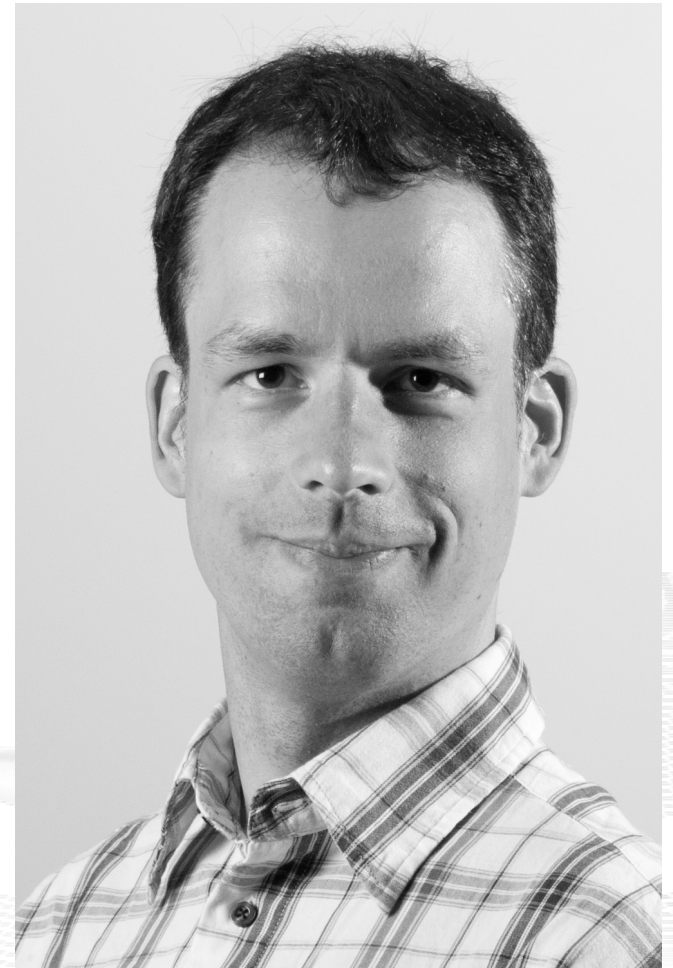# Invited Talk at Kungliga Tekniska högskolan Stockholm

The NorNet Testbed
–
An Overview for the GENI Meeting

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Simula Research Laboratory

15 September 2014

Contents

- Motivation

- The NorNet Testbed

    - NorNet Core

    - NorNet Edge

- Users and Research

- Conclusion

Overview:
Motivation

Motivation: Robust Networks

- More and more applications rely on ubiquitous Internet access!

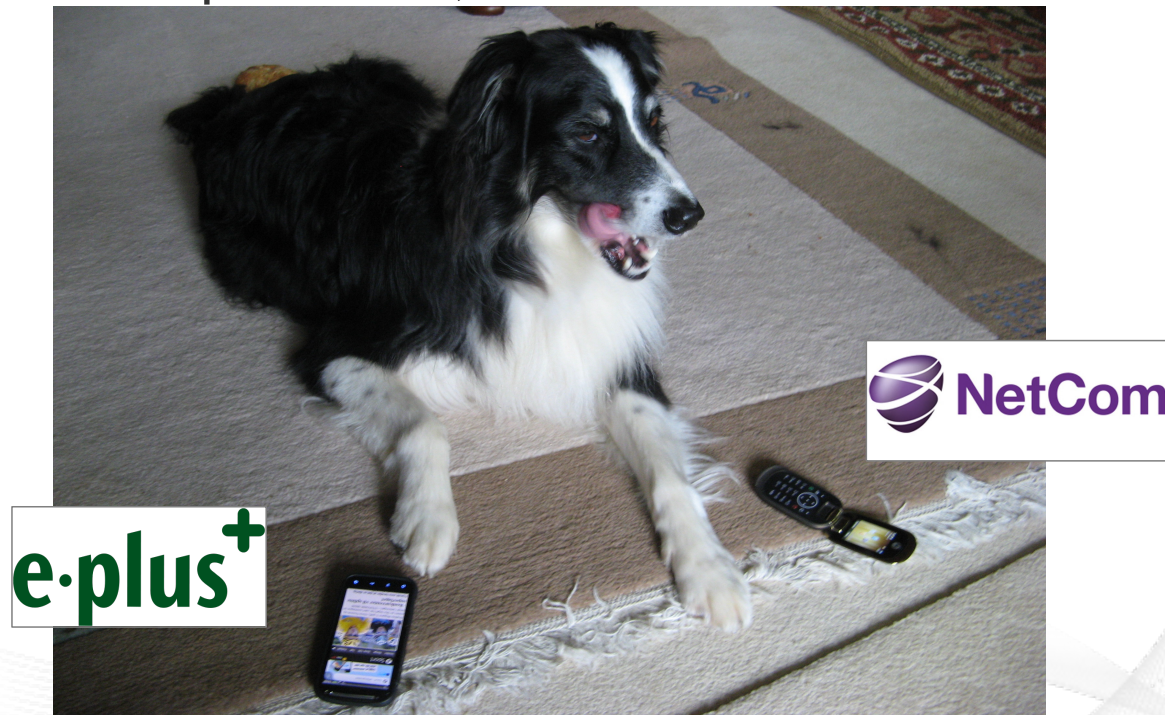- However, our current networks are not as robust as they should be ...

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

https://www.nntb.no

Overview:
The NorNet Project

- **Motivation**

- **The NorNet Testbed**

  - NorNet Core

  - NorNet Edge

- Users and Research

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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
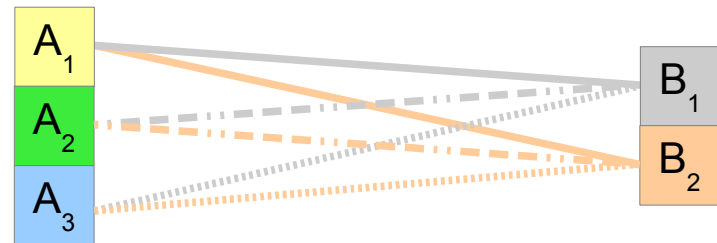
  - IP tunnel for each combination:
    $A_1 \leftrightarrow B_1$, $A_1 \leftrightarrow B_2$, $A_2 \leftrightarrow B_1$, $A_2 \leftrightarrow B_2$, $A_3 \leftrightarrow B_1$, $A_3 \leftrightarrow B_2$

  - 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 **UNINETT**

  - Other providers
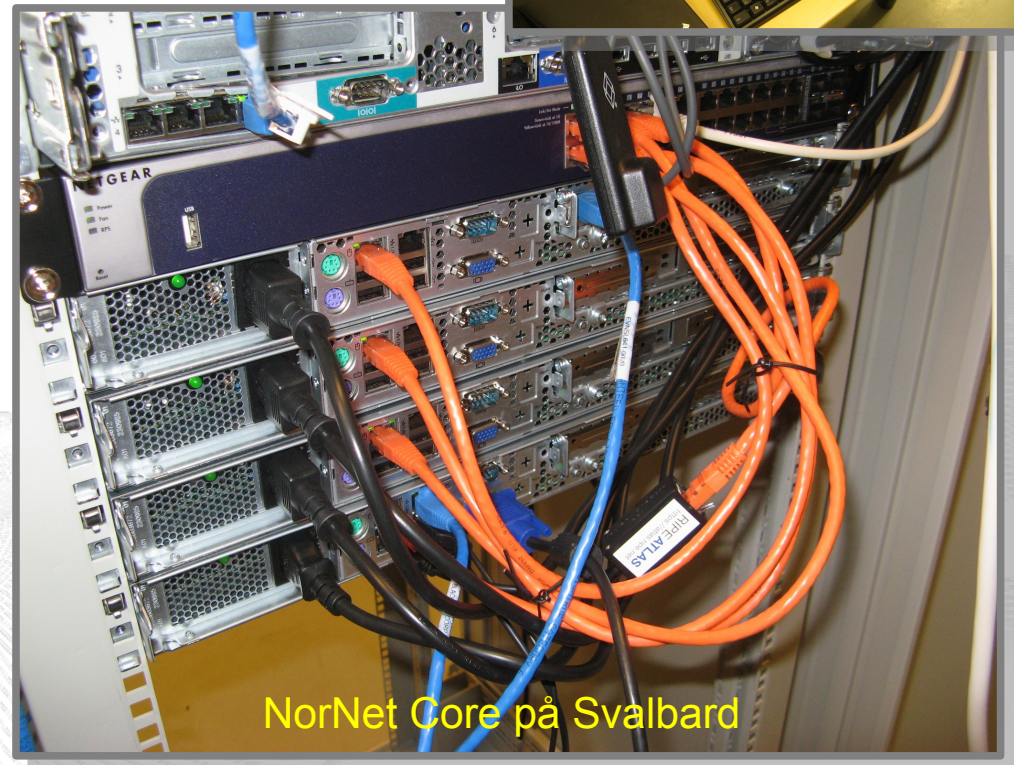
- IPv4 and IPv6 (if available)

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
- 🟧 IPv4 only (ISP without IPv6 support ☹)
- 🟦 ISP negotiation in progress
- 🟨 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/nornet-configuration/NorNetCore-Sites.html

Remote Systems

Our servers may be really <u>remote</u>!

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
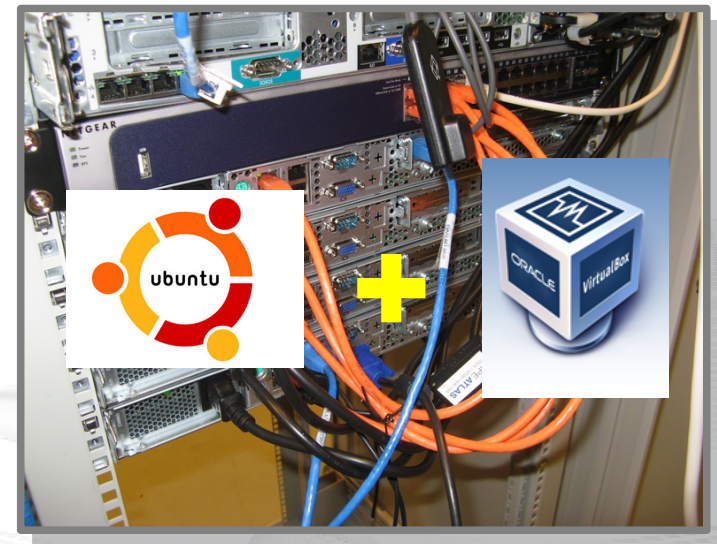
PlanetLab-based Software for Experiments

- 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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DUISBURG
ESSEN

Overview:
NorNet Edge

- **Motivation**

- **The NorNet Testbed**

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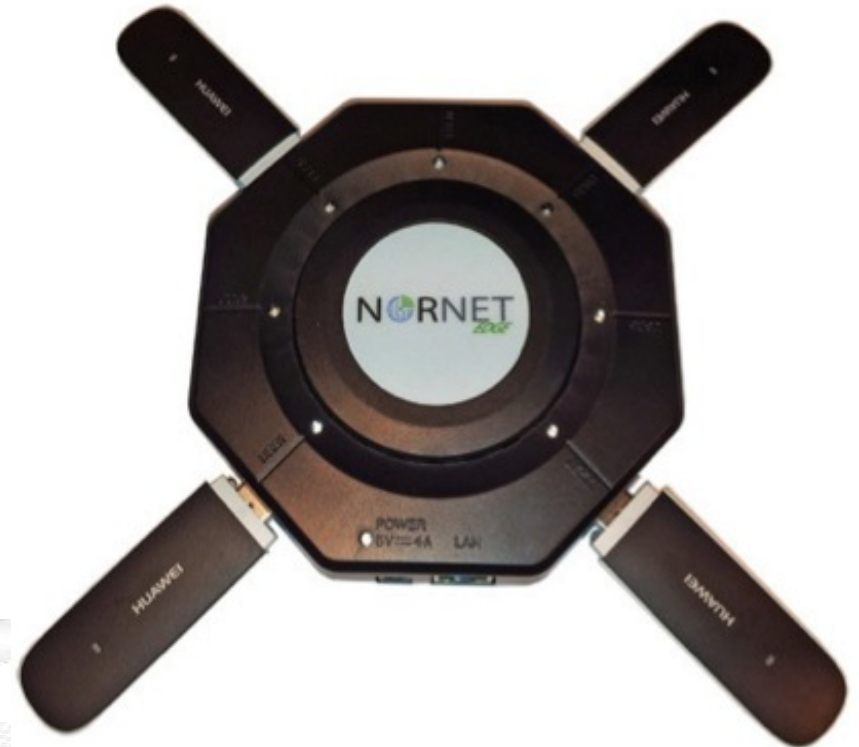# The NorNet Edge Box: Ready for Deployment (1)

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

NorNet Edge på Kringsjå, Oslo

The NorNet Edge Box: Ready for Deployment (2)

Ufoboard:

- Debian Linux

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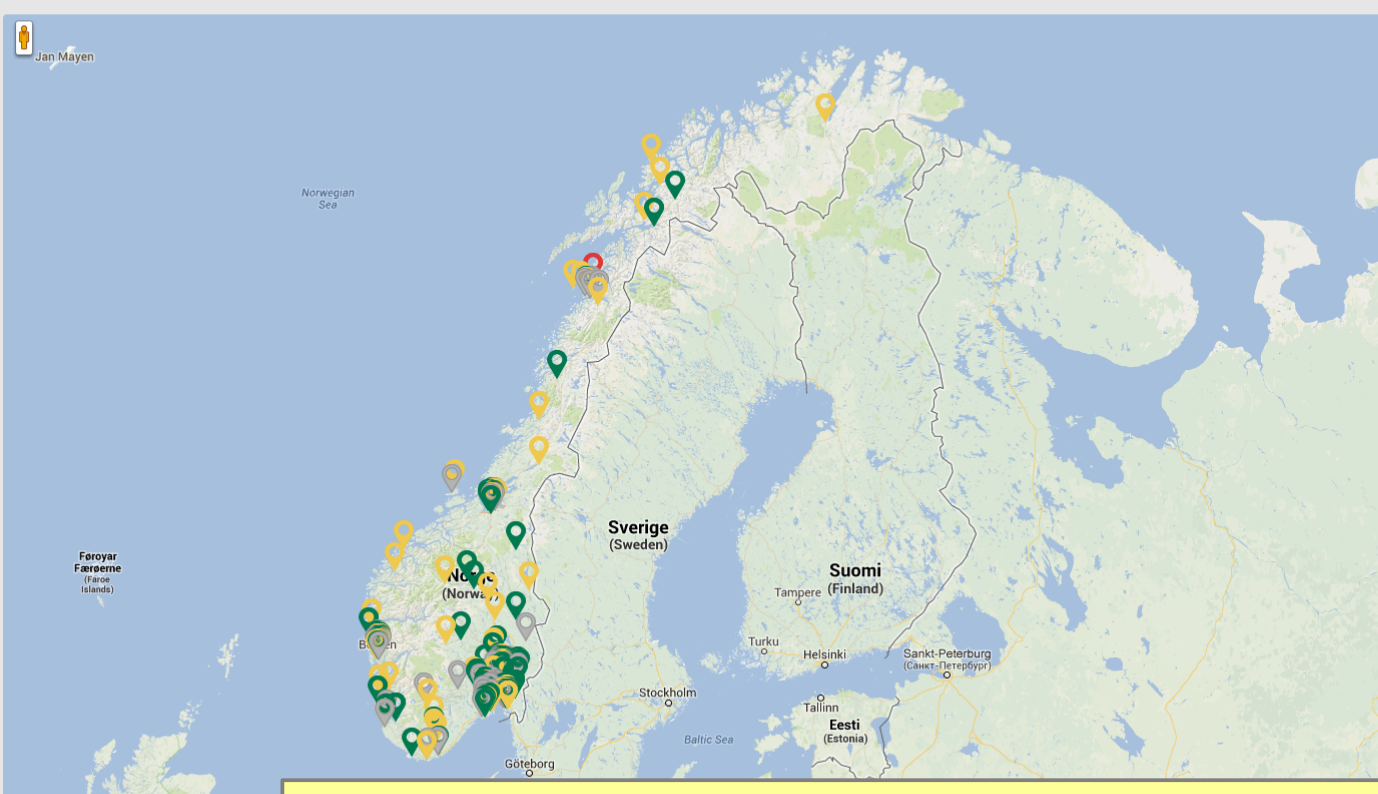
- **MPTCP (0.88)**

NorNet Edge Visualisation

See http://demo.robustenett.no!

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: … [pla
  [planned]/Austr

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
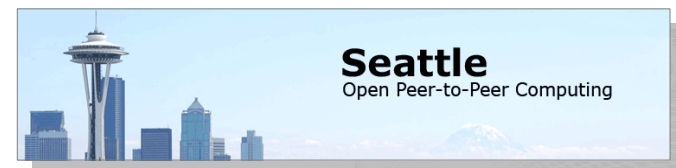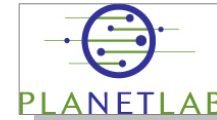
Overview:
Conclusion

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- **Users and Research**

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Conclusion and Future Work

- The NorNet testbed is progressing!

  – Initial deployment completed

  – Ready for experiments (also for <u>your</u> 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 <u>you</u>?)

> **And, of course, do some <u>research</u>!**

"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?

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