NS-3 Consortium
Annual Meeting

NS-3 Annual Meeting
June 25, 2021
Agenda

• Consortium overview
  – History, structure, membership, budget
  – Advisory Board introductions
  – Recent activities and future plans
  – Q&A about the consortium

• Open source project status and discussion
  – Summary of recent project activity
  – Q&A/discussion about the open source project
About the ns-3 Consortium

• Sustainment organization for the open source project
  – Officially organized as a University of Washington program

• Functions:
  – Handle funding and provide infrastructure 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

NS-3 Annual Meeting June 2021
Current membership

- Founding Executive Members
  - UNIVERSITY OF WASHINGTON
  - INRIA

- Executive Members
  - Georgia Tech
  - CTTC
  - National Institute of Technology Karnataka, Surathkal
  - INESCTEC

- Members
  - University of Science and Technology, Dalian
  - CableLabs®

NS-3 Annual Meeting June 2021
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)
- 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)
- Greg White (CableLabs)
Member activities and interests

Brief overview of the technical agenda for Advisory Board members

- University of Washington
- Georgia Tech
- CableLabs
- INESC TEC
- HUST
- CTTC
- NITK Surathkal
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. 2021

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

EESM-log-SGN: State-of-Art PHY Layer Abstraction for Complex Network Simulation

A Hands-On Tutorial
2021 WNS-3 Workshop

Sian Jin, Thomas R. Henderson

Outline

1. Motivations for efficient PHY layer abstraction
2. Principles of EESM-log-SGN
3. Implementation guide of EESM-log-SGN
4. Demo of MATLAB offline link simulation steps (main part of this tutorial)
5. Demo of ns-3 online network simulation steps
Using AI/ML frameworks with ns-3
Tutorial w-ns3 2021

Hao Yin
U. Washington

• AI/ML in communication (10 min)
• Introduction of the ns3-ai module (15-20 min)
• Basic usage of the ns3-ai module (30 min)
  • Basic functions and usage
  • Demos and instructions with code (step by step)
• Example: Wi-Fi Rate Control (40-60 min)

Collaborators:
Pengyu Liu, Keshu Liu, Xun Deng (Huazhong University of Science and Technology, HUST)
Lyutianyang Zhang, Liu Cao, Collin Brady, Sachin Nayak (University of Washington, UW)
Advisors:
Xiaojun Hei, Yayu Gao (HUST), Sumit Roy, Thomas R. Henderson (UW)
Dense Overlapping WLANs

- Dense and overlapping WLAN networks – multiple Basic Service Set (BSS)
- Each BSS interferes with others
- Several factors impact system performance:
  - Carrier Sense Range (CSR)
  - Interference Range (IR)
  - MCS per frame

✔ Spatial Reuse in 802.11ax
✔ Rate Adaptation
Georgia Tech

- obstacle modeling for mmWave indoor environments with differentiated LoS/NLoS channel models
  - integrated obstacle modeling, line-of-sight (LoS) calculations, and differentiated LoS/NLoS channel modeling into latest 802.11ad/ay code from IMDEA
  - added sparse cluster-based (S-V) model for mmWave channels, compared throughput performance and time complexity of S-V channels and quasi-deterministic (Q-D) channels from NIST (Liu, et al., “Performance Study of Statistical and Deterministic Channel Models for mmWave Wi-Fi Networks in ns-3” wns3 2021)
  - creating example WiGig-targeted network scenarios based on “Evaluation Methodology” document produced by IEEE TGad

- efficient parallel simulation for partitioned environments with limited interference, e.g. mmWave communications in different rooms with highly directional antennas (in early stages)
CableLabs DOCSIS Module

- Extension Module listed in ns-3 App Store
  - Last updated 9/11/2020
- Update for ns-3.34 available in GitHub
- New module version 1.2 to be released shortly
  - Improved configuration of DOCSIS system/service, aligned with configuration syntax used in real equipment
  - Improved scheduler
  - ns-3.34 compatible
  - Several bug fixes
INESC TEC activities and interests

**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
  - Doctoral Programmes (~ 10 students / year)
  - Summer Internships (~ 4 students / year, 10 in 2021)
  - Presentation at Univ. of Porto: “Realistic Simulation of Wireless Networks using ns-3” (~ 200 MSc finalists, Choose Your Path Event)

- Increasing awareness of ns-3 to national research communities
  - Keynote: “ns-3 as a Digital Twin for Wireless Testbeds”, 29th Seminar of the Thematic Network for Mobile Communications (RTCM)

- Increasing awareness of ns-3 to experimentation focused communities and SMEs
  - Participation in 6 Fed4FIRE+ conferences (~ 10M€ project)
INESC TEC activities and interests

ns-3 as a Digital Twin for Wireless Testbeds

• Trace-based simulation (TS) apps for ns-3 app store → ongoing
  – Reproducing the same SNR, Channel Occupancy, MCS and MIMO of past real experiments

• ns-3 as a Digital Twin for Wireless Testbeds
  – Real-time TS
    • Digital Twins synchronized with the real resources and experimental conditions
  – ML-based models specialized to specific experimental conditions
    • E.g.: Path Loss, Fast Fading
  – Augmented experimentation
    • Interaction between digital twins and fully virtual resources

• Related Projects
  – SIMBED and SIMBED+ European projects
    • ns-3 used to reproduce past experimental conditions
  – SMART European project (ongoing)
    • ns-3 as the trace-based environment to train new RL-based models before experimentation
HUST: ns3-AI: Artificial Intelligence for networking

- AI/ML in communication (10 min)
- Introduction of the ns3-ai module (15-20 min)
- Basic usage of the ns3-ai module (30 min)
  - Basic functions and usage
  - Demos and instructions with code (step by step)
- Example: Wi-Fi Rate Control (40-60 min)
HUST: ns3lab as a Scalable Online NS-3 Lab Platform

- Tutorial lab
- IEEE 802.11 DCF protocol
- Physical layer simulation
- Ns3-AI case labs
- Independent experimental environment
- computing resources statistically reused
CTTC activities and interests

- All activities focused on 5G-LENA
- We are about to release a NR V2X branch first version
- We will soon make a new release with a significantly updated RRC
- We have received contributions from Rediet on the code of NR-U, which will be soon incorporated to upgrade the current code to ns-3-dev and to build a coexistence example with 11ax
- We plan to merge NR-U branch to master.
- We have recently started a new project which will significantly improve the MIMO models.
NITK Surathkal activities and interests

- The focus is on Congestion control models and Queue disciplines
- BBRv1 model merged in ns-3 mainline
  - https://github.com/mohittahiliani/BBR-Validation
- BBRv2 model for ns-3 is under development; expected to be released by October 2021
- RACK and its prerequisite algorithms: FACK, DSACK, TLP have been upgraded to work with current ns-3-dev
- Update TCP examples and documentation
- Merge request is open for simplifying the implementation of FQ based queue disciplines
- Implement bandwidth shaper to support CAKE qdisc in ns-3
- Merge pending set of queue disciplines and ECN models (PI, BLUE and REM, and ECN++ and Accurate ECN)
• Consortium raises small amounts of funding to pay for annual meeting, low-cost infrastructure/services, and software development

• Income sources
  – Consortium membership fees
  – Google Summer of Code payments (migrating to SPI account)
  – WNS3 registration fees (but usually to cover costs)

• Consortium accounts currently hold roughly $16,000 (through June 2021)
Current activities

• Contracted software development
  – Current phase focuses on WiGig integration to wifi module
  – Phase 1 (through May 2020): PHY abstraction, Bianchi example, and rate controls
  – Phase 2 (through December 2020): LAA-Wifi coexistence, PHY error models, and PHY refactoring work
  – Technical reports available at: https://www.nsnam.org/consortium/activities/software/

• Training
  – 5G NR overview (Lorenza Giupponi and Tom Henderson), ACMSE Conference, 2021
  – Past annual meetings (through 2019) offered two days of basic training
Other Consortium funding

• Hardware and software infrastructure
  – Mac Mini for University of Washington purchased this month
  – Vimeo subscription for video hosting
  – VMWare Fusion subscription for Jenkins installation
  – Website design/maintenance

• Travel support
WNS3 acknowledgments

• Thanks to Michele Polese, Stefano Avallone, and Eric Gamess, and our TPC, for WNS3 2021
  – No significant issues arose during WNS3 review process
  – Stefano is completing a two-year term

• Thanks to tutorial leads Hao Yin, Davide Magrin, Sian Jin, and Evan Black
Consortium next steps

• Working groups around Research, Education, and Training
  – Develop more online training and outreach
• A return to (hybrid) in-person meeting in 2022?
• Raise more funding to support common-benefit contracted ns-3 improvements

Questions?
Open source project status
Open source project highlights

- Three releases since last June
- Four students in Google Summer of Code 2020 completed projects in September
- Google Summer of Code 2021 awarded us three students
  - **Org. admins:** Tommaso Pecorella, Mohit Tahiliani
  - **Mentors:** Davide Magrin, Mattia Lecci, Tommaso Pecorella, Mohit Tahiliani, Apoorva Bhargava, Vivek Jain, Manoj Kumar Rana, Jared Ivey, Tom Henderson
  - Two supplemental ns-3 summer of code (NSOC) programs
Code statistics and maintainer commits

Since last annual meeting (June 18, 2021)

• **909 commits** by **58 authors** *(33 new!)*

• **Maintainer commits** from
  – Alexander Krotov, Biljana Bojovic, Federico Guerra, Gustavo Carneiro, Mohit Tahiliani, Natale Patriciello, Peter Barnes, Getachew Redietab, Sebastien Deronne, Stefano Avallone, Tom Henderson, Tommaso Pecorella, Vivek Jain, Zoraze Ali

• **159,000 lines** of C++ code added/deleted *(ns-3-dev)*
  – parsed output of git diff --stat filtered for `{cc,h}`
  – 114,000 lines due to wifi module and wireless examples

• **330 Merge Requests** opened

• **196 Issues** filed
Summer projects

Details available on https://www.nsnam.org/wiki

• Parth Pratim Chatterjee, *Direct Code Execution Modernization*
• Ameya Deshpande, *IPv6 Nix-Vector Routing*
• Akshit Patel, *Add logging support to Simulation Execution Manager (SEM)*
• Zakaria Arzoo, *Integration of MIPv6 module into ns-3*
• Nitya Chandra, *Enable IPv6 support for ad-hoc routing protocols in ns-3*
Software in the Public Interest (SPI)

- ns-3 also joined the SPI umbrella organization in 2020 (https://www.spi-inc.org)

### SPI associated projects

We are proud to be able to list the following 40 free and open source projects as being associated with SPI.

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Funded project priorities

- Wi-Fi module architecture/maintenance
- Scalable wireless simulations (NSF Award, Sandia National Laboratories)
- Wi-Fi 7 models (802.11be aspects)
- NR V2X-based public safety models and scenarios
- Update Direct Code Execution (DCE)
- Alignment with PAWR testbeds
Summary

• Thanks to all who have built and continue to care for ns-3
• 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
• Consortium members wanted
  – Funding and industrial participation will help us scale and take the next steps
  – Email: consortium@nsnam.org
• Apps wanted
  – Help us populate the app store ([https://apps.nsnam.org](https://apps.nsnam.org))
Questions or comments about the consortium or open source project?