CAPACITY EXPANSION OF FIBRE OPTIC NETWORK IN SRI LANKA

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ABSTRACT

The traditional copper network used for the telecommunications networks have reached its extinction. The probability of wireless transmission at high speed is still an issue. Fiber as a physical medium gives the solution of a faster network without loss of data. In Sri Lanka, Fiber technology was adapted in the central network system. The number of customers who wants to get Fiber to the Home (FTTH), is still in low numbers. People opt to use the traditional wireless approach and copper network to access the internet. But the demand for high speed internet is increasing with the introduction of Internet of Things (IoT).People often find fiber optic connection is expensive to get and the initial cost is quite high. The aim of the paper is to propose technologies that could be adopted in Sri Lanka to increase the number of consumers using FTTH. It is discussed how the connectivity of FTTH can be improved in Sri Lanka. Five Methods are discussed to improve the customer connectivity of FTTH. Analysis of methods is done on how they can help to fulfil the purpose of connecting more users by improved efficient systems and reduced cost thus enabling people to access the fastest connectivity.

Keywords: networks, FTTH, optical fiber communication, Passive Optical Network (PON)

1. INTRODUCTION

FTTH can be identified as one of the significant broadband technologies that supply data, voice and video services with a high speed to the home (or business) via optical fiber cable. Optical components have replaced more than half of the copper network. It has facilitated a faster data rate. With the vast development of internet and telecommunication services, the information capacity has increased. With the increased demand for more advanced services such as distance learning, videogames, IPTV, high-speed internet access, digital cable television, carrier-class telephony, and interactive two- way video-based services to the end-user, service providers will face an unstable condition if they were unable to fulfill customer requirements. And also, it is widely known that the copper media have limited speed and capacity and data transmission in traditional Digital Subscriber Line systems are few Mbps though it is unable to supply fast accurate services through traditional connections. Copper cables' limitations hustled service providers to explore new technologies. As a result, fiber optic technology was recognized as the most convenient technology due to its greater bandwidth and faster service that uses light impulses instead of electrical signals for transmission. (Caka & Hulaj, 2011) And also, fiber optic cables less susceptible

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to signal degradations. Likewise, fiber-optic technology provides more benefits than copper cable systems.

Fiber-to-the-home (FTTH) is one of the widely known technologies that come under Fiber to the x (FTTX) broadband network architecture. This architecture was introduced to supply the best services to users by extending optical fiber connection to the customer termination point (CTP). When expanding the connection to customer premises, cost and installation are issues that need to be answered. Due to rapid growth in customer requirements, the current optical communication system will be out of transmission capacity in the near future. In the present context, Sri Lanka is connected to the world through SEA-ME-WE cables owned by SLT and the Bay of Bengal Gateway submarine cable system by Dialog Axiata. These cable system has enabled to carry a passage over 6.4 Terabits per second (Tbps) of worldly bandwidth to Sri Lanka. The activities contributed a fast connectivity to Sri Lanka (Murshid, n.d.). The promised bandwidth of 100Mbps to the end user is not always provided. The fastest connectivity should be made available to the end users. Enhancing the connectivity will benefit in a longer span means of communication. Improvements can be made in the current infrastructure. The set of existing fiber-fed Fiber to The Node (FTTN) locations has to be backhauled using PON. These are the locations where the small cells will be installed and therefore the ONTs are to be placed. Splitters can be located to connect feeder fibers to the distribution fibers (Ranaweera, Iannone, Oikonomou, Reichmann, & Sinha, 2013).

In this paper, special importance will be paid given to the architecture of optical fibers in Sri Lanka. By suggesting altered options on the subject of the network, the capacity can be increased. Putting up solutions to enhance the optical communication system is focused on this paper. We have mainly focused on five different mythologies that currently exist worldwide. These mythologies can be implemented to current Sri Lanka architecture to improve the quality of the connection. By suggesting these methods, we are mainly focusing on enhancing the capacity of current fiber optic services. Because when the number of customers in the connection area increased, installing new systems might be more costly. So we are suggesting technologies that can be implemented to existing systems to provide service to the maximum number of customers. And also, we have analyzed the advantages and disadvantages of each architecture.

The following options can be considered to enhance the connectivity,

a. Increase in the Splitter Ratio in a Passive Optical Network (PON)
b. Optical Code Division Multiple Access
c. Long-Reach Passive Optical Networks
d. Coexistence of Giga.fast (G.fast) and VDSL2 in FTTP and FTTC

e. Wave Division Multiplexing

2. METHODOLOGY

2.1. Increase in the Splitter Ratio in a Passive Optical Network

A Passive Optical Network interface is to be shared among many subscribers. There are optical splitters. They are installed between the Optical Line Terminal (OLT) and Optical Network Terminal (ONT). (FS, 2016) The optical power splitter is a key component that can be seen in any passive optical network.

Optical Splitters are installed in each optical network between the PON Optical Line Terminal (OLT) and the Optical Network Terminals (ONTs) that the OLT. (FS, 2016)

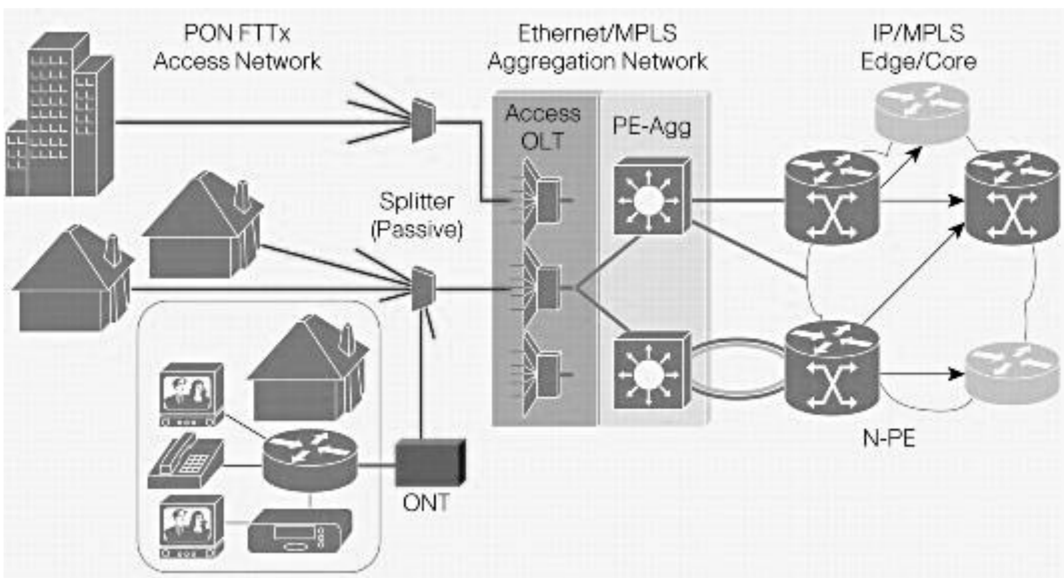

Figure 1. Standard FTTH PON

The network is to have a 20 km reach. The PON splitting ratio is to be doubled considering the earliest technology available. The future technology is considered with the increase in split ratio. Thus, the reach length will also be doubled (Vaughn, Kozischek, Meis, Boskovic, & Wagner, 2004). The assumption in the scenario is made such that the available bandwidth is enough to deliver the required service to the customer.

The below table specifies the split ratio that required to implement in this method to the existing technology to 20 km reach. In practice, the maximum reach of 20 km and enhanced split ration cannot be achieved simultaneously. So the distance divided into two and for one part of the distance can be used current existing split ration and other parts can be designed with the upgraded split ratio as shown in the below table.

Table 1. Engineering Rules

Scenario	0-5 km reach	5-20 km reach
Current Technology	1:32 split	1:16 split
Future Technology	1:64 split	1:32 split

For the ideal singe mode, 1xN splitters will access with zero excess loss. But in most practical upstream optical link limits the overall PON link budget and maximum split ratio. This upstream signal light gone to waste in a single-mode 1xN splitter can be recovered by straight-forward and practical electrical or optical methods. (Piehler, 2011)

From comprehensive studies for cost modeling of fiber-to-the-home passive optical network, it concludes that 4% - 5% of savings per subscriber for networks will reach with enhanced reach-and-split ration compared with equipment available today. (Vaughn, Kozischek, Meis, Boskovic, & Wagner, 2004)

Advantages:

This configuration allows for longer distances communication between central office and customer premises, every information source can be provided in different wavelengths without mixing signals together, passive elements are cheaper for implementation, high bandwidth, and flexibility of the connection

Disadvantages:

In PON architecture all information flow through the same channel so losing security, splitter connections will have losses, when the connection is in the same stage or distribution tree, it causes a drop in network efficiency

2.2. Optical Code Division Multiple Access

A single optical fiber medium can be used by several users to transmit simultaneously. The technology called, “Fiber Optic Code Division Multiple Accesses (FO-CDMA)” enables the aforementioned purpose. OCDMA is a multiplexing technique with a number of advantages. The large bandwidth of the medium is combined by OCDMA. With the flexible CDMA scheme, high-speed connectivity is achieved by OCDMA. Large capacity, resistance to interference and high security are the major advantages of this technique. (Caka & Hulaj, 2011)

OCDMA is adapted from the successful implementation of CDMA in the wireless domain. A sequence of code is assigned, and it acts as its address. The code is modulated to bits and thereafter the transmission is initiated. Data that are coming from different users are encoded and decoded optically. The received signal is multiplexed and it is only de-multiplexed when the address is matched in a strict pattern (H.W. Chen, 2009).

Advantages:

Equal distribution of available bandwidth, Provisioning of value-added service, Security, All-optical Communications, Security performance, Low cost, Asynchronous access.

Disadvantages:

Noise, Error correction, Encoding/Decoding

2.3. Long-Reach Passive Optical Networks(LR-PON)

LR-PON is an advancement in the current PON infrastructure. The span of the network can be increased from 20km to 100km by the advancement in the current PON technology. A large number of customers can be a part of the transmission circle and have access to internet facilities. At the same time, capital and operational expenditures are minimized.

A PON offers unlimited bandwidth to the fiber to the home (FTTH) to be utilized. Current PON architecture provided a dedicated path to the customer and the bandwidth of the path is not fully used. The architecture can be modified to share the portions of the network. The number of users is to be increased, and Bandwidth can be used without wastage.

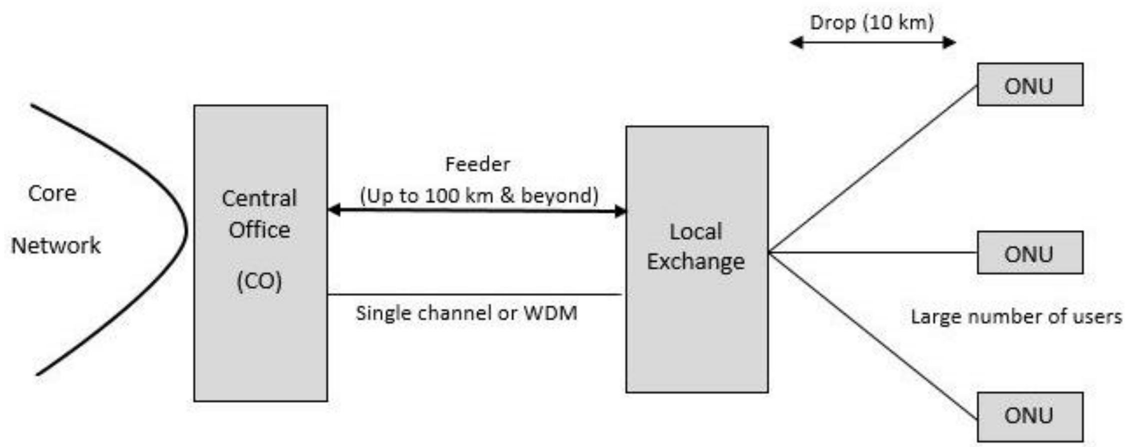

Figure 2. LR-PON architecture

The architecture of a LR-PON is as follows:

- The core and the access network is connected by the central office. Resource allocation, service, management, and control is done at the central office
- The local exchange is located in proximity to the customers. Optical Network Unit (ONU) is at the local exchange.
- The optical signal travels between the central office and local exchanges through Fiber
- The fiber is split and connected to several ONUs. Optical Amplifiers are used to retrieve the signal efficiently

LR-PON includes multiple Optical Line Terminals (OLTs) and central offices. The operational cost is reduced by the extended coverage of the geographical area. LR-PON combines the current PON architecture and acts as an integration to the current system.

2.4. Coexistence of G.fast and VDSL2 in Fiber To The Curb

G.fast copper network can be combined together with existing ADSL architecture. G.fast combination with Very High-Speed Digital Subscriber Line (VDSL2) is a key success to the proposed technology. The fiber is drawn until the road, which is Fiber to the Curb (FTTC). From there, the G.fast copper medium is used to transmit to the Customer Premises Equipment (CPE).

The spectral characteristics of both services are very different. G.fast consumes less amount of 4 dBm, which is spread over a wide frequency band from 2.2 MHz to 106 MHz, while VDSL2 consumes around the power of 14.5 dBm which is concentrated on a smaller frequency band from 25 kHz to 17.6 MHz ("G.9701: Fast access to subscriber terminals (G.fast) - Physical layer specification," n.d.).

The problems with G.fast with VDSL2

- G.fast and VDSL2 use two different symbol rates.
- G.fast uses the Time Division Duplex technique while VDSL2 uses Frequency Division Duplex.
- Sometimes there is crosstalk due to overlapped frequency spectrum. ("G.9701: Fast access to subscriber terminals (G.fast) - Physical layer specification," n.d.)

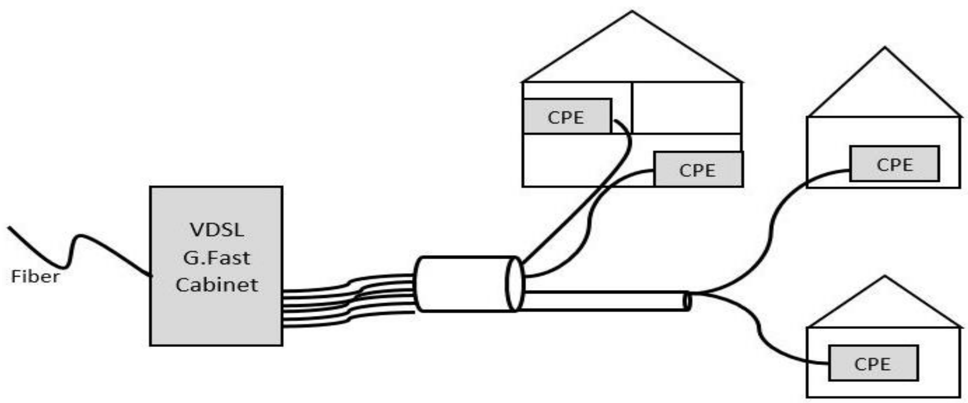

Figure 3. VDSL2/G.fast multi-mode cabinet

G.fast combination with VDSL2 is a good alternative way. By using an extended VDSL2, the overlapping frequency band is increased. Long reach G.fast can be done. G.fast allows higher transmit power with the extended VDSL2. Future upgrades can be successfully implemented.

2.5. Wave Division Multiplexing (WDM)

Passive Optical networks approach can be used to address the challenges in Fiber networks. It is a method that is generally applied to overcoming the negative effects of fiber exhaust. A WDM-PON is usable to separate Optical Network Unit (ONU) into a number of points to pint virtual connections with the same physical arrangement. This WDM feature of Fiber is more efficient than the point to point Ethernet. The FTTH is enabled as high-speed access through this method.

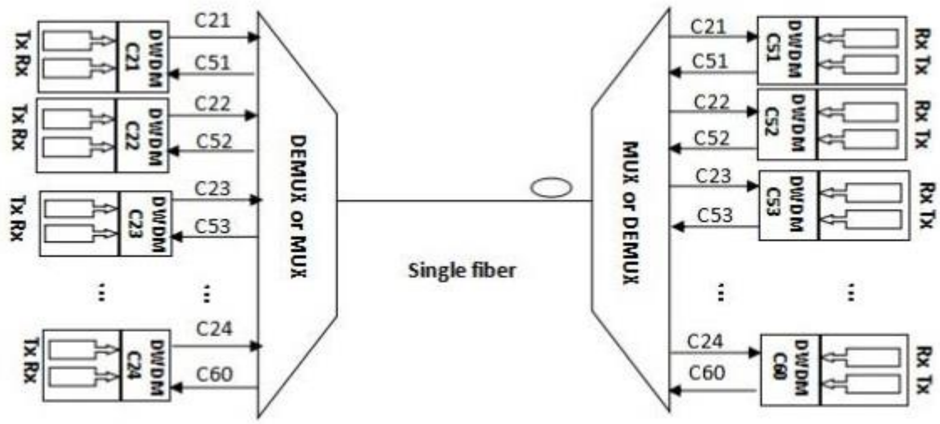

Figure 4. WDM

a. WDM-PON technology

WDM allows multiple wavelength signals in a single fiber strand. WDM deals with the mapping of multiple wavelength optical signals and does multiplexing function to a single fiber strand. For a high number of channel usage applications, WDM is very useful.

There are two types of WDM. Coarse wave-division multiplexing (CWDM) or dense wave division multiplexing (DWDM), operators can combine many different services on a single fiber by assigning different parameters.

b. Improvements in WDM - PON

a) Longer Reach can be achieved by the replacement of current tree-type topology to ring type topology.

When implementing WDM-PON, the ring structure is taken instead of tree structure. In a ring structure, cascaded filters may decrease the effective channel passband. Amplifiers are used in order to reach a longer distance (Einar In De Betou, 2014). It shows that WDM-PON will be able to extend its reach to a greater distance. Future deployments are possible with this technique.

b) WDM extended reach passive optical networks using Orthogonal Frequency Division Multiplexing –Quadrature Amplitude Modulation (OFDM-QAM)

There is a need to reduce the cost of the fiber network. Network operators are required to simplify the current system and integrate it into one single system Using WDM in Extended Reach PON(ER-PON), a high data rate of upstream and downstream can be achieved. The longer reach also can be achieved.

3. CONCLUSION

In this paper, we have discussed five options to increase-capacity and the span length of the optical communication system in Sri Lanka. Most current fiber technologies use only a sliver of the available bandwidth capacity of single-mode, a properly designed network can unlock a floodgate of available power in a network. Using many channels on the same piece of optical fiber enables operators to serve businesses, cell towers and residential customers with the same fiber. In this paper, research activities are focusing on possible extensions of current structures as these systems are affected bandwidth limitations later on, and existing structures don't make use of the full optical bandwidth. By implementing new methods, we have mainly focused on expanding the current fiber network in Sri Lanka. Thus, the major goal would be to assure an amazing symmetrical bandwidth per user, establishing an optical passive transparent infrastructure over a dense extended-range area, capable of supporting unknown future demands.

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