Invited Talk at Princeton University

The NorNet Testbed for Multi-Homed Systems – Introduction and Status

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Contents

Overview: Motivation

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

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. 3G) 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
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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
- NorNet Core:
  - Currently 11+3 sites
- NorNet Edge:
  - Currently ca. 400 nodes

Overview:
NorNet Core

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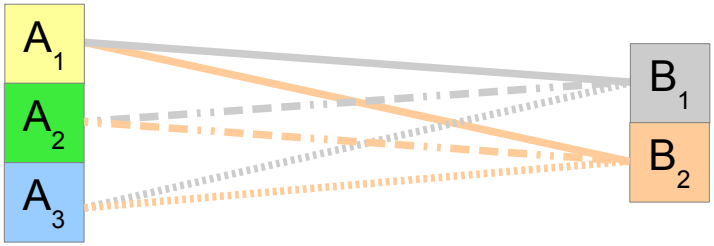
Idea: Tunnelling

- 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 (< 20)
  - 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)

Make it as easy as possible to keep the overview!

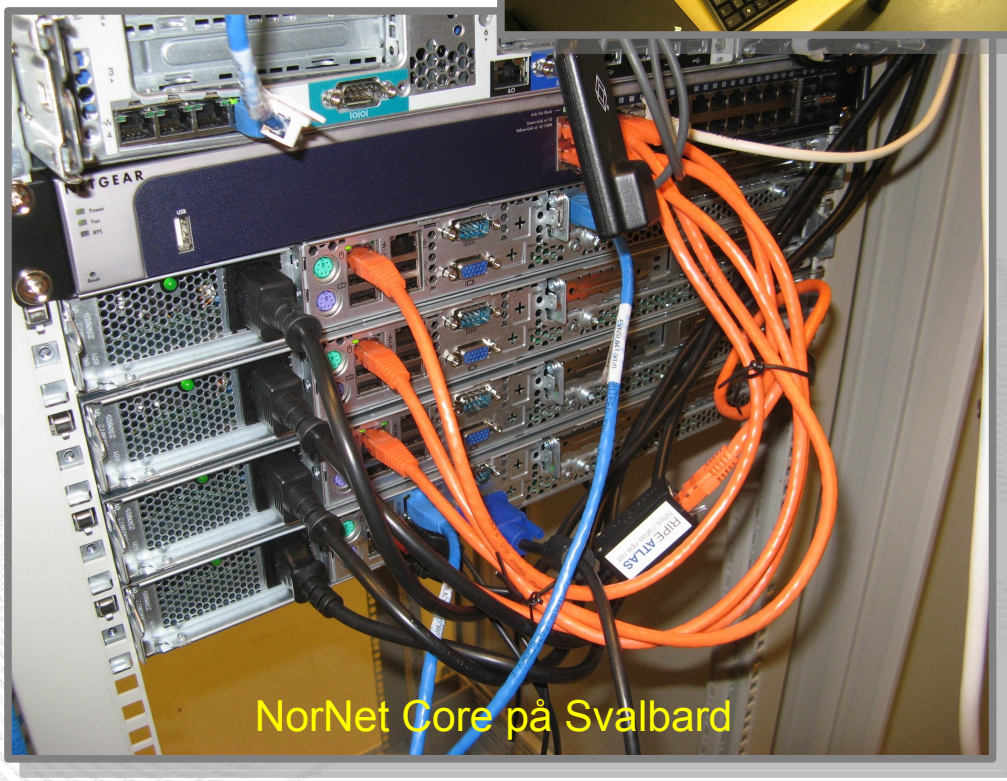
A NorNet Core Site Deployment

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)

UNIS

Longyearbyen 78.2°N,15.6°E



NorNet Core på Svalbard

Site Deployment Status (May 2014)

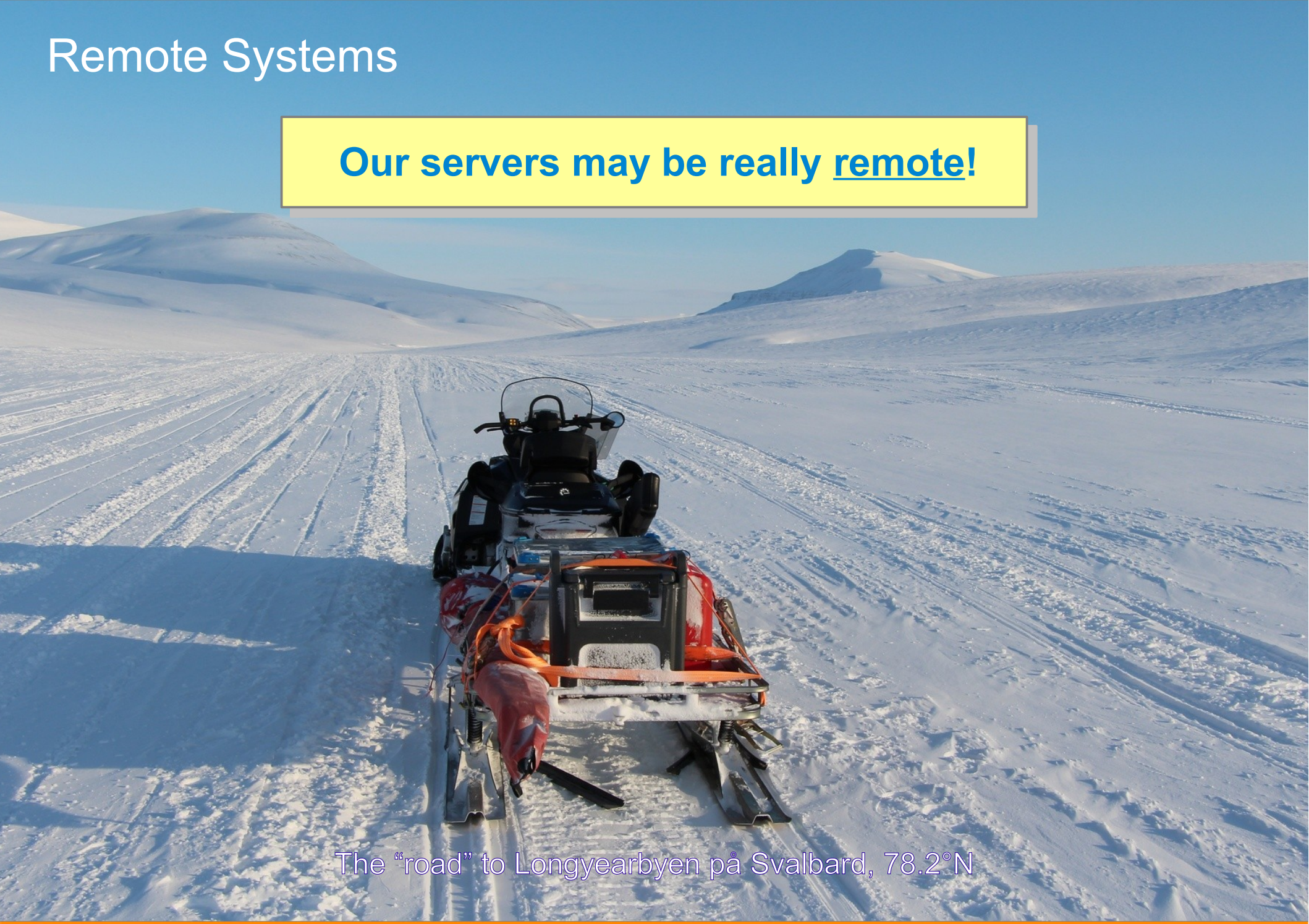
Site	Location	ISP 1	ISP 2	ISP 3
Simula Research Laboratory	Fornebu, Akershus	UNINETT	Kvantel	Telenor [2]
Universitetet i Oslo	Blindern, Oslo	UNINETT	PowerTech	Broadnet [2]
Høgskolen i Gjøvik	Gjøvik, Oppland	UNINETT	PowerTech	
Universitetet i Tromsø	Tromsø, Troms	UNINETT [1]	PowerTech	Telenor [2]
Universitetet i Stavanger	Stavanger, Rogaland	UNINETT [1]	PowerTech	
Universitetet i Bergen	Bergen, Hordaland	UNINETT	BKK	
Universitetet i Agder	Kristiansand, Vest-Agder	UNINETT	PowerTech	
Universitetet på Svalbard	Longyearbyen, Svalbard	UNINETT [1]	Telenor [2,4]	
NTNU Trondheim	Trondheim, Sør-Trøndelag	UNINETT	PowerTech	
Høgskolen i Narvik	Narvik, Norland	UNINETT	PowerTech	Broadnet [2]
Høgskolen i Oslo og Akershus	St. Hanshaugen, Oslo	UNINETT		
University of Duisburg-Essen	Essen/Germany	DFN	Versatel [2,3]	
Hainan University	Haikou, Hainan/China	CERNET [1]	Unicom [1]	
Karlstads Universitet	Karlstad, Värmland/Sweden	SUNET	– [4]	

What about a site at Princeton University?

1) IPv6 available from ISP, but not deployed to setup
2) IPv6 not available from ISP ☹
3) Consumer-grade ADSL connection
4) Negotiations in progress

Remote Systems

Our servers may be really remote!

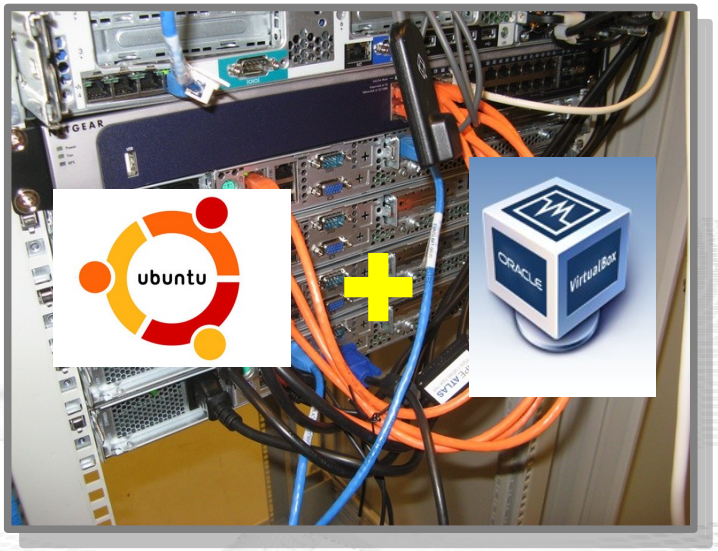


The “road” to Longyearbyen på Svalbard, 78.2°N

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



Idea: *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*
    - NorNet-specific branch (builds on http://benlomond.nntb.no/)

The LXC-based *PlanetLab*/*OneLab* Software

- Researchers get container (sliver) inside a Linux environment
- Same kernel, but slivers are separated from each other
- LXC uses *Open vSwitch*:
  - Slivers are connected to a virtual switch
  - Switch is bridged into real network
  - **Own IPv4/IPv6 addresses** for each sliver!
- Fedora Core 18 Linux environment inside the slivers

A full-featured, multi-homed Linux system!

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

Box contents:

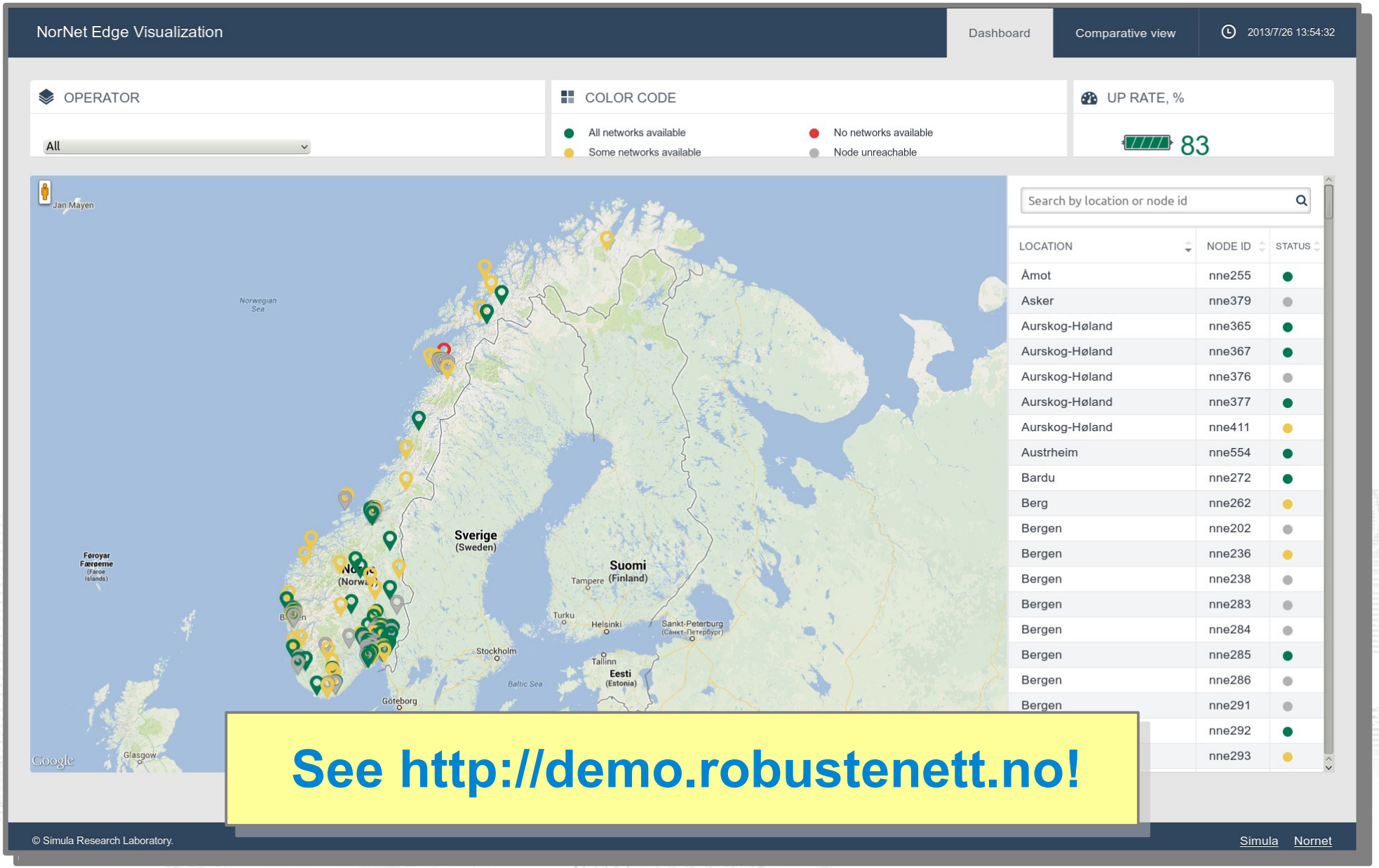
- Ufoboard or Beagle Bone embedded Linux system
- 4x USB UMTS:
  - Telenor, NetCom,
  - Network Norway, Tele2
- 1x ICE CDMA mobile broadband
- 1x Ethernet
- 1x WLAN (optional)
- Power supplies
- Handbook

The NorNet Edge Box: Ready for Deployment (2)

Ufoboard:

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

NorNet Edge Visualisation



See http://demo.robustenett.no!

Overview: Research

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Research and Users

> ***"The road to hell is paved with unused testbeds."***
> **[James P. G. Sterbenz]**

- Of course, NorNet does **not** intend to be another unused testbed!
  Goal: "NorNet wants to be a building block of the railroad to heaven."
- NorNet will be open for all interested researchers!
  - Similar to *PlanetLab* ...
  - … but with higher node availability and tighter monitoring
  - … and, of course, **multi-homing and IPv6**
- **Particularly, it can also be used at Princeton University!**

Just talk with us about the details!

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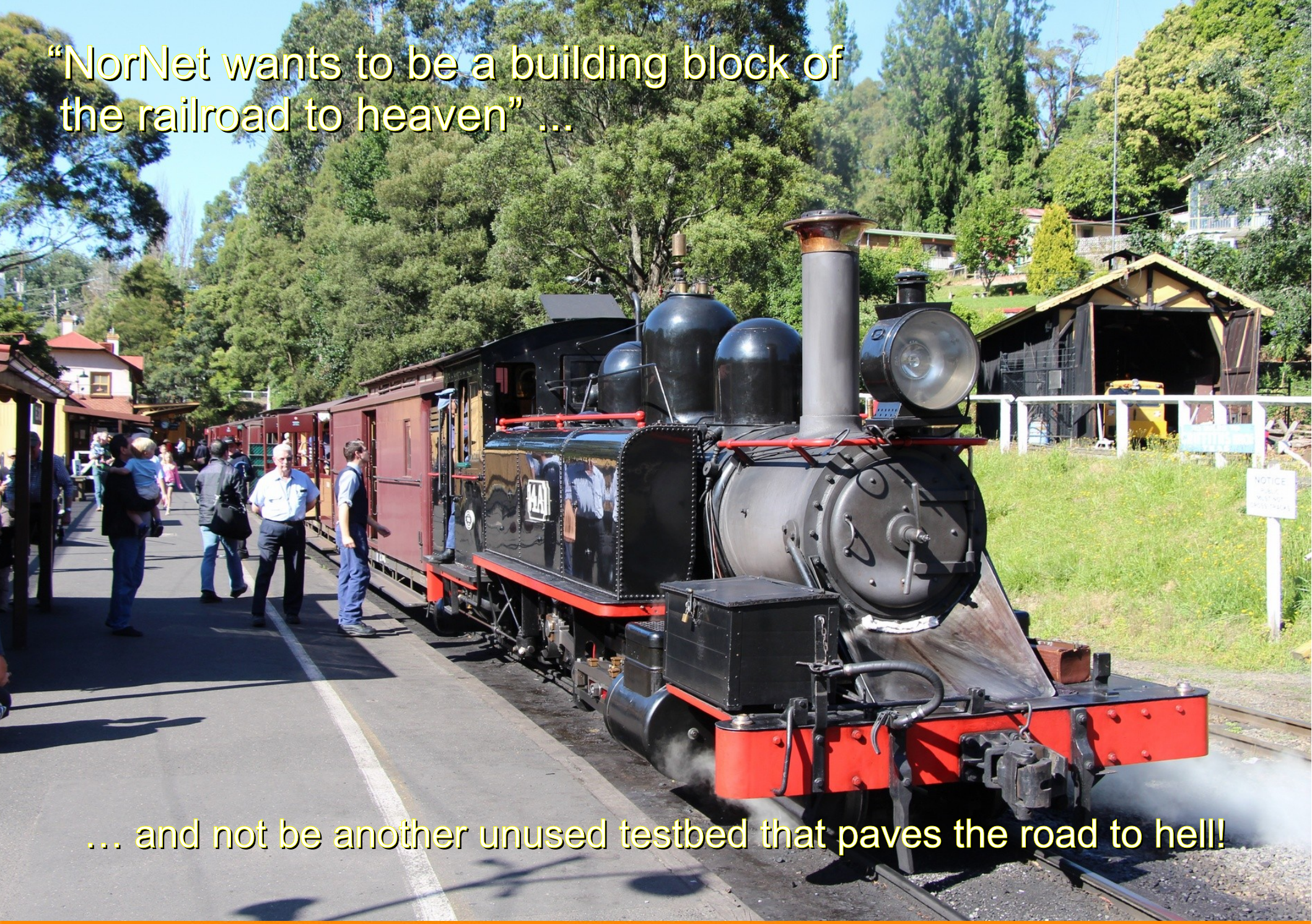
Conclusion and Future Work

- The NorNet testbed is progressing!
  - Initial deployment completed
  - Ready for experiments (also for your experiments!)

- Future work:
  - Make more NorNet Core sites multi-homed (second and third ISP, 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!

Coming Soon:
The 2nd NorNet Users Workshop (NNUW-2)

See https://www.nntb.no!

Any Questions?

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