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A New and Innovator Method of Designing a Fiber Optic Network for the Extension of the Local Area Network of a Building.

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TITLE

A new and innovator method of designing a fiber optic network for the extension of the local area network of a building.

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Abstract

This study intends to cover the design of a Point-to-Point optical fiber network for the extension of a company's local area network, which is housed in two nearby buildings, which will be done without the intermediary of a provider but directly between buildings. Initially, the project and its requirements will be analyzed, i.e. the existing network, the company's building facilities and the services that will be transmitted through optical fibers, which will also set the requirements for bandwidth and security. Fiber optic network architectures on which the design was based as well as technologies and protocols used will be described. Finally, the design and implementation of the link will be described, as well as the materials and devices that will be used.

Additional Keywords and Phrases: P2P, LAN, IP, FTTX, HDPE, Switch, SFP, Single Mode, ONT, SMF Filter, Media conventer

Introduction

Fiber optic networks have become an increasingly popular solution to cover applications that require long distances, high bandwidth and excellent security, such as IP surveillance, wireless coverage and access controls, etc. In addition, a point-to-point fiber optic system Point-to-Point tends to be the optimal choice for implementing Ethernet or PoE extension and obtaining high network speed, which plays an important role in home and business network extension design. Fiber optic network uses glass or plastic fiber optic cable to achieve fast speed and low latency data transmission over long distance. The scenario dealt with in the study concerns the expansion of a company's local network, due to the installation of additional jobs in another building. The buildings are located on the same street and on the same side without communicating with each other with partition walls and without another building between them (Figure 1 & Figure 2).

Figure 1: Building A & B

Figure 2: Building A & B (Satellite)

Description of the Buildings and Equipment's

Building A houses shared network resources, which will also need to be accessed in the new building, i.e. file servers, application servers, network printers, video conference rooms as well as internet access via cable and access points. There are also 300 corporate computers, about one personal wireless device per person (mobile, tablet, etc.) – non-corporate devices do not have access to network resources as they are designed to connect to a separate VLAN, but access the internet through the of the same line – and finally 30 IP and CCTV cameras for site monitoring which are accessible via LAN and also via the internet. Building B will add an additional 200 new employees with one corporate and one personal device each, new network printers, 2 video conference rooms and 10 surveillance cameras. The two buildings will share the same line for internet access. Figure 3 shows the network deployment after the completion of the implementation.

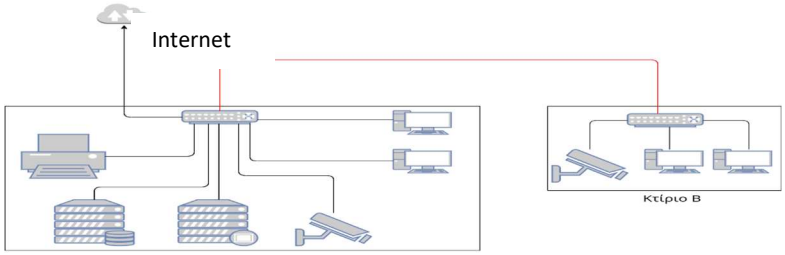

Figure 3: Final network deployment after the completion of the implementation.

Network Architectures

FTTH (fiber to the home): The optical fiber reaches the customer's premises. That is, it ends at a specific home or business.

The project described in this study is classified in the FTTH architecture. As it is known, FTTH is the installation and use of optical fiber from a central point directly to individual buildings such as homes, apartment buildings and businesses to provide high speed internet access. There are two popular architectures used with FTTH – Point to Point (P2P) architecture which uses active equipment across the link & Point to Multi-Point (P2M)/Passive Optical Network (PON) architecture which uses optical splitters (Passive Optical Splitters) in the aggregation layer, as shown in Figure 4a,4b below [1]:

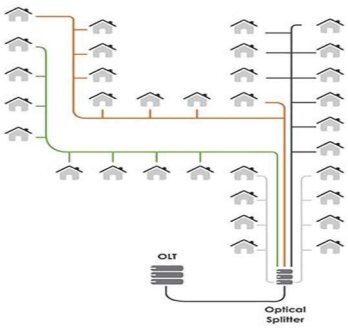

Figure 1a: PON infrastructure

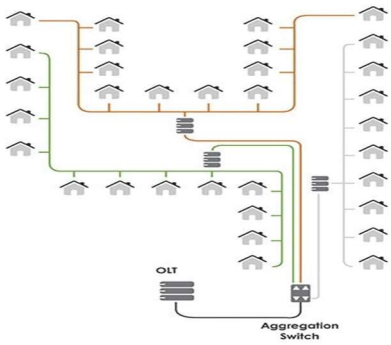

Figure 2b: P2P infrastructure

Infrastructure Selection

Is P2P right for this project? Listed below are the factors evaluated for the final selection of technologies, materials and providers for network development based on the needs of the project. P2P fiber optic networks has many advantages. One of the most basic is that it is simple in design and installation. This in itself saves time and money and makes the decision easier for organizations that have to choose how to implement such networks.. A P2P link can give Building B users the same experience and network speed as the LAN in Building A's central facility as well as equal download and upload bandwidth [2].

Here are some P2P use cases of fiber optic networks:
- Connection of multiple buildings e.g. University campus
- Need for high availability and security in remote workstations
- Very high bandwidth requirements per port
- Requirements for equal upload and download bandwidth
- Specific security issues or compliance requirements

Sometimes, organizations and companies choose P2P links because of their management features. This forms a continuous path connecting a switch at the carrier's central office directly to the carrier's local aggregation switch located in the customer's building [3].

Installation of Optical Fiber

As mentioned in the paper, the two buildings are in close proximity, with no barriers between them with no canal between the buildings. The fact that the computer rooms and network equipment in the two buildings are located on the ground floor led to the choice of an underground connection by means of the excavation of a channel in the space between them.

Cable protection

Cable deterioration (eg cutting), which affects all fibers of the cable and all customers in the area served by it, is by far the most common type of network problem in an urban or suburban areaHDPE pipe is flexible and can be used in areas with more demanding terrain

HDPE is more flexible than PVC. This makes it easier to work and install in areas with difficult terrain. It can bend and contour to the ground, making it more suitable for areas with rocky or uneven ground. PVC pipe is not recommended for use in areas with extreme temperatures as it can become brittle and crack when exposed to low temperatures. HDPE, on the other hand, is more resistant to temperature extremes and can be used in a wide range of temperatures. Due to the fact that repairing damage to an underground cable is a time-consuming process and due to the importance and reliability that the connection between the two buildings must provide, the use of a protective HDPE pipe was chosen (Figure 5).

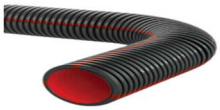

Figure 5: HDPE pipe

Types of fiber optic cables

There are different types of fiber optic cables used in different applications and environments. The main difference between them is the number of fibers they contain, the type of fibers they use and the type of lining they have. Single-mode optical fiber: Single-mode optical fibers have a dimension of up to 10μm. Because of its design, single-mode fiber is compatible with higher data transmission rates (bandwidth) and longer distances [4]. And this surprisingly does not happen. Single-mode transmission fiber is easier to manufacture, leading to an average savings of 30% over multimode fiber (figure 7)

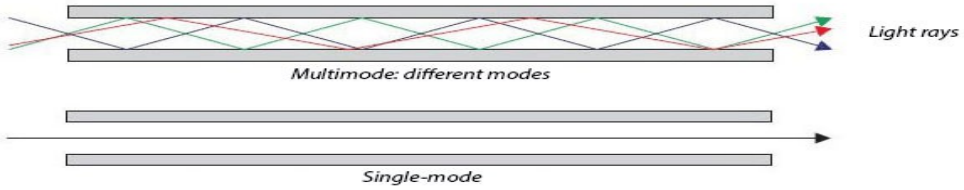

Figure 6: Transmission over multi-mode and single-mode fiber optics

According to the above, the single-mode optical cable is the ideal choice for connecting two points located at a relatively short distance from each other. Between buildings, outdoor cable or direct burial cables. For this paper, prefabricated LC/LC Duplex 9/125 Single-Mode 150m outdoor cable will be used (Figure 7) and for the indoor installation the same type of patch cable (Figure 8)

Figure 7: External connection cable

Figure 8: Patch cord for connection within a building

Outdoor distribution box

Finally, for terminating the cable outside the buildings, wall-mounted outdoor distribution and protection boxes with built-in couplers will be used to connect the indoor and outdoor cables. These boxes provide a safe transition point between the 2 different types of cables, manage excess cable and protect the optical fiber. In order to connect the two buildings, it will be necessary to use, in addition to the cable, active equipment such as switches, SFP modules to connect the optical fiber as well as an optical fiber to RJ45 converter [5].

Active equipment

Starting with listing the equipment that will be used for the connection, we will describe and illustrate how it will be implemented. In the computer room of Building A there is the core switch to which the switches of the other floors are connected via RJ45 cables as well as the servers located in the same area.. The second switch will be connected to a fiber optic to RJ45 converter. The SFP and converter should be fully compatible with the cable chosen for the connection (LC/LC Duplex Single Mode). In the present paper, the role of the aggregation switch in the architecture is played by the switch of Building A, which could aggregate connections from different remote points.

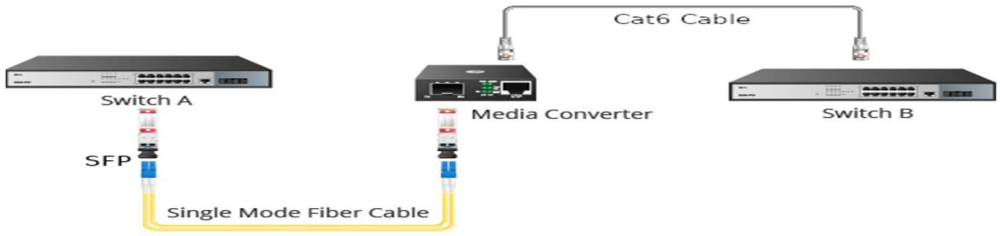

Figure 9: Network Deployment

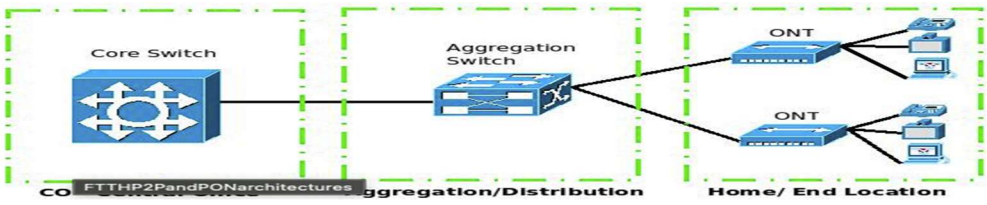

Figure 10: – P2P FTTH architecture using Active Aggregation Switch

SFP

Small form-factor pluggable, or SFP, devices are hot-swappable interfaces used primarily in network and storage switches. The SFP ports on a switch and SFP modules enable the switch to connect to fiber and Ethernet cables of different types and speeds [6]. Based on transmission speed, the most common SFP module on the market today is 1Gb, including 1000base-T/TX, 1000base-SX, 1000base-LX/LX10, 1000base-BX10, 1000base-LX/LHbase-10, 10, and 1000base -ZX. With the expansion of networks and the ever-increasing demand for

bandwidth, the SFP+ module is becoming increasingly popular for 10 Gigabit Ethernet networking (figure 11).

Figure 11 – 1000BASE-LX/LH SFP for use with LC duplex SMF fiber

Media Converter

A media converter is a device used to convert one type of signal into another. Fiber to RJ45 converter for Gigabit Ethernet will be used in this project. Fiber to Ethernet media converters usually have a fiber optic connector, such as an SC or LC connector, or a slot for an SFP module on one side to connect to the fiber optic cable, and an Ethernet connector (figure 12)

Figyre 12: TP-LINK MC220L v4 Gigabit Ethernet Media Converter

Conclusion

In this paper, an attempt was made to present a study which intends to cover the design of a Point-to-Point optical fiber network for the extension of a company's local area network, which is housed in two nearby buildings, which will be done without the intermediary of a provider but directly between buildings. Initially, the project and its requirements will be analyzed, i.e. the existing network, the company's building facilities and the services that will be transmitted through optical fibers, which will also set the requirements for bandwidth and security. Fiber optic network architectures on which the design was based as well as technologies and protocols used will be described. Finally, the design and implementation of the link will be described, as well as the materials and devices that will be used.

References

[1] X. Wang, Y. Ji, J. Zhang, L. Bai, M. Zhang, Low-latency oriented network planning for MEC-enabled WDM-PON based fiber-wireless access networks, IEEE Access 7 (2019) 183383–183395, http://dx.doi.org/10.1109/ACCESS.2019. 2926795.
[2] Rifat Sarker Apu, Mohammad Sabbir Ahmed, Mainul Hasan Raian, Mohammad Abdul Matin, "Performance Evaluation of Different Types of modulation in Optical Communication", 2021 2nd International Conference for Emerging Technology (INCET), pp.1-4, 2021.
[3] Luigi La Spada, Yang Hao, "Modeling and manufacturing for surface wave control", 2017 IEEE MTT-S International Microwave Workshop Series on Advanced Materials and Processes for RF and THz Applications (IMWS-AMP), pp.1-3, 2017.
[4] Stefani, A. et al. Multimaterial and flexible devices made by fiber drawing. in 2020 22nd International Conference on Transparent Optical Networks (ICTON) 1–3 (2020).
[5] T. Thangappan, B. Therese, A. Suvarnamma, G.S. Swapna, Review on dynamic bandwidth allocation of GPON and EPON, J. Electron. Sci. Technol. 18 (4) (2020) 100044.
[6] K.A. Memon, K.H. Mohammadani, A.A. Laghari, R. Yadav, B. Das, W.U. Khan Tareen, N. ul Ain Memon, X. Xin, Dynamic bandwidth allocation algorithm with demand forecasting mechanism for bandwidth allocations in 10-gigabitcapable passive optical network, Optik 183 (2019) 1032–1042