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Performance Analysis of Resource Allocation in LTE Cellular Network

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ABSTRACT

The demands for visitors and services via the mobile networks are ever growing. Multi-tier has turn out to be a first-rate fashion inside the layout of new generations of cellular networks along with long term evolution (LTE) networks is a good way to support the excessive capacity call required for multiservice visitors. Traffic analysis and size in huge networks could be very challenging mission for network managers. Bandwidth allocation will become a critical issue for effective network control. Two-tier networks, comprising a LTE mobile network overlaid with smaller coverage picocells provide an economically critical technique to improve the LTE potentiality. On this kind of network an efficient call admission control (CAC) scheme is needed to improve the Quality of Service (QoS) in terms of dropping probability and waiting time etc. This paper proposes a two-tier call admission control scheme for LTE and picocells as a single unit in a cell to enhance the network coverage.

Keywords: Picocell, LTE, Traffic, Droping Probability, Waiting time.

1. INTRODUCTION

The present global trend is now heading towards wireless services in various fields (e.g. e-commerce, data, voice, multimedia, e-Health, e-Banking sectors, etc.) which has increased enormously and in significantly. Eight specifications came up as a part of Third Generation Partnership Project(3GPP) which evolved from the Long Term Evaluation(LTE) in the year 2009[12]. 3GPP came up with a higher version and better standard in technology of cellular network study called as LTE or Long Term Evolution, this gives a high spectral-efficiency, low latency, low complexity, higher data rates and reinforced QoS to cell-phone users.

The most common way of improving signal quality in a certain area is to place more base stations in that area. Because macro/LTE cells are expensive to install, the concept of small cells emerged called picocells. These consist of less expensive equipment with smaller coverage area, optimal for placement in hotspots. The comparison of a LTE cellular network with shorter range and low power picocells offers economical important to improve the LTE network capability in two-tier networks.

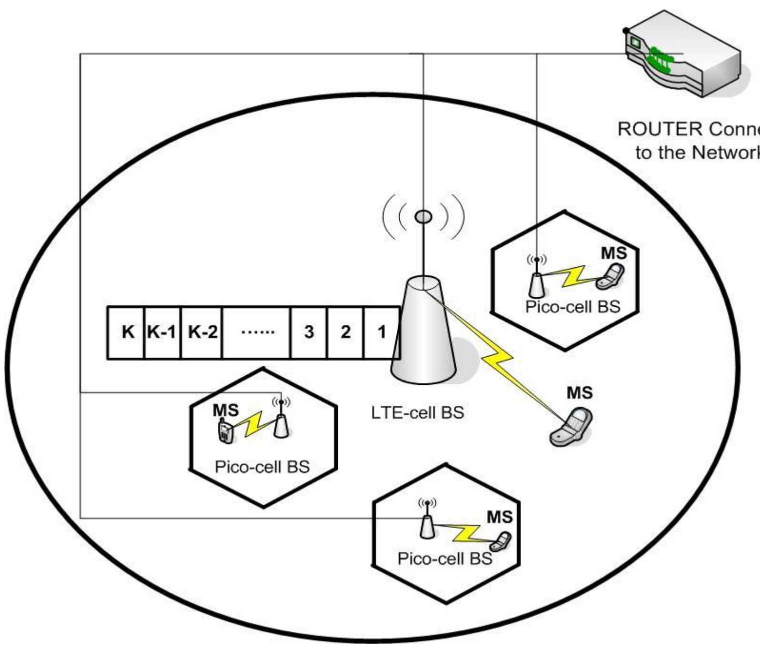

Figure 1: The architecture of call admission control in LTE

Two-tier networks, comprising a LTE- cellular network overlaid with shorter range and low power Pico-cells offer an economically important approach to improve the LTE network capacity. The architecture of the integrated LTE-Pico cell is shown in figure 1. In order to achieve the advantages of this type of integrated network, an efficient call admission control scheme is required to improve the connection level Quality of Service (QoS) of the wireless networks in terms of dropping probability, blocking probability and resources utilization. This paper proposes a two-tier call admission control scheme for integrated LTE/ Picocell to efficiently utilize the available resources by improving the network coverage and minimizing call dropping probability.

The rest of this paper is organized as follows. In Section 2, the related works and research contributions are presented. In Section 3, we proposed CAC schemes in terms of system model and study the performance factors. Section 4 illustrates the numerical analysis where we show the effectiveness of the channel allocation model for the two-tier networks. Finally, Section 5 concludes the paper.

2. LITERATURE REVIEW

Numerous analysts had been achieved in correlated to CAC in LTE network[12, 13]. In[1], any other lineup fashions or topologies using heterogeneous networks to decorate the performance of those networks are offered. In[2,11] a quality based call admission control and aid allocation mechanism are provided to avoid aid overloading and contact satisfactory degradation. The hassle of the inter-mobile interference between macrocell and picocell are addressed and the device is enhanced[7]. In[14], the authors studied the impact of picocell deployment to the device capacity; they found out that the deployment of picocells on the mobile area is more useful than within the mobile center. In[6] the author proposed a deployment scheme of Picocell on Macrocell, and discovered out that the deployment of picocells inside the hotspot regions in which there is excessive depth of traffics make greater enhancement in system performance extra than radio get right of entry to features consisting of cellular variety expansions (CRE). In[6,10] the overall performances of mixed admission manipulate and packet scheduling for QoS help and provider differentiation is provided.

The issues of CAC in LTE relay machine that is based totally on resource sharing is presented in[4]. A Wi-Fi backhaul channel shared amongst Picocells is supplied in[9]. A backhaul scheduling technique primarily based on visitors' demands on picocells that maximizes the picocell application is proposed and evaluated. In[12,13] the author has proposed and analyzed a new resource allocation manage framework called a preemption-primarily based call admission control scheme (PCAC) for integrating unbiased underlying Picocell with Macrocell networks, he aimed to utilize the Resource Blocks (RBs) of picocells (owned with the aid of multi-operators) correctly to enhance Macro-cell consumer performance through permitting its consumers of Macro-cell, traffic to utilize unused Picocell RBs without any degradation for Picocell customers[5]. He discovered out that the device throughput is stepped forward the usage of the proposed CAC. For LTE integrated with Picocells in stages networks, the aid management must be designed in an efficient manner to maximize the utilization of radio assets and also to boom the gadget throughput and reduce the blocking probability[8,15]. The principle contribution of this paper is to deal with this difficulty.

A dynamic CAC within the cells of LTE-Pico networks in is proposed to correctly utilized the available sources and enhance the coverage area. We study and examine techniques for the CAC in single and two-tier LTE networks. In[5] single tier, LTE and picocell have its very own users and its very own assets where in two-tier the available sources of Picocell can be shared with the aid of LTE users and users of that area.

3. SYSTEM MODEL

In this paper we considered a model for call admission control in combined LTE-Pico cellular network. Incoming call requests are generated in two ways.

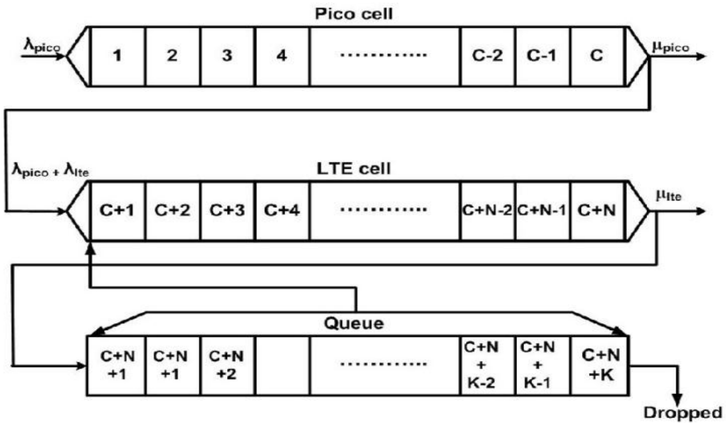

Figure 2: The system model for CAC

Case 1: Incoming calls to picocells use upto 'C' number of channels allocated to it. If channel is not available in picocell an incoming call is forwarded to LTE cell.

Case 2: LTE cell is equipped with 'N' number of channels for proving channel resources to incoming calls from LTE cell as well as picocell. In case all channels are filled in LTE cell incoming calls are entered in to queue to wait until availability of free channel in LTE cell. The queue is considered to have a buffer space to accommodate 'K' number of incoming calls. If the queue is full then the incoming calls are dropped. Call arrivals to both the Pico and LTE cell components are following a Poisson process at a rate λ_{pico} and λ_{lte} respectively.

Incoming channel requests are served by the BS's of respective LTE and Pico cellular network and the service time is an exponentially distributed random variable with mean μ_{pico}. if channels available in Pico cellular network and service is from LTE cellular network and the service time is an exponentially distributed random variable with mean μ_{lte}. The traffic density in combined LTE-Pico cell is denoted by $\rho = \lambda / \mu$, where $\lambda = \lambda_{lte} + \lambda_{pico}$. The system model is shown in figure 2.

3.1 MARKOV CHAIN ANALYSIS OF LTE-PICO CELLS

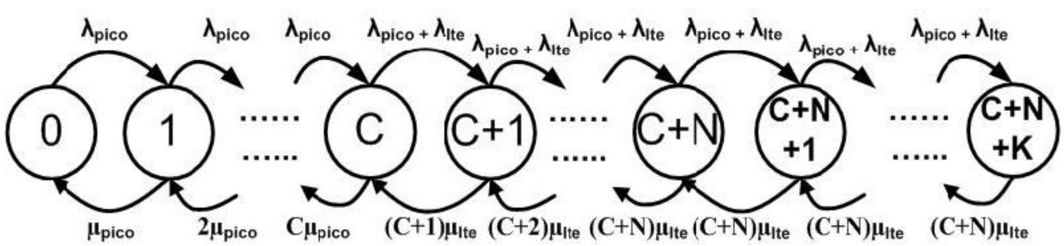

Figure 3: State transition diagram

The proposed model is analyzed using a Markov state transition diagram as shown in figure 3. The balanced equation can be written as follows:

$\lambda_{pico} P_0 = \mu_{pico} P_1$

$(\lambda_{pico} + i\mu_{pico}) P_i = \lambda_{pico} P_{i-1} + (i+1)\mu_{pico} P_{i+1},\ 1 \le i < C$

$(\lambda_{pico} + \lambda_{lte} + C\mu_{pico})P_C = \lambda_{pico}P_{C-1} + (C+1)\mu_{lte}P_{C+1}$

$(\lambda_{pico} + \lambda_{lte} + i\mu_{lte})P_i = (\lambda_{pico} + \lambda_{lte})P_{i-1} + (i+1)\mu_{lte}P_{i+1},\ (C+1) \le i < (C+N)$

$(\lambda_{pico} + \lambda_{lte} + (C+N)\mu_{lte})P_i = (\lambda_{pico} + \lambda_{lte}) P_{i-1} + (C+N)\mu_{lte}P_{i+1},\ (C+N) \le i < (C+N+K)$

$((C+N)\mu_{lte})P_{(C+N+K)} = (\lambda_{pico} + \lambda_{lte})P_{(C+N+K-1)}$

As the same Mobile Station is approaching to LTE cell area. So arrival rate for both Picocell and LTE cell are assume to be same, i.e. $\lambda_{pico} = \lambda_{lte} = \lambda$ and service rate is assumed to be $\mu_{pico} = \mu_{lte} = \mu$.

Hence the above equations are be reduced to:

$\lambda P_0 = \mu P_1$

$(\lambda + i\mu)P_i = \lambda P_{i-1} + (i+1)\mu P_{i+1},\ 1 \le i < C$

$(\lambda + \lambda + C\mu)P_C = \lambda P_{C-1} + (C+1)\mu P_{C+1}$

$(\lambda + \lambda + i\mu)P_i = (\lambda + \lambda)P_{i-1} + (i+1)\mu P_{i+1},\ (C+1) \le i < (C+N)$

$(\lambda + \lambda + (C+N)\mu)P_i = (\lambda + \lambda)P_{i-1} + (C+N)\mu P_{i+1},\ (C+N) \le i < (C+N+K)$

$((C+N)\mu)P_{(C+N+K)} = (\lambda + \lambda)P_{(C+N+K-1)}$

Solving for individual state probability in terms of P_0, it is found that:

$$P_j = \begin{cases} \frac{1}{i!}\left[\frac{\lambda}{\mu}\right]^i P_0 & : 1 \le i \le C \\ \frac{2^{i-C}}{i!}\left[\frac{\lambda}{\mu}\right]^i P_0 & : C+1 \le i \le C+N \\ \frac{2^{i-C}}{(C+N)!(C+N)^{i-(C+N)}}\left[\frac{\lambda}{\mu}\right]^i P_0 & : C+N+1 \le i \le C+N+K \end{cases}$$

Applying normalization Condition:

$\sum_{i=0}^{C+N+K} P_i = 1$

$\Rightarrow P_0 + P_1 + P_2 + \ldots + P_{C-1} + P_C + P_{C+1} + \cdots + P_{C+N-1} + P_{C+N} + P_{C+N+1} + \ldots + P_{C+N+K} = 1$

$$\Rightarrow P_0 + \frac{P_0}{1!}\left(\frac{\lambda}{\mu}\right)^1 + \frac{P_0}{2!}\left(\frac{\lambda}{\mu}\right)^2 + \cdots + \frac{P_0}{C!}\left(\frac{\lambda}{\mu}\right)^C + \frac{(2^1)P_0}{(C+1)!}\left(\frac{\lambda}{\mu}\right)^{C+1} + \cdots + \frac{(2^N)P_0}{(C+N)!}\left(\frac{\lambda}{\mu}\right)^{C+N} + \frac{(2^{N+1})P_0}{(C+N)!(C+N)^1}\left(\frac{\lambda}{\mu}\right)^{C+N+1} + \frac{(2^{N+K})P_0}{(C+N)!(C+N)^K}\left(\frac{\lambda}{\mu}\right)^{C+N+K} = 1$$

Solving for P_0:

$$P_0 = \left[1 + \sum_{i=1}^{C}\frac{1}{i!}\left(\frac{\lambda}{\mu}\right)^i + \sum_{i=(C+1)}^{C+N}\frac{2^{i-C}}{i!}\left(\frac{\lambda}{\mu}\right)^i + \sum_{i=(C+N+1)}^{C+N+K}\frac{2^{i-C}}{(C+N)!(C+N)^{(i-C-N)}}\left(\frac{\lambda}{\mu}\right)^i\right]^{-1}$$

3.2 PERFORMANCE INDICES

Here the performance indices of the proposed model are evaluated. The QoS of the system is maintained by the following performance factors:

The dropping probability (P_d) of calls is calculated due to unavailability of channels and when the buffer became full i.e. no queue available.

$$P_d = P_{(C+N+K)} = \frac{2^{(N+K)}}{(C+N)!(C+N)^K}\left[\frac{\lambda}{\mu}\right]^{C+N+K} P_0$$

The expected number of busy channels is obtained as:

For Pico cells:

$$E(N)_{pico} = \sum_{i=1}^{C} iP_i$$

For LTE cells:

$$E(N)_{lte} = \sum_{i=C+1}^{C+N} iP_i$$

The expected queue length:

$$L_q = \sum_{i=C+N+1}^{C+N+K}[i - C - N]P_i$$

The expected waiting time of calls in the queue is:

$$W_q = \frac{L_q}{\lambda}$$

4. NUMERICAL ANALYSIS

This section describes the performance of the model in terms of numerical results and presented in the form of graphs as described below.

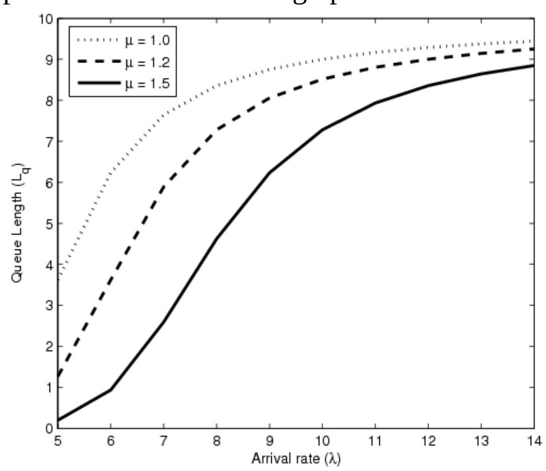

Figure 4: Arrival rate vs. queue length for different service rate

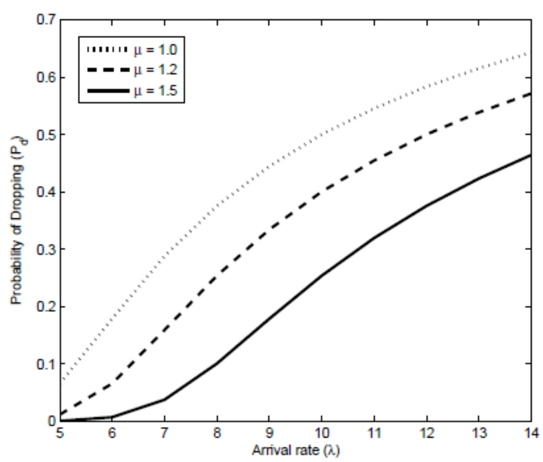

Figure 5: Arrival rate vs. probability of dropping for different service rate

Figure 4 represents the behaviors of queue length (L_q) i.e. number of calls admitted into the queue with respect to different arrival rate (λ). It also the variation of queue length for different service rate (μ) in terms of allocating channels for requesting calls. Here queue length increases rapidly with increase of arrival rate but slowdowns when arrival rate widens. On the other hand by increasing the service rate, queue length can be minimized. Hence to achieve quality of service a tradeoff between arrival rate and service rate is required.

Figure 5 describes the probability of dropping (P_d) i.e. number of calls dropped due to unavailability of channels with respect to different arrival rate (λ). And dropping probability of calls for different service rate (μ) in terms of unavailability of channels for requesting calls. Here dropping probability increases rapidly with increase rate of arrivals but initially slowdowns when arrival rate is shorten. Under increasing the service rate condition the dropping probability can be run down. Henceforth to produce the quality of service, a establishment between arrival rate and service rate is enforced.

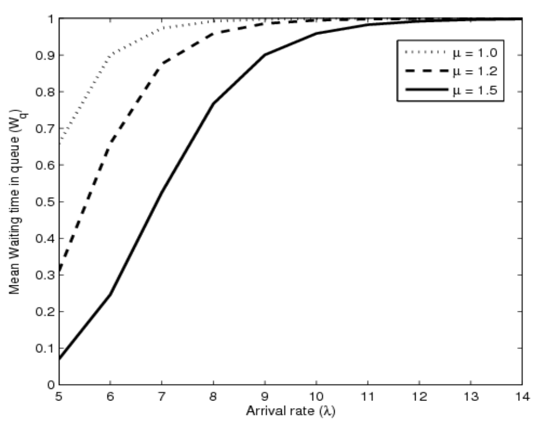

Figure 6: Arrival rate vs. Mean waiting time in queue for different service rate

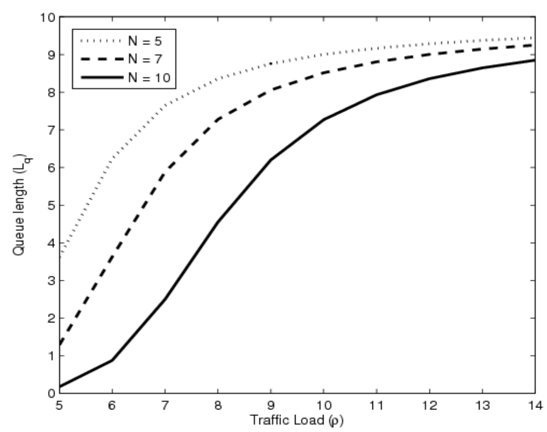

Figure 7: Traffic load vs. queue length for varying no of channels availability

Figure 6 illustrate the mean waiting time (W_q) in queue i.e. how much time an admitted call wait in the queue to get service with respect to various arrival rate (λ). This also mean waiting time in queue length for individual service rate (μ) in terms of getting served by channels the queued calls. On this spot waiting time boost speedily with increasing arrivals rate but shrink when arrival rate grow larger. When the service rate increase, the waiting time can be minimized in the queue. Thence to attrib the quality of service a resolution needed between rate of service and number of arrivals.

Figure 7 depicts traffic load (ρ) Verses queue length (L_q) with respects number of channels available in LTE cell. It can be observed that with increases of traffic load. There is a sharp increase in queue length as number of available channels are existed and incoming calls are entering to the queue. Further by increasing number of channels in pico cells queue length decreased in a significant manner up to modulate level of traffic load and after that the difference in queue length is very minimum. This shows that by requesting traffic load and number of channels available decreases the queue length.

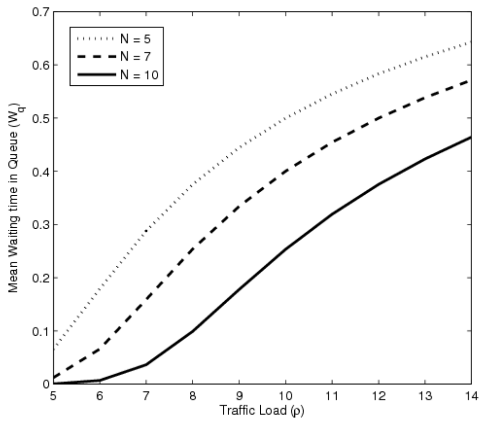

Figure 8: Traffic load vs. mean waiting time in queue for varying no of channels availability

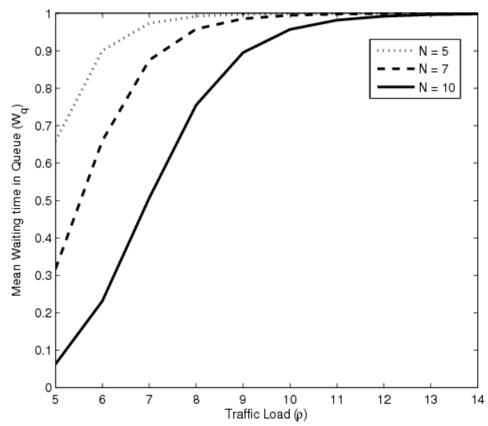

Figure 9: Traffic load vs. mean waiting times in queue varying no of channels availability

Figure 8 expressed the dropping probability (P_d) i.e. the number of calls dropped due to unavailability of channels in LTE cell with respect to varying in traffic load (ρ). And also probability of dropping calls is depends on the channels available in LTE cell. Here dropping probability accelerated with the increasing of the traffic load but initially crawling down when arrival rate is shortens. When the number of channels in LTE cell increases the probability of dropping is being downturn. Hence to calculate a quality of service, a establishment between channel numbers and Traffic Load is deserved.

Figure 9 Depicts the Mean waiting times in queue (W_q) versus Traffic Load (ρ) and Mean waiting time with respect to Number of channels available i.e. due to all channel of LTE is busy and no free channel available in queue, then the calls become dropped. Here mean waiting time rise up rapidly when traffic load increase but shrink when load in traffic go wider. On other hand if the LTE channels increase the waiting time can be down ward in the queue. So, to get the quality of service an adjustment is needed between traffic load and Number of channels available in LTE.

5. CONCLUSION AND FUTURE SCOPE

We proposed a call admission control scheme for LTE and picocell combined network to efficiently allocate the bandwidth resources and improve the QoS. The coverage area of the network also increased and call dropping is minimized. The resources are shared by both the coverage area to maximize the utilization. Performance of the system is studies in numerical section by presenting the graphs. The above model can be enhanced in future by adding inter adaptability of resources with exchange of available bandwidth between LTE and picocells.

REFERENCES

1. A. Khandekar, N. Bhushan, T. Ji, and V. Vanghi, LTE-Advanced: Heterogeneous networks, in *Wireless Conference (EW)*, European, pp. 978-982 (2010).

2. C. Olariu, J. Fitzpatrick, P. Perry, and L. Murphy, A QoS based call admission control and resource allocation mechanism for LTE femtocell deployment, in *Consumer Communications and Networking Conference (CCNC)*, IEEE, pp.884-888 (2012).
3. F. Liu, X. She, L. Chen, and H. Otsuka, Improved Recursive Maximum Expansion Scheduling Algorithms for Uplink Single Carrier FDMA System, in *Vehicular Technology Conference (VTC 2010- Spring)*, IEEE 71st, pp. 1-5 (2010).
4. H. Han and J. Zhao, Call admission control based on resource sharing in LTEAdvanced relay system, in *Advanced Communication Technology (ICACT)*, 16th International Conference on, pp. 1071-1076 (2014).
5. Itu telecommunications indicators update-2009. Online https://www.itu.int/itunews/issue/2002/10/indicators.html, 2009. Accessed: 2017-07-01.
6. M. Anas, C. Rosa, F. D. Calabrese, K. I. Pedersen, and P. E. Mogensen, Combined Admission Control and Scheduling for QoS Differentiation in LTE Uplink, in *Vehicular Technology Conference*, VTC 2008-Fall. IEEE 68th, pp. 1-5 (2008).
7. M. Eguizabal and A. Hernandez, Interference management and cell range expansion analysis for LTE picocell deployments, in *Personal Indoor and Mobile Radio Communications (PIMRC)*, 2013 IEEE 24th International Symposium on, pp. 1592-1597.
8. M. Rumney, Introducing lte advanced, agilent technologies. Online http://www.eetimes.com/design/microwave-rfdesign/ 4212869/IntroducingLTEAdvanced, May (2011).
9. Maric, x, I., Bos, x030C, tjanc, x030C, ic, x030C, B., and A. Goldsmith, Resource allocation for constrained backhaul in picocell networks, in *Information Theory and Applications Workshop (ITA)*, 2011, pp. 1-6 (2011).
10. P.C. Sethi and P.K. Behera, An Efficient Dynamic Bandwidth Allocation Algorithm for improving the Quality of Service of Networks, *European Journal of Academic Essays*, Vol – 1, Special Issue(1), pp. 31-35, (2014).
11. P.C. Sethi and P.K. Behera, Network Traffic Management using Dynamic Bandwidth on Demand, *International Journal of Computer Science and Information Security (IJCSIS)*, Vol- 15, Issue-6, 2017/6
12. S. A. AlQahtani and N. M. Ahmed Call Admission Control for Two-Tier LTE Macro/Pico Cellular Networks, Proceedings of the *World Congress on Engineering and Computer Science 2015*, Vol-II, WCECS 2015, October 21-23, 2015, San Francisco, USA.
13. S. A. Alqahtani, Performance Analysis of Preemption-Based Call Admission Scheme for Macrocell Users in Multi-Operator LTE PicocellularMacrocellular Networks, *Arabian Journal for Science and Engineering*, pp. 1-15, (2015).
14. S. Landstrom, H. Murai, and A. Simonsson, Deployment aspects of LTE pico nodes, in *Communications Workshops (ICC)*, IEEE International Conference on, 2011, pp.1-5 (2011).
15. T. Peng, T. Hui, G. Liqi, W. Jing, S. Xiaoming, and C. Lan, Deployment analysis and optimization of Macro-Pico heterogeneous networks in LTE-A system, in *Wireless Personal Multimedia Communications(WPMC)*, 2012 15th International Symposium, pp. 246-250 (2012).