

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





Current membership

Founding Executive Members





Executive Members



INESCTEC



Centre Tecnològic de Telecomunicacions de Catalunya



National Institute of Technology Karnataka, Surathkal

• Members

NETWORK SIMULATO





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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/improvementsto-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)

> Fundamentals of Networking Lab U Washington



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

Sian Jin, Sumit Roy & T. R. Henderson, "Efficient PHY Layer Abstraction for Fast Singulations in Complex System Environments" IEEE TCOM, 2021.

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 Al/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)



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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
 - https://ieeexplore.ieee.org/document/9461188
- 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-3dev 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)



Budget status

- 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: <u>https://www.nsnam.org/consortium/activities/software/</u>
- 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

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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 <u>https://www.nsnam.org/wiki</u>

- 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 (<u>https://www.spi-inc.org</u>)



SPI associated projects

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

0 A.D.	ankur.org.in	aptosid	Arch Linux	Arch Linux 32	ArduPilot	Chakra
Debian	FFmpeg	Fluxbox	Gallery	Ganeti	Glucosio	GNUstep
GNU TeXmacs	haskell.org	LibreOffice	MinGW	NTPsec	ns-3	OFTC
Open Bioinformatics Foundation	Open MPI	Open Voting Foundation	OpenEmbedded	OpenSAF	OpenVAS	OpenWrt
OpenZFS	Performance Co-Pilot	PostgreSQL	Privoxy	SproutCore	Swathanthra Malayalam Computing	systemd
The Mana World	translatewiki.net	Tux4Kids	X.Org	YafaRay		



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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: <u>consortium@nsnam.org</u>
- Apps wanted
 - Help us populate the app store (<u>https://apps.nsnam.org</u>)



Questions or comments about the consortium or open source project?

