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Analysis of Advance Modulation Format Using Triple Play Services in WDM/TDM PON and Scaling Technique: A Review

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Abstract: Today's optical network media is not expensive anymore with end to end communication system. PONs are the upgraded version of fiber to home access networks. APON, BPON, EPON and GPON are some of recent PON technologies. Different factors like bandwidth utilization jitter and delay plays a major role in PONs standards. In telecommunication Triple play service make a connection with single broadband services, these two bandwidth services are broadband, Internet access and telephone. Triple play services play a major role in PONs standards. Different PON architectures are analyses with the use of different filters. The performances of different system are compared with current state of art PON architecture. Hybrid WDM/TDM network is one of the best choice as it eliminates all the practical problem in time division multiplexing and wave length division multiplexing. With increase in data consumption sharply, scaling technique of triple play services in passive optical networks optimized the allocation of data transmission.

Keywords: Fiber to the home (FTTH); Optical line terminal (OLT); Optical Network Unit (ONU); Remote Node(RN)

I. INTRODUCTION

In Today's world, access network have to be compactable with great requirement, high reliability, performance, and be cost efficiently. These requirements make system efficient to FTTH networks. Low cost and reliability was achieved by requirement. At the customer level, premises used a passive optical network in FTTH networks that's why they are called passive optical network. Tree topology is used to maximize the coverage with minimum network splits. This is reducing the optical power. TDM-PON deliver Broadband PON with downstream of 622Mbps, Ethernet PON 1.25Gbps downstream, and Gigabit PON with 2.5Gbps downstream. Gigabit-capacity passive optical network is the basic technology to help the structure of next generation fiber to the home (FTTH) system. It helps in multi speed rates, full service, high efficiency and other advantages. For the broadband access network best technique is GPON. An amplifier between the transmitter and the splitter is use to increase the transmission distance of the system.[1]

WDM transmitter is use as a seeding source with wavelength of 1550 nm with a bidirectional fiber to home technology. In FTTH architecture, travelling wave semiconductor optical amplifier (TSOM) is demonstrate for upstream and downstream channel. To meet data rates in optical links in today's PON access networks, this scheme is practical solution.[2]

APON i.e. ATM passive optical network is one of the full service access network that belongs to telecommunication standardization network of international telecommunication union (ITU-T). It is an asynchronous transfer mode cell having upstream data rate of 155Mbits/s. It consists of 43 byte of payload and 5 byte of header and can support 32 subscribers. Its wavelength is centred as 1390 nm.[3]

Another network evolved from APON is broadband passive optical network (BPON). This network supports triple play services. It has many feature like increased quality of services and upstream channel usage DBA, video broadcast service at 1550 nm and increased data rate.[3]

EPON i.e. Ethernet passive optical networks are use to increase the quality of service and provide full duplex transmission mode development Ethernet. One of the disadvantages related with EPON is that it requires 13% more bits to transmit IP datagram. [4]

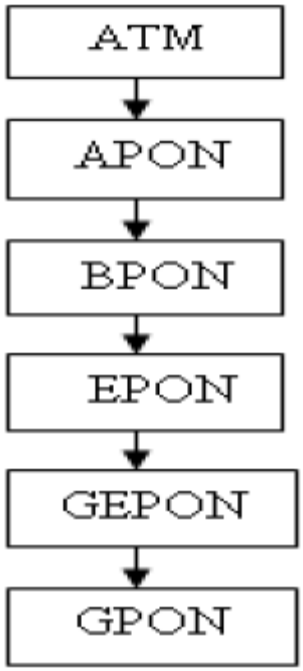

Figure 1. PON Standards[1]

Gigabit Ethernet passive optical network (GEPON) is a optical fiber based new technology in wired access network that provides low cost and high bandwidth access more than longer distances to the subscriber locations. Worldwide interoperability for microwave access (WiMAX) is also a promising low cost new generation wireless access network technology that is able to given the long reach high bandwidth, mobility management, and finely provisioned quality of service (QoS). These technologies are similar for instance, they both have a broadcast and select style

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downstream and a shared upstream. These are low-cost and far-reach new-generation access network technologies, but operate over different interfaces like that wired and wireless interfaces, respectively. [5]

Gigabit passive optical network (GPON) technology is one of the best technology to meet the demands of high speed internet access (HSI) and video on demand (VOD).While asymmetrical digital subscriber line (ADSL) technology was not able to do so. For broadband access network in future, GPON is the one of the best choice and it is defined as the point to multipoint mechanism.[1]

Now a day, Gigabit-PONs is mostly used to meet different requirements. The need of high speed access for transport new bandwidth consuming services and application like that HD TV, online gaming, VOD, and video conference. The CO and the RN services required a high speed internet connection. The wide area broadband access network give the high speed connection to the services.PON services provide the low cost subscriber network to the fiber-to-the-home system. They are upgradability, large capacity and flexibility. These unlimited bandwidth qualities are make it promising candidate.[6]

WDM PON was one of the best technique in PON networks. It provided two types of video services i.e. unicast and multicast service. The basic difference between two type of services was that in unicast services like VOD, its depends upon users that what content had to be delivered and at what time where as in multicast service, the schedule content of broadcast service providers were served to users. Video head end was one of the element of video service that broadcasted video contents and acted as a content administrator. Each connection in Vod formed a service based VLAN.[7]

Two major standards for PON network are Ethernet PON and Gigabit PON. The two were differentiated on basis of their philosophies as EPON was based on simple standard with lose hardware requirement where as the latter one depends on relatively complex standard including tighter hardware requirements.[3]

In scaling technique of triple play services, fairness of services was maintained by giving different scalability on main services. This technique was provided the portion of bandwidth by allocating the different portion of subcarrier for every type services. Different throughputs were obtained and fairness of service was achieved.[8]

The Delineation of Triple Play Services in WDM/TDM PON and Scaling Technique:

In year 2004, WDM-PON system was used as a platform for triple play services (TPS) which required 75 Mb/s per subscriber data rate for convergence. TPS is basically a combination of integrated voice, video and data communications and converged network is used for its delivery. Amplifier spontaneous emission (ASE)-injected Fabry-Perot laser diode scheme was employed in this system. Ethernet was adopted as second layer and it consists of 32 channels of 125Mb/s. Many services such as high definition broadcast internet protocol, video telephone, video on demand and voice over internet protocol were demonstrated using the WDM-PON system. To optical the access networks, FTTH is more favourable because the infrastructure having copper was not supporting the required bandwidth. As there was no practical solution for WDM light source, WDM-PON was less successful in commercialization but it has some prestigious features compared to TDMA-PON. ASE-injected FP-LD scheme in WDM-PON showed FP-LD as WDM light source having operating wavelength of 40nm. C and L bands were used for upstream and downstream respectively thin film filter in ONU and OLT separated the AWG in RN and OLT. The result showed that sensitivity was -38 dBm with bit error rate of 10^{-9} at 155Mb/s. VLAN and multicast feature in Ethernet protocol were effective in IP broadcast and services such as data, video and voice. WDM-PON system successfully demonstrated HDTV broadcasting, VoIP, video telephony services and VOD.[9]

Coming to year 2005, advances in optical access networks were discussed. EPON is the only access network architecture that privately enterprises data networks. Main emphasis was on preserving the architectural modal of Ethernet. No framing structural exist in EPON and frames were transmitted in burst with certain gap in frames many algorithm like DBA assumes that the total available bandwidth in EPON is 1Gbps and it is constant it requires future upgrade because 1Gb capacity was not large enough to accommodate more than 100HDTv broadcasting channel wavelength upgrade scenario shifts the existing wavelength to new wavelength where as in spatial upgrade scenario some ONUs migrates to new PONs. So, wavelength and spatial upgrade scenario are the two upgrading methods in EPON. To add certain path and redundancy two PON for fast protection switching by the use of different alternatives.[3]

After that in year 2006, different technology and method for delivery IP triple play i.e. voice, video, data over GEPON and GPON were discussed. The services were TDM over PON via PWE3, IP TV and voice over IP. The bandwidth was leveraged by the providers on the PON to deliver VLAN and 802.1p priority bit services. Minimal no of ALLOC Id's(allocation ID) for GPON expedited the role out of triple play over PON. So PON technology expended the services and delivers the full triple play over IP having voice, video and data.[10]

Then in year 2007, a novel WDM PON architecture having multiple new optical add drop multiplexers was used for next generation PON. The traffic was bidirectional and system was operating at 2.5Gb/s for triple play services. Basically the needs and advantages of WDM-PON for next generation access network were discuss this propose architecture used addition PON OADM having the capability to virtually limitlessly scale the network with no change to existing network this OADM imposed 1DB power penalty with an error free 2.5Gb/s transmission run 30 KM passive optical link. This scalability feature of this architecture was the main advantage and multiple logical wavelength light tree's was created by new design PON OADM.[11]

Again in year 2007, a novel WDM PON architecture having centralized light wave source in OLT for providing triple play services was proposed and demonstrated. In WDM PON network a subcarrier carries the signal and optical carrier carries the phase modulated signals having 10Gb/s downstream signal stream. Remodulation was done by intensity modulation upstream signals. The power was negligible for upstream and downstream signals after 20 KM transmission where as it was 0.4dB for video signals so the triple play services with 10Gb/s upstream signal and 10Gb/s

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downstream signal, 2.5Gb/s video signals per channel was successfully realized.[12]

In year 2008, An AWG-based WDM-PON architecture with multicast capability was proposed this architecture employed two stages AWG and MWC which supports multicast efficiently. A switch array, unicast and multicast component with MWC were included in OLT. Many terms such as cost, link capacity, scalability, bandwidth per user etc were used to evaluate the performance of this architecture and it was concluded that it exhibit good performance. Different appropriate scheduling algorithms were designed for unicast and multicast services. This architecture provided high scalability and single copy broadcast capability at remote node and multi wave length converter at OLT.[13]

Again in 2008, DBA algorithm was introduced to efficiently manage system in GPON. Different problems related with GPON DBA were unfairness among buffers and over assignment and bandwidth to buffers. To improve the problems of DBA, function evaluation of SR –DBA and NSR-DBA were carried out for BR-DBA. Fairly assigning bandwidth, borrowing and refunding if there happen to be difference bandwidth in BR-DBA was one of the best solution to improve the algorithm of DBA. Amount assigned to time slot and function of system for queue delay was evaluated using NS 2 check weather the algorithm improved or not. Result showed that BR-DBA was superior to GPON DBA in aspects of fairness, amount process and system queue delay.[14]

After that in 2008, one single arm intensity modulator was used in WDM PON configuration with light waves centralized that OLT. It was the best way to realized triple play services without requiring DI and modulator for cascaded modulation. Both power budget and system reliability was improved because WDM PON contained less number of optical components. 10 GB/s baseband signal and 2.5Gb/s subcarrier downstream transmission was demonstrated in which baseband signal was demodulated by RSOA for earth stream traffic. The power penalties were less than 0.5dB and 0.2 dB for both downstream and upstream channels. It was concluded that after 20KM SSMF, power penalty of all channel was less than 0.5 dB.[15]

Next architecture was designed in 2009, a self-restored ring star architecture was proposed for TDM PON to remove fiber fault. Triple play management in optical layer was one of the feature of this architecture. Data traffic performance, both for uplink and downlink was studied. Standard CATV video signal broadcasting to each ONU was used in the architecture. OS_2 (switch) was added in each ONU for controlling the video signal distribution in optical layer which severed a large number of users. This used the reloading of Mac layer management. CATV channels were isolated when OS_2 was of state.[4]

Coming to year 2009, next generation TDM-PON and GPON protocol performance trends as the function of maximum polling cycle was maintained and their optical performance was improved. GPON performance respond quickly to momentary traffic load due to the ability of DBA which avoids single buffer overflows. AS a result delay of the system reduces and throughput increases EPON algorithm is modified for better quality of services employing a more static poling cycle. The length of the poling cycle plays a crucial role in the operation of DBA with two standards minor differences for current and next generation PONs were found.[16]

After that in 2011, a WDM PON migration from FTTB to FTTH was introduced by employing bidirectional amplification having linear raised semiconductor optical amplifier this amplifier at the entry of group of ONU's boosted the loss budget which compensated the losses of passive splitter and allowed to upgrade existing structure to permit the fiber to reach final user home. Presence of LSOA also upgraded a pure TDM PON to hybrid WDM TDM PON. In this individual wave length were upgraded independently. Longer extension of links and high splitting rates can also be achieved by LSOA.[17]

Again in year 2011, AWG-RSO were used in next generation access network (NGAN) which overcome the limitation of high insertion loss of splitter used in GPON. It also increases the length of network, providing multiple logical point to point connections on a point to multi point network. Basically AWG and RSO over come to the problem in terms of flexibility, scalability and bandwidth. WDM-PON considered in terms of ultra broadband, long period, scalable and open technology solution for next generation access network.[18]

Another architecture was proposed in year 2012, where overlapped subcarrier multiplexing technique was purposed for single feeder wave length diffusion multiplexing. This was an innovating solution for next generation WDM-PON that exploited the modulation bandwidth of commercial RSOA's to its maximum. Error free operation was achieved without composition without the need of DSP ONT power was optimised through ONU design which maximizes the PON link margin. Bit rates were more double as compare to conventional SCM and were mainly attributed to use of FCE codes which improved the system performance with in low implementation cost.[19]

A Progress in network year 2013, GEPON based FTTH access network was introduced to provide residential subscribers with triple play services optimised architecture and some technical issue like bit error rate were considered to realise the GEPON based FTTH access network. Fiber to the home GEPON linked design for 56 subscribers at 20 km reach and 2Gbps bit rate was evaluated and compare The result showed that as the number of user increases beyond 56 users the bit error rate comes to unacceptable levels and 45Gbps i.e. if data rate of system is increased, sharp change in bit error rate can be observed. If the number of users were increased beyond 56 and for acceptable bit error rate level, boosting amplifier was used which decreased the bit error rate from unacceptable level to acceptable level. So with the use of boosting amplifier more number of users were accommodated.[20]

Coming to year 2013, a multiuser 4/wavelength OFDM WDM-PON providing quintuple play services was introduced on the field in long reach FTTH networks. OFDM signal bundle was transmitted providing 1.45Gb/s per user. The result confirmed at 60.8 KM distance including optical and electrical distribution of 100mtr BISMF and 20 metre coaxial distribution in home.[21]

New technique designed in 2014, A complete fiber to home stricter was introduced in which CO was used as transmitter for downstream, ONU's and a receiver for upstream. Bit rate of 10Gbps and 20Gbps was used for downstream data

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transmission in which the wavelength was shared 32 users. There was no need for optical laser source at user side for data transmission in upstream because SCM technique was used. For different pulse shape and for getting better pulse shape many factors such as Q factors, BER and eye diagram were analysed. Return to zero pulse shape was selected for downstream and hyperbolic secant at ONU where as non return to zero shape was selected for high Q factor both at upstream and downstream data transmission.[22]

Again in year 2014, a frame based QOS provision dynamic bandwidth allocation FQ/DBA scheme was proposed and it was applied to an array wave guide grating (AWG) based on WDM EPON network to provide efficient triple play transmission in all directions. The time domains of all upstream wave length were synchronously divided in to continuous wave with fixed length. Interleaving was one of the best technique to maximize the bandwidth of utilization effectively. So result showed that FQDBA scheme satisfy the QOS requirement of triple play services as well as utilize the property of AWG module efficiently. Due to spatial property of AWG module, throughput of system was also improved.[23]

Coming to year 2015, theoretical model of multi band modulation in WDM PON system was proposed which help to reduce the infrastructure cost without any fact of baseband signal. IS signal is digital modulated in different format and then it was used in multi band modulation technique. As the wavelength usage was not sufficient WDM-PON so further improvement was required result showed that when WDM PON was combined with wireless signal, it can send up to 25 KM distance without any distortion. This technique also can be applied to hybrid WDM PON for long distance and higher data rate. The system showed that the baseband signal was not much affected by IF digitally modulated signal.[24]

Again in 2015 TWDM PON architecture was introduced in which 128 users were connected with 2.5 Gb/s upstream and 10 Gb/s downstream over a 50 Km maximum distance. This was shared among 32 users with TDM and TDMA. QPSK, 8ASK, 4ASK scheme were used to get high spectral efficiency and in order to reduce the channel bandwidth. Two amplifiers were used in RM i.e. SOA and MRA. MRA was characterized by gain of 20 dB in downstream where as SOA was characterised by 10 dB gain upstream. Broadband amplifiers, UDWDM components etc were purposed to make the system cost effective and two migrate it towards UDWDM PON architecture.[25]

Then again in year 2015, advance modulation format were evaluated use in triple play services in GPON based FTTH. Comparative analysis of different formats were carried out for triple play services on the basis of such as Q factor, bit error rate, received optical power, OSNR etc as the bit error rate increases the Q factor decreases because both are inversely proportional to each other. For a suitable advance modulation format good eye diagram, maximum Q factor and minimum bit error rate were some required features. Result showed that outcome was better for RZ DQPSK.[26]

Recently in year 2016, a passive optical communication in downward direction was presented. Current bursts methods were modified to scheduling distribution SC on system OFDM from OLT to ONU. As previous study was limited only to the fairness among users but there was no fairness of services, so optimization was required for the allocation of data transmission which was provided by this network. When the link is congested while allocating sub carrier based on services with FDMA, significant gain of bandwidth efficiency up to 60% was obtained. This system maintained the video services for HD quality TV up to 125 users which was better than other systems having capacity only up to 75 users. Introduction services pattern in layer 1 was less accurate due to development of new release applications which need further analyses.[27]

In previous year, 2016 a multi-service (MS) code based Spectral Amplitude Coding Optical Code Division Multiple Access (SACOCDMA) system had different number of basic users. It was used for the investigation on video, audio and data transmission. The work was carried out to revel the possibility of the previous work that has been demonstrated using mathematical computation. This simulation covered transmission distance at 50 km and it was running on 622Mb speed. The obtained results indicated that the system was much more stable and gave better performance. More so, These services were focused on video, audio and text data as previously done with varying degree of minimum bit error rate requirement (10-12, 10-9, 10-3) correspondingly.[28]

In year 2017, issue of false detection in optical coding based PON system was addressed. Average no of false detection was calculated and the performance of the system was a evaluated in terms of false detection. This was very useful tool for designing monitoring system. It gave the estimate of the detections that are false in network discovery detection. It was concluded that a low cost and feasible scheme monitored a large number of users with less than one false detection per user in high density PON's.[29]

II. CONCLUSION

For creating new business modals network providers are finding the best way of innovating the infrastructure of existing network. Triple play services improved the social benefit as well as created new business chance for network provider. The required bandwidth for triple play services in near future will be greater than 75Mb/s per subscriber. WDN PON had little success in commercialization as compare to TDM PON due to low cost solution and no practical solution for WDM light source. In next generation TDM PON the performance trend as the function of maximum polling cycle at the optical performances improved. GPON enable triple play services at meet the requirement of higher bandwidth. Its speed is more than other PON technologies. Bidirectional passive optical network can accommodate 128 users for high capacitive triple play services providing acceptable Q factor and eye height. Scaling technique for triple play services with the use of subcarrier allocation algorithm maintain the video services for HD quality TV which is better than other system. Virtual local area network and multicast features were used for integration of services.

III. REFRENCES

[1] Sumanpreet, Mr. Sanjeev Dewra, "A review on Gigabit Passive Optical Network (GPON)" International Journal of Advanced Research in Computer and Communication Engineering, vol 3, no 3, March 2014.

[2] O.Akanbi, Jianjun Yu, Gee-Kung Chang, "New scheme for bidirectional WDM-PON using Upstream and downstream

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channel generated by optical carrier suppression and separated technique", IEEE photon technology, vol 18, pp 340-342, January 2006.

[3] Glen karme, keiji Tanaka, "Advance in optical access network", optical fiber communication, vol 4, pp 6-11, March2005.

[4] Bjorn Skubic, Jiajia Chen, Jawwad Ahmed, Lena Wosinska, Biswanath Mukherjee, "A comparison of Dynamic Bandwidth Allocation For EPON GPON and Next generation TDM PON", IEEE communication, vol 7, no 3, pp 40-48, March 2009

[5] Brownson O. Obele, Mohsin Iftikhar, Suparek Manipornsut, and Minho Kang, "Analysis of the Behavior of Self-Similar Traffic in a QoS-Aware Architecture for Integrating WiMAX and GEPON", vol 1, no 4, September 2009.

[6] Jisha V, Sunaina, "Performance Analysis of Hybrid WDM/TDM PON Using Various Coding Techniques" ,International Journal of Science and Research (IJSR), vol 4, no 2, February 2015

[7] H.D.kim, S.G.Kang and C.H.lee, "A low cost WDM source with an ASE injected Fabry Perot semiconductor laser", IEEE Photon Tech. Lett, vol 12 pp 1067-1069, August 2000.

[8] Neda Cvijetic, "OFDM for next generation optical access Networks", Journal of light wave technology, vol 30, no 4, 2012

[9] Soo-jin Park, chang-Hee Lee, "Fiber to the home services based on wavelength division multiplexing passive optical network," IEEE Journal of Light wave Technology, vol 22, no 11, pp 2582–2591, November 2004.

[10] Mark Abrams and Ariel Maislos, "Insights on Delivering an IP Triple Play over GE-PON and GPON", Optical Fiber Communication Conference and the National Fiber Optic Engineers Conference,CA, USA, pp 1-8, March2006.

[11] Sahrul Hilmi Ibrahim, Dr. Abu Bakar Mohammad, "New PON Add/Drop Multiplexer to support Next-Generation PON", Asia Optical Fiber Communication and Optoelectronics Conference, Shanghai, China, vol 60, pp 543-545, 2007.

[12] Jianjun Yu, Oladeji Akanbi, Yuanqiu Luo, Lei Zong, Zhensheng Jia, Ting Wang, and Gee-Kung Chang, " WDM-PON Architecture with Centralized Light waves in the OLT for Providing Triple Play Services", OFC/NFOEC 2007 - 2007 Conference on Optical Fiber Communication and the National Fiber Optic Engineers Conference, CA, USA, pp 543 - 545,2007.

[13] Kyeong-Eun Han, Won-Hyuk Yang, Kyoung-Min Yoo, Young-Chon Kim, "Design of AWG-based WDM-PON Architecture with Multicast Capability",IEEE INFOCOM Workshops, Phoenix, USA, pp 1-6, 2008.

[14] Seung Kun Lee, Jong Wook Jang, Moon Han Bae, Improvement of GPON MAC Protocol for IP TV Service" Third International Conference on Systems and Networks Communications, Salima, Malta, pp 212-217, October 2008

[15] Ming-Fang Huang, Jianjun Yu,Hung Chang Chien, Arshad Chowdhury, Jason Chen, Sien Chi,Gee KungChang, "A Simple WDM-PON Architecture to Simultaneously Provide Triple play Services by Using One Single Modulator", OFC/NFOEC 2008 - 2008 Conference on Optical Fiber Communication/National Fiber Optic Engineers Conference, California, USA, pp 1-6, February 2008.

[16] C. H. Yeh, C. W. Chow, Y. L. Liu, "Self-Restored Ring-Star-Architecture TDM-PON", 2009 Conference on Lasers & Electro Optics & The Pacific Rim Conference on Lasers and Electro-Optics,Shanghai, China, pp 1-2, August 2009.

[17] J. J. Martinez, N. Merayo, A. Villafranca, "WDM-PON network up scaling using in building linear SOAs", Stockholm, Sweden, pp 1-4, 2011.

[18] MarcoLeo,MariangelaTrotta,"Performance evaluation of WDM-PON RSOA based solutions in NGAN scenario", 50th FITCE Congress - "ICT: Bridging an Ever Shifting Digital Divide", pp 1-4, September 2011.

[19] Deeksha kocher, R.S Kaler, Rajnesh Randhawa, "Simulation of fiber to home triple play services at 2Gbits/s using GE-PON architecture for 56 ONU's," Optik-International Journal of Light and Electron Optics, vol 124, no 21, pp 5007-5010, 2013.

[20] Ziad A. El-Sahn,Jonathan M. Buset, David V. Plant, "Overlapped-Subcarrier Multiplexing for WDM Passive Optical Networks", IEEE Journal of Light wave Technology, vol 30, no 5, pp 754-763, 2012.

[21] Roberto Llorente, Maria Morant, Eloy Pellicer, Milan Herman, Zsolt Nagy, Tiago Alves, Adolfo Cartaxo, Javier Herrera, Jose Correcher, Terence Quinlan, Stuart Walker, Claudio Rodrigues, Pierre Cluzeaud, Axel Schmidt, Radoslaw Piesiewicz, Rakesh Sambaraju, "On-the-field demonstration of quintuple-play service provision in long-reach OFDM based WDM-PON access networks", 39 European Conference and Exhibition on Optical Communication, London, UK, pp1-3, September 2013.

[22] A. Elrashidi, I. Ashry, A. Mahros, M. Alhaddad, and K. Elleithy, "Performance Analysis of WDM-PON FTTH Using Different Pulse Shapes at 10 Gbps and 20 Gbps, Proceding of the 2014 Zone 1 Conference of the American Society for Engineering Education,Bridgeport, Conecticut,USA, pp 1-5, April 2014.

[23] Hui-Tang Lin, Chia-Lin Lai1,Tzy-Shiah Wang and Yu-Chia Huang ,"Supporting triple play services with private networking over WDM EPONs", 2014 14th International Symposium on Communications and Information Technologies, Incheon, Korea, pp 414-418, September 2014.

[24] Sreereshmi T S, Joseph Zacharias, Vijayakumar Narayanan, "Simulation of WDM-PON and Radio Over Fiber with Single Mach Zehnder Modulator", 2015 International Conference on Control Communication & Computing India, Kerala, India, pp 401-406, November 2015.

[25] Tommaso Muciaccia, Fabio Gargano, and Vittorio M. N. Passaro, "A TWDM-PON with Advanced Modulation Techniques and a Multi-Pump Raman Amplifier for Cost-Effective Migration to Future UDWDM-PONs", IEEE Journal of Light wave Technology, vol 33, no 14, pp 2986-2996, 2015.

[26] Muhammad Irfan, M. Shahbaz Qureshi, Saad Zafar,"Evaluation of Advanced Modulation Formats using Triple-Play Services in GPON Based FTTH", 2015 International Conference on Cloud Computing (ICCC), Riyadh, Saudi Arabia, pp 1-6, April 2015.

[27] Mihya Zaki, Rina Pudji Asluti, "2016 International Conference on Control, Electronics, Renewable Energy and Communications (ICCEREC)", IEEE journal of Renewable Energy and Communications, Bandung, Indonesia, pp 81-85, September 2016.

[28] Ambali Taiwo, Juliana Basri, Yahaya Idriss, Majid Kakaee, Makhfudzah Mokhtar, "Experimental Demonstration of MS-Code Based SACOCDMA for Triple Play Services", IEEE 6th International Conference on Photonics (ICP), Kuching, Malaysia, pp 1-3, March 2016.

[29] Manuel P. Fernández, Pablo A. Costanzo Caso, Laureano A. Bulus Rossini, "False Detections in an Optical Coding-Based PON Monitoring Scheme", IEEE Photonics Technology Letter, pp 1-1, no 99, 2017.

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