Techno-economic planning with different topologies of Fiber to the Home access networks with Gigabit Passive Optical Network technologies

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Abstract

The Optical Network is considered an important asset to any telecom operator. One of the most critical issues to the operators is how they can minimize the deployment cost and maximize the Return of Investments (ROI) by optimizing the operational costs in the optical network. Deployment of future-proof access networks requires new infrastructure and new equipment and, on top of it, raises many questions regarding the costs and risks associated with the technology, telecommunications market, and legal regulations of these networks. This paper presents the techno-economic analysis of the planning of FTTH access network topologies with GPON technologies that includes a series of scenarios in combination with tree, eye and tree topologies of eye and architectures Home-Run and GPON. In order to get realistic results, the techno-economic study has been applied to different urban areas in the city of Peshawar, capital of KPK. Cost/benefit analysis is performed in order to determine the most influential parameters and give general guidelines for the deployment of new-generation optical access networks in different environments. Analysis also shows that the price for new services that a customer needs to pay is competitive in the market today. Today, the service providers seek penetrate the telecommunications market with more advanced plans and complex network designs to reach a greater number of users and expand the range of services that offer. This is where FTTH networks along with technology GPON play an important role, as they meet this challenge. In this work, we present a FTTH network with GPON technology, the parameters related to the main conduit and network Elements (NE) connected to the Splice points (SP), among other aspects. Combining these topologies with their respective architectures would help the network planners to reduce the planning time of this type of networks and investment costs.

Keywords: Fiber to the Home, Access Network Topologies, Home-Run and Gigabit Passive Optical Network architectures
I. Introduction

The growing demand for smart services such as data, video and high-speed Internet access on behalf of the users makes the service providers to propose new strategies in technologies to meet the demands of customers. In this context the FTTH access networks is best solution for service provider that provide huge bandwidth and better quality in the service for data hungry customers. This technology is divides the access network into two categories: active and passive [X]. The Access Optic Networks (AON) and Passive Optic Network (PON) are shown in figure 1. It uses a traditional Ethernet point-to-point (EP2P) topology, with dedicated fiber optic (OF) between the Central Office switch (CO) or a Remote Node (RN) and Optical Network Terminal (ONU / ONT) to the end user. Simultaneously these network maintains the necessary expenditure, both capital (CAPEX) and operational (OPEX), at a reasonable level compared to competing technologies.

![Fig.1: AON (Point-to-Point Ethernet) and PON (Point to Multipoint) topologies](image)

Therefore, in this research CAPEX relates to optimal investments and the commitment that will have to be made to harmonize the various changes to ensure what was planned and also the possible evolution in network architecture. OPEX, are the operational expenses referred to the costs of the day to day activities. In this case, the OAM (Operational and Maintenance) cost will try to reduce by decreasing the administration activities and restoration time of network for each user, due to the exclusive use of ports in CO and OSP. This Type of topologies are commonly used in access networks in buildings (FTTB), because the average data upload occurs in Gb / sec in the equipment configuration [VIII], [IX]. On the other hand, passive optical networks (PONs) use three types of topologies:

1. Point to Point,
2. Point to Active Multipoint
3. Point to Passive Multipoint

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The topology (EP2P) determines that N fibers in the communication channel must be installed for X consumers depending on the distance to be covered. However, it’s depend on the location of an electrical-optical connector in the OLT and ONT, in total 2xN connectors are required. In the case of the (P2MA) topology, to cover the X customers, you need to install a fiber for the largest stretch, apart from that, you need to use an electro-optical connector in the ONT and the Curb Switch, in total 2xN + 2 connectors in addition to (P2MP) topology are required. In this topology to cover the X users, Optic fiber cable must be installed according to the route. It is necessary to install and electro-optic connector for a total of N+1 connectors for each customer, both in the ONT and in the OLT. The main advantage of this topology is passive optical splitter, which is the intermediate element between the ONT and the OLT, does not require an electrical power supply. There for it’s known as passive optical network (PON). This topology is the least expensive.

The (P2MP) topology incorporates Gigabit passive optical networks (GPON) and passive optical Ethernet networks (EPON) in its standards. The specific characteristics of the transmission convergence layer (TC) are defined in recommendation G.984.3 of ITU-T, [IV]. The TC layer in a GPON system consists of two sublayers: a framework sublayer and adaptation sublayer. The framework sublayer has three functions, the multiplexing and de-multiplexing, the generation and decoding of the header and the internal routing of frames. On the other side, according to G.984.3 standard the adaptation sublayer must provide two adapters, which are the GPON interface adapter and the OMC I interface adapter (Optical termination management and control interface). The two sub-layers are responsible for the various services that operators can offer at any given time. In accordance to the G.984.3 standards, the Convergence layer and its sublayers provides the DBA (dynamic Bandwidth allocation) protocol layer, ONT Activation, performance tracking, encryption and redundancy algorithms. In ITU-T Standard G.984 [6], Ethernet frames are encapsulated within the GTC (Convergence Layer in a GPON system), through the Gigabit encapsulation method (GEM) protocol, generating the GEP-like format, derived from the procedure of a generic frame, under the standard (ITU G.7401).The GEM protocol is encapsulated within the GTC, such as SONET and SDH, so that download speeds can be obtained in a synchronous communication system of 1.25 Gb/sec to 2.5 Gb/sec, while uploading speed can oscillate between 622Mb/Sec to 1.25 Gb/Sec. Compared to next-generation passive optical network (XG-PON) where uploading and downloading bandwidth oscillate between (10G/2.5 G), respectively; so, they have been standardized in XG-PON1 and 10G / 10G in XGPON2. The IEEE 802.3 ah EPON standard, based on Ethernet technology, has a symmetric capacity of 1G, which can be upgraded to 10G / 10G (down and up), through the IEEE 802.3 av standard; when transporting Ethernet frames without fragmentation and supporting only 32 users.
Table 1: Different standards of PON technology

| Parameters          | BPON  | EPON       | GPON       | XGPON       | 10G-EPO     |
|---------------------|-------|------------|------------|-------------|-------------|
| Standard            | ITU-T G.983 | IEEE 802.3 ah | ITU-T G.984 | ITU-T G.987 | IEEE802.3av |
| Average upload data | 622 Mbps | 1.25 Gbps  | 2.5 Gbps   | 10 Gbps     | 10 Gbps - asymmetric |
| Average download data | 155 Mbps | 1.25 Gbps  | 1.25 Gbps  | 2.5 Gbps    | 1Gbps Asymmetric |

II. Literature Review

Next, some associated research is evaluated with the FTTH access network planning topologies to be offered with GPON techniques. According to [V], it proposes the design and implementation of an FTTH network based on a GPON architecture in the city of Baghdad / Al-Gehad, which is part of Iraq's telecommunications and postal network (ITPC). In this model, a number of PON network ports need to be established based on the average time of access to the different types of services performed by users, it's also able to attain an adequate capacity to transport data in the FTTH network through the service operator. Furthermore, in this model it optimizes the costs of FTTH network's cable allocation, Power cables and complete cost through GPON technology in terms of the amount of customers.

The Authors of [XII], collects in the publications of other authors, which discussed the planning and design of FTTH networks, different aspects related to the efficiency of FTTH networks, implementation costs, modeling of FTTH networks, changes related to networks of next generation PONs. The proposal is a new implementation of this type of FTTH networks, called OLT trademarks, with class B protection.

The purpose of implementing this Class B protection in the OLT ports is to be able, on the one hand, to guarantee the redundancy process of the splitters with respect to the OLT and, on the other hand, to maintain communication between the communication cables connected to the splitters in the case of failures, so that minimum bidirectional communication levels can be established and maintained. So that the system of the FTTH GPON network continues to function normally if users demand the consumption of new services. The functioning of the FTTH network must be continuous at all times in order to guarantee the quality of the service offered by the operators to their customers.

The proposal of [IX] presents solutions for the planning and design of FTTH networks based on the service provider or operator. It identifies factors linked to component management for this type of networks, mapping of network elements, automation of resource design, customer data base etc. On the other hand, the author mentions the dynamic aspect and the life cycle of a network. In this model it is
realized that in the planning and designing phase the FTTH network will cover vast area occupied by rural fields, towns, family homes, summer houses, which means that the network must retain the service it offers through its various operators, 7 days a week and 24 hours a day, with brief interruptions for preventive and corrective maintenance. With respect to the life cycle, within the process of planning and designing the network, it is necessary to foresee an adaptation of the infrastructure to the new technologies that arise over time, in order not to become obsolete with the passage of time. Therefore, the aspects raised by this author are closely related to the aforementioned fundamental points, which outline [V], [XII], [XVII] [VI]and [I].

It also establishes the elements of the FTTH network, with respect to the location of the central offices (CO) and nodes, power cables and their configuration. Also, consider the economic geographic location (GEL), since not all areas, corners or apples have the same characteristics and number of houses and users. Keep in mind that for a uniform density, the ideal position of the node or reference point should be in half of the areas that serve. Many of the aspects raised by Stallworth, are related to the study proposed in this work at the level of planning and design of FTTH networks based on zoning and services to be provided.

Another work of great interest in the field of planning and design of FTTH networks is that of [XIV]. Its proposal includes the elements of a generic FTTH network, where the data layer, the optical network, the home terminal stand out. It also establishes compatibility at the element level of FTTH networks with HFC systems, which are hybrid fibers: they support copper and optical fiber, simultaneously in the same communication channel. These common elements are related to the electrical power of the equipment, compatibility with bandwidth, support terminals, data interfaces, voice protocol, and quality of service (QoS), among other relevant aspects.

In this way, [XVI] he explains in his work, that a network planner starts with a large area within a network. Scope of a central office (CO) that is divided into sub-areas that are planned individually. Also, this process of manual division is time consuming and does not allow optimizing the costs assigned to the design of the network, so the researcher proposes a software tool that helps the network planner to locate the elements of an FTTH network, as well as a correct distribution of the costs incurred in this type of networks.

The authors of [II] proposed a tool for semi-automated network planning. It defines a suboptimal route distribution for deployment cost. It utilizes existing cable channels. After clustering customers, the authors of this research utilize GA for route deployment process. The outcomes are compared to network designs attained by manual process which depicted that in most cases this tool generates an inexpensive network.

Though, none of research work considered different types of network elements selection, such as research work in paper [VIII] emphasized on decisive
optimum locations of network elements and cable assigning. They assumed a specific type of network element.

In [XV] the authors proposed a model of a real life network. Real data of building sites and streets was mined from a Geographical Information System (GIS) by use of an open source map known as Open Street Map (OSM). This model was adapted to single level passive optical network (PON). These remote nodes are located for serving the customers. For more decrease costs sustained, cables channels shared by different routes of cable.

In [VII], the networks that based on MILP, a design tool for GPON/FTTH networks are proposed. This tool automates the planning process of networks. By providing positions of customers and probable positions of SPs and DC’s, it adopts optimum positions of DCs and SPs as well as assignment of cables in network elements and customers. Thus minimizes entire network development cost. The researchers took in to consideration future progression and introduced a technique for planning large networks.

According to [IV], an approach is presented that is based on meta-heuristic. This approach used Ant Colony Optimization (ACO). This algorithm achieves cable assignment on a multilevel network which emphasizing on cost minimizing. This algorithm allocates customers to DCs as well as DCs to splitters simultaneously.

In the particular scenario described in this article, the planning of FTTH service network topologies with GPON technology to be supported with a large area, identified as a rural area, which in fact includes a number of houses subdivided into residential homes, guest houses etc. Likewise, the remote nodes or central offices (CO) are assigned according to the number of towns that make up this rural area, number of households, number of inhabitants and coverage area expressed in square kilometers.

This article is organized in the following sections: section 3 describe Motivation, Section 4, discussed the methods and materials of this study; section 5, describe the results and discussion and in section 6, the conclusions of the work are presented.

### III. Motivation

The implications of broadband technology in Pakistan are completely different as compared to international trends where wire-line is the best option for broadband services. In Pakistan the broadband growth in Wireline is very slow which is very much obvious. The slow growth is due to some factors that need improvement; these factors include [X, XV, VII]

- Low literacy rate,
- low (level of) consumer awareness,
- No coverage of Broadband services,
- Traffic reduction in broadband services,
- Low computer penetration, cost of service (tariff)
In the above mention factors the most important is the coverage area and wire line infrastructure deployment especially for Passive Optical Networks (PON). Fiber Optic (FO) is the latest and the most advanced mode of data transmission having the huge bandwidth, interference free, best signal security, fast upgradability, low cost, small size and less weight etc.

The service providers are facing problems for the maintenance and monitoring of their wire-line networks i.e. copper network, which needs the uplifting, continuous maintenance and rehabilitation to improve the satisfaction index.

In this paper, a network design tool for the GPON/FTTH network is proposed to automate the planning process. Thus, given the locations of customer plots, possible locations of CDs and SPs, the tool decides the optimal or near optimal locations of CDs and SPs taking into account the future growth and spare capacity distribution. In addition, cables are assigned from each plot to a CD and to the selected SP. The solution is optimal in the sense that it leads to the minimum cost of deployment which includes the number of network elements required, the total cabling distance and the installation costs.

By using an automated planning assistant tool, the planner can:

- Minimize network capital expenditure, i.e., installation and materials costs.
- Quickly achieve the network design of a given area.
- Compare what-if scenarios to meet changes in planning requirements.
- Rapidly re-cost networks for contract control and installation.
- Produce cable design and bill-of-materials automatically.
- Specify pre-determined locations for network elements prior to performing the network optimization.

The benefits of automating, network design includes reducing installation and material expenses, decreasing time to make a design from hours to minutes, speedily re-costing networks for different laboring or equipment costs and making network design as well as automatically making bill-of-materials too.

IV. Methodology

The method is based on the critical study of the state of the art in the area of planning of FTTH access network topologies with GPON technologies, at the end of which the proposal that supports this work will be presented. To do this, first of all, a systematic process of review of the documentation will be carried out, as well as a classification of the different existing proposals. Subsequently a specific assessment of the proposals of [XII] and [V] will be made as references of the work that will be presented here. The presentation of the study will begin with an analysis of the components of an FTTH GPON access network as well as its architecture, considering the different points of view raised by the authors. Subsequently, new elements and techniques will be introduced in order to optimize the services offered...
by the operators. The planning of automated networks will be used, mapping by area and services will be added, network topologies will be considered, the number of users, the distribution of apples, the point of reference for the layout and installation of the optical fiber and the distribution of splitters of first and second level per block.

GPON technology is the reference in this work because it has also been adopted by multiple service providers, which allows a comparison in the Quality of Services (QoS) in scenarios with multiple services. In addition, being a more complex architecture than EPON, it helps to plan the topologies of FTTH access networks with GPON technologies, taking into account the topologies, in a first time, and subsequently the network architectures.

The planning of the network is carried out considering aspects related to the geographical area, elements of the network, services to be provided, technological infrastructure, architectures and techniques. During the network designing, consideration of number of ports, number of cards per port, access node number of uplink interface are most important.

IV.i Network topologies

The topology is very important for designing and planning of access network distribution through links among different nodes in the framework. Some network topologies only project the connection of one network while others address aspects related to redundancy and network availability.

The network planner, during the planning and designing a network they try to manage it in the most economical way, by optimizing all resources, available for the network. One of the topologies that combines these characteristics are describe below

IV.i.a Eye - Tree Topology

In this section, the most relevant characteristics of Tree and Eye topologies are taken. On the one hand, we have the Eye topology that offers to connect the distribution nodes (DNs) to the Splice Points (SP), while with the Tree topology, the splice points (SP) are connected to the Network Elements (NE). The Eye-Tree topology with two distribution nodes, located in the same place is shown in fig 2.
The Eye Tree topology with two distribution nodes located in different place are shown in Fig 3. In tree topology configuration, the splice points (SP) are connected with two separated fibers from two different network elements (NE), which would cause the splice points (SP) to be redundant. In the tree topology the links are produced between the splice points (SP) and the network Elements (NE), while in the Eye tree topology, the size of optical fiber route may rise for expending the service to other location. Obviously, there is no redundancy in the Eye-Tree topology, but the attenuation (noise in the channel) is minimal, below 5dB.

IV.ii. Home - Run architecture and gigabit passive optical networks (GPON)

The Home-Run (HR) architecture is composed of a dedicated fiber, which allows it’s implementation in various forms from the central offices (CO) or distribution centers to each subscriber. Therefore, this architecture requires more fiber optic compared to other infrastructures as seen in figure 4. However, this architecture
is also called point-to-point architecture [XIV], not only because of the amount of fiber required for its installation but also for the high operating costs incurred.

Absolutely, in every process of planning and designing a GPON network, it is important to use the best topology. Therefore the Eye-Tree topology is the best option for smooth service which cause the best customer satisfaction, regardless of the problems that may arise in the network, having two distribution nodes located in different places helps if one of the nodes stops working the other that is located elsewhere it will allow providing in service in a continuous and interrupted form, being this way, the fault that appears in the network a transparent process for the user.

That is why, for this research, the topology proposed and chosen is the Eye-Tree topology with GPON architecture, as shown in figure 5, since it has two distribution nodes located in a different place, which reduces enormously the amount of optical fiber to install, respectively.

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4.3 Component-based software engineering

It is a branch of software engineering that emphasizes the separation of issues (Separation of Concerns - SoC), so it allows to reuse software to define, implement and compose weakly coupled software components in systems, thus allowing benefits for the same software as for the companies that sponsor them [III].

In this way, the components are considered as an initial part of a platform of services represented through components such as web services or service-oriented architectures (SOA).

In our study, we will use service-oriented architectures (SOA), since it is an IT architecture style that is based on the orientation of services, thus allowing us to think about services, their construction and their results [XI]. In turn, a service is considered as a logical representation of a business activity that results in a specific business, in the particular case of this study, reduction in the purchase of optical fiber for various connections, constant uninterrupted services, satisfied users, among others.

Therefore, these services can be seen in our study, in the first stage, through metrics such as the main conduits and the NEs connected to the SPs when comparing the Home-Run and GPON architectures, as observed in table 3 and table 4, respectively. In the second stage, we have metrics related to the number of users and operating costs, as shown in table 5, related to each municipality as to their respective users.
Just as there are companies that need their services to be operational in an integrated manner to identify various processes, information flows and people [XIII], the same happens with the planning of FTTH and GPON access networks, which are seen as systems complexes, which have to be built in a predetermined time and with the highest quality standards.

One of the characteristics that are part of SOA is that it is based on the design of services that reflect the activities of the business in the real world [XV]. Based on this principle, the case study proposed in this study is made up of a system that bases its planning on FTTH networks with GPON technologies, allowing it to offer services to its users of HDTV, VoIP, Internet, cloud storage, among others. Reducing the cost of fiber optic installation to the home as much as possible.

V. Experimental Results

For the research work, first we will select the different residential locality of district Peshawar. These localities are composed of 6000 family residences and 4500 business offices; the current technological infrastructure is one of the characteristic of a developing area. The different residential locality which are selected, Hayatabad, University Town, Cantt, City and GT Rd. For these localities, it is decided to select 5 distribution centers or central offices (COs) located in each locality and installed by the corresponding operator. The distribution centers were selected according to the network access nodes.

V.i. Stages and Implementation Scenarios

This work is broken down into two stages. In the first we focus on a dense local area where tests are carried out and comparisons are made between different scenarios. The second stage is aimed at selecting the results generated in the first stage and applying the best solution in large areas, including rural areas. One of the works that allow to use different implementation scenarios [XIII] with the application of multiple services is identified in [XI], are used as a reference for this study.

V.1.a. First Stage

The first stage initially consist of three types of scenarios, as shown in table 2. In which the different topologies studied (Tree, Eye and Eye-Tree) and the different architectures (Home-Run and GPON), taking into account distribution nodes, either in the same place or not.
Table 2. Different Scenario approach

| Topology | TREE | EYE | EYE-TREE |
|----------|------|-----|----------|
|          | With 2 distribution nodes |       |
| Architecture | Same location | Different Location | Same location | Different Location | Same location | Different Location |
| Home-RUN | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 |
| GPON | Scenario 7 | Scenario 8 | Scenario 9 | Scenario 10 | Scenario 11 | Scenario 12 |

Therefore, if we consider that the number of GPON ports are equal to the number of first level splitters, then there would be a total of 18 GPON ports, which are required to meet the demand for services among the respective users, divided by blocks and streets, respectively. In table 3, the results for scenarios 1 to 6 are presented.

Table 3. Results of the Home-Run architecture

| Scenario | Main Conduit | NEs connected to SPs |
|----------|--------------|----------------------|
| 1        | 12500 m      | 180000 m             |
| 2        | 6250 m       | 180000 m             |
| 3        | 24000 m      | 490000 m             |
| 4        | 24000 m      | 490000 m             |
| 5        | 24000 m      | 180000 m             |
| 6        | 24000 m      | 180000 m             |

As seen in table 3, in scenarios 3 and 4, respectively, the use of optical fiber is tripled with respect to scenarios 1, 2, 5, and 6, while, with respect to the main conduit, the scenarios 3, 4, 5, and 6 maintain the same length consumption in meters. It is important to highlight, in scenario 2, a significant reduction in the requirements of optical fiber and main conduit, with respect to the other scenarios.

In the same way, in the case of the GPON architecture (Scenarios 7 to 12) the following results are obtained. See table 4.

Table 4. Results of the GPON architecture

| Scenario | Main Conduit | TRs connected to PEs |
|----------|--------------|----------------------|
| 7        | 24000 m      | 180000 m             |
| 8        | 24000 m      | 180000 m             |
| 9        | 55000 m      | 490000 m             |
As seen in table 4, in scenarios 9 and 10, in a GPON architecture, the use of optical fiber is tripled with respect to scenarios 7, 8, 11 and 12, respectively. However, with respect to the use of the main duct, scenarios 9, 10, 11 and 12 maintain the same section consumption in meters.

In Figure 6, which shows the comparison of the two architectures, with their respective scenarios, taking into account their respective topologies, it can be seen that, at the cost level, if we compare the Tree topology with the Eye-Tree topology, there is an increase of 25% between both through each of the scenarios that arise. In the second stage of this case study, we go deeper into the study of the Eye-Tree topology.

V.i.b. Second stage

The second stage focuses on the use of the best results from the first stage in order to place them in a more real scenario. To achieve this, a series of criteria are proposed for this second stage, which are outlined below:

- Large-scale tests, since the rest of the localities are taken into account.
- Investigate the customer demand of the localities as well as their size.
- Two network scenarios are planned, such as the Tree topology and the Eye-Tree topology.
In this research the above criteria are taken into consideration as we are interested in seeing how service provider can give more services to their customers through the latest generation network, such as GPON networks. For this reason, it takes into consideration that a large number of customers situated in scattered localities to which the service is not only provided but must be constant without any interruption. In comparison of Eye-Tree topology with GPON architecture and tree topology with home-Run architecture, it is clear that the Eye-Tree topology with GPON architecture allows a significant reduction in the number of optical fiber which also reduce the CAPEX cost.

In this second stage, instead of considering one locality of Peshawar city, different localities of the city are considered. For the analysis, the respective localities are considered, as well as the operating costs (represented in PKR) are calculated considering the network elements, whether 30 to 40 customers to be connected multiplied by the total of users to whom the respective service), which are shown in the following Table 5.

| Localities | Number of Users | Operating Costs |
|------------|-----------------|-----------------|
| Hayatabad  | 2000            | Rs 10,000,000   |
| Khyber     | 2000            | Rs 10,000,000   |
| Cantt      | 1200            | Rs 6,000,000    |
| City       | 1000            | Rs 5,000,000    |
| GT Rd      | 1000            | Rs 5,000,000    |

Thus, if we take these results and apply these operating costs, as shown in Table 5, there is an increase of 17% in the purchase of fiber among the different localities. The comparison is started with two localities where high number of customers are connected through access network and having a huge demand of services offered by service provider because they are developed and highly populated localities. While the other localities having less numbers of customers and population density. In one selected locality Hayatabad town Tree topology is used and in the other locality University town (Khyber) Eye-Tree topology used, it shows that Eye-Tree topology decrease, it justify that Tree topology increase 17% consumption of optical fiber amount, this is the reason why Eye-Tree Topology is used in the planning and optimization of FTTH network with GPON technology. The number of distribution Nodes and Network elements connected to the splice point depends upon the used topology, it is clear that the number of fiber cable to be used can increase or decrease for a specified time.

### VI. Conclusion and Future Work

A planning of FTTH access networks topologies with GPON architectures was suggested, which was analyzed through a research paper and divided into two Stages. In this first stage, Tree, Eye and Eye-Tree topologies have been considered,
comparatively, in association with the Home-Run and GPON architectures, which developed 12 different scenarios in which there are two distribution nodes located in the same place or different place. The results obtained from this first stage enable us to identify that the Eye-Tree topology connected to the GPON architecture helps to reduce the amount of optical fiber in the deployment phase between the network elements and their respective splice points.

In the second stage, the results of the first stage have been taken and implemented in a more real scenario, taking into account a series of previously defined criteria. It is concluded that the Eye-Tree topology is the most viable topology in this type of scenario, because it reduces operating costs in the purchase of optical fiber and on the other hand, allows to establish between 30 to 40 network elements per locality.

The use of service-oriented architectures (SOA), enable us to have a model consisting of criteria such as: main conduit, NEs connected to SPs, number of users, operating costs that allow and according to the characteristics of SOA, have a service-oriented system so that customers can consume services such as: internet, VoIP, HDTV.

In addition, in the process of planning and designing of FTTH network, it is recommended to use of cartography that helps to locate the distribution Nodes of the locality, as well as the reference point for the undergrounding of the optical fiber to each locality, that will allow to take the respective services of the operators to their customers. It also helps the equal distribution at the first and second level of splitters, the right positioning of distribution centers in the various blocks and streets, since all of these are equally responsible for provisioning of multiple services demanded by customers. However, it is important to point out that there has been no experimentation with these systems due to the economic cost of their implementation.

The results obtained initially and experimentally, allow to have an initial approximation of what could cost the implementation of a network of FTTH accesses with GPON technology. This experimental study would have to incorporate the cost of measurement between optical fiber splices, data losses in the reception and transmission of data, among other fundamental aspects. As future work, the identification of applications that support bandwidth and reliability in FTTH networks, would be a study that would be carried out later.
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