Invited Talk at the Centre for Advanced Internet Architectures

NorNet
An Open, Large-Scale Testbed for Multi-Homed Systems

Thomas Dreibholz, dreibh@simula.no
Simula Research Laboratory A/S

30 January 2014
Contents

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

http://www.nntb.no
Overview:
The NorNet Project

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

- **NorNet Core:**
  - Currently 10+3 sites

- **NorNet Edge:**
  - Currently ca. 400 nodes
Overview:
NorNet Core

- Motivation
- The NorNet Testbed
  - NorNet Core
  - NorNet Edge
- Research and Users
- Conclusion
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:
  - IPv6: 2001:700:4100:<PP><SS>::/64 (PP=Provider ID; SS=Site ID)

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)
## Site Deployment Status (January 2014)

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Primary ISP</th>
<th>Second ISP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simula Research Laboratory</td>
<td>Fornebu, Akershus</td>
<td>UNINETT</td>
<td>Kvantel (Hafslund)</td>
</tr>
<tr>
<td>Universitetet i Oslo</td>
<td>Blindern, Oslo</td>
<td>UNINETT</td>
<td>PowerTech</td>
</tr>
<tr>
<td>Høgskolen i Gjøvik</td>
<td>Gjøvik, Oppland</td>
<td>UNINETT</td>
<td>PowerTech</td>
</tr>
<tr>
<td>Universitetet i Tromsø</td>
<td>Tromsø, Troms</td>
<td>UNINETT 1</td>
<td>PowerTech</td>
</tr>
<tr>
<td>Universitetet i Stavanger</td>
<td>Stavanger, Rogaland</td>
<td>UNINETT 1</td>
<td>BKK</td>
</tr>
<tr>
<td>Universitetet i Bergen</td>
<td>Bergen, Hordaland</td>
<td>UNINETT</td>
<td>BKK</td>
</tr>
<tr>
<td>Universitetet i Agder</td>
<td>Kristiansand, Vest-Agder</td>
<td>UNINETT 4</td>
<td>PowerTech</td>
</tr>
<tr>
<td>Universitetet på Svalbard</td>
<td>Longyearbyen, Svalbard</td>
<td>UNINETT 1</td>
<td>Telenor 4</td>
</tr>
<tr>
<td>NTNU Trondheim</td>
<td>Trondheim, Sør-Trøndelag</td>
<td>UNINETT</td>
<td>PowerTech</td>
</tr>
<tr>
<td>Høgskolen i Narvik</td>
<td>Narvik, Norland</td>
<td>UNINETT</td>
<td>PowerTech</td>
</tr>
<tr>
<td>University of Duisburg-Essen</td>
<td>Essen/Germany</td>
<td>DFN</td>
<td>Versatel 2,3</td>
</tr>
<tr>
<td>Hainan University</td>
<td>Haikou, Hainan/China</td>
<td>CERNET 1</td>
<td>China Unicom 1</td>
</tr>
<tr>
<td>Karlstads Universitet</td>
<td>Karlstad, Värmland/Sweden</td>
<td>SUNET</td>
<td>_ 4</td>
</tr>
</tbody>
</table>

1) IPv6 available from ISP, but not deployed to NorNet Core site
2) IPv6 not available from ISP 😞
3) Consumer-grade ADSL connection
4) Negotiations in progress

---

What about a site at CAIA/Swinburne University?
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*
    - We are involved in testing the LXC software
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!
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
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
Monitoring

- PlanetLab:
  - 575 nodes of 1042 nodes alive (September 9, 2013) ⇒ availability ca. 55%
  - NorNet should do much better!
- Direct contact to technical staff/researchers at sites
- Monitoring using Nagios
  - Flexible
  - Extendable by service-specific plug-ins

How to visualise NorNet?
“Kontrollsenteret”

Velkommen til NorNet-Kontrollsenter på Simula Research Laboratory, Fornebu

Lokasjon

Problemer:

😊 Ingen problem! 😊

I orden:
- Strømsgolen i Gjøvik
- Gripingskolen i Narvik
- Simula Research Laboratory
- Universitetet i Agder
- Universitetet i Bergen
- Universitetet i Oslo
- Universitetet i Stavanger
- Universitetet i Tromsø
- Universitetet i Trondheim
- Universität Duisburg-Essen

For mer informasjon om NorNet-prosjektet, se http://www.norNet.no

-simularesearchlaboratory- by thinking constantly about it
Overview:
NorNet Edge

- Motivation
- The NorNet Testbed
  - NorNet Core
  - NorNet Edge
- Research and Users
- Conclusion
The NorNet Edge Box: Ready for Deployment (1)

Box contents:

- Beagle Bone or Ufoboard embedded Linux system
- 4x USB UMTS:
  - Telenor, NetCom,
  - Network Norway, Tele2
- 1x ICE CDMA mobile broadband
- 1x Ethernet
- Power supplies
- Handbook
The NorNet Edge Box: Ready for Deployment (2)

Box contents:

- Ufoboard embedded Linux system (3.11.x)
- **MPTCP (0.88)**
- 4x USB UMTS:
  - Telenor, NetCom,
  - Network Norway, Tele2
NorNet Edge Visualisation

See http://demo.robustenett.no!
Overview:
Research

- Motivation
- The NorNet Testbed
  - NorNet Core
  - NorNet Edge
- Research and Users
- Conclusion
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 by **CAIA/Swinburne University**!

Just talk with us about the details!
Overview:

Conclusion

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

- The NorNet testbed is progressing!
  - Initial deployment completed
  - Software setup already used for some 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

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!