

**INDOOR AIR QUALITY REAL-TIME
MONITORING BASED ON IEEE 802.15.4 WSN IN
UPNM MEDICAL CENTER**

KHAIRUNNISA BT AHAMAD@AHMAD

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BASED ON IEEE 802.15.4 WSN IN UPNM MEDICAL CENTER**

KHAIRUNNISA BT AHAMAD@AHMAD

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ABSTRACT

Medical centers have very high potential to centralize patients with diseases related to the sick building syndrome health problem. This study is conducted at the Universiti Pertahanan Nasional Malaysia Medical Centre using the Wireless Sensor Network which is able to collect and disseminate the environmental data using a low cost, less complex and reliable system. The IEEE 802.15.4 standard with a 2.4GHz band was used as the wireless standard for measurement. The sensors were attached to several points at the wall of the waiting area and were controlled by the personal computer module. Lab VIEW was used to manage the data acquisition due to its ability to program a real-time system. The number of admission patients will be compared to the level of carbon dioxide, temperature and relative humidity in the medical center. Manual measurement using a handheld particle counter was used to determine the level of 2.5 μm and 0.3 μm particles in the medical center. The outdoor air index was collected from Department of Environmental Malaysia and compared to the indoor air quality and the occupant comfort access by conducting using a random survey. The collected data of the indoor air quality parameters and questionnaire survey determined the current indoor air quality in the medical center. Recommendations that have been made can be apply to improve the indoor air quality in the medical center.

ABSTRAK

Pusat kesihatan mempunyai potensi yang tinggi sebagai tempat pesakit yang menghadapi penyakit berkaitan bangunan berkumpul dan seterusnya mengalami masalah kesihatan. Kajian ini dilaksanakan di Pusat Kesihatan Universiti Pertahanan Nasional Malaysia dengan menggunakan penderia tanpa wayar yang mampu mengumpulkan data persekitaran. Alat ini lebih murah, kurang kompleks dan mempunyai tahap kebergantungan yang tinggi. Standard yang digunakan adalah IEEE802.15.4 dengan keupayaan jalur frekuensi sebanyak 2.4GHz. Penderia telah diletakkan di beberapa bahagian syiling tempat menunggu dan dikawal oleh komputer peribadi. Lab VIEW akan menguruskan data yang diterima kerana ia merupakan sistem yang real-time. Rekod kemasukan pesakit yang berada di pusat kesihatan ini dibandingkan dengan paras karbon dioksida, suhu dan kelembapan relatif. Manakala, paras zarah bersaiz $2.5\mu\text{m}$ dan $0.3\mu\text{m}$ diukur menggunakan hand-held particle counter. Indeks udara di persekitaran luar diambil daripada Jabatan Alam Sekitar Malaysia. Sementara itu, keselesaan penghuni dinilai melalui survey yang dijalankan ke atas pesakit dan staf di dalam pusat kesihatan ini secara rawak. Cadangan penambahbaikan boleh dilakukan untuk memperbaiki kualiti udara terhadap pusat kesihatan tersebut.

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Every Challenging works needs self-efforts as well as guidance of elders

especially those who were very closed to our heart.

My humble effort I dedicated to my sweet and loving

Husband,

Muhamad Hazim bin Abdullah

Father & Mother,

Ahamad @ Ahmad bin Alias & Maimun bt Mohamad

Whose affection, love, encouragement and prays of day and night

make me able to get the success and honor,

Along with all hardworking, loving, understanding, and respected

Supervisor,

Mdm. Chew Sue Ping

Thank you very much for guidance, wisdom and support.

APPROVAL

I certify that an Examination Committee has met on 6th October 2016 to conduct the final examination of Khairunnisa bt Ahamad@Ahmad on her degree thesis entitled 'Indoor Air Quality Real-Time Monitoring Based on IEEE 802.15.4 WSN in UPNM Medical Center'. The committee recommends that the student be awarded the Master of Science (Electrical and Electronic Engineering)

Members of the Examination Committee were as follows.

Nik Ghazali Bin Nik Daud, PhD

Associate Professor Ir
Faculty of Engineering
Universiti Pertahanan Nasional Malaysia
(Chairman)

Siti Nooraya Mohd Tawil, PhD

Associate Professor
Faculty of Engineering
Universiti Pertahanan Nasional Malaysia
(Internal Examiner)

Nurul Adilah Abdul Latiff, PhD

Faculty Engineering
Universiti Putra Malaysia
(External Examiner)

APPROVAL

This thesis was submitted to the Senate of Universiti Pertahanan Nasional Malaysia and has been accepted as fulfillment of the requirements for the degree of **Master of Science (Electrical and Electronic Engineering)**. The members of the Supervisory Committee were as follows.

Chew Sue Ping

Faculty of Engineering

Universiti Pertahanan Nasional Malaysia

(Main Supervisor)

UNIVERSITI PERTAHANAN NASIONAL MALAYSIA

DECLARATION OF THESIS

Author's full name :KHAIRUNNISA BT AHAMAD@AHMAD
Date of birth :3RD OCTOBER 1989
Title :INDOOR AIR QUALITY REAL-TIME MONITORING
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LIST OF ABBREVIATIONS

SBS	Sick Building Syndrome
WSN	Wireless Sensor Network
CO ₂	Carbon Dioxide
DOE	Department of Environmental
IAQ	Indoor Air Quality
PC	Personal Computer
BRI	Building-related Illness
ASHRAE	American Society of Health, Refrigerating and Air Conditioning Engineers
RH	Relative Humidity
AH	Absolute Humidity
PM _{2.5}	Particulate Matter 2.5
PPM	Part Per Million
CO	Carbon monoxide
HVAC	Heating Ventilation and Air-Conditioning
NI	National Instruments
UPNM	Universiti Pertahanan Nasional Malaysia
IVT	Influenza Virus Transmssion
OSHA	Occupational Safety and Health Association
WHO	World Health Organization
US EPA	United State Environmental Protection Agency
TSP	Total Suspended Particles

OR	Operation Room
VOC	Volatile Organic Compound
OSI	Open Systems Interconnection
TCP	Transmission Control Protocol
IP	Internet protocol
MAC	Medium Access Control
API	Air Pollution Index
PAN	Personal Area Network
NI	National Instruments
IAP	Indoor Air Pollution

CHAPTER 1

INTRODUCTION

1.0 Introduction

The indoor air quality in building occupancy has become a very strong concern because it is related to the occupant's health. Apart from the occupants themselves, the engineers and maintenance manager are constantly looking for ways to improve the IAQ. The evaluation process was used to diagnose and monitor the building system and components for IAQ deficiencies. Air supply intake in the building is mainly resourced from the contaminated outdoor air while the limited exchange of outdoor and indoor air can build contaminations that can cause harm to human beings and other living things in the building. Indoor air quality can be defined as the air quality within and around buildings and structures. It is closely related to the health and comfort of the buildings occupants.

Previous research and investigations on air quality particularly indoor air have taken place in different location such as shopping complexes[1], office buildings [2, 3] and classrooms [4, 5]. This research was carried out at the medical center as it has very high potential to centralize the patient with disease related to health problems such as asthma, respiratory and cardiovascular related diseases.

The aim of this study is to recommend effective guidelines for the control and management of the medical center's IAQ. The airborne pollutants that exist in this premise may affect health in various degrees of severity ranging from SBS to BRI [1, 6]. The ventilation requirement for all areas in the medical center used the standard set by ASHRAE which was used to compare the collected data and the IAQ in the targeted area.

An air monitoring system was used to manage air pollution, protect human health, social sensitivity and to measure the air pollutants concentrations for the study area. The purpose and use of the monitoring system can be divided into six areas which includes; the geographical distribution of pollution, determination of air pollution trends, origin of the pollution, the effect of the pollution and compliance with air quality standards and the assessments of control. The units of these systems involve monitoring stations, sensors, data collection, data transmission and control and the regional center. The monitoring stations contained the equipment for sampling, measuring, and data collection of the viruses in the air.

As for sensors, there were some considerations to choose from which are the ranges to cover, required averaging times, operations and maintenance of the systems and the available facilities. WSN will be used to monitor the indoor air quality. Advantages of using WSN were that it is small and low cost. Furthermore, it is able to collect and disseminate environmental data [7]. A proper wireless sensor network WSN topology must be determined to reduce its cost and complexity while at the same time improve its reliability. There are four types of topology namely peer to peer, star, tree and mesh.

Peer to peer allows the node to communicate directly with another node. This type of topology had limited ability to collect data since it covered only small areas. As for star, the server is connected to a centralized communications hub. Tree topology works as the main communications router which will allow the node to communicate from one main router. Meanwhile, mesh WSN is the most common type of sensors used since it allows data to transmit from one another and can be self-healing. This type of network is quite complex and can cost a significant amount of money to deploy properly. A proper star topology was selected by using 2 nodes as suggested based on the LabVIEW WSN design.

1.1 Objectives

- 1) To investigate the reliability of WSN IAQ monitoring system based on appropriate topology placement of nodes and time interval for measurement to be taken.
- 2) To evaluate IAQ pollutants in UPNM Medical Center included concentrations of CO₂ temperature, RH and PM_{2.5}.
- 3) To conduct the thermal comfort survey on occupants in the medical center with considerations of environmental parameters and demographic values.

1.2 Problem Statements

The existence of indoor air quality standard is not new, and has existed over 150 years. A popular German scientist, Peter Koffer is the one who develop the IAQ standard during his research on lighting at that time. He found that the health effect of the CO and recommended an exposure standard of 50 ppm in 1849. Following his work, the interest in IAQ still gets interest by continuing research over the years. Due to this development, the application of IAQ monitoring in widen from various area. A good building should have proper ventilation and air quality so that the occupants are comfortable and any SBS or BRI is not existed. Human nowadays spent more time in building either office, school, shopping complex or even their own house. The main problem in this study is to determine the IAQ in medical center. As everyone may concern, medical

center is the centralized public area for patient to get treatment. The existing disease by the patient can become harmful to others near to them, especially in the closed area. Other than that, indoor air pollution can also come from the sources from outside the building which produced by industrial pollutants, vehicle exhaust and pollen. Apart from that, the contaminated air may come from the building design and equipment itself such as its furniture, wall, carpets, curtain and the HVAC system. Although the chemical compound used in medical center is safe, but it also can affect the occupants in the pharmacy and nearest area.

Thus, an effective IAQ monitoring system is required for a reliable ambient air pollution measurement. 4 indoor air parameters have been chosen for analysis; carbon dioxide, temperature, relative humidity and particulate matter ($PM_{2.5}$). The complexity of WSN also becomes a challenge in designing its topology. Therefore, a proper WSN IAQ measurement is installed based in LabVIEW WSN design recommended by NI. The other problem is that in air monitoring, it can cause high cost. The simplest WSN equipment and devices is chosen to get the best cost, yet effective and reliable for air quality monitoring.

1.3 Research scope

The completion of this research is mainly focusing on stated research scopes:

- 1) Reviews and study the development on the previous technology and research on the air quality monitoring system, focusing on WSN IAQ monitoring.
- 2) Study the WSN including its data transmission and the network reliability in real-time communication as the system in the air quality monitoring is implemented in this study.
- 3) To install a reliable WSN system to collect data of the indoor air pollution and record, analyzed and as well as interpret the data and results as the study outcomes in IAQ monitoring.
- 4) To conduct the survey (questionnaire) among the visitors and patients to determine the occupants comfort in the medical center and the data of IAQ is compared and discussed based on the comparison of the measured data and thermal survey.
- 5) The research has been done in UPNM Medical Center.