

# **Praktikum Rechnernetze**

Protokoll zu Versuch 2 (Protokollanalyse mit Wireshark) von  
Gruppe 1

---

Jakob Waibel    Daniel Hiller    Elia Wüstner    Felix Pojtinger

2021-10-26

# Einführung

---

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](https://github.com/pojntfx/uni-netpractice-notes)):



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

# Lizenz

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



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

Uni Network Practice Notes (c) 2021 Jakob Waibel, Daniel Hiller,  
Elia Wüstner, Felix Pojtinger

SPDX-License-Identifier: AGPL-3.0

# Wireshark

---

## Einführung

An welchem Koppelement im Systemschrank sollte der Hardware-Analysator/Netzwerk-Sniffer sinnvollerweise angeschlossen werden und warum? Welche grundsätzlichen Möglichkeiten gibt es noch?

- Switch, damit Nachrichten auf Layer 2 auch abgefangen werden können
  - Grundsätzlich könnte, vor allem auch in Heimnetzwerken, der Router hierzu verwendet werden, da hier oft Router und Switch zu einem Gerät kombiniert sind.

**Starten Sie Wireshark und capturern Sie den aktuellen Traffic. Dokumentieren Sie zunächst, was alles auf Wireshark einprasselt.**



# Ping

Senden Sie einen Ping zu nachfolgenden Empfängern und zeichnen Sie die entsprechenden Protokolle gezielt mit Wireshark auf. Vergleichen Sie die Protokollabläufe: wer sendet welches Protokoll warum an wen? Pingen Sie an ....

**Einen Rechner Ihrer Wahl im Labornetz:**

| *eng0s3lf6 |              |              |              |          |        |   |
|------------|--------------|--------------|--------------|----------|--------|---|
| No.        | Time         | Source       | Destination  | Protocol | Length | Info  |
| 19         | 3.0149000067 | 141.62.66.5  | 141.62.66.13 | ICMP     | 98     | Echo (ping) request id=0xclcd, seq=1/256, ttl=64 (reply in 20)  |
| 28         | 3.0156959823 | 141.62.66.13 | 141.62.66.5  | ICMP     | 98     | Echo (ping) reply id=0xc1cd, seq=1/256, ttl=128 (request in 19) |
| 33         | 4.0367852560 | 141.62.66.5  | 141.62.66.13 | ICMP     | 98     | Echo (ping) request id=0xc1cd, seq=2/512, ttl=64 (reply in 34)  |
| 34         | 4.0375620000 | 141.62.66.13 | 141.62.66.5  | ICMP     | 98     | Echo (ping) reply id=0xclcd, seq=2/512, ttl=128 (request in 33) |
| 42         | 5.0697798847 | 141.62.66.5  | 141.62.66.13 | ICMP     | 98     | Echo (ping) request id=0xc1cd, seq=3/768, ttl=64 (reply in 43)  |
| 43         | 5.0851982114 | 141.62.66.13 | 141.62.66.5  | ICMP     | 98     | Echo (ping) reply id=0xclcd, seq=3/768, ttl=128 (request in 42) |

# DHCP

**Analysieren Sie die Abläufe bei DHCP (im Labor installiert).  
Ihre Teilgruppe am Nachbartisch bootet den PC am Arbeitsplatz, protokollieren Sie die DHCP-Abläufe sowie sonstigen Netzverkehr, den der PC bis zum Erhalt der IP-Adresse erzeugt.**

Während des Startens werden drei DHCP-Requests für verschiedene Komponenten abgehandelt.

| No. | Time          | Source                  | Destination     | Protocol | Length | Info                                       |
|-----|---------------|-------------------------|-----------------|----------|--------|--|
| 47  | 36.2408724335 | 0.0.0.0                 | 255.255.255.255 | DHCP     | 590    | DHCP Discover - Transaction ID 0x620e53eb  |
| 48  | 36.2408844427 | ognsense-router.rml...  | 255.255.255.255 | DHCP     | 348    | DHCP Offer - Transaction ID 0x620e53eb     |
| 55  | 40.250252423  | 0.0.0.0                 | 255.255.255.255 | DHCP     | 590    | DHCP Request - Transaction ID 0x620e53eb   |
| 56  | 40.250518728  | ognsense-router.rml...  | 255.255.255.255 | DHCP     | 348    | DHCP ACK - Transaction ID 0x620e53eb       |
| 57  | 40.2509797973 | linux.local             | Broadcast       | ARP      | 60     | Who has 141.62.66.236? Tell 141.62.66.4    |
| 58  | 40.278416173  | linux.local             | Broadcast       | ARP      | 60     | Who has 141.62.66.250? Tell 141.62.66.4    |
| 63  | 45.478669439  | fog.rnrlabor.hdm-stu... | linux.local     | ARP      | 60     | Who has 141.62.66.47 Tell 141.62.66.236    |
| 65  | 46.478669439  | fog.rnrlabor.hdm-stu... | 1.1.1.1         | ARP      | 60     | Who has 141.62.66.47 Tell 1.1.1.1          |
| 70  | 47.526653889  | fog.rnrlabor.hdm-stu... | linux.local     | ARP      | 60     | Who has 141.62.66.47 Tell 141.62.66.236    |
| 72  | 49.407126304  | 0.0.0.9                 | 255.255.255.255 | DHCP     | 451    | DHCP Discover - Transaction ID 0xc1478931  |
| 73  | 49.498452675  | ognsense-router.rml...  | 255.255.255.255 | DHCP     | 348    | DHCP Offer - Transaction ID 0xc1478931     |
| 79  | 50.529353450  | 0.0.0.0                 | 255.255.255.255 | DHCP     | 463    | DHCP Request - Transaction ID 0xc1478931   |
| 80  | 50.531124992  | ognsense-router.rml...  | 255.255.255.255 | DHCP     | 348    | DHCP ACK - Transaction ID 0xc1478931       |
| 81  | 50.531125138  | linux.local             | Broadcast       | ARP      | 60     | ARP Announcement for 141.62.66.4           |
| 82  | 50.5845464928 | 0.0.0.0                 | Broadcast       | ARP      | 60     | Who has 141.62.66.236? Tell 141.62.66.4    |
| 85  | 54.820515489  | linux.local             | Broadcast       | ARP      | 60     | Who has 141.62.66.236? Tell 141.62.66.4    |
| 92  | 56.342356749  | 0.0.0.0                 | 255.255.255.255 | DHCP     | 348    | DHCP Discover - Transaction ID 0xadic98d59 |
| 93  | 66.342356749  | 0.0.0.0                 | 255.255.255.255 | DHCP     | 345    | DHCP Offer - Transaction ID 0xadic98d59    |
| 95  | 66.6292416640 | linux.local             | Broadcast       | ARP      | 60     | Who has 141.62.66.250? Tell 141.62.66.4    |

**Figure 9: Gesamter Bootprozess**

## Dokumentieren Sie den Ablauf bei einer DNS-Abfrage

### Fall 1: DNS-Server 141.62.66.250:

Mittels folgendem Command wurde eine DNS-Abfrage gemacht:

```
$ dig @141.62.66.250 google.com
google.com.      163 IN  A    142.250.186.174
```

| dns && frame.number < 20 |             |                     |                     |          |        |   |
|--------------------------|-------------|---------------------|---------------------|----------|--------|---|
| No.                      | Time        | Source              | Destination         | Protocol | Length | Info  |
| 11                       | 1.357358668 | rn05.rnlab0.hdm-st  | opnsense-router.rn1 | DNS      | 93     | Standard query 0xa276 A google.com OPT                            |
| 12                       | 1.371692878 | opnsense-router.rn1 | rn05.rnlab0.hdm-st  | DNS      | 97     | Standard query response 0xa276 A google.com A 142.250.186.174 OPT |

**Figure 12:** Ablauf der Anfrage

Hier nutzten wir den internen DNS Server und machen eine Anfrage auf google.com.

### Fall 2: DNS-Server 1.1.1.1 (Cloudflare):

Mit folgendem Command kann die DNS-Aufgabe mit dem

## Lösen Sie eine ARP-Anfrage aus und protokollieren Sie die Datenpakete.

Hierzu wurde ein Rechner, welcher zuvor nicht im lokalen ARP-Cache war, neu gestartet.

| No. | Time          | Source        | Destination   | Protocol | Length | Info                                  |
|-----|---------------|---------------|---------------|----------|--------|---------------------------------------|
| 214 | 110.515578213 | Linux-2.local | Broadcast     | ARP      | 42     | who has 141.62.66.6 Tell 141.62.66.5  |
| 215 | 110.515867298 | Linux-3.local | Linux-2.local | ARP      | 60     | 141.62.66.6 is at 4c:52:62:0e:54:2b   |
| 231 | 115.073154795 | Linux-3.local | Linux-2.local | ARP      | 60     | who has 141.62.66.57 Tell 141.62.66.6 |
| 232 | 115.073186793 | Linux-2.local | Linux-3.local | ARP      | 42     | 141.62.66.5 is at 4c:52:62:0e:54:2b   |

Figure 15: Ablauf der Anfrage

## Wann wird eine ARP-Anfrage gestartet?

Sobald ein Paket an die Zieladresse (in unserem Fall 141.62.66.6) gesendet werden soll, wird eine ARP-Anfrage in Form eines Broadcasts gestartet, um das Zielgerät im Netzwerk zu ermitteln, sofern sich diese nicht bereits im ARP-Cache befindet. Dieser kann mit ip neigh show ausgelesen werden. Mit ip neigh flush all

# Layer-2-Protokolle

**Gelegentlich werden vom Analyzer Broadcasts erkannt. Wer sendet sie, warum und in welchen zeitlichen Abständen?**

Die Broadcasts sind ARP-Requests. Sie entstehen dadurch, da Geräte versuchen Daten an andere Geräte zu übertragen, für welche sie keinen Eintrag in ihrem ARP-Cache haben, deshalb muss eine ARP-Anfrage in Form eines Broadcasts gesendet werden, da jeder Host potenziell der gesuchte Host sein kann. Dieser besitzt gesuchte IP X und antwortet daraufhin mit seiner Mac.

| Apply a display filter... <Ctrl>/> |                |                        |                      |          |        |   |
|------------------------------------|----------------|------------------------|----------------------|----------|--------|---|
| No.                                | Time           | Source                 | Destination          | Protocol | Length | Info  |
| 173                                | 70.088137336   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 174                                | 71.09953778    | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 175                                | 72.086751887   | Linux-2.local          | 224.0.0.255          | MDNS     | 62     | Standard query 0x0000 PTR _popkey-hp._tcp.local. "Qn" question  |
| 176                                | 72.086751887   | Linux-2.local          | 224.0.0.255          | MDNS     | 62     | Standard query 0x0000 PTR _popkey-hp._tcp.local. "Qn" question  |
| 177                                | 75.099556889   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 178                                | 77.099639982   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 179                                | 79.099888085   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 180                                | 81.099888085   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 181                                | 83.099537782   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 182                                | 84.099547941   | Libremes-226.rnlabor.h | Broadcast            | ARP      | 60     | who has 141.02.66.226 Tell 141.02.66.226  |
| 183                                | 84.731177879   | Libremes-226.rnlabor.h | Broadcast            | ARP      | 60     | who has 141.02.66.227 Tell 141.02.66.229  |
| 184                                | 85.099547941   | Libremes-226.rnlabor.h | Broadcast            | ARP      | 60     | who has 141.02.66.227 Tell 141.02.66.229  |
| 185                                | 85.761495159   | Libremes-226.rnlabor.h | Broadcast            | ARP      | 60     | who has 141.02.66.227 Tell 141.02.66.226  |
| 186                                | 85.91.08676527 | linux-2.local          | opensemse.rnlabor.h  | DNS      | 66     | Standard query 0x0e2a PTR 226.66.62.141.in-addr.arpa  |
| 187                                | 85.955623699   | opensemse.rnlabor.h    | linux-2.local        | DNS      | 137    | Standard query response 0x0e2a PTR 226.66.62.141.in-addr.arpa PTR libremes-226.rnlabor.h.dmn-stuttgart.de         |
| 188                                | 86.721654749   | Libremes-226.rnlabor.h | Broadcast            | ARP      | 60     | who has 141.02.66.227 Tell 141.02.66.226  |
| 189                                | 86.785467391   | Libremes-226.rnlabor.h | Broadcast            | ARP      | 60     | who has 141.02.66.227 Tell 141.02.66.226  |
| 190                                | 87.099791211   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 191                                | 87.099791211   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 192                                | 88.029704588   | Linux-3.local          | 224.0.0.255          | MDNS     | 62     | Standard query 0x0000 PTR _www-0193._tcp.local. "Qn" question   |
| 193                                | 88.029704588   | Linux-3.local          | 224.0.0.255          | MDNS     | 62     | Standard query 0x0000 PTR _www-0193._tcp.local. "Qn" question   |
| 194                                | 91.087505484   | Linux-2.local          | opensemse.rnlabor.h  | ARP      | 42     | who has 141.02.66.259? Tell 141.02.66.5   |
| 195                                | 91.086717289   | opensemse.rnlabor.h    | linux-2.local        | ARP      | 60     | 141.02.66.259 is at 00:0c:09:48:b8:14   |
| 196                                | 91.086717289   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 197                                | 93.086371935   | HewlettP..aa:0b:be     | LLDP Multicast       | LLDP     | 312    | Ma/0:4:0973:aa:bb/Lv/2/12 Sys=C19-HP-2920-24# Syst=HP 3972EA 2920-240 Switch, revision W8.10.0015, ROM W8.16.03 - |
| 198                                | 93.086371935   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 199                                | 93.086371935   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |
| 200                                | 93.086371935   | HewlettP..aa:0b:be     | Spanning-tree-(For-) | STP      | 119    | MST. Root = 32768/0:00:1a:c1:5e:eb:c0 Cost = 228020 Port = 0x80002  |

# HTTP und TCP

## Initiiieren Sie eine HTTP-TCP-Sitzung (beliebige Website) und zeichnen Sie die Protokollabläufe auf

Zuerst wird ein DNS-Request getätigt. Daraufhin folgt der 3-Way-Handshake. Dieser ist an der charakteristischen Abfolge SYN, SYN-ACK, ACK zu erkennen.

| No. | Time      | Source          | Destination     | Protocol | Length | Info  |
|-----|-----------|-----------------|-----------------|----------|--------|---|
| 714 | 7.598625  | 100.64.84.66    | 141.78.124.5    | DNS      | 88     | Standard query 0x189d A news.ycombinator.com  |
| 715 | 7.598681  | 100.64.84.66    | 141.78.124.5    | DNS      | 88     | Standard query 0x58df AAAA news.ycombinator.com   |
| 716 | 7.600834  | 141.78.124.5    | 100.64.84.66    | DNS      | 158    | Standard query response 0x58df AAAA news.ycombinator.com 504 ns=225.awdns-28.com  |
| 717 | 7.603297  | 141.78.124.5    | 100.64.84.66    | DNS      | 233    | Standard query response 0x189d A news.ycombinator.com A 209.216.230.248 NS ns=1914.awdns-47.co...   |
| 718 | 7.613186  | 100.64.84.66    | 209.216.230.248 | TCP      | 74     | 49314 - 443 [SYN, ECR, CWR] Seq=0 Win=65535 Len=0 TSval=2512581059 TSecr=0 SACK_PERM=1  |
| 719 | 7.615318  | 209.216.230.248 | 100.64.84.66    | TCP      | 74     | 49314 - 443 [SYN, ACK] Seq=1 Win=65535 Len=0 TSval=2512581059 TSecr=0 SACK_PERM=1 TSeq=2845828468   |
| 720 | 7.616534  | 100.64.84.66    | 209.216.230.248 | TCP      | 74     | 49314 - 443 [ACK] Seq=1 Ack=1 Win=31712 Len=0 TSval=2512581211 TSecr=0 SACK_PERM=1  |
| 721 | 7.6165826 | 100.64.84.66    | 209.216.230.248 | TLSv1... | 583    | Client Hello  |
| 722 | 7.917493  | 209.216.230.248 | 100.64.84.66    | TLSv1... | 1514   | Server Hello  |
| 723 | 7.917494  | 209.216.230.248 | 100.64.84.66    | TCP      | 1514   | 443 - 49314 [ACK] Seq=1449 Ack=518 Win=65664 Len=1448 TSval=2045828612 TSecr=2512581211 [TCP segment of a reassembled PDU]                            |
| 724 | 7.917495  | 209.216.230.248 | 100.64.84.66    | TLSv1... | 1062   | Certificate, Certificate, Server Key Exchange, Server Key Exchange, Server Hello Done   |
| 725 | 7.917581  | 100.64.84.66    | 209.216.230.248 | TCP      | 66     | 49314 - 443 [ACK] Seq=518 Ack=3893 Win=127872 Len=0 TSval=2512581363 TSecr=2045828612   |
| 726 | 7.917726  | 100.64.84.66    | 209.216.230.248 | TCP      | 66     | [TCP Window Update] 49314 - 443 [ACK] Seq=518 Ack=3893 Win=131072 Len=0 TSval=2512581363 TSecr=2045828612   |
| 727 | 7.937248  | 100.64.84.66    | 209.216.230.248 | TLSv1... | 192    | Client Key Exchange, Change Cipher Spec, Encrypted Handshake Message  |
| 728 | 7.937649  | 100.64.84.66    | 209.216.230.248 | TLSv1... | 786    | Application Data  |
| 729 | 8.088785  | 209.216.230.248 | 100.64.84.66    | TCP      | 66     | 443 - 49314 [ACK] Seq=3893 Ack=1364 Win=64832 Len=0 TSval=2045828783 TSecr=2512581383   |
| 729 | 8.093869  | 209.216.230.248 | 100.64.84.66    | TCP      | 66     | 49314 - 443 [New Session Ticket, Change Cipher Spec, Encrypted Handshake Message] Seq=3893 Ack=1364 Win=64832 Len=0 TSval=2045828783 TSecr=2512581383 |
| 731 | 8.093957  | 100.64.84.66    | 209.216.230.248 | TCP      | 1514   | 443 - 49314 [ACK] Seq=1361 Ack=3893 Win=138752 Len=0 TSval=2045828783 TSecr=2512581383 [TCP segment of a reassembled PDU]                             |
| 732 | 8.094055  | 209.216.230.248 | 100.64.84.66    | TCP      | 1514   | 443 - 49314 [ACK] Seq=1361 Ack=3893 Win=138752 Len=0 TSval=2045828783 TSecr=2512581383 [TCP segment of a reassembled PDU]                             |
| 732 | 8.094696  | 209.216.230.248 | 100.64.84.66    | TCP      | 1514   | 443 - 49314 [ACK] Seq=5599 Ack=1364 Win=65664 Len=1448 TSval=2045828783 TSecr=2512581383 [TCP segment of a reassembled PDU]                           |
| 734 | 8.096206  | 209.216.230.248 | 100.64.84.66    | TCP      | 1514   | 443 - 49314 [ACK] Seq=7847 Ack=1364 Win=65664 Len=1448 TSval=2045828783 TSecr=2512581383 [TCP segment of a reassembled PDU]                           |
| 735 | 8.096297  | 209.216.230.248 | 100.64.84.66    | TCP      | 1514   | 443 - 49314 [ACK] Seq=9495 Ack=1364 Win=65664 Len=1448 TSval=2045828783 TSecr=2512581383 [TCP segment of a reassembled PDU]                           |
| 736 | 8.096298  | 209.216.230.248 | 100.64.84.66    | TLSv1... | 681    | Application Data  |
| 737 | 8.096371  | 100.64.84.66    | 209.216.230.248 | TCP      | 66     | 49314 - 443 [ACK] Seq=1364 Ack=18558 Win=124688 Len=0 TSval=2512581542 TSecr=2045828789   |
| 738 | 8.096484  | 100.64.84.66    | 209.216.230.248 | TCP      | 66     | [TCP Window Update] 49314 - 443 [ACK] Seq=1364 Ack=18558 Win=131072 Len=0 TSval=2512581542 TSecr=2045828789   |
| 739 | 8.223532  | 100.64.84.66    | 209.216.230.248 | TLSv1... | 691    | Application Data  |
| 740 | 8.223598  | 100.64.84.66    | 209.216.230.248 | TCP      | 78     | 49315 - 443 [SYN, ECR, CWR] Seq=0 Win=65535 Len=0 TSval=1387975097 TSecr=0 SACK_PERM=1  |
| 741 | 8.374585  | 209.216.230.248 | 100.64.84.66    | TCP      | 1514   | 49314 - 443 [ACK] Seq=18558 Ack=1989 Win=65664 Len=1448 TSval=2045829070 TSecr=2512581669 [TCP segment of a reassembled PDU]                          |
| 742 | 8.374587  | 209.216.230.248 | 100.64.84.66    | TLSv1... | 823    | Application Data  |
| 743 | 8.374653  | 100.64.84.66    | 209.216.230.248 | TCP      | 66     | 49314 - 443 [ACK] Seq=1989 Ack=17263 Win=128832 Len=0 TSval=2512581820 TSecr=2045829070   |
| 744 | 8.376801  | 100.64.84.66    | 209.216.230.248 | TLSv1... | 674    | Application Data  |
| 758 | 8.419434  | 209.216.230.248 | 100.64.84.66    | TCP      | 74     | 443 - 49315 [SYN, ECR, CWR] Seq=0 Win=65535 Len=0 TSval=1535768379 TSecr=0 SACK_PERM=1  |
| 751 | 8.419586  | 100.64.84.66    | 209.216.230.248 | TCP      | 66     | 49315 - 443 [ACK] Seq=1 Ack=1 Win=31712 Len=0 TSval=1382789759 TSecr=0 SACK_PERM=1  |
| 752 | 8.424337  | 100.64.84.66    | 209.216.230.248 | TLSv1... | 585    | Client Hello  |
| 759 | 8.527457  | 209.216.230.248 | 100.64.84.66    | TCP      | 1514   | 443 - 49314 [ACK] Seq=12763 Ack=2597 Win=65664 Len=1448 TSval=2045829221 TSecr=2512581821 [TCP segment of a reassembled PDU]                          |
| 760 | 8.527968  | 100.64.84.66    | 209.216.230.248 | TLSv1... | 793    | Application Data  |
| 761 | 8.527151  | 100.64.84.66    | 209.216.230.248 | TCP      | 66     | 49314 - 443 [ACK] Seq=12763 Ack=18939 Win=128996 Len=0 TSval=2512581972 TSecr=2045829221  |
| 762 | 8.528143  | 209.216.230.248 | 100.64.84.66    | TLSv1... | 223    | Server Hello, Change Cipher Spec, Encrypted Handshake Message   |
| 763 | 8.591467  | 100.64.84.66    | 209.216.230.248 | TCP      | 66     | 49315 - 443 [ACK] Seq=15184 Win=131072 Len=0 TSval=3827897926 TSecr=1535705550  |
| 764 | 8.591589  | 100.64.84.66    | 209.216.230.248 | TLSv1... | 132    | Change Cipher Spec, Encrypted Handshake Message   |

## Wie lauten die MAC-Adressen der im Labor befindlichen Ethernet-Switches? Wie haben Sie die Switches identifizieren können. Welche Möglichkeiten der Identifizierung gibt es?

Beim Spanning-Tree-Protocol lässt sich sehen, dass die Quelle der Nachrichten immer ein HP-Gerät ist. Dieses muss ein fähiges Kopplungselement des Netzwerkes sein, welches das Spanning-Tree-Protocol unterstützt. Daher wird dies mit hoher Wahrscheinlichkeit der Ethernet-Switch sein.

**MAC-Adresse:** 04:09:73:aa:8b:be

| No.                | Time | Source             | Destination          | Protocol | Length Info   |
|--------------------|------|--------------------|----------------------|----------|---|
| 179 63.999710934   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 171 85.9998037575  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 172 85.9998037575  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 173 70.998137336   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 174 71.99950885778 |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 178 73.999729543   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 175 73.999729543   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 176 77.999639982   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 179 79.999888985   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 180 81.999602380   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 181 83.999531792   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 182 83.999531792   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 183 85.999999785   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 198 91.999634042   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 199 93.999634042   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 200 93.999634042   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 200 97.999550051   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 201 100.999216873  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 203 100.999550734  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 204 100.999550734  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 206 105.999842753  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 212 105.999842753  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 191 87.999791212   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 192 88.999791212   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 196 91.999634042   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 198 93.999634042   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 199 93.999634042   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 200 97.999550051   |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 201 100.999216873  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 203 100.999550734  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 204 100.999550734  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 206 105.999842753  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |
| 212 105.999842753  |      | HewlettPc_an:00:00 | Spanning-tree-(For-) | STP      | 119 MST_Root = 32768/0/0/0/10:c1:5e:eb:c0 Cost = 229020 Port 1 = 0x8002 |

## Filtern Sie auf das Protokoll BPDU/STP. Wer sendet es und welchen Sinn hat dieses Protokoll?

Das STP-Protokoll ist das Spanning Tree Protocol. Das STP-Protokoll verhindert Schleifenbildung; dies ist besonders dann von Nutzen, wenn Redundanzen vorhanden sind. Beim STP-Protokoll werden durch alle am Netz beteiligten Switches eine "Root Bridge" gewählt und redundante Links werden deaktiviert. Wie anhand der OUI der MAC-Adresse erkannt werden kann wird dieses hier von einem HP-Switch verwendet.

| No. | Time          | Source            | Destination         | Protocol | Length Info   |
|-----|---------------|-------------------|---------------------|----------|---|
| 393 | 182.000315869 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 394 | 184.001058920 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 395 | 186.000287784 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 397 | 188.000282830 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 398 | 190.000313040 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 400 | 192.000560847 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 407 | 194.000287119 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 408 | 196.000287119 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 411 | 198.000053859 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 412 | 200.000287784 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 413 | 202.000287113 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 417 | 204.000287113 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 418 | 206.000285952 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 423 | 208.000053793 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 424 | 210.000285871 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 425 | 212.000287231 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 426 | 214.001058472 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 427 | 216.000287784 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 429 | 218.000280932 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |
| 430 | 220.000514685 | HuaweiTP_aa:00:be | Spanning-tree-(For- | STP      | 119 MST Root = 32768/0/0/0:1a:c1:5e:eb:09 Cost = 220629 Port = 0x8002 |

# SNMP

## Auf welchen Komponenten im Netzwerk wird das Protokoll SNMP ausgeführt?

Es konnte kein SNMP-Traffic im Netzwerk gefunden werden. SNMP, das Simple Network Management Protocol, wird jedoch meist zur Wartung von verbundenen Geräte im Network verwendet, woraus sich schließen lässt, dass es auf Komponenten wie Switches, Routern oder Servern zum Einsatz kommen würde.

# Streaming and Downloads

Starten Sie einen Download einer größeren Datei aus dem Internet und stoppen Sie ihn während der Übertragung. Dokumentieren Sie, wie der Stop-Befehl innerhalb der Protokolle umgesetzt wird

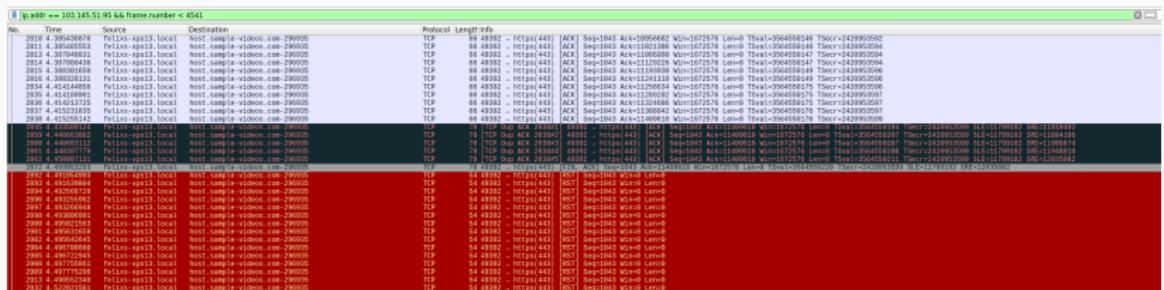


Figure 28: Capture beim Canceln des eines Downloads über HTTPS

Da der Download hier via HTTPS durchgeführt wurde, kann erkannt werden, dass die darunterliegende TCP-Verbindung unterbrochen wurde, indem die RST-Flag gesetzt wurde. Auch ein

# Telnet und SSH

Protokollieren Sie den Ablauf einer TELNET-Verbindung zur IP-Adresse 141.62.66.207 (login: praktikum; passwd: versuch). Können Sie Passwörter im Wireshark-Trace identifizieren? Wie verhält sich im Vergleich dazu eine SSH-Verbindung zum gleichen Server?

Wie zu erkennen ist, wird für eine Telnet-Verbindung eine TCP-Verbindung aufgebaut. Die Passwörter sind zu erkennen.

| No. | Time            | Source        | Destination   | Protocol | Length | Info            |
|-----|-----------------|---------------|---------------|----------|--------|-----------------|
| 53  | 13:37:38.897798 | 141.62.66.5   | 141.62.66.207 | TELNET   | 69     | Telnet Data ... |
| 55  | 13:37:38.917798 | 141.62.66.5   | 141.62.66.207 | TELNET   | 69     | Telnet Data ... |
| 57  | 13:37:38.904843 | 141.62.66.5   | 141.62.66.207 | TELNET   | 69     | Telnet Data ... |
| 58  | 13:37:32.424887 | 141.62.66.207 | 141.62.66.5   | TELNET   | 86     | Telnet Data ... |
| 61  | 13:37:32.639131 | 141.62.66.207 | 141.62.66.5   | TELNET   | 69     | Telnet Data ... |
| 65  | 13:37:34.021221 | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 67  | 13:37:34.058081 | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 69  | 15:7124333764   | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 71  | 15:7131438985   | 141.62.66.207 | 141.62.66.5   | TELNET   | 67     | Telnet Data ... |
| 73  | 15:7844526862   | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 74  | 15:7844526863   | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 76  | 15:8643885545   | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 77  | 15:865698282    | 141.62.66.207 | 141.62.66.5   | TELNET   | 67     | Telnet Data ... |
| 79  | 15:991754757    | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 80  | 15:992584487    | 141.62.66.207 | 141.62.66.5   | TELNET   | 67     | Telnet Data ... |
| 82  | 16:0027779317   | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 83  | 16:0027779317   | 141.62.66.207 | 141.62.66.5   | TELNET   | 67     | Telnet Data ... |
| 86  | 16:1764916985   | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 87  | 16:177386617    | 141.62.66.207 | 141.62.66.5   | TELNET   | 67     | Telnet Data ... |
| 89  | 16:3444256886   | 141.62.66.5   | 141.62.66.207 | TELNET   | 67     | Telnet Data ... |
| 90  | 16:3458939881   | 141.62.66.207 | 141.62.66.5   | TELNET   | 67     | Telnet Data ... |

Frame 1: Telnet -> 141.62.66.207 [TCP port 23] (ttl 64, len 146) at 13:37:38.897798 (local), transmitted (0x00) from interface eth0 (id 0)

Ethernet II, Src: RnLabor [16:39:f0:7b:0b:87] (16:39:f0:7b:0b:87), Dst: rnLabor [0:0:0:0:0:0] (4c:52:62:0e:54:b8)

Internet Protocol Version 4, Src: 141.62.66.207, Dst: 141.62.66.5

Transmission Control Protocol, Src Port: 23, Dst Port: 36234, Seq: 78, Ack: 163, Len: 14

Telnet:

- Data: telnet login:

# Wireshark-Filter

Entwickeln, testen und dokumentieren Sie Wireshark-Filter zur Lösung folgender Aufgaben:

Nur IP-Pakete, deren TTL größer ist als ein von Ihnen sinnvoll gewählter Referenzwert

| No.   | TTL | Time            | Source         | Destination       | Protocol | Length | Info  |
|-------|-----|-----------------|----------------|-------------------|----------|--------|---|
| 25    | 255 | 1.1.444955690   | 190.64.104.254 | felix-xps13.local | ICMP     | 68     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 29    | 255 | 1.147708847     | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 31    | 255 | 1.1.819793372   | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 89    | 255 | 1.1.498431131   | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 90    | 255 | 1.1.3.100000000 | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 112   | 255 | 1.1.4.854393550 | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 113   | 255 | 1.1.4.854393675 | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 1527  | 255 | 1.21.511698853  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 1597  | 255 | 1.21.511698853  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 2031  | 255 | 1.25.441388647  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 2844  | 255 | 1.25.456637949  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 2845  | 255 | 1.25.456619783  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 2849  | 255 | 1.25.598822269  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 2869  | 255 | 1.25.598822605  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 2881  | 255 | 1.25.598822634  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 2882  | 255 | 1.25.598822662  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 11826 | 255 | 74.573785926    | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 12018 | 255 | 75.597596960    | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 12049 | 255 | 75.597596785    | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 13269 | 255 | 87.123833737    | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 16051 | 255 | 1.134.49847999  | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 16866 | 255 | 1.134.622113475 | 190.64.104.254 | felix-xps13.local | ICMP     | 70     | Time-to-live exceeded (Time to live exceeded in transit)  |
| 16946 | 255 | 140.929138747   | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 16952 | 255 | 145.929138747   | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 23824 | 255 | 1.294237189     | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 21865 | 255 | 154.345932968   | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 21935 | 255 | 158.472539784   | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 22148 | 255 | 158.441338164   | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 22784 | 255 | 161.657466049   | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |
| 22852 | 255 | 161.657466049   | 190.64.104.245 | 224.0.0.251       | MDNS     | 198    | Standard query 0x0000 PTR lb._dns-sd._udp.local, "QDN" question PTR_companion-link._tcp.local, "QDN" quest. |

Figure 34: Capture der TTL-Werte ab 200

Der Linux-Kernel stellt standardmäßig die TTL auf 64; hier wurde