Computer Networks
COL 334/672

Application Layer: video streaming

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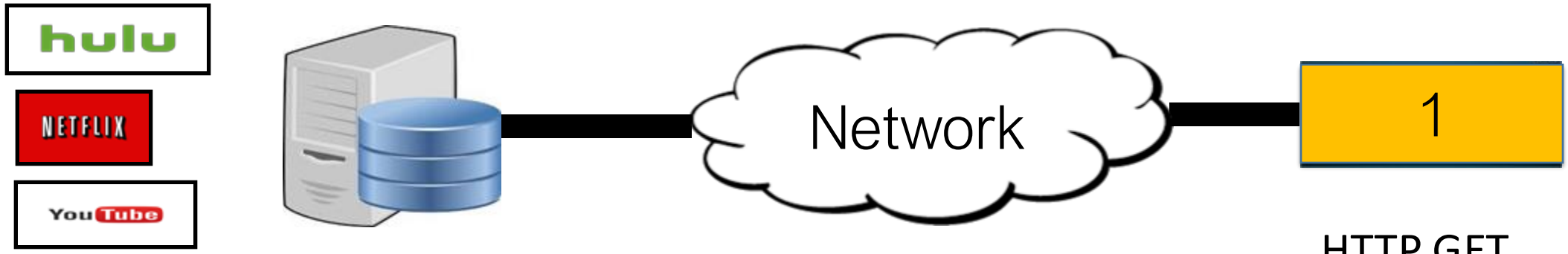
Slides adapted from KR

Sem 1, 2024-25

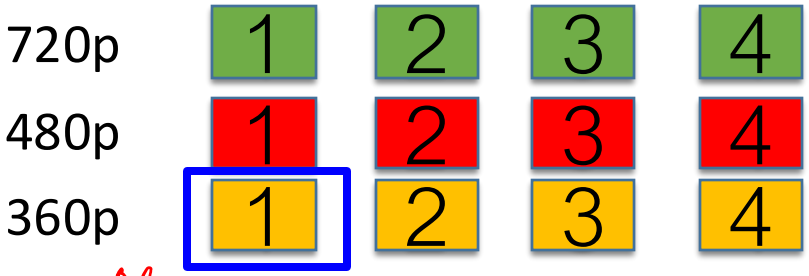
HTTP Adaptive Streaming (HAS)

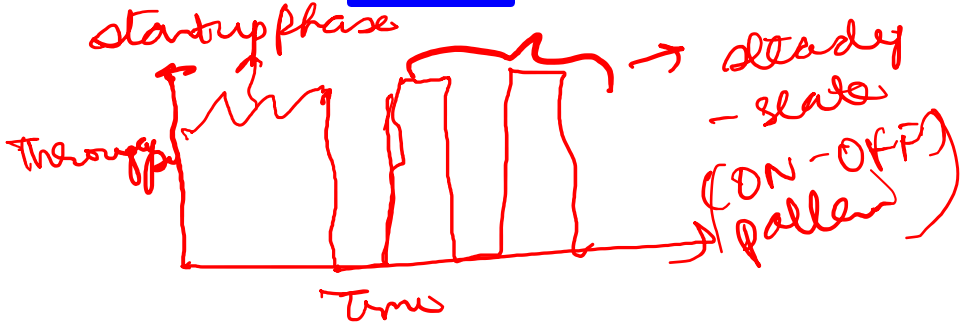
Manifest file

HTTP GET manifest



HTTP GET
"Seg1@360p"





- *"intelligence"* at client: client determines
  - *when* to request chunk (so that buffer starvation, or overflow does not occur)
  - *what encoding rate* to request (higher quality when more bandwidth available)

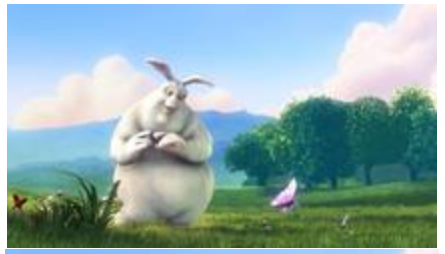
Bitrate adaptation

Designing Bitrate Adaptation Algorithm

- Design goal: Maximize application performance
- Q: What does application performance depend on in adaptive streaming?
  - Video stalls
  - Video quality
  - Video smoothness

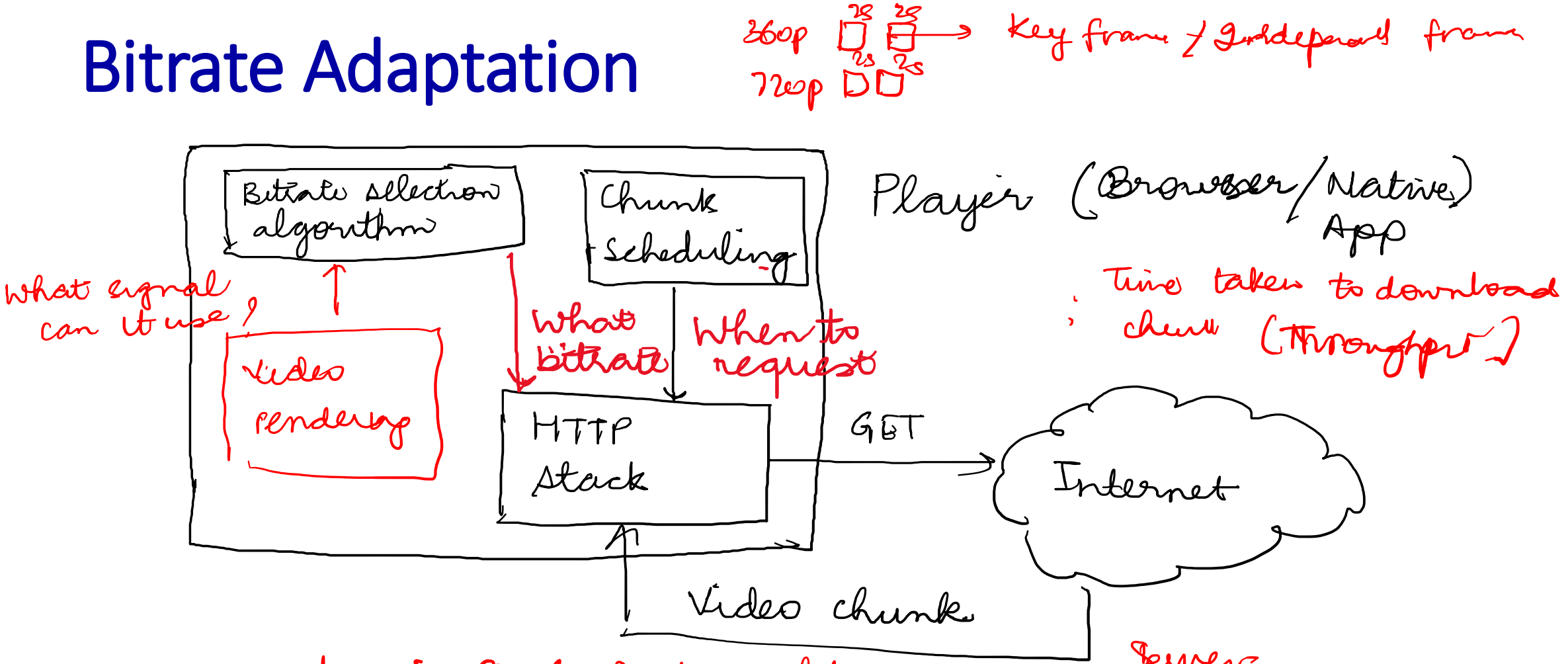
Minimize stall duration

Maximize average bitrate



Minimize bitrate switches

Bitrate Adaptation

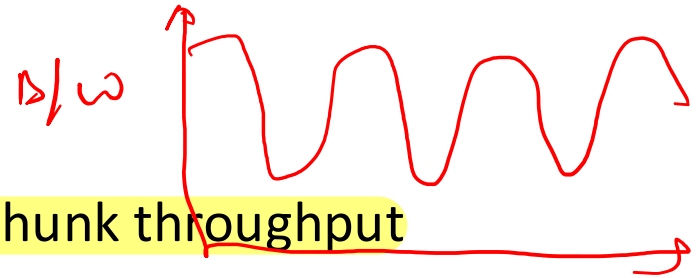


- Q: What are the signals available to the player for bitrate adaptation?

Bitrate adaptation: Algo #1

(Rate-based adaptation)

- Idea:
  - Estimate network bandwidth based on the past download rate.
  - Download chunk at a bitrate just less than the estimated network bandwidth



- Algorithm

1. Estimation: Take into account historical values, not just the last chunk throughput
2. Smoothing: Apply a smoothing filter such as average, harmonic mean or EWMA
3. Quantization: Select bitrate from the discrete set of bitrates based on estimated throughput

T

$T \geq \frac{\text{(chunk) throughput}}{R_i}$, $R_i \leq \max$

{700, conservative, 700}

Example

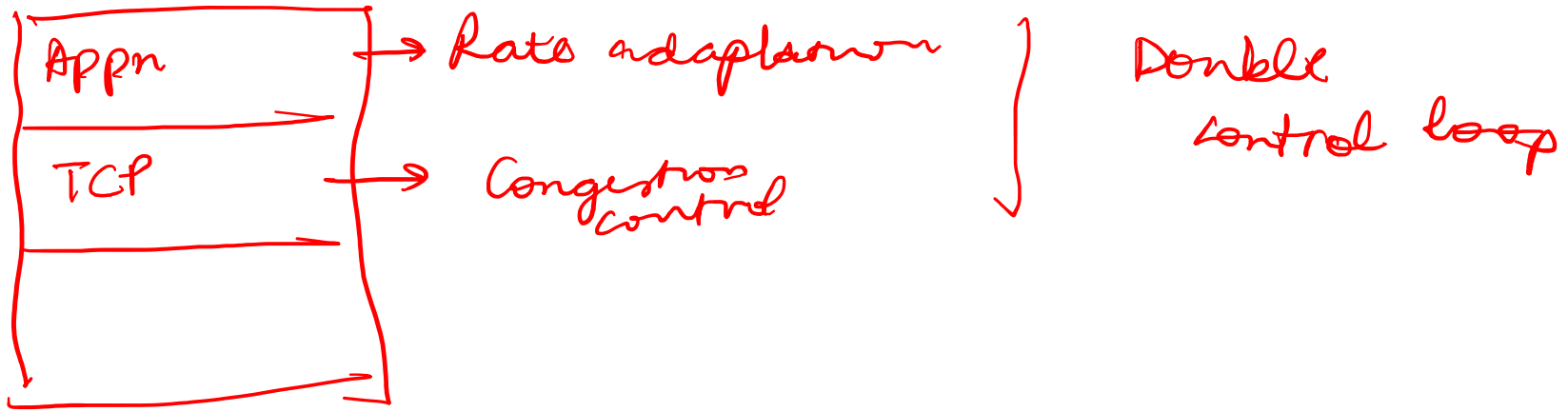
Available bitrates

= {200, 400, 800, 1600} Kbps

Issue with Rate-based Adaptation

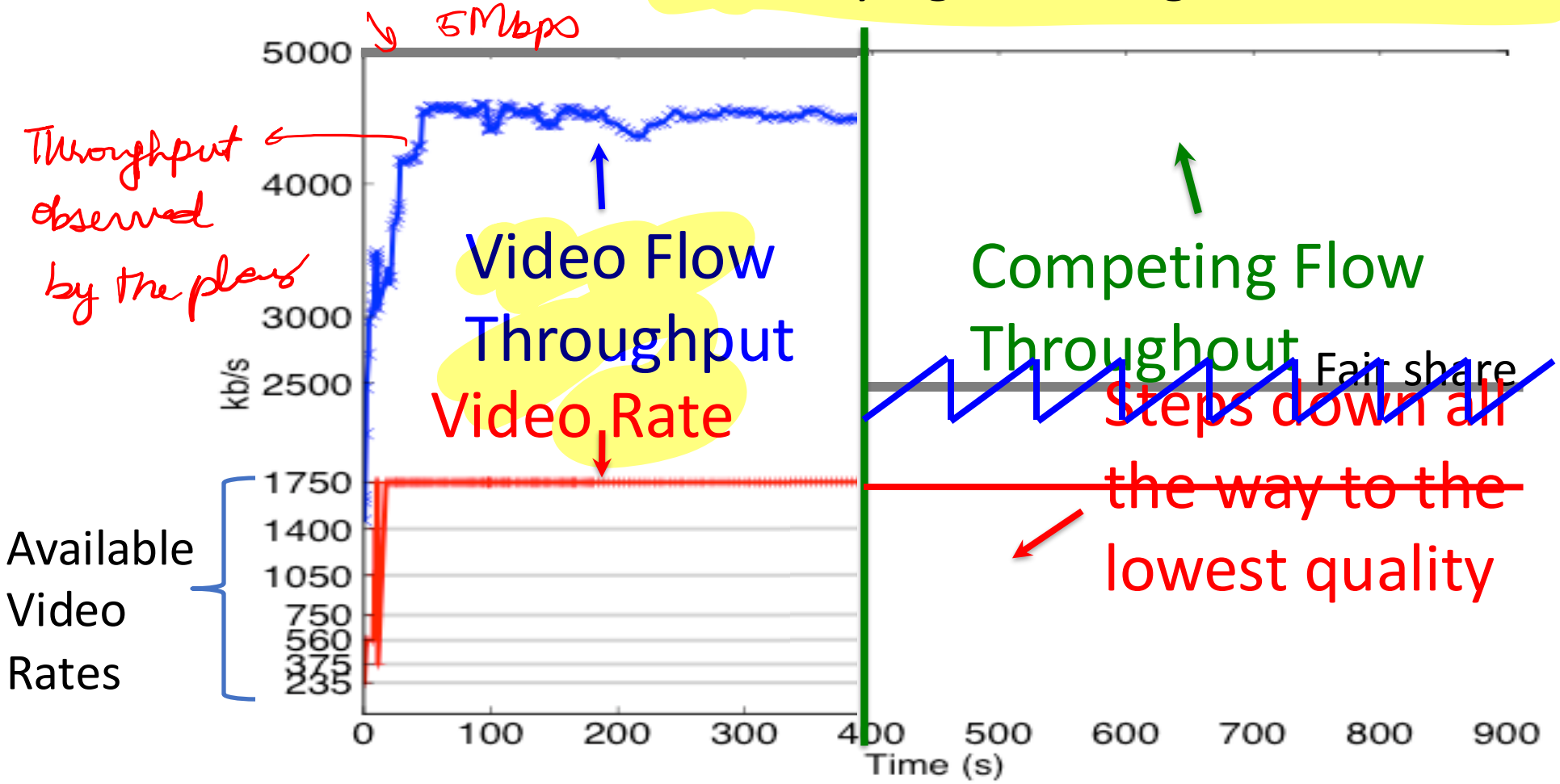
① Fluctuation :

moving average or smoothing can help



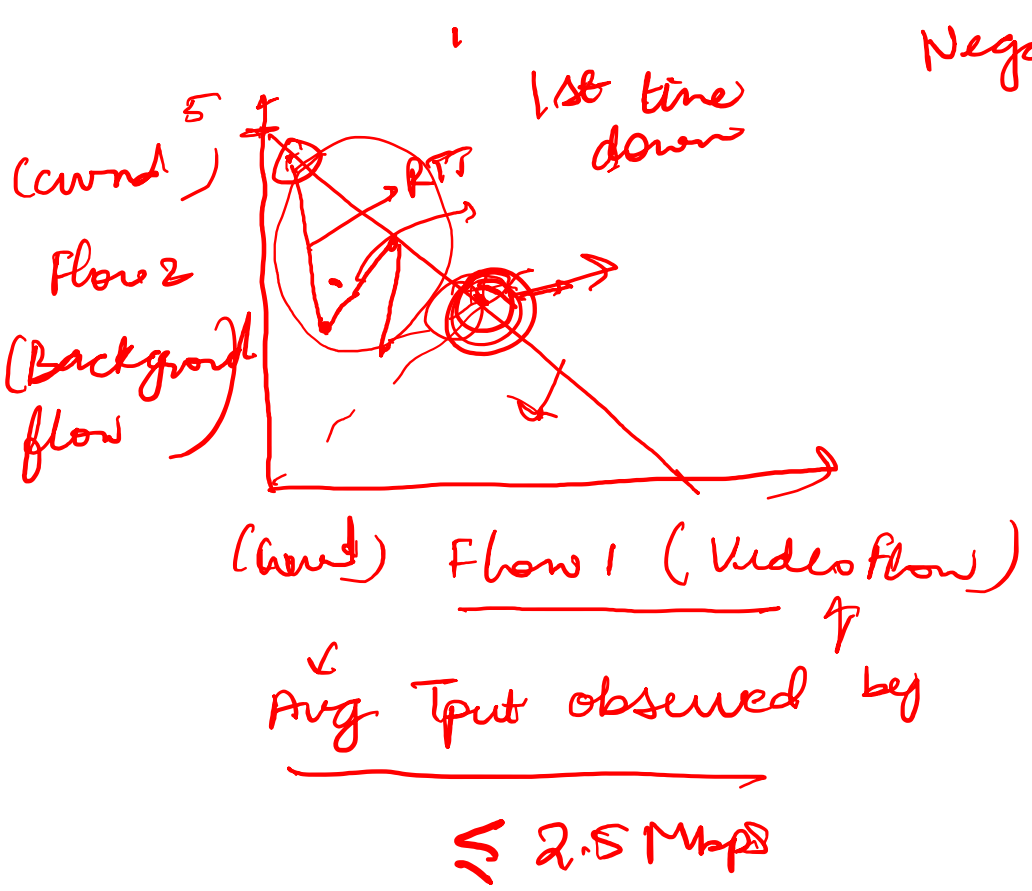
Issue with Rate-based Adaptation

- Poor interaction with the underlying TCP congestion control



Source: Confused, Timid and Unstable: Picking a Video Rate is Hard

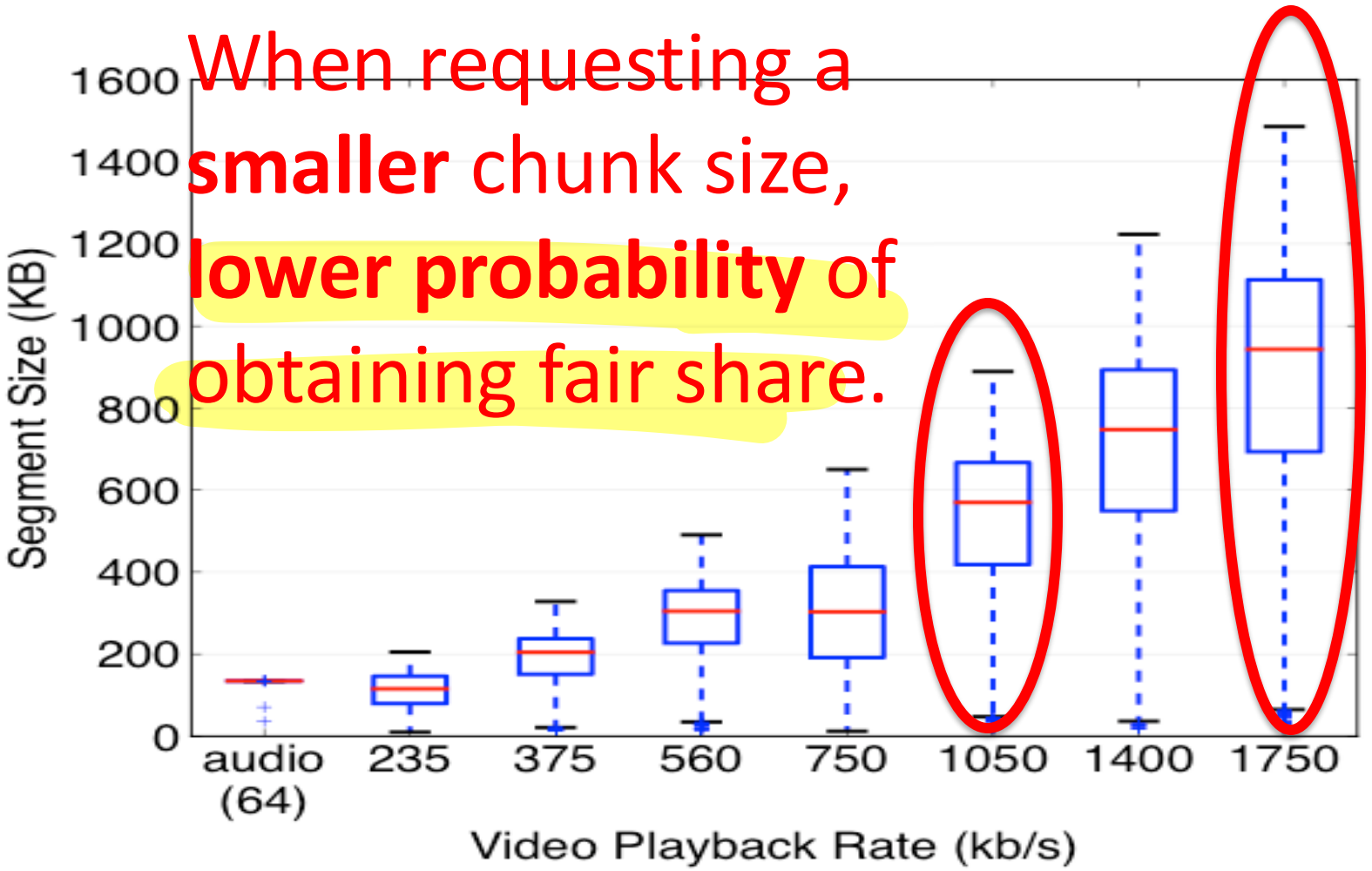
TCP Throughput of the Video Flow



- TCP sender resets its congestion window during OFF period
- Throughput will be affected especially with a competing flow
- Experience packet loss during slow start
- 50% of the ~~segments~~ packets get < 1.8Mb/s

Source: Confused, Timid and Unstable: Picking a Video Rate is Hard

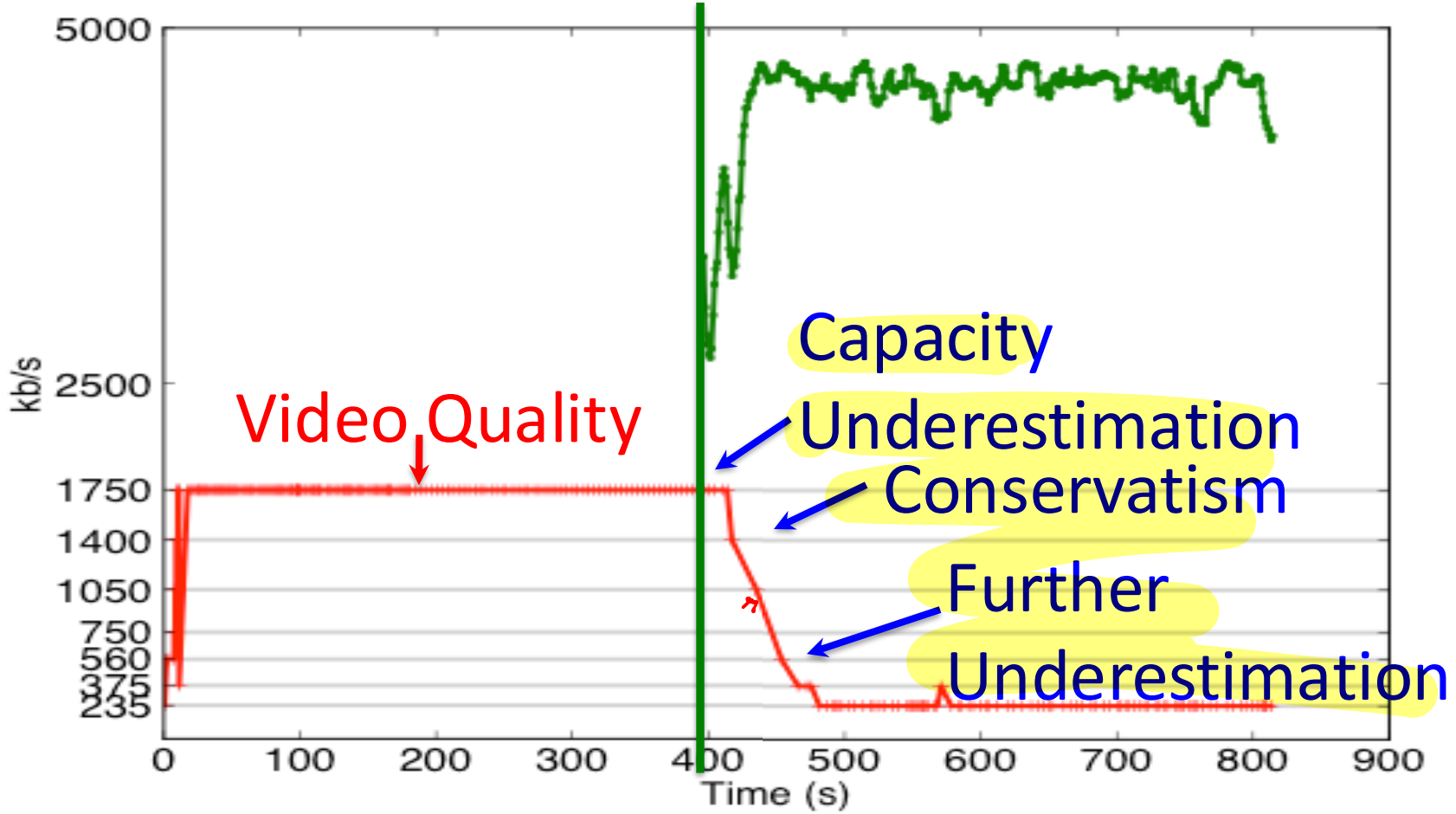
Smaller Chunk Size for Lower Video Rate



Source: Confused, Timid and Unstable: Picking a Video Rate is Hard

Buffer

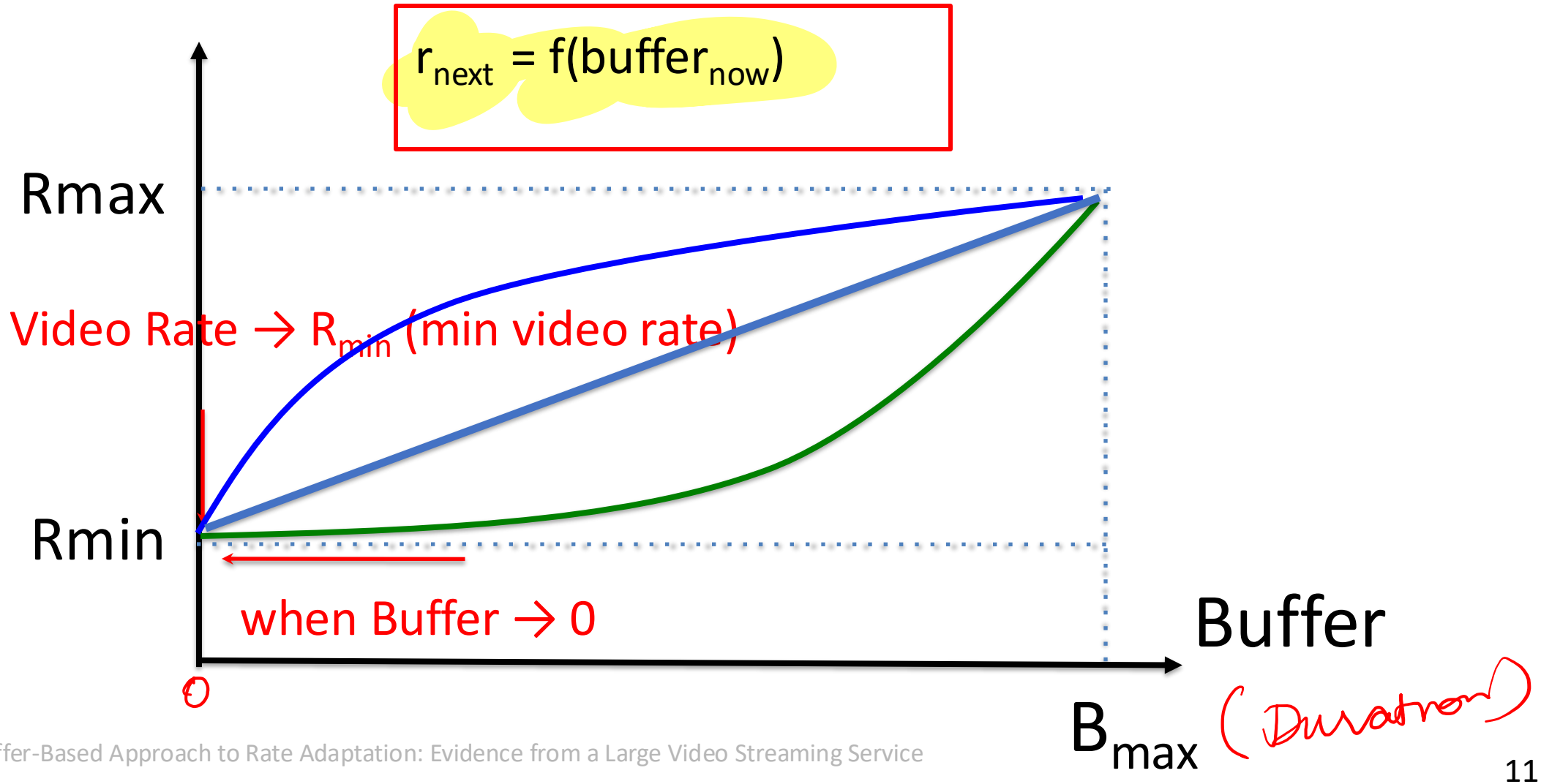
The Complete Story



Being conservative can trigger a vicious cycle!

Source: Confused, Timid and Unstable: Picking a Video Rate is Hard

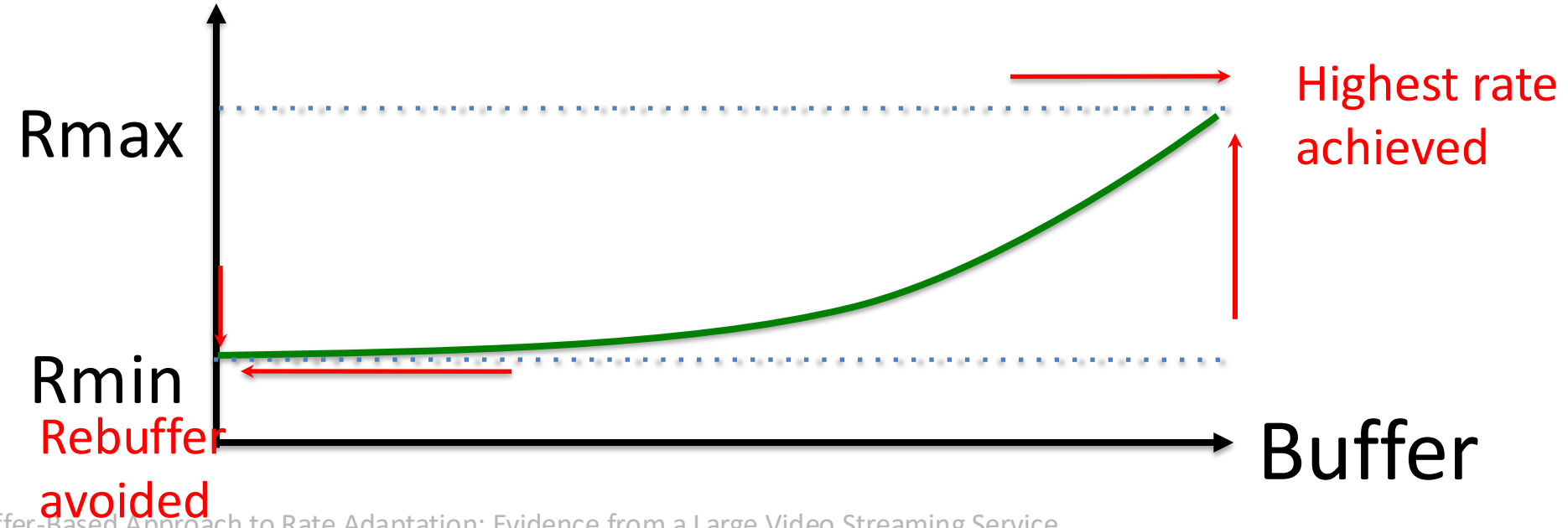
Buffer-based adaptation: Algorithm Sketch



Source: A Buffer-Based Approach to Rate Adaptation: Evidence from a Large Video Streaming Service

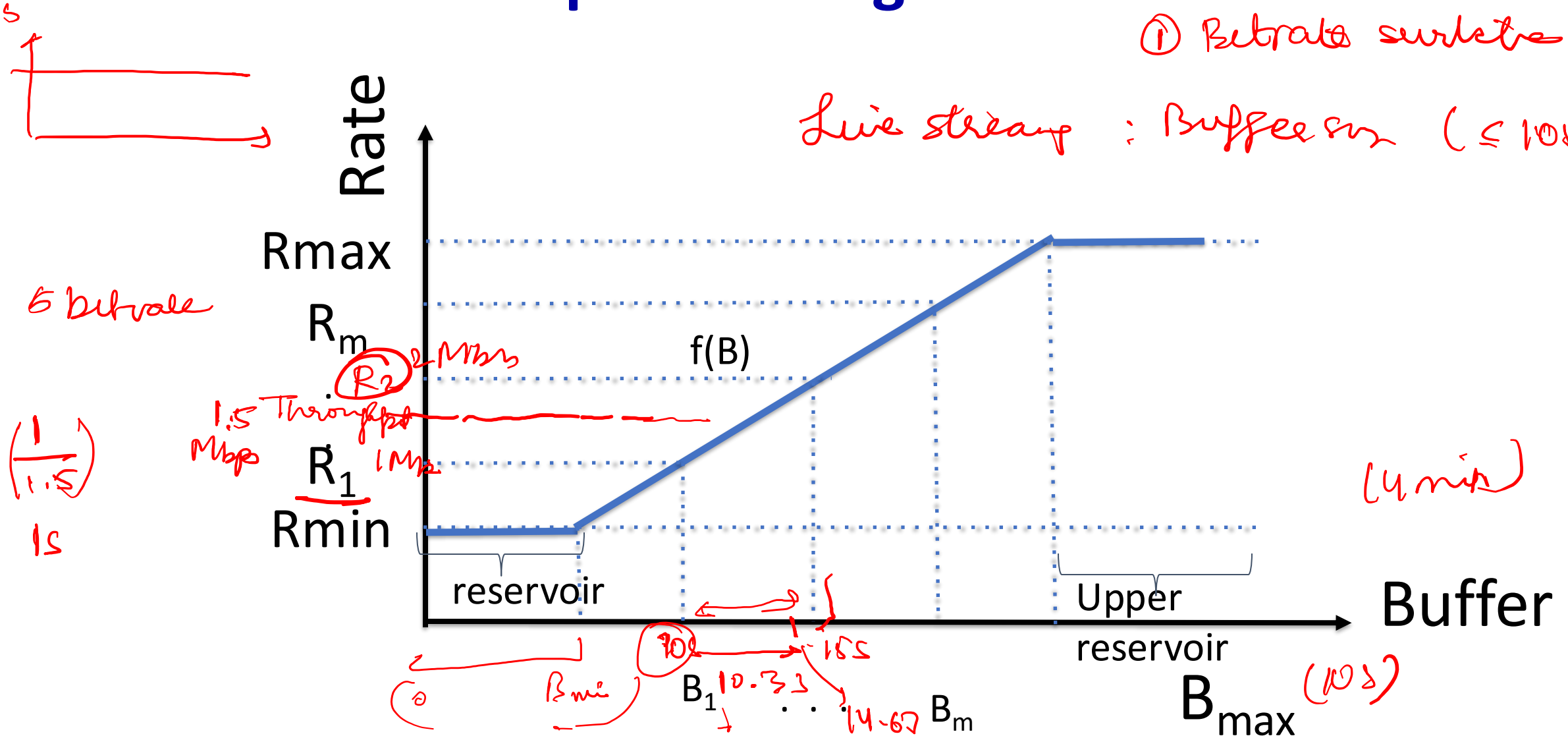
Advantages of buffer-based adaptation

- Utilize the full capacity of the link
  - Avoid on-off behavior as long as the video quality is less than maximum
  - Request the highest video rate before the buffer is full
- Avoid "unnecessary" re-buffering
  - Reduce the bitrate as the buffer occupancy decreases



Source: A Buffer-Based Approach to Rate Adaptation: Evidence from a Large Video Streaming Service

Buffer-based adaptation: Algorithm



Summary

- HTTP-based adaptive streaming (HAS) used for delivering Internet video
- Bitrate adaptation is important to ensure a high Quality of Experience (QoE)
- Various bitrate adaptation algorithms have been proposed
  - Rate-based: Rely on past observed throughput
  - Buffer-based: Rely on current buffer occupancy
  - Other methods: Control theory approach, machine learning
- Open problems: Bitrate adaptation, encoding, storage, server selection …