Distributed Link Scheduling
Multiple Access for Wireless Multi-hop Network

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Contents

- Motivation
- Principle of Distributed Link Scheduling Multiple Access (D-LSMA)
- Simulation Results
- Conclusion and Future Work
802.11 MAC in Wireless ad-hoc Network

- Model: Wireless Broadcasting media with a disc coverage
- Packet delivery with multiple hops
- 802.11 MAC is used. How about the performance with multiple flows?
Hidden Terminal

- Collision with Potential hidden node’s transmission A→B, C does not know
- 802.11 MAC use RTS/CTS exchange to prohibit neighbors to send or receive
Exposed Terminal

Nodes within RTS/CTS range lose the chance of
- Parallel transmission
- Parallel reception

Link Scheduling Rule for parallel events:
It is possible when there is no direct cross-link between the transmitter and receiver in those two pairs of Tx-Rx nodes.

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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

- Nodes have to know the connectivity of neighbors (who is with my range?). **Easy with simple discovery protocol.**
- DATA+ACK: Impact on Link Scheduling. **Disable ACK and MAC retransmissions**
- Nodes have to discover the chances of link scheduling. **Broadcasting reservation with RTS/CTS, other nodes overhear those information.**
- Make nodes able to utilize this chance, not blocked by HOL (head of Line) problem. **Use Multiple Queues.**
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.

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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.

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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

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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 using an aggressive manner
- 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topology size</td>
<td>800m X 800m</td>
</tr>
<tr>
<td>Transmission Range</td>
<td>250m</td>
</tr>
<tr>
<td>Channel rate</td>
<td>1Mbps</td>
</tr>
<tr>
<td>Packet Size of CBR traffic</td>
<td>512B, 1024B</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>200 seconds</td>
</tr>
</tbody>
</table>

- 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

- 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
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 real-time traffic performance in a multi-hop environment

Future Work

- Optimize some key design parameters
  - How to choose reservation gap based on the traffic in neighborhood.
  - Investigate the successful rate of reservations, the accuracy of schedule table built in a distributed manner.
- Integrate D-LSMA with default 802.11, test with combined CBR and best-effort traffic for a more realistic scheme
Thank you!