Double Sense Multiple Access for Hidden Terminal Avoidance in Wireless Ad Hoc Networks

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Double Sense Multiple Access

In wireless ad hoc networks, it is a challenging problem to design an efficient media access control (MAC) protocol that can completely avoid the interference from the hidden terminals, which are defined as the terminals beyond the communication range of the transmitter but within that of the receiver. In [1], Haas and Deng have proposed the dual busy tone multiple access (DBTMA) protocol where the transmitter and the receiver can clear other packet transmissions in their communication ranges by broadcasting two different busy tone (BT) signals. To avoid the still possible packet collisions due to the propagation delay, a mandatory waiting time is inserted between the successful reception of a ready-to-send (RTS) packet and the transmission of a data packet. In addition, all terminals are required to keep sensing the BT signals, even while they are transmitting packets.

In this paper, we propose and analyse a novel dual channel random access protocol, called "Double Sense Multiple Access" (DSMA), for solving the hidden terminal problem. Two time-slotted channels are used for transmitting control (e.g. RTS) and data packets separately. Under DSMA, a transmitter will sense the BT signals twice before sending the data packet to the receiver. In doing so, the transmitter can identify if it is the intended transmitter for sending a data packet and, therefore, the possible data packet collisions due to propagation delay can be completely avoided. Compared with DBTMA, our DSMA protocol has the following advantages: (1) higher channel efficiency by completely avoiding the collisions between control and data packets; (2) higher power efficiency by setting lower data rate, i.e. lower transmission power, in the control channel; (3) shorter transmission delay by removing the "mandatory waiting time" in DBTMA; and (4) less complexity and cost by reducing the "keep sensing" requirement in DBTMA to "sense twice" in DSMA.

Throughput Analysis

The analytical results given in [1] are for a fully connected network wherein no hidden terminal exists. In contrary, we consider a realistic non-fully connected network and have derived the throughput S of DSMA as follows.

$$S = \frac{G \cdot \delta e^{-\gamma G}}{(\delta + 4) \cdot G e^{-\gamma G} + e^{(\gamma - 1)G}},$$

where γ and δ denote, respectively, the lengths of control packet and data packet. G is the offered traffic.

Fig. 1 and Fig. 2 show the throughput S versus offered traffic G with γ and δ as parameters, respectively. The analytical results shown in solid lines are perfectly verified by the simulation results in markers ($\gamma = 3$ and $\delta = 20$). As expected, the throughput performance is closely related to the ratio between γ and δ. The smaller the ratio γ/δ, the higher the throughput curve we can obtain. These curves are very useful for traffic sizing, especially when the radio channel effects are taken into account.

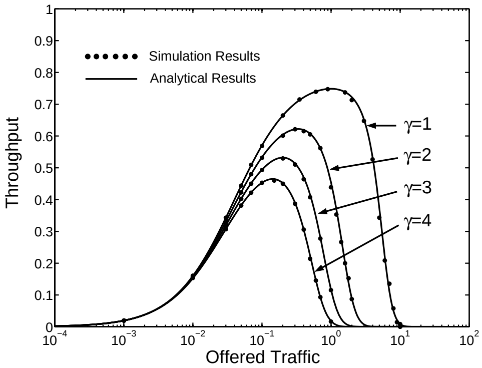

Figure 1: Throughput, $\gamma = 1, 2, 3, 4$, $\delta = 20$.

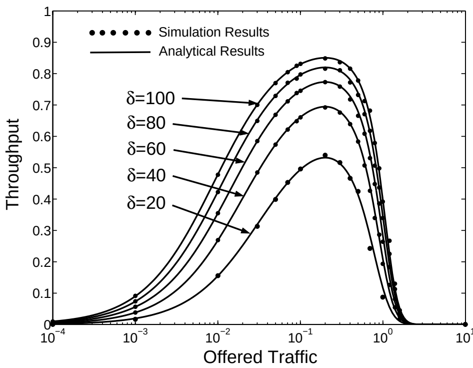

Figure 2: Throughput, $\gamma = 3$, $\delta = 20, 40, 60, 80, 100$.

We are currently studying the delay and stability performance of DSMA and the results will be available soon.

References

[1] Z. J. Haas and J. Deng, "Dual busy tone multiple access (DBTMA) – a multiple access control scheme for ad hoc networks," *IEEE Transactions on Communications*, vol. 50, pp.975–985, June 2002.

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