Fiber in the Loop for Ultra High Speed Optical Networks

Manjeet Singh¹, Amanpreet Kaur²

¹System Engineer, TCS, India
¹manjeetdaviet@gmail.com
²Assistant Professor, VCoE (HP), India
²amanlubana13@gmail.com

Abstract—Optical fiber communication is gaining popularity as broadband technology by providing high data rate, secure and reliable transmission. With the advent of HD videos and latency sensitive services, the demand for optical networks for the individual subscribers is increasing. For the purpose, FTTH is emerging as a viable solution. This paper focuses on various possibilities in optical networks, its implementation in local loop and network planning considerations.

Keywords—Broadband, fiber, FTTH, optical, PON

I. INTRODUCTION

The growing popularity of the Internet is the key driver behind the development of new access methods which would enable a customer to experience a real broadband. In comparison to various other technologies, the access methods based on the optical fiber are getting more and more attention as they offer superior quality of service over longer distance communications and provide higher bandwidth than existing wired networks at comparatively lesser cost of operation [1], as shown in fig 1.

![Fig 1: Prices per Mb by technology and region](image)

Hence, to obtain real broadband existing wires need to be replaced or supplemented with fibers. Further, various architectures using Active Optical Networks (AON) and Passive Optical Networks (PON) are possible to facilitate the Fiber-in-the-loop infrastructure. Active Optical Networks generally offers point to point solutions where as Passive Optical Networks offers point to multipoint solutions. Thus, in an AON, only the intended recipient receives the information, whereas in a PON the entire downstream bandwidth is transmitted to the power splitter and a portion of the optical power is delivered to each subscriber. As the available bandwidth in a passive system is not dedicated, each user shares the total capacity of the system. Different flavors of Passive Optical Networks (such as BPON, EPON and GPON) with time division multiplexing access (TDMA) and wavelength division multiplexing access (WDM) are getting more widespread as necessary equipment is becoming available on the market. [2] Typical PON architecture is as shown in fig 2.

![Fig 2: PON Architecture](image)

The passive optical networks (PONs) do not contain any electronics between the CO switch and the customer premises equipment. In a PON, the active optoelectronics is situated on either ends of the passive network. There are two main factors that restrict the total reach of PON deployments. The first is the total available optical power budget, which is a factor of the OLT (Optical Line Terminal) laser port and the total loss budget, i.e. by considering fiber feeder and splitters loss also. Secondly, as all the connected ONU (optical network units) share the optical feeder and OLT port, a systematized procedure is required among all devices to prevent more than one unit from transmitting at same time, which would cause
collision of network traffic rendering applications like video unusable.

II. FTTH

FTTH is widely recognized as the optimal solution for providing broadband to new and existing alike. Based on the immense capacity of fiber FTTH is now being deployed all around for various high data rate communication services. At homes, the bandwidth required for HDTV and Video on Demand services is building up pressure for high speed networks. Even with data compression techniques like MPEG4, the bandwidth required for fast action videos is around 8Mbps. The bandwidth provided by coaxial copper cable is of the order of few Mbps over a distance of few hundred meters only and available bandwidth keeps on decreasing with increase in distance. For instance, a coaxial copper cable can carry a signal of more than 200 Mbps only for about 750 feet and for over a distance of a mile; it can deliver only about 30 Mbps. On the other hand, an optical fiber provides a bandwidth of few Gbps over distances of few kilometers.[3] In addition to bandwidth availability, fiber networks provide other advantages such as thin size, easy network upgradability (since only end point electronics needs to changed, fiber may remain the same), noise immunity, no electromagnetic emissions and difficult to tap or eavesdrop. Practically it has been found that FTTH solution provides highest average upload and download speed along with minimum average cost per Mbps. Deploying single mode fiber in the network implementation maintains the signal integrity and allows the wide spread network expansion at extremely high data rates. On the other hand, use of multimode fiber significantly reduces the cost but compromises with bandwidth and network expansion.

III. FIBER IN THE LOOP

Fiber to the x (FTTx) is a generic term for any broadband network architecture using Optical Fiber in the local loop for telecommunication applications. The generic term (FTTx) is a generalization for several configurations of fiber deployment such as FTTN, FTTC, FTTB, FTTH; all starting by FTT but differentiated by the last letter. In FTTN, fiber is terminated in a street cabinet up to several hundred meters away from the customer premises, with the final connection established by copper cables, as shown in fig 3. Fiber-to-the-node is often seen as an interim step towards full FTTH and is currently used by telecoms service providers to deliver advanced triple play services. The FTTC is similar to the FTTN but here the street cabinet is closer to the user’s premises; typically within 300m. Here also the end connection is supported by existing high-bandwidth copper technologies. In FTTB, fiber reaches the boundary of the building; like basement, with ultimate connection to the desired place being made via wired or wireless alternatives. [4] At last, the FTTH, where the fiber reaches the boundary of the living space. Sometimes, term FTTH is interchangeably used with FTTP which stands for Fiber-to-the-Premises. Also, in case fiber is terminating at the desk, the technology may be termed as FTTD (Fiber to the Desk).

![Fiber in the loop architecture](image)

IV. FUNDAMENTALS OF FTTH PLANNING AND NETWORK DESIGN

Selecting appropriate fiber-to-the-home network design strategy is very important, but the best strategy may not achieve the desired results if network elements are not placed economically in the field. FTTH planning focuses on fiber network design, location of central offices, and nodes. The initial study consists of moving the CO’s or node around the area to study the effects of its position on total network costs. Most of the variation was in outside-plant cost, as other costs (switches, terminations and so forth) remained constant. Generally, most economical location for a CO or node is exactly in the middle of the area it serves.[5] This position yields lowest cost for all customers in the serving area and provides lowest optical signal loss to all customers. For a square geographical area with uniform density throughout, the ideal node location is acceptable. But in practice, user density may not be uniform, in such a case, the ideal location moves from the center of the serving area closer to the denser area, but not all the way there. The CO location shift depend on that fact that denser area has more customers and requires more
facilities, at the same time, other area’s costs increase as the CO or node is moved further away. In the real world, not many geographical areas are ideal, the planner must make adjustments to fit actual city or area layouts. However, the principles of the ideal world still apply and planners should make every effort to come as close as possible to the ideal. The cost rises exponentially as the location moves away from the ideal point. Similar approach is followed to decide the location of cabinets, splitters and other network component. [6]

V. CONFIGURATION OF FIBER FEEDER ROUTES

The technique used for positioning network elements can also be used to determine the ideal configurations for fiber feeder routes. Fig 4 shows the two kinds of feeder cables – a main feeder, which originates in a CO, node or cabinet, and branch feeders, which terminate in the main feeder cable.

Notice that they are perpendicular to the main feeder routes, not parallel to them. Paralleling a main route may require building more infrastructures to reach the same number of customers.

A. Setting Boundaries

The boundary lines exits the CO at 45-degree angles, towards the end of the study area. These separate the routes and define which route will serve each customer. Placing boundaries allows a designer to identify the area served by each main feeder and makes planning for future demand easier. The boundaries also tend to reduce the distance from the CO to each customer. There is no ideal number of branch feeder routes. The number used depends on the density and size of the area and sometimes also on whether splitters are centralized in cabinets or distributed in each PON area. Branch feeder routes are also determined by road configuration and the number of units served in each area. Generally, a single branch feeder should serve an area that is consistent in nature. For example, serving a business area and a residential area with two separate branch feeders may be a good idea. This requires establishing a branch feeder route boundary between residential and business areas and placing two branch routes with different paths from the main feeder into these two areas. However, the goal of creating uniform service areas must be balanced against the competing goal of keeping the total number of branch feeders low to minimize infrastructure and cable cost. Street layout further limits the choices for feeder routes. Good engineering judgment is important in establishing the branch feeder routes properly. Locating the main feeder route relative to the main feeder boundaries is very important. Generally, the most economical place for a main feeder route is in the middle of the area it is going to serve. This keeps the branch feeders relatively short and helps reduce total length to the CO in the long run. In the same way, a branch feeder route should bisect the area this feeder will serve.

B. Subdividing the Areas

Once the main feeder and branch feeder routes have been established along with the associated boundaries, the areas defined by the branch feeder route boundaries can be further divided up into small serving areas. These serving areas are defined by the size of the facilities that will serve them. For instance, if a PON technology is used and the optical splitters will be deployed in field cabinets, each branch feeder area can be divided into cabinet serving areas (CSA). Creating the CSAs may require some boundary adjustment so that the number of homes served by each cabinet is roughly equal. The size of each CSA is determined by the size of the cabinets to be deployed. If a switched Ethernet solution is to be deployed, the cabinets will not hold splitters but rather will act like cross boxes in the copper world, distributing and adding feeder as needed. In either case, once the cabinet size is known, feeder areas can be divided into appropriate sizes and each cabinet can be located in the middle of the area it serves.

VI. CONCLUSION

The optical fiber networks are becoming the main building block for future high-capacity broadband networks. Moreover, the capacity of optical fiber at longer distances is miraculously higher than existing co-axial cables. FTTH is one of the techniques providing access to home based future broadband demands. In addition, technological advancement in passive optical networks presents cost effective solutions to meet the requirement for high data rate large distances, making it desired solution for domestic as well as corporate needs. By adopting discussed technology, a low cost and much better quality services can be realized.
References


