Power Control Technique for Efficient Call Admission Control in Advanced Wirless Networks

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***Abstract*— In 4G networks, call admission control techniques have been proposed to provide Quality of Service (QoS) in a network by restricting the access to network resources. Power control is essential in call admission control in order to provide fair access to all users, improve battery lifetime and system performance. But the existing call admission control algorithms rarely consider the power controlling techniques in the handoff process for different traffic classes. In this paper, we propose to develop a power controlled call admission control scheme for handoff in the advanced wireless networks. The incoming call measures the initial interference on it and then the base station starts transmitting the packets to the new call. The new call is rejected when the interference reaches a threshold value. Whenever an existing call meets the power constraint, the transmit power is decremented based on the traffic class and incoming call obtains this information by monitoring the interference received on it. The convergence of the power control algorithm is checked and the power levels of all incoming calls are adjusted. From our simulation results we prove that this power control technique provides efficient handoff in the 4G networks by increasing the throughput and reducing the delay of the existing users.**

Keywords-Quality of Service (QoS), 4G networks, Power Control, CDMA.

I. INTRODUCTION

A.Fourth Generation (4G) Networks

The diverse nature of the 4G networks helps in providing services to multiple users equipped with varied technologies which offer different services for user's benefit. There is no need for pre-registration or pre-subscription in 4G networks for accessing services and bandwidth which are offered by other service providers. Interface management technology is required by the diverse mobility options in order to provide convergence of the varied services offered and service provider coordination based on MIPv6 core architecture. Spectrum or shared spectrum can be monitored on providing additional components. [1]

The major features of 4G networks include

High usability *and global roaming:* With various technologies the end users should be user friendly in spite of the location and timing. The mobile should be portable anywhere though it uses CDMA or GSM.

Multimedia support: Higher data rate multimedia services which stresses on higher bandwidth and higher data rate, are received by the users.

Personalization: Any person can access the service by personalization. For different type of users, the service providers need to provide customized services. [2]

Notable features of 4G wireless system include high data transfer rates, effective user control, and seamless mobility. A massive amount of varying heterogeneous networks which includes 1G to 4G, WLANs, satellite system, 802.16 and Bluetooth can be integrated using 4G. There are chances for various issues caused in different type of technologies due to roaming. Mobility management, vertical handoff, resource coordination, resource allocation, location management, provisioning quality of service, security, pricing and billing are considered as the major challenges in 4G networks. [3]

B.Admission Control in 4G Networks

The access to network resources can be restricted by the call admission control (CAC) technique in order to provide QoS in a network. Only when sufficient free resources are provided for meeting the QoS requirements, the admission control mechanism accepts the new call request. The committed QoS of already accepted calls should not be violated during the call admission. The CAC schemes in cellular networks are classified into two:

1) Deterministic CAC: The knowledge about the system parameters such as user mobility is required in these schemes but since this is not practical, the deterministic QoS bounds can be satisfied by sacrificing the scarce radio resources.
2) Stochastic CAC: On comforting the QoS guarantees, the QoS parameters can be guaranteed with some probabilistic confidence. When compared to the deterministic approaches, higher utilization can be provided by stochastic schemes.

The admission of a new user in an access network is decided based upon condition for establishing their services. These services should not worsen the existing condition of the active users. The diverse resources may or may not be critical, for different types of services. For instance, HSDPA is directly proportional to the transmission power of the B Node. Due to this the most critical resource for the VoIP call established in the HS-DSCH shared channel is the e2e delay but critical resource for the FTP downloads is bit rate. [5]

Classification of admission requests are done in accordance with different classes and each class containing interference are classified. The effective bandwidth based on QoS targets are assigned for the new users. When the total interference of all the classes is less than the threshold value, then call admission control admits new users according to their classes. [6]

C.Need for Power Control in Handoff

In 4G networks, in addition to the user terminal the base station equipments also consume more energy. Mobile switching and handoff process also consume large power and causes battery drainage. Power consumption is increased due to unnecessary interface activation in network discovery which causes power saving issues. During handoff decision, integrating the power consumption factor is an essential factor. [7]

Only a limited power resource is present in the networks and the tainting this resource may cause significant capacity decrease. A considerable amount of power is used for multicast or broadcast transmission in order to provide a significant factor of cell coverage in multicast or broadcast services. [8]

In CDMA, the main intention is to transmit the users signal with similar power level at the base station. Signal interference may occur when any signal transmits with a higher power level than others. When all the users drain its power level, a very strong signal may cause the CDMA system to become unfeasible. The jamming of signals may lead to catastrophic effects on a system level. The capacity of the system can be maximized and the data rates are set to a theoretical bound. The battery life on each mobile handset needs to be maximized because the power wastage can cause shorter battery life for each user. [9]

The transmission performance can be directly influenced by the two major system resources, transmission power and channel. Better performance can be expected when the transmission power is higher. Many users can share one channel, or many channels can be used a single user in a multi-user multi-channel system. Summing up of all the channels utilized by the user gives us the instantaneous capacity. Higher capacity can be achieved when the transmission power and the channel allocation are tuned properly. [10]

Due to frequency reuse, there are chances of inter-cell interference. Power control in cellular systems is used to alleviate this inter-cell interference in spite of the mode of multiple accesses. The intra-cell multiple access interference can be minimized and system capacity can be enhanced using power control using CDMA networks since it has an interference-limited nature. Near-far problem can be avoided by the power control which helps in providing fair access to all users. [11]

D.Problem Identification and Proposed Solution

In our previous work, we have proposed a QoS Based Adaptive Admission Controller (QAAC). The admission control algorithm manages the various service requests in their queues and adaptively schedules them as per their assigned priorities. The basic concept of the algorithm is to simultaneously provide transmission priority and space priority for the data flows of the same end-user. A hybrid priority queuing mechanism is used to queue priority TP and BP for the same user. The algorithm tries to minimize the number of the sessions that are blocked due to insufficient resources in the target network. But this QAAC technique doesn’t consider the power control issues. This may lead to problems such as jamming, capacity degradation, power drainage, huge power consumption, degradation in the system performance, near-far problems, etc.

Thus in order to overcome the issues related to the power control, we provide a power control technique for handoff decision as an extension to the previous paper. As an addition to the hybrid priority queuing mechanisms for call requests and efficient scheduling a power controlling mechanism is included in the handoff process. This power control technique provides efficient handoff in the 4G networks by not degrading the QoS parameters like throughput and delay.

II. Related Work

Antonios Alexiou et al [8] have presented the prevailing radio bearer selection mechanisms and examines their performance in terms of power consumption. E-MBMS can be recognized by high power requirements and the proposed techniques/solutions are evaluated in this mechanism. During E-MBMS transmissions, the efficient power control can be presented in this novel mechanism. This conforms to LTE requirements for simultaneous provision of multiple multimedia sessions.

Xiaochen Li et al [10] have discussed the problem of power control and dynamic channel allocation for the downlink of a multi-channel, multi-user wireless cellular network. The delay sensitive applications can be supported here. The three scheduling algorithms proposed here reduce the resource usage while explicitly guaranteeing the users' QoS requirements.

Gaurav Bansal et al [12] have proposed a method the new call's arrival can affect the system and can lead to power constraint violation of any existing call. The new call can be rejected depending upon this. The method can be used at call admission stage in practical systems which are power constrained.

N. Mohan et al [13] have proposed to design a new CAC algorithm with power control for multiple services like voice, video and data for multi-class users. This power control algorithm minimizes the interference level and call rejection rate by determining the optimum set of admissible users with the optimum transmitting power level. The scheduling delay can also be minimized by the adaptive scheduling scheme which allocates optimum rate for each traffic queue.

Rainer Schoenen et al [14] have proposed a power control which saves power on the users within the cell. This leads to a reduced interference into neighbor cells, especially for future reuse one systems. At the cell edge, the transmissions can be enhanced using saved power. They introduce an adaptive power control concept in order to arrange a closed loop control system. For all adaptive algorithms for modulation, power, subchannel usage and channel quality indication the systems provides the blocks.

Woo Jin Shin et al [15] have proposed a framework for dynamic spectrum sharing between primary and secondary networks. Large-scale QoS and interference constraints under the constraints on the outage and violation probabilities can be satisfied allocating resources to users in the proposed algorithm.

Stepan Kucera et al [16] have proposed adaptive algorithms that employ realtime tracking of the spectral radius of the Foschini-Miljanic matrix by means of distributed interference measurements. The algorithm design is characterized by an inherent resistant to the effects of stochastic radio propagation phenomena and an exponential convergence rate - a fact**.**

Jin-Ghoo Choi et al [17] have proposed a power-based call admission control (CAC) scheme. This scheme directly extends the number-based CAC scheme which helps in multiclass traffic accommodating. Few related mathematical properties were also developed in multicode CDMA networks. They demonstrate the complete partitioning (CP) of the received signal power at a base station for each traffic class which is against the conventional findings. This approach proves to be as useful as complete sharing (CS) in accommodating an appropriate number of users.

III. Proposed Work

A. Overview

In this paper, we propose to develop a power controlled call admission control algorithm in order to provide efficient handoff in the 4G networks by increasing the lifetime of battery, and the system performance. In addition to the transmission priority and the space priority the call admission control needs power control. So a power control algorithm was proposed in which the existing call decreases its transmitting power when there is a violation of power constraint. Based upon this the entry of new call can be decided.

In this proposed method, we assume that whenever an existing call hits the power constraint, it decreases its transmit power level and the incoming call obtains this information by monitoring the interference received on it and hence, the incoming call determines that whether an existing call can hit the power constraint due to its inclusion in the system. The power constraint for admitting a new call is determined using the present uplink interference, increased uplink interference, and the target threshold. The power decrement value is calculated for both the real-time packets and the non-real time packets. Using this algorithm, the call admission is processed based upon the power constraints.

B. QoS Based Adaptive Admission Controller (QAAC)

The QAAC technique which measures the channel quality and separate queues for maintaining each class of service was proposed previously in paper [18]. The basic concept of this algorithm is to simultaneously provide transmission priority and space priority for the data flows of the same end-user. The algorithm tries to minimize the number of the sessions that are blocked due to insufficient resources in the target network.

C. Call Admission Control Scheme

Initially, we denote the downlink transmitted power of the a^{th} base station communicating with the a^{th} terminal by Ta. The gain on the radio link from base station of user *b* to user *a* is denoted by N_{ab}. Let Ra denote the receiver noise at the a^{th} terminal and Sa be the desired SIR threshold of the i^{th} terminal. Then to maintain the downlink connection for the a^{th} terminal we require that

$$SIR_a = \frac{N_{aa}T_a}{\sum_{b \neq a} N_{ab} T_j + R_a} \geq S_a \quad (1)$$

It has been considered that the transmitted powers are regulated by the distributed power control algorithm given in equation (2)

$$T_a(k+1) = \frac{S_a}{SIR_a(k)} T_a(k) \quad (2)$$

where $T_a(k)$ and $SIR_a(k)$ denote the power and SIR respectively for user a at the k^{th} iteration.

Based upon the monotonic and optimal power control algorithm, the PCT-CAC scheme has been proposed. The received interference of new user is measured in each iteration and when the threshold value is reached, the call can be rejected. The convergence of power control algorithm is not required here for making admission decision.

In this proposed method, when the power constraint is violated by any existing call, the transmit power level is decremented. This data is sent to the incoming call in order to determine the interference received on it. By this, the incoming call can know whether its inclusion affects the power constraints of the existing calls. The power constraint for the call is explained in section 3.3.1.

The equation for the interference received at the incoming call C_{n+1} is

$$I_{n+1} = [N_{n+1,1}, N_{n+1,2}, \cdots, N_{n+1,n}][T_1, T_2, \cdots, T_n]^L \quad (3)$$

The percentage decrease in a call when it hits the power constraint is taken as d. The power value for the existing users which doesn't hit the constraint is fixed. We assume that *i*th existing call hits the constraint and the new interference which is received at the incoming call is denoted as

$$I_{n+1} = [N_{n+1,1}, N_{n+1,2}, \cdots, N_{n+1,n}][T_1, T_2, \cdots, T_i - dT_i, \cdots, T_n]^L \quad (4)$$

The sudden decrease in the received interference is measured by the incoming call in order to know the information about the power constraint in the existing call. The incoming call needs to be rejected when more than one existing call violates the power constraint simultaneously and also the powers of the existing calls are decreased. [12]

Based upon the implementation of the algorithm, the decision for power decrement is processed. The decrementing value shouldn't be either too large or too small because larger value can degrade the QoS of existing call and smaller value is not enough to change the interference.

This degradation is explained in section 3.3.2.

1) Power Constraint

The power constraint for admitting a new call depends upon the present uplink interference, increased uplink interference, and the target threshold. When the target threshold exceeds the sum of the present uplink interference and the increased uplink interference then the call cannot be admitted. This is represented using the below equation:

$$F_{u\ total} + \delta F_{u\ total} > F_t \quad (5)$$

Where $F_{u\ total}$ - total uplink interference present in the cell (which includes intra-cell interference, inter-cell interference and background noise),

$\delta F_{u\ total}$ -uplink interference increase due to the new call,

F_t -target threshold for total interference. [19]

2) Power Decrement Value

In our previous work [18] queue management is done for both real time packets and non-real time packets. It has been considered that the total queuing time is t, time for queuing real-time packets is a_t and time for queuing non-real time packets is b_t. The decrease in power should be large enough so that the change in the interference due to it becomes visible and at the same time it should not be very large, as it will degrade the QoS of the existing call. Thus the value *d* which needs to be decremented is given below.

For Real time packets - d = a_t / t (6)

For non-real time packets - d = b_t / t (7)

D. Power Controlled Technique for Call Admission Control (PCT-CAC)

The improved PCT-CAC with power constraints is explained in the algorithm below:

Let the initial interference be I_{n+1}^{n} , received interference be I_{n+1}, threshold value for received interference be T_I, power decrement value be d . Initially the incoming call C_{n+1} measure the initial interference I_{n+1}^{n} on it. Then the base station starts transmitting the packets to the new call in a fixed proportion. The power of the existing calls increase according to the equation (2). During iteration process, I_{n+1}^{n} is measured on it and when the threshold T_I is reached, the new call is rejected. If the initial interference is below the threshold then the new call again measures the received interference. Now when any existing calls hits the power constraint, the power value is decremented based upon the type of packet (real time packets or non-real time packets). Then the power control algorithm is checked whether it converges or not. If the algorithm doesn't converge then again the existing calls adjust their power levels. When the power control algorithm converges, the power levels of all incoming calls are adjusted and the power value is set according to the type of packet. Again the power control algorithm is checked for convergence and when it converges the call is admitted. The power level of the entire incoming all again adjusted if the algorithm doesn't converge.

2. Initially the incoming call C_{n+1} measures initial interference I_{n+1}^{n}.
3. BS transmits the packets to the calls C_{n+1} in a fixed proportion.
4. The existing calls in the network adjust their power levels using equation (2).
5. The new call measures the received interference I_{n+1}.
6. If $I_{n+1} > T_1$,

```
 Reject the call
    Else
  Repeat step 4.
  If any existing call satisfies equation 5.
      Check if it has real time packet
        5.3.1.1 Decrement power value using
         equation 6  and reject the incoming call.
Else
        5.3.1.2 Decrement power value using
              equation 7 and reject the incoming call.
    End if
Else

If power control algorithm converges
             Adjust power level of all existing
              calls according to equation 2.
Repeat step  5.3

If power control algorithm converges
                                  Call is admitted
                              Else
                             Repeat 5.3.2.1
                          End if
                          Else
         Repeat steps from 3 for next iteration
                   End if
              End if
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End if

IV. PERFORMANCE EVALUATION

A. Simulation Model and Parameters

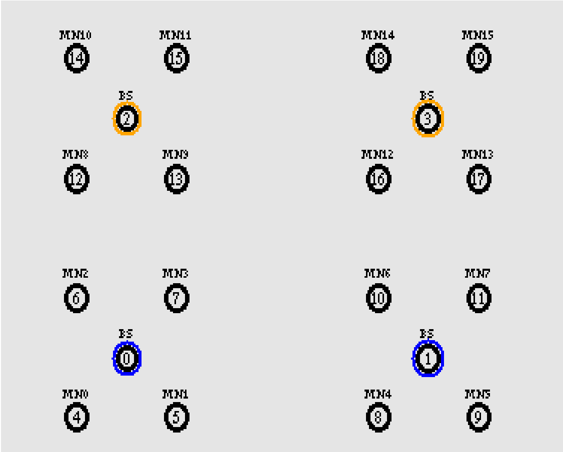

Figure.1. Simulation Topology

To simulate the proposed scheme, network simulator (NS2) [15] is used. In the simulation, clients (SS) and the base station (BS) are deployed in a 1000 meter x 1000 meter region for 50 seconds simulation time. It consists of 4 base stations among which, 2 are based on 802.16 WiMax and remaining 2 are based on 802.11 WLAN. The base stations marked with orange circle belongs to 802.11 WLAN and the base stations marked with blue circle belongs to WiMax 802.16 network. Each network contains 4 mobile nodes (refer Figure. 2). All nodes have the same transmission range of 250 meters. In our simulation, Mobile node 9 and 3 perform horizontal and vertical handoff, respectively.

The simulation settings and parameters are summarized in table 1.

TABLE.1. SIMULATION SETTINGS AND PARAMETERS

Area Size	1000mtsX 1000mts
Mac	802.16 and 802.11
Base stations	4
Clients	16
Radio Range	250m
Simulation Time	50 sec
Routing Protocol	DSDV
Traffic Source	CBR and Video
No. of Users	2,4,6 and 8
No. of CBR Flows	4
No. of Video Flows	4
Video Trace File	JurassikH263-256k_trace.dat
Physical Layer	OFDM
Packet Size	100 bytes
Frame Duration	0.005
Rate	50 to 250 kb
Time	35 seconds

B. Performance Metrics

We compare our proposed Power Control Technique for effective Call Admission Control (PCT-CAC) with the Distributed Admission Control (DAC) algorithm for power constrained cellular wireless systems [12]. We mainly evaluate the performance according to the following metrics:

Throughput: It is the amount of traffic (real time or non-real time) that is received in the destination, represented in Megabits / second.

Delay: It is the average end to end delay occurred at the destination for all flows.

Packet Delivery Ratio: It is the ratio of packets received successfully to the total number of packets sent for both RT and NRT flows.

A. Based on Rate

In the initial experiment, we vary the rate of each traffic flow from 50kb to 250kb and measured the performance for real time (RT) and non-real time (NRT) traffic. In the simulation, both the CBR (NRT) and Video (RT) traffic are used. Among the 8 user requests, there are 4 video flows and 4 CBR flows. There are 4 uplink and 4 downlink flows.

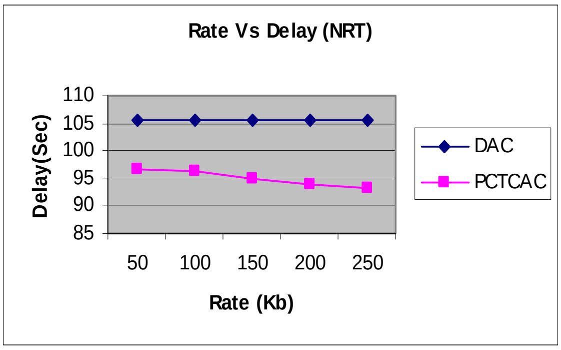

Figure 2. Rate Vs Delay (NRT)

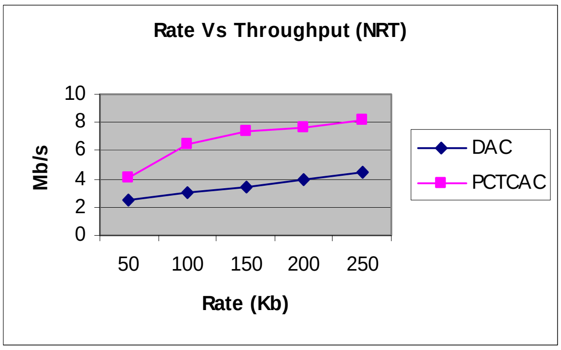

Figure 3. Rate Vs Throughput (NRT)

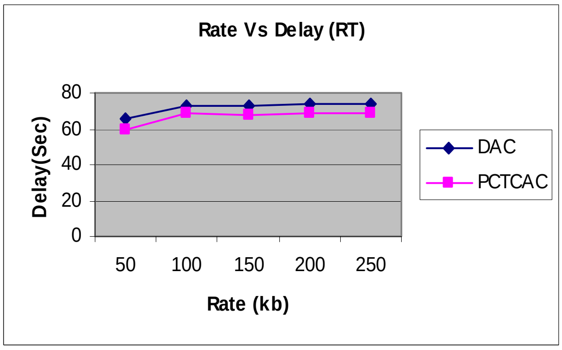

Figure 4: Rate Vs Delay (RT)

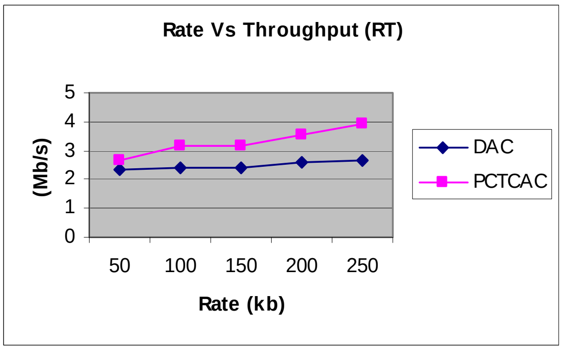

Figure 5. Rate Vs Throughput (RT)

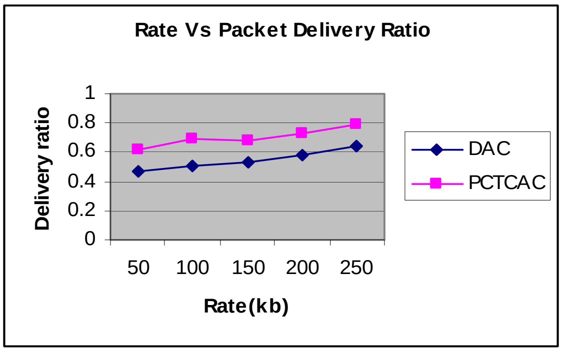

Figure 6. Rate Vs Packet Delivery Ratio

Figures 2 and 3 show the delay and throughput for the NRT traffic. Clearly we can see that our PCTCAC technique is better than DAC when the rate is increased. This is because our PCTCAC technique provides bandwidth priority for NRT flows.

Figures 4 and 5 show the delay and throughput for the RT traffic. It can be observed that our PCTCAC technique yields better results than DAC when the rate is increased. This is because our PCTCAC technique provides transmission priority for RT flows.

B. Based On Users

In this experiment, the no. of user request (including CBR and Video) is varied from 2 to 8 with the traffic sending rate as 50kb.

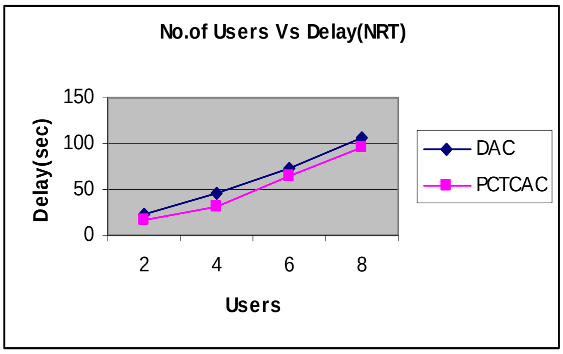

Figure 7. Users Vs Delay for NRT flows

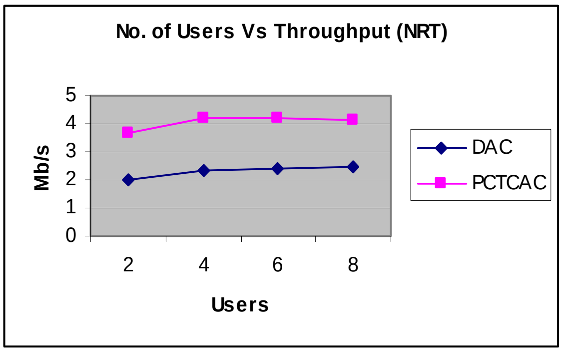

Figure 8. Users Vs Throughput for NRT flows

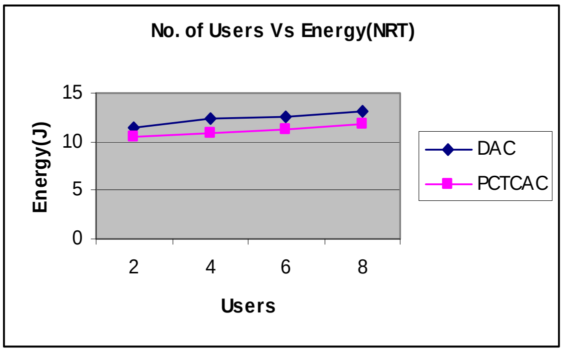

Figure 9. Users Vs Energy Consumption for NRT flows

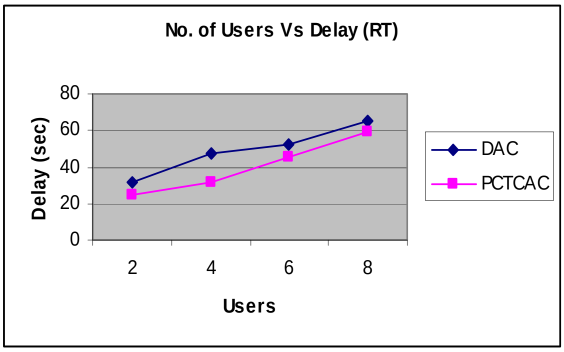

Figure 10. Users Vs Delay for RT flows

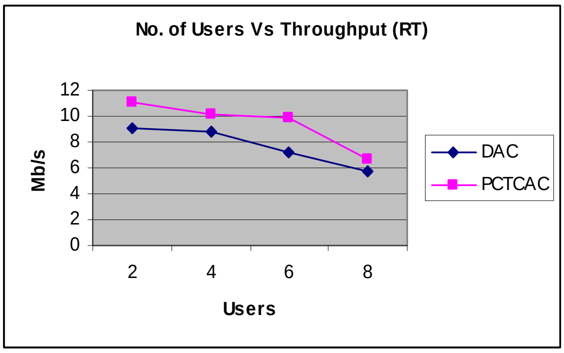

Figure 11. Users Vs Throughput for RT flows

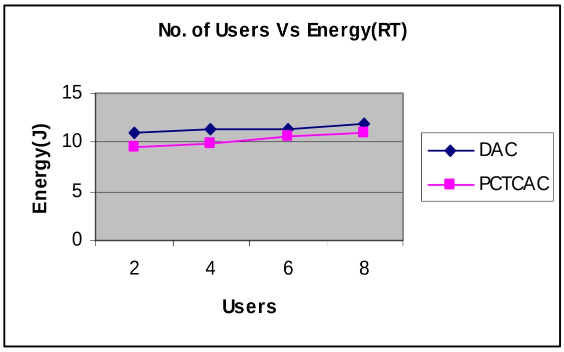

Fig 12: Users Vs Energy Consumption for RT flows

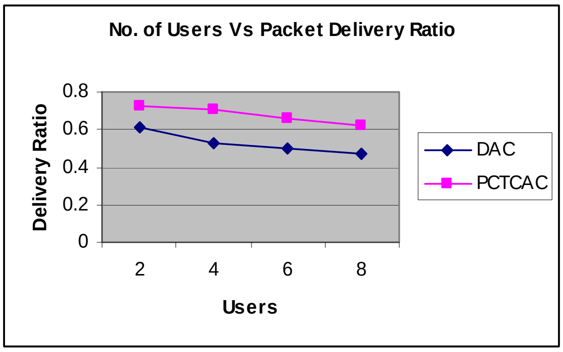

Figure 13. Users Vs Packet Delivery Ratio

Increasing the no. of users results in increased delay for both RT and NRT flows whereas the throughput of RT flows is decreased when the users are increased. Due to this throughput degradation, the packet delivery ratio is also decreased.

Figures 7 and 8 show the delay and throughput for the NRT traffic. Clearly we can see that our PCTCAC technique is better than DAC when the users are increased. This is because our PCTCAC technique provides bandwidth priority for NRT flows.

Figure 9 shows the average energy consumption of NRT flows when the no. of users is increased. Since increase in number of users results in increased power consumption, the energy for NRT users increases linearly. As we can see from the figure, PCTCAC technique has less energy consumption for the users when compared to DAC.

Figures 10 and 11 show the delay and throughput for the RT traffic. It can be observed that our PCTCAC technique yields better results than DAC when the rate is increased. This is because our PCTCAC technique provides transmission priority for RT flows.

Figure 12 shows the average energy consumption of RT flows when the no. of users is increased. Since increase in number of users results in increased power consumption, the energy for NRT users increases linearly, but comparatively less than that of NRT flows. As we can see from the figure, PCTCAC technique has less energy consumption for the users when compared to DAC.

Figure 13 shows the packet delivery ratio of both RT and NRT traffic flows. We can see that PCTCAC has packet delivery ratio slightly higher than DAC.

V. Conclusion

In this paper, we have proposed a power controlled call admission control scheme for handoff in the 4G networks. The algorithm was proposed based on the condition that it should be monotonic and optimal. The received interference is measured and depending upon the interference value, the call can be admitted. When the received interference is greater than a particular threshold value, then the call is rejected. If it is lesser than the threshold, then the existing calls are checked whether it violates the power constraint. The power constraint is calculated based upon the present uplink interference, increased uplink interference, and the target threshold. Whenever an existing call hits the power constraint, the transmit power is decremented based on the packet type whether it is real time packet or non-real time packet. This information is given to the incoming calls in order to monitor the received interference on it. From our simulation results we have proven that this power control technique provides efficient handoff in the 4G networks by increasing the throughput and reducing the delay of the existing users.

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