

Invited Talk at the University of Sydney

NorNet at the
University of Sydney

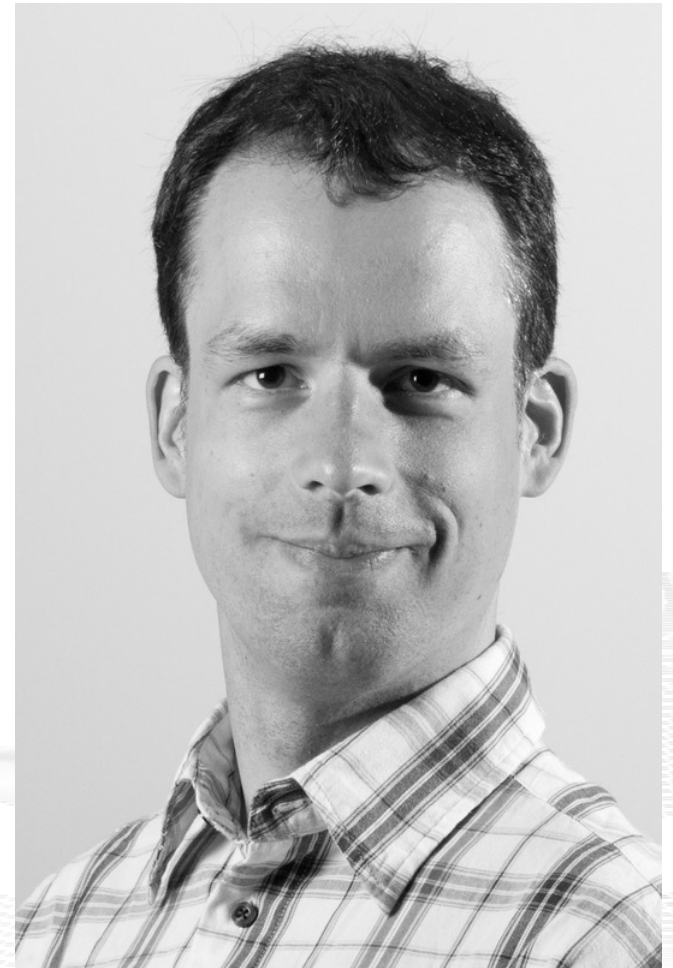
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An Introduction to the
NorNet Core Testbed

Thomas Dreibholz

Simula Research Laboratory

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Contents

- About Norway and the Simula Research Laboratory
- Motivation
- The NorNet Core Testbed
- Conclusion

Overview:

About Norway and the Simula Research Laboratory

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Where is Norway?



Oslo 奥斯陆



ca. 7,100 km



Beijing 北京

ca. 16,000 km



Sydney
悉尼

Facts about Norway

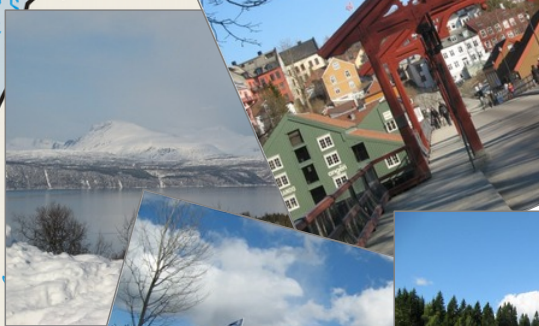
Capital: Oslo
Size: ca. 385,000 km²
Population: ca. 5,165,800
Internet TLD: .no



The Kingdom of Norway (Kongeriket Norge)



King Harald V



The Simula Research Laboratory

- Located in Fornebu
 - Just outside of Oslo
 - In the IT Fornebu complex
- Public limited company
 - Non-profit research organisation
 - 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

[**simula** . research laboratory]



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

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 ...

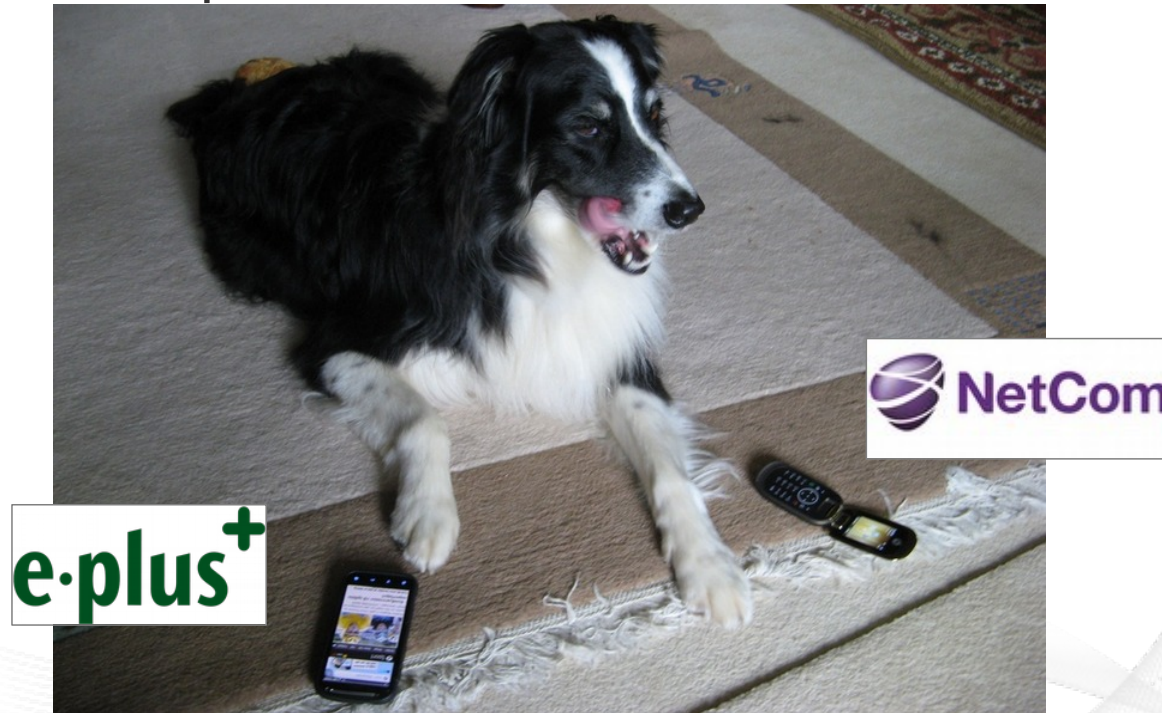


How to make networks more robust?

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

NORNET

<https://www.nntb.no>

Overview: The NorNet Project

- About Norway and the Simula Research Laboratory
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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 + CN, DE (4x), SE, US, KR, AU
 - Edge: hundreds of nodes in Norway



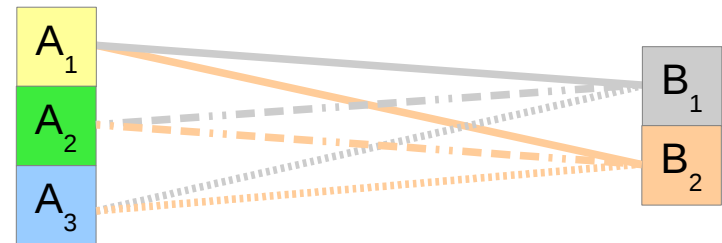
Overview:

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:

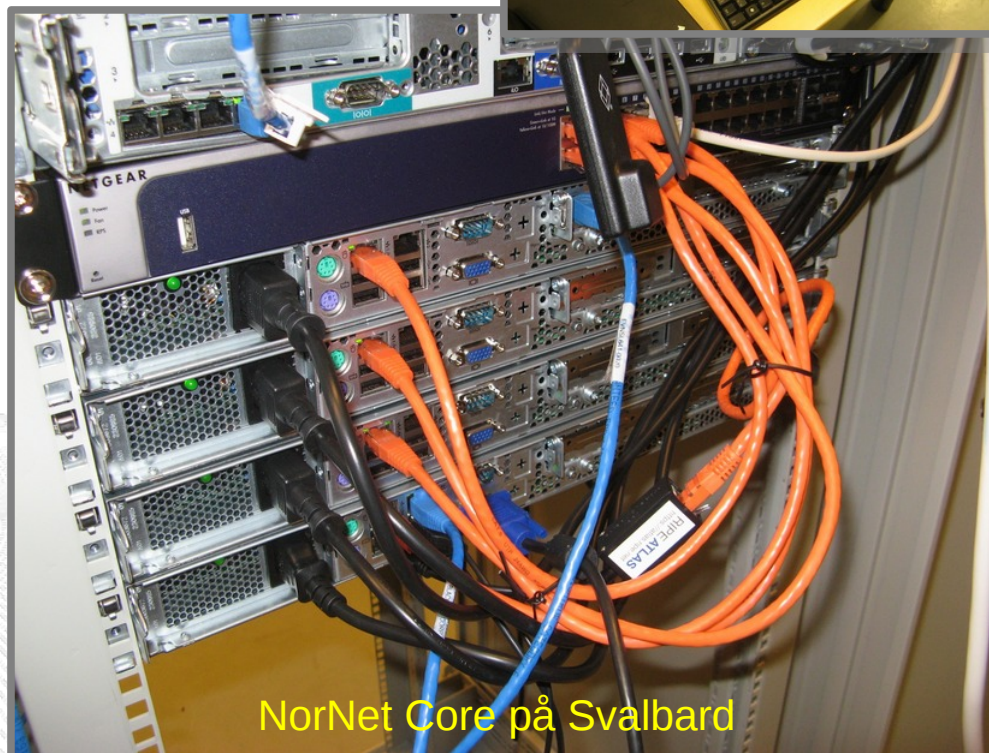
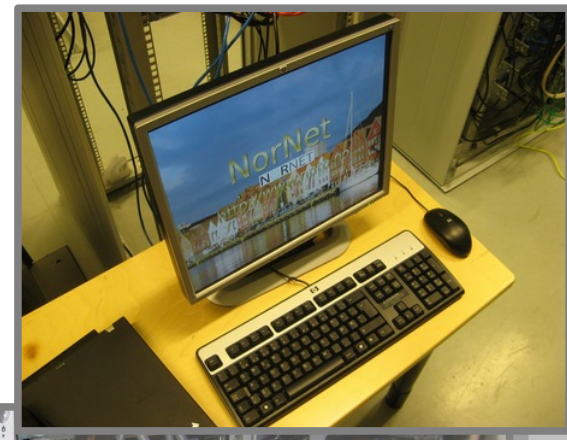
- 1x switch
- 4x server
 - 1x tunnelbox
 - 3x research systems
- At least two ISP connections
 - Research network provider
 - Other providers
- IPv4 and IPv6 (if available)

Additional researcher-provided sites:

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



Longyearbyen 78.2°N,15.6°E



NorNet Core Site Deployment Status (December 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			
21	Haikou Cg. of Econ. 海口经济学院	China Telecom	CERNET		

- IPv4 and IPv6
- IPv4 only (ISP without IPv6 support ☹)
- IPv4 only (site's network without IPv6 support)
- ISP negotiation in progress

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

Some Site Statistics (January 2017)



Active Sites	23
Distinct ISPs of Active Sites	18
Distinct Countries of Active Sites	8
Total IPv4 Interfaces	42
Total IPv4 Tunnels	861
Total IPv6 Interfaces	26
Total IPv6 Tunnels	325

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

Remote Systems

❄ -30°C
Longyearbyen

Our servers may be really remote!

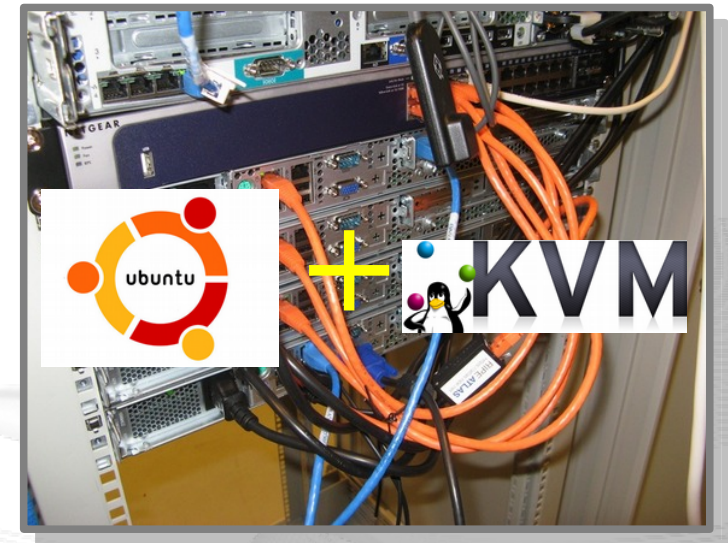


The “road” to Longyearbyen på Svalbard, 78.2°N

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 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



You may use NorNet Core, too!

**Join the tutorial session today!
Here at the University of Sydney!**

- Contents:
 - Get access to NorNet Core
 - User and slice management
 - Access to slices
 - Using and configuring slivers with own software
 - How to make use of multi-homing?

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Conclusion and Future Work

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

- The NorNet Core testbed is ready for experiments!
 - Do you have experiment ideas? → Talk to us!
- Future work:
 - NorNet Core
 - More multi-homing, i.e. further ISPs, IPv6
 - Additional sites
 - Improve and refine management software
 - Get more users, may be you?



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

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



<https://www.nntb.no>

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