Volume 8, No. 3, March – April 2017

ISSN No. 0976-5697

International Journal of Advanced Research in Computer Science

REVIEW ARTICLE

Available Online at www.ijarcs.info

Analysis of Next-Generation Multiuser Hybrid Optical Wireless Access Network (HOWAN) with Different Technologies; A Review

Jyoti* and Harmanjot Singh
M.Tech Student*, Assistant Professor
Electronics and Communication Department, Punjabi University, Patiala, India

***Abstract*:** Today's rapid speed internet demand has become high to satisfy the request of higher data rate and expensive transmission capacity another communication system required. Optical fiber is used to fulfill these demands. Optical communication is needed for higher speed data transmission. In optical fiber communication, multi carrier modulation (MCM) gives more attention instead of single carrier modulation (SCM). Orthogonal Frequency Division Multiplexing (OFDM) is a very attractive multiplexing and modulation technique that is used for both wireless and wired communication system. Advantages of optical orthogonal system are spectrum efficiency and channel robustness. Optical Orthogonal Frequency Division Multiplexing (OFDM), without complex Equalization can easily adjust to severe channel condition. This paper provides an overview of beginnings, different technologies and latest development of Next Generation of Passive Optical Network

Keywords: Orthogonal Frequency Division Multiplexing (OFDM); Coherent receiving; Optical heterodyne; Passive Optical Network; Radio over Fiber (ROF); XG-PON; Multicast.

1. INTRODUCTION

With increase in high speed internet demand, system needs very high data rate and large bandwidth. Communication system requires large bandwidth and large number of users. The optical data transmission rate can burst up to Terabit per second (Tb/s) in long haul distance [1]. Optical fiber is used to support large number of users because it has large bandwidth. In optical fiber communication, multi carrier modulation (MCM) gives more attention instead of single carrier modulation (SCM) due to its ability to reduce the effect of selective fading and decrease Inter-symbol Interference (ISI).

Frequency Division Multiplexing (FDM) and Wavelength Division Multiplexing (WDM) are used to transmit high data rates over long distances. In Wavelength Division Multiplexing different channels are separated by a frequency band and for de-multiplexing the different channels, analog filters are used.

Orthogonal Frequency Division Multiplexing (OFDM) is a very attractive modulation and multiplexing technique that is used in broadband wireless and wired communication system. Advantages of optical orthogonal system are spectrum efficiency and channel robustness. Orthogonal Frequency Division Multiplexing (OFDM) is well known flexible modulation format. Optical orthogonal frequency division multiplexing (O-OFDM) has become one of the most capable technologies that have capability to equalize chromatic dispersion (CD) and polarization mode dispersion (PMD) efficiently. [2] For next generation broadband optical access, Hybrid Wavelength Division Multiplexing / Time Division Multiplexing (WDM/TDM) is the best solution. Hybrid WDM/TDM PON increases the number of working wavelengths.

A. WDM PON (Wavelength Division Multiplexing Passive Optical Network)

The Wavelength Division Multiplexing (WDM) technology, in the optical communication systems, has great potential to enhance system design and flexibility. The use of WDM in optical networks increases the fiber bandwidth. [3] In the Wavelength Division Multiplexing (WDM) network, the optical transmission spectrum divides into a number of discrete wavelength bands. With the use of WDM technology, the network achieved link capacities on the order of 50THz. [4] Passive Optical Network (PON) is a technology that implements a point-to-multipoint network. A PON takes advantage of Wavelength Division Multiplexing (WDM), using one wavelength for downstream signal and another for upstream signal on single mode fiber. Wavelength Division Multiplexing Passive Optical Network (WDM-PON) is very attractive solution for future broadband access network due to its feasible data delivery for network subscribers. In general, the system needs to increase the speed and maximum reach at the same time. To fulfill these objectives, design the high speed WDM PON operating at per wavelength speed of > 10Gb/s with the use of Reflective Semiconductor Optical Amplifier (RSOA) and digital coherent detection techniques [5]. WDM-PON technology is based on RSOA and digital coherent detection technique and is best for progress in long reach and high speed.

B. TDM PON (Time Division Multiplexing Passive Optical Network)

Time Division Multiplexing is a digital multiplexing technique for combining different low-rate digital channels into a high-rate one. Time Division Multiplexing (TDM) is a method of transferring multiple data streams in a single signal by separating the signal into many segments, each

having a very short duration. Time Division Multiplexing Passive Optical Network (TDM-PON) was more efficient than Wavelength Division Multiplexing Passive Optical Network (WDM-PON) because in TDM-PON network bandwidth supply was growing faster than subscriber bandwidth demand. TDM-PON was the network that used only passive components between the customer and the central office. This network delivered future ultra-high speed services. TDM-PON over WDM-PON intended to extend the long reach from 20Km to 100Km distances [6]. For next generation system, TDM-PON architecture will be the most promising system among several technologies.

C. WDM/TDM PON (Wavelength Division Multiplexing/Time Division Multiplexing Passive Optical Network)

After the Wavelength Division Multiplexing Passive Optical Network and Time Division Multiplexing Passive Optical Network designed, the combined WDM and TDM approach was used which provide advanced features. A system-to-system approach for Wavelength Division Multiplexing and Time Division Multiplexing Fiber-to-the-Home telecommunication network was designed [7]. The system was very cost efficient. In the Hybrid WDM/TDM PON system that combines TDM and WDM PON increased the high bandwidth capacity [8]. WDM/TDM PON system is of two types: static WDM/TDM PON and dynamic WDM/TDM PON. The Hybrid system combines the high bandwidth capacity of WDM-PON and the bandwidth efficiency of TDM-PON. Gigabit Passive Optical Network (GPON) is a Hybrid Passive Optical Network, in which WDM and TDM are implemented into a single passive optical network to increase the link capacity and decrease the cost [9].

D. Next Generation PON (Passive Optical Network)

With the rapid growth of internet data traffic and high demand of bandwidth, Passive Optical Network is the most popular and the lowest cost system which enables high speed access for users [10]. These objectives are achieved by using different multiplexing and modulation format. For advancement of technology, a next generation PONs format is used. Next generation access network provides large data bandwidth, high quality of service (QOS) and mobility [11]. The next generation PON is divided into two types: NG-PON1and NG-PON2. The NGPON-1 is called mid-term upgrades and NG-PON2 is called long term solution.

E. Hybrid WDM/TDM ROF PON OFDM (Wavelength Division Multiplexing/Time Division Multiplexing Radio Over Fiber Passive Network Orthogonal Frequency Division Multiplexing)

The new idea about PON/ROF (Radio over Fiber) can be used for both wireless and wire-line access. Further, Long reach Hybrid Wavelength Division Multiplexing Time Division Multiplexing Passive Optical Networks was designed to provide services to centre offices. In the structure of Hybrid Wavelength Division Multiplexing Time Division Multiplexing Passive Optical Network, to cover the large area, Array Waveguide Grating (AWG) was used to provide the connections [12]. Using Radio over Fiber (ROF) technique in the GPON network, 2.5 GB/s hybrid WDM/TDM downstream link was designed [13]. Hybrid long reach WDM-TDM PON covered the long distance and provided wavelength to multiple users at the same time. The main objective of network was minimizing the total fiber length to be used. Hybrid WDM/TDMA PON, with digital coherent detection and OFDM format, system achieved high bandwidth and high spectral efficiency [14].

F. Simple Architecture of Hybrid WDM/TDM Network:

In the structure of Hybrid WDM/TDM, the network is divided into three parts: optical line terminal (OLT), optical distributed network (ODN) and optical network unit (ONU). The network consists of different signals which are multiplexed by multiplexer.

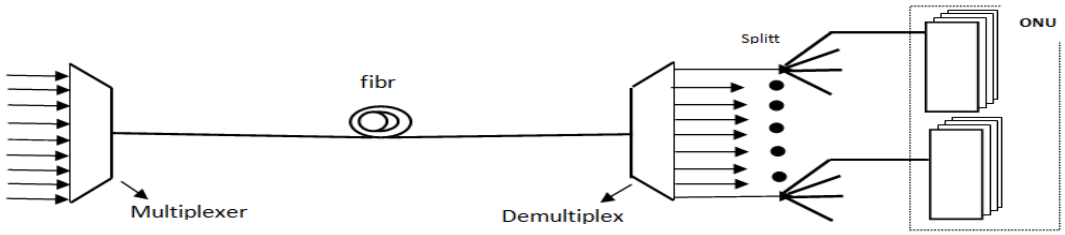

Figure1. WDM/TDM Hybrid GPON Network Architecture [17]

In the OLT side, TX is used as transmitter and RX is used as receiver. The Remote Node (RN) consists of Array Waveguide Grating (AWG) which is separated by the two wavelengths. In the ONU side we use Reflective Semiconductor Optical Amplifier (RSOA). Receiver is for receiving the signal at the end.

G. Spreading out of Next Generation Passive Optical Network are given as:

Passive Optical Network Conventional Passive Optical Networks (PON), which had some issues such as limited protection feature, any component or fiber failure would lead to huge loss of data. To overcome this problem an additional functionalities network, Wavelength Division Multiplexing Passive Optical Network (WDM-PON) was designed. WDM-PON was an approach to realize high capacity and flexible data delivery for subscribers.

Orthogonal Frequency Division Multiplexing (OFDM) often accompanies suppressed carrier OSSB that was used to compensate for disperse in ultra long haul Wavelength Division Multiplexing (WDM) optical links during 2006 [15]. For adaptive compensation of system, Orthogonal Frequency Division Multiplexing (OFDM) could be an attractive technology. With optical single sideband modulation, adaptive compensation dispersion could achieve 4000-Km 32x10Gbps and Wavelength Division Multiplexing (WDM) single mode fiber (SMF) links with 40% spectral efficiency. [15]

In the year 2007, ultra long haul Wavelength Division Multiplexing (WDM) systems, the combination of Orthogonal Frequency Division Multiplexing (OFDM) and optical single sideband modulation could be used to compensate for chromatic dispersion. The system had better receiver sensitivity than NRZ system. This system did not give a feedback path which added an advantage to it. [16] With the year 2008, a combination of Wavelength Division Multiplexing, Orthogonal Frequency Division Multiplexing and optical single sideband modulation could be used to compensate for chromatic dispersion. After designing this combinational network, a multicast WDM Passive Optical Network was designed. This network was based on Differential Phase Shift Keying (DPSK) and Non-Return-to-Zero (NRZ) orthogonal modulation technique. The multicast operation was based on the principle of demodulation of DPSK signal. The system achieved 10Gb/s point-to-point data and 10Gb/s multicast data. [17]

Coming to the year 2009, fiber dispersion and Kerr effect helped phase distortion of optical Orthogonal Frequency Division Multiplexed signal by analyzing it [1]. Orthogonal Frequency Division Multiplexing technique had been applied to increase the system performance to achieve higher data rates and longer length. [1]

With the demand of high bandwidth services, the access network system was putting pressure to increase the bandwidth for different services. Combine system of Radio over Fiber (ROF) and Passive Optical Network (PON), which was an optimal solution to increased capacity and bandwidth as well as decreased costs in the access network. But with the comparison of Wavelength Division Multiplexing Passive Optical Network (WDM-PON) with Radio over Fiber Passive Optical Network (ROF-PON), WDM-PON would play more important role in next generation access network. [18] So the merged system with WDM-PON was designed in 2010, which was better solution for providing high bandwidth and high link capacity. After that, another candidate was Wavelength Division Multiplexing/Time Division Multiplexing Passive Optical Network (WDM/TDM PON) which combined WDM with TDM technology. In WDM/TDM PON, each wavelength was shared among several Optical Network Units (ONUs) rather than being dedicated to single ONU. [19]

For the next generation broadband optical access, Hybrid Wavelength Division Multiplexing / Time Division Multiplexing (WDM/TDM) Passive Optical Network (PON) was becoming an attractive solution. Hybrid WDM/TDM PON with tunable laser was an attractive way for dynamic wavelength assignment and time allocation problem in single resource allocation cycle, during 2011. In Hybrid Wavelength Division Multiplexing / Time Division Multiplexing (WDM/TDM) PON, a tunable laser was potential candidate light source accumulated to their multi wavelength provisioning capability and color-free property [20]. Simulation could achieve in terms of scheduling algorithm. Approximation ratios of heuristic preemptive scheduling algorithm and heuristic non preemptive scheduling algorithm were 2 and 2-1/m, where m was called number of wavelengths. The preemptive scheduling algorithm had slightly better performance as compared to non preemptive scheduling algorithm. [20]

According to the studied done in the year 2012, Gigabit-Passive Optical Network (GPON) was used to send high data rate with high frequencies. A Hybrid GPON was a hybrid passive optical network, where WDM and TDM were integrated into a single passive optical network, which aimed to increase link capacity [13]. The Hybrid WDM/TDM PON system achieved 2.5 GB/s using Radio over Fiber (ROF) techniques. [13]

Wavelength Division Multiplexing Passive Optical Network (WDM PON) had been considered an effective solution to solve the future bandwidth demands of next generation wireless access networks, which provided more than 10 GB/s data for each user. In 2012, design symmetric 10 GB/s Wavelength Division Multiplexing Passive Optical Network (WDMPON) with using directly modulated semiconductor. A Directly Modulator Laser (DML) was used for the downlink and RSOA (Reflective Semiconductor Optical Amplifier) for uplink. The network achieved bit error rate less than10^{-4} for both uplink and downlink. [21]

In the year 2013, a Wavelength Division Multiplexed Radio- Over- Fiber Passive Optical Network (WDM-ROF-PON) was designed. WDM-ROF-PON was based on polarization multiplexing and carrier suppressed return-to-zero quadrature differential-phase-shift keying (CSRZ-QDPSK). Using of Polarization multiplexing (PM) and QDPSK modulation could improve the bandwidth utility of the network. The system was a source free optical network units with wireless access. With the use of reflective semiconductor optical amplifier (RSOA) and reuse of downstream light source, the laser source was omitted and made WDM PON color-less with the wireless and fiber transmission, the network had good transmission property. The system achieved 40GB/s per wavelength channel downstream signal transmission with the use of 10GB/s modulator. [22]

With the use of source free optical network, the next system designed a Wavelength Division Multiplexing-Radio over Fiber-Passive Optical Network (WDM-ROF-PON) which was based on Orthogonal Frequency Division Multiplexing (OFDM) and optical heterodyne. The network achieved high bandwidth and excellent transporting property. Performance of the network was measured in terms of bit error rate, coverage area and receiving eye diagram. [23]

Coming to the year 2014, a cost-efficient network that was based on the simultaneous combination of WDM PON and ROF using a Hybrid mode-locked laser was designed. This architecture could work for 60GHz applications and transmission over up to 30Km long standard single mode optical fiber (SSMF) of 10Gbps OFDM PON and 5Gbps OFDM ROF. Using Orthogonal Frequency Division Multiplexing (OFDM) modulation format in this network a bit error rate was below 10^{-3}. [24]

After the design of WDM-ROF-PON network based on OFDM technology, the network design in the year 2015 was based on improved Orthogonal Frequency Division Multiplexing and heterodyne coherent receiving technology. The network became high bandwidth efficient and achieved fine transporting properties. The frequency of the network implemented 60GHz wireless access without adding a radio source. The transporting property and bandwidth utilization of improved Return-to-Zero OFDM format was same as that of Non-Return-to-Zero OFDM (NRZ-OFDM) and Return-to-Zero OFDM (RZ-OFDM). But with the combination of coherent receiving technology and improved RZ-OFDM format, the system attained high bandwidth and excellent transporting property. At 80Km distance the system had good receiving constellations and low bit error rate. [25]

Wavelength Division Multiplexing Passive Optical Network (WDM PON) was considered for Next-generation broadband backhaul and radio access networking during 2016 [29]. In this paper, a WDM-PON system based on tunable lasers and a centralized wavelength locker was designed. The system achieved bit error rate (BER) below 2.10^{-6} for received power -40dBm. A WDM-PON system was designed with high bandwidth at low cost lasers. [26]

Next system was designed in 2016, which was a Bidirectional Hybrid Orthogonal Frequency Multiplexed WDM Passive Optical Network. The network had 2688 users downstream which consisted 256 for optical fiber and 80 users for free space along with the radio signal. In the structure of networking, one OLT achieved 240 GB/s access bandwidth with 8 downstream wavelengths. Direct detection OFDM was less efficient as compared to coherent detection. Coherent detection achieved high bandwidth, wire and wireless synchronously. Improved RZ-OFDM and coherent receiving technologies had made system's transporting property excellent. At 60Km transmission, the downstream had low bit error rate and fine receiving constellation. The result could be achieved in terms of Bit Error Rate, coverage area and eye diagram. [27]

2. CONCLUSION

This paper explains the overview of various techniques which were used to extend the system length and enhance the higher data rate. With the growth of internet traffic, systems need very high data rate and large bandwidth. Accounting with the previous years, these requirements are fulfilled by different technologies. OFDM is an advance modulation format for wireless, wire-line and broadcast networks. Benefit of that modulation format is to reduce the effect of selective fading and decreased Inter-Symbol-Interference (ISI). The merged system of OFDM and WDM could be analyzed to compensate for chromatic dispersion and system achieves better sensitivity. After that, Passive Optical Network (PON) was designed, which had capability to provide a low cost solution. WDM-PON was very effective solution for future broadband access network. With the design of WDM/TDM PON, the systems combined both WDM and TDM technology which increased the link capacity and decreased the cost. For advancement of technology, the Next-Generation PONs format was used with different techniques to provide high quality of service (QOS) and mobility. A new system WDM-ROF-PON was designed which was based on improved OFDM and optical heterodyne receiving detection. Performance of these networks could be analyzed in terms of Bit Error Rate, coverage area and eye diagram. In future, transmission distance can be enhanced by using advanced and suitable compensation method. High data rate and large bandwidth can be achieved by using advanced modulation format such as return-to-zero format. A lot of work can be done on WDM-PON's, TDM-PON's, NG-PON's and XGPON's.

3. REFERENCES

[1] Boonaue Pirom and Pasu Kaewplung, "Analysis of Phase Distortion in Optical OFDM Signal Transmission in Optical Fiber," International Conference on Information and Multimedia Technology (ICIMT), pp. 465–469, Bangkok, Thailand, 2009.

[2] S. Chandrasekhar and Xiang Liu, "OFDM Based Super channel Transmission Technology," Journal of Lightwave Technology, Vol. 30, No. 24, pp. 3816–3823, December 2012.

[3] Hideki Ishio, Junichiro Minowa and Kiyoshi Nosu, "Review and Status of WDM Technology and Its Application," Journal of Lightwave Technology, Vol. 2, No. 4, pp. 448–463, August 1984.

[4] Michael S. Borella, Jasonp. Jue, Byrav Ramamurthy and Biswanath, "Optical components for Wavelength Division Multiplexing Lightwave Networks," Proceedings of the IEEE, Vol. 85, No. 8, pp. 1274–1307, August 1997.

[5] Y.C.Chung, Yuseong-Gu, "High Speed Coherent WDM PON for Next–Generation Access Network," International Conference on Transparent Optical Network (ICTON), PP. 1–4, Korea 2013.

[6] Maged Abdullah Esmail and Habib Fathallah, "Physical Layer Monitoring Techniques for Time Division Multiplexing Passive Optical Network," IEEE Communications Surveys and Tutorials, (Accepted) for Publication, Vol. 15, No. 2, pp. 943–958, OSA 2012.

[7] Theodore Rokkas, Ioannis Neokosmidis, Dimitris Katsianis and Dimitris Varoutas, "Cost Analysis of WDM and TDM Fiber-to-the-Home Networks," IEEE Transactions on Systems, Vol. 42, No. 6, pp. 1842–1853, November 2012.

[8] Jung Mi Oh, Sang Geun Koo and Donghau Lee, "Enhancement of the Performance of a Reflective SOA-Based Hybrid WDM/TDM PON System with a Remotely Pumped Erbium Doped Fiber Amplifier," Journal of Lightwave Technology, Vol. 26, No. 1, pp. 144–149, January 2008.

[9] Yang Liu, Guoping Zhang and Qing Li, "WDM/TDM Hybrid GPON Technology," IEEE Conference Publications, Symposium on Photonics and Optoelectronics (SOPO), Wuhan, Hubei, China, 2011.

[10] J.L. Wei, K. Grobe and H.Gsiesser, "High Speed Next Generation Passive Optical Networks: Performance, Cost and Power Dissipation," Progress in Electromagnetic Research Symposium (PIERS), pp. 4856–4857, Shanghai, China, August 2016.

[11] Leonid Kazovsky, Shing Wawong, Tolga Ayhan, Kadir Melih Albeyoglu, Moises R.N. Ribeiro and Aunjit Shastri, "Hybrid Optical Wireless Access Networks," Proceedings of The IEEE, Vol. 100, No. 5, pp. 1197–1225, May 2012.

[12] Dier Linh Truong, Phan Thuan Do, Quang Huy Duong, "A Local Improvement Approach for Survivable Long Reach Hybrid WDM-TDM Design," International Conference on Communications and Electronics (ICCE), pp. 7–12, 2012.

[13] A.O. Aldhaibani, S.M. Idrus and N.Zulkifli, "2.5Gb/s Hybrid WDM/TDM PON using Radio over Fiber Techniques," International Conference on Photonics, pp. 255–257, Penang, October 2012.

[14] Elaine Wong, "Next-Generation Broadband Access Networks and Technologies," Journal of Lightwave Technology, Vol. 30, No. 4, pp. 597–608, February 2012.

[15] Liang Du and Jean Armstrong, "Orthogonal Frequency Division Multiplexing for Adaptive Dispersion Compensation in Long Haul WDM systems," Optical Fiber Communication Conference and the National Fiber Optic Engineers Conference, Optical Society of America, 2006.

[16] Jelena Grubor, Volker Jungniekel and Klaus-Dieter Langer, "Adapative Optical Wireless OFDM System with Controlled Asymmetric Clipping," Conference Record of the Forty- First Asilomar Conference on Signals, System and Computers, pp.1896–1902, 2007.

[17] Yin Zhang, Ning Deng, Chun-Kit Chan, Lian-Kuan Chen, "A Multicast WDM Passive Optical Network Architecture Using DPSK/NRZ Orthogonal Modulation," IEEE Photonics Technology Letters, Vol. 20, No. 17, pp. 1479–1481, September 2008.

[18] Zhang Chunlei, Geng Ling and Zhang Pengtu, "An Overview of Integration of ROF with PON," IEEE Conference on Computer Application and System Modeling (ICCASM), Vol. 15, pp. V15-40–V15-43, Lanzhou China, 2010.

[19] Jun-ichi Kani, "Enabling Technologies for Future Scalable and Flexible WDM-PON and WDM/TDM PON Systems," IEEE Journal of Selected Topics in Quantum Electronics, Vol. 16, No. 5, pp. 1290–1297, September/October 2010.

[20] Jingjing Zhang and Nirwan Ansari, "Hybrid WDM/TDM Passive Optical Networks with Nonzero Laser Tuning Time," IEEE/ACM Transaction on Networking, Vol. 19, No. 4, pp. 1014–1027, August 2011.

[21] Zaineb Al-Qazwini and Hoon Kim, "Symmetric 10Gb/s WDM-PON Using Directly Modulated Lasers for Downlink and RSOAs for Uplink," Journal of Lightwave Technology, Vol. 30, No. 12, pp. 1891–1899, June 2012.

[22] Wei Ji and Jun Chang, "Design of WDM-ROF-PON for wireless and wire-line access with source-free ONUs," Journal of Optical Communication Network, Vol. 5, No. 2, pp. 127–.133, 2013.

[23] Wei Ji and Zhaoyuan Kang, "Design of WDM ROF PON Based on OFDM and Optical Heterodyne," Journal of Optical Communication Network, Vol. 5, No. 6, pp. 652–657, 2013.

[24] Ivan Aldaya, Gabriel Campuzano and Christophe Gosset, "Simultaneous Generation of WDM PON and ROF Signals using a Hybrid mode locked laser," International Conference on Transparent Optical Network (ICTON), pp. 1–4, Mexico 2014.

[25] Wei Ji, Xiao Li, Zhaoyuan Kang and Xuwei Xue, "Design of WDM-ROF-PON Based on Improved OFDM Mechanism and Optical Coherent Technology," Journal of Optical Communication Network, Vol. 7, No. 2, pp. 74–82, 2015.

[26] Christoph Wagner, Michad H.Eiselt, Jim Zou, Klaus Grobe, Mirko Lawin, Juan Jose Vegas Olmos and Idelfonso Tafur Monroy, "Impairment Analysis of WDM-PON based on Low-Cost Tunable Lasers," Journal of Lightwave Technology, Vol. 34, No. 22, pp. 5300–5307, 2016.

[27] Amandeep Kaur, Harmanjot Singh, "WDM-TDM OFDM Hybrid PON incorporating Wireless Transmission and Pulse Width Reduction Access Network," International Journal of Scientific Development and Research (IJSDR), Vol. 1, No. 8, pp. 76–79, August 2016.

