



Mission ~~Im~~Possible

Turning IPv4 Off in an Enterprise Network

(High-level overview - come to the side meeting for the full version)

Jen Linkova, furry@google.com

Motivation

Running out of private IPv4 addresses

Dogfood and testing

Dual stack is hard



Source: www.wikipedia.org

"Entities should not be multiplied without necessity."

William of Ockham

Network Overview

- SLAAC-only (no DHCPv6 for address assignment)
- NAT64/DNS64 to access IPv4-only destinations
 - NAT64 at the site edge
 - Router Advertisements options for DNS64 and PREF64
- Centralized DHCPv4 infrastructure
- Wired ports: 802.1x + dynamic vlan assignment

Previously on...

2020: IPv6-only Guest WiFi and wired networks

Dedicated IPv4-enabled SSID and wired vlan for fallback

Reclaimed a lot of IPv4 addresses

More details: ["The Day I Broke All the Treadmills" RIPE81 presentation](#)

IPv6-Only Guest: Lessons Learned

Dedicated SSID/VLAN: not a good idea

- Confusing for users
- Higher IPv4 consumption
- Lower visibility to issues
- Scalability concerns
- Operational complexity

We need something better!

IPv6-mostly Network

A network enabling co-existence of IPv6-only and IPv4-enabled devices

Client Indicates IPv6-only Capability

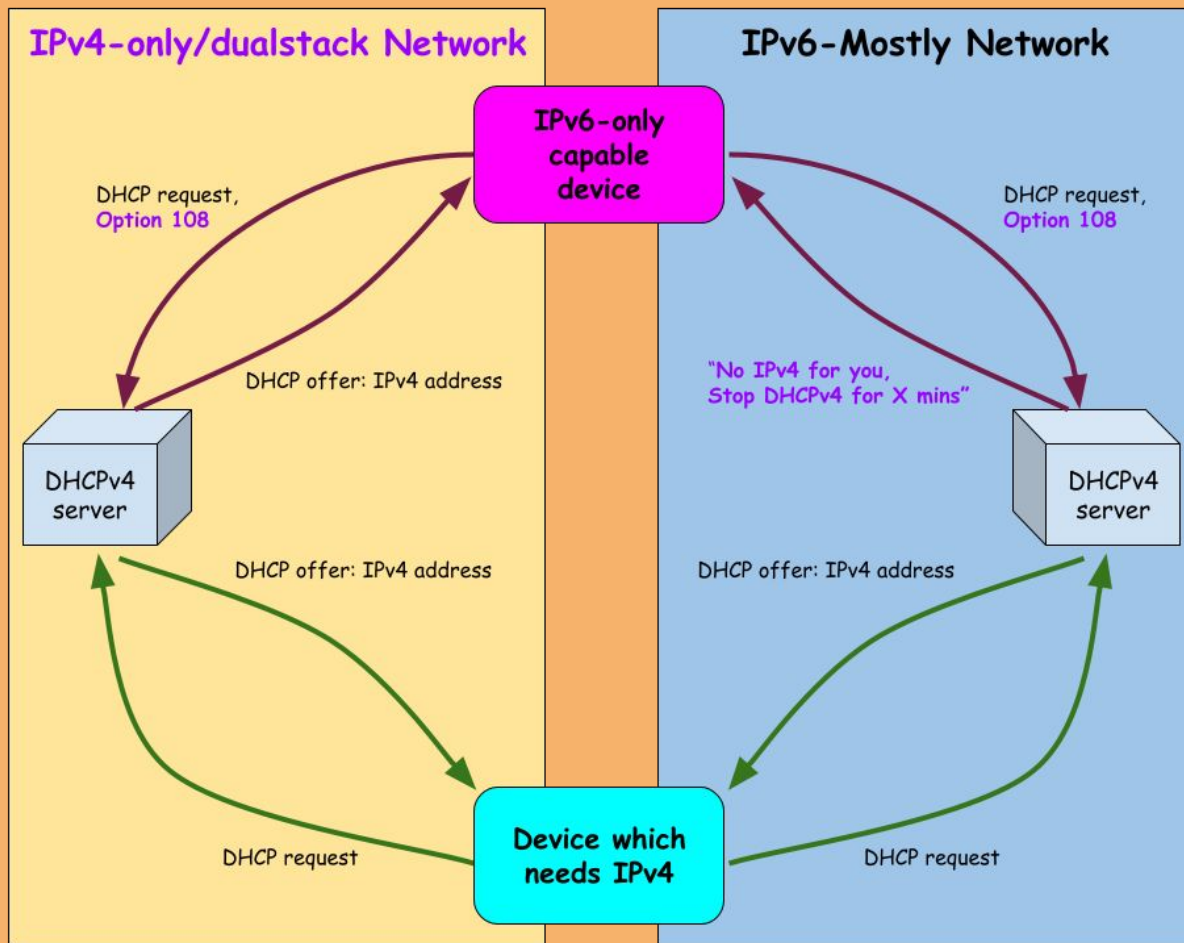
```
graph TD; A[Client Indicates IPv6-only Capability] --> B[Server checks if the given network supports IPv6-only clients]; B --> C[IPv6-Only Capable client on IPv6-Only capable network No IPv4 allocated]; B --> D[All other cases: IPv4 Allocated];
```

Server checks if the given network supports IPv6-only clients

IPv6-Only Capable client on
IPv6-Only capable network
No IPv4 allocated

All other cases:
IPv4 Allocated

RFC8925: Use DHCPv4 to Turn IPv4 Off



Project Scope

Network Infrastructure across all offices globally:

- Corporate WiFi and IPv4-enabled (fallback) Guest WiFi
- Wired user-facing segments

Devices migrated to IPv6-Only:

- All Android, iOS (15+), MacOS 13+
 - send DHCPv4 Option 108
 - support 464XLAT and PREF64
- Opt-in for selected ChromeOS and Linux devices

Rollout Schedule: March - Nov 2023

- Pilot in 3 locations for 2 months
- Extended pilot in 5 locations for 1 month
- “Stop the bleeding”: enable IPv6-mostly for greenfields
- Incremental rollout in 4 months, enabling Option 108 per subnet (10, 15, 25, 50, 60, 70, 80, 90, 100% of all networks)

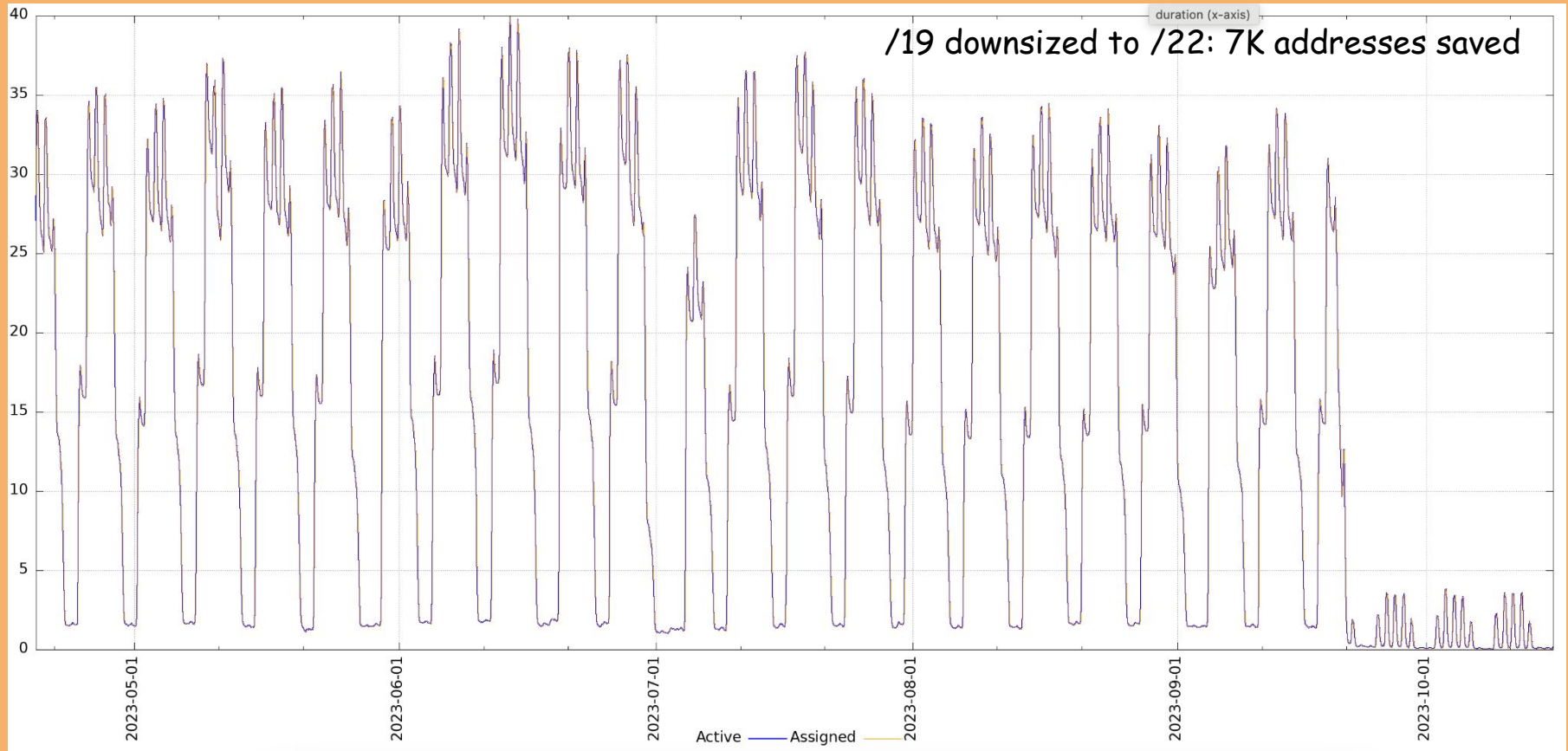
WE ARE HERE



Results

- No blocking issues found
 - *A few cosmetic issues: all fixed in MacOS Sonoma*
- DHCPv4 utilization drops by 3-4 times (average) on WiFi
- Expecting to reclaim at least 300K addresses

A Random Network: DHCP Utilization Drop



Lesson Learned #0

The only way to get IPv6 deployed is to run out of IPv4

Lesson Learned #1: "You Know Nothing, Jon Snow"

You do not really operate IPv6 until you turn IPv4 off

- Happy Eyeballs hide the problems
 - *"My workstation loses IPv6 DNS for a few mins after waking up"*
- Users do not report issues
- Issues are not getting fixed

Discovery #1: ~~Duck~~ Host Test

Dual-stack network segment
192.0.2.0/24, 2001:db8:1::/64

192.0.2.100

2001:db8:1::192

A device which
looks like a host
and
behaves like a host,
it's probably a host

..or is it a router?

dual-stack network segment
192.0.2.0/24, 2001:db8:1::/64

IPv6-mostly
migration

IPv6-mostly network segment
2001:db8:1::/64

192.0.2.100 2001:db8:1::192

Nat 10.0.0.0/24 ↔ 192.0.2.100

10.0.0.0/24

tethered system

Tethered system

192.0.2.100 2001:db8:1::192

~~Nat 10.0.0.0/24 ↔ 192.0.2.100~~

Broken connectivity

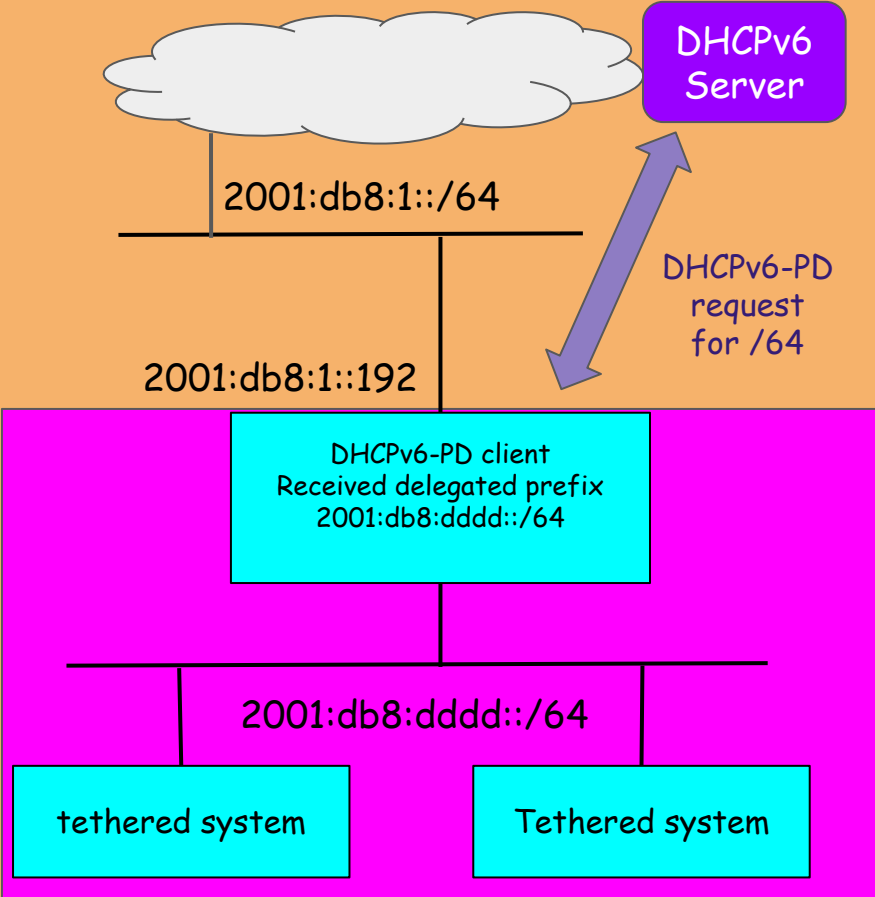
10.0.0.0/24

tethered system

Tethered system



Solution: DHCPv6-PD



Other Keys To Success

- Having IPv6 enabled on endpoints ;)
- Allowing extension headers
 - Fragment header
 - Almost inevitable for NAT64 + UDP
 - ESP
 - Required by WiFi calling and VPNs
- Default Address Selection Rule 5.5
 - Critical when clients move between segments

More details in the side-meeting talk

New Drafts

- Using DHCPv6-PD to Allocate Unique IPv6 Prefix per Client in Large Broadcast Networks ([draft-ietf-v6ops-dhcp-pd-per-device](#))
- 464 Customer-side Translator (CLAT): Node Recommendations ([draft-link-v6ops-claton](#))
- Using Subnet-Specific Link-Local Addresses ([draft-link-v6ops-gulla](#))

Next Steps

2024: Migrate ChromeOS and Linux endpoints

The screenshot shows the ChromeOS Experiments page. At the top left, the word "Experiments" is displayed. A blue box in the top right corner contains the text "ChromeOS 114 and above". Below the title, there are two columns: "Available" on the left and "Unavailable" on the right. A horizontal line separates the "Available" section from the "Unavailable" section. In the "Available" section, the experiment "Enable RFC8925 (prefer IPv6-only on IPv6-only-capable network)" is listed. Below the title, there is a description: "Let ChromeOS DHCPv4 client voluntarily drop DHCPv4 lease and prefer to cooperate IPv6-only, if the network is also IPv6-only capable. – ChromeOS". Below the description is the code "#enable-rfc-8925". To the right of the code is a dropdown menu with the following options: "Default" (selected), "Enabled", and "Disabled".

Experiments

ChromeOS 114 and above

Available Unavailable

Enable RFC8925 (prefer IPv6-only on IPv6-only-capable network)

Let ChromeOS DHCPv4 client voluntarily drop DHCPv4 lease and prefer to cooperate IPv6-only, if the network is also IPv6-only capable. – ChromeOS

#enable-rfc-8925

Default ▾

Default

Enabled

Disabled

QUESTIONS?