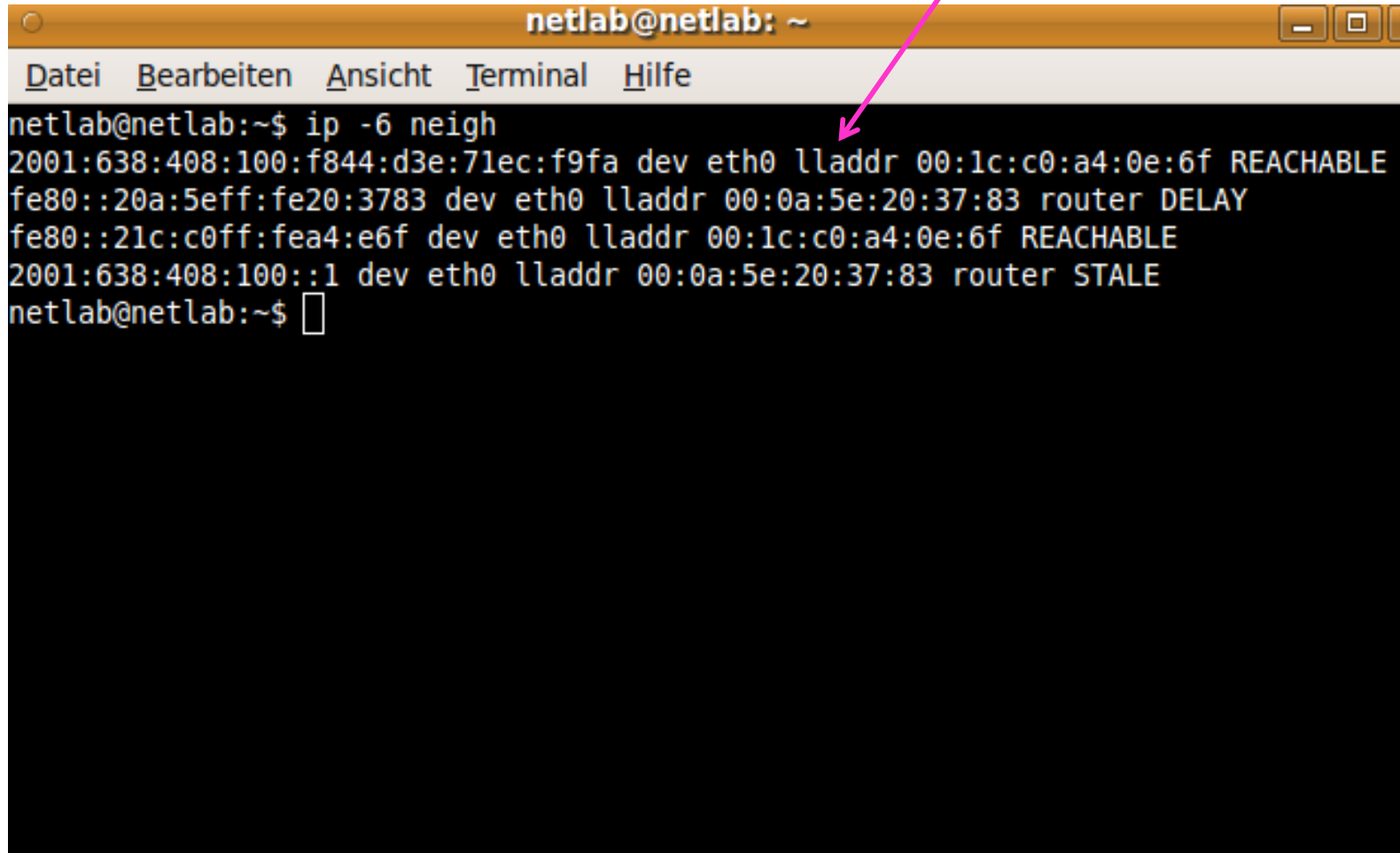


Praktikum Netze SS 2018

- Praktikumsblatt 3 -

Neighbor Cache

lladdr = link local address
= MAC-Adresse



```
netlab@netlab: ~  
Datei Bearbeiten Ansicht Terminal Hilfe  
netlab@netlab:~$ ip -6 neigh  
2001:638:408:100:f844:d3e:71ec:f9fa dev eth0 lladdr 00:1c:c0:a4:0e:6f REACHABLE  
fe80::20a:5eff:fe20:3783 dev eth0 lladdr 00:0a:5e:20:37:83 router DELAY  
fe80::21c:c0ff:fea4:e6f dev eth0 lladdr 00:1c:c0:a4:0e:6f REACHABLE  
2001:638:408:100::1 dev eth0 lladdr 00:0a:5e:20:37:83 router STALE  
netlab@netlab:~$
```

Neighbor Cache Entry States

State	Description
INCOMPLETE	Address Resolution in progress. A NS (Neighbor Solicitation, Nachbar-Anfrage) message has been sent to determine the link-layer address, but a NA message has not been received yet.
REACHABLE	A NA (Neighbor Advertisement, Nachbar-Anzeige) message with link-layer address is received within 30 seconds and queued packets can now be transmitted
STALE	The reachability is not verified for an entry in the Neighbor Cache for more than 30 seconds. A STALE state is entered upon receiving an unsolicited neighbor discovery message (Anzeige-Änderungen) for that entry. However, reachability is not verified until that entry is used.
DELAY	The reachability is not verified for more than 30 seconds, and a packet has been sent to the neighbor in past 5 seconds. If no confirmation is received with the 5 seconds of entering the DELAY state, a NS message is sent and the state is changed to PROBE. If confirmation is received using NA message within 5 seconds, the entry state is changed to REACHABLE.
PROBE	A NS message is sent but no confirmation has been received yet. An NS message is sent every 1 second. If no confirmation is received within three seconds, the entry is deleted from the cache.

Ping6 - 1

```
netlab@netlab: ~  
netlab@netlab:~$ ping6 2001:638:408:100::963  
PING 2001:638:408:100::963(2001:638:408:100::963) 56 data bytes  
64 bytes from 2001:638:408:100::963: icmp_seq=1 ttl=64 time=0.491 ms  
64 bytes from 2001:638:408:100::963: icmp_seq=2 ttl=64 time=0.222 ms  
64 bytes from 2001:638:408:100::963: icmp_seq=3 ttl=64 time=0.151 ms  
64 bytes from 2001:638:408:100::963: icmp_seq=4 ttl=64 time=0.256 ms  
^C  
--- 2001:638:408:100::963 ping statistics ---  
4 packets transmitted, 4 received, 0% packet loss, time 2999ms  
rtt min/avg/max/mdev = 0.151/0.280/0.491/0.127 ms  
netlab@netlab:~$
```

Ping6 - 2

```
netlab@netlab: ~  
netlab@netlab:~$ ping6 -I eth3 fe80::20a:5eff:fe20:3789  
PING fe80::20a:5eff:fe20:3789(fe80::20a:5eff:fe20:3789) from fe80::21c:c0ff:fea4:e6f eth3: 56 data bytes  
64 bytes from fe80::20a:5eff:fe20:3789: icmp_seq=1 ttl=64 time=0.488 ms  
64 bytes from fe80::20a:5eff:fe20:3789: icmp_seq=2 ttl=64 time=0.278 ms  
64 bytes from fe80::20a:5eff:fe20:3789: icmp_seq=3 ttl=64 time=0.224 ms  
64 bytes from fe80::20a:5eff:fe20:3789: icmp_seq=4 ttl=64 time=0.333 ms  
64 bytes from fe80::20a:5eff:fe20:3789: icmp_seq=5 ttl=64 time=0.231 ms  
64 bytes from fe80::20a:5eff:fe20:3789: icmp_seq=6 ttl=64 time=0.295 ms  
64 bytes from fe80::20a:5eff:fe20:3789: icmp_seq=7 ttl=64 time=0.277 ms  
^C  
--- fe80::20a:5eff:fe20:3789 ping statistics ---  
7 packets transmitted, 7 received, 0% packet loss, time 5997ms  
rtt min/avg/max/mdev = 0.224/0.303/0.488/0.085 ms  
netlab@netlab:~$
```

ICMPv6 Neighbor Solicitation + Advertisement

IPv6-Multicast (ff02:: ...)

No.	Time	Source	Destination	Protocol	Info
60	3.168382	2001:638:408:100:70cf:b84b:4e3c:cffe	ff02::1:ffec:f9fa	ICMPv6	Neighbor solicitation
61	3.168641	2001:638:408:100:f844:d3e:71ec:f9fa	2001:638:408:100:70cf:b84b:4e3c:cffe	ICMPv6	Neighbor advertisement
62	3.168655	2001:638:408:100:70cf:b84b:4e3c:cffe	2001:638:408:100:f844:d3e:71ec:f9fa	ICMPv6	Echo request
63	3.168910	2001:638:408:100:f844:d3e:71ec:f9fa	2001:638:408:100:70cf:b84b:4e3c:cffe	ICMPv6	Echo reply
64	3.369609	fe80::20a:5eff:fe20:3783	ff02::1	ICMPv6	Router advertisement
67	4.161005	2001:638:408:100:70cf:b84b:4e3c:cffe	2001:638:408:100:f844:d3e:71ec:f9fa	ICMPv6	Echo request
68	4.161390	2001:638:408:100:f844:d3e:71ec:f9fa	2001:638:408:100:70cf:b84b:4e3c:cffe	ICMPv6	Echo reply
69	5.002778	fe80::250:56ff:fea7:2f	fe80::20a:5eff:fe20:3783	ICMPv6	Neighbor solicitation
70	5.002793	fe80::20a:5eff:fe20:3783	fe80::250:56ff:fea7:2f	ICMPv6	Neighbor advertisement
72	5.160005	2001:638:408:100:70cf:b84b:4e3c:cffe	2001:638:408:100:f844:d3e:71ec:f9fa	ICMPv6	Echo request
73	5.160253	2001:638:408:100:f844:d3e:71ec:f9fa	2001:638:408:100:70cf:b84b:4e3c:cffe	ICMPv6	Echo reply
80	6.159001	2001:638:408:100:70cf:b84b:4e3c:cffe	2001:638:408:100:f844:d3e:71ec:f9fa	ICMPv6	Echo request
81	6.159376	2001:638:408:100:f844:d3e:71ec:f9fa	2001:638:408:100:70cf:b84b:4e3c:cffe	ICMPv6	Echo reply

```
Frame 60 (86 bytes on wire, 86 bytes captured)
Ethernet II, Src: 3com_50:b9:57 (00:01:02:50:b9:57), Dst: IPv6mcast_ff:ec:f9:fa (33:33:ff:ec:f9:fa)
  Destination: IPv6mcast_ff:ec:f9:fa (33:33:ff:ec:f9:fa)
  Source: 3com_50:b9:57 (00:01:02:50:b9:57)
  Type: IPv6 (0x86dd)
Internet Protocol Version 6
  0110 .... = Version: 6
  .... 0000 0000 .... = Traffic class: 0x00000000
  .... 0000 0000 0000 0000 0000 = Flowlabel: 0x00000000
  Payload length: 32
  Next header: ICMPv6 (0x3a)
  Hop limit: 255
  Source: 2001:638:408:100:70cf:b84b:4e3c:cffe (2001:638:408:100:70cf:b84b:4e3c:cffe)
  Destination: ff02::1:ffec:f9fa (ff02::1:ffec:f9fa)
Internet Control Message Protocol v6
  Type: 135 (Neighbor solicitation)
  Code: 0
  Checksum: 0xb3cc [correct]
  Target: 2001:638:408:100:f844:d3e:71ec:f9fa (2001:638:408:100:f844:d3e:71ec:f9fa)
  ICMPv6 Option (Source link-layer address)
```

Interessante
Koinzidenzen auf
Schicht 2/3

Multicast Prefix (16 bit)

Prefix	Scope
ff02::	Link Local: spans the same topological region as the corresponding unicast scope, i.e. all nodes on the same LAN.
ff05::	Site local: is intended to span a single site
ff08::	Organization scope: Intended to span multiple sites within the same organization
ff0e::	Global scope, assigned by IANA.
ff01::	Interface local: Spans only a single interface on a node and is useful only for loopback transmission of multicast.

Beispiele IPv6-Multicast-Adressen

Multicast-Adresse (128bit)= Multicast-Präfix (16bit)
+ Multicast-Group-ID (112bit)

Address	Target
FF02:0:0:0:0:0:0:2	All Routers
FF02:0:0:0:0:0:0:9	RIP Routers
FF02:0:0:0:0:0:0:F	UPnP
FF02:0:0:0:0:0:0:12	VRRP - Virtual Router Redudancy Protocol (Einsatz redundanter Router zur Effizienzsteigerung)
FF02:0:0:0:0:0:0:FB	mDNS - Multicast DNS

Multicast für ND

IPv6

Solicited-Node-Multicast-Adresse =
Multicast-Präfix (104Bits) + 24 Bits

Die 24 Bits enthalten die hinteren 24 Bits der angefragten Unicast-Adresse.

Insgesamt ergibt sich die Solicited-Node-Multicast-Adresse:

FF02:0000:0000:0000:0000:0001:FFxx:xxxx

xx:xxxx : die hintere 24 Bits der angefragten Unicast-Adresse

Ethernet

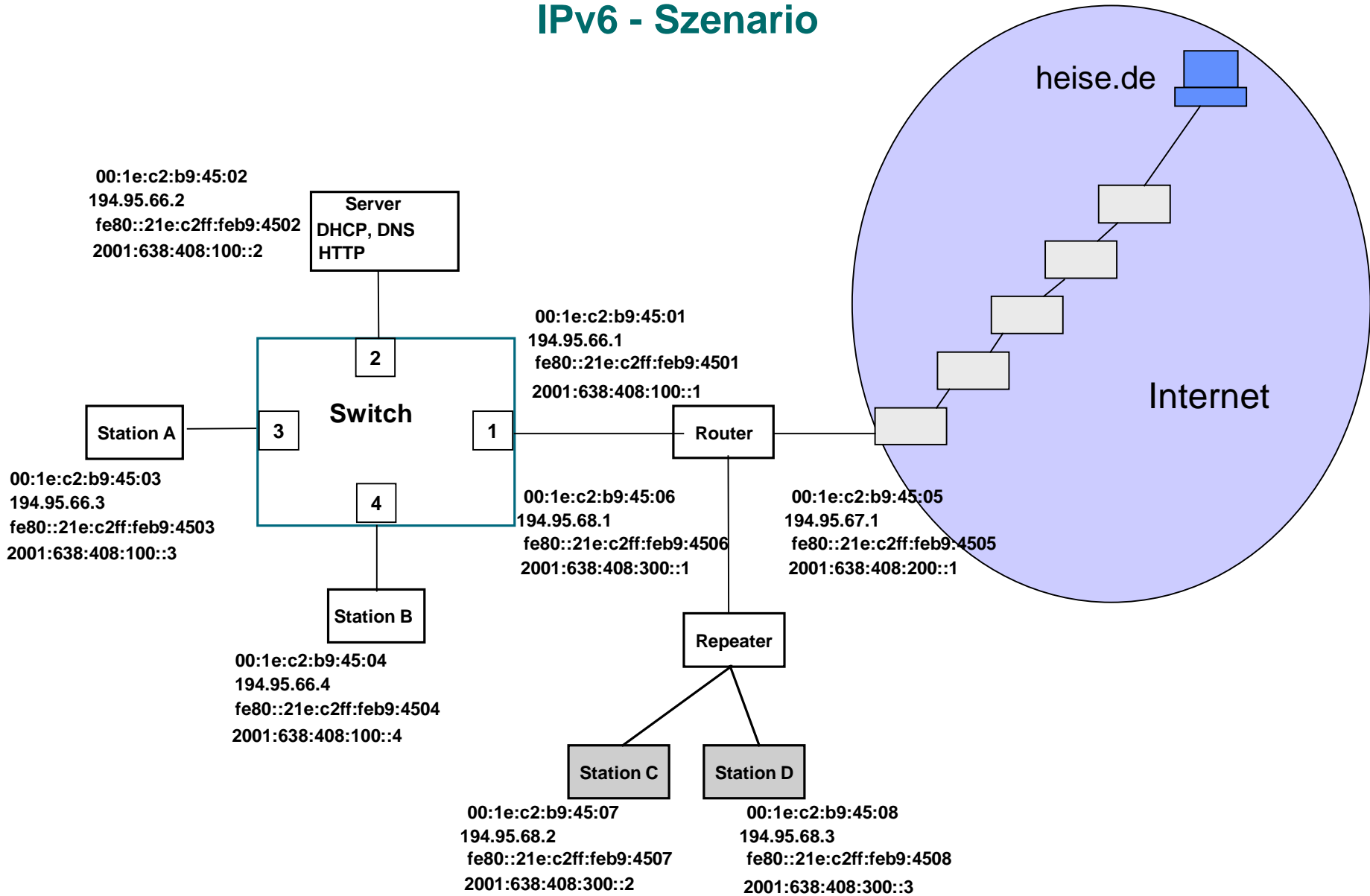
MAC-Multicast-Adresse-Raum (verwendet für IPv6-Multicast) =
33-33-xx-xx-xx-xx

Effektiv erzeugte MAC-Multicast-Adresse: 33-33-FF-xx-xx-xx

Fazit: Wegen „xx-xx-xx“ in der MAC-Adresse weiß jede Station schon auf Schicht 2 (näherungsweise!), welche IPv6-Multicast-Pakete für sie bestimmt sind.

Ein Interface (Ethernet- bzw. WLAN-Karte) bindet sich also schon auf Schicht 2 an den richtigen IPv6-Multicast.

IPv6 - Szenario



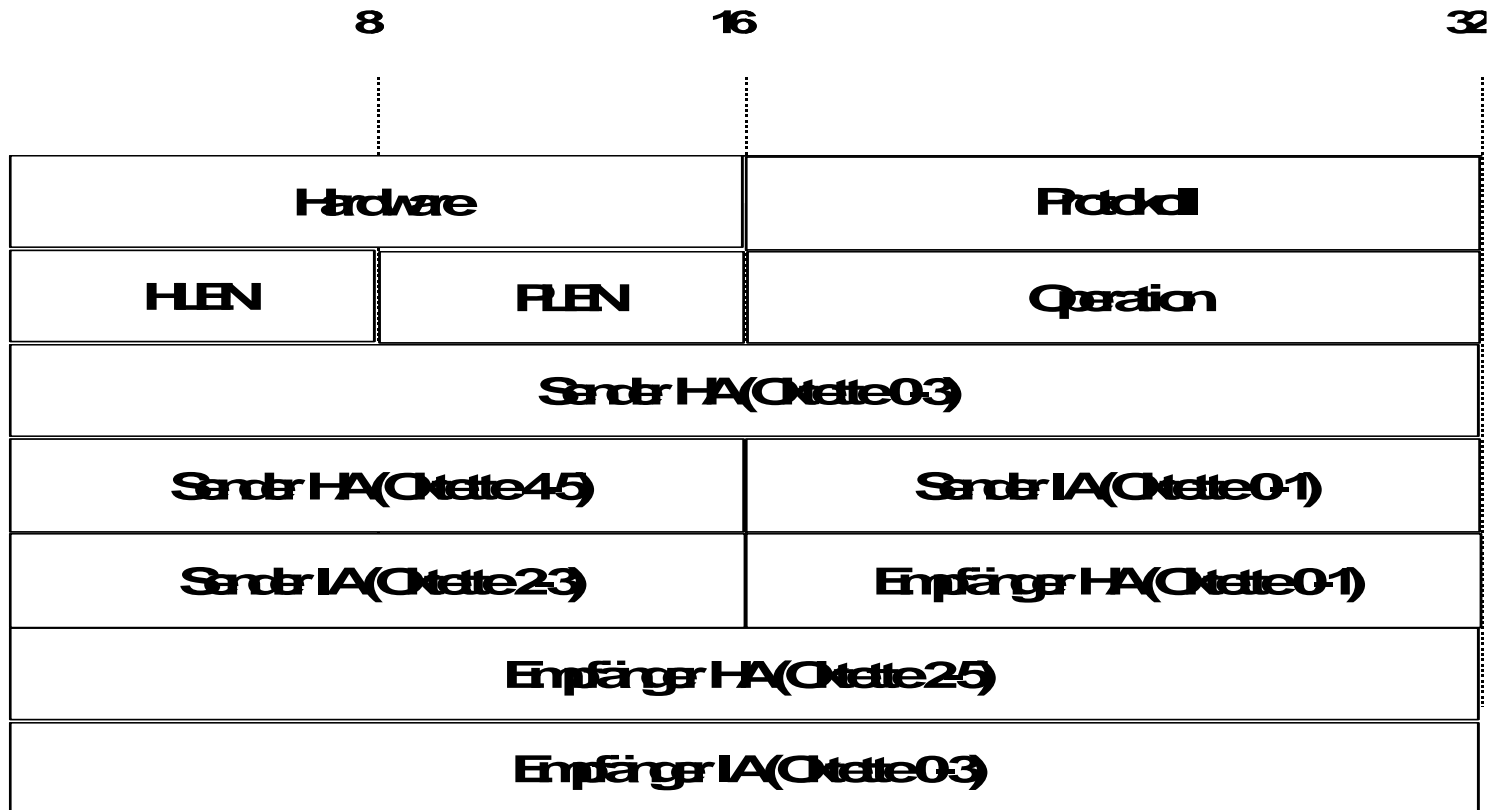
Neighbor Discovery ping6 auf google.de

No. .	Time	Source	Destination	Protocol	Info
3	0.219994	2001:638:408:100::121	ff02::1:ffec:f9fa	ICMPv6	Neighbor solicitation
13	2.717299	2001:638:408:100:70cf:b84b:4e3c:cffe	2a00:1450:4016:800::101f	ICMPv6	Echo request
14	2.732758	fe80::20a:5eff:fe20:3783	ff02::1:ff3c:cffe	ICMPv6	Neighbor solicitation
15	2.732785	2001:638:408:100:70cf:b84b:4e3c:cffe	fe80::20a:5eff:fe20:3783	ICMPv6	Neighbor advertisement
16	2.732869	2a00:1450:4016:800::101f	2001:638:408:100:70cf:b84b:4e3c:cffe	ICMPv6	Echo reply
21	3.719354	2001:638:408:100:70cf:b84b:4e3c:cffe	2a00:1450:4016:800::101f	ICMPv6	Echo request
22	3.733508	2a00:1450:4016:800::101f	2001:638:408:100:70cf:b84b:4e3c:cffe	ICMPv6	Echo reply
28	4.656953	fe80::20a:5eff:fe20:3783	ff02::1	ICMPv6	Router advertisement
29	4.721185	2001:638:408:100:70cf:b84b:4e3c:cffe	2a00:1450:4016:800::101f	ICMPv6	Echo request
30	4.735571	2a00:1450:4016:800::101f	2001:638:408:100:70cf:b84b:4e3c:cffe	ICMPv6	Echo reply
33	4.768801	fe80::20a:5eff:fe20:3783	2001:638:408:100::106	ICMPv6	Neighbor solicitation
34	4.769208	2001:638:408:100::106	fe80::20a:5eff:fe20:3783	ICMPv6	Neighbor advertisement
47	5.722359	2001:638:408:100:70cf:b84b:4e3c:cffe	2a00:1450:4016:800::101f	ICMPv6	Echo request

> Frame 15 (86 bytes on wire, 86 bytes captured)
 > Ethernet II, Src: 3com 50:b9:57 (00:01:02:50:b9:57), Dst: 3com_20:37:83 (00:0a:5e:20:37:83)
 > Destination: 3com_20:37:83 (00:0a:5e:20:37:83)
 > Source: 3com_50:b9:57 (00:01:02:50:b9:57)
 Type: IPv6 (0x86dd)
 > Internet Protocol Version 6
 > 0110 = Version: 6
 0000 0000 = Traffic class: 0x00000000
 0000 0000 0000 0000 0000 = Flowlabel: 0x00000000
 Payload length: 32
 Next header: ICMPv6 (0x3a)
 Hop limit: 255
 Source: 2001:638:408:100:70cf:b84b:4e3c:cffe (2001:638:408:100:70cf:b84b:4e3c:cffe)
 Destination: fe80::20a:5eff:fe20:3783 (fe80::20a:5eff:fe20:3783)
 > Internet Control Message Protocol v6
 Type: 136 (Neighbor advertisement)
 Code: 0
 Checksum: 0xdf9d [correct]
 > Flags: 0x60000000
 Target: 2001:638:408:100:70cf:b84b:4e3c:cffe (2001:638:408:100:70cf:b84b:4e3c:cffe)
 > ICMPv6 Option (Target link-layer address)

Ende

ARP-Protokoll



Router Advertisement

Filter: **ipv6** Expression... Clear Apply Speichern

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	fe80::250:5eff:fea7:77ca	2001:638:408:100::1	ICMPv6	86	Neighbor Solicitation for 2001:638:408:100::1 from 00:50:56:a7:77:ca
2	0.000003	2001:638:408:100::1	fe80::250:5eff:fea7:77ca	ICMPv6	78	Neighbor Advertisement 2001:638:408:100::1 (rtr, sol)
8	1.337502	fe80::20a:5eff:fe20:3783	ff02::1	ICMPv6	78	Router Advertisement from 00:0a:5e:20:37:83
29	3.015073	fe80::250:daff:fe34:26b7	ff02::1:ffa3:e398	ICMPv6	86	Neighbor Solicitation for fe80::21c:c0ff:fea3:e398 from 00:50:da:34:26:b7
30	3.015395	fe80::21c:c0ff:fea3:e398	fe80::250:daff:fe34:26b7	ICMPv6	86	Neighbor Advertisement fe80::21c:c0ff:fea3:e398 (sol, ovr) is at 00:1c:c0:a3:e3:98
31	3.015410	fe80::250:daff:fe34:26b7	fe80::21c:c0ff:fea3:e398	ICMPv6	118	Echo (ping) request id=0xe737, seq=1, hop limit=64 (reply in 32)
32	3.015659	fe80::21c:c0ff:fea3:e398	fe80::250:daff:fe34:26b7	ICMPv6	118	Echo (ping) reply id=0xe737, seq=1, hop limit=64 (request in 31)
36	3.413001	fe80::20a:5eff:fe20:3783	fe80::250:daff:fe34:26b7	ICMPv6	86	Neighbor Solicitation for fe80::250:daff:fe34:26b7 from 00:0a:5e:20:37:83
37	3.413017	fe80::250:daff:fe34:26b7	fe80::20a:5eff:fe20:3783	ICMPv6	78	Neighbor Advertisement fe80::250:daff:fe34:26b7 (sol)
38	3.507133	2001:638:408:100:fa75:1a67:5e3e:befd	2001:638:408:200::2	NTP	110	NTP Version 4, client
39	3.507302	2001:638:408:200::2	2001:638:408:100:fa75:1a67:5e3e:befd	NTP	110	NTP Version 4, server
42	4.006763	fe80::250:daff:fe34:26b7	fe80::21c:c0ff:fea3:e398	ICMPv6	118	Echo (ping) request id=0xe737, seq=2, hop limit=64 (reply in 43)
43	4.007013	fe80::21c:c0ff:fea3:e398	fe80::250:daff:fe34:26b7	ICMPv6	118	Echo (ping) reply id=0xe737, seq=2, hop limit=64 (request in 42)
46	5.008565	fe80::250:daff:fe34:26b7	fe80::21c:c0ff:fea3:e398	ICMPv6	118	Echo (ping) request id=0xe737, seq=3, hop limit=64 (reply in 47)
47	5.008860	fe80::21c:c0ff:fea3:e398	fe80::250:daff:fe34:26b7	ICMPv6	118	Echo (ping) reply id=0xe737, seq=3, hop limit=64 (request in 46)
48	5.052147	2001:638:408:100::123	ff02::1:ffd4:e52a	ICMPv6	86	Neighbor Solicitation for 2001:638:408:100:1642:8441:2dd4:e52a from 00:50:56:a7:77:ca
55	6.052164	2001:638:408:100::123	ff02::1:ffd4:e52a	ICMPv6	86	Neighbor Solicitation for 2001:638:408:100:1642:8441:2dd4:e52a from 00:50:56:a7:77:ca
59	6.420002	2001:638:408:100:f3fe:b755:29bf:8	2001:638:408:100::1	NTP	110	NTP Version 4, client
60	6.420166	2001:638:408:100::1	2001:638:408:100:f3fe:b755:29bf:8	NTP	110	NTP Version 4, server
65	7.052173	2001:638:408:100::123	ff02::1:ffd4:e52a	ICMPv6	86	Neighbor Solicitation for 2001:638:408:100:1642:8441:2dd4:e52a from 00:50:56:a7:77:ca
70	8.012851	fe80::21c:c0ff:fea3:e398	fe80::250:daff:fe34:26b7	ICMPv6	86	Neighbor Solicitation for fe80::250:daff:fe34:26b7 from 00:1c:c0:a3:e3:98
71	8.012879	fe80::250:daff:fe34:26b7	fe80::21c:c0ff:fea3:e398	ICMPv6	78	Neighbor Advertisement fe80::250:daff:fe34:26b7 (sol)

Frame 8: 78 bytes on wire (624 bits), 78 bytes captured (624 bits)

- Ethernet II, Src: 3com_20:37:83 (00:0a:5e:20:37:83), Dst: IPv6mcast_01 (33:33:00:00:00:01)
- Internet Protocol Version 6, Src: fe80::20a:5eff:fe20:3783 (fe80::20a:5eff:fe20:3783), Dst: ff02::1 (ff02::1)
- Internet Control Message Protocol v6
 - Type: Router Advertisement (134)
 - Code: 0
 - Checksum: 0x0eae [correct]
 - Cur hop limit: 64
 - Flags: 0x00
 - Router lifetime (s): 30
 - Reachable time (ms): 0
 - Retrans timer (ms): 0
 - ICMPv6 Option (Source link-layer address : 00:0a:5e:20:37:83)
 - Type: Source link-layer address (1)
 - Length: 1 (8 bytes)
 - Link-layer address: 3com_20:37:83 (00:0a:5e:20:37:83)

```

0000 33 33 00 00 00 01 00 0a 5e 20 37 83 86 dd 60 00 33.....^7...
0010 00 00 00 19 3a ff fe 80 00 00 00 00 00 02 0a .....:.....
0020 5e ff fe 20 37 83 ff 02 00 00 00 00 00 00 00 5e ff fe 20 37 83 ff 02 00 00 00 00 00 00 00
0030 00 00 00 00 00 01 86 00 0e ae 40 00 00 1e 00 00 .....@.....
0040 00 00 00 00 00 00 01 01 00 0a 5e 20 37 83 .....^7
  
```

Windows 7: Zuordnung der IPv6/Ethernet-Multicast-Adressen

```
cmd: Eingabeaufforderung

C:\Users\Wolfgang Pein>netsh interface ipv6 show neighbor

Schnittstelle 1: Loopback Pseudo-Interface 1

Internetadresse                               Physische Adresse   Typ
-----
ff02::c                                       Permanent
ff02::16                                      Permanent
ff02::1:2                                     Permanent
ff02::1:ff2c:e17                              Permanent

Schnittstelle 13: Drahtlosnetzwerkverbindung

Internetadresse                               Physische Adresse   Typ
-----
fe80::20a:5eff:fe20:3782                      00-0a-5e-20-37-82   Abgelaufen
ter)
ff02::2                                       33-33-00-00-00-02   Permanent
ff02::c                                       33-33-00-00-00-0c   Permanent
ff02::16                                      33-33-00-00-00-16   Permanent
ff02::1:2                                     33-33-00-01-00-02   Permanent
ff02::1:3                                     33-33-00-01-00-03   Permanent
ff02::1:ff20:3782                             33-33-ff-20-37-82   Permanent
ff02::1:ff2c:e17                              33-33-ff-2c-0e-17   Permanent
ff02::1:ffb1:7fa4                             33-33-ff-b1-7f-a4   Permanent
ff02::1:ffea:3cb1                             33-33-ff-ea-3c-b1   Permanent

Schnittstelle 17: Drahtlosnetzwerkverbindung 2
```