International Journal of
Science and Engineering Investigations
vol. 5, issue 55, August 2016
ISSN: 2251-8843

A Novel Burst Mapping Algorithm for WiMAX with DL-MAP Reduction Approach

Mohammad Mostafavi
Faculty of Electrical and Computer Engineering, University of Zanjan, Zanjan, Iran
(mmostafavi@znu.ac.ir)

Abstract- OFDMA is used in wideband wireless networks. Mobile WiMAX is one of these networks. In IEEE 802.16e-based mobile WiMAX network the data frame is a two dimensional time–frequency region that must be allocated to users. Firstly, the number of slots is allocated to users. Then, the allocated resources are mapped to rectangular areas in this two dimensional region. The reason is that these regions must be addressed in the first of the frame; the rectangular mapping minimizes this overhead. In this mapping, a user might receive more slots than its requirement and therefore the mapping area might be subjected to stretch and some slots might be unused. Moreover, a part of this two dimensional region is used for DL-MAP overhead. The algorithm must be optimal to minimize these wastages. It is known that finding the optimal solution for such a resource mapping problem is NP-complete [1]. Therefore, a practical optimal solution cannot be developed. In this paper we propose a new mapping scheme which efficiently maps user requirements to WiMAX. The proposed scheme has the advantage of order in column widths (number of OFDMA symbols) which help to reduce the DL-MAP overhead. This overhead reducing is very important for WiMAX frame utilization improvement.

Keywords- *Burst map, DL-MAP, OFDMA, WiMAX*

I. INTRODUCTION

The emerging demands for high rate data communications combined with ease of deployment motivate to use of broadband wireless networks. Because of wireless nature, these networks encounter with some challenging problems such as non-line-of-sight operation and multipath fading channels. So the recommended network requires a technology that can work efficiently in those conditions. Multi-carrier modulation techniques such as OFDM can efficiently support these applications. The OFDM based communication systems transmit multiple data symbols simultaneously using orthogonal sub-carriers. The principle behind the OFDM system is to decompose the high rate data stream of bandwidth W into N lower rate data streams and then to transmit them simultaneously over a large number of sub-carriers. Value of N is kept sufficiently high to make the individual bandwidth (W/N) of sub-carriers narrower than the coherence bandwidth (B_c) of the channel. The flat fading experienced by the individual sub-carriers is compensated using single tap equalizers.

These sub-carriers are orthogonal to each other which allows for the overlapping of the sub-carriers. The orthogonally ensures the separation of sub-carriers at the receiver end. As compared to FDMA systems, which do not allow spectral overlapping of carriers, OFDMA systems are more spectrally efficient. In OFDMA, the active sub-carriers are divided into subsets of sub-carriers. Each subset represents a sub-channel. These sub-carriers that form a single sub-channel need not be adjacent. This grouping process is called sub-channelization [2]. WiMAX is a wireless network that uses OFDMA, two different methods of sub-channelization or permutation can be used in WiMAX, distributed and adjacent permutation. Difference between these permutation methods is as follows:

Adjacent permutation: in adjacent permutation like Band Adaptive Modulation and Coding (AMC) a sub-channel is formed by grouping a block of contiguous data sub-carriers. Adjacent Permutation is suitable for fixed, portable, or low mobility environments. This type of permutation can exploit multi user diversity at the cost of an increased feedback from the stations.

Distributed permutation: This is implemented as Down Link Full Usage Sub-carriers (DL-FUSC), Downlink Partial Usage Sub-carriers (DL-PUSC) and Uplink Partial Usage Sub-carriers (UL-PUSC). Sub-channels are allocated with sub-carriers in a pseudo random way. Distributed permutation schemes spread the sub-carriers contained in a logical sub-channel across the available spectrum, hence reducing fading effects by exploiting frequency diversity. Distributed permutation schemes are suited for mobile environments, because the fading is an important factor that degrades the mobile communication quality[2].

OFDMA combines the TDMA and FDMA schemes. In OFDMA each frequency in each time can be allocated to users. So the allocation region of resources is a two dimensional region. In the IEEE 802.16e specification, each data burst is mapped in a two dimensional time -frequency region.

Resource allocation in WiMAX is a challenging problem. Mobile WiMAX uses a fixed frame based resource allocation, usually of 5 ms duration. Bi-directional communication can be achieved by Frequency Division Duplexing (FDD) that different frequency bands is allocated for uplink and downlink or by Time Division Duplexing (TDD) that different times is allocated to uplink (UL) and downlink (DL) in which the downlink traffic follows the uplink traffic in the time domain. For data traffic, the TDD provides a flexible partitioning of the frame into DL and UL sub-frames. The Mobile WiMAX frame ,as depicted in Fig.1, starts with a downlink preamble and a frame control header (FCH) followed by the downlink map (DL-MAP) and the uplink map (UL-MAP). These maps contain the informational elements (IEs) that specify the burst profile for each burst. The profile consists of a burst-start time, a burst-end time, a modulation type, and a forward error control (FEC) used or to be used in the burst. Each frame is a two dimensional time-frequency (OFDMA symbol-sub-channel) region that can be allocated to mobile stations (MS). If the number of sub-channels is H and the number of OFDMA symbols is W, there will be W × H resources which can be allocated to mobile users. When the resources are assigned, these resources must be mapped to the two dimensional region.

Data bursts of all users must be packed in this region. The constraint of the packing process which called mapping is that all regions must be rectangular in which the needed DL-MAP will be decreased. Because of this rectangular mapping, some users might give a larger region than its need and some portion of the granted region might be unused. We call these, over allocated and unused spaces, respectively. This spaces are the wasted spaces. Therefore, because of this wasted spaces, some columns or OFDMA symbols must be added in order to map all of the allocated resources in this two dimensional region. These columns are called the additional columns. We propose heuristic algorithms which maps these resources into this two dimensional region. The key idea which is used in the proposed algorithms is that the resources are mapped in column wise order, such that each column constitute some OFDMA symbol times. We propose a new heuristic algorithm that also maps the resources in column wise but the widths of columns are fixed except of the last column which can be different from other columns. In spite of fixed widths, which simplifies the algorithm, the algorithm has better performance compared to the other algorithms for example eOCSA[3] .

The rest of this paper is organized as follows: first we refer to related works about the burst mapping in section II the algorithm is described in section III, for clarification of algorithm one example of mapping is mentioned in this section and the simulation results are described in section IV.

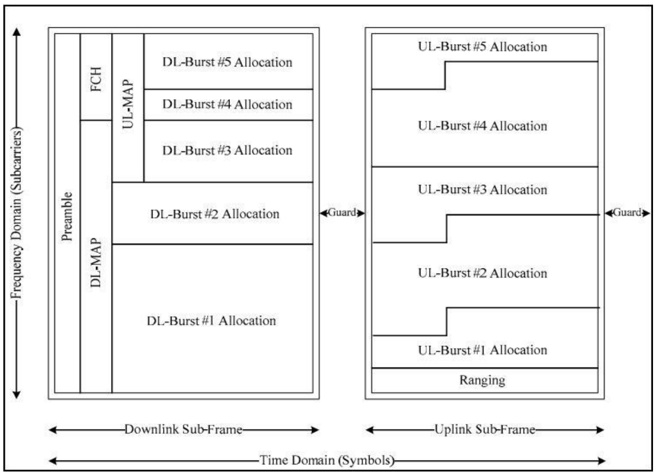

Figure 1. Wimax TDD Frame structure

II. RELATED WORKS

In this section, we briefly explain some of the other burst mapping algorithms which were proposed for IEEE 802.16e. In [4] the algorithm is full search and the number of mobile users is lower than 8. In[5] the mapping is in multiple rectangles, which results an increased DL-MAP overhead. In [6] the largest resource is mapped first but unused space is not considered. In [7] and [3] two simple heuristic mapping schemes have been proposed, aiming to keep the mapping operational complexity low. The algorithm OCSA [7] maps the resources from bottom to top and right to left; in this algorithm all possible mapping-pairs were considered. This algorithm attempts to reduce the unused space. The algorithm eOCSA [3] like[7] maps the resources from bottom to top and from left to right, In first step the algorithm sorts the incoming bursts in a descending order. During the second step, sorted resources are mapped in columns on the basis of a suggested mapping strategy. The algorithm attempts to map the largest of remaining resources in unallocated space in each column. In this algorithm the width of each column is computed with the largest remaining resource, so the widths of columns are not equal. Because of rectangular mapping which is used in this algorithm, DL-MAP overhead is reduced. In [8] the fairness of mapping is considered but because of complexity increasing is not suitable for large number of users, in the simulation the number of users is lower than 20. In [9] the best width for each column is computed and the complexity is increased. In all of this papers and some of the others for example [10], the value of DL-MAP which is important is not considered. In our new proposed algorithms, in addition of mapping efficiency improvement, the DL-MAP increasing will be considered and reduced.

III. PROBLEM DEFINITION

There is a two dimensional matrix with $h \times w$ dimensions. Such that h is the number of sub-channels and w is the number of OFDMA symbols. Also, there is n allocated resources which their sizes are

$\{a_1,\ a_2,\ a_3, \ldots\ ,\ a_n\}$. These resources must be packed into this two dimensional matrix, one important constraint which must be considered, is that the regions must be rectangular. This constraint reduces the DL-MAP. This two dimensional packing problem is an NP-complete problem that no optimum solution was proposed for that.

Now we define this problem clearly. We define the mapping function with $\text{map}(a_i) = (w_i^s, h_i^s, w_i^e, h_i^e)$ such that w_i^s and h_i^s are the start point symbol number and sub- channel number, w_i^e and h_i^e are the end point symbol number and sub-channel number if h_i is the needed sub- channel number and and w_i is the number of time slots or OFDMA symbols that are needed for mapping of this user in the region so $h_i = h_i^e - h_i^s$ and $w_i = w_i^e - w_i^s$.

so $area(map(a_i)) = h_i \times w_i$, This area must be greater than or equal to a_i (or $a_i \leq area((map(a_i))$). The best mapping is the mapping that this area equals to a_i. If the area be greater than a_i , some of that region will be wasted, this wasted area is called the over allocated area. We attempt to reduce this over allocated area. Because of rectangular mapping constraint, some regions in the region may be unused or no user can be mapped in this region. These regions will be called as unused spaces. We attempt to reduce these regions also. For specifying the users location in the matrix a DL-MAP is needed for all. This DL-MAP is located in the start of this matrix.

The greater DL_MAP results lower region for mapping so the users which can be packed in this region will be reduced. So we attempt to reduce the DL_MAP as much as possible.

IV. ORDERED WIDTH BURST MAPPING

The principle of two proposed algorithms in this section is the two important key features. First, the packing process in the DL sub-frame is in the column-wise. Second, the widths of all columns except of the last column have an order. This order of column widths can help us to reduce the DL-MAP overhead. The DL-MAP overhead is an important factor on increasing the utilization efficiency of the WiMAX frame. When the number of users increases, the DL-MAP may be increased critically in which whole of frame will be filled and no space will be remained for the packing process. So performance improvement combined with reducing of DL-MAP must be considered. In this paper we propose some new DL-MAP construction manners that decrease this overhead. In this section we explain our proposed algorithm.

A. Decreasing Width Burst Mapping(DWBM)

This algorithm is a burst mapping algorithm that maps the allocated resources in the vertical columns. The idea behind of this algorithm is that the widths of columns have an order that can help us to reduce the DL-MAP overhead. This order is decreasing of the columns` widths, such that the width of first column is w, the next columns have the widths $w, w-1, w-2, \ldots$. The stages of this algorithm are as following.

Suppose that the resources of the set $\varphi = \{a_1,\ a_2,\ a_3, \ldots\ ,\ a_N\}$.have been allocated to users.

1) Sort these resources in the descending order.

2) Suppose that the resources of the set $\varphi_1 = \{a_1',\ a_2',\ a_3', \ldots\ , a_K'\}$ are greater than h, that we assume, is equal to 30. So we have K users that their allocated resources are greater than h.

3) Find the temporal width of these columns by the equation:

$$w_i^t = \left\lceil \frac{a_i'}{h} \right\rceil \tag{1}$$

4) The K's user has the width …., that is the minimum value of widths, we can find the width of first column with:

$$w = max((w_K^t + K - 1), w_1^t) \tag{2}$$

5) We map the first resource of the set in this column. If it's height be h_i that is equal to $h_i = \left\lceil \frac{a_i}{w} \right\rceil$, we find the remained space height in this column by:

$$h_r = h - h_i \tag{3}$$

Next we find the largest resource that can be mapped in this area. It's height after mapping must be lower than or equal to h_r after this, we find the newer h_r From the following equation:

$$h_r(new) = h_r(old) - h_j \tag{4}$$

Continue this manner until that h_r be lower than all remained resources.

6) The widths of other columns can be calculated from the following equation:

$$w_i = \max(w_{i-1} - 1, 1) \tag{5}$$

Now we map the remained resources with the order of prior column and continue this manner for all other columns.

7) We continue this manner until the frame after subtracting the DL-MAP overhead has no other space for mapping. In this stage the algorithm ends.

B. Semi fix Width Burst Mapping (SFWBM)

In this algorithm we use a semi fix width manner that simplifies the DL-MAP construction. The idea behind of this method is that a defined number of users has a width and the remaining columns have the width of one. The stages of this algorithm are:

1) As the previous algorithm sort the resources in the descending manner.

2) Suppose that the number of resources that are greater than h, is K, now we find the width of this columns that is w_f, as following:

$$w_f = \left\lceil \frac{max(a_i)}{h} \right\rceil \tag{6}$$

3) The other columns have the width of one.

4) Now we map the resources as stage fifth of the previous algorithm and continue until all of resources be mapped.

For some clarification we assume that a be equal to [16, 18, 19, 7, 19, 19, 5, 4, 18, 38, 14, 27, 12, 55, 89] and map these elements with four algorithms. As we see eOCSA has different column widths, the widths of FWBM are equal except of the end column, DWBM has a decreasing column width until the width reaches to 1, the SFWBM has 3 columns with width 3 and two columns with width1. Some of this region must be used for DL-MAP and the remaining region can be used for users.

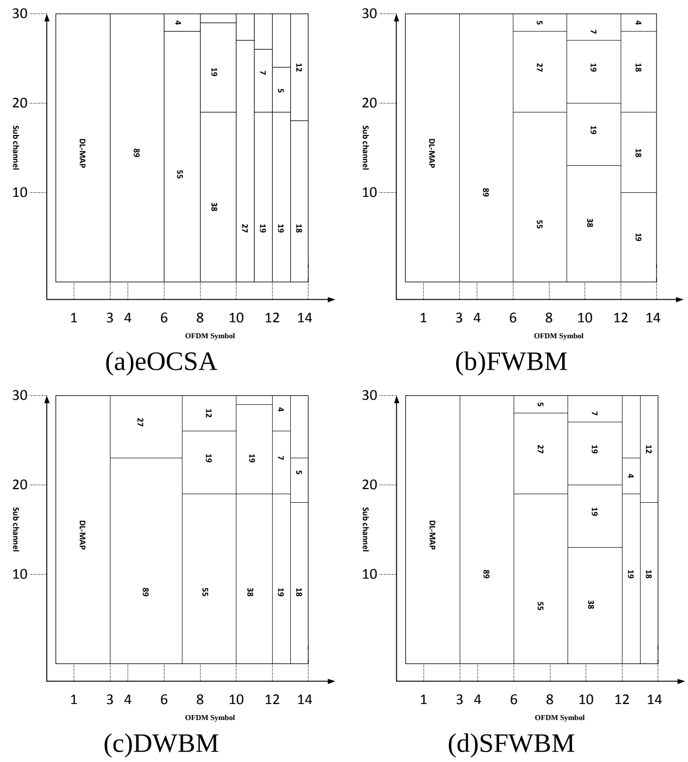

Figure 2. An example of mapping process in three algorithms.

Some of users cannot be served for example in eOCSA, DWBM and SFWBM the resources [18, 16, 14] and in FWBM the resources [16, 14, 12] cannot be served.

C. DL-MAP Construction

In this subsection first we explain the traditional DL-MAP construction and next our new method of DL-MAP construction that reduces this parameter and accordingly increases the mapping efficiency. In the traditional rectangular mapping that each user resource will be mapped in a two dimensional rectangle, for determination of each user location, four parameter is needed, that two is for start point OFDMA symbol and sub-carrier location and two for end point of each rectangle[11].

Number of bytes that is needed for DL-MAP in the traditional rectangular mapping can be computed by[12]:

$$DL-MAP(bytes) = \frac{88+60\times\#\,DL\text{−}users}{8} \tag{7}$$

The first part of this equation is fixed, namely 11 bytes is not related to number of users but the second part is related to this, we see that 60 bit is needed for each user DL-MAP, so for each parameter 15 bit is needed.

And number of slots that is needed for this can be computed from next equation [12]:

$$DL-MAP(slots) = \left\lceil \frac{DL\text{−}MAP(bytes)}{S_i} \right\rceil \times r \tag{8}$$

r is the repetition factor , S_i is the slot size(bytes) given ith modulation and coding scheme. Note that basically QPSK 1/2 is used for computation of UL and DL-MAPs.so slot size is 6 bytes and repetition factor r is 4.

So the area of DL-MAP or the needed slots in the traditional rectangular mapping can be computed from the following formula:

$$area(DL-MAP) = \left\lceil \frac{11+\#\,DL\text{−}users \times\frac{60}{8}}{6} \right\rceil \times 4 \tag{9}$$

In our proposed algorithm the resources are mapped in a column wise method and the widths of these columns except of the last are fixed. So the rectangles have a regularity that can help for simplification of this DL-MAP construction. The last mapped elements will be in a column with different width, we can realign that column to first column and the other users in the rest columns. Now the first column has a width and the others have a fix width, these two different widths most reported in the first.

We propose two new methods for DL-MAP construction.

First: we can use three parameters for each user location, column number, start point in column and the end point in this column and the widths are known already. So the DL-MAP function can be as the following:

$$DL-MAP(a_i) = (c_i, h_i^s, h_i^e) \tag{10}$$

Second: by two parameters we can rather reduce the DL-MAP. In this method, column number, and the end point of each user in that column can be used. Thus the new DL-MAP function will be as:

$$DL-MAP(a_i) = (c_i,\ h_i^e) \tag{11}$$

The start point of first user in each column is 1 and for the other users in that column can be computed as the following:

$$h_i^s = h_i^e + 1 \tag{12}$$

Third: we can use two parameters for DL-MAP without needing for column numbers (c_i). In this propose for all users two parameter are needed, that we indicate by $sum\_h_i^s$ and $sum\_h_i^e$. If a user be in (c_i, h_i^s, h_i^e) position it's $sum\_h_i^s$ and $sum\_h_i^e$ can be computed by following equation:

$$sum\_h_i^s = h * c_i + h_i^s$$
$$sum\_h_i^e = h * c_i + h_i^e \tag{13}$$

In this method DL-MAP function can be defined as:

$$DL-MAP(a_i) = (sum\_h_i^s, sum\_h_i^e) \tag{14}$$

In the receivers or users, the users' location can be computed by the followings:

$$c_i = \left\lfloor \frac{sum\_h_i^s}{\mathrm{h}} \right\rfloor$$

$$h_i^s = sum\_h_i^s - h * c_i \quad (15)$$

$$h_i^e = sum\_h_i^e - h * c_i$$

So in the third propose we have two parameters for DL-MAP and unlike of second propose for each user we did not need to other users' DL-MAP.

The second method that have a differential form may have a large probability of error in user's addresses. So this method cannot be appropriate for mobile users and is suitable for fixed users.

Therefore, in our mapping algorithm the number of elements that is needed for DL-MAP can be reduced to 3 or 2 so we can use from the following equation for computing of DL-MAP area that is needed:

$$area(DL-MAP) = \left\lceil \frac{11+\#\beta\times DL-users \times\frac{60}{8}}{6} \right\rceil \times 4 \quad (16)$$

That β can be 0.75 (for the first method) or 0.5 (for the second and third method).

In the next table for some users' number we compared our proposed methods and the traditional method.

We can compute the number of OFDMA symbols or columns that is needed for DL-MAP with the following equation:

$$\mathrm{N} = \left\lceil \frac{area(DL-MAP)}{h} \right\rceil \quad (17)$$

The results for proposed and traditional methods will be compared. The number of DL-MAP slots and columns in our three proposed algorithms are equal. As we see in table 2, when the number of users increases, the DL-MAP overhead will be increased critically. For example when the number of users is 50, the number of columns that must be allocated to DL-MAP is equal to 9, so the number columns that can be used for users' resources will be 14-9=5. This is not considered on simulation in [3]. So reducing of DL-MAP can increase throughput. As we see, in this number of users, by first propose the number of this columns is 7 and in second and third propose is 5 and in fourth is 3.

TABLE I. NUMBER OF SLOTS THAT IS NEEDED FOR DL-MAP

Number of users	Traditional method (eOCSA)	First propose (FWBM)	Second and third propose (FWBM)
5	36	32	24
10	60	48	36
15	88	68	48
20	112	88	60
25	136	104	76
30	160	124	88
35	188	144	100
40	212	160	112
45	236	180	124
50	260	200	136

TABLE II. NUMBER OF COLUMNS THAT IS NEEDED FOR DL-MAP

Number of users	Traditional method (eOCSA)	First propose (FWBM)	Second and third propose (FWBM)
5	2	2	**1**
10	2	2	2
15	3	3	2
20	4	3	2
25	5	4	3
30	6	5	3
35	7	5	4
40	8	6	4
45	8	6	5
50	9	7	5

So the reduced region can be used for mapping of more other users.

V. SIMULATION AND RESULTS

We used MATLAB 2010 for simulation and evaluation of the proposed algorithms, we assume that the number of users is 1 to 50 and the total number of OFDMA frame slots is 30 × 14 = 420 and we performed the simulation for each number of users (MS) 300 trials and averaged the results for unuserved users, over allocation space and additional columns. The number of allocated resources for each number of users is randomly generated with the uniform distribution. We do this for eOCSA algorithm, that was explained in [3], FWBM algorithm and enhance version of FWBM (eFWBM).

Because of fixed width, DL-MAP overhead will be lower than the other algorithms. In the all of mapping algorithms four elements is required in DL-MAP overhead for indicating of the user's location in the WiMAX frame. In the our proposed algorithm the widths of columns is fixed so for indicating the location of users, we can address the users with column number, the start and the end of user's location in each column.

So we can use three, two or one elements and the DL-MAP can be reduced to about 20, 50 percent.

We can use one other overhead that we name differentially overhead, in this manner instead of addressing the users location individually we can address the column of user and end of each user in each column that can reduce the DL-MAP about 50 percent compared with the traditional DL-MAP overhead. In this manner each user knows its location column and its end and start is the previous user end plus one. One method of differentially overhead can use one parameter for DL-MAP that can reduce this value to 75 percent of traditional method. Differentially addressing is appropriate for media that has not fading, for example for fixed users. For mobile users the other methods (first and fourth) are used.

In our simulation we assume that after subtracting the DL_MAP from frame, some of the frame will remain, we use this space for mapping. Number of users change from 1 to 50, some of users can't be mapped. We calculate this unserved users and unserved slots. In this simulation we use two different DL-MAP construction, with three (first propose) and two (second and third propose).

We use four algorithms in our simulation, eOCSA[3] and three our proposed algorithms. In eOCSA, because of no order in columns' width, we use from traditional addressing in DL-MAP and other algorithms that have an order in column width use from our proposed DL-MAP construction.

Fig. 3. Indicates the percent of unserved users in the first propose, as we see, when the number of users is low (until 15), all of four algorithms are better than eOCSA (with traditional DL-MAP). When the number of users is 50, these three algorithms can serve 20% users greater than eOCSA.

Fig. 4. Indicates the percent of unserved users in the second and third propose, as we see, because of two element in DL-MAP, all of three algorithms act better than eOCSA. As we see FWBM has poorer efficiency than others.

Fig. 5 and 6. Indicate the percent of unserved slots in four algorithms. As we see our proposed algorithms is better than eOCSA, FWBM is poorer than two other proposed.

Fig. 7. Shows the run time of algorithms. For best comparing, we compare the four algorithms in traditional address manner. As we see FWBM has lower run time than others. This is because of almost fixed width that eases the mapping.

Fig. 8. Shows not useful space that is sum of unused, over allocated and DL-MAP space that are the wastage of mapping. As we see our proposed algorithms are better than eOCSA with traditional addressing.

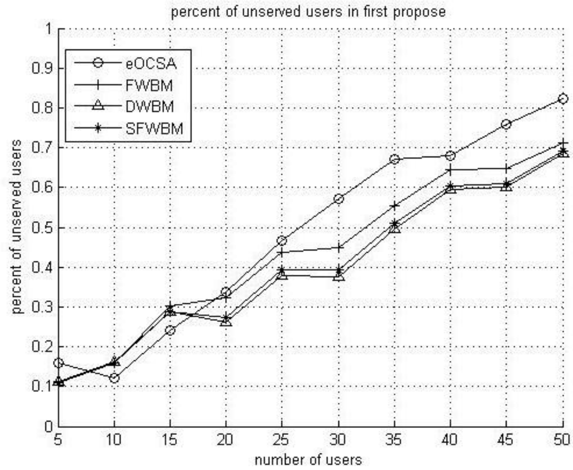

Figure 3. Unserved user's number in the first propose

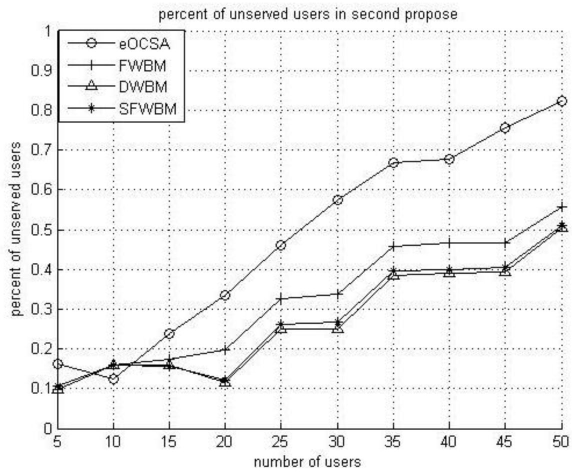

Figure 4. Unserved user's number in the second propose

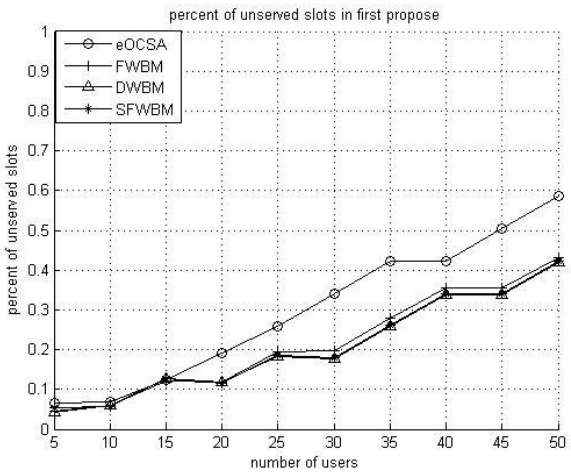

Figure 5. Unserved slot's number in the first propose

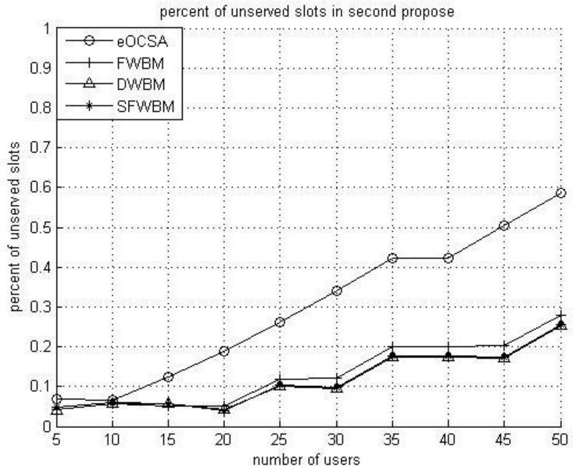

Figure 6. Unserved slot’s number in the second propose

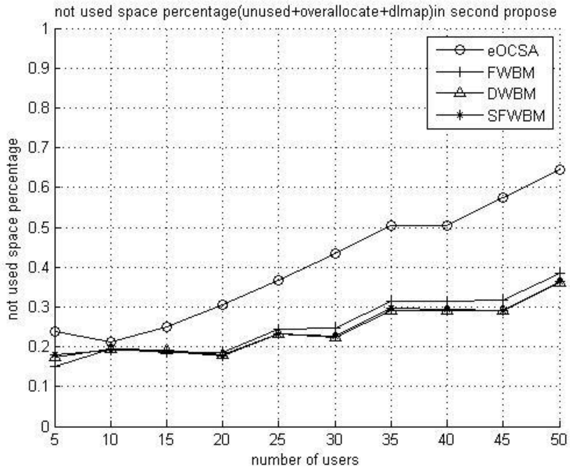

Figure 9. Not useful space in the second and third propose

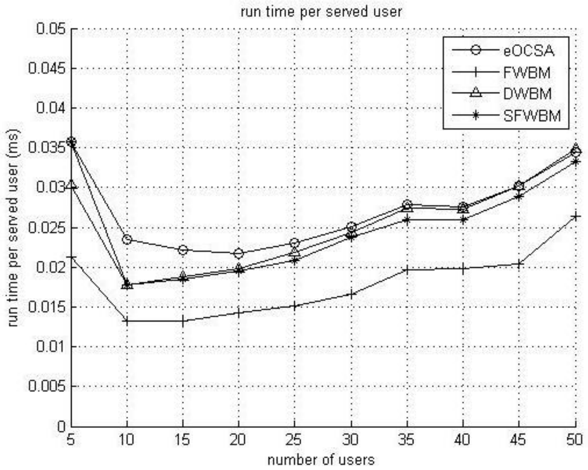

Figure 7. Run time per served user

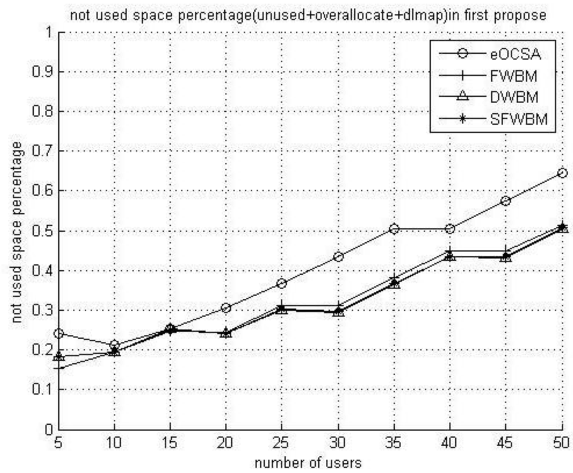

Figure 8. Not useful space in the first propose

VI. CONCLUSION

In this paper we proposed an algorithm that maps the allocated resources to users in a two dimensional region, the resources will be mapped in column based manner, such that the allocated resources will be mapped in the vertical columns, the important aspect that is considered in our proposed algorithms is the DL-MAP reduction that can increase the efficiency of frame usage that didn’t considered in the previous works. For this purpose we use an order in the column widths that will help us.by means of this order we proposed some new DL-MAP constructions that reduce this overhead. As we saw this change can reduce one or two parameters in the DL-MAP overhead per user.

DL-MAP has an important effect on the frame utilization. Because that DL-MAP must transmitted with low error so a high confident coding that in turn take a lot of frame size, must be used. So reducing of this overhead can increase the frame utilization, because that this reduced space can be used for other users.

As we saw by using of our proposed algorithms and DL-MAP constructions, the number of users or slots that cannot be served in the current frame will be decreased. Of course this reduction in low number of users is not considerable. Certainly DL-MAP in low number of users is not. The running time of our proposed algorithms is not greater than eOCSA.

REFERENCES

[1] E. Hopper and B. Turton, "A review of the application of meta-heuristic algorithms to 2D strip packing problems," *Artificial Intelligence Review*, vol. 16, pp. 257-300, 2001.

[2] J. G. Andrews, et al., Fundamentals of WiMAX: understanding broadband wireless networking: Prentice Hall PTR, 2007.

[3] C. So-In, *et al.*, "eOCSA: an algorithm for burst mapping with strict QoS requirements in IEEE 802.16 e mobile WiMAX networks," in *Wireless Days (WD), 2009 2nd IFIP*, 2009, pp. 1-5.

[4] C. Desset, *et al.*, "WiMAX downlink OFDMA burst placement for optimized receiver duty-cycling," in *Communications, 2007. ICC'07. IEEE International Conference on*, 2007, pp. 5149-5154.

[5] A. Bacioccola, *et al.*, "A downlink data region allocation algorithm for IEEE 802.16 e OFDMA," in *Information, Communications & Signal Processing, 2007 6th International Conference on*, 2007, pp. 1-5.

[6] Y. Ben-Shimol, *et al.*, "Two-dimensional mapping for wireless OFDMA systems," *Broadcasting, IEEE Transactions on,* vol. 52, pp. 388-396, 2006.

[7] C. So-In, *et al.*, "OCSA: An algorithm for burst mapping in IEEE 802.16 e mobile WiMAX networks," in *Communications, 2009. APCC 2009. 15th Asia-Pacific Conference on*, 2009, pp. 52-58.

[8] P. G. Sarigiannidis, et al., "A novel fair mapping scheme for IEEE 802.16 downlink sub-frame," in Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT), 2010 International Congress on, 2010, pp. 763-768.

[9] P. G. Sarigiannidis, *et al.*, "A novel adaptive mapping scheme for IEEE 802.16 mobile downlink framing," in *Global Telecommunications Conference (GLOBECOM 2010), 2010 IEEE*, 2010, pp. 1-5.

[10] K. Jumari, "OBBP: an efficient burst packing algorithm for IEEE802. 16e systems," *ISRN Communications and Networking,* vol. 2011, 2011.

[11] L. Nuaymi, WiMAX: technology for broadband wireless access: John Wiley & Sons, 2007.

[12] C. So-In, *et al.*, "Capacity evaluation for IEEE 802.16 e mobile WiMAX," *Journal of Computer Systems, Networks, and Communications,* vol. 2010, p. 1, 2010

Mohammad Mostafavi received his B.S. degree from K. N. Torsi University of Technology, Iran, M.S. degree in electrical engineering from Tarbiat Modares University, Iran and Ph.D. degree in electrical engineering from University of Tabriz, Iran. He is working as an Assistant Professor in the Faculty of Electrical and Computer Engineering, University of Zanjan.

His research interests include digital communication systems, OFDMA-based wireless networks.