Network Telemetry for Measuring and Enhancing Online Gaming Experience

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05-Sep-2019

Outline

- Gaming *opportunity*
  - Market growth, network requirements, game acceleration
- Gaming *anatomy*
  - Game detection
  - Game discovery
- Gaming *experience*
  - Contention / congestion
  - Network jitter
- *Implementation* and evaluation
  - What can ISPs do?
  - Neutrality concerns

The Gaming Market

- eGaming made $140 billion in 2018
  - **Shooting**: Fortnite ($2.4b); Crossfire ($1.3b); Call-of-Duty ($689m); CS:GO ($414m)
  - **Strategy**: Honour of Kings ($2.1b); League of Legends ($1.4b); Dota2
  - **Sports**: FIFA 18 ($830m); Madden

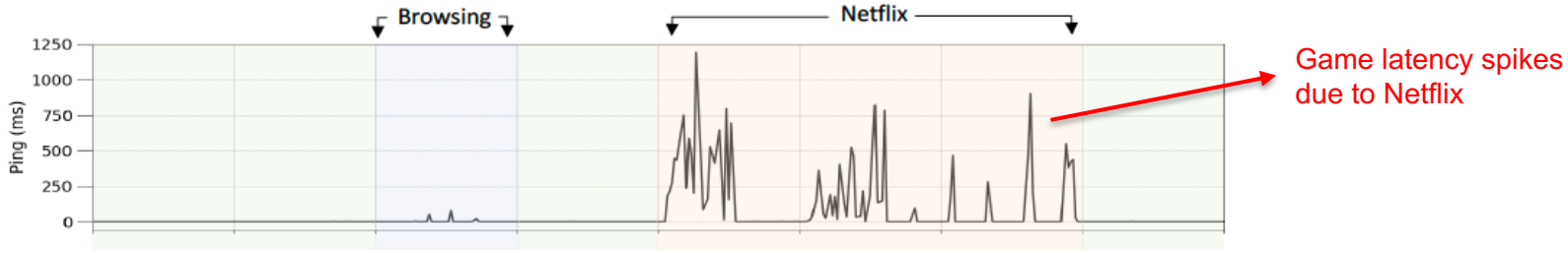
- Cloud gaming coming soon:
  - Google Stadia, Microsoft xCloud
  - Amazon? Facebook? Apple?

Top free-to-play games by revenue, 2018

Rank	Title	Publisher	Genre	Revenue
1	*Fortnite*	Epic Games	Shooter	$2.4B
2	*Honour of Kings*	Tencent	MOBA	$2.1B
3	*Dungeon Fighter Online*	Nexon	RPG	$1.5B
4	*QQ Speed*	Tencent	Racing	$1.4B
5	*League of Legends*	Riot Games, Tencent	MOBA	$1.4B
6	*Crossfire*	Neowiz Games	Shooter	$1.3B
7	*Pokemon GO*	Niantic	Adventure	$1.1B
8	*Candy Crush Saga*	King, Activision Blizzard	Puzzle	$1.0B
9	*Fate/Grand Order*	Aniplex	RPG	$1.0B

Gaming Network Requirements

- Gaming is extremely real-time, needs consistent latency < 250ms
  - Glitch of 100ms can kill, causing extreme frustration
  - Game-play streams are usually in Kbps



- Current methods do not suffice
  - Buffering is not an option
  - Over-provisioning is expensive (and will be used by video anyway)
  - Edge compute can reduce baseline latency, but congestion in access still causes jitter
- Cloud gaming:
  - High bandwidth (15Mbps) + low latency (250 msec) = huge stress on the network

Gaming acceleration (and monetization)

- Subscribers paying $7-$15 per month for boosted gaming
  - "Middle-mile" acceleration (rerouting)
  - Client-based detection and tunneling

ONLINE GAMING —

Cox Internet now charges $15 extra for faster access to online game servers

Cox is reselling a PC-only game service—there's no net neutrality issue here.

JON BRODKIN - 4/27/2019, 2:36 AM

27-Apr-2019

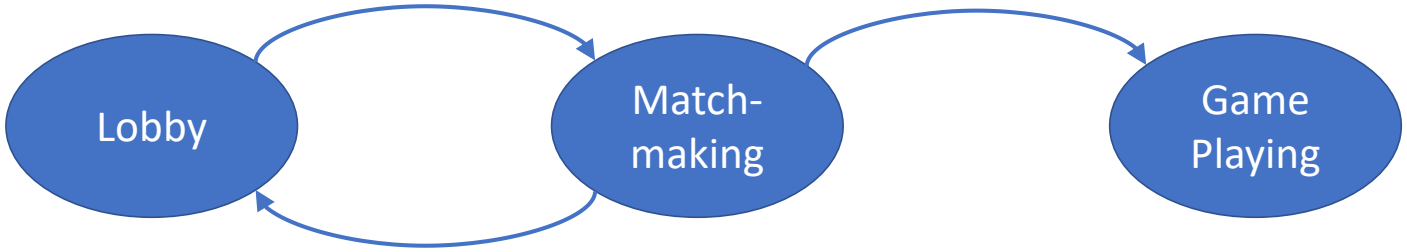
- "Last mile" acceleration
  - Transparent to user
  - Network detection and prioritization (non-neutral)

Light Reading, 14-Jun-2019

> Operators' best bet is perhaps to court business customers and technology partners. Niantic, a games company in edge trials with Deutsche Telekom, might be persuaded to pay the German operator for low-latency guarantees -- effectively sharing its gaming revenues -- although Deutsche Telekom has acknowledged that commercial arrangements are still "up in the air."

Anatomy of modern games

- Analyzed 12 games:
  - **Shooting:** Fortnite, PUBG, PUBG Mobile, CS:GO, Apex Legends, Overwatch, CoD
  - **Strategy:** League of Legends, Starcraft II, Dota2
  - **Sports:** FIFA, Rocket League
- Variety of distributor/developers:
  - Epic, Steam/Valve, Tencent, Blizzard, Riot, Origin
- Common state machine:



Foreplay vs Gameplay

- Foreplay services:
  - Encrypted TCP connections (with DNS lookup and TLS certificates)

Service	SNI	Purpose
Launcher	launcher-public-service-prod06.ol.epicgames.com	Epic games launcher for login and authentication
Waiting Room	fortnitewaitingroom-public-service-prod.ol.epicgames.com	The user decides the game mode
Party	party-service-prod.ol.epicgames.com	Lobby area to invite friends to play together
Social Network	Friends-public-service-prod.ol.epicgames.com	In-game social network
Matchmaking	fortnite-matchmaking-public-service-live-prod-b.ol.epicgames.com	Groups waiting players to start a match
Anti-cheat	hydra.anticheat.com	Third-party service to prevent cheating
Data reporting	data-router.ol.epicgames.com	Anonymous stats reporting for analytics purposes

- Gameplay is UDP
  - Game-server IP address exchanged during foreplay
    - Pings may be done to determine best server from a small set
  - Packet up/down rates are reasonably steady for most games (30-60 pkts/sec)
    - Data rates very low: < 100 Kbps

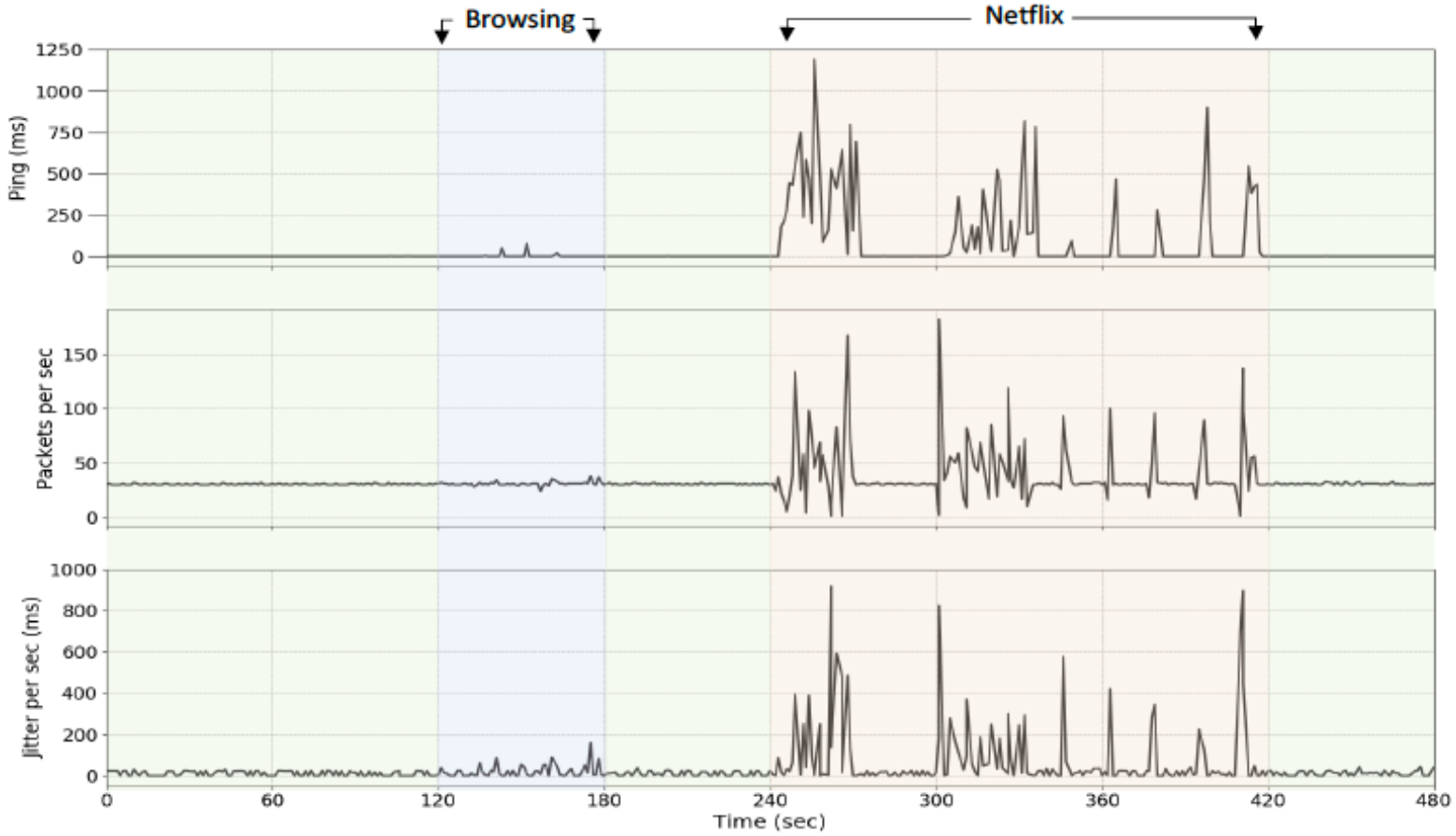
Game detection and discovery

- Look for foreplay: indicates which client and which game title
- Look for ping-tests
- Look for UDP stream with known server-side port range
- Verify rate and duration of UDP stream
- CS:GO example:

Attribute	Match values
Indicator SNI	api.steampowered.com
Server-side UDP Port	27000-27100
Upstream packet rate	64 pkt/sec
Downstream packet rate	64 pkt/sec
Duration	> 10 sec

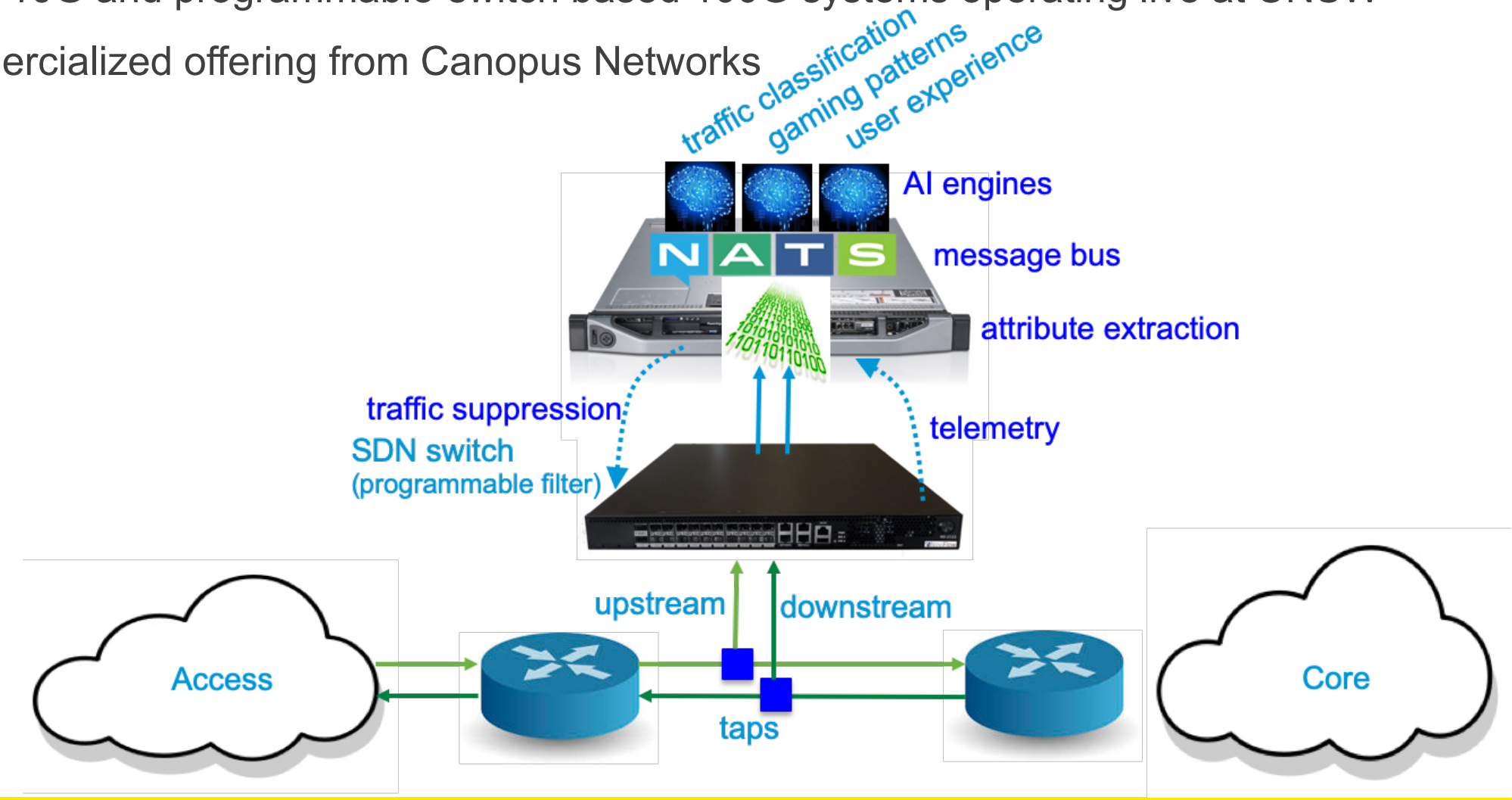
Gaming experience

- Latency jitter is affected by other traffic (browsing, streaming, downloads, …)
- Jitters can be estimated from network traffic (model validated against game-reported lag)

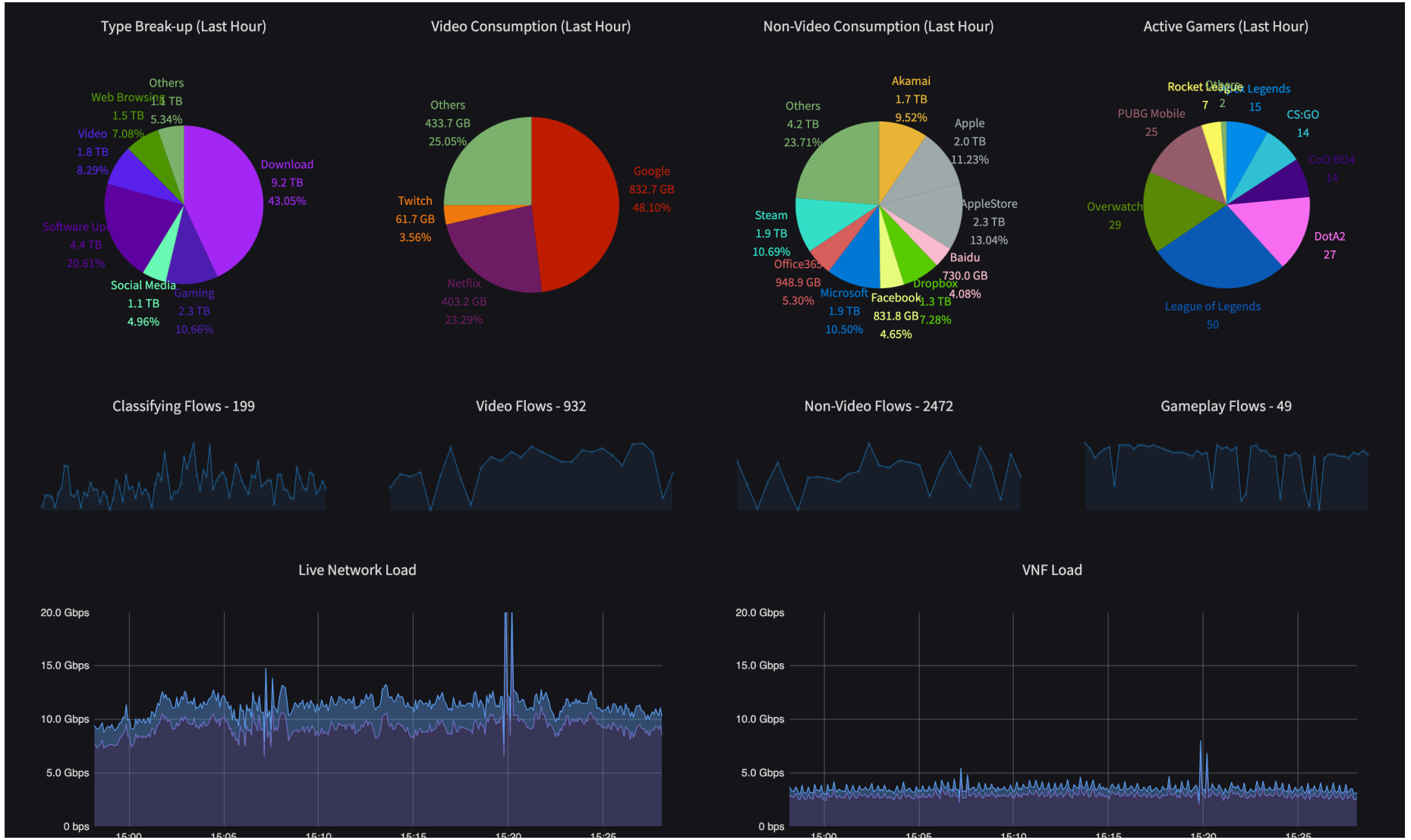


Implementation

- Virtual 10G and programmable-switch based 100G systems operating live at UNSW
- Commercialized offering from Canopus Networks

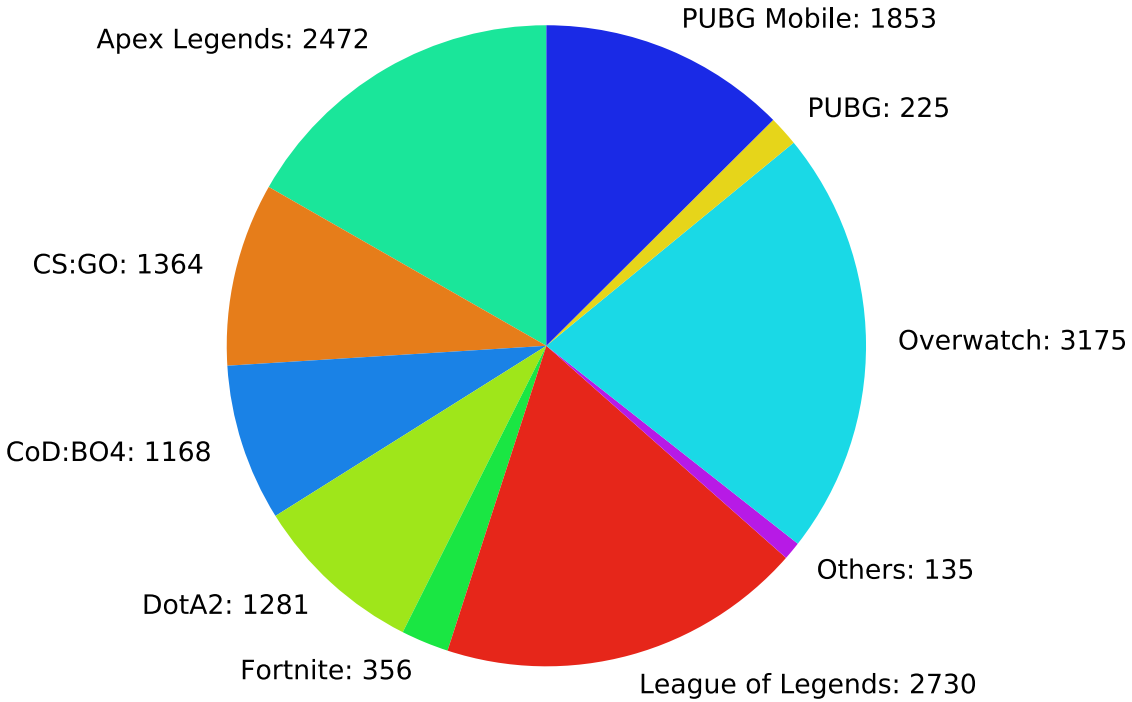


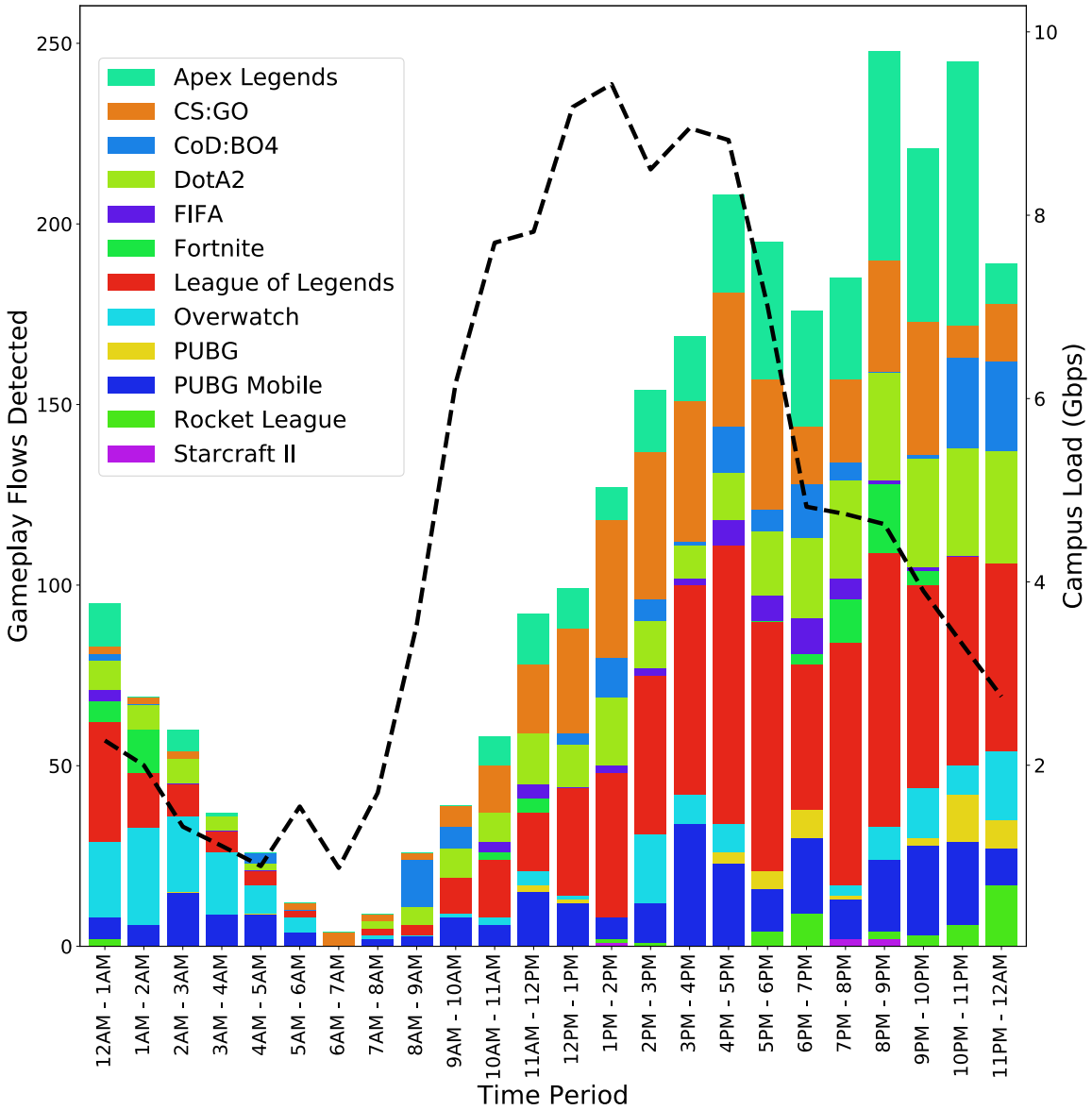
UNSW traffic patterns



UNSW gaming patterns

- Fortnite comes via AWS links



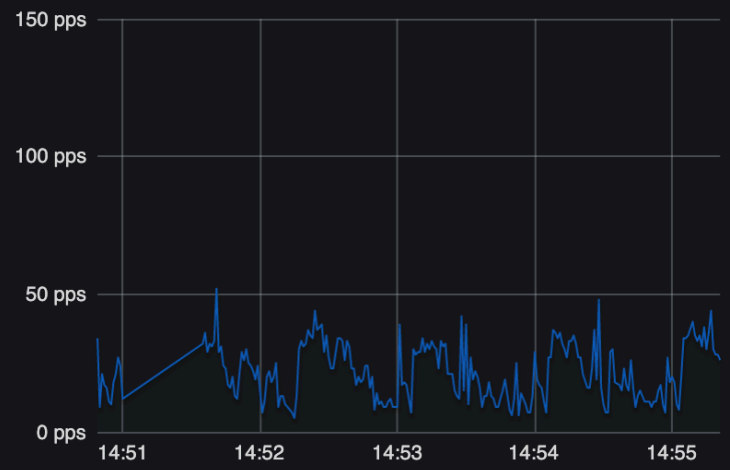


[1] S. Madanapalli, M. Perera, H. Kumar, H. Habibi Gharakheili, V. Sivaraman, "OMG! Online Multiplayer Gaming hits the Network", submitted to ACM HotNets'19, Nov 2019.

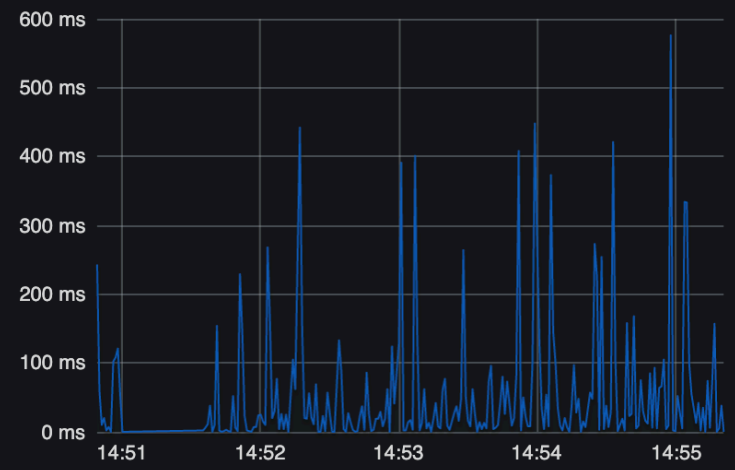
Per-stream Gaming Experience

Client IP	Server IP	Title	Down Packet Rate	Average Jitter	Duration	Status
129.94.8.212	103.10.124.101	DotA2	31 pps	16 ms	4.7 mins	Active Now
129.94.8.188	150.109.11.147	PUBG Mobile	21 pps	28 ms	1.2 mins	Active Now
129.94.8.86	103.10.125.162	DotA2	30 pps	13 ms	5.6 mins	Active Now
131.236.156.4	35.189.45.127	Fortnite	43 pps	36 ms	9.4 mins	Active Now
129.94.8.63	103.240.227.191	League of Legends	22 pps	59 ms	4.5 mins	Active Now

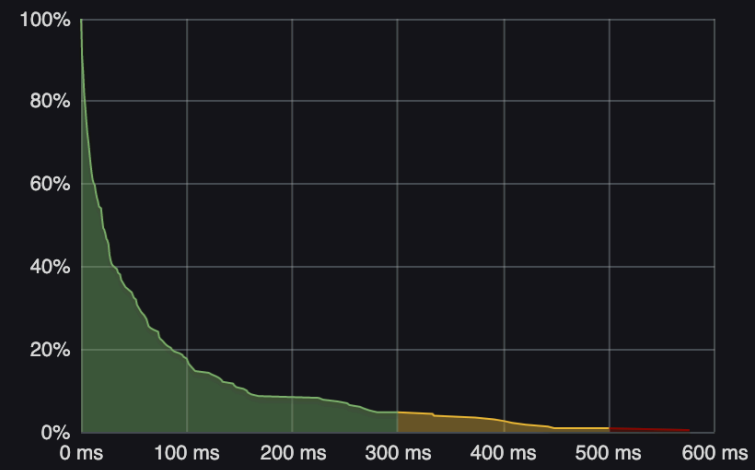
Packet Rate



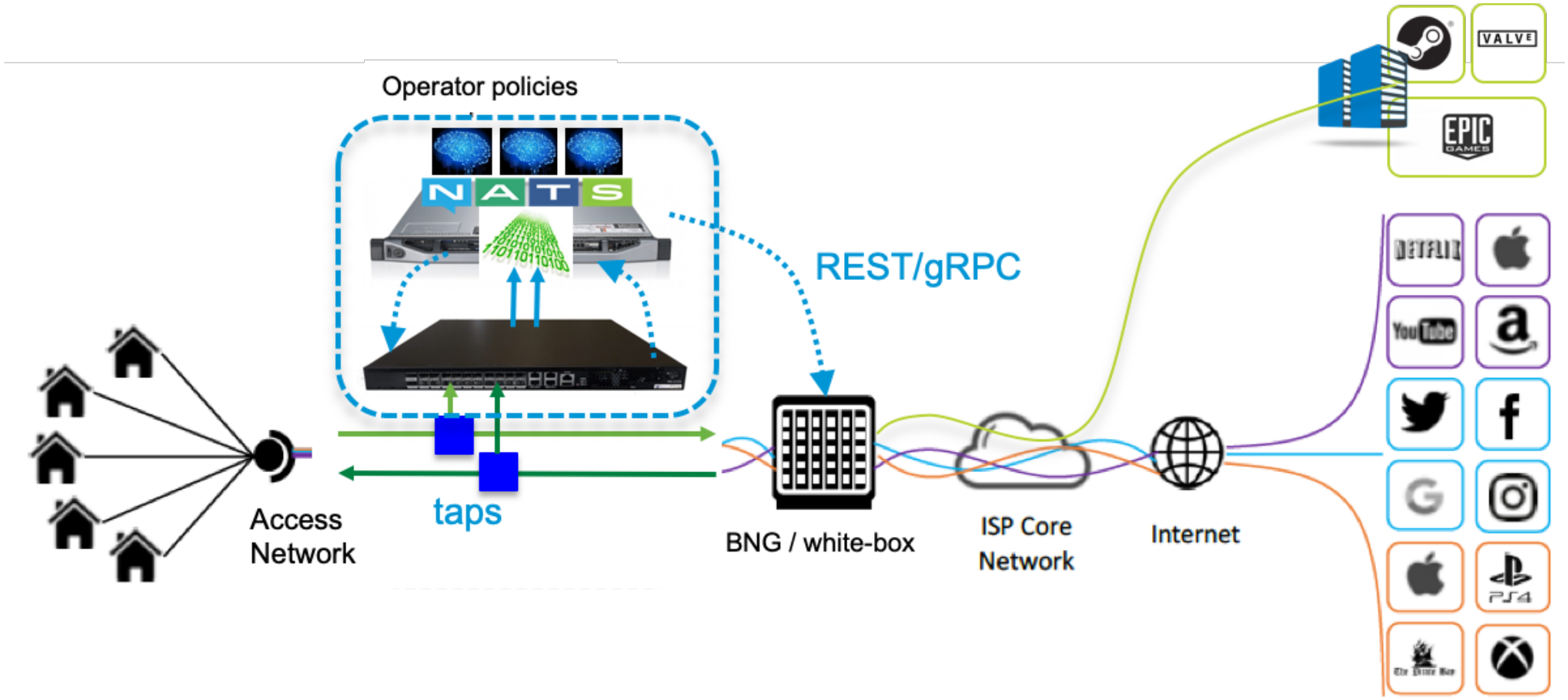
Jitter



Jitter CCDF



Protecting gaming experience



- Game-play flows identified, isolated, prioritised, and (potentially) relayed

Gaming and Neutrality

- Gaming experience can be easily protected via prioritization
  - Increasing CVC bandwidth is expensive, and will be taken up by other traffic (e.g. video)
- Neutrality principle: network should provide a level playing field to applications
  - More applicable to monopolistic right-of-way; Australia has nationalized infrastructure
    - Mobile networks have always been non-neutral and yet seen thriving innovation in applications
  - Playing field hardly level for applications: global cache footprint + sophisticated algorithms
    - On-net content and application-specific routing violate the principle anyway
  - Neutrality inhibits network innovation and threatens growth
- Framework for a post-neutral world [2]:
  - Open, flexible, and rigorous specification of policy
  - RSPs should be able to distinguish themselves on experience
  - Let customers pick RSP to suit their preferences

[2] V. Sivaraman, S. Madanapalli, H. Kumar, H. Habibi Gharakheili, "OpenTD: Open Traffic Differentiation in a Post-Neutral World", ACM SOSR'19, San Jose, CA, USA, Apr 2019.

Conclusions

- Gaming is growing explosively (like video was 5 years back) and making money
- Gaming experience is extremely sensitive to network conditions
- ISPs **can** detect gaming traffic and measure experience (at 100Gbps and above)
- ISPs are well positioned to protect gaming experience
  - Adding bandwidth is not economically viable; prioritization is
  - Consumers are willing to pay for good experience
  - Content providers cannot solve this problem on their own
- Recommend taking action now
  - Before “speed ranking” gets equated with gaming experience
  - Before cloud gaming hits