802.11 Distributed Coordination Function: An ORBIT Case Study

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Outline

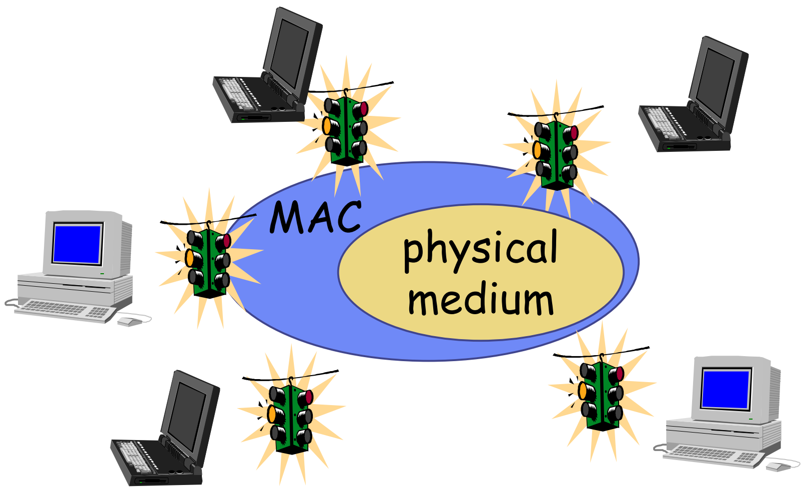
- Motivation and goals
- Experimental setup
- The first case study: adaptive PHY rate
- The second case study: fixed PHY rate
- Conclusions

Motivation

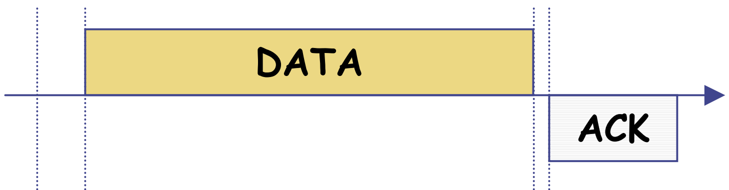
- The protocol is complex and hard to analyze analytically
- Analytical models [Bianchi'00, Cali et al '00] consider:
  - saturation - always a packet available for transmission
  - ideal channel - zero bit error probability
- Simulation studies trade model accuracy for processing effort
- Prior experimental work considers simple topologies and a small number of nodes [Kamerman '00, Anastasi et al '03 and '04, ...]

802.11 Distributed Coordination Function

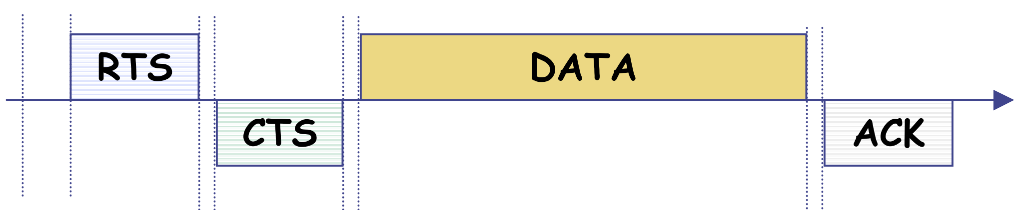
- MAC arbitrates access to the physical medium



- DCF is a random access scheme:
  - basic access



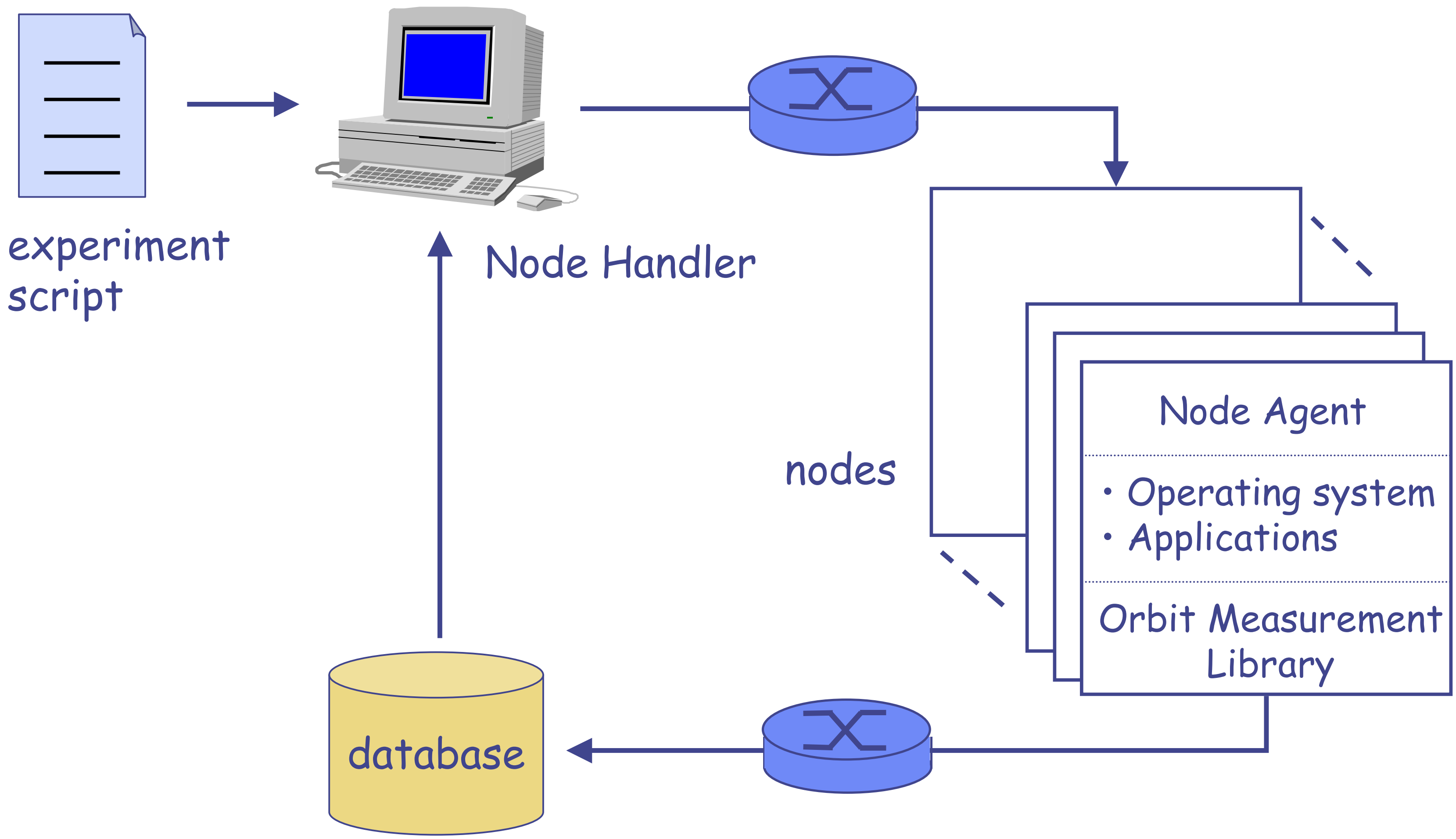
  - RTS/CTS



Goals

- Test the network under different conditions:
  - PHY rate mechanism
    - adaptive rate
    - fixed rate
  - network topology
    - point-to-point
    - sink
  - network size
  - offered load
    - payload lengths
    - packet rates
- Compare results to the analytical model for saturation throughput from [Bianchi '00]

ORBIT testbed



Framework common to all experiments

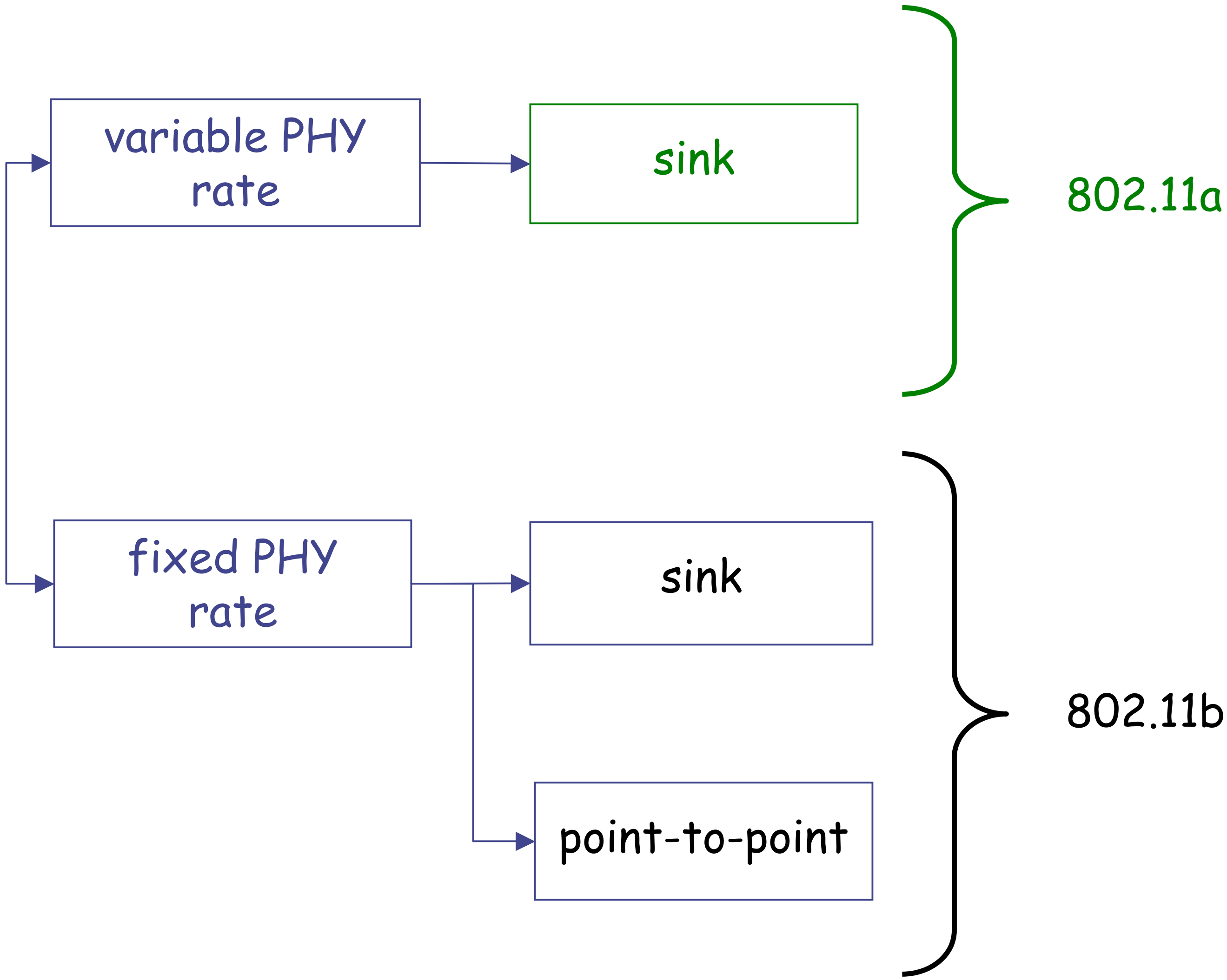
Aggregate performance on the transport layer:

- aggregate offered load (for all senders)
- aggregate throughput (for all receivers)
- average latency for successfully delivered packets

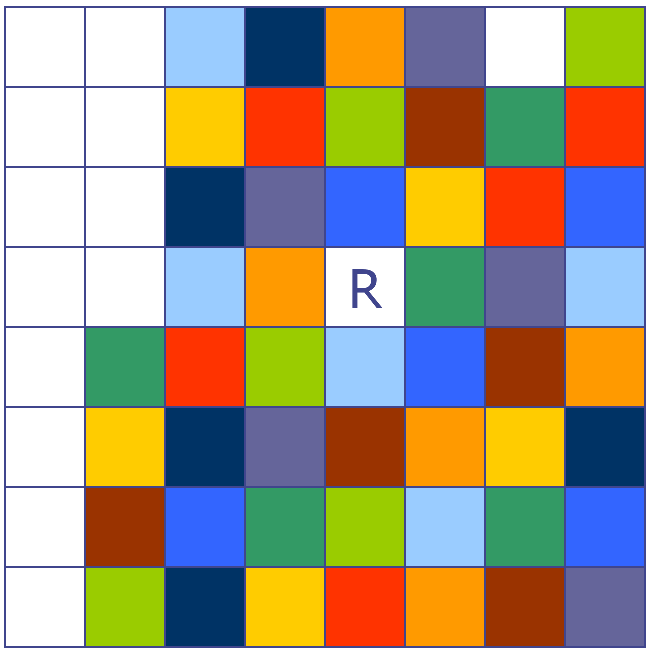
Common features:

- UDP CBR traffic
- high SNR due to the physical proximity
- fixed transmit power
- measurements collected every second
- settings fixed for 120 seconds

ORBIT case studies



First case study: Adaptive PHY rate

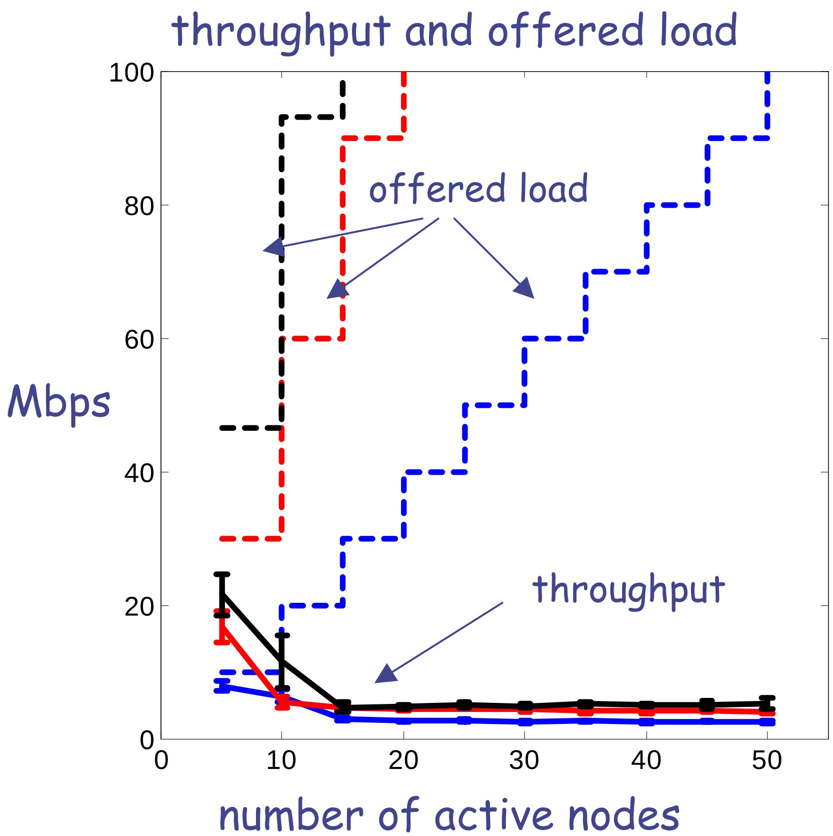


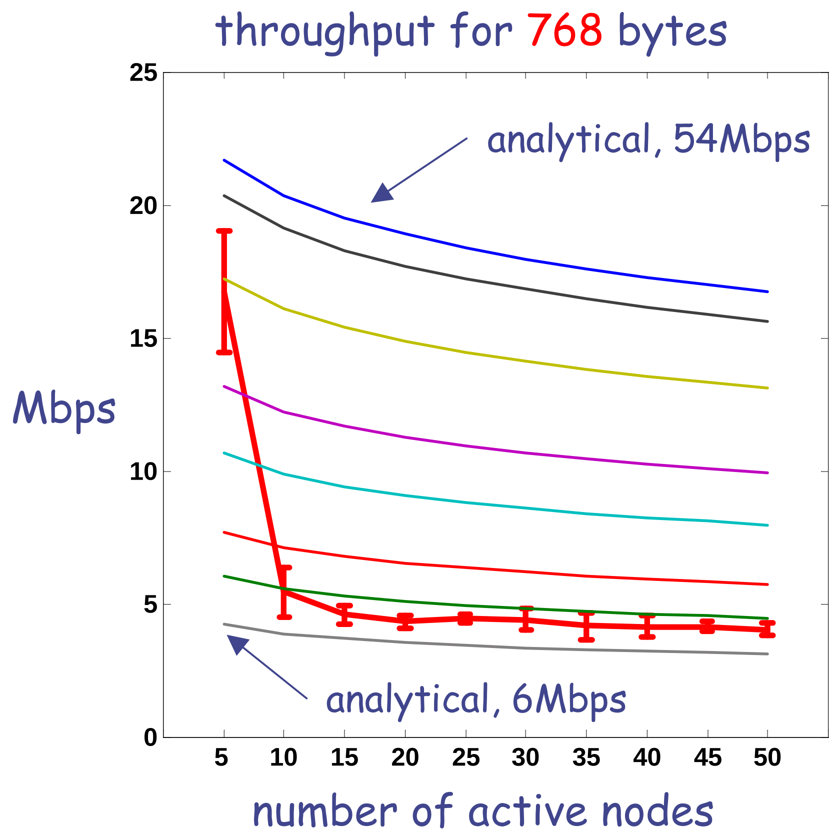
Saturated network:

- every 2 minutes add 5 senders
- total 50 senders

Throughput versus the number of nodes

802.11a basic access with payloads 256, 768, and 1280 bytes





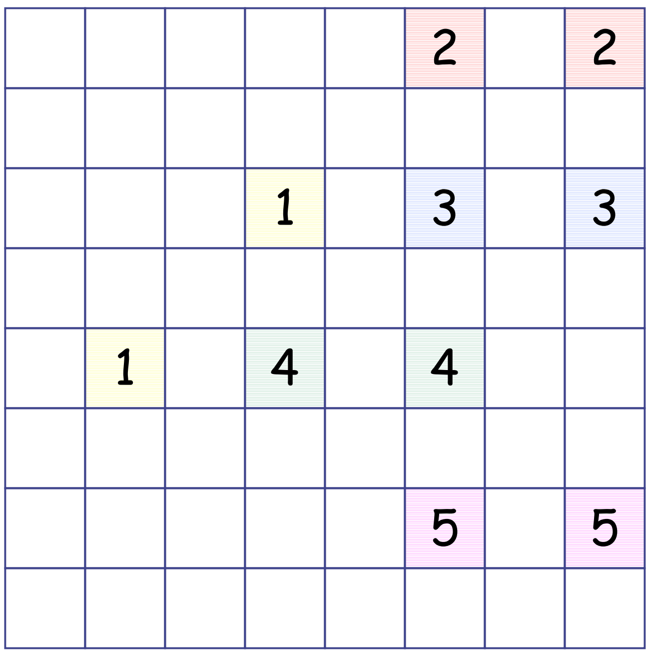
Adaptive PHY rate algorithm

- Algorithm operation:
  - count missing acknowledgements
  - adjust the rate according to the number of failures
- Assumes low SNR as the source of packet loss
- Does not take into account DCF as a source of packet loss
- Conjecture:
  PHY rate should be fixed in a congested network

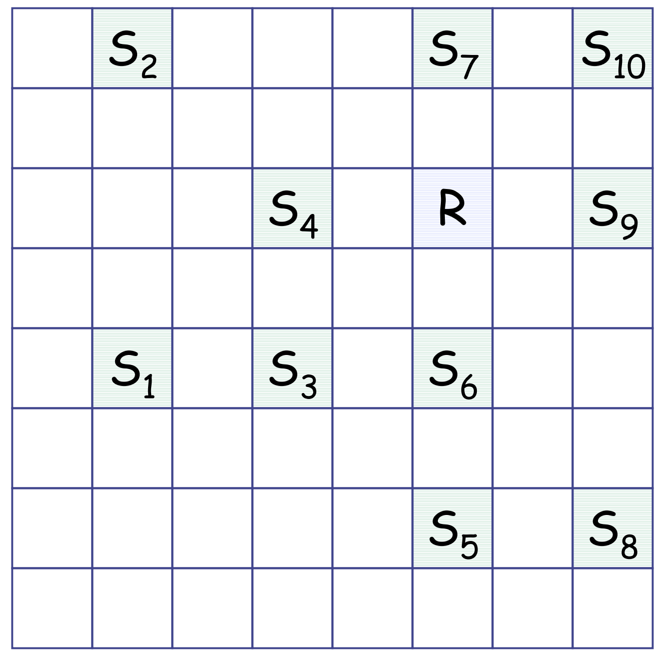
The second case study: fixed PHY rate

topologies for the fixed PHY rate study

point-to-point

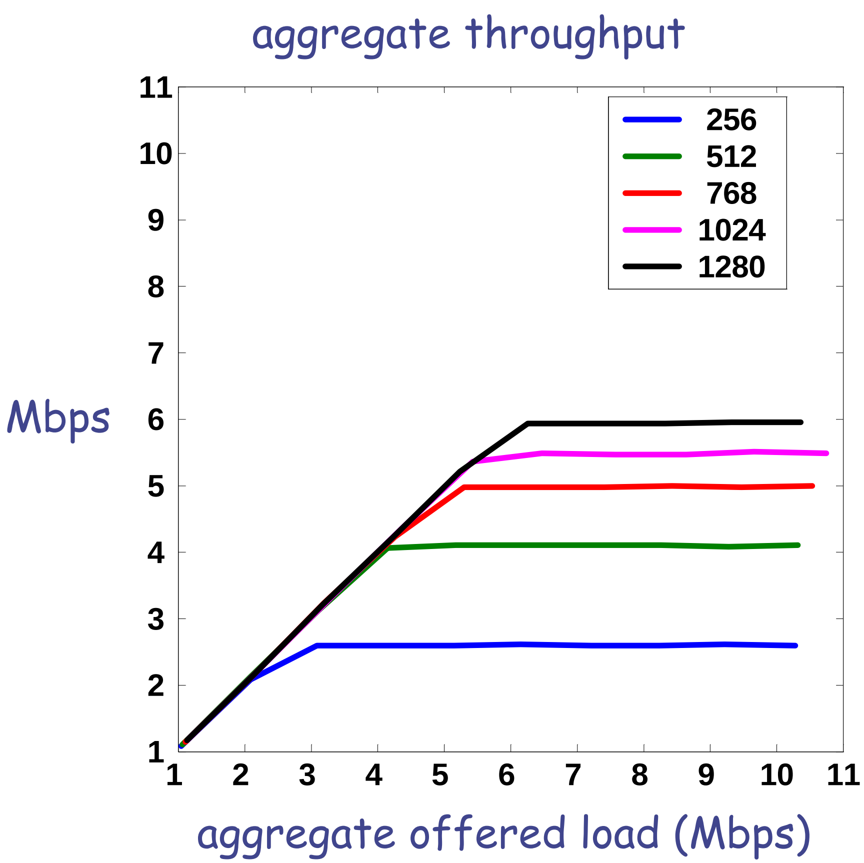


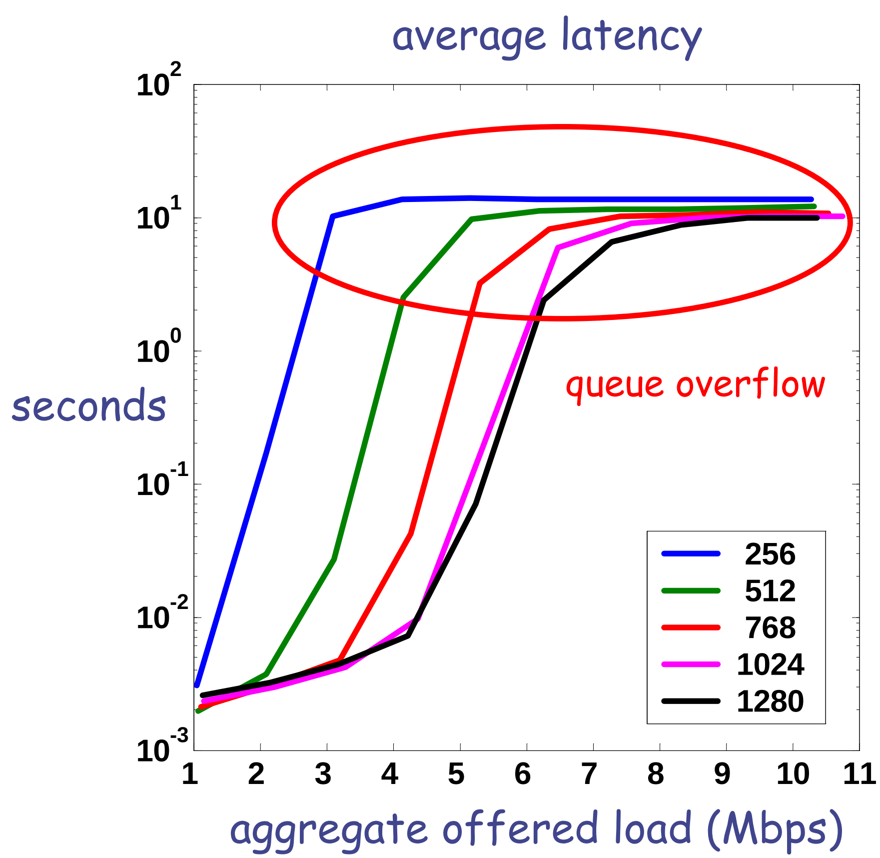
sink



Throughput and latency versus offered load

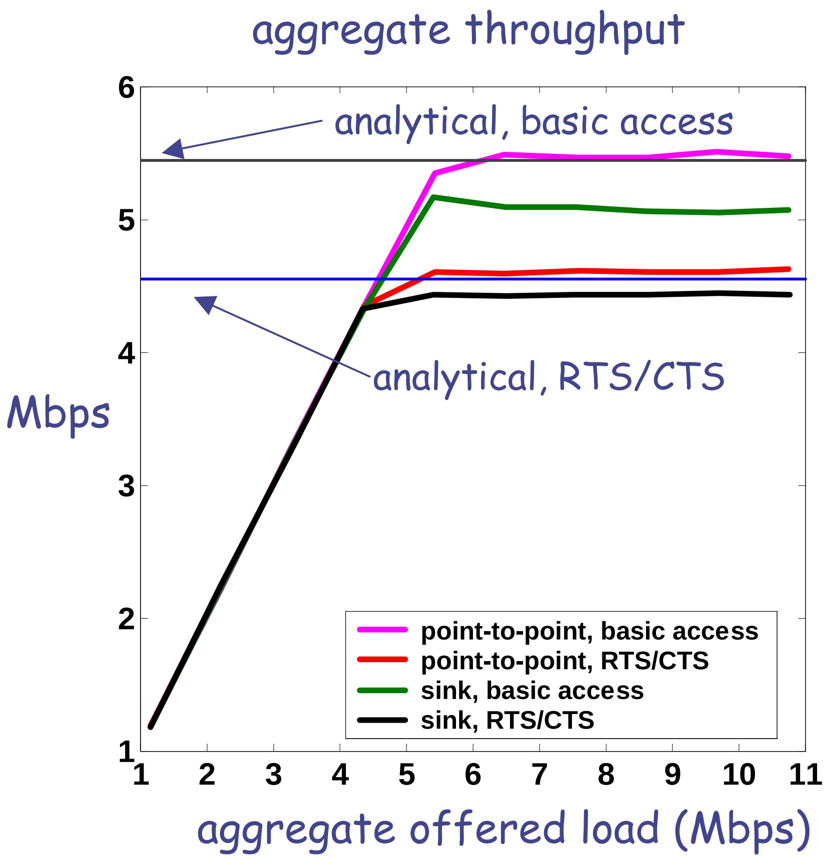
802.11b basic access, rate 11Mbps, point-to-point

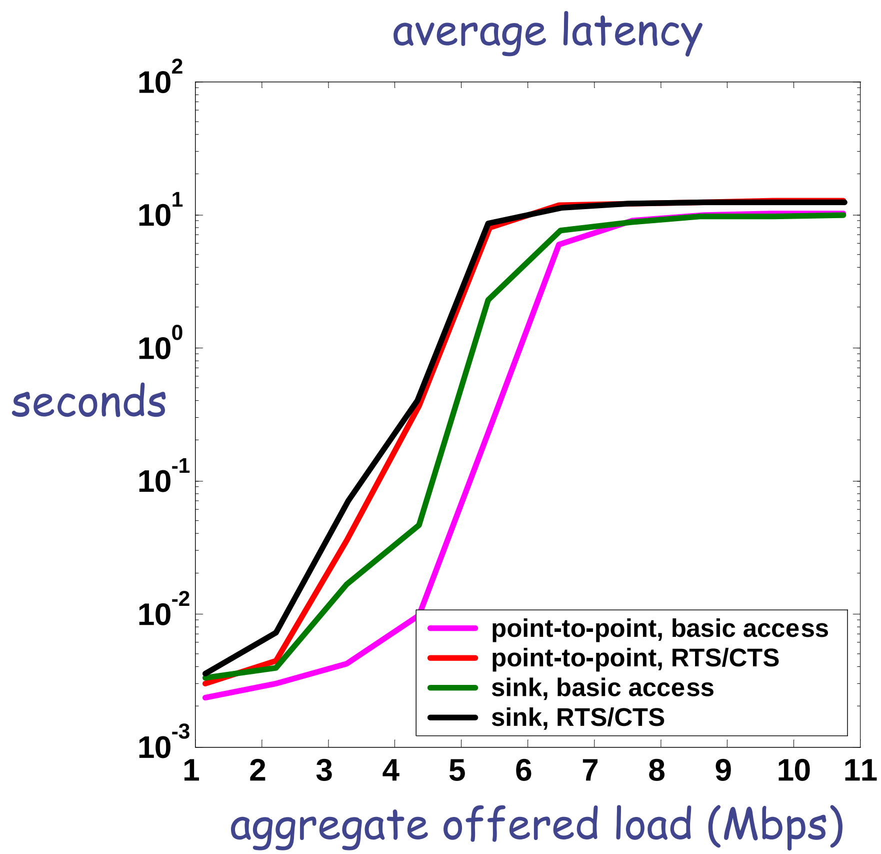




Throughput and latency: Basic access versus RTS/CTS

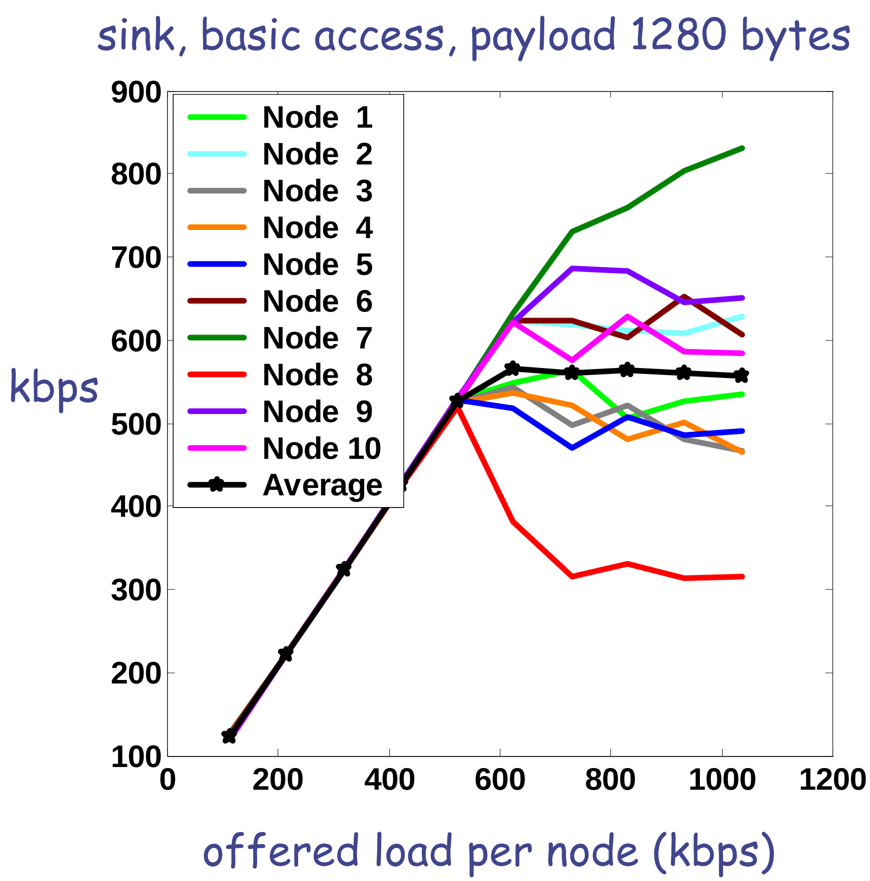
802.11b, payload 1024 bytes, rate 11Mbps

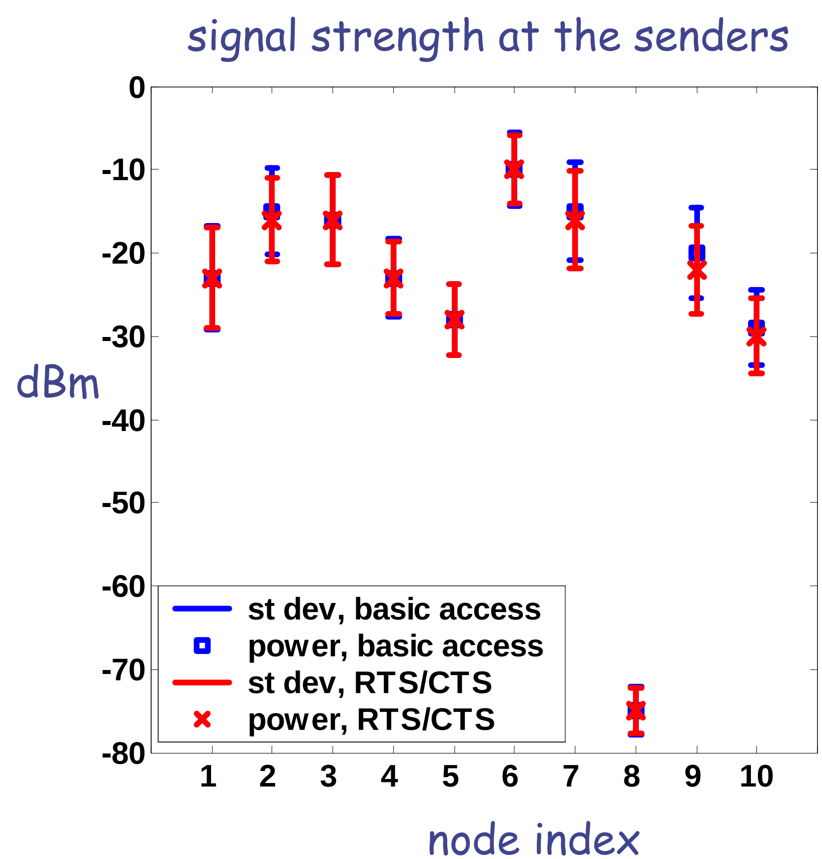




Throughput per node

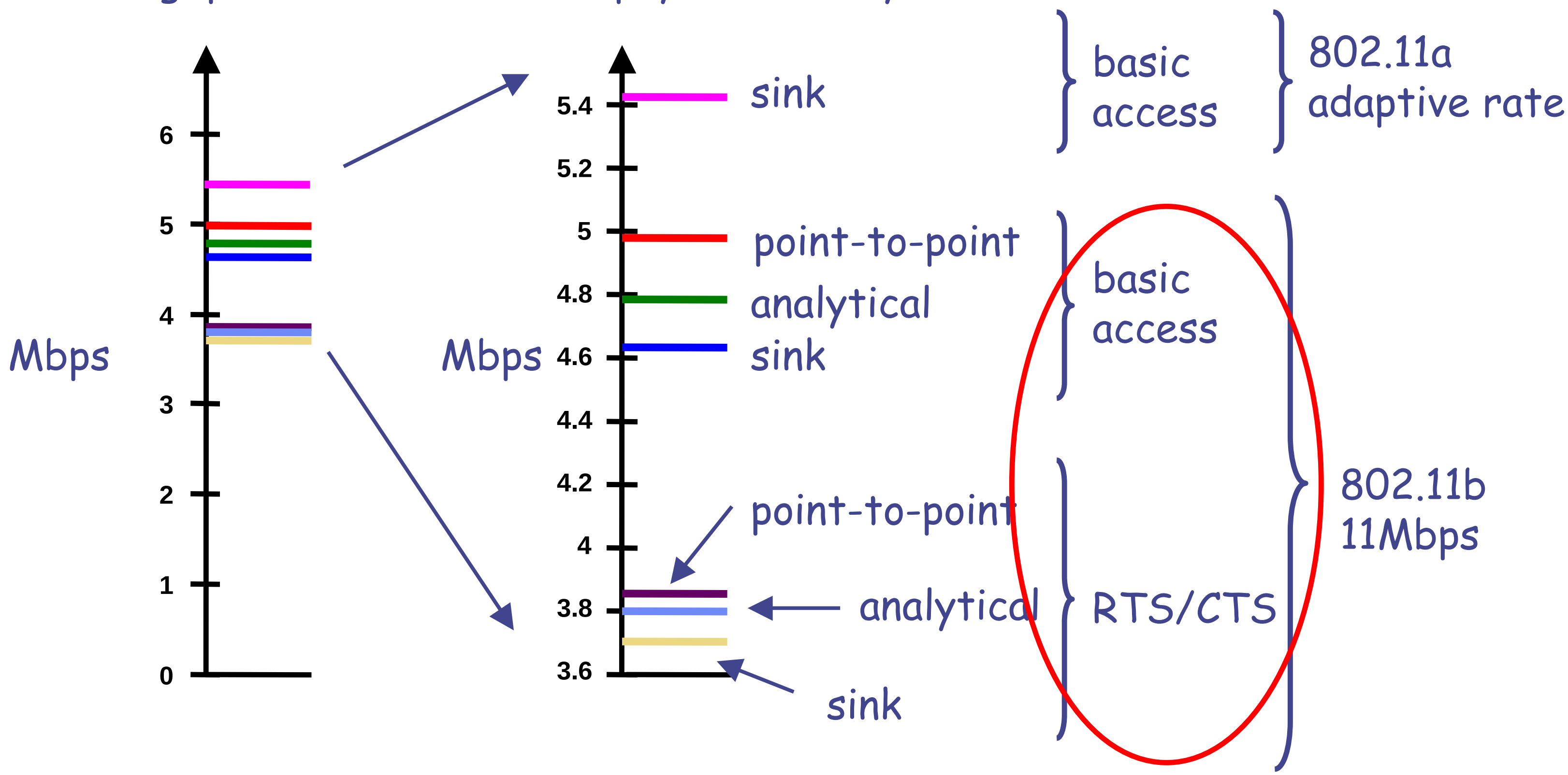
- number of acknowledged packets multiplied with payload length in bits
- no fairness in saturation because of the capture effect





Saturation throughput: The comparison of two case studies

throughput for 10 nodes and payload 768 bytes



basic access outperforms RTS/CTS

Conclusions

The study with adaptive PHY rate shows:

- adaptive PHY rate degrades the throughput in a congested network

The study with fixed PHY rate shows:

- for a relatively small network basic access outperforms RTS/CTS
- latency grows exponentially with an increase in the aggregate offered load
- in saturation nodes unequally contribute to the aggregate throughput
  - caused by the difference in signal strengths

Both studies show:

- [Bianchi '00] predicts well saturation throughput for networks with up to 50 nodes