited power source of less than 0.5 Ah and 1.2 V.

B. Microcontroller

As shown in Fig 43, the microcontroller performs tasks, processes data and controls functionality of other components in the sensor node.

Other alternatives are General purpose desktop microprocessor, Application-specific integrated circuit (IC), Digital signal processors (DSP) or Field Programmable Gate Array (FPGA). Microcontrollers are the most suitable choice for sensor node due to flexibility in connecting to other devices, programmability and low power consumption as parts of the controller are active other parts can hibernate.

Microprocessor on the other hand, consumes more power, therefore it is not a suitable choice for sensor node. This project shall not be utilizing DSP either since the required wireless communication is modest and simple. This sensor node only requires easy to process modulation and signal processing tasks which is less complicated than the actual sensing of input data.

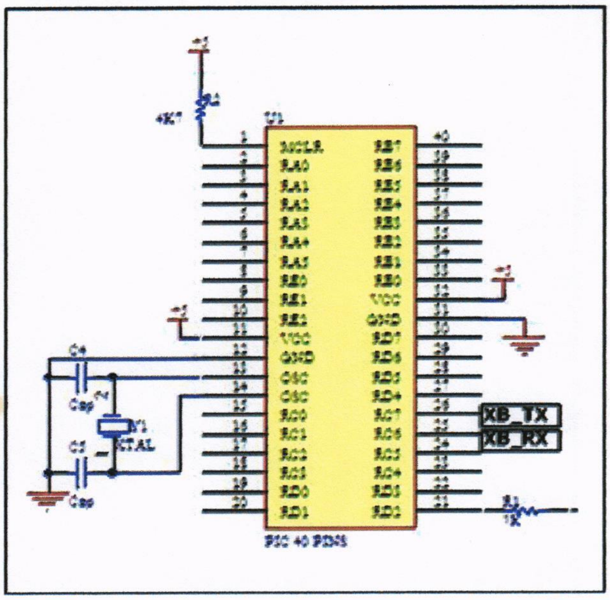

Figure 4 : PIC Microcontroller circuit

C. Transceiver

Sensor nodes make use of ISM band which gives free radio, huge spectrum allocation and global availability. The various choices of wireless transmission media are Radio frequency, Optical communication (Laser) and Infrared. Laser requires less energy, but needs line-of-sight for communication and also sensitive to atmospheric conditions. Infrared like laser, needs no antenna but is limited in its broadcasting capacity. Radio Frequency (RF) based communication is the most relevant that fits to most of the WSN applications. WSN's use the communication frequencies between about 433 MHz and 2.4 GHz. The functionality of both transmitter and receiver are combined into a single device know as transceivers are used in sensor nodes.

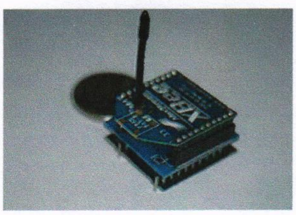

Figure 4 : XBee module

For Xbee, it is open specification for low power wireless networking aiming for control and monitoring application, where low power consumption is the main requirement. Xbee comply with IEEE 802.15.4 standard and operates at 2.4GHz frequency with maximum data rate of 250kbps. This frequency band has the lost potential for large scale WSN application due to its high radio data rate. Xbee product also utilizes 128 bit Advance Encryption Standard (AES) encryption for security purposes and therefore is suitable for various WSN applications. XBee, offers indoor communication range up to 30m and outdoor line of sight range up to 100m. While XBee PRO, offers indoor communication range up to 100m and outdoor line of sight range up to 1500m.

D. Software Disription

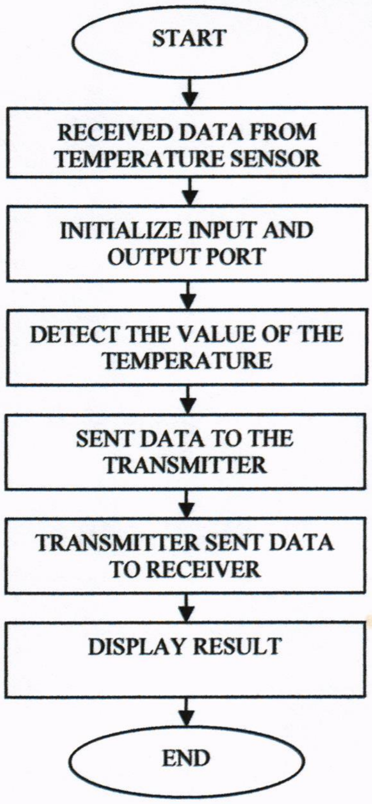

Figure 5: Flowchart of total program.

The PIC was programmed using MicroC software that utilized C language. A program was developed to receive analog signal from the sensor circuit and display the output on the computer screen. The C program was converted into hex file before uploaded to the PIC using the PICKIT ver2 programmer from MICROCHIP. Few functions such as display, receive and delay were written in one main program and were called upon when needed. This limits the size of the program and eventually limits the memory space and processing time.

Beside PIC, the Xbee nodes also need to be programmed to include it own Personal Area Network ID (PAN ID). This is done through the X-CTU software with AT command. The PIC based sensor nodes extremely resource limited and therefore the operating system or the program should be as small as possible. Sensor nodes usually are installed in an unmanned area for periods ranging from month to years. Therefore, the hardware and software used in the sensor node must work on low power.

Fig. 6 encompasses the overall system conceiving a power supply, temperature sensor, PIC and transmitter on the sensor node side.

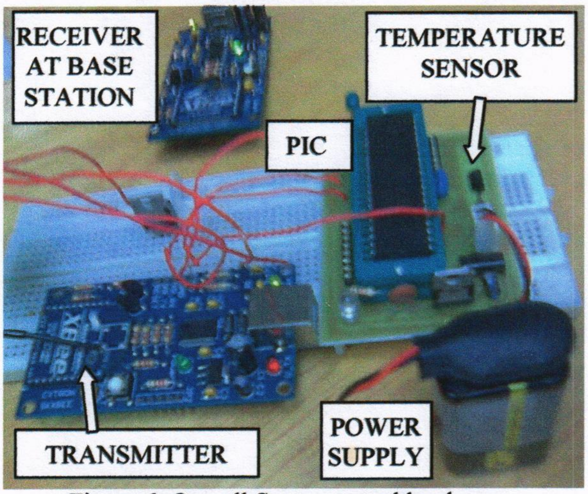

Figure 6: Overall System actual hardware.

III. Result and Discussion

Beside hardware development, the overall objective of this implementation is to set up a WSN topology consisting of several nodes for different position in a specified environment. However this paper shall present the communication result a WSN with a single node to be tested in 3 different positions. Environment chosen were; outside of a building. The inside of a building is separated into an air-conditioned laboratory and a room at room temperature. This is mainly intended for hardware functionality verification and operation ability in different building environment.

Figure 6, 7 and 8 show that the result output display at the base station screen. The results proved that for different parts of the building, the sensor can sent sensed data from closed environment such as a laboratory, to any room in the building and even from the outside of the building to the base station. These outputs are basically temperature values, send by the wireless sensor via the Xbee transmitter to the base station receiver at the some environment. The results are displayed on the screen by using X-CTU software.

The temperature from the wireless sensor network for laboratory, outside and room temperature is much closer to the actual temperature. Although there are obstacle between the base station and the sensor node, the data at the base station still remains the same. Experiment is carried out at ground level.

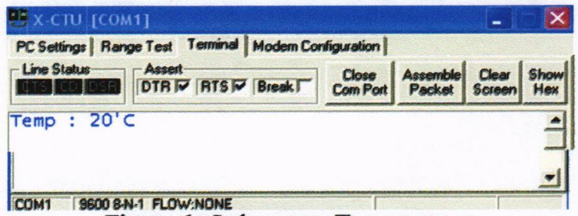

Figure 6 : Laboratory Temperature

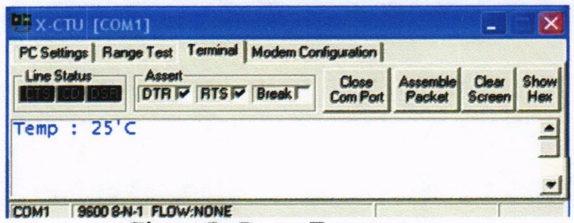

Figure 7 : Room Temperature

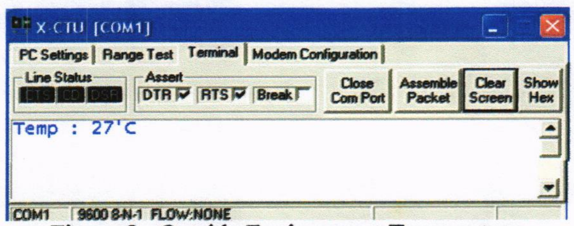

Figure 8 : Outside Environment Temperature

For the next part of the experiment, the environment chosen is a room at room temperature. Room dimension is given in Figure 9. Base station is located at position (7) while sensor node is moved from position (7) to (5), (4) then (3). Data transmission is set at a delay of 3 seconds. Experiment was carried out in a building, 100 meters above ground. This experiment is to proof the operationability of the sensor and the sensor transmitter.

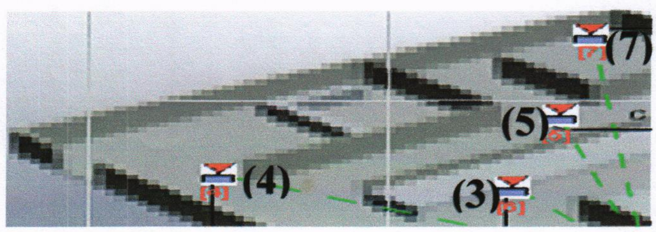

Figure 9 : Building corridor and internal plaster walls

The result as shown in fig.10 is the first part of this experiment. This experiment is to prove the functionality of the temperature sensor. When sensor is at position (7), heat is applied to the sensor and the temperature increase can be observed from the data received at base station.

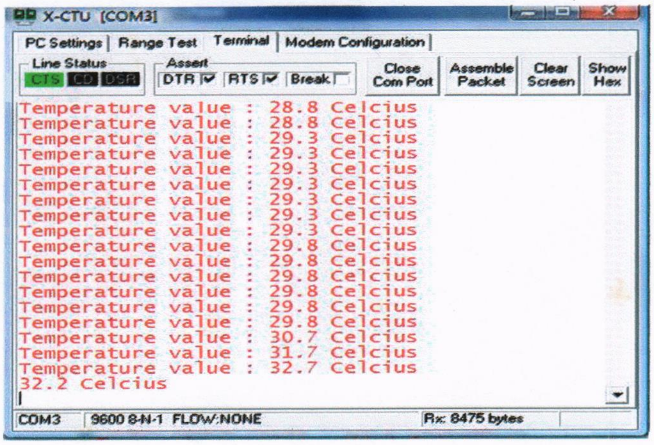

Figure 10 : Result of temperature reading at base station

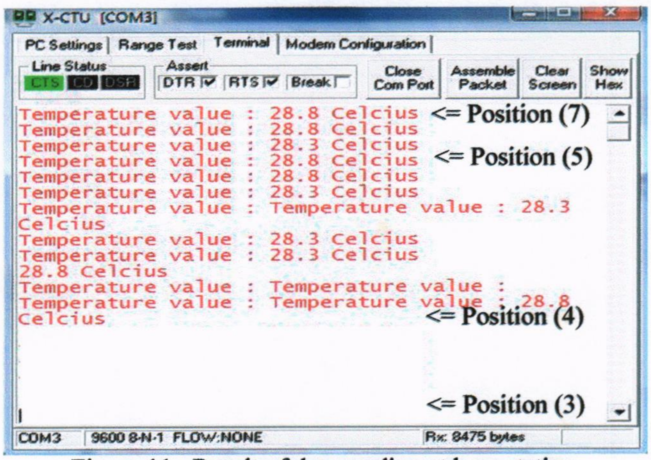

Figure 11 : Result of data reading at base station

Results from Fig. 10, shows that sensor was able to communicate with base station between point (7) to point (5) at walking speed. Loss of communication occurred between point (5) to (4) where irregularity in data received at the base station can be observed. At position (3), total communication loss occurred where no data is sent at all.

IV. CONCLUSION

This paper present a wireless sensor network system based on Xbee technology and microcontroller (PIC) for simple application is temperature sensor by exploring its system framework and technology characters. The experiment was also done to prove its feasibility. And the sensor node has successfully transmitted sensored data to the base station located in the same environment. It is a preliminary work toward a better design of a PIC based wireless sensor node and a complete WSN.

In this project, the sensor node has successful transmit the data to the base station and displayed the environment temperature. As result, the successfully transmitted temperature for outside environment is 27C, for laboratory temperature is 20C and for room temperature is 25C. And for the next experiment, the environment chosen is a room with plaster walls and corridor at room temperature. Experiment was carried out in a building, 100 meters above ground. This experiment is to proof the mobility of the sensor and the sensor transmitter. Loss of communication occurred where irregularity in data received at the base station can be observed and total communication loss occurred where no data is sent at all resulted when sensor node is moved far away from the base station. It is because of the many walls that separate the radio frequency when the sensor node at different position transmits data to the base station.

The system possesses low cost, low power, wider coverage, and especially the character of mobility on wiring to remove the limitation of traditional wired network system.

V. FUTURE DEVELOPMENT

Further development of more nodes should be highly considered. The simulation of WSN topology has already been carried out [1]. It is in the hope of the writer that with the success of the development of this sensor node, hardware duplication could be carried to produce several nodes. With more number of nodes, the feasibility of the simulated WSN system developed earlier can be proven.

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