A Buffer-Based Approach to Rate Adaptation

Huang et al. SIGCOMM 2014.

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Background

- Video streaming services account for the majority of internet traffic in the US during peak hours

- Video streaming services are demanding
  - Sustained performance required
  - Daily fluctuations in usage
Background

- Clients experience high variability in throughput over time
  - 35x difference not uncommon
  - Causes unnecessary rebuffers (20-30%)
Motivation

● Adaptive Bit-Rate (ABR) selection algorithms
  ○ Adjust the bit-rate based on estimated capacity of the network
  ○ Estimating capacity is difficult b/c of variability
  ○ Playback buffer occupancy can be used as a heuristic

● Q: Can we set the bit-rate based solely on the buffer?
  ○ Goals: 1) high average rate with 2) minimal rebuffering
Playback Buffer

- ABR picks a video rate: $R(t)$
- If larger than system rate, $C(t)$: $C(t) / R(t) < 1$
- Difficult to pick the right adjustment function when $C(t)$ is highly variable in practice
Playback Buffer

- Too aggressive a video rate can hurt performance
ARB Algorithm

- First step: pure buffer-based approach
Algorithm

Assumptions:
- Chunk size is infinitesimal
- Any video rate between $R_{\text{min}}$ and $R_{\text{max}}$ possible
- Videos are encoded at a constant bit-rate (CBR)
- Videos are infinitely long
BBA-0 Algorithm

- Rate map for BBA-0 algorithm
- $R_{\text{max}}$ is reached when the buffer is 90% full
- Adjust rate based on $f(B)$, which stays in the safe “cushion” area
  - $f(B)$ is a piecewise linear function
BBA-0 Results

(a) Number of rebufs per playhour during the day.

(b) Normalized number of rebufs per playhour, normalized to the average rebuffer rate of Control in each two hour period.
BBA-0 Results
BBA-0 Results

- BBA-0 decreases the rebuffer rate significantly using solely the buffer’s state
- BBA-0’s video rate was significantly worse than the control algorithm
  - How can we increase the average video rate?
BBA-1 Algorithm

- We assumed CBR, but in reality VBR is used
  - Chunk sizes vary dramatically in time
  - Ex: opening credits
For VBR: buffer dynamics depend on upcoming chunk size, instead of video rate
BBA-1 Results
BBA-2 Algorithm

- BBA-1 still suffers from poor video rate while the buffer is still filling up initially
  - The algorithm is too conservative in startup
  - Chunk map is useful for steady-state
  - Capacity estimate is still useful for startup
    - Estimate based on the throughput of the last chunk
BBA-2 Results

- BBA-2 ramps up to steady-state faster than BBA-1
- BBA-2 switches to BBA-1 after the buffer is built up
BBA-2 Results
BBA-2 Results

- BBA-2 has higher video rate than Control
- BBA-2 suffers slightly more rebuffers than BBA-1, but less than Control
Further Optimizations

- **Outage Protection:**
  - Handle transient network outages by shifting the chunk map to maintain increased occupancy

- **Video switch rates:**
  - Chunk map approach can change the video rate for every chunk request
  - Handle by looking at multiple future chunks
Video Switch Rates

- BBA-1 and BBA-2 dynamically change the buffer rate ~60% more than Control
- Does this hurt the end user’s experience?
BBA-Others

- BBA-Others looks ahead at the same number of chunks as are in the buffer
BBA-Others Results

- Still low rebuffering rates compared to Control
Conclusions

- ABR algorithms can and should be based on the buffer’s state when possible/productive
  - In steady-state, buffer is the best metric
  - In start-up, capacity estimation is better metric
- BBA-Others decreases rebuffer rate by ~20%, and off-peak video rate by 30 KB/s
Discussion

- Authors did a good job addressing the assumptions made for BBA-0
- Comparisons to Control are difficult to make without knowing more about the Control algorithm
- Utility of video switch rates as a metric?
Questions?