



Aflevering 1

NGK

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Øvelse 3

Formålet med øvelsen er at anvende Wireshark til analyse af netværksfunktionalitet og at undersøge DNS-protokollens funktionalitet.

DNS

1. Undersøg vha. Wireshark hvilke DNS-telegrammer der initielt genereres når en hjemmeside (www.au.dk) tilgås fra en webbrowser (fokuser på A telegrammerne). Forklar hvad der sker?

Først foretages en DNS-forespørgsel (Query) til en DNS-server. Da vi kun fokuserer på A telegrammerne betyder det at vi beder om en IPv4-adresse. DNS-serveren returnerer et svar som indeholder IPv4-adressen, der svarer til www.au.dk (som vi bruger i denne øvelse). IP-adressen bruges til at sende en http-forespørgsel til serveren, hvor selve hjemmesiden hentes.



DNS Query:

1.1 Hvilken information indeholder "Queries" feltet i DNS query telegrammet (dokumenter med Wireshark)?

Vi åbner "Queries" feltet i DNS telegrammet for A www.au.dk:

No.	Time	Source	Destination	Protocol	Length	Info
4	1.657254662	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x33ff HTTPS www.au.dk OPT
5	1.657771451	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x3f3b A www.au.dk OPT
6	1.658421590	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0xc44a AAAA www.au.dk OPT
7	1.675960577	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	157	Standard query response 0x33ff HTTPS www.au.dk

▶ Frame 5: 100 bytes on wire (800 bits), 100 bytes captured (800 bits) on interface eth1, id 0

▶ Ethernet II, Src: VMware_fc:28:b0 (00:0c:29:fc:28:b0), Dst: ARRISGroup_c6:0a:d7 (70:df:f7:c6:0a:d7)

▶ Internet Protocol Version 6, Src: 2a13:2540:1e3:6b00::466a, Dst: 2a13:2547:303::10

▶ User Datagram Protocol, Src Port: 38062, Dst Port: 53

▼ Domain Name System (query)

Transaction ID: 0x3f3b

▶ Flags: 0x0100 Standard query

Questions: 1

Answer RRs: 0

Authority RRs: 0

Additional RRs: 1

▼ Queries

▼ www.au.dk: type A, class IN

Name: www.au.dk

[Name Length: 9]

[Label Count: 3]

Type: A (1) (Host Address)

Class: IN (0x0001)

▶ Additional records

[\[Response In: 9\]](#)

Figur 1 DNS query telegrammet i wireshark

Queries for www.au.dk indeholder

- Domænets navn: www.au.dk
- Hvor mange symboler der er i navnet: 9 (inklusive punktum)
- Antal dele i navnet: 3 (www, au, dk)
- Typen: A (IPv4)
- Klasse: IN = internet



1.2 Hvilken Destination Port har telegrammet (dokumenter med Wireshark)?

Destination Port'en findes under User Datagram Protocol:

No.	Time	Source	Destination	Protocol	Length	Info
4	1.657254662	2a13:2540:1e3:6b00:...	2a13:2547:303::10	DNS	100	Standard query 0x33ff HTTPS www.au.dk OPT
5	1.657771451	2a13:2540:1e3:6b00:...	2a13:2547:303::10	DNS	100	Standard query 0x3f3b A www.au.dk OPT
6	1.658421590	2a13:2540:1e3:6b00:...	2a13:2547:303::10	DNS	100	Standard query 0xc44a AAAA www.au.dk OPT
7	1.675960577	2a13:2547:303::10	2a13:2540:1e3:6b00:...	DNS	157	Standard query response 0x33ff HTTPS www.au.dk

▶ Frame 5: 100 bytes on wire (800 bits), 100 bytes captured (800 bits) on interface eth1, id 0
▶ Ethernet II, Src: VMware_fc:28:b0 (00:0c:29:fc:28:b0), Dst: ARRISGroup_c6:0a:d7 (70:df:f7:c6:0a:d7)
▶ Internet Protocol Version 6, Src: 2a13:2540:1e3:6b00::466a, Dst: 2a13:2547:303::10
▼ User Datagram Protocol, Src Port: 38062, Dst Port: 53
Source Port: 38062
Destination Port: 53
Length: 46
Checksum: 0x554d [unverified]
[Checksum Status: Unverified]
[Stream index: 1]
[Timestamps]
UDP payload (38 bytes)
Domain Name System (query)

Figur 2 Destination port for www.au.dk i wireshark

Telegrammet har destination port 53.



DNS Query Response:

1.3 Hvilken information indeholder "Answers" feltet i DNS query response telegrammet, og hvad betyder det (dokumenter med Wireshark)?

Vi vælger respons telegrammet:

No.	Time	Source	Destination	Protocol	Length	Info
4	1.657254662	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x33ff HTTPS www.au.dk OPT
5	1.657771451	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x3f3b A www.au.dk OPT
6	1.658421590	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0xc44a AAAA www.au.dk OPT
7	1.675969577	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	157	Standard query response 0x33ff HTTPS www.au.dk SOA infobloxgm3.au.dk OPT
8	1.677379828	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	157	Standard query response 0xc44a AAAA www.au.dk SOA infobloxgm3.au.dk OPT
9	1.687345155	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	116	Standard query response 0x3f3b A www.au.dk A 185.45.20.48 OPT
10	1.787780422	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	105	Standard query 0x490c A e5.o.lencr.org OPT

▶ Frame 9: 116 bytes on wire (928 bits), 116 bytes captured (928 bits) on interface eth1, id 0
▶ Ethernet II, Src: ARRISGroup_c6:0a:d7 (70:df:f7:c6:0a:d7), Dst: VMware_fc:28:b0 (00:0c:29:fc:28:b0)
▶ Internet Protocol Version 6, Src: 2a13:2547:303::10, Dst: 2a13:2540:1e3:6b00::466a
▶ User Datagram Protocol, Src Port: 53, Dst Port: 38062
▶ Domain Name System (response)
Transaction ID: 0x3f3b
Flags: 0x8180 Standard query response, No error
Questions: 1
Answer RRs: 1
Authority RRs: 0
Additional RRs: 1
Queries
Answers
▶ www.au.dk: type A, class IN, addr 185.45.20.48
Name: www.au.dk
Type: A (1) (Host Address)
Class: IN (0x0001)
Time to live: 120 (2 minutes)
Data length: 4
Address: 185.45.20.48
▶ Additional records
[Request In: 5]
[Time: 0.029573704 seconds]

Figur 3 - DNS respons telegram

Answers indeholder

- Navn på domænet: www.au.dk
- Typen: A (IPv4)
- Klasse: IN = Internet
- Den tidsinterval informationen lagres på siden før den glemmes/opdateres.
- Data længde: 4
- IP-adressen for www.au.dk, som er 185.45.20.48



1.4 Hvilken Source Port har telegrammet (dokumenter med Wireshark)?

No.	Time	Source	Destination	Protocol	Length	Info
4	1.657254662	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x33ff HTTPS www.au.dk OPT
5	1.657771451	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x3f3b A www.au.dk OPT
6	1.658421590	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0xc44a AAAA www.au.dk OPT
7	1.675960577	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	157	Standard query response 0x33ff HTTPS www.au.dk

Frame 5: 100 bytes on wire (800 bits), 100 bytes captured (800 bits) on interface eth1, id 0
Ethernet II, Src: VMware_fc:28:b0 (00:0c:29:fc:28:b0), Dst: ARRISGroup_c6:0a:d7 (70:df:f7:c6:0a:d7)
Internet Protocol Version 6, Src: 2a13:2540:1e3:6b00::466a, Dst: 2a13:2547:303::10
User Datagram Protocol, Src Port: 38062, Dst Port: 53
Source Port: 38062
Destination Port: 53
Length: 46
Checksum: 0x554d [unverified]
[Checksum Status: Unverified]
[Stream index: 1]
[Timestamps]
UDP payload (38 bytes)
Domain Name System (query)

Figur 4 Source Port for www.au.dk DNS telegram

Telegrammet har source port 56161.

1.5 Generes der yderligere DNS-opslag fra selve hjemmesiden efter det initielle DNS-opslag (indsæt oversigt over DNS-telegrammer – max et screen dump fra Wireshark)?

Vi filtrerer, så vi kun ser DNS telegrammer:

No.	Time	Source	Destination	Protocol	Length	Info
4	1.657254662	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x33ff HTTPS www.au.dk OPT
5	1.657771451	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x3f3b A www.au.dk OPT
6	1.658421590	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0xc44a AAAA www.au.dk OPT
7	1.675960577	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	157	Standard query response 0x33ff HTTPS www.au.dk 50A infoblobxg3.au.dk OPT
8	1.677379828	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	157	Standard query response 0xc44a AAAA www.au.dk 50A infoblobxg3.au.dk OPT
9	1.687345155	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	116	Standard query response 0x3f3b A www.au.dk A 185.45.20.48 OPT
10	1.787788422	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x490c A v5.o.lencr.org OPT
11	1.788584096	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x5dc1 AAAA v5.o.lencr.org OPT
12	1.807812308	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	204	Standard query response 0x490c A v5.o.lencr.org CNAME o.lencr.edgesuite.net CNAME a1887.dscg.akamai.net A 2.23.173.83 A 2.23.173.75 OPT
13	1.807812309	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	228	Standard query response 0x5dc1 AAAA v5.o.lencr.org CNAME o.lencr.edgesuite.net CNAME a1887.dscg.akamai.net AAAA 2a02:188:2:df::1074:6810 AAAA 2a02:188:2:df::d974:6823 OPT
20	2.078495308	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x02a7 A cdn.au.dk OPT
21	2.078497318	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x28ec HTTPS cdn.au.dk OPT
30	2.080645226	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x70a0 AAAA cdn.au.dk OPT
31	2.080731523	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0xf7a7 A customer.cludo.com OPT
32	2.080645171	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0xc3f9 AAAA customer.cludo.com OPT
33	2.091534264	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x02a7 A cdn.au.dk CNAME au-cdn-web-endpoint.azureedge.net CNAME au-cdn-web-endpoint.afd.azureedge.net CNAME azureedge-t-prod.trafficmanager.net CNAME s
34	2.092752396	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	107	Standard query 0xf7a7 A customer.cludo.com CNAME customer.cludo.com.cdn.cloudflare.net A 194.22.29.96 A 172.67.27.152 OPT
35	2.093325212	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	107	Standard query 0x01e0 AAAA cdn.jsdelivr.net OPT
36	2.093778106	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	107	Standard query 0x8c9 HTTPS cdn.jsdelivr.net OPT
37	2.099447476	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	411	Standard query response 0x70a0 AAAA cdn.au.dk CNAME au-cdn-web-endpoint.azureedge.net CNAME au-cdn-web-endpoint.afd.azureedge.net CNAME azureedge-t-prod.trafficmanager.net CNAME s
38	2.099447796	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	443	Standard query response 0x28ec HTTPS cdn.au.dk CNAME au-cdn-web-endpoint.azureedge.net CNAME au-cdn-web-endpoint.afd.azureedge.net CNAME azureedge-t-prod.trafficmanager.net CNAME s
39	2.099447827	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	399	Standard query response 0x02a7 A cdn.au.dk CNAME au-cdn-web-endpoint.azureedge.net CNAME au-cdn-web-endpoint.afd.azureedge.net CNAME azureedge-t-prod.trafficmanager.net CNAME s
40	2.103188569	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	200	Standard query response 0xf7a7 A customer.cludo.com CNAME customer.cludo.com.cdn.cloudflare.net A 194.22.29.96 A 172.67.27.152 OPT
41	2.105388493	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	125	Standard query 0x770 HTTPS s-part-0026.t-0009.fb-t-msedge.net OPT
42	2.111202287	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	211	Standard query response 0x8c9 HTTPS cdn.jsdelivr.net CNAME cdn.jsdelivr.net.cdn.cloudflare.net A 194.19.187.31 A 194.19.186.31 OPT
43	2.111598532	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	126	Standard query response 0x02a7 A cdn.au.dk CNAME au-cdn-web-endpoint.azureedge.net CNAME au-cdn-web-endpoint.afd.azureedge.net CNAME azureedge-t-prod.trafficmanager.net CNAME s
44	2.112759829	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	185	Standard query response 0x01e0 AAAA cdn.jsdelivr.net CNAME cdn.jsdelivr.net.cdn.cloudflare.net A 194.22.29.96 A 172.67.27.152 OPT
45	2.117624069	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	209	Standard query response 0x01e0 AAAA cdn.jsdelivr.net CNAME cdn.jsdelivr.net.cdn.cloudflare.net AAAA 2606:4700::6812:b01f OPT
46	2.117624254	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	253	Standard query response 0x02a7 A customer.cludo.com CNAME customer.cludo.com.cdn.cloudflare.net CNAME customer.cludo.com.cdn.cloudflare.net AAAA 2606:4700::6812:b01f OPT
47	2.117624278	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	244	Standard query response 0xc3f9 AAAA customer.cludo.com CNAME customer.cludo.com.cdn.cloudflare.net AAAA 2606:4700::6812:b01f OPT
50	2.124888061	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	185	Standard query response 0x770 HTTPS s-part-0026.t-0009.fb-t-msedge.net SOA nsl.fb-t-msedge.net OPT
57	2.130998559	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	184	Standard query response 0x02a7 A cdn.au.dk CNAME au-cdn-web-endpoint.azureedge.net CNAME au-cdn-web-endpoint.afd.azureedge.net CNAME azureedge-t-prod.trafficmanager.net CNAME s
173	2.242701416	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x03bd A ocp.digicert.com OPT
174	2.244629416	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	100	Standard query 0x3fac AAAA ocp.digicert.com OPT
205	2.262841099	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	229	Standard query response 0x03bd A ocp.digicert.com CNAME ocp.edge.digicert.com CNAME cac-ocsp.digicert.com.edgesuite.net CNAME a3913.cd.akamaiedge.net A 184.86.11.11 OPT
218	2.272754442	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	272	Standard query response 0x3fac AAAA ocp.digicert.com CNAME ocp.edge.digicert.com CNAME cac-ocsp.digicert.com.edgesuite.net CNAME a3913.cd.akamaiedge.net SOA nacd.akamaiedge.net OPT
219	2.271730738	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	114	Standard query 0x4a2 AAAA a3913.cd.akamaiedge.net OPT
324	2.512373026	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	170	Standard query response 0x4a2 AAAA a3913.cd.akamaiedge.net SOA nacd.akamaiedge.net OPT
590	2.790380888	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	110	Standard query 0x0e7 A maps.googleapis.com OPT
591	2.791208883	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	110	Standard query 0x0e7 A maps.googleapis.com OPT
592	2.793127762	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	110	Standard query 0x0e7 A maps.googleapis.com OPT
593	2.795117209	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	115	Standard query 0x0e7 A www.googletagmanager.com OPT
594	2.795256063	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	110	Standard query 0x17ac AAAA www.googletagmanager.com OPT
595	2.795782426	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	115	Standard query 0x0e7 A www.googletagmanager.com OPT
600	2.804664190	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	158	Standard query response 0x0e7 A maps.googleapis.com A 142.251.289.138 A 172.217.19.74 A 142.250.181.202 OPT
601	2.809398025	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0x0e7 A run-static.pingdom.net OPT
602	2.816408050	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0x0e7 A run-static.pingdom.net OPT
603	2.810745252	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0x0e7 A run-static.pingdom.net OPT
604	2.813938997	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	131	Standard query response 0x0e7 A www.googletagmanager.com A 142.250.181.200 OPT
605	2.814382376	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	122	Standard query response 0x0e7 A maps.googleapis.com AAAA 2a00:1450:4005:80b::200a AAAA 2a00:1450:4005:80b::200a AAAA 2a00:1450:4005:80b::200a AAAA 2a00:1450:4005:80b::200a OPT
606	2.814382738	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	167	Standard query response 0x0e7 A maps.googleapis.com SOA nsl.google.com OPT
609	2.820942096	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	172	Standard query response 0x0e7 A www.googletagmanager.com SOA nsl.google.com OPT

Figur 5 - Samtlige DNS telegrammer

Ja, au.dk fremgår på adskillige linjer efterfølgende.



Delay

2. Mål den tid der går fra en ping kommando startes i H1 til ping-respons fra H2 modtages i H1.

```
Terminal - ase@ase: ~/Desktop
File Edit View Terminal Tabs Help
ase@ase:~/Desktop$ ping -c 5 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=2.92 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.854 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=1.24 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=1.82 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=1.60 ms

--- 10.0.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4070ms
rtt min/avg/max/mdev = 0.854/1.685/2.921/0.699 ms
ase@ase:~/Desktop$ ping -c 1 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=1.22 ms

--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.219/1.219/1.219/0.000 ms
ase@ase:~/Desktop$ ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.741 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.670 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.455 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.712 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=1.26 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=1.43 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=1.49 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=1.35 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.992 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=1.50 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.590 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=0.421 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=1.74 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=0.992 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=1.38 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=2.21 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=1.90 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=0.673 ms
64 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=1.06 ms
^C
--- 10.0.0.2 ping statistics ---
20 packets transmitted, 19 received, 5% packet loss, time 19186ms
rtt min/avg/max/mdev = 0.421/1.135/2.214/0.495 ms
ase@ase:~/Desktop$
```

Figur 6 - Terminal med ping kommando

5 ping:	1 ping:	19 ping:
Min = 0,854 ms	Min = 1,219 ms	Min = 0,421 ms
Avg = 1,685 ms	Avg = 1,219 ms	Avg = 1,135 ms
Max = 2,921 ms	Max = 1,219 ms	Max = 2,214 ms
Mdev = 0,699 ms	Mdev = 0,000 ms	Mdev = 0,495 ms



3. Mål minimum-/maksimum-/gennemsnits-forsinkelsestider og standardafvigelsen for 10 på hinanden følgende ping-kommandoer, udført som i punkt 2.

```
ase@ase:~/Desktop$ ping -c 10 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=1.43 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=2.38 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.749 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=2.34 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=1.38 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.871 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=1.88 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.732 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=1.73 ms

--- 10.0.0.2 ping statistics ---
10 packets transmitted, 9 received, 10% packet loss, time 9040ms
rtt min/avg/max/mdev = 0.732/1.499/2.377/0.600 ms
```

Figur 7 - 10 ping vist i terminalen

Min = 0,732 ms

Avg = 1,499 ms

Max = 2,377 ms

Mdev = 0,600 ms

I de følgende punkter skal der måles den tidsforsinkelse der opstår, når den virtuelle maskine via eth0 kommunikerer med en server, som er placeret et sted på internettet.

4. Mål den tid der går fra kommandoen ping -c 1 www.google.dk startes i H1 til ping-respons fra web-serveren www.google.dk modtages i H1.

```
ase@ase:~/Desktop$ ping -c 1 www.google.dk
PING www.google.dk (142.251.39.99) 56(84) bytes of data.
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=1 ttl=128 time=20.5 ms

--- www.google.dk ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 20.549/20.549/20.549/0.000 ms
ase@ase:~/Desktop$
```

Figur 8 - enkelt ping på www.google.dk i terminalen

Min = 20,549 ms

Avg = 20,549 ms

Max = 20,549 ms

Mdev = 0,000 ms



5. Mål minimum-/maksimum-/gennemsnits-forsinkelsestider og standardafvigelsen for 10 på hinanden følgende ping-kommandoer, der tester www.google.dk

```
ase@ase:~/Desktop$ ping -c 10 www.google.dk
PING www.google.dk (142.251.39.99) 56(84) bytes of data.
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=1 ttl=128 time=21.4 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=2 ttl=128 time=20.8 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=3 ttl=128 time=21.3 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=4 ttl=128 time=22.6 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=5 ttl=128 time=21.9 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=6 ttl=128 time=23.3 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=7 ttl=128 time=22.2 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=8 ttl=128 time=23.1 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=9 ttl=128 time=23.3 ms
64 bytes from ams15s48-in-f3.1e100.net (142.251.39.99): icmp_seq=10 ttl=128 time=20.9 ms

--- www.google.dk ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9017ms
rtt min/avg/max/mdev = 20.845/22.077/23.331/0.913 ms
ase@ase:~/Desktop$
```

Figur 9 - 10 ping på www.google.dk

Min = 20,845 ms

Avg = 22,077 ms

Max = 23,331 ms

Mdev = 0,913 ms



6. Anvend Wireshark til måling af tidsforsinkelsen til www.au.dk (Bemærk: www.au.dk understøtter ping respons, men måling af responstiden SKAL foregå med Wireshark i dette punkt ved at analysere SYN / SYN-ACK). Anvend din Web Browser i H1 som klient.

Vi beregner RTT ved at se på tidsforsinkelsen mellem hvornår en SYN-pakke bliver sendt fra klienten og serveren svarer med en SYN-ACK-pakke:

No.	Time	Source	Destination	Protocol	Length	Info
11	0.053973776	192.168.125.128	185.45.20.48	TCP	74	60788 → 443 [SYN] Seq=0 Win=32120 Len=0 MSS=1460 SACK_PERM TSval=401773281 TSecr=0 WS=128
12	0.054222361	192.168.125.128	185.45.20.48	TCP	74	60802 → 443 [SYN] Seq=0 Win=32120 Len=0 MSS=1460 SACK_PERM TSval=401773282 TSecr=0 WS=128
13	0.080810247	185.45.20.48	192.168.125.128	TCP	60	443 → 60788 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0 MSS=1460
14	0.080858650	192.168.125.128	185.45.20.48	TCP	54	60788 → 443 [ACK] Seq=1 Ack=1 Win=32120 Len=0
15	0.082190428	192.168.125.128	185.45.20.48	TLSv1.3	1948	Client Hello (SNI=www.au.dk)
16	0.082728553	185.45.20.48	192.168.125.128	TCP	60	443 → 60788 [ACK] Seq=1 Ack=1461 Win=64240 Len=0
17	0.082728831	185.45.20.48	192.168.125.128	TCP	60	443 → 60788 [ACK] Seq=1 Ack=1895 Win=64240 Len=0
18	0.083981030	185.45.20.48	192.168.125.128	TCP	60	443 → 60802 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0 MSS=1460
19	0.084006158	192.168.125.128	185.45.20.48	TCP	54	60802 → 443 [ACK] Seq=1 Ack=1 Win=32120 Len=0
20	0.084599321	192.168.125.128	185.45.20.48	TLSv1.3	1948	Client Hello (SNI=www.au.dk)
21	0.085001236	185.45.20.48	192.168.125.128	TCP	60	443 → 60802 [ACK] Seq=1 Ack=1461 Win=64240 Len=0
22	0.085001296	185.45.20.48	192.168.125.128	TCP	60	443 → 60802 [ACK] Seq=1 Ack=1895 Win=64240 Len=0
23	0.142259570	185.45.20.48	192.168.125.128	TLSv1.3	2852	Server Hello, Change Cipher Spec, Application Data
24	0.142260153	185.45.20.48	192.168.125.128	TLSv1.3	1712	Application Data, Application Data, Application Data, Application Data
25	0.142343931	192.168.125.128	185.45.20.48	TCP	54	60788 → 443 [ACK] Seq=1895 Ack=2799 Win=30660 Len=0
26	0.142422433	192.168.125.128	185.45.20.48	TCP	54	60788 → 443 [ACK] Seq=1895 Ack=4457 Win=30660 Len=0
29	0.210744845	185.45.20.48	192.168.125.128	TLSv1.3	4510	Server Hello, Change Cipher Spec, Application Data, Application Data, Application Data, Application Data
30	0.210797057	192.168.125.128	185.45.20.48	TCP	54	60802 → 443 [ACK] Seq=1895 Ack=4457 Win=30660 Len=0

Figur 10 - TCP pakker i wireshark med fokus på SYN / SYN-ACK

Tiden for den første SYN-pakke: 0,053973776 sekunder

Tiden for SYN-ACK pakken: 0,080810247 sekunder

Vi beregner RTT:

$$0,080810247 - 0,053973776 = 0,02683647 \text{ sekunder}$$



7. Udvælg en australsk web-server og undersøg vha. Wireshark DNS-opslag for denne server. Dokumenter med Wireshark.

Vi har valgt www.thenewdaily.com.au

7.1 Hvilken information indeholder "Queries" feltet i DNS query telegrammet (dokumenter med Wireshark)?

The screenshot shows the Wireshark interface with the 'dns' filter applied. The packet list pane displays several DNS queries and responses. The selected packet (No. 1) is a Standard query from 192.168.46.131 to 192.168.46.2 for the domain www.thenewdaily.com.au. The packet details pane shows the following information:

- Frame 1: 93 bytes on wire (744 bits), 93 bytes captured (744 bits) on interface eth0, id 0
- Ethernet II, Src: VMware_06:99:ff (00:0c:29:06:99:ff), Dst: VMware_f2:a1:93 (00:50:56:f2:a1:93)
- Internet Protocol Version 4, Src: 192.168.46.131, Dst: 192.168.46.2
- User Datagram Protocol, Src Port: 44051, Dst Port: 53
- Domain Name System (query)
 - Transaction ID: 0xc88a
 - Flags: 0x0100 Standard query
 - Questions: 1
 - Answer RRs: 0
 - Authority RRs: 0
 - Additional RRs: 1
- Queries
 - www.thenewdaily.com.au: type A, class IN
 - Name: www.thenewdaily.com.au
 - [Name Length: 22]
 - [Label Count: 4]
 - Type: A (1) (Host Address)
 - Class: IN (0x0001)
- Additional records
 - [Response In: 6]

Figur 11 - DNS pakker for australsk hjemmeside

- Hjemmesidens navn: www.thenewdaily.com.au
- Hvor mange symboler der er i navnet: 22 (inklusive punktum)
- Antal dele i navnet: 4 (www, thenewdaily, com, au)
- Typen: A (IPv4)
- Klasse: IN = internet



7.2 Hvilken information indeholder "Answers" feltet i DNS query response telegrammet, og hvad betyder det (dokumenter med Wireshark)?

```
▼ Answers
  ▶ www.thenewdaily.com.au: type A, class IN, addr 104.26.6.91
  ▶ www.thenewdaily.com.au: type A, class IN, addr 104.26.7.91
  ▶ www.thenewdaily.com.au: type A, class IN, addr 172.67.69.42
▼ Additional records
```

Figur 12 - Answer felt i DNS query response telegrammet

Answers indeholder samtlige IP-adresser for domænet.

7.3 Hvilken ip-adresse har den australske server (dokumenter med Wireshark)?

IP-adresserne fremgår i forrige screenshot.

IP-adresserne er:

104.26.6.91

104.26.7.91

172.67.69.42



8. Anvend Wireshark til måling af responstiden til den australske server fra pkt. 7. Anvend din Web Browser i H1 som klient. Måling af responstiden SKAL foregå med Wireshark i dette punkt ved at analysere SYN / SYN-ACK.

Vi skal igen beregne RTT ved at se på tidsforsinkelsen mellem hvornår en SYN-pakke bliver sendt fra klienten og serveren svarer med en SYN-ACK-pakke:

No.	Time	Source	Destination	Protocol	Length	Info
8	1.284921258	2a13:2540:1e3:6b00::...	2606:4700:20::ac43::...	TCP	94	51148 → 443 [SYN] Seq=0 Win=33120 Len=0 MSS=1440 SACK_PERM TSval=2895033096 TSecr=0 WS=128
9	1.285165890	2a13:2540:1e3:6b00::...	2606:4700:20::ac43::...	TCP	94	51154 → 443 [SYN] Seq=0 Win=33120 Len=0 MSS=1440 SACK_PERM TSval=2895033096 TSecr=0 WS=128
10	1.285343124	2a13:2540:1e3:6b00::...	2606:4700:20::ac43::...	TCP	94	51166 → 443 [SYN] Seq=0 Win=33120 Len=0 MSS=1440 SACK_PERM TSval=2895033096 TSecr=0 WS=128
11	1.300303060	2606:4700:20::ac43::...	2a13:2540:1e3:6b00::...	TCP	94	443 → 51148 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1360 SACK_PERM TSval=3730014038 TSecr=2895033096 WS=8192
12	1.300345421	2a13:2540:1e3:6b00::...	2606:4700:20::ac43::...	TCP	86	51148 → 443 [ACK] Seq=1 Ack=1 Win=33152 Len=0 TSval=2895033111 TSecr=3730014038
13	1.301156491	2a13:2540:1e3:6b00::...	2606:4700:20::ac43::...	TCP	1434	51148 → 443 [ACK] Seq=1 Ack=1 Win=33152 Len=1348 TSval=2895033112 TSecr=3730014038 [TCP segment of a reassembled PDU]
14	1.301160916	2a13:2540:1e3:6b00::...	2606:4700:20::ac43::...	TLSv1.3	645	Client Hello (SN=www.thewebdaily.com.au)
15	1.311933705	2606:4700:20::ac43::...	2a13:2540:1e3:6b00::...	TCP	94	443 → 51166 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1360 SACK_PERM TSval=2504421251 TSecr=2895033096 WS=8192
16	1.311934075	2606:4700:20::ac43::...	2a13:2540:1e3:6b00::...	TCP	94	443 → 51154 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1360 SACK_PERM TSval=2978956551 TSecr=2895033096 WS=8192
17	1.311976319	2a13:2540:1e3:6b00::...	2606:4700:20::ac43::...	TCP	86	51166 → 443 [ACK] Seq=1 Ack=1 Win=33152 Len=0 TSval=2895033123 TSecr=2504421251
18	1.312077259	2a13:2540:1e3:6b00::...	2606:4700:20::ac43::...	TCP	86	51154 → 443 [ACK] Seq=1 Ack=1 Win=33152 Len=0 TSval=2895033123 TSecr=2978956551

Figur 13 - TCP pakker for den australske hjemmeside

Tiden for den første SYN-pakke: 1,284921258 sekunder

Tiden for SYN-ACK pakken: 1,300303060 sekunder

Vi beregner RTT:

$$1,300303060 - 1,284921258 = 0,0153818 \text{ sekunder}$$

9. Analyser målingerne i punkt 6 og punkt 8.

Man ville forvente at der er en større tidsforsinkelse til den australske hjemmeside, men umiddelbart er det ikke det man ser.

9.1 Beregn forskellen mellem responstiderne for de 2 servere?

$$0,02683647 - 0,0153818 = 0,01145467 \text{ sekunder}$$

9.2 Hvad kan årsagen til denne forskel være?

Selvom man ville forvente at responstiden er længere for en australsk server, kunne forespørgslen måske blive håndteret af en server i Europa eller hurtige udbydere, som ikke påvirker distancen.



Øvelse 4

HTTP Client/Server

Formålet med øvelsen er at anvende Wireshark til analyse af netværksfunktionalitet og at undersøge http-protokollens funktionalitet.

4.1 Undersøg vha. Wireshark hvad der sker, når denne webside hentes vha. en web-browser:

<http://iha-i4prj2.uni.au.dk>

DNS-opslag og DNS-respons:

Hvilken relevant information indeholder DNS opslaget?

No.	Time	Source	Destination	Protocol	Length	Info
13	2.411085277	127.0.0.1	127.0.0.53	DNS	93	Standard query 0x0fd8 A iha-i4prj2.uni.au.dk OPT
14	2.411089941	127.0.0.1	127.0.0.53	DNS	93	Standard query 0xd4d9 AAAA iha-i4prj2.uni.au.dk OPT
15	2.411313083	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0xe3dc HTTPS iha-i4prj2.uni.au.dk OPT
16	2.412090233	192.168.125.2	192.168.125.2	DNS	93	Standard query 0xc0d0 iha-i4prj2.uni.au.dk OPT
17	2.412339740	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0xa02e A iha-i4prj2.uni.au.dk OPT
18	2.413040173	192.168.125.128	192.168.125.2	DNS	93	Standard query 0xf949 A iha-i4prj2.uni.au.dk OPT
19	2.413253861	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0x7c25 AAAA iha-i4prj2.uni.au.dk OPT
20	2.413390151	192.168.125.128	192.168.125.2	DNS	93	Standard query 0x8164 AAAA iha-i4prj2.uni.au.dk OPT
21	2.416731596	127.0.0.1	127.0.0.53	DNS	93	Standard query 0xb017 A iha-i4prj2.uni.au.dk OPT
22	2.416743026	127.0.0.1	127.0.0.53	DNS	93	Standard query 0x3315 AAAA iha-i4prj2.uni.au.dk OPT
23	2.420605953	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	170	Standard query response 0xe3dc No such name HTTPS iha-i4prj2.uni.au.dk SOA infobloxgm3.au.dk OPT
24	2.432090251	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	170	Standard query response 0x7c25 No such name AAAA iha-i4prj2.uni.au.dk SOA infobloxgm3.au.dk OPT
25	2.434200458	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	170	Standard query response 0xa02e No such name A iha-i4prj2.uni.au.dk SOA infobloxgm3.au.dk OPT
26	2.442729989	192.168.125.2	192.168.125.128	DNS	145	Standard query response 0x8164 AAAA iha-i4prj2.uni.au.dk SOA dc21.uni.au.dk OPT
27	2.442730188	192.168.125.2	192.168.125.128	DNS	145	Standard query response 0x6da0 HTTPS iha-i4prj2.uni.au.dk SOA dc21.uni.au.dk OPT
28	2.442730221	192.168.125.2	192.168.125.128	DNS	109	Standard query response 0xf949 A iha-i4prj2.uni.au.dk A 10.83.21.250 OPT

▶ Frame 16: 93 bytes on wire (744 bits), 93 bytes captured (744 bits) on interface any, id 0
▶ Linux cooked capture v1
▶ Internet Protocol Version 4, Src: 192.168.125.128, Dst: 192.168.125.2
▶ User Datagram Protocol, Src Port: 60194, Dst Port: 53
▼ Domain Name System (query)
Transaction ID: 0x6da0
Flags: 0x0100 Standard query
Questions: 1
Answer RRs: 0
Authority RRs: 0
Additional RRs: 1
▼ Queries
iha-i4prj2.uni.au.dk: type HTTPS, class IN
Name: iha-i4prj2.uni.au.dk
[Name Length: 20]
[Label Count: 4]
Type: HTTPS (65) (HTTPS Specific Service Endpoints)
Class: IN (0x0001)
▶ Additional records
[Response In: 27]

Figur 14 - DNS opslag ved indlæsning af <http://iha-i4prj2.uni.au.dk>

DNS opslaget indeholder:

- Transaction ID: 0x6da0
- Flags: 0x0100 Standard Query - Det er en standard forespørgsel
- Questions: 1 - Der er en enkelt DNS forespørgsel i pakken
- Queries - Navn på domænet, type etc.



Hvilken relevant information indeholder DNS responset?

No.	Time	Source	Destination	Protocol	Length	Info
13	2.411885277	127.0.0.1	127.0.0.53	DNS	93	Standard query 0x0fd8 A iha-14prj2.uni.au.dk OPT
14	2.411889841	127.0.0.1	127.0.0.53	DNS	93	Standard query 0xd409 AAAA iha-14prj2.uni.au.dk OPT
15	2.411313083	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0xe3dc HTTPS iha-14prj2.uni.au.dk OPT
16	2.412999993	192.168.125.128	192.168.125.2	DNS	93	Standard query 0x6da0 HTTPS iha-14prj2.uni.au.dk OPT
17	2.412339740	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0xa02e A iha-14prj2.uni.au.dk OPT
18	2.413940173	192.168.125.128	192.168.125.2	DNS	93	Standard query 0xf949 A iha-14prj2.uni.au.dk OPT
19	2.413253861	2a13:2540:1e3:6b00::...	2a13:2547:303::10	DNS	113	Standard query 0x7c25 AAAA iha-14prj2.uni.au.dk OPT
20	2.413390151	192.168.125.128	192.168.125.2	DNS	93	Standard query 0x8164 AAAA iha-14prj2.uni.au.dk OPT
21	2.416731596	127.0.0.1	127.0.0.53	DNS	93	Standard query 0xb017 A iha-14prj2.uni.au.dk OPT
22	2.416743026	127.0.0.1	127.0.0.53	DNS	93	Standard query 0x3315 AAAA iha-14prj2.uni.au.dk OPT
23	2.426065053	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	170	Standard query response 0xe3dc No such name HTTPS iha-14prj2.uni.au.dk SOA infobloxgm3.au.dk OPT
24	2.434290251	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	170	Standard query response 0x7c25 No such name AAAA iha-14prj2.uni.au.dk SOA infobloxgm3.au.dk OPT
25	2.434290458	2a13:2547:303::10	2a13:2540:1e3:6b00::...	DNS	170	Standard query response 0xa02e No such name A iha-14prj2.uni.au.dk SOA infobloxgm3.au.dk OPT
26	2.442729989	192.168.125.2	192.168.125.128	DNS	145	Standard query response 0x8164 AAAA iha-14prj2.uni.au.dk SOA dc21.uni.au.dk OPT
27	2.442739188	192.168.125.2	192.168.125.128	DNS	145	Standard query response 0x6da0 HTTPS iha-14prj2.uni.au.dk SOA dc21.uni.au.dk OPT
28	2.442730221	192.168.125.2	192.168.125.128	DNS	109	Standard query response 0xf949 A iha-14prj2.uni.au.dk A 10.83.21.250 OPT

Frame 27: 145 bytes on wire (1160 bits), 145 bytes captured (1160 bits) on interface any, id 0

Linux cooked capture v1

Internet Protocol Version 4, Src: 192.168.125.2, Dst: 192.168.125.128

User Datagram Protocol, Src Port: 53, Dst Port: 60194

Domain Name System (response)

Transaction ID: 0x6da0

Flags: 0x8180 Standard query response, No error

Questions: 1

Answer RRs: 0

Authority RRs: 1

Additional RRs: 1

Queries

ih-14prj2.uni.au.dk: type HTTPS, class IN

Name: iha-14prj2.uni.au.dk

[Name Length: 26]

[Label Count: 4]

Type: HTTPS (65) (HTTPS Specific Service Endpoints)

Class: IN (0x0001)

Authoritative nameservers

Additional records

[Request In: 16]

[Time: 0.030639195 seconds]

Figur 15 - DNS respons ved indlæsning af <http://iha-14prj2.uni.au.dk>

DNS-responset indeholder:

- Transaction ID: 0x6da0 - skal matche med opslaget
- Flags: 0x8180 Standard query response, no error
- Questions: 1 - Der bliver svaret på en enkelt forespørgsel i pakken
- Queries - Navn på domænet, type etc.



Tidsforsinkelse til web siden:

Mål Round Trip Time (RTT) til server ved at måle på SYN / SYN-ACK telegrammerne?

No.	Time	Source	Destination	Protocol	Length	Info
37	2.444760212	192.168.125.128	10.83.21.250	TCP	76	54164 → 80 [SYN] Seq=0 Win=32120 Len=0 MSS=1460 SACK_PERM TSval=2611794165 TSecr=0 WS=128
43	2.478120541	10.83.21.250	192.168.125.128	TCP	62	80 → 54164 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0 MSS=1460
45	2.478156073	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=1 Ack=1 Win=32120 Len=0
47	2.478655587	192.168.125.128	10.83.21.250	HTTP	404	GET / HTTP/1.1
48	2.479198899	10.83.21.250	192.168.125.128	TCP	62	80 → 54164 [ACK] Seq=1 Ack=349 Win=64240 Len=0
49	2.519673594	10.83.21.250	192.168.125.128	TCP	12206	80 → 54164 [PSH, ACK] Seq=1 Ack=349 Win=64240 Len=12150 [TCP segment of a reassembled PDU]
50	2.519783903	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=12151 Win=30660 Len=0
51	2.511976304	10.83.21.250	192.168.125.128	TCP	1406	80 → 54164 [PSH, ACK] Seq=12151 Ack=349 Win=64240 Len=1350 [TCP segment of a reassembled PDU]
52	2.511992068	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=13501 Win=30660 Len=0
53	2.542794446	10.83.21.250	192.168.125.128	TCP	25706	80 → 54164 [PSH, ACK] Seq=13501 Ack=349 Win=64240 Len=25650 [TCP segment of a reassembled PDU]

Figur 16 - SYN / SYN-ACK telegrammer til udregning af RTT

Tiden for den første SYN-pakke: 2,444760212 sekunder

Tiden for SYN-ACK pakken: 2,478120541 sekunder

Vi beregner RTT:

$$2,478120541 - 2,444760212 = 0,03336033 \text{ sekunder}$$

http request header:

Vis indhold af http request header telegram der sendes til server.

No.	Time	Source	Destination	Protocol	Length	Info
38	2.532495834	192.168.125.128	10.83.21.250	TCP	76	41712 → 80 [SYN] Seq=0 Win=32120 Len=0 MSS=1460 SACK_PERM TSval=2609459883 TSecr=0 WS=128
43	2.556777037	10.83.21.250	192.168.125.128	TCP	62	80 → 41712 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0 MSS=1460
44	2.556814307	192.168.125.128	10.83.21.250	TCP	56	41712 → 80 [ACK] Seq=1 Ack=1 Win=32120 Len=0
45	2.557053450	192.168.125.128	10.83.21.250	HTTP	490	GET / HTTP/1.1
46	2.557220224	10.83.21.250	192.168.125.128	TCP	62	80 → 41712 [ACK] Seq=1 Ack=435 Win=64240 Len=0
47	2.585342229	10.83.21.250	192.168.125.128	HTTP	199	HTTP/1.1 304 Not Modified
48	2.585374383	192.168.125.128	10.83.21.250	TCP	56	41712 → 80 [ACK] Seq=435 Ack=144 Win=31977 Len=0

▶ Frame 45: 490 bytes on wire (3920 bits), 490 bytes captured (3920 bits) on interface any, id 0

▶ Linux cooked capture v1

▶ Internet Protocol Version 4, Src: 192.168.125.128, Dst: 10.83.21.250

▶ Transmission Control Protocol, Src Port: 41712, Dst Port: 80, Seq: 1, Ack: 1, Len: 434

▼ Hypertext Transfer Protocol

▶ GET / HTTP/1.1\r\n

Host: iha-i4prj2.uni.au.dk\r\n

User-Agent: Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:136.0) Gecko/20100101 Firefox/136.0\r\n

Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8\r\n

Accept-Language: en-US,en;q=0.5\r\n

Accept-Encoding: gzip, deflate\r\n

Connection: keep-alive\r\n

Upgrade-Insecure-Requests: 1\r\n

If-Modified-Since: Thu, 06 Feb 2025 10:19:21 GMT\r\n

If-None-Match: "349159968078db1:0"\r\n

Priority: u=0, i\r\n

\r\n

[Full request URI: http://iha-i4prj2.uni.au.dk/]

[HTTP request 1/1]

[Response in frame: 47]

Figur 17 - Indhold af http request header

Indhold af request header:

- GET / http/1.1
- Host: iha-i4prj2.uni.au.dk - Værtsnavnet på serveren
- User-Agent: Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:136.0) Gecko/20100101 Firefox/136.0 - Fortæller at vi har at gøre med en Firefox browser på Ubuntu i Linux
- Accept: text/html, application/xhtml+xml, application/xml;q=0.9, */*;q=0.8 - Fortæller at klienten accepterer HTML-sider, XHTML og XML som foretrukne formater



- Accept-Language: en-US, en;q=0.5 - Klienten foretrækker engelsk
- Accept-Encoding: gzip, deflate
- Connection: keep-alive
- Osv.

http respons header:

Vis indhold af http respons header telegram der modtages fra server.

No.	Time	Source	Destination	Protocol	Length	Info
70	2.603241291	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=125551 Win=65535 Len=0
71	2.616216570	10.83.21.250	192.168.125.128	TCP	32456	80 → 54164 [PSH, ACK] Seq=125551 Ack=349 Win=64240 Len=32400 [TCP segment of a reassembled PDU]
72	2.616263581	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=157951 Win=65535 Len=0
73	2.630574923	10.83.21.250	192.168.125.128	TCP	62156	80 → 54164 [PSH, ACK] Seq=157951 Ack=349 Win=64240 Len=62100 [TCP segment of a reassembled PDU]
74	2.630612840	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=220051 Win=65535 Len=0
75	2.642413681	10.83.21.250	192.168.125.128	HTTP	5530	HTTP/1.1 200 OK (text/html)
76	2.642442624	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=225525 Win=65535 Len=0
77	2.667084474	192.168.125.128	10.83.21.250	HTTP	427	GET /favicon.ico HTTP/1.1
78	2.667692932	10.83.21.250	192.168.125.128	TCP	62	80 → 54164 [ACK] Seq=225525 Ack=720 Win=64240 Len=0
79	2.701027271	10.83.21.250	192.168.125.128	HTTP	1439	HTTP/1.1 404 Not Found (text/html)

▶ Frame 75: 5530 bytes on wire (44240 bits), 5530 bytes captured (44240 bits) on interface any, id 0

▶ Linux cooked capture v1

▶ Internet Protocol Version 4, Src: 10.83.21.250, Dst: 192.168.125.128

▶ Transmission Control Protocol, Src Port: 80, Dst Port: 54164, Seq: 220051, Ack: 349, Len: 5474

▶ [14 Reassembled TCP Segments (225524 bytes): #49(12150), #51(1350), #53(25650), #55(14850), #57(13140), #59(2670), #60(8490), #63(1350), #65(30660), #67(13890), #69(1350), #7

▶ Hypertext Transfer Protocol

▶ HTTP/1.1 200 OK\r\n

Content-Type: text/html\r\n

Last-Modified: Thu, 06 Feb 2025 10:19:21 GMT\r\n

Accept-Ranges: bytes\r\n

ETag: "349159968078db1:0"\r\n

Server: Microsoft-IIS/10.0\r\n

Date: Tue, 01 Apr 2025 20:07:26 GMT\r\n

Content-Length: 225296\r\n

\r\n

[HTTP response 1/2]

[Time since request: 0.163558094 seconds]

[Request in frame: 47]

[Next request in frame: 77]

[Next response in frame: 79]

[Request URI: http://iha-14prj2.uni.au.dk/]

File Data: 225296 bytes

▶ Line-based text data: text/html (5530 lines)

Figur 18 - Indhold af http respons header

Indhold af respons header:

- HTTP/1.1 200 OK - Andmodningen var en succes
- Content-Type: text/html
- Accept-Ranges: bytes - Serveren understøtter range requests
- ETag: "349159968078db1" - Hvis klienten har ETag i sin cache, kan den undlade at downloade filen igen
- Server: Microsoft-IIS/10.0

Hvilken webserver type anvendes, og hvilken version har den?

I forrige spørgsmål kunne vi aflæse i respons headeren at der anvendes Microsoft IIS versions 10.0.



Hvor mange linjer data (text/html) modtages der i http respons?

No.	Time	Source	Destination	Protocol	Length	Info
73	2.639574923	10.83.21.250	192.168.125.128	TCP	62156	80 → 54164 [PSH, ACK] Seq=157951 Ack=349 Win=64240 Len=62100 [TCP segment of a reassembled PDU]
74	2.639612840	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=220051 Win=65535 Len=0
75	2.642116891	192.168.125.128	192.168.125.128	HTTP	5538	HTTP/1.1 200 OK (text/html)
76	2.642442624	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=225525 Win=65535 Len=0
77	2.667084474	192.168.125.128	10.83.21.250	HTTP	427	GET /favicon.ico HTTP/1.1

▶ Frame 75: 5538 bytes on wire (44240 bits), 5538 bytes captured (44240 bits) on interface any, id 0

▶ Linux cooked capture v1

▶ Internet Protocol Version 4, Src: 10.83.21.250, Dst: 192.168.125.128

▶ Transmission Control Protocol, Src Port: 80, Dst Port: 54164, Seq: 220051, Ack: 349, Len: 5474

▶ [14 Reassembled TCP Segments (225524 bytes): #49(12150), #51(1350), #53(25650), #55(14850), #57(13140), #59(2670), #60(8490), #63(1350), #65(30660), #67(13890), #69(1350), #71(1350), #73(1350), #75(1350)]

▶ Hypertext Transfer Protocol

▼ Line-based text data: text/html (5538 lines)

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Author: William Shakespeare\n

\n

Release date: June 1, 1999 [eBook #1787]\nMost recently updated: May 24, 2019\n

\n

Language: English\n

\n

\n

Figur 19 - Line-based text data i respons header

Der modtages 5538 linjer.

Vis indhold af de første linjer (text/html) i http respons telegram der modtages fra server.

De første linjer ses nedenfor:

▼ Line-based text data: text/html (5538 lines)
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Figur 20 - Første linjer i http telegrammet



Hvor lang tid går der fra der er afsendt en http GET fra klienten til der modtages en http 200 OK fra serveren?

GET ses på linje 47 og 200 OK er på linje 75:

No.	Time	Source	Destination	Protocol	Length	Info
37	2.444760212	192.168.125.128	10.83.21.250	TCP	76	54164 → 80 [SYN] Seq=0 Win=32120 Len=0 MSS=1460 SACK_PERM TSval=2611794165 TSecr=0 WS=128
43	2.478120541	10.83.21.250	192.168.125.128	TCP	62	80 → 54164 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0 MSS=1460
45	2.478156073	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=1 Ack=1 Win=32120 Len=0
47	2.478855587	192.168.125.128	10.83.21.250	HTTP	404	GET / HTTP/1.1
48	2.479198899	10.83.21.250	192.168.125.128	TCP	62	80 → 54164 [ACK] Seq=1 Ack=349 Win=64240 Len=0
49	2.510673594	10.83.21.250	192.168.125.128	TCP	12206	80 → 54164 [PSH, ACK] Seq=1 Ack=349 Win=64240 Len=12150 [TCP segment of a reassembled PDU]
50	2.510703093	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=12151 Win=30660 Len=0
51	2.511976304	10.83.21.250	192.168.125.128	TCP	1406	80 → 54164 [PSH, ACK] Seq=12151 Ack=349 Win=64240 Len=1350 [TCP segment of a reassembled PDU]
52	2.511992068	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=13501 Win=30660 Len=0
53	2.542794446	10.83.21.250	192.168.125.128	TCP	25706	80 → 54164 [PSH, ACK] Seq=13501 Ack=349 Win=64240 Len=25650 [TCP segment of a reassembled PDU]
54	2.542822233	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=39151 Win=30660 Len=0
55	2.574930222	10.83.21.250	192.168.125.128	TCP	14906	80 → 54164 [PSH, ACK] Seq=39151 Ack=349 Win=64240 Len=14850 [TCP segment of a reassembled PDU]
56	2.574959657	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=54001 Win=30660 Len=0
57	2.575242136	10.83.21.250	192.168.125.128	TCP	13196	80 → 54164 [ACK] Seq=54001 Ack=349 Win=64240 Len=13140 [TCP segment of a reassembled PDU]
58	2.575253266	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=67141 Win=30660 Len=0
59	2.575349353	10.83.21.250	192.168.125.128	TCP	2720	80 → 54164 [PSH, ACK] Seq=67141 Ack=349 Win=64240 Len=2670 [TCP segment of a reassembled PDU]
60	2.575349379	10.83.21.250	192.168.125.128	TCP	8546	80 → 54164 [PSH, ACK] Seq=69811 Ack=349 Win=64240 Len=8490 [TCP segment of a reassembled PDU]
61	2.575356269	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=69811 Win=30660 Len=0
62	2.575364291	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=78301 Win=30660 Len=0
63	2.577913681	10.83.21.250	192.168.125.128	TCP	1406	80 → 54164 [PSH, ACK] Seq=78301 Ack=349 Win=64240 Len=1350 [TCP segment of a reassembled PDU]
64	2.577928021	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=79651 Win=30660 Len=0
65	2.601757128	10.83.21.250	192.168.125.128	TCP	30716	[TCP Window Full] 80 → 54164 [PSH, ACK] Seq=79651 Ack=349 Win=64240 Len=30660 [TCP segment of a reassembled PDU]
66	2.601793167	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=110311 Win=65535 Len=0
67	2.602046297	10.83.21.250	192.168.125.128	TCP	13946	80 → 54164 [PSH, ACK] Seq=110311 Ack=349 Win=64240 Len=13890 [TCP segment of a reassembled PDU]
68	2.602062600	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=124201 Win=65535 Len=0
69	2.603232208	10.83.21.250	192.168.125.128	TCP	1406	80 → 54164 [PSH, ACK] Seq=124201 Ack=349 Win=64240 Len=1350 [TCP segment of a reassembled PDU]
70	2.603241291	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=125551 Win=65535 Len=0
71	2.616216570	10.83.21.250	192.168.125.128	TCP	32456	80 → 54164 [PSH, ACK] Seq=125551 Ack=349 Win=64240 Len=32400 [TCP segment of a reassembled PDU]
72	2.616263591	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=157951 Win=65535 Len=0
73	2.630574923	10.83.21.250	192.168.125.128	TCP	62156	80 → 54164 [PSH, ACK] Seq=157951 Ack=349 Win=64240 Len=62100 [TCP segment of a reassembled PDU]
74	2.630612840	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=220951 Win=65535 Len=0
75	2.642413681	10.83.21.250	192.168.125.128	HTTP	5530	HTTP/1.1 200 OK (text/html)
76	2.642442624	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=349 Ack=225525 Win=65535 Len=0
77	2.667084474	192.168.125.128	10.83.21.250	HTTP	427	GET /favicon.ico HTTP/1.1
78	2.667692932	10.83.21.250	192.168.125.128	TCP	62	80 → 54164 [ACK] Seq=225525 Ack=720 Win=64240 Len=0
79	2.701027271	10.83.21.250	192.168.125.128	HTTP	1439	HTTP/1.1 404 Not Found (text/html)
80	2.741480846	192.168.125.128	10.83.21.250	TCP	56	54164 → 80 [ACK] Seq=720 Ack=226908 Win=65535 Len=0
84	9.215499231	2a13:2540:1e3:6b00::	2600:1901:0:38d7::	TCP	88	50612 → 80 [ACK] Seq=1 Ack=1 Win=256 Len=0 TSval=4172410413 TSecr=1767639583
85	9.215813488	2a13:2540:1e3:6b00::	2600:1901:0:38d7::	TCP	88	50602 → 80 [ACK] Seq=1 Ack=1 Win=256 Len=0 TSval=4172410413 TSecr=15889553488

Figur 21 screenshot af wireshark

Tid ved GET: 2,478855587

Tid ved 200 OK: 2,642413681

Tid:

$$2,642413681 - 2,478855587 = 0,1635581 \text{ sekunder}$$



4.2. Test http 1.1 protokollen vha. telnet med fokus på:

- Oprettelse/nedlukning af TCP-connection
- Persistent/non-persistent HTTP-kommunikation vha. HTTP-protokollen (uden/med pipelining).

Dette testes og ses nedenfor i terminalen:

```
Terminal - ase@ase: ~/Desktop
File Edit View Terminal Tabs Help
ase@ase:~/Desktop$ telnet 10.0.0.1 80
Trying 10.0.0.1...
Connected to 10.0.0.1.
Escape character is '^]'.
GET / HTTP/1.1
host:10.0.0.2

HTTP/1.1 200 OK
Date: Tue, 01 Apr 2025 21:24:30 GMT
Server: Apache/2.4.58 (Ubuntu)
Last-Modified: Mon, 10 Feb 2025 12:31:52 GMT
ETag: "103-62dc8e49f31fd"
Accept-Ranges: bytes
Content-Length: 259
Vary: Accept-Encoding
Content-Type: text/html

<!DOCTYPE html>
<html>
<head>
<title>Page Title</title>
</head>
<body>

<h1>This is a Heading</h1>
<p>This is a paragraph.</p>


<br>

<br>


</body>
</html>Connection closed by foreign host.
ase@ase:~/Desktop$
```

Figur 22 - 1.1 protokol vha. telnet

Bemærkning: 4.3 er lavet forinden denne test...



Hvor lang tid går der inden en TCP-forbindelsen lukkes når HTTP 1.1 anvendes?

Der kan ses i nedenstående figur, at tiden mellem den sidste ACK og FIN er cirka 5.027 sekunde:

16	*REF*	10.0.0.2	10.0.0.1	TCP	66 54988 → 80 [ACK] Seq=34 Ack=10927
17	5.027848356	10.0.0.1	10.0.0.2	TCP	66 80 → 54988 [FIN, ACK] Seq=10927
18	5.028151673	10.0.0.2	10.0.0.1	TCP	66 54988 → 80 [FIN, ACK] Seq=34 Ack=

Figur 23 - Tid for TCP forbindelse

Yderligere dokumentation der viser GET-request og 200 OK telegrammerne:

No.	Time	Source	Destination	Protocol	Length	Info
13	9.761883	10.0.0.2	10.0.0.1	TCP	74	56328 → 80 [SYN] Seq=0 Win=32120 Len=0 MSS=1460 SACK_PERM TSval=544382875 TSecr=0 WS=128
14	9.762442	10.0.0.1	10.0.0.2	TCP	74	80 → 56328 [SYN, ACK] Seq=0 Ack=1 Win=31856 Len=0 MSS=1460 SACK_PERM TSval=623165212 TSecr=544382875 WS=128
15	9.762475	10.0.0.2	10.0.0.1	TCP	66	56328 → 80 [ACK] Seq=1 Ack=1 Win=32128 Len=0 TSval=544382876 TSecr=623165212
20	22.81491	10.0.0.2	10.0.0.1	TCP	82	56328 → 80 [PSH, ACK] Seq=1 Ack=1 Win=32128 Len=16 TSval=544395128 TSecr=623165212 [TCP segment of a reassembled PDU]
21	22.81553	10.0.0.1	10.0.0.2	TCP	66	80 → 56328 [ACK] Seq=1 Ack=17 Win=31872 Len=0 TSval=623177465 TSecr=544395128
22	32.78487	10.0.0.2	10.0.0.1	TCP	81	56328 → 80 [PSH, ACK] Seq=17 Ack=1 Win=32128 Len=15 TSval=544405818 TSecr=623177465 [TCP segment of a reassembled PDU]
23	32.78539	10.0.0.1	10.0.0.2	TCP	66	80 → 56328 [ACK] Seq=1 Ack=32 Win=31872 Len=0 TSval=623188155 TSecr=544405818
24	33.11425	10.0.0.2	10.0.0.1	HTTP	68	GET / HTTP/1.1
25	33.11461	10.0.0.1	10.0.0.2	TCP	66	80 → 56328 [ACK] Seq=1 Ack=34 Win=31872 Len=0 TSval=623188564 TSecr=544406227
26	33.11515	10.0.0.1	10.0.0.2	TCP	29	80 → 56328 [PSH, ACK] Seq=1 Ack=34 Win=31872 Len=2896 TSval=623188564 TSecr=544406227 [TCP segment of a reassembled PDU]
27	33.11519	10.0.0.2	10.0.0.1	TCP	66	56328 → 80 [ACK] Seq=34 Ack=2897 Win=31872 Len=0 TSval=544406228 TSecr=623188564
28	33.11528	10.0.0.1	10.0.0.2	TCP	29	80 → 56328 [PSH, ACK] Seq=2897 Ack=34 Win=31872 Len=2896 TSval=623188564 TSecr=544406227 [TCP segment of a reassembled PDU]
29	33.11528	10.0.0.1	10.0.0.2	TCP	29	80 → 56328 [PSH, ACK] Seq=5793 Ack=34 Win=31872 Len=2896 TSval=623188564 TSecr=544406227 [TCP segment of a reassembled PDU]
30	33.11539	10.0.0.2	10.0.0.1	TCP	66	56328 → 80 [ACK] Seq=34 Ack=5793 Win=31872 Len=0 TSval=544406228 TSecr=623188564
31	33.11536	10.0.0.2	10.0.0.1	TCP	66	56328 → 80 [ACK] Seq=34 Ack=8689 Win=31872 Len=0 TSval=544406229 TSecr=623188564
32	33.11542	10.0.0.1	10.0.0.2	HTTP	23	HTTP/1.1 200 OK (text/html)
33	*REF*	10.0.0.2	10.0.0.1	TCP	66	56328 → 80 [ACK] Seq=34 Ack=10927 Win=31872 Len=0 TSval=544406229 TSecr=623188564
34	5.086249	10.0.0.1	10.0.0.2	TCP	66	80 → 56328 [FIN, ACK] Seq=10927 Ack=34 Win=31872 Len=0 TSval=623193571 TSecr=544406229

Figur 24 - GET-request og 200 OK telegrammer i samme screenshot

Hvad er fordelene ved at nedlukningen af TCP-forbindelsen udskydes?

I stedet for at lukke med det samme holder den forbindelsen åben indtil alt er hentet, før forbindelsen lukkes.

Er det web-server eller web-client, der starter nedlukning af TCP-forbindelsen?

16	*REF*	10.0.0.2	10.0.0.1	TCP	66 54988 → 80 [ACK] Seq=34 Ack=10927
17	5.027848356	10.0.0.1	10.0.0.2	TCP	66 80 → 54988 [FIN, ACK] Seq=10927
18	5.028151673	10.0.0.2	10.0.0.1	TCP	66 54988 → 80 [FIN, ACK] Seq=34 Ack=

Figur 25 - Nedlukning af TCP-forbindelse

Vi kan se ovenfor i Wireshark at nedlukning kommer fra web-serveren, altså 10.0.0.1.



Fremgår version af Apache serveren af http respons, og I givet fald hvor?

Den fremgår som Apache version 2.4.58 under 200 OK telegrammet:

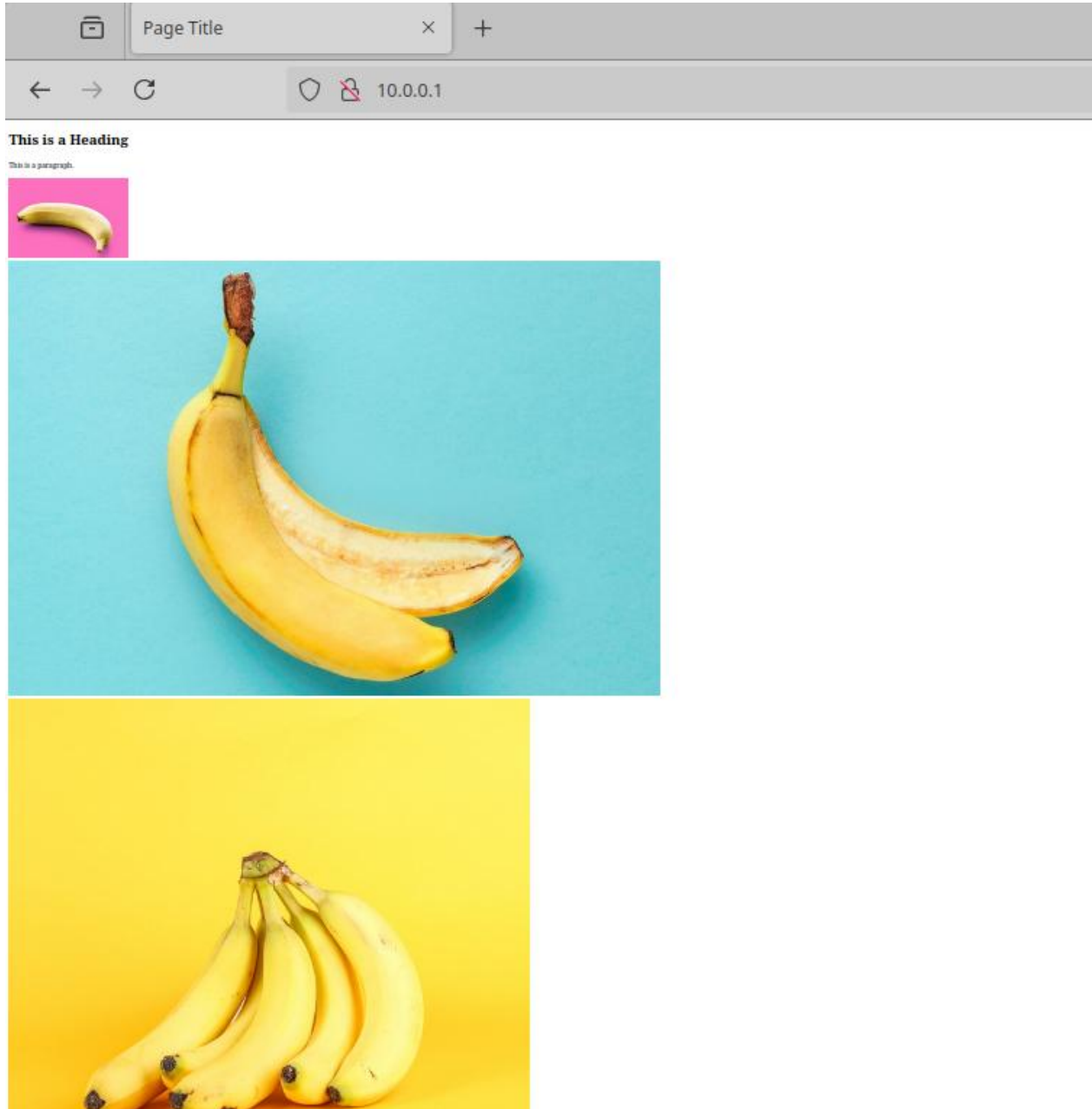
11	11.804286032	10.0.0.1	10.0.0.2	TCP	2962	80 → 54988	[PSH, ACK] Seq=2897 Ack=34 Win=249 Len=2896 TSval=14
12	11.804307373	10.0.0.2	10.0.0.1	TCP	66	54988 → 80	[ACK] Seq=34 Ack=5793 Win=249 Len=0 TSval=1019769305
13	11.804722226	10.0.0.1	10.0.0.2	TCP	2962	80 → 54988	[PSH, ACK] Seq=5793 Ack=34 Win=249 Len=2896 TSval=14
14	11.804722432	10.0.0.1	10.0.0.2	HTTP	2304	HTTP/1.1 200 OK (text/html)	
15	11.804752326	10.0.0.2	10.0.0.1	TCP	66	54988 → 80	[ACK] Seq=34 Ack=8689 Win=249 Len=0 TSval=1019769306
16	*REF*	10.0.0.2	10.0.0.1	TCP	66	54988 → 80	[ACK] Seq=34 Ack=10927 Win=249 Len=0 TSval=1019769309
17	5.027848356	10.0.0.1	10.0.0.2	TCP	66	80 → 54988	[FIN, ACK] Seq=10927 Ack=34 Win=249 Len=0 TSval=1434
18	5.028151673	10.0.0.2	10.0.0.1	TCP	66	54988 → 80	[FIN, ACK] Seq=34 Ack=10928 Win=249 Len=0 TSval=1019
19	5.038214545	10.0.0.1	10.0.0.2	TCP	66	80 → 54988	[ACK] Seq=10928 Ack=35 Win=249 Len=0 TSval=143446036
20	19.949604793	10.192.59.209	255.255.255.255	BJNP	60	Scanner Command: Discover	
21	19.949605413	10.192.59.209	255.255.255.255	BJNP	60	Scanner Command: Discover	

▶ Frame 14: 2304 bytes on wire (18432 bits), 2304 bytes captured (18432 bits) on interface eth1, id 0	0030	20
▶ Ethernet II, Src: VMware_fc:28:b0 (00:0c:29:fc:28:b0), Dst: VMware_9d:03:de (00:0c:29:9d:03:de)	0040	61
▶ Internet Protocol Version 4, Src: 10.0.0.1, Dst: 10.0.0.2	0050	6e
▶ Transmission Control Protocol, Src Port: 80, Dst Port: 54988, Seq: 8689, Ack: 34, Len: 2238	0060	69
▶ [4 Reassembled TCP Segments (10926 bytes): #9(2896), #11(2896), #13(2896), #14(2238)]	0070	20
▼ Hypertext Transfer Protocol	0080	4d
▶ HTTP/1.1 200 OK\r\n	0090	36
Date: Mon, 10 Feb 2025 12:10:18 GMT\r\n	00a0	41
Server: Apache/2.4.58 (Ubuntu)\r\n	00b0	79
Last-Modified: Mon, 10 Feb 2025 11:36:07 GMT\r\n	00c0	6e
ETag: "29af-62dc81d35392e"\r\n	00d0	79
Accept-Ranges: bytes\r\n	00e0	6e
▶ Content-Length: 10671\r\n	00f0	3a
Vary: Accept-Encoding\r\n	0100	21
Content-Type: text/html\r\n	0110	42
\r\n	0120	44
[HTTP response 1/1]	0130	73
[Time since request: 0.002954333 seconds]	0140	74
[Request in frame: 7]	0150	2f
[Request URI: http://10.0.0.2/]	0160	68
File Data: 10671 bytes	0170	61

Figur 26 - Apache server version

4.3. Anvend Firefox web-browser som web-client i H2 sammen med apache-server i H1

Her ses et screenshot af web-browseren:



Figur 27 screenshot af web-browser



Analyser vha. Wireshark relevante hændelser på LAN-segmentet. Herunder: dokumenter den anvendte:

1. HTTP-version - Wireshark

TCP	66	47988	→	80	[ACK]	Seq=1	Ack=1	Win=32
HTTP	448				GET / HTTP/1.1			
TCP	66	80	→	47988	[ACK]	Seq=1	Ack=383	Win=
HTTP	580				HTTP/1.1 200 OK (text/html)			

Figur 28 http-version

HTTP/1.1

2. Request header – Wireshark /beskriv indhold

```
Hypertext Transfer Protocol
  GET / HTTP/1.1\r\n
  Host: 10.0.0.1\r\n
  User-Agent: Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:129.0) Gecko/20100101 Firefox/129.0\r\n
  Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/png,image/svg+xml,*/*;q=0.8\r\n
  Accept-Language: en-US,en;q=0.5\r\n
  Accept-Encoding: gzip, deflate\r\n
  Connection: keep-alive\r\n
  Upgrade-Insecure-Requests: 1\r\n
  Priority: u=0, i\r\n
  \r\n
  [Full request URI: http://10.0.0.1/]
  [HTTP request 1/4]
  [Response in frame: 6]
  [Next request in frame: 8]
```

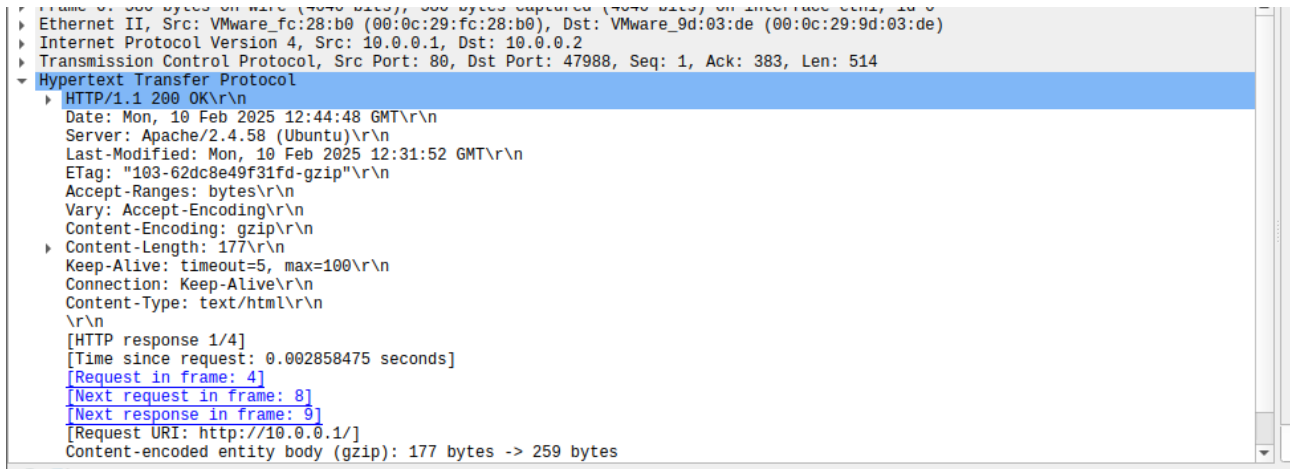
Figur 29 - Request header

Request headeren indeholder:

- HTTP/1.1 bruges som protocol.
- Host'en er 10.0.0.1.
- Browseren identificeres som Firefox.
- Samtlige "Accept", der beskriver ting som understøttede billedformater og sprog.
- "Connection: keep-alive" fortæller at forbindelsen skal holdes åben for flere forespørgsler og ikke lukke efter én request.
- Signal til serveren om, at klienten foretrækker en HTTPS forbindelse.
- Angivelse af prioritet af forespørgslen.



3. Response header – Wireshark/beskriv indhold



Figur 30 screenshot af wireshark

Respons headeren indeholder:

- HTTP/1.1 200 OK indikerer at anmodningen blev behandlet som den skulle og serveren returnerede det ønskede indhold.
- Dato for tidspunkt af serverens respons, i dette tilfælde mandag d. 10 februar 2025.
- Serveren kører på en ubuntu server.
- Tidspunkt for hvornår den sidst returnerede ressource blev ændret, i dette tilfælde er det også mandag d. 10 februar 2025.
- "Accept-Ranges: bytes" fortæller at serveren understøtter delvise downloads.
- "Keep-Alive: timeout=5, max=100" fortæller at forbindelsen holdes åben i 5 sekunder, og at der kan foretages op til 100 anmodninger, før forbindelsen lukkes.
- "Connection: Keep alive" fortæller at forbindelsen ikke lukkes efter responsen.
- Respons indholdet er en HTML-side.



4. Persistent/non-persistent connection – der indsættes en oversigt fra Wireshark over den samlede kommunikation mellem klient og server. Bemærk at hvis de 3 billeder overføres i en tcp-connection er det en persistent connection. Hvis de 3 billeder hver kræver en connection er det en nonpersistent connection. Hvilken connection der anvendes dokumenteres med Wireshark, ved at observere hvordan billederne overføres.

108	0.556491913	10.0.0.1	10.0.0.2	TCP	2962	80 → 47994 [PSH, ACK] Seq=43441 Ack=350 Win=31872 Len=2896 TSval=1436519199 TSecr=1021833159 [TCP segment of a reassembled PDU]
109	0.556491966	10.0.0.1	10.0.0.2	TCP	2962	80 → 47994 [PSH, ACK] Seq=46337 Ack=350 Win=31872 Len=2896 TSval=1436519199 TSecr=1021833159 [TCP segment of a reassembled PDU]
110	0.556674807	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=40545 Win=31872 Len=0 TSval=1021833168 TSecr=1436519190
111	0.557073772	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=43441 Win=31872 Len=0 TSval=1021833169 TSecr=1436519199
112	0.557109589	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=46337 Win=31872 Len=0 TSval=1021833169 TSecr=1436519199
113	0.557132477	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=49233 Win=31872 Len=0 TSval=1021833169 TSecr=1436519199
114	0.557196030	10.0.0.1	10.0.0.2	TCP	2962	80 → 47994 [PSH, ACK] Seq=49233 Ack=350 Win=31872 Len=2896 TSval=1436519199 TSecr=1021833159 [TCP segment of a reassembled PDU]
115	0.557196199	10.0.0.1	10.0.0.2	TCP	2962	80 → 47994 [PSH, ACK] Seq=52129 Ack=350 Win=31872 Len=2896 TSval=1436519199 TSecr=1021833161 [TCP segment of a reassembled PDU]
116	0.557196233	10.0.0.1	10.0.0.2	TCP	4410	80 → 47994 [PSH, ACK] Seq=55025 Ack=350 Win=31872 Len=4344 TSval=1436519199 TSecr=1021833163 [TCP segment of a reassembled PDU]
117	0.557204335	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=52129 Win=31872 Len=0 TSval=1021833169 TSecr=1436519199
118	0.557229289	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=55025 Win=31872 Len=0 TSval=1021833169 TSecr=1436519199
119	0.557255763	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=59369 Win=31872 Len=0 TSval=1021833169 TSecr=1436519199
120	0.558175526	10.0.0.1	10.0.0.2	TCP	2962	80 → 47994 [PSH, ACK] Seq=59369 Ack=350 Win=31872 Len=2896 TSval=1436519199 TSecr=1021833163 [TCP segment of a reassembled PDU]
121	0.558175879	10.0.0.1	10.0.0.2	TCP	4410	80 → 47994 [PSH, ACK] Seq=62265 Ack=350 Win=31872 Len=4344 TSval=1436519199 TSecr=1021833163 [TCP segment of a reassembled PDU]
122	0.558175925	10.0.0.1	10.0.0.2	TCP	1514	80 → 47988 [ACK] Seq=405525 Ack=1082 Win=31872 Len=1448 TSval=1436519201 TSecr=1021833163 [TCP segment of a reassembled PDU]
123	0.559224165	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=62265 Win=31872 Len=0 TSval=1021833170 TSecr=1436519199
124	0.559399090	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=66609 Win=31872 Len=0 TSval=1021833170 TSecr=1436519199
125	0.558784835	10.0.0.1	10.0.0.2	TCP	14546	80 → 47988 [PSH, ACK] Seq=466973 Ack=1082 Win=31872 Len=14480 TSval=1436519201 TSecr=1021833163 [TCP segment of a reassembled PDU]
126	0.559898641	10.0.0.1	10.0.0.2	TCP	5858	80 → 47994 [PSH, ACK] Seq=66609 Ack=350 Win=31872 Len=5782 TSval=1436519202 TSecr=1021833168 [TCP segment of a reassembled PDU]
127	0.559899061	10.0.0.1	10.0.0.2	TCP	5858	80 → 47994 [PSH, ACK] Seq=72401 Ack=350 Win=31872 Len=5792 TSval=1436519202 TSecr=1021833169 [TCP segment of a reassembled PDU]
128	0.559939053	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=72401 Win=31872 Len=0 TSval=1021833172 TSecr=1436519202
129	0.560959620	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=78193 Win=31872 Len=0 TSval=1021833172 TSecr=1436519202
130	0.560918624	10.0.0.1	10.0.0.2	HTTP	9100	HTTP/1.1 200 OK (JPEG JFIF image)
131	0.562116980	10.0.0.2	10.0.0.1	TCP	66	47988 → 80 [ACK] Seq=1082 Ack=465525 Win=355200 Len=0 TSval=1021833177 TSecr=1436519193
132	0.565445446	10.0.0.2	10.0.0.1	TCP	66	47988 → 80 [ACK] Seq=1082 Ack=481453 Win=355200 Len=0 TSval=1021833177 TSecr=1436519201
133	0.566331587	10.0.0.1	10.0.0.2	HTTP	28658	HTTP/1.1 200 OK (JPEG JFIF image)
134	0.566355906	10.0.0.2	10.0.0.1	TCP	66	47988 → 80 [ACK] Seq=1082 Ack=510645 Win=442752 Len=0 TSval=1021833178 TSecr=1436519208
135	0.567182814	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [ACK] Seq=350 Ack=87227 Win=31872 Len=0 TSval=1021833179 TSecr=1436519202
136	1.501959696	10.0.0.2	10.0.0.1	HTTP	413	GET /favicon.ico HTTP/1.1
137	1.503830969	10.0.0.1	10.0.0.2	HTTP	552	HTTP/1.1 404 Not Found (text/html)
138	1.544729628	10.0.0.2	10.0.0.1	TCP	66	47988 → 80 [ACK] Seq=1429 Ack=510531 Win=445696 Len=0 TSval=1021834157 TSecr=1436520146
139	5.562804085	10.0.0.1	10.0.0.2	TCP	66	80 → 47994 [FIN, ACK] Seq=87227 Ack=350 Win=31872 Len=0 TSval=1436524204 TSecr=1021833179
140	5.563283020	10.0.0.2	10.0.0.1	TCP	66	47994 → 80 [FIN, ACK] Seq=350 Ack=87228 Win=31872 Len=0 TSval=1021838175 TSecr=1436524204
141	5.564345399	10.0.0.1	10.0.0.2	TCP	66	80 → 47994 [ACK] Seq=87228 Ack=351 Win=31872 Len=0 TSval=1436524206 TSecr=1021838175
142	6.156638359	10.0.0.2	10.0.0.1	TCP	66	47990 → 80 [FIN, ACK] Seq=1 Ack=1 Win=32128 Len=0 TSval=1021838769 TSecr=1436519148
143	6.158118370	10.0.0.1	10.0.0.2	TCP	66	80 → 47990 [ACK] Seq=1 Ack=2 Win=31872 Len=0 TSval=1436524801 TSecr=1021838769
144	6.160621116	10.0.0.1	10.0.0.2	TCP	66	80 → 47990 [FIN, ACK] Seq=1 Ack=2 Win=31872 Len=0 TSval=1436524803 TSecr=1021838769
145	6.160680454	10.0.0.2	10.0.0.1	TCP	66	47990 → 80 [ACK] Seq=2 Ack=2 Win=32128 Len=0 TSval=1021838772 TSecr=1436524803
146	6.506692470	10.0.0.1	10.0.0.2	TCP	66	80 → 47988 [FIN, ACK] Seq=510531 Ack=1429 Win=31872 Len=0 TSval=1436525148 TSecr=1021834157
147	6.507045819	10.0.0.2	10.0.0.1	TCP	66	47988 → 80 [FIN, ACK] Seq=1429 Ack=510532 Win=445696 Len=0 TSval=1021839119 TSecr=1436525148
148	6.508992288	10.0.0.1	10.0.0.2	TCP	66	80 → 47988 [ACK] Seq=510532 Ack=1430 Win=31872 Len=0 TSval=1436525150 TSecr=1021839119

Figur 31 - TCP telegrammer

Vi ser at der er en persistent connection fordi FIN først opstår sidst, efter billederne er hentet.



Øvelse 5

DNS client

Afprøv kommandoerne `host` og `nslookup` på forskellige web-sites. Anvend også options til kommandoerne, så detaljeret information bliver udskrevet (hint til at finde detaljeret information om en kommando: man kommando, for `host`'s vedkommende kan du også prøve at skrive `host <enter>`)

Her kan der ses hvad der forekommer når kommandoen køres på www.au.dk:

```
Terminal - ase@ase: ~/Desktop
File Edit View Terminal Tabs Help
ase@ase:~/Desktop$ host www.au.dk
www.au.dk has address 10.83.252.23
ase@ase:~/Desktop$ nslookup www.au.dk
Server:         127.0.0.53
Address:        127.0.0.53#53

Non-authoritative answer:
Name:   www.au.dk
Address: 10.83.252.23

ase@ase:~/Desktop$
```

Figur 32 - kommandoer køres på www.au.dk

```
ase@ase:~/Desktop$ host -a www.au.dk
Trying "www.au.dk"
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 36092
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 0

;; QUESTION SECTION:
;www.au.dk.                IN      ANY

;; ANSWER SECTION:
www.au.dk.                 5       IN      A       10.83.252.23
```

Figur 33 - yderligere kommando køres på www.au.dk



Her kan der ses hvad der forekommer når kommandoen køres på www.google.dk:

```
Terminal - ase@ase: ~/Desktop
File Edit View Terminal Tabs Help
ase@ase:~/Desktop$ host www.google.dk
www.google.dk has address 142.251.39.99
www.google.dk has IPv6 address 2a00:1450:400e:811::2003
ase@ase:~/Desktop$ nslookup www.google.dk
Server:      127.0.0.53
Address:     127.0.0.53#53

Non-authoritative answer:
Name:   www.google.dk
Address: 142.251.39.99
Name:   www.google.dk
Address: 2a00:1450:400e:811::2003

ase@ase:~/Desktop$
```

Figur 34 - kommandoer køres på www.google.dk

Her kan der ses hvad der forekommer når kommandoen køres på www.facebook.com:

```
ase@ase:~/Desktop$ host www.facebook.com
www.facebook.com is an alias for star-mini.c10r.facebook.com.
star-mini.c10r.facebook.com has address 31.13.72.36
star-mini.c10r.facebook.com has IPv6 address 2a03:2880:f10a:83:face:b00c:0:25de
ase@ase:~/Desktop$ nslookup www.facebook.com
Server:      127.0.0.53
Address:     127.0.0.53#53

Non-authoritative answer:
www.facebook.com      canonical name = star-mini.c10r.facebook.com.
Name:   star-mini.c10r.facebook.com
Address: 31.13.72.36
Name:   star-mini.c10r.facebook.com
Address: 2a03:2880:f10a:83:face:b00c:0:25de

ase@ase:~/Desktop$
```

Figur 35 - kommandoer køres på www.facebook.dk



Øvelse 6

Se filer i mappe

Accepttest:

Krav:	Passed
1. Serveren er baseret på "Server" template i "Exercise6-template.zip" filen.	✓
2. Klienten er baseret på "Client" template i "Exercise6-template.zip" filen.	✓
3. Serveren er på port 9000.	✓
<u>Normal scenarie: – Hent billede fra Server</u>	
1. Server startes fra en terminal (H1) med kommandoen: <code>./file_server</code>	✓
2. Serveren udskriver status på opstartssekvens	✓
3. Serveren udskriver at den venter på "Accept"	✓
4. Klienten startes fra en terminal (H2) med kommandoen: <code>./file_client 10.0.0.1 <filnavn> (<filnavn> er navn på billede der skal hentes fra server)</code>	✓
5. Klienten udskriver <filnavn>.	✓
6. Serveren udskriver navn på filen modtaget fra klienten.	✓
7. Serveren udskriver størrelsen på filen	✓
8. Klienten udskriver størrelsen på filen	✓
9. Server og klient udskriver størrelse på segmenter der sendes indtil alle segmenter, er overført (max størrelse på segmenter er 1000 bytes)	✓
10. Serveren afslutter og er klar til ny Accept	✓



11. Klienten afslutter	✓
12. Den overførte fil <filnavn> verificeres på klienten	✓
<u>Fejl scenarie: <filnavn> findes ikke på server</u> Pre condition: Serveren er startet.	
1. Klienten startes fra en terminal (H2) med kommandoen: ./file_client 10.0.0.1 <filnavn> (<filnavn> er navn på fil der ikke findes på server)	✓
2. Klienten udskriver filnavn (navn på billede som skal hentes fra serveren.)	✓
3. Serveren udskriver navnet på filen modtaget fra klienten.	✓
4. Serveren udskriver størrelsen (=0) på filen	✓
5. Klienten udskriver en fejlbesked om at filen ikke findes på serveren	✓
6. Serveren afslutter og er klar til ny Accept	✓
7. Klienten afslutter	✓

Tabel 1 - Accepttest af TCP server



Øvelse 7

Se filer i mappe

Accepttest:

Krav:	Passed
"Normalt scenarie:" - Server	
1. Serveren er på port 9000	Check
2. Server kan startes fra en terminal med kommandoen: <code>./measurement_server</code>	Check
3. Serveren udskriver ved kommandoer beskrevet under <i>"Normalt scenarie"</i> - klient information om kommandoer modtaget fra klienten	Check
"Normalt scenarie:" - Klient	
1. <code>./get_measurement 10.0.0.1 u</code> medfører at klienten udskriver hele indholdet af filen uptime modtaget fra server.	Check
2. <code>./get_measurement 10.0.0.1 U</code> medfører at klienten udskriver hele indholdet af filen uptime modtaget fra server.	Check



3. <code>./get_measurement 10.0.0.1 l</code> medfører at klienten udskriver hele indholdet af filen loadavg modtaget fra server.	Check
4. <code>./get_measurement 10.0.0.1 L</code> medfører at klienten udskriver hele indholdet af filen loadavg modtaget fra server.	Check
5. <code>./get_measurement 10.0.0.1 e</code> medfører at klienten udskriver fejlbesked på klienten	Check

Tabel 2 - Accepttest af UDP server