

Uni Network Practice Notes

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1 Introduction

1.1 Contributing

These study materials are heavily based on [professor Kiefer's "Praktikum Rechnernetze" lecture at HdM Stuttgart](#).

Found an error or have a suggestion? Please open an issue on GitHub (github.com/pojntfx/uni-netpractice-notes):



Figure 1: QR code to source repository

If you like the study materials, a GitHub star is always appreciated :)

1.2 License



Figure 2: AGPL-3.0 license badge

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SPDX-License-Identifier: AGPL-3.0

2 IP-Subnetz-Berechnung

Ergänzen Sie die Tabelle

IP-Adresse	SN-Mask	Klasse	Netz- adresse	Anzahl Subnetze	Broadcast- Adresse	Anzahl Hosts	Vorheriges Netz	nachgelag. Netz
14.21.4.210	255.255.128.0	A	14.21.0.0	512	14.21.127.255	32.768	14.20.128.0	14.21.128.0
184.16.12.80	255.255.255.224	B	184.16.12.64	2048	184.16.12.95	30	184.16.12.32	184.16.12.95
143.62.67.32	255.255.255.240	B	143.62.67.32	4096	143.62.67.47	16	143.62.67.16	143.62.67.50
264.12.14.81	255.255.192.0	/	/	/	/	/	/	/
192.168.1.42	255.255.255.0	C	192.168.1.0	1	192.168.1.255	254	/	/
10.15.119.237	255.255.255.252	A	10.15.119.232	4.096.000	10.15.119.239	2	10.15.119.232	10.15.119.240

184.16.12.80 → Class B

255.255.255.224

8 + 8 + 8 + 8 → 32 → 184.16.12.80/32 1 LINE

255.255.255.11110000 → 224

184.16.12.01010000 → 80

01000000 → 64 → 184.16.12.64 1 Block ohne

01001111 → 95 → 184.16.12.95 1 Broadcast ohne

6+1=7
2⁷ = 256
2⁷ - 2 = 254 Hosts pro Netzwerk

255.255.255.11110000 → 96 → 184.16.12.96 1 Primary network's network address

255.255.255.01010000 → 32 → 184.16.12.32/32 1 Primary network's network address

143.62.67.32

255.255.255.240 → Class B

$14.21.4.210$
 $255.255.128.0 \rightarrow \text{Class A}$

$8 + 8 + 1 \rightarrow 17 \rightarrow 14.21.4.210/17 \rightarrow 1618$

$255.255.10000000 \rightarrow 128$
 $14.21.01000100 \rightarrow 4$

$00000000 \rightarrow 0 \rightarrow 14.21.0.0/12 \rightarrow \text{Network address}$
 $01111111 \rightarrow 127 \rightarrow 14.21.127.255/12 \rightarrow \text{Broadcast address}$

$8 \cdot 16 = 128$
 $2^{11} = 2048$
 $2^{11} = 2048$

$14.00010101.0$
 $+ 00000000.1$
 $00010101.1 \rightarrow 14.21.128.0/12 \rightarrow \text{Secondary network's network address}$

$14.00010101.0$
 $- 00000000.1$
 $00010100.1 \rightarrow 14.20.128.0/12 \rightarrow \text{Secondary network's network address}$

3 Tools des OS

3.1 IP-Konfiguration

Überprüfen Sie zunächst die Netzkonfiguration Ihres PC. IP-Adresse, Subnetzmaske, Default-Gateway und DNS-Server Erfragen Sie den Klartextnamen Ihres PC.

IP-Adresse: 142.62.66.5 Subnetzmaske: 255.255.255.0 Default-Gateway: 141.62.66.250 DNS-Server: 141.62.66.250 Klartextnamen: rn05

Wie können Sie die korrekte Installation der Netzwerkkarten-Treiber testen?

```

$ lspci
# ...
00:1f.6 Ethernet controller: Intel Corporation Ethernet Connection (2) I219-LM
# ...
$ find /sys | grep drivers.*00:1f.6
# ...
/sys/bus/pci/drivers/e1000e/0000:00:1f.6

```

Testen Sie die DNS-Namensauflösung mit nslookup/dig

```
$ dig +noall +answer +multiline www.hdm-stuttgart.de
www.hdm-stuttgart.de. 3553 IN A 141.62.1.53
www.hdm-stuttgart.de. 3553 IN A 141.62.1.59
```

3.2 Anschluss des PC an das Labornetz

Betrachten Sie die Verbindungen der Labor-Switches untereinander. Welche Wege können Sie erkennen?

Wenn die Verbindung am Patch-Panel zu 1-01 unterbrochen wird, so verliert die Netzwerkkarte die Verbindung, was der Kernel-Buffer bestätigt:

```
$ dmesg -w
# ...
[ 6.048643] e1000e 0000:00:1f.6 enp0s31f6: NIC Link is Up 1000 Mbps Full Duplex, Flow Co
[ 1360.221984] e1000e 0000:00:1f.6 enp0s31f6: NIC Link is Down
# ...
```

Folgende Verbindungen konnten erkannt werden:

Desktop-Netzwerkkarte via CAT-6-Kabel → RJ45/LAN-Buchse an Tisch → Patch-Feld → Switch → Router

Verfolgen Sie den im Netzwerkschrank gepatchten Weg, auf dem die Pakete Ihres Rechners zum Router gelangen

Patch-Feld → Switch → Router → Rest der Infrastruktur

Verfolgen Sie den Weg, auf dem die Pakete Ihres Rechners den gegenüberliegenden Netzwerkschrank erreichen

Mittels Glasfaserverbindung.

Warum ist im Netzwerkschrank wohl ein Hub installiert?

Es ist ein Switch installiert, sodass die verschiedenen Nodes im LAN-Netzwerk miteinander kommunizieren können. Dies ermöglicht zudem auch einfacheres Debugging über Sniffing.

3.3 Überprüfung der korrekten Installation

Sehen Sie sich die IP-Konfiguration Ihres Rechners an durch Eingabe von ipconfig bzw. ipconfig/all in der DOS-Box.

ipconfig ist deprecated, es wird stattdessen ip verwendet.

```
$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
```

```
2: enp0s31f6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default
    link/ether 4c:52:62:0e:54:8b brd ff:ff:ff:ff:ff:ff
    inet 141.62.66.5/24 brd 141.62.66.255 scope global dynamic enp0s31f6
        valid_lft 11902sec preferred_lft 11902sec
```

Senden Sie einen ping-command an einen zweiten Rechner, der am gleichen Switch angeschlossen ist

```
$ ping 141.62.66.4
PING 141.62.66.4 (141.62.66.4) 56(84) bytes of data.
64 bytes from 141.62.66.4: icmp_seq=1 ttl=64 time=0.670 ms
64 bytes from 141.62.66.4: icmp_seq=2 ttl=64 time=0.509 ms
64 bytes from 141.62.66.4: icmp_seq=3 ttl=64 time=0.532 ms
64 bytes from 141.62.66.4: icmp_seq=4 ttl=64 time=0.526 ms
64 bytes from 141.62.66.4: icmp_seq=5 ttl=64 time=0.533 ms
^C
--- 141.62.66.4 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4085ms
rtt min/avg/max/mdev = 0.509/0.554/0.670/0.058 ms
```

Senden Sie einen ping-command zu einem Rechner, der am Switch im gegenüberliegenden Netzwerkschrank angeschlossen ist

```
$ ping 141.62.66.13
PING 141.62.66.13 (141.62.66.13) 56(84) bytes of data.
64 bytes from 141.62.66.13: icmp_seq=1 ttl=128 time=0.786 ms
64 bytes from 141.62.66.13: icmp_seq=2 ttl=128 time=0.775 ms
64 bytes from 141.62.66.13: icmp_seq=3 ttl=128 time=0.853 ms
64 bytes from 141.62.66.13: icmp_seq=4 ttl=128 time=0.752 ms
64 bytes from 141.62.66.13: icmp_seq=5 ttl=128 time=0.793 ms
^C
--- 141.62.66.13 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4095ms
rtt min/avg/max/mdev = 0.752/0.791/0.853/0.033 ms
```

Senden Sie einen ping-command zum Labor-Router

```
$ $ ping 141.62.66.250
PING 141.62.66.250 (141.62.66.250) 56(84) bytes of data.
64 bytes from 141.62.66.250: icmp_seq=1 ttl=64 time=1.13 ms
64 bytes from 141.62.66.250: icmp_seq=2 ttl=64 time=1.07 ms
64 bytes from 141.62.66.250: icmp_seq=3 ttl=64 time=1.03 ms
64 bytes from 141.62.66.250: icmp_seq=4 ttl=64 time=1.02 ms
64 bytes from 141.62.66.250: icmp_seq=5 ttl=64 time=1.02 ms
64 bytes from 141.62.66.250: icmp_seq=6 ttl=64 time=1.03 ms
^C
--- 141.62.66.250 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5007ms
rtt min/avg/max/mdev = 1.015/1.046/1.127/0.040 ms
```

Starten Sie einen Web-Browser und überprüfen Sie die korrekte Funktion des DNS-Servers durch Aufruf einer beliebigen URL

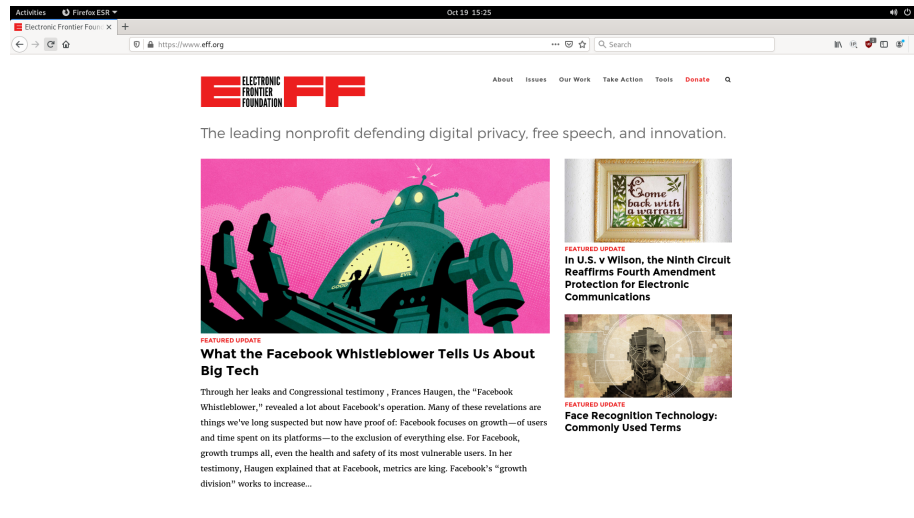


Figure 3: Screenshot

Sehen Sie sich den DNS-Cache an

```
$ sudo journalctl -u systemd-resolved
-- Journal begins at Tue 2021-10-05 07:59:05 CEST, ends at Tue 2021-10-19 15:33:33 CEST. --
Oct 19 15:31:00 rn05 systemd[1]: Starting Network Name Resolution...
Oct 19 15:31:00 rn05 systemd-resolved[34579]: Positive Trust Anchors:
Oct 19 15:31:00 rn05 systemd-resolved[34579]: . IN DS 20326 8 2 e06d44b80b8f1d39a95c0b0d7c68
Oct 19 15:31:00 rn05 systemd-resolved[34579]: Negative trust anchors: 10.in-addr.arpa 16.172
Oct 19 15:31:00 rn05 systemd-resolved[34579]: Using system hostname 'rn05'.
Oct 19 15:31:00 rn05 systemd[1]: Started Network Name Resolution.
Oct 19 15:31:29 rn05 systemd-resolved[34579]: [Scope protocol=llmnr interface=enp0s31f6 fam
Oct 19 15:31:29 rn05 systemd-resolved[34579]: ZONE:
Oct 19 15:31:29 rn05 systemd-resolved[34579]: 5.66.62.141.in-addr.arpa IN PTR rn05
Oct 19 15:31:29 rn05 systemd-resolved[34579]: rn05 IN A 141.62.66.5
Oct 19 15:31:29 rn05 systemd-resolved[34579]: [Scope protocol=dns]
Oct 19 15:31:29 rn05 systemd-resolved[34579]: [Server 141.62.66.250 type=system]
Oct 19 15:31:29 rn05 systemd-resolved[34579]: Verified feature level: n/a
Oct 19 15:31:29 rn05 systemd-resolved[34579]: Possible feature level: TLS+EDNS0+D0
Oct 19 15:31:29 rn05 systemd-resolved[34579]: DNSSEC Mode: no
Oct 19 15:31:29 rn05 systemd-resolved[34579]: Can do DNSSEC: yes
Oct 19 15:31:29 rn05 systemd-resolved[34579]: Maximum UDP packet size received: 512
Oct 19 15:31:29 rn05 systemd-resolved[34579]: Failed UDP attempts: 0
Oct 19 15:31:29 rn05 systemd-resolved[34579]: Failed TCP attempts: 0
Oct 19 15:31:29 rn05 systemd-resolved[34579]: Seen truncated packet: no
```

```

Oct 19 15:31:29 rn05 systemd-resolved[34579]: Seen OPT RR getting lost: no
Oct 19 15:31:29 rn05 systemd-resolved[34579]: Seen RRSIG RR missing: no
Oct 19 15:32:38 rn05 systemd-resolved[34579]: [Scope protocol=llmnr interface=enp0s31f6 fam
Oct 19 15:32:38 rn05 systemd-resolved[34579]: ZONE:
Oct 19 15:32:38 rn05 systemd-resolved[34579]: 5.66.62.141.in-addr.arpa IN PTR rn05
Oct 19 15:32:38 rn05 systemd-resolved[34579]: rn05 IN A 141.62.66.5
Oct 19 15:32:38 rn05 systemd-resolved[34579]: [Scope protocol=dns]
Oct 19 15:32:38 rn05 systemd-resolved[34579]: [Server 141.62.66.250 type=system]
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Verified feature level: n/a
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Possible feature level: TLS+EDNS0+DO
Oct 19 15:32:38 rn05 systemd-resolved[34579]: DNSSEC Mode: no
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Can do DNSSEC: yes
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Maximum UDP packet size received: 512
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Failed UDP attempts: 0
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Failed TCP attempts: 0
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Seen truncated packet: no
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Seen OPT RR getting lost: no
Oct 19 15:32:38 rn05 systemd-resolved[34579]: Seen RRSIG RR missing: no
Oct 19 15:33:00 rn05 systemd-resolved[34579]: [Scope protocol=llmnr interface=enp0s31f6 fam
Oct 19 15:33:00 rn05 systemd-resolved[34579]: ZONE:
Oct 19 15:33:00 rn05 systemd-resolved[34579]: 5.66.62.141.in-addr.arpa IN PTR rn05
Oct 19 15:33:00 rn05 systemd-resolved[34579]: rn05 IN A 141.62.66.5
Oct 19 15:33:00 rn05 systemd-resolved[34579]: [Scope protocol=dns]
Oct 19 15:33:00 rn05 systemd-resolved[34579]: CACHE:
Oct 19 15:33:00 rn05 systemd-resolved[34579]: test.com IN A 67.225.146.248
Oct 19 15:33:00 rn05 systemd-resolved[34579]: test.com IN AAAA -- NODATA
Oct 19 15:33:00 rn05 systemd-resolved[34579]: [Server 141.62.66.250 type=system]
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Verified feature level: UDP+EDNS0
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Possible feature level: UDP+EDNS0
Oct 19 15:33:00 rn05 systemd-resolved[34579]: DNSSEC Mode: no
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Can do DNSSEC: no
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Maximum UDP packet size received: 512
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Failed UDP attempts: 0
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Failed TCP attempts: 0
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Seen truncated packet: no
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Seen OPT RR getting lost: no
Oct 19 15:33:00 rn05 systemd-resolved[34579]: Seen RRSIG RR missing: no
Oct 19 15:33:30 rn05 systemd-resolved[34579]: [Scope protocol=llmnr interface=enp0s31f6 fam
Oct 19 15:33:30 rn05 systemd-resolved[34579]: ZONE:
Oct 19 15:33:30 rn05 systemd-resolved[34579]: 5.66.62.141.in-addr.arpa IN PTR rn05
Oct 19 15:33:30 rn05 systemd-resolved[34579]: rn05 IN A 141.62.66.5
Oct 19 15:33:30 rn05 systemd-resolved[34579]: [Scope protocol=dns]
Oct 19 15:33:30 rn05 systemd-resolved[34579]: CACHE:
Oct 19 15:33:30 rn05 systemd-resolved[34579]: test.com IN AAAA -- NODATA
Oct 19 15:33:30 rn05 systemd-resolved[34579]: example.com IN AAAA 2606:2800:220:1:2
Oct 19 15:33:30 rn05 systemd-resolved[34579]: test.com IN A 67.225.146.248

```



```

Oct 19 15:33:30 rn05 systemd-resolved[34579]: example.com IN A 93.184.216.34
Oct 19 15:33:30 rn05 systemd-resolved[34579]: [Server 141.62.66.250 type=system]
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Verified feature level: UDP+EDNS0
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Possible feature level: UDP+EDNS0
Oct 19 15:33:30 rn05 systemd-resolved[34579]: DNSSEC Mode: no
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Can do DNSSEC: no
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Maximum UDP packet size received: 512
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Failed UDP attempts: 0
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Failed TCP attempts: 0
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Seen truncated packet: no
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Seen OPT RR getting lost: no
Oct 19 15:33:30 rn05 systemd-resolved[34579]: Seen RRSIG RR missing: no

```

Wie zu erkennen ist, befinden sich mom. 2 Einträge im DNS-Cache: `test.com` und `example.com`, für welche jeweils die A und AAAA-Records gecached wurden.

3.4 Adress Resolution Protocol ARP

`arp` ist deprecated, es wird stattdessen `ip neigh` verwendet.

Dokumentieren Sie den Inhalt der ARP-Tabelle Ihres PC (arp-a, DOS-Box).

```

$ ip neigh show
141.62.66.186 dev enp0s31f6 lladdr 10:82:86:01:36:6d STALE
141.62.66.12 dev enp0s31f6 lladdr 4c:52:62:0e:e0:e9 STALE
141.62.66.14 dev enp0s31f6 lladdr 4c:52:62:0e:e0:ae STALE
141.62.66.250 dev enp0s31f6 lladdr 00:0d:b9:4f:b8:14 REACHABLE
141.62.66.4 dev enp0s31f6 lladdr 4c:52:62:0e:53:eb STALE
141.62.66.13 dev enp0s31f6 lladdr 4c:52:62:0e:54:5d STALE
141.62.66.22 dev enp0s31f6 FAILED
141.62.66.216 dev enp0s31f6 lladdr 44:31:92:50:6c:61 STALE

```

Nun pingen Sie einen beliebigen anderen Arbeitsplatz an und beobachten Sie evtl. Veränderungen der ARP-Tabelle

```

$ ping 141.62.66.236
PING 141.62.66.236 (141.62.66.236) 56(84) bytes of data.
64 bytes from 141.62.66.236: icmp_seq=1 ttl=64 time=0.530 ms
64 bytes from 141.62.66.236: icmp_seq=2 ttl=64 time=0.684 ms
64 bytes from 141.62.66.236: icmp_seq=3 ttl=64 time=0.424 ms
^C
--- 141.62.66.236 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2031ms
$ ip neigh show
141.62.66.186 dev enp0s31f6 lladdr 10:82:86:01:36:6d STALE
141.62.66.12 dev enp0s31f6 lladdr 4c:52:62:0e:e0:e9 STALE
141.62.66.236 dev enp0s31f6 lladdr 26:c5:04:8a:fa:eb STALE

```

```

141.62.66.14 dev enp0s31f6 lladdr 4c:52:62:0e:e0:ae STALE
141.62.66.250 dev enp0s31f6 lladdr 00:0d:b9:4f:b8:14 REACHABLE
141.62.66.4 dev enp0s31f6 lladdr 4c:52:62:0e:53:eb STALE
141.62.66.13 dev enp0s31f6 lladdr 4c:52:62:0e:54:5d STALE
141.62.66.22 dev enp0s31f6 FAILED
141.62.66.216 dev enp0s31f6 lladdr 44:31:92:50:6c:61 STALE

```

Ist die MAC-Adresse Ihres PC lokal oder global vergeben?

```

$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
2: enp0s31f6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default
    link/ether 4c:52:62:0e:54:8b brd ff:ff:ff:ff:ff:ff
    inet 141.62.66.5/24 brd 141.62.66.255 scope global dynamic enp0s31f6
        valid_lft 10201sec preferred_lft 10201sec

```

Es findet sich die MAC-Adresse 4c:52:62:0e:54:8b; ein Lookup der OUI ergibt: 4C:52:62 Fujitsu Technology Solutions GmbH, woraus sich schließen lässt, dass die MAC global vergeben ist.

Was würde geschehen, wenn ein weiterer PC mit gleicher IP (aber selbstverständlich anderer MAC) ans gleiche Subnetz angeschlossen würde?

Gleiche IP, andere MAC: Reines Ethernet-Frame würde noch den Host korrekt erreichen, aber da die IP nun mehreren Hosts zugeordnet wäre würden IP-Pakete nicht mehr den richtigen Host erreichen.

Vergleichen Sie die Vorteile / Nachteile einer statischen und dynamischen ARP-Tabelle

Vorteile einer statischen/Nachteile einer dynamischen:

- Schneller und weniger Traffic; ARP-Request muss nicht gemacht werden
- Chain of Trust ist kürzer, da nicht dem Host, welche den ARP-Request beantwortet, vertraut werden muss

Vorteile einer dynamischen/Nachteile einer statischen:

- Wenn Geräte entfernt werden, dann müssen die Einträge manuell gelöscht werden
- Neue Geräte müssen nicht manuell hinzugefügt werden

Warum wird die ARP-Tabelle ganz oder teilweise nach Ablauf einer bestimmten Zeit gelöscht, wie Sie leicht nachvollziehen können?

Durch die Löschung der ARP-Tabelle werden die ARP-Anfragen erneut gemacht; wenn Geräte zum Netzwerk hinzukommen oder entfernt werden, so werden diese Änderungen dadurch repräsentiert.

3.5 Ping

Ping-Nutzung

```
$ ping --help
ping: invalid option -- '-'
```

Usage

```
ping [options] <destination>
```

Options:

<destination>	dns name or ip address
-a	use audible ping
-A	use adaptive ping
-B	sticky source address
-c <count>	stop after <count> replies
-D	print timestamps
-d	use SO_DEBUG socket option
-f	flood ping
-h	print help and exit
-I <interface>	either interface name or address
-i <interval>	seconds between sending each packet
-L	suppress loopback of multicast packets
-l <preload>	send <preload> number of packages while waiting replies
-m <mark>	tag the packets going out
-M <pmtud opt>	define mtu discovery, can be one of <do dont want>
-n	no dns name resolution
-O	report outstanding replies
-p <pattern>	contents of padding byte
-q	quiet output
-Q <tclass>	use quality of service <tclass> bits
-s <size>	use <size> as number of data bytes to be sent
-S <size>	use <size> as SO_SNDBUF socket option value
-t <ttl>	define time to live
-U	print user-to-user latency
-v	verbose output
-V	print version and exit
-w <deadline>	reply wait <deadline> in seconds
-W <timeout>	time to wait for response

IPv4 options:

-4	use IPv4
-b	allow pinging broadcast
-R	record route
-T <timestamp>	define timestamp, can be one of <tsonly tsandaddr tsprespec>

IPv6 options:

- 6 use IPv6
- F <flowlabel> define flow label, default is random
- N <nodeinfo opt> use icmp6 node info query, try <help> as argument

For more details see ping(8).

```
praktikum@rn05:~$ ping -4 google.com
PING google.com (142.250.185.78) 56(84) bytes of data.
64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=1 ttl=114 time=4.58 ms
64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=2 ttl=114 time=5.40 ms
^C
--- google.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 4.582/4.989/5.397/0.407 ms
praktikum@rn05:~$ ping -6 google.com
ping: connect: Cannot assign requested address
praktikum@rn05:~$ ping -n 2 google.com
PING google.com (142.250.185.78) 56(124) bytes of data.
```

```
^C
--- google.com ping statistics ---
11 packets transmitted, 0 received, 100% packet loss, time 10240ms
```

```
praktikum@rn05:~$ ping -c 2 google.com
PING google.com (142.250.185.78) 56(84) bytes of data.
64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=1 ttl=114 time=4.45 ms
64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=2 ttl=114 time=4.46 ms

--- google.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 4.447/4.453/4.460/0.006 ms
praktikum@rn05:~$ ping -i 2 google.com
PING google.com (142.250.185.78) 56(84) bytes of data.
64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=1 ttl=114 time=4.69 ms
64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=2 ttl=114 time=4.59 ms
^C
--- google.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 2003ms
rtt min/avg/max/mdev = 4.586/4.639/4.693/0.053 ms
```

HRPing-Nutzung

```
$ wine64 hrping.exe
```

This is hrPING v5.04 by cFos Software GmbH -- <http://www.cfos.de>

usage: hrPING [options] host

data options:

- f Set Don't Fragment bit in IP header
- i TTL Time To Live (default 255 for ping, 30 for traceroute)
- v TOS Type Of Service (default 0, deprecated)
- l size Send buffer size (payload size, default 32)
- l s1[:s2[:i]] Size sweep: send buffer size from <s1> to <s2> step <i>
- L s1[:s2[:i]] IP datagram size (payload size + 28, default 60) [with sweep]
- M Send ICMP timestamp requests
- u [port] Send UDP packets (port 7 by default)

operational options:

- t Ping the specified host until stopped (Ctrl-C to stop)
- n count Number of packets to send (default 4)
- w timeout Timeout in msec to wait for a reply (default 2000)
- s time Sending interval between packets in msec (default 500)
- c [num] Concurrent sending of up to <num> pings at a time (default 1)
- r [count] Be a traceroute (do <count> pings each hop, default 3)
- a [hop] Resolve addresses to names for traceroute (start at <hop>)
- p Trace path to destination, then ping all hops on path

output options:

- lic Show public license and warranty
- fwhelp Print firewall help text
- F file Log output into <file> as well, even if -q is set
- T Print timestamp in front of each line
- q[r|e|t] Be quiet (-qr=no replies, -qe=no errors, -qt=no timeouts)
- y [sec] Print summary of the last <sec> secs (default 10)
- g -G Show graph (-gg=close graph on exit, -G use running grping.exe)
- ? -h This help (-??=more help)

hrPING is Freeware, please share it! See www.cfos.de for our other solutions:

- Internet Acceleration via Traffic Shaping : cFosSpeed
- Webserver for home users and professionals : cFos Personal Net
- IPv6 Connectivity for XP, Vista and Windows 7 : cFos IPv6 Link

\$ fping --help

Usage: fping [options] [targets...]

Probing options:

- 4, --ipv4 only ping IPv4 addresses
- 6, --ipv6 only ping IPv6 addresses
- b, --size=BYTES amount of ping data to send, in bytes (default: 56)
- B, --backoff=N set exponential backoff factor to N (default: 1.5)
- c, --count=N count mode: send N pings to each target
- f, --file=FILE read list of targets from a file (- means stdin)
- g, --generate generate target list (only if no -f specified)
(give start and end IP in the target list, or a CIDR address)

(ex. `fping -g 192.168.1.0 192.168.1.255` or `fping -g 192.168.1.0/24`)

- H, --ttl=N set the IP TTL value (Time To Live hops)
- I, --iface=IFACE bind to a particular interface
- l, --loop loop mode: send pings forever
- m, --all use all IPs of provided hostnames (e.g. IPv4 and IPv6), use with -A
- M, --dontfrag set the Don't Fragment flag
- O, --tos=N set the type of service (tos) flag on the ICMP packets
- p, --period=MSEC interval between ping packets to one target (in ms)
(in loop and count modes, default: 1000 ms)
- r, --retry=N number of retries (default: 3)
- R, --random random packet data (to foil link data compression)
- S, --src=IP set source address
- t, --timeout=MSEC individual target initial timeout (default: 500 ms,
except with -l/-c/-C, where it's the -p period up to 2000 ms)

Output options:

- a, --alive show targets that are alive
- A, --addr show targets by address
- C, --vcount=N same as -c, report results in verbose format
- D, --timestamp print timestamp before each output line
- e, --elapsed show elapsed time on return packets
- i, --interval=MSEC interval between sending ping packets (default: 10 ms)
- n, --name show targets by name (-d is equivalent)
- N, --netdata output compatible for netdata (-l -Q are required)
- o, --outage show the accumulated outage time (lost packets * packet interval)
- q, --quiet quiet (don't show per-target/per-ping results)
- Q, --squiet=SECS same as -q, but show summary every n seconds
- s, --stats print final stats
- u, --unreach show targets that are unreachable
- v, --version show version
- x, --reachable=N shows if >=N hosts are reachable or not

```
$ fping -e 10.60.43.50
```

```
10.60.43.50 is alive (70.9 ms)
```

```
$ sudo ip -s -s neigh flush all
```

```
10.60.63.252 dev wlp0s20f3 lladdr 3c:fd:fe:b6:ed:2d ref 1 used 10/10/10 probes 4 REACHABLE
```

```
10.60.43.50 dev wlp0s20f3 lladdr 7a:11:bd:7c:f9:ff ref 1 used 2/19/2 probes 4 DELAY
```

```
*** Round 1, deleting 2 entries ***
```

```
*** Flush is complete after 1 round ***
```

```
$ fping -e 10.60.43.50
```

```
10.60.43.50 is alive (212 ms)
```

3.6 Traceroute & MTR

Versuchen Sie, den zentralen Peering-Point (DE-CIX) in Deutschland geographisch anhand des Namens zu lokalisieren.

```
$ traceroute de-cix.net
traceroute to de-cix.net (46.31.121.136), 30 hops max, 60 byte packets
 1 opnsense-router.rnlabor.hdm-stuttgart.de (141.62.66.250) 0.509 ms 1.566 ms 0.991 ms
 2 ciscovlgw318.hdm-stuttgart.de (141.62.31.246) 2.047 ms 1.295 ms 1.019 ms
 3 firewall-h.hdm-stuttgart.de (141.62.1.1) 1.118 ms 1.450 ms 1.120 ms
 4 * * *
 5 stu-al30-1-te0-0-0-17.belwue.net (129.143.56.53) 3.625 ms 3.191 ms 3.331 ms
 6 stu-nwz-a99-hu0-3-0-5.belwue.net (129.143.56.106) 3.030 ms 1.325 ms 1.440 ms
 7 fra-decix-1-hu0-0-0-4.belwue.net (129.143.60.113) 5.149 ms fra-decix-1-hu0-0-0-3.belwue.net
 8 sgw2-te-0-0-2-3-ixp.fra.de-cix.net (80.81.194.116) 7.276 ms 7.181 ms 7.103 ms
 9 * * *
10 * * *
11 * * *
12 * * *
13 * * *
14 *^C
```

1. opnsense-router.rnlabor.hdm-stuttgart.de: Gateway des RN-Labors
2. ciscovlgw318.hdm-stuttgart.de: Gateway zwischen RN-Labor-Router und Firewall
3. firewall-h.hdm-stuttgart.de: Firewall der HdM
4. stu-al30-1-te0-0-0-17.belwue.net und stu-nwz-a99-hu0-3-0-5.belwue.net: Router Belwue in Stuttgart
5. fra-decix-1-hu0-0-0-4.belwue.net: Router Belwue in Frankfurt
6. sgw2-te-0-0-2-3-ixp.fra.de-cix.net: Router DE-CIX in Frankfurt

Zeichnen Sie den Weg eines Pakets zu www.aol.com auf.

```
$ traceroute www.aol.com
traceroute to www.aol.com (212.82.100.163), 30 hops max, 60 byte packets
 1 opnsense.rnlabor.hdm-stuttgart.de (141.62.66.250) 1.284 ms 0.653 ms 0.956 ms
 2 ciscovlgw318.hdm-stuttgart.de (141.62.31.246) 1.168 ms 1.601 ms 2.339 ms
 3 firewall-h.hdm-stuttgart.de (141.62.1.1) 1.800 ms 1.896 ms 2.378 ms
 4 * * *
 5 stu-al30-1-te0-0-0-17.belwue.net (129.143.56.53) 3.143 ms 3.819 ms 3.212 ms
 6 stu-nwz-a99-hu0-3-0-5.belwue.net (129.143.56.106) 3.510 ms 2.147 ms 3.579 ms
 7 fra-decix-1-hu0-0-0-3.belwue.net (129.143.57.127) 5.073 ms 5.193 ms 4.812 ms
 8 ge-1-3-0.pat1.dee.yahoo.com (80.81.192.115) 5.630 ms 5.656 ms 5.699 ms
 9 ae-3.pat1.frz.yahoo.com (209.191.112.17) 13.928 ms 14.322 ms 13.942 ms
10 ae-2.pat1.iry.yahoo.com (209.191.112.54) 30.229 ms 30.613 ms 30.790 ms
11 et-1-1-2.msrl.ir2.yahoo.com (66.196.65.19) 30.763 ms 29.649 ms 29.854 ms
12 lo0.fab2-1-gdc.ir2.yahoo.com (77.238.190.3) 29.678 ms lo0.fab3-1-gdc.ir2.yahoo.com (77.238.190.4)
13 usw2-1-lba.ir2.yahoo.com (77.238.190.103) 29.724 ms 29.602 ms usw1-1-lba.ir2.yahoo.com (77.238.190.104)
14 media-router-aol71.prod.media.vip.ir2.yahoo.com (212.82.100.163) 29.546 ms 30.166 ms
```

Beobachten Sie Zeitüberschreitungen? Wie können Sie tracert so manipulieren, dass möglichst selten Zeitüberschreitungen auftauchen?

Eine Zeitüberschreitung kann zwischen `firewall-h.hdm-stuttgart.de` und `stu-al30-1-te0-0-0-17.belwue.net` erkannt werden; hier wurde versucht das Timeout auf 5 Sekunden mittels `-w` zu setzen und mit `-I` über die Raw Sockets API direkt die Pakete am Kernel-Stack vorbei zu schicken, was jedoch in beiden Fällen die durch `* * *` gekennzeichneten Timeouts nicht umgehen kann.

```
$ traceroute --help
```

Usage:

```
traceroute [ -4dFITnreAUDV ] [ -f first_ttl ] [ -g gate,... ] [ -i device ] [ -m max_ttl
```

Options:

```
-4                      Use IPv4
-6                      Use IPv6
-d  --debug            Enable socket level debugging
-F  --dont-fragment    Do not fragment packets
-f first_ttl  --first=first_ttl
                        Start from the first_ttl hop (instead from 1)
-g gate,...  --gateway=gate,...
                        Route packets through the specified gateway
                        (maximum 8 for IPv4 and 127 for IPv6)
-I  --icmp             Use ICMP ECHO for tracerouting
-T  --tcp              Use TCP SYN for tracerouting (default port is 80)
-i device  --interface=device
                        Specify a network interface to operate with
-m max_ttl  --max-hops=max_ttl
                        Set the max number of hops (max TTL to be
                        reached). Default is 30
-N squeries  --sim-queries=squeries
                        Set the number of probes to be tried
                        simultaneously (default is 16)
-n                      Do not resolve IP addresses to their domain names
-p port  --port=port    Set the destination port to use. It is either
                        initial udp port value for "default" method
                        (incremented by each probe, default is 33434), or
                        initial seq for "icmp" (incremented as well,
                        default from 1), or some constant destination
                        port for other methods (with default of 80 for
                        "tcp", 53 for "udp", etc.)
-t tos  --tos=tos       Set the TOS (IPv4 type of service) or TC (IPv6
                        traffic class) value for outgoing packets
-l flow_label  --flowlabel=flow_label
                        Use specified flow_label for IPv6 packets
-w MAX,HERE,NEAR  --wait=MAX,HERE,NEAR
                        Wait for a probe no more than HERE (default 3)
                        times longer than a response from the same hop,
                        or no more than NEAR (default 10) times than some
                        next hop, or MAX (default 5.0) seconds (float
```


point values allowed too)

-q nqueries --queries=nqueries Set the number of probes per each hop. Default is 3

-r Bypass the normal routing and send directly to a host on an attached network

-s src_addr --source=src_addr Use source src_addr for outgoing packets

-z sendwait --sendwait=sendwait Minimal time interval between probes (default 0). If the value is more than 10, then it specifies a number in milliseconds, else it is a number of seconds (float point values allowed too)

-e --extensions Show ICMP extensions (if present), including MPLS

-A --as-path-lookups Perform AS path lookups in routing registries and print results directly after the corresponding addresses

-M name --module=name Use specified module (either builtin or external) for traceroute operations. Most methods have their shortcuts ('-I' means '-M icmp' etc.)

-O OPTS,... --options=OPTS,... Use module-specific option OPTS for the traceroute module. Several OPTS allowed, separated by comma. If OPTS is "help", print info about available options

--sport=num Use source port num for outgoing packets. Implies '-N 1'

--fwmark=num Set firewall mark for outgoing packets

-U --udp Use UDP to particular port for tracerouting (instead of increasing the port per each probe), default port is 53

-UL Use UDPLITE for tracerouting (default dest port is 53)

-D --dccp Use DCCP Request for tracerouting (default port is 33434)

-P prot --protocol=prot Use raw packet of protocol prot for tracerouting

--mtu Discover MTU along the path being traced. Implies '-F -N 1'

--back Guess the number of hops in the backward path and print if it differs

-V --version Print version info and exit

--help Read this help and exit

Arguments:

+ host The host to traceroute to

packetlen The full packet length (default is the length of an IP

header plus 40). Can be ignored or increased to a minimal
allowed value

```
$ traceroute www.aol.com
```

```
traceroute to www.aol.com (212.82.100.163), 30 hops max, 60 byte packets
```

```
 1 opnsense.rnlabor.hdm-stuttgart.de (141.62.66.250)  1.284 ms  0.653 ms  0.956 ms
 2 ciscovlgw318.hdm-stuttgart.de (141.62.31.246)  1.168 ms  1.601 ms  2.339 ms
 3 firewall-h.hdm-stuttgart.de (141.62.1.1)  1.800 ms  1.896 ms  2.378 ms
 4 * * *
 5 stu-al30-1-te0-0-0-17.belwue.net (129.143.56.53)  3.143 ms  3.819 ms  3.212 ms
 6 stu-nwz-a99-hu0-3-0-5.belwue.net (129.143.56.106)  3.510 ms  2.147 ms  3.579 ms
 7 fra-decix-1-hu0-0-0-3.belwue.net (129.143.57.127)  5.073 ms  5.193 ms  4.812 ms
 8 ge-1-3-0.pat1.dee.yahoo.com (80.81.192.115)  5.630 ms  5.656 ms  5.699 ms
 9 ae-3.pat1.frz.yahoo.com (209.191.112.17)  13.928 ms  14.322 ms  13.942 ms
10 ae-2.pat1.iry.yahoo.com (209.191.112.54)  30.229 ms  30.613 ms  30.790 ms
11 et-1-1-2.msrl.ir2.yahoo.com (66.196.65.19)  30.763 ms  29.649 ms  29.854 ms
12 lo0.fab2-1-gdc.ir2.yahoo.com (77.238.190.3)  29.678 ms lo0.fab3-1-gdc.ir2.yahoo.com (77.238.190.4)  29.678 ms
13 usw2-1-lba.ir2.yahoo.com (77.238.190.103)  29.724 ms  29.602 ms usw1-1-lba.ir2.yahoo.com (77.238.190.102)  29.517 ms
14 media-router-aol71.prod.media.vip.ir2.yahoo.com (212.82.100.163)  29.546 ms  30.166 ms
[pojntfx@felixs-xps13 hrping-v504]$ ssh pojntfx@159.223.25.154 "nc -lp 6969"
```

```
$ traceroute -w 5 www.aol.com
```

```
traceroute to www.aol.com (212.82.100.163), 30 hops max, 60 byte packets
```

```
 1 opnsense.rnlabor.hdm-stuttgart.de (141.62.66.250)  0.707 ms  3.001 ms  1.312 ms
 2 ciscovlgw318.hdm-stuttgart.de (141.62.31.246)  1.782 ms  2.642 ms  2.615 ms
 3 firewall-h.hdm-stuttgart.de (141.62.1.1)  3.417 ms  0.907 ms  2.692 ms
 4 * * *
 5 stu-al30-1-te0-0-0-17.belwue.net (129.143.56.53)  2.044 ms  2.630 ms  2.032 ms
 6 stu-nwz-a99-hu0-3-0-5.belwue.net (129.143.56.106)  3.323 ms  1.287 ms  1.541 ms
 7 fra-decix-1-hu0-0-0-4.belwue.net (129.143.60.113)  7.004 ms  7.114 ms  7.266 ms
 8 ge-1-3-0.pat1.dee.yahoo.com (80.81.192.115)  6.009 ms  4.880 ms  4.545 ms
 9 ae-3.pat1.frz.yahoo.com (209.191.112.17)  14.326 ms  13.727 ms  13.700 ms
10 ae-2.pat1.iry.yahoo.com (209.191.112.54)  31.291 ms  31.060 ms  31.097 ms
11 ge-0-3-9-d104.pat1.the.yahoo.com (66.196.65.21)  29.823 ms  29.921 ms et-1-1-2.msrl.ir2.yahoo.com (66.196.65.19)  29.854 ms
12 lo0.fab4-1-gdc.ir2.yahoo.com (77.238.190.5)  29.809 ms lo0.fab1-1-gdc.ir2.yahoo.com (77.238.190.4)  29.678 ms
13 usw1-1-lba.ir2.yahoo.com (77.238.190.102)  29.517 ms  29.572 ms  29.759 ms
14 media-router-aol71.prod.media.vip.ir2.yahoo.com (212.82.100.163)  29.563 ms  29.706 ms
```

```
$ sudo traceroute -I www.aol.com
```

```
traceroute to www.aol.com (212.82.100.163), 30 hops max, 60 byte packets
```

```
 1 opnsense-router.rnlabor.hdm-stuttgart.de (141.62.66.250)  0.461 ms  0.551 ms  0.664 ms
 2 ciscovlgw318.hdm-stuttgart.de (141.62.31.246)  2.064 ms  2.290 ms  2.657 ms
 3 firewall-h.hdm-stuttgart.de (141.62.1.1)  1.315 ms  1.628 ms  1.878 ms
 4 * * *
 5 stu-al30-1-te0-0-0-17.belwue.net (129.143.56.53)  2.891 ms  3.008 ms  3.068 ms
 6 stu-nwz-a99-hu0-3-0-5.belwue.net (129.143.56.106)  3.175 ms  1.587 ms  1.432 ms
 7 fra-decix-1-hu0-0-0-3.belwue.net (129.143.57.127)  5.115 ms  5.213 ms  5.328 ms
 8 ge-1-3-0.pat1.dee.yahoo.com (80.81.192.115)  4.916 ms  4.915 ms  5.005 ms
 9 ae-3.pat1.frz.yahoo.com (209.191.112.17)  13.831 ms  13.886 ms  14.163 ms
```

```

10 ae-2.pat1.iry.yahoo.com (209.191.112.54) 30.506 ms 30.505 ms 30.108 ms
11 ge-0-3-9-d104.pat1.the.yahoo.com (66.196.65.21) 29.434 ms 29.657 ms 29.699 ms
12 lo0.fab3-1-gdc.ir2.yahoo.com (77.238.190.4) 29.757 ms 29.662 ms 29.707 ms
13 usw2-1-lba.ir2.yahoo.com (77.238.190.103) 29.685 ms 29.690 ms 29.696 ms
14 media-router-aol71.prod.media.vip.ir2.yahoo.com (212.82.100.163) 29.631 ms 29.915 ms

```

Besuchen Sie das DENIC (www.denic.de) und erfragen Sie den Besitzer von Domain-Namen, die Sie interessieren.

```

$ whois www.hdm-stuttgart.de
[Querying whois.denic.de]
[whois.denic.de]
% Restricted rights.
%
% Terms and Conditions of Use
%
% The above data may only be used within the scope of technical or
% administrative necessities of Internet operation or to remedy legal
% problems.
% The use for other purposes, in particular for advertising, is not permitted.
%
% The DENIC whois service on port 43 doesn't disclose any information concerning
% the domain holder, general request and abuse contact.
% This information can be obtained through use of our web-based whois service
% available at the DENIC website:
% http://www.denic.de/en/domains/whois-service/web-whois.html
%
%

```

```

Domain: hdm-stuttgart.de
Nserver: dns1.belwue.de
Nserver: dns3.belwue.de
Nserver: iz-net-2.hdm-stuttgart.de 141.62.1.2
Nserver: iz-net-3.hdm-stuttgart.de 141.62.1.3
Nserver: iz-net-4.hdm-stuttgart.de 141.62.1.4
Status: connect
Changed: 2015-04-22T16:37:06+02:00

```

Sehen Sie sich die Möglichkeiten von Pathping an.

Als freie Alternative zu Pathping wurde mtr verwendet:

```

Name      : mtr
Epoch    : 2
Version   : 0.94
Release   : 3.fc34
Architecture : x86_64
Size      : 191 k

```

```

Source       : mtr-0.94-3.fc34.src.rpm
Repository   : @System
From repo    : updates
Summary      : Network diagnostic tool combining 'traceroute' and 'ping'
URL          : https://www.bitwizzard.nl/mtr/
License      : GPLv2
Description  : MTR combines the functionality of the 'traceroute' and 'ping'
              : programs in a single network diagnostic tool.
              :
              : When MTR is started, it investigates the network connection
              : between the host MTR runs on and the user-specified destination
              : host. Afterwards it determines the address of each network hop
              : between the machines and sends a sequence of ICMP echo requests
              : to each one to determine the quality of the link to each machine.
              : While doing this, it prints running statistics about each
              : machine.
              :
              : MTR provides two user interfaces: an ncurses interface, useful
              : for the command line, e.g. for SSH sessions; and a GTK interface
              : for X (provided in the mtr-gtk package).

```

Usage:

```
mtr [options] hostname
```

```

-F, --filename FILE      read hostname(s) from a file
-4                        use IPv4 only
-6                        use IPv6 only
-u, --udp                use UDP instead of ICMP echo
-T, --tcp                use TCP instead of ICMP echo
-I, --interface NAME     use named network interface
-a, --address ADDRESS    bind the outgoing socket to ADDRESS
-f, --first-ttl NUMBER   set what TTL to start
-m, --max-ttl NUMBER     maximum number of hops
-U, --max-unknown NUMBER maximum unknown host
-P, --port PORT          target port number for TCP, SCTP, or UDP
-L, --localport LOCALPORT source port number for UDP
-s, --psize PACKETSIZE   set the packet size used for probing
-B, --bitpattern NUMBER  set bit pattern to use in payload
-i, --interval SECONDS   ICMP echo request interval
-G, --gracetime SECONDS  number of seconds to wait for responses
-Q, --tos NUMBER         type of service field in IP header
-e, --mpls               display information from ICMP extensions
-Z, --timeout SECONDS    seconds to keep probe sockets open
-M, --mark MARK          mark each sent packet
-r, --report             output using report mode

```

-w, --report-wide	output wide report
-c, --report-cycles COUNT	set the number of pings sent
-j, --json	output json
-x, --xml	output xml
-C, --csv	output comma separated values
-l, --raw	output raw format
-p, --split	split output
-t, --curses	use curses terminal interface
--displaymode MODE	select initial display mode
-n, --no-dns	do not resolve host names
-b, --show-ips	show IP numbers and host names
-o, --order FIELDS	select output fields
-y, --ipinfo NUMBER	select IP information in output
-z, --aslookup	display AS number
-h, --help	display this help and exit
-v, --version	output version information and exit

See the 'man 8 mtr' for details.

```
$ mtr -n --json www.aol.com
```

```
{
  "report": {
    "mtr": {
      "src": "felixs-xps13",
      "dst": "www.aol.com",
      "tos": 0,
      "tests": 10,
      "psize": "64",
      "bitpattern": "0x00"
    },
    "hubs": [
      {
        "count": 1,
        "host": "10.60.63.252",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 88.565,
        "Avg": 10.379,
        "Best": 1.066,
        "Wrst": 88.565,
        "StDev": 27.477
      },
      {
        "count": 2,
        "host": "141.62.31.94",
        "Loss%": 0.0,
        "Snt": 10,
```

```

        "Last": 11.83,
        "Avg": 2.541,
        "Best": 1.24,
        "Wrst": 11.83,
        "StDev": 3.272
    },
    {
        "count": 3,
        "host": "???",
        "Loss%": 100.0,
        "Snt": 10,
        "Last": 0.0,
        "Avg": 0.0,
        "Best": 0.0,
        "Wrst": 0.0,
        "StDev": 0.0
    },
    {
        "count": 4,
        "host": "129.143.56.53",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 16.222,
        "Avg": 3.928,
        "Best": 1.613,
        "Wrst": 16.222,
        "StDev": 4.422
    },
    {
        "count": 5,
        "host": "129.143.56.106",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 231.77,
        "Avg": 25.22,
        "Best": 1.846,
        "Wrst": 231.77,
        "StDev": 72.574
    },
    {
        "count": 6,
        "host": "129.143.60.113",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 77.414,
        "Avg": 13.153,

```

```

        "Best": 5.437,
        "Wrst": 77.414,
        "StDev": 22.584
    },
    {
        "count": 7,
        "host": "80.81.192.115",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 86.385,
        "Avg": 13.403,
        "Best": 5.122,
        "Wrst": 86.385,
        "StDev": 25.643
    },
    {
        "count": 8,
        "host": "209.191.112.17",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 138.72,
        "Avg": 29.309,
        "Best": 13.844,
        "Wrst": 138.72,
        "StDev": 39.424
    },
    {
        "count": 9,
        "host": "209.191.112.54",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 116.04,
        "Avg": 41.328,
        "Best": 29.978,
        "Wrst": 116.04,
        "StDev": 26.988
    },
    {
        "count": 10,
        "host": "66.196.65.21",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 39.317,
        "Avg": 31.703,
        "Best": 30.246,
        "Wrst": 39.317,

```

```

        "StDev": 2.747
    },
    {
        "count": 11,
        "host": "77.238.190.5",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 32.85,
        "Avg": 31.768,
        "Best": 30.18,
        "Wrst": 38.489,
        "StDev": 2.535
    },
    {
        "count": 12,
        "host": "77.238.190.103",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 30.614,
        "Avg": 33.189,
        "Best": 30.017,
        "Wrst": 56.002,
        "StDev": 8.102
    },
    {
        "count": 13,
        "host": "212.82.100.163",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 32.157,
        "Avg": 30.531,
        "Best": 29.846,
        "Wrst": 32.157,
        "StDev": 0.818
    }
]
}
$ mtr --json www.aol.com
{
    "report": {
        "mtr": {
            "src": "felixs-xps13",
            "dst": "www.aol.com",
            "tos": 0,
            "tests": 10,

```



```

    "psize": "64",
    "bitpattern": "0x00"
  },
  "hubs": [
    {
      "count": 1,
      "host": "_gateway",
      "Loss%": 0.0,
      "Snt": 10,
      "Last": 35.643,
      "Avg": 5.191,
      "Best": 1.074,
      "Wrst": 35.643,
      "StDev": 10.757
    },
    {
      "count": 2,
      "host": "141.62.31.94",
      "Loss%": 0.0,
      "Snt": 10,
      "Last": 49.069,
      "Avg": 14.104,
      "Best": 1.404,
      "Wrst": 77.221,
      "StDev": 26.687
    },
    {
      "count": 3,
      "host": "???",
      "Loss%": 100.0,
      "Snt": 10,
      "Last": 0.0,
      "Avg": 0.0,
      "Best": 0.0,
      "Wrst": 0.0,
      "StDev": 0.0
    },
    {
      "count": 4,
      "host": "stu-al30-1-te0-0-0-17.belwue.net",
      "Loss%": 0.0,
      "Snt": 10,
      "Last": 14.869,
      "Avg": 11.953,
      "Best": 1.886,
      "Wrst": 50.552,

```

```

    "StDev": 17.083
  },
  {
    "count": 5,
    "host": "stu-nwz-a99-hu0-3-0-5.belwue.net",
    "Loss%": 0.0,
    "Snt": 10,
    "Last": 2.332,
    "Avg": 2.954,
    "Best": 1.847,
    "Wrst": 7.302,
    "StDev": 1.961
  },
  {
    "count": 6,
    "host": "fra-decix-1-hu0-0-0-4.belwue.net",
    "Loss%": 0.0,
    "Snt": 10,
    "Last": 58.059,
    "Avg": 22.657,
    "Best": 5.208,
    "Wrst": 74.371,
    "StDev": 27.785
  },
  {
    "count": 7,
    "host": "ge-1-3-0.pat1.dee.yahoo.com",
    "Loss%": 0.0,
    "Snt": 10,
    "Last": 5.488,
    "Avg": 6.379,
    "Best": 4.908,
    "Wrst": 13.858,
    "StDev": 2.716
  },
  {
    "count": 8,
    "host": "ae-3.pat1.frz.yahoo.com",
    "Loss%": 0.0,
    "Snt": 10,
    "Last": 125.22,
    "Avg": 33.495,
    "Best": 14.004,
    "Wrst": 125.22,
    "StDev": 40.562
  },

```

```

{
  "count": 9,
  "host": "ae-2.pat1.iry.yahoo.com",
  "Loss%": 0.0,
  "Snt": 10,
  "Last": 86.809,
  "Avg": 36.314,
  "Best": 29.889,
  "Wrst": 86.809,
  "StDev": 17.76
},
{
  "count": 10,
  "host": "ge-0-3-9-d104.pat1.the.yahoo.com",
  "Loss%": 0.0,
  "Snt": 10,
  "Last": 31.651,
  "Avg": 41.326,
  "Best": 30.095,
  "Wrst": 134.5,
  "StDev": 32.747
},
{
  "count": 11,
  "host": "lo0.fab4-1-gdc.ir2.yahoo.com",
  "Loss%": 0.0,
  "Snt": 10,
  "Last": 130.62,
  "Avg": 46.746,
  "Best": 30.125,
  "Wrst": 130.62,
  "StDev": 34.357
},
{
  "count": 12,
  "host": "usw1-1-lba.ir2.yahoo.com",
  "Loss%": 0.0,
  "Snt": 10,
  "Last": 53.336,
  "Avg": 34.049,
  "Best": 30.023,
  "Wrst": 53.336,
  "StDev": 8.066
},
{
  "count": 13,

```

```

        "host": "media-router-aol71.prod.media.vip.ir2.yahoo.com",
        "Loss%": 0.0,
        "Snt": 10,
        "Last": 30.159,
        "Avg": 41.64,
        "Best": 30.008,
        "Wrst": 141.8,
        "StDev": 35.2
    }
}
]
}
}

```

Wie zu erkennen ist wird durch die `-n`-Flag die Hostnamen-Auflösungen übersprungen, was die Geschwindigkeit erhöht.

3.7 SS

Netstat ist deprecated, es wird stattdessen dessen Nachfolger `ss` aus dem `iproute2`-Package verwendet:

```

Name           : iproute
Version        : 5.10.0
Release        : 2.fc34
Architecture   : x86_64
Size           : 1.7 M
Source         : iproute-5.10.0-2.fc34.src.rpm
Repository     : @System
From repo      : anaconda
Summary        : Advanced IP routing and network device configuration tools
URL            : http://kernel.org/pub/linux/utils/net/iproute2/
License        : GPLv2+ and Public Domain
Description    : The iproute package contains networking utilities (ip and rtmon,
                : for example) which are designed to use the advanced networking
                : capabilities of the Linux kernel.

```

Gehen Sie ins `www` und beobachten Sie die Veränderungen der `netstat`-Tabelle (`netstat -an`). Interpretieren Sie die Anzeige

Zuvor:

```

$ ss -tnp
State          Recv-Q          Send-Q
FIN-WAIT-1     0                1
FIN-WAIT-1     0                1
ESTAB          0                0
FIN-WAIT-1     0                1
FIN-WAIT-1     0                1

```

FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
ESTAB	0	0
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
ESTAB	0	0
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1

Nach dem Aufruf von `news.ycombinator.com`:

```
$ ss -tnp
```

State	Recv-Q	Send-Q
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
ESTAB	0	0
ESTAB	0	0
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
FIN-WAIT-2	0	0
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
ESTAB	0	0
ESTAB	0	0
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
ESTAB	0	0
FIN-WAIT-1	0	1
ESTAB	0	0
FIN-WAIT-1	0	1
ESTAB	0	0
FIN-WAIT-1	0	1
LAST-ACK	1	1
LAST-ACK	0	1043
LAST-ACK	1	1
FIN-WAIT-1	0	1
ESTAB	0	0
ESTAB	0	0
FIN-WAIT-1	0	1
FIN-WAIT-1	0	1
ESTAB	0	0
ESTAB	0	0

[2001:7c7:2121:8d00
[2001:7c7:2121:8d00

Wie zu sehen ist wurde eine TCP-Verbindung mit news.ycombinator.com aufgebaut:

```
$ dig +noall +answer news.ycombinator.com
news.ycombinator.com. 228 IN A 209.216.230.240
```

Testen Sie nun die Verbindung zwischen Ihrem PC und dem PC einer anderen Praktikumsgruppe und loten Sie die Möglichkeiten zur Verkehrsanalyse aus (netstat -s).

Auf Host A

```
$ ss -tlnp
```

State	Recv-Q	Send-Q	Local Address:Port	Peer Address:Port	Process
LISTEN	0	128	0.0.0.0:22	0.0.0.0:*	
LISTEN	0	1	0.0.0.0:6767	0.0.0.0:*	users:((("nc
LISTEN	0	2	:::ffff:127.0.0.1]:3350	:::*	
LISTEN	0	128	:::] :22	:::] :*	
LISTEN	0	2	:::3389	:::*	

```
$ nc -lp 6767
```

asdf

asdf

```
$ ss -tlnp
```

State	Recv-Q	Send-Q	Local Address:Port	Peer Address:Port	Process
LISTEN	0	128	0.0.0.0:22	0.0.0.0:*	
LISTEN	0	2	:::ffff:127.0.0.1]:3350	:::*	
LISTEN	0	128	:::] :22	:::] :*	
LISTEN	0	2	:::3389	:::*	

Auf Host B

```
$ ss -tnp | grep 6767
```

State	Recv-Q	Send-Q	Local Address:Port	Peer Address:Port	Process
ESTAB	0	0	141.62.66.5:54694	141.62.66.4:6767	users:((("nc",pid=3

```
$ nc 141.62.66.4 6767
```

asdf

asdf

```
$ ss -tnp | grep 6767
```

State	Recv-Q	Send-Q	Local Address:Port	Peer Address:Port
-------	--------	--------	--------------------	-------------------

Wie zu Erkennen ist wurde eine TCP-Verbindung zwischen Host A und Host B erstellt, über welcher hier folgende Nachricht gesendet wurde:

asdf

asdf

Beobachten, dokumentieren und interpretieren Sie die Veränderungen der netstat-Tabelle beim „Durchklicken“ eines beliebigen

Internet-Angebots.

```
$ ss -tnp
State      Recv-Q      Send-Q      Local Address:Port      Peer Address:Port
$ ss -tnp
State Recv-Q Send-Q Local Address:Port      Peer Address:Port Process
ESTAB 0      0      141.62.66.5:54096      34.107.221.82:80      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:52748      65.9.84.27:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:53806      54.239.39.102:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:40840      142.250.186.138:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:36194      173.239.79.196:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:33678      93.184.220.29:80      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:55186      162.219.226.52:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:54384      209.216.230.240:80      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:36590      52.95.122.8:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:46840      65.9.83.39:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:37550      54.239.39.102:80      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:43074      142.250.185.67:80      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:54094      34.107.221.82:80      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:42432      209.216.230.240:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:42430      209.216.230.240:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:36288      65.9.83.11:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:50220      151.101.12.201:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:42822      54.194.65.3:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:43710      2.21.21.24:80      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:43922      54.68.102.210:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:42428      209.216.230.240:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:42434      209.216.230.240:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:34436      162.219.224.163:443      users:(("firefox-esr",pid=36
ESTAB 0      0      141.62.66.5:44868      65.9.84.191:80      users:(("firefox-esr",pid=36
$ ss -tnp
State      Recv-Q      Send-Q      Local Address:Port      Peer Address:Port
```

Wie zu erkennen ist werden viele TCP-Verbindungen zu Webservern (Port 80 & Port 443) aufgebaut, hier zu news.ycombinator.com, eff.org und Amazon.

3.8 Route

route ist deprecated, es wird stattdessen `ip route` verwendet.

Interpretieren Sie die Einträge in der Routing-Tabelle Ihres Rechners.

```
$ ip route show table all
default via 141.62.66.250 dev enp0s31f6
141.62.66.0/24 dev enp0s31f6 proto kernel scope link src 141.62.66.5
broadcast 127.0.0.0 dev lo table local proto kernel scope link src 127.0.0.1
local 127.0.0.0/8 dev lo table local proto kernel scope host src 127.0.0.1
local 127.0.0.1 dev lo table local proto kernel scope host src 127.0.0.1
```

```

broadcast 127.255.255.255 dev lo table local proto kernel scope link src 127.0.0.1
broadcast 141.62.66.0 dev enp0s31f6 table local proto kernel scope link src 141.62.66.5
local 141.62.66.5 dev enp0s31f6 table local proto kernel scope host src 141.62.66.5
broadcast 141.62.66.255 dev enp0s31f6 table local proto kernel scope link src 141.62.66.5

```

Zu Erkennen ist dass das Default-Gateway 141.62.66.250 ist, über das Netzwerkgerät **enp0s31f6**. Auf localhost wird über den Kernel geroutet, d.h. dass Traffic niemals das System verlässt. Andere Subnetze werden über das Default-Gateway gerouted.

Erweitern oder modifizieren Sie die Routing-Tabelle Ihres PC

```

$ sudo ip route add 192.0.2.128/25 via 141.62.66.4
$ ip route show table all
default via 141.62.66.250 dev enp0s31f6
141.62.66.0/24 dev enp0s31f6 proto kernel scope link src 141.62.66.5
192.0.2.128/25 via 141.62.66.4 dev enp0s31f6
broadcast 127.0.0.0 dev lo table local proto kernel scope link src 127.0.0.1
local 127.0.0.0/8 dev lo table local proto kernel scope host src 127.0.0.1
local 127.0.0.1 dev lo table local proto kernel scope host src 127.0.0.1
broadcast 127.255.255.255 dev lo table local proto kernel scope link src 127.0.0.1
broadcast 141.62.66.0 dev enp0s31f6 table local proto kernel scope link src 141.62.66.5
local 141.62.66.5 dev enp0s31f6 table local proto kernel scope host src 141.62.66.5
broadcast 141.62.66.255 dev enp0s31f6 table local proto kernel scope link src 141.62.66.5

```

Hier wurde nun eine neue Route hinzugefügt, welche das Subnet 192.0.2.128/25 über den Host 141.62.66.4 routed.

iperf

Mittels iperf3 kann die Übertragungsrate zwischen zwei Hosts getestet werden.

```

# Host A
$ iperf3 -s
-----
Server listening on 5201
-----
Accepted connection from 141.62.66.4, port 54336
[ 5] local 141.62.66.5 port 5201 connected to 141.62.66.4 port 54338
[ ID] Interval           Transfer    Bitrate
[ 5]  0.00-1.00    sec   99.4 MBytes    834 Mbits/sec
[ 5]  1.00-2.00    sec   99.5 MBytes    835 Mbits/sec
[ 5]  2.00-3.00    sec   101 MBytes    846 Mbits/sec
[ 5]  3.00-4.00    sec   101 MBytes    845 Mbits/sec
[ 5]  4.00-5.00    sec   101 MBytes    845 Mbits/sec
[ 5]  5.00-6.00    sec   101 MBytes    844 Mbits/sec
[ 5]  6.00-7.00    sec   101 MBytes    844 Mbits/sec
[ 5]  7.00-8.00    sec   101 MBytes    850 Mbits/sec
[ 5]  8.00-9.00    sec   102 MBytes    853 Mbits/sec

```



```
[ 5] 9.00-10.00 sec 102 MBytes 856 Mbits/sec
[ 5] 10.00-10.00 sec 222 KBytes 756 Mbits/sec
```

```
-----
```

```
[ ID] Interval          Transfer      Bitrate
```

```
# Host B
```

```
$ sudo iperf3 -c 141.62.66.5
```

```
Connecting to host 141.62.66.5, port 5201
```

```
[ 5] local 141.62.66.4 port 54338 connected to 141.62.66.5 port 5201
```

```
[ ID] Interval          Transfer      Bitrate      Retr  Cwnd
[ 5] 0.00-1.00 sec 101 MBytes 845 Mbits/sec 0 342 KBytes
[ 5] 1.00-2.00 sec 99.9 MBytes 838 Mbits/sec 0 359 KBytes
[ 5] 2.00-3.00 sec 101 MBytes 845 Mbits/sec 0 359 KBytes
[ 5] 3.00-4.00 sec 101 MBytes 846 Mbits/sec 0 359 KBytes
[ 5] 4.00-5.00 sec 101 MBytes 846 Mbits/sec 0 359 KBytes
[ 5] 5.00-6.00 sec 100 MBytes 840 Mbits/sec 0 359 KBytes
[ 5] 6.00-7.00 sec 101 MBytes 844 Mbits/sec 0 359 KBytes
[ 5] 7.00-8.00 sec 101 MBytes 851 Mbits/sec 0 359 KBytes
[ 5] 8.00-9.00 sec 102 MBytes 852 Mbits/sec 0 359 KBytes
[ 5] 9.00-10.00 sec 102 MBytes 859 Mbits/sec 0 359 KBytes
```

```
-----
```

```
[ ID] Interval          Transfer      Bitrate      Retr
```

```
[ 5] 0.00-10.00 sec 1009 MBytes 847 Mbits/sec 0 sender
[ 5] 0.00-10.00 sec 1008 MBytes 845 Mbits/sec receiver
```

```
iperf Done.
```

Hier kann z.B. erkannt werden, dass ca. 850 Mbits/sec erreicht werden können, was für die verwendete Gigabit-Netzwerkkarte mit CAT-5e-Kabel zu erwarten ist.