

Performance Analysis of Bus Topology in Fiber Optic Communication

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ABSTRACT:

Topology refers to the layout of connected devices in a network. It describes the way in which the elements of the network are mapped. Optical network topologies such as bus, star and tree reduce complexity by using minimum number of couplers, multiplexers, demultiplexers and optical amplifiers and can reduce cost in large network. The performance of bus topology is investigated and identified that, for bus topology the quality of signal goes on decreasing with increase in number of nodes. The performance of bus topology is investigated in presence of optical amplifiers such as Semiconductor Optical Amplifiers (SOA) and Erbium Doped Fiber Amplifier (EDFA) and photodiodes such as PIN and Avalanche photodiode (APD). By considering the signal quality factor and bit error rate it is investigated that bus topology using EDFA with PIN photodiode serves better.

KEYWORDS: Avalanche photodiode (APD), data rate, Erbium Doped Fiber Amplifier (EDFA), LAN (Local area Network), Q factor, Semiconductor Optical Amplifiers (SOA), Topology

I. INTRODUCTION

Optical fibers are essentially very thin glass cylinders or filaments which carry signals in the form of light (optical signals). An optical network connects computers using optical fibers. Optical networks have found widespread use because the bandwidth of such networks using current technology is 50 tera-bits per second. Optical network uses optical multiplexing and switching technique to increase its capacity. The implementation of time multiplexers, demultiplexers and encoders/decoders at terabits per second is very difficult in networks. Optical network topologies such as bus, star and tree reduces complexity by using minimum number of couplers, multiplexers, demultiplexers and optical amplifiers and can reduce cost in large networks. Also maximum number of users can be supported with minimum received power for a given bit error rate.

Bus is the network topology in which all of the nodes of the network are connected to a common transmission medium which has exactly two endpoints. All data that is transmitted between nodes in the network is transmitted over this common transmission medium and is able to be received by all nodes in the network virtually simultaneously. Star is the topology in which each of the nodes of the network is connected to a central node with a point-to-point link. All data that is transmitted between nodes in the network is transmitted to this central node, which is usually some type of device that then retransmits the data to some or all of the other nodes in the network. A tree topology combines characteristics of linear bus and star topologies. It consists of groups of star configured workstations connected to a linear bus backbone cable.

Optical fiber accommodates today's increasingly complex network architectures. Using optical fiber various topologies came into being. Each topology has its strengths and weaknesses, and some network types work better for one application while another application would use a different network type.

II. OPTICAL NETWORK TOPOLOGY

The optical networks can be configured in a number of topologies. These include a bus, a star network, a tree network, or some combination of these. Network topology is the study of the arrangement or mapping of the elements (links, nodes, etc.) of a network, especially the physical (real) and logical (virtual) interconnections between nodes. A local area network (LAN) is one example of a network that exhibits both a physical and a logical topology. Any given node in the LAN will have one or more links to one or more other nodes in the network and the mapping of these links and nodes onto a graph results in a geometrical shape that determines the physical topology of the network. Likewise, the mapping of the flow of data between the nodes in the network determines the logical topology of the network. It is important to note that the physical and logical topologies might be identical in any particular network but they also may be different.

Network Topology is, therefore, technically a part of graph theory. Distances between nodes, physical interconnections, transmission rates, or signal types may differ in two networks and yet their topologies may be identical. In addition to its advantages (i.e., bandwidth, durability, ease of installation, immunity to EMI/RFI and harsh environmental conditions, long-term economies, etc.), optical fiber better accommodates today's increasingly complex network architectures than copper alternatives. Using optical fiber various topologies came into being. Each topology has its strengths and weaknesses, and some network types work better for one application while another application would use a different network type.

III. BUS TOPOLOGY

Bus network topology is a network architecture in which a set of clients are connected via a shared communications line, called a bus. This topology is easy to implement and install. It is well-suited for temporary or small networks not requiring high speeds, resulting in faster networks. Cost effective and easy identification of cable faults is possible. Moreover, Bus networks are the simplest way to connect multiple clients, but often have problems when two clients want to transmit at the same time on the same bus. Many active architectures can also be described as a bus, as they provide the same logical functions as a passive bus, for example, switched Ethernet can still be regarded as a logical bus network, if not a physical one. The advantage of bus topology is it is cheap, easy to handle and implement, require less cable and suitable for small networks. The disadvantage of using bus topology is, the cable length is limited and it limits the number of stations that can be connected.

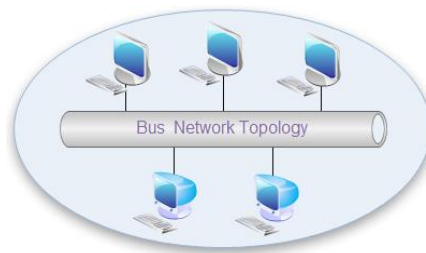


Figure 1: Bus Topology

Figure 2 given below shows the block diagram of bus topology having two users, the transmitter section is composed of data source, NRZ rectangular driver, CW Lorentzian laser, optical amplitude modulator and optical link section. The outputs from driver and laser source are passed to the optical amplitude modulator. The optical signal from the modulator is passed through the fixed gain amplifier and splitter. Each user in the bus is connected through the optical splitter; each user is connected to every other user by a Single Mode Fiber (SMF) and Dispersion Compensating Fiber (DCF) through an amplifier. The combination of SMF and DCF fibers for long distance scenario has been considered to mitigate the nonlinear effects. The placement of one amplifier is done at the start of each segment in order to continue broadcasting the information from transmitter users. A single user section is composed of optical raised cosine filter (Raised cosine1), PIN photodiode (IdealRX1) and low pass Bessel filter (Bessel5poles 1). At receiver measurements are made with the help of optical spectrum analyzer, optical probe and electrical scope. Electrical scope is used to obtain eye diagram and from the eye diagram Q factor can be determined.

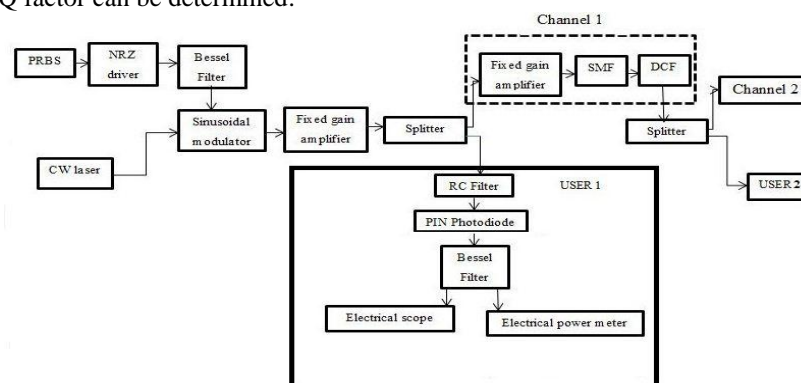


Figure 2: Block Diagram of bus topology

IV. SYSTEM DESIGN

The design model of bus topology shown in Figure 3, the transmitter section consists of data source with data rate 10Gbps, laser source (CW Lorentzian) and optical amplitude modulator (Sin2 MZI). Data source is customized by baud rate, sequence, logical signal level and the period length. In this transmitter set up NRZ modulation format is used. Laser source provides transmission at 1552.52nm laser emission frequency. Laser phase noise is taken into account by generating a lorentzian whose power spectrum width at half maximum is specified at 10 MHz. The output from driver and laser source is passed to the optical amplitude modulator. The optical signal from the modulator is passed through a fixed gain amplifier where the optical signal is get amplified. Each user in the bus is connected through the optical splitter; every user is connected to every other user by a single mode fiber (SMF) and dispersion compensating fiber (DCF) with reference frequency 193.41449 THz. A single user section is composed of optical raised cosine filter (Raised cosine1), PIN photodiode (Ideal RX1) and low pass Bessel filter (Bessel 5 poles 1). At receiver measurements are made with the help of electrical scope and electrical power meter. Electrical scope is used to obtain eye diagram and from the eye diagram determines the values of Q factor. Electrical power meter is used to obtain the received power value. In the above simulation diagram different combinations of optical amplifiers and photodiodes can be used for comparison, they are SOA with PIN, SOA with APD, EDFA with PIN and EDFA with APD.

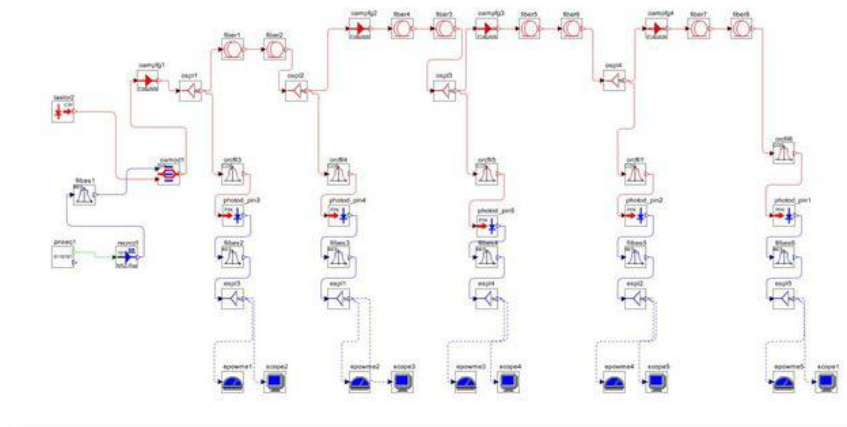


Figure 3: Simulation diagram of bus topology

V. RESULT AND DISCUSSION

Bus topology is designed and simulated using the Optisim software. The results of these simulations are obtained with the help of measurement tool such as Electrical scope. Eye diagram is the methodology used to evaluate the performance of the system.

5.1. Relationship between Q Factor with internode distance

As the internode distance increases the quality of signal received at the receiver section begins to fade and hence bus topology serves better for short distance communication.

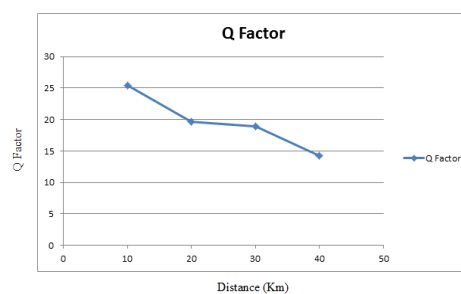


Figure 4: Relationship between Q Factor and internode distance

5.2. Eye diagram of different users with different internode distances

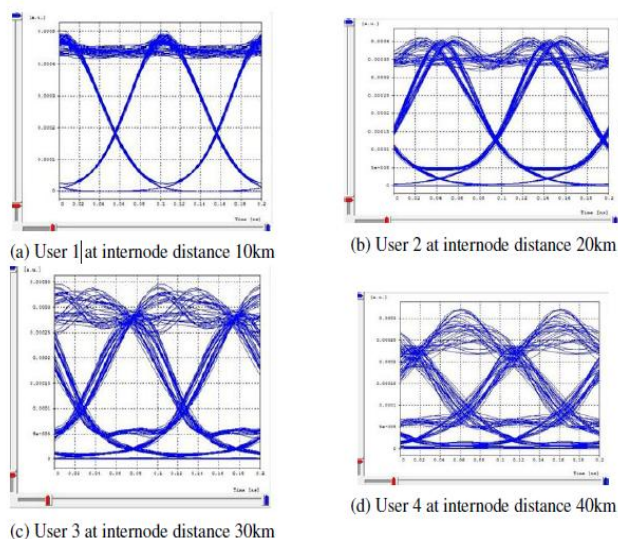


Figure 5: Eye diagram of different users with different Internode distances

5.3. Relationship between received power at different nodes with variable input power

The value of received power is observed at different nodes with variable input power and it is observed that with increase in input power, the received power also increases.

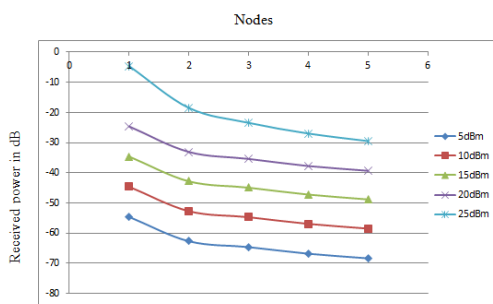


Figure 6: Relationship between received power at different nodes with variable input power

5.4. Relationship between data rate and Q factor

The value of Q Factor is observed at different nodes with variable data rate and observed that with increase in data rate the Q Factor get decreased.

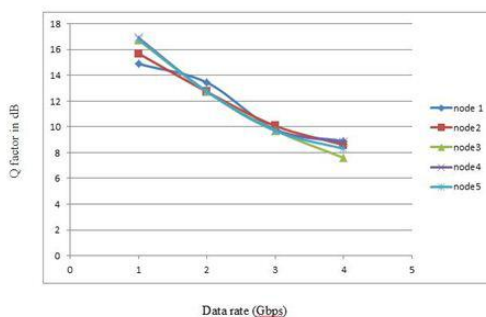


Figure 7: Relationship between data rate and Q factor

5.5. Comparison of Bus Topology using different Optical Amplifiers (SOA and EDFA) and different Photodiodes (PIN and APD)

By analyzing the results it is clear that bus topology using optical amplifier EDFA and photodiode PIN serves better because EDFA is having less noise figure and high gain and PIN serves better for longer wavelength region.

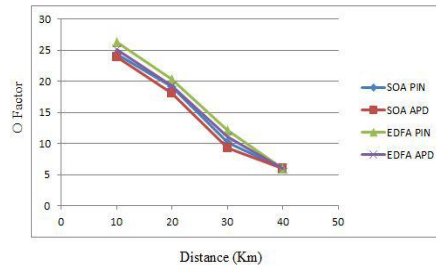


Figure 8: Comparison of bus topology using different Optical Amplifier and Photodiode in terms of Q factor

VI. CONCLUSION

The performance of bus topology is investigated and identified that, for bus topology the quality of signal goes on decreasing with increase in number of nodes. So it is used for short distance communication. As the internode distance increases Q factor decreases and as the data rate increases the Q factor decreases. The value of received power is observed at different nodes with variable input power and it is observed that with increase in input power, the received power also increases. Simulation and performance analysis of bus and star topology is done using different optical amplifier (SOA and EDFA) and different photodiodes (PIN and APD) and analyzed that bus topology using optical amplifier EDFA with PIN photodiode serves better.

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