Design and Evaluation of IEEE 802.11 based Dual MAC in MANETs

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Motivation

• Traffic pattern in most of the Multihop Ad-Hoc Network applications is centralized.

• The nodes need to send data to one or more preferred destinations. For example,
  – Military: Soldiers talk to commander.
  – Disaster management teams: Stations talk to control/management center.
  – Sensor Networks: Stations feed data to a central database.
Hidden Node Problem: If A and C want to transmit to B there will be collision at B, since A and C are hidden to each other.

Exposed Node Problem: If B is transmitting to A, C cannot transmit to D, since it senses the medium busy.
The preferred destination is the *central station*.

Nodes within one-hop range of central station are *inner stations*.

Stations at one hop distance are *boundary stations*.

Stations beyond one-hop are *outer stations*. 
The preferred destination is the *central station*.

Nodes within one-hop range of central station are *inner stations*

Stations at one hop distance are *boundary stations*.

Stations beyond one-hop are *outer stations*. 
● We focus on performance of IEEE 802.11 MAC in centralized multihop ad hoc networks.

● Suggest design and architecture of a new MAC called Dual MAC for such a topology.

● Effect of station Mobility is not considered.
Multihop ad-hoc networks require a distributed medium access mechanism.

We investigate IEEE 802.11 MAC as it is the most popular MAC for multihop ad-hoc networks.

The Distributed Coordination Function (DCF) operation of IEEE 802.11 MAC provides the distributed medium access mechanism.

The Point Coordination Function (PCF) operation of IEEE 802.11 MAC provides a polled medium access mechanism, and is used in fixed Wireless LANs.
IEEE 802.11 DCF and PCF Operation

DCF Operation

PCF Operation
Problems with Centralized Scenario

- As the flows converge towards destination, nodes close to the preferred destination operate in high load condition.
- If the distributed MAC (DCF) is used, lot of stations try to access medium at the same time.
- This increases the collisions, and the throughput decreases heavily.
- It is well known that the scheduled MAC protocols perform better than distributed MAC protocols in high load conditions.
- We suggest using a scheduled MAC in one hop region around the central station.
Requirement for a scheduled MAC

- The scheduled MAC must work smoothly with distributed MAC.

In an IEEE 802.11 Network, DCF is used as distributed MAC.

PCF mode of 802.11 can serve as scheduled MAC.
Problems with PCF as scheduled MAC

- During the Contention Free Period (CFP) of PCF, the NAV setting of stations around PC prevents them to communicate with outer stations.
- This means that these stations (esp. boundary stations) become exposed to PC during CFP.
- As there is no RTS/CTS exchange during CFP, the transmissions from outer stations could collide with the poll of the PC.
- This means that during the CFP, outer stations become hidden to PC, and vice versa.
We equip boundary stations with Dual MAC.

Dual MAC is a MAC with two independent MACs
- *PCF MAC* communicates with PC in PCF mode,
- *DCF MAC* communicates with outer stations in DCF mode.
• However, the DCF MAC communication can still cause collisions with stations that are using PCF.

• To avoid this we use PCF on one channel and DCF on another.

• Dual MAC interface handles the data packets to/from appropriate MAC and channel.
For outgoing packets:

    if ( packet is broadcast ) {
        send packet to both PCF MAC and DCF MAC;
    } else {
        channel = get_destination_MAC_channel();
        if ( channel == DCF_channel )
            send packet on DCF MAC;
        else
            send packet on PCF MAC;
    }

For incoming packets:

    hand over the packet to Link Layer;
We have implemented the Dual MAC in NS-2.

Simulation was performed in NS with 50 stations spread around an area of 1500m x 1500m.

Simulation setup

- Central station (PC) at 750m x 750m.
- 8 stations use Dual MAC, and are 240m away from PC.
- 12 stations are inside one-hop boundary of PC, and use PCF.
- 29 stations are outside one hop boundary of PC, and use DCF.
- Routing protocol is DSDV.
Results: Packet Delivery Ratio

performance of DCF and Dual MAC at 30 packets/sec

Packet Delivery Ratio

CBR connections

dual

DCF

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Results: Throughput

Performance of DCF and Dual MAC

Throughput vs. Offered Load (Kbytes)
Conclusion

- Use of Dual MAC gives more throughput per channel than DCF, even with a small number of Dual Stations.
- The scheduled MAC can be used to increase throughput in a multihop ad-hoc networks.
- Dual MAC can act as interface between stations using scheduled and unscheduled MAC.

Future Work

- A station could automatically switch-on PCF seeing high traffic in its surrounding.
- This would enable small groups of stations forming a cluster in high traffic areas, and use scheduled MAC to increase throughput.
Thank You