# Praktikum Rechnernetze

Protokoll zu Versuch 1 (Troubleshooting TCP/IP) von Gruppe 1

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# 1 Einführung

## 1.1 Mitwirken

Diese Materialien basieren auf Professor Kiefers "Praktikum Rechnernetze"-Vorlesung der HdM Stuttgart.

**Sie haben einen Fehler gefunden oder haben einen Verbesserungsvorschlag?** Bitte eröffnen Sie ein Issue auf GitHub (github.com/pojntfx/uni-netpractice-notes):

**Abbildung 1:** QR-Code zum Quelltext auf GitHub

Wenn ihnen die Materialien gefallen, würden wir uns über einen GitHub-Stern sehr freuen.

## 1.2 Lizenz

Dieses Dokument und der enthaltene Quelltext ist freie Kultur bzw. freie Software.


**Abbildung 2:** Badge der AGPL-3.0-Lizenz

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# 2 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 | 143.62.67.16 | 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 | 10.15.119.236 | 4 194 304 | 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 address

010|1 1111 → 95 → 184.16.12.95 | Broadcast address

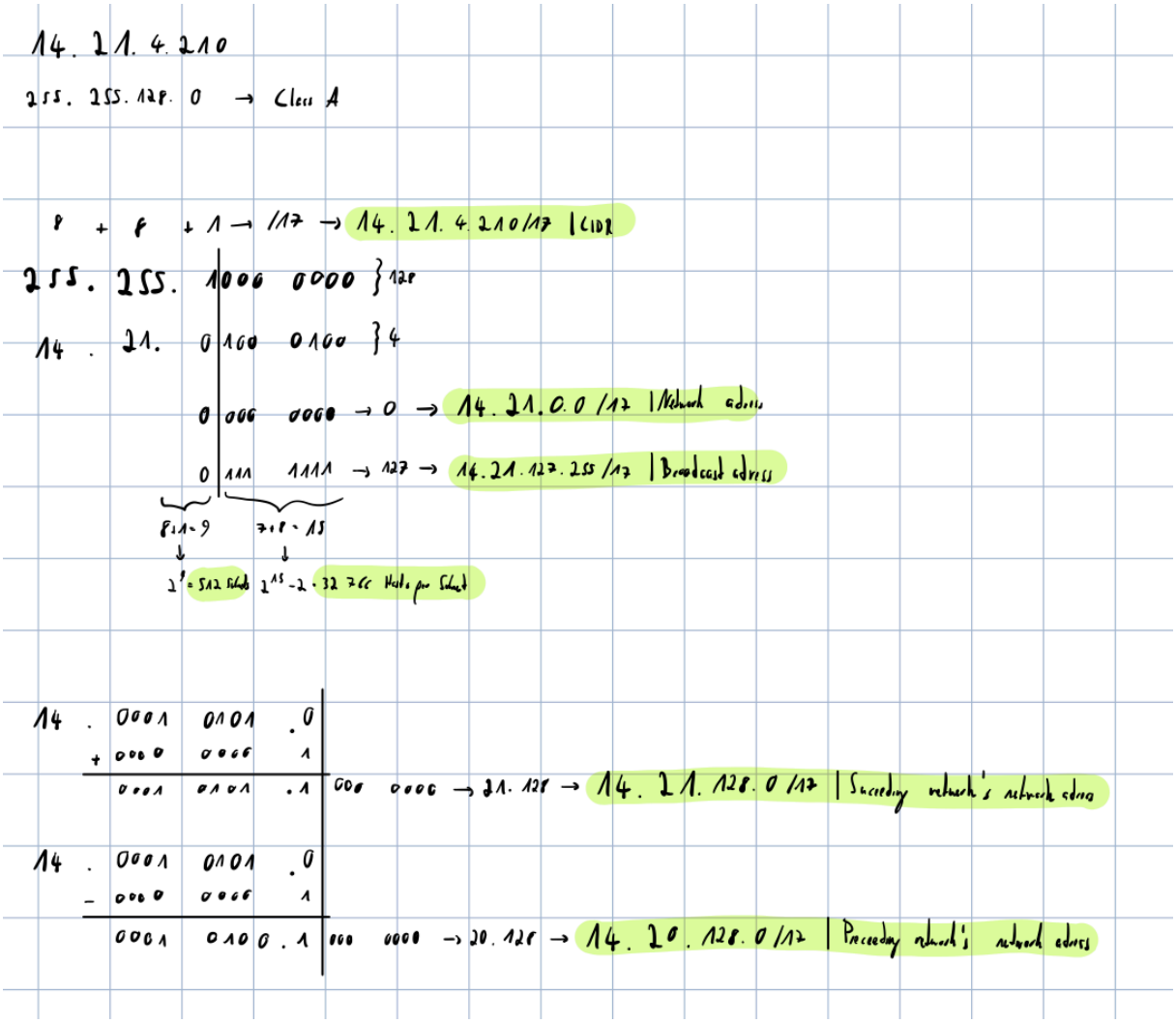
5+3 = 11 → $2^{11}$ = 2048 Subnets; 5 → $2^5 - 2$ = 30 Hosts per subnet

0000 0000 010|0 + 0000 0000 00|1 = 011|1 → 0 0000 → 96 → 184.16.12.96/27 | Security network's network address

0000 0000 010|0 − 0000 0000 00|1 = 001|1 → 0 0000 → 32 → 184.16.12.32/27 | Private network's network address

143. 62. 67. 32

255. 255. 255. 240 → Class B




# 3 Werkzeuge des Betriebssystems

## 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-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
# ...
$ find /sys | grep drivers.*00:1f.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
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.

## 3.2 Anschluss des PC an das Labornetz

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

Folgende Verbindungen konnten erkannt werden:

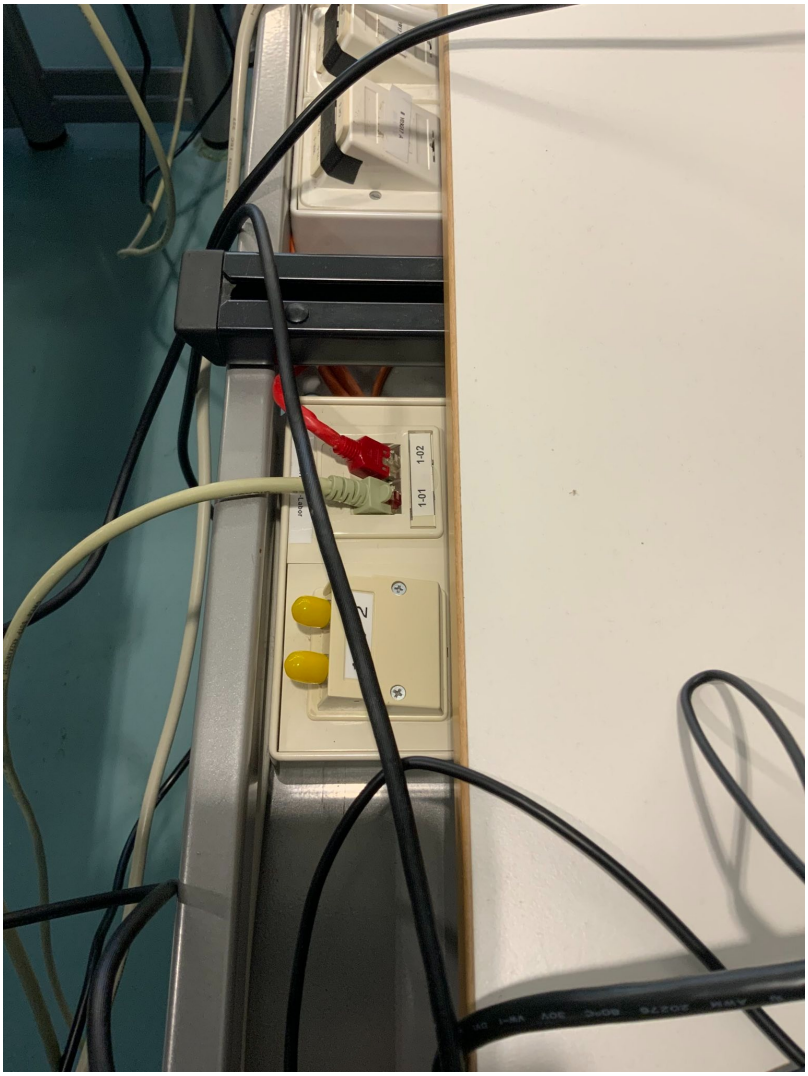



**Abbildung 3:** Unser Computer ist an die RJ-45-Buchse 1-01 angeschlossen. Das Kabel der Buchse führt dann in den Netzwerkschrank.

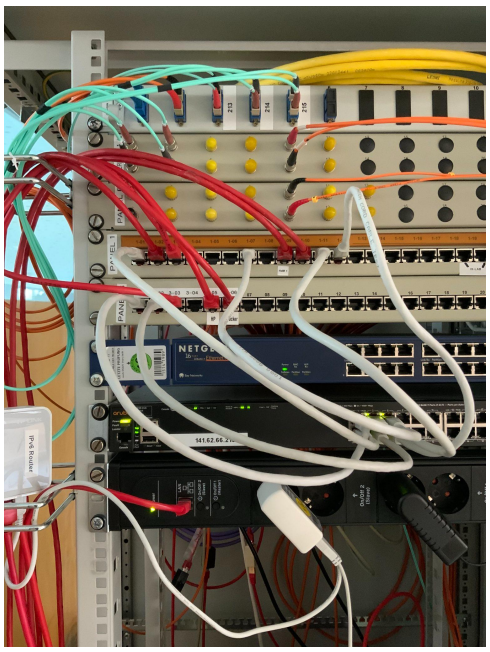


**Abbildung 4:** Auf diesem Bild ist der Netzwerkschrank zu sehen. Man sieht hier das Patchfeld, an welchem die 1-01 angeschlossen ist. Vom Patchfeld führt ein weiteres LAN-Kabel (CAT-5e) zu einem Switch.


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

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 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**

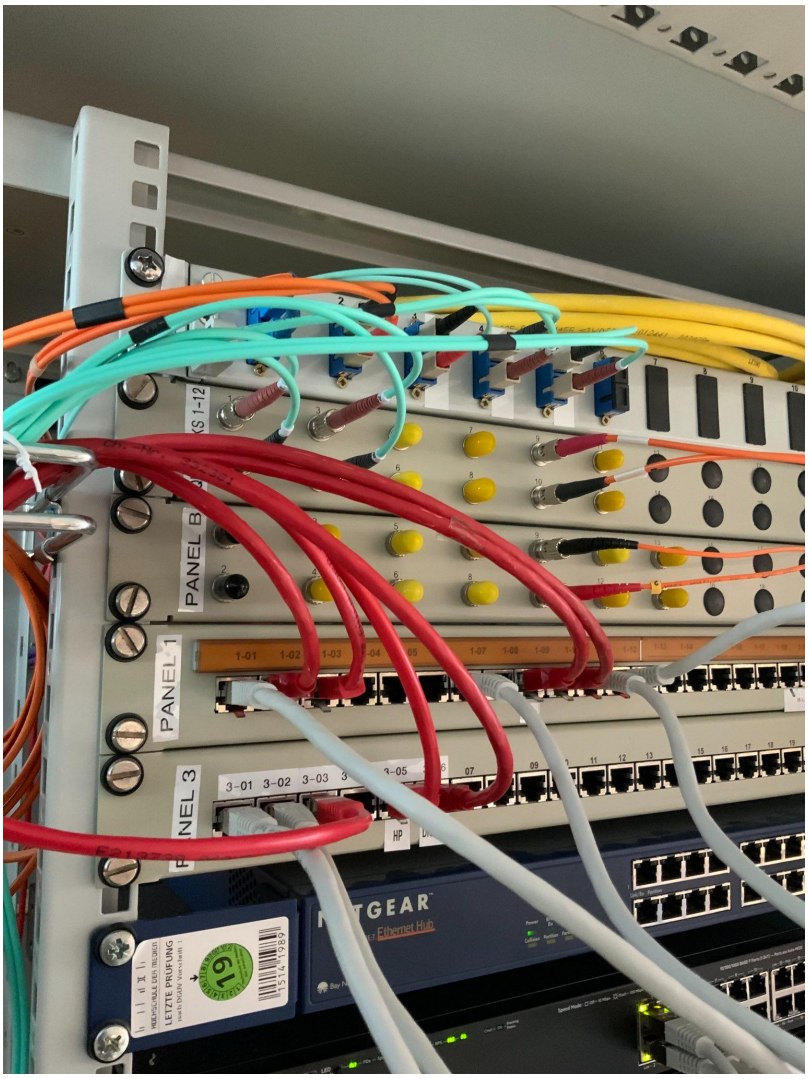



**Abbildung 6:** Der gegenüberliegende Netzwerkschrank wird durch Glasfaser erreicht. Wie im Bild zu sehen, sind zwei Glasfaserkabel an das Panel mit der Aufschrift “Panel B” angeschlossen. Zwei Kabel daher, da eines der beiden Kabel für das eingehende Signal reserviert ist und das andere für das ausgehende 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.

**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.

## 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.**

`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
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

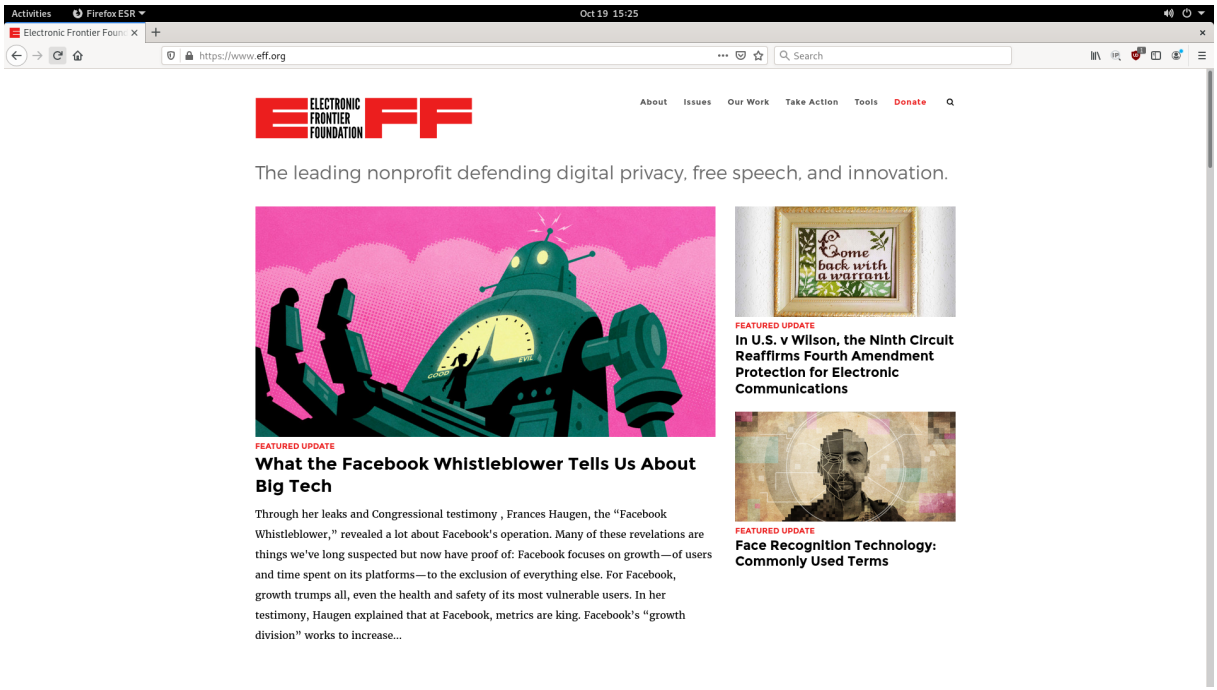



**Abbildung 7:** Screenshot

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]
```

```
26 Oct 19 15:32:38 rn05 systemd-resolved[34579]: ZONE:
27 Oct 19 15:32:38 rn05 systemd-resolved[34579]:         5.66.62.141.in-
       addr.arpa IN PTR rn05
28 Oct 19 15:32:38 rn05 systemd-resolved[34579]:         rn05 IN A
       141.62.66.5
29 Oct 19 15:32:38 rn05 systemd-resolved[34579]: [Scope protocol=dns]
30 Oct 19 15:32:38 rn05 systemd-resolved[34579]: [Server 141.62.66.250
       type=system]
31 Oct 19 15:32:38 rn05 systemd-resolved[34579]:         Verified feature
       level: n/a
32 Oct 19 15:32:38 rn05 systemd-resolved[34579]:         Possible feature
       level: TLS+EDNS0+D0
33 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
35 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
37 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
39 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
41 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:
43 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
45 Oct 19 15:33:00 rn05 systemd-resolved[34579]: [Scope protocol=dns]
46 Oct 19 15:33:00 rn05 systemd-resolved[34579]: CACHE:
47 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
49 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
51 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
53 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
55 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 family=AF_INET]
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 2606:2800:220:1:248:1893:25c8:1946
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
```

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.

## 3.5 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
  -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

```

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

Erzwungenes IPv4:

```
1 $ ping -4 google.com
2 PING google.com (142.250.185.78) 56(84) bytes of data.
3 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
5 ^C
6 --- google.com ping statistics ---
7 2 packets transmitted, 2 received, 0% packet loss, time 1002ms
8 rtt min/avg/max/mdev = 4.582/4.989/5.397/0.407 ms
```

Nur zwei Pakete:

```
1 praktikum@rn05:~$ ping -c 2 google.com
2 PING google.com (142.250.185.78) 56(84) bytes of data.
3 64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=1
     ttl=114 time=4.45 ms
4 64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=2
     ttl=114 time=4.46 ms
5
6 --- google.com ping statistics ---
7 2 packets transmitted, 2 received, 0% packet loss, time 1002ms
8 rtt min/avg/max/mdev = 4.447/4.453/4.460/0.006 ms
```

2 Sekunden Pause zwischen den Paketen:

```
1 $ ping -i 2 google.com
2 PING google.com (142.250.185.78) 56(84) bytes of data.
3 64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=1
     ttl=114 time=4.69 ms
4 64 bytes from fra16s48-in-f14.1e100.net (142.250.185.78): icmp_seq=2
     ttl=114 time=4.59 ms
5 ^C
6 --- google.com ping statistics ---
7 2 packets transmitted, 2 received, 0% packet loss, time 2003ms
8 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
  -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
```

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: Als freien Äquivalent wurde deshalb `fping` verwendet:

```
Name         : fping
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
20     -p, --period=MSEC  interval between ping packets to one target (in
          ms)
21                        (in loop and count modes, default: 1000 ms)
22     -r, --retry=N      number of retries (default: 3)
23     -R, --random       random packet data (to foil link data compression
          )
24     -S, --src=IP       set source address
25     -t, --timeout=MSEC individual target initial timeout (default: 500
          ms,
26                        except with -l/-c/-C, where it's the -p period up
                               to 2000 ms)
27
28  Output options:
29     -a, --alive        show targets that are alive
30     -A, --addr         show targets by address
31     -C, --vcount=N     same as -c, report results in verbose format
32     -D, --timestamp    print timestamp before each output line
33     -e, --elapsed      show elapsed time on return packets
34     -i, --interval=MSEC  interval between sending ping packets (default:
           10 ms)
35     -n, --name         show targets by name (-d is equivalent)
36     -N, --netdata      output compatible for netdata (-l -Q are required
          )
37     -o, --outage       show the accumulated outage time (lost packets *
          packet interval)
38     -q, --quiet        quiet (don't show per-target/per-ping results)
39     -Q, --squiet=SECS  same as -q, but show summary every n seconds
40     -s, --stats        print final stats
41     -u, --unreach      show targets that are unreachable
42     -v, --version      show version
43     -x, --reachable=N  shows if >=N hosts are reachable or not
```

Die Verwendung ist ähnlich wie `ping`.

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

```
1  $ fping -e 10.60.43.50
2  10.60.43.50 is alive (70.9 ms)
3  $ 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
5  10.60.43.50 dev wlp0s20f3 lladdr 7a:11:bd:7c:f9:ff ref 1 used 2/19/2
      probes 4 DELAY
6
7  *** Round 1, deleting 2 entries ***
8  *** Flush is complete after 1 round ***
9  $ fping -e 10.60.43.50
10 10.60.43.50 is alive (212 ms)
```

Nach dem Löschen der ARP-Tabelle ist eine deutlich längere Antwortzeit zu messen.

### 3.6 Traceroute & MTR

**Versuchen Sie, den zentralen Peering-Point (DE-CIX) in Deutschland geografisch 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 vorbeizuschicken, 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
  -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
30                              port for other methods (with default of
                                80 for
31                              "tcp", 53 for "udp", etc.)
32    -t tos  --tos=tos         Set the TOS (IPv4 type of service) or TC
      (IPv6
33                              traffic class) value for outgoing packets
34    -l flow_label  --flowlabel=flow_label
35                              Use specified flow_label for IPv6 packets
36    -w MAX,HERE,NEAR  --wait=MAX,HERE,NEAR
37                              Wait for a probe no more than HERE (
                                default 3)
38                              times longer than a response from the
                                same hop,
39                              or no more than NEAR (default 10) times
                                than some
40                              next hop, or MAX (default 5.0) seconds (
                                float
41                              point values allowed too)
42    -q nqueries  --queries=nqueries
43                              Set the number of probes per each hop.
                                Default is
44                              3
45    -r                        Bypass the normal routing and send
      directly to a
46                              host on an attached network
47    -s src_addr  --source=src_addr
48                              Use source src_addr for outgoing packets
49    -z sendwait  --sendwait=sendwait
50                              Minimal time interval between probes (
                                default 0).
51                              If the value is more than 10, then it
                                specifies a
52                              number in milliseconds, else it is a
                                number of
53                              seconds (float point values allowed too)
54    -e  --extensions          Show ICMP extensions (if present),
      including MPLS
55    -A  --as-path-lookups     Perform AS path lookups in routing
      registries and
56                              print results directly after the
                                corresponding
57                              addresses
58    -M name  --module=name    Use specified module (either builtin or
      external)
59                              for traceroute operations. Most methods
                                have
60                              their shortcuts (`-I' means `-M icmp' etc
                                .)
61    -O OPTS,...  --options=OPTS,...
62                              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.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
[pojntfx@felicitass-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.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
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
$ 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
125   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
127   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
129   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
131   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
133  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
135  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
137  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
2  [Querying whois.denic.de]
3  [whois.denic.de]
4  % Restricted rights.
5  %
6  % Terms and Conditions of Use
7  %
8  % The above data may only be used within the scope of technical or
9  % administrative necessities of Internet operation or to remedy legal
10 % problems.
11 % The use for other purposes, in particular for advertising, is not
       permitted.
12 %
13 % The DENIC whois service on port 43 doesn't disclose any information
       concerning
14 % 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.
31
32 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.**

PathPing ist unfreie Software und respektiert deshalb nicht die digitalen Rechte der Versuchs- durchführenden; zudem funktioniert es nicht auf freien Systemen und der Quellcode steht nicht zur Verfügung, was ein Sicherheitsrisiko darstellt. Als freien Äquivalent zu PathPing wurde deshalb `mtr` verwendet:

```
 1 Name         : mtr
 2 Epoch        : 2
 3 Version      : 0.94
 4 Release      : 3.fc34
 5 Architecture : x86_64
 6 Size         : 191 k
 7 Source       : mtr-0.94-3.fc34.src.rpm
 8 Repository   : @System
 9 From repo    : updates
10 Summary      : Network diagnostic tool combining 'traceroute' and 'ping
       '
11 URL          : https://www.bitwizard.nl/mtr/
12 License      : GPLv2
13 Description  : MTR combines the functionality of the 'traceroute' and '
       ping'
14               : programs in a single network diagnostic tool.
15               :
16               : When MTR is started, it investigates the network
                   connection
17               : between the host MTR runs on and the user-specified
                   destination
```

```
18              : host. Afterwards it determines the address of each
                  network hop
19              : 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.
21              : While doing this, it prints running statistics about
                  each
22              : machine.
23              :
24              : MTR provides two user interfaces: an ncurses interface,
                  useful
25              : 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:

```
1  Usage:
2   mtr [options] hostname
3
4   -F, --filename FILE        read hostname(s) from a file
5   -4                         use IPv4 only
6   -6                         use IPv6 only
7   -u, --udp                  use UDP instead of ICMP echo
8   -T, --tcp                  use TCP instead of ICMP echo
9   -I, --interface NAME       use named network interface
10  -a, --address ADDRESS      bind the outgoing socket to ADDRESS
11  -f, --first-ttl NUMBER     set what TTL to start
12  -m, --max-ttl NUMBER       maximum number of hops
13  -U, --max-unknown NUMBER   maximum unknown host
14  -P, --port PORT            target port number for TCP, SCTP, or UDP
15  -L, --localport LOCALPORT  source port number for UDP
16  -s, --psize PACKETSIZE     set the packet size used for probing
17  -B, --bitpattern NUMBER    set bit pattern to use in payload
18  -i, --interval SECONDS     ICMP echo request interval
19  -G, --gracetime SECONDS    number of seconds to wait for responses
20  -Q, --tos NUMBER           type of service field in IP header
21  -e, --mpls                 display information from ICMP extensions
22  -Z, --timeout SECONDS      seconds to keep probe sockets open
23  -M, --mark MARK            mark each sent packet
24  -r, --report               output using report mode
25  -w, --report-wide          output wide report
26  -c, --report-cycles COUNT  set the number of pings sent
27  -j, --json                 output json
28  -x, --xml                  output xml
29  -C, --csv                  output comma separated values
30  -l, --raw                  output raw format
31  -p, --split                split output
32  -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.
```

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

```
$ mtr -n --json www.aol.com
{
    "report": {
        "mtr": {
            "src": "felicitass-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": 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": "felicitass-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": 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
            }
```

```
140           ]
141       }
142   }
```

Wie zu erkennen ist wird durch diese z.B. 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:

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

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

Zuvor:

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

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

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

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

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

      10.60.54.18:45862                                      23.185.0.3:443
10 ESTAB                0                  0

      10.60.6.89:52008                                    66.102.1.188:5228
                 users:(("chrome",pid=57314,fd=26))
11 FIN-WAIT-1           0                  1

      10.60.54.18:42784                                  104.244.42.193:443
12 FIN-WAIT-1           0                  1

      10.60.54.18:43802                                    140.82.121.3:443
13 FIN-WAIT-1           0                  1

      10.60.54.18:56072                                   104.19.154.83:443
14 ESTAB                0                  0

      10.60.54.18:57766                                  159.69.63.133:443
                  users:(("nextcloud",pid=4890,fd=38))
15 FIN-WAIT-1           0                  1

      10.60.54.18:58314                                    104.244.42.2:443
16 FIN-WAIT-1           0                  1

      10.60.54.18:41736                                 185.199.109.154:443
```

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

```
1 $ ss -tnp
2 State                  Recv-Q             Send-Q
                                                    Local Address:
      Port                                 Peer Address:Port
                Process
3 FIN-WAIT-1             0                  1

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

      10.60.54.18:52990                                    104.16.18.94:443
```

```
5  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))
7  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
9  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
11 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
13 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))
15 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
17 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
19 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))
21 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))
23 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))
25 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
27 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
29 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))
31 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
33 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))
35 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:

```
1 $ 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
$ 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",pid=10523,fd=3))
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=36529,fd=3))
$ nc 141.62.66.4 6767
asdf

asdf
$ 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:

```
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      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))
28 ESTAB 0      0        141.62.66.5:44868       65.9.84.191:80    users
      :(("firefox-esr",pid=36809,fd=140))
29 $ ss -tnp
30 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.

### 3.8 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.

```
1  $ ip route show table all
2  default via 141.62.66.250 dev enp0s31f6
3  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
5  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
7  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
9  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 Subnetz `192.0.2.128/25` über den Host `141.62.66.4` routed. Lädt der Host die richtigen Kernel-Module und wird IP-Weiterleitung mittels `sysctl` aktiviert, so könnte dieser damit als Router fungieren.

```
$ 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
```

# 4 Weitere Werkzeuge

## 4.1 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.

### 4.2 Nmap

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

Es gibt verschiedene Möglichkeiten Scans durchzuführen, der gängige (und die Standardeinstellung) 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
$ 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:

```
$ 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
```