UNIVERSIDAD TÉCNICA DEL NORTE

FACULTAD DE INGENIERÍA EN CIENCIAS APLICADAS

CARRERA DE INGENIERÍA EN ELECTRÓNICA Y REDES DE COMUNICACIÓN

SCIENTIFIC REPORT

THEME:

DESIGN OF A NETWORK OF OPTICAL FIBER OF ACCESS MULTISERVICE FTTH (FIBER TO THE HOME) FOR THE COMPANY AIRMAXTELECOM SOLUCIONES TECNOLÓGICAS S.A., IN URCUQUI PROVINCE OF IMBABURA.

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Design of a network of optical fiber of de access multiservice FTTH (Fiber to the Home), for the company ARMAXTELECOM SOLUCIONES TECNOLÓGICAS S.A, in Urcuqui province of Imbabura

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Summary—The present project treats on the study and design of a network of access based on the use of the technology G-PON, for the Urcuquí sector, province of Imbabura, in order to that an ISP provides services of telecommunications of better quality analyzing the advantages and disadvantages of the current technologies, as well as also the cost of implementation and the time of recovery of the investment.

The present project is composed basically of three parts, the study of the technology FTTx based on the technology G-PON, the design of a network of last mile FTTH, from the point of view of a Provider of Internet services, and the financial analysis with referential costs of the solutions FTTH that get ready on the market. Next the realized is described briefly.

Index of terms— Access, FTTx, FTTH, GPON, Optical Fiber.

I. INTRODUTION

TECHNOLOGIES OF ACCESS FOR OPTICAL FIBER. The need to obtain a quality communication at long distances is easier and easier thanks to the different means of broadcast, existing, this is the case of the optical fiber, since at present it develops a very important role in linkage of short and big distances like systems of terrestrial telecommunications and marine (Internet and telephony), telephone linkage between head offices, medicine, lighting between others. Increasing the efficiency in telecommunications services and hence contributing to the technological development. AIRMAXTELECOM S.A. is located in the City of Ibarra, Imbabura province, Bearing in mind that at present it is a WISP (Wireless Internet Service Provider), compromised by its users, it is indispensable that the company is provided with a network of access (FTTH) in the parish of Urcuquí, since this will help to overcome the requests of its users, improving of such a way the quality of the given services, benefiting the current and future users in this area and therefore maintaining the business model of the company.

II. SYSTEMS OF COMMUNICATION FOR OPTICAL FIBER GENERAL ANALYSIS

A. Optical Fiber

The optical fiber is a way that allows the communication between two points, origin - destination, by means of the light employment, the same that is confined and guided along its trip, basically it is constituted by the nucleus that is the central part where most of the light are spread, the revetment divides that it makes a detour to the nucleus and that it makes the manipulation of the fiber possible.

1) Single-mode optical Fiber: It allows to increase the capacity, since, on having had a smaller core, it allows the light beams to travel in parallel to

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the axis of the fiber, allowing to come at major distances, typically this fiber is used in networks MAN and networks WAN.

2) Multi-mode Optical Fiber: As its name indicates it in this fiber is possible that spread multiple light beams across the core, in exchange for sacrificing distance, that is to say, with this fiber it is possible only to come at short distances, being an ideal for ambiences LAN.

3) Advantages of the optical fiber: The optical fiber systems have more capacity due to the big band, immunity to the electromagnetic interference, immunity to the static interference, allow to operate on a wide status of change of temperature, light weight and small size that does that its manipulation is easier, needless physical space, allow to come at major distances without needing relay and regenerated elements.

2) Disadvantages of the optical fiber: The electro-optical conversion process needs a considerable cost, the maintenance, installation and repair of the systems of optical fiber is more difficult and costly, one needs personnel specialized for the installation, repair and maintenance.

B. Technology FTTx - Network of Access

The transmission technologies, they allow to users to communicate to themselves with companies that offer telecommunications services that they should be these of big or small scale.

A network of access FTTx, it is only a network based on the deployment of cable of optical fiber that comes at certain distance of the final user, turning to the network of access as such a network of major speed with regard to its counterpart, the copper.

In order to supply services of wide band to the final users, in places where is difficult to come with technologies xDSL, for limitations of technical aspect as for functioning conditions, there arises the idea of bringing the nodes over towards the hearths and small business, what returned to the term: Fiber to the x (FTTx).

Next there appear some acronyms used in the technical and commercial literature.

- FTTB *(Fiber to the business).*

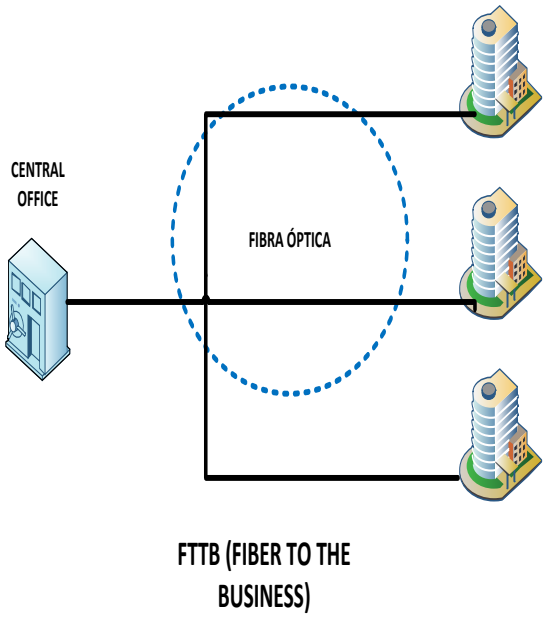

Figure 1. Fiber to the business
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- FTTC *(Fiber to the curb).*

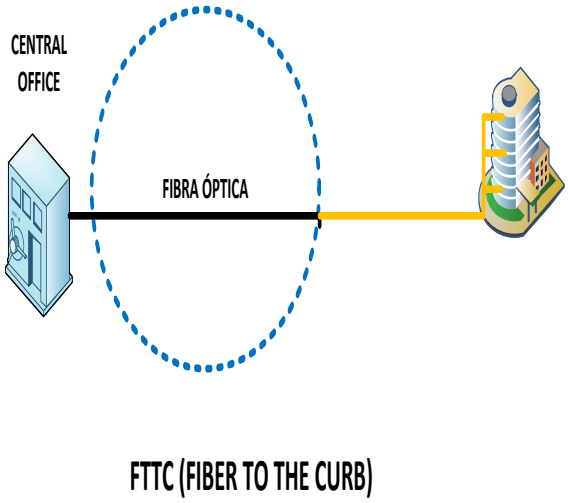

Figure 2. FTTC. Fiber to the curb.
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- FTTH *(Fiber to the home).*

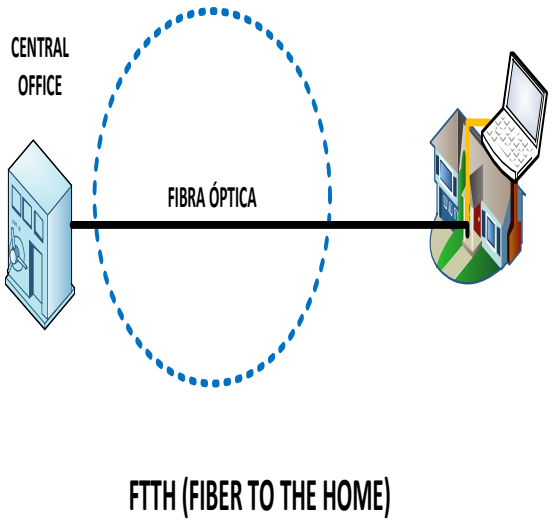

Figure 3. FTTH. Fiber to the home.

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C. *Technology PON – Networks of Access*

The main characteristic of the technology PON (Passive Optical Network), is that no active element exists between the central office and the locality of the client. What provides certain advantages to the operators like: savings in maintenance, eliminating this way the need for supply of energy and administration of active devices.

The main element in a PON network, it is the Splitter, which works as a multiplexer, that is to say, is optical fiber tandem device with many input terminals and many output terminals. Next there are mentioned the elements that shape a PON network:

OLT— Optical Line Terminal. Located where the service provider gives the interface between SET and the services of Network of the provider that they include typically: traffic IP on Gigabit, 10G or 100Mbps Ethernet, Interfaces standard such TDM like SONET or SDH, ATM.

ONT— Optical Network Terminal. Located in the final user, presents the native service interfaces to the user. Services that can include: POTS or VoIP, data, video, etc.

ODN— Optical Distribution Network. It is everything what exists between the active devices of a PON network, the ODN is shaped basically for: splitters, cables of Optical fiber and protection elements of splices and for route derivation.

The ODN is the most important part to be considered in the design of a PON network, since in the ODN it is where most of losses appears in a PON system, its deployment and maintenance is costlier, it needs an important consideration in Ecuador due to restrictions for control entities with what to the plan of burial of cables it refers, this involves expenses in civil work, payment of tax in case of cables laying's, another very important consideration to be taken into consideration is that the design of the ODN must go of the hand with the politics of the company.

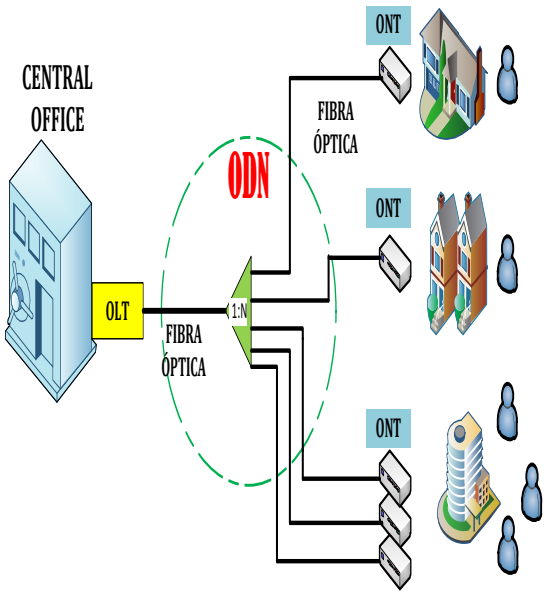

Figure 4. Elements of a Passive Optical Network

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D. *PON Standards*

APON— There was developed by the FSAN the one who developed the initial recommendations for APON as its initials indicate it that this standard was based on the ATM capacities, but its life was short.

BPON— Due to the limited ATM capacity, this standard developed since the idea was to improve and to increase the transmission capacities, briefly

BPON was an APON progress, since it allows WDM, it became bigger and dynamic, he was used for business applications and it was based on ATM, this standard defines the terminology, wavelengths, the fiber, components and the levels of Potency.

GPON— Of equal way as a BPON progress arises GPON, obviously increasing the capacity, allows to come to major distances, support for major number of ONT's, increases the transmission cup up to 2,48Gbps downstream and 1,24Gbps in upstream.

EPON & GEPON— In contrast to APON and BPON, this technology does not transport cells ATM without Ethernet, optimizing the traffic IP. Next there appears a table which sums up the main characteristics of the technology SET.

III. Analysis of Request – Sector Urcuquí, Province of Imbabura

Current situation of the network of access in the parish Urcuquí, Imbabura province — The company AirmaxTelecom S.A., at present it offers to its clients Internet service, by means of the wireless technology. Nevertheless, the used technology, it does not supply the needs for band, since one hopes that the number of clients should increase during the course of the years, since the city of Urcuquí is considered to be a city of growth.

Therefore it is indispensable that the company is provided with a robust way of transmission, which should provide major band to the users in this area, therefore a network of access FTTH is an indispensable solution, since the optical fiber to the immune being to the interference, to have less extenuation, to provide major band and to allow to come with different types of services to the final user at greatly big distances, puts in advantage to this way, front, to the current wireless technology, what will help to keep on fulfilling the targets of the company allowing to its clients to enjoy multiple services and excellent quality.

Next there appears the physical topology of the current network.

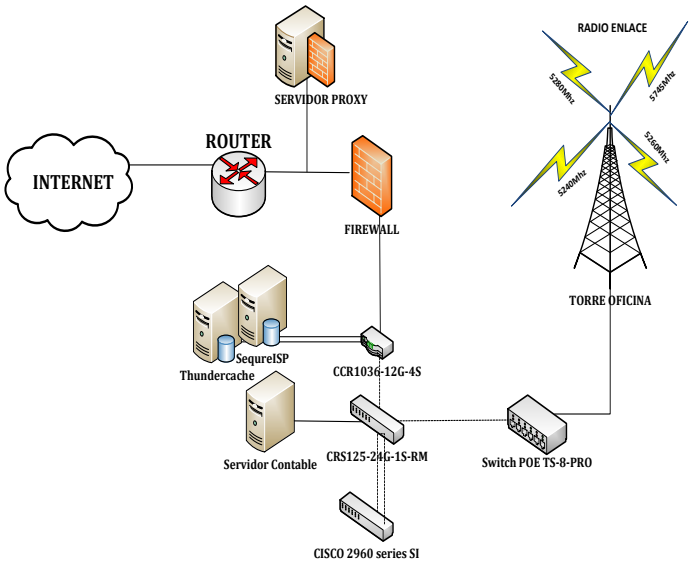

Figure 5. Scheme of Network of AIRMAXTELECOM S.A.

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Projection of the situation of the network of access in the parish Urcuquí, Imbabura province— The idea is to realize an appropriate design of the network of access for optical fiber towards the subscriber or final user FTTH (Fiber To The Home), in the Urcuquí urban area, for it will be considered to be the projection of future users who will exist during five years projected for the network in the above mentioned area. According to historical information obtained and facilitated by the company, there was obtained an annual average growth of 75% percent and that next, is detailed (Table I).

TABLE I
WHOLE OF PROJECTED USERS

Year	Users per year	Majority client
2012	20	Residential
2013	40	Residential
2014	60	Residential
2015	105	Residential
2016	184	Residential
2017	322	Residential
2018	423	Residential
2019	740	Residential

*Note: Adapted table. Source: AIRMAXTELECOM S.A, Datos de Contratos. Sequreisp_Contracts_2014-11-14.cvs [Excel document]

The applications to be offered for the company AIRMAXTELECOM TECHNOLOGICAL SOLUTION S. A. its users, it has always been the access to Internet, nevertheless by means of the

technology FTTH, the speed of the access to this service will increase and to a future if the company needs it, he will be able to add services of audio and video.

Select type of optical fiber — It has been decided that the used type of optical fiber will be a single-mode G.652D, since it allows to reach major distance, major capacity and a less attenuation. It is necessary to highlight that the fiber G.652D was perfected to work in 1310nm (where there are transmitted the voice and information) and 1550nm, nevertheless also it can be employed at other wavelengths. The fiber G.652D also water peak (ZWP) is considered to be the fiber of low peak of water (LWP) or fiber of zero what offers to him advantage with its previous versions like for example the fiber G.652A where the water peak was very high giving place to impurities as there are the ions OH, product of it the extenuation would increase in this point.

On the other hand, the type of optical fiber to be used for the interconnection of the users from the last box of optical derivation will be, the guy G.657 class A, since he has necessary attributes to support installation of networks of put access that this fiber is insensitive to fold what turns his ideal for facilities FTTH. With regard to the characteristics of the cable to be used there proposes to use the cable type ADSS, single-mode G.652D, for the interconnection between the OLT and the optical divisors of the first, power cutoff point (FEEDER).

IV. Design of the Network

Logical diagram of the Network— this item considers all the necessary elements that a network GPON uses, from the point of view of an ISP. Climbing vine it will use a equipment OLT, same that he is located in the node designated by the company AIRMAXTELECOM S.A. the same one that will make the division possible between users by means of splitter's; from which ones there will go out the threads of optical fiber that will come towards the domicile of the final user.

Next the Figure 6, shows in a general way the logical diagram of network that will take the access network as an optical fiber.

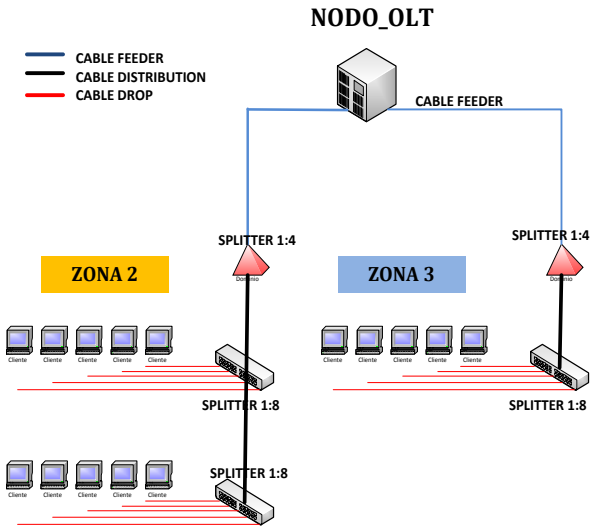

Figure 6. Scheme of a Network with topology Point Multipoint.

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The Figure 7, shows the configuration that a network GPON presents when the operator wants to offer such multiple services like; Voice, Information (Internet) and Video (signs of Radio Frequency, Low Video Demands and/or Signs Satellites).Como is observed in the previous figure, the miscellany of different wavelengths is possible by means of an adapter WDM, the same one that mixes wavelengths of 1490nm for voice and information and 1550nm for signs of video.

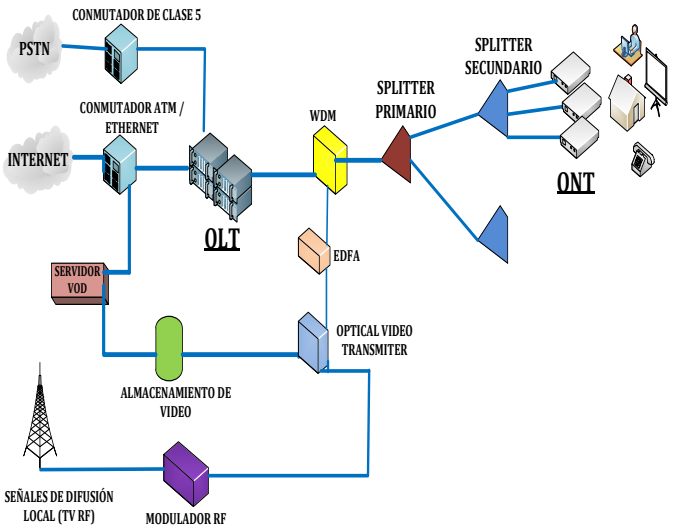

Figure 7. General architecture of the Network of access FTTH for an ISP.

Developed by Jennyfer Arteaga

General description of the network of access FTTH— Next there is detailed the general description of the network of access by optical fiber.

• The central connection point will be the OLT, the same one that will expire with certain characteristics that further on will be mentioned. is necessary to locate the OLT in the node located in the area to be served since it provides major scalability of the network, savings in maintenance, saving in cable of F.O, easy operation and maintenance, and especially it is fulfilled by the physical scope of 20Km described in the Rec. UIT-T G.984.1, measured from the OLT towards the domicile of the client. For it, it is recommended to have a suitable office for external plant, the same one that the main equipment (OLT) will lodge.

• Every module GPON will have to have the aptitude to support applications FTTH, monitor the optical potency got for every ONT, to offer safety to the information in the linkage downstream by means of encryption AES. Additionally it will have to provide the entire management of the ONT across the protocol OMCI (Operation Management Control Interface). In addition to having a port Gigabit Ethernet or 10GE that allows the connection between the network of access and the network of transport.

• Every area will be supplied by one or several formed primary splitters in such a way that they cover the demand of users projected for five years.

• The second splitting level will be the manager of providing the threads to the users. For it the primary splitter is who delivers the threads to the secondary splitter. The optical fiber backbone will be opened in an air way, across the existing postería since it is easier and less costly than the underground deployment, for it the bases will be cited as an example geo indexed, granted by the company EMELNORTE S.A., this is detailed further on in the raising of the respective planes of the network FTTH in the parish Urcuquí.

Initially there is planned a transfer of the current users (60 users) in its entirety, so they would be interested in obtaining an access to services of telecommunications by means of the technology FTTH. It is necessary to highlight that this area, it is considered to be an area in development, for such a reason it is advisable that the company uses a methodology of marketing based on the new infrastructure since he will wake up and there will increase in the inhabitants the interest to acquire access to services of telecommunications by means of the technology FTTH.

To connect 60 current users in the parish Urcuquí 4 ports GPON will be needed, every area will be connected to a port that he will be able to support up to 64 connections, what it promises scalability to the network as the number of users should increase. Next there presents the percentage of distribution users for areas.

For the physical scheme of the network GPON, he decided to split to the Urcuquí sector into four areas (to See Figure 8), in which one considers there will be different level of demand of services of telecommunications.

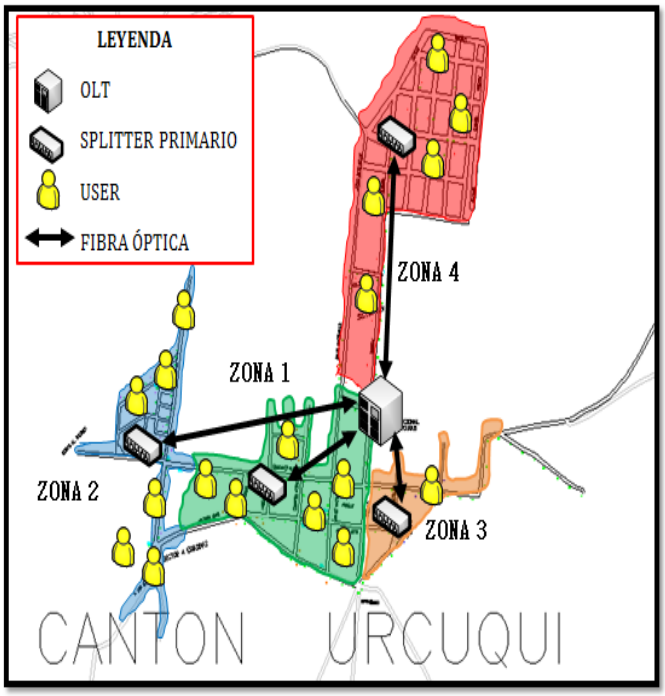

Figure 7. Areas distribution for Users' Thickness.

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• The Area 1 delimited by the green color and the area 2 for blue color; there are the places of Urcuquí, in which there agglomerates big part of the current users.

• The Areas 3 delimited by the blue color and the area 4 combined with two previous ones, there are

areas in which it is expected there will be an increasing demand in the next years.

The type of optical fiber that will be used for this project will be a single-mode and that expires with the standard G.652D, since it allows coming at major distances and be employed at the status of 1310 to 1625nm.

TABLE II
AREAS DISTRIBUTION FOR USER'S THICKNESS

Area	%	Number of Users (2014)	Number of Ports	Number of Users (2019)	Number of Ports
1	30%	18	1	222	1
2	30%	18	1	222	1
3	25%	9	1	185	1
4	15%	15	1	111	1
		60		**740**	

*Note: Adapted table. Developed by Jennyfer Arteaga

Interconnection of the network GPON— The equipment OLT will have to support stages FTTH, which allow last connection mile by means of optical fiber, will have to support the standard ITU-T G.984, the same one that describes the functioning GPON, possess ports with capacity Gigabit Ethernet that allows the integration with networks IP/MPLS, capacity of transmission in the windows of 1310nm, 1490 and 1550nm, for data transmission, voice and video, will have to support transmission distances up to 20Km. The equipment of last mile ONT will have to provide the interfaces that there support VoIP, Internet and services of Video HD, in addition to being employed at the windows of 1310, 1490 and 1550nm since it will allow the integration of the previous services.

Main characteristics of the equipment OLT— the standard G.983.1 specifies that for every port GPON of the OLT, he will have to support a maximum of 64 ONT's, with this essential precedent, next there are described the minimal characteristics needed for the equipment OLT and ONT GPON. The select equipment is of the mark HUAWEI for being the mark that expires with the minimal requisites of the network of access for optical fiber in the parish of Urcuquí. The equipment ONT will be of the same mark, since it is necessary to assure that it should be a 100 % compatible with the equipment OLT of the same mark.

TABLEIII
MAIN CHARACTERISTICS OF THE EQUIPMENT OLT

	HUAWEI
To support of standard ITU-T G.984	YES
GPON Port (minimum 8 ports GPON)	YES
Ports with capacity Gigabit Ethernet	YES
Quality of Services (QoS).	YES
To allow speed UP / DOWN: 1.24 Gbps / 2.4 Gbps	YES
Administrable vaguely and locally	YES
Aptitude to provide Video services in the lambda of 1550nm	YES
Transmission capacity in the windows 1310nm and 1490	YES
To support transmission distances up to 20Km.	YES
Hot Swap	YES
802.3z (Support Gigabit Ethernet for fiber in UPLINK)	YES
802.1p (priority of traffic for different applications)	YES

*Note: Adapted table. Source: Equipment selection. Design of a last network mile, using a network GPON, for the sector of the new Airport of Quito.

Determination of the worst and best case of linkage— Next there appears the analysis of the budget of loss of the network of access FTTH. By means of a review in the planes of the base geo-reference and earlier described in the development of the design of the network FTTH, in the city of Urcuquí the following described case presents as it to itself, like the best. The figure 8 describes the scheme for the ONT, which is more remote, for that a 2 kilometers approximate distance is had, with an attenuation of 0,37dB/Km for 1310nm and 0,24 dB/Km in 1550nm, four connectors are had each one with 0,5dB of loss of insertion, six mergers with 0,1dB and two splitters connected in cascade of 1x4 with 7,8 dB and 1x8 with 11,4dB of loss. .

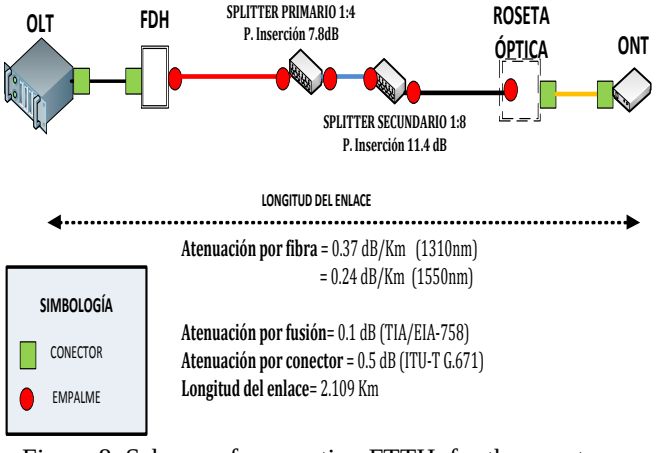

Figure 8. Scheme of connection FTTH, for the worst case.

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$$Atotal_{peor_{caso}} = 0.78dB + 2dB + 0.6dB + 19.2dB$$
$$Atotal_{peor_{caso}} = 22.98\ dB$$
$$Atotal_{peor_{caso}} = 22.7\ dB$$

(1)

The equation (1), 22,98 is the entire value of the extenuation obtained by the sum of the implicit extenuations in the linkage dB for the window of 1310nm and of 22,7 dB for the case of 1550nm. Of equal way the Figure 9 represents the best case, that is to say, in which the distance between the OLT and ONT is shorter.

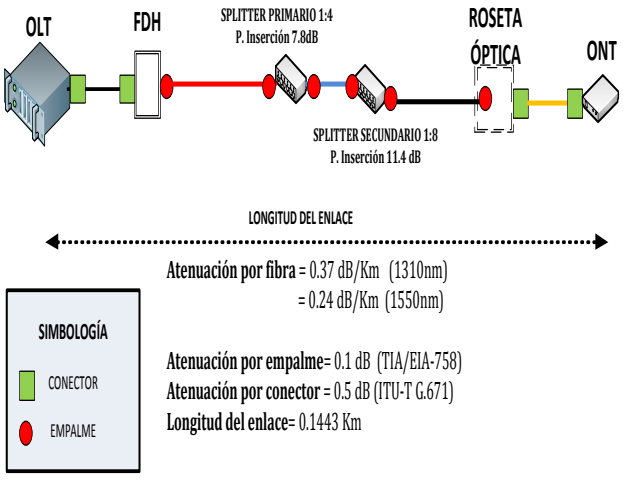

Figure 9. Scheme of connection FTTH, for the worst case.

Developed by Jennyfer Arteaga

$$Atotal_{mejor\ caso} = 21.75\ dB$$
$$Atotal_{mejor\ caso} = 21.73\ dB$$

(2)

The equation (2), it represents the losses obtained for the best case, the difference is the distance, as the graph is indicated the obtained distance is lower than one kilometer.

Obtaining 21,74dB in case of 1310nm and 21,73dB for the lambda of 1550m. For the obtained values one concludes that the loss budget is in the status allowed according to the standard.

V. Financial Analysis

A. *Budget of the Project*

The budget of a project is the stage in which there is analyzed the cost of investment of the cash commodities that will allow to guarantee the correct operation of the above mentioned project, in other words the budget of the project is the document in which there consists the quantity of money that will be needed to carry out the planned activities.

Investment Active Equipment— This item consists of the teams necessary for the implementation of the network of access FTTH, same that they allow the communication to be possible.

The Table IV reflects the entire cost of the investment in active equipment, goods that are used to guarantee the operation of the project.

TABLA IV
INVESTMENT ACTIVE EQUIPMENT

ITEM	DESCRIPTION	QTY	PRICE UNIT	PRICE TOTAL
F01	OLT HUAWEI MA5603T SERIES	1,00	$ 43.953,26	$ 43.953,26
F02	ONT HUAWEI HG8247 SERIES	60,00	$ 224,00	$ 13.440,00
F03	LICENSE MA5600T	1,00	$ 3.549,16	$ 3.549,16
			TOTAL	**$ 60.942,42**

*Note: Adapted table. Developed by Jennyfer Arteaga. The table was filled according to the quotations provided for Huawei Co. Ltda.

Investment Passive Equipment— It implies the cost of the passive equipment, the same one that there composes the ODN (Network of Distribution Or Optical Dispersion), where they are included: cables of optical fiber, splitter closure, patch cord & pigtail, adapter, fiber socket, general tool, PLC splitter, EDFA, etc.

It is necessary to highlight that the values that appear next include the element FTTH and the labor cost for the laying of the above mentioned elements, it presents the entire cost in equipment for the network of access FTTH, which there indicates the sum of the passive equipment and the active equipment.

TABLE V
ENTIRE COST OF EQUIPMENT NETWORK OF ACCESS FTTH-GPON

DESCRIPTION	U	QTY	TOTAL
VOLUMEN DE OBRA - RED DE DISPERSIÓN - ELEMENTOS PASIVOS	u	1	$ 44.955,64
EQUIPO ACTIVO FTTH-GPON	u	1	$ 60.942,42
		TOTAL	**$ 105.898,06**

*Note: Adapted table. Developed by Jennyfer Arteaga

***Operational Expenses*—** defined as the ordinary expenses and that it are tied by the starting of a project, the same that the company must confront for the purpose of obtaining benefits. Next the Table VI reflects the typical expenses that the company will have to face in the course of the years of operation of the network. Inside these expenses we take the cost as the lease of existing postería in the area to serve, since the deployment of the network will be an airline, the cost for monthly hiring of the international exit. Finally for the maintenance of the network it has been estimated like 10% percent of the entire cost of the implementation of the same one (cost of passive network). The table has been refilled by fixed values for the following five years with the exception of the year in which the implementation of the project begins, since it was estimated, that the installation of the network lasts about three month, of that time the value of the payment for exit hiring on the outside where an extension of three months has been done by which the entire value of payment to the Carrier ($ 42.000,00) has been divided for 12meses and this value multiplied by three giving a whole of ($ 10 500,00), by the beginning of the execution of the project.

TABLE VI
ENTIRE COST OF EQUIPMENT NETWORK OF ACCESS FTTH-GPON

DESCRIPTION		YEAR 1 - 5
PAYMENT CARRIER	$ 10.500,00	$ 42.000,00
LEASE OF POST	**	$ 13.200,00
MAINTENANCE OF THE NETWORK 10 % PASSIVE NETWORK	**	$ 4.495,56

*Note: Adapted table. Developed by Jennyfer Arteaga

***Depreciation of Active Equipment* —** To take a correct balance it is necessary to consider the costs of depreciation of the teams, for the present project it is considered to be the useful life of five years since it is a question of technological team with a value of depreciation per year of 20% percent.

The elements that shape the passive network, that is to say, the system of wiring of fiber, the external plant and other elements that shape the ODN (network of passive dispersion), have a time of useful life superior to ten years, by what it has not been considered to be depreciation elements in this analysis.

TABLE VII
DEPRECIATION OF ACTIVE EQUIPMENT

DESCRIPTION	VALUE OF THE EQUIPMENT	ANNUAL DEPRECIATION TO 20 %
OLT HUAWEI SERIE MA5603T	$ 43.953,26	$ 8.790,65
ONT HUAWEI SERIE HG8247	$ 13.440,00	$ 2.688,00
	TOTAL	**$ 11.478,65**

*Note: Adapted table. Developed by Jennyfer Arteaga

***Financing* —** The Company will have to consider, obtain a bank put credit that has not the necessary budget, for which it is important to know the value of the monthly quota that the company will have to cancel.

According to the web page of the Central Bank of the Ecuador in which the rates of current interest appear to January, 2015, the referential interest rate for a managerial productive loan is 9.53 % percent, it appraises that will be considered during the space of five years (60 months).

***Income of the Project*—** Next there is detailed the summary of the bundles of service by subscription and monthly payment, depending on the plans that can be; Home or Residential, in that there is offered band sufficient for applications or tasks of the hearth and PYMES for kidlings and

medium enterprises.

Also it is necessary to highlight that the values showed next are referential, since these will depend and have to fit to the politics of the company therefore they might be subject to changes.

TABLE VIII
VALUES FOR SERVICE RESIDENTIAL

Internet Services	Price +V.A.T	Suscrip. +V.A.T	Sharing
3Mbps	$ 41,22	$ 112,00	2:1
6Mbps	$ 69,79	$ 112,00	2:1
9Mbps	$ 88,60	$ 112,00	2:1
15Mbps	$ 142,54	$ 112,00	2:1
18Mbps	$ 173,90	$ 112,00	2:1

*Note: Adapted table. Developed by Jennyfer Arteaga. The Table was refilled by approximate values, according to companies that offer this service in the Imbabura province.

Income Cash flow— For this project it has been considered to be a percentage of growth of 75% percent in accordance with the realized analysis, with this information it is possible to be believed the new users and the cash flow that they will generate in the next five years, this will be able to be demonstrated next in the following table, which shows the revenue that will be obtained by installation concept for which will take only the new users per year.

TABLE IX
INCOME CASH FLOW

INCOME	USERS	SUSCRIPTION	YEAR INCOME
INICIO	60	$ 3.360,00	-----
AÑO 1	105(45n)	$ 5.040,00	$ 51.932,16
AÑO 2	184(79n)	$ 8.848,00	$ 91.004,93
AÑO 3	322(138n)	$ 15.456,00	$ 159.258,62
AÑO 4	463(101n)	$ 11.312,00	$ 228.996,10
AÑO 5	740(317n)	$ 35.504,00	$ 365.998,08

*Note: Adapted table. Developed by Jennyfer Arteaga

To obtain the income for subscription 60 current users will be taken into consideration in the first year and there will do to them the discount of 50 % percent of the cost of installation $ 56,00 (price includes V.A.T) and the subscription will have to new users a cost of $ 112,00 (price includes V.A.T).

To obtain the value of monthly revenue for the service, it was considered that the cost that has a Residential plan or basic Home of 3Mbps, which is of $ 41,22 (price includes V.A.T), this value will be multiplied by the whole of users a year and for 12 months since it will give as the value of annual income proved.

Departures Cash flow— there are considered to be the values by concept of all the teams involved during the implementation of the project.

Initially an entire transfer of the users appears at present wireless (60 users) towards the optical fiber network since they are interested in having access to telecommunications services with the technology FTTH, additional to this, they are considered to be the new users projected in the same year.

TABLE X
DEPARTURES CASH FLOW

DESCRIPTION	UNIT PRICE
ONT HUAWEI SERIES HG8247	$ 224,00
SUPPLY AND LAYING OF PATCH CORD	$11,78
SUPPLY AND LAYING OF FIBER TERMINAL BOXES	$ 24,98
TOTAL COST FOR USER	**$ 260,76**

*Note: Adapted table. Developed by Jennyfer Arteaga

Next the implementation cost appears for user for it was considered, that whenever a new client integrates to the network, the unitary implementation cost dear will be of $ 260,76.

Since the users will increase every year, the cost of annual implementation will be calculated multiplying the number of new users, for the value of the cost of implementation.

TABLE XI
PROFIT & LOSS STATEMENT

INCOME		Year 2015	Year 2016	Year 2017	Year 2018	Year 2019
USERS		105	184	322	463	740
NEW / USERS	60	45	79	138	101	317
SUSCRIPTIÓN (Residential)		$ 8.400,00	$ 8.848,00	$ 15.456,00	$ 11.312,00	$ 35.504,00
SERVICES (Residential)		$ 51.932,16	$ 91.004,93	$ 159.258,62	$ 228.996,10	$ 365.998,08
TOTAL INCOME	$ -	$ 60.332,16	$ 99.852,93	$ 174.714,62	$ 240.308,10	$ 401.502,08
EXPENSES						
ACTIVE EQUIPMENT - IMPLEMENTATIÓN	$ 60.942,42	$ 11.734,20	$ 20.600,04	$ 35.984,88	$ 26.336,76	$ 82.660,92
PASSIVE NETWORK DISPERSION	$ 44.955,64	**	**	**	**	**
LEASE POSTS	**	$ 13.200,00	$ 13.200,00	$ 13.200,00	$ 13.200,00	$ 13.200,00
PAYMENT CARRIER	$ 10.500,00	$ 42.000,00	$ 42.000,00	$ 42.000,00	$ 42.000,00	$ 42.000,00
ENGINEERING & INSTALLATION	$ 7.412,86	**	**	**	**	**
MAINTENANCE OF THE NETWORK	**	$ 4.495,56	$ 4.495,56	$ 4.495,56	$ 4.495,56	$ 4.495,56
PAYMENT BANK LOAN	**	$ 26.707,31	$ 26.707,31	$ 26.707,31	$ 26.707,31	$ 26.707,31
DEPRECIATIÓN ACTIVE EQUIPMENT	**	$ 11.478,65	$ 11.478,65	$ 11.478,65	$ 11.478,65	$ 11.478,65
TOTAL EXPENSES	**$ 123.810,92**	**$ 109.615,73**	**$ 118.481,57**	**$ 133.866,41**	**$ 124.218,29**	**$ 180.542,45**
CASH FLOW(USD)	-123810,92	$ -49.283,57	$ -18.628,64	$ 40.848,22	$ 116.089,81	$ 220.959,63

*Nota: Adapted table. Developed by Jennyfer Arteaga.

Profitability of the Project— To determine if the project is profitable, it is needed to identify certain parameters that there will do this possibly the same ones that will be the following ones: NPV (net present value), ROI (rate of return on investment), C/B (relation cost benefit) and PRI (period of recovery of investment).

NPV (net present value***)*** — According to the web page of the Central Bank of the Ecuador to January, 2015, the current interest rate of the market is of i=10,21% percent per year, the time for which to realize the project is five years old, it is necessary to stress that the interest rate can change in the course of the years.

$$VAN = -123.810,92 - \frac{49283,57}{(1+0,1021)^1} - \frac{18628,64}{(1+0,1021)^2} + \frac{40848,22}{(1+0,1021)^3} + \frac{116089,81}{(1+0,1021)^4} + \frac{220959,63}{(1+0,1021)^5}$$

$$VAN = 61\,235,02\ dólares$$

(3)

The equation (3) indicates the obtained value of the VAN and according to the obtained value and observing that the same one is bigger than zero it is possible to conclude that the implementation of the project is profitable.

ROI (rate of return on investment) — The value of the TIR is bigger than the current interest rate on the market that is 10,21% percent.

$$-123.810,92 - \frac{49283,57}{(1+r)^1} - \frac{18628,64}{(1+r)^2} + \frac{40848,22}{(1+r)^3} + \frac{116089,81}{(1+r)^4} + \frac{220959,63}{(1+r)^5}$$

$$TIR = 18\%$$

(4)

The equation (4), it indicates the value of TIR of 18% percent therefore one concludes that the project is profitable for its implementation.

PRI (period of recovery of investment) — It indicates the time necessary to recover the laid-down capital. To calculate the PRI there is necessary to be accumulating the clear flows

obtained in every year up to going so far as to cover the investment for it next appears a table in which there are detailed the flows accumulated during the estimated period of the project.

As it is observed that next the value of clear flows accumulated in the fifth year is major than the investment. Therefore the period of recovery of the investment would happen approximately in five years.

TABLE XII
PERIOD OF RECOVERY OF INVESTMENT

PRI

YEAR	CASH FLOW (USD)	CASH FLOW CUMULATIVE (USD)
1	$ -49.283,57	$ -49.283,57
2	$ -18.628,64	$ -67.912,21
3	$ 40.848,22	$ -27.063,99
4	$116.089,81	$ 89.025,82
5	$220.959,63	$ 309.985,45

*Note: Adapted table. Developed by Jennyfer Arteaga

TABLA XIII
PERIODO DE RECUPERACIÓN DE INVERSIÓN.

TIME	INVESTMENT (USD)	COST NEW USERS	INCOME ANNUAL
INICIO	**$ 123.810,92**	$ 60.942,42	
AÑO 1		$ 11.734,20	$ 51.932,16
AÑO 2		$ 20.600,04	$ 91.004,93
AÑO 3		$ 35.984,88	$ 159.258,62
AÑO 4		$ 26.336,76	$ 228.996,10
AÑO 5		$ 82.660,92	$ 365.998,08
TOTAL	**$ 123.810,92**	$ 238.259,22	$ 897.189,89

*Note: Adapted table. Developed by Jennyfer Arteaga

Cost-Benefit (C/B) **—** this parameter determines the profitability of the project in general terms, that is to say, the result expresses the money gained in every dollar invested in the project.

$$BC = \frac{897.189,89}{238.259,22 + 123.810,92} = \mathbf{2,4\ D\acute{o}lares} \quad (5)$$

The equation (5), it indicates that the value cost-benefit is 2,4 dollars that is to say, this value would be gained by every annual inverted dollar. With the information obtained in this chapter one concludes that the project is a profitable position that the period of recovery of investment is five years, the valuation is of investment comeback it is 18% percent and the value that the company will obtain will be of 2,4 dollars what it implies that every dollar that inverted, this one will be duplicated, by what it is recommended that to be implemented the project.

VI. CONCLUSIONS

The evolution of the networks SET it has allowed, that telecommunications services up to the hearth (FTTx) improve, since speeds that go from 1,24/2,4 Gbps in downstream and upstream, it allows to offer such services like; VOIP, IPTV, Internet applications between others.

The change of technology in the city of Urcuquí, undoubtedly will allow offering more number of services with excellent quality as for speed, covering the expectations of the clients who every day need of services and applications of telecommunications of major band, since a basic need has turned.

There has been designed the network of access FTTH (Fiber up to the hearth) in the parish of Urcuquí by means of the employment of the technology GPON, opened from the node (OLT), located in the area to be served up to the domicile of the final user (ONT).

Of the realized study one concludes that the project is a profitable position that is counted by the physical way for the deployment of the network, which will be by means of postería existing, in addition to being provided with companies that provide equipment needed for the implementation of this design.

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