1. INTRODUCTION

Cellular wireless networks have become an indispensable part of the communications infrastructure. CDMA is an important air-interface technology for cellular wireless networks. Traditionally, these wireless access networks, the base stations are connected to radio network controllers (or) base station controllers by point-to-point links. As with the development of networks, the current point-to-point links is evolving to an IP based Radio Access Networks (RAN). This project work aims to realize a congestion control mechanism for CDMA based IP-RAN networks. This project implements congestion avoidance, using the mechanism router control. To realize Router control mechanism an AQM-RED is to be implemented to maximize network capability while maintaining good voice quality. The performance of implementing system using AQM-RED is to be evaluated with Drop tail AQM method. Simulation results show that how congestion is controlled using Router Control Algorithms.

CDMA has been selected for implementation in both the North American and European 3G standards. Several telecommunication equipment vendors are pursuing IP-based Radio Access Network(RAN)(e.g.,[2],[3]).IP RAN is also being provided as an option in the 3G standards[4]. While the use of an IP RAN results many ad-vantages, mechanisms must be designed to control IP RAN congestion. Congestion occurs when the offered traffic exceeds the engineered IP RAN capacity. So, to avoid the congestion the best approach is to assume a best effort IP RAN and use properly designed policies to control and avoid congestion.

We study the impact of congestion in a best-effort IP RAN on CDMA cellular voice networks. Congestion introduces loss and delay jitter in the user traffic. Uncontrolled loss and delay jitter could drastically reduce the voice quality. Therefore congestion control techniques are essential in maintaining good voice quality. We focus on the voice application for two reasons:

1. Cost is reduced: Point-to-Point links, including T1 links, are expensive and cannot be shared. An IP network will benefit from statistical multiplexing gains and could be shared with other wireless and wire line applications.

2. Reliability and Scalability: Replacing point-to-point links by a distributed IP network will provide alternate paths to more than one network controller, there by improving reliability and scalability. For example it is shown in [1] that adding a selected few paths between base stations and network controllers results in the majority of the gains in resiliency to failures.

3. Data Applications: Increasingly, a large number of IP-based “data applications” including Web browsing, email and voice over IP (packetized voice) are being offered in wireless networks. Hence wireless access networks must support IP traffic. An IP RAN efficiently addresses this concept.

We propose and evaluate congestion control mechanism to maximize network capacity while maintaining good voice quality. This is done with the Router control Mechanism. In this we study the impact of router control in the form of
active queue management[5]. IP routers using a drop tail mechanism during congestion could produce high delays and bursty losses resulting in poor voice quality. Use of active queue management at the routers reduces delays and loss correlation, thereby improving voice quality during congestion.

The paper is organized as follows.

In section 2, an overview of the problem is explained.

In section 3, background of CDMA and router control is explained. In section 4, design and implementation of router control mechanism RED is explained. In section 5, results are shown. The conclusion of this paper is shown in section 6.

2. Problem Definition

In this section, the components of a CDMA wireless access network that uses an IP RAN is shown. Here the Problem space is identified. Fig. 1 shows a wireless access network with mobile devices communicating with base stations over wireless links. The base stations communicate with the rest of the voice or data network through the access network controllers (ANCs) (also called Radio Network Controller, RNC, in 3G UMTS [6], and Base Station Controller, BSC, in CDMA2000 [7]). This part of the network is common to both wireless voice and data traffic. The network separates only beyond the ANC where voice frames are forwarded to the MSC (PSTN) and data frames are forwarded to the Service Nodes (Internet). Each base station typically communicates with hundred or more mobiles and each ANC typically controls several tens of base stations. An ANC performs two main wireless functions, frame selection and reverse outer loop power control.

Frame selection exploits one of the key properties of a CDMA network, namely, soft-handoff. In soft-handoff, a mobile communicates with more than one base station simultaneously. Soft-handoff helps reduce interference on the wireless link thereby increasing CDMA capacity. When in soft-handoff, a mobile receives multiple frames in the downlink direction (also called forward link) and combines them to construct a single voice frame. In the uplink direction (also called the reverse link) the ANC receives multiple frames from the mobile. It performs the frame selection function, which involves selecting the frame with the best quality among the ones it receives. If the frames from all the different legs of a call in soft-handoff call do not arrive within a preset time interval (20ms in the case of CDMA2000), the ANC forwards the current best frame to the network. In other words, a late frame is treated as if it were a dropped frame and thus, controlling delay in the access network is extremely important. In addition to frame selection, the ANC also performs reverse outer loop power control, in which it sets target signal to noise ratio (Eb/It) for each mobile at each base station.
only on the reverse path from base stations towards the ANC, most of the techniques described here can be applied to the forward path as well. In summary, in this paper, we will study the effect of a single bottleneck link in the common path from the base stations towards their ANC for aggregated CDMA voice traffic arriving as IP packets and propose solutions to control congestion gracefully.

3. Background of CDMA and Router Control

CDMA (Code Division Multiple Access) is the most suitable multiple access transmission technology for Mobile Communications and all the 3rd Generation Mobile Communication Standards suggest CDMA for the Air-Interface[10]. The main reason for the success of this technology is the huge increase in capacity and coverage covered by CDMA systems when compared to other analog (FM) or digital (TDMA) transmission systems due to higher bandwidth and coherent uplink detection. Transmission of code combined with the useful information requires the availability of a much greater radio frequency bandwidth than that required transmitting the information. This is the reason why one refers to Spread Spectrum Multiple Access.CDMA Architectural diagram is implemented in this project.

When congested, a router typically follows a drop tail policy where packets arriving at the router are queued as long as there is space to buffer them and dropped otherwise. Even though it is simple to implement, the drop tail poses two important problems:

Firstly, this mechanism allows a few connections with prior request to dominant the queue space allowing the other flows to starve making the network flow slower. Second, Drop Tail allows queues to be full for a long period of time. During that period, incoming packets are dropped in bursts. This causes a severe reduction in throughput of the TCP flows. One solution to overcome is to employ active queue management (AQM) algorithms. The purpose of AQM is to react to incipient congestion before the buffer overflows. AQM allows responsive flows, such as TCP flows, to react timely and reduce their sending rates in order to prevent congestion and severe packet losses.

Active queue management (AQM)[5] is a form of router control that attempts to provide congestion control by monitoring the congestion state of a router queue and proactively dropping packets before the buffers become full and queuing delays become too high. Some of the AQM policies (e.g.[8]) drop packets with a certain probability to avoid bursty loss. Random dropping and tight delay features of AQM policies are an excellent fit for the unique delay deadline and soft-handoff requirements of a CDMA access network.AQM could also help prevent all the frames associated with different legs of a soft hand off call from being dropped.In order to examine the benefits of AQM, we study the use a variant of the RED AQM policy called SRED, first proposed in the context of signaling over load control in [9].

4. Design Approach

a. RED Algorithm

RED (Random Early Detection) drops the packets randomly instead the tail part as in Droptail. This mechanism contains two key algorithms. One is used to calculate the exponentially weighted moving average of the queue size, so as to determine the burstiness that is allowed in the gateway queue and to detect possible congestion. The second algorithm is for computing the drop or marking probability, which determines how frequently the gateway drops or marks arrival packets. This algorithm can avoid global synchronization by dropping or marking packets at fairly evenly spaced intervals. Furthermore, sufficiently dropping or marking packets, this algorithm can maintain a reasonable bound of the average delay, if the average queue length is under control.

The Random Early Detection (RED) algorithm is given as,

Let ‘wq’ be the weight factor and qwk+1 be the new instantaneous queue size.

‘q’ is the average queue size and ‘qk’ is the instantaneous queue size. Then at every packet arrival, the RED gateway updates the average queue size as

\[
\overline{q}_{k+1} = (1 - w_q) \cdot \overline{q}_k + w_q \cdot q_{k+1}
\]

During the period when the RED gateway queue is empty, the system will estimate the number of packets ‘m’ that might have been transmitted by the router. So, the average queue size is updated as

\[
\overline{q}_{k+1} = (1 - w_q)^m \cdot \overline{q}_k,
\]

where

\[m = \frac{idle \text{ time}}{transmission \text{ time}}\]

where ‘idle time’ is the period that the queue is empty and ‘transmission time’ is the typical time that a packet takes to be transmitted.

The average queue size is compared to two parameters: the minimum queue threshold qmin, and the maximum queue threshold qmax. If the average queue size is smaller than qmin, the packet is admitted to the queue. If it exceeds qmax, the packet is marked or dropped.

If the average queue size is between qmin and qmax, the packet is dropped with a drop probability pb that is a function of the average queue size. This is mathematically explained as:
\[
p_{b_{k+1}} = \begin{cases} 
0 & \text{if } \bar{q}_{k+1} \leq q_{\min} \\
1 & \text{if } \bar{q}_{k+1} \geq q_{\max}, \\
q_{\max} - q_{\min} & \text{otherwise} 
\end{cases}
\]

Where \( p_{\text{max}} \) is the maximum packet drop probability. The relationship between the drop probability and average queue size is shown below. The final drop probability \( p_{a} \) is given by

\[
p_{a} = \frac{p_{b}}{1 - \text{count} \cdot p_{b}}
\]

\( \text{Count} \) is the cumulative number of the packets that are not marked or dropped since the last marked or dropped packet. It is increased by one if the incoming packet is not marked or dropped. Therefore, as \( \text{count} \) increases, the drop probability increases. However, if the incoming packet is marked or dropped, \( \text{count} \) is reset to 0. The minimum threshold value should be set high enough to maximize the link utilization. If the minimum threshold is too low, packets may be dropped unnecessarily, and the transmission link will not be fully used. The difference between the maximum threshold and the minimum threshold should be large enough to avoid global synchronization. If the difference is too small, many packets may be dropped at once, resulting in global synchronization.

b. RED Architecture Overview

The fig.2 shows the architectural overview of RED system. The function of each block is described below.

1. **Control Unit**: This is the core controller unit of the whole system. This module reads the status of every module and controls the operation of each module synchronously by enabling each system one after the other at the correct time.

2. **Packet Drop Probability Unit (PDPU)**: This module calculates the probability from the obtained \( q \)-size and decides whether to accept or drop the packets received. This module also controls the operation of the RPDU unit operation.

3. **Random Packet Drop Unit (RPDU)**: This function reads the random value form the CRVU unit for the computation of average value for deciding the packet dropping and acceptance.

4. **Compute Random Value Unit (CRVU)**: This module computes the random value using LFSR logic for the random generation of the value for RPDU unit where the RPDU unit calculates the threshold for the buffer length.

5. **Input Interface**

This module is used for the interfacing of input data to the buffer module. The interfacing module reads the input data from the input data module, which is generated randomly at each cycle.

6. **Buffer**

Implements the buffer module for the RED system. The buffer realized is of a maximum length of 1024 cells. This module receives the data from the input device in every 16 cycles and passes two cells after every slot count. The module passes out the \( q \)-size to the PDPU unit for the calculation of average value. This architecture is implemented for the analysis of the obtained results for efficiency plot and to plot congestion level for the system.
5. RESULTS

Input Samples:

In Fig.5, congestion level of RED is compared with the Drop Tail method and has seen the congestion is controlled up to 65 percent.

Fig.3: Input Test Samples of Image and Speech Considered for Design Implementation

Here two speech signals and two images are transmitted and they are retrieved back with the implemented CDMA IP-Network design.

Fig.4: Retrieved Outputs Obtained for the Implemented CDMA based AQM-RED

In Fig.5, congestion plot

In Fig.6, throughputs of RED is compared with Drop tail policy and has seen that the throughput is increased for RED for fixed values of buffer Q-size.

Fig.5: Congestion Plot

Fig.6: Throughput Plot

6. CONCLUSION

In this paper, the problem of congestion control in the IP RAN of a CDMA wireless Access network is discussed and examined the Router control mechanism. In the case of router control, an active queue management policy called AQM-RED is evaluated and found that router control that ensures low delays is essential for achieving low frame error rate during congestion. CDMA is implemented with AQM-
RED and has seen how the congestion is avoided and the throughput is increased. Some samples of voice and pictures has been taken and are checked with the implemented RED system. Here AQM-RED is compared with the drop tail and has been proven the results. The Router Control mechanism proposed in this paper maximize network capability while maintaining good voice quality.

REFERENCES