Fiber Optics as a Possibility for Improvement Supply Chain Information Distribution

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Abstract

It is well known fact that fibre-optic technology practically has no bandwidth limit. The usual limitation is made by financial budget constraints. Optical industry have developed different kind of electro-optical equipments creating different types of optical access network architectures that have been already deployed in many regions of the world. There are some different kinds of fibre deployment. Very often optical access network are together named with the term Fibre-To-The-X FTTx. The major three key points to be considered when building any kind of optical access network for enterprise purposes are customers' bandwidth requirements, cost per installation unit and regulation. Assuming that subscribers' bandwidth requirements are well known and that there are no regulation constraints, in this paper we will be particularly dealing with the techno - economic side of optical access implementation in supply chain. In that manner, we study FTTx as a cost-optimized solution for existing and new access network upgrades. This technology can achieve lower fixed and variable costs in comparison with other deployment options for access network with similar (or worst) capabilities. It can represent flexible approach in constructing the network which primary aim is improvement of supply chain information distribution.

Keywords: fiber optics, optical access networks, supply chain

1. Introduction

According to (Yücesan, 2007) a supply chain presents a network that consists of suppliers, manufacturers, distributors, retailers, and customers. This network supports three types of flows that require careful planning, close coordination and constant improvements. These are: Material flows, which represent physical product flows from suppliers to customers; Information flows, which represent information distribution mostly about order transmission and tracking to coordinate the physical flows; and Financial flows, which represent credit terms, payment schedules, tax considerations, and other contractual arrangements. It is very important to emphasis that all three flows are bidirectional. In order to improve supply chain information

distribution one technology is showing many advantages considering all others – fiber optic technology.

It is well known fact that fibre-optic technology practically has no bandwidth limit. The usual limitation is made by financial budget constraints. Optical industry have developed different kind of electro-optical equipments creating different types of optical access network architectures that have been already deployed in many regions of the world. Although many authors for optical access networks often use the term Fiber To The Home - FTTH, it may not be entirely correct. There are some different kinds of fibre deployment. Fiber deployment could be FTTA (Fiber To The Apartment) - includes fiber from the basement switch to the apartment itself; FTTB (Fiber To The Building) – includes fiber to an office/apartment block, but not to each floor, desk, or apartment; FTTP (Fiber To The Premises) – includes fiber to any kind of building; FTTD (Fiber To The Dormitory) - usually on college and university halls of residence; FTTN (Fiber To The Node) - up to about 1,500 meters from the premises; FTTC (Fiber To The Curb) - up to about 150 meters from the premises, but not in the final drop etc. Very often optical access network are together named with the term FTTx (Fibre-To-The-X) (Finnie, 2011), (Jenko, 2009).

The preference between three major fiber deployment techniques FTTC, FTTB, and FTTH should be based essentially on the unit cost per end user, which is influenced by the customer density in the area and by the number, type and quality of services the operator is planning to offer (Fijnvandraat and Bouwman, 2006). By the term end-users we will assume all possible users of any kind of broadband services regardless their formal status that could be business or residential. Service, in a broader sense could be offered or requested by a service provider or some business firm that is part of the supply chain.

The major three key points to be considered when building any kind of optical access network for enterprise purposes are customers' bandwidth requirements, cost per installation unit and regulation. Assuming that subscribers' bandwidth requirements are well known and that there are no regulation constraints, in this paper we will be particularly dealing with the techno - economic side of optical access implementation in supply chain. In that manner, we study FTTx as a cost-optimized solution for existing and new access network upgrades. This technology can achieve lower fixed and variable costs in comparison with other deployment options for access network with similar (or worst) capabilities. It can represent flexible approach in constructing the network which primary aim is improvement of supply chain information distribution.

This paper is organised as follows: after the introduction short literature review is presented. Third part of our paper is dealing with economical considerations regarding fiber optic implementation in access part of communication network. In fourth part of this paper is architecture of optical access networks presented. At the end of paper are some concluding remarks.

2. Literature Review

Although FTTH technology is very well covered in literature as in books (Shami, Maier and ASSI, 2009), (Lin, 2006), (Prat, 2008) as well as in scientific papers (Breuer et. al., 2011), (Hooghe and Guentach, 2011), (Casier et. al., 2008a) there are not so many authors that are dealing with one of the major issue in FTTx deployment – economical issue. When it comes to the implementation first thing that is necessary for the operator to calculate in cost analysis is the equipment costs. Research papers (Artundo et. al., 2009), (Artundo et. al., 2010) analyzed the costs of installing any fibre optical network. They investigated the change of prices of components in time, with the special emphasis on the pricing and installation costs of some passive optical components. In their work, they introduced certain parametric method, which made possible for them to conclude that there will be large price falls of 33% for splitters and 78% for attenuators for the following years. A FTTx deployment cost with proper analysis of realistic case study in smaller city is investigated in (Casier et al., 2008b). Li and Shen in (Li and Shen, 2009) made research about Greenfield PON (Passive Optical Network) and suggested certain algorithm in order to minimize planning and deployment costs within PON scenario.

3. Economic issues in FTTH deployment

FTTx has many advantages for end-users because it is able to provide better performance than those achieved by the provisioning of services with existing broadband technologies over copper network. The most important advantage is the possibility of high-speed Internet access in the downstream and upstream. Although, the term next generation access often means VDSL2 (Very-high-speed Digital Subscriber Line 2) and DOCSIS 3.0 (Data Over Cable Service Interface Specification 3.0) implementation, the fact is that they are not competitive with their performance to FTTx technology.

Namely, the speed achieved using optical fibre in the access part of the network does not depend on the distance from the user's telephone exchange, as in the case with DSL family of technologies. Maximum speed achieved by DSL technology is the theoretical maximum that can be achieved only in the immediate area of the end user and the telephone system. In addition, DSL is subject to the influence of noise, interference and crosstalk, which further impact on reducing the flow. As for the cable distribution system, the biggest problem is a problem of extremely low upstream bandwidth. The fact that all communication is based on the shared medium is neither in favour nor a cable or wireless operators (Alcatel-Lucent, 2007).

It is well known that large enterprises around the world are already connected to the fibre-optic networks due to their distinguished performances like higher bandwidth, superior reliability and advanced security requirements that go beyond those in the residential sector. Since they have special requirements regarding communication networks, these firms are not usually connected directly to the residential infrastructure (Kulkarni et.al., 2008).

On the other hand, Small and medium-size businesses (SMEs) have almost the same needs for higher bandwidth, but considerably less funds to

pay for it. They can easily satisfy their optical fiber needs within some residential FTTx network. Even if this network is consumer focused, it is worth some changing according to any businesses that shows interest for connection within the coverage area (FTTH Business guide, 2012)

Cloud computing, with its outsourcing applications, is appropriate and accepted by all kinds of businesses. It's well known that any cloud computing services, regardless they are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), or Software as a Service (SaaS), can properly work only with high speed symmetric optical fibre connections.

Firms participating in a specific supply chain should be capable to invest in such equipment that can ensure rapid information retrieval. Thus, it could be more economical for a firm to download information from the cloud each time, than to store data and maintain large servers.

One activity that is very often ignored in a business study is the cost of attracting end users (especially business users) to the network – marketing costs. Broadband marketing is usually focused on downstream bandwidth, although upstream bandwidth definitely is becoming increasingly important for business. The main reason for that is expansion of applications that require two-way communication like cloud computing services. Besides offering the highest upstream data rates fiber optics also enables symmetrical bandwidth. Many telecomm operators, especially new entrants and small ones in some cases decide to rent out the network to one or more established service providers that will do marketing, billing and customer care. In that case, the operator has to allow a suitable margin to cover these costs. The first marketing campaign was directed to commercial properties by focusing on a single area and getting as many firms as possible to sign up. As well as encouraging the benefits of fibre, their marketing campaign claimed that it would be more expensive to connect to the network at a later phase. This marketing strategy was greatly successful, with more than 95% of businesses registering for connections.

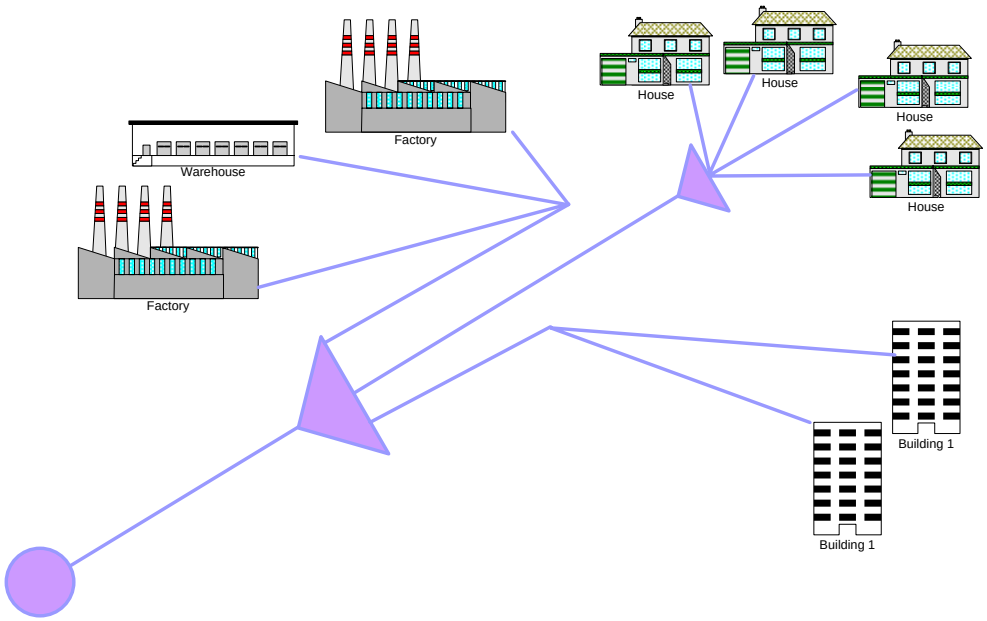
Building or labour costs of all the segment of the access network, from the Central Office (CO) to the subscribers home, are the most significant (digging, trenching, installation of ducts, laying the fibre optic in ducts or aerial installation of fibre optic using poles). They can be nearly 60% of the total estimated costs. The total equipment, such as: fibre, splitter, drop cable, electro-optical transmission equipments produce about 40% of the total estimated charges. On the other side, PON architecture was created to bring important advantages concerning operation expense (OPEX). The operation expense or annual maintenance charge for a mile of FTTH PON plant is about 10% of the ones to maintain hybrid-fibre-coax infrastructure (Casier, 2008a).

4. Optical networks architecture

The major issue for operators rolling out FTTH and FTTB is choosing network architecture to implement. There are many options, but they can primarily be divided into two broad categories: PONs (passive optical networks) that does not require an active electrical components between the end-user and the central office; and AONs (Active Optical Networks) with active electrical components installed between the end-user and the central office. Figure 1 presents passive optical network.

When considering PON architecture three major point-to-multipoint alternative are available: BPON (Broadband PON), GPON (Gigabit PON) and EPON (Ethernet EPON).

Figure 1. Passive optical network



In PON architecture implementation, two protocols are used in organizing the service layer transmission: Ethernet developed within the IEEE 802.3 standards and Gigabit Encapsulation Method, GEM protocol, developed within the ITU-T G.984 recommendation. The PON architecture uses passive splitter components in the fibre access network to allow multiple end-users, typically a group of 4, 8, 16 or 32, to share a distribution fibre with usually 2.5 Gbps of traffic for GPON. The PON FTTH architecture employs significantly a smaller amount of fibre than point-to-point Ethernet FTTH.

A PON access network uses at least two wavelengths, one wavelength downstream, usually 1490 nm, and one wavelength upstream, usually 1310 nm. The characteristic distance of a PON FTTH access network is 20 km. The typical downstream bandwidth per end-user is 80 Mbps for a gigabit passive optical network (GPON), or 2.5 Gbps with 32 splits. The upstream bandwidth, per end-user, is typically 40 Mbps, or 1.25 Gbps with 32 splits. Passive optical network PON architectures involve significant capital expense (CAPEX) investment, particularly when fibre optic is not already installed in the access network.

The PON equipment comprises an optical line terminal (OLT) in the point of presence (POP) or central office, one fibre to the passive optical splitter and a fan-out towards a maximum of 64 endusers, each having an optical network unit (ONU), where the fibre is terminated. The ONU exists in several versions, including an MDU version that handles many customers for in-building applications, reusing existing in-building cabling (FTTH Handbook, 2012)

Advantages of PON include reduced fibre usage (between POP and splitters), the absence of active equipment between the OLT and ONU,

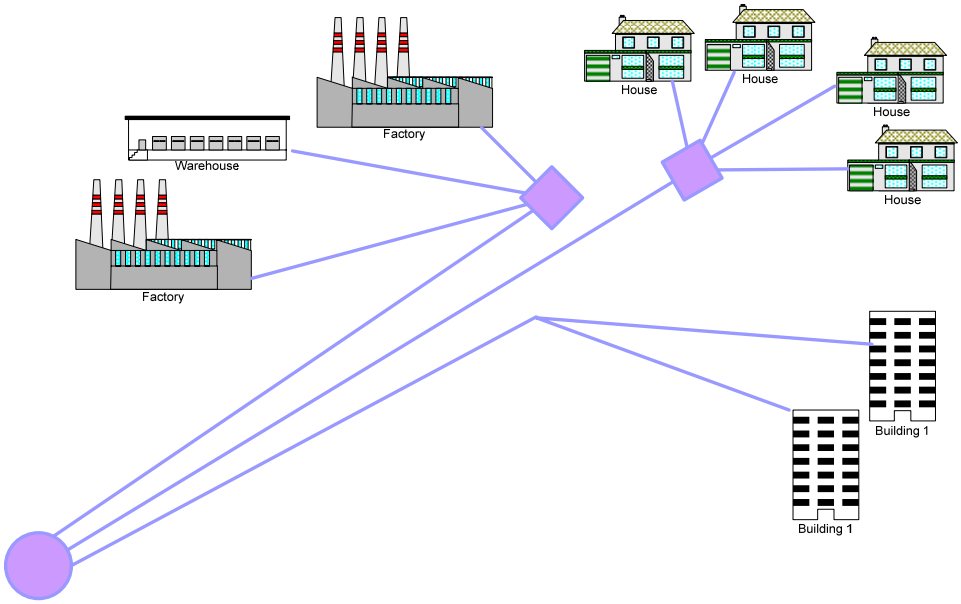
dynamic bandwidth allocation capabilities and the possibility of high bandwidth bursts, which could lead to capital and operational cost savings.

It is important to note that the last part of the network – between the last splitter and the end-user – is the same for a point-to-point or a PON solution: every building/business premises passed will be connected with one (or more) fibres up to the point where the last splitter will be installed, also known as a fibre concentration point (FCP) or fibre flexibility point (FFP). One of the differentiators of PON will be that the number of fibres between the FFPs and the POP can be reduced significantly (splitting ratio in combination with the subscriber take rate can result in a 1:100 fibre need reduction).

As active optical networks representative is point-to-point Ethernet (or home-run) mostly implemented. Figure 2 presents Active Ethernet network. Point-to-Point Ethernet FTTH (Home-Run FTTH) architecture is formed by connecting an end-user with a dedicated connection between the end user's location and the operators central office (CO). In some region of the world, this architecture was deployed and financed by municipality, with the end-user as the owner of its access network connection. This architecture can support 1 Gbps rate with the installation of proper transmission equipments at both ends. In the case of point-to-point Ethernet FTTH transmission rates are always symmetrical.

The major drawback of this architecture is that the quantity of fibre in the access network is more significant than in other FTTH architectures. Reason for this lies in the fact that this architecture does not use passive splitter to combine the traffic of many end-users; each end-user has its own dedicated optical fibre from the CO to its premises. The distance between the CO and the end-user location depends on the quality and power of the laser. When applying 1550 nm optical transceivers distance of 40 km can be achieved with good quality, and with 1310 nm optical transceivers 20 km can be achieved.

Figure 2. Active Ethernet network



Based on point-to-point fibre deployments various network architectures can be implemented. The selection of the architectures depends on a large

amount of criterion, including end-user densities, requirements for open access, regulatory constraints, business models, required per-customer bit rates, oversubscription factors, availability of fibre infrastructure etc.

In favour of optical access expansion goes the fact that optical fibres are optimised for the implementation in indoor environment. Many researches about bending loss optimized fibers (Ieda et.al.,2008), (Rostami and Makouei, 2011) resulted with its standardisation (ITU G.657, 2009).

5. Conclusions

A high bandwidth fibre optic network is the best option for an enterprise. It could cover all aspects of business like manufacturing, engineering, projects, finance, materials, personnel and logistics. It can be designed to have interface to connect to mobile units through a terrestrial or satellite radio link. Also, connection to the Internet can allow web-site retailing, publicity and electronic commerce.

Trends for access technology over the next ten years will be towards more symmetrical bandwidth. This statement goes for both residential a business user. Cloud computing with its applications and services is one of the major originators for symmetric bandwidth. Multimedia file sharing, peer-to-peer applications and the more data-intensive applications used by end-users will drive upstream bandwidth, but small businesses and also large enterprises, could benefit from symmetric broadband connectivity. All kinds of business firms participating in any supply chain system could benefit from connecting to the fiber optical network. Also, fiber optics enables firm's better, reliable and more secure local private connectivity.

Acknowledgment

This work was partially supported by Serbian Ministry of Education and Science through Research and Development projects TR 32025 and TR 36006 for the period 2011-2014.

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