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Design of an FTTH (Fiber To The Home) network for improving voice, broadband, and television services in hard-to-reach areas the Colombian case

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ABSTRACT

This project establishes the process of designing a fiber optic Ftth network that reaches the homes of each end customer, which allows providing voice services, broadband internet, and television, the above using GPON technology, based on the tree architecture through passive elements, where the node or central is connected to other nodes through a common link, which is shared by all the nodes (ONTs) of the network. This network will be designed in two levels, the first level that starts from the OLT to the level one splitter and the second level that begins from the level one splitter to the OTB element that the level two Splitters have. The entire design will be subject to standards that must be met to achieve the percentage of attenuation allowed. At the design level, it has two directions: one from left to right, where the nodes insert traffic, and another from right to left, where the nodes only have two functions: read or read and delete traffic. It is nothing more than the convergence of the primary communication services of today, such as fixed telephony, the Internet, and television. The FTTH Network is designed for the Municipality of Usiacurí of the Department of Atlántico, using the Top-Down Design methodology, where the requirements are analyzed, the designs are developed, and the tests are carried out. The operation of this network is monitored.

1. Introduction

The demand for communications services such as Internet speed and cable image quality has increased considerably, so much so that the current infrastructure for providing the service is insufficient and inefficient. Networks that use copper cable as a transmission have difficulty maintaining internet speed in distant sections because of power losses over long distances and interference in the same network.

Based on the above, new technologies are born and implemented with another type of material, fiber. With this, there is a way to multiply the threads by optimizing resources. It is essential to design and deploy cost-effective fiber networks that benefit both the company and the community, as expressed by [1].

Telecommunications have advanced based on the demands that are born today worldwide. It is known that the way of communicating has changed, and there is a need to study the constant evolution of technology in detail. An analysis of the global operation is made, and what is mentioned by [2] is taken as a basis: "Mobile connections have grown in the last ten years, surpassing fixed connections; likewise, there is an increase in people using the internet and broadband connections." However, there must be a constant and fully connected network infrastructure, so it is vital to know the topology, the scope, and the means for data transmission.

According to [3], "the topology defines the physical map the network follows to establish communication between users. It is how computers and nodes connect ". Topologies can be point-to-point, star, mesh, ring, bus, or tree. Having the previous concept clear, it is necessary to know the area level they can reach and how these influence the establishment of good communication. The LAN, CAN, MAN, and WAN stand out.

It is identified that the fundamental problem that the Municipality of Usiacurí presents today is the limitations that exist when connecting. A new design of network Based on FTTH technology is proposed so that many users stop having problems when starting their connection. This project focuses on the Municipality of Usiacurí, which has been mentioned as a beneficiary of the development of new projects that, at the government's initiative, have tried to offer a better service, but none has materialized. [4]. The rest of the paper is structured as follows. The second part is the literature review on FTTH networks. Likewise, the applied research methodology is shown. The third section describes the explanations and results when simulating the browsing experience of customers who contract the different plans where the contracted bandwidth is guaranteed. Finally, the conclusions are presented, highlighting the results obtained from this research.

2. Literature Review

Initially, a report published by the newspaper El Tiempo was taken as a basis. The Department of Atlántico reserves connectivity for urban centers and municipalities close to large cities. Three towns with the worst connectivity stand out, among which are Candelaria, Manatí, and Usiacurí, as shown in Fig. 1 [5].

Municipalities	Homes with Internet			Homes without Internet		
	Urban	Rural	Total	Urban	Rural	Total
Candelaria	17	1	18	2630	1268	3898
Manati	42	3	45	3718	856	4374
Usiacuri	23	0	23	2130	376	2506

Fig. 1. Municipalities with the worst connectivity in Atlantico

To have a broader overview of the terms that describe this research, it is necessary to highlight the importance of those concepts that help understand the purpose of this research. It is not easy to design without having the bases for each definition. That is why the ideal is to strengthen each piece of knowledge by clarifying its meaning. Design is defined globally as a process carried out before any solution works in all fields and is usually applied in areas such as engineering, architecture, marketing, and all those requiring creativity and innovation. Supporting this concept in what [6] indicates, "there are many languages in which the word design does not exist. At present, the term design is understandable throughout the world." The design of FTTH Networks can be defined as the network topology used to connect clients to their homes. Its design starts from a telephone exchange and differs from the others by implementing dividers responsible for multiplying the wires used in the network, as [7] explains. This type of design is widely known worldwide. Under their commercial brand, such as Movistar, Claro, and Tigo-Une, large companies have used and executed this type of design that provides a solution to the current established demand. "On the other hand, there is the concept of bandwidth in network connections, better known as transmission speed, which is the number of bits that can be sent in a unit of time" [8]. [9] indicate that "all FTTH infrastructures are based on PON networks, which stand out for the absence of active elements along the stretch deployed to the users." Elements such as the ONT oversee receiving and filtering the information intended for a specific user from an OLT [10]. They are usually installed in homes together with the corresponding optical rosette, as shown in Fig. 2.

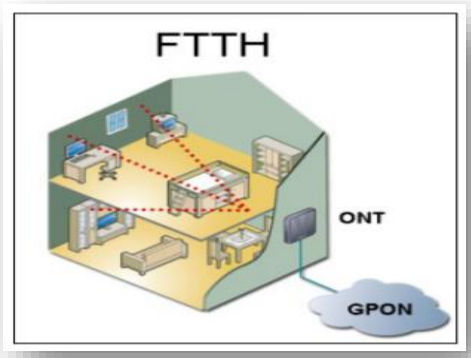


Fig. 2. ONT Active Equipment Diagrams

According to [11], "the splitter is also known as an optical splitter and is responsible for dividing the light into a certain number of output streams of up to 128 lines". For a better understanding of the previous definition, a scheme is related in Fig. 3.

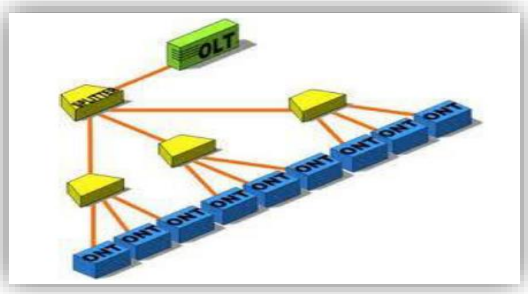


Fig. 3. Elements of a PON Network

Articles and guiding projects highlighted below are used to develop this project. [12] and [13] to comply with the characteristics of a GPON network, it recommended following the guidelines proposed in the design of the network; in such a way that it is possible to exploit all the benefits offered by GPON technology, installing the most significant possible number of services per user. The main objective narrated in this article was to address the best practices applicable to the design and deployment of GPON fiber optic networks, with which stability in the services they provide is guaranteed. Its methodology indicated the criteria that must be taken when starting with this type of design. Initially, the sector in which the strategy is to be implemented must be known, being clear about the number of inhabitants to determine a possible current demand and future.

The second is to determine the bandwidth offered to each user and the splitter level to implement. One of the results was reducing the deployment cost and the maintenance of the designed network by avoiding installing and maintaining parallel networks for each of its services. [14] explored the importance for internet providers to implement traffic management methods increasingly focused on giving better administration to the bandwidth of residential and corporate clients since this grows exponentially and with them their needs.

The research's objective was to simulate tunnels based on traffic engineering on an IP/MPLS Core using the eNSP software that demonstrates its effectiveness in traffic routing. It used a methodology in a descriptive, analytical, and experimental explanatory way. [15] use Particle Swarm Optimization (PSO) to propose an Optical Distribution Network (ODN) design in the FTTH network. Another FTTH network design is explained by [16] in an urban area.

[17] had the objective of analyzing and studying new types of network devices that have emerged in the national market, acquiring the necessary knowledge of their manipulation and configuration, and choosing routers and switches that had the characteristics required for the implementation of a network topology where students and professors at their university can make physical configurations. The project aims to ground the theoretical concepts in teachers and students of Telecommunications Networks at ESFOT through developing networks in Mikrotik brand equipment. They used an explanatory and applicative methodology to build their project since this methodology is evidenced in managing information and resources.

It considers what [15] mentions in Fig. 4 about the differences in single-mode and multimode fibers suitable for long-distance applications. In contrast, multimode optical fiber is designed for short-distance routes. Considering what was previously studied as the primary goal, it is desired to develop a technically viable network that provides Internet service to the entire municipality of Usiacurí Atlántico through the deployment of fiber optics using FTTH technology, allowing people to have access to services such as TV, TELEPHONY, and INTERNET, with different navigation plans depending on the economic capacity of the client. For this, it is necessary to implement a type of optical fiber that establishes long-distance communication. It is optimal and has a high speed at the time of propagation.

[18] in his research, he showed the distributed design of a corporate network topology of a multinational, specifying changes in fiber optic lines (single mode and multimode) and equipment updating, highlighting the importance of having high connectivity through fiber.

Cable Distance							
Cable Type		**Fast Ethernet 100**	**1GB Ethernet-SX**	**1GB Ethernet- LX**	**10GB-SE-SR**	**40GB-SR4**	**100GB-SR10**
Single Mode	OS2	200m	500m	500m	10km	X	X
Multimode	OM1	200m	275m	550m	X	X	X
Multimode	OM2	200m	550m	550m	X	X	X
Multimod	OM3	200m	550m	550m	300m	100m	100m
Multimod	OM4	200m	550m	550m	400m	150m	150m
Multimod	OM5	200m	550m	550m	300m	400m	400m

Fig. 4. Distance difference between multimode fiber vs. single-mode fiber

2.1. Conceptual framework

Based on the research and the points given in this research, the concepts of the most relevant terms of this project are defined below.

- FTTH: FTTH is defined as Fiber To The Home, which means fiber to the home, thanks to which the world can live connected better. It relies on fiber optics to offer better services to customers by taking them to your home without the need to transition, as happens with copper cables. [19] FTTH indicates this "constitutes a fiber-based access network, connecting many end users to a central point known as an access node or point of presence (POP)." This term is used worldwide to differentiate it from other types of technologies, and its difference lies in the last word, the H, which means. This technology is identified in the world of companies. [19] states that most large companies also offer FTTH technology, which is responsible for using optical fibers and optical distribution systems, reducing costs.
- FTTH Network Design: This design is defined as the network topology used to connect customers to their homes [20]. Its design starts from a telephone exchange and differs from the others by implementing dividers responsible for multiplying the wires used in the network. This type of design is highly known worldwide. Large companies under its trademark, such as Movistar, Claro, and Tigo-Une, have used and executed this type of design that provides a solution to the current demand established. This type of design is characterized by implementing levels of optical splitters, which are responsible for multiplying the fiber strands used for this type of design. With the design of an FTTH network, each home will be able to receive its service through fiber to its own home. This further facilitates its performance and the speed of the services offered. The design of FTTH networks is characterized by implementing passive elements in their topology. They do not need any energy except for the main and the end active components.

3. Method

According to [21], "Methodology is the study of methods and deals with what corresponds to research strategies and tactics." Based on the above, the methodology can be defined as a collection process that allows ordering and organizing the information to be interpreted according to each proposed approach. Given that the purpose of this project will be to design an FTTH (Fiber To The Home)

network to improve voice, broadband, and television services in the municipality of Usiacurí Atlántico, a quantitative approach was used from where it originated. A survey addressed all the municipality inhabitants, where closed questions were noted that served for a better interpretation, as shown by Albas et al. [fifteen]. Considering that the subject of the project requires good theoretical sources, a descriptive investigation was carried out. A type of non-experimental design will be used that will be applied in a transactional way. The Top-Down methodology represented in Fig. 5 will be used for this project. This methodology is focused on the design of communications and computing networks. It allows solving a problem associated with information technologies by dividing it into a series of levels, segmenting them from top to bottom. These modules must have a hierarchy and be integrated. To solve each project objective [22].

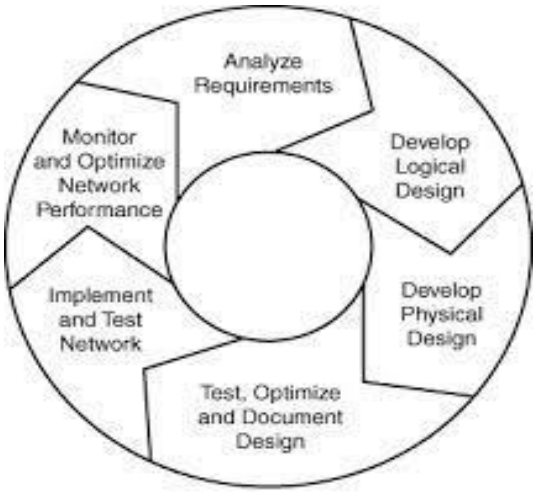


Fig. 5. Top-Down Methodology

With the above methodology, analyzing the requirements for which three engineering departments are defined to carry out this project is necessary. Each of the functions required to meet the objectives is stipulated. The first is Planning Engineering, which is responsible for the place's location, laws, and census. External Plant Engineering is responsible for all the designs defined in two levels for which a series of deliverables were limited. The last Engineering is the Internal Plant, which is responsible for the configuration of equipment and physical and logical designs of the network, taking into account the Core & Distribution layer, the rules of segmentation of the network in WAN, LAN, global, and the ISP service provider will be defined, as well as IP addressing and VLANs in addition to the design of the access layer.

Finally, it is necessary to ensure that the network works as desired. For this, a simulation will be carried out with Mikrotik brand equipment, which will be configured with its software, Winbox, where it is expected to obtain the broadband capacity required by the client by performing a speed test to check the configured bandwidth.

3.1. Stages of the Project

To carry out this project, it was necessary to implement stages according to the top-down methodology, which is mentioned below: STAGE 1. Three engineerings are defined to carry out this project and are shown in Fig. 6.

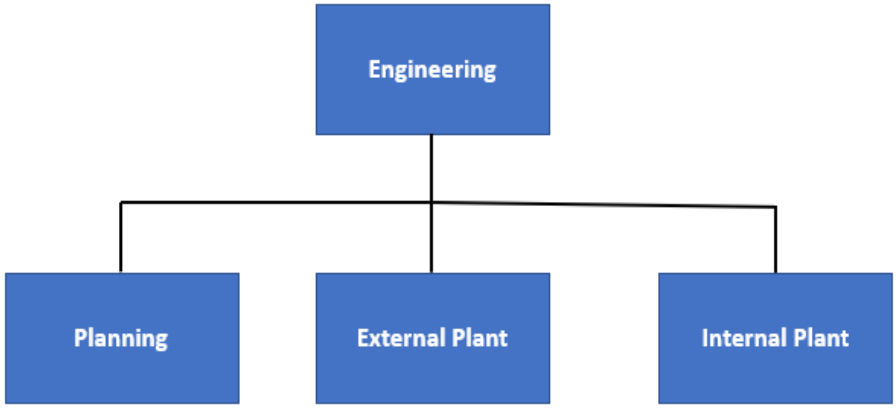


Fig. 6. Engineering organization chart

STAGE 2. The activities of each dependence are defined, which are shown in Table I

Table 1. Definition of Activities

Engineering	Activities
Planning	• Planning Engineering definitions and policies (Census, spaces, surveys, and design penetration percentage) • Design Budget • Schedule of activities
External Plant	• External Plant Engineering Policies (First and Second Level Designs, Reserves, Allowed Optical Distance) • Design Overview
Internal Plant	• Internal Plant Engineering Policies (Logical and Physical Designs) • Equipment configuration, segmentation, and addressing rules in the Mikrotik equipment

STAGE 3. The three engineering companies analyzed the results obtained from the project.

4. Results and Discussion

The results are identified considering the order taken to outline the topology of the physical FTTH network and the logical topology using Mikrotik equipment, complying with the attenuation coefficient through the ITU standard that establishes the correct speed of the FTTH network design. The design and implementation of this FTTH solution are similar to that developed by [23] and [24].

4.1. Geographic Location

The geographical location was identified to select the sector to be designed with the Google Earth program, as shown in Fig. 7.

Fig. 7. Geographic Location

4.2. Population Census

In this research, the population is finite. It comprises the inhabitants who are part of existing households in Colombia, department of Atlántico, Municipality of Usiacurí. To find the total number of users who live there, it was necessary to carry out a census, from house to house, to count each home and apartment, if applicable, outside buildings or residential complexes in the sector. It should be noted that accounting is recorded by households and not by their inhabitants, for example; If there is a house with two floors and six people live in each of them, the result will not be twelve but the number of households that can be called clients and which in this case would be two houses, but if there is a building or residential complex made up of For fifty people, the internal distribution of the building is validated, that is, the number of apartments in each tower, if applicable, that is, if there were two towers and each one had ten apartments, including the administration, the amount thrown for This building would be twenty housing units, which would become potential customers. Previously, the number of 1744 households was obtained using a confidence level percentage of 90%. For this case, the sample size is 66 households.

Based on the census it was carried out, 1.763 households will be the possible beneficiaries. Because it is a considerable number, Equation 1 was implemented to find a sample using a confidence level percentage of 90%. For this case, the sample size is 66 households.

$$n = \frac{k^2 * p * q * N}{(e^2 * (N-1)) + k^2 * p * q} \quad (1)$$

N is the population size, p is the probability of success, q is the probability of failing, k is the confidence level, and e is the standard error.

4.3. Survey

The research technique used to collect quantitative data from the primary sources in this project will be the implementation of a survey addressed to the inhabitants of the Municipality of Usiacurí Atlántico. This survey was uploaded to Google, and when the census was carried out, the link was shared with some sector inhabitants. A random form was used, selecting 66 households based on the sample obtained in the previous point. According to the results obtained in the survey, when evaluating the conformity of the users of the Municipality of Usiacurí Atlántico concerning voice services, television, and broadband

internet speed, most of the people surveyed are dissatisfied. To know their current level of satisfaction with the services they receive and the availability, they would have to have a better service. Based on the above, what is desired is to guarantee that with this project's deployment, the municipality's inhabitants can count on the services through this new fiber optic technology that can reach any part of the country today.

4.4. Type of fiber used in the project

The optical fiber to be implemented in the project is single mode. This is the fiber that offers the most significant information transport capacity. It has a pass band of the order of 100 GHz/km. The highest flows are achieved with this fiber, but it is also the most complex to implant. The rays it has followed a trajectory that follows the fiber axis, which is why it has earned the name "single mode" (propagation mode, or path of the light beam, single). Its main characteristic is how it can be manipulated without any affectation if it complies with the standards defined for its proper use. They are widely used to send large amounts of data over a long distance, with speeds like radio and faster than conventional cable. It could be affirmed that they are the transmission medium par excellence as they are immune to electromagnetic interference. They are also used for local networks, where it is necessary to take advantage of fiber optics over other transmission media.

4.5. Active and Passive Networks

- Active Networks: fiber optic network with active elements (outside the central), as in the case of SDH-NG or a Metro Ethernet network sufficiently distributed so customers can connect directly to the network. In this case, these networks would fulfill the access network function and not only transport as it is currently.
- Passive Networks: these are fiber optic networks whose components are entirely passive in the distribution network (not in the customer's headquarters and domicile). These are called PON (Passive Optical Networks). They allow the same fiber to be shared among several users.

In addition to the above, it states that PON networks have a wide range of protocols and standards. The two technologies currently leading the market arePON (sometimes also called GEPON) and GPON, as [25] explain in their study. Table 2 shows the main characteristics of both standards.

Table 2. Characteristics of PON Standards

	EPON	GPON
Standard	IEEE 803,2 ah	ITU-T G,984
Bandwidth	Hasta 1,25 Gbps symmetrical	Symmetrical or asymmetrical up to 2,5/1,25 Gbps of DL/UL
Downstream (nm)	1490 (IP voice and data) and 1,550(video RF)	1490 (IP voice and data) and 1,550(video RF)
Upstream (nm)	1,31	1,31
Transmission	Ethernet	1,31

4.6. First Level Design

It starts from the OLT to the first-level Splitters housed in the optical muffles. The feeder cables that begin their journey from a muffle housed in the feeder cable to the first-level Splitters housed in the muffles will also be part of this design. These results already reflected in the plans are evidenced in Fig. 8, where the optical network plan, multiwire plan of mergers, and km are shown.

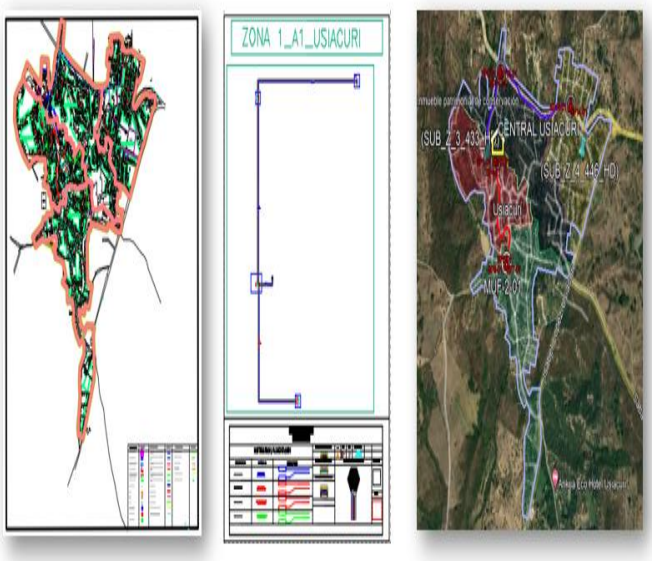
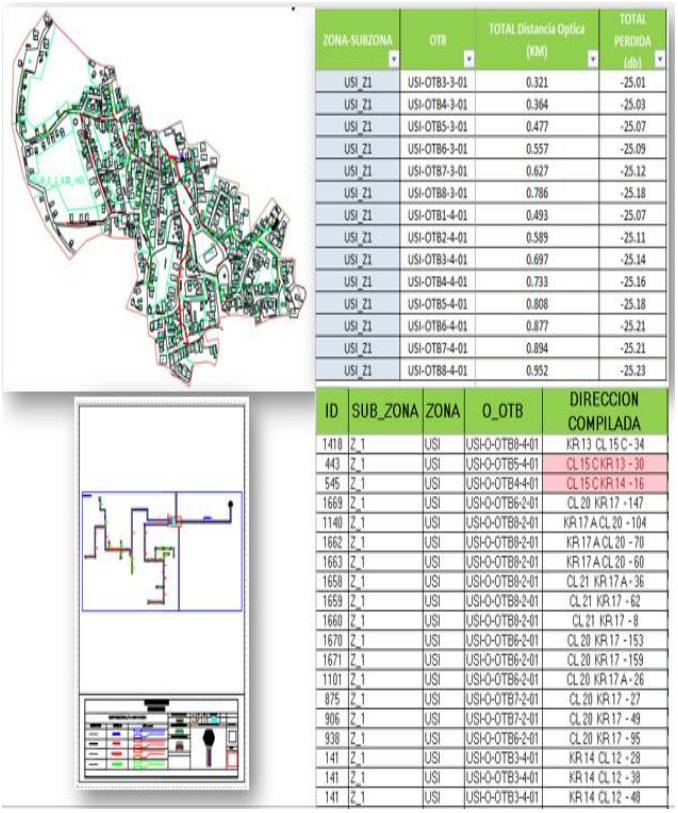


Fig. 8. Deliverables First Level Design

4.7. Second Level Design

Part of this design will be the distribution cables that start their route from the first-level Splitters housed in the optical muffles to the OTBs, where the second-level splitters are located. These could be in the O-OTB, I- OTB, or U-OTB. Depending on the design, the distribution cables that may be derived from the previous branch will also be part of this design. These results, already reflected in the Excel plans and tables, are evidenced in Fig. 9, where the optical network plans, the multiwire fusion plan, the power table, and the HD table are shown.



ZONA-SUBZONA	OTB	TOTAL Distancia Optica (KM)	TOTAL PERDIDA (db)
USI_Z1	USI-OTB3-3-01	0.321	-25.01
USI_Z1	USI-OTB4-3-01	0.364	-25.03
USI_Z1	USI-OTB5-3-01	0.477	-25.07
USI_Z1	USI-OTB6-3-01	0.557	-25.09
USI_Z1	USI-OTB7-3-01	0.627	-25.12
USI_Z1	USI-OTB8-3-01	0.786	-25.18
USI_Z1	USI-OTB1-4-01	0.493	-25.07
USI_Z1	USI-OTB2-4-01	0.589	-25.11
USI_Z1	USI-OTB3-4-01	0.697	-25.14
USI_Z1	USI-OTB4-4-01	0.733	-25.16
USI_Z1	USI-OTB5-4-01	0.808	-25.18
USI_Z1	USI-OTB6-4-01	0.877	-25.21
USI_Z1	USI-OTB7-4-01	0.894	-25.21
USI_Z1	USI-OTB8-4-01	0.952	-25.23

ID	SUB_ZONA	ZONA	O_OTB	DIRECCION COMPILADA
1418	Z_1	USI	USI-O-OTB8-4-01	KR 13 CL 15 C - 34
443	Z_1	USI	USI-O-OTB5-4-01	CL 15 C KR 13 - 30
545	Z_1	USI	USI-O-OTB4-4-01	CL 15 C KR 14 - 16
1669	Z_1	USI	USI-O-OTB6-2-01	CL 20 KR 17 - 147
1140	Z_1	USI	USI-O-OTB8-2-01	KR 17 A CL 20 - 104
1662	Z_1	USI	USI-O-OTB8-2-01	KR 17 A CL 20 - 70
1663	Z_1	USI	USI-O-OTB8-2-01	KR 17 A CL 20 - 60
1658	Z_1	USI	USI-O-OTB8-2-01	CL 21 KR 17 A - 36
1659	Z_1	USI	USI-O-OTB8-2-01	CL 21 KR 17 - 62
1660	Z_1	USI	USI-O-OTB8-2-01	CL 21 KR 17 - 8
1670	Z_1	USI	USI-O-OTB6-2-01	CL 20 KR 17 - 153
1671	Z_1	USI	USI-O-OTB6-2-01	CL 20 KR 17 - 159
1101	Z_1	USI	USI-O-OTB6-2-01	CL 20 KR 17 A - 26
875	Z_1	USI	USI-O-OTB7-2-01	CL 20 KR 17 - 27
906	Z_1	USI	USI-O-OTB7-2-01	CL 20 KR 17 - 49
938	Z_1	USI	USI-O-OTB6-2-01	CL 20 KR 17 - 95
141	Z_1	USI	USI-O-OTB3-4-01	KR 14 CL 12 - 28
141	Z_1	USI	USI-O-OTB3-4-01	KR 14 CL 12 - 38
141	Z_1	USI	USI-O-OTB3-4-01	KR 14 CL 12 - 48

Fig. 9. Deliverables Second Level Design

4.8. Physical and Logical Design

This result refers to the physical and logical designs of the entire network. Fig. 10 shows the logical scheme of the Core & Distribution layers, identifying the WAN connections of the two headquarters that communicate, creating a site-to-site VPN, and the segments of the internal corporate networks designed.

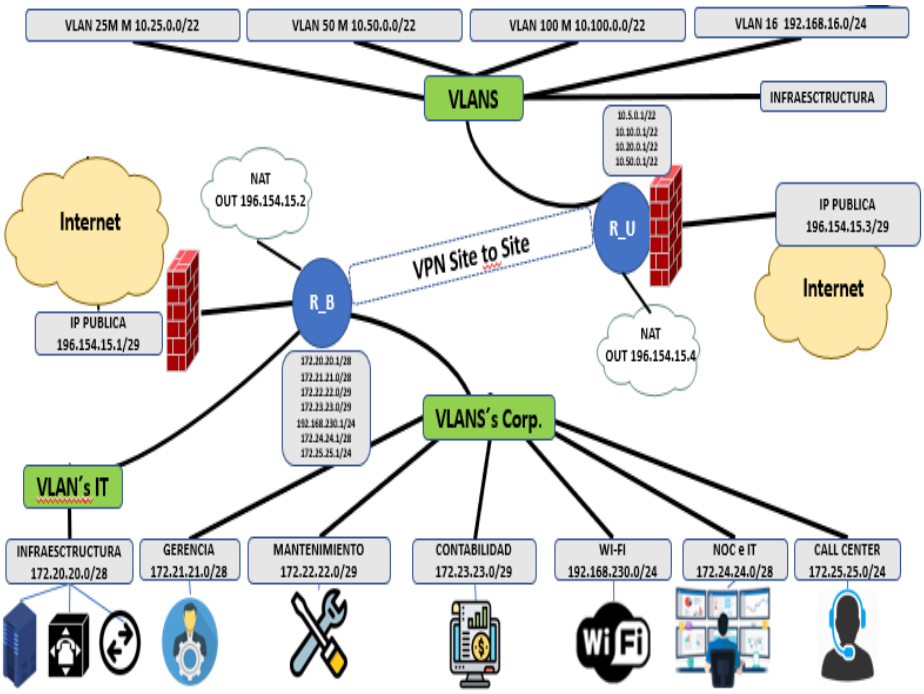


Fig. 10. Core and Distribution Layers Logical Designs

In Fig. 11, the logical connection between the users and the node is represented.

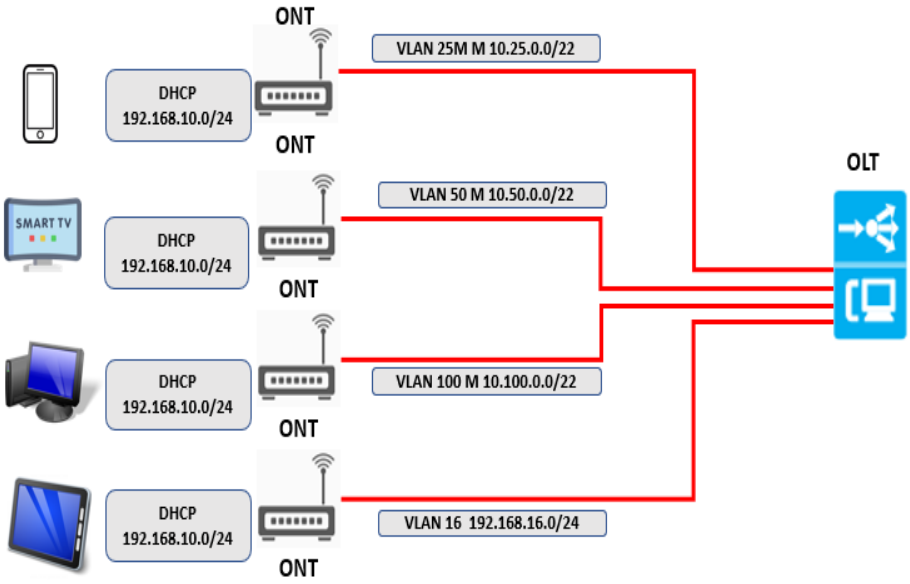


Fig. 11. Access Layer Logical Design

In Fig. 12, the physical connections of the equipment that are part of the infrastructure of the Core & Distribution Layer of the network are assigned.

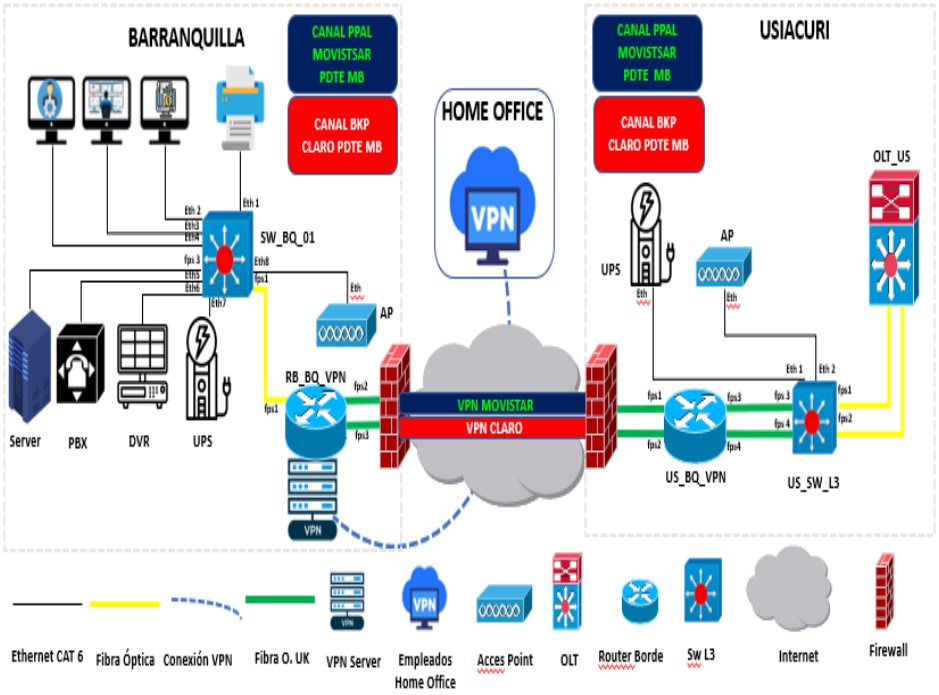


Fig. 12. Core and Distribution Layers Physical Design

In Fig. 13, the physical connections of the equipment that are part of the Access Layer infrastructure are assigned, such as the OLT, Muffles, Splitters, OTBs, and ONTs.

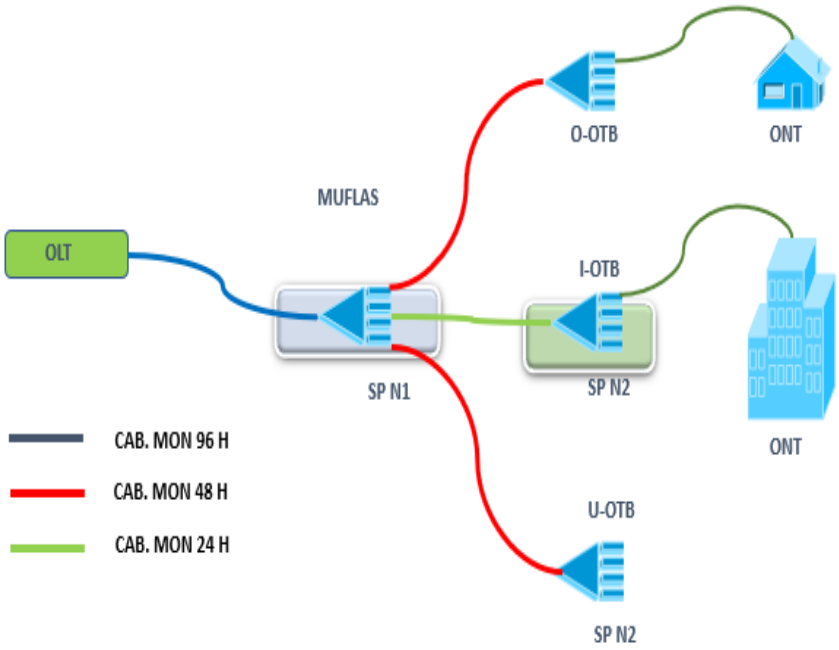


Fig. 13. Access Layer Physical Design

Taking into account the Branches allowed based on the Attenuation coefficient, the detail of the designs made in Fig. 14 is presented below.

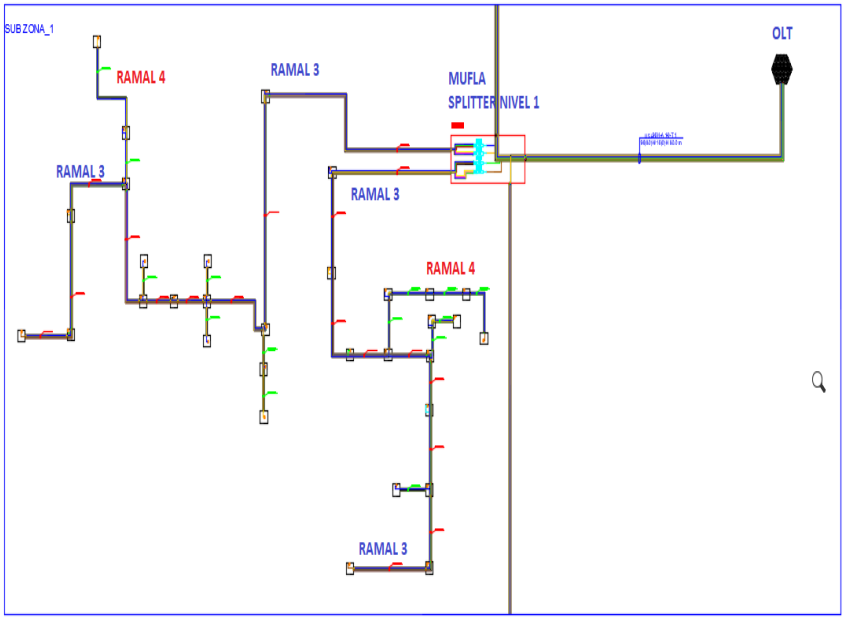


Fig. 14. Second Level Design R3 and R4

In the study, the optical calculations of the network were projected to determine the losses of each element of the implemented design within the established range. To validate the result of this objective, the powers that are part of the level 2 design are taken as a basis. Table 3 shows the results (partial sample) taken in the four subzones, through which the losses of the network elements.

Table 3. Loss Level by Zones (Partial)

Zone/Subzone	OTB	Cable Distance (Km)	Number of Leads	Cable Dist	Total loss (dB)
USI_Z1	USI-OTB1-1-01	0.08	1	0.072	-23.97
USI_Z1	USI-OTB2-1-01	0.08	1	0.137	-23.99
USI_Z1	USI-OTB4-1-01	0.08	2	0.411	-24.19
USI_Z1	USI-OTB5-1-01	0.08	1	0.513	-24.12
USI_Z2	USI-O-OTB1-5-01	0.6	1	0.07	24.15
USI_Z2	USI-O-OTB2-5-01	0.6	1	0.158	24.18
USI_Z2	USI-O-OTB3-5-01	0.6	2	0.075	24.25
USI_Z2	USI-O-OTB4-5-01	0.6	2	0.165	24.28
USI_Z3	USI-O-OTB1-9-01	0.51	1	0.281	24.19
USI_Z3	USI-O-OTB2-9-01	0.51	1	0.26	24.19
USI_Z3	USI-O-OTB3-9-01	0.51	2	0.473	24.36
USI_Z3	USI-O-OTB4-9-01	0.51	2	0.473	24.36
USI_Z4	USI-O-OTB6-16-01	1.23	1	0.073	25.37
USI_Z4	USI-O-OTB7-16-01	1.23	1	0.112	25.39
USI_Z4	USI-O-OTB1-15-01	1.23	1	0.15	25.40
USI_Z4	USI-O-OTB2-15-01	1.23	1	0.237	25.43

Considering that the minimum output optical power of the OLT is 6dbs and that the maximum distance allowed from the OLT to the OTBs is -26dbs, in the previous table, it can be verified that the elements comply with the permitted loss since they are between the ranges of -24.37 and -25.62, even without adding the 6dbs that are part of the OLT.

4.9. Mikrotik Device Configuration

This result refers to the configuration based on the designs made in the Core & Distribution layers. It is associated in the Address list module, the segments of the different networks; in order not to overload the capacity of the equipment, it was only added the management one and the one for the 25, 50, and 70 Mbps plans, as shown below in Fig. 15.

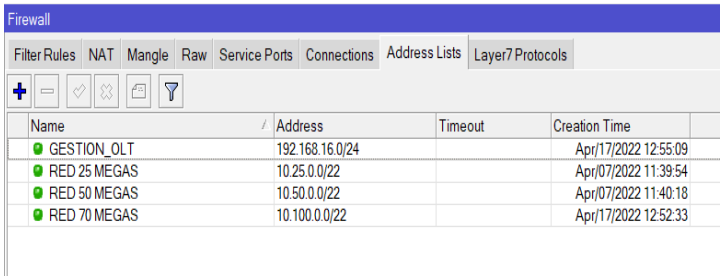


Fig. 15. Address Lists Configuration

It is evidenced in Fig. 16 how the router assigns the connection brands, and according to the previously created rules, how the traffic is labeled is observed.

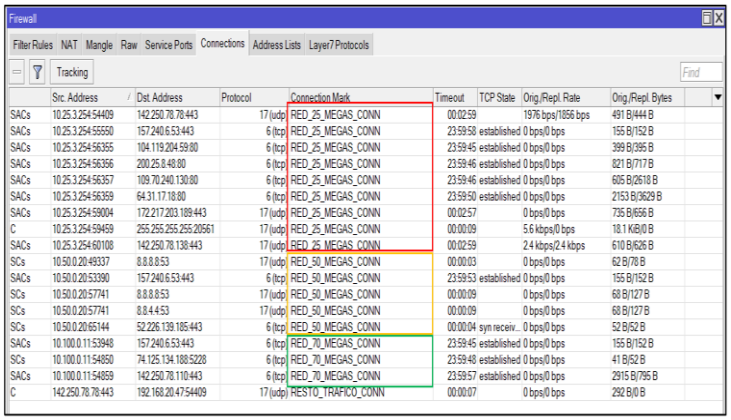


Fig. 16. Labels in the Mangrove

4.10. Speed Tests

This result refers to the speed tests carried out on the equipment connected to 25 and 70 Mbps, as shown below in Fig. 17 and Fig. 18.

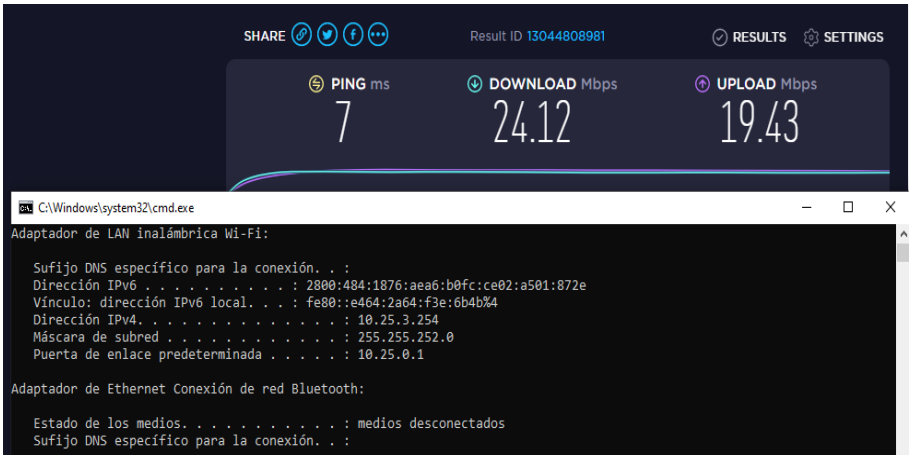


Fig. 17. Download 25M network-connected equipment

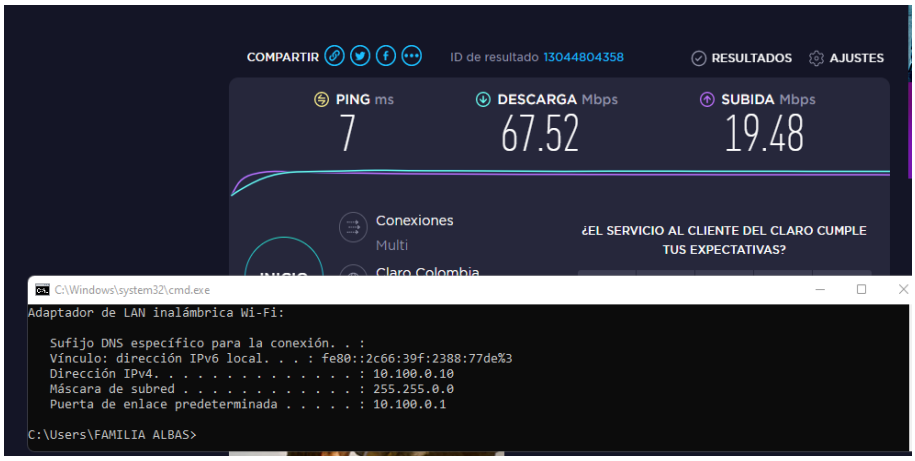


Fig. 18. Download 70M network-connected equipment

5. Conclusion

During this project, the design of an FTTH network has been developed, describing in detail each of the stages that this type of design entails. It is necessary that before starting to implement this type of design, the type of optical fiber that will be implemented in this type of network design is established in this document.

Once the different types of networks have been studied according to their topology, the design to be implemented is based on the local or urban network, which consists of a network that extends throughout a city, municipality, or area with a high population grade. These networks are directly connected to the primary node or a secondary (redundant) distribution node, capable of directing traffic to the immediately superior municipal network fundamentals of fiber optics and FTTH technology. With this structure, it is straightforward to establish low-cost solutions to build user access networks.

The project consists of designing an FTTH (Fiber To The Home) network in the municipality of Usiacurí in the department of Atlántico, for which a population of 1763 households was identified through a census carried out, for which a sample was calculated, which gave; as a result, 66 families were subsequently surveyed, to obtain from them the results already explained above. For this type of design, the process and the necessary guidelines to implement a highly demanding strategy were shown. That demand a reasonable price for their needs, and the only way that exists today is to implement this type of design. It should be noted that the deployment of the FTTH network in the cities of Colombia and other countries is increasing every day. This has ledoperators to measure their high degree of competitiveness, show the best of each of them, and seek customers.

In the future, it is desired to bring this project to its full implementation, not only in the municipality of Usiacurí but in the entire department of Atlántico, where there are severe shortcomings in connectivity, to satisfy and experience the knowledge obtained through this research and contribute to the promotion and strengthening of the use of ICTs to a more significant number of inhabitants. Likewise, the implementation could be analyzed, under conditions similar to those of the study carried out, of new trends for the optimization of FTTH networks such as wavelength division multiplexing passive optical network (WDM-PON), explained by [26], or software-defined passive optical networks with multi-PON technology [27].

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