Enhancing Multimedia Support in IEEE 802.11 Wireless LANs

Abhishek Goliya, Leena Chandran-Wadia,* and Sridhar Iyer
K. R. School of Information Technology,
Indian Institute of Technology Bombay,
Powai, Mumbai - 400 076
(e-mail: {abhishek,leena,sri}@it.iitb.ac.in)

1 Introduction

The IEEE 802.11 wireless LAN standard features two mode of operation: Distributed Coordination Function (DCF) and Point Coordination Function (PCF). The DCF is a CSMA/CA based random access protocol which uses exponential backoff to avoid collisions. The PCF is an optional part of the standard in which a Point Coordinator (PC) provides scheduled access to the channel by polling nodes in turn. Most of the hardware available currently implement only the DCF mode. The PCF mode is thought to have too much overhead since polls are wasted whenever nodes do not have data to send.

Recently, several papers have appeared [1, 2] which advocate the use of the PCF mode for supporting multimedia, voice in particular. In this work we show that there is substantial improvement in throughput when the PC monitors the network and learns from the traffic it overhears. This network monitoring approach does not require any changes to frame formats as defined in the IEEE 802.11 standard [3], or introduce any new frame types. It adds minimal management overhead at the PC while the functionality of the rest of the nodes is left unchanged.

2 Performance limitations of PCF

The PCF comprises of Contention Free Periods (CFP), in which the PC polls nodes for data, alternating with Contention Periods (CP) in which DCF rules are followed [3]. In order to enhance multimedia support, unnecessary delays suffered by the nodes waiting for polls need to be reduced. If most of the nodes have data to send, the scheduled channel access provided by PCF performs better than DCF because it reduces contention and collisions. If only a few nodes have data to send, then the same polling mechanism adds overheads which are proportional to the number of wasted polls. Figure 1 compares the overall throughput of a 16-node network in which all nodes have data to send, with a

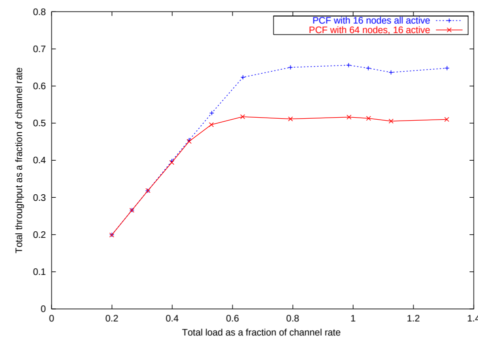

Figure 1: Effect of polling overhead on throughput

64-node network in which only 16 nodes have data to send. We observe sizeable throughput degradation.

The configuration parameters of PCF e.g., the CFP Repetition Interval, also contribute to poor performance because they are statically defined. Optimal values of these parameters are sensitive to network size and traffic load, both of which vary with time. So there is need for a dynamic adaptation protocol which continuously adjusts these parameters to current load values resulting in near optimal behaviour.

In the following we first describe an optimized polling strategy for PCF which relies on the PC monitoring and learning from current traffic to dynamically build its polling list. Then we move on to discuss tuning of the CFPCount parameter. The latter is basically the number of beacon intervals contained in the CFP Repetition Interval [3].

3 Network Learning for Intelligent Polling in PCF

The PC normally maintains a list of all nodes that are associated with it. Based on network learning, it classifies these into two logical lists, the list of Active nodes, and the list of Passive nodes.

- **Active Node :** Node likely to transmit data with high probability when polled.
- **Passive Node:** Node unlikely to transmit.

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During CFP, every node on the active list retains its position in the list if it transmits data in response to a poll. If a node does not respond to the poll or sends a null frame then it is termed as passive, and placed in the passive list. In addition, the PC monitors traffic in the CP and moves nodes which are *CF_Pollable* from the passive list into its active list when they send data. This is based on the premise that data is often generated in bursts, so if a node which has been passive sends a frame, then it is likely to have more frames to send. *CF_nonPollable* data must continue to use the CP as per the standard. This network-learning based polling list preparation replaces simple round robin scheduling of all nodes in the CFP.

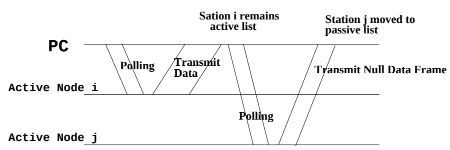

Figure 2: Transmission and list updation in CFP

All nodes in the active list have the same priority and are polled in a simple round robin fashion. Nodes in the passive list are assigned lower priority. For the results presented in this paper, the passive list is not scanned at all.

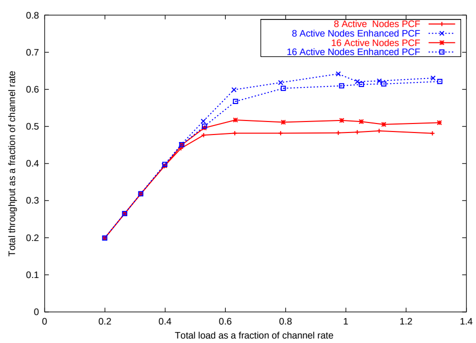

Figure 3: Goodput comparison with 64 nodes

Our simulations are done using the public domain network simulator(NS-2) [4]. Data is generated at each node according to a Poisson process and the traffic pattern is one in which all nodes are sending towards the PC. As shown in Figure 3, polling overhead has reduced significantly leading to the improvement in throughput upto 35% for a 64-node network when either 8 or 16 nodes are active.

4 CFPCount Adaptation

The performance of PCF mode is sensitive to various configuration parameters. The CFP Repetition Interval is defined as CFPCount $\times$ beacon interval. Here we dynamically adjust the value of CFPCount to suit network size and load. We do this on the basis of the measured CFP utilization. The latter is calculated as a percentage of the CFP Max Duration utilized in polling. We have exponentially averaged the CFP utilization.

Every update ensures that the new value is also a multiple of the beacon interval and that it does not fall below the minimum boundary defined by the standard. If CFP utilization is $U\%$ then the new CFP repetition count C is defined as

$$C = \begin{cases} \lfloor C/2 \rfloor & U \leq 50\% \\ C+1 & U \geq 80\% \text{ or CFP MaxDur. expires} \\ C-1 & \text{else} \end{cases}$$

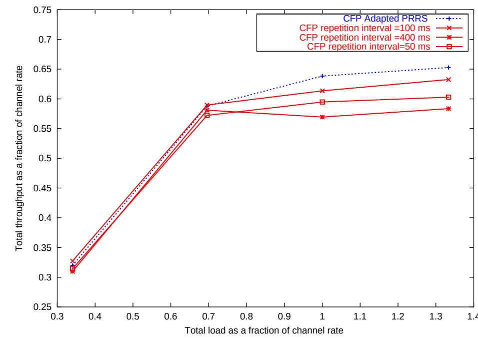

Figure 4: CFPadapted v/s statically configured PCF

Figure 4 compares throughput for different statically configured values with CFPCount adaptation. Preliminary results show that the performance of adaptive PCF is better than the statically configured PCF.

5 Conclusion

The new polling criteria minimizes polling overhead and shows better suitability for multimedia support. Our CFPCount adaptation protocol successfully adapts CFPCount to suit current load and achieves significantly lower delays than statically configured PCF. We are further refining the learning approach for optimal performance.

References

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