Attacking all your IPv4 devices at home from the Internet via Dual-Stack Lite

Micha Borrmann

SySS GmbH

October 10th, 2015

Who am I?

Micha Borrmann

- From Germany
- Working in information security since 1997

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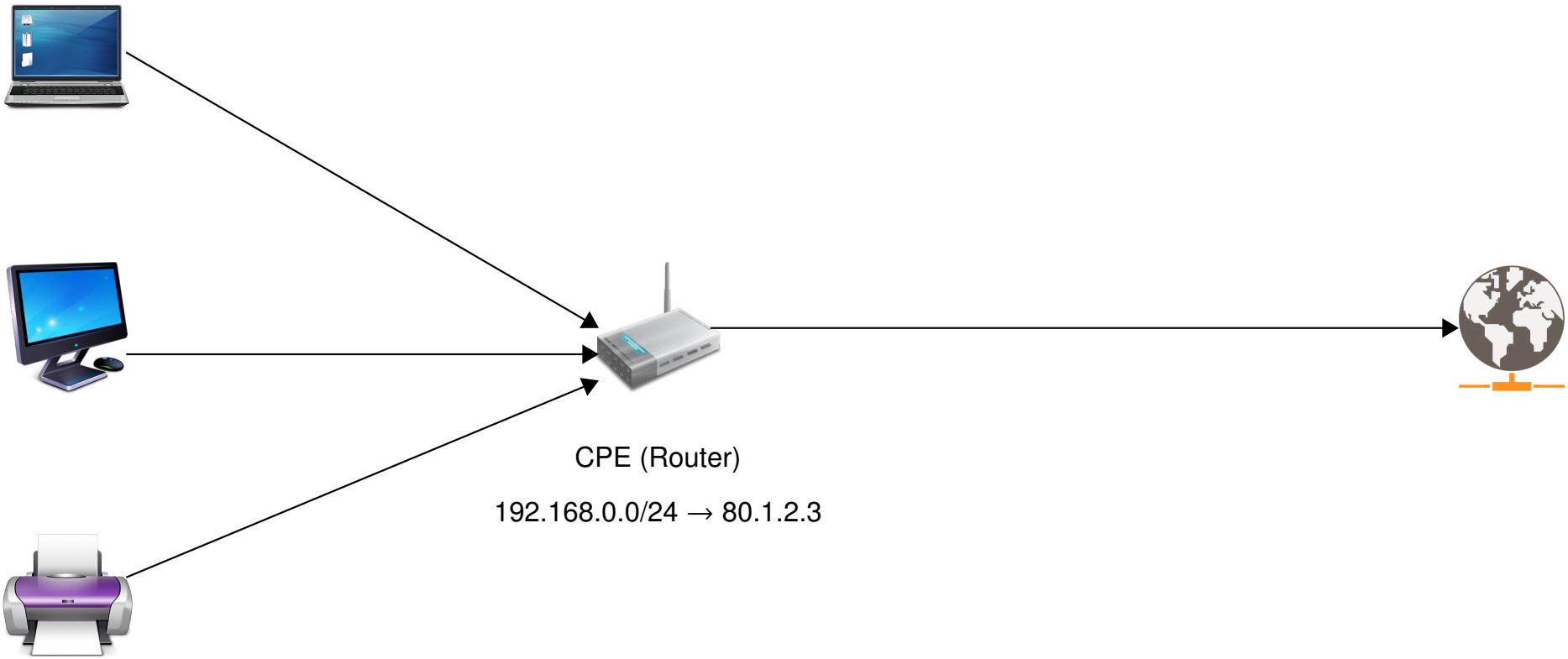
My Point of View

- I am working at a company which is offering professional penetration tests to help clients to improve their level of IT security
- This talk is based on real professional penetration tests with strong NDAs: no company names are published and also no specific security issues

Traditional Internet Access (IPv4 only with NAT)



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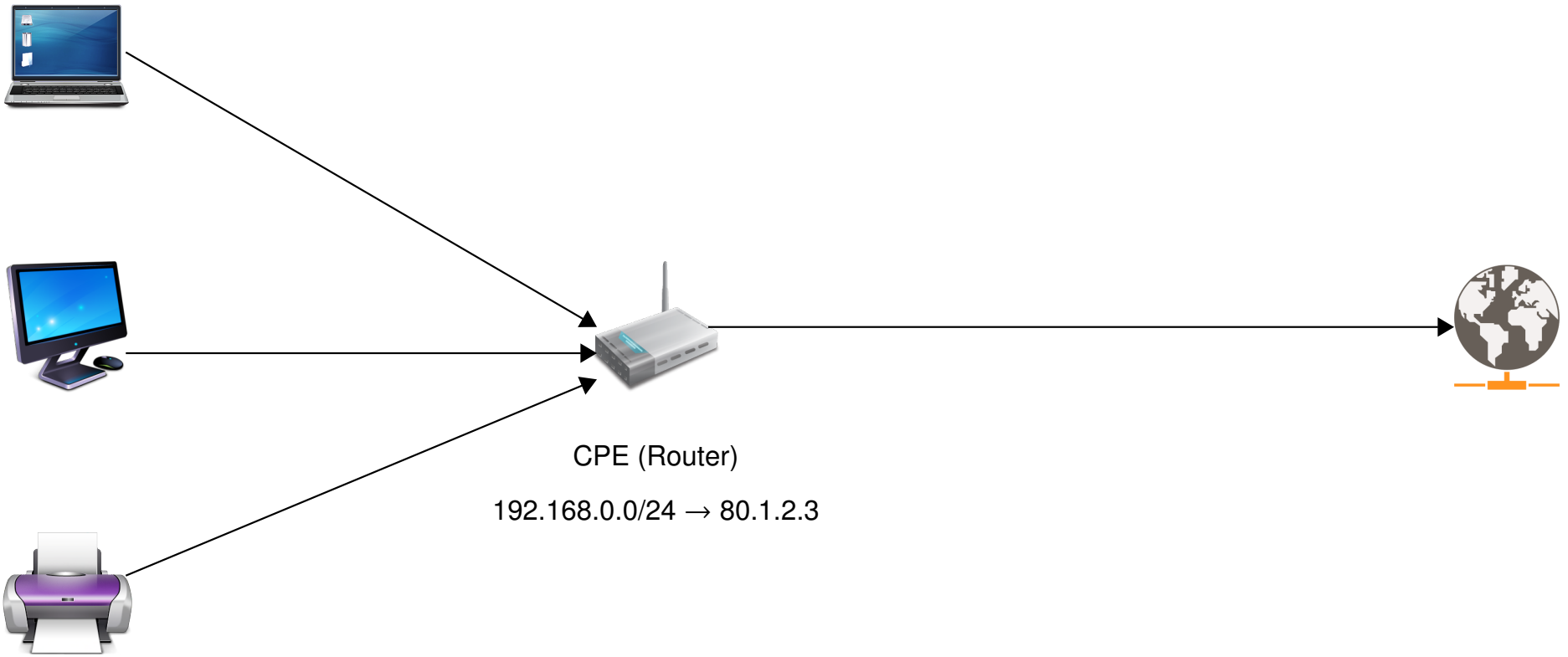
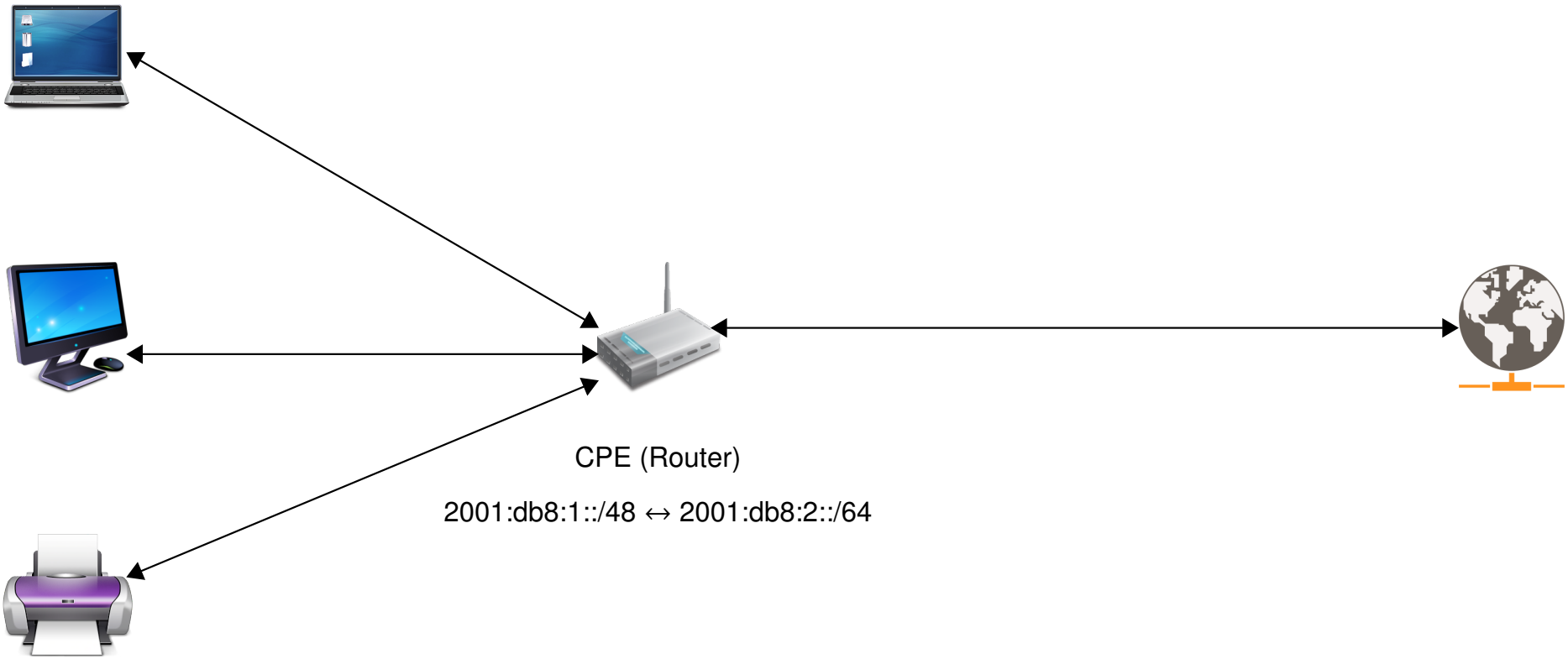


CPE

Customer Premise Equipment

Futuristic Internet Access (IPv6 only, no NAT)



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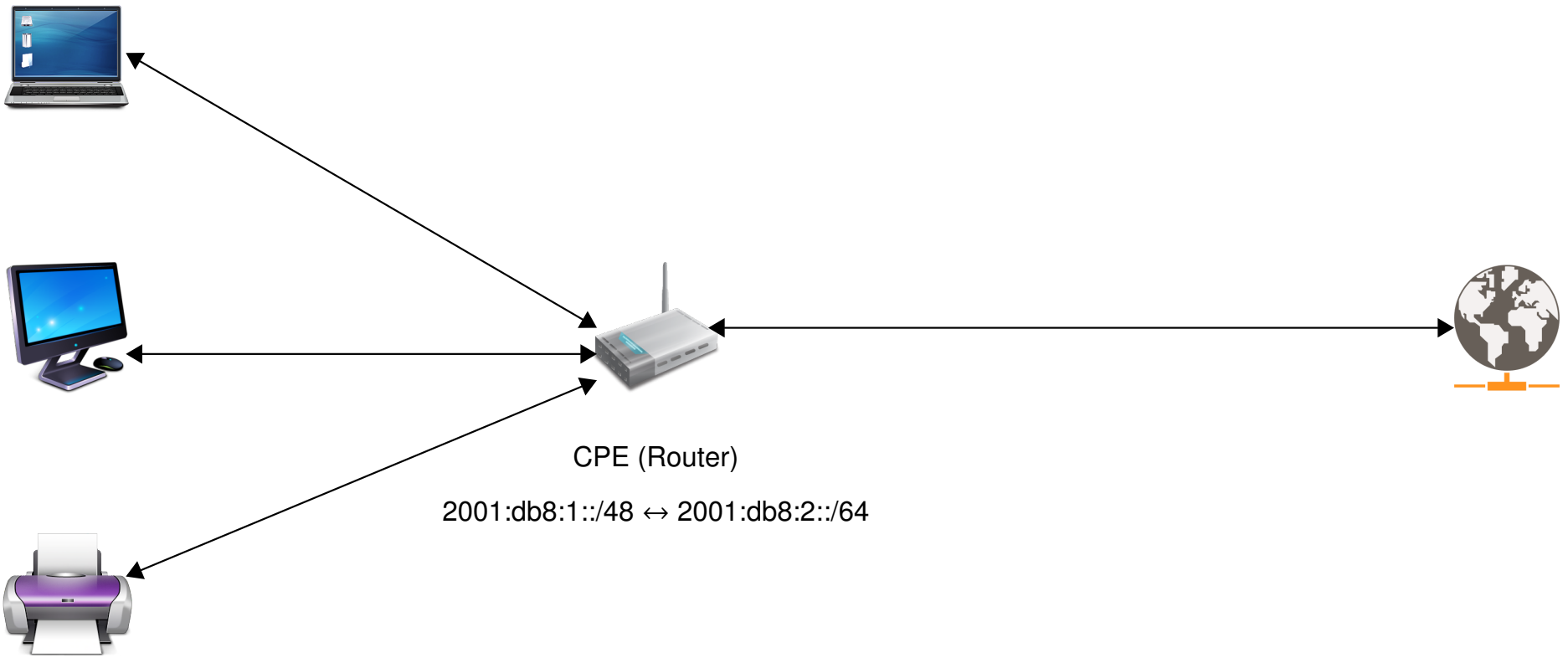
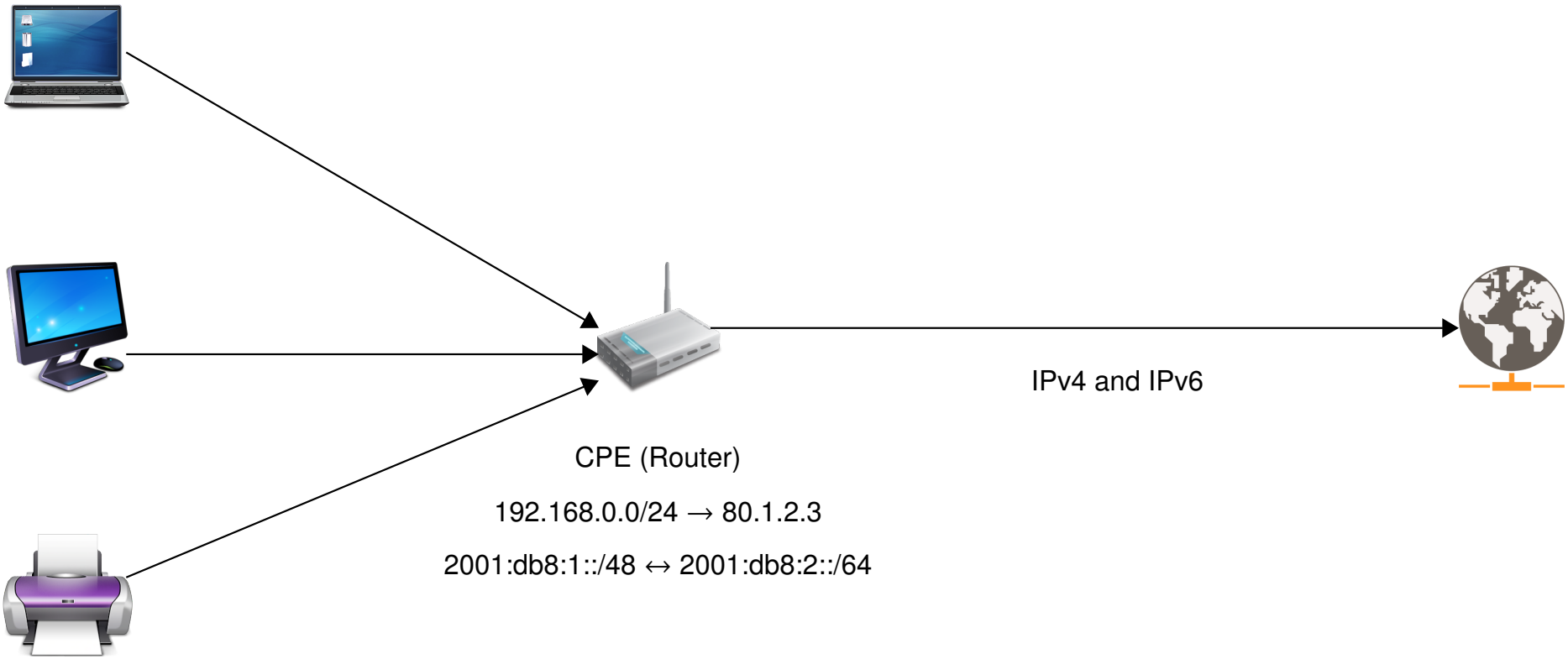


Direct Access

With IPv6 every device can be reached directly over the Internet

Recent Internet Access (Dual-Stack)



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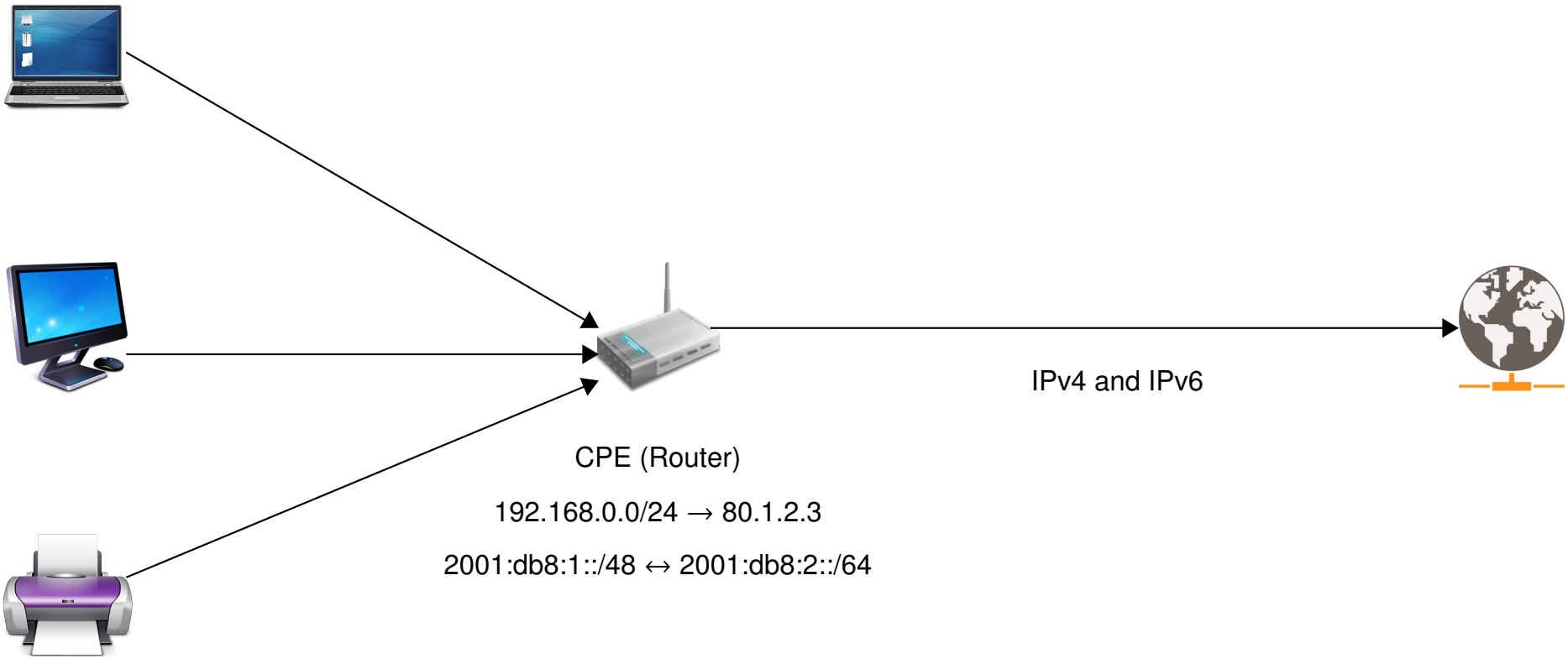
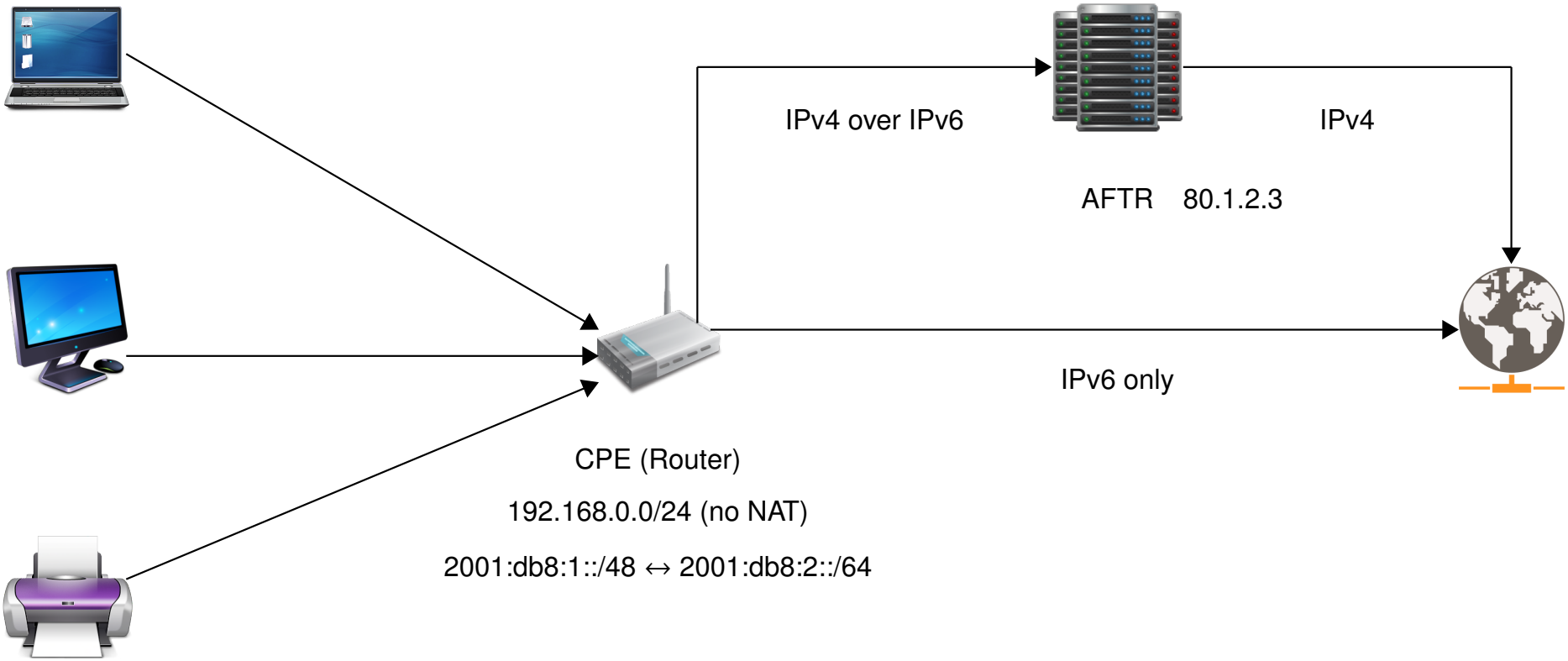


RFC 6540

IPv6 Support Required for All IP-Capable Nodes

DS-Lite Internet Access (Insufficient IPv4 Addresses)



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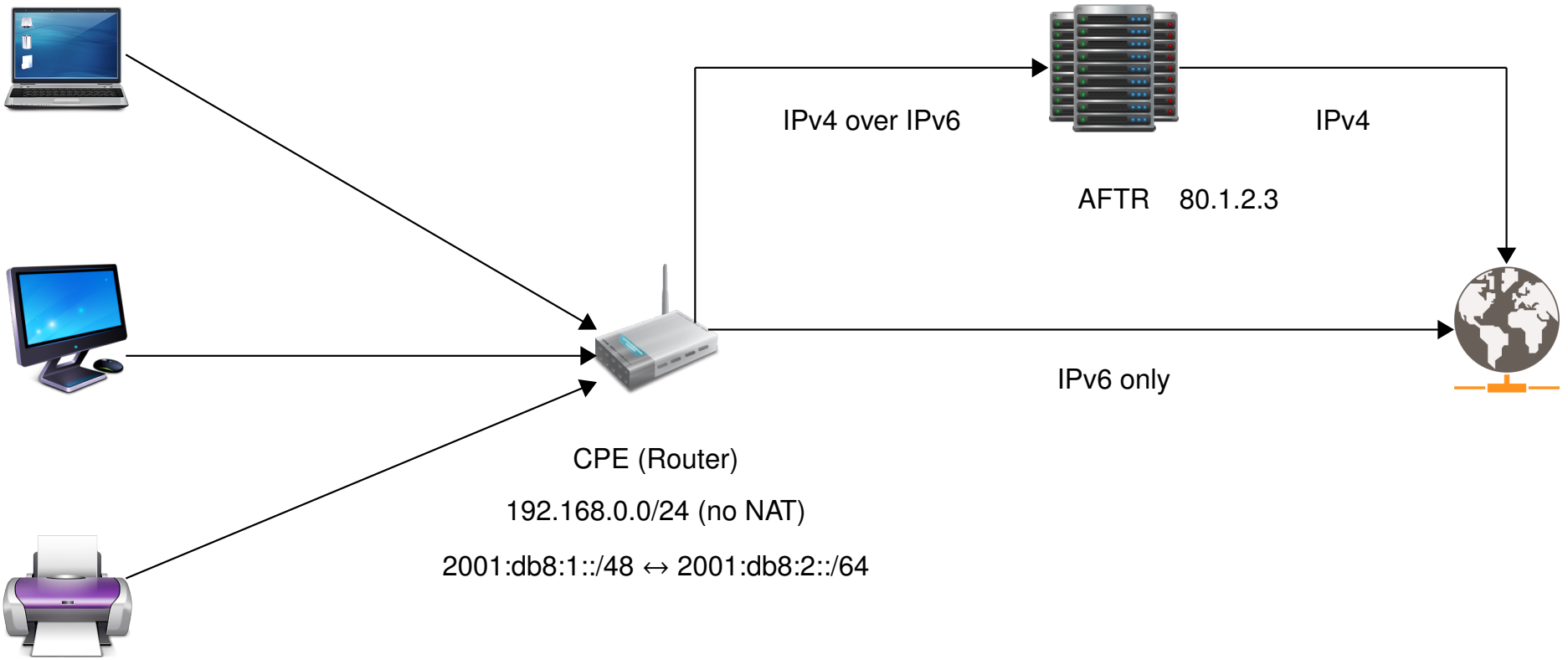

RFC 6333

Dual-Stack Lite (DS-Lite), Address Family Transition Router (AFTR)

About this Talk

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- Not about bugs in a specific AFTR
- Only the DS-Lite technology (RFC 6333) is in the focus

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- A limited number of source ports are assigned for each CPE by the AFTR
- A number of CPEs share one IPv4 address

Source Port Analysis I

http://ptmb.sy.gs/rfc6333.php

```
<?PHP
 $sourceip=$_SERVER[REMOTE_ADDR];
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79.1.2.3,39068
79.1.2.3,39069
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79.1.2.3,39069
```
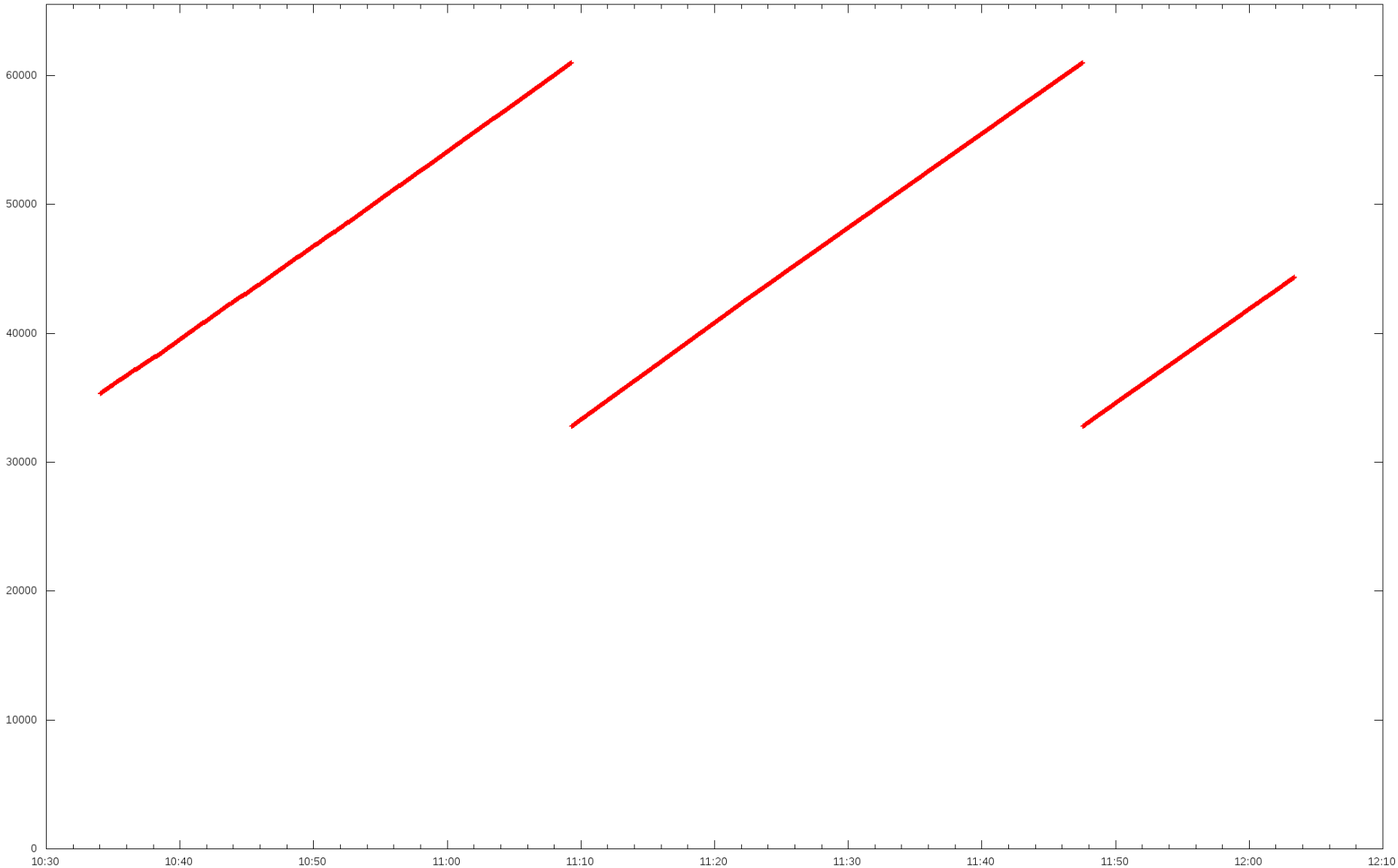
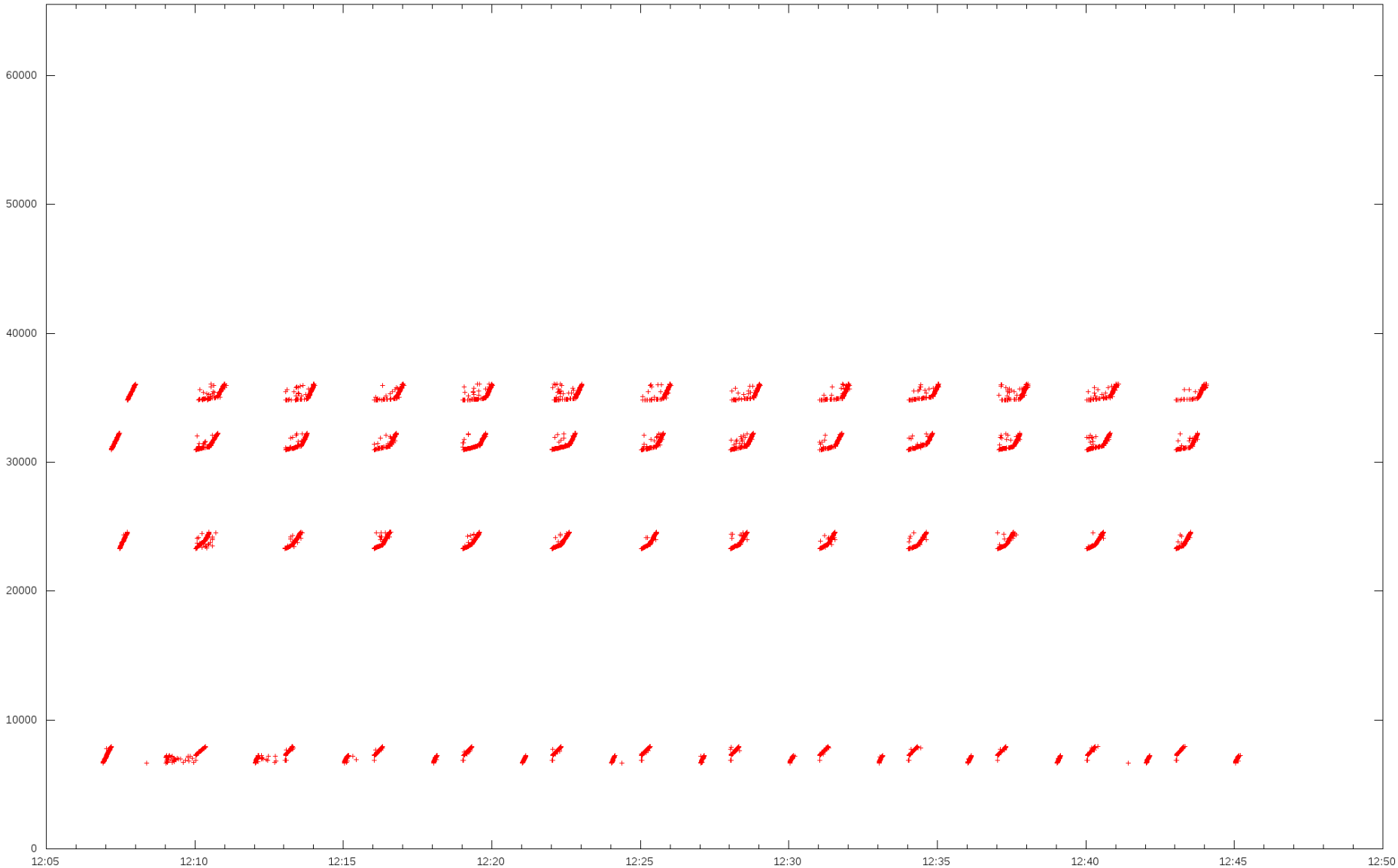

IPv4 via DS-Lite

```
80.1.2.3,36088
80.1.2.3,36093
curl: (7) Failed connect to ptmb.sy.gs:80
curl: (7) Failed connect to ptmb.sy.gs:80
...
curl: (7) Failed connect to ptmb.sy.gs:80
curl: (7) Failed connect to ptmb.sy.gs:80
80.1.2.3,7258
80.1.2.3,7263
```

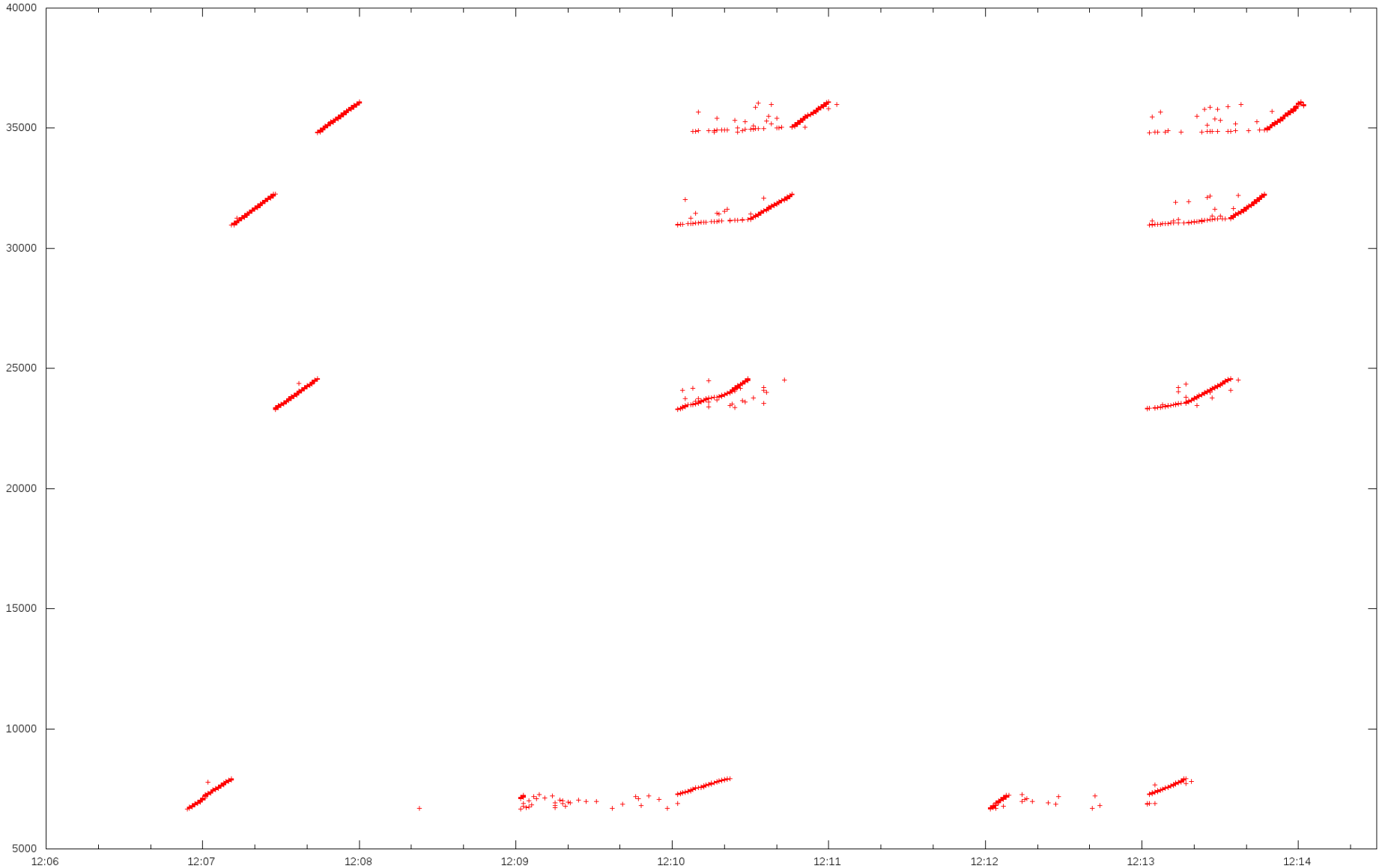
Analysis of Used Source Ports (IPv4 or IPv6)



Analysis of Used Source Ports (IPv4 with DS-Lite) I



Analysis of Used Source Ports (IPv4 with DS-Lite) II



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Attention

- During heavy load, a source port of an IPv4 address can be reassigned to another CPE within less than one minute!

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Attention

- During heavy load, a source port of an IPv4 address can be reassigned to another CPE within less than one minute!
- Thousands of CPEs can use a single IPv4 address

Hints for Service Providers

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- Enable IPv6 (Dual-Stack), especially for IPsec

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- Increase the number of concurrent connections from one IP address
- Enable source port logging (RFC 6302)

Source Port Logging with Apache

```
LogFormat "%h %{remote}p %l %u %t \"%r\" %>s %O \"%{Referer}i\"
\"%{User-Agent}i\" %{SSL_PROTOCOL}x %{SSL_CIPHER}x " mylogfile
```

IPv4 over IPv6 (RFC 2473) – Two Times Layer III

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Scapy

```
sr1(IPv6(dst="2001:db8:ff::1",nh=4)/IP(src="10.1.2.3",↵
dst="192.168.1.1")/ICMP())
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TCPdump

```
IP6 2a01:238:43ef:2c00:b468:d389:548f:5cab >
2001:db8:ff::1:  IP 10.1.2.3 > 192.168.1.1:
ICMP echo request, id 0, seq 0, length 8
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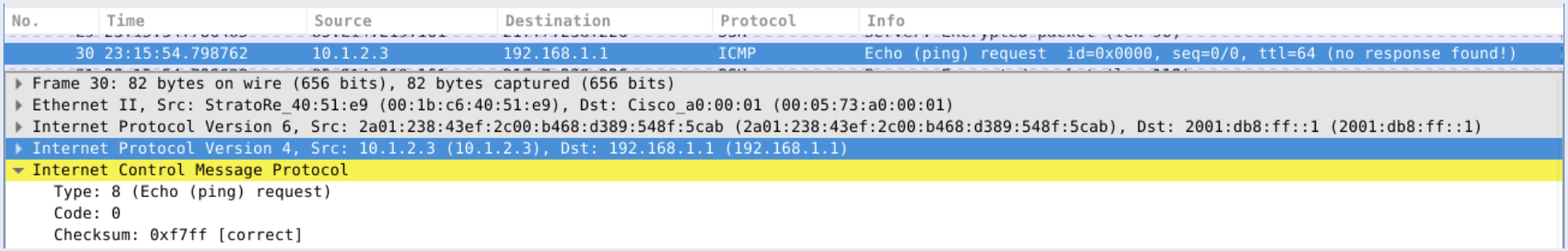
Wireshark



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- With DS-Lite, your access provider can see your used RFC 1918 addresses
- Carrier-Grade NAT (CGN) is in use (RFC 6264)
- It means the number of devices which are in use behind the CPE can be monitored by the access provider

IPv4 over IPv6

Authentication

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Authentication

No!

Attacking a Device Behind the CPE

2001:db8:3::1/64 AFTR 80.1.2.3

DS-Lite

Attacking all your IPv4 devices at home

Attacking a Device Behind the CPE

2001:db8:3::1/64 AFTR 80.1.2.3

Spoofed IPv6-Source of AFTR
IPv4 over IPv6
2001:db8:2::1 ← 2001:db8:3::1
192.168.0.1 ← 81.1.2.3

Attacker (81.1.2.3)

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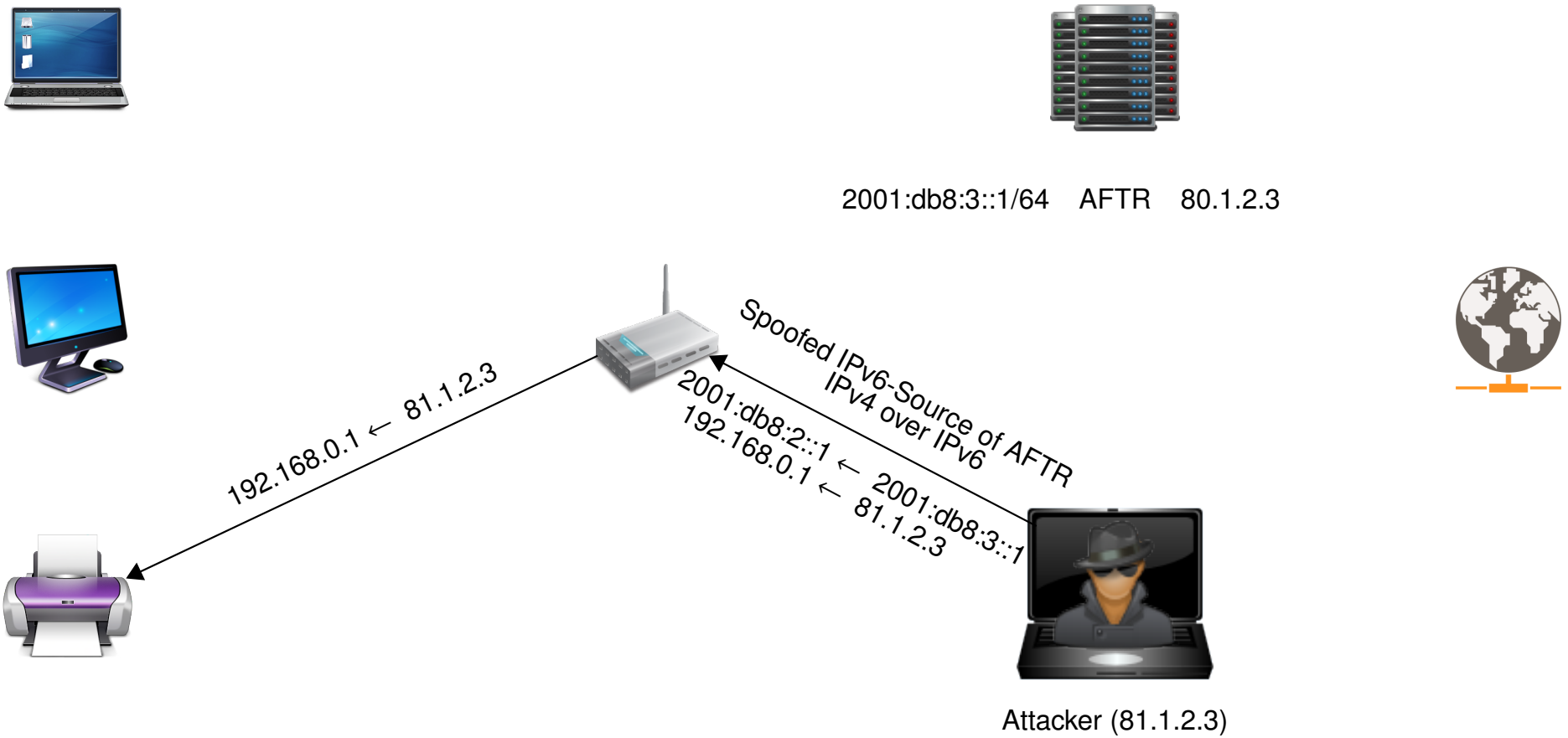

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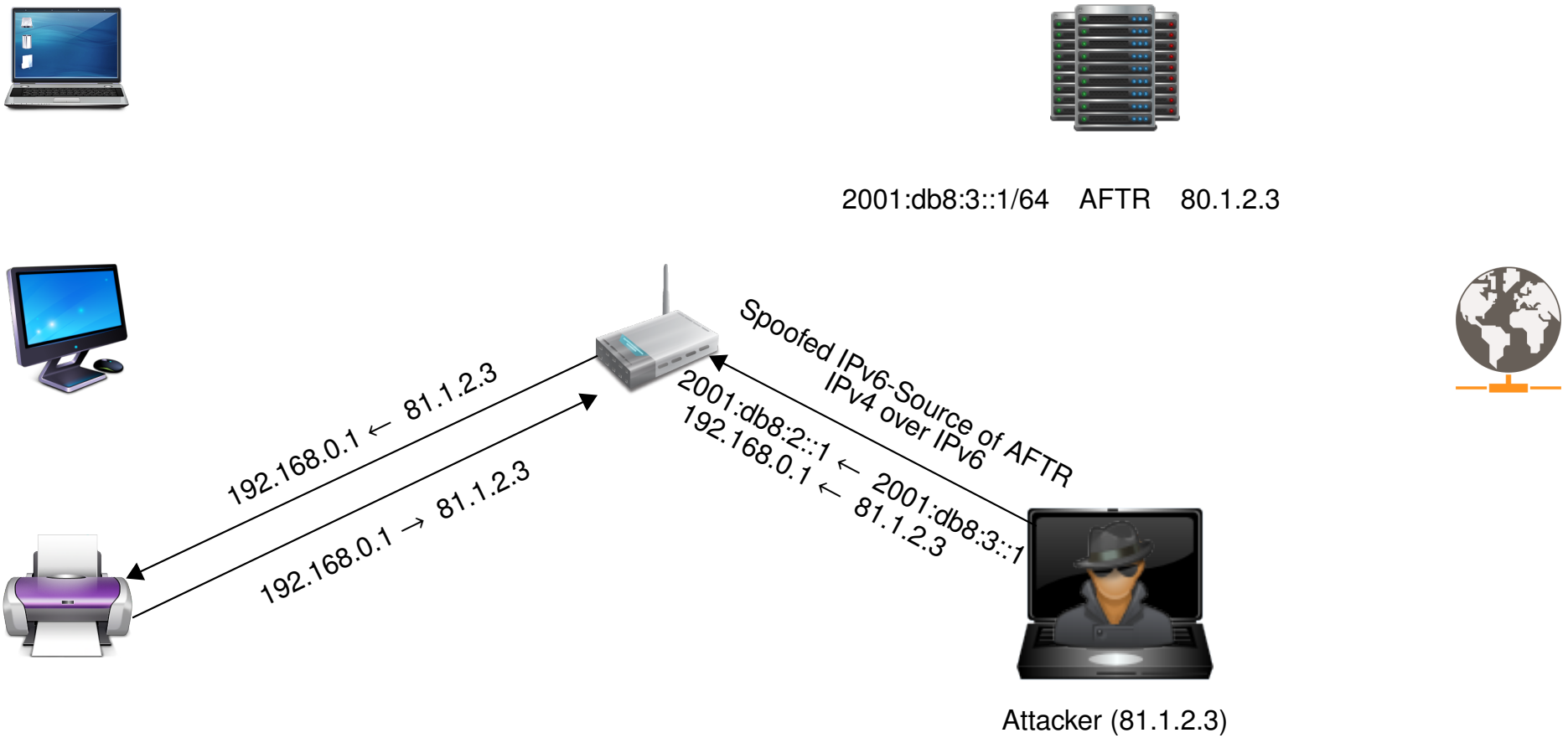

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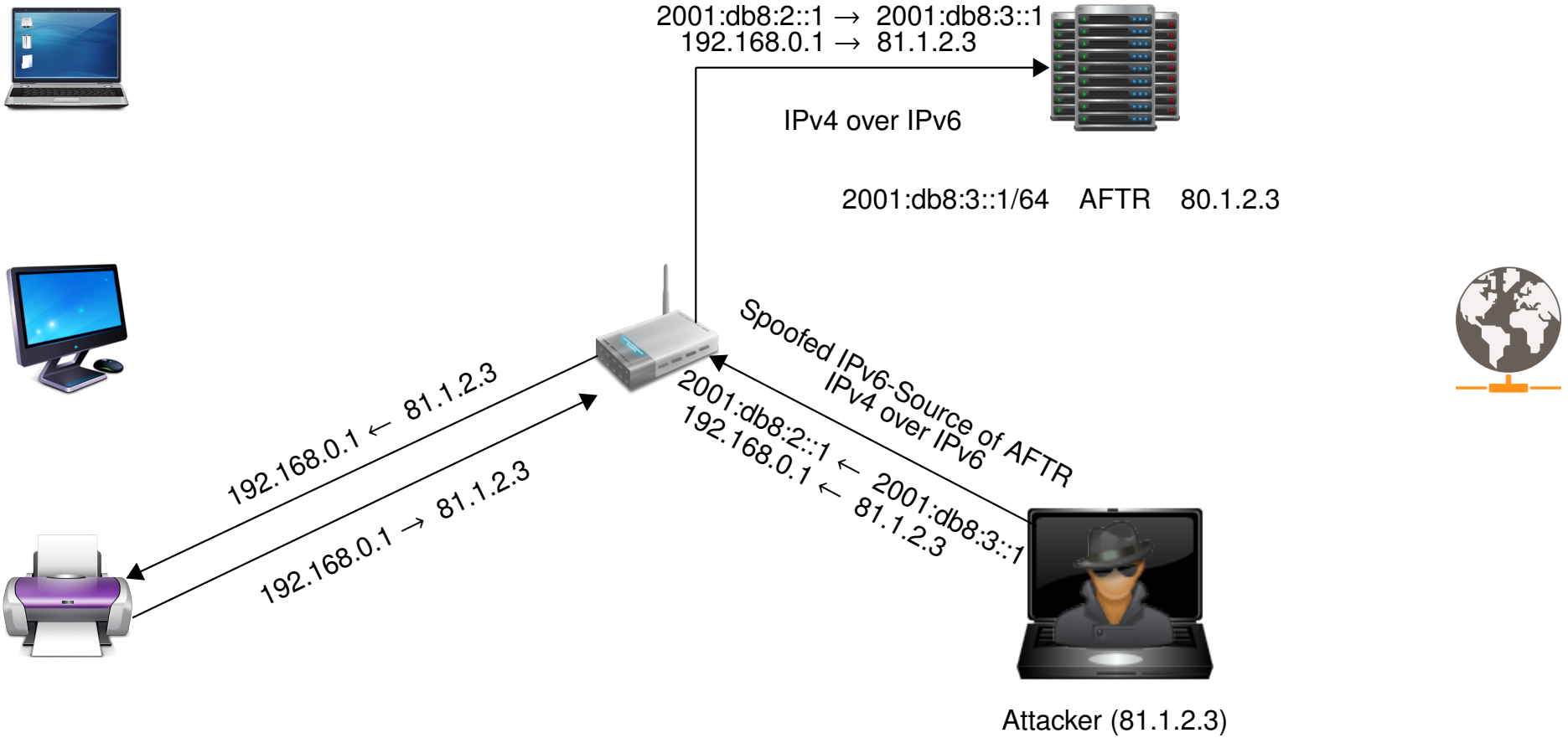

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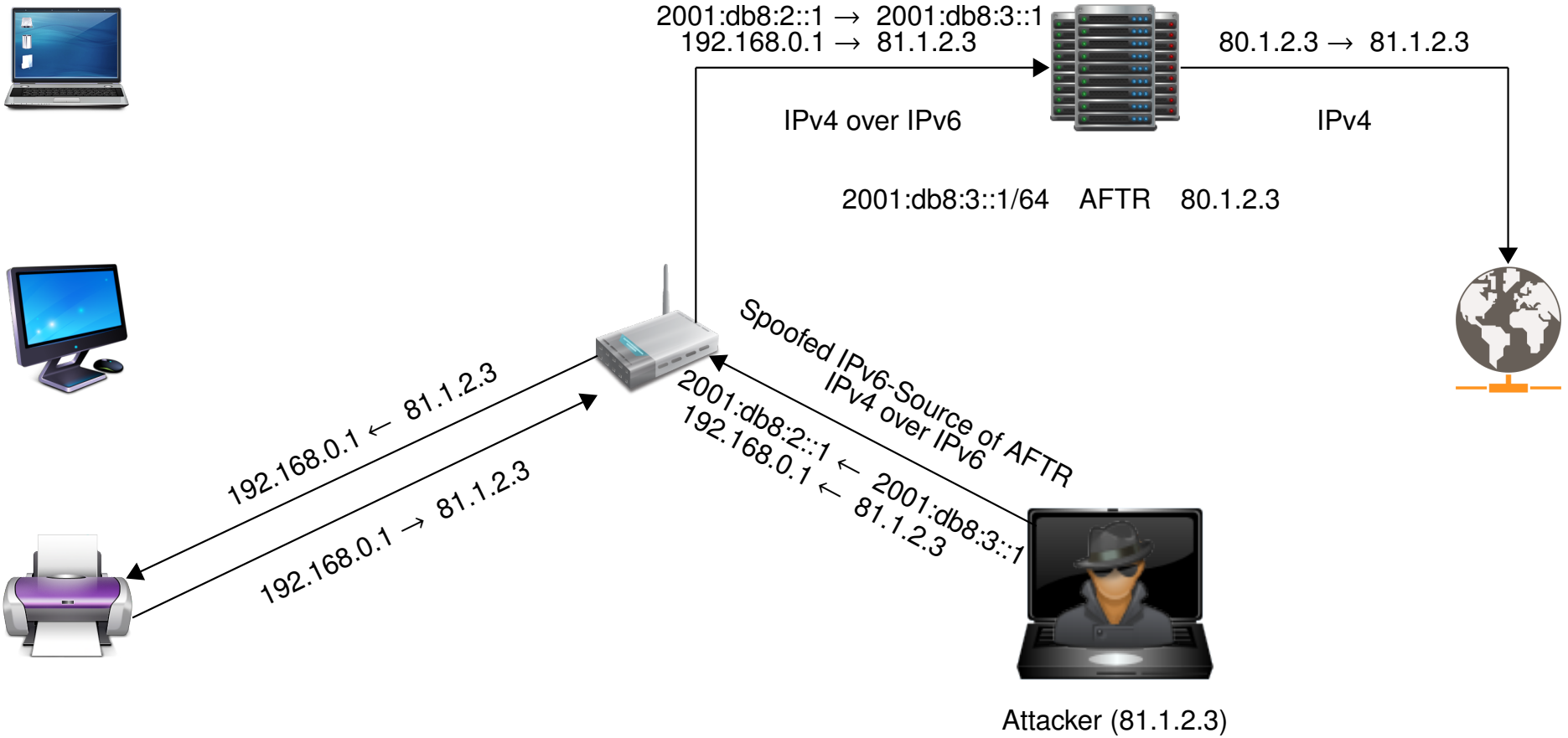

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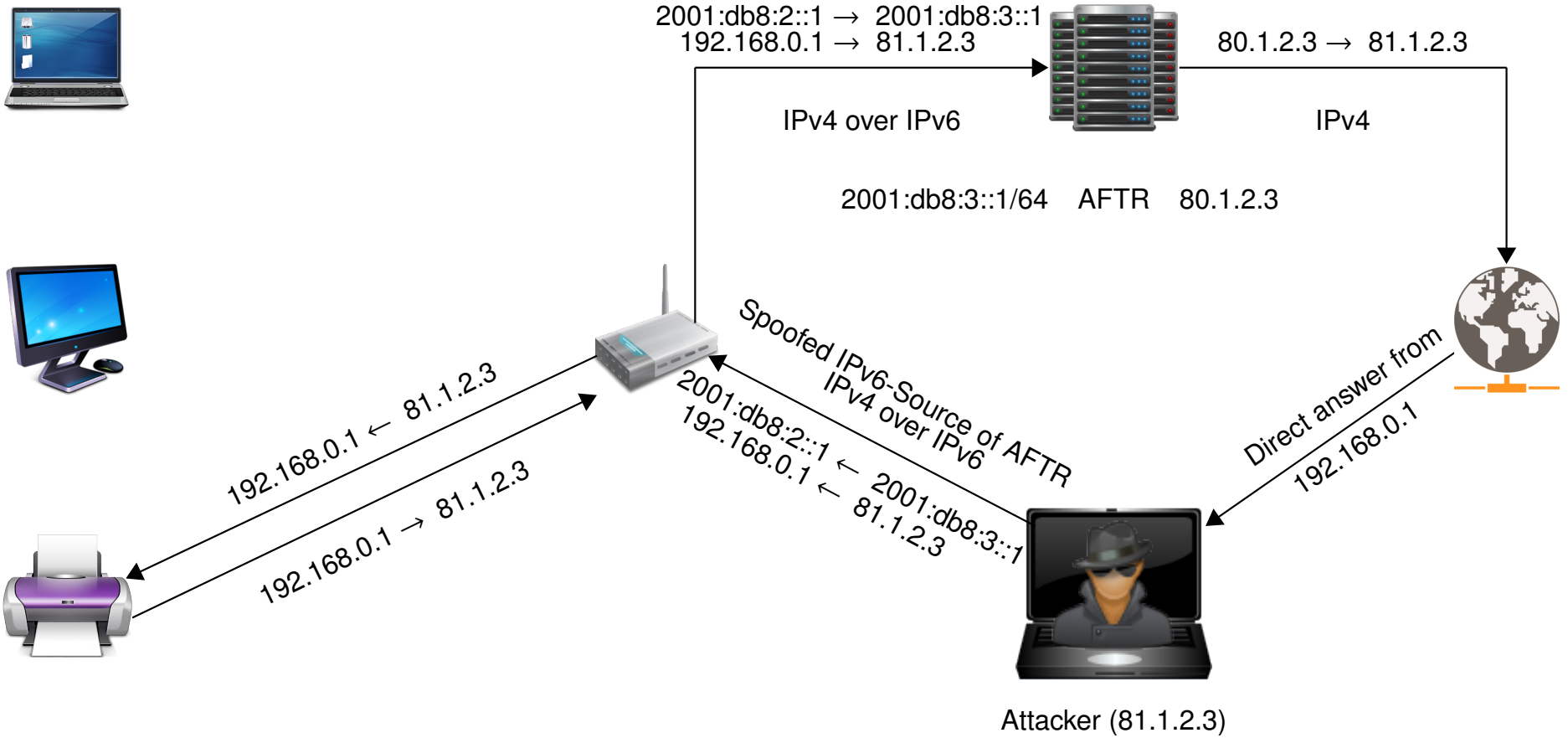

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4. Enable the tunnel

   ```
   # ip link set dev no-more-private-ips up
   ```

Howto for Linux II

5. Route the private network behind the CPE via the configured tunnel

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# ip route add 192.168.0.0/24 dev no-more-private-ips
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Why is it not working?

Response will be received from different source IP address and source port as the request was going on

Recording the Answer

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```
# tcpdump -n -i eth0 -vvvvX
tcpdump: listening on eth0, link-type EN10MB (Ethernet), capture size 65535 bytes
11:30:00.652626 IP (tos 0xc0, ttl 55, id 0, offset 0, flags [DF], proto UDP (17), length 420)
    80.1.2.3.55310 > 81.1.2.3.49544: [udp sum ok] UDP, length 392
        0x0000:  45c0 01a4 0000 4000 3711 0309 5001 0203  E.....@.7.......
        0x0010:  5101 0203 d80e c188 0190 7cfb 1682 0001  ..........|.....
        0x0020:  0615 0000 0000 017c 7665 7273 696f 6e3d  .......|version=
        0x0030:  226e 7470 6420 342e 322e 3670 3540 312e  "ntpd.4.2.6p5@1.
        0x0040:  3233 3439 2d6f 2053 6174 204d 6179 2031  2349-o.Sat.May.1
        0x0050:  3220 3039 3a35 343a 3535 2055 5443 2032  2.09:54:55.UTC.2
        0x0060:  3031 3220 2831 2922 2c0d 0a70 726f 6365  012.(1)",..proce
        0x0070:  7373 6f72 3d22 7838 365f 3634 222c 2073  ssor="x86_64",.s
        0x0080:  7973 7465 6d3d 224c 696e 7578 2f33 2e32  ystem="Linux/3.2
        0x0090:  2e30 2d34 2d61 6d64 3634 222c 206c 6561  .0-4-amd64",.lea
        0x00a0:  703d 302c 2073 7472 6174 756d 3d33 2c0d  p=0,.stratum=3,.
        0x00b0:  0a70 7265 6369 7369 6f6e 3d2d 3233 2c20  .precision=-23,.
        0x00c0:  726f 6f74 6465 6c61 793d 3234 2e39 3631  rootdelay=24.961
        0x00d0:  2c20 726f 6f74 6469 7370 3d34 372e 3132  ,.rootdisp=47.12
        0x00e0:  322c 2072 6566 6964 3d33 372e 3539 2e31  2,.refid=37.59.1
        0x00f0:  3135 2e32 3331 2c0d 0a72 6566 7469 6d65  15.231,..reftime
        0x0100:  3d30 7864 3537 3533 3131 652e 3134 6136  =0xd575311e.14a6
        0x0110:  6635 3064 2c20 636c 6f63 6b3d 3078 6435  f50d,.clock=0xd5
        0x0120:  3735 3333 3138 2e61 3536 3363 6634 382c  753318.a563cf48,
        0x0130:  2070 6565 723d 3432 3539 2c20 7463 3d36  .peer=4259,.tc=6
        0x0140:  2c0d 0a6d 696e 7463 3d33 2c20 6f66 6673  ,..mintc=3,.offs
        0x0150:  6574 3d2d 332e 3638 382c 2066 7265 7175  et=-3.688,.frequ
        0x0160:  656e 6379 3d31 362e 3139 332c 2073 7973  ency=16.193,.sys
        0x0170:  5f6a 6974 7465 723d 322e 3036 302c 0d0a  _jitter=2.060,..
        0x0180:  636c 6b5f 6a69 7474 6572 3d31 2e34 3334  clk_jitter=1.434
        0x0190:  2c20 636c 6b5f 7761 6e64 6572 3d30 2e31  ,.clk_wander=0.1
        0x01a0:  3339 0d0a                                39..
```

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- IPv6 address of a CPE from a DS-Lite customer

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- Works not with TCP directly, (the SYN-ACK will be received after sending a SYN to a private IPv4 address); however, some AFTRs have an integrated *stateful inspection* firewall, SYN-ACK will not be received because the firewall drops such packets
- But: port scanning in general is possible

Requirements for the attacker

- System with Dual-Stack on the Internet
- IPv6 address of a CPE from a DS-Lite customer
- IPv6 address of the AFTR which is used by the CPE

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- System with Dual-Stack on the Internet
- IPv6 address of a CPE from a DS-Lite customer
- IPv6 address of the AFTR which is used by the CPE
- IPv4 address of a device in the home network
- Possibility to spoof the IPv6 address from the AFTR against the CPE

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Protect your logfiles of CPE firmware updates, because these logs contain the IPv6 addresses of CPEs

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- RFC 6333 (6.3 "Fragmentation and Reassembly"): *Fragmentation MUST happen after the encapsulation on the IPv6 packet. Reassembly MUST happen before the decapsulation of the IPv6 header.*
- RFC 2473 (7.2 "IPv4 Tunnel Packet Fragmentation"): *the tunnel entry-point node encapsulates the original packet, and subsequently fragments the resulting IPv6 tunnel packet into IPv6 fragments that do not exceed the Path MTU to the tunnel exit-point*

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- As the number of packets increases, the performance will decrease (in general)

Thank You for Your Attention

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