CDMA2000시스템에서 전송률 제어에 기반한 호 수락제어 기법

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Rate Control Based Call Admission Control Scheme for CDMA2000 System

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ABSTRACT

In a CDMA system, the capacity is variable and mainly depends on multiple access interference. The multiple access interference has a deep relationship with transmitted or received power. The capacity of CDMA2000 system is considered to be limited by the forward link capacity. In this paper, we show that the forward link cell load can be represented by the total transmitted power of base station and we propose a forward link call admission control (CAC) strategy for CDMA2000 system. The proposed call admission scheme adopts the rate control algorithm for data call. This call admission scheme enables the system to utilize radio resource dynamically by controlling data rate according to the cell load status, and enhance the system throughput and grade of service (GoS)/ quality of service(QoS) such as blocking and outage probability.

Key Words : Call admission control, CDMA, Rate control.

I. Introduction

Contrary to frequency division multiple access (FDMA) and time division multiple access (TDMA), CDMA system has not absolute number of maximum available channels. The limit in CDMA capacity is determined by the multiple access interference. Hence, in the interference limited CDMA systems, good interference handling scheme for radio resource allocation play a key role to enhance the performance and increase the capacity. Call admission control handles new incoming traffic to the cell. When the traffic is congested, admitting a new call can only make the link quality worse and may result in call dropping. Thus, CDMA system needs a call admission policy for new call request to maintain acceptable connections for existing users.

Several studies have been done on the capacity and CAC for CDMA system [1]-[4]. However most of these studies addressed the reverse link. This is due to the fact that most believe that a CDMA system is limited by reverse link. It is generally accepted in industry that the capacity of IS-95A/B [5][6] systems are reverse link limited. While IS-2000 [7] improves reverse link with pilot aided coherent demodulation and emerging data services are likely to require higher data rates in forward link than the reverse link. Hence, the capacity of CDMA2000 system is limited by the forward link capacity[8][9] and the forward link call admission control is required.

On the forward link, a small fraction of users are assigned a large fraction of transmitted power

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budget. The capacity of a cell is limited if the higher data user is closer to the boundary, while very large capacities are available if the high data rate user is in the interior of the cell. The higher data rate users with mixed traffic result in large adjacent cell interference variation which drastically degrades the system capacity. Hence, rate control scheme is necessary to utilize resource efficiently.

In this paper, we show that the transmitted power can represent the total cell load and we propose forward link CAC strategy for CDMA2000 system. Since high rate data has a low processing gain, the allocated power to the data call is proportional to the data rate. In this paper, we assumed perfect power control and the assigned power to each traffic is controlled to satisfy its required SIR (signal to interference ratio) at mobile station. Even with perfect power control, users at higher data rates in a system with mixed traffic result in large adjacent cell interference variation which drastically degrade the system capacity. The proposed CAC algorithm guarantees QoS and enables the system to utilize radio resource dynamically by controlling data rate according to the cell load status.

This paper is organized as follows: Section II shows that the cell load can be measured by transmitted power. Section III describes the proposed call admission control strategy. Section IV shows the simulation model and result, and the conclusions are given in Section V.

II. Forward link cell load measurement

Call admission control is an essential strategy to utilize radio resources dynamically and guarantee QoS. To determine the call admission, the system should know the total cell load. In this Section, we show that the total cell load can be measured by the total transmitted power at base station.

As a generally accepted radio propagation model for DS-CDMA system, log normal distribution of shadowing with its mean path loss of l-th power is adopted. The long term path loss model used in this paper is given by

$$g_{k,i} = r(k,i)^{-l} \cdot 10^{\xi/10} \quad (1)$$

where l is path loss exponent, typically 3 or 4 and ξ is a Gaussian random variable with mean of zero and standard deviation of σ [dB], representing shadow fading and typically σ is 4" 12dB. $r(k,i)$ is the distance from the base station k to the mobile station i. In the forward link, the received SIR from base station k to mobile station i is given as follows

$$\gamma = \frac{S_{0,i} g_{0,i}}{\delta P_0 g_{0,i} + I_{oc,i} + \eta} \quad (2)$$

where δ is the orthogonality factor, P_k is the total output power of base station k, S_{ki} is the transmitted power allocated to mobile i in the k-th base station coverage, and η is back ground noise. The other cell interference to the i-th mobile, from adjacent base is given by

$$I_{oc,i} = \sum_{k=1}^{K-1} P_k g_{k,i} \quad (3)$$

Under perfect power control assumption, it is assumed that $\gamma = \gamma_{target}$. In this paper we consider voice and data traffic and the target SIR can be γ_v and γ_d for voice and data call, respectively. In general, the background noise is negligible compared to the total power received from all base station. From (2) the transmitted power of mobile station can be obtained.

$$S_{0,i} = \frac{\gamma(\delta P_0 g_{k,i} + I_{oc,i})}{g_{k,i}} \quad (4)$$

The total transmitted power at base station can be written as

$$P_0 = \alpha_v \sum_{i}^{N_v} S_{0,i} + \alpha_d \sum_{j}^{N_d} S_{0,j} + P_{over} \quad (5)$$

where N_v and N_d is the number of data and voice users in the cell, and a_v and a_v is voice and data activity factor, respectively. P_{over} is the allocated power for overhead channels such as pilot, synch and paging channels. The ratio $F_{k,i}$ for k-th cell and i-th user is defined as the ratio of the received intercell and inracell power.

$$F_{k,i} = \frac{I_{oc,i}}{P_k g_{k,i}} \tag{6}$$

Assuming that $F_{k,i} \approx F_{k,j} \approx F$ for all users [10], the equation for the total base station output power can be obtained

$$P_0 = \alpha_v \gamma_v P_0 N_v (\delta + F) + \alpha_d \gamma_d P_0 N_d (\delta + F) + P_{over} \tag{7}$$

From (7), the total transmitted power at base station, P_0, can be obtained as follows.

$$P_0 = \frac{P_{over}}{1 - \{\alpha_v \gamma_v N_v (\delta + F) + \alpha_d \gamma_d N_d (\delta + F)\}} = \frac{P_{over}}{1 - \left(\frac{N_d}{N_{pole,d}} + \frac{N_d}{N_{pole,d}} \right)} \tag{8}$$

where N_{pole} is the absolute maximum downlink pole capacity [10]. When the power control problem has no feasible solution and transmitted powers are unconstrained, all powers will increase without bound.

$$N_{pole,v} = \frac{1}{\alpha \gamma_v (\delta + F)}, \quad N_{pole,d} = \frac{1}{\alpha \gamma_d (\delta + F)} \tag{9}$$

Maximum downlink capacity shown in (9) is obtained on the assumption of an infinite base station power and no overhead channel. To measure the load of the cell, the load factor L is defined as

$$L = \frac{N_d}{N_{pole,d}} + \frac{N_d}{N_{pole,d}} \tag{10}$$

From (8) and (10), the load factor can be expressed by the function of total transmitted power of base station.

$$L = 1 - P_{over}/P_0 \tag{11}$$

The maximum transmitted power should be chosen such that users can have sufficient transmitted power to achieve their quality requirements when the system reaches the allowable system load. The maximum load function is obtained when the transmitted power reaches maximum power. Equation (11) shows that call load can be measured by total transmitted power at the base station.

In this paper, we consider the variable data rate but the feasible transmission rates are limited to a small number of discrete values. For the radio configuration 3 of IS-2000, the feasible data rates are 19.2Kbps 38.4Kbps, 76.8Kbps and 153.6Kbps [7]. Since the high rate data has small spreading gain, the assigned power should increase as the data rate increase to guarantee the required QoS. We assume equal bit energy for the data traffic and the allocated power increases in proportion to the data rate and the required E_b/N_0 of data call is identical regardless of data rate and the relationship between the required SIR of R_i data rate call and R_j data rate call

$$\gamma_{R_i} = \frac{R_i}{R_j} \gamma_{R_j} \tag{12}$$

Different data rate call requires different γ and different transmitted power. It enables the system to handle the cell load by controlling data rate. A large fraction of transmitted power is assigned to a small fraction of data users. Hence, the capacity of the cell is limited if the higher data user is closer to the boundary. In that case, by reducing the data rate of the data user in the cell boundary, the system can have redundant resources and reduce blocking probability.

III. Proposed call admission Strategies

In forward link, the number of simultaneous users that the system can support is limited by available resource. As shown in Section II, the transmitted power represents cell load, that is, the resource and cell capacity. The data users are assigned a higher transmission power level than voice users to achieve a required QoS and the higher data rate requires higher transmission power level than that of rower data rate to compensate low processing gain. On the forward link, a small fraction of users are assigned a large fraction of transmitted power budget. Hence, the capacity of the cell is limited if the higher data user is closer to the boundary, while very large capacities are available if the high-data-rate user is in the interior of the cell.

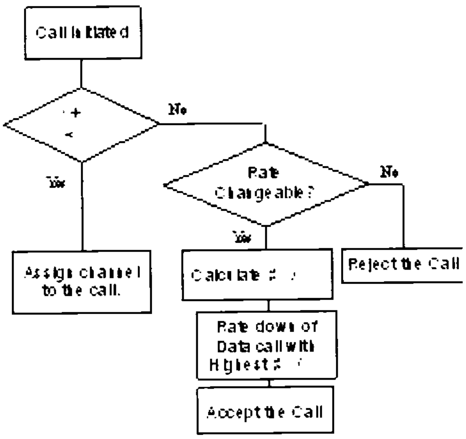

Fig. 1. Call Admission Control Algorithms with Rate Control

The proposed call admission algorithm is based on a threshold mechanism and utilizes the relationship between data rate and required SIR. Figure 1 shows the call admission control algorithm. When a new call is initiated, the system monitors current total transmitted power, P_0, and required power for the newly initiated call, P_{req},. The system compares the total transmitted power at base station including the required power for the newly initiated call with the CAC threshold, P_{th}, for the call admission. The CAC threshold value should be lower than the maximum transmitted power of base station. If the total required power, P_0+P_{req}, is lower than CAC threshold, the system accepts the new call. If the total required transmitted power is over the CAC threshold value, base station investigates whether the new call can be accepted by reducing the data rate of in service or initiated data calls. If the total transmitted power becomes lower than power threshold by reducing the data rate, the system reduces data rate and admits the newly initiated call. The system reduces the data rate of which data call has highest transmitted channel power compared to its data rate. The reason why reduce the data rate of which highest power data call is that the user suffering worse channel condition requires more transmitted power by power control algorithm. In this paper, we assume EBE (Equal Bit Energy), and for the same channel condition, the system allocates power proportional to data rate.

$$E_{b_i} = \frac{S_{k,i}}{R_{k,i}} = E_b \qquad (13)$$

where $S_{k,i}$ is transmitted power and $R_{k,i}$ is data rate for i-th data call in the k-th base station coverage. However, under the different channel condition, the required transmitted power is changed and the system can monitor channel condition by calculating $S_{k,i}/R_{k,i}$, and the difference of the calculated values shows the difference of channel condition. When the system tries to reduce data rate, the system calculates $S_{k,i}/R_{k,i}$ and chooses the date call having highest $S_{k,i}/R_{k,i}$ value which suffers from worst channel condition and has highest transmitted power comparing with its data rate. The reduction of data rate means the reduction of required transmitted power. If there is no data call of which data rate can be reduced, the newly initiated call is rejected.

IV. System simulation and results

To evaluate the performance of the proposed call admission strategy, system level simulation is performed. In this simulation, only the forward link is considered. Hence it is assumed that, whenever the forward link channel is assigned, the reverse link is established. The simulated area consists of 19 hexagonal cells and the geometry of the interference model is shown in Figure 2.

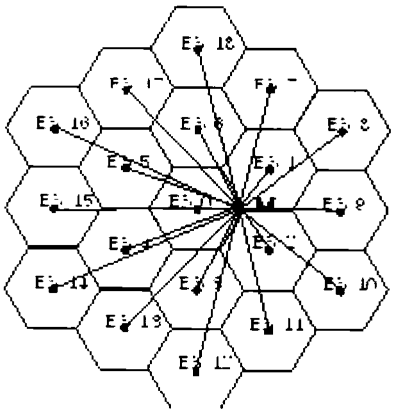

Fig. 2. Cell configuration and forward link interference model

Table 1. Simulation Parameters

Parameter	Value
Cell radius	1Km
Chip rate	1.2288 Mcps
Mean of voice rate (μ_v)	1/90 (1/sec)
Mean of data rate (μ_d)	1/200 (1/sec)
Maximum Power of base station	20W
Target $(E_b/N_0)_v$	5dB
Target $(E_b/N_0)_d$	4dB
Activity Factor	0.4(voice), 1(data)
Standard deviation of shadowing	8dB
The power ratio of overhead ch.	30%

The call arrival process is modeled as an independent Poission process with mean arrival rate λ_i for service type i and call duration has the exponential distribution with mead call duration $1/\mu_i$. The parameter μ_i is the mean of service rate for service type i. In this paper, i is d and v for data and voice service, respectively. The users are assumed to be uniformly distributed and the velocity of mobile is assumed to be uniformly distributed over 0~100km/h. For the forward link, each user communicates with the strongest base station and was perfectly power controlled by serving base station. We assume equal bit energy for data traffic and it is assumed that the required E_b/N_0 for data traffic is 4dB regardless of data rate. The fraction of overhead channel is assumed to be fixed and not varies with traffic load, that is, 30% of maximum transmitted power. The simulation parameters used in simulations are listed in table 1

For the performance measure, blocking and outage probability is defined. Blocking probability is the probability that initiated calls are rejected because of lack of resources to be allocated. Outage probability is defined as the probability that the current call does not meet the required SIR. Outage happens and some calls are terminated when the total transmitted power is over maximum power at base station. Blocking probability represents GoS and outage probability represents QoS of the system.

Fig. 3 and 4 show blocking probability according to rate control scheme. Fig3. is for voice and data call, and Fig. 4 is for data call. As shown in Fig. 3 and 4, when the rate control scheme is adopted, blocking probability is much lower than the other case. Even if the system reaches maximum cell load, the system can reduce the cell load by reducing the data rate and it enable the new call to be admitted. The CAC threshold also affect on the blocking probability. When the CAC threshold set high, blocking probability comes low. However higher CAC threshold induce higher outage probability because many active calls in a cell induce high interference and it reduce the quality of calls.

Fig. 5 shows the outage probability of voice and data call and Fig.6 shows the outage probability of data call. The result is similar to that of blocking probability. When the rate control scheme is adopted in the CAC algorithm, outage probability becomes lower. Higher CAC threshold induce higher outage probability. Fig. 7 shows the system throughput in a cell. The system without rate control scheme has higher blocking and outage probability and it reduce total system throughput. In case of CAC with rate control, the system has up to about 180Kbps. On the other hand, without rate control, the system has up to about 150 Kbps. If there is not rate control scheme, the system cannot utilize the radio resource efficiently. By using the CAC algorithm with rate control, the system increases the data throughput and increase data capacity.

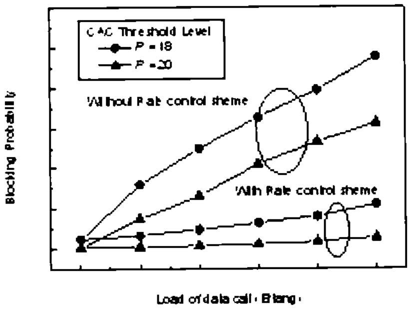

Fig. 3. Blocking Probability with varying data call load when CAC threshold is 18, 20 voice call load is 20 Erlang

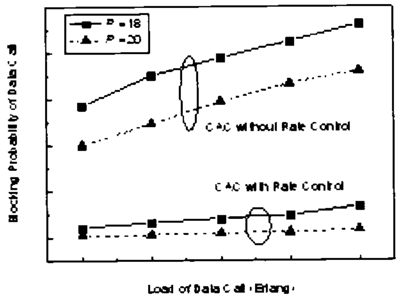

Fig. 4. Blocking Probability of data call with varying data call load when CAC threshold is 18, 20 voice call load is 20 Erlang

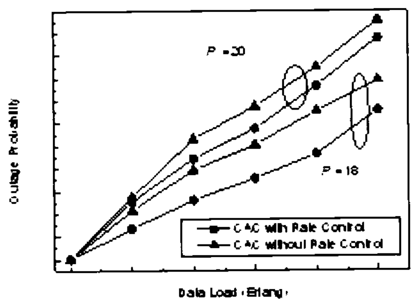

Fig. 5.Outage Probability with varying data call load when CAC threshold is 18, 20 and voice call load is 20 Erlang

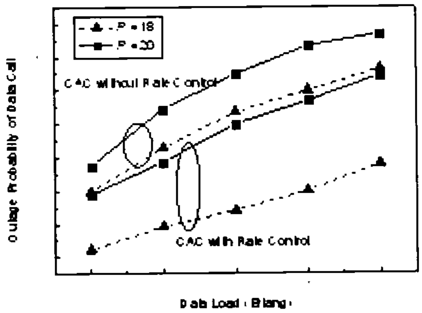

Fig. 6. Outage Probability of data call with varying data call load when CAC threshold is 18, 20 and voice call load is 20 Erlang

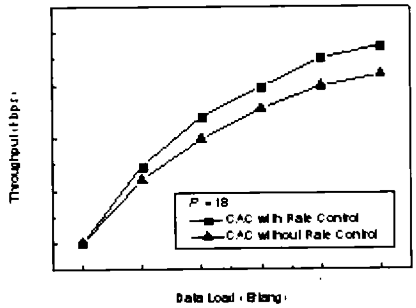

Fig. 7. Throughput with varying data call load when CAC threshold is 18 and voice call load is 20 Erlang

V. Conclusions

In this paper, we show that the transmitted power can represent system cell load and we propose the call admission algorithm for CDMA2000 system using the total transmitted power and rate control algorithm. CDMA system has a flexible radio resource since the CDMA system is the interference limited system. By adopting the rate control algorithm in the call admission control scheme, we can reduce the call blocking and outage probability, and it means the enhancement of system GoS/QoS. This call admission control also enhances the system throughput. Enhancement of System throughput has a deep relationship with the cost of data service. As shown in this paper, the proposed call admission scheme can be applied to the CDMA2000 system and it is very practical sheme to be applied to CMDA2000 system.

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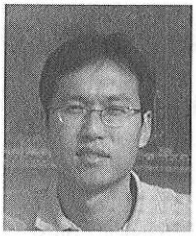

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