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An Efficient Handoff Scheme for Multimedia Traffic in OFDMA System

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Abstract— The IEEE 802.16e Broadband Wireless Access (BWA) system is developed to cater for rapidly growing requirement for multimedia wireless services. Since the heterogeneous services provided by the system are connection-oriented, Call Admission Control and required resource reservation mechanisms are needed to achieve desired quality of service (QoS). Traditional admission control algorithms are based on bandwidth or channel reservation policy, which may be incompetent in IEEE 802.16e OFDMA systems for two reasons: (i) WiMAX system supports dynamic and flexible resource allocation, and (ii) there exists a fundamental tradeoff between bandwidth resource and power resource. In this paper, we propose an efficient call admission control scheme based on maximum use of subchannels using AMC to minimize the overall transmit power in OFDMA systems. Based on power reservation, we propose two power reservation schemes for inter-cell handoff calls and intra-cell handoff calls, respectively. Correspondingly, two reservation factors are introduced, the values of which are determined by optimizing the metric of Grade of Service (GoS). Computer simulation is carried out to evaluate the performance of the proposed call admission control scheme based on power reservation.

Index Terms— Call Admission Control (CAC), Call Blocking Probability (CBP), Call Dropping Probability (CDP), Broadband Wireless Access (BWA), OFDMA, IEEE 802.16e, Grade of Service (GoS)

1 INTRODUCTION

THE IEEE 802.16e broadband wireless mobile system based on OFDM(A) physical structure has been developed recently, which is expected to support high-speed multimedia services applications for mobile stations (MSs) moving at vehicular speeds [1], there is a growing interest in deploying multimedia services in mobile cellular networks (MCNs). Call Admission Control (CAC) is one of such areas in need of adaptation to accommodate multimedia traffic. The connection-level quality of service (QoS) in MCNs is usually expressed in terms of call blocking probability and call dropping probability [2,3]. The call dropping probability is the probability that an accepted call will be forced to terminate before the completion of its service. According to [3],[4] the call dropping probability is directly proportional to the handoff dropping probability which is the probability that a handoff attempt fails. A significant number of CAC schemes have been proposed during the last two decades. Because of the scarcity of bandwidth resource in wireless networks, the most prevalent approaches among them are the channel reservation schemes. These schemes can be classified into two categories: the traditional guard channel schemes and the dynamic control schemes. The traditional guard channel schemes reserve a fixed number of channels exclusively for handoff calls [5], [6], [7], which do not adapt to changes in the traffic pattern. The dynamic control schemes make the admission decision in a distributed manner relying on status information exchanging between adjacent cells [8], [9], [10].Typical CAC policies in wireline multiclass networks are complete sharing (CS), complete partitioning (CP) and threshold. In the CS policy, calls of every class share the bandwidth pool, in the CP policy, bandwidth for each class is exclusively reserved, whereas in the threshold policy, a newly arriving call is blocked if the number of calls of each class is greater than or equal to a predefined threshold [11].

In this paper, we consider two kinds of handoffs: inter-cell handoff and intra-cell handoff. Inter-cell handoff is the process to maintain conversation continuity when a MS moves across the boundary between its serving cell and the destination cell to accept the handoff. Dropping occurs if there is no sufficient resource for the incoming handoff request in the target cell. Intra-cell handoff is a resource reassignment process due to channel condition degradation of an active call caused by terminal movement, during which additional resource is requested to maintain the QoS requirements and call may drop because of resource insufficiency. In case of call drop during resource reassignment, one or more active calls have to be dropped according to a certain predefined criterion, which is out of the scope of this study. Considering the different characteristics of these two kinds of handoffs, two different power reservation strategies are proposed for them respectively, and for each strategy, a corresponding reservation factor is introduced. It is tradeoff between handoff dropping rate and call blocking rate; we determine the values of the reservation factors based on the optimization of the grade of service (GoS) performance.

The rest of this paper is organized as follows Section 2 describes the system model for multimedia traffic of IEEE 802.16e. We present the framework for the efficient call admission control scheme to deal with real and non real time multimedia traffic in Section 3 The section 4 presents our power reservation-based admission control scheme for both inter handoff and intra handoff calls. In

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Section 5 the results and analysis in terms of the performance evolution are discussed. Section 6 concludes this paper.

2 SYSTEM MODEL

2.1 Network Model

Consider an IEEE 802.16e cellular system consisting of 19 cells, with six cells in the first tier and twelve cells in the second tier (figure 1), surrounding the central cell. A single BS is located at each center of the cell, and the cell radius is set to 1Km. The wraparound technique is used to eliminate boundary effect and MSs are uniformly distributed throughout the whole system topology.

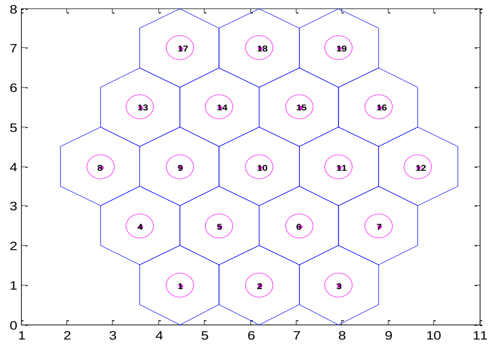

Fig 1: IEEE 802.16e cellular 19 Hexagonal Cells.

The centre frequency (*fc*) is 3.5GHz, and the total bandwidth in each cell (*Bt*) is 10MHz. The subcarriers of each logical subchannel are spread though the whole frequency band of that cell. The technique of adaptive modulation and coding (AMC) is used, thus the AMC scheme of each active call could be dynamically adjusted according the factors such as channel conditions and available radio resource. Information about the IEEE 802.16e OFDMA Parameters and specified AMC schemes are listed in TABLE 1 & TABLE 2 respectively.

TABLE 1
IEEE 802.16e OFDMA Parameters

Parameters	Values			
Bandwidth (MHz)	1.25	5	10	20
FFT Size(Sub-carrier)	128	512	1024	2048
Sub-carier Spacing (K Hz)	9.8	9.8	9.8	9.8

TABLE 2
AMC levels in IEEE 802.16e

AMC level	bit/s /Hz	AMC mode	SINR thrsh. (dB)
1 (*Lmin*)	1.0	QPSK-1/2	7.6
2	1.5	QPSK-3/4	10.3
3	2.0	16QAM-1/2	14.3
4	3.0	16QAM-3/4	17.4
5	4.0	16QAM-2/3	21.0
6 (*Lmax*)	4.5	16QAM-3/4	22.0

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2.2 Traffic Model

Real-time services and non real time services are considered in this paper, multiple classes and direction of calls are listed in TABLE 3 & TABLE 4 respectively.

TABLE 3
Traffic model of multimedia services

Services	Data Rate In K bps Random	Call duration In Sec Random
Class 1	3.5 to 4.5	01 to 60
Class II	64 to 144	90 to 180
Class III	256 to 1Mb	210 to 300

TABLE 4
Traffic model of direction

Direction No	Direction
1	West
2	North-West
3	North-East
4	East
5	South-East
6	South-West

2.3 Propagation Model

Path loss and shadow fading are taken into account in then propagation model, which is given by

$$PL(d) = PL(d0) + 10a \log(d/d0) + \chi\sigma \qquad (1)$$

Where d is the transmitter-receiver separation distance; $d0$ is the reference distance, which is set to 30m; a is the path-loss exponent with the value of 3.5; $\chi\sigma$ denotes the log-normal shadow fading, with a zero mean and a standard deviation of 8dB.

3 CALL ADMISSION CONTROL SCHEME

Considering the fact that admission control strategies are highly dependent on the resource allocation algorithms adopted in the system, an optimal admission control algorithm for multimedia system is proposed in this section. The optimization objective of this resource allocation problem is to minimize the overall transmit power of the BS while guarantee the data rate requirements of all users.

Let S denote the total number of available sub-

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channels in a cell and P denote the maximum transmit power in the BS. Suppose there are N active calls in the cell at present, and the data rate requirement of the ith user is DR_i ($1 \le i \le N$), the number of subchannels and the transmit power assigned to user i can be denoted by Si and Pi, respectively. If user i's AMC level is set to MCi, the resulting data rate per unit of bandwidth from AMC level MCi can be denoted by $DR(MCi)$, and the corresponding SINR are $f(MCi)$ requirement, can be looked up in Table II.

Accordingly, the number of subchannels required by user i is given by

$$Si = DR_i / (DR(MCi) * B0) \quad (2)$$

where $B0$ denotes the bandwidth of each subchannel. The required transmit power on each subchannel of user i is

$$P\_SC = (f(MC_i) * (\eta + I_i)) / G_i \quad (3)$$

where η is the thermal noise assumed to be the same at each receiver, Ii denotes the co-channel interference perceived by user i, and Gi denotes the channel gain of the link from the BS to the ith user (i.e path loss). The required power from the BS to user i is given by:

$$Pi = Si * P_{SC} \quad (4)$$

At first, each user is assigned the highest AMC level $Lmax$ (according to Table II, $Lmax = 6$). Then, in each iteration, we try to reduce each user's AMC level to the next lower level. Consequently, for user i, there will be an increment in subchannel requirement denoted by ΔSi and a decrement in transmit power requirement denoted by ΔPi, thus a metric of unified power reduction can be defined as $\Delta Pi/\Delta Si$. The user with the largest unified power reduction is selected to lower its AMC level, and gets the right to obtain additional subchannels. This iteration process continues until every user reaches the lowest AMC level $Lmin$ or no subchannels are left unoccupied. The details of this algorithm can be described as follows:

1) Initialization: For each user i, initializes $MCi = Lmax$, the Corresponding subchannel and power requirements are given by

$$Si = [DRi/(DR(Lmax)*B0$$
$$Pi = Si*P\_SCi$$

2) For each user i that satisfies $MCi > Lmin$, Calculate the required resource for the next lower AMC level:

$$MC_i^* = MC_i - 1$$

$$S_i^* = \left[\frac{DRi}{DR(MC_i^*)} Bo\right]$$

$$P_i^* = S_i^* \; P\_SC$$

The subchannel requirement increment and the power requirementdecrement are given by

$$\Delta S_i = \mathbf{S_i^*} - S_i, \text{ and } \Delta P_i = P_i - \mathbf{P_i^*}$$

3) Find user i^* with the largest unified power reduction:

$$i^* = \max(\Delta P_i / \Delta S_i)$$

then, update the allocation information of the selected user i^*

$$MC_{i^*} = MC_{i^*} - 1$$

$$S_{i^*} = (DR_i / (DR(MC_{i^*}) \times B0)$$

$$P_{i^*} = S_{i^*} \times P\_SC$$

4) Repeat step 2) and 3) until all users reach the lowest AMC level or all the subchannels are assigned.

5) Check the assignment results.

If $\sum_{i=1}^{N} Pi < P$

Then allocation is finished successfully, else resource allocation is failed.

4 POWER RESRVATION BASED- CALL ADMISSION CONTROL

We develop an efficient call admission control scheme based on power reservation for handoff calls.

Let *Pcurrent* denote the reserved power for intra-cell Handoff calls residing in current cell and

Let *Phandoff* inter-cell handoff calls moving into the curent cell from its neighbor cells.

Then, the overall reserved power in the BS, *Poverall*, is given by:

$$\text{Poverall} = \text{Pcurrent} + \text{Phandoff} \quad (5)$$

we have develop algorithm to determine Pcurrent and Phandoff ,respectively.

4.1 Power Reservation for Inter-cell Handoff Calls

To find an appropriate value of *Phandoff*, let's first consider the average power and subchannel requirements for an inter-cell handoff call. Due to the bad channel condition on the edge of a cell, the AMC level assigned to an inter-cell handoff call is almost equal to *Lmin*. Thus, the average number of subchannels that should be allocated to an inter-cell handoff call can be given by $[DR/(DR(Lmin) \cdot B0)]$, and the corresponding average power requirement is

$$\text{Paverage power} = \left[\frac{\text{DR average}}{\text{DR(Lmin)}*\text{Bo}}\right].\text{F(Lmin)} \quad (6)$$

where *DRaverage* denotes the average data rate requirement, which can be determined from the data rate distribution presented in Section II. Since it is hard to predict the exact channel gain at the cell boundary, we use the average channel gain which is only determined by path loss in Eq.(1). Since no subchannels are reserved in our resource allocation strategy, some subchannels occupied by the ongoing calls in the current cell have to be reallocated to the handoff call by assigned an additional amount of power, *Phc* to the ongoing calls to make up for the loss in subchannel resource.

Let P_s denote the total power requirements as *S* subchannels
and $P_{s\_averagel}$ denote the power required *as* subchannels are occupied in all, according to the call admission control algorithm described in Section 3.

Then, the power gap can be given by

$$Phc = P_{s\_average} - P_s \quad (7)$$

The total power reservation for inter-cell handoff calls is given by:

$$Phandoff = K(Paverage\ power + Phc) \quad (8)$$

where $K(K \geq 0)$ is a reservation factor introduced for inter-cell handoff calls, which is related to the probability that inter-cell handoff occurs, as well as the degree of the tradeoff between the call blocking probability and the drop probability. The optimal value of *K* will be decided later.

4.2 Power Reservation for Intra-cell Handoff Calls

As the power reservation for intra-cell handoff calls is difficult to determine due to the arbitrary movement of the MSs, we propose the following method to get estimation.

Let *Pcurrent [i]*denote the transmit power of the *i*th user from the BS determined by the allocation algorithm.

Let *Pboundary[i]* denote the required power to maintain its AMC level and subchannel requirement when user *i* reaches the cell edge. The power ratio at the edge of cell is *Pcurrent[i] / Pboundary [i]*. The smaller power ratio indicates a less probability of a user to reach the cell edge. Therefore, the approximate power reservation for user *i* in our scheme is described as

$$Preserv[i] = \frac{(Pboundary[i] - Pcurrent[i])Pcurrent[i]}{Pboundary[i]} \quad (9)$$

Accordingly, the total power reservation for intra-cell handoff calls is:

$$Preserv_{intra} = B\sum_{i=1}^{N} Preserv[i] \quad (10)$$

where *B* is a reservation factor introduced for intra-cell handoffs. Similar to *K*, the value of *B* should be carefully designed to balance between the call blocking probability and the drop probability.It should be noted that, although the reserved powers for the two kinds of handoff calls are determined separately, the overall reserved power *Poverall* is shared by both inter-cell handoff calls and intra-cell handoff calls, because both kinds of handoff calls are ongoing calls in the system, and should be treated with the same priority.

4.3 Determination of Reservation Factors K and B

Since inadequate power reservation causes intolerable call drop probability while excessive reservation results in high call block probability, the metric of GoS is adopted to specify the degree of tradeoff between the call drop probability and the call block probability, which is given by

$$GoS = \alpha Pdrop(\lambda) + Pblock(\lambda) \quad (11)$$

Herein, *Pdrop* (λ) and *Pblock*(λ) respectively denote the call drop probability and the call block probability under the call arrival rate λ, *a* is a weighting factor to describe the relative importance of *Pdrop*(λ) comparing to *Pblock*(λ), and a value of 10 is used in this paper.

Consequently, under a given call arrival rate, the two reservation factors, *K* and *B*, can be determined by solving the following two dimensional optimization problems:

$$(Kopt, Bopt) = \arg\min_{B>0,K>0} (10Pdrop + Pblock) \quad (12)$$

Obviously, it is extremely complicated to yield an optimal solution to the above problem. To reduce computational complexity, we decompose this two dimensional optimization problem into two one dimensional subproblems, and solve each subproblem separately to find the local optimal solutions, i.e., *K* and *B* then join them together to be the suboptimal solution to the original problem in Eq. (12).

To determine *K* no power is reserved for intra-cell handoff calls by setting *B* to zero, and the droppings caused by intra-cell handoff calls are ignored, thus *Pdrop* is replaced by *Pdrop_intra*, the dropping probability of the inter-cell handoff calls. Therefore, the corresponding one dimensional subproblem is formulated as follows:

$$K = \arg\min_{K>0} (10Pdrop\_intra + Pblock) \quad (13)$$

Similarly, when determine *B* the overall reserved power in a BS is equal to *Pcurrent* by setting *K* to zero, and the drop calls of inter-cell handoff calls is not considered by replacing *Pdrop* with *Pdrop_inter*, the probability of dropping caused by intra-cell handoff calls. Thus, the second one dimensional subproblem is formulated as

$$B = \arg\min_{B>0} (10Pdrop\_inter + Pblock) \quad (14)$$

Numerical simulation is utilized the above algorithm for call blocking probability and call dropping probability for proposed call admission control scheme and separate algorithm for intra-cell handoff and inter-cell handoff. Grade of Service has of prome importance in the proposed algorithm.

5 Simulation Results

The performance of the proposed algorithm has been evaluated by simulation in terms of Call block probability, Call drop probability and GoS with effect of various call arrival rate. We simulated IEEE 802.16e OFDMA cellular network consisting of 19 cells, with six cells in the first tier and twelve cells in the second tier (Fig.1), surrounding the central cell. A single BS is located at each cell center, and the cell radius is set to 1Km. The wraparound technique is used to eliminate boundary effect and mobile stations are uniformly distributed throughout the whole system topology. The total number of subchannels in each cell is set to 1024, the overall transmit power of each BS is restricted to 100W and the thermal noise is -90dBm. We developed admission control scheme based on power reservation for handoff calls. Power is reserved for intra-cell handoff calls residing in current cell and inter-cell handoff calls moving into the current cell from its neighbor cells. Then, the overall reserved power in the BS is sum of reserved power for intra-cell handoff calls and inter-cell handoff calls.

5.1 Power Reservation for Inter-cell Handoff Calls

K is a reservation factor introduced for inter-cell handoff calls, which is related to the probability that inter-cell handoff occurs, as well as the degree of the tradeoff between the call blocking probability and the drop probability

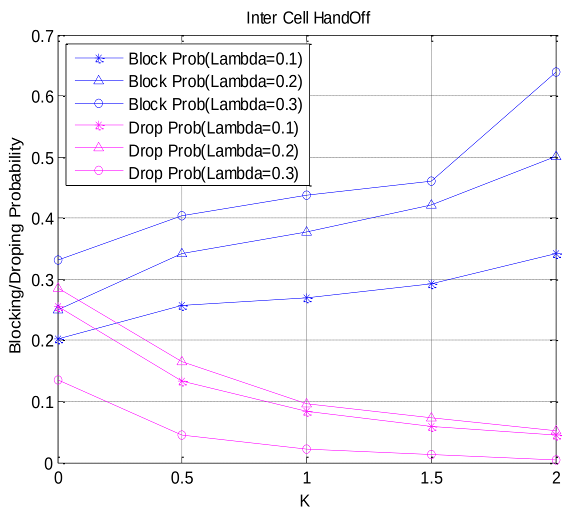

Fig. 2: Blocking and Dropping probability for Multimedia traffic versus K reservation factor for inter-cell handoff calls

Fig. 2. plots the call blocking probability and the call dropping probability of inter-cell handoff calls plotted against K reservation factor for inter-cell handoff calls at 3 different call arrival rate for multimedia traffic. In the simulation, we ignore intra-cell handoffs and set B=0. In each call arrival case, as K increases, the amount of reserved power increases, causing a reduction in the dropping probability and an increase in call blocking probability.

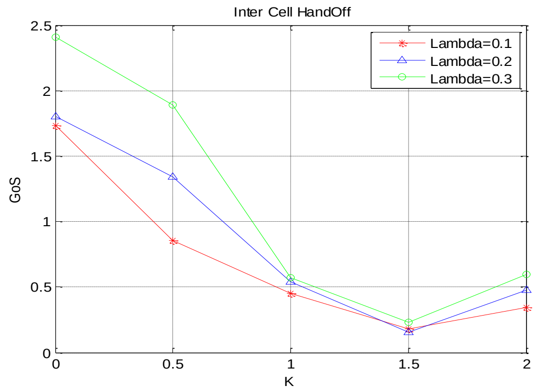

Fig. 3: Grad of Service **for** Multimedia traffic versus K reservation factor for inter-cell handoff calls

The Grad of Service (GoS) performances versus K reservation factor for inter-cell handoff calls for 3 different call arrival rates for multimedia traffic are presented in Fig. 15. It is seen that a GoS curve versus K is always convex, because either deficient or excessive amount of reservation will lead to a poor GoS performance. A minimum GoS which corresponds to K∗ can be found for each call arrival case. For call arrival rate 0.1, 0.2 and 0.3, the corresponding K∗ are all equal to 1.5 for multimedia traffic.

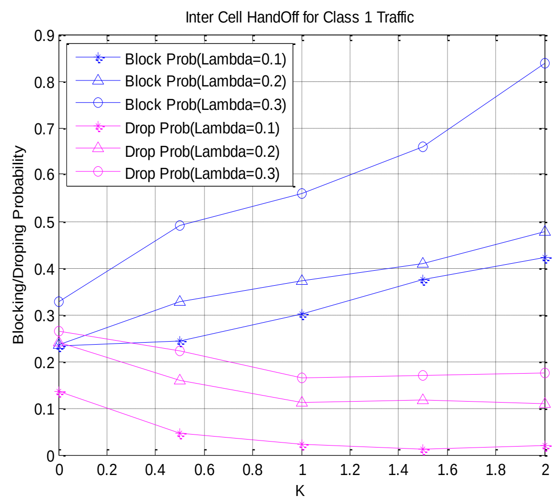

Fig. 4: Blocking and Dropping probability for Class 1 traffic versus K reservation factor for inter-cell handoff calls

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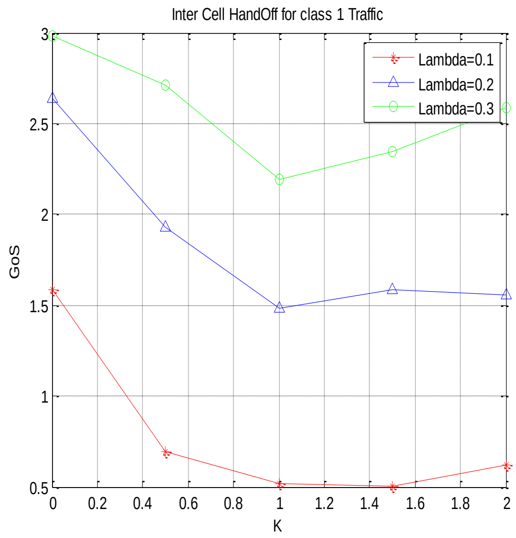

Fig. 5: Grad of Service **for** Class 1 traffic versus K reservation factor for inter-cell handoff calls

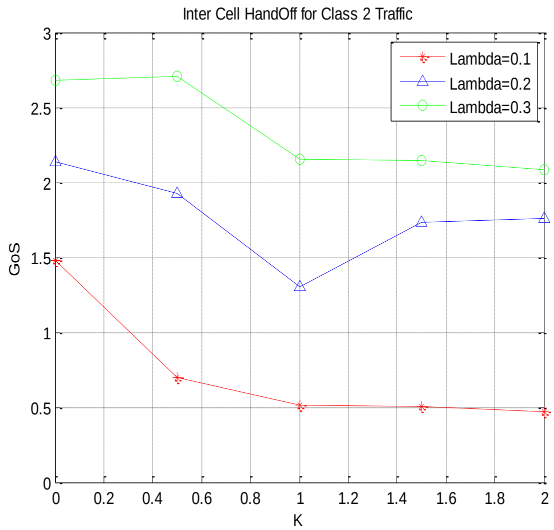

Fig. 7: Grad of Service for Class 2 traffic versus K reservation factor for inter-cell handoff calls

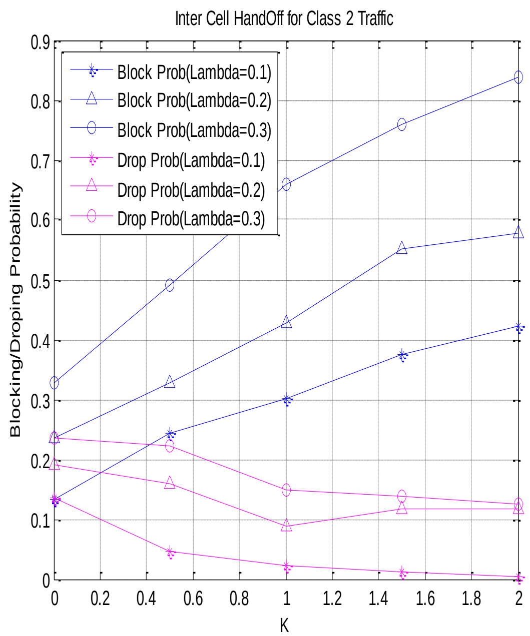

Fig. 6: Blocking and Dropping probability for Class 2 traffic versus K reservation factor for inter-cell handoff calls

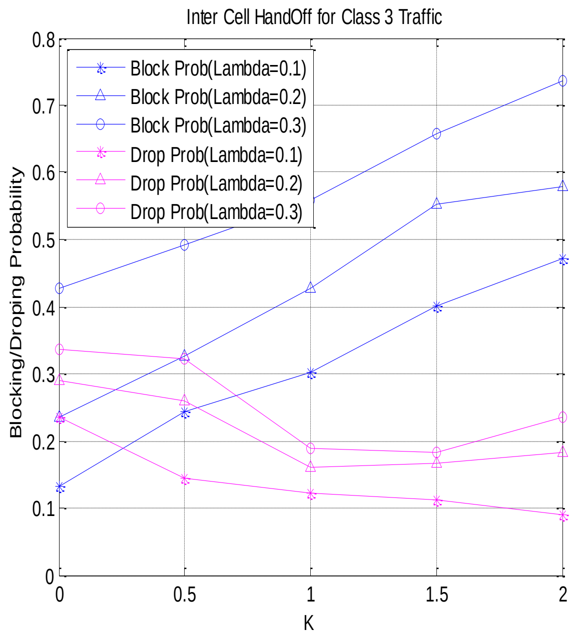

Fig. 8: Blocking and Dropping probability for Class 3 traffic versus K reservation factor for inter-cell handoff calls

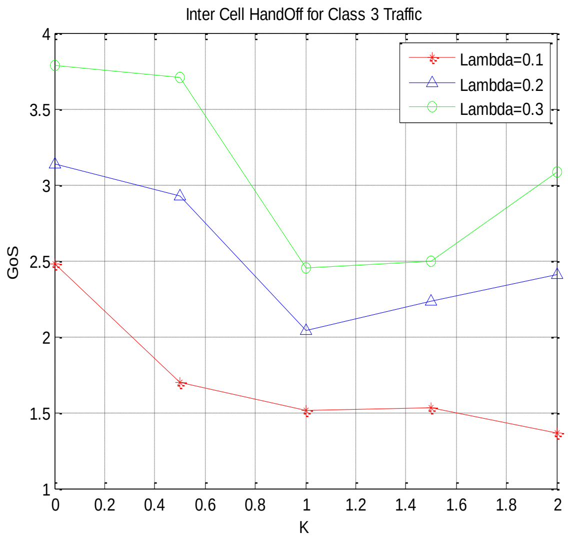

Fig. 9: Grad of Service for Class 3 traffic versus K reservation factor for inter-cell handoff calls

5.1 Power Reservation for Intra-cell Handoff Calls

B is a reservation factor introduced for intra-cell handoff calls, which is related to the probability that intra-cell handoff occurs, as well as the degree of the tradeoff between the call blocking probability and the drop probability.

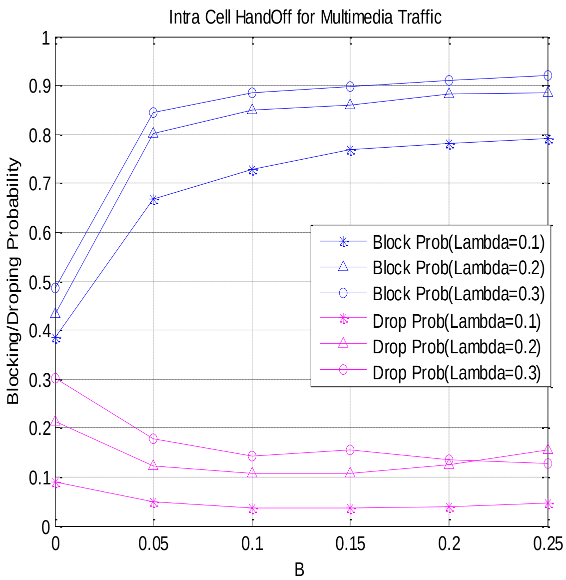

Fig. 10: Blocking and Dropping probability for Multimedia traffic versus B reservation factor for intra-cell handoff calls

Fig. 10. plots the call blocking probability and the Dropping probability of intra-cell handoff calls at 3 different call arrival rate for multimedia traffic versus B reservation factor for intra-cell handoff calls. In the simulation, we ignore inter-cell handoffs and set K=0. In each call arrival rate condition, as B increases, the amount of reserved power increases, causing a reduction in intra-cell handoff dropping probability and an increment in call blocking probability.

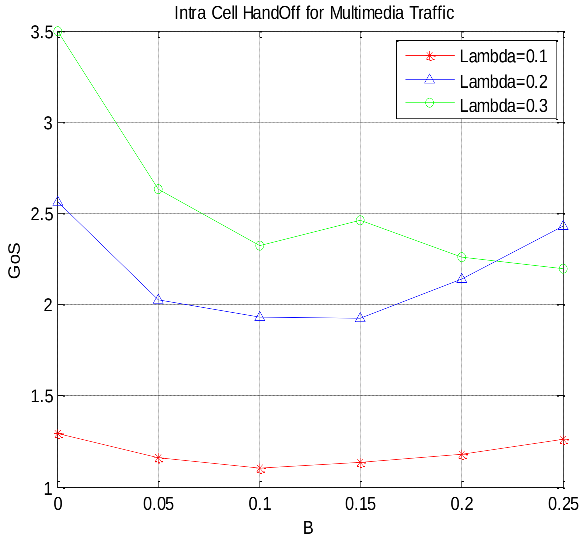

Fig.11: Grad of Service **for** Multimedia traffic versus B reservation factor for intra-cell handoff calls

The Grad of Service (GoS) performances versus B reservation factor for intra-cell handoff calls for 3 different call arrival rate for multimedia traffic are presented in Fig. 11. It is seen that a GoS curve versus B is always convex, because either deficient or excessive amount of reservation will lead to a poor GoS performance. A minimum GoS which corresponds to B∗ can be found for each call arrival case. For call arrival rate 0.1,0.2 and 0.3, the corresponding B∗ are all equal to 0.1, 0.15 and 0.25 for multimedia traffic.

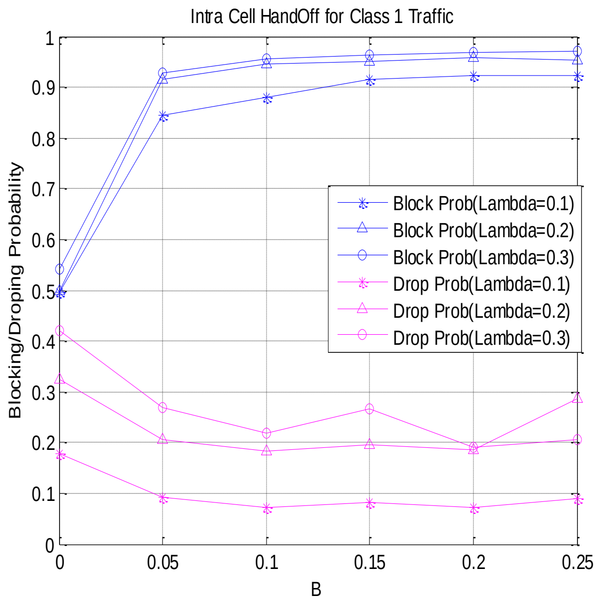

Fig. 12: Blocking and Dropping probability for Class 1 traffic versus B reservation factor for intra-cell handoff calls

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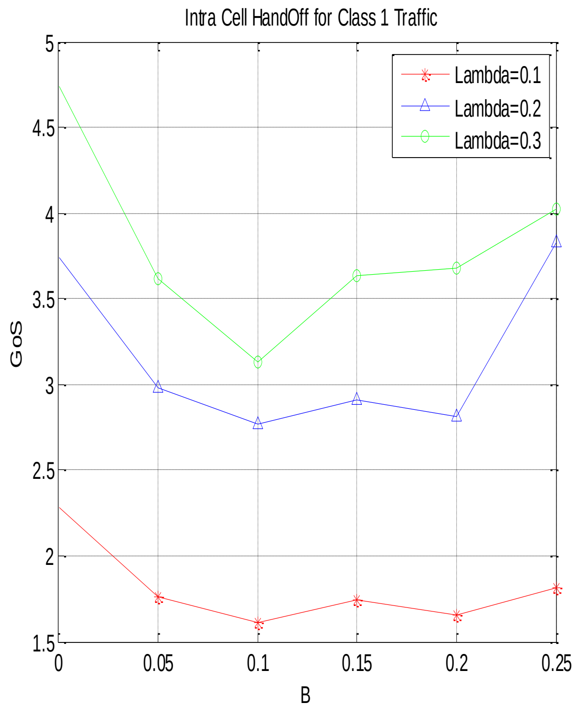

Fig. 13: Grad of Service for Class 1 traffic versus B reservation factor for intra-cell handoff calls

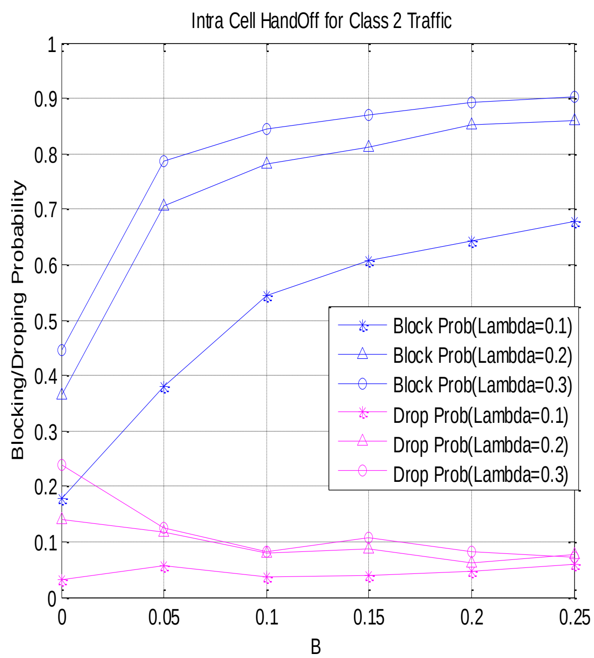

Fig. 14: Blocking and Dropping probability for Class 2 traffic versus B reservation factor for intra-cell handoff calls

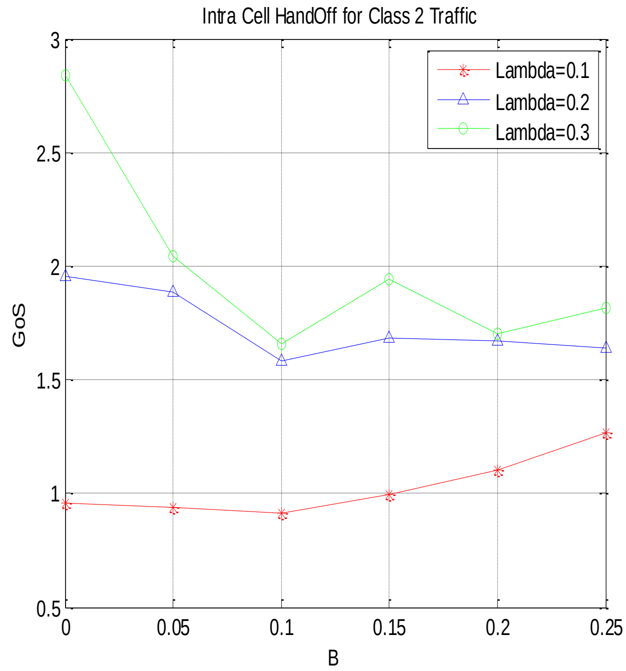

Fig. 15: Grad of Service for Class 2 traffic versus B reservation factor for intra-cell handoff calls

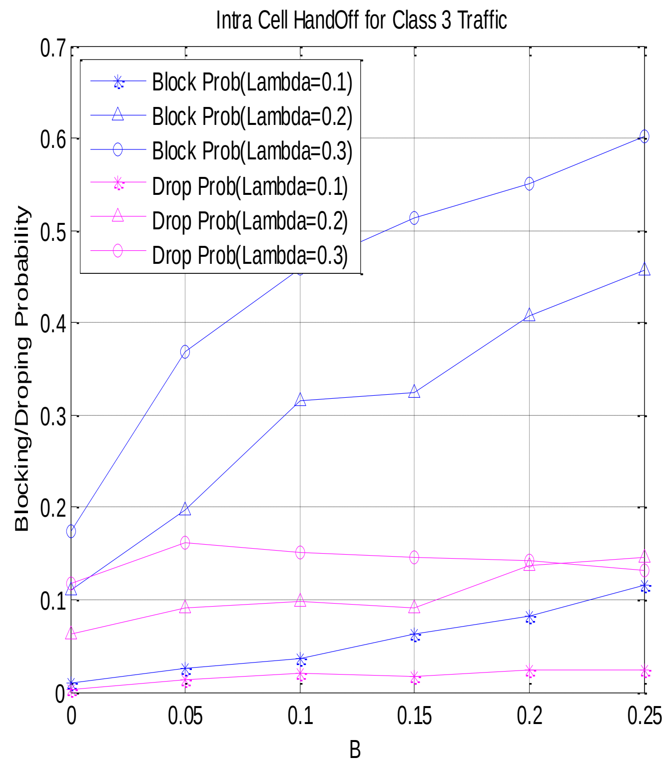

Fig. 16: Blocking and Dropping probability for Class 3 traffic versus B reservation factor for intra-cell handoff calls

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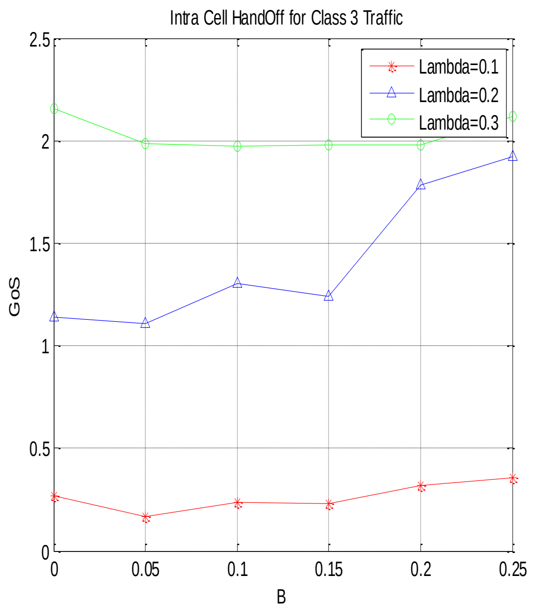

Fig. 17: Grad of Service for Class 3 traffic versus B reservation factor for intra-cell handoff calls

6 Conclusion

It is anticipated that demands for multimedia services will grow in future wireless networks. Call Admission Control is essential for the efficient utilization of scarce radio bandwidth. In this paper, considering the support provided to multimedia service in IEEE802.16e standards, An Efficient Call Admission Control Scheme with power based Reservation for Multimedia Traffic is proposed for IEEE 802.16e network, based on maximum use of subchannels using AMC to minimize the overall transmit power in OFDMA systems.

Traditional admission control schemes based on channel reservation have a couple of shortcomings in WiMAX systems. Channel reservation is not fit for flexible radio resource allocation and inevitably increase transmits power at BS. These problems can be well solved if power reservation is used instead of channel reservation. In this paper, we have proposed an efficient call admission control strategy based on power reservation. Two kinds of handoffs are considered: inter-cell handoff and intra cell handoff, and two reservation factors *K* and *B* are introduced, in order to balance the handoff call dropping rate and new call blocking rate. It is seen that from the result of GoS curve versus K & B, GoS curve is always convex, because either deficient or excessive amount of reservation will lead to a poor GoS performance. A minimum GoS which corresponds to K∗ & B∗ can be found for each call arrival rate. For call arrival rate 0.1,0.2 and 0.3, the corresponding K∗ are all equal to 1.5 for multimedia traffic. For call arrival rate 0.1, 0.2 and 0.3, the corresponding B∗ are all equal to 0.1, 0.15 and 0.25 for multimedia traffic.

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