PERFORMANCE AND COST COMPARISONS FOR A-PON AND S-PON FTTH SYSTEMS

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ABSTRACT

The high cost of fibers has always been a main concern as to why they have not been deployed in access networks. As the fiber technology is maturing, the costs of fibers are slowly decreasing, and hence the above issue is no longer an issue. This paper discusses the performance comparison of A-PON and S-PON FTTH architecture as well as its cost. It is established that the relationship between the fiber span and distributed area offered by S-PON is due to the power enhancement boosted by an amplifier. Meanwhile the cost of S-PON will be reasonable if there are enough users sharing the same feeder line or transmission path.

Keywords: A-PON, S-PON, FTTH, Performance and Cost.

1.0 INTRODUCTION

The demand for high-speed Internet access has increased dramatically due to the need for multimedia applications directly to the desktop. Traffic pattern in access networks have evolved from voice- and text-oriented services to video- and image-based services. Fig. 1 shows the trend of demand for Internet, worldwide. This trend will require new access network that will support high-speed (<100 Mbps), symmetric and guaranteed bandwidth for future video services with high-definition TV quality (Lee et al., 2006).

According to Copley (2000), it is expected that 2.8 million connections are needed to support the linearly increasing number of users that will balloon into 550 million in near future. Thus it is crucial to discover an access network with high bit rate at a low cost. ATM-Passive Optical Network (A-PON) seems to be the suitable choice to satisfy the user requirement in the future (Steve and Mark, 1998). Today, optical fiber is being installed at a rate of about 3,000 miles per hour. Commercial systems of 400Gbps over a single fiber are now available (Alastair, Glass, David, Thomas and Andrew et al., 1990). Fig. 1 shows the commercially available users access in the local loop. The main limitation of deploying fiber access networks is due to the high cost needed for installation. According to Paul (1990), costs incurred for installation include the equipment cost, installation cost and labor cost. As stated by Kramer (2005), amongst the advantages of PON are allowing longer distances between central offices to customer premises, providing higher bandwidth, eliminating the necessity of installing multiplexers and demultiplexers in the splitting location and easy upgrading to higher bit rates or additional wave-lengths.

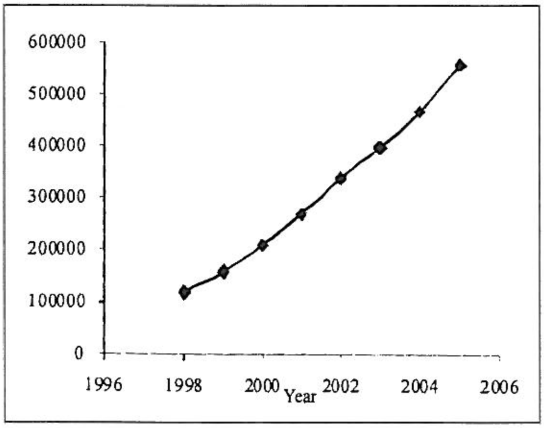

Fig. 1: Growth in the number of users on the Internet

2.0 FTTH EVOLUTIONS

Various solutions have been proposed to alleviate the bottleneck at the access network. This is includes the Fiber-to-the-Home (FTTH), Fiber-to-the-Building (FTTB) and Fiber-to-the-Curb (FTTC). Fig. 2 shows the evolution of FTTH system from ATM-Passive Optical Network (A-PON) to Super-Passive Optical Network (S-PON).

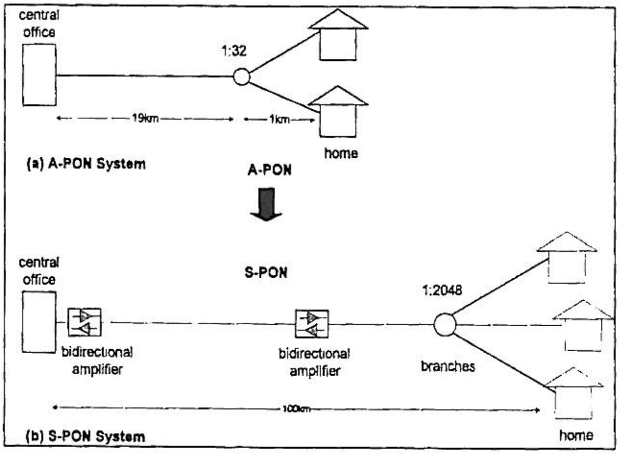

Fig. 2: Evolution of FTTH systems; (a) A-PON System (b) S-PON System

This paper clarifies the design optimization for certain important parameters for a FTTH system in passive optical network. Two types of FTTH architecture; A-PON and S-PON are studied. The performance parameter concerned is the Bit Error Rate (BER).

3.0 SIMULATION

The schematic diagram of the simulation setup is shown in Fig. 3. It consists of the three elements of the FTTH systems. The three main sections are the transmitter section, the outside plant section and the receiver section. This is an A-PON FTTH system. The same setup is used to simulate the S-PON FTTH architecture using in-line amplifiers between the transmitter section and the receiver section.

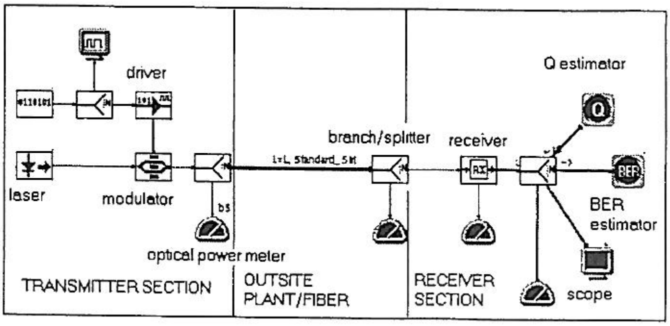

Fig. 3: FTTH system simulation layout

The two set parameters are the transmitting power and the number of subscribers. The transmitting power for both systems is set to 0dBm. The distance for the A-PON is set to 19km and 100km for the S-PON system.

4.0 RESULTS AND DISCUSSION

The effects of varying branch numbers are related to the level of received power. A large number of branches had a higher insertion loss (at the coupler) as a result of smaller output power at the receiver. Fig. 4 shows the increment of the BER with the number of branches. The number of branches that can be reached is 58 at the tolerable BER level of 10^{-10}.

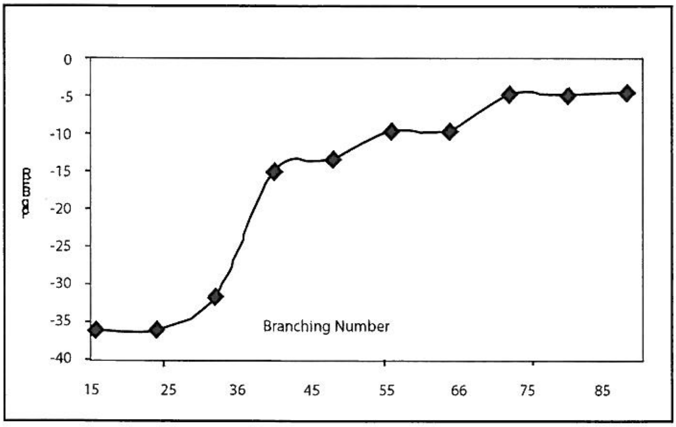

Fig. 4: BER versus branch number at 622Mbps and 19km distance

5.0 COST COMPARISON

The main consideration in this section is the cost of high fiber span for a large number of subscribers. These two parameters are associated with the S-PON system utilizing two amplifiers upstream and downstream.

Let the cost of a transmitter equipment, A, transmitter module per subscriber, B, installation cost per km, C, amplifier, D, and ONU per subscriber, E, while L¬¬1 is the fiber length at the out-side plant and L2 is the fiber length from branches to ONU, and N is the number of subscribers.

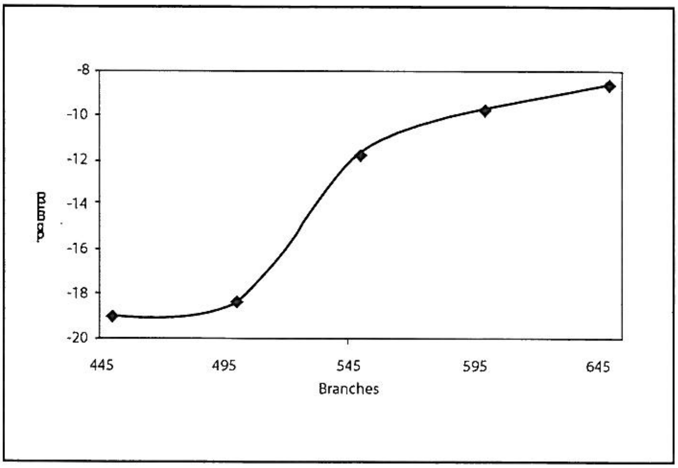

Fig. 5: BER versus branch number with 30dB gain at 100km fiber span

The total cost for the S-PON (Ps) system can be modeled as;

$$Ps = A+BN+CL_1+CL_2N+2D+EN \qquad (1)$$

While the total cost for A-PON (PA) system is described below;

$$P_A = A+BN+CL_1+CL_2N+EN \qquad (2)$$

Consider the equation (1) and (2). There are several costs that are common to the whole system and specific to the individual users. Thus, we divide the cost into two parts; the shared cost and the individual cost. The shared cost is shared by the customer and the individual cost is dependent on the number of subscriber in the set up.

The individual cost for the S-PON and A-PON system are the same, given by the equation;

$$C_{ind,s}=C_{ind,A} = (B+E+CL_2)N \qquad (3)$$

On the contrary, the shared cost for S-PON and the A-PON can be described as;

$$C_{share,s}= A+CL1+2D \qquad (4)$$

$$C_{share,A}=A+CL1 \qquad (5)$$

Since (4) and (5) are different, these two equation are compared. The shared cost over subscriber number for both systems can be depicted as;

Fig. 5 shows the branches enhancement achieved by S-PON FTTH architecture. The initial transmitter power is 0dBm. As the powers are boosted by the inline amplifier transplanted in between transmitter and receiver section (Fig. 3), a high receiving power resulted in a low BER. Hence the branch or subscriber line can be extended to 600 users. Thus, the users enhancement offered by S-PON compared to the A-PON system is about 200%. For the A-PON system,

$$\frac{C_{share,s}}{N} = \frac{A + CL_1 + 2D}{N} \quad (6)$$

$$\frac{C_{share,A}}{N} = \frac{A + CL_1}{N} \quad (7)$$

the shared cost at optimum configuration is N=32 and L1=20, this take into the consideration the maximum number of subscribers allowed and the maximum distance to each customer; To compare the S-PON cost with A-PON cost, and

$$\frac{C_{share,A}}{N} = \frac{A + 10C}{32} \quad (8)$$

to determine the breakeven cost for S-PON, the breakeven cost is given as;

$$N_{BE} = \frac{32A + 32CL_1 + 64D}{A + 10C} \quad (9)$$

Assuming that D=C=1/2A

$$N_{BE} = \frac{64C + 32CL_1 + 64C}{12C}$$

$$= \frac{C(128 + 32CL_1)}{12C} \qquad = 10.67 + 2.67L_1$$

for $L_1 \geq 10$ (10)

The cost comparison graph in Fig. 6 shows that the S-PON system can be made much cheaper than A-PON at various spans. For example, at 90km span, the cost for S-PON per customer is the same as that for the A-PON if there are enough customers 6.0

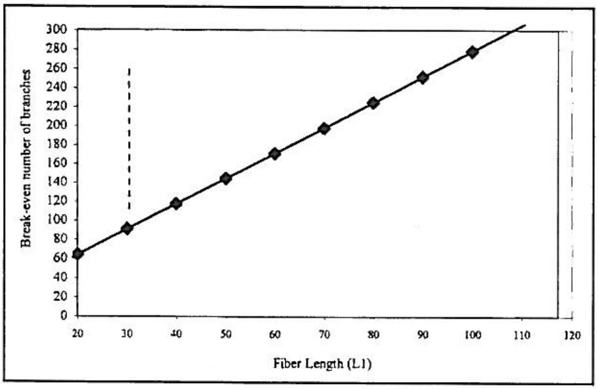

Fig. 6: Cost comparisons; breakeven number of branches versus fiber length

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