

LIGHTNING EFFECTS ON WIRELESS NETWORK PERFORMANCES

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Dedicated to my beloved family especially and also to all my friends

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ABSTRACT

The one of natural interferences that classified in radio communication is lightning. The occurrence of lightning strokes will generate electromagnetic radiation that causes the Co-Channel Interference (CCI) and Adjacent Channel Interference (ACI) over the Radio Signal Strength Indicator (RSSI). By this phenomena, we believed that the performance of WLAN will be affected severely because the channel of lightning would be interfere the system capacity in same time the value throughput also been affected. Previous study show that lightning induced are affected bit error rate (BER) severely on the frequency that operate below than 1 GHz in 14 different channel that used in walkie-talkie communication. The investigation is extending at two different frequencies: 2.4 GHz and 5.2 GHz which using in Wi-Fi frequency to observe the performance of WLAN by conducting RSSI and Throughput measurement particularly. The result RSSI and both non-streaming and streaming protocol have been collect to investigate the interferences outcomes by lightning-induced and comparison will be made in two scenario which are without lightning and with lightning condition. Observation from the result of throughput measurement, there are different value of average throughput between two different scenario and different frequency that being used. As we discovered, lightning caused a dropped RSSI and the value of throughput also changed.

ABSTRAK

Salah satu gangguan semulajadi yang dikelaskan dalam komunikasi radio ialah petir. Kejadian panahan petir akan menjana radiasi elektromagnetik yang menyebabkan terhasilnya Gangguan Saluran Bertindih (CCI) dan Gangguan Saluran Berhampiran (ACI) terhadap Penunjuk Kekuatan Isyarat (RSSI). Dengan fenomena ini, kami percaya bahawa prestasi Rangkaian Kawasan Setempat Tanpa Wayar (WLAN) akan terjejas dengan teruk disebabkan oleh saluran petir yang mampu mengganggu kapasiti system dalam masa yang sama nilai daya pemprosesan juga akan terjejas. Kajian lepas menunjukkan aruhan petir telah menjejaskan kadar kesilapan bit (BER) dengan teruk pada frekuensi yang beroperasi di bawah 1 GHz dengan 14 saluran berbeza yang digunakan dalam peralatan komunikasi walkie-talkie. Penyelidikan diteruskan pada dua frekuensi yang berbeza: 2.4 GHz and 5.2 GHz di mana ia digunakan secara meluas dalam frekuensi untuk memerhatikan prestasi WLAN dengan mengendalikan RSSI dan juga Daya Pemprosesan secara khususnya. Keputusan kedua-dua RSSI dan juga protocol penjurusan dan bukan penjurusan telah dikumpul untuk dikaji kesan gangguan yang dihasilkan oleh aruhan petir dan perbandingan telah dibuat ke atas dua senario keadaan tanpa petir dan keadaan dengan kehadiran petir. Berdasarkan pemerhatian daripada keputusan pengukuran daya pemprosesan yang telah dibuat, terdapat perbezaan besar berlaku pada nilai purata daya pemprosesan di antara kedua-dua senario yang berbeza dengan menggunakan dua frekuensi berbeza. Seperti yang kita temui, petir juga menyebabkan kejatuhan nilai RSSI dan nilai Daya Pemprosesan juga berubah.

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LIST OF ABBREVIATIONS

ACI	-	Adjacent Channel Interferences
BER	-	Bit Error Rate
CCI	-	Co-Channel Interferences
EMI	-	Electromagnetic Interferences
WLAN	-	Wireless Local Area Network
FTP	-	File Transfer Protocol
HTTP	-	Hypertext Transfer Protocol
LOS	-	Line of Sight
RSSI	-	Received Signal Strength Indicator
POP	-	Post Office Protocol
SMTP	-	Simple Mail Transfer Protocol
TCP	-	Transmission Control Protocol
UDP	-	User Datagram Protocol

CHAPTER I

INTRODUCTION

1.0 General

Wireless network nowadays have gained strong popularity in a number of vertical markets, including the health-care, retail, manufacturing, warehousing, and academic arenas. Wireless network generally known as transmitting data to receiver over the air using radio frequency, in the same time minimizing the need for wired connections. As the WLAN network promising, wireless LAN networks are playing an increasingly important role in the future generations of wireless mobile networks.

However, the development of large wireless network projects especially outdoor deployment has been made in urban area therefore in term of technology growth; the criteria of outdoor environmental interference also must be considered in order to design and preserve their reliability of wireless link. In equatorial climate, lightning is often occurred in everywhere. The particular frequency of lightning is the critical factor that might be cause a vulnerability of wireless link outdoor deployment.

1.1 Problem Statement

Malaysia's climate is categorized as equatorial, being hot and humid throughout the year that has annual rainfall over 2000mm a year [7]. The possibility is very high for lightning to occur accompanied with high rainfall. As the WLAN network been deployed in outdoor area to fulfill the need of Internet in domestic, the occurrence of lightning may be affecting the signal strengths between the links of WLAN router performance. The radiations that produce from lightning strike may cause interference to microwave communication system such as WLAN.

1.2 Objectives

The objective of this project is:

- To evaluate the effects of lightning on WLAN network performances in terms of RSSI and throughput.

1.3 Motivation

The throughput of Wireless LAN network performance is the most important to maintain especially for UDP protocol that contains speech content and audio video streaming. However, the factor of interference from lightning must be considered to provide reliable UDP data transmission. The reason we extend this research to high frequency region is because 2.4 GHz and 5.2 GHz are the popular frequencies that used nowadays.

1.4 Contribution

From the experiment done, the evaluation and analysis the results can be used as a guideline for further researcher in order to develop a vulnerable protocol that affected by lightning radiation in same time network planner or designer must mention a percentage of data lost and corrupted those are intently to deploy a reliable wireless

outdoor especially located at the equatorial climate country. It is because; the most affected throughput went to streaming protocol which is important to carry an audio video streaming and speech content. Apart from that, the damage of packet that has been sending also will affect connectivity between transmitter and receiver.

1.5 Thesis Organization

This thesis is divided into five chapters. The first chapter introduces the project background. In the second chapter, literature review is covered. In chapter 3 which is called experimental setup, all the method related to this project is explained details. In chapter 4, the collected is analyzed and also findings of the results are explained as well to the theory. The final chapter, Chapter 5 concludes the entire previous chapter. The future work also included in this chapter as well.

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

Lightning is a naturally phenomenon which is come out with electrical spark that produce billions of volts of natural static electricity. Usually it came altogether with thunderstorm and rain [1]. The cloudy is a most conventional source occurrence of lightning [2]. From the other theory, lightning is a huge sparking by electrical that perform in electron that moving quickly from anywhere to another place like earth or ground and another cloud. That theory also tells that the phenomenon formed by lightning and the period time of lightning occurs [3]. Furthermore, lightning is a discharge of electron from the negative charges to the positive charge [4]. Lightning also caused the interference to an electronics devices and also communication systems. The transient produced by lightning have effect to the telecommunication equipment. Electromagnetic that produce by lightning-induced transient could cause some form of data corruption at frequency below than 1 GHz in different 14 channels on wireless communication link at UHF band. Obviously, the lightning-induced transient has direct impact on the wireless network performance [14].

2.1 How Lightning Happen?

Lightning is phenomenon that no one can describe their behavior precisely and all the process the generated of storm cells also not be confirm and still in research. However, the charges at atmosphere separated and the cell that created mostly located in the night cloudy. The generated cell will produce the charges from top to the base or ground [15]. As a result, the cloudy release the negative charges and the electron moved quickly to the positive charges nearby [4]. In thunderstorm, electrostatic field able to achieve levels of voltage between 10,000 and 30,000 Volts per meter of elevation above the earth's surface [15].

According to the figure 2.1, the negative electrons in the bottom of the cloud are attracted to the positive atoms in the top of the cloud. Commonly the electrons are also attracted to positive atoms in near cloud and on the ground. After the attraction is getting strong each other, the lightning stroke suddenly moved as a shoot towards the group of positive charges. Resulting of the moving charges, the flash is can be see and sound heard immediately [4]. The lightning flash can probably see if watching the right spot at the right time [3].

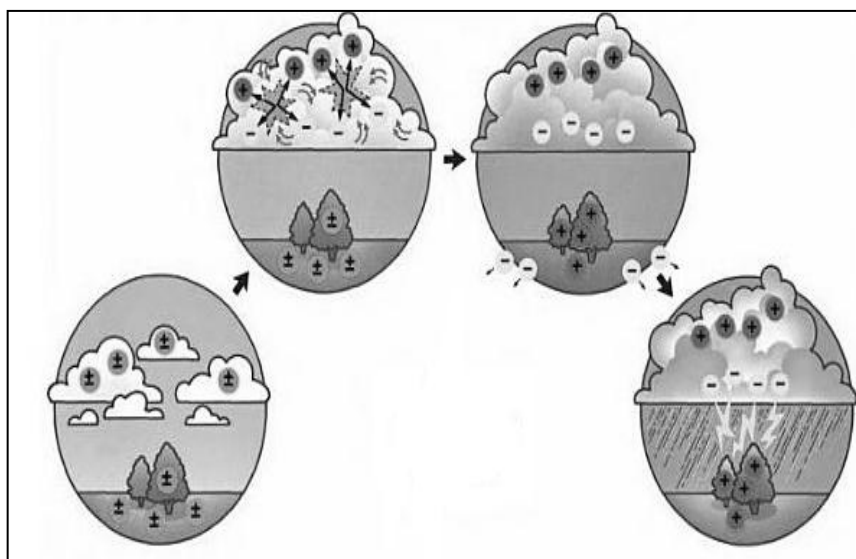


Figure 2.1: Lightning Perform[3]

2.2 Effects of Lightning on Wireless Communication Below 1 GHz

The investigation the Effects of Lightning on Wireless Communication below 1 GHz was carried out and it focused on two scenarios namely high voltage and high current scenarios that can be produced during the artificial lightning phenomena. From the experiment had done, the current value with 440A, 850A and 2000A was proven disrupt the transmission link at UHF band and the loss of bit had been identified [14].

In the experiment, 1000 bits of speech signal were transmitted by using FSK modulation technique and resulting the total bit loss for those current values is 25 bits equal percentage loss of 0.0025% out of 1000bits of binary data. For the measurement without lightning and with lightning condition, result of comparison shows minimum delay of received signal (case for without lightning condition) is 18.0ms. For the maximum delay of received signal compared to the original 10 seconds data is 29.ms.While maximum delay of received signal compared to without lightning condition is 11.2ms. There, we can see quite different of losing power received by the effects of induced lightning-transient. However, high voltage experiment produced no error with 2 ms delay. The delay was calculated based on delay experiencing during lightning relative to delay with absent of lightning [14].

2.3 Streaming versus Non-streaming protocols

Streaming is a network control protocol designed for use in entertainment and communications systems to control streaming media servers also known as UDP Protocol. Non-streaming is whereas the IP protocol deals only with packets, TCP enables two hosts to establish a connection and exchange streams of data[9]. That protocol is used for establishing and controlling media sessions between end points. Streaming scripts emulate multimedia applications, which send data without acknowledgments. Datagrams are sent in one direction only, from endpoint 1 to endpoint 2. Streaming scripts are used with IPX, RTP, or UDP. The endpoints running a streaming script do not require reliable data delivery. When running a streaming script,

Endpoint 2 keeps statistics on lost data and returns this information as part of the results. When using the RTP protocol, endpoint 2 records statistics on jitter and returns this information as part of the test results [10].

2.3.1 TCP

Transmission Control protocol is designed to guarantee delivery of data from the sending device to the receiving device. In this type of pair, TCP requires additional control information in the header. Each data packet is placed in the correct sequence order when it is received. Below show the Transmission Control protocol layer that had in OSI layer [11].

2.3.1.1 TCP Layer Encapsulation

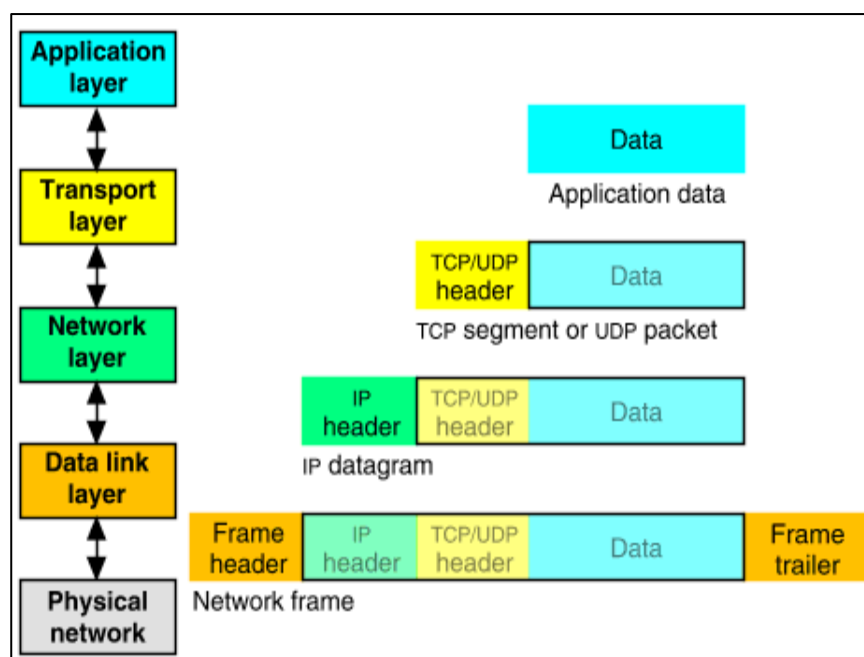


Figure 2.2: TCP Layer Encapsulation Process [11]

The process can be defined as one computer requests to send data to another over a network. The data message flows through the Application Layer by using a TCP or UDP port to pass onto the internet layer. The data segment

obtains logical addressing at the Internet Layer via the IP protocol, and the data is then encapsulated into a datagram. The datagram enters the Network Access Layer, where software will interface with the physical network. A data frame encapsulates the datagram for entry onto the physical network. At the end of the process, the frame is converted to a stream of bits that is then transmitted to the receiving computer. The receiving computer removes the frame, and passes the packet onto the Internet Layer. The Internet Layer will then remove the header information and send the data to the Transport layer. Likewise, the Transport layer removes header information and passes data to the final layer. At this final layer the data is whole again, and can be read by the receiving computer if no errors are present [9].

2.3.2 UDP

User Data Program also called UDP is an alternative to TCP is User Datagram Protocol. Different with TCP, UDP is not guaranteed delivery the packet that sent. UDP also have no preservation of sequence which every packet are not well arranged but keep sending to the destination. Apart from that, there is no protection against duplication of packet had been sent [12].

2.4 TCP vs UDP

Those two types of main protocol had a different in term of the way how sender send the data or packet to the destination. In TCP protocol, this protocol had completely designed to guarantee delivery of data from the transmitter (sending device) to the receiving device [13]. In UDP, they are not guaranteed whether all the data or packet successfully received or corrupt in during the transmission. For the term of speed, TCP is much slower than UDP. UDP not contain the additional control information in the header as TCP had. That's why the packet is slower sent compare in the UDP. In other terms of speed, UDP does not have an acknowledgement as TCP had. Because of that,

TCP take a long time to guarantee data is sent. TCP also known as reliable connection while UDP is unreliable [12]

2.5 Summary

In this chapter, all the literature that related to lightning, streaming and non-streaming protocol are being read and presented to gain a better understanding on that particular topic. This knowledge and information is important to prepare and being apply in the experimental setup.

Literature review started with the basic which covers lightning theory and lightning phenomenon, which produce an electromagnetic field. Besides that, two type protocol which namely streaming as UDP and non-streaming as TCP are also reviewed which plays important role in the computer network. The investigation in this project include with measuring the RSSI performances. Followed by review on behavior of lightning induced transient, electromagnetic may be causing interferences to a microwave link as theoretically. Here the investigation has been made to prove the effects of lightning particularly to the network protocol. Finally, this chapter ends with the comparison between TCP and UDP to find out overall behavior of this protocol that being measure in this experiment.

CHAPTER III

RESEARCH METHODOLOGY

3.0 Introduction

In this chapter we will explain the method of measurement campaign that has been used using the reliable hardware and software tools. A test bed as shown in Figure 3.1 has been chosen for all measurement around UTeM. The test bed is free from CCI and ACI.

3.1 Flowchart

The project consists three phase to be completed. This flowchart is important to in order to ensure the steps taken are in the right track. Some missing steps will cause obtain a non-valid results along comply an experiment. The flow chart is shown as in Figure 3.1.