Invited Talk at the Haikou College of Economics (海口经济学院)

NorNet at the Haikou College of Economics

–

An Introduction to the NorNet Testbed

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- About Norway and the Simula Research Laboratory

- Motivation

- The NorNet Testbed

  - NorNet Core

  - NorNet Edge

- Conclusion

Overview:
About Norway and the Simula Research Laboratory

- **About Norway and the Simula Research Laboratory**

- Motivation

- The NorNet Testbed

    - NorNet Core

    - NorNet Edge

- Conclusion

Where is Norway?

Oslo 奥斯陆

ca. 8,700 km

Haikou 海口

Svalbard

Facts about Norway

Capital: Oslo

Size: ca. 385,000 km^2

Population: ca. 5,165,800

Internet TLD: .no

The Simula Research Laboratory

- Located in Fornebu
  - Just outside of Oslo
  - In the IT Fornebu complex
- Public limited company
  - Owned by Norwegian government
  - Strong connection to Universitetet i Oslo
  - Ca. 160 people from all over the world
- Research groups
  - Scientific Computing
  - Software Engineering
  - **Resilient Networks and Applications**
- Norway's leading place for computer science research

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

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

N RNET

https://www.nntb.no

Overview:
The NorNet Project

- **Motivation**

- **The NorNet Testbed**

  - NorNet Core

  - NorNet Edge

- Conclusion

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 +
    CN, DE (4x), SE, US, KR, AU

  – Edge:
    hundreds of nodes in Norway

Overview:
NorNet Core

- **Motivation**

- **The NorNet Testbed**

  - NorNet Core
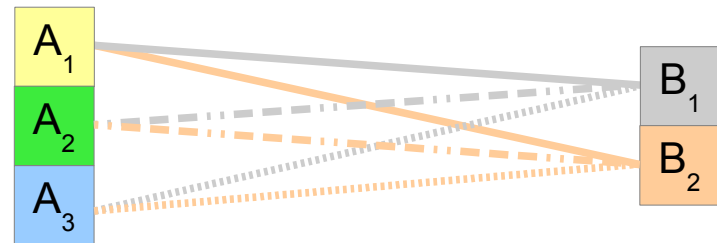
  - NorNet Edge

- Conclusion

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:
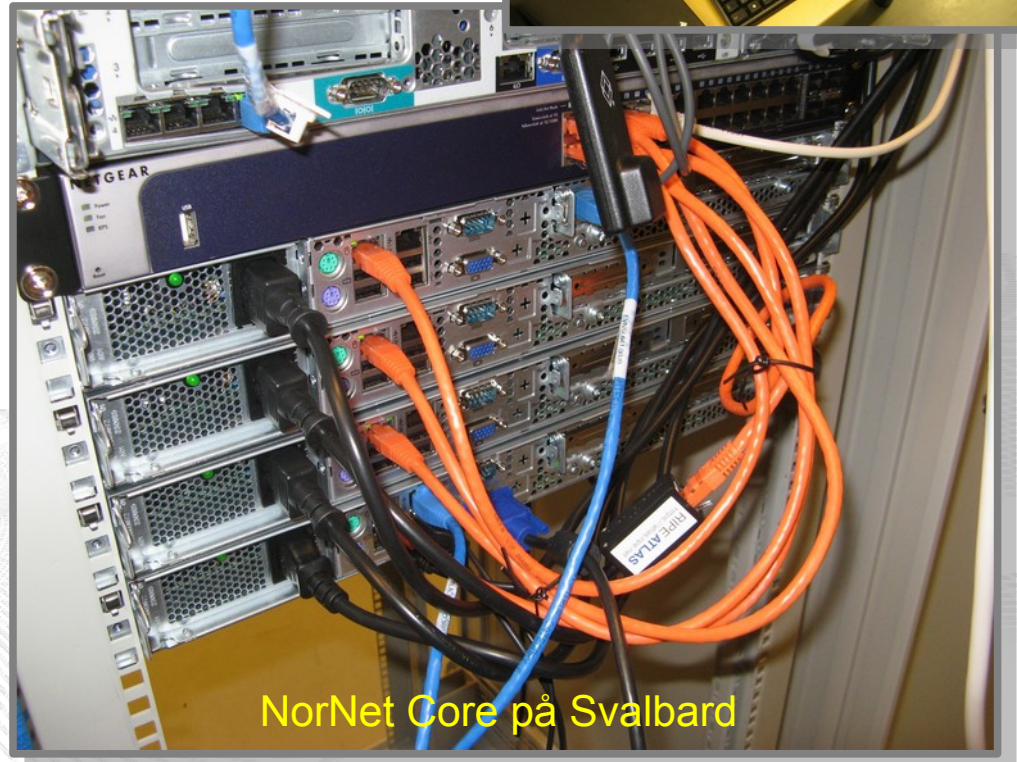
- 1x switch

- 4x server
    - 1x tunnelbox
    - 3x research systems

- At least two ISP connections
    - Research network provider
    - 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

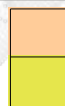NorNet Core på Svalbard

NorNet Core Site Deployment Status (May 2016)

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 海南大学	CERNET	China Unicom		
16	The University of Kansas	KanREN			
17	Korea University 고려대학교	KREONET			
18	National ICT Australia (NICTA)	AARNet			
19	HAW Hamburg	DFN			
20	Technische Universität Darmstadt	DFN			

- 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
(May 2016)
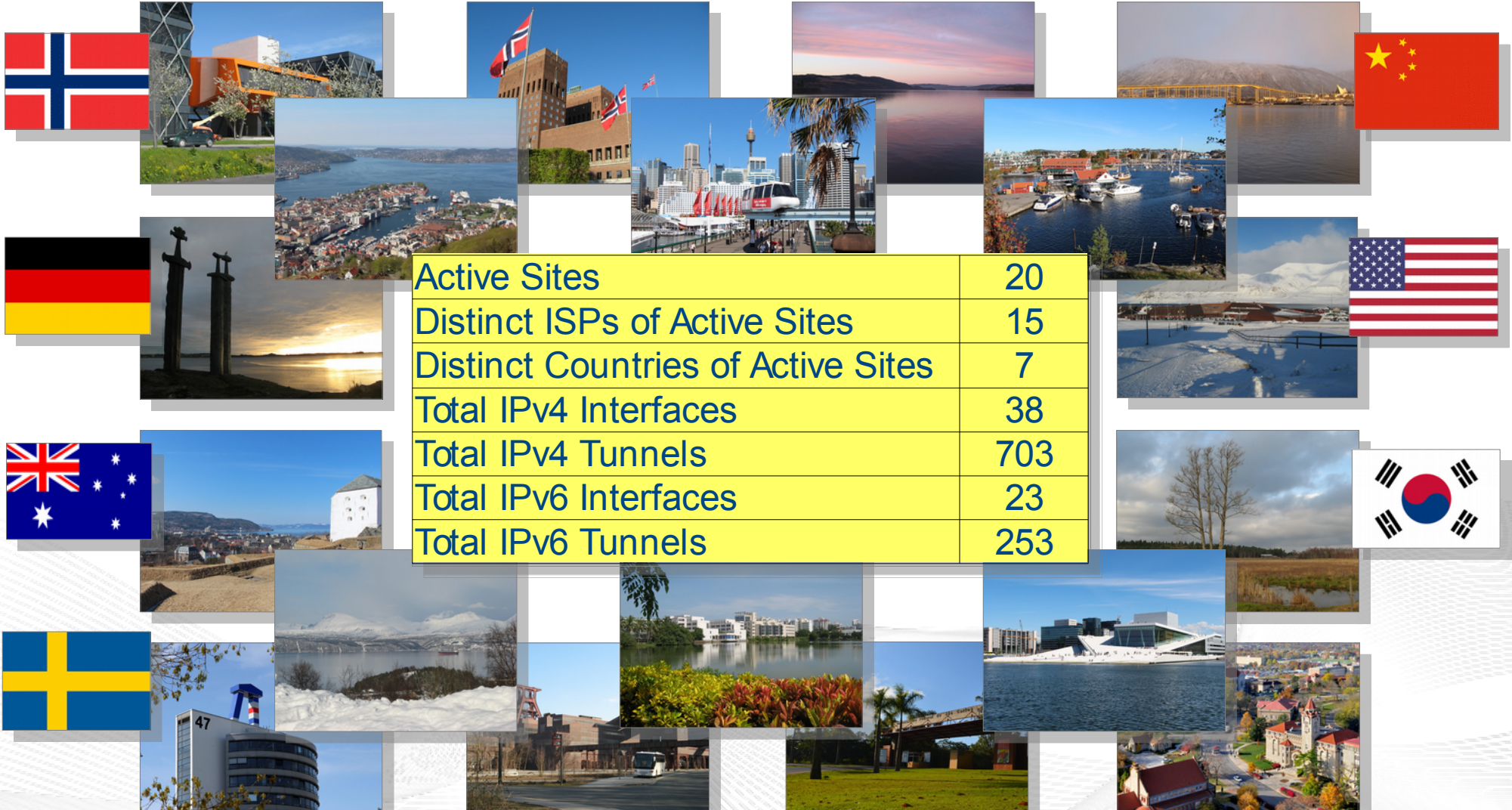
Active Sites	20
Distinct ISPs of Active Sites	15
Distinct Countries of Active Sites	7
Total IPv4 Interfaces	38
Total IPv4 Tunnels	703
Total IPv6 Interfaces	23
Total IPv6 Tunnels	253

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

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 14.04 LTS

    - KVM (Kernel-based Virtual Machine)

    - Other software runs in 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
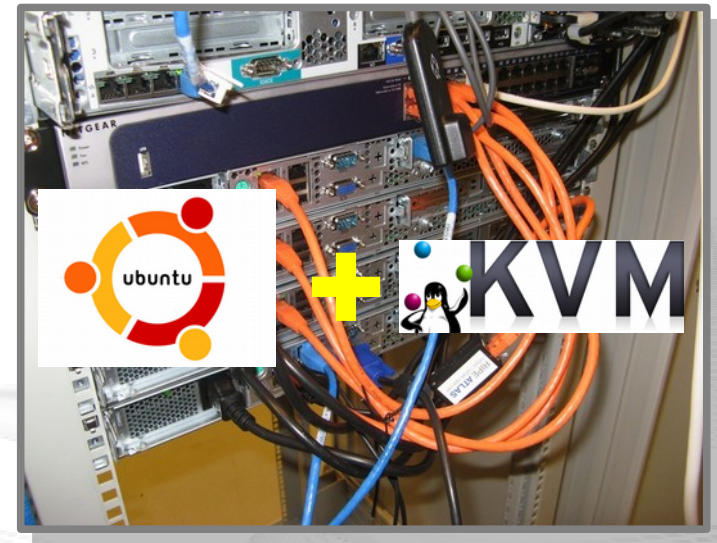
Overview:
NorNet Edge

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NorNet Edge – Wireless Network Conditions at Heterogeneous Locations

NorNet Edge needs to cover <u>many</u> locations!
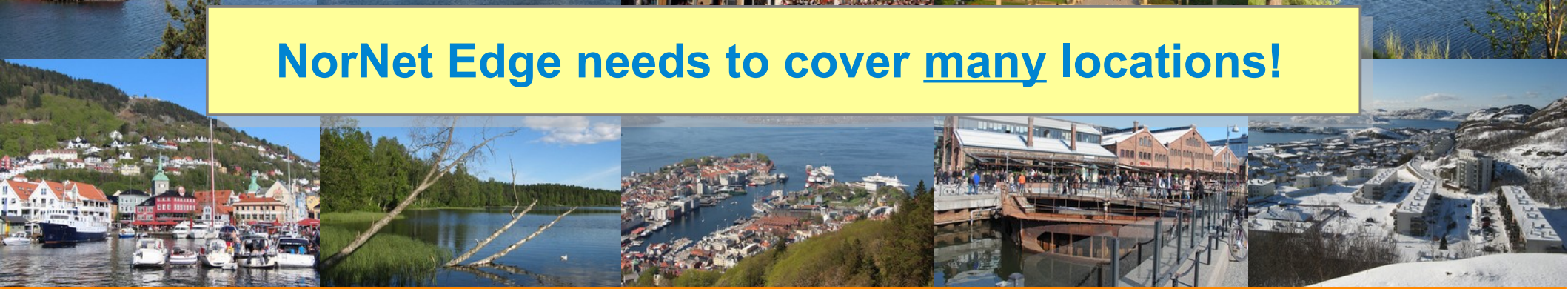
NorNet Edge Nodes

Ufoboard:

- Custom-made for NorNet

- Based on off-the-shelf smartphone board (Samsung Galaxy S)

- 1 GHz ARM Cortex-A8 CPU

- 512 MiB RAM

- 16-32 GB disk (SD card)

- 7 USB ports + Ethernet port

- Debian Linux 7.6 ("Wheezy")

The NorNet Edge Box: Ready for Deployment

Box contents:

- Ufoboard

- Up to 4x USB UMTS or LTE:

  - Telenor, Telia,

  - Network Norway, Tele2

- 1x ICE CDMA mobile broadband

- 1x Ethernet

- 1x WLAN (optional)

- Power supplies

- Handbook

NorNet Edge på Kringsjå, Oslo

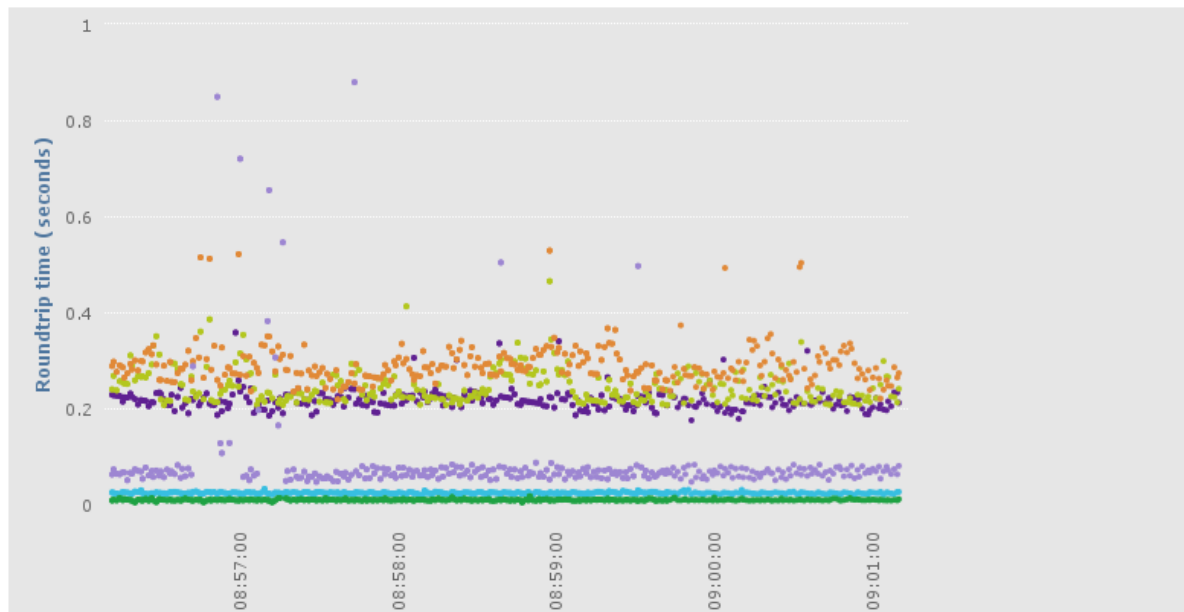NorNet
http://www.nntb.no

Live Visualisation of NorNet Edge (1)

See http://robustenett.no/map!
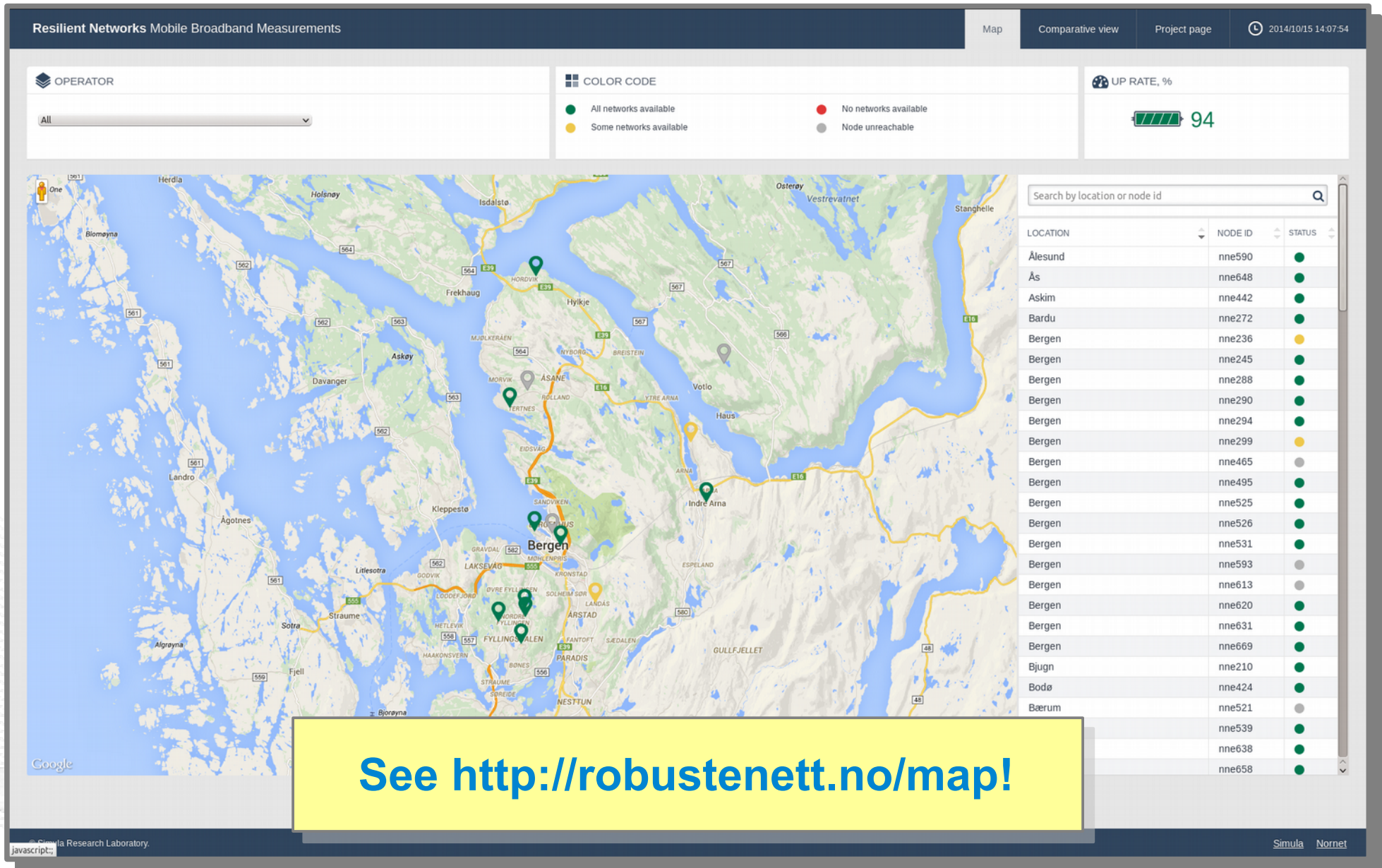
Live Visualisation of NorNet Edge (2): Real-Time Data and Statistics Database

See http://robustenett.no/map!

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Conclusion and Future Work

- The NorNet testbed is ready for experiments!

    – Do <u>you</u> have experiment ideas? → Talk to us!

- Future work:

    – Extend NorNet Core

        - More multi-homing, i.e. further ISPs, IPv6
        - Additional sites

    – Extend NorNet Edge

        - Cover additional countries
        - Node upgrades (UMTS → LTE, WLAN, subscriptions, …)

    – Improve and refine management software

    – Get more users, may be <u>you</u>?

And, of course, do more <u>research</u>!

Any Questions?

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