**Towards a Realistic Model of Interference in the ns-2 Network Simulator**

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**Motivation: CDMA and UWB Simulations in ns-2**

- **ns-2 Mobile Node**

**Shortcomings of the Original PHY/MAC**

- PHY checks for receive power > receive threshold hands *all* such packets immediately to the MAC → deterministic decision at the beginning of a packet
- MAC keeps state RX/TX/COLLISION/IDLE self-schedules eventual packet reception checks for collisions during reception

This model is used in *all* ns-2 simulations but:

No proper separation of PHY and MAC (designed specifically for IEEE 802.11), no notion of bandwidth (just center frequency), no modulation, no probability of error (0/1 decision), interference not additive, duration of interference neglected, no interference from packets below the capture threshold, ...

**Implementation**

- no perceptible overhead in simulation with 100 nodes (100 x 100 m²) and AODV compared to old PHY/MAC
- complete reimplementation of PHY and Modulation, minor changes to existing MAC protocols
- to be released toward the end of this year (contact: joerg.widmer,ruben.merz@epfl.ch)

**Future Work**

The above modifications form the basis for simulation of, for example, CDMA or UWB. Now we need to add concrete models to ns-2.

- new MAC protocols (research on UWB MAC)
- models for multi-user interference in CDMA / UWB
- code distribution (for concurrent transmissions)
- synchronization of sender and receiver
- coding and forward error correction
- (fix routing protocols for reasonable performance with bit errors and fading)

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**Simulation Example**

- PHY capacity 2 MBit/s
- random topology (16 nodes, 600 x 600 m²)
- radio range ≈ 250 m
- AODV ad-hoc routing protocol
- each source sends packets of 250 bytes every 10 ms (200 KBit/s)

**Modified PHY/MAC**

Separation of PHY and MAC to be able to exchange these modules independently from each other.

**Physical Layer:**

- interference handling moved from MAC to PHY
- list of all ongoing packet transmissions allows to calculate a bit error rate based on the actual interference at the receiver
- PHY keeps RX/TX/COLLISION/IDLE state (simply mirrored by MAC)
- bit error probability based on average interference
- current modulation BPSK: $BER = \frac{1}{2} \text{erfc} \left( \frac{F}{\sqrt{2(1+N)}} \right)$

**Throughput (KBit/s)**

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Throughput (KBit/s)</th>
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<tbody>
<tr>
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<td>100</td>
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<td>5</td>
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<td>10</td>
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<td>350</td>
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<td>30</td>
<td>400</td>
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**Original PHY with IEEE 802.11:** collision induced route flap, RTS/CTS, sharing of capacity at nodes 0 and 6

**Modified PHY with Aloha:** interference from node 6 results in high bit error rate and temporary loss of route at node 0

**Fading:**

- included Ricean fading from [http://www.ece.cmu.edu/wireless](http://www.ece.cmu.edu/wireless)
- new UWB propagation model from Ghassemzadeh/Tarokh

**MAC Layer:**

- basic MAC works without modifications
- some modifications to 802.11 to make it work with the new PHY

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