Packet Fair Queueing Scheduling in an Integrated CDMA System Based on Channel Status Information

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Abstract. A Fair Queueing Algorithm is proposed for data services in an integrated voice/data CDMA system. We introduce short-term and long-term fairness concepts to allocate data users fairly. Using these concepts, we propose Weighted Fair Queueing with Status Control(WFQS) in the consideration of a Generalized Processor Sharing(GPS) fluid-flow model. This proposed scheme allocates resources using channel status information. In order to implement this fair resource allocation scheme, a virtual clock for short-term fairness and a credit table method for long-term fairness are used. The throughput and delay of data users could be improved when this scheme is applied to wireless channels. . . .

1 Introduction

Scheduling research is needed in wired and wireless networks to support various Quality of Service (QoS) levels. In wired networks, a considerable body of works has been devoted to the Generalized Processor Sharing(GPS) policy, in which, at any given time, all backlogged sessions send data at their fair rates. However, in wireless environment, some mobile stations may not be able to transmit data due to bad channel conditions while other stations may have good channels and can transmit data. Considering these wireless characteristics, a new model for fair scheduling in wireless packet networks has been proposed. A set of properties that a fair queueing algorithm should possess in wireless networks was and Channel-Condition Independent Fair Queueing has been suggested to support these properties.

However, this proposal did not consider the physical and Medium Access Control(MAC) protocol. A packet fair queueing scheme based on the multirate CDMA protocol was proposed and a time scheduling scheme suitable for hybrid CDMA/TDMA systems was introduced. Based on this approach, a Throughput Maximization(TM) scheme was developed. Fig.1 shows the TM scheme, which maximizes the throughput of data users by allocating resources to one data user in each frame. The main advantage of this scheme is that it...
increases throughput by reducing intracell interference. Thus, the scheme is efficient for supporting high speed packet data services in CDMA systems. Therefore, it is important to distribute resources to data users fairly using wireless channel conditions because only one data user is allowed to transmit per frame.

2 System Model

Consider the interference of a reverse link in a single cell CDMA system. Let $N$ be the number of users. Each user has QoS requirements and rate constraints. The chip rate for all users is fixed and the total bandwidth $B_w$ is available to all users. Let the spreading gain of the $i$-th mobile be $G_i$, the channel gain be $h_i$, the background noise be $\eta_o$, the $(E_b/N_0)$ requirement be $\gamma_i$, the maximum power of a mobile station be $p_{max}$, and the transmission rate be $r_i$. Then, the condition minimizing total transmitted power is given by

$$
\sum_{i=1}^{N} g_i \leq 1 - R_m
$$

where

$$
g_i = \frac{\gamma_i}{\gamma_i + G_i} \quad \text{and} \quad R_m = \frac{\eta_o B_w}{\min_i \left(h_i p_{max}/g_i\right)}
$$

From this result, we define $g_i$ as the power index of mobile $i$. This indicates the power resource that is allocated to mobile $i$. The power index $g_i$, which depends on the spreading gain and the $(E_b/N_0)$ requirement, is a good representation of a resource in a CDMA system. Therefore, the summation of $g_i$ indicates the admission threshold in each frame.

Let $N_v$ be the number of voice users and $N_d$ be the number of data users. Voice users are numbered from 1 to $N_v$ and data users are numbered from $N_v + 1$ to $N$, where $N = N_v + N_d$. Let $B(t)$ represent the number of active voice users at time $t$. Then, the resource $R_v(\tau, t)$ for voice users during the interval of $(\tau, t]$ (we assume that $(\tau, t]$ is the same as frame duration) is given by