Characterizing QoE in Large-Scale Live Streaming

Thiago Guarnieri[1], **Ítalo Cunha**[1], Jussara Almeida[1]
Idilio Drago[3], Alex B. Vieira[2]

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Victory in live video streaming: Trump inauguration drew record online audiences

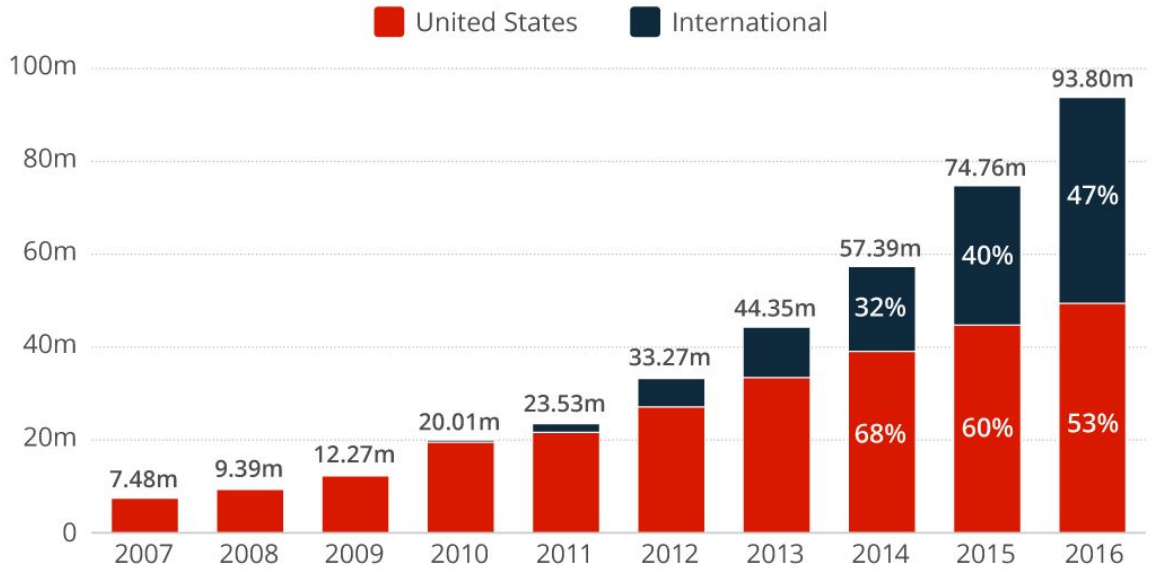
Obama Inauguration Sets Standard For Live Video Streaming

Eric Papczun on January 29, 2009 at 4:07 pm

Tech Chart of the Day

Netflix Continues to Build Its Global Audience

Number of Netflix subscribers at the end of the respective period*



* U.S. subscriber figures from 2007 through 2010 include DVD subscribers

BUSINESS INSIDER

Source: Netflix

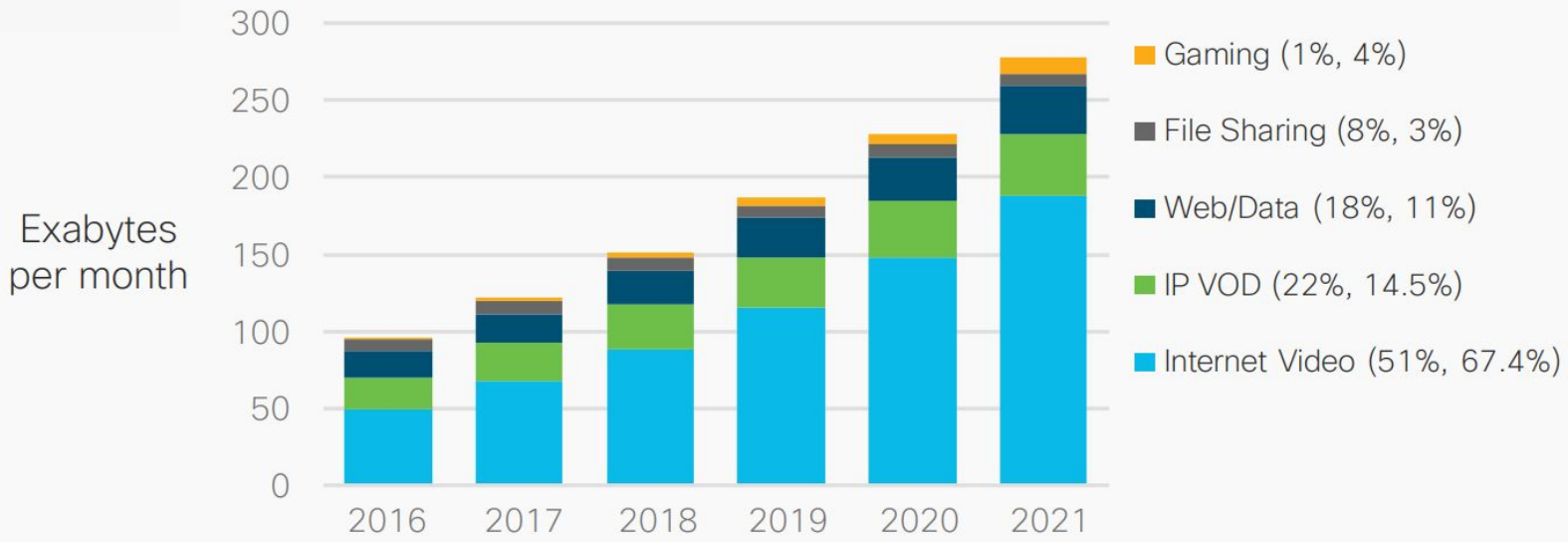
statista

Twitch Viewers More Than Double to 45 Million in 2013

The game streaming service grew immensely last year.

News by Mike Williams, 01/16/2014.

Cisco traffic volume estimates



Figures (n) refer to 2016, 2021 traffic shares.

Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.


SSIMplus TV Expert;SSIMplus Sony 55 in. T
PSNR-YUV
PSNR-Y
Frame 1123
SSIMplus Index
SSIMplus Core
SSIMplus TV Expert
SSIMplus Sony 55 in. TV
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00:00:41.166
00:00:42.541
00:00:43.916
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00:00:46.750
SSIMplus Core;SSIMplus Sony 55 in. TV;SSI
SSIMplus Core
SSIMplus Sony 55 in. TV
SSIMplus TV Expert
SSIMplus iPhone 5S
SSIMplus Lenovo W530
67
54
40
71
49
Bad
Poor
Fair
Good
Excellent
SSIMplus Index

Characterize live streaming QoE from readily-available performance data

Outline

- The dataset we use
- The streaming system under consideration
- Performance metrics
- Correlation of performance and QoE
- Findings

Dataset: FIFA 2014 World Soccer Cup

- Live online streaming of FIFA's 2014 World Soccer Cup
- HTTP logs for each video segment request
  - Timestamp
  - Client IP address
  - URL (channel ID, bitrate)
  - User agent
- All 64 matches
- Majority of Brazil's online audience of the World Cup

Dataset: FIFA 2014 World Soccer Cup

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  - Us
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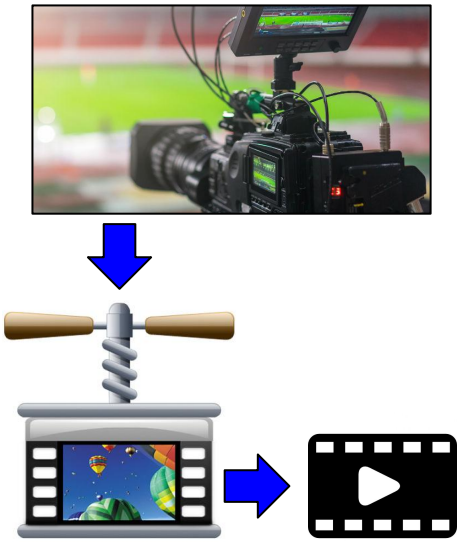
HTTP live streaming infrastructure

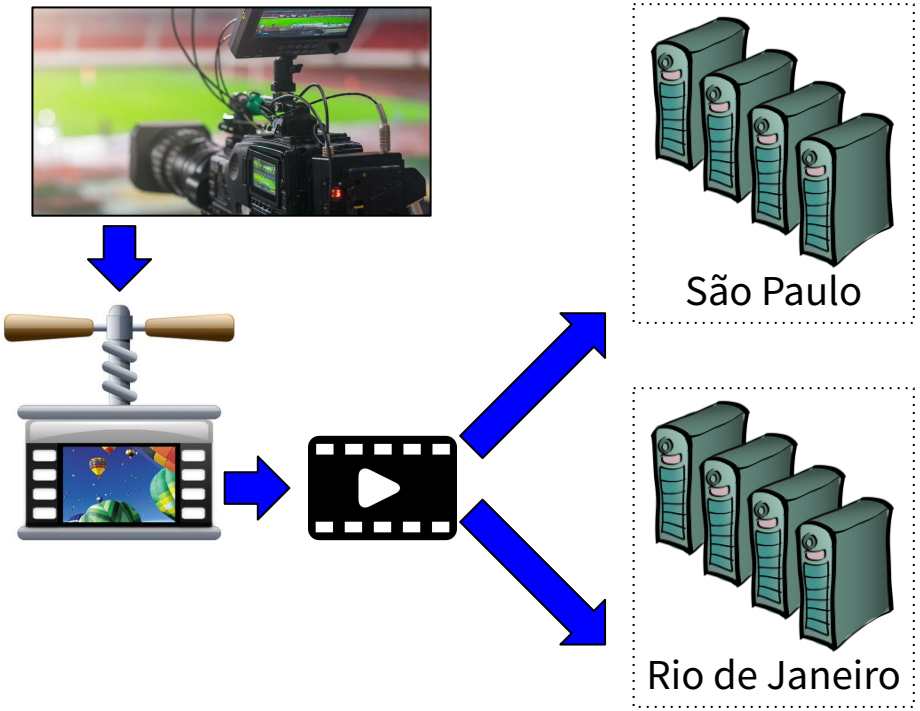
Video Capture and Encoding

HTTP live streaming infrastructure



Video Capture and Encoding

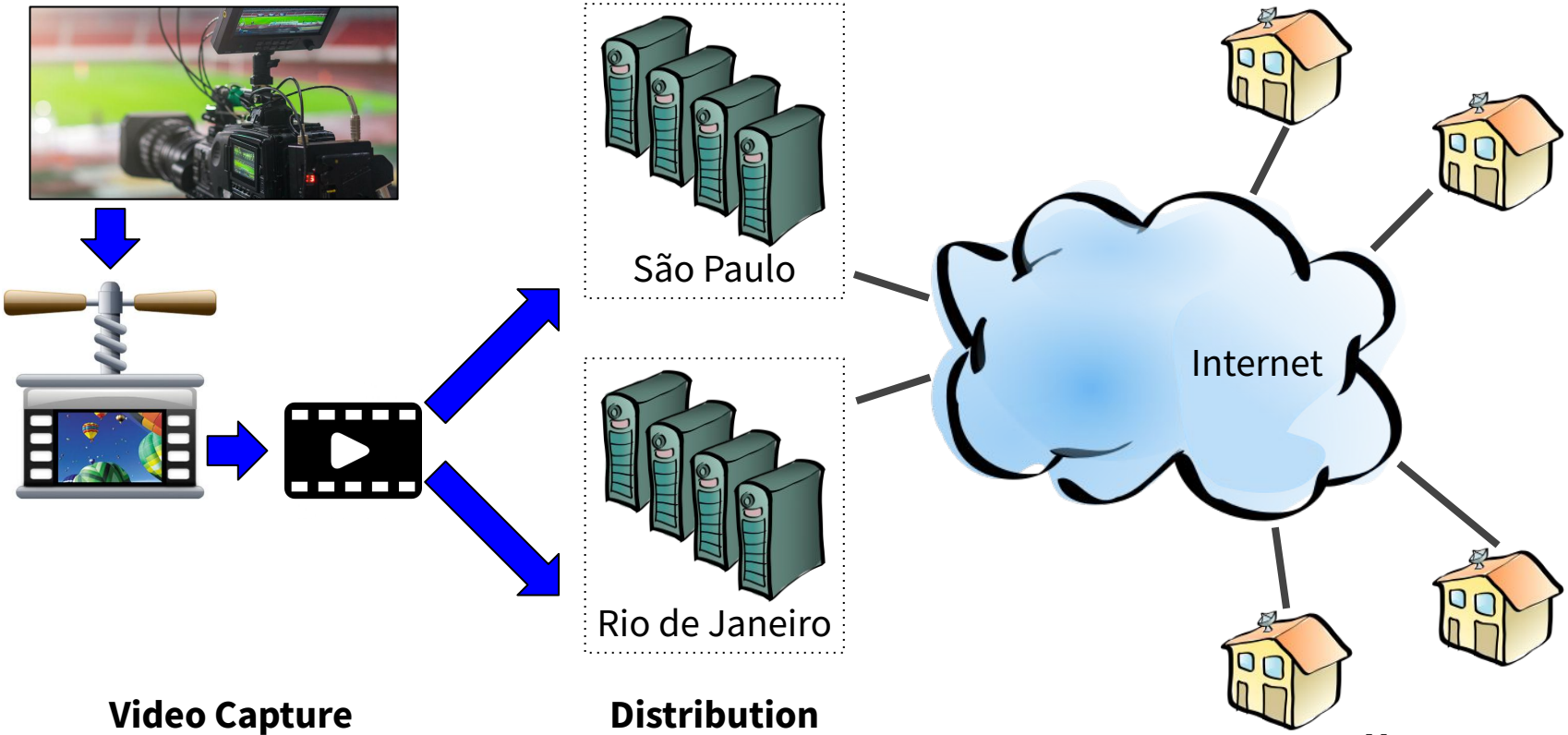
HTTP live streaming infrastructure



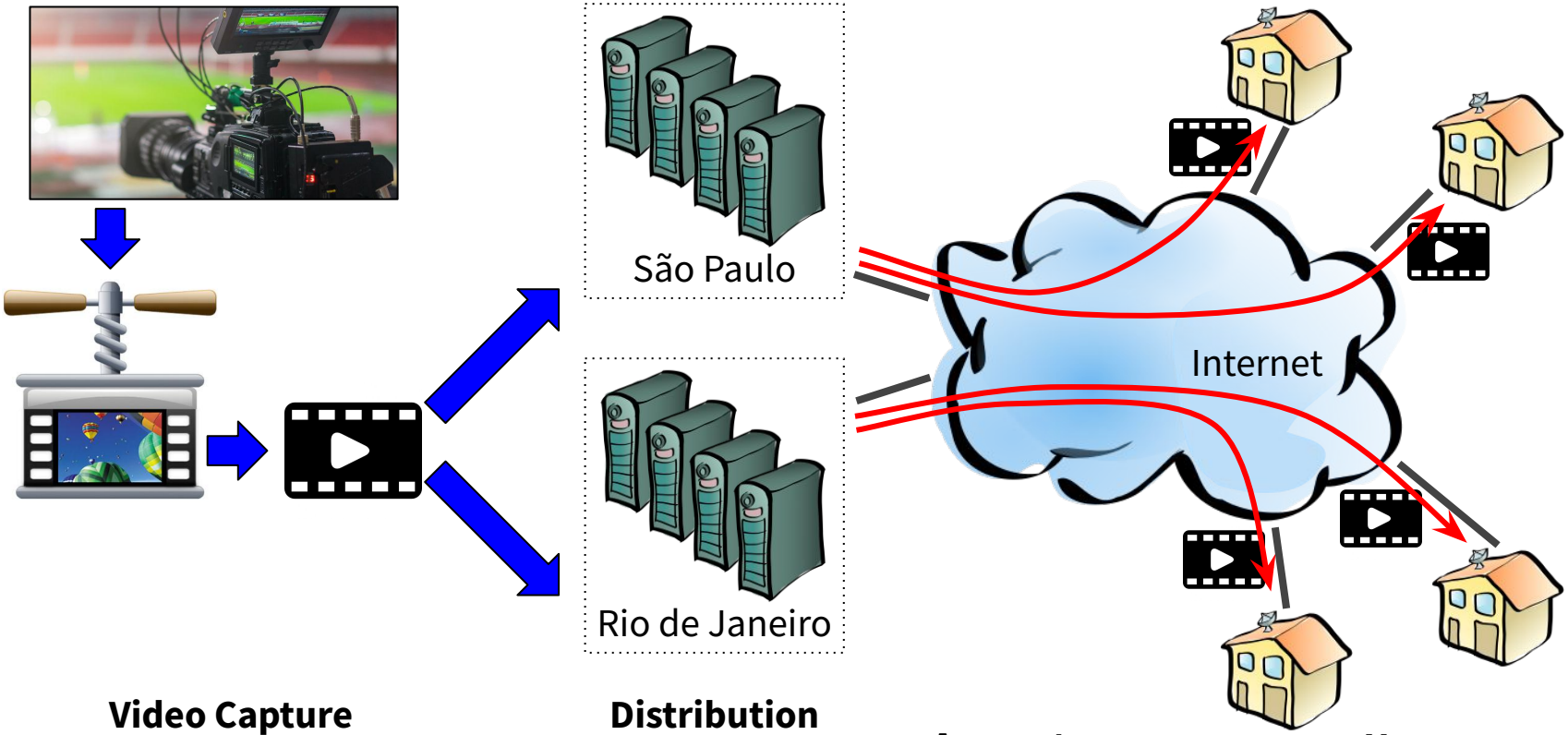
Video Capture and Encoding

Distribution Centers

HTTP live streaming infrastructure



HTTP live streaming infrastructure



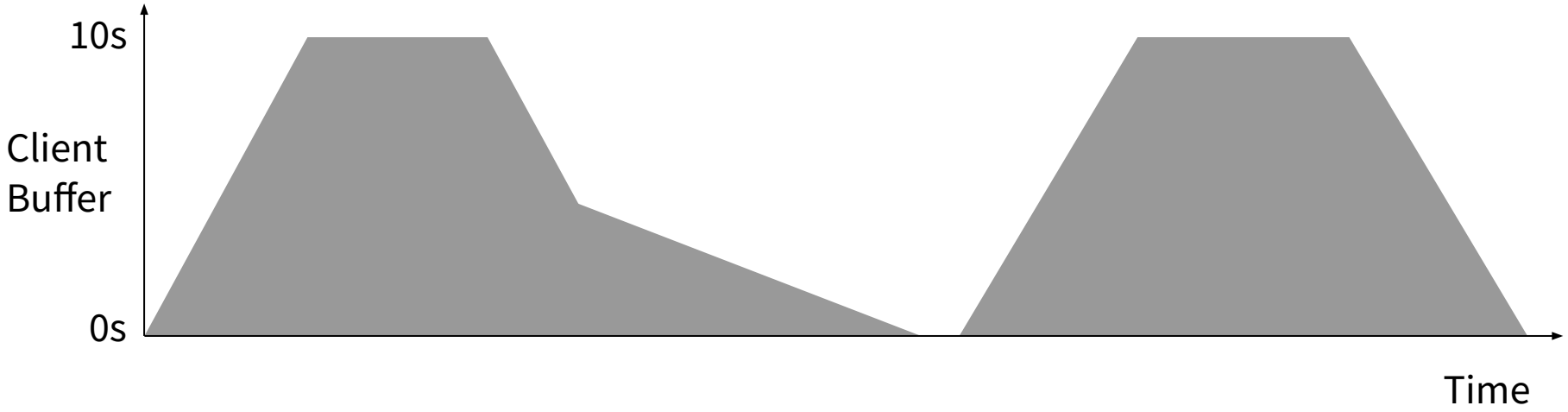
Infrastructure and client configuration

- Different bitrates between 264–2564 kbps
  - From 240p to 1080p
  - Automatic bitrate adaptation
- Clients buffer 10s before starting playback
- 3-second video segments
  - Requests grouped into sessions

Dataset overview

- Up to 1.1 million unique clients in a day
- Up to 470 thousand simultaneous sessions in a match
- 81% of sessions started from PCs, 18% mobile

Performance metrics



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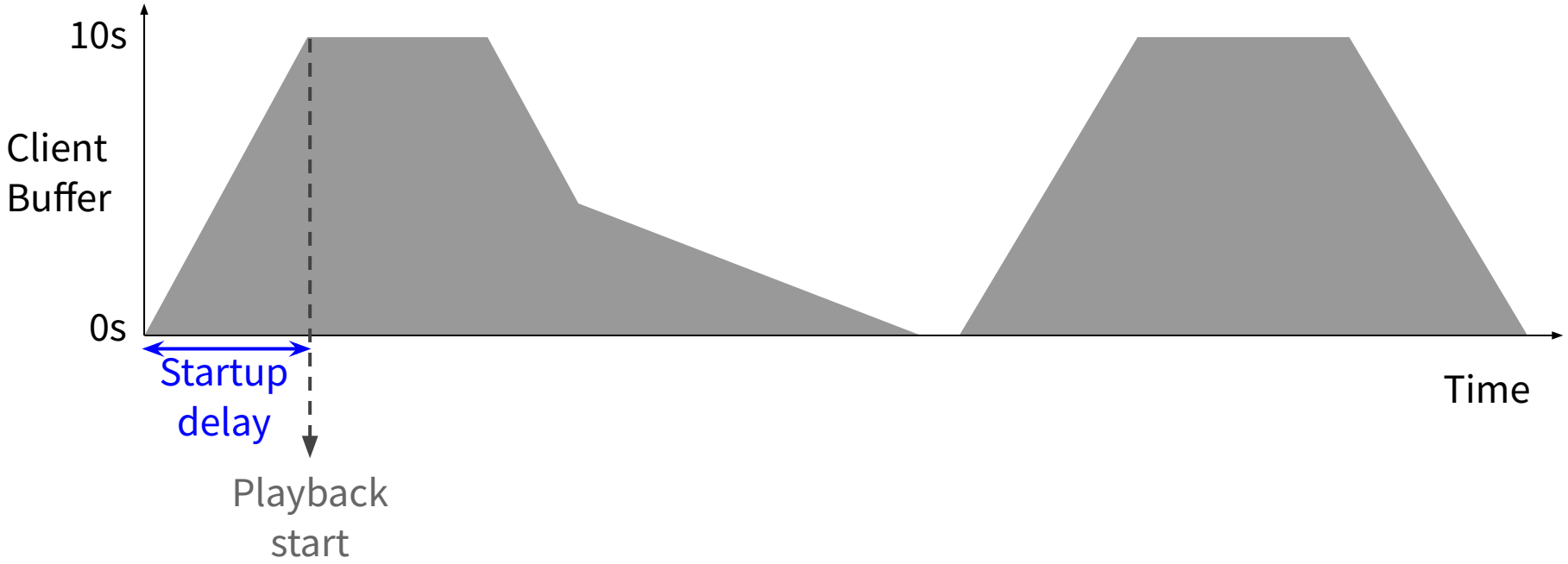

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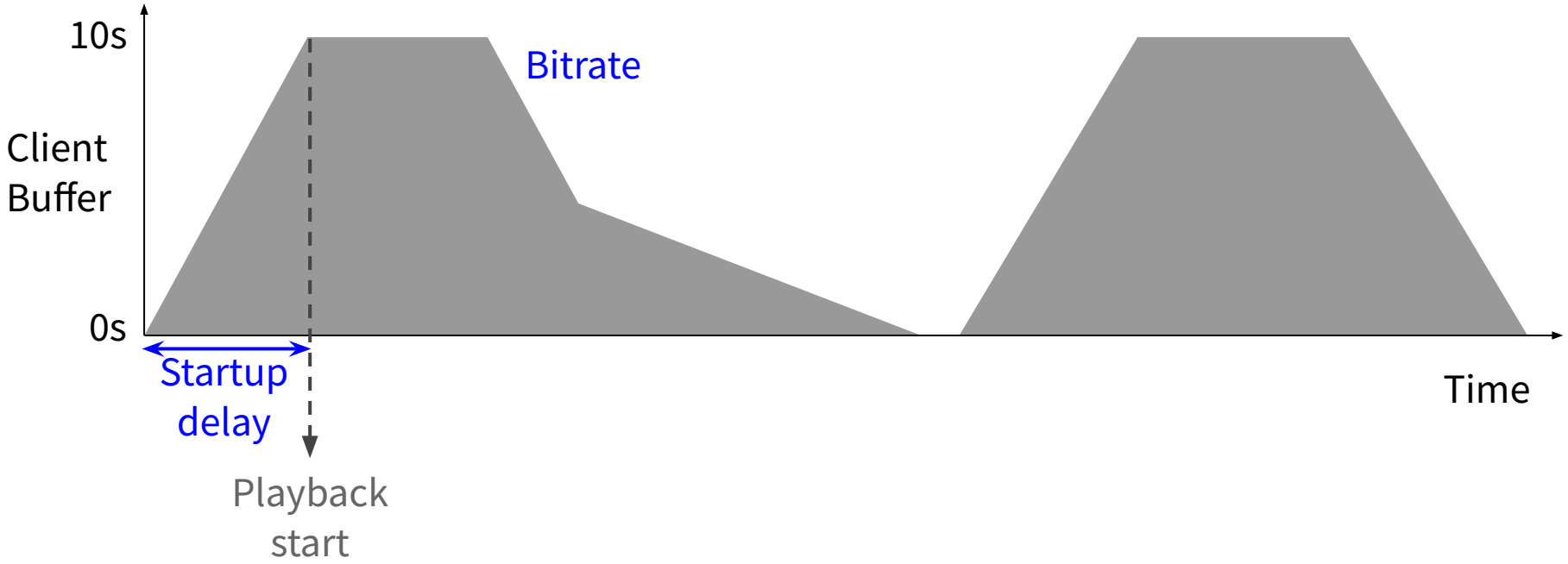

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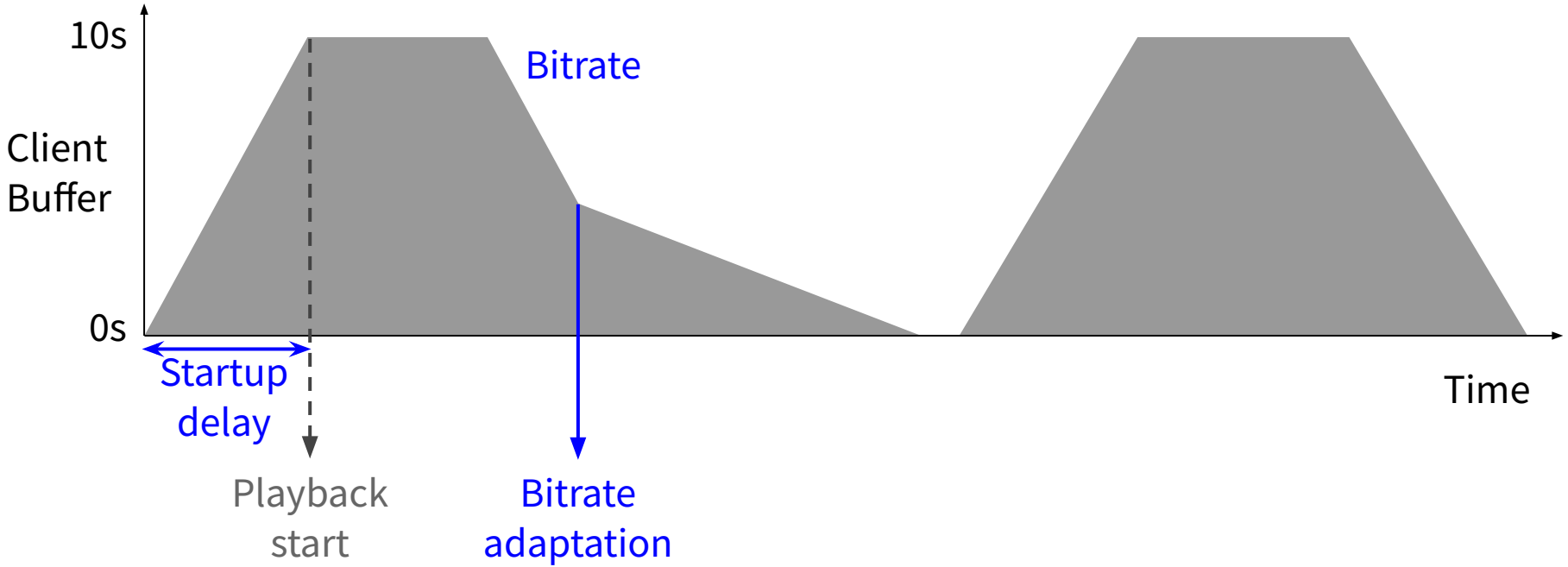

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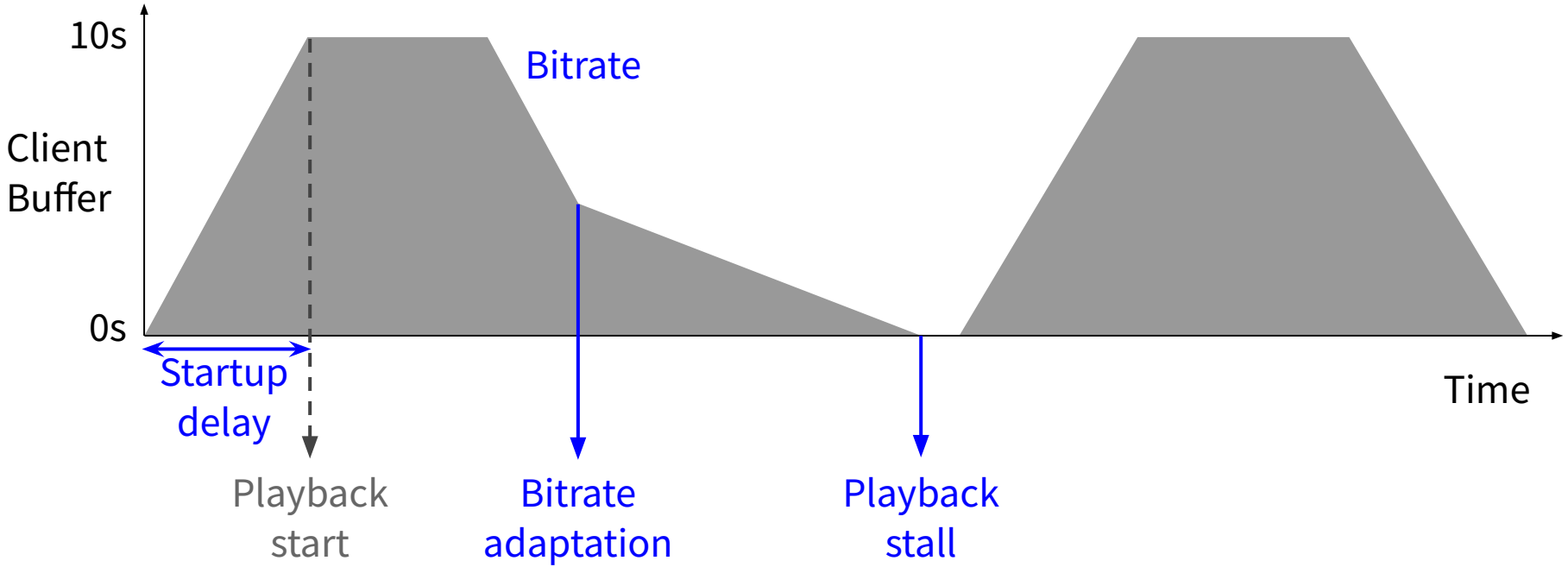
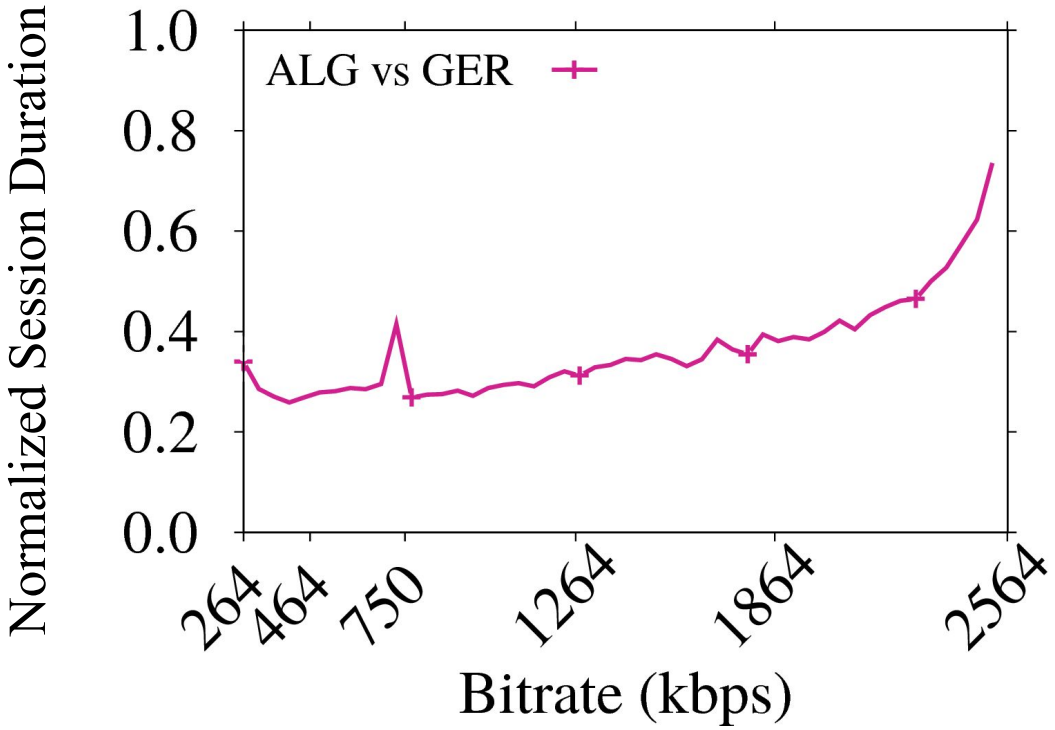


Session duration as proxy for QoE

- QoE is subjective
- Depends on user context

- Unsatisfied users leave the system

Streaming bitrate



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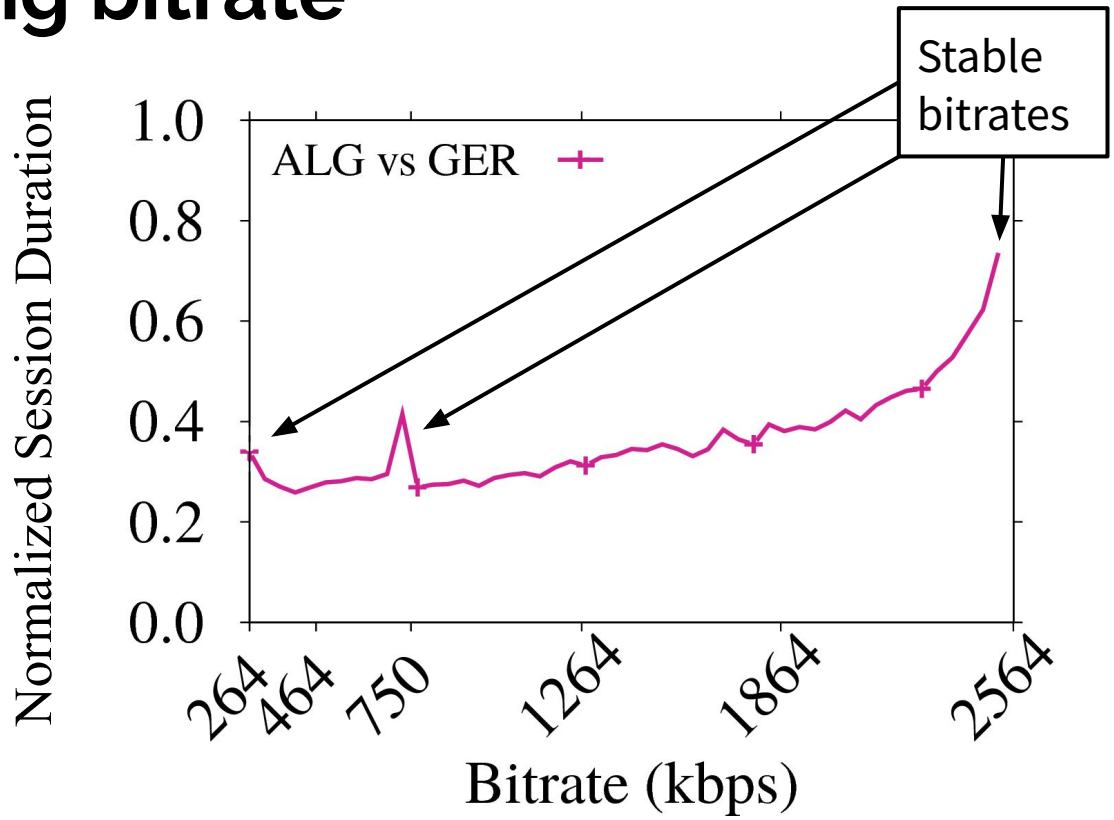
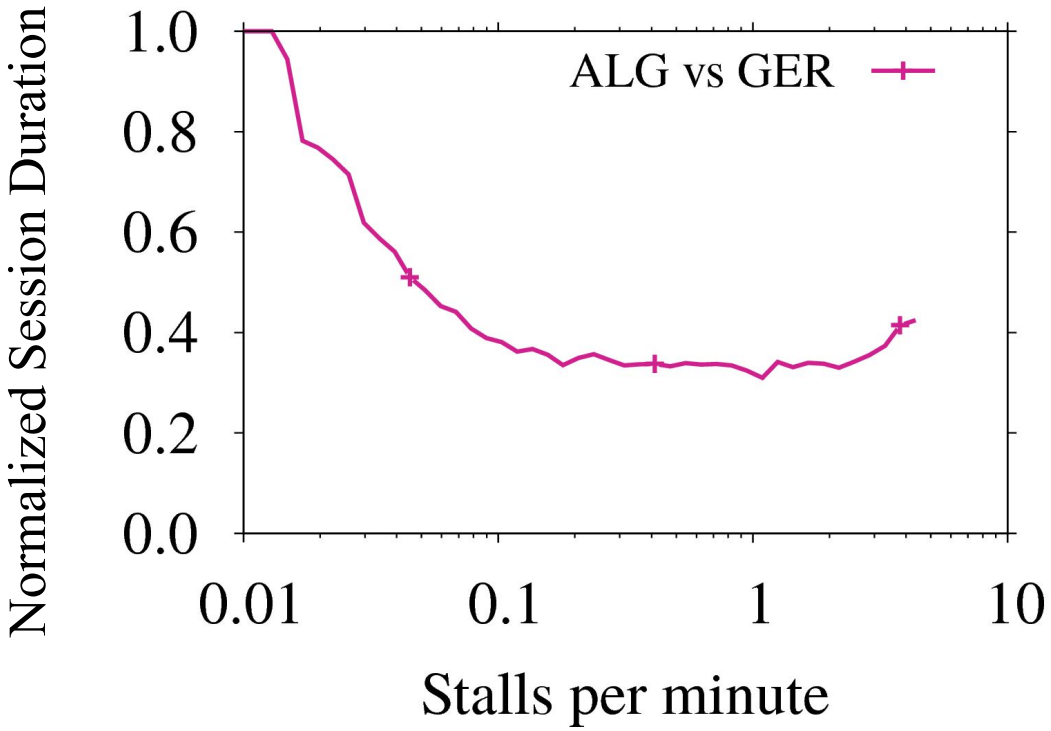
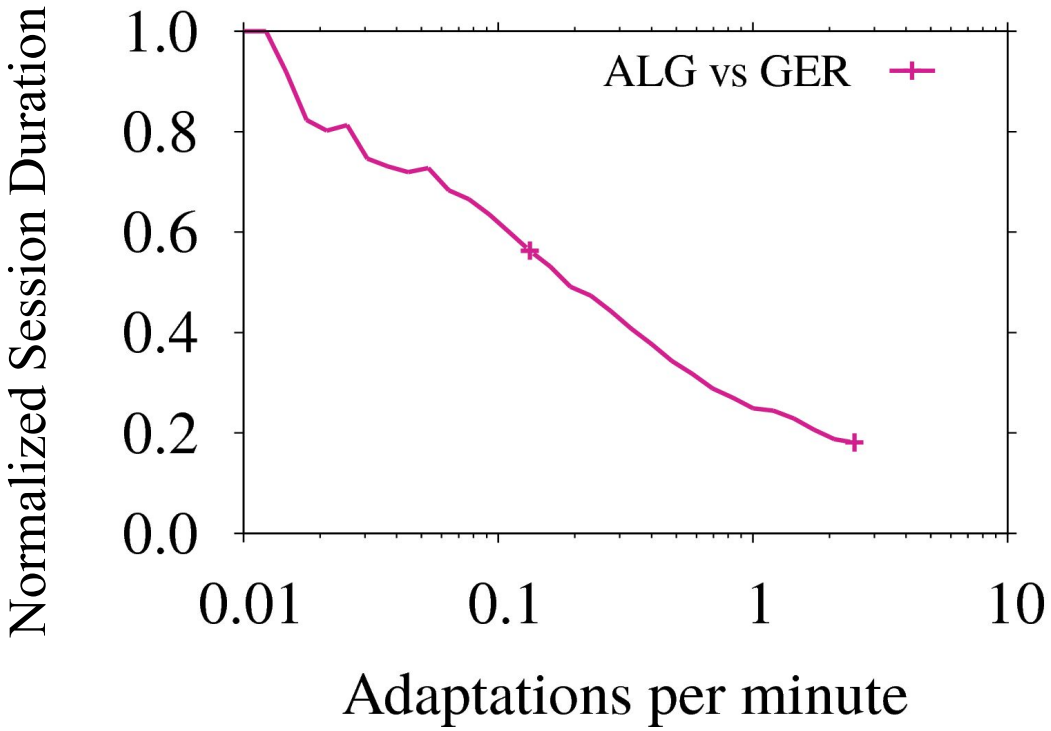


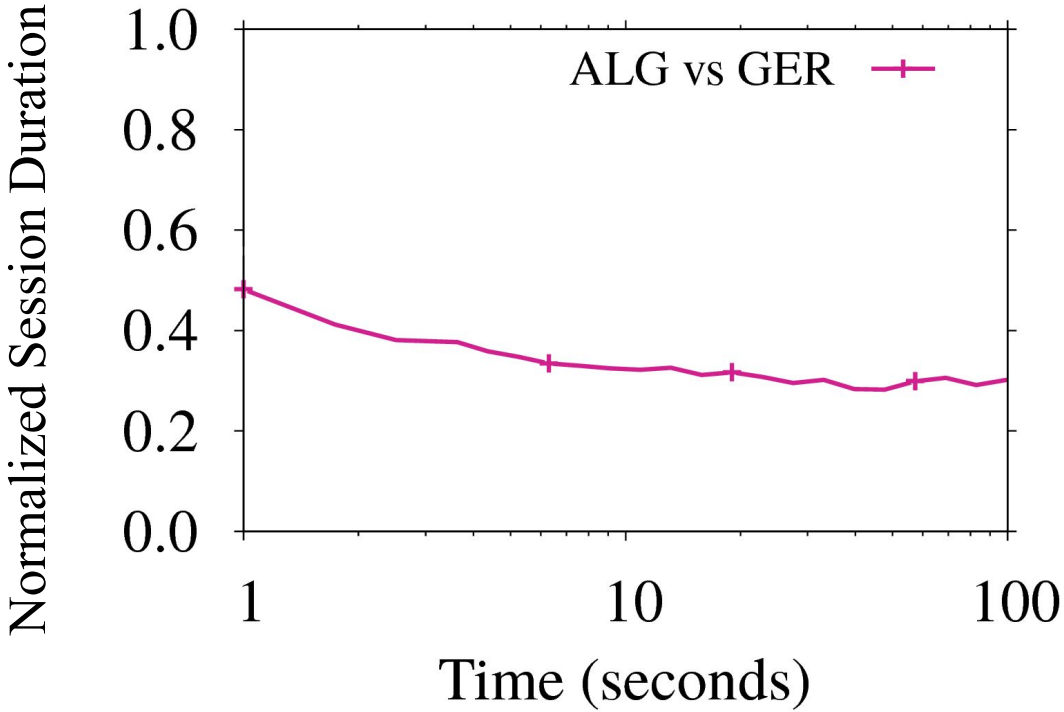
Rate of stalls



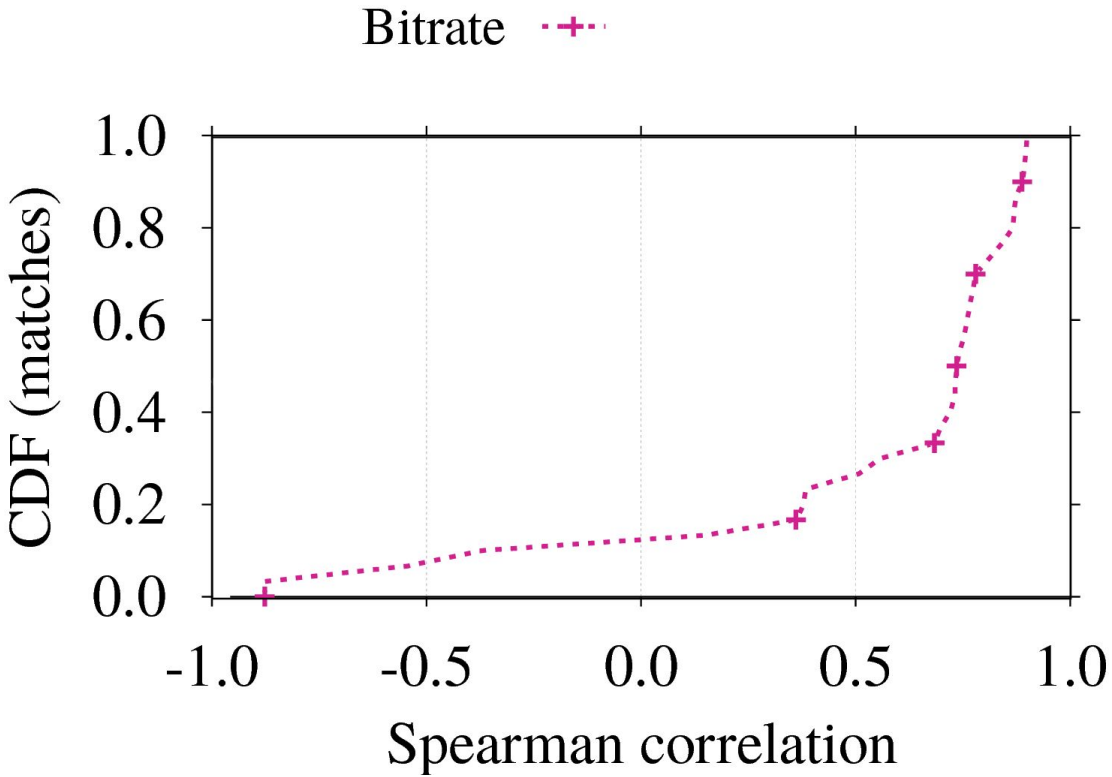
Rate of adaptations



Startup delay



Correlation between performance and QoE on PCs



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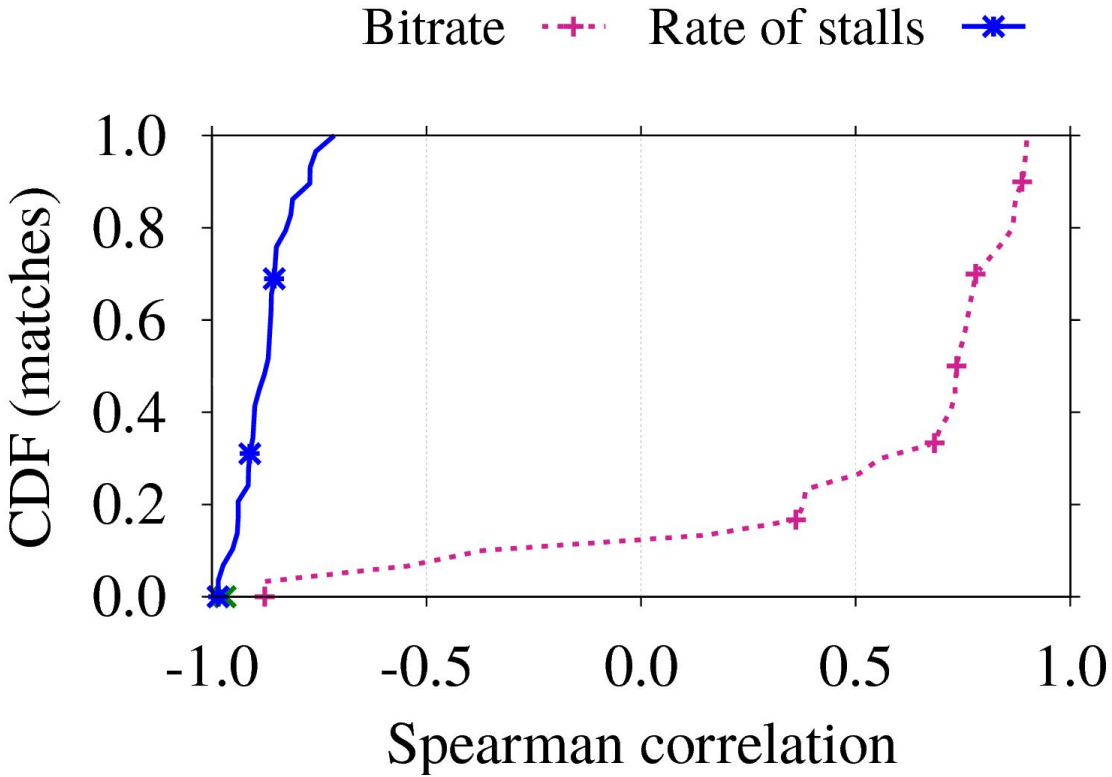

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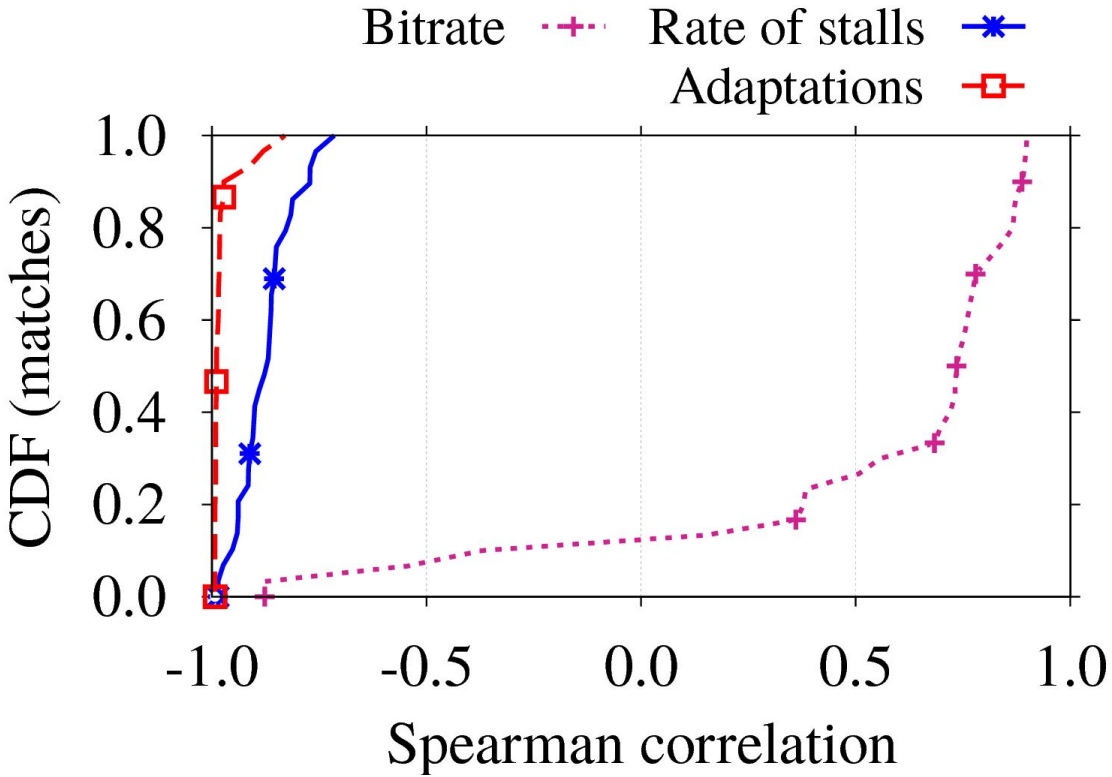

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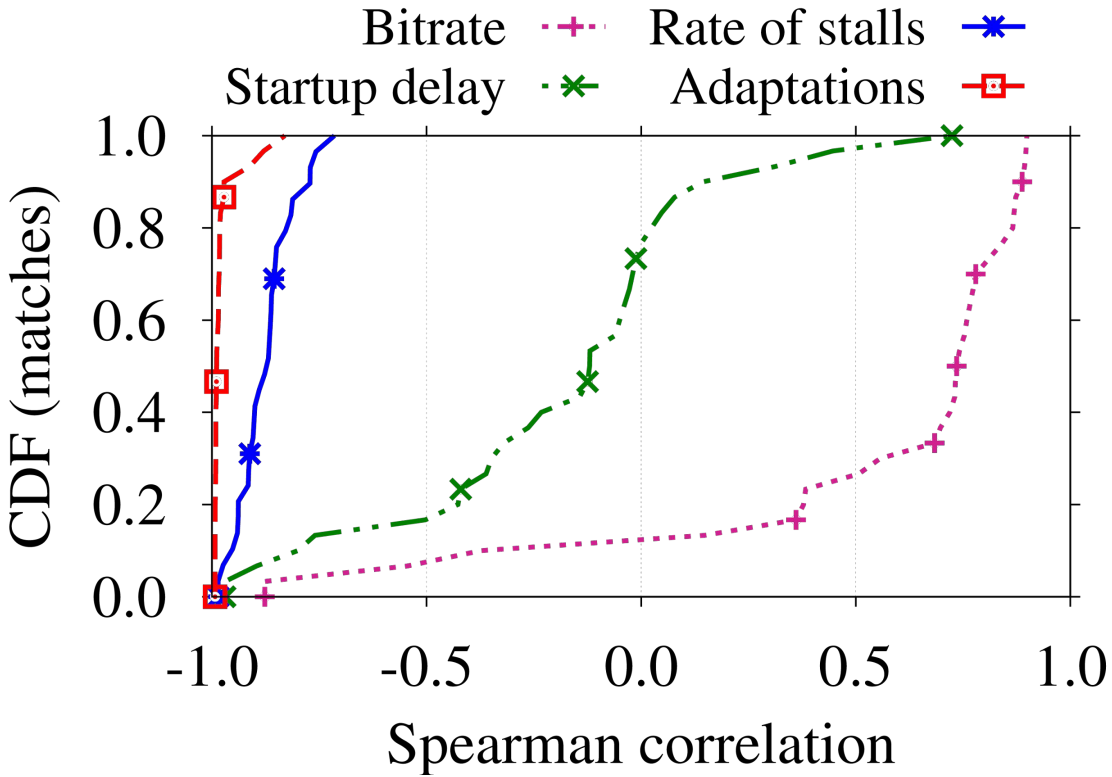
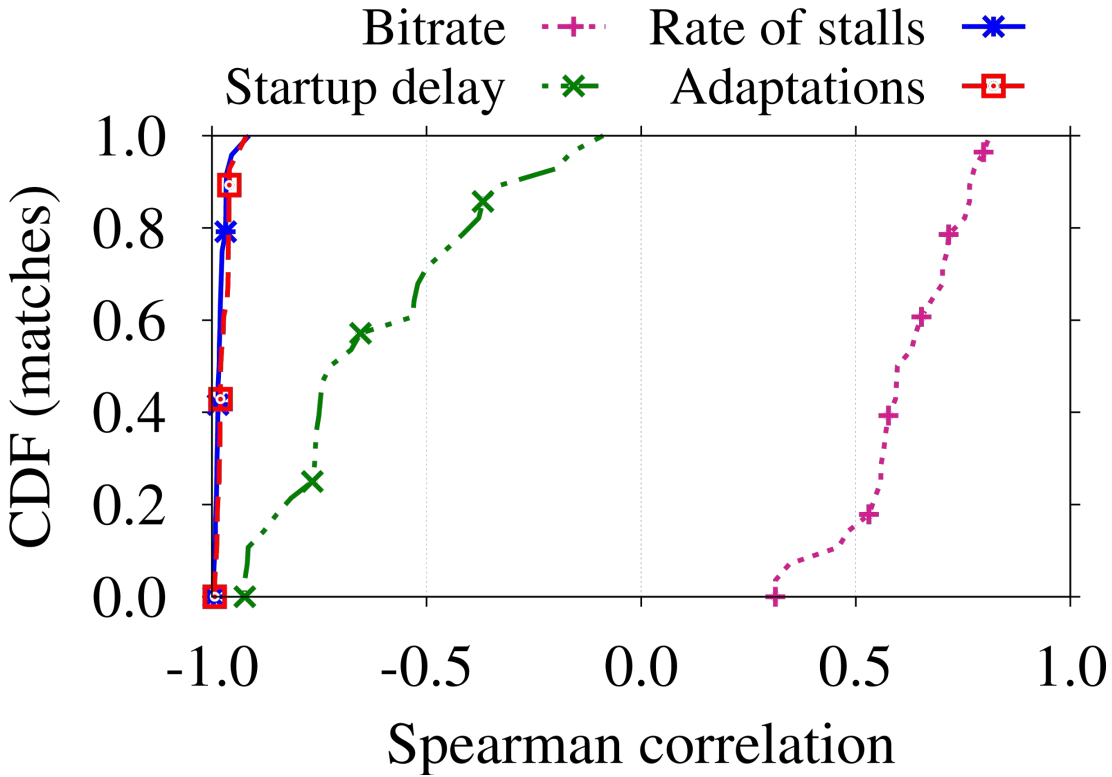


Correlation between performance and QoE on mobile



Conclusions

- How to infer QoE from widely available HTTP logs
  - Simulate state on the client
  - Use session duration as proxy for QoE
- Different performance metrics have different impact on QoE
  - Bitrate adaptations ≈ stalls > bitrate > startup delay

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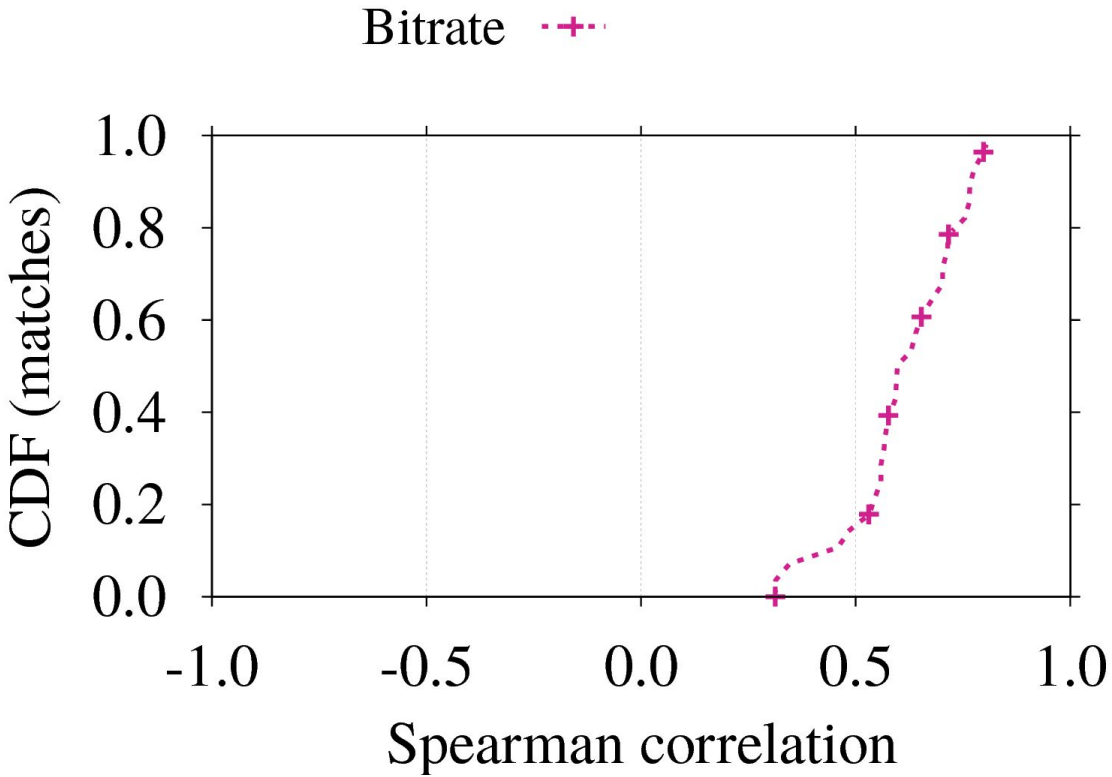

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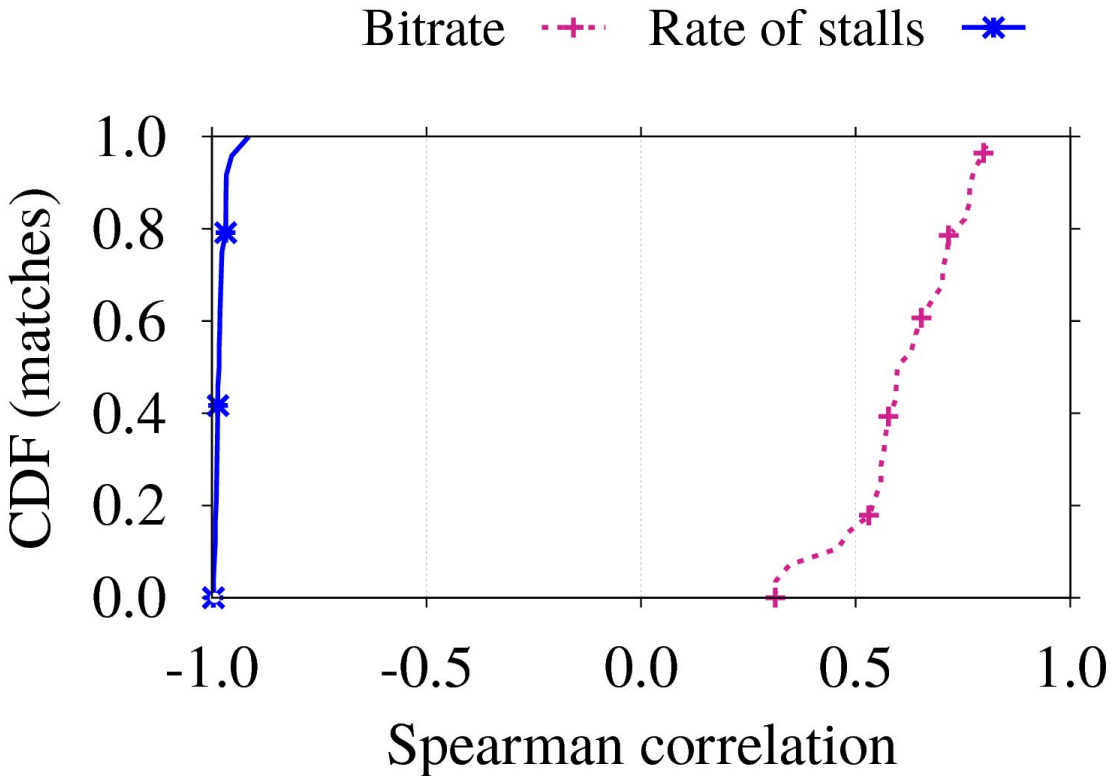

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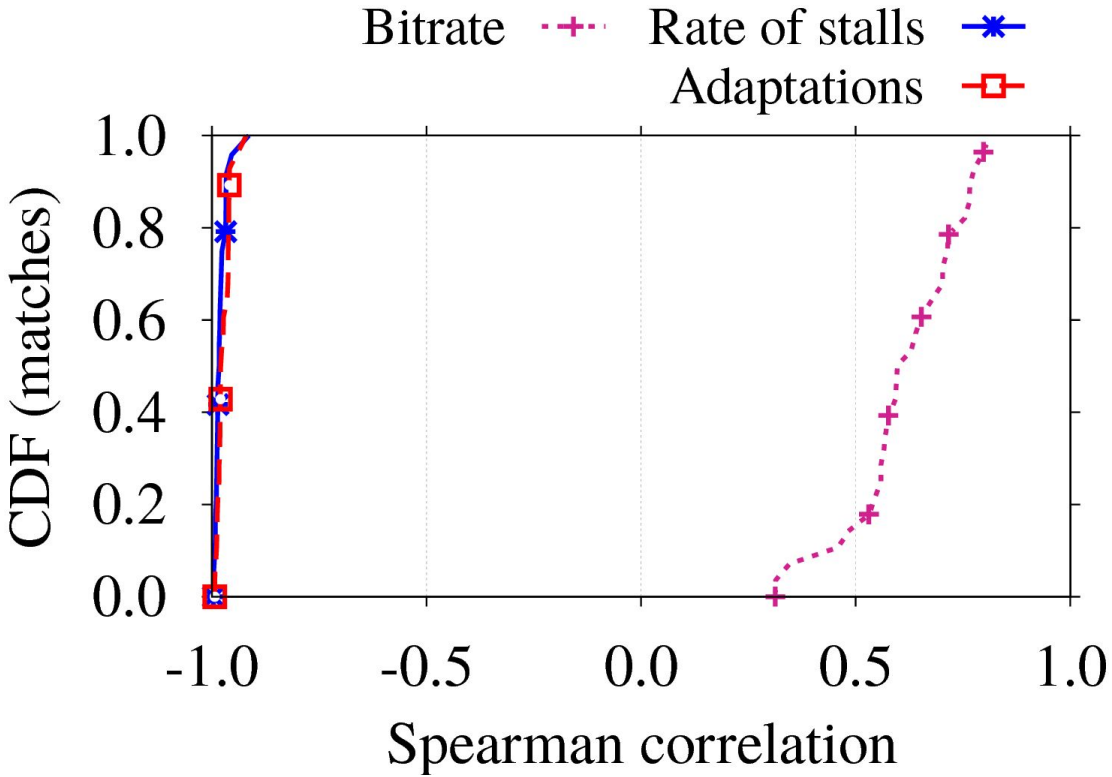
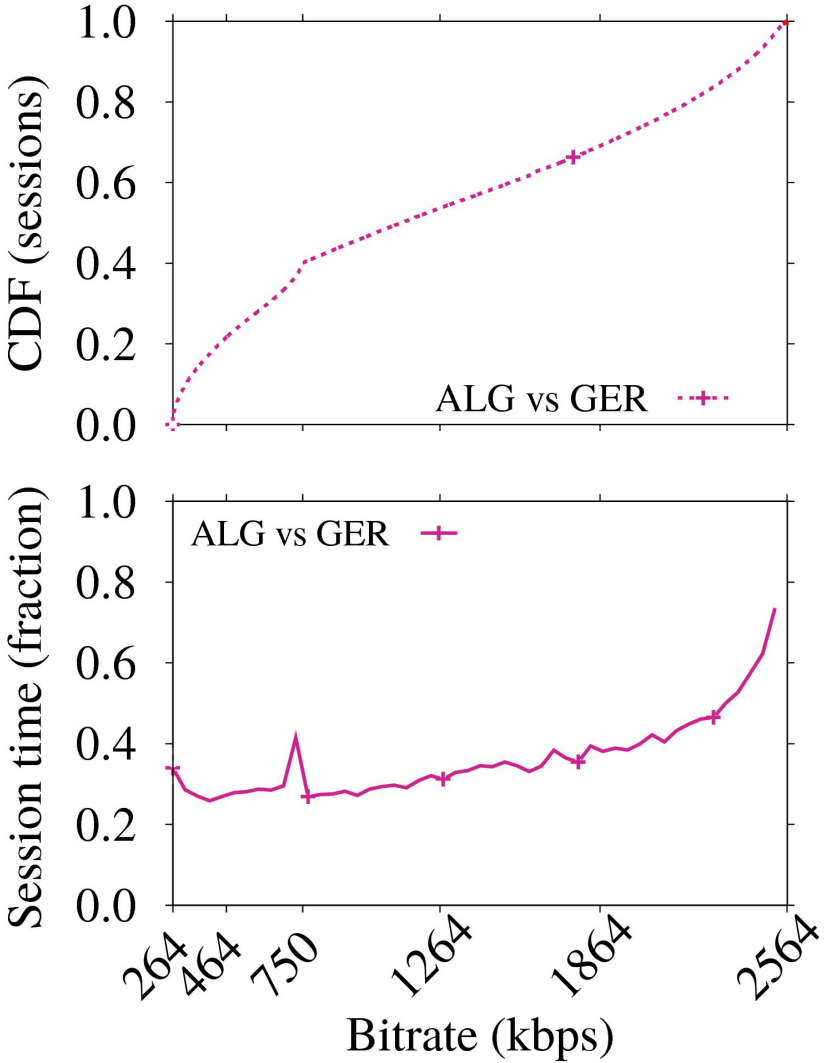


Streaming bitrate



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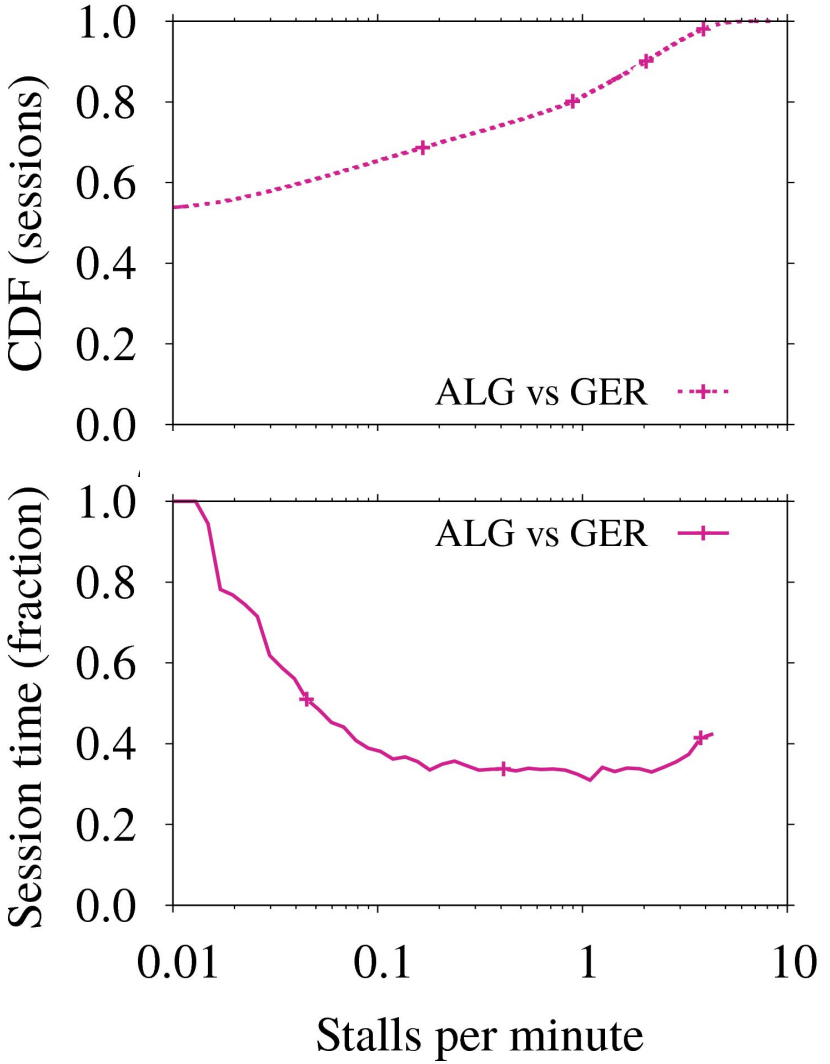
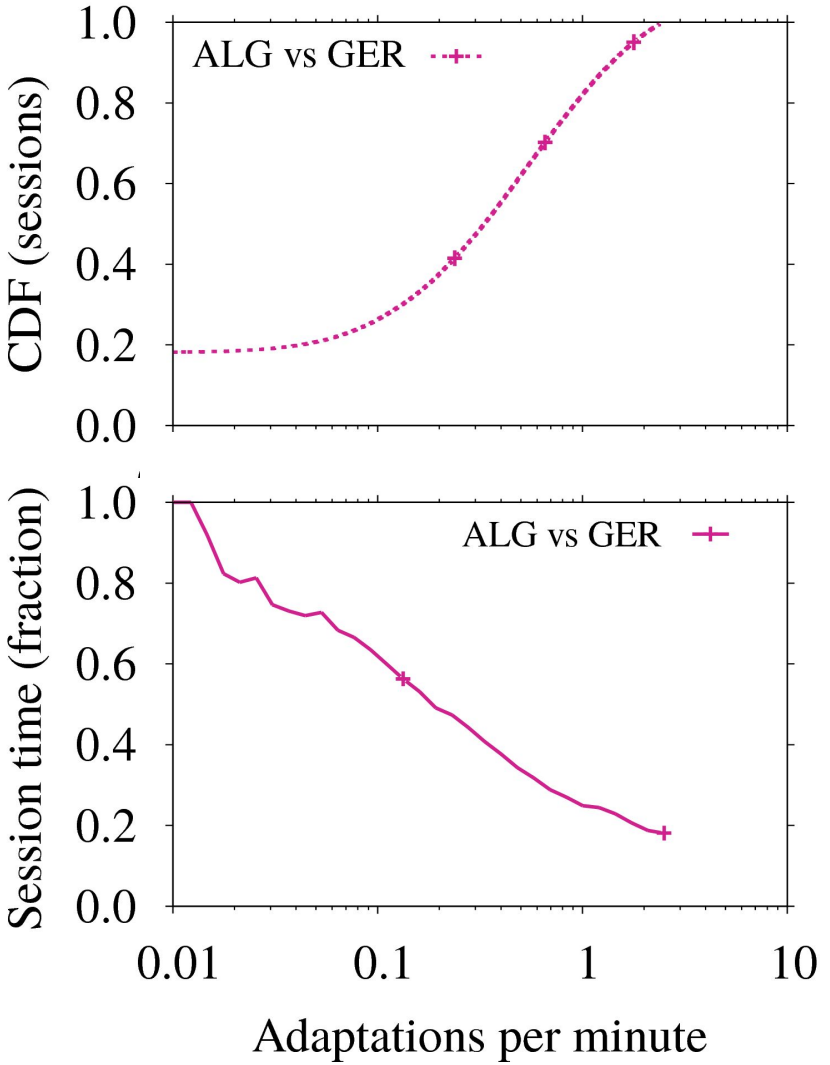
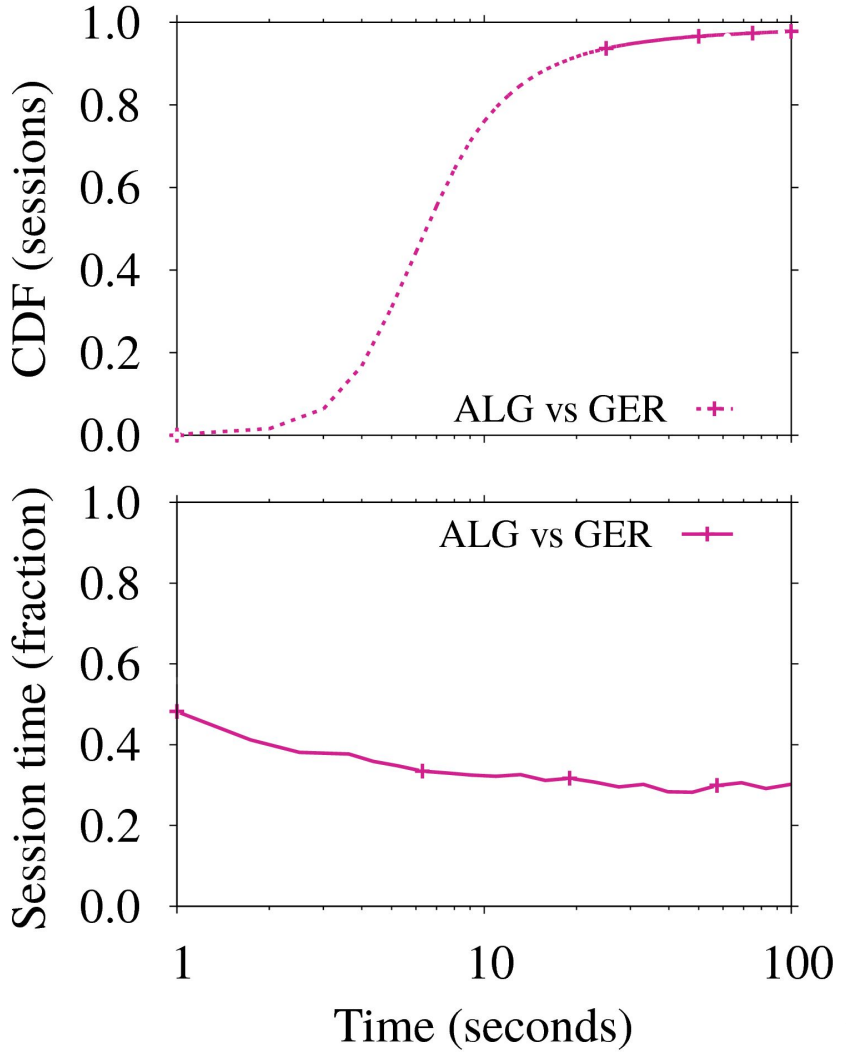


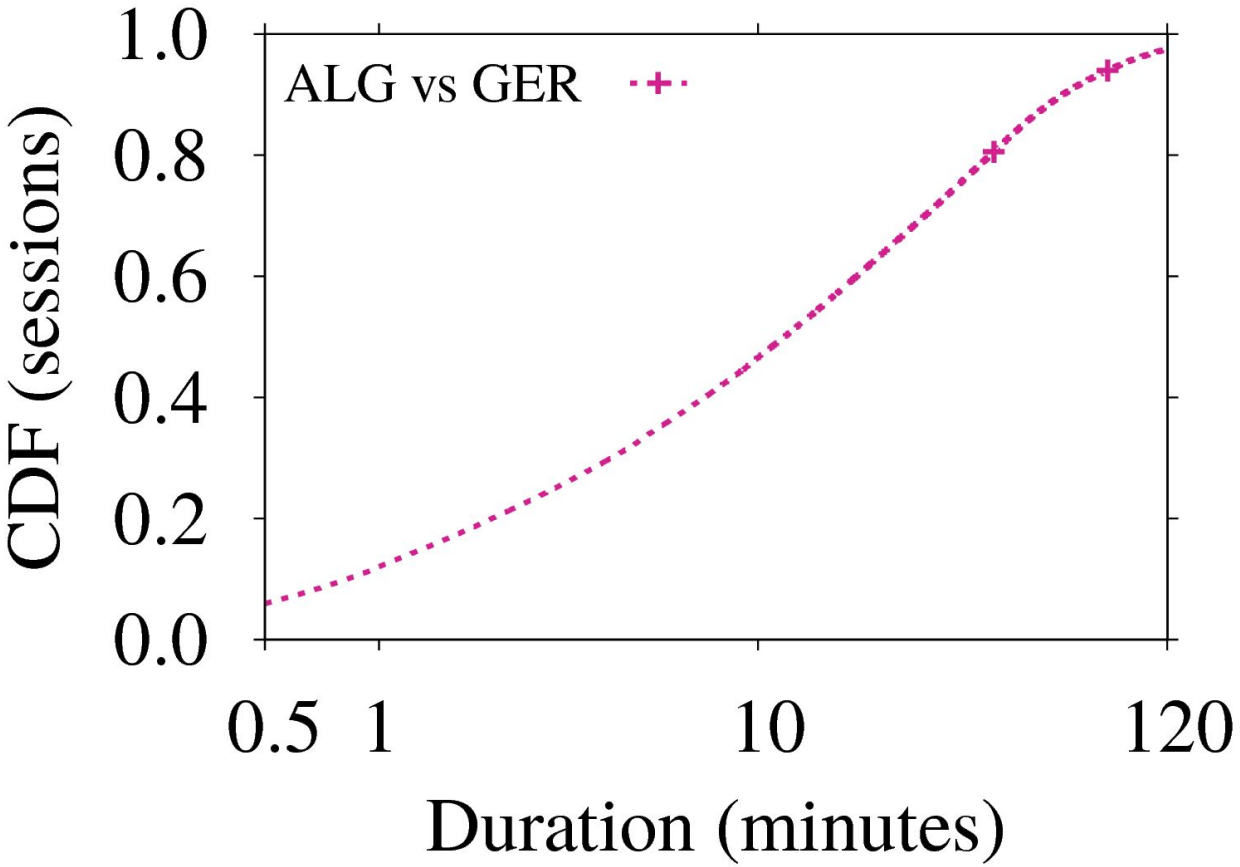
Rate of adaptations



Startup delay



Dataset overview: user session duration



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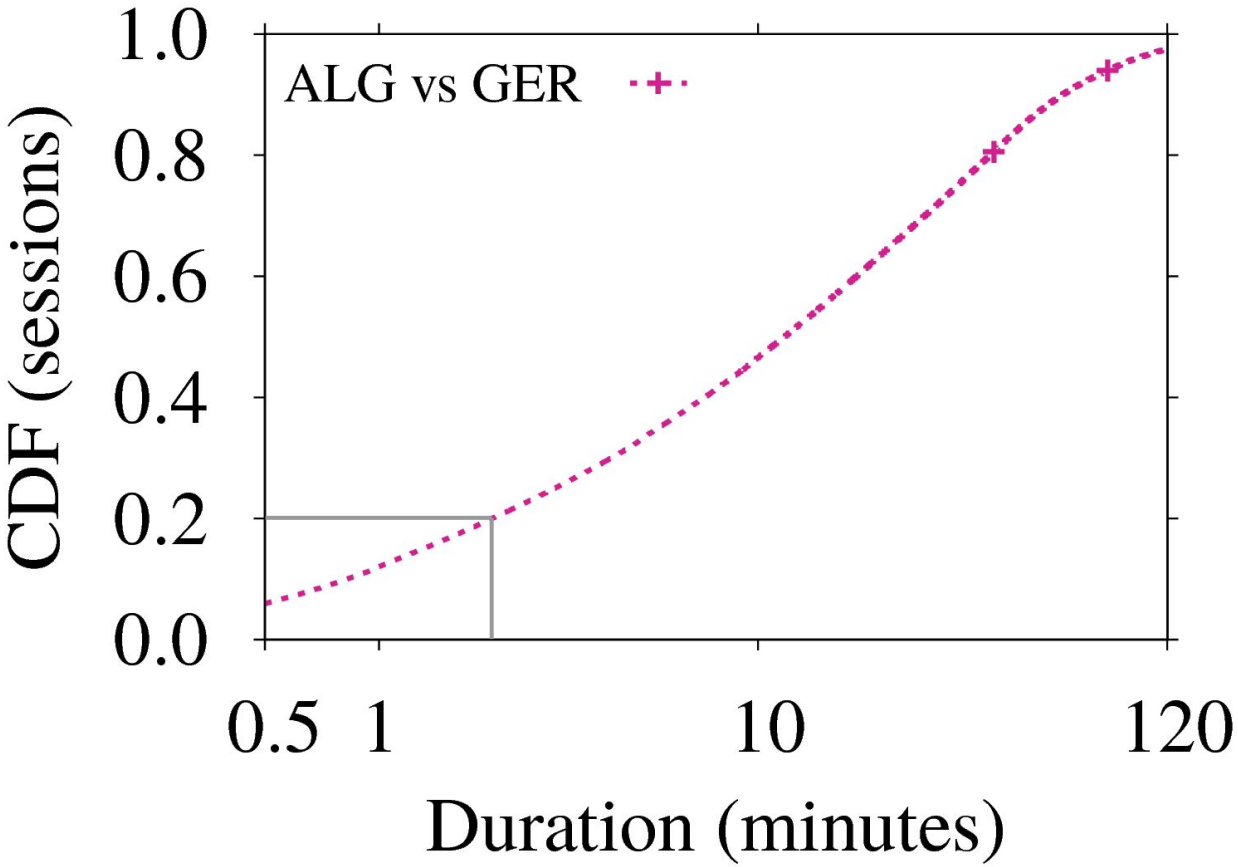

20% of sessions last less than two minutes.

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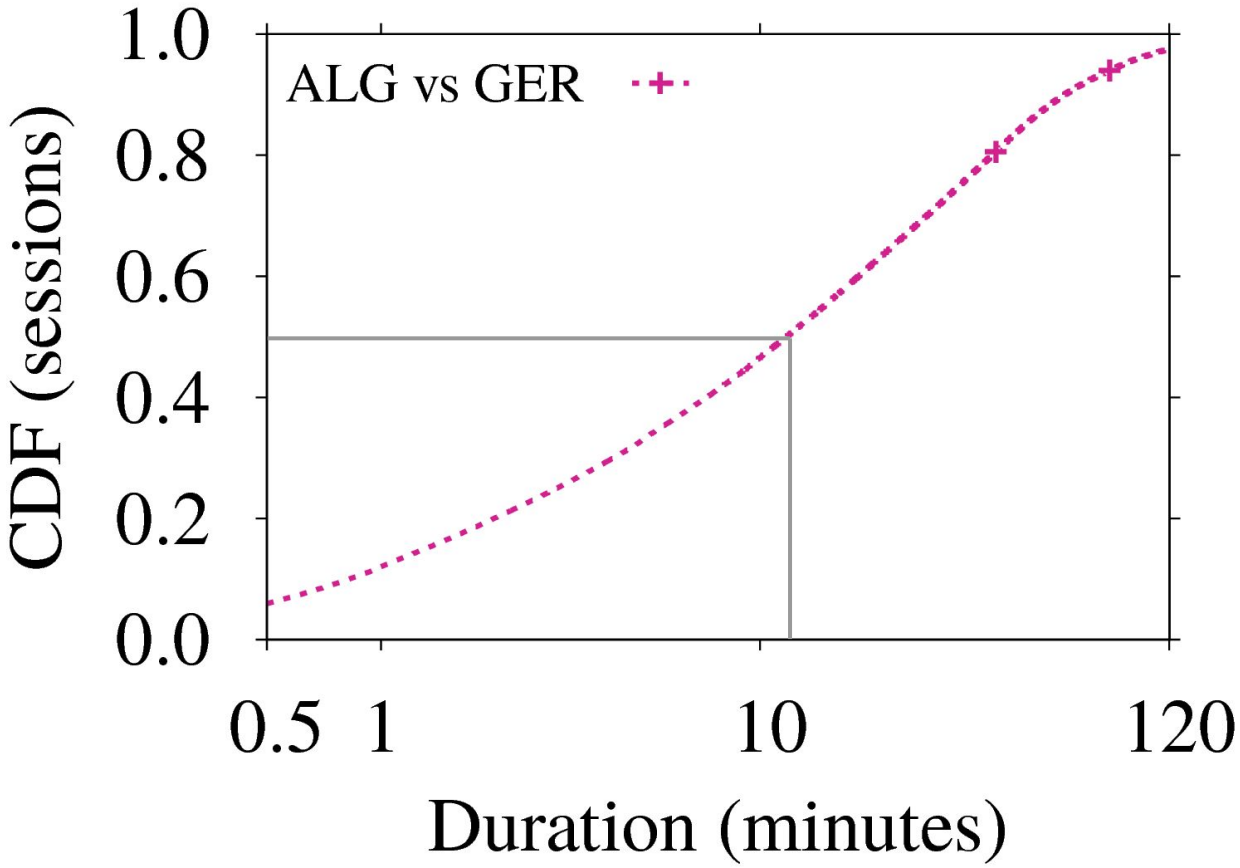

20% of sessions last less than two minutes.

Median session time is around 10 minutes.

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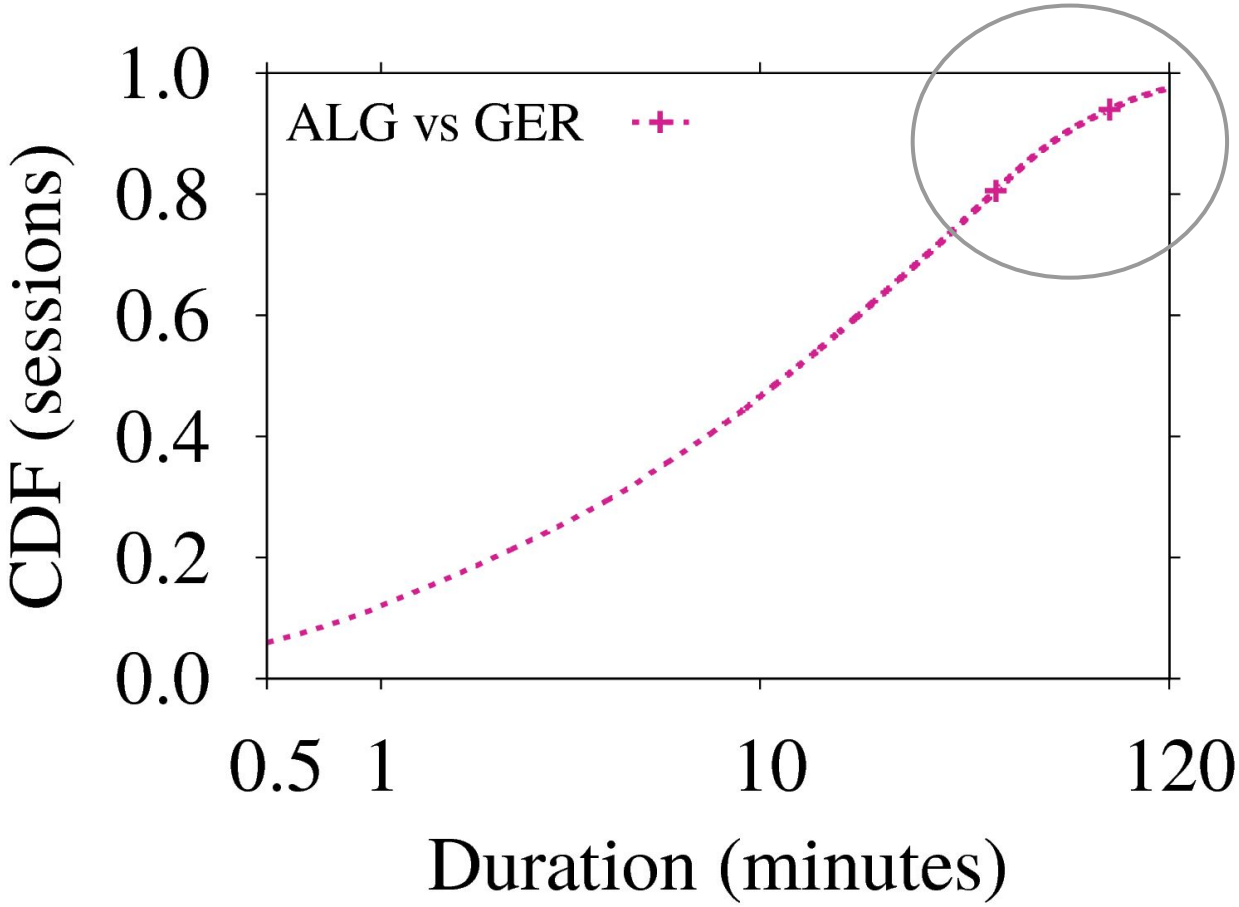

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Some sessions span the whole game.

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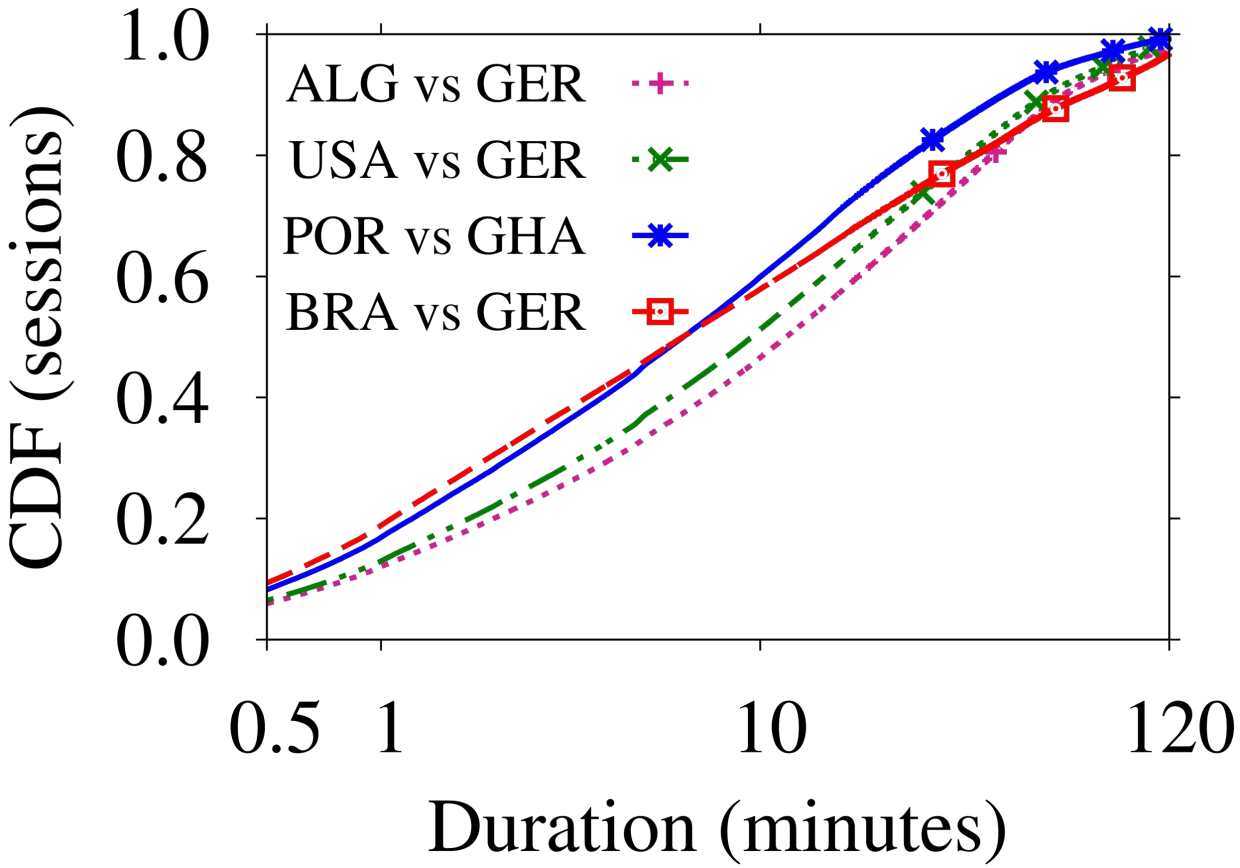

All games have similar behavior.

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