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FTTH PLANNING AND IMPLEMENTATION OF FIBER WORLD COMMUNICATION PVT. LTD.

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ABSTRACT

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The increase in demand for fast and reliable internet is why businesses are now depending on Fiber-to-the-Home (FTTH) technology. This work focuses on the implementation of modern fiber optic networks at Fiber World Communication Pvt. Ltd. (FWCPL) in Nepal. At this time, it considers both their practical and technological issues. A well-designed and flexible FTTH plan is prepared by the study, Google Earth for mapping, Dalo radius for user authentication, and Cacti for monitoring its performance. The use of both instruction and experimentation to handle matters such as network improvement, reducing costly resources, and improving service for customers. Since this study highlights FWCPL's path, it gives suggestions that other enterprises can apply despite resource limits. Design mistakes like cramping networks or inaccurately measuring distances are discussed to reflect common issues.

Keywords: GPON, Planning, Implementation, Configuration

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ABBREVIATIONS

AAA	Authentication, Authorization, Accounting
ADSL	Asymmetric Digital Subscriber Line
BGP	Border Gateway Protocol
EM/EMI	Electromagnetic Interference
FTTH	Fiber To The Home
FWCPL	Fiber World Communication Private Limited
GPON	Gigabit Passive Optical Network
LACP	Link Aggregation Control Protocol
MPLS	Multiprotocol Label Switching
ODN	Optical Distribution Network
OLT	Optical Line Terminal
ONT	Optical Network Terminal
ONU	Optical Network Unit
PON	Passive Optical Network
PPPOE	Point-to-Point-Protocol Ethernet
STP	Spanning Tree Protocol
SNMP	Simple Network Management Protocol
TDMA	Time Division Multiple Access
VLAN	Virtual Local Area Network
VOIP	Voice over Internet Protocol
VPN	Virtual Private Network
WDM	Wavelength Division Multiplexing

1 INTRODUCTION

The digital economy is much stronger because of the telecom sector's ability to provide fast communication, exchange data, and connect people for all types of use. The sharp rise in digital services in Nepal means a faster internet and better protection are now needed (Pandey & Regmi, 2017). Many experts predict that FTTH will become the most popular internet access method in the near future due to its lightning-fast connections, capacity to handle massive volumes of data, and nearly nonexistent latency (Zhou et al., 2017). Fiber World Communication Pvt. Ltd. (FWCPL), a top telecom company in Nepal, is changing to FTTH so it can offer better services, follow new trends in the internet, and remain competitive.

When adopting FTTH, it's necessary to plan the project well, create new infrastructure, and verify that it will work with old systems. Moving from copper cables or basic wireless systems to fiber means overcoming high costs, updating technology, and managing how things are carried out daily (Butt et al., 2015). Installing fiber lines, using the security and control technologies available today, building systems that can expand in the future, and confirming the new network is compatible with customers' devices.

The thesis outlines the process FWCPL used to plan and construct its FTTH network, as well as details about designing, installing, and connecting to existing infrastructure. In addition, it takes on issues such as maintaining top service while changing, ensuring customers are satisfied, and avoiding any disturbances. The research includes specific strategies that make it easier for the company to adopt fiber internet. After examining both the positives and negatives of FTTH, the thesis creates strategies for FWCPL to upgrade its internet services sustainably at a low cost.

1.1 Rationale

At present, Nepal needs to upgrade its network infrastructure. With digital activities increasing these days, the outdated copper line and sparse wireless network system are unable to manage everything. When we want to stream videos, game online, or use cloud services, the current setup's unstable connections make it hard to do so. Many people often face delays in video calls, slow movement of files online, and lag when playing games. This gap shows how quickly we need a better answer, and FTTH has been proven to be the best solution available. Fiber-optic cables, which are used in FTTH, transfer electromagnetic (EM) light signals to carry data. The amount of information transferred over time is defined by the bit rate at which the data is transmitted, which is measured in bits per second (bps) (Rashed, 2011). Regardless of bit rate, the electromagnetic signal itself moves through the fiber at almost the speed of light, or kilometers per second (km/s), up to gigabits each second, which traditional copper cables cannot do. This helps you download much quicker, reduces lag times (important for gamers and those on video calls), and allows your network to handle 8K streaming and smart homes in the future.

This transition to FTTH in Nepal is mainly being led by FWCPL. They hope to connect homes and businesses as more people seek strong, dependable, high-speed broadband connections. The rise in the number of connected devices puts pressure on today's networks. With FTTH, these connected devices perform well, and Nepal is ready for upcoming technology advancements. On the other hand, changing to FTTH doesn't happen overnight. Planning the network's fiber lines, deciding where to put equipment, and assigning bandwidth can handle a growing number of users and more data as time goes on. Another challenge is installation, which is not easy in Nepal's mixed landscape, as both hills and cities offer different obstacles (Khatiwoda & Dawadi, 2021). Google Earth is one way to create efficient maps and estimate expenses;

however, in order to provide perfect service, FTTH equipment must be configured precisely.

Using FTTH along with the previous systems brings new challenges. FWCPL has to guarantee a smooth transition so that existing users do not experience interruptions, even if that calls for temporary use of both existing and new connection types. Protecting data is very important, too. Blocking unauthorized access, protecting information, and enhancing privacy are all responsibilities of a network and its security tools (George et al., 2023). DaloRadius is used to handle logins and fees, while Cacti monitors and detects issues in network performance.

Understanding your customers and their needs makes a difference. By asking users through surveys, we discover what matters most, like how fast they need the site to be and how much they are willing to spend (Naeem et al., 2020). Reviewing data usage patterns gives FWCPL the chance to increase network speed at popular times and help more users. Looking at competitors can show your company how to make their services unique by focusing on quality support or offering various service combos. By focusing on these factors, FWCPL hopes to provide trusted services to its current customers, encourage new ones to join with faster internet, and support Nepal's digital economy by helping businesses succeed.

1.2 Aim and Objectives

This project's goal is to evaluate Fiber World Communication Pvt. Ltd.'s Planning and Deployment of FTTH technology. Developing a clear plan for utilizing FTTH to raise customer happiness, improve the level of service, and streamline operations is the core idea. By addressing both technical and strategic aspects, the project will help the business figure out how to seamlessly integrate FTTH with its current systems while overcoming any issues that may arise.

Key Objectives:

- **Create a Flexible Network Configuration:** Create a FTTH network that can accommodate current needs and readily grow in the future. Prioritize giving users quick, safe connections with minimal delays (Adiati et al., 2022).

- **Implement Customer Management Systems:** Provide cutting-edge platforms for billing and customer service, such as DaloRadius, for managing user accounts.

- **Network Security:** Use techniques like firewalls, data encryption, and secure routing to protect the network and data from clients.

- **Install and Test the Network:** Set up actual fiber cables, routers, and equipment (such as OLTs and ONTs) in order to install and test the network. To verify the network design's functionality.

- **Exchange Advice and Lessons:** Record any technical, financial, or operational difficulties encountered throughout the planning process and provide solutions to improve FTTH initiatives in the future.

2 FTTH TECHNOLOGY

This chapter explains in detail the main technologies needed for building the FTTH system at FWCPL. The project uses GPON, which is recognized as the best choice for delivering high-speed broadband access. The purpose of this chapter is to outline how GPON is built and works, explain its positive aspects compared to copper-based technologies, and compare GPON to the ADSL network FWCPL currently uses.

2.1 Optical Fiber Structure and Electromagnetic Immunity

Structure of fiber optic

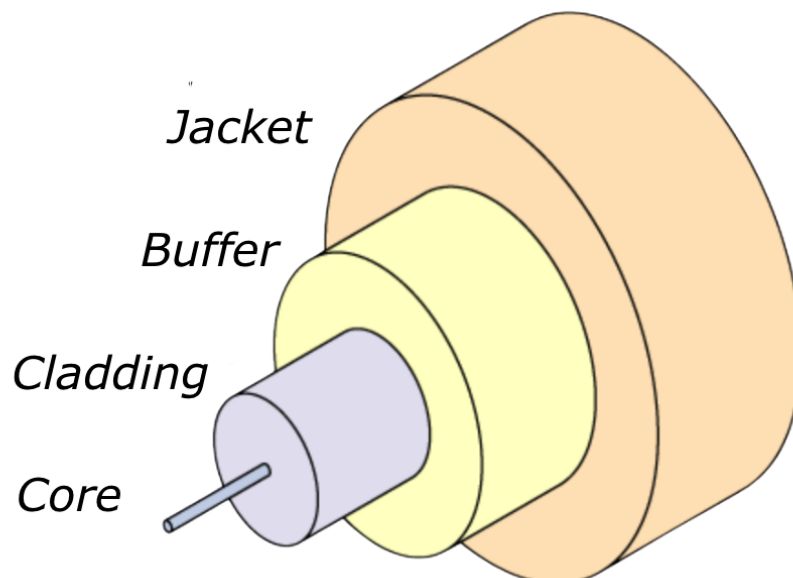


Figure 1: Structure of Fiber Optic

In the structure of fiber optic, Figure 1, we can see how the structure is made in layers. At the center, there is a glass core. This is the most important part where the light signals pass through. The glass core is very tiny, but it carries a large amount of data using light. Around this core, there is another layer called glass cladding. This cladding keeps the light inside the core by reflecting it back, kind of like a mirror, so the

signal don't escape. Then, outside of the cladding, there is a plastic buffer. This part helps to protect the inner glass parts from small damage or moisture. At the very outside, we have the outer jacket. This is a strong cover made from plastic or other material that gives strength and protection to the cable. It saves the fiber from dust, water, or people stepping on it by mistake. Together, these layers make the fiber cable very useful and safe for carrying fast internet or data over long distances.

Copper wires can be affected by Electromagnetic Interference (EMI), and their signals weaken as they move over distance (Wetherhold & McManaman, 2005), but optical fibers are safe from electromagnetic disturbances since they allow the signal to travel by light pulses (Gage et al., 1984). As a result, fiber optic cables provide more stable data, less chance of signals disappearing, and better transmission quality when data is sent long distances. Because of these features, optical fiber offers greater reliability and security with modern communication systems (Fok et al., 2011).

A lot of GPON users are satisfied because their internet connections are much faster and more reliable (Marmur & Shraga, 2004). In addition, fiber optic technology means the networks are more dependable and easier to maintain, making them less expensive over time (Agboje et al., 2017). To meet the needs for better and faster internet, FWCP must adopt the GPON technology and leave behind copper-based ADSL.

2.2 Passive Optical Network (PON) Structure

A PON distributes optical waves from a central source to multiple locations by means of passive splitters and with no electronic components in the wires between them. The most important elements in a GPON system are:

- **Fiber Optic Cable:** Fibre optic technology is used in FTTH and offers both greater speed and a more reliable service than wireless, DSL, and standard copper-based internet setups. Data is transmitted via optical signals on these cables, which ensures data transfer happens very quickly and efficiently with little possible interference.

Most networks in buildings use either single-mode or multi-mode fiber optic cables. Multi-mode fiber optic cables are often used for communication within a building or on a campus, because the light signals inside them can use various paths or modes. Short-range systems are good value, but they do not work well for far-distance transmission because the signals can become distorted over time.

- **Optical Line Terminals (OLTs):** At a service provider's central office or data center, OLTs control the process by which data moves between users' homes and the internet. The routers are the final point in the service provider's network, where data traveling through fiber optics is received, processed, and circulated. An important thing the OLT does is to take the input signal and break it into several smaller streams, which makes it possible for several subscribers to access the network at the same time. As a result, Internet users benefit from both saving bandwidth and maintaining fast service. FTTH networks use OLTs to control lots of data and support steadfast connections between end-users and internet companies.
- **Optical Network Terminals (ONTs):** ONTs, which are shorthand for Optical Network Terminals, are placed on customers' premises to transmit data between the fiber network and their electronics. They take high-speed optical data from the OLT and turn it into an electrical form. This is important since

these devices, including desktop computers, laptops, smartphones, and smart TVs, are built to use electronic signals, not optical ones. With the ONT's help, end-users can easily use the internet for streaming movies, video chats, online calls, and different digital applications.

The ITU-T G series of Recommendations (G.984 series) is the one in which the GPON standard that defines download speeds of 2.5 Gbps and upload speeds of 1.25 Gbps is primarily defined (Abdellaoui et al., 2021). Thus, these speeds are covered in more detail in ITU-T G.984.2, which details the physical media dependent (PMD) layer specification for the Gigabit-capable passive optical networks (GPON), and these speeds are shared between many users. A GPON network's long-range ability (up to 20 kilometers) supports its use in both cities and semi-urban areas. The fact that there are no active components in the field greatly reduces what it costs to maintain the system and use energy (Gilfedder, 2006).

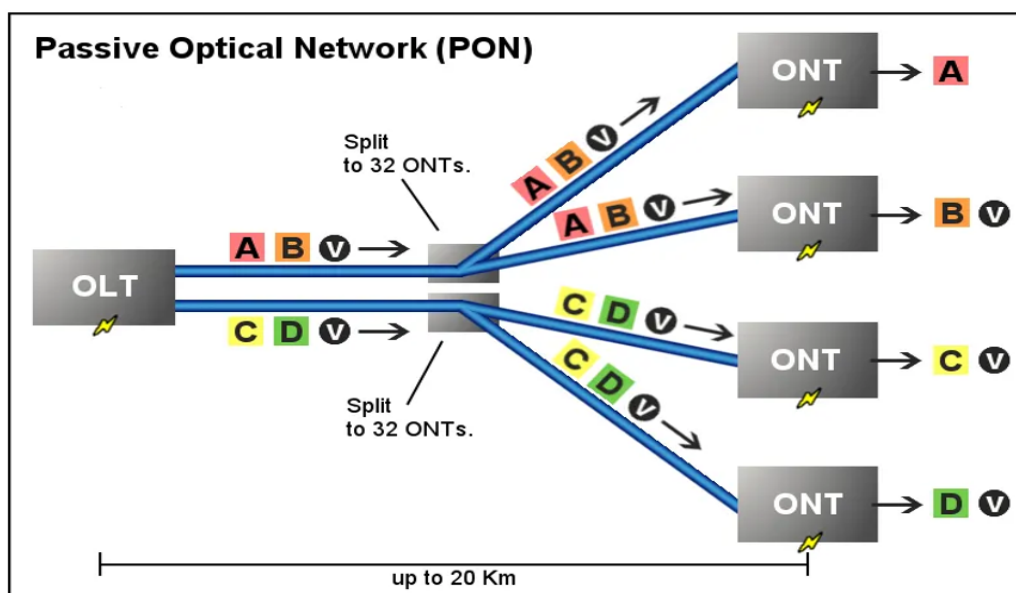


Figure 2: PON Structure ("Passive Optical Network," 2025).

Figure 2 represents the design of a Passive Optical Network (PON). Two optical fibers take downstream signals from the Optical Line Terminal (OLT) and then send these downstream signals to several Optical Network Terminations (ONTs) at the customer premises by using passive optical splitters. The key of the figure states that the OLT simultaneously sends different types of data: unicast (A, B, C, D), which is data or voice destined for a specific customer, and multicast or broadcast data (V) to deliver the video content of several customers. The relevant optical signals for its specific subscriber it received and converted.

Although Time-Division Multiple Access (TDMA) is indeed used as technology for upstream traffic coordination from Optical Network Terminals (ONTs) to the Optical Line Terminal (OLT) in order to allow multiple users to share the same fiber without collision, taking into consideration the fact of high-speed data throughput over long distances (up to 20 Km), the feasibility of this is considered to be critically dependent on optic fiber link budget calculations. The calculations for these are important to the network design to ensure the transmitted optical power is adequate enough to reach the receiver with sufficient optical strength to preserve signal quality and bit error rate targets. In other words, the link budget accounts for all anticipated losses to power, due to such factors as fiber attenuation, connectors, splices, and passive optical splitters, and therefore determines the longest attainable distance where reliable data transmission is possible at a given level of performance (Nowak & Murphy, 2005). Thus, this meticulous calculation ensures the integrity and quality of high-speed data services over the entire PON infrastructure.

2.3 Wavelength Division Multiplexing (WDM)

The use of Wavelength Division Multiplexing (WDM) in GPON allows multiple signals to be sent on the same fiber in different directions (Gutierrez et al., 2010). Separate data streams are sent over different wavelengths of light. Most commonly, the downstream wavelength is about 1490 nm, and the upstream wavelength is about 1310 nm. Reserving an additional wavelength, such as 1550 nm, enables analog or RF video communication.

By enabling bidirectional communication without signal collision or interference, WDM improves the optical network's efficiency (Yeh et al., 2019). WDM maintains a safe and effective connection by making sure each ONU receives the intended data stream at the optical splitter point.

2.4 Existing Copper-Based ADSL Network at FWCPL

Presently, the FWCPL network relies on ADSL technology, which delivers the internet using older copper telephone lines. The maximum speeds you can expect from ADSL for downloading are approximately 24 Mbps, and for uploading are about 3.5 Mbps, when all things are working smoothly. ADSL faces major problems when used far from the central office, as it gets disrupted by electromagnetic radiation and can cause more latency, jitter, and packet loss (Abdullah et al., 2009). In addition, ADSL networks require higher maintenance costs because the copper wires are old and damaged easily by moisture (Lee & Lee, 2003), electricity, or damage to the wires.

Table 1 below summarizes the key technical and economic differences between ADSL and GPON technologies (Oboyerulu & Felix, 2016):

Table 1: Technical and Economic Comparison: ADSL vs. GPON.

Parameter	ADSL(Copper Network)	gPON (Fiber Network)
Downstream Speed	Up to 24 Mbps	Up to 2.5 Gbps
Upstream Speed	Up to 3.5 Mbps	Up to 1.25 Gbps
Maximum Coverage	< 5 km	Up to 20 km
Electromagnetic Immunity	Low	High (immune)
Latency and Jitter	High	Very Low
Maintenance Cost	High (Frequent issue)	Low (minimal upkeep)
User Density Support	Low to Medium	High (1:32 or more per splitter)
Customer Satisfaction	Moderate	High
Long-term Viability	Limited	Future-ready and scalable

It points out that users get faster internet, wider areas of coverage, enhanced dependability, and lower service costs (Arévalo et al., 2017). A fiber-based service is better prepared for the future because it is more effective for many users and improves customer satisfaction.

3 METHODOLOGY

In this study, how Fiber World Communication Pvt. Ltd.(FWCPL) implemented FTTH technology in Nepal is thoroughly discussed in this chapter. Because FTTH is complex and consists of technical, financial, and customer aspects, a robust combination of research methods was applied to understand it fully. The specified framework was created to focus on examining FWCPL's FTTH strategy, finding the main issues, and creating a solid plan for increasing customer satisfaction, reducing problems, and streamlining operations. The chapter describes what research approach was used, how data was gathered and analyzed, the factors limiting the study, and the ethical aspects involved in each stage of this study.

3.1 Design Of FTTH Technology

This study used explanatory studies to explore in detail the views of customers on FTTH technology, its effect on companies, and how customers use it. This type of method helps reveal reasons, motivations, and the processes that create certain observed results. The main aim was to analyze what shapes the acceptance of FTTH and to see how it affects customers.

The topic was studied using both data and company experiences. To identify trends, costs, the rate at which people use different products, and the financial impact were all investigated by analyzing the numbers. Interviews were conducted both with selected users and with FTTH experts to understand their opinions on user satisfaction and adopting FTTH.

3.2 Configuring the Approach to Collecting Data

This study applied a range of methods to gather and analyze the data using several approaches. Because the study used a mixed-methods approach, different types of data were both collected and analyzed. Mixing data about adoption, financial costs, trouble with installation, and satisfaction with the technology gave a clearer picture of internet options through foot access.

3.2.1 Quantitative Data Collection

The study used official documents, company reports, and academic papers to obtain recent information on the costs, use, and financial effects of FTTH technology. Several key topics were the focus of the data used.

- **Cost of Deployment:** The analysis included all of the costs connected to FTTH rollout, including registration, maintenance, and buying equipment. The study also examined whether rural or urban locations cost more to cover with mobile networks.
- **Adoption Levels:** The analysis measured the level of FTTH adoption in homes and businesses from one part of a region to another.
- **Economic Changes:** Research was conducted to find out how adopting FTTH influences economic expansion, improved work output, and broadened broadband availability in places where FTTH services exist.
- **Customer Satisfaction:** The study looked at many things that play into satisfaction, including how good the network works, how fast it is, and how organized the customer service is, based on prior surveys and research.

Having both descriptive and inferential statistical tools at hand, the analysis was carried out. Instead of focusing on every individual number, the standard deviation, mean, and median were examined to show the primary patterns. In a specific instance, the study examined how the percentage of households with FTTH relates to changes in GDP growth or the level of broadband adoption.

3.2.2 Qualitative Data Collection and Relationship to Results

The study included semi-structured interviews, allowing for a detailed account of the experiences. The participants in the study were 5 specialists from FWCPL (e.g., project managers, technical leads) and 10 FTTH users. Those selected for the study were identified using purposive sampling to discover information on strategy, challenges, and how things are done operationally. In order to learn about their day-to-day use, satisfaction with the services, and any issues they face, people using FTTH were chosen.

Interviews that usually took 20 minutes each were guided by open-ended questions chosen to match the study aims and the type of qualitative data to be gathered. Key areas were used to organize these questions.

- **FTTH Implementation Processes:** Questions focus on FWCPL's planning, carrying out in phases, and the resources applied to each project.
- **Network Infrastructure and Issues:** Covering topics on network setup, ensuring equipment lasts, and dealing with different problems.

- **Customer Experience and Satisfaction:** People are concerned about the dependability of their internet connection, the service itself, having installation completed, support from customer care, and whether their total experience meets expectations.
- **Popularity and Prospects:** Opinions on whether FTTH can compete effectively and how it might affect Nepalese society and the economy.

The relationship was built by drawing themes from the quantitative and qualitative data using thematic analysis. The process was to go through the transcripts several times, find similar ideas, phrases, and concepts, and arrange these into general themes. Examples where people described their issues with slow installation or sluggish support helped the category of Challenges in Service Delivery shape the highly consistent trend found in customer satisfaction. Also, constant guidance from experts on the cost-effectiveness of fiber deployment supported the conclusion about Financial Viability. NVivo helped keep the process organized and clear from the collection of raw interview data to the production of qualitative results.

3.2.3 Data Validation through Triangulation

A triangulation method was included to ensure the conclusions were trustworthy, made possible because the study involved both qualitative and quantitative approaches. To do this, various data from different sources and research methods, such as the costs of FTTH and user responses from interviews, were used. When results were compared and validated from many different sources, the study found important common trends and made its conclusions stronger.

Going further than cross-checking data, triangulation also revealed more about the underlying reasons for the findings. Though it appears that

rolling out FTTH costs more in rural areas, speaking with local residents provided an answer—either rural areas are not densely populated, or they do not have the needed infrastructure. Because of these two perspectives, the findings were understood better and more accurately.

3.2.4 Analysis Techniques

In this study, numerical data were analyzed using descriptive statistics and correlation analysis. The investigators carried out a correlation analysis to see if there was a relationship between GDP growth and access to broadband. A thematic coding method was used to study customer experiences, as well as issues, advantages, and satisfaction with FTTH. An additional manual analysis was done on the data to confirm the results of the software approach.

4 CONCEPTUAL FRAMEWORK/DEPLOYMENT

This Chapter thoroughly explains the basic ideas and real-world use of FTTH technology. It seeks to show how elements such as technology, investment, and user experiences join forces in organizing, developing, and optimizing FTTH networks. Studying these areas together allows us to learn what influences the spread and growth of FTTH technology.

The deployment section focuses on the practical implementation of theoretical frameworks in much of the deployment section. This phase carries out detailing of how an FTTH network can be architected; how it can be constructed and made operational in practice. Furthermore, it facilitates a better understanding of the complex processes, such as aspects taken into consideration and costs associated with having functional FTTH infrastructures, thereby aiding in more realistic judgment in terms of feasibility and more strategic applicability of this study.

4.1 Economic Considerations

FTTH technology costs money initially to set up and has benefits for those who use it and those who provide the service. Setting up a FTTH network is costly because it involves difficult infrastructure, special equipment, and highly trained staff. The price is affected by how many people live in the area, where it is located, and how well the present infrastructure is maintained. Serving a large number of people in cities means 5G equipment can be set up at a lower cost. However, in rural locations, where fiber optic cables must be installed across long distances, costs could be higher.

- **Capital Expenditure:** Capital Expenditure (CapEx) pays for the first investment in cables, routers, switches, OLTs, ONTs, plus

covering costs for setup, licenses, and workers who install the equipment.

- **Operating Expenditure:** This expense refers to regular costs of keeping the network running, including powering equipment, monitoring, attending to customers, updating systems, and repairing networks. Maintaining FTTH networks is more expensive than traditional broadband because they cannot be left unattended.

- **Revenue Generation:** The majority of Comcast's income comes from charging subscribers for things like high-speed internet, television, VoIP, and cloud services. Your monthly fee can change according to the data speed and the number of data usage limits set.

- **Economic Benefits:** FTTH makes a positive economic contribution by enabling important services in education, healthcare, remote working, and entertainment. With the help of reliable high-speed internet, organizations are able to bring about change, become more productive, and explore fresh business directions.

4.1.1 Customer Experience in FTTH Networks

High customer satisfaction and retaining subscribers are achieved by FTTH service providers who focus on providing an outstanding user experience. As there is very low latency and high-speed service, FTTH improves the way people use the internet. Many factors are essential for increasing and understanding customer satisfaction.

- **Fast Internet:** By using FTTH, it is possible to deliver very fast internet service, frequently with Gbps available for users. A larger bandwidth improves how smoothly you can work, play games,

watch streaming videos or see high definition content on the internet.

- **Network Uptime:** Because fiber optic networks resist interference and weather, they have a much higher level of reliability than copper or wireless systems. Consistent operations over a long period mean there are fewer disruptions, which is vital for happy users.
- **Ease of Installation:** The installation process affects how customers perceive a product. Having a clear plan, minimal disruptions, and giving clear information about rates and plans can make your installation go smoothly.
- **Support and Maintenance Services:** Quality customer assistance is very important in FTTH services. Consumers want prompt, educated, and supportive help with installation, problem-solving technology, bills, and maintenance duties. Good service from responsive teams increases trust and confidence in who you are buying from.

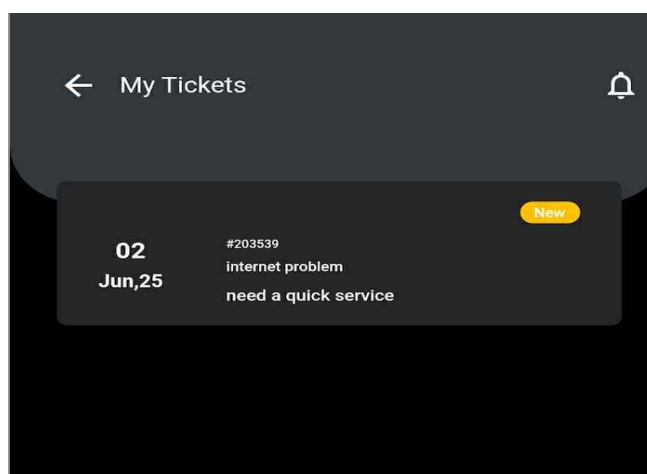


Figure 3: Ticket issued by the customer.

The mobile app for offering customer support and maintenance services is shown in Figure 3. Those facing connectivity problems

can make use of this platform to quickly create a ticket with the service provider. With the application, customers communicate directly with the technical support team, which helps resolve the issue in an efficient manner. When the user notices a problem, they can simply visit the area in the app meant for submitting tickets. It not only speeds up support at Fiber World Communication(FWCPL)., but it also enhances customer satisfaction.

- **Customer Feedback:** Asking customers for input in surveys, talking with them directly, and reviewing their reviews enables providers to find ways to do better. Addressing what users need encourages them to continue using your services for a longer period.

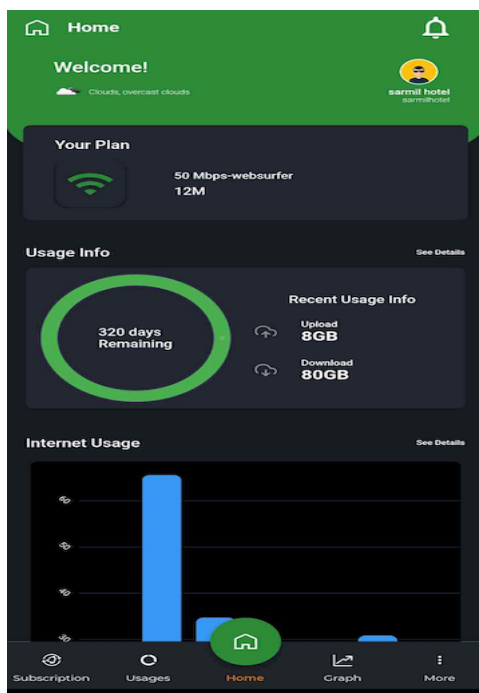


Figure 4: Customer Application

Figure 4 outlines the dashboard of a mobile app that is used by an ISP for connecting with its customers. It provides subscribers with a way to check their service details, such as the plan name (e.g., "50 Mbps-websurfer") and the time they have left on the service. The data for recent uploads and downloads is displayed in large numbers (e.g., 8GB

upload and 80GB download), as well as a chart to show how the internet is being used. Significantly, this mobile app allows clients to communicate their thoughts, ask about QoS, and give ideas, which increases their engagement and helps the ISP improve its services.

4.2 Network Design and Implementation

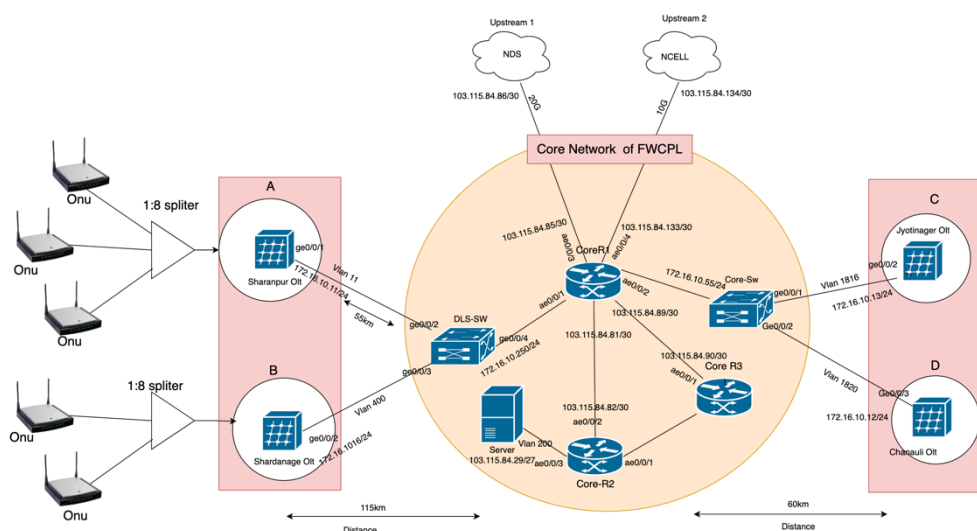


Figure 5: Core Network Diagram Of FWCP.

A complete architectural overview of the FWCP core network, along with its distributed branch topology, is shown in Figure 5. The network design consists of two upstream links from NDS and Ncell, which are essentially primary bandwidth providers, making Ncell and NDS provide robust internet connectivity to FWCP. For the management of Border Gateway Protocol (BGP) sessions and steering the routing across the core network, the main core router (R1) is placed strategically. In addition to this, the Core Router 2 and Core Router 3 role of Broadband Network Gateway (BNG) devices, which authenticate and manage PPPoE users over the network. In addition, the essential network management equipment, including real-time traffic monitor—Cacti, and central Authentication, Authorization, and Accounting (AAA) service—RADIUS server, are placed at a central server.

Distribution Layer Switch (DLS SW) and Core-SW are used to network distribution to different branches. The context of the switch DLS is that of specific branches served by means of these switches, for example, the Shardanagar branch at an approximate distance of 115 km, and Sharanpur at an approximate distance of 10 km, which is conveyed through fiber to be directly connected with the DLS switch. Moreover, Jyotnagar and Chanauli branches are connected using a Core-SW switch, and each of these branches has its own OLT and switching equipment. VLAN segmentation is meticulously designed all over the core network, and different branch networks and services are assigned with specific IP address ranges (for example, a dedicated PPPoE VLAN is assigned for Saranpur OLT, for this concept represented as branch segments A, B, C, and D, respectively. The network is a robust GPON infrastructure beyond branch OLTs and provides high FTTH services deployment to the end users.

Table 2: Vlan Segmentation and IP Subnet

Name	Vlan ID	Ip Address
Office Network	9	100.100.123.1/24
Device Management	12	172.16.10.1/24
PPPoE	11, 250, 400, 35, 1482	172.16.100.0/23
Server	200	103.115.84.29/27

As shown in Table 2, the VLAN (Virtual Local Area Network) segmentation and the attendant IP Subnetting are meticulously shown within the network architecture, which would have been recommended in any modern network design for Fiber-to-the-Home (FTTH) deployments. This is a segmentation strategy that separates network traffic in a logical way in order to provide security, reduce broadcast domains, and optimize the use of resources. VLAN 9 is the Office Network (100.100.123.1/24) that specifically allows internal

administrative communications. Device Management VLAN 12 172.16.10.1/24 is for Device Management only. On this VLAN, we have dedicated, secure, and controlled devices for controlling the rest of the network infrastructure. For PPPoE (Point-to-Point Protocol over Ethernet) users, several VLAN IDs (11, 35, 250, 400, 1482) are used in aggregate for subscriber services and get IP addresses in the larger 172.16.100.0/23 network. For PPPoE users, this is a multi-VLAN approach that affords the ability to manage the subscriber traffic more granularly, and potentially based on service tier or geographical distribution, and still be able to utilize one IP address pool for dynamic assignment. Lastly, the Server infrastructure (103.115.84.29/27) is assigned to VLAN 200 for stable and isolated connectivity of core services. The more robust VLAN and IP subnetting scheme is therefore a fundamental element to maintain the network scalability, security, and traffic efficiency in a complex FTTH environment.

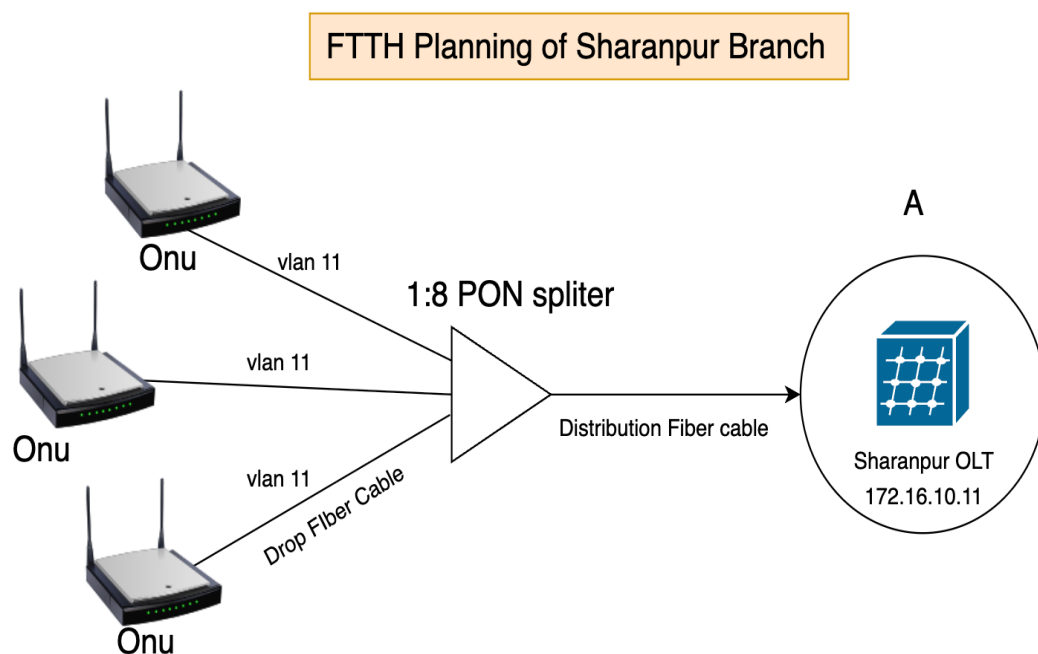


Figure 6: FTTH planning of Sharanpur Branch

Figure 6 is derived from Figure 5. Figure 6 shows the detailed Fiber-to-the-Home (FTTH) planning that was done for the Sharanpur branch. It

displayed a practical implementation of GPON technology in the Sharanpur branch. In the setup, the start site of the branch's OLT is very far away from the Distribution Layer Switch (DLS), around 10km distance, from where the link between the core network and the branch is provided in the form of fiber optic connectivity. GPON infrastructure is used to provision efficient high-speed broadband service, which forms the basis of the entire Sharanpur branch network. A central aspect of this design is 1:8 passive optical splitters used to support a single fiber in the OLT to serve up to eight Optical Network Terminals (ONTs) at customer premises. This approach optimizes the use of fibers, lowers the deployment costs, and sustains the reliability in service delivery to the end users in the Sharanpur area as well.

4.3 Server installation and Software deployment

4.3.1 Installing Cacti for Network Administration

Fiber World Communication Pvt. Ltd (FWCPL) needs to effectively monitor their network. Set up Cacti, which is web-based, to display live network performance using charts and graphs. It was picked because it integrates well with devices using SNMP and has the function to present bandwidth, device, and network stats clearly. Both physical and virtual environments were combined in the deployment to achieve flexible, scalable, and reliable systems. The deployment was run on a Dell PowerEdge R710 server, and vSphere ESXi 6.7 handled the virtualized system. Using virtualization, using the Ubuntu Server 20.04 on a virtual machine, using it as the operating system and host system for Cacti. As a result, the fiber network could be monitored 24/7 from one place, which allowed regular fixes and smooth management.

To start the system setup, set up a virtual machine to host the network monitoring platform. It was decided to give the virtual machine 50 GB for storage, 8 GB of RAM and 4 CPU cores to make sure it operates

smoothly and efficiently. First, Ubuntu Server 20.04 LTS was downloaded and installed through the virtual machine and then the system packages were updated to the latest levels for better security and compatibility. At that point, all vital packages needed were installed: Apache was set up as the web server, MariaDB (MySQL) as the database manager, PHP for making web pages, and SNMP for retrieving network data. After putting everything in place, the system installed Cacti from its official repository. After installation, the system was set up to keep track of information in MySQL, ensuring that the network could be observed and details logged in real time.

- Apache, MySQL, and PHP installation

```

kb@cacti:~$ sudo systemctl restart apache2
kb@cacti:~$ sudo systemctl status apache2
● apache2.service - The Apache HTTP Server
   Loaded: loaded (/lib/systemd/system/apache2.service; enabled; vendor preset: enabled)
   Active: active (running) since Thu 2023-05-25 17:43:08 UTC; 8s ago
     Docs: https://httpd.apache.org/docs/2.4/
   Process: 29133 ExecStart=/usr/sbin/apachectl start (code=exited, status=0/SUCCESS)
  Main PID: 29137 (apache2)
    Tasks: 6 (limit: 4531)
   Memory: 13.0M
      CPU: 40ms
   CGroup: /system.slice/apache2.service
           └─29137 /usr/sbin/apache2 -k start
             └─29138 /usr/sbin/apache2 -k start
               └─29139 /usr/sbin/apache2 -k start
                 └─29140 /usr/sbin/apache2 -k start
                   └─29141 /usr/sbin/apache2 -k start
                     └─29142 /usr/sbin/apache2 -k start

May 25 17:43:08 cacti systemd[1]: Starting The Apache HTTP Server...
May 25 17:43:08 cacti apachectl[29136]: AH00558: apache2: Could not reliably determine the
May 25 17:43:08 cacti systemd[1]: Started The Apache HTTP Server.

```

Figure 7: Installation of Apache.

The process for setting up Apache as a web server, which is important for Cacti, is shown in Figure 7. The process starts by updating the system's package list to check if everything is up to date. Now, the Apache web server is installed so that Cacti can be used properly. When installation is complete, the system starts the Apache service and makes sure it automatically restarts at each boot. The installation is successful once you can open the default Apache welcome page from your browser. It is done to ensure that the server will effectively run the Cacti monitoring system.

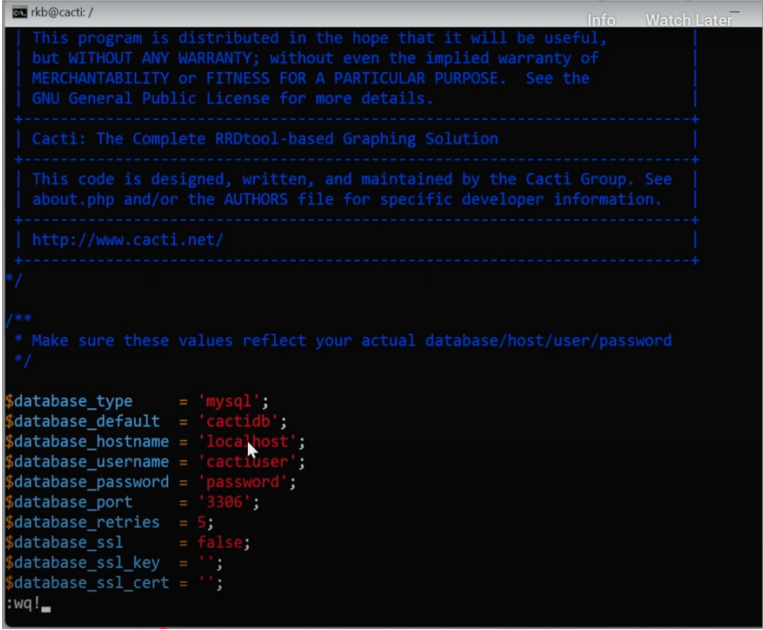
- Configure Cacti to connect to the database

```
$ sudo nano /etc/cacti/debian.php
```

Modify the following variables with the database username & password:

```
# $database_username = 'cactiuser';  
# $database_password = 'your_secure_password';
```

The `debian.php` file, when configured to include Cacti MySQL database connection to the Cacti application, is of great importance in the configuration process of Cacti. In this file, parameters like `$database_username` and `$database_password` should have been properly set to reflect the credentials of the database user created for Cacti (`cactiuser`, for example). All of the parameters that we define here make sure that Cacti is allowed to monitor and manage data as it pertains to monitoring and graphing network performance. It's very important to configure these values properly for the proper running of the Cacti system.



```
rkb@cacti: / Info Watch Later  
-----  
| This program is distributed in the hope that it will be useful,  
| but WITHOUT ANY WARRANTY; without even the implied warranty of  
| MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the  
| GNU General Public License for more details.  
-----  
| Cacti: The Complete RRDtool-based Graphing Solution  
-----  
| This code is designed, written, and maintained by the Cacti Group. See  
| about.php and/or the AUTHORS file for specific developer information.  
-----  
| http://www.cacti.net/  
-----  
*/  
/**  
 * Make sure these values reflect your actual database/host/user/password  
 */  
*/  
$database_type      = 'mysql';  
$database_default  = 'cactidb';  
$database_hostname = 'localhost';  
$database_username = 'cactiuser';  
$database_password = 'password';  
$database_port     = '3306';  
$database_retries  = 5;  
$database_ssl      = false;  
$database_ssl_key  = '';  
$database_ssl_cert = '';  
:wq!
```

Figure 8: Database Configuration

Figure 8 presents an important configuration file that sets up the database for Cacti, a graphical monitoring system. Having this configuration is important for building the connection between Cacti and its stored data. ('mysql': This value in the `database_type` parameter

shows that a MySQL-compatible database management system will be used. The `database_default` parameter holds the name 'cactidb' for the database Cacti saves all its charts and other data. Since the term `database_hostname` is set to 'localhost', this means the server system is the same platform as Cacti. This is accomplished through usernames and passwords taken from the database, where `database_username` equals 'cactiuser' and the password should be strong and secure as you use it for real applications. It is important to set `database_port` as 3306 because it is the norm for MySQL talk. Setting up these settings is very important as it makes sure Cacti can safely gather and use the large amounts of network data it needs for monitoring and graph making.

As seen in Figure 8 above, these are the actions needed to set up the database for the Cacti server. First, a relational database management system is installed so that Cacti can save the data needed for its operation. After you have installed Cacti, a new database is made for it, and a new user account with the required rights is set up. The setup makes sure both Cacti and the database can interact securely. After the setup, the connection is checked to see if the Cacti application has the ability to store and retrieve the necessary data.

- **Configure the SNMP daemon to enable device monitoring**

SNMP (Simple Network Management Protocol) is required during the Cacti installation, so Cacti can acquire real-time data from a network device (like a router, switches, servers, etc., or any device that supports SNMP) by utilizing this tool. These devices are queried by Cacti using SNMP to obtain performance metrics such as how much bandwidth a device is using, its CPU load, memory usage, and so on. Then this data is stored in the database, and graphs are visualized for it. Cacti allows the external network devices to use the SNMP scripts to gather the information, which is not possible without SNMP.

```
$ sudo nano /etc/snmp/snmpd.conf
```

- # Adjust the configuration file to allow SNMP requests as needed
- **Open the Cacti web interface on your web browser.**
- # Open <https://cacti.fiberworld.net.np/>
- # Complete the installation by following the web-based setup wizard

```

snmp-agent
snmp-agent local-engid 80007DB036CE8748C7AE0
snmp-agent community plaintext enable
snmp-agent community write cipher %^#7MULU^F#R=sQ!%:YSKKE]`j0F`z`]=&S8SDv05s<5d%-s+U,0G'J-COB; **p,0VRT'+)z^/vC{4X#,%^%#
snmp-agent community complexity-check disable
snmp-agent sys-info contact FIBERWORLD
snmp-agent sys-info location pragatinagar
snmp-agent sys-info version all
snmp-agent protocol source-status all-interface
undo snmp-agent protocol source-status ipv6 all-interface
#

```

Figure 9: SNMP Configuration in DLS-Switch

Figure 9 illustrates how SNMP is set up on the DLS switch, which is necessary for Cacti traffic monitoring. SNMP makes it possible for Cacti to gather information on the switch's performance, like network traffic activity and interface details. When SNMP is configured properly, the switch and the monitoring server can exchange accurate and secure data, which helps manage and analyze the network traffic and device performance well.

changan-hasanpur-ot1.fiberworld.net.np	172.16.35.99	182	3	3	Up	60d 0h:44m	20h:1m	0.31	12.26	12.34	99.76%	□
changan-hasanpur-sw4.fiberworld.net.np	172.16.35.98	183	4	4	Up	60d 0h:44m	19h:5m	0.33	11.26	9.2	99.76%	□
changan2-ot1.fiberworld.net.np	172.16.35.83	184	3	3	Up	709d 11h:39m	161d 1h:5m	0.23	12.45	9.41	100%	□
changan-ot2.fiberworld.net.np	172.16.35.84	185	3	3	Up	709d 11h:39m	160d 23h:52m	0.29	11.85	9.47	100%	□
changan-ot3.fiberworld.net.np	172.16.35.85	186	3	3	Up	709d 11h:39m	160d 23h:34m	0.28	12.44	9.57	100%	□
changan-sw1.fiberworld.net.np	172.16.35.82	187	3	3	Up	709d 11h:39m	249d 12h:37m	0.25	8.2	8.36	100%	□
Dhanushadham-epon-ot1.fiberworld.net.np	172.16.253.3	188	3	3	Up	709d 11h:39m	19d 0h:57m	0.2	6.62	5.34	100%	□
Dhanushadham-Huav-ot1.fiberworld.net.np	172.16.253.4	189	3	3	Up	709d 11h:39m	20d 7h:59m	0.28	8.72	6.68	100%	□
DHCP-RTR1-100.99.99.21	100.99.99.21	190	3	3	Up	709d 11h:39m	277d 23h:15m	0.19	2.22	2.18	100%	□
dhpc-1000-rs.fiberworld.net.np	100.99.99.50	191	3	3	Up	709d 11h:39m	483d 7h:1m	0.16	2.1	2.1	99.97%	□
dhurbar-sw1.fiberworld.net.np	172.22.22.206	9	7	7	Up	189d 4h:52m	71d 12h:19m	0.52	3.69	9.71	98.47%	□
dkol-sw1.fiberworld.net.np	172.16.30.5	192	4	4	Up	709d 11h:39m	9d 5h:19m	0.35	6.99	9.37	99.59%	□
dlipai-Huawei-ot2.fiberworld.net.np	172.16.29.16	193	3	3	Down	17h:10m	N/A	1.07	3.95	4.18	92.88%	□
dlipai-ot1.fiberworld.net.np	172.16.29.12	194	3	3	Up	709d 0h:4m	296d 7h:33m	0.2	2.11	2.25	100%	□
DLS-SW1	192.168.200.7	28	11	11	Up	717d 7h:41m	498d 15h:45m	0.4	1.34	5.85	100%	□
DLS-SW2	192.168.200.7	39	3	3	Up	717d 7h:41m	498d 15h:45m	0.32	1.34	5.85	100%	□
DLS-SW3	192.168.200.14	40	3	3	Down	3d 0h:5m	N/A	2.07	0	0	0%	□
dmz-sw1-NEW	172.22.22.103	42	4	4	Up	305d 0h:46m	498d 16h:1m	0.35	2.94	4.13	100%	□
Dudha-Huav-ot1.fiberworld.net.np	100.126.255.23	195	5	5	Up	66d 20h:14m	2d 20h:14m	0.28	11.87	11.01	95%	□
dudha-ot1.fiberworld.net.np	172.16.41.143	196	3	3	Recovering	10m	7h:4m	0.26	6.71	9.45	55.55%	□
dulgada-powerch-ot2.fiberworld.net.np	172.16.40.108	197	5	5	Up	644d 14h:14m	9d 3h:13m	0.36	5.31	6.03	99.76%	□
dulgada-sec-Rolcom-ot1.fiberworld.net.np	172.16.40.109	198	4	4	Up	701d 11h:14m	9d 3h:13m	0.23	8.27	8.6	99.83%	□
Dumkibas-Huawei-ot2.fiberworld.net.np	172.16.18.5	199	5	5	Up	32d 2h:4m	11h:15m	0.16	3.78	3.33	98.7%	□
Dumkibas-ot1.fiberworld.net.np	172.16.18.4	200	3	3	Up	32d 2h:4m	11h:15m	0.12	1.68	1.81	98.7%	□
Dumkibas-sw1.fiberworld.net.np	172.16.18.2	201	9	9	Up	32d 2h:4m	11h:15m	0.24	2.38	3.47	99.76%	□
dumre-sa.fiberworld.net.np	172.16.35.53	202	3	3	Up	74d 3h:13m	41d 0h:3m	0.21	3.29	4.21	77.48%	□
ecore-r2	103.175.92.9	36	6	6	Up	3509d 6h:27m	498d 15h:14m	0.32	0.93	4.04	100%	□
FW-ENG-01-MAX400	100.99.99.100	203	3	3	Down	1d 0h:5m	N/A	2.03	0	0	0%	□
FW-ENG-02-MAX400	100.99.99.101	88	3	3	Down	244d 11h:45m	N/A	2.04	0	0	0%	□
FW-ENG-06-MAX104	100.99.99.102	204	3	3	Down	1d 0h:5m	N/A	2.04	0	0	0%	□

Figure 10: Lists of Devices in Cacti.

Figure 10 gives an overview of adding all devices with SNMP and managing their network data from Cacti. Every device has been added by typing in its IP address or hostname to confirm that they all belong to the same network. Displays that Cacti lists the core network devices and their present state, revealing whether devices are up or down.

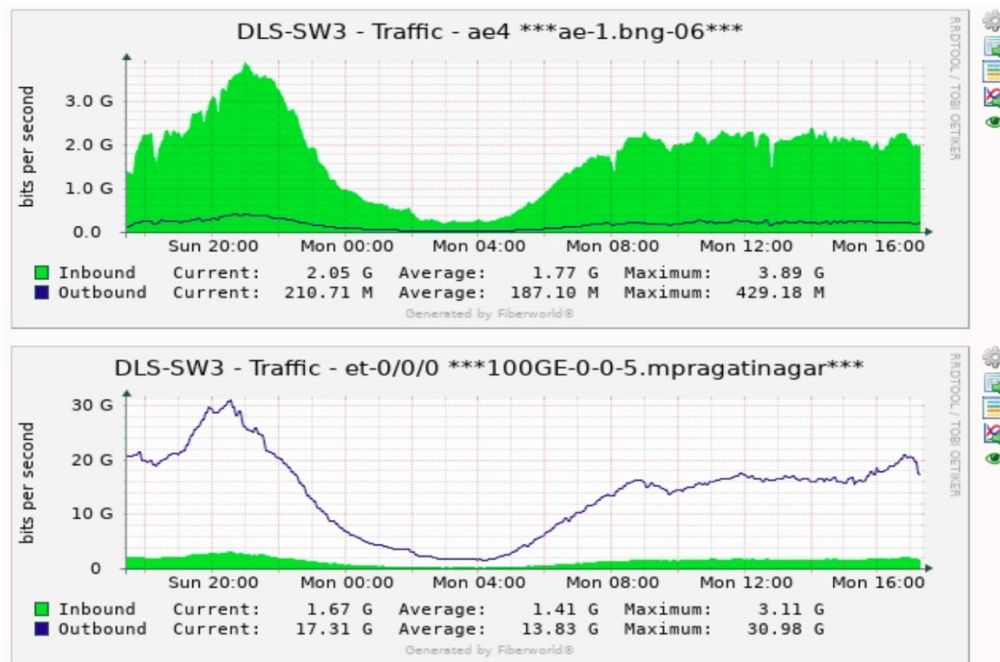


Figure 11: Traffic Monitoring On Cacti.

Figure 11 shows that the traffic is monitored at the interface ae-0/0 of the DLS switch, which is connected to the BNG router via interface ae-0/1. The graph uses bps to display both the incoming and outgoing traffic on the interface and the current use of the interface. Cacti is able to plot network traffic data as fine as every 5 seconds, which helps analyze details of network traffic and monitor bandwidth accurately on the specified port.

Cacti enables FWCPL to easily and quickly detect and address issues involving its key network components, which leads to better reliability and uptime of its services.

4.3.2 Dalo Radius installation

FWCPL needed a centralized solution to effectively handle user access and network authentication. Deploying the DaloRADIUS web user interface on virtual servers solved this problem. DaloRADIUS was selected because it has an easy-to-use interface, provides excellent user management, and is very compatible with RADIUS protocols. Virtualization was performed using VMware vSphere ESXi 6.7 on the

same Dell PowerEdge R710 server, which hosted the Linux virtual machines. Under this environment, a virtual machine with Ubuntu Server 20.04 was used as the main operating system. AAA (Authentication, Authorization, Accounting) is handled by FreeRADIUS and DaloRADIUS, both of which were installed and configured on this virtual machine.

The functionality was improved by combining a third-party CRM portal with backend integration of DaloRADIUS. Some of the main features in this CRM are customer management, ticketing support, TR-069 device setup, stock control, and bandwidth oversight. There is no change to customer data, which makes it easy for networks to run access and service management, handle concerns quickly, and provide better service. This system allows for secure, real-time monitoring and centralized control of the fiber network, which makes it grow smoothly, function well, and support uninterrupted service.

- **System Preparation:** The setup of daloRADIUS, a new virtual machine was created to run the services for authentication and accounting. A virtual machine with 2 TB of storage, 16 GB of RAM and 8 CPU cores was created to performed reliably and could grow as needed. After set up machine, install Ubuntu Server 20.04 LTS and all system packages were update the latest versions to support stability and security prior to installing daloRADIUS.
- **Download and move DaloRADIUS**
 - `cd /var/www/html/`
 - `sudo git clone https://github.com/lirantal/daloradius.git`
 - `sudo mv daloradius /var/www/html/daloradius`

```

root@ubuntu:~# sudo apt-get install freeradius freeradius-mysql freeradius-utils -
y
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  freeradius-common freeradius-config freetds-common libct4 libfreeradius3
  libpcap0.8 libtalloc2 libtevent0 libwbclient0 make
Suggested packages:
  freeradius-ldap freeradius-postgresql freeradius-krb5 snmp freeradius-python3
  make-doc
The following NEW packages will be installed:
  freeradius freeradius-common freeradius-config freeradius-mysql
  freeradius-utils freetds-common libct4 libfreeradius3 libpcap0.8 libtalloc2
  libtevent0 libwbclient0 make
0 upgraded, 13 newly installed, 0 to remove and 11 not upgraded.
Need to get 1,922 kB of archives.
After this operation, 7,847 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu focal/main amd64 libtalloc2 amd64 2.3.0-
3ubuntu1 [29.5 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu focal/main amd64 libtevent0 amd64 0.10.1
-4 [35.5 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libwbclient0 am
d64 2:4.11.6+dfsg-0ubuntu1.10 [221 kB]

```

Figure 12: Dalo Radius Installation.

Figure 12 shows how FreeRADIUS can be set up by using the system package manager. At this stage, the vital RADIUS server is installed and will handle all authentication, authorization, and accounting in the network. This part of the system is responsible for dealing with users and their access rules on daloRADIUS.

During the installation of DaloRADIUS and FreeRADIUS work in a complementary relation. The FreeRADIUS is the core of the RADIUS server, which is responsible of authentication, authorization, and accounting (AAA) for network access. However, FreeRADIUS has a management interface, DaloRADIUS, which is a web-based one that makes FreeRADIUS administration easier. It has a user-friendly GUI to manage users, view logs, monitor usage, and set other settings. DaloRADIUS is just the front-end interface that makes it easier for the administrators to work and manage the FreeRADIUS server, the actual engine that processes everything in the background is FreeRADIUS.

- **Create the FreeRADIUS MySQL database and user**

```
sudo mysql -u root -p
```

```
# Inside the MySQL shell, run:
```

```
CREATE DATABASE radius;
```

```
GRANT ALL ON radius.* TO 'radiususer'@'localhost'  
IDENTIFIED BY 'your_secure_password';  
FLUSH PRIVILEGES;  
EXIT;
```

- **Start and enable FreeRADIUS**

```
sudo systemctl restart freeradius
```

```
sudo systemctl enable freeradius
```

```
# Step 10: Access DaloRADIUS in your browser
```

```
# URL: http://192.168.100.44/daloradius
```

```
# Default login:
```

```
# Username: administrator
```

```
# Password: radius
```

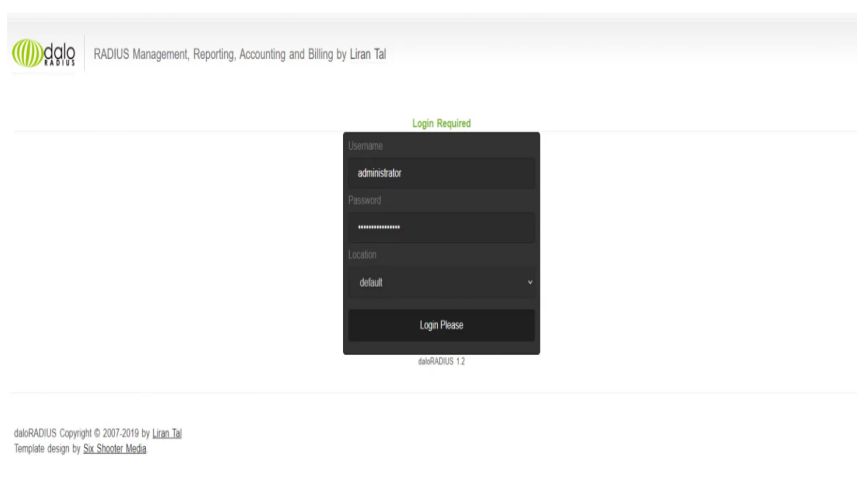


Figure 13: Dalo Radius UI.

When the daloRADIUS system was successfully installed, more settings had to be applied to manage customers and control network access. Customer needs were met by developing private packages that included just the right amount of bandwidth and usable data. Furthermore, the user was given a dynamic or static IP address from the IP pool, helping to organize and control the network.

The addition of a third-party Customer Relationship Management (CRM) platform to daloRADIUS helps run things more smoothly and manage all

aspects more easily. With this synchronization, administrators can control major functions such as accounts, bandwidth packages, IPs, and billing in a central place. TR-069 device provisioning, customer support ticketing, stock control, and tracking how services are used are some of the advanced features available in the CRM portal. Thanks to daloRADIUS, instant updates and easier control were made possible, making both customer service and network management more effective.

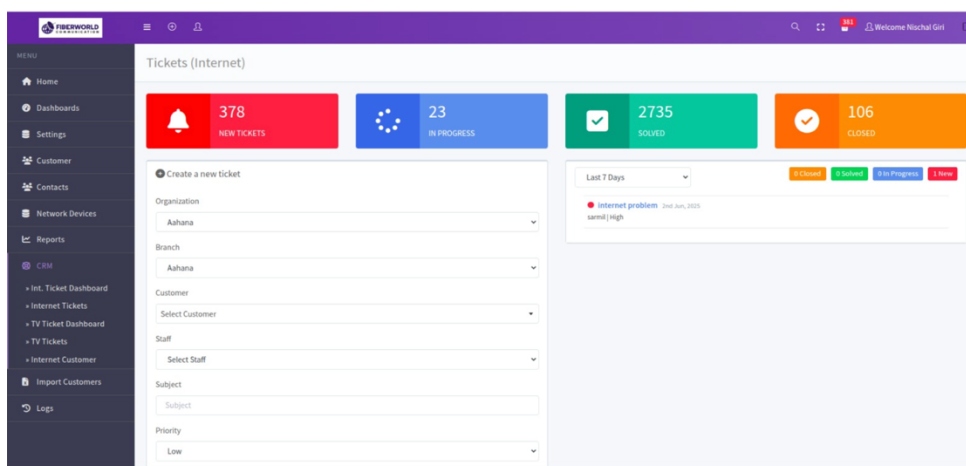


Figure 14: CRM portal in Dalo-Radius.

4.3.3 Designing an FTTH network with a Google Earth map

Google Earth is used to plan the fiber route and decide where to place equipment. It helps people study Earth's structure because it offers detailed satellite pictures and 3D views that are required for planning fiber optic systems. With it, planners review the land, look at nearby objects, and check existing lines to choose the smartest and most cost-effective routes for fiber. It allows for figuring out the best locations for routers, switches, and OLTs so they remain accessible and function efficiently. Moreover, Google Earth can find places where it might be important to pay attention, such as building projects or areas that often flood. When interactive maps are provided to team members, stakeholders, or those in charge, partnership becomes stronger and

projects proceed as planned. On the whole, Google Earth boosts the efficiency, sharpness, and usefulness of fiber network planning.

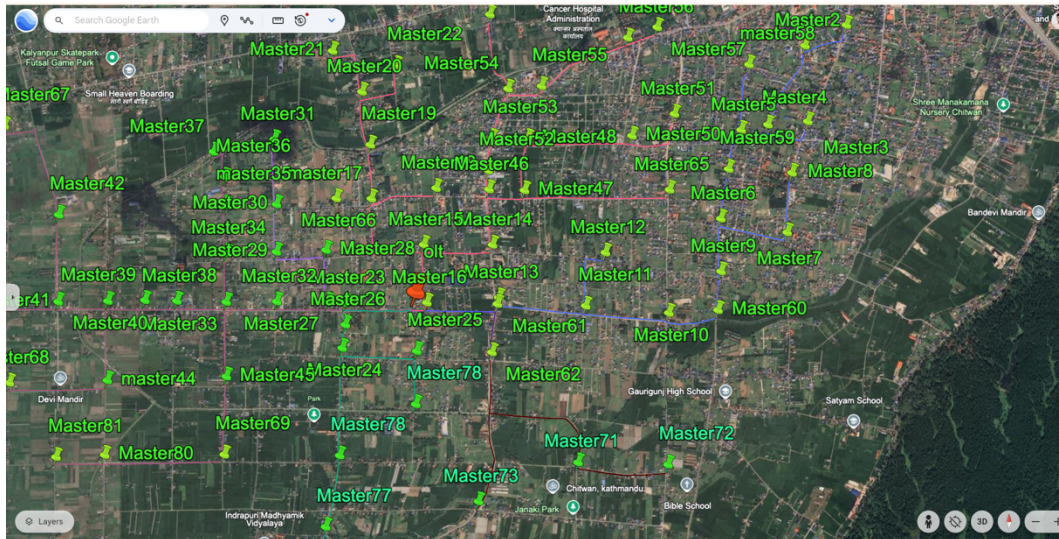


Figure 15: Planning Fiber using Google Earth.

Figure 15 highlights fiber network planning for a Sharannpur branch that belongs to the core network detailed in Figure 5. During the planning of the FTTH network at the FWCLP. In Sharannpur, GPON technology is being used. The access network design consists of PON architecture, so a single OLT can provide service to various ONTs through passive optical splitters.

A 1:8 ratio is used for the network, so every PON port from the OLT can connect to a maximum of eight ONTs through an intermediate splitter. Informally called "Master 1" and "Master 2" by the technical team, these splitters are put on electricity poles in places important for best coverage and efficient signals. Under good power conditions, the OLT PON port will reach areas within a 20 km effective optical range.

Google Earth helped design the route for the cables, discover the proper splitter points, and avoid any troubles with the present infrastructure. Figure 15 outlines a separate branch that is 10 kilometers distant from the central part of the network. Though connected to the main network,

this part is managed independently and set up to meet the needs of Sharannpur Olt with distinct placements and fibers.

To ease maintenance and fault finding, cables are marked with different colors in the design of the network. Red lines indicate 12-core trunk fiber cables, which provide the main uplink and downlink paths to and from the central office. These areas are marked with green and blue lines, showing 6-core distribution fibers going from the splitter points to service locations. Likewise, purple lines are used to show the backbone fibers that link the main networks to the intermediate Master boxes. The use of colors for marking fiber routes greatly improves how technicians perform daily tasks, locate outages, inspect regular operations, and respond quickly to service cuts.

4.3.4 Network Devices Deployment

- OLTs Deployment

A Huawei MA5600 series OLT is used by FWCPL for effective network administration and automated customer support. Client authentication has been set up for VLANs 35 and 1482, providing secure and reliable user access. Furthermore, the TR-069 protocol, which is utilized for remote customer device administration, is assigned to VLAN 22. TR-069 doesn't need on-site technical help by enabling the configuration to be immediately pushed from the system with a single click in a case where a customer's ONT or router is reset. By reducing field trips, this configuration lowers operating expenses and enhances service dependability.

```

#
[sysmode]
<sysmode>
switch adsl mode to rfc2662 vdsl mode to tr129
xpon mode switch-to profile-mode
voice-spec set vag-num 8
protocol support h248
system ex-mode backup
system workscene msan
router mode basic
#
[global-config]
<global-config>
sysname taulihawa-huawei
undo system snmp-user password security
terminal user name buildrun_new_password root *j$1b$|dcCZE*u{G$bGGk"}fJ3>0Q5YTM'pNWK_R}JL[.]Q!-[nK05+b7$* 7
0000:00:00:00:00:00 2000:01:01:00:39:24 root 1 first-login-info 0 "-----"
terminal user name buildrun_new_password portal *~kc$1b$(VSP(ZM*+$R1W"4(GiU-urAi1=[H9VHL_iC^#]D(x,ep0F-fn@$* 0
2000:01:01:00:39:50 2000:01:01:00:39:50 root 2 first-login-info 0 "-----"
terminal user name buildrun_new_password durgesh *~kb$1b$RKLZNoQSLU${n(<.>.Z\;N5epXBAMRx6!i\0KdA'qM**4"D[8lLQ$* 0
2000:01:02:09:05:57 2000:01:02:09:05:57 root 3 first-login-info 0 "-----"
terminal user name history_password root *j$1b$6&!30~}j&0-$jRE1L>A6<3|UCR(japw.maej$V{_0ZLf<-IDBsnB$*
dba-profile add profile-id 11 profile-name "max-band" type4 max 1024000
ont tr069-server-profile add profile-id 1 profile-name "AUTO-TR069" url "http://103.148.22.51:7547" user "fiberworld"
"%##PF1Hf6B)Ak)HJy)CT1$oiB'v#!6/xJx#XDEnFW7%i;@;fK$Yx^DLA~-3,%##"
ont-srvprofile gpon profile-id 4 profile-name "FTTH"
ont-port pots adaptive 32 eth adaptive 8
commit
ont-lineprofile gpon profile-id 0 profile-name "line-profile_default_0"
tcont 0 dba-profile-id 2
tcont 1 dba-profile-id 0
commit
quit
ont-lineprofile gpon profile-id 4 profile-name "FTTH"
tr069-management enable
tcont 1 dba-profile-id 11
gem add 2 eth tcont 1
gem add 4 eth tcont 1
gem add 5 eth tcont 1
gem mapping 2 0 vlan 22
gem mapping 4 0 vlan 1482
gem mapping 5 0 vlan untag
commit
....

```

Figure 16: OLT Current configuration.

Figure 16 explains the process by which FTTH services are enabled on the Optical Line Terminal (OLT). This consists of creating a local ONT, registering it, making a DBA called "max-band" to manage bandwidth settings, and configuring the TR-069 server for remote control. Besides, service types were mapped to L2 segments with the help of GEM and T-CONT interfaces, and different traffic patterns were supported through VLANs (22, 1482, and untagged) for an efficient and differentiated service setup.

Testing:

- **Check Connection:** I checked the connection by doing ping and traceroute tests to check if ONTs are working, the internet is accessible, and the right VLAN is configured for every customer.
- **Monitoring Optical Signal:** Checked the optical power (dBm) for every connected ONT in the controller to make sure no problems with the service were occurring.

```

sharanpur-olt1(config-if-gpon-0/5)#display ont info 0 4
-----
F/S/P           : 0/5/0
ONT-ID          : 4
Control flag    : active
Run state       : online
Config state    : normal
Match state     : match
DBA type        : SR
ONT distance(m) : 239
ONT battery state : not support
Memory occupation : 75%
CPU occupation  : 2%
Temperature     : 64(C)
Authentic type  : SN-auth
SN              : 485754435B4BEA9A (HWTC-5B4BEA9A)
Management mode : OMCI
Software work mode : normal
Isolation state : normal
ONT IP 0 address/mask : -
Description     : samsher9845068074
Last down cause : dying-gasp
Last up time    : 2025-06-02 21:26:22+05:45
Last down time  : 2025-06-02 21:24:54+05:45

sharanpur-olt1(config-if-gpon-0/5)#display ont optical-info 0 4
-----
ONU NNI port ID : 0
Module type      : GPON
Module sub-type  : CLASS B+
Used type        : ONU
Encapsulation Type : BOSA ON BOARD
Optical power precision(dBm) : 3.0
Vendor name      : HUAWEI
Vendor rev       : -
Vendor FN        : HW-BOB-0007
Vendor SN        : 1718Y4640355B
Date Code        : 17-07-21
Rx optical power(dBm) : -23.28
Rx power current warning threshold(dBm) : [-,-]
Rx power current alarm threshold(dBm) : [-29.0,-7.0]
Tx optical power(dBm) : 2.41
Tx power current warning threshold(dBm) : [-,-]
Tx power current alarm threshold(dBm) : [0.0,5.0]

```

Figure 17: ONU Optical Status.

Figure 17 shows the network connections on the ONT with the GPON interface on the OLT. It gives clear specifications such as the type of module used (CLASS B+), the amount of optical power available, names of the vendors, and data related to transmission performance. The links are stable because the optical power indicator of -23.98 dBm is acceptable at the OLT and 2.14 dBm at the ONT, which are within the predetermined alarm limits.

- Switch Deployment:

At FWCPD we use Cisco and Huawei switches in our network design to manage traffic effectively. They have support for modern protocols, including MPLS for efficient routing, LACP for merging links, STP for stopping loops, and ERPS for protecting Ethernet rings. They allow smooth and flexible switching of data traffic over the FTTH network.

```

interface Eth-Trunk2
description **damak-unified-poi**
port link-type trunk
undo port trunk allow-pass vlan 1
port trunk allow-pass vlan 15 to 16 21 23 49 66 150 202 205 400 402 to 409
port trunk allow-pass vlan 601 to 602 813 1313 to 1314 3002
stp disable
mode lacp
load-balance enhanced profile MPLBPP
#
return
[damak-nea-Eth-Trunk2]dis
[damak-nea-Eth-Trunk2]display ur
[damak-nea-Eth-Trunk2]display url-template int
[damak-nea-Eth-Trunk2]display url-template intxg
[damak-nea-Eth-Trunk2]display url-template in
[damak-nea-Eth-Trunk2]display url-template it
[damak-nea-Eth-Trunk2]display cur
[damak-nea-Eth-Trunk2]display current-configuration int
[damak-nea-Eth-Trunk2]display current-configuration interface xg
[damak-nea-Eth-Trunk2]display current-configuration interface XGigabitEthernet 0/0/3
#
interface XGigabitEthernet0/0/3
#
return
[damak-nea-Eth-Trunk2]display current-configuration interface XGigabitEthernet 0/0/4
#
interface XGigabitEthernet0/0/4
description **unified-office-ET2**
eth-trunk 2
#
return
[damak-nea-Eth-Trunk2]display current-configuration interface XGigabitEthernet 0/0/5
#
interface XGigabitEthernet0/0/5
description **unified-office-ET2**
eth-trunk 2
#
return
[damak-nea-Eth-Trunk2]

```

Figure 18:LACP configuration of the Interface

Figure 18 provided here is a CLI configuration for setting up an Eth-Trunk (Link Aggregation Group). By using LACP mode, this configuration helps increase the network bandwidth, divide the workload evenly, and ensure extra support in case one link fails. It is made to work with a particular set of VLANs by allowing only the necessary traffic, proving its function in targeting network traffic.

- Router deployment

High-performance routers from Juniper and MikroTik are used by FWCP to control customer traffic and secure their networks. The routers handle the process of authenticating customers with PPPoE, as well as BGP and eBGP routing, and adjusting the bandwidth according to each user's settings. Also, network security is enhanced by putting a firewall and VPN configurations in place. VLANs are used to keep specific areas secure by separating traffic, which also increases performance in FTTH networks.

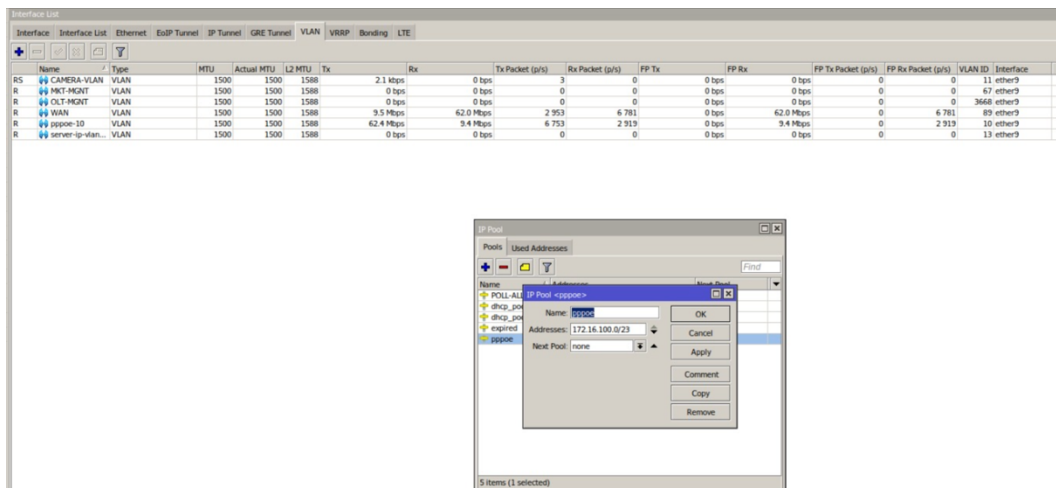


Figure 19: Configuring the VLAN interface.

Figure 19 demonstrates how to set up a network management interface for operating a FTTH network. This file describes three VLAN interfaces (CAMERA-VLAN, OLT-MGMT, and WAN) and displays the current traffic rates and VLAN IDs for each one. This proves that the network is logically separated and can be closely monitored. Below that, a configuration window for an IP Pool appears, giving the dynamic IP range 172.16.100.0/23 to the pool named "pppoe." IP pool is important for mobile devices, as it allows PPPoE to assign IPs automatically to connected customer devices, streamlining both customer service delivery and subscriber management.

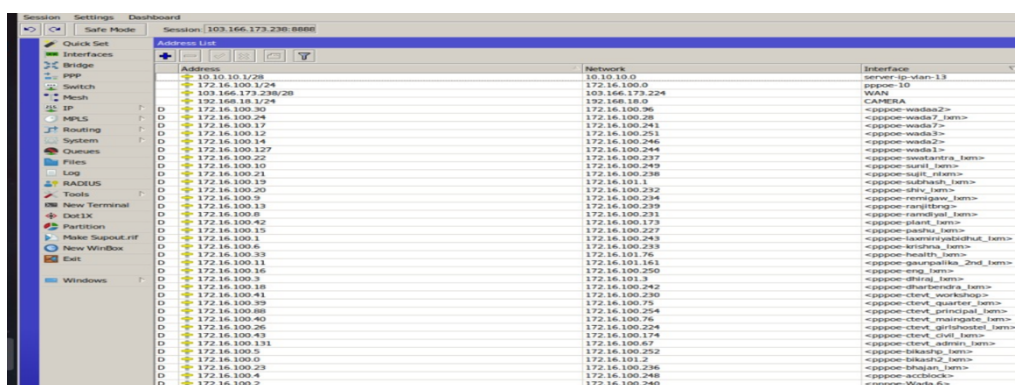


Figure 20: IP Config and PPPoE connection

Figure 20 shows a network device's management interface and highlights an important IP Address List. This section shows the IP addresses, their related network ranges and the related network interfaces. A lot of entries involving "PPPoE" interfaces suggest that IP addresses are dynamically assigned to each customer connection. This figure outlines a major aspect of handling subscriber connections in an FTTH network: each connected device gets its unique network identifier for data communication.

Router role in FTTH:

- **Traffic Management and Routing:** Routers at the customer end of an FTTH network direct traffic, manage PPPoE sessions, and guide it using protocols such as BGP and eBGP for a steady and reliable internet service.

- **Security and Network Control:** With firewall protection, VPN services, and VLAN grouping, they keep user information safe, stop harmful attacks, and arrange the network into different zones.

- **ONU/ONT setup**

The ONT is one-of-a-kind for every customer and gets verified using VLAN by the OLT for internet, IPTV, and voice services. Network settings, including VLAN tagging, service profiles, and user logins, are transmitted wirelessly so that the network can be efficiently activated and supervised remotely. The process of automatically running provisioning makes customers happier and helps minimize errors.

Configuration:

- The ONUs are assigned to specific VLANs by the operator, including one for the internet (VLAN 35), one for authentication (VLAN 1482), and one for remote management (VLAN 22).

- Remote Configuration: Using the TR-069 protocol in OLT, service providers can enable services, update software, and manage the customer profile all remotely, without going to the site.

Basic Information	
Enable WAN:	<input checked="" type="checkbox"/>
Encapsulation Mode:	<input type="radio"/> IPoE <input checked="" type="radio"/> PPPoE
Protocol Type:	IPv4
WAN Mode:	Route WAN
Service Type:	INTERNET
Enable VLAN:	<input checked="" type="checkbox"/>
VLAN ID:	1482 <small>*(1-4094)</small>
802.1p Policy:	Use the specified value
802.1p:	0
MRU:	<input type="text"/> <small>(1-1540)</small>
User Name:	fwcpl_hotel
Password:
Enable LCP Detection:	<input type="checkbox"/>
Binding Options:	<input type="checkbox"/> LAN1 <input type="checkbox"/> LAN2 <input type="checkbox"/> LAN3 <input type="checkbox"/> LAN4 <input type="checkbox"/> SSID1 <input type="checkbox"/> SSID2 <input type="checkbox"/> SSID3 <input type="checkbox"/> SSID4
IPv4 Information	

Figure 21: Onu configuration.

Figure 21 shows a PPPoE setup with the precise configuration of the Huawei ONU. However, this setup requires detailing out the authentication parameters of the user appropriately user identified as fwcpl_hotel, belonging to VLAN ID 1482. Establishing and managing individual subscriber connections within the FTTH network in a secure way requires this kind of configuration to properly segment traffic and to properly authenticate the users.

Testing:

- Optical power checking (at both ends of the fiber link) verified that the OLT and ONU are connected correctly.
- Tested internet, IPTV, and VoIP services to make sure connectivity is correct by thoroughly investigating VLAN tagging, IP addresses, and data transfer.

ONT Information		
	Current Value	Reference Value
Optical Signal Sending Status:	Auto	Auto
TX Optical Power:	2.28 dBm	0.5 to 5 dBm
RX Optical Power:	-21.49 dBm	-30 to -8 dBm
Working Voltage:	3299 mV	3100 to 3500 mV
Bias Current:	13 mA	0 to 90 mA
Working Temperature:	52 °C	-10 to +85 °C

Figure 22: ONT Optical information.

In Figure 22, ONT Information is provided, which provides the confirmation of the ONT active status and optical parameters of the fiber link from OLT to ONT. The operational values are presented in the table comparing their current values with the established reference values for the optical connection health and performance. Specifically, the TX Optical Power of 2.28 dBm and RX Optical Power of -21.49 dBm lie in their reference range (0.5 to 5 dBm for TX, -30 to -8 dBm for RX) respectively, which means no signal distortion during transmission and reception. More than that, other parameters like Working Voltage (3299 mV), Bias Current (13 mA), and Working Temperature (52 °C) are also in the allowable range of operation. These are measurements that allow for make diagnosis of link quality, guarantee stable data transmission, and confirm the reliability of FTTH service delivered up to the customer's premises.

4.4 Key Learnings and Future Recommendations from FTTH Deployment

This study discusses the main learnings and useful experiences gained by deploying and analyzing Fiber to the Home (FTTH) technology. Covering the steps of design, building, testing, and reviewing performance gave important information for constructing efficient fiber-based networks. The observations here are real-world and highlight how important it is to balance productivity, customer experience, and a company's ability to last over time. The findings have resulted in specific recommendations aimed at increasing the scalability, security, and usefulness of FTTH infrastructure in the future.

Network Efficiency and Infrastructure Role Analysis in FTTH Systems

- **Enhanced Network Performance:** Results from testing demonstrated that FTTH has much greater bandwidth and lower latency compared to traditional broadband. The end-user devices were able to reach close to gigabit speeds because of the fiber-optic infrastructure, proving the network's effectiveness.
- **Low-Latency Communication:** Because of FTTH networks, online gaming, video conferencing, and platforms requiring a lot of data became more responsive and experienced less delay.

Functionality of Core Devices

- **Router Functionality:** Routers managed the traffic flow between the central office and users, automatically routing data using OSPF to keep all data routes balanced and working properly.
- performance was not affected, but later scaling may require replacing or upgrading some networking devices.

4.4.1 Recommendation

Based on the FTTH infrastructure setup at Fiber World, a number of recommendations are suggested to help the network perform better. The goal of these suggestions is to improve performance, make the network more secure, ensure customers are happy and get ready for future growth.

- **Performance enhancement**

Advanced routing techniques are necessary to make the network more effective and guarantee trouble-free service. Even though OSPF ensures good routing stability, it is advised to switch to Border Gateway Protocol (BGP) when growing in the future. BGP gives better options for selecting routes and makes networks more reliable in cases where multiple autonomous systems join up. In addition, using strong Quality of Service (QoS) features will boost the priority of emergency services and VoIP, so these data transmissions get preferred attention over usual traffic.

- **Security Reinforcement**

To ensure good service quality and reduce network response time, using VLAN segmentation is recommended. Separating management, voice, data and IPTV services using VLANs can reduce congestion, increase the speed of transfer and limit the number of broadcast domains, leading to better efficiency and easier fault isolation. Using a reliable system for network monitoring is necessary as well. Using network monitoring tools that measure bandwidth, latency, jitter and packet loss.

A larger network also has more vulnerability points. To minimize security risks, performing network penetration testing and vulnerability checks should be done on a regular basis. Employing ethical hacking will enable authorities to try out possible attacks and develop effective ways to defend the infrastructure. Besides, setting up security tools driven by AI is a highly recommended step. Such systems are designed to spot and deal with new threats as they appear, using an efficient and automatic process. It is important to pay attention to end-user education.

Programs aimed at detecting phishing, malware and social engineering attacks will increase awareness among users and decrease security events caused by human mistakes.

- **User Experience Upgrades**

When multi-channel support systems are put in place, customer experience can be made better. Providing support through channels such as live chat, support tickets, and technical teams will help fix issues promptly and properly. Moreover, mobile support tools and apps allow users to check data usage, resolve problems they might have, and reach out to customer service by themselves. With the self-service option, customers will be less likely to complain, and their satisfaction can rise.

- **Scalable Infrastructure Planning**

To keep growing, it is necessary to upgrade the infrastructure that will support future developments. Updating the network by choosing equipment with modular ports, significant processing power, and flexible ways to upgrade will help it remain valuable as needs increase. In addition, adding edge computing to the FTTH system can lessen the delay experienced by users and help reduce the traffic on central servers. Because of edge nodes, local traffic is handled well in highly populated areas, resulting in faster responses and better service.

5 FINDINGS AND DISCUSSION

This section focuses on the assessment of Fiber-to-the-Home (FTTH) technology in practical deployment settings. The goal is to examine the critical factors that influence successful FTTH implementation, such as cost-effectiveness, infrastructure readiness, and user satisfaction. The findings are based on real-world applications, documented cases, and deployment experiences that provide a comprehensive understanding of how FTTH performs under various conditions.

FWCPL began using FTTH technology, which has allowed the company to observe how network transformation, better operations, and a higher level of customer satisfaction can help meet the objectives of this study. Using technology, it is clearly found that moving from copper-based ADSL to GPON networks brings a significant change in how well the network performs. Results from the detailed comparison (Table 1) and live network installations (Figures 14, 15, 16, 17, 18) prove that GPON is much faster, has greater coverage, is barely influenced by electrical interference, and experiences much less latency and jitter than ADSL. This makes it possible for people in Nepal to enjoy high-quality streaming, big downloads, and online gaming without lag, responding directly to what the market wants.

FTTH, although requiring a lot of upfront investment on infrastructure such as OLTs, ONTs, and fiber, should reduce expenses in the years to come because fibers require little maintenance and last a long time. Using detailed planning with Google Earth and network monitoring software like Cacti and DaloRADIUS points out that having solid network management systems helps to conserve network resources and keep services responsive. Proper configuration of routers and switches using protocols like LACP and STP reinforces that FWCPL can build a highly flexible and available network that handles large amounts of traffic and provides effective routing.

When looking at customer experience, it is clear that happy users tend to use up service more when they experience fast and high-quality internet access. The presence of a customer portal and a ticketing system (Figures 2 and 3) allows clients to add suggestions, report issues, and see how much they are using, which all lead to a better client experience. The findings in the customer experience section further indicate that challenges during setup can be solved by delivering services with care and when users need help. As a result, the well-established and still improving FTTH services at FWCPL now give a model that can grow with the nation, showcasing fiber optic technology's value for its digital advancements and positive effects on the economy

6 CONCLUSION

The study examined in detail the planning and implementation of the FTTH project at FWCPL in Nepal, all aimed at improving the network's structure, guaranteeing our services, and increasing customer contentment. The objectives relating to flexible network configuration, customer management, network security, and installation of products have been met by carrying out both quantitative and qualitative analyses.

The study clearly shows that GPON FTTH is a greater advancement than ADSL, which uses copper networks. The connection it provides has a higher data speed, extends farther, is more dependable, and has a much lower delay, helping today's digital needs like 4K streaming and virtual gaming. It is costly to install a FTTH network at the start, but its durability and low maintenance mean that the network will save money in the long run. Well-utilized tools such as Cacti and DaloRADIUS, and precise planning with Google Earth, show the significance of effective planning and management in building a fast and secure network. As well, according to the findings, although having top technology matters, people are equally satisfied when the installation goes smoothly, support remains strong, and they can easily convey their feedback.

To conclude, using the FTTH model like FWCPL has proven to be a wise and future-focused option for internet service providers worldwide. Because of the effective planning, adjusted network settings, and heavy attention on customer needs, FWCPL can now offer reliable and fast internet to meet the demand in Nepal. This study confirms the benefits of FTTH in terms of technology and economics, and it offers helpful guidance on dealing with the challenges of deployment and making the broadband environment more resilient and customer-centric.

REFERENCE

- Abdullah, W. W., Chuah, T., Abidin, A. Z., & Jenu, M. (2009). Measurement and verification of the impact of electromagnetic interference from household appliances on digital subscriber loop systems. *IET Science Measurement & Technology*, 3(6), 384–394. <https://doi.org/10.1049/iet-smt.2009.0002>
- Abdellaoui, Z., Dieudonne, Y., & Aleya, A. (2021). Design, implementation and evaluation of a Fiber To The Home (FTTH) access network based on a Giga Passive Optical Network GPON. *Array*, 10, 100058. <https://doi.org/10.1016/j.array.2021.100058>
- Adiati, R. F., Kusumawardhani, A., & Setijono, H. (2022). Design and analysis of an FTTH-GPON in a residential area. *Jurnal Pendidikan Fisika Dan Teknologi*, 8(2), 228–237. <https://doi.org/10.29303/jpft.v8i2.4233>
- Agboje, O., Adedoyin, S., & Ndujiuba, C. (2017). State of fiber optic networks for internet broadband penetration in Nigeria - a review. *International Journal of Optoelectronic Engineering*, 2017, 1–12. <https://doi.org/10.5923/j.ijoe.20170701.01>
- Arévalo, G. V., Hincapié, R. C., & Gaudino, R. (2017). Optimization of multiple PON deployment costs and comparison between GPON, XGPON, NGPON2 and UDWDM PON. *Optical Switching and Networking*, 25, 80–90. <https://doi.org/10.1016/j.osn.2017.03.003>

- Butt, R. A., Mohammad, S. H., Idrus, S. M., & Rehman, S. U. (2015). EVOLUTION OF ACCESS NETWORK FROM COPPER TO PON — CURRENT STATUS. *ARPJ Journal of Engineering and Applied Sciences*, 10(18), 8431–8440.
http://www.arpnjournals.org/jeas/research_papers/rp_2015/jeas_1015_2740.pdf
- Fok, M. P., Wang, Z., Deng, Y., & Prucnal, P. R. (2011). Optical layer security in Fiber-Optic networks. *IEEE Transactions on Information Forensics and Security*, 6(3), 725–736.
<https://doi.org/10.1109/tifs.2011.2141990>
- Gage, B., Greenwell, R., Summerlin, M., & Zetlen, B. (1984). Fiber optic aircraft Systems Electromagnetic Pulse (EMP) survivability. *Proceedings of SPIE, the International Society for Optical Engineering/Proceedings of SPIE, 0506*, 109.
<https://doi.org/10.1117/12.944912>
- George, D., George, A., & Dr.T.Baskar. (2023). SD-WAN Security Threats, Bandwidth Issues, SLA, and Flaws: An In-Depth Analysis of FTTH, 4G, 5G, and Broadband technologies. *Zenodo (CERN European Organization for Nuclear Research)*. <https://doi.org/10.5281/zenodo.8057014>
- Gilfedder, T. (2006). Deploying GPON technology for backhaul applications. *BT Technology Journal*, 24(2), 20–25.
<https://doi.org/10.1007/s10550-006-0034-9>
- Gutierrez, L., Garfias, P., De, M., Cervello-Pastor, C., & Sallent, S. (2010). Next Generation Optical Access Networks: from TDM to WDM. In *InTech eBooks*.
<https://doi.org/10.5772/8473>
- Khatiwoda, N. R., & Dawadi, B. R. (2021). A study on FTTH implementation and migration in Nepal. *Journal of*

Engineering Issues and Solutions, 1(1), 174–196.

<https://doi.org/10.3126/joeis.v1i1.36836>

Lee, J., Dhital, D., & Yoon, D. (2010). Investigation of cladding and coating stripping methods for specialty optical fibers.

Optics and Lasers in Engineering, 49(3), 324–330.

<https://doi.org/10.1016/j.optlaseng.2010.10.008>

Lee, N. Y., & Lee, N. D. (2003). Broadband access in korea: experience and future perspective. *IEEE Communications Magazine*, 41(12), 30–36.

<https://doi.org/10.1109/mcom.2003.1252796>

Marmur, O., & Shraga, E. (2004). GPON: the next big thing in optical access networks. *Proceedings of SPIE, the International Society for Optical Engineering/Proceedings of SPIE*, 5282, 199. <https://doi.org/10.1117/12.516435>

Naeem, A., Qurashi, S. S., Khan, Y., Ahmed, S., & Safwan, N. (2020). Fiber to the Home (FTTH) Automation Planning, Its Impact on Customer Satisfaction & Cost-Effectiveness.

Wireless Personal Communications, 117(2), 503–524.

<https://doi.org/10.1007/s11277-020-07880-4>

Nowak, D., & Murphy, J. (2005). FTTH: the overview of existing technologies. *Proceedings of SPIE, the International Society for Optical Engineering/Proceedings of SPIE*, 5825, 500.

<https://doi.org/10.1117/12.604960>

- Oboyerulu, A., & Felix, O. (2016). Comparative analysis of GPON and DSL access technologies for enhancing broadband internet penetration in Nigeria. *International Journal of Applied Information Systems*, 10(8), 16–21.
<https://doi.org/10.5120/ijais2016451466>
- Pandey, S., & Regmi, N. (2017). Changing connectivities and renewed priorities: Status and challenges facing Nepali Internet. *First Monday*.
<https://doi.org/10.5210/fm.v23i1.8071>
- Passive optical network. (2025). In *Wikipedia*. Retrieved June 11, 2025, from
https://en.wikipedia.org/wiki/Passive_optical_network
- Rashed, A. N. Z. (2011). High Transmission Bit Rate of Multi Giga Bit per second for Short Range Optical Wireless Access Communication Networks. *Journal of Electrical and Electronics Engineering Research*, 3(5), 80–86.
<https://doi.org/10.5897/jeeer.9000018>
- Sun, Y., Srivastava, A. K., Zhou, J., & Sulhoff, J. W. (2002). Optical fiber amplifiers for WDM optical networks. *Bell Labs Technical Journal*, 4(1), 187–206.
<https://doi.org/10.1002/bltj.2153>
- Wetherhold, R. C., & McManaman, J. M. (2005). EMI shielding effectiveness of Copper/Epoxy composites. *Polymers and Polymer Composites*, 13(7), 657–668.
<https://doi.org/10.1177/096739110501300702>

Zhou, S., Liu, X., Effenberger, F., & Chao, J. (2017). Low-Latency High-Efficiency mobile Fronthaul with TDM-PON (Mobile-PON). *Journal of Optical Communications and Networking*, 10(1), A20.
<https://doi.org/10.1364/jocn.10.000a20>

APPENDIX



FIBERWORLD Communication Pvt Ltd

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Toll Free: Ncell: - 9801571250, Ntc: - 16607852003

Reg No: 230738/076/077

Date: 15th January 2025

Subject: Authorization for use of tools and Resources for a Research project

Dear Rabindra Adhikari,

I am pleased to formally authorize the use of the requested tools and resources for your research project titled: "FTTH Planning and Implementation of Fiberworld Communication Pvt. Ltd." This project is scheduled to run from August 2024 to July 2025 and aligns with our goals to enhance network infrastructure through effective FTTH deployment.

You are granted permission to access and utilize the following tools and resources solely for the purposes of this research:

- Servers
- Routers
- mapping
- Switches
- Optical Line Terminal (OLT)
- Customer Details
- Company Documents
- Company Device Credentials

Please ensure that all resources and data are handled with strict confidentiality and in accordance with applicable organizational policies, ethical standards, and data protection regulations. We trust that you will carry out your work with professionalism and integrity. Should you require any additional assistance or clarification during your project, feel free to reach out. We appreciate your contribution to advancing networking technologies and look forward to the successful completion of your research.

Best regards,

Nischal Giri

Network & System Engineer

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Figure 23: Authorized Letter form Company.

```
interface Eth-Trunk1
description **LACP-huawei-olt-[20g]**
port link-type trunk
undo port trunk allow-pass vlan 1
port trunk allow-pass vlan 14 39 206 to 208
stp disable
mode lacp
mac-address flapping action error-down
#
return
[bhedabari_sw1-Eth-Trunk1]q
[bhedabari_sw1]int
[bhedabari_sw1]interface xg
[bhedabari_sw1]interface XGigabitEthernet 0/0/17
[bhedabari_sw1-XGigabitEthernet0/0/17]dis
[bhedabari_sw1-XGigabitEthernet0/0/17]display th
[bhedabari_sw1-XGigabitEthernet0/0/17]display this
#
interface XGigabitEthernet0/0/17
description ***to-huawei-olt-giu-0/8/0-et1***
eth-trunk 1
#
return
[bhedabari_sw1-XGigabitEthernet0/0/17]interface XGigabitEthernet
0/0/19
[bhedabari_sw1-XGigabitEthernet0/0/19]display this
#
interface XGigabitEthernet0/0/19
description ***to-huawei-olt-giu-0/8/1-et1***
eth-trunk 1
#
return
[bhedabari_sw1-XGigabitEthernet0/0/19]
```