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A Dynamic Radio Resource Allocation Policy in a Multi-cell System Configuration for IEEE 802.16m Standard

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Abstract: Supporting users' mobility seems to be a promising and challenging feature of emerging IEEE 802.16m wireless networks. Encouraged by its low complexity in terms of configuration [1], we implement a Hard Handover (HHO) mechanism to manage users' mobility in a multi-cell system context. However, the "break before make" principle of such handover type decreases the system performances in terms of dropped users ratio and latency time [2]. To resolve such problems, we propose a new adaptive sub-channels allocation scheme in a downlink Orthogonal Frequency Division Multiple Access (OFDMA) system. Our basic idea is to reserve a part of radio resources based on a configurable HHO-threshold and then to allocate them to users in handover depending on their maximum Signal-to-Interference Noise Ratio (SINR) in order to maximize the total system capacity. Our proposed sub-channels assignment scheme is based on statistic parameters, mean and variance of the frequency response channel gain for every Mobile Station (MS). Simulation results demonstrate that our proposed scheme decreases dropped users ratio, reduces calls latency time and enhances the total system capacity while enjoying a low computational complexity.

Keywords: IEEE 802.16m; mobility; hard handover; HHO-threshold; sub-channels reservation.

I. INTRODUCTION

Mobile Worldwide Interoperability for Microwave Access (WiMAX) Release 2 is a promising technology to offer higher data rates, satisfy a larger number of mobile users and support user's mobility and high mobility through a very large radio bandwidth [3]. Orthogonal Frequency Division Multiple Access (OFDMA) has emerged as an attractive solution for Mobile WiMAX system to mitigate intra-cell interferences [4].

In order to manage users' mobility, Mobile WiMAX Forum describes three basic types of handover mechanisms which are: Hard Handover (HHO), Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO) [1]. The HHO mechanism is a mandatory while the FBSS and MDHO mechanisms are optional [2]. HHO method permits only one connection between a Mobile Station (MS) and a Base Station (BS) at any given time. It is based on a "break before make" principle, meaning that the connection between the MS and its source BS is broken before the connection between the MS and its target BS is established. The main objective of a Handover (HO) design is to minimize the time spent in transition from a BS to another one, called a "latency time", leading to minimize the dropped users' ratio. This objective seems to be not satisfied with the HHO method [1].

For overcoming the above-mentioned HHO inconvenience, we propose in this paper an adaptive radio resource allocation scheme in a downlink multi-cell Mobile WiMAX system based on a user mobility management mechanism. In this work, the key idea is to reserve a part of available sub-channels to users in HO based on a configurable HHO-threshold, to manage users' mobility. Our proposed scheme includes three steps which are: (1) Determine users in HHO based on their received power, distance between each MS and its serving BS and distance between each MS and its target BS. (2) Allocate reserved sub-channels for users in HO based on their Signal-to-Interference Noise Ratio (SINR) values on each reserved sub-channel. (3) Allocate remaining sub-channels for regular users, moving in the same cell, based on the channel gain of each MS on each sub-channel. Once the sub-channels assignment is applied, an equal power is allocated for each sub-channel in downlink sense in order to reduce complexity [16]. Simulation results demonstrate that our proposed scheme satisfies a greater number of users in HO, requires a lower latency time and provides an efficient use of the available bandwidth.

The reminder of this paper is organized as follows. In section II, we present an overview of handover mechanisms in IEEE 802.16 m standard. Then, we explore some related works that are recently proposed in section III. In section IV, our simulated topology is described and our optimization problem is formulated. Then, our distributed radio resource allocation in a multi-cell system is proposed in section V. Finally, simulation results and performance analysis are provided in section VI.

II. MOBILITY MANAGEMENT FOR MOBILE WIMAX RELEASE 2 NETWORKS

Handover mechanism proves crucial to ensure a good communication quality when users are moving from a cell to another. IEEE 802.16m standard recommendations define three types of handover which are Hard Handover (HHO), Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO) [5]. The HHO method is mandatory while the FBSS and MDHO methods are optional [2].

A. Hard Handover (HHO):

This handover type is known as "break before make" principle, because the connection with the serving BS is broken before the connection with the target BS is established [6]. Therefore, the MS is linked to only one cell at any given time and then needs only one radio link. However, if the handover fails, the call may be temporally disrupted or dropped. As a solution to this inconvenience, a re-establishing procedure is introduced to re-establish the connection to the serving cell, if the connection to the target cell cannot be made, which is not always possible.

B. Fast Base Station Switching (FBSS):

In FBSS, each MS maintains an active set list, called "Diversity Set", which includes a list of the BSs, which may be used by the MS in the handover procedure [3]. The MS monitors in permanence the BSs in the Diversity Set and defines only one BS, called an "Anchor BS", that is used for registration, synchronization, communication and controlling. This Anchor BS can be changed from a frame to another based on a BS selection scheme [7]. As all BSs in the Diversity Set are prepared to communicate with the MS, switching from a BS to another can be performed quickly.

C. Macro Diversity Handover (MDHO):

In MDHO, each MS communicates with all the BSs involved in the Diversity Set [8]. For downlink in MDHO, two or more BSs communicate with MS such that diversity combining can be performed by the MS. For uplink in MDHO, MS transmission is received by several BSs such that selection diversity of the received information can be performed. The BS that has not a strong signal level is classified as a "Neighbor BS", even it receives communication among MSs and BSs [7].

III. RELATED WORKS

In the literature, many researches designed to support multi-cell environment are described. Authors, in [16], aim to maximize the total system capacity. They use a dynamic inter-cell coordination in order to avoid or minimize dominant co-channel interferences using a dominant interferer group formed by a number of mutually interfering neighboring cells. In order to reduce computational complexity, authors in this paper assume that power is equally distributed among chunks, where each chunk consists of adjacent sub-carriers number.

Authors in [17] prove that the sub-carrier allocation process can be performed prior to power distribution process. They propose a resource allocation scheme in a sectored two-cell downlink OFDMA system aiming to maximize the total throughput impaired by multi-cell interferences. In this paper, power control is performed in each cell such that inter-cell interferences do not exceed a certain threshold in each sub-carrier. Considering two cells A and B, proposed resource allocation scheme is described as follows: (1) Allocate sub-channels in cell A and then in cell B. (2) Compute sub-carrier power limit in each sub-carrier for cell A and cell B based on sub-carrier allocation step. (3) Power allocation for cell A and then B such that inter-cell interference in each subcarrier does not exceed a predetermined threshold.

Researchers in [18] describe a heuristic method for distributed sum power minimization under target data rate requirements, known as Margin Adaptive (MA) optimization problem. In order to reduce computational complexity, sub-carrier allocation procedure and power allocation procedure are separately treated. Firstly, only users that have not yet reached their target throughput are assigned sub-carriers. Secondly, power is allocated to sub-carriers based on a defined SINR. An admission control step is introduced to control transmitted power where users with highest power in a cell are rejected, if the sum power exceeds a maximum power value $P_{\max}$. The same process is repeated until the sum power becomes less than $P_{\max}$. However, rejecting users with highest power values means that these users are close to their serving BS which may influence badly on the total system performances.

Authors in [14] analyze the problem of allocating power and sub-channels in a multi-cell downlink OFDMA cellular system by maximizing the cell rate subject to a power constraint in a full frequency reuse scenario. Authors propose in this paper, three heuristic methods which are: Water-Filling Allocation (WFA), Water-filling and Sub-carrier Removal Allocation (WSRA), and Uniform Power Allocation (UPA). On one hand, WFA scheme selects user with the highest SINR that is made by taking into account the interference level in the previous time interval introducing time dimension criterion. On the other hand, WSRA and UPA extend the previous algorithm, respectively, by allocating transmission power with water-filling principle and allocating transmitted power uniformly among sub-channels. Although, the heuristic based on the water-filling policy significantly outperforms the algorithm based on uniform power allocation, Water-filling procedure has a high computational complexity and needs an important processing time, which is not adequate for real-time applications.

In our work, we propose a new dynamic resource allocation scheme in a downlink multi-cell system. Our basic idea is to reserve a part of allocated radio resources for users in handover based on a HHO-threshold and then allocates reserved sub-channels based on their maximum SINR values.

IV. SIMULATED TOPOLOGY AND PROBLEM FORMULATION

We consider an OFDMA system for mobile wireless networks, based on IEEE 802.16 m standard. The system consists of two adjacent cells noted A and B symbolized by two BSs BS^A and BS^B transmitting data to K^A and K^B mobile stations that are randomly distributed, respectively, in cell A and cell B as it is depicted by Fig.1. N^i represents the number of sub-channels composed by a group of M^i adjacent sub-carriers in a single sub-channel with $N^i = L^i / M^i$ and L^i is the total number of sub-carriers, where $i \in \{A, B\}$.

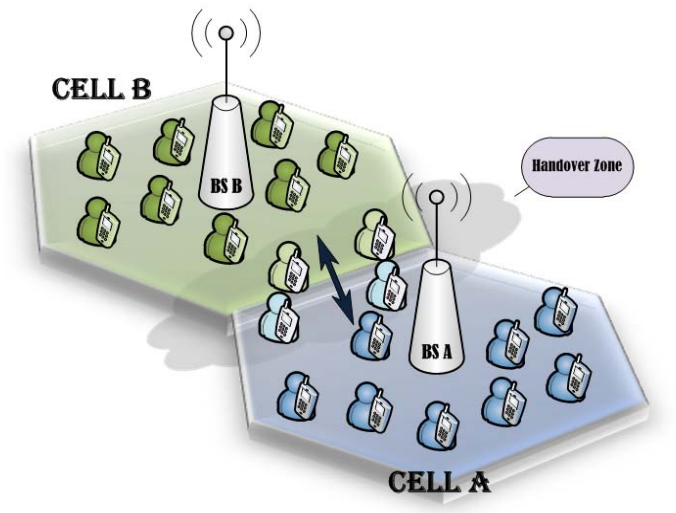

Figure 1. A Multi-cell System Model

Considering $G_{k,n}^{i}$ as the channel gain of the k^{th} user on n^{th} sub-channel in cell *i*, $i \in \{A, B\}$, it follows the complex Gaussian distribution and its magnitude, called fading factor, follows Rayleigh distribution [9]. $G_{k,n}^{i}$ is computed according to an efficient "sliding window" method, well described in [12].

The SINR of each user *k* in sub-channel *n* served by BS^{S} as [10]:

$$SINR_{k,n} = \frac{P_{k,n}^{S} G_{k,n}^{S}}{\sum_{i \neq S}^{N_{BS}} P_{k,n}^{i} G_{k,n}^{i} + N_0}. \quad (1)$$

where $P_{k,n}^{i}$ presents the power transmitted by its serving base station BS^{i} in sub-channel *n* of user *k*. N_0 presents the Additive White Gaussian Noise (AWGN) variance noise. As we assume a two-cell system, $N_{BS} = 2$. Each MS feeds back its Channel State Information (CSI), including the measured interference and the path gains to the MS's BS in each sub-channel as well as those to the adjacent cell. Receiving the CSI, the BSs perform sub-channels assignment and power allocation procedure. We assume that each sub-channel is allocated to one and only one user in each cell. The total capacity in cell *i* is given by [11]:

$$C^{i} = \sum_{t=1}^{T} \sum_{k=1}^{K^{i}} \sum_{n=1}^{N^{i}} \alpha_{k,n}^{i} \cdot M^{i} \cdot N_{AMC_{k,n}}^{i} \cdot N_{sym/SF}^{i}. \quad (2)$$

where $N_{AMC_{k,n}}^{i}$ represents the number of bits per symbol. It depends on the modulation type selected by BS^{i} to MS_k. T is the total simulation duration. M^{i} is the number of sub-carriers per sub-channel in cell *i*. In contiguous method, within IEEE 802.16 m standards, a sub-channel is a group of 18 adjacent subcarriers, which one or two sub-carriers are used to estimate channel. In this case study, we are assumed that all sub-carriers in each sub-channel use the same Adaptive Modulation and Coding (AMC) type. $N_{sym/SF}^{i}$ denotes the number of symbols per a sub-frame. $\alpha_{k,n}^{i}$ is equal to 1 if sub-channel *n* is allocated to user *k* in cell *i* and zero otherwise. The proof of (2) is well described in [11]. Having the target to maximize the system capacity, the optimization problem is formulated as follows:

Maximize

$$C_{sys} = \sum_{i \in \{A,B\}} \sum_{t=1}^{T} \sum_{k=1}^{K^{i}} \sum_{n=1}^{N^{i}} \alpha_{k,n}^{i} \cdot M^{i} \cdot N_{AMC_{k,n}}^{i} \cdot N_{sym/SF}^{i}. \quad (3)$$

Subject to

C1: $\alpha_{k,n}^{i} \in \{0,1\}, \forall k \in \Psi^{i}, \forall n \in \Gamma^{i}, \forall i \in \{A, B\}.$ (4)

C2: $\sum_{k=1}^{K^{i}} \alpha_{k,n}^{i} = 1, \forall n \in \Gamma^{i}, \forall i \in \{A, B\}.$ (5)

C3: $\sum_{n=1}^{N^{i}} \alpha_{k,n}^{i} \leq 1, \forall k \in \Psi^{i}, \forall i \in \{A, B\}.$ (6)

The constraints are denoted by C1, C2 and C3. The two constraints C1 and C2 are on sub-channels allocation to ensure that each sub-channel is assigned to only one user where Ψ^{i} and Γ^{i} denote respectively, the set of active users and sub-channels in cell A and B where $i \in \{A, B\}$. The constraint C3 denotes that one MS could have only one sub-channel in the same time.

V. PROPOSED RESOURCE MANAGEMENT ALGORITHM IN HO MECHANISM

A. *Mobility Model:*

We adopt a mobility model to show user's mobility in the network. Assuming that $X(t)$ and $Y(t)$ represent respectively the user location abscissa and the user location ordinate at a given time *t*, user mobility is modeled as follows: $X(t+1) = X(t) + v \cdot \Delta t \cdot \cos(\theta)$ and $Y(t+1) = Y(t) + v \cdot \Delta t \cdot \sin(\theta)$, where *v* is the user velocity, angle θ is randomly chosen in our simulation.

Fig.2 shows the path travelled by user 1 and user 2 in order to prove mobility users support. Let $(X_k, Y_k)_{t_i}$ represent crossing point coordinates for user *k* in time t_i. As $(X_k, Y_k)_{t_i} \neq (X_k, Y_k)_{t_{i+1}}$, it is obvious that user *k* is in mobility.

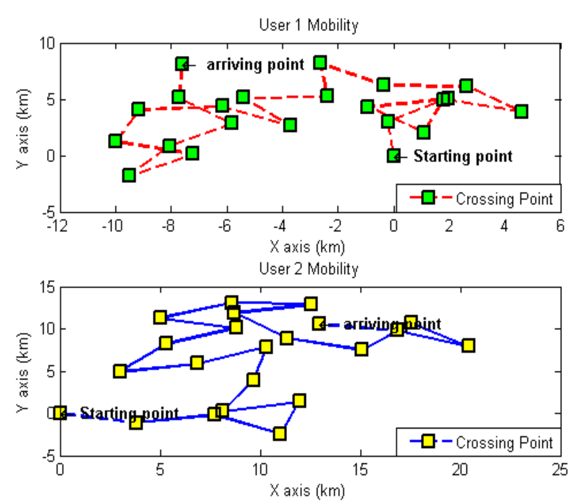

Figure 2. Paths travelled by user 1 and user 2

B. Proposed Sub-channels Allocation Scheme:

In this work, sub-channels allocation procedure performs in each BS independently, assuming that each cell has its own resources. In order to manage user's mobility, each BS reserves some sub-channels N^i_{HO} for a prospective handover with respect to a configurable HHO-threshold S^i_{th} where:

$$N^i_{HO} = N^i - N^i_u \leq S^i_{th}\ ,\ i \in \{A, B\}. \quad (7)$$

where N^i and N^i_u denote respectively the total sub-channels' number and the sub-channels' number to be allocated to regular users in the cell *i*. Our proposed sub-channels allocation scheme consists of three steps which are:

(i) Determine users in HHO based on their received power, distance between each MS and its serving BS and distance between each MS and its target BS as it is presented by the following pseudo code.

Pseudo Code 1: Handover Testing (*cell A→ cell B*)

for $k = 1$ **to** K^A **do**
 if $P_r(k) \leq P_{HO}$ and $d_{MS_k - BS^A} \geq d_{HO^A}$ and $d_{MS_k - BS^B} \leq d_{HO^B}$ **then**
  $\Psi^B_{HO} = \Psi^B_{HO} + \{k\}; \Psi^A = \Psi^A - \{k\}$
 end if
end for

Fig.3 shows users' number in HO versus total users' number in Cell A and Cell B. It is remarkable that the number of users in HO increases when the total number of users in the cell rises and then network access becomes more competitive, especially for users in HO, which is recovered by our proposed sub-channels reservation phase introduced in pseudo code 2.

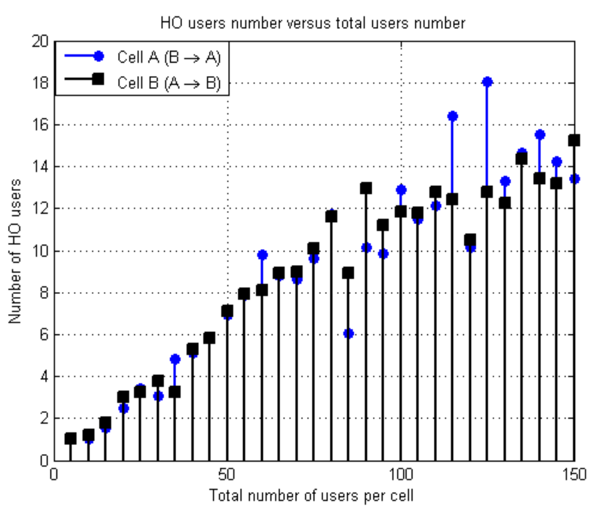

Figure 3. HO users' number versus total users' number

(ii) Allocate reserved sub-channels for users in handover based on their SINR values on each reserved sub-channel.

Pseudo Code 2: Sub-channels Allocation Scheme to HHO users (*cell A→ cell B*)

(i) Handover Users Ordering

for $k = 1$ **to** K^B_{HO} **do**
 Compute $SINR_{k,n}$ in each sub-channel in cell B.
end for
Order handover users in decreasing order according to $SINR_{k,n}$, $\forall k \in \{1,2,\ldots,K^A_{HO}\}$, $\forall n \in \{1,2,\ldots,N^B_{HO}\}$.

(ii) Reserved Sub-channels Allocation

for $k = 1$ **to** K^B_{HO} **where** $order(k) \leq order(k+1)$ **do**
 $n \leftarrow$ find sub-channel n where user k has its best SINR.
 Step (1):
  if (uniqueorder=1) **then**
   Sub-step(1.a):
    if $\alpha^B_{1 \to K^B_{HO}, n} = 0$ **then**
     $\alpha^B_{k,n} \leftarrow 1$; $\Gamma^B_{HO} \leftarrow \Gamma^B_{HO} - \{n\}$; Update data rate R^B_k
    end if
   Sub-step(1.b):
    if $\alpha^B_{1 \to K^B_{HO}, n} = 1$ **then**
     repeat $j = j + 1$;
     until ($\alpha^B_{1 \to K^B_{HO}, n} = 0$) or ($SINR_{k,j} < SINR_{k^*,j}$)
     Jump to *Sub-step(1.a);*
    end if
 Step (2):
  if (uniqueorder=0) **then**
   Sub-step(2.a):
    if (uniquesubchannel=0) **then**
     Jump to *Sub-step(1.a)* or *Sub-step(1.b)*
    end if
   Sub-step(2.b):
    if (uniquesubchannel=1) **then**
     if $\alpha^B_{1 \to K^B_{HO}, n} = 0$ **then**
      $\hat{k} \leftarrow$ find the user with the minimum best SINR ;
      Jump to Sub-step (1:a)
     end if
     if $\alpha^B_{1 \to K^B_{HO}, n} = 1$ **then**
      $\hat{k} \leftarrow$ find user with the minimum second best sub-channel;
      Jump to Sub-step (1:b)
     end if
    end if
  end if
end for

(iii) Allocate remaining sub-channels for users moving in the same cell based on channel gain of each mobile user on each sub-channel. In this step the same pseudo code described above is used, however in this case, regular users are putted in order according to the computed channel gain of each MS on each sub-channel. The same algorithm proposed in [11] is adopted in this step.

C. Computational Complexity:

Let's recall that K^i_{HO} refers to HO users' number and N^i_{HO} is the reserved sub-channels' number for users in HO. The HO users' ordering step sorts sub-channels in descending order for each user depending on their SINR values. The sorting process requires $(N^i_{HO}\log_2(N^i_{HO}))$ operations for each user. Sorting sub-channels in decreasing order for K^i_{HO} users requires then $K^i_{HO}\cdot(N^i_{HO}\log_2(N^i_{HO}))$. The same process is applied for regular users, where N^i_u and K^i_u denote, respectively, the number of sub-channels reserved to regular users and the number of regular users in Cell *i*. Our proposed sub-channels allocation scheme to regular users depending on sub-channels gain requires $K^i_u\cdot(N^i_u\log_2(N^i_u))$ .Thus, the asymptotic complexity is equal to $O(K^i_{HO}\cdot(N^i_{HO}\log_2(N^i_{HO})+K^i_u\cdot(N^i_u\log_2(N^i_u))$.

VI. SIMULATION RESULTS

In this section, we present simulation results in order to show the performances of our proposed radio resource allocation scheme using IEEE 802.16m standard parameters as it is depicted by Table I. Our adopted system consists of two neighboring cells *A* and *B* where each cell has a radius $D = 5.1\,\text{Km}$, considering an urban environment. The distance between a mobile user and its serving BS, noted d_{MS-BS_i} , $i\in\{A,B\}$ is randomly defined and updated dynamically depending on a defined mobility model and user velocity $v = 50km/h$. Our reserved sub-channels for users in handover is equal to $N^i_{HO} = \gamma.N^i \le S_{th}$, where γ is defined and dynamically updated depending on the loaded system traffic and HHO-threshold S_{th} is fixed to 12 sub-channels in each cell. We assume that the total power of each BS is equal to 20 watts as it is described in [13].

Table I. OFDMA Parameters for IEEE 802.16m

Parameter	*Symbol*	*Value*
Sub-carriers' number	L^i	1024
Sub-channels' number	N^i	48
Sub-carriers number per sub-channel	M^i	18
Sub-carrier spacing (KHz)	Δf	7.813
Sub-frame delay (μs)		714.286

The performances of our proposed sub-channels allocation scheme in a multi-cell system are compared to two recent methods [14] and [15].On one hand, authors in [14] allocate resources by assigning each sub-channel to the user with the highest SINR on that sub-channel and distributing the power uniformly among sub-channels aiming to maximize of the total achieved data rate. On the other hand, authors in [15] implement Proportional Fair scheduler (PF), which means that each MS has proportional data rate. They enable the MS having bad channel condition to have more sub-channels so as to have similar data rate as those having good channel conditions, in order to maximize the total system capacity.

A. Total System Capacity:

The spectral efficiency is computed based on (2). In Fig.4, the total spectral efficiency under our proposed scheme, MSINR [14] and PF [15] in cell *A* and *B* is investigated.

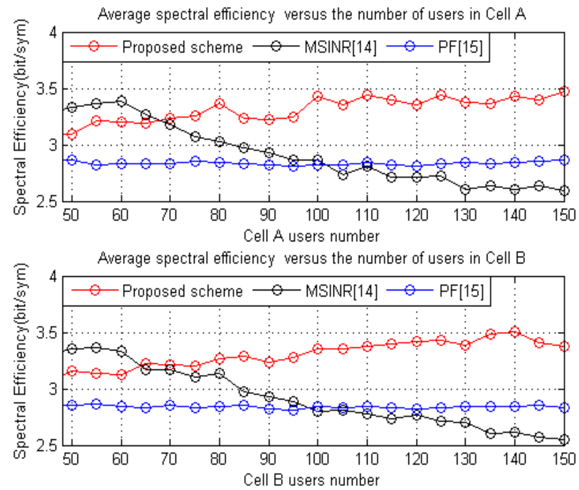

Figure 4. Average spectral efficiency versus users' number

Table II shows variation intervals in terms of total spectral efficiency in bits/symbol (b/s). Let SE_{PSINR_i} and SE_{PPF_i} denote the average total Spectral Efficiency in different variation users' intervals, $i\in\{A,B\}$. These values are computed based on, respectively, the mean difference between our proposed scheme and MSINR method and the mean difference between our contribution and PF method in cell A and cell B.

Table II. Variation Intervals in Terms of Spectral Efficiency

	[48,70[	*[70,100[*	*[100,125[*	*[125,150[*
SE_{PSINR_A} (b/s)	-0.068	0.366	0.655	0.792
SE_{PPF_A} (b/s)	0.357	0.468	0.568	0.562
SE_{PSINR_B} (b/s)	-0.071	0.339	0.637	0.823
SE_{PPF_B} (b/s)	0.33	0.449	0.561	0.585

As $SE_{PSINR_i} > 0$, when the number of users is greater than 70, it is obvious that the proposed method provides greater spectral efficiency than MSINR method [14], because our radio resource allocation scheme deals better with the loaded system case as it described by pseudo code 2. Moreover, the difference between our proposed method and existing methods increases when the number of users rises, proving that our contribution operates well with multi-users diversity and our sub-channels reservation phase is more efficient when the number of mobile users is important, approaching the practical case. However, when the number of users is lower than 70, MSINR method [14] provides better performance in terms of total spectral efficiency due to the sub-channels reservation phase that reserves some sub-channels to be allocated for users in HHO, so the number of available sub-channels reduces. Hence, our proposed scheme performs better in a loaded system, which generally reflects the practical case.

B. Dropped users Ratio:

Fig.5 shows the average dropped users' percentage versus the number of users where the dropped users' percentage represents the rejected HHO users' percentage. When a mobile user does not get its required sub-channel in the target cell, the number of rejected user increases. Then, the average dropped users percentage is the ratio of the number of dropped users and the total number of active users in the cell.

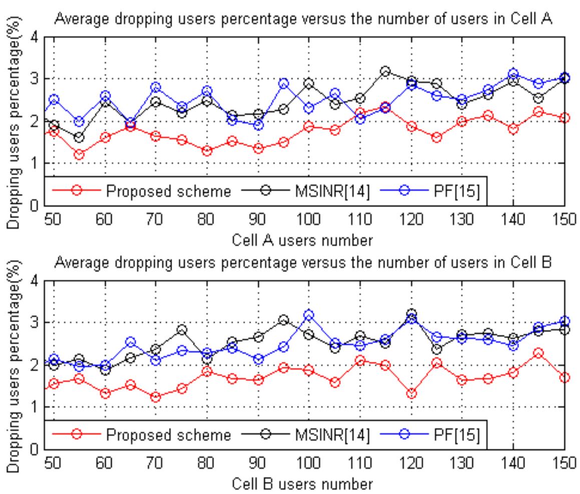

Figure 5. Average dropped HO users' percentage versus total users' number

Table III shows variation intervals in terms of mean dropped users' percentage in (%). Let DP_{PSINR_i} and DP_{PPF_i} denote the Dropped users Percentage for different users variation intervals based on, respectively, the mean difference between our proposed scheme and MSINR method [14] and the mean difference between our proposed scheme and PF method [15] in cell A and cell B.

Table III. Variation Intervals in Terms of Dropped Users Percentage

	[48,75[	*[75,100[*	*[100,125[*	*[125,150[*
DP_{PSINR_A} (%)	-0.489	-0.886	-0.824	-0.662
DP_{PPF_A} (%)	-0.754	-0.856	-0.529	-0.813
DP_{PSINR_B} (%)	-0.771	-0.836	-0.819	-0.919
DP_{PPF_B} (%)	-0.721	-0.695	-0.843	-0.895

As $DP_{PSINR_i} < 0$ and $DP_{PPF_i} < 0$, $i \in \{A, B\}$, for all intervals, it is obvious that our proposed scheme provides lower dropped users percentage than other existing methods [14,15], because with the proposed scheme, we reserve radio resources to be allocated for incoming HO calls which can limit dropped connections. Although, with existing methods incoming HO calls may be rejected due to insufficient resources to be allocated for users in HO.

C. Latency Time:

Fig.6 shows the average Latency Time (LT) versus the number of users where the latency time is the difference between the connection establishment moment $T_{HO_{ESTAB}}$ and the connection clipping moment $T_{HO_{CLIP}}$, meaning $LT = T_{HO_{ESTAB}} - T_{HO_{CLIP}}$. It is outstanding that the latency time increases exponentially in existing methods [14,15] when the number of users rises, while it is quite steady in our contribution.

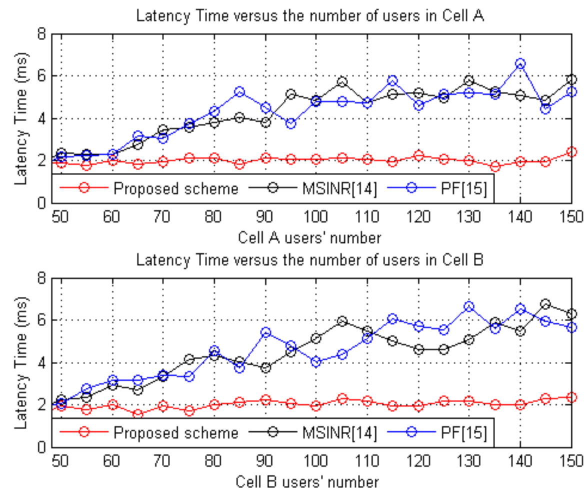

Figure 6. Latency Time versus the total users' number

Table IV shows variation intervals in terms of latency time in (*ms*). Let LT_{PSINR_i} and LT_{PPF_i} denote the Latency Time for different users variation intervals. These values are computed based on, respectively, the mean difference between proposed scheme and MSINR method [14] and the mean difference between proposed scheme and PF method [15] in Cell i.

Table IV. Variation Intervals in terms of Latency Time

	[48,75[	*[75,100[*	*[100,125[*	*[125,150[*
LT_{PSINR_A} (ms)	-0.838	-2.283	-3.050	-3.364
LT_{PPF_A} (ms)	-0.825	-2.479	-2.915	-3.314
LT_{PSINR_B} (ms)	-1.134	-2.273	-3.029	-3.721
LT_{PPF_B} (ms)	-1.151	-2.431	-3.256	-3.886

As and $LT_{PSINR_i} < 0$ and $LT_{PPF_i} < 0$, for all intervals, it is obvious that the proposed scheme requires lower latency time than other existing methods [14,15]. Moreover, the differences between the proposed method and existing methods increase when the number of HO users rises, proving that our contribution operates well with multi-users diversity. When making the connection with the target BS, a set of sub-channels are ready to be allocated to users in HO, due to our reservation phase, which accelerates the BSs switching procedure, and then reduces the latency time.

Simulation results illustrate that our contribution provides better performances than existing methods in terms of total system capacity, latency time and dropped users percentage, because our proposed scheme includes a reservation resource phase, that reserves resources to be allocated for users in hard handover. Moreover, our resource allocation algorithm treats the case of a loaded system, when the number of users is much important than the number of available resources, leading to better performances when the users number rises.

VII. CONCLUSION

This paper has considered the problem of resource allocation for mobile users in a two-cell system context. The main objective in this work is to resolve the problem of sub-channels assignment to users either moving from a cell to another or moving in the same cell, in order to take into account our radio resources use maximization objective. In this context, we proposed a new dynamic radio resource allocation scheme for IEEE 802.16m standard.

After handover tripping test based on received power, distance separating mobile from its serving BS and the handover target BS, our proposed algorithm reserves a part of sub-channels to users in handover and then allocates radio resource based on statistic indicators and HHO-threshold.

Our proposed resource allocation procedure was evaluated and compared to other existing methods, by using IEEE 802.16m standard parameters. Simulation results demonstrate that our proposed scheme satisfies a greater number of users in handover, requires a lower latency time and provides an efficient use of the available bandwidth. As future works, we propose to extend the present contribution from single service to multi-services with Quality of Service (QoS) support configuration.

VIII. REFERENCES

[1]. C.C. Lin, K. Sandrasegaran, H. A. M. Ramli, and R. Basukala. Optimized performance evaluation of lte hard handover algorithm with average rsrp constraint. International Journal of Wireless and Mobile Networks (IJWMN), 3(2):pp. 9–19, April 2011.

[2]. Md. I. Anwar, A. Khosla, and N. Sood. A Mobility Improvement Handover Scheme for Mobile-WiMAX. International Journal of Computer Applications, 11(3):pp.28–31, December 2010.

[3]. IEEE802.16-2005, part 16: Air interface for fixed and mobile broadband wireless access systems. IEEE standard for local and metropolitan area networks, February 2006.

[4]. W. Lihua, M. Wenchao, and G. Zihua. A Cross-layer Packet Scheduling and Subchannel Allocation Scheme in 802.16e OFDMA System. Wireless Communications and Networking Conference (WCNC), pp.1867–1872, June 2007.

[5]. Mustafa Ergen. “Mobile Broadband Including WIMAX and LTE”, volume 515. Springer, 2009.

[6]. Z. Becvar and J. Zelenka. Implementation of handover delay timer into WiMAX. 6th Conference on Telecommunication (2007), pp.1–4, Portugal 2007.

[7]. Z. Becvar, J. Zelenka, and R. Bestak. Comparison of Handovers in UMTS and WiMAX. Czech Technical University, pp.1–4, April 2006.

[8]. W. Jiao, P. Jiang, and Y. Ma. Fast Handover Scheme for Real-Time Applications in Mobile WiMAX. IEEE International Conference on Communications (ICC) 2007, pp. 6038 – 6042, June 2007.

[9]. Zhu. Huiling and J. Wang. Wireless communications and networking conference (wcnc), 2010 ieee. Wireless Communications and Networking Conference (WCNC), 2010 IEEE, pp.1–6, April 2010.

[10]. M. Pischella and J.C. Belfiore. Distributed Resource Allocation for Rate-Constrained users in Multi-Cell OFDMA Networks. IEEE Communications Letters, 12(4):pp.250–252, April 2008.

[11]. F. Khelifa, W. Ben Hassen, M. Afif, and A. Samet. Adaptive resource allocation scheme using sliding window sub-channel gain computation: Context of OFDMA wireless mobiles systems . Conference on Systems, Signals and Devices (SSD) 2011, pp.1–6, May 2011.

[12]. W. Ben Hassen, M. Afif, F. Khelifa, A. Samet. A sliding window method for subchannels gain computation in OFDMA wireless systems: Context IEEE 802.16m. International Conference on Communications, Computing and Control Applications (CCCA) 2011, pp. 1 – 6, March 2011.

[13]. M. K. Karray. Spectral and energy efficiencies of ofdma wireless cellular networks. In Proc. of IFIP Wireless Days, Venice, Italy,October 2010.

[14]. M. Moretti, A. Todini, and A. Baiocchi. Distributed radio resource allocation for the downlink of multi-cell OFDMA radio systems. The 22nd International Teletraffic Congress (ITC), 2010. pp.1-7, October 2010.

[15]. W. Fu, Z. Tao, J. Zhang and D. P. Agrawal. Clustering Based Fractional Frequency Reuse and Fair Resource Allocation in Multi-Cell Networks. The Internationa IEEE Conference on Communications (ICC). pp.1-7, July 2010.

[16]. R. Mahmudur and H. Yanikomeroglu. Multicell Downlink OFDM Subchannel Allocations Using Dynamic Intercell Coordination. IEEE Global Communication Conference (GLOBECOM), pp. 5220–5225, March 2007.

[17]. S.M.H Andargoli and K. Mohamed. Distributed Resource Allocation for Downlink Multicell OFDMA Systems. Proceedings of the International Multi-Conference of Engineers and Computer Sciences (IMECS), 1: pp.5220–5225, March 2011.

[18]. M. Pischella and J.C. Belfiore. Distributed Resource Allocation for Rate-Constrained users in Multi-Cell OFDMA Networks. IEEE Communications Letters, 12(4):pp.250– 252, April 2008.

