

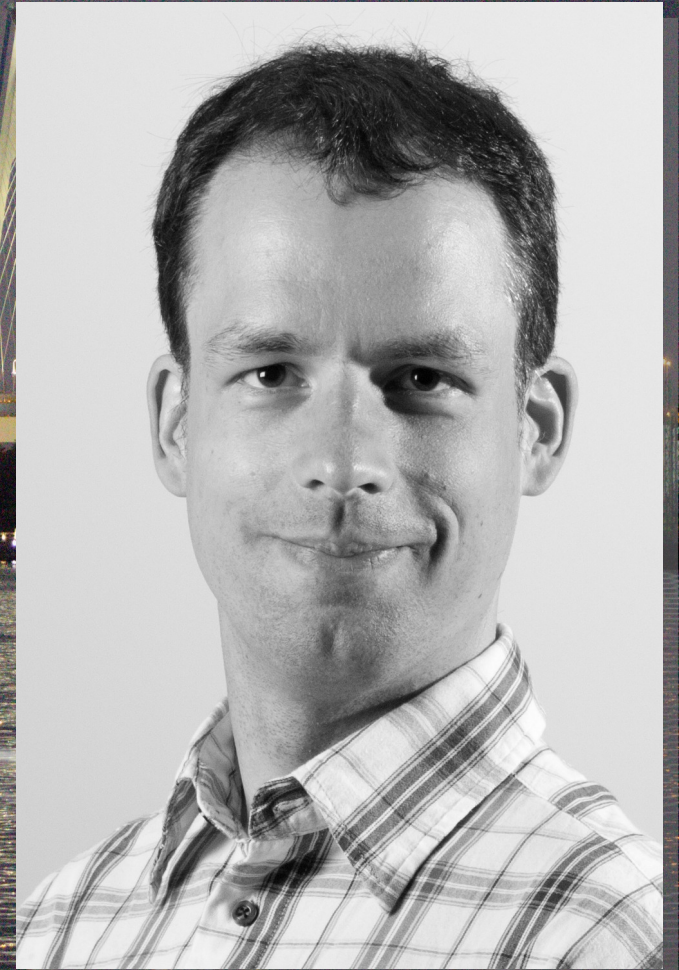
Tutorial at Hainan University (海南大学)

NorNet at Hainan University: Getting Started with NorNet Core

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16 April 2019



Contents

- Preparations
- Getting an Overview of the Testbed
- Using a Slice
- A Practical Example
- Conclusion
- Literature

Overview: Preparations

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Tutorial Accounts

- You should have received an account
 - Username
 - Password
- Valid for:
 - SSH login server
 - PLC server

Do you have an account? If not, ask!

Initial Tasks

- **Account for our SSH login server gatekeeper.nntb.no:**
 - Server is gateway into NorNet Core network
 - `ssh <username>@gatekeeper.nntb.no`
 - Use port forwarding to access PLC and Monitor servers:
 - `ssh <username>@gatekeeper.nntb.no \`
`-L 2000:plc.simula.nornet:443 \`
`-L 2001:monitor.simula.nornet:80`
 - Forwards TCP port 2000 to PLC server's HTTPS port
 - Forwards TCP port 2001 to Monitor server's HTTP port
- **Account for the PLC server plc.simula.nornet (inside NorNet Core only):**
 - Login: *<your e-mail address>*
- **VPN into NorNet Core may be possible in the future**

Try to directly connect to your NorNet Core switch

Access to PLC and Monitor

- Via port forwarding:
 - Monitor: <http://localhost:2001/>
 - PLC: <https://localhost:2000/>
- Inside NorNet Core network:
 - Monitor: <http://monitor.simula.nor-net>
 - PLC: <https://plc.simula.nor-net>

Is everybody able to log in?

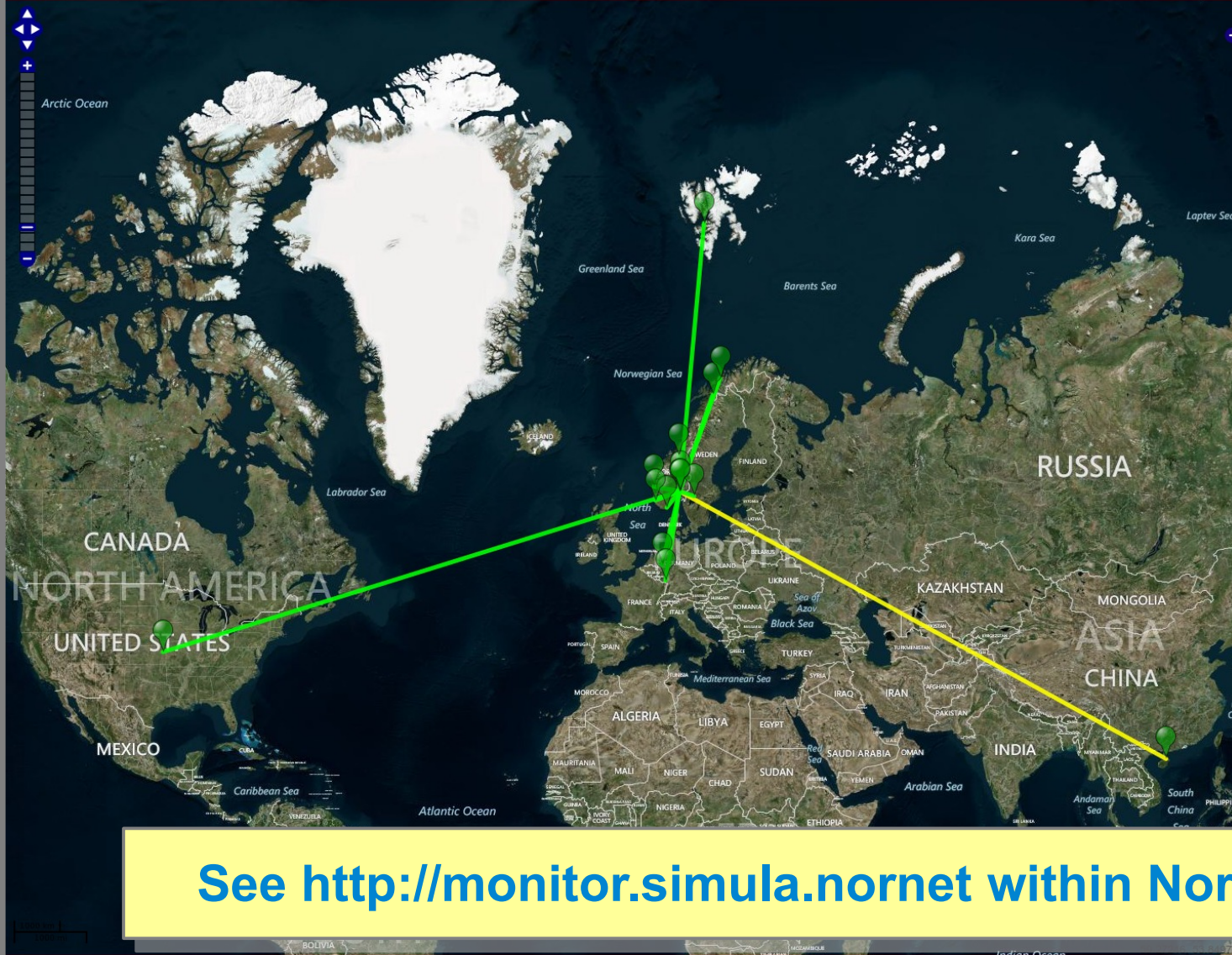
Overview:

Getting an Overview of the Testbed

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“Kontrollsenteret”

Velkommen til NorNet-Kontrollsenter på Simula Research Laboratory, Fornebu



15:10:22

Mandag, 28. juli 2014

Lofasjon

Problemer:

😊 Ingen problem! 😊

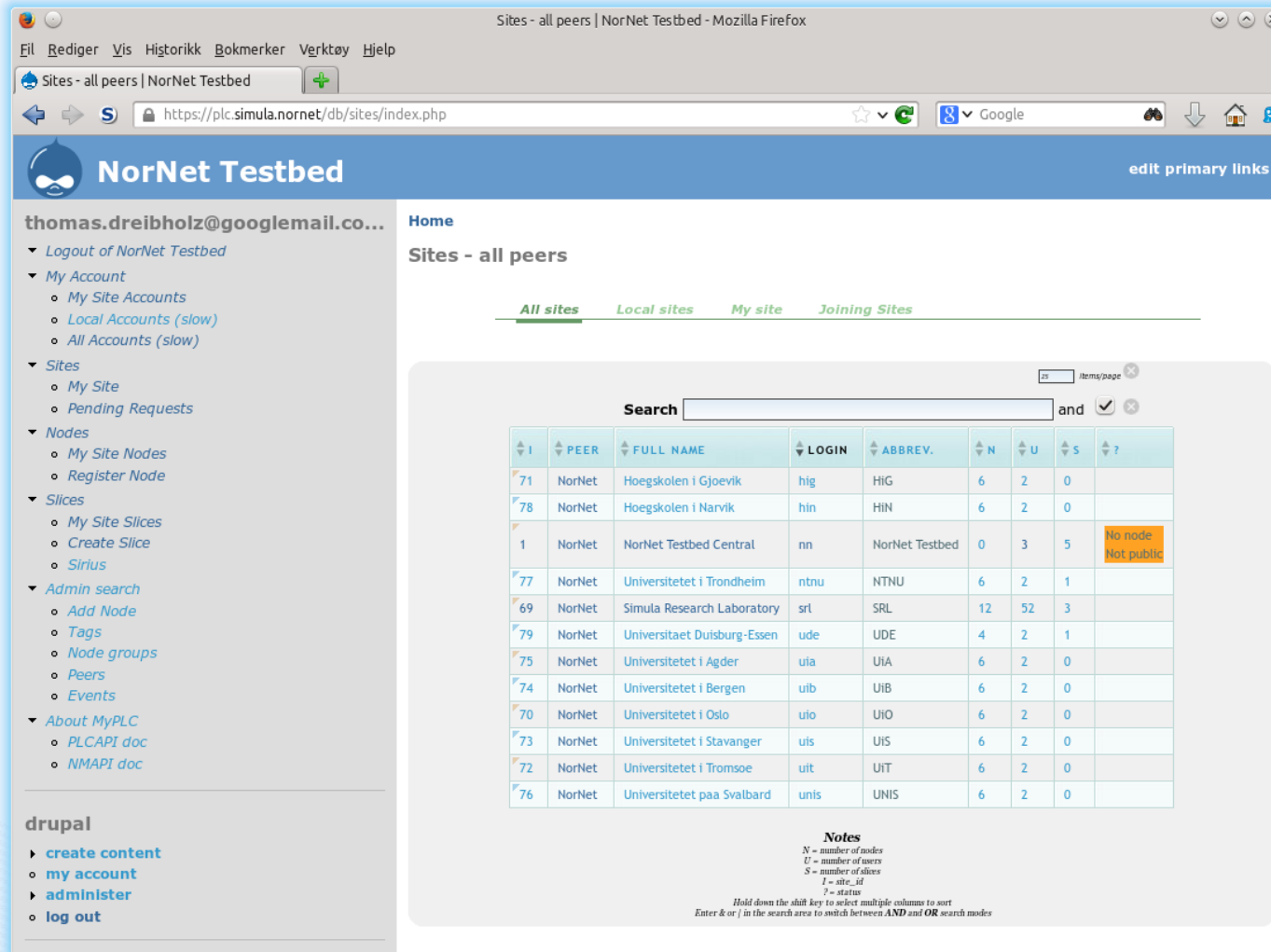
J orden:

- @Hainan University
- @Høgskolen i Gjøvik
- @Høgskolen i Narvik
- @Høgskolen i Oslo og Akershus
- @Karlstads Universitet
- @Simula Research Laboratory
- @Universitetet i Agder
- @Universitetet i Bergen
- @Universitetet i Oslo
- @Universitetet i Stavanger
- @Universitetet i Tromsø
- @Universitetet i Trondheim

See <http://monitor.simula.nor-net> within NorNet Core!

For mer informasjon om NorNet-prosjektet, se <https://www.nnfd.no>!

PLC User Interface: Sites View



NorNet Testbed edit primary links

thomas.dreibholz@googlemail.co... Home

Sites - all peers

[All sites](#) [Local sites](#) [My site](#) [Joining Sites](#)

Search and

↓ ↑ 1	↓ ↑ PEER	↓ ↑ FULL NAME	↓ ↑ LOGIN	↓ ↑ ABBREV.	↓ ↑ N	↓ ↑ U	↓ ↑ S	↓ ↑ ?
71	NorNet	Hoegskolen i Gjoevik	hig	HiG	6	2	0	
78	NorNet	Hoegskolen i Narvik	hin	HiN	6	2	0	
1	NorNet	NorNet Testbed Central	nn	NorNet Testbed	0	3	5	No node Not public
77	NorNet	Universitetet i Trondheim	ntnu	NTNU	6	2	1	
69	NorNet	Simula Research Laboratory	srl	SRL	12	52	3	
79	NorNet	Universitaet Duisburg-Essen	ude	UDE	4	2	1	
75	NorNet	Universitetet i Agder	uia	UIA	6	2	0	
74	NorNet	Universitetet i Bergen	uib	UiB	6	2	0	
70	NorNet	Universitetet i Oslo	uio	UiO	6	2	0	
73	NorNet	Universitetet i Stavanger	uis	UIS	6	2	0	
72	NorNet	Universitetet i Tromsoe	uit	UiT	6	2	0	
76	NorNet	Universitetet paa Svalbard	unis	UNIS	6	2	0	

Notes
N = number of nodes
U = number of users
S = number of slices
1 = site_id
? = status
Hold down the shift key to select multiple columns to sort
Enter & or | in the search area to switch between AND and OR search modes

drupal

- create content
- my account
- administer
- log out

See <https://plc.simula.nor-net> within NorNet Core!

PLC User Interface: Nodes View

The screenshot shows the 'Nodes - all peers' view in the NorNet Testbed interface. The browser address bar shows the URL `https://plc.simula.nor-net/db/nodes/index.php`. The page has a sidebar with user information and navigation links, and a main content area with a table of nodes.

Node table layout
can't open file

Add/remove columns

Column	Description	Selected
A	Architecture name	<input type="checkbox"/>
DA	Date added	<input type="checkbox"/>
DL	Deployment	<input type="checkbox"/>
DN	Toplevel domain name	<input type="checkbox"/>
IP	IP address	<input checked="" type="checkbox"/>
OS	Operating system	<input type="checkbox"/>
SN	Site name	<input checked="" type="checkbox"/>

Column description and configuration

Authority

Node state: should be "boot"

Search []

ID	HOSTNAME	AU	ST	RES	IP	SN	?
456	adventfjorden.unis.nor-net	NorNet	boot		10.1.4.104	unis	
404	akerbrygge.simula.nor-net	NorNet	boot		10.1.1.100	srl	
414	akerseiva.simula.nor-net	NorNet	boot		10.1.1.110	srl	
470	altenessen.ude.nor-net	NorNet	boot		10.30.42.100	ude	
428	amundsen.uit.nor-net	NorNet	boot		10.1.4.100	uit	
432	arctandria.uit.nor-net	NorNet	boot		10.1.4.104	uit	
436	askje.uis.nor-net	NorNet	boot		10.1.5.102	uis	
430	aunegaarden.uit.nor-net	NorNet	boot		10.1.4.102	uit	
459	bakklandet.ntnu.nor-net	NorNet	boot		10.1.9.101	ntnu	
471	baldeneysee.ude.nor-net	NorNet	boot		10.30.42.101	ude	

PLC User Interface: Account View

The screenshot shows a web browser window titled "Details for account Thomas Dreibholz | NorNet Testbed - Mozilla Firefox". The address bar shows the URL "https://plc.simula.nornet/db/persons/index.php?id=25". The page content includes a navigation menu on the left and a main section titled "Details for account Thomas Dreibholz".

Navigation Menu:

- Logout of NorNet Testbed
- My Account
 - My Site Accounts
 - Local Accounts (slow)
 - All Accounts (slow)
- Sites
 - My Site
 - Pending Requests
- Nodes
 - My Site Nodes
 - Register Node
- Slices
 - My Site Slices
 - Create Slice
 - Sirius
- Admin search
 - Add Node
 - Tags
 - Node groups
 - Peers
 - Events
- About MyPLC

Account Details:

Home Details for account Thomas Dreibholz

[Become](#) [Disable](#) [Delete](#)

Details

Title	<input type="text"/>
First Name	Thomas
Last Name	Dreibholz
Email	thomas1@simula.nornet
SFA hrn	planetlab.test.srl.thomas1
Phone	<input type="text"/>
URL	thomas.dreibholz@googlemail.com
Bio	<input type="text"/>
Password	*****

One key

TYPE	KEY	
ssh-rsa	AAAAB3NzaC1yc2EAAAADAQABAAQDboXaLZxyrD3njS5ZvN59tsrJ2F9ougn/VL_Ohni+182GZ8dDpE1wHseOR05oHrOL8kUWaaahJ/zGrISpo1tRBknZCkXlsZY5Ev+hwJndOnjFCovr3FJ3QuOmyO6UY0oMH/fsah7zhmrVENw3739ysljKbbxGIBF8lnCCqahywxHJzs2Gh0IDbc.4pCbTTAmk1TwI7bWGGQeEINadhfk4z1OeYW2GvoLVZYWppfrWxftBjDjJ6nTY2xBGDlr2aL3AQYxhdiDstwntGVKGPBaWcyBIDU6zVJKbDU9tarMLuDH8DQoGsv8OCq61eESbZYWjAWLJsJNWyUp+n/DZfFLBy5KQH thomas1@oesthorn.simula.nornet	<input type="checkbox"/>
ssh		<input type="checkbox"/>

Upload new key [Bla gjennom ...](#) Ingen fil valgt. [Remove keys](#) [Upload key](#)

- Upload your SSH public key here!
- Public keys get distributed to all nodes (may take up to 1 hour!)

Overview: Using a Slice

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The Test Slice *srl_test*

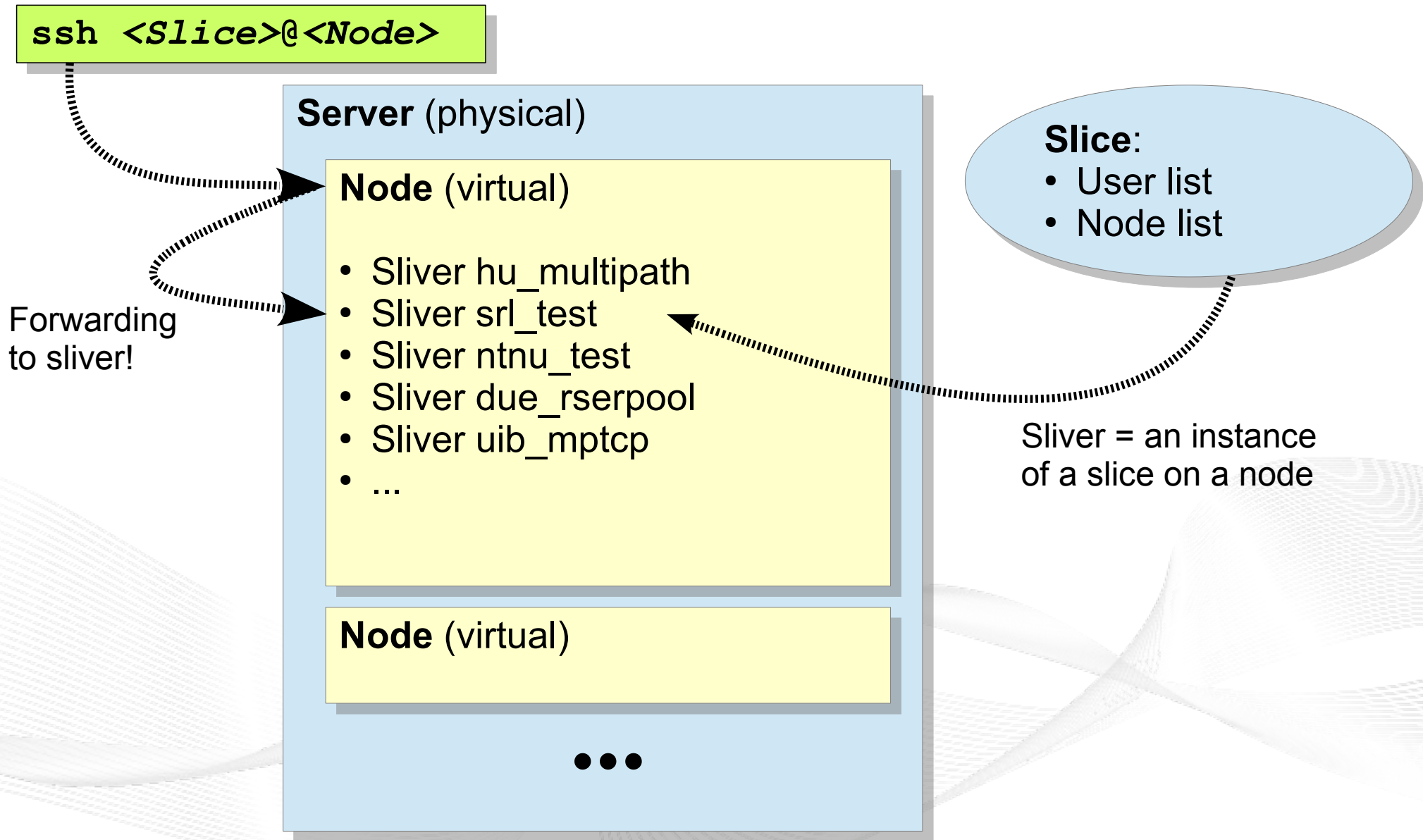
- A test slice has already been created:
 - Name: *srl_test*
 - Special NorNet Core properties:
 - Own IP addresses on each node
 - IPv4 and IPv6
 - Multiple ISPs (at sites with several ISPs)
- The slice is instantiated on all nodes by a sliver (LXC container)
- Your account is mapped as user to *srl_test*

Logging In

- From the login server:
 - `ssh -i <your private key> <slice name>@<node name>`
- Examples (private key is in `~/.ssh/id_rsa`, slice is `srl_test`):
 - `ssh -i ~/.ssh/id_rsa srl_test@boao.hu.nor-net`
 - `ssh -i ~/.ssh/id_rsa srl_test@altenessen.ude.nor-net`
 - `ssh -i ~/.ssh/id_rsa srl_test@nordlys.unis.nor-net`
 - `ssh -i ~/.ssh/id_rsa srl_test@julennisse.uia.nor-net`
 - `ssh -i ~/.ssh/id_rsa srl_test@watson.ku.nor-net`
- Note: login is via node's SSH server to sliver on the node!

Use PLC to find other nodes. There are more than 100 nodes!

Note the Different Entities: Server, Node, Sliver



Inside a Sliver

- Each sliver contains a Fedora Core 25 environment
- **Obtain root access:**
 - `su`
 - `sudo bash`
- **Install custom software:**
 - `dnf install <package> ...`
 - **Example:** `dnf install netperf`
- **Show IP addresses and routes:**
 - `ip -4 addr show ; ip -4 route show`
 - `ip -6 addr show ; ip -6 route show`

Remember: slivers have their own addresses!

Nodes, Slivers and Addresses

- Node:
 - The node itself, e.g. altenessen.ude.nor-net
 - Used for SSH login
- How to find sliver addresses of a node?
 - Look inside the sliver itself (login to sliver → ip addr show)
 - Ask the DNS server:
 - Use “dig” (part of bind-utils package for Fedora Core)
 - `dig <slice name>.<node name>.<site name>.nor-net`
 - But replace “_” by “-” in slice name!
 - Examples for srl_test slice:
 - `dig srl-test.altenessen.ude.nor-net any`
to obtain primary provider (it is in the CNAME, here: “dfn”)
 - `dig srl-test.altenessen.all.ude.nor-net any`
to obtain all providers' addresses
 - `dig srl-test.solvang.all.simula.nor-net`
without “any” → gets only A RRs (i.e. IPv4 addresses)

A dig Example

```
ola1@nordberg:~$ dig srl-test.solvang.all.simula.nor-net any
; <<>> DiG 9.9.2-P1 <<>> srl-test.solvang.all.simula.nor-net any
...
;; ANSWER SECTION:
srl-test.solvang.all.simula.nor-net. 86400 IN A 10.2.1.130
srl-test.solvang.all.simula.nor-net. 86400 IN A 10.1.1.130
srl-test.solvang.all.simula.nor-net. 86400 IN AAAA 2001:700:4100:101::82:69
srl-test.solvang.all.simula.nor-net. 86400 IN AAAA 2001:700:4100:201::82:69
srl-test.solvang.all.simula.nor-net. 86400 IN HINFO "Amiga 5000" "Slice srl_test"
srl-test.solvang.all.simula.nor-net. 86400 IN LOC 59 53 45.240 N 10 37 39.360 E 15.00m
;; AUTHORITY SECTION:
simula.nor-net. 86400 IN NS ns.ntnu.nor-net.
...
```

IPv4

IPv6

Geographic location

Software

Overview: A Practical Example

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A Multi-Path Routing Test

- Select two nodes at different sites
 - List: <https://www.nntb.no/pub/nor-net-configuration/NorNetCore-Sites.html>
 - Login to *srl_test* sliver: `ssh srl_test@<node name>`
 - Check IP addresses: `ip -4 addr show dev eth0`
 - Example:
 - `srl-test.kettwig.ude.nor-net:` 10.30.42.122 10.31.42.122
 - ISPs: 30=DFN, 31=Versatel (an ADSL connection)
 - `srl-test.frogner.simula.nor-net:` 10.1.1.131 10.2.1.131 10.4.1.131 10.9.1.131
 - ISPs: 1=UNINETT, 2=Kvantel, 4=Telenor, 9=PowerTech
- Try ping/traceroute:
 - `ping [-f] [-s <size>] [-c <count>] <dest IP> -I <src IP>`
 - `traceroute <dest IP> -s <src IP>`
 - Look at the second and third hop (and their reverse DNS lookups)!
 - What do you see?

Some Flood Ping Results

```
srl_test@kettwig.ude.nornet # ping -c 1000 -s 1400 -f 10.1.1.129 -I 10.30.42.122
PING 10.1.1.129 (10.1.1.129) from 10.30.42.122 : 1400(1428) bytes of data.
1000 packets transmitted, 1000 received, 0% packet loss, time 14591ms
rtt min/avg/max/mdev = 70.115/108.064/177.958/26.870 ms
```

DFN → UNINETT

```
srl_test@kettwig.ude.nornet # ping -c 1000 -s 1400 -f 10.2.1.129 -I 10.30.42.122
PING 10.2.1.129 (10.2.1.129) from 10.30.42.122 : 1400(1428) bytes of data.
1000 packets transmitted, 1000 received, 0% packet loss, time 14783ms
rtt min/avg/max/mdev = 31.009/76.446/136.024/27.666 ms
```

DFN → Kvantel

```
srl_test@kettwig.ude.nornet # ping -c 1000 -s 1400 -f 10.1.1.129 -I 10.31.42.122
PING 10.1.1.129 (10.1.1.129) from 10.31.42.122 : 1400(1428) bytes of data.
1000 packets transmitted, 999 received, 0% packet loss, time 14412ms
rtt min/avg/max/mdev = 121.153/175.432/252.685/28.585 ms
```

Versatel → UNINETT

```
srl_test@kettwig.ude.nornet # ping -c 1000 -s 1400 -f 10.2.1.129 -I 10.31.42.122
PING 10.2.1.129 (10.2.1.129) from 10.31.42.122 : 1400(1428) bytes of data.
1000 packets transmitted, 999 received, 0% packet loss, time 14182ms
rtt min/avg/max/mdev = 78.643/124.496/207.773/26.729 ms
```

Versatel → Kvantel

RTT differences among provider combinations; higher ADSL delay (Versatel)

Some Traceroute Results

```
srl_test@kettwig.ude.nornet # traceroute 10.1.1.129 -s 10.30.42.122
```

```
traceroute to 10.1.1.129 (10.1.1.129), 30 hops max, 60 byte packets
```

- 1 essen.dfn.ude.nornet (10.30.42.1) 2.104 ms 2.849 ms 2.831 ms
- 2 dfn.ude.uninett.simula.nornet (192.168.178.10) 95.059 ms 95.024 ms 94.961 ms
- 3 srl-test.frogner.uninett.simula.nornet (10.1.1.129) 105.432 ms 105.281 ms 105.220 ms

DFN → UNINETT

```
srl_test@kettwig.ude.nornet # traceroute 10.2.1.129 -s 10.30.42.122
```

```
traceroute to 10.2.1.129 (10.2.1.129), 30 hops max, 60 byte packets
```

- 1 essen.dfn.ude.nornet (10.30.42.1) 1.190 ms 1.739 ms 1.031 ms
- 2 dfn.ude.uninett.simula.nornet (192.168.178.10) 56.972 ms 56.722 ms 56.853 ms
- 3 srl-test.frogner.kvantel.simula.nornet (10.2.1.129) 100.773 ms 99.513 ms 99.337 ms

DFN → Kvantel

```
srl_test@kettwig.ude.nornet # traceroute 10.1.1.129 -s 10.31.42.122
```

```
traceroute to 10.1.1.129 (10.1.1.129), 30 hops max, 60 byte packets
```

- 1 essen.versatel.ude.nornet (10.31.42.1) 1.830 ms 2.633 ms 2.609 ms
- 2 versatel.ude.uninett.simula.nornet (192.168.133.222) 127.768 ms 127.954 ms 127.507 ms
- 3 srl-test.frogner.uninett.simula.nornet (10.1.1.129) 182.544 ms 182.564 ms 182.269 ms

Versatel → UNINETT

```
srl_test@kettwig.ude.nornet # traceroute 10.2.1.129 -s 10.31.42.122
```

```
traceroute to 10.2.1.129 (10.2.1.129), 30 hops max, 60 byte packets
```

- 1 essen.versatel.ude.nornet (10.31.42.1) 1.178 ms 1.805 ms 1.769 ms
- 2 versatel.ude.uninett.simula.nornet (192.168.133.222) 88.834 ms 91.932 ms 96.620 ms
- 3 srl-test.frogner.kvantel.simula.nornet (10.2.1.129) 79.603 ms 75.599 ms 69.910 ms

Versatel → Kvantel

Hop 2: Router's ICMP TTL Exceeded is sent back via Simula's primary ISP!

What else to do?

- Try the same with IPv6!
 - `ping6 [-f] [-s <size>] [-c <count>] <dest IP> -I <src IP>`
 - `traceroute6 <dest IP> -s <src IP>`
- Try NetPerfMeter!
 - Supports TCP including **MPTCP**, SCTP, UDP, DCCP
 - Server side: `netperfmeter <port>`
 - Client side: `netperfmeter <server>:<port> <flow details> ...`
(see manpage for details!)
- Install custom software
 - But note: do not assume the slivers to be permanent storages
 - Write scripts to automatise installation
 - **In case of problems, nodes may just be wiped and reinstalled**

And, of course, try your own experiments in NorNet!

Overview: Conclusion

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Conclusion and Future Work

- **NorNet Core is ready for your ideas!**
 - Think about your experiments
 - Let them run in NorNet Core
- How to get permanent access?
 - **Talk to us!**
 - Provide some information on your project
Let us **discuss the details** about running your experiment in NorNet Core!

In case of questions, ask us!

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



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

Overview: Literature

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Literature

Dreibholz, T.; Ferlin, S.; Alay, Ö.; Elmokashfi, A. M.; Livadariu, I. A.; Zhou, X.: “[MPTCP Experiences in the NorNet Testbed](#)” (TXT, 24 KiB), IETF, Individual Submission, Internet Draft draft-dreibholz-mptcp-nornet-experience-04, March 30, 2017.

Wang, K.; Dreibholz, T.; Zhou, X.; Fu, F.; Tan, Y.; Cheng, X.; Tan, Q.: “[On the Path Management of Multi-Path TCP in Internet Scenarios based on the NorNet Testbed](#)” (PDF, 379 KiB), Proceedings of the IEEE International Conference on Advanced Information Networking and Applications (AINA), pp. 1–8, DOI [10.1109/AINA.2017.29](#), ISBN 978-1-5090-6028-3, Taipei, Taiwan/People's Republic of China, March 27, 2017.

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Gran, E. G.; Dreibholz, T.; Kvalbein, A.: “[NorNet Core – A Multi-Homed Research Testbed](#)” (PDF, 1458 KiB), Computer Networks, Special Issue on Future Internet Testbeds, vol. 61, pp. 75–87, DOI [10.1016/j.bjp.2013.12.035](#), ISSN 1389-1286, March 14, 2014.

Dreibholz, T.; Gran, E. G.: “[Design and Implementation of the NorNet Core Research Testbed for Multi-Homed Systems](#)” (PDF, 20082 KiB), Proceedings of the 3rd International Workshop on Protocols and Applications with Multi-Homing Support (PAMS), pp. 1094–1100, DOI [10.1109/WAINA.2013.71](#), ISBN 978-0-7695-4952-1, Barcelona, Catalonia/Spain, March 27, 2013.

Any Questions?

N  R N E T

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