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Simple & Scalable Resource Scheduling in LTE-Advanced Network

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Abstract: A simple and scalable resource scheduling algorithm is proposed in current paper. Proposed algorithm is based on carrier aggregation feature. It is utilizes carrier aggregation capability of users in resource allocation. It is true that resources are always constraint with respect to its demand. So, current algorithm ensures provisioning of resources to each user in the network. These users are type of LTE supported users or LTE-advanced supported users. Current algorithm is not complex because there are less number of computation in a performance metriccorresponding to users need to be computed whereas conventional techniques are more complex because of higher computation are required. Current algorithm is adaptive and it updates it allocation in each TTI (transmit time interval). Results of current algorithm are compared with conventionaltechniques such as i.e. round robin, proportional fairness and maximum throughput technique, which show that current algorithmis simple and is providing high fairness and satisfactory data rate.

Keywords: scheuling algorthm, data rate, fairness, LTE-advanced , carrier aggregation, performance matric.

I. Introduction

LTE called as “Long Term Evolution” is a fourth generation technology in telecommunication. LTE is a 3GPP standard, which is designed for further evolution of conventional UMTS/HSPDA based third generation telecommunication system. High mobile data usage, high multimedia applications, mobile gaming, web 2.0, mobile TV etc. are main motivation in developing LTE standard. LTE provides high data rate LTE up to 300MBPS in downlink and 75MBPS in uplink. It is a complete packet based switching system working on an OFDM technology.

LTE is not a true 4G technology rather it is a 3.9G technology as it does not complied with recommendation of International Telecommunication Union (ITU). Later, LTE-Advanced (LTEA) is developed in according to the guidelines of ITU and is called as true 4G technology. LTE-Advanced provides 1GBPS data rate in downlink and 500 MBPS data rate in uplink. Such higher data rate and low latency are achieved in LTE-A by inclusion of new technologies, such as carrier aggregation, coordinated multi point network, MIMO, Relay Node.

LTE resources are divided into number of time (called as OFSM symbols) and frequency (called as sub-carriers) slots. A resource element (RE) is a smallest resource unit having a single sub-carrier in frequency domain and an OFDM symbol in time domain. A resource block (RB) is a smallest resource allocation to user equipment, having 12 sub-carriers and 6 or 7 OFDM symbols. Therefore, a resource block can have 72 or 84 resource elements. LTE supports scalable bandwidths which are 1.4MHz, 3MHz, 5MHZ, 10MHz, 15MHz and 20MHz. Each bandwidth has different number of resource block available i.e. 6, 15, 25, 50, 75 and 100 resource blocks respectively.

Carrier aggregationtechnique is a part of LTE advanced technology. It aggregates number of carries up to five to increase the bandwidth up to 100 MHz.Different survey papers on LTE and LTE-advanced network [1-4] suggest that multiple scheduling methods are available in literature. Conventional scheduling methods are round robin, maximum throughput and proportional fairness (PF) scheduling methods. Radio resource manager (RRM) is a main component for scheduling resources. A packet scheduler or PDSCH scheduler allocates resources based on various parameter considerations, such as channel condition, buffer status, queue length, previous average data rate, fairness, delay etc. Fig. 1 suggests a general resource allocation block diagram.

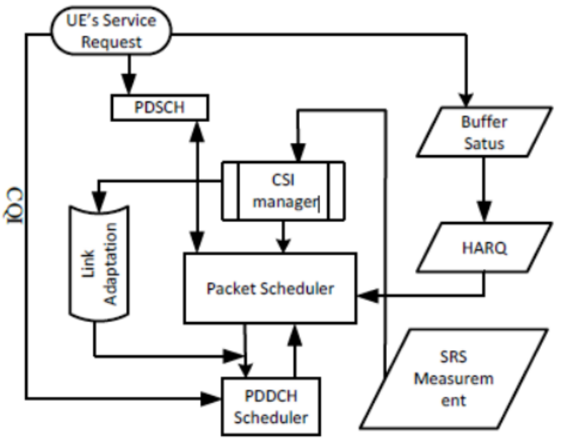

Fig. 1: General Resource Scheduler

Most of the conventional scheduling methods are complex as they design performance metric corresponding to each resource block and for each carrier with respect to each user. Further, someof the scheduling methods based on CA technique [4-6] suggest static allocation of carriers. Carriers allocated for long time does not provide good performance.

Therefore, current paper suggests a simple resource allocation method in which carriers are dynamically scheduled in each TTI i.e. total transmit time interval. Further, once the carriers are allocated, performance metric is designed such that it does not require higher computation for scheduling.

II. PROPOSED DESIGN

Let a LTE-A network at least includes a base station i.e.eNBs. The base station includes a scheduler to schedule resources based on channel qualities received from the users. Let number of users in base station are N_i, where $i = 1,2,3 \ldots, I$. Each user can support different number of carriers, so their carrier aggregation capability can be defined as

$$CA = \left\{CA_j \middle| CA \in \{1,2,3,4,5\}\right\}_{1\times I}$$

CA_jdefinescarrier aggregation capability supported by a $N_i \in I$ users.Number of RBs (resource blocks) for each carrier are different which are defined as

$$RB = \left\{RB_j \middle| RB_j \in \{6,15,25,50,75,100\}\right\}_{1\times K} S$$

Scheduler in the base station determines which users support which carriers and accordingly it designs a CC (component carriers) scheduling matrix $\widehat{CC}_{ij}$ which is shown below:

$$\widehat{CC} = \left\{\widehat{CC}_{ij} \middle| \widehat{CC}_{ij} \in \{0,1\}\right\}_{I\times J}$$

Value of $\widehat{CC}_{ij}$ suggests that j^{th} component carrier is allocated to the i^{th} user. If its values is zero, then corresponding user does not support that carrier.

Each user in the network transmits channel quality report to the user. The CQI report is transmitted for each RB of each supporting CC. Based on received CQI report, proposed scheduler in base station allocated resources to users. Channel quality matrix in scheduler is defined as below:

$$CQ = \left\{CQ_{ijk} \middle| CQ_{ijk} \in \{0,1,---,h\}\right\}_{I\times J\times K}$$

where CQ_{ijk}stands for channel quality perceived by N_i user on CA_j carrier in k^{th} resource block. The maximum values of CQI can be “h” (which value is well defines standards as 15). Below table show relationship between CQI index, modulation scheme and SNR value.

CQI Index	Modulation Order	Code Rate × 1024	β	SINR threshold (dB)
0	No transmission			
1	QPSK	78	1.00	-9.478
2	QPSK	120	1.40	-6.658
3	QPSK	193	1.40	-4.098
4	QPSK	308	1.48	-1.798
5	QPSK	449	1.50	0.399
6	QPSK	602	1.62	2.424
7	16QAM	378	3.10	4.489
8	16QAM	490	4.32	6.367
9	16QAM	616	5.37	8.456
10	64QAM	466	7.71	10.266
11	64QAM	567	15.5	12.218
12	64QAM	666	19.6	14.122
13	64QAM	772	24.7	15.849
14	64QAM	873	27.6	17.786
15	64QAM	948	28.0	19.809

Resource allocation in proposed algorithm:

Scheduler in proposed algorithm initially creates a resource scheduling metric which is shows below

$$SM = \left\{SM_{ijk} \middle| SM_{ijk} \in \{0,1\}\right\}_{I\times J\times K}$$

Where $SM_{ijk} = 1$ suggests that k^{th} resource block ofj^{th} component carrier is allocated to i^{th} user and similarity $SM_{ijk} = 0$ suggests that k^{th} resource block of j^{th} component carrier is not allocated to i^{th} user. The value of SM_{ijk} is determined by number of scheduling conditions defined by proposed algorithm.

Condition 1: A resource block should be allocate to a single user. It cannot be allocated to more than one user. This condition is defined as below:

$$\sum_{i=1}^{I} SM_{ijk} \leq 1$$

$$\text{For } 1 \leq j \leq J \text{and} 1 \leq k \leq K$$

Condition 2:Least number of carrier supporting users should be scheduled first. Then, as per increasing order of number of carriers supporting users should be scheduled.

For example, scheduler in base station determines number of users are supporting in a different number of carriers. Let out of N total users, M1 users support a single carrier, M2 users support two carriers, M3 users support three carriers, M4 users support four carriers and M5 users support all five carrier. Scheduler initially allocates resource blocks to only M1 users as they only support a single carriers.During allocation, schedule determines channel qualitiesof resource blocks of corresponding carrier perceived by M1 users in CQ_{ijk} metric. If value is above a predetermined threshold, then only it allocates resource blocks to user.Once the single carriers supporting users are scheduled, then as per algorithm M2 users need to be scheduled and so on. In this way, M1 users has higher priority then M2 users and so on (in short priority of M1>M2>M3>M4>M5).

Condition 3: Resource blocks are scheduled only when value of CQ_{ijk} corresponding to resource block is greater than a predetermined channel quality threshold.

Condition 4: Scheduling of carriers and corresponding resource blocks are updated in each TTI.

Condition 5:In each TTI, resource blocks are scheduledto be users conspiring their past throughput.

Based on described conditions in proposed algorithm value of SM_{ijk} in resource scheduling metric is determined and based on value of SM_{ijk}resource blocks are scheduled to users.

III. Simulation and Results Comparison

A. Simuation parameters

Simulation parameters as per proposed scheduling algorithm are shown in table. Simulation is performed using LTE system toolbox of MATLAB software.

Parameters	Value
System Bandwidth (BW)	10 MHz
Number of resource blocks	50
Subcarriers per RB	12
Frame Structure	FDD
Carrier Frequency	2.1 GHz
Simulation Time	10 Sec
Transmission Time Interval	1000
Cyclic prefix (CP)	Normal
Mobility Model	Random direction
User Traffic model	Poison Traffic
Modulation scheme	QPSK, 16QAM, 64QAM
Scheduler	Round robin, Maximum throughput, Proportional fair, Proposed schedulers

B. Performance calculation parameter

Fairness: Fairness parameter defines equal opportunity to all users in accessing of radio resources. Fairness parameter is calculated in terms of Jain's fairness index shown below:

$$f(x) = \frac{(\sum_{i=0}^{n} x_i)^2}{n \sum_{i=0}^{n} x_i^2}$$

AverageThroughput: Average Throughputis definedby average ofdata rates of all users.

C. Simulation Results:

Simulation results suggest performance indication of the proposed scheduling algorithm. It is assumed that all users in LTE network have not same type of capability for carrier aggregation. Different users have different CA capability. Proposedscheduling algorithm provides less complex, higher fairness and average throughput. Details of each performance parameter is described below.

Less Complex or Simple design: Proposed scheduling algorithm is very simple in design. Its computational time is also very less because less number of computation are required in performance metric. Initially, performance metric for all resource blocks for M1 users supporting a single carrier need to be calculated, but at same time, calculation is not required for same resource blocks for other users than M1. Similarly, less number of computation is required during resource scheduling for M2, M3, M4 and M5 uses.

Scaling: Proposed algorithm is applicable for both less or higher number of users. It provides approx similar results for both less or high number of users.

Fairness: Fig. 2 show fairness plots of different techniques supporting carrier aggregation scheme. It shows that current technique has highest fairness than conventional techniques. Current technique provides better fairness than proportion fairness technique. This is because dynamic allocation of carriers provide better load balancing than static allocation of carriers in proportional fairness parameter. Further, resources are scheduling with keeping priority to users with least supporting carriers. Fairness value is lowest for best CQI (maximum throughput) technique, then it is increased for round robin technique, then proportional fairness and it is highest for proposed technique. Proposed technique show same fairness characteristic for any number of users.

Throughput: fig. 3shows throughputs result for number of users which are scheduled using proposed scheduling algorithm and using conventional techniques. Result show that maximum throughput or best CQI has highest throughput. This is obvious because it schedules resources to only good channel quality users. However, proposed algorithm is also provide satisfactory throughput result. It is not too less than maximum throughput technique and it is approx equal or higher than other conventional techniques.

IV. Conclusion

Proposed algorithm are mainly focused on a simple and scalable scheduler design, which are achieved by this. We also achieved high fairness and average throughput.

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Adaptive carrier allocation is also advantage of proposed algorithm. Future improvement in proposed algorithm is possible by focusing on other performance parameters which are weak or average. Further, same scheduler should also need to be investigate for MIMO, heterogeneous network.

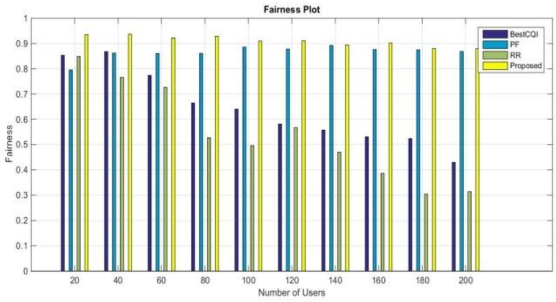

Fig. 2: Fairness Index VsNumber of Users

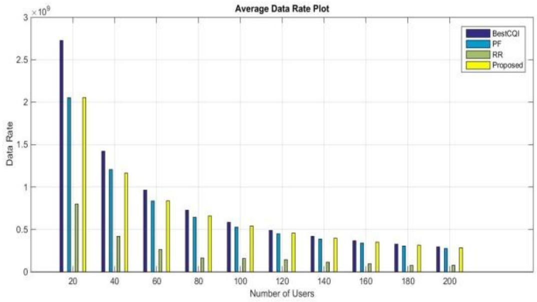

Fig. 3: ThroughputVsNumber of Users

References

[1] F. Capozzi, G. Piro, L. Grieco, G. Boggia, and P. Camarda, "Downlink packet scheduling in LTE cellular networks: Key design issues and a survey", IEEE Communications Surveys Tutorials, vol. 15, no. 2, pp. 678-700, 2013.

[2] Abu-Ali, Najah; Taha, Abd-Elhamid M. ; Salah, Mohamed ; Hassanein, Hossam "Uplink Scheduling in LTE and LTE-Advanced: Tutorial, Survey and Evaluation Framework", IEEE, 2014.

[3] Mohammad T. Kawser, Hasib M. A. B. Farid, Abduhu R. Hasin, Adil M. J. Sadik, and Ibrahim K. Razu, "Performance Comparison between Round Robin and Proportional Fair Scheduling Methods for LTE", International Journal of Information and Electronics Engineering, Vol. 2, No. 5, Sept 2012.

[4] F. Afroz, K. Sandrasegaran and P. Ghosal, "Performance analysis of PF, M-LWDF and EXP/PF packet scheduling algorithms in 3GPP LTE downlink," 2014 Australasian Telecommunication Networks and Applications Conference (ATNAC), Southbank, VIC, 2014, pp. 87-92.

[5] Y. Wang, K. Pedersen, T. Soensen, and P. Mogensen, “Carrier Load Balancing and Packet Scheduling for Multi-Carrier Systems,” IEEE Trans. On Wireless Comm., May 2010.

[6] H. Tian, S. Gao, J. Zhu, and L. Chen, “Improved Component Carrier Selection Method for Non-Continuous Carrier Aggregation in LTEAdvanced Systems,” in Vehicular Technology Conference (VTC Fall), 2011 IEEE, Sept 2011, pp. 1–5.

[7] F. Wu, Y. Mao, S. Leng, and X. Huang, “A carrier aggregation based resource allocation scheme for pervasive wireless networks,” in Dependable, Autonomic and Secure Computing (DASC), 2011 IEEE Ninth International Conference on, Dec 2011, pp. 196–201.