Admission Control and Resource Allocation for DS-CDMA Networks with Multiple Traffic Classes

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Abstract — **The purpose of this paper is to provide a framework for resource allocation and admission control in a DS-CDMA system in which there are several traffic classes with different rates and quality of service requirements. We focus on uplink (mobile to base) transmission, in which the transmissions from different mobiles are uncoordinated. For special cases of two traffic classes, we show that, for large systems, a Gaussian approximation for the interference yields that the boundary of the admission control region is approximately a straight line and the optimal power ratio P_2/P_1 is roughly the same throughout the boundary of the admission control region.**

I. Introduction

Our framework is based on the following assumptions:
(a) The users transmit using fixed-length packets, and are assumed to be synchronized at the packet level. Thus, the system is time-slotted, with a slot equal to a packet duration.
(b) The traffic generated by a user may be bursty (e.g., voice, variable bit rate video, TCP). However, we assume that the bit rate over a given packet is constant, which means that the processing gain over a packet is fixed (since the chip rate is fixed).
(c) The event of packet loss for a given user is well approximated by the event that the Signal-to-Interference-plus-Noise Ratio (SINR) falls below a threshold.

II. System Model

We consider on-off traffic sources here, for which the offered bit rate can take one of only two possible values, the peak rate and zero. For an on-off source of traffic class i, the processing gain when the source is on is determined by its peak rate, and is denoted by N_i. Our purpose is to determine the region determined by the allowable tuples $(K_1, K_2, ...)$, where K_i denotes the number of sources of type i. This also requires determining the optimal values of the received powers $\{P_i\}$, where P_i denotes the desired received power for a user of type i. Our model is simpler than the models in [1] and [2], in that we allow the processing gain to be fixed by the offered rate, and only choose the received powers for the different traffic classes. This enables us to obtain a simpler characterization of the admission control region.

III. Main results

Since we consider on-off sources, at each given time slot, we assume each user of traffic type i is active with probability p_i. The allowable packet loss rate for a user of type i is q_i. The packet loss event for a user of type i is approximated by the event that the SINR seen by the packet falls below a threshold γ_i. For simplicity of illustration, we employ the SINR expression for a chip-synchronous DS-CDMA system with conventional matched filter reception, so that the SINR for a typical packet of type i is given by

$$SINR_i = \frac{P_i N_i}{\sum_{k=1}^{K_i-1} \chi_{ik} P_i + \sum_{j\neq i}^{2} \sum_{k=1}^{K_j} \chi_{jk} P_j + \sigma^2}$$

where χ_{ik} is an on/off indicator (i.e., $\chi_{ik} = 1$ if user k of type i is active, and 0 else), and σ^2 is the background noise power, which indicates the inter-cell interference. The on/off indicators $\{\chi_{ik}\}$ are assumed to be independent random variables and $P[\chi_{ik} = 1] = p_i, P[\chi_{ik} = 0] = 1 - p_i$. We consider the case of two traffic classes. Given K_1 and K_2, we say that (K_1, K_2) is *admissible* if the following conditions are satisfied:

$$P[SINR_i < \gamma_i] < q_i, \ i = 1, 2. \tag{1}$$

Assuming that the contribution of a single user's power to the total transmitted power is negligible, we can rewrite (1) as

$$P[X_1 + rX_2 > a_1] < q_1, \quad P[X_1 + rX_2 > a_2 r] < q_2, \tag{2}$$

where $r = P_2/P_1$, $a_i = N_i/\gamma_i - \sigma^2/P_1$, $X_i = \sum_{k=1}^{K_i} \chi_{i_k}$, $i = 1, 2$. When the system size is large, we may approximate $X_1 + rX_2$ by a Gaussian random variable based on the Central Limit Theorem. For a class of specific scenarios considered in the paper, we obtain the following results:

(a) Given K_1, the number of users of type 1, there is an optimal value of $r(K_1)$ such that the number of users of type 2 admissible is maximized.

(b) For a large system, the maximum number of users of type 2 is approximately a linear function of K_1. Also, the power ratio $r(K_1)$ equals approximately a constant r^*.

Simulation results show that, for large systems, the Gaussian approximation provides an admission region close to the exact admission region, which is also well approximated by fixing the power ratio $r(K_1)$ as a constant r^*.

References

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