A Survey On Mechanism Utilized For Rate And Energy Control In OFDMA Based Base Station

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ABSTRACT

In new advanced cellular technologies, more than one component carrier (CC) is utilized in a base station. As the development of the cellular technologies (such as LTE-Advanced) progress, use of multi CCs may not be necessary at light traffic loads, from the point of view of green communication. In this paper, numerous mechanisms propose by researchers on rate and energy controlled transmission are studied to compensate the problem of energy minimization at base stations by considering certain quality of service and fairness requirements for all users. Orthogonal frequency – division multiple access multiple CCs in downlink transmissions of base station is considered for the communication activities.

Keywords: *Component carrier, Green communication technology, OFDMA, Admission Control Mechanism, SUI channel model.*

I. INTRODUCTION

The fourth generation base station has been developed to use carrier aggregation features to achieve high network capacity in LTE- A. Carrier aggregation is used in LTE-Advanced [1] in order to increase the bandwidth, and thereby increase the bit rate. As a result problem with energy consumption for network access in base stations and emission of greenhouse gases like CO_2 have become critical concern. For minimization of total energy consumption and minimizing resource green communication [2] is used in all branches of communication. Multiuser OFDM System is used in to improve system performance.

In OFDMA based multi CC system scheduling process was executed sub frame by sub frame for transmission. OFDMA adds multiple accesses by allowing a number of users to share an OFDMA symbol. In OFDM the entire transmission bandwidth is divided into N-orthogonal sub channels, inter-symbol and inter-carrier interference can be removed by adding a cyclic prefix (CP) to each OFDM symbol, the channel appears to be circular if the CP length is longer than the channel length. Each sub channel thus can be modeled as a gain plus additive white Gaussian noise. To improve resistance to fast fading multicarrier effects of OFDM systems, multiple access is used because the sub channels are independent of each other.

For minimization of energy certain quality of service (QoS) and fairness among the users are maintained. Here QoS is considered to be the blocking probability and data rate. Downlink transmission supports both real time and non-real time traffics. International Telecommunication Union (ITU) Extended Pedestrian a (EPU) model [3] was adopted by most of the researchers for transmission such that most of the parameter setting follows the third generation partnership project i.e. 3GPP [4].

Resource scheduling algorithm is used for allocating subcarriers and energy among users, and through which activating and deactivating of CCs during periods of relatively light traffic loads is done. This scheme can yield significant reductions in the power consumed during data transmission. Previously researchers were using fixed resource allocation algorithm to provide constant power but due to constant power allocation there is loss of too much power, so to save that power Energy adaptive rate control algorithm known as EARCA [5] can be used.

For better QoS and fairness among user SUI channel model [6] may be a good option for transmission. The 802.16 IEEE group, has joined with the Stanford University, and has carried out an extensive work with the aim to develop a channel model for Wi-MAX applications in suburban environments. The most important results are obtained by the SUI (Stanford University Interim) propagation loss model, which is an extension of an early work carried out by AT&T (American Telephone & Telegraph Company) Wireless. According to IEEE 802.16, the SUI model is a suitable propagation model for Wi-MAX based on Erceg's model, for frequencies around 2 GHz, receiver antenna below 2 m. It is suitable to suburban environments and maintains the acceptable levels of users according to their requirements.

II. COMPARATIVE STUDY

R.Madan et.al [7] derived an efficient optimization algorithm to compute the optimal resource allocation in the downlink of an OFDM wireless cellular network. They showed that the algorithm converge all the optimal solution and has a complexity for N number of users. They showed that the algorithm converges was very fast in practice. Frequency selective fading is a application to scheduling algorithms with memory are also discussed, but their design were not capable of handling memory critical energy consumptions.

G. Micallef et.al [8] specified traffic profile, switching off the secondary carrier that enables DC-HSDPA and noted an energy saving of 14%. This gain was achieved without any affect to networks' performance, ensuring the same levels of users' satisfaction. Through switching off one of the two carriers a reduction in network capacity was done, and reduces the achievable gains in data rate that generally result from a reduction in network traffic, but fairness concept was not considered so it is unable to show the effectiveness of overall system.

Chunhua et.al [10] stated that novel constrained entropy-based multi path routing algorithm is used to reduce the number of route reconstruction so as to provide quality of service guarantee and save power in the ad-hoc network The ad hoc routing protocols commonly utilize the number of hops of the routes as the exclusive parameter to consider in the selection of the path to employ in order to forward the packets. Multipath routing problem deal with the entropy metric and describes a network model for researching the MANET multipath routing problem. The main idea is to reduce the number of route reconstruction so as to provide QoS guarantee in the ad hoc network.

Wu Z. et.al [12] explained that adaptive searching range routing algorithm is used to reduce power consumption by adjusting the link distance in the routes. A short transmission range requires a larger number of hops for a data packet to reach its destination, but consumes less transmission energy.

Chaba.et.al [13] explained that performance of on demand distance vector protocol with packet delivery ratio is better than other protocol. This section gives the some of the existed research ideas on the remaining energy of nodes and network lifetime in the mobile ad-hoc networks. In previous, researchers have ignored power consumption control problem in the mobile ad-hoc networks. It is observed that On-demand power management frame work is not effective for large size network due to dynamic configuration of network. Energy saving algorithms are not adequate in case of high speed dynamic network. Network efficiency could not e by using routing algorithm. Power control is not maintained by power saving.

Krishnamurity. et.al [9] described throughput-oriented based transmission energy control schemes to use per-packet energy consumption control. It is observed that mobile ad-hoc network arbitrarily motion of nodes results in unpredictable and frequent topology changes. Nodes cannot communicate directly with each other as nodes in a mobile ad hoc network normally have limited transmission ranges, hence, routing paths in mobile ad-hoc networks contain multiple hops, and each node in mobile ad hoc networks has the responsibility to act as a router.

C.T. Tung, et.al [4] successfully proposed an efficient energy-saving scheme for downlink transmission in OFDM-based multiple-CC system. Through this scheme several algorithms that can joint allocate the radio resource to users with a low computational complexity and actually conserve the unnecessary energy consumption. SCC has to be active or inactive on the basis of the fluctuating traffic load and the energy consumption. Here Data rate was not efficiently adjusted to the network load and fairness concept was not considered among the users due to which there was lack of overall system efficiency.

Shun Lung Cheng et.al [11] proposed several channel allocation policies for various types of user profiles under various fluctuation traffic loads in dual-band multi-cell environments. The considered policies include fixed allocation with admission control, reallocation on hourly basis and reallocation on hourly basis with forced dropping. Performance comparisons of the system utility and the band utilization with various policies are investigated by them. Also, how the bandwidth concentration ratio is balanced between the operator’s revenue and user’s satisfaction under a selected policy was shown.

Didem Kivanc et.al [14] tried to solve the problem of minimizing total energy consumption with constraints on bit-error rate. A computationally efficient class of algorithms for allocating subcarriers and energy among users is used. Based on the users average signal-to-noise ratio the number of subcarriers that each user was determined when every user experiencing a flat-fading channel.

Yao liang Chung et.al [5] proposed a novel energy-saving downlink transmission scheme in OFDMA-based multi-CC network systems. With the help of this allocation can be done by radio resource with an adaptively rate-and-energy control to users and which support an acceptable level of the QoS and the fairness at the same time, and effectively avoid unnecessary energy consumption. Resource scheduling algorithm, is used so that energy could be efficiently utilized. Since proposed scheme is based on the modification on work done by Didem Kivanc et.al, so computational complexity is small and it still have the issue to maintain the acceptable level for user requirement which can be solved by interaction of power and rate control protocols such as SUI channel model [6].

III. PROPOSED WORK

As described by the researchers downlink transmission was considered which supports both the real-time (RT) and the non-real-time (NRT) traffics simultaneously. Motivated by the practical need to more reasonable energy-saving designs in this area, a novel green scheme based on the rate-and-power control design is therefore proposed for efficiently solving the considered problem. The presented scheme also includes necessary scheduling and call admission control mechanisms [5]. The base station uses two component carrier that are classified into primary component carrier (PCC) and secondarycomponent Carrier (SCC).Here PCC is the main component carrier, while SCC will act as supplement component carrier which is considered when traffic signal is relatively heavy. Assume that both the component carriers are located in same band and each has bandwidth β in Hz. The LTE – A [1] frame structure is used in which scheduling process is executed sub frame by sub frame. Each sub frame is consist of J sub channels and two time slots. The resource block (RB) is set as a smallest allocation unit, in which there are seven OFDM symbols are present in one time slot and 12 subcarriers are there in one sub channel.

The system model is conceptually shown in fig. 1, in which session–level transmission is assumed. When a session requests arrives, the classifier present in the system will first classify the session into either RT or NRT session, and then it will be forwarded to scheduling queue. Next the admission control mechanism is used to resolve whether to block the session request in scheduling queue and if the session is allowed toaccess the network then which CC should be assigned. Those allowed sessions are transmitted through a resource scheduling algorithm. Reduction in date rate is represented by reduction ratio and enforced date to an NRT user are compared with the largest allowed data rate.

A. Admission Control Mechanism

By using this mechanism the requirements of the data rate is going to be checked. Below data rate formula is there which is derived from the basic formula of channel capacity. First let us define $(m, j)_{RB}$ as the RB on the mth time slot and jth sub channel. The ideal transmission rate of $(m,j)_{RB}$ on cc k for supporting session n as $r^{(k)}_{m,j\_n}$ is defined

Using basic formula of channel capacity, $r^{(k)}_{m,j\_n}$ can be derived as

$$r^{(k)}_{m,j\_n} = \beta \log_2\left(1 + \frac{K P^{(k)}_{m,j}\left|H^{(k)}_{j\_n}\right|}{\beta N_0}\right)$$

Here N_0 is the noise power spectral density, $\left|H^{(k)}_{j\_n}\right|$ is the channel gain between subchannel j and user session n on CC k, β=12.15000 is the bandwidth in Hz for RB. K= -1.5 /log (5BER), where BER is the desired bit error rate.

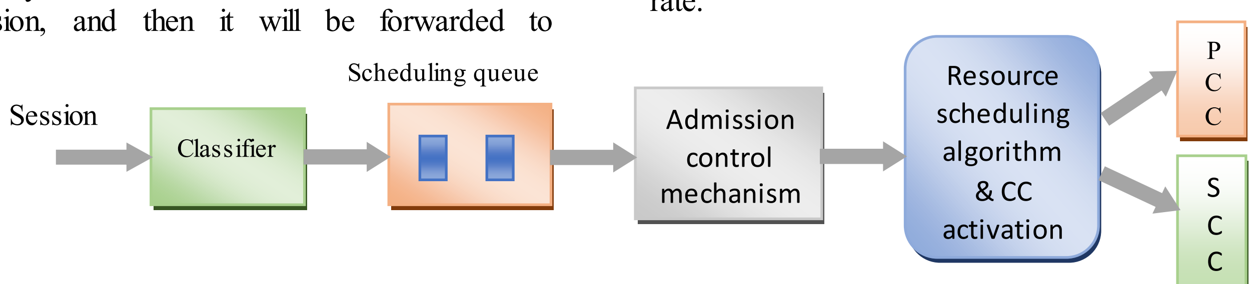

Fig 1:- Admission Control Mechanism [5]

B. Fixed Allocation with Admission Control

This allocation policy was proposed by Shun-Lung Cheng et.al.[11] with additional admission control on band B. When users are not able to use band A, the spectrum manager will decide whether they could use band B according to the user profile. For both original mobile users and slow handoff mobile users, they can use band B, as long as band B has available channels. For nomadic users, if they are assigned 1 channel, they can directly use available channels in band B; if they are assigned 2 channels, they can use band B when the available channels in band B are more than 50%; if they are assigned 4 channels, they are not allowed to use band B.

C. Reallocation on Hourly Basis

In this allocation admission control mechanism is done on hourly basis. When users are not able to use band A, they can still directly use available channels in band B. However, in this policy, the spectrum manager will predict the network congestion index at next hour. The predicted congestion index is intended to estimate how many channels should be reallocated to nomadic users in both band A and band B at the next hour. Here, we define two thresholds, ρ_{lower} and ρ_{upper}. If $\rho \leq \rho_{lower}$, 4 channels will be assigned to nomadic users; if $\rho_{lower} \leq \rho \leq \rho_{upper}$, 2 channels will be assigned to them; if $\rho \geq \rho_{upper}$, they can only obtain1channel. Notice that the time epoch of reallocating channels is on an hourly basis.

D. Reallocation on Hourly Basis with Forced Dropping

In order to increase the satisfaction with a mechanism of forced dropping. The spectrum manager will enable forced dropping of existing users on hourly basis, and the selection of dropped users is based on how long they haveconnected. In other words, the user with the longest connection time is considered a heavy user and he/she is on the priority list of forced dropping whenever $\rho \geq \rho_{upper}$.

E. Fixed Assignment Method[14]

The simplest approach to subcarrier assignment is to ignore channel information and allocate carriers to users proportional to their rate requirements. Subcarriers which was allocated in consecutive chunks (bands) or interleaved to improve frequency diversity.

F. Dual-Cell HSDPA Model

In Dual cell HSDPA model [18] both carriers have identical setup. During dual-cell operation, the achievable data rate is set to be the summation of the achievable data rate on both separate carriers. In comparision to multiplying the achieved data rate on the anchor carrier by 2, this addition process becomes relevant when selected sites have their secondary carrier switched off, reducing their interference to neighboring sites.

Table 1: Comparison of Researcher's Algorithms and their Conclusion

Researcher	Research paper	Mechanism/ Algorithm	Remarks
R.Madan, S. Boyd, and S. Lall [7]	Fast algorithms for resource allocation in wireless cellular networks	>Efficient optimization algorithm.	> Converges was fast with frequency selective fading. > Not capable of handling memory critical energy consumptions.
G.Micallef, P.Mogensen, & H.O.Scheck [8]	Dual-cell HSDPA for network energy saving	>Switching off secondary carrier	> Reduction in network capacity by switching off one CC. > Unable to show effectiveness of system.
Chunhua Xia. [10]	A Kind of Novel Constrained Multipath Routing Algorithm in Mobile Ad Hoc Networks	>Novel constrained entropy-based multi path algorithm	> Reduces the number of route reconstruction and provide QoS in the ad hoc network.
Wu Z, Dong X J, Cui L [12]	A grid-based energy aware node disjoint multipath routing algorithm for MANETs	>Adaptive searching range routing algorithm	> Reduces power consumption by adjusting the link distance in the routes.
Yao-liang Chung [5]	An efficient power-saving algorithm for the downlink transmission in OFDM-based multiple component carrier systems	>Resource scheduling algorithm	> Rate-and-energy controlled with QoS and fairness among user. > Issue of acceptable level for user.
D.Kivanc, G.Li & H.Liu [14]	Computationally efficient bandwidth allocation and power control for OFDMA	>Computationally efficient class algorithms	> Minimizing total energy consumption with constrains of bit error rate.
C.T.Tung, Y.L.Chung & Z. Tsai [3]	An efficient power-saving algorithm for the downlink transmission in OFDM-based multiple component carrier systems	>Radio resource algorithms	> Energy consumption with computational complexity. > Data rate not adjusted to the network load and fairness concept was not considered among the users.
Shun Lang Cheng, Yao Liang Chang [11]	A Multi-Channel MAC Protocol with Power Control for Multi-Hop Mobile Ad Hoc Networks	> Fixed allocation with admission control. > Reallocation on hourly basis with forced dropping	> Bandwidth concentration ratio is balanced

IV. CONCLUSION

For OFDMA based multicarrier network systems most of the researchers have used resource scheduling algorithm, which acts as an basic algorithm for avoiding unnecessary energy consumption for the fluctuating traffic load by using ITU- EPA [3] channel model. But the main problem was that in all the above discussed mythologies, data allocation is fixed due to which same amount of energy is still being used when traffic is light. With the help of SUI channel model, and energy adaptive rate control algorithm the rate and energy is being controlled and good QoS and the fairness may be obtained at the same time,and unnecessary energy consumption for the fluctuating traffic load can be avoided.

REFERENCES

[1]. A. Ghosh, R. Ratasuk, B. Mondal, N. Mangalvedhe, and T. Thomas, "LTE-advanced: Next-generation wireless broadband technology," IEEEWireless Commun., vol. 17, no. 3, pp. 10–22, Jun. 2010.

[2]. V. Mancuso and S. Alouf, "Reducing costs and pollution in cellular networks," IEEE Commun. Mag., vol. 49, no. 8, pp. 63–71, Aug. 2011.

[3]. C.-T. Tung, Y.-L. Chung, and Z. Tsai, "An efficient power-saving algorithm for the downlink transmission in OFDM-based multiple component carrier systems," in Proc. Proc. 14th IEEE Int. Conf. Advanced.Commun. Technol. (IEEE ICACT), Phoenix Park, Korea, Feb. 2012, pp.116–120.

[4]. Telecommunication Management: Study on Energy Savings Management, 3GPP TR 32.82 V10.0.0, Tech. Spec. Group Services and System Aspects, Rel. 10, Mar. 2010.

[5]. Yao-Liang Chung, IEEE, "Rate-and-Power Control Based Energy-Saving Transmissions in OFDMA-Based Multicarrier Base Stations". IEEE systems journal, vol. 9, no. 2, June 2015.

[6]. Appendix c: Stanford university interim channel models by brunoclerckx from MIMO wireless communications: from real-world propagation to space-time code design.

[7]. R. Madan, S. Boyd, and S. Lall, "Fast algorithms for resource allocation in wirelesscellular networks," IEEE/ACM Tans. Netw., vol. 18, no. 3, pp. 973–984, Jun. 2010.

[8]. G. Micallef, P. Mogensen, and H.-O. Scheck, "Dual-cell HSDPA for network energy saving," in Proc. IEEE VTC Spring 2010.

[9]. Mohapatra, P., Krishnamurthy, "S.Ad-Hoc Networks, technologies and Protocols", Springer Science Business Media, 2005.

[10]. Chunhua, Xia. "A Kind of Novel Constrained Multipath Routing Algorithm in Mobile Ad Hoc Networks", Proc. International Conference on Computational Intelligence and Software Engineering, pp.1-3, 2009.

[11]. Shun Lang Cheng,Yao–Liang Chang "A study of user profile based dynamic channel allocation in dual band environment"2010 IEEE 71st Vehicular Technology Conference,2010.

[12]. Wu Z, Dong X J, Cui L., "A grid-based energy aware node disjoint multipath routing algorithm for MANETs.", Proc. International Conference on Natural Computation,pp.244- 248,2007.

[13]. ChabaWu SL, Tseng YC, Lin CY:Sheu JP, "A Multi-Channel MAC Protocol with

Power Control for Multi-Hop Mobile Ad Hoc Networks". The Computer Journal, vol.45, pp.101-110, 2002.

[14]. D. Kivanc, G. Li, and H. Liu, "Computationally efficient bandwidth allocation and power control for OFDMA," IEEE Trans. Wireless Commun., vol. 2, no. 6, pp. 1150–1158,Nov. 2003