Medium Access Control with Packet Length Priority Towards a Real Time Ethernet

Rupo Yin, Yunze Cai, Weidong Zhang, and Gang Shen

Abstract—**This paper proposed a real time medium access control method over the predominant Ethernet broadcast channel. Taking advantages of intrinsic characteristic of standard Ethernet frame, packet length based priority and channel state signaling are introduced. Medium access control provides a deterministic performance through contending and blocking. Moreover, it is compatible with IEEE 802.3. Analysis and simulation results show the correctness and effectiveness.**

I. Introduction

Ethernet has become the most prevailing communication technology in LAN environments. But, due to the nondeterministic nature of CSMA/CD, broadcast Ethernet is not suitable for applications with stringent time constrains [1], [2], as in industrial floor, despite owning the virtues of simplicity, flexibility, and economy compared with switch technology. Typical schemes, such as VT-CSMA [3], CSMA/DCR [4], RETHER [5] and etc[1][6], were proposed in past years. Recent efforts, such as CSMA/CD based on persistent contention [7] or on varying collision intervals [8], aim at efficient link layer solutions that are completely compatible with IEEE802.3. In this paper, we propose a medium access control scheme belonging to this category.

II. Real Time Medium Access Control

A. Packet Length Based Priority

According to IEEE802.3 [2], length of standard Ethernet frame, shown in Fig.1. (a), is variable. The minimum size of data field is required to be at least 46 octets to provide normal CSMA/CD operation, while the maximum size is defined as 1500 octets. This suggests that frame's priority may be defined by introducing length range dividing over the data field, where prioritized messages are restricted to certain length ranges that are prohibited to overlay. Considering time critical control or alarm messages with shorter length are common in industrial floor, a possible rule is that priority decreases as data size increases. As another benefit, channel state signaling is achieved by carrier length sensing within whole network. State information includes: transmission, collision, contention as well as additional priority. A length-dividing scheme is shown in Fig.1. (b), where a sub-range *Contention* is reserved due to collision.

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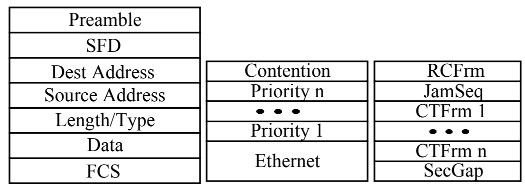

(a) (b) (c)

Fig. 1. Length based priority definition. (a) Standard frame. (b) Real time data field dividing. (c) *Contention* sub-range structure.

B. Medium Access Control

Once a new MAC is initiated, it starts to sense channel continuously. When a packet arrives, its priority is first calculated. If the channel is sensed open, new MAC operates as normal CSMA/CD. If a frame collides with other frames transmitting at the same time, after finished sending Jam signal, new MAC persists sending a series of contention frames, with one slot long each to promise necessary collision detection time, as in [7], [8]. Higher current priority is, longer contention signal is to be sent. For example, consider a MAC with two priorities, where class 2 and 1 correspond to hard and soft real time respectively. The maximum contention signal is 2 and 1 slots accordingly.

First, assume contention takes place between different priorities and there is only one frame with high priority involved. By sending longer contention signal, the sole high priority node will detect sometime that collision disappears before it quits contention. It is the only winner at last. While detecting collision throughout their contention period and finding there still exists continued contention when they quit contention, low priority nodes fail in the contention. In order to grant winning nodes with the sole access right, failed nodes will defer retransmissions. New MAC also prevents other nodes from transmitting any new frames with priorities lower than the winning one. They become blocking. Once collision has been resolved, to make the channel open again as soon as possible so that blocked nodes may resume transmission, event of the first successful transmission of a high priority frame is used to identify the end of blocking period.

On the other hand, if a node quits contention with collision detected throughout, but no continued contention found, it collides with some nodes of the same priority. All of them are accepted as winners. They back off according to BEB random algorithm for the reason of fairness. It is important to mention that collision between different priorities does not change the value of collision counter in the new MAC. Failed node that retreats from contending just initiates another backoff with the same collision counter immediately after it quit contention and waits for the end of resolution to try transmission of destroyed messages according to backoff status.

C. Delay Performance Analysis

Use τ_p to denote propagation delay between two nodes. τ_i denotes transmission delay for priority *i, i=2,1*. The time to transmit a Jam is *J*. The time for persistent contention of priority i is C_i. T_I denotes usual interframe spacing time. Assume the interarrival distribution of hard real time messages satisfies that there will be no newly arrival of the same priority before current message has been granted with the channel access right. Therefore, under the new MAC, in the worst case, a hard real time frame experiences at most one additional contention after having waited for a complete transmission of a soft real time frame due to carrier sensing, shown as fig.2. The maximum delivery delay is calculated as $\tau_1+T_I+2\tau_p+J+C_2+T_I+\tau_2$. It is deterministic. The minimum interarrival time for hard real time priority is $\tau_1+T_I+2\tau_p+J+C_2+T_I+\tau_p$.

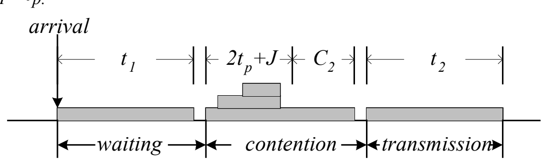

Fig. 2. Deterministic transmission process of hard real time frames

When a conventional Ethernet node with frame size only confined in the *Ethernet* range added in real time network, which usually serves data query and system maintenance operations, it can communicate with real time nodes directly. Though deterministic performance is not always strictly guaranteed, statistic real time is still well promised.

III. SIMULATION RESULTS

Simulations have been done for a network composed of 20 real time nodes under the new MAC. During simulation, data transmission rate is set to 10Mb/s. Signal propagation velocity is 5.1282×10^{-9}s/m. Consistent with Ethernet, interframe gap and jam sequence are set to 96 and 32 bits respectively. As a result, the maximum contention carrier is 1632 bit long. For convenience, only one node is selected to produce messages with fixed length of 180 octets that belonging to hard real time priority. It generates packets according to a periodic process with periodicity 0.001s that satisfies the deterministic condition. Serving as soft real time role, all the other nodes independently generate packets with fixed length of 184 octets to a Poisson process with mean arrival rate 10 packets per second. Results are shown in fig.3

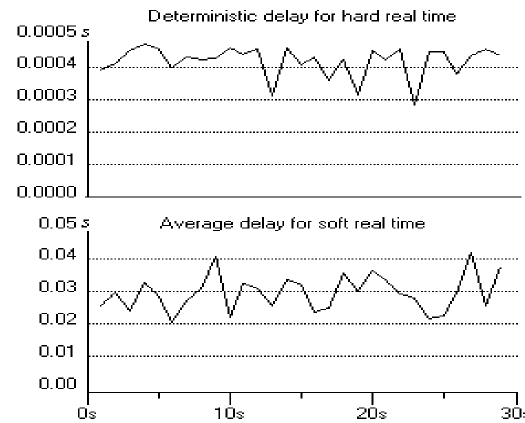

Fig. 3. Delivery delay performance of the new MAC

Simulations show the new MAC can guarantee a bounded delivery delay for hard real time priority. Comparing with conventional Ethernet also shows even under heavy traffic load, average delay for soft real time is kept considerably low. However, overall throughput of the channel will decrease due to additional channel contentions especially as the load increases.

IV. CONCLUSION

The main drawback of Ethernet lies in the fact that it cannot guarantee a deterministic behavior in time critical environments. This paper introduces a real time medium access control scheme based on packet length priority. Meanwhile, taking advantage of the intrinsic nature of current standard also makes the proposed MAC very easy to implement with commercially available interface chips and boards, thus makes it more practical.

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