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Cost Installation Analysis of FTTH Test Bed Network Set Up-Previous, Present and Future

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ABSTRACT

There are several methods for testing and troubleshooting a fiber-to-the-home passive optical network (FTTH-PON). The simplest and low cost method would be using a power meter which is able to detect the total loss on the network. However, to identify faulty sections of a network, segmentation need to be done together with the Optical Power Meter (OPM). Another testing and troubleshooting method would be using the optical time-domain reflectometer (OTDR). The OTDR within the network is able to detect the component that causes losses in the network. However, elements acting as a power splitter are not being able to be detected by the OTDR. Therefore, the Access Control System (ACS) is developed to bypass those elements and allows the use of OTDR entirely. With the combination of SANTAD and CAPU we ensure the monitoring can be handled efficiently and failures can be restored immediately just after be detected by the sensor. This method is proven to be a faster, efficient, reliable method than the first. Additionally, it can be upgraded to monitor the line status by accumulate all the result in one display computer screen. The new configuration of FTTH is named as modified FTTH. But this mechanism is not interested to be implemented due the installation is too high which is three times higher. We come out we another device which assembly all the features offered by the modified FTTH onto one single device named as Multi access Detection Unit (MADU). In the end, we compare the installation cost between the conventional, modified FTTH and MADS based solution for different network size/number of users.

Key words:

Introduction

As we know, there are three market drivers available in broadband services, there are bandwidth-intensive, interactive-connectivity and time utilization. Two major users of these broadband services include the consumer community and the business community. The consumer community uses broadband services for entertainment services (unicast, multicast), education (interactive learning, distance learning) and digital home (security, telemetry, home automation, information, health-care). On the other hand, the business community uses broadband services for telecommuting, hosted applications, remote real-time computing, remote CAD design and data storage and back-up purposes.

‘Bursty Traffic’ is the Killer Application (e.g. Video, Movie, Games, E-learning), which simply depends on “Bandwidth Utilization”, “Time Utilization” and “Interactive Connectivity”. Bursty traffic is traffic in which the short-term bandwidth exceeds the average bandwidth. It is caused by TCP’s slow start and ACK compression. The Passive Optical Network (PON) is a technology with two main drivers, there are ITU-T and IEEE.

ATM/Broadband PON (ITU-T G.983) uses ATM as bearer protocol and is developed in FSAN.

Gigabit-Capable PON (GPON) that is ITU-T G.984 standard represents a boost, compared to BPON, in both the total bandwidth and bandwidth efficiency. However, GPON’s chipsets are lacking.

Ethernet PON (EPON) that is IEEE 802.3, is developed by IEEE. 10GigEPON will use separate wavelengths for 10G and 1G downstream.

There are 4 technologies in FTTx technology, Fiber to the home (FTTH), Fiber to the curb (FTTC), Fiber to the building (FTTB), and Fiber to the node/neighborhood (FTTN). FTTH is almost the same with the FTTB, but splitter is used in this network. FTTC is a telecommunication system based on fiber-optic cables. FTTB is a new generation network structure in RING topology. FTTN can be called as fiber to the cabinet (FTTCab), which
telecommunication architecture based on fiber-optic cables run to a cabinet serving a neighborhood. Customers connect to this cabinet using traditional coaxial cable or twisted pair wiring. FTTx can be deployed using Active Optical Network (AON) or Passive Optical Network (PON). PON uses 3 components which are Optical Line Terminal (OLT), splitter and Optical Network Terminal (ONT/ONU). OLT is used to send data and voice through fibers. It will convert electrical signal to optical signal. A splitter, an active device, is used to separate the optical signals. ONU is to convert the optical signal back into electrical signal before distributing to the users.

Multi Service Traffic can be divided into 3 types, there are IP Video Traffic, Voice Traffic (VoIP), and Internet Traffic (Data). For IP Video Traffic, Video streams transformed into IP packets by encoding, receiving and streaming to become MPEG2/MPEG4 encoded IP packets. There are two types of IP video Traffic, Unicast (VOD) and Multicast (Broadcast TV). Unicast is a single sender and receiver that dedicate point to point connection whereas Multicast is group of interested receivers with single IP datagram send to multicast address, it dedicatess a point to multipoint connection. For voice traffic, voice signal is coded. Internet traffic is the flow of data around the Internet.

Fig. 1: Multi service traffic can be accommodated in fiber optic bandwidth.

Modified Ftth-Pon:

We have proposed the restoration architecture that can be applied in FTTH-PON, especially in the drop region (from optical splitter to ONUs). Any failure occurs in this region will be sensed by Access Control System (ACS) by the 3% tapped signal that is connected to every access line. The activation signal is then sent to activate the dedicated protection scheme. But if fault is still not restored, the shared protection scheme will be activated. The monitoring signal section is responsible for sensing fault and its location whereas generation of activation of signal is sent by activation section in ACS. ACS is focusing on providing survivability through the Restoration Scheme Architecture (RSA) against failure by means of dedicated and shared protection that is applied in PON. ACS is used to monitor the status of the working and restoration fibers. ACS recognized the types of failure and sent the activation signal to the related optical switch according to the activated protection mechanisms. In our proposed system, we designed the RSA that enable to configure the faults until fourth order means the failures can occur at four communication lines but the signal can still be transmit to the users. This was explained detail in (Ab-Rahman et al., 2009a).

In this paper, we shared an experience in installing, testing and troubleshooting the network by using low cost equipment which are standard type power meter, OTDR and our own developed centralized monitoring program to monitor the status of each line connected to ONU onto one display screen (computer). The testing process is towards to the installation of Centralized Fiber Troubleshooting System (CFTS) (Ab-Rahman et al., 2009b, Ab-Rahman et al., 2009c). Our proposed centralized monitoring technique is the first reported up to this time.

Fig. 1: PON architecture which consist of three main elements; OLT, optical splitter and ONU. The survivability and scalability scheme is not been recommended yet.
The proposed system architecture is presented in Figure 2 (a). The proposed system is associated with optical monitoring, data analyzing, remotely controlling, failure detection, protection switching, and automatic recovery apparatus. The CFDS installed in the network to divert the OTDR testing signal 1625 nm to bypass the filter therefore the line status can be monitored by using OTDR. ACS is the microcontroller based system that has been designed to handle the centralized line detection. The routing mechanism is described in Figure 2 (b). ACS is function to divert the OTDR test signal to each line connected to the ONU. As a result, the monitoring graph can be observed at the static point where the OTDR injecting the signal (Ab-Rahman et al., 2008). The communication system between CO and ACS is done via the copper-based LAN network to enable the controlled switch in ACS can be handled manually or automatically. The web-based is designed to interface the system to the user operator (Hassan et al., 2009).

Fig. 2: Once the OTDR Test signal bypasses the optical splitter, the status of FTTH-PON is able to be monitored centrally (Ab-Rahman et al., 2009c).

Fault Detection with MADS:

We have developed a monitoring system and tested it during FTTH engineering work in a central office. This system lets technicians performing engineering work observe the link and service status in real time and thus avoid mistakes like improper fiber disconnection and connection. The system also reduces the workload for confirming the results of engineering work because it provides real-time link status checks. Furthermore, its display of the real-time service statuses helps to avoid interruptions to services that are in use. A fault detection method for multiple access communication is proposed. By using the occupancy term of a time-domain equalized signal as a detection system. The MADS is embedded in ACS used to detect any line fault occurs in the network which purposely focused on passive optical network (PON). MADS used the tapping mechanism to verify the status of each line by using 10 dB couplers. With the assisting of optical switch matrix and microcontroller system, the status of each line connected to ONU will be identified. The result is the fault number represent occupancy counter which means the number of none traffic flow detected in the specified line during the detection process. MADS plays an important role in failure detection in Access Control System (ACS). Although the mechanism is more on monitoring but with the combination of SANTAD, the error occurs in the line can be sensed efficiently. Figure 5 shown the flowchart of fault detection in Access Control System with used the combine concept of MADs and CFDS/SANTAD.

Fig. 6: MADS prototype developed to detect failure which occurs in the active FTTH’s line.
Fig. 7: Experimental of fault detection by using MADS handling by one of our engineer. Disconnection of fiber line will trigger the transmitter to send message to receive for further activation system.

Fig. 7: FTTH test bed installed with MADS to handling monitoring and redundancy scheme system.

Installation Cost Analysis:

Our modified FTTH has tremendously offers high and effective solution for customer premises and bandwidth demand by introducing prototypes to increase the system performance such as SANTAD, ACS, PIM and CAPU. These equipments offer low cost and simple installation. SANTAD offers fast monitoring and failure detection on one screen display. Any failure/breakdown occurs in the network will be restored by switching the traffic to protection line while the status of the failure will be sent automatically to field engineer for repairing and maintenance operation. The failure status will be determined by SANTAD while the restoration scheme will be activate by ACS, and CAPU is the routing device to handling the switching function. The information will be sent to field engineer and PIM is used to determine sharply the point of failure before it is been repaired. Besides that, the specified line test is also applicable to be activated by field engineer. This section calculates the cost budget between ordinary FTTH and modified FTTH and according to the network sizes. The cost for each upgraded devices are also included and this can be observed detail in Figure 9. Figure 10 shows the cost comparison between ordinary FTTH, total improvement and modified FTTH according to the network size (Kasimin et al., 2009). Although modified FTTH is much higher and obviously for the big size network but the features offer by modified FTTH is exclusive. The status of all the time can be monitored and ready to be restored is breakdown or something faulty happens in the line.
**Fig. 9:** Bar chart shows the cost comparison for different splitting ratio which is 1:8, 1:16, 1:32 and 1:64 for conventional FTTH and modified FTTH include the support elements such as SANTAD, ACS, CAPU

**Fig. 10:** Bar chart shows the cost comparison for conventional FTTH, total support elements and modified FTTH according to the splitting ratio which are 1:8, 1:16, 1:32 and 1:64

**Conclusion:**

Testing and troubleshooting an FTTH-PON network can be done either by using an Optical Power Meter (OPM) or by OTDR. While using the OPM can be proved simplest, this device only allows measurement on the loss of the entire network only, unless segmentation is done. By using OTDR, on the other hand, proves to be a faster and better method than the OPM. Even though elements acting as a power splitter cannot be detected by the OTDR, but through the use of ACS, it allows the use of OTDR in troubleshooting a FTTH network downwardly. Our proposal is expected the increase the efficient of monitoring scheme that previously used upwardly and from one ONU to the other ONU. Even though our modified FTTH has high cost installation as compare to the conventional FTTH, but the safety and survivability issue have already been solved efficiently. Our solution is the first reported up to the current time.

**References**


