

# DEVELOPMENT OF WIRELESS NETWORK USING ZIGBEE

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2013



# **UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

## **DEVELOPMENT OF WIRELESS MONITORING NETWORK USING ZIGBEE**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering

( Robotic and Automation ) (Hons.)

By

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2013

# DECLARATION

I hereby, declared this report entitled “ Development of Wireless Mesh Network using Zigbee for Monitoring Manufacturing Activities” is the results of my own research except as cited in the references.

Signature : .....

Author's Name : .....

Date : .....

## APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering ( Robotic and Automation ) (Hons.). The member of the supervisory committee is as follow:

.....

(Official Stamp of Supervisor)

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(Official Stamp of Principal Supervisor)

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(Official Stamp of Co-Supervisor)



## **ABSTRAK**

Seperti yang kita tahu, kebanyakan kaedah yang digunakan dalam pemantauan pengeluaran pembuatan adalah menggunakan cara manual. Maka, objektif utama dalam projek ini adalah untuk membina Rangkaian Perhubungan Tanpa Wayar menggunakan Zigbee untuk memantau aktiviti perkilangan. Perkembangan ke semua pembangunan sistem ini adalah sangat penting untuk meningkatkan pengeluaran dan mengurangkan pembaziran produk. Tujuan utama projek ini adalah untuk mengenal pasti keupayaan Zigbee sebagai salah satu sensor Rangkaian Perhubungan Tanpa Wayar melalui kajian spesifikasi dan protokolnya. Kemudian, sistem projek ini akan dibangunkan menggunakan perisian Visual, Zigbee dan pengawal mikro bagi menilai prestasi sistem ini. Prosedur eksperimen adalah konfigurasi antara pengawal mikro dan Zigbee yang bertindak sebagai terminal mesin. Pengeluaran output akan dipaparkan di Komputer di mana pengguna grafik antara muka akan di bina menggunakan perisian VB.net. Dari eksperimen didapati bahawa Zigbee dapat menghantar data maksimum sejauh 70 meter tanpa sebarang halangan. Sekiranya terdapat halangan di dalam eksperimen ini, jarak maksimum data yang dapat dihantar oleh Zigbee adalah sejauh 60 meter sahaja. Dari eksperimen ini dapat diperhatikan bahawa terdapat kelewatan masa dan kehilangan data ketika data dihantar oleh Zigbee. Senario ini dapat diperhatikan sekiranya terminal mesin diletakkan pada kedudukan yang jauh dari terminal Komputer dan terdapat beberapa halangan. Namun begitu, Zigbee masih mempunyai stabiliti dalam menghantaran data pada parameter ketinggian iaitu sehingga pada paras ketinggian tiga tingkat. Kesimpulannya dari eksperimen ini dapat memperolehi lokasi jarak terbaik antara terminal mesin dan terminal Komputer.

## **ABSTRACT**

As we know, mostly the current methods of monitoring manufacturing activities are done in manual ways. The main objective of this project is to build a Wireless Monitoring Network using Zigbee to monitor manufacturing activities. The emerging of all development system has become important to improve production and minimize the cause of implementing network and caused by waste. This project aims to investigate Zigbee's capabilities as Wireless Network which the study will look into Zigbee's specifications and protocol. This is followed by the development of a manufacturing monitoring system using Visual basic, Zigbee and microcontroller and to evaluate the system performances. The work includes the configuration between microcontroller and Zigbee as the act of machine terminal. The end output will be displayed on a PC where a Graphical User Interface (GUI) has been developed using VB.net. From the experiment, the result obtains that Zigbee can send data at maximum range distances of 70 meters without any obstacle. With some obstacle apply which is in different places; the maximum range Zigbee can support is only 60 meters. From the experiment can be observed that Zigbee has delay time and losses in transmitting data. These scenarios obviously appear if the terminal machines located far away from PC terminal and with some obstacle. However, Zigbee still have stability in transmitting data in altitude parameter till third floor. The conclusion of this experiment can obtain the best distance should the machines and PC terminal located.



# **DEDICATION**

To my beloved parents

## **ACKNOWLEDGEMENT**

First of all, thank to Allah S.W.T. with His blessings and for the strength given for me to prepare this report. I would like to extend heartfelt gratitude to En Mohd Nazrin bin Muhammad as my supervisor for giving the opportunity to undergo final year project under him. The co-operation is much indeed appreciated. I would like to express my appreciation for all FKP staff that involve for giving the knowledge, information, cooperation, support and instruction during the preparation of final year project. Great deals appreciated goes to the contribution of my Faculty of Manufacturing Engineering (FKP).

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# CHAPTER 1

## INTRODUCTION

### 1.1 Project Background

Over the last 10 years, the communication technology (ICT) innovations and other early information have gradually embraced business and society and are widely increasing in every aspect of our life. Emerging by miniaturization and the accelerating convergence between computing, communications, media and knowledge technologies are like foster profound changes for at least one or more two decades. There are different types of network which is their design depends on scale and scope. The common types of networks are Local Area Network (LAN), Wireless Local Area Network (WLAN), Wide Area Network (WAN), Metropolitan Area Network (MAN), Campus Area Network, Controller Area Network, or sometimes called Cluster Area Network (CAN), Personal Area Network (PAN), Desk Area Network (DAN). The network architectures were shown in the Figure 1.1, 1.2 and 1.3.



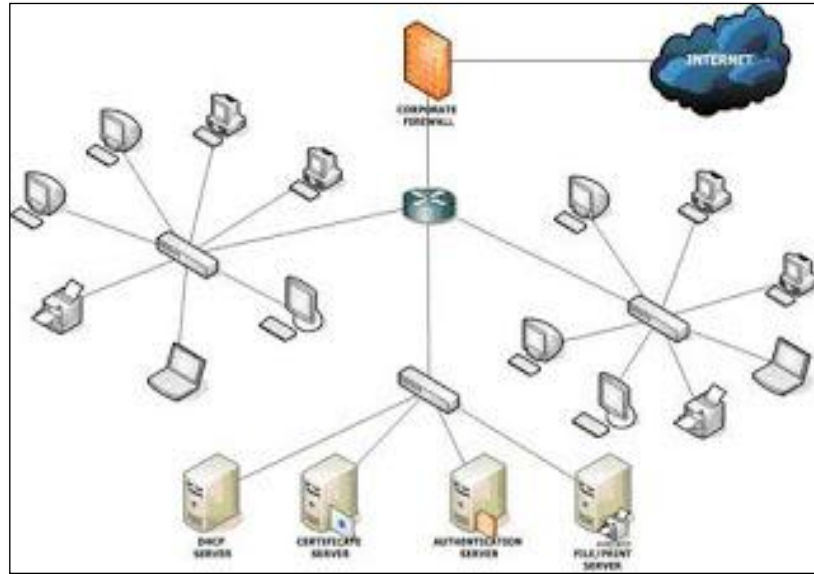


Figure 1.1: Local Area Network (LAN)  
 (Source : <<http://www.dudleysenanayakacc.blogspot.com>>)

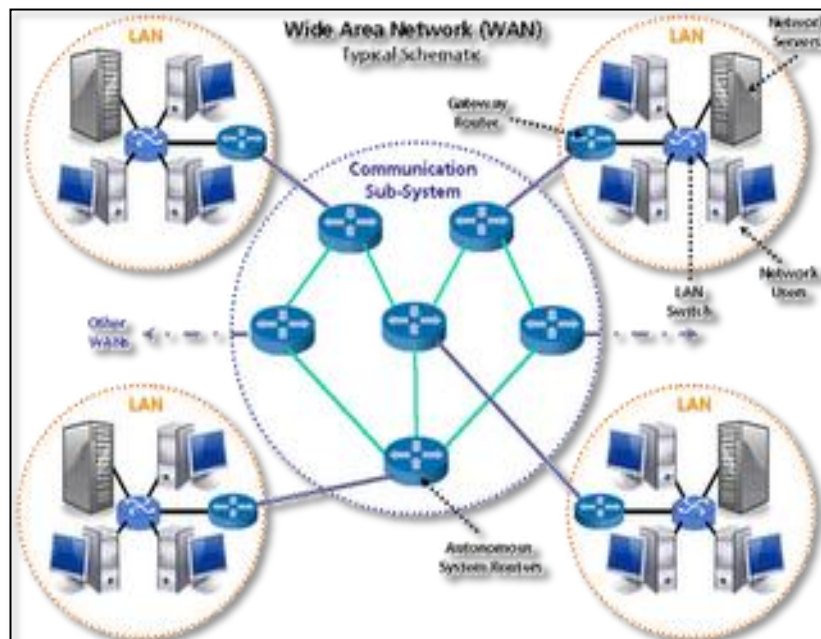


Figure 1.2: Wide Area Network (WAN)  
 (Source : <<http://www.dudleysenanayakacc.blogspot.com>>)

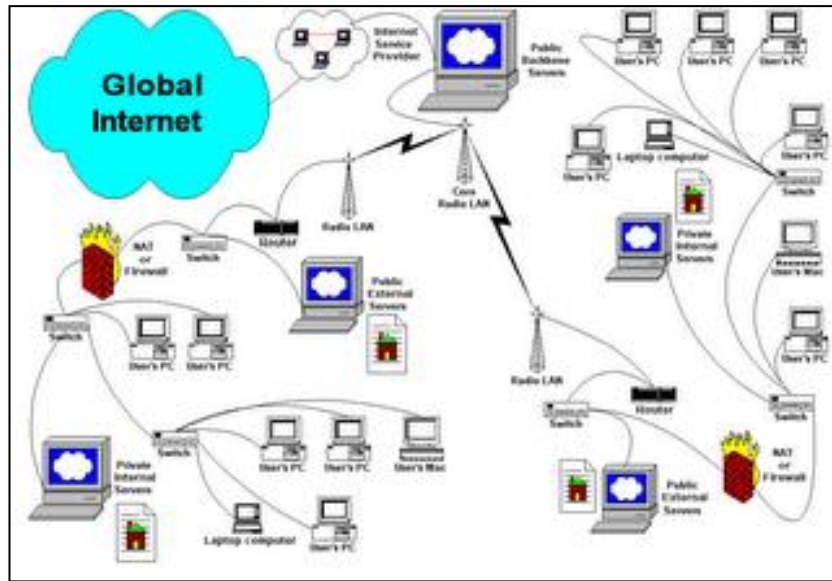


Figure 1.3: Metropolitan Area Network (MAN)  
 (Source : <<http://www.dudleysenanayakacc.blogspot.com>>)

A Wireless Mesh Network (WMN) is a network of wireless which is more mobile and self organized in arbitrary and temporary network topologies. The communication of this network is made up from radio nodes and organized in a mesh topology. Wireless Mesh Network is significantly upgrading the performance of LANs, PANs and MANs. The application of Wireless Mesh Network is must be simple, energy efficient, scalable, robust and cost effective over a certain geographic area. Unlike cellular network which is the failure of a single base station are leading to unavailability of communication. WMN is built from peer radio devices and doesn't need any cabled to wire port like traditional WLAN access point. The advantage of using WMN it is still can communicate with other nodes directly, through one or more intermediate nodes even one of the nodes are not operating. It shows that WMN is self form and self heal. The configuration of Wireless Mesh Network can be either hierarchical, flat or hybrid. By WLAN network is divided into Bluetooth, WI-Fi and Zigbee. There are different characteristics of this network as shown in the Table 1.1.

Table 1.1: Comparison between WIFI, Bluetooth, Zigbee  
(Source: ZigBee Alliance)

Types of module	WIFI	Bluetooth	Zigbee
Underlying Standard	802.11 lbs	802.15.1 lbs	802.15.4 lbs
Application focus	Web, email, video	Cable replacement	Monitoring & control
Battery life ( days )	0.5 – 5	1 – 7	100 – 1,000+
Network size	32	16	100s to 1000s
Bandwidth K bits/s	11,000+	720	20 - 50
Range meters	1 – 30+	1 – 10+	1 – 1000+
Network Architecture	Star	Star	Mesh
Optimized for	Speed	Low cost, convenient	Reliability, low power, low cost, scalability

Bluetooth only support a short range distance and implemented in Wireless Personal Network state in Sewook et al (2007) approaches the problem by analyzing the Bluetooth periodic inquiry mode and by finding the optimum inquiry/connection time settings. At the application layer, the BlueTorrent index/block dissemination protocol is then designed and analyzed. The entire system is integrated and implemented both in simulation and in an experimental testbed. Simulation and measurement results are used to evaluate and validate the performance of BlueTorrent in content sharing scenarios. While, L. Ruiz-Garcia an et al (2008) approached the progress in fruit logistics using Zigbee technology required an increasing number of measurements to be performed in refrigerated chambers and during transport. Wireless sensor networks (WSN) are a promising solution in this field. This paper explores the potential of wireless sensor technology for monitoring fruit storage and transport conditions. It focuses in particular on ZigBee technology with special regard to two different commercial modules (Xbow and Xbee). The main contributions of the paper relate to the analysis of battery life under cooling conditions and the evaluation of the reliability of communications and measurements. Psychometric equations were used

for quick assessment of changes in the absolute water content of air, allowing estimation of future water loss, and detection of condensation on the product. According to Bhavneet et al (2007), WIFI is a data transmission designed to provide network access between computing devices by using radio waves rather than cable infrastructure. The network type is 802.11 could transfer the data up to 11 megabits per second (Mbps) and the WLAN hardware built around 802.11g was quickly embraced by consumers and businesses seeking higher bandwidth. The Figure 1.4, 1.5 and 1.6 shows the WIFI module, Bluetooth dongle and XBee Pro antenna.



Figure 1.4: WIFI moduleSerial (RS232)  
(Source: <<http://www.toboc.com>>)



Figure 1.5: Mini USB 2.0 Bluetooth Dongle (Source: <<http://www.basco.com>>)



Figure 1.6: XBee Pro 60mW Wire Antenna  
(Source: <<http://www.cytron.com.my>>)

In the earliest development of machinery, the monitoring manufacturing activities using the human feel of touch, smell, taste, looking and listening. Nowadays, many scientific and sophisticated instrumentation have been produced to allow us to quantify the health or condition of industrial equipments so the problem can be diagnosed early and be corrected by suitable maintenance before they become

serious enough to break down. The monitoring technique involved the designing and sensing arrangement on industrial plant together with data acquisition and analysis system plus with predictive and diagnostic method. Although to engineer and manufacture is human, but to fulfill the consumer perception towards order with the criteria such as total quality, reliability, health and safety, environmental issues, energy conservation and cost of ownership, the automatic system and equipments will be used to monitor manufacturing activities. For example the speeds of rotating machinery need high capabilities to control and process the system. Recently, monitoring manufacturing activities have become critically important to achieving cost – effective plant maintenance, economics of production and productive production (A. Davies, 1998).

This research project will be focused to develop Wireless Mesh Network using the Zigbee application for monitoring manufacturing activities. The reasons using Zigbee because it is carried only low data rate. This Zigbee is the most suitable application to use because its reliability, low power, low cost and thus the application are focusing on monitoring and control is suitable to the research project which is to monitor manufacturing activities.

## **1.1 Problem Statement**

In order to monitor manufacturing activities, operators will need to collect data from machines for every hour. The collected data are required to manage the process or to improve equipment reliability. The data will imply in some type of database such as manual tank inventories in refineries and the cycle will be counted in the process. Some of analysis and action will be required after the data collected such as adjusting the machine temperature. Normally in manual ways the data will be recorded on paper (Life Cycle Engineering, Inc, 2011). It will cause waste of energy to the operator because they need to monitor the operation regularly in order to optimize manufacturing production. In this research project, the WMN using Zigbee for monitoring manufacturing activities can overcome the problem. Furthermore, it will

have minimal change in infrastructure as it works using WLAN instead of wired. However, implementation of WIFI is complicated compares to other wireless technique. Meanwhile Bluetooth only covers a short-range distance which is 1 to 10 meters only. Therefore, this project will focus on applying Zigbee in monitoring the manufacturing environment where the machines are located in different locations. By using Zigbee, the cost to implement is more reasonable and, cheaper than WIFI.

### **1.3 Objective**

- a. To develop a manufacturing monitoring system using visual basic, Zigbee and microcontroller.
- b. To evaluate the system performance.

### **1.4 Scope**

- a. The simulation of PLC machine will be count using simple switches as the act of monitoring manufacturing activities.
- b. Distance to be covered will be limited to 50m radius.
- c. The Zigbee modules will be used one as main terminal and other as client.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Wireless Network

In this project, the wireless network protocols to be focused are showed in Figure 2.1:

1. Zigbee
2. WIFI
3. Bluetooth

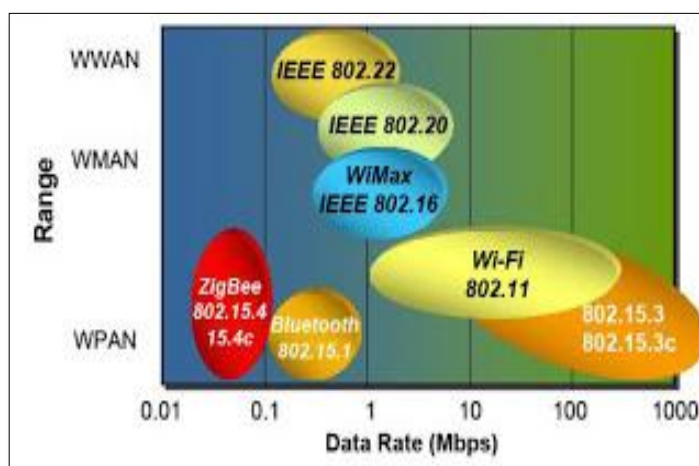


Figure 2.1: Types of Wireless Network  
(Source :<<http://www.neuralenergy.info/2009/06/zigbee.html>>).

In Zigbee, it is a wireless network with an Internet Protocol (IP) IEEE 802.15.4 MAC / PHY radio technology in 2.4 GHz unlicensed frequency band and enables worldwide operation, low power consumption cost and convenience. The Zigbee tech is intended to be simpler and less than WPANs such as Bluetooth. Zigbee is targeted at radio - frequency (RF) applications that required a low data rate, long battery life and a long transmission range compared to Bluetooth. Zigbee applications are more focused on monitoring and control such as control wireless light switches, electric meter with in home display and other consumer and industrial equipment (Jon Adams, 2006).

While Bluetooth is a wireless network with an Internet Protocol (IP) IEEE 802.15.1 to 2.4 GHz range for the use of low power radio communications to link phones, computer and other network devices in short distances without wires. Bluetooth is simply designed to support simple wireless networking of personal consumer devices such as cell phone, PDA, and wireless headsets. To compare Bluetooth with Zigbee, Bluetooth cover the short distance typically 10 meters and communicate less than 1Mbps, slower and support fewer devices. The Bluetooth application more focused on transmit data with low data rate and it is cable replacement. The Figure 2.2 had shown the Bluetooth transmission.

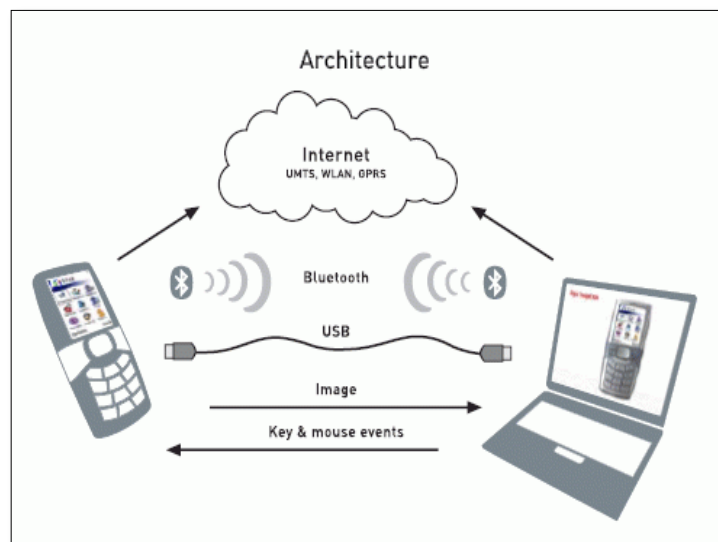


Figure 2.2: Bluetooth Architecture  
(Source: <<http://www.s60tips.com/2007/04/19/featured-software-imageexpo>>).