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Improving Quality Of Service by Comparison and Evaluation Performance Of SC-AC and MC-AC in Wireless Communication Network

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Abstract :

The main aim of this paper is analysis and modeling different types of call admission control, using Multi Cell admission control algorithms (MC-AC) algorithm in the communication systems over using Single-Cell Admission Control (SC-AC). The analysis of the technical issues that is related to communication systems will help the operators in the field of telecom sector, in some way that provides the ability to improve the quality of service of the communication system. The simulation model takes into consideration the effect of multipath fading and signal to interference noise ratio that degrades the quality of the service, and it shows that the diversity techniques is a very important technique to deal with multi path fading channels. The traffic model of this paper expands the performance of three types of service classes: the voice calls, multimedia, and video. The class services were categorized to real time and non-real time services upon the priority of the service.

The research comes with the conclusion that MC-CAC is more effective in the communication system than the SC-CAC as the simulated results of the outage probability and channel capacity were implied; this means the quality of service (QoS) will be improved with the MC-CAC schemes.

Key words: Wireless Communication, Performance Evaluation, Quality of Service (QoS), Call Admission Control (CAC), Outage Probability.

تحسين جودة الخدمة بمقارنة وتقييم أداء نظامي الخلية الواحدة و الخلايا المتعددة في شبكة الاتصالات اللاسلكية

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الخلاصة:

إن الهدف الرئيسي من هذا البحث هو تحليل ونمذجة أنواع مختلفة من السيطرة على تسليم المكالمة باستخدام خوارزمية نظام الخلايا المتعددة (MC-AC) في أنظمة الاتصالات إضافة إلى استخدام خوارزمية تسليم المكالمة في نظام الخلية الواحدة (SC-AC) .

ان عملية تحليل المسائل التقنية التي تتعلق بنظام الاتصالات تساعد العاملين في قطاع الاتصالات بطريقة ما توفر القدرة على تحسين نوعية الخدمة في نظام الاتصالات وقد اخذ نموذج المحاكاة بعين الاعتبار اثر تعدد مسارات المكالمة ونسبة ضوضاء التداخل التي تخفض من جودة الخدمة وهذا يظهر بان تقنيات التنوع هي أسلوب مهم جدا للتعامل مع قنوات المسار المتعدد.نموذج حركة المرور في هذه الدراسة يوسع الاداء من خلال استخدام ثلاثة انواع من انماط الخدمة وهي مكالمة الصوت والوسائط المتعددة والفيديو.صنفت خدمات الانماط في الوقت الحقيقي وغير الحقيقي نسبة الى أولوية الخدمة.

أتى البحث باستنتاج ان MC-CAC هو اكثر فعالية في نظام الاتصالات من SC-CAC من خلال نتائج المحاكاة التي انطوت على احتمال انقطاع الخدمة وقدرة القناة وهذا يعني ان جودة خدمة (Qos) سوف تتحسن مع مخططات MC-CAC.

1. Introduction:

Code division multiple access (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. If the code is correlated with the signal at any time offset other than zero, the correlation should be as close to zero as possible. This is referred to as auto-correlation and is used to reject multi-path interference. [1]

To discriminate CDMA from others technologies that they are in the same range, CDMA a professional Multi class Call Admission Control and Adaptive Scheduling (or the process that identify, prioritize and coordinate the time required for transmission of packets) for WCDMA Wireless Network allocates typical codes for every communication. [2, 3]

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 mobile telecommunication systems are the coverage and capacity. The third generation of mobile communication changed the way of communication due to the dynamic use of the capacity and network coverage. As the numbers of the users are increased, the capacity of the network and quality of service is degrading. Where WCDMA technology can accepts more number of users therefore the capacity of the network is increased. [4, 5]

By controlling the number of accepted calls, the CAC improves the performance and yields to high throughput in the system, also the CAC should be capable to accept new users without any effects on the other connected users.

Two categories of the CAC are considered, the ideal CAC and the interactive CAC. The ideal CAC is based on the power algorithm so the CAC prior to accept any call it checks the resulting power after the new user is accepted to maintain a good quality of service, while the interactive CAC can accept the users during the test of the connection. [6]

New CAC based on the power control was proposed. In this schemes the interference measurements inside and outside the cell are compared with a threshold value which is a value that reduces the error probability. If the new call is under the threshold value it will be accepted, otherwise it will be rejected. [5, 6]

In all cases the target is to increase the performance of the system by decreasing the blocking probability, dropping probability, outage probability and increasing the quality of the service. [5]

The probability of a handoff failure is called handoff failure probability during the life of a call; a mobile user may cross several cell boundaries and hence may require several successful handoffs. Failure to get a successful handoff at any cell in the path forces the network to discontinue service to the user. A multiple power scheme thresholds for multiple services are one of the CAC algorithms. Another scheme works by estimating the power change that may results due to accept a new user either the power of the servicing cell or the power of the nearing cells.[7] Another two common schemes in the field of CAC, are the SC-CAC and MC-CAC; these two schemes will be describes in following sections.

In [8] Zreikat A. et al. presented a mechanism using intelligent control by using Asynchronous Transfer Mode (ATM) networks to traffic and control.

Most implementations of new studies in this field only considered a single service class with identical traffic characteristics. Although it is known that, the implementation converges slowly, a multi-service connection admission control is proposed that harness the fast learning capability of modular networks for cell-loss-ratio prediction. The proposed scheme in their studies does not require accurate models of network process. Simulation was done to compare the performance of the proposed scheme with an identical bandwidth. An integrated approach was proposed towards multi service admission control that uses a powerful modular Neural Networks known as Hierarchical Mixture of Experts (HME).The approach used Cell Less Ratio (CLR) predictions by an HME at each switch. Due to random weight initialization, the controller does not perform well. Catrein D. [9] presented power based cell call admission control scheme. This approach investigates the trade off in the up-link direction using an (MC-AC) algorithm based on power multi cell admission control. The simulation shows that the proposed algorithm has many advantages over the single call admission control, due to more system stability and total system throughput. A tradeoff between the dropping and blocking probabilities has bee also discussed. The dropping probability can be lowered without much increase in the blocking probability.

A high capacity gain can be done under heterogeneous load distribution, but these services have a limited converge.

In [10] Kwon E. et al proposed a scheme for multi-SC wireless Next Generation Network (NGN) under the Probabilistic Bandwidth Reservation Scheme (PBRS) which depends on the total number of Bus housed in a cell. The various SCs supported by the network led to the use of multidimensional Markov chains, and each dimension of the chain corresponds to another SC call stream. As the network traffic is building up, call streams are reduced to make room for high priority SC calls and guarantee the quality of service of current calls, for that, when the available resources are decreased, the number of especially low priority calls is again decreased. This is achieved by implement certain admission probabilities to various states of the multi dimensional Markov chain to different SC traffic conditions. The admission probability of less priority SC calls is decreased while the network traffic is going up.

2. Call Admission control:

2.1 Single Cell Call Admission Control (SC-CAC):

A single cell call admission control scheme has a fixed link capacity. 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 a capacity of all channels should be less than the threshold to be able for the cell to accept new calls. [11, 12]

In the single cell CAC, the type of modulation is one of the important requirements of the system and in some cases two or more types of modulation can be used up to (11) types such as Multi-Level Quadrature Amplitude Modulation (M-QAM) and Quadrature Phase Shift Keying (QPSK).The call requests that the single cell receives are of three types that are new user, modulation switched, and handoff. The new user request call will be dropped when the connection is not idle and the channels are performing the process of handoff or modulation switching. [13]

The SC-CAC algorithms are used to measure the performance of the system based on some points such as the outage probability that affects the quality of service. The outage probability is related to the Bit Error Rate (BER). [14]

The SC-CAC provides availability of reserving channels for both data such as multimedia, video and voice. The cell sets an upper limit for the channel. If this limit is exceeded the new voice calls will be rejected. In order to deal with the handoff calls a queuing system can be used.[15]

Another algorithm scheme is based on the Guaranteed Bit Rate (GBR). The Admission Control (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. The requirements to accept a new call in such algorithm is the number of the Physical Resource Blocks (PRB). [16]

Many tradeoff parameters should be into account when comparing between SC-CAC and MC-CAC algorithms (which is the subject of the following section) such stability of the system, throughput, capacity, probability of outage, dropping and blocking probability. [15]

2.2 Multi Cell Call Admission control (MC-CAC):

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 is 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. **Figure (1)** shows the procedure to move the mobile station from one node (B) which is the base station to another one, but the user is connected to one node B at a specific time. [17]

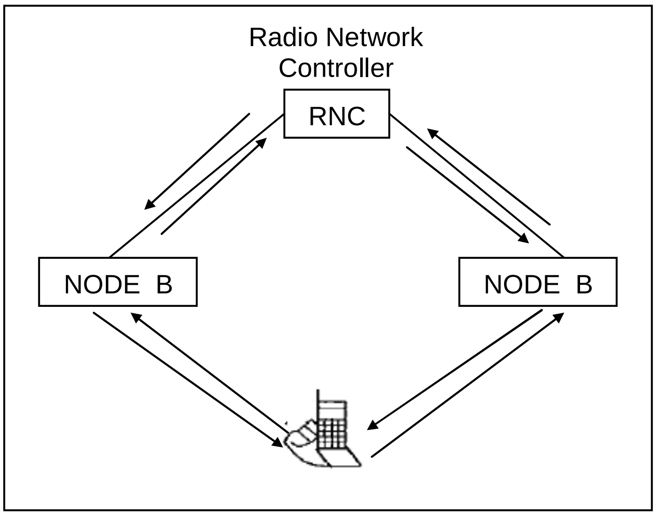

Fig .(1): Moving the user between base stations [17]

In the case of power-based MC-CAC, the network transfers a mixed type of data and voice (service classes) where each class requires a specific value of bit rate. When a new user with a certain class of service transmits, an important factor should be taken in consideration, which is the ratio between the received power from the mobile station to the total value of the interference. [18, 19]

Multi-Cell admission control algorithms reduce the probability of noise in the neighboring 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. [20]

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.

The power of the transmitter is increased if the received SIR is less than the target value while the power of the transmitter is decreased if the received SIR is more than the target value .[21]

2.3 System Model:

The work considered a Wideband Code Division Multiple Access (WCDMA) cellular radio system. (M) is base station and (K) is service classes. Three cells scheme is used. The SC-CAC algorithm will take place in the case that the number of cells is one while the MC-CAC will take place if the number of cells is two or three.

The system model considers the effect of Additive White Gaussian Noise (AWGN) and the effect of Rayleigh multi path fading. Assuming the transmitted signal is $s(t)$ and the noise is $n(t)$, then the received signal $r(t)$ can be written with regards to the AWGN as in equation below. [22]

$$r(t) = n(t) + s(t) \qquad \text{.......................................} (1)$$

The system considers the transmitted power vector. P_t of the traveling users of any class as:

$$P_t = [P^1, P^2, P^3, ..., P^M] \qquad \text{.......................................} (2)$$

The model represents the attenuation that the propagated signal will face through the medium by the path gain H. H it is a channel matrix . Path gain can be written as the following matrix: [19]

$$H = \begin{bmatrix} h_{1,1} & h_{1,2} & h_{1,M} \\ : & : & : \\ h_{N,1} & ..... & h_{N,M} \end{bmatrix} \qquad \text{.......................................} (3)$$

Where $h_{N,M}$ is the path gain between the user N and base station M in the uplink direction.

N_t is the total number of users in cell .

The total received power at base station M is written as matrix notations:

$$P_{tot,M} = P_t.H + P_N \qquad \text{.......................................} (4)$$

Where $P_{tot,M}$ the total received power at base station is M , P_N is the back ground noise.

Therefore, the total received signal can be written as : [19]

$$P_{tot,M} = P_{own,M} + P_{neigh,M} + P_N \qquad \text{.......................................} (5)$$

Where $P_{own,M}$ is the received power from the mobile station in the serving cell , and $P_{neigh,M}$ is the received power from mobile station in the neighboring cells.

The algorithm makes the decision based on the threshold value of signal to interference noise ratio (SINR) which can be written as: [23]

$$SINR = \frac{P_r}{N_o B + P_I} \qquad \text{.......................................} (6)$$

Where P_r is the received power, N_o is the noise power, B is the bandwidth, P_I is the average power of the interference.

The transmitted power after the CAC accepts a new user will be:

$$P_{t,new} = P_t \frac{SNIR_o}{SNIR_i} \qquad (7)$$

P_t is the old transmitted power prior to accept the new users, $SNIR_o$ is the target value of the $SNIR$, and $SNIR_i$ is the current value of the signal to interference noise ratio.

The system consider a control admission criteria based on the outage probability after admitting new users in the case of SC-CAC and MC-CAC, beside of the calculated capacity of the system based on Shannon capacity theory, to measure the performance of the system and the quality of service QoS. In Rayleigh fading channel the bit error rate is given by this formula: [22]

$$P_p = \frac{1}{2} erfc\left(\sqrt{\frac{|h|^2 E_b}{N_o}}\right) = \frac{1}{2} erfc\sqrt{g} \qquad (8)$$

Where γ is the effective bit energy to noise ratio, h is the Rayleigh multipath channel complex scaling factor, this factor is a slope of the received signal in Rayleigh fading channel [21].

$\frac{E_b}{N_o}$ is the bit energy to noise ratio

The outage probability is described as the probability that the Signal to Noise Ratio (SNR) at the output is being below an outage threshold value (Γ_{th}). The outage threshold is a limit value for the SNR to measure the quality of service (QoS) .The outage probability is the integration of the Probability Density Function (PDF) of the communication channel with limits of integration from zero to the value(Γ_{th}) . [21]

In the system model of this paper the techniques are used to avoid the effects of multipath fading in order to increase the quality of service of the system. The system model considers a Nakagami-m distribution channel, the distribution or probability density function of this channel is written as: [23]

$$P_{Z(Z)} = \frac{2m^m z^{2m-1}}{\Gamma(m) P_r^m} e^{\left[-\frac{mz^2}{P_r}\right]} \qquad (9)$$

Where P_r: average received power , $\Gamma(\ )$: Gamma function , m : Nakagami fading parameter and z : probability distribution .

Now let $x = z^2$, and x is a random variable , then equation (6) will be: [23]

$$P_{z^2(x)} = \frac{m^m}{P_r^{\,m}} \frac{x^{m-1}}{\Gamma(m)} e^{\left[\frac{-mx}{P_r}\right]} \qquad \text{...} (10)$$

The outage probability is computed for the channel with Rayleigh fading parameter $m=1$ so the distribution represents Rayleigh fading, then the outage probability P_{out} written as :

$$P_{out} = \int_0^{\Gamma_{th}} p_z(x)dx \qquad \text{...} (11)$$

2.4 Simulation Model:

The model of system performance used in this research which is call admission control methods using Matlab software (R 2010 b).The simulation aims to evaluate the performance and compare the QoS for the SC-CAC and the MC-CAC under three services classes based on the computed outage probability and the computed channel capacity. The simulation used cells system with respect to the topology of system model used in section (2.3). A noisy and multipath fading channel, Nakagami and Rayleigh fading are considered in propagation channel in addition with attenuations affect that represented by the equation of the path gain. Two types of services, real-time and non-real time services are used in WCDMA system as Traffic model. Related to 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 voice calls, video and multimedia classes used with an outage threshold (dB) (-19.9,-13.7,-11.57) for each one of them.

3. Simulation Results:

In this section a comparison between the performance of SC-CAC and MC-CAC with three different traffic service classes is done with respect to the outage probability of the fading channel (in both algorithms) in terms of the BER values using the Bit Error Rate Test (BERT).

Table (1) shows the input parameters and their relative values used in the simulation model. Parameters including Cellular layout, Noise power, Bandwidth, Iteration, SNR, Γ (Gamma), BER_T, Base station Antenna and Average SNR are all used while their values are shown in **Table (1).**

Table .(1): The input parameters in the simulated model

Parameter	***Value***
Cellular Layout	**3 cells Maximum**
Noise power	**1x 10^{-5} db**
Bandwidth	**10 Mbps**
Iteration	**100Epoch**
SNR	**[0,1, ... , 20 dB]**
Γ (Gamma)	**[0,1, ... ,35 dB]**
BER_T	**1x10^{-3} , 1x10^{-6}**
Base station Antenna	**Omni directional**
Average SNR	**0: 35 dB**

3.1 Voice calls service simulation results:

The threshold value used in outage SIR is -19.9 dB wile the BER is set to 1*10^{-3} and 1*10^{-6} . Theses values were taken to study the performance of two algorithms based on actual and ideal cases. After that, the code will compute the corresponding probability for the SC and MC cells and find out the Shannon capacity for the computed probabilities. The system has compared the outage probability for MC and SC based on a predefined BER and SIR then plotted for the average SNR against the probability of each of the systems. The voice service class is considered, with a value of outage SIR threshold of -19.9 dB .The average SNR was inputted 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 the outage probability P_{out} at 35 dB SNR when the number of cells is 1 (single cell). The outage probability P_{out} is close to 1*10^{-2} with a BER of 1*10^{-3}.

The outage probability is very close to 1x10^{-4} with same value of average SNR and BER in the case of two cells, wile the outage probability for the case of three cells case with the same varying parameters is very close to the 1*10^{-6}. The probability of outage P_{out} results for the case of 1*10^{-6} BER which is an ideal case also shown in **Figure (2).** The outage probability difference between the three cases becomes larger after a 15 dB average SNR. This section assumes equal power of SNR for multi cells usage.

The main aim of the simulation is to show the relation between the average SNR (dB) and the outage probability for SC and MC.

The BERT was given the values 10^{-3} and 10^{-6} for single cell, 2 cells and 3 cells.

The simulation can include other numbers of cells, but it is worth mentioning that studying and testing the SNR against the outage probability for two cells and three cells is enough to reach for the results required related to the MC scenario.

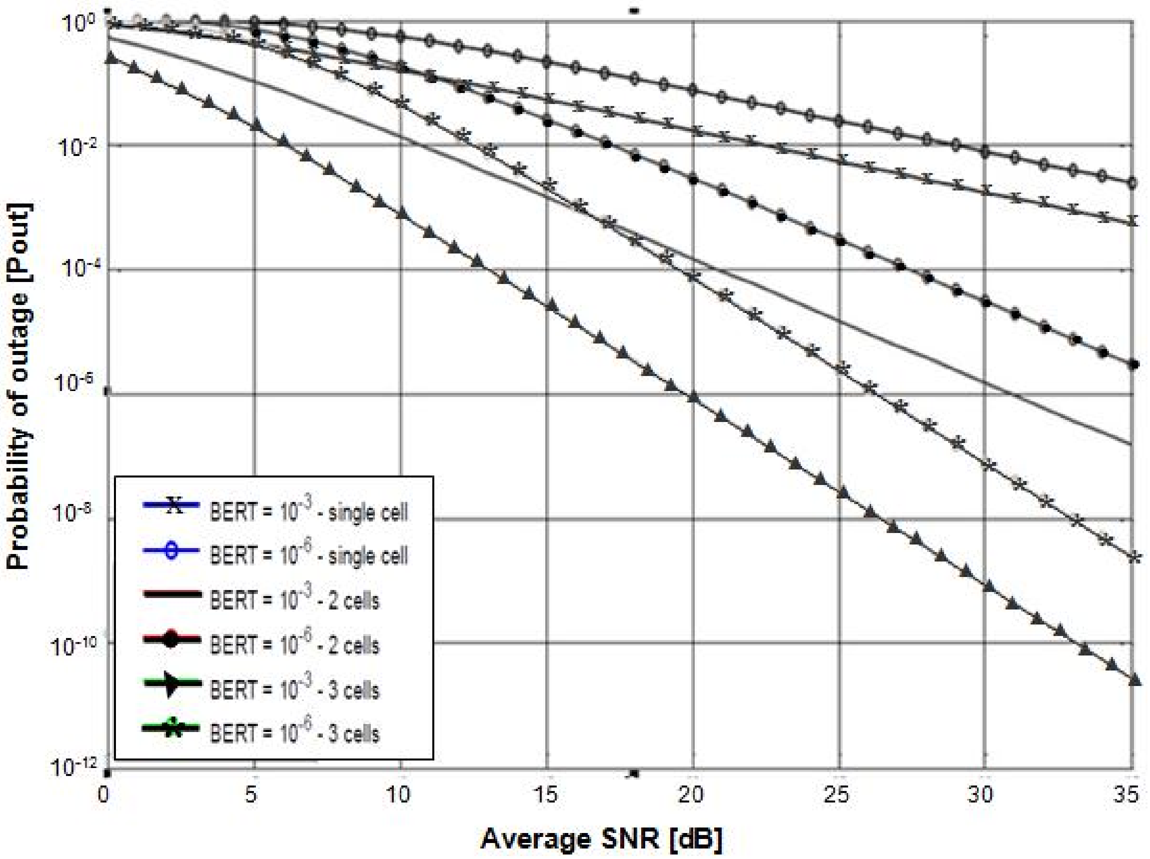

Fig .(2): Probability of outage (Pout) vs. Average SNR [dB] for only class 1 (voice) users for equal power

At average SNR equal to 35 dB, the outage probability of three cells case is approximately close to zero. Figure(2) also shows that in voice calls class the probability of SNR at output is being below the threshold value (-19.9 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. The same procedure is applied for Nakagmia fading channel where the distribution of this channels same as equation (10), but with $m = 2$ to explain of Nakagami fading effect, this channel is more practical and is very common in wireless communications. For voice services and Nakagami fading channel. **Figure (3)** represents the case, as shown that the outage probability is enhanced compared to Rayleigh mode under voice service.

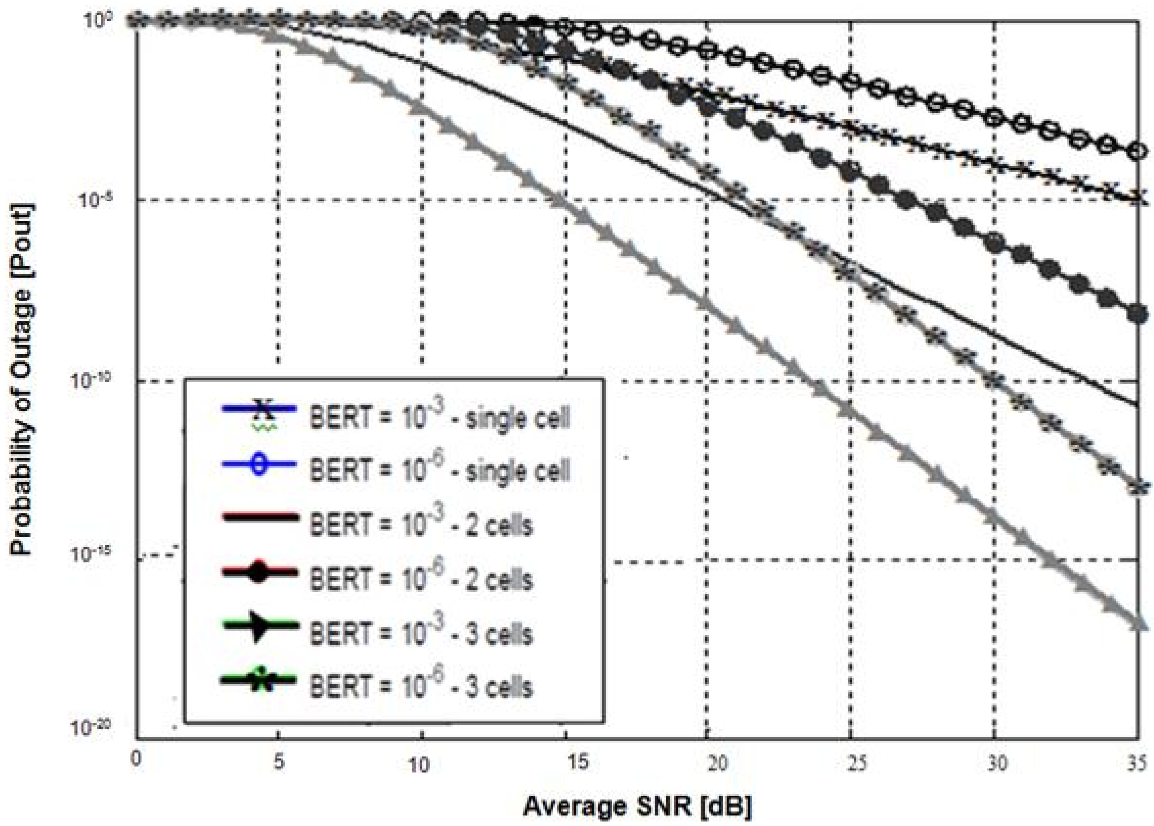

Fig .(3): Probability of outage (Pout) vs. Average SNR [dB] for only class 1 (voice) users. Nakagami channel for equal power

3.2 Multimedia services simulation results:

The outage signal-to-interference ratio threshold is set to the threshold value: -13.7 dB. Then the value of BER is set to two values which are: $1*10^{-3}$ and $1*x10^{-6}$.

The Shannon capacity will be found for SC and MC cells probabilities comparing these results with respect to BER & SIR. The implemented code aims to find the QoS as well for the multimedia services. Multimedia services require better quality of service as seen in the results of the simulation analysis that also shows the BER role in the relation between the average SNR and the outage probability of the system.

Multimedia services (images, movies, music, and medium multimedia) which considered as low data rate services has -13.7 outage SIR threshold for the multimedia class users. SNR varies from 0 to 35 dB. (QoS) is measured depending on these values for both SC-CAC and MC-CAC. The BER used $1*10^{-3}$ and $1*10^{-6}$ values.

Figure (4) shows that the outage probability P_{out} is less than $1*10^{-2}$at 35 dB SNR if the number of cells is 1 (single cell), with a BER of $1*10^{-3}$ while P_{out} is $1*10^{-5}$ in the case of two cells with same value of average SNR and BER Furthermore, the outage probability for the case of three cells with the same varying parameters is very close to $1*10^{-8}$. The Figure also shows the probability of outage P_{out} 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, while 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 CAC that results to higher quality of service performance than the case of single cell.

Figure (5) represents probability of outage for multimedia service under Nakagami fading channel, as shown that the results is better than Rayleigh mode due to that in case of $m = 2$, the fading effect will be quite small, while the worst case of fading at Rayleigh channel.

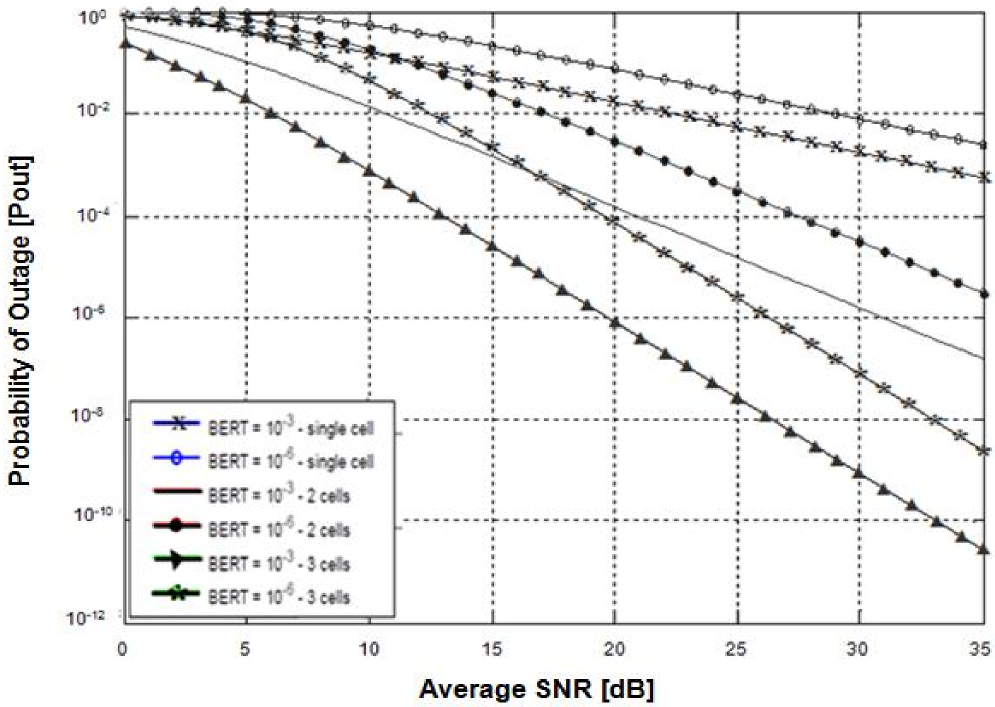

Fig (4): Probability of outage (Pout) vs. Average SNR [dB] for only class 2 (multimedia) users using equal power

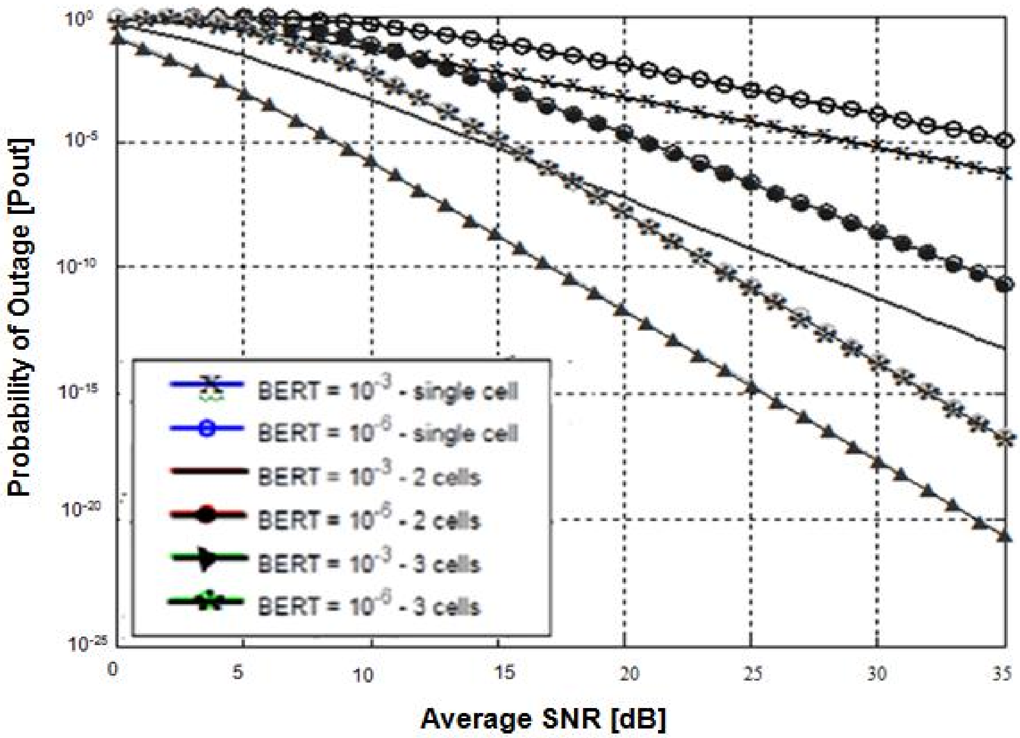

Fig .(5) Probability of outage (Pout) vs. Average SNR [dB] for only class 1 (multimedia) users. Nakagami channel using equal power SNR

3.3 Video service simulation results:

The outage signal-to-interference ratio threshold is set to the value -11.57 dB then the value of BER is set to two values which are $1*10^{-3}$ and $1*10^{-6}$.

After that, the code computes using the same procedures of computing with SC and MC cells with predefined of BER and SIR in (4.1) that aim to find QoS as well for the video services. The BER also plays a major role in the relation between the average SNR and the outage probability of the system.

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

Figure (6) 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 P_{out} is near $1*10^{-3}$. While in the case of two cells with same value of average SNR and BER, the outage probability is near $1*10^{-6}$.

Furthermore, the outage probability for the case of three cells with the same varying parameters is $1*10^{-8}$. 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.

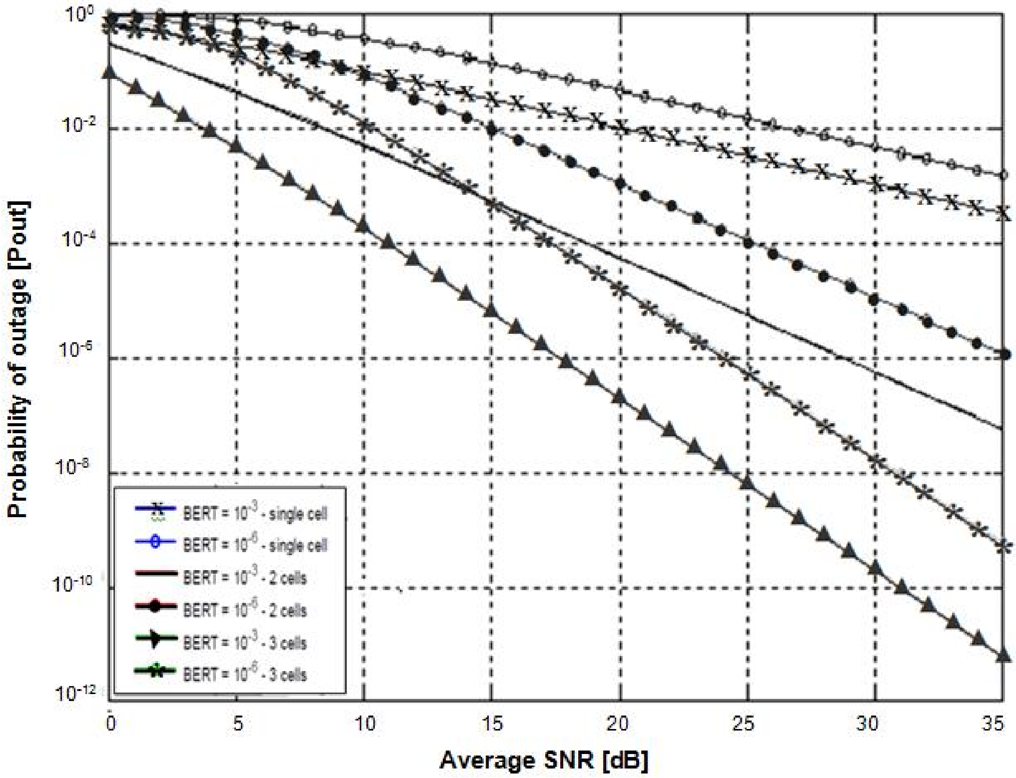

Fig (6): Probability of outage (Pout) vs. Average SNR [dB] for only class 3 (video) users using equal power SNR

Figure (6) 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.

Figure.7 represents probability of outage for video service under Nakagami fading channel, as shown that the results are better than Rayleigh mode.

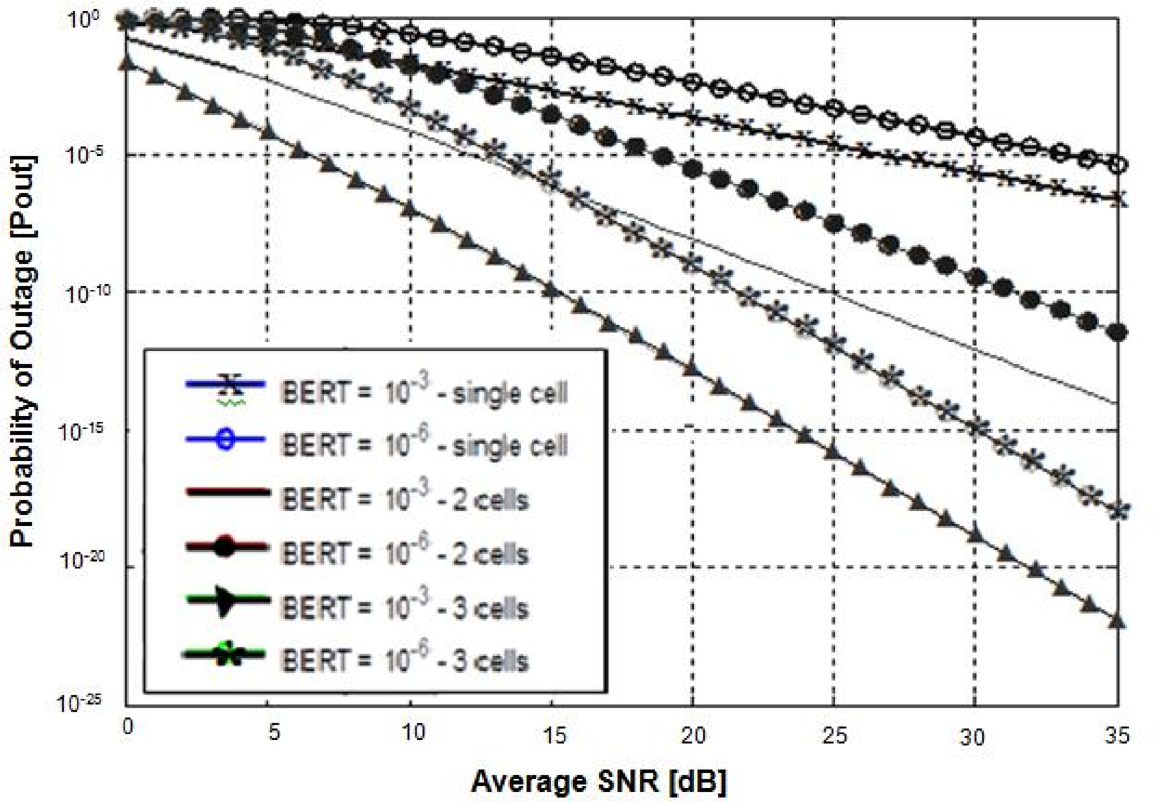

Fig .(7) Probability of outage (Pout) vs. Average SNR [dB] for only class 3 (video) users. Under Nakagami fading channel using equal power SNR

4. Conclusions:

A simple analytical model was used in this research to evaluate WCDMA system used Matlab software (R 2010 b) with respect to SC-CAC and MC-CAC performance .The results show indicative and relative effects of key system parameters variations. Simulation results show that the call admission controls type MC-CAC is suitable work for a high quality of service because it have minimum value of outage probability and minimum SNR that required for a high quality of service. On the other hand, the SC-CAC shows high values of outage probability, therefore the quality of service is not as high as needed 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.

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 result shows MC-CAC has many advantages over SC-CAC in terms of channel capacity and probability of outage. In addition these results can enhance a mobile application testing model which required ensuring continuous evaluation of the mobile application under development. This is an ongoing research to propose a mobile application testing model and in this paper, we look into all possible aspects for the design criteria of the model and designed a mobile application testing model to be evaluated later.

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