wjert, 2021, Vol. 7, Issue 2, 11-20. *Original Article* ISSN 2454-695X

World Journal of Engineering Research and Technology

WJERT

www.wjert.org Impact Factor Value: 5.924

OPTIMIZED RADIO RESOURCE MANAGEMENT ALGORITHM FOR OFDMA-BASED CELLULAR RELAY NETWORKS

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Article Received on 02/01/2021 Article Revised on 22/01/2021 Article Accepted on 12/02/2021

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ABSTRACT

The availability or lack of an efficient Radio Resource Management (RRM) in a network could either make or mar the Radio Resource opportunities in the network. Orthogonal Frequency Division Multiple Access (OFDMA) and Relaying techniques are the accepted technologies in wireless communication by standards such as LTE-Advanced to use the Radio Resource Management in a network to maximize the cell throughput and network capacity. Simulated results using matlab shows that the proposed scheme saves substantial Radio resource and as such provides fairness among users with respect to the network throughput.

KEYWORDS: *Matlab, RRM, OFDMA, LTE-Advanced, Relaying, Routing, Scheduling.*

INTRODUCTION

Orthogonal Frequency Division Multiple Access (OFDMA), a user interface for 4G networks and beyond in wireless networks which provides strength of frequency selective multi-path fading and the flexibility which it offers in Radio Resource Allocation. However, in order to truly realize a widespread of coverage, the high data rate opportunity in OFDMA scheme has to reach all the User Terminal (UT_s), for example, Cell edge UT_s.

Therefore, relaying techniques have been embarked as a suitable best option to address this problem since relay stations (RS_s) with less functionality and cost than the base station (BS) can forward high data rates to remote areas of the cell and thus overcome the high path loss while maintaining low infrastructure cost (IEEE P802.16j/D1, 2007).

The combination of relaying and OFDMA techniques has the potential aim to provide high data rate to UT_s everywhere, anytime. Where the load on a particular node (RS) is high compared to other serving nodes within the cell, the base station fairly schedules and routs for a best subchannel through another serving node to send feedback to the users within that network or cell.

Performance analysis on MC-CDMA and OFDM in wireless communication Rayleigh channel had been considered to allow high data rate transmission compared with respect to BER and Channel Capacity parameter which showed a rapid decrease in BER with increase in the Antenna Speed (Jagan, et al, 2010).

Schematic Block Diagram

A schematic Block Diagram shows the Base Station Routing and Scheduling Implementation and the Radio Resource Management Algorithm Model.

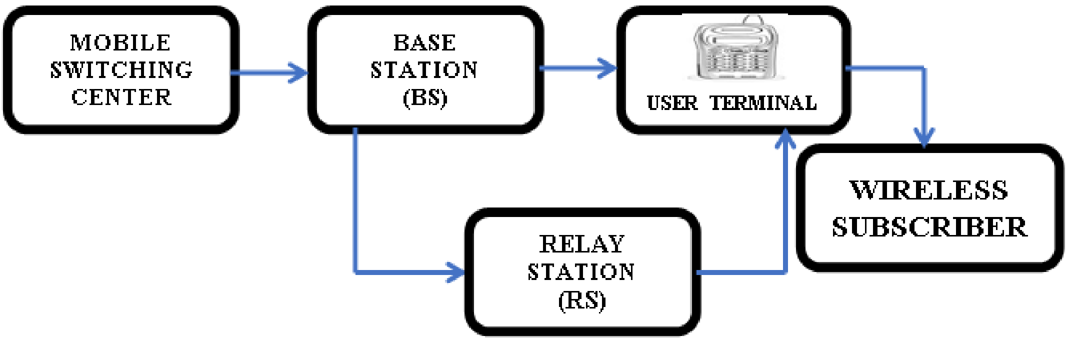

Figure 1: Representation of the Network in Multicellular Relay Networks.

Mobile Switching Center (MSC)

The Mobile Switching Center coordinates the call set-up, release and routing in a large geographical area. For a cellular Radio Systems, the MSC connects the cellular Base Station and the Mobile or Wireless Subscriber to the Public Switched Telephone Network (PSTN). This controls the transmission and reception of data between two or more wireless subscribers within a geographical location.

Base Station (BS)

The Base Station performs radio communication with the Mobile Station or User Terminal which consists of Radio Channels with Transmitter and Receiver antennas mounted on a tower. It is capable of serving the User Terminal directly or through the Relay Station.

Relay Staion (RS)

Relay Stations are broadcast transmitter which repeats the signal of another radio station (BS) usually to an area or region not covered by the originating station (BS). They serve to expand the broadcast range of the radio station (BS) beyond the primary signal coverage area.

User Terminal (UT)

User Terminal or Mobile Station is a station in a cellular radio service intended for use while in motion at unspecified locations. Mobile stations may be hand-held, personal units (portable) or installed in vehicles (mobiles).

Wireless Subscriber (WS)

Wireless Subscriber is a user who pays subscription charges for using a mobile communication system. That is, Users that transmit and receive data signal or calls through the help of the BS within the cell.

Multicellular Network Description

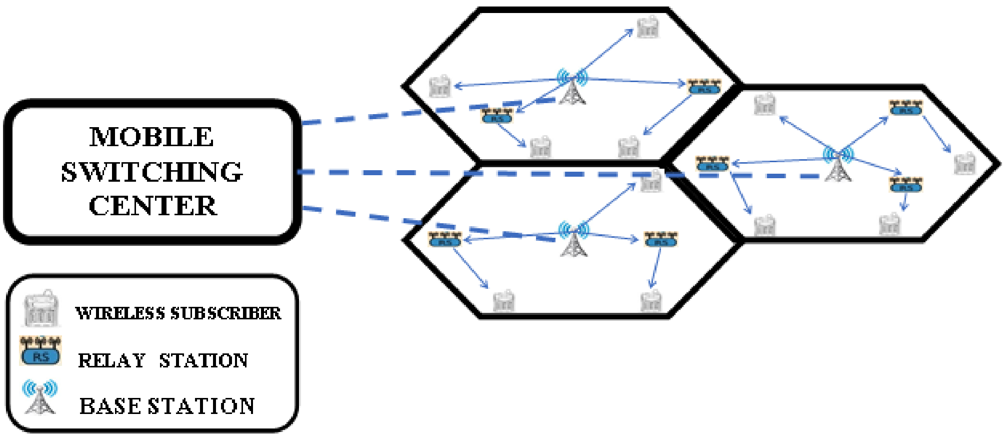

Figure 2: A partial Network in Multicellular Relay Networks.

In a multi-cellular network as shown above, the BS serves the KUT$_s$ (k number of User Terminals) either directly or through MRS$_s$ (m number of Relay Stations) within a cell with all of its resources available in each cell. The total bandwidth for each cell is divided into N subchannels. The serving BS and each of the MRS$_s$ (m number of Relay Stations) in a cell are equipped with *K* user-buffers. We first consider that there is no restriction to any specific geographical arrangement of RS_s. As shown in Fig 2.

Any UT has the ability to connect to any combination of the *M*RS_s (*m* number of Relay Stations) in two hops since the RS_s does not have the ability to exchange user data. Such relay selection or 'open routing' exposes the ability of the routing strategy to choose for the best route(s) for each UT.

Load Balancing is a very important mechanism in conventional cellular networks. It refers to the handover of some UT_s between cells to distribute load among BS_s while maintaining user Quality of Service (Q*o*S). It is a function which is an integral part of any RRM scheme. An even distribution of subcarriers thus balances the load among each node (Fan, et al, 2009). A balanced traffic load thus reduces the packet processing delays at the relays. Load balancing results in the 'relay fairness'; a fair utilization of the energy sources of the RS_s if the network requires battery/solar-powered RS_s (Li and Liu, 2006).

Design parameteres

Base station joint routing and fair schedulling

The idea of the routing and scheduling policy is to maximize the total cell throughput whereas maintaining a fair throughput among users which are within a cell. The fairness of the policy is a special case due to the cellular network system model where we consider all users to belong to the same class of service and thus have the same QoS requirements.

To truly realize the maximum total cell capacity, the algorithm has to execute the following steps:

1. The demand metric for each of the RS_m on subchannel *n* is the maximum of *K* UT_k links as:

$$D_{n,m} = \max_k\{R_{m,k,n}Q_k^m\}, m = 1,2,\ldots,M \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$D_{n,m}$ for a RS_m to use a subchannel *n*, thereby the UT which is associated with the maximum is then the receiver.

While the demand metric for the BS node is the maximum of M + K links as:

$$D_{n,0} = \max_j\{D_{n,0\to j}\}. \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$D_{n,0}$ for the BS to use a subchannel *n*.

1. After the calculation of the demand metrics on each of the subchannels, the algorithm then solves an optimization problem to maximize the total demand.
2. Then the algorithm updates all the UTs of its previous assignments.
3. Step 1-3 is then repeated for all unassigned subchannels until all subchannels are exhausted for allocating all user data to all users.

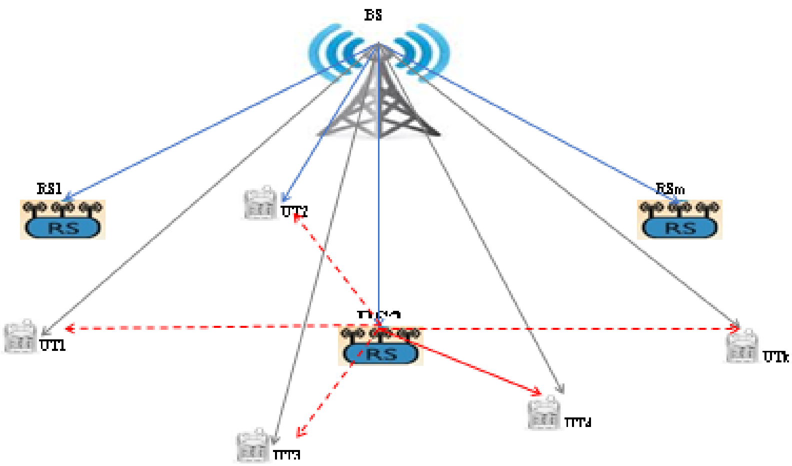

Figure 3: A partial network example of BS and relays and the links of the BS and RSs.

PSEUDOCODE FOR THE RRM ALGORITHM

Initialization: $U = N$
While $\|U\| \neq 0$ and $\sum Q^m \neq 0$
  For each $n \in U$
    For m = 1 to M
    $D_{n,m} = \max_k\{R_{m,k,n}Q_k^m\}$
    $K_{n,m} = arg\max_k\{R_{m,k,n}Q_k^m\}$
    $D_{n,0\to m} = \max_k\{(Q_k^0 - Q_k^m)^+\},\ K \in K - K_{cnst}^m$
    $K^m = arg\max_k\{Q_k^0 - Q_k^m\}$
    End for
    $D_{n,0\to k} = R_{0,k,m}Q_k^0$
    $D_{n,0} = \max_j\{D_{n,0\to j}\},\ j \epsilon K \cup M$
    $K_{n,0} = arg\max_j\{D_{n,0\to j}\}$
  End for
End while

Where ***U, N, K, M*** are the set of unassigned subchannels, all subchannels, UT_s and RS_s respectively.

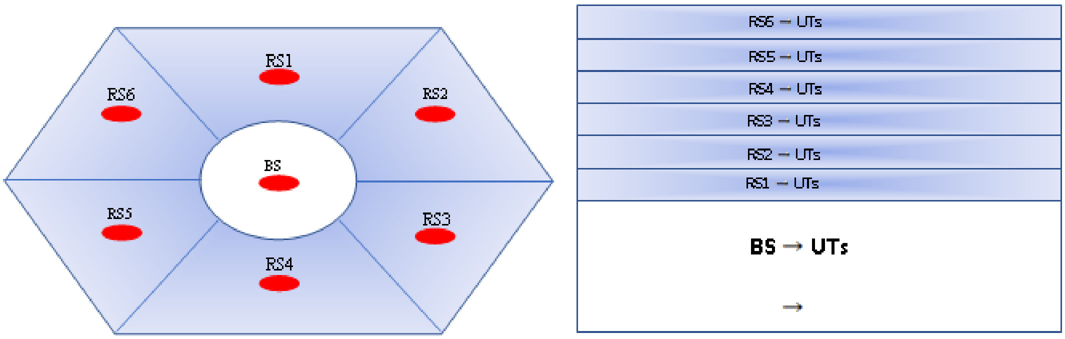

Figure 4: User Partitioning in a Relay PFS Scheme.

SIMULATION AND RESULT

Simulation Parameters

Simulated network parameters are listed in the table below. The relays are assumed to be placed at a distance of 50m from the BS having a uniform angular spacing. The UT_s are evenly distributed within the cell area.

The RS_s transmits to the UT_s with an omni-directional antenna and then receives from the BS with a high directive antenna. The BS-RS link is assumed to be in Line Of Sight (LOS) while all other links are assumed to be in Non Line Of Sight (NLOS).

Table 1: Simulation Parameters.

Parameters	Values
BS-BS Distance	200m
BS-RS Distance	50m
UT max. distance from BS	35m
BS Tx antenna gain	15dB
RS Tx antenna gain	10dB
UT Rx antenna gain	0dB
Total no. of subchannels/node	16
BS Tx power gain	40dBm
RS Tx power gain	37dBm
Total no. of users/node	25
Target SIR	3.00dB
Noise Power (watt)	0.1
No. of Bits	10^{-15}
No. of Bits per symbol	52

Simulation Results and Discussion

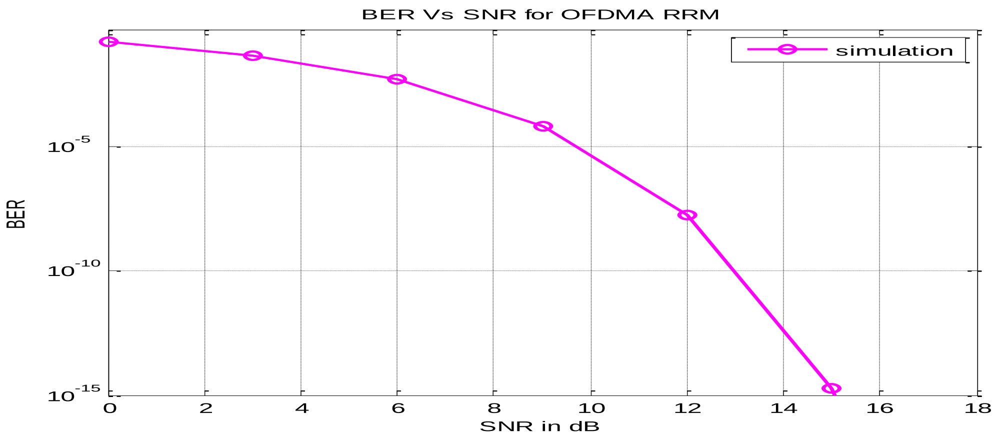

Figure 5: Bit Error Performance to Signal to Noise Ratio on the OFDMA system.

In every digital communication system, Bit Error Rate testing is one of the most frequent simulation tasks and it is necessary to perform a bit error rate test to determine the number of errors to be found at the received signal.

From Fig 5 we can deduce that at a BER of 10^{-15}, i.e, at a high SNR, only one bit out of every quadrillion bit will be in error which means if our transmitted signal contains 1000000000000000 bits, there will like not be any visible error at this BER.

In order to be statistically significant, at a high SNR, the tested transmitted signal is required to contain millions or billions or more bits as seen from the simulated graph.

From the simulation parameters and assumption of 25 users which are connected to the nearest serving node, the serving BS forwards the user data of the 25 users through this nearest serving node. With all users allocated different subchannels which are further divided into different subchannels by the OFDMA technique, all users are able to receive data through its subchannel with this subchannels allocated different date resources (voice, text, video, etc) using the MIMO rule, Multiple In Multiple Out. The Radio Resource Management algorithm on the Base Station is solely guarded towards the allocation of resources to the users as such perform the Routing strategy and PFS scheme to enable well load balancing at any serving node so as to maximize cell throughput and prevent traffic and loss of user data.

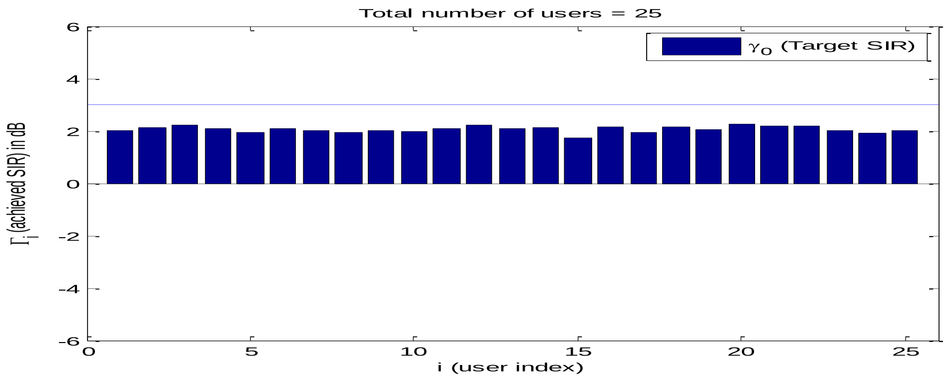

Figure 6: Achieved SIR for total number of users = 25.

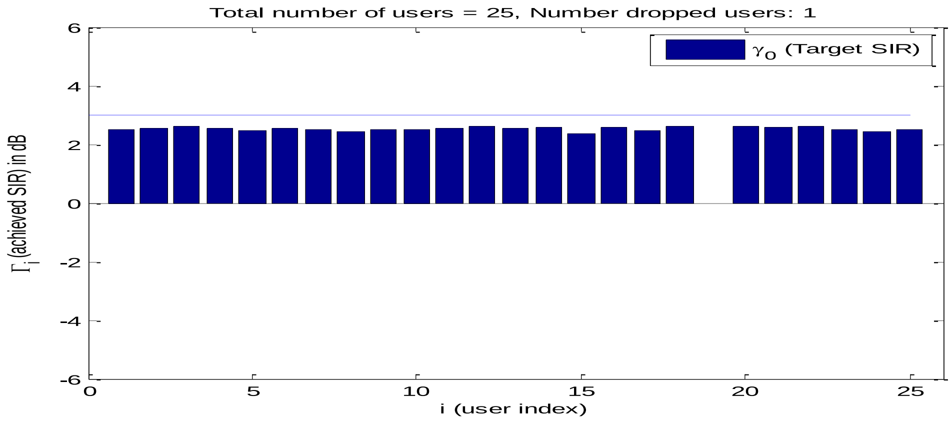

Figure 7: Achieved SIR for number of dropped user = 1.

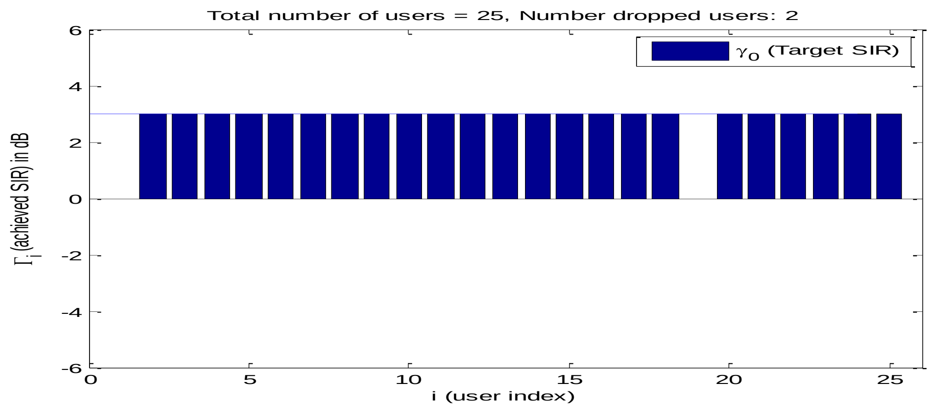

Figure 8: Achieved SIR for number of dropped users = 2.

From Fig 6, each user is assigned different subchannels for receiving of data from the BS. In order to balance the load among nodes to avoid traffic and loss of user data, target signal strength is generated with respect to the number of users, as such to truly realize ubiquitous cell coverage.

From Fig 7, Assuming user 19 has a heavily shadowed link to its serving node due to traffic, the BS routes user 19 data to the best possible link (RS) closer to that user. Thus, user 19 does not have to receive its data directly from the BS, rather from the BS through the nearest RS thereby reducing the traffic on that particular node and loss of user data.

This however shows that with all resources being assigned to users, this increase or maximizes the cell throughput, thereby ensuring that all users, especially the cell edge users are able to get good quality network service.

As such, from Fig 8, if user 1 is assumed to be affected due to its shadow link to the BS due to traffic, the algorithm then performs the routing implementation on that user in order to reduce traffic and loss or user data, ensuring maximized ubiquitous network coverage. With such performance in terms of network throughput, fairness is then achieved without over load or nodes (BS or RS) and ensuring no loss of user data.

Fig 8 shows the cumulative distribution function of the time-average user throughput for 25 users in the routing mode. The throughput of the CDF's is associated with the cell edge users in LTE evaluation methodology (Ahn and Kim, 2008).

CONCLUSION

An efficient Radio Resource Management scheme is always required to harness the network opportunities which are available in a network and future Relay-enhanced OFDMA cellular networks. As such provides fairness in joint routing and proportional fair scheduling algorithm for the OFDMA cellular networks. Its general performance is then superior to that of a proportional relay scheme solely in terms on ubiquitous coverage.

Simulation results have proven to show the learning ability in the RRM algorithm of joint routing and PFS scheme.

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