Invited Talk at Kungliga Tekniska högskolan Stockholm

The NorNet Testbed
An Overview for the GENI Meeting

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Overview:
Motivation

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  – NorNet Edge
• Users and Research
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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 ...
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:
  - 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 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)

Additional researcher-provided sites:

- Varying configurations
- VM setups, powerful servers, “retro-style” PCs ...
# Site Deployment Status (September 2014)

<table>
<thead>
<tr>
<th>No.</th>
<th>Site</th>
<th>ISP 1</th>
<th>ISP 2</th>
<th>ISP 3</th>
<th>ISP 4</th>
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<tr>
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<td>Uninett</td>
<td>Kvantel</td>
<td>Telenor</td>
<td>PowerTech</td>
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<td>Telenor</td>
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<td>SUNET</td>
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<td>Hainan University</td>
<td>CERNET</td>
<td>China Unicom</td>
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<td>16</td>
<td>The University of Kansas</td>
<td>KanREN</td>
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</tr>
</tbody>
</table>

- **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](https://www.nntb.no/pub/nornet-configuration/NorNetCore-Sites.html)
Some Site Statistics (September 2014)

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Sites</td>
<td>16</td>
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<tr>
<td>Distinct ISPs of Active Sites</td>
<td>13</td>
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<td>Distinct Countries of Active Sites</td>
<td>5</td>
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<tr>
<td>Total IPv4 Interfaces</td>
<td>34</td>
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<tr>
<td>Total IPv4 Tunnels</td>
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<tr>
<td>Total IPv6 Interfaces</td>
<td>22</td>
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<tr>
<td>Total IPv6 Tunnels</td>
<td>231</td>
</tr>
<tr>
<td>Inactive Sites</td>
<td>0</td>
</tr>
</tbody>
</table>

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

Our servers may be really remote!

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

- 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

“Anything that can go wrong, will go wrong.”
[Murphy's law]
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

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

Special requirements for your experiment? Ask!
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NorNet Edge

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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
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)
  - ...

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: 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: … [planned]/Australia

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
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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 (further ISPs, 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!
Any Questions?

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