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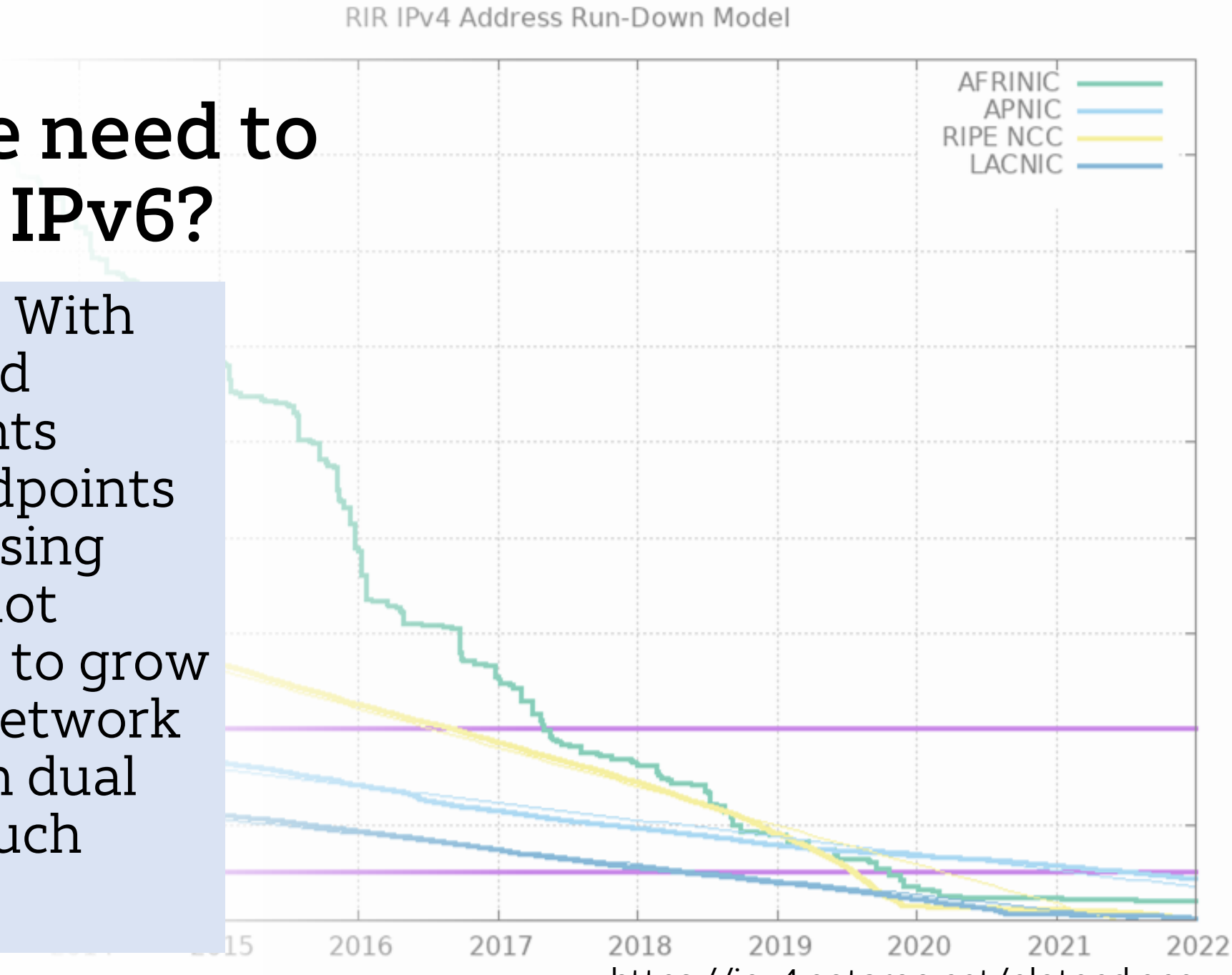
Increasing IPv6 Utilization in Consumer Networks

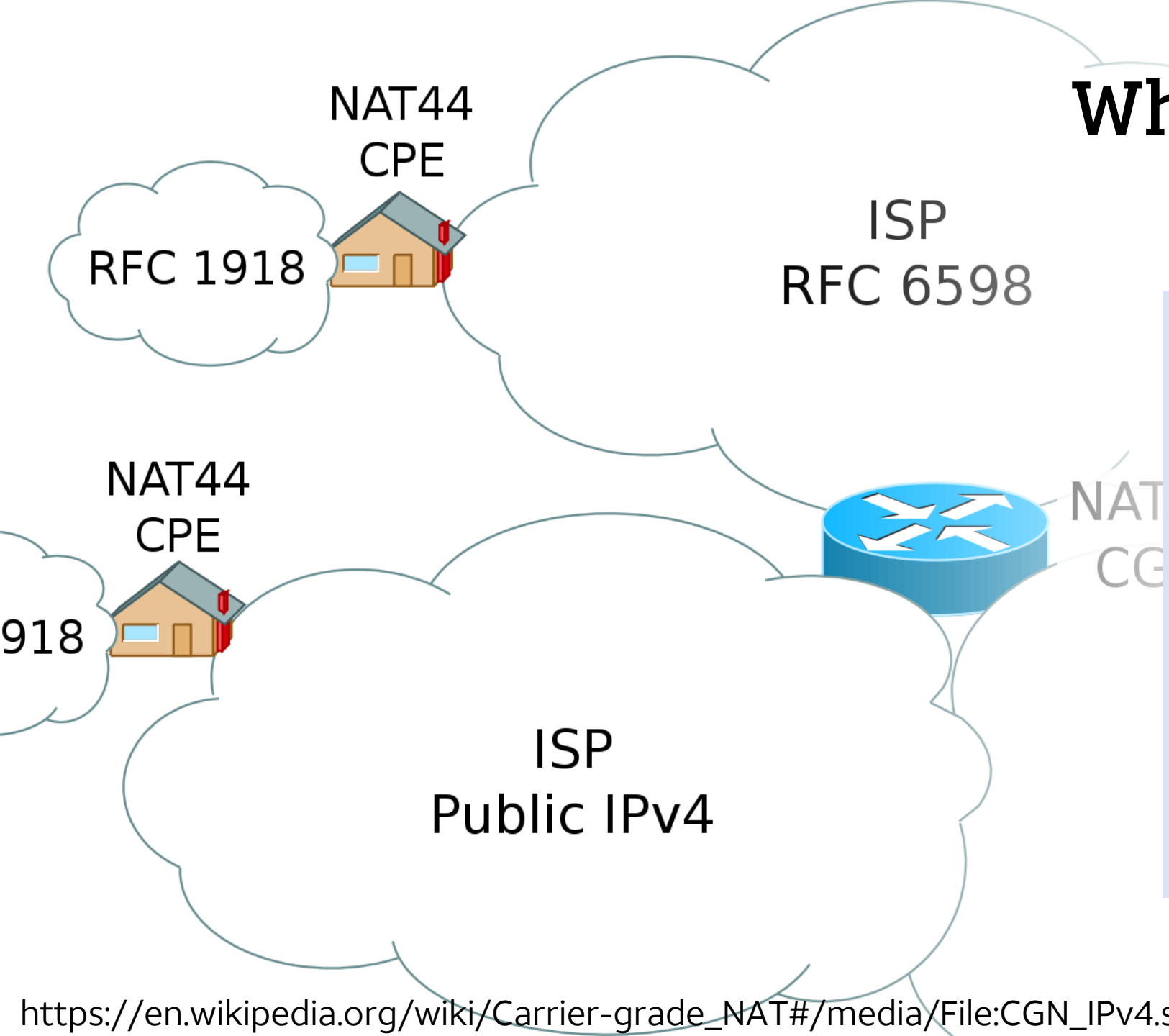
Why do we need to shift to IPv6?

IPv4 exhaust is real. With more broadband and mobility deployments every day, more endpoints means more addressing requirements. It is not feasible to continue to grow with the same old network designs operating in dual stack (v4+v6) for much longer.



https://ipv4.potaroo.net/plotend.png

Why do we need to shift to IPv6?



Eventually will need some form of CGN (MAP-T, etc….) to deal with IPv4 exhaust on consumer networks. These CGN deployments will have to be MASSIVE to be able to handle the load of existing IPv4 traffic.

https://en.wikipedia.org/wiki/Carrier-grade_NAT#/media/File:CGN_IPv4.svg

Where is IPv6 supported?

(Examples only, not a complete list)

Many large consumer networks support IPv6 to the CPE

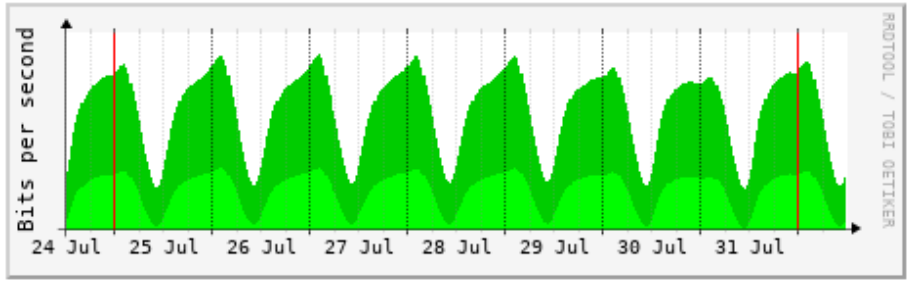
- AT&T
- Comcast
- T-Mobile
- Verizon

Many big content providers support IPv6

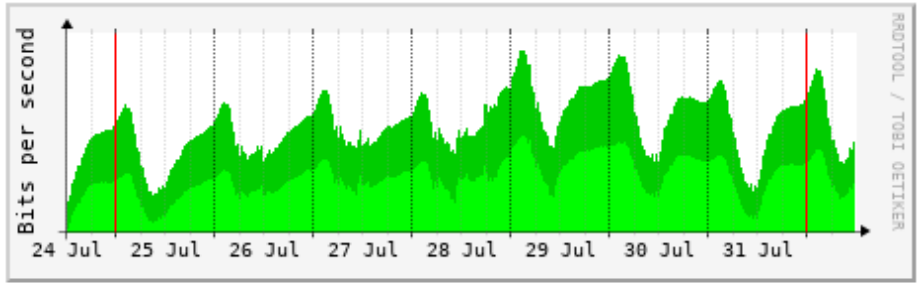
- Akamai
- Amazon
- Facebook
- Google
- Netflix

Mobile and Desktop content

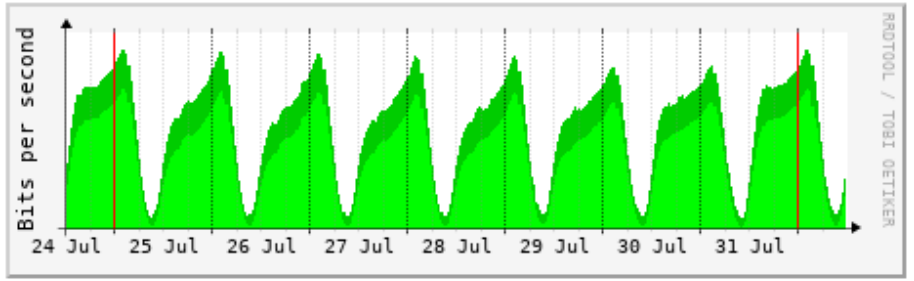
Different kinds of content providers have different ratios of IPv6 traffic



Maximum Percent of traffic that is IPv6: 46.45%



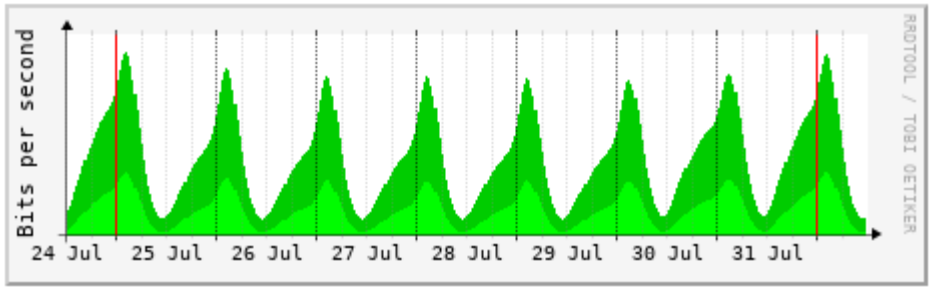
Maximum Percent of traffic that is IPv6: 70.87%



Maximum Percent of traffic that is IPv6: 84.00%

Video

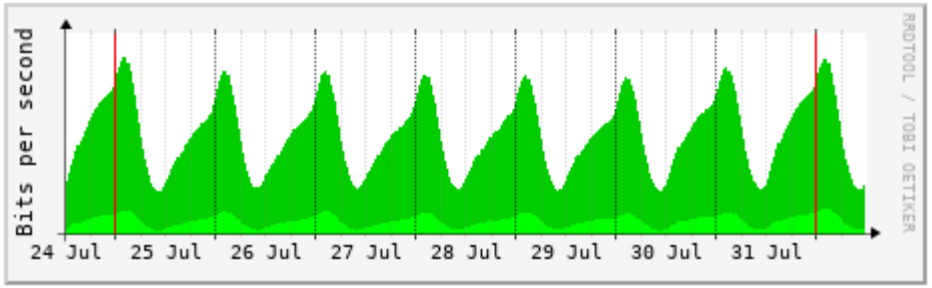
Different kinds of content providers have different ratios of IPv6 traffic



Maximum Percent of traffic that is IPv6: 38.77%

Cloud Hosting

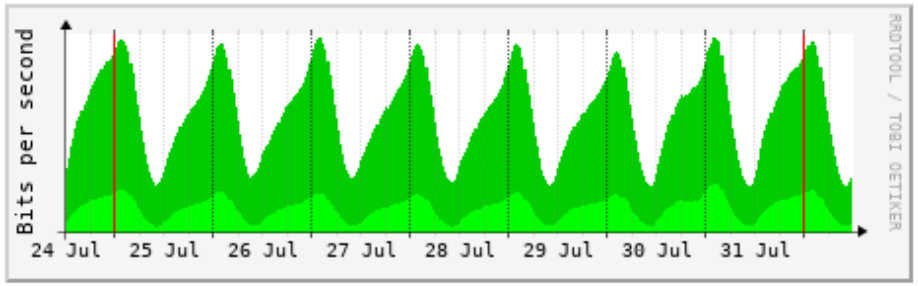
Different kinds of content providers have different ratios of IPv6 traffic



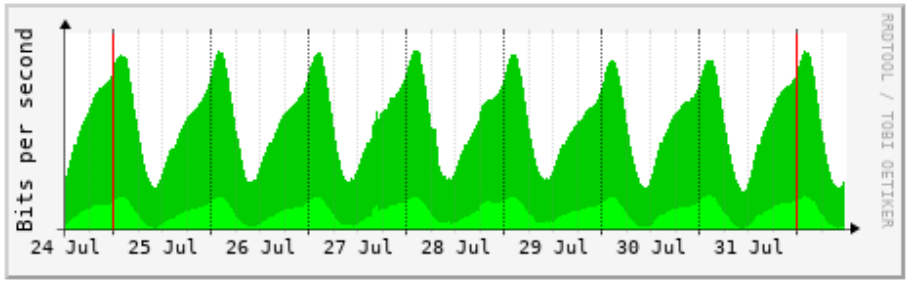
Maximum Percent of traffic that is IPv6: 22.11%

CDN

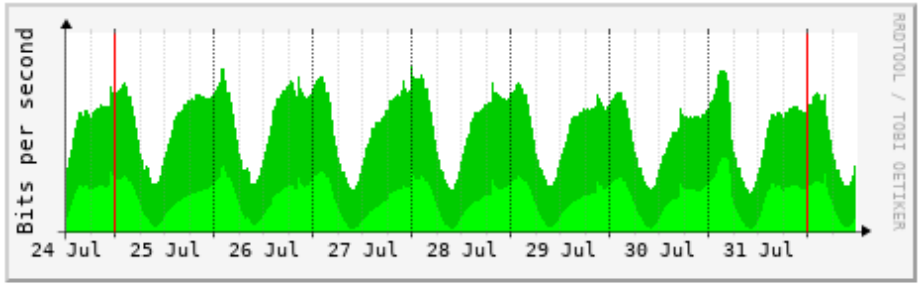
Different kinds of content providers have different ratios of IPv6 traffic



Maximum Percent of traffic that is IPv6: 26.79%

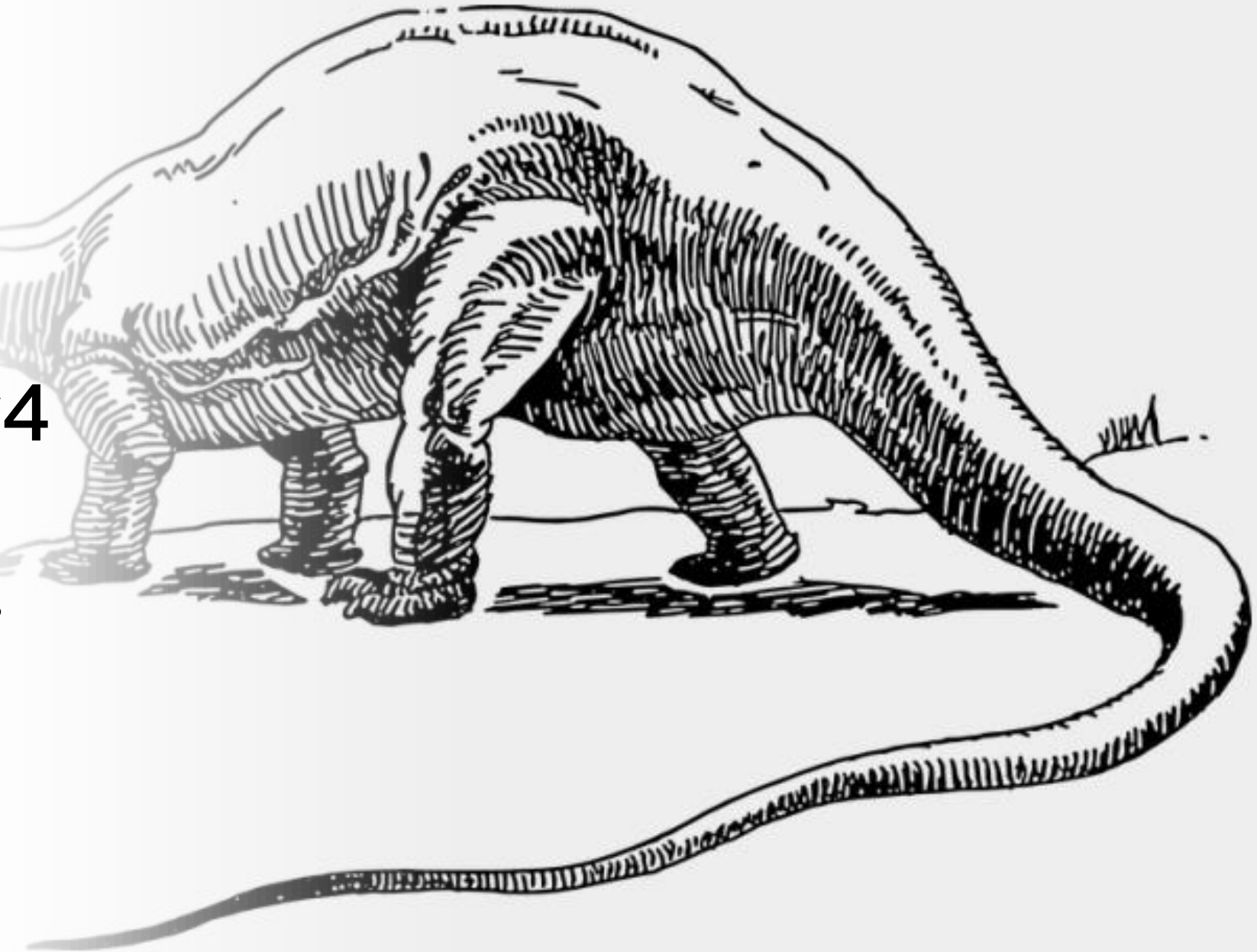


Maximum Percent of traffic that is IPv6: 28.50%



Maximum Percent of traffic that is IPv6: 52.13%

The migration away from IPv4 will have a VERY long tail.



So why do we not have more ipv6 traffic?

IPv6

28%

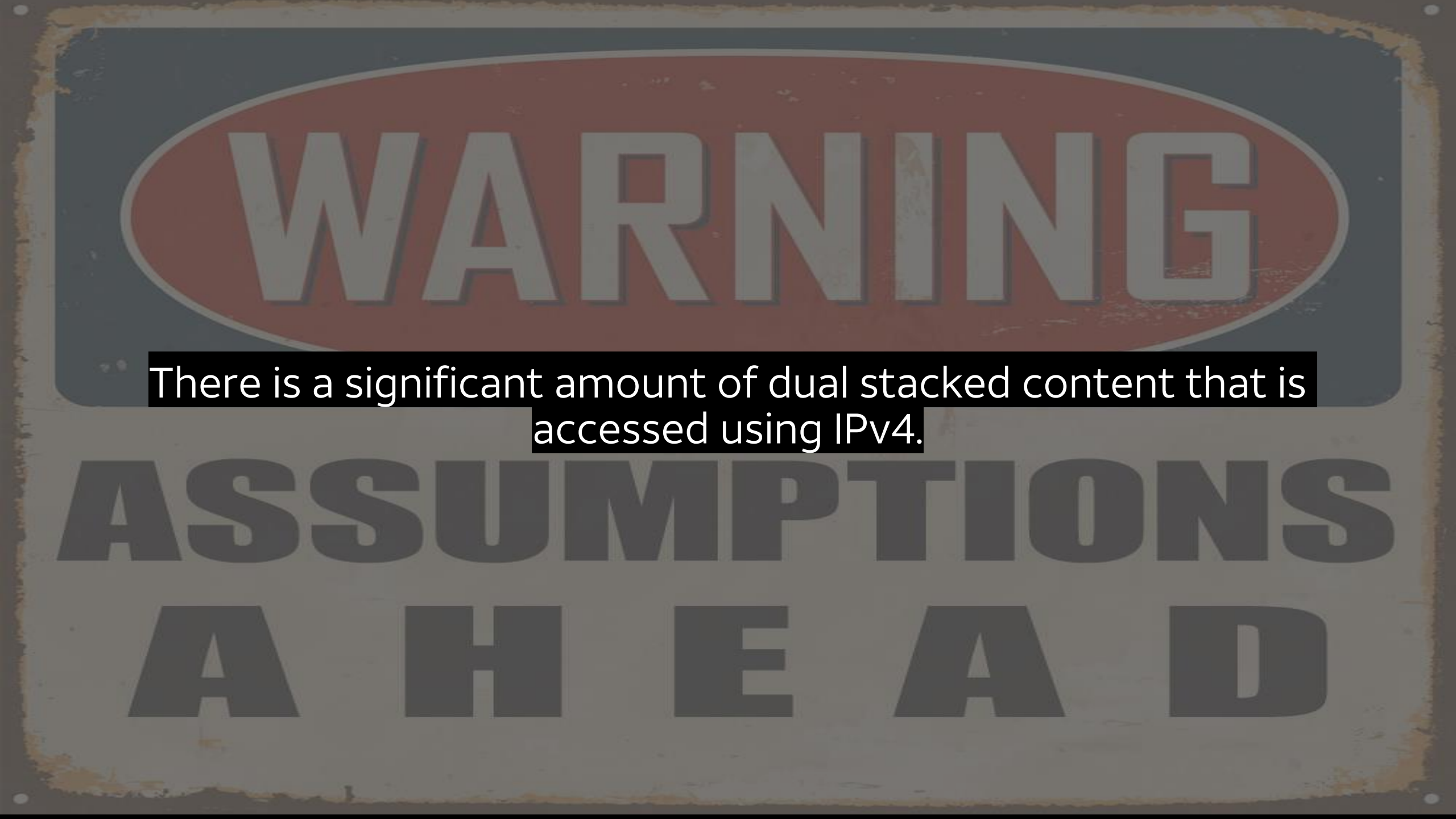
Current percentage of top 1000 websites globally that support IPv6.

https://pulse.internetsociety.org/wp-content/uploads/2022/06/Screenshot-2022-06-08-at-15.38.43.png

So why do we not have more ipv6 traffic?

- This is a (sanitized) listing of devices on a real home network.
  - 28 devices listed
  - Only devices 10 using IPv6
    - Maybe 3-5 devices that could use v6 but are not online when the snapshot was taken.

Device	IP Address(es)
Samsung	192.168.1.118 2001:db8:1111:2222::6bf
Antec902Main	192.168.1.71 2001:db8:1111:2222:6101:d0e8:c0af:303f 2001:db8:1111:2222::400
uverse_DVR_ETH_XX:XX:XX:XX:XX:XX	192.168.1.74
uverse_NODE_ETH_XX:XX:XX:XX:XX:XX	192.168.1.72
amazon-xxxxx	192.168.1.83 2001:db8:1111:2222:626d:3cff:fe1d:9f5b
uverse_NODE_ETH_XX:XX:XX:XX:XX:XX	192.168.1.70
uverse_NODE_ETH_XX:XX:XX:XX:XX:XX	192.168.1.73
uverse_NODE_ETH_XX:XX:XX:XX:XX:XX	192.168.1.81
amazon-xxxxx	192.168.1.68 2001:db8:1111:2222:f5d5:7867:ef02:4738
amazon-xxxxx	192.168.1.96 2001:db8:1111:2222:7ed5:66ff:fe7e:cb5d
unknownxxxxx	192.168.1.112
LAPTOP-XXXXX	192.168.1.84
unknownxxxxx	192.168.1.110
unknownxxxxx	192.168.1.54
8NMHPV2-XXXX	192.168.1.88
viziocastdisplay	192.168.1.87
RingPro-dc	192.168.1.97
unknownxxxxx	192.168.1.103 2001:db8:1111:2222:a4f6:dfcf:36c:1ad6
iPhone	192.168.1.65
work-laptop	192.168.1.108
XBOXONE	192.168.1.101 2001:db8:1111:2222::404 2001:db8:1111:2222:48a4:e922:2ec5:7cdc 2001:db8:1111:2222::56b
iPad-3	192.168.1.105
unknownxxxxx	192.168.1.115
unknownxxxxx	192.168.1.113 2001:db8:1111:2222:3073:b5cb:576c:8bd8 2001:db8:1111:2222::76e
unknownxxxxx	192.168.1.117 2001:db8:1111:2222::503
unknownxxxxx	192.168.1.119
iPhone	192.168.1.128
iPhone	192.168.1.131 2001:db8:1111:2222::511

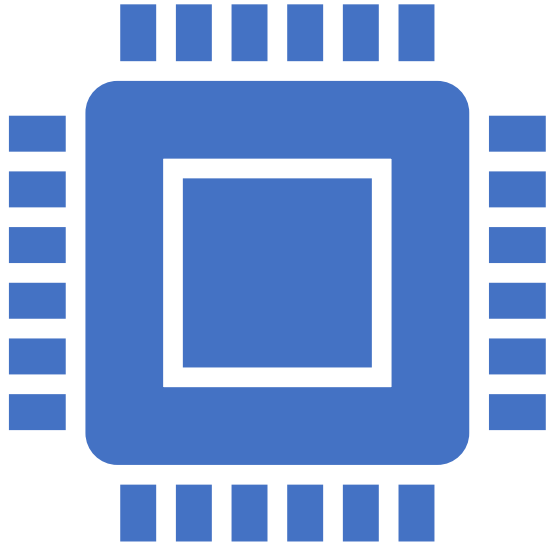


There is a significant amount of dual stacked content that is accessed using IPv4.

If the content is available via IPv6

The “natural path” for this upgrade will be to wait for vendors of set-top boxes and other IoT devices to release software updates to support IPv6, or they need to release new versions that consumers would have to purchase.

Neither is likely since vendors don’t like supporting older equipment, and consumers don’t like to spend money to replace items that still “just work”.



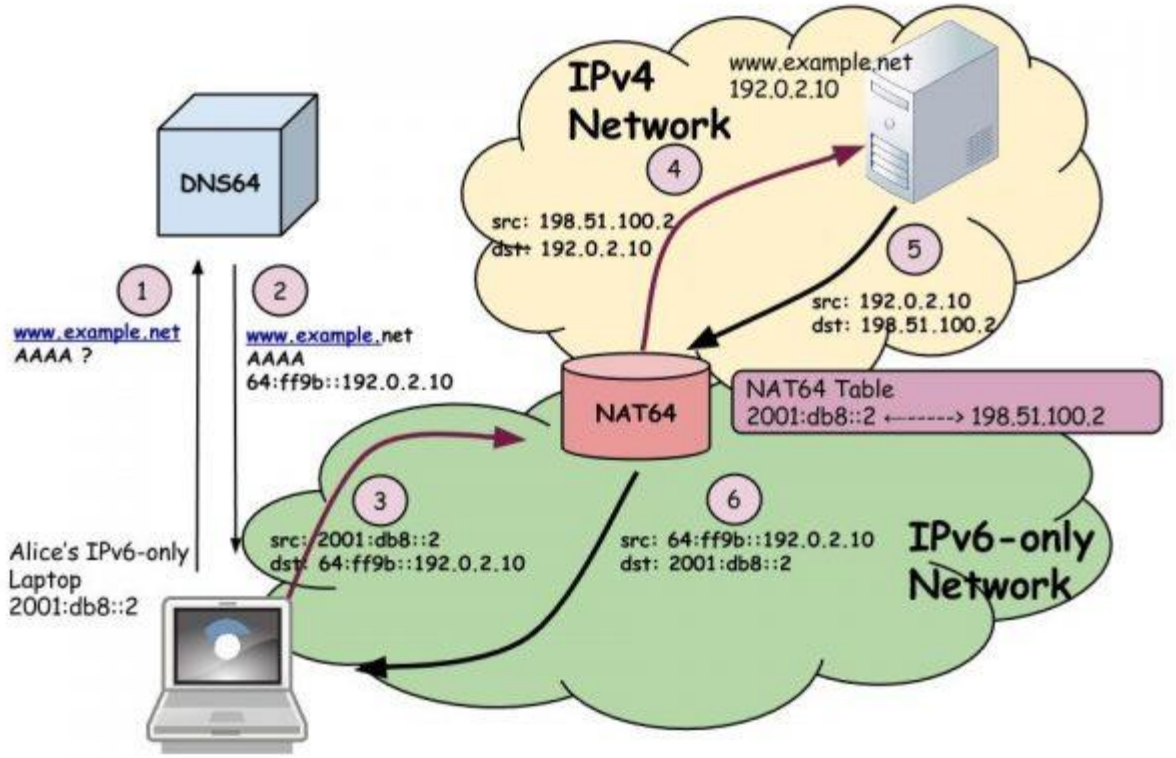
What can we do to promote IPv6 adoption?

- Wait?
- Incentivize vendors and consumers to upgrade devices?
- Wait longer?


I hate waiting

We have DNS64/NAT64

Consider an IPv6 only network. Standards exist for translations so that IPv6 only hosts can communicate with IPv4 only hosts.

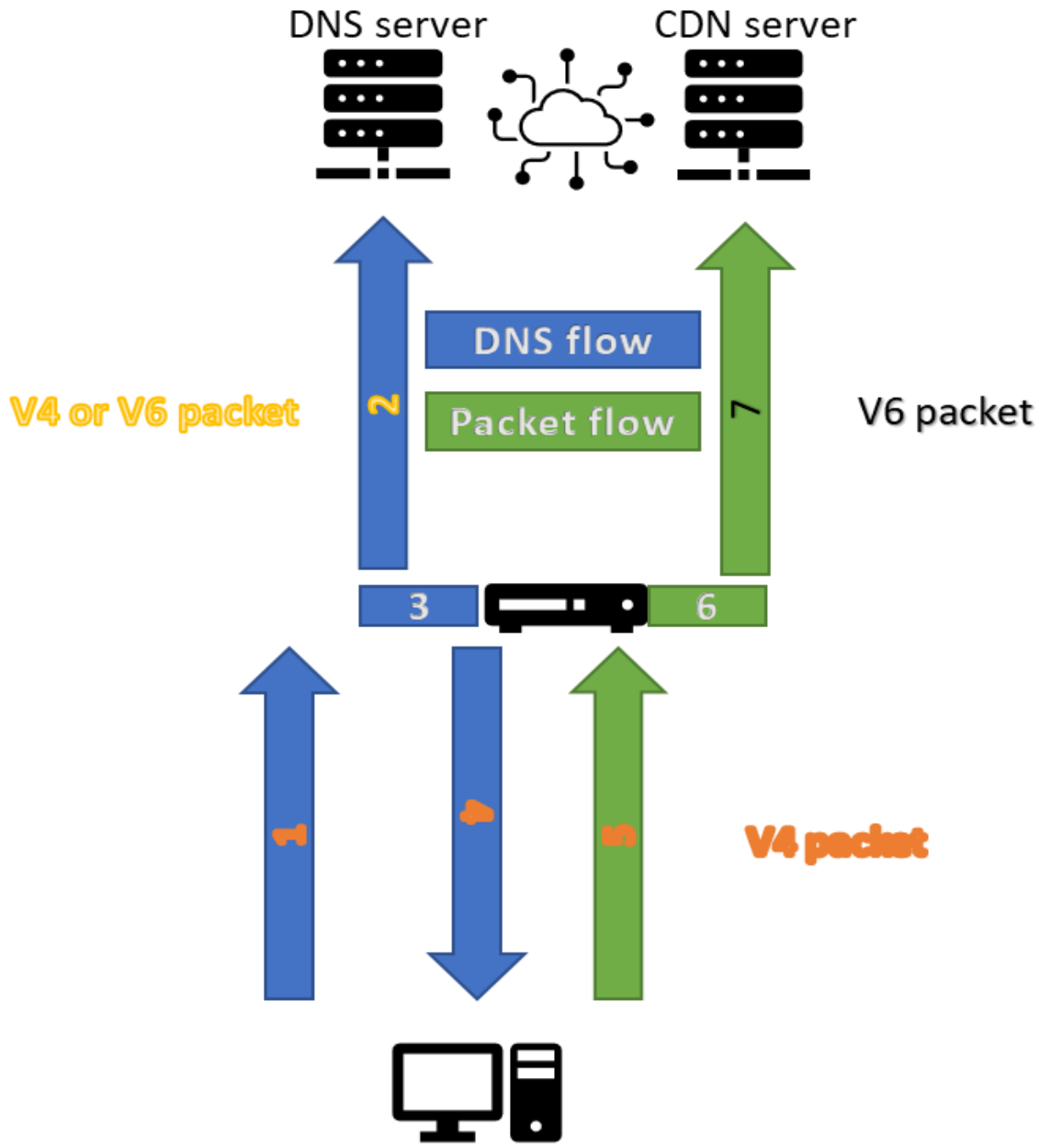


https://blog.apnic.net/2016/06/09/lets-talk-ipv6-dns64-dnssec/

Why can’t we turn that around and use DNS46/NAT46

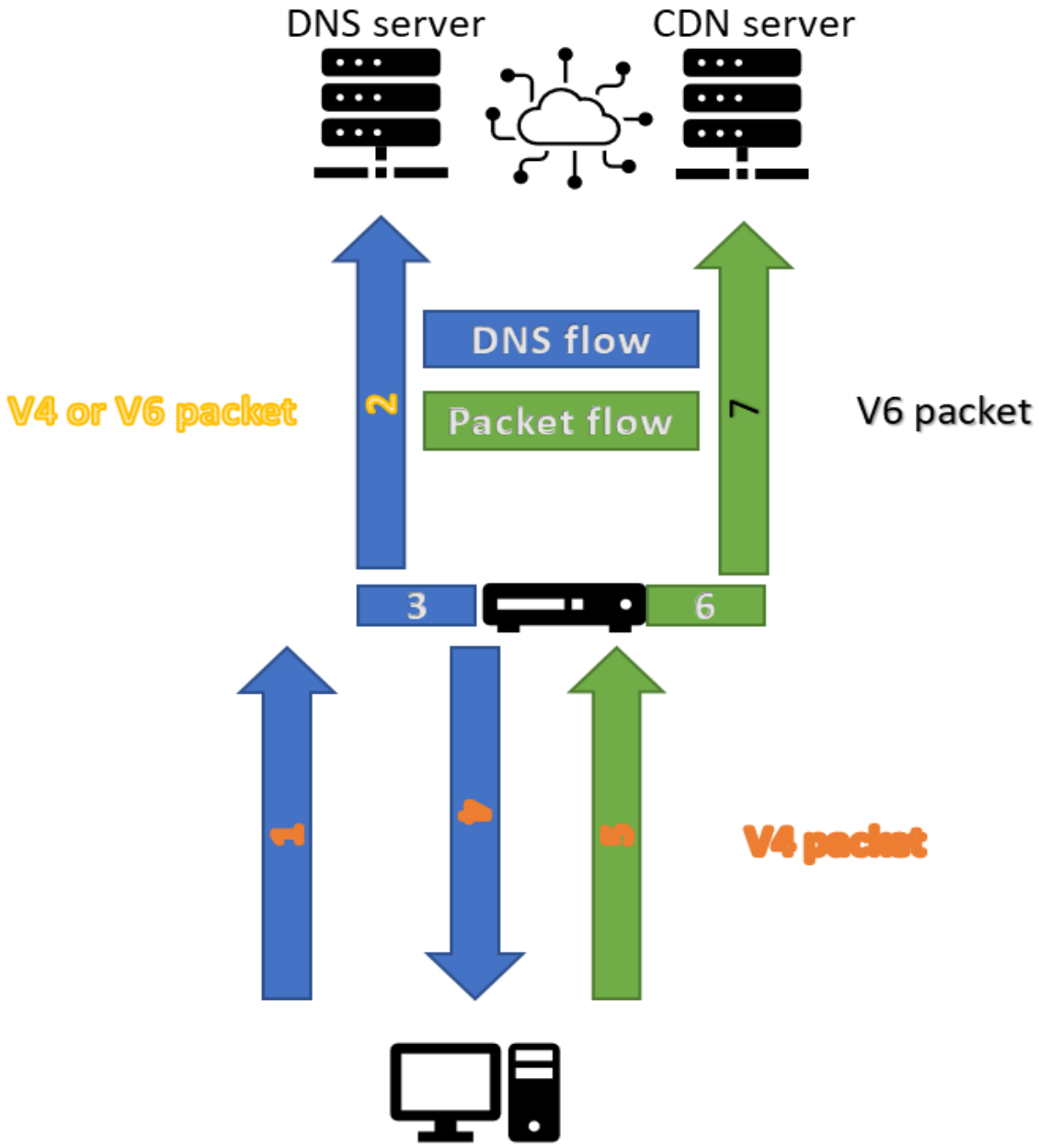
DNS46

1. IPv4 only device makes DNS A request
2. CPE receives A request and makes AAAA request upstream
3. CPE receives AAAA response and creates entry in local state table associating AAAA response with locally routed private IP (100.64.x.x?)
   - Each AAAA response is associated with a unique locally routed IPv4 address.
4. CPE replies to IPv4 host with private IP as A response



NAT46

5. Host sends packet with private IP as destination
6. CPE routes that packet to translation software. Looks up the IPv4 destination in state table to find IPv6 destination.
7. CPE Repackages the packet payload into new IPv6 packet and forwards as normal IPv6.
    - Additional state needs to be stored to get the return packet back to the original host.



What Could Break?

(maybe other stuff too)

DNSSEC: Clients that do local DNSSEC validation will fail. This is a rare configuration if it exists at all. The clients that are in scope for this sort of address translation don't support IPv6 and are not likely to implement DNSSEC either.

Applications that embed literal IP addresses: It's possible that an application could detect an IPv6 connection and embed an IPv6 address in a response for the client to connect to. Since the client doesn't actually support IPv6, it will not be able to connect. Embedding IP addresses has not been a best practice for some time and should be avoided.

Benefits

- Converting traffic to IPv6 means less CGN capacity required.
- As we move to CGN solutions, devices and services that only support IPv4 could begin to incur performance penalties. This incentivizes CDNs to make content available via IPv6 regardless if the end device supports it or not since flow is direct to CPE vs via CGN.

Benefits

- DNS46/NAT46 can be implemented on the CPE and will operate transparently to the customer. They won't notice any difference. With some possible corner cases already discussed.
- Cost over time should be less than building and maintaining a full scale CGN while we wait for device vendors to update and for users to purchase new equipment that supports IPv6.

Next steps

1

Work with CPE vendors to develop required features to certify and deploy.

2

PROFIT?!?!?!?!

Thanks to those who helped refine this idea

James Shank – Team Cymru

Rich Compton - Charter

Louie Lee - Google

Questions?