Faculty of Electrical and Electronic Engineering Technology

DESIGN OF FIBER-TO-THE-HOME (FTTH) ACCESS NETWORK WITH REDUNDANCY BASED ON GIS

MOHAMAD SYAFIQ BIN MOHD ZUKERI

Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

2021

DESIGN OF FIBER-TO-THE-HOME (FTTH) ACCESS NETWORK WITH REDUNDANCY BASED ON GIS

MOHAMAD SYAFIQ BIN MOHD ZUKERI

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN OF FIBER-TO-THE-HOME (FTTH) ACCESS NETWORK REDUNDANCY BASED ON GIS

Sesi Pengajian : 2021

Saya Mohamad Syafiq Bin Mohd Zukeri 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**	

Disahkan oleh:

Syafiqz

(TANDATANGAN PENULIS)

Alamat Tetap:
No 11, Tingkat Zarib 6,
Taman Pinji Mewah, 31500,
Lahat, Perak

(COP DAN TANDATANGAN PENYELIA)

FAKHRULLAH BIN IDRIS
Jurutera Pengajar
Jabatan Teknologi Kejuruteraan Elektrik dan Komputer
Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik
Universiti Teknikal Malaysia Melaka

Tarikh: 10 JANUARY 2022

Tarikh:10 JANUARY 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.

DECLARATION

I declare that this project report entitled "Design of Fiber-To-The-Home (FTTH) Access Network With Redundancy Based On GIS" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : Syafiq

Student Name : MOHAMAD SYAFIQ BIN MOHD ZUKERI

Date : 10 JANUARY 2022

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

Signature : .....

Supervisor Name : TS. FAKHRULLAH BIN IDRIS

Date : 10 JANUARY 2022

Signature : .....

Co-Supervisor Name (if any) : .....

Date : .....

DEDICATION

I want to dedicate this project to my loving and supportive parents, Mohd Zukeri Bin Hasbullah and Inaliza Binti Abd Rahim. They have been a source of inspiration and strength throughout my journey to finish this project. Not to mention my siblings, who are constantly motivating me to grow as a person in the future. Furthermore, I have nothing but love and the deepest appreciation for TS. Fakhrullah Bin Idris, my gentle and kind-hearted supervisor, for his encouragement and advice. Finally, I want to express my gratitude to Allah S.W.T. for blessing my life much more than I.

ABSTRACT

The IEEE and the International Telecommunication Union's Telecommunications Standardization Sector (ITU-T) and a host of other industry organisations lay down standards. The Society of Cable Telecommunication Engineers (SCTE) specified radio frequencies through the glass and signal transmission over a passive optical network. FTTH infrastructure involves integrating fibre optics into a worldwide network, both for the backbone network service provider and the final kilometres. The last mile refers to the fibre that goes from the central office to every dwelling requiring amenities. Different physical configurations may be employed to connect the end subscriber to the service delivery node.Telecommunications firms often draw out business cases for introducing high-speed fiber-to-the-home networks. This project aims to improve the design of every passive optical fibre to home (PON) network (FTTH) because of the necessity for physical visits. Taman Sutera Wangi Fasa 2, Melaka, has been chosen for this project to demonstrate the efficacy of utilising GIS to build and build a network of FTTH access. GIS such as Google Maps delivers actual data and may minimise design costs. Network designs may be planned earlier using CAD and web mapping before actual deployment. As a result, telecom operators frequently refuse to spend or postpone FTTH networks or operations to achieve a steady, delayed implementation. A fibre tool based on a Geographic Information System (GIS) enables new fibre networks to be more precisely developed and the overall linked infrastructure to be controlled more effectively. OptiSystem simulation based on FTTH device simulation provides BER and Q factor system performance data, which can be obtained in Optisystem.

ABSTRAK

Sektor Standardisasi Telekomunikasi IEEE dan Kesatuan Telekomunikasi Antarabangsa (ITU-T) dan sebilangan organisasi industri lain menetapkan standard. Persatuan Jurutera Telekomunikasi Kabel (SCTE) menentukan frekuensi radio melalui penghantaran kaca dan isyarat melalui rangkaian optik pasif. Infrastruktur FTTH melibatkan penyatuan serat optik ke dalam rangkaian di seluruh dunia, baik untuk penyedia perkhidmatan rangkaian tulang belakang dan kilometer akhir. Konfigurasi fizikal yang berbeza boleh digunakan untuk menghubungkan pelanggan akhir ke nod penyampaian perkhidmatan. Syarikat-syarikat telekomunikasi sering membuat kes perniagaan kerana memperkenalkan rangkaian fiber-to-the-home berkelajuan tinggi. Projek ini bertujuan untuk meningkatkan reka bentuk setiap rangkaian serat optik pasif ke rumah (PON) (FTTH) kerana keperluan untuk lawatan fizikal. Taman Sutera Wangi Fasa 2, Melaka, telah dipilih untuk projek ini untuk menunjukkan keberkesanan penggunaan GIS untuk membina dan membina rangkaian akses FTTH. GIS seperti Peta Google memberikan data sebenar dan dapat meminimumkan kos reka bentuk. Reka bentuk rangkaian mungkin dirancang lebih awal menggunakan pemetaan CAD dan web sebelum penggunaan sebenar. Akibatnya, pengendali telekomunikasi sering menolak untuk membelanjakan atau menangguhkan rangkaian atau operasi FTTH untuk mencapai pelaksanaan yang stabil dan tertunda. Alat gentian berdasarkan Sistem Maklumat Geografi (GIS) membolehkan rangkaian gentian baru dikembangkan dengan lebih tepat dan infrastruktur yang dihubungkan secara keseluruhan dapat dikendalikan dengan lebih berkesan. Simulasi OptiSystem berdasarkan simulasi peranti FTTH menyediakan data prestasi sistem faktor BER dan Q, yang boleh diperolehi dalam Optisystem.

ACKNOWLEDGEMENTS

First and foremost, I want to express my gratitude to Ts. Fakhrullah Bin Idris, my supervisor, for his excellent guidance, unwavering support, and patience during my Bachelor's degree programme. Their vast knowledge and wealth of experience have aided me throughout my academic career and daily life.

I owe a debt of gratitude to Universiti Teknikal Malaysia Melaka (UTeM) and my siblings for their financial assistance in helping me to complete the project during a challenging time.

My heartfelt gratitude goes to my parents and family members for their love and prayers during my studies. An honourable mention also goes to my father, Mohd Zukeri Bin Hasbullah and Khairunajwa Binti M Kamal for all his motivation and understanding.

Finally, I would like to thank all my friends, colleagues, classmates, faculty members, and other individuals who are not listed here for being cooperative and helpful.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

FTTH	-	Fiber-To-The-Home
FTTN	-	Fiber-To-The-Node
FTTx	-	Fiber -To-The- x
VOIP	-	Voice Over IP
GIS	-	Geographic Information System
GPON	-	Gigabit Passive Optical Network
BPON	-	Broadband Passive Optical Network
P2MP / PTMP	-	Point-To-MultiPoint
PTP	-	Point-To-Point
PSTN	-	Public Switched Telephone Network
ONT	-	Optical Network Terminal
GHz	-	Gigahertz
HSI	-	High Speed Internet
OLT	-	Optical Line Termination
ONU	-	Optical Network Unit
ODF	-	Optical Distribution Frame
OSP	-	Outside Plant Fiber
POTS	-	Plain Old Telphony Service
SP	-	Splitter
PB	-	Power Budget
PS	-	Link Margin
PM	-	Power Margin
P_{TMin}	-	Minimum Trasmitter Power
P_{RMIN}	-	Minimum Receiver Sensivitiy
TDM	-	Time-Division Multiplexing
WDM	-	Wavelenght-Division Multiplexing
BoQ	-	Quantity Bills
GUI	-	Graphical User Interface
LLU	-	Local Loop Unbunding
HFC	-	Hybrid Fiber-Coaxial
APD	-	Avalanche Photodiode
ISDN	-	Integrated Service Digital Network
APON	-	ATM Passive Optical Network
ATM	-	Asynchronous Transfer Mode
ISP	-	Internet Service Provider
FDT	-	Fiber Distribution Terminal
FAT	-	Fibre Access Terminal
TB	-	Terminal Box
dB	-	Decibel
dBm	-	Decibel Miliwatts
Km	-	Kilometre
2D	-	2 Dimension
3D	-	3 Dimension
CAD	-	Computer Aided Design

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Fiber-to-the-home (FTTH) is an expression that refers to a connection between the home and the premises. In the previous ten years, bandwidth for services such as High-Definition TV and the Internet has expanded considerably. With this in mind, several telecommunications providers have already finalised FTTH programmes, and numerous others are serious about implementing such a network. Given the massive commitments that must be made, such an endeavour must be well planned; for example, it is estimated that Germany alone has committed to EUR 40-60 billion. FTTH is a long-term alternative to providing internet content, such as on-demand video, online games, HD TV and VoIP.

The PON-based FTTH Access Network is a fiber-to-the-based multi-point network design that uses unpowered optical splitters to enable a single optical fibre; generally, 32-128, to operate on numerous premises. Fiber to home networks benefits from low attenuation of single-mode (0.2–0.6 dB/km) and high bandwidth (> 30.000 GHz) optical fibres to provide bandwidths many times higher than traditional broadband technologies presently feasible. The planning of an FTTH network is a challenging procedure, including a range of exciting optimisation issues. A fibre tool based on GIS enables the existing fibres and simplified management of the whole linked infrastructure to be better prepared. This project aims to propose a new approach to the best implementation using the GIS network architecture. GIS is a system for capturing, storage, manipulation, analysis, management and presentation of all types of geographic information. GIS is an abbreviation for geographic

information systems research or practice, known as geospatial information research or geospatial information science. The lineage of GIS as an integrative instrument shows its importance.

1.2 Problem Statement

There is currently a Fiber-to-the-Home (FTTH) broadband service offered by hundreds of millions of homes all over the globe that benefits from current technology. FTTH uses fibre-optic cables to transmit signals from a central network of an operator to individual homes, buildings and homes, replacing antiquated copper infrastructures and enabling consumers to provide more bandwidth. Many solutions have been implemented to fulfil the requirement for high bandwidth, but it are not considered as a long-term expansion in access networks is predicted. A fiber-to-the-home (FTTH) network based on the Gigabit Passive Optical Network (GPON) is an excellent answer to rising bandwidth requirements.

1.3 Project Objective

This project aims to design a Fiber-To-The-Home (FTTH) Access Network with Redundancy Using GIS. The design is based on an implementation using a GIS network architecture. The main objective is:

i) To learn more about FTTH, use animation, analysis, design and simulation.

ii) To analyze and design an FTTH network for a specified region.

iii) To improve the service quality of standard passive optical networks, with lower network costs.

1.4 Scope of Project

The scope of this project is as follows:

i) Demonstrate FTTH to explain FTTH in Fiber-Optical Communication Link as an Access Technology through design and simulation.

ii) Design an FTTH with a parameter area specified by analysis.

iii) For planning, the design will make extensive use of GIS and AutoCad software.

iv) In the simulation, the optical part will be analyzed and designed using OptiSystem Software.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The Fibre-to-the-Home (FTTH) broadband service already provides hundreds of millions of households around the globe with several benefits over older technologies. FTTH employs fiber-optical cables to transfer communication signals from the central network of operators to individual residences, buildings, and residences, substitute for ancient copper infrastructures, and provide customers with additional bandwidth [1]. The FTTH networks, which employ Fiber Optics to communicate, will meet the demands of home consumers who need faster connectivity for internet services [2].

FTTH is a network architecture that employs optical fibre cables to deliver customer-friendly, high-speed triple-play communications (data, audio and video) [3]. FTTH is called a cost-cutting deployment approach or a fixed investment strategy that maximises network coverage. Consequently, telecommunications providers frequently neglect to invest money in FTTH networks or operations to assure a progressive and gradual implementation [4].

2.2 FTTH Technology

As optical networks reached the telecommunications world, the cost of fibre on the ground (initial civil construction) was much higher than the cost. Therefore, the first phase (P2MP) is to choose between point-to-point (PTP) and point-to-multipoint (PTMP) architectures to construct an FTTH network [5].

2.3 FTTH Access Network Architecture

The primary purpose of this design is to decrease the length of the optical cable utilised for fibre transmission and drop, which reduces the cost of the cable plant when constructing an FTTH network. The OLT should be sturdy, durable and thick. The FTTH network delivers two kinds of services: Voice over IP (VoIP) and the Internet at high speed (HSI). The placement of the OLT is dictated by the power required, space and the connection accessible 24 hours, seven days [6]. Figure 2.2 shows the layout of the FTTH network divided into five sections: the HCO, feeder, delivery, distribution and consumer networks [7].

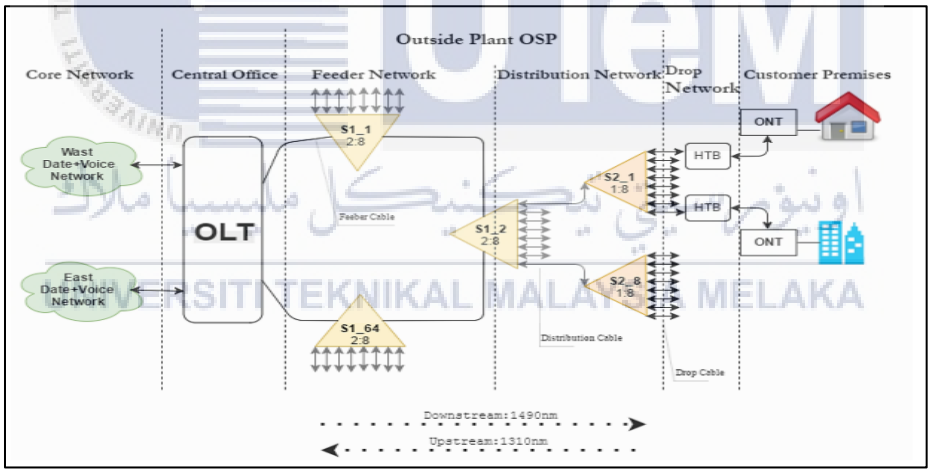

Figure 2.1 Basic architecture of FTTH

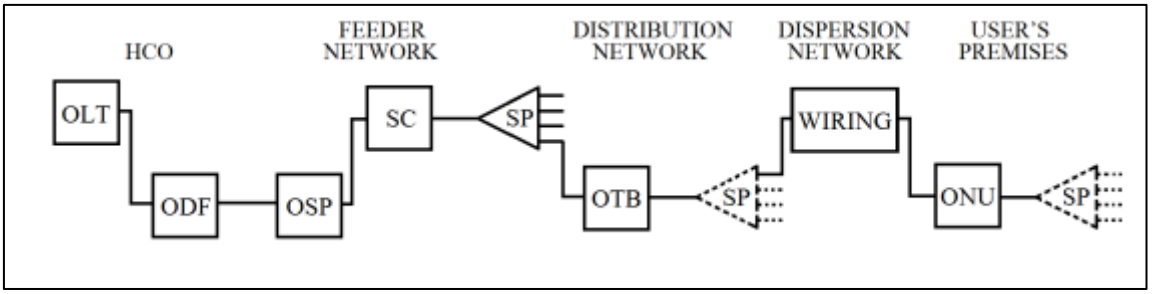

Figure 2.2 A FTTH network's basic structure is made up of five parts

2.3.1 Optical Line Terminal (OLT)

In a PON, the OLT is the endpoint unit, generally on the local exchange. The critical roles of the OLT are bandwidth allocation, buffer management and traffic scheduling [8].

2.3.2 Passive Optical Network (PON) Design

In recent years, PON architecture has become quite popular. For most Ethernet FTTH systems, the capacity to support prospective offers and the reliability of the business model are the two key considerations [9]. PON is a multi-point infrastructure that employs passive (non-powered) optical splitters and couplers to add fibre. All PON systems enable a single Optical Line Termination (OLT) on a central distributor unit linked through an individual port on the leading distribution unit to numerous subscriber terminals called Optical Network Units. Passive optical dividers are connected to a single OLT terminal using a single optical cable (a single fibre strand). The usual splitting ratio for each strand of a PON network is 1:32 or 1:64 [5].

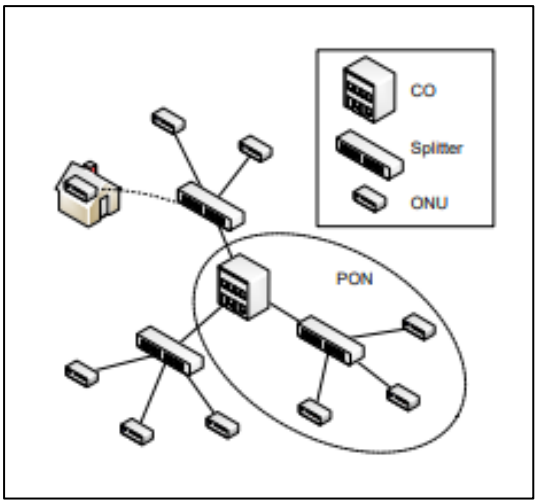

Figure 2.3 PON architecture

2.3.3 GIS Design

A GIS-based fibre tool enables a more accurate design of new fibre networks and easier maintenance of the linked infrastructure. The ideal communication options (wireless or cable), scheduling network architectures and target clients have been assessed using GIS. In GIS, we know three different ways: the database view, the map view and the model view [6].

GIS supports area analysis as well as the estimation of present and predicted future demand [10]. The design uses GIS data on the specified region of service, i.e., road segment digital maps and subscriber locations [11]. In addition, geographical data on the OLT, ONT linked to OLT, all fibre interconnect point (FPOI) placements, splitter points, connecting boxes, connectors and splits used for connecting to the ONTs are all part of the GIS data set [12].