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)


➤ Method - EESM based link-2-system mapping for SISO slow, freq-selective channel (TGn Channel Model D)

MAC - PHY Workflow

- **ns-3 MAC Layer**
  - Transmit Power
  - Pick a Realization
  - Table Spectrum Propagation Loss Model

- **ns-3 PHY Layer**
  - Subcarrier SNRs: \( \Upsilon_i \) (1 to N)
  - Effective SNR: \( \Upsilon_{\text{eff}} \)
  - EESM
  - MatlabOFDM Error Model

\[
\Upsilon_{\text{eff}} = -\beta \ln \left( \frac{1}{N_d} \sum_{i=1}^{N_d} \exp \left( -\frac{\Upsilon_i}{\beta} \right) \right)
\]

- Number of subcarriers:
  - Channel Model D
  - \(-1.04 + j0.98 \ldots -0.78 + j1.28\)
  - \(0.94 - j1.08 \ldots 0.91 + j1.02\)
  - \(1.24 + j0.89 \ldots 0.87 + j1.12\)

- Offline
  - No channel realization generation @ run-time \(\rightarrow\) large # channel realizations,
  - \(\beta\) parameter tables pre-computed/stored
Contributions (2)


  - 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)


  > **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 $\gamma_{\text{eff}}$!
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

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

\[ CW_{\text{LAA}}^{\text{min}} = CW_{\text{WiFi}}^{\text{min}} = 15, \quad m^{\text{LAA}} = m^{\text{WiFi}} = 6 \]

\[ T_d = AIFS = 43 \mu s \]
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

![Website Screenshot]

NS-3 Annual Meeting June 2020
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
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

• 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
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?