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Wireless Sensor Networks for Industrial Applications: Practical Approach

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ABSTRACT: Wireless Sensor Networks (WSN) provides information for data acquisition and data distribution. It is a network that consists of spatially distributed and automated wireless sensor nodes which are capable of monitoring several physical environmental fields such as air pressure, luminosity, vibration and temperature. This paper focuses on the design of a WSN utilising ZigBee protocol and Waspmote technologies; the purpose is to provide telemetry services for industrial applications which will be required to collect data about light bulb luminosity as well as its associated surroundings. At the end of the processes, WSN framework was designed showing initial results of bulb luminescence reading, temperature and accelerometer; the designed system has the capability of sending real-time data over a network platform utilising the ZigBee 802.15.4 protocol with sensor nodes attached to the circuit board; this will provide radio frequency telemetric services, utilising a cost effective platform that has the benefits of overcoming the cumbersome measures presently in operation. Sensor networks methods of development overtime have suffered setbacks for lack of well-defined practical approach that will produce results patterned for industrial acceptance; this paper measures on this area using a model that is environmental and eco-friendly.

KEYWORDS: Wireless Sensor Networks, Waspmote, Nodes, ecology, data, ZigBee.

1 INTRODUCTION

The technological advancement in the world has over time taken a new turn and measures to monitor activities in industries are being developed to provide free access to information and support for end users [1]. This is as a result of the high demand for resources capable in assisting industrialists to accomplish set goals and develop programs for the establishment of time delivery of materials and create opportunity for increased knowledge [2].

The importance of providing a well detailed prototype Wireless Sensor Network (WSN) in an industrial application cannot be over-emphasised; hence this project focuses on bridging the gap between the availability of adequate monitoring data reporting to improve on the existing systems and the conventional method of operations.

WSN are technologies in which characteristically constrained nodes assists each other in transmitting packets of data through the network from source to destination. The WSN consists of nodes that can send and receive messages in a mesh pattern and a node that can function as a router and can also relay messages for its neighbour. Through this process, [3] wireless packet data will find its way to the predetermined destination, passing through intermediate nodes with reliable communication channels.

WSN application varies from one location to another. Various fields such as fire, military installations, pollution, machine health and environment monitoring have experienced expanding revolution in the implementation of this technology in manning activities encompass them. In most network design, basic routing is used as the network architecture, while new flooding-based technology provides the opportunity and advantages especially in large networks [4].

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2 RESEARCH CONTEXT

There have been notable challenges in monitoring the light build luminosity with a view to ascertain its level of use which may result to instant maintenance or replacement; with these, this paper work and methods employed will develop a new and improved system to overcome these challenges [5],[6]. The goal is to design a prototype WSN system capable to test for light bulbs luminosity which will be measured in lumen. There is need for an integrated system with automation which is required to assist the process that will bring about clarity and cost effective in implementation [7], [8]. This designed prototype will improve further research in this area utilising more sophisticated wireless sensor devices.

The research methodology adopted for this process follows a well thought after procedures in development a complex system of this nature [9]. The in-lab experience has been conducted with results which are in line with the challenges being faced and design specifications [10]. Wireless Sensor Networks is an increasing aspect of networking technologies which scholars have identified as the new evolution in the information and communication technology industry [11]. This network consists of tiny nodes with sensor technology used for wireless communications across different networking topology.

This kind of network was developed to truncate the barrier of wire networking design, although security in wireless sensor networking is a challenging height; a portion of this research highlights areas on how these challenges can be curbed [12].

3 SENSOR TECHNOLOGIES

Sensor Technologies functions in highly powered high-speed and low-cost electronic circuits. In a developing world, the need for sensor technologies with a view to support systems automation, security and information dissemination is on the increase [13]. The application of sensor technology in diverse ways has eventually enforced the increase of the requirement for the implementation [14]. The design of smart homes and environment is made possible by the use of sensor devices. Sensor technologies in this respect are expected to provide novel approaches and solutions as required.

Sensor can be considered as complex devices that can be used to detect and respond to signals being produced. A sensor primarily converts physical parameters into signal. These parameters can be; temperature, humidity, and speed. The signal produced can be measured electronically.

When deciding on a particular sensor to use in a given task, the following consideration will be employed; Cost, Range, Accuracy, Environmental consideration, and Resolution [15].

4 WIRELESS SENSOR PROTOCOL

Currently, sensor networks are widely gaining ground because of its numerous applications ranging from environment monitoring, industrial machine and home appliances monitoring. Such network is best described as a network that consists of sensor nodes assigned for a specific function [16].

The sensor node will have full computational ability for sensing and transmitting data in wireless communications model. Inter-connective protocol is considered suitable for wireless sensor networks. Inter-connective protocol is capable of detecting damaged node on time through the help of another node closed to the faulty one. For the purpose of this project, the 802.15.4 and ZigBee standards will be discussed for its peculiarity and reliability.

The 802.15.4 and ZigBee standards are considered as a wireless technology with open global standard, addressing the area of power, cost and high radio frequency [17].

5 AIM AND OBJECTIVES

The main aim and objective of this paper is to support the developmental scale WSN in a development world of technlogical advancement and design processes to build capacity for new skills.

The paper aims to help non-professionals to setup WSN systems and to make decisions on pressing issues relating to monitoring the health conditions of industrial applications [17], [18]. The following outlined specific areas in the objectives;

- Learning the technology and applications of wireless sensor networks.
- Analysing the current system and make possible solutions where appropriate.

- Understanding the limitations of sensor network technology and to evaluate possible solutions based on these limitations.
- Providing strategic alternatives for the systems to be improved.
- Evaluating the suitability of the implemented sensor system utilising *Waspmote* and ZigBee technology.
- Analysing different WSN development techniques and methods.

6 MAIN TASKS

Table 1. Tasks Schedule And Requirements Involved In Designing The System

Tasks	Requirements	Solutions
Device movement	Accelerometer	*Waspmote*
Power provision	Solar panel	Power harvesting
Light tensity measurement	Photocell Light Sensor 3K-11K 5.10ohms	Light sensor
Wireless Communication	xBee adapter with 2.4Ghz RF	Device interaction
Wireless transmission	*Waspmote* device	Nodes interaction
Programming	*Waspmote* IDE v2.0	Serial monitor
Signal transmission	Relay device	
Device firmware configuration	X-CTU	Firmware uprade andconfiguration.

Each systems design requirements are carefully chosen as a means of developing the program to meet the expected results. The entire system will generate the data and transmit simutanously over the network design using the *Waspmote* interface. The processed data will be stored in an external device for further interpretation.

6.1 DESIGN COMPONENTS

As stated in Table 1 the components required to design this system are products from *Libelium* and from *Digi Tech* working with the device configurations requirements. Below are listed components that will be used for the designing phase to achieve the objectives of the tasks.

- Waspmote - this is the network now with embedded system capabilities.
- X-CTU - xBee device firmware configuration platform.
- Light Sensor - electronic device used to determine the intensity of light.
- SD CARD - Mini SD Card used for external storage purpose for data analysis.
- Waspmote IDE - the programming platform as the compiler for the Waspmote product.
- USB cable - used to connect the network node to the system for programming purposes.
- XBee Adapter - serves as the gateway, receives data and transmits it to the base station.

6.2 DEVICE SETUP AND TESTING

Devices are connected and programmed using Waspmote program library support in C++ platform. The platform comes with a user friendly interface and compatibility for expansion and flexibility. The choice of using this program ranges from easy error correction and dubbing. The implementation of elements detailed above follows some critical phase for efficient results taking and to make any form of fault finding process less difficult. This includes;

- Assessment of requirements
- Components evaluation
- Setup and configuration
- Validation
- Testing

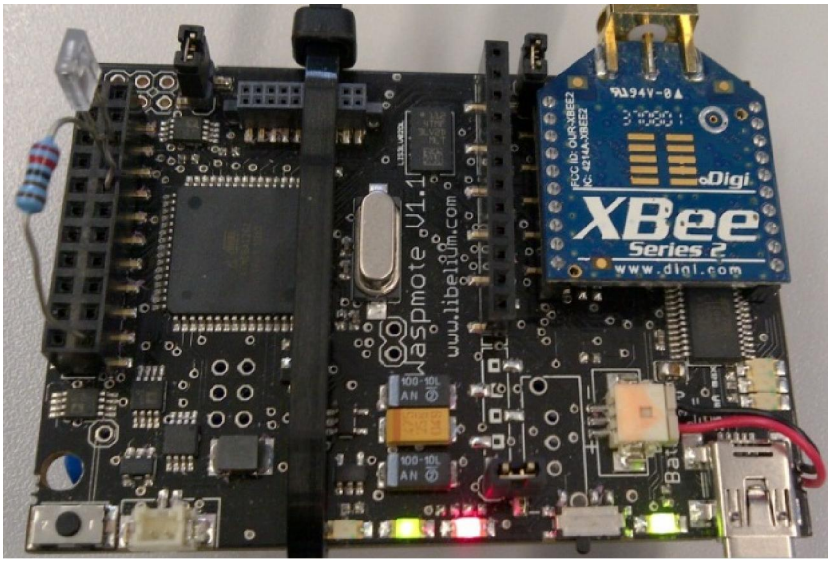

Fig. 1. Actual sensor board used

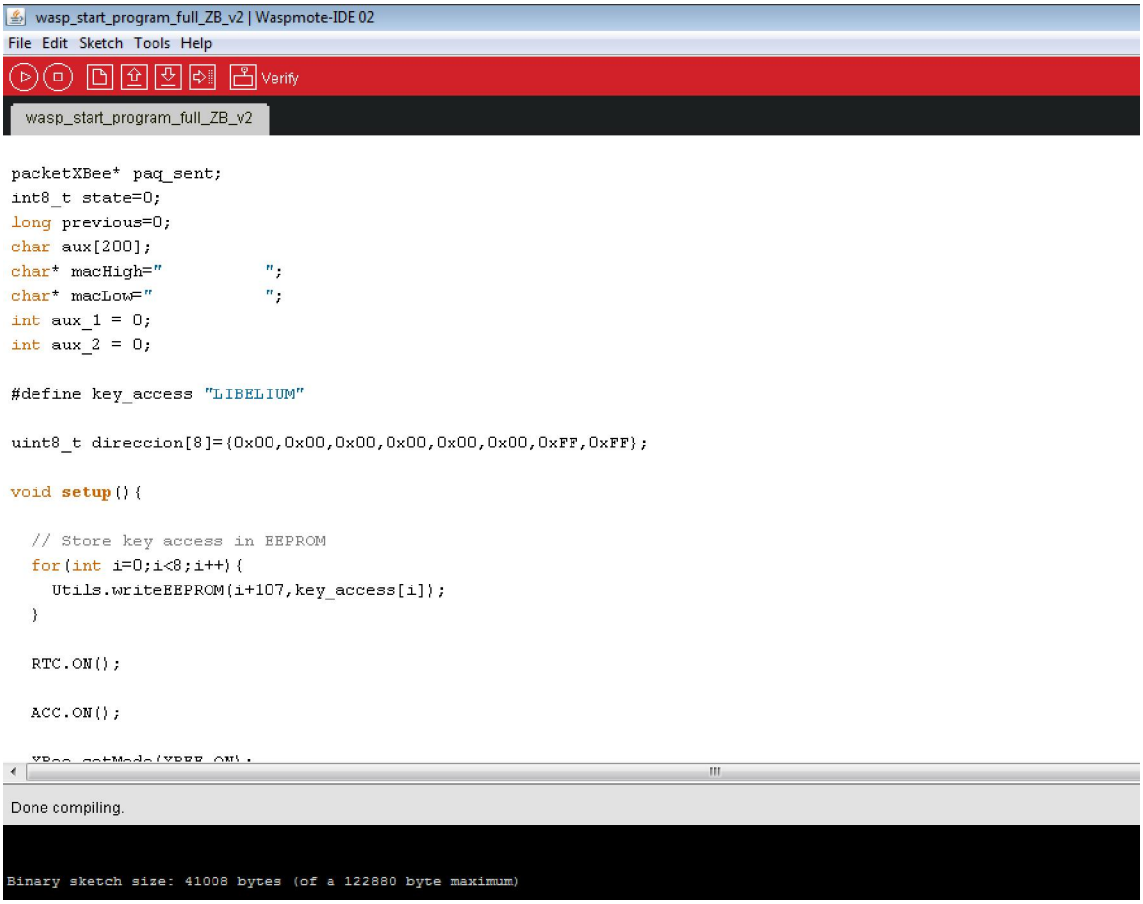

Fig. 2. Waspmote IDE programme session

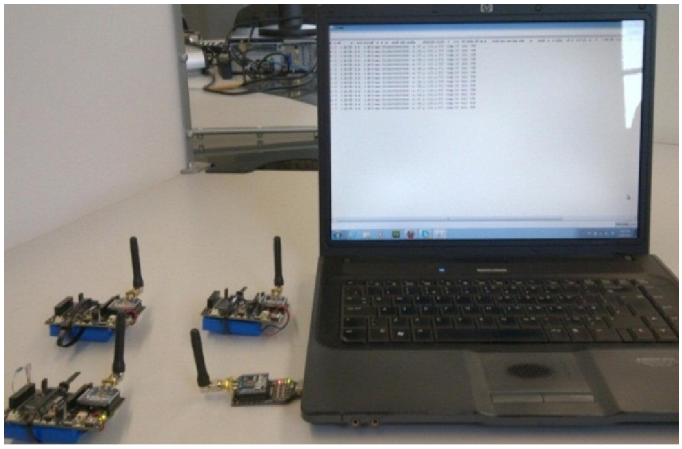

Fig. 3. Actual Setup and Program monitoring session

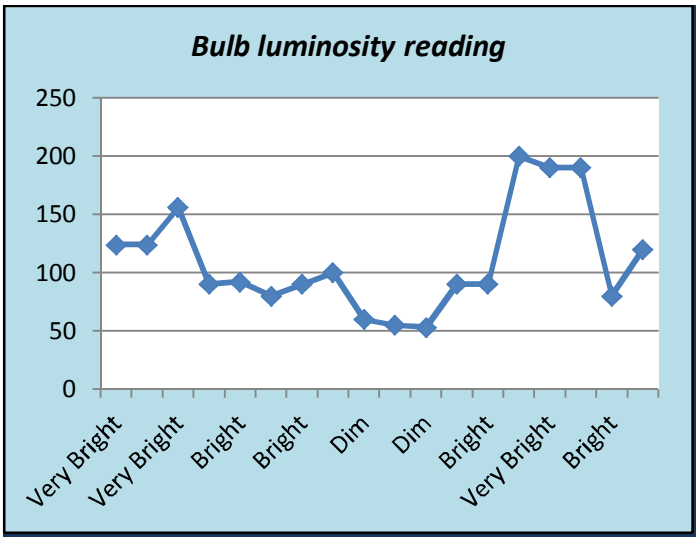

Fig. 4. Data collection graph for bulb luminosity

COM7

```
Temperature: 26
~   R }3 R # VxSensor Light Reading!È  woke up
Landing Light Readings =223 - Very bright
Temperature: 26
~   R }3 R # VxSensor Light Reading!È
Landing Light Readings =222 - Very bright
Temperature: 26
~   R }3 R # VxSensor Light Reading!È woke up
Landing Light Readings =221 - Very bright
Temperature: 26
~   R }3 R # VxSensor Light Reading!È woke up
Landing Light Readings =221 - Very bright
Temperature: 27
~   R }3 R # VxSensor Light Reading!È woke up
Landing Light Readings =221 - Very bright
Temperature: 27
~   R }3 R # VxSensor Light Reading!È woke up
Landing Light Readings =220 - Very bright
Temperature: 27
```

Fig. 5. Light Sensor readings output

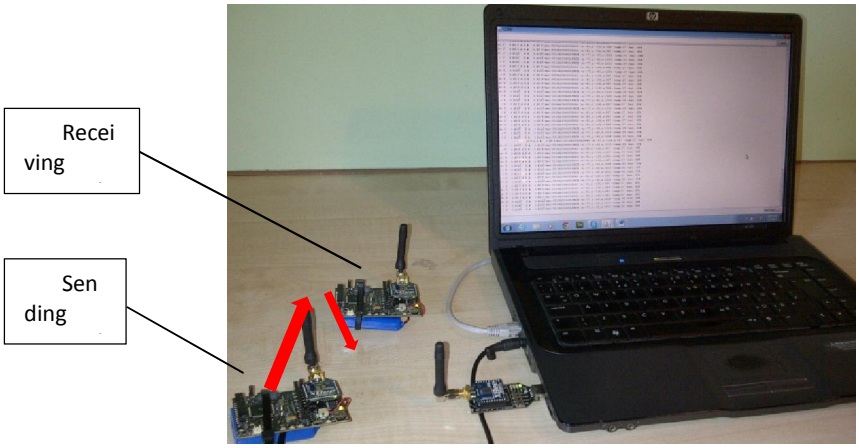

Fig. 6. Nodes communicating with each other

7 CHALLENGES AND RECOMMENDATIONS

Setting up an industrial based WSN standard through practical approach requires elaboration to a large extent stating the challenges encountered and the possible recommendations within the same framework in ensuring that a range of improvement is visible. The following challenges and recommendations have been identified as significant;

- To ensure that devices are securely deployed to meet global standard for WSN deployment with regards to the environment; it is recommended that each node be secured with a specialised plastic casing to keep a standard enclosure.
- Power supply to the nodes after being developed is limited as the inbuilt battery of the Waspmote can only be in operation between 4 – 6 hours; therefore an alternative power supply is recommended which will consist of tiny Solar panels that will be attached to each node on the field for power harvesting purposes aiding energy saving needs. For example, IEEE 802.15.4 and ZigBee standards can run for years on self-provision batteries by limiting the amount of data received and the transmitted frequency respectively.
- Date storage and security are also key areas which recommendations are being made for future data encryption using cryptographic techniques. And in storage, recommendation is based on the need for a secured storage location which can automatically expand itself and strong enough to resist unauthorized interference. Security in wireless communications is viewed as the most important aspect of wireless technologies. *Encryption* and *Authentication* are part of the critical areas where high wireless security measures should be addressed.

8 CONCLUSION

The primary goal of this paper is to show a design of a system that can provide automated monitoring assistant for industrial application; it focuses on learning the technology and applications of wireless sensor networks, to understand the limitations of sensor network technology and to evaluate possible solutions based on these limitations and to evaluate the suitability of the implemented sensor system using Waspmote and ZigBee technology. Progressively, a Wireless Sensor Networks prototype designed with the ZigBee network protocol was deployed to the site after due success achieved with the program testing stage as shown in this paper. Testing procedures were carried out with results output attached accordingly.

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