PERFORMANCE ANALYSIS OF CALL ADMISSION CONTROL IN WCDMA FOR CELLULAR SYSTEM

Dr. Wail A.H. Hadi[1] Dr. Ghaidaa K. Salih[2]

(1) University of Technology, Iraq, E-mail: wail_alsaadi@yahoo,com

(2) University of Technology, Iraq, E-mail: g_kaain@yahoo.com

ABSTRACT

The quality of service (QoS) is a key element in the communication system; many call admission control algorithms are being used to improve the performance of the system as well as the quality of service. This work represents the effective differences between the Single Cell-Call Admission Control (SC-CAC) and Multi Cell-Call Admission Control (MC-CAC) in mobile communication networks. MATLAB simulation model was implemented to compare between these two CACs in terms of probability of outage and optimal power allocation. The results show that MC-CAC has better performance than the SC-CAC which means minimum values of probability of outage and maximum values of Shannon channel capacity can be achieved by using MC-CAC, and this will improve the quality of service. Three load traffic classes have been considered which are voice, multimedia and video. This work shows that MC-CAC has many advantages over SC-CAC.

KEYWORDS

Quality of service; Admission control; wireless communications

1 INTRODUCTION

Call Admission Control (CAC) is a provisioning tactic to limit the amount of call connections into the network in order to decrease the network jamming and call dropping. Wideband Code Division Multiple Access (WCDMA) systems had limited interference. When WCDMA is fully operated, new user will affect on its stability [1],[2]. Call Admission Control (CAC) is one of the techniques for radio resource management of WCDMA [1]. Signal to Noise and Interference Ratio (SINR) based CAC algorithms set a threshold value. The call is not accepted if the received SINR is less than the threshold [1],[3]. Code Division Multiple Access (CDMA) gives improved capacity for data and voice communications all the time which allows extra subscribers to join any time and it is the main familiar platform to construct 3G technologies. CDMA is defined as “spread spectrum” technology which allows more users to exist in the matching time and frequency distributions in a given band or space [1],[3],[4]. In WCDMA systems, users are controlled depending on their use of spreading codes. This makes transmutation of several users at the same time on the same frequency achievable. As a reason of the daily increasing demands on wireless, the world packet scheduler is serious for QoS provisioning. So MAC algorithm which requires more from the wireless technologies. Third-Generation (3G) wireless data services and applications like wireless email, web, digital picture taking/sending and assisted- Global Positioning System (GPS) applications, audio streaming, video; TV broadcasting and wireless networks are the main cause to excite it. These cases lead to need CDMA technology [2],[4],[5]. In CDMA systems, the interference between users occurs due to the increase in the users' number due to which the quality can get worse. Hence, a standard should be maintained for providing a fine service to the users. This standard is known as Quality of Service (QoS) [4], [6]. Well-organized CAC and Medium Access Control (MAC) protocols are required for the QoS provisioning in WCDMA environment. But CAC unaccompanied is not enough to supply finest resource utilizations because of the unarranged nature of packet traffic. In an incorporated multiclass packetized network, professional has competent packet scheduler is required to be shared with an admission Controller [6],[7].

2 RELATED WORKS

The call admission control (CAC) method and the resource reservation estimation (BER) method which are suitable for wideband code division multiple access (CDMA). [8] In this method, the network is divided into cells. A new call is admitted only if the number of newly arriving calls is less than or equal to maximum number of calls than can be admitted in the cell. This type of threshold algorithm does not give efficient bandwidth utilization in multimedia network. [9] have studied the radio resource allocation problem of distributed joint transmission power control and spreading gain allocation in a DS-CDMA mobile data network. The network consists of K base stations and M wireless data users. The data flows which are produced by the users are considered as best-effort traffic, in the sense that there are no prespecified restrictions on the quality of the radio channels. They are interested in designing a distributed algorithm that attains maximal (or near-maximal in some reasonable sense) aggregate throughput, subject to peak power constraints. [10] have specified the uplink capacity and the interference statistics for a W-CDMA 3-D Airto-Ground (AG) cellular like network assuming imperfect power control and finite transmitted power. The free space model of propagation was used to calculate the intercellular interference. The uplink capacity has been considered for various frequencies and situations. It has been shown that the effect of rain was to reduce the uplink capacity and the maximum permissible cell radius. Also it was shown that, the frequency of operation should be lower or equal to 2 GHz. For a frequency of operation of 2 GHz, the cell capacity can reach 70 voice users or 46 data users when the cell radius is 350km. The new contribution of their work was the study of the effect of an imperfect power control and the finite transmitted power on the uplink capacity of the Air-Ground system for various values of outage. [11] have designed a resource sharing of BE applications with the RT applications in WCDMA networks. Both the types of traffic have flexibility to adapt the obtainable bandwidth but not like the BE traffic. RT traffic requires strict minimum bounds on the throughput. They have examined the performance of both BE and RT traffic and examined the effect of reservation for some portions of the bandwidth for the BE applications. Also they have presented a novel capacity definition associated to the delay of BE traffic and showed how to calculate it. [12] propose a two-level call admission control (CAC) scheme for direct sequence code division multiple access (DS-CDMA) wire-less networks supporting multimedia trafic and evaluate its performance. The first-level admission control assigns higher priority to real-time calls (also referred to as class 0 calls) in gaining access to the system resources. The second level admits nonreal-time calls (or class 1 calls) based on the resources remaining after meeting the resource needs for real-time calls. The analytic results are validated by simulation results. The numerical results show that the proposed two-level CAC scheme provides better performance than the single-level CAC scheme. Based on these results, it is concluded that the proposed two-level CAC scheme serves as a good solution for supporting multimedia applications in DS-CDMA wireless communication systems.

3 CELL-CALL ADMISSION CONTROL

Call Admission Control CAC is one of the effective strategies that can be used to improve the quality of service in the field of telecommunication. The problems that were facing the mobile telecommunication systems are the coverage and capacity. A single cell call admission control scheme has a fixed link capacity, a part of this capacity is occupied by the handoff calls, so the priority of handoff calls is more than that of the other calls, the SC-CAC sets a threshold value and the capacity of all channels should be less than the threshold to be able for the cell to accept new calls [13], [14]. One of the SC-CAC schemes provides the availability of reserving channels for both data such as (multimedia, video) and voice. The cell sets an upper limit for the channel and if this limit is exceeded the new voice calls will be rejected; for dealing with the handoff calls a queuing system can be used [15]. Another algorithm scheme is based on the Guaranteed Bit Rate (GBR), in this scheme the AC algorithm accepts a new call if the sum of GBR of the new user and the old users is not exceeded the average uplink cell. One of the requirements to accept a new call in this scheme is the number of the Physical Resource Blocks (PRB) [13]. Many tradeoff parameters should be taken in consideration when comparing between SC-CAC and MC-CAC algorithms (which is the subject of the following section) like stability of the system, throughput, capacity, probability of outage, dropping and blocking probability [15], [16]. When the communication system is working based on CDMA technology, the user is connected to more than one base station. In 3G networks the Radio Network Controller (RNC) transfers calls between base stations without any disconnection, so if one base station does not able to accept a user the RNC will move the user to another base station and this will increase the quality of service and reduce the blocking and dropping probabilities. In uplink WCDMA system with a specific number of base stations and number of service classes, in the central cell the total received power equals the summation of the received power from the mobile users in the centre cell and the power from the nearing cells, beside the background noise. Figure 1 shows one of the multi cell networks [15],[17].

Multi-Cell admission control algorithms reduce the probability of noise in the neighbouring cells, and this results to an increase in the admission control process, and due to reduce the blocking probability to maintain a good quality of service, the MC-CAC rejects more calls than the SC-CAC and this means that the MC-CAC admits calls less than the single cell. The MC-CAC power control based, set a target for the Signal-to-Interference Ratio (SIR), then the algorithm compares the received SIR with the target value, if received SIR is less than the target value then the power of the transmitter is increased, and if the received SIR is more than the target value the power of the transmitter is then decreased [18], [19].

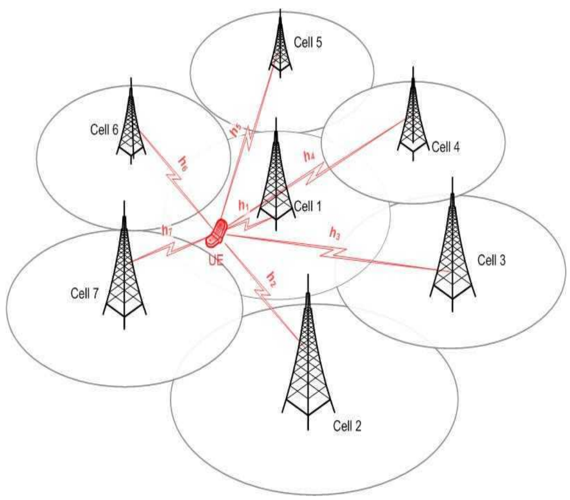

Figure 1. Seven cell scheme (MC)

4 PROPOSED MODEL AND SIMULATION

In this section presents the simulation models, parameter tests and performance analysis of the proposed CAC for single-cell and multi-cell. These proposed models applied on different load traffic voice, multimedia and video. In this simulation the SNR with respect to probability of outage are considered.

4-1 NETWORK TOPOLOGY

The simulation considers a three cells system, each cell has a center base station with an omnidirectional antennas. When m (the number of cells) is equal one, then the SC-CAC is the algorithm for the network, otherwise the algorithm is MC-CAC

4-2 PROPAGATION MODEL

The propagation channel is assumed to be a noisy and multipath fading channel, AWGN and Rayleigh fading is considered, beside the affect of attenuation that is represented by the equation of the path gain.

4-3 TRAFFIC MODEL

The WCDMA system contains two types of services, real-time services and non-real time services, and as the WCDMA system is limited capacity, the real-time services have higher priority than the non-real time services to reserve a part of the channel capacity. The simulation assumed three types of service classes voice calls, video, and multimedia with an outage threshold for each service class. Table 1 shows these service classes and their outage thresholds.

Table 1. Shows service classes

Service Class	Outage threshold (dB)
Class 1 : Voice	-19.9
Class 2 : Multimedia	-13.7
Class 3 : Video	-11.57

4-4 SIMULATION AND RESULTS

The simulation compares between the performance of SC-CAC and MC-CAC with three different traffic service classes, and computes the outage probability of the fading channel in both algorithms in terms of the BER values. Capacity of the channel also is computed based on Shannon capacity formula to compare the performance of the admission control mechanism of the two algorithms. All simulation results under the condition of unequal received power. The simulation parameters input used through simulation summarized in Table 2.

Table 2. Summarized the input parameters in the simulation model.

Parameters	Value
Cellular Layout	3 Cell maximum
Noise Power	$1*10^{-5}$
Bandwidth	10 Mbps
Iteration	100
SNR	[0,1,.....35 dB]
BER (test)	$1*10^{-3}$,$1*10^{-6}$
Base station antenna	Omnidirectional
Average SNR	0:35 dB

Voice service class is considered, with a value of outage SIR threshold of -19.9 dB. The main difference than the voice service over Rayleigh channel for equal power that in this scenario it is assumed un-equal power, so the total SNR from the three cells for examples not equal (3*SNR) .

This represents that for single cell, the unequal power cases will be same as equal power cases, for that the system has different practical scenarios of different power types and different service cases. The average SNR varies from 0 to 35 dB; the target is to compute the outage probability to measure the quality of service for both SC-CAC and MC-CAC. The BER has two values $1*10^{-3}$ and $1*10^{-6}$. Figure.2 shows that at 35 dB SNR and if the number of cells is 1 (single cell), with a BER of $1*10^{-3}$ then the outage probability (Pout) is $1.11*10^{-3}$. While in the case of two cells with same value of average SNR and BER, the outage probability is $2*10^{-6}$. Furthermore, the outage probability for the case of three cells case with the same varying parameters is very close to $1*10^{-8}$. The figure also shows the probability of outage Pout results for the case of $1*10^{-6}$ BER which is an ideal case. The outage probability difference between the three cases becomes larger after a 15 dB average SNR. This section assumes unequal power of SNR for multi cells usage.

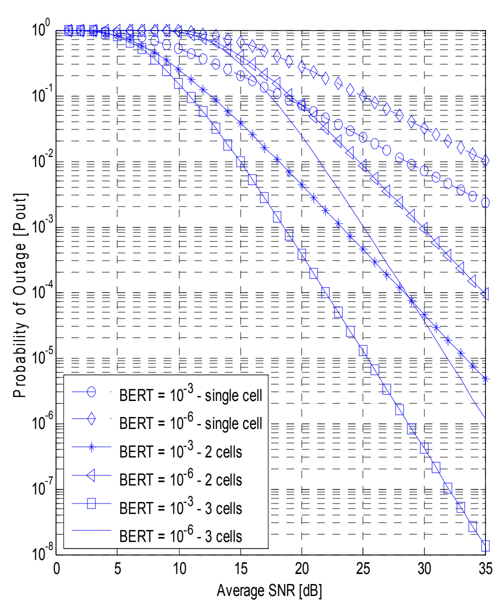

Fig 2. Probability of outage (Pout) vs. Average SNR [dB] for only class 1 (voice) users for unequal power.

The outage probability for the three cells case is approximately close to zero when the average SNR is 35 dB. The above figure implies that the probability of SNR at output is being below the threshold value of class 1 users (voice calls) which is -19.9 dB, is very small in the case when two and three cells are involved in the call admission control (CAC), that results to higher quality of service performance than the case of single cell.

Multimedia services include images, movies, music, and medium multimedia; it considered a low data rate services. This part of simulation considers a -13.7 outage SIR threshold for the multimedia class users. The average SNR varies from 0 to 35 dB; the target is to compute the outage probability to measure the quality of service (QoS) for both SC-CAC and MC-CAC. The BER has two values $1*10^{-3}$ and $1*10^{-6}$. Figure 3 shows that at 35 dB SNR and if the number of cells is 1 (single cell), with a BER of $1*10^{-3}$ then the outage probability (Pout) is $2.5*10^{-4}$.

While in the case of two cells with same value of average SNR and BER, the outage probability is $1.25*10^{-7}$. Furthermore, the outage probability for the case of three cells with the same varying parameters is very close to $1*10^{-10}$. The figure also shows the probability of outage Pout results for the case of $1*10^{-6}$ BER which is an ideal case. The outage probability difference between the three cases becomes larger after a 17 dB average SNR.

The figure 3 implies that the probability of SNR at output is being below the threshold value of class 2 users (Multimedia services) which is -13.7 dB , is very small in the case when two and three cells are involved in the call admission control (CAC) , that results to higher quality of service performance than the case of single cell.

Video services are high data rate services; this part of simulation considers a -11.57 outage SIR threshold for the video class users. The average SNR varies from 0 to 35 dB; the target is to compute the outage probability to measure the quality of service (QoS) for both SC-CAC and MC-CAC. The BER has two values $1*10^{-3}$ and $1*10^{-6}$.

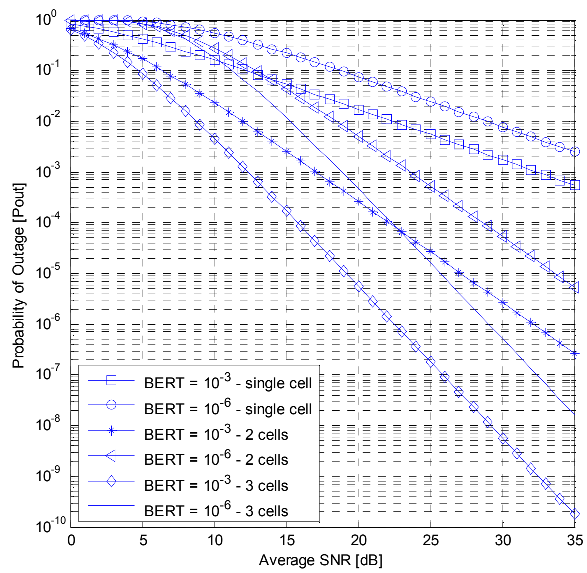

Figure 3. Probability of outage (Pout) vs. Average SNR [dB] for only class 2 (multimedia) users using unequal power.

Figure 4 shows that at 35 dB SNR and if the number of cells is 1 (single cell), with a BER of $1*10^{-3}$ then the outage probability (Pout) is $1.25*10^{-4}$. While in the case of two cells with same value of average SNR and BER, the outage probability is $1*10^{-7}$. Furthermore, the outage probability for the case of three cells with the same varying parameters is $2.5*10^{-12}$. The figure also shows the probability of outage Pout results for the case of $1*10^{-6}$ BER which is an ideal case. The outage probability difference between the three cases becomes larger after a 15 dB average SNR.

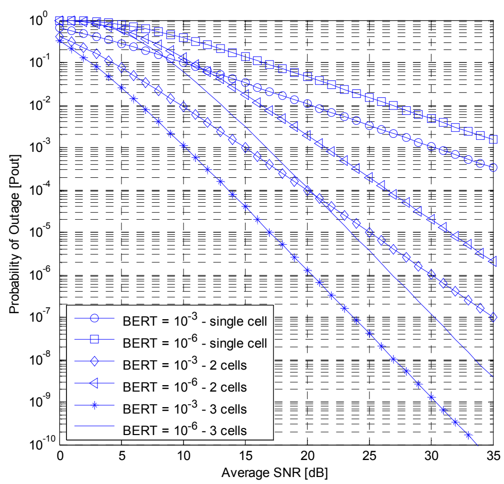

Figure 4. Probability of outage (Pout) vs. Average SNR [dB] for only class 3 (video) users using unequal power SNR

The above figure implies that the probability of SNR at output is being below the threshold value of class 2 users (Multimedia services) which is -11.57 dB, is very small in the case when two and three cells are involved in the CAC that results to higher quality of service performance than the case of single cell.

5 CONCLUSIONS

This research made the analysis by discussing different scenarios of call admission control, and the simulation results come with new conclusions about the performance of SC-CAC and MC-CAC, in terms of the mechanisms that the both algorithms are using to admit or reject new users or calls based on specific control admission criteria.

From the simulation results of the probability outage, and under a fixed value of BER and average signal to noise ratio, the MC-CAC shows the minimum values of outage probability which means that this type of call admission controls maintains the minimum in this simulation the best situation to operate the voice services with a good quality of service will be achieved in the case of three cell layout. The outage probability difference between the SC and MC cases becomes larger. The comparison between the results of voice and multimedia the outage probability in multimedia service class is less than that of voice service class, so the conclusion is that the QoS performance with multi cell scheme for the multimedia class users is better than the QoS for the voice call, this is due to the increased demands on voice calls because the voice service is real time service.

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