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Wireless with Collision Avoidance (CSMA - CA)

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Abstract: The most popular strategies for dealing with packet collisions at the Medium Access Control (MAC) layer in distributed wireless networks use a combination of carrier sensing and collision avoidance. When the collision avoidance strategy fails such schemes cannot detect collisions, and corrupted data frames are still transmitted in their entirety, thereby wasting the channel bandwidth and significantly reducing the network throughput. To address this problem, this paper proposes a new wireless MAC protocol capable of collision detection. The basic idea of the proposed protocol is the use of pulses in an out-of-band control channel for exploring channel condition and medium reservation and achieving both collision avoidance and collision detection. The performance of the proposed MAC protocol has been investigated using extensive analysis and simulations. Our results show that as compared with existing MAC protocols, the proposed protocol has significant performance gains in terms of node throughput. Additionally, the proposed protocol is fully distributed and requires no time synchronization among nodes.

Index Terms: MAC, CSMA, Collision detection, Collision avoidance.

I. INTRODUCTION

Mobility in computing and communications has recently become more and more essential, especially for business usage. The suitable transmission technique for mobile applications is wireless communication. Networks of which Wireless Local Area Networks are one kind. Wireless LAN can be categorized by its MAC protocol. One of the major protocols used for wireless LAN is the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), which is a variation of CSMA/CD used for Ethernet. The problem with CSMA/CD is that bandwidth efficient collision detection in radio channels is difficult to achieve. This inefficiency is a result of the high dynamic attenuation of radio signals. This high attenuation makes it practically very difficult for a radio transceiver to listen to other signals while transmitting, which is essential for the collision detection part of CSMA/CD. To be able to overcome this problem and still achieve an acceptable performance, the collision detection is replaced by collision avoidance [1].

CSMA/CA is used for IEEE 802.11 distributed access and has been adopted in many products existing inthe market, such as the Waveland RF Wireless LAN of AT&T. Due to its importance, this protocol is reviewed in some details in this paper. The protocol differs from the CSMA/CD in two ways, the first is that it doesn't contain a collision detection algorithm, and the second is that it defers the transmission for a random exponential back off in case of medium busy. Hence, models for CSMA/CD cannot be directly applied to this protocol and a model needs to be established from scratch. The work done onthe protocol till now either used simulation or ignored the back-off feature of the protocol to get to a mathematical model.

II. CARRIER SENSE

Collision avoidance is used to improve the performance of the CSMA method by attempting to divide the channel somewhat equally among all transmitting nodes within the collision domain.

Carrier Sense: Prior to transmitting, a node first listens to the shared medium (such as listening for wireless signals in a wireless network) to determine whether another node is transmitting or not. Note that the hidden node problem means another node may be transmitting which goes undetected at this stage.

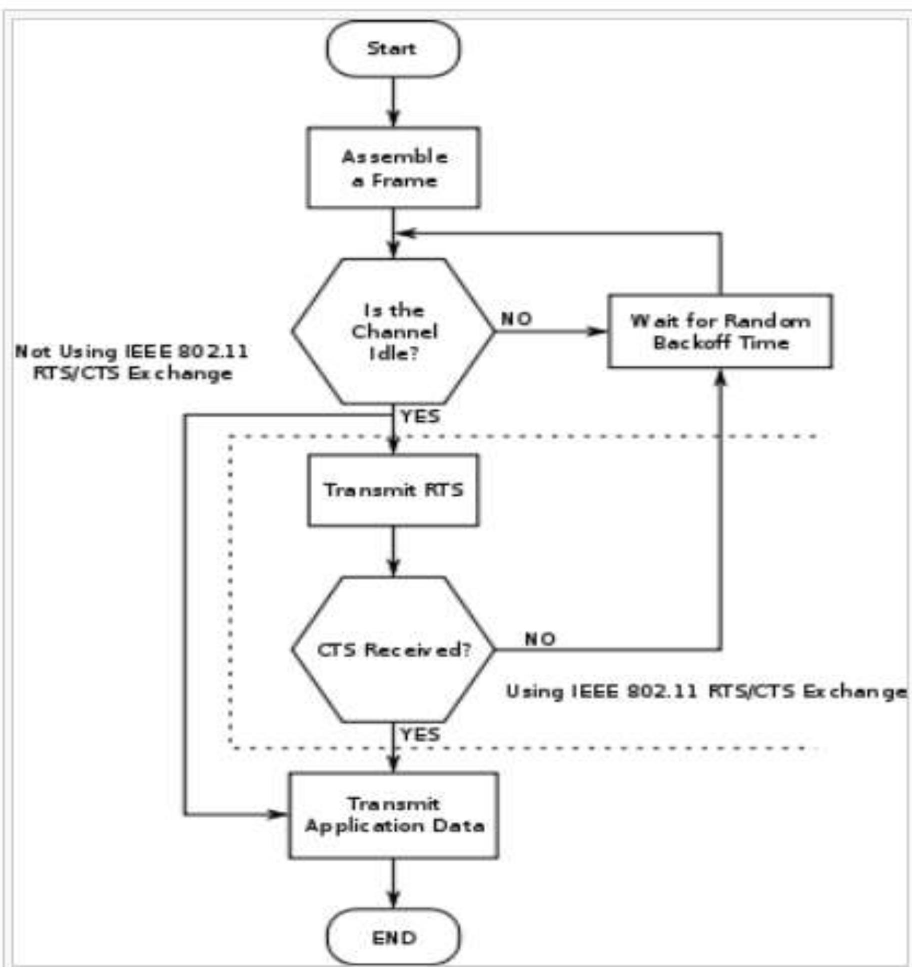
Collision Avoidance: if another node was heard, we wait for a period of time for the node to stop transmitting before listening again for a free communications channel.

Request to Send/Clear: To Send (RTS/CTS) may optionally be used at this point to mediate access to the shared medium. This goes some way to alleviating the problem of hidden nodes because, for instance, in a wireless network, the Access Point only issues a Clear to Send to one node at a time. However, wireless 802.11 implementations do not typically implement RTS/CTS for all transmissions; they may turn it off completely, or at least not use it for small packets (the overhead of RTS, CTS and transmission is too great for small data transfers).

Transmission: if the medium was identified as being clear or the node received a CTS to explicitly indicate it can send, it sends the frame in its entirety. Unlike CSMA/CD, it is very challenging for a wireless node to listen at the same time as it transmits (its transmission will dwarf any attempt to listen). Continuing the wireless example, the node awaits receipt of an acknowledgement packet from the Access Point to indicate the packet was received and check summed correctly. If such acknowledgement does not arrive after a timely manner, it assumes the packet collided with some other transmission, causing the node to enter a period of binary exponential back off prior to attempting to re-transmit.

Although CSMA/CA has been used in a variety of wired communication systems, it is particularly beneficial in a wireless LAN due to a common problem of multiple stations being able to see the Access Point, but not each other. This is due to differences in transmit power, and receive sensitivity, as well as distance, and location with respect to the AP.[4] This will cause a station to not be able to 'hear' another station's broadcast. This is the so-called 'hidden node', or 'hidden station' problem. Devices utilizing 802.11 based standards can enjoy the benefits of collision avoidance (RTS / CTS handshake, also Point coordination function), although they do not do so by default. By default they use a Carrier sensing mechanism called 'exponential back off', or (Distributed coordination function) that relies upon a station attempting to 'listen' for another station's broadcast before sending. CA, or PCF relies upon the AP (or the 'receiver' for Ad hoc networks) granting a station the exclusive right to transmit for a given period of time after requesting it (Request to Send / Clear to Send).

III. COLLISION AVOIDANCE ALGORITHM



IV. PERFORMANCE OF CSMA-CA

CSMA/CA performance is based largely upon the modulation technique used to transmit the data between nodes. Studies show that under ideal propagation conditions (simulations), Direct Sequence Spread Spectrum (DSSS) provides the highest throughput for all nodes on a network when used in conjunction with CSMA/CA and the IEEE 802.11 RTS/CTS exchange under light network load conditions. Frequency Hopping Spread Spectrum (FHSS) follows distantly behind DSSS with regard to throughput with a greater throughput once network load becomes substantially heavy. However, the throughput is generally the same under real world conditions due to radio propagation factors.

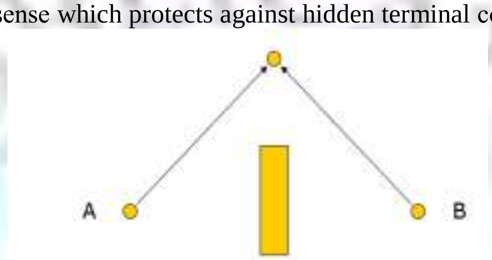
V. PLUS AND MINUS OF CSMA-CA

Effective: Avoids data collisions.

Reliable: Intent signals are sent until the cable is clear so that data will travel and reach its destination safely.

Small control frames lessen the cost of collisions (when data is large)

RTS + CTS provide "virtual" carrier sense which protects against hidden terminal collisions (where A can't hear B).



Relatively slow: A signal of intent must be sent every time a computer wants to transmit causing signal traffic.

Inappropriate for large/active networks: The slowdown increases, as the network grows larger.

Limited: suffers from same distance limitations as CSMA/CD since it must listen for the signals of intent.

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