Performance Analysis of a Multimedia CDMA System Using Dynamic Rate Control

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Abstract. In this paper, we propose an effective access control scheme in an voice/video/data integrated CDMA system. The proposed scheme schedules the transmission of data traffic during low voice/video traffic density period. In addition, to guarantee the delay requirements of data traffic, the transmission rate control of video traffic is triggered when the access delay of data traffic exceeds delay requirements. Numerical results show that outage probability is decreased by allowing the delay of data traffic and decreasing the transmission rates of video traffic.

1 Introduction

Recently, researches on an integrated voice/data CDMA system are performed. In reference [1], the power resource management concept was introduced and the feasible condition was derived. In reference [2], the capacity for data calls can be increased by scheduling data transmissions during low voice load and curtailing data transmissions when the voice traffic is heavy. This control scheme was extended and the prediction control scheme was suggested[3]. To support multimedia traffic in next generation systems, it is required to control resources in reverse links[4]. In reference [5], the transmission rate control of video traffic over wireless channels is proposed. Therefore, the increase of delay sensitive data traffic such as internet web service, requires to control not only data traffic but also video traffic. In this paper, we propose an effective access control scheme using delay and transmission control.

2 Proposed Access Control Scheme

The main characteristics of the proposed scheme is to control the delay of data traffic and the transmission rates of video traffic. Delay-based access control(DAC) scheme enables data traffic to be transmitted during inactive period of voice/video traffic. But, this scheme can't guarantee the quality of service(QoS) of data traffic because data traffic has larger delay in the case of heavy traffic condition. Due to this reason, it is required that video traffic should also be controlled when the delay requirements of data traffic can't be guaranteed. For video

traffic, rate control scheme changes the transmission rate of video codec. For example, if the access delay of data traffic exceeds the access delay requirement, it triggers the transmission rate control of video traffic. Then, the station decreases the transmission rates of video traffics according to feedback information. In this paper, the access control scheme is called Delay and Transmission-based access control(DTAC) scheme.

3 Performance Analysis

Let the transmission rate of voice/video/data be r_u, r_v and r_w and the E_b/N_o requirement of each class be γ_u, γ_v and γ_w . The number of voice/video/data users are K_u, K_v and K_w , respectively. If mobile stations in each class have the same transmission rate and BER requirement, the feasibility condition in n -th slot can be obtained as

$$S(n) = \frac{U(n)}{a_u} + \frac{V(n)}{a_v} + \frac{W(n)}{a_w} < 1 \quad (1)$$

where

$$a_u = 1 + \frac{B}{r_u \gamma_u}, \quad a_v = 1 + \frac{B}{r_v \gamma_v}, \quad a_w = 1 + \frac{B}{r_w \gamma_w} \quad (2)$$

Here B is the total bandwidth. Based on the number of packets in the current slot, the permission probability for data traffic in the next slot is computed so that the target outage probability could be met.

Define $R(u, v)$ as the number of data users which are allowed in the next slot based on current active voice and video users. We can obtain $R(u, v)$ based on equation (1), the access probability of data traffic in next $(n+1)$ th slot can be calculated as following.

$$p(n+1) = \max \left\{ p \in [0, 1] \mid \sum_{j=0}^{\lfloor R(u,v) \rfloor} \binom{K_w}{j} p^j (1-p)^{K_w-j} = \delta \right\} \quad (3)$$

where $1-\delta$ is the outage probability requirements (normally 0.01). If the delay requirement of data traffic is D_{max} slot, the access probability of data users [4], p_{min} , can be computed by

$$p_{min} = \frac{1}{1 + D_{max}} \quad (4)$$

If $p(n+1)$ is greater than p_{min} , delay-based access control can be used. The minimum number of data users, $N_{w,min}$, is given by

$$N_{w,min} = \min \left\{ k \in (0, K_w) \mid \sum_{j=0}^k \binom{K_w}{j} p_{min}^j (1-p_{min})^{K_w-j} = \delta \right\} \quad (5)$$

Let us define a'_v as the modified value of a_v , when the transmission rate control is applied. From (1), a'_v can be given by

$$a'_v > \frac{V(n)}{1 - \frac{U(n)}{a_u} - \frac{N_{w,min}}{a_w}} \quad (6)$$

The transmission ratio of video traffic, $q(n+1)$, where $0 \leq q \leq 1$ (1 : normal transmission, 0 : no transmission), is computed from (2) as following

$$q(n+1) = \begin{cases} \frac{B}{r_v \gamma_v (a'_v - 1)}, & \text{if } p(n+1) < p_{min} \\ 1, & \text{otherwise} \end{cases} \quad (7)$$

If the access probability of data traffic, $p(n+1)$, is lower than minimum value, p_{min} , video transmission control is triggered.

4 Numerical Results

Consider a CDMA system with three classes of service such as voice, video and data. Each traffic has ON/OFF characteristics. The E_b/N_o , which is defined for service characteristics of voice, video and data traffic, is 6, 7 and 8 dB respectively. The system bandwidth is 32Mhz and minimum access delay in DTAC scheme is constrained by $p_{min}=0.5$. Based on these parameters, performances of DTAC scheme proposed in this paper is compared with those of DAC(delay-based access control) scheme and no access control scheme. The

Fig. 1. Outage probability vs. number of voice users (when $K_v=7$, $K_w=10$ and E_b/N_o of data = 8 dB)

Fig. 2. Throughput vs.number of voice users(when $K_v=7$, $K_w=10$ and E_b/N_o of data = 8 dB)

outage probability of three control schemes is shown in Fig. 1. It is shown that DTAC scheme has lower outage probability compared with two other schemes because it controls access of data and video traffics according to the traffic condition. The data/video throughput is shown in Fig.2. The data throughput in DTAC scheme is increased because the outage probability is decreased by the transmission rate control of video traffic. It is noted that the video throughput of DTAC scheme is increased even though the transmission rates of video traffics is decreased in heavy traffic condition. This result is due to the fact that the outage probability is decreased by DTAC scheme. It is shown that we could get more advantages by decreasing transmission rates of video traffics.

References

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