Fuzzy Based Resource Allocation In 4g-Lte

M. Naresh, D. Venkat Reddy, K. Ramalinga Reddy

Abstract: Long Term Evolution network or LTE network is a 4G network extension that provides higher data rate by combining multiple technologies and channels through a demand based selection of the appropriate one. This implements an evolved node base station (eNB). The Integrated eNB's in 4G network are responsible for seamless switching between different technologies and channels. Such a switching decision is often affected by several parameters like available bandwidth, desired load,; inter channel interference, available signal to noise ratio, fading, downlink power and so on. Frequent switch between channels result in waste of a portion of bandwidth in control signal whereas delayed switching results in low packet delivery ratio and in turn low data rate. Hence, an optimal solution is desired to maintain high data rate under scalable 4G network. In this work, we propose an optimal channel selection and switching by suitably controlling the downlink power depending upon fuzzy classification of performance parameters. Results show that the proposed system improves effective data rate and packet delivery ratio in comparison with conventional linear techniques.

Index Terms: LTE, eNB, optimal solution, 4G

1. INTRODUCTION

LTE systems are essentially based on GSM/UMTS system which integrates IP based services into the communication system for reducing the packet latency a typical LTE system in collaboration with other networks is shown in figure 1. The system supports maximum download rates up to about 300 Mbps and upload rate to about 75.4Mbps. The rates however depend on the user equipment (UE). The UE can operate with multiple micro strip antenna or antenna array (standard 4×4 antenna array over 20 MHz). The system is also marked by low data latency of less than 5ms for small IP packets under ideal conditions. Multi radio environment also needs good handoff speed if the UE wants to access various technologies. This offers a very good service under high mobility. Such is the service quality of LTE systems, that it supports as high mobility as 350 Km/h. The system ideally useless OFDMA for the downlink. SC-FDMA is commonly used for the uplink. Due to power conserving nature of FDMA based systems, it suppers significant power saving for UEs. The uplink and downlink transmission technologies are showing in Figure 2.

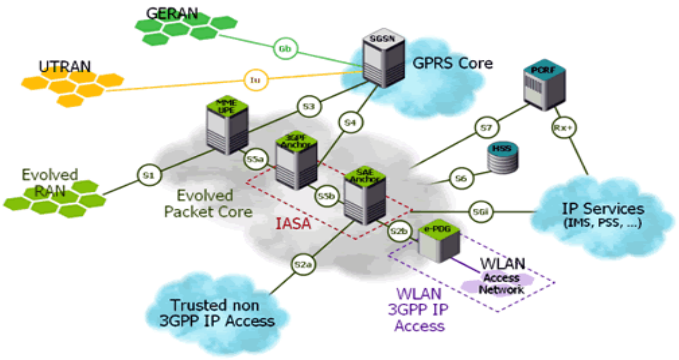

Figure1. *Collaborative LTE Network*

Different data rates at (1.4, 3 , 5 , 10 , 15, 20) MHz are supported. LTE system divides the region into micro cells (100 km range), followed by PICO cells and FEMTO cells which ranges within meters. 200 active nodes can transmit simultaneously in 5 MHz transmission cell. The network is mainly monitored by eNBs. The eNBs also supports legacy systems like 3G and 2G cellular network systems. In this work we mainly focus on OFDM based System for data transmission. We simulate the network with image transmission from eNBs to mobile nodes in the context of downlink transmission and measure the transmission quality at UEs. Further the measurement in transmitted back to the eNBs. Each eNB collaborates to change the modulation index, signal power and data rate for the nodes.

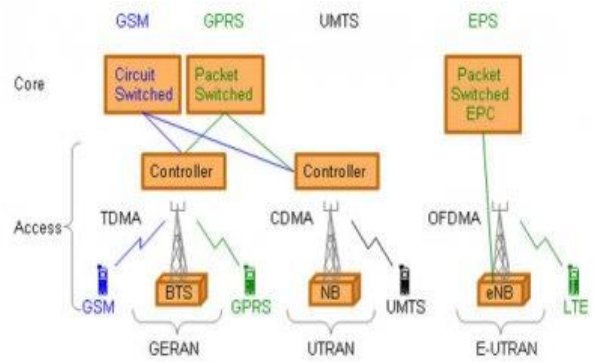

Figure2. *Transmission Technologies of LTE System*

- *M. Naresh is currently working as Assistant Professor in the Department of ECE, Matrusri Engineering College, Hyderabad, Telangana state, PH – 9949224090. E-mail: nareshmuddamalla@matrusri.edu.in*
- *D. Venkat Reddy is currently working as Professor in the Department of ECE, Mahatma Gandhi Institute of Technology, Hyderabad .E-mail: dasari_reddy@yahoo.com.*
- *K. Ramalinga Reddy is currently working as Professor and Head in the Department of ETM, G. Narayanamma Institute of Technology and Science for Women, Hyderabad. E-mail: kattareddy2000@yahoo.com.*

2 .REVIEW OF LITERATURE

LTE is developed to have a provision for broadband services in mobiles for the existing and forth coming systems. In this context D2D [1-3] has evolved which has enhanced the utilization of LTE-Advanced networks. This will be effected by two parameters. One is the interference caused by these devices which further effects the Qos. Hence a novel resource allocation is required[4]. A distributed and coordinated resource allocation of the RF is defined for OFDM that is based on the cellular networks such that they can self organize and efficiency reuse the frequency patterns. Each cell is allocated modulation as well as the coding schemes dynamically to reduce the transmit power by maintaining the users demand [5]. Device to device communications are expected to have seamless connectivity without human support [6]. An adaptive almost blank sub frame (A-ABS) optimization scheme by considering the traffic loads of two coexisted systems in order to guarantee the overall performance and fairness between LTE and WiFi systems. To quantitatively analyze this problem, utilize the M/G/1 queuing model. [7]. For reduction of complexity in joint optimization problem user pairing and resource allocation need to be optimized. Hence several complexity reduction techniques are proposed and a joint user pairing and resource allocation is considered, resulting in better throughput [8]. The proposed joint relaying and scheduling strategy enhance the capacity and optimize the energy consumption of the network [9]. Each user equipment is allocated a utility function based on the applications that the user requires. Users are divided into two groups as elastic and inelastic. Users running with adaptive real time applications are given priority. For this purpose carrier aggregation rate allocation algorithm is used to allocate carriers among users [10]. It is quite necessary to investigate the device to device communication under various channel uncertainties. A error free distributed solution for the allocation of resources by taking into consideration the network sum rate when the link and its parameters, relays are uncertain. This has become an optimization problem, where, convex and gradient aided dual decomposition algorithm is applied to allocate the radio resources [11]. Relay is an important factor that gives the information regarding the extension of the cell coverage and how to improve the capacity. Relays may be co-operating using Amplifying and Forwarding (A&F) and Decode and Forwarding (D&F) relay scheme to boost the entire system attainment in mobile networks [12]. Self organization strategy is investigated for physical resource block for resource allocation under quality of service constraints, which further resulted in reduction of co-channel interference [13]. The system capacity in a LTE system can be improved by using various frequency reuse schemes. As the power allocation and subcarriers to each cell are predefined, reduces the performance of such schemes. Hence, if these can be optimized then capacity can be improved [14].By the application of OFDMA in a LTE network multiple resource blocks can be scheduled overtime and frequency. The prime factors in resource allocation are resource block scheduling, power control and client association. Fuzzy Inference system is proposed for intelligent priority resource allocation for systems in LTE - A for multimedia traffic. Such a system is observed to have high throughput and better quality of service with more traffic load. The main feature of a LTE system is the advance resource management methods for improving the system performance up to Shannon limit. Resource allocation is a maximization problem which comes under statistical quality of service provisioning. Invasive weed optimization is used for energy efficient uplink design which outperformed the existing algorithms. A review of Machine to Machine communication techniques in LTE -Advanced networks are outlined [15].

3. PROBLEM DEFINITION

From the literature we learn that most of the past works are focused on resource allocation as link layer problem or combining Qos with application requirement. However, practical transmission quality depends upon several parameters like bandwidth, signal to noise ratio, interference, power loss due to fading, inter carrier spacing, load burst in the sub carriers and so on. Fuzzy logic has been used effectively in many conventional networks for obtaining optimal route for a session. As handoff and resource allocation are the biggest challenges of 4G network, we have proposed the fuzzy based system for resource allocation problem which guarantees better quality of transmission.

4. METHODOLOGY

Topology

We simulate the proposed Fuzzy based resource allocation protocol using a standard hexagonal cellular architecture where each cell is divided into multiple Femto cells; the architecture is shown in figure 3. Nodes at the edges are allocated different subcarrier (starting and ending subcarriers), where as the nodes in the middle are allocated with middle subcarriers. The base station is located at the center. Each Femto cell is considered to be handled by an eNB. It is also assumed that the operating environment in the physical layer is a multi radio wireless network, forming a mesh architecture within the cell. each eNBs and Femto cells can handle multiple radio and needs to suitably switching the subcarriers and the radio depending upon the network conditions to ensure Qos.

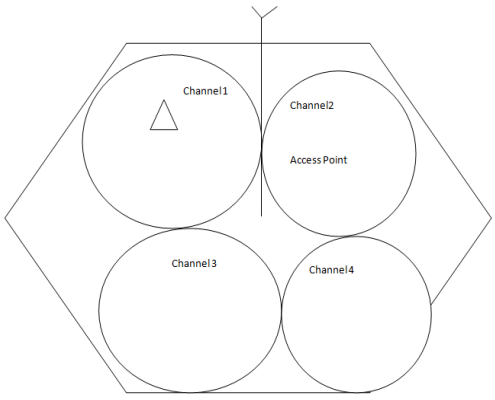

Figure3. *Hexagonal cellular architecture*

1. Each Femto cell is an independent sub network monitored by a access point.
2. Each Femto cell operates at different sub carriers and have different allocated power.
3. A mobile device instead of directly accessing the services through base station access the service through Femto cells.

4. Based on the user's demand user can be allocated to different sub carriers. Based on quality of transmission, user may be serviced by appropriate cells.
5. Each of the cells will divide the allocated spectrum through subcarriers.
6. When base station finds out that in SNR is low in a mobile's transmission specific to a particular cell, it assigns the mobile to another cell. It means that when one particular type of LAN has more congestion/delay/packet loss/BER, a node can be made to access the base station through other network.
7. Finally the objective is to show that by adopting Femto cell structure; effective throughput of the system can be significantly improved.

The overall functioning of the technique can be represented as a flow chart as shown in figure 4. An access point is the coordinator of the Femto cell. Each periodically broadcasts request beacon. The nodes receiving the beacon respond with a known image data. Access point calculates PSNR, BER and edge similarity percentage of the image with the actual image. This cumulative information is fuzzified and estimation for the interference is calculated. This information calculated at the edge is mitigated to the base station which decides on the subcarrier allocation to the cells. The overall block diagram is represented in the figure 5. This shows 2 channel radio network with two different QAM OFDM. The wireless data is affected by both white noise as well as interference from the other node's transmission. We transmit the packets at 11Mbps constant load. The resource {BW, POWER, SUBCARRIER] is determined from the fuzzy analysis of the observation data.

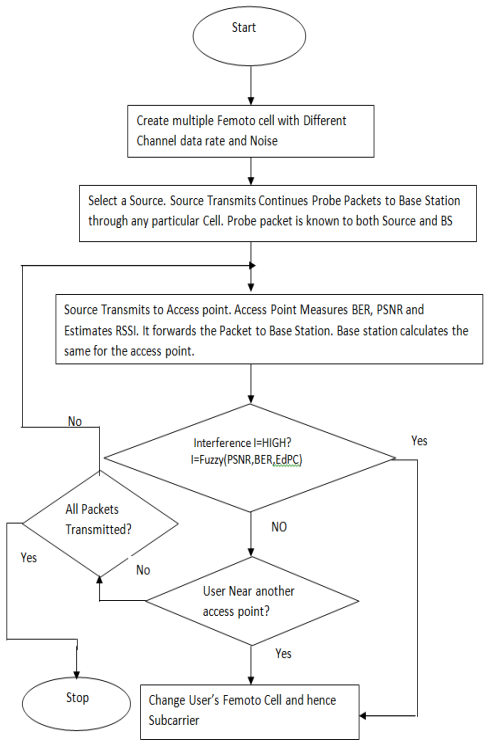

Figure4. *Flow chart of fuzzy based resource allocation*

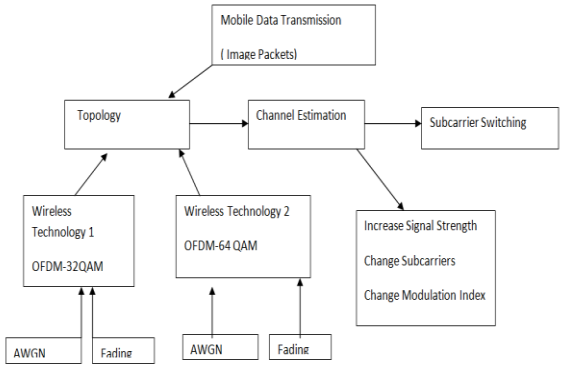

Figure5. *Overall block diagram*

Overall work can be represented using modular algorithm which is presented below figure 6.

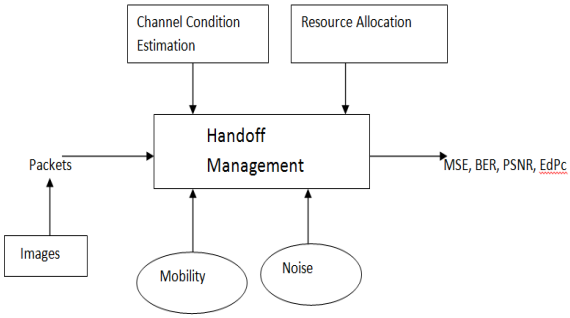

Figure6. *Module diagram*

ALGORITHM:

1. Network is divided into cells, each cell have one base Stations, each base station have set of frequency pools, Each pool contains set f frequencies
2. Number of nodes N is randomly selected and randomly Placed on different cells
3. Each node is allocated with a specific frequency from a Specific pool by a base station nearer to it.
4. Now S pairs of source destination nodes are selected to Communicate. We assume only mobile node to base Station. Packet transmission.
5. Images are converted into packets depending upon data rate which in turn depends upon number of sub carriers being allocated to the user. Packets are modulated using OFDM modulation. Modulated signal passes through channel when it suffers frequency selective noise and Fading. It also suffers interfering signals from other sub carriers.
6. Base station Collects PSNR, BER, MSE and Edge Similarity.

It passes the value to a fuzzy based system which gives a Qualities result of the monitored parameters.

5. RESULTS

It can be seen that Image quality significantly improves when SNR is increased are shown in the figure 7. SNR will be high when the node is nearer to eNB and will decrease when the node goes away. This is performed using fading channel.

Quality of transmission depends on the SNR which in turn depends on the distance from the access point. However the signal fading is not linear with distance. The fading also depends upon the channel error. This is simulated through fading model where we vary the distance from a range of 50m to 600m and measure the fading. This data is utilized by our simulation model. It is clear from the above graph that as the modulation index increases, BER also increases. This is because higher constellation more level of noise creeps into the transmission. Therefore by controlling the modulation index depending upon the error helps in reducing BER is shown in figure 8. We simulate resource allocation by varying UE and compare the performances of bandwidth estimation based resource allocation with that of proposed Fuzzy based technique. Figure x to y shows the performance comparison of the techniques. It can be seen that when User element increases, present resource allocation technique results in high BER even under high SNR. That is because overall packet delivery and accuracy of the transmission not only depends upon the bandwidth but also interference. As we know that the channel interference depends upon the subcarrier spacing, as the number of user increases, inter sub carrier interference also increases. This needs to be compensated either through enhanced power allocation or reallocation of the subcarrier suitably. It can be seen from the graph that increasing the transmission power (SNR) doesn't always result in improved BER performance. Hence suitable bandwidth allocation is needed. In plain bandwidth estimation based technique, the eNB nodes tries to measure the throughput and allocates bandwidth to ensure fairness. However, the proposed technique calculates the interference, power loss and available bandwidth from the trained signal. Fuzzy inference system establishes the mutual dependency of the parameters and therefore results in better resource allocation. It can be clearly seen that the proposed Fuzzy based technique is closer to theoretical limit of BER.

6. CONCLUSION

Allocation and reallocation of network resources like power, subcarriers and data rate are important issue in 4G LTE Network. The system supports mobility management in inter-cell mobility through horizontal handoff. The main demerit of such a system is that as the network operates with set of legacy radio network, the resource allocation needs to accommodate decisions from all the underneath networks and their quality of transmission. In a high speed network like 4G LTE, modeling the performance of various radio links into a quantitative index is immensely challenging because of the dependency of such a system on multiple factors like power, bandwidth, inter symbol interference, fading, inter-cell interference, inter carrier interference, channel utilization and so on. The current state of art mainly operates over on-demand allocation of resources. The current technique mainly relies on single matrix like bandwidth or power loss. Some of the techniques also combine multiple matrices to obtain a cost, based on which the resource allocation takes place. However, such methods fail to utilize the inherent relationship between the matrices. The Proposed fuzzy based resource allocation system transforms quantitative SNR, BER, power loss and available bandwidth into qualitative fuzzy values. These are turther resolved for optimality to obtain a qualitative classification of every channel. Channel with highest quality is selected for transmitting next data burst. Thus the proposed system can be considered is more stable and reliable in comparison to non-fuzzy based system. Results show that the proposed technique provides a significantly high throughput under very low SNR and improves BER in comparison to current state of art. The system can be further investigated for application specific analysis like Voice and video transmission.

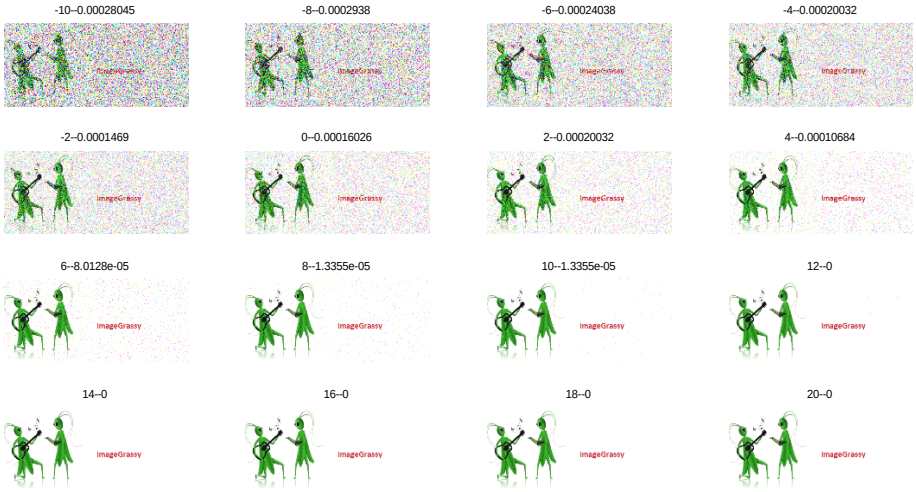

Figure7. *Transmission of PNG Icon with varying Modulation Index*

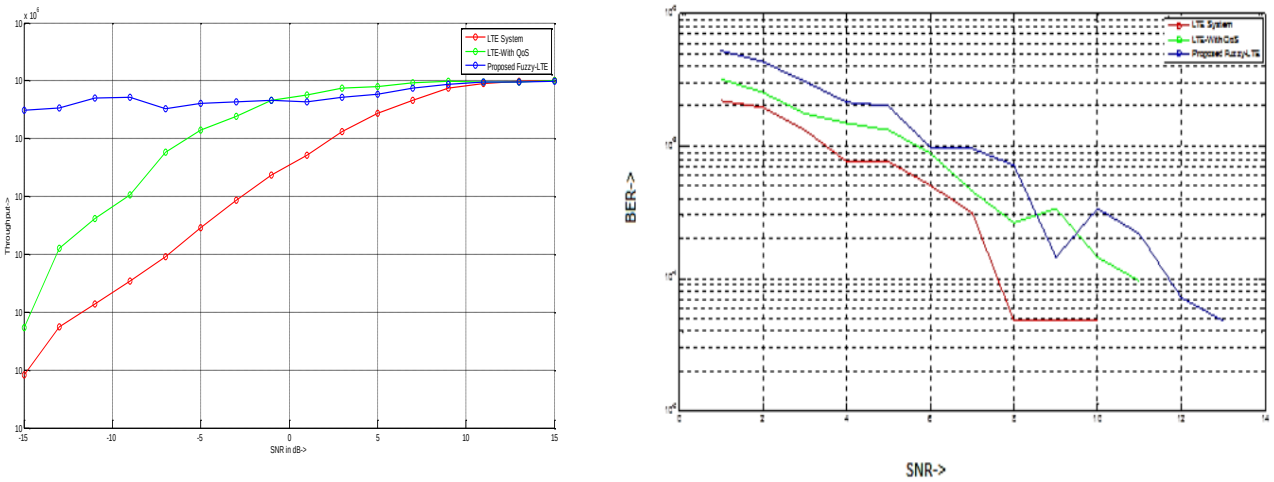

Figure8. *SNR Vs Throughput and SNR Vs BER*

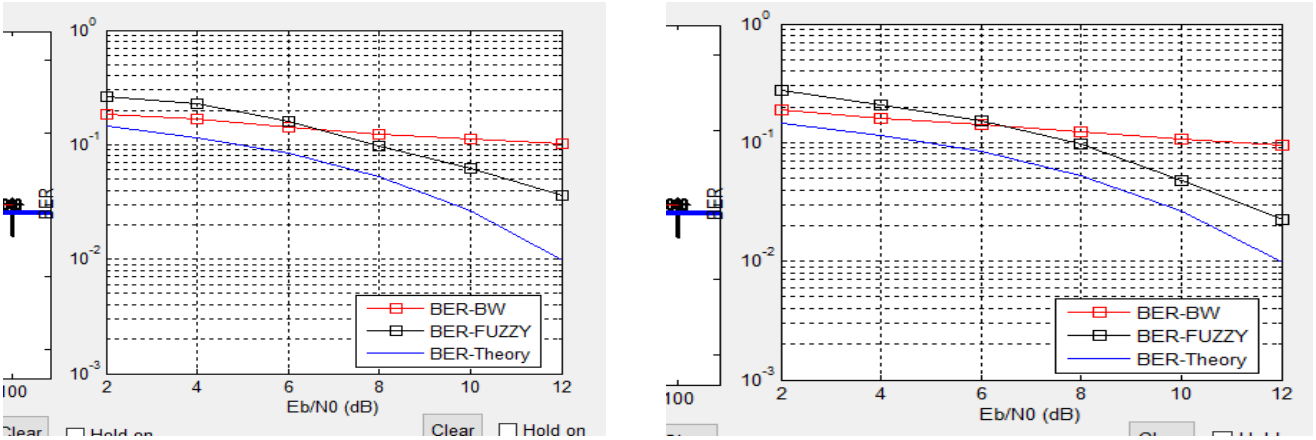

Figure9. *Bit error rate (BER) Vs E_b/N_o for UE3 and UE4*

REFERENCES

[1] Lei Lei and zHangdui Zhong, "Operator Controlled Device-To-Device communicatio ns in LTE-Advanced Networks", IEEE Wireless communications. 2012,pp:96-104.

[2] D. Tsolkas E. Liotou ; N. Passas ; L. Merakos, "A graph-Coloring secondary resource allocation for D2D Communications in LTE networks", 2012 IEEE 17th Inte rnational Workshop on Computer Aided Modeling And Design of Communic ation Links and Networks (CAMAD), September 2012, pp. 56-60.

[3] Bilal Maaz ; Kinda Khawam ; Samir Tohme ; Steven Martin ; Samer Lahoud ; "Joint scheduling and power control in multi-cell networks for inter-cell interfere nce coordination ", 2015 IEEE WiMOB, DOI :10.1109/WiMOB.2015.7348041

[4] P. Phunchongharn,E. Hossain, D. I. Kim, "Resource Allocation for Device to Device Communications Underlaying LTE Advanced Networks", IEEE Wireless Communic ations, Vol. 20, Issue 4, 2013, pp. 91-100.

[5] David López-Pérez, Xiaoli Chu, Athanasios V. Vasilakos, Holger Claussen, "On distributed and coordinated resource allocation for interference mitigation in self-organizi ng LTE networks", IEEE Transactions on Networking, Vol. 21, Issue 4, 2013,

[6] pp. 1145-1158.

[7] Mohammad Reza Mardani ; Salman Mohebi ; Behrouz Maham ; Mehdi Bennis, " Radio Resource Allocation in LTE-Advanced Cellular Networks with M2M Communi cations". 2017 IEEE Symposium on Computers and Communications ISCC),3-6

[8] July 2017, DOI: 10.1109/ISCC.2017.8024661

[9] Zhijian Guo ; Qixun Zhang ; Yifei Cai ; Zhiyong Feng ; Wei Li " Traffic Load Based Adaptive Almost Blank Subframe Optimization in LTE-U and WiFi Coexisted Systems", 2018 IEEE/CIC International Conference on Communications in China (ICCC Workshops) , 16-18 Aug. 2018.

[10] Jiale Zhao ; Shuangzhi Li ; Dan Ma ; Xiaomin Mu , " Research on Joint Mode Selection and Resource Allocation Scheme in D2D Networks ", IEEE 2018 Intern ational Conference on Cyber-Enabled Distributed Computing and knowled ge Discovery (CyberC) , 18-20 Oct. 2018 .

[11] Molabanti Ramya Sree ; P Vetrivelan ; R Ratheesh, " Energy aware joint relaying and adaptive resource scheduling strategies for multimedia traffics in LTE-A networks", 2017 International Conference on Nextgen Electronic Technologies: Silicon to Software (ICNETS2), IEEE, DOI: 10.1109/ICNETS2.2017.8067973

[12] André Pérez," Carrier Aggregation" Wiley Telecom, 2018.

DOI: 10:1002/97811 19516521.ch11
[13] M. Hasan, E. Hossain, Dong In Kim, "Resource Allocation Under Channel Unc ertainties for Relay-Aided Device-to-Device Communication Underlaying LTE- A Cellular Networks", IEEE Transactions on Wireless Communications, vol.13 No. 4, 2014, pp. 2322-2338.
[14] M. Rathika ; P. Sivakumar, " A Survey On Co-Operative Communication in 4G-Lte WirelessNetworks ", IEEE –ICRTAC, Sept 2018, DOI: 10.1109/ICRTAC. 2018.8679477.
[15] Feifei Zhao ; Wenping Ma ; Momiao Zhou ; Chengli Zhang "A Graph-Based QoS-Aware Resource Management Scheme for OFDMA Femtocell Networks" IEEE Access (Volume: 6), 2018.
[16] OwusuAgyeman Antwi ,Amevi Acakpovi," Evaluation of Inter-Cell interference BER on a Downlink PDSCH of the LTE Network", 20 June 2019, IEEE-ICCMA 2019 DOI: 10.1109/ICCMA.2019.00022
[17] T Huda Althumali ,Mohamed Othman " A Survey of Random Access Control Techniques for M to M Communications in LTE/LTE-A network" , IEEE Acces2018, DOI: 10.1109/ACCESS.2018.2883440.