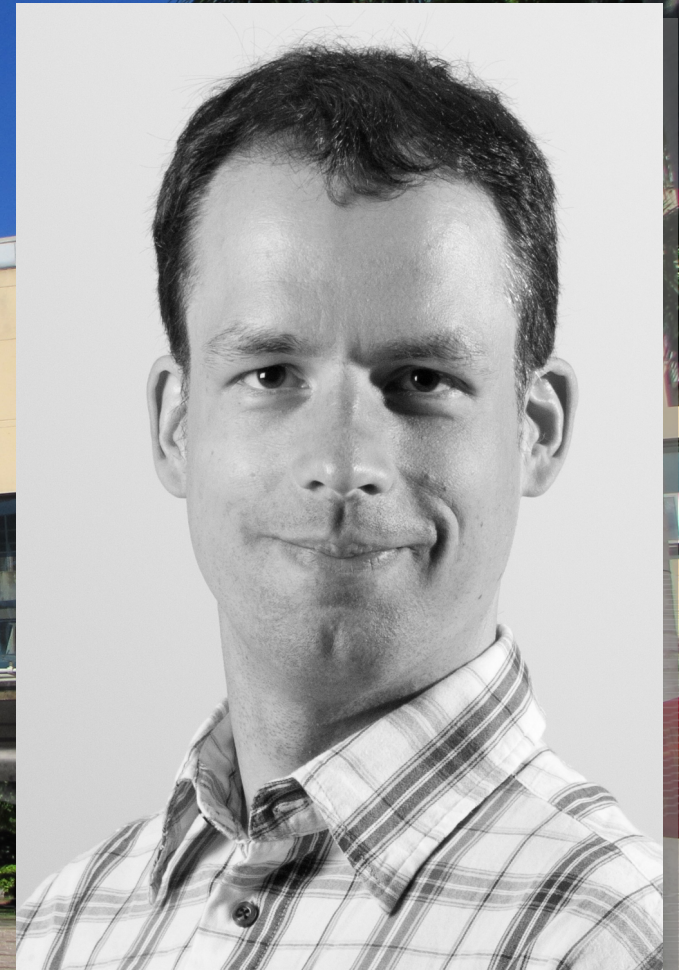**Invited Talk at Hainan University（海南大学）**

Combining NorNet Core with MELODIC

Thomas Dreibholz（托马斯博士）

Simula Research Laboratory

29 December 2017

[simula . research laboratory]

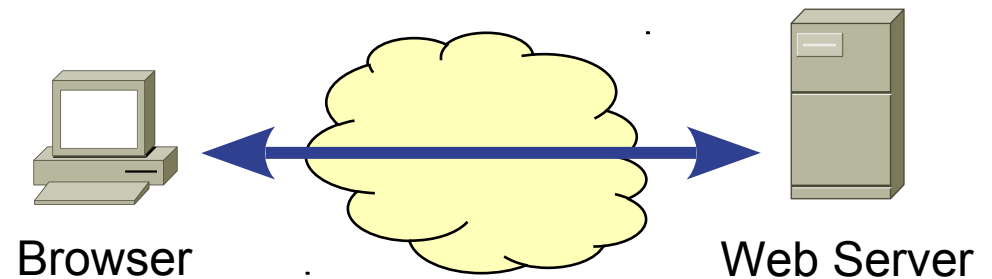*- by thinking constantly about it*

Contents

- Motivation

- The NorNet Testbed

- Combination with MELODIC

- Conclusion

- Literature

„Classic" Internet Communication

- Example: World-Wide Web

Browser   Web Server
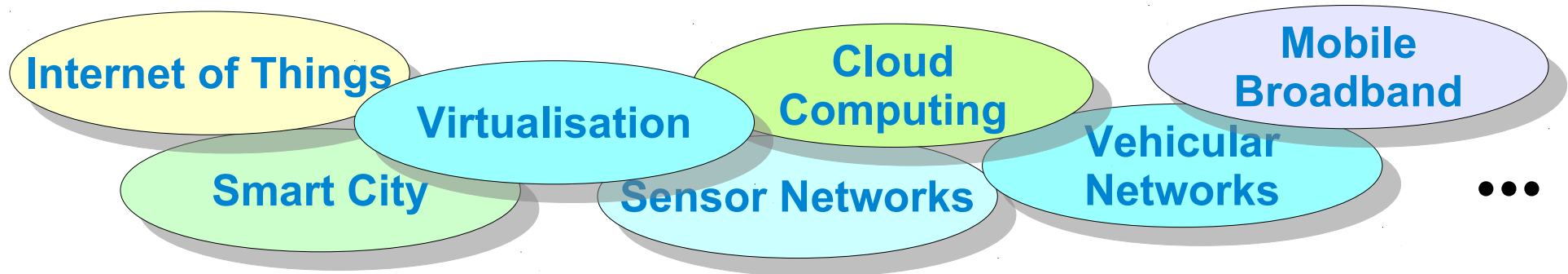
- Client ↔ Server Communication
  - 1 network interface per device → 1 **IPv4** address
  - Communication with Transmission Control Protocol (**TCP**)

The Current and Future Internet
The Big Picture

Internet of Things

Virtualisation

Cloud Computing

Mobile Broadband

Smart City

Sensor Networks

Vehicular Networks

· · ·

- IPv6
  - Devices are frequently IPv4/IPv6 dual stack
  - Usually multiple addresses per interface
- Mobility → address change
- Devices with multiple interfaces
  - Router
  - **Smartphone** (LTE/UMTS, WLAN, Bluetooth?)
  - **Laptop** (Ethernet, WLAN, LTE/UMTS?)

WLAN

2G/3G/4G

Bluetooth

Multi-Homing and Multi-Path Transport

- Multi-Homing

  - Multiple interfaces (addresses)

  - **Redundancy** →
    Communication even when
    some paths fail

- Multi-Path Transport

  - Also utilise paths <u>simultaneously</u>
    → better throughput

  - **MPTCP:** Multi-Path TCP

  - **CMT-SCTP:** Concurrent
    Multi-Path Transfer for SCTP

Redundancy is <u>expensive</u>!

telenor

Telia

SCTP: Stream Control Transmission Protocol
TCP: Transmission Control Protocol

We need a realistic Internet testbed for testing and research!

Idea: Distribution of NorNet Testbed 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, SE, US, KR, AU, FR
  - Edge: hundreds of nodes in Norway

A NorNet Core Site Deployment
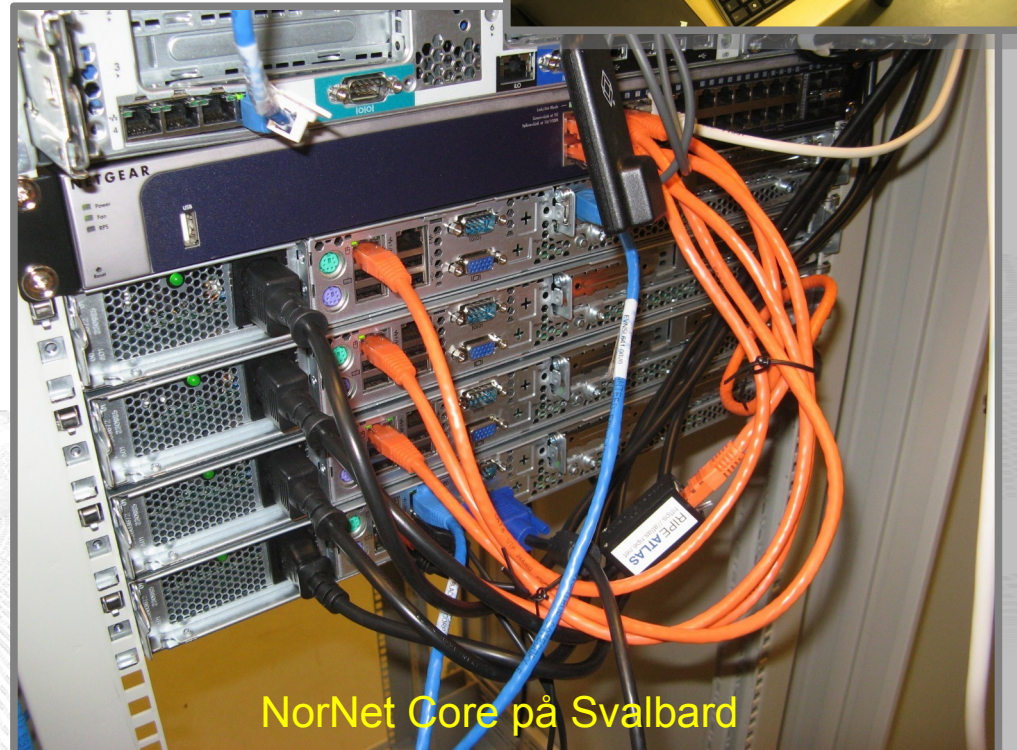
A usual NorNet Core site:

- 1x switch

- 4x server

  - 1x router (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
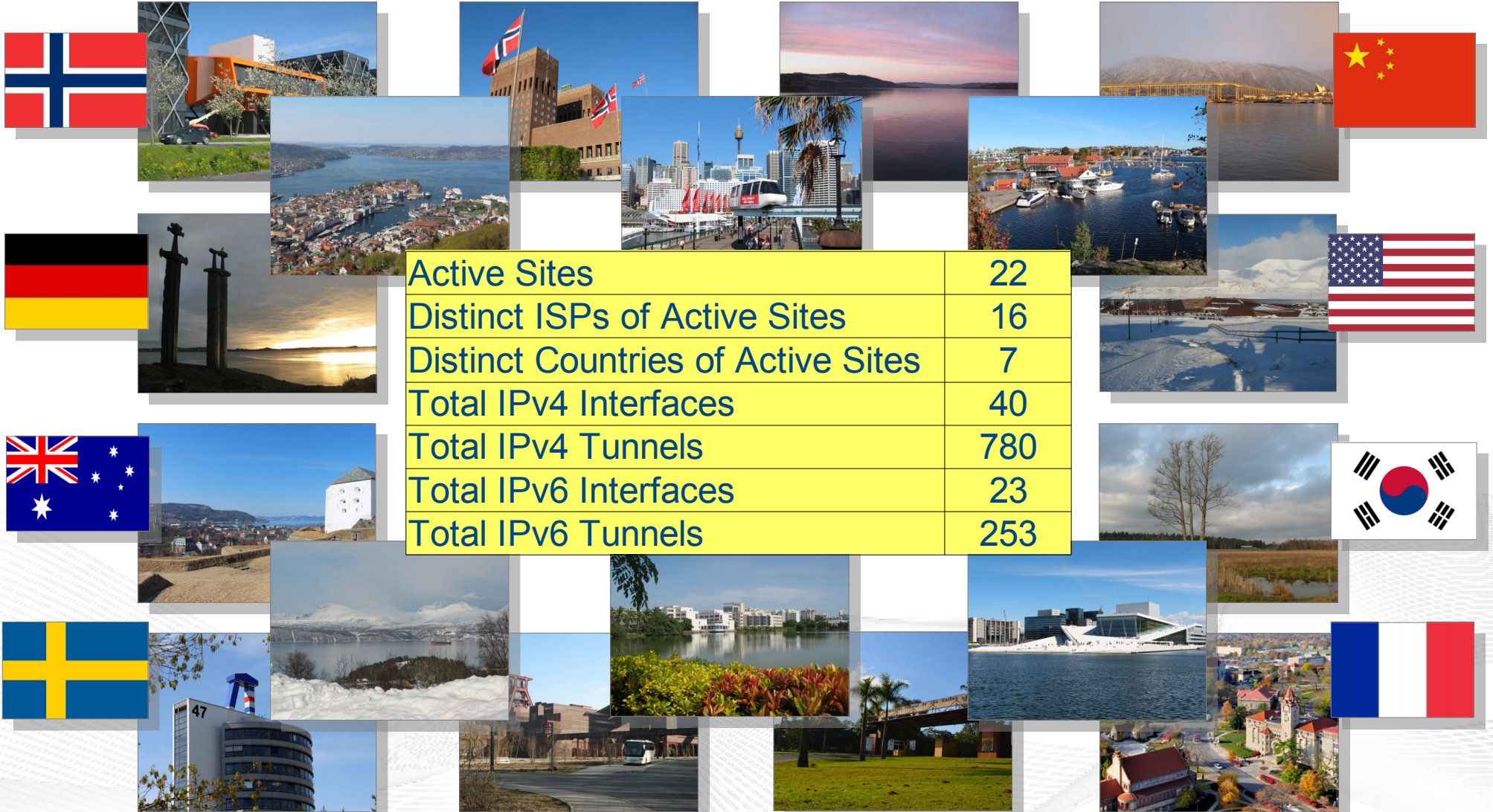
NorNet Core på Svalbard

NorNet Core Site Deployment Status (December 2017)

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	HAW Hamburg	DFN			
19	Technische Universität Darmstadt	DFN			
20	Lab. Informatique Grenoble	RENATER			
21	New York University	Lightower			
22	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
(December 2017)

Active Sites	22
Distinct ISPs of Active Sites	16
Distinct Countries of Active Sites	7
Total IPv4 Interfaces	40
Total IPv4 Tunnels	780
Total IPv6 Interfaces	23
Total IPv6 Tunnels	253

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

[simula . research laboratory]   *- by thinking constantly about it*

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 16.04 LTS

  - KVM (Kernel-based Virtual Machine)

  - Other software runs in VMs:

    - Tunnelbox (router)

    - Research nodes (users' experiments)

  - In case of problem: manual/automatic restart or reinstall of VM
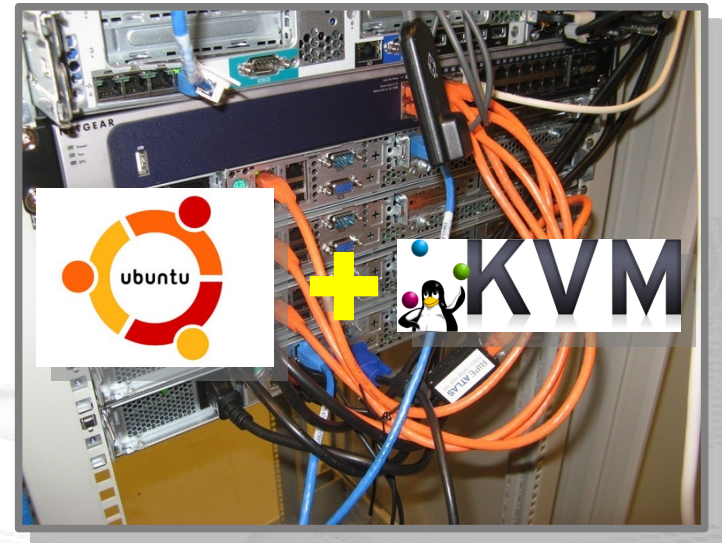
Combination of NorNet Core with MELODIC!

NorNet Core systems on top of MELODIC!

- OpenStack for managing VMs
  - VMs with different operating systems (Linux, FreeBSD, AROS, …)
    - Access to multiple ISPs per site
    - IPv4 and IPv6
  - Easy management of sites, VMs, users, storage, …
- VMs for MELODIC users at interesting locations
- Current status:
  - Controller at Simula (nisse.nntb.no)
  - 2 powerful new servers (troll.nntb.no, huldra.nntb.no)

Details for further discussion!

Conclusion and Ongoing Work

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

- The NorNet Core testbed is ready for experiments!

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

- Ongoing work:

  - NorNet Core combination with MELODIC

    - **OpenStack support**

    - Opportunities for interesting
      tests, experiments, student projects, ...

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

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