Forget <u>Speed</u>; Let's talk <u>Experience</u>

Vijay Sivaraman

Professor in Telecommunications, UNSW Sydney

Co-Founder & CEO, Canopus Networks

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Key Messages

1. Speed comparisons are <u>flawed</u>
   a) There is no consensus on what to measure, how to measure, and what conditions to measure under
   b) Many factors bias the results, and give contradictory results
   c) Current measurement regimes are nonsensical and irrelevant

2. The obsession with speed is <u>detrimental</u> to the Telco industry
   a) Applications like video, gaming, and conferencing do not need speed
   b) Speed does not translate to Telco profitability
   c) Speed / volume are divergent from "value" to consumers & OTTs

3. Focusing on user <u>experience</u> instead of speed
   a) Application experience can be measured accurately and cost-effectively at scale
   b) Case study of gaming as the "killer app"
   c) Knowing you customer

1a) What do we mean by Speed?

❑ Measuring "link", "ISP", or "end-to-end path" speed?

➢ Where does path start: CPE or user client?

➢ Where does path stop: ISP boundary or test-server?

❑ Measuring (static) capacity or (dynamic) throughput?

➢ Capacity measured using packet pair[1] (or train): elegant ☺

➢ Throughput measured using brute force[2] ☹

  » UDP – half-duplex, non-feedback-controlled

  » TCP – full-duplex, inbuilt feedback control

Capacity estimation using packet pair/train [1]
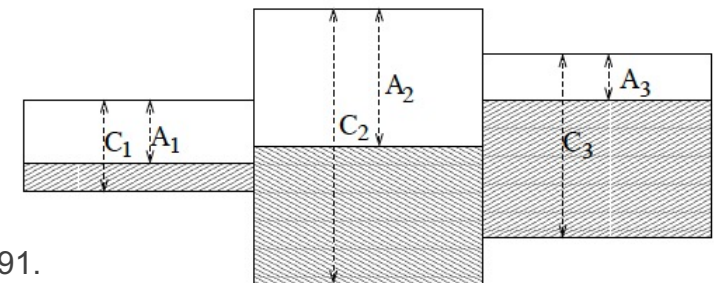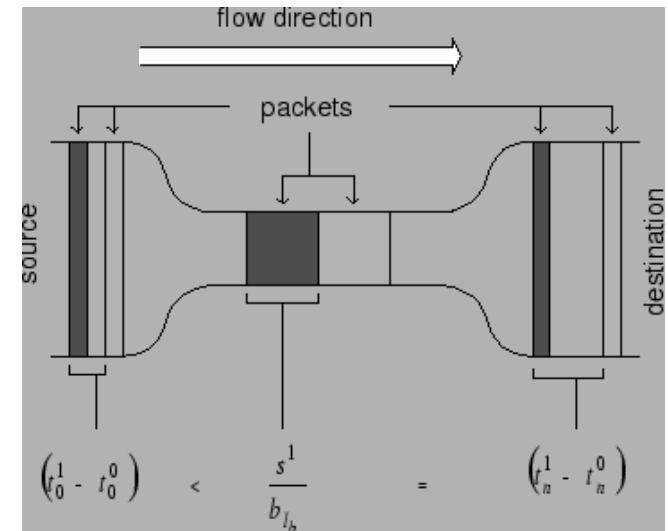
Available bandwidth estimation [2]

[1] S. Keshav, "A Control-Theoretic Approach to Flow Control," Proc. ACM SIGCOMM, Sept. 1991.
[2] R. S. Prasad, M. Murray, C. Dovrolis, K. Claffy, "Bandwidth Estimation: Metrics, Measurement Techniques, and Tools", IEEE Network, 17(6):27-35, Nov 2003.
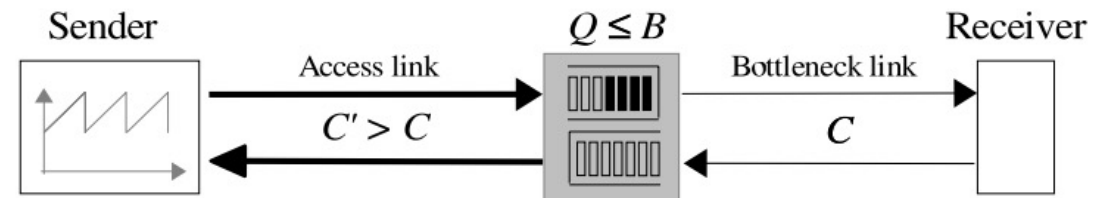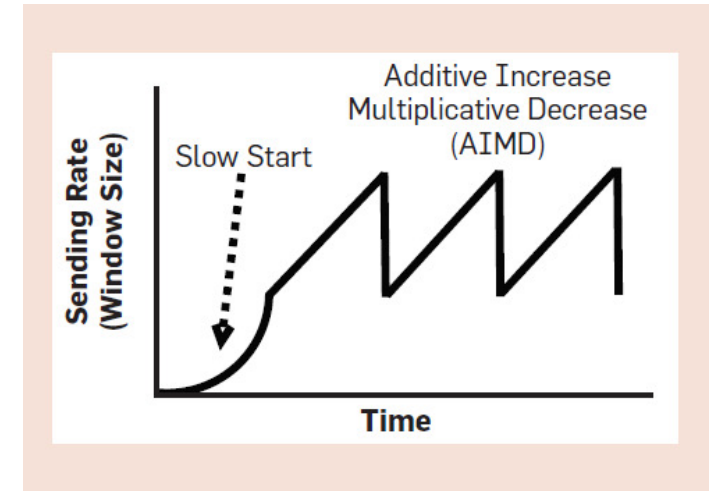
1b) Speed depends on many factors

❑ Tester can tune <u>many</u> factors[3]:

➢ TCP variant[4]: Tahoe, Reno, Vegas, CUBIC, BBR, ...

➢ Speed server location (distance impacts latency & RTT)

➢ Number of flows / threads

➢ Packet size (MSS)

➢ Receiver window size (flow control)

➢ Duration of test (sprint vs marathon)

❑ End users and/or network operators determine ·

➢ CPE port speeds

➢ Router buffer size B (determines loss L)

➢ "class of service" treatment (neutrality assumed?)

[3] N. Feamster, J. Livingood, "Measuring Internet Speed: Current Challenges and Future Recommendations", Communications of the ACM, 63(12):72-80, 2020.
[4] R. Ware, M. Mukerjee, S. Seshan, J. Sherry, "Beyond Jain's Fairness Index: Setting the Bar for the Deployment of Congestion Control Algorithms", Proc. ACM HotNets, Nov 2019.

$$\text{TCP throughput} = \frac{1.22 \cdot \text{MSS}}{\text{RTT} \sqrt{L}}$$

1b) Test conditions bias results: test duration

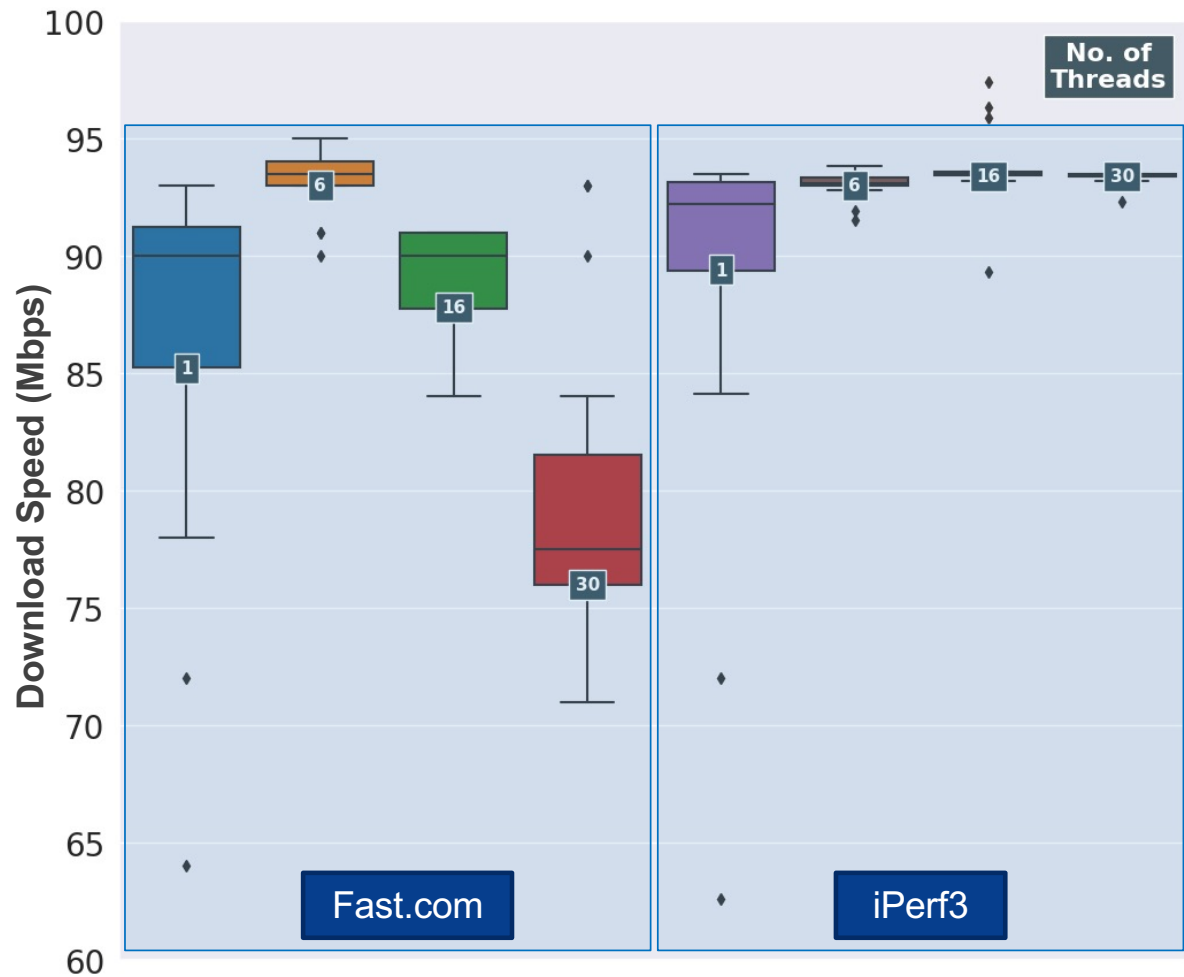

Usain Bolt
(fastest at 100m)
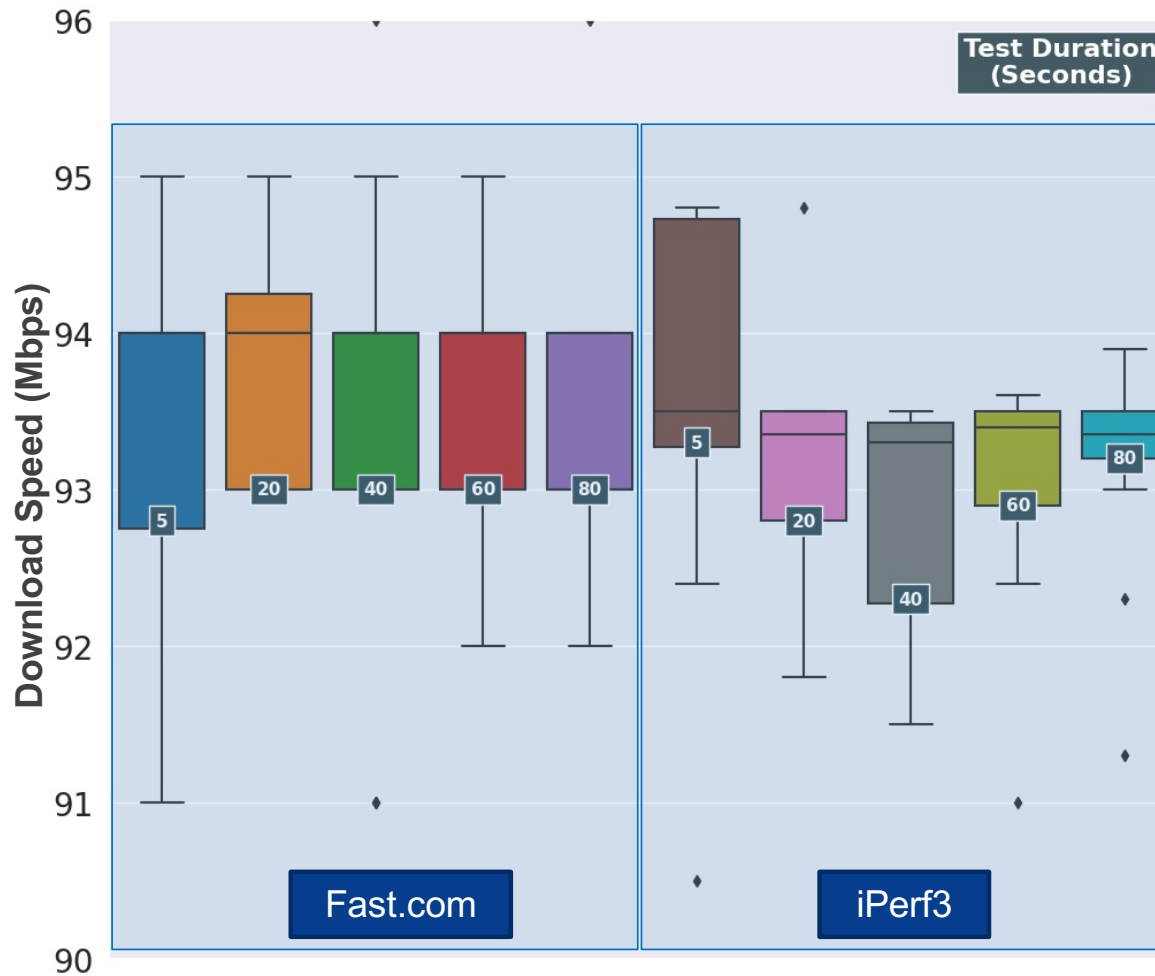
Eliud Kipchoge
(fastest at 42km)
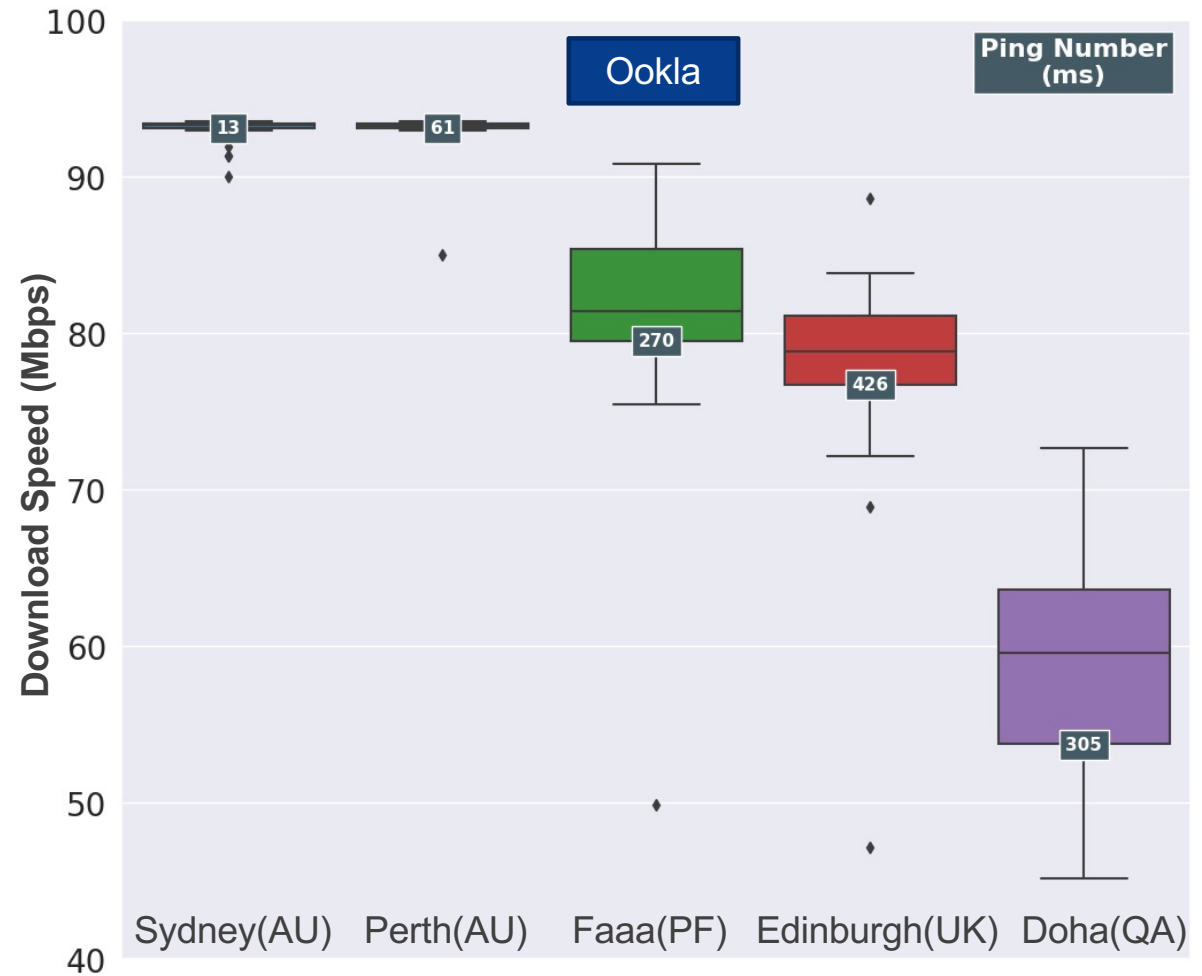
1b) Test conditions bias results: number of threads

(1 x 400m) versus (4 x 100m) relay

1b) Test conditions bias results: server distance

Uphill run not the same as a flat run

1c) Current speed testing regimes are nonsensical
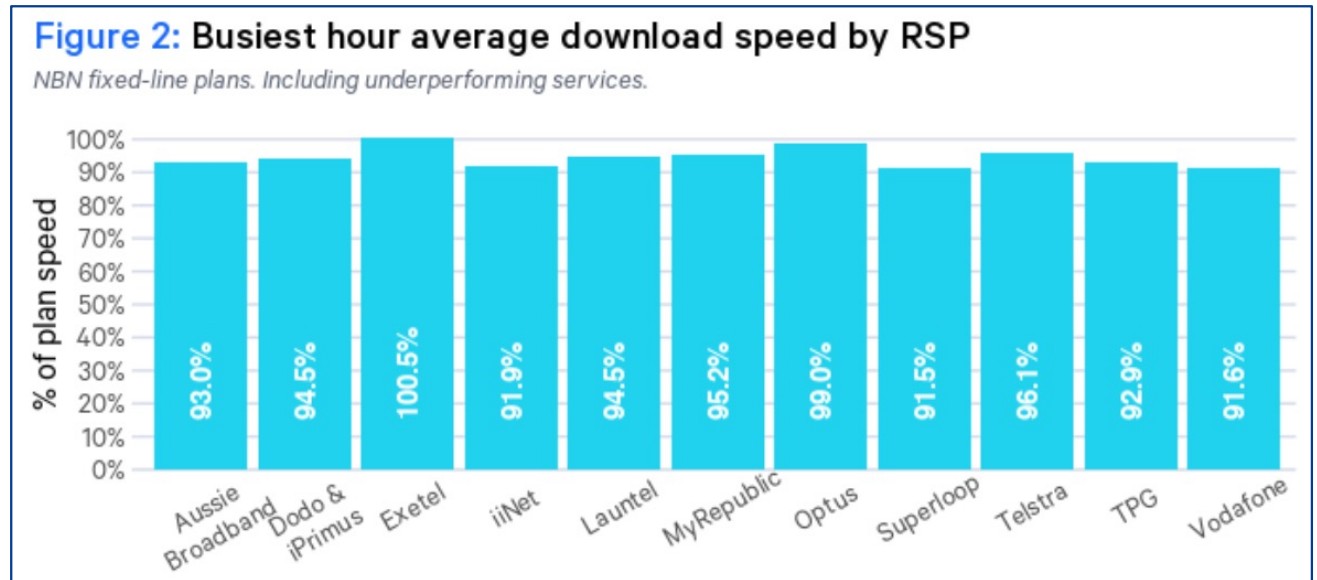
- ❑ ACCC MBA Program [5]:
  - ➢ Optus 99.6%
  - ➢ Telstra 96.1%
  - ➢ AussieBB 93.0%

- ❑ Differences are meaningless …
  - ➢ Samples are low and noise is high
  - ➢ Test server locations are biased
  - ➢ Sample sizes are skewed

- ❑ … but creates perverse incentives
  - ➢ RSP aspire to climb the charts
  - ➢ Can tune router buffers for speed tests
    - » which can degrade gaming jitters ☹

Figure 2: Busiest hour average download speed by RSP

NBN fixed-line plans. Including underperforming services.

% of plan speed — Aussie Broadband 93.0%, Dodo & iPrimus 94.5%, Exetel 100.5%, iiNet 91.9%, Launtel 94.5%, MyRepublic 95.2%, Optus 99.0%, Superloop 91.5%, Telstra 96.1%, TPG 92.9%, Vodafone 91.6%

[5] ACCC Measuring Broadband Australia, Report 16, March 2022

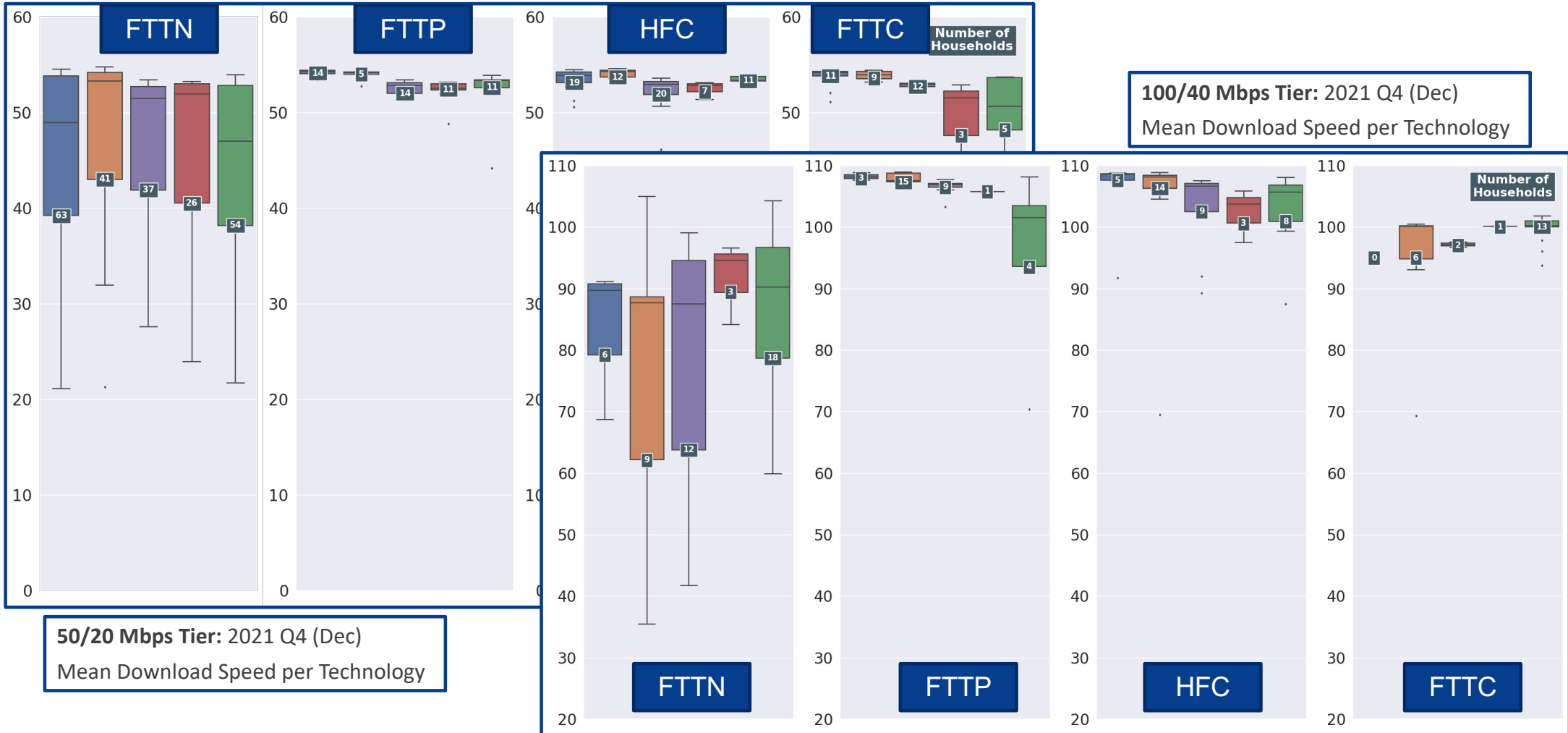**Raw data is available at: https://data.gov.au/data/organization/accc**

Measuring Broadband Australia Report 16 Dataset Release

The Measuring Broadband Australia (MBA) program relies on households across Australia volunteering to receive a Whitebox that tests the performance of their fixed-line broadband...
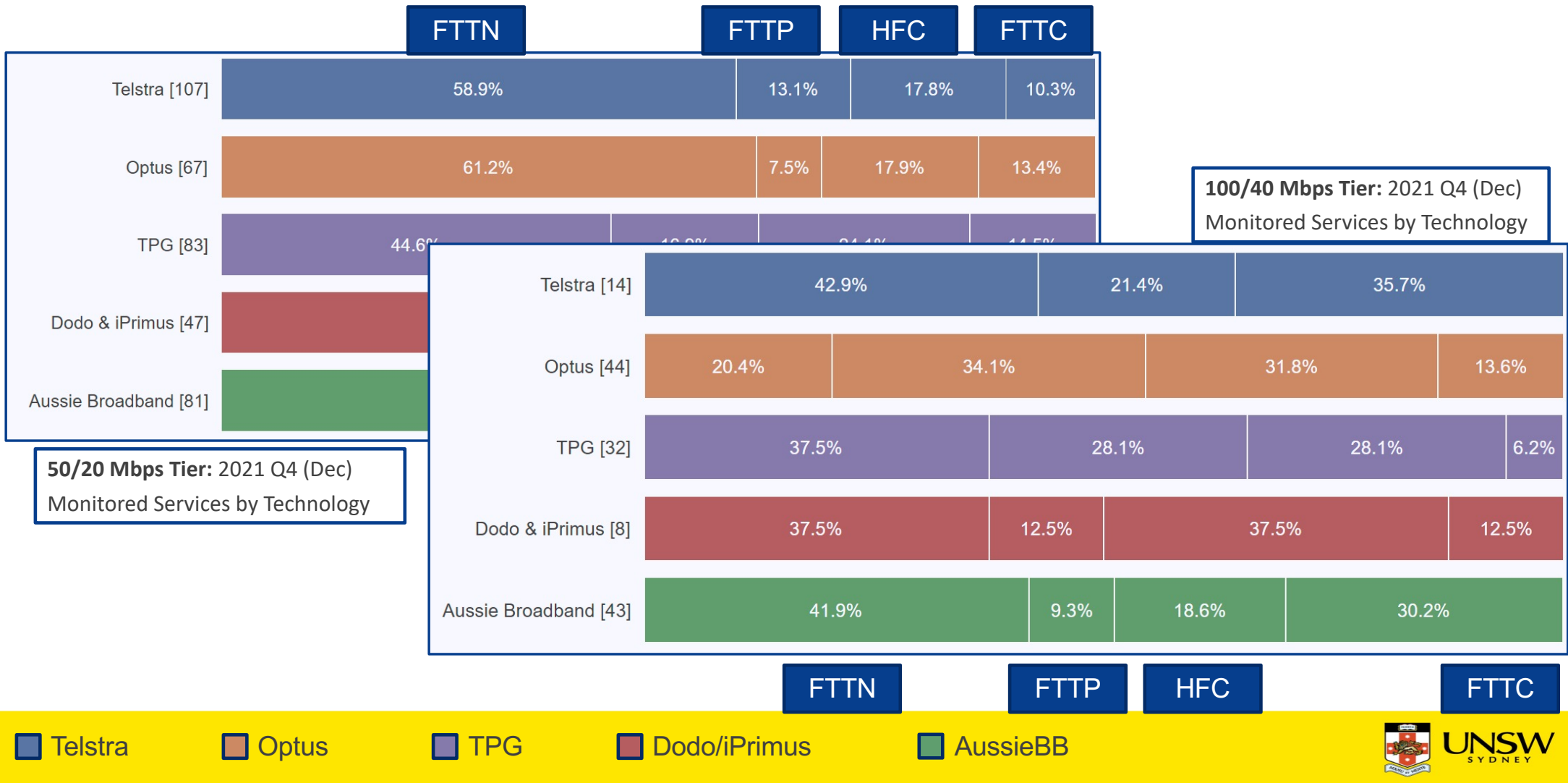
CSV PDF

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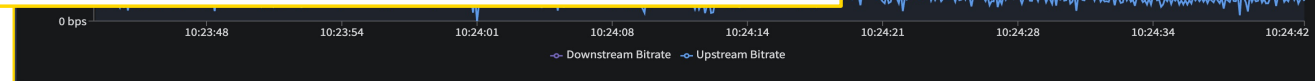# 1c) Speed test comparisons are riddled with bias

1c) Speed test comparisons are riddled with bias (contd.)

2a) Most real-time applications do not need high speeds
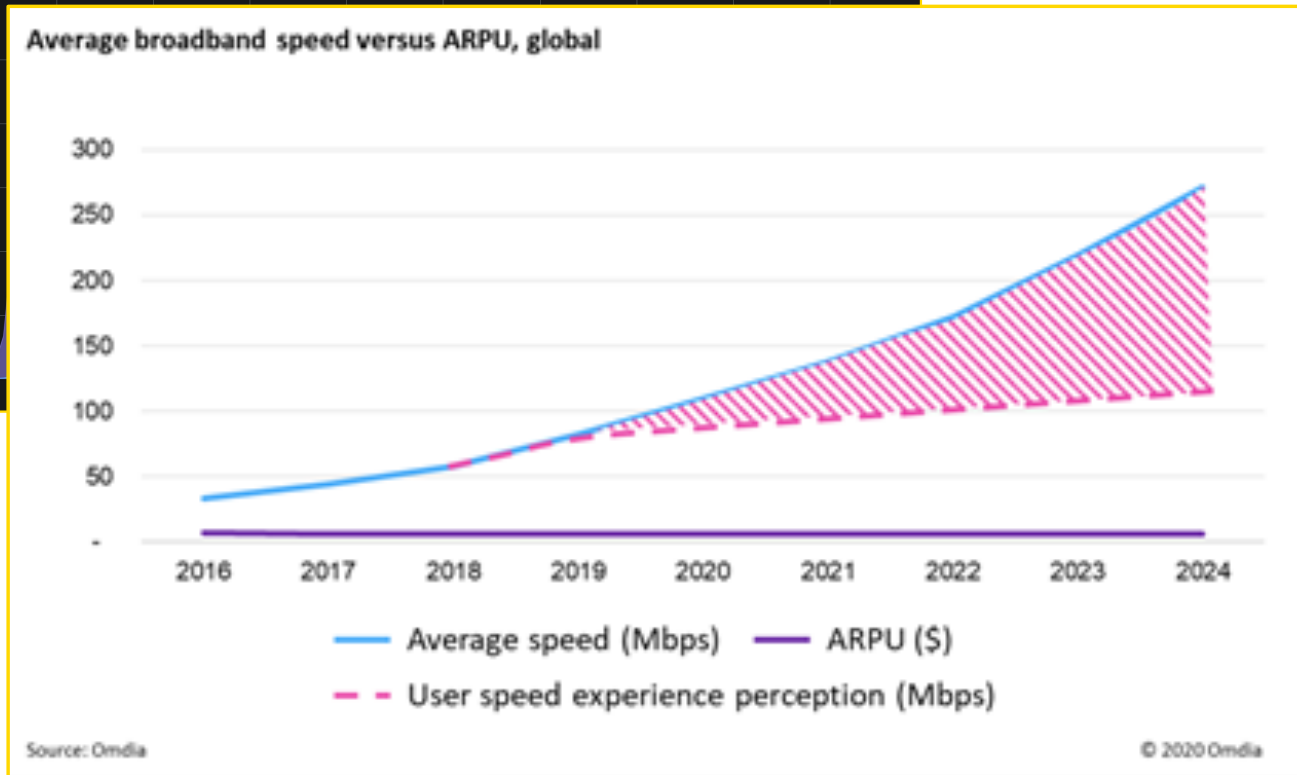
2b) Speed does not translate to profits

Australia : Fixed Services ARPU by Service Category, 2019-2024

❑ Spectrum is expensive but ARPU is stagnant

❑ OTTs reap the benefit of higher Telco investments

2c) Value vs Volume

Derived from Telsyte, Statista, PwC, SEC, and other sources

Revenue Per Household
Avg. industry revenue for each application type
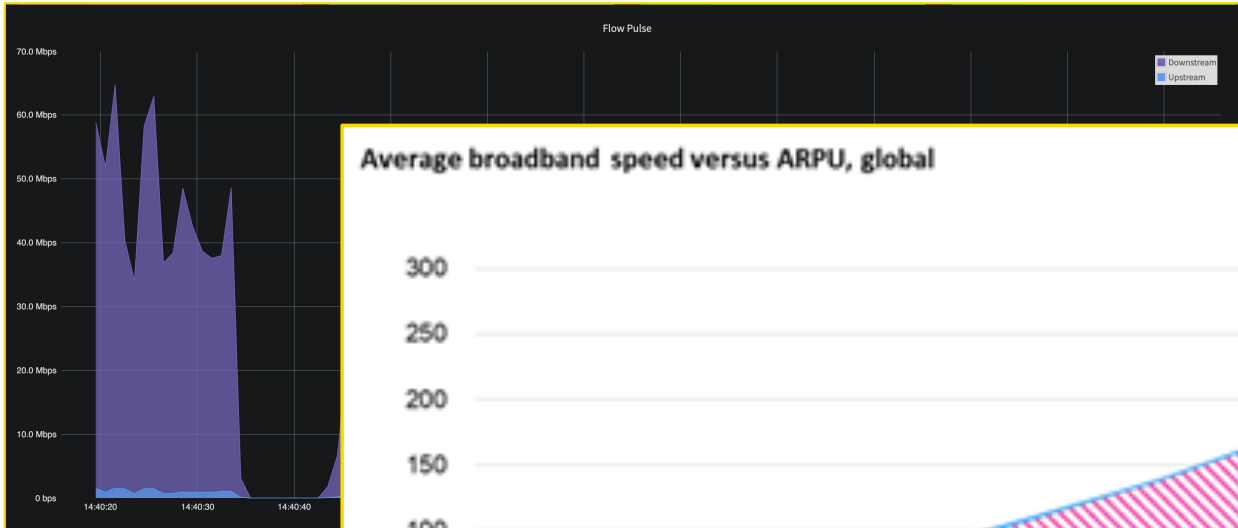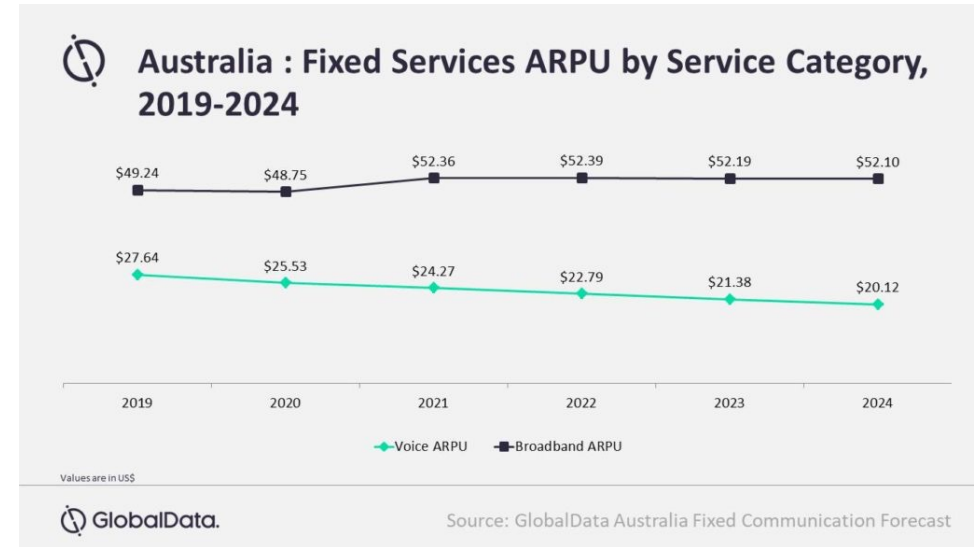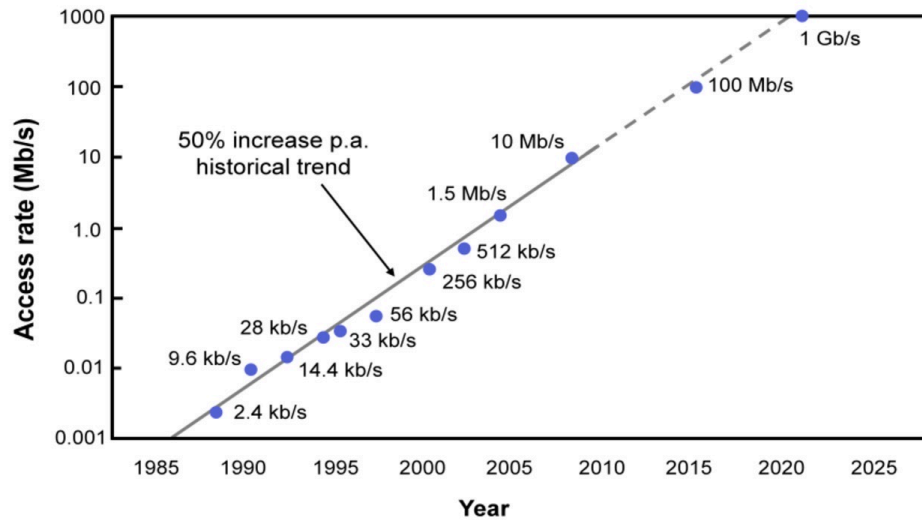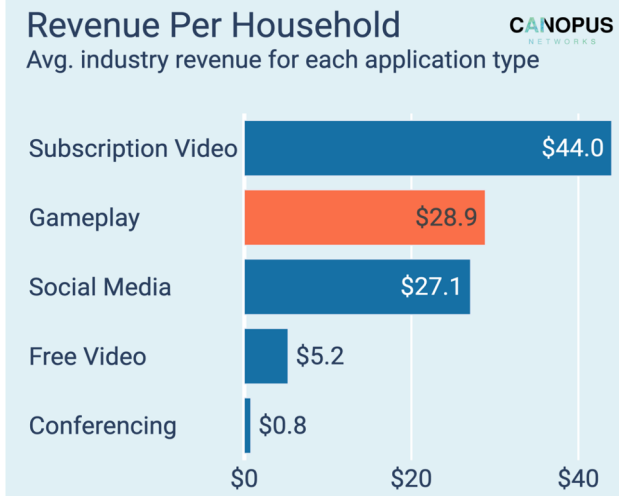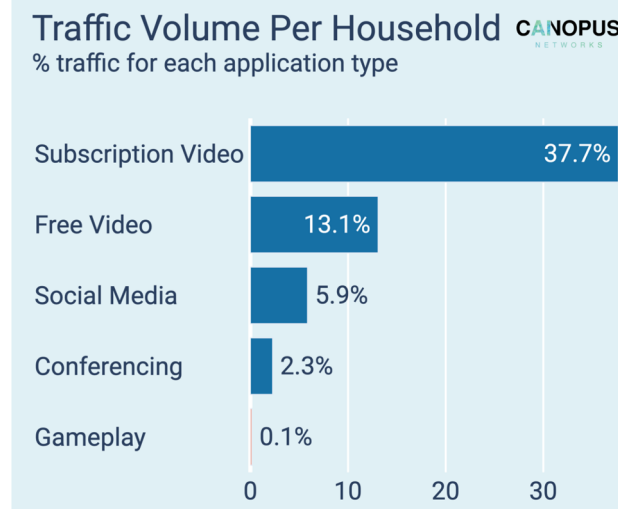
Application	Revenue
Subscription Video	$44.0
Gameplay	$28.9
Social Media	$27.1
Free Video	$5.2
Conferencing	$0.8

Measured by Canopus across 100,000 premises

Traffic Volume Per Household
% traffic for each application type

Application	% Traffic
Subscription Video	37.7%
Free Video	13.1%
Social Media	5.9%
Conferencing	2.3%
Gameplay	0.1%

Traffic type	Value per household	Volume per household	Value* per Broadband GB
Subscription Video	$44.00	184.88 GB	$0.21
Free Video	$5.25	64.18 GB	$0.07
Social Media	$27.10	28.71 GB	$0.84
Conferencing	$0.79	11.19 GB	$0.06
Gaming	$28.87	0.73 GB	$35.37
*Aggregate***	*$72*	*502.63 GB*	*$0.14*

❑ Broadband ISPs make $0.14 per GB

❑ SVOD providers make $0.22 per GB [1.5x]

❑ Gaming providers make $35.37 per GB [250x]

[6] Canopus WhitePaper March 2022, "Not all Bytes are the Same: Focusing on Value not Speed", https://www.canopusnet.com/post/not-all-bytes-are-the-same-focusing-on-value-not-speed

3a) Measuring User Experience accurately at scale

❑ What the consumer really cares about:

➢ SVOD (Netflix, Disney+, Stan, …) is grainy

➢ Live sport (Kayo, Optus, …) is stalling

➢ Games (CS:GO, CoD, …) have high lag

➢ Teleconferencing (Zoom, Teams, …) is stuttering

❑ Measuring "application experience":

➢ AI analysis of application traffic behavior

  » SVOD and Live Video chunk fetch patterns [7,8]

  » Game server mapping and path latency measurement [9]

➢ Can be done at scale using P4-programmable switches

  » Multi-Tbps with commodity hyper-scaler hardware

FLOWPULSE TECHNOLOGY

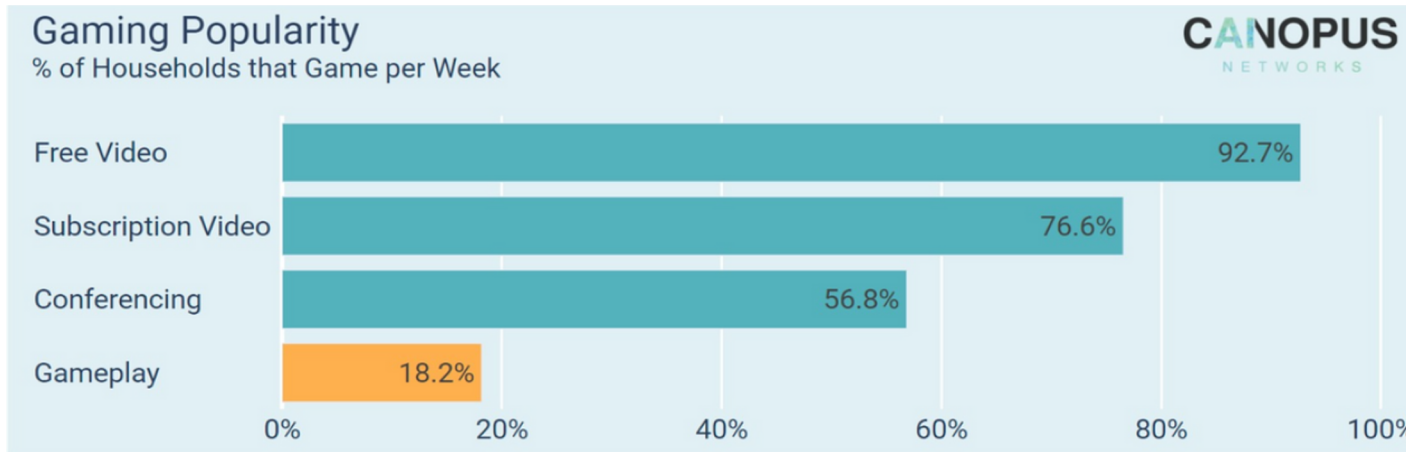AI-powered application traffic signature detection.
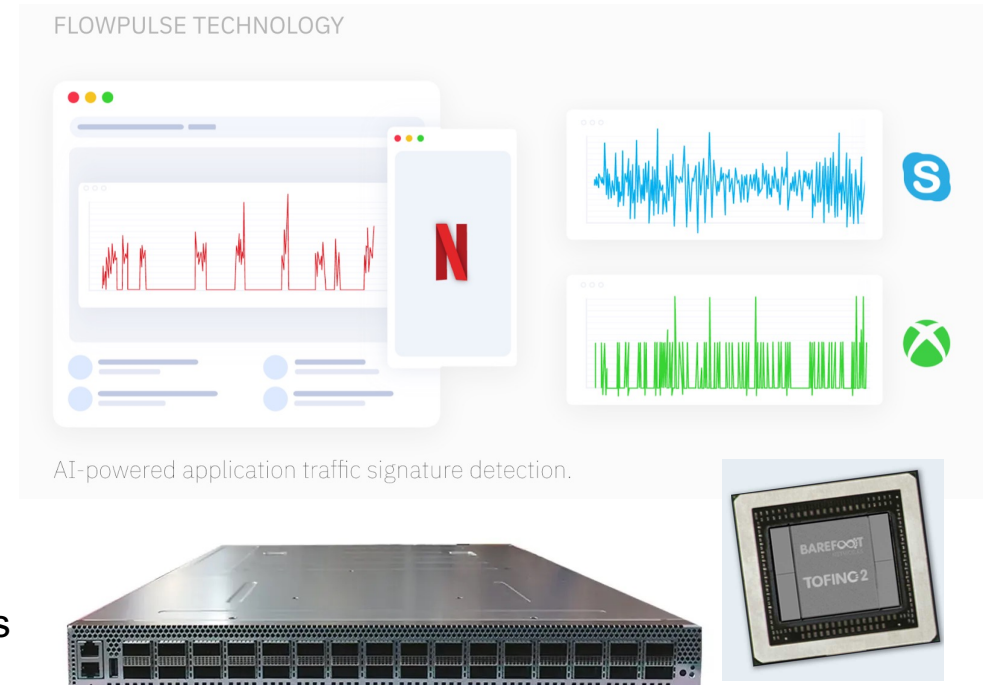
[7] S. Madanapalli, H. Habibi Gharakheili and V. Sivaraman, "Inferring Netflix User Experience from Broadband Network Measurement", Proc. IFIP Traffic Measurement and Analysis (TMA), Paris, France, Jun 2019.

[8] S. Madanapalli, A. Mathai, H. Habibi Gharakheili and V. Sivaraman, "ReClive: Real-Time Classification and QoE Inference of Live Video Streaming Services", IEEE IWQoS, Japan, Aug 2021.
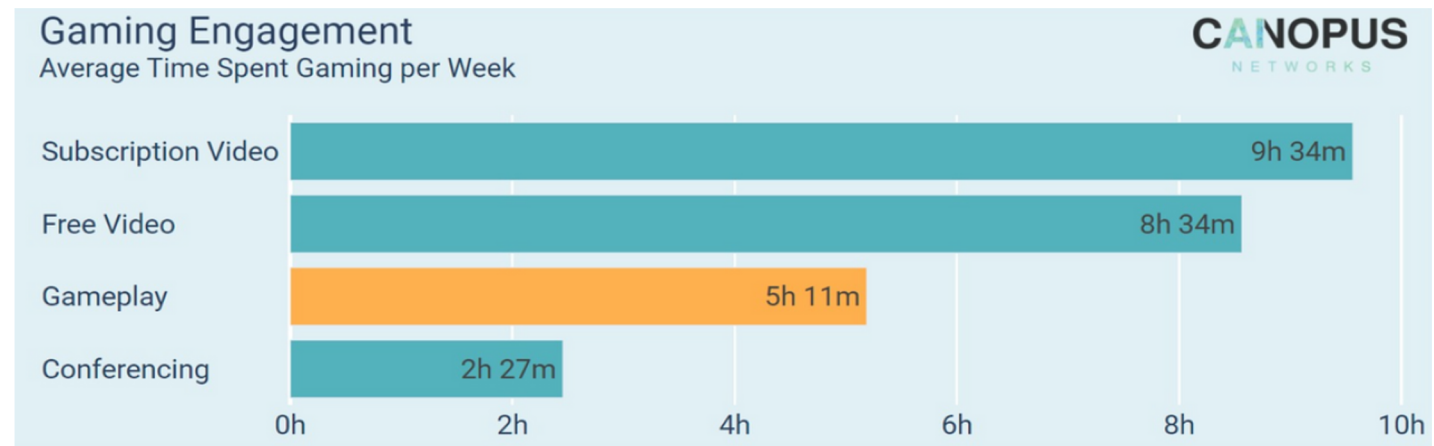
[9] S. Madanapalli, H. Habibi Gharakheili and V. Sivaraman, "Know Thy Lag: In-Network Game Detection and Latency Measurement", Passive and Active Measurement (PAM), Netherlands, March 2022.

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3b) OMG!

Gaming Popularity
% of Households that Game per Week

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Free Video	92.7%
Subscription Video	76.6%
Conferencing	56.8%
Gameplay	18.2%

0%   20%   40%   60%   80%   100%

Data collected by Canopus Networks across 100,000 NSW services in Feb 2022

Gaming Engagement
Average Time Spent Gaming per Week

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Subscription Video	9h 34m
Free Video	8h 34m
Gameplay	5h 11m
Conferencing	2h 27m

0h   2h   4h   6h   8h   10h

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3b) Thriving Gaming Ecosystem

Most Popular Games (% of Gaming Households)
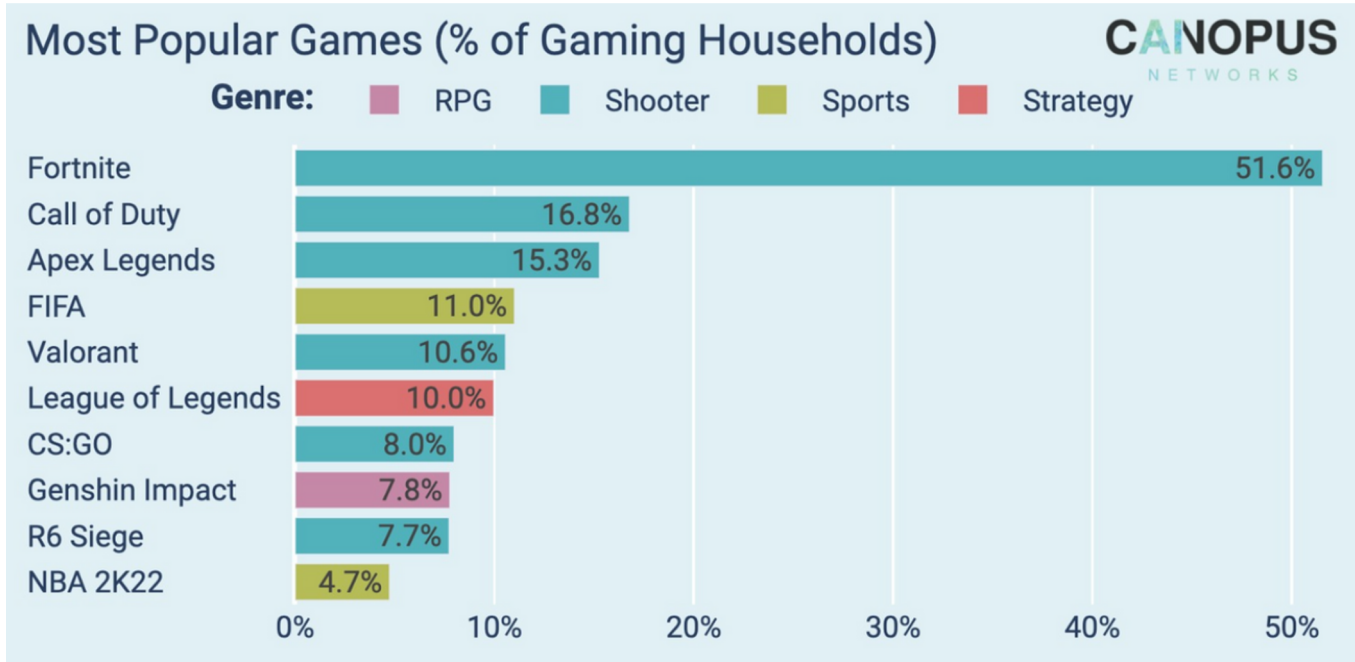
Cumulative Engagement by Publishers
% of Total Gameplay Hours
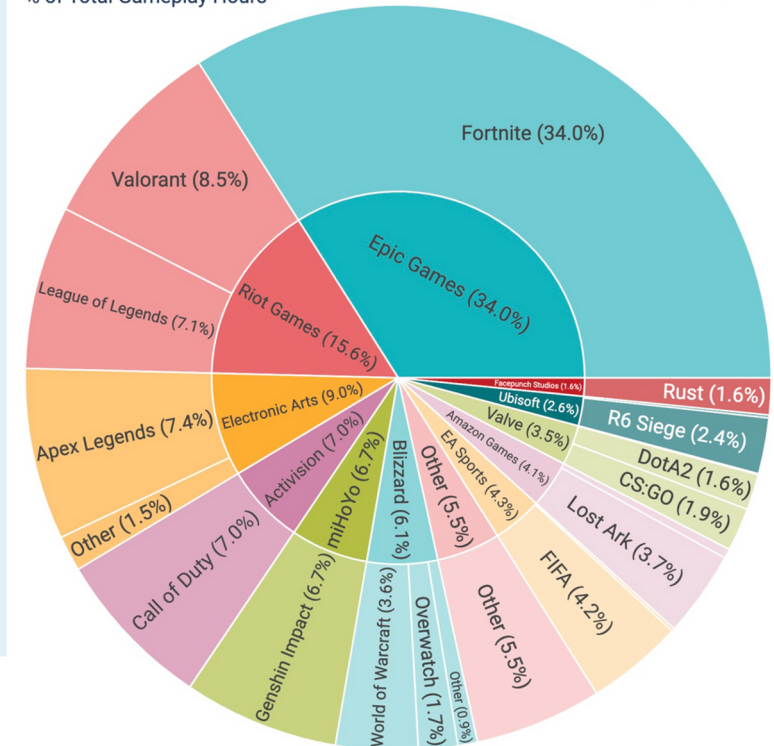
Shooter games dominate and demand low latency.
Game publishers are competing to increase engagement.

3b) Gaming paths and latencies

% denotes game time on servers in that geography
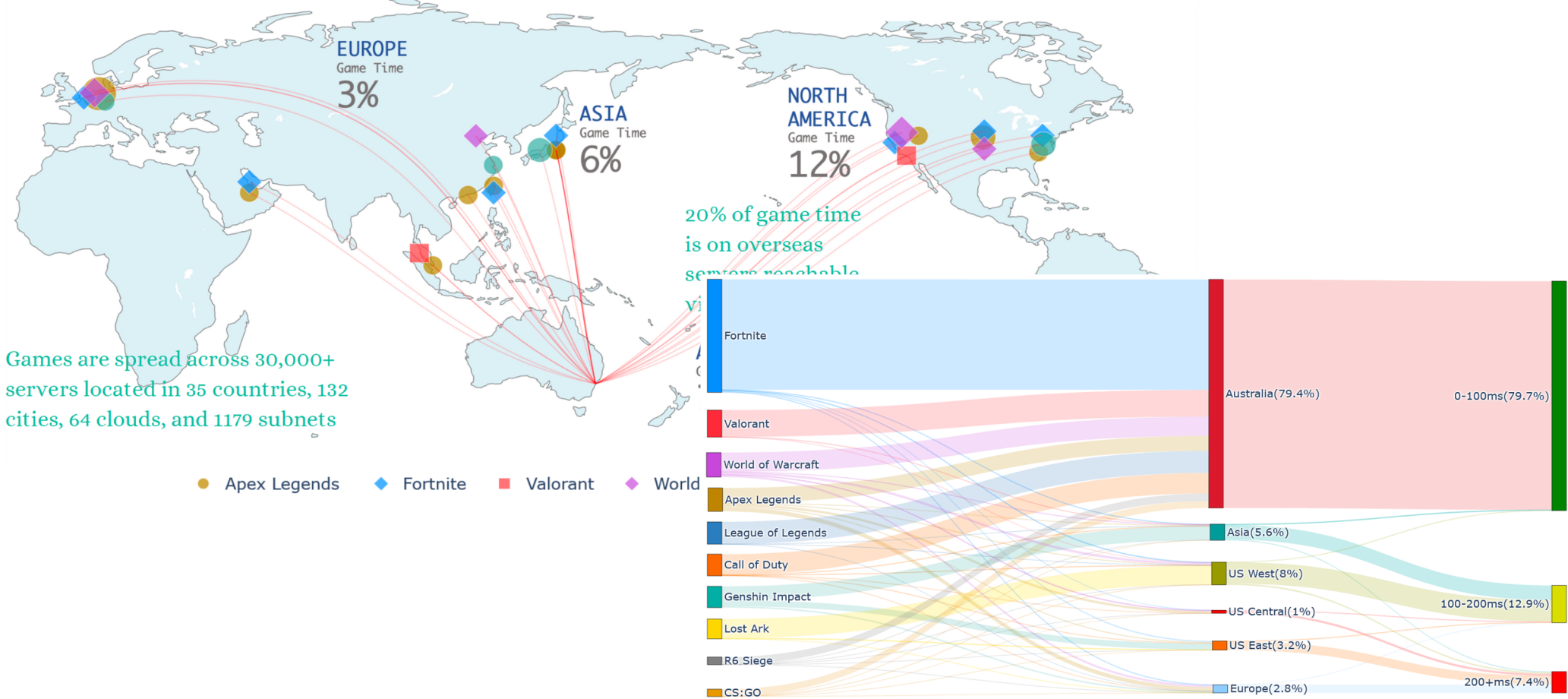

EUROPE
Game Time
3%

ASIA
Game Time
6%

NORTH
AMERICA
Game Time
12%

20% of game time
is on overseas
servers reachable
vi...

Games are spread across 30,000+
servers located in 35 countries, 132
cities, 64 clouds, and 1179 subnets

● Apex Legends   ◆ Fortnite   ■ Valorant   ◆ World

Fortnite
Valorant
World of Warcraft
Apex Legends
League of Legends
Call of Duty
Genshin Impact
Lost Ark
R6 Siege
CS:GO

Australia(79.4%)

Asia(5.6%)
US West(8%)
US Central(1%)
US East(3.2%)
Europe(2.8%)

0-100ms(79.7%)

100-200ms(12.9%)

200+ms(7.4%)

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3c) Know Your Customer

❑ Telcos can build strong customer relationships:

  ➢ Self support application performance issues (e.g. game lag)

  ➢ Manage household "Screen Time"

  ➢ Manage multitude of subscriptions

❑ Engaged users are more sticky and likely to purchase new or premium products
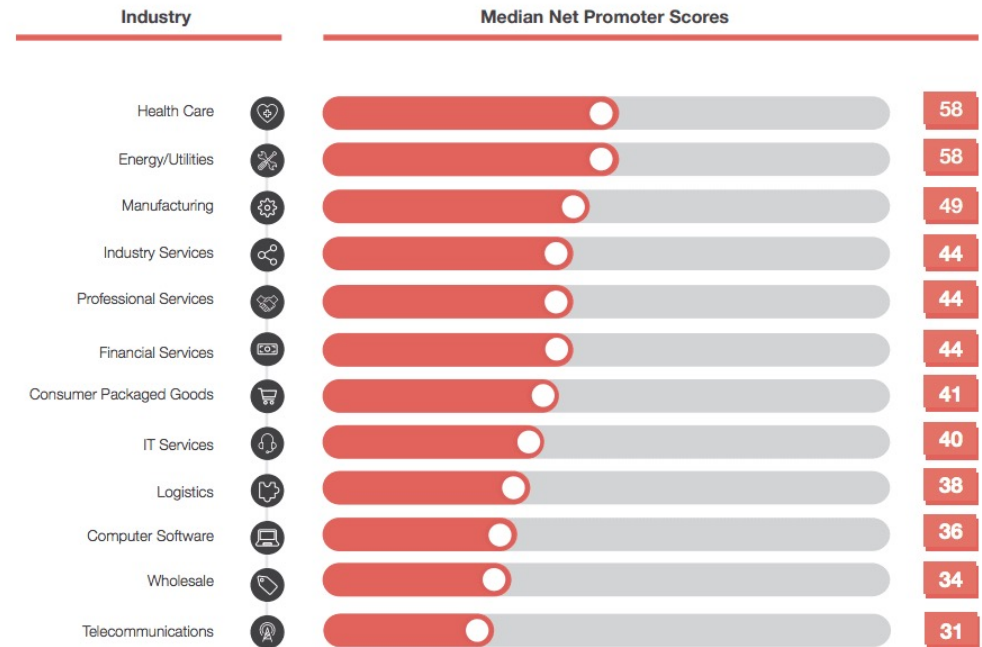
This is a Wake-up Call

❑ Speed is ill defined, ill measured, and largely irrelevant

❑ Speed is not sustainable as a business model

❑ The Telco industry needs to shift its focus to user experience

❑ Application intelligence technology and skills exist right here in Australia

❑ Let's work together as an industry to use this intelligence to lift both NPS and margins