IPv6 in our network (šestka.sin.cvut.cz)

Pavel Valach

Sincoolka

Studentská unie ČVUT

Sincoolka

- A member of Studentská unie ČVUT – established in 1998
- Dormitory club of Sinkuleho and Dejvická dorms
- **We are volunteers!**
- ~430 members,
  ~20 active, 5 admins, some netadmins
- Cooperating with CTU in Prague, CESNET, and other dorm clubs :-)

  https://sin.cvut.cz

Pavel Valach

- Formerly an admin of Sinkuleho and Dejvická dorms
- Now – a member of CESNET SOC & CESNET CERTS.

… more at paulos.cz
Mastodon: @paulos@infosec.exchange

Net infrastructure

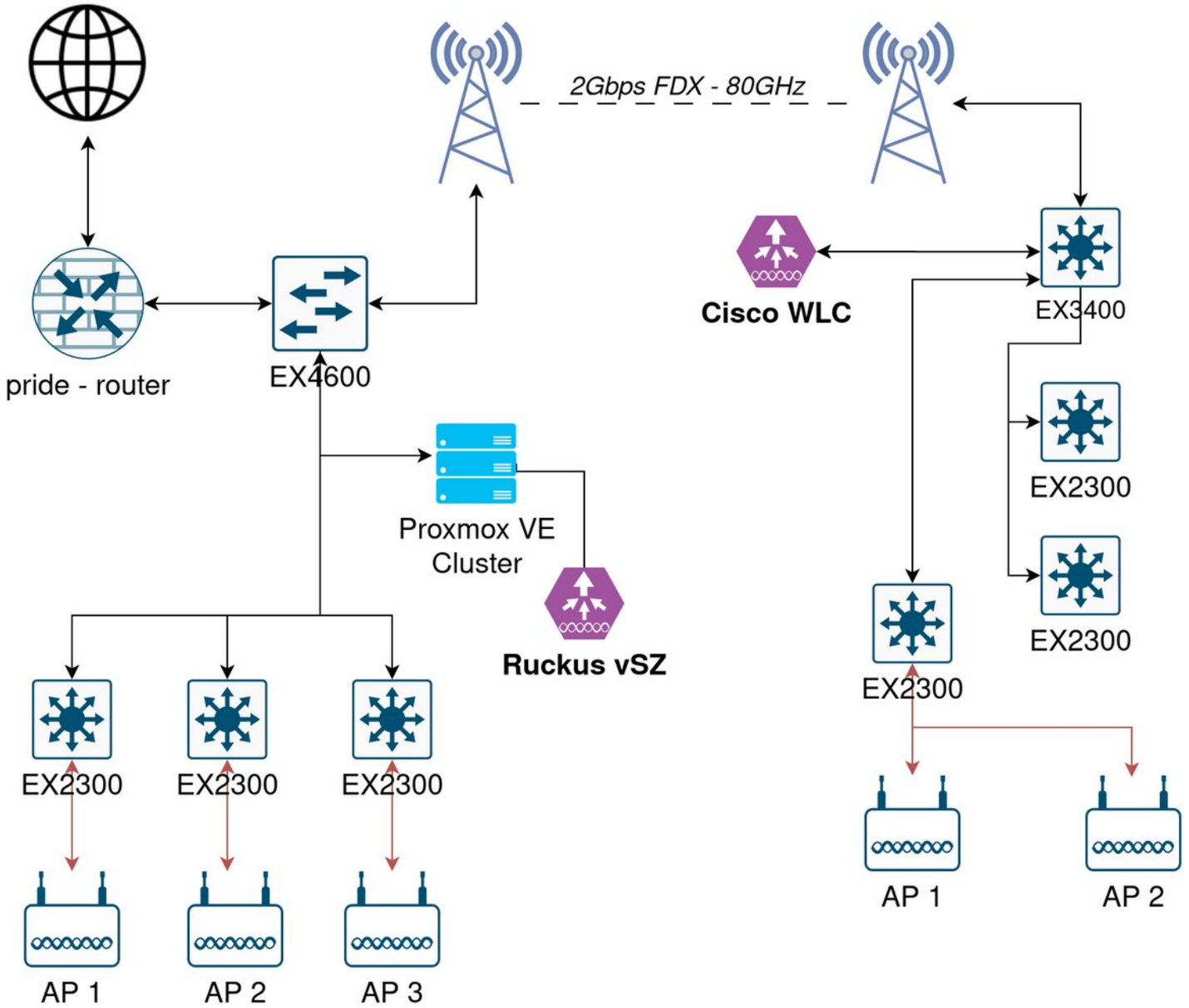
- Switches
- Wi-Fi APs & controllers
- Linux servers
- Hypervisors, VMs, LXC & Docker containers
- Printers (oh boy)
- Ericsson link
- Appliances, monitoring etc.

Net infrastructure

- … and it’s almost all* running via IPv6!

** with small exceptions*

High-level network architecture overview



Net infrastructure

- **History:**
  - Core/Aggregation — Cisco Catalyst 3560G, a ještě další
  - Access — Cisco Catalyst 2960 (100M), 3Com Switch 5500(G)-EI
  - Wi-Fi — our own solution (W-Sin), then Extricom (!), later Ruckus ZoneDirector 1100 AP ZF7372
- Switches had general IPv6 support incl. IPv6 RA Guard.

Net infrastructure

- **Now:**
  - Core — Juniper EX4600, distribution EX3400
  - Access — Juniper EX2300
  - Wi-Fi — Ruckus Virtual SmartZone, Cisco WLC
    Ruckus R550, R650, Cisco Aironet 1852i

Our IPv6 ranges

- 2001:718:2:880::/57
  - 880:0:0:0:0 – 8FF:FFFF:FFFF:FFFF:FFFF
- ~~2001:718:2:A80::/57~~
- That is 128 prefixes of length /64
  - More than 128 students → cannot assign /64 to each
  - Some degree of separation is possible

Our IPv6 partitioning

2001:718:2:8[8-9a-f][0-9a-f]::	Description
:880::/64	**Ethernet** members
:881::/64	Ethernet guests
:88[2-9a-f]::/64	Ethernet testing / unused
:8a0::/64	**Wi-Fi** members
:8a1::/64	Wi-Fi guests
:8a[2-9a-f]::/64	Wi-Fi testing / unused
:8b0::/60	**Docker** containers
:8[c-e]0::/60	Unused / testing
:8f0::/60	**Network**, management, AP, CCTV VLANs

Side story:
CTU and their IPv6 prefixes

- They mostly give out /57, because **they only have a single /48!**
- There have been talks to get an entirely separate range for us. May happen someday.
- **Historical table of address assignments:**

Kolej	Klub SU	Doména	IP rozsah	UNIX style	IPv6 rozsah
Strahov	Silicon Hill	sh.cvut.cz	147.32.112-127.* 147.32.30-31.*	147.32.112.0/20 147.32.30.0/23	2001:718:2::/56
Hlávkova kolej	Silicon Hill	hk.cvut.cz	147.32.98.*	147.32.98.0/24	2001:718:2:131::/64
Podolí	Pod-O-Lee	pod.cvut.cz	147.32.88-95.*	147.32.88.0/21	2001:718:2:800::/57
Sinkuleho a Dejvická	Klub Sinkuleho koleje	sin.cvut.cz dk.cvut.cz	147.32.110-111.* 147.32.107.*	147.32.110.0/23 147.32.107.0/24	2001:718:2:880::/57 2001:718:2:a80::/57
Masarykova	Masařka	mk.cvut.cz	147.32.96-97.*	147.32.96.0/23	2001:718:2:900::/57
Bubeneč	Buben	buk.cvut.cz	147.32.104-105.*	147.32.104.0/23	2001:718:2:980::/57
Orlík	Orlík	ok.cvut.cz	147.32.108.*	147.32.108.0/24	2001:718:2:a00::/57

Infrastructure Software 1

- Authoritative DNS – ISC BIND 9, Knot DNS
- Recursive DNS – Knot Resolver
- SLAAC and RA – radvd
- DHCPv6 Server – Kea DHCPv6, dhcpy6d
- RADIUS server – FreeRADIUS
- Firewall – IPtables+ipset, nftables

- Config scripts – Perl, Python, Bash

Infrastructure Software 2

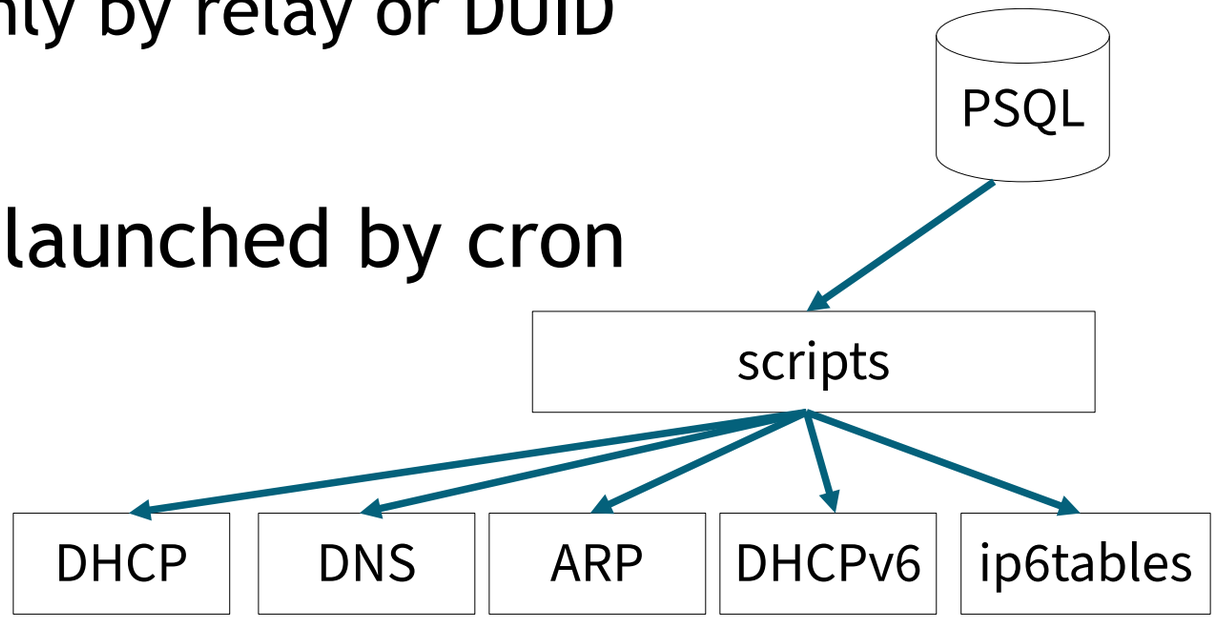
- Monitoring – Icinga 2, Observium
- Switch config backup – RANCID

- Hypervisors – Proxmox VE, LXD
- Containers – Docker + Docker Compose

Some config notes

- Kea DHCPv6 & dhcpy6d run **alongside**
  - dhcpy6d gives static IPv6 to our Ethernet clients **by MAC**
  - Kea cannot do that yet, only by relay or DUID

- Most config is by scripts, launched by cron
  1) Read database
  2) Prepare config file
  3) Reload service

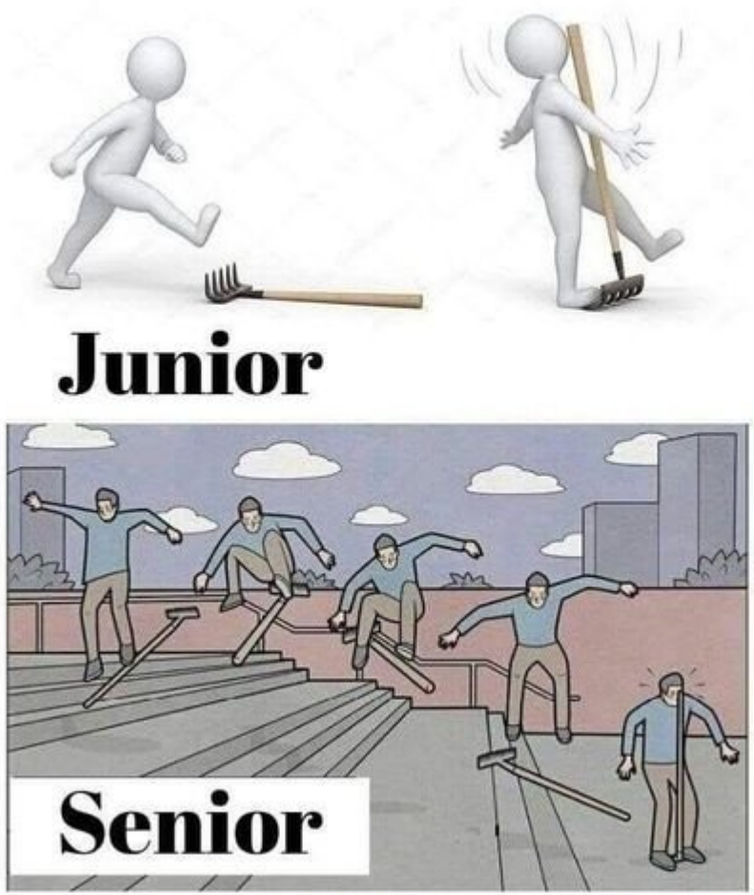


Servers — iLO, iDRAC, IPMI

- **Old machines (HP Gen5-7, DELL Rx10)**
- HP iLO 3 (1.94) – supports IPv6, cannot test KVM
- DELL iDRAC 6 supports IPv6, static IP, SLAAC, DHCPv6 (not tested), KVM also works through IPv6

- New versions will surely not be worse :-)

Switches, APs, servers and other disasters



Juniper and IPv6 — 1

- IPv6 support for DNS, NTP, syslog, management (SSH, J-Web), SNMP, streaming telemetry
- IPv6 support for RADIUS AAA in 802.1X and switch auth
- First-Hop Security
  - RA Guard, DHCPv6 Snooping, IPv6 Source Guard, ND Guard, SLAAC Snooping (since 19.2R1)

```
set groups sin-dhcp-sec vlans <*> forwarding-options dhcp-security
set groups sin-dhcp-sec vlans <*> forwarding-options dhcp-security neighbor-discovery-inspection
set groups sin-dhcp-sec vlans <*> forwarding-options dhcp-security ipv6-source-guard
set vlans vlan_20_connected apply-groups sin-dhcp-sec
```

Juniper and IPv6 — 2

- Does not need an IPv4 management address
  - Some switches do not have IPv4
- But: The VME interface does not support IPv6 (virtual chassis virtual IP).
  - If you set IPv6 there, it will break with some changes in configuration
- ERSPAN (port mirror through IP) – cannot set IPv6:

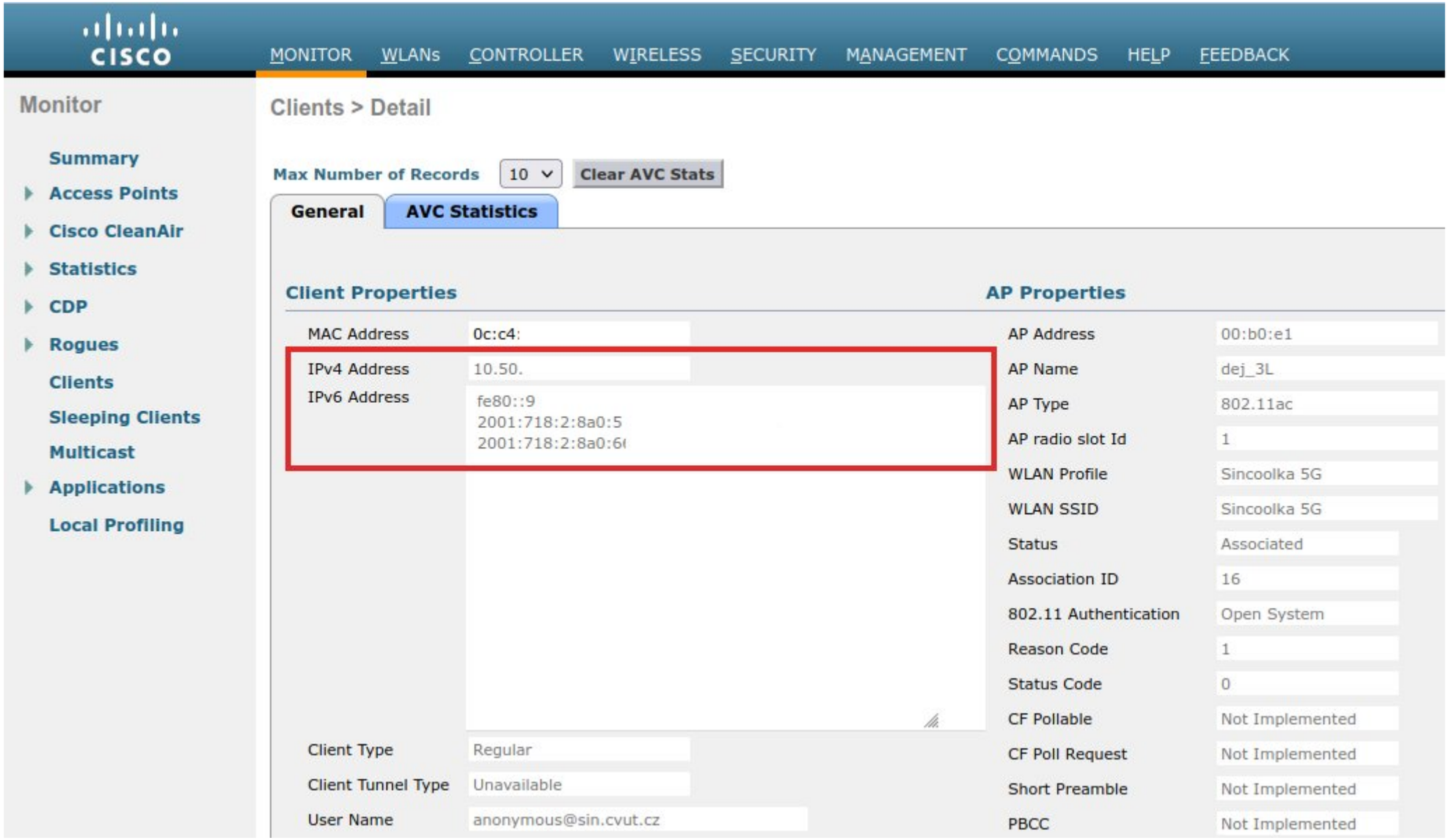
```
{master:0}[edit]
root@sin-switch-lab-1# set forwarding-options analyzer port-48 output ip-address 2001:718:2:8a0:444:22:33:44
                                                                                  ^
invalid ip address or hostname: 2001:718:2:8a0:444:22:33:44 at '2001:718:2:8a0:444:22:33:44'
```

Wi-Fi

Controllers

- Ruckus Virtual SmartZone (Sinkuleho dorm)
- Cisco WLC 2504 (Dejvická dorm)

Wi-Fi Cisco


MONITOR WLANs CONTROLLER WIRELESS SECURITY MANAGEMENT COMMANDS HELP FEEDBACK
Monitor
Summary
Access Points
Cisco CleanAir
Statistics
CDP
Rogues
Clients
Sleeping Clients
Multicast
Applications
Local Profiling
Clients > Detail
Max Number of Records
10
Clear AVC Stats
General
AVC Statistics
Client Properties
MAC Address
0c:c4:
IPv4 Address
10.50.
IPv6 Address
fe80::9
2001:718:2:8a0:5
2001:718:2:8a0:6
Client Type
Regular
Client Tunnel Type
Unavailable
User Name
anonymous@sin.cvut.cz
AP Properties
AP Address
00:b0:e1
AP Name
dej_3L
AP Type
802.11ac
AP radio slot Id
1
WLAN Profile
Sincoolka 5G
WLAN SSID
Sincoolka 5G
Status
Associated
Association ID
16
802.11 Authentication
Open System
Reason Code
1
Status Code
0
CF Pollable
Not Implemented
CF Poll Request
Not Implemented
Short Preamble
Not Implemented
PBCC
Not Implemented

Wi-Fi Cisco


CISCO
MONITOR WLANs CONTROLLER WIRELESS SECURITY MANAGEMENT COMMANDS HELP FEEDBACK
Wireless
Access Points
All APs
Direct APs
Radios
802.11a/n/ac
802.11b/g/n
Dual-Band Radios
Global Configuration
Advanced
Mesh
ATF
RF Profiles
All APs
Current Filter
Operational Status: UP,REG
[Change Filter] [Clear Filter]
Number of APs 12
AP Name
IP Address(Ipv4/Ipv6)
AP Model
AP MAC
dej_0P 2001:718:2:8f AIR-AP1852I-E-K9 00:b0:e1:
dej_1L 2001:718:2:8f AIR-AP1852I-E-K9 00:b0:e1:
dej_1P 2001:718:2:8f AIR-AP1852I-E-K9 00:b0:e1:
dej_4P 2001:718:2:8f AIR-AP1852I-E-K9 00:b0:e1:
dej_4L 2001:718:2:8f AIR-AP1852I-E-K9 00:b0:e1:
dej_2L 2001:718:2:8f AIR-AP1852I-E-K9 00:b0:e1:

Wi-Fi Cisco 1

Cisco WLC 2504 (8.5.X); AP Cisco Aironet 1852i

- Supports IPv6 with all commonly used management protocols, including CAPWAP, and setting IPv6 as the default.

- Tip: do NOT use SLAAC and DHCPv6 at the same time for APs.
  - APs will switch addresses and reboot periodically.

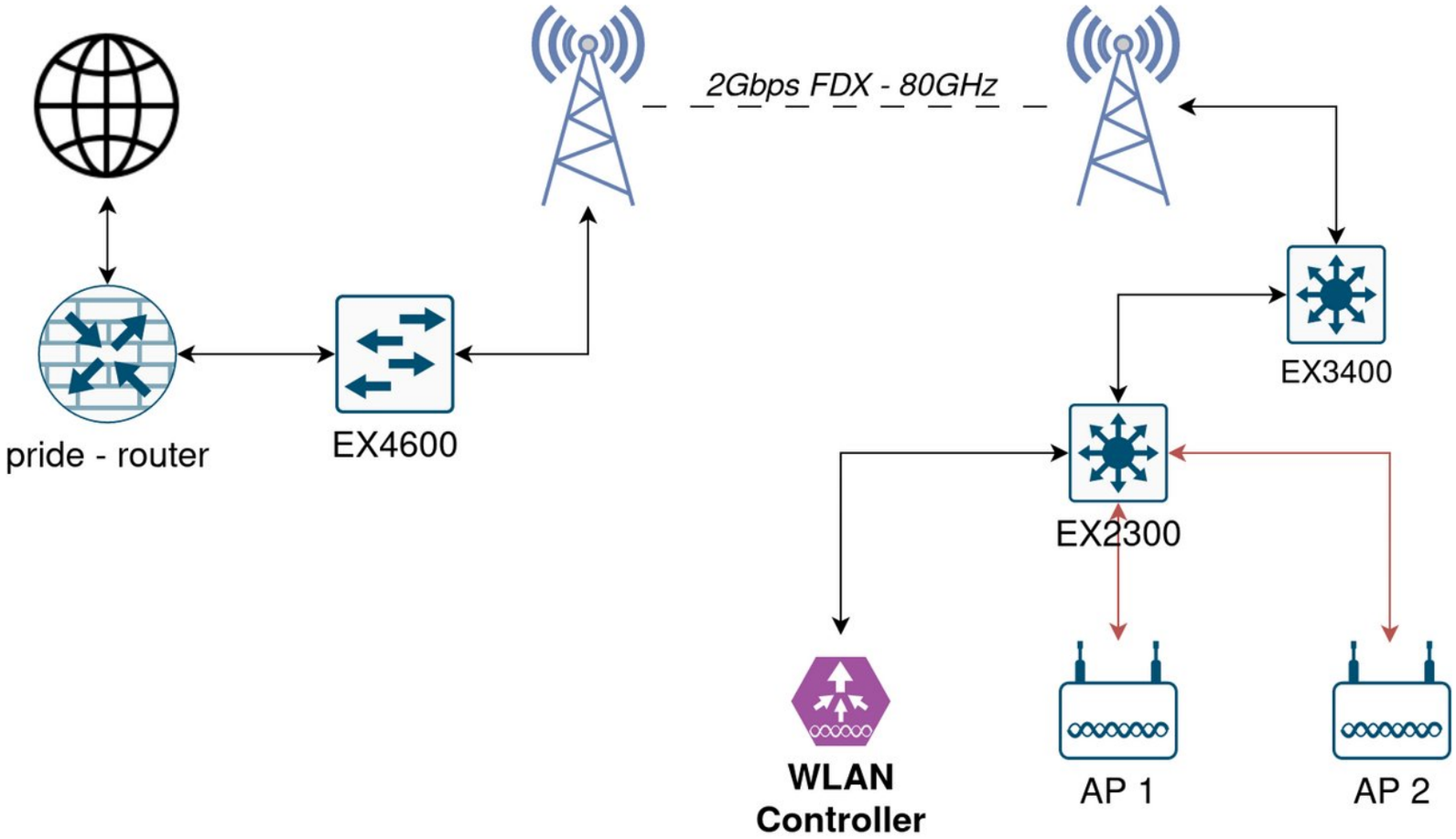
Wi-Fi Cisco 2

- APs with IPv6 always attempt to send packets to the default gateway. It is a documented behavior.

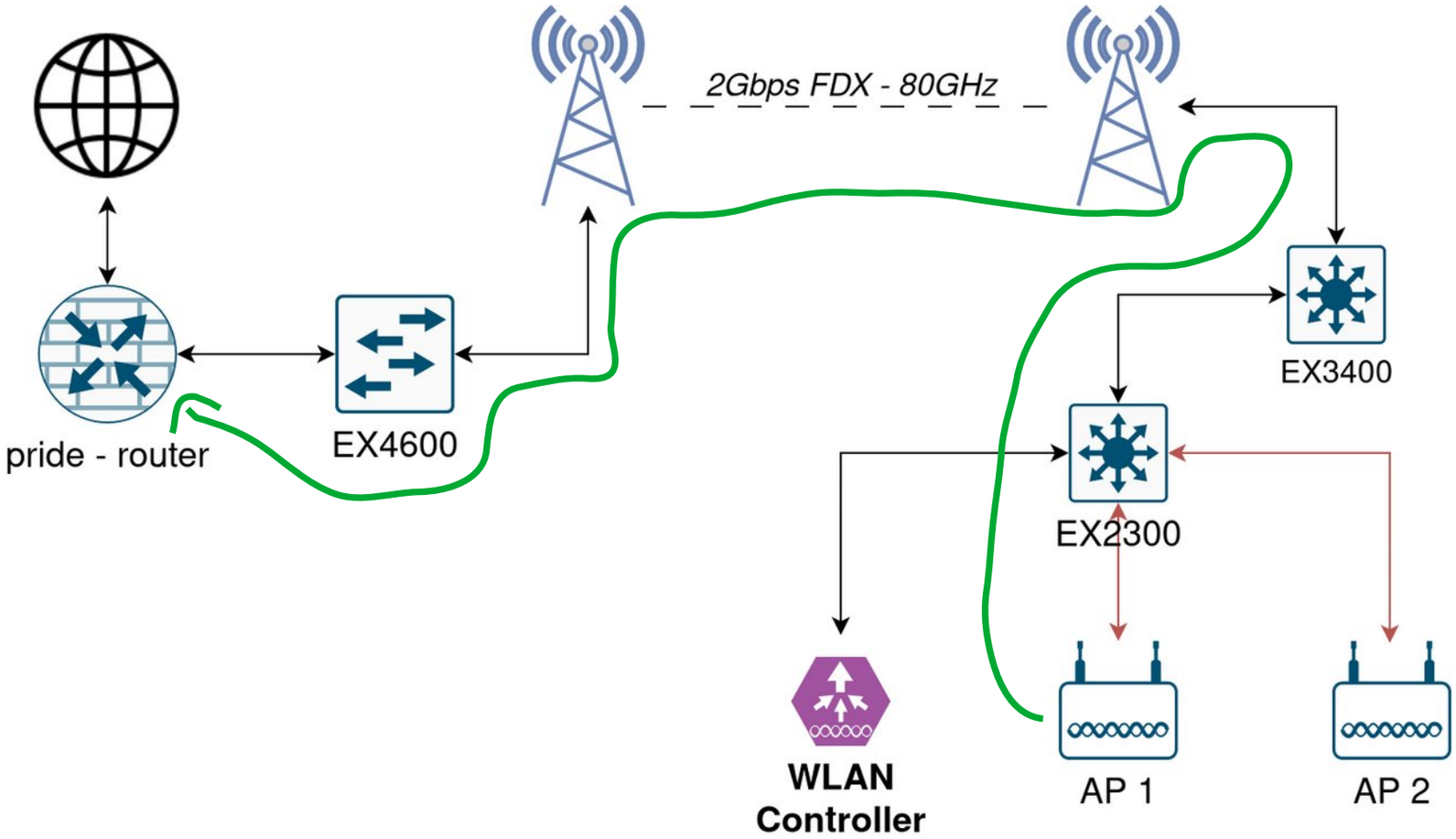
> ***"In a setup where IPv6 is used, we recommend the APs to be at least one hop away from the controller. As the IPv6 packets are always sent to the Gateway, if the AP and controller are in the same subnet, it increases the packet hops and impacts the performance."***

- That has caused a few issues...

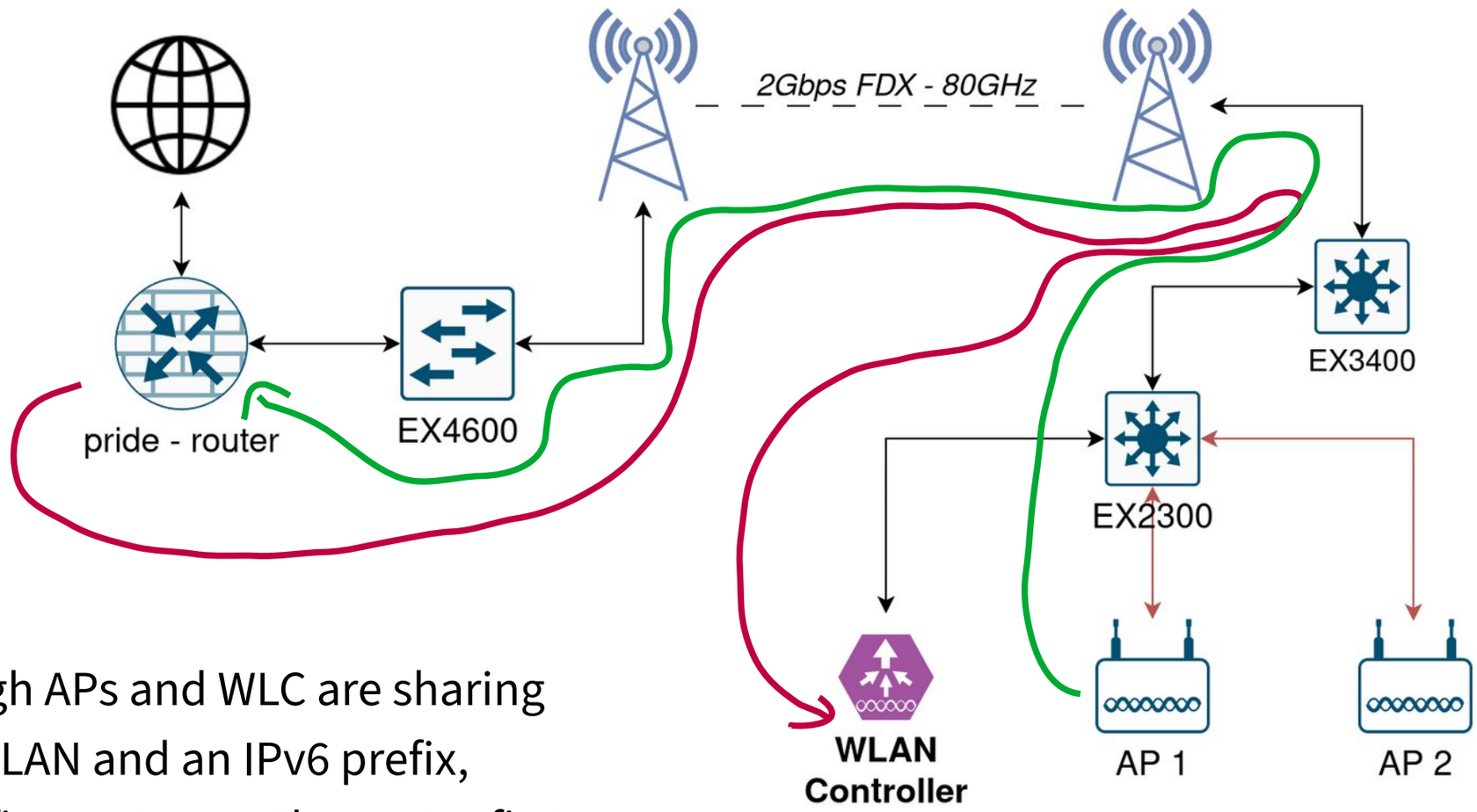
long long trip (Cisco WLC)



long long trip (Cisco WLC)

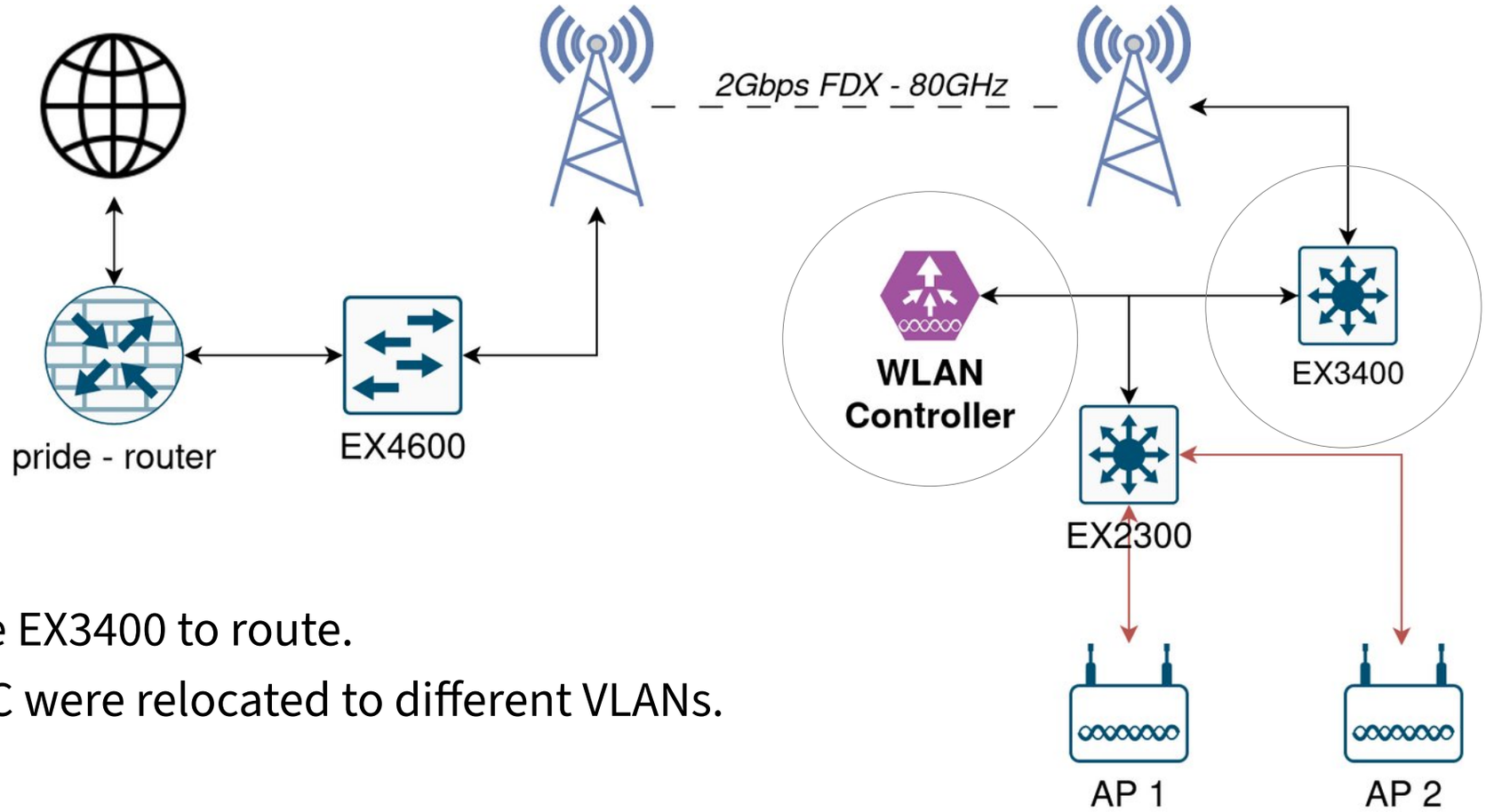


long long trip (Cisco WLC)



Even though APs and WLC are sharing
the same VLAN and an IPv6 prefix,
all the traffic must cross the router first.

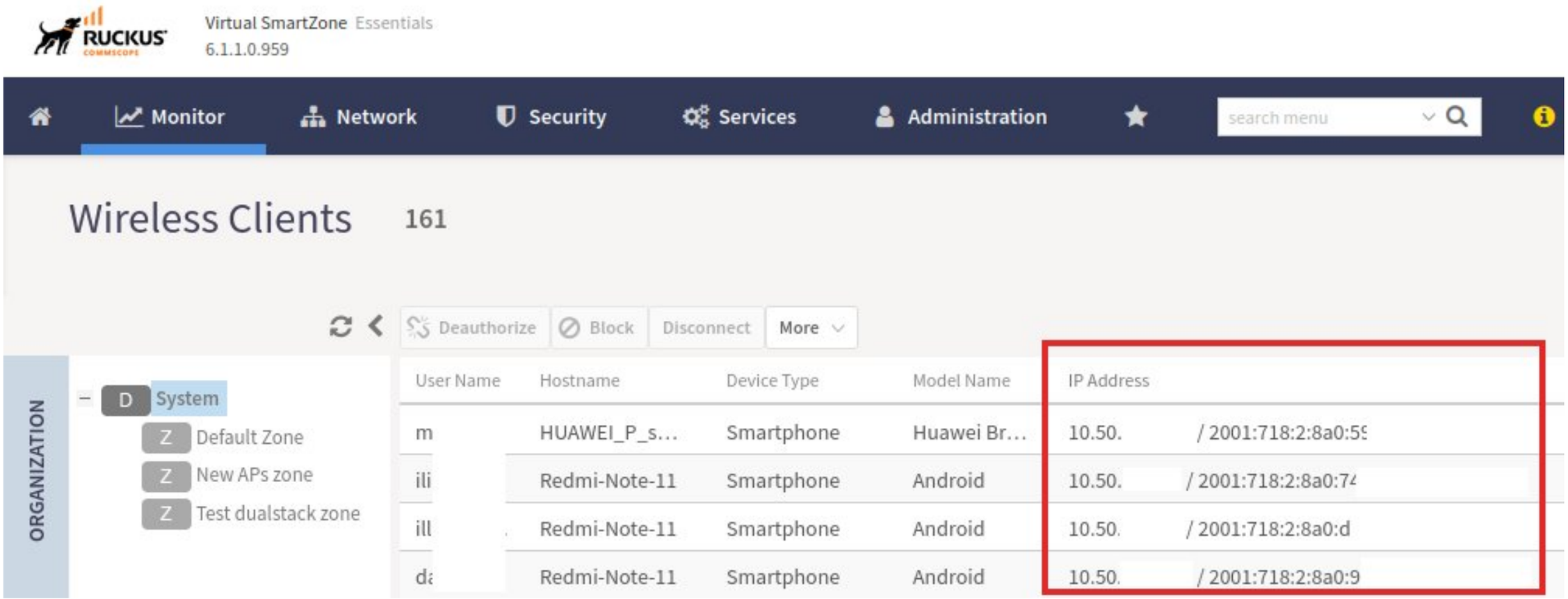
! fix long long trip



I taught the EX3400 to route.

AP and WLC were relocated to different VLANs.

Wi-Fi Ruckus


RUCKUS
Virtual SmartZone Essentials
6.1.1.0.959
Monitor
Network
Security
Services
Administration
search menu
Wireless Clients 161
Deauthorize
Block
Disconnect
More
ORGANIZATION
System
Default Zone
New APs zone
Test dualstack zone
User Name
Hostname
Device Type
Model Name
IP Address
m
HUAWEI_P_s...
Smartphone
Huawei Br...
10.50.
/ 2001:718:2:8a0:5
ili
Redmi-Note-11
Smartphone
Android
10.50.
/ 2001:718:2:8a0:7
ill
Redmi-Note-11
Smartphone
Android
10.50.
/ 2001:718:2:8a0:d
Redmi-Note-11
Smartphone
Android
10.50.
/ 2001:718:2:8a0:9

Wi-Fi Ruckus

AP Name	Status	Alarm	Total Traffic (1hr)	IP Address	Latency (2.4G)	Latency (5G)	Clients
SIN_14V_room_L...	Online	1	5.8GB	2001:718:2:8f	0ms	9.9ms	4
SIN_11S_R650	Online	2	1.7GB	2001:718:2:8f	0ms	23.5ms	16
SIN_14Z_R550	Online	2	586.2MB	2001:718:2:8f	0ms	6.6ms	3
SIN_04S_R550	Online	2	360.7MB	2001:718:2:8f	0ms	47.5ms	5
SIN_12Z_R550	Online	1	3.4GB	2001:718:2:8f	0ms	37.1ms	8
SIN_08V_R550	Online	2	325.5MB	2001:718:2:8f	0ms	28.4ms	4
SIN_12V_R550	Online	2	588.7MB	2001:718:2:8f	0ms	14.0ms	3

Wi-Fi Ruckus 1

Ruckus Virtual SmartZone 6.1.1; AP Ruckus R550, R650

- SmartZone can be set to IPv4/IPv6 mode, but not *IPv6-only* – probably because of licensing server and other functions such as Streaming Telemetry, which do not work over IPv6.
- AP can be set to IPv4/IPv6 or IPv6-only when creating a zone.
- Change is possible only by moving AP to a different zone.

Wi-Fi Ruckus 2

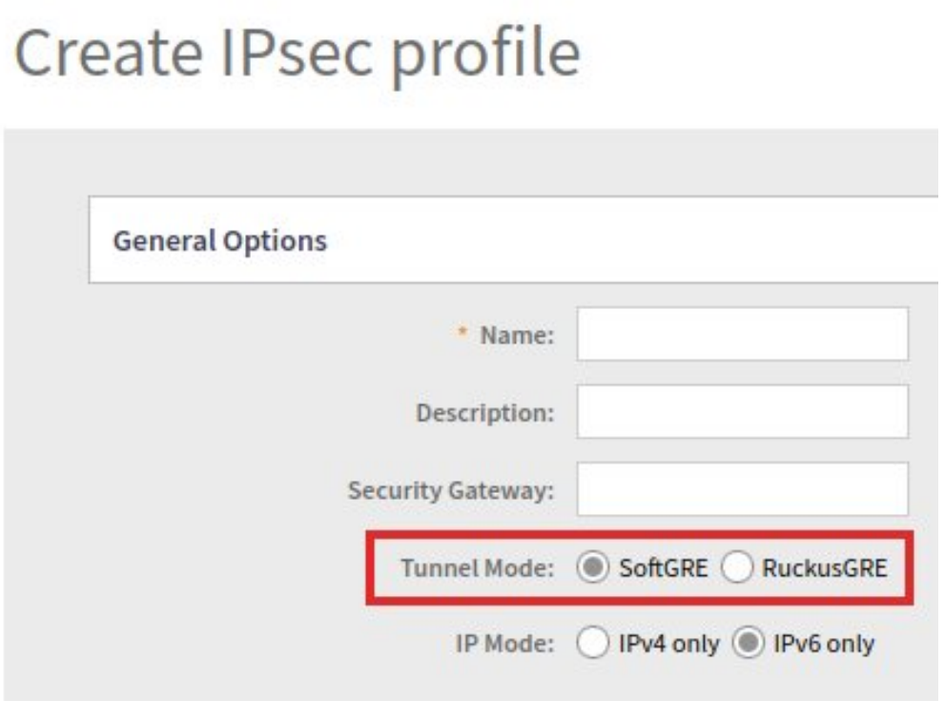
- In general – AP in dual IPv4/IPv6 mode prefer IPv4. :-(
- Traffic capture only works over IPv6 in the *IPv6-only* mode.
  - However it works well – verified during a support case.

- Older ZF7372 – IPv6 often stopped working with Client Isolation turned on.

  R550 is fine.

Ruckus – Not everything is IPv6-ready

Tunelling AP traffic through a data plane – L2oGRE+IPsec vs. RuckusGRE:



vs

Proprietary Ruckus technology fails to support IPv6.

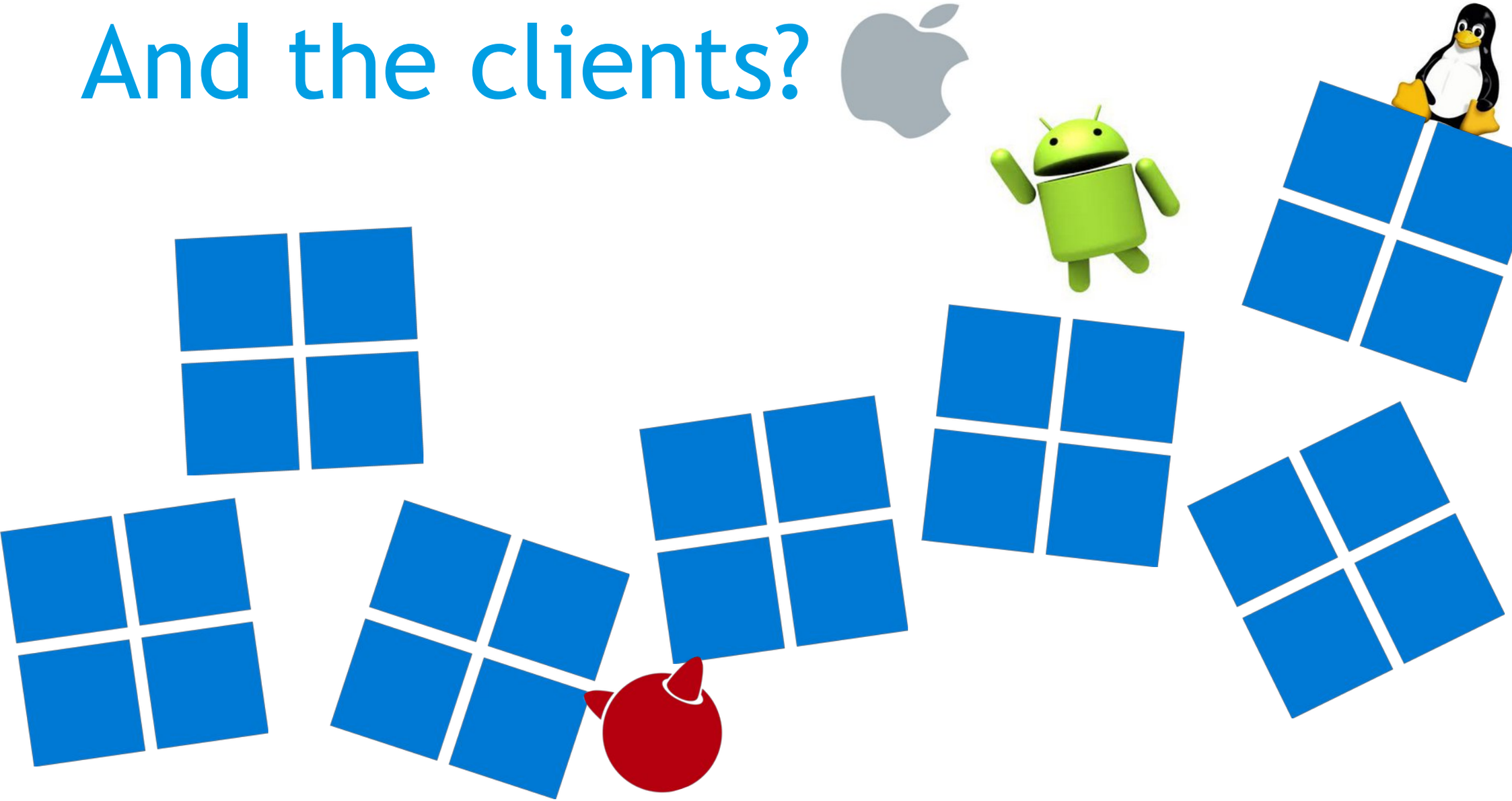
Ruckus – SoftGRE over IPv6

- SoftGRE = L2oGRE [RFC 1701/2784]
- In vSZ 5.2.2, a combination of SoftGRE and IPsec worked over IPv4, but not IPv6.
- SoftGRE without IPsec worked even over IPv6.
- SoftGRE concentrator can be created on Linux:
  - Example: https://github.com/jpereira/softgre/wiki
  - Or just use the `[ip6]gretap` module.

Proxmox VE cluster

- Hypervisors for VMs and LXC containers.
- Three members in our cluster, interconnected primarily via IPv6, with IPv4 as backup.
- IPv6 support is solid in Debian :-)

And the clients?



We had tested IPv6 some years ago

- After we had turned IPv6 on for the cable (DHCPv6)...
- No one complained, and I think no one noticed.
- 30 % of traffic immediately switched to IPv6 (Google, Facebook and similar).
- SLAAC on the Wi-Fi – the same.

- *A positive surprise overall...*

IPv6 and the clients – historically 1

- MAC address → static IPv6 (EUI-64).
  - 1F-B8-C1-CB-6E-EA → 2001:718:2:880:**1DB8:C1FF:FECB:6EEA**
- SLAAC [RFC4862].
- IPv6 RA Options for DNS [RFC6106].

- **Advantages:**
  - Easier access management for the admins.
- **Drawbacks:**
  - Privacy extensions → need to manually configure *every single client station*.

IPv6 and the clients – historically 2

- **Iteration no. 2:**
  Assigning IPv6 addresses via DHCPv6 based on MAC addresses.
  - Firewall only allows these IPv6 addresses.

  +++

  - Administrators have it simple®.
  - Common systems (Win, Linux, Mac) work without issues.

  - Android will not support DHCPv6.
    https://issuetracker.google.com/issues/36949085

DHCPv6 with MAC addresses

- DUID was supposed to replace MAC addresses for client ID, but it is not reliable.
- Mapping MAC addresses to IP addresses for DHCPv6 [RFC8415]
  - Kea DHCPv6 server cannot read raw MAC addresses.
  - But it can do DHCPv6-relayed addresses [RFC6939].
  - We have to use `dhcpy6d` alongside.

- … what about Wi-Fi?

Snake accounting 1

- The solution for the Android Wi-Fi issue?
  - Give in to SLAAC? **YES!**
  - But we need to watch the IPv6 addresses for each client and match them with their user identity...
  - **Wi-Fi APs track IP address changes and send them to the RADIUS Accounting server.** Cisco, Ruckus and Aruba do it, IPv4 and IPv6.
- Once we implemented 802.1X for user login, adding the accounting was not difficult.
- We track sessions by their ID, user identity, MAC addresses and IPv4/IPv6 addresses.

Snake accounting 2

- A client can change their address multiple times a day.

BettyKuffel, pixabay, Content License
https://pixabay.com/photos/snake-serpent-snake-shedding-skin-2932454/

```
/var/log/radius/radacct/
2001:718:2:8fx::abcd $ grep -R -F 24-
95-XX-XX-XX-XX -B11 ./detail-20230601
| grep Framed-Interface-Id |cut -d= -
f2 | sort | uniq
```

- 22c0:e80c:xxxx:xxxx
- 24ac:ba5b:xxxx:xxxx
- 6550:5570:xxxx:xxxx
- 96fb:188c:xxxx:xxxx
- 9748:2355:xxxx:xxxx
- a61f:7303:xxxx:xxxx
- beab:e709:xxxx:xxxx
- c12a:29a1:xxxx:xxxx
- d37:1364:xxxx:xxxx
- e645:ffc0:xxxx:xxxx

Snake accounting 3

- **FreeRADIUS**
  - Logging to `/var/log/radius/radius.log`.
  - Logging to `/var/log/radius/radacct/<NAS_IP>/detail-YYYYMMDD`.
    - Record of IPv6 addresses in time.
  - Accounting to the SQL DB.

/etc/raddb/sites-enabled/default

```
authorize {
    ...
    auth_log
    ....
}
accounting {
    ...
    detail
    ...
    -sql
    ...
}
post-auth {
    ...
    reply_log
    ...
}
```

Ruckus (Wi-Fi)

```
Thu Jun  1 00:02:07 2023
   Acct-Session-Id = "6477XXXX-12345678"
   Framed-IP-Address = 10.50.123.45
   Framed-Interface-Id = b501:xxxx:xxxx:xxxx
   Framed-IPv6-Prefix = 2001:718:2:8a0::/64
   Acct-Multi-Session-Id = "94b3……."
   Acct-Link-Count = 1
   Acct-Status-Type = Interim-Update
   Acct-Authentic = RADIUS
   User-Name = "anonymous@sin.cvut.cz"
   NAS-IPv6-Address = 2001:718:2:8fX::ABCD:DEFA
   NAS-Identifier = "94-B3-4F-XX-YY-ZZ"
   NAS-Port = 17
   Called-Station-Id = "94-B3-4F-XX-YY-ZZ:Sincoolka"
   Calling-Station-Id = "7C-7A-XX-XX-XX-XX"
```

Juniper (Ethernet)

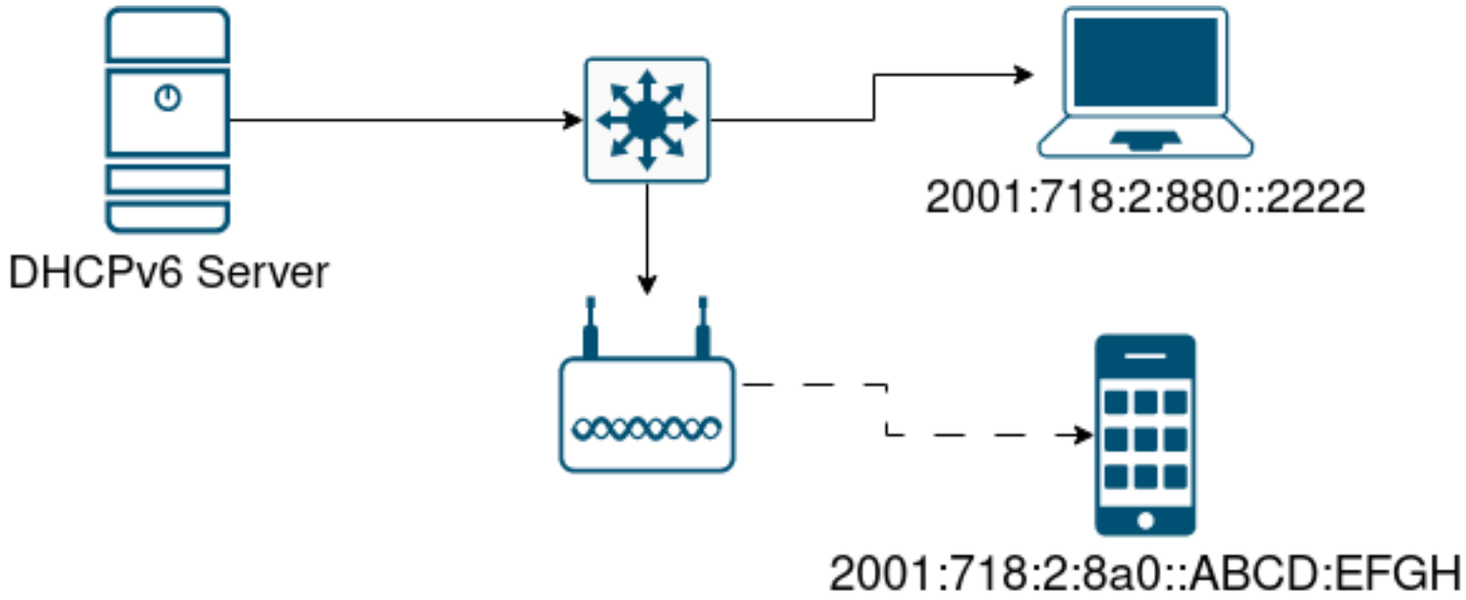
```
Sun Jun  4 18:30:20 2023
   User-Name = "28d2xxxxxxxx"
   NAS-Identifier = "sin-switch-lab-1"
   NAS-Port = 572
   Service-Type = Call-Check
   ...
   NAS-Port-Id = "ge-0/0/16.0"
   Acct-Authentic = RADIUS
   Acct-Status-Type = Start
   Acct-Session-Id = "8O2.1x8120000xxxxxxxx"
   Called-Station-Id = "20-d8-XX-XX-XX-XX"
   Calling-Station-Id = "28-D2-XX-XX-XX-XX"
   Framed-IP-Address = 147.32.XXX.YYY
   Framed-IPv6-Address = 2001:718:2:880:2ad2:XXXX:XXXX:XXXX
```

TL;DR Matching IPv6 to a client

- User identity + MAC address + port number.
- RADIUS Accounting with attributes:
  - Framed-IPv6-Address for Cisco, Juniper
  - Framed-IPv6-Prefix + Framed-Interface-Id for Ruckus
- Last IPv6 address in the SQL database, the rest in the files.

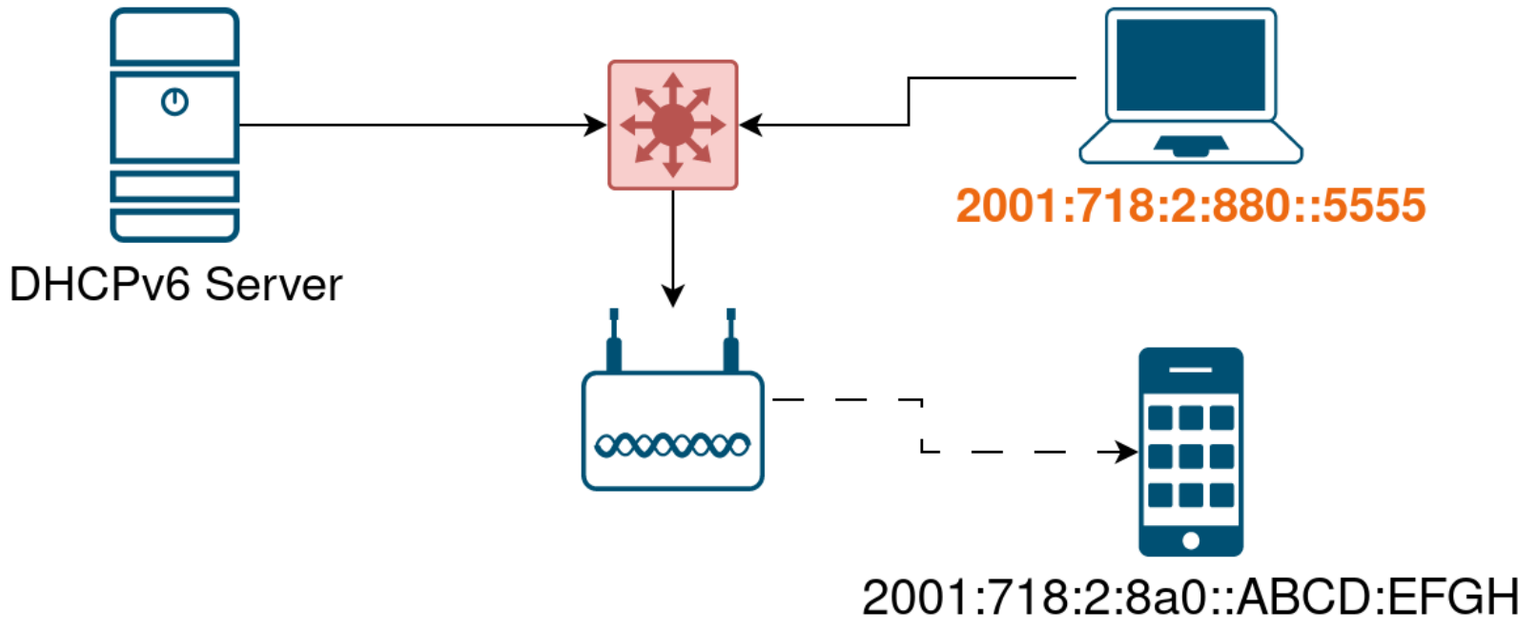
Next question.
How to ensure that the client does not steal a different address?

First-Hop Security



What happens if a client stops respecting their DHCPv6-assigned IPv6 address?

First-Hop Security



In the ideal case, the access switch/AP will enforce the assignment and discard packets with other source IPv6 addresses.

First-Hop Security

- **Switches (Juniper - Junos OS):**
  - DHCPv6 Snooping
  - Router Advertisement Guard
  - IPv6 Source Guard
  - Neighbor Discovery Inspection

- Not using:
  - SLAAC Snooping

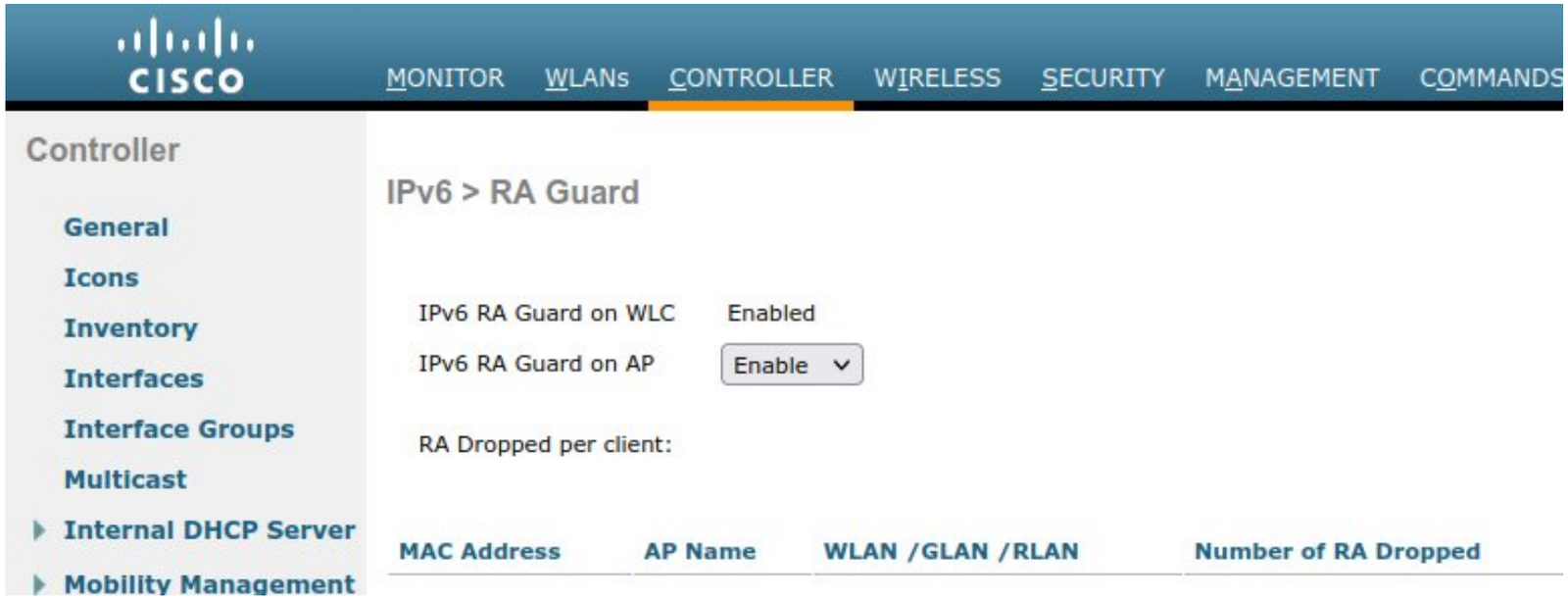
IPv6 Neighbor Discovery Inspection

- Jun 4 18:36:40 sin-switch-lab-1 dc-pfe[13269]:

  AS_PKT_NDI_FAILED: NDI FAILED: ND received, interface: **ge-0/0/16.0** [index: 572], vlan-id: 20, sender ip/mac: **2001:718:2:880:2ad2:xxxx:xxxx:xxxx/28:d2:xx:xx:xx:xx**, receiver ip/mac: 2001:718:2:880::1/54:52:00:xx:xx:xx

First-Hop Security

- **Wi-Fi (Cisco):**
  - Router Advertisement Guard
  - DHCPv6 Snooping
  - *? IPv6 Source Guard (not tested)*
  - IPv6 ACLs
  - *Etc.*



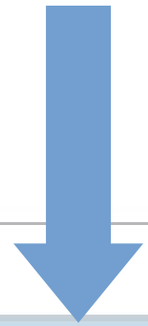
First-Hop Security

- **Wi-Fi (Ruckus):**
  - Router Advertisement Guard
  - DHCPv6 / SLAAC Snooping
  - ~~*IPv6 Source Guard*~~
  - IPv6 ACLs
- However, we can account for all the IP addresses used by the client.

First-Hop Security: DHCPv6 - Ruckus

```
$ ip -br a
wlan0    UP    2001:718:2:8a1::1000/128
$ ping -Iwlan0 google.com
64 bytes from prg03s12-in-x0e.1e100.net
(2a00:1450:4014:80e::200e): icmp_seq=1 ttl=120 time=1.96 ms


$ sudo ip a del dev wlan0 2001:718:2:8a1::1000/128
$ sudo ip a add dev wlan0 2001:718:2:8a1::2555/128
$ ping -Iwlan0 google.com
64 bytes from prg03s12-in-x0e.1e100.net
(2a00:1450:4014:80e::200e): icmp_seq=1 ttl=120 time=1.55 ms
```



Activity
Client [7c7a @10.51. @7C:7A] IP address was updated/renewed on WLAN [SinLAB-5G] from AP [SIN_13Z
Client [7c7a @10.51. @7C:7A] IP address was updated/renewed on WLAN [SinLAB-5G] from AP [SIN_13Z
Client [7c7a @10.51. @7C:7A] IP address was updated/renewed on WLAN [SinLAB-5G] from AP [SIN_13Z
Client [7C:7A] IP address was updated/renewed on WLAN [SinLAB-5G] from AP [SIN_13Z_R550@94:B3].
Client [7C:7A] joined WLAN [SinLAB-5G] from AP [SIN_13Z_R550@94:B3] on [a/n/ac].

Printers

(American Chopper,
"NHL Bike B2 Bomber Bike,"
aired April 9th, 2009)

Printers can do IPv6, but… 1

Test OKI C542dn (cca 2016)

- Works with IPv6, but cannot set IPv6 DNS.
  IPv6 SNTP works, but only with static IPv6 setting, not hostname.
- Printing over 9100/tcp works.
- Cannot set static IPv6, only DHCPv6 / SLAAC.
- „IPv6-only“ mode is unreliable.
  - If the default IPv4 gateway is unreachable, printer’s web interface freezes up, incl. IPP.
  - At least some IPv4 must be set. Gateway and DNS can be set to 0.0.0.0, then DNS does not work, but at least the web interface does not freeze anymore.
  - Connection to the printer using a hostname works, if the host and domain name are set properly. If not, either the web interface freezes, or you receive a "Bad Request." (400)
- TL;DR IPv6 works, even though it’s not good.
- Firmware upgrade only uses IPv4.

Printers can do IPv6, but… 2

Test HP Color LaserJet Professional CP5225dn (cca 2009?)

- HPLIP does not support IPv6. socket:// works though.
- 9100/tcp raw printing works.
- net-snmp (snmpwalk atd.) prefers the IPv4 when a hostname is resolved, but if only an AAAA record exists, it will use that.
- No support for IPv6 DNS, very limited settings.
- No option to set static IPv6, only DHCPv6 / SLAAC.
- Firmware upgrades? ***TODO TEST, but I don't believe it***

Printing for members over IPv6

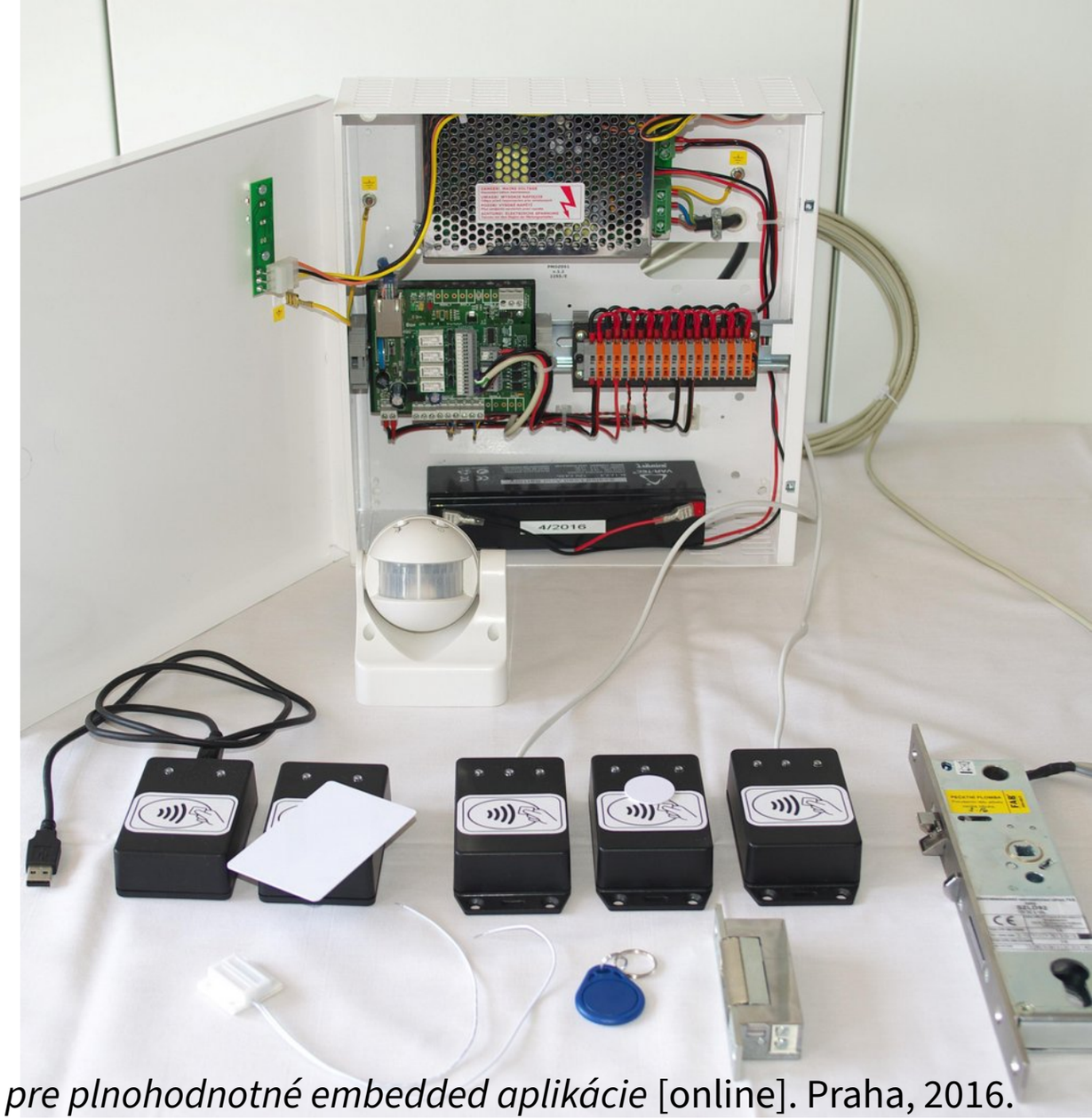
- **TL;DR not working yet**
- Our members can print to our printer.
- The user identity is identified via their IPv4 address, and the print is accounted to the user.
- We currently do not support IPv6 because of Wi-Fi and address generation.
- But if we could dynamically update last used IPv6 address, via RADIUS Accounting, then it could work.

TL;DR Printers

- Our systems communicate with our printers over IPv6.
- We keep an IPv4 address for them, so that they don't break altogether.
- Printing for members is over IPv4 only – we need to identify the user.

The gym

- Embedded devices with ARM
- VoCore, OpenWRT



DROZD, Stanislav. *ARM9 platforma ako low-cost riešenie pre plnohodnotné embedded aplikácie* [online]. Praha, 2016. [vid. 2023-05-24]. Diplomová práce. ČVUT v Praze, Fakulta elektrotechnická. Dostupné z: https://dspace.cvut.cz/handle/10467/64632

The gym and the card system 1

- The control unit is IPv4+IPv6 now.

```
# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast qlen 1000
    link/ether 00:0c:c6           brd ff:ff:ff:ff:ff:ff
    inet 10.10.110.  /24 brd 10.10.110.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 2001:718:2:8f      /64 scope global
       valid_lft forever preferred_lft forever
    inet6 fe80::20c:c6ff:f         /64 scope link
       valid lft forever preferred lft forever
```

The gym and the card system 2

- The satellite card readers are IPv4, because our SINIS connects to them.
- There is no DHCPv6 allocation for them yet.
- Some devices don’t have an IPv6 ping executable. This does not prevent IPv6 function in any way.

```
# ping 2001:718:2:880::1
ping: bad address '2001:718:2:880::1'
# ping6 2001:718:2:880::1
-sh: ping6: not found
```

The gym and the card system 3

```
# cat /etc/os-release
NAME=Buildroot
VERSION=2014.08-00650-g1f8fb45-dirty
ID=buildroot
VERSION_ID=2014.08
PRETTY_NAME="Buildroot 2014.08"
#
```

- Historical OpenWRT.
- In a network disconnected from the Internet.

What else is there that has IPv6

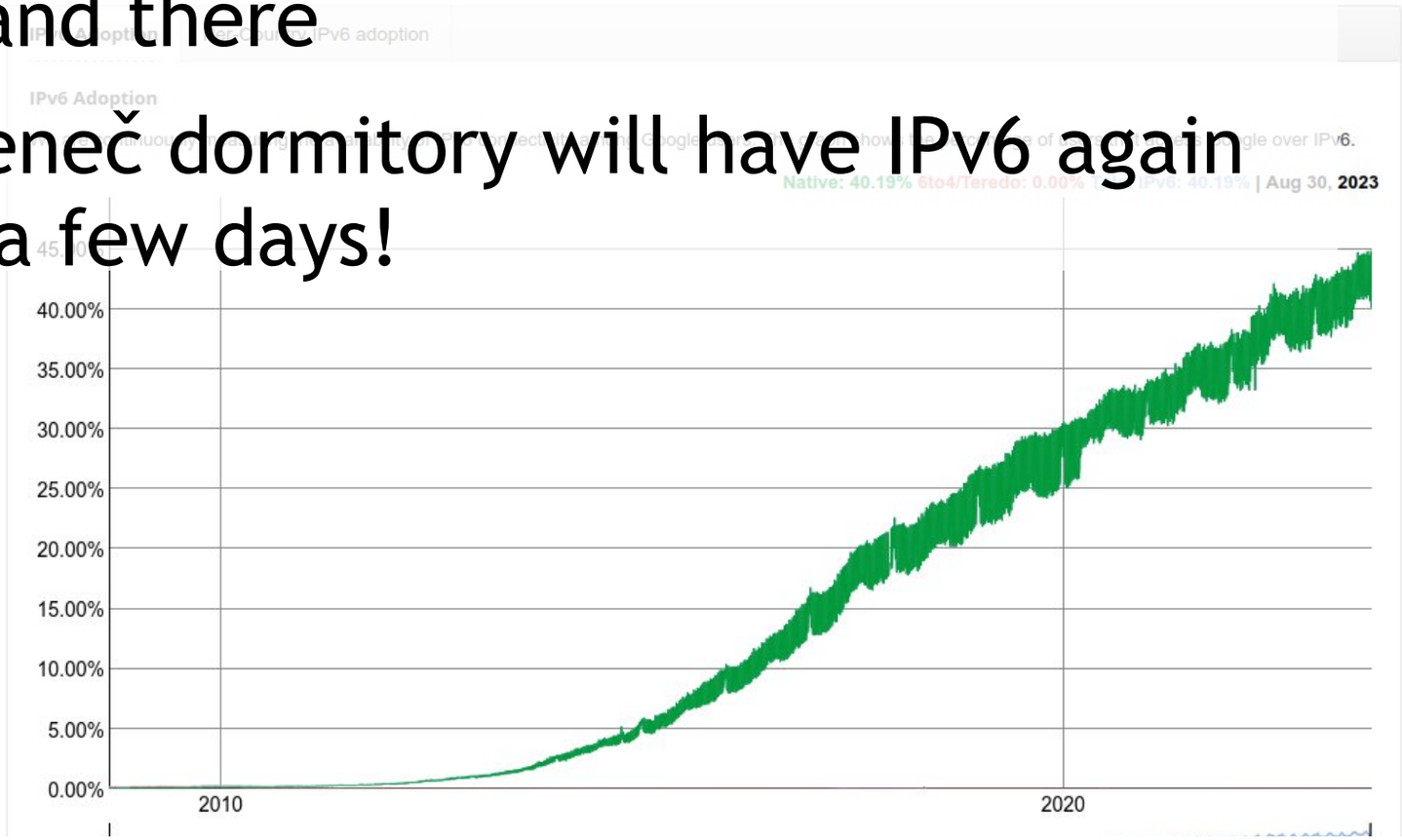
- DCN with the Ericsson.
- Several Mikrotiks.
- Raspberry Pi.

NOT on IPv6 yet

- „Poseidon“ monitoring probes (old)
  - No IPv6 support.
- Guest network
  - Needs a modification of the SINIS.
- Printing for our members
  - Because of user identification.
- Satellite card readers
  - A change in the system architecture is necessary.

… so, what's next?

- An IPv6-only network for the brave
- Smaller fixes here and there
- A big success – Bubeneč dormitory will have IPv6 again when it reopens in a few days!



Thank you!

- Download slides at sestka.sin.cvut.cz later.
- **Thanks to:**
  - Silicon Hill and other clubs for the ideas and prior research
  - Our admins during the years
  - You for watching! :)