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A high performance MAC protocol for broadcast LANs with bursty traffic

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Abstract

An new medium access control protocol for broadcast LANs, which is capable of achieving a high performance under bursty traffic conditions, is introduced. According to the proposed protocol, the network stations are separated into groups. All the groups are granted permission to transmit in a round-robin fashion. The main objective of the grouping algorithm is to have exactly one ready station in each group. In this way, idle slots and collisions are minimized and a nearly optimal throughput-delay performance is achieved. The grouping of stations is dynamically modified at each time slot according to the network feedback information. Due to the dynamic nature of the grouping algorithm, the protocol is capable of being adapted to the sharp changes of the stations' traffic.

Keywords: Broadcast LANs; Medium access control; Bursty traffic; Adaptive grouping protocol

1. Introduction

Channel allocation is the key problem in multiaccess networks. A broad range of Demand Assignment, Random Access and Fixed Assignment Medium Access Control (MAC) protocols have been proposed as solutions to this problem [1,2]. However, most MAC protocols suffer from low performance when operating under bursty traffic conditions.

Recently, a new class of adaptive protocols [3–7] which are capable of operating efficiently in a bursty traffic environment has been introduced. Although these protocols achieve a high throughput-delay performance even when the traffic is bursty, they suffer from a significant drawback. They have difficulty in sensing the transition of a station from idle to ready state. Thus, when an idle station becomes ready, it has to wait for a relatively long period before being granted permission to transmit. Therefore, newly arriving packets suffer a significant delay, even when the offered load is low.

In this paper, a new medium access control protocol that overcomes the above drawback is introduced. According to the proposed protocol, the network stations are separated into groups. All the groups are granted permission to transmit in a round-robin fashion. The main objective of the grouping algorithm is to have exactly one ready station in each group. In this way, idle slots and collisions are minimized and a nearly optimal throughput-delay performance is achieved. The grouping of stations is dynamically modified at each time slot according to the network feedback information. Due to the dynamic nature of the grouping algorithm, the protocol is capable of being adapted to the sharp changes of the stations' traffic.

The proposed Adaptive Grouping Protocol (AGP) is applicable to a broad range of broadcast network architectures, including bus, star and wireless LANs. This paper focuses on the general principles of operation of the proposed protocol rather than on its application to specific network architectures.

The paper is organized as follows: The proposed AGP protocol is presented in Section II. Simulation results which indicate the superiority of the AGP protocol over other well-known protocols, are presented in Section III. Finally, concluding remarks are given in Section IV.

2. The adaptive grouping protocol

Let $A=\{a_1,\ldots,a_N\}$ be the set of stations, where N is the number of stations. The stations communicate via a slotted broadcast channel. Each station is provided with a waiting queue of length Q, where the arriving packets are buffered before being transmitted. The traffic which is offered to the

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stations is assumed to be bursty. Thus, each station can be in one of two states: active or idle. When a station is active it has one packet arrival at each time slot. On the other hand, when a station is idle it has no packet arrivals. Each station operates independently from the others and has no knowledge of their states.

According to the proposed AGP protocol, the set of stations A is divided into N subsets $A_1, A_2, \ldots, A_N$ with: $A_1 \cup A_2 \cup, \ldots, \cup A_N = A$ and $A_1 \cap A_2 \cap, \ldots, \cap A_N =$. Some of the subsets $A_j (j=1,\ldots,N)$ may be empty sets. All the nonempty subsets are granted permission to transmit in a round-robin fashion. The main objective of AGP is to have exactly one ready station in each nonempty subset. In this way, idle slots and collisions are minimized and the throughput-delay performance is significantly improved.

In order to achieve the above objective, the grouping of stations into subsets is updated at each time slot, according to the network feedback information, in line with the following rules:

(1) If the previous time slot t was idle, then the subset $A(t)$ which was granted permission to transmit in this time slot is assumed to contain no ready stations and consequently, it is merged with a nonempty subset.
(2) If a collision took place during the previous time slot t, then $A(t)$ is assumed to contain more than one ready station and consequently it is split into two subsets of equal size in an effort to avoid further collisions.
(3) If a successful transmission took place during the previous slot then the grouping of stations into subsets is assumed to be satisfactory and remains invariant.

All the stations execute the same grouping algorithm and, due to the broadcast nature of the stations, the feedback is common for all the stations. Therefore, all the stations arrive at the same conclusion on which subset of stations is granted permission to transmit at each time slot.

The algorithmic description of the AGP protocol is presented below. In the following description, the network feedback information at time slot t is: $slot(t) \in \{success, idle, collision\}$. Initially, each subset $A_j (j=1,\ldots,N)$ contains exactly one station.

PROCEDURE AGP;
REPEAT
  $t := t+1$;
  All stations in $A_i(t)$ are granted permission to transmit in slot t;
  If $slot(t) = idle$ then
  BEGIN
    $k := i$; repeat $k := (k \bmod N)+1$; until $((A_k(t) \neq \phi)$or $(k=i))$;
    if $k \neq i$ then
    BEGIN (* Merge A_i with a nonempty set *)
      $A_k(t+1) := A_k(t) \cup A_i(t))$;
      $A_i(t+1) := \phi$;
    END
    repeat $i := (i \bmod N)+1$; until $(A_i(t+1) \neq \phi)$;
  END
  else if $slot(t) = collision$ then
  BEGIN
    $k := i$; repeat $k := (k \bmod N)+1$; until $((A_k(t) = \phi)$or $(k=i))$;
    if $k \neq i$ then
    BEGIN (* Split A_i into two sets *)

$$A_k(t+1) := \{a_{i,1}(t), \ldots, a_{i,\lceil |A_i(t)|/2 \rceil}(t)\};$$

$$A_i(t+1) := A_i(t) - A_k(t+1);$$

    END
  END
  else if $slot(t) = success$ then
  BEGIN
    repeat $i := (i \bmod N)+1$; until $(A_i(t+1) \neq \phi)$;
  END
FOREVER;

It should be noted, that the use of the proposed AGP protocol in a wireless LAN environment is not straightforward. In such an environment, the bit error rate is high and consequently, the assumptions of the common feedback and the absense of packet losses due to noise do not hold. We are currently working on a protocol of the AGP family (based on the adaptive grouping of stations) capable of operating efficiently in a wireless LAN environment.

3. Simulation results

In the following, the proposed AGP protocol is compared to protocols LTDMA [3], ATDMA [4] and URN [9]. LTDMA and ATDMA are adaptive protocols which use the same network feedback information which is used by the AGP scheme. Therefore, a performance comparison between the two schemes will be very helpful in evaluating the proposed AGP protocol. URN is a limited contention protocol that achieves a high performance when operating under low load conditions. This protocol can not be fairly compared to the other three protocols because it requires additional feedback information (the number of ready users). However, a performance comparison between the proposed AGP protocol and URN could be very useful in evaluating the AGP performance under low load conditions.

The protocols which are under comparison were simulated to be applied to four networks (N_1 to N_4) under bursty traffic conditions. The bursty traffic was modelled in the same way used in [3,4] and [8]. Each station can be in one of two states S_0 and S_1. When a station is in state S_0 then it has no packet arrivals. When a station is in state S_1 then, it