Simula Knowledge Festival 2025

HiPerConTracer: A Versatile Tool for Obtaining Insights into Today's Communication Networks

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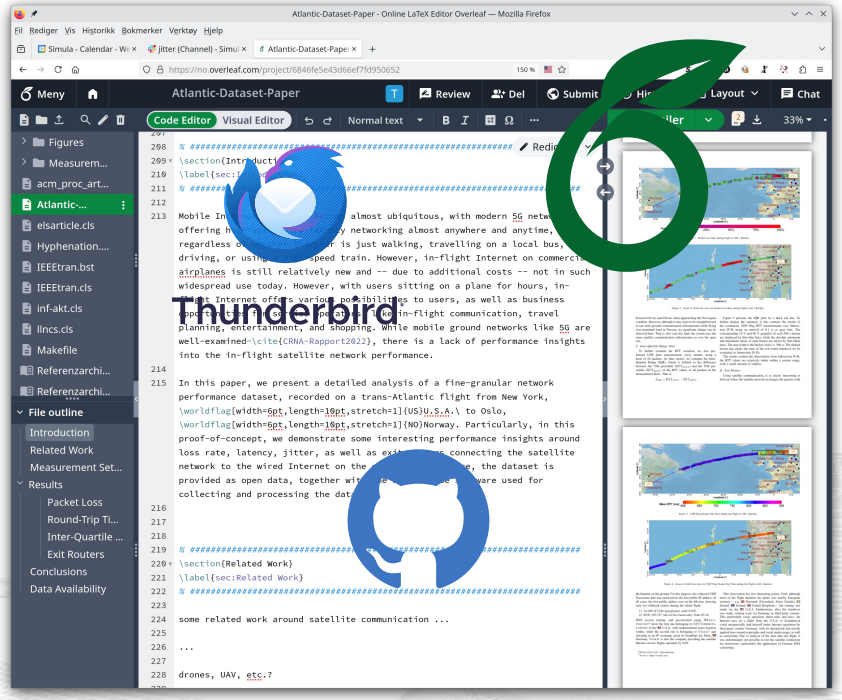
A very brief introduction to computer networks

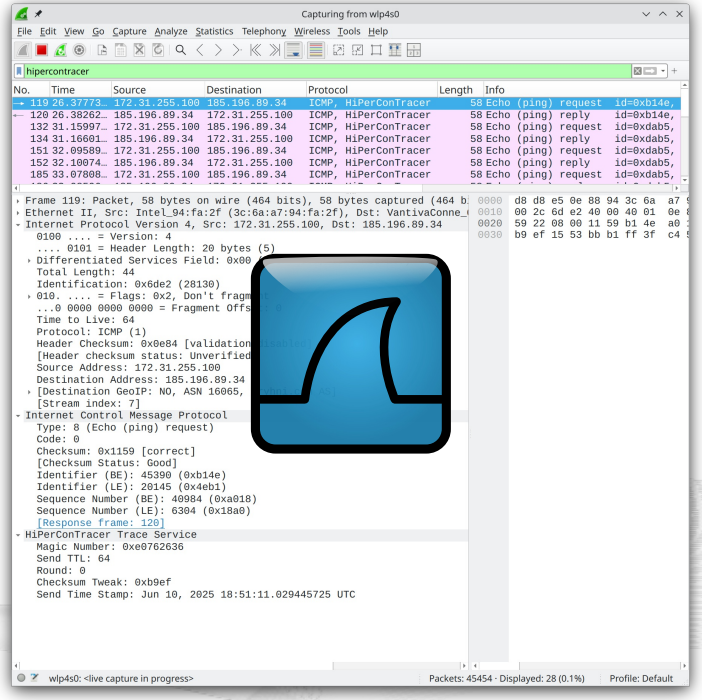
- Today, almost all applications rely on Internet access
  - Cloud application (e.g. Overleaf)
  - Cloud services (e.g. Git)
  - E-mail
  - Network storage
  - Video conferencing
  - …



Obviously, reliable network access is quite important!

A very brief introduction to computer networks: Packets

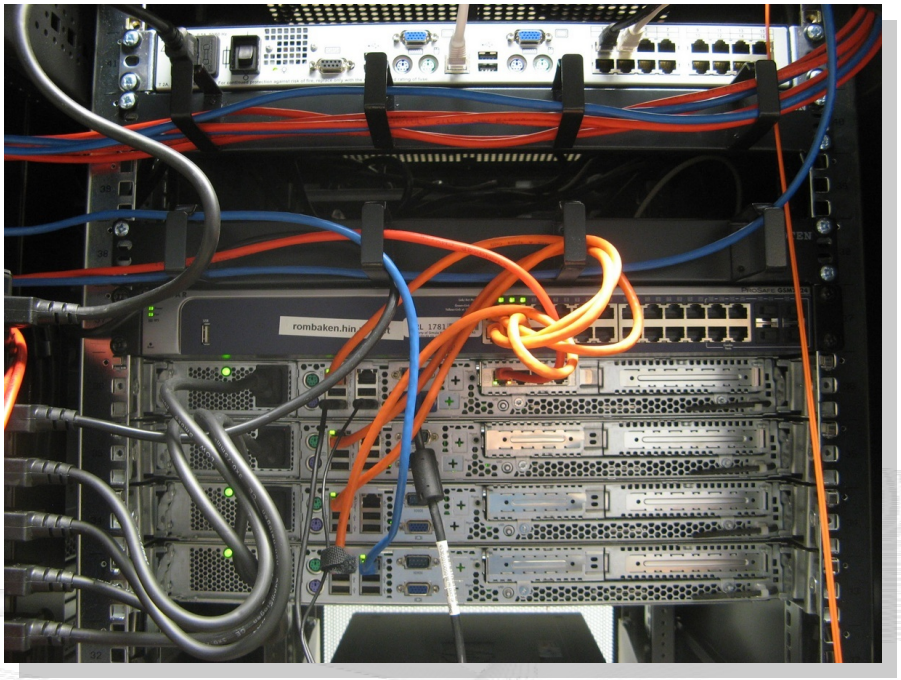
- The Internet works by using packet forwarding
  - Data is encapsulated into small packets (usually up to ~1,500 bytes)
  - Sent independently over the network
  - Original payload is decapsulated from the packets
- Nicely observable e.g. in Wireshark



What is the implication on performance?

A very brief introduction to computer networks: Latency

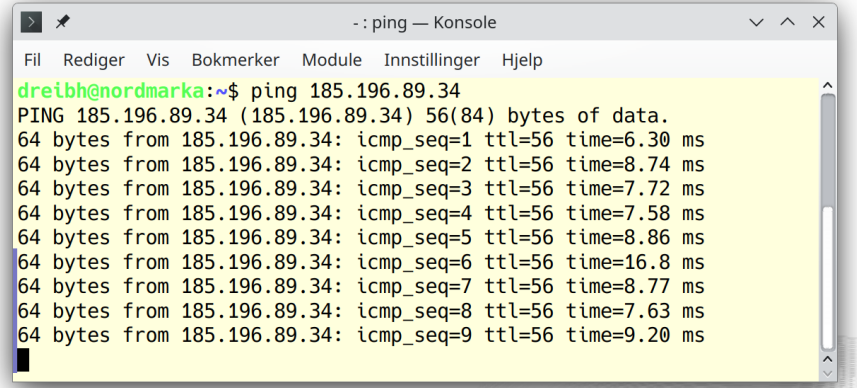
- Transporting packets takes time
  - Transmission: speed limit is *c* (c≈3*10^8 m/s)!
  - Processing
  - Congestion
  - ...



How long does packet transport take?

A very brief introduction to computer networks: Round-Trip Time and “Ping”

- Let’s measure the round-trip time!
  - Get current system time t_1
  - Send a packet to a remote server
  - Remote server sends a response
  - Get current system time t_2
  - Round-trip time: RTT = $t_2 - t_1$
- This is the purpose of the “Ping” tool
  - Also a test for network connectivity



What about the routes taken by the packets?

A very brief introduction to computer networks: Traceroute

- IP has a “Time-to-Live” (or “Hop Limit”) field in its header
  - Decremented each time a packet is forwarded (by a router)
  - If it reaches 0:
    - The packet is dropped (prevents infinite loops)
    - An ICMP “Time Exceeded” error message is sent to the sender
  - Idea: send packet sequence, with increasing Time-to-Live (Hop Limit)
  - Collect responses => list of routers + actual destination
- This is the purpose of the “Traceroute” tool

Naïve idea: Continuous run of Ping+Traceroute from different PCs

The Challenge:
Large-Scale, Continuous Measurements

- Many different implementations/variants of Ping and Traceroute
  - Different ways of collecting the time stamps, different accuracies
  - Occurrence of load balancing in the networks
  - Different ways of error handling
  - Security limitations
  - ...
- Collection and management of results
  - Not just a few MiB or GiB, let's collect manyTiBs data → big data!

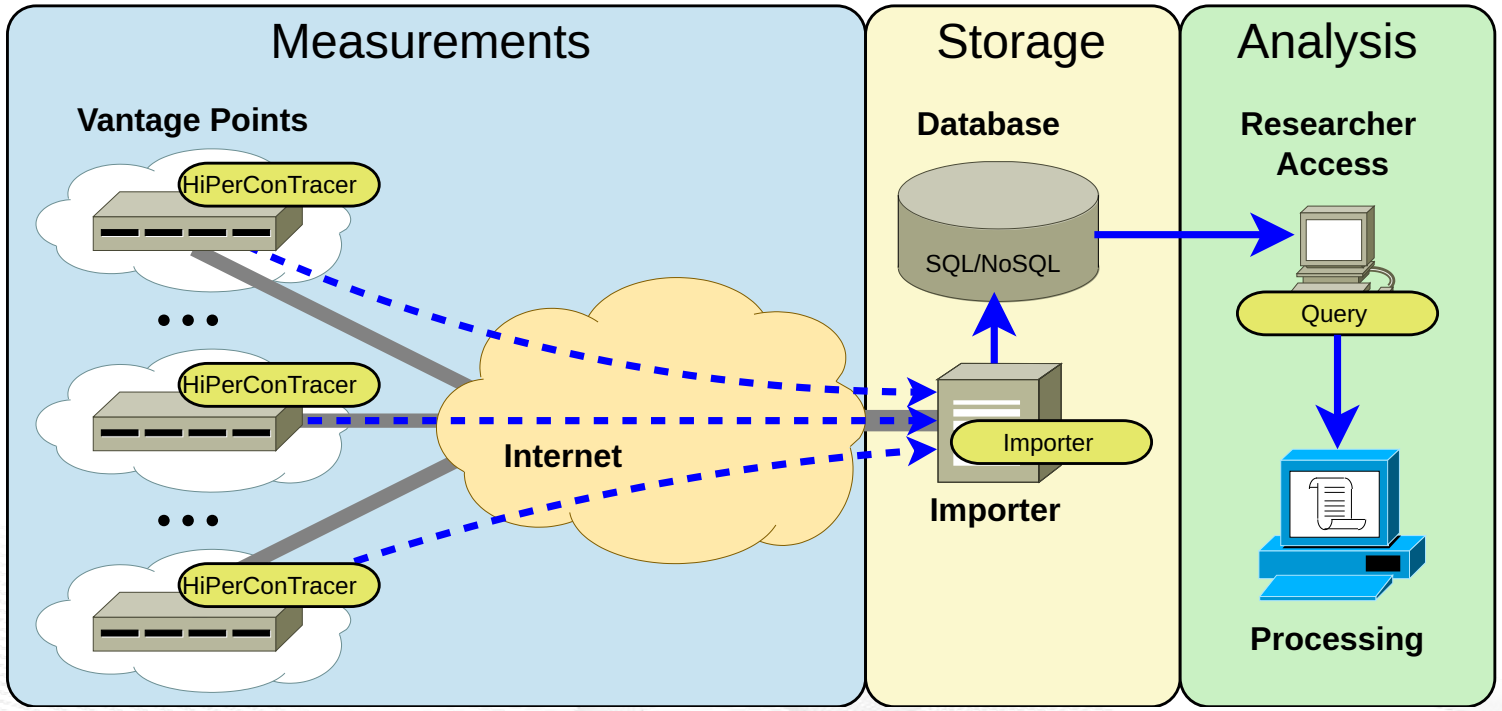
A proper solution for this challenge is needed: HiPerConTracer!

The Solution:
HiPerConTracer – High-Performance Connectivity Tracer

- High-volume, high-frequency Ping/Traceroute/etc. framework
  - Multi-transport-protocol support (ICMP, UDP, TCP)
  - High-precision packet timestamping
  - Database import and export (MariaDB, PostgreSQL, MongoDB)
  - Measurement node/collector scripting (monitoring, rev. tunnel, sync.)
- Open source!

Homepage: https://www.nntb.no/~dreibh/hipercontracer/

HiPerConTracer Framework Live Demo!



Homepage: https://www.nntb.no/~dreibh/hipercontracer/

Installing HiPerConTracer is simple!

- From sources (it is Open Source!)
  - Git: https://github.com/dreibh/hipercontracer
- From PPA binary packages, e.g.:
  - Ubuntu:
    ```
    sudo apt-add-repository -sy ppa:dreibh/ppa
    sudo apt install -y hipercontracer-all
    ```
  - FreeBSD:
    ```
    sudo pkg install -y hipercontracer
    ```
- Of course, there is detailed documentation available:

https://github.com/dreibh/hipercontracer/blob/master/README.md

Running HiPerConTracer is easy!

- A simple test: Ping to SimulaMet in Stensberggata 27, Oslo
  `sudo hipercontracer --destination 185.196.89.70 --ping`
  How is your RTT to Oslo?
- This works for IPv6 as well, and parameters can be shortened:
  `sudo hipercontracer -D 2a02:f0:2:8504::70 --ping`
- It even works with multiple addresses:
  `sudo hipercontracer -D 185.196.89.70 -D 2a02:f0:2:8504::70 -P`
- HiPerConTracer has a detailed manpage with documentation!
  `man hipercontracer`
- And it has shell completions →
  just press the TAB key to suggest and complete options!

Let’s try some further endpoints

- Examples:
  - 🇨🇳Beijing: 101.6.15.130, 2402:f000:1:400::2 (mirrors.tuna.tsinghua.edu.cn/)
  - 🇳🇿Dunedin: 139.80.137.41 (dns-1.otago.ac.nz)
  - 🇩🇪Hannover: 193.99.144.80, 2a02:2e0:3fe:1001:302:: (www.heise.de)
  - 🇵🇫Papeete: 202.3.225.10 (ns1.mana.pf)
  - 🇭🇷Split: 161.53.167.47 (www.fesb.unist.hr)
  - 🇺🇸Tampa: 131.247.1.40, 2607:fe50:0:102::2 (ziggy.usf.edu)
- It is possible to read destinations from a file (--destinations-from-file)!

Reading the output is confusing → why not saving it into files?

A Measurement Setup

- Specify targets (list of IP addresses)
- A data directory: `/home/<user>/data`
- Run HiPerConTracer:

```
sudo hipercontracer \
-# 12345678 -P \
--destinations-from-file ping.list \
--resultstransactionlength 60 \
--resultsdirectory /home/<user>/data
```

- Starts new file every 60s (--resultstransactionlength parameter)
- Wait until a file is finished (.tmp extension removed)!

ping.list:

```
101.6.15.130
131.247.1.40
139.80.137.41
161.53.167.47
193.99.144.80
202.3.225.10
2402:f000:1:400::2
2607:fe50:0:102::2
2a02:2e0:3fe:1001:302::
```

Also see the HiPerConTracer manpage for option details!

There are more results options!

- Set a measurement ID (-# <number>),
  e.g. to identify a vantage point
- Specify compression (-C <compression>), e.g:
  None, GZip, BZip2, XZ (default), ZSTD (from HiPerConTracer 2.1!)
- Hierarchical storage in directories (--resultstimestampdepth), e.g.:
  <Year>/<Month>/<Day>, <Year>/<Month>/<Day>/<Hour>
- Other services (e.g. Traceroute) and protocols (e.g. ICMP, UDP)
- Plenty of service-specific options ...

How to view the results?

Viewing a Results File

- Just display a file:
  `hpct-viewer <file>`

```
#? HPCT Ping 2 HiPerConTracer/2.0.17
#Pi 0 10.44.41.51 101.6.15.130 1847f1613999b395 0 0 44 44 ac2f 0 0 255 116666aa 26903 20003 125379 162399768 162227483 162190750
#Pi 0 10.44.41.51 131.247.1.40 1847f161399c424a 0 0 44 44 ac2f 0 0 255 116666aa 14460 9303 104194 129582201 129454444 129380375
#Pi 0 10.44.41.51 139.80.137.41 1847f161399dce76 0 0 44 44 ac2f 0 0 255 116666aa 7452 3013 91157 315012426 314910804 -1
#Pi 0 10.44.41.51 161.53.167.47 1847f161399efe60 0 0 44 44 ac2f 0 0 255 116666a0 6434 3109 70643 63494917 63414731 -1
#Pi 0 10.44.41.51 193.99.144.80 1847f16139a0674b 0 0 44 44 ac2f 0 0 255 116666a0 6562 3449 127939 24487053 24349103 -1
#Pi 0 10.44.41.51 101.6.15.130 1847f161759236b1 0 0 44 44 ac15 0 0 255 116666aa 31482 22785 91413 162252247 162106567 162061375
...
```

- Want to process the results in own programs, e.g. as CSV file?
  - `hpct-results Ping-ICMP-*.xz -o ping.csv`
- It is also possible so specify compression and separator:
  - `hpct-results Ping-ICMP-*.xz -o ping.csv.gz -s,`

See the HiPerConTracer manpage for file format descriptions!

A Database Setup

- Choose your preferred DBMS
  MariaDB/MySQL, PostgreSQL, MongoDB
- Set up DBMS, prepare database, schemata, users, permissions
  - SQL: https://github.com/dreibh/hipercontracer/tree/master/src/SQL
  - NoSQL: https://github.com/dreibh/hipercontracer/tree/master/src/NoSQL
- CI test run scripts, used for automated setups:
  https://github.com/dreibh/hipercontracer/tree/master/src/TestDB
- Do the setup properly, particularly with **security** in mind!

See the HiPerConTracer documentation, and DBMS tutorials!

How to Test a Fully Configured HiPerConTracer Setup?

- Just download a VirtualBox VM image, with your preferred OS!
  - Ubuntu Linux / Debian Linux
  - Fedora Linux
  - FreeBSD
- Each VM includes:
  - Fully configured MariaDB database setup
  - Development tools installed
  - A fully-configured KDE desktop

https://packages.nntb.no/hipercontracer/

References

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Thank you for your attention!
Any questions?

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