Praktikum Rechnernetze

Versuch 1: Troubleshooting TCP/IP

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Introduction

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 :)

License

Figure 2: AGPL-3.0 license badge

IP-Subnetz-Berechnung

Ergänzen Sie die Tabelle

IP-Adresse	SN-Mask	Klasse	Netz-addresse	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	32766	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	14	143.62.67.15	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	256	/	/
10.15.119.237	255.255.255.252	A	10.15.119.236	4194304	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 + 3 → /27 → 184.16.12.80/27 | CIDR

255. 255. 255. 111|0 0000 } 224

184. 16. 12. 010|1 0000 } 80

010 | 0 0000 → 64 → 184.16.12.64 | Network adress

010 | 1 1111 → 95 → 184.16.12.95 | Broadcast adress

6+2=11 → 2^{11} = 2048 subnets

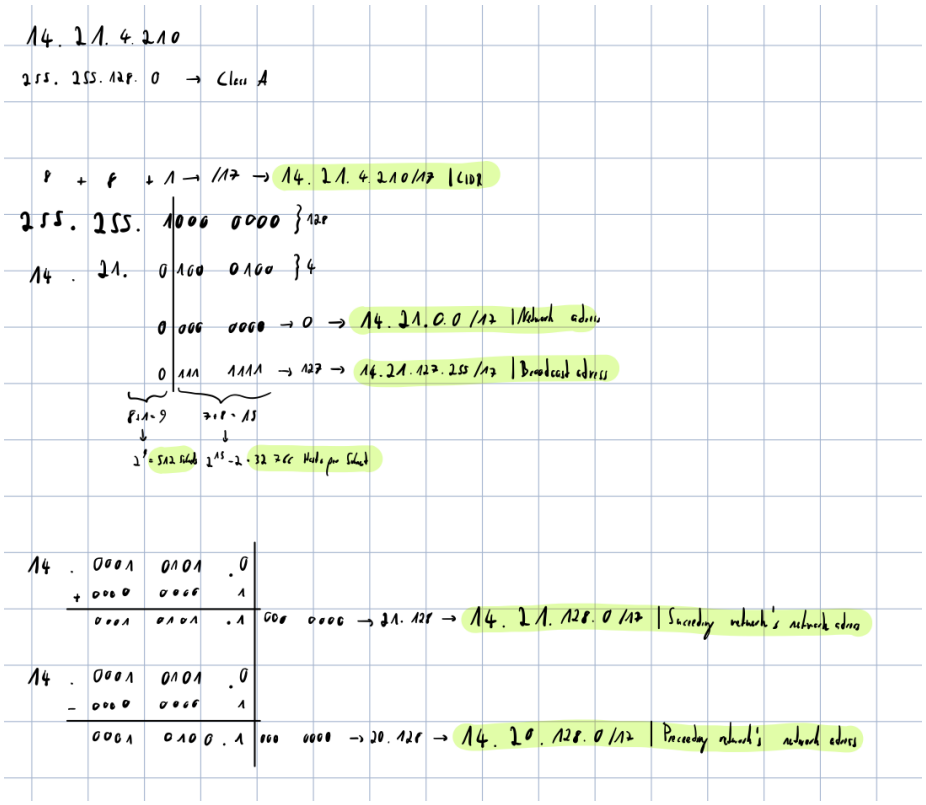
5 → $2^5 - 2$ = 30 Hosts per subnets

0000 0000 010 / 0000 0000 001 | 0 0000 → 96 → 184.16.12.96/27 | Secondly network's network address

0000 0000 010 / 0000 0000 001 | 0 0000 → 32 → 184.16.12.32/27 | Primary network's network address

143. 62. 67. 32

255. 255. 255. 240 → Class B



Tools des OS

IP-Konfiguration

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

IP-Addresse: 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
```

```
4 # ...
  $ find /sys | grep drivers.*00:1f.6
6 # ...
  /sys/bus/pci/drivers/e1000e/0000:00:1f.6
```

Testen Sie die DNS-Namensauflösung mit nslookup

Wir verwenden an dieser Stelle dig, da nslookup deprecated ist. Die Option +noall entfernt alle Display-Flags und +answer zeigt dann nur die Antwortsektion des Outputs an.

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

Wir erhalten zwei Ergebnisse auf unsere Anfrage. Das könnte daran liegen, dass die HdM zur Lastenaufteilung zwei Webserver einsetzt.

Anschluss des PC an das Labornetz

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

Folgende Verbindungen konnten erkannt werden:

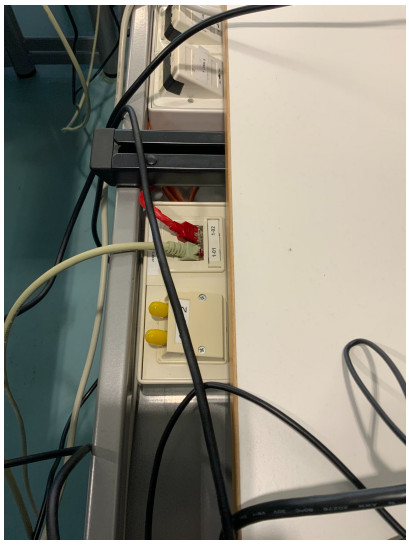


Figure 3: Unser Computer ist an die RJ-45-Buchse 1-01 angeschlossen. Das Kabel der Buchse führt dann in den Netzwerkschrank

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

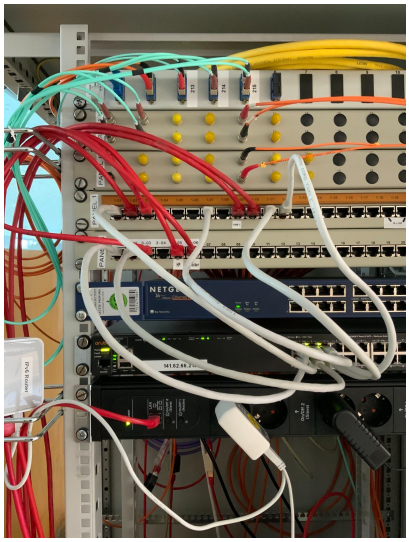


Figure 4: Auf diesem Bild ist der Netzwerkschrank zu sehen. Man sieht hier das Patchfeld, an welchem die 1-01 angeschlossen ist. Vom Patchfeld führt ein weiteres LAN-Kabel (CAT-5e) zu einem Switch.

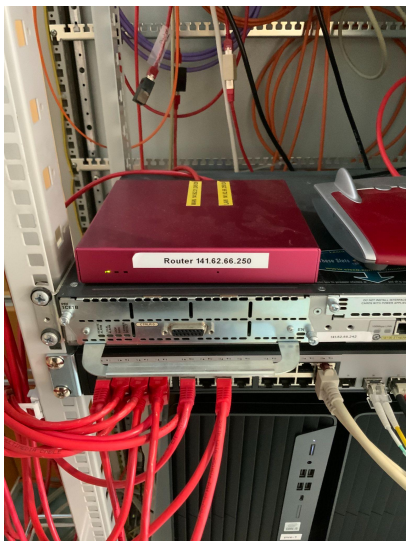


Figure 5: Der Switch ist dann mit dem hier zu sehenden Router verbunden. Der Router führt dann zur restlichen Infrastruktur des Hauses bzw. zum Internet.

```
$ dmesg -w
# ...
[    6.048643] e1000e 0000:00:1f.6 enp0s31f6: NIC Link is Up
    1000 Mbps Full Duplex, Flow Control: None
[ 1360.221984] e1000e 0000:00:1f.6 enp0s31f6: NIC Link is Down
# ...
```

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

Wie schon an den Bildern vorher illustriert lässt sich folgender Weg ableiten:

```
Patch-Feld -> Switch -> Router -> Rest der Infrastruktur
```

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

Warum ist im Netzwerkschrank wohl ein Hub installiert?

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

Überprüfung der korrekten Installation

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

ifconfig 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 qlen 1000
    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

Hier wird ein anderer Laborrechner, 141.62.66.4, angepingt.

```
$ 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
```

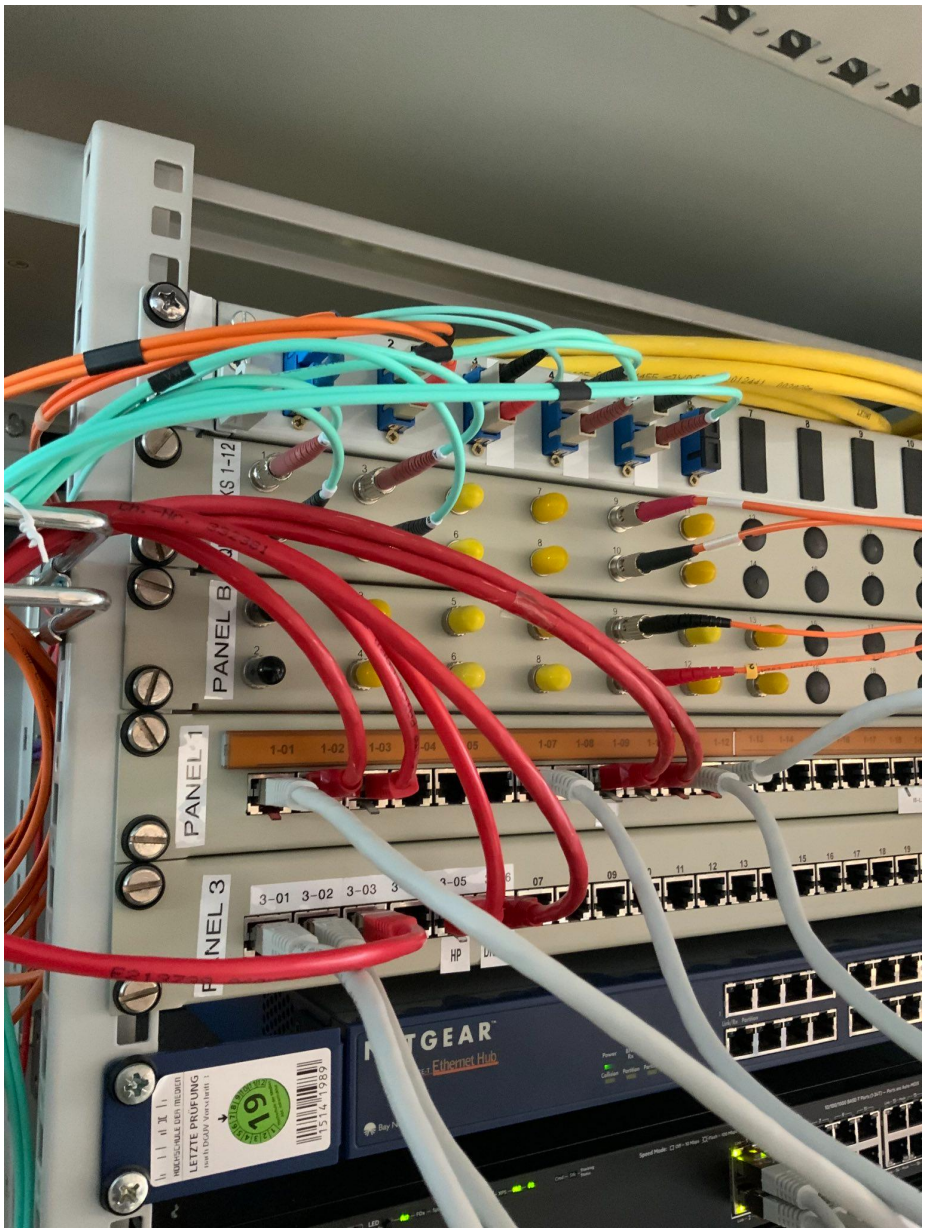


Figure 6: Der gegenüberliegende Netzwerkschrank wird durch Glasfaser erreicht. Wie im Bild zu sehen, sind zwei Glasfaserkabel an das Panel mit der Aufschrift "Panel B" angeschlossen. Zwei Kabel daher, da eines der beiden Kabel für das eingehende Signal reserviert ist und das andere für das ausgehende Signal. Durch diese beiden Kabel sind die Netzwerkschränke miteinander verbunden. Bei Glasfaserkabel muss beachtet werden, dass die Kabel nicht zu stark gebogen sind, da dies sonst zu Signalverlust führt.

```
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

Hier wird nun ein Rechner mit der IP 141.62.66.13 angepingt, welcher am Switch im gegenüberliegenden Netzwerkschrank angeschlossen ist. Wie zu sehen ist ist die Latenz um ~0.2 ms größer.

```
$ 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

Der Labor-Router hat die IP-Addresse 141.62.66.250. Die Latenz beläuft sich bei diesem mal auf ~1.05 ms.

```
$ 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

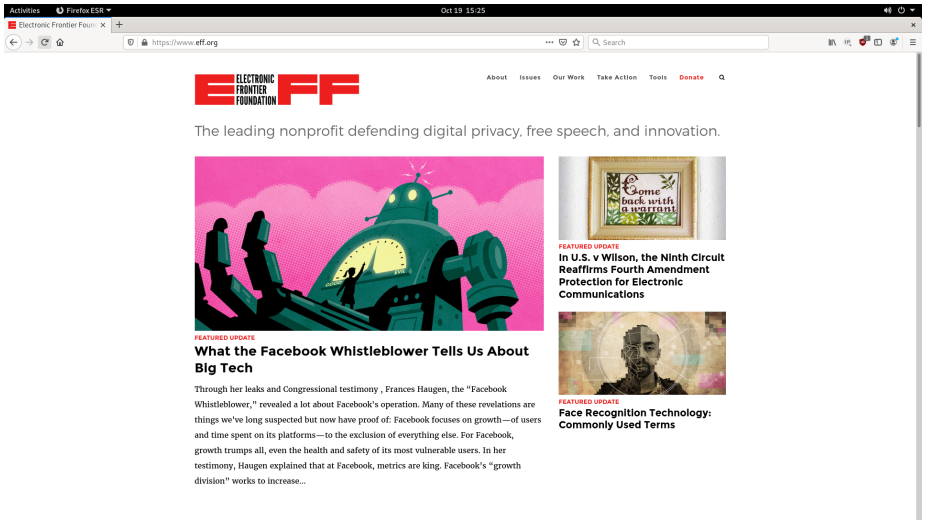


Figure 7: Screenshot

Die Seite ist erreichbar und war davor nicht gecached. Daraus lässt sich schließen, dass die DNS-Abfrage erfolgreich funktioniert hat.

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
    e06d44b80b8f1d39a95c0b0d7c65d08458e880409bbc683457104237c7f8ec8d
Oct 19 15:31:00 rn05 systemd-resolved[34579]: Negative trust
    anchors: 10.in-addr.arpa 16.172.in-addr.arpa
    17.172.in-addr.arpa 18.172.in-addr.arpa
    19.172.in-addr.arpa 20.172.in-addr.arpa
    21.172.in-addr.arpa 22.172.in-addr.arpa
    23.172.in-addr.arpa 24.172.in-addr.arpa
    25.172.in-addr.arpa 26.172.in-addr.arpa
    27.172.in-addr.arpa 28.172.in-addr.arpa
    29.172.in-addr.arpa 30.172.in-addr.arpa
    31.172.in-addr.arpa 168.192.in-addr.arpa d.f.ip6.arpa
    corp home internal intranet lan local private test
```

```
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 family=AF_INET]
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 family=AF_INET]
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+D0
```

```
   Oct 19 15:32:38 rn05 systemd-resolved[34579]:          DNSSEC
       Mode: no
34 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
36 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
38 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
40 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 family=AF_INET]
42 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
44 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]
46 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
48 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]
50 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
52 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
54 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
56 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
58 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
60 Oct 19 15:33:30 rn05 systemd-resolved[34579]: [Scope
       protocol=llmnr interface=enp0s31f6 family=AF_INET]
   Oct 19 15:33:30 rn05 systemd-resolved[34579]: ZONE:
62 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
64 Oct 19 15:33:30 rn05 systemd-resolved[34579]: [Scope
       protocol=dns]
   Oct 19 15:33:30 rn05 systemd-resolved[34579]: CACHE:
66 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 2606:2800:220:1:248:1893:25c8:1946
68 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
70 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
72 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
74 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
76 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
78 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
80 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.

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
```

Nun wurde die Adresse 141.62.66.236 zur ARP-Tabelle hinzugefügt.

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 qlen 1000
    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-Addresse 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?

Ein reines Ethernet-Frame würde den Host noch korrekt erreichen, aber da die IP nun mehreren Hosts zugeordnet wäre würden IP-Packete nicht mehr den richtigen Host erreichen.

Vergleichen Sie die Vorteile / Nachteile einer statischen und dynamische 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.

Ping

Ping-Nutzung

```
$ ping --help
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
12  -d                  use SO_DEBUG socket option
    -f                  flood ping
14  -h                  print help and exit
    -I <interface>      either interface name or address
16  -i <interval>       seconds between sending each packet
    -L                  suppress loopback of multicast packets
18  -l <preload>        send <preload> number of packages while
        waiting replies
    -m <mark>           tag the packets going out
20  -M <pmtud opt>      define mtu discovery, can be one of
        <do|dont|want>
    -n                  no dns name resolution
22  -O                  report outstanding replies
    -p <pattern>        contents of padding byte
24  -q                  quiet output
    -Q <tclass>         use quality of service <tclass> bits
26  -s <size>           use <size> as number of data bytes to be
        sent
    -S <size>           use <size> as SO_SNDBUF socket option
        value
28  -t <ttl>            define time to live
    -U                  print user-to-user latency
30  -v                  verbose output
    -V                  print version and exit
32  -w <deadline>       reply wait <deadline> in seconds
    -W <timeout>        time to wait for response
34
IPv4 options:
36  -4                  use IPv4
    -b                  allow pinging broadcast
38  -R                  record route
    -T <timestamp>      define timestamp, can be one of
        <tsonly|tsandaddr|tsprespec>
40
IPv6 options:
42  -6                  use IPv6
    -F <flowlabel>      define flow label, default is random
44  -N <nodeinfo opt>   use icmp6 node info query, try <help> as
        argument

46 For more details see ping(8).
```

Erzwungenes IPv4:

```
$ ping -4 google.com
2 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
4 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
```

Nur zwei Pakete:

```
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
```

2 Sekunden Pause zwischen den Paketen:

```
$ 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

HRPing ist ein erweiteres Ping-Command mit folgenden Optionen:

```
$ 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
14  -u [port]   Send UDP packets (port 7 by default)

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

26 output options:
    -lic        Show public license and warranty
28  -fwhelp     Print firewall help text
    -F file     Log output into <file> as well, even if -q is
        set
30  -T          Print timestamp in front of each line
    -q[r|e|t]   Be quiet (-qr=no replies, -qe=no errors,
       -qt=no timeouts)
32  -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)
34  -? -h       This help (-??=more help)

36 hrPING is Freeware, please share it!  See www.cfos.de for our
     other solutions:
    -- Internet Acceleration via Traffic Shaping     : cFosSpeed
38  -- Webserver for home users and professionals    : cFos
        Personal Net
    -- IPv6 Connectivity for XP, Vista and Windows 7 : cFos
        IPv6 Link
```

HRPing jedoch ist unfreie Software und respektiert deshalb nicht die digitalen Rechte der Versuchsdurchführenden; zudem funktioniert es nicht auf freien Systemen und der Quellcode steht nicht zur Verfügung, was ein Sicherheitsrisiko darstellt. Stattdessen wurde deshalb die freie Implementation fping verwendet:

```
Name        : fping
2 Version     : 5.0
Release     : 3.fc34
```

```
Architecture : x86_64
Size         : 63 k
Source       : fping-5.0-3.fc34.src.rpm
Repository   : @System
From repo    : fedora
Summary      : Scriptable, parallelized ping-like utility
URL          : http://www.fping.org/
License      : BSD with advertising
Description  : fping is a ping-like program which can
    determine the
             : accessibility of multiple hosts using ICMP
               echo requests. fping
             : is designed for parallelized monitoring of
               large numbers of
             : systems, and is developed with ease of use in
               scripting in mind.
```

Diese hat ähnliche Optionen:

```
$ 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)
23  -R, --random        random packet data (to foil link data
        compression)
    -S, --src=IP        set source address
25  -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)
27
  Output options:
29  -a, --alive         show targets that are alive
    -A, --addr          show targets by address
31  -C, --vcount=N      same as -c, report results in verbose
        format
    -D, --timestamp     print timestamp before each output line
33  -e, --elapsed       show elapsed time on return packets
    -i, --interval=MSEC  interval between sending ping packets
        (default: 10 ms)
35  -n, --name          show targets by name (-d is equivalent)
    -N, --netdata       output compatible for netdata (-l -Q
        are required)
37  -o, --outage        show the accumulated outage time (lost
        packets * packet interval)
    -q, --quiet         quiet (don't show per-target/per-ping
        results)
39  -Q, --squiet=SECS   same as -q, but show summary every n
        seconds
    -s, --stats         print final stats
41  -u, --unreach       show targets that are unreachable
    -v, --version       show version
43  -x, --reachable=N   shows if >=N hosts are reachable or not
```

Die Verwendung ist ähnlich wie ping.

Weisen Sie mit Hilfe von HRPING nach, dass ein Ping, der zuerst eine ARP-Auflösung erforderlich macht, zu deutlich erhöhten Antwortzeiten führt.

```
  $ fping -e 10.60.43.50
2 10.60.43.50 is alive (70.9 ms)
  $ sudo ip -s -s neigh flush all
4 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
6
  *** Round 1, deleting 2 entries ***
8 *** Flush is complete after 1 round ***
  $ fping -e 10.60.43.50
10 10.60.43.50 is alive (212 ms)
```

Zu erkennen ist, dass nach der Löschen der ARP-Tabelle eine deutlich längere Antwortzeit zu messen ist.

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 (129.143.57.127)  5.283 ms  5.465 ms
 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.msr1.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)  29.709 ms
    lo0.fab2-1-gdc.ir2.yahoo.com (77.238.190.3)  29.842 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)
    29.750 ms
14  media-router-aol71.prod.media.vip.ir2.yahoo.com
    (212.82.100.163)  29.546 ms  30.166 ms  29.797 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 [ -46dFITnreAUDV ] [ -f first_ttl ] [ -g
      gate,... ] [ -i device ] [ -m max_ttl ] [ -N squeries ]
      [ -p port ] [ -t tos ] [ -l flow_label ] [ -w
      MAX,HERE,NEAR ] [ -q nqueries ] [ -s src_addr ] [ -z
      sendwait ] [ --fwmark=num ] host [ packetlen ]
Options:
  -4                        Use IPv4
  -6                        Use IPv6
  -d  --debug               Enable socket level debugging
```

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

```
                                or no more than NEAR (default
                                    10) times than some
40                              next hop, or MAX (default 5.0)
                                    seconds (float
                                point values allowed too)
42  -q nqueries  --queries=nqueries
                                Set the number of probes per
                                    each hop. Default is
44                              3
    -r                          Bypass the normal routing and
        send directly to a
46                              host on an attached network
    -s src_addr  --source=src_addr
48                              Use source src_addr for
                                    outgoing packets
    -z sendwait  --sendwait=sendwait
50                              Minimal time interval between
                                    probes (default 0).
                                If the value is more than 10,
                                    then it specifies a
52                              number in milliseconds, else it
                                    is a number of
                                seconds (float point values
                                    allowed too)
54  -e  --extensions            Show ICMP extensions (if
        present), including MPLS
    -A  --as-path-lookups       Perform AS path lookups in
        routing registries and
56                              print results directly after
                                    the corresponding
                                addresses
58  -M name  --module=name      Use specified module (either
        builtin or external)
                                for traceroute operations. Most
                                    methods have
60                              their shortcuts ('-I' means '-M
                                    icmp' etc.)
    -O OPTS,...  --options=OPTS,...
62                              Use module-specific option OPTS
                                    for the
                                traceroute module. Several OPTS
                                    allowed,
64                              separated by comma. If OPTS is
                                    "help", print info
                                about available options
66  --sport=num                 Use source port num for
        outgoing packets. Implies
                                '-N 1'
68  --fwmark=num                Set firewall mark for outgoing
        packets
```

```
    -U  --udp                   Use UDP to particular port for
        traceroutes
70                              (instead of increasing the port
                                    per each probe),
                                default port is 53
72  -UL                         Use UDPLITE for traceroute
        (default dest port
                                is 53)
74  -D  --dccp                  Use DCCP Request for
        traceroute (default port
                                is 33434)
76  -P prot  --protocol=prot    Use raw packet of protocol prot
        for traceroute
    --mtu                       Discover MTU along the path
        being traced. Implies
78                              '-F -N 1'
    --back                      Guess the number of hops in the
        backward path and
80                              print if it differs
    -V  --version               Print version info and exit
82  --help                      Read this help and exit

84 Arguments:
  +     host          The host to traceroute to
86      packetlen     The full packet length (default is the
            length of an IP
                      header plus 40). Can be ignored or
                          increased to a minimal
88                    allowed value
  $ traceroute www.aol.com
90 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
92  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
94  4  * * *
    5  stu-al30-1-te0-0-0-17.belwue.net (129.143.56.53)  3.143
        ms  3.819 ms  3.212 ms
96  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
98  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
100 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.msr1.ir2.yahoo.com (66.196.65.19)  30.763 ms
        29.649 ms  29.854 ms
102 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)  29.709 ms
        lo0.fab2-1-gdc.ir2.yahoo.com (77.238.190.3)  29.842 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)
        29.750 ms
104 14  media-router-aol71.prod.media.vip.ir2.yahoo.com
        (212.82.100.163)  29.546 ms  30.166 ms  29.797 ms
    [pojntfx@felixs-xps13 hrping-v504]$ ssh
        pojntfx@159.223.25.154 "nc -lp 6969"
106 $ traceroute -w 5 www.aol.com
    traceroute to www.aol.com (212.82.100.163), 30 hops max, 60
        byte packets
108  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
110  3  firewall-h.hdm-stuttgart.de (141.62.1.1)  3.417 ms  0.907
         ms  2.692 ms
     4  * * *
112  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
114  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
116  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
118 11  ge-0-3-9-d104.pat1.the.yahoo.com (66.196.65.21)  29.823
        ms  29.921 ms et-1-1-2.msr1.ir2.yahoo.com (66.196.65.19)
        29.735 ms
    12  lo0.fab4-1-gdc.ir2.yahoo.com (77.238.190.5)  29.809 ms
        lo0.fab1-1-gdc.ir2.yahoo.com (77.238.190.2)  29.664 ms
        29.659 ms
120 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  29.883 ms
122 $ sudo traceroute -I www.aol.com
    traceroute to www.aol.com (212.82.100.163), 30 hops max, 60
        byte packets
124  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
126  3  firewall-h.hdm-stuttgart.de (141.62.1.1)  1.315 ms  1.628
        ms  1.878 ms
     4  * * *
128  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
130  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
132  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
134 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
136 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  30.152 ms
```

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

Hier z.B. die HdM Stuttgart:

```
 1 $ whois www.hdm-stuttgart.de
   [Querying whois.denic.de]
 3 [whois.denic.de]
   % Restricted rights.
 5 %
   % Terms and Conditions of Use
 7 %
   % The above data may only be used within the scope of
       technical or
 9 % administrative necessities of Internet operation or to
       remedy legal
   % problems.
11 % The use for other purposes, in particular for advertising,
       is not permitted.
   %
13 % The DENIC whois service on port 43 doesn't disclose any
       information concerning
   % the domain holder, general request and abuse contact.
15 % 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
```

Und die Electronic Frontier Foundation:

```
$ whois eff.org
[Querying whois.pir.org]
[whois.pir.org]
Domain Name: EFF.ORG
Registry Domain ID: D2234962-LROR
Registrar WHOIS Server: whois.gandi.net
Registrar URL: http://www.gandi.net
Updated Date: 2018-03-08T02:19:58Z
Creation Date: 1990-10-10T04:00:00Z
Registry Expiry Date: 2022-10-09T04:00:00Z
Registrar Registration Expiration Date:
Registrar: Gandi SAS
Registrar IANA ID: 81
Registrar Abuse Contact Email: abuse@support.gandi.net
Registrar Abuse Contact Phone: +33.170377661
Reseller:
Domain Status: clientTransferProhibited
    https://icann.org/epp#clientTransferProhibited
Registrant Organization: Electronic Frontier Foundation
Registrant State/Province: CA
Registrant Country: US
Name Server: NS1.EFF.ORG
Name Server: NS2.EFF.ORG
Name Server: NS4.EFF.ORG
DNSSEC: unsigned
URL of the ICANN Whois Inaccuracy Complaint Form
    https://www.icann.org/wicf/)
>>> Last update of WHOIS database: 2021-10-20T20:35:43Z <<<

For more information on Whois status codes, please visit
    https://icann.org/epp

Access to Public Interest Registry WHOIS information is
    provided to assist persons in determining the contents of
```

```
    a domain name registration record in the Public Interest
    Registry registry database. The data in this record is
    provided by Public Interest Registry for informational
    purposes only, and Public Interest Registry does not
    guarantee its accuracy. This service is intended only for
    query-based access. You agree that you will use this data
    only for lawful purposes and that, under no circumstances
    will you use this data to (a) allow, enable, or otherwise
    support the transmission by e-mail, telephone, or
    facsimile of mass unsolicited, commercial advertising or
    solicitations to entities other than the data recipient's
    own existing customers; or (b) enable high volume,
    automated, electronic processes that send queries or data
    to the systems of Registry Operator, a Registrar, or
    Afilias except as reasonably necessary to register domain
    names or modify existing registrations. All rights
    reserved. Public Interest Registry reserves the right to
    modify these terms at any time. By submitting this query,
    you agree to abide by this policy.

The Registrar of Record identified in this output may have an
    RDDS service that can be queried for additional
    information on how to contact the Registrant, Admin, or
    Tech contact of the queried domain name.
```

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.bitwizard.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
```

```
18              : host. Afterwards it determines the address of
                    each network hop
                : between the machines and sends a sequence of
                    ICMP echo requests
20              : to each one to determine the quality of the
                    link to each machine.
                : While doing this, it prints running statistics
                    about each
22              : machine.
                :
24              : MTR provides two user interfaces: an ncurses
                    interface, useful
                : for the command line, e.g. for SSH sessions;
                    and a GTK interface
26              : for X (provided in the mtr-gtk package).
```

mtr kombiniert die Funktionalität von traceroute und ping, was folgende Optionen ermöglicht:

```
Usage:
 2  mtr [options] hostname

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

```
    -j, --json                  output json
28  -x, --xml                   output xml
    -C, --csv                   output comma separated values
30  -l, --raw                   output raw format
    -p, --split                 split output
32  -t, --curses                use curses terminal interface
        --displaymode MODE      select initial display mode
34  -n, --no-dns                do not resolve host names
    -b, --show-ips              show IP numbers and host names
36  -o, --order FIELDS          select output fields
    -y, --ipinfo NUMBER         select IP information in output
38  -z, --aslookup              display AS number
    -h, --help                  display this help and exit
40  -v, --version               output version information and
        exit

42 See the 'man 8 mtr' for details.
```

Interessant ist z.B. die -n-Flag:

```
    $ mtr -n --json www.aol.com
 2 {
       "report": {
 4         "mtr": {
               "src": "felixs-xps13",
 6             "dst": "www.aol.com",
               "tos": 0,
 8             "tests": 10,
               "psize": "64",
10             "bitpattern": "0x00"
           },
12         "hubs": [
               {
14                 "count": 1,
                   "host": "10.60.63.252",
16                 "Loss%": 0.0,
                   "Snt": 10,
18                 "Last": 88.565,
                   "Avg": 10.379,
20                 "Best": 1.066,
                   "Wrst": 88.565,
22                 "StDev": 27.477
               },
24             {
                   "count": 2,
26                 "host": "141.62.31.94",
                   "Loss%": 0.0,
28                 "Snt": 10,
                   "Last": 11.83,
30                 "Avg": 2.541,
```

```
                "Best": 1.24,
32              "Wrst": 11.83,
                "StDev": 3.272
34          },
            {
36              "count": 3,
                "host": "???",
38              "Loss%": 100.0,
                "Snt": 10,
40              "Last": 0.0,
                "Avg": 0.0,
42              "Best": 0.0,
                "Wrst": 0.0,
44              "StDev": 0.0
            },
46          {
                "count": 4,
48              "host": "129.143.56.53",
                "Loss%": 0.0,
50              "Snt": 10,
                "Last": 16.222,
52              "Avg": 3.928,
                "Best": 1.613,
54              "Wrst": 16.222,
                "StDev": 4.422
56          },
            {
58              "count": 5,
                "host": "129.143.56.106",
60              "Loss%": 0.0,
                "Snt": 10,
62              "Last": 231.77,
                "Avg": 25.22,
64              "Best": 1.846,
                "Wrst": 231.77,
66              "StDev": 72.574
            },
68          {
                "count": 6,
70              "host": "129.143.60.113",
                "Loss%": 0.0,
72              "Snt": 10,
                "Last": 77.414,
74              "Avg": 13.153,
                "Best": 5.437,
76              "Wrst": 77.414,
                "StDev": 22.584
78          },
            {
80              "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,
232             "Avg": 22.657,
                "Best": 5.208,
234             "Wrst": 74.371,
                "StDev": 27.785
236         },
            {
238             "count": 7,
                "host": "ge-1-3-0.pat1.dee.yahoo.com",
240             "Loss%": 0.0,
                "Snt": 10,
242             "Last": 5.488,
                "Avg": 6.379,
244             "Best": 4.908,
                "Wrst": 13.858,
246             "StDev": 2.716
            },
248         {
                "count": 8,
250             "host": "ae-3.pat1.frz.yahoo.com",
                "Loss%": 0.0,
252             "Snt": 10,
                "Last": 125.22,
254             "Avg": 33.495,
                "Best": 14.004,
256             "Wrst": 125.22,
                "StDev": 40.562
258         },
            {
260             "count": 9,
                "host": "ae-2.pat1.iry.yahoo.com",
262             "Loss%": 0.0,
                "Snt": 10,
264             "Last": 86.809,
                "Avg": 36.314,
266             "Best": 29.889,
                "Wrst": 86.809,
268             "StDev": 17.76
            },
270         {
                "count": 10,
272             "host": "ge-0-3-9-d104.pat1.the.yahoo.com",
                "Loss%": 0.0,
274             "Snt": 10,
                "Last": 31.651,
276             "Avg": 41.326,
                "Best": 30.095,
278             "Wrst": 134.5,
                "StDev": 32.747
280         },
```

```
                {
282                 "count": 11,
                    "host": "lo0.fab4-1-gdc.ir2.yahoo.com",
284                 "Loss%": 0.0,
                    "Snt": 10,
286                 "Last": 130.62,
                    "Avg": 46.746,
288                 "Best": 30.125,
                    "Wrst": 130.62,
290                 "StDev": 34.357
                },
292             {
                    "count": 12,
294                 "host": "usw1-1-lba.ir2.yahoo.com",
                    "Loss%": 0.0,
296                 "Snt": 10,
                    "Last": 53.336,
298                 "Avg": 34.049,
                    "Best": 30.023,
300                 "Wrst": 53.336,
                    "StDev": 8.066
302             },
                {
304                 "count": 13,
                    "host":
                        "media-router-aol71.prod.media.vip.ir2.yahoo.com",
306                 "Loss%": 0.0,
                    "Snt": 10,
308                 "Last": 30.159,
                    "Avg": 41.64,
310                 "Best": 30.008,
                    "Wrst": 141.8,
312                 "StDev": 35.2
                }
314         ]
        }
316 }
```


Wie zu erkennen ist wird durch diese z.B. die Hostnamen-Auflösungen übersprungen, was die Geschwindigkeit erhöht.

SS

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

```
Name            : iproute
2 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
                                                        Local
    Address:Port                                    Peer
    Address:Port              Process
FIN-WAIT-1             0                  1

    10.60.54.18:60340
    104.17.239.204:443
FIN-WAIT-1             0                  1

    10.60.54.18:52990
    104.16.18.94:443
ESTAB                  0                  0

    10.60.54.18:49524
    198.252.206.25:443
    users:(("chrome",pid=57314,fd=55))
FIN-WAIT-1             0                  1

    10.60.54.18:48368
    151.101.1.69:443
FIN-WAIT-1             0                  1

    10.60.54.18:45586
    142.250.186.161:443
FIN-WAIT-1             0                  1

    10.60.54.18:60886
    151.101.14.217:443
```

```
FIN-WAIT-1                0                      1
    10.60.54.18:45862
    23.185.0.3:443
ESTAB                     0                      0
    10.60.6.89:52008
    66.102.1.188:5228
    users:(("chrome",pid=57314,fd=26))
FIN-WAIT-1                0                      1
    10.60.54.18:42784
    104.244.42.193:443
FIN-WAIT-1                0                      1
    10.60.54.18:43802
    140.82.121.3:443
FIN-WAIT-1                0                      1
    10.60.54.18:56072
    104.19.154.83:443
ESTAB                     0                      0
    10.60.54.18:57766
    159.69.63.133:443
    users:(("nextcloud",pid=4890,fd=38))
FIN-WAIT-1                0                      1
    10.60.54.18:58314
    104.244.42.2:443
FIN-WAIT-1                0                      1
    10.60.54.18:41736
    185.199.109.154:443
```

Nach dem Aufruf von news.ycombinator.com:

```
$ ss -tnp
State                     Recv-Q                 Send-Q
                                                        Local
    Address:Port                                    Peer
    Address:Port                 Process
FIN-WAIT-1                0                      1
    10.60.54.18:60340
    104.17.239.204:443
FIN-WAIT-1                0                      1
    10.60.54.18:52990
    104.16.18.94:443
```

```
ESTAB                  0                      0

         10.60.54.18:49524
         198.252.206.25:443
         users:(("chrome",pid=57314,fd=55))
6 ESTAB                0                      0

         10.60.6.89:50696
         159.69.63.133:443
         users:(("nextcloud",pid=4890,fd=65))
  FIN-WAIT-1           0                      1

         10.60.54.18:48368
         151.101.1.69:443
8 FIN-WAIT-1           0                      1

         10.60.54.18:45586
         142.250.186.161:443
  FIN-WAIT-1           0                      1

         10.60.54.18:60886
         151.101.14.217:443
10 FIN-WAIT-1          0                      1

         10.60.54.18:45862
         23.185.0.3:443
  FIN-WAIT-2           0                      0

         10.60.6.89:52008
         66.102.1.188:5228
12 FIN-WAIT-1          0                      1

         10.60.54.18:56072
         104.19.154.83:443
  FIN-WAIT-1           0                      1

         10.60.54.18:41736
         185.199.109.154:443
14 ESTAB               0                      0

         10.60.6.89:50692
         159.69.63.133:443
         users:(("nextcloud",pid=4890,fd=38))
  ESTAB                0                      0

         10.60.6.89:47334
         188.166.16.132:443
         users:(("chrome",pid=57314,fd=40))
16 FIN-WAIT-1          0                      1
```

```
        10.60.54.18:54590
        104.17.131.171:443
    FIN-WAIT-1              0                       1

        10.60.54.18:53934
        172.66.43.53:443
18  FIN-WAIT-1              0                       1

        10.60.54.18:44820
        185.199.111.133:443
    FIN-WAIT-1              0                       1

        10.60.54.18:41740
        185.199.109.154:443
20  ESTAB                   0                       0

        10.60.6.89:47336
        188.166.16.132:443
        users:(("chrome",pid=57314,fd=44))
    FIN-WAIT-1              0                       1

        10.60.54.18:45360
        104.17.211.204:443
22  ESTAB                   0                       0

        10.60.6.89:50686
        159.69.63.133:443
        users:(("nextcloud",pid=4890,fd=62))
    FIN-WAIT-1              0                       1

        10.60.54.18:32944
        151.101.13.132:443
24  ESTAB                   0                       0

        10.60.6.89:55356
        209.216.230.240:443
        users:(("chrome",pid=57314,fd=43))
    FIN-WAIT-1              0                       1

        10.60.54.18:52794
        66.102.1.188:5228
26  LAST-ACK                1                       1

        10.60.54.18:37382
        209.216.230.240:443
    LAST-ACK                0                       1043

        10.60.54.18:57762
        159.69.63.133:443
28  LAST-ACK                1                       1
```

```
        10.60.54.18:37378
        209.216.230.240:443
    FIN-WAIT-1              0                       1

        10.60.54.18:60308
        151.101.12.193:443
30  ESTAB                   0                       0

        10.60.6.89:50694
        159.69.63.133:443
        users:(("nextcloud",pid=4890,fd=63))
    ESTAB                   0                       0

        10.60.6.89:52010
        66.102.1.188:5228
        users:(("chrome",pid=57314,fd=26))
32  FIN-WAIT-1              0                       1

        10.60.54.18:41304
        40.68.78.177:443
    FIN-WAIT-1              0                       1

        10.60.54.18:38950
        104.17.233.204:443
34  ESTAB                   0                       0

        [2001:7c7:2121:8d00:1902:f308:6c8b:acb7]:50102
                                [2606:50c0:8001::153]:443
                    users:(("gnome-software",pid=4888,fd=92))
    ESTAB                   0                       0

        [2001:7c7:2121:8d00:1902:f308:6c8b:acb7]:50100
                                [2606:50c0:8001::153]:443
                    users:(("gnome-software",pid=4888,fd=42))
```

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

```
$ dig +noall +answer news.ycombinator.com
2 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
2 $ ss -tlnp
  State      Recv-Q   Send-Q              Local Address:Port
      Peer Address:Port    Process
```

```
4 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",pid=10523,fd=3))
6 LISTEN     0          2                [::ffff:127.0.0.1]:3350
                        *:*
  LISTEN     0          128                           [::]:22
                       [::]:*
8 LISTEN     0          2                                *:3389
                        *:*
  $ nc -lp 6767
10 asdf

12 asdf
  $ ss -tlnp
14 State    Recv-Q  Send-Q          Local Address:Port      Peer
       Address:Port   Process
  LISTEN   0        128                    0.0.0.0:22
       0.0.0.0:*
16 LISTEN   0        2           [::ffff:127.0.0.1]:3350
                      *:*
  LISTEN   0        128                       [::]:22
       [::]:*
18 LISTEN   0        2                            *:3389
                      *:*

20 # Auf Host B
  $ ss -tnp | grep 6767
22 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=36529,fd=3))
24 $ nc 141.62.66.4 6767
  asdf
26
  asdf
28 $ ss -tnp | grep 6767
  State       Recv-Q       Send-Q            Local Address:Port
                  Peer Address:Port      Process
```

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

```
1 asdf

3 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       Process
$ 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=36809,fd=98))
ESTAB 0       0          141.62.66.5:52748        65.9.84.27:443
        users:(("firefox-esr",pid=36809,fd=41))
ESTAB 0       0          141.62.66.5:53806      54.239.39.102:443
        users:(("firefox-esr",pid=36809,fd=111))
ESTAB 0       0          141.62.66.5:40840    142.250.186.138:443
        users:(("firefox-esr",pid=36809,fd=86))
ESTAB 0       0          141.62.66.5:36194     173.239.79.196:443
        users:(("firefox-esr",pid=36809,fd=77))
ESTAB 0       0          141.62.66.5:33678       93.184.220.29:80
         users:(("firefox-esr",pid=36809,fd=34))
ESTAB 0       0          141.62.66.5:55186     162.219.226.52:443
        users:(("firefox-esr",pid=36809,fd=119))
ESTAB 0       0          141.62.66.5:54384    209.216.230.240:80
         users:(("firefox-esr",pid=36809,fd=161))
ESTAB 0       0          141.62.66.5:36590        52.95.122.8:443
        users:(("firefox-esr",pid=36809,fd=141))
ESTAB 0       0          141.62.66.5:46840        65.9.83.39:443
        users:(("firefox-esr",pid=36809,fd=74))
ESTAB 0       0          141.62.66.5:37550      54.239.39.102:80
         users:(("firefox-esr",pid=36809,fd=109))
ESTAB 0       0          141.62.66.5:43074     142.250.185.67:80
         users:(("firefox-esr",pid=36809,fd=96))
ESTAB 0       0          141.62.66.5:54094      34.107.221.82:80
         users:(("firefox-esr",pid=36809,fd=85))
ESTAB 0       0          141.62.66.5:42432    209.216.230.240:443
        users:(("firefox-esr",pid=36809,fd=172))
ESTAB 0       0          141.62.66.5:42430    209.216.230.240:443
        users:(("firefox-esr",pid=36809,fd=164))
ESTAB 0       0          141.62.66.5:36288        65.9.83.11:443
        users:(("firefox-esr",pid=36809,fd=105))
ESTAB 0       0          141.62.66.5:50220     151.101.12.201:443
        users:(("firefox-esr",pid=36809,fd=84))
ESTAB 0       0          141.62.66.5:42822       54.194.65.3:443
        users:(("firefox-esr",pid=36809,fd=120))
ESTAB 0       0          141.62.66.5:43710         2.21.21.24:80
         users:(("firefox-esr",pid=36809,fd=83))
ESTAB 0       0          141.62.66.5:43922      54.68.102.210:443
        users:(("firefox-esr",pid=36809,fd=125))
ESTAB 0       0          141.62.66.5:42428    209.216.230.240:443
        users:(("firefox-esr",pid=36809,fd=162))
ESTAB 0       0          141.62.66.5:42434    209.216.230.240:443
        users:(("firefox-esr",pid=36809,fd=176))
```

```
27 ESTAB 0      0          141.62.66.5:34436    162.219.224.163:443
       users:(("firefox-esr",pid=36809,fd=113))
   ESTAB 0      0          141.62.66.5:44868      65.9.84.191:80
       users:(("firefox-esr",pid=36809,fd=140))
29 $ ss -tnp
   State      Recv-Q      Send-Q           Local Address:Port
                 Peer Address:Port      Process
```

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

Route

route ist deprecated, es wird stattdessen ip route verwendet.

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

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.

```
  $ ip route show table all
2 default via 141.62.66.250 dev enp0s31f6
  141.62.66.0/24 dev enp0s31f6 proto kernel scope link src
      141.62.66.5
4 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
6 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
8 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
10 broadcast 141.62.66.255 dev enp0s31f6 table local proto
      kernel scope link src 141.62.66.5
```

Erweitern oder modifizieren Sie die Routing-Tabelle Ihres PC

Hier wurde nun eine neue Route hinzugefügt, welche das Subnet 192.0.2.128/25 über den Host 141.62.66.4 routed. Lädt der Host die richtigen Kernel-Module und wird IP-Forwarding mittels sysctl aktiviert, so könnte dieser damit als Router fungieren.

```
  $ sudo ip route add 192.0.2.128/25 via 141.62.66.4
2 $ 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
```

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
```

```
26 [ ID] Interval           Transfer     Bitrate         Retr
       Cwnd
   [  5]   0.00-1.00   sec   101 MBytes   845 Mbits/sec    0
       342 KBytes
28 [  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
30 [  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
32 [  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
34 [  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
36 [  5]   9.00-10.00  sec   102 MBytes   859 Mbits/sec    0
       359 KBytes
   - - - - - - - - - - - - - - - - - - - - - - - - -
38 [ ID] Interval           Transfer     Bitrate         Retr
   [  5]   0.00-10.00  sec  1009 MBytes   847 Mbits/sec    0
                    sender
40 [  5]   0.00-10.00  sec  1008 MBytes   845 Mbits/sec
                  receiver

42 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. ### NMAP Nmap ist die kurzform für Network Mapper. Mit diesem kann man Ports scannen, Informationen über die Services bekommen (Version, Betriebsystem etc.) und vorinstallierte als auch eigene Skripts verwenden.

Es gibt verschiedene Möglichkeiten Scans durchzuführen, der gängige (auch default) ist der TCP connect Port Scan. Es gibt noch weitere, welche situativ über Flags verwendet werden können:

```
  $ nmap 10.10.247.15 -sS                 # TCP SYN Port Scan
2 $ nmap 10.10.247.15 -sA                 # TCP ACK Port Scan
  $ nmap 10.10.247.15 -sU                 # UDP Port Scan
```

Es besteht die Möglichkeit mehrere IPs zu scannen, ebenso wie ein Bereich von IPs, eine einzige IP oder eine Domain:

```
1 $ nmap 10.10.247.15                     # Scannen einer
      einzigen IP
```

```
$ nmap 10.10.247.15 10.10.247.240      # Scannen mehrerer IPs
$ nmap 10.10.247.15-240                # Scannen des Bereichs
    von .15-.240
$ nmap scanme.nmap.org                 # Scannen der Domain
    scanme.nmap.org
```

Es lassen sich ebenfalls die Ports definieren, welche auf einer IP gescannt werden sollen:

```
$ nmap 10.10.247.15 -p-                # Scannen der gesamten
    Portrange
$ nmap 10.10.247.15 -p 21              # Scannen des Port 21
$ nmap 10.10.247.15 -p 21-200          # Scannen alle Ports
    von 21 bis 200
```

Um Informationen bezüglich der verwendeten Versionen und Betriebssysteme zu erhalten können folgende Flags verwendet werden:

```
$ nmap 10.10.247.15 -sV                # Versucht die Version
    des Services zu ermitteln
$ nmap 10.10.247.15 -O                 # Versucht das
    Betriebsystem zu ermitteln
```