Performance Comparison of a Custom Emulation-based Test Environment Against a Real-world LTE Testbed

TRANSFORMANDO
EM REALIDADE

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Motivation

- LTE´s high complexity poses computational and time burdens on testing tasks involving real-world platforms.
- Simulation is the tool most widely used for this purpose.
- Emulation in research has been ramping up recently as alternatives to pure simulation.
- Most simulators found in the literature tend to rely on built-in traffic generation processes.

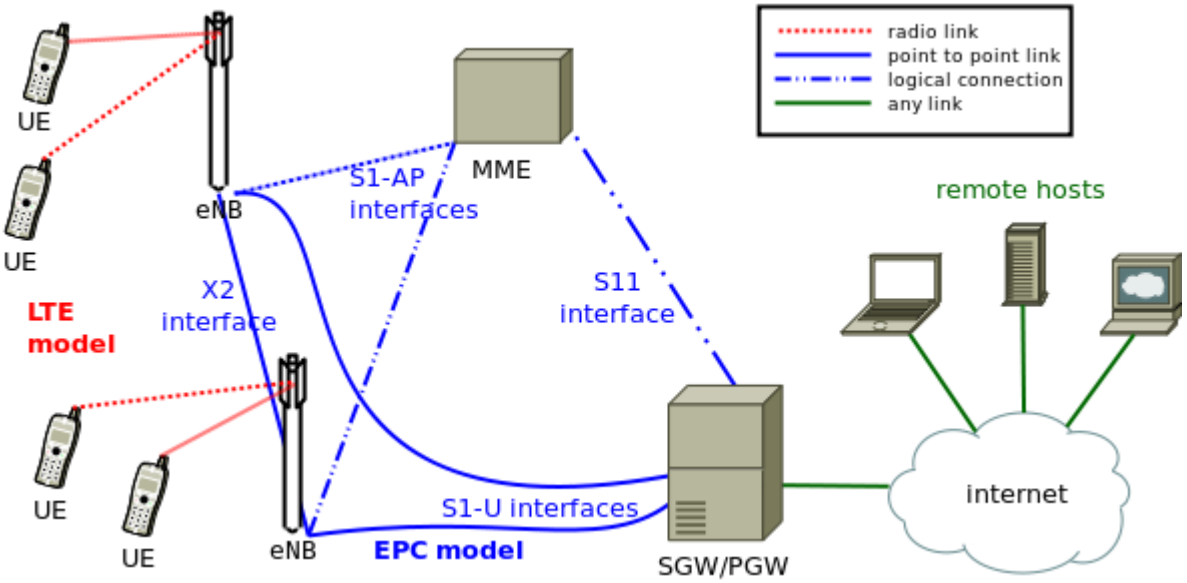
Agenda

- LENA
- Experiments
- Measurements
- Results
- Concluding Remarks
- Future Works
- Questions

LENA
Overview

- LENA: ns-3 module whose use has been leveraged within the community in view of the LTE functionalities.
- Simulates evolved packet core (EPC) network, evolved node B (eNodeB), user equipment (UE), and respective protocol stacks.
- Does *not* support the use of external traffic entities in conjunction with the LTE simulation.

LENA
Network Topology



Source: http://networks.cttc.es/mobile-networks/software-tools/lena/

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Experiments Proposal

- Customize LENA for use in an emulation-based test Environment.
- Connect the ns-3 server to other computers running industry-standard testing tools.
- Assess the performance of the emulator in terms of voice quality, latency, and throughput. Focus on VoIP applications.
- Validate the results obtained through emulation against an (real) LTE testbed.

Experiments Overview

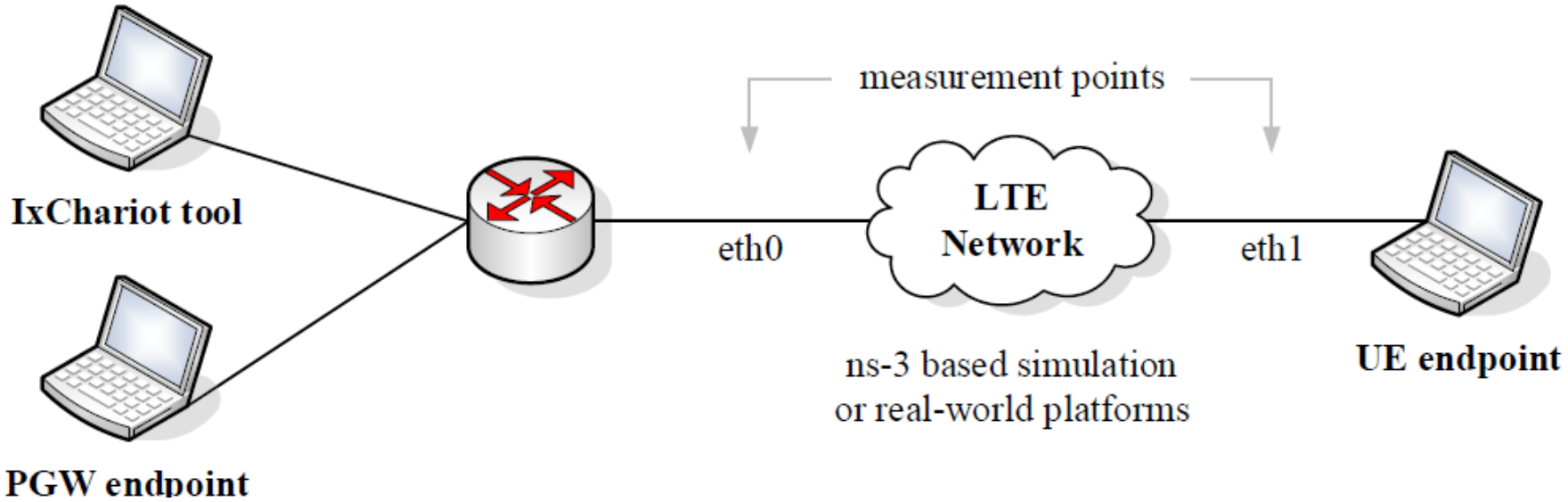
- Two different experiments:
  - Emulation-based: Simulated LTE Network
  - Testbed-based: Real-world LTE Network
- Same functionality is implemented in both experiments.
- Same traffic generation and test tools are used in both experiments:
  - IxCharriot
  - Iperf

Experiments
LTE Configuration

Same configuration in both experiments:

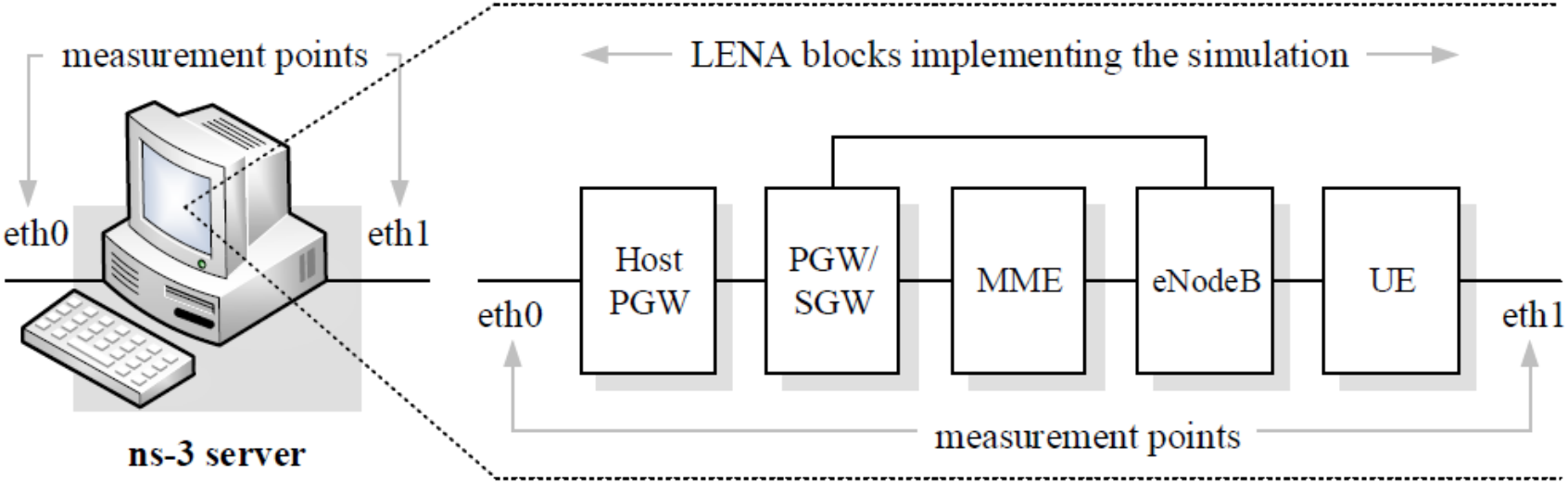
- Band 31 (450-470 MHz)
- 5MHz bandwidth
- Frequency Division Duplexing (FDD) mode
- Adaptative modulation
- Round robin scheduler
- SISO operation mode

Experiments
General Architecture



The measurement architecture depicted here is common to both experiments.

Experiments
Experiment I: Simulated LTE Network

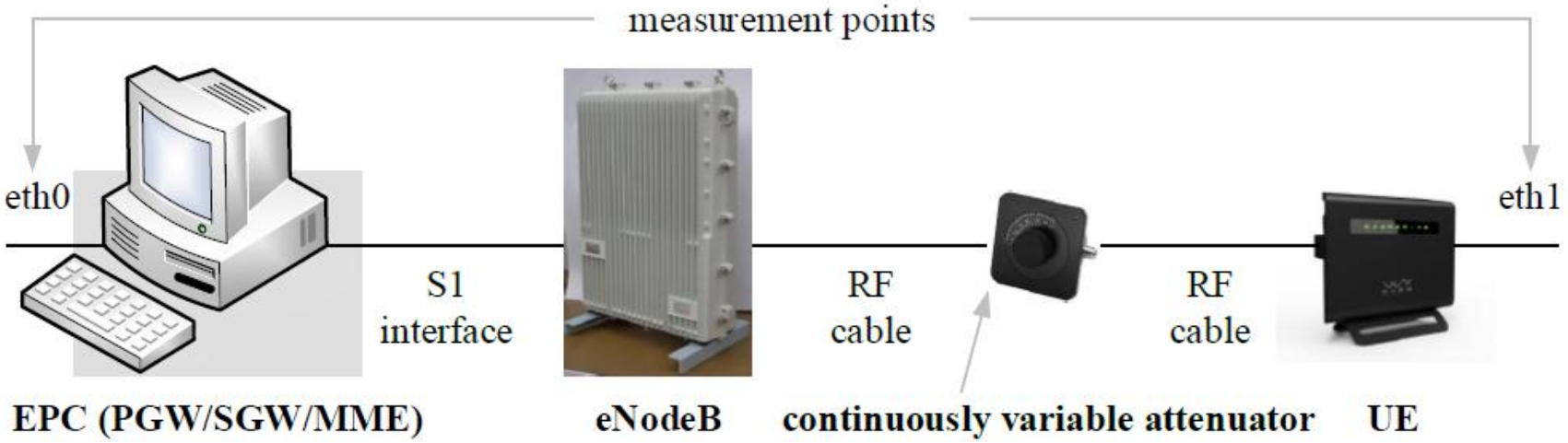


- "LTE Network" is replaced with ns-3 server
- SNR is set by changing the simulator parameters related to line of sight distance between eNodeB and UE.

Experiments
LENA Customization and Configuration

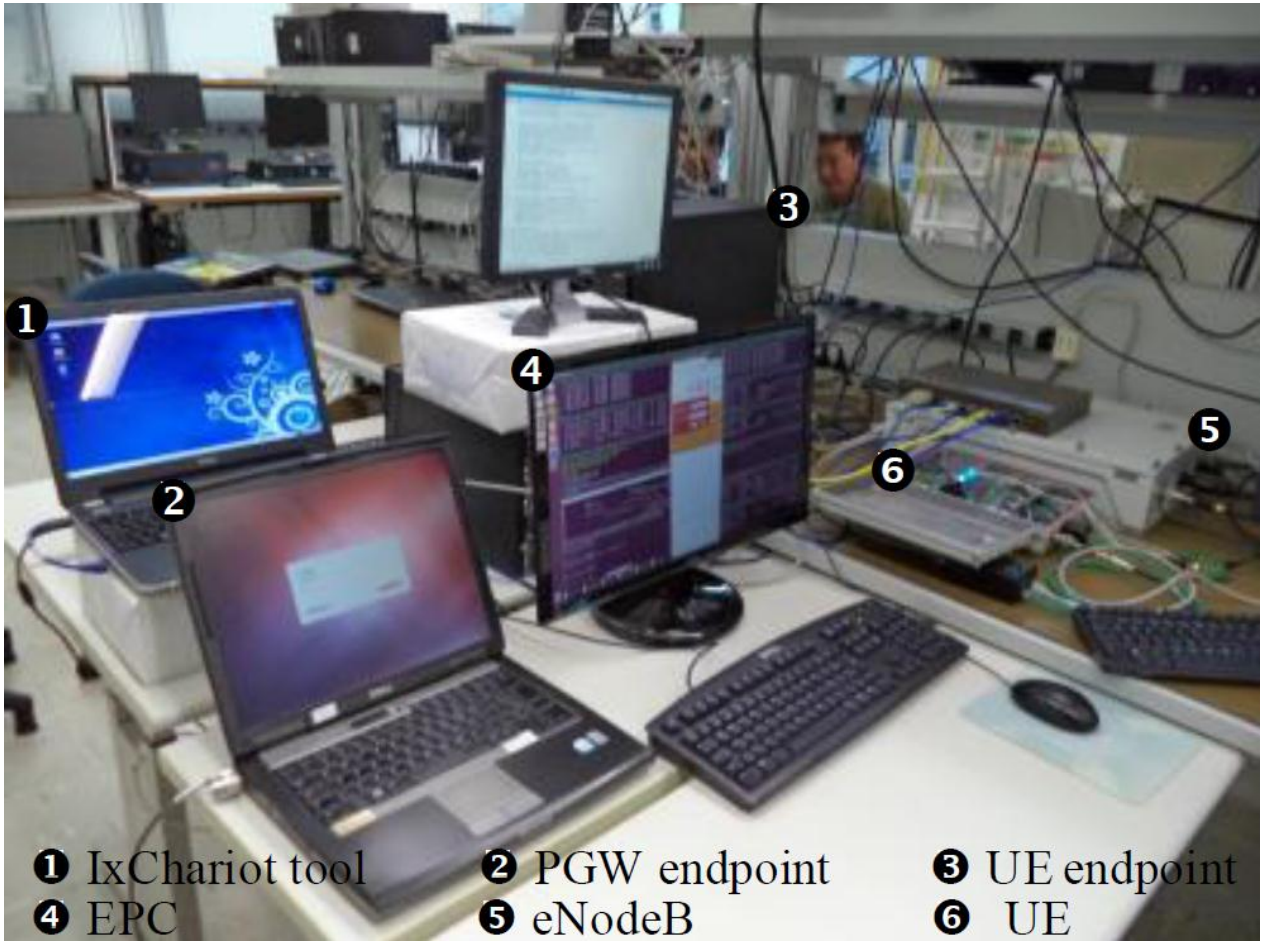
- Use class “FdNetDevice” to create in LTE simulation two ethernet interfaces mapped onto two real physical ethernet interfaces on the server:
  - One interface created in an UE modem (*LTE user side*) – mapped onto “**eth1**” physical ethernet interface.
  - One interface created in a host connected to the EPC *(LTE core network side*) – mapped onto “**eth0**” physical ethernet interface.
- Customize and configure simulation data plane & routing to support LTE data flow between the two ethernet interfaces.
- Configure LENA operation mode to realtime mode.
- Use mapped physical ethernet interfaces to connect simulated elements (UE and host) to the external traffic generation/test tools.

Experiments
Experiment II: Real-world LTE Network



- "LTE Network" is replaced with real LTE testbed
- SNR is set by changing attenuation between eNodeB and UE.

Experiments
Laboratory Environment



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Measurements
VoIP

- VoIP traffic test elements:
  - IxCharriot server
  - IxCharriot endpoint 1 – UE side PC
  - IxCharriot endpoint 2 – EPC side PC
- IxCharriot endpoints generate 1-10 VoIP calls:
  - RTP
  - G.711 codec
- SNR range: 5-25 dB
- Performance metrics: mean opinion score (MOS) and average latency estimated by IxCharriot.

Obs. 1: Each SNR x Data Traffic point: 3 measurements, 1 minute duration.

Obs. 2: IxCharriot is a commercial test tool used to predict device and system performance.

Obs. 3: IxCharriot MOS estimation takes into consideration end-to-end delay, packeterization delay, jitter buffer delay, additional fixed delay, data loss, and jitter.

Measurements
Throughput

UDP data traffic elements:

- Iperf client at UE side PC
- Iperf server at EPC side PC

Configured data rate: 20 Mbps

SNR range: 5-25 dB

Direction: Downlink

Performance metrics: data rate received at iperf server side

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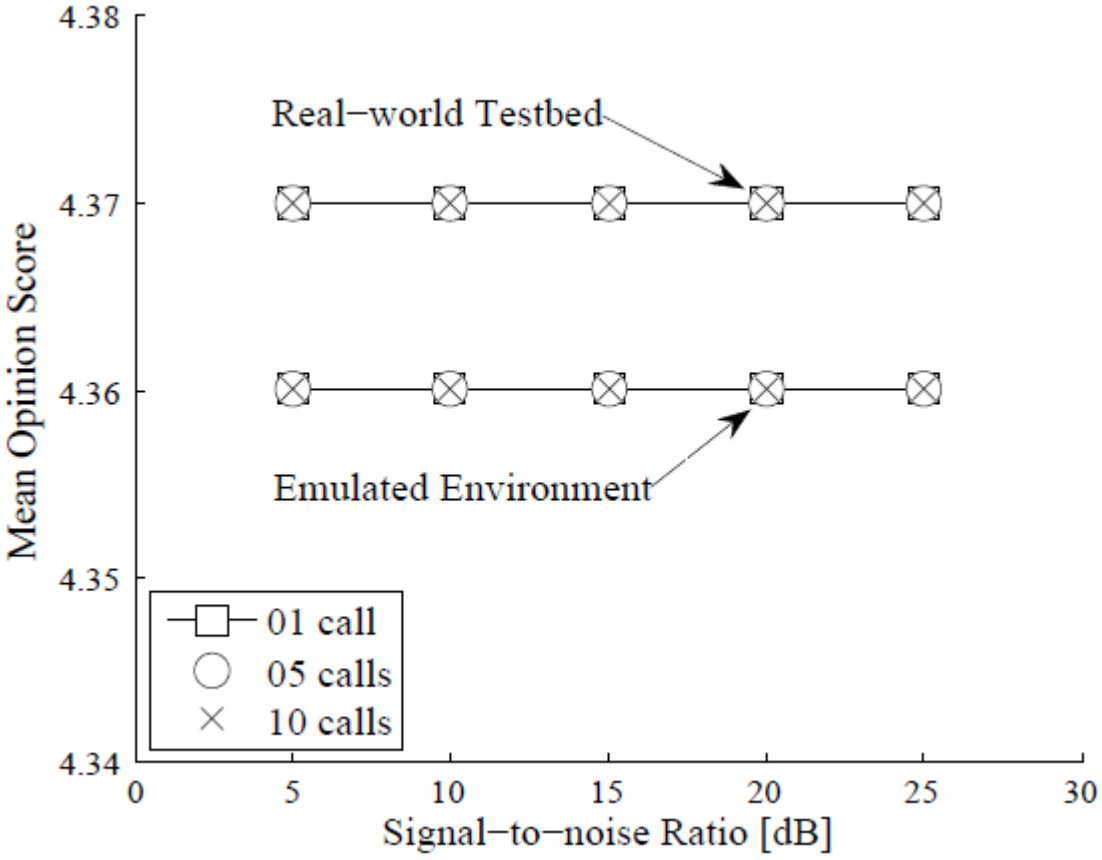
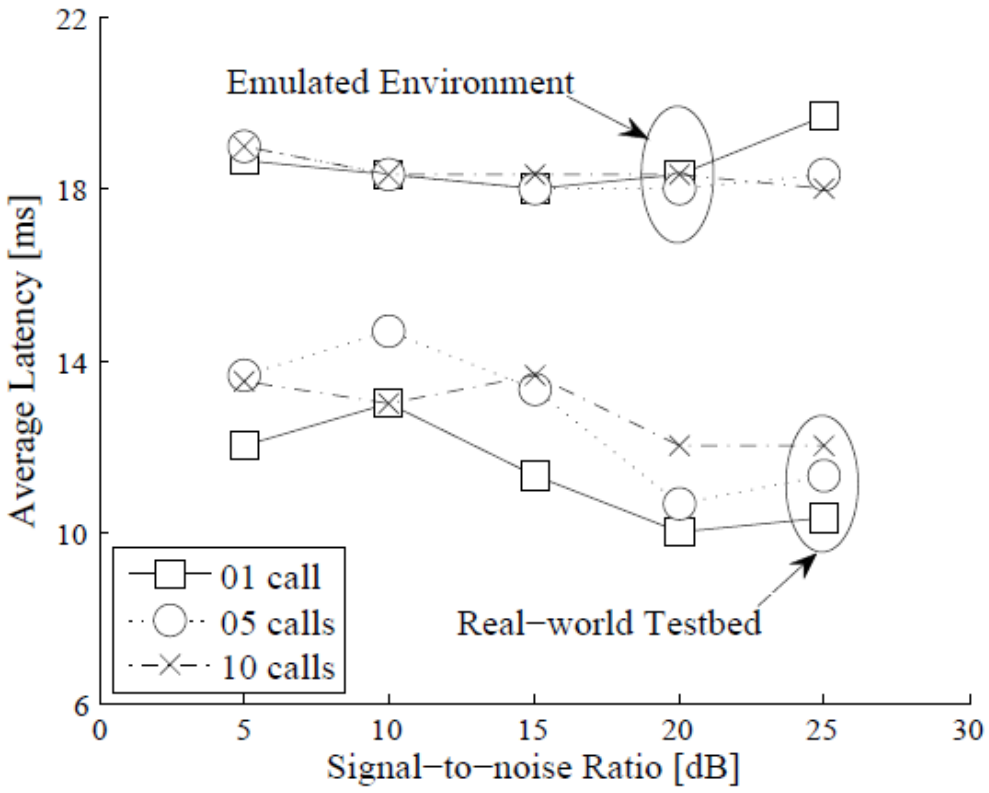
Results
VoIP MOS measurements



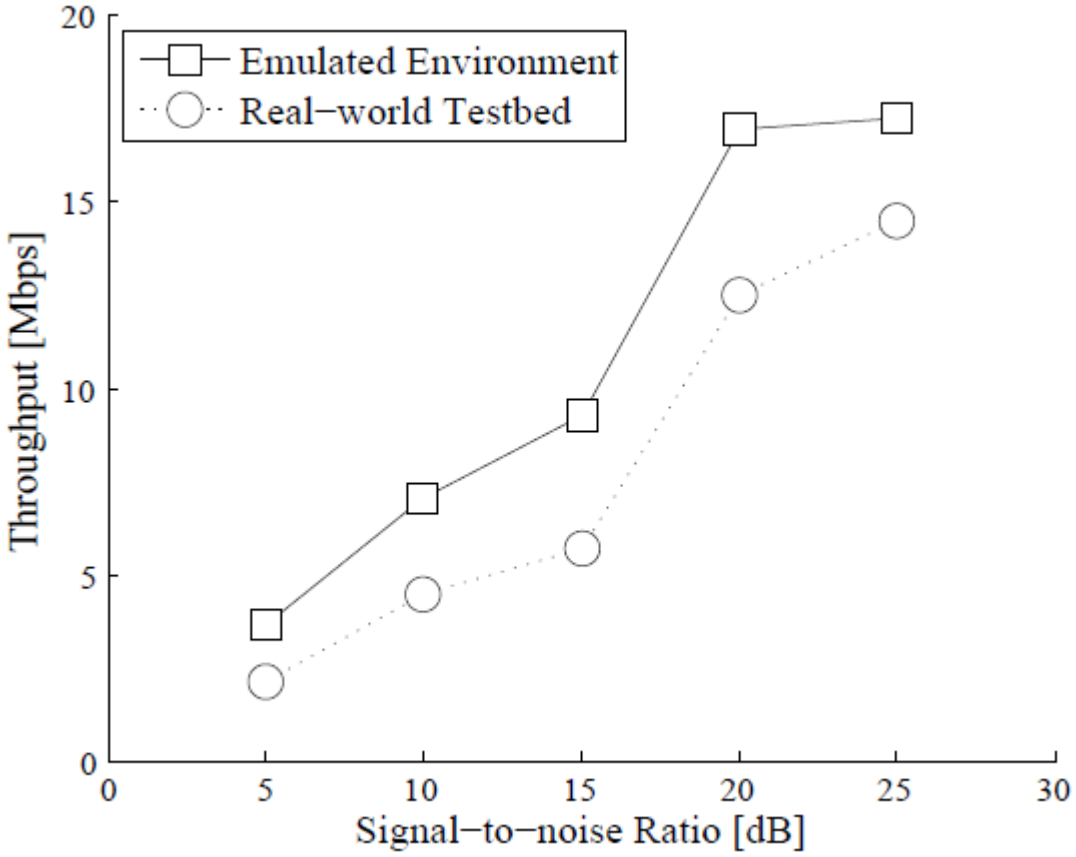
- The perceived voice quality is above "good" (MOS=4:00) and below "excellent“ (MOS=5:00) for both experiments.
- No significant MOS performance difference between Emulation and Real-world testbed (0.01).

Results
VoIP latency measurements



- Average Latencies are no longer than 20 ms.
- Emulation latency almost constant.
- Performance of the Real-world Testbed is shown to be slightly better than that of the Emulated Environment due to the characteristic latency of the latter, which does not suffer significant variations as the number of simultaneous calls is varied.

Results
Throughput measurements



- Achieved throughput increases as a function of the SNR.
- Emulated Environment slightly outperforms the Real-world Testbed along all the SNRs considered.
- Slight advantage of the Emulation over Real-world testbed caused by simplications of the simulation implementation.

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Concluding Remarks

- Initial results confirms the suitability of emulation approach as a viable means to predict performance in real LTE networks.
- ns-3 LTE models can deliver MOS voice quality and latency *as good as* an experimental testbed using actual LTE equipment over a range of SNRs.
- The good agreement of our experimental results is possible not only because the *same* functionality is implemented in *both* experiments but due to the use of the *same* traffic generation tools in the simulated and real-world LTE networks (*not* possible in standard LENA simulation).

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Future works

- Future work suggestions could involve extensions of the experiments proposed in this paper to different types of data traffic, e:g: web browsing, le transfers, and video.
- Another research path that may be worth investigating is to consider multiple UEs and verify the validity of the comparisons made here for the case of multiuser environments.

Questions

Thank you!

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