Bandwidth partitioning for mobile WiMAX service provisioning

Sondes Khemiri*, Khaled Boussetta† and Nadjib Achir†
*LIP6 – University Paris 6
104, avenue du president Kennedy, 75016 Paris, France
Email: firstname.lastname@lip6.fr
†L2TI – Institut Galilée – University Paris 13
99 Avenue J-B Clément, 93430 Villetaneuse, France
Email: firstname.lastname@l2ti.univ-paris13.fr

***Abstract*—This paper addresses the issue of wireless bandwidth partitioning of a Mobile WiMAX cell. We consider a Complete Partitioning strategy, where the wireless bandwidth capacity of a cell is divided into trunks. Each partition is strictly reserved to a particular type of connection. Precisely, we distinguish four IEEE 802.16e 2005 service classes: UGS, rtPS, nrtPS and ErtPS. As we consider mobility, we also differentiate new call request from handoff ones. In addition, we take into consideration the Adaptive Modulation and Coding (AMC) scheme, through the partition of the cell into different areas associated to a particular modulation and coding scheme. The purpose of the paper is to determine, using an analytical model and a heuristic approach, the nearly-optimal sizes of the partition sizes dedicated to each type of connection, which is characterized by 1) its service class, 2) type of request and 3) modulation and coding scheme. The main concern here is to propose simple and robust computational methods, which can be easily and efficiently used to dimension a Mobile WiMAX network.**

I. Introduction

Up to present, investigations on bandwidth allocation strategies for IEEE802.16e is still a pilot work. To the best of our knowledge, most of the existing works have focused on the proposal of bandwidth allocation and CAC policies for the fixed WiMAX technology [3], [4], [6], [8].

In [8], the proposed bandwidth allocation strategy is based on the sharing with Upper Limits strategy [2]. The latter one belongs to the coordinate convex CAC policies. Consequently, performances parameters could be computed analytically. Nevertheless, in [8], only the maximum number of bandwidth units which can be allocated to aggregated UGS traffics was considered. nrtPS and rtPS calls are in competition for the remaining radio resources, without any protection mechanism. In addition, the methodology to determine the value of the optimal UGS bandwidth threshold was not discussed in the paper.

In [3], a hierarchical Trunk Reservation CAC strategy has been considered. This strategy is known to be a nearly optimal CAC policy. However, performance metrics requires the numerical resolution of a Markov chain of four state space dimension. Such computational method is not suitable for a realistic WiMAX dimensioning case study, since numerical difficulties may rise due to the resulting huge state space dimension. In addition, computing the optimal trunk reservation thresholds for hierarchical Trunk Reservation policy is not easy, and it was not investigated in the paper.

In [6], the authors presented a joint bandwidth allocation and CAC policy for radio resource management in IEEE 802.16-based multiservice Broadband Wireless Access (BWA) networks. The aim of the proposal is to guarantee both the packet-level and the connection-level QoS requirements for different types of services while maximizing the system utility. In this work the total available bandwidth is shared among the different types of services using a Complete Partitioning approach. The authors developed an interesting mathematical model, which takes into account the specificities of the IEEE 802.16 technology. Different sophisticated aspects, like Adaptive Modulation and Coding (AMC) were considered in the model. From their mathematical modeling, they formulated the optimization problem that needs to be solved in order to obtain the optimal partition sizes, but unfortunately without providing a particular resolution methodology. Partition sizes values were considered in the performance evaluation section, but without further justifications.

In [4], we have investigated the computational of the optimal CAC policy for an IEEE 802.16 Wireless MAN, which satisfies the following two objectives: (i) statistically guarantee the QoS of the various scheduling services, (ii) maximize the average gain of the wireless link. To find such optimal policy, we have modeled our CAC agent as a Constrained Semi-Markov Decision Processes (CSMDP). We also have proposed an alternative iterative algorithm that can be used to overcome the difficulties faced when resolving the CSMDP. Although, our method is more robust than the classical approach (Linear Programming) to state space dimension problem, numerical problems could not totally be avoided for large state spaces, like those observed in realistic dimensioning case studies. Consequently, in [5] we considered the Guaranteed Minimum bandwidth sharing strategy. The latter belongs also to the coordinate convex CAC policies, which means that the average performances of the system could be obtained analytically. Our main contribution in [5] was the proposal of a heuristic method, based on Tabu search approach, to find the optimal bandwidth reservation thresholds. The present paper differs from [5] by the fact that we consider mobile WiMAX instead

978-1-4244-2829-8/08/$25.00 ©2008 IEEE

of fixed WiMAX technology. We also consider here Complete partitioning rather than Guaranteed Minimum bandwidth sharing strategy. Finally, we integrate here Adaptive Modulation and Coding (AMC) scheme into our problem formulation.

All these works were done assuming fixed WiMAX. As far as we know, little works on bandwidth allocation have concentrated on the mobile WiMAX version (IEEE 802.16e Standard). A notable work is [7], where an adjustable Quadra Threshold Bandwidth Reservation scheme (QTBR) based on trunk reservation (TR) policy and a QoS aware bandwidth allocation algorithm (QoSABAA) for mobile WiMAX networks was proposed. In this proposal, classes may use resources in a system until the remained unused resource is equal to a certain threshold. The main objective of the work was to maximize the radio efficiency (utilization ratio). But, as in previously mentioned works, the authors have not proposed a methodology to set the bandwidth reservation thresholds. Moreover, contrarily to our work, ErtPS class service was not integrated in the study.

In this paper, we focus on Complete Partitioning as a wireless bandwidth allocation strategy for a mobile WiMAX network. The purpose of the paper is to determine, using an analytical model and a heuristic approach, the nearly-optimal sizes of the partition sizes which are dedicated to each type of connection in a aim to fulfill two objectives: (i) statistically guarantee that the connection blocking probabilities remains under a given threshold, (ii) maximize the average gain of the wireless link. As BE service does not requires any QoS guarantees, we distinguish in our model four IEEE 802.16e 2005 service classes: UGS, rtPS, nrtPS and ErtPS. We also differentiate new call request from handoff ones and we integrate in the system model the Adaptive Modulation and Coding (AMC) scheme.

The rest of this paper is organized as follows: in the next section we formulate our problem. The bandwidth sharing strategy is discussed in section III. Our algorithm to determine the partition sizes is detailed in section IV. The performance evaluation results are presented in section V. Finally, section VI summarizes the contributions of this work.

II. Problem statement

A. System Modeling

1) System description: We consider a network relying on IEEE 802.16e 2005 technology with WirelessMAN OFDMA physical layer. The system provides a quadruple-play service to multiple mobile subscribers (MSS), which can have access anytime and anywhere to various application types, like file downloading, video streaming, emails and VoIP. In order to guarantee the quality of service required by these applications, the service provider has to distinguish four service classes. Namely: UGS for VoIP, rtPS for video streaming, nrtPS for file downloading and ErtPS for voice without silence suppression. For notation simplicity, we will refer to UGS, rtPS, nrtPS and ErtPS as a class 1, 2, 3 and 4, respectively. Let $T = \{1, 2, 3, 4\}$.

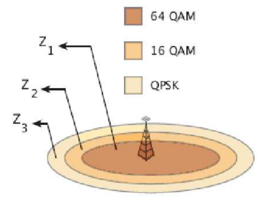

Fig. 1. System Description

In order to adapt the transmission rate according to the channel quality we consider that the system supports an Adaptive Modulation and Coding (AMC) scheme. Precisely, we assume that the cell is divided into Z areas where a same modulation and coding scheme is used for all calls ongoing in a specific area. Without loss of generality, we assume that $Z = \{1, 2, 3\}$ and that the areas border shape are concentric perfect circles. Figure 1 illustrates the system, with a typical example of modulation schemes associated to each area.

In this study, we consider that the bandwidth is a crucial resource that has to be shared and that the wireless link is the main bottleneck. The total offered bandwidth capacity of the cell S is supposed to be a fixed number of bandwidth units, which we note C. We assume that the bandwidth allocation is Granted Per Connection (GPC). Thus, for each MSS an amount of bandwidth units is assigned to each established connection. Precisely, any class $j \in T$ connection request associated to an MSS located in an area $i \in Z$ will be assigned a given number of bandwidth units, noted s_{ij}. This assigned capacity has to be carefully chosen so that the connection could be established and maintained with satisfied QoS requirements in the downlink and uplink directions.

As rtPS, nrtPS and ErtPS connections generate variable bit rate traffic, then the allocated bandwidth capacity could be variable over the time. Nevertheless, in order to guarantee the QoS, a minimum capacity is required to accept any corresponding request. For any class $j \in T$ request arriving in an area $i \in Z$ we note $\underline{s}_{ij}$ the associated minimum required bandwidth units. Similarly, we assume that a given maximum bandwidth capacity is sufficient to fulfill the QoS constraints of the supported classes. Therefore, any class $j \in T$ request arriving in an area $i \in Z$ will be assigned at maximum $\overline{s}_{ij}$ bandwidth units. So, formally, $\forall i \in Z$ and $\forall j \in T$ we have $s_{ij} \in [\underline{s}_{ij}, \overline{s}_{ij}]$. Here, it is worth to note that since UGS connections generate constant bit rate traffic then $s_{i1} = \underline{s}_{i1} = \overline{s}_{i1}$.

2) Traffic model and system parameters: Since an IEEE 802.16e 2005 cell's coverage can reach a diameter of several kilometers, we could reasonably assume an infinite population traffic model. Precisely, class $j \in T$ connection requests arrive to the each area $i \in Z$ according to a Poisson process with a rate λ_{ij}^{nc}. Any class $j \in T$ request in the cell S could be rejected if its acceptance violates the QoS guarantee of ongoing connections or if the system does not have enough resources. Otherwise, it is accepted and generates a revenue

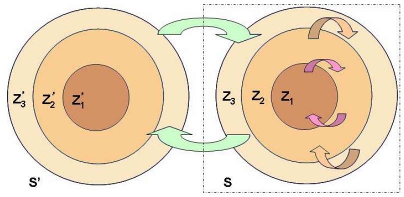

Fig. 2. Possible transition between zones

[1] at a rate R_j during the connection holding time, which is supposed to be exponentially distributed with mean $[\mu_j^h]^{-1}$.

3) Mobility: As the considered technology supports mobility, we will distinguish between two type of connection requests: (1) new calls (nc) entering to the system, and (2) handoff (ho) demands associated to ongoing connections of MSS moving from an area $i \in Z$ to another adjacent area $l \in Z$ or from a cell to a neighbor one. Precisely, we assume that the sojourn duration of an MSS in an area $i \in Z$ is exponentially distributed with mean $[\mu_i^s]^{-1}$. A connection of class $j \in T$ can leave an area $i \in Z$ if (1) the call is terminated or (2) if the MSS moves to an adjacent area (i.e handoff). Hence, the duration time of a class $j \in T$ connection in an area $i \in Z$ is exponentially distributed with mean $[\mu_{ij}]^{-1}$, where $\mu_{ij} = \mu_i^s + \mu_j^h$.

Let λ_{ij}^{ho} and Λ_{ij}^{ho} be respectively, the arrival and the departure handoff rates associated to traffic class $j \in T$ in the area $i \in Z$. As illustrated in figure 2, there is a dependency between these rates and the different areas. Precisely, in one hand, the arrival rate in a given area is dependent on the departure rate from neighbors areas. Formally, we have,

$$\lambda_{ij}^{ho} = \sum_{l \in V(i)} \Lambda_{lj}^{ho}.t_{li} \quad (1)$$

where, $V(i)$ is the set of neighbor areas to $i \in Z$ and t_{li} is the transition probability from the area $i \in Z$ to the neighbor area $l \in V(i)$. Transition possibilities between areas are illustrated in figure 2. One can see that Z_2 is the only neighbor to Z_1, while the neighbors of Z_3 are Z_2 and the Z_3 areas of adjacent cells.

On the other hand, the departure handoff rate for class $j \in T$ connections from an area $i \in Z$ can be computed as follow:

$$\Lambda_{ij}^{ho} = \frac{\mu_i^s}{\mu_{ij}}(\lambda_{ij}^{nc}\left(1 - B_{ij}^{nc}\right) + \lambda_{ij}^{ho}\left(1 - B_{ij}^{ho}\right)) \quad (2)$$

were B_{ij}^{nc} and B_{ij}^{ho} are respectively, the nc and ho blocking probabilities of class $j \in T$ calls in the area $i \in Z$.

B. Problem formulation

Following this system modeling, we consider that the packet-level's QoS parameters (loss rates, delays, jitters etc.) of a class j connection are statistically guaranteed in the wireless link part of the WiMAX network as long as the allocated bandwidth s_{ij} remains in the $\left[\underline{s}_{ij}, \overline{s}_{ij}\right]$. We can then focus on the connection-level's QoS parameters, namely the connection blocking probability. Formally, we would like to find the optimal CAC policy solution, noted π^*, to the following optimization problem:

Problem 1 Optimal CAC problem

`maximize`	R
`subject to`	$B_{ij}^{nc} \leq \beta_j^{nc}, \forall i \in Z \, \forall j \in T$
	$B_{ij}^{ho} \leq \beta_j^{ho}, \forall i \in Z \, \forall j \in T$

where

- R is the average revenue of the cell. Formally,

$$R = \sum_{j \in T} R_j \sum_{i \in Z} \frac{\lambda_{ij}^{nc}}{\mu_{ij}}\left(1 - B_{ij}^{nc}\right) + \frac{\lambda_{ij}^{ho}}{\mu_{ij}}\left(1 - B_{ij}^{ho}\right) \quad (3)$$

- $\forall j \in T$, β_j^{nc} and β_j^{ho} are the given nc and ho tolerated blocking thresholds, respectively.

III. Bandwidth Partitioning

A. Bandwidth Sharing Scheme

In realistic case studies, the value of the thresholds β_j^{nc} and β_j^{ho} are usually set by the network operator to very low values. Typically, in the magnitude of 10^{-3} and 10^{-4}, respectively. Therefore, any CAC policy π which can satisfy the constraints of the problem 1 will generates an average revenue which will be very close to the one obtained by the optimal CAC policy π^*. Hence, in this paper we do not seek to find π^*, but rather a simple and computational CAC policy which satisfy the constraints of the problem 1.

Among the CAC policies which can be considered, we choose to focus on the *coordinate convex* category. This choice is motivated by the fact that the steady states probabilities of the resulting system have closed form expression. This is very suitable since the blocking probabilities can be derived analytically, avoiding by this way the difficulties raised by numerical computations.

There are several policies which belong to the *coordinate convex* category. In this paper, we choose the Complete Partitioning (PC) strategy, which is know to has the capacity to guarantee the QoS constraints of each traffic class. This is simply achieved by allocating a specific bandwidth partition to the exclusive use of each traffic class.

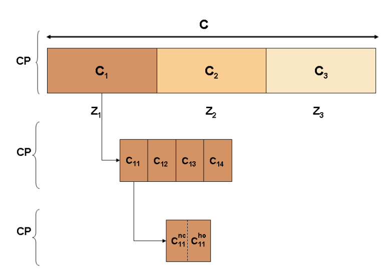

Fig. 3. Bandwidth Sharing Scheme

[1]For instance, the revenue rate could correspond to the amount of money per second earned by the system for carrying this call.

The application of CP for our case study is illustrated in figure 3. The capacity C is divided into 3 partitions. Each partition C_i is assigned to the calls associated to the area Z_i. This capacity is also partitioned into 4 trunks of capacity C_{ij} ($i \in Z$ and $j \in T$), each one being reserved to the traffic class j. Finally, each partition C_{ij} is splitted into two trunks, noted C_{ij}^{nc} and C_{ij}^{ho}, allocated respectively to nc and ho class j connections in area i.

B. Optimal partitions size problem

Assuming the CP strategy, each partition C_{ij}^k, $(i,j,k) \in Z \times T \times \{nc, ho\}$ can be modeled as an Erlang B queue model. Therefore, the call blocking probabilities can be analytically expressed as:

$$B_{ij}^k = \frac{1}{G_{ij}^k} \frac{(\frac{\lambda_{ij}^k}{\mu_{ij}})^{\lfloor \frac{C_{ij}^k}{\underline{s}_{ij}} \rfloor}}{\lfloor \frac{C_{ij}^k}{\underline{s}_{ij}} \rfloor !} \tag{4}$$

where the normalization constant $G_{ij}^k = \sum_{n=0}^{\lfloor \frac{C_{ij}^k}{\underline{s}_{ij}} \rfloor} \frac{(\frac{\lambda_{ij}^k}{\mu_{ij}})^n}{n!}$.

Equation 4 shows clearly that the call blocking probabilities are dependant on the partition sizes. Thus, problem 1 can be associated to a dual problem, where the aim is to find the optimal partitions reservation vector $\overrightarrow{C^*} = (C_{ij}^k; (i,j,k) \in Z \times T \times \{nc, ho\})$, solution to the following optimization problem:

Problem 2 Optimal partitions size problem

$$\begin{array}{ll} \texttt{maximize} & R \\ \texttt{subject to} & B_{ij}^{nc} \leq \beta_j^{nc}, \forall i \in Z \forall j \in T \\ & B_{ij}^{ho} \leq \beta_j^{ho}, \forall i \in Z \forall j \in T \\ & \sum_{i \in Z} \sum_{j \in T} C_{ij}^{nc} + C_{ij}^{ho} \leq C \end{array}$$

Finding $\overrightarrow{C^*}$ is not a trivial task. Especially, when the dimension of the solutions space is large. The latter is dependant on C. In our case study, the dimension of the reservation vector is 24 and in realistic WiMAX systems the capacity C is quite large (e.g. 2000 bandwidth units). To the best of our knowledge, and as indicated in the introduction section, few works have focused on this problem or proposed a scalable solution to determine the partitions size. In the next section we detail our proposal to derive a nearly-optimal reservation vector.

IV. Incremental Partitions Size Algorithm

Our Incremental Partitions Size Algorithm is executed following two steps. In the first step, the objective is to find a vector $\overrightarrow{C^0}$ which can satisfy the blocking probabilities constraints, but without necessarily ensuring that the vector capacity is equal to C. In other words, we seek to determine the smallest partition sizes required to satisfy the constraints of problem 1.

Finding the smallest required partition sizes for nc calls is trivial using equation 4. One can simply increment the capacity C_{ij}^{nc} ($\forall i \in Z$ and $\forall j \in T$) until that the resulting nc blocking probabilities, given by equation 4 are below the thresholds β_i^{ho}. This algorithm can also be used for the case of ho calls. However, for the latter case, the difficulty is that the handoff arrival rates λ_{ij}^{ho} $\forall i \in Z$ and $\forall j \in T$ are not initially known. Indeed, as indicated in equations 1, 2 and 4, the handoff rates, the blocking probabilities and the partition sizes are related.

We propose to solve this dependency problem, using a fixed point algorithm. Precisely, after having obtained the smallest required partition sizes for nc calls, we derive an initial estimation of the departure rates using equation 2 and assuming that $\lambda_{ij}^{ho} = 0$ $\forall i \in Z$ and $\forall j \in T$. Then, λ_{ij}^{ho} are updated using equation 1. The resulting values are then injected in equation 4, which serves to find the smallest required partition sizes for ho calls. These three-steps are repeated, considering the recent values of λ_{ij}^{ho} until that each handoff blocking probability B_{ij}^{ho}, $\forall i \in Z$ and $\forall j \in T$, converges toward a stable value.

If the total capacity of the smallest required partition sizes is above C, then we consider that the problem 2 is infeasible for C and with our algorithm. Else, if the total capacity of the partitions reservation vector obtained in this first step is equal to C, then it's considered as our solution to the problem 2. Otherwise, we proceed with the execution of the second step of our algorithm.

Since the blocking constraints are satisfied, the objective is now to share the remaining capacity, noted C_r, among the partitions so that the average revenue of the system is maximized.

According to equation 3 and given that our sharing policy is based on Complet Partitioning, maximizing the revenue R leads to maximize the quantities $R_j \frac{\lambda_{ij}^k}{\mu_{ij}} \left(1 - B_{ij}^k\right)$, $\forall k \in \{nc, ho\}$, $\forall i \in Z$ and $\forall j \in T$. Thus, the basic idea to share judiciously the remained capacity C_r is to select the tuple (i,j,k) which minimizes the quantity $R_j \frac{\lambda_{ij}^k}{\mu_{ij}} B_{ij}^k$, $\forall k \in \{nc, ho\}$, $\forall i \in Z$ and $\forall j \in T$. The capacity C_{ij}^k associated to the elected tuple (i,j,k) is incremented by a capacity of $\underline{s}_{ij}$ bandwidth units (at the condition that $C_r \geq \underline{s}_{ij}$). The new value of C_{ij}^k is then used to update the blocking probabilities expressed by equation 4. The algorithm pursue its iterations by selecting again a tuple (i,j,k) which minimizes the quantity $R_j \frac{\lambda_{ij}^k}{\mu_{ij}} B_{ij}^k$, $\forall k \in \{nc, ho\}$, $\forall i \in Z$ and $\forall j \in T$. These incremental assignment iterations are repeated as long as $\exists i \in Z$ and $\exists j \in T$ such that $C_r \geq \underline{s}_{ij}$.

V. Results

A. Parameters and scenario

We evaluated our proposal assuming a single mobile WIMAX cell. The physical layer is based on WirelessMAN OFDMA with three burst profiles (1,3,5) [1] corresponding to QPSK ($coding\ rate = \frac{1}{2}$), 16 QAM ($coding\ rate = \frac{1}{2}$) and 64 QAM ($coding\ rate = \frac{2}{3}$) modulation schemes. We considered a system capacity of 70 Mbps with a bandwidth unit set to 32kbps. That is, $C = 2200$. The following parameters were chosen:

Parameters	Area $i=1$	Area $i=2$	Area $i=3$
$\mu_{i1}=\mu_{i2}=\mu_{i3}=\mu_{i4}$	0.5	0.5	0.5
$\left(\underline{s}_{i1},\underline{s}_{i2},\underline{s}_{i3},\underline{s}_{i4}\right)$	$(1,8,4,2)$	$(2,16,8,4)$	$(3,24,12,6)$

Following the previous table we fixed the minimal and maximal assignable bandwidth units as follows :

Classes	Area 1	Area 2	Area 3
UGS (1)	$[32,128]$ kbps	$[64,256]$ kbps	$[96,384]$ kbps
rtPS (2)	$[256,1024]$ kbps	$[512,2048]$ kbps	$[768,3072]$ kbps
nrtPS (3)	$[128,512]$ kbps	$[256,1024]$ kbps	$[384,1536]$ kbps
ErtPS (4)	$[64,256]$ kbps	$[128,512]$ kbps	$[192,768]$ kbps

The call blocking probability constraints were set to $(\beta_1^{nc},\beta_2^{nc},\beta_3^{nc},\beta_4^{nc})=\left(10^{-4},10^{-3},10^{-3},10^{-3}\right)$ and $\forall j\in T$, $\beta_j^{ho}=10^{-1}\beta_j^{nc}$ We also assumed that the generated revenue rate for each classes is equal to $\left(R_j\right)_{j\in T}=(1,0.1,0.05,0.5)$.

In our test scenarios, we assumed the following transition probabilities of mobiles users among areas: $t_{12}=1$, $t_{21}=t_{32}=t_{33'}=0.5$. Finally, we considered that $\forall\,(i,j)\in Z\times T$, $\lambda_{ij}^{nc}=\lambda$, where $\lambda\in\{1,1.1,1.2\ldots,3.9\}$. For each λ value we used our algorithm, described in section IV to obtain the CP reservation vector $\overrightarrow{C^*}$.

B. results

The following table shows the reservation vector obtained while varying the new call arrival rate. Each line corresponds to the reservation vector that a provider need to use in order to share his system bandwidth to obtain a chosen call blocking probability constraints and to maximize his revenue.

		New call				Handoff			
λ_{ij}^{nc}	Area	UGS	rtPS	nrtPS	ErtPS	UGS	rtPS	nrtPS	ErtPS
1	1	13	96	48	26	14	80	40	20
1	2	26	192	96	52	28	208	104	56
1	3	39	288	144	78	42	288	144	78
2	1	13	96	48	26	10	72	36	20
2	2	26	192	96	52	30	224	104	60
2	3	39	288	132	78	42	288	144	84
3	1	14	96	44	26	10	80	32	20
3	2	28	192	88	52	32	224	104	60
3	3	42	288	132	78	42	288	144	84
3.9	1	14	96	44	26	10	72	36	20
3.9	2	28	176	88	52	32	224	112	60
3.9	3	39	264	132	78	45	312	156	84

We also can see that we retrieve the same ratio between the allocated capacity for the 3 areas for a done arrival rate and the minimal bandwidth units described in parameters table in section V-A. For example for the first column and the three first lines we allocate 13 units for UGS in area 1 the double for area 2 and the triple for area 3.

RtPS are the most bandwidth allocated service class because we assumed that the minimum allocated bandwidth for this class is the highest minimum bandwidth unit of all classes.

Note that this method is very fast because the execution of our algorithm takes 15 seconds to compute the needed vector.

Next, we evaluate the system performance. We first plot the call blocking probability while varying the arrival rate for the four ho classes $(1,2,3,4)$ in the area 1. The figure prove that the handoff blocking probability increases with the arrival rate, the threshold constraints are fulfilled for all classes (i.e $\forall(i,j)\in Z\times T\left(B_{ij}^{ho}\leq\beta_j^{ho}\right)$)

Note that these observations holds also for new calls (because of the lack of space we choose to present only results for hand-off calls). Note that the fluctuations shown in figure 4 are resulting from the discrete nature of the partitions size,

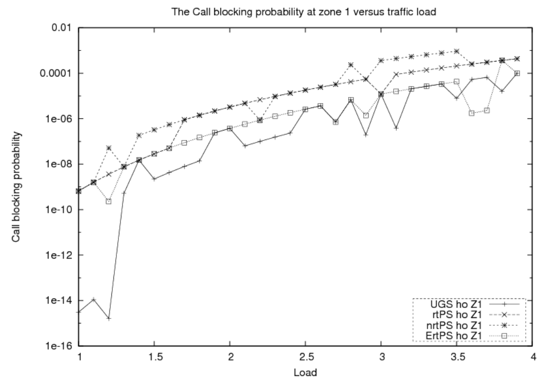

Fig. 4. Handoff blocking probabilities in the area 1

their relative important proportion to the total capacity and the log scale representation of the y axis.

VI. Conclusion

The purpose of the paper is to determine, using an analytical model and a heuristic approach, the nearly-optimal sizes of the partition sizes dedicated to each type of connection in a Mobile WiMAX cell. Our incremental partition size algorithm is simple, fast, an scalable. Moreover, since typical blocking thresholds considered in dimensionning studies are very low, our algorithm can lead to obtain blocking probabilities and and average gain which are very close to the ones obtained by an optimal CAC policy (i.e. using a CSMDP approach).

References

[1] IEEE Std 802.16e 2005. *IEEE Standard 802.16e-2005, Amendment to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems- Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands*. 2005.

[2] G. Choudhury, K. Leung, and W. Whitt. An algorithm to compute blocking probabilities in multi-rate multi-class multi-resource loss models. *Advances in Applied Probability*, 27:1104–1143, 1995.

[3] F. Hou, P.-H. Ho, and X. Shen. Performance analysis of a reservation-based connection admission scheme in 802.16 networks. *IEEE Global Telecommunications Conference*, November 2006.

[4] S. Khemiri, K. Boussetta, N. Achir, and G. Pujolle. Optimal call admission control for an ieee 802.16 wireless metropolitan area network. *International Conference on Network Control and Optimization (NET-COOP'2007)*, June, 2007.

[5] S. Khemiri, K. Boussetta, N. Achir, and G. Pujolle. Wimax bandwidth provisioning service to residential customers. *IFIP/IEEE International Conference on Mobile and Wireless Communications Networks (MWCN'2007)*, September, 2007.

[6] Dusit Niyato and Ekram Hossain. A queuing-theoretic and optimization-based model for radio resource management in ieee 802.16 broadband wireless networks. *IEEE Transactions on Computers*, 55(11):1473–1488, 2006.

[7] K.F. Lee L.T. Ko K.T. Tung, H.Y. Tsang. qos for mobile wimax networks : Call admission control and bandwidth allocation. *Consumer Communications and Networking Conference, 2008. CCNC 2008. 5th IEEE*, pages 576–580, Janary 2008.

[8] H. Wang and W. Li. Dynamic admission control and qos for 802.16 wireless man. *Wireless Telecommunications Symposium*, pages 60–66, April 2005.