ISSN 2229-5518

Cell Resizing Based Interference Reduction and Delay Avoid Rate Scheduling for WCDMA

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Abstract - In WCDMA, the interference is produced by different factors such as thermal noise, intra cell traffic, traffic in adjacent cells and external traffic. In addition, the increase in number of users in a cell consequently increases the total interference in the network. Hence, the interference must be controlled to improve the throughput of the network. In this paper, we propose an Interference Revocation Technique in WCDMA using Cell Resizing approach. Our technique classifies the access points into three types as normal, saturated and cooperative based on its signal to noise ratio (SNR). The saturated cell triggers the process of cell resizing. This process balances the number of users in each cell and thereby cancels the interference completely. We prove the efficiency of our technique through simulation results. And we proposed Delay Avoid Rate Scheduling Algorithm to allocate the optimum rate for each traffic queue. By simulation experiments, we have shown that the proposed algorithms achieve reduced call blocking probability, optimum rate with reduced delay.

Index Terms – Call admission control, Cell Resizing, electromagnetic compatibility, Radio Frequency, Signal to Noise Ratio, Wide Band Code Division Multiple Access, Delay Avoid Rate Scheduling Algorithm

1. INTRODUCTION

1.1. Wideband Code Division Multiple Access

Wideband Code Division Multiple Access (W-CDMA) is an approved 3G technology which increases data transmission rates via the Code Division Multiplexing air interface rather than the Time Division Multiplexing air interface of GSM systems. It supports very high-speed multimedia services such as full-motion video, Internet access and video conferencing. It can also easily handle bandwidth-intensive applications such as data and image transmission via the Internet. WCDMA is a direct spread technology it spreads its transmissions over a wide range, 5MHz carrier and can carry both voice and data simultaneously.

It features a peak data rate of 384 kbps with peak network downlink speed of 2 Mbps and average user of 220-320 kbps. WCDMA boasts increased capacity over EDGE for high-bandwidth applications and features which include,

enhanced security, Quality of service, multimedia support and reduced latency. It works with fiber based wireless access using radio over-fiber (RoF) technology. Access schemes effectively combine the high capacity of optical fiber with the flexibility of wireless networks. W-CDMA RoF system will have an impact not only on multiple-user interference but also on inter-modulation distortion and clipping noise power.

W-CDMA or family of Universal Mobile Telecommunications System (UMTS) along with UMTS-FDD, UTRA-FDD or IMT-2000 CDMA Direct Spread are air interface standard found in 3G mobile telecommunications networks that is being developed as W-CDMA. Unlike GSM and GPRS which rely on the use of the TDMA protocol, WCDMA which is like CDMA allows all users to transmit at the same time and to share the same RF carrier. Each mobile user's call is uniquely differentiated from other calls by a set of specialized codes added to the transmission. [1]

1.2. Causes of Interference

With CDMA technology, interference is a critical factor because communications occur on the same frequency band and time slot such as in the UMTS FDD mode. On the one hand, it is directly linked to coverage and capacity of such a network. So, understanding the relationship between coverage and capacity and how it is affected by interference and transmit power is essential for UMTS network planning. The interference level is directly related to the users density in the considered cell and its neighbors and affects both the cell range and the capacity of the system. The higher the number of users in the system, the higher the interference and the smaller the cell range [4].

The causes of interference are diverse. Radio Frequency (RF) interference to mobile communication network may be caused by such parameters as an original dedicated radio system occupying an existing frequency resource, improper network configuration by different operators (value of power), cell overlapping, the radio channel, electromagnetic compatibility(EMC), external interference

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sources. The primary forms of interference to mobile communication systems mainly include: common-frequency interference, adjacent-frequency interference, out of band spurious emission, inter-modulation emission, and blocking interference. The problem of interference between systems working in different frequencies is caused by hardware problem in the transmitter (Tx) and the receiver (Rx). Also the interference between the Tx and the Rx depends on some parameters such as the interval between the working frequency ranges of the two systems and the spatial distance which separate the Tx and Rx. For a WCDMA system, the interference can be generated by different source, namely, thermal noise, traffic intra-cell, traffic in adjacent cells and external traffic [3].

1.3. Problem Identification

Call admission control (CAC) is one of the resource management functions, which regulates network access to ensure QoS provisioning. Efficient CAC is necessary for the QoS provisioning in WCDMA environment. In our previous work, we have proposed to design a new fuzzy based CAC with power control for multiple services like voice, video and data for multiclass users. It determines the optimum set of admissible users with optimum transmitting power level using fuzzy logic, to minimize the interference level and call rejection rate.

To cancel the interference completely in WCDMA, in this paper we propose an Interference Revocation Technique in WCDMA using Cell Resizing.

2. RELATED WORKS

Jraifi Abdelouahed [3] has proposed the system in which, radio frequency interference is caused by occupying exiting radio frequency resource, improper configuration of network by different operators, cell overlapping external interference sources and electromagnetic compatibility. Mobile communication interference is common-frequency, adjacent- frequency, out of band spurious emission, inter-modulation emission and blocking interference. He has developed an analytical expression of the Signal to Noise Ratio (SNR) which is used to predict some parameters. By fixing the SNR to a specific value, he has extracted easily information on the optimal numbers of users.

Anis Masmoudi and Sami Tabbane [4] have proposed two systems called uniform and non-uniform traffic environment in interference of WCDMA. It presents an analytical work which provides exact derivations of the general F-factor, CDF and PDF distributions laws, mathematical expressions in WCDMA systems with one interferer. Their approach doesn't depend on any assumption or values range. They have also investigated the unequally-loaded cell case referring to the more general non-uniform mobile distribution. They have proved that this model refines the planning process and thus increase the quality and capacity of a cellular network

Derong Liu and Hossein Zare [6] have proposed the method to cancel the multi-path interference in WCDMA. The first chips at the beginning of each frame are free from multipath interference. These chip samples with the knowledge of the channel coefficients to estimate the corresponding interfering chips and then cancel the multipath effect from the second chip samples of the received signal. Similarly, these second chips to cancel the multipath effect from the third samples of the received signal. This procedure can be continued until the end of the frame to cancel the multipath effects from the whole frame. It is possible to cancel all multipath effects and recover the orthogonality property of the received signal. This algorithm is not complex and does not consume much time since each information bit can be detected after the interfering chip cancellation is done in a bit interval. The simplicity of the algorithm with the perfect cancellation of multiple access interference (MAI) comes at the expense of noise enhancement. Although this noise enhancement causes a loss of few dBs in signal to noise ratio (SNR) compared to the single user system, the performance of the receiver simulation results show, is much higher than the RAKE receiver and is free from any error floor.

Maan A. S. Al-Adwany et al. [7] have proposed interference canceller. In WCDMA base station receiver, the BER can be considerably reduced by using the proposed interference canceller. Initially, they have extracted the TDMA interference through the use of a low pass FIR filter. They have constructed a threshold circuit to eliminate the residual WCDMA signal that passes with the extracted TDMA signal. Finally, they have also evaluated the performance of WCDMA uplink system for UMTS mobile communications.

Pon Rattanawichai et al. [8] have proposed the Field Programmable Gate Array known as FPGA. It is a self interference cancellation technique based on an adaptive LMS (Least Mean Square) algorithm. With their technique, the field data measured through a RF repeater is adopted to improve a signal quality using the FPGA Virtex@6 HW module. Their technique also reduces the oscillation of the system due to the feedback interference signal coming from

ISSN 2229-5518

transmit antenna of a WCDMA radio repeater. Their technique offers more flexibility.

3. PROPOSED SOLUTION

3.1. Overview

In this paper, we propose an Interference Revocation Technique in WCDMA using Cell Resizing. In our technique, each access point (AP) periodically measures SNR value. Based on this value, the AP is categorized into three types as normal, saturated and cooperative. Saturated cells are the cells that exceed avg SNR value. When an AP founded to have SNR grater than avg SNR, it invokes cell-resizing approach. The saturated cell transmits SUPPORT-REQ to all its neighboring cells. On receiving this message, cooperative cells replies with SUPPORT-REP. If the saturated cell receives multiple SUPPORT-REPs, then it selects the one that nearer to it. Upon receiving SUPPORT-REP message, the saturated cell shrinks its size to expel the excessive users. Simultaneously, the cooperative cell enlarges its size and accepts expelled users. Thus, our cell resizing approach cancels the interference by balancing the users in cells.

3.2. Estimation of Signal to Noise Ratio (SNR)

In WCDMA, the signal to noise ratio can be computed as follows, [3]

$$SNR = \left[\left[\frac{B_e}{P_n} \right]^{-1} + [ICI] + [CCI] \right]^{-1}$$

Whereas, $\left(\frac{B_e}{P_n} \right)$ is the signal to noise ratio that is caused by the Additive White Gaussian Noise, ICI represents intra-cell interference, CCI is the co-channel interference, P_n denote noise power and B_e signifies average bit energy.

The average bit energy (B_e) can be obtain as,

$$B_e = avg\ T_r . B_D$$

Here, $avg\ T_r$ is the average transmitted power and B_D refer to bit duration.

The intra cell interference (ICI) of the cell can be obtained as,

$$ICI = \frac{2}{3G} \sum_{n=1}^{N} \frac{T_n}{T_0}$$

Where, G is the system processing gain, N denotes the number of users; T_n is the average transmitted power.

Seong-Jun Oh et al. [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.

The call admission control (CAC) method and the resource reservation estimation (RRE) method are suitable for the wideband code division multiple access (W-CDMA) systems were proposed by Huan Chen et al. [10] . Their CAC method gives special treatment to high priority calls such as handoff calls by pre-reserving a certain amount of channel margin in opposition to the interference effect.

Young-Long Chen et al. [11] have proposed a method which combines the CAC and power control mechanisms and operates in a centralized control manner. The spirit of their centralized call admission control (CCAC) scheme was to merge the two mechanisms and to treat the call admission decision as an eigen-decomposition problem. In their method, a new call was attended only if the quality-of-service (QoS) requirements of all the active links in the network are maintained.

Jyoti Laxmi Mishra et al. [12] have evaluated various types of call admission control algorithm. The objective of their research was to improve the same algorithm with multiclass users and multiservice using fuzzy logic.

The fuzzy based CAC scheme for wideband CDMA cellular system, to meet the disputes in CAC due to user mobility, limited radio spectrum, heterogeneous and dynamic nature of multimedia traffic, and QoS constraints have been studied and its performance was examined by S.Malarkkan and V.C.Ravichandran[13]. The fuzzy approach overcomes measurement errors, mobility and traffic model uncertainty, and avoid the necessities of complex mathematical relations among various design parameters.

3.3. Interference Revocation Using Cell Resizing

The interference in WCDMA is produced by different attributes such as thermal noise, intra cell traffic, traffic in adjacent cells and external traffic. Therefore, we preferred to use signal to noise ratio (SNR) as a suitable metric to estimate the quality of the cell. The SNR value of each cell is directly related to its interference. The increase of number of users in a cell consequently increases the total interference at the access point (AP). In simple, the high SNR value represents the more number of users in that cell. Consequently, low SNR value of the cell denotes less number of users.

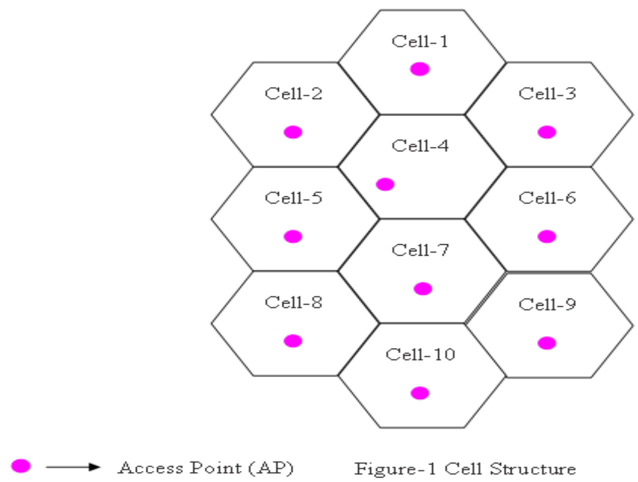

Figure-1 Cell Structure

3.4. Classification of Access Points

We assume that access point (AP) in every cell is capable of measuring its SNR. The computation method of SNR is described in section 3.2. By considering SNR value of cells, we can categorize them into three states as Normal, Saturated and cooperative.

- **Normal State**

An AP that is in this category will have average SNR value in the neighborhood. The AP's of this type does not require any accomplishment to be done regarding interference.

- **Saturated State**

In this category, the AP's SNR is larger than average SNR in the neighborhood and it is ready to minimize its cell size. This type needs appropriate method to reduce its cell size.

- **Cooperative State**

These AP's have SNR below average SNR in the neighborhood. Converse to the saturated type, this category is ready to increase its cell size.

3.5. Interference Cancellation using Cell Resizing

After the classification of access points (AP), we can cancel the interference more easily using cell-resizing approach. This approach reduces the size of cell that has more SNR and call off the interference by expelling some nodes to neighbor cell that has low SNR. Cell resizing alleviates the interference of the cell by reducing the number users. That is it achieves interference cancellation by maintaining the number of users in the cell.

The cell resizing approach is performed as follows,

1) When the measured SNR exceeds avg SNR, it is categorized as Saturated and it sends SUPPORT REQ message to all neighboring cells.

$$\text{Saturated Cell} \xrightarrow{\textit{SUPPORT–REQ}} \text{Neighboring Cells}$$

2) While receiving SUPPORT-REQ, the cells that belong to cooperative state send SUPPORT-REP message to the corresponding cell.

$$\text{Saturated Cell} \xleftarrow{\textit{SUPPORT–REP}} \text{Cooperative Cell}$$

3) If the Saturated cell receives more than a SUPPORT-REP message, it selects the Cooperative cell that is nearer to it.

4) The Saturated cell shrinks its size to expel some of the users to the Cooperative cell

5) On the other hand, the Cooperative cell enlarge its size to accept new users

6) Both, the Saturated and Cooperative cell estimates the new SNR value.

Consider the cell structure given in figure-1, which consists of 10 cells. In that, consider cell-4 is saturated cell and cell-7 is Cooperative cell. Then the cell resizing approach is portrayed in Figure-2a, 2b and 2c. Figure-2a represents saturated cell and Cooperative cell. As soon as, Cell-4 receives reply from cell-7, it shrinks its size and expels a user. In response to this, Cell-7 enlarges its size and provides accommodations to the expelled user. Now,

ISSN 2229-5518

Saturated and Cooperative cells become Normal cell. Thereby, it cancels the interference.

Algorithm

Step-1
Each AP periodically measures SNR (as per equation-1)

Step-2
AP categorized into three types
(2.1) If (SNR = avg SNR) then it is Normal
(2.2) If (SNR > avg SNR) then it is Saturated
(2.3) If (SNR < avg SNR) then it is Cooperative

Step-3
The Saturated cell transmit SUPPORT-REQ to all its neighboring cells

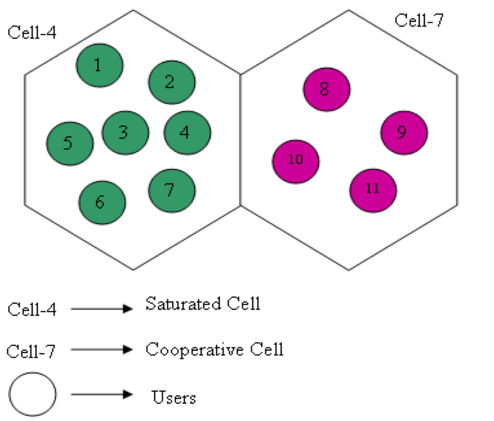

Figure-2a Saturated and Cooperative Cells

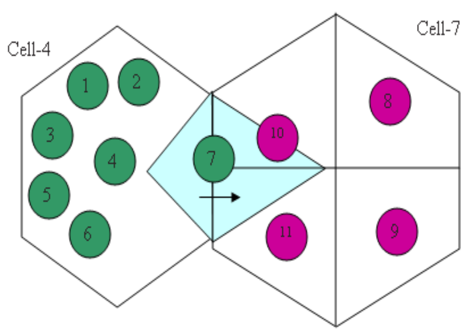

Figure-2b Cell-4 shrinks to expel user 7 to Cell-7

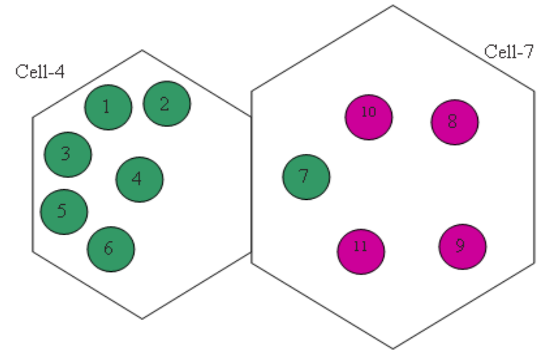

Figure-2c Cell-7 enlarges its size and accepts user-7

Step-4

Among neighboring cells, the cooperative cell transmit SUPPORT-REP to the Saturated cell

Step-5

The Saturated cell, reduces its size and expels some users

Step-6

The Cooperative cell enlarges its size and accepts saturated cell

Step-7

The Saturated and Cooperative cell calculates SNR

4. DELAY AVOID RATE SCHEDULING

4.1. Objectives and Architecture

The packet scheduler optimally allocates the available capacity for the active mobile user in each scheduling time interval Ti. When an admitted user wants to send a packet in the next time interval Tnext, he may send the transmission request to the base station BS in the current time interval Tcur. Base station BS collects all the transmission requests of the users for the next time interval. BS then classifies the requests based on their class and stores into M FIFO type class queues.

BS executes the proposed rate scheduling algorithm at the end of the time interval. The proposed scheduling algorithm returns to the optimal rate allocations for each traffic-queue, there by minimizing the delay.

We propose an optimal rate scheduling scheme to provide rate scheduling for QoS support by quickly adapting the changing traffic conditions. By predicting the estimation of future packet arrival rates, it adaptively performs rate scheduling. When the rate scheduling fails, it uses a feedback based approach to control the delay. It handles the delay and bandwidth separately.

The architecture consists of the following components:

(i) The arrival rate of the packets are estimated for the next time interval Tnext.
(ii) The average delay acquired by each class is monitored and sent as a feedback. If the delay is more than a pre-defined threshold value, the rate is adjusted.
(iii) The available CDMA capacity is dynamically calculated and checked for the feasibility of new rate allocation.

4.2. Delay Avoid Rate Scheduling Algorithm (DARSA)

Let Ak[i], be the estimated arrival rate of the class i. (i=1, 2,.M) for the kth scheduling time interval.

Let Lk[i], be the queue length of the queue Q[i] , for the class i at the kth interval.

Then the scheduling delay of Q[i] is given by

$$Dk[i] = (Lk[i] + Ak[i]) / Rk[i] \quad (1)$$

Where Rk[i] is the actual rate allotted to Q[i] in the kth time interval, by our rate scheduling scheme. The allocated rate should minimize the overall scheduling delay Dk[i].

Sicne Dk[i], highly depends on the estimated arrival rate Ak[i], slight errors in estimation may cause wrong rate assignments , degrading the performance.

For mitigating the estimation errors and to minimize the overall scheduling delay, the following algorithm is proposed.

Algorithm

(i) Let Dth[i] denote the mean delay threshold for class i packets. Let Dk[i] denote the mean monitored scheduling delay of each class i , at time interval k. Let Pr[i] denote the priority of each class i.
(ii) Sort Pr[i] in the descending order.
(iii) Find the set of classes {Cj,j=1,2….} such that
$$Dk[j] > Dth[j]$$
(iv) Then the set {Cm, m$\neq$j, m=1,2….. } denote the classes , such that
$$Dk[m] < Dth[m]$$
(v) Then rearrange the priorities Pr[i] such that Priorities of {Cm} get shifted upwards and priorities of {Cj} shifted downwards. (ie) class {Cm} is scheduled before class {Cj}
(vi) Now for the class {Cm} , recalculate allocated rate Rk[m] as
Rk[m] = Rmin , where Rmin is the minimum guaranteed rate .
(vii) Send the recalculated rate as a feedback to the BS.
(viii) BS adjusts the rate for the class {Cm} as per the feedback.

The class{Cm} whose priorities are rearranged for scheduling , is allocated minimum guaranteed rate and it is prevented from using additional resources in that interval. When the monitored scheduling delay of class {Cj} has stabilized, the normal rate allocation is performed for all classes.

5. SIMULATION

5.1. Simulation Model and Parameters

In this section, we simulate our proposed Interference Reduction Technique using Cell Resizing (IRT-CR) in WCDMA cellular networks. The simulation tool used is NS2 [17], which is a general purpose simulation tool that provides discrete event simulation of user defined networks. In the simulation, mobile nodes move in a 600 meter x 600 meter rectangular region for 50 seconds simulation time. Initial locations and movements of the nodes are obtained using the random waypoint (RWP) model of NS2. All nodes have the same transmission range of 250 meters.

The simulation parameters are summarized in Table 1.

Number Of Nodes	36
No. of Cells	6
Users per Cell	6
Slot Duration	2 msec
SINR threshold	5
Frame Length	3 slots
Txpower	0.66 w
RxPower	0.395 w

ISSN 2229-5518

Routing Protocol	AODV
Speed of mobile	25 m/s
Traffic Model	CBR
Initial Energy	4.1 J

Table 1- Simulation Parameters

The initial scenario for our experiment is shown in Figure 3. The user 19 from cell 4 and user 25 from cell 6 handoff to cell 5 at 2.00 seconds, there by increasing the load and interference on cell 2, which is illustrated in Figure 4. Similarly, user 40 from cell 2 handoff to cell 3 at 3.00 seconds. Then by our cell resizing concept, user 32 and 33 at cell 5 will be admitted into cell 4 and 6, respectively. Similarly user 12 at cell 3 will be accommodated into cell 2. See Figure 5.

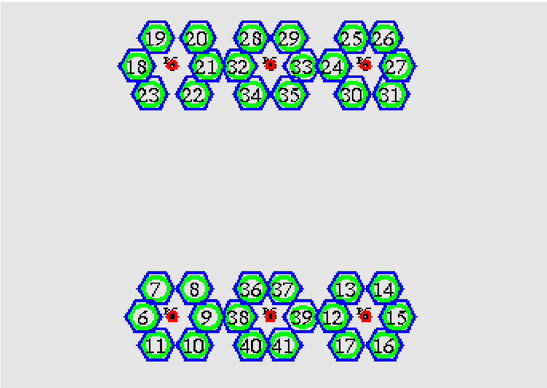

Figure: 3 - Simulation Topology

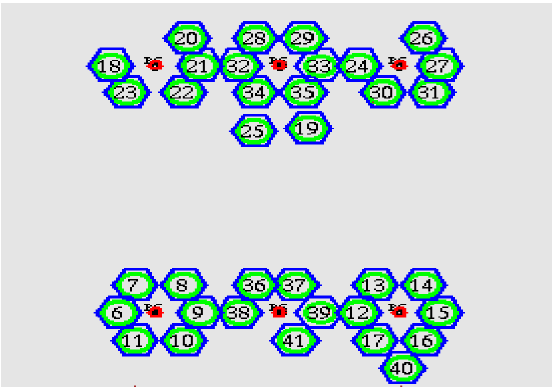

Figure 4 – User Movement

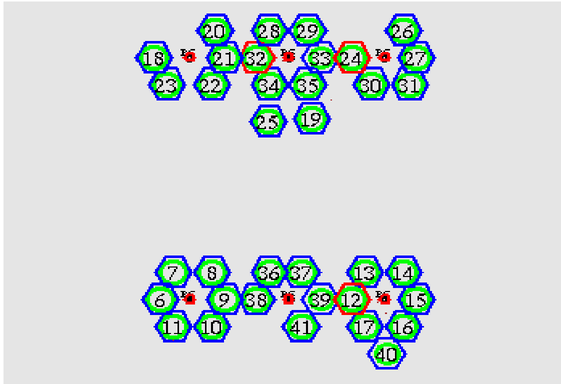

Figure 5 – Cell Resizing based on Users

5.2. Simulation Results

In our experiment, based on simulation time we measure the average throughput of each cell.

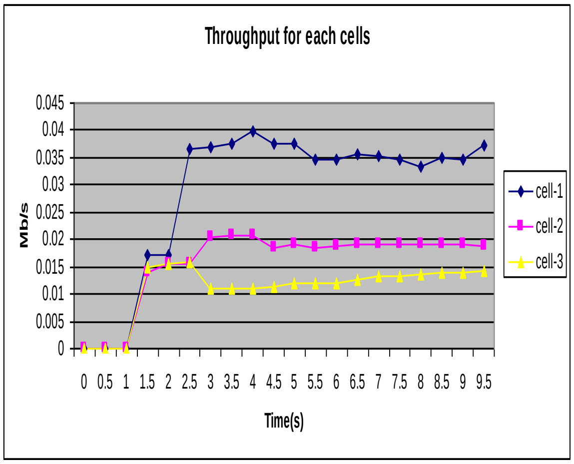

Figure 6. Time Vs Throughput for cells 1-3

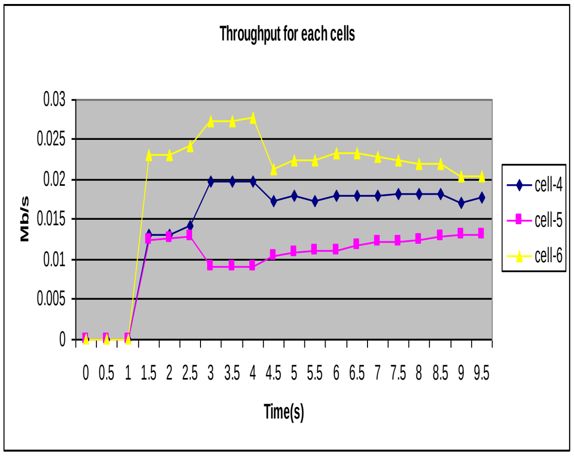

Figure 7. Time Vs Throughput for cells 4-6

Figure 4 – U

5.3. Based on Data Arrival Rate

ISSN 2229-5518

In our first experiment, we vary the data arrival rate as 0.1,0.2,…0.5Mb.

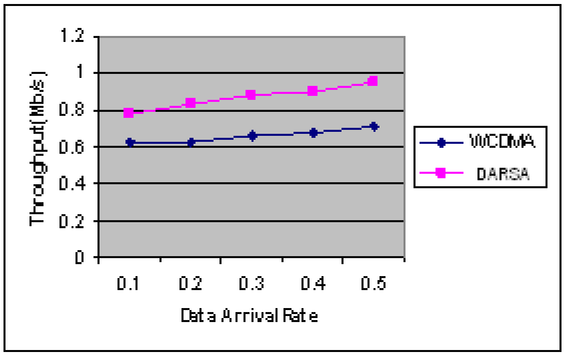

Figure 8. Arrival Rate Vs Throughput

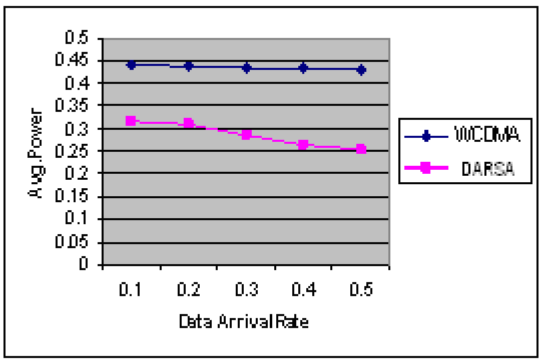

Figure 9: Arrival Rate Vs Average Power

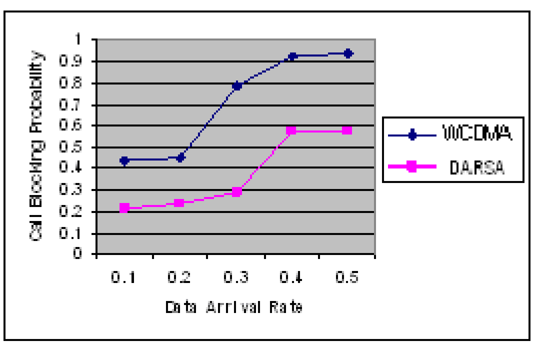

Figure 10. Arrival Rate Vs Call Blocking probability

Figure 6 shows the average throughput of cells 1 to 3. Since Cell 1 is not affected with any new user's arrival, its throughput is almost constant and high when compared to other cells. Since one user is moved from cell 2 to 3 at 3 seconds, its throughput is increased from 3 to 4.5 seconds. After 4.5 seconds, the cell 2 is resized to accommodate one user from cell 3, so that it decreases and remains constant thereafter. For cell 3, one new user is arrived at 3 seconds. So its throughput falls down from 3 to 4.5 seconds. At 4.5 seconds, the cell 3 is resized to expel one user to cell 2 , there by slightly increasing the throughput.

Figure 7 shows the average throughput of cells 4 to 6. Since one user is moved from cell 4 and 6 to cell 5 at 2.5 seconds, their throughput is increased from 3 to 4.5 seconds. After 4.5 seconds, the cells 4 and 6 are resized to accommodate two users from cell 5, so that the throughput decreases and remains constant thereafter. For cell 5, two new users are arrived at 3 seconds. So its throughput falls down from 3 to 4.5 seconds. At 4.5 seconds, the cell 5 is resized to expel two users to cells 4 and 6, there by slightly increasing the throughput.

Fig. 8 gives the average throughput measured. From the figure, it is clear that our DARSA scheme attains more throughputs when compared to the normal WCDMA scheme.

From fig. 9 and 10 , we can observe that the proposed new scheme has low average power consumption and low call blocking rate, respectively.

5. CONCLUSION

In this paper, we have proposed an Interference Reduction Technique in WCDMA using Cell Resizing technique. In our technique, each access point (AP) periodically measures SNR value. Based on this value, the AP is categorized into three types as normal, saturated and cooperative. Saturated cells are the cells that exceed the avg SNR value. When an AP founded to have SNR grater than avg SNR, it invokes cell-resizing approach. The saturated cell transmits support message to all its neighboring cells. On receiving this message, cooperative cells replies to the corresponding cell. If the saturated cell receives multiple replies, then it selects the one that nearer to it. Upon receiving the reply, the saturated cell shrinks its size to expel the excessive users. Simultaneously, the cooperative cell enlarges its size and accepts expelled users. Thus, our cell resizing approach cancels the interference by balancing the users in cells. We have proved the efficiency of our technique through simulation results. Our technique absolutely cancels the interference. Further, it considerably increases the average throughput of each cells.

To allocate the optimum rate for each traffic queue, a delay avoid scheduling scheme is proposed. By simulation experiments, we have shown that the proposed algorithms achieve reduced call blocking probability, optimum rate with reduced delay.

REFERENCES

[1] "Practical Tips on WCDMA Measurements", Application Note

[2] Chien-Jen Huang and Hsi-Pin Ma, "A Baseband Transceiver Architecture for WCDMA/HSDPA Comnmnunications", IEE International Conference on Wireless Networks, Communications and Mobile Computing, 2005

[3] Jraifi Abdelouahed, "A Theoretical Prediction of Users in WCDMA Interference", Journal of Theoretical and Applied Information Technology, Vol. 35 No.2, 31st January 2012.

[4] Anis Masmoudi and Sami Tabbane, "Other-cell-interference factor Distribution Model in Downlink WCDMA Systems", ACM International Journal of Wireless Personal Communications, Volume 36 Issue 3, Pages 245 – 275, February 2006

[5] Muhammad Suryanegara, Edwardo Rizky Hutabarat and Dadang Gunawan, "The Interference on Wcdma System in 3g Coexistence Network", 17th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC'06), 2006

[6] Derong Liu.y and Hossein Zarez, "A multipath interference cancellation technique for WCDMA downlink receivers", International Journal of Communication Systems, pp- 661–668, 2007

[7] Maan A. S. Al-Adwany and Amin M. Abbosh, "Interference Reduction in Overlaid WCDMA and TDMA Systems", Journal of Networks, Vol. 6, No. 4, April 2011

[8] Pon Rattanawichai and Chaiyod Pirak, "Implementation of Self Interference Cancellation for WCDMA Repeater", International Conference on Circuits, System and Simulation, 2011

[9] S.-J. Oh, T. L. Olsen, and K. M. Wasserman, "Distributed power control and spreading gain allocation in CDMA data networks," in Proc. IEEE INFOCOM, vol. 2, pp: 379-385, September 2000.

[10] H. Chen, S. Kumar and C.-C. Jay Kuo, Interference-based Guard Margin Call Admission Control for CDMA Multimedia Wireless Systems, Proc. SPIE Visual Communications and Image Processing Conf., vol. 4671, pp: 344-355, Jan. 20-25, San Jose, CA, 2002.

[11] Young-Long Chen, Jyu-Wei Wang, Jyh-Liang Chen and Jyh-Horng Wen "Performance of Call Admission Control with Power Control in Multimedia Cellular Systems" International Journal of Applied Science and Engineering , vol. 5, no. 1, pp: 65 – 74, 2007.

[12] Jyoti Laxmi Mishra, Keshav. P. Dahal and M.A. Hossain "Multiclass Call Admission Control for Performance Evaluation of Wideband CDMA.

[13] S.Malarkkan and V.C.Ravichandran "Performance Analysis of Call Admission Control in WCDMA System with Adaptive Multi Class Traffic based on Fuzzy Logic" IJCSNS International Journal of Computer Science and Network Security, vol.6, no.11, November 2006.