Roadmap

1 Thesis Objectives

2 Enhancements
   - Propagation Loss Models
   - Reception Criteria
   - Frame Capture Effect
   - EDCA Implementation

3 Speed Comparison

4 Conclusion
Objectives

- Compare 802.11 implementations of new ns-3 network simulator with ns-2.
- Transfer extended ns-2 features added by the DSN to new ns-3 design.
- Implement EDCA extensions in ns-3.
- Evaluate performance gain of switching to ns-3.

Constraints

- All features must be thoroughly tested, evaluated and documented.
- Integrate cleanly into ns-3 design, which uses state-of-the-art software engineering methods.
- Researchers must be able to use them without detailed lower-layer knowledge.
Feature Comparison: ns-3.3 vs. ns-2.33

PHY Layer:
- No probabilistic Nakagami propagation model.
- Lacks modeling of frame capture effect.
+ BER/PER reception criterion for 802.11a.
  Results unequal to ns-2’s SINR criterion.

MAC Layer:
- Support for EDCA extensions missing.
+ Overall good software design.

Nakagami Propagation Loss Model in ns-3

Ported Nakagami propagation loss model to ns-3.
Extensively verified against ns-2 and the analytic probability density function.
Reception Criteria: SINR

Implemented ns-2’s SINR reception criterion in ns-3 as Ns2ExtWifiPhy.

Discussion of SINR and BER/PER

Detailed explanation of existing BER/PER reception in ns-3. Discussion and comparison against SINR.
Frame Capture Effect

Added frame capture effect to Ns2ExtWifiPhy. Evaluated against ns-2.

ns-2

ns-3

802.11 Enhancements in ns-3
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EDCA Implementation

- Extended ns-3 with EDCA capabilities.
- Builds up on the well designed DCF classes.
- Added TXOP limits and burst sequences.
- Tested individual maximum throughput against analytical reference values.
- Experiment with differently prioritized traffic streams shows relative QoS.
Maximum Throughput Experiment

Reference value in B/s and relative difference of experimental result with 99% error margin for 54 Mb/s data rate.

<table>
<thead>
<tr>
<th></th>
<th>80 B - noACK</th>
<th>80 B - ACK</th>
<th>2304 B - ACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCF</td>
<td>4 522 908</td>
<td>3 176 179</td>
<td>34 810 198</td>
</tr>
<tr>
<td></td>
<td>0.01 ± 0.11%</td>
<td>0.01 ± 0.10%</td>
<td>0.01 ± 0.04%</td>
</tr>
<tr>
<td>AC_VO</td>
<td>7 314 286</td>
<td>4 338 983</td>
<td>38 763 407</td>
</tr>
<tr>
<td>802.11p/D4.02</td>
<td>0.03 ± 0.05%</td>
<td>0.01 ± 0.02%</td>
<td>0.01 ± 0.01%</td>
</tr>
<tr>
<td>AC_BK</td>
<td>3 129 584</td>
<td>2 419 660</td>
<td>31 108 861</td>
</tr>
<tr>
<td>802.11p/D4.02</td>
<td>−0.06 ± 0.1%</td>
<td>0.02 ± 0.09%</td>
<td>0.01 ± 0.04%</td>
</tr>
</tbody>
</table>

Tested 216 configurations.
Maximum relative difference was 0.85 ± 0.11%.
EDCA Traffic Streams Experiment

Each node sends four 160 Kb/s streams with different ACs. As the number of nodes increases the medium is saturated.

Speed Comparison – Highway Scenario

- Modeled identically in both ns-2 and ns-3.
- Made possible with newly added components.
Speed Comparison – Results

![Graph showing packets sent and packets received versus number of nodes for different simulations.]

- **ns-2 unoptimized**
- **ns-2 optimized**
- **ns-2 icc optimized**
- **ns-3 debug**
- **ns-3 optimized**
- **ns-3 optimized static**
- **ns-3 32-bit optimized**
- **ns-3 32-bit optimized static**
- **ns-2 nakagami optimized**
- **ns-3 nakagami optimized static**
3 Speed Comparison

Speed Comparison – Results

- Slowest configuration: ns-3 in debug mode.
- ns-3 optimized mode gives 76.3±0.5% reduction.
- ns-3 optimized with static linking yields further reduction of 42.6±1.2%.
- Compilation without \(-f\text{PIC}\) yielded a reduction of only 1.1±0.3%.
- icc vs. gcc: no improvement, even slight speed decrease (1.9±0.4%).
- Speed increase of ns-3 over identical ns-2 simulation: 58.6±1.8%.
- Enabling Nakagami propagation increases run time by 8.1±1.0% in ns-3 and 3.8±0.4% in ns-2.

4 Conclusion

- Extended ns-3 802.11 PHY layer to show equivalent behavior as ns-2.
- Improved MAC layer with EDCA extensions.
- All enhancements thoroughly verified.
- Speed test of ns-3 shows up to 59 % execution time reduction over ns-2.

Thank you for your attention.