

Forget Speed; Let's talk Experience



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Key Messages

1. Speed comparisons are flawed
 - 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

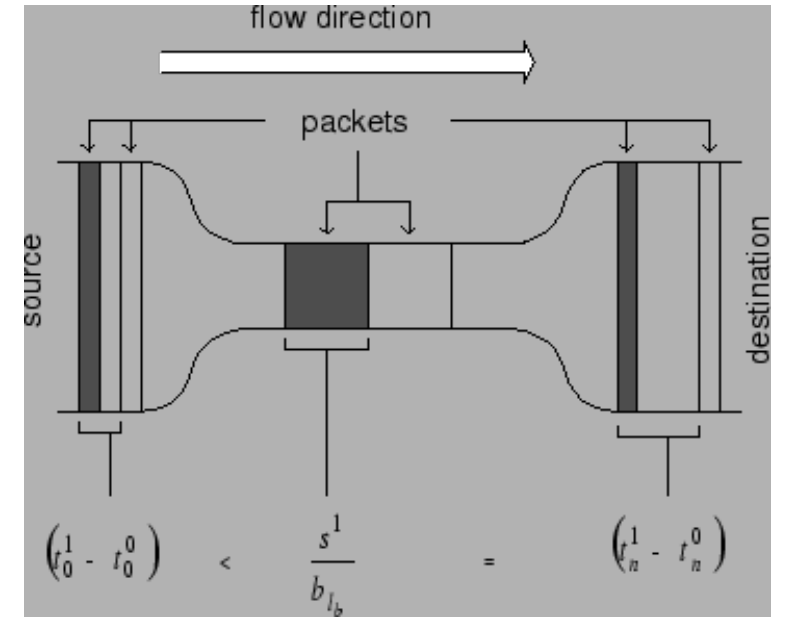
2. The obsession with speed is detrimental to the Telco industry
 - a) Applications like video, gaming, and conferencing do not need speed
 - b) Speed does not translate to Telco profitability
 - c) Speed / volume are divergent from “value” to consumers & OTTs

3. Focusing on user experience 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

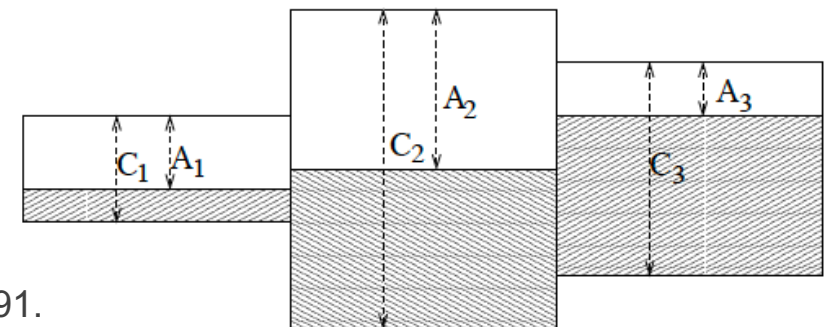
1a) What do we mean by Speed?

- ❑ 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.

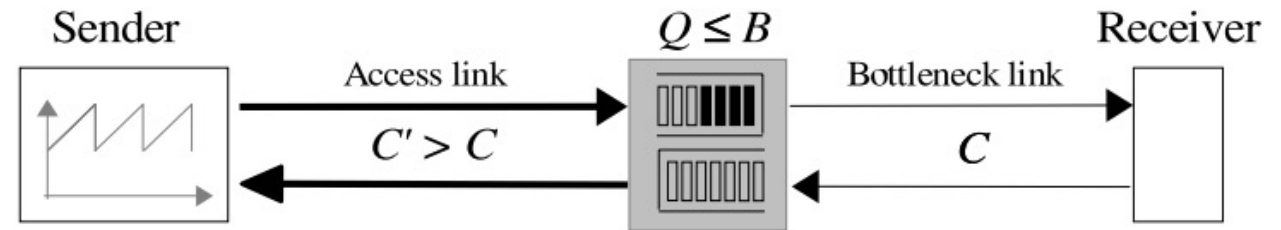
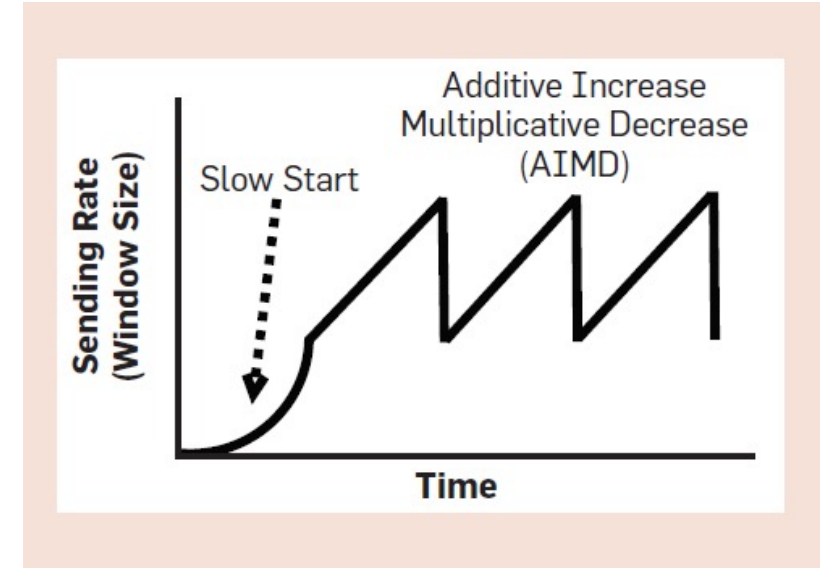
1b) Speed depends on many factors

❑ Tester can tune many 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?)



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

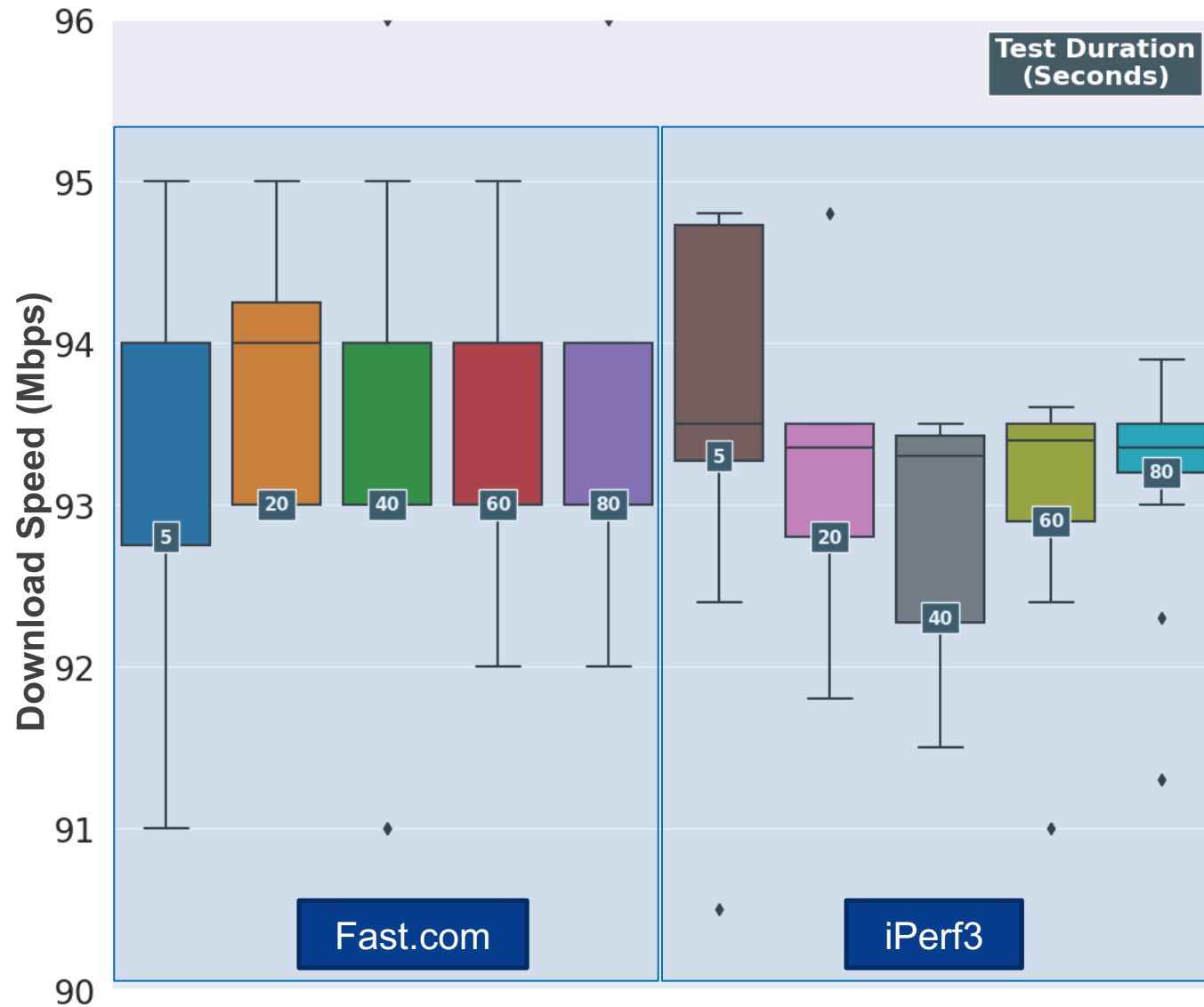
[3] N. Feamster, J. Livingood, “Measuring Internet Speed: Current Challenges and Future Recommendations”, Communications of the ACM, 63(12):72-80, 2020.

[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.

1b) Test conditions bias results: test duration



Usain Bolt
(fastest at 100m)

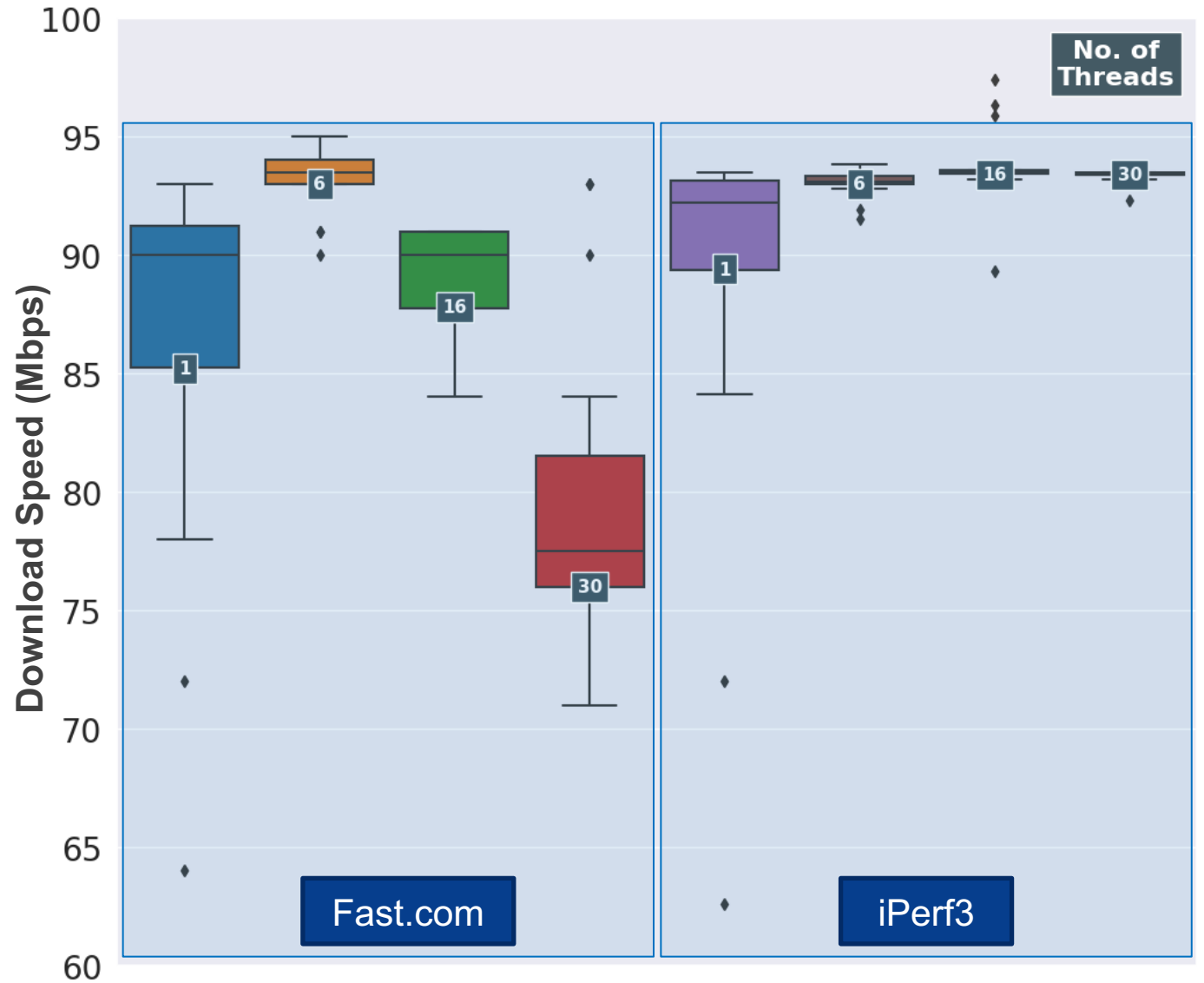


Eliud Kipchoge
(fastest at 42km)

1b) Test conditions bias results: number of threads



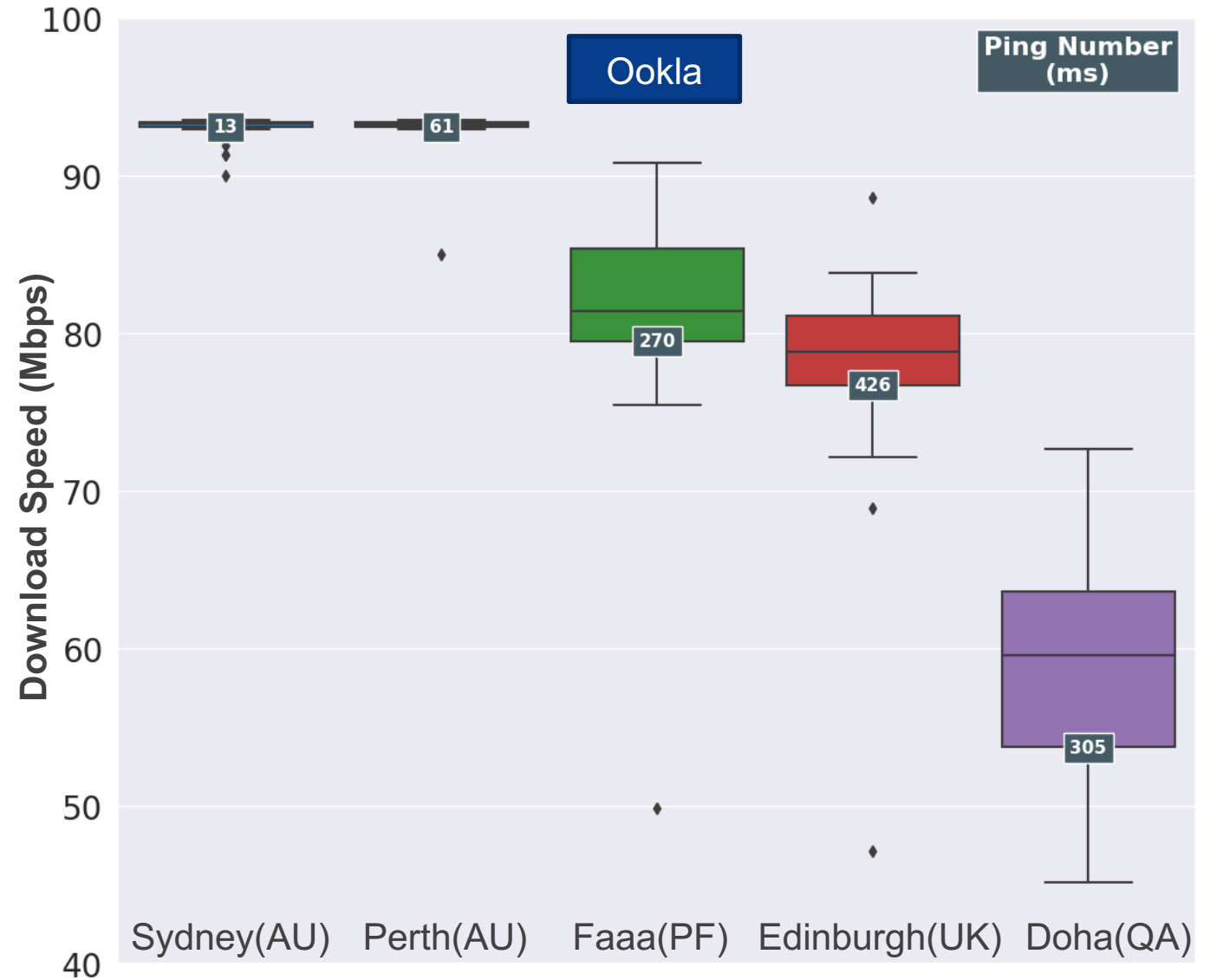
(1 x 400m) versus (4 x 100m) relay



1b) Test conditions bias results: server distance



Uphill run not the same as a flat run



Server Locations



UNSW SYDNEY

1c) Current speed testing regimes are nonsensical

❑ ACCC MBA Program [5]:

- Optus 99.6%
- Telstra 96.1%
- AussieBB 93.0%

❑ Differences are meaningless ...

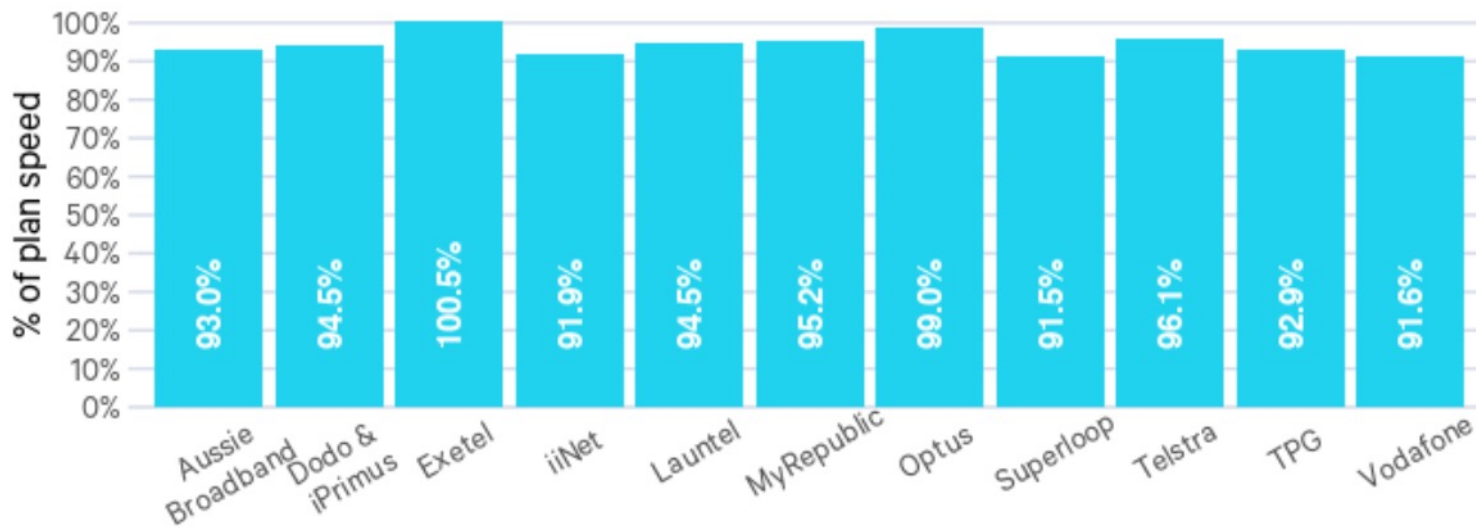
- Samples are low and noise is high
- Test server locations are biased
- Sample sizes are skewed

❑ ... 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.



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

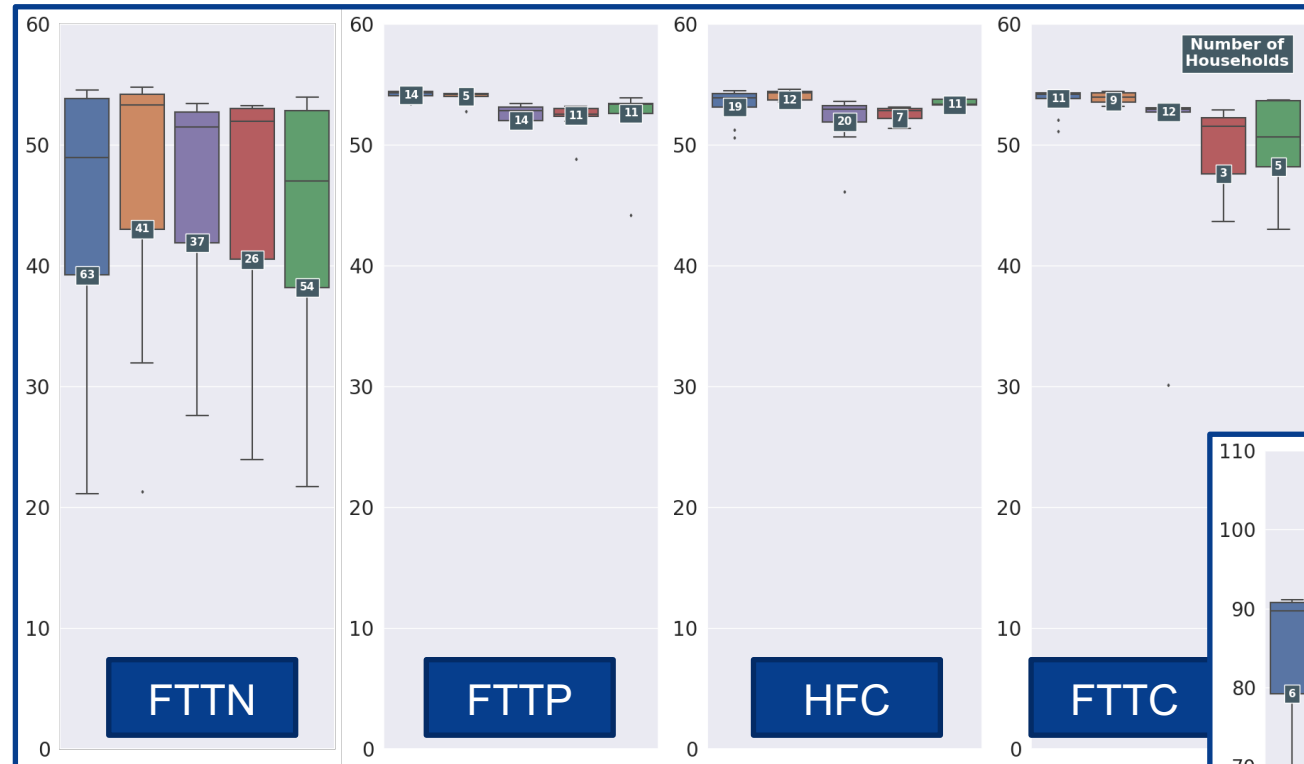
Raw data is available at: <https://data.gov.au/data/organization/acc>

Measuring Broadband Australia Report 16 Dataset Release

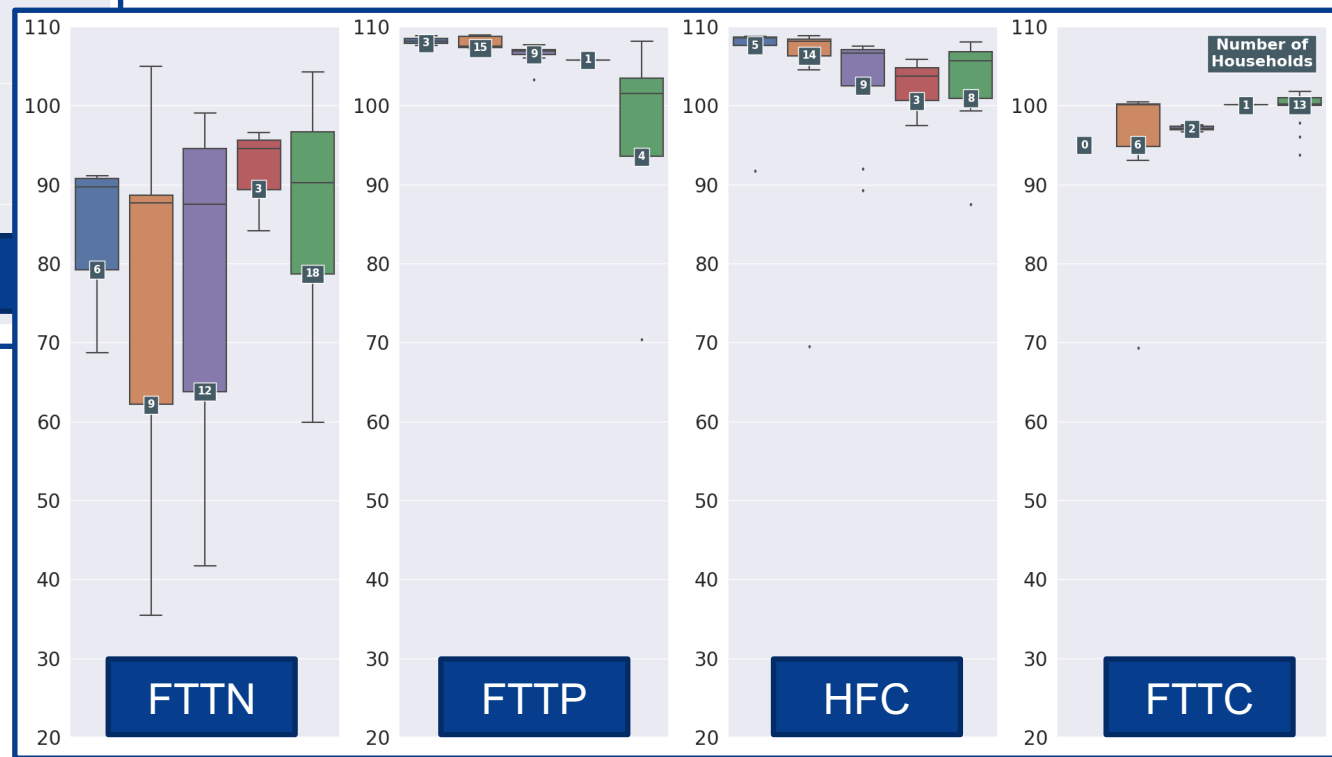
The Measuring Broadband Australia (MBA) program relies on households across Australia volunteering to receive a Whitebox that tests the performance of their fixed-line broadband...

[CSV](#) [PDF](#)

1c) Speed test comparisons are riddled with bias

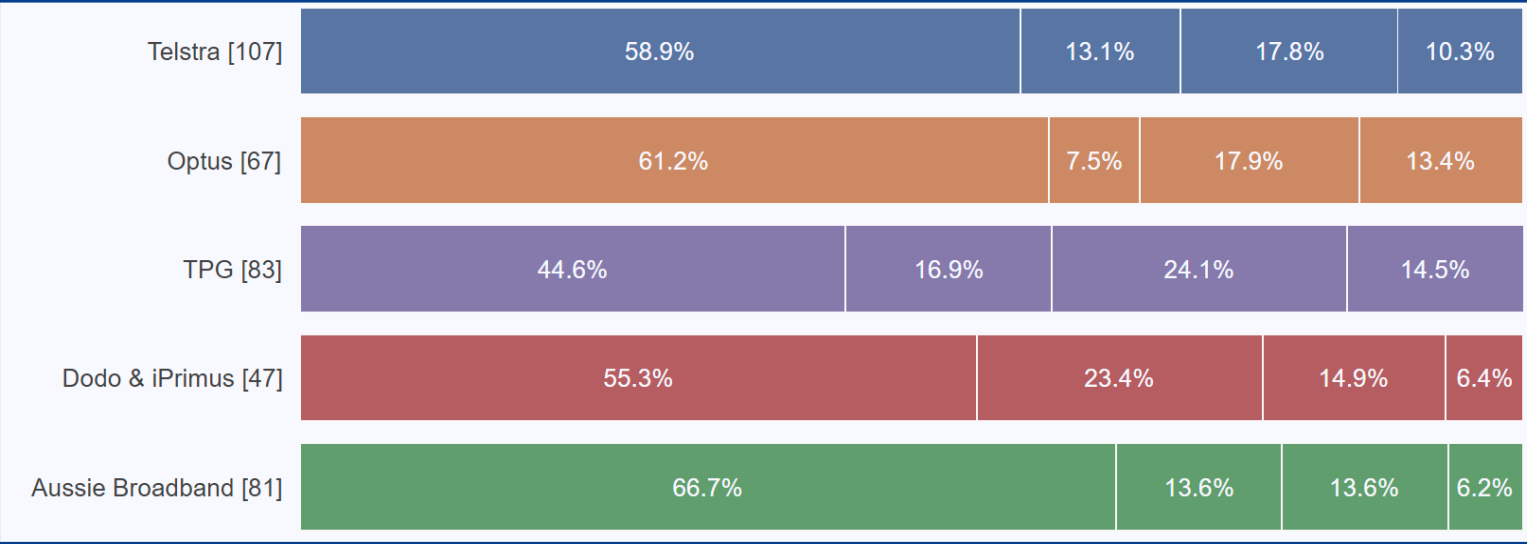


100/40 Mbps Tier: 2021 Q4 (Dec)
Mean Download Speed per Technology



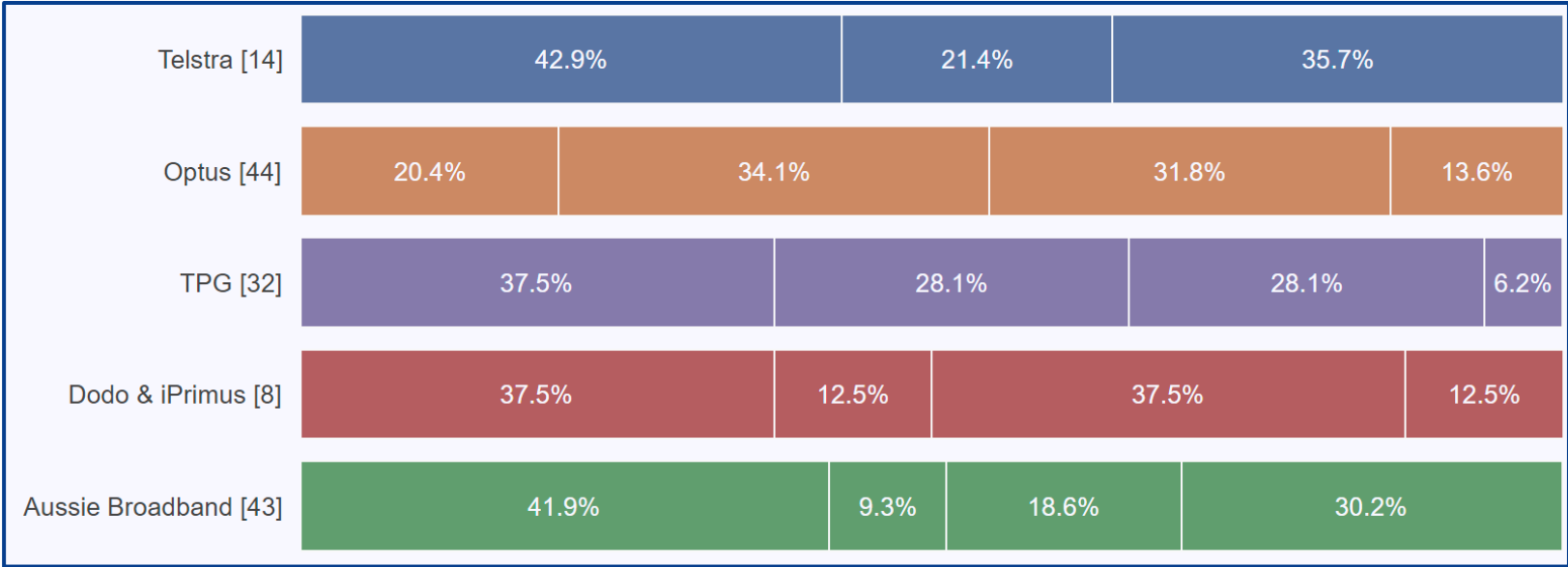
1c) Test cohort bias

FTN FTTP HFC FTTC

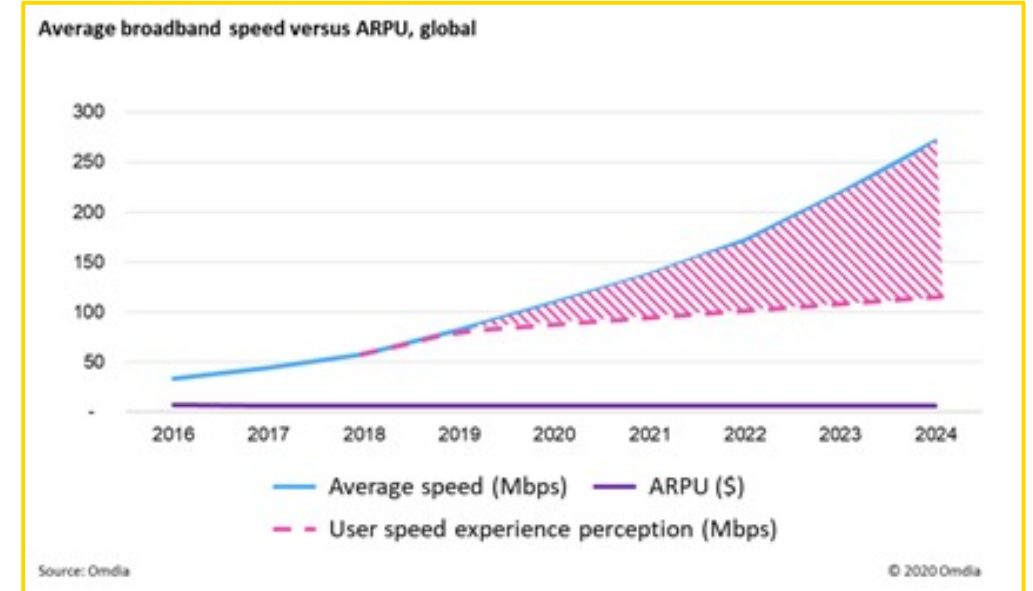
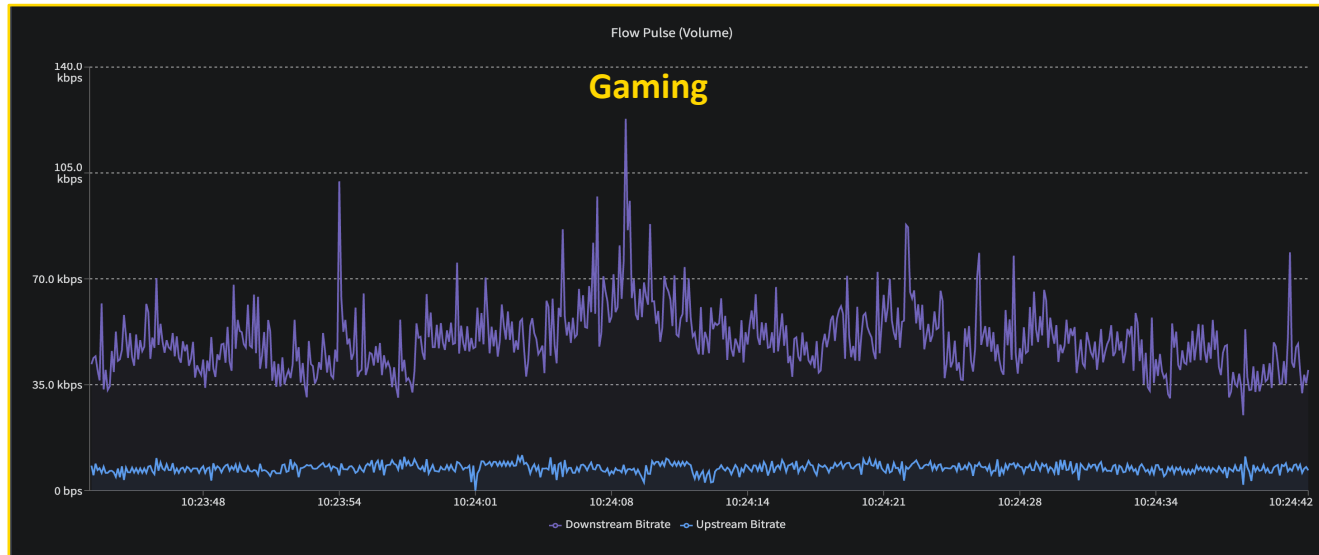
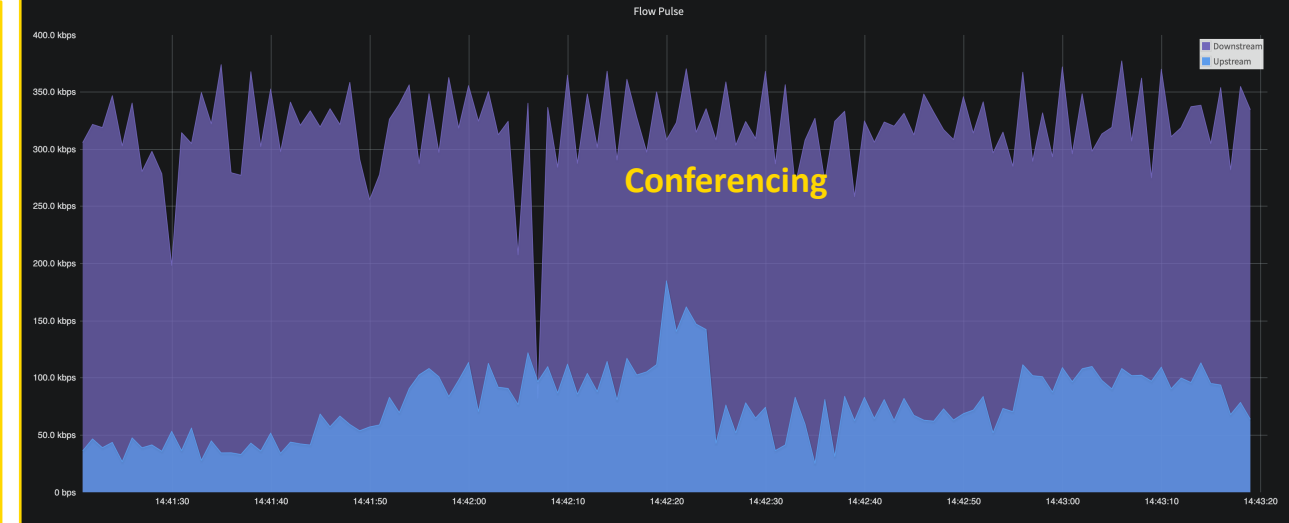
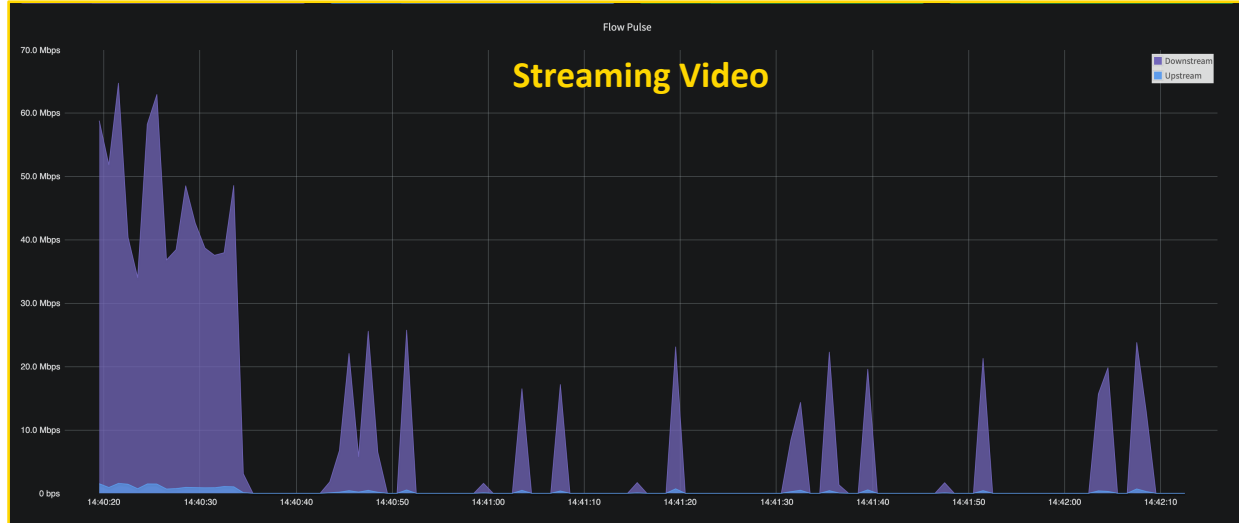


100/40 Mbps Tier: 2021 Q4 (Dec)
Monitored Services by Technology

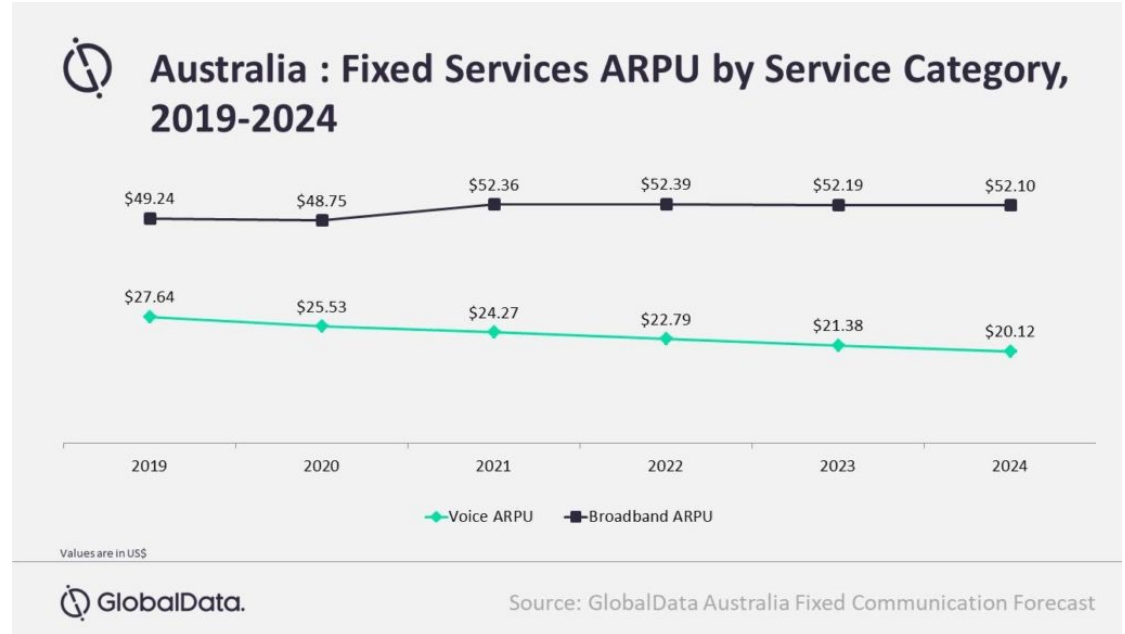
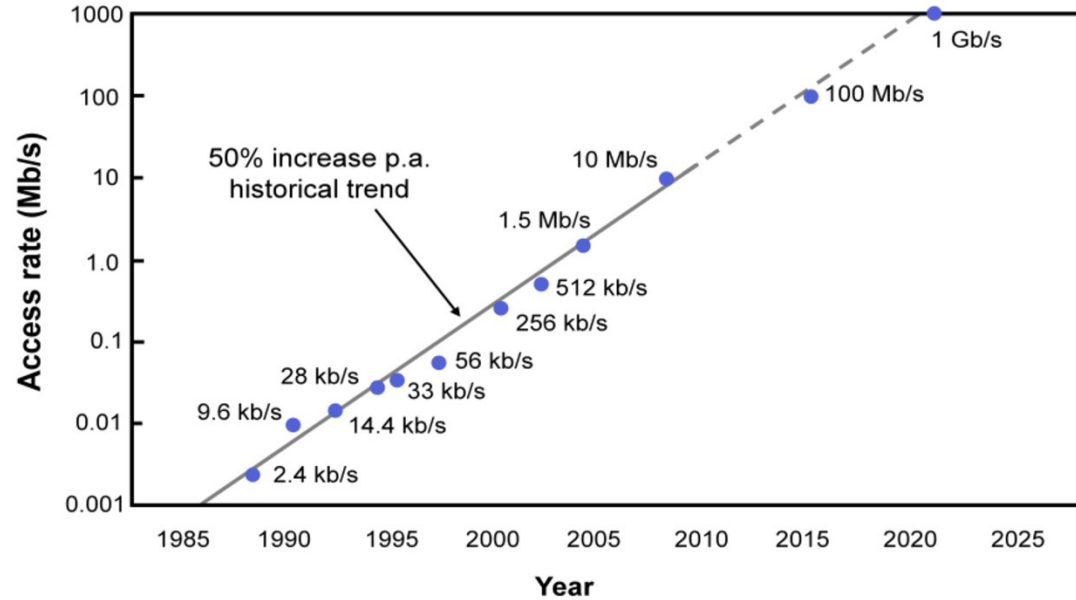
50/20 Mbps Tier: 2021 Q4 (Dec)
Monitored Services by Technology



2a) Most real-time applications do not need high speeds



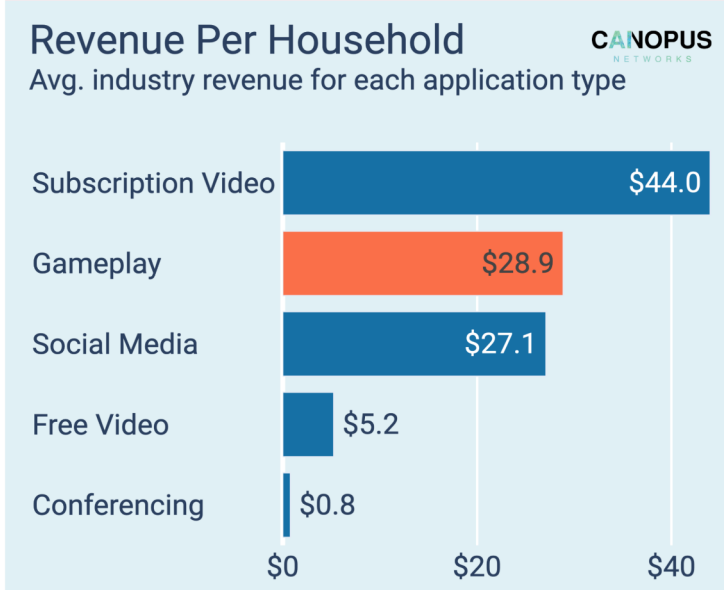
2b) Speed does not translate to profits



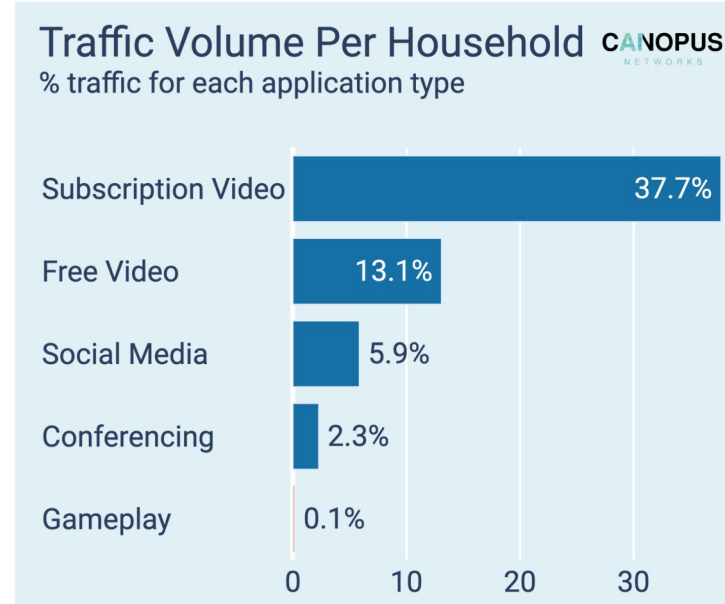
- ❑ Spectrum is expensive but ARPU is stagnant
- ❑ OTTs reap the benefit of higher Telco investments

2c) Value vs Volume

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



Measured by Canopus across 100,000 premises



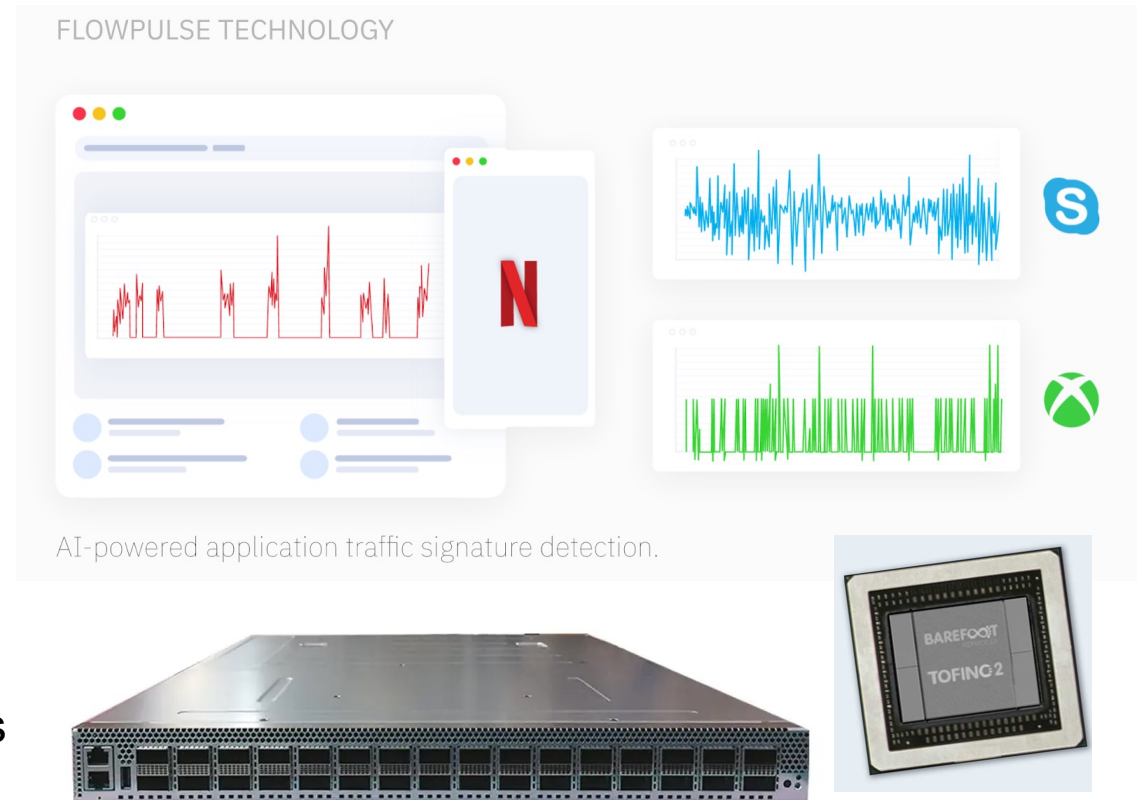
Traffic type	Value per household	Volume per household	Value* per Broadband GB
Subscription Video	\$44.00	184.88 GB	\$0.21
Free Video	\$5.25	64.18 GB	\$0.07
Social Media	\$27.10	28.71 GB	\$0.84
Conferencing	\$0.79	11.19 GB	\$0.06
Gaming	\$28.87	0.73 GB	\$35.37
Aggregate**	\$72	502.63 GB	\$0.14

- ❑ 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



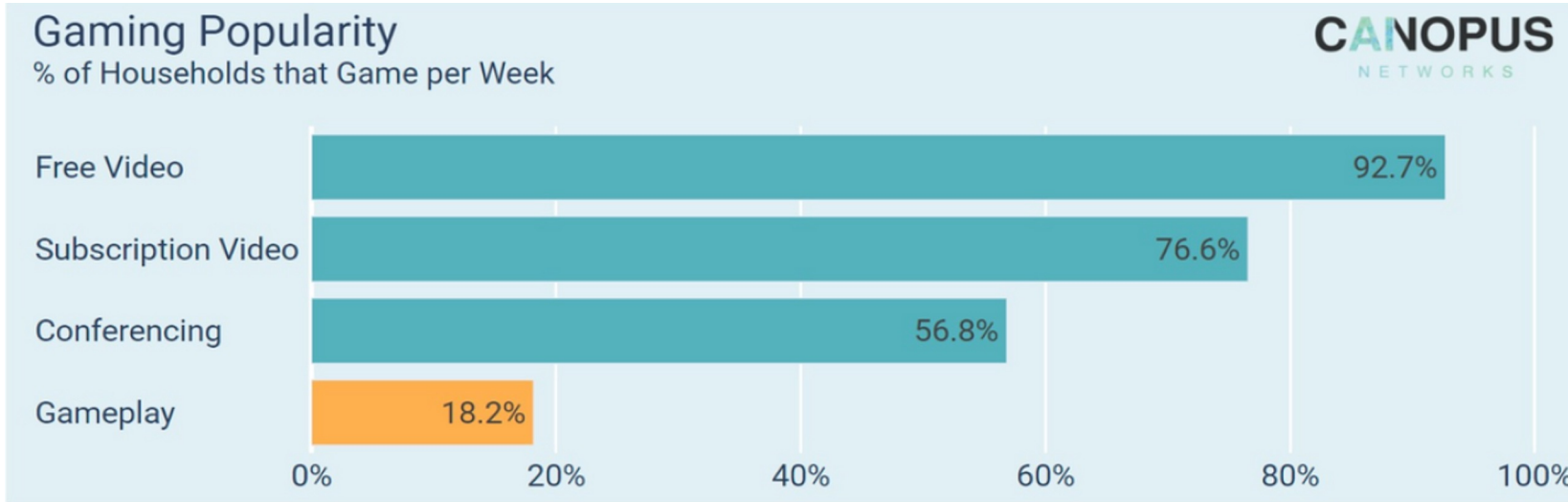
[7] S. Madanapalli, H. Habibi Gharakheili and V. Sivaraman, "Inferring Netflix User Experience from Broadband Network Measurement", Proc. IFIP Traffic Measurement and Analysis (TMA), Paris, France, Jun 2019.

[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.

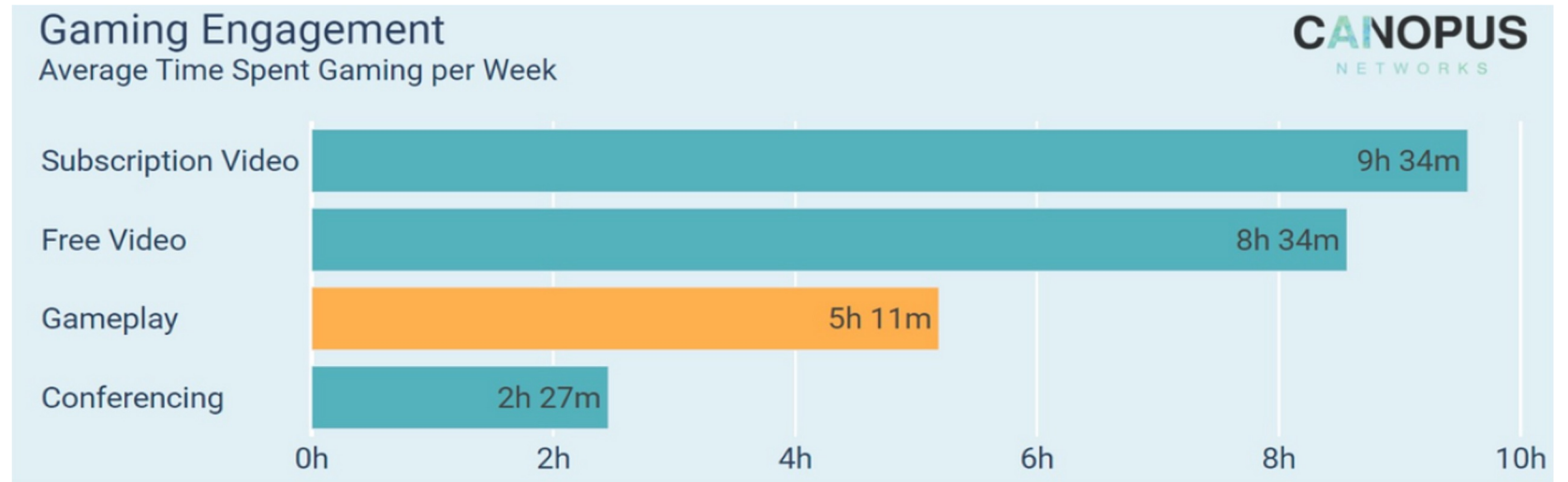
[9] S. Madanapalli, H. Habibi Gharakheili and V. Sivaraman, "Know Thy Lag: In-Network Game Detection and Latency Measurement", Passive and Active Measurement (PAM), Netherlands, March 2022.

3b) OMG!

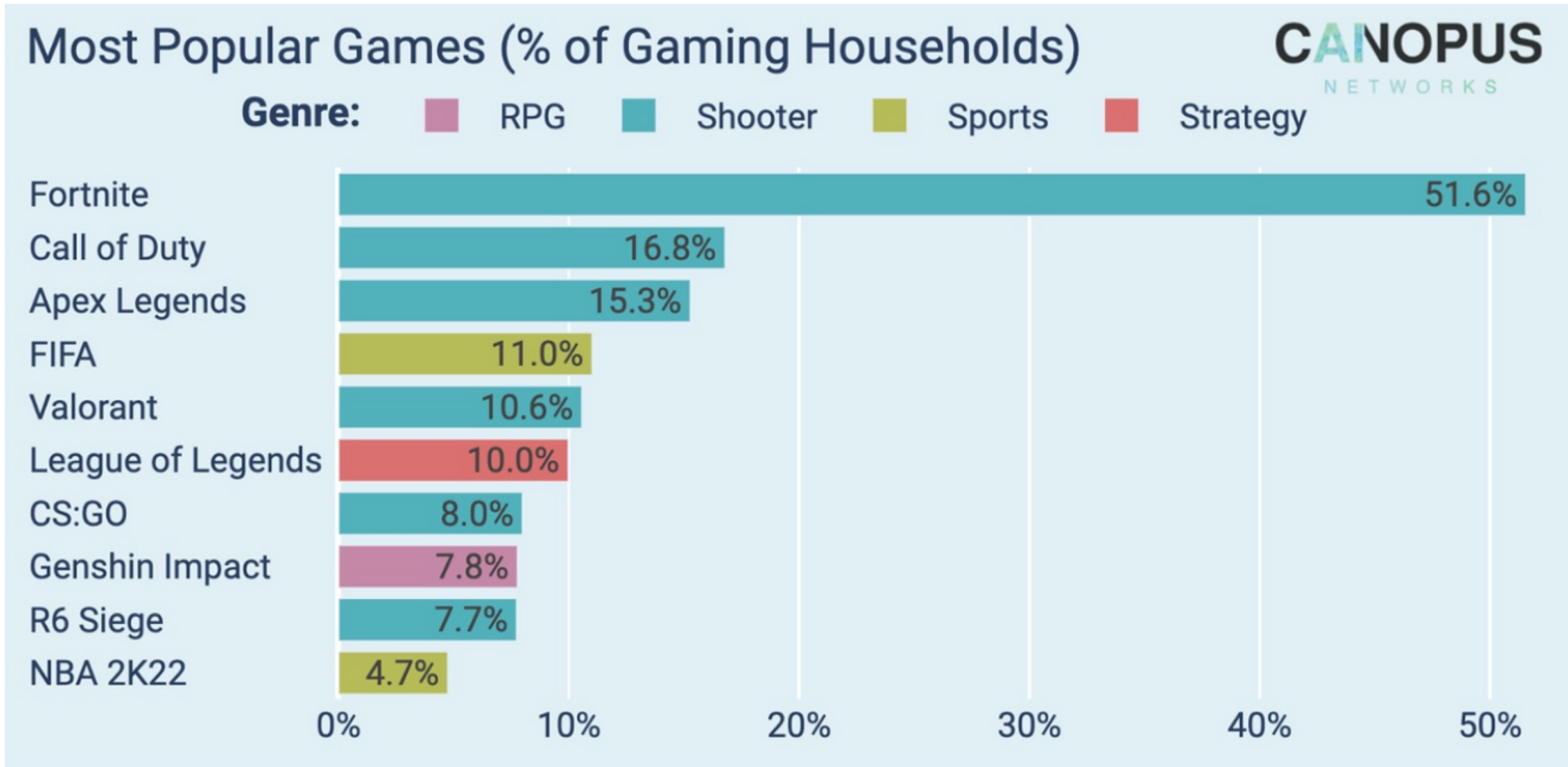
<https://www.canopusnet.com/post/omg-2022-02>



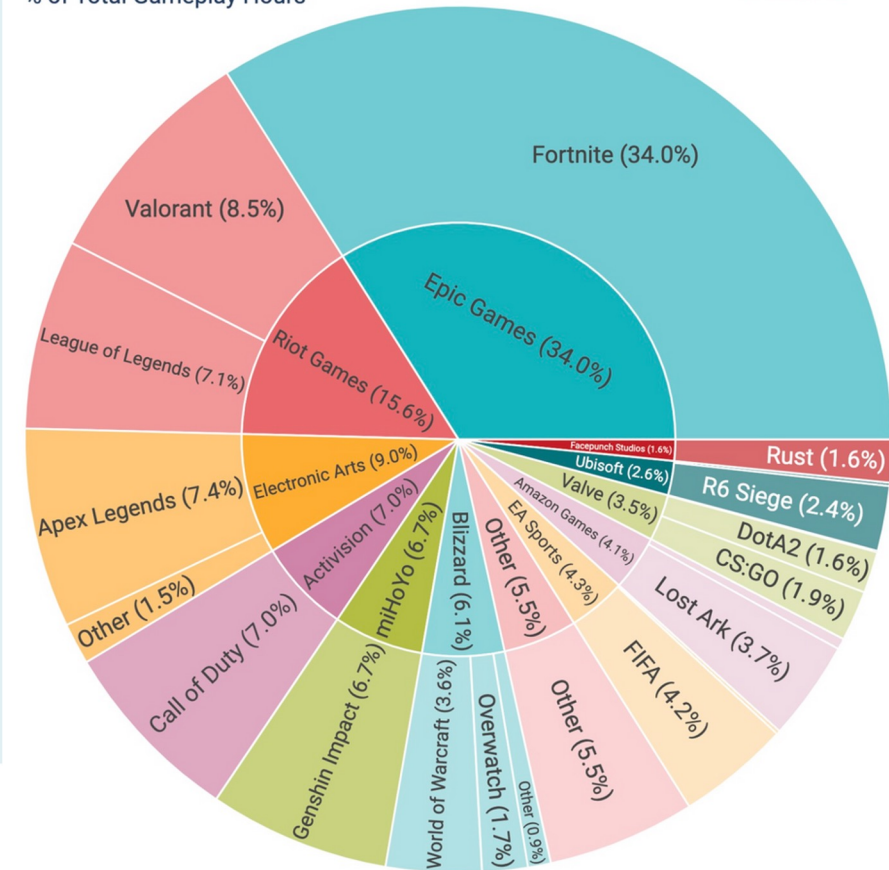
Data collected by Canopus Networks across 100,000 NSW services in Feb 2022



3b) Thriving Gaming Ecosystem



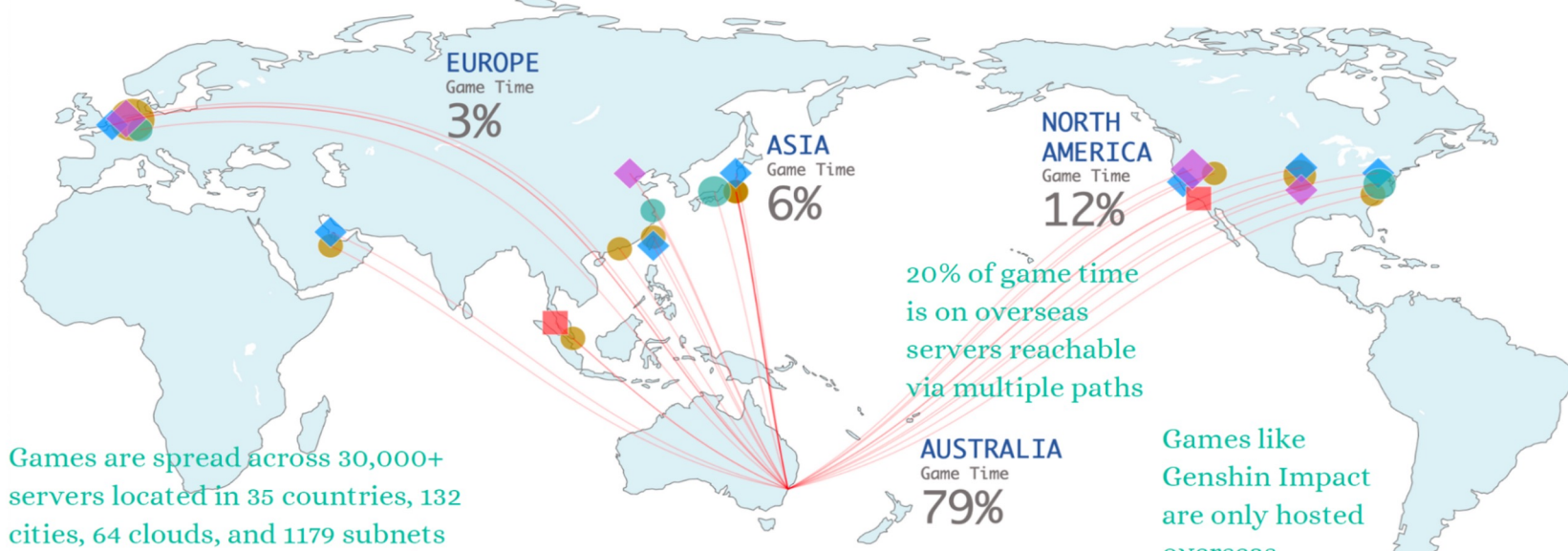
Cumulative Engagement by Publishers
% of Total Gameplay Hours



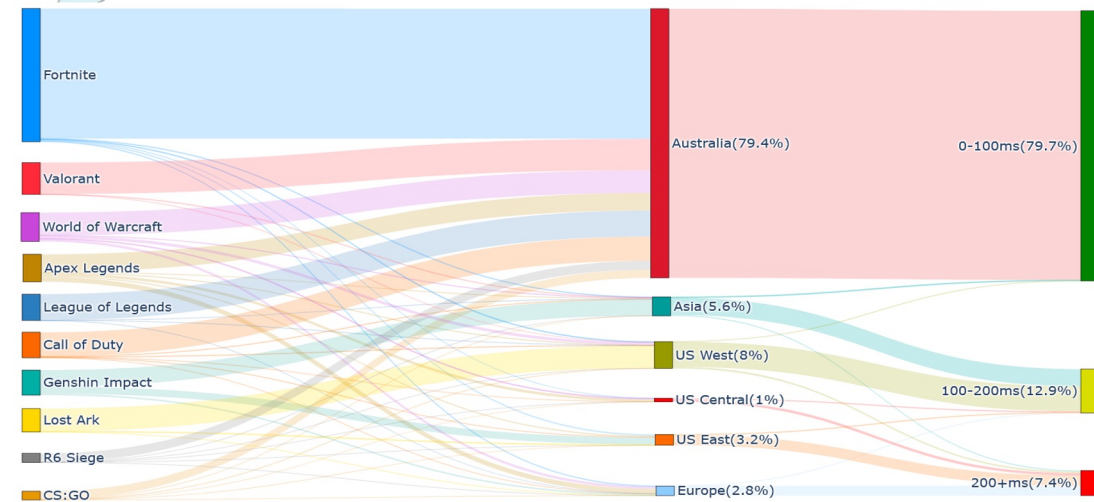
Shooter games dominate and demand low latency.
Game publishers are competing to increase engagement.

3b) Gaming paths and latencies

% denotes game time on servers in that geography



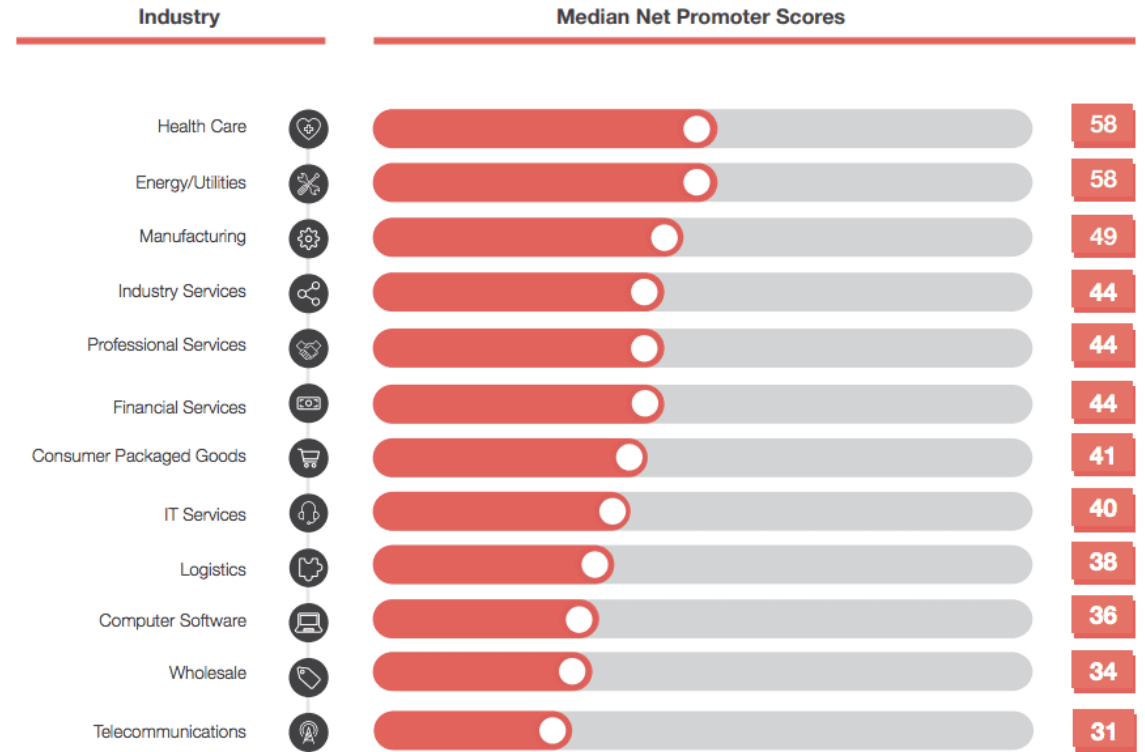
- Apex Legends
- ◆ Fortnite
- Valorant
- ◆ World of Warcraft
- Genshin Impact



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