CSP-NET Interface Breakout Session

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UNIVERSITY of WASHINGTON

Synopsis

- Problem: Accurate network-level simulators for end-to-end performance assessment
- Issues:
  - the role of channel models in network simulation
  - the appropriate PHY abstraction for network simulation
  - the role of channel and system measurements from sounders and testbeds
  - the role of ray tracing in channel modeling.

Discussion points

- PHY layer abstraction issue
  - Blockage characterization and modeling
  - Antenna radiation patterns – modeling and abstraction
  - The role of ray-tracing in developing channel models
  - How to combine measurements and ray-tracing?
  - Calibrating simulation models with emerging experimental results
  - Beam training/tracking abstraction for simulators
  - How can channel/network simulators complement hardware testbeds?
  - How can hardware testbeds be leveraged for accurate network simulation?
  - Role of machine learning at PHY/NET interface

Outcomes

- Ideas taken from 2nd mmWave workshop report [1]:
  - Try and define a reference CSP-NET ‘dictionary/language’ that can help push a productive dialogue forward.
  - Create a taskforce and invite appropriate researchers to participate (mailing list?).
  - Continue this cross-community interaction offline, (mailing list?), aiming to let the signal processing community better understand the details of current PHY/MAC abstraction schemes, such as the ones adopted as part of the mmWave module for ns3;
  - Let the networking community better grasp the signal processing angles/needs.
  - Lay the foundation for a white paper on these topic

Starting point?

- NYU Wireless mmWave models for ns-3 [2], [3]

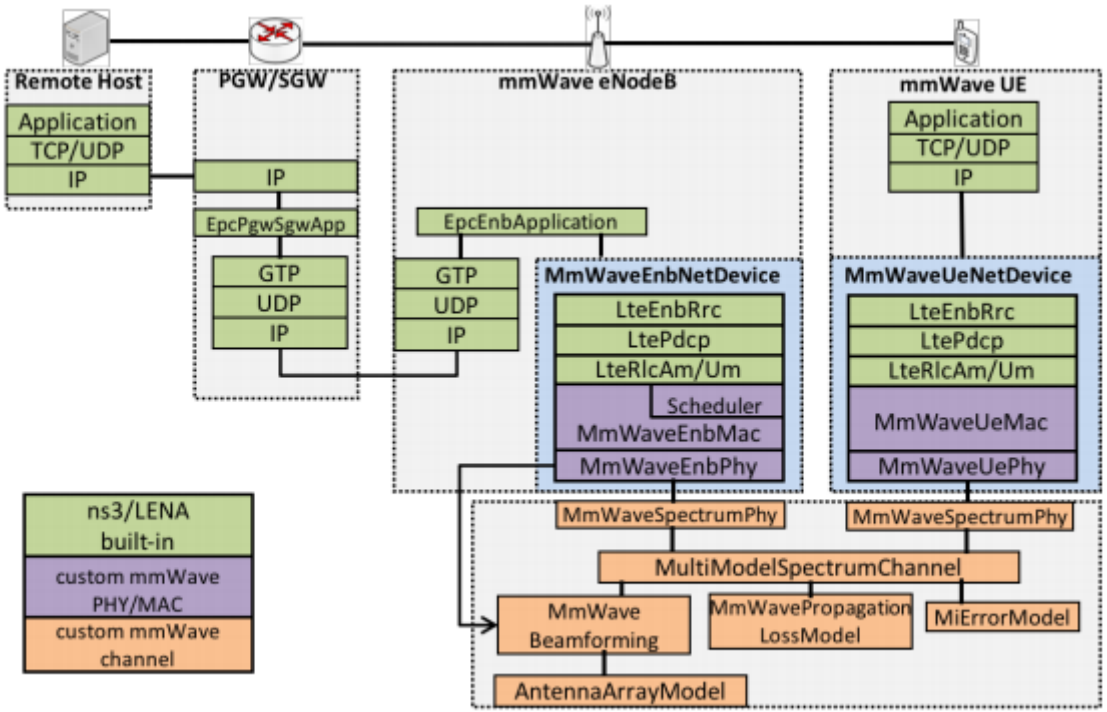


Figure 1: Class diagram of the end-to-end mmWave module.

Figure copied from [2]

Feedback sought on models and abstractions

Current models and abstractions

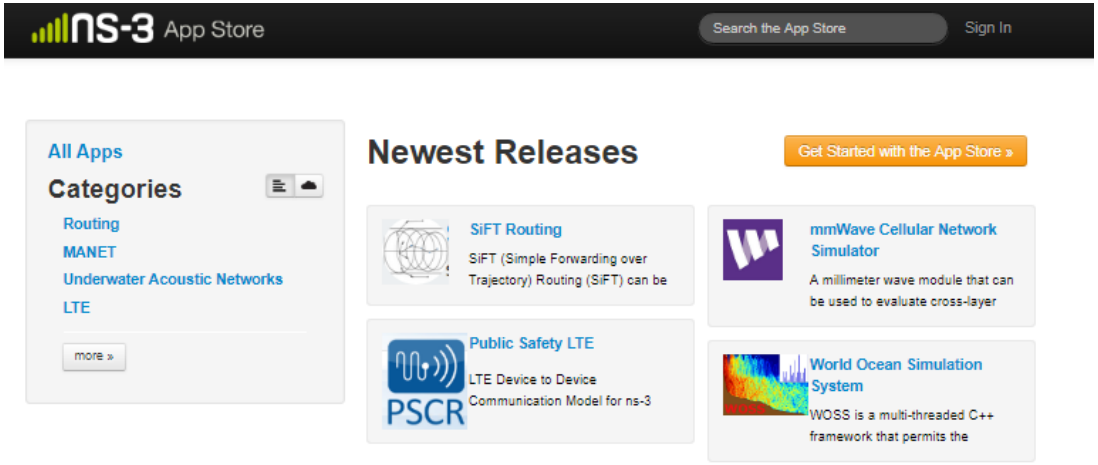
- To be completed: Marco or Tom to introduce
  - channel model options (3GPP, ray tracing, NYU statistical model)
  - beamforming gain models (long-term covariance matrix method, beam search method)
  - Interference model
  - error model based on LTE MIESM

Open issues

- Current error model is based on the MIESM-derived one for LTE (OFDM-based) [4]. Is this obsolete for mmWave; if so, how could we go about developing a different one?
- How important is modeling blocking and antenna patterns, and if so, what papers (beyond [5], [6]) can be referenced?
- Can simpler statistical channel/error models be developed, such as a finite state Markov channel [7]?
- Fast-fading MIMO channel models are computationally intensive, leading to approaches in which channels are computed offline and looked up. A valid approach?
- Can we parallelize (or otherwise optimize) 5G wireless ns-3 simulations for faster run times?

Next steps

- Software plans
  - Michele Polese preparing mmWave for ns-3 release compatibility, and app store



Beta site: http://ns-apps.ee.washington.edu

- Draft white paper, bibliography, list of issues?

References

[1] Report on the 2nd Workshop of the NSF mmW RCN, July 2017. https://mmwrcn.ece.wisc.edu/?page_id=356

[2] Marco Mezzavilla, Menglei Zhang, Michele Polese, Russell Ford, Sourjya Dutta, Sundeep Rangan, Michele Zorzi. End-to-End Simulation of 5G mmWave Networks, https://arxiv.org/abs/1705.02882, October 2017.

[3] Menglei Zhang, Michele Polese, Marco Mezzavilla, Sundeep Rangan, and Michele Zorzi. ns-3 Implementation of the 3GPP MIMO Channel Model for Frequency Spectrum above 6 GHz. In *Proceedings of the Workshop on ns-3* (WNS3 '17).

[4] Marco Mezzavilla, Marco Miozzo, Michele Rossi, Nicola Baldo, and Michele Zorzi. A lightweight and accurate link abstraction model for the simulation of LTE networks in ns-3. In *Proceedings of the 15th ACM international conference on Modeling, analysis and simulation of wireless and mobile systems* (MSWiM '12).

References

[5] Vasanthan Raghavan, Lida Akhoondzadeh-asl, Vladimir Podshivalov, Joakim Hulten, M. Ali Tassoudji, Ozge Hizir Koymen, Ashwin Sampath, Junyi Li. "Statistical Blockage Modeling and Robustness of Beamforming in Millimeter Wave Systems," https://arxiv.org/pdf/1801.03346.pdf, January 2018.

[6] George R. MacCartney Jr., Theodore S. Rappaport, Sundeep Rangan, "Rapid Fading Due to Human Blockage in Pedestrian Crowds at 5G Millimeter-Wave Frequencies," https://arxiv.org/pdf/1709.05883.pdf, September 2017

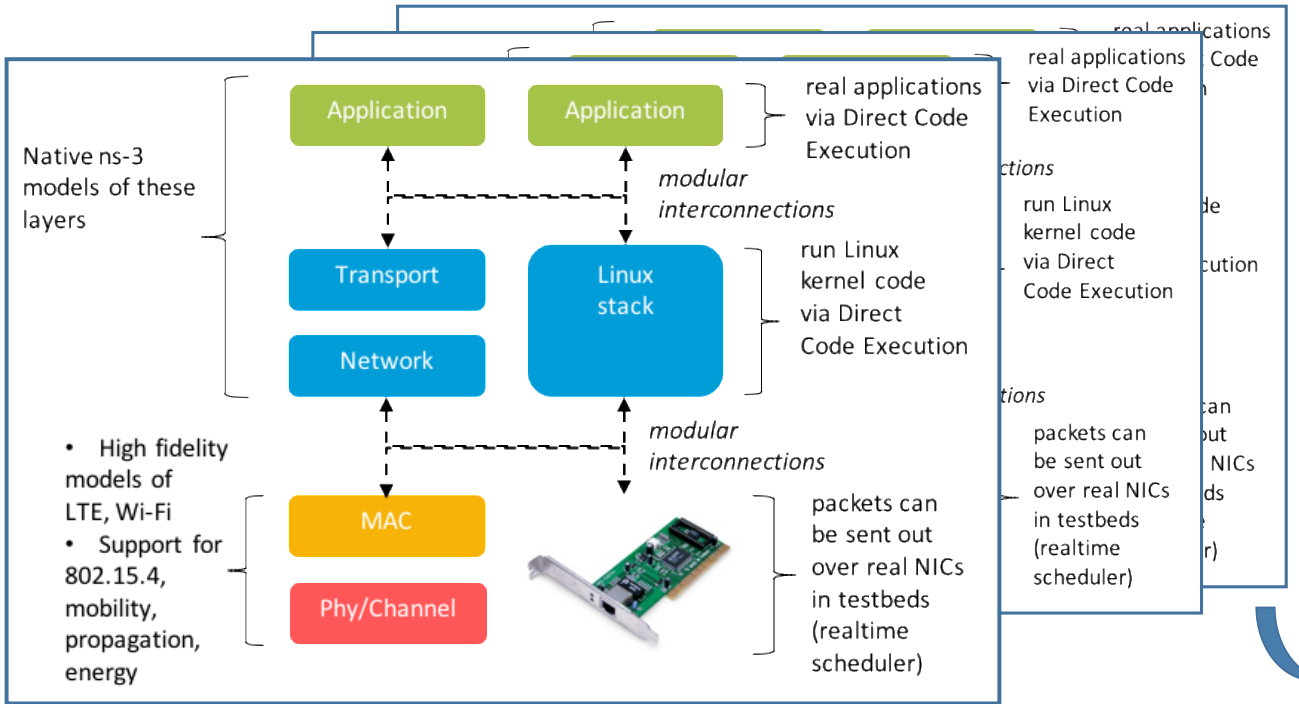
[7] Hong Shen Wang and Nader Moayeri, "Finite-State Markov Channel-- A Useful Model for Radio Communications Channels," IEEE Transactions on Vehicular Technology, Vol. 44, No. 1, February 1995, pp. 163-171.

Backup

ns-3 overview

- ns-3 is a leading open source, **packet-level network simulator** oriented towards network research, featuring a **high-performance core** enabling **parallelization across a cluster** (for large scenarios), **ability to run real code**, and **interaction with testbeds**

Runs on a single machine



or partitioned across a cluster

Recent work on Phy abstractions for ns-3

- Wi-Fi OFDM error models for TGn fading channels
  - leveraging MATLAB WLAN System Toolbox
  - maps link system simulation results into AWGN tables in the ns-3 simulator

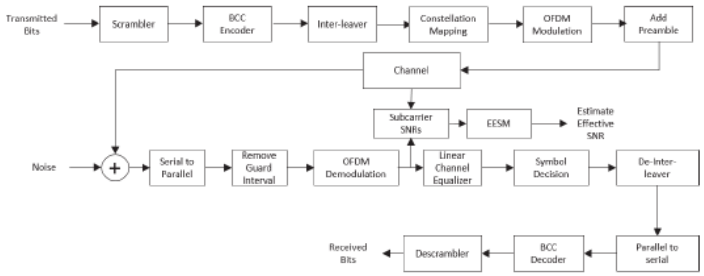


Figure 3: System block diagram for 802.11n

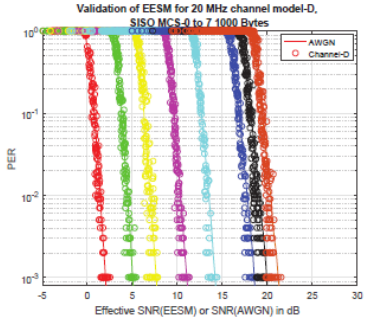


Figure 9: EESM validation for 20 MHz channel model-D, MCS 0-7

  - Past work [1] on 802.11 n/ac using the EESM approach
  - Current work on 802.11ax using the RBIR approach

[1] Patidar et al., Univ. Washington, WNS3 2017, June 2017

Testbed inputs can drive simulations

- INESC SUNNY project aerial link traces

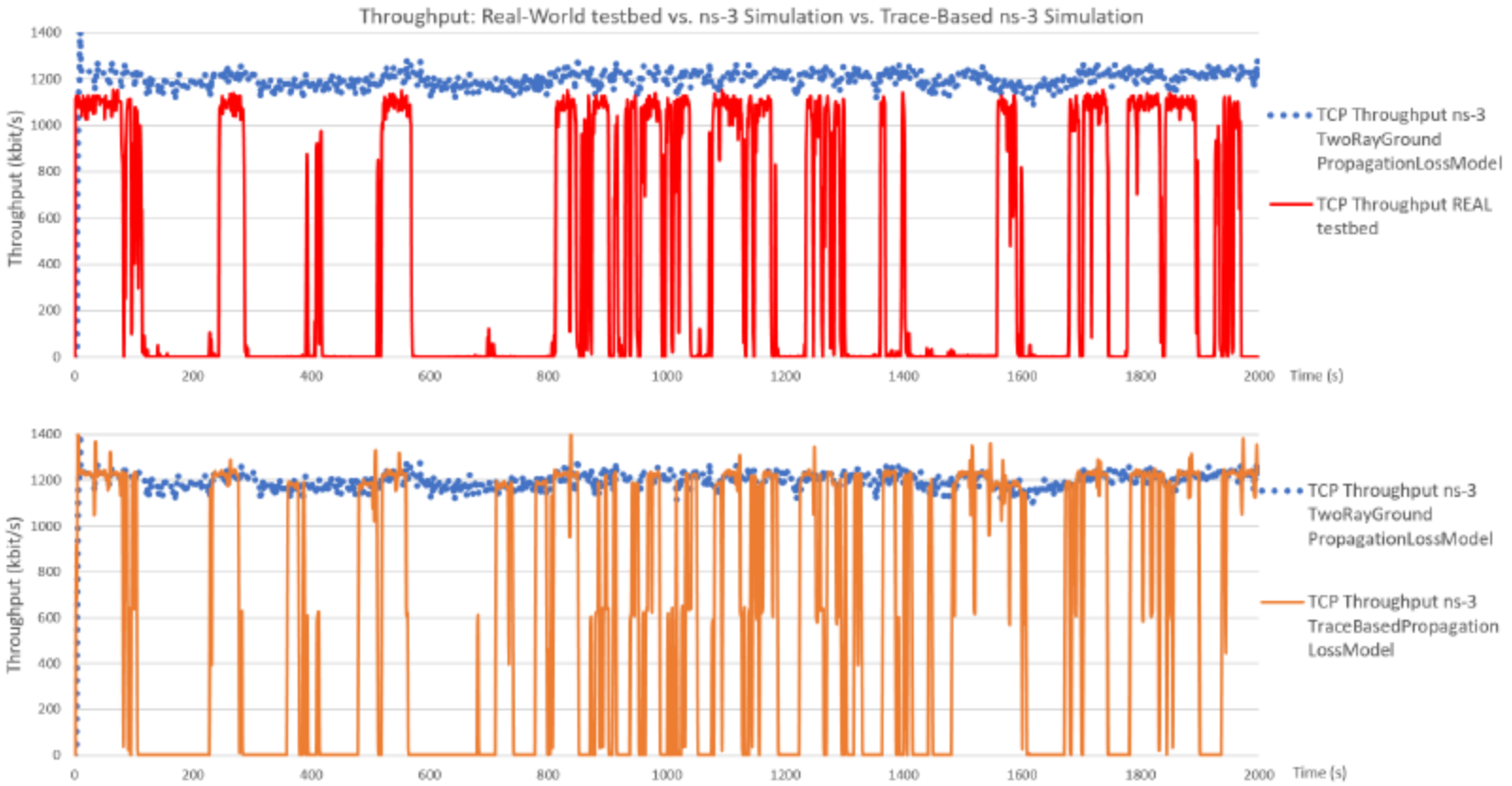


Figure courtesy of Helder Fontes, INESC Porto