Evaluation of Path Dependent Scheduling in Ad Hoc Networks: a Suitable Fairness Mechanism?

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Outline

• Introduction
• The QoS Architecture
• Scheduling
• Simulations
• Conclusion
Introduction (1/3)

- An ad hoc network consists of nodes that communicate on a shared wireless channel without any infrastructure.

- The wireless environment gives time-varying conditions that, along with mobility, cause capacity and traffic load variations.
• The variability in a wireless network increases the complexity of QoS provisioning.

• If the QoS mechanisms can only provide a time dependent predictable service, the users will not judge the service as predictable.

• Given the time varying conditions in an ad hoc network, the only predictable service is no service at all.
• It is therefore a trade-off between the absolute performance of the service (ex: max throughput) versus the fair distribution among communication parties with different paths.

• The objective of this work is to see whether packet scheduling based on the path properties can improve the predictability in QoS, thus increasing the fairness in the ad hoc network.
The QoS Architecture

Fig. 1. The QoS architecture
The QoS Architecture (cont.)

• Shadow class:
  – Use to check whether a flow can be sent in the requested class.
  – A new RT (real-time) flow must be sent in its class' shadow class before it can be admitted.

• Based on reports from the receiver on the end-to-end quality, the flow is either admitted into its original class or dropped.
The QoS Architecture (cont.)

- ECN (Explicit congestion notification)
  - An intermediate node mark packets to notify a receiver about a possible congestion.
  - The last two bits in the ToS-field in the IP-packet is used to mark packets with ECN
Scheduling

• **LTvTT scheme** (differentiates local traffic from transfer traffic)

• **L HvEH scheme** (differentiates last hop packets from earlier hop packets)
LTvTT

Packet 2 from A to D, destination is “F”

To D, 2 is transfer traffic
LHvEH

Packet 2 from B to D, destination is G

To D, 2 is last hop packet
Scheduling (cont.)

- **LTvTT scheme**
  - We except that giving more resources (set by weight) to the transfer traffic will reduce the path dependence

- **LHvEH scheme**
  - We except that giving more resources (set by weight) to the earlier hop packets will reduce the path dependence
Fairness

• We illustrate the fairness by indicating variability in the performance. Two measures we used

• Coefficient of Variation (CoV)
  – considers how the flows’ performance are distributed; more even performance gives a low value.

• The Min/Max ratio.
  – considers the extreme points; it gives the relationship between the lowest performing flow and the highest performing flow
Simulations

• Scenario 1: simple chain topology
  – Objective: to investigate the trade-offs between improvement in fairness versus effective resource usage and absolute performance.
Simulations

• Simulation environment
  – J-sim network simulator ver1.3 patch4 with wireless extension package
  – Total buffer size set to 25kB
  – IEEE 802.11 MAC capacity set to 2 Mbps
  – Transmission range 250 metres
  – Use RTS/CTS to avoid the hidden terminal problem
Simulations

• Results

Table I

<table>
<thead>
<tr>
<th>CBR SOURCES IN THE CHAIN</th>
<th>Node 1</th>
<th>Node 2</th>
<th>Node 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss</td>
<td>0.66</td>
<td>0.43</td>
<td>0.40</td>
</tr>
<tr>
<td>Delay</td>
<td>550 ms</td>
<td>190 ms</td>
<td>160 ms</td>
</tr>
<tr>
<td>Goodput</td>
<td>70 kbps</td>
<td>117 kbps</td>
<td>123 kbps</td>
</tr>
</tbody>
</table>

Table I summarizes some performance values, and shows the increase in loss and delay for longer paths.
Less weight to local, increase node 1’s & node 2’s good put, while decrease node 3’s good put.

Use CoV or Min/Max ratio, the best fairness achieved with a weight between $1/2(0.62,0.07)$ to $1/3 (0.77,0.10)$
Simulations (cont.)

Table III
LHV EH average goodput in Kbps

<table>
<thead>
<tr>
<th></th>
<th>Node 1</th>
<th>Node 2</th>
<th>Node 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std sched.</td>
<td>20</td>
<td>228</td>
<td>352</td>
</tr>
<tr>
<td>9/10 last</td>
<td>15</td>
<td>201</td>
<td>406</td>
</tr>
<tr>
<td>4/5 last</td>
<td>23</td>
<td>217</td>
<td>337</td>
</tr>
<tr>
<td>2/3 last</td>
<td>33</td>
<td>207</td>
<td>305</td>
</tr>
<tr>
<td>1/2 last</td>
<td>38</td>
<td>203</td>
<td>261</td>
</tr>
<tr>
<td>1/3 last</td>
<td>50</td>
<td>185</td>
<td>182</td>
</tr>
<tr>
<td>1/5 last</td>
<td>62</td>
<td>142</td>
<td>130</td>
</tr>
<tr>
<td>1/10 last</td>
<td>69</td>
<td>97</td>
<td>80</td>
</tr>
</tbody>
</table>

Less weight to last hop packets decrease two hop and one hop left good put but increase three hop left good put to even equal to others.
Simulations (cont.)

- In terms of CoV&Min/Max ratio, we find best fairness (0.15, 0.63) in 1/10 case in LHvEH. (But the goodput is low for all three nodes)

- The best mix of resources might be between 1/2 and 1/3, with CoV and Min/Max ration (0.58, 0.10) and (0.46, 0.23)
Simulations (cont.)

• Scenario 2: random topologies
  – Objective: to investigate the effect the scheduling has on a full QoS architecture with both CBR and TCP traffic, and used in random topologies.
Simulation environment

- J-sim network simulator ver1.3 patch4 with wireless extension package
- 650 x 650 metres area, total of 30 nodes
- EF class is used for VoIP traffic over RTP and UDP
- AF class have CBR source emulates video app over RTP and UDP
- BE class consists of TCP traffic

(In the simulation select 1/2 weight for both LTvTT & LHvEH)

- Every node drew a new starting point for each replication (10 replications in total) and moved within the simulation area according to the Random Waypoint model.
- Use NegExp waiting time to avoid synchronous transmission
Simulations (cont.)

Table IV

The performance variability (CoV)

<table>
<thead>
<tr>
<th></th>
<th>EF</th>
<th>AF</th>
<th>BE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. sched</td>
<td>0.44</td>
<td>0.49</td>
<td>0.56</td>
</tr>
<tr>
<td>LTvTT</td>
<td>0.34</td>
<td>0.42</td>
<td>0.24</td>
</tr>
<tr>
<td>LHvEH</td>
<td>0.52</td>
<td>0.64</td>
<td>0.40</td>
</tr>
</tbody>
</table>

The LHvEH shows a more even goodput for the TCP nodes on the cost of the EF and AF classes compared to standard scheduling.

The LTvTT lets that all classes experience more even performance (lower CoV) than without path scheduling.
Simulations (cont.)

Table V

<table>
<thead>
<tr>
<th>PERFORMANCE VALUES</th>
<th>Adm. ratio</th>
<th>Loss</th>
<th>Delay (ms)</th>
<th>Goodput</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EF</td>
<td>AF</td>
<td>EF</td>
<td>AF</td>
</tr>
<tr>
<td>Std. sched.</td>
<td>0.44</td>
<td>0.27</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>LTvTT</td>
<td>0.37</td>
<td>0.19</td>
<td>10%</td>
<td>14%</td>
</tr>
<tr>
<td>LHvEH</td>
<td>0.39</td>
<td>0.21</td>
<td>10%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Table VI

<table>
<thead>
<tr>
<th>UTILIZATION IN DELIVERED MBYTES</th>
<th>EF</th>
<th>AF</th>
<th>BE</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. sched.</td>
<td>10.4</td>
<td>40.8</td>
<td>39.7</td>
<td>77 %</td>
</tr>
<tr>
<td>LTvTT</td>
<td>11.2</td>
<td>43.3</td>
<td>63.7</td>
<td>100 %</td>
</tr>
<tr>
<td>LHvEH</td>
<td>12.0</td>
<td>45.8</td>
<td>34.5</td>
<td>78 %</td>
</tr>
</tbody>
</table>
Simulations (cont.)

• We notice from the table V that both schemes give lower performance for the EF and AF classes.

• In LTvTT, TCP goodput is higher than standard scheduling. It might appears the LTvTT improves TCP traffic’s condition at cost of EF and AF classes.

• LHvEH offers more EF and AF traffic than standard scheduling, so less BE traffic than std sched.
Conclusion

• In this research we want to get a more even performance among the nodes. (by using two path dependent scheduling)
• However, the improved fairness comes a cost (It must be trade-off)
• In static topology, we get lower utilization; in random topology, the higher prioritized classes (EF and AF) showed lower absolute performance.