

Prototyping LTE-WiFi Interworking on a Single SDR Platform

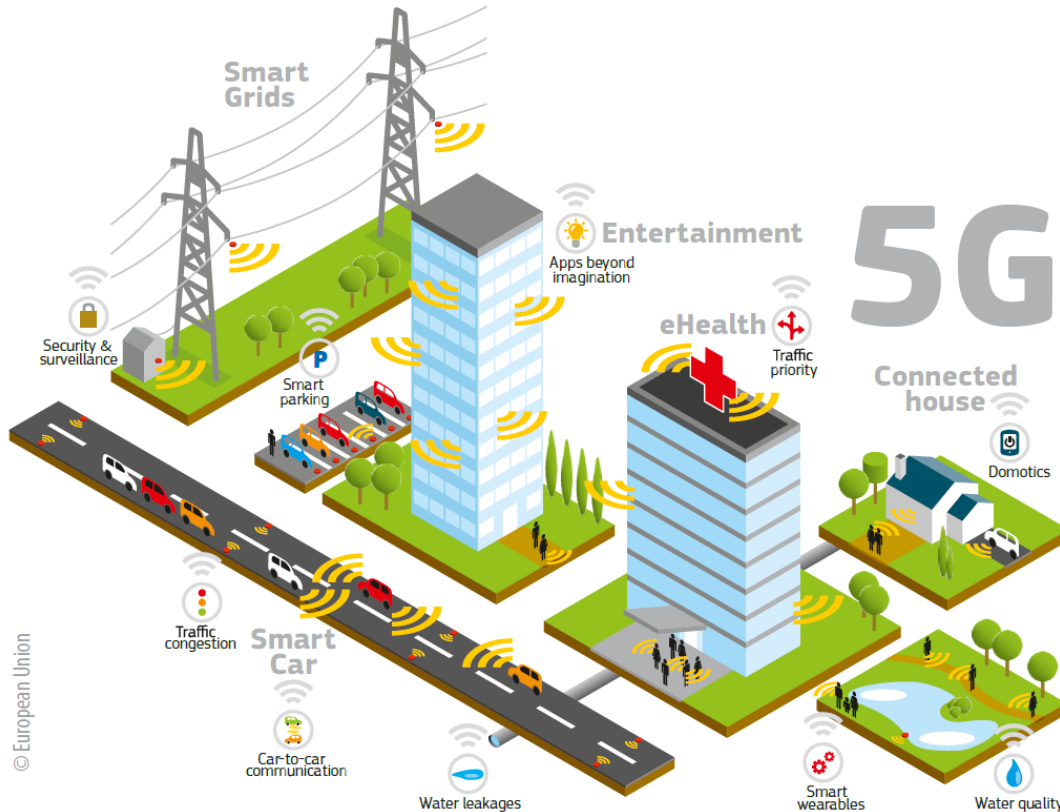
Clemens Felber

Workshop on Next-Generation Wireless (WNGW) with ns-3

National Instruments Dresden GmbH, Germany

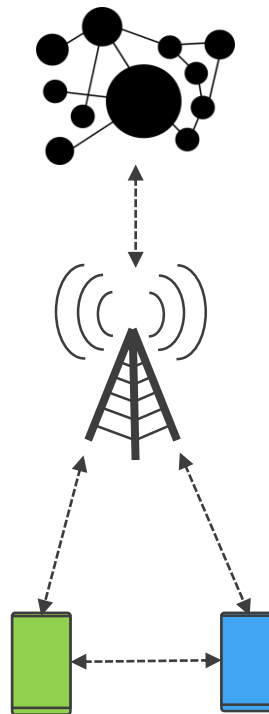
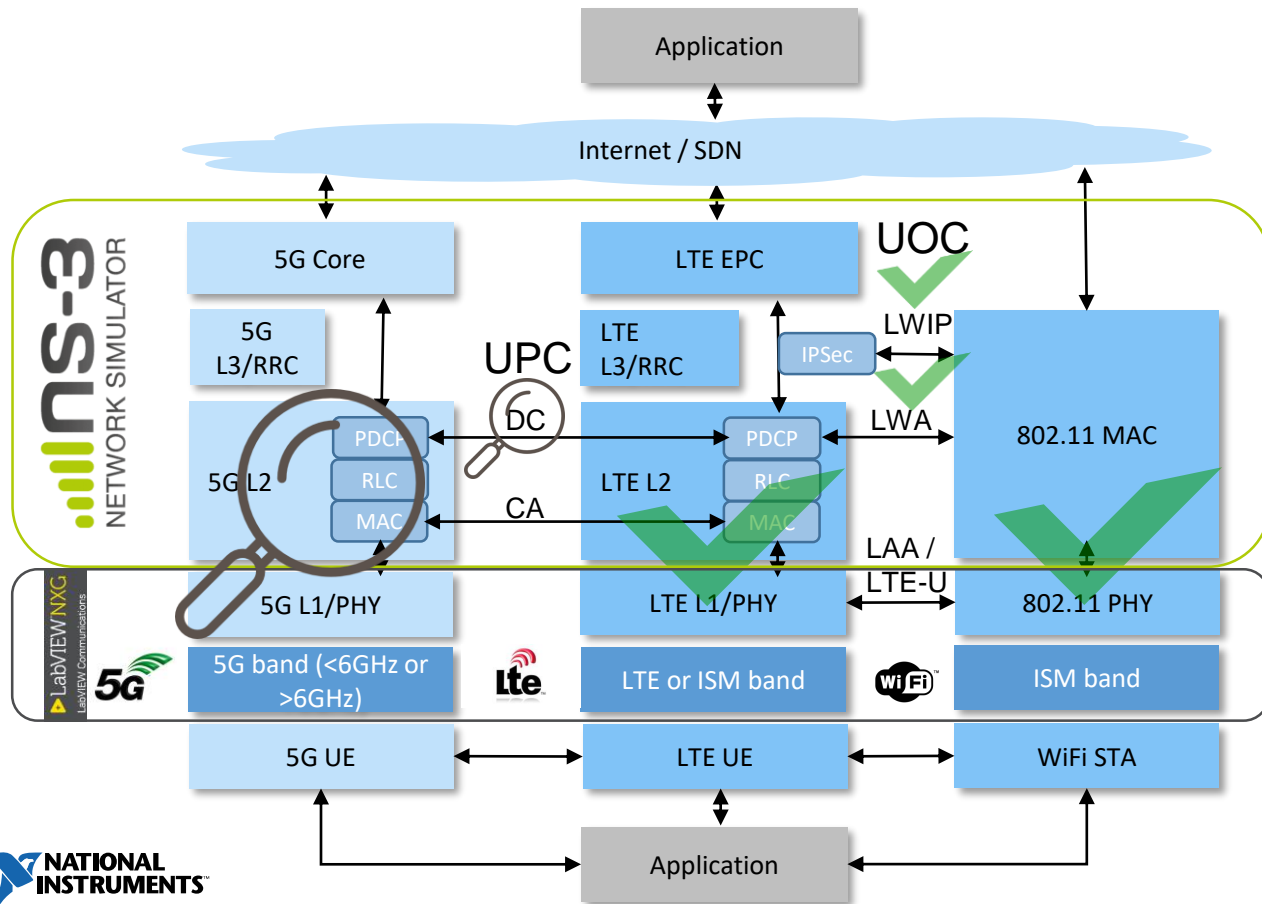
21-June-2019, Florence, Italy

Challenges in Future Wireless Networks

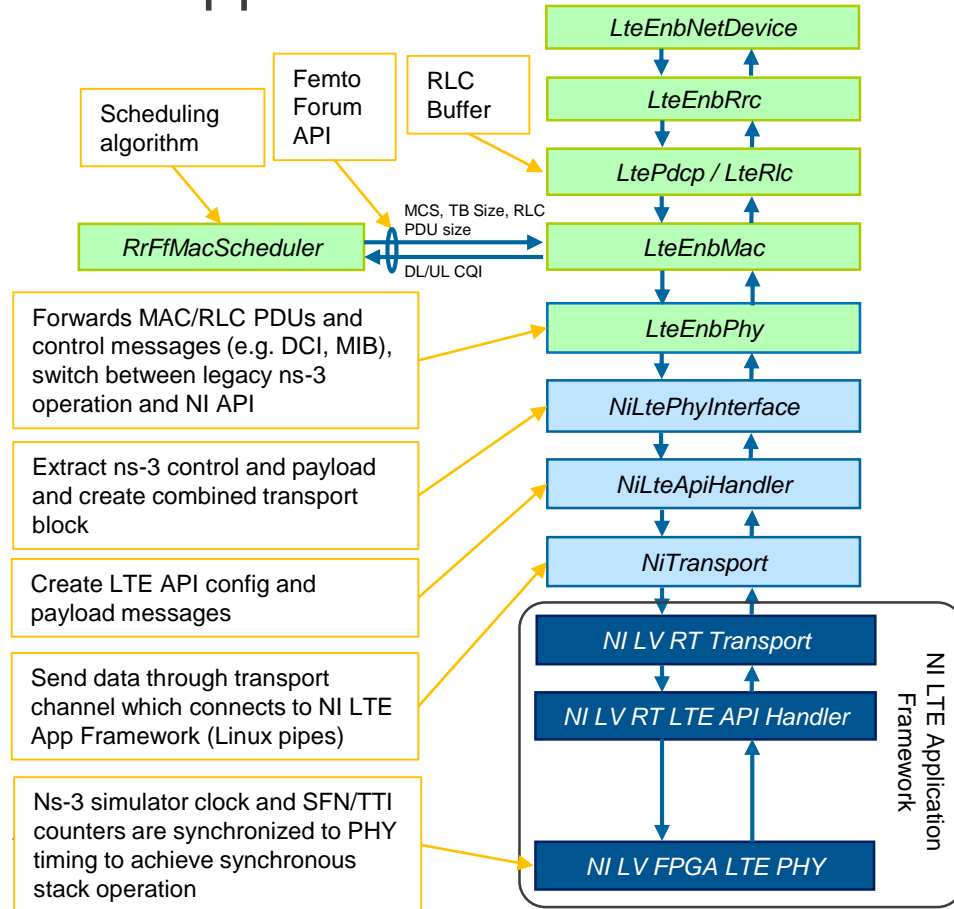


New 5G use cases will bring unprecedented diversity and density to future wireless networks

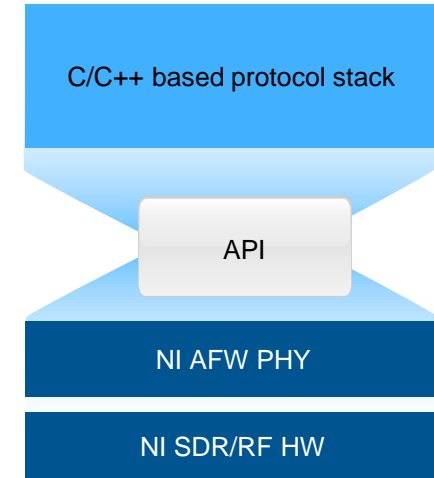
NI's Multi-RAT Platform Vision for Research



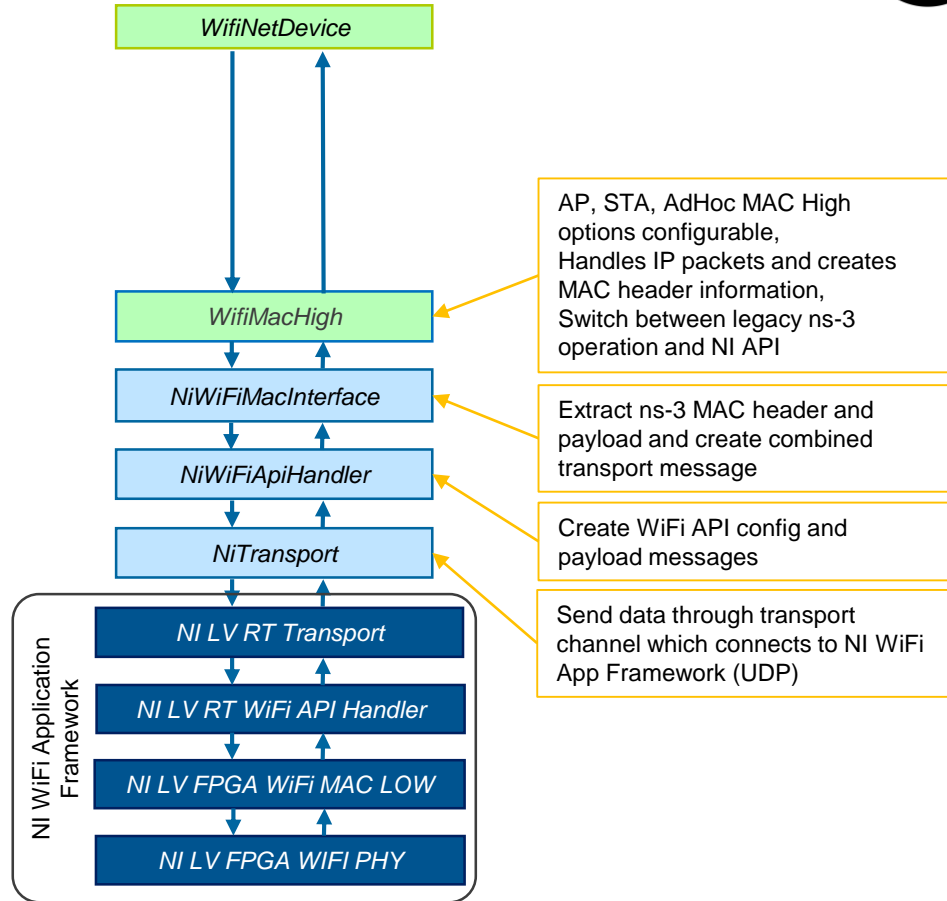
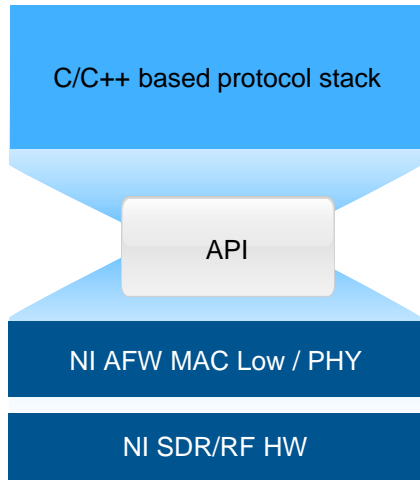
Flexible API Concept to Connect Upper Layer to NI Application Frameworks



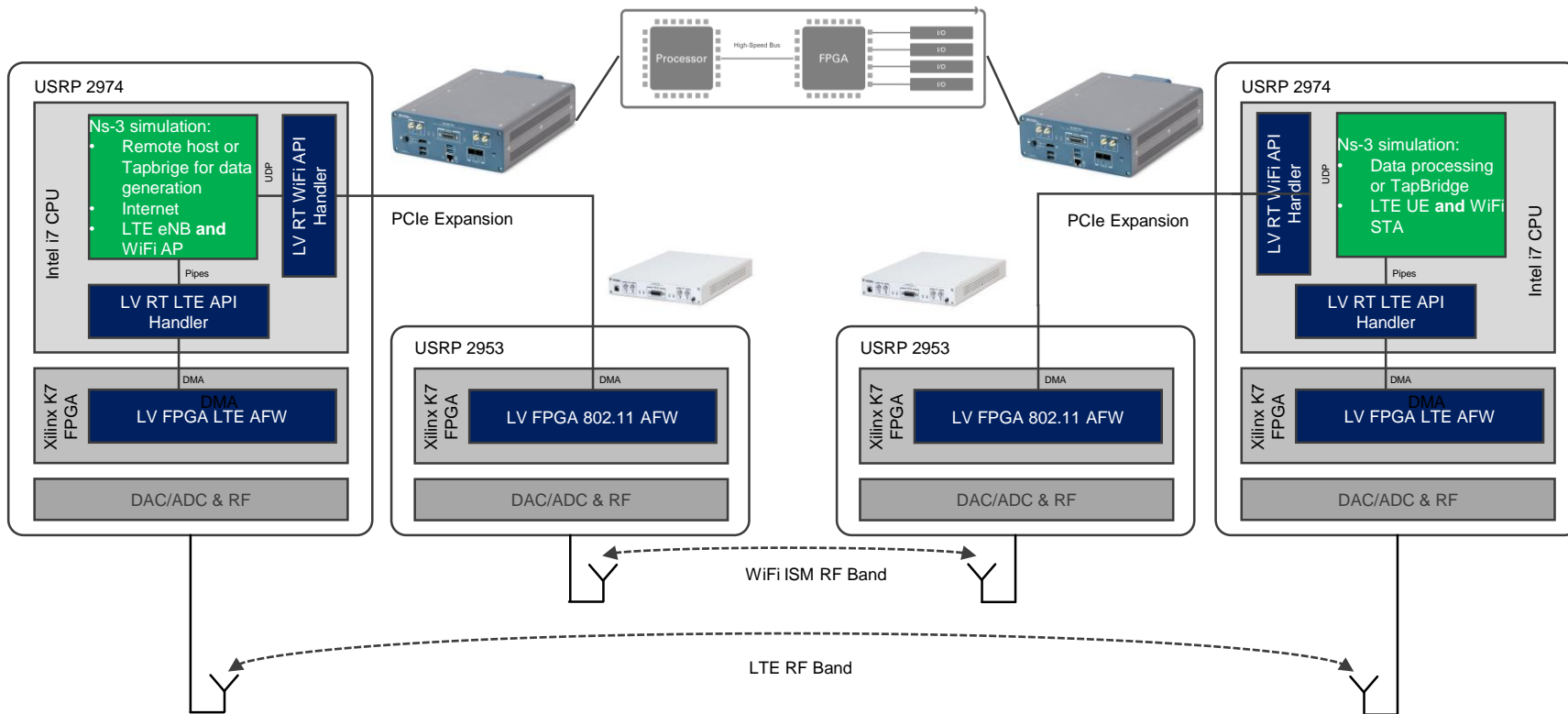
ns-3
NETWORK SIMULATOR



Flexible API Concept to Connect Upper Layer to NI Application Frameworks

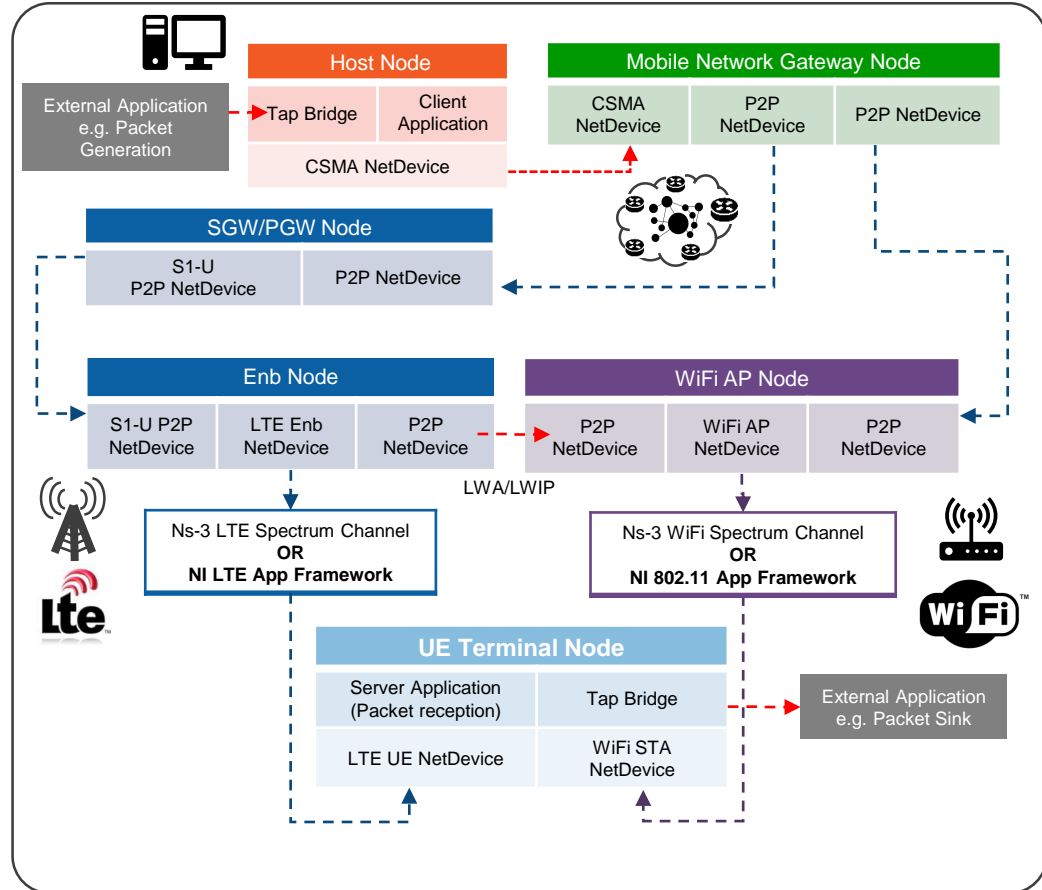


SDR Hardware partitioning



NS-3 End-to-End Multi-RAT Scenario

- Internet emulation using nodes connected via ETH/CSMA
- Mobile network gateway connects LTE and WiFi access networks to internet via P2P
- LTE and WiFi access networks can run in parallel supporting interworking options
- Terminal includes LTE and WiFi network interfaces as in real devices
- External traffic possible through Tap Bridge



Integration within LTE Application Framework

LTE Application Framework

See the diagram for more information.

Overview

Demonstrates a LTE base station (eNodeB) comprising a DL Transmitter ("eNB Transmitter") and an UL Receiver ("eNB Receiver")

Instructions

1. Setup the hardware according to the instructions in the "Getting Started Guide"
2. Set the "RIO Device" to the alias of the RIO device connected to your system
3. Start the VI and enable "eNB Transmitter" and "eNB Receiver"

Reference Clock Source: Internal
RIO Device: RIO0
External MAC: Start Extern:
stop

eNB Transmitter: eNB TX Active
eNB Receiver: eNB RX Active
Status: System Init Complete! FPGA Ready: device bandwidth [MHz]: 120

Basic | Advanced | Status

External MAC Output

```
----- NS-3 Topology Information -----  
Number of ETH devices = 3  
Number of LTE UE devices = 1  
Router GW IP Addr = 10.1.1.1  
LTE Net GW IP Addr = 10.1.2.2  
LTE EPC PGW IP Addr = 7.0.0.1  
LTE UE#1 IP Addr = 7.0.0.2  
Client IP Addr = 10.1.1.2  
Server IP Addr = 7.0.0.2
```

--> Please enable now Rx/Tx in LTE Application Framework!

[>] Start simulation
Waiting for first LTE PHY timing indication...
LTE.ENB.RRC: INITIAL_RANDOM_ACCESS --> CONNECTION_SETUP (IMSI=1, RNTI=1)
LTE.ENB.RRC: CONNECTION_SETUP --> CONNECTED_NORMALLY (IMSI=1, RNTI=1)
LTE.ENB.RRC: CONNECTED_NORMALLY --> CONNECTION_RECONFIGURATION (IMSI=1, RNTI=1)
LTE.ENB.RRC: CONNECTION_RECONFIGURATION -->

ns3.26-ni-lte-simple-optimized

--numPackets=100 --simTime=120 --niApiDevMode="NI_API_BS" --niApiEnableLogging="true" --niApiLteEnabled="true"

SFN: 406
TTI: 4
Max MAC TX Delay: 395
IP Packets Size Exceeded Count: 0
UL RX Indication CRC OK:

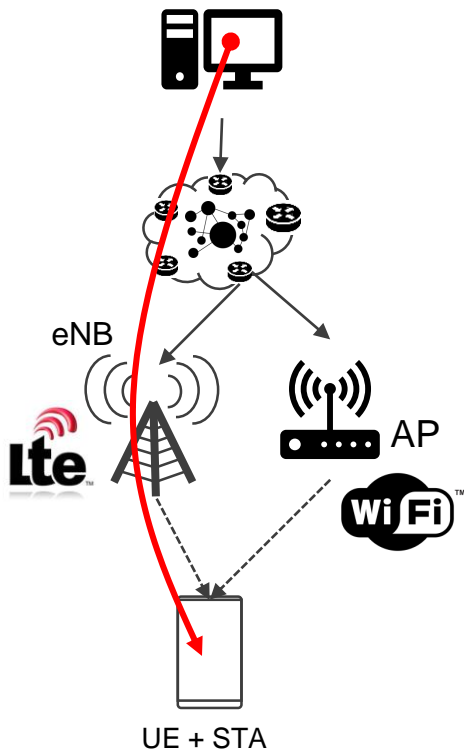
Stop on API Confirmation Errors

Received Confirmations	Negatives
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0
Success	0

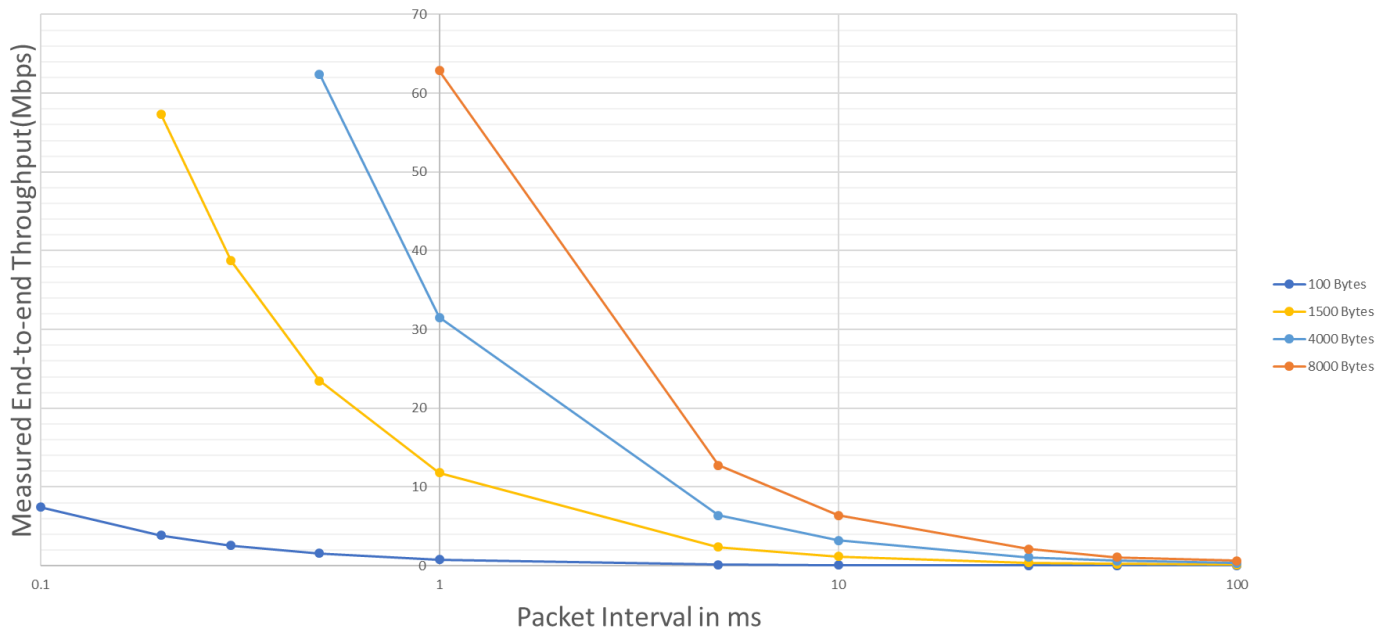
Error Report

ns-3 console output

Measurement of End-to-End Throughput - LTE



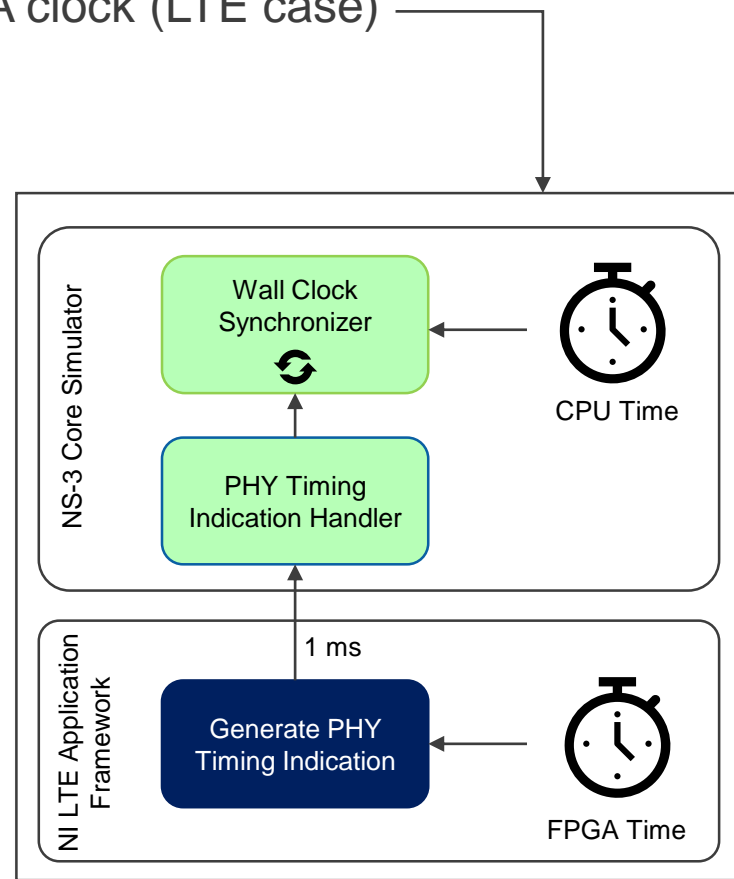
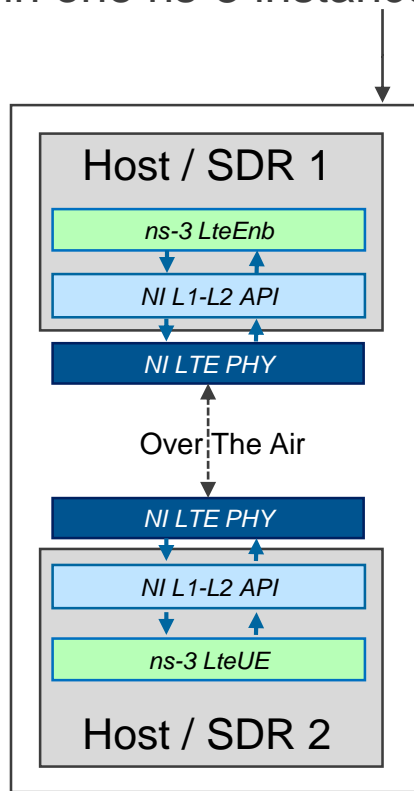
Measured End-to-end Throughput for (Mbps) for different Packet sizes



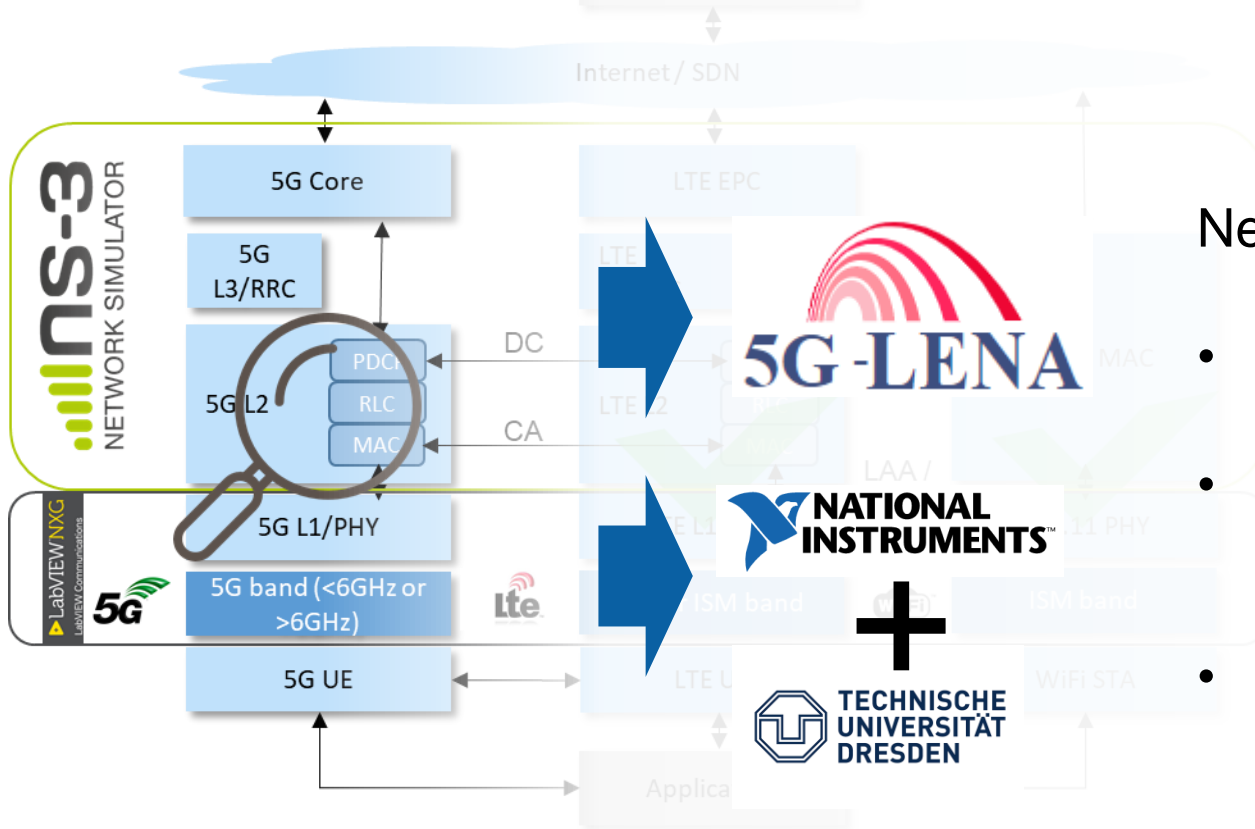
- Close to capacity limit of LTE PHY layer

Main Challenges

- Synchronization of ns-3 Simulator with the FPGA clock (LTE case)
- Separation of eNB and UE in one ns-3 instance
- Single threaded simulator
 - Tx and Rx needs to be executed asynchronously in a communications systems



Outlook: Develop the 5G path for NI's Multi-RAT Platform



Next Steps

- Analyzing the 5G-LENA module
- Migrate and adapt NI changes from LTE module to 5G-LENA
- Connect to 5G SDR in collaboration with TUD

Thank you!

NS-3 code modifications publicly available under:

<https://github.com/ni/NI-ns3-ApplicationExample>



3rd Open Call for Experiments – NOW OPEN!

<https://www.orca-project.eu>

