DESIGN AND IMPLEMENTATION OF PRECISION AGRICULTURE USING LORAWAN IOT

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

Special thanks to my beloved family members, Ong See Lim, Nyen Chui Mei, Ong Tze Tung and Ong Kai Yin.

ABSTRACT

Agriculture is an important sector in Malaysia because it contributes to the economic development of the country. Hence, the technology related to agriculture is growing rapidly in line with the market demand. This includes the technology related to Internet of Things (IoT) in agriculture industries which requires access to the internet. However, most farms and ranches are in rural areas that do not have access to cellular network or GSM coverage. To solve this problem, an alternative network infrastructure is required to allow IoT application to be implemented for precision farming. LoRaWAN IoT solution offers low power consumption device to communicate over up to 10km range from its gateway. Therefore, this project aims to utilize the advantage of LoRaWAN capability to enable large scale precision farming by monitoring the important parameters for optimized output. The project will monitor the soil pH, surrounding temperature, humidity of crop and the moisture level of the soil and enable farmer to monitor the real time data collected by the sensors that scattered across the farm using ThingSpeak IoT Platform. For further validation of the function of the LoRaWAN gateway, the prototype of this project is used to determine the range of connectivity and the signal strength using The Things Network and Cayenne LPP.

ABSTRAK

Pertanian merupakan sector yang penting dalam Malaysia kerana sector ini menyumbang kepada perkembangan ekonomi negara. Oleh yang demikian, teknologi yang berkaitan dengan pertanian turut berkembang dengan pesat seiring dengan permintaan pasaran yang tinggi. Ini termasuklah teknologi berkaitan Internet of Things (IoT) dalam industri pertanian yang memerlukan capaian ke internet. Walau bagaimanapun, kebanyakan ladang berada di kawasan luar bandar yang tidak mempunyai capaian kepada rangkaian selular atau liputan GSM. Untuk menyelesaikan masalah ini, satu infrastruktur rangkaian alternative diperlukan untuk membolehkan aplikasi IoT dilaksanakan untuk tujuan perladangan jitu. LoRaWan IoT menawarkan peranti berkuasa rendah berkomunikasi dengan Get laluan pada jarak sehingga 10 km. Projek ini bertujuan untuk menggunakan kelebihan LoRaWan untuk membolehkan pertanian jitu berskala besar dengan memantau parameter penting untuk mengoptimumkan keluaran. Projek ini disasarkan untuk memantau pH tanah, suhu sekitar, kelembapan tanaman dan kelembapan tanah serta membolehkan petani memantau data yang dikumpul oleh penderia di ladang menggunakan platform ThingSpeak. Seterusnya, prototaip projek ini akan digunakan untuk menguji jarak

rangkaian sambungan dan kekuatan isyaratnya dengan menggunakan The Things Network dan Cayenne LPP.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

LoRaWAN	:	Long Range Wide Area Network
LoRa	:	Long Range
IoT	:	Internet of Things
LPWAN	:	Low Power Wide Area Network
FSK	:	Frequency Shifting Keying
CSS	:	Chirp Spread Spectrum
MAC	:	Media Access Control
WSN	:	Wireless Sensor Network
SF	:	Spreading Factor
DR	:	Data Rate
RSSI	:	Received Signal Strength Indicator
TTN	:	The Things Network
CR	:	Coding Rate
TX	:	Transmit
RX	:	Receive
PDR	:	Packet Delivery Ratio
SNR	:	Signal-to-Noise Ratio

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This project is about the design and implementation of the precision agriculture using LoRaWAN (long range wide area network) and Internet of Things in order to make farming more controllable and this technology is becoming more common in a large scale precision farming. In order to increase the quality and quantity of food produced, we need to practice the technology in the farms and ranches in rural area. This project is mainly implementing precision agriculture using sensors and LoRaWAN. One of the reason to use LoRaWAN is because of the long range connectivity for Internet of Things (IoT) devices in rural area. This long range connectivity of LoRaWAN enables the data collected from sensors scattered across the farm to upload to the LoRa gateway placed around 5km-10km. After uploading to the gateway, the data will then be uploaded to the network server and allow farmers to monitor the real time data collected through an online platform.

1.1 Project Background

As the human population on Earth are increasing, the demand for food is also increasing. Engineers and farmers nowadays are working hand in hand to create a technological solution for precision agriculture (smart farming). Smart farming or precision agriculture is the combination of advanced technology into the existing practices of farming to increase the productivity of the agriculture products. In addition, smart farming can also reduce the heavy labour and difficult tas0k of farmers and workers which may improve their life quality. To optimize the precision agriculture in the rural area or area without internet access, LoRaWAN is used. A LoRaWAN setup contains three main components which is end-node, gateways and the network server. The end-node is a low-powered or battery-powered sensor that collect and upload the data to the gateways. The end-node of the project will be different kinds of sensors. While gateway is used to accept data from the end-node and upload the data to the network server. The third component is the network server which acts as the manager of LoRaWAN as shown in Figure 1.1.

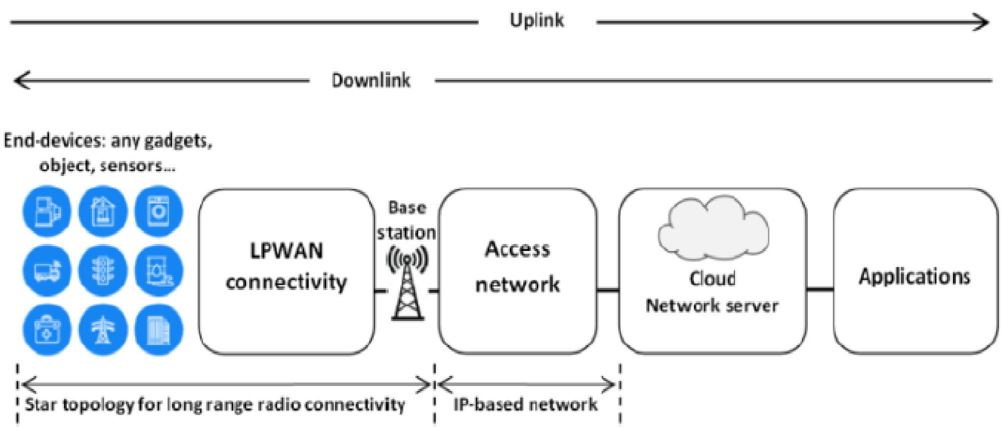

Figure 1.1 : Network Topology for LoRaWAN [1]

The end-node chosen to use is a DHT 11 sensor, a pH sensor and a soil moisture sensor while the network server that enable the farmers to monitor the real time data is ThingSpeak. A wireless connection between the LoRa gateway and the LoRa Shield is built through Arduino IDE. The completed system will be able help farmers to task control on the crops by knowing which part of his farm need more water supply when the data collected from the sensors showed low moisture level. The other part of the project is to measure the maximum range between the end node with gps shield and the gateway using different spreading factor where the higher the spreading factor, the higher the network coverage. In order to do that the end node is connected to Cayenne integration installed in The Things Network.

1.2 Problem Statement

Nowadays, large scale macro-farming operation are becoming more common and smart agriculture are slowly replacing the traditional technology. In order to accelerate the worldwide adoption of IoT technology, farmers and ranchers need low cost, low-power sensors. To monitor the condition of crop across the whole field and keep all the crop in good condition, farmer need to be alert. For example, if only half a field needs extra fertilizer or water supply, farmer will only need to analyze and take action based on the data collected by sensors that are placed strategically in the field. If they continue to use the traditional technology, the owner may need more workers to stay around the farm and make sure the crops are in good condition or farmers may overuse pesticide and cause soil and water contamination around the farming area.

However, many farms and ranches in rural area do not have access to cellular and network coverage, they need an easy to install device that can work up to 5 to 10 km range. To solve all the problem, a project of precision farming that allow farmer to monitor and control their farm using LoRaWAN. Precision agriculture benefits the environment by targeted use of water or pesticides that reduce losses from excess applications and from reduction of losses due to nutrient imbalances of crops or crop damage by pesticides[2] and also fulfill the condition where it use in rural area macro-farming with minimal battery usage and increase efficiency at the same time save unnecessary expenses.

For precision farming that does not need to upload data every minute, LoRa is the best choice because LoRaWAN is a device that can sleep for as little or as long as the application desire. This determine the battery life of LoRa to be longer than any other technology. Besides, study showed that LoRa can cover a whole country (Belgium) with just seven gateways/ base stations. [1] The success of this project may help farmers to overcome the limitation of traditional method where the farming is dependent on natural environment condition like drastic weather and drought.

1.3 Objectives

a) To design and implement a system that allow farmers to monitor and control the real time data of pH, temperature, humidity of surrounding and the moisture level of soil using LoRaWAN IoT.

b) To determine the range of connectivity and the signal strength of LoRaWAN.

1.4 Scope of Work

In this project, LoRaWAN IoT solution is chosen to use as the main feature. The specification of this project is that this system can help farmers in rural area to monitor the pH, temperature and humidity of surrounding and the moisture level of soil. To fulfill the objective, different sensors like pH sensor, DHT 11 and soil moisture sensor are chosen to use in this project. Beside sensor, Arduino as an open-source electronics platform based on easy-to-use hardware and software are chosen. To build a LoRa sensor node, LoRa Shield is added to Arduino Uno to send data to the gateway which is LoRA Gateway-LG01. LG01 is an open source single channel LoRa Gateway which enable user to bridge LoRa wireless network to an IP network base on wifi, Ethernet, 3G/4G cellular. It has a USB port that can be used to connect cellular modules so LG01 is very flexible to bridge LoRa Netwrok to different kinds of network to fits user's requirement [3]. In order to keep the farmer on track of the data collected from the sensors, an online IoT platform ThingSpeak is chosen. After the prototype is built, a test is done on the range of connectivity and the signal strength where the base station will be placed at a specific location and the end-device will move around to find both the maximum range of connection and the signal strength between the end-device and the gateway using Cayenne integration built in The Things Network. The range of study is around 200m to 1km in suburban area using different spreading factor from SF7 to SF12 where the greater the SF value, the transmission link increases and therefore increase the receiver sensitivity. The changing of spreading factor helps to determine the suitable range for the gateway to receive every data sent from the end node.

1.5 Thesis Outlines

Chapter 1 explains about the overview of whole project and the problem statement before starting this project. While the objective is something that this project aimed to attain after completing this project and the scope is the boundary of this project to make sure this project meets the expectation. In the last part, thesis outline is the brief explanation of every chapter in this project. Next, chapter 2 discussed about the theories of projects that are similar to precision farming or smart agriculture using IoT by others researchers. Beside, background of project and different methods used to complete their research are also compared and analyzed in this chapter. In chapter 3 methodology, the whole process of this project is explained in a detailed manner. A flowchart of correct procedures that is employed to find solutions for research problems is included. In addition to the flow chart, brief description of each steps are also included in this chapter. Furthermore, chapter 4 will show the outcome of the project whereby the data collected by the sensors will be shown in the network server and the range of connectivity of the Lora will be determined. The testing and verification of each steps of the system will also be shown in this chapter. Furthermore, the results obtained will be analyzed and discussed in this chapter. The last chapter will include the summary and conclusion of this project. Recommendation on this project will also be suggested as reference for research in the future.