INSTITUTE OF RESEARCH ADVANCES

IRA-International Journal of Technology & Engineering
ISSN 2455-4480 Vol. 03 Issue 01 (April, 2016)
Paper DOI: https://dx.doi.org/10.21013/jte.v3.n1.p2

Wavelength Allocation in Passive Optical Networks: A Survey

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ABSTRACT

In the preceding years, the research society and genuine users have enabled to increase the consideration of Passive Optical Networks. Several authors discussed the various wavelength allocation techniques for different layers. This paper provides a detailed study about all the existing wavelength allocation techniques and also explains about limitations available in the techniques. Wavelength allocation includes 1524-1544 nm in upstream direction and 1596-1602 nm in downstream direction. Finally, this paper concludes with insights for research techniques about wavelength allocation in Passive Optical Networks.

Keywords: DWBA, Energy efficiency, Long reach, Passive Optical Network, Wavelength allocation

Introduction

An Optical Network by using optical fibers connects computers. These provide reduced cost and higher capacity due to the optical layer present in it.

Passive Optical Network has increased its name in the recent years as it provides high speed internet. It has high bandwidth Point to multipoint optical fiber network based on Asynchronous Transfer Mode, Ethernet or Time Division Multiplexing. For data transfer it rely on light waves. It minimizes the fiber consumption in both the local loop and local exchange office. It is a single, shared optical fiber that uses splitter to segregate the signal towards individual subscribers. It is a network that provides broadband services to users with the help of optical fiber access. The practice of passive architecture reduces cost. Passive Optical Network is called passive because there is no active element other than at the central office within the access network. Is enables the provider to convey a true triple play submission of video, data and voice. These are getting more useful and well-known in rollout of Fiber to the Home infrastructure.

The rest of the paper is prearranged as follows: In Section 2 Architecture of Passive Optical Network is considered. In Section 3 Related work is surveyed. Section 4 is all about the parameters. Section 5 evaluates the performance of the various parameters. Section 6 summarizes and concludes the paper. Finally, in Section 7 future scope of the work is presented.

1. PON ARCHITECTURE

The elements of Passive Optical Network are:

- Optical Line Terminal
- Passive Optical Splitter
- Optical Network Unit

The **Optical Line Terminal** is placed in a central office and reins the bidirectional flow of information across the ODN (Optical Distribution Network). An OLT support transmission distances across the ODN upto 20 km. Each OLT is tasked to shun interference among the contents of downlink and uplink channel, using two dissimilar wavelengths superimposed. For this, techniques for WDM are used, and are based on the use of optical filters.

Splitters are passive power dividers that allow communication between the OLT and their relevant ONT who serve. However, not only are committed to multiplex or demultiplex signals, but also combine power: they are bidirectional optical distribution devices with one input and multiple outputs. The actuality of being passive elements, it allows them to operate without external power, lowering their cost of deployment, operation and preservation. They just introduce optical power loss on communication signals, which are intrinsic in nature.

An **Optical Network Unit** normally is housed in an outdoor equipment shelter. These installations include shelters located in a centralized place within an open area. Thus, the ONU equipment must be environmentally rugged to withstand huge temperature variations. The shelter for the outdoor ONU must be water-resistant, vandal-proof. In addition, there has to be a local power source to run the kit, together with emergency battery backup. The link from the ONU to the customer's location can be a twisted-pair copper wire, a coaxial cable or an independent optical fiber link. An unconventional approach is to allow ONUs to adjust their transmitter powers such that power levels received by OLT from all ONU become identical.

2. RELATED WORK

The researchers have worked a lot on wavelength allocation in the field of Passive Optical Network. In this paper, survey of work from 2013-2015 is being done.
In 2013, the highly flexible and efficient model for quality of service of WDM-EPON was proposed for converged triple play networks [18]. The network model was

developed in MATLAB. The limits on high bit rate wavelength reuse by using ultralong semiconductor optical amplifier by modulating amplitude upto 56Gb/s was revealed [17]. FDMA-PON with low speed ONU at data rate of 31.25 Gbit/s was described [16].

In 2014, OFDM based Metro Access Integrated Network was studied [15] to enable scalable virtual private network by placing light sources in central office. [13] gave energy efficient solution for reconfigurable long reach ultra flow access network by installing layers of switching devices at central office and remote node.
In 2015, the demonstration of OFDM-PON with multiband ONU and elastic bandwidth allocation was carried out at 2.5/5 Gb/s [11]. Downstream and uplink were measured on direct detection and intensity modulation. Scalability of λ tuning sequence was done at Dynamic Wavelength Allocation in WDM/TDM PON that induces no data frame loss [9]. Wavelength pre assignment was proposed for WDM/TDM PON in λ tuning protection method [7]. Energy savings and network performance was described for reconfigurable TWDM-PON [4]. Designing and evaluation of elastic optical network based on technology of WDM and OFDM was realized. The simulation of performance of system in both downlink and uplink was carried out [1].

In this comprehensive study of work done by various scientists, researchers and engineers with regard to study of wavelength allocation in Passive Optical Network is studied. In previous years firstly the state of art of PON, architecture and components were described and several open research issues were taken into consideration so that it can be taken as challenges so as to improve the performance of PON. Various advantages and disadvantages were also discussed. Different kind of algorithms are studied to optimize wavelength allocation

2.1 GAPS OBSERVED

- Average frame delay is deeply affected by tuning time while slightly by timeslot duration.
- Nyquist OTDM-WDM network must be highly efficient.
- Processing effort can be reduced by increasing the number of sub bands and oversampling factor.
- The additional cycle in DWPBA-TCH model degrades the system performance.
- DWBA algorithm for hybrid WDM/TDM PON must include impact of lasers.
- By enabling ultra-high spectral efficiency, and low-complexity, the approach achieves a breakthrough for future high-capacity Mobile Front Haul systems.
- The experimental platform of SPP algorithm to authenticate the simulation results will be designed.
- The EAM can be replaced by a product with inferior loss.
- A reflective EAM, polarization-independent MZM could be employed to save preamplifying SOA.
- Oversampling can be reduced from a factor of 2 to 1.33..

3. PON PARAMETERS

- **Bandwidth:** It is the range of wavelengths over which manufacturer guarantees performance of device. It is quantified using Hz.
- **Insertion Loss:** It is the optical power loss caused by insertion of component into fiber optic system. It is measured in decibels.
- **Transmission distance:** When an acoustic wave travels during a medium, its intensity decreases exponentially with distance travelled.
- **Data rate:** It is the number of bits that are conveyed or processed per unit time. It is quantified using bits per second. 1 byte/s = 8 bit/s
- **Carrier frequency:** It is the frequency of unmodulated electromagnetic wave at output of conventional amplitude/frequency/phase modulated radio transmitter.
- **Radio frequency:** It refers to sporadic current having features such that if current is input to antenna, an electromagnetic field is generated appropriate for wireless communication.
- **Throughput:** It is the rate of flourishing message delivery above a communication means. The data these messages go to may be delivered over physical link or it can pass through any network node.
- **Bit Error Rate:** It is the number of bit errors per unit time. The number of bit errors is number of received bits of data stream over communication channel that have been altered due to noise, distortion and interference errors.
- **Optical Power Budget:** It is the allocation of accessible optical power amongst various loss producing mechanisms such as connector losses and coupling loss to ensure that adequate signal strength is available at receiver.

4. PERFORMANCE EVALUATION

Different parameters have been considered after survey of unlike papers based on wavelength allocation in Passive Optical Networks.
Following are the considered parameters:

- No. Of ONU
- Transmission distance
- Data rate
- Bandwidth
- Network Reach
- Wavelength tuning time
- Throughput

After comparing dissimilar parameters, the best values are determined for the system to work most excellent in a desired condition.

4.1 COMPARISON OF NO. OF ONU

Different PON's proposed by researchers have diverse number of ONU. These number of ONU are being compared in a tabular form as shown in table 1 and the corresponding graph is also given in figure 1.

Table 1 Comparison of No. Of ONU

S.NO	WAVELENGTH ALLOCATION	NO. OF ONU
1	[1]	32
2	[3]	64
3	[6]	64
4	[7]	32
5	[13]	32
6	[14]	128
7	[18]	64

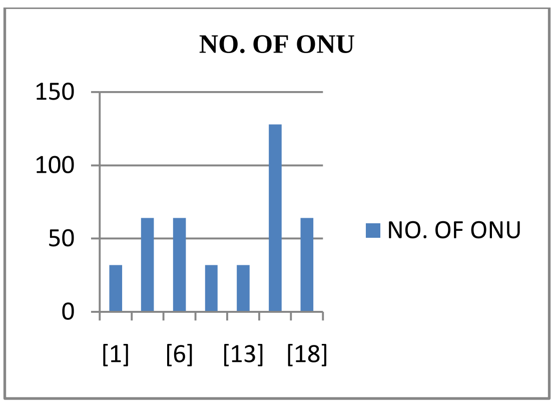

Figure 1 Comparison of No. Of ONU

As of the graph it can clearly be concluded that the wavelength allocation [14] shows the maximum number of ONU compared to all the other six allocation techniques.

4.2 COMPARISON OF DATA RATES

A comparison among the values of data rates is being carried out for the different proposed wavelength allocation techniques by various researchers. The data rate is in gigabits per second. The values of data rate is written in a tabular form as shown in table 2, also the graph between the different values of data rate is being plotted as shown in figure 2

Table 2 Comparison of Data Rates

S.NO	WAVELENGTH ALLOCATION	DATA RATE(Gb/s)
1	[2]	0.108
2	[3]	40
3	[4]	0.256
4	[7]	4.5
5	[9]	10
6	[17]	10

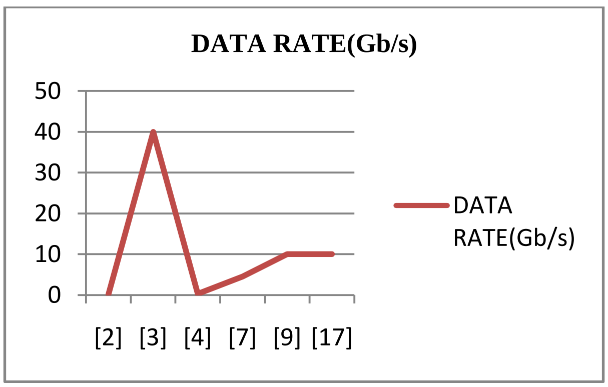

Figure 2 Comparison of Data Rates

On seeing the graph above it is clearly observed that the wavelength allocation [3] has the maximum data rate. Hence it is better than the other five proposed techniques in terms of data rate.

4.3 COMPARISON OF BANDWIDTH

The different values of bandwidth are compared between six wavelength allocation techniques of lightwave technology. Bandwidth is in gigahertz. It is the range of frequencies. Further wavelength is inversely proportional to frequency. It differs according to the technique used like WDM, EPON, OFDM etc. The comparison table of varying bandwidths is shown in table 3, also the analogous bar graph is shown in figure 3. The bandwidths defined are at different wavelength intervals and also depend on data rate.

Table 3 Comparison of Bandwidth

S.NO	WAVELENGTH ALLOCATION	BANDWIDTH (GHz)
1	[2]	0.02
2	[6]	11
3	[10]	1
4	[11]	2.5
5	[15]	3
6	[16]	15.625

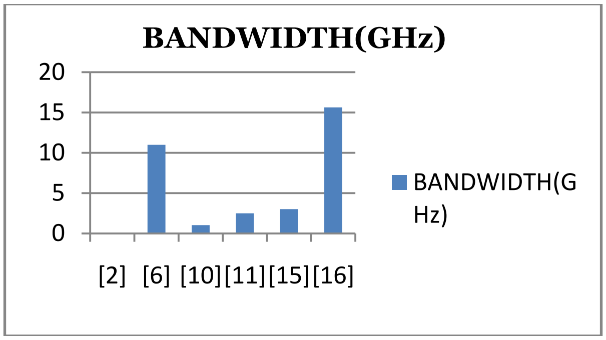

Figure 3 Comparison of Bandwidth

A comparison graph for bandwidth shows that the wavelength allocation [16] has better performance.

4.4 COMPARISON OF Λ TUNING TIME AND THROUGHPUT

The values of λ tuning time and throughput are compared between two wavelength allocation techniques. λ tuning time is in nanosecond while throughput is in gigabits per second. The comparison table in shown in table 5, also two different graphs ,the first one comparing the values of λ tuning time and the second one comparing throughput are shown in figure 5 and 6 respectively.

Table 4 Comparison of λ tuning time and throughput

WAVELENGTH ALLOCATION	λ TUNING TIME(ns)	THROUGHPUT (Gb/s)
[7]	100	4.5
[9]	100	8.7

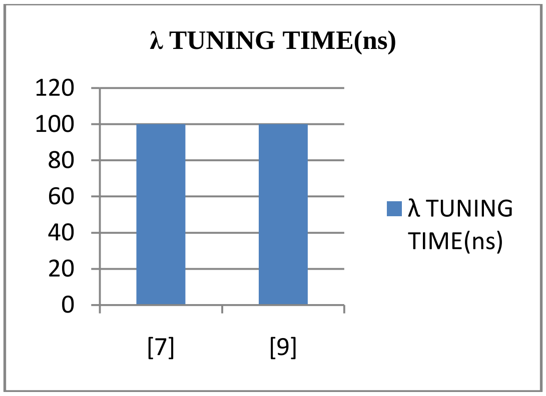

Figure 4 Comparison of λ tuning time

By seeing the graph a comparison could be made and concluded that both the techniques have same value.

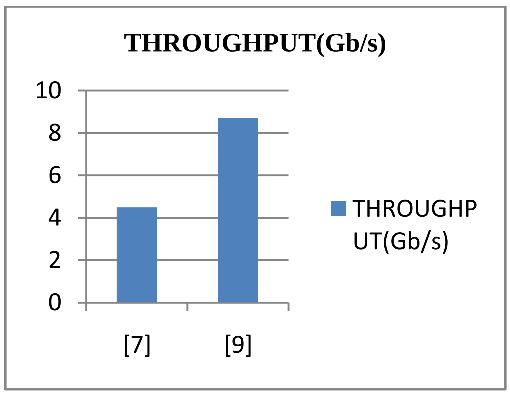

Figure 5 Comparison of throughput

A comparison graph for throughput shows that the technique [9] has better performance.

4.5 CONCLUSION OF PERFORMANCE EVALUATION

A comparison among different parameters of wavelength allocation like bandwidth, throughput has been successfully made and it can be seen that the wavelength allocation technique [16] has the highest bandwidth. The transmission distance is maximum for technique [10]

5. CONCLUSION

The algorithms used and parameters evaluated are concluded in brief. The system architecture for Passive Optical Network is capable of addressing the strict requirements. By utilizing a wavelength the architecture is able to support flexible and dynamic allocation without sacrificing efficiency. The architecture has been validated throughout the improvement of software operating. With the increasing popularity and applications of Passive Optical Networks, wavelength allocation has become an essential requirement to ensure upstream and downstream transmission between optical network unit and optical line terminal. Different kinds of algorithms are studied to optimize wavelength allocation. The elastic optical access system based on wavelength-division multiplexing, in which finer bandwidth allocation granularity is there a flexible wavelength switch are realized. The principal focus of this work is to present a survey on widely used algorithms used in Passive Optical Network and to study various types of techniques of wavelength allocation.

6. FUTURE SCOPE

Further researches on wavelength allocation in Passive Optical Network should be conducted. In the coming future, access based on the PONs will be dominant. The introduction of PONs with WDM access is a huge area for research. In such a network, the OLT will have to formulate decisions not only about allocating time slots to ONUs but also about choosing an appropriate wavelength to carry the signal. As the complexity of such a system is much higher, the problems faced by the bandwidth allocation algorithm are harder to solve. A possible research work for the future is to design a added flexible architecture for WDM-PONs, which can not only support multicast data transmission but also provide self-protection. In the meantime, a novel energy-saving scheme for WDM-PON could be also incorporated. developing a potentially small cost WDM-PON based on self-seeding reflective semiconductor optical amplifiers will be much desired. Nevertheless, several key technical issues should be some investigated that could severely affect the transmission performance of self-seeding RSOAs. DBWA algorithm for hybrid WDM/TDM PON must include the investigation of the impact of the lasers tuning time on the performance of such allocation schemes. By increasing the number of sub bands and by employing a rational oversampling factor, the processing effort can be further reduced.

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