Quality Analysis Of Epon Network For Uplink and Downlink Design

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***Abstract*--- Internet has procreated unpretentious petition for broadband facilities, foremost to extraordinary development in Internet Protocol (IP) data traffic. This huge data traffic is placing burden on shippers to evaluate their networks.**

A development beyond 56 Kb/s is not able to offer enough bandwidth for video on demand (VOD), shared gaming, IP telephony & video communication.

An Ethernet passive optical network (EPON) is a scalable access complex technology that provide optical access path between a carrier office (CO) and customer's site at a low-cost.

In other words, EPON means the merger of Ethernet equipment and low cost fiber infrastructure at low cost. It is going to be the finest aspirant for the next generation access system.

In an EPON, the method of transmitting data downstream from the OLT to numerous ONUs is essentially different from transmitting data upstream several ONUs to the OLT.

Here we discuss some scenarios of EPON network at different distances and analysis the quality of the network.

I. INTRODUCTION

EPON is the abbreviation of Ethernet Passive Optical Network. EPON is IEEE Ethernet standard for PONs. A passive optical network (PON) is a point-to-multipoint, fiber to the premises network architecture in which optical splitters are used to enable a single optical

Fiber to serve multiple premises, typically 16-128. A PON Consists of an optical line terminal (OLT) at the service provider's central office and a number of optical network units (ONUs) near end users. [1] There are no optical repeaters or other active devices in a PON, hence the name "passive".

II. ARCHITECTURE OF EPON

A typical EPON system consists of OLT, ODN, POS and ONU. The OLT (Optical Line Terminal) resides in the Central Office (CO) and connects the optical network to the metropolitan-area network or wide-area network, also known as the backbone or long-haul network. OLT is both a switch or router and a multi-service platform which provides EPON-oriented optical interfaces.

III. DESIGN OF TDM EPON

TDM EPON is designed by using bus topology. This design describes each of the elements with its most significant parameters and their functions .It will describe the design from the OLT to the different ONUs for downstream, and from the ONUs located at different distances to the OLT for upstream.

IV. TDM EPON NETWORK DESIGNS

On left side of the design the OLT will transmit information to different users and it will receive information from the ONUs. All this information will be transmitted at single wavelength through a single optical fiber, and then it is distributed to different ONUs located at different distances from OLT via optical splitters in downstream. In upstream data will be accepted from different ONUs on TDM multiplexing basis by OLT. [2] In this scenario the bus topology of EPON network has been designed as shown in Fig [1a], Fig [1b] & Fig [1c].

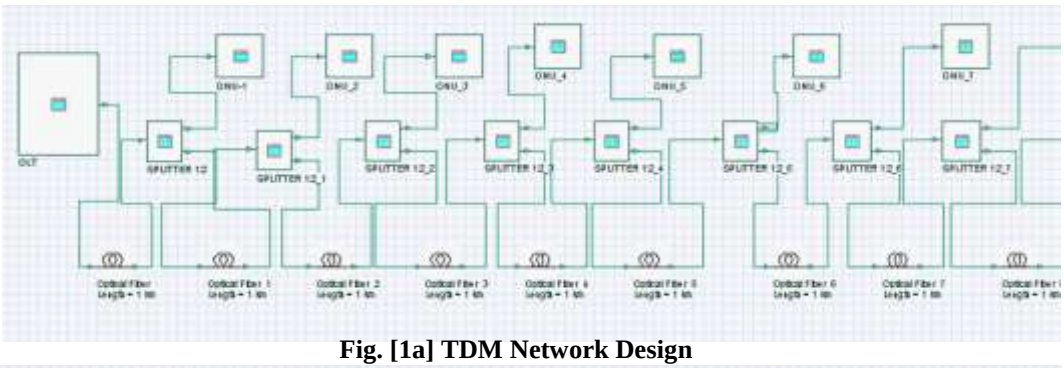


Fig. [1a] TDM Network Design

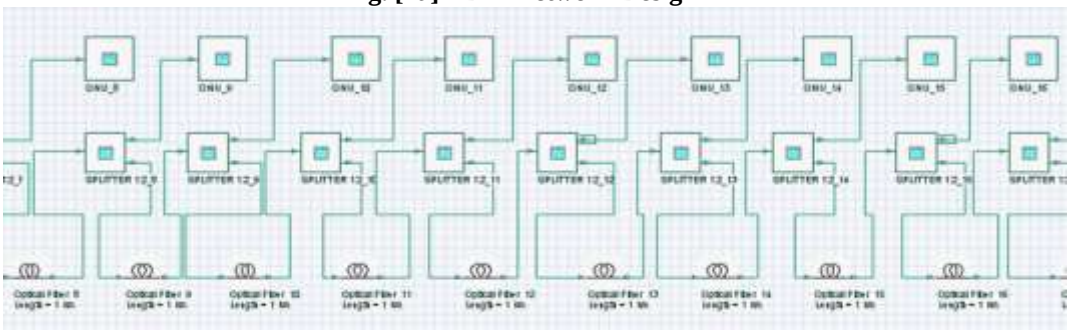


Fig. [1b] TDM Network Design

Fig. [1] TDM EPON Network Design

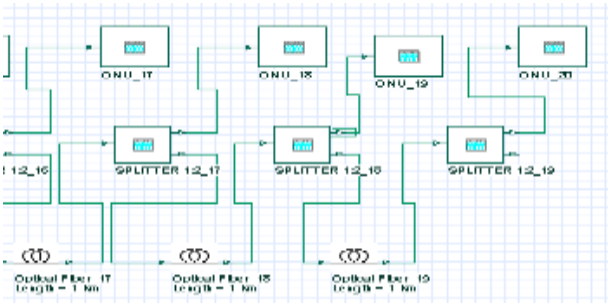


Fig. [1c] TDM Network Design

The bit rate used for the design is 1.25 Gbps. This bit rate is used for both uplink and downlink. Other important parameters are the sequence length (128 bits) and the samples per bit (64). These will make a total of 8192 samples.

V. EPON DOWNSTREAM

In downstream, the OLT broadcast the information to the ONUs located at different distances. First network element is the optical transmitter located inside the OLT. This laser will broadcast one wavelength 1490 nm at a bit rate of 1.25 Gbps. The transmission power will be 0 dBm and it will use NRZ modulation.

i. OLT Section for Downlink of EPON

As Shown in **Fig.[2],** Pseudo-Random Bit Sequence Generator is responsible for PN sequence generation at bit rate of 1.25 Gbps in the form of NRZ pulses and optical signal of 1490nm wavelength from laser are modulated in the Mach-Zehnder Modulator. [3]

Due to optical splitters the signal will suffer more loss, so we have placed an EDFA of 10dB gain has been placed inside of OLT in order to ensure good quality signal in the case of major losses.

The optical signal from OLT will be inserted into the optical fiber which will reach the optical splitters located at after every 1km from the central office. The most important parameters of this fiber, which will carry information in both directions, are 0.2 dB/km of attenuation, 16.75 ps/nm/km of dispersion and 0.075 ps/nm2/km of dispersion slope.

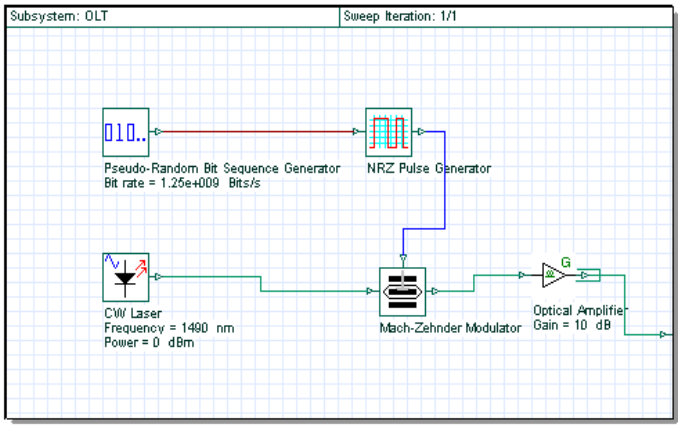
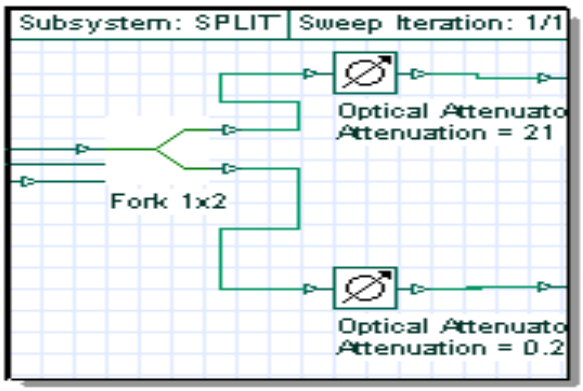


Fig. [2] OLT Section for Downlink of EPON

Following the fiber after every 1 km, there is an Optical Splitter as shown in **Fig [3].** These Optical Splitters of 1:2 have coupling efficiency of 1/99 and insertion loss of 21dB /0.2 dB. The first branch of the splitter will be directed to the ONU block, the second to the next splitter and so on up to 20 km.



ii. ONU Section of EPON For Downlink

Fig. [3] Optical Splitter

The last element of EPON network is the Optical Network Unit (ONU) where the signal will be received and transformed into electrical form to visualize it in the BER Analyzer in the downlink scenario. This block is shown in **Fig [4],** it consist of a photo detector PIN which will transform the optical signal to electrical signal then that signal will be filtered by a low pass Bessel filter with a cutoff frequency of 0.75*Bit rate (in this design 1.25Gbps).

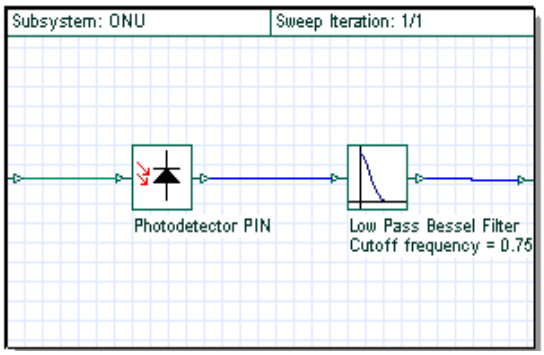


Fig. [4] ONU Section of EPON for Downlink

VI. EPON UPSTREAM

In upstream direction, the optical signal will travel from each of the ONUs to the OLT. The various blocks of ONUs and end up explaining the OLT receiver. Note that the signal in upstream will pass through the same elements and therefore they will have the same characteristics and parameters. [4]

It is also important to note that each ONU will transmit the data at same wavelength of 1310 nm. Therefore, TDMA will be implemented in each of the ONU for each user transmits in a determined instant of time. This will avoid that two ONU might collide when they wish to transmit information at the same time.

In **Fig [5],** the ONU Section for uplink is shown. It consists of an optical transmitter which in this case will transmit at 1310

nm wavelength at a bit rate of 1.25 Gbps with a power of 4 dBm and same NRZ modulation is used here.
In uplink scenario, as more than one ONU are operating at the same wavelength, it must take into account the time division multiple access (TDMA).Therefore we have used here a Dynamic Select Y which will allow to pass the signal only at a determined time instant and the rest of time signal will be zero. Here 20 ONU's will transmit data with a 1.25 Gbps bit rate and a wavelength of 1310 nm.

i. ONU Section of EPON For Uplink

However, to adjust the interval of time in which each ONU has to transmit, we must change the formula in the Dynamic Select Y by the following:
Timeslot * (1/Bit rate) * Sequence length/20 + Time window/20.
Whereas Timeslot value for the first ONU is 0, 1 for the second and so on until the twentieth ONU which will value 19.

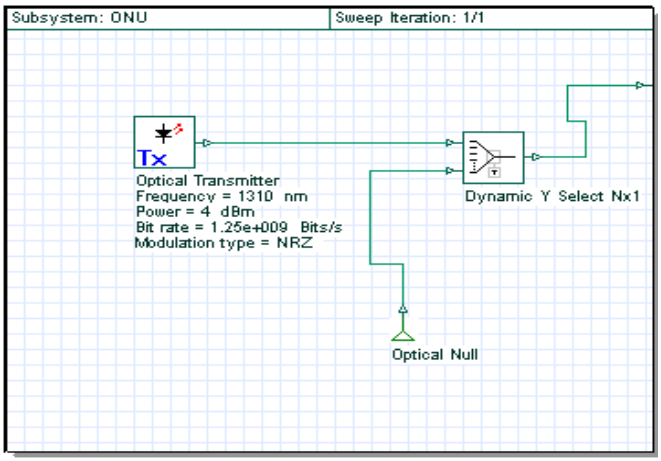


Fig. [5] ONU Section of EPON for Uplink

ii. OLT Section for Uplink

Finally the signal from ONUs will arrive at the OLT, where it will be sent to the optical receiver.
The first element of the OLT receiver is the Buffer Selector, which is used to select only the latest iteration of the simulation that will be the one with the correct results. After this element, the signal will pass through the PIN Photo detector where it will be converted to electrical domain and as in other cases it will be filtered through a Low Pass Bessel Filter with a cutoff frequency of 0.75 * Bit Rate. To end, this signal will be regenerated in order to be displayed on the BER Analyzer. The OLT receiver for uplink is shown in **Fig [6]**

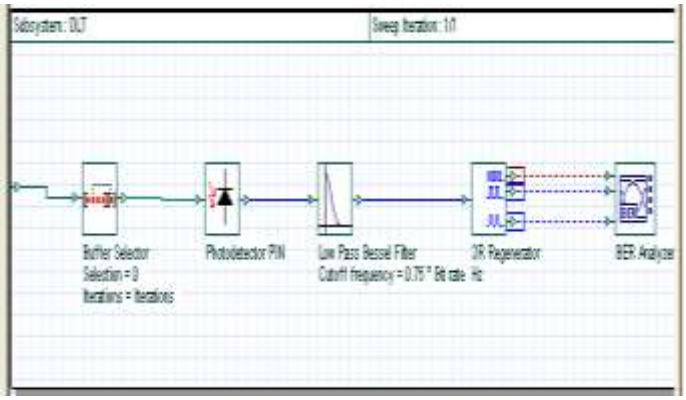


Fig. [6] OLT Section for Uplink

VII. EPON OPTICAL TIME DOMAIN VISUALIZER

The following **Fig [7]** shows the first three time intervals for the first three ONU's transmission. Similarly for the others the same formula is used and therefore each will transmit at unique time interval.

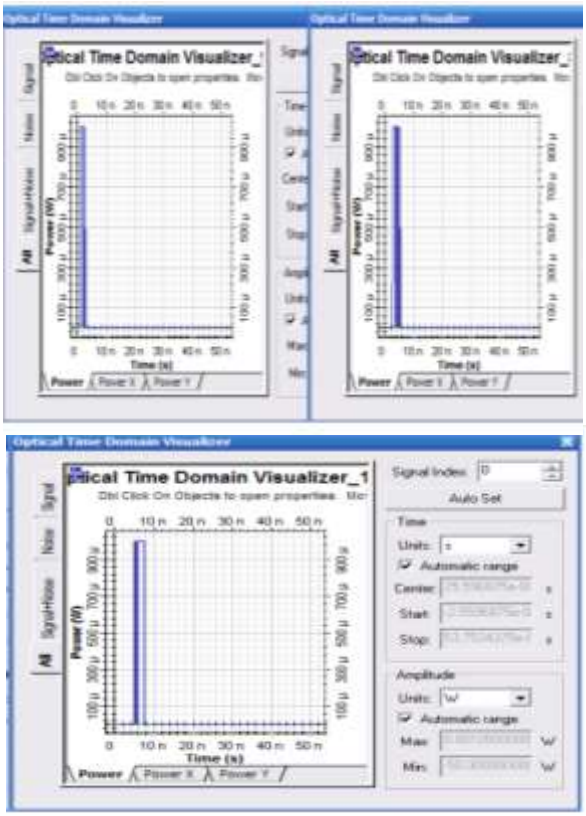


Fig. [7] EPON Optical Time Domain Visualizer

VIII. EXPERIMENTAL RESULTS

The following results obtained in the form of eye diagram, the quality factor, the minimum probability of error (BER) and the decision threshold as a function of the width of the bit. The downstream results are observed first and then upstream results.

Since there are 20 ONU's located at after every 1 km from OLT at central office. To expose the results of the 20 ONU's will require a lot of space, so only the results of the closest ONUs (located at 5 km and 10 km from the OLT) and the farthest ONUs (situated at 15km and 20 km from the OLT) are explained.

Following results in ONUs **Fig [8a], Fig [8b], Fig [8c] & Fig [8d]** are showing variations in Q-factor, eye diagram, minimum BER and threshold for minimum BER. ONUs, which are placed at the shorter distance have better results than the results of the ONUs , which are placed at the longer distance from OLT.

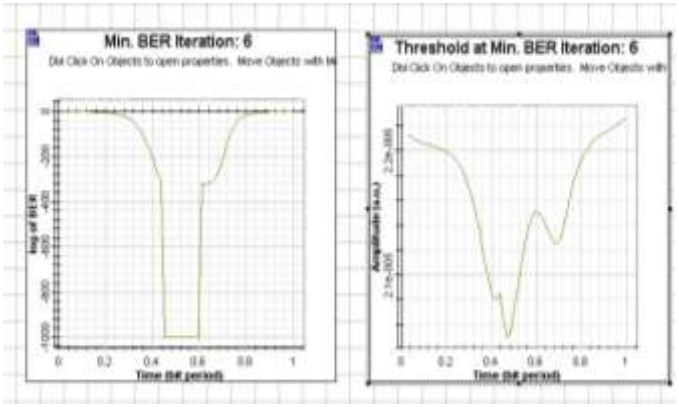


Fig. [8a] EPON ONU-5 at 5km (Downstream)

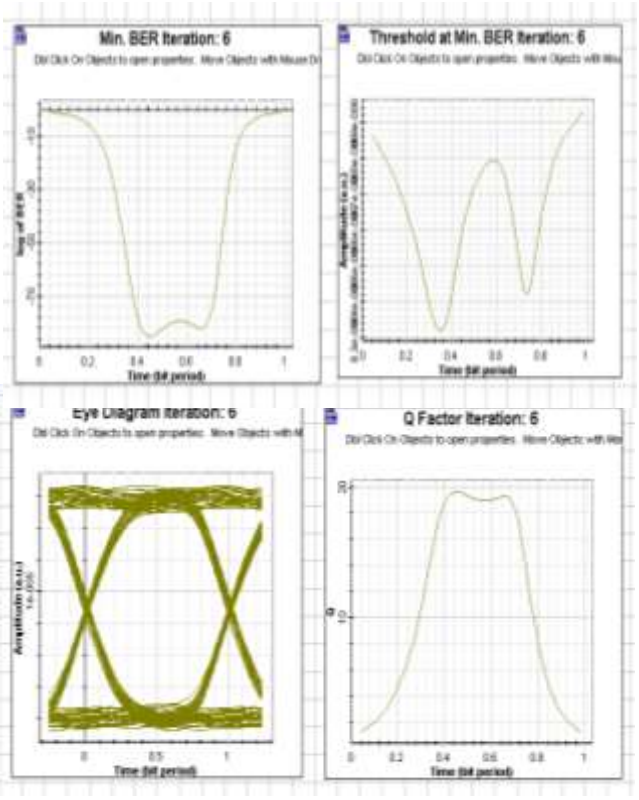
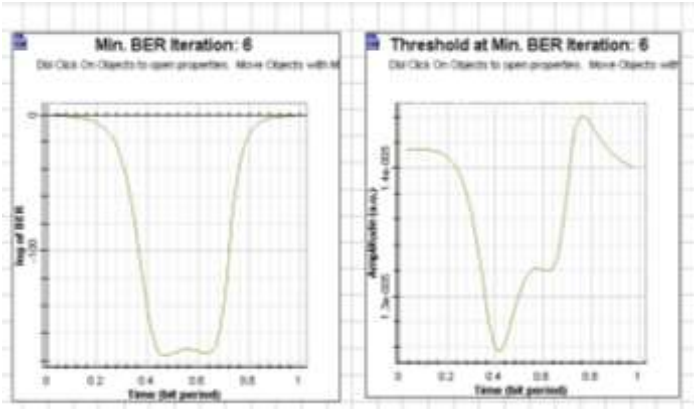


Fig. [8b] EPON ONU-10 at 10km (Downstream)



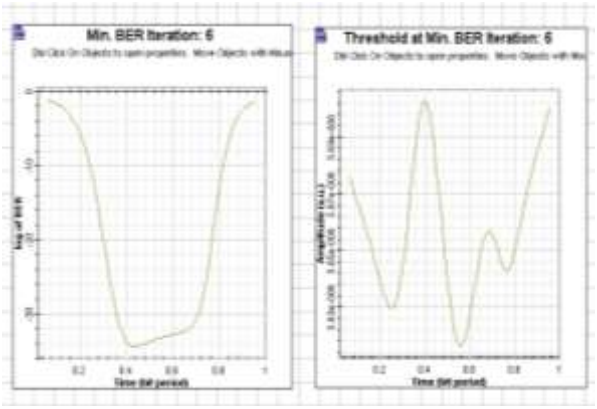


Fig. [8c] EPON ONU-15 at 15km (Downstream)

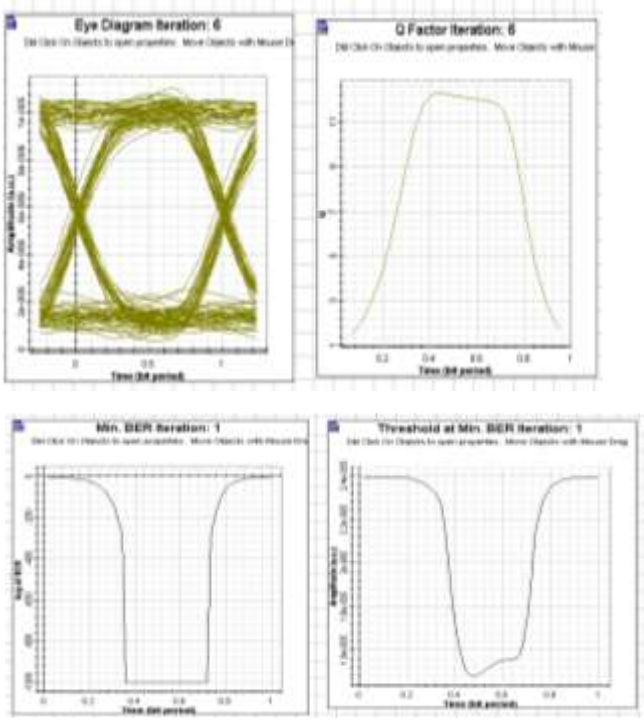
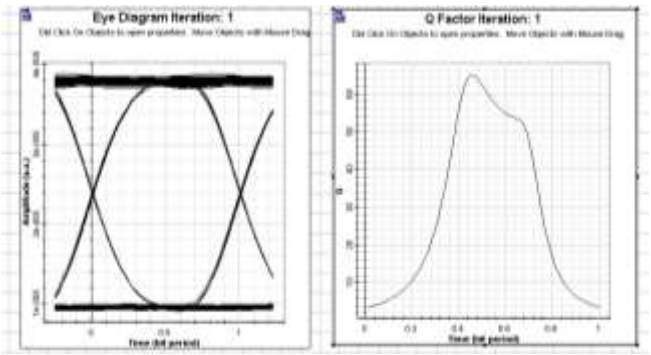


Fig. [8d] EPON ONU-20 at 20km (Downstream)



Analysis	
Max. Q Factor	65.0261
Min. BER	0
Eye Height	2.70563e-005
Threshold	2.13425e-005
Decision Inst.	0.359375

Fig. [9] EPON OLT Receiver (Upstream)

The above results in **Fig [9],** the uplink scenario obtained from OLT receiver are showing a better performance of EPON network.

IX. CONCLUSION

The uplink, the results obtained in the **OLT** receiver are Shown in **Table 1.1**

Analysis:

EPON ONU |Downstream| at:	5km	10km	15km	20km
Max Q-Factor	40.2079	28.3695	19.6068	12.3098
Min. BER	0	2.38506e-177	6.75506e-086	4.01076e-035
Eye Height	3.21302e-005	1.95499e-005	1.17014e-005	6.59085e-006
Threshold	2.06632e-005	1.28131e-005	8.62247e-006	5.6885e-006
Decision Inst.	0.453125	0.46875	0.453125	0.4375

Table. 1.1

- Quality factor is decreases with respect to distance.
- BER increases with the increase of distance.
- Eye Height & Threshold level varies with irrespectively.
- Decision Inst. Also changes but with less variants.

For EPON network the results i.e. bit error rate and Q factor in both uplink and downlink scenario is better than the desired ones.

X. ADVANTAGES

EPONs are simpler, more efficient, and less expensive than alternate multiservice access solutions. Key advantages of EPONs include the following:

i. **Higher Bandwidth:** up to 1.25 Gbps symmetric Ethernet bandwidth.
ii. **Lower Costs:** lower up-front capital equipment and ongoing operational costs.
iii. **More Revenue:** broad range of flexible services offering means higher revenues.

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