

The analysis of different FTTH architectures and possibilities of their implementation in Kosovo

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Abstract: - It is a well known fact that the optical fiber as a telecommunications medium is faster than the copper wire, because it uses light instead of electricity for data transmission. One of the main technologies in this sector is Fiber to the Home (FTTH). The FTTH deployment trends are rising rapidly, especially in Europe. In this aspect, this trend is present in Kosovo also. The transmission network in Kosovo is based in fiber optic technology and in microwave technology. This paper treats the fiber optic implementation in Kosovo and the benefits of such implementation, especially for transmitting multimedia services through fiber optic technology. In the current infrastructure of Kosovo, the main access network is based in copper wires. This infrastructure is a limiting factor in achieving the objectives of penetration and delivery of multimedia services. In their efforts to keep the leading position in the competitive market of telecommunications services in Kosovo, companies involved in providing telecommunications services in Kosovo are making efforts in implementing the strategy for technological development which imply application of FTTH technology in order to provide various multimedia services to the users without degradation. In this paper, we present the current architecture of optical fibers in Kosovo and the implementation of FTTH technology. We will analyze all the advantages and disadvantages of using different FTTH architectures in Kosovo. In the end, a model of FTTH network implementation is presented and the measurements made in this model are analyzed.

Key-Words: - Access network, FTTH, PON, GPON, Fiber optic, Kosovo, Telecommunications, Architecture

1 Introduction

The fact that the ambitions and demands for more advanced services such as IPTV, videogames, videoconferencing, internet, distance learning, etc., are constantly growing, has made that service providers are often in uncomfortable position concerning the fulfillment of customers requirements. On the other hand, it is known that the copper media have limited capacity and speed [1]. The data transmission capability of Digital Subscriber Line (DSL) systems is to several Mbps.

These limitations of copper wire network hustled the service providers to move towards other technologies. One of the most appropriate technologies is undoubtedly fiber optic technology. Fiber optic technology, compared with copper wires technology is faster and has greater bandwidth, because it uses light impulses instead of electrical signals for data transmission. Also, it is immune to electromagnetic interferences and less susceptible to signal (impulse) degradations.

In order to provide the best possible services to users, service providers made even bolder steps,

sending optical fiber to the customer termination point (CTP), a technology known as fiber-to-the-home (FTTH).

Given the rapid growth trend of optical technology throughout the globe, Kosovo too has made positive steps in this direction, extending hundreds of kilometers optical cables across its territory. Most of fiber optic network was carried out by company "Post-Telecommunications of Kosovo" (PTK).

In this paper a special importance will be paid to the architecture of optical fibers in Kosovo, where we will dwell on a detailed analysis regarding the proposal most advantageous architecture for FTTH implementation in Kosovo. Also in this case the advantages and disadvantages of the proposed architecture will be identified in order to justify the implementation of the proposed architecture. At the end a possible model of implementation of a FTTH network in Kosovo is given and the appropriate measurement and analysis done.

2 Existing architecture

Currently the entire transmitter network in Kosovo is based on fiber optic and microwave technology, while the access network is based on copper cables.

In developing their strategies, companies operating in Kosovo are examining the possibilities of implementing access technologies based on fiber

optic (Fiber to the x, FTTx) and wireless network to increase speed of access network.

In 2002 in Kosovo there were only a few kilometers of optical cables laid [2], while today there are over 1000 km. The optical ring (ring network with optical cable), implemented by the PTK, links major cities of Kosovo and some villages, making the first steps towards the implementation of FTTH technology (Fig. 1).

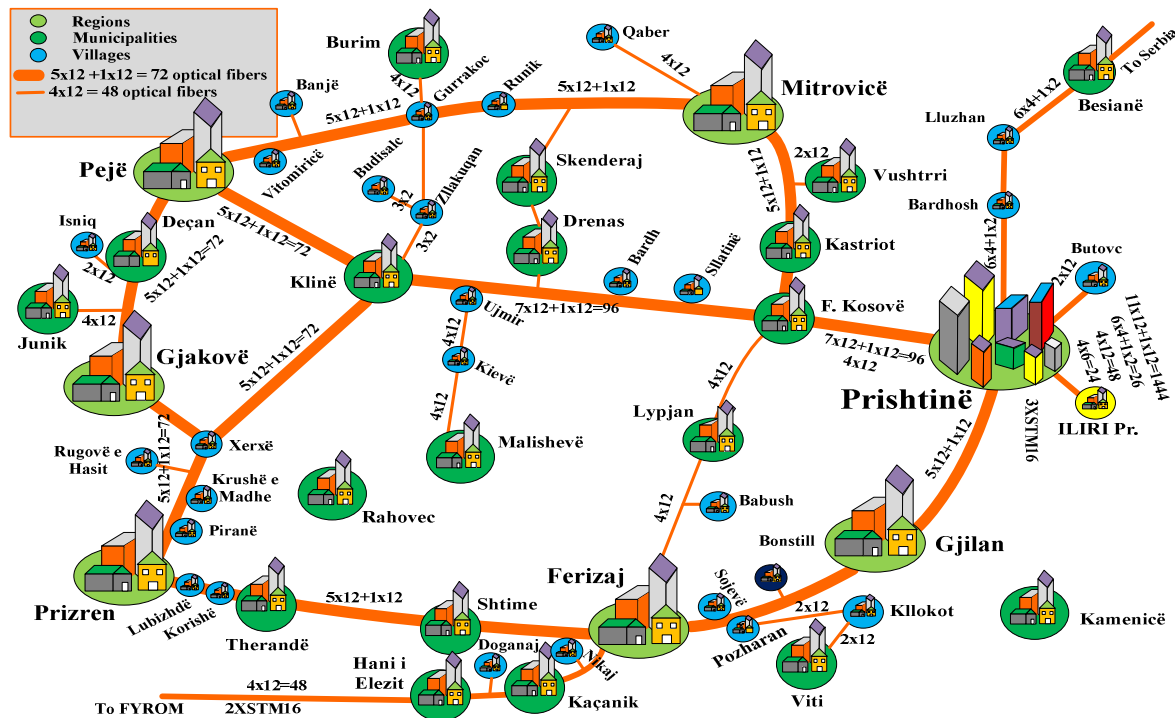


Fig. 1. Current optical network in Kosovo implemented by PTK. Source: Post and Telecommunications of Kosovo (PTK). (Synchronous Transport Module – 3x STM 16 = 3x 16 x 155.52 Mbps = 3x(~2.5 Gbps))

From Fig 1 it is shown that Kosovo has achieved to have a pretty good stretch of the fiber optic network, but to achieve long term goals and to be in step with technology, there is still much work to be done. It may be asked: why to implement FTTH in Kosovo? It is true that current demands by consumers in Kosovo can be realized through the copper access networks. But to answer this question let us anticipate the evolution of services and the need for higher speed.

2.1 Capacity needs assessment

Capacity needs assessment for today, within 2-3 years and for the next 5 years is presented in tables 1, 2 and 3.

Table 1. The need for capacity today

Item	Minimal needs	Maximal needs
Voice	64 kbps	100 kbps
Data	1 Mbps	2 Mbps
Video (2 SDTV)	4 Mbps	6 Mbps
HDTV (up to 40")	6 Mbps	9 Mbps
Total	11 Mbps	17 Mbps

Table 2. The need for capacity within 2-3 years

Voice/ Multimedia	300 kbps	600 kbps
Data	2 Mbps	4 Mbps
Video (2 SDTV)	4 Mbps	6 Mbps
HDTV (27")	3 Mbps	5 Mbps
HDTV (50")	10 Mbps	15 Mbps
Total	19 Mbps	30 Mbps

Table 3. The need for capacity for 5 next years

Voice/ Multimedia	1 Mbps	2 Mbps
Data	5 Mbps	10 Mbps
HDTV x 2 (35")	6 Mbps	8 Mbps
60 frames per seconds, SHDTV (over 50")	20 Mbps	25 Mbps
HDTV (PIP)	6-8 Mbps	8 Mbps
Total	38 Mbps	53 Mbps

One could note from these results that the fulfillment of these demands for higher speed in the longer term is impossible for access networks based on copper cables.

3 FTTH architecture proposed for implementation in Kosovo

In Kosovo, although there are some companies that offer mobile telephony and internet, with the exception of mobile telephony, still many rural areas are left without proper communication infrastructure. Companies are constantly working on providing the best possible services, not excluding FTTH technology to all residents of Kosovo who want to be their clients. This can best be seen in the Fig. 1, where a number of villages have already been connected to the telecommunications network by fiber optic cable. This shows the intentions of companies in Kosovo towards FTTH. On the other hand, the territory of Kosovo is organized so that the majority of rural areas are rather grouped, creating very favorable conditions for service providers to implement FTTH at a cost not too high.

Given the expansion of settlements in Kosovo, the most suitable architecture for implementation of FTTH would be PON. Why PON? PON has a lower cost implementation [3]. Why lower cost? In the case of point-to-point (P2P) architecture, individual fibers run from the central office to each home or to end-user building [4]. This architecture requires separate fiber optic cable for each end-user. This makes the first installation to have a very high cost. On the other hand, the point-to-multipoint (P2MP) architecture uses a single fiber for multiple premises [5]. But this architecture needs the active splitter which requires a continuous supply of energy, which increases the cost of maintenance. Unlike P2P and P2MP network, PON network has a simple structure: the same transmission medium is used by more clients, and no need for active devices. All that is required for PON network is the passive optical splitter. Passive optical splitter requires no power supply, having a direct impact on reducing costs for maintenance and network configuration. Given

these, we can conclude that PON architectures would be among the most favorable for implementation in Kosovo.

The main generations of passive optical network (PON) technology are: ATM passive optical networking (APON), broadband PON (BPON), Ethernet PON (EPON) and Gigabit PON (GPON). Which one of these technologies to use for implementation of FTTH in Kosovo? As the most appropriate technology will be GPON. Why GPON? BPON has limited capacity to 622 Mb/s [2], [6], which when divided into 32 end-users will result in insufficient capacity within 2-3 years. While EPON offers a speed of 1 Gb/s [3] and compared to BPON, EPON has a lower cost for implementation. GPON technology is designed for access networks, taking into account the specifics of telecommunications service operators. For GPON the flexible standards [7] are defined that enable interoperability with existing networks, whether TDM, ATM or IP/Ethernet [6]. In addition, GPON has a significant advantage in terms of transmission speed compared to other technologies. So, companies in Kosovo, when deciding on an investment such as FTTH, must choose the technology that will ensure sustainability of the investment made at least 10 to 20 years in the future. Therefore, GPON technology, relying on its advantages over other technologies, would be most appropriate technology for use in Kosovo for FTTH.

3.1 Advantages and disadvantages of implementation of FTTH technology in Kosovo

Advantages of FTTH network implementation in Kosovo, can largely be divided into two groups: the advantages associated with the service provider and the advantages associated with the service user.

Advantages of FTTH technology for the providers of service are:

- Very large transmission medium and speed.
- Network immunity against electromagnetic interfering.
- Easy and fast installation.
- Low-cost maintenance.
- Low cost for connecting additional users.
- Simple configuration and administration, using dedicated management network systems.
- Low losses, less than 0.5 dB/km.
- Increased reliability of broadband transmissions in comparison to other networks, either today or in the future.

Advantages of FTTH for the users of services are:

- High bandwidth
- Shortening the time of searching and browsing on the Internet.
- Increased security at home or in any other building, keeping it under surveillance through video monitoring.
- Represents a wide range of opportunities to learn or to search the site regardless of where you are, using electronic learning.
- Ensure that access to work areas (meetings, workshops) without being present, through the videoconferences.
- Provides interactive entertainment, e.g. various videogames, internet protocol television (IPTV).

Besides the advantages, implementation of FTTH has some drawbacks, such as:

- Cost of implementation of FTTH is still too high
- There is no real need for FTTH technology currently in Kosovo.
- The current economic situation of Kosovo and the large number of unemployed may make such an investment by the companies not be able to justify.

As shown, the disadvantages when compared with the advantages are very small. Thus, companies that provide communication services in Kosovo, in order to maintain primacy in the communications market in Kosovo, and to afford the competition that exists in Kosovo should think in the future for such a strategy to implement FTTH networks.

3.2 Implementation of FTTH network in Kosovo

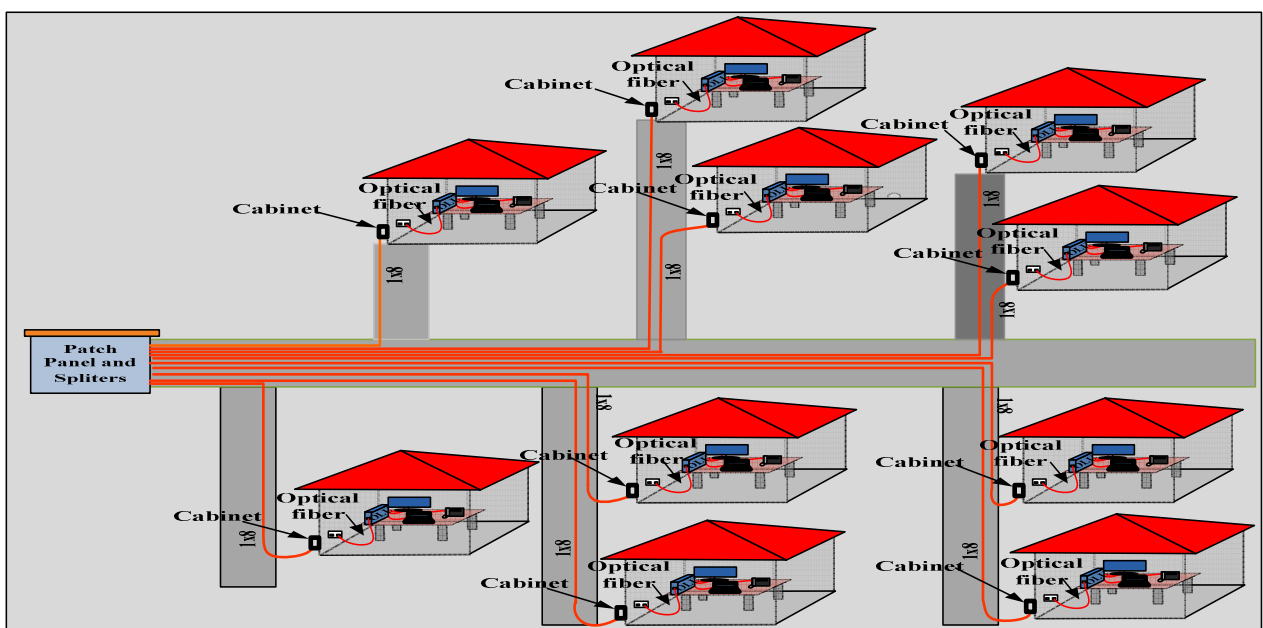


Fig. 2. Implementation of a FTTH connection for 10 houses.

In Fig. 2 is shown the implementation of a FTTH connection for 10 houses. The FTTH distribution is presented starting from patch panel, where passive distributors are placed. Patch panel can be placed in the basement or in the annex of a house, or in any special place somewhere in the neighborhood. For this distribution it is planned to use a 1x4 splitter and 3 passive splitters 1x32. From the patch panel an optical cable with 8 fibers will be sent to each house. Fibers will be sent to the cabinet which is placed somewhere near the house. From the cabinet, 2 of 8 fibers will be sent to optical line unit (OLU), which is placed in the customer termination point (CTP). Other 6 fibers sent to the cabinet will serve as spare fibers which can be used by different companies operating in Kosovo to provide various customer services. In this case the whole network is passive, with the exception of the OLU device, which requires electricity. This is the main reason why the PON technology is proposed for implementation of FTTH.

Since many villages in Kosovo are grouped, the realization of such an optical network will be quite convenient and cost not too high. Such a network implementation is especially suited in the case of building new neighborhoods, whether in rural or in urban areas, since the extension of optical fiber can be accomplished simultaneously with the construction of associated infrastructure to neighborhood, as sewer, water, etc. This would reduce the cost in terms of realizing such an optical network access.

For such a case of FTTH network carried out specific measurements using JDSU MTS-6000 device [8].

3.3 Results and discussions

The losses due to reflectance (in dB) and the losses along the optical fiber (in dB/km) are measured for two wavelengths $\lambda = 1310$ nm and $\lambda = 1550$ nm and presented in graphical form, using *Fiber Trace Viewer* software.

Measurements were conducted and analyzed for two cases.

The first case: Along optical fiber appear the different reflectances and signal losses during light propagation, as a result of fiber bending caused during its laying.

Measurements are performed for $\lambda = 1310$ nm and $\lambda = 1550$ nm. In Fig. 3 is presented the case for $\lambda = 1310$ nm, while in Fig. 4 is presented the case for $\lambda = 1550$ nm.

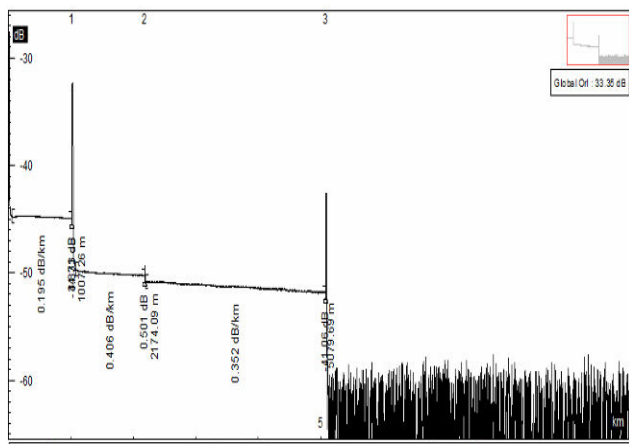


Fig. 3. Graphical representation of measurements for the first case for $\lambda = 1310$ nm.

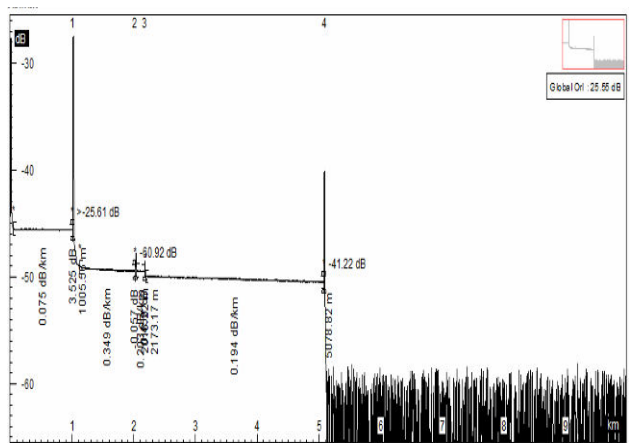


Fig. 4. Graphical representation of measurements for the first case for $\lambda = 1550$ nm.

From this can be seen that for the distance of 1 km (point 1 in Fig. 3 and 4) at $\lambda = 1310$ nm, the loss is 0.195 dB/km, while for the same distance at $\lambda = 1550$ nm the loss is 0.075 dB/km. From 1007 m to

2173.17 m, the loss for $\lambda = 1310$ nm is 0.406 dB/km, while for $\lambda = 1550$ nm the loss is 0.349 dB/km. In the distance 2173.17 m, as a result of the fiber bending, we have 0.501 dB loss for $\lambda = 1310$ nm, and 0.458 dB loss for $\lambda = 1550$ nm. At $\lambda = 1550$ nm, in the distance 2016.22 m, a reflectance of -0.92 dB appear. This reflectance does not appear at $\lambda = 1310$ nm. At the distance between 2016 m and 2173 m the loss is 0.203 dB/km, for $\lambda = 1550$ nm. At distance from 2173 m to 5079 m the loss is 0.352 dB/km for $\lambda = 1310$ nm, and 0.194 dB/km for $\lambda = 1550$ nm. The total loss is 7.065 dB for $\lambda = 1310$ nm, and 4.95 dB for $\lambda = 1550$ nm. This shows that when transmission is performed $\lambda = 1550$ nm, the total loss is smaller for more than 2 dB.

The second case: The fiber is analyzed within a shorter distance than in the first case, but with a much better laying than in the first case. In Fig. 5 is shown the case where transmission is realized at $\lambda = 1310$ nm, while in Fig. 6 is shown the case where transmission is realized at $\lambda = 1550$ nm.

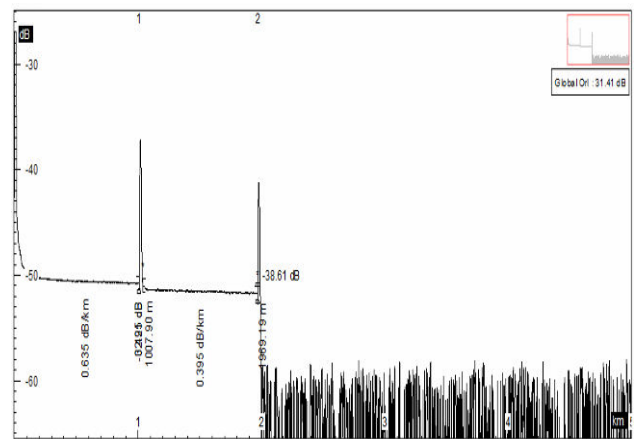


Fig. 5. Graphical representation of measurements for the second case for $\lambda = 1310$ nm.

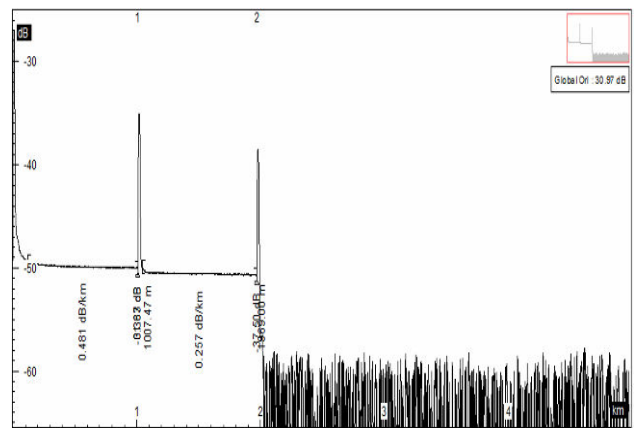


Fig. 6. Graphical representation of measurements for the second case for $\lambda = 1550$ nm.

In the second case, compared with the first case, the total distance is 1969 m, a distance of approximately 3 km shorter. From this can be seen that for distance 0 m to 1007 m, the loss for $\lambda = 1310$ nm is 0.635 dB/km, while the loss for $\lambda = 1550$ nm is 0.481 dB/km. From distance 1007 m to 1969 m, the loss for $\lambda = 1310$ nm is 0.395 dB/km, while for $\lambda = 1550$ nm, the loss is 0.257 dB/km. The total loss is 1.515 dB for $\lambda = 1310$ nm, and 1.099 nm for $\lambda = 1550$ nm. In this case even the distance of fiber is shorter, the difference in loss, depending at which wavelength the transmission is realized, is significant.

4 Conclusion

In this paper the current architecture of optical fiber in Kosovo has been analyzed. The current and in the future expected requirements for speed and the possibilities of meeting these requirements through the implementation of FTTH are discussed. In this context, the best possible FTTH architecture for implementation have been proposed. Based on the cost of implementation, simplicity of implementation and capacity, we concluded that the most appropriate FTTH architecture is GPON.

From the analysis made we came at the conclusion that realization of a FTTH network in Kosovo is more suitable for those areas or neighborhoods in which the associated infrastructure is not yet regulated, and those neighborhoods that are being built as a new neighborhood (greenfield), or anticipated to be constructed in the future.

This conclusion is based on the following parameters: territorial organization of Kosovo, the need for capacity in the long term period, the advantages of this technology (capacity, flexibility, etc.), and cost of implementation.

Also, from measurements made, we came at the conclusion that if the transmission is realized at $\lambda = 1310$ nm losses will be larger for the same distance than when the transmission is realized at $\lambda = 1550$ nm.

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