The LENA Project

a product-oriented open source LTE/EPC Network Simulator based on ns-3

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About the project

• CTTC working with Ubiquisys, the leading femtocell manufacturer

• Objective: develop a common platform for LTE femto/macro cell vendors to evaluate their different solutions
  • e.g., make sure that large and small cells from different vendors will work harmoniously before they are deployed
  • Open Source to foster adoption and contributions
  • Based on ns-3

• Use case: LTE-based Self Organized Networks
  • Need to test SONs algorithms before deployment
  • Ubiquisys made extensive use of simulation to design its first generation of WCDMA intelligent femtocells

• Product –oriented:
  • Real-world interfaces for SON algorithms
  • FemtoForum MAC Scheduler API specification
  • Allow testing real code in the simulator
Current Features

- PHY and MAC for UL and DL
  - frame/subframe structure
  - Ideal control channel
  - Adaptive Modulation and Coding
- Inter-cell interference modeling
- Packet Scheduling
  - FemtoForum MAC Scheduler API
  - Round Robin and Proportional Fair schedulers available
- Abstract RLC model
  - PDU generator with infinite queue
- Simplified RRC
  - UE Attach procedure
  - Bearer setup
- Configuration via ns-3 attribute system
- Output: MAC and RLC statistics
eNB protocol stack architecture

- **global configuration**

- **Radio Bearer setup & mgmt**
- generation of per-flow application data

- multiplexing of Logical Channels into Transport Channels
- Radio Resource Allocation & Scheduling
- Adaptive Modulation and Coding

- handling of frames / subframes
- simulation of signal processing
- Interference calculation
- CQI calculation

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- **LteEnbNetDevice**
  - config
  - create and config

- **LteEnbRrc**
- **LteEnbCmacSap**
- **LteEnbMac**
- **LteEnbPhySap**

- **LteEnbRlc**
  - one instance per active Radio Bearer
  - FfCschdSap
  - FfSchedSap
  - FfMacScheduler

- **LteEnbPhy**
  - StartTx ()
  - StartRx ()

- **LteSpectrumPhy**
  - one instance per UE

- **SpectrumChannel**

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- **DownLink**
- **UpLink**
UE protocol stack architecture

- Global configuration

- Radio bearer setup & mgmt
  - Generation of per-flow application data

- Multiplexing of logical channels into transport channels

- Handling of frames / subframes
  - Simulation of signal processing
  - Interference calculation
  - CQI calculation

StartRx ()

StartTx ()

LteSpectrumPhy

SpectrumChannel

Downlink

eNB's DL SpectrumPhy

StartRx ()

StartTx ()

LteSpectrumPhy

SpectrumChannel

Uplink

StartRx ()

StartTx ()

LteSpectrumPhy

UEs' UL SpectrumPhy
Testing and Validation: some examples

Unit test: AMC

System test: interference

System tests: RR & PF scheduler performance
run-time performance
Work in progress

- Path loss models
  - Well known models
    - Path loss: OH, ITU-R 1411, ITU-R 1238…
    - Shadowing, fading, building penetration loss
  - Appropriate combination selected at runtime based on the topology
- E-UTRA protocol stack
  - RLC UM & AM
  - PDCP
- EPC Data Plane
  - SGW / PGW
  - S1-U interface
  - GTP over UDP/IP
  - Traffic Flow Templates
Future development

- PHY enhancements:
  - Error model
  - HARQ
  - MIMO

- More EPC features:
  - MME
  - X2 interface
    - Handover support
    - Inter-cell interference coordination support
    - Neighbor Discovery support
Check it out!

• Links:
  • http://www.cttc.es
  • http://iptechwiki.cttc.es/LTE-EPC_Network_Simulator_(LENA)
  • http://www.nsnam.org
  • http://code.nsnam.org/nbaldo/ns-3-lena-dev

• Documentation:
  • User Docs, Design Docs & Testing Docs
    • distributed with source code
    • pdf available
  • API documentation
    • doxygen

• Feedback & contributions welcome!
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