An Advanced Resource Allocation Algorithm for PON-LTE Converged Networks

Abhishek Gaur[1], Dr. Vibhakar Shrimali[2]

[1] abhishek.usict.010164@ipu.ac.in, [2] vibhakar.shrimali@gmail.com
[1]Ph.D Research Scholar, USICT, Guru Gobind Singh Indraprastha University, Delhi, India
[2]Professor, GB Pant Govt. Engineering College, Govt. of NCT of Delhi, Delhi, India

Abstract

Enhanced radio access technologies (RAT) are deployed in Next Generation Convergence Networks by the service providers so as to satisfy the basic requirements of end-users for e.g. QoS. Whenever the available resources are being shared simultaneously and dynamically by multiple users or distribution of allocated channels randomly, the deficiency of spectral resources and dynamic behavior of Network traffic in real time Networking, we may have problem. In order to evaluate the performance of our proposed algorithm, computer simulation has been performed on NS-2 simulator and a comparison with the existing algorithms has been made.

Keywords:

PON (Passive Optical Networks), LTE (Long Term Evolution), LTE-A (Long Term Evolution-Advanced), DBA (Dynamic Bandwidth Allocation), QoS (Quality of Service), Mobile speed (MS), latency (L), packet size (PS), packet loss (PL), and jitter (J), Medium Access Control (MAC)

1. Introduction

In the last developing years of Networking, a rapid development in the field of converged networks has been observed.

Typical converged network architecture is shown in Fig. 1. represents a typical converged architecture. UMTS, LTE, LTE Advanced, PON, RATs all are typical subsystems of 5th generation cellular mobile systems. In converged networks, basically integration of two or more different access technologies have been done for providing an enhanced version of mobility, better coverage, improved bandwidth & lesser delay while using various kinds of multimedia services over the communication channel. By using RATs, end users are able to transmit their data simultaneously.

Manuscript received July 5, 2023
Manuscript revised July 20, 2023
https://doi.org/10.22937/IJCSNS.2023.23.7.3

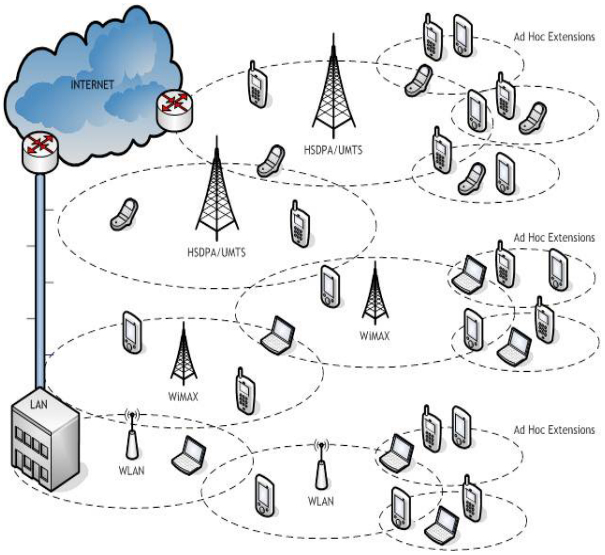

Fig. 1. Typical Converged Network

2. Literature Survey

We have observed a massive development over the past years in the field of wireless communication & its related entity. [1–41].

Real-time & non-real time allocation of resources due to random distribution of channels have caused congestion problem in network. Traffic [1–12, 17–41]. When large no. of users tries to share the available resources simultaneously, it may cause the problem in the system. We already have three existing resource allocation algorithms viz.,dynamic bandwidth allocation (DBA) algorithm, staticbandwidth allocation algorithm, and joint

power band-width allocation (JPBA) algorithm which had been proposedfor Converged wireless Networks [25–41]. The schemes were more focused on resourceallocation and they have ignored the trafficmanagement in their implementation which leads to end-to-end delay,data packets loss andan overall poor network throughput in converged networks[25–41]. Hence, these existing schemes are not so efficient for dynamic allocation of data. In order to overcome this limitation of existing resource allocation algorithms we have proposed a modified &enhanced resource allocation (ERA) algorithm with traffic diversifying feature & improved throughput characteristics.

3. Proposed resource allocation algorithm

In order to improve Network Performance in Converged Networks the resource allocation is done as per the traffic load & QoS Criteria.
In order to design, the proposed ERA Algorithm, a wavelet based Neural Network prediction model has been used & this algorithm uses Latency, Packet Size, Packet loss, Mobile speed & Jitter as input parameters for efficient allocation of bandwidth in converged networks.
By doing so, it is observed that this minimizes end to end delay & packet losses resulting in improved throughput performance and QoS in converged networks. A flowchart has been presented for the proposed Enhanced-Resource Allocation algorithm in Fig. 2.

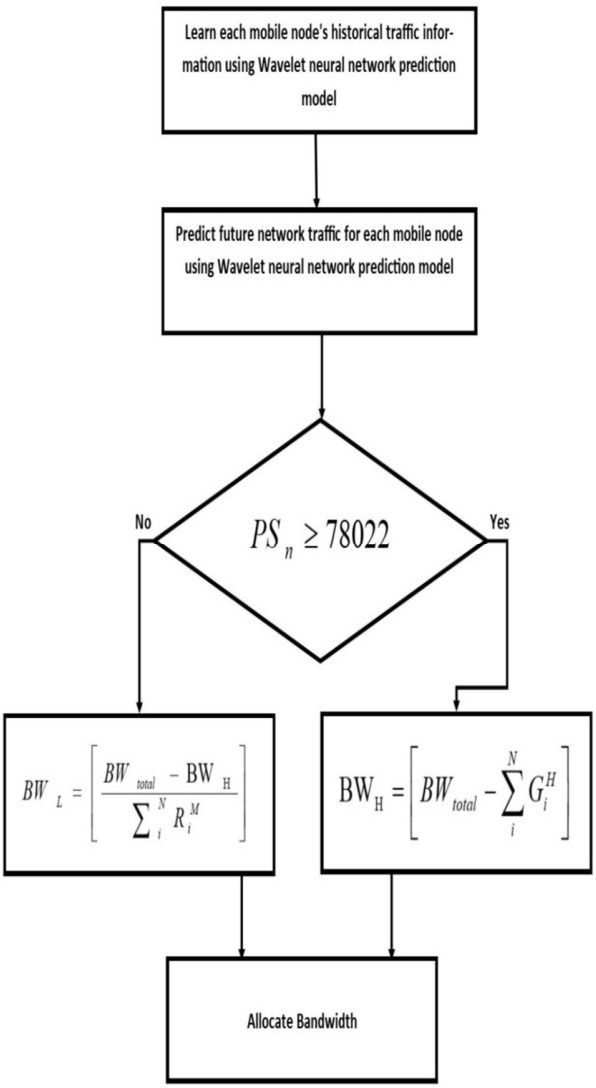

Fig.2. Proposed ERA Algorithm Flowchart

4. Simulation based Performance Evaluation

A real time simulation has been done for testing the efficiency of the proposed algorithm. For this purpose, an Open Source Software viz., Network Simulator (NS-2) has been used since it is an open source software which is widely used for developing real time simulation environment in applications like Network Traffic Models & Networking Protocols [13–24]. In the simulation, the simulated radius for each base station is assumedwithin a radius of

250 m. IEEE 802.11 standard has been considered with a data transmission rate of 2Mbps with a bandwidth of 2.4 GHz. The simulation parameters are listed in Table 1. A comparison has been made between the proposed ERA algorithm along with that of JPBA and DBA algorithms.The JPBA and DBA algorithms are conventional algorithms which has already been tested previously[25–41].

Table 1. Parameters for Experimental Simulation

Simulation Parameters	
Routing Algorithm	Link State Vector Routing
Standard Protocol used	IEEE 802.11 (MAC Protocol)
Propagation Model	Rayleigh Fading
Queuing Model	Drop Tail
Total No. of participatingNodes	10
Allocated Bandwidth of the Network	10 Gbps
Area chosen for simulation	250m X 250m

5. Analysis based on simulated results

I. Average Bandwidth Allocation

It is observed that simulation results shown above depicts that the proposed algorithm utilizes 98.2% of the allocated bandwidth whereas it is observed that JPBA utilizes 82% of the allocated bandwidth and DBA algorithm utilizes only 79% of the allocated bandwidth.

The reason behind it is that the proposed algorithm is using wavelet-based prediction model for analyzing the bandwidth requirement & forecasting the traffic where DBA & JPBA algorithms do not have any such mechanism as a result of which both of them are failed to analyze and predict the bandwidth requirement & forecasting the real time Network Traffic.

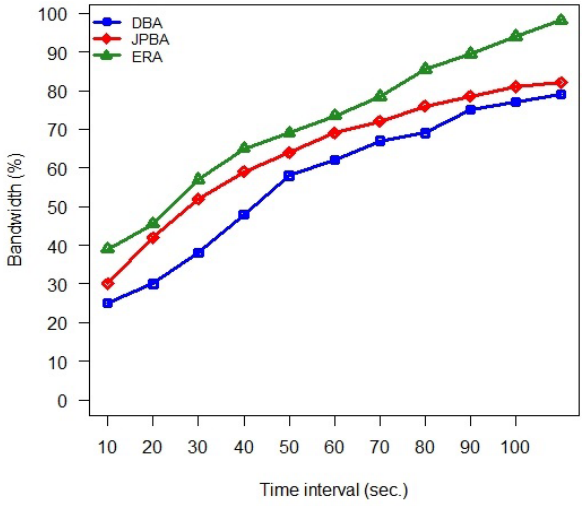

Fig. 3. Average Bandwidth Allocation

II. Average End-End delay

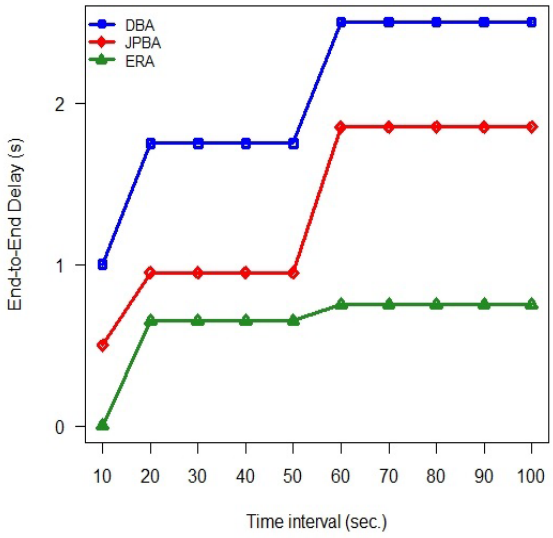

Fig. 4. Average End-End delay

The average time taken by the data packets to reach its destination from its source is termed as average end to end delay. From the simulation results, it is observed that ERA

algorithm with minimum average end to end delay performs better than JPBA and DBA algorithms with a value of 0.75 as compared to JPBA and DBA algorithms with a value of 1.6 and 2.2 respectively for a time interval of 100 seconds. The reason behind it is that the ERA algorithm has historical information about the traffic intensity of each participating nodes since it is based on prediction model whereas other two algorithms are completely failed for real time analysis of traffic intensity in the network.

III. Average Packet loss

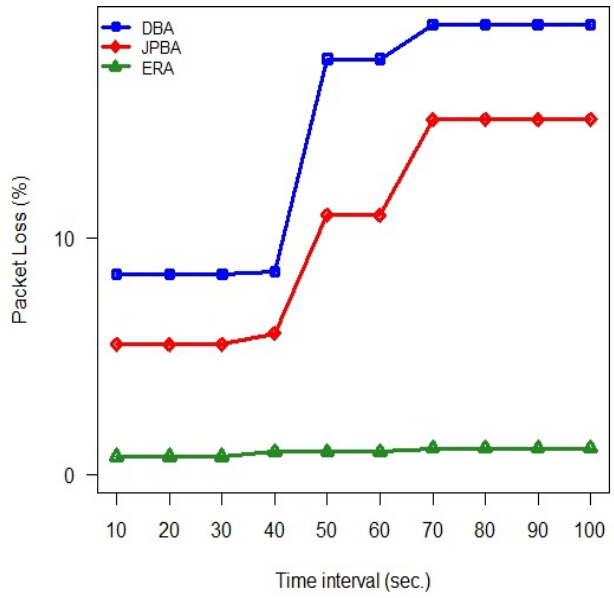

Fig. 5. Average Packet loss

Packet loss refers to a phenomenon when or more data packets are failed to reach its destination. The possible reason behind the loss of data packet is slow transmission speed, network disruption due to failure of any intermediate networking device like switch, router, etc., & loss of network connectivity. From the above simulated result, it has been clearly observed that the ERA algorithm experiences comparatively a lesser average packet loss of approximately 1.1% whereas the other algorithms viz. JPBA & DBA experiences the average packet loss of around 15% and 19% respectively. The higher average packet loss of JPBA & DBA is due to the inefficient allocation of bandwidth as discussed in first simulated result.

IV. Average Throughput

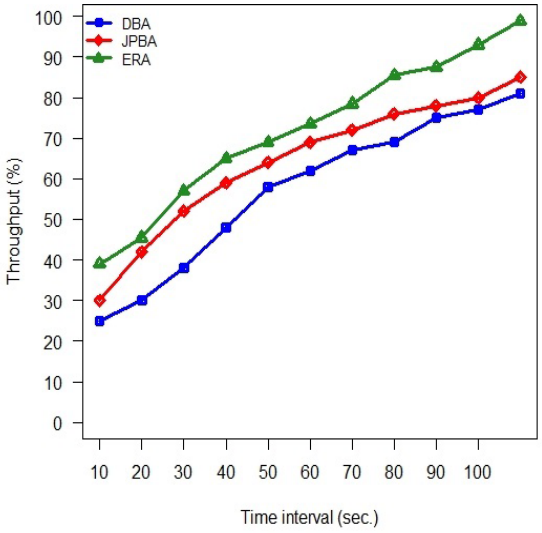

Fig.6. Average Throughput

With an efficient bandwidth allocation, the proposed algorithm results in 98.9% throughput performance in overall networking. The improved and better throughput is also contributed by lesser end-end delay & minimized packet losses in the proposed algorithm. The average throughput performance of the proposed algorithm outperforms the throughput performance of JPBA & DBA as indicated in Fig. 6 with 85% & 81% respectively.

6. Conclusion & Future Work

Exploiting the wavelet based Network Predication Model for forecasting and analyzing the real time traffic and Bandwidth

requirement of each participating node, an ERA algorithm has been proposed.

As a further scope of study, the performance of the proposed algorithm may be evaluated in more complex network environment with larger no. of nodes & greater coverage radius in information systems.

References:

[1] M. Nasimi, F. Hashim, and C. K. Ng, "Characterizing energy efficiency for heterogeneous cellular networks," Proc. of IEEE Student Conf. On Research and Development (SCOReD),pp.198-202,2012.

[2] A. Sahin, E. Bala, I. Guvenc, R. Yang, and H. Arslan, "Partially overlapping tones for uncoordinated networks," IEEE Trans. On Communications,Vol.62,No.9,pp.3363-3375,2014.

[3] M. H. Yilmaz and H. Arslan, "Game theoretical partially over-lapping filtered multi-tones in cognitive heterogeneousnetworks,"Proc.ofMilitaryCommunicationsConf.(MILCOM),pp.411-415,2014.

[4] Y. Xu, Q. Wu, J. Wang, L. Shen, and A. Anpalagan, "Opportunistic spectrum access using partially overlapping channels: Graphical game and uncoupled learning," IEEE Trans. on Communications,Vol.61, No.9,pp. 3906-3918,2013.

[5] P.Duarte, Z.Fadlullah, A.Vasilakos, andN.Kato, "On the partially overlapped channel assignment on wireless mesh network back-bone: A game theoretic approach," IEEE J. on Selected Areas in Communications,Vol.30, No.1, pp.119-127,2 012.

[6] S. Bu, F. Yu, and H. Yanikomeroglu, "Interference-aware energy efficient resource allocation for OFDMA-based heterogeneous networks with incomplete channel state information," IEEE Trans. onVehicularTechnology,Vol.64,No.3,pp.1036-1050,2015.

[7] M.Yilmaz,M.Abdallah,K.Qaraqe,andH.Arslan,"Randomsub-carrier allocation with supermodular game in cognitive heterogeneous networks," Proc. IEEE Wireless Communications and Net-working Conf. (WCNC), pp.1450-1455,2014.

[8] M.Yilmaz,M.Abdallah,K.Qaraqe,andH.Arslan,"On the performance of subcarrier allocation techniques for multiuser OFDM cognitive networks with reconfigurable antennas," IEEE Global Com-munications Conf.(GLOBECOM),pp.1059-1064,2014.

[9] G.Cherubini,E.Eleftheriou,andS.Olcer,"Filteredmultitonemodulation for very high-speed digital subscriber lines," IEEE J. on Selected Areas in Communications, Vol.20, No.5, pp. 1016-1028,2002.

[10] L. Liang and G. Feng, "A game-theoretic framework for interference coordination in OFDMA relay networks,"IEEE Trans. On Vehicular Technology,Vol.61,No.1,pp.321-332,2012.

[11] D.Monderer and L.S.Shapley,"Potential games,"Games and Economic Behavior, Vol.14,No.1, pp.124-143,1996.

[12] A. Fattahi and F. Paganini, "New economic perspectives for resource allocation in wireless networks," Proc. American Control Conf, Vol.6, pp.3960-3965,2005.

[13] T. E. Mathonsi, O. P. Kogeda, and T. O. Olwal,"Inter-system Handover Decision Model for Heterogeneous Wireless Networks, "Proc. of IEEE Open Innovations Conf.2018 (IEEEOI2018),pp.1-7,2018.

[14] T. E. Mathonsi, O. P. Kogeda, and T. O. Olwal, "A Survey of Inter-system Handover Algorithms in Heterogeneous Wireless Networks,"Asian Journal of InformationTechnology,Vol.16,No.6,pp.422-439,2017.

[15] T. E. Mathonsi and O. P. Kogeda, "Handoff Delay Reduction Modelfor Heterogeneous Wireless Networks," Proc. of IST-Africa 2016Conf.,pp.1-7,2016.

[16] T. E. Mathonsi, O. P. Kogeda, and T. O. Olwal, "Intersystem Handover Delay Minimization Model for Heterogeneous Wireless Networks, "Proc. of South African Institute of Computer Scientists and Information Technologists 2017(SAICSIT2017) ,p.377,2017.

[17] T. E. Mathonsi, "Optimized Handoff and Secure Roaming Model for Wireless Networks," Proc. of the 2nd Int. Conf. on Information Security and Cyber Forensics 2015 (InfoSec2015), pp. 134-139,2015.

[18] Y. Choi, H. Kim, S. Han, and Y. Han, "Joint resource allocation for parallel multi-radio access in heterogeneous wireless networks," IEEE Trans. On Wireless Communications, Vol.9,No.10,pp.3324-3329, 2010.

[19] H.B.Chang and L.Rubin,"Optimal downlink and uplink fractional frequency reuse in cellular wireless networks,"IEEE Trans. On Vehicular Technology, Vol.65,No.4,pp.2295-2308, 2016.

[20] H. Zhang,Y. Wang,and H. Ji,"Resource Optimization-Based Interference Management for Hybrid Self-Organized Small-Cell Network," IEEE Trans. on Vehicular Technology, Vol.65, No.2,pp.936-946,2016.

[21] G.J. Yu and H.N.B. Khac, "A Novel Downlink Interference Management Mechanism for Two Tier OFDMA Femtocell Networks,"J. of Advances in Computer Networks, Vol.4, No.2, pp. 80-85,2016.

[22] H. Holma, A. Toskala, and J. Reunanen (Eds.), "LTE Small Cell Optimization: 3GPP Evolution," John Wiley&Sons,2016.

[23] Y. L. Lee, T. C. Chuah, J. Loo, and A. Vinel, "Recent Advances in Radio Resource Management for Heterogeneous LTE/LTE-A Networks, "IEEE Communications Surveys & Tutorials, Vol.16 ,No.4, pp.2142-2180,2014.

[24] L. Ndlovu, O. Kogeda, and M. Lall, "Enhanced Service Discovery Model for Wireless Mesh Networks,"J.Adv. Comput. Intell. Intell. Inform., Vol.22, No.1, pp. 44-53, doi: 10.20965/jaciii.2018.p0044,2018.

[25] L. H. Bonani, A. dos Santos Tozetti, F. Callegati, and Walter Cer-roni, "Routing Issues on Spectrum Sharing and Partitioning for Flexible Optical Networks,"16thInt. Conf. on Transparent Optical Networks(ICTON),2014.

[26] F.Callegati,L.H.Bonani,F.Lezama,W.Cerroni,A.Campi,andG. Castanon, "Trunk Reservation for Fair Utilization in Flexible Optical Networks," IEEE Communications Letters, Vol.18, No.5,pp.889-892,2014.

[27] X. Hesselbach, J. Dantas, J. R. Amazonas, J.-F. Botero, and J.-R.Piney, "Management of Resources under Priorities in EON Using a Modified RDM Based on the Squatting-Kicking Approach,"18th Int. Conf. on Transparent Optical Networks(ICTON),2016.

[28] S. K. Sadon, N. M. Din, M. H. Al-Mansoori, N. A. Radzi, I. S.Mustafa, M. Yaacob, and M. S. A. Majid,

"Dynamic hierarchical bandwidth allocation using Russian Doll Model in EPON," Computers and Electrical Engineering, Vol.38, No.6, pp. 1480-1489,2012.

[29] J.Sócrates Dantas, R.M.Silveira, D.Careglio, J.R.Amazonas, J.SoléPareta and W.V.Ruggiero,"Novel Differentiated Service Methodology based on Constrained Allocation of Resources for Transparent WDM Backbone Networks," Brazilian Symp. On Computer Networks and Distributed Systems(SBRC),pp.853-866,2014.

[30] B. Chatterjee, N. Sarma, and E. Oki, "Routing and SpectrumAllocationinElasticOpticalNetworks:ATutorial,"IEEECommunicationsSurvey&Tutorials,Vol.17,No.3,pp.1776-1800,2015.

[31] A. Fekete, G. Vattay, and L. Kocarev, "Traffic dynamics & scale-free networks,"Complexus,Vol.3, No.3, pp.97-107, 2006.

[32] X. Ling, M.-B. Hu, W.-B. Du, R. Jiang, Y.-H. Wu, and Q.-S. Wu,"Bandwidth allocation strategy for traffic systems of scale-freenet-work," Physics LettersA,Vol.374,No.48, pp.4825-5830, 2010.

[33] Z.-Y.Jiang,M.-G.Liang,S.Zhang,S.-J.Wang ,and D.-C.Guo,"An efficient bandwidth allocation strategy for scale-freenetworks,"Int. Journal of Modern Physics C,Vol.23,No.10,2012.

[34] Z.-Y.Jiang,M.-G.Liang,Q.Li,andD.-C.Guo,"Optimal dynamic bandwidth allocation for complex networks," Physica A: Statistical Mechanics and its Applications,Vol.392,No.5,pp.1256-1262,2013.

[35] S. Zhang,N. Huang, X. Sun, and Y. Zhang,"A novel application classification and its impact on network performance,"Modern Physics Letters B, Vol.30, No.21,2016.

[36] K. Kanonakis and I. Tomkos, "Improving the efficiency of on-line upstream scheduling and wavelength assignment in hybrid WDM/TDMA EPON networks," IEEE J. on Selected Areas inCommunications,Vol.28,No.6,pp.838-848,2010.

[37] G. Kramer, B. Mukherjee, and G. Pesavento, "IPACT a dynamic protocol for an Ethernet PON (EPON)," IEEE CommunicationsMagazine,Vol.40, No.2,pp.74-80, 2002.

[38] M. P. McGarry and M. Reisslein, "Investigation of the DBA algorithm design space for EPONs," J. of Lightwave Technology, Vol.30,No.14,pp. 2271-2280,2012.

[39] F. Usmani, S. M. H. Zaidi, A. Awais, and M. Y. A. Raja, "Efficient dynamic bandwidth allocation schemes in long-reach passive optical networks – A survey," 11th Annual High-Capacity Optical Networks and Emerging/Enabling Technologies (HONET),2014.

[40] C. Knittle,"IEEE 100G-EPON," Optical Fiber CommunicationConf.,2016.

[41] Z. Vujicic, A. Shahpari, B. Neto, N. Pavlovic,A. Almeida, A.Tavares, M. Ribeiro, S. Ziaie, R. Ferreira, R. Bastos, and A. Teixeira, "Considerations on performance, cost and power consumption of candidate 100G EPON architectures," 18th Int. Conf. Transparent Optical Networks(ICTON),2016.

VIII. Author's Biographies

ABHISHEK GAUR
(abhishek.usict.010164@ipu.ac.in)

Mr. Abhishek Gaur is a research scholar in the field of ECE (with specialization in the field of Converged Networks). He is pursuing his doctorate degree from USICT (University School of Information, Communication & Technology), Guru Gobind Singh Indraprastha University, Delhi. He received his B.Tech degree in the field of Electronics & Communication Engineering and M.Tech degree in the area of Digital Communication from Guru Gobind Singh Indraprastha University, Delhi, India in the year 2010 & 2012 respectively. His research interests include Optical-Wireless converged Networks, Optical Access Networks, Advanced Computer Networks, Heterogeneous Networks (HETNET), LTE Networks, Wireless Communications, Digital Design, Microwaves, Antennas and Wireless Backhauling. He has presented & published various research papers in the field of Converged networks, Wireless networks & Optical Access Networks.

Dr. VIBHAKAR SHRIMALI
(vibhakar.shrimali@gmail.com)

Dr. Vibhakar Shrimali is an eminent Professor & researcher in the field of Electronics Engineering. He graduated in Electronics and Communication Engineering from MBM Engineering College, Jodhpur, India, in 1987, and received his Masters' degree in Electronics and Communication Engineering from Delhi College of Engineering, Delhi India. He obtained his doctorate degree from IIT Roorkee (An institute of National Importance). He Joined GB Pant Govt. Engineering College, Delhi in the year 2014 as an Associate Professor in Electronics & Communication Engineering department. He has a rich teaching & administrative experience of more than 25 years. He has guided many technical projects of UG, PG & Research Students in the field of Electronics & Communication Engineering. He has chaired a no. of technical conferences and presented various research papers of ECE domain. His research interest includes image processing, signal processing, wireless communication, Next Generation Mobile Networks, Optical networks, Ad-hoc & Sensor Networks, Heterogeneous networks, Advanced Communication Engineering. He is member of Institute of Electrical and Electronics Engineers (IEEE), USA, Society of Engineering in Medicine and Biology, Society (EMBS), USA, a fellow member of Institute of Electronics and Telecommunication Engineers (IETE), India. Institute of Engineering (IE), India and Life member of Computer Society of India (CSI).