INDOOR PERFORMANCE OF WIRELESS SENSOR NETWORK

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For my beloved wife, Nor Afifah Binti Mohamad@Abdullah,

My beautiful daughter, Nur Hana Maisara Bin Hasri

&

My mother and father

For your infinite love, encouragement and best wishes

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ABSTRACT

Wireless sensor networks have the potential to become significant subsystems of engineering applications where every each node functions as transmitter, receiver, router and data sink. It is necessary to understand the dynamic behaviour of these systems in simulation environments. It is critical to develop simulation platforms that are useful which can be used to explore both networking and wireless sensor networks issues. A discrete-event simulation is a trusted platform for modeling and simulating a variety of systems. This project emphasize on using new simulator for wireless sensor networks that is based on the discrete event simulation framework called Objective Modular Network Test bed in C++ version 4.1 (OMNeT++4.1) Simulator. This simulator is used to test the performance of sensor nodes within the networking in wireless communication networks based on indoor scenario. The test performances are focussed on aspects such as the time delay and packet utilization of the particular approach. The analysis approach is done through simulation software by the following metrics: packet frames delivery, packet loss and time delay experience within the system.

ABSTRAK

Rangkaian pengesan tanpa wayar mempunyai potensi untuk menjadi subsistem penting dalam aplikasi kejuruteraan di mana setiap nod boleh berfungsi sebagai pemancar, penerima, router dan sink data. Ia adalah perlu untuk memahami tingkah laku dinamik sistem-sistem ini dalam persekitaran suatu simulasi. Ia adalah sangat penting dalam membangunkan sebuah platform simulasi yang berguna untuk digunakan dalam meneroka isu-isu rangkaian dan rangkaian pengesan tanpa wayar. Penyelakuan diskret-acara adalah satu platform yang dipercayai untuk pemodelan dan simulasi pelbagai sistem. Projek ini menekankan penggunaan simulator baru ini bagi suatu rangkaian pengesan tanpa wayar berdasarkan rangka kerja simulasi peristiwa diskret yang dipanggil Simulator Ujian Objektif Rangkaian Modular Katil dalam C + + versi 4.1 (OMNeT + 4,1). Simulator ini digunakan untuk menguji prestasi nod pengesan dalam sesuatu rangkaian komunikasi tanpa wayar berdasarkan senario yang tertutup. Penilaian prestasi ujian tertumpu kepada aspek-aspek seperti penangguhan masa dan penghantaran paket berdasarkan pendekatan tertentu. Pendekatan analisis dilakukan melalui perisian simulasi melalui metrik berikut: penghantaran rangka paket, kehilangan paket dan penangguhan masa berlandaskan dalam sistem.

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LIST OF SYMBOLS AND ABBREVIATIONS

WSN	-	Wireless Sensor Network
IEEE	-	Institute of Electrical and Electronic Engineers
OMNeT++	-	Objective Modular Network Test-bed in C++
RSSI	-	Received Signal Strength Indication
CPU	-	Central Processing Unit
OPNET	-	Optimized Network Engineering Tools
TCP/IP	-	Transmission Control Protocol/Internet Protocol
GUI	-	Graphical User Interface
NED	-	Network Description
MiXiM	-	Mix Simulator
MANET	-	Mobile Ad Hoc Network
PAN	-	Personal Area Network
WPAN	-	Wireless Personal Area Network
LR – WPAN	-	Low Rate Wireless Personal Area Network
ZDO	-	Zigbee Device Object
CAP	-	Contention Access Period
CFP	-	Contention Free Period
CSMA – CA	-	Carrier Sense Multiple Access – Collision Avoidance
MAC	-	Medium Access Control
FFD	-	Full Function Device
RFD	-	Reeduce Function Ddevice
LOS	-	Line Of Sight
OSI	-	Open System Interconnection
PL	-	Path Loss
α	-	Path Loss Exponent
P_{RX}	-	Received Power
d	-	Length or Distance Path
h	-	Antenna Height

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CHAPTER 1

INTRODUCTION

1.1 Background and History

The Wireless Sensor Network (WSN) is built of "nodes" where from a few to several hundreds or even thousands, where each node is connected to one or several sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

In general, wireless sensor networks have made a lot of progress recently and have been widely discussed in many applications. According to J.Kenyeres et al (2010) it is expected that this technology will play an important role in improving the quality of the living environment through the creation of so called sensing environments. However, there is a gap in knowledge about WSN to help at least not to broaden this gap, but it is important that some scientific and educational research should be done in this area and that young generation should gain opportunity to study this technology.

A wireless sensor network consists of spatially distributed autonomus sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. The development of wireless sensor networks was motivated by the military applications such as battlefield surveillance. Nowadays, it is also used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation, and traffic control.

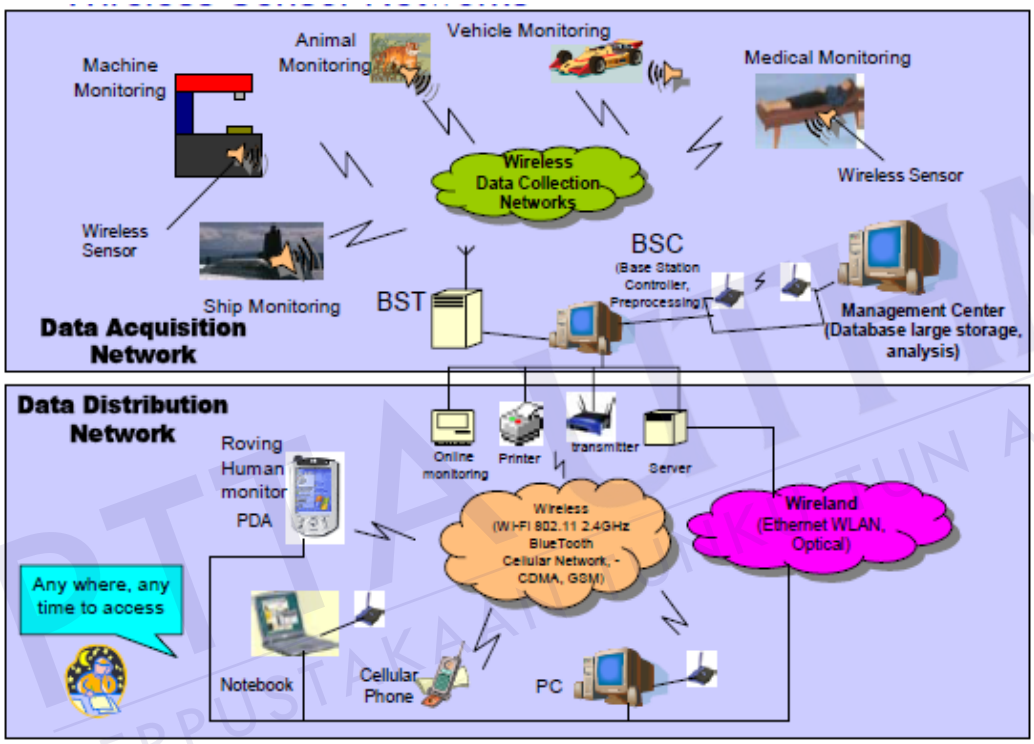

Figure 1.1 : A Wireless Sensor Network. (F.L.Lewis, 2004)

Feng Chen et al (2010) indicate that in wireless sensor network deployment techniques experiment, the important parameters such as connectivity of nodes, cost effective, energy efficiency and lifetime. Experimentation might be too expensive for such setups or infeasible due to physical limitations. Thus, in most cases performance evaluation is based on simulation models. For this study, the simulation experiment on the coexistence between wireless technologies based on IEEE 802.15.4 and IEEE 802.11b standards can be considered using OMNeT++ software. OMNeT++ software is suitable to implement simulation experiment and to evaluate the performance of the WSN network within indoor environment.

1.2 Problem Statement

In the last decade, significant advances have been achieved in the domain of Wireless Sensor Networks (WSN). In the recent years, Wireless Sensor Networks probably plays a crucial role in creation of ubiquitous intelligent sensing environment. According to J.Kenyeres et al (2010), WSN are suitable for great variety of environments and conditions, what broadens the scale of their applications. Furthermore, simulation is frequently used to evaluate the performance of networking algorithms and techniques in wireless communication networks. Feng Chen et al (2010) indicate that however, performance aspects such as the transmission delay, the channel utilization, or the throughput provide only limited information about the feasibility of the particular approach. Some of the most challenging issues that have been studied are the medium access, routing strategies, clustering schemes, and application layer dynamics. All these approaches contribute to enable designers to develop and to deploy applications under various environmental conditions.

The idea is to provide a broad range of design variants that can be chosen and combined in order to provide the optimal behaviour of the wireless sensor network. In certain cases, monitoring and automatic control of building environment is a crucial application of WSN in which maximizing network lifetime. It shows that transitional region is particular concern its accommodates high variance unreliable links due to the inside building environment could be the obstacles such as concrete or brick walls, partitions, office furniture and other items as additional absorption term to the path loss according to C. Mallanda (2005). Most of the approaches are targeted to improve the performance of the wireless communication with respect to the quality of service. Therefore, all the individual algorithms and techniques have been analyzed with regard to their performance, example, the speed of adaptation to environmental changes and the end-to-end nodes performance. Furthermore, most of the aim in wireless communication networks and especially for sensor networks is to reduce the energy consumption.

1.3 Objectives of Project

The main objectives of this project are:

i. To design a simulation process for wireless sensor network in an indoor scenario using OMNeT++ 4.1
ii. To test the performance of packet delivery among the nodes within indoor scenario using OMNeT++4.1

1.4 Scope of Project

The scopes of this project is to evaluate wireless sensor network routing through research and simulation process. An open source software called OMNeT++ version 4.1 will be used in this project to run simulation process according to certain parameters that acquired according to indoor scenario. The parameters such as numbers on nodes, transmitting power used by the nodes and distances between nodes. Throughout the simulation process, the performances of packet delivery among the nodes within the network will be analyzed based on the results.

1.5 Thesis Layout

The thesis layout is organized as follows:

Chapter 1: This chapter explain on the introduction to wireless sensor network (WSN). It is also consists of background, problem statement, objectives of project and scope of project.

Chapter 2: In this chapter, it discussed on literature reviews of other research or previous studies which conclude theoritical and results. It is also to clarified, justified and compared between results based on related research.

Chapter 3: In order to achieve the goal of this project, this chapter will expalin on the methodology of the project. It showed the steps or protocols used in completion of this project. The simulation process and parameters are also explained and discussed in this chapter.

Chapter 4: The results of this studies are presented and compared within this chapter. Analysis and simulation output and comparison between results such as graphs are explained in this chapter.

Chapter 5: Lastly, this chapter will summarizes all the results and concluded the conclusions of the project studies including the recommendation for future works.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The objective of this chapter is to survey on previous studies that had been carried out among other researchers in order to gain more information related to the project. It is critically important to review the existing research on wireless sensor network routing protocols within indoor scenario. By critically reviewing the following previous thesis, journals, articles and reports, substantially it provides great significance knowledge and information to this project.

2.2 Related Works

In this section, related works on the routing protocol for WSN that improve the energy consumption are studied and critically analyzed.

J. Kenyeres et al. (2010) focused on the monitoring of functionality and reliability as well as on the influence on varying parameters of wireless sensor network placed in the indoor environment. The experiment clearly revealed the relationship between data rate and reponsibility of the whole WSN network. In reducing error rate and increase number of packets for static WSN can be achieved by reducing topology, decrease the distance between nodes and increase packet sending interval.

Malka N. Halgamuge et al. (2009) investigate the link quality distribution to obtain full coverage of the signal strength within a single floor of a building environment. The results comfirmed where the transitional region in wireless sensor network since it accomodates high variance unreliable links. The reason is due to this transitional region

inside a building environment could be the obstacles including concrete walls, partitions, furnitures and other items affect as additional absorption term to path loss.

Yunchun Zhang et al. (2009) presented the existing localization algorithm in Wireless Sensor Network (WSN) which can be divided into two categories: range based and range free. Most of the range based localization algorithms proposed made use of the Received Signal Strength Indication (RSSI) to make an estimation of the distance between transmitter and receiver. Throughout the experiment it shows there is no relationship between RSSI and distance in indoor situations. Only the outdoor shows that RSSI is closely related with distance, direction of antenna, the height of nodes above the ground and obstructions.

D. J. Dechene examined currently proposed clustering algorithms for Wireless Sensor Networks (WSN) which discussed the operations of the algorithms, as well as comparisons on the performance between the various schemes. Optimal clustering in terms of energy efficiency should eliminate all overhead associated not only with the cluster-head selection process, but also with node association to their respective cluster-heads. Sensor network reliability is currently addressed in various algorithms by utilizing re-clustering that occurs at various time intervals; however inefficient energy and limits the time available within a network for data transmission and sensing tasks. Further improvements in reliability should examine possible modifications to the re-clustering mechanisms following the initial cluster-head selection. Other mechanisms such as the ability of nodes to maintain membership in auxiliary clusters can reinforce the current state of sensor network reliability.

Feng Chen et al. (2010) introduced a generic energy model developed for the simulation framework OMNeT++. The sensor was designed based on the IEEE802.14.5 architecture by using a simple CPU model to estimate the energy consumption for computationally intensive operations. The aspect discuss in this paper is more on the sensor design and not taking into account the routing algorithm. The model allows to accurately evaluate the energy performance in terms of energy consumption or network lifetime of the wireless sensor network.

2.3 Wireless Sensor Network

Wireless Sensor Networks (WSN) comprises of numerous tiny sensors that are deployed in spatially distributed terrain. These sensors are endowed with small amount of computing and communication capability and can be deployed in ways that wired sensor systems couldn't be deployed. Yunchun Zhang et al. (2009) indicates that despite the prolific conceptualization of sensor networks as being useful for large-scale military applications which originally motivated by military applications such as battlefield surveillance, is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations.

Wireless sensor networks have the potential to become significant subsystems of engineering applications. Before relegating important and safety-critical tasks to such subsystems, it is necessary to understand the dynamic behavior of these subsystems in simulation environments. C Mallanda et al. (2005) urge that it is an urgent need to develop simulation platforms that are useful to explore both the networking issues and the distributed computing aspects of wireless sensor networks.

According to J. Kenyeres et al. (2010) of the experiments aim was to estimate how parameters such as number of packet errors and retransmissions deteriorate real WSN functionality. The experiment with WSN was realized in indoor area, which resulted in a variety of different conditions influencing functionality of sensor nodes. This area offers lot of different spaces ranging from long, open sight hallways, stairways, lifts and many others. This surrounding environment at the main hallway consists of many different materials, like concrete, steel, glass and so on, what causes heterogeneous influences on WSN.

WSN signal in this area might be interfaced with signals from other sources, for example from 802.11b communication. Main goal of this experiment was to create WSN network covering almost whole area of hallway and also to test its functionality with various parameters set up. Discrete-event simulation is a trusted platform for modeling and simulating a variety of systems. Results can be obtained from a new simulator for wireless sensor networks networks that is based on the discrete event simulation framework called OMNeT++.

Work is underway to develop a simulation platform that allows developers and researchers to investigate topological, phenomenological, networking, robustness and

scaling issues related to wireless sensor networks. Such simulation studies must explore the effects of scale, density, node-level architecture, energy efficiency, communication architecture, failure modes at node and communication media levels, system architecture, algorithms, protocols and configuration among other issues. C Mallanda et al. (2005) told that unlike traditional computer systems, it is not sufficient to simulate the behavior of the sensor network in isolation because of the tight and ubiquitous coupling between the sensor network and its application.

2.4 Objective Modular Network Test-bed in C++ (OMNeT++)

Thru simulation, there are many types of current available simulators such as ns2, SensorSim, OPNET, J-Sim, GlomoSim and etc. all these simulators have certain function that provides support or platform for simulating TCP/IP, routing protocols, energy models, sensor channels and etc. In this project, the selected simulator used is Objective Modular Network Test-bed in C++ (OMNeT++).

2.4.1 Background And History

OMNeT++ started with a programming assignment at the Technical University of Budapest (Hungary), to which two students applied. One of them, András Varga, still is the maintainer of this open source simulation package. During the years several people contributed to OMNeT++, among which several students from the Technical University of Delft (The Netherlands) and Budapest. Milestones in the development are the first public release in 1997 and the added animation functionality in 1998, which made the package even more usable for education.

In 2000 several people at the University of Karlsruhe created the TCP model for OMNeT++. This version included several bug fixes and important changes and additions to the manual. The website also had a major update. A beta version of version 3.0 is now also available. All simulations in this report were done using OMNeT++ version 4.1. It is also offers an Eclipse-based IDE, a graphical runtime environment, and a host of other tools. There are extensions for real-time simulation, network emulation, alternative programming languages (Java, C#), database integration, SystemC integration, and several other functions. The latest extension version is OMNeT++4.2.

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