DESIGN AND IMPLEMENTATION OF AN OPTICAL DISTRIBUTION NETWORK BASED ON MIKROTIK ROUTER AND OPTICAL LINE TERMINAL

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This Report in Partial Fulfilment of the Requirements for the Degree of Bachelor of Science in Electronics and Telecommunication Engineering.

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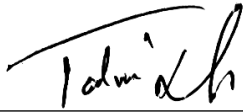Daffodil International University

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Approval

This Project titled "DESIGN AND IMPLEMENTATION OF AN OPTICAL DISTRIBUTION NETWORK BASED ON MIKROTIK ROUTER AND OPTICAL LINE TERMINAL'', submitted by Md. Rafid Bhuian ID: 181-19-2012. Mehedi Mahmud Ankon ID 181-19-2023 Most. Yeamin Tasnim Upoma ID: 181-19-2018 to the Department of Electronics and Telecommunication Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfilment of the requirements for the degree of B.Sc. in Electronics and Telecommunication Engineering (E.T.E) and approved as to its style and contents. The presentation has been held in January 2023.

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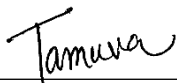Daffodil International University

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Declaration

We hereby declare that this thesis has been done by us under the supervision of **Md. Taslim Arefin, Associate Professor and Head**, Faculty of Engineering, Department of Electronics and Telecommunication Engineering (ETE) under my honorable supervisor. We also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for the award of any degree or diploma.

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This internship report is not consuming possible without the provision and direction of **Md. Taslim Arefin, Associate Professor and Head**, Department of Electronics and Telecommunication Engineering (ETE), Daffodil International University Dhaka. Under the direction I choose this subject, In the staff of the department of Electronics and Telecommunication (ETE) at the Daffodil International University. For the kind assistance and also to other faculty participants, must grant this for final internship with the partial support of my family members**.**

We would like to express our gratitude to him for his kind help and unwavering support in completing our thesis and also thank to other faculty member's department of Electronics and Telecommunication Engineering.

Dedication

To our parents and teachers who have sacrificed a lot for our education and helped us to become well human beings with all the attributes of our spiritual origin.

Abstract

High speed internet connectivity is one of the requirements of every home and every office. Now-a-days every home and office has also the requirement for high regulation cable television (HDTV) and Voice over Internet (VoIP) services. As all this service can be only provided through the help of GPON technology because the GPON technology support the triple play services. Using the Mikrotik router for controlling the layer 3 and GPON OLT for layer 2 management. Using VLAN for providing the different services through the same fiber and same ONU. GPON technology based on ATM (Asynchronous Transfer Mode) technology. As GPON has 2.5 Gbps Upstream and 1.25 Gbps Downstream in each PON and due to ATM (Asynchronous Transfer Mode) technology its support the dynamic bandwidth allocation which is suitable for huge traffic areas. Due to using the GPON the network infrastructure become simplified and flexible. GPON support 128 clients in each PON and the distance support up to 20 km.

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CHAPTER 1
Introduction

1.1 Introduction

There has been an ascension in web traffic thanks to the extraordinary use of internet services together with triple play Services and Cloud-primarily based Solutions, which have offered several new business opportunities to telecommunication operators like providing subscribers with added services (via triple play solutions such as internet, Voice and Video). several technologies are adopted to satisfy the necessity for top information measure however they're not taken into consideration as a result of longer-term growth is predicted for access networks. the information Centre has contended an important role in providing the infrastructure and services required for internet operations. the information Centre serves as a hub to access the net, permitting an operator to attach multiple networks and devices simultaneously. so as to supply the correct level of performance, network operators got to make sure that their network isn't overloaded, which may result in unplanned outages and lower revenue. the expansion of internet services has resulted during a demand for a lot of bandwidth, particularly for high-speed internet connections. thanks to the increasing demand from telecommunications corporations and different businesses, there has been a rise within the number of various applications that are victimization knowledge centers across all platforms. the quantity of applications using data centers has raised considerably over the previous few years thanks to increased demand for higher information measures and higher performance. so as to satisfy this increasing need, operators are forced to invest heavily in new servers and storage systems with high bandwidth needs in any respect times together with throughout peak times once a lot of bandwidth is required.

1.2 Motivation of Report

As the whole world is walking forward to the forth industry revelation which will be based on cyber physical space and ending the third industry revelation which is based on the IT, Electronics and Automatic production still we are try to improve our IT sector by providing a well stabilized and suitable network platform for the people of our country. Any network can be improved by implementing the latest an affordable technology. By implementing the Passive Optical Network in any existing network, the performance and the quality of the network can be improved in a dramatic way.

1.3 Objectives

The objective of this project is-

- To Design an Optical Distribution Network.
- To configure MikroTik router and configure the Optical Line Terminal.
- To implement the Optical Distribution Network.
- To improve the performance of the network.
- To improve the services quality in the network.
- To simplify the physical structure of the network.
- To provide multiple services through the single network infrastructure.
- To evaluate the proposed network.

1.4 Report Layout

- In first chapter Introduction, Motivation of Report and Objectives have been discussed.

- In second chapter the circumstances about this topic and details about this topic have discussed.

- In third chapter all the details information about the configuration of Mikrotik and OLT have been discussed.

- In forth chapter the final output and the improvement in the network have been discussed.

- In fifth chapter the proposed network has been evaluated.

- In sixth chapter the summary of the paper and the future scope have been discussed.

CHAPTER 2
Background

2.1 Finding the Problem

Innovative access technologies are dynamic in the recent means of accessing telecommunications services. In fact, not solely do establish users have a bigger variety of potential suppliers and technological choices but new interfaces and technologies let new users enter the market as allowed by restrictive authorities. This competition may stimulate original services which might be supported by freshly developed technologies. An awfully dynamic evolution within the style of access networks is secure nice edges to customers and therefore the industry. Telephony access networks appeared from the telephone's earliest days. They have been extended to reach the majority of businesses and homes in the world [1].

PON's application technology for supplying broadband connectivity in access network to small businesses commonly, multiple-occupancy units and homes is named fiber-to-the-x. This application is stand for the designation FTTx [2]. Optical fiber has nearly infinite bandwidth compare to the UTP or coaxial cable. This allows to have more user with high speed connectivity in any network. The by using UTP can provide up to 1000 Mbps in a distance of 100 meter. But the GPON network can reach up to 20 km with speed up to 1000 Mbps depending on the ONU. PON technology allows to connect multiple high-speed user up to 1000 Gbps using a single fiber cable.

Broadband network allows to use triple play services such as Television service, Telephone service and connection of Internet at a same time using a single fiber cable. By doing this it can dramatically reduce the price of any well stablished network and reduce the cost of service in any area. Using the ODN (Optical Distribution Network) allows to improve the redundancy over crosstalk and EMI (Electromagnetic Interference) and it also helps to create large network in low cost and make the operation in a small size and weight area. Optical fiber does not create any kind of crosstalk or EMF (Electromagnetic Field) as a result it can not be tapped in without destroying the fiber cable. After introducing the multicore fiber cable, its very hard to finding the proper core through which data may pass is nearly impossible.

As PON (Passive Optical Network) use light for transmitting data between any points it does not need any additional power or any repeater or any amplifier to boost the signal as like the ethernet network which can only provide connection in a short distance.

As there is no electrical power in the optical fiber so it completely eliminates the chance of getting shocked by electricity to any person who is working of who might touch the cable. Light can not travel a lot in the air media that's why optical fiber is used to carry the light to long distance and different wavelength light is used for transmitting and receiving 1310 nm and 1490 nm respectively.
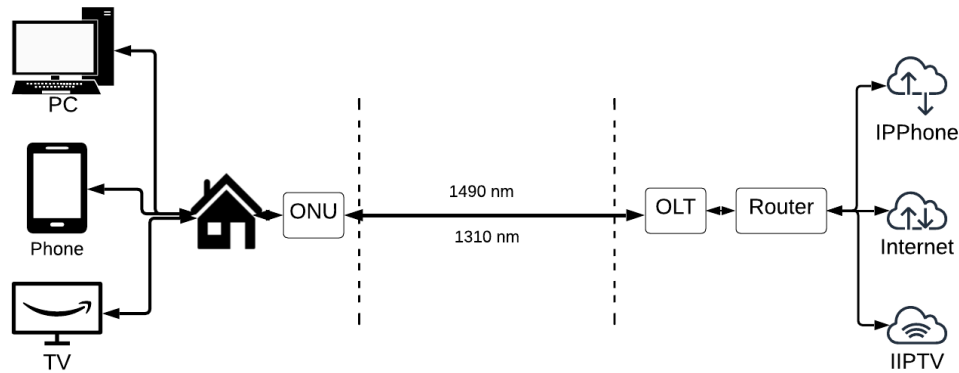

Figure 2.1 Point to Point optical access network

Nowadays, Broadband Access paradigm has witnessed exceptional growth and is an integral part of the daily lives of billions of people [3]. In recent years, the capacity of optical communication systems has increased exponentially in order to meet the demands of higher bandwidth for data traffic [4]. By the end of Q2 2022, the number of global fixed broadband connections grew by 1.34% and stood at 1.32bn [5]. Up 2020, traffic video represents 80% of almost all traffic IP over the world [6].

CHAPTER 3
Methodology
3.1 Schematic of the Network

Here is the schematic diagram of existing network has been showed. First, we will look at the network diagram,
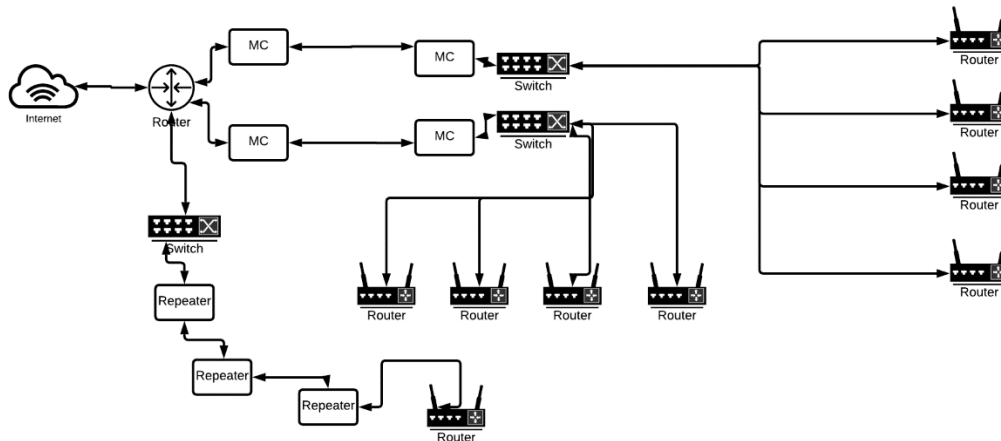

Figure 3.1.1 Existing Network diagram

There were many problems in the existing network, there were high delay in network, low throughput and low data transmission rate. As the UTP cable only can support a 1000 Mbps up to 100 meters distance and by the increase of distance the bit error rate increase and the latency also increase.

As the fiber optical cable has an unlimited bandwidth and it can transfer the data in speed of light, it is superior then the UTP cable. Due to using better protection against the environment it provides a long service life then the UTP. It uses the light to transfer the data so there is no need for any repeater or amplifier or signal booster like the UPT cable as a result it can travel a huge distance when used in any active optical network it can be used up to 100 km and in passive optical network it can be used up to 20 km.

By replacing the UTP cable with the fiber cable and the switch with the OLT. The new proposed network schematic is showed below,
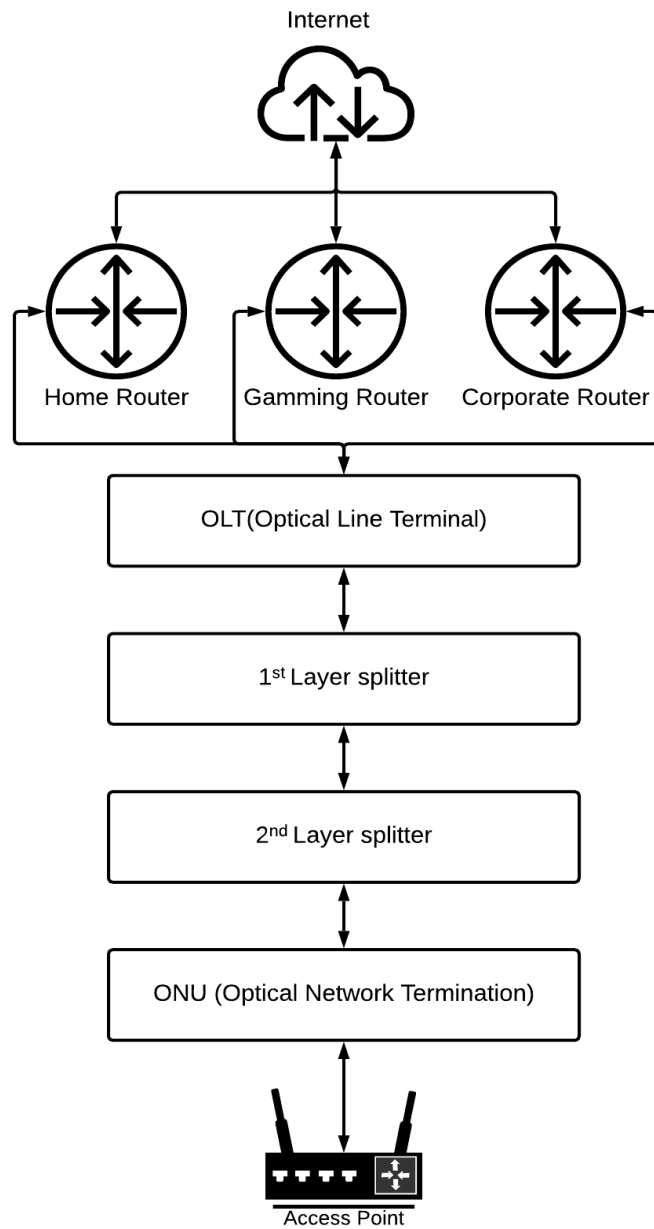

Figure 3.1.2 Proposed Network Diagram

The process includes, first configure the Mikrotik Router for connecting to the internet. Then we need configure the OLT (Optical Line Terminal) so that we can transmit the connection to the clients. Then fiber should be distribute using the 1st Splitter and then the splitter should be split again using 2nd splitter. Then using the ONU (Optical Network Termination) we convert the optical to the electric signal. From there the client can use any UTP (Unshielded twisted pair) cable to connect the ONU (Optical Network Unit) to any Assess Point and by using the Assess Point Client can connect to the internet.

3.2 Internet Connectivity in Worldwide

The world has changed due to the pandemic huge number of people has started to work remotely. For remote work all of them has to relay on the data and internet connectivity. In the Figure 3.2.1 number of internet user in some countries are given showed. All the data showed in the Table 3.2 in respect to years is millions of people used internet.

Table 3.2 number of internet user in some countries

| Year	United States	India	Brazil	Japan	France	South-Africa	Australia	Bangladesh
2015	242.01	197.11	119.68	115.87	49.78	29.01	20.14	54.11
2016	279.91	220.87	125.92	118.34	50.72	30.47	20.94	66.62
2017	287.82	246.46	140.68	116.18	51.64	31.81	21.28	80.48
2018	293.94	274.91	148.03	115.25	52.74	35.78	21.88	89.1
2019	298.98	406.63	156.53	116.65	53.57	39.62	22.47	99.43
2020	305.37	600.45	173.42	113	54.68	41.16	23	111.87
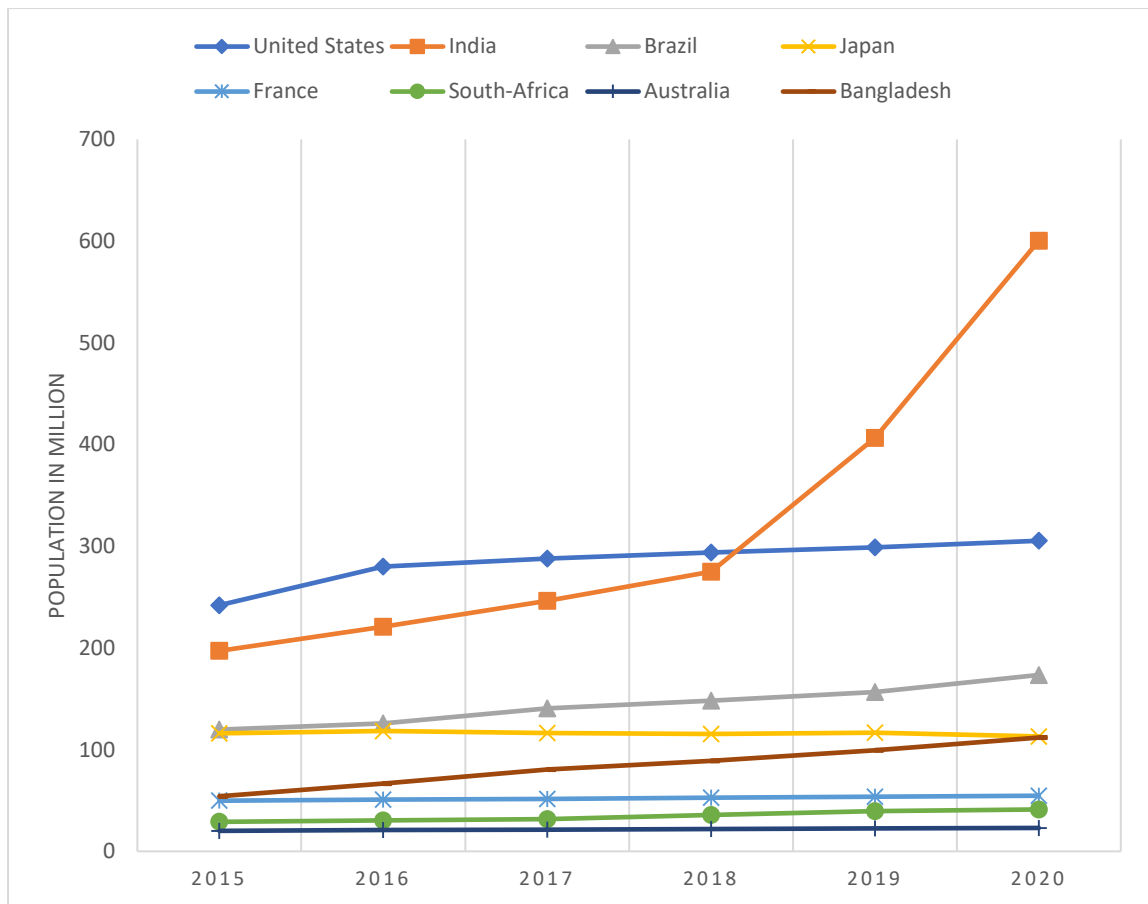
Figure 3.2.1 Number of Internet user in different countries

The chart shows number of Internet user in different country of the world which include USA, India, South-Africa, Australia as well as Bangladesh. This can show the improvement of Data and Internet connectivity all over the world since 2015. Bangladesh has improved a lot during this time, it has a higher number of Internet user than the Australia, France and South-Africa.
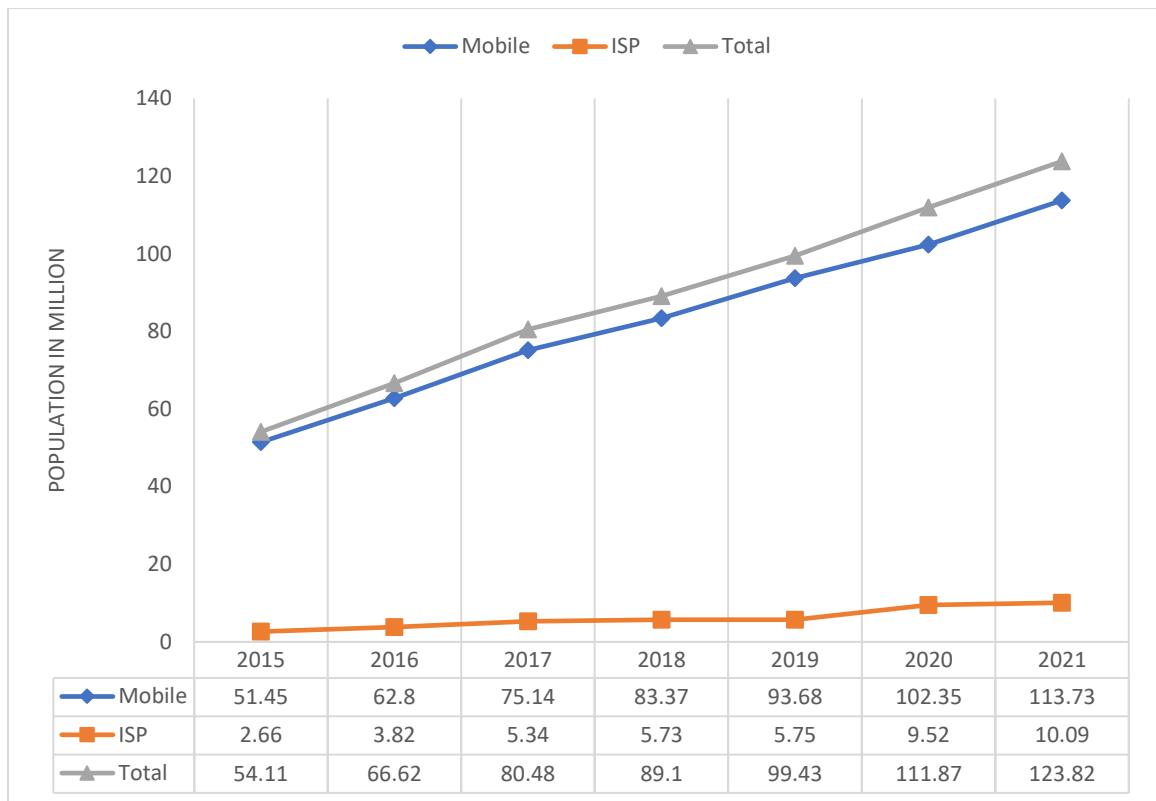
	2015	2016	2017	2018	2019	2020	2021
Mobile	51.45	62.8	75.14	83.37	93.68	102.35	113.73
ISP	2.66	3.82	5.34	5.73	5.75	9.52	10.09
Total	54.11	66.62	80.48	89.1	99.43	111.87	123.82

Figure 3.2.2 Number of Internet user in Bangladesh

Huge number of people are using broadband connection in the world. This refers to fixed subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s [7]. Bangladesh has a huge number of ISP. The total number of Internet Subscribers has reached 103.253 Million at the end of March, 2020 [8].

3.3 Mikrotik Configuration

Mikrotik is a software company which is one of the lead manufacturer of networking component and software. Their one of the best components is Mikrotik Router and which is used worldwide for its user-friendly operating system. This allows the company to produce one of the best routers which can control the network. For our project we have chosen a CCR (Cloud Core Router). The model is CCR1036-12G which has 8GB RAM and 36-core processor that can handle a huge number of client and it's a power efficient router.

To configure the Mikrotik router first we need to power up the device and by using the and then we need to connect to the Mikrotik using the UTP (Unshielded twisted pair) cable from any ethernet port of the Mikrotik to the ethernet port of Laptop or any PC (Personal Computer). Then using the WINBOX software from the Laptop or PC (Personal Computer) we can connect to the Mikrotik Router.
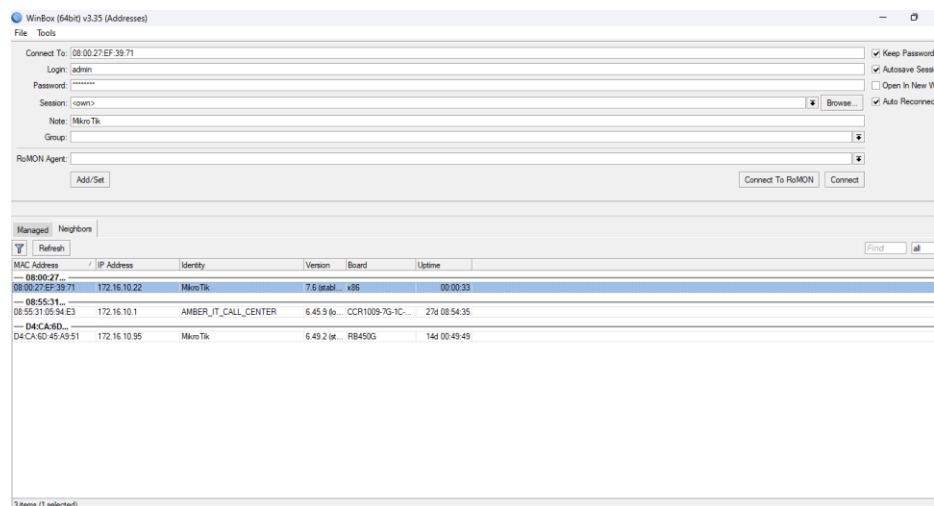

Figure 3.3.1 Winbox Interface

Now to configure the Mikrotik first we need to connect the Uplink cable to any of the ether port but we have selected the Ether 1 port as our Mikrotik's uplink port. The configuration process is showed in the Figure 3.2.2 and the configuration steps are given below.

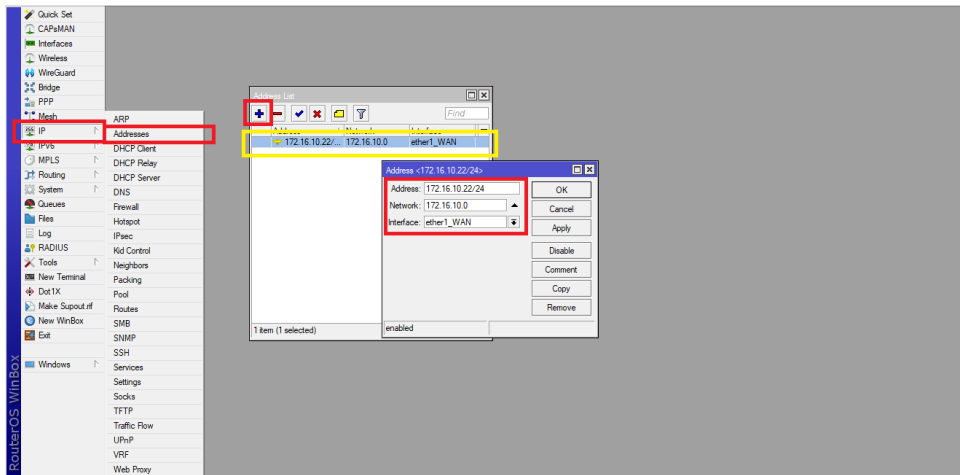IP→ Address → "+" → Provided IP address →interface (WAN) → OK

Figure 3.3.2 Mikrotik's Uplink Configuration

After that we need to configure the gateway through which all the traffic of the router will pass through. The configuration steps are given below,
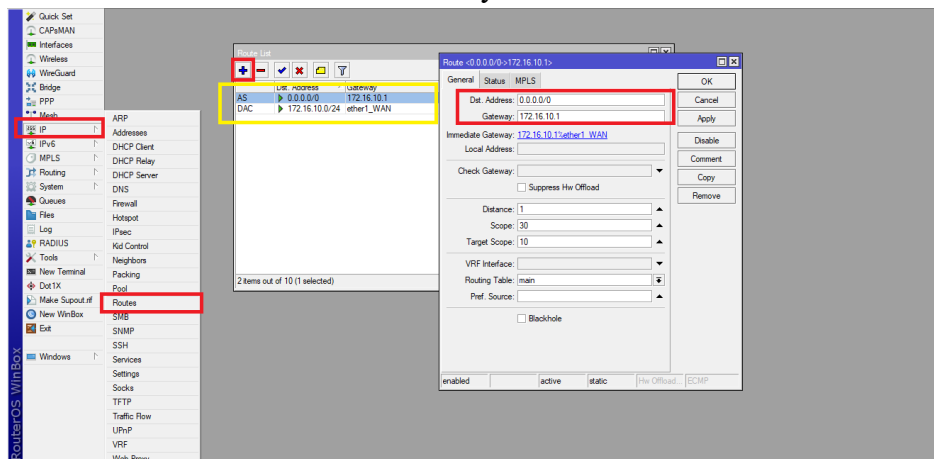
IP → Routes → "+" →Provided IP Gateway

Figure 3.3.3 Mikrotik's Gateway Configuration

We know privet IP cannot get internet to get internet it needs helps from any Public IP. For this we need to connect to the Public IP to Privet IP this process is also known as the NAT (Network Address Translation). NAT allows multiple IP to any single or multiple IP addresses. With multiple IP addresses, it is possible to connect to any organization anywhere in the world, while still being able to access data to your data center at home. The benefit of using multiple IP addresses is that it allows you to connect to any organization anywhere in the world and still be able to access data to your data center at home. The process of NAT is showed in the Figure 3.2.4 and explained below,

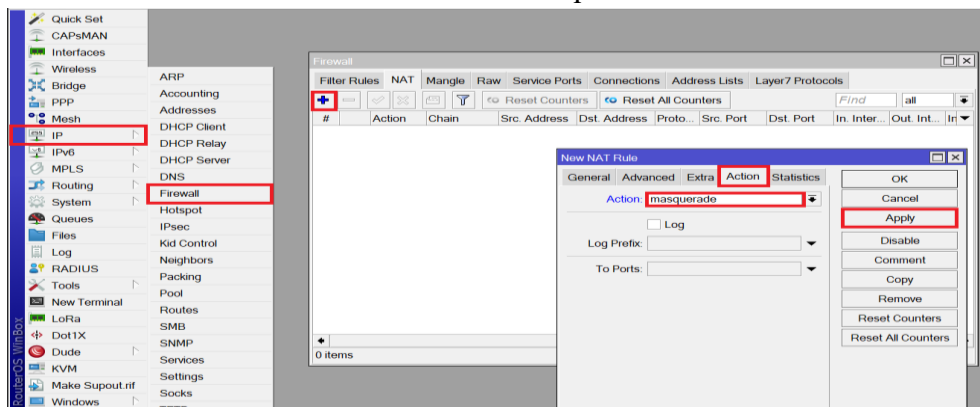IP→ Firewall → NAT →"+" → Action → masquerade → OK

Figure 3.3.4 NAT Configuration

NAT can be two types Static NAT and Dynamic NAT. When a single IP is connected to any single IP is known as the Static NAT. When we connect multiple IP to any single IP that's called Dynamic NAT. We can NAT any public IP to Public IP or Privet to Public IP or Privet IP to Privet IP. Generally, after applying the NAT rules all the connected IP of that router will get connected to the Internet. At that stage we can connect to the internet but we cannot browse the internet as we don't know all the IP of the website. For converting the website name into the website IP we need to sate up the DNS (Domain Name System). The DNS (Domain Name System) process is showed below,
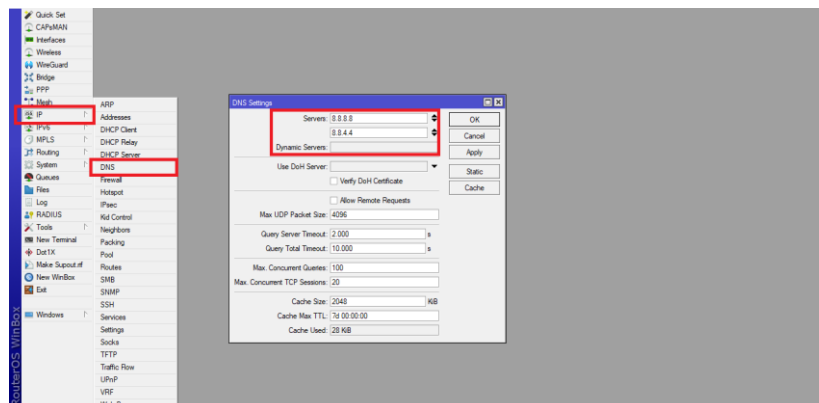

Figure 3.3.5 DNS Configuration

At this stage we can ping from the Mikrotik to the DNS server IP and then we will get the Ping return. This means the physical and the logical path from the IIG (International Internet Gateway) to our Mikrotik is clear. If there is no ping return then we have to check and solve the upper stage. Those stapeses are for Mikrotik's uplink configuration or WAN configuration.

As we configure the Mikrotik's Uplink now we will configure the Mikrotik's downlink from where the OLT will be connected and later it will be distributed to the clients end. For downlink configuration we will chose any of the ether port and then we will plot any IP to that port. Then we will plot the IP to that interface. The configuration process is showed in the Figure 3.2.6.

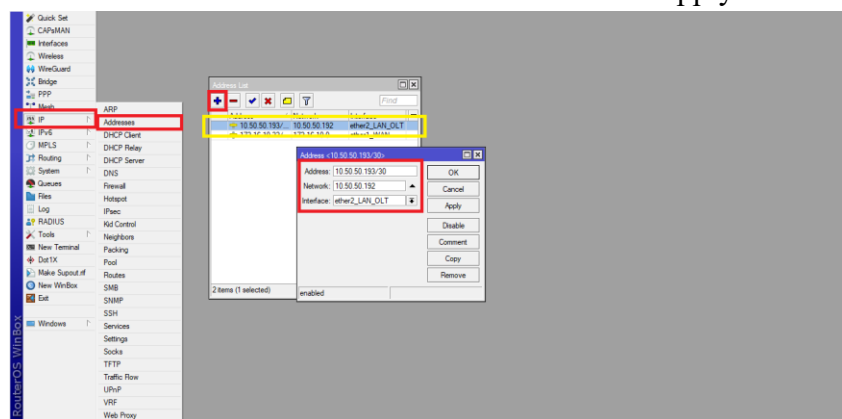IP→ Address→ "+" → enter IP address →chose Interface→ apply

Figure 3.3.6 Downlink Configuration

3.4 OLT configuration

We will use the OLT (Optical Line Terminal) for connecting clients over a distance of up to 20 km. We use GPON (Gigabyte Passive Optical Network) OLT (Optical Line Terminal) as by using this we can use multiple services over the same line. We need to plot the management IP in the in the PC's ethernet port and then connect the ethernet port to the OLT's management port using UTP (Unshielded twisted pair) cable and then ping to the IP there will be return as showed in the Figure 3.3.1.
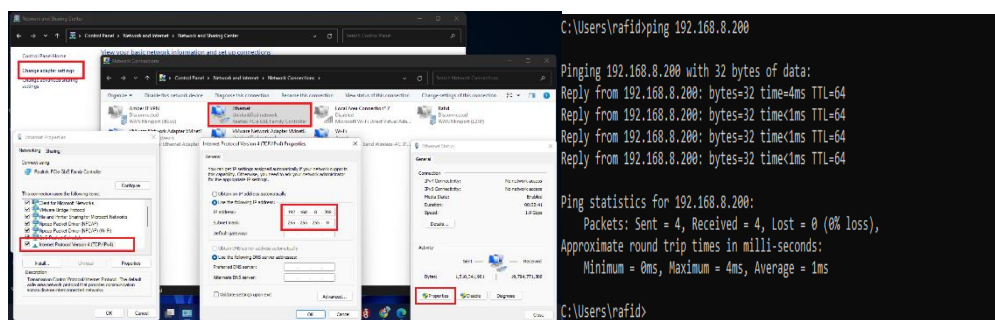

Figure 3.4.1 OLT point to point connection

Now using the provided username password login to the OLT (Optical Line Terminal) and then change the name to the desire name as we changed it to TEST_GPON_OLT.


```
Test_GPON_OLT(config)#
Test_GPON_OLT(config)# interface vlan 1
Test_GPON_OLT(interface-vlan-1)#
Test_GPON_OLT(interface-vlan-1)#
Test_GPON_OLT(interface-vlan-1)# ip address 10.10.5.2 255.255.255.252
Test_GPON_OLT(interface-vlan-1)#
Test_GPON_OLT(interface-vlan-1)#
Test_GPON_OLT(interface-vlan-1)#
Test_GPON_OLT(interface-vlan-1)# ex
Test_GPON_OLT(interface-vlan-1)# exit
Test_GPON_OLT(config)#
```

```
Test_GPON_OLT(config)#
Test_GPON_OLT(config)# ip route 0.0.0.0/0 10.10.5.1
Test_GPON_OLT(config)#
```

```
Test_GPON_OLT(config)#
Test_GPON_OLT(config)# vl
Test_GPON_OLT(config)# vlan 100 - 150
Test_GPON_OLT(config)#
```

```
Test_GPON_OLT(config)#
Test_GPON_OLT(config)# in
Test_GPON_OLT(config)# interface gi
Test_GPON_OLT(config)# interface gigabitethernet 0/5
Test_GPON_OLT(config-if-ge0/5)# sw
Test_GPON_OLT(config-if-ge0/5)# switchport t
Test_GPON_OLT(config-if-ge0/5)# switchport mo
Test_GPON_OLT(config-if-ge0/5)# switchport mode t
Test_GPON_OLT(config-if-ge0/5)# switchport mode trunk
Test_GPON_OLT(config-if-ge0/5)# sw
Test_GPON_OLT(config-if-ge0/5)# switchport t
Test_GPON_OLT(config-if-ge0/5)# switchport trunk a
Test_GPON_OLT(config-if-ge0/5)# sw
Test_GPON_OLT(config-if-ge0/5)# switchport t
Test_GPON_OLT(config-if-ge0/5)# switchport trunk v
Test_GPON_OLT(config-if-ge0/5)# switchport trunk vlan
  <1-4094>  VLAN ID of the VLAN when this port is in trunk mode.
Test_GPON_OLT(config-if-ge0/5)# switchport trunk vlan 100 - 150
Test_GPON_OLT(config-if-ge0/5)# com
Test_GPON_OLT(config-if-ge0/5)# ex
Test_GPON_OLT(config-if-ge0/5)# exit
```

```
Test_GPON_OLT(config)#
Test_GPON_OLT(config)# profile onu id 10 name D401
profile_id:10 create success
Test_GPON_OLT(profile-onu:10)# port-num eth 4
Test_GPON_OLT(profile-onu:10)# commit
Commit ok.
Test_GPON_OLT(profile-onu:10)# ex
ex-omci    exit
Test_GPON_OLT(profile-onu:10)# ex
Test_GPON_OLT(config)#
```

```
Test_GPON_OLT(config)#
Test_GPON_OLT(config)# profile dba id 10 name 1GE
profile_id:10 create success
Test_GPON_OLT(profile-dba:10)# type 3 assured 1024 maximum 1024000
config DBA profile success.
                    Test_GPON_OLT(profile-dba:10)# commit
Test_GPON_OLT(profile-dba:10)# exit
Test_GPON_OLT(config)#
```

Figure 3.4.2 OLT Configuration

In the Figure 3.3.2 we have configured the OLT (Optical Line Terminal). There we have configured the OLT (Optical Line Terminal) in static way where we have plotted the IP in one VLAN interface. Through this IP OLT (Optical Line Terminal) and the Mikrotik will communicate with each other. Then we have created a VLAN from the downlink through which clients will communicate with the OLT (Optical Line Terminal). Then we have allowed the VLAN to the uplink Port of the OLT (Optical Line Terminal). We have created the dBa profile for bandwidth control from the OLT (Optical Line Terminal) and then ONU profile for defining the maximum ONU ether port allows in the OLT (Optical Line Terminal).

Figure 3.4.3 ONU Configuration

We can configure the ONU (Optical Network Unit) automatically and manually but we have chosen the manual process as this increase the work process also the security and its helps to maintain the OLT (Optical Line Terminal) processor uses low. This also make the troubleshoot easier as the administrators can identify each client by its service and by any other identification number. In the Figure 3.3.3 ONU configuration is showed.

3.5 Client Management

A virtual LAN is a type of network that is created to connect computers and servers in different locations. It is often used for shared computer resources such as printers and storage space. The main purpose of a virtual LAN is to allow users to connect to a server from anywhere in the world. This allows users to share files and data, such as web pages, with friends and family members. For different client we can use different VLAN or we can use same VLAN for same types of services clients. For each PON of the OLT (Optical Line Terminal) we use 2101 to 2108 VLAN respectively for the Home clients for the gaming clients we used 2151 to 2158 VLAN respectively. For the corporate clients and others services we used all others VLAN. As VLAN reduce the latency and incise the security of any network. The VLAN configuration process is shown in the Figure 3.4.1.

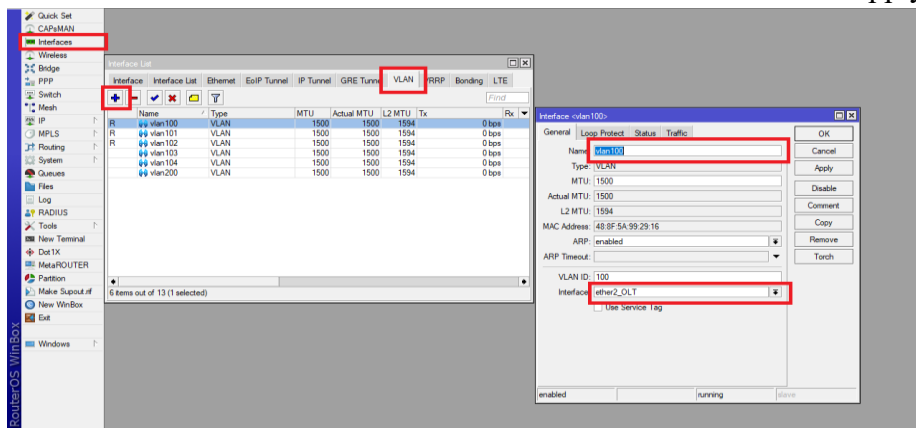Interface→ VLAN→ "+" → VLAN100→ VLAN ID 100→ interface → apply

Figure 3.5.1 VLAN Configuration

Ethernet is a large, uninterruptible electrical network used for remote management and connections between hosts. It is a highly scalable network that can be designed to handle multiple simultaneous connections. With the use of a Point-to-Point Protocol over Ethernet (PPPoE), you can connect up to four devices to a single computer and manage them as one. This can be used for remote access, file management, or as a corporate data center. With PPPoE, you don't have to worry about providing power to each device or install a plug in so there is no need to purchase a separate power supply. The process is shown below,

PPP → Profile → "+" → Local (Private IP); DNS (given or 8.8.8.8); Remote Address (IP Pool) → limit (only one) → OK
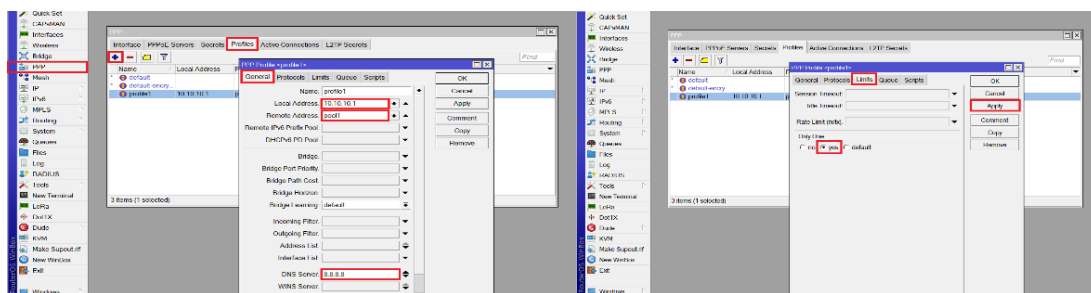

Figure 3.5.2 PPPoE server Configuration

PoE is a protocol for connecting devices to power supplies. It is a network protocol that uses a device's power supply to provide power to the device. This allows devices to be powered on and off without having to touch the wall. The connection can be made by using a cable or an Ethernet connection. In order for a device to connect, it must have the right configuration and software installed on it. The software typically consists of drivers that are installed on the device itself. The driver is then configured in the device's settings. Once the driver is installed, it is ready to connect and use with the device. The PoE connection can be used in many different situations, such as powering up computers or other devices when they are connected through USB ports, or powering up laptops when they are connected through Ethernet ports. PPPoE secrets allows clients to connect to internet through Mikrotik. The Mikrotik IPsec protocol is an encryption protocol based on the IPsec protocol. It allows clients to connect to the internet through a public network, such as the internet. The Mikrotik IPsec protocol is a secret protocol that is used by many applications. It provides secure communication between clients and servers. This means that it can be used for file-sharing, file-sharing services, and other purposes. It also provides authentication and authentication services for applications such as apps, web browsers, and mobile devices. One of the main uses of Mikrotik IPsec is file sharing and file-sharing services. This is because it can be used to share files over the internet without having to worry about security or privacy issues.

File-sharing services such as Dropbox, Google Drive, and others can be used to share files between users without having to worry about security or privacy issues. Files can also be shared using other applications such as Google Drive or Dropbox, which are secure storage solutions available on all major platforms including Windows, Mac OS X, Linux, Android, iOS, and BlackBerry devices. The PPPoE secrets configuration is showed in Figure 3.4.3.
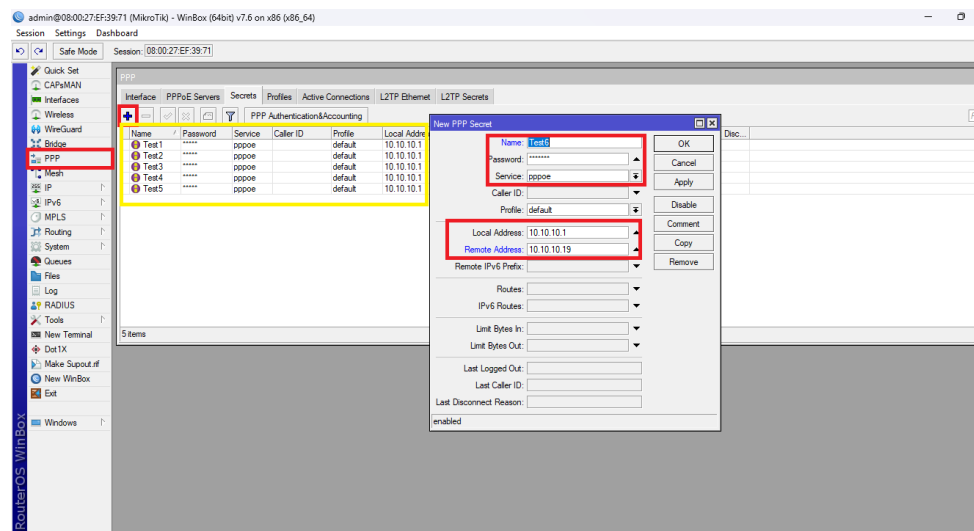

Figure 3.5.3 PPPoE Secrets Configuration

Here Local IP will be the gateway and the Remote IP will be the clients IP. Both IP is needed as the remote IP can be used for client identification. Which helps us to monitor the traffic as per the LAW. The local IP is needed for connecting the client right direction or the right port as its name suggest that it works as the gateway.

Bandwidth is not just about the transfer of data. It is also about the transfer of information. When an individual post a link to a website, that link is interpreted as a request for additional information, and data is sent back to the website. The website then sends back a response with additional data and information, this time in the form of a link. The website owner then receives a traffic update and changes its algorithms accordingly.

Per Connection Queue (PCQ) is a queuing discipline that can be used to dynamically equalize or shape traffic for multiple endpoints. When used with a security service, it is used to limit connections to approved users. When used with an application, it is used to limit requests to authorized users. t is a key piece of the overall network architecture and is most commonly used for traffic sharing between different parts of the network.
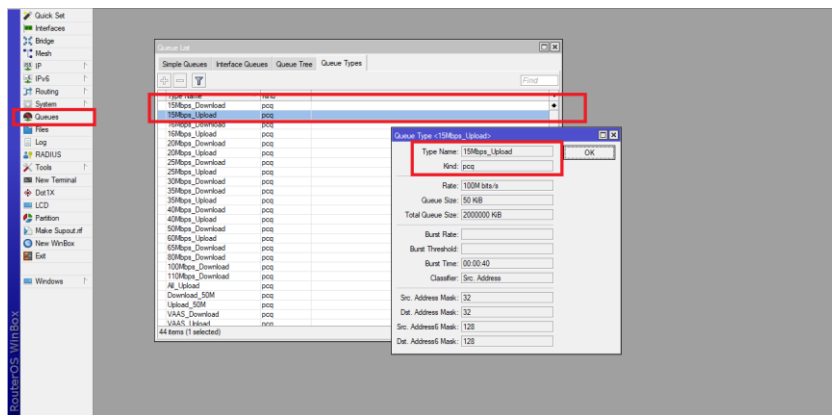
Figure 3.5.4 PCQ Configuration

We can directly apply the PCQ to any clients IP to control his/her bandwidth or we can apply to the whole block of IP to control. By this way we can manage the whole bandwidth more efficiently and more productively. Which helps to maintain the traffic more efficiently that's helps clients to use internet uninterrupted. The simplest way to limit data rate for specific IP addresses or subnets is to use simple queues where the entries are filled only when the state of the queue changes. For example, if you have many websites and you want to limit the number of requests to a certain website, you can create a simple website-side queue and assign it the task of handling all the requests to that website.
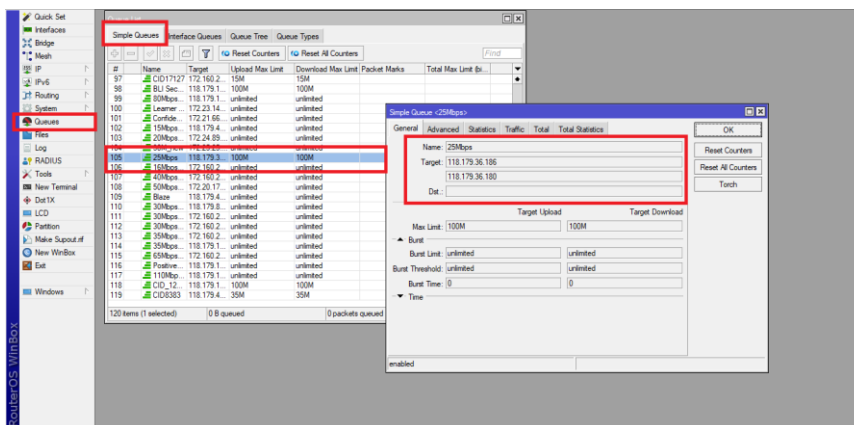

Figure 3.5.5 Simple queue Configuration

In simple queues we can apply an amount of bandwidth for a specific IP block or a huge number of IP block. Peer-to-peer bandwidth traffic queuing is the process by which people try to transfer data as quickly as possible. We're all consumers of bandwidth, and we need to balance that with responsible use of bandwidth. The best policy for every aspect of your organization's content and communications strategy will depend on your specific circumstances. Peer-to-peer queuing can be a serious concern for a large portion of the public, particularly when bandwidth is limited.

3.6 Physical Layout and Component

The physical layout will be the fiber cable between the office to the client ends. In that path we used the fiber cable and PLC splitter for the distributing the fiber to the clients. In Figure 3.5.1 the network layout with two stage splitting is showed.
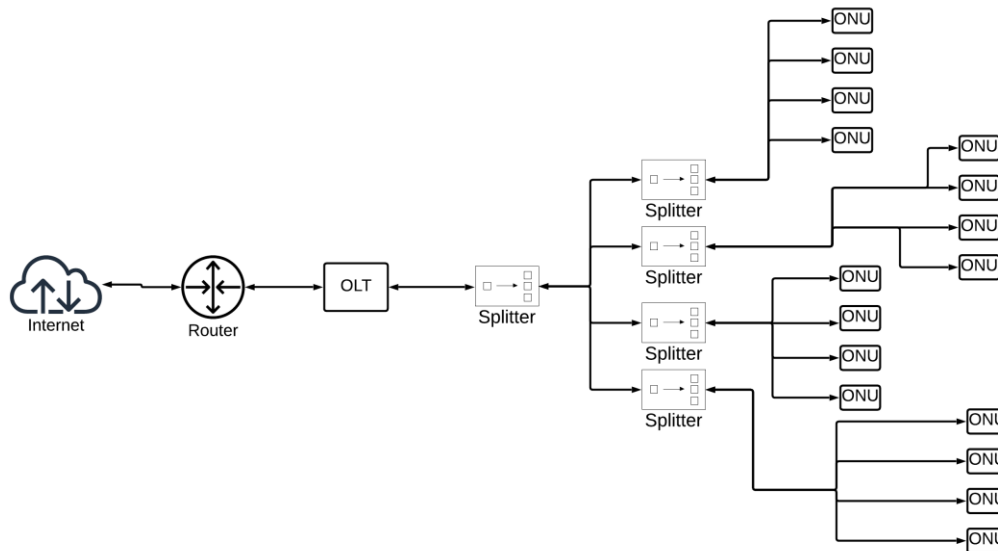

Figure 3.6.1 Complete Network layout

Each OLT has 4 to 8 PON depending on the manufacturer. We have chosen 8 port GPON OLT with 128 client capacity per PON. As we need to use different types of splitter for reaching 128 clients. We can use 1:8 splitter and then 1:16 PLC splitter. The FBT splitter uses two (or more) fibers. The upper layer of fibers is removed. Both fibers are stretched simultaneously under a heating zone, creating a double cone. This special waveguide structure allows control of the splitting ratio by controlling the length of the twist angle and the stretching of the fiber. The FBT Splitter includes common low-cost materials (quartz substrate, stainless steel, fiber, seedbed, GEL) and an adjustable split Ratio. However, its losses are wavelength dependent, it offers poor spectral uniformity, it cannot guarantee uniform spectroscopy, and it is temperature sensitive. The PLC splitter is a micro-optical element that uses photolithographic techniques to form an optical waveguide a medium or semiconductor substrate to perform the function of branch distribution. The losses of the SPS splitter are independent of wavelength, the spectral uniformity is greater, and it is more compact and inexpensive and effective with higher degrees of division. However, the manufacturing process of the device is more complex.

Table 3.6 dBm loss by PLC and FBT splitter

Type	Splitting Ratio	dBm Loss
PLC	1:2	3.6
	1:4	6.8
	1:8	10.3
	1:16	13.5
	1:32	16.8
FBT	50|50	3.2|3.2
	25|75	6.2|1.5
	5|95	13|0.42
	50|25|25	3.2|6.2|6.2
	80|10|10	1.2|10|10
	25|25|25|25	6.2|6.2|6.2|6.2

When we subtract the total splitter loss and fiber dBm loss from the PON module dBm then we will get the client end dBm. As standard we know the dBm loss of fiber optic is -0.5 dBm per kilometer.

Client dBm = PON module dBm - (Total splitter dBm loss + total fiber dBm loss) – fiber coupling loss

It is the optical terminal in the fiber access network that provides users with multiple service interfaces. The network side of the ONU is the optical interface. The user side is the electrical side. Interface Therefore, ONU can convert optical signals into electrical signals and vice versa.

Figure 3.6.2 ONU

A fiber cable has mainly three-part Core, Cladding and Coating. The central part which is made of doped silica. The cladding is the first protective layer around the Core it also made of silica but it prevents the light from escaping the core. The coating is made of polymer which prevent the cladding the from the weather. The fiber is mainly two types single core fiber and multi core fiber. The single mode fiber's core is narrow as a result it allows only a single laser. In the multi-mode fiber's core is wider then the single mode fiber because it allows multiple laser to pass through at the same time.

CHAPTER 4
Data Collection and Analysis
4.1 Data Collection and Analysis

1Year data uses graph of an EPON OLT is showed in the Figure 4.1.1.

This graph shows total uses clients that are connected through the EPON OLT. This means, the data are collected after a certain time-interval and then the plotted in the graph.
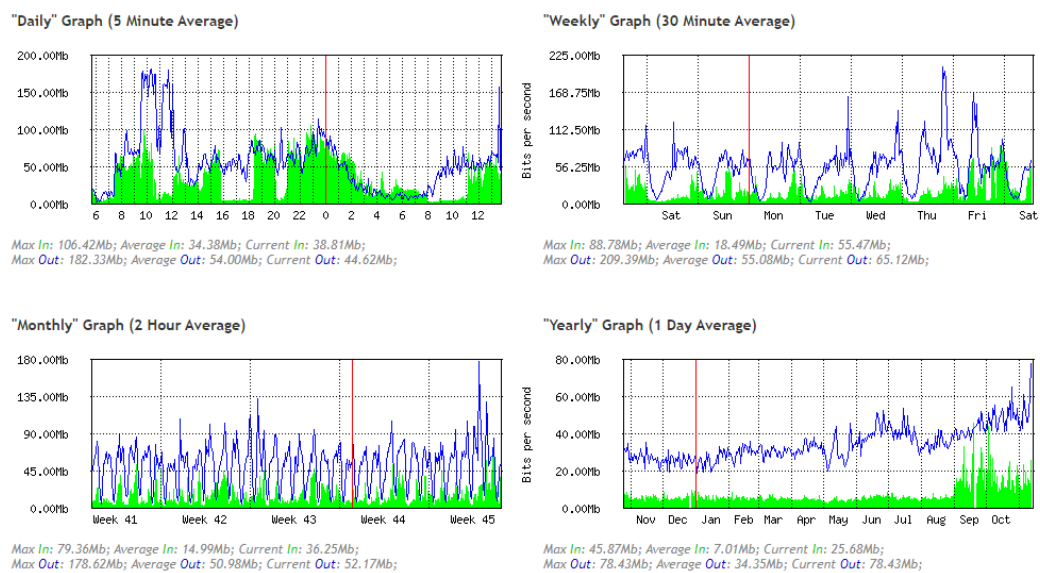

Figure 4.1.1 EPON OLT data used graph

The Daily graph shows data used in 24 hours times all the data is collected after 5 minutes interval. We take data usages after every five minute and then plotted the data in graph. By this graph we can easily find out the max usages and the pick hours. In this graph we can see that max upload speed reach its peek during the time of 10 am to 12 am. Then the max download speed reaches its peek during the time of morning 8 am to 10 am then in evening 6 pm to 8 pm and at night 9 pm to 1 am.

The weekly graph shows that during which days in week we can expect the maximum network load, all the data is collected after 30 minutes interval. As we know during the normal holidays people stay at home and this means we can expect high network load then the normal days. The graph shows that during the Friday and Saturday there is more download and upload during those days. As many people are at home and they all are browsing internet at the same time.

The Monthly graph shows that during which period of month any problem has happened and this allows us to find the work on that problem so that we can prevent that problem from happening next time. In the graph we can observe that at the end of each week there is a huge spike in download and upload graph which means all the holidays has maximum bandwidth usages.

The yearly graph shows that average use of bandwidth in a year all the data has been collected at 1-day time interval. By this graph we can understand that the usages of bandwidth throughout the years. At the last end as the number of clients increased the download and upload speed respectively.

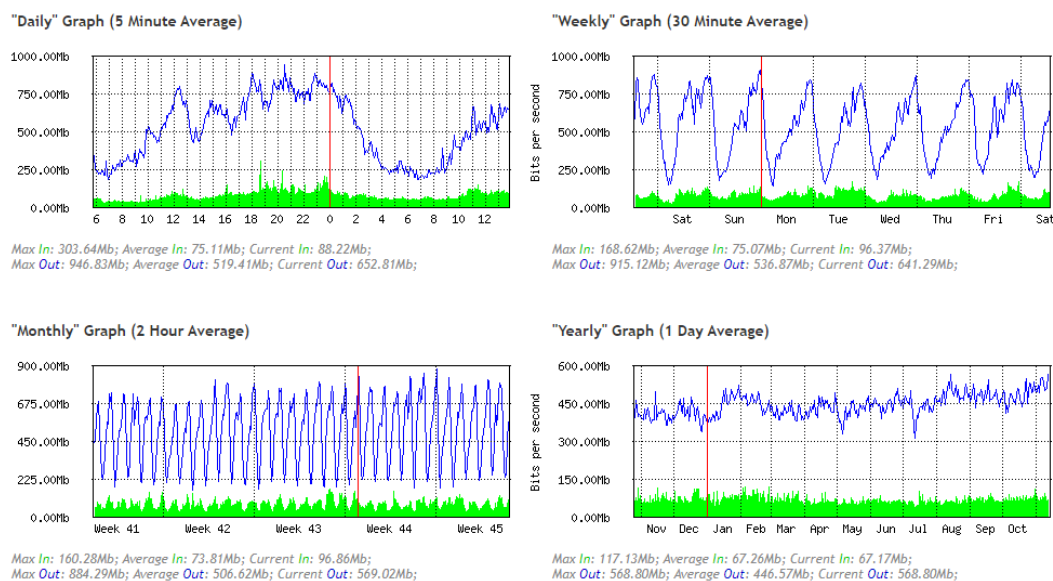1 Year data uses graph of a GPON OLT showed in the Figure 4.1.2.

Figure 4.1.2 GPON OLT data used graph

In the graph the data has been collected in a time period of 1 years and for the different graph different time interval have been selected and the then plotted in the graph.

In the Daily graph is consisted of all the data used in the period of 24 hours time with an interval of 5 minutes. We can see that there is only a slight down of upload speed during the time of 4 am to 8 am. As GPON can provide multiple services at a same time that means the speed will be always high as long as there is any service running. As now-a-days many people work late night that's the main reason for high data traffic.

In the Weekly graph is consisted of all the data used in the period of 1-week time with an interval of 30 minutes. As there is running the multiple services the daily speed differentiates between the 250 Mbps to 750 Mbps.

The Yearly graph shows that the uses have increased as the time pass number of clients increased and the total uses also increased. The data has been collected in a time interval of 1 day. This allows to find any problem in the network uses and then solve the problem as soon as possible and prevent it from future. This will help to improve the network and also improve user experience.

After comparing the both graph we can clearly understand that GPON OLT and Mikrotik with two stage PLC splitter ODN network perform well in the network.

4.2 Comparison between EPON and GPON

EPON is less costly then the GPON. As the EPON OLT has less features then GPON OLT and depending on the manufacturer they may provide some feature such as ONU monitoring, ONU LAN port monitoring, ONU LAN side MAC, ONU dBm check.

But GPON has the higher security then the EPON. As the QoS (Quality and Security) is high in the GPON. As GPON support ATM and in ATM the data is send and received at the same time.

In GPON we can use multiple services at the same time, such as IP-Phone, IP TV, VOIP and internet over same connection. But which is not possible in the EPON OLT. OAM (Operate and Maintain) in the GPON OLT the is Loop detection, Error monitoring, Data Encryption and Status monitoring. But in the EPON same of the feature are complimentary such as loop detection and status monitoring.

EPON uplink downlink both speed 1 Gbps and GPON uplink 2.5 Gbps downlink 1.25 Gbps. This means the huge different in the client's end serves. The number of clients will be high in the GPON then the EPON as the downlink speed is high and this also means the clients can get huge data package.
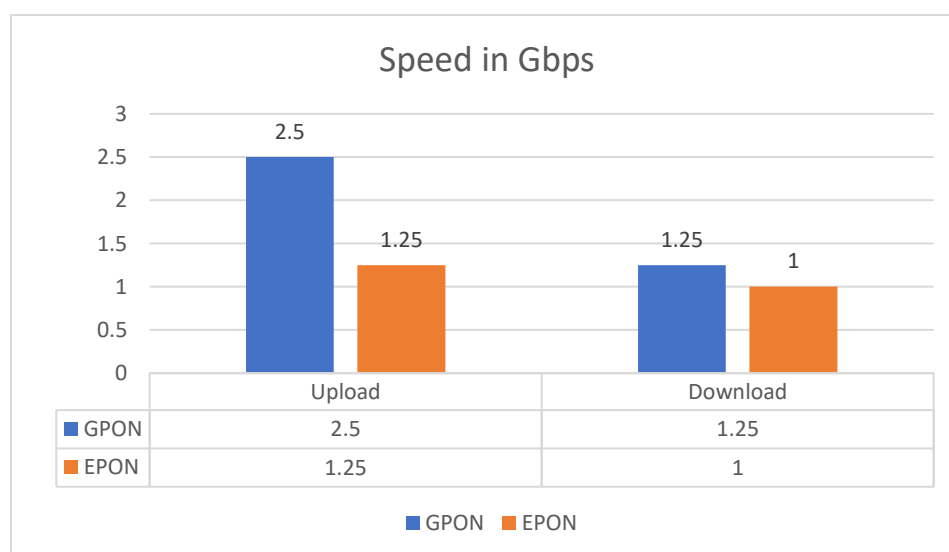

Figure 4.2.1 EPON GPON OLT upload and download speed

In the chart we can see that there is a huge change in the Upload speed of GPON OLT then the EPON OLT. Compare to the EPON technology's 1.25 Gbps upload speed GPON technology have 2.5 Gbps which is 100 present improvement of upload speed in the GPON technology. There is also improvement in the download speed in EPON technology there is only 1 Gbps download speed on the other hand there is a slight improvement in the GPON technology which is 1.25 Gbps. This means there is only 25 present improvement in the GPON technology download speed. This changes along with the ATM improve the client's services.
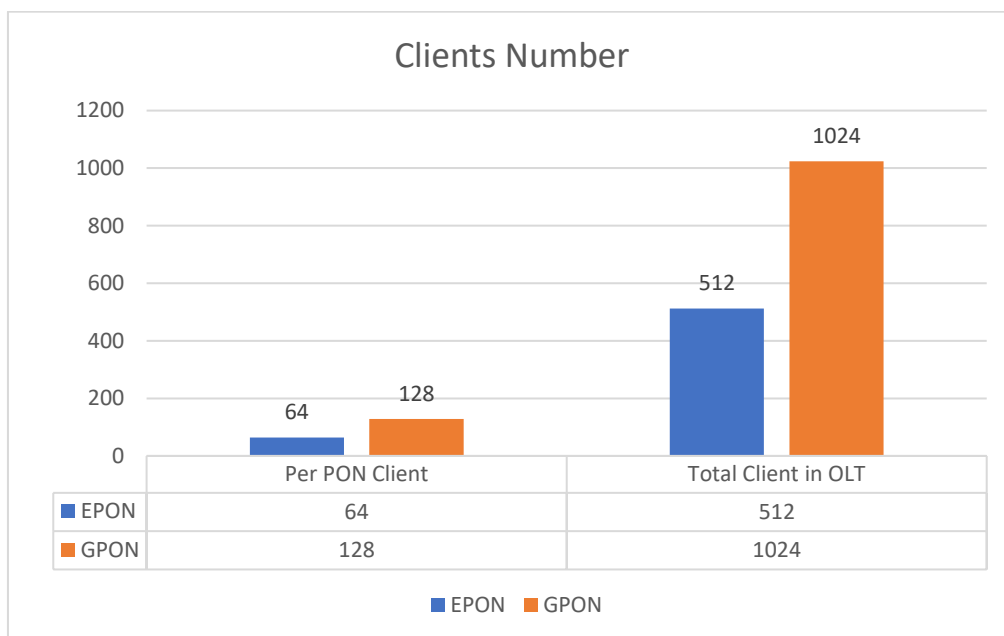

Figure 4.2.2 EPON GPON OLT client number comparison

In GPON OLT in each PON there will be up to 128 clients and EPON OLT in each PON there can be only 64 clients and which is 50 percent less than the GPON OLT. This different increase as the number of PON increase, for 8 port EPON OLT total client will be 512 and for 8 port GPON OLT total number of clients will be 1024 clients. This is also the 50 percent different, this means one GPON OLT can handle twice the number of client then the EPON OLT. In other word one GPON OLT can accommodate two EPON OLT's clients.

Table 4.2 EPON and GPON Splitter Comparison

Type	Splitting Ratio	EPON	GPON
PLC	1:2	Yes	Yes
	1:4	Yes	Yes
	1:8	Yes	Yes
	1:16	Yes	Yes
	1:32	Yes	Yes
	1:64	Yes	Yes
	1:128	No	Yes
FBT	50|50	Yes	Yes
	25|75	Yes	Yes
	5|95	Yes	Yes
	10|90	Yes	Yes
	50|25|25	Yes	Yes
	80|10|10	Yes	Yes
	25|25|25|25	Yes	Yes

The above table shows that EPON OLT support all types of PLC and FBT splitter except the 1:128 PLC type splitter. As the number of max clients in EPON OLT is 64 in per PON. So, its not possible to use 1:128 PLC splitter in EPON OLT. But in GPON OLT all types of PLC and FBT splitter can be used. EPON supports 1:2 1:4 1:8 1:16 1:32 and 1:64 splitter but GPON support 1:2 1:4 1:8 1:16 1:32 1:64 and 1:128 splitters. This means the number of clients increase per PON. GPON client's number 128*8 EPON client's number 64*8.

If we bring all the all the different data of EPON OLT and GPON OLT and plot it into the graph. The graph is showed in the Figure 4.2.3.
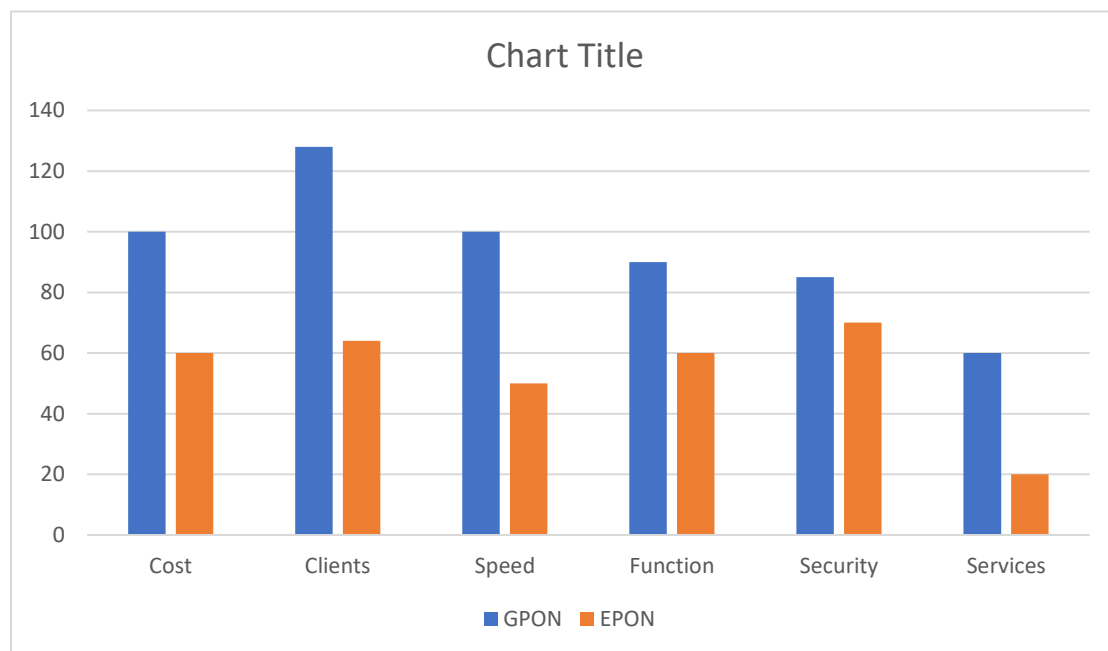

Figure 4.2.3 EPON GPON OLT comparison on different parameter

Most of the operator chose EPON OLT over the GPON OLT due to its low price and its less complex function. But other operator uses the GPON OLT due to its flexible and more function which can provided multi service at a same time. Through the GPON at a same High-Resolution Television (HDTV), High speed internet and voice over internet (VOIP) can be provided using the same Cable for the internet. As GPON is based on the ATM its security is higher than the EPON OLT. This means there can be high number of clients in each OLT and the office server can be cleaner and less fiber need to use as using one GPON OLT can be replace the two EPON OLT which means there will less feeder cable in the server room and the server room will be cleaner. Also, finding the problem become easier and solving the problem become easy for the administrator.

4.3 Comparison

The fiber optic provides a huge advantage over the UTP cable. Fiber can transmit the data over the light speed and in a long distance as there is no EMI and less loss then the UTP. The proposed network has higher Upload and Download speed over the existing network as the existing network has 1000 Mbps upload and download speed with a high latency and low throughput. But the proposed network has 2500 Mbps upload and 1000 Mbps download speed with low latency and high throughput.
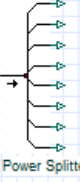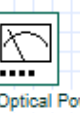
In other word it can be said that the proposed network has 40% improvement over the existing network.

CHAPTER 5
Evaluation

5.1 Evaluation of Proposed Network

OptiSystem is a simulation softer which allows to use real life component in a simulated environment and allows to create any problem which can occurred in real life. The component used for are described below,

Table 5.1 Component used for simulation

Component	Function
Optical Transmitter	Create and modulate binary bits and then transmit the signal using light through the optical fiber.
Power Splitter 1x8	Split one optical fiber into many optical fibers as well as the optical signal. As it is a PLC type splitter all the splatted fiber will get equal optical signal
Optical Fiber	A media used for traveling the optical signal from one place to another
Optical Power Meter	Allows to measure the strength of any optical signal
Optical Receiver	Receive the optical signal and then convert it into the electrical signal
BER Analyzer	Measure and compare the signal performance before and after propagation then create graphs

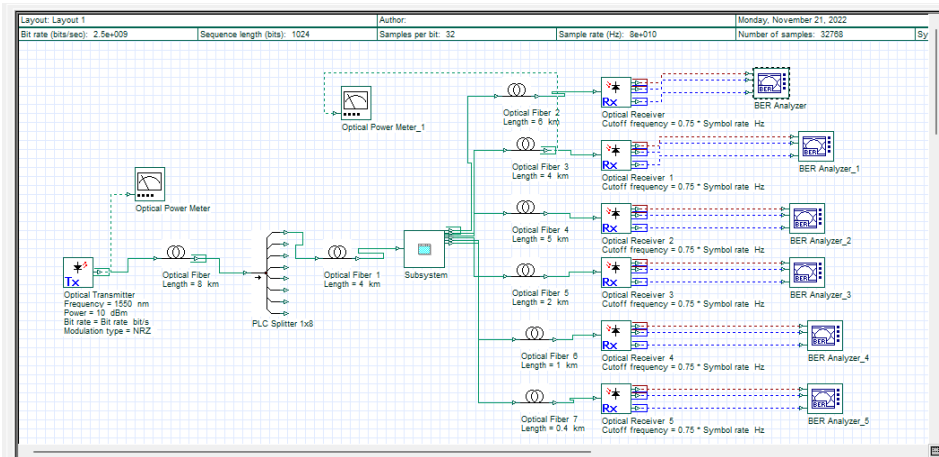After connecting all the component in the simulator, the network diagram is showed in the Figure 5.1.1,

Figure 5.1.1 Simulated network diagram

In the simulation software different component have been used for emulate the real environment.

Figure 5.1.2 Simulation parameter

Using the Optical transmitter emulation of the OLT have been done. Then using the fiber cable and different types of PLC splitter emulation of the real transmission have been emulated. Using the optical receiver which can emulate the ONU of real life, a client end condition can be emulated. By attaching the BER analyzer we can get the BER graph and Q factor values. Which allows to measure the loss and gain the network based on the before and after the propagation.

After completing the simulation, the BER graph can be examine and the result can be found. The BER graph is showed in the Figure 5.1.3
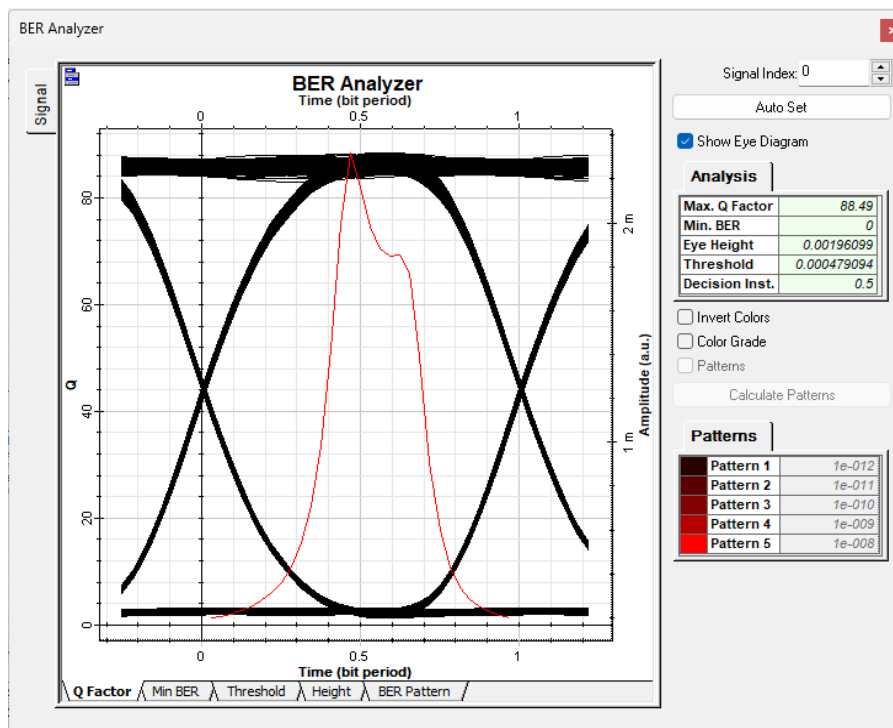

Figure 5.1.3 BER graph

From the graph we can see that, noise near to zero, min BER is zero, eye diagram is wide open which means there is a good transmission and the jitter is near zero. The distance between the OLT and the ONU is up to 20 km that why there is near zero attenuation. This means by implementing the proposed network improvement of the network has been achieved.
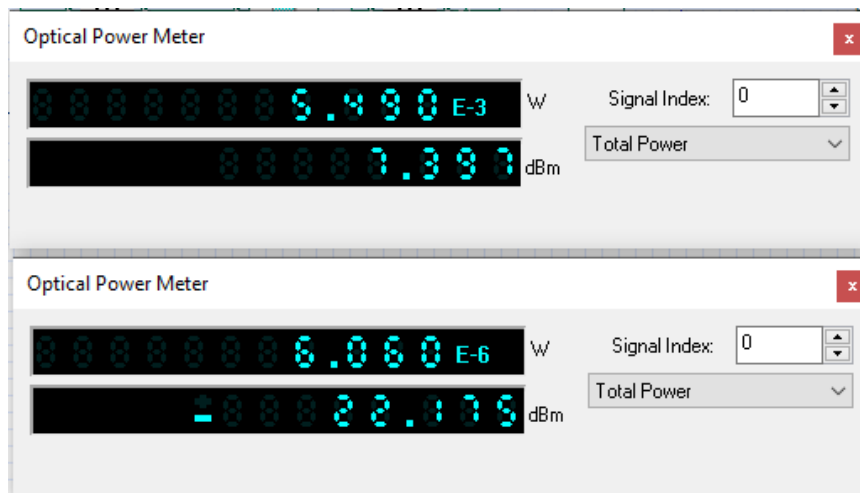
Figure 5.1.4 Optical Power meter reading

As the link budget calculation, the optical power should be,

Client end dBm = PON module dBm - (Total splitter dBm loss + total fiber dBm loss) - fiber coupling loss

$$= 7.39 - (10.3 + 13.5 + 5) - 0.77 \text{ dBm}$$

$$= -22.17 \text{ dBm}$$

As there will be a slight loss in the dBm when coupling two fiber cable.

CHAPTER 6
Conclusion

6.1 Conclusion

In conclusion, using GPON OLT and Mikrotik router a complete ISP network based on two stage PLC splitting ODN have been designed and tasted for a long time. This network has been tasted for a long time period and data have been collected than it was compared against the EPON OLT based network. In multiple case based on the result GPON OLT based two stage PLC splitting ODN is superior then the EPON OLT based network. This network provides multiple services such as Internet, Telephone, HDTV along with higher security then other network, higher network speed then EPON or Ethernet network also simplify the physical network by using less fiber and less device then the Media Converter network or any switch network and higher capacity of clients in a minimalistic setup over a distance up to 20km.

6.2 Future Scope

There is a huge growth in the network sector and its demand is increasing day by day. To meet the demand implementation of the ODN is necessary and with point to multipoint style because it can provide better quality services in a simple physical structure. To fulfill the demand and improve the service quality 10G GPON OLT can used in place of GPON OLT for improving the upload and download speed. To improve the overall security of the network firewall router can be introduce in the network.

APPENDIX

ACRONYMS

CCR	:	Cloud Core Router
BER	:	Bit Error Rate
DNS	:	Domain Name System
EMF	:	Electromagnetic Field
EMI	:	Electromagnetic Interference
EPON	:	Ethernet Passive Optical Network
FBT	:	Fused Biconical Taper
FTTH	:	Fiber to the Home
FTTx	:	Fiber to the X
GEPON	:	Gigabyte Ethernet Passive Optical Network
GPON	:	Gigabyte Passive Optical Network
IIG	:	International Internet Gateway
IP	:	Internet Protocol
ISP	:	Internet Service Provider
LAN	:	Local Area Network
NAT	:	Network Address Translation
ODN	:	Optical Distribution Network
OLT	:	Optical Line Terminal
ONU	:	Optical Network Unite
PAN	:	Personal Area Network
PC	:	Personal Computer
PLC	:	Planar Lightwave Circuit
PON	:	Passive Optical Network
PPPoE	:	Point-to-Point Protocol over Ethernet
VLAN	:	Virtual Local Area Network
VOIP	:	Voice Over Internet
UTP	:	Unshielded Twisted Pair

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