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Next Generation Dynamic Inter-Cellular Scheduler

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***Abstract*—Orthogonal frequency division multiple access (OFDMA) in Long Term Evolution (LTE) can effectively eliminate intra-cell interferences between the subcarriers in a single serving cell. But, there is more critical issue that, OFDMA cannot accomplish to decrease the inter-cell interference. In our proposed method, we aimed to increase signal to interference plus noise ratio (SINR) by dividing the cells as cell center and cell edge. While decreasing the interference between cells, we also aimed to increase overall system throughput. For this reason, we proposed a dynamic resource allocation technique that is called Experience-Based Dynamic Soft Frequency Reuse (EB_{DSFR}). We compared our proposed scheme with different resource allocation schemes that are Dynamic Inter-cellular Bandwidth Fair Sharing FFR (FFR_{DIBFS}) and Dynamic Inter-cellular Bandwidth Fair Sharing Reuse-3 ($Reuse3_{DIBFS}$). Simulation results indicate that, proposed EB_{DSFR} benefits from overall cell throughput and obtains higher user fairness than the reference schemes.**

***Keywords*—Frequency Reuse, Inter-Cell Interference Coordination, LTE, OFDMA, Throughput, SINR, Capacity, Scheduling, Load Balancing**

I. INTRODUCTION

WITH the fast growth of wireless system devices and services, the expectations that mobile services will get faster and better than ever. In order to meet these requirements LTE technology was proposed. Long Term Evolution (LTE) uses the Orthogonal Frequency Division Multiple Access (OFDMA) to minimize the intra-cell interference [1][2]. OFDMA offers better spectral effectiveness and bandwidth efficiency than the Orthogonal Frequency Division Multiplexing (OFDM). A huge number of parallel narrow-band subcarriers are provided with OFDMA system data. Furthermore, the bandwidth is divided into the small resource units that are called Resource Blocks (RB) [3] and they assign to the users.

Intra-cell interference is eliminated due to the orthogonality. There is however an important issue for cellular networks, known as Inter-cell Interference (ICI) [4]. This causes lower transfer rates for different users simultaneously. Moreover, bandwidth of cellular systems is limited to more efficient of the available spectrum. In the cellular system, when the adjacent cells use same frequency, cell edge users are exposed the inter-cell interference. For this reason, SINR is lessen and overall system throughput becomes lower rates. Inter-cell interference coordination (ICIC) strategy [5][6] can be utilized to prevent this problem. This enhances the cellular system's performance and reduces interference. The main ICIC methods for minimizing the inter-cell interference are Reuse-N, Fractional Frequency Reuse (FFR) [7], and Soft Frequency Reuse (SFR) [8][9]. We will explain these methods in next section.

Many users want to share limited data at the same time in multi-cell systems. The use of multi-carrier dynamic scheduling shares these resources between users. Dynamic scheduling includes the calculation of the assignment of physical layer resource to each cell and user in each given time slots (TTI) [10] and the optimization of the system. Generally, there may be some disorder at the traffic conditions in the wireless network. Some cell has suffering from overload and some cell has less traffic load. This can cause to data wastage. To overcome this problem, according to dynamic systems, RBs are shared between receiver cell (R_c) and donor cell (D_c) in each time slots. Receiver cell is the cell that has the highest traffic load and donor cell has the lowest load. In addition to this, we are interested in fairness among the users in the receiver cell. In this case, we used our previous proposed scheduling technique EBPS. This technique considers the users past experience and it gives priority of the worst experience user. All these techniques have been combined in a one method as EB_{DSFR}.

This is the way our paper is structured. In Section II, the ICI techniques are described in detail. In Section III describes our proposed scheme EB_{DSFR} and system model. Section IV shows simulation results and performance of our proposed scheme. Final section, we finished the research and presented our final comment together with the future work.

II. RELATED WORKS

In this part of the paper, ICIC schemes are explained more detailly, especially Soft Frequency Reuse (SFR) scheme which have been used by our proposed scheme. First ICIC method that is the most common one is Reuse-1 [11]. In Reuse-1 method all cells in a cluster with equal power and use the uniform frequency. This approach is one of the most efficient approach in terms of spectrum efficiency. All the frequency band are used but, it cannot solve the inter-cell interference problem. Because neighboring cells uses same frequency. In fig. 1. Frequency Reuse-1 approach showed.

Reuse-3 has been suggested to solve the ICI problem [20]. In the Reuse-3 method all the adjacent cell uses different frequency in a cluster and this solve the ICI problem. Inner cell and outer cell users have higher SINR. However, in this approach main problem is that; every cell is bandwidth limited. A cell consists of 3 equal parts of the frequency band and RBs are 1/3 of the total RBs. In fig. 2. Frequency Resue-3 method are shown.

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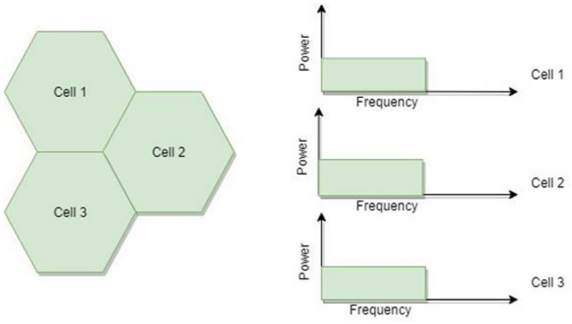

Fig. 1. Frequency Reuse-1 Approach

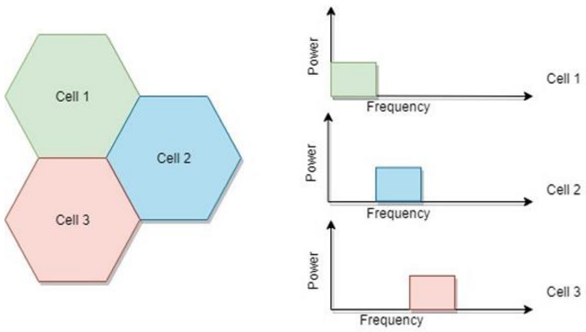

Fig. 2. Frequency Reuse-3 Approach

The Fractional Frequency Reuse (FFR) scheme is suggested to in order to serve good quality signal to the cell edge users. In this scheme, each cell consists of two different frequency part as cell center and cell edge. In the cell center part all frequency spectrum is allocated to the users and in the cell edge part 1/3 of all frequency spectrum are allocated. For this reason, user in the cell has high SINR but, some RBs are missing. In fig. 3. FFR approach is shown and total spectrum is divided into two different parts.

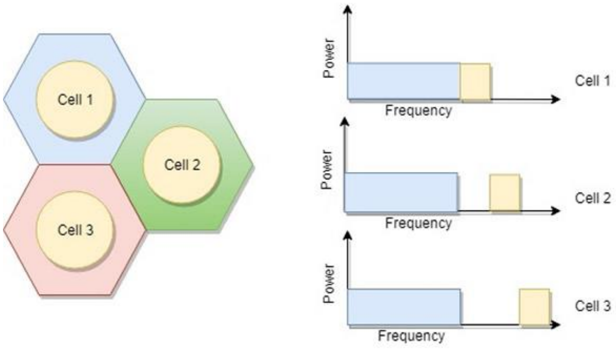

Fig. 3. Fractional Frequency Reuse (FFR) Approach

The last ICI method [21] which we used in our proposed scheme is Soft Frequency Reuse (SFR) [17] [18] method. It provides both frequency efficiency and higher system performance. SFR uses two different frequency part as cell center and cell edge. In the SFR scheme all frequency bandwidth is used and this means that all RBs are allocated to the users. Also, cell edge users can use cell edge bandwidth and cell center users can use both cell center and cell edge bandwidth. In the SFR, power allocation [14] is restricted. RBs in the inner cell band have lower transmission capacity, since the inner cell has the same bandwidth with the adjacent cell outer region. Outer cell users, on the other hand, need to transmit maximum power to achieve maximum throughput. Therefore, SINR level [13] [22] of the cell center users is high and SINR level of the cell edge users is lower. We can see the SFR approach in the fig. 3.

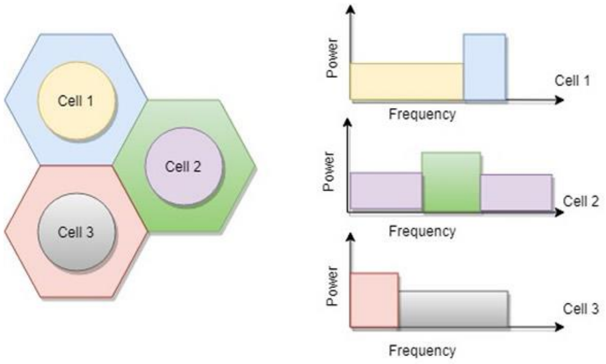

Fig. 4. Soft Frequency Reuse (SFR) Approach

III. SYSTEM MODEL

A. LTE Downlink

The parameters of the LTE downlink are used in this paper. A hexagonal cell is supposed, which is encircled by six cells in an OFDMA cluster. In the cluster each cell has their own base station and also, they have omnidirectional antenna. The bandwidths are chancing as 1.4, 3, 5, 10, 15 and 20 MHz. Table I shows that how many sub-carriers and RBs are in each bandwidth for downlink and uplink.

TABLE I
FREQUENCY MEASUREMENT

Bandwidth	Resource Blocks	Subcarriers (downlink)	Subcarriers (uplink)
1.4 MHz	6	73	73
3 MHz	15	181	180
5 MHz	25	301	300
10 MHz	50	601	600
15 MHz	75	901	900
20 MHz	100	1201	1200

We assumed 20 MHz channel bandwidth for LTE in this proposed method. The specified bandwidth is split into the small carrier units known as the sub-carrier. The spacing of the LTE sub-carriers is 15 kHz [16]. Furthermore, resources are allocated to the users as a resource block (RB). The RBs consist of 12 sub-carriers. At the same time, each RBs are 180 kHz as a frequency and 1 slot (0.5 ms) as a time. 100 RBs are shared between the users that are located inside a cell in our proposed algorithm. Also, our scheme determines which user gets the RB first.

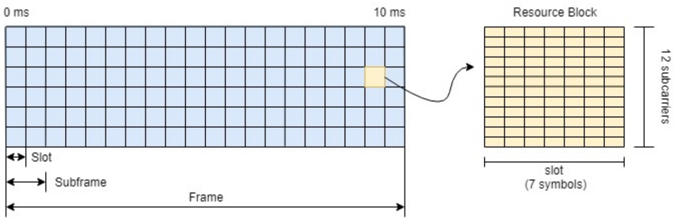

Fig. 5. LTE Downlink OFDMA Physical Layer

B. Channel Model

In our proposed scheme, we have 7 different cells in one cluster. In each cell, there are 10 users and 5 of them are in the cell center and 5 of them are in the cell edge. In LTE systems, we used Adaptive Coding Modulation (ACM) on channel state information (CSI) [11]. First of all, we start to calculate spectral efficiency $\eta_{x,y}$ of user x on sub-carrier y as in the formula 1:

$$\eta_{x,y} = log_2(1 + \frac{SINR_{x,y}}{\Gamma}) \tag{1}$$

where $\Gamma = \ln(5BER)/1.5$ is SINR correction factor.

TABLE II
LTE CQI INDEX AND EFFICIENCY

CQI Index	Modulation Scheme	Coding Rate	Interval for Spectral Efficiency (η)	Efficiency (Bps/HZ)
0	No Transmission	-	0	-
1	QPSK	0.0762	0-0.15	0.1523
2	QPSK	0.1172	0.15-0.23	0.2344
3	QPSK	0.1885	0.23-0.38	0.3770
4	QPSK	0.3008	0.38-0.60	0.6016
5	QPSK	0.4385	0.60-0.88	0.8770
6	QPSK	0.5879	0.88-1.18	1.1758
7	16-QAM	0.3691	1.18-1.48	1.4766
8	16-QAM	0.4785	1.48-1.91	1.9141
9	16-QAM	0.6016	1.91-2.40	2.4063
10	64-QAM	0.4551	2.40-2.73	2.7305
11	64-QAM	0.5537	2.73-3.32	3.3223
12	64-QAM	0.6504	3.32-3.90	3.9023
13	64-QAM	0.7539	3.90-4.52	4.5234
14	64-QAM	0.8525	4.52-5.12	5.1152
15	64-QAM	0.9258	≥ 5.12	5.5547

$SINR_{x,y}$ is the given signal to interference plus noise ratio of the user x on the y. Also, the signal to interference plus noise ratio is calculated as equation 2;

$$SINR_{x,y} = \frac{P_{m,s} . G_{m,s}}{N_0 + \sum_{j \in \mathrm{NC}}^{I} P_{j,n} . G_{j,n}} \tag{2}$$

Where $P_{m,s}$ indicates the transmitted power on RB m of serving cell and $G_{m,s}$ is the channel gain between the user m and the serving cell. Furthermore, $P_{j,n}$ denotes the transmitted power on RB j of neighboring cell (N_C) and $G_{j,n}$ is the channel gain between the RB j and the neighboring cell. Finally, N_0 is the thermal noise density.

The system throughput for the serving cell can be expressed as;

$$T_{total} = \sum_{a=1}^{A} \sum_{b=1}^{B} T_{a,b} \tag{3}$$

Where A is the number of users is the cell and B is the number of total RBs in the reference cell.

C. Power Allocation

The power assigned by RB differs from the frequency reuse method. In Frequency Reuse-1, every resource block has same power as;

$$Pt = \frac{P_{total}}{N} \tag{4}$$

where P_{total} is the total transmitting power and N is the total number of resource blocks in each cell. In the Reuse 3, the bandwidth is divided in 3 and the transmitted power per resource block is;

$$Pt = P_{total}/(\frac{N}{3}) \tag{5}$$

For this reason; total transmitted power is 3 times greater than Reuse 1.

In the FFR total RBs are allocated according to cell center and cell edge coverage. Number of RBs in the cell center is N_{center} and number of RBs in the cell edge is N_{edge}. And this number of RBs varies by the center and edge cell radius. Total cell radius is R, cell center radius is R_{center} and cell edge radius is R_{edge}. So, cell center radius is calculated as;

$$R_{center} = \alpha R \tag{6}$$

where α (0<α<1) is the ratio of center radius and the cell radius. As a result, number of RBs in the cell center is calculated as;

$$N_{center} = \alpha N \tag{7}$$

or

$$N_{center} = N . (R_{center}/R) \tag{8}$$

and number of RBs in the cell edge is calculated as;

$$N_{edge} = (N - N_{center})/3 \tag{9}$$

where 3 is the reuse factor of Reuse 3 [14] [15]. For the power allocation of resource blocks as follows;

$$\mathrm{Pt} = \frac{P_{total}}{N_{center} + N_{edge}} \tag{10}$$

Finally, in the SFR, all the bandwidth can be used. As in FFR, RBs are shared to the users according to the α. In SFR there is a difference between the transmitted power of cell center and cell edge. If the center power is P_{center} and edge power P_{edge} and then power of center becomes as;

$$P_{center} = \beta P_{edge} \tag{11}$$

where β is the power ratio $(0 < \beta < 1)$. If $\beta = 1$ it becomes Reuse-1 and this means that cell center and cell edge RBs have same power level.

$$P_{edge} = \frac{3P_{total}}{N(1+\beta(3-1))} \tag{12}$$

$$P_{center} = \beta P_{edge} \tag{13}$$

D. The Proposed Experience Based Dynamic Inter-Cellular Bandwidth Sharing for LTE OFDMA Network

In order to equalize for cell load, we offered a dynamic scheme that allows the neighboring cells in any time to share RBs. In each TTI, packets that are not transmitted or received in the delay threshold (packet delay) and packets that are transmitted and received are calculated. This is done for each cell and we divide packets not transmitted in time into packets which are transmitted in time for system delay calculation. Packet delay ratio (PDR) which is known as this process.

$$PDR = \frac{n_{out}}{n_{tot}} \tag{14}$$

Then, PDR is divided by the number of users in the cell in order to calculate Mean Packet Delay Ratio (MPDR).

$$MPDR = \frac{\sum_{i=1}^{i=10}}{10} \tag{15}$$

According to MPDR value, resource allocation procedure starts. Highest MPDR value determines the Receiver Cell (R_C). On the other hand, there is a Donor Cell (D_C) that can give its part of RBs considered as Lendable Bandwidth (W_L). Dc has the highest W_L. In addition to this every cell has a minimum bandwidth (W_{min}) that never given to the D_c. Every cell stores number of

RBs as W_{min} for its own user. Another coefficient is Borrowable Bandwidth (W_B). D_c takes the number of RBs from R_c as amount of W_B. Before this process, every cell has 100 RBs in our proposed scheme EB_{DSFR} (Wi; i=1.2.3…7). In every TTI W_i, Wmin W_L and W_B are computed. Also, cell center bandwidth (W_{in}) and cell edge bandwidth (W_{out}) changes according to α value. In fig. 6. We can see the initial condition of the system.

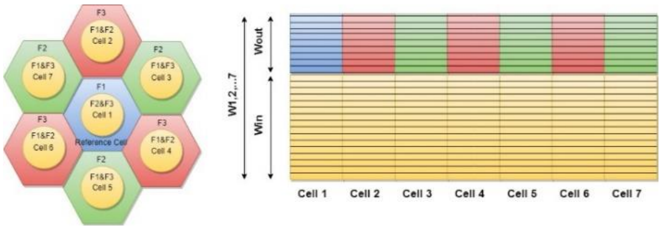

Fig. 6. Initial System Model
(a) Seven-Cells Hexagonal Layout (b) Initial RBs Allocation Among Cells

In our proposed scheme, number of RBs in the cell center and cell edge changes according to α value. For example, if we suppose that α value as a 0.4, this means that cell center has 40 RBs and cell edge has 60 RBs. This is used to achieve best throughput values and fairness percentage. Also, in our proposed scheme, resource sharing occurs between the cell center of the D_c and cell edge of the R_c. If donor cell lendable bandwidth (D_CW_L) becomes higher than the receiver cell borrowable bandwidth (R_CW_B), donor cell shares RBs as R_CW_B with the receiver cell. R_CW_{in} increases as the amount of R_CW_B and D_CW_{out} decreases as the amount of R_CW_B. On the other hands, if D_CW_L is less than the R_CW_B then receiver cell still gets R_CW_B but, donor cell gives only amount of RBs as D_CW_L. Receiver cell takes the remaining RBs from the second highest MPDOR cell. It gives R_CW_B minus D_CW_L RBs to the receiver cell. After one TTI, the new configuration becomes like in fig. 7.

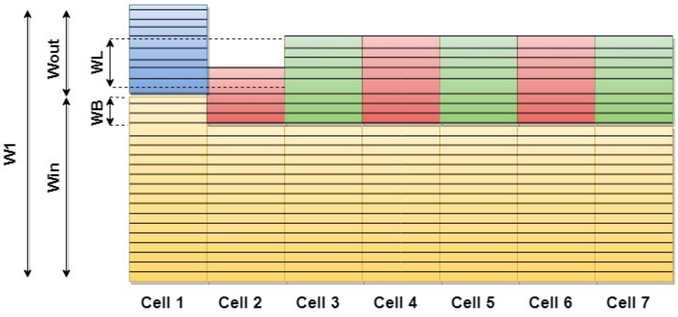

Fig. 7. RBs allocation among cells

Algorithm 1 The EB_{DSFR} Scheduling Algorithm

```
BEGIN
  At each scheduling time
  for each cell $i \in C$ do
  Update (PDR(i), TRPR(i), PDOR(i), MPDOR(i))
  Update ($W_B$(i), $W_L$(i), Wmin(i))
  end for
  Select $R_C$ that has the highest MPDOR from all cell
  Select $D_C$ that has the highest $W_L$ from the neighboring cell of $R_C$
  At the starting point $W_{in}(i) = \alpha W(i)$ RBs and
      $W_{out}(i) = W(i) - W_{in}(i)$ RBs
  if $W_L \neq 0$ then
    if $D_C W_L(i) \geq R_C W_B$ then
      $R_C W_{in}(i) \leftarrow R_C W_{in}(i) + R_C W_B(i)$
      $D_C W_{out}(i) \leftarrow D_C W_{out}(i) - R_C W_B(i)$
    else
      $R_C W_{in}(i) \leftarrow R_C W_{in}(i) + R_C W_B(i)$
      $D_C W_{out}(i) \leftarrow D_C W_{out}(i) - D_C W_L(i)$ then
      Select the second highest MPDOR from all cell
      except the cell that $W_L(i)$ and $W_B(i)$ then
      $SD_C W_{out}(i) \leftarrow SD_C W_{out}(i) - [(R_C W_B(i) - D_C W_L(i))]$
    end if
  end if
  for each user $u \in R_C$ do
  Update (CSR(u), BER(u), R(u), EC(u) and EBPS(u)
  end for
  for $R_C W_{in}(i)$
  Allocate RBsin to all users according to EBPSin
  First give the RBin to the user that has the highest EBPSin
  Second give the RBin to the user that has the second highest EBPSin
  Until all RBsin are allocate
  end for
  for $R_C W_{out}(i)$
  Allocate RBsout to all users according to EBPSout
  First give the RBout to the user that has the highest EBPSout
  Second give the RBout to the user that has the second highest EBPSout
  Until all RBsout are allocated
  end for
END
```

We used our previous scheduling algorithm that is called Experience-Based Packet Scheduler (EBPS) [12] [23]. It determines the user who is the first receiver about the RB. Also, EBPS supplies to allocation of the RBs in a fair manner.

$$EBPS_u(n) = \frac{QoS_u(n)\Theta Ri_u(n)^{\Phi}(n)EC_u(n)L}{Ra_u(n)} \tag{16}$$

We used experience classifier $EC_u(n)$, quality of service $QoS_u(n)$, instant throughput $Ri_u(n)$ and channel load (L) of cell for the EBPS formulation. Then, average throughput $Ra_u(n)$ is divided to above coefficients. Finally, we allocate RBs to the user who had a bad service quality previously takes the RB first. Another subject is determining the user's place in the cell. We used SINR method to find the location of the users. According to this method, users who have higher SINR value than the threshold value, they are considered in the cell center and users who have a lower SINR value, they are considered in the cell edge. Then, SINR values are calculated for each user and RB that is the highest SINR value belonging to maximum EBPS user is allocated first. This is done until all RBs have been assigned to all users in a TTI.

TABLE III
LIST OF SYMBOLS

Symbol	Definition
C	Cluster
D_C	Donor Cell
R_C	Receiver Cell
RB	Resource Block
PDR	Packet Delay Ratio
$W_{in}(i)$	Cell Center Bandwidth (RBs) of Cell i
$W_{out}(i)$	Cell Edge Bandwidth (RBs) of Cell i
$W_L(i)$	Lendable Bandwidth (RBs) of Cell i
$W_B(i)$	Borrowable Bandwidth (RBs) of Cell i
$W_{min}(i)$	Minimum Bandwidth (RBs) of Cell i
W(i)	Total Number of Resource Blocks of the Cell i
SFR	Soft Frequency Reuse
FFR	Fractional Frequency Reuse
EBPS	Experiment Based Packet Scheduler
EB_{DSFR}	Experiment Based Dynamic Soft Frequency Reuse

IV. SIMULATION RESULTS AND ANALYSIS

We compared our proposed algorithm EB_{DSFR} with the reference techniques [10] that are Dynamic Inter-cellular Bandwidth Fair Sharing FFR (FFR_{DIBFS}) and Dynamic Inter-cellular Bandwidth Fair Sharing Reuse-3 ($Reuse3_{DIBFS}$). We took average throughput and user's SNIR [20] as major referencing elements for performance of the schemes. As like reference techniques have, we focused on performance of a reference cell that is cell 1. Cell 1 is the center cell and other 6 cells surround it. In table IV, we can see the simulation parameters.

TABLE IV
SIMULATION PARAMETERS

Parameter	Value
Cell geometry	Hexagonal
Cell radius	1 km
Cell center radius	Variable according to α
Operating bandwidth	20 MHz
Number of users per cell	10
Subcarriers frequency	15 kHz (1 RB 12 Subcarriers)
RB bandwidth	180 kHz
Number of RBs	100
TTI	1 ms
Thermal noise density	-174 dBm/Hz
BS transmit power	20 W (43 dBm)
Scheduler	Experiment Based Packet Scheduler
SFR power ratio (β)	0.25
Pathloss model	15.3 + 127.6 log10(D)

In fig. 8, we can see the average user SINR values of our proposed EB_{DSFR} and reference reuse techniques FFR_{DIBFS} and $Reuse3_{DIBFS}$. As we mentioned above; In $Reuse3_{DIBFS}$ method, all the adjacent cells use different frequency, and all the users have very high SINR values. In the FFR_{DIBFS} method, cell center zone uses frequency reuse-1 method and cell edge zone uses frequency reuse-3 method. Also, cell center and cell edge use different frequency band, and this provides better SINR values compared to EB_{DSFR}. When we look at the SINR values of the EB_{DSFR}, in the cell center band, frequency spectrum is allocated lower transmission power because cell center user shares same bandwidth with cell edge of the neighboring cells cell center users have good SINR values but, cell edge users have low SINR values. EB_{DSFR} has less SINR values compared to the reference techniques, but it uses all the available spectrum and has better throughput values.

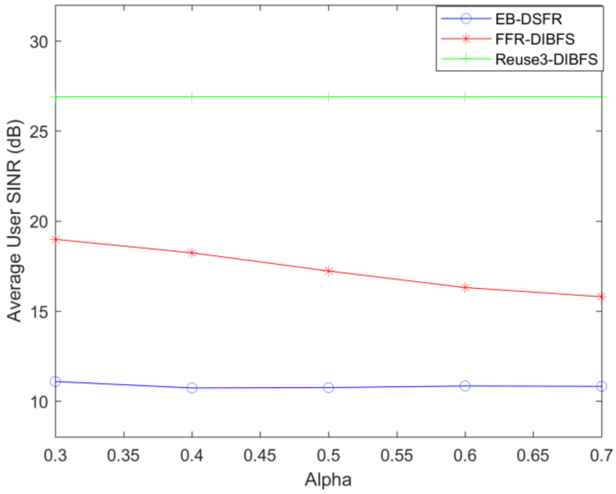

Fig. 8. Average user SINR for EBDSFR, FFRDIBFS and Reuse3DIBFS with different α values

As we seen in the fig. 9, $Reuse3_{DIBFS}$ method has the highest cell center SINR values. As we explained before, all neighboring cell use different frequency, and this causes high SINR values but, lower throughput values. Our proposed method EB_{DSFR} has worst SINR values as we see. In the EB_{DSFR} method, cell center users use same bandwidth with the neighboring cells' cell edges, but in FFR_{DIBFS} method it is not like this. They use same bandwidth with neighboring cells' cell center. Because of the more distance, they have better SINR values than the EB_{DSFR} method. In addition to this, when α increases, the SINR values of the EB_{DSFR} and FFR_{DIBFS} decreases. Because, cell center expands and users who locates in the cell center are away from the base station. This causes less average SINR values.

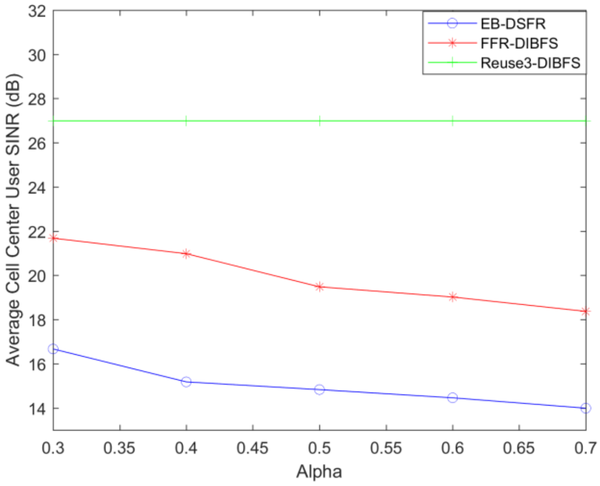

Fig. 9. Average cell center user SINR for EBDSFR, FFRDIBFS and Reuse3DIBFS with different α values

In fig. 10 we can see that, the SINR values of the EB_{DSFR} is less than FFR_{DIBFS} and $Reuse3_{DIBFS}$ methods. Cell edge users of the EB_{DSFR} must transmit maximum power level to achieve maximum throughput rates. This cause Low SINR levels for the proposed scheme.

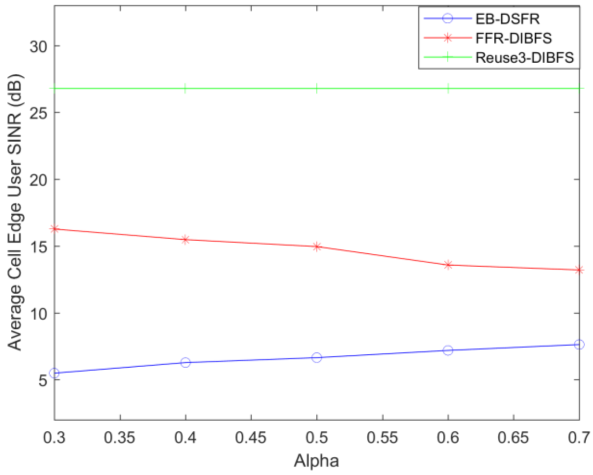

Fig. 10. Average cell edge user SINR for EBDSFR, FFRDIBFS and Reuse3DIBFS with different α values

In fig. 11 we showed total number of resource blocks (W_i) in the reference cells (Cell 1) of our proposed scheme EB_{DSFR} and reference reuse schemes FFR_{DIBFS} and $Reuse3_{DIBFS}$. For these comparisons, we took the $R_C W_B(i)$ constant as 8 for all the simulated techniques. This means that, reference cell is the receiver cell (R_C) that has the highest MPDOR value and other 6 cells can be donor cell according to their $W_L(i)$ values. In every TTI R_C takes 8 RBs from D_C to allocate its own users.

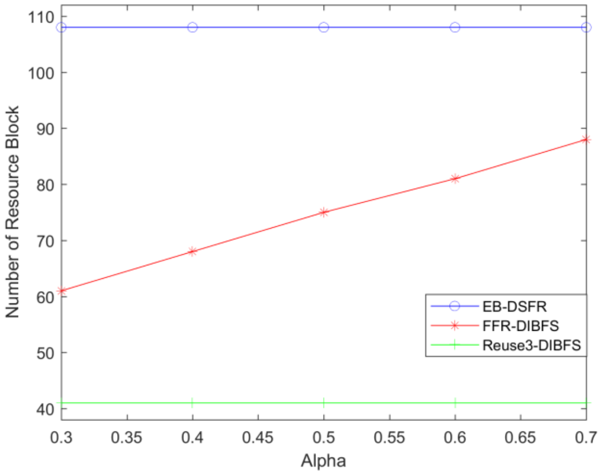

Fig. 11. Number of resource blocks in the reference cell for EBDSFR, FFRDIBFS and Reuse3DIBFS with different α values

For $Reuse3_{DIBFS}$, receiver cell has the smallest number of RBs. Because it can use just 1/3 of the available spectrum. When we look at the FFR_{DIBFS} technique, RBs values increase when the α values increase. In the FFR_{DIBFS} method, cell center zone uses frequency reuse-1 method and cell edge zone uses frequency reuse-3 method. And when α increases, number of cell center RBs increases and number of cell edge RBs decreases. But, it does not happen direct proportionally, amount of increment is higher than the decrement. EB_{DSFR} has the highest number of RBs. Because in the EB_{DSFR} method, all the available spectrum is used and in the reference cell 108 RBs are available to allocate to the users.

Fig. 12 depicts the average number of RBs in the 7 different cells for different reuse schemes. In each cell EB_{DSFR} has maximum number of RBs because of the available spectrum usage. EB_{DSFR} uses whole available spectrum and for this reason it has more RBs than the reference schemes. When we look the FFR_{DIBFS}, it uses partial spectrum at the cell edge so, it has less RBs than our proposed scheme. Finally, $Reuse3_{DIBFS}$ uses 1/3 of al spectrum and it has smallest number of RBs. Furthermore, in each scheme, cell 1 has the maximum number of RBs. Cell 1 is the receiver cell and in each TTI it takes some part of RBs of the other cells according to the load.

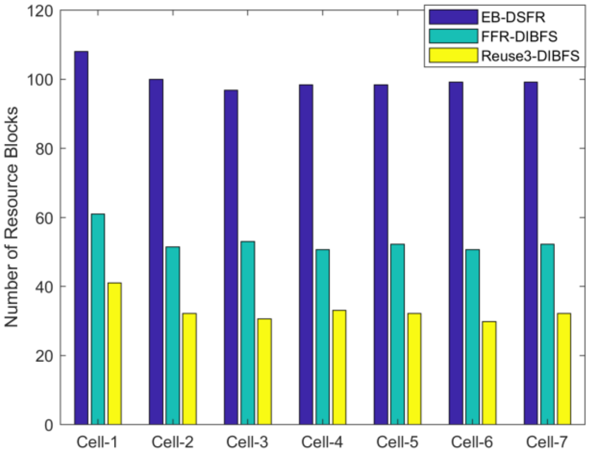

Fig. 12. Average number of resource blocks in each cell for EBDSFR, FFRDIBFS and Reuse3DIBFS

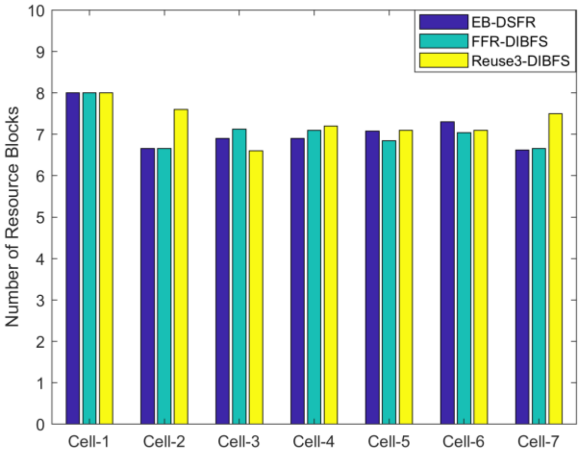

Fig. 13. Average number of borrowable resource blocks (WB) in each cell for EBDSFR, FFRDIBFS and Reuse3DIBFS

Fig. 13 respectively shows the average number of borrowable bandwidth W_B in the 7 different cells for different reuse schemes. W_B is the bandwidth or number of resource blocks that R_C can borrow from the D_C. In each TTI, W_B is calculated and the cell which has the highest MPDOR takes the number of RBs as the amount of W_B from the receiver cell (R_C). In this figure we can clearly see that, Cell 1 has the highest RBs because it is the cell that has the highest load.

In fig. 14 we can see the average number of lendable bandwidth W_L in the 7 different cells for different reuse schemes. W_L is the bandwidth or number of resource blocks that R_C can take from the D_C. In each TTI, W_L is calculated and the cell which has the highest W_L gives the number of RBs as the amount of W_L to the receiver cell (R_C). In this figure we can clearly see that, Cell 1 has the smallest RBs because it is the cell that has the highest load.

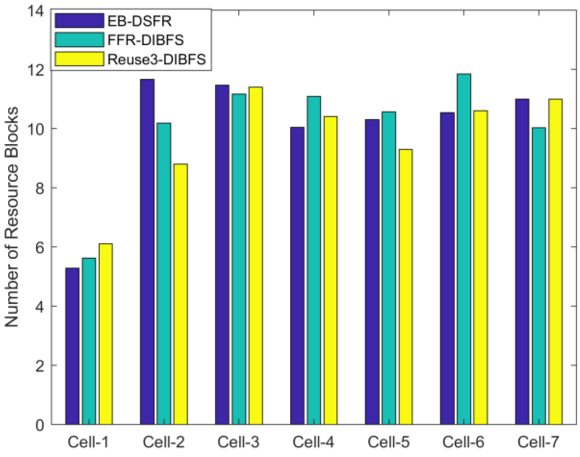

Fig. 14. Average number of lendable resource blocks (WL) in each cell for EBDSFR, FFRDIBFS and Reuse3DIBFS

Fig. 14 shows that, mean user throughputs for our proposed scheme and other reference techniques. In the reference techniques we used Round Robin (RR) scheduling to allocate RBs. From the figure we ca clearly see that, EB_{DSFR} scheme gives the best performance for user average throughput because of the all available spectrum usage. Second efficient scheme is FFR_{DIBFS}. Our proposed technique provides advantage up to 30% when we compare with the FFR_{DIBFS}. For both schemes, when α increase average user throughput increase direct proportional. Also, $Reuse3_{DIBFS}$ mean user throughput values are less because it uses 1/3 of the available spectrum.

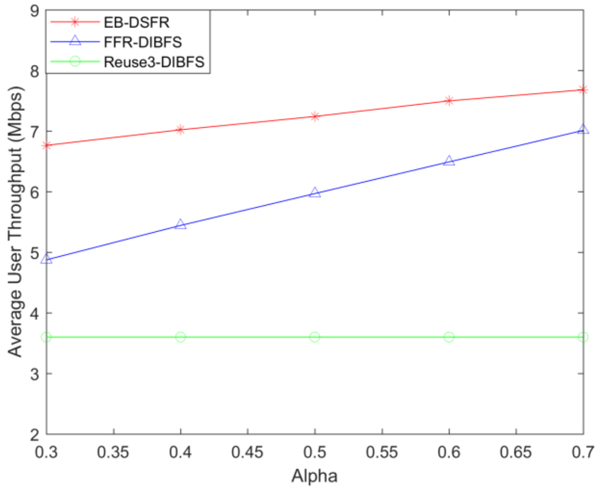

Fig. 15. Average user throughput for EBDSFR, FFRDIBFS and Reuse3DIBFS with different α values

In fig. 16 total process time are shown for different Schemes. For determining the total process time, we supposed that every user has service flow with a traffic of 50 Megabyte video stream. When all the users in the cell reach 50 Megabyte total data, we measured the total time. Our proposed scheme has the best performance for allocating the data. For each α values EB_{DSFR} has better performance up to 37.5% than the reference schemes. The reason of this, EB_{DSFR} has more RBs in one slot time.

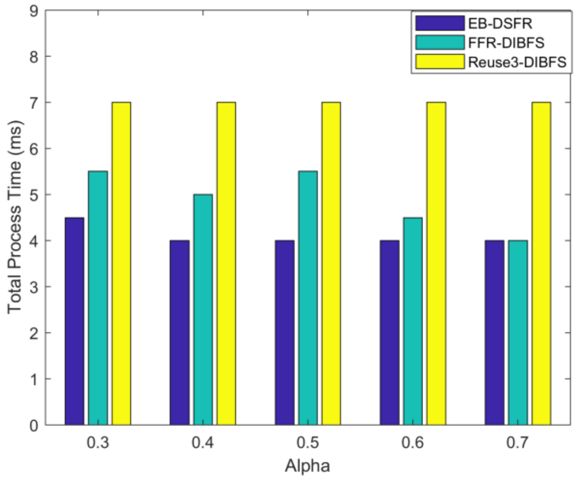

Fig. 16. Total process time for EBDSFR, FFRDIBFS and Reuse3DIBFS with different α values

CONCLUSION

We proposed inter-cell interference cancellation and resource allocation technique to increase throughput of whole system. It also helps users to share resource in a fairer way by taking into account previous user experiments. It dynamically allocates the resources and considers user's QoS. Also, we used our previous scheduling algorithm Experience-Based Packet Scheduler to allocate the resource blocks to the user. To see the benefits of our proposed scheme, we compared EB_{DSFR} with the FFR_{DIBFS} and $Reuse3_{DIBFS}$. We used MATLAB to simulate all the scheme and then we compared these schemes. We can clearly see that, EB_{DSFR} has a better performance at average user throughput and delay. It provides more throughput up to 30% and 37.5% less time compared to the FFR_{DIBFS}. When we compared the SINR values, our proposed scheme has worse than the reference schemes. But, EB_{DSFR} uses all available spectrum and this disadvantage is eliminated for the throughput levels. As a future works, we can increase SINR by setting the power levels. Furthermore, we can minimize the total process time.

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