SCALABILITY ANALYSIS OF LORA NETWORK USING MULTIPLE GATEWAYS

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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

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ABSTRACT

LoRa is a long-range low-power network technology that is distinct and impressive due to its low power consumption and low-cost system architecture. LoRa is a wireless technology that provides secure data transmission for M2M and IoT applications. While applications of LoRa are increasing at tremendous pace, little attention has been paid to the scalability and performance analysis of such networks. It is very important to analyze how well these technologies will scale as the number of connected devices grows in the future. Numerous end-nodes transmits the data signal to a single gateway and this causes traffic overload. In this project, firstly the traffic overload analysis of a single LoRa gateway that receives signal from numerous end-nodes is performed. Then, this project propose to scale LoRa network by using multiple gateways as receivers to reduce the data signal overload by the single gateway. Finally, LoRa performance based on the collision behavior of the data signal from end-node to the gateway is analyzed using Matlab platform. The results shows that the received values become stable at the multiple gateways but were fluctuating at the single gateway. Thus, the traffic collision is present when the number of end nodes increases and by adding another receiver to the gateway, the traffic collision reduces. This project will be extremely beneficial because a system designer can use the LoRa information and specifications as a foundation for future projects. Furthermore, because the LoRa parameter has been determined, this project will facilitate the development of IoT-related products.

ABSTRAK

LoRa ialah teknologi rangkaian kuasa rendah jarak jauh yang berbeza dan mengagumkan kerana penggunaan kuasa yang rendah dan seni bina sistem kos rendah. LoRa ialah teknologi wayarles yang menyediakan penghantaran data selamat untuk aplikasi M2M dan IoT. Walaupun aplikasi LoRa meningkat pada kadar yang luar biasa, sedikit perhatian telah diberikan kepada kebolehskalaan dan analisis prestasi rangkaian tersebut. Adalah sangat penting untuk menganalisis sejauh mana teknologi ini akan berskala apabila bilangan peranti yang disambungkan semakin meningkat pada masa hadapan. Banyak nod sensor menghantar isyarat data ke satu get laluan dan ini menyebabkan beban lalu lintas. Dalam projek ini, pertama sekali analisis beban lampau trafik bagi get laluan LoRa tunggal yang menerima isyarat daripada banyak nod sensor dilakukan. Kemudian, projek ini mencadangkan untuk menskala rangkaian LoRa dengan menggunakan berbilang get laluan sebagai penerima untuk mengurangkan lebihan isyarat data oleh get laluan tunggal. Akhir sekali, prestasi LoRa berdasarkan kelakuan perlanggaran isyarat data dari nod hujung ke get laluan dianalisis menggunakan platform Matlab. Keputusan menunjukkan bahawa nilai yang diterima menjadi stabil pada gerbang berbilang tetapi turun naik pada get laluan tunggal. Oleh itu, perlanggaran lalu lintas hadir apabila bilangan nod akhir meningkat dan dengan menambahkan penerima lain ke pintu masuk, perlanggaran lalu lintas berkurangan. Projek ini akan sangat bermanfaat kerana pereka bentuk sistem boleh menggunakan maklumat dan spesifikasi LoRa sebagai asas untuk projek masa depan. Tambahan pula, kerana parameter LoRa telah ditentukan, projek ini akan memudahkan pembangunan produk berkaitan IoT.

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CHAPTER 1

INTRODUCTION

In this chapter, the project background, problem statement, objective, and scope of work discussed. The structure of the report also included in this section.

1.1 Project Background

Advances in the development of Internet-of-Things (IoT) have accelerated the rise of new, inventive, convenient, and cost-effective applications in recent years. Things are any devices that are capable of detecting, computing, and exchanging information with other devices over the internet. [1]. IoT-inspired technology is thought to improve the efficiency of energy consumption, resource management, productivity, and environmental monitoring. The Internet of Things has broadened its importance to a variety of fields that previously had limitations in terms of different conceivable uses,

such as, real-time environmental, remote health-care, industrial control, productions systems, smart city, and transportation [2]. Developers have worked on a variety of IoT apps for varied needs, and unique applications necessitate specialized technologies to function properly. Traditional short-range communication technologies such as Bluetooth and ZigBee are not ideal for applications that require long-range communication. While cellular technology can provide broader coverage than conventional radio technology, it requires much energy to operate, which is not ideal for low power applications. Recent advances in the development of a new communication technology known as the Low Power Wide Area Network has demonstrated positive results in applications that demand smaller size devices, low power consumption, and cost-effectiveness (LPWAN). By enhancing the functionality and requirements for IoT applications, the new technology becomes a complement to traditional communication technologies such as cellular and short-range wireless technologies. The unique characteristics of LPWAN technology, including as high coverage, low bandwidth, and low power consumption, are ideal for IoT applications that only need to send small amounts of data over long distances. LPWAN technology is designed to support billions of devices for the various applications of IoT.

LoRa is a long-range, low-power network technology that was deployed by Semtech Cooperation in 2012 as an open-source network and supported by LoRa Alliance [7],[8]. LoRa Technology is now the best option for the growth of LPWAN. LoRa is awireless technology that is unique and impressive because of its minimal powerconsumption and inexpensive system architecture. LoRa also gives secure data transmission for a machine-to-machine M2M and IoT applications. In

Malaysia, LoRa can be used by anyone without the permission and payment for a radio operator license because LoRa uses unlicensed sub-gigahertz radio frequency [11]. The frequency bandused in Malaysia is from range 433MhZ to 915 MHz [7].

LoRa technology uses a star topology architecture in which multiple end-nodes communicate directly to the gateway [1]. However, numerous end-nodes transmit the data signal to the gateway and this cause traffic overload, and eventually, there will be data signal loss at the gateway. Increasing the number of gateways can reduce the data signal overload by the single gateway. Even so, the scalability analysis frequently onlyused a single gateway to study the performance of LoRa. In this study, the performance of the LoRa in the capability to scale using multiple gateways. The development and simulation of the proposed network model were done based on the collision behavior of the data signal from the end-node at the gateway using the MATLAB platform.

This paper consists of five-parts, where the first part discusses previous research. The second part describes the LoRa experiments, and the third part describes the LoRa performance analysis. The fourth part is the most important part of this article that is the scalability analysis of LoRa Network using Multiple Gateways. Finally, the conclusion introduced in the final chapter of this project.

1.2 Problem Statement

LPWAN technology is designed to support billions of devices for the various applications of IoT. The technology uses a star topology architecture in which multiple end-nodes communicate directly to the gateway [1]. One of the main technical challenges with LPWAN technologies is scalability as these technologies are required to provide connectivity for a massive number of IoT devices. However, given the fact that LPWANs cover a large geographic area, a large number of end devices have to share the wireless medium. Numerous end-nodes transmit the data signal to the gateway and this cause traffic overload, and eventually, there will be data signal loss at the gateway [2].

This has profound consequences for the scalability of such networks and naturally raises the question of how many devices can be supported in the same area without dissatisfying application quality of service (QoS) requirements [3]. Thus, this study propose to focus on LoRa, one of the most popular LPWAN technologies, and examine its important performance parameters and scalability. The goal of this study is to give concrete data on LoRa's performance in order to assist in determining its suitability for IoT applications. The research focuses on the experimental evaluation of LoRa throughput and coverage.

This project will be beneficial to network engineers or designers that uses LoRa applications as major applications foreseen for LPWAN, among which are the automotive and intelligent transportation systems (incident report and alerts, fleet management, *etc*.), metering applications (*e.g.*, electrical, water and gas consumption

monitoring, medical metering and alerts) and smart homes (*e.g.*, thermostat control and security systems) where numerous end-nodes will be applied in a large geographical area that causes traffic overload and signal lost at the gateway. Besides, by improving the quality of service (QoS), more end-nodes can be added and it also improves the linkavailability of networks.

1.3 Objectives

Every project has a reason behind decision of taking up the topic. Therefore, in this section, it will discuss the main objectives of taking up this project and what is intended to be obtained from this project. The objectives of this project is as followed:

- To scale LoRa network by using multiple gateways as receivers to reduce thedata signal overload by the single gateway.
- To analyze LoRa's performance based on the collision behavior of the datasignal from end-node to the gateway using Matlab software.

Through the introduction of the objectives, the goals will be used as guidelines in completing this project. The first objective will be focusing on the development of the single gateway where numerous end nodes will be placed at a location in various positions. The end-nodes will then be linked to multiple gateways. The scalability of LoRa will be examined after the results are obtained. Finally, based on the collected data and measurements, the reduction of traffic overload at the single gateway will be demonstrated.

The second objective focuses on the scalability of Lora using Matlab Software. The performance of the proposed model will be simulated using Matlab software based on the previous measurements. Then the percentage of received packet data (PPD) and Packet Loss will be calculated. PPD is the ratio of the total number of datasignals received at the gateway to the total number of data signals transmitted from the end-node.

The objectives of the project is important as it is guidelines on achieving the final outcome of the project to produce the best results and outcome.

1.4 Scope

This project uses LoRa shield with a 915MHz frequency band since this is the latest frequency band provided by LoRa Alliance for Malaysia. All the LoRa shield willbe embedded with Arduino UNO or Arduino Mega 2560. Furthermore, Matlab software will be used to analyze LoRa's performance based on the collision behavior. This project will be conducted in an open ground with numerous end-nodes that transmits the data signal to the receiver in terms of single and multiple gateway. This study propose to focus on LoRa and examine its important performance parameters such as RSSI and SNR to analyze the scalability by using multiple gateways as receivers to reduce the data signal overload by the single gateway.

1.5 Expected Outcome

By the end of of these project the objectives are intended to be achieved along with several outcomes. These outcome will result in providing a well conducted analysis on the project based on important parameters and perspectives. Therefore, the expected outcome of the project is as followed:

- Minimize the data signal overload at the single gateway
- Analysis of LoRa based on collision behavior using Matlab Software
- Measurements of RSSI and SNR values at the gateways
- A fully developed LoRa system using numerous end-nodes that transmit datasignal to the single and multiple gateways