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
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- Some Experiment Results
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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

DASH Data Model

- Media Presentation Description (MPD)


How DASH Works (simplified)

In a Nutshell


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- TEACUP Testbed
  - Use Case Model
  - Experiment Setup
  - DASH Client(s)
  - DASH Dataset
Use Case Model: Home Network

- OPTUS
- iiNet
- Content Distribution Networks
- Last mile ISPs
- Home Network
- Bottleneck
- Domestic/international delays
- End-users in Australia

TEACUP Testbed

- Internet
- Control Network
- 10.1.1.0
- Data and control server
- NAT router
- DHCP+TRIP server
- Triple-boot Hosts
- Experiment Networks
- 172.16.10.0
- Bottleneck Router
- Dummynet (FreeBSD)
- Netem/tc (Linux)
- 172.16.11.0
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)
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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

On/Off traffic pattern

Playout buffer pre-filling phase

NewReno across pfifo & AQMs - cwnd

pfifo

PIE

CoDel

FQ-CoDel
NewReno across pfifo & AQMs - RTT

pfifo  PIE

CoDel  FQ-CoDel

FreeBSD NewReno CDG across pfifo

Throughput  NewReno  CDG

SPP RTT
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)

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

Representation Selection & RTT (CoDel)

- 10Mbps symmetric, 40ms RTT, 1000-pkt buffer
- Video bitrate
- SPP RTT
**Representation Selection & RTT (FQ-CoDel)**

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

**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 optimisation 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