Modified CSMA/CD protocol using a time slot allocation device

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Abstract- The Carrier Sense Multiple Access with Collision Detection works on the basis of the back-off algorithm which gives a range of time slots for a particular device and a particular packet, once a collision is detected. The node selects a random time slot to retransmit and each time if collision occurs, the probability of success keeps on increasing for that node only, decreasing the probability for other nodes in the network, who might want to transmit packets in an empty time slot. I propose an external device which allocates specific time slots for the nodes who might want to transmit packets after a collision has occurred. This method also utilizes a clock on each node and the channel must be divided into multiple bandwidth gaps.

Index Terms- CSMA/CD, time slot allocation, subdivision of time slots, dynamic time slots

I. Introduction

The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is a multiple access protocol in which each node senses the media channel before transmitting. If the channel is idle, it transmits the packet with a probability of 1. However, if more than one channel sends their packets at the same time, collision occurs in the channel. A jamming signal is now send by the node across the link to notify every other node to stop their transmissions immediately. The collision counters of the nodes involved in collision now increment by 1 according to the binary exponential back-off algorithm (BEB). The BEB algorithm also calculates a range of time slots ranging from 0 to 2^n-1 where n is the number of collisions experienced by a single node for a single packet transmission. The node then waits a random amount of time before trying to transmit again, assuming that no other station has started transmitting in the meantime. There are two problems associated with this method. First, the nodes must wait a particular amount of time before transmitting again. In the meantime, the channel remains empty and other nodes cannot utilize the resources for transmitting. This is the packet starvation effect and significantly reduces the efficiency of CSMA/CD. Second, the time slots selected by the nodes which underwent collision is random. Consider two nodes trying to retransmit after an initial first collision. In this situation, according to BEB algorithm the time slots can either be 0 or 1. If both the nodes select 0 or 1, the probability of success is 50% only. Also, as the number of collisions increases for both the nodes, one node always transmits in greater priority compared to the other. The probability of success decreases further if more than 2 nodes suffer collision in the first occurrence itself.

II. RESEARCH IDEA

In my variant of CSMA/CD, the channel is divided into multiple bandwidth gaps allocated for each of the nodes. The node which wants to transmit senses if the channel is idle. Then it sends the packet with 100% probability using the full capacity of the channel. If a collision occurs, a device attached to the channel then sends a jamming signal across the link to notify all the nodes to immediately stop all transmission as the channel may be busy. Now, after the signal has been sent, each of the nodes which want to transmit, send a signal in their respective bandwidth to the external device. The nodes which experienced a collision just before, also send their corresponding collision counters, as part of the back-off algorithm. The device marks all the bandwidths that want to transmit next and gets the maximum of all collision counters. Say that the maximum collision counter for a packet is n, therefore we have a total of 0 to 2^n-1 time slots. My idea aims at reducing the collision occurrence probability to minimum after an initial collision has occurred. Say a collision occurs between two nodes A and B, the counter for each increases to 1. The device collects this data and calculates the two time slots 0 and 1. Now, in normal CSMA/CD, both the nodes can randomly select any time slot. However, in this alternative, say nodes A and B want to transmit again. Then the device let say, notifies node A to use time slot 0 and node B to use time slot 1 through their respective bandwidths. A clock attached to both the nodes tells the nodes when their allocated slot comes up and the nodes then transmit packets using the full capacity of the channel. Since the time slots are different, the chances of collision are reduced to almost 0%. Here, we can see that the external device 'allocates' time slots to the transmitting nodes. Now, let us say if a third node also wants to transmit along with A and B, but we only have two time slots 0 and 1. In this case, one of the time slots is subdivided into equal time slots for any of the two nodes and transmission occurs accordingly. I also propose a timer attached to each node to estimate the time required to send a single packet and this data must be sent to the device. In a situation such as if the subdivided time slots are not big enough to send a complete packet, the device may extend the duration of the time slots. This strategy is required in the earlier stages of a packet transmission, when the collision counters are less than 1 or 2 and many nodes want to transmit next after the initial collision has occurred. Also some collisions may occur due to propagation delay. Once the total number of time slots following a particular collision becomes greater than or equal to the number of nodes in the network, each node transmits with almost 0% probability thereafter. Until then, the available time slots are divided according to the number of nodes. My idea implements the concept of pipelining to the transmission of packets. In the event of a collision between node A and B, where A sends out its first packet, the unoccupied time slots can be used by say node C to send its second packet and so on. Hence, the channel is occupied most of the times by some node or the other trying to transmit. This significantly reduces the packet starvation effect.

III. RELATED RESEARCH

While coming up with a variant for CSMA/CD, I studied about some other protocol(s) which helped me frame my idea and apply it to existing CSMA/CD. These protocols are briefly discussed below:

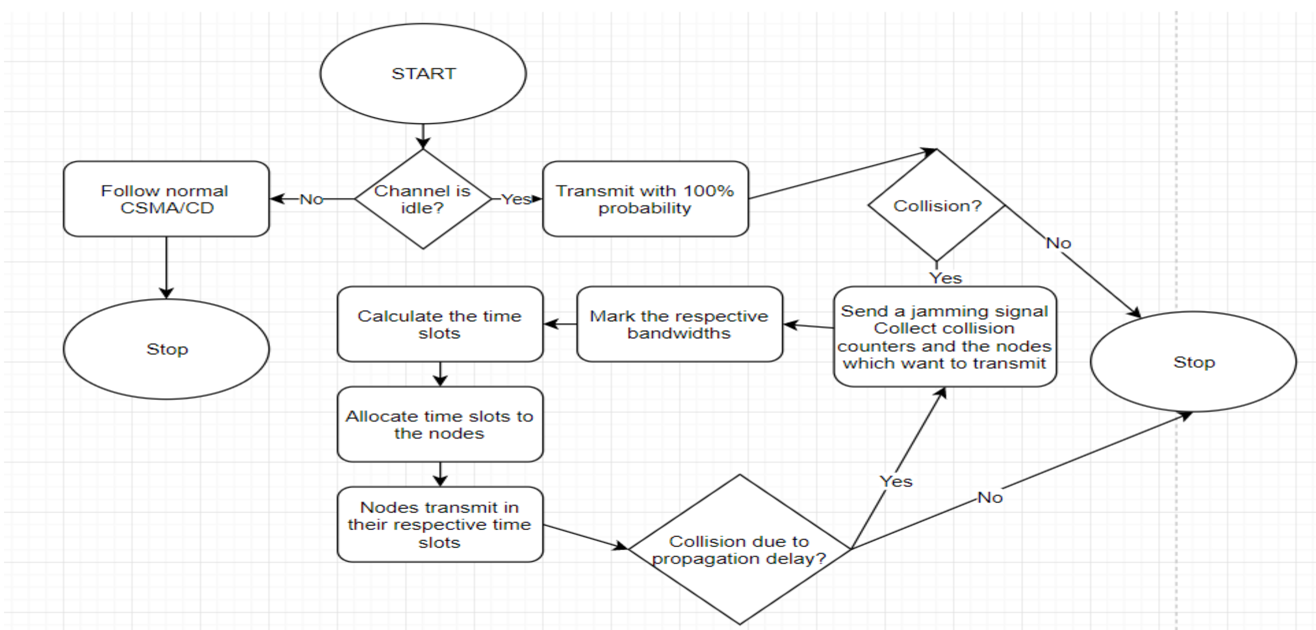
Time Division Multiple Access (TDMA)

TDMA is a multiple access protocol in which the same frequency channel is divided into different time slots for each of the nodes in the network. Nodes can transmit in the allocated time slot in a sequential manner. This slot allocation remains fixed during the entire communication process. In my idea, however, there are different time slots for different nodes but these time slot allocations are dynamic in nature as they can change depending upon the nodes that want to transmit just after a collision and the selection of time slots by the external device which may not be the same for every collision. The period of time assigned to a time slot for a station is determined by the number of TDMA channels on a carrier frequency. In TDMA, for most of the cases the entire system bandwidth for an interval of time is not assigned to a station. In reality, the frequency of the system is divided into sub-bands called carrier frequencies. In my alternative, however, the time period of the time slots for a single collision may change depending upon the total transmission time required for one packet. TDMA also requires accurate synchronization between the transmitter and the receiver and the inability to maintain this can cause interference with other devices.

IV. PROBLEMS WITH THE IDEA

In normal CSMA/CD, the nodes after a collision wait a random period of time which is the duration of the time slot. In this alternative, however, since the duration of a time slot can be extended in case of an overflow of frames, nodes may need to wait a significant amount of time before the previous node have finished transmitting. This occurs during the beginning stages of a packet transmission. As one might notice, the allocation of time slots is properly distributed if there are more number of time slots. Hence, this variant requires some initial collisions to occur to get some collision counters which are not zero in order to give the time slots for the next nodes waiting to transmit. Moreover, a particular network may have an upper limit of time duration i.e. the maximum amount of time that can be permitted for a time slot. If say in a situation where the time slot has reached its limit but the subdivided slots are not able to accommodate a packet, it causes error in the network. Hence, it is preferable that this method be used for smaller networks where the number of nodes are limited in order to keep the required number of collisions as less as possible.

V. ILLUSTRATION



VI. CONCLUSION

My idea simply takes an aspect of Time Division Multiple Access (TDMA) and combines it with the existing CSMA/CD in order to bring down the probability of collision to as low as possible. The only difference is that in TDMA, the time slots are fixed for the nodes and are dynamic while here it is variable for all the nodes for a particular packet transmission. It outperforms the original CSMA/CD in terms of collision probability as long as the number of nodes in the network is limited otherwise in a worst case scenario, in order to allocate the time slots evenly, the number of collisions may increase to an extent that reduces the efficiency of the system.

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