NS-3 Consortium
Plenary Talk

Tom Henderson (University of Washington and Boeing Research & Technology)
Walid Dabbous (INRIA)

March 2013
Agenda

• Opening Remarks
• Meeting Agenda and Logistics
• ns-3: An Overview
• ns-3 Consortium: An Overview
• How to Get Involved
Meeting agenda

• **Plenary talks** (09h00-12h00)
  – Introduction to the NS-3 Consortium (Walid Dabbous and Tom Henderson)
  – The LENA Project (Nicola Baldo)
  – Direct Code Execution with ns-3 (Mathieu Lacage and Hajime Tazaki)
  – Using Network Simulation in Classroom Education (George Riley)
  – The Evolution of a Computer Aided Simulation System (Felipe Perrone)

• Lunch (courtesy of INRIA) (12h00-13h00)

• **Tutorial Session 1** (13h00-15h00)
  – 13h00-15h00: ns-3 introductory tutorial (Part 1)
  – 13h00-14h00: A technical overview of the ns-3 LTE module by the LENA project
  – 14h00-15h00: Direct Code Execution

• **Tutorial Session 2** (15h30-17h00)
  – 15h30-17h00: ns-3 introductory tutorial (Part 2)
  – 15h30-16h15: NEPI
  – 16h15-17h00: Visualization and data collection

• Cocktail (17h00-18h00)

• Coffee breaks will additionally be provided.
ns-3: An Open Source Network Simulator

- ns-3 is a **discrete-event network simulator** targeted for **research and educational use**

![Diagram showing the relationship between model developers, NS-3 Consortium, ns-3 software, and ns-3 maintainers.](image)
ns-3 project goals

Develop an extensible simulation environment for networking research

1) a tool aligned with the experimentation needs of modern networking research
2) a tool that elevates the technical rigor of network simulation practice
3) an open-source project that encourages community contribution, peer review, and long-term maintenance and validation of the software
ns timeline

1988: REAL (Keshav)
1990s: ns-1
1996: ns-2
1997-2000: DARPA VINT
2001-04: DARPA SAMAN, NSF CONSER
2006: NSF CISE CRI Awards

Inputs: yans, GTNetS, ns-2

ns-3 core development (2006-08)
June 2008: ns-3.1
December 2012: ns-3.16

1st SIMUTools, March 2008
regular releases

NS-3 Consortium Meeting
March 2013
Recent statistics

- 50,000 downloads in 2012
- ~20 maintainers, ~100 contributors
- 2400 subscribers to ns-3-users
- 1300 subscribers to ns-developers
- ~300 citations in ACM and IEEE digital libraries
  - search 'ns-3 simulator' keyword

ns-3-users list subscribers vs time

ns-3 downloads per month (no data for Nov. 2009)
Current models

- devices
  - bridge
  - csma
  - emu
  - point-to-point
  - lte
  - mesh
  - spectrum
  - tap-bridge
  - uan
  - virtual-net-device
  - wifi
  - wimax

- applications
  - internet (IPv4/v6)

- core
- propagation
- mobility
- energy
- mpi

- network

- protocols
  - aodv
  - dsdv
  - olsr
  - click

- utilities
  - config-store
  - flow-monitor
  - netanim
  - stats
  - topology-read
  - BRITE

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March 2013
Models under current review

- TCP Westwood and Westwood+
- IEEE 802.11n extensions
- General purpose emulation device (FDNetDevice)
- BitTorrent clients and servers
- SMECN (Small Minimum Energy Communication Network) / RNS (Redundant Node Selection)
- Directional antenna models
- Longley-Rice and ITU terrain-aware propagation models
- Low resolution radio model
- Wideband propagation model
- IEEE 802.11b indoor wireless channel models
- HTTP traffic generator
- GPSR routing
- TMIX and DelayBox
- Basic TDMA model
- Poisson Pareto Burst Process traffic generator
- CLWPR (Cross Layer, Weighted, Position-based, Routing)
- Virtual Access Points (VAP) for WiFi
- Directional antenna models
- TCP Options
- Switched Ethernet Device
How the project operates

• Project provides three annual software releases
• Users interact on mailing lists and using Bugzilla bug tracker
• Code may be proposed for merge
  – Code reviews occur on a Google site
• Maintainers (one for each module) fix or delegate bugs, participate in reviews
• Project has been conducting annual workshop and developer meeting around SIMUTools
  – Some additional meetings on ad hoc basis
• Google Summer of Code (March-August) four of the past five summers
LTE Medium Access Control (MAC) Schedulers

- **Student:** Dizhi Zhou
- **Mentors:** Nicola Baldo, Marco Miozzo

- **Project rationale:** Improve the accuracy and realism of the MAC scheduling models in ns-3 LTE
- **Accomplishments:** Implemented, tested, documented eight new schedulers for the LTE MAC
Maintenance load

Project funding is needed for the core project maintenance

• Core software maintenance
• New code integration and review
• Usability and documentation improvements
Roadmap Priorities

• Software modularity and long-term maintenance
• Integration of direct code execution
• Integration with container-based and testbed-based experiment infrastructures
• Simulation-based experiment management
• Usability
Modularity

- Open source project maintains a (more stable) core
- Models migrate to a more federated development process

"bake" tool (Lacage and Camara)

Components:
- build client
- "module store" server
- module metadata

Figure source: Daniel Camara
Direct Code Execution

- Developed by Mathieu Lacage and Frederic Urbani, INRIA, Hajime Tazaki (NICT)
- Run unmodified application binaries in ns-3
  - Also, can run entire Linux stack in ns-3

Figure 4.6: The Linux network stack running inside ns-3

http://www-sop.inria.fr/members/Frederic.Urbani/ns3dceccnx/index.html
Container-based Integration

- Common Open Research Emulator (CORE)
  - http://pf.itd.nrl.navy.mil
- Python-based framework using ns-3 Python bindings, distributed computing library, and ns-3 TapBridge framework

Figure source: Jeff Ahrenholz
Network Experiment Management Framework (NEPI)

- Network experiment management framework to automate experiment life-cycle
- Allows scenarios involving heterogeneous resources (ns-3, PlanetLab, netns, ...)
- Wiki: http://nepi.inria.fr

Figure source: Alina Quereilhac, INRIA
Global Environment for Network Innovations (GENI)

Figure source: GENI at a Glance.pdf
URL: http://www.geni.net
General issues with hybrid environments

• Ease of use
  – Configuration management and coherence
  – Information coordination (two sets of state)
    • e.g. IP/MAC address coordination
  – Output data exists in two domains
  – Debugging

• Error-free operation (avoidance of misuse)
  – Synchronization, information sharing, exception handling
    • Checkpoints for execution bring-up
    • Inoperative commands within an execution domain
    • Deal with run-time errors
  – Soft performance degradation (CPU) and time discontinuities
SAFE: Simulation Automation Framework

- Data collection, transient analysis, management of independent replications, graphical configuration and visualization
- In ns-2 realm, similar to projects like ANSWER, ns2measure, and Akaroa2

Figure source: Felipe Perrone
Usability

- Animation and visualization
- Linkage to external tools (topology, mobility, statistics)
- Improved helper APIs

PyVis (Carneiro)  NetAnim (Riley and Abraham)
Acknowledgment of support
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• ns-3 Consortium: An Overview
• How to Get Involved
Goals of the consortium

• The NS-3 Consortium is a collection of organizations cooperating to support and develop the ns-3 software.
• It operates in support of the open source project
  – by providing a point of contact between industrial members and ns-3 developers,
  – by sponsoring events in support of ns-3 such as users' days and workshops,
  – by guaranteeing maintenance support for ns-3's core, and
  – by supporting administrative activities necessary to conduct a large open source project.
Governance

Open Source Community

Contributors

Suggestions & Maintenance

Feedback

Steering Committee

Appoint Directors

1 Executive Director
10 Directors

Feedback & Funding

Reports, Feedback, Training

Consortium Members

Founding Executive Members
UWA INRIA

Executive Members
INESC BU CTTC GT

Other Consortium Members
Membership

• The Consortium is governed by an agreement established between the founding members: INRIA and the University of Washington.

• Membership to the Consortium is open to those institutions that sign the member application form.

• The Consortium is overseen by a Steering Committee composed of individuals appointed by Executive Members of the Consortium.
The Steering Committee

• Initially composed of six directors appointed by the Founding Executive Members (three directors each).
• Including one rotating Executive Director
• Additional institutions may be invited to become Executive Members by the Steering Committee.
• Executive Members who are not Founding Executive Members (UW and INRIA) may appoint one individual to serve on the Steering Committee.
• The initial Steering Committee consists of:
  – Tom Henderson (director), Sumit Roy, Mike Clarke (University of Washington)
  – Walid Dabbous, Gérard Giraudon, Marc Barrett (INRIA)
New Executive Members

• Two new Executive Members joined in February 2013:
  – Centre Tecnològic de Telecomunicacions de Catalunya (CTTC)
  – INstituto de Engenharia de Sistemas e Computadores do Porto (INESC Porto)
New Executive Members

- Two other Executive members are joining the consortium:
  - Georgia Institute of Technology (George Riley)
  - Bucknell University (Felipe Perrone)
Role of the Steering Committee

• Making decisions on how the Consortium's funds shall be expended, accordingly with its objectives
  – organization of training courses, workshops, etc.

• Supervising the roadmap of the software maintenance.

• Organizing the various events in relation to the NS-3 Consortium.

• Receiving and collecting Consortium Members' feedback and suggestions concerning NS-3 software development.

• Submit suggestions made by Consortium Members to NS-3 Maintainers.

• Preparing a yearly scientific, technical and financial report.

• Accepting new Members
Consortium Members

• Not-for-profit organizations, small, and large companies may apply to become Consortium Members.

• Each Consortium Member may:
  – Submit suggestions, requests and feedback concerning the ns-3 software development directions and roadmap, to be discussed during the yearly plenary assembly.
  – Attend the Consortium annual meeting during which the ns-3 most recent release shall be presented and during which a sample of suggestions made by Consortium Members shall be discussed.
  – Designate attendees (1 for small companies and universities and 2 for large companies) to attend a yearly, one day ns-3 training course.
  – Have their name, including logo, placed on the ns-3 website www.nsnam.org.
Financial

• Finances are managed by the Steering Committee
• Financial goal is to ultimately support two full-time software maintainers
• Provide other financial support for smaller items (e.g. DNS registration, software, events, etc.)
• Support sponsored research expenditures as needed
Cost structures

Three ways to contribute funding

• 1) unrestricted gift
• 2) membership dues (subject to low institutional overhead)
• 3) sponsored research project (subject to regular institutional overhead)
Activities

• Annual meeting and tutorials
• Maintenance of the ns-3 website
• Student travel grants
  – Vedran Miletić (WNS3 2013)
• Other activities anticipated
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How to Get Involved

• Membership
• Sponsored research
• Unrestricted gifts
• Summer of Code program
• Participation in the open source project
Membership

• Membership is a way for your organization to sponsor recurring investment in the open source project

Inria’s dues and overhead for Inria-based Consortium Members:

<table>
<thead>
<tr>
<th>Category</th>
<th>Dues Before Overhead</th>
<th>Overhead (15%)</th>
<th>VAT</th>
<th>Total Dues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universities and non-profit</td>
<td>€1,000</td>
<td>€176</td>
<td></td>
<td>€1,176 + VAT</td>
</tr>
<tr>
<td>Very small companies</td>
<td>€1,000</td>
<td>€176</td>
<td></td>
<td>€1,176 + VAT</td>
</tr>
<tr>
<td>Small companies</td>
<td>€5,000</td>
<td>€882</td>
<td></td>
<td>€5,882 + VAT</td>
</tr>
<tr>
<td>Large companies</td>
<td>€10,000</td>
<td>€1,765</td>
<td></td>
<td>€11,765 + VAT</td>
</tr>
</tbody>
</table>

*For Inria, overhead is assessed on total payment.

University of Washington’s dues and overhead for University of Washington-based Consortium Members:

<table>
<thead>
<tr>
<th>Category</th>
<th>Dues Before Overhead</th>
<th>Overhead (20%)**</th>
<th>Taxes</th>
<th>Total Dues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universities and non-profit</td>
<td>$1,250</td>
<td>$250</td>
<td></td>
<td>$1,500 + Taxes</td>
</tr>
<tr>
<td>Very small companies</td>
<td>$1,250</td>
<td>$250</td>
<td></td>
<td>$1,500 + Taxes</td>
</tr>
<tr>
<td>Small companies</td>
<td>$6,250</td>
<td>$1,250</td>
<td></td>
<td>$7,500 + Taxes</td>
</tr>
<tr>
<td>Large companies</td>
<td>$12,500</td>
<td>$2,500</td>
<td></td>
<td>$15,000 + Taxes</td>
</tr>
</tbody>
</table>

**For the University of Washington, overhead is assessed on expenditures.
Sponsored Research and Gifts

• Sponsored research (request for specific development) incurs the research overhead rate

• One-time gifts (unrestricted) are not subject to overhead and can be made at any time
Summer of Code Program

• Looking to develop a program combining industry and ns-3 mentoring, through the consortium

• 10 week program, student paired with a mentoring team (1 ns-3 maintainer, 1 industry mentor)
  – ns-3 maintainer focuses on ns-3 development
  – industry mentor provides guidance on modeling and validation
Benefits to membership

• Send attendees to (annual) Consortium meetings for training
• (Optionally) place your logo on the website as a member/supporter of ns-3
Questions?