SE-CAC: A Novel Call Admission Control Scheme for Multi-service IDMA Systems

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Abstract

In this paper a simple and effective call admission control (CAC) scheme is proposed for the emerging interleave-division multiple-access (IDMA) systems, supporting a variety of traffic types and offering different quality of service (QoS) requirements and priority levels. The proposed scheme is signal-to-interference-plus-noise ratio (SINR) evolution based CAC (SE-CAC). The key idea behind the scheme is to take advantage of the SINR evolution technique in the process of making admission decisions, which is developed from the effective chip-by-chip (CBC) multi-user detection (MUD) process in IDMA systems. By virtue of this semi-analytical technique, the MUD efficiency can be estimated accurately. Additionally, the computational complexity can be considerably reduced. These features make the scheme highly suitable for IDMA systems, which can combat intra-cell interference efficiently with simple CBC MUD. Analysis and simulation results show that compared to the traditional CAC scheme considering MUD efficiency as a constant, the proposed SE-CAC scheme can guarantee high power efficiency and throughput for multimedia traffic even in heavy load conditions, illustrating the high efficiency of CBC MUD. Furthermore, based on the SINR evolution, the SE-CAC can make accurate estimation of available resource considering the effect of MUD, leading to low outage probability as well as low blocking and dropping probability.

Keywords: IDMA, call admission control, multi-user detection, SINR evolution

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1. Introduction

Within the past few years, a great deal of attention has been drawn towards the emerging interleave-division multiple-access (IDMA) in next-generation wireless communication systems, which employs random interleavers as the only method for user separation [1]. As a particular case of CDMA, IDMA inherits many distinguished features of well-studied CDMA [2]. Furthermore, IDMA allows a simple and effective turbo-type chip-by-chip (CBC) iterative multi-user detection (MUD) scheme applicable to system with a large number of users, which is crucial for system achieving high throughput [3]. Additionally, a simple and accurate performance analysis method, signal-to-interference-plus-noise ratio (SINR) evolution technique, is developed from this CBC detection [4].

Call admission control (CAC) is one of the most important issues for radio resource management of wireless communication systems. The object of CAC is to maximize the utilization of resource as long as the required quality of service (QoS) for all calls is guaranteed. According to our knowledge, most of the research on CAC is focused on TDMA and CDMA systems while IDMA, as a newly arisen technique, has been investigated limited to its physical layer and the role of CAC scheme has not been studied yet. IDMA exhibits some unique features that should be intelligently reflected in the design of an effective CAC. In view of the performance of IDMA systems is mainly limited by the interference among the users, the call admission decision based on total interference or SINR measurement is suitable. A significant number of publications have appeared on the topic of SINR-based or interference-based CAC design [5][6][7][8][9][10]. In [5], a lower bound of SINR threshold is derived for CDMA systems which support only a single-class service. After investigating current issues in traffic management based on SINR prediction, a frame work for CAC is presented in [6], while each node has to broadcast an omnidirectional request in every transmission interval in order to form ANGLE-SINR TABLE, leading to high computational complexity. An interference-based scheme is proposed in [7]. The scheme is evaluated for a fixed number of users in neighboring cells, while the impact of a new call on ongoing calls in adjacent cells is not considered. W. Jeon et al. extend the previous work and propose a new scheme based on SINR measurements [8]. Upon the arrival of a new or handoff call request, the base station evaluates the SINR for each service if the call is accepted, and checks if it is over a predefined threshold. However, considering the performance evaluation for MUD in CDMA systems is difficult to implement, this scheme neglects the effect of MUD. The study in [9] focuses on a SINR-based CAC scheme both uplink and downlink. The scheme takes account of the different bottlenecks between uplink and downlink, but it does not take the effect of MUD into consideration either. [10] presents a CAC strategy considering the effect of MUD. However, it roughly assumes the efficiency of MUD as a constant, which is inaccurate considering the performance of MUD is related to the SINR levels corresponding to different services. Here we call them fixed MUD efficiency CAC (FME-CAC). While the motivation of IDMA technology for future mobile communication systems is the potential to overcome both intra-cell and inter-cells multiple access interference (MAI) with simple

CBC MUD efficiently, it is more necessary to consider the CAC scheme combined with the effect of MUD in order to make better use of resource. In light of the above observations, the present work proposes a new implementation of the earlier work incorporating several substantial improvements to the original FME-CAC scheme. We introduce a novel SINR evolution based CAC (SE-CAC) that solves the problem of the performance evaluation for MUD and makes the scheme easy to implement. This operation helps to increase throughput and power efficiency and prevent outage due to the higher accuracy of resource estimation. It ultimately enhances the overall performance of the network.

The rest of this paper is organized as follows. In section 2, iterative CBC MUD scheme and SINR evolution technique of IDMA systems are illustrated respectively. And then, the novel SE-CAC scheme is proposed for IDMA systems in section 3. In section 4, simulation results and performance evaluation are provided. Finally, the paper concludes in section 5.

2. Multi-user detection and SINR evolution in IDMA systems

Similar to Turbo decoding, IDMA-CBC MUD is an iterative procedure with two decoding components, namely an elementary signal estimator (ESE) and K a posteriori probability (APP) decoders (DECs) [4]. During each iteration they exchange extrinsic log-likelihood ratios (LLRs) about $x_k\left(j\right)$, which is the jth chip output from the user-k dependent permutation. From the central limited theorem, the MAI to every chip is reasonably approximated by a Gaussian distribution. Furthermore, the key principle of IDMA is that the user separation is made possible by using different interleavers invoked after the spreading and chip level interleaving makes MAI appear as an additive uncorrelated Gaussian process. Based on the above assumptions, the extrinsic LLRs about each chip becomes equivalent to the mean and variance of $x_k\left(j\right)$ upon iteration convergence. The complete computational procedure of IDMA-CBC MUD is given in [1] and [11].

The performance of IDMA-CBC detection scheme depends on the amount of cancelled MAI, equivalently, the amount of variance reduced from the $\left\{x_k\left(j\right), \forall k, j\right\}$ variables [12]. Since all data symbols are assumed to be independently and identically distributed, the variance of an arbitrary chip from user-k is independent with j, which can be written as

$$V_k(j) \approx V_k \,. \tag{1}$$

This variance reduction is obtained in the ESE by utilizing all extrinsic variable $\left\{e_{DEC}\left(x_k\left(j\right)\right), \forall k, j\right\}$ generated by DEC$_s$ for each iteration. Simulation observations and analysis reveal that upon iteration convergence, $\left\{e_{DEC}\left(x_k\left(j\right)\right), \forall k, j\right\}$, denoted by Y_{SINR_k}, is approximated by a Gaussian random variable whose mean and variance are determined by the SINR of the chip signal. For BPSK with repetition-code (each bit is replicated N times over the symbol chips), it can be shown that for large number of chips, Y_{SINR_k} is approximately Gaussian with mean and variance $2(N-1)SINR_k$ and $4(N-1)SINR_k$, respectively [12]. In this paper we concern with the decoder performance at the iteration convergence point, where, by (1) can be further written as

$$V_k = 1 - \tanh^2\left(\frac{Y_{SINR_k}}{2}\right), k = 1,\ldots,K . \tag{2}$$

As shown in (2), the variance of an arbitrary chip from user-*k*, V_k, is a function of $SINR_k$, which by defination is the power factor of the interference introduced by user-*k* at the iteration convergence point.

Suppose that in a single cell model, for each user-*k*, a fixed received power, S_k can be maintained under the ideal power control which aims at achieving the SINR targets upon iteration convergence when MAI interference is maximally cancelled. Consequently, the total interference power received by user-*k* can be estimated as:

$$I_k = P_N + \sum_{i \neq k} S_i \cdot E\left(V_i\right), \tag{3}$$

where P_N is the thermal background noise and by (3), we define

$$f(SINR_i) = E\left(V_i\right) = 1 - E\left[\tanh^2\left(\frac{Y_{SINR_i}}{2}\right)\right], \quad i = 1,\ldots,K \tag{4}$$

and (3) can be written as:

$$I_k = P_N + \sum_{i \neq k} S_i \cdot f(SINR_i) . \tag{5}$$

The function $f(SINR)$ is referred as the uncancelled percentage of the intra-cell interference, reflecting the efficiency of the CBC MUD. Generally, $f(SINR)$ does not have an analytical expression and is derived by simulation [1][12]. Based on (5), the intra-cell interference considering the efficiency of CBC MUD can be estimated accurately.

3. CAC scheme for IDMA systems based on SINR evolution

Generally, call admission scheme can be implemented in three steps. First, it estimates the current resource utilization in intra-cell and inter-cells. Second, it predicts the increase in resource usage that would result if the call seeking admission were admitted. Finally, the decision to admit or reject the incoming call is made by comparing the predicted resource utilization with a threshold. Since the restrictions imposed on the uplink and downlink are not of the same nature, the system is power limited from the perspective of the downlink, while it is interference limited in the uplink. Considering the distinct capacity bottlenecks in uplink and downlink, two different CAC policies, namely uplink CAC based on interference and downlink CAC based on the base station transmitted power, are implemented respectively. The special concerns in designing the scheme are:

i. The priority mechanism for different service classes and between new and handoff calls;

ii. The traffic asymmetry and distinct capacity bottlenecks between uplink and downlink which will be discussed in detail;

iii. The easy implementation without compromising performance.

In section 2, the CBC MUD scheme and SINR evolution technique for fast performance evaluation of IDMA are briefly introduced. Here we extend this accurate and effective technique to the estimation of interference level. Based on this semi-analytical technique, a novel CAC scheme considering the effect of MUD with much lower computational complexity and higher accuracy is developed for IDMA systems.

3.1 Estimation of uplink interference level

In cellular IDMA systems the same pair of frequency bands are reused for each cell. Thus, each base station not only receives interference from mobiles in the home cell (intra-cell interference) but also from terminals located in adjacent cells (inter-cell interference). The received total interference power of a base station， I_{total} ， without considering MUD is

$$I_{total} = I_{intra} + I_{inter} + P_N \tag{6}$$

with

I_{intra} : The intra-cell interference from users in home cell.

I_{inter} : Received power from adjacent cells in home cell.

For simplification, here we define the inter-cell interference factor f^u as the ratio of the total interference power from adjacent cells (I_{inter}) and the interference power generated by users in the home cell (I_{intra}). If average interference is used, the average ratio f^u can be seen as a constant 0.55, which was found analytically for the situation without shadowing and is confirmed by results presented in previous studies [13]. Thus the total interference received in the home cell is

$$I_{total} = I_{intra} + f^u \cdot I_{intra} + P_N \,. \tag{7}$$

The received bit energy to interference power spectral density ratio for service type *k*,

γ_k under perfect power control (PPC) is assumed to be:

$$\gamma_k = \left(E_b / I_0\right)_k = \frac{S_k}{\left(I_{total} - S_k\right)} \cdot \frac{W}{\left(R_k \cdot \alpha_k\right)} \tag{8}$$

where W is spread-spectrum bandwidth, R_k , α_k and S_k are the data rate, activity factor and required transmission power of active users of traffic type *k*. After defining the load factor of a single connection as

$$L_k = \frac{S_k}{I_{total}} = 1 \Big/ \left(1 + \frac{W}{\gamma_k R_k \alpha_k}\right), \tag{9}$$

the total intra-cell interference power from users in home cell can be written as

$$. I_{intra} = \sum_{k=1}^{N} L_k \cdot I_{total} \cdot N_k \ . \tag{10}$$

where N and N_k are the number of different service types and users corresponding to service type *k*. Similarly, we define the fractional load factor in the home cell η as

$$\eta = (1 + f^u) \sum_{k=1}^{N} L_k \cdot N_k \ , \tag{11}$$

which is normally used as the home cell load indicator [13]. Based on (10), the total interference received in the home cell can be written as

$$I_{total} = \frac{P_N}{1-\eta} . \tag{12}$$

With the derivative form of Eqs. (12), the uplink power increase of the total interference level due to a new requiring user-*k* can be estimated as follows

$$\Delta I = \frac{I_{total}}{1 - \eta - L_k} L_k \ . \tag{13}$$

Based on the semi-analytical SINR evolution technique proposed in section 2, MUD efficiency is considered here as the percentage of the intra-cell interference cancelled by the multi-user detector. Thus, by (5), the intra-cell interference received by base station considering the effect of CBC MUD is

$$I_{\mathrm{int}ra} = \sum_{k=1}^{N} L_k \cdot I_{total} \cdot N_k \cdot f\left(SINR_k\right) \tag{14}$$

and the fractional load factor in the home cell can be derived as

$$\eta = \sum_{k=1}^{N} \left(f\left(SINR_k\right) + f^{u} \right) \cdot L_k \cdot N_k \tag{15}$$

Similarly, from Eqs. (13) and (15) the estimated interference increase due to user-*k* with CBC MUD in IDMA systems is simply as follows

$$\Delta I = \frac{I_{total} \cdot f\left(SINR_k\right)}{1 - \eta - f\left(SINR_k\right) \cdot L_{\mathrm{k}}} L_{\mathrm{k}} \,. \tag{16}$$

3.2 Estimation of downlink transmitted power level

For the uplink, CAC decision based on interference level is reasonable, while for the downlink the total transmitted power of the base station becomes the determinant, leading to a different CAC policy from uplink.

Similar to the uplink, all users share the common bandwidth and each new connection increases the interference level of other connections, affecting the service quality expressed in terms of a certain $\left(E_b/I_0\right)_i^d$. For *N* users receiving signal simultaneously from a given cell, the received $\left(E_b/I_0\right)_i^d$ can be written as:

$$\left(E_b/I_0\right)_i^d = \frac{W}{R_i^d} \cdot \frac{g_{i0} p_i^N}{\sum_{\substack{j=1 \\ j \neq i}}^{N} \theta_j g_{i0} p_j^N + g_{i0} P_p + I_i + P_N} \geq \gamma_i^{\,d} \tag{17}$$

$$P_{total\_N} = \sum_{j=1}^{N} p_j^N + P_p \tag{18}$$

where .. represents the base station transmitted power, p_j^N is the power devoted to the *j*-th user, I_i is the inter-cell interference observed by the *i*-th user, g_{i0} is the path loss to the user i , P_P is the power assigned to pilot channel, and θ_j is the orthogonality factor in the downlink direction. It can be obtained that the minimum transmitted power p_i^N to satisfy the *i*-th user demands should be:

$$p_i^N = \eta_i \left(\sum_{j=1}^{N} \theta_j p_j^N + P_p + \frac{I_i + P_N}{g_{i0}} \right) \tag{19}$$

and

$$\eta_i = \frac{\gamma_i^d R_i^d}{W + \theta_i \gamma_i^d R_i^d} . \tag{20}$$

The later expression is commonly known as the downlink load factor for the *i*-th user.

Assumed the subscript number of a new call is *0*, the total amount of the users in home cell is *N*+1 if it is accepted. Now the transmitted power to the *i*-th user is

$$p_i^{N+1} = \eta_i \left(\sum_{j=0}^{N} \theta_j p_j^{N+1} + P_p + \frac{I_i + P_N}{g_{i0}} \right). \tag{21}$$

From above the increase in power demand to the *i*-th user Δp_i is estimated as follow:

$$\Delta p_i = \eta_i \left(\sum_{j \neq 0} \theta_j \Delta p_j + \theta_0 p_0 \right) \tag{22}$$

and transmitted power to the *0*-th user can be written as

$$p_0 = \frac{\left(1 - \sum_{j \neq 0} \theta_j \eta_j \right)}{\left(1 - \sum_{j=0}^{N} \theta_j \eta_j \right)} \eta_0 \left(\sum_{j \neq 0} \theta_j p_j^N + P_p + \frac{I_0 + P_N}{g_{00}} \right). \tag{23}$$

After accumulating all the $\Delta p_j \ \left(j = 1, \ldots, N \right)$, total transmitted power for *N*+1 users is

$$\begin{aligned} P_{total\_N+1} &= P_{total\_N} + \sum_{j\neq 0} \Delta p_j + p_0 \\ &= \frac{\eta_0 P_{total\_N}\left(\theta_0 + \dfrac{I_0 + P_N}{g_{00} P_{total\_N}}\right)}{\left(1 - \sum_{j=0}^{N} \theta_j \eta_j\right)} + P_{total\_N} \end{aligned} \tag{24}$$

where $\sum_{j=0}^{N} \eta_j$ is the downlink fractional load factor.

f^d is defined as the ratio of the total base station transmitted power from adjacent cells and the power generated by base station in the home cell. Similar to the uplink, f^d is set as its typical value as 0.55 [14]. When the background noise is ignored, (24) can be written as

$$P_{total\_N+1} = \frac{\eta_0 P_{total\_N}\left(\theta_0 + f^d\right)}{\left(1 - \sum_{j=0}^{N} \theta_j \eta_j\right)} + P_{total\_N} . \tag{25}$$

Considering the downlink receivers in IDMA systems also benefit from CBC detection [15], the uncancelled percentage of intra-cell interference is $f(SINR)$. Then the orthogonality factor in the downlink direction can be equivalent to $f(SINR)$. With the aid of SINR evolution, the downlink load factor for the *i*-th user and the total transmitted power can be accurately and easily estimated as:

$$\eta_i = \frac{\gamma_i^{\,d} R_i^{\,d}}{W + f(SINR_i)\gamma_i^{\,d} R_i^{\,d}} \tag{26}$$

$$P_{total\_N+1} = \frac{\eta_0 P_{total\_N}\left(f\left(SINR_0\right) + f^d\right)}{\left(1 - \sum_{j=0}^{N} f\left(SINR_j\right)\eta_j\right)} + P_{total\_N} . \tag{27}$$

3.3 SE-CAC scheme

The proposed CAC scheme consists of three stages, explained in **Fig. 1**.

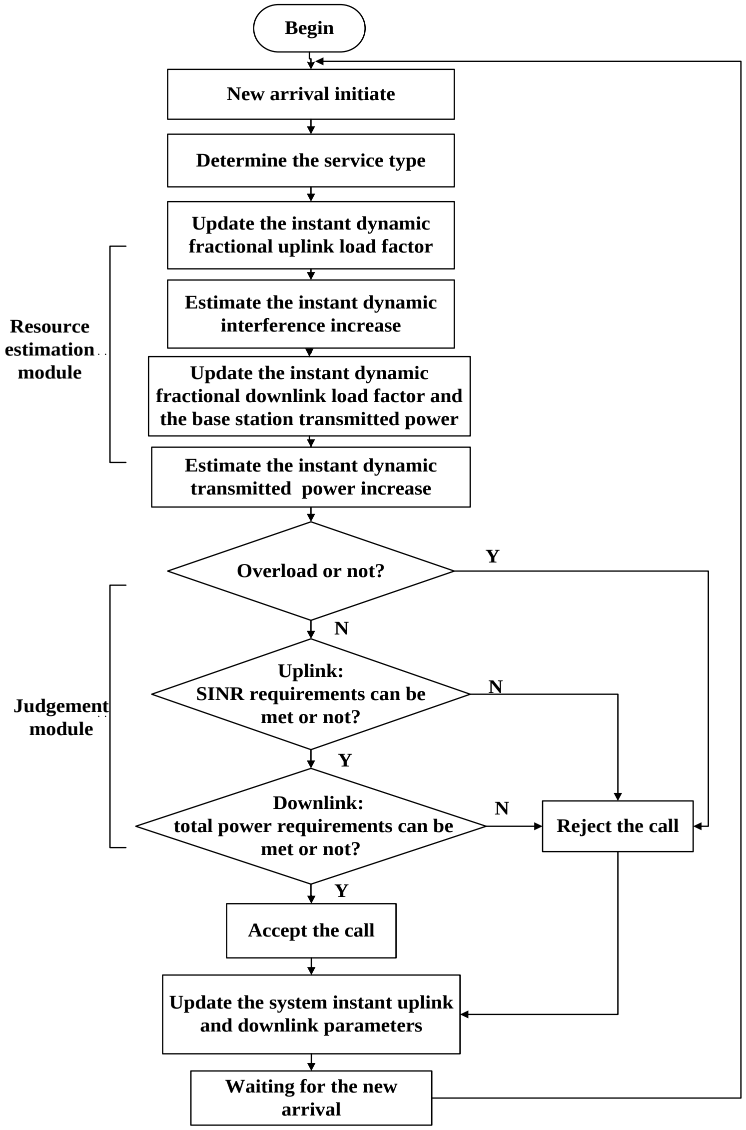

Fig. 1. Flowchart of the proposed SE-CAC scheme

Stage 1: Resource estimation and prediction. Resource requirements are considered separately for the uplink and downlink. For the uplink, the current total received power at the home cell base station I_{total} and the interference increase ΔI due to the new arrival should be estimated. Estimation of downlink takes the form of the total transmitted power from the base station P_{total_old} and traffic declaration of the new call in terms of the expected increase in transmitted power ΔP_{total} [9].

Stage 2: Consider uplink. A call is admitted if the interference is below a certain level that guarantees the communication quality. When a new call request arrives, it will be accepted if

$$I_{total-old} + \Delta I \le I_{THRESHOLD} \tag{28}$$

is satisfied. Similarly, if a handoff call arrives, the CAC scheme decides whether to admit the call according to the result of

$$I_{total-old} + \Delta I \le I_{threshold} \,. \tag{29}$$

In the proposed CAC scheme, handoff requests have higher priority over new calls of the same class. This is supported by setting $I_{threshold} > I_{THRESHOLD}$ [16].

Stage 3: Consider downlink. In the downlink, physical limitations into the power levels are given by the maximum base station transmitted power, so an admission decision based on measure power levels is more suitable. With this context, the considered admission control scheme checks the following condition to decide the acceptance of a new connection request in the system:

$$P_{total\_old} + \Delta P_{total} < P_{threshold} \,. \tag{30}$$

It is a very simple policy easily to be implemented, provided that the total interference level and the transmitted power can be estimated accurately by (15), (16) and (27). It is worth noting that SINR evolution in IDMA systems can evaluate the MUD performance with low computational complexity and high accuracy, leading to higher utilization rate in the resource limited system.

4. Performance evaluation

Having described the details of our proposed SE-CAC, we now direct our focus on evaluating its performance. SE-CAC is compared to FME-CAC that fixes the MUD efficiency as a constant so as to show the benefits behind using SE-CAC. The simulations focus on the abilities of our CAC to: (i) lower computational complexity, (ii) higher accuracy of resource estimation.

4.1 Traffic model and simulation parameters

A 19-cell layout is considered, in which mobiles are distributed uniformly. Suppose the uplink and downlink bandwidth is 3.84MHz. For each cell there are three classes of traffic, i.e., conversational, streaming and interactive class. Conversational class is Constant Bit Rate (CBR) under an ON/OFF activity model. As in [17] and [18], streaming class is modeled as a discrete state, continuous time Markov process. The Interactive traffic is approximately modeled as the Pareto process, described in [19]. Further, there are two major types of calls can arrive at any cell: new calls originated from the local cell and handoff calls coming from adjacent cells corresponding to each traffic. Since it is more reluctant to block a handoff call than a new call, the handoff calls should be given higher priority. Based on the multimedia traffic requirements and the 3GPP specification, the traffic characteristics and QoS requirements are defined in **Table 1**.

Table 1. Traffic model

		Conversational class		**Streaming class**		**Interactive class**	
Link		Uplink	Downlink	Uplink	Downlink	Uplink	Downlink
Maximum		12.2	12.2	64	256	122	384
Activity factor		0.6	0.6	0.00285	0.95	0.00285	0.015
E_b/N_0 target/dB		7		5		3.7	
Portion of arrival	New call	30%		5%		15%	
	Handoff	30%		5%		15%	
Mean call duration/s		100		1200		1200	
Priority		Premium		Assured		Best effort	

4.2 Simulation results and performance evaluation

Fig. 2 illustrates the decision process with SE-CAC for 10000 calls when the total arrival rate is 1 users/s. After numbering the different services respectively, **Fig. 2** shows the classes of the new arrivals, the arrival time and whether it is accepted or not from 10000s to 10200s clearly.

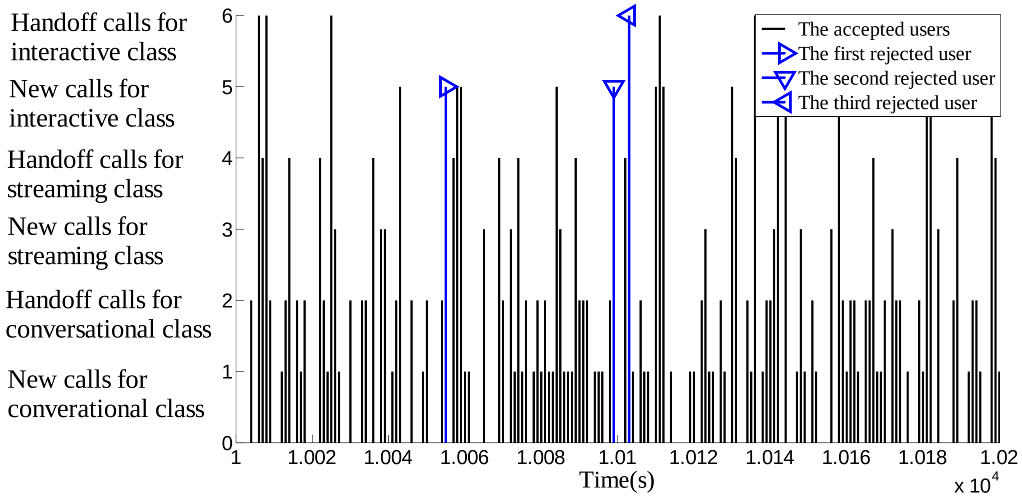

Fig. 2. The process of CAC

The blocking probability of new calls and the dropping probability of handover calls of different priorities are compared in **Figs. 3-4** and **6-7**. As can be seen, services with higher priorities have lower blocking/dropping probability, i.e. the conversational class has the lowest blocking/dropping probability as it has the highest priority. Meanwhile, the dropping probability is lower than the blocking probability corresponding to each service, in accord with priority levels.

It is also interesting to compare the performance of SE-CAC and FME-CAC in IDMA systems. In order to examine the ability of the CAC scheme to assure the QoS of all users during their whole service time, the schemes are assessed in terms of outage probability. The outage probability is defined as the probability that the QoS of a specific user falls below the required value for maintaining adequate transmission quality during its whole service time, that is, the measured SINR in the uplink direction and the total base station transmitted power in the downlink. Therefore, from this performance index we can evaluate the accuracy of the proposed CAC scheme. We consider orthogonality factor in the downlink direction is 0.2 [20] in FME-CAC. As can be seen from **Fig. 3-5**, the outage probability of FME-CAC with β=0.8 is impressively higher than one achieved by the SE-CAC. This can be explained by the fact that the MUD efficiency is overestimated in case of FME-CAC and too many calls are accepted. On the other hand, **Fig. 3-4** indicate that when setting β=0.2 in FME-CAC, the blocking and dropping probability is much higher than that in SE-CAC since the intra-cell interference is overestimated and users are erroneously rejected. Thus, the conventional FME-CAC fails to estimate the MUD efficiency accurately. However this comes at the price of high outage probability or poor utilization of resources.

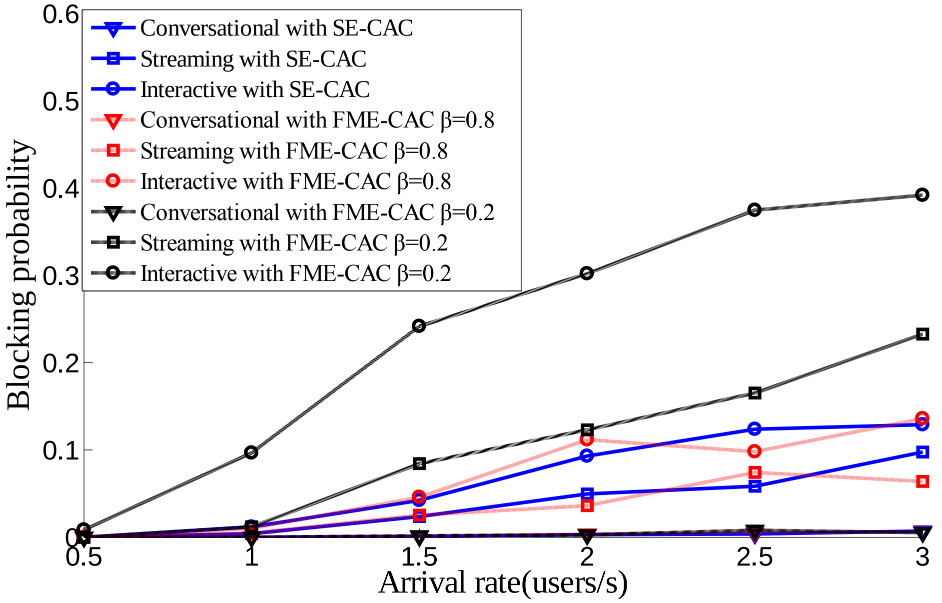

Fig. 3. Averaged blocking probability for different services between SE-CAC and FME-CAC with different β versus arrival rate

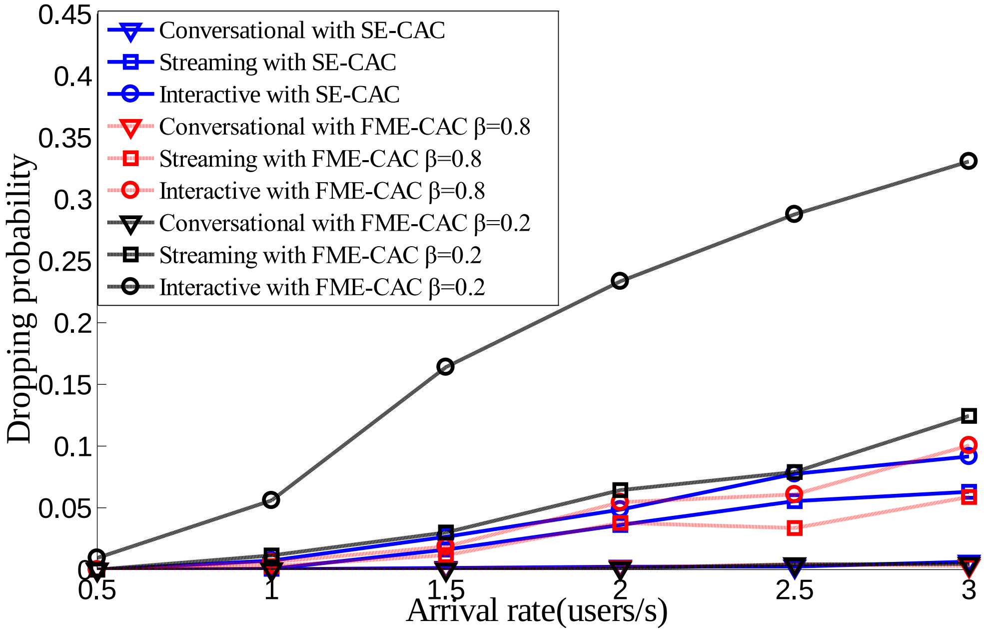

Fig. 4. Averaged dropping probability for different services between SE-CAC and FME-CAC with different β versus arrival rate

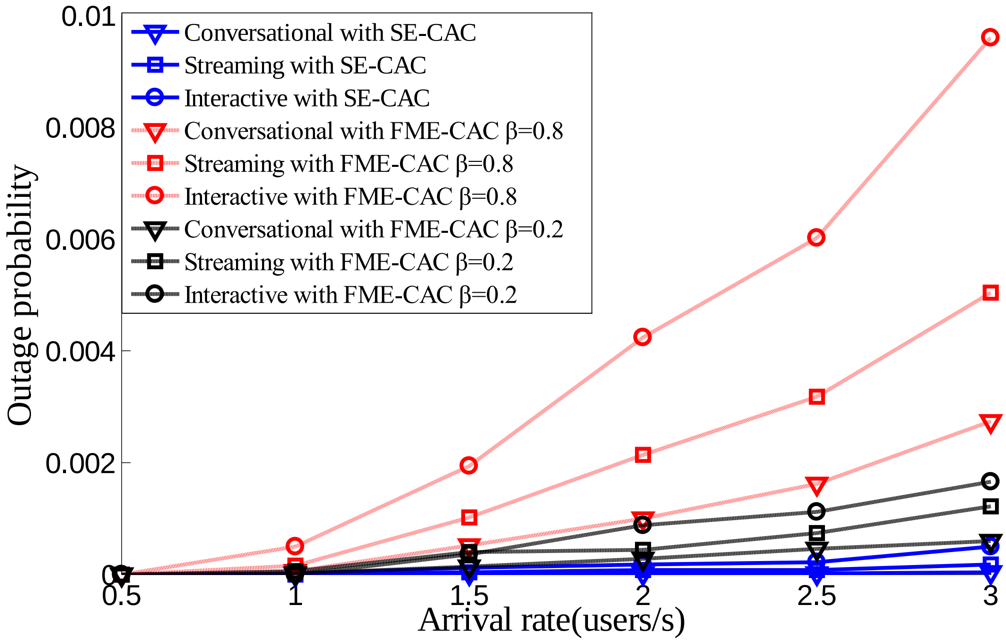

Fig. 5. Outage probability for different services between SE-CAC and FME-CAC with different β versus arrival rate

Based on the analysis above, it reasonable to compare the performance between SE-CAC and FME-CAC with β =0.5. It can be seen in **Fig. 6-7**, in addition to the advantage of low outage probability as well as low blocking/dropping probability, SE-CAC shows its advantage in power efficiency and throughput.

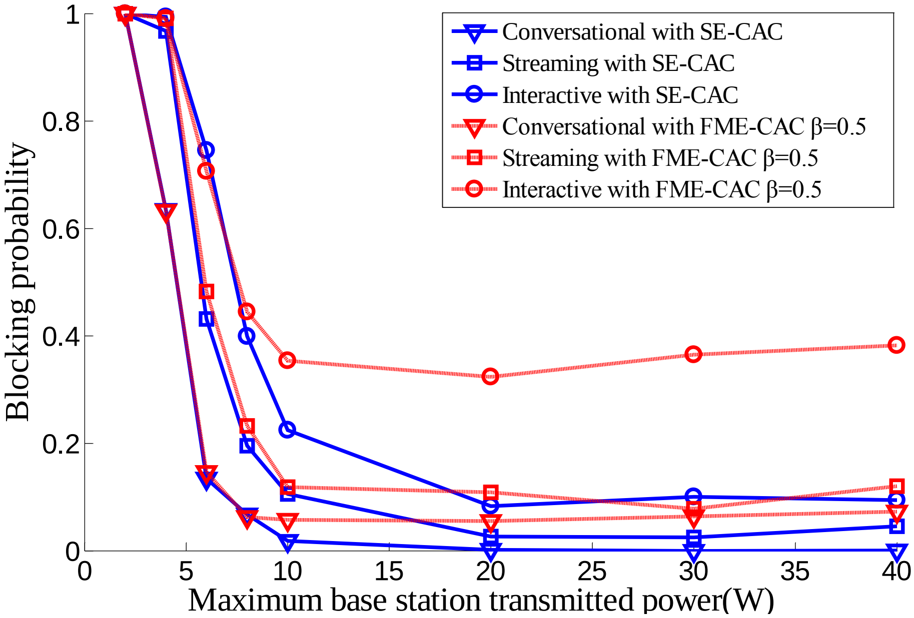

Fig. 6. The blocking probability of different services between SE-CAC and FME-CAC versus the maximum base station transmitted power

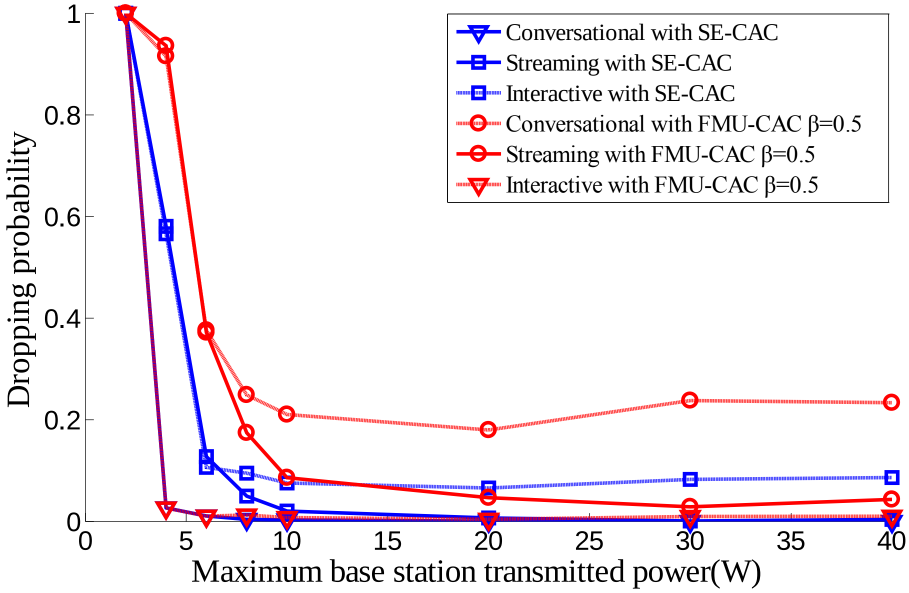

Fig. 7. The dropping probability of different services between SE-CAC and FME-CAC versus the maximum base station transmitted power

As can be seen in **Fig. 6** and **7**, the effect of the maximum base station transmitted power is illustrated. The blocking/dropping probability of each service declines sharply with the increase of maximum allowed output powers before a specified turning point, since the system is power limited in the downlink direction. Then the blocking/dropping probability remains constant, because that when the maximum allowed output power exceeds a specified value, the system will be interference limited rather than power limited. As can be seen, with the increase of maximum transmitted power, the turning point appears latter in SE-CAC, from which another advantage of SE-CAC rises. When seriously interfered, IDMA with SE-CAC can lowered down the blocking/dropping probability further by raising the maximum base station transmitted power, which is not useful in FME-CAC. In light of this, the capacity of IDMA can be further improved while satisfying the service requirements of the admitted calls even in heavy load conditions. Furthermore, when setting the same blocking and dropping probability respectively, IDMA with SE-CAC requires lower base station output power than with FME-CAC. It is well known that in an interference system, effective throughput is maximized when all user signals are transmitted at the minimum power necessary to attain the specified SINR requirements. With higher power efficiency, the transmitted power of each user in IDMA systems can be reduced, which is beneficial to cellular systems.

The normalized throughput performance of IDMA systems is illustrated in **Fig. 8**. Compared with the FME-CAC, the proposed SE-CAC scheme can guarantee a higher throughput and the performance advantage of it is more evident when the traffic load increases. The normalized throughput remains stable with increase of the traffic load with SE-CAC while it declines sharply with FME-CAC.

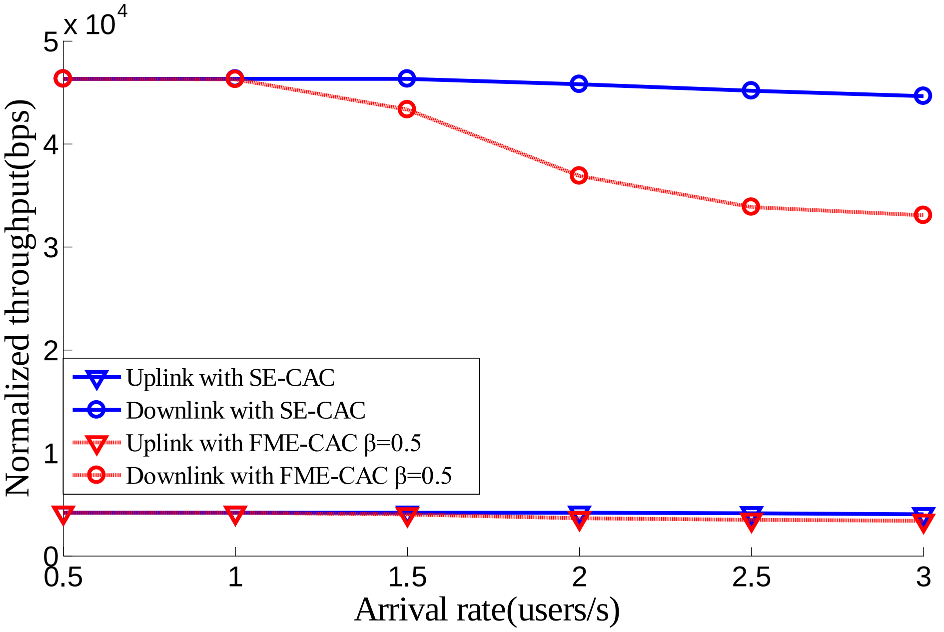

Fig. 8. Performance comparison of normalized throughput between SE-CAC and FME-CAC

5. Conclusion

In this work, we have addressed the problem of the conventional FME-CAC scheme. As a remedy, we proposed and evaluated a novel CAC scheme, SE-CAC, for multi-service IDMA systems, considering both uplink and downlink channels. The mechanism behind the proposed scheme that guarantees a better performance relies on the SINR evolution technique deduced from the CBC-MUD process in IDMA. By virtue of this fast and relatively accurate semi-analytical technique, the proposed CAC scheme can estimate the system state considering the effect of MUD accurately, and more concise admission decision can be made to maximize the resource utilization consequently. It has been shown by the presented simulation results that the CAC scheme not only provides better QoS, in terms of the blocking probability, dropping probability as well as outage probability, but also improves the power efficiency and normalized throughput, especially in heavy load conditions.

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