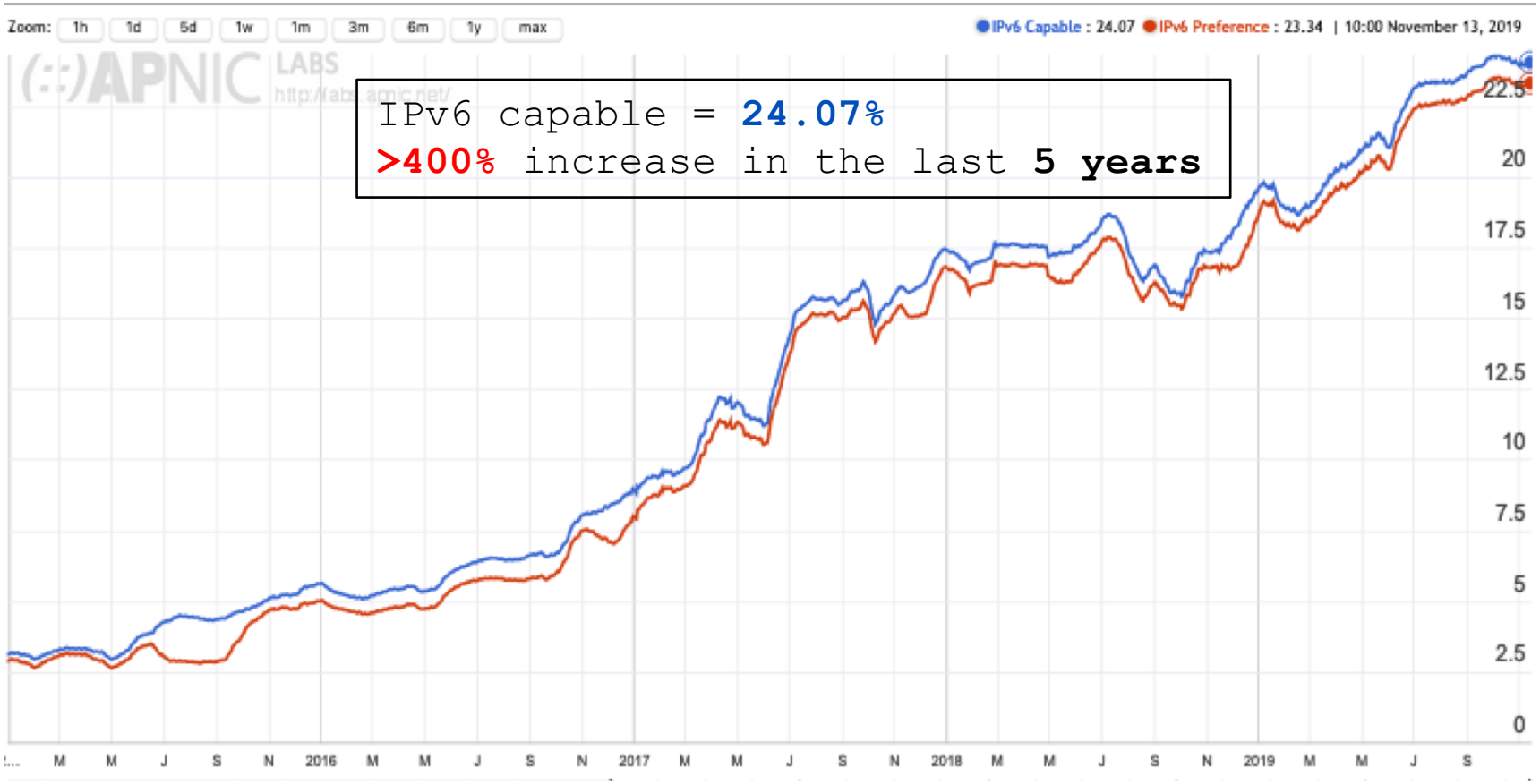
IPv6 Deployment Update
(Where are we now?)

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

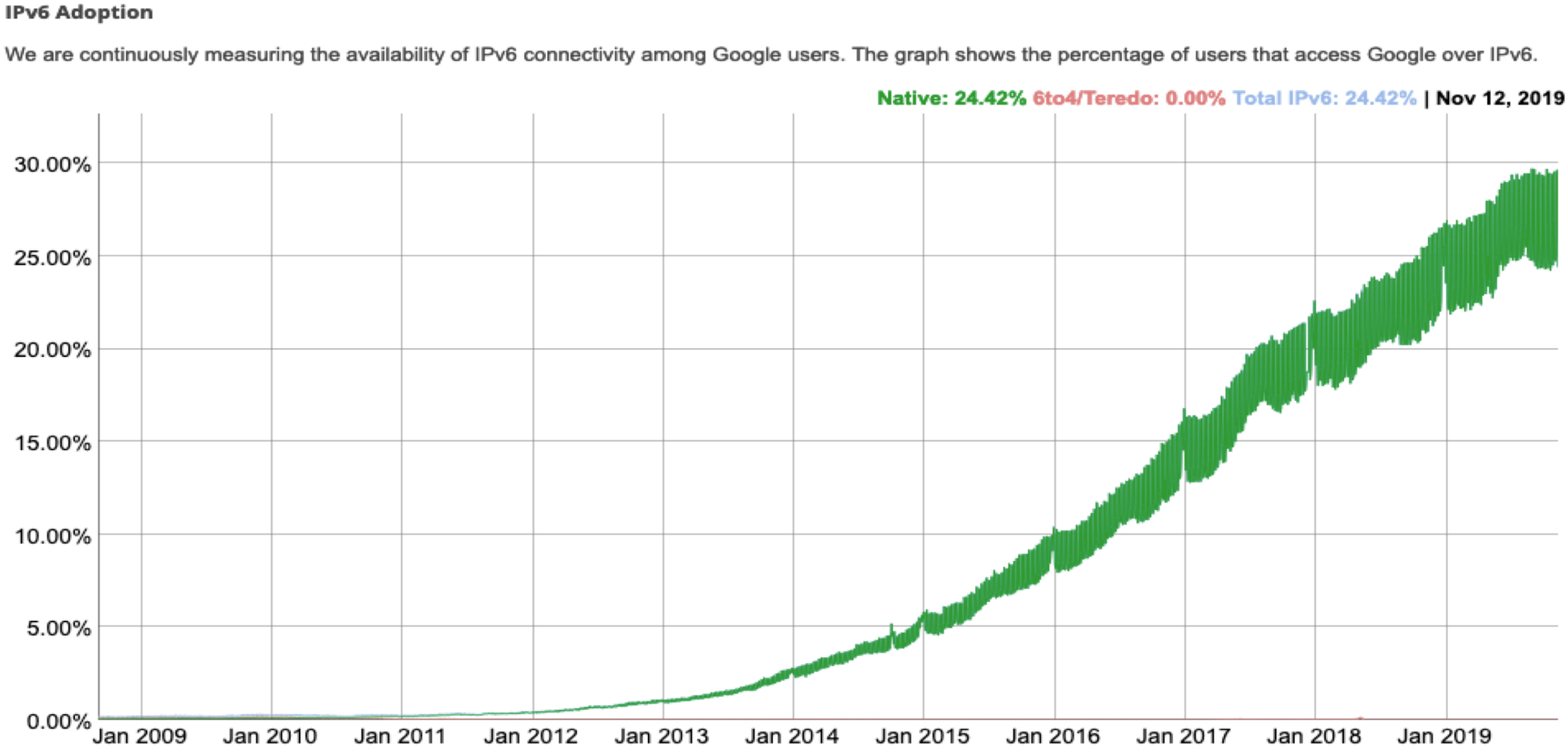
Economy	IPv6 capable (%)
India	63.79
Belgium	57.74
United States	56.74
Taiwan	45.29
Malaysia	45.07
Greece	44.17
Germany	40.96
France	38.21
Vietnam	38.14
Luxembourg	36.45
Japan	35.52
Switzerland	33.89

Economy	IPv6 capable (%)
Finland	32.93
Portugal	32.28
Uruguay	32.10
United Kingdom	31.82
Brazil	31.45
Mexico	30.87
Norway	29.64
Thailand	28.74
Canada	26.10
Sri Lanka	25.36
Hungary	25.20
UAE	24.95

Economy	IPv6 capable (%)
Estonia	24.94
New Zealand	23.37
Australia	23.27
Trinidad & Tobago	22.45
Netherlands	21.22
Ireland	20.62
Peru	19.83
South Korea	16.09
Romania	15.82
China	15.32
Ecuador	15.29

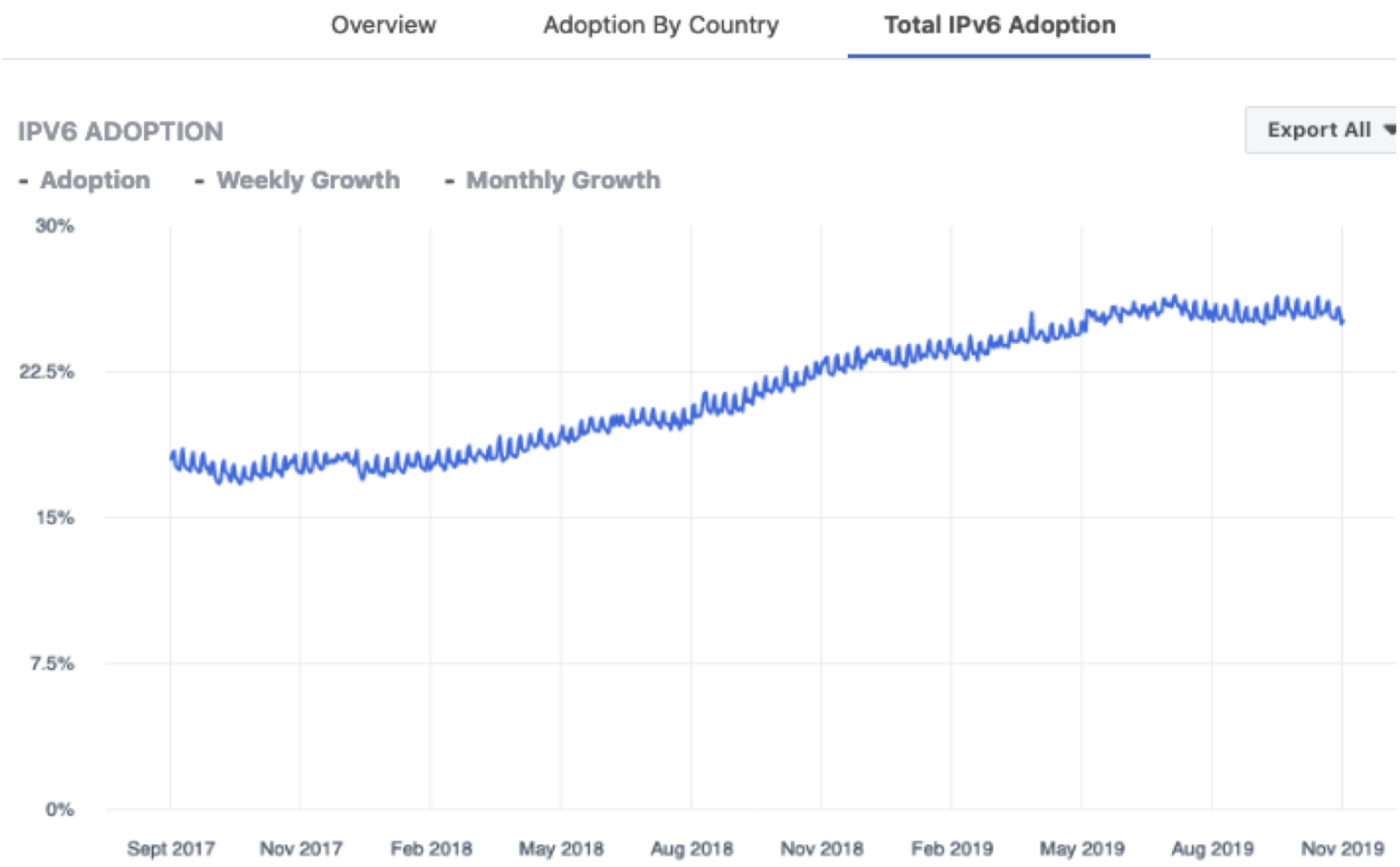
https://stats.labs.apnic.net/ipv6/ (15 Nov 2019)

IPv6 in Action - Google



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

IPv6 in Action - Facebook



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

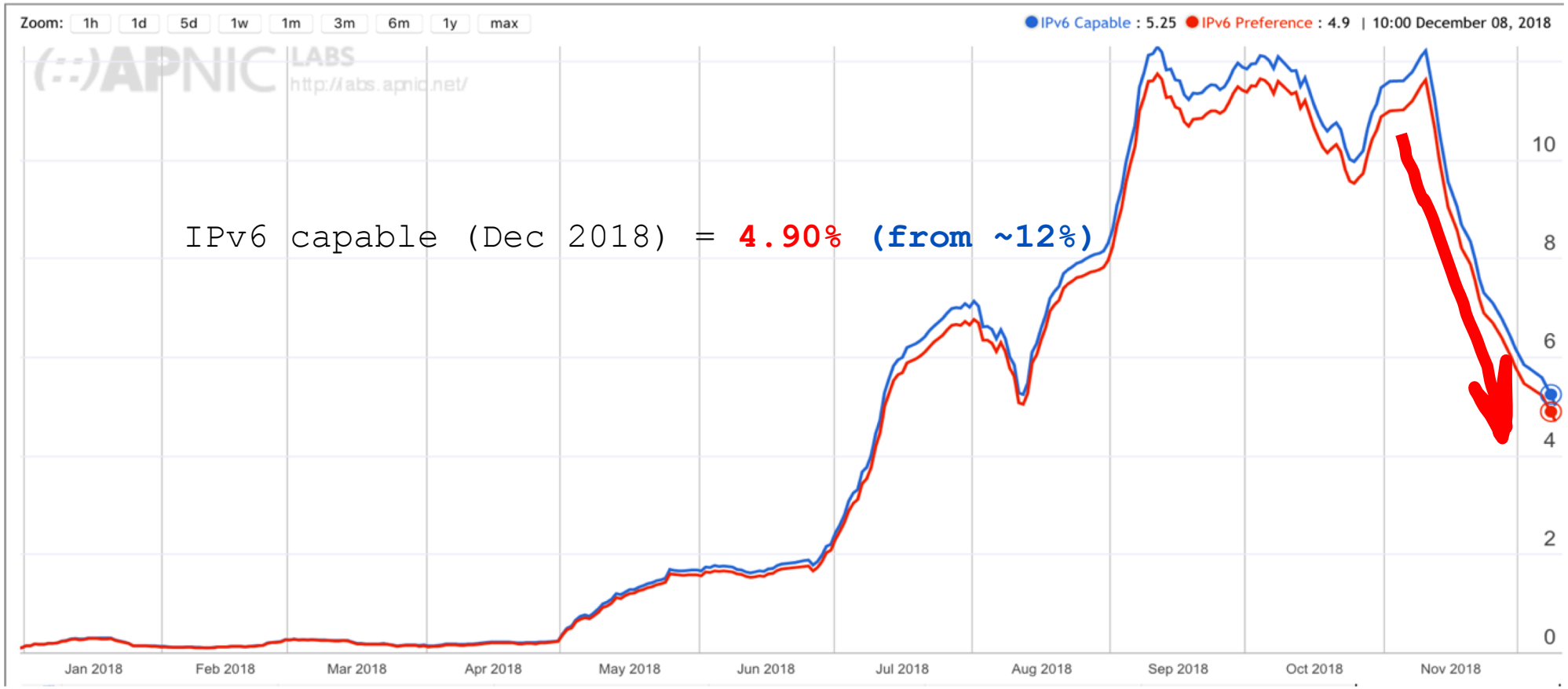
What about Asia-Pacific?

Economy	IPv6 capable (%)
India	**63.81**
Taiwan	**45.23**
Malaysia	**45.11**
Vietnam	**38.20**
Japan	35.54
Thailand	**28.75**
Sri Lanka	**25.23**
New Zealand	**23.38**
Australia	**23.29**
South Korea	16.08
Singapore	13.51
Myanmar	8.78
Bhutan	**7.57**

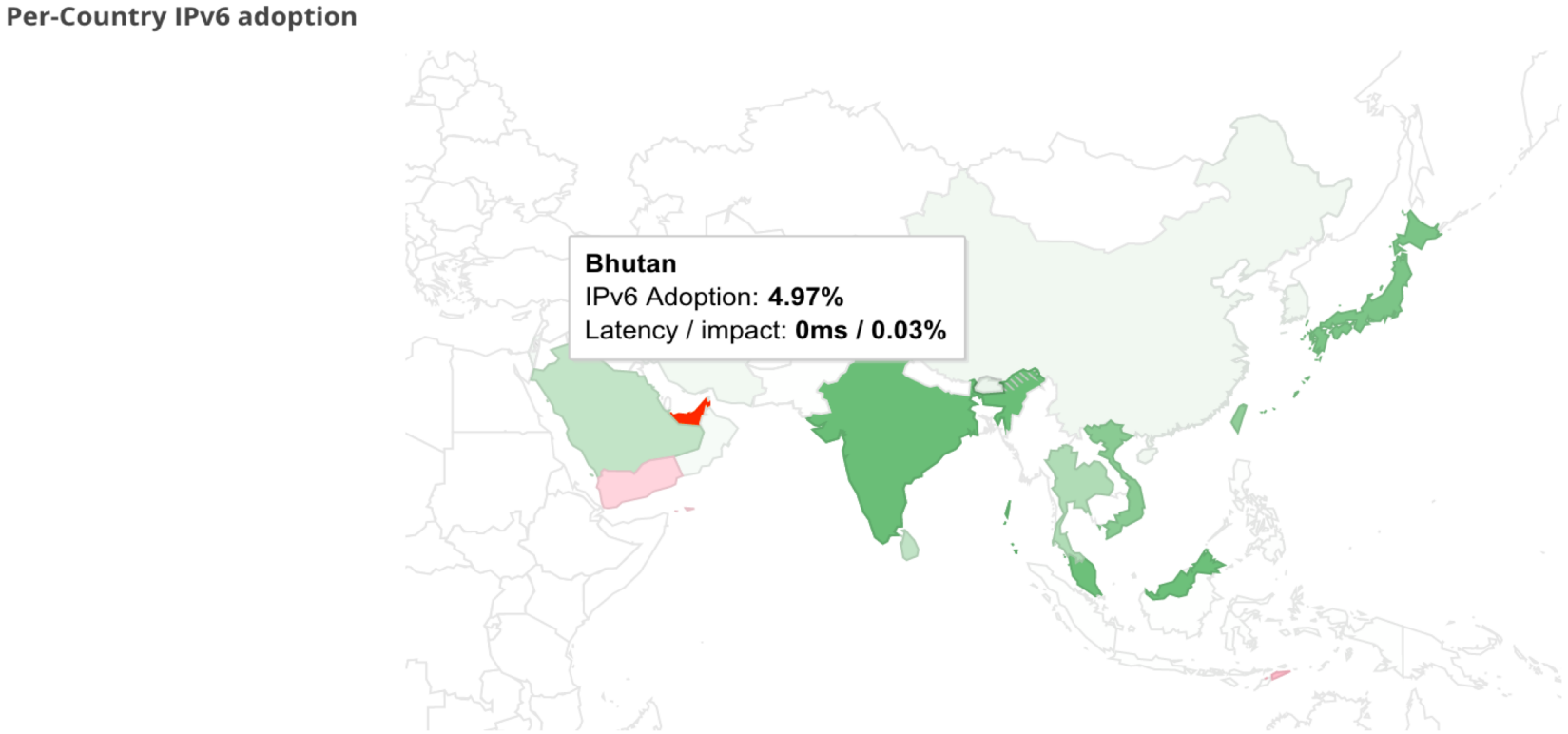
South Asia Focus

Economy	IPv6 capable (%)
India	**63.81**
Sri Lanka	**25.23**
Bhutan	7.57
Maldives	3.99
Nepal	3.62
Afghanistan	0.12
Pakistan	0.04
Bangladesh	0.03

Something interesting - BT

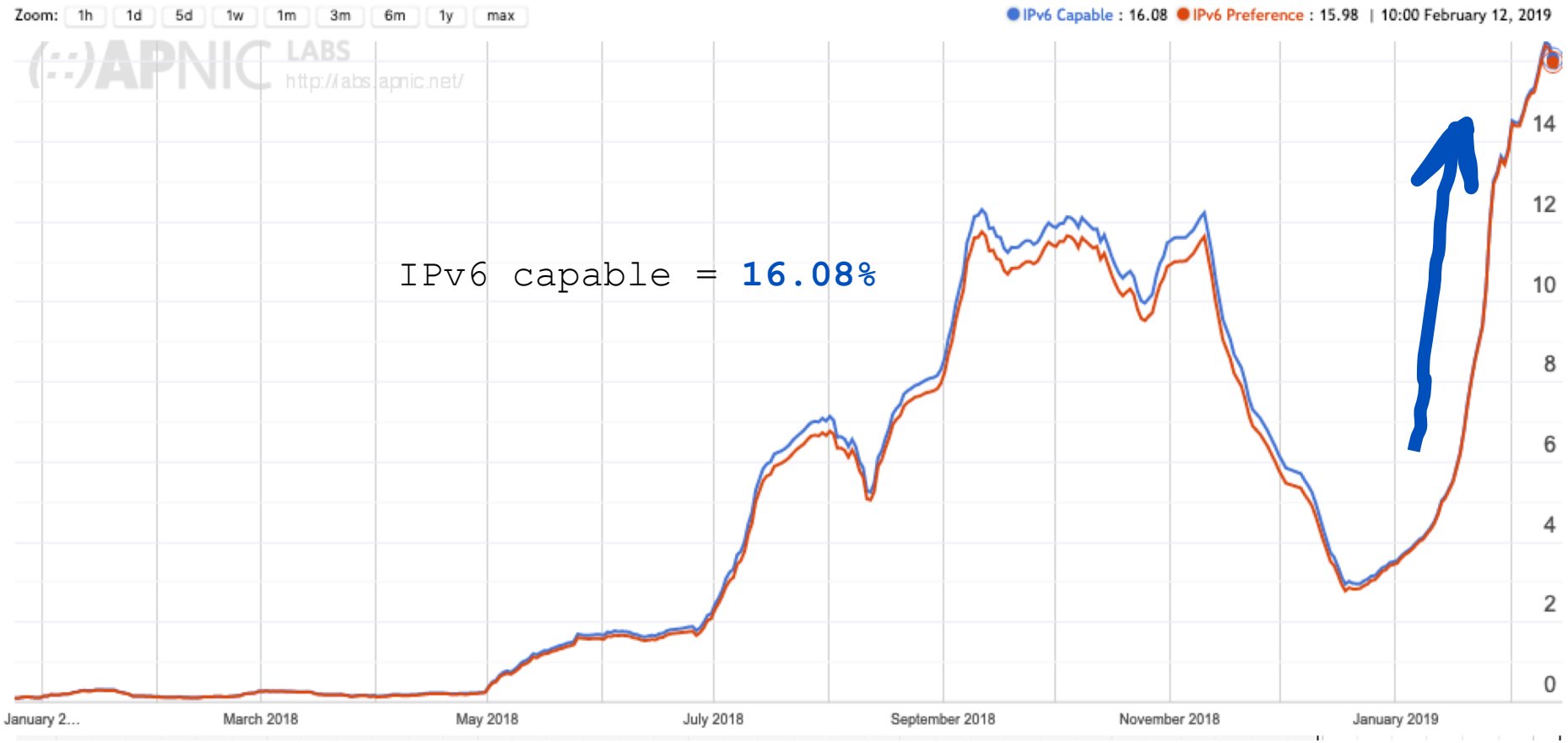


Google’s view - BT

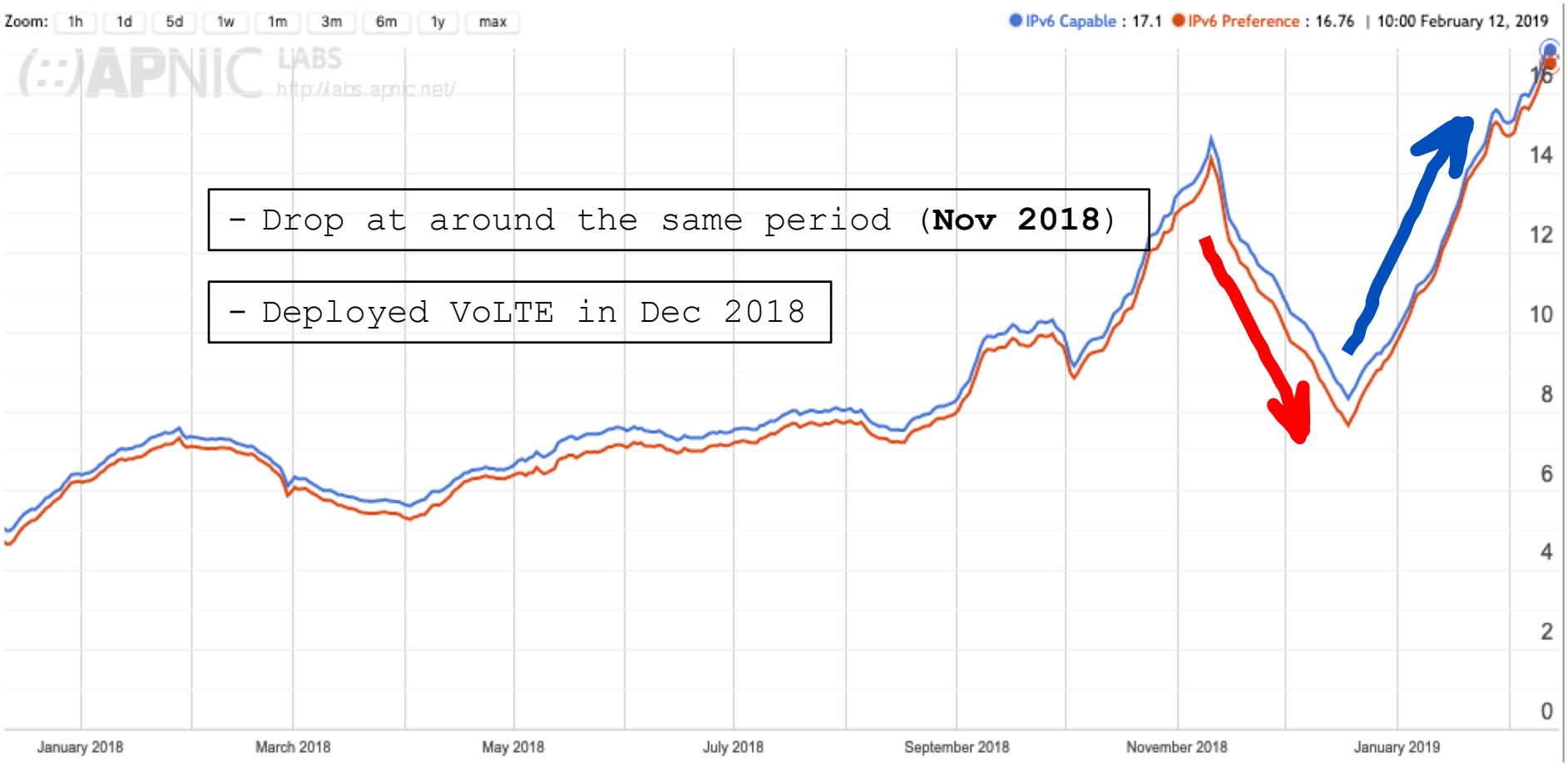


https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption

After the fix - BT



Coincidence - LK?



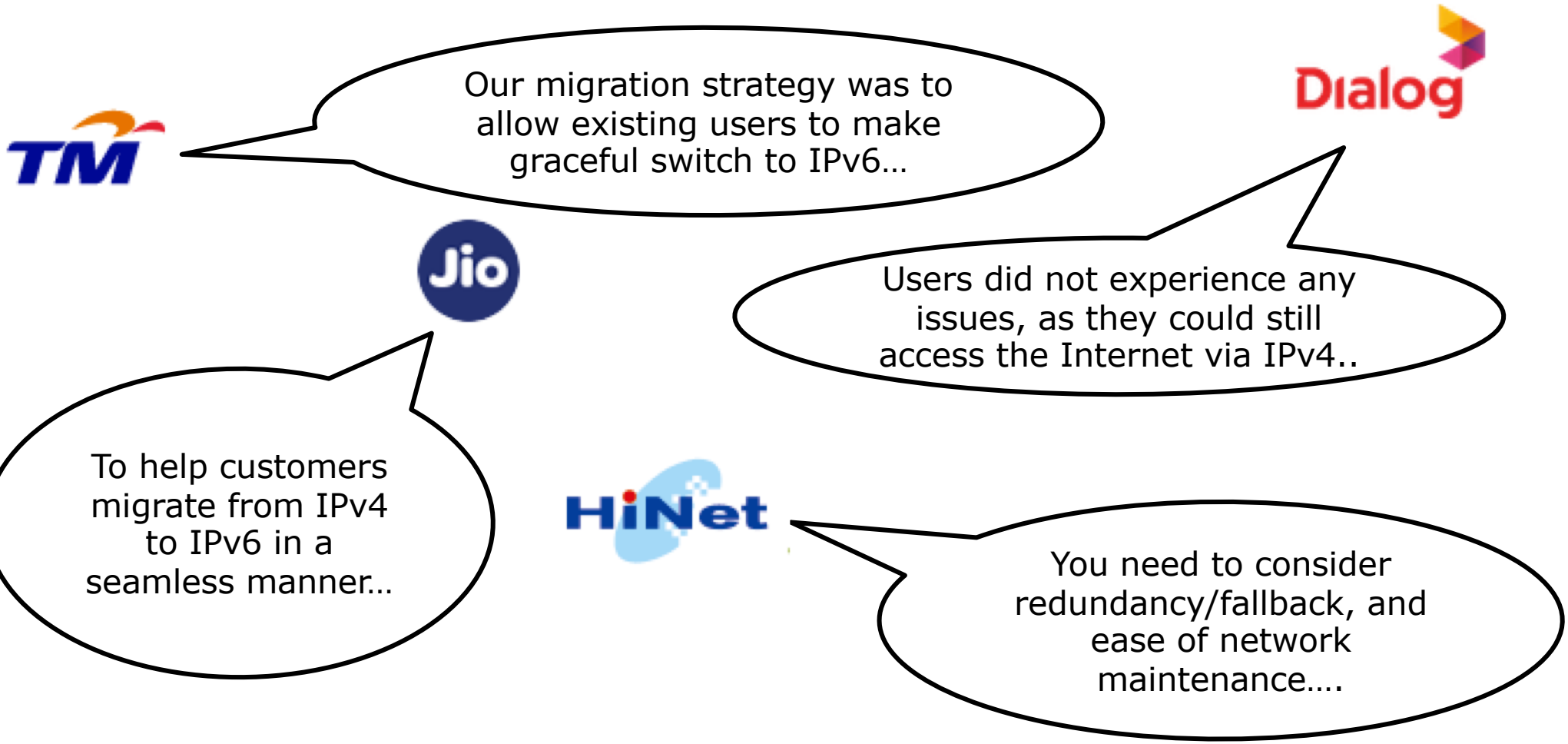
IPv6 - Who is in control?

- 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?

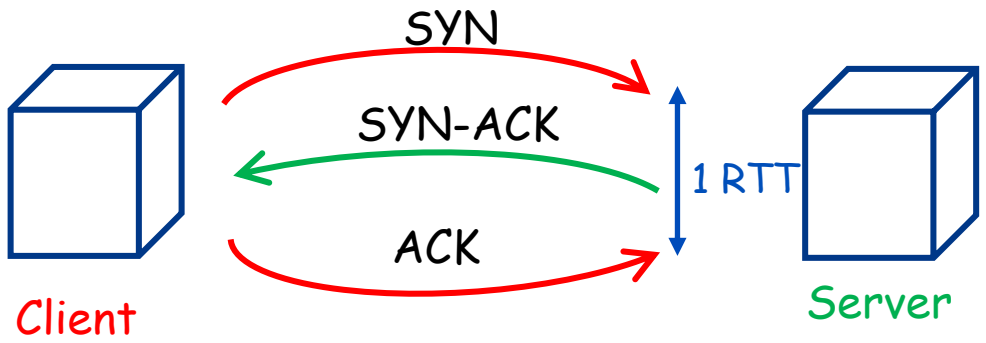


IPv6 - Mobile Devices

- 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*)

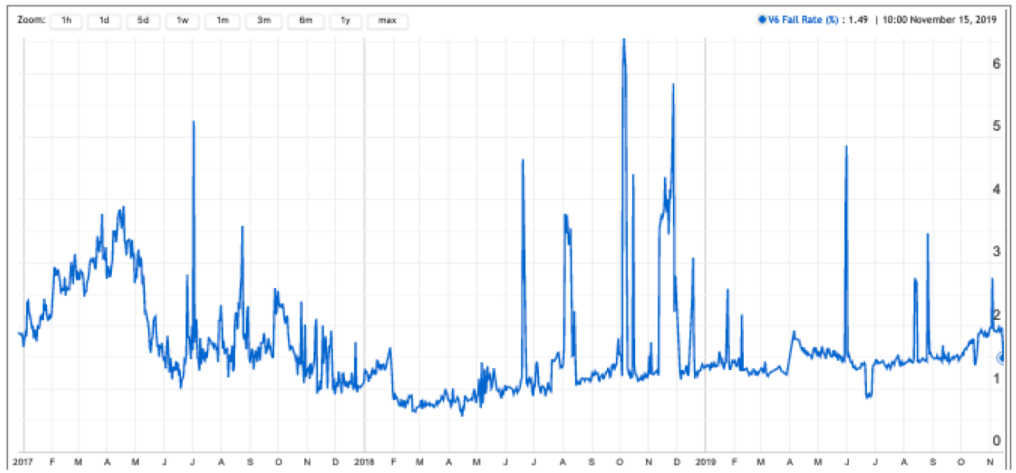


IPv6 Performance

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

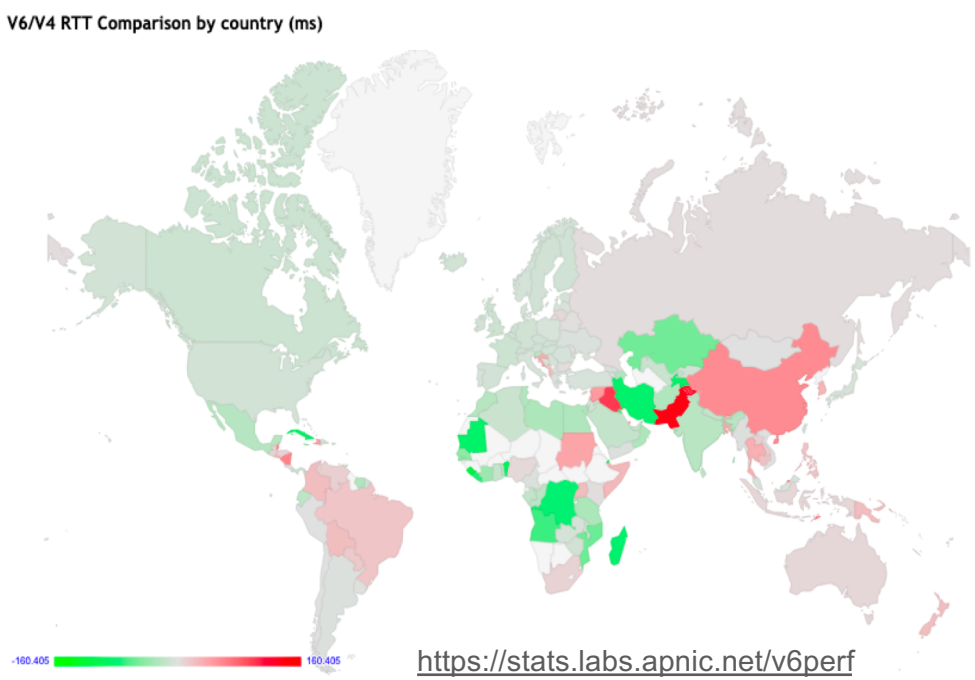
- Global IPv6 failure rate 1.4% ☹
  - End point filters/firewalls?
    - Not allowing inbound IPv6? or
    - ICMPv6 (PTB) filtered? PMTUD failure?
  - End points on unreachable IPv6 address?

Average V6 Connection Failure Rate for World (XA)



IPv6 Performance

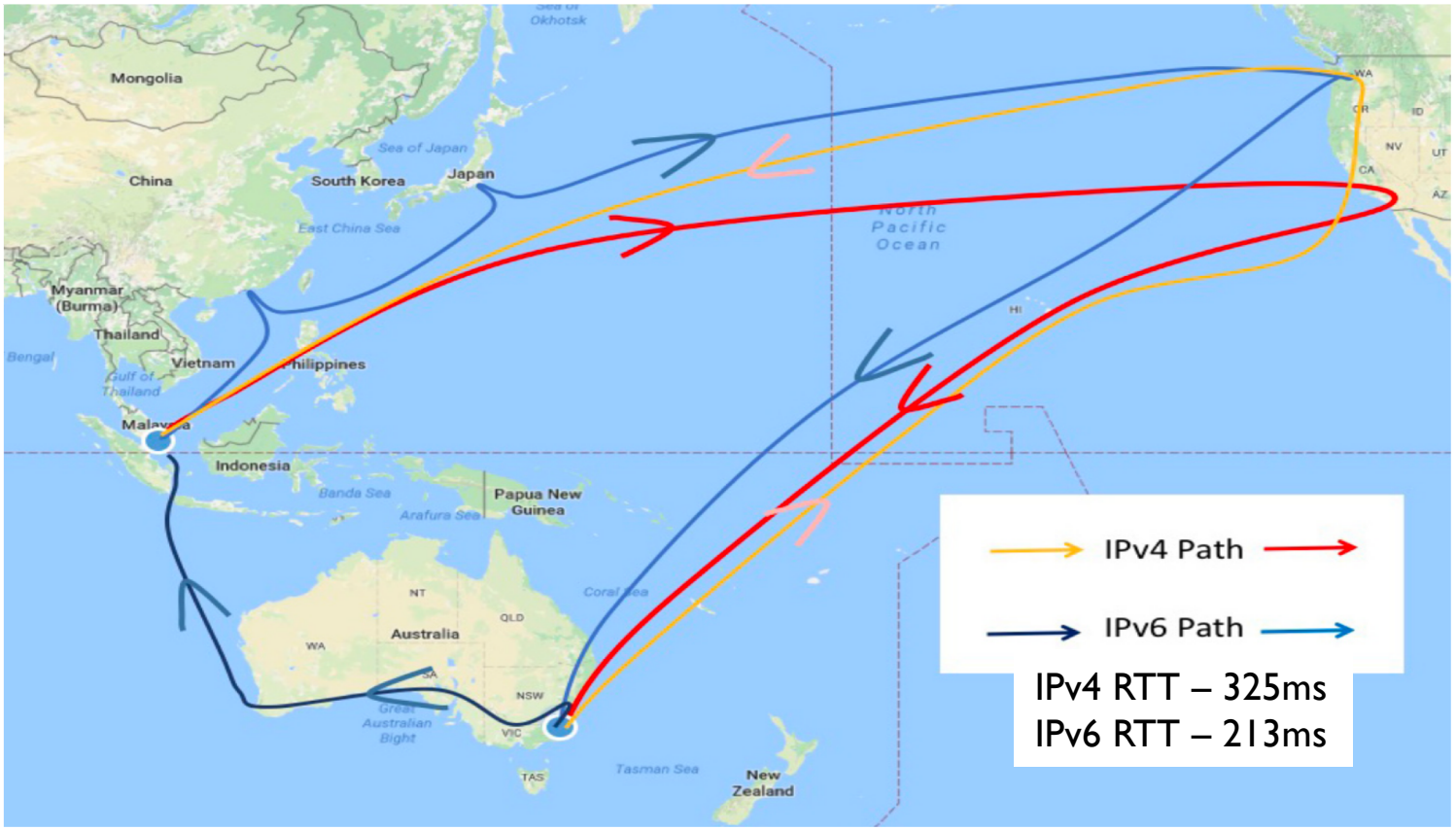
- Is IPv6 as fast as IPv4?
  - Comparison of RTT
    - time since SYN and subsequent ACK



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

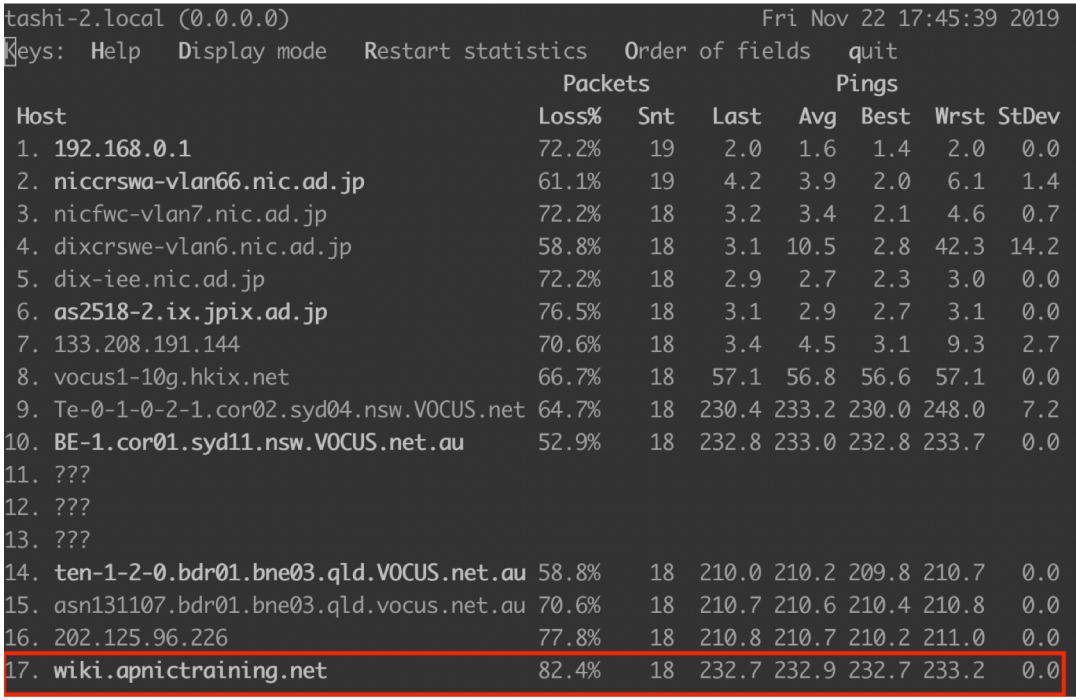
- IPv6 appears faster
  - Africa, Europe, and the Americas
  - CG-NAT/NAT boxes?
- IPv4 seems faster
  - Asia & Oceania
  - Different routing paths for IPv4 and IPv6?

IPv6 Performance & Routing Path



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

IPv6 Performance & Routing Path

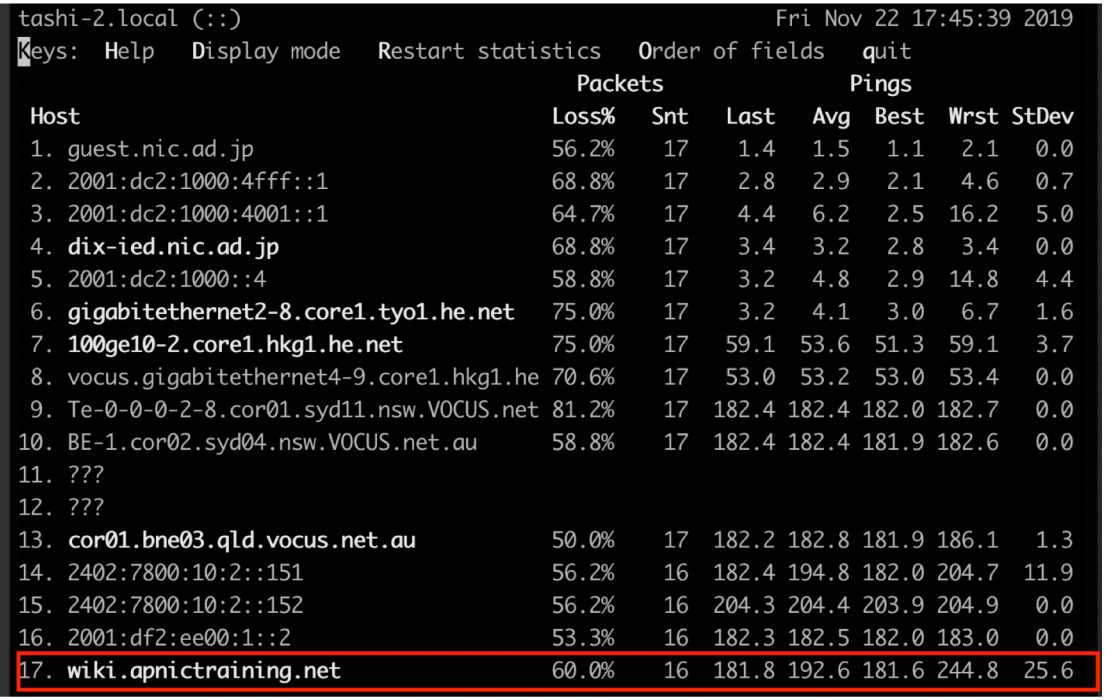


tashi-2.local (0.0.0.0) Fri Nov 22 17:45:39 2019

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?

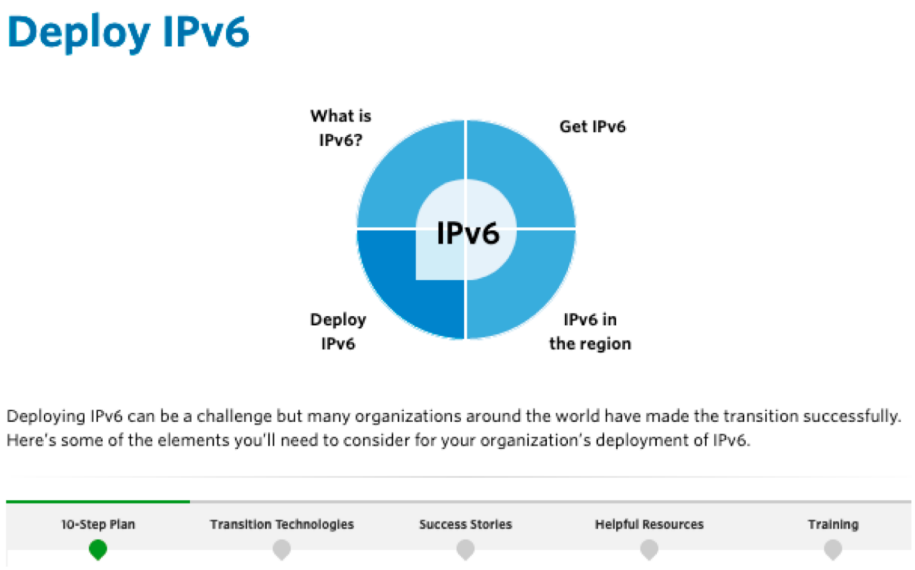
- Global IPv6 end-user readiness ~ 24%
- IPv6 deployments on the rise (across diverse economy profiles)
  - 63% of network operators in Asia-Pacific have IPv6 resources
- Observed trend of dual-stack in recent deployments

"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