Performance Analysis of CDMA System Integrated Voice And WWW Traffic With Different Velocity Users

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Abstract: An analytical of throughput and delay on reverse link in a cellular slotted CDMA system with integrated voice and World Wide Web (WWW) traffic is presented in this paper. Our results show that the Gaussian approximation it was found that the voice traffic can have a significant impact on the WWW traffic. It was also found that the different mobiles velocity and number of resolvable paths is impact each other the system performance.

Keywords: CDMA system**,** Integrated Voice**,** WWW traffic

1. INTRODUCTION

In third generation mobile, the system users are expected to have access to a variety of services such as high quality voice, data, video, multimedia, and internet utilizing the advanced multiple access techniques. CDMA technique is being considered for the next generation of wireless cellular systems due to it has many advantages over FDMA and TDMA. CDMA system offers the potential of high spectrum efficiency. This capacity of advantages is compared together with other features such as soft capacity, multipath resistance, inherent frequency diversity and interference rejection.

The performance analysis of a packet oriented, slotted single cell CDMA system with imperfect power control is presented. Packet CDMA systems have attracted a lot of attention, due to the part of the rapid growth of Internet penetration and the expected future demand for mobile access to Internet services. One reason for the increased Internet usage is the emergence of the World Wide Web (WWW). As an user wants to download a web page, there has to send a page request message to the base station. This message will eventually be relayed to the required server and download of a page will be initiated. During a session a user can make a number of requests for pages to be downloaded. It has been shown that for a large number of users, the interarrival time between page requests at the base-station is exponentially distributed. Hence, the page arrival process at the base station can be considered to be a Poisson process. Let λ_w is the arrival rate of WWW users to the cell and N_p is the mean number of page requests per session then we can assume that λ_P, the arrival rate of page requests at the base station, is given by;

$$\lambda_P = \lambda_w N_P \qquad (1)$$

Each page request is generally small (in size). Assume that the mean number of bytes per page request is 2600 bytes [1]. Assume further that the messages are transmitted at a constant bit rate then; the transmission time of the page request message will also follow the same distribution as the message size i.e. lognormal, with a modified mean and variance, for the case of page request. The page requests is focused, the CDMA cell can be modeled as an M/G/∞ queue [2]. The arrival process is Poisson and the service time is lognormally distributed. For the M/G/∞ queue; the mean number of active page request in a cell at steady state becomes a poission random variable with the mean; λ_P/μ_P.

2. SYSTEM MODEL

Consider the uplink channel of a single cell slotted power controlled CDMA system for packet transmission with frequency duplex division, that is the uplink and downlink channels are allocated to different bands. We consider that the system is unlimited by the number of receivers (RAKE receivers) and the mobile users are permitted to transmit only at fixed time instants. The considered data services here are of long enough duration so that closed loop power control can be performed. Assume a Rayleigh multipath fading channel with M is equal to the strength paths.

Due to the fact that perfect power control cannot be achieved in practical systems, the received power levels from each user suffer a deviation from the mean value. The received power level in a base station from each mobile will be modeled with a lognormal random variable. The mean of the received power level is a function of the communication environment [3], and is adjusted by the power control mechanism. In a fading channel, the standard deviation is a function of the mobiles velocity, number of resolvable paths and whether the mobile is communicating with the base station where the power is measured or with another base station in the system [4]. When uplink fast power control is able to follow the fast fading, the power level from mobiles transmitting to a different base station than the considered one arrive at the desired base station with a higher deviation due to the fact that the mobile's transmitted power is trying to mitigate the fading effect in another base station. Of course, this implies that the multipath fading is independent processes to different base stations.

This paper will employ the obtained results from the reference of Hashem and Sousa [4] to model the effect of power control imperfections. These results are presented in Table 1, where it is shown the standard deviation, measured in dB, of the received signal from users communicating with the desired base station, σ. Results are presented for different mobiles velocity and different number of resolvable paths.

Table 1 Standard deviation of mobiles communicating with the desired base station.

	M = 2	M = 3	M = 4
V(Km/h)	σ dB	σ dB	σ dB
10	0.67	0.43	0.37
20	1.40	0.94	0.6
30	1.88	1.40	0.83
40	2.20	1.75	1.25

This paper will focus our attention on the impact of power control error, on system performance and no enhance MAC protocol.

3. PERFORMANCE ANALYSIS

Assume that K_v voice and K_w data active users on the reverse link exist in a single cell and the users of all cells are uniformly distributed. To a potential $(K_v+1)^{st}$ voice user or $(K_w+1)^{st}$ data user, the total power for a single cell is given by [2];

$$P_{Total} = \sum_{i=1}^{K_V} \alpha_{V,i} P_{V,i} + \sum_{j=1}^{K_W} \alpha_{W,j} P_{W,j} + N_O W = I_O W \quad (2)$$

Where $\alpha_{v,i}$ and $\alpha_{w,j}$ are the voice and data activity factor for K_v^{th} voice user and K_w^{th} data user, respectively. $P_{v,i}$ and $P_{w,j}$ are the received signal power for K_v^{th} voice user and K_w^{th} data user. W is the spread spectrum bandwidth N_O is the noise spectral density and I_O is the interference spectral density.
The non blocking condition for the single cell is

$$\sum_{i=1}^{K_V} \alpha_{v,i} E_i^v R_v + \sum_{j=1}^{K_W} \alpha_{w,j} E_j^w R_w + N_O W \le I_O W \quad (3)$$

Where E_i^v and E_j^w are the bit energy of i^{th} voice user and j^{th} data user, respectively. R_v and R_w are bit rate of voice user and data user. K_v and K_w are the number of users, being a Poisson random variable with mean $(\lambda/\mu)_v$ and $(\lambda/\mu)_w$, respectively. Normalize (3) by $I_O W$, and then let the random variable Z be defined as follows;

$$Z = \frac{1}{G_v}\sum_{i=1}^{K_V} \alpha_{v,i}\varepsilon_i^v + \frac{1}{G_w}\sum_{j=1}^{K_W} \alpha_{w,j}\varepsilon_j^w \le 1-\eta \quad (4)$$

where $\varepsilon_i^v = E_i^v/I_O$ and $\varepsilon_i^w = E_i^w/I_O$ are the bit energy for K_v^{th} voice user and K_w^{th} web user to the interference spectral density, which are modeled as lognormal random variables, respectively. G_v and G_w are the processing gain of voice and web traffic. $\eta = N_O/I_O$ is the total interference-to-background noise level.

Since Z is a sum of random variable, Z will be a Guassian random variable by applying the central limit theorem [5], [6]. Therefore, the blocking probability may be approximated.

$$P_B = P\{Z > Z_O\} \approx Q\left(\frac{Z_O - E(Z)}{\sqrt{Var[Z]}}\right) \quad (5)$$

Where Z_O is a certain critical threshold value occurring in blocking. In the previous paper [2], the system is considered to be overloaded with interference for $\eta < 10$ dB.
So that, the mean and variance of RV Z, $E(Z)$ and $Var[Z]$, are;

$$E[Z] = \frac{1}{G_v}\left(\frac{\alpha\lambda}{\mu}\right)_v f(m_v,\sigma_v) + \frac{1}{G_w}\left(\frac{\alpha\lambda}{\mu}\right)_w f(m_w,\sigma_w) \quad (6)$$

$$Var(Z) = \frac{1}{G_v^2}\left(\frac{\alpha\lambda}{\mu}\right)_v g(m_v,\sigma_v) + \frac{1}{G_w^2}\left(\frac{\alpha\lambda}{\mu}\right)_w g(m_w,\sigma_w) \quad (7)$$

$$f(a,b) = \exp\left(\beta a + \frac{1}{2}\beta^2 b^2\right)$$

$$g(a,b) = \exp\left(2\beta a + 2\beta^2 b^2\right), \quad \beta = \frac{\ln(10)}{10}$$

This paper considers a slotted system, implying that each user is allowed to transmit packets only at fixed time instants. In a packet network, throughput and delay are appropriate parameters, rather than maximum user capacity. The throughput determines the average number of successfully received packets per time slot, given a certain amount of traffic. For a certain amount of throughput it is important to know what will be the average delay of a packet. The throughput is defined as the average number of successfully received packets per time slot, which is as follow from the previous paper [3].

$$S = \sum_{k=1}^{N} k P_T(k) P_s(k) \quad (8)$$

Where N is the number of users per cell, $P_T(k)$ is the probability of k packets being transmitted in a time slot. Assuming a Poisson arrival distribution of the offered traffic, $P_T(k)$ is written as;

$$P_T(k) = \frac{G^k}{k!} e^{-G} \quad (9)$$

The offered traffic G is defined as the average number of offered packets per time slot. Here it is assumed that the offered traffic consists of new packets and retransmission packets.

On the other hand, $P_s(k)$ is the packet success probability, and defined as the probability of k packets being successfully transmitted in a time slot. To consider a worse case, assume that, when a blocking occurs, all transmitted packets in that time slot are destroyed, hence, $P_s(k)$ will be given as;

$$P_s(k) = 1 - P_{blocking}(k) \quad (10)$$

With $P_{blocking}(k)$ being the probability of blocking when k packets are trasmitted in a time slot, which is given as (5) for the Gaussian approximations.
The average delay in the system is defined as the average time beteween the generation and successful reception of a packet. Assuming a positive acknowledgment scheme and no transmission errors in the acknowledgment packets, the expression for the delay in a slotted CDMA system is [3];

$$D = (1.5 + d) + \left[\frac{G}{S} - 1 \right] (\lfloor \delta + 1 \rfloor + 1 + 2d) \quad (11)$$

Where δ is the mean of the retransmission delay, which is uniformly distributed over the range form which the retransmission delay is selected, S is the throughput, G is the offered traffic and d is the propagation delay, all normalised to the duration of one slot time. Here $\lfloor X \rfloor$ is the largest integer smaller than or equal to X.

4. NUMERICAL RESULTS

In this section, the curves are presented showing the obtained results for the Gaussian approximation. Throughput and delay are the selected performance parameter measured. For all the following figures, assume the bandwidth of W-CDMA is 5 MHz. For the delay calculations assume a mean retransmission delay δ = 10 time slots and negligible propagation delay. Both degree of power control error of voice and WWW traffic are identical. All presented Figs. in this section are valid for the reverse link.

Figs. 1 and 2 show the throughput and delay of WWW traffic for different of voice traffic (30, 60, 90 Erlang). The value for standard deviation of the received power from mobiles in the desired base station has been taken from Table 1. For users moving at 40 Km/h and number of resolvable paths that received at the receiver of desired base station, M = 4 path. We have assumed a required E_b/I_O ratio of 5 dB. From the Figs. it is clear that the performance of WWW traffic decreases as the voice traffic increases. A decrease in performance implies that the maximum throughput is lower and that the delay corresponding to a throughput value is higher.

The influence of velocity when the number of resolvable path M = 4 is depicted in Fig. 3 and Fig 4. From Table 1, for users moving at 10 30 and 40 km/h we have assumed a standard deviation of 0.37 0.83 and 1.25 dB, respectively. It should be noted that the degree of imperfect power control higher as increasing mobile's velocity. Then, it is obviously shown that the performance decrease as the mobile's velocity increases.

Figs. 5 and 6 show the performance for the case in which all mobiles in the system arrive at the desired base station with the same standard deviation of received power level with user velocity is 40 km/h. And the number of resolvable paths is varying (M = 2, 3 and 4). It can be seen that, we are achieved the higher performance as the increase the number of resolvable path for M = 2, 3 and 4 respectively.

5. CONCLUSIONS

In this work, we investigated the cellular slotted CDMA system with integrated voice and World Wide Web (WWW) traffic. The Gaussian approximation, throughput and delay were evaluated and the system performance was measured. From the results, higher voice traffic is impact one another the transmission of WWW traffic. And the degradation of performance has occured with increase mobile's velocity. In addition, the higher performance can be achieved with increasing number of resolvable paths.

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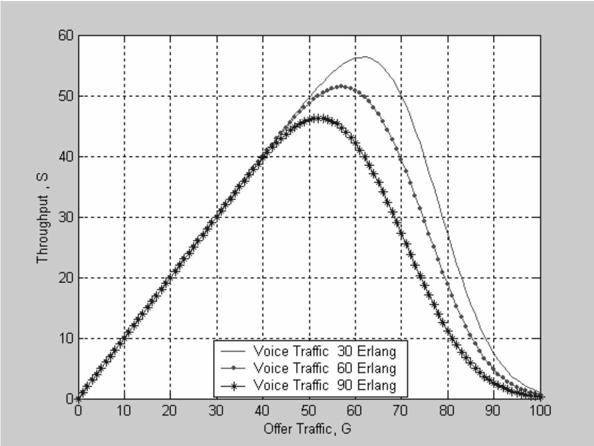

Fig. 1 Throughput (S) of WWW Traffic comparison with different Voice Traffic

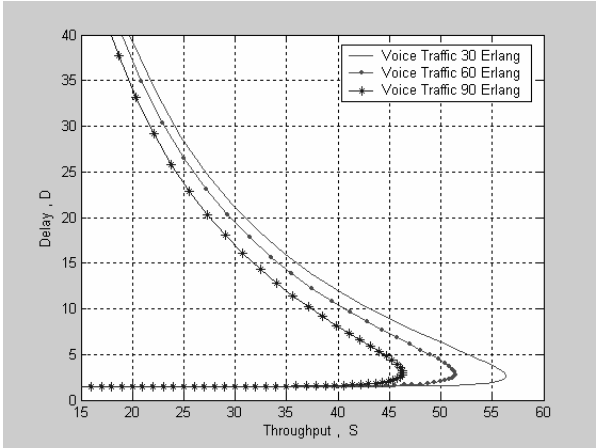

Fig. 2 Delay (D) of WWW Traffic comparison with different Voice Traffic

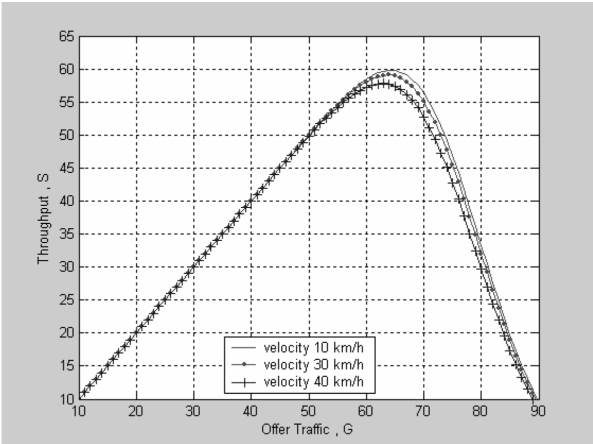

Fig. 3 Throughput (S) of WWW Traffic comparison with Voice Traffic for different velocity of user

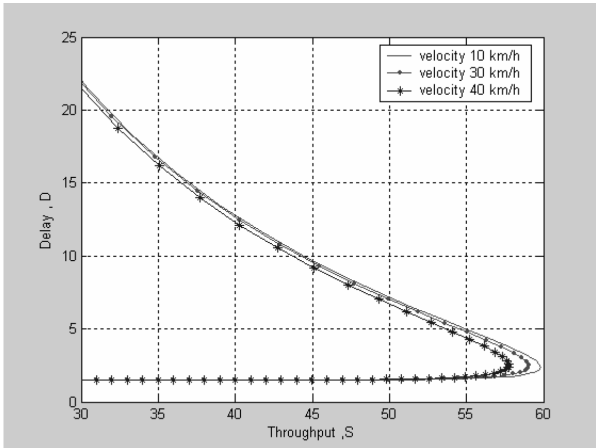

Fig. 5 Delay (D) of WWW Traffic comparison with Voice Traffic for different velocity of user

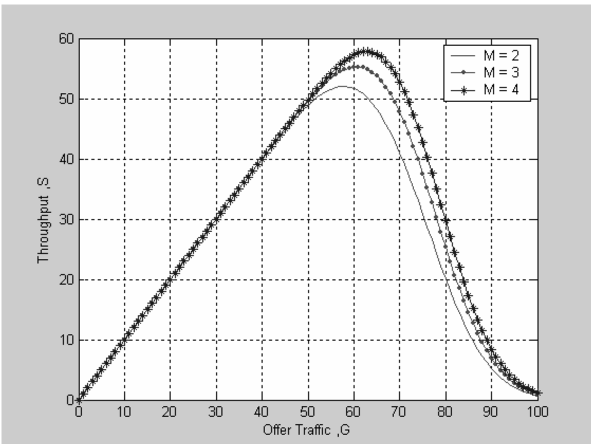

Fig. 5 Throughput (S) of WWW Traffic comparison with Voice Traffic by varying number of resolvable paths

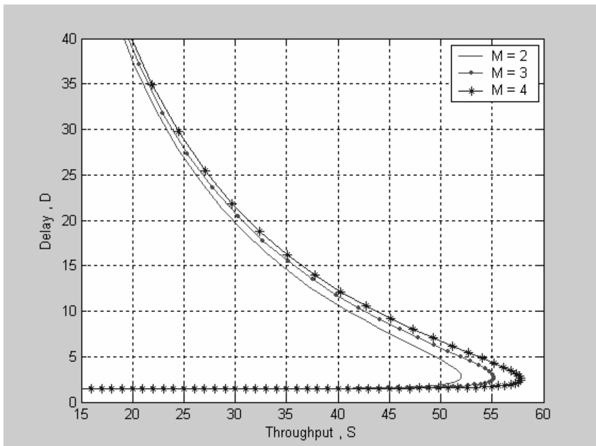

Fig. 6 Delay (D) of WWW Traffic comparison with Voice Traffic by varying number of resolvable paths