CHARACTERIZATION OF PROPAGATION IN WIRELESS SENSOR NETWORK (WSN) FOR AQUACULTURE APPLICATION

KHADIJAH BINTI HASBULLAH

UNIVERSITI SAINS MALAYSIA
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by

KHADIJAH BINTI HASBULLAH

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LIST OF ABBREVIATIONS

FAO	Fishery and Agriculture Organization
LNSM	Log Normal Shadowing Model
PC	Personal Computer
PCB	Printed Circuit Board
RSSI	Received Signal Strength inidication
USB	Universal Series Bus
VCC	Variable Corneal Compensator
WPAN	Wireless Personal Area Network
WSN	Wireless Sensor Network
LOS	Line of Sight
NLOS	Non Line of Sight

LIST OF SYMBOL

List	**Symbol**
Degree	°
Hertz	Hz
Ohm	Ω
Lambda	λ

PENCIRIAN PERAMBATAN DALAM RANGKAIAN PENDERIA TANPA WAYAR (WSN) UNTUK APLIKASI AKUAKULTUR

ABSTRAK

Projek ini mencadangkan satu ciri perambatan dalam WSN untuk aplikasi akuakultur. Ia menekankan kepada anggaran jarak optimum dalam pembangunan rangkaian yang kukuh untuk penghantaran data dalam WSN. Penyelidikan peringkat pertama bertujuan untuk memilih jenis antena dan sudut penghantaran optimum, dan juga untuk menentukan jarak penghantaran optimum antara penyelaras dan nod sensor bagi rangkaian yang dicadangkan. Jenis antena dan sudut penghantaran terbaik dicapai melalui penyiasatan ke atas kesan orientasi antena terhadap kekuatan isyarat. Corak perambatan yang diplot daripada data menunjukkan bahawa antena cip adalah antena berarah yang lebih baik dan paling sesuai digunakan untuk nod sensor, dengan sudut penghantaran terbaik pada 90°. Antena dwikutub yang mempunyai bacaan RSSI yang baik pada semua sudut pula adalah sesuai untuk digunakan bagi penyelaras. Kajian ke atas jarak penghantaran pula membolehkan anggaran jarak optimum antara penyelaras dan nod sensor diperoleh. Anggaran jarak dikira menggunakan persamaan log-jarak yang dijana daripada graf RSSI melawan log jarak, yang diplot daripada data eksperimen. Peratus ralat untuk jarak anggaran berbanding dengan jarak yang diukur adalah 6.2%, 18.8% dan 22% untuk kawasan yang padat tumbuh-tumbuhan, kawasan pokok-pokok kecil dan semak, dan kawasan bangunan. Kajian lapangan untuk menguji topologi rangkaian yang dibina berdasarkan dapatan penyelidikan peringkat pertama menunjukkan hasil yang positif, yang membuktikan bahawa orientasi optimum antena yang diguna pakai, dan juga

penggunaan persamaan log-jarak yang ditemui dalam kajian ini dalam menganggarkan jarak optimum adalah sesuai.

CHARACTERIZATION OF PROPAGATION IN WIRELESS SENSOR NETWORK (WSN) FOR AQUACULTURE APPLICATION

ABSTRACT

This project proposed propagation characteristics in WSN for aquaculture application. It emphasized on optimum distance estimation in the development of a strong network for delivering data in WSN. Stage 1 of the research was aimed to select the type of antenna and its optimum transmission angle, and also to determine the optimum transmission distance between coordinator and sensor node for the proposed topology. The type of antenna and its best transmission angle were achieved by investigating the effect of antennas orientation on signal strength. The radiation patterns plotted from the data showed that chip antenna was a better directional antenna and most suitable for sensor node application with best transmission angle of 90°. Dipole antenna that had good RSSI reading at all angle was suitable to be used for coordinator. The study on transmission distance enabled the estimation of optimum distance between coordinator and sensor node be made. Distance estimation was calculated using the log of distance equation generated from the RSSI versus log of distance graph plotted from the experiment data. The percentage error for the estimated distance when compared with the measured distance were 6.2%, 18.8% and 22% for dense vegetation area, small trees and bushes area and building area respectively. The result of the field study to test the network topology constructed based on the result of research stage 1 showed positive result, proving that the optimum antenna orientation used and the application of the

discovered log-distance equation in estimating the optimum distance were appropriate.

CHAPTER 1

INTRODUCTION

1.1 Overview

Aquaculture is the fastest growing food producing sector in the world (Zhu et al., 2010). The aquaculture sector in Malaysia has become a priority area in the government's recent policy program for year 1998-2010 (FAO, 2010). There are various types of freshwater fish, hundreds of species number found in Malaysia. Some are bred for food and some are bred as ornamental fish. Based on the statistic provided by the Kemajuan Perikanan Malaysia on Aquaculture Production, in 2012 the production from the national aquaculture sector was 634,376.38 tonnes contributed mainly by the production from freshwater fish culture, 163,746.80 tonnes and brackish water ponds produce 470,619.57 tonnes (DoF, 2012). Ornamental fish industry produced approximately 377 million pieces of fish valued of more than RM12 million. As the market for this industry is highly potential, Malaysia targets to export 900 million ornamental fish by the year of 2020 (Bernama, 2014).

There are numerous specific types of fish farming namely freshwater ponds and cages, cement tanks, canvas tanks, tailings and pen culture. In 2012, more than 70 percent of the freshwater aquaculture production were contributed mainly by the Freshwater Catfish (46,522.98 tonnes), Red Tilapia (38,841.60 tonnes), River Catfish (18,388.83 tonnes) and Big Head Carp (11,040.66 tonnes). The pie chart in Figure 1.1 shows the statistic of the number and area of freshwater ponds and cages, former mining pools, cement tanks, canvas tanks, pen culture and the number of culturists provided by the Jabatan Perikanan Malaysia in 2012.

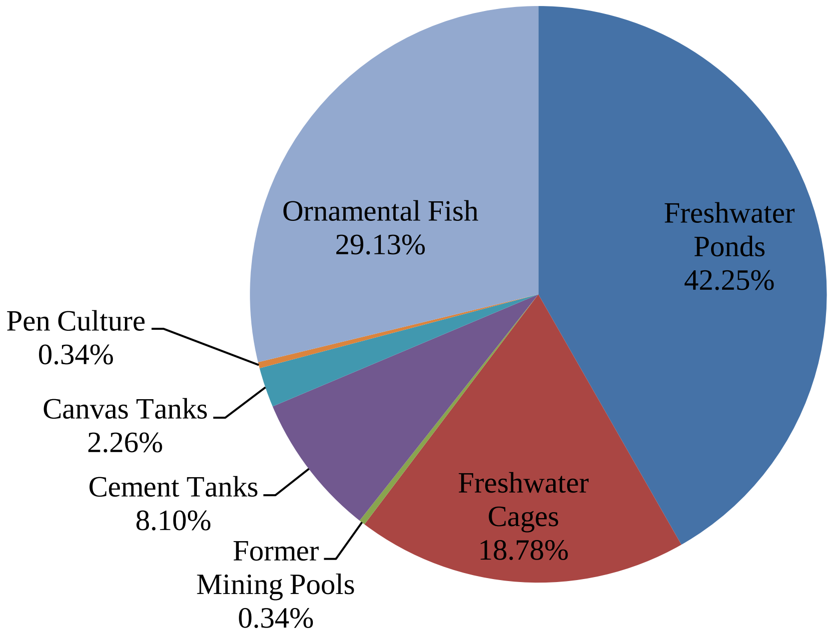

Figure 0.1: Freshwater fish cultures activities Malaysia (Kemajuan Perikanan Malaysia, 2012)

From the statistic, most of the aqua culturists in Malaysia prefer freshwater ponds and on average, every culturist has two to three ponds. It was reported that a total of 5,462 hectares for 48,402 ponds were in operation with pond size of 0.1129 hectares. Besides freshwater ponds, cage culture system has also grown rapidly lately due to the shortage of essential supplies and livestock area for outdoor growing. The cages of 18.78 m^2 in size are placed in rivers, canals and other sources of freshwater. Another popular aquaculture medium is cement tank. On average, seven to eight cement tanks are used by culturist to breed freshwater fish.

Fish is very sensitive to some environmental parameters and the lack of appropriate water quality monitoring can be a disaster in just a short time (Harris et al., 1991). In Malaysia, cases of farmers experiencing loss due environmental parameter have been widely reported. Utusan Malaysia in 2011 reported that thousands of freshwater fish from pond culture in Tambun, Perak died due to water pollution (Utusan Malaysia, 2011). Harian Metro in 2014 also reported that farmers had to bear a loss of more than RM30, 000 after nearly 7,000 cultivated Tilapia fish dead from one of his pond which was also caused by water pollution. The incident was only realized on the next morning. Another case was in July 2014 where Sinar Harian reported that three farmers experiencing loss after all 12,000 farmed Barramundi fish died probably due to water temperature being too low.

The fishes need a balance ecosystem to stay alive in their habitat. Factors outside their natural environment or behavioural needs will subject them to stress resulting in negative effects on fish growth and survival. These stress factors affect their health, reduce their life span and increase their vulnerability to be affected by disease. Proper monitoring on water quality is therefore essential to achieve balance ecosystem for fish safety hence ensuring higher productivity.

Most of the current technique in water quality monitoring system is portable. Culturists have to go to every pond to collect data manually. Inefficiencies in manual data collection could result in polluted water not detected earlier. Heavily polluted water could cause the fish to die in just few hours and will result in great loss to farmers. Continuous water monitoring is the best solution to this problem. Besides improving the efficiency of the process, this system can save money and time for the farmers.

There are two types of continuous water monitoring system being used in Malaysia. Nowadays, the system was done over wired-network where the implementation cost is high and could be difficult in certain type of environment. Wireless system (Wireless Sensor Network, WSN) on the other hand is low in installation and maintenance cost. Another advantage of WSN is its capability to perform dynamic network from a number of nodes sensing and sending the water condition or concentration to a single reader or called coordinator. WSN is useful for a big-area of fish culture where in such case; the routers are used to extend the transmission from the ponds to the database station. The culturists can view the condition of water real time from all ponds continuously.

1.2 Problem Statement

The benefits of WSN in water quality monitoring system for aquaculture application can only be obtained if a proper network topology of WSN is applied. Without a proper topology, lost of data may happen particularly when the sensor nodes are placed too far from the base station. On the other hand, if the sensors, coordinator and router are placed too close, the capability of WSN is not fully utilized and the implementation cost will increase.

Different aquaculture type may have different type of environment. For example; outdoor fish pond might be surrounded by dense vegetation, cages by small and large trees and in between building environment for tanks aquaculture. The study on the effect of different environment is necessary because the quality of the wireless signal is highly dependent on the environment characteristic. The propagation environment may be influenced by the present of obstacles that will obstruct the propagation path such as trees, rocks, mountain and also walls. As a result, the signal power may decay and the communication range is limited.

Therefore, a detail knowledge of wireless propagation within a specific aquaculture environment is required in order to achieve a good connectivity (Harun et al., 2012). The knowledge of the optimum range between nodes is important in order to deploy the optimum number of device and hence reducing the costs. Specifically the optimum Euclidean distance between sensors and database station in