Design and Evaluation of IEEE 802.11 based Dual MAC in MANETs

Guides:

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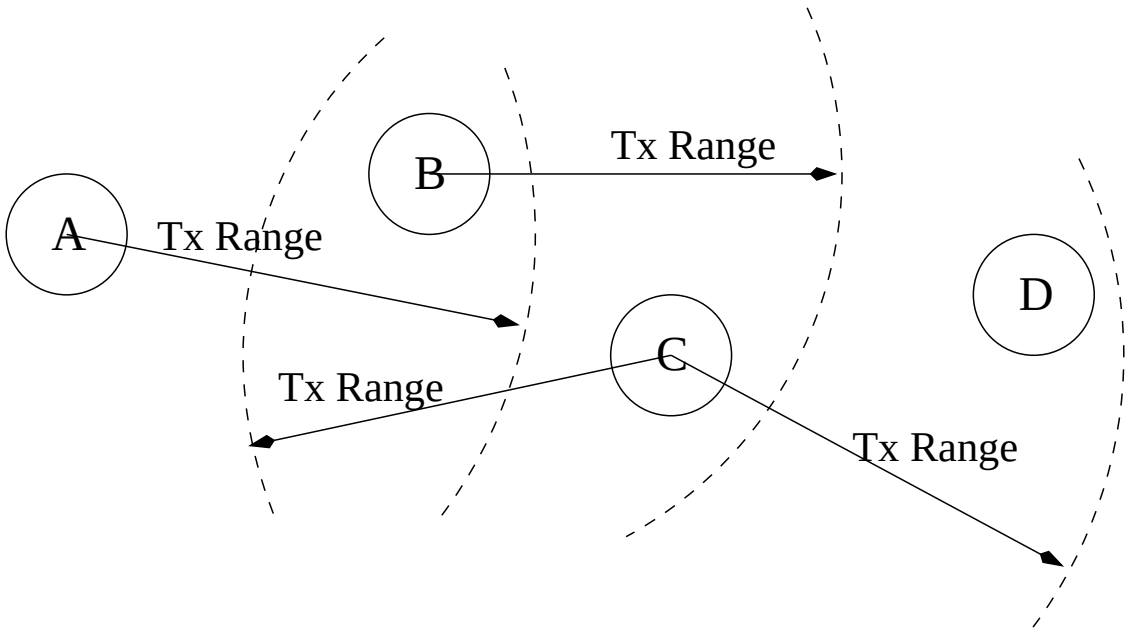
Motivation

- 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.

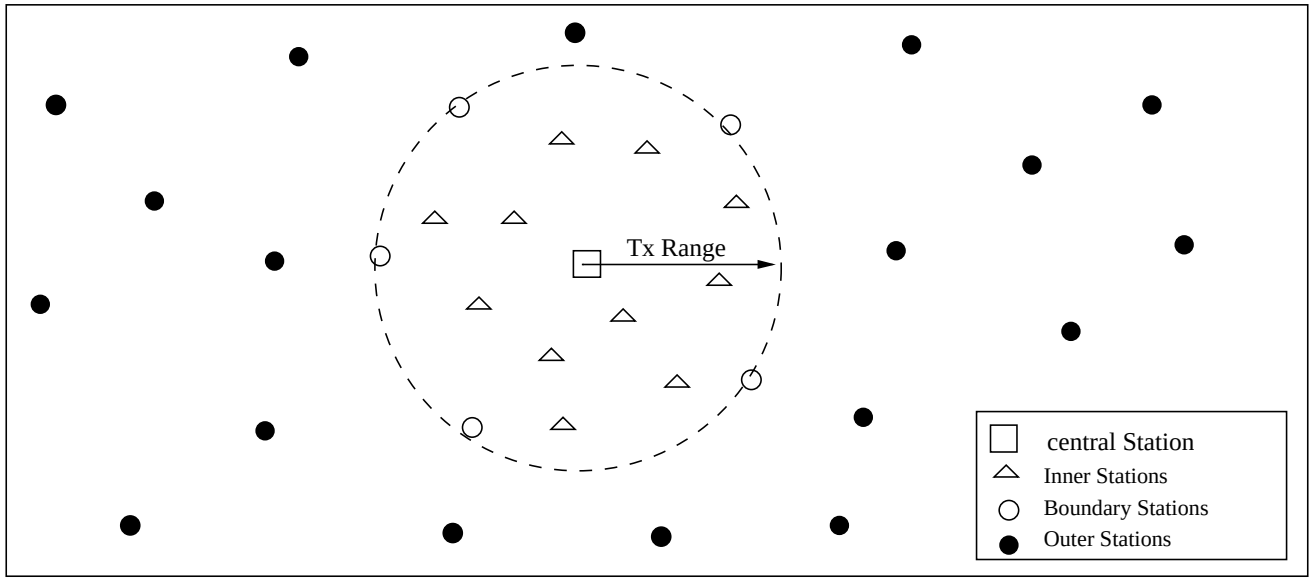
Hidden and Exposed Node Problems



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.

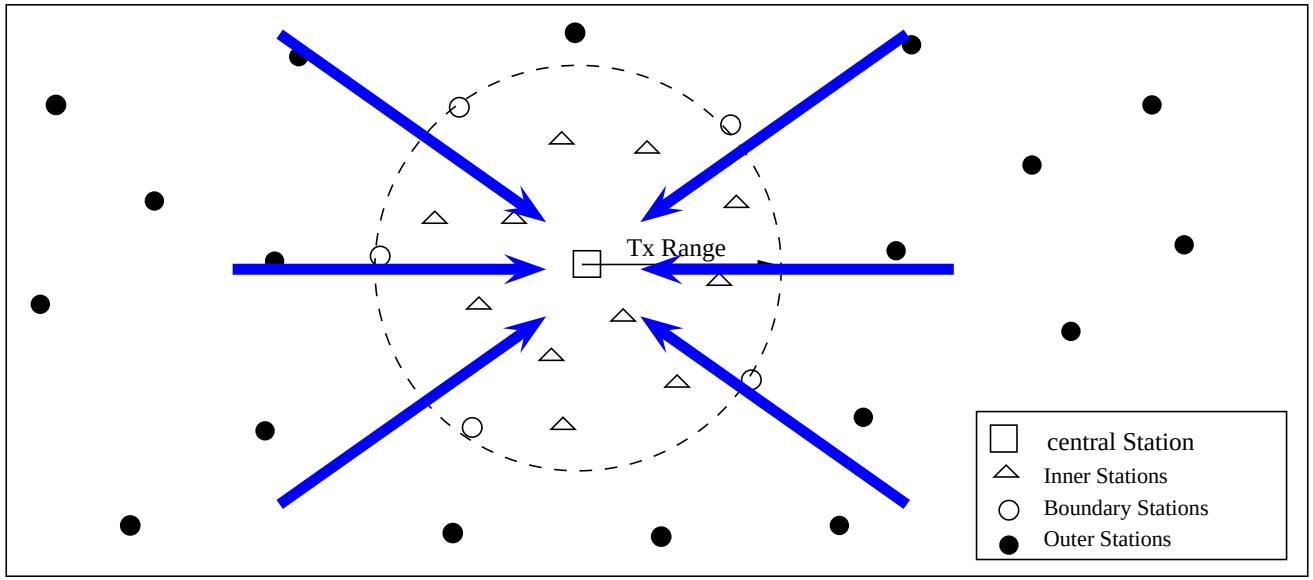
Exposed Node Problem: If B is transmitting to A, C can not transmit to D, since it senses the medium busy.

Centralized Multihop Scenario



- 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*.

Centralized Multihop Scenario



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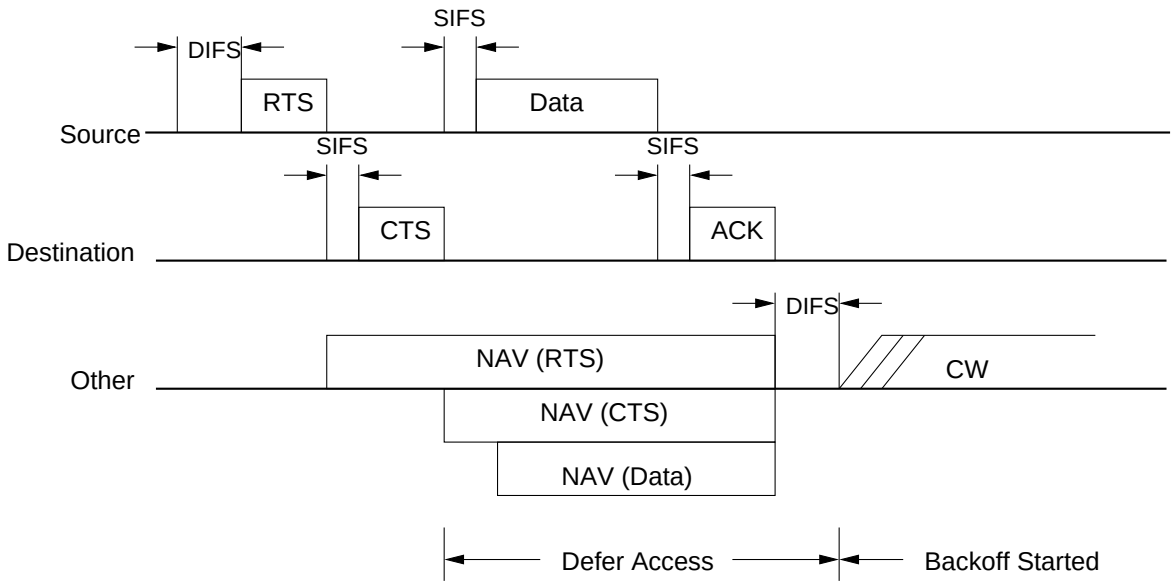
Focus of the Work

- 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.

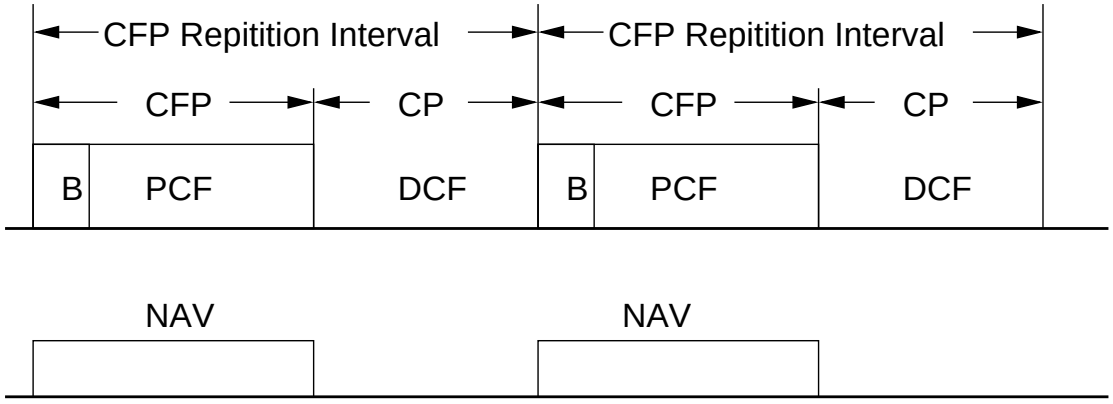
MAC in Multihop Networks

- 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

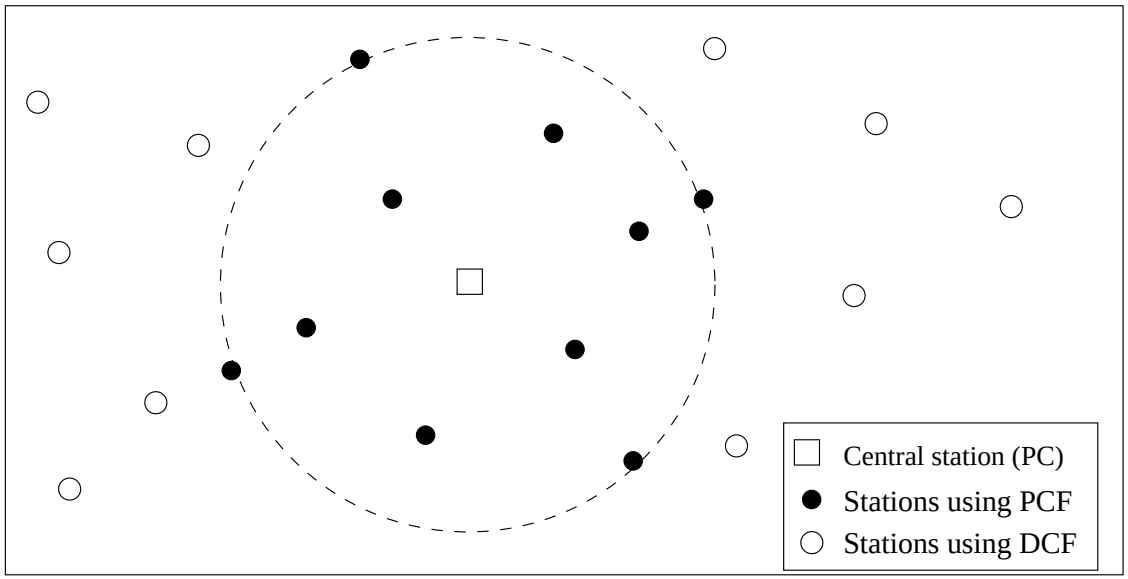


PCF Operation

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.

Scheduled MAC in Multihop Networks

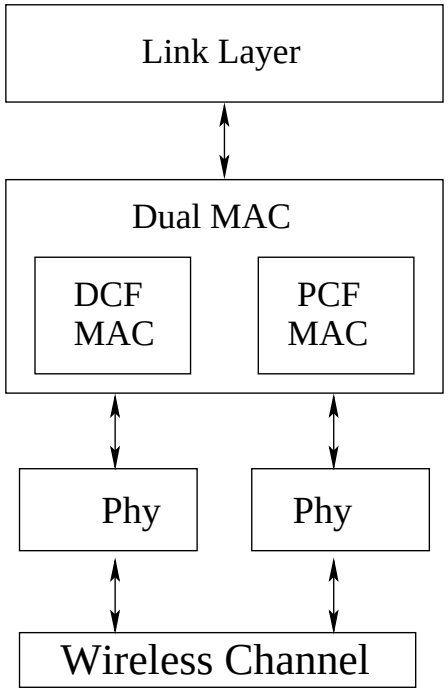


- Requirement for a scheduled MAC
  - The scheduled MAC must work smoothly with distributed MAC.
- In an IEEE 802.11 Network, DCF is used as distributed MAC.
- PCF mode of 802.11 can serve as scheduled MAC.

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 not 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.

Solution: Dual MAC



- 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.

Solution: Dual MAC

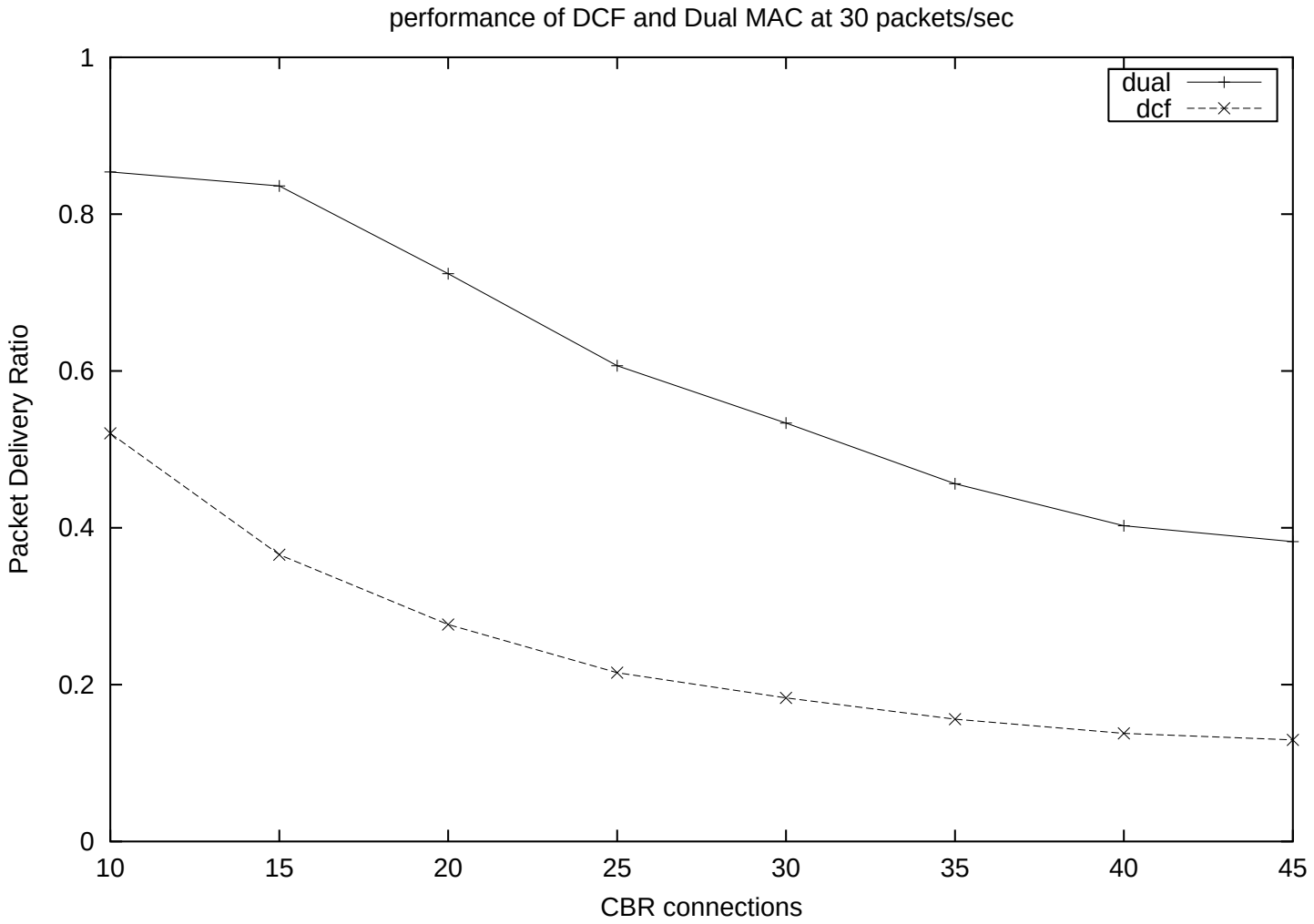
- However, the DCF MAC communication can still cause collisions with stations that are using PCF.
- To avoid this we use PCF on one channel and DCF on another.
- Dual MAC interface handles the data packets to/from appropriate MAC and channel.

Dual MAC: Working

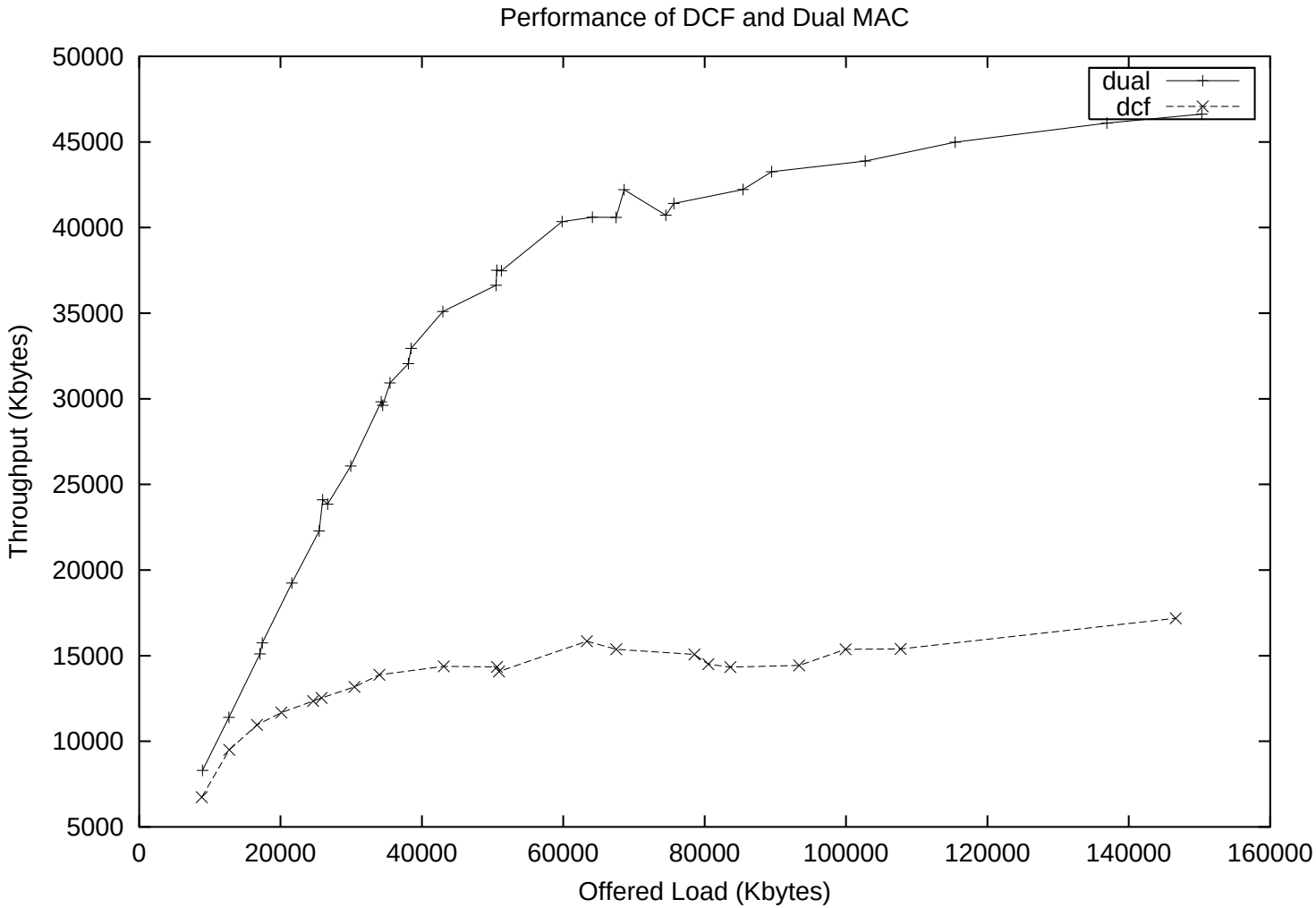
```
For outgoing packets:
        if ( packet is broadcast ) {
                send packet to both PCF MAC and DCF MAC;
        } else {
                channel = get_destination_MAC_channel();
                if ( channel == DCF_channel )
                        send packet on DCF MAC;
            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



Results: Throughput



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