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RESEARCH ARTICLE

ACCESS TO HIDDEN TERMINAL PROBLEM USING CHANNEL TONE MULTIPLE ACCESS

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Abstract— Wireless Networking is one of the fastest growing areas in the network industry today. Wireless Local Area Networks (WLANs) are gaining special interest as they provide flexibility of location along with low infrastructural and maintenance costs. The hidden terminal problem is unique to wireless networks that decrease the performance of the network. In this paper we propose a new MAC protocol to resolve the "hidden terminal problem" wireless local area net- works. This protocol, called Channel Tone Multiple Access has been compared with CSMA through computer simulations in terms of throughput characteristics. With the Channel Tone Multiple Access protocol, the maximum throughput is sensitive to normalized propagation delay. For small propagation delays, performance with hidden terminals is better than that of CSMA without hidden terminals, making Channel Tone Multiple Access protocol at- tractive WLAN environment. Making the request packet length sufficiently short compared with the data packet length can significantly reduce wasted transmissions caused by hidden terminals.

Keywords— Hidden terminal, Channel Tone Multiple Access, CSMA

I. INTRODUCTION

The popularity of wireless transmission and devices used for computation has made the dream of communication of anytime and anywhere possible. The number of terminals within the modern workplace has an explosive growth. Local Area Networks are now being used widely in this scenario. To provide quick terminal portability, and inexpensive relocation, wireless is preferable to other media because it does not require facility wiring.

Carrier Sense Multiple Access (CSMA), which provides excellent performance and is widely used in wired LANs, has also been proposed for communication between wireless terminals. However, it cannot be readily applied in such networks because locally generated signals overwhelm remote transmissions, making it impossible to tell whether a collision has occurred or not. Further, CSMA has difficulty dealing with the "hidden terminal problem" in the wireless LAN environment.

In this paper, we propose a Media Access Control (MAC) scheme to resolve the "hidden terminal problem." The Channel Tone Multiple Access scheme uses three channels: a message channel, a channel- tone channel, and a jam channel. In this scheme, a radio terminal tests the channel tone channel before transmitting. If idle, the terminal begins to transmit a channel-tone and gets ready to transmit data. Each terminal avoids collisions of its data packets with terminals in range by sensing the channel-tone. When "hidden terminal" collisions occur, a central station uses the jam channel to notify the terminal of the conflict. The remainder of this paper is organized as follows. Section 2 describes the "hidden terminal problem" and provides simulation results which indicate the effect of this problem on the CSMA scheme. Section 3 outlines the Channel Tone Multiple Access protocol. Section 4 provides the results of computer simulations evaluating both schemes in comparison to CSMA in terms of throughput characteristics.

II. HIDDEN TERMINAL PROBLEM

In wireless networking, the hidden node problem or hidden terminal problem occurs when a node is visible from a wireless access point (AP), but not from other nodes communicating with said AP. For example, two terminals within range of a central station cannot always hear each other, perhaps due to some physical obstacles blocking the radio waves. We call these terminals "hidden terminals". Hidden nodes in a wireless network refer to nodes that are out of range of other nodes or a collection of nodes.

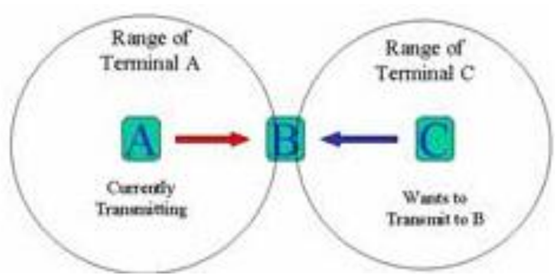


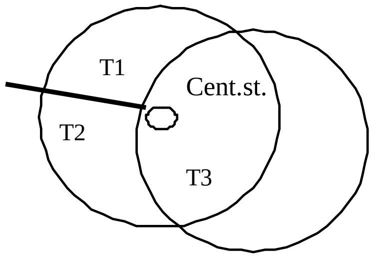
Fig.1. Hidden Terminal Problem

CSMA, reduces wasted transmission due to overlapping packets in a random-access environment by sensing the carrier on the message channel. This allows the terminal to detect collision by testing the state of the channel to determine whether the channel is in use by another terminal or not. When all terminals can detect each other , CSMA is very effective. In the wireless LAN environment, all terminals must be in line-of-sight to allow mutual detection.

However, in a wireless-based environment, there are many situation when terminals are not within range of all others. Adding such a requirement to the wireless based environment drastically limits the original flexibility that makes wireless LAN use desirable, yet, it is evident that "hidden terminals" degrade the performance of CSMA.

Let us consider an environment where hidden terminals exist. First, assume that terminals are distributed within a circular area with radius of R, where one station is located at the center. Each terminal has a transmission range τ (> n). So all terminals are within range of the central station, but they cannot always hear communication from all others.

Fig.2 shows at least two kind of hidden terminals that may exist in this environment. First, there may be obstacles blocking communications between terminals (Terminal l and Terminal 2). Second, some terminals are simply out of range of other terminals, even though all are within range of the central station (Terminal 1 and Terminal 3). In both case, the normal CSMA sensing of carrier on the message channel fails to reduce collisions of message packets since these terminals cannot hear each other.



T1 and T2 are hidden from each other.

T1 and T2 are hidden from T3.

Fig.2. The concept of two kinds hidden-terminal

III. Effect of the Problem on CSMA

Fig.3 shows the effect of hidden terminals on CSMA. This figure shows the throughput S versus the offered traffic G for a value of u=0.3 (U is normalized propagation delay). The addition of hidden terminals has a drastic effect on maximum throughput. For instance, when the communication range r changes from 100m to 80m, the increase in the number of hidden terminals is 5%, while the decrease in the maximum throughput is l0% ,. In summary, the existence of hidden terminals badly degrades the performance of CSMA.

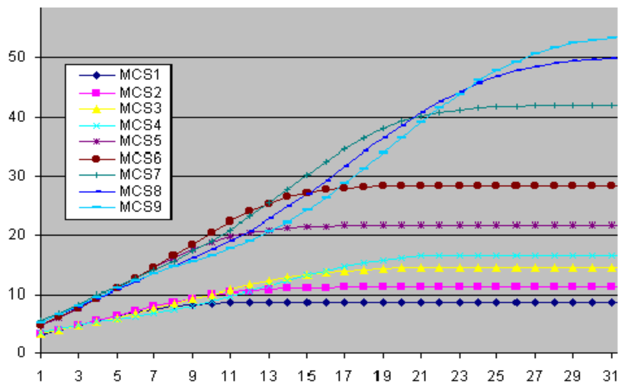


Fig.3 Throughput- traffic characteristic

Using the CSMA scheme with no hidden terminals, successful transmission of a data packet until τ (maximum propagation delay) after the beginning of transmission makes any other terminals recognize that someone is occupying the transmission channel. After this recognition, packets never collide. But when hidden terminals exist, some terminals, cannot recognize the use of the message channel. In the worst case, collision of packets will waste up to 2T (T is the packet length). This degrades the performance of CSMA. We propose two new media access schemes to resolve this problem. Channel Tone Multiple Access allows each terminal to avoid collisions of its data packets to some degree by sensing the channel-tone, and extends collision detection by having the central station jam signal when collisions occur.

IV. Channel Tone Multiple Access

Channel Tone Multiple Access uses three channels: a message channel, a channel-tone channel, and a jam channel. We assume that all terminals can communicate with the central station. A terminals that has a packet ready for transmission (either a newly generated packet or a packet rescheduled for transmission) operates as follows:

1. The terminal senses the carrier on the channel tone channel. If the channel-tone is idle, the terminal begins to transmit a channel- t.one on the channel-tone channel. It continues to transmit the channel-tone during the packet transmission time T_i. As shown in Figure3., it will transmit tlie packet on the

message channel after $2\tau + z$(r : one-way propagation delay, z: extremely small value, $0 < L < \tau$) from the time it began to transmit the channel-tone, unless it receive a jam signal during $2\tau + z$.

The jam signal is transmitted from the central station when that station receives another carrier on the channel-tone-channel while a previous carrier is using the channel-tone-channel.

There are two cases of this :

(i) First, when both terminals receive the jam signal before either has started to transmit data on the message channel (that is, during 27 + z). In this case, both terminals schedule retransmissions of the data and stop transmitting the channel-tone when the jam signal is received.

(ii) Second when one terminal receives the jam signal after starting transmission of the data in the message channel, while the other terminal receives the jam signal before transmission of data.

In this case, the first terminal succeeds in transmitting the data, while the second terminal schedules retransmission of the data and stops transmitting the channel-tone when the jam signal is received.

These two situations are the only conditions when collision of the channel-tone on the channel-tone channel will occur. As can be seen, conflict of the data packets on the message channel never occurs. Note that whenever the central station senses the carrier on the channel tone channel, it transmits a channel-tone to all terminals. Thus any other terminal communicating with the central station can test if there is any other terminal attempting to transmit on the message channel by sensing either the original or central station channel-tone.

2. If the channel-tone is busy, the terminal schedules a random retransmission delay, After this delay, at a new point in time, it senses the carrier on the channel-tone channel again and repeats the algorithm

Although the channel-tone sent by a terminal may not be sensed by all other terminals due to the existence of hidden terminals, it can at least be sensed by the central station. When the central station senses the channel-tone, it then sends the jam signal to all the terminals in its range. In other words, the central station acts as a channel-tone repeater. Since all terminals are in line-of-sight of the central station, this eliminates the hidden terminal problem.

V. SIMULATION MODEL

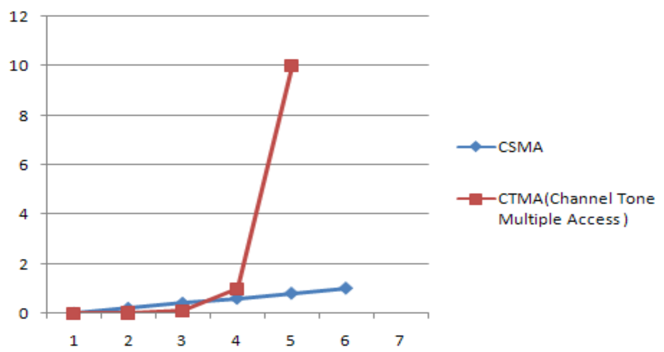
A discrete system model was used for simulations, based on the following assumptions:

(i) We define the LAN service area as a circle with a radius of 50 meters consisting of a random distribution of 100 terminals communicating with a central station over a shared radio channel. Every radio terminal can sense the carrier of any other transmission within a radius r (r is variable) from itself.

(ii) The traffic source collectively form a Poisson source. The traffic offered to the channels from the radio terminals consists of both new packets and previously collided packets.

(iii) Each packet is of constant length requiring T_i

a. Seconds transmission time.



Throughput- traffic characteristic

Comparison between CTMA and CSMA

VI. CONCLUSION

Channel Tone Multiple Access protocol provides Media Access Control which largely eliminates the "hidden terminal problem". This has been shown through computer simulation studies based on a discrete model. These studies allow us to compare the performance of these protocol and the CSMA scheme.

Channel Tone Multiple Access protocol, while sensitive to the normalized propagation delay, has maximum throughput and packet delay values with hidden terminals that are better than CSMA without hidden terminals when a is small. CTMA is well-adapted for the Radio LAN environment which has small propagation delays.

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