**openWNS**

Open Source Wireless Network Simulator

Status and Road Ahead

Daniel Bültmann

Department of Communication Networks
RWTH Aachen University, Germany

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Overview

• In January 2009 ComNets has released significant parts of its simulation platform
• This is the major milestone of continuous effort since end of 2007
• The simulation platform has been released under the LGPL, i.e. it can be included in commercial closed source projects
• Friendly user groups at TU Munich & University of Bremen have become obsolete
• Since January dynamic system level simulators for IEEE 802.11 & IEEE 802.16 are freely available

• This presentation gives an overview of the openWNS simulation tool
openWNS Architecture
openWNS Architecture
openWNS Architecture

Configuration

```
# Python
import hexagonal
scen = hexagonal()
scen.addUTs(
   UniformSpaced(100)
)
```
D. Bültmann, ComNets, RWTH Aachen University

openWNS Architecture

Configuration

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Simulation Platform

Plugin Support

Embedded Python Interpreter  Module Loader  Event Scheduler  Random Distributions  Statistics Support
openWNS Architecture

Simulation Models

Queueing System Simulation Model

\[ \lambda \rightarrow \text{startup} \rightarrow \mu \rightarrow \text{shutdown} \]

Configuration

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Simulation Platform

Embedded Python Interpreter | Module Loader | Event Scheduler | Random Distributions | Statistics Support
import hexagonal
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openWNS Architecture

Configuration

Simulation Models

Node-Component Simulation Model

Node BS1

Traffic Generator
IP
WiFi-MAC
WIFI-PHY
Transceiver
Antenna

Propagation & Channel Models
Mutual Interference Calculation

Node STA1

Traffic Generator
IP
WiFi-MAC
WIFI-PHY
Transceiver
Antenna

Component Support

Evaluation

IP Throughput
Per Station Type
Moments
Moments

SINR
Per Station
Per Selected MCS
PDF
PDF

Simulation Platform

Embedded Python Interpreter
Module Loader
Event Scheduler
Random Distributions
Statistics Support
• Toolbox of standard protocol building blocks
• Based on Functional Unit Networks*
• Available Functional Units
  – Buffers
  – CRC
  – ARQs
  – SAR
  – Concatenation
  – Packet Schedulers
  – Flow-separators
  – Multiplexer
  – Throughput & Delay Measurements

openWNS Modules
Radio Interference Simulation Engine

\[ P_R = P_T - L_{PL}(d) - L_{SH}(x, y) - L_{FF}(f, t) + G_T(\theta, \varphi) + G_R(\theta, \varphi) \]

- **Pathloss Models**
  - Free Space
  - Single Slope
  - Multi-Slope (e.g. for IMT-A EVAL)
- **Shadowing**
  - Log-Normal
  - Map based
  - Wall attenuation
- **Fast Fading**
  - Ricean
  - Time correlated and frequency selective
- **Antenna Gains**
  - Omnidirectional
  - 2D/3D Antenna patterns
  - Beamforming (Dynamically adjusted directivity)
IEEE 802.16 Module

- IEEE 802.16e Physical Layer
  - OFDM TDD profile
  - OFDMA profile for flat channels
- IEEE 802.16e MAC Layer
  - Frame Control Header
  - UL and DL Maps
  - Bandwidth Requests
  - Scanning / Ranging / Association
  - Connection Management
  - Handover
- IEEE 802.16j Relaying
  - Transparent Relay Mode
- Current work: IEEE 802.16m compliance
- Physical Layer
  - 20/40 MHz bandwidth
  - Physical + virtual carrier sensing
  - Simplistic MIMO Model
- IEEE 802.11 2007
  - Distributed Coordination Function (DCF)
  - RTS/CTS mechanism
  - Transmission Opportunities (TxOPs)
- IEEE 802.11n
  - Block acknowledgements
  - Frame aggregation
  - SINR & ARQ-based rate adaptation with MIMO support
- IEEE 802.11s
  - Path selection module → Enables Mesh-Setups
TCP/IP Module

- Internet Protocol
  - Multiple MAC-Layers in one Node
  - Enables Hybrid Terminals
  - Models of DNS, DHCP & ARP
  - Static Routing, TTL & IP Tables
  - Tunneling (IP in IP encapsulation)
- TCP/UDP
  - Accurate headers
  - Congestion Avoidance & Slow Start
  - Tahoe & Reno strategies are available
- Utilities
  - Write Wireshark compatible traces
  - Operating system integration through TUN Device (beta)
Traffic Generation

- **Point Processes**
  - Constant Bitrate
  - Poisson
  - Arbitrary random distributions for both inter-arrival time and packet size

- **Markov-Modulated Poisson Processes**
  - IMT-A VoIP model
  - MPEG 2

- Can be connected at different points to the protocol stack
  - TCP/UDP
  - IP
  - Data Link Layer
openWNS Metrics
openWNS Source Code Metrics

openWNS Source Code Metric

<table>
<thead>
<tr>
<th>Platform</th>
<th>Lines of Source Code</th>
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<td>DLLBase</td>
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<td>WIMAC</td>
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<td>OFDMAPHY</td>
<td>3400</td>
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<tr>
<td>Constanze</td>
<td>6275</td>
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</table>

Total 143.175
openWNS Test-Coverage Metrics

1049 Unit-Tests in total
953 System-Test Expectations

Library
- Platform: 893
- RISE: 119
- OFDM PHY: 123
- DLL: 2
- WIFI: 814
- IP: 16
- SIMPLE TL: 21

System-Tests: Dark Purple
Unit-Tests: Light Purple
Support & Documentation

Textbook Manuals (PDF)
110 Pages in Total

Mailing List

develop@openwns.org Mailinglist Activity

Bugs in openWNS SDK

<table>
<thead>
<tr>
<th>ID</th>
<th>Summary</th>
<th>Importance</th>
<th>Status</th>
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<td>High</td>
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<td>High</td>
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<td>21644</td>
<td>Unlabeled font found</td>
<td>Medium</td>
<td>Fixed</td>
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<td>Fixed</td>
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Live DVD
Conclusions & Road Ahead

• Conclusions
  – IEEE 802.11 & IEEE 802.16 system level simulators released
  – openWNS is extensible at multiple levels of detail
    • Simulation Models
    • Layers
    • Functional Units
  – Released under the LPGL license (commercial use permitted)

• Road Ahead
  – CELTIC WINNER+ is registered IMT-Advanced Evaluation Group
  – ComNets uses openWNS for LTE-Advanced (Rel. 10) and IEEE 802.16m system level simulations
  – Evaluation Models & Scenarios as described in ITU-R IMT.EVAL (M.2135) and IMT.TECH (M.2134) to be implemented and released
**openWNS Demonstration**

1. Create Campaign
2. Queue Campaign Simulations
3. Parallel Simulation Runs
4. Query Simulation Parameters
   - 4a. Query Simulation Parameters
   - 4b. Write Results
5. Analyze Results

- SUN Grid Engine
- Postgres Database Server
- Users Workstation

D. Bültmann, ComNets, RWTH Aachen University
openWNS

Open Source Wireless Network Simulator

Available Online at

http://www.openwns.org
Thank you for your attention!

Daniel Bültmann

dbn@comnets.rwth-aachen.de

Credits:

Marc Schinnenburg  Daniel C. Schulz
Maciej Mühleisen  Ole Klein
Ralf Pabst        Klaus Sambale
Christian Hoymann Ralf Jennen
Sebastian Max    Rainer Schoenen
Karsten Klagges  Dirk Kuypers
Arif Otyakmaz    Stephan Goebbels
Andreas Kemper   Jan Ellenbeck
Matthias Malkowski Mohammad Siddique

And all their student and diploma thesis workers!