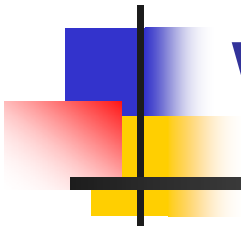

D-LSMA: Distributed Link Scheduling Multiple Access for Wireless Multi-hop Network

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&

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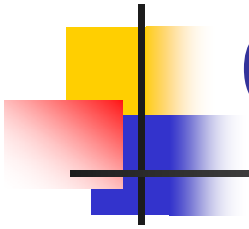
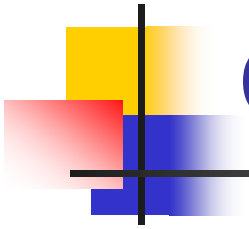


Contents

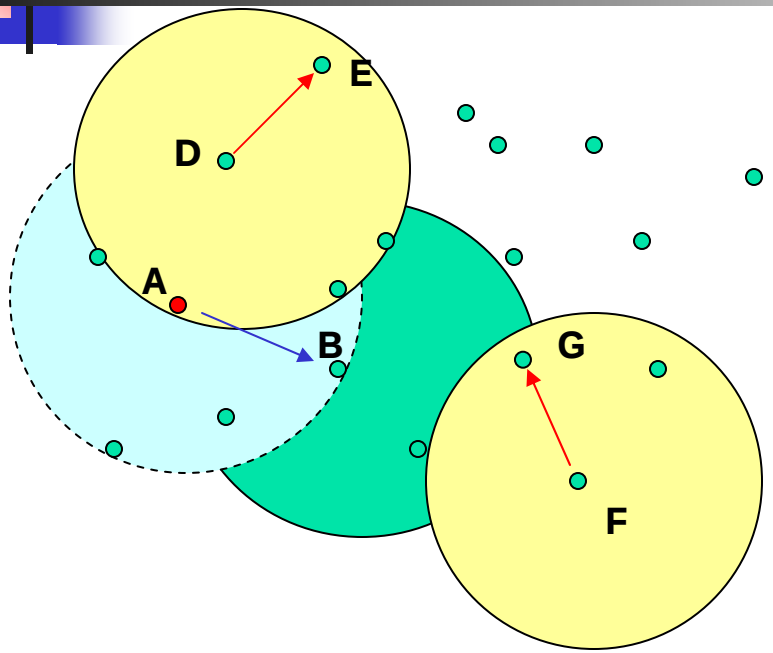
- Motivation
- Principle of Distributed Link Scheduling Multiple Access (D-LSMA)
- Simulation Results
- Conclusion and Future Work



Challenges: MAC for multi-hop flow

- Collision hurts Packet delivery reliability
  - Avoidance: Carrier-sense & RTS/CTS
    - No complete solution for multi-hop scenario
  - Precaution measure hurts throughput
    - Exposed Terminals
- Contention-based Random Access
  - Head-of-Line Problem
  - Scheduling (Local .vs. End-to-End)

Exposed Terminal



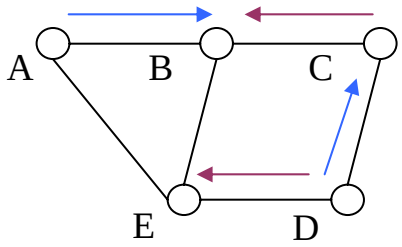
Nodes within RTS/CTS range lose chances of

- Parallel transmission
- Parallel reception

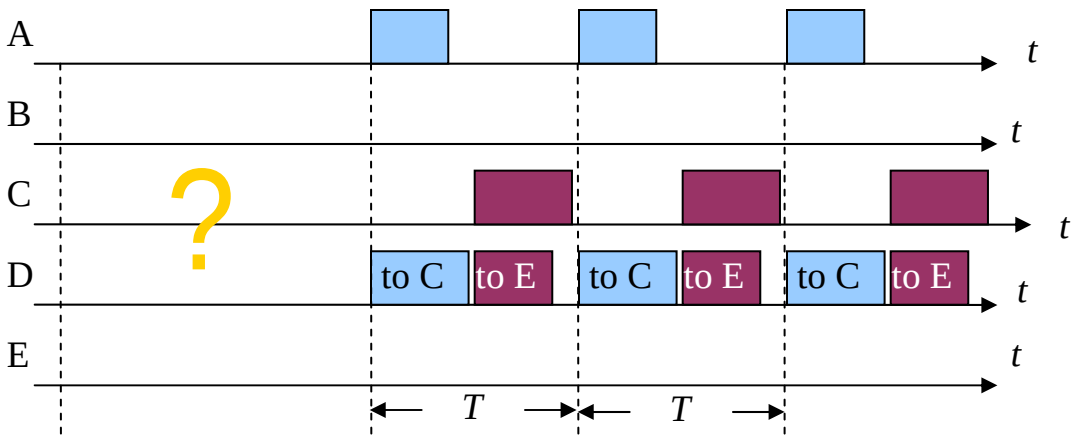
Link Scheduling Rule for parallel events:

Two Links can scheduled at the same time when there is no direct cross-link between the transmitter and receiver in those two pairs of Tx-Rx nodes.

Apply Link Scheduling: Example



Packets:
A→B; C→B;
D→C; D→E

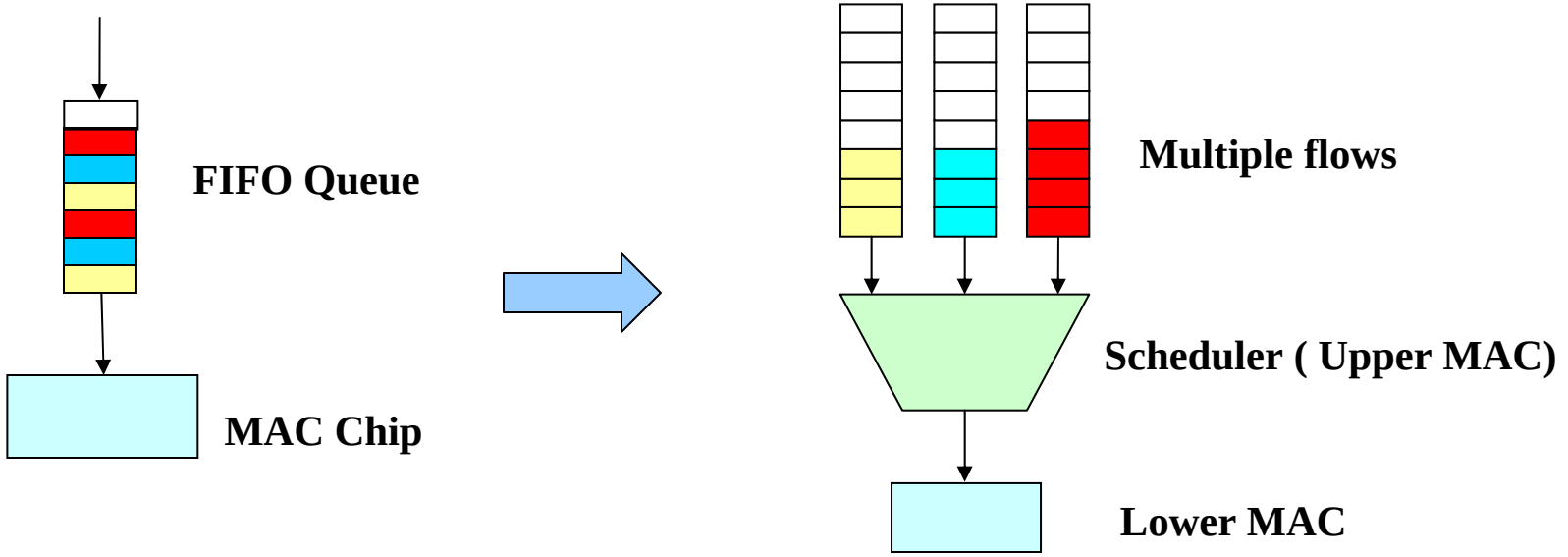


- With periodic traffic pattern, better efficiency to serve CBR flows
- How to realize?
  - Centralized TDMA Scheduling
  - Motivation to design practical distributed algorithm

Design D-LSMA

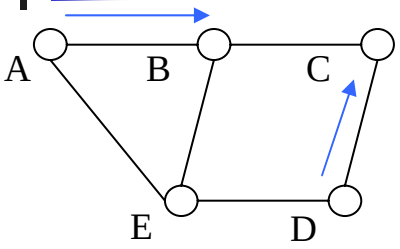
- Knowledge of neighborhood connectivity
  - Easy with simple discovery protocol.
- DATA+ACK: Impact on Link Scheduling.
  - Disable ACK frame and MAC retransmissions
- Nodes have to discover the chances of link scheduling.
  - Reserve with RTS/CTS, other nodes overhear control frames.
  - Build a schedule table by processing overheard RTS/CTS.
- Make nodes able to utilize this chance, not blocked by HOL (head of Line) problem.
  - Use Multiple Queues instead of one FIFO queue

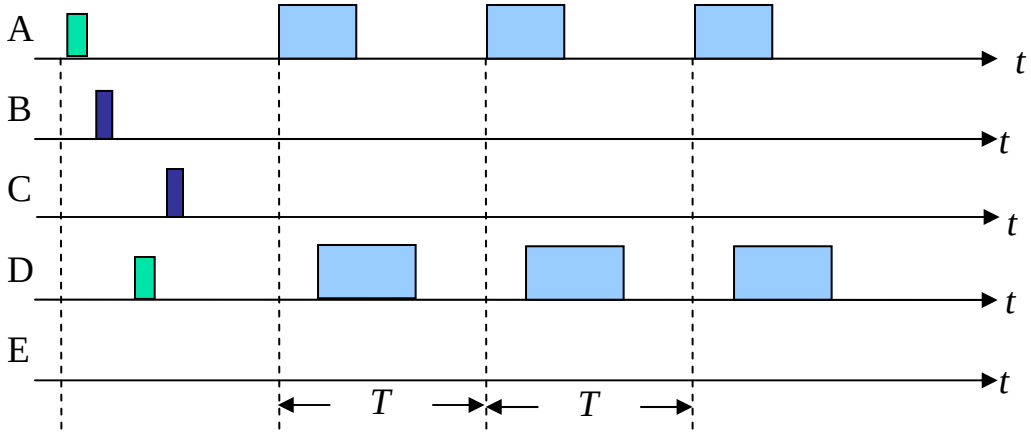
New MAC Architecture



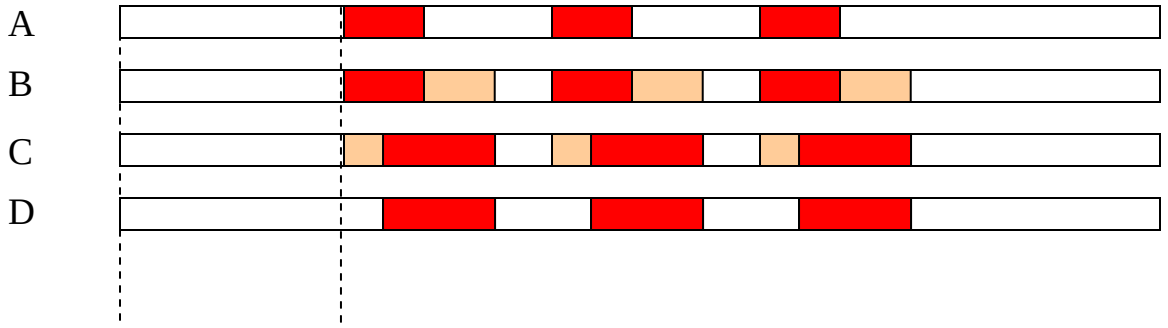
- Old
  - Same MAC scheme for all kinds of traffic in a single FIFO queue
- New
  - Classify packets based on different destination or traffic demands.
  - Scheduler: Choose a “good” schedule for buffered packets or flows and make reservation decisions.

D-LSMA Algorithm: Example



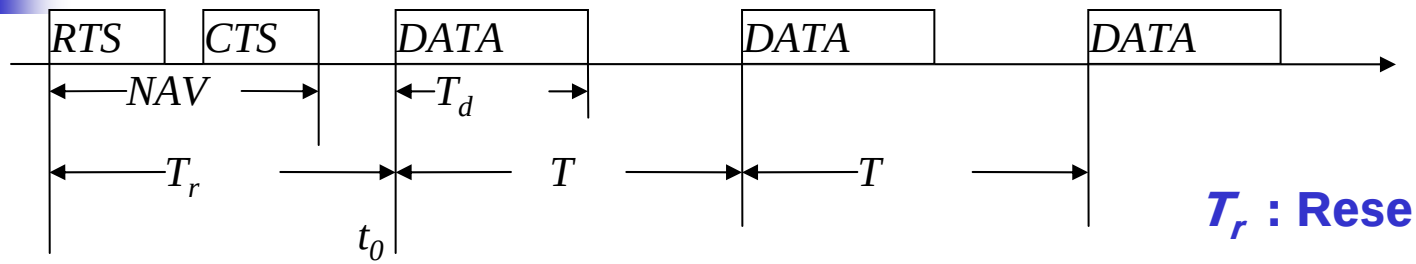


Schedule Table



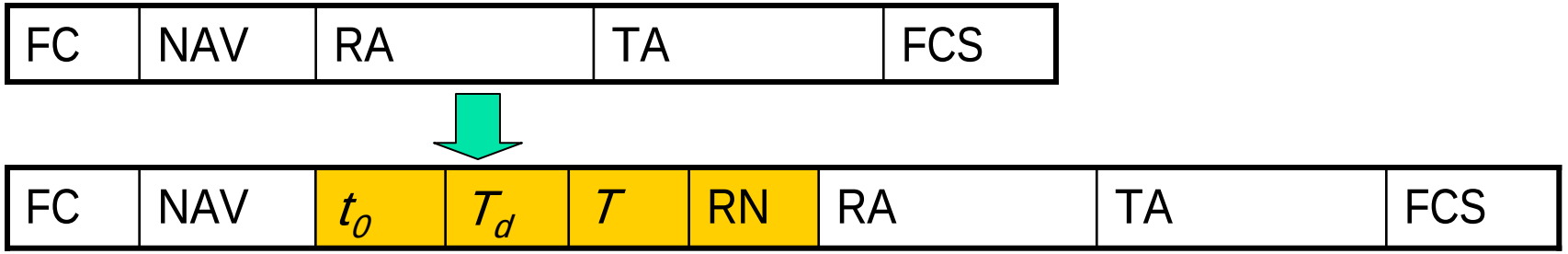
- **Note: Scheduler does not make decisions to align transmissions like MACA-P scheme, just simply "Yes/No" the request.**

Timing Relationship



T_r : Reservation Gap

Modified format of RTS frame



- Time Synchronization
  - Use global synchronization in design prototype
  - Could be synchronized by local channel events

Implementation of Lower MAC

- Extended from 802.11, Keep
  - Carrier Sense & Backoff scheme
  - SIFS, DIFS timings
- Modifications
  - Suppress ACK and disable retransmission
  - Changed RTS/CTS format, reserve multiple packets
  - Handling of overheard RTS/CTS frames
  - Sending RTS based on the command from Scheduler.

Features of D-LSMA

- Use link scheduling rules to avoid conflicts and exploit parallel transmission and reception opportunities.
- Reservation is separated with transmission, scheduler has latitude to select scheduling disciplines.
- A distributed algorithm without using slot structure
- Trying to derive schedule information of neighborhood by sniffing
- Packet errors has to be handled by end-to-end solutions, applicable for scheduling real-time flows

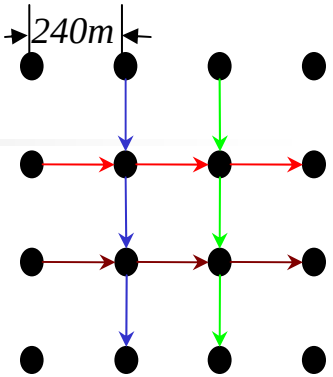
Simulation Experiment

- Performance Evaluation when multiple flows are present over a wireless mesh network
- NS-2 Simulation Parameters

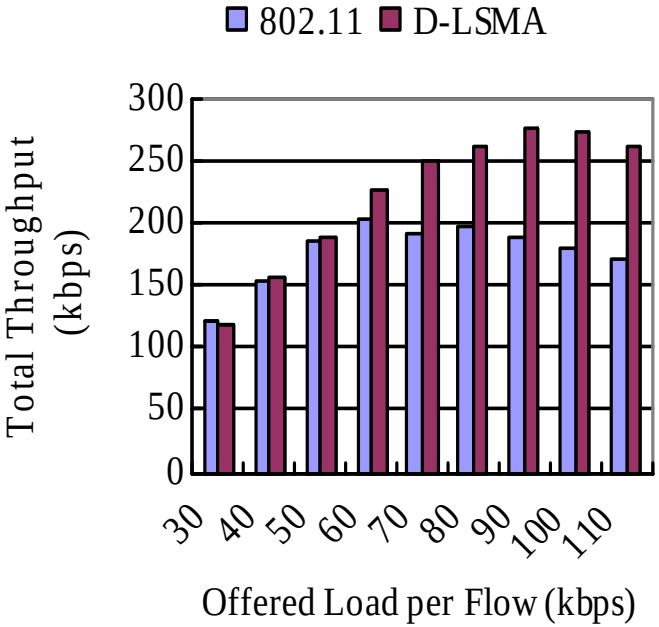
Transmission Range	250m
Channel rate	1Mbps
Packet Size of CBR traffic	512B, 1024B
Simulation Time	200 seconds

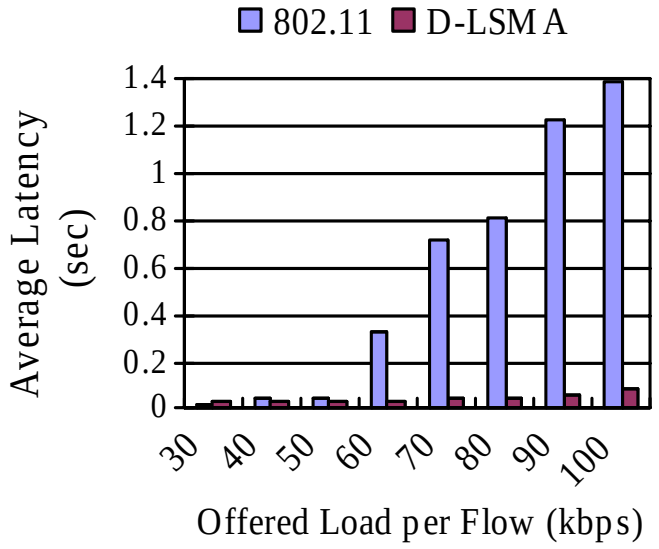
- Scheduler used in simulation
  - Reservation Gap: 1.5 ms
  - Round-Robin serving of each flow to different destinations
  - Make simple Yes/No decisions with incoming request

Grid Topology

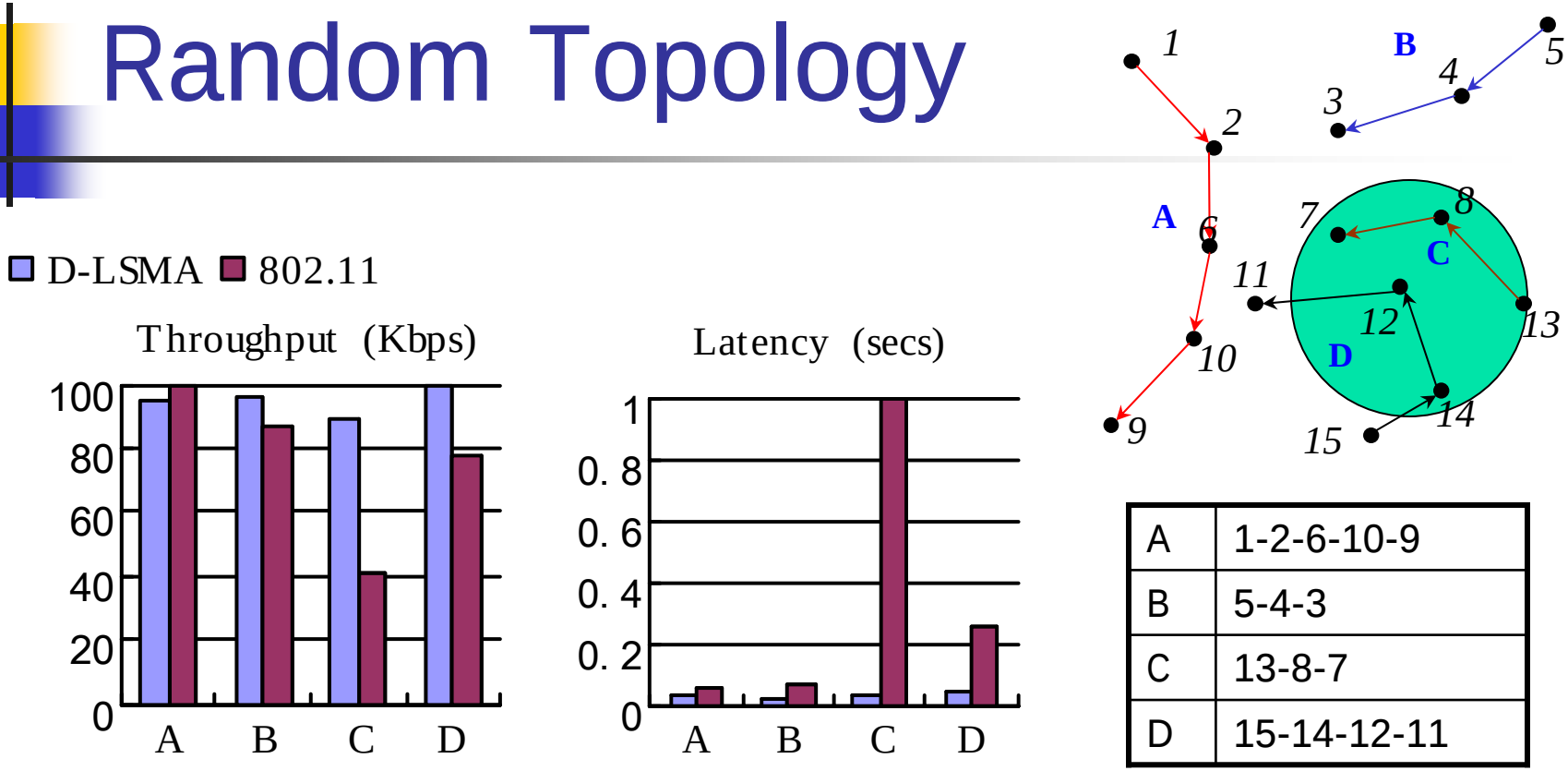


- Measure average throughput and delay per flow





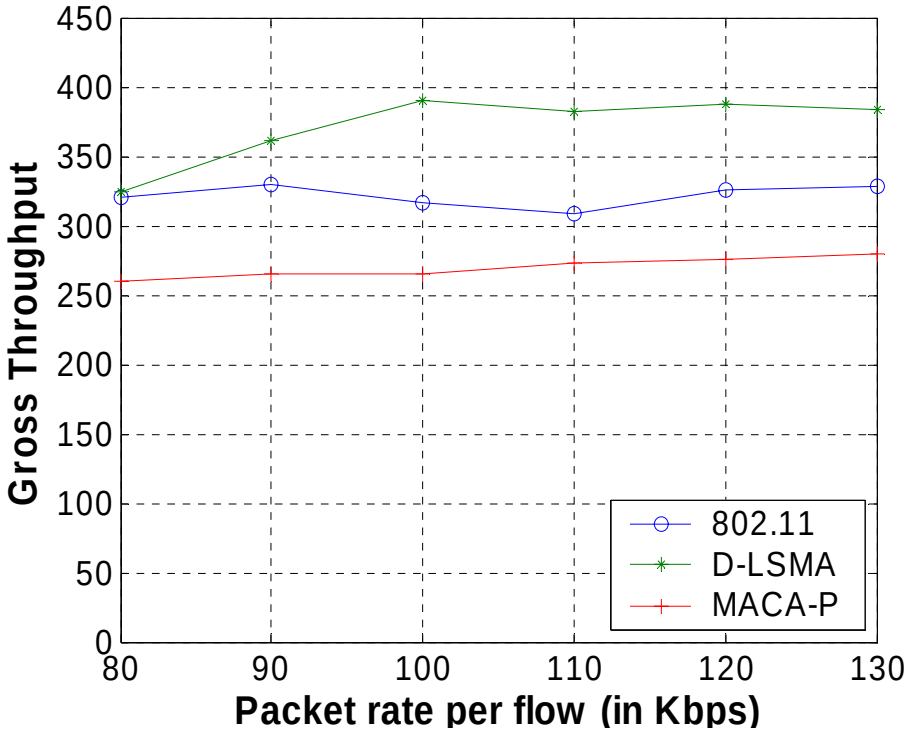
Random Topology

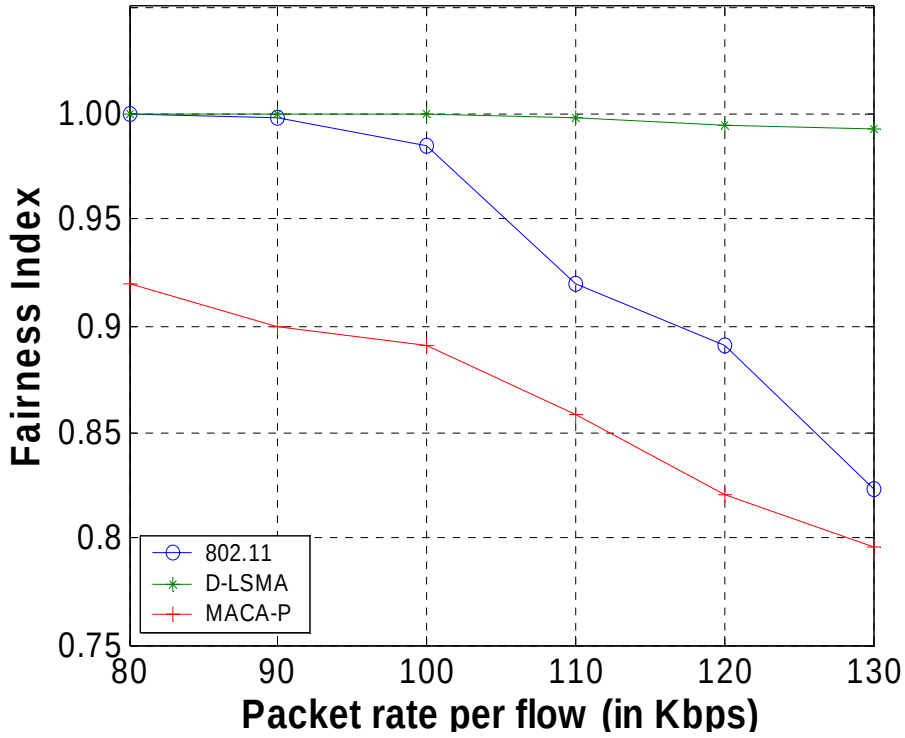


A	1-2-6-10-9
B	5-4-3
C	13-8-7
D	15-14-12-11

- Throughput and delay measured when offered load is 110 Kbps for each flow
- Flow C has degraded performance due to heavy contention
- D-LSMA provide relief for this contention by enable parallel transmission opportunities

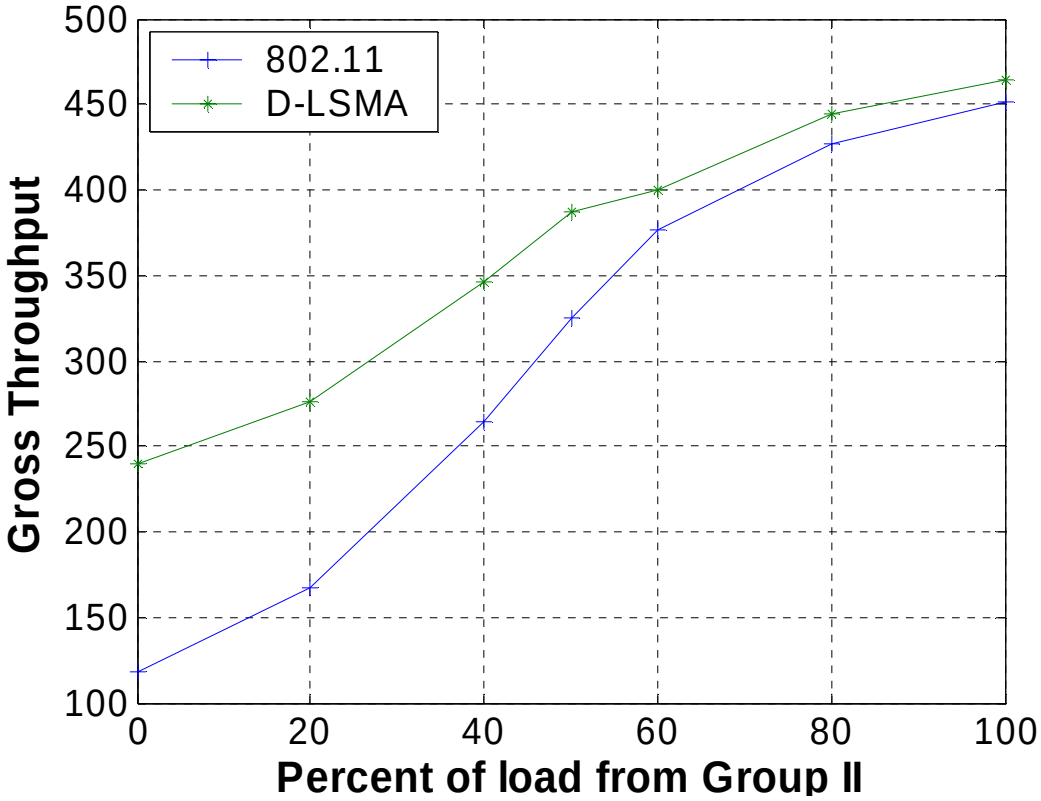
Compare with MACA-P and 802.11

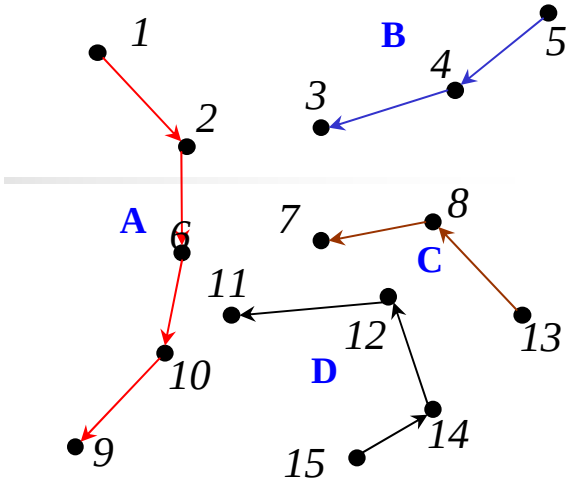




- Better throughput than MACA-P and 802.11
  - MACA-P align both DATA and ACK frames, complex control compromise performance
- Fairness is good even after congestion.

Compare 2 Groups





Group I (A,C) : A Typical Exposed (Hidden) Terminal Scenario

Group II (B,D) : Two independent flows

By varying the share of two groups in traffic, D-LSMA show improved performances in serving the contending flows.

Conclusion & Future work

- D-LSMA is a feasible method to improve performance in a multi-hop environment
  - Throughput increases ~20%
  - Better Performance due to scheduling multiple flows
- Future Work
  - Optimize some key design parameters
    - choose reservation gap based on traffic in neighborhood.
  - Investigate the accuracy of schedule table
  - Integrate D-LSMA with default 802.11