Sizing Network Buffers: A HTTP Adaptive Streaming Perspective

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This publication has emanated from research conducted with the financial support of Science Foundation Ireland (SFI) under Grant Number 13/IA/1892.

Current Trends

MISL

Top 10 Peak Period Applications[1] 2016

Aggregate	
Netflix	32.72%
YouTube	17.31%
HTTP - OTHER	4.14%
Amazon Video	3.96%
SSL - OTHER	3.12%
BitTorrent	2.85%
iTunes	2.67%
Hulu	2.47%
Xbox One Games Download	2.15%
Facebook	2.01%
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North America

[1]https://www.sandvine.com/

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56% of total traffic is multimedia traffic

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Noticeable, among top three there is also Web browsing + Facebook

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Why HTTP Adaptive Streaming?

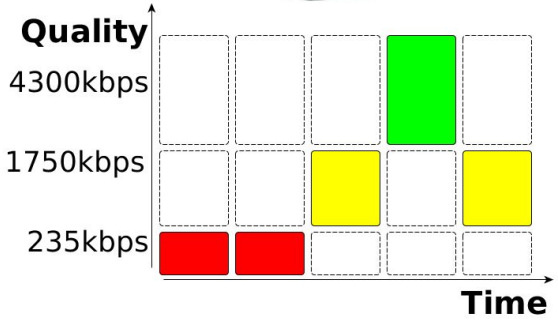
Challenge

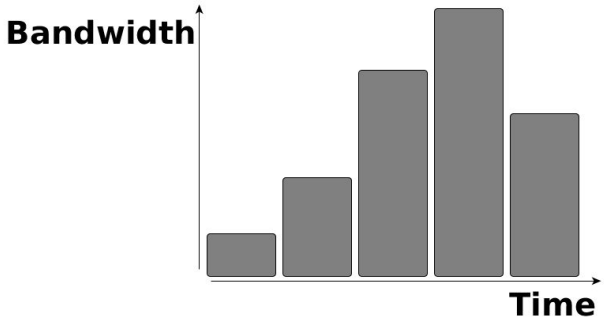
- Internet is not multimedia friendly
  - best-effort delivery

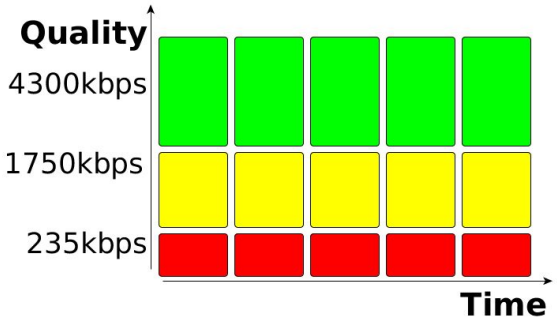
Solution

- adapt multimedia content and delivery to Internet
  - adapt to network conditions - ABR (adaptive bit-rate)
  - HTTP: scalable, firewall and NAT friendly, cost-effective

HTTP Adaptive Streaming Architecture





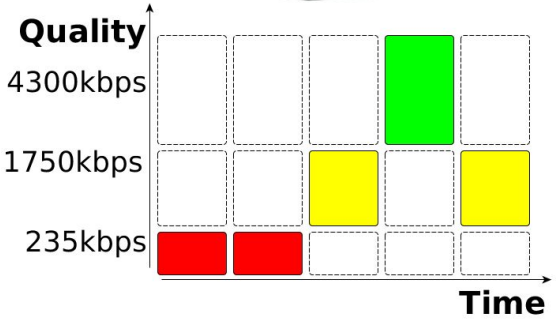


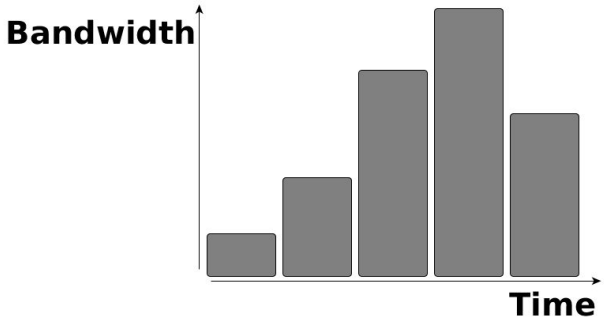
Decision logic is at the client side

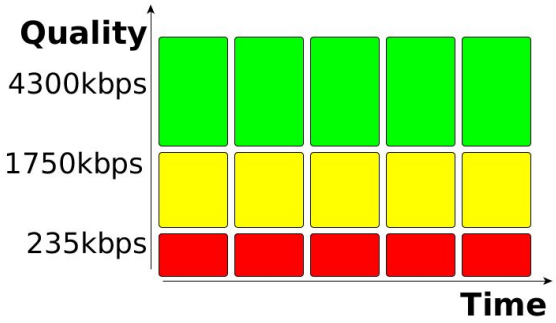
Video content is split into multiple segments

HTTP Adaptive Streaming Architecture

1. Client sends request for first segment



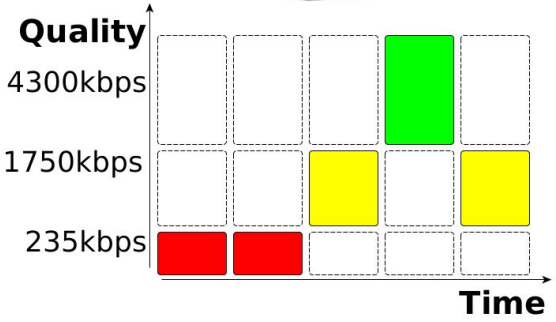


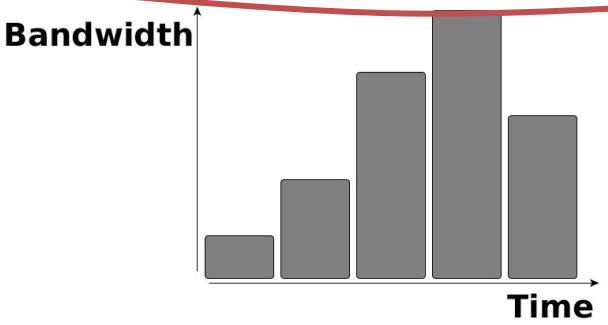


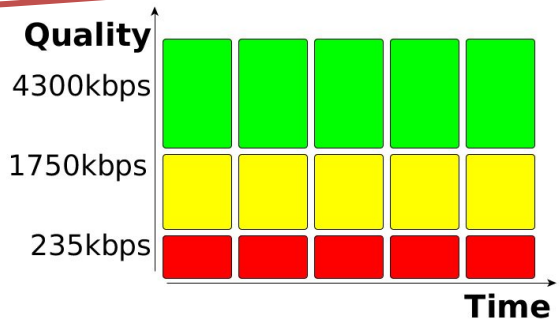
HTTP Adaptive Streaming Architecture

3. Client estimates available bandwidth

2. Server sends requested segment

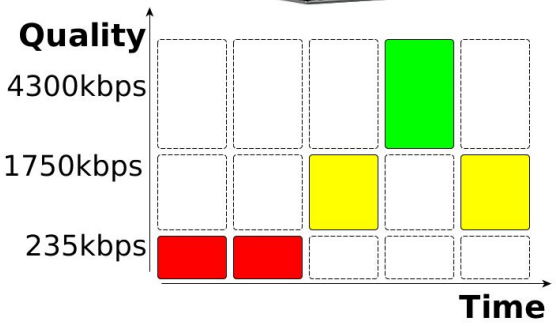


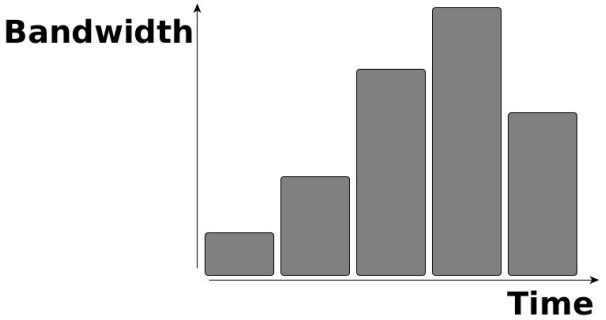


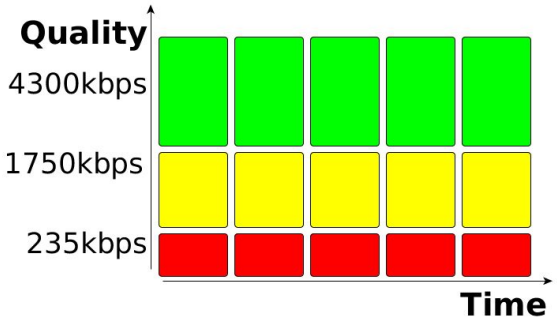


HTTP Adaptive Streaming Architecture

4. Based on the network and application state, the streaming client would adapt the requested quality over time







Motivation (1/2)

Use-case: several HAS clients share a bottleneck link

Examples:

- Home network
- Campus

- **Problems:**
  - frequent quality variations
  - re-buffering events
  - unfair share of network resources (bandwidth)

Motivation (2/2)

Example

Motivation (2/2)

Example

How does the network impact multiple HAS clients sharing a bottleneck link?

Our Experiments

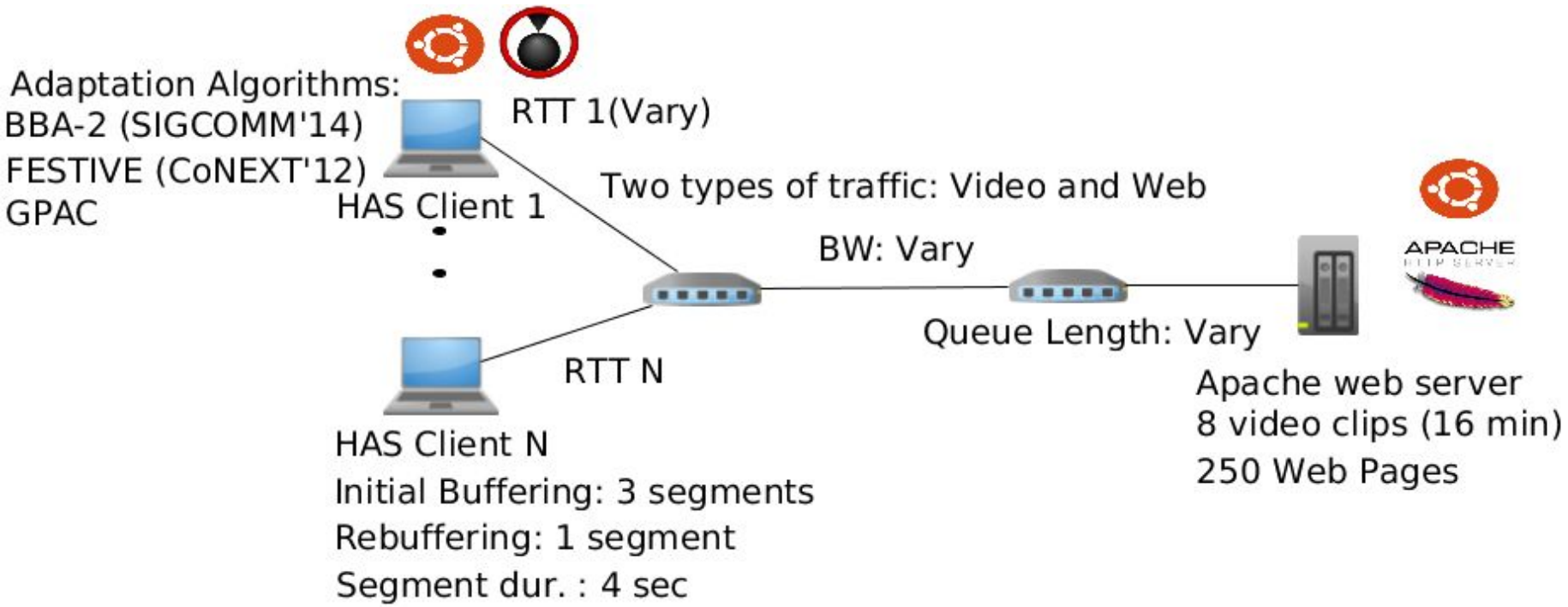
- Investigate the impact of network queue length on video performance
- Investigate the impact of RTT on video performance: homogeneous and heterogeneous case
- Investigate impact of number of clients and link capacity on video performance
- Investigate impact of mixed-traffic on video performance

Our Experiments

- **Investigate the impact of network queue length on video performance**
- **Investigate the impact of RTT on video performance:** homogeneous and **heterogeneous case**
- Investigate impact of number of clients and link capacity on video performance
- **Investigate impact of mixed-traffic on video performance**

Experiment Setup (1/2)

- Experiments were emulated using Mininet network emulator



Experiment Setup (2/2)

- Eight clips are from a publicly available HAS dataset: *https://www.ucc.ie/en/misl/research/current/ivid_dataset/*
- Representation rates: **235**, **380**, **568**, **760**, **1065**, **1777**, **2387**, **3046**, **3906**, **4361** Kbps (Netflix)
- Bottleneck Queue Lengths: expressed in BDP (bandwidth-delay product)
- Rule of thumb: **1xBDP** - reference point

Performance metrics

- **HTTP Adaptive Streaming (HAS) metrics:**
  - Bandwidth utilisation
  - Average quality representation rate
  - Unfairness
  - Instability
  - Stall performance
- **Web metrics:**
  - Page loading time
  - Fraction of abandoned pages

Performance metrics

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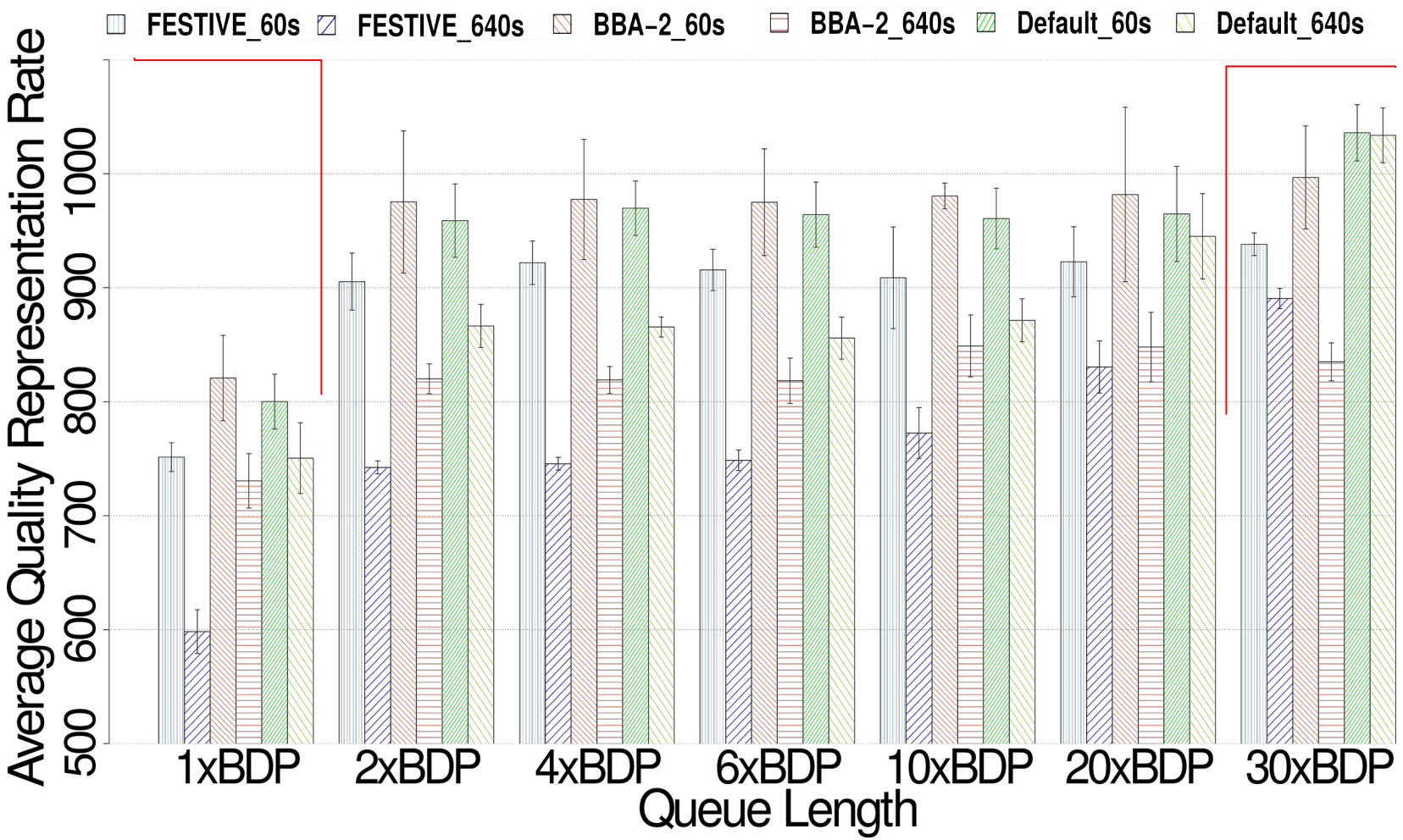
Impact of Queue Lengths on Video Performance (1/2)

Setup

- Six clients sharing a **6Mbps** link with **40ms** RTT
- Each scenario repeated **5** times
- Queue lengths: **1xBDP**, **2xBDP**, **4xBDP**, **6xBDP**, **10xBDP**, **20xBDP**, **30xBDP**
- Two client buffer size: **60** and **640** seconds

Impact of Queue Lengths on Video Performance (2/2)



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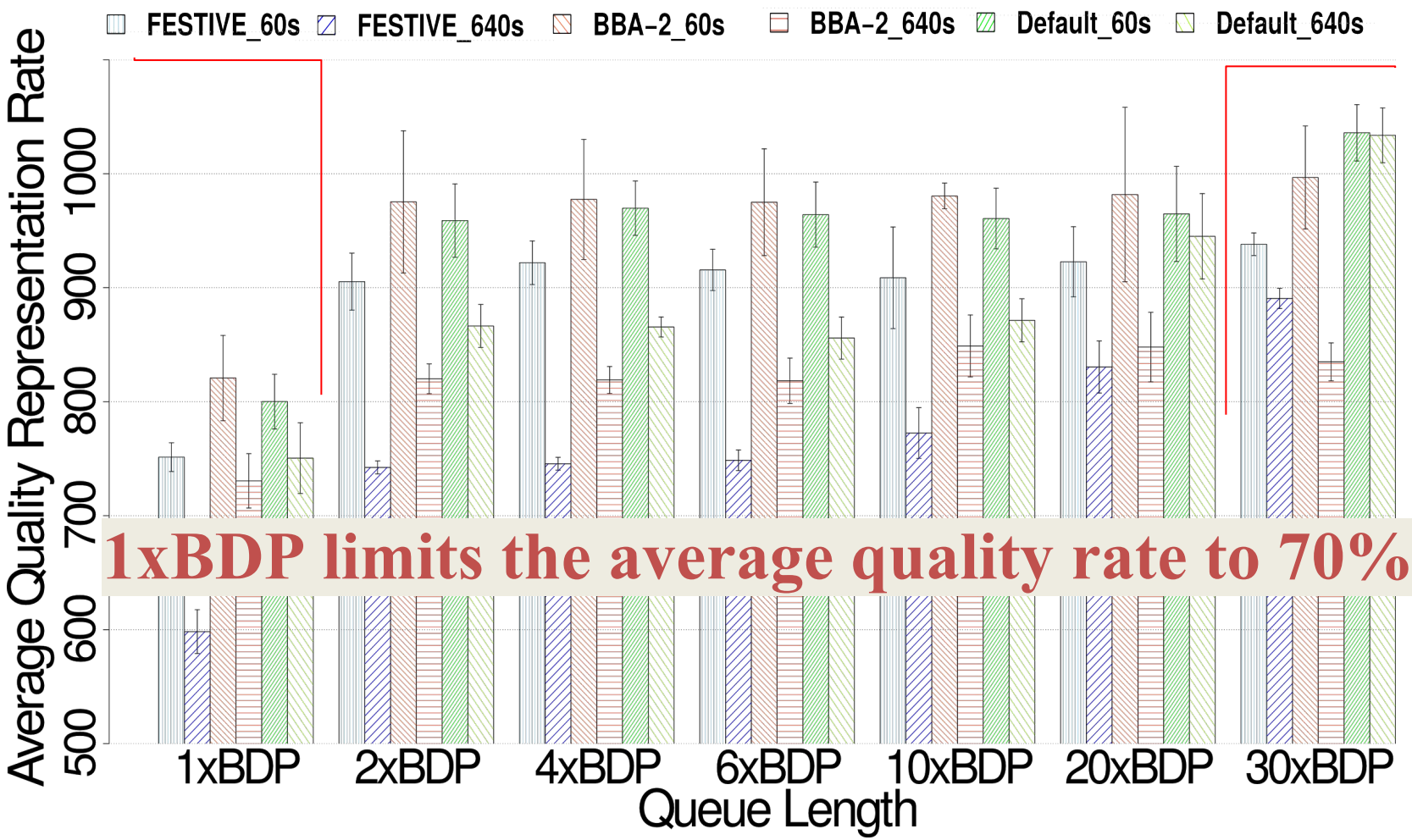
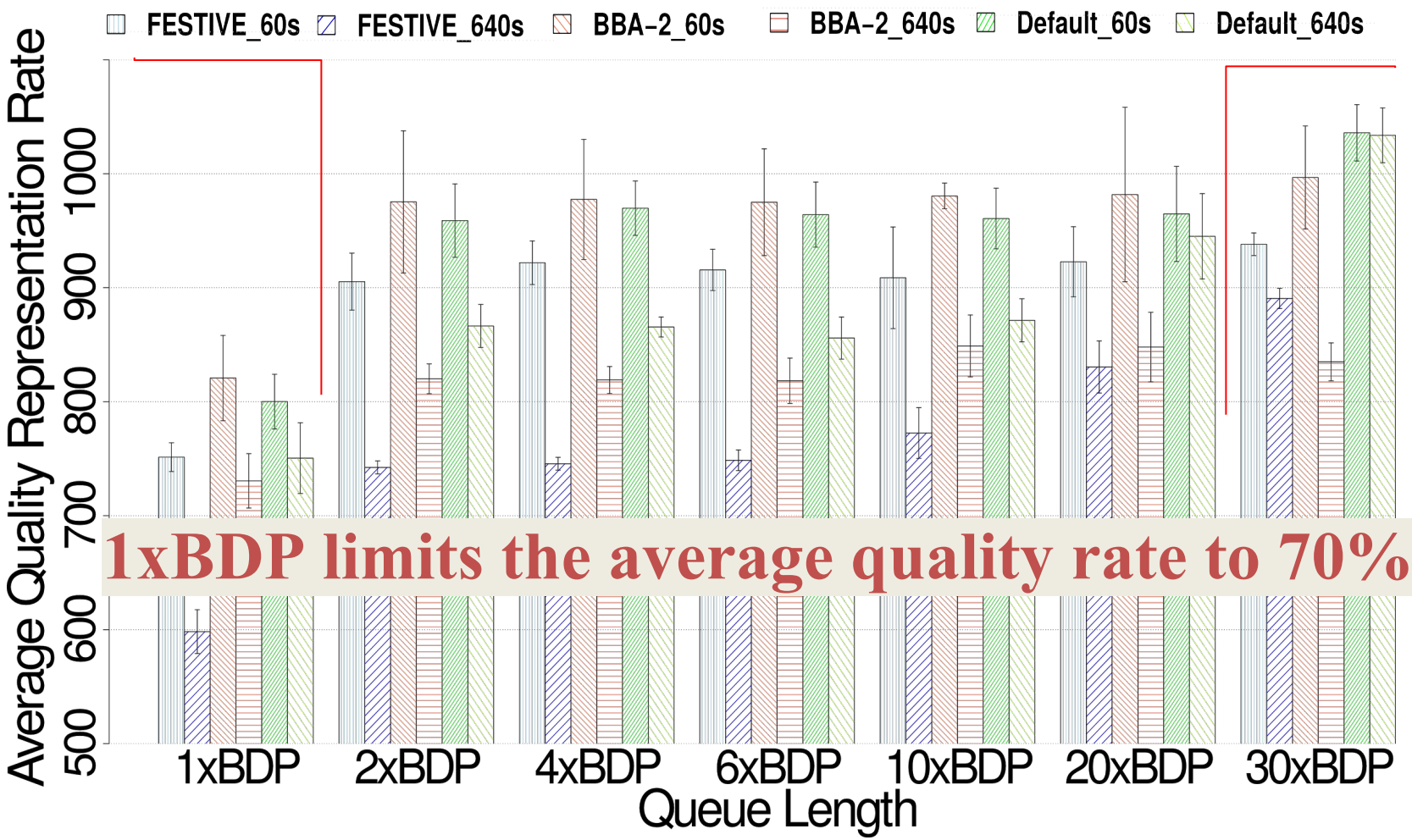


1xBDP limits the average quality rate to 70%

Impact of Queue Lengths on Video Performance (2/2)



1xBDP limits the average quality rate to 70%

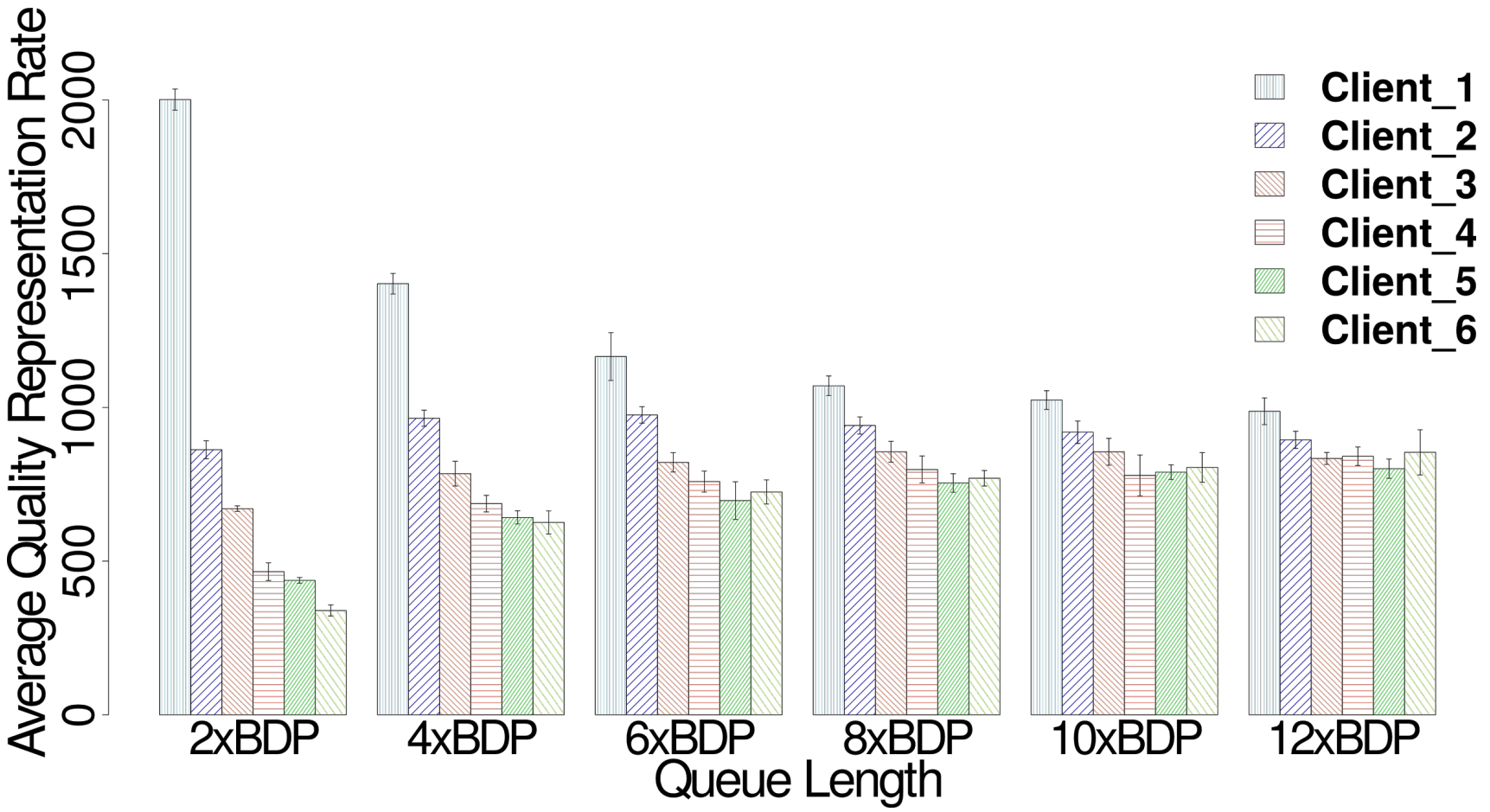
Recommended size: 2xBDP

Impact of Heterogeneous RTT on Video Performance (1/2)

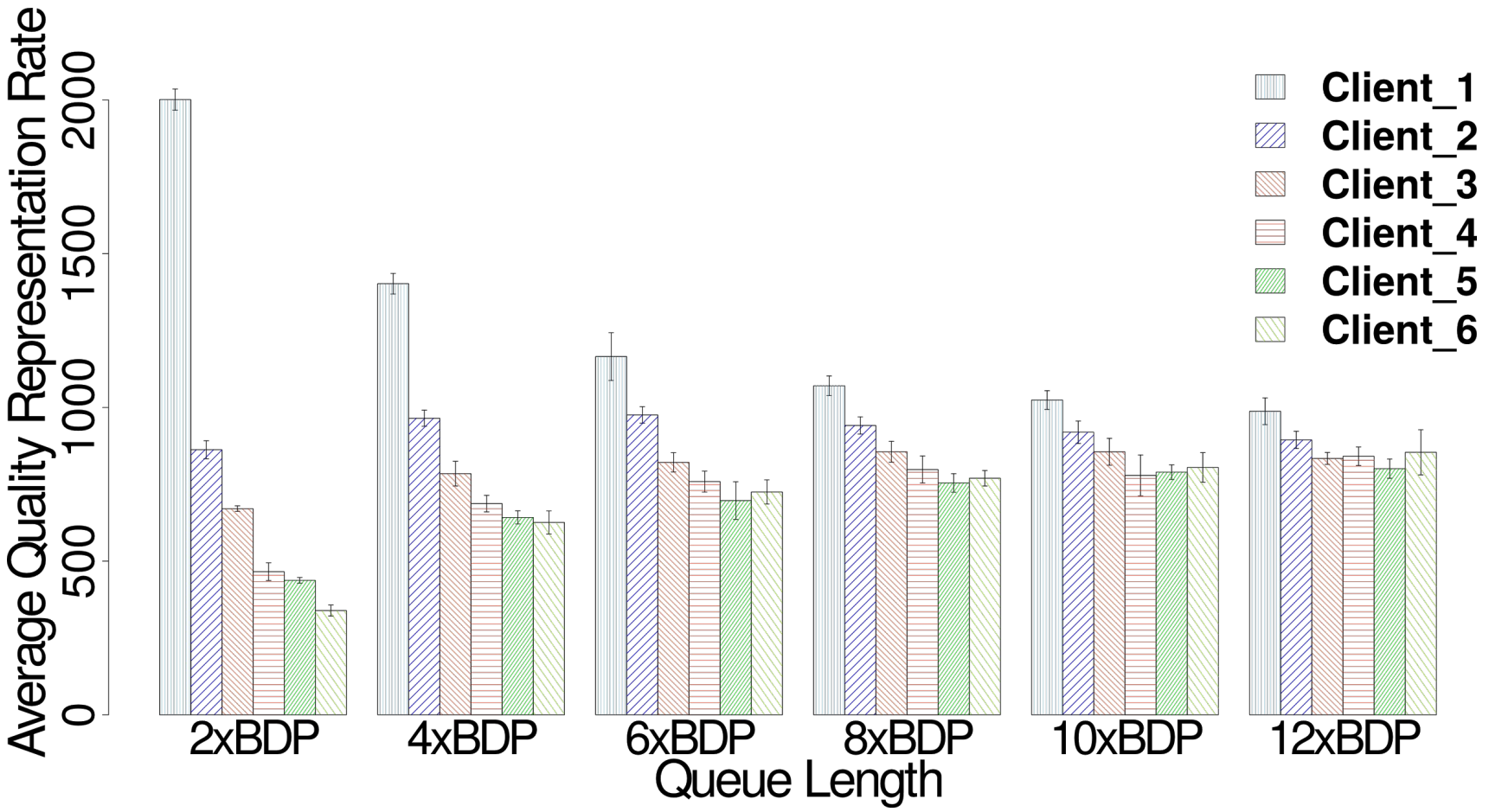
Setup

- Six clients competing for resources
- Each client has a different RTT:
  - First client has **20ms**
  - Second **40ms**
  - …
  - Sixth has **120ms**

Impact of Heterogeneous RTT on Video Performance (2/2)



Impact of Heterogeneous RTT on Video Performance (2/2)



Larger Queue improves system fairness

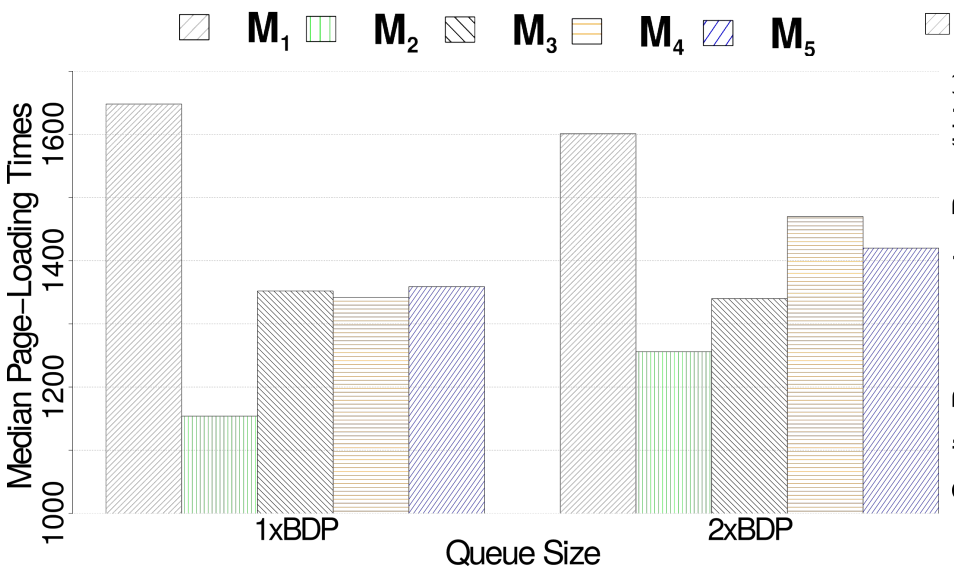
Mixed Traffic Experiments (1/2)

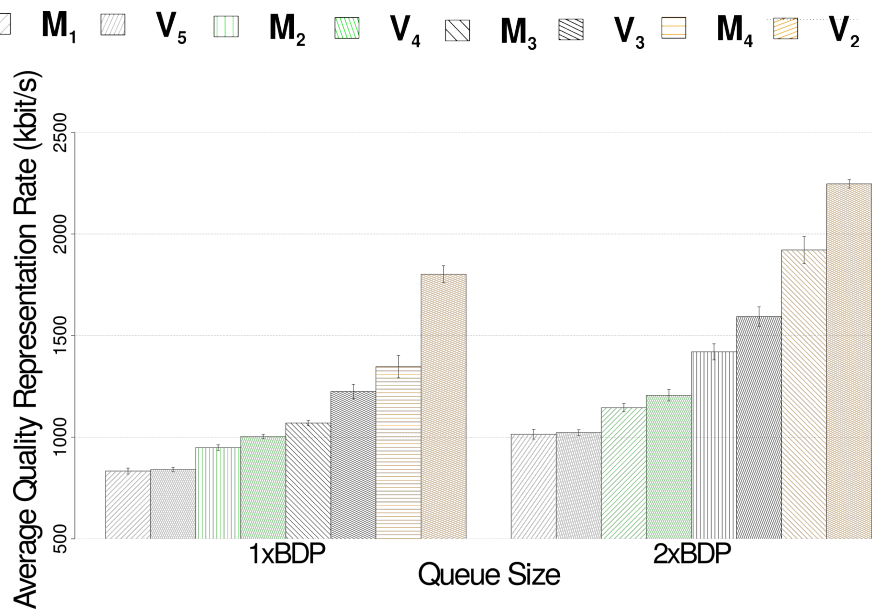
Setup

- *n* web clients with *6-n* video clients sharing a link ($n \in 1...6$)
- Web clients emulated with Firefox and Selenium
- 250 most visited web pages collected from 10 different categories:
  - Science, Travel, Recreation, Computers, Entertainment, Finance, Relationships, Education, Society and Vehicles

Mixed Traffic Experiments (2/2)

Notation: M_n - *n* web users, 6-n video users, V_m - *m* video users (no web clients)





Web traffic metric

Video traffic metric

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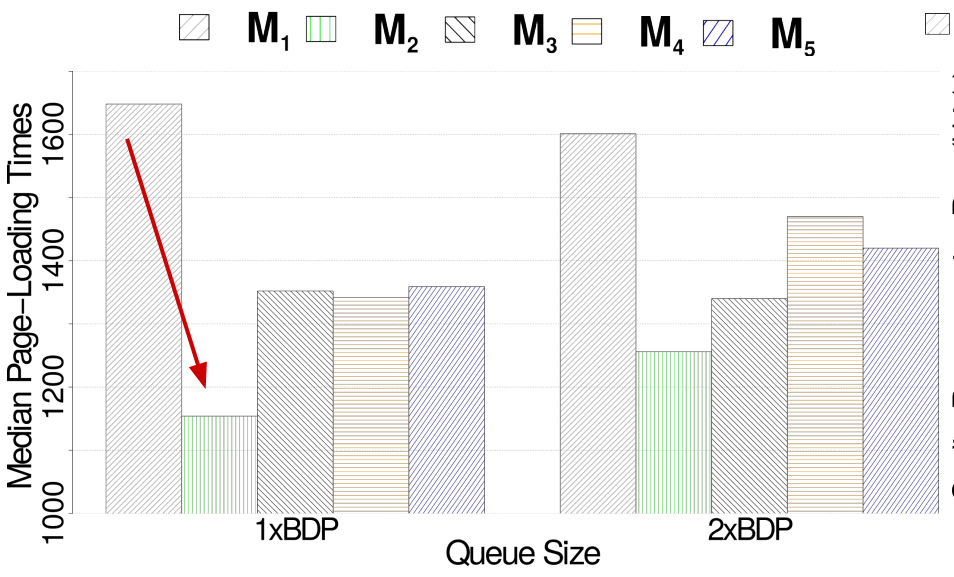

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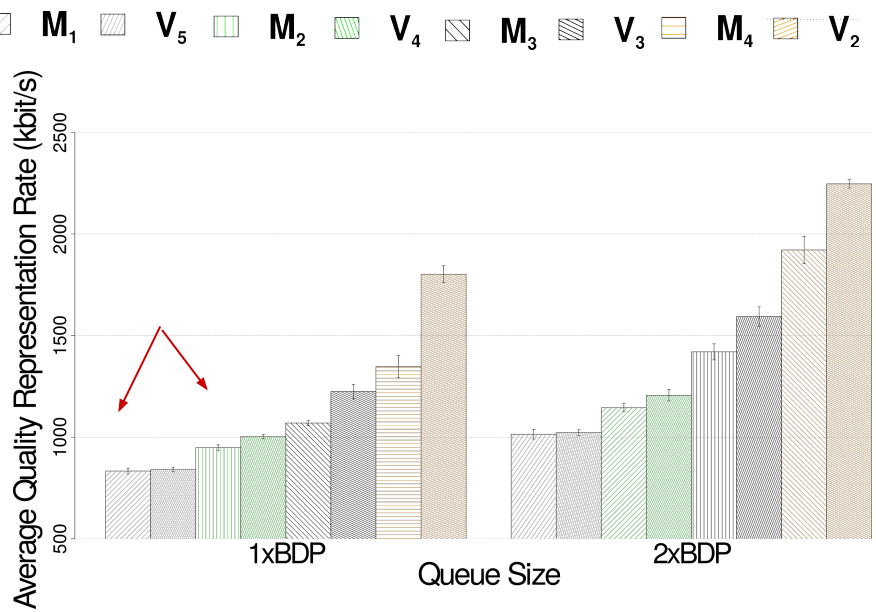

Video traffic metric

Conclusion

- Recommended “rule of thumb” for network queue length causes underutilisation of network resources
  - **Our recommendation**: 2xBDP
- In system with heterogeneous RTTs, large network queue improves overall fairness
- In mixed traffic scenario performance metrics are scenario dependent and vary depending on bitrate distribution, video adaptation algorithm and offered web traffic load

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