



# Bandwidth Prediction for Multi-Bitrate Streaming at Low Latency

DVB Webinar – March 31, 2020

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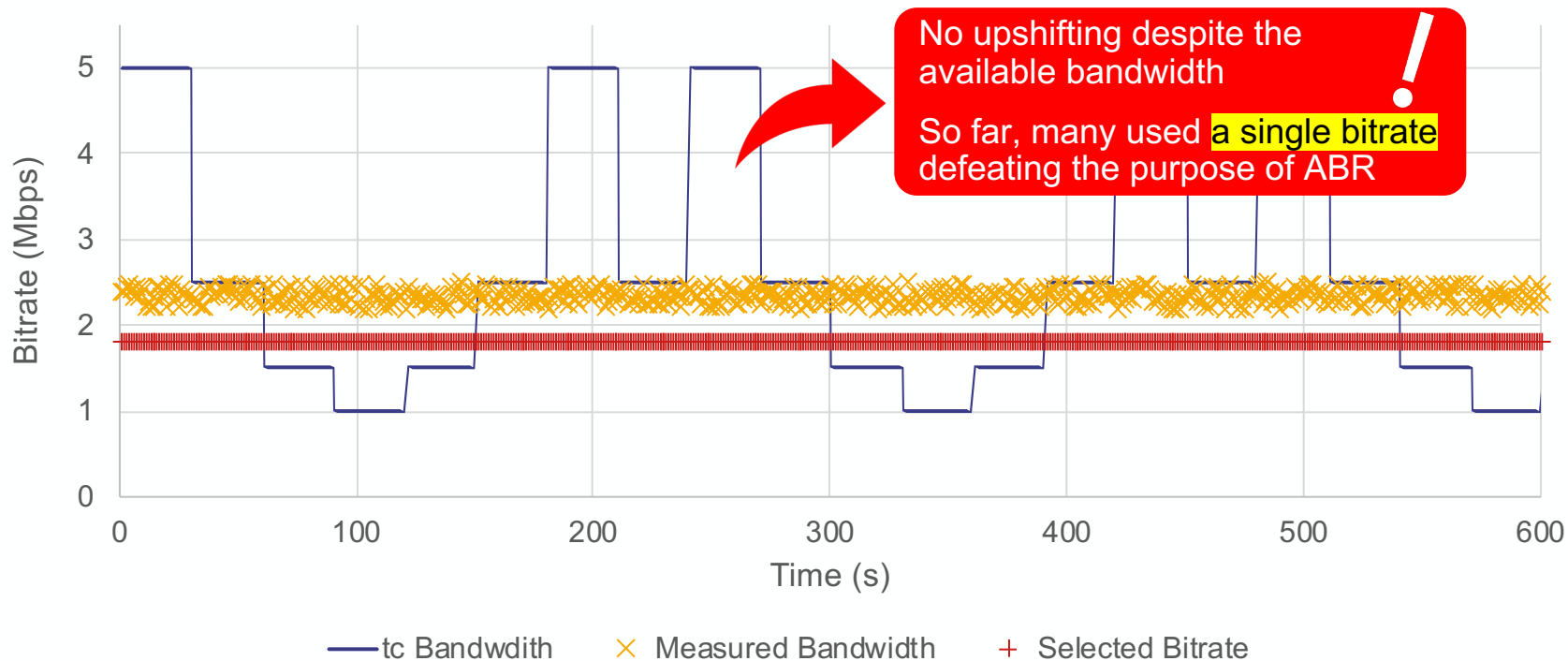
**Ali C. Begen, PhD**

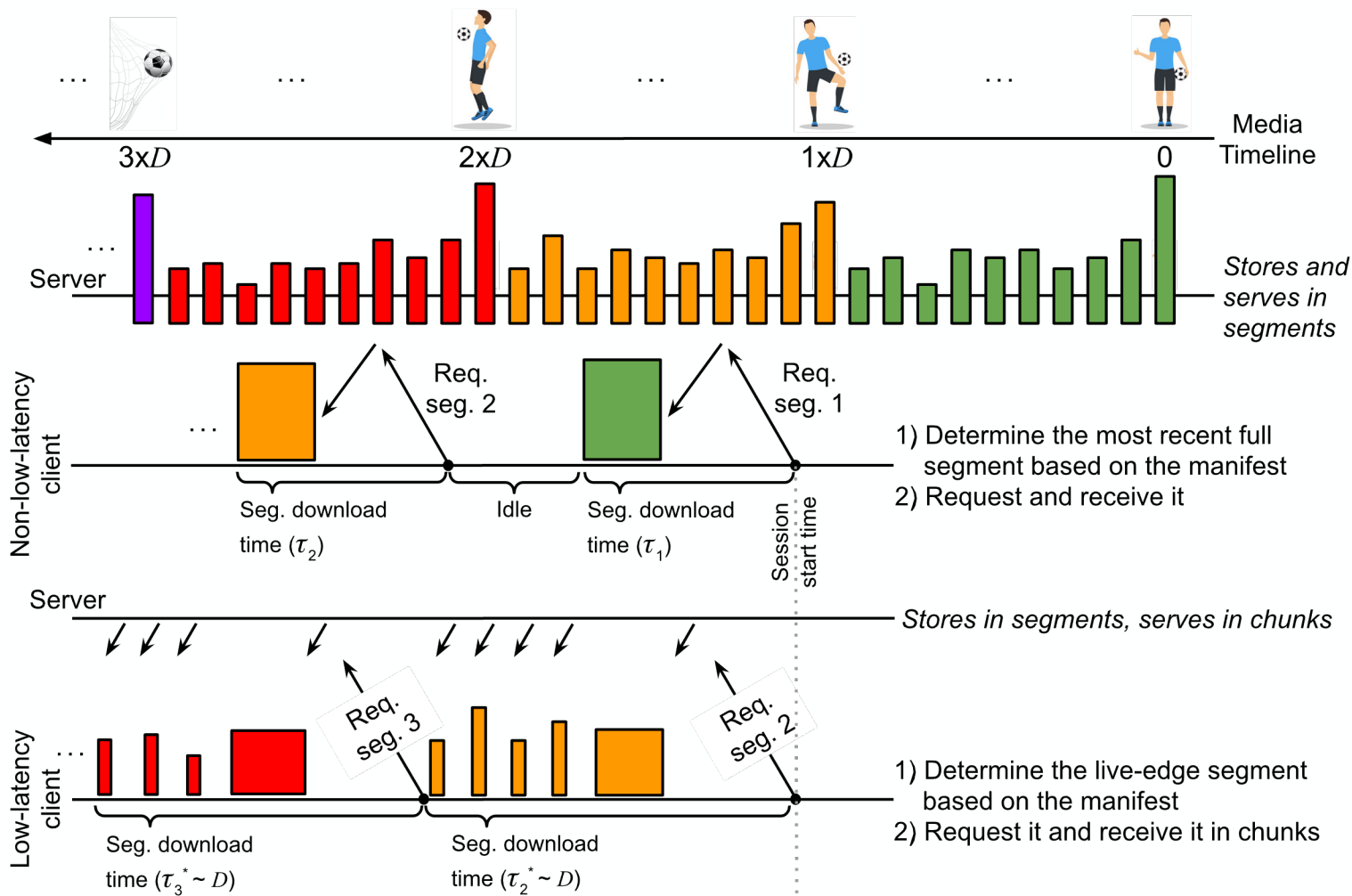
<http://ali.begen.net> and <http://streaming.university>



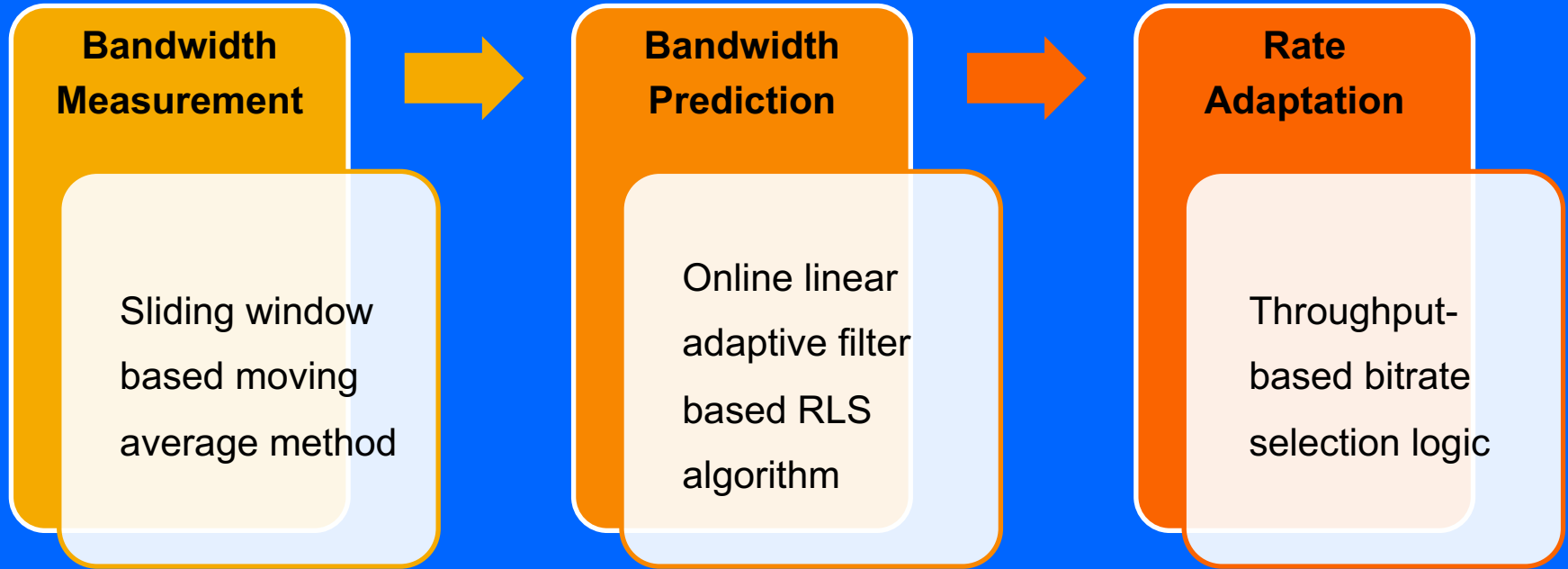
# Bandwidth Measurement is Tricky

Live Twitch Data\* (Nov. 2018)





# ABR for Chunked Transfer Encoding (ACTE)

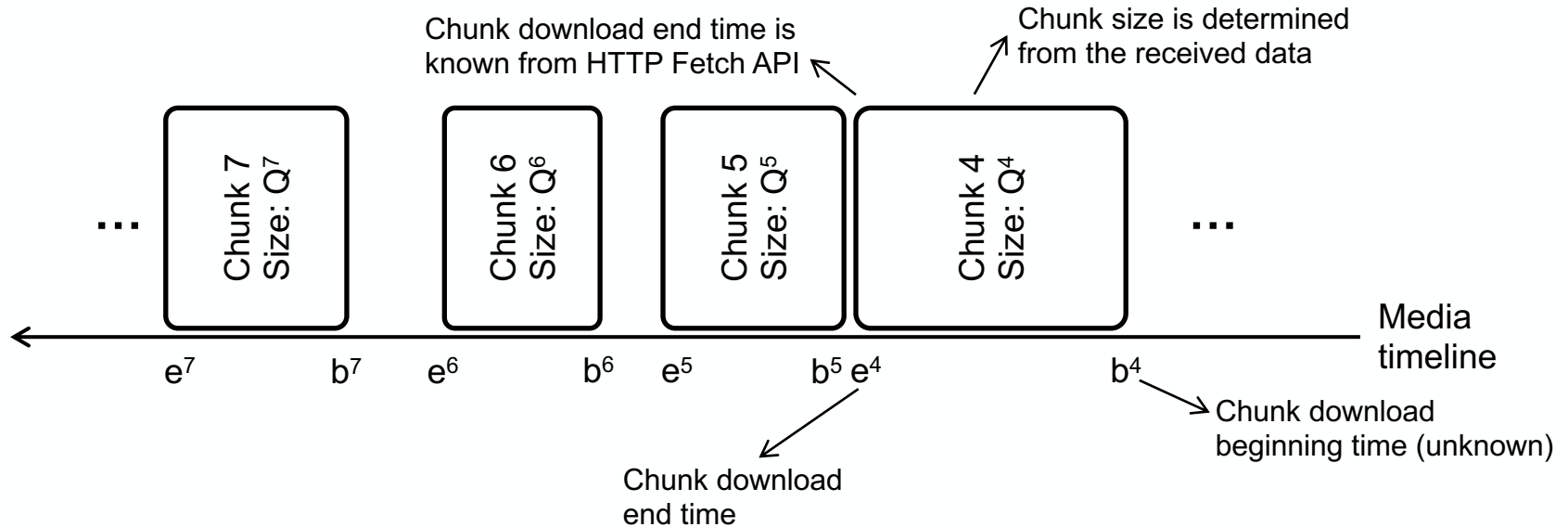


Reading: "Bandwidth prediction in low-latency chunked streaming," ACM NOSSDAV 2019 (DOI=10.1145/3304112.3325611)

More reading: "Performance analysis of ACTE: a bandwidth prediction method for low-latency chunked streaming," ACM TOMM (to appear)

# Bandwidth Measurement

## Identifying the “Good” Chunks



- Compute the download rate for the chunks where the transmission is network limited
  - If there is a negligible idle period after a chunk download, use that chunk, otherwise disregard it

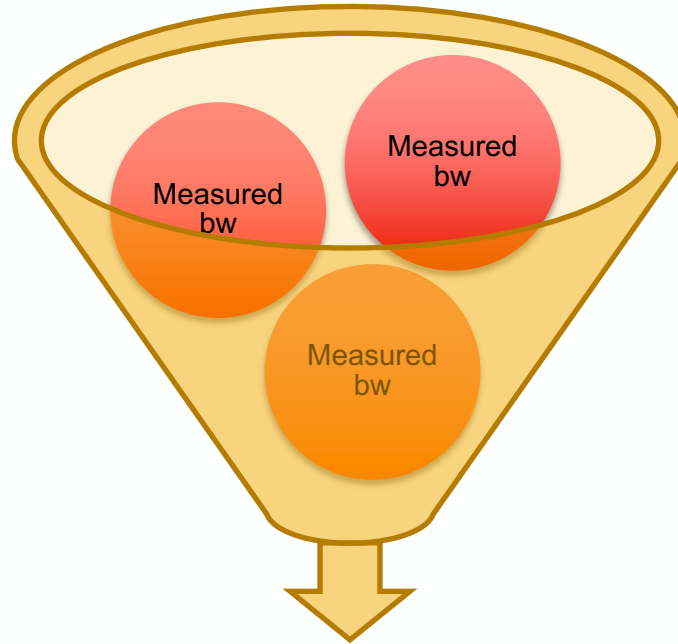
# Bandwidth Measurement

## Identifying the “Good” Chunks without the $b^n$ Values

- Reasonable assumption: Idle periods cannot happen within a chunk, happen only between the chunks
  - Since the server pushes the chunks at full network speed
- For each chunk, compute its download rate, which equals its size divided by this chunk’s end time minus previous chunk’s end time
  - If this download rate is close (+/- 20%) to the average segment download rate, there must be significant idle time between these two chunks
    - Transmission is source limited
    - Disregard the current chunk
  - Else, the idle time is negligible
    - Transmission is network limited
    - The current chunk’s download rate is a good approximation of the available bandwidth
- Use a sliding window based moving average method over the last three successful chunk downloads

# (Future) Bandwidth Prediction and Rate Adaptation

## Online Linear Adaptive Filter Using Recursive Least Squares (RLS)



**Predicted bw  
and rate adaptation**

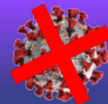
# Adaptation Algorithms for Near-Second Latency

Grand Challenge Organized and Sponsored by



**Submissions:** This Friday (Apr. 3, 2020)

**Presentations:** @ ACM MMSys week



**Twitch's blog post and testbed:** <https://tinyurl.com/2020llgc>

**Awards:** Winner (5,000 USD) and runner-up (2,500 USD)



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# Performance Evaluation

## Schemes Implemented

Bandwidth Measurement	ABR Schemes		
	Throughput-based	Buffer-based	Hybrid
SLBW	$TH_{sl}$	-	-
EWMA	$TH_{ew}$	-	-
SWMA	$TH_{sw}$	$BOLA_{sw}$	$Dynamic_{sw}$
WSSL	$TH_{wss}$	-	-

SLBW: Segment-based last bandwidth

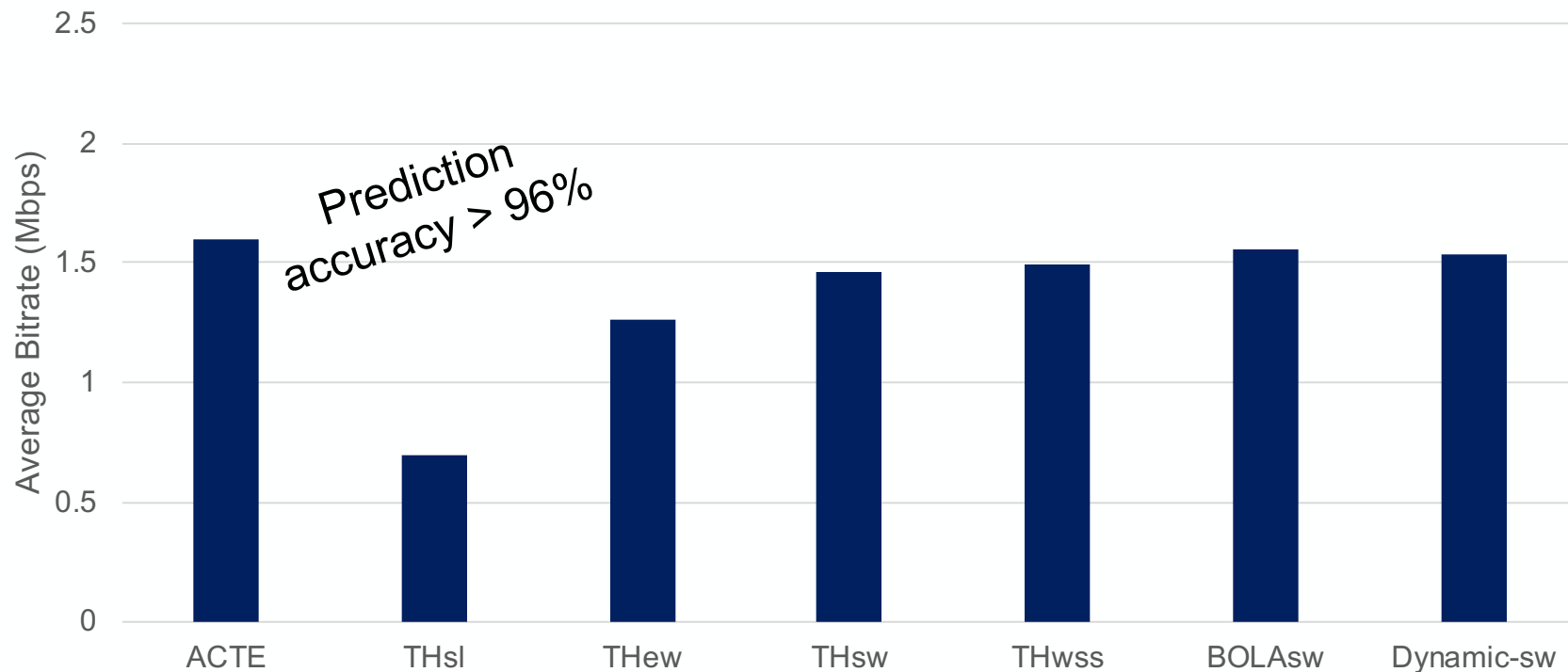
EWMA: Chunk-based exponentially weighted moving average

SWMA: Chunk-based sliding window moving average

WSSL: Will's simple side-load

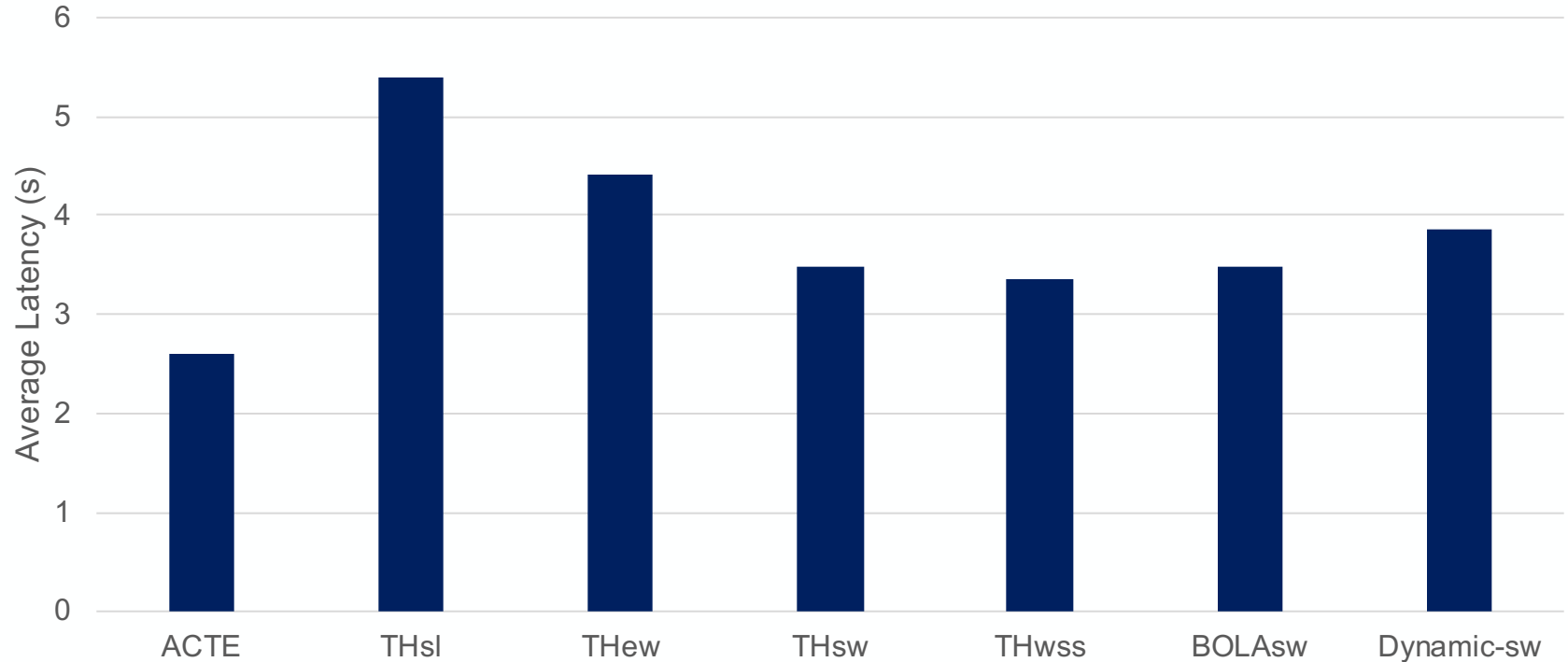
# Average Selected Bitrate

28.6% Improvement by ACTE over Other Schemes



# Average Live Latency

36.2% Improvement by ACTE over Other Schemes



# Average Normalized QoE

49.3% Improvement by ACTE over Other Schemes

