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2021 Fall Technical Forum
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Wireline Access Network

Fastest Path to Low Latency Services

Sebnem Ozer, Ph.D.

Senior Principal Network Architect
Comcast

2021 Fall Technical Forum
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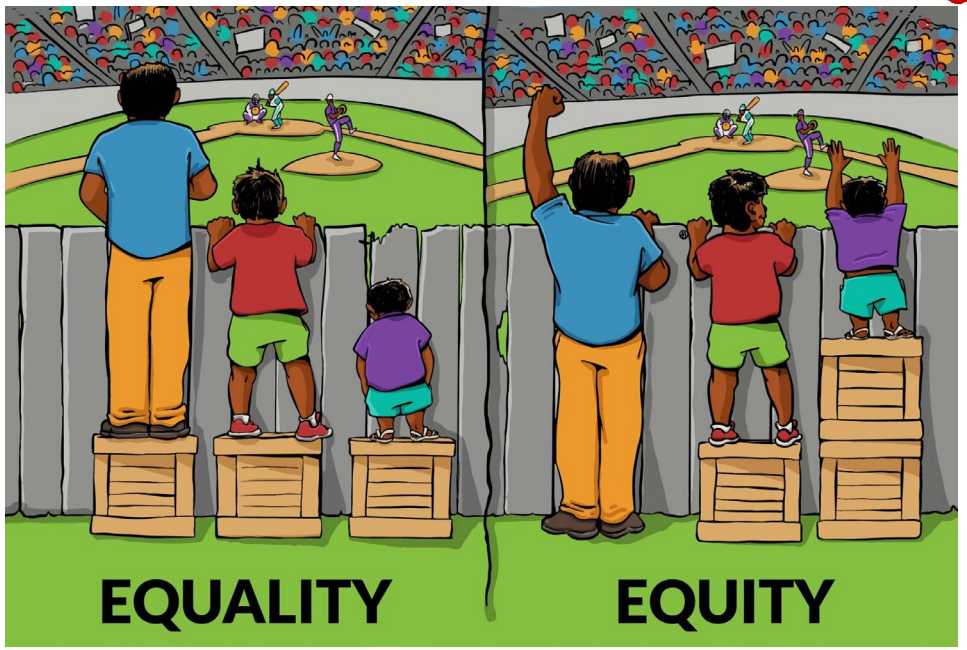
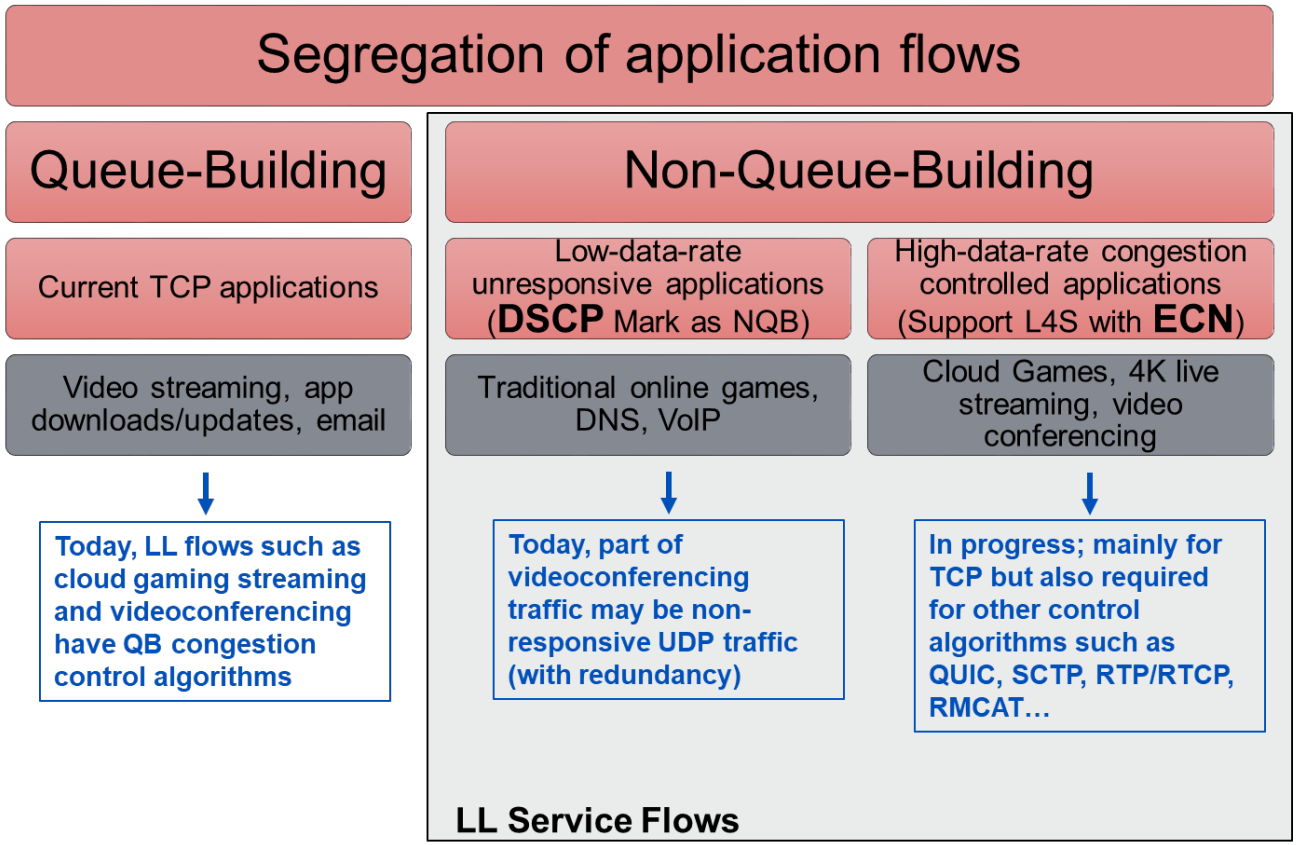
Low Latency Services

- Real-time Gaming
- Cloud Gaming
- Video/Audio-conferencing
- Real-time interactive video streaming
- Web Browsing (e.g. e-commerce)
- Emerging LL services
  - Holographic Type Communications
  - Multi-Sense Network
  - Time Engineered Applications
  - Critical Infrastructure Services

Rocket League



LL Services Traffic



Use cases	Intra BSS latency/ms	Jitter variance/ms	Packet loss	Data rate/ Mbps
Real-time gaming	< 5	< 2	< 0.1 %	< 1

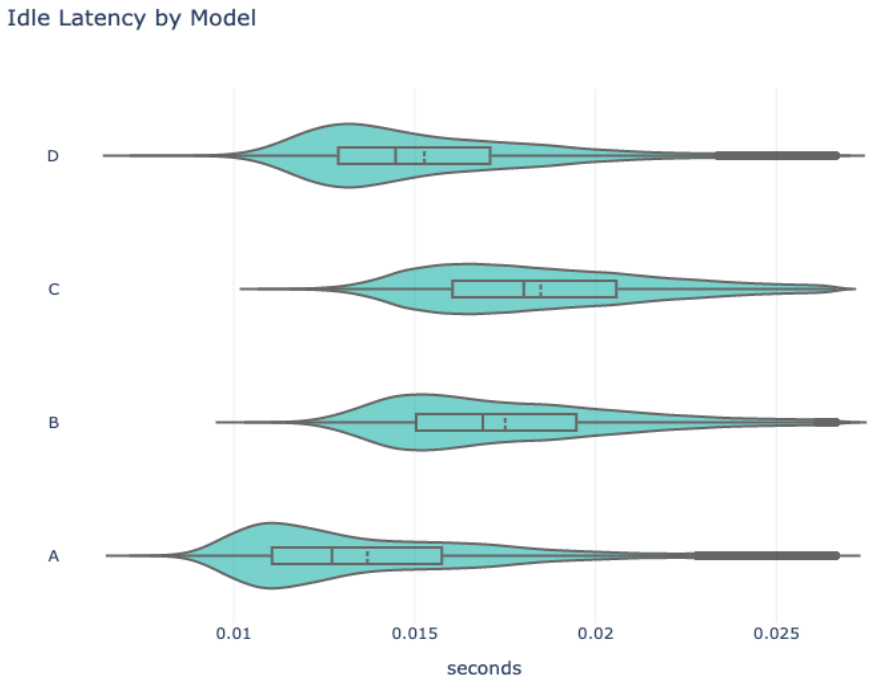
Wi-Fi Requirements Metrics

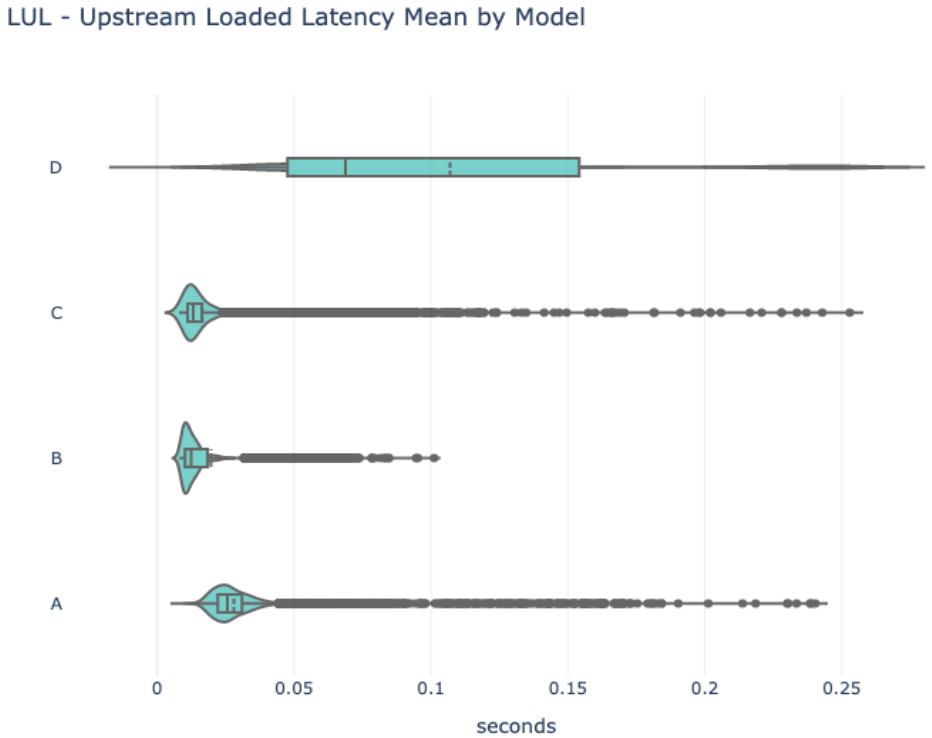
QCI	Resource Type	Priority Level	Packet Delay Budget	Packet Error Loss Rate	Example Services
3		3	50 ms	10^{-3}	Real Time Gaming

3GPP E2E Requirements Metrics

- The requirements are for “working latency” (latency under load)
- LLD aims < 10ms working latency for LL services

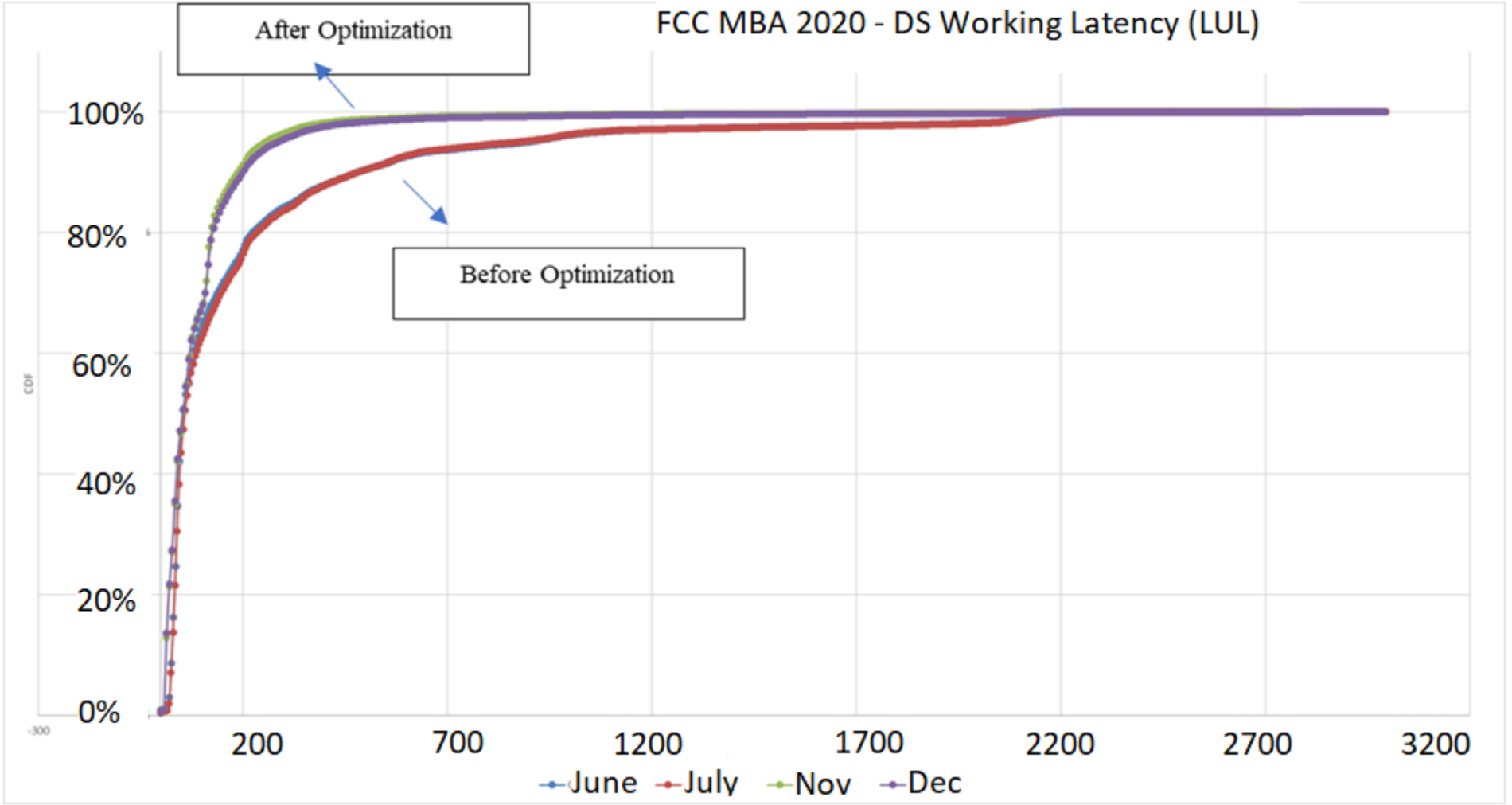
Idle vs Working Latency



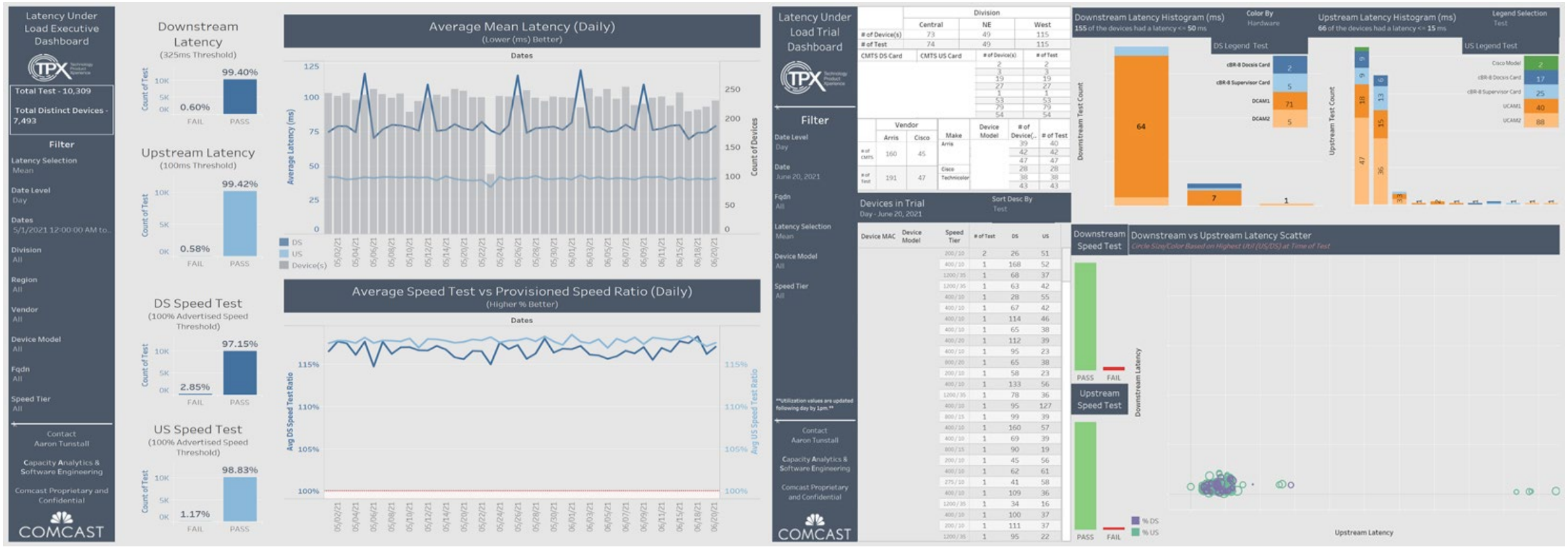


- Working latency (LUL) is the real-world measure of responsiveness when a network connection is actively used.
- “Buffer Bloat” may happen when gaming or videoconference is interrupted by large file download or many devices in homes.
- Solutions: Buffer Control, AQM, Weighted Schedulers
- The idle latency portion of the measurement uses an HTTP CURL request / response with TCP protocol
- The latency under load portion of the measurement uses Netperf’s request / response test, with UDP
- The throughput portion of the measurement uses the Iperf3 open source measurement tool, with TCP

AQM Optimizations



Latency Dashboards



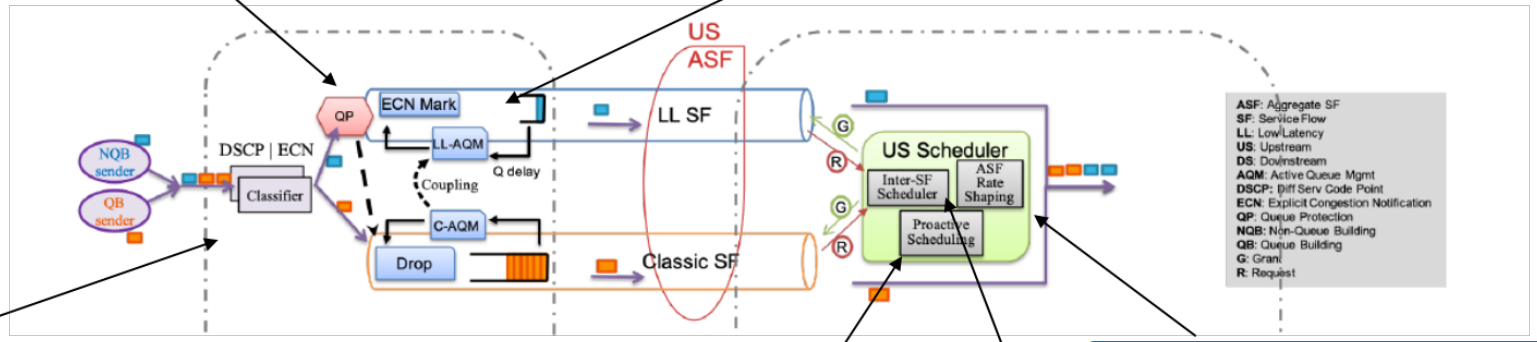
Latency Monitoring and Management Roadmap

- The impact of different TCP congestion control algorithms
- UDP based data loading for high speed tiers (>1Gbps symmetric rates)
- Marking test data to measure latency for different services, such as low latency HSD flows.
- Exploring various control protocols to standardize test requests & results reporting
- From ELK cluster workload maintenance to internal streaming data platform and Kinesis streaming for download
- Dashboarding with thresholds and alarms
- Latency prediction for a given network RF conditions, utilization levels and device/router configs

US LLD Features

2) CM implements the queue protection function for the upstream, which protects the Low Latency Service Flow from being overwhelmed by mismarked traffic

3) CM implements AQM: Each of these Service Flows implements an AQM which is coupled to the other (see Section 7.7.3.1), where the Low Latency Service Flow AQM implements Explicit Congestion Notification, while the Classic Service Flow AQM utilizes packet drops.



1) ASF Instantiation: Default Classifiers for LL services are DSCP and ECN bits. CMTS creates the LL SF and the Classic SF. It also configures classifiers for them (if needed). CM classifies each packet accordingly.

4a) CMTS rate shapes the upstream Aggregate Service Flow by ensuring that the sum of the grants to the Low Latency Service Flow and the Classic Service Flow do not exceed the QoS envelope for the Aggregate Service Flow.

4b) The CMTS schedules across the two SFs using an Interqueue Scheduler.

5) The CMTS also proactively issues grants to the CM, using a Proactive Grant Service (PGS) scheduling type (see Section 7.2.3.6), in order to reduce the media acquisition delay seen by upstream traffic.

CM supports latency histogram reporting

CMTS functionality

CM functionality

DS LLD Features

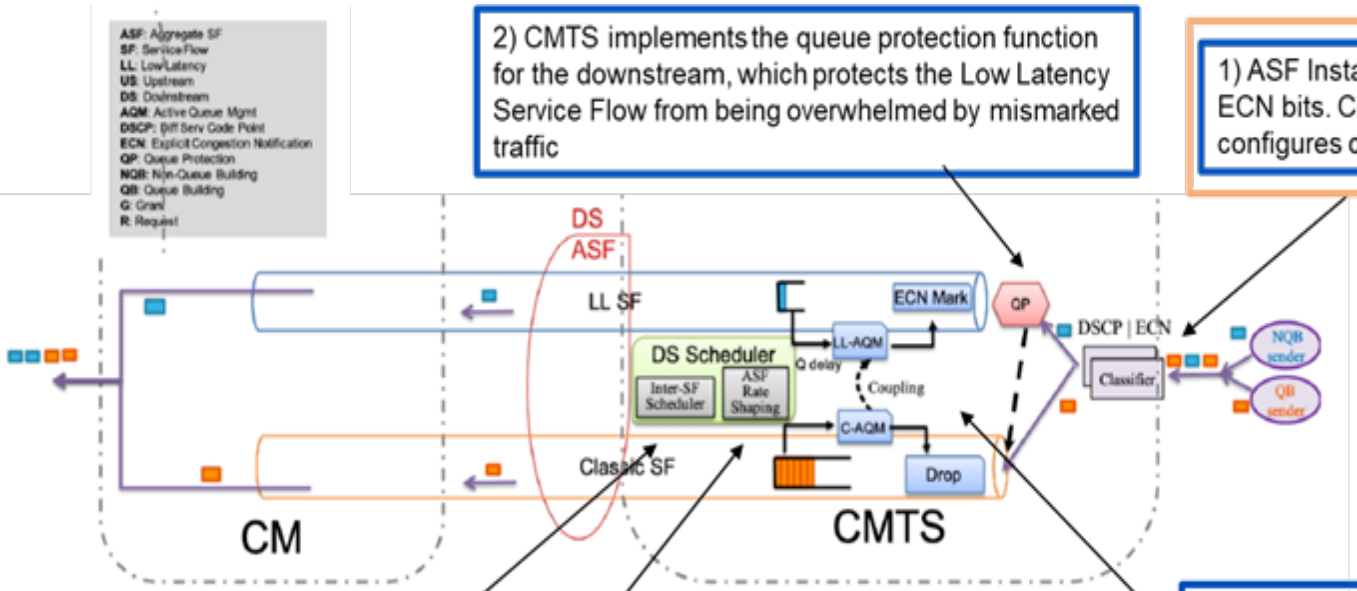


Figure 117 - Low Latency System Architecture Diagram

2) CMTS implements the queue protection function for the downstream, which protects the Low Latency Service Flow from being overwhelmed by mismarked traffic

1) ASF Instantiation: Default Classifiers for LL services are DSCP and ECN bits. CMTS creates the LL SF and the Classic SF. It also configures classifiers for them (if needed).

3) Each of these Service Flows implements an AQM which is coupled to the other (see Section 7.7.3.1), where the Low Latency Service Flow AQM implements Explicit Congestion Notification, while the Classic Service Flow AQM utilizes packet drops.

4a) CMTS rate shapes the downstream Aggregate Service Flow by ensuring that the combined traffic on the Low Latency Service Flow and the Classic Service Flow do not exceed the QoS envelope for the Aggregate Service Flow.

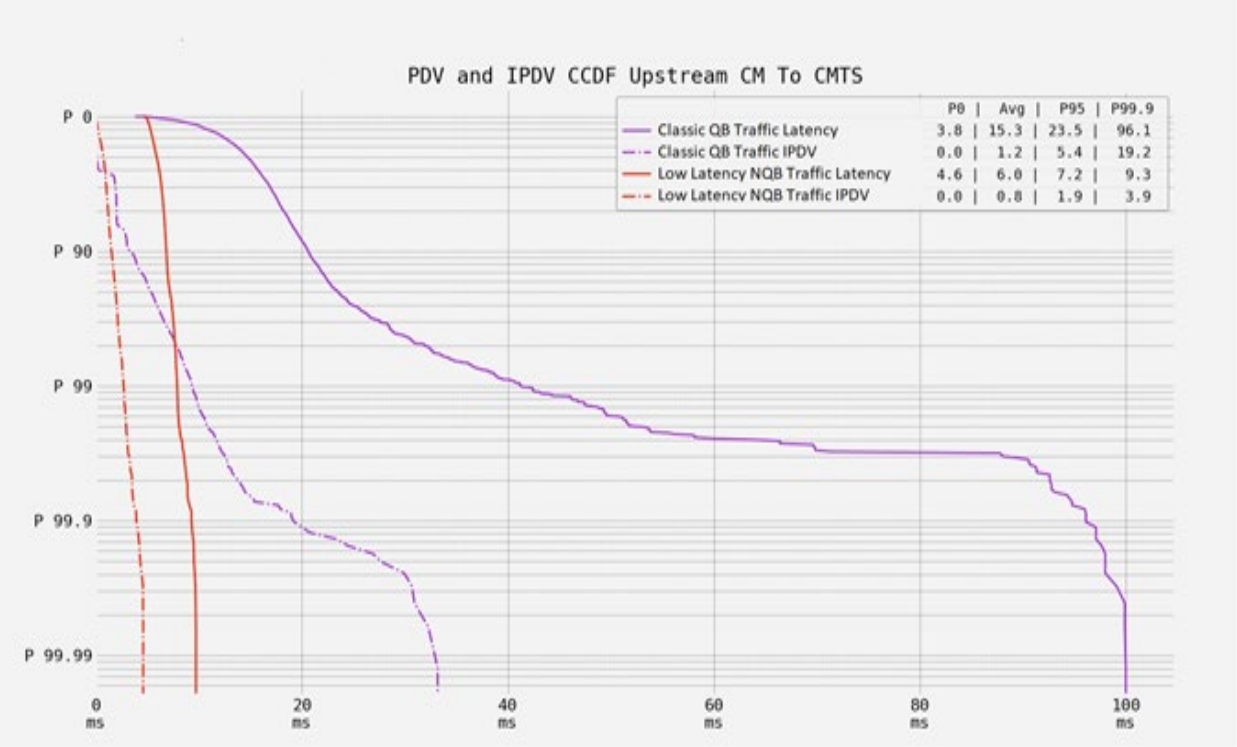
4b) CMTS schedules across the two SFs using an Interqueue Scheduler.

5) CMTS supports latency histogram reporting

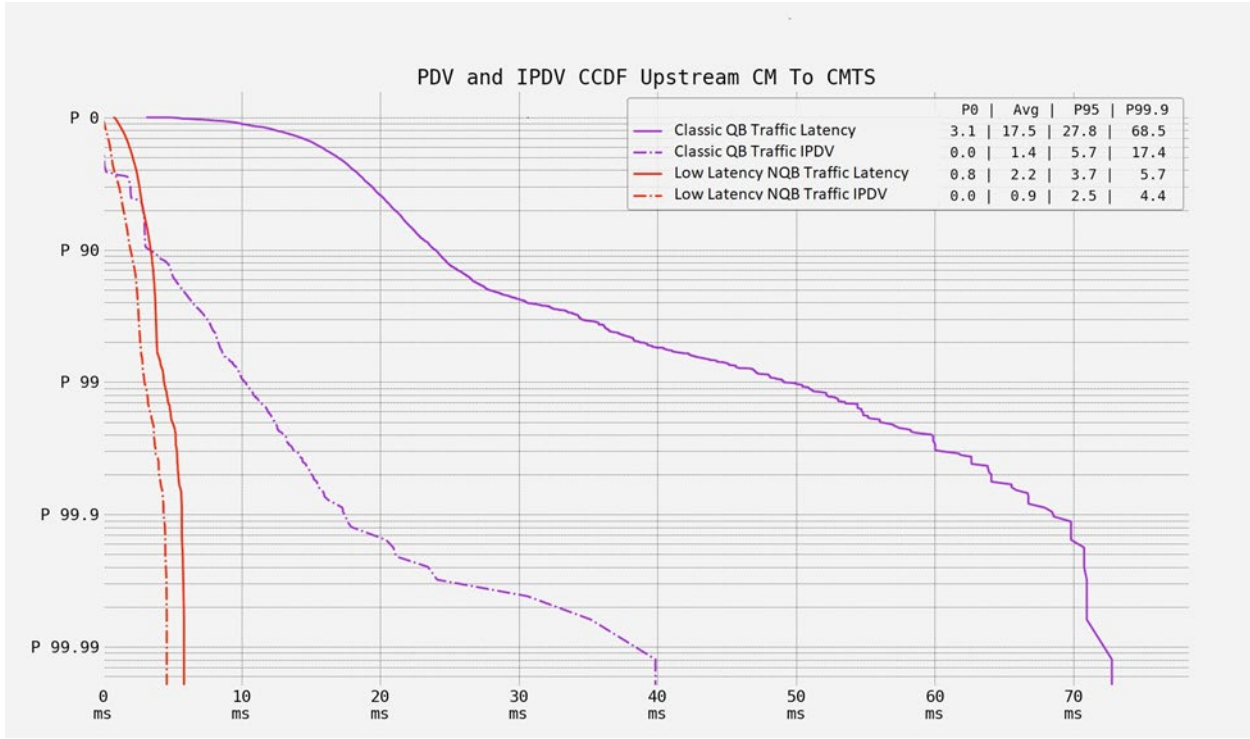
CMTS functionality

CM functionality

Cablelabs LLD Tests

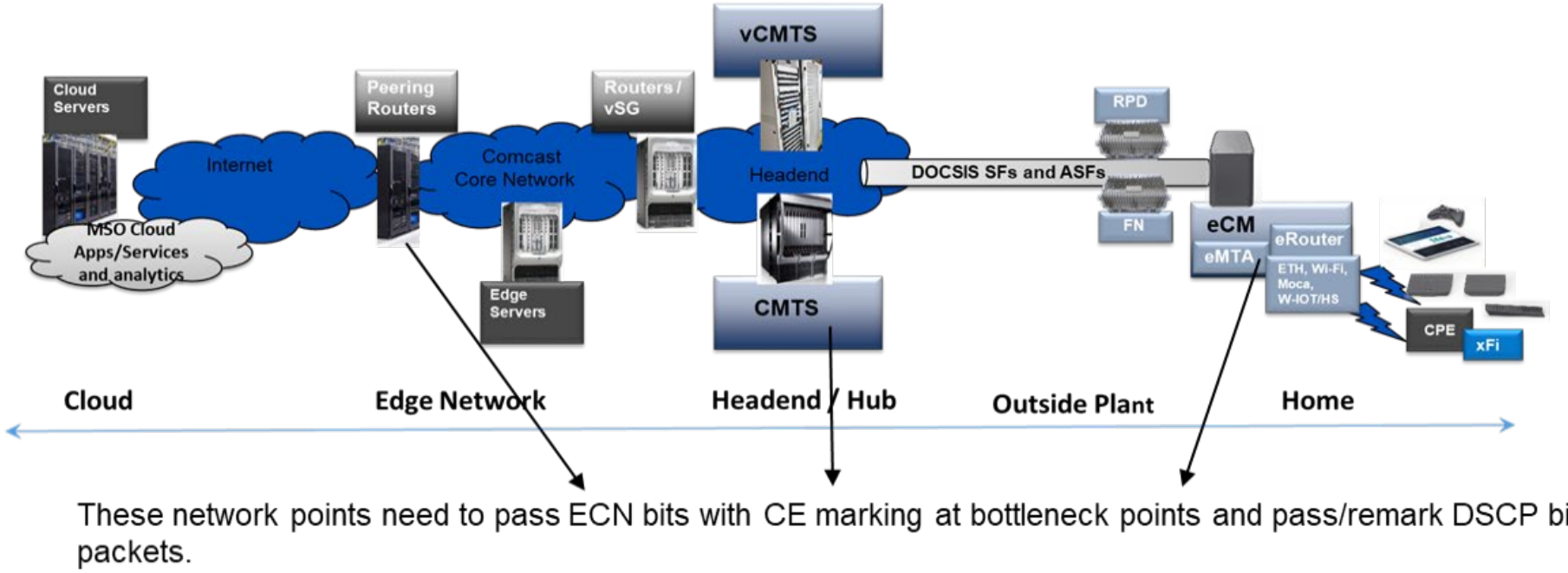


US LLD With Dual Queue and no PGS



US LLD With Dual Queue and PGS

Conclusions



- Better standardize/define how latency, jitter, packet loss and other QoS metrics are measured and create open global internet measurement platforms to focus on end-to-end QoE assessment.
- Start breaking legacy chains through digitization, software defined, virtualized and cloud based systems with open source software, platform models with partners and co-innovators to meet the consumers' demands in an agile way.
- Apply an end-to-end approach for traffic differentiation and QoE management with new upcoming 10G technologies.

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Thank You!

Sebnem Ozer, Ph.D.

Senior Principal Network Architect
Comcast
sebnem_ozer@Comcast.com