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THROUGHPUT ANALYSIS OF IEEE 802.11 DCF IN PRESENCE OF HIDDEN NODES

Motivation

Scheduling packets in wireless networks is different than wired networks and the actual scheduling is almost always preceded by a *contention phase* where wireless nodes compete to gain access to the shared medium. The reasons behind the contention are the inherent lossy properties and limited bandwidth of wireless media resulting in frequent packet losses and retransmissions. The situation is exacerbated by the presence of hidden nodes. The "hidden node problem" is well known in wireless networks where two communicating nodes can communicate with a third station, but cannot directly communicate with each other due to physical or spatial limitations.

One of the emerging wireless LAN standards, IEEE 802.11 provides three mechanisms to deal with the *contention phase*: Distributed Coordination Function (DCF), Point Coordination Function (PCF) and Hybrid Coordination Function (HCF). The DCF is the most popular method that operates in a true distributed manner without any central arbitration and provides the RTS/CTS mechanism to avoid the "hidden node problem". Bianchi presents a Markovian model for throughput analysis of wireless networks employing DCF in [1]. Wu, et. al. in [2] extends it to include station retry limits. However, nobody has done the throughput analysis of DCF in presence of hidden nodes based on analytical models. I intend to do so with motivation of quantifying the effect(s) of the "hidden node problem" on wireless network throughput with and without RTS/CTS access methods of DCF.

Related Work

Sadalgi provides some limited simulation results in [3]. Chatzimisios, et. al. suggests doing so as future research in [4]. Other than these, currently there is no known work exists.

The Basic Idea

The basic probabilistic model of the presence of hidden node may be based on the *Probability of hidden nodes, Pr(h),* which depends on the relative spatial characteristics of the nodes. The concept of *reachability*, *R* may be used to quantify *Pr(h)* as *R* determines whether two nodes can hear each other or not. It is expected that the classic CSMA hidden terminal model used by Tobagi and Kleinrock in [5] can be studied to add suitable extensions to Bianchi's model. The throughput analysis may then follow. I intend to do some infrastructure WLAN simulation in *ns-2* in order to get some degree of validation of the analytical results. Current version of *ns-2* implements DCF and simulating hidden nodes should be straight forward using it.

Deliverables

The deliverables of the my project are-

- An analytical model incorporating the effect of hidden nodes extending Bianchi's DCF model for throughput
- Analytical throughput results using the above model under different traffic loads (e.g. Bernoulli, Geometric, Hyper-geometric)
- Simulation results of the DCF with hidden nodes throughput under the similar loads
- A comparing discussion of the analytical and simulation results with concluding remarks

Project Plan

Week 1 (20 April 2003)	Detailed study of hidden node models in shared medium (CSMA)
Week 4 (11 May 2003)	Analytical model development for DCF with hidden nodes
Week 5 (18 May 2003)	Analytical throughput results with different traffic loads
Week 6 (25 May 2003)	Simulation or DCF with hidden nodes and results from *ns-2*
Week 7 (1 June 2003)	Comparison, discussions and conclusion

References

[1] G. Bianchi, "Performance Analysis of the IEEE 802.11 Distributed Coordination Function", *IEEE Journal on Selected Area in Communications* V18, N3, 2000.

[2] H. Wu, Y. Peng, K. Long, S. Cheng, J. Ma, "Performance of Reliable Transport Protocol over IEEE 802.11 Wireless LAN: Analysis And Enhancement", *IEEE INFOCOM*'2002.

[3] S. Sadalgi, "A Performance Analysis of the Basic Access of IEEE 802.11 Wireless LAN MAC Protocol (CSMA/CA)", *Tech Report*, CS-Rutgers University, NJ 2000.

[4] P. Chatzimisios, V. Vitsas and A. C. Boucouvalas, "Throughput and Delay Analysis of IEEE 802.11 Protocol", *Tech Report*, Bournemouth University, UK 2002.

[5] L. Kleinrock and F. Tobagi, "Packet Switching in Radio Channels, Part II - The Hidden Terminal Problem in Carrier Sense Multiple Access and the Busy Tone Solution", *IEEE Transactions On Communications*, vol.23, pp. 1417-1433, 1975.