An Introduction to National Instrument’s
NS-3 / LTE Platform for Network Prototyping

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What is 5G?

- **100x more devices**
  Massive numbers of devices: Think sensor networks.

- **>10 Gb/s peak rate**
  Focus on expanding the user experience.

- **<1 ms latency**
  Ultra reliability and low latency for mission critical applications: Think car-to-car communications that help prevent collisions.
The Need for 5G MAC/PHY Prototyping

- Real-time prototyping and simulation of end-to-end 5G dense wireless networks including cellular, WLAN and mmWave
- Software defined networks (SDN) experimentation for advanced network coordination and optimization research
- Cross layer optimizations between the protocol layers
Existing Platforms for Network Research

Limitations

- Conventional CPUs prohibit a full physical layer implementation because of computationally heavy operations like FFT or decoding.
- Programming FPGA requires HDL expertise, where interface design and parametrization are not as straightforward as in C/C++, Python, etc.
- The source code may be not available for modifications.
The NI NS-3/LTE Application Example

- NI LTE Application Framework
- Network Simulator NS-3
- Flexible L1-L2 interface
### LTE Protocol Stack

**user plane**

- **S1-U**
  - **MME**
  - **SGW**
  - **PGW**
- **S5/S8**
  - **SGi**
- **Internet Service**

**control plane**

- **S1-MME**
- **S11**

### LTE Protocol Stack Details

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<thead>
<tr>
<th>Layer</th>
<th>Protocol</th>
<th>Lower Layer</th>
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<tbody>
<tr>
<td>L3</td>
<td>NAS</td>
<td>L2</td>
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<td>RRC</td>
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**LTE-Uu**

- E-UTRAN (LTE) + EPC (SAE) = EPS

**LTE-Uu**

- E-UTRAN (LTE)
- EPC (SAE)
NI Extensions to NS-3

- NI extension to NS-3
  - Disable PHY emulation
  - Separate eNB and UE
  - Incorporate real PHY

**Diagram:**

- **UE** (User Equipment)
  - APP
  - IP
  - PDCP
  - RLC
  - MAC
  - L1-L2 API
- **eNB** (Evolved Node Base)
  - SGW/PGW
  - IP
  - GTP
  - UDP
  - IP
- **NI Extension**
  - DA/AD+RF
- **LabVIEW**
  - L1-L2 API
  - PHY
  - DA/AD+RF
Hardware Setup

GUI
LV Comms v2.0 on Windows 7

eNB PHY
FPGA IP on USRP-RIO

UNB MAC
NS-3 on RT controller with NI Linux RT

UE MAC
NS-3 on RT controller with NI Linux RT

Switch

Switch

Switch
The NS-3/LTE Application Example provides a flexible message-based interface that can be modified and extended.

It is intended as a starting point to begin network research.

Users must understand how to use all three software components proficiently, including NS-3 which is an open source tool that is not created by National Instruments.
Learning Resources (1)

LabVIEW Communications

Training courses available
- Host programming
- FPGA programming with LabVIEW
- Real-time programming with LabVIEW

LTE Application Framework

Training course available
- Understand the architecture of the LTE physical layer.
- Learn which parameters can be controlled with software.
- Learn how to use and modify the LTE physical layer.

NS-3/LTE Application Example

NS-3 is an open source tool
- Find learning resources at www.nsnam.org
- NS-3 training is not offered by National Instruments.
Learning Resources (2)

National Instruments technical support is available for LabVIEW Communications and the LTE Application Framework

✓ Contact your local Sales representative for details.

Documentation material for the NS-3/LTE Network Prototyping Application Example


NS-3 related links

✓ NS-3 model library – [https://www.nsnam.org/docs/models/ns-3-model-library.pdf](https://www.nsnam.org/docs/models/ns-3-model-library.pdf)
Questions?

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