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A Technical Review on Optical Access Networks

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Abstract. This paper has illustrated optical fiber technologies for the access networks. An access network is the network between Central Office (CO) and end users and is traditionally called last-mile networks. They are also called first-mile networks in recent years as they are the first segment of the broader network seen by users of telecom services. However, our research includes optical access networks and methods to deploy FTTH in user premises. Similarly, we review the advantages of PON, WDM-PON and their scope in future research field in this paper. We also review Hybrid network, in-band signal transmission process and their advantages for optical fiber transmission. To aid the future researches of passive optical networks and technologies is the main goal of our research.

Keywords: optical access network, PON, TDM-PON, WAN, FTTH

AMS Mathematics Subject Classification (2010): 91A28, 90B18

1. Introduction

The so-called last mile networks are known as access networks [1]. The "last mile" is the most expensive part of the network because there are far more end users than backbone nodes [2]. Example of access networks are i) twisted copper pairs connecting to each individual Household ii) residential coaxial cable drops from CATV service providers. Wi-Max is another type of access technology which uses radio waves for last-mile connectivity. Traditionally, optical fibers have been widely used in backbone networks because of their huge available bandwidth and very low loss. However, until the beginning of this century, fiber has not been used as the technology of last-mile connection. The most widely deployed "broadband" solutions today are Digital Subscriber Line (DSL) and Cable Modem networks. Although broadband copper-based access networks provide much higher data rate than 56 Kbps dial-up lines, they are unable to provide enough bandwidth for the tremendous growth of Internet traffic, emerging services such as Video-On-Demand, High Definition Television and interactive gaming, or two-way video conferencing. These Copper based access technologies are close to their bandwidth limit, and provide only few Mb/s per user over a short distance. These technologies generate a bottleneck at the gateway of the backbone to the access networks, shown schematically in Fig. 1. In this place there is often a lot of traffic causing to slow down or stop.

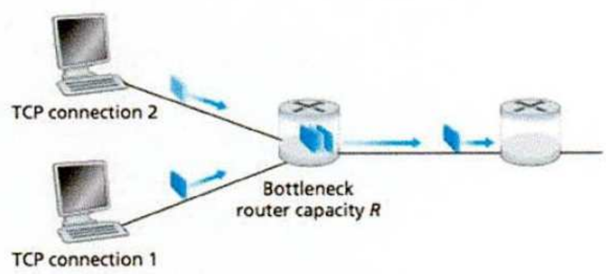

Figure 1: Multiple Connections share a common bottleneck to the access networks

Access network contrasted with the core network, (for example the Network Switching Subsystem in GSM) which connects local providers to each other. The access network may be further divided between feeder plant or distribution network, and drop plant or edge network. When the architecture of access network is based on wireless or wired (optical fiber) optical link is called optical access network and also shown below in Fig. 2

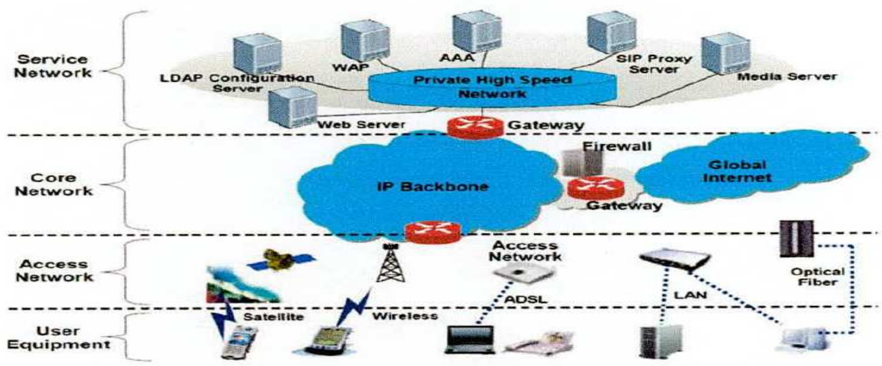

Figure 2: A typical optical networking architecture.

We can identify three ellipses representing the core network, the edge network, and the access network. The long-haul core network interconnects big cities, major communications hubs, and even different continents by means of submarine transmission systems. The core networks are often called the wide area networks (WANs) or interchange carrier networks. The edge optical networks are deployed within smaller geographical areas and are commonly recognized as Metropolitan area networks (MANs) or local exchange carrier networks. The access networks represent peripheral part of optical network and provide the last-mile access or the bandwidth distribution to the individual end-users. The common access networks are local area networks (LANs) and distribution networks. The common physical network topologies are mesh network (often present in core networks), ring network (in edge networks), and star networks (commonly used in access networks).

2. Brief on FTTx architectures

An enhancement of the PON supports an additional downstream wavelength, which may be used to carry video and CATV services separately. Many telecom operators are considering deploying PONs using a fiber-to-the-x (FTTx) model (where, x = building (B), curb (C), home (H), premises (P), etc.) to support converged Internet protocol (IP) video, voice, and data services—defined as "triple play"—at a cheaper subscription cost than the cumulative of the above services deployed separately. PUNs is in the initial stages of deployment in many parts of the world. In an FTTC system, fiber is connected to the curb of a community where the optical signal is converted into the electrical domain and distributed to end users through twisted pairs. Therefore, an FTTC system can also be regarded as a hybrid fiber twisted pair system. FTTx which brings high-capacity optical fiber networks closer to the end users appears to be the best candidate for the next-generation access network. FTTx is considered an ideal solution for access networks because of the inherent advantages of optical fiber in terms of low cost, huge capacity, small size and weight, and its immunity to electromagnetic interference and crosstalk. Fiber to the home (FTTH) is the delivery of a communications signal over optical fiber from the operator's switching equipment all the way to a home or business, thereby replacing existing copper infrastructure such as telephone wires and coaxial cable. FTTH is a relatively new and fast growing method of providing vastly higher bandwidth to consumers and businesses, and thereby enabling more robust video, internet and voice services. There are two important types of systems that make FTTH broadband connections possible. The straightforward way perhaps the most expensive one, is with active point to point (P2P) Ethernet technologies. Active optical networks depend on some electrically powered equipment, i.e., switch, router, multiplexer. Such networks are analogous to the conventional computer networks used in office and educational institutions.

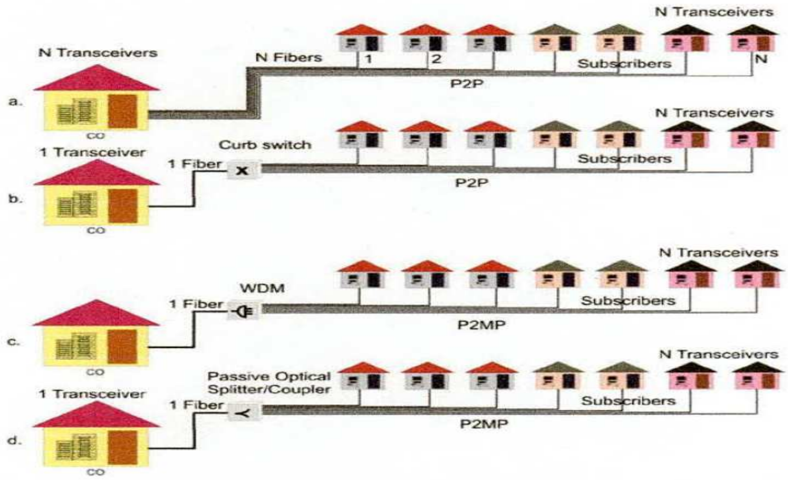

Figure 3: Different architectures for fiber to the home (FTTH).

Figure 3(a) shows direct P2P architecture which is simple but expensive because of its extensive use of fiber. Figure 3(b) shows a curbed switch which reduces the deployed fiber. Inauspiciously, the curbed switch is an active component which requires power supply and backup power. Figure 3(c) and Figure 3(c) referred passive optical network, where only passive optical devices, i.e., fiber, splitters/couplers, combiners, or web length multiplexer/de multiplexers, are used.

3. An overview on passive optical network (PON)

Passive optical networks are an ultimate broadband access solution for future Internet they bring many advantages such as cost-effectiveness, energy savings, service transparency and signal security over other last/first-mile technologies [3]. A typical design of PON is shown in Fig. 4.

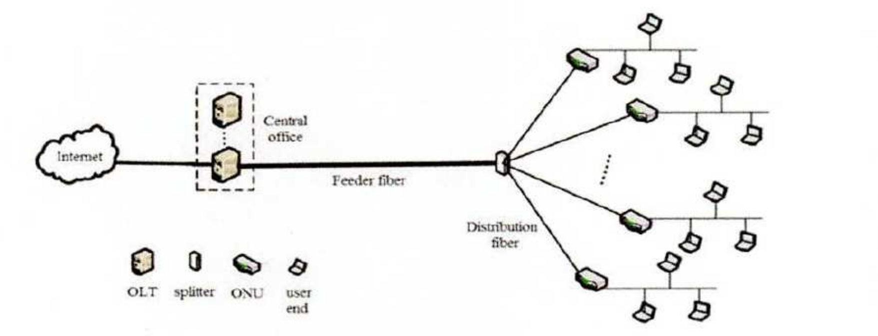

Figure 4: PON architecture.

Commonly PON has a tree topology. The OLT is located at the service provider's central office. The ONU is located near end users. The optical distribution network refers to the collection of fibers and passive optical splitters or couplers that lies between the optical line terminal and the various optical network terminals and optical network units connects them in the Central Office (CO) sequentially. The capacity of the feeder fiber is shared between all optical network units by means of time division multiplexing technology. Each optical network unit has the capacity according to the bandwidth distribution scheme [4]. Fig. 4 PON architecture. The key interface points of passive optical networks are in the Central office equipment called the OLT for optical line terminal and the CPE, called ONU for optical network unit (for EPON) and ONT for optical network terminal (for GPON). The main difference between optical line terminal and optical network terminal devices is their purpose regardless of their classification. Optical line terminal devices manage maximum up to 128 downstream links and support management functions. Generally, In the Central Office only 8-32 ports to be linked to a single optical line terminal. Therefore, the optical network unit devices are much less costly while the optical line terminals tend to be more capable and thus more expensive.

3.1. PON standards analysis

The currently deployed PON systems includes ATM PON, Broadband PON, Ethernet PON, Gigabit PON, 10G EPON, and Next-generation PON for different data rates. The initial PON specifications are ATM PON is defined by the FSAN committee. APON uses ATM as their signaling protocol in layer 2. In APON downstream transmission is a continuous ATM stream at a bit rate of I 55.52Mb/s or 622.08 Mb/s. upstream transmissions are in the form of bursts of ATM cells. Broadband PON as defined in ITU-

T G.983 series is a further improvement of the APON system [5]. With the purpose of achieving early and cost-effective operation of broadband optical access systems, BPON offers many broadband services including video distribution, ATM and Ethernet access. Ethernet passive optical network is a point to multipoint network topology implemented with passive optical splitters along with many advantages such as fine scalability, simplicity and the ability of providing full service access. Different types of PON and their standards are shown in the given Table 1.

Table 1: Comparison among BPON, EPON & GPON

	BPON	***EPON***	***GPON***
Standard	ITU G.983	IEEE 802.3ah	ITU G.984
Downstream speeds	622/1 244 Mbps	1244Mbps	1244 or 2488Mbps
Upstream speeds	155 Mbps or 622 Mbps	1244Mbps	155 to 2488Mbps
Downstream wavelength	1480-1500 nm	1500 nm	1480-1500 nm
Upstream wavelength	1260-1360 nm	1310 nm	1260-1360 nm
Protocol	ATM	Ethernet	Ethernet and ATM
Voice support	TDM over ATM	TDM over packet	Ethernet over ATM
Video Support	RF overlay	IP video	RF overlay
Number of splits	32	16	64
Distance	>20 Km	<20km	<60km

3.2. TDM-PON

TDM passive optical networks like Gigabit Passive Optical Network and Ethernet Passive Optical Network are now widely accepted as optical access network solutions to distribute reasonably high bandwidth to the customers through an optical fiber network infrastructure [6]. Fig. 5 shows TDM-PON architecture where, Fig. 5(a) shows downstream link (Broadcasting) and Fig. 5(b) shows Upstream link (TDM Traffic) for both link a single wavelength channel shared by all the users attached to a time division multiplexing passive optical network, the average dedicated bandwidth assigned to each user in either direction is usually limited to a few percent of the channel capacity i.e., a few tens of Mbps [7].

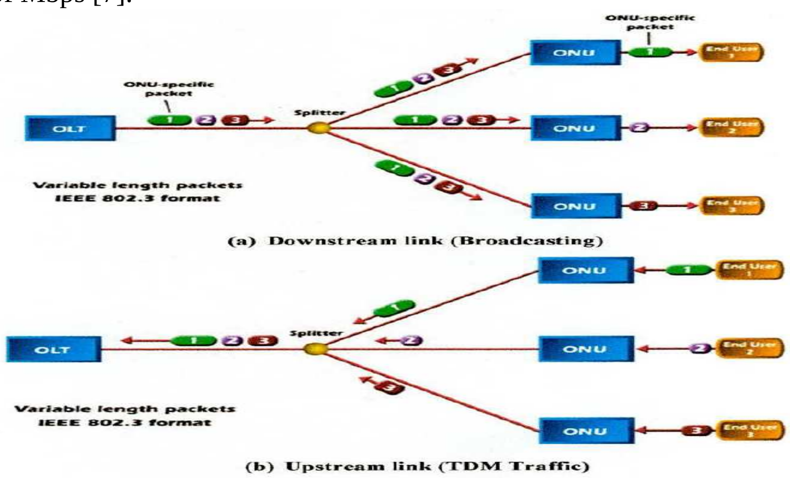

Figure 5: TDM-PON architecture

Due to lower maintenance costs and more reliable operation network operators tend to support the TDM-PON scheme. However, the bandwidth provided by one wavelength is shared by the whole optical network units in the network because the time division multiplexing passive optical network architecture provides only limited scope for improving the bandwidth performance. As compare to TDM, in WDM-PON architecture all the optical network units can transmit data independently since each optical network unit is assigned its own dedicated wavelength [8]. However, TDM-PONs has some drawbacks which hinder their future-proof application. These shortcomings can be outlined as follows:

- Security issues due to broadcasting nature of downstream traffic.
- Bandwidth sharing of upstream traffic which diminishes the maximum bandwidth
- offered by a single wavelength.
- Short coverage reaches due to the power split losses associated with the optical splitter.
- Complicated bandwidth allocation protocols.
- Requirement for ranging protocols and timely synchronization between nodes

3.3. WDM-PON

Wavelength division multiplexing is the ultimate solution for fast, efficient and secure bandwidth allocation in passive optical networks, and the subject of research proposals for next generation broadband access. WDM-PON was first proposed in WDM-PON systems can eliminate the complicated time-sharing issues in TDM-PON systems by providing virtual point-to point (P2P) optical connectivity to multiple end users through a dedicated pair of wavelengths. In addition to the advantages of high scalability and flexibility, longer transmission distance can be achieved because of the efficient use of optical power at the remote node. The architecture of a WDMPON system is shown in Fig. 6. The big difference in the outside fiber plant is replacing the optical-power splitter in a TDM-PON with an array waveguide Grating (AWG) to de-multiplex the downstream wavelengths and multiplex the upstream wavelengths. In the downstream direction of a WDM-PON, the wavelength channels are transmitted from the OLT to the ONUs on a single fiber using an array of tunable lasers located at the OLT. The wavelength channels are then de-multiplexed by an arrayed waveguide grating (AWG) router located at the passive RN, and a unique wavelength is assigned to each ONU port.

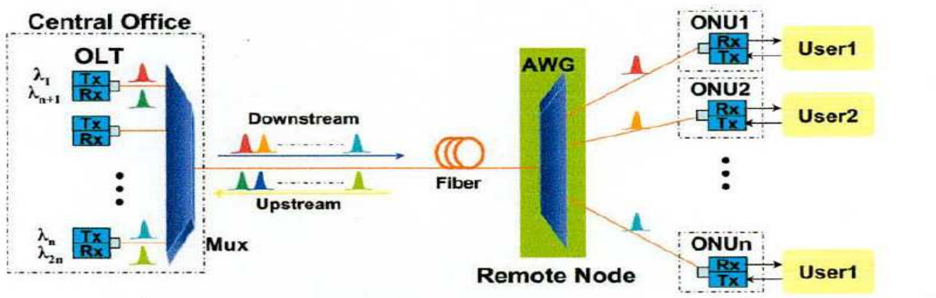

Figure 6: WDM-PON architecture.

The AWG ports are periodic in nature, where multiple spectral orders of input wavelength channels are routed to the same output port. This cyclic feature of the AWG allows for downstream and upstream transmission to occur in different wavelength windows. Within each wavelength window, the wavelengths are separated with wavelength spacing's determined by AWG ports. The Wavelength spacing's and wavelength bands are further discussed in the next section. Cost is the final factor to limit the commercial deployment of WDM-PON systems. To reduce the cost, many researches have been conducted on colorless ONUs based on centralized light sources using amplified spontaneous emission (ASE)-injected Fabry-Perot laser diodes (FPLDs), ASE-seeded reflective semiconductor optical amplifiers (RSOAs), and spectrum sliced RSOAs [9-10]. Other efforts have been carried out on the reduction of Rayleigh noise or remodulation noise for longer transmission distance, protection and restoration scheme, architecture design, and wavelength management.

4. WDM wavelength allocation

It is very important to allocate upstream and downstream wavelength channels with maintaining standards. The downstream and upstream wavelengths allocated to each ONU are intentionally spaced at a multiple of the free spectral range (FSR) of the AWG, allowing both wavelengths to be directed in and out of the same AWG port that is connected to the destination ONU. WDM allocates operational wavelengths to users in a systematic manner. The wavelength spacing for WDM networks can be categorized as either Coarse WDM (CWDM) with around 20 nm spacing or dense WDM (DWDM) with less than 1 nm. The spectral grid for CWDM is defined in ITU G.694.2, with a wavelength spacing of 20 nm. If the full wavelength band from 1270-1610 nm is used, it can house 18 individual wavelength channels seen in Fig. 7. CWDM networks have less stringent operational requirements for temperature-controlled environments due to larger spectral range. However, using a conventional single-mode optical fiber for these systems limits the number of available channels due to the presence of water peak attenuation in the 1370-1410 nm range.

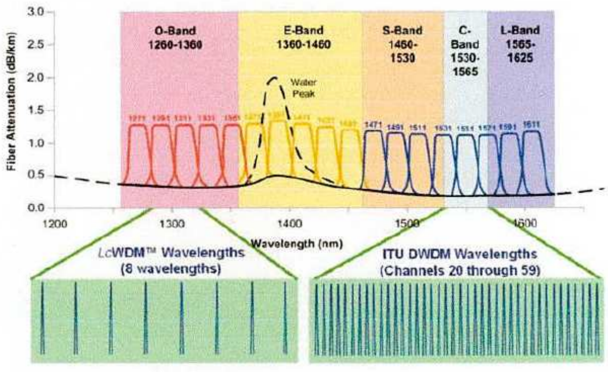

Figure 7: CWDM and DWDM wavelength grids based on ITU standards.

The wavelength spacing in a CWDM for all wavelength bands is shown in Fig. 7. In DWDM, on the other hand, the wavelength spacing can be as narrow as 0.2 nm (25 GHz). Because DWDM can allocate many wavelength channels within a narrow range; it is considered the ultimate solution for WDM-PON. The devices used for DWDM applications need to be controlled for cross talk between adjacent channels and also temperature controlled. Therefore, the DWDM scheme introduces more cost than CWDM. The multiplexing devices must also support the requirements for dense channel spacing with low channel cross-talk. The standardized wavelength spacing for 0.8 urn (100 GHz) channel spacing is shown in Fig. 7.

5. Bidirectional transmission in PONs

WDM allows bidirectional communication over a single fiber since it is a method of combining multiple laser wavelengths for transmission along a fiber media. This method also increases signal capacity. Bidirectional single-wavelength single-fiber transmission (BSFSW) is the most interesting scheme for application in the access network domain, mainly because of its cost-efficiency in terms of capital expenditure per customer (CAPEX). The share of cost per subscriber for the needed infrastructure and scalability in terms of both number of users and bit rate are fundamental constraints for the development of novel designs.

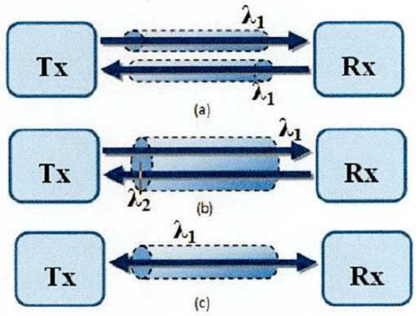

Figure 8: Bidirectional options for PON.

One of the major barriers of FTTH technologies is the deployment of new fiber infrastructure. The size of the outside plant is then a critical constraint when deploying the access network. The number of kilometers of fiber required and the number of optical fusions needed to connect the ONUs to the OLT depends not only on the network topology but also on the number of fibers used for the transmission. In Fig. 8 there are represented the basic options for bidirectional transmission. To deploy compact architecture in both directions, it is necessary to deal with general aspects of bidirectional transmission. A plain option is the two-fiber solution, consisting in one fiber for each direction, Fig. 8 (a). Even if this is not a cost-effective design, most of the actual commercial technologies for PONs are based on this architecture. The main reason is that optical components employed are less restrictive and inexpensive laser or even LED sources can be employed achieving correct transmission results. Single fiber transmission presents a more efficient solution because only half of the amount of fibers is necessary; as well, the cost for connectors, splices and other network components decrease. Transmission over a single fiber can be implemented using two strategies. The simplest is to transmit down-and uplink data using different wavelength Fig. 8 (b). Thus, the signals do not interfere with each other, as they are carried in separated frequencies. This option requires sources of different wavelength as well as and optical filters to divide up- and down-link channels. The second alternative consists in using the same wavelength in both directions; Fig. 8 (c).The last strategy presents a clear advantage for WDM networks, as wavelengths for both directions are now available especially for Coarse WDM (CWDM) networks where the number of wavelength is limited.

6. WDM PON architectures

Fig. 9 illustrates a typical WDM PON architecture comprising a CO, two cyclic AWGs, a trunk or feeder fiber, a series of distributions fibers, and optical network units (ONUs) at the subscriber premises. The first cyclic AWG located at the CO multiplexes downstream wavelengths to the ONUs and de-multiplexes upstream wavelengths from the ONUs. The trunk fiber carries the multiplexed downstream wavelengths to a second cyclic AWG located at a remote node. The second AWG de-multiplexes the downstream wavelengths and directs each into a distribution fiber for transmission to the ONUs The downstream and upstream wavelengths allocated to each ONU are intentionally spaced at a multiple of the free spectral range (FSR) of the AWG, allowing both wavelengths to be directed in and out of the same AWG port that is connected to the destination ONU. In Fig. 10, the downstream wavelengths destined for ONU 1, ONU 2..., and ONU N, are denoted by λ_1, λ_2, λ_N respectively.

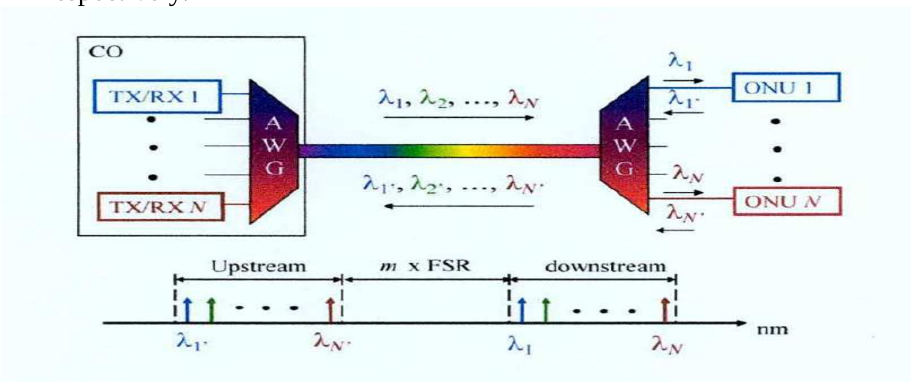

Figure 9: Architecture of a WDM-PON. Inset: Allocation of upstream and downstream wave length channels into two separate wavebands.

Likewise, upstream wavelengths from ONU 1, ONU 2..., and ONU N, that are destined for the CO are denoted λ_1, λ_2, λ_N respectively. In a typical WDM PUN, wavelength channels are spaced 100 GHz (0.8 nm) apart. In systems classified as dense WDM-PON (DWDM), a channel spacing of 50 GHz or less is deployed. Although a WDM PUN has a physical P2MP topology, logical P2P connections are facilitated between the CO and each ONU. In the example shown in Fig. 9, ONU N receives downstream signals on λ_N and transmits upstream signals on λ_N. The capacity on these wavelengths is solely dedicated to that ONU. Commonly cited benefits of WDM PUN resulting from this unique feature include protocol and bit-rate transparency, security and privacy, and ease of upgradeability and network management.

6.1. Tunable laser WDM PON

Fast tunable lasers are widely deployed in WDM-PON. Tunable lasers can also be considered for generating an upstream signal at the ONU. The concept is shown in Fig. 10. A dedicated tunable laser along with an external modulator is deployed at every ONU node. The laser spectral width is narrower than AWG spacing. Such deployment offers great optical performance and flexibility in terms of wavelength. The number of ONUs supported will be determined by the channel spacing of the AWGs, and the tuning range of the laser. The problem with this scheme is the high cost of a much more sophisticated laser at the source, need for maintenance, and an internal wavelength locker to ensure the laser operates at the correct wavelength channel. It has the benefits of long transmission distances & high bandwidth and Easy scaling of bandwidth, end users and reach. Since each ONU is assigned a unique upstream wavelength, distinct wavelength transmitters must be deployed at the subscriber premises. The simplest solution is to utilize fixed wavelength transmitters. Long transmission distances and high speed transmission can be achieved with this solution.

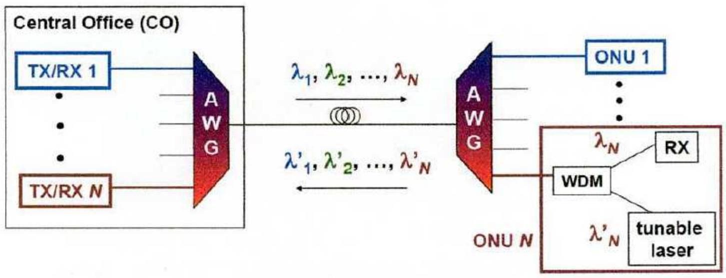

Figure 10: Tunable Laser WDM-PON.

However, such a network deployment would be cost prohibitive with increased complexity in network operation, administration, and management. Alternatively, identical tunable lasers can be utilized in all ONUs with each laser tuned to the pre-assigned transmission wavelength [11 -12]. Potential candidate technologies include tunable distributed feedback (DFB) laser[12]and tunable vertical cavity surface emitting lasers (VCSELs) [13]. The use of tunable lasers avoids the need for centralized light source(s) as compared to other solutions, and subsequently the Rayleigh backscattering penalty from using these CW source(s). However, true colorless feature necessitates prior knowledge of which wavelength each laser has to be tuned to. Also, some form of wavelength control must be implemented to ensure that crosstalk is minimized between the wavelength channels during operation and that the wavelength alignment between the AWGs and lasers is maintained. Reducing the cost of tunable DFBs and VCSELs are challenges that are currently being addressed. An additional constraint on tunable lasers for use in a dynamic WDM PON is the tuning speed [14-15].

6.2. Wavelength reuses WDM PON

In wavelength reuse schemes such as those proposed in [16- 17], the optical source is eliminated altogether in the ONU. Downstream wavelength channels are re-modulated with upstream data, and then sent upstream towards the CO. Fig. 11 depicts a WDM PON that uses the wavelength reuse scheme. Aside from carrying downstream signals, the downstream wavelength is used to wavelength seed an RSOA located at the designated ONU. Each RSOA is intentionally operated in the gain saturation region such that the amplitude squeezing effect can be used to erase the downstream modulation on the seeding wavelength [18].

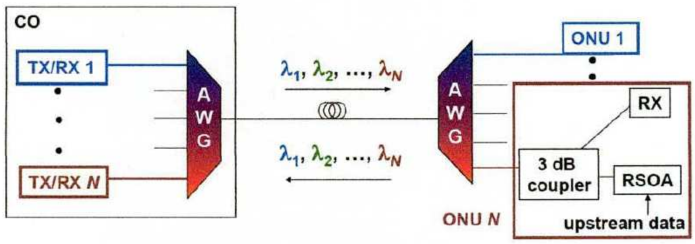

Figure 11: Wavelength Reuse WDM-PON.

As illustrated in Fig. 11, the downstream and upstream wavelengths designated to and from an ONU are identical. The benefits of the wavelength reuse scheme include the re-modulation of the downstream wavelength channel, thereby eliminating the need for seeding sources, is less costly than using tunable lasers, and direct modulation of the RSOA. However, upstream performance can be severely degraded by the interference between the residual downstream and upstream data at the CO. A solution to minimize residual downstream modulation is to ensure that the upstream and downstream modulation formats are orthogonal. In [19], phase modulation and frequency shift keying modulation are used for the downstream modulation with upstream being modulated with the on-off keying (OOK) format. In another solution reported in [20], data is RF subcarrier modulated onto a carrier and sent downstream towards the ONU. At the ONU, the carrier is filtered and then modulated with upstream data. Therefore, to minimize residual downstream signal, unconventional modulation formats and thereby unconventional transceivers must be used. Recently, line coding approaches such as Manchester coding [21] and DC balanced line coding [22] have been demonstrated to eliminate the DC component on the downstream data to improve upstream performance in a WDM PON.

6.3. Coherent injection and seeding WDM PON

In addressing the potential large inventory and cost of wavelength specific sources, researchers have been concentrating on developing cost-efficient and wavelength independent sources termed "colorless" sources. Optical light originating from the CO is fed into the ONUs to injection- lock Fabry—Perot laser diodes (FP LDs) [23]—[24] or to wavelength-seed reflective semiconductor optical amplifiers (RSOAs) [25]—[28]. As illustrated in Fig. 12, the injection- locking or wavelength seeding light may be furnished by CW light from a centralized light source located at the CO. The wavelength seeding scheme is identical to the injection-locking scheme except for the use of an RSOA which amplifies and modulates the incoming continuous wave (CW) light.

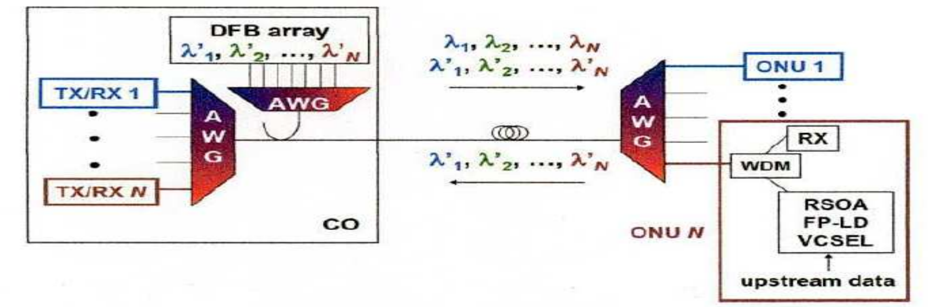

Figure 12: Coherent-injection and CW-seeding WDM-PON

As the transmitting wavelength of a colorless ONU is determined externally by the wavelength of the incoming light, all ONUs may be implemented with identical FP-LDs or RSOAs. Fig.12 uses DFB laser array that is placed in CO where ONU N receives downstream signals on and transmits upstream signals on transmits from CO towards ONU N and a reflective modulator use it to modulate the upstream data and sent back to CO.

7. Hybrid transmission

Hybrid is defined as combination of base band and RF (broadcast) signal transmission. Hybrid WDM- PON is defined as a PON in which separate wavelength for broadcast services or by sharing a single wavelength for both baseband and broadcast data traffic to establish communication between the OLT and number of ONUs.

7.1. Separate wavelength hybrid WDM- PON

To increase the utility of WDM-PON, it needs to supply diverse services such as video-on-demand and multimedia broadcasting using a minimum number of wave lengths. The Hybrid WDM-PON architecture is shown in Fig. 13. A CO consists of a distributed feedback laser diode (DFB-LD) array which offers the wavelength from λ_1, to λ_N for downlink. Baseband signals are carrier by wavelength, i) 1 and broadcast (RF) signals are carrier by another wavelength λ_2. Then the optical signal is transmitted from the CO to the ONUs through an AWG at the remote node (RN).

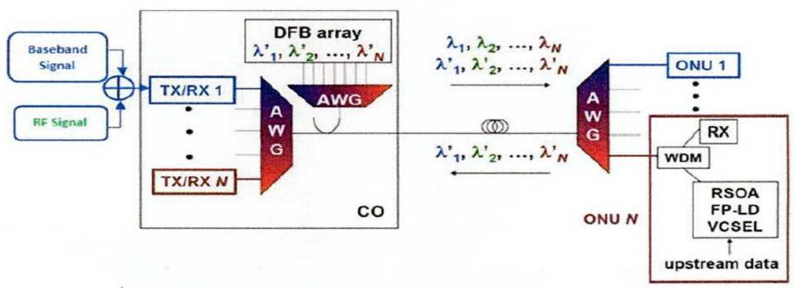

Figure 13: Separate wavelength Hybrid WDM- PON

At the ONU side, signal received by colorless ONU is determined externally by the wavelength of the incoming light, all ONUs may be implemented with identical FP-LDs or RSOAs. Fig. 13 uses DFB laser array that is placed in CO where ONU N receives downstream signals on and transmits upstream signals on transmits from CO towards ONU N and an reflective modulator use it to modulate the upstream data and sent back to CO. For each wavelength window, the wavelengths are separated with wavelength spacing's determined by AWG ports but the transmission cost is high. To reduce the cost of separated wavelength we need to build up a architecture by using single wavelength for different service.

7.2. Single wavelength hybrid WDM- PON

For simultaneous transmission of the baseband signal and subcarrier multiplexing (SCM) signals for broadcasting service using a single source. Fig. 14 shows the schematic diagram of the WDM-PON link. Basic link structure of the WDM-PON scheme is the same as the link structure where RSOA in ONU re-modulates the downstream source as an upstream signal. In CO. the baseband digital signal for downstream data service and the SCM signal for broadcasting service are simultaneously modulated using a single distributed feedback (DFB) LD. A portion of the C downstream source containing the broadcasting signal is detected by PD in ONU and electrical filters separate the digital and SCM signals.

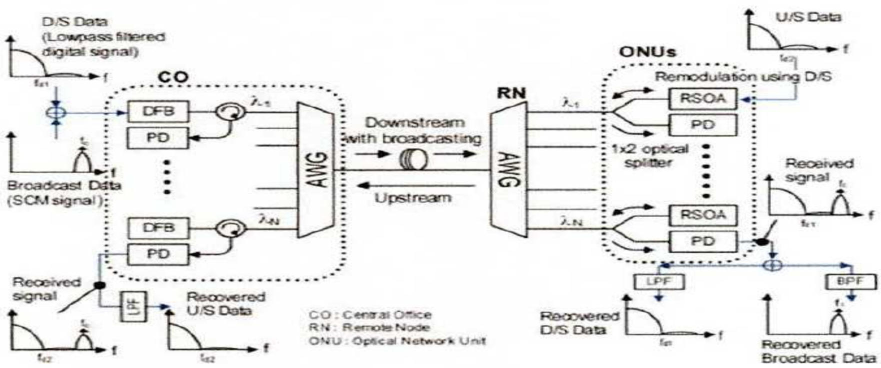

Figure 14: Schematic diagram of single wavelength WDM-PON link [29].

The residue of the downstream source becomes injected in RSOA as a seeding source and remodulated by RSOA with the digital signal for upstream. For an effective re-modulation using an RSOA, an extinction ratio (ER) of the downstream signal should be small enough to be suppressed by a high-pass characteristic of RSOA. Fortunately, since the reduction of ER is required to minimize the signal distortion in simultaneous modulation of the digital and SCM signals using a single LD, generate downstream containing the broadcasting signal suitable for re-modulation of RSOA. The unsuppressed SCM signal in the re-modulation process could be removed by a simple electrical low-pass filtering in CO [33]. Since each transmitter in CO can offer the different broadcasting service, the proposed WDM-PON scheme can provide adaptive broadcasting service satisfying the diverse demands of customers. The ER of the digital signal in downstream is a key factor to determining the performance of all signals in up/downstream. This cost-effective, colorless WDM-PON overcomes the wavelength selectivity feature by using RSOAs as optical modulators at both the OLT and the ONUs. Also, the SCM-based broadcasting service can be stably offered without performance deterioration of the digital signals both in upstream and downstream.

8. In-band simultaneous transmission

Different approaches have been proposed, where a single wavelength can be shared by both the baseband and broadcast data where the system utilizes the subcarrier multiplexing (SCM) signals for broadcasting service and finally combined with baseband data to modulate a single optical source. Here, we want to study about an approach where a wavelength reuse RSOA based bidirectional WDM-PON is proposed for the transmission of both baseband and broadcast data in single wavelength [30-32]. The proposed wavelength reuse bi-directional RSOA based WDM-PON with in-band transmission of both unicast and broadcast data is shown in Fig. 15 (a)

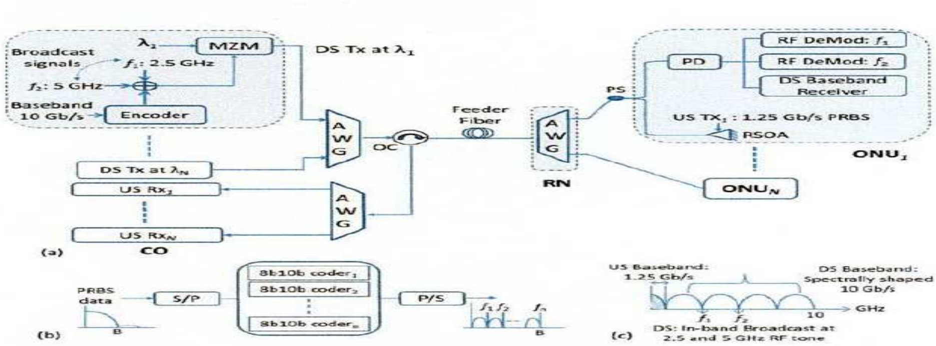

Figure 15: a) Proposed architecture of broadcast overlay wavelength reused WDM-PON. b) Encoder for spectrally shaped 8b10b coded signal. c) Bi-directional transmission with spectral separation of downstream and upstream signals.

Fig. 15 (b) shows the architecture of encoder where incoming PRBS serial data stream is parallelized in n blocks, each of which individually encoded to 8b10b data and finally, transmitted again as a serial stream. Fig.15 (c) shows the proposed approach of bi-directional transmission with minimized re-modulation noise in 10 Gb/s 8b10b coded spectrally shaped downstream for carrying RF data overlay on baseband signal and 1.25 Gb/s PRBS upstream. Due to the effective suppression of frequency components from DC to 1.25 GHz in 8b 1 Ob coded signal, the upstream data with 1.25 Gb/s PRBS can be transmitted over the downstream modulated signal by spectral separation [34]. Finally, the re-modulated wavelength with 1.25 Gb/s US data is transmitted over the same feeder fiber and received by the PD in CO through an optical circulator. Therefore, the proposed WDMPON with spectrally shaped downstream baseband signal is not only carrying the in-band broadcast signals but also reduces the re-modulation noise for the transmission of upstream signal with the same wavelength.

8. Conclusion

With a view to introduce different optical fiber access networks and technologies, this paper is introduced. The methods to deploy FTTH in user premises, Hybrid network, in-band signal transmission process, etc., are the key concern of this paper. We believe that this review can help the researchers of these sectors.

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