

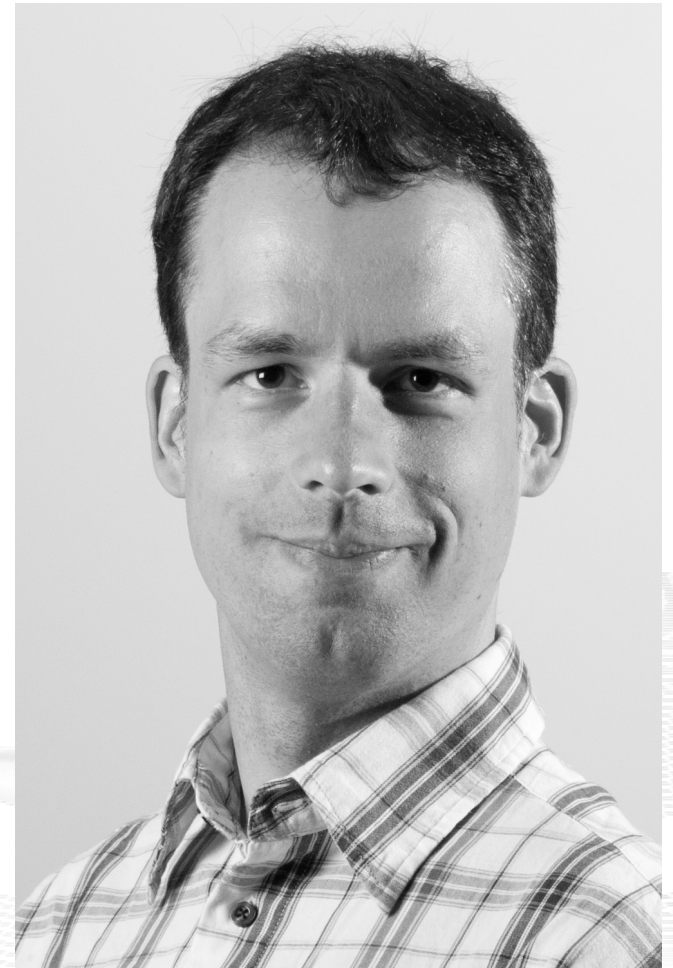
Invited Talk at Kungliga Tekniska högskolan Stockholm

The NorNet Testbed — An Overview for the GENI Meeting

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15 September 2014



Contents

- Motivation
- The NorNet Testbed
 - NorNet Core
 - NorNet Edge
- Users and Research
- Conclusion

Overview: Motivation

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Motivation: Robust Networks

- More and more applications rely on ubiquitous Internet access!
- However, our current networks are not as robust as they should be ...

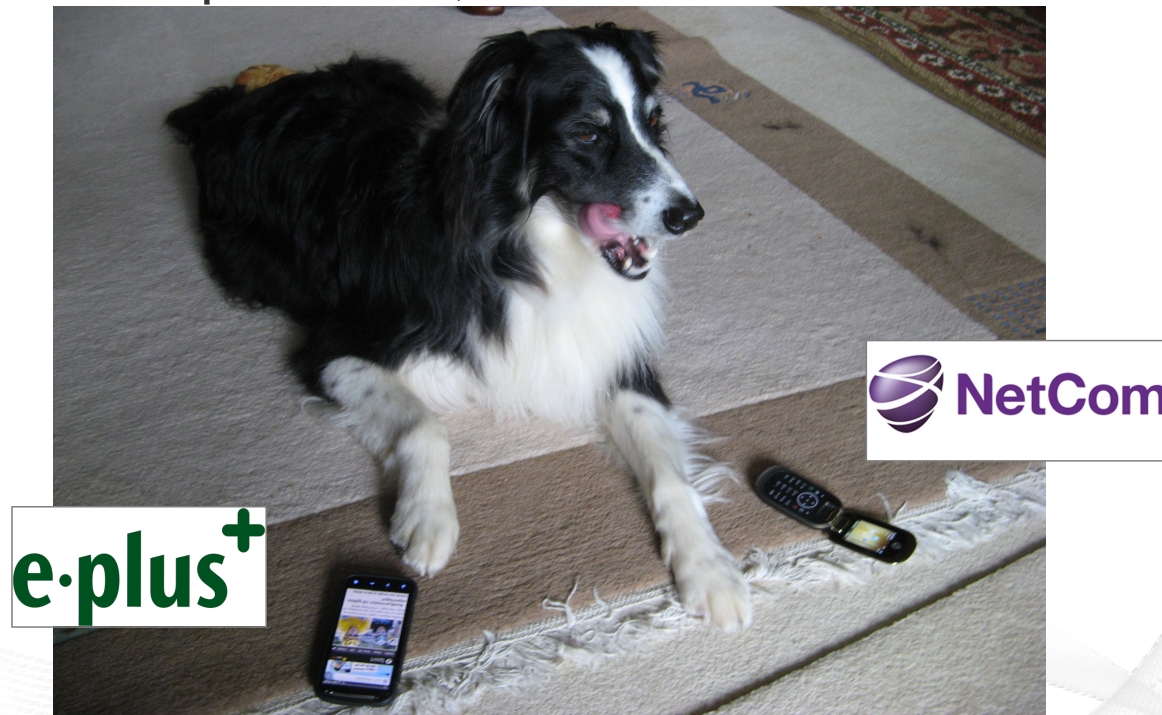


How to make networks more robust?

Resilience by Redundancy

Multi-Homing

- Connections to multiple Internet Service Providers (ISP)
- Idea: if one ISP has problems, another connection still works



Is resilience really improved? What about multi-path transport?

Idea: A Testbed for Multi-Homed Systems

Research in realistic setups is necessary!

- A multi-homed Internet testbed would be useful
 - Something like PlanetLab?
 - Perhaps with better node availability?
 - Support for mobile access (e.g. 2G/3G/4G/CDMA) as well as wired?
- **NorNet** – A research testbed for multi-homed systems!
 - Lead by the Simula Research Laboratory in Fornebu, Norway
 - Supported by Forskningsrådet

N  **RNET**

<https://www.nntb.no>

Overview: The NorNet Project

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Goals of the NorNet Project

- Building up a **realistic** multi-homing testbed
- Wired and wireless
 - Wired → “NorNet Core”
 - Wireless → “NorNet Edge”
- **Perform research with the testbed!**



How to get a realistic testbed?

Idea: Distribution of NorNet over whole Norway

- **Challenging topology:**
 - Large distances
 - A few “big” cities, many large rural areas
 - Svalbard:
 - Interesting location
 - Many polar research institutions
- **Deployment:**
 - Core: 11 sites in Norway + 5 in CN, DE (2x), SE, US
 - Edge: hundreds of nodes in Norway



Overview: NorNet Core

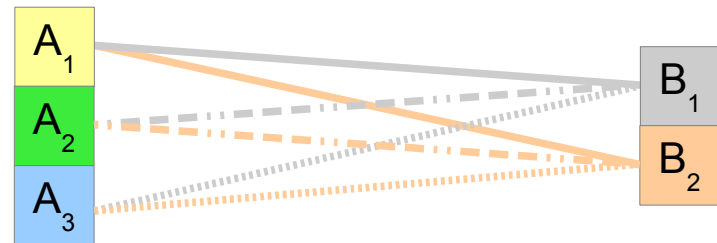
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Idea for NorNet Core: Tunnelling

- Researchers require control over used ISP interfaces
 - Which outgoing (local site) interface
 - Which incoming (remote site) interface

- Idea: Tunnels among sites

- Router at site A: IPs A_1, A_2, A_3
- Router at site B: IPs B_1, B_2



- IP tunnel for each combination:

$A_1 \leftrightarrow B_1, A_1 \leftrightarrow B_2, A_2 \leftrightarrow B_1, A_2 \leftrightarrow B_2, A_3 \leftrightarrow B_1, A_3 \leftrightarrow B_2$

- Fully-connected tunnel mesh among NorNet Core sites
- Each site's router (called **tunnelbox**) maintains the tunnels
 - Static tunnels
 - NorNet-internal addressing and routing over tunnels


Address Assignment

- NorNet-internal address spaces:
 - Private NorNet-internal IPv4 “/8” address space (NAT to outside)
 - Public NorNet-internal IPv6 “/48” address space
- Systematic address assignment:
 - IPv4: 10.<Provider ID>.<Site ID>.<Node ID>/24 per site
 - IPv6: 2001:700:4100:<PP><SS>::<NN>/64
(PP=Provider ID; SS=Site ID; NN=Node ID)
- NorNet-internal DNS setup including reverse lookup

Make it as easy as possible to keep the overview!

A NorNet Core Site Deployment

A usual NorNet Core site:

- 1x switch
- 4x server
 - 1x tunnelbox
 - 3x research systems
- At least two ISP connections
 - Uninett 
 - Other providers
- IPv4 and IPv6 (if available)

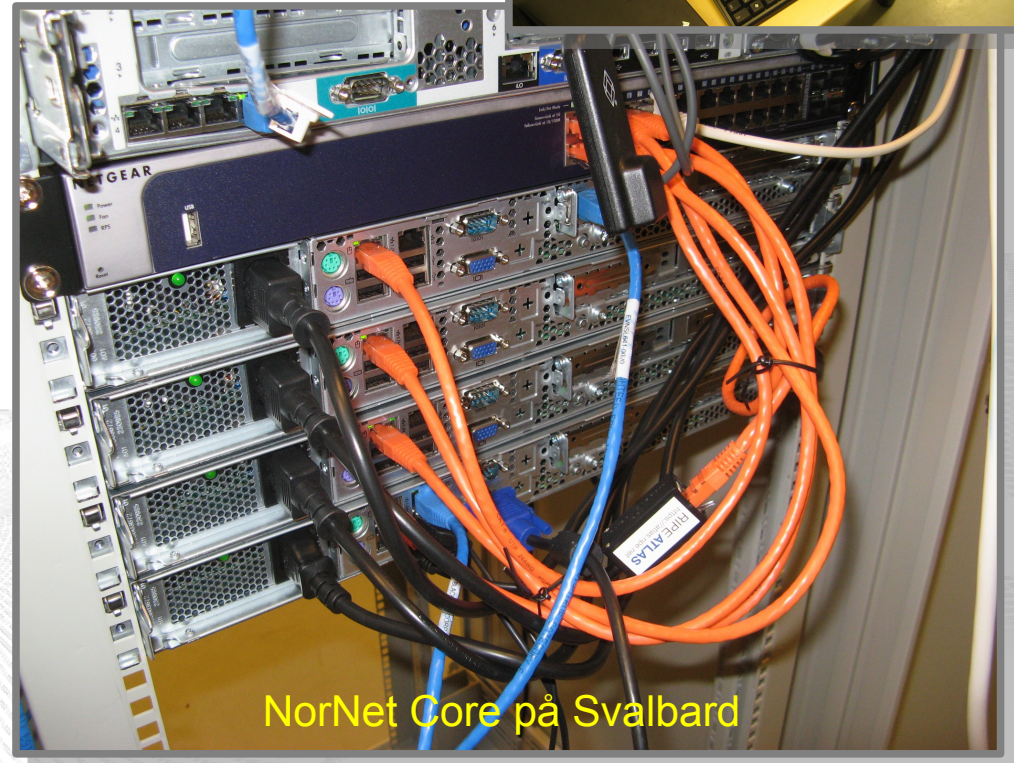
Additional researcher-provided sites:

- Varying configurations
- VM setups, powerful servers, “retro-style” PCs ...



UNIS



Longyearbyen 78.2°N, 15.6°E



NorNet Core på Svalbard

Site Deployment Status (September 2014)


| No. | Site | ISP 1 | ISP 2 | ISP 3 | ISP 4 |
|-----|------------------------------|---------|--------------|-----------|-----------|
| 1 | Simula Research Laboratory | Uninett | Kvantel | Telenor | PowerTech |
| 2 | Universitetet i Oslo | Uninett | Broadnet | PowerTech | |
| 3 | Høgskolen i Gjøvik | Uninett | PowerTech | | |
| 4 | Universitetet i Tromsø | Uninett | Telenor | PowerTech | |
| 5 | Universitetet i Stavanger | Uninett | Altibox | PowerTech | |
| 6 | Universitetet i Bergen | Uninett | BKK | | |
| 7 | Universitetet i Agder | Uninett | PowerTech | – | |
| 8 | Universitetet på Svalbard | Uninett | Telenor | | |
| 9 | Universitetet i Trondheim | Uninett | PowerTech | | |
| 10 | Høgskolen i Narvik | Uninett | Broadnet | PowerTech | |
| 11 | Høgskolen i Oslo og Akershus | Uninett | – | | |
| 12 | Karlstads Universitet | SUNET | | | |
| 13 | Universität Kaiserslautern | DFN | | | |
| 14 | Universität Duisburg-Essen | DFN | Versatel | | |
| 15 | Hainan University | CERNET | China Unicom | | |
| 16 | The University of Kansas | KanREN | | | |

 IPv4 and IPv6
 ISP negotiation in progress

 IPv4 only (ISP without IPv6 support ☹)
 IPv4 only (site's network without IPv6 support)

<https://www.nntb.no/pub/nornet-configuration/NorNetCore-Sites.html>

Some Site Statistics (September 2014)



| | |
|------------------------------------|-----|
| Active Sites | 16 |
| Distinct ISPs of Active Sites | 13 |
| Distinct Countries of Active Sites | 5 |
| Total IPv4 Interfaces | 34 |
| Total IPv4 Tunnels | 561 |
| Total IPv6 Interfaces | 22 |
| Total IPv6 Tunnels | 231 |
| Inactive Sites | 0 |

<https://www.nntb.no/pub/nor-net-configuration/NorNetCore-Sites.html>

Remote Systems

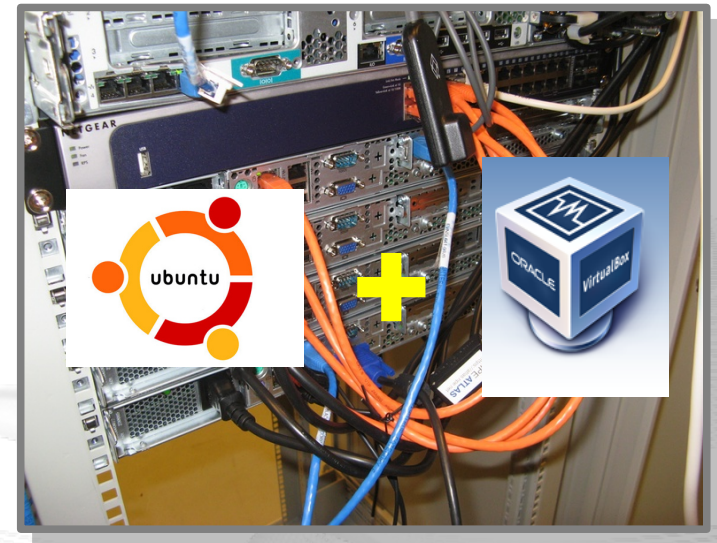
Our servers may be really remote!

The “road” to Longyearbyen på Svalbard, 78.2°N

Virtualisation

“Anything that can go wrong, will go wrong.”
[Murphy's law]

- Experimentation software is experimental
- How to avoid software issues making a remote machine unusable?
- Idea: virtualisation
 - Lightweight, stable software setup:
Ubuntu Server 12.04 LTS
 - VirtualBox 4.3
 - Other software runs in VirtualBox VMs:
 - Tunnelbox VM on physical server #1
 - 2 LXC-based research node VMs on physical servers #2 to #4
 - In case of problem: manual/automatic restart or reinstall of VM



PlanetLab-based Software for Experiments

- Key idea:
 - Researchers should get virtual machines for their experiments
 - Like *PlanetLab* ...
 - ... but with multi-homing and IPv6, of course
- *PlanetLab* software:
 - Different “stable” distributions: *PlanetLab*, *OneLab*, etc.
 - Current implementation: based on *Linux VServers*
 - Not in mainline kernel
 - Patched kernel, makes upgrades difficult
 - The future: **Linux Containers (LXC)**
 - Active development by *PlanetLab/OneLab*
 - We are involved in developing and testing the LXC software

Experiments with Special Requirements

Special requirements for your experiment? Ask!

- **NorNet Core can satisfy special setup requirements for experiments!**
- Example: VMs with **custom operating system**
 - For example: custom Linux, **FreeBSD**, AROS, ...
 - Currently still requires manual setup, automation as future work
- Other example: VoIP **SIP honeypot**
 - Security project at University of Duisburg-Essen (UDE)
 - Tunnelboxes tunnel SIP traffic to a central honeypot server at UDE site
 - Analysis of SIP attacks tried on the tunnelbox addresses at different sites

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ESSEN

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The NorNet Edge Box: Ready for Deployment (1)

Box contents:

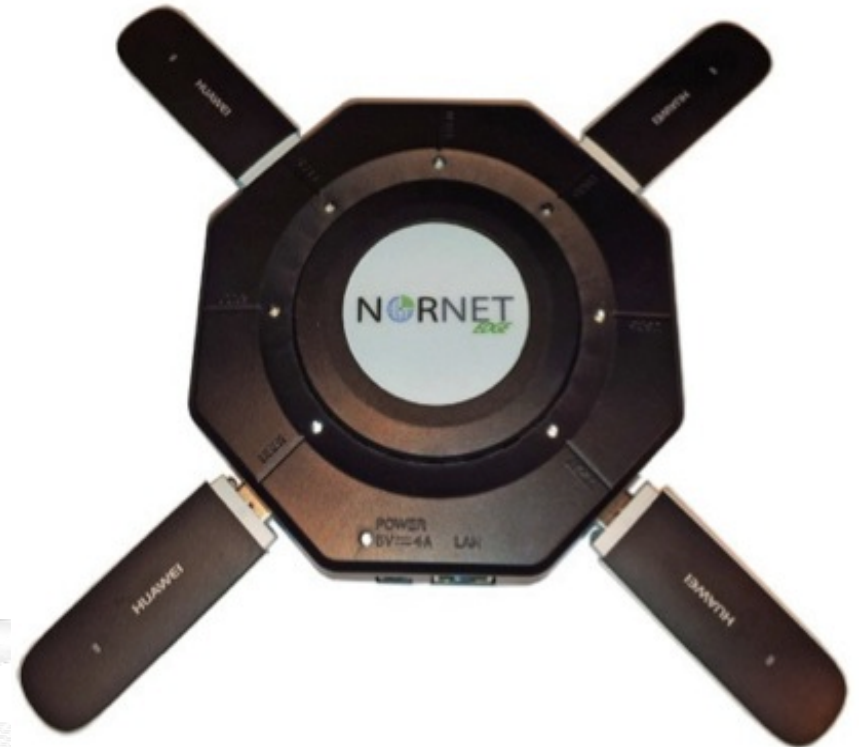
- Ufoboard or Beagle Bone embedded Linux system
- 4x USB UMTS (some with LTE):
 - Telenor, NetCom,
 - Network Norway, Tele2
- 1x ICE CDMA mobile broadband
- 1x Ethernet
- 1x WLAN (optional)
- Power supplies
- Handbook



The NorNet Edge Box: Ready for Deployment (2)

Ufoboard:

- Debian Linux
- Kernel 3.11.x
- **MPTCP (0.88)**



NorNet Edge Visualisation

NorNet Edge Visualization

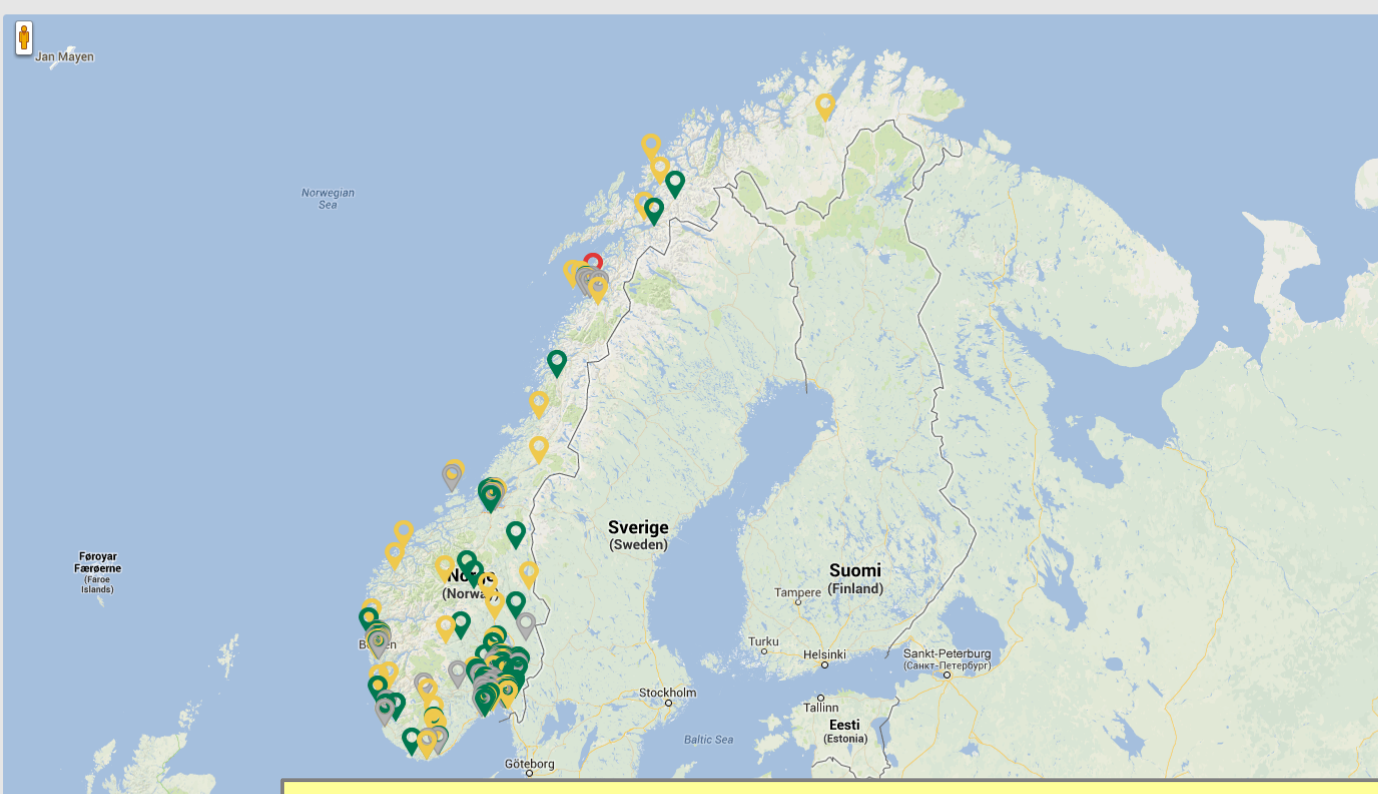
Dashboard Comparative view 2013/7/26 13:54:32

OPERATOR: All

COLOR CODE

- All networks available
- Some networks available
- No networks available
- Node unreachable

UP RATE, %: 83



Search by location or node id

| LOCATION | NODE ID | STATUS |
|----------------|---------|--------|
| Åmot | nne255 | ● |
| Asker | nne379 | ● |
| Aurskog-Høland | nne365 | ● |
| Aurskog-Høland | nne367 | ● |
| Aurskog-Høland | nne376 | ● |
| Aurskog-Høland | nne377 | ● |
| Aurskog-Høland | nne411 | ● |
| Austrheim | nne554 | ● |
| Bardu | nne272 | ● |
| Berg | nne262 | ● |
| Bergen | nne202 | ● |
| Bergen | nne236 | ● |
| Bergen | nne238 | ● |
| Bergen | nne283 | ● |
| Bergen | nne284 | ● |
| Bergen | nne285 | ● |
| Bergen | nne286 | ● |
| Bergen | nne291 | ● |
| Bergen | nne292 | ● |
| Bergen | nne293 | ● |

See <http://demo.robustenett.no>

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Overview:

Users and Research

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Users and Research

“The road to hell is paved with unused testbeds.”

[James P. G. Sterbenz]

- We already got some users!
- Examples:
 - Shared Bottleneck Detection (UiO+Simula)
 - VoIP Misuse Detection (UDE)
 - Multi-Path Transport (Simula, UDE, UiO, HU, etc.)
 - Balia Congestion Control (Bell Labs in South Korea)
 - IPv4/IPv6 Performance Comparison (Simula)
 - ...

List to be extended!

See <https://www.nntb.no/projects/> for further projects using NorNet!

Next step: get even more users!

The “NorNet World Tour 2014”

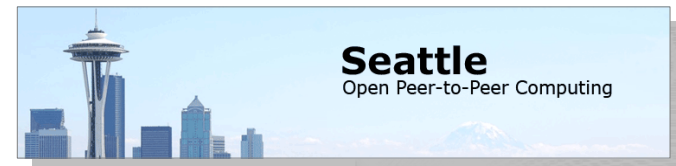
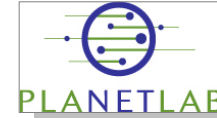
- 01/2014: Centre for Advanced Internet Architectures (CAIA) at Swinburne University
Melbourne, Victoria/Australia
- 05/2014: Polytechnic School of Engineering at New York University (NYU)
Brooklyn, New York/U.S.A.
- 05/2014: PlanetLab Consortium at Princeton University
Princeton, New Jersey/U.S.A.
- 05/2014: University of British Columbia (UBC)
Vancouver, British Columbia/Canada
- 09/2014: Kungliga Tekniska högskolan (KTH Royal Institute of Technology)
Stockholm/Sweden
- 10/2014: Academy, Industry and Government of the Hainan Province
Haikou, Hainan/China
- 10/2014: Tsinghua University
Beijing/China
- 12/2014: NorNet demo presentation at the IEEE GLOBECOM
Austin, Texas/U.S.A.
- 01/2015: ... [planned]/Australia



Interested in a NorNet presentation? Just ask!

Collaborations

- PlanetLab/OneLab
 - Development and testing of the research software
 - URLs: <https://www.planet-lab.org>, <https://www.onelab.eu>
- RIPE Atlas
 - Connectivity and reachability measurements
 - URL: <https://atlas.ripe.net>
 - Node deployed at site in Longyearbyen
- Seattle
 - Open Peer-to-Peer Computing, project at NYU
 - URL: <https://seattle.poly.edu>
 - Running inside NorNet Core slice
- ToMaTo
 - Topology Management Tool
 - URL: <http://tomato-lab.org>
 - Part of the G-Lab testbed



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Conclusion and Future Work

- The NorNet testbed is progressing!
 - Initial deployment completed
 - Ready for experiments (also for your experiments!)
- Future work:
 - Make more NorNet Core sites multi-homed (further ISPs, IPv6)
 - Some additional sites
 - Improve and refine management software
 - Get more users (may be you?)

And, of course, do some research!

“NorNet wants to be a building block of the railroad to heaven” ...



... and not be another unused testbed that paves the road to hell!

Any Questions?

N  RNET

Visit <https://www.nntb.no> for further information!