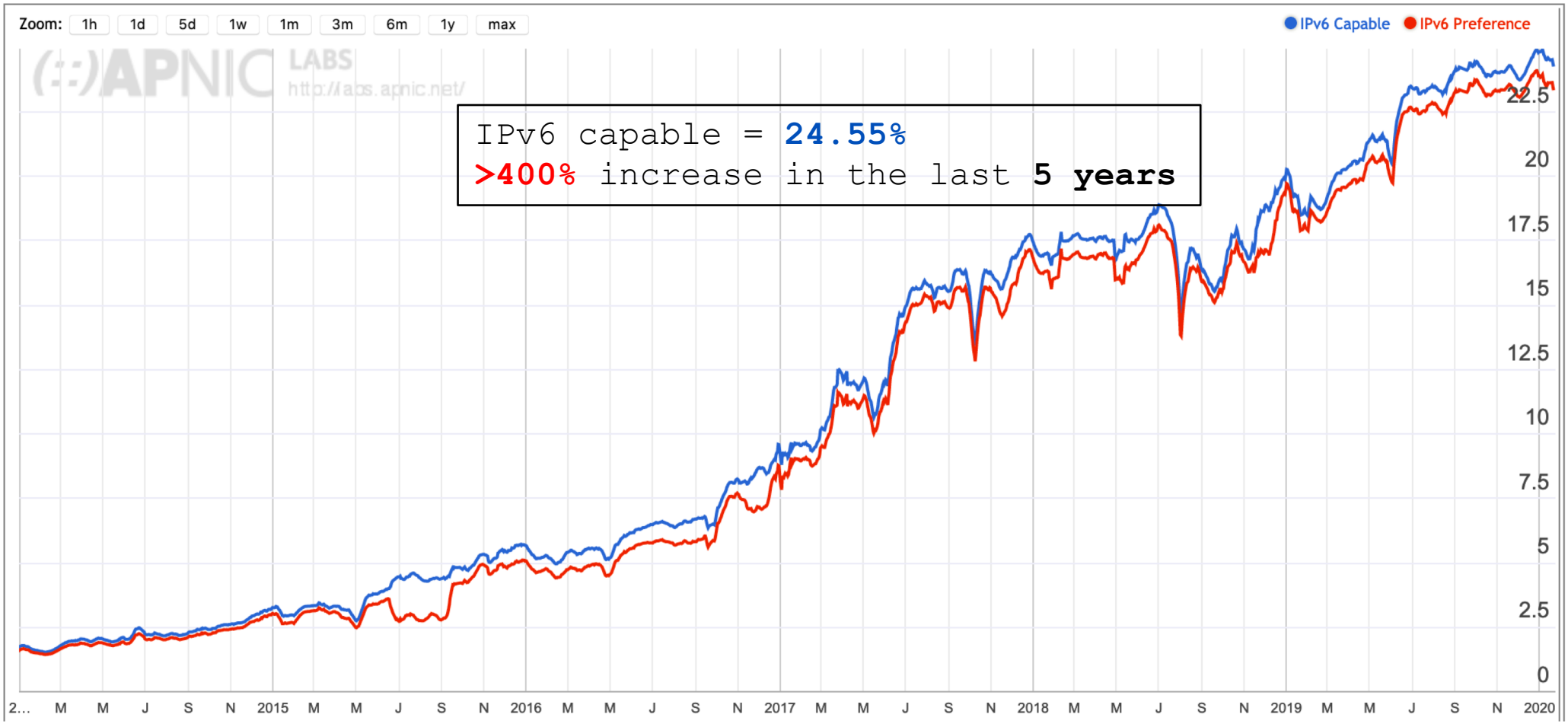
IPv6 Deployment Update
(Where are we now?)

22nd January 2020

IPv6 Measurement

- Uses scripted online advertisement
  - Over **12M** measurements/day!!
- The ad-script fetches three URLs
  - IPv6 only URL, Dual-stack URL, IPv4 only URL
- If the device can fetch:
  - IPv6 URLs (*native/dual-stack*) over IPv6, deemed *IPv6 capable*
  - dual-stack URL over IPv6, deemed to *prefer IPv6*
    - RFC8305 (Happy Eyeballs) bias?

IPv6 end user Readiness



https://stats.labs.apnic.net/ipv6/

IPv6 Table – World

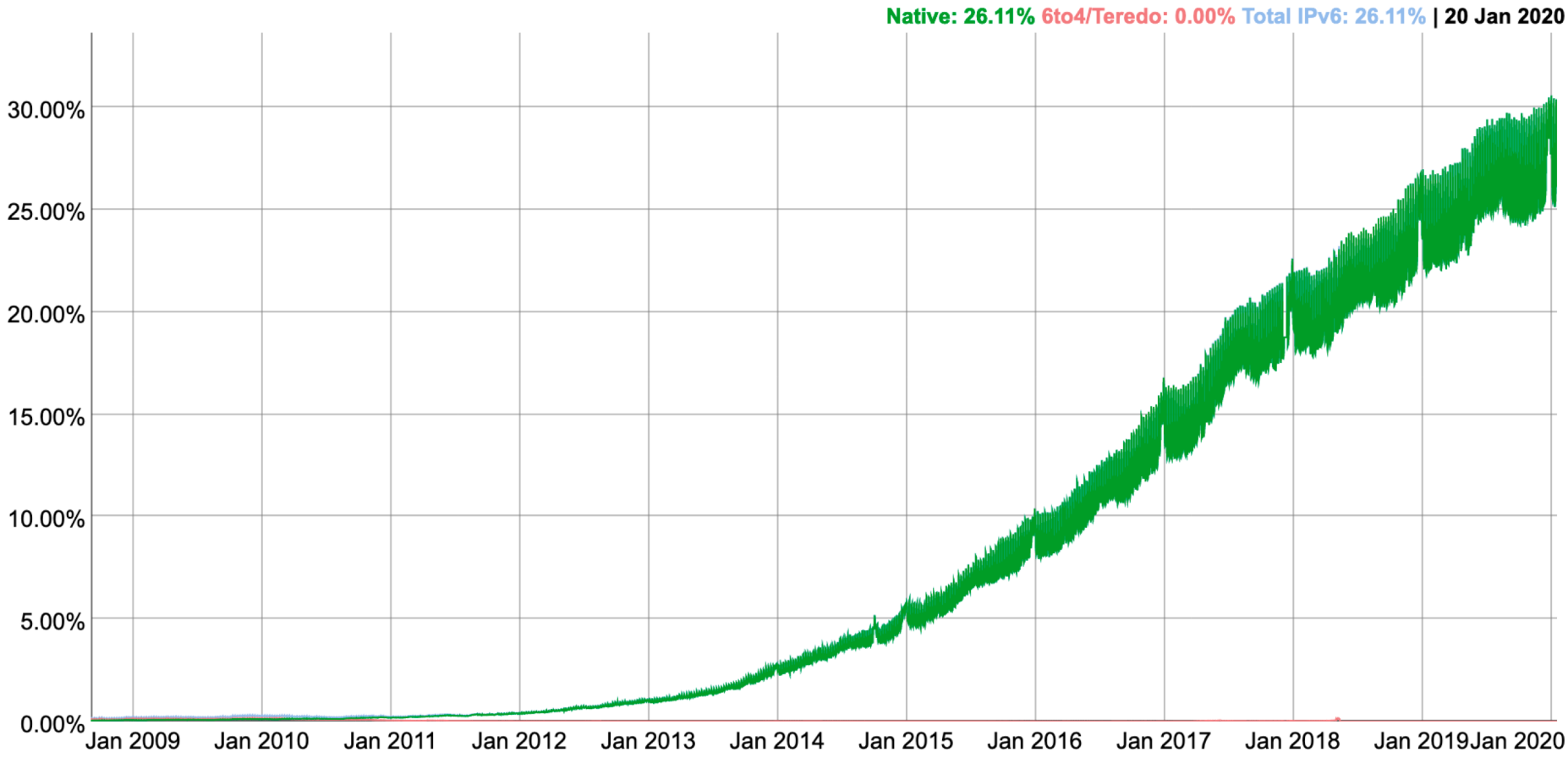
Economy	IPv6 capable (%)	Economy	IPv6 capable (%)	Economy	IPv6 capable (%)
Mayotte	64.88	Japan	35.87	Canada	28.64
India	64.52	French Guiana	35.44	Aland Islands	26.10
Belgium	58.73	Luxembourg	35.05	Hungary	25.07
United States	56.19	Finland	33.92	Estonia	24.91
Malaysia	45.42	Uruguay	33.30	UAE	24.49
Greece	45.38	UK	32.61	Australia	24.30
Germany	44.24	Portugal	31.68	New Zealand	23.89
Taiwan	44.48	Brazil	31.31	Sri Lanka	23.83
Vietnam	39.23	Saint Barthelemy	30.83	Trinidad&Tobago	22.95
Saint Martin	38.72	Mexico	30.69	Netherlands	22.84
France	37.54	Thailand	29.47	Guadeloupe	22.83
Switzerland	36.54	Norway	26.99	Reunion	21.80

https://stats.labs.apnic.net/ipv6/ (22 Jan 2020)

IPv6 in Action - Google

IPv6 Adoption

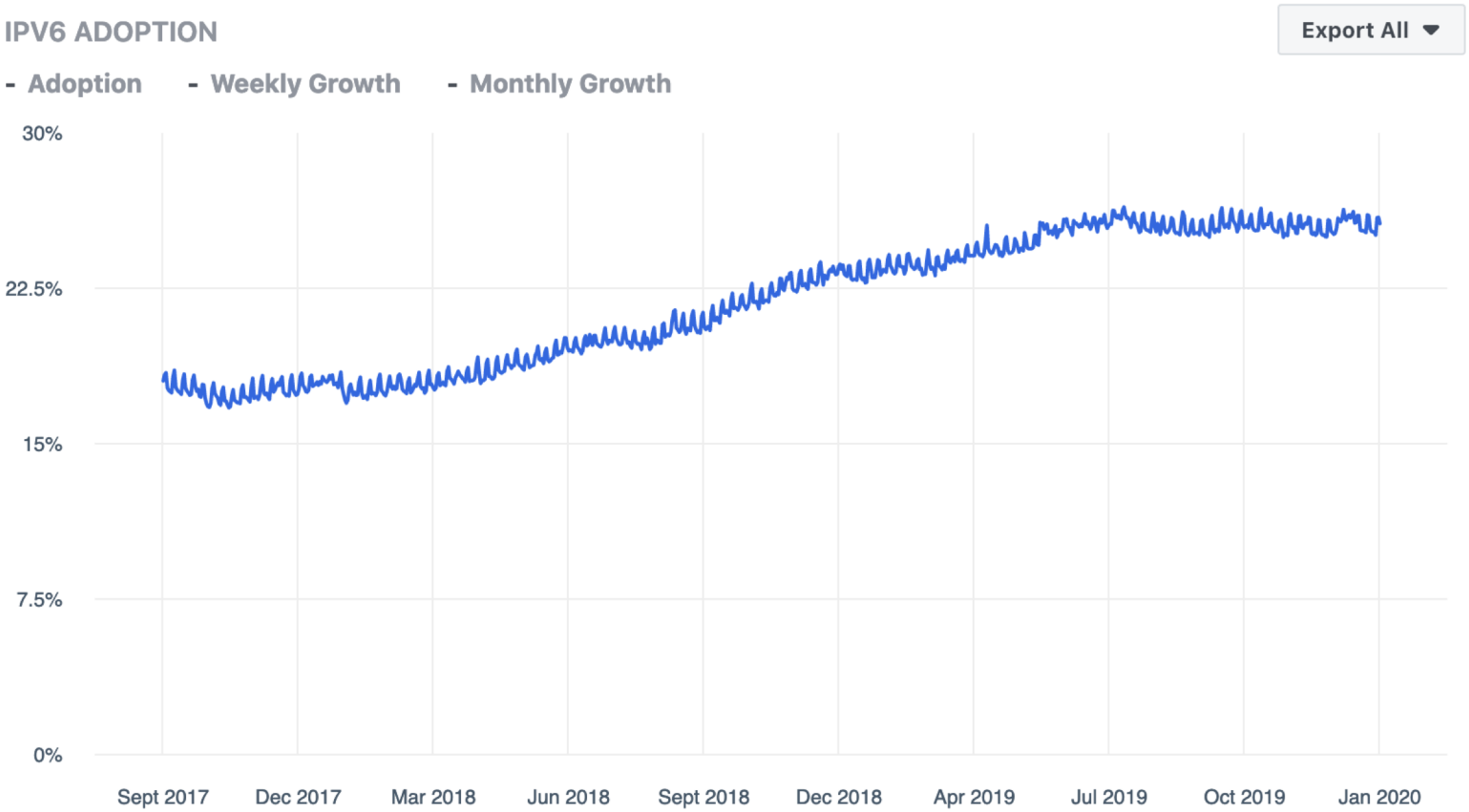
We are continuously measuring the availability of IPv6 connectivity among Google users. The graph shows the percentage of users that access Google over IPv6.



https://www.google.com/intl/en/ipv6/statistics.html

IPv6 in Action - Facebook

Overview | Adoption By Country | **Total IPv6 Adoption**



https://www.facebook.com/ipv6/

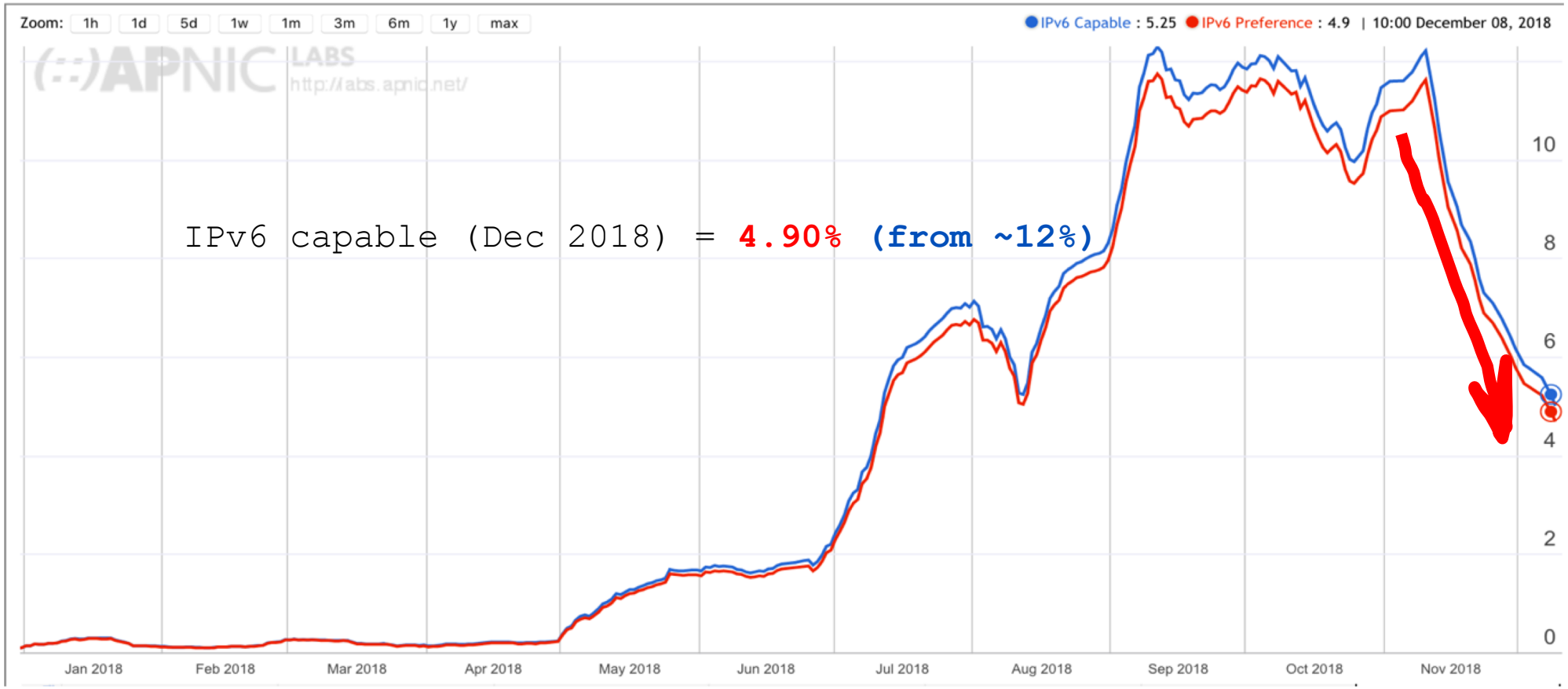
What about Asia-Pacific?

Economy	IPv6 capable (%)
India	64.52
Malaysia	45.42
Taiwan	44.08
Vietnam	39.23
Japan	35.87
Thailand	29.47
Australia	24.30
New Zealand	23.89
Sri Lanka	23.83
China	15.59
South Korea	15.25
Singapore	13.72
Macao	11.59

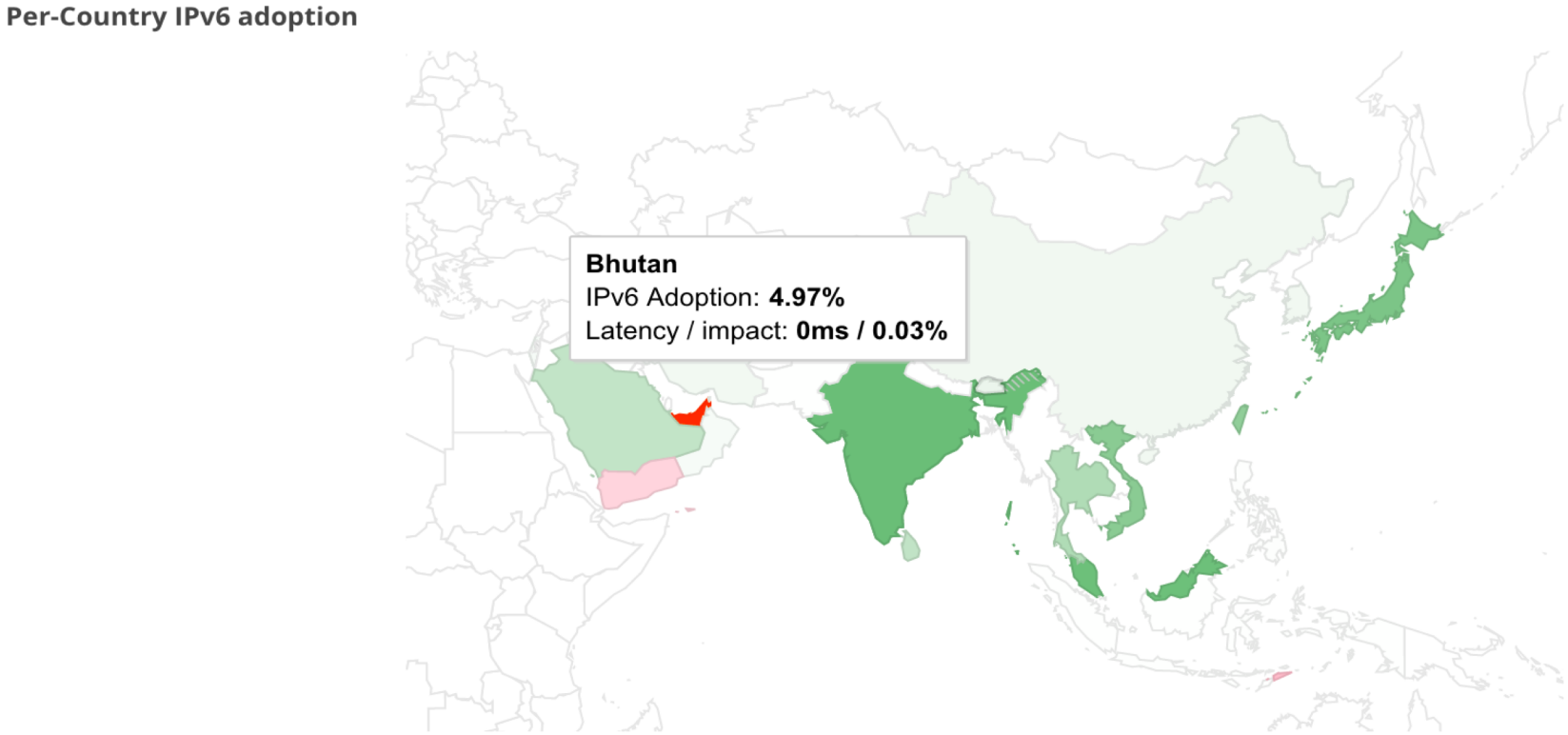
South Asia Focus

Economy	IPv6 capable (%)
India	64.52
Sri Lanka	23.83
Bhutan	8.64
Nepal	6.13
Maldives	3.39
Afghanistan	0.36
Bangladesh	0.05
Pakistan	0.04

Something interesting - BT

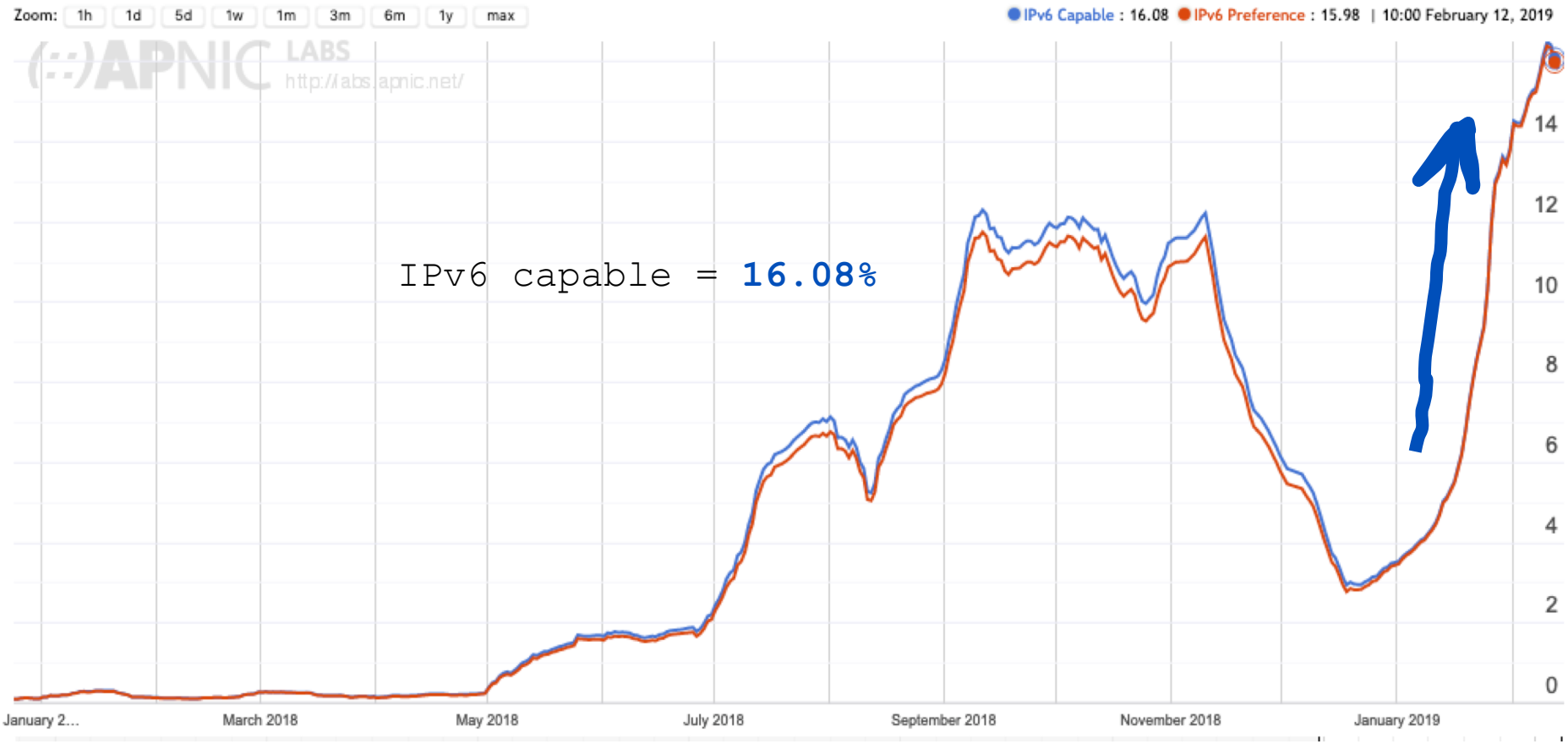


Google’s view - BT

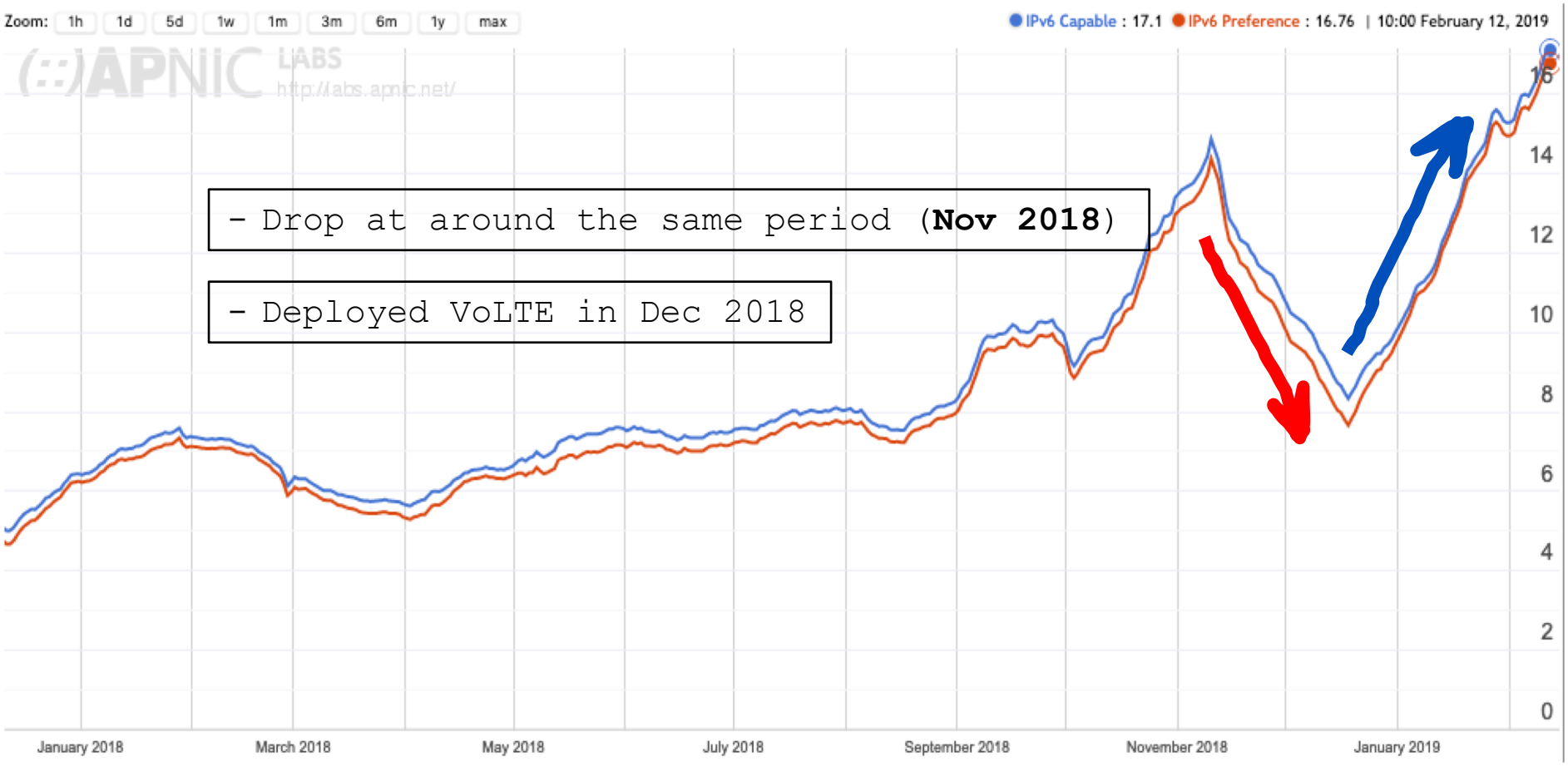


https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption

After the fix - BT



Coincidence - LK?



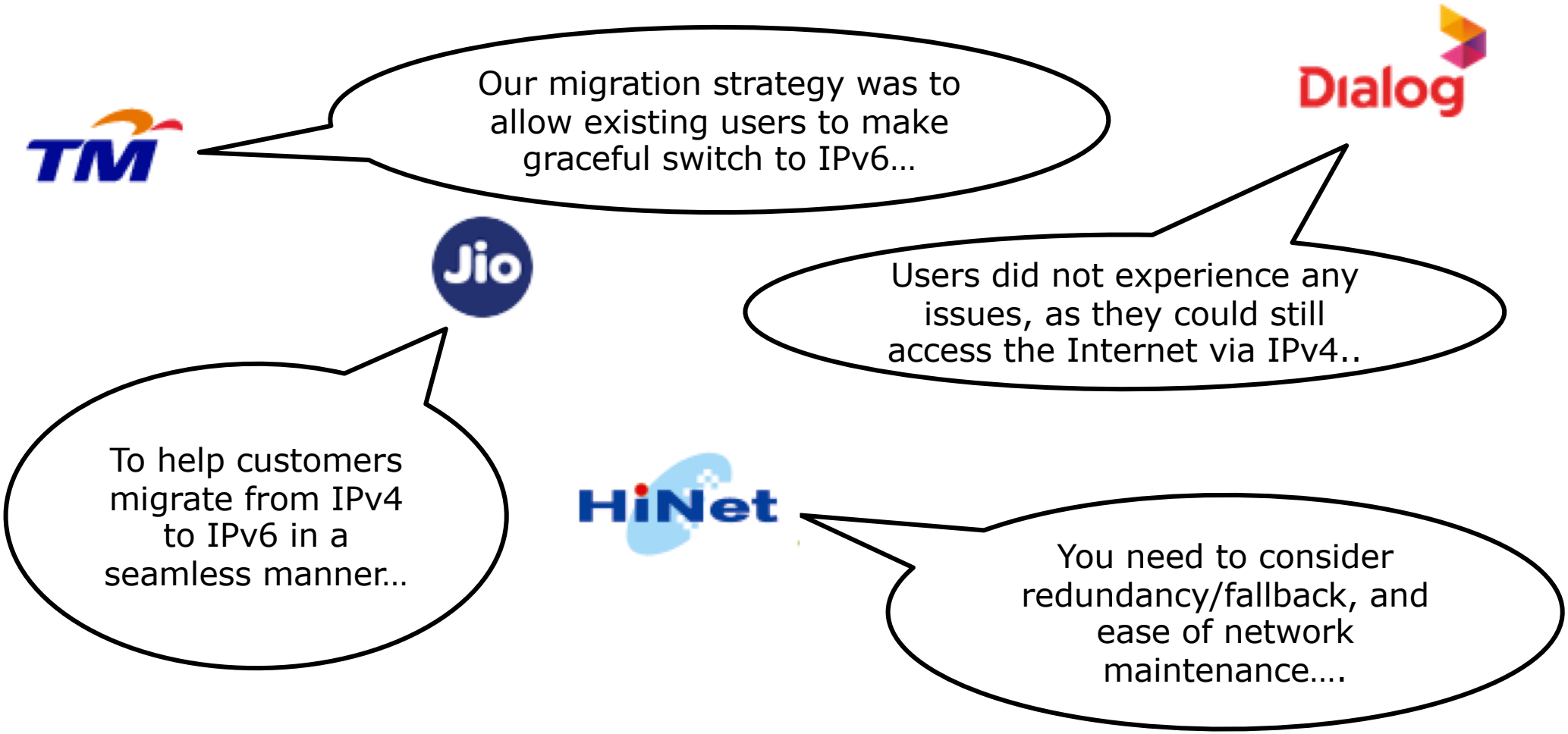
IPv6 - Who is in control?

- The true driver for IPv6 adoption - Mobile Internet!
- However, born and raised on NAT!
  - Still heavily based on CG-NAT

IPv6 in Action: Mobile Networks

Carrier	Economy	Deployment
Verizon Wireless	USA	Dual-stack (2011)
T-Mobile	USA	464XLAT (2012)
Telekom Malaysia	Malaysia	Dual-stack (2013)
SK Telecom	Korea	464XLAT (2014)
Telstra	Australia	464XLAT (2016)
Reliance Jio	India	**Dual-stack (2016)**
Dialog Axiata	Sri Lanka	**Dual-stack (2016)**
AIS	Thailand	**Dual-stack (2017)**
Bhutan Telecom	Bhutan	**Dual-stack (2018)**
Chungwa Telecom	Taiwan	**Dual-stack (2018)**

Dual-stack preference?

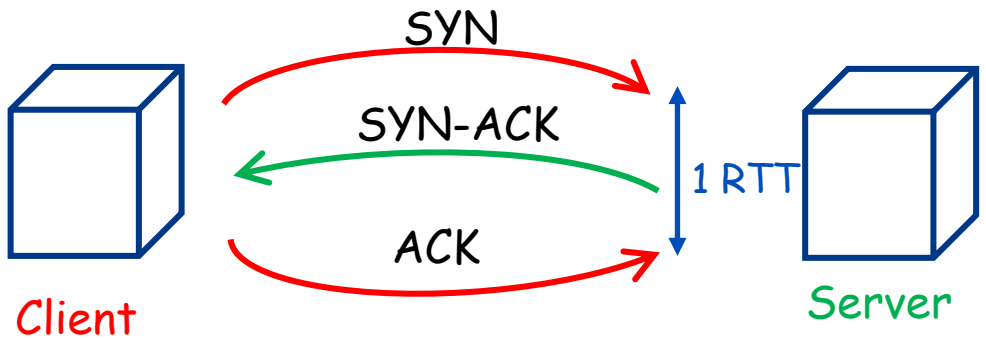


IPv6 - Mobile Devices

- 464XLAT:
  - Android (4.3 - Jelly Bean)
  - Windows Phone (8.1+)
- IPv6-only:
  - iOS
    - since iOS 9 (*supported on WiFi for a long time)*
    - since June 2016, apps in App Store must support IPv6 https://developer.apple.com/support/ipv6/
- DHCPv6:
  - Windows
  - iOS
- Dual-stack:
  - KaiOS
    - Jio/Nokia 8110 feature handsets
  - iOS
    - reports for dual-stack since 11.3 (through carrier update)

IPv6 Performance - Analysis

- We look at TCP (3-way) handshake
  - A received SYN with no subsequent ACK is interpreted as a failed connection attempt
  - The time between the receipt of the SYN and the subsequent ACK at the server is interpreted as the RTT (*not implicit RTT*)

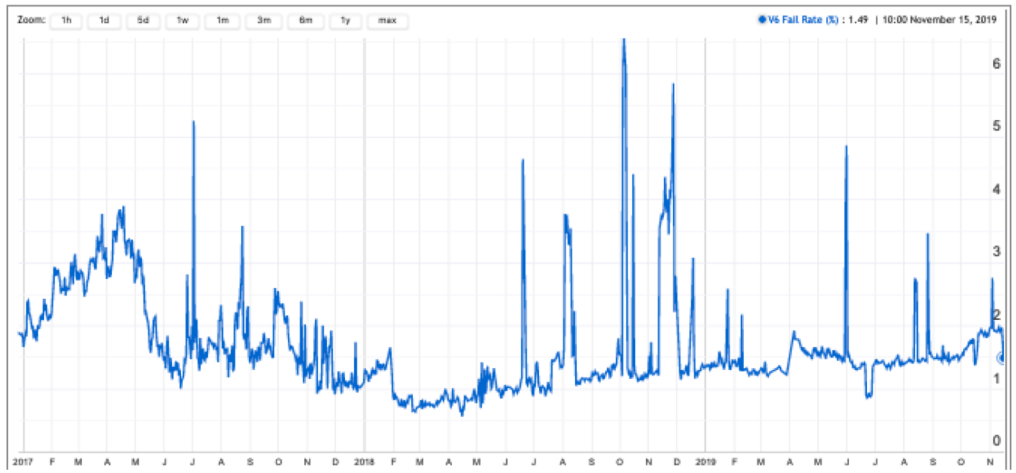


IPv6 Performance

- Is IPv6 as reliable (robust) as IPv4?
  - Do all TCP connection attempts succeed?
    - Failure ~ no ACK for a received SYN

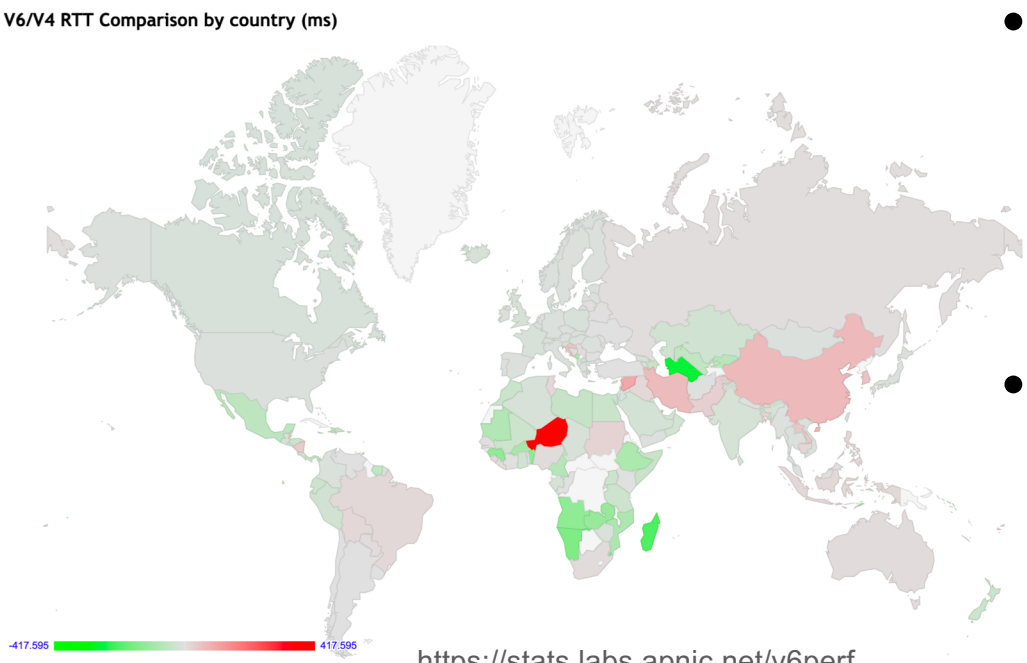
- Global IPv6 failure rate 1.4% ☹
  - End point filters/firewalls?
    - Not allowing inbound IPv6? or
    - ICMPv6 (PTB) filtered? PMTUD failure?
  - End points on unreachable IPv6 address?

Average V6 Connection Failure Rate for World (XA)



IPv6 Performance

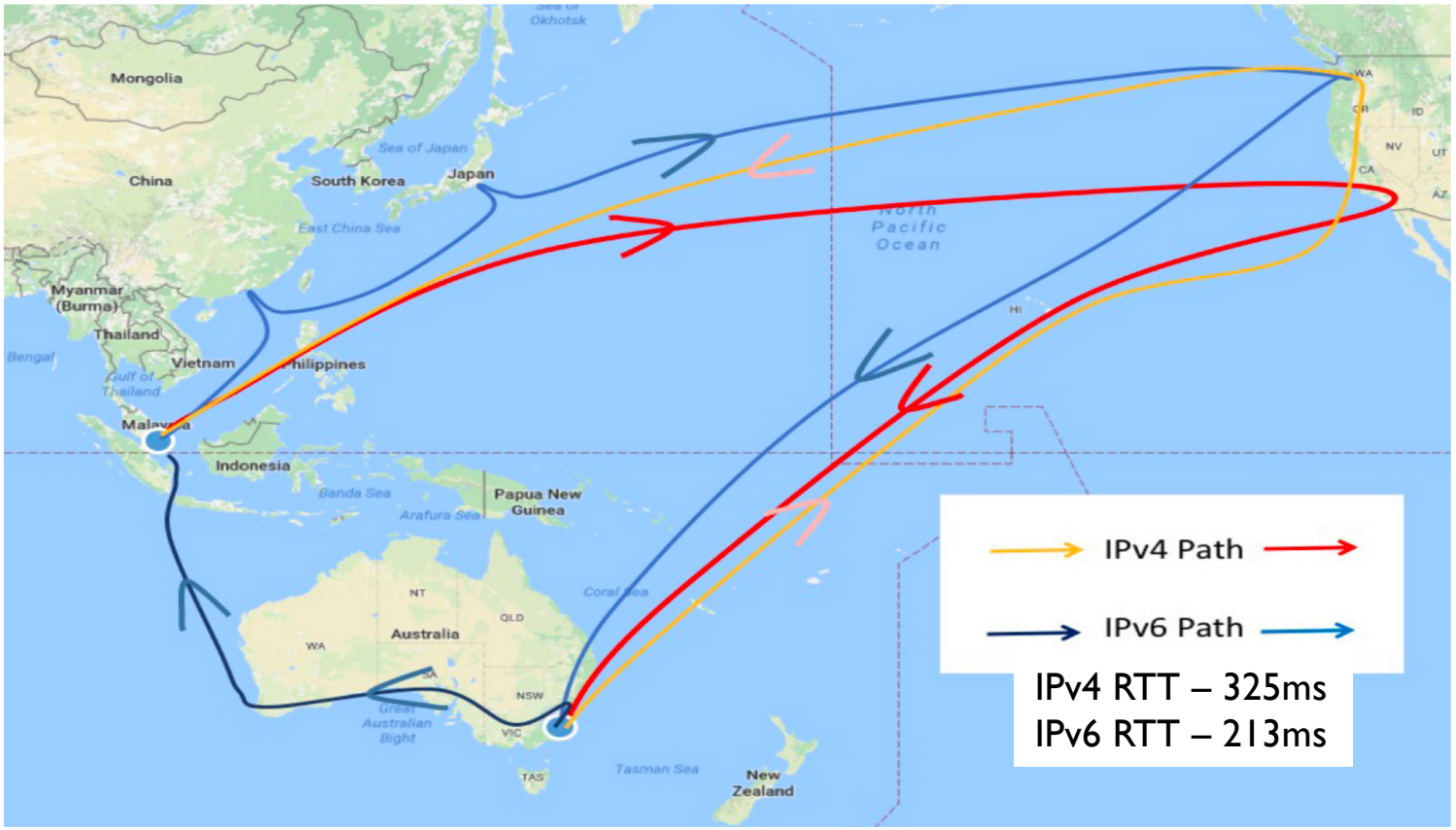
- Is IPv6 as fast as IPv4?
  - Comparison of RTT
    - time since SYN and subsequent ACK



https://stats.labs.apnic.net/v6perf

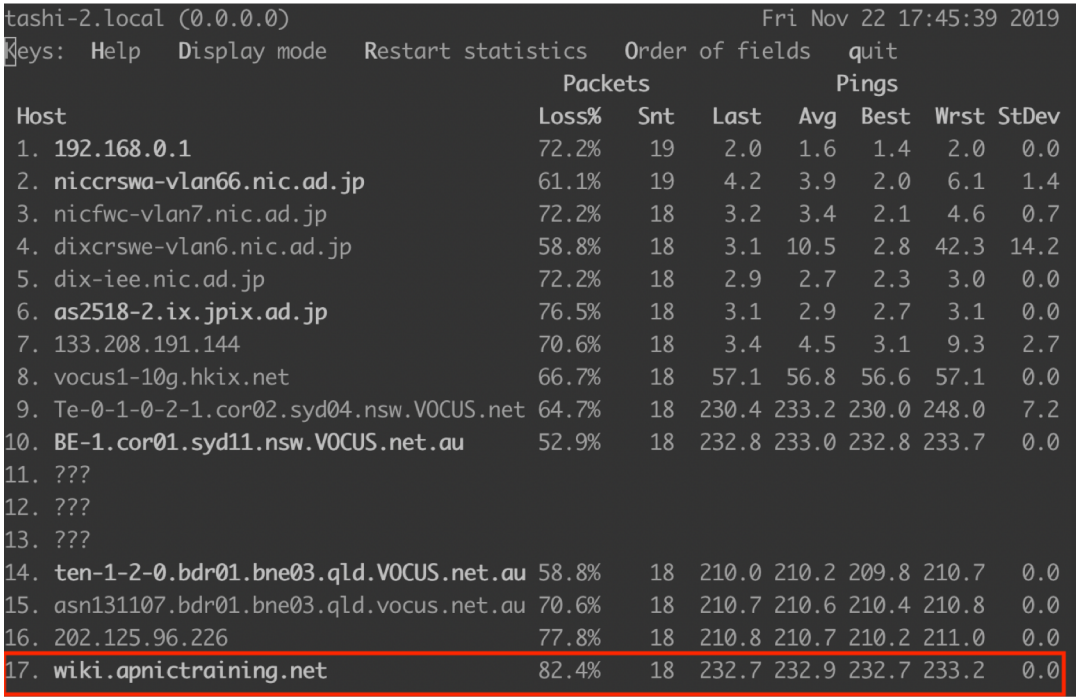
- IPv6 appears faster
  - Africa, Europe, and the Americas
  - CG-NAT/NAT boxes?
- IPv4 seems faster
  - Asia & Oceania
  - Different routing paths for IPv4 and IPv6?

IPv6 Performance & Routing Path



https://labs.apnic.net/?p=850

IPv6 Performance & Routing Path

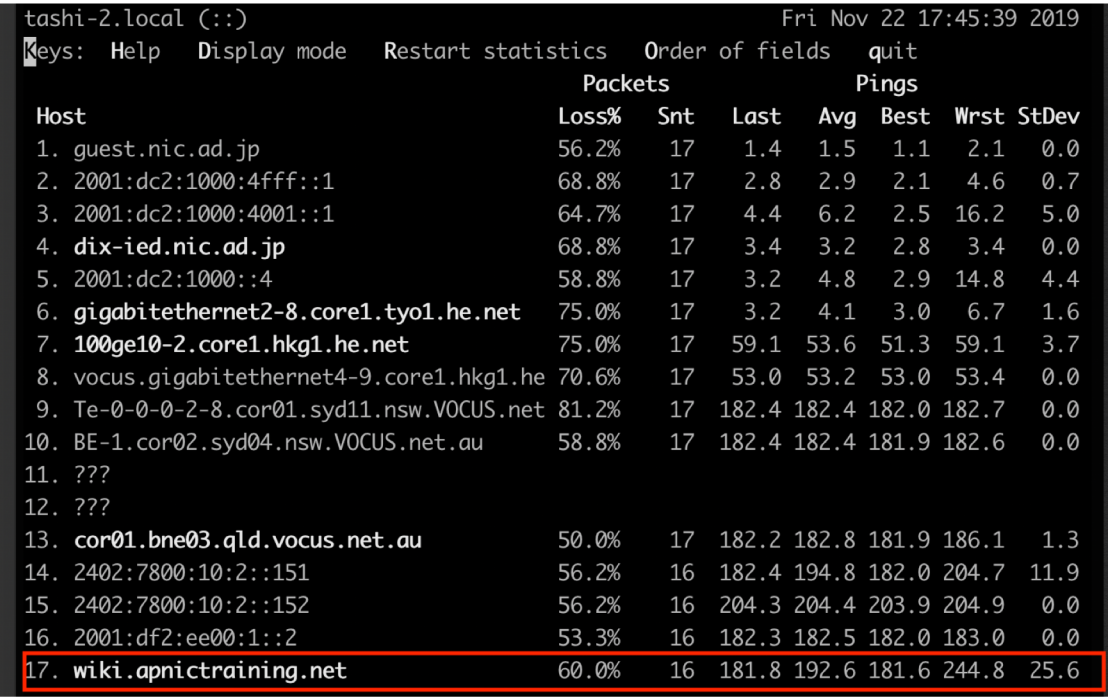


tashi-2.local (0.0.0.0) Fri Nov 22 17:45:39 2019

Keys: Help Display mode Restart statistics Order of fields quit

Host	Packets Loss%	Snt	Pings Last	Avg	Best	Wrst	StDev
1. 192.168.0.1	72.2%	19	2.0	1.6	1.4	2.0	0.0
2. niccrswa-vlan66.nic.ad.jp	61.1%	19	4.2	3.9	2.0	6.1	1.4
3. nicfwc-vlan7.nic.ad.jp	72.2%	18	3.2	3.4	2.1	4.6	0.7
4. dixcrswe-vlan6.nic.ad.jp	58.8%	18	3.1	10.5	2.8	42.3	14.2
5. dix-iee.nic.ad.jp	72.2%	18	2.9	2.7	2.3	3.0	0.0
6. as2518-2.ix.jpix.ad.jp	76.5%	18	3.1	2.9	2.7	3.1	0.0
7. 133.208.191.144	70.6%	18	3.4	4.5	3.1	9.3	2.7
8. vocus1-10g.hkix.net	66.7%	18	57.1	56.8	56.6	57.1	0.0
9. Te-0-1-0-2-1.cor02.syd04.nsw.VOCUS.net	64.7%	18	230.4	233.2	230.0	248.0	7.2
10. BE-1.cor01.syd11.nsw.VOCUS.net.au	52.9%	18	232.8	233.0	232.8	233.7	0.0
11. ???							
12. ???							
13. ???							
14. ten-1-2-0.bdr01.bne03.qld.VOCUS.net.au	58.8%	18	210.0	210.2	209.8	210.7	0.0
15. asn131107.bdr01.bne03.qld.vocus.net.au	70.6%	18	210.7	210.6	210.4	210.8	0.0
16. 202.125.96.226	77.8%	18	210.8	210.7	210.2	211.0	0.0
17. wiki.apnictraining.net	82.4%	18	232.7	232.9	232.7	233.2	0.0

IPv4



tashi-2.local (::) Fri Nov 22 17:45:39 2019

Keys: Help Display mode Restart statistics Order of fields quit

Host	Packets Loss%	Snt	Pings Last	Avg	Best	Wrst	StDev
1. guest.nic.ad.jp	56.2%	17	1.4	1.5	1.1	2.1	0.0
2. 2001:dc2:1000:4fff::1	68.8%	17	2.8	2.9	2.1	4.6	0.7
3. 2001:dc2:1000:4001::1	64.7%	17	4.4	6.2	2.5	16.2	5.0
4. dix-ied.nic.ad.jp	68.8%	17	3.4	3.2	2.8	3.4	0.0
5. 2001:dc2:1000::4	58.8%	17	3.2	4.8	2.9	14.8	4.4
6. gigabitethernet2-8.core1.tyo1.he.net	75.0%	17	3.2	4.1	3.0	6.7	1.6
7. 100ge10-2.core1.hkg1.he.net	75.0%	17	59.1	53.6	51.3	59.1	3.7
8. vocus.gigabitethernet4-9.core1.hkg1.he	70.6%	17	53.0	53.2	53.0	53.4	0.0
9. Te-0-0-0-2-8.cor01.syd11.nsw.VOCUS.net	81.2%	17	182.4	182.4	182.0	182.7	0.0
10. BE-1.cor02.syd04.nsw.VOCUS.net.au	58.8%	17	182.4	182.4	181.9	182.6	0.0
11. ???							
12. ???							
13. cor01.bne03.qld.vocus.net.au	50.0%	17	182.2	182.8	181.9	186.1	1.3
14. 2402:7800:10:2::151	56.2%	16	182.4	194.8	182.0	204.7	11.9
15. 2402:7800:10:2::152	56.2%	16	204.3	204.4	203.9	204.9	0.0
16. 2001:df2:ee00:1::2	53.3%	16	182.3	182.5	182.0	183.0	0.0
17. wiki.apnictraining.net	60.0%	16	181.8	192.6	181.6	244.8	25.6

IPv6

Where are we now?

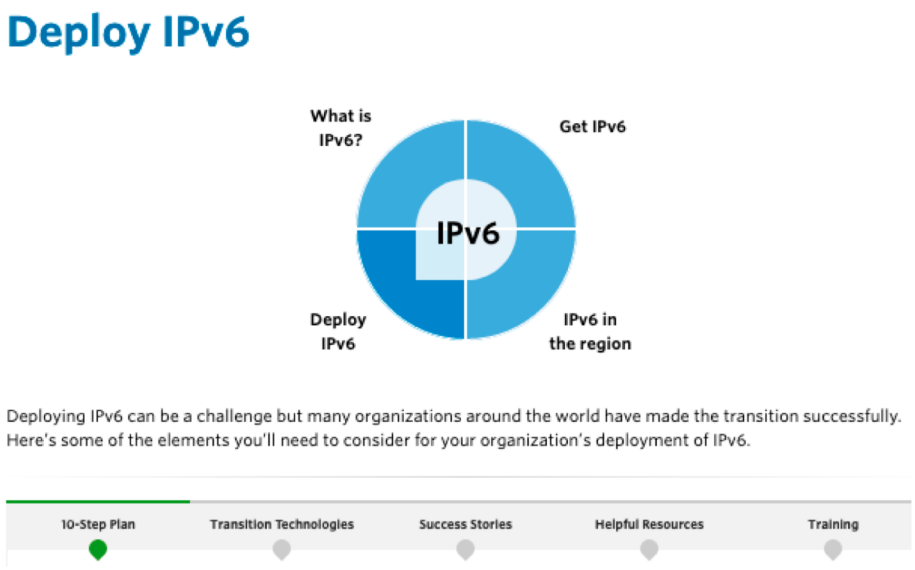
- Global IPv6 end-user readiness ~ 24%
- IPv6 deployments on the rise (across diverse economy profiles)
  - 63% of network operators in Asia-Pacific have IPv6 resources
- Observed trend of dual-stack in recent deployments

"IPv6 has emerged from the 'Innovators' and 'Early Adoption' stages of deployment, and is now in the 'Early Majority phase"

- ISOC State of IPv6 Deployment (2018)

How can we help?

- Track, measure, report
  - End-user readiness,
  - Performance analysis
- Trainings
  - Direct country assistance (Gov)
  - Standalone workshops
  - NOGs
- Technical Assistance
  - Remote or F2F



https://www.apnic.net/community/ipv6

THANK YOU