PERFORMANCE ANALYSIS OF NETWORK TRAFFIC FOR LTE WIRELESS COMMUNICATION LINKS INTERFERED BY LIGHTNING

MUHAMMAD A'MMAR BIN JAMAL AKBAR

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PERFORMANCE ANALYSIS OF NETWORK TRAFFIC FOR LTE WIRELESS COMMUNICATION LINKS INTERFERED BY LIGHTNING

MUHAMMAD A'MMAR BIN JAMAL AKBAR

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

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2022

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : PERFORMANCE ANALYSIS OF NETWORK TRAFFIC FOR LTE WIRELESS COMMUNICATION LINKS INTERFERED BY LIGHTNING

Sesi Pengajian : 2021/2022

Saya MUHAMMAD A'MMAR BIN JAMAL AKBAR mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☑	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.)
☐	**TIDAK TERHAD**	

(TANDATANGAN PENULIS)

Alamat Tetap: A-276 KAMPUNG WAKAF MEMPELAM,20050, KUALA TERENGGANU, TERENGGANU

Tarikh : 13 Jun 2022

Disahkan oleh:

DR. MOHD RIDUAN BIN AHMAD
Profesor Madya
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

(COP DAN TANDATANGAN PENYELIA)

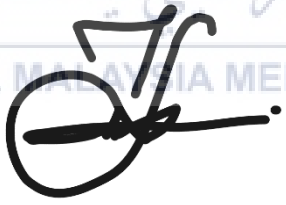
JABATAN KEJURUTERAAN KOMPUTER, FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER (FKEKK), UTeM

Tarikh : 13 Jun 2022

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

D ECLARATION

I declare that this report entitled “PERFORMANCE ANALYSIS OF NETWORK TRAFFIC FOR LTE WIRELESS COMMUNICATION LINKS INTERFERED BY LIGHTNING” is the result of my own work except for quotes as cited in the references.



Signature : ……

Author : MUHAMMAD A’MMAR BIN JAMAL AKBAR ……

Date : 13/6/2022 ……

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : .....

DR. MOHD RIDUAN BIN AHMAD
Profesor Madya
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Supervisor Name : .....

Date : 13 June 2022

DEDICATION

To my beloved parents and siblings, who has been my source of strength and encouragement.

To my lecturers and colleagues for guidance and shared knowledge throughout those sleepless night.

Thank you

ABSTRACT

Lightning is a natural event occurs in nature due to electrical discharges in the air. These electrical discharges emit a wide spectrum of electromagnetic (EM) fields. This EM spectrum includes the frequency of mobile communication networks particularly 4G frequency band at 2.3 GHz which is the interest of this study. In this thesis, experiments have been conducted to measure 4G network performances during lightning and thunderstorm events. A measurement system has been designed and developed to measure lightning interference effects toward 4G data transmissions. The measurement includes protocol that is commonly used by the end-user which is User Datagram Protocol (UDP). The measurement results were evaluated in terms of packet loss, jitter, throughput, and consecutive loss datagrams (CLDs). The significant finding is that, during heavy storm events, there were significant drop in throughput and significant increase in packet loss, jitter, and CLDs. Therefore, it can be concluded that EM radiation emitted by lightning interfered with 4G data transmission to the extent of reducing the overall performance of the 4G network.

ABSTRAK

Kilat adalah kejadian alam semula jadi yang berlaku disebabkan oleh penyahcasan elektrik di udara. Penyahcasan elektrik ini mengeluarkan medan elektromagnet (EM) yang merangkumi spektrum yang luas. Spektrum ini juga merangkumi frekuensi yang diguna pakai oleh rangkaian mudah alih termasuklah frekuensi 4G iaitu 2.3 GHz iaitu salah satu kepentingan kajian ini. Dalam tesis ini, eksperimentasi telah dijalankan bagi mengukur prestasi rangkaian 4G dalam keadaan fenomena kilat dan ribut. Satu sistem pengukuran yang telah direka bentuk dan dibangunkan bagi mengukur kesan gangguan kilat terhadap transmisi data 4G. pengukuran tersebut termasuklah protocol yang kebiasaanya digunakan oleh pengguna awam iaitu User Datagram Protokol (UDP). Keputusan pengukuran telah dinilai dalam terma, Kehilangan Paket, Jitter, Daya Pengeluaran dan Kehilangan Datagram Berterusan (CLD). Penemuan yang penting dari kajian ini adalah, Ketika ribut yang teruk, terdapat penurunan ketara dalam Daya Pengeluaran dan peningkatan ketara dalam Kehilangan Paket, Jitter dan CLD. Oleh itu dapat dikonklusikan bahawa radiasi EM yang dikeluarkan oleh kilat memberi kesan gangguan kepada transmisi data 4G yang membawa kepada penurunan prestasi keseluruhan rangkaian 4G

ACKNOWLEDGEMENTS

In the name of Allah SWT, the Most Gracious, the Ever Merciful. Praise is to Allah, Lord of the Universe. Peace and Prayers be upon His final Prophet and Messenger Muhammad SAW.

First and foremost, I would like to offer my highest appreciation to my supervisor, Dr. Mohd Riduan bin Ahmad for his fathomless and irreplaceable guidance. His supervision and endless support truly guide me on progression and smoothness of my work until I succeed to complete this project. His kindness and leadership will always be remembered closely to my heart all the time. Not to forget his willingness to share his time and energy to help guide me in every path that I take since day 1.

Nothing has been more important to me in the pursuit of this project other than the members of my family. I would like to thank my parents, Mr Jamal Akbar and Mrs Khamsiah; whose love and guidance are with me in whatever I pursue. They have been the ultimate role models. This accomplishment would not have been possible without them. I would also like to spare my gratitude to my grandparents,

Late Hajjah Hatmah and Hj, Mansor for always giving tremendous support and for believing in me when no one else did.

Also, not to forget thanks to all the BBNET lab members, Shamsul Ammar, Sulaiman, Azim, and Hj Yusri. Thank you for all the guidance and cooperation provided throughout the journey. Not forgetting my brothers in arms, my housemates whose, together we support each other and push ourselves in completing our degree journey. thank

Thank you, Assalamualaikum.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

MCMC	:	Malaysian Communication and Multimedia Commissioner
ISP	:	Internet Service Provider
UDP	:	User Datagram Protocols
PTP	:	Point to point
RWT	:	Round way trip
OWT	:	One way trip
WWW	:	World Wide Web
ITU-R	:	International Telecommunications Union Radiocommunications Sector
NA	:	Not available
LAN	:	Local Area Network
Wi-Fi	:	Wireless Fidelity
OFDM	:	Orthogonal Frequency Division Multiplexing
OSI	:	Open Systems Interface
NBE	:	narrow bipolar event
IC	:	Intra-Cloud

CG	:	Cloud-to-Ground
BLR	:	Bit Loss rate
UHF	:	Ultra-High Frequency
PMR	:	Private mobile radio
IVG	:	Impulse Voltage Generator
RCT	:	Recloser Test-Set
LOS	:	Line Of Sight
FSK	:	Frequency Shift Keying
DO	:	Digital Oscilloscope
MET	:	Malaysian Meteorological Department

CHAPTER 1

INTRODUCTION

In this chapter, the general information of the project which consists of the project introduction, problem statement, objectives, scope of work, and expected outcome are explained. Project introduction explains the main idea of the project. The problem statement and the objective explain the purpose of this project and the scope of work outlines the process that is needed for the completion of the project.

1.1 Project introduction

The Fourth Generation Long Term Evolution (4G LTE) network has become an essential element for mankind today. With the fast connectivity, humans can be connected across the globe just at the tip of the finger. This mobile network traffic travels to and from cell towers on radio waves. Even in a fair-weather condition the wireless communication system experiences interference and noise but it is

negligible as the level is low. However, in a harsher condition, like lightning and thunderstorm, it has a more significance effect to the 4G network connection.

This project is a collaborative project with U Mobile SDN BHD and Malaysian Communication and Multimedia Commissioner (MCMC) to model lightning interference on LTE wireless communication links. This project involves extensive measurement campaign and network traffic data analysis from the interference of lightning.

The packet data generated for measurement campaign is User Datagram Protocol (UDP). The parameters that are monitored using the iPerf3 software are the bandwidth, latency, speed of data transfer, datagram, and data loss during the lightning interference events.

1.2 Problem statement

Based on the finding in [1], a wireless communication system in microwave band at 2.4 GHz [2][3] experienced noise and interferences even under fair weather condition. However, the study was done with only 2.4 GHz Wireless Fidelity (Wi-Fi) connection with one protocol which is UDP and with only one parameter of packet loss. The findings from the studies are the baseline for this project. Several aspects from the research paper can be further improvised to the next level. Some further improvements applied for this project are:

1.2.1 Data measurement and analysis on UDP packet

The UDP is a connectionless internet protocol which unlike Transmission Control Protocol (TCP), it doesn't have error checking and recovery service. In UDP packet transmission, data is continuously sent to the receiver, whether they receive it

or not. Common usage for UDP is for real-time communication such as steaming, broadcasting, online games, and Voice over IP. The main difference between TPC and UDP is the speed of data transfer. The UDP is much faster compared to TCP due to is simple and efficient protocols. Referring to the studies conducted in [1], [4-8], the studies only focus on UDP protocol, the additional TCP data will provide a variety of result for the result analysis in the MATLAB. Comparing TCP protocol with UDP, the protocol has a slower speed compared to UDP due to the 'Handshake' protocol that ensures a connection is established and it is maintained until the exchange between sending and receiving message is completed [9].

1.2.2 Additional performance parameter

According to [1] the research was done with only the measurement of bit error rate and packet loss. The performance parameter then is added for the data analysis of effect of the lightning interference to the network performance. The parameter that are measured are bandwidth, jitter, datagram, and packet loss. These parameters are measured using iPerf which can be seen in the logfile recorded.

i. **Throughput at Client and Server (Round-way trip (RWT) and one-way Trip (OWT))**

   The maximum amount of data transmitted over an internet connection within a specific time. A larger bandwidth allows more data to be transmitted at the same time.

ii. **Jitter**

   Jitter occurs when data packets are sent over your network connection with a temporal delay. It is commonly due to congestion on the

network, as well as data route changes. Jitter can cause negative impact on the video and audio quality, causing a glitchy output.

iii. **Total number of Transmitted Datagram**

A datagram is a fundamental transfer unit of a packet-switched network. The header and payload components of a datagram are normally separated. In a packet-switched network, datagrams provide a connectionless communication service. The delivery, arrival time, and order of arrival of datagrams need not be guaranteed by the network. This can be seen in the UDP protocol data.

iv. **Packet loss**

packet loss is the failure of small unit of data (packet) to reach it intended destination during transmission. It is a causes network disruption, slow service, and loss of network connectivity. It mainly occurred in protocols that has real-time processing such as UDP that are used in video, audio, and streaming.

1.2.3 A different set of network connection (Mobile connection).

The result from [1] was obtained only by using a Dual-band Linksys WRT610N router with multiple antennas. It was connected through local area network (LAN) cables to a laptop acting as a server and another laptop acted as a client and was connected to the router wirelessly. Thus, it only limits the network connection to a Wi-Fi network.

In comparison, a wi-fi network has a faster speed connection than a cellular network. However, a cellular network has a wider range of connection that is limited by its cellular tower coverage. According to [10], the mean speed of 4G in Malaysia