Background talk: Internet Video streaming

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We want the highest video quality ("bit rate")
Without seeing this ... (called a “rebuffer”)

Why do we care?

Mark Cuban: Only a 'Moron' Would Buy YouTube

Data: Cisco VNI. 2016 to 2020 forecasted.
Akamai conducted a user study* across 1200 viewers

Skin conductance (related to sweat glands)

Facial coding (capturing emotions)

Survey

“Higher bit rates can boost viewer engagement by 10.4%”

“2-second rebuffer is enough for disgust to jump 9%”

* https://www.akamai.com/quality
Naive approach
Broad solution approach

• Encode video in multiple bitrates
• Replicate using a content delivery network
• Video player picks bitrate adaptively
  • Estimate connection’s available bandwidth
  • Pick a bitrate \( \leq \) available bandwidth
“Chunks” of video at each bitrate
Client gets metadata about chunks via “Manifest”

```xml
<?xml version="1.0" encoding="UTF-8"?>
<MPD xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xmlns="urn:mpeg:DASH:schema:MPD:2011"
     xsi:schemaLocation="urn:mpeg:DASH:schema:MPD:2011"
     profiles="urn:mpeg:dash:profile:isoff-main:2011"
     type="static"
     mediaPresentationDuration="PT0H9M56.46S"
     minBufferTime="PT15.0S">
  <BaseUrl>http://witestlab.poly.edu/~ffund/video/2s_480p_only/</BaseUrl>
  <Period start="PT0S">
    <AdaptationSet bitstreamSwitching="true">
      <Representation id="0" codecs="avc1" mimeType="video/mp4"
                      width="480" height="360" startWithSAP="1" bandwidth="101492">
        <SegmentBase>
          <Initialization sourceURL="bunny_2s_100kbit/bunny_100kbit.mp4"/>
        </SegmentBase>
      </Representation>
    </AdaptationSet>
  </Period>
</MPD>
```
A client can fetch chunks of different qualities
Network

Downloading

1s chunks at different bit-rates

Time

Capacity (Mbps)

Playing out

Capacity < current rate ⇒ decrease rate
Common solution approach

- Encode video in multiple bitrates
- Replicate using a content delivery network
- Video player picks bitrate adaptively
  - Estimate connection’s available bandwidth
  - Pick a bitrate \( \leq \) available bandwidth
Estimating available capacity

[A Buffer-Based Approach to Rate Adaptation: Evidence from a Large Video Streaming Service, Huang et al., ACM SIGCOMM 2014]
Estimating available capacity

“A random sample of 300,000 Netflix sessions shows that roughly 10% of sessions experience a median throughput less than half of the 95th percentile throughput.”

“20–30% of rebuffers are unnecessary”

[A Buffer-Based Approach to Rate Adaptation: Evidence from a Large Video Streaming Service, Huang et al., ACM SIGCOMM 2014]
Capacity estimation

Decide based on the buffer alone?
Buffer-based adaptation

Nearly full buffer $\Rightarrow$ large rate
Buffer-based adaptation

Network

Nearly empty buffer ⇒ small rate
Buffer-based adaptation

Low buffer: use $R_{\text{min}}$

High buffer: use $R_{\text{max}}$

[Buffer occupancy vs. Next chunk’s rate]

Risky Area

Safe from Unnecessary rebuffering

[A Buffer-Based Approach to Rate Adaptation: Evidence from a Large Video Streaming Service, Huang et al., ACM SIGCOMM 2014]
Buffer-based adaptation

Normalized number of rebuffers per hour (%)

[A Buffer-Based Approach to Rate Adaptation: Evidence from a Large Video Streaming Service, Huang et al., ACM SIGCOMM 2014]
Buffer-based adaptation

Video rate difference (kbps)

[B.A. Buffer-Based Approach to Rate Adaptation: Evidence from a Large Video Streaming Service, Huang et al., ACM SIGCOMM 2014]