International Journal of Advance Research, IJOAR .org
Volume 1, Issue 3, March 2013, Online: ISSN 2320-9199

ENHANCEMENT OF NETWORK CAPACITY OF PON USING WDM AND SONET/SDH

By Vimal Zalariya

At Institute of technology, Nirma university, Ahmedabad

Abstract-

In recent era of digitalization life has become faster, but due to more and more digitalization we need to transmit and receive tremendous amount of data or in other words our bandwidth requirement is increasing like anything. In this era of competition and crisis we need efficient way to communicate which reduces overall budget. For the home applications like broadband and for the networks of big company's best alternative is "fiber to home". It refers to the installation and use of fiber optic cable directly to the home. Fiber Optic wiring replaces the duplicate infrastructure that the Telephone and Cable companies have installed in the past in a neighborhood setting. Fiber has a higher bandwidth capacity and can easily be used in traditional applications like telephone, television, and internet, for larger amount of data transmission with plenty of capacity left over for applications in the future. Active Fiber Optic Network is deployed using point to point active optics which requires power. So better option is Passive Optic Network (PON) which is deployed using passive optical splitter which doesn't require any power hence they are "GREEN".A passive optical network (PON) is a point-to-multipoint, fiber to the premises network architecture in which unpowered optical splitters are used to enable a single optical fiber to serve multiple premises[3]. There are many advantages to installing fiber to home. PON has advantages like Cost savings, Future proof Technology. PON works without electricity at end-user. PON is network without switches. The advantage of PON needs fewer ports in the exchange and thus less space and energy requirements for switches. In PON Downstream signals are broadcast to all premises sharing multiple fibers. Encryption can prevent eavesdropping. Upstream signals are combined using a multiple access protocol, usually time division multiple access (TDMA).Problem with PON is bandwidth for downstream. For upstream since it is using common fiber line and TDMA so uploading capacity of each user is limited. In this paper we described and showed how to enhance downstream capacity of PON using WDM and SONET and upstream capacity using higher level SONET. We can use WDM PON which uses a different wavelength for each user group to greatly enhance network capacity. E.g. we can divide each user group to OC-12 (622 Mbps). e.g. For downstream, Let initially we had 100 users, Now using WDM we can have 10 groups of 100 users operating at slightly diff. wavelengths on same fiber line. Now for
100 users we can allocate spaces in SONET rings for their bytes.so we can have 1000 users using same fiber line. To increase upstream capacity we have used Higher SONET (e.g. OC-12) so for same time we can send more data from user to server using TDM.

Keywords-

PON (passive optical network), TDM (time division multiplexing), SONET (synchronous optical network), SDH (synchronous digital hierarchy), TDMA (time division multiple access)

I. INTRODUCTION TO OPTICAL NETWORK

Optical networks can be defined as networks implemented with help of light. [1] All the networks using optical fiber as transmission medium -optical networks. Optical networks use an optical communication. Optical communication is any form of telecommunication that uses light as the transmission medium. An optical communication system consists of a transmitter, which encodes a message into an optical signal, a channel, which carries the signal to its destination, and a receiver, which reproduces the message from the received optical signal. The transmitters in optical fiber links are generally light-emitting diodes (LEDs) or laser diodes which emits light in infra-red or visible region. Optical fiber is the most common type of channel for optical communications. Receiver consists of photo detectors to detect the light signal coming from fiber and transducers to convert it in to electrical signal. [1]Optical fiber uses carrier frequency of the order of 100THz. Bandwidth generally a smaller fraction of carrier frequency. Large BW is available (of the order of 40 THz). Advantages of using optical fiber as channel are Large Bandwidth-distance product, immunity to noise and interferences, very low cost per unit bandwidth, easy upgradability using WDM technology.

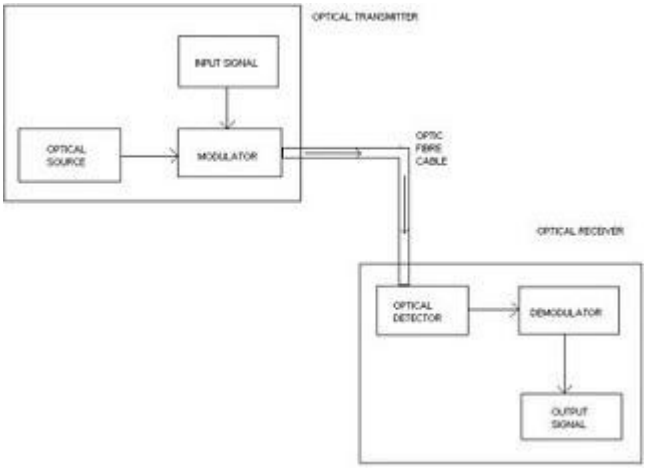


Fig. 1 Block Diagram of optical communication system[2]

Networks can be divided in to four broad categories mainly Metropolitan Area Networks (MAN), Local Area Networks (LAN), Wide Area Networks (WAN) and Access Networks. An access network lies between metro networks and a LAN. This network category encompasses connection that extends from a switching facility to individual business, organizations and homes. PON is a perfect example of such a network.

II. Passive Optical Network

A passive optical network (PON) is a point-to-multipoint, fiber to the premises network architecture in which unpowered 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. A PON reduces the amount of fiber and central office equipment required compared with point to point architectures. A passive optical network is a form of fiber-optic access network [3]. A passive optical network is a fiber optic network, which works for signal distribution without any active components. It works with optical splitters that have no electrical switching functions. Passive optical networks are installed in the area between the exchange and local loop to fiber gigabit connections. They function as access networks for the participants to the worldwide data and communication networks. Downstream signals are broadcast to all premises sharing multiple fibers. Encryption can prevent eavesdropping. Upstream signals are combined using a multiple access protocol, usually time division multiple access (TDMA). A PON takes advantage of wavelength division multiplexing (WDM), using one wavelength for downstream traffic and another for upstream traffic on a single non-dispersion-shifted fiber (ITU-T G.652). BPON, EPON, GEPON, and GPON have the same basic wavelength plan and use the 1,490 nanometer (nm) wavelengths for downstream traffic and 1310 nm wavelength for upstream traffic. 1550 nm is reserved for optional overlay services, typically RF (analog) video.

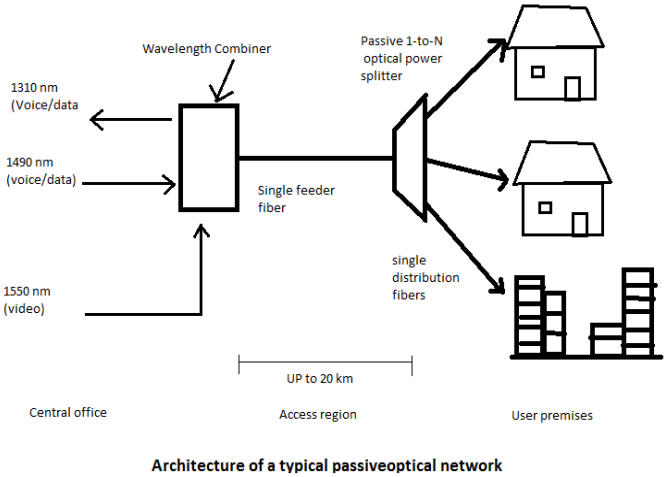


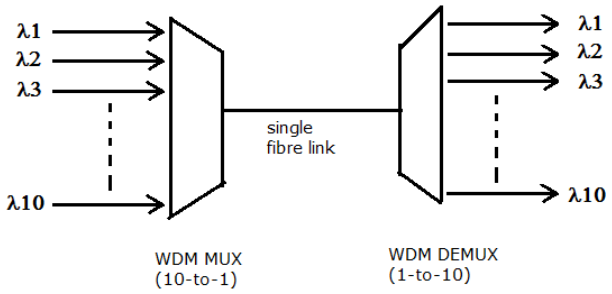
Fig. 2 Block Diagram of PON [4]

A PON consists of a central office node, called an optical line terminal (OLT), one or more user nodes, called optical network units (ONUs) or optical network terminals (ONTs), and the fibers and splitters between them, called the optical distribution network (ODN). ONT is an ITU-T term to describe a special, single-user case of an ONU. In Multiple Tenant Units, the ONU may be bridged to a customer premises device within the individual dwelling unit using technologies such as Ethernet over twisted pair, G.hn (a high-speed ITU-T standard that can operate over any existing home wiring - power lines, phone lines and coaxial cables) or DSL. An ONU is a device that terminates the PON and presents customer service interfaces to the user. Some ONUs implements a separate subscriber unit to provide services such as telephony, Ethernet data, or video.

III. Enhancement of Downstream Capacity Using WDM

In a typical PON central office, data and digital voice are combined and sent downstream to customers over the optical link by using 1490-nm wavelengths. Video services are sent downstream using 1550-nm wavelengths. There is no video service in the upstream direction. Now to enhance the data rate over a same link WDM can be used. In place of single 1490-nm wavelengths set of a signal with slightly different wavelengths can be transmitted in one fiber at a time. This concept is called wavelength division multiplexing. With the advent of high-quality light sources with extremely narrow spectral emission width (less than 1 nm), many independent wavelength channels spaced less than a nanometer apart could be placed on same fiber. First, the capacity of standard installed fiber is far greater than is currently used (by at least a factor of 1000). This potential capacity can be exploited in two possible ways. The first is through the use of wavelength division multiplexing (WDM) in which signals on different

carrier frequencies (wavelengths) are multiplexed onto a fiber such that the available fiber spectrum is more efficiently used. The second is through the use of ultra-high bit rate transmission (e.g., up to 100 Gb/s). This approach uses extremely narrow pulses with correspondingly large bandwidths, which again more efficiently utilize the available fiber spectrum [5]. Typically each wavelength supports independent transmission rate of 10 GB/s, then each additional channel will provide fiber with more capacity [4].



Concept of enhancement of data capacity of PON using WDM

For downstream, Let initially we had 100 users, Now using WDM we can have 10 groups of 100 users operating at slightly diff. wavelengths on same fiber line. Now for 100 users we can allocate spaces in SONET rings for their bytes.so we can have 1000 users using same fiber line. This will reduce the cost per channel.
Following is a proposed ten frequencies which are separated by 100 GHz that can be used for each channel in WDM.

channel	Frequency(THz)	Wavelength(nm)
1	191.00	1569.59
2	191.10	1568.77
3	191.20	1567.95
4	191.30	1567.13
5	191.40	1566.31
6	191.50	1565.30
7	191.60	1564.68
8	191.70	1563.86
9	191.80	1563.05
10	191.90	1562.23

IV. ENHANCEMENT OF UPSTREAM CAPACITY USING SONET

In PON Upstream signals are combined using a multiple access Protocol, usually time division multiple access (TDMA). So main problem with typical PON network is capacity of each channel. Capacity is equally divided among the number of users operating in that channel.

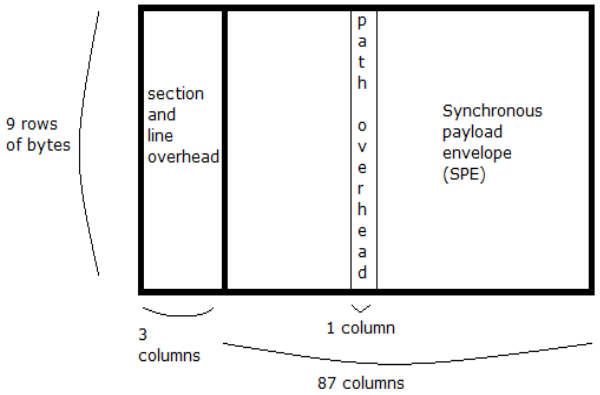


Fig. 3 Basic Structure of an STS-1 SONET Frame

Data rate of STS-1[4]
=(90 bytes/row)*(9 rows/frame)*(8 bits/byte)*125 us/frame
=51.84 Mb/s

Let the no. of user per channel is 10 and PON is using SONET level-1 i.e. OC-1 ring for upstream transmission. Now one OC-1 supports line rate of 51.84 Mb/s so each user can have uploading speed up to 5.184 Mb/s.

Improvement in optical electronics devices helped us to use more dense SONET rings which supports higher data rates. now to increase this uploading speed we can use OC-12 inplace of OC-1.

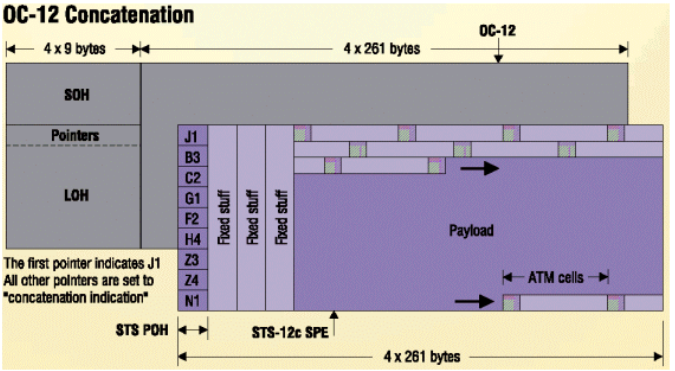


Fig. 4 Structure of an OC-12 SONET Frame

So, new upstream data rate is given by
New Upstream rate=51.84 * 12 = 622.08 Mb/s.
So per user uploading speed will be increased. On the other way no.of users per channel can be increased maintainig uploading speed constant for each user. So enhancement of upstream data rate is obtained effectively at the cost of increaed equipments complexity.

V. CONCLUSION

This paper presents the PON system, problems of data-rates for downstream and upstream links. Further paper provides solution to increase the data rates effectively using advanced techniques i.e.WDM and OC-12.downstram data rate is increased by factor of 10 and upstream data rate is increased by factor of 12.

VI. REFERENCES

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