Understanding the Share of IPv6 Traffic in a Dual-Stack ISP

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IPv6 adoption metrics

User end hosts
Server-side measurements

e.g., Google reports 20% of the hosts have IPv6

IPv6 adoption metrics

User end hosts	Networks
Server-side measurements	Allocations (IANA) Routing (BGP) ...

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IPv6 adoption metrics

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e.g., 13% of the Alexa top 1M Web sites have set IPv6

IPv6 adoption metrics

User end hosts	Networks	Services / Content
Server-side measurements	Allocations (IANA) Routing (BGP) ...	Client-side measurements

Many different “connectivity” metrics. What about traffic?

e.g., 23% of the Autonomous Systems announce IPv6

13% of the Alexa top 1M Web sites have set IPv6

IPv6 traffic statistics

Vantage point	% of IPv6 traffic	Year
260 networks	< 1 %	2013
Dual-stack ISP	**11 %**	2016
AMS-IX (IXP)	1-3 %	2017

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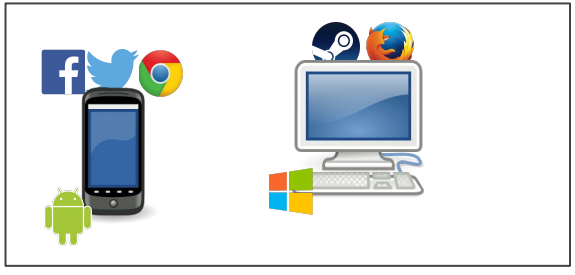
What is the interplay between connectivity and traffic?

A dual-stack ISP is ideal to study barriers for IPv6 traffic

Dual-stack ISP: when is IPv6 connectivity used?

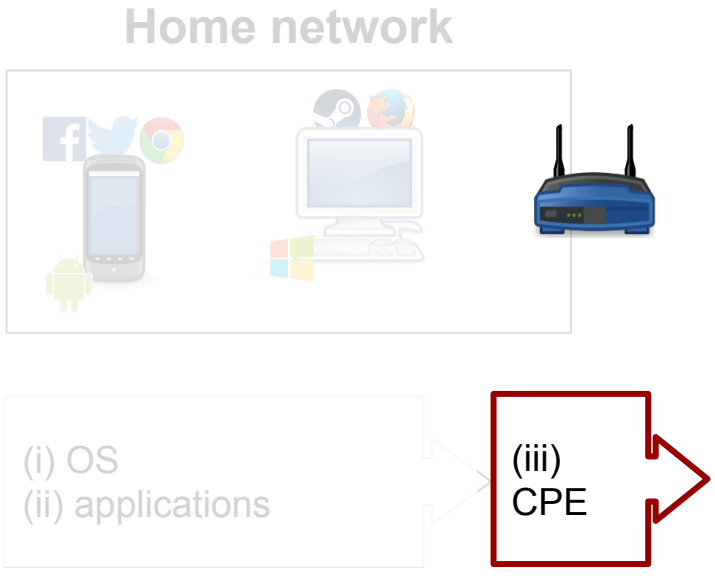
Home network



(i) OS
(ii) applications

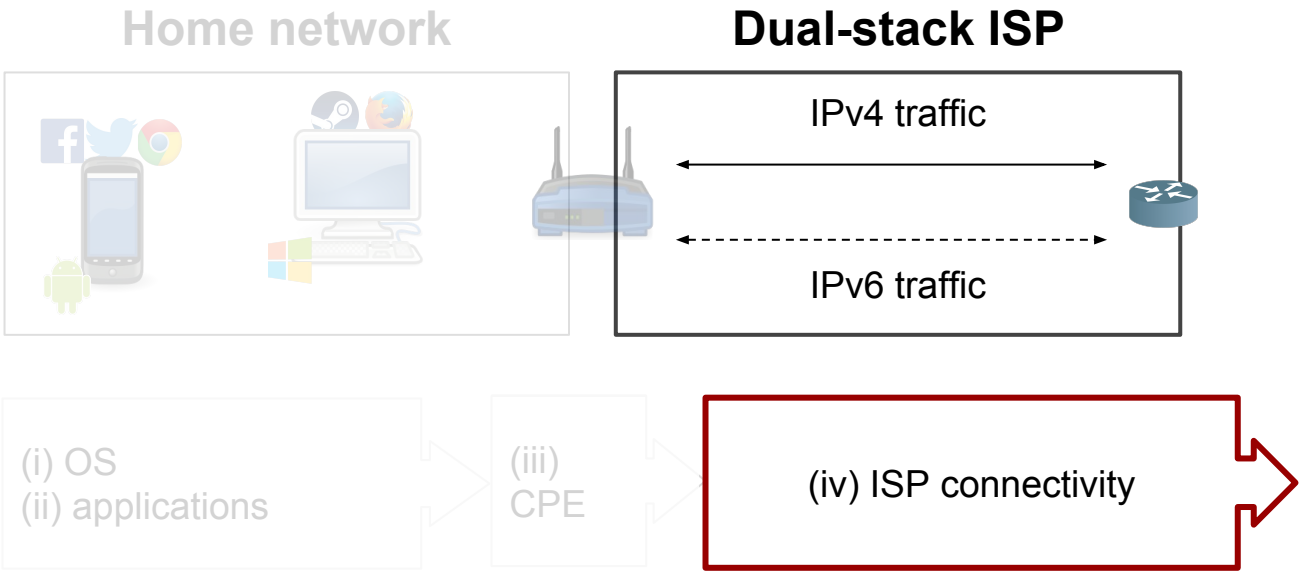
Devices need to support IPv6 e.g., old OSes, some IoT don't

Dual-stack ISP: when is IPv6 connectivity used?



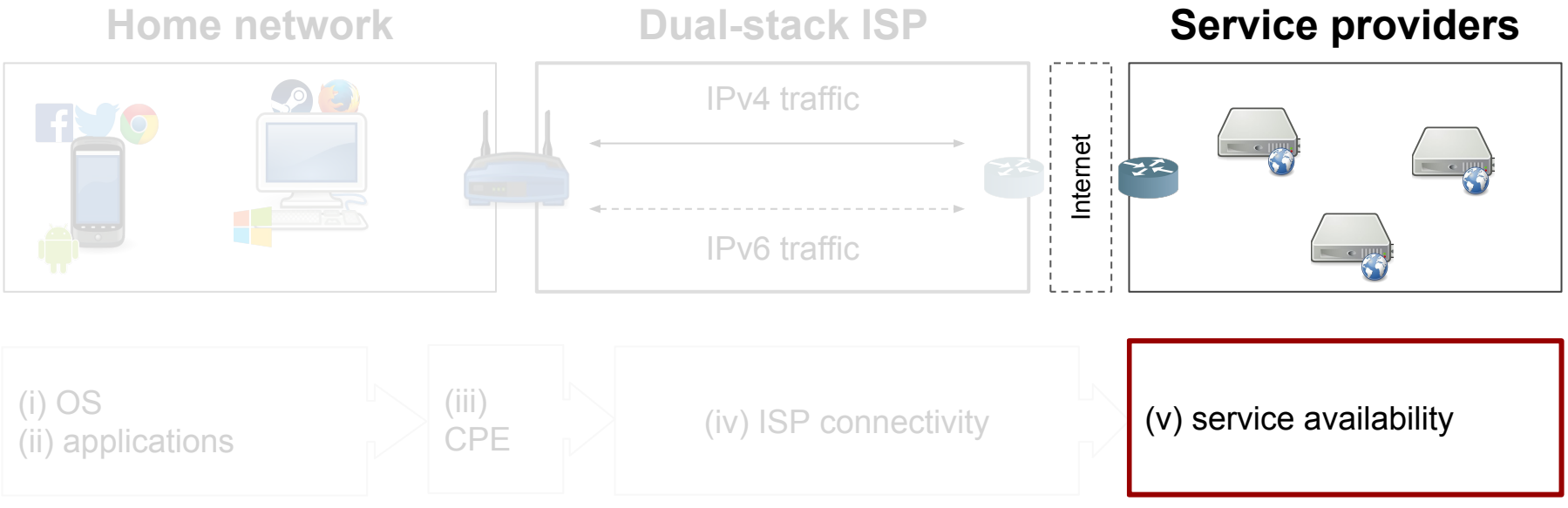
IPv6 needs to be enabled at many CPEs

Dual-stack ISP: when is IPv6 connectivity used?



ISP has to provide IPv6 connectivity to all subscribers

Dual-stack ISP: when is IPv6 connectivity used?

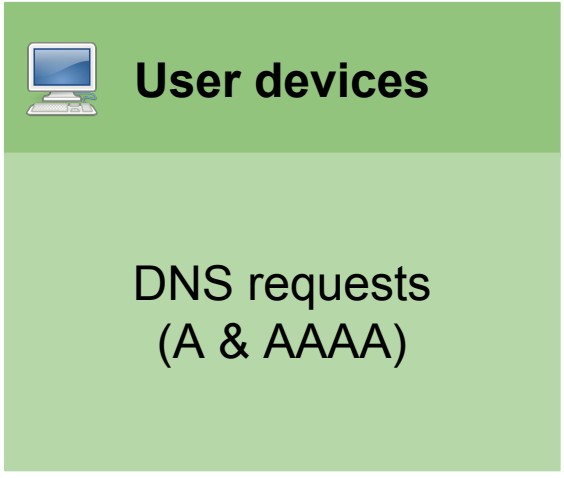


IPv6 upstream and DNS RRs correctly set

Dual-stack ISP: when is IPv6 connectivity used?

First we need to understand this “chain” of connectivity

Inferring connectivity



IPv6-speaking vs. IPv4-only devices

Inferring connectivity

User devices

DNS requests
(A & AAAA)

CPEs / ISP

Local
AAAA DNS reqs

Global
RADIUS (ISP)

Obtain an IPv6 prefix and make use of it

Inferring connectivity

 **User devices**	 **CPEs / ISP**	 **Services**
DNS requests (A & AAAA)	*Local* AAAA DNS reqs *Global* RADIUS (ISP)	DNS responses (AAAA) active measurements (connectivity)

A service is a Fully-Qualified Domain Name (FQDN)

Inferring connectivity

Inferring connectivity

User devices	CPEs / ISP	Services
	Local	DNS responses
(A & AAAA)	*Global* RADIUS (ISP)	active measurements (connectivity)

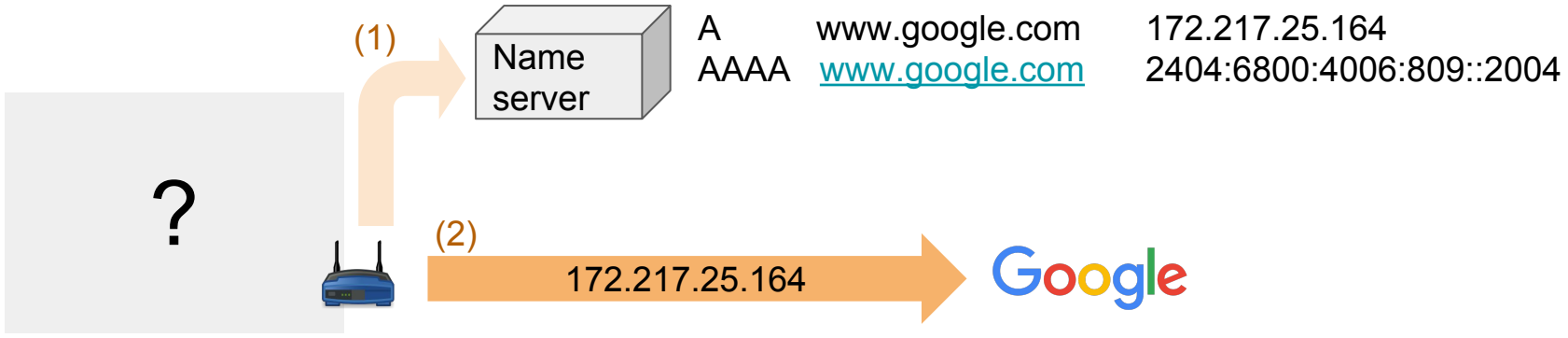
That is connectivity, what about traffic?

Annotate network flows: <DSL_{ID},FQDN, #bytes>

DSL_{ID} has IPv6?	A request?	A RR?	AAAA request?	AAAA RR?

We can now reason about traffic!

From connectivity to traffic: example



Flow: <DSL_{XY},www.google.com,100KB>

DSL_{ID} has IPv6	A request	A RR present	AAAA request	AAAA RR present

IPv6-speaking device uses IPv4 to connect to Google

Dataset

Dual-stack ISP with **12.9K subscribers**, **45 h** trace (winter 15/16)

Trace	Total
# bytes	64.5TB
# flows	356.2M

First question: do all subscribers get and use IPv6?

DSL subscribers

Question: Do all subscribers get IPv6?

IPv4-only (17%)

IPv6 connectivity ×
IPv6 traffic ×

We see AAAA

1) **Operator's policy: new contracts get IPv6**
2) **DNS requests are not always indicative**

DSL subscribers

Question: Do all subscribers get IPv6?

IPv4-only (17%)	**IPv6-inactive (30%)**
IPv6 connectivity ✗	IPv6 connectivity ✔
IPv6 traffic ✗	IPv6 traffic ✗
We see AAAA	Almost no AAAA

CPE does not support/provide IPv6 → default conf.?

DSL subscribers

Question: Do all subscribers get IPv6?

IPv4-only (17%)	**IPv6-inactive (30%)**	**IPv6-active (53%)**
IPv6 connectivity ✗	IPv6 connectivity ✔	IPv6 connectivity ✔
IPv6 traffic ✗	IPv6 traffic ✗	IPv6 traffic ✔
We see AAAA	Almost no AAAA	IPv6 share is 21%

Let's study their interaction with services...

Questions

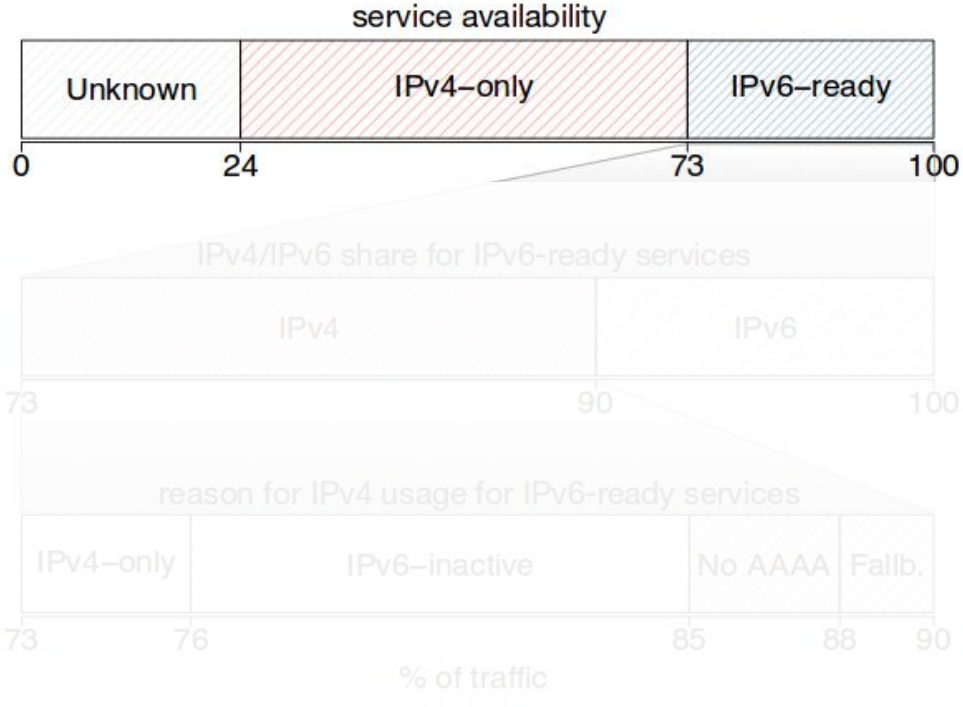
What is the interplay between connectivity and traffic?

IPv6 barriers: services offered on IPv6 but clients accessed on IPv4

IPv6 intent: services offered on IPv4 but clients requested IPv6

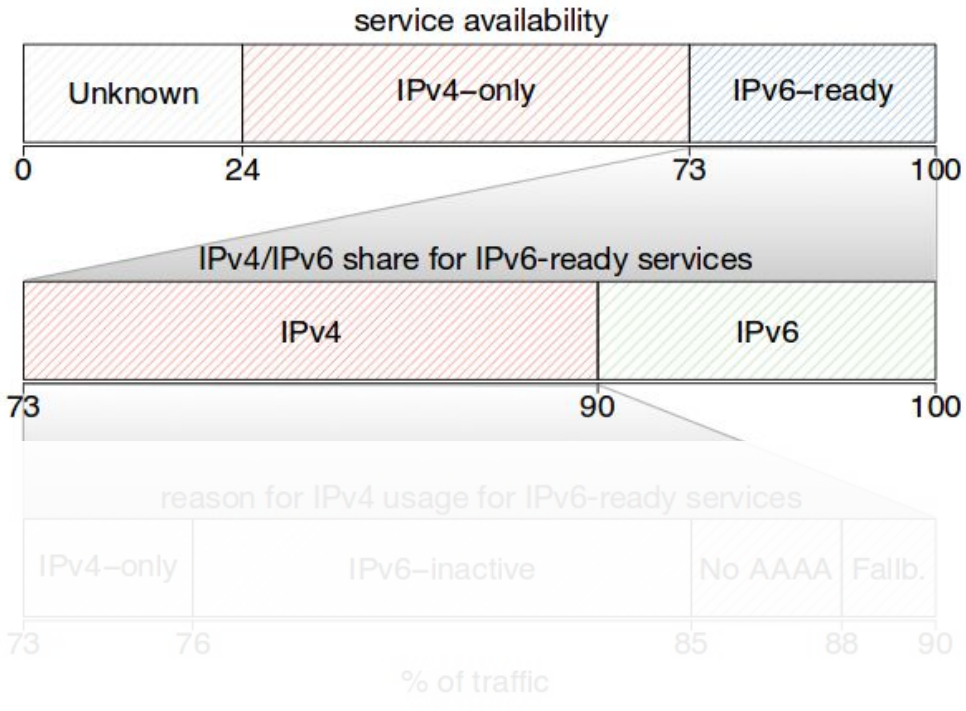
When will we see more IPv6 traffic in these networks?

IPv6 barriers



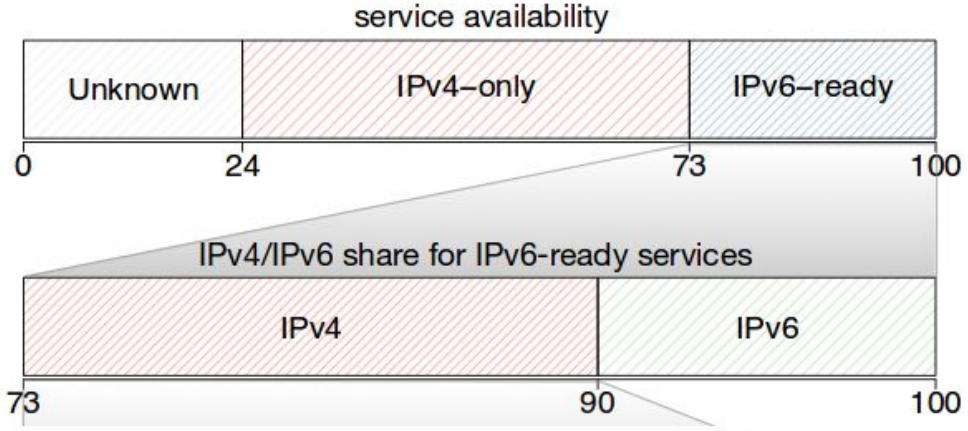
27% of the overall traffic relates to IPv6-ready services

IPv6 barriers



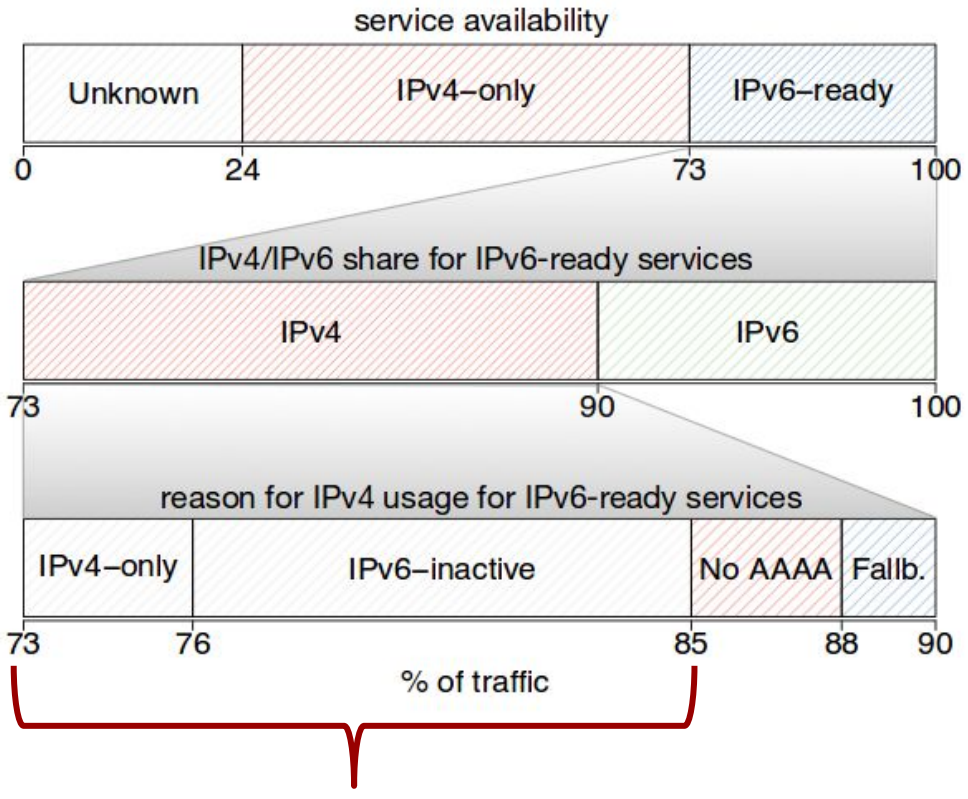
yet only ~⅓ of that is carried over IPv6!

IPv6 barriers



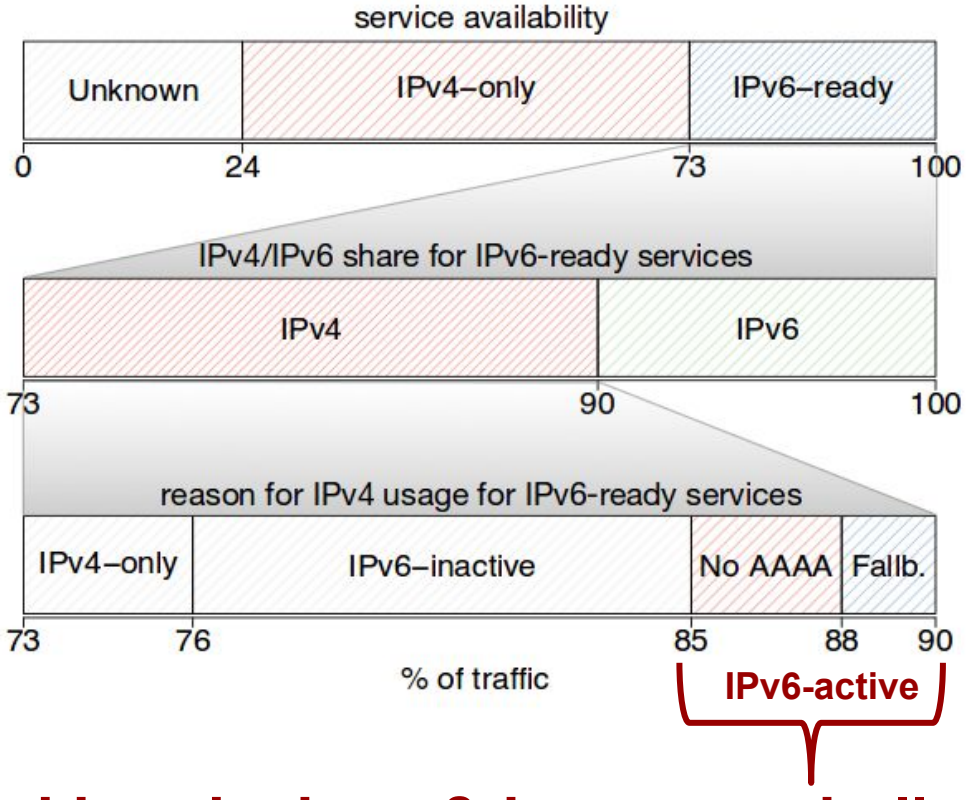
Why does IPv4 dominate?

IPv6 barriers



70% due to CPE configuration & ISP policy!

IPv6 barriers



IPv4-only speaking devices & happy-eyeballs fallbacks

Questions

What is the interplay between connectivity and traffic?

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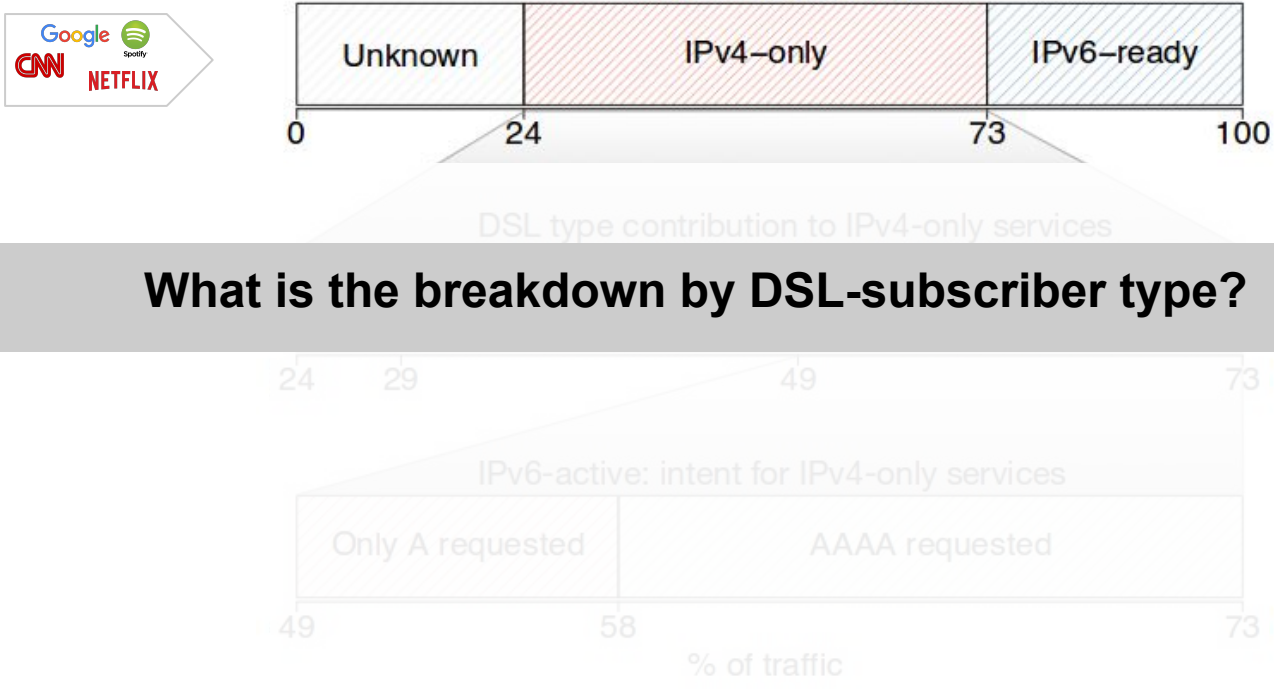
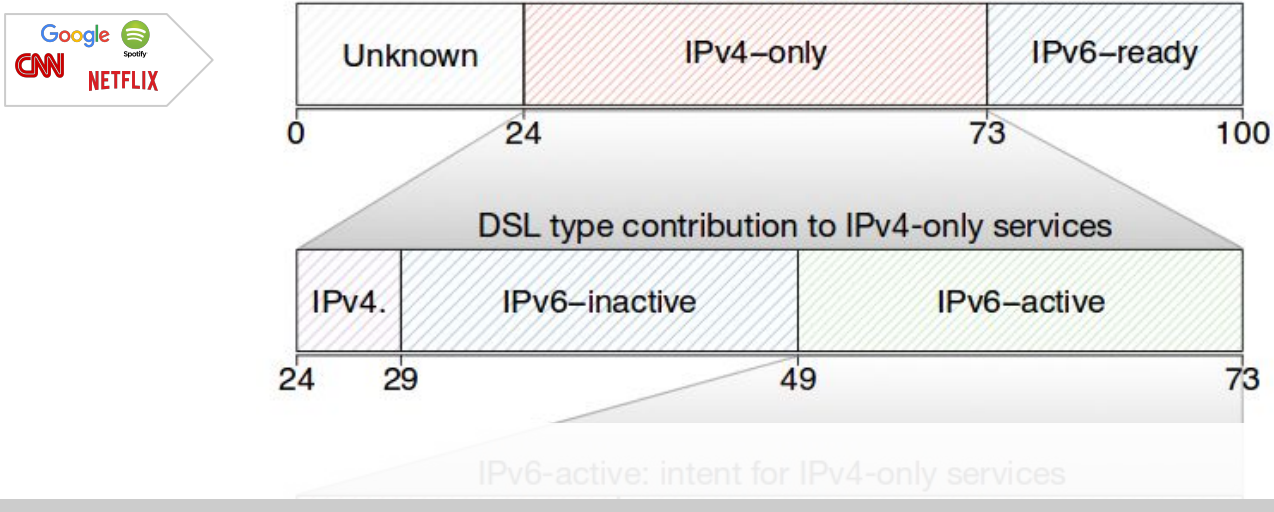
When will we see more IPv6 traffic in these networks?

IPv6 intent



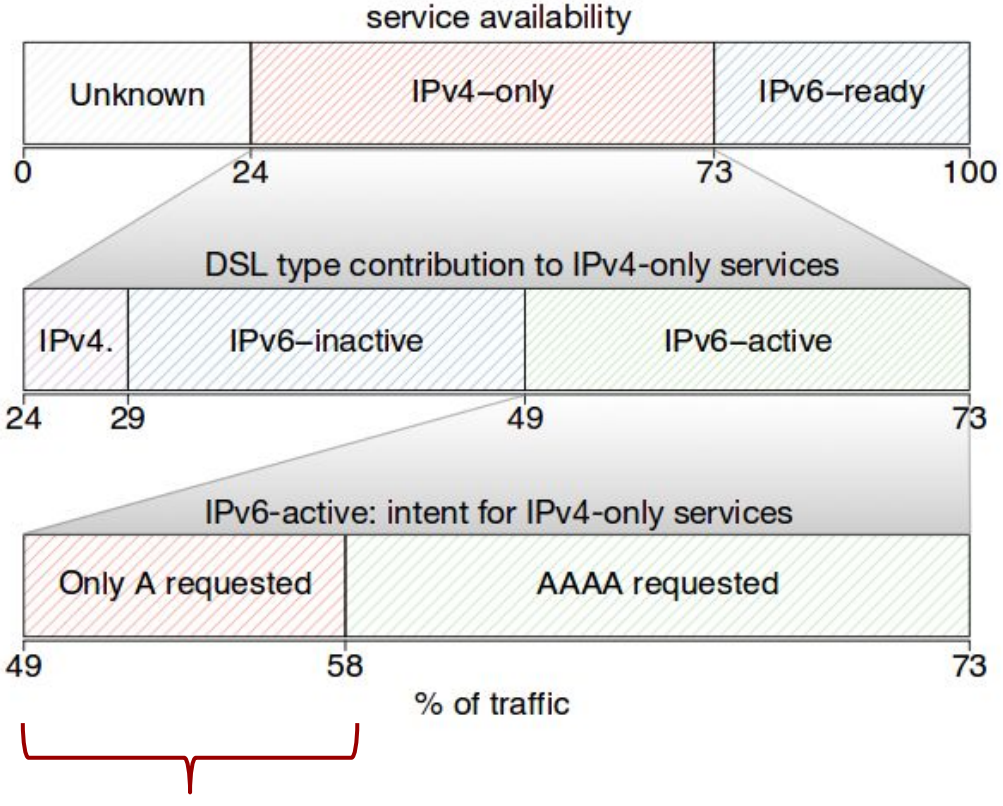
What is the breakdown by DSL-subscriber type?

IPv6 intent



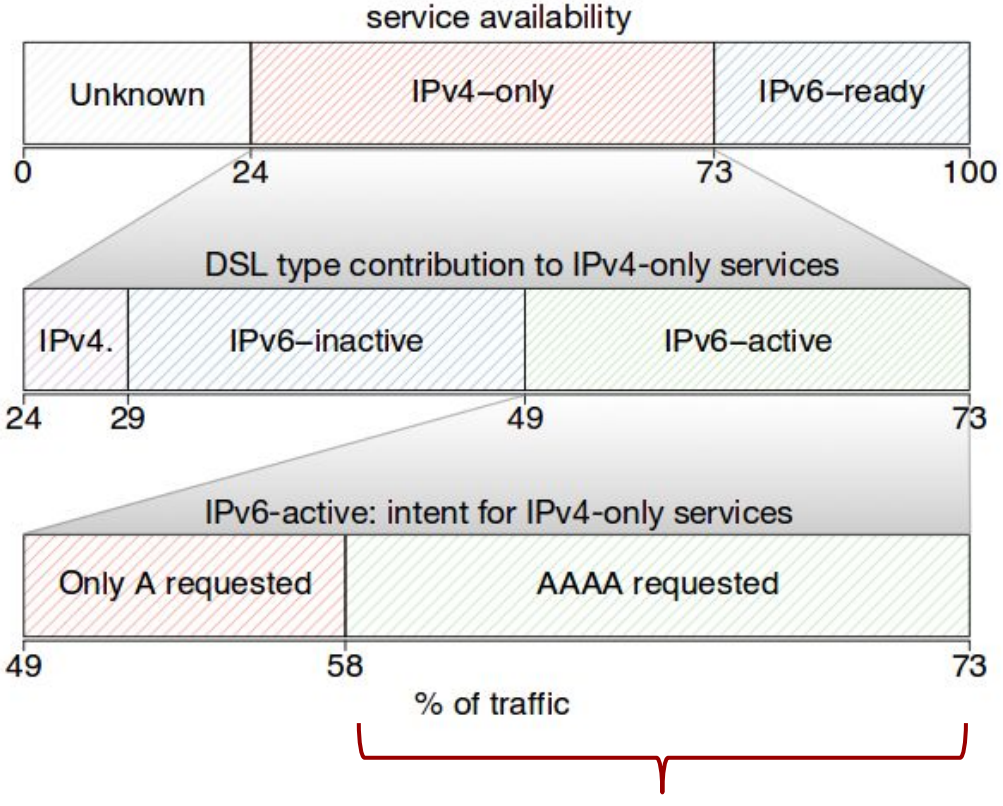
What if these services would be made available for IPv6?

IPv6 intent



IPv4-only speaking devices? (*)

IPv6 intent



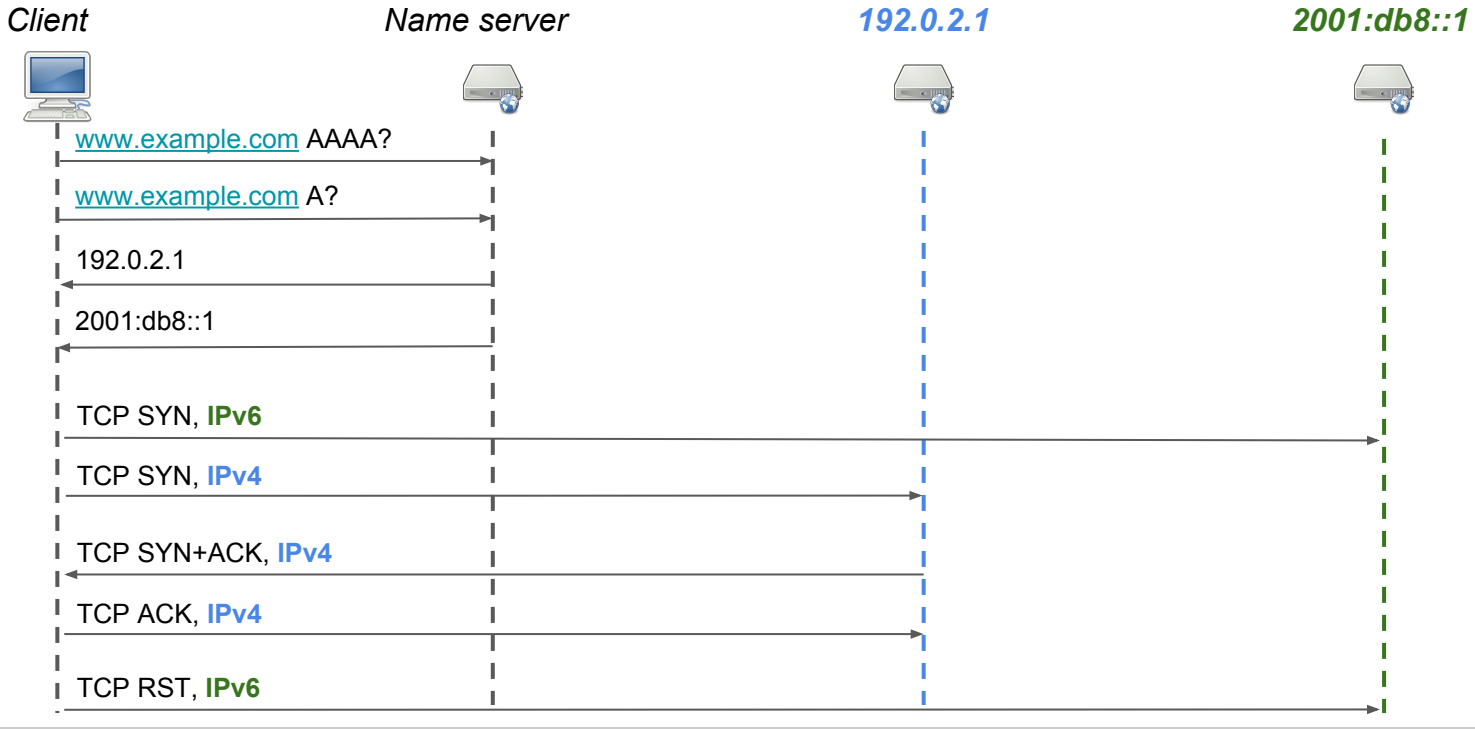
Most traffic could be exchanged over IPv6!

Questions

What is the interplay between connectivity and traffic?	
IPv6 barriers:	services offered on IPv6 but clients accessed on IPv4
IPv6 intent:	services offered on IPv4 but clients requested IPv6

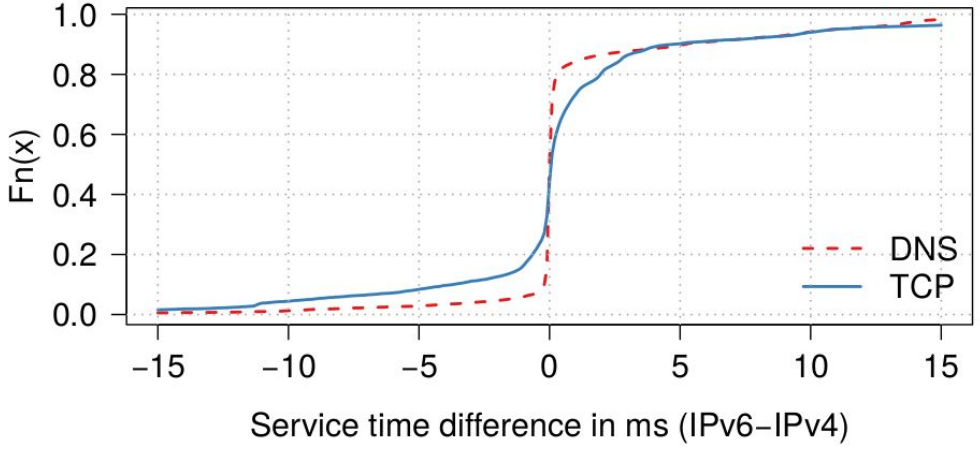
When will we see more IPv6 traffic in these networks?
Happy eyeballs
What-if scenarios

Happy eyeballs (RFC 6555): fallback to IPv4



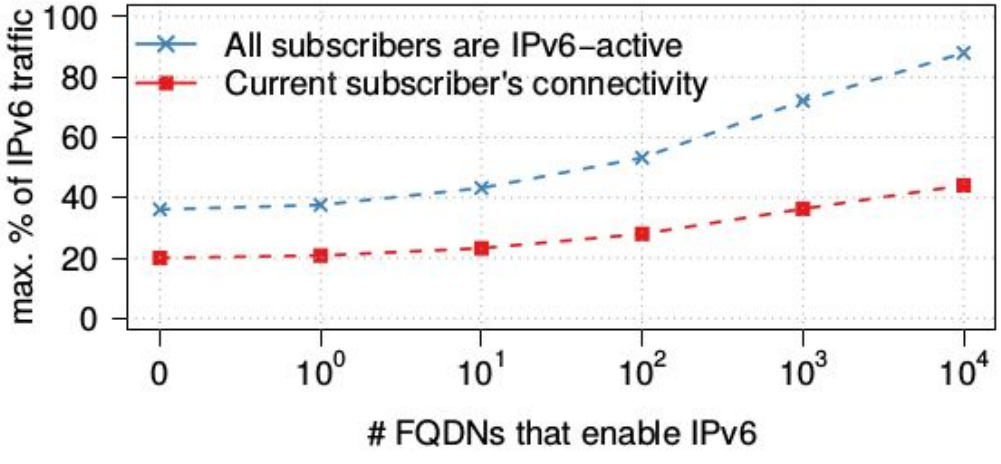
Collect TCP handshakes completion times and DNS lookups per FQDN

Metrics for happy eyeballs (TCP vs DNS resolution)



80% of the times ± 10ms → will use IPv6

Transition to IPv6: What if...



Optimistic: IPv4-only devices, happy eyeballs, etc.

Summary

Not every subscriber uses IPv6 connectivity at a dual-stack ISP

1) **17 %** of the IPv4 traffic to IPv6-ready services is a result of the **ISP policy**
2) **53 %** of the IPv4 traffic to IPv6-ready services is due to **CPEs**

Devices want IPv6 but many services do not operate on IPv6 yet

1) **At least 62%** of the traffic to IPv4-only services from IPv6-active DSLs

We may see substantial and fast changes in dual-stack networks!

Thank you! Questions?