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Investigation and Improving of Call Admission Control and Load Estimation in WCDMA system

Md. Khairul Islam, Dr. M. Mahbubur Rahman, M. Amzad Hossain, Dr. Tapan Kumar Godder, Md. Sipon Miah

Abstract— Wideband Code Division Multiple Access (WCDMA) is interference limited multiple access technique. It is widely used in the 3rd generation mobile networks like UMTS. When a new call arrives in the system to get admission, it checks whether the call is admitted or not based on some parameters like signal to interference ratio (SIR), transmission power of the Radio Access Network (RAN) and the air interface load .The maximum capacity of Wideband Code Division Multiple Access (WCDMA) depends on the current interference in the system. Admitting new call and user movement increase the interference level. However, high interference causes the system degradation of quality of service (QoS). Therefore robust call admission control and load estimation is needed. In this paper, we have investigated the wideband interference based call admission control that is much better to block the access of a user to the network than having to drop already active users. Such decisions are made by the admission control routine. Simulation results show that new user is admitted into the system if the total interference is less than threshold noise otherwise the user is rejected. Also throughput rate is increased within threshold limit of noise rise with power decreased and improving the blocking probability and dropping probability. Adaptive call admission control is combination of WPB and TB CAC that provides lower probability of call blocking and call dropping than WPB and TB CAC. Therefore ACAC is the best CAC algorithm that provides most efficient and best quality of services.

Index Terms—WCDMA, CAC, Load Estimation, Throughput, Noise Rise.

1. Introduction

WCDMA is a promising technique for achieving the high data capacity and spectral efficiency requirements for wireless communication system of the near future [1]. Call Admission Control (CAC) schemes are the most critical part for wireless networks.CAC schemes provide users with access to a wireless network for services. A good CAC scheme has to balance call blocking and call dropping in order to provide the desired QoS requirements.

Several admission control schemes have been suggested in [1–5]. In [1, 3, 4], the use of the total power received by the Radio Network Centre (RNC) is supported as the primary uplink admission control decision criterion, relative to the noise level. In [1,4] a downlink admission control algorithm based on the total downlink transmission power is presented.

Young-Long Chen et al. [6] have proposed a method which combines the CAC and power control mechanisms and operates in a centralized control manner.

- Md. Khairul Islam, Corresponding Author
  Lecturer, Dept. of Computer Science and Engineering,
  Prime University
  E-mail: khairul.ice06@gmail.com
- Dr. M. Mahbubur Rahman,, Professor in Dept. of Information and Communication Engineering , Islamic University
  Email: mrahman@ice.iu.ac.bd
- Mohammad Amzad Hossain, Lecturer, Dept. of ICE, Noakhali Science and Technology, Email: amzadiceiu@gmail.com
- Dr. Tapan Kumar Godder, Professor in Dept. of Information and Communication Engineering, Islamic University
  Email: tkice@iu.ac.bd
- Md. Sipon Miah, Assistant Professor in Dept. of Information and Communication Engineering, Islamic University
  Email:sipon@ice.iu.ac.bd

In this paper, interference based admission control provide better service because it is noise sensitive. Power control is also necessary for getting better QoS in distributed environment. When noise is exceed than threshold then new user is not admitted into the system. So existing user could get better service and call dropping probability is very low. To optimize the threshold is more important because too large and too small threshold may degrade the performance of the system.

The rest of this paper is organized as follows. In section II the admission control strategy problem formulation is presented. In section III, describe the system model and uplink load estimation and downlink load estimations based on the wideband received power and throughput. While section IV presents the simulation model, the obtained results, as well as the discussion. Finally, the paper is concluded in section V.

2. Admission Control

2.1 Admission Control Principle

If the air interface loading is allowed to increase excessively, the coverage area of the cell is reduced below the planned values, and the quality of service of the existing connections cannot be guaranteed. Before admitting new user equipment (UE), admission control needs to check that the

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admittance will not sacrifice the planned coverage area or the quality of the existing connections [10]. Admission control accepts or rejects a request to establish a radio access bearer in the radio access network.

Based on previous studies [1–5], I proposed a new complex wideband interference based call admission control which improve the quality of WCDMA system and decrease the probability of blocking rate, probability of call dropping The interference-based schemes can be further classified into:

a. Wideband Power-based CAC: This method computes the increase in the interference (power) caused by the establishment of a new user in the cell in uplink and accepts the call only if the total interference does not exceed a predefined threshold.

b. Throughput-based CAC: A throughput-based CAC algorithm computes the increase in the load caused by the establishment of a new user in the cell in uplink and accept the call only if the total load does not exceed a predefined threshold.

c. Adaptive Call Admission Control: This algorithm is combination of WPB and TB CAC. When a new user want to admit into the system then it uses an algorithm to identify which method is used.

2.2 Wideband Power-based CAC

In the interference-based admission control strategy the new UE is not admitted by the uplink admission control algorithm if the new resulting total interference level is higher than the threshold value:

$$I_{old} + \Delta I < I_{threshold} \quad (1)$$

Where ΔI is the increase interference due to new user. The threshold value $I_{threshold}$ is the same as the maximum uplink noise rise and can be set by radio network planning.

The load curve is based on the derivative of uplink interference with respect to the uplink load factor given as $\frac{dI_{total}}{d\eta}$.

This can be calculated as follows

$$\text{Noise rise} = \frac{I_{total}}{P_N} = \frac{1}{1-\eta} \quad (2)$$

$$\text{Or} \quad I_{total} = \frac{P_N}{1-\eta}$$

$$\text{Or} \quad \frac{dI_{total}}{d\eta} = \frac{P_N}{(1-\eta)^2} \quad (3)$$

The change in uplink interference power can be obtained by Equation (4). The load factor of the new UE ΔL is obtained as-

$$\Delta I \approx \frac{dI_{total}}{d\eta}\Delta L \cong$$

$$\Delta I \approx \frac{P_N}{(1-\eta)^2}\Delta L \cong \quad (4)$$

$$\Delta I \approx \frac{I_{total}}{1-\eta}\Delta L$$

The second uplink power increase estimation based on the integration method, in which the derivative of interference with respect to the load factor is integrated from the old value of the load factor ($\boldsymbol{\eta}_{old}=\boldsymbol{\eta}$) to the new value of the load factor ($\boldsymbol{\eta}_{new} = \boldsymbol{\eta}+\Delta L$) as follows:

$$\Delta I = \int_{\eta}^{\eta+\Delta I} \frac{P_N}{(1-\eta)^2} d\eta \cong \quad (5)$$

$$\Delta I = \frac{P_N}{1-\eta-\Delta L} - \frac{P_N}{1-\eta} \cong \quad (6)$$

$$\Delta I = \frac{\Delta L}{1-\eta-\Delta L} \times \frac{P_N}{1-\eta} \cong$$

$$\Delta I \approx \frac{I_{total}}{1-\eta-\Delta L}\Delta L \quad (7)$$

In Equations (4) and (6) the load factor of the new UE ΔL is the estimated load factor of the new connection and can be obtained as

$$\Delta L = \frac{1}{1+\frac{W}{v.{}^{E_b}/_{N_0}.R}} \quad (8)$$

where W is the chip rate, R is the bit rate of the new UE, E_b/N_0 is the assumed E_b/N_0 of the new connection and v is the assumed voice activity factor of the new connection.

The downlink admission control strategy is the same as in the uplink, i.e. the UE is admitted if the new total downlink transmission power does not exceed the predefined target value:

$$P_{total\_old} + P_{total} > P_{threshold} \quad (9)$$

The threshold value $P_{threshold}$ is set by radio network planning.

2.3 Throughput-Based Admission Control Strategy

In the throughput-based admission control strategy, the new requesting UE is admitted into the radio access network if

$$\eta_{UL} + \Delta L < \eta_{UL-threshold} \quad (10)$$

and the same in downlink:

$$\eta_{DL} + \Delta L < \eta_{DL-threshold} \quad (11)$$

where $\boldsymbol{\eta}_{UL}$ and $\boldsymbol{\eta}_{DL}$ are the uplink and downlink load factors before the admittance of the new connection. The load factor of the new UE ΔL is calculated as in Equation (8).

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3 SYSTEM MODEL

3.1 Propagation Model

The relationship between the received power and the transmitted power is given by [3]:

$$P_r = P_t \alpha^2 10^{\frac{\varepsilon}{10}} \frac{1}{L} \qquad (12)$$

where L is the path loss.

3.2 The Receiver Model

At the receiver side the SIR after dispreading is evaluated for each transmission as [4,6]:

$$SIR = SF \times \frac{P_r}{I_{tot} + P_{thermal}} \qquad (13)$$

where P_r is the received power and I_{tot} the measured interference for each active call. $P_{thermal}$ is the thermal noise power.

3.3 Measurement of Air Interface Load

If the radio resource management is based on the interference levels in the air interface, the air interface load needs to be measured [3,5].

3.4 Uplink L oad Estimation

There are two load estimation techniques: load estimation based on wideband received power, and load estimation based on throughput.

Load Estimation Based on Wideband Received Power: The wideband received power level can be used in estimating the uplink load. The received power levels can be measured in the Node Radio Network Center. Based on these measurements, the uplink load factor can be obtained. The calculations are shown below.

The receive wideband interference power, I_{total} can be divided into two powers of own-

cell(=intra cell) users, I_{own}, other cell (=inter-cell) users, I_{oth}, and receive noise, P_N.

$$I_{total} = I_{own} + I_{oth} + P_N \qquad (14)$$

The uplink noise rise is defined as the ratio of the total received power to the noise power:

$$\text{Noise rise} = \frac{I_{total}}{P_N} = \frac{1}{1-\eta_{UL}}$$

This equation can be rearranged to give the uplink load factor

$$\eta_{UL} = 1 - \frac{P_N}{I_{total}} = \frac{\text{Noise rise} - 1}{\text{Noise rise}} \qquad (15)$$

where I_{total} can be measured by the RNC and P_N is known beforehand.

Load estimation based on the received power level is also presented in [8,9].

Load Estimation Based on Throughput: The uplink load factor η_{UL} can be calculated as the sum of the load factors of the UEs that are connected to RNC:

$$\eta_{UL} = (1+i).\sum_{j=1}^{N} L_j = (1+i).\sum_{j=1}^{N} \frac{1}{1 - \frac{W}{(E_b/N_0)_j R_j v_j}} \qquad (16)$$

where N is the number of UEs in the own cell, W is the chip rate, L_j is the load factor of the jth UE, R_j is the bit rate of the jth UE, $(E_b/N_0)_j$ is E_b/N_0 of the jth UE. V_j is the voice activity factor of the jth UE, and i is the other-to-own cell interference ratio.

3.5 Downlink Load Estimation

Power-Based Load Estimation: The downlink load of the cell can be determined by the total downlink transmission power, P_{total} [3,5]. The downlink load factor , η_{DL} , can be defined to be the ratio of the current total transmission power divided by the maximum RNC transmission power P_{max}:

$$\eta_{DL} = \frac{P_{total}}{P_{max}} \qquad (17)$$

Throughput-Based Load Estimation: In the downlink, throughput-based load estimation can be effected by using the sum of the downlink allocated bit rates as the downlink load factor, η_{DL} , as follows:

$$\eta_{DL} = \frac{\sum_j^N R_j}{R_{max}} \qquad (18)$$

where N is the number of downlink connections, including the common channels, Rj is the bit rate of the jth UE, and R_{max} is the maximum allowed throughput of the cell. It is also possible to weight the UE bit rates with Eb/N0 values as follows:

$$\eta_{DL} = \sum_j^N R_j \frac{v_j (\frac{E_b}{N_0})}{W} . [(1-\alpha) + i] \qquad (19)$$

where W is the chip rate, $(E_b/N_0)j$ is the E_b/N_0 of the jth UE, V_j is the voice activity factor of the jth UE, α is the average orthogonality of the cell, and i is the average downlink other-to own cell interference ratio of the cell.

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4. Simulation and Result Discussion

For performing simulations, we have taken the activation factor v_j=0.1,0.3,0.5,0.7,0.9 bit rate r_j=32Kbps, 64 Kbps and 128 Kbps, received noise power which include inter cell noise and intra cell nose and thermal noise in dB and threshold Noise T_h = 6dB and 7 dB.

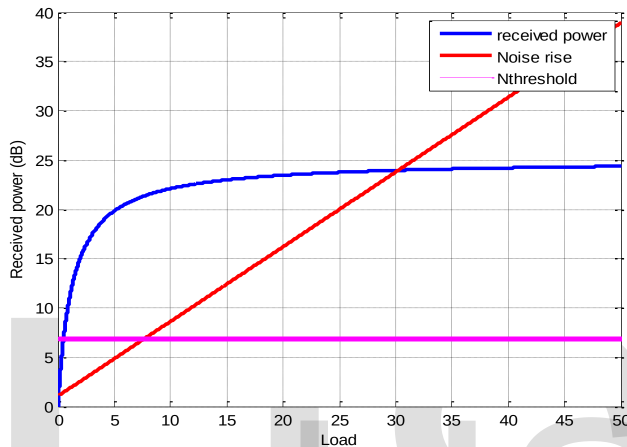

Figure 1: WPB CAC where R= 32Kbps, Vj = 0.1, Th=7 dB.

In figure 1, When user is admitted into the system then the system calculate the nose rise and compare with threshold. The user for which noise rise is exceeded the threshold cannot be admitted into the system. So the system provides best quality of service.

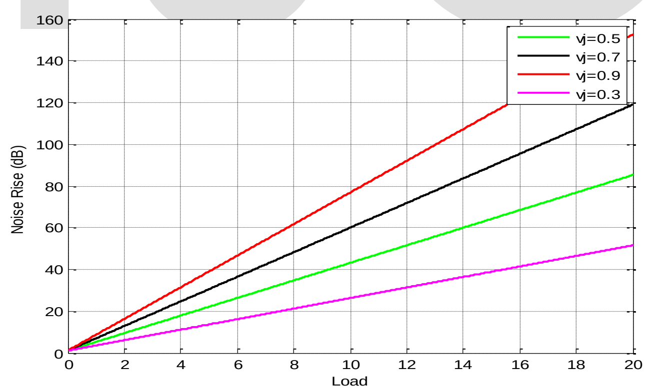

Figure 2: WPB noise rise for varying activating factor.

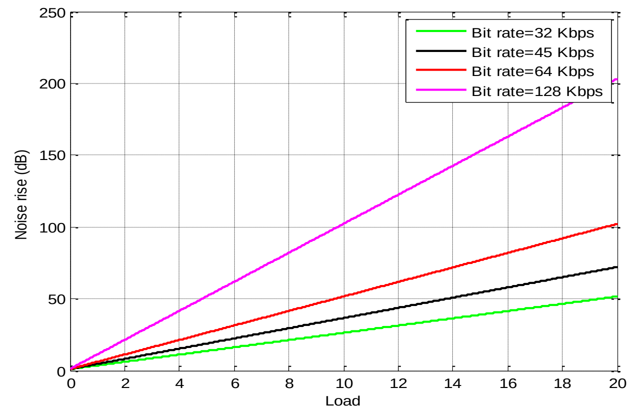

Figure 3: WPB noise rise for varying data rate.

In figure 2 and figure 3, noise rise is varied according to bit rate and activating factor. Our main goal is minimize the noise rise, so bit rate and activating factors are important parameter. In figure 2, noise rise is smaller when activating factor is lower. In figure 3, when bit rate is lower, then noise rise is decreased.

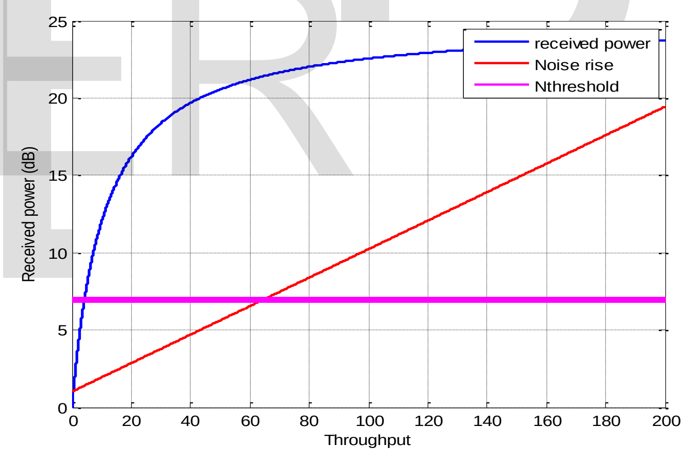

Figure 4: WPB CAC where P = 70 dB, Vj = 0.1, Th=7 dB.

In figure 4, users are admitted until the noise rise is higher than threshold i.e. noise rise is lower than threshold. In this case power and throughput is inter-related. When power is 70 db fixed and threshold is 7 db, noise rise is below threshold until throughput 63 Kbps. When power is decreased then throughput will be is increased within noise rise limit.

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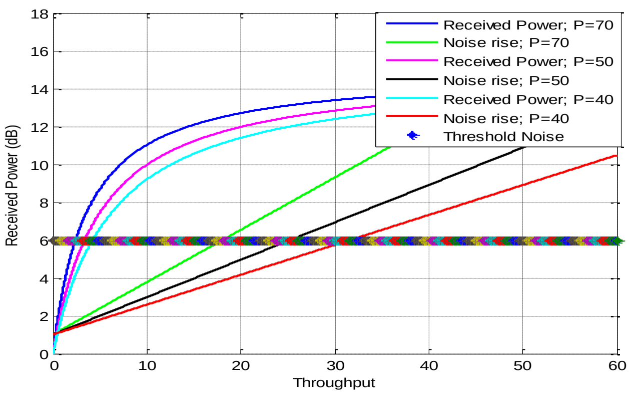

Figure 5: Received power and noise rise when power is varied.

In figure 5, shown the comparison of noise rise and received power of the user when power and activating factor are varied. Therefore power of the system and activating factor are more important parameter of the system to minimize the interference.

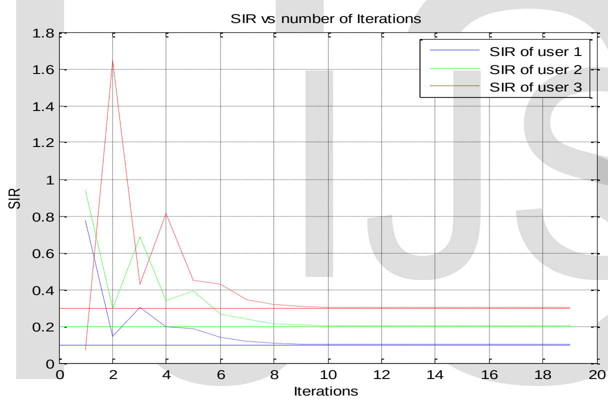

Figure 6 SIR Vs Iteration of the system in distributed environment.

For improving the admission control we have to determine the desired signal level. In order to receive required level of signal the system have to control the power in distributed environment. In figure 6 three users is considered each required different power level.

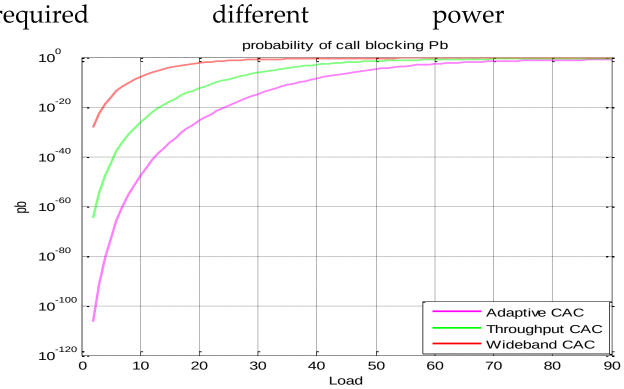

Figure 7: Call blocking probability of WPB, TB and ACAC scheme

In figure 7 and figure 8, shown the performance comparison of the WPB, TB and ACAC schemes. The limitations of WPB and TB overcome by the ACAC scheme. The call blocking probability and call dropping probability of ACAC is tends to be zero comparing other two methods. So we can say that the ACAC is best algorithm.

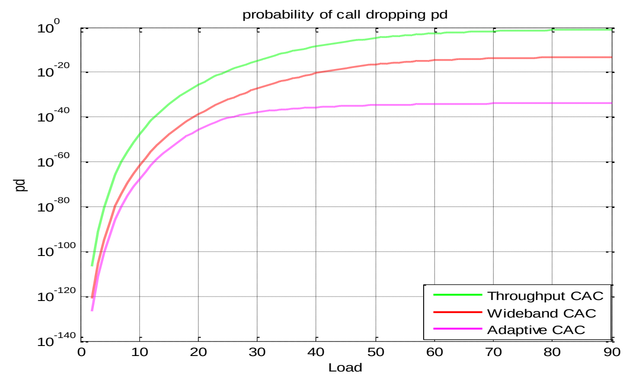

Figure 8: Call dropping probability of WPB, TB and ACAC scheme

5. Conclusion

WCDMA which has been very attractive for future high rate wireless communication is providing high transmission data rate with high spectral efficiency. From the simulation it is observed that the system determines the noise rise for individual user and compares with the threshold noise rise. If the total noise rise exceeds the threshold then the new user is rejected and is not admitted into the system but when the noise rise is bellow the target noise or threshold noise then the user is admitted into the system. We have also observed that activating factor, transmission power, bit rate and threshold noise rise is more important parameters in the system. According to call admission control, a system provides better service and better performance. But the system bandwidth sometimes may not be proper utilized by this CAC method due to noise rise. So it may waste the system capacity. . Power control is a fundamental procedure that can be used to minimize the transmission power of each connection, in order to limit the multiple access interference, while obtaining the desirable SIR levels. We have seen from simulation results ACAC provides better efficiency than WPB and TB CAC schemes. The call dropping and call blocking probability of ACAC is lower than WPB and TB CAC. Therefore ACAC provides the better performance

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