MACHINE OPERATION MONITORING BASED ON WIRELESS SENSOR NETWORK

NURSABILLILAH BINTI MOHD ALI

MAY 2009

© Universiti Teknikal Malaysia Melaka

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering."

Signature : ……..……

Supervisor's Name : ZULHANI BIN RASIN

Date : 07th MAY 2009

© Universiti Teknikal Malaysia Melaka

MACHINE OPERATION MONITORING BASED ON WIRELESS SENSOR NETWORK

NURSABILLILAH BINTI MOHD ALI

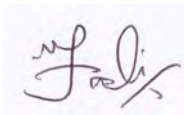
This Report is submitted in Partial Fulfillment of Requirements for the Degree of Bachelor in Mechatronic Engineering

Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

MAY 2009

© Universiti Teknikal Malaysia Melaka

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."



Signature : ……

Name : NURSABILLILAH BINTI MOHD ALI

Date : 07th MAY 2009

© Universiti Teknikal Malaysia Melaka

Specially dedicated to:

Mak

Abah

My lovers

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

There are a number of people without whom I would not have started or completed this thesis. First among these people is my supervisor, Zulhani Rasin. Without his guidance my studies in this area would not have been possible. It was through Zulhani's suggestions that I began researching the area of basis programming. I am grateful for both his suggestions and guidance. Most importantly, I would like to acknowledge my friends and family for their support. All too often I would ramble on about a point they wouldn't care about, and still they offered their assistance, support and encouragement. I have valued each comment.

Million thanks to everyone for making life enjoyable and easier through these studies. With heartfelt gratitude I acknowledge those who over the years have answered my questions. It is to those family members and friends who patiently faced my curiosity that I owe my knowledge and abilities.

Finally, this work is reliant on those mentioned in the references and upon the people mentioned above. Without these giants, this work would be mere supposition and I thank them for the solidity their shoulders have granted me.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

In industrial applications, the monitoring of machine condition or operation has been performed manually. This has cause a demanding in wireless system due to high cost in wired technology for monitoring purpose. The objectives of the project are to develop a monitoring machine using Wireless Sensor Network (WSN) based on ZigBee Technology. This project system is started by developing a machine monitoring system which measures the temperature and voltages of the DC motor that acts as a machine and all the parameters are displayed through a Graphical User Interface (GUI). The GUI is designed using Visual Basic 6.0 software programming language. The hardware component consists of sensor circuit, DC motor machine and the ZigBee WSN module is developed to be integrated with the software component. The hardware implemented is based on WSN of ZigBee Technology. In order to evaluate the overall performance of the machine monitoring system, several measurements was carried out within the indoor and outdoor environment and the result is also discussed.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Dalam aplikasi di industri, pemantauan keadaan mesin dilakukan secara manual. Ini telah menyebabkan tuntutan sistem tanpa wayar disebabkan kos yang tinggi di bidang teknologi berwayar melalui aplikasi pemantauan. Objektif projek adalah untuk membangunkan sistem pemantauan mesin menggunakan Rangkaian Sensor Tanpa Wayar (WSN) berdasarkan Teknologi ZigBee. Projek ini bermula dengan membangunkan sistem pemantauan mesin yang akan mengukur suhu, voltan DC motor yang juga bertindak sebagai mesin dan parameter lain akan di paparkan melalui Paparan Pengguna Grafik (GUI). GUI itu direkacipta menggunakan perisian bahasa program *Visual Basic 6.0*. Komponen perkakas mengandungi litar suhu, mesin DC motor and modul WSN ZigBee telah dibangunkan untuk di satukan dengan komponen perisian. Pembangunan perkakasan dilakukan berdasarkan Teknologi WSN ZigBee. Untuk menilai prestasi sistem pemantauan mesin, beberapa pengukuran telah dilakukan pada dalaman dan luaran kawasan dan keputusan prestasi itu akan dibincangkan.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	PROJECT TITLE	**i**
	DECLARATION	**ii**
	DEDICATION	**iii**
	ACKNOWLEDGEMENT	**iv**
	ABSTRACT	**v**
	ABSTRAK	**vi**
	TABLE OF CONTENTS	**vii**
	LIST OF FIGURES	**xi**
	LIST OF TABLES	**xiv**
	LIST OF ABBREVIATIONS	**xv**
I	**INTRODUCTION**	
	1.1 Background	1
	1.2 Problem Statement	2
	1.3 Project objectives	3
	1.4 Scope of work	3
	1.5 Project Report Outline	4
II	**LITERATURE REVIEW**	
	2.1 Wireless sensor network	5
	2.2 Component of WSN	7
	2.3 Characteristics of WSN	8

© Universiti Teknikal Malaysia Melaka

2.3.1	Lifetime	8
2.3.2	Scalability and reliability	8
2.3.3	Maintenance	9
2.3.4	Data Collection	9
2.4	Deployment of WSN	9
2.4.1	Network Topology in WSN	9
2.5	WSN Application	10
2.5.1	Industrial Application	11
2.5.2	Biomedical monitoring	13
2.5.3	Habitat monitoring	14
2.5.4	Traffic control monitoring	16
2.6	WSN Case Study	16
2.6.1	WSN Case Study: Condition monitoring in end mill	16

III THEORETICAL BACKGROUND

3.1	ZigBee Overview	18
3.1.1	Features of ZigBee WSN	19
3.1.2	General characteristics of ZigBee or IEEE 802.15.4	20
3.2	Comparison of the ZigBee with other standard	21
3.3	ZigBee Architecture	22
3.4	Types of Network Devices	25
3.4.1	PAN (Personal Area Network) coordinator	26
3.4.2	Full Function Device	27
3.4.3	Reduced Function Device	27
3.5	RS232 Serial Port	28
3.6	Sensor	29
3.6.1	Sensor determination	30
3.6.2	Types of sensor	30
3.7	Temperature Sensor	31
3.7.1	Thermistor	31

© Universiti Teknikal Malaysia Melaka

	3.7.2 Temperature circuit	33
3.8	Software for GUI Development	33
	3.8.1 Visual Basic 6.0	33
	3.8.2 Visual Basic's 6.0 Features	35

IV METHODOLOGY

4.1	Background of project	39
4.2	Project flow	40
	4.2.1 Literature review	41
4.3	Software Component Development	41
	4.3.1 Software selected for GUI development	41
	4.3.2 Important steps used in VB programming	41
	4.4 Development of Hardware Component	45
	4.4.1 Sensor circuitry	45
	4.4.2 Machine board unit	46
	4.4.3 ZMN2405HP ZigBee module	47
	4.4.3.1 Receiver Energy detection (ED)	48
	4.4.3.2 Link Quality Indicator (LQI)	48
	4.4.4 ZigBee Development Board Block Diagram	49
	4.4.5 I/O specification	51
4.5	Integration between software and hardware component	51
4.6	Performance analysis	52
	4.6.1 Coverage performance analysis for indoor environment	52
	4.6.1 Coverage performance analysis for indoor environment	55
4.7	Project Planning	57

© Universiti Teknikal Malaysia Melaka

V	**RESULT AND DISCUSSION**	
	5.1 Overview	58
	5.2 GUI of the project	58
	5.3 Software and hardware component evaluation	62
	5.3.1 Voltage divider of sensor circuit	63
	5.4 Result of the performance analysis	67
	5.4.1 Result coverage performance for indoor	76
	5.4.2 Result coverage performance of outdoor	68
	5.5 Discussion	70
VI	**CONCLUSION & RECOMMENDATION**	
	6.1 Conclusion	71
	6.2 Recommendation	72
REFERENCES		73
APPENDICES		75

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

NO	TITLE	PAGE
2.1	WSN network	5
2.2	Wireless sensor nodes and base station	6
2.3	Typical application of WSNs	6
2.4	WSN component	7
2.5	WSN configuration	8
2.6	Common WSN Topologies	10
2.7	Various application of WSN	10
2.8	Wireless Field Instrument maintenance	11
2.9	Wireless Monitoring System	12
2.10	Industrial sensor or actuator networks	13
2.11	WSN Biomedical monitoring	14
2.12	Structure architecture for habitat monitoring	15
2.13	Available monitoring solution of WSN	15
2.14	WSN application in traffic control monitoring	16
2.15	Architecture milling machine tool environment	17
3.1	ZigBee Development module	19
3.2	IEEE 802.15.4 or ZigBee software stack architecture	23
3.3	Detailed architecture of ZigBee software stack	23
3.4	ZigBee Network configuration	26
3.5	Handshake looping a PC serial connector	29
3.6	Environmental sensor	29
3.7	NTC Thermistor	31

© Universiti Teknikal Malaysia Melaka

3.8	Resistivity vs. Temperature	32
3.9	Temperature circuit	33
3.10	Microsoft Visual Basic Window	34
4.1	Project workflow	40
4.2	Steps in Visual Basic Programming	43
4.3	Steps in Building Program	44
4.4	Sensor circuit	45
4.5	Sensor circuit board	45
4.6	Connection between sensor circuit and ZigBee module	46
4.7	Motor speed controller circuit	46
4.8	Machine board unit	47
4.9	ZMN2405HP ZigBee module	47
4.10	ZigBee Development Board Block Diagram	49
4.11	Board Components Location	50
4.12	Integration between hardware and software component	52
4.13	Coordinator and End Device positioning	54
4.14	GUI of ZBDemo	54
4.15	Coordinator and End Device positioning	56
4.16	Progress of the project	57
5.1	Introduction form	59
5.2	Login form	59
5.3	Main form of project	60
5.4	A registered login user	60
5.5	Functional hardware component	62
5.6	Thermistor of sensor circuit is stick together with DC motor	62
5.7	Sensor circuit	63
5.8	Thermistor voltage is same with the calculated result	64
5.9	JP4 of the ZigBee end device 1 module is removed	64
5.10	Temperature is increased but thermistor voltage decreased	65
5.11	Potentiometer for both ZigBee WSN coordinator and end device	65
5.12	Steps of the Save as and the exit application	66

© Universiti Teknikal Malaysia Melaka

5.13	Save as form	66
5.14	Coordinator and End Device positioning	67
5.15	Average value of LQI between Coordinator and End Device	68
5.16	Graph of Link Quality Indicator based on data in Table 5.2	69
5.17	Graph of Link Quality Indicator for a distance at 0 degree	69

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

NO	TITLE	PAGE
3.1	Comparison with other wireless standard	22
3.2	D Type 9 Pin and D Type 25 Pin Connectors	28
3.3	Types of sensor	31
5.1	Button or variable function available of the system project	61
5.2	Average value of LQI between coordinator and end device	68

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATIONS

AC	-	Alternate Current
APL	-	Application layer
APS	-	Application support layer
CSMA/CA	-	Carrier Sense Multiple Access/Collision Avoidance
DC	-	Direct Current
ED	-	Energy Detection
FFD	-	Full function device
GHz	-	Giga Hertz
GPS	-	Global Positioning System
GPRS	-	General Packet Radio Service
GUI	-	Graphical User Interface
GTS	-	Guaranteed Time Slot
IA	-	Industrial Automation
ISO	-	International Organization for Standardization
LQI	-	Link Quality Indication
MAC	-	Media access control
MEMS	-	Micro Electro Mechanical Sensor
MHz	-	Mega Hertz
NWK	-	Network
OSI	-	Open System Interconnection
PAN	-	Personal Area Network
PC	-	Personal Computer
PHY	-	Physical layer
RAM	-	Random Access Memory

© Universiti Teknikal Malaysia Melaka

RFD	-	Reduced function device
ROM	-	Read only memory
SMS	-	Short Message Service
SSP	-	Security Service Provider
VB	-	Visual Basic
WiFi	-	Wireless fidelity
WSN	-	Wireless Sensor Network
WPAN	-	wireless personal area network
ZDO	-	ZigBee Defne Object

© Universiti Teknikal Malaysia Melaka

CHAPTER I

INTRODUCTION

1.1 Project Background

The application of Wireless Sensor Network technology in the design of field area network for industrial communication and control systems has the potential to provide major benefits in terms of flexible installation and maintenance of field devices, support for monitoring the operations of mobile robots and reduction in costs and problems due to wire cabling.

Usually, there are thousands of sensors in a factory, such as pressure transmitter, flow meter, temperature transmitters, and so on. Until now, wired network are used to connect sensors to transfer sampled process data to control systems. Wired networks are very reliable and stable communication systems for instruments and controls. However, the wired technology is very costly. Therefore, recently a low cost wireless networks are more strongly demanded by customers to be used, for example, in the temporary instrument networks or some non-critical permanent sites.

This project is about to develop the hardware and software for monitoring system by applying the WSNs based on ZigBee Technology which measure the temperature and voltages where all the parameter is displayed through the Graphical User Interfaces (GUI).

© Universiti Teknikal Malaysia Melaka

1.2 Problem Statement

Currently, industrial technology using wired technology in most of their automation system. There are many disadvantages of wired technology such as the high cost of installation, the high failure rate of connectors, and the difficulty in troubleshooting connections are just some of the factors driving used to investigate wired alternatives. The utility of wireless sensor technology is expected to affect many aspects of plant operation, most notably those applications that benefit from the deployment of sensors or networks of sensors.

sensors are essential to Industrial Automation (IA). They provide the vital link between control systems and the physical world. Today's sophisticated hardware and software for control systems are creating many new possibilities for automation in factories, refineries and processing plants. But cost-efficient use of sensors is restricted in industrial applications by:

i. The expense of wiring and monitoring sensor networks
ii. The safety and regulatory obstacles to running cables in constricted or dangerous areas
iii. Protocol incompatibility between various sensor types and control system hardware or software

The wired connections are not always realistic. Some rural areas are still not wired for broadband Internet connections. This forces users to subscribe to satellite access. Ethernet cables can run a maximum of 100 meters before the signal needs to be boosted. This can cause problems if you don't have an environment that allows this luxury. Remember that the longer the cable is, the more signal loss occurs and the signal travels down the wire. This is why special cables have been developed to help preserve the strength of the signal. However, the use of such technology usually comes at a significantly higher price.

Wire system monitoring is very expensive and it is difficult to get funding to address wiring issues before a system break down and becoming more complex with increasing computerization of operations and of information about it operations .Current practices flow and are limited by the current state of the art of wire systems technology in terms of design, installation, diagnosis and maintenance [1].

© Universiti Teknikal Malaysia Melaka

1.3 Project Objectives

The objectives of the project are stated as follows:

a) To implement a monitoring system using WSNs based on ZigBee Technology which consists of hardware and software part.
b) To build a GUI using Visual Basic 6.0 (VB) software programming language.
c) To develop a sensor circuit to be integrate with the software component using VB 6.0.
d) To make an analysis showing performance of the ZigBee wireless sensor network characteristics within indoor and outdoor environment.

1.4 Scope of Project

This project will focus on the design and development of a machine monitoring system consists of a sensory circuit and graphical user interface (GUI) connected using WSN on Zigbee Technology. Scopes of the project are as follow:

a) To apply the Zigbee Technology based on Wireless Sensor Network (WSN) in the monitoring of operation in wireless manner.
b) Develop a GUI that able to display data of the monitored system in real time.
c) To build simple sensor circuit to sense and then pre-determined parameter such as temperature over voltage.
d) To make a measurement showing performance of the ZigBee wireless sensor network that conducted within indoor and outdoor environment.

© Universiti Teknikal Malaysia Melaka

1.5 Project Report Outline

This report is divided into six chapters .Chapter 1 is basically the introduction part of the project chosen. In this chapter, the project background, problems statements, objectives and scope will be discussed clearly. Besides, elaboration on the project objectives and project scope will be explained in details so that a better view of the project can be obtained.

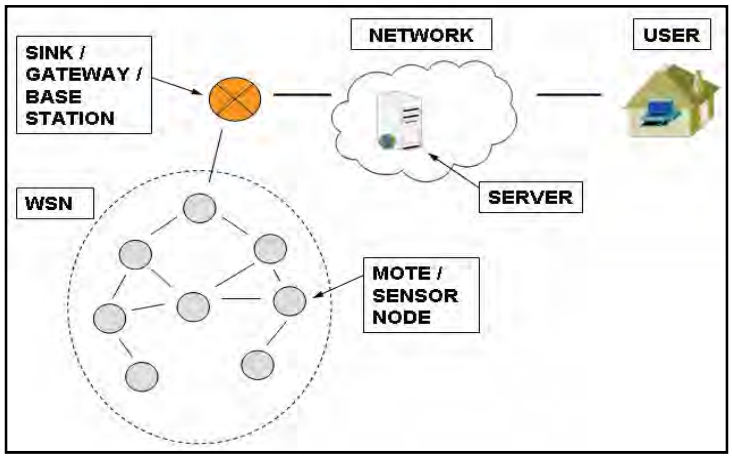
Chapter 2 and 3 provided the literature reviews where similar project and researches are reviewed, discussed and analyzed. Here, all main aspects of WSN such as its fundamental, network topology, communication protocol and historical development and the case study are covered. Sensors that had been used for the project is state clearly. Since the WSN has been described, the theoretical background of ZigBee based on IEEE standard will be cited clearly. Finally, the software development features and the advantages are described.

The methodology including the hardware and software development in this project is detailed in Chapter 4. Here, all aspects such as literature review, software component involving GUI development, hardware consists of ZigBee module, a DC motor that will be acts as a machine and sensor chosen are explained. Some analysis procedures on how measurement of ZigBee wireless sensor network done are included in this chapter.

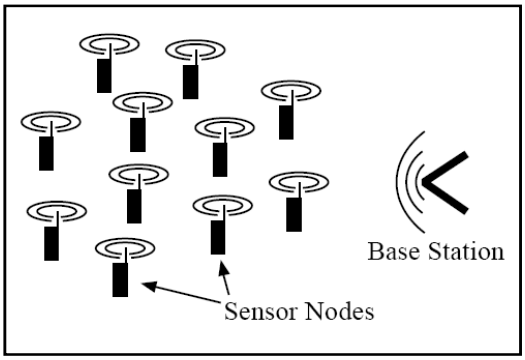
Chapter 5 will be explained the results and discussion of project. The result including the GUI component, DC motor and sensor used are described. The result of analysis showing performance of the ZigBee wireless sensor network characteristics conducted within indoor and outdoor environment is also detailed in this chapter. Here, comparison between indoor and outdoor environment is explained based on ZigBee WSN configuration.

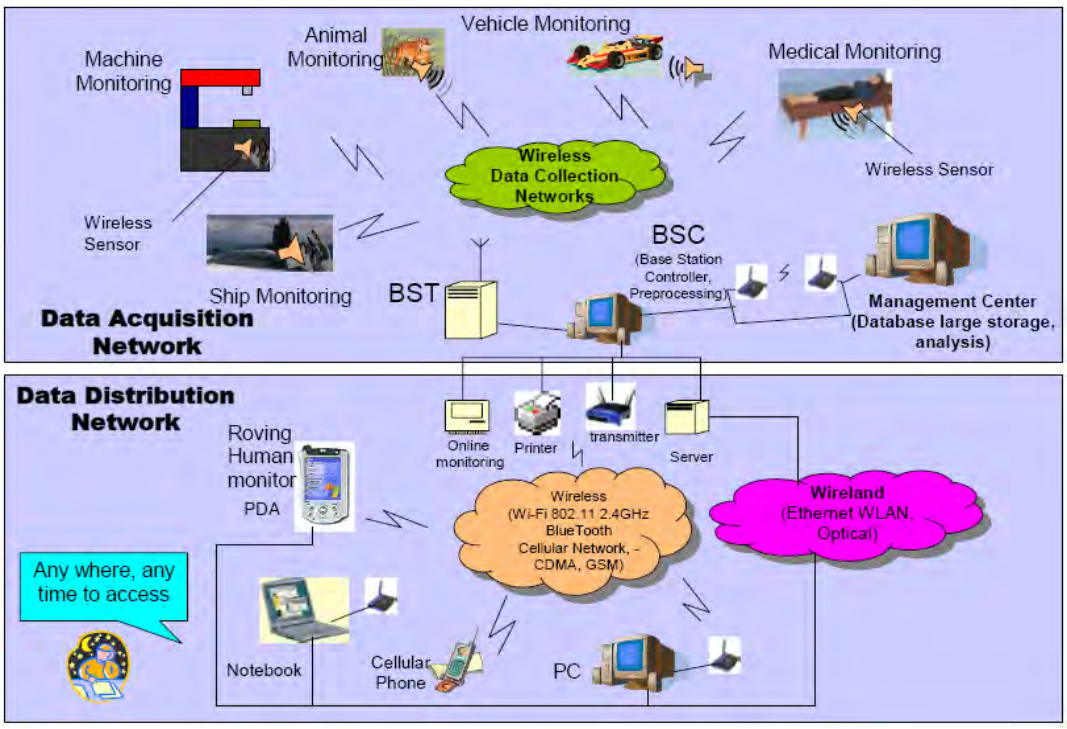
Lastly, in Chapter 6, based on the result obtained in previous chapter, the overall measurement and performance of the project is concluded. Last but not the least, possible improvement for future work is also outlined.

© Universiti Teknikal Malaysia Melaka



© Universiti Teknikal Malaysia Melaka





© Universiti Teknikal Malaysia Melaka