NS-3 Consortium

Annual Meeting

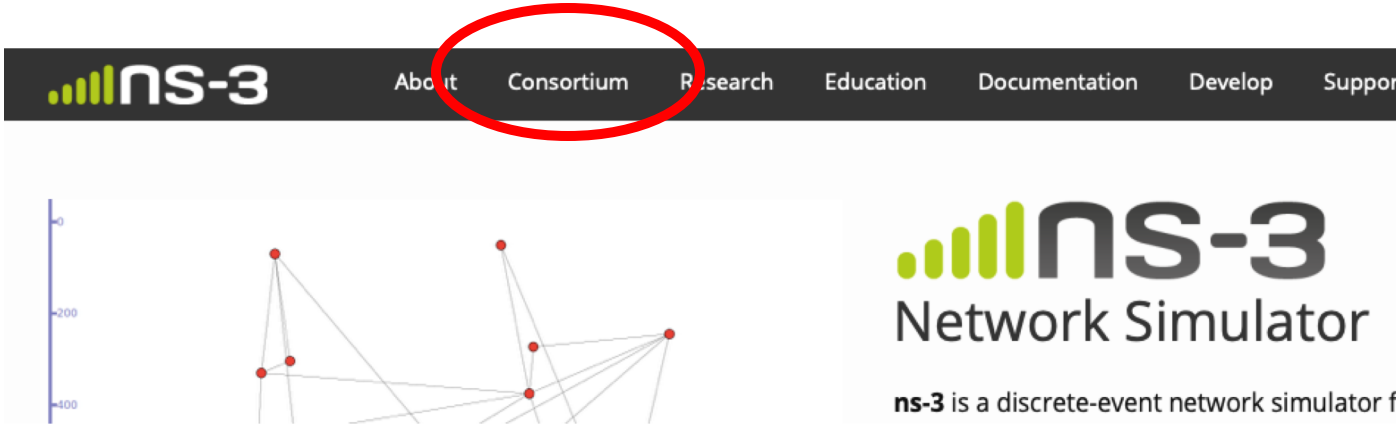
NS-3 Annual Meeting
June 18, 2020

Agenda

- Consortium overview
  - History, structure, membership, budget
  - WNS3 2020 (review) and future plans
  - Q&A about the consortium
- Open source project status and discussion
  - Recognition
  - Summary of recent software activity
  - Future directions
- Any other business

About the ns-3 Consortium

- Sustainment organization for the open source project
  - Officially organized as a University of Washington program
- Functions:
  - Handle funding for the project
  - Organize an annual workshop and meeting
  - Provide an interface for industrial and academic members to contribute and interact with the open source project



Current membership

- Founding Executive Members

- Executive Members

- Members

CMMB Vision

Classes of Consortium Members

- Class I Consortium Members:
  - For-profit entities with more than 500 employees
  - Annual Dues: $15,000
- Class II Consortium Members:
  - For-profit entities with 20 or more and less than 500 employees
  - Annual Dues: $7,500
- Class III Consortium Members:
  - For-profit entities with less than 20 employees
  - Annual Dues: $1,500
- Class IV Consortium Members:
  - Non-Profit Organizations, governmental organizations, and U.S. Federally Funded Research and Development Centers (FFRDCs)
  - Annual Dues: $1,500

Current Advisory Board

- Tom Henderson (Director, University of Washington)
- Sumit Roy (Associate Director, University of Washington)
- Walid Dabbous (INRIA)
- Damien Saucez (INRIA)
- Lorenza Giupponi (CTTC)
- Manuel Ricardo (INESC TEC)
- Doug Blough (Georgia Institute of Technology)
- Mohit Tahiliani (NITK Surathkal)
- Xiaojun Hei (Huazhong University of Science and Technology)
- Hui Liu (CMMB Vision)
- Greg White (CableLabs)

Member activities and interests

- University of Washington
  - PHY error models, cross-layer (PHY/MAC) issues, coexistence, public safety communications, future wireless testbeds
- Georgia Tech
  - obstacle modeling for 802.11ad indoor environments with differentiated LoS/NLos channel models
- HUST
  - ns3-AI: Artificial Intelligence for networking research
  - LAA and WiFi Coexistence: ns-3 vs MATLAB
  - ns-3 labs for a computer networking course

UW FUNLaB Contributions Summary: PHY Model Abstractions for 802.11

https://depts.washington.edu/funlab/projects/improvements-to-ns-3-simulator/ns-3-11ax-project/

Sumit Roy

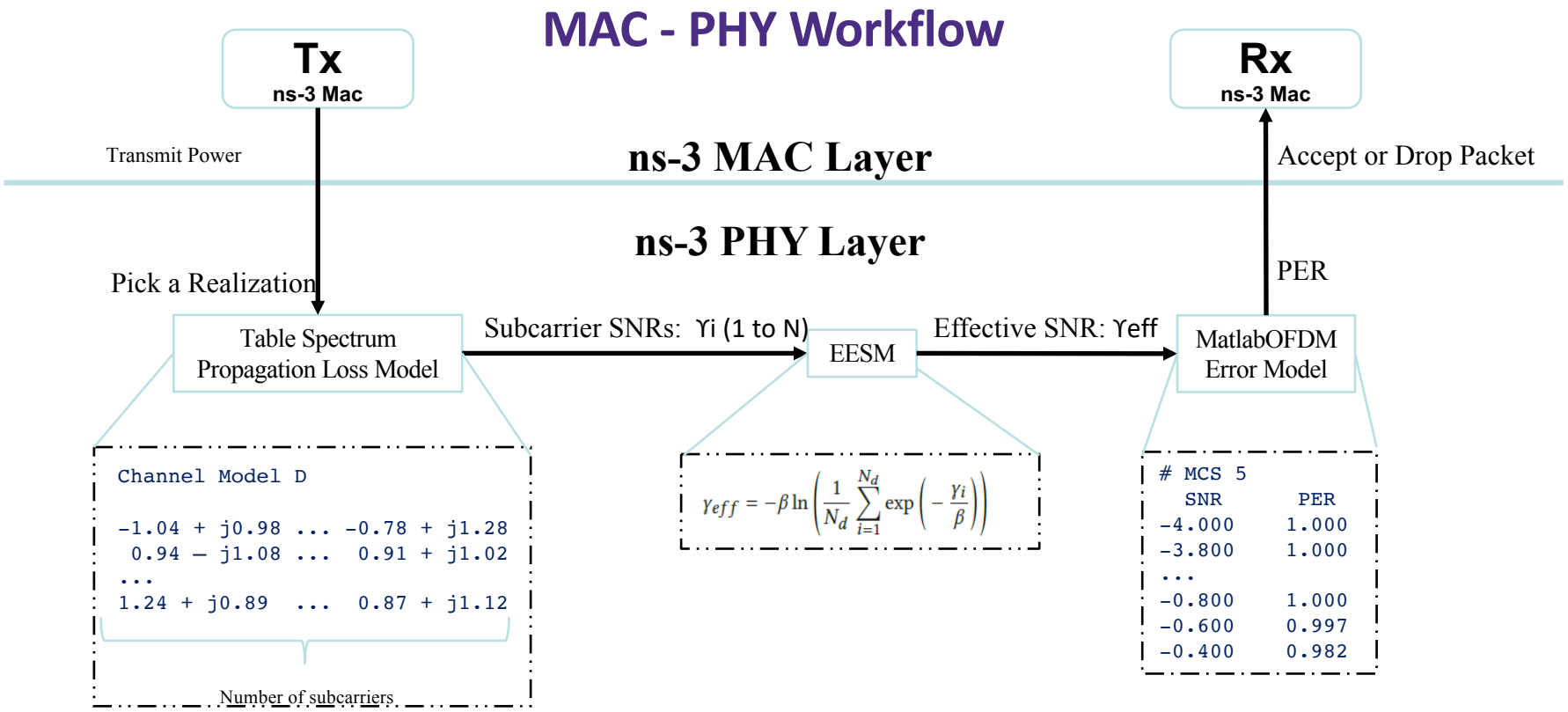
sroy@uw.edu

w-ns3 Consortium Annual Mtg. 2020

- **FUNLaB responsible for all PHY layer model improvements to ns-3 Spectrum WiFi (802.11a → n/ac → ax)**

Contributions (1)

- Patidar et al ``Link-to-System Mapping for ns-3 Wi-Fi OFDM Error Models," w-ns-3, Porto, Jun. 2017.
  - ➢ Method - EESM based link-2-system mapping for SISO slow, freq-selective channel (TGn Channel Model D)

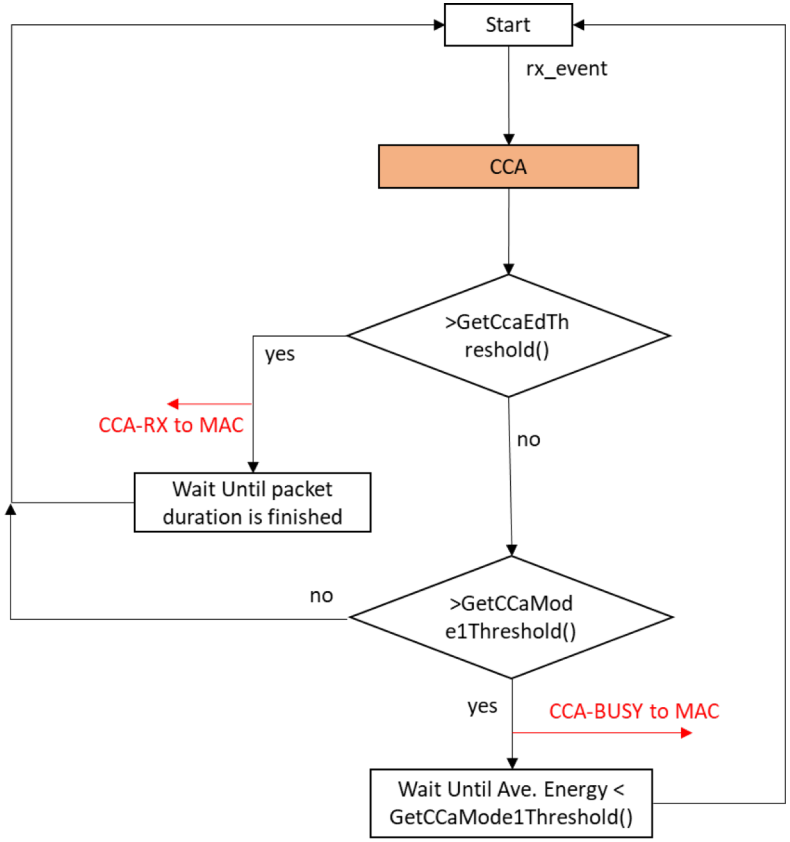


> Offline

- No channel realization generation @ run-time → large # channel realizations,
  β parameter tables pre-computed/stored

Contributions (2)

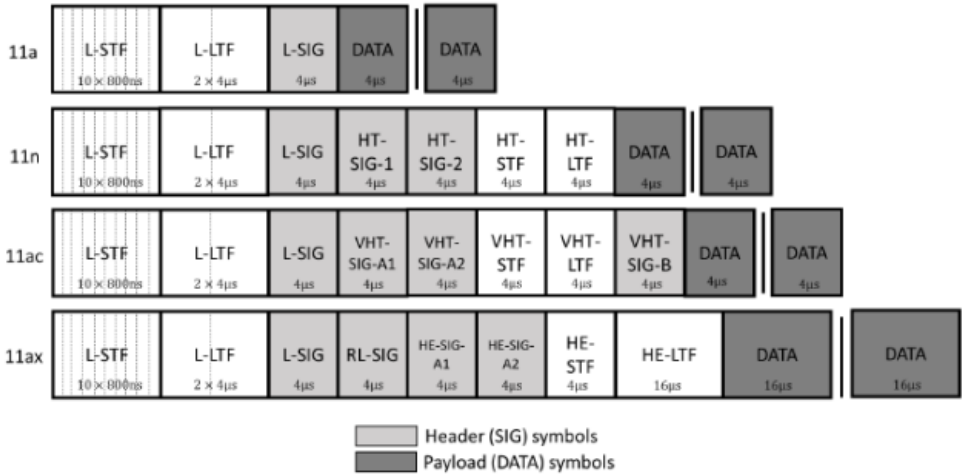
- Lanante et al. ``Improved Abstraction for Clear Channel Assessment in ns-3 802.11 WLAN Model," w-ns-3, Florence, 2019.
  - ❑ **significantly improved CCA module to track WiFi family PLCP evolution – to support for multi-BSS network performance evaluation**



Issues Resolved → accurate multi-stage process

1. Instantaneous decision regarding channel state
   - ED & SD implemented with resp. CCA_ED & CCA_SD thresholds that take effect after 4 micro-sec (per standard)

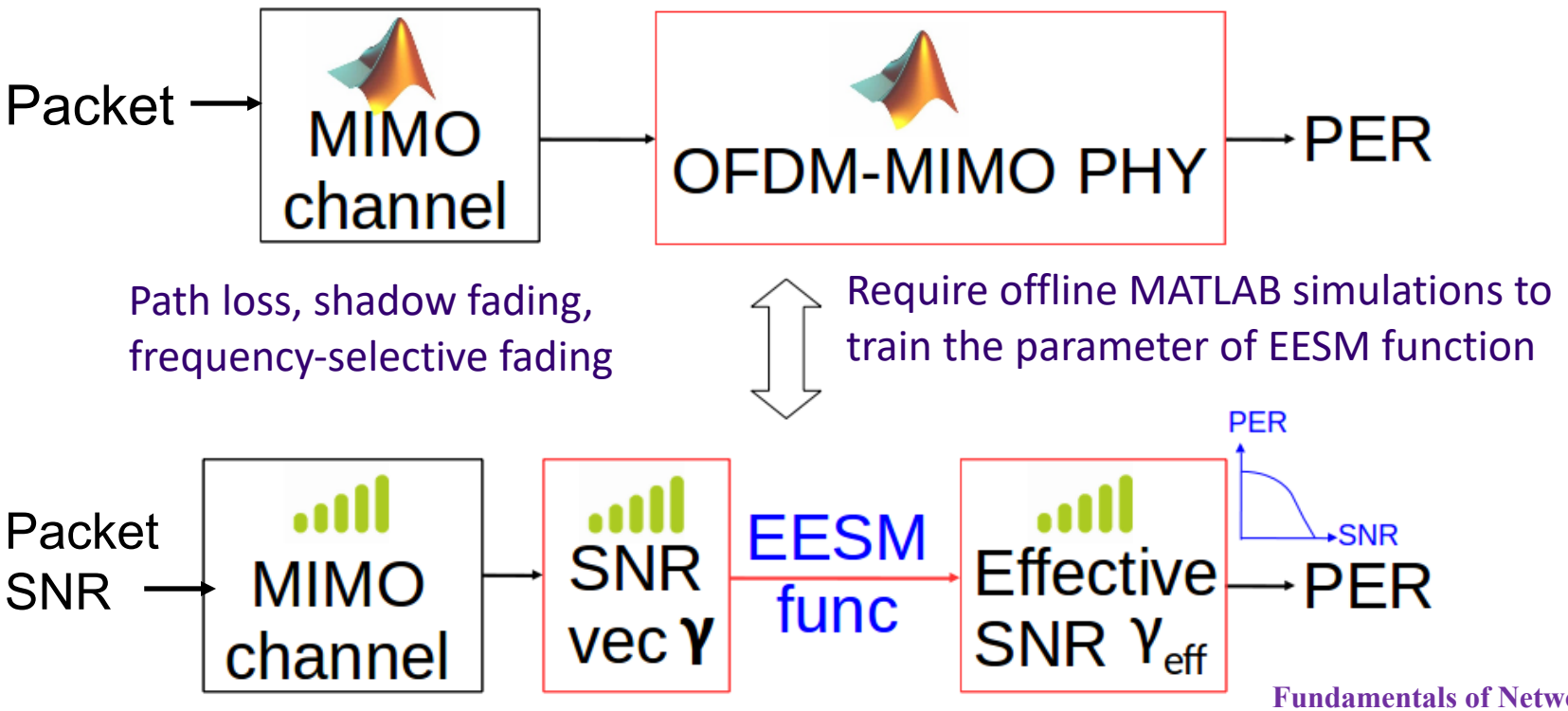
2 . No concept of PHY header [STAs can drop packets that fail the SIG field decoding] → implemented SIG decode step



Contributions (3)

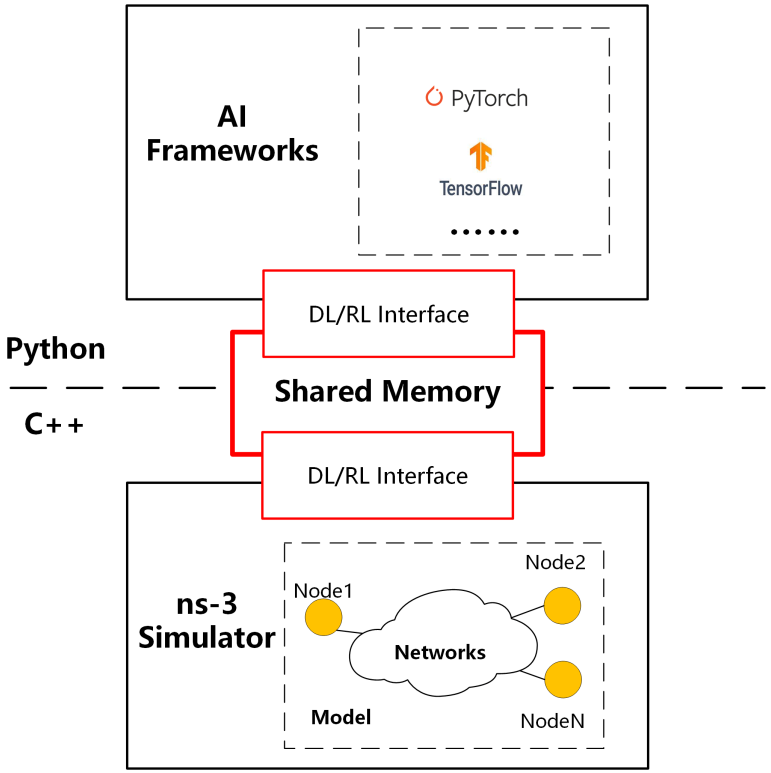
- Jin et al. ``Efficient Abstractions for Implementing TGn Channel and OFDM-MIMO Links in ns-3," Proc. Workshop on ns-3, Jun. 2020.

  > **Motivation/Outcome :** Substantially faster (compared to Patidar 2017!) link-to-system model for increasingly complex (OFDM-MIMO) Wi-Fi PHY: constant run-time, modest storage
  > **New Approach:** NEW DIRECT statistical characterization for γeff !

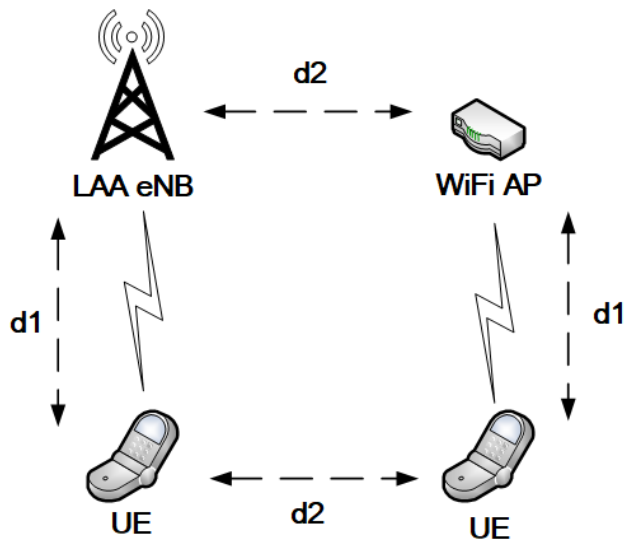


HUST: ns3-AI: Artificial Intelligence for networking

- Use shared memory as a data transmission module
- Divide the data transmission module into two parts
  - Python side
  - C++ side
- Data Interface
  - DL interface
  - RL interface



LAA and WiFi Coexistence: ns-3 vs MATLAB



Single LAA & Single WiFi

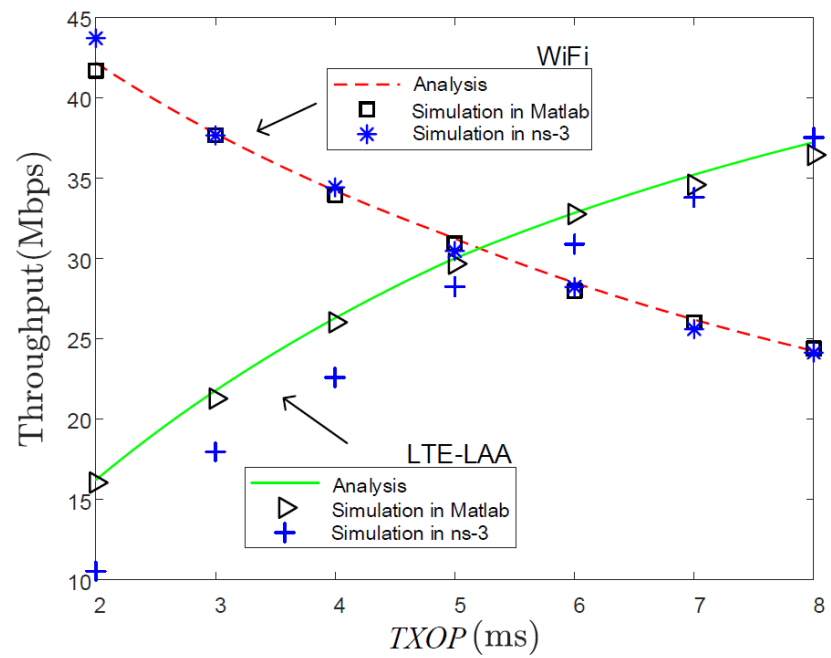


Fig 1 illustrates how the throughput of the LAA eNB and the WiFi AP vary with the $TXOP$ of LAA. We can clearly see that the throughput of LAA steadily increases as its $TXOP$ grows.

Fig 2:Throughput of LAA and WiFi versus the $TXOP$ of LAA in the single-LAA and single-WiFi coexistence scenario

$$CW_{\min}^{LAA} = CW_{\min}^{WiFi} = 15, \quad m^{LAA} = m^{WiFi} = 6$$

$$T_d = AIFS = 43\mu s$$

ns-3 NETWORK SIMULATOR

HUST: ns-3 lab course

- Tutorial lab
- IEEE 802.11 DCF protocol
- Physical layer simulation
- Active queue management
- TCP congestion control
- Openflow protocol
- Ns3-AI case labs

INESC TEC contributions to ns-3

- Dissemination
  - Using ns-3 for teaching Mobile Communications course
    - Wi-Fi and LTE (~ 30 students / year)
  - Introducing students to ns-3 and related research topics
    - Used in Doctoral Programmes (~ 10 students / year)
    - Summer Internships (~ 4 students / year)
  - Increasing awareness of ns-3 to experimentation focused communities and SMEs
    - Participation in Global Experimentation for Future Internet (GEFI) 2019 meeting @ Coimbra
    - Fed4FIRE+ Porto Roadshow event (January 2020) (~ 75 participants)
    - Participation in 5 Fed4FIRE+ conferences (~ 10M€ project)

INESC TEC contributions to ns-3

- **Trace-based Simulation Approach** (Simulation-Experimentation Synergy)
  - SIMBED and SIMBED+ European projects
    - Synergy with experimentation community
  - Developing **new apps** for ns-3 app store → *ongoing*
    - Reproducing the same **SNR** of real experiments
    - Reproducing the real **PHY rates** and **MIMO** operation
    - Reproducing real **Channel Occupancy** of concurrent wireless networks
  - Tutorial: How to use ns-3 to reproduce past Wi-Fi experiments in Fed4FIRE+ testbeds → *ongoing*

Member activities and interests

- INESC TEC
  - Trace-based Simulation Approach, new apps for ns-3 app store, tutorial for Fed4FIRE+
- NITK Surathkal
  - alignment of ns-3 TCP with Linux, Congestion control (BBR), queue disciplines, emulation support using DPDK

DOCSIS Module

- Newly published module in ns-3 App Store
- Contributed by CableLabs
  - Written by: Tom Henderson, Greg White, Karthik Sundaresan, Joey Padden, Takashi Hayakawa
- Models a DOCSIS 3.1 link (CM & CMTS)
  - OFDM/OFDMA PHY channel
  - DOCSIS MAC
  - Service Flow QoS configuration
  - Support for traditional service and Low Latency DOCSIS service

Budget status

- Consortium raises small amounts of funding, to pay for annual meeting and low-cost infrastructure/services
- Income sources
  - Google Summer of Code and GCI organization payments
  - Consortium membership fees
  - WNS3 registration fees
- Consortium accounts currently hold roughly $23,500, prior to recent software and web site design work
  - $10,000 for these future obligations

Current activities

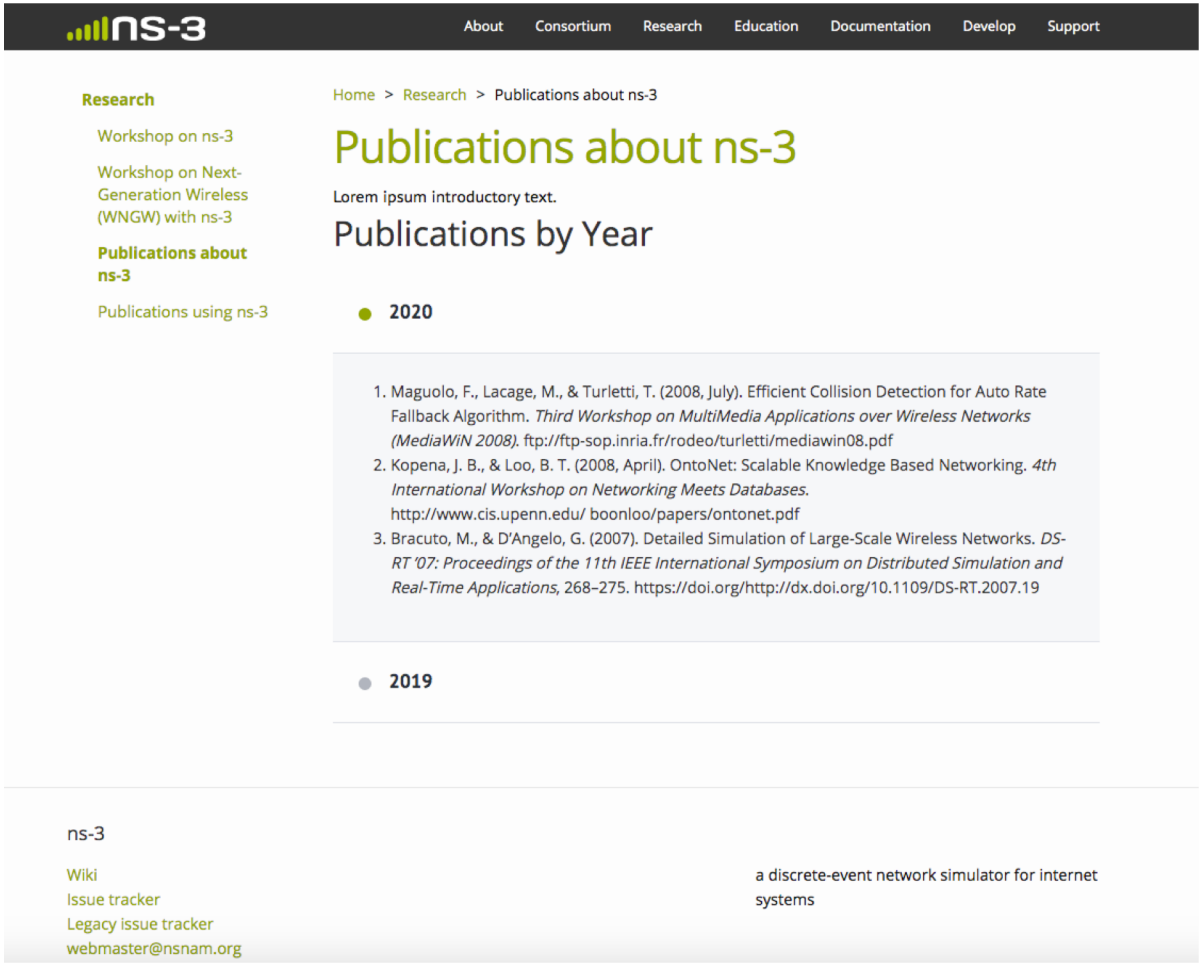
- Contracted software development
  - Web site development
  - ns-3 wifi module upgrades
- Training (postponed)
  - 5G NR and 802.11ax training was planned for an IEEE conference later this year
  - Advisory Board members are currently discussing the possibilities for training later this year

Website development

- Contracted to University of Washington Creative Communications
  - Custom search bar
  - Citation rendering (bibtex to HTML)
  - Front page improvements (carousel)
  - Some custom page design
  - Content migration from previous Wordpress site

Website Bibtex integration

- Jekyll-scholar plugin to render Bibtex



ns-3 wifi maintenance

- Contracted to Sebastien Deronne
  - Add missing PHY primitives
  - Finish off and merge the Bianchi (saturation) validation program
  - Fix and enhance ideal rate manager for 11n/ac/ax (channel width, MIMO, ...)
  - Update LAA-WiFi coexistence code
  - Integrate Link-to-System mapping-based error models

WNS3 acknowledgments

- Thanks to Matthieu Coudron, Stefano Avallone, and Eric Gamess for WNS3 2020
  - No significant issues arose during WNS3 review process
  - Matt is completing a two-year term
- Thanks to Richard Rouil, NIST, for planning to host WNS3 2020
  - Currently expecting to try again with WNS3 2021 at NIST (Gaithersburg, MD) if possible
  - Future hybrid physical/virtual meetings are likely

Consortium next steps

- Develop more training and outreach
  - Must be replanned in the wake of COVID-19
- Raise more funding to support common-benefit contracted software

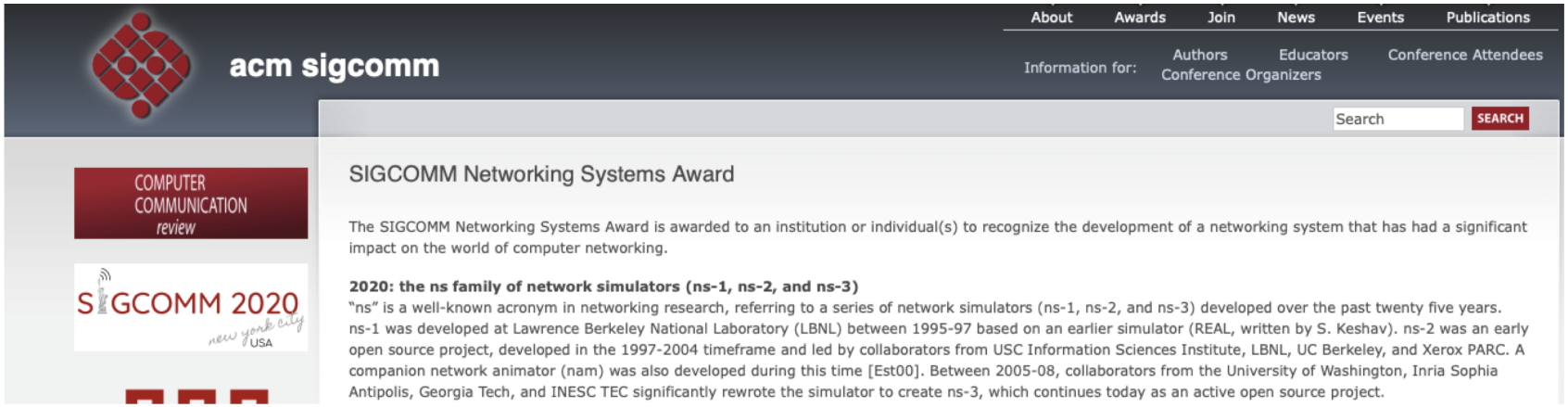
Open source project status

Outline

- Recognition
- Software status
- Summer projects
- Next steps

SIGCOMM Networking Systems Award

- The 2020 ACM SIGCOMM Networking Systems Award went to the ”ns” family of simulators (ns-1, ns-2, ns-3)
  - https://www.sigcomm.org/content/sigcomm-networking-systems-award



Open source project highlights

- ns-3.30 published in August 2019
- Google Summer of Code 2019 ended successfully in September 2019
- Google Code-In in December and January attracted 42 pre-university students who completed on 292 tasks
- Google Summer of Code 2020 awarded us four students
  - Two supplemental ns-3 summer of code (NSOC) programs

Program mentorship

- Mohit Tahiliani led our 2019-20 **Google Code-In** program
  - 24 mentors and 11 backup mentors
- Tom Henderson and Tommaso Pecorella lead our **Google Summer of Code** programs
  - 2020 mentors: Ankit Deepak, Abhijith Anilkumar, Mishal Shah, Mohit Tahiliani, Vivek Jain, Viyom Mittal, Dizhi Zhou, Zoraze Ali
- **ns-3 Summer of Code**: Tom Henderson, Mohit Tahiliani, Sebastien Deronne, Hany Assasa, Davide Magrin

Code statistics and maintainer commits

Since last annual meeting (June 2019)

- **578 commits** by **51 authors** (33 new!)
- **Maintainer commits** from
  - Alexander Krotov, Biljana Bojovic, Manuel Requena, Mohit Tahiliani, Natale Patriciello, Peter Barnes, Getachew Redietab, Sebastien Deronne, Stefano Avallone, Tom Henderson, Tommaso Pecorella, Zoraze Ali
- **72,696 lines** of C++ code added/deleted
  - parsed output of git diff --stat
- **261 Merge Requests** opened
  - GitLab.com code review award: **Getachew Redietab**
- **160 Issues** filed

Open source project status

- ns-3.30 (August 2019)
  - LTE Radio Link Failure (RLF)
  - Enhanced EPC and backhaul
  - Wi-Fi preamble detection model and PHY upgrades
  - Wi-Fi 802.11ax spatial reuse model
  - Cobalt queue disc
  - Full Python 3 support
- New apps in app store
  - LoRaWAN, ns3-ai, Terasim, DOCSIS
- ns-3.31 (June 2020)
  - 3GPP TR 38.901 pathloss, channel conditions, fast-fading
  - Building-aware random walk mobility model

Open source project status

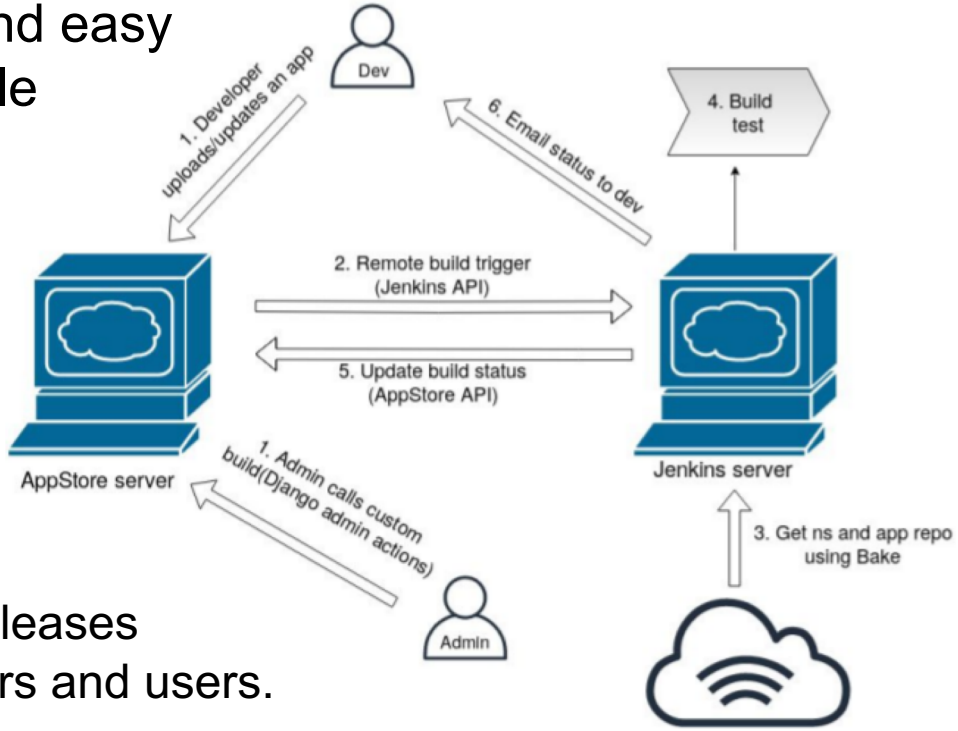
- ns-3.31 for June 2020 (cont.)
  - DCTCP, and better ECN support for TCP and AQMs
  - Bianchi validation and example for Wi-Fi
  - Various improvements to Wi-Fi PHY and MAC

- ns-3.32 for Sept 2020
  - TCP Cubic
  - TCP Prague and L4S AQMs
  - 802.11ax OFDMA
  - Other GSOC 2020 code
  - others...

ns-3.32? Maintainer coordination meeting
Tuesday June 23, 14:00 UTC

GSOC: Improving the ns-3 App Store and making it CI (Jenkins) aware

- **Student:** Shivamani Patil, National Institute of Technology Karnataka, India.
- **Mentors:** Abhijith Anilkumar, Ankit Deepak, Mishal Shah
- **Project goal:** The project aims to develop an automated workflow for checking compatibility of App Store modules with various ns-3 versions.
- **Benefit to ns-3:** Automated and easy workflow for App Store module compatibility management.
- **Milestones:**
  - **Phase 1:** Jenkins customization and pipelines setup.
  - **Phase 2:** Making App Store Jenkins Server compatible and aware.
  - **Phase 3:** Server deployment, Gitlab webhooks for new ns-3 releases and documentation for developers and users.



GSOC: NetDevice Up/Down Consistency and Event Chain

- **Student:** Ananthakrishnan S, NITK Surathkal, India
- **Mentors:** Tommaso Pecorella, Dizhi Zhou, Zoraze Ali
- **Project goal:**
  - To make NetDevice's Up/Down events consistent across NetDevices.
  - Modify IP to react to such events.
- **Benefit to ns-3:**
  - Consistency on NetDevices, enabling modules to react to network changes.
  - Implement complex simulation scenarios involving mobility across networks
- **Milestones:**
  - **Phase 1:** Define behavior of NetDevice API and correct P2PNetDevice.
  - **Phase 2:** Correct CsmaNetDevice and WifiNetDevice.
  - **Phase 3:** Check and correct EventChains. Bonus: LteNetDevice.

GSOC: Improving TCP Prague in ns-3

- **Student:** Deepak K, National Institute of Technology Karnataka
- **Mentors:** Ankit Deepak, Vivek Jain, Viyom Mittal, Tom Henderson
- **Project goal:** Improve the TCP Prague model in ns-3 and align it with current Linux implementation
- **Main Milestones:**
  - **Phase 1:** Pacing
  - **Phase 2:** RTT Independence
  - **Phase 3:** Classic ECN Detection

TCP

GSoC: SCE AQMs and TCP along with CNQ-CoDelAF and LFQ

- **Student:** Bhaskar Kataria, National Institute of Technology Karnataka
- **Mentor:** Tom Henderson, Mohit P. Tahiliani, Vivek Jain, Ankit Deepak
- **Project goal:** To add L4S to ns-3 FqCoDel and add FQ scheduling to IETF dual queue model, and add CoDelAF draft-morton-tsvwg-approx.-fair-01, and support TCP prague with overload signal
- **Benefit to ns-3:** Better support of L4S models will help the community to conduct tests under various scenarios
- **Milestones:**
  - **Phase 1:** Add L4S to ns-3 FqCoDel and add FQ scheduling to IETF dual queue
  - **Phase 2:** CoDelAF draft-Morton-tsvwg-codel-approx.-fair-01
  - **Phase 3:** Support TCP Prague with overload signal.

NSOC projects in 2020

- **Project:** Routing for community wireless
- **Student:** Rahul Bothra
- **Mentors:** Tom Henderson, Mohit Tahiliani
- **Project goals:**
  - B.A.T.M.A.N.-adv routing daemon
  - Application to community mesh network (Freifunk.net)

- **Project:** L4S Evaluation Framework
- **Student:** Harsha Sharma
- **Mentors:** Tom Henderson, Mohit Tahiliani, Davide Magrin
- **Project goals:**
  - Experiment control framework focused on IETF L4S experiments
  - Build on Davide Magrin's SEM tool and other Bash scripting lore

NSOC projects in 2020

- **Project:** Wi-Fi PHY Restructure
- **Student:** Muhammad Iqbal Rochman
- **Mentors:** Sebastien Deronne, Hany Assasa, Rediet
- **Project goals:**
  - Restructuring PHY layer of Wi-Fi module, which includes WifiPhy, WifiMode, and WifiPpdu.

Project priorities

- Support for advanced wireless: 802.11ax, 5G NR, and beyond
- TCP, QUIC, AQM alignment with Linux
- GUIs and ease-of-use
  - animators not well maintained
  - simple, canonical models
- DCE sorely in need of updates
  - stuck on kernel 4.4 (Jan. 2016) and Ubuntu 16
- More modules into the app store
- Fewer private chats
- Documentation updating
  - Particularly onboarding and educational
- Others?

Summary

- ***ns***: 25 years and counting!
  - Thanks to all who have built and continue to care for ns-3
- Consortium members wanted
  - Funding and industrial participation will help us scale and take the next steps
- Apps wanted
  - Help us populate the app store
- Maintenance help will always be needed and appreciated
  - Great job by a small maintainer team in the past year
  - Nice to see many new contributors this year

Questions about the consortium or open source project?