SWINBURNE UNIVERSITY OF TECHNOLOGY

Evaluating DASH and TCP Interactions with TEACUP Testbed

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Outline

- Introduction to DASH
- TEACUP Testbed
- Experiment Results
- Future Research Directions

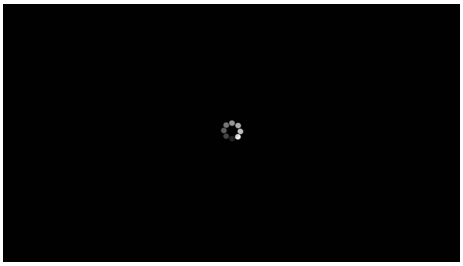
Detailed Outline

- Introduction to DASH
- TEACUP Testbed
- Some Experiment Results
- Future Research Directions

- Introduction to DASH
  - What? Why? How?

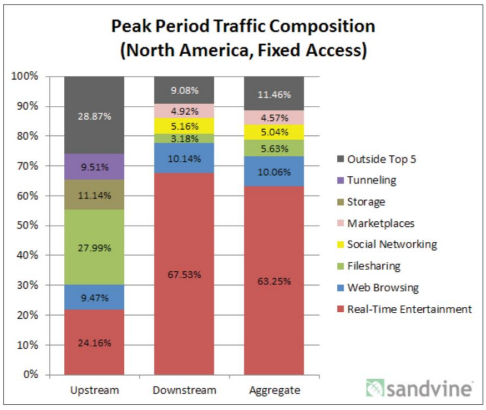
Buffering = Frustrations!

" I don't mind ads, I don't mind buffer, but when ads buffer, I suffer." – Unknown source



Multimedia is Dominating the Internet

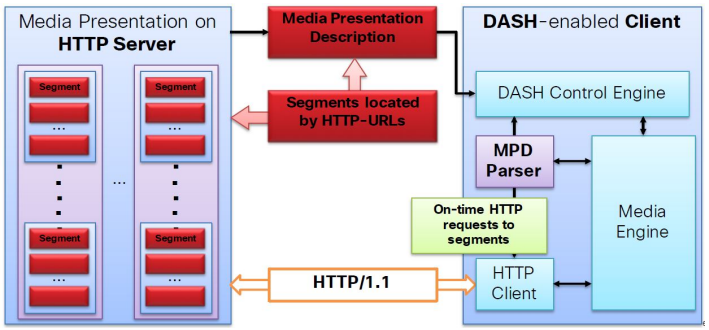
- Real-time entertainment
  - Video/audio streaming
  - > 60% of Internet traffic at peak periods
  - Netflix (34.9%), YouTube (14%)
  - All over-the-top delivery



Source: Global Internet Phenomena Report 2H 2014

MPEG-DASH ISO/IEC 23009

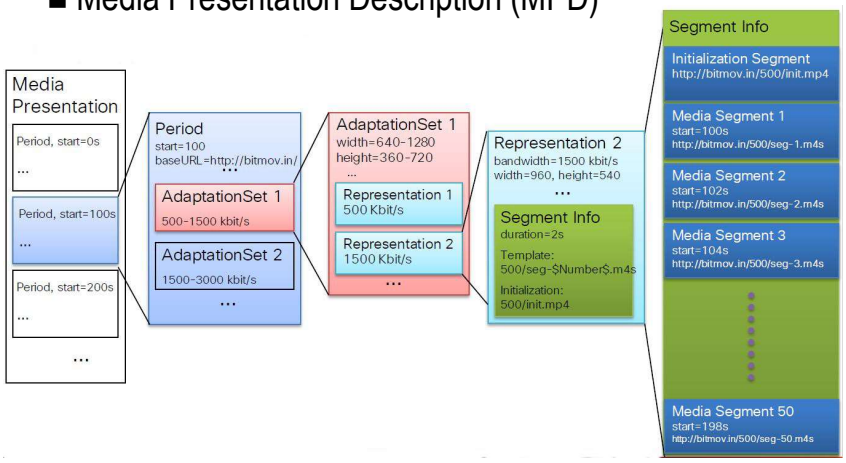
- DASH is NOT a protocol, codec, DRM, client specs
- DASH is an *enabler* - provides formats for efficient/high-quality video streaming, flexible design choices



C. Timmerer, "Over the Top Content Delivery: State of the Art and Challenges Ahead", **IEEE International Conference on Multimedia and Expo**, Torino, Italy, June/July 2015.

DASH Data Model

- Media Presentation Description (MPD)



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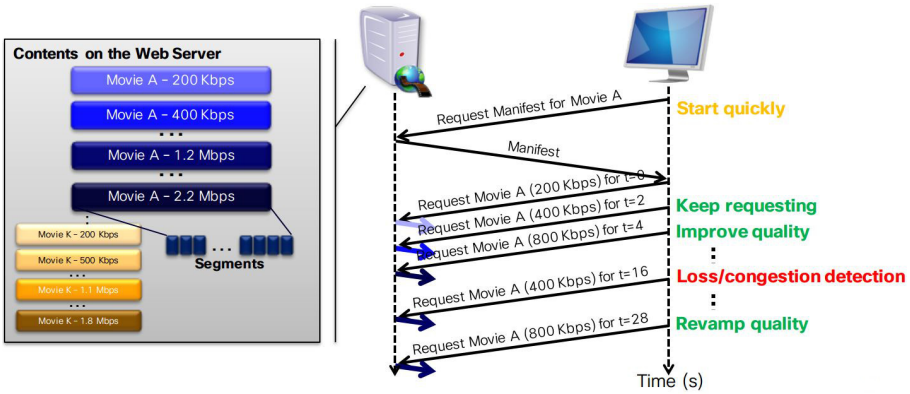
How DASH Works (simplified)



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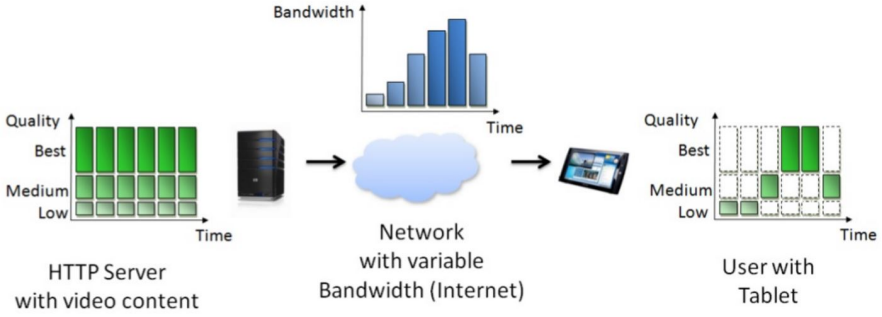
In a Nutshell



C. Timmerer and C. Griwodz, "Dynamic adaptive streaming over HTTP: from content creation to consumption", **In Proceedings of the 20th ACM International conference on Multimedia (MM'12)**, Nara, Japan, Oct./Nov. 2012.

Detailed Outline

- Introduction to DASH
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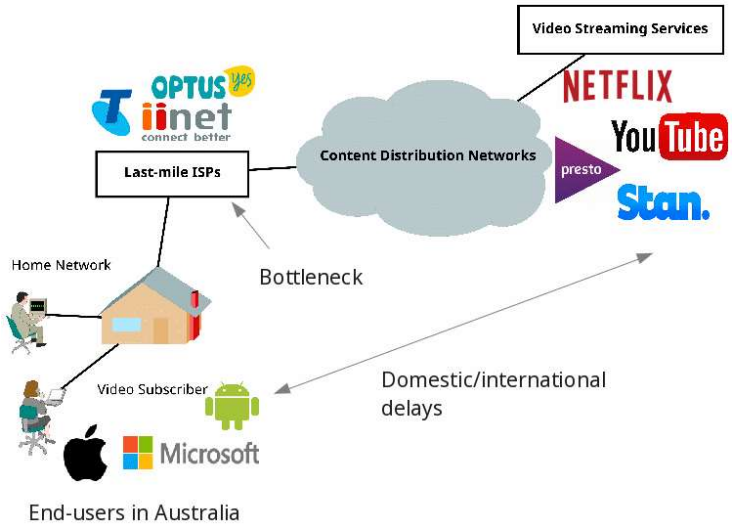
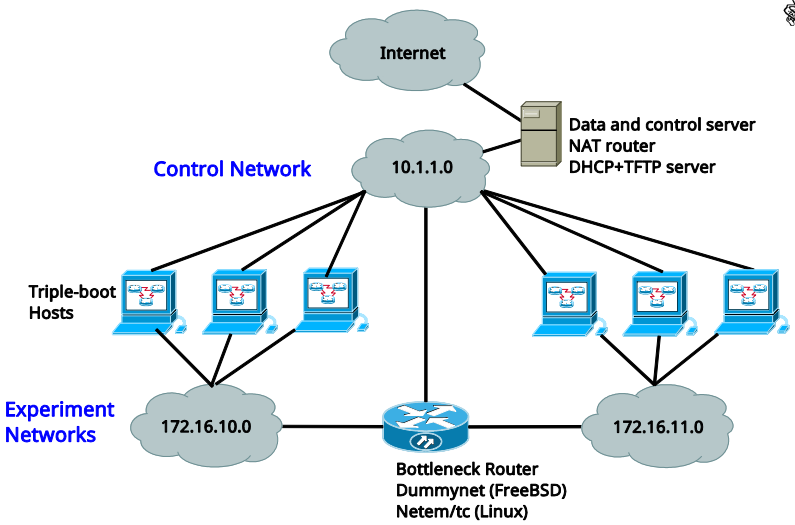
- TEACUP Testbed
  - Use Case Model
  - Experiment Setup
  - DASH Client(s)
  - DASH Dataset

Use Case Model: Home Network



TEACUP Testbed



TEACUP Testbed

- FreeBSD/Linux hosts
- Congestion Control algorithms: NewReno, CUBIC, CDG
- SIFTR/Web10G for statistics logging
- Linux *netem/tc* bottleneck router
- DASH dataset (ITEC)
  - 1, 2, 4, 10, 15-sec chunks VBR encoded at 20 levels
- VLC Player, dash.js client

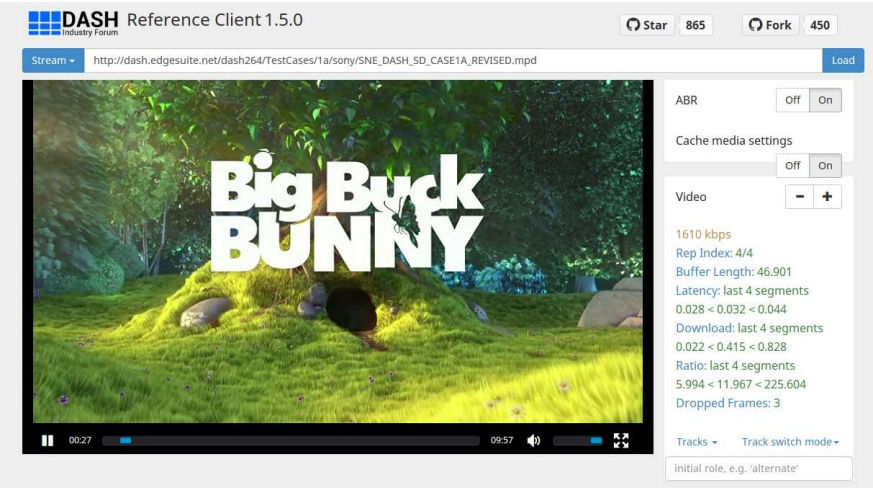
DASH Client – VLC Player

- VLC player (nightly build)
- Patched to build under FreeBSD
- Modified to log various video streaming statistics
  - Video/Audio decoded blocks, dropped frames, content bitrate, corrupted frames, etc.
  - Bandwidth estimation, selected representation, HTTP GET request timestamps

DASH Client – dash.js (v1.5.0)

- HTML5-based player in Chromium
- DASH Industry Forum (DASH-IF) initiative
- Modified to log various video streaming statistics
  - Video/Audio playback bitrate, playout buffer occupancy, download latency, etc.
- Widely used in industry (Akamai actively involved) and research
- Currently undergoing major code refactoring (to v2.0)

DASH Client – dash.js



Detailed Outline

- Introduction to DASH
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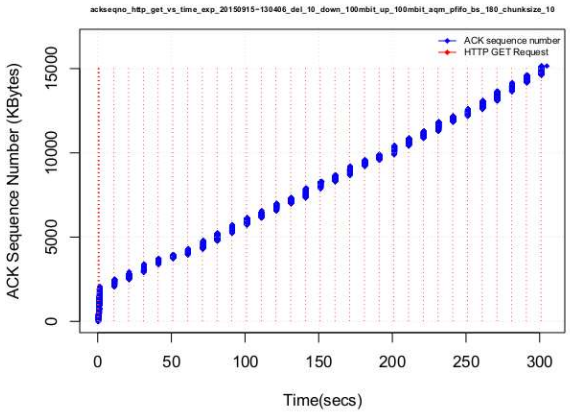
- Experiment Results
  - Various TCP Variants (NewReno, CUBIC, CDG)
  - Various bottleneck characteristics (bandwidths, RTTs, AQMs)

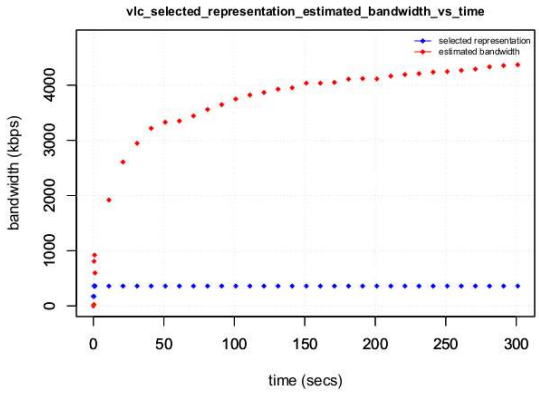
Experiment Results - VLC

- NewReno, 100Mbps symmetric, 20ms RTT, 180-pkt pfifo, 10-sec video chunks



VLC Bandwidth Estimation

- NewReno, 100Mbps symmetric, 20ms RTT, 180-pkt pfifo, 10-sec video chunks

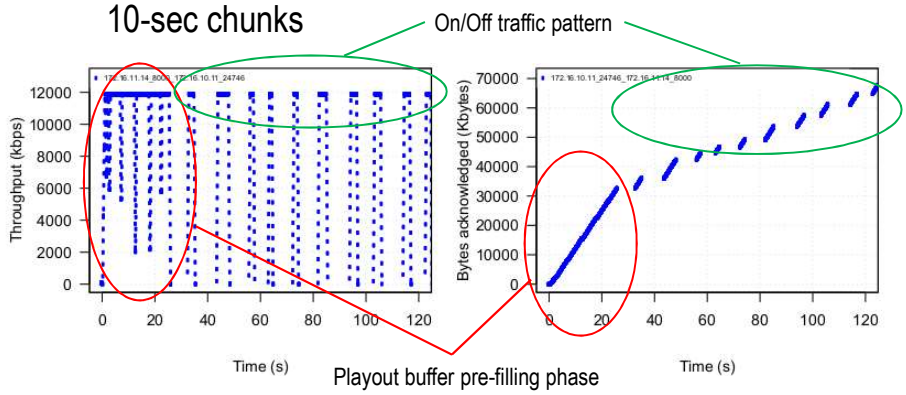


Experiment Scenarios

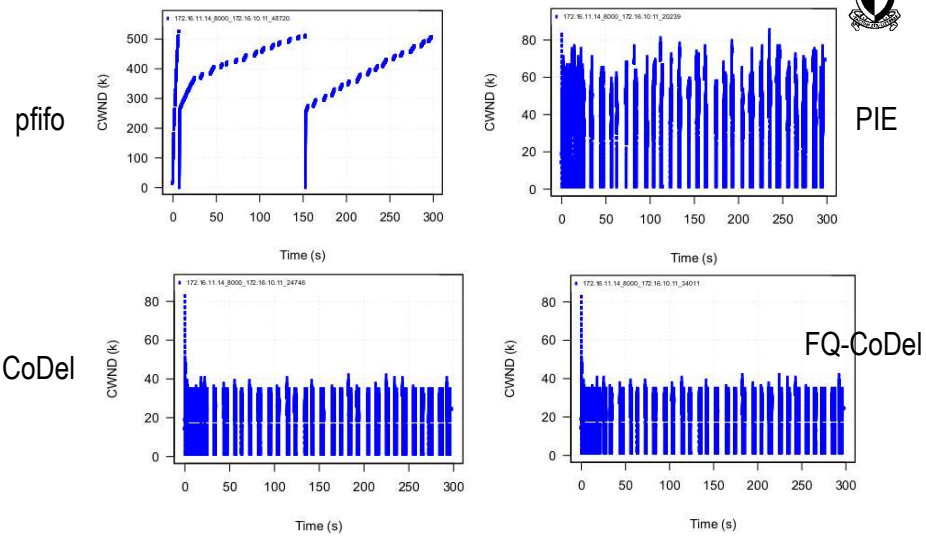
- Host OS, TCP algorithms
  - FreeBSD NewReno, CDG v1.0
  - Linux CUBIC
- Path characteristics:
  - Bandwidths: 12Mbps down, 1Mbps up
  - One Way Delay: 5, 20, 90, 120, 170 ms.
  - AQM: pfifo (340 pkts), PIE, CoDel, FQ-CoDel (1000 pkts)
- dash.js client requesting 10-sec video chunks

Throughput & ACK Sequence Number

- Video Traffic is bursty
- 12Mbps down, 1Mbps up, 10ms RTT, 1000-pkt CoDel, 10-sec chunks

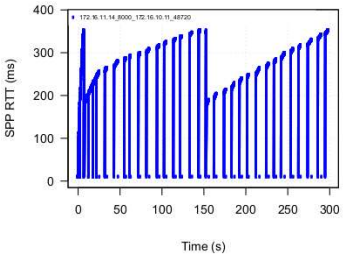


NewReno across pfifo & AQMs - cwnd

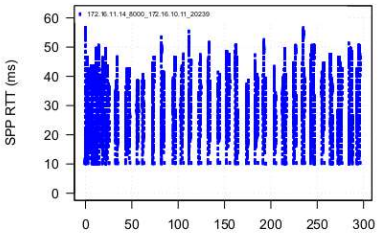


NewReno across pfifo & AQMs - RTT

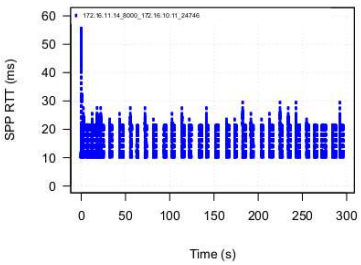
pfifo



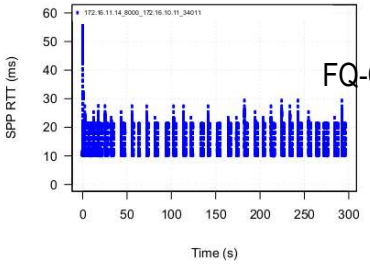
PIE



CoDel



FQ-CoDel



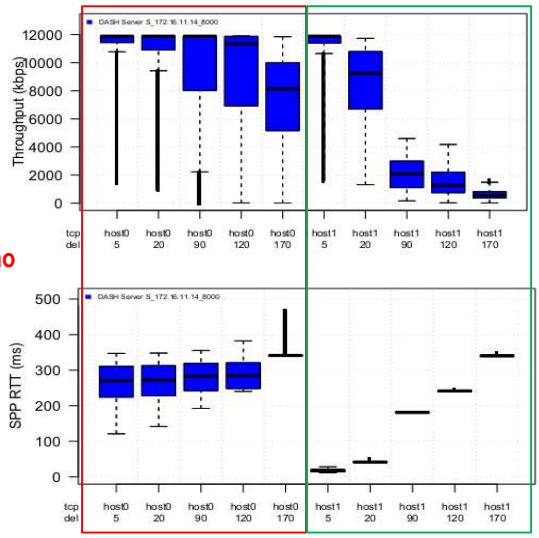
FreeBSD NewReno CDG across pfifo

Throughput

SPP RTT

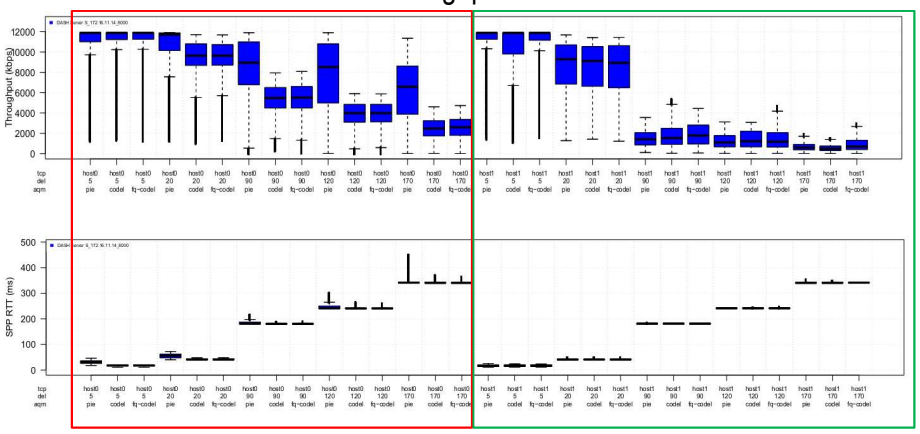
NewReno

CDG



FreeBSD NewReno CDG across AQMs

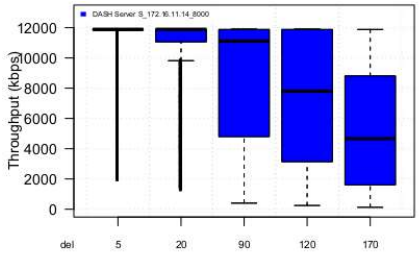
Throughput



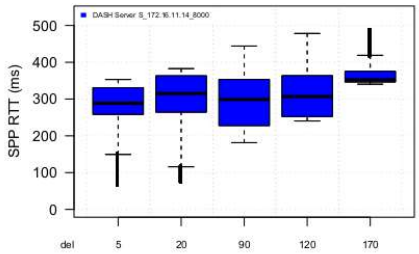
NewReno SPP RTT CDG

Linux CUBIC across pfifo

Throughput

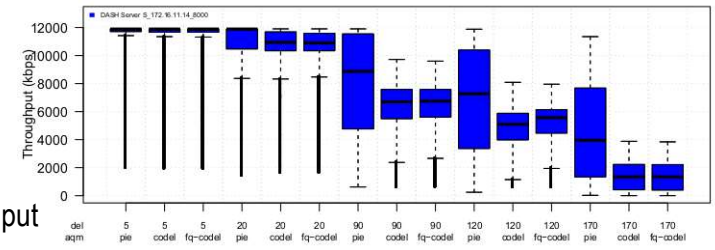


SPP RTT

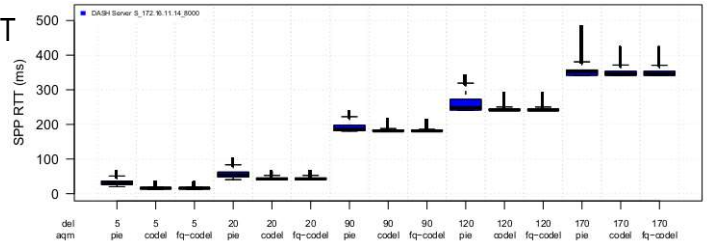


Linux CUBIC AQMs

Throughput

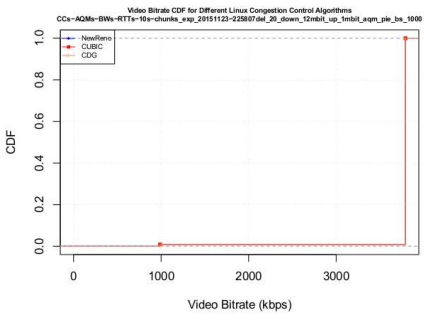


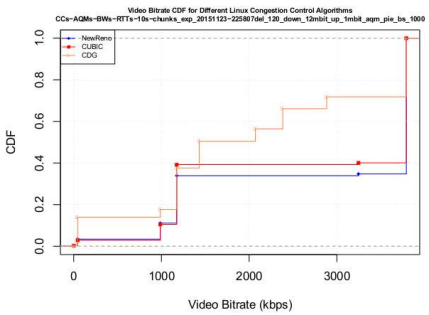
SPP RTT



Representation Selection (PIE)

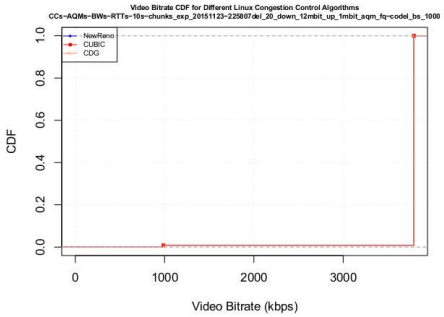
- 12Mbps down, 1Mbps up, 1000-pkt buffer
- 40ms RTT
- 240ms RTT

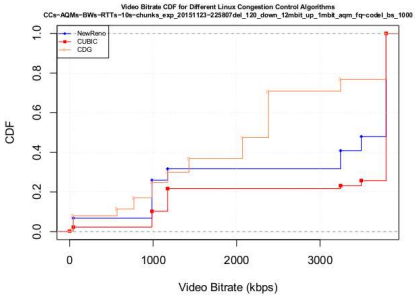




Representation Selection (FQ-CoDel)

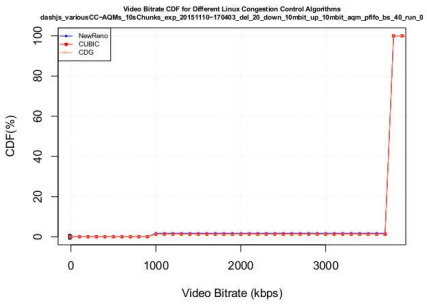
- 12Mbps down, 1Mbps up, 1000-pkt buffer
- 40ms RTT
- 240ms RTT

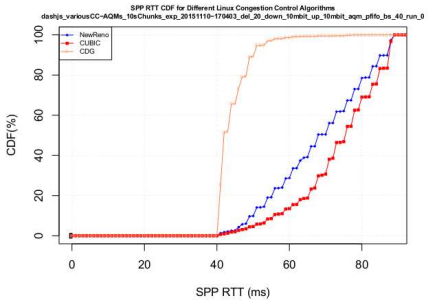




Representation Selection & RTT (pfifo)

- 10Mbps symmetric, 40ms RTT, 40-pkt buffer
- Video Bitrate
- SPP RTT





Representation Selection & RTT (PIE)

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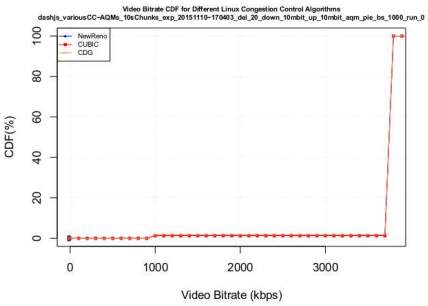
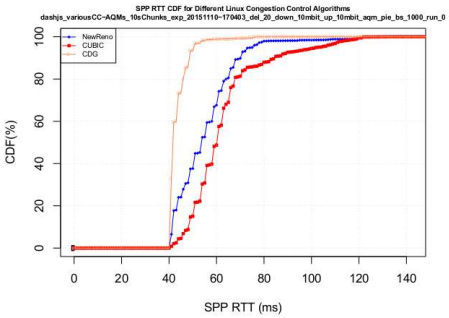
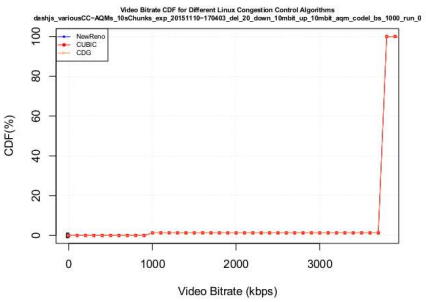
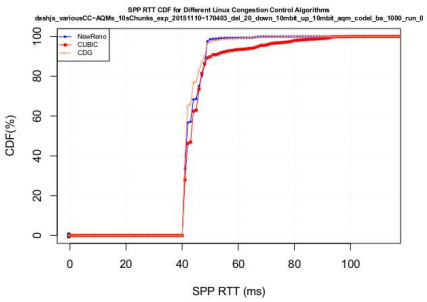




Representation Selection & RTT (CoDel)

- 10Mbps symmetric, 40ms RTT, 1000-pkt buffer
- Video bitrate
- SPP RTT





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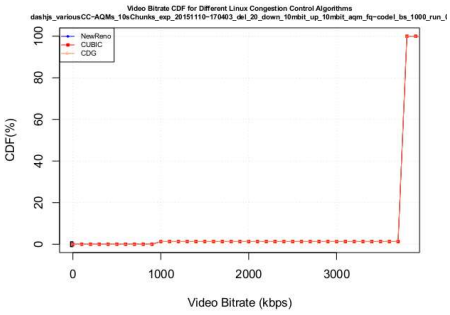
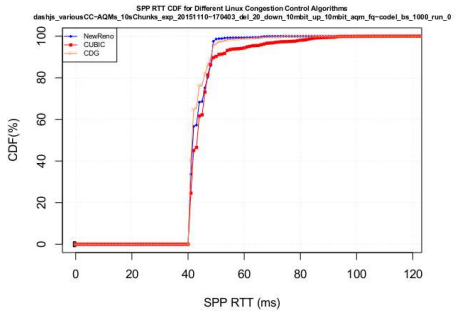
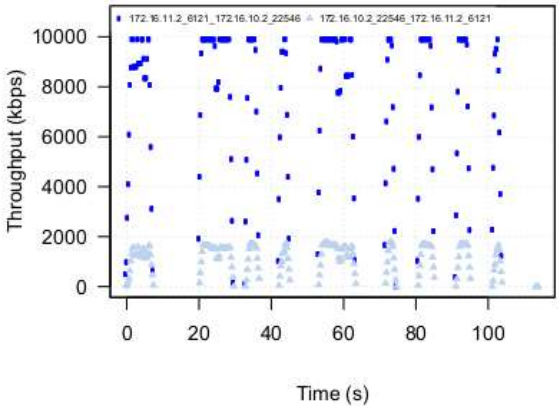




Experimental: dash.js and Google QUIC

- CUBIC, 20ms RTT, 10Mbps symmetric, 30-pkt pfifo



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  - Challenges ahead

Possible Future Research Directions

- Server-side optimistaion to control fairness
  - Delay-based TCP to minimise queuing delays?
- Better caching, replication, positioning of content
  - CDN selection algorithms
- Any other transport options other than TCP?
  - MPTCP, DCCP, SCTP, QUIC
- Modelling Quality-of-Experience (QoE)
- Client-side Adaptive Bitrate (ABR) algorithms

Conclusion

- DASH traffic generator extension to TEACUP v1.0
  - VLC Client
  - dash.js Client
- Evaluated various TCP CCs across different bottleneck bandwidths, RTTs, AQMs
- CAIA Delay Gradient (CDG) achieves the same QoE (video bitrate) under low BDP paths while maintaining low induced RTTs

Thank You

Thank You!