Packet Scheduling For Interference Mitigation in Heterogeneous Network

S. Gospel Ruben, B. Jesvin Veancy, P.Yogesh

Abstract— In heterogeneous network the deployment of pico cells is vital in offering higher data rates. Pico cell range extension is the feature of LTE-A where pico cell in a Het-net can increase the coverage area with an positive bias and neighboring macro cell can offload their users to pico cell to reduce load in them. Deployment of pico and macro will result in downlink interference for users in the range extension area. This leads to the multi-user downlink communication problem. The main task of low power cells deployed in a heterogeneous network is to allow the cell edge users benefit from the extra bandwidth that is introduced in the network. Scheduling of pico cell users can reduce the interference for the users in the cell range extension area of the Heterogeneous network. In this paper, downlink packet scheduling performance with Modified Largest Weighted Delay First has been analyzed.

Index Terms— eNB - eNodeB, LTE - Long term Evolution,QoS-Quality of Service, TTI-Transit Time Interval, UE - User Equipment.

1 Introduction

A homogeneous cellular network is a network of base stations in a planned layout in which all the basestations have similar transmit power levels and similar backhaul connectivity to the (packet) data network. The positioning of macro base station is carefully done through network planning. The base station settings are properly configured to maximize the coverage. A heterogeneous cellular network (LTE-A) is a network that consist of the traditional macro base station with pico cells deployed in it. To enhance the performance we have to improve the network topology and offer high spectral efficiency, low latency and high data rates. This can be achieved in the scenario of Heterogeneous networks by overlaying the planned network of high power Macro base stations with low power pico cells that are deployed in an unplanned way or simply in hotspots where a lot of traffic is generated. The areas enclosed by the pico cell are often allocated in the unplanned manner closely based on the sector where the traffic generation is high [1]. This can improve the overall capacity and the cell edge user performance and also improve the data rate. For pico base stations, the technique of range extension gives an opportunity to reduce the traffic at the macrocell by offloading macro cell user equipments to the picocell layer. The transmitting power difference of macro and pico is large, so the user equipment that are attached to the low power pico base station suffers interference from the high power macro base station.This is mainly seen in the cell edge coverage area of picocell. It is the one and only drawback for the users in LTE-A. The scheduling of pico users can help to reduce the interference in the network.

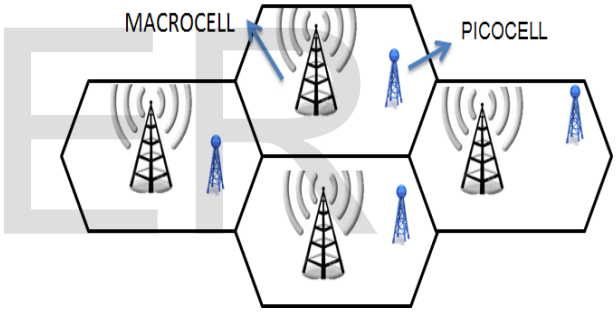

Fig 1.1 Heterogeneous network with Pico-eNBs deployed in Macro-eNBs

2 Cell Range Extension

In cellular networks, when a mobile moves from cell to cell and performs cell selection and handoff, it has to measure the received signal strength of the neighbour cells. In order to reduce the load in macrocell, the user equipment offloading is done in macro cell to picocell .The range extension technique is the addition of positive bias to the power of pico which is used in expanding the pico cell coverage area so that more user equipment are linked to the pico cell [2]. The positioning of the pico results in coverage area of lower signal to interference noise values, which inturn results in a task to increase performance of users in pico cell-edge area [2]. The large difference in the transmitting power of macro cell and pico cells indicates a lesser downlink coverage area for a pico when compared to macro cell. The Cell selection scheme is according to the user equipments measurement of the reference signal received power or cell specific reference signaling (CRS). Only user equipments that are nearer to pico is attached to pico cell. Higher number of user equipments are attached to macro cell

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since the transmitting power of macro is high which inturn results in increased coverage area.

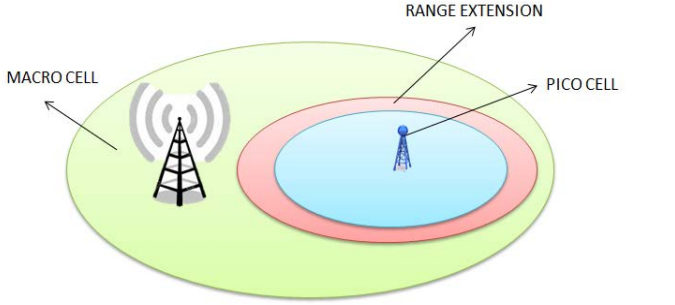

Fig 1.2 Range Extension Technique

Some of the properties of picocell are they can be deployed to eliminate coverage holes,Offer high data rate and capacity where they are deployed,Offloading the Macro-eNBs by serving some users that belong to the Macro-eNBs, which allows the Macro-eNB to serve better for its users.

2.1 Interference in Heterogeneous Network

The positive bias i.e. Range Extension value addition is used to increase the coverage area of the picocell [3]. The presence of two cells with dissimilar power levels introduces interference problems for the user euipments in the cell, which if not governed appropriately, can worsen the overall system performance (i.e. the coverage and user throughput). As there is large variation in transmit power of the macrocell and pico cell, the user equipments downlink signal power received from macro is higher than power received from pico, so the users present in the pico cell range extension areas are prone to macrocell interference. Those users in the extended area (i.e. cell-edge users) will suffer strong macrocell interference as depicted in fig1.3

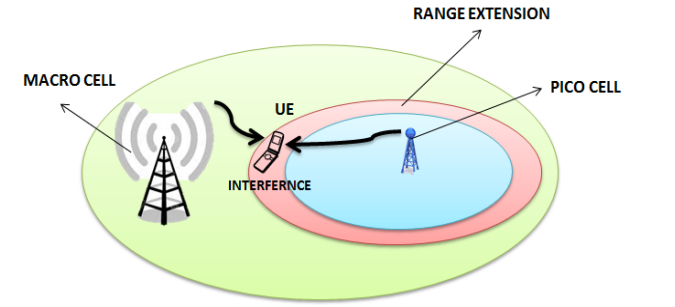

Fig 1.3 Macrocell interference to user equipment in Range Extension area

2.2 Positive Bias Addition

Cell selection is based on the receive signal strength [4]. The presence of the pico cell increases the fairness for cell edge users where they are placed in the Het-net. Let the receive signal strength be P(t).The user selects the serving cell -W by

$$W = \arg\max (P(t) + \beta) \quad (1)$$

Where,

β - bias value.

By assigning higher bias value to low power pico cell we can make sure that low power pico cell is utilized in an efficient way by offloading the more users from macrocell [5].

3 Packet Scheduling

Downlink Packet Scheduling in LTE are conducted by eNodeB. Scheduling in the downlink LTE system is performed at 1 ms interval known as Transmit Time Interval (TTI) which consists of 2 time slots, or resource-block-pair basis (RB). One sub frame of 0.5ms over 180 kHz. In each TTI the user calculates the received signal strength on the reference signals received from serving eNodeB [10]. Once the effective SINR values in each RB are determined, each user reports these values to the serving eNodeB in each TTI. The received effective SINR values of each user in each RB are used by the serving eNodeB to determine the modulation and coding scheme to be used for packet transmission. The QoS in a communication system differs with increasing traffic, so the choice of the scheduling algorithm significantly influennce the performance of the system.

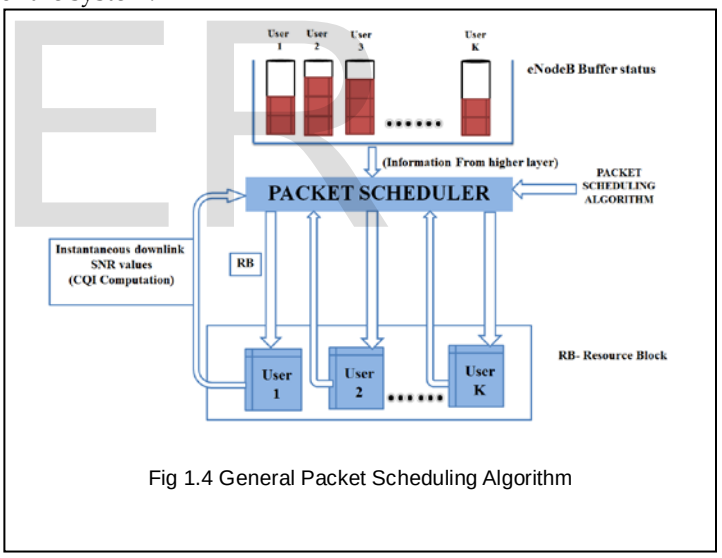

Fig 1.4 General Packet Scheduling Algorithm

At serving eNodeB, the packet scheduler assigns a buffer for each user. Packets that arrive into the buffer are time stamped and queued for transmission. For each packet in the eNodeB, the Head of the line (HOL) packet delay is computed. HOL packet delay is the time difference between the current time and the arrival time of the packet. Packet Scheduler determines the user's priority based on the packet scheduling algorithm.

3.1 Modified Largest Weighted Delay First

The Modified-Largest Weighted Delay First (M-LWDF) algorithm is proposed to support Real Time services. MLWDF algorithm introduces two new parameters: User's Quality of Service and data packet delay [10]. The M-LWDF scheduler is developed to support multiple Real Time data users. The

scheduler assigns resource blocks to different flows by considering the properties of the classical Proportional Fair rule and the Head of Line packet delay for the Real Time flows. For a multi-carrier system, M-LWDF algorithm is adopted for each subcarrier assignment. The following equation illustrates the metric used to represent the M-LWDF scheduler:

$$M = \text{argmax}\ a_i W_i(t) [r_i(t)/R_i(t)] \quad (2)$$

where,

$r_i(t)$= Instantaneous achievable datarate.

Ri(t)=Average datarate of user i at time t.

and

$$a_i = -(\log \alpha_i)/t_i \quad (3)$$

where,

$W_i(t)$= HOL packet delay of user i at time t.

t_i= delay threshold of user i

α_i= denotes the maximum probability of HOL delay to exceed the delay threshold of user i.

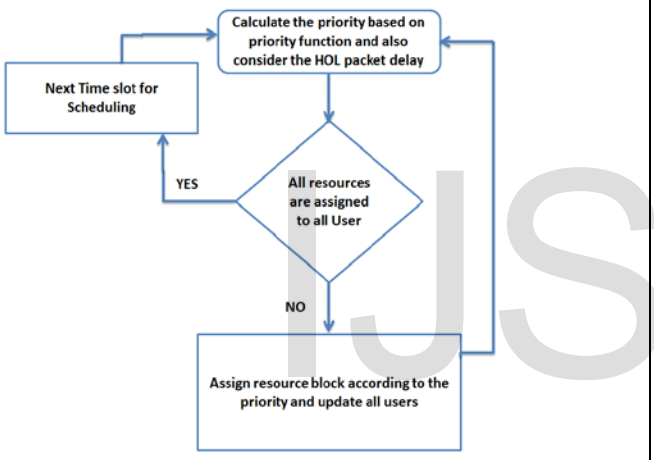

Fig 1.5 Flowchart of Modified Largest weighted delay First

4 Results And Discussions

Pico cell Range is extended by the positive bias value, this drives mobile users to perform offloading to the pico cell, although the received signal strength of the pico is relatively lower than macro cell. Some of the simulation parametes used is as follows

TABLE 1
SIMULATION PARAMETERS

Parameters	*Value*
TTI	1ms
Scheduler	Modified largest weighted delay first
Bias	0,6,9,15
Sub frame duration	0.5ms

Figure 1.6 shows the throughput of the various bias values of 0, 6, 9, 15dB for range expansion without scheduling has been improved for pico cell by using the Modified largest weighted delay first scheduling strategy. This shows that the throughput of various range extension value has been improved.

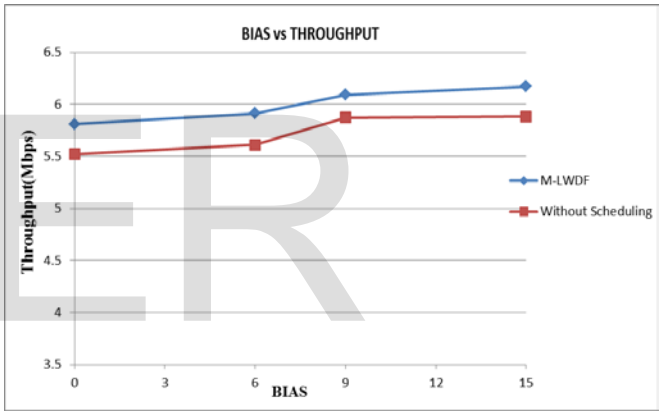

Fig 1.6 Comparison for various bias values with Throughput for without scheduling and M-LWDF scheduling

Figure 1.7 shows the packet deliver ratio for the various bias values of 0, 6, 9, 15dB for range expansion without scheduling has been improved by using the Modified largest weighted delay first scheduling strategy.

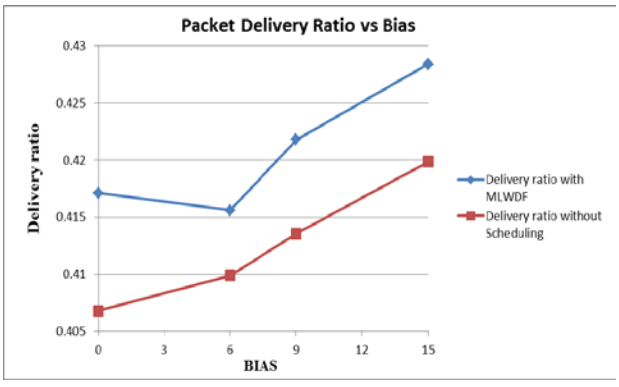

Fig 1.7 Comparison for various bias values with Packet Delivery ratio for without scheduling and M-LWDF scheduling

5 CONCLUSION

The performance shows that pico cell range extension value has to be properly selected based to the traffic and adjust to the user equipment distribution. When the pico cell range extension is applied, more users are forced to use pico cell as their base station.The scheduling of the users in pico cell protects offloaded users in range extension area from interference caused by macrocell. Thus by using the modified largest weighted delay first algorithm the throughput and the packet deliver ratio has been improved for the pico cell in the range expansion area. This increase in throughput in the range expansion area for the modified largest weighted delay first shows that the interference caused by the macro cell is being reduced for users in the pico cell range expansion area. By using various scheduling algorithm the throughput can be enhanced in the range extension area.

REFERENCES

[1]. Andreas Weber, Oliver Stanze. ,"Scheduling Strategies For Hetnets Using eICIC", International workshop on small cell wireless networks, 2012.

[2]. Mohammed Al-Rawi. "A Dynamic Approach for Cell Range Expansion in Interference Coordinated LTE-Advanced Heterogeneous Networks", *IEEE ICCS Proceedings of the* 2012.

[3]. Kenta Okino, Taku Nakayama, Chiharu Yamazaki, Hirotaka Sato, and Yoshimasa Kusano. "Pico Cell Range Expansion with Interference Mitigation toward LTE-Advanced Heterogeneous Networks", *IEEE International conference, Communications Workshop(ICC)*, 2011.

[4]. Yuanye Wang and Klaus I.Pedersen, "Performance Analysis of Enhanced Inter-cell Interference Coordination in LTE-Advanced Heterogeneous Networks", 2012.

[5]. Andrias Racz, Norbert Reider and Gabor Fodor, "On the impact of Inter-cell Interference in LTE", IEEE "GLOBECOM" 2008.

[6]. 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,September-2012.

[7]. Amitabha Ghosh, Nitin Mangalvedhe, Rapeepat Ratasuk, Bishwarup Mondal, Mark Cudak, Eugene Visotsky, and Timothy A. Thomas, "Heterogeneous Cellular Networks: from theory to practice", IEEE communications magazine, June 2012.

[8]. Haidar Safa and Kamal Tohme, "LTE Uplink Scheduling Algorithms: Performance and Challenges", International Conference on Telecommunications, 2012.

[9]. Cornel Balint, Georgeta Budura, Eugen Marza, "Scheduling Techniques Evaluation in LTE systems with Mixed Data Traffic", 2010.

[10]. F. Capozzi, G. Piro. L.A. Grieco, G. Boggia, "Downlink Packet Scheduling in LTE Cellular Networks: Key Design Issues and a Survey" Communications Surveys & Tutorials, IEEE, Second Quarter 2013.