IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834, p- ISSN: 2278-8735.
PP 37-43
www.iosrjournals.org

Fairness-Aware Radio Resource Management in OFDMA Networks

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Abstract : *In 4G technology especially LTE relaying and orthogonal frequency division multiple access (OFDMA) are widely accepted techniques in downlink. To obtain ubiquitous coverage with high data rate to user terminals even in difficult channel conditions (e.g. cell edge) a centralized RRM algorithm has been proposed for cellular fixed relay networks in OFDMA networks. The proposed method provides the fairness for user with minimal impact on network throughput.*

Keywords - *RRM, OFDMA, relaying, routing, scheduling, fairness, load balancing, proportional fairness*

I. Introduction

Orthogonal frequency division multiple access (OFDMA) is the envisioned air-interface for 4G and beyond wireless networks mainly due to its robustness to frequency selective multipath fading, and the flexibility it offers in radio resource allocation [1]. Efficient radio resource allocation and management are crucial for providing quality-of-service (QoS) to multimedia applications in an OFDMA network. In general, there are three main objectives of radio resource allocation, namely 1) maximizing throughput, 2) minimizing transmission power, and 3) maintaining fairness among the users.

However, in order to truly realize ubiquitous coverage, the high data rate opportunity in OFDMA schemes has to reach to user terminals (UTs) in the most difficult channel conditions, for example, cell edge UTs. Therefore, relaying techniques have been earmarked as the best option to address this problem since relay stations (RSs), with less functionality than a base station (BS), can forward high data rates to remote areas of the cell, and thus overcome the high path losses, while maintaining low infrastructure cost [2]. Hence, the future network roll-out is expected to include various forms of relays. We consider networks enhanced with fixed digital relays deployed by service providers in strategic locations.

The combination of relaying and OFDMA techniques has the potential to provide high data rate to UTs everywhere, anytime. In contrast, conventional opportunistic schedulers will rarely serve UTs with bad channel conditions such as cell edge UTs; this defeats the notion of ubiquitous coverage targeted in future networks, and exposes the importance of fair RRM algorithms to facilitate location-independent service, especially when users subscribed to the same service class are charged similarly regardless of their channel conditions. In this paper, we propose a novel formulation with a novel low-complexity centralized algorithm that achieves a ubiquitous coverage, high degree of user fairness and enables intra-cell load balancing in downlink OFDMA-based multicell fixed relay networks. The proposed scheme utilizes the opportunities provided in channel dynamism, spatial, and queue and traffic diversities. We show that the scheme provides an efficient tradeoff between network throughput and fairness to all UTs, even to those at the cell edge.

RRM algorithm is based on queue aware and the functions such as scheduling, dynamic routing and load balancing are jointly performed by it. The information about wireless link capability or the remaining capacities are collected by RRM function. The basic RRM functions are performed at various layers. Layer 3 is semi dynamic mainly executed during setup of new data flows. Layer 2 is dynamic new actions conducted every Transmission Time Interval (TTI).

TABLE 1: RRM functions at layers

LAYER 3	QOS Management
	Admission Control
	Persistent Scheduling
LAYER 2	HARQ
	Dynamic Scheduling
	Link Adaptation
LAYER 1	Physical downlink control channel adaptation
	Channel quality indicator
	Dynamic Scheduling

Layer 1 is fast dynamic. The high data rate is obtained even at the cell edge by the users due to the combined operation of relay and OFDMA. This leads to ubiquitous coverage in the cell. High degree of user fairness and intra-cell, load balancing has been obtained. The opportunities provided in channel dynamism, spatial diversities have been utilized. Many queue/traffic aware fair scheduling algorithms have been proposed in conventional cellular networks and few among them are

a. Channel State Dependent Packet Scheduling
b. Channel Independent packet Fair-Queuing (CIF-Q).
c. OFMDA based algorithms.

The algorithms cannot be applied directly to relay-enhanced networks because it provides solution only to scheduling. The fairness awareness schemes such as Proportional Fair Scheduling (PFS) which depend on achievable and allocated capacities, does not provide the desired fairness.

II. System Description and Assumptions

Let, UD be the number of user terminals (UT), B be the base station(BS), E be the number of relay stations(RS) and SD be the number of sub-channels. The total bandwidth is divided into ,SD number of sub-channels and each sub-channel is further divided into LD subcarriers. Assign UD user buffers at B and each of E Relay stations in a cell. Based on the traffic model the user packets arrive at corresponding „BD buffer. In the particular frame duration channel fading is considered to be time invariant. Two modes of operation have been considered (in this paper).

1) Open routing
2) Constrained routing

Open routing deployment any user can be connected to any combination of "E" Relay stations only in two hops. Constrained mode of routing a user terminal can receive from a group of nodes (B or E) & any node can transmit to many destinations simultaneously using different orthogonal sub channels. This mode provides substantial savings in feedback overhead. Using orthogonal sub-channels any Relay station can concurrently receive and transmit. Two antennas have been deployed for the fixed Relay stations.

Directional antenna : BS —Feeder link→ RS

Omni directional : RS ——→ All UT's antenna

Load balancing is performed by providing equal distribution of subcarriers among the nodes [5]. Balancing the traffic load reduces the packet processing delays at the regenerative relays.

III. Proposed Method

By maintaining throughput fairness among users, the process of maximizing the total cell throughput is carried out. Throughput optimal scheduling policy which stabilizes user queues at all nodes in a system that receives equal inelastic arrival rates at BS using two hops at most is operated [11]. The RRA scheme needs to assign the sub-channels with the highest capacities at any node to achieve the maximum total cell throughput. Radio resource at BS can be allocated using

a. Binary Integer Linear Programming (BILP)
b. Hungarian algorithm (proposed)

TABLE 2: Complexity comparison of RRA algorithms

Allocating Scheme	Complexity
BILP	$(((O(E+1)^3)S$
HUNGARIAN ALGORITHM	$O(S^3)$

3.1 Mathematical Formulation of the RRA at the BS

In order to maximize the total cell throughput while stabilizing user queues at all nodes, the RRA scheme needs to assign the sub channels with the highest capacities at any node to the outstanding queues at that node. This can be achieved by optimizing the assignment of sub channels to all links and the assignment of user buffers to feeder links so that the demand is maximized at each allocation instant.

1. Calculate the (E+1) demand metrics on each sub-channel and apply Hungarian algorithm to Sx(E+1) demand matrix |Fs,e|.
2. On each sub-channel find the lowest demand metric and subtract it from the remaining values .
3. If there results any zero in each row, then mark the zero and assign the particular sub-channel to that corresponding Relay stations / Base station.
4. Check whether all Relay station / Base station have an assigned sub-channel.
5. If a particular Relay station / Base station doesn't have assigned then consider that corresponding column and find the minimum value and subtract it from other values in that column.
6. Even then, still there is any Relay station / Base station doesn't have an assigned sub-channel.
7. Then follow the given steps initially, assign as many RS / BS as possible
   - Mark all sub-channels that are unassigned
   - Then mark all zeros in that sub-channel
   - Then find any assignment to that particular RS / BS and encircle over the whole particular RS / BS.
   - Mark that corresponding sub-channel to that particular RS / BS
   - Select all sub-channels that were unmarked
   - From the remaining elements that were not encircled find the minimum value and subtract it from the elements that were considered.
   - This results a value zero which indicates a new assignment of sub-channel to a particular RS / BS
   - Repeat this procedure till all RS / BS are assigned with a sub channel.
   - All sub-channels were assigned.

The unique aspects of the problem formulation leading to the outstanding performance of the proposed scheme are summarized as follows:

- No explicit non-linear fairness constraints or functions are imposed and thus a single linear objective function is maximized towards achieving a remarkable combination of both high ubiquitous throughput and user fairness, under the system model considered.
- The formulation does not imply any kind of preset routes, user partitioning, or resource partitioning, which are known to be suboptimal simplifying techniques.
- Dynamic routing and scheduling are performed jointly using the 'differential backlog' represented by the queue length difference between BS and RSs ; this is analogous to the hydrostatic pressure between fluid tanks connected with pipes of different capacities, which are controlled by the on-off assignment variables, while Its represent the relevant sinks of individual user flows.
- Traffic diversity (statistical multiplexing) is exploited through incorporating the buffer states; this does not require knowledge of the arrival process statistics.
- Load balancing between relay nodes is achieved jointly as well, as in [20], and not by rearranging the optimal allocation, e.g., [9].

The computational complexity, however, of such three dimensional BILP problem is non-polynomial in time and can be approximated to $\mathcal{O}(((M + 1)K)N)$. As such, the complexity might reach prohibitive limits in a system with high density of UTs and RSs given the expected high number of sub channels. Therefore, in the next subsection, we propose a low-complexity iterative algorithm that virtually updates the buffer states between iterations while satisfying all of the aforementioned constraints.

IV. Models and Parameters for Simulation

Simulated network and parameters for channels are indicated in Table 3. UTs are considered to be uniformly distributed within the cell. For BS-RS (LOS) links Rician type of fading is considered and for all other (NLOS) links Rayleigh type of fading is considered. Queues at BS are assumed to be arriving independently in the form of Poisson process. On the contrary, the coverage of the PFS reference scheme is significantly distance dependent as the mean throughput depreciates when users move away from the serving node, especially at the cell edge. That is mainly due the fact that spatial diversity is not exploited (due to static routing) while scheduling a UT on the available sub channels partially exploits the frequency diversity and, moreover, may not overcome large path loss (e.g., due to heavy shadowing) which dominates all the UT's sub channels. This results in a very poor time-average throughput for such UT (i.e., points at the bottom of the scatter plot). Whereas, the scatter points for the proposed algorithm have high throughput and narrow spread. This indicates the ability of the dynamic routing strategy to find the appropriate path(s) for such UTs and to deliver a fair service. The difference in performance is further emphasized in the scenario with 3 RSs as more users are expected to have poor link qualities from their serving RSs in the PFS scheme. However, the proposed scheme still offers a reasonable ubiquity and substantial throughput gains over the reference scheme, especially at the cell edge.

TABLE 3. Parameters –simulation

Parameter	Volume
BS Distance	1 km
Carrier frequency	2.5 GHZ
Total bandwidth	20 MHZ
Total number of sub channels	102
TDD frame length	2 ms

V. Result and discussion

The average cell throughput for varying users per cell at different values of BER (Bit Error Rate) are calculated by using

$T_K=\sum_{U=1}^{U} Þ_{U,S}\ Y_{u,S}$ (1)

$Þ_{U,S}$ is the $_{Þ}{}^{th}$ UT binary assignment variable to e^{th} node

Fairness index= users throughput/ average throughput (2)

$$FIu(t) = \frac{Tu(t)}{\frac{1}{U}\sum_{i=1}^{U} Ti(t)}$$

$FIu(t) \longrightarrow$ Fairness Index

$Tu(t) \longrightarrow$ User's throughput rate

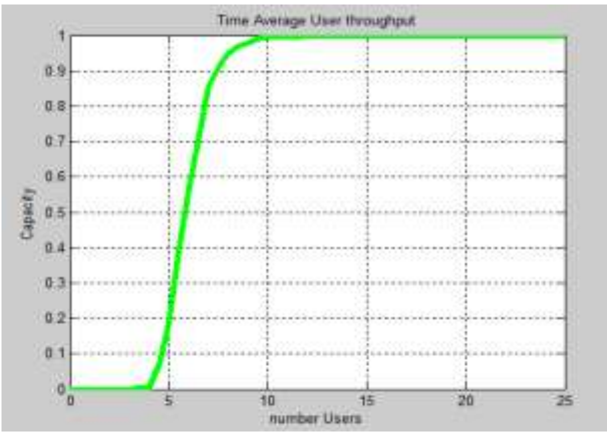

Fig 1: Fairness Index CDF for 25 Users

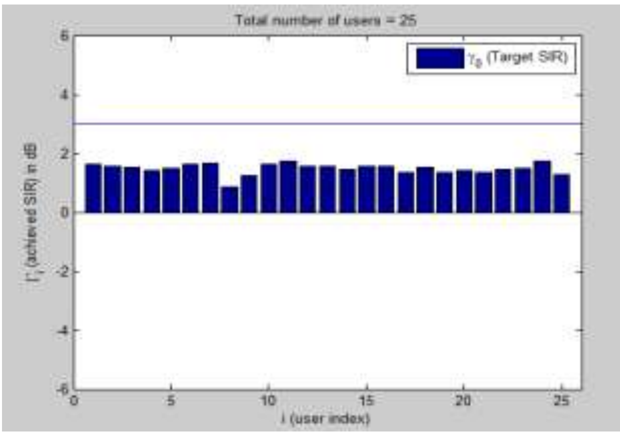

Fig 2 : Dropped users=0

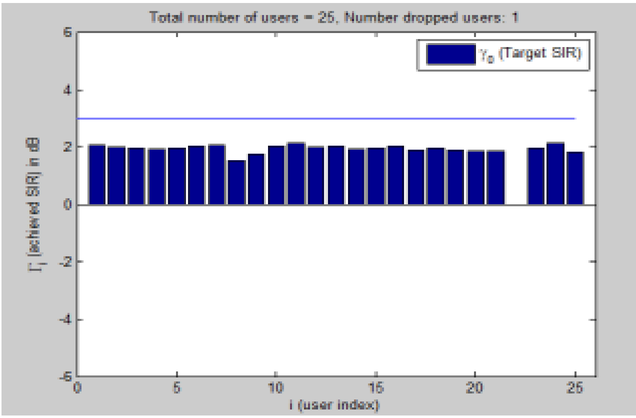

Fig 3: Dropped users=1

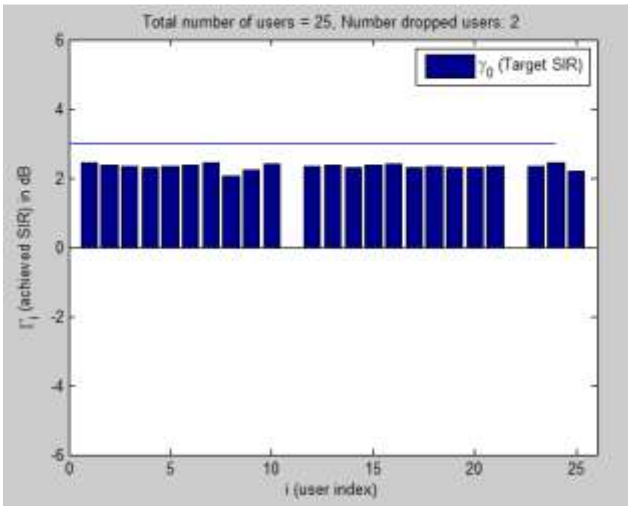

Fig 4: Dropped users=2

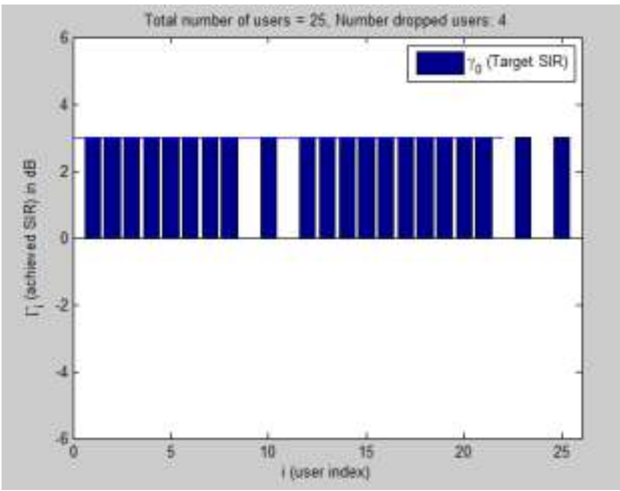

Fig 5: Dropped users=4

In Fig.1, for various bit error values, the average cell throughput value increases as the number of users per cell increases. It maximizes total cell throughput by exploiting the diversities such as frequency, traffic, multi user and spatial. The fairness index is used to determine whether users are receiving fair share of resources. As the number of users per cell gets increased its difficult to maintain fairness.Fig.2,3,4 shows the number of dropped users for different power level utilization. As the power level utilization increases number of dropped users Also Increases

VI. Conclusion

The proposed scheme provides fairness aware power management in cellular environment. Efficient RRM schemes are required to harness the opportunities in the future relay-enhanced OFDMA-based networks in which user fairness is crucial. This paper provides a novel fairness-aware joint routing and scheduling algorithm for such it provides ubiquitous coverage, cell edge throughput, fairness and load balancing which makes it superior over other previous methods irrespective of geographical deployment by exploiting the opportunities in frequency, spatial and traffic diversities

Acknowledgement

I would like to thank Asst.Prof .Mr.Jijo Varghese for his valuable guidance .I would also like to thank entire EC department for their cooperation.

References

[1] IEEE P802.16j/D1, "*Draft IEEE standard for local and metropolitan area networks Part 16: air interface for fixed and mobile broadband wireless access systems: Multihop relay specification," pp. 1002-1007, Aug. 2007.*

[2] R. Pabst, B. Walke, D. Schultz, P. Herhold, H. Yanikomeroglu, S. Mukherjee, H. Viswanathan, M. Lott, W. Zirwas, M. Dohler, H. Aghvami, D. Falconer, and G. Fettweis, *"Relay-based deployment concepts for wireless and mobile broadband cellular radio," IEEE Commun. Mag., vol. 42, no. 9, pp. 80-89, Sep. 2004.*

[3] Z. Han and K. J. Liu, "Resource Allocation for Wireless Networks: Basics, Techniques, and Applications". Cambridge University Press, 2008.

[4] D. Niyato and E. Hossain, "*Adaptive fair subcarrier/rate allocation in multi rate OFDMA networks: radio link level queuing performance analysis," IEEE Trans. Veh. Technol., vol. 55, no. 6, pp. 1897-1907, Nov. 2006.*

[5] P. Parag, S. Bhashyam, and R. Aravind, "*A subcarrier allocation algorithm for OFDMA using buffer and channel state information," in Proc. IEEE Veh. Technol. Conf., pp. 622-625, Sep. 2005*.

[6] M. Kobayashi and G. Caire, "*Joint beam forming and scheduling for a multi-antenna downlink with imperfect transmitter channel knowledge," IEEE J. Sel. Areas Commun., vol. 25, no. 7, pp. 1468-1477, Sep. 2007.*

[7] P. Viswanath, D. Tse, and R. Laroia, "*Opportunistic beam forming using dumb antennas," IEEE Trans. Inf. Theory, vol. 48, no. 6, pp. 1277-1294, June 2002.*

[8] H. Kim and Y. Han, "*A proportional fair scheduling for multicarrier transmission systems," IEEE Commun. Lett., vol. 9, no. 3, pp. 210-212, Mar. 2005.*

[9] C. Bae and D.-H. Cho, "*Fairness-aware adaptive resource allocation scheme in multi hop OFDMA systems," IEEE Commun. Lett., vol. 11, no. 2, pp. 134-136, Feb. 2007.*

[10] R. Kwak and J. M. Cioffi, "*Resource-allocation for OFDMA multi-hop relaying downlink systems," in Proc. IEEE Global Commun. Conf., pp. 3225-3229, Nov. 2007.*

[11] M. Kaneko and P. Popovski, "*Radio resource allocation algorithm for relay-aided cellular OFDMA system," in Proc. IEEE International Conf. Commun., pp. 4831-4836, June 2007.*
[12] W. Nam, W. Chang, S.-Y. Chung, and Y. Lee, "*Transmit optimization for relay-based cellular OFDMA systems," in Proc. IEEE International Conf. Commun., pp. 5714-5719, June 2007.*
[13] Ö. Oyman, "*Opportunistic scheduling and spectrum reuse in relay-based cellular OFDMA networks," in Proc. IEEE Global Commun. Conf., pp.3699-3703, Nov. 2007.*