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A New Policy for Improving the Performance of the Slotted Persistent CSMA/CD Protocol

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Abstract

In this paper a new policy for improving the performance of the slotted persistent CSMA/CD protocol is proposed. The policy is based on using the channel feedback information to adaptively adjust the level of traffic intensity in order to achieve an optimum system performance. The algorithm for choosing the required step size of the variability for the adjustment of the loading percent of each station in the network is also introduced. A special simulator was build, and the simulation results show that the proposed control policy is able to steer the optimum load percent, which maximize the overall system performance.

Keywords: CSMA/CD, P-Persistent, self adaptive, segmentation, and backoff.

1. Introduction

One class of multi-access protocols for packet communication system is the random access (or contention) technique, where the entire bandwidth is provided to the users as a single channel to be accessed randomly. Carrier Sense Multiple Access [1], is included in this category. One of the LAN medium access control standard created by IEEE project 802 is the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) medium access control [2].
Performance studies [3,4] indicate that CSMA/CD performs better at light network loads. Different studies [5,6], show that CSMA/CD LAN performance tends to degrade rapidly as the load exceeds 40% of the bus capacity. Above these loads, the number of packet collision rises rapidly due to the interaction among repeated transactions and the new packet arrivals. Collided packets back-off based on the truncates binary back-off algorithms as defined in IEEE 802.3 standard. These retransmitted packets also collided with the newly arriving packet [7].

There have been a number of studies concerned with the ways used to overcome the limitations of CSMA/CD protocols as:

a) Collision resolution [8].
b) Retransmission back-off scheme [9].
c) CSMA/CD networks segmentation [10].
d) Slotted CSMA/CD [11].

The disadvantage of these approaches is that they provide only small improvements in performance (less than 10% in the maximum channel utilization).
One of the basic measures of the protocol efficiency is throughput, i. e, the average fraction of time used by the channel for useful data communication. There are three factors accounting for the throughput degradation: propagation delay, users idle time (not transmitting), and packet collision inherent in the random access. This paper aimed to reduce the level of packet collision by adjusting either the protocol parameters (as the probability of transmission) or the offered traffic in order to improve the system performance. An adaptive algorithm is developed to maximize the throughput of the network by varying the load percent of each station in order to control the transmission into channel.

The rest of the paper is organized as follows: the P-persistent CSMA/CD protocol is reviewed in section 2, relation to other works is presented in section 3. Section 4 contains the proposed algorithm for improving the performance of P-persistent CSMA/CD protocol. Simulation model and parameters are presented in section 5. Section 6 contains the simulation results. Finally, conclusions are drawn in section 7.

2. General Description of the P-persistent CSMA/CD protocol.

The P-persistent protocol is an enhancement of the 1-persistent protocol (special case of the P-persistent) by allowing ready terminal to randomize the start of the transmission following the instant at which the channel become idle [12]. Thus, a ready terminal senses the channel and proceeds as follows:

1) if the channel is sensed idle, the terminal initiates transmission of the packet.
2) If the channel is busy, the terminal persists unit the channel is idle, and
A) with probability (P) it initiates transmission of packet;
B) with probability (1-P) it delays transmission by T seconds (the end –to-end propagation delay). If, at this new point in time, the channel is sensed idle, then the terminal repeats this process (steps A,B), otherwise, it schedules retransmission of the packet to some later time.
3) if a collision is detected during transmission, this transmission is aborted and the packet is scheduled for transmission at some later time. The terminal then repeats the algorithm.

3. Relation to Other Works

The first study of CMSA was done by Kleinrock and Tobagi [1]. In addtion to versions of CMSA protocols studied by Kleinrock and Tobagi, Kleinrock and Hunt [13], add collision detection to work of Tobagi and Kleinrock [14]. Collision detection is a feature that informs a source that its packet has been destroyed soon after the collision occurs. In a subsequent paper; Tobagi and Kleinrock [15], investigated various forms of persistent CSMA, slotted CSMA with and without collision detection. Then they derived in detail the explicit formula for throughput evaluation for various finite population models assuming that there is: a constant packet length whose transmission time is chosen the unit of time, finite number of users transmits devoted by M, each non empty user who has a buffered packet starts transmission with probability P at the slot boundaries following any idle slot, where 0<P<1, and the total offered traffic is G.
Since the major purpose presented by Tobagi and Kleinrock [15] is to provide the mathematical formula for throughput of various CSMA protocols, they haven't gone into the area of optimization with respect to G and P or comparison of optimized throughput values (capacities) among protocols. From this point, this paper is presented to give an advanced technique used to improve the throughput with respect to these two parameters. Parameter which was studied in detail is the total offered traffic G in view of its effect on the system performance when the second parameter P is fixed.

4. The Proposed Policy

from the previous section , we can see that the system throughput is a function of many network parameters, among it G and P. there exist a mathematical relation [16] between the average number of packet offered for transmission by the stations in any slot G and the remaining parameters given by:

$$G=\frac{1}{a[M(1-e^{-1/\lambda})]} \qquad (1)$$

Where,
α: propagation delay;
M: number of transmitting stations; and
λ: Inverse the package arrival rate which is related to the loading per station by the following equation:

$$\lambda = n(\frac{s(L+1)-L}{s(L+2)-L})]^{-1} \text{ Slot} \qquad (2)$$

Where,
L: packet length in slots, and
S: fraction load provided by each station, where 10% load per station means that in the case of any station transmitting on the channel, the output of the station would occupy the channel for 10% of the time, if no other station were allowed to transmit.

The basic idea of the policy depends on adjusting the loading per station S in order to control the packet arrival rate which consequently adopt the total offered traffic that finally maximize the system

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throughput. The proposed algorithm uses dynamic loading per station percent S, which can control the transmission into the channel.

The proposed algorithm does not require any change in the standard CSMA/CD frame format described in section 2. Moreover, any station in the network deduces to send a packet, it follows the same three pre-mentioned rules of the P-persistent CSMA/CD, in addition to the following steps:

a) The channel throughput, TH is monitored continuously over fixed consecutive intervals. A station measures the duration of time during which the channel is occupied by successful packet transmission in each fixed monitoring period.
b) At the end of each monitoring period, a station has to calculate the loading percent. The variation of the throughput over consecutive intervals are used to steer the direction and quantum of change in the loading per station percent S. For n^{th} interval, the loading per station S(n) is given by:

$$s(n)=s(n-1)\left\{ 1+\alpha \, \text{sign}\left(\frac{\Delta Th}{\Delta S}\right) \right\} \quad (3)$$

where,

α: the step size of quantum change in the loading per station percent for the n^{th} interval. It depends strongly on the factor $\left(\frac{\Delta Th}{Th}\right)$, where ΔTh = Th(n)- Th(n-1).

Th(n-1) and Th(n), are measured throughputs for the intervals (n-1), n respectively. The values of α are shown below as chosen as a result of many simulations which show that it works reasonably well.

$\left(\frac{\Delta Th}{Th}\right)$	
0	$\alpha = 0$
0.03	$0<\alpha<=0.05$
0.07	$0.05<\alpha<=0.11$
0.12	$0.11<\alpha<=0.18$
0.24	$0.18<\alpha$

Sign$\left(\frac{\Delta Th}{Th}\right)$: determine the direction of change in the loading per station, that is, if ΔTh and ΔS have the same sign, then S(n)> S(n-1), otherwise S(n)<S(n-1).

5. Verification of the Proposed Algorithm and Simulation Results

To investigate the performance of the proposed self adaptive P-persistent CSMAC/CD protocol for a large number of stations and various probabilities of transmission, we use an analytical simulator [16] based on a probabilistic model which takes into account the network speed, size and propagation delay. The simulation program is written using C ++language and is run on PII .300.Below is a list of the input parameters to the simulation model:

- Packet size: 512 byte
- Bus length: 1.5 km
- No of station: 500
- Bus bandwidth: 10 Mbps
- Jamming signal: 32 bit
- Bakeoff algorithm: binary exponential bakeoff, with a maximum of 15 transmission attempts,
- Base bakeoff time: 52 msec
- Fixed monitoring period: 3 msec. It was tested different intervals ranging form 1 msec to 10 m sec; the 3 m sec fixed interval is shown to provide stable and quick response to the adaptive algorithm.

Through simulation, we have verified the improved performance of the self adaptive P-persistent CSMA/CD protocol .In fig (1), we shown to provide stable and quick response to the adaptive algorithm

Through simulation, we have verified the improved performance of the self adaptive P-persistent CSMA/CD protocol .In fig (1), we show the relation between the distribution of the number of transmission per packet for all the successful packets (the probability of transmission for each station in the network P=0.15) and the number of transmission. Form this gig, we note that about 95% of the packets that use the proposed algorithm and 85% of the packets that use persistent CSMA/CD protocol are successful in their first transmission .About 15% of the traditional P-persistent CSMA/CD packets need up to 7 transmission .In fig(2), we repeat the previous relation but for another value of probability of transmission "P" equal to 0.75 .In this case, there exist about 40% of the standard P-persistent CSMA/CD packets are successful in the first transmission and other packets require up to15 transmission. These are expected results because when we raise the value of the transmission collision increases and consequently the number of transmission increase the standard P-persistent CSMA/CD protocol inappropriate.

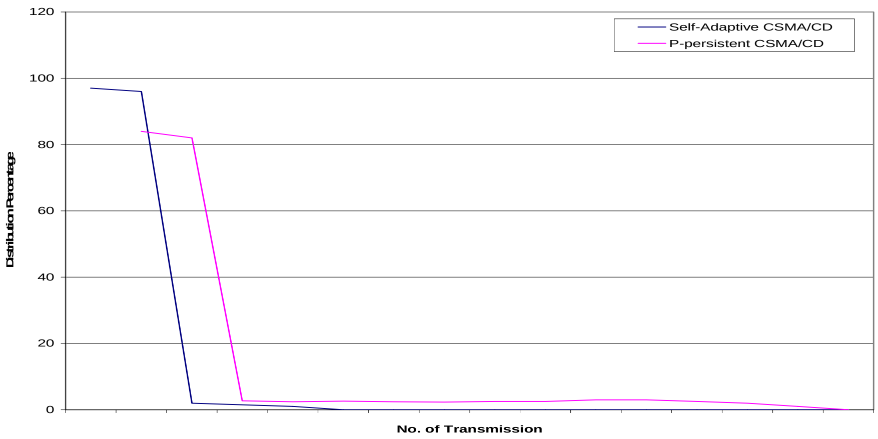

Figure 1: Distribution of the No. of Transmissions per Packet for the Self Adaptive CSMA/CD and the P-Persistent CSMA/CD for P=0.15.

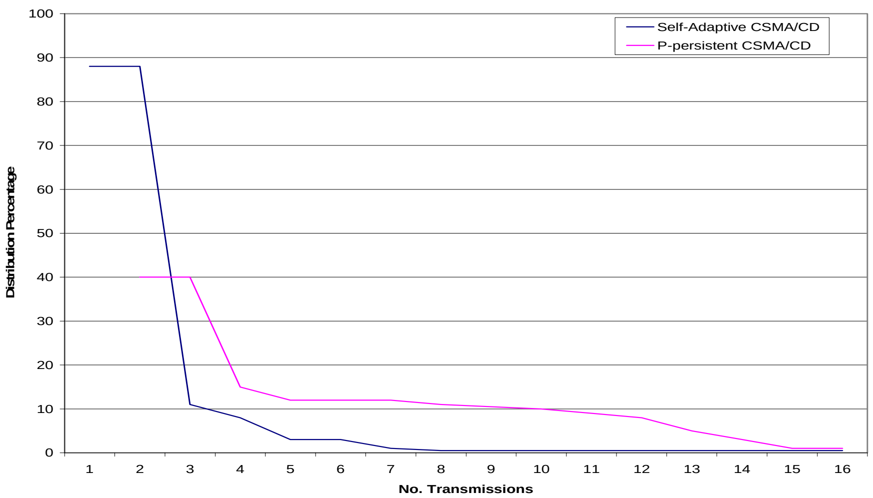

Figure 2: Distribution of the No. of Transmissions per Packet for the Self Adaptive CSMA/CD and the P-Persistent CSMA/CD for P=0.75.

On the other hand 85% of the packets that use the proposed algorithm need only one transmission and the rest exceeds 12 transmissions. This is, because the proposed algorithm has ability, through ΔTh/Th calculation, to estimate the throughput changes for the selection of the appropriate value of the loading per station percent "S", which controls the hence the number of retransmissions.

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Figure (3) shows the throughput of both standard CSMA/CD and the proposed algorithm as function of the offered load. The throughput attainable by the proposed algorithm is about 20% higher in the overload condition due to the controlling mechanism, which applied on the network. For P below 0.3, both throughputs are nearly equal when packet loss is considered, the simulation results in Fig (4) show that the proposed algorithm may support 65% bus loading before any packet is discarded. This is a substantial gain of 65% channel capacity over 50% achievable in the standard P-persistent CSMA/CD protocol.

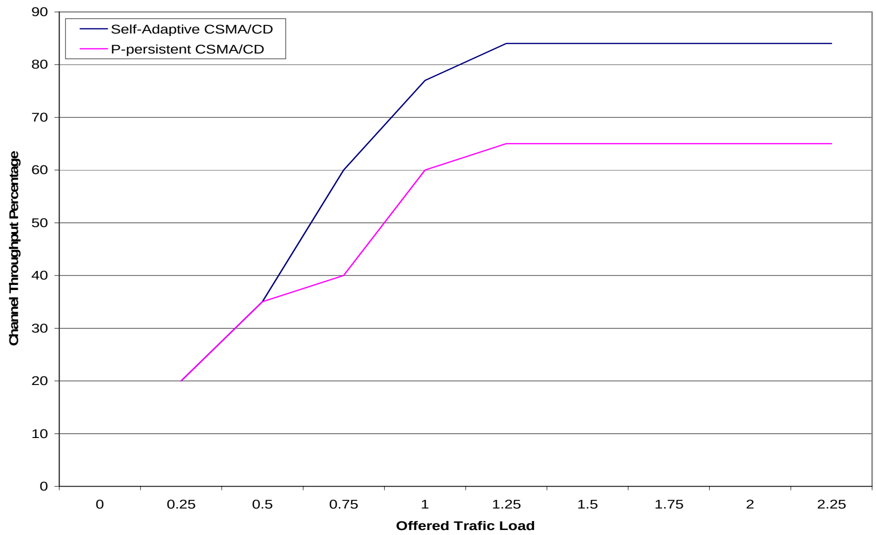

Figure 3: Throughput Comparison of the Self Adaptive CSMA/CD and the P-Persistent CSMA/CD.

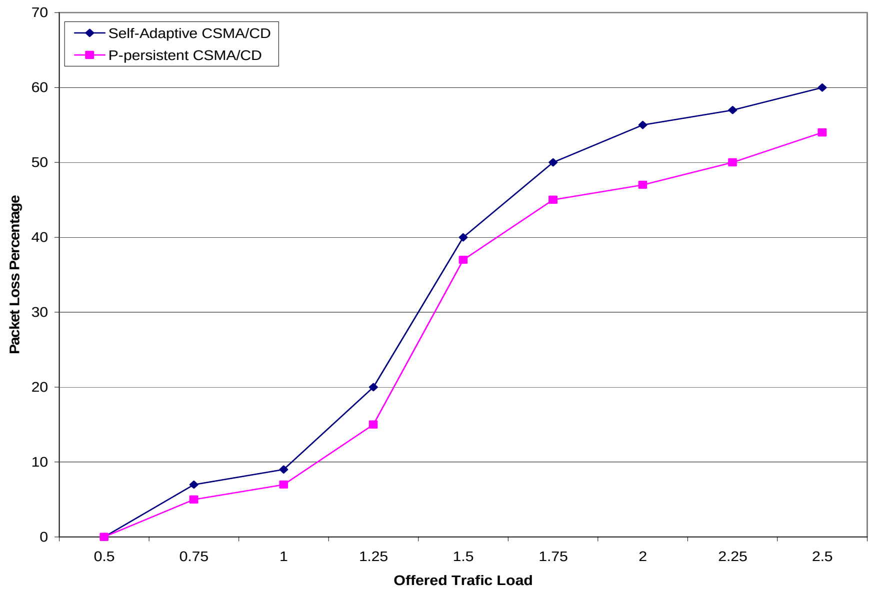

Figure 4: Packet Loss Comparison of the Self Adaptive CSMA/CD and the P-Persistent CSMA/CD.

6. Conclusion

In this paper, we have presented a self-adaptive P-persistent CSMA/CD protocol for performance improvement through controlling the transmission into the channel. Unlike the standard P-persistent CSMA/CD protocol. The proposed algorithm uses dynamic loading per station percent to regulate and adapt the transmission into the channel .Simulation results show that the proposed algorithm performs better than the standard P-persistent CSMA/CD protocol.

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