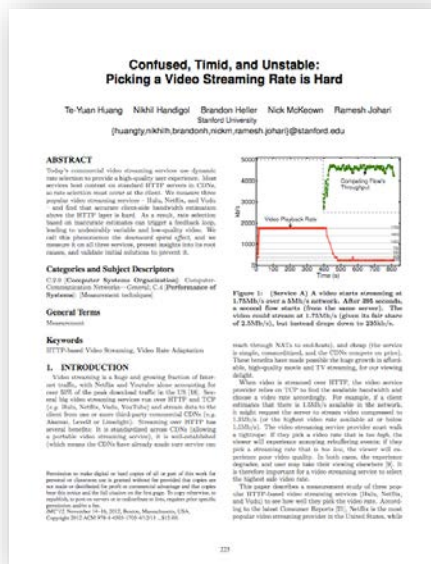


Confused, Timid, and Unstable: Picking a Video Streaming Rate is Hard



- Five students from Stanford
- Published in 2012
- ACM's Internet Measurement Conference (IMC)
- 23 citations

Ahmad Tahir

- Problem
- Background Knowledge
- Research Motivation
- Experimental Setup
- First Results
- Downward Spiral
- Intervention
- Before, After

The streaming video quality deteriorates when another competing flow for a limited bandwidth starts.

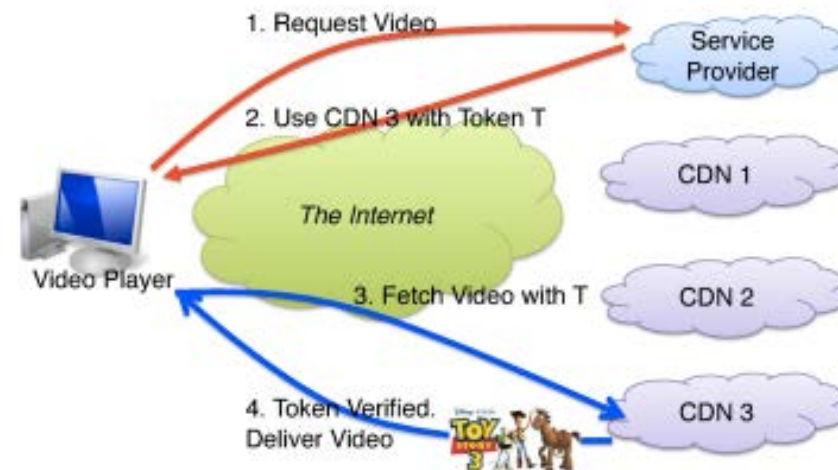
Maintaining a careful balance between:

- not wanting to cause a re-buffer
- not wanting to deliver unnecessarily low quality

- Problem
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Typical HTTP streaming setup

- Client must pick what to request
- Careful balance for user satisfaction



- ✓ Problem
- ✓ Background Knowledge
- **Research Motivation**
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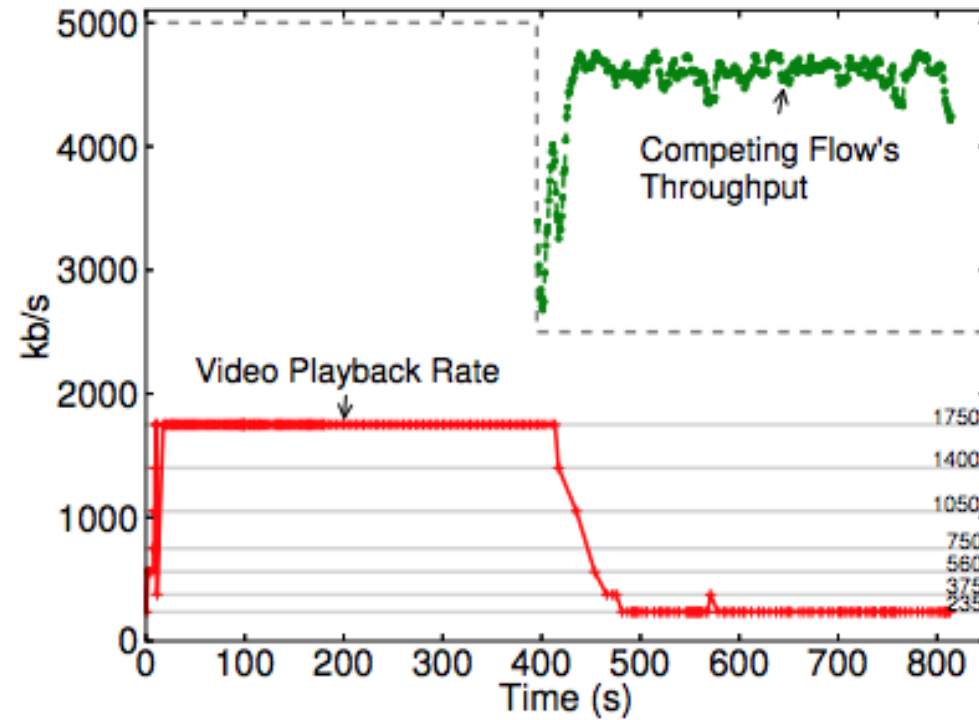
How well do they pick what to request?

The Hulu logo is displayed in a green, lowercase, sans-serif font.The Netflix logo is displayed in a red, uppercase, sans-serif font.The Vudu logo is displayed in a blue, lowercase, sans-serif font.

It's bad

Maximum: 5 Mb/s
Fair Share: 2.5 Mb/s
Optimal: 1.75 Mb/s
Used: 235 kb/s

What makes this so difficult?



- ✓ Problem
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Services are similar - not identical

Ways to stream HTTP video:

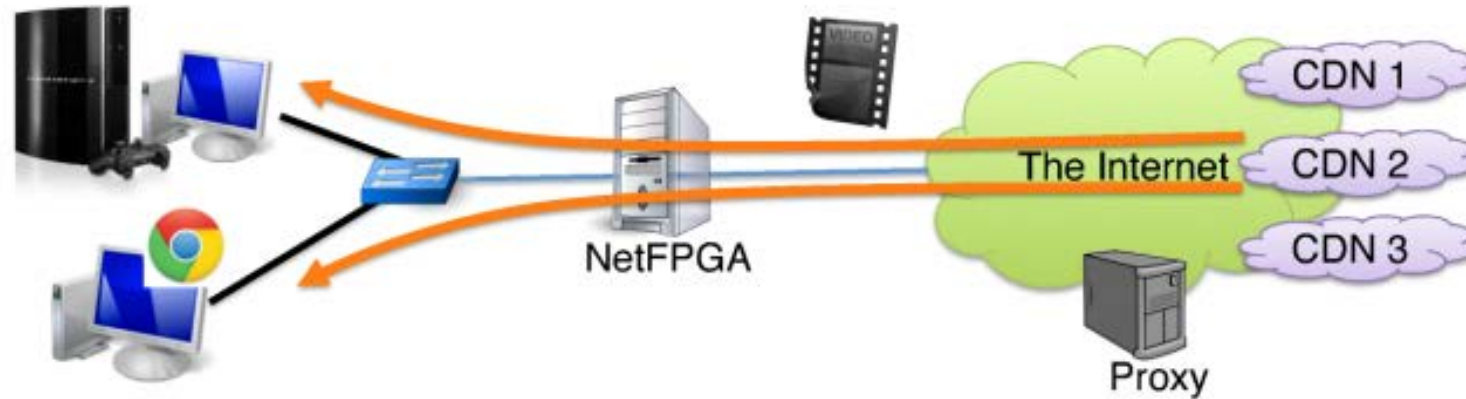
- Web browser vs. PS3
- Single connection vs. many
- Entire file vs. chunks

Implementation Details

Provider	Platform	Download Strategy
Service A	Web Browser	Segment-by-segment download (Persistent connection)
Service B	Sony PlayStation 3	Segment-by-segment download (New connection)
Service C	Sony PlayStation 3	Progressive download (Open-ended download)

Provider	HTTP Request Format	Available Playback Rates (kb/s)
Service A	GET /filename/byte_range?token	235, 375, 560, 750, 1050, 1400, 1750(SD), 2350, 3600(HD)
Service B	GET /filename/clip_num?br=bitrate&token	650, 1000, 1500, 2000, 2500, 3200
Service C	GET /filename?token	SD: 1000, 1500, 2000 HD: 3000, 4500, 6750, 9000

Network Parameter Controls

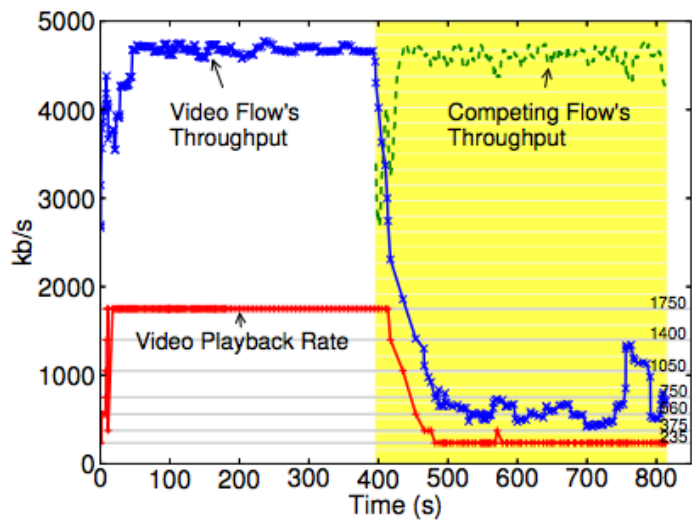


NetFPGA rate limiter: 5 MB/s

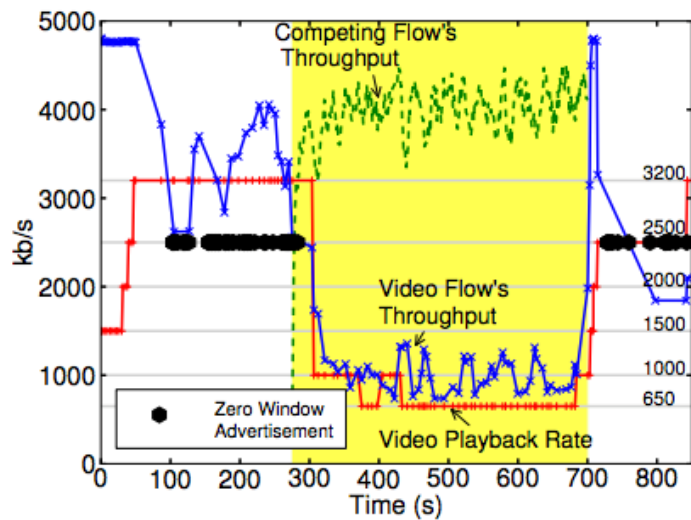
Competing flow: same file, same CDN, simple TCP file download

- ✓ Problem
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- ✓ Research Motivation
- ✓ Experimental Setup
- **First Results**
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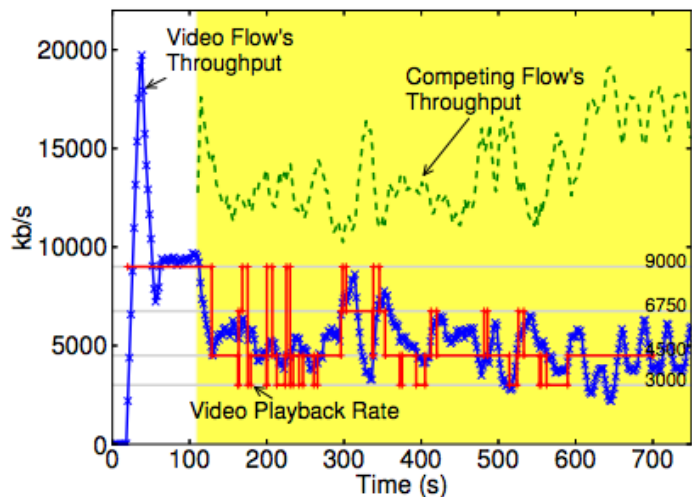
- No surprises - they're terrible 😞
- Repeated 76 times over four days
- 91% of cases failed predictably



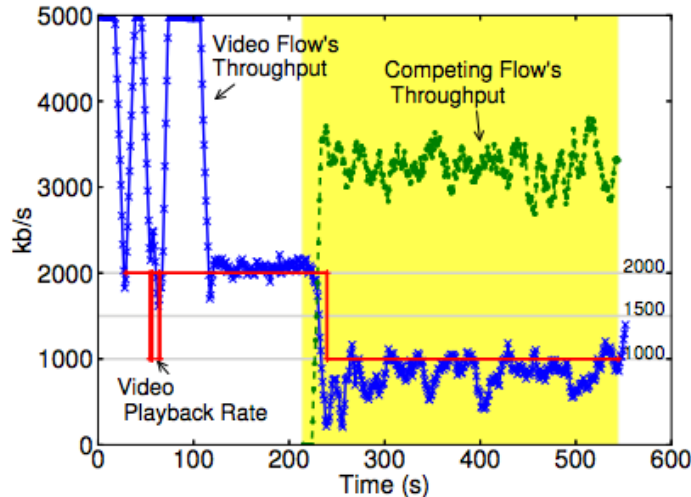
(a) Service A. Network bottleneck set to 5Mb/s.



(b) Service B. Network bottleneck set to 5Mb/s.



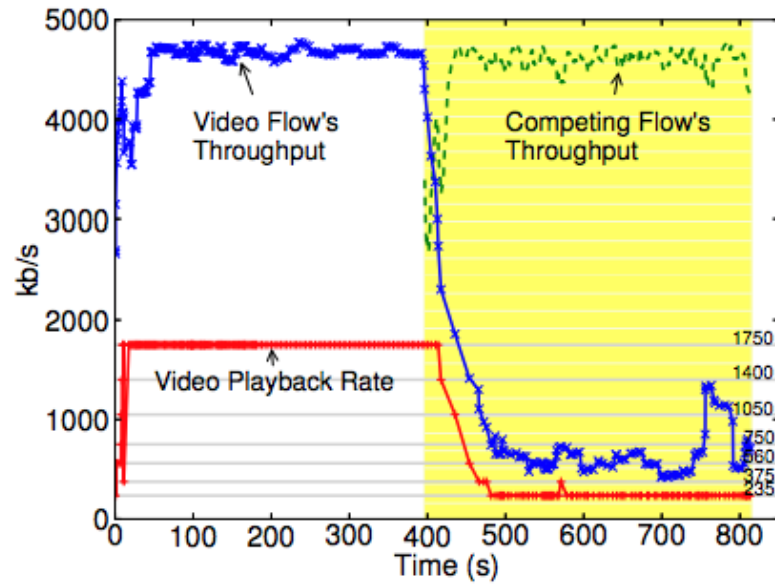
(c) Service C HD. Network bottleneck set to 22Mb/s.



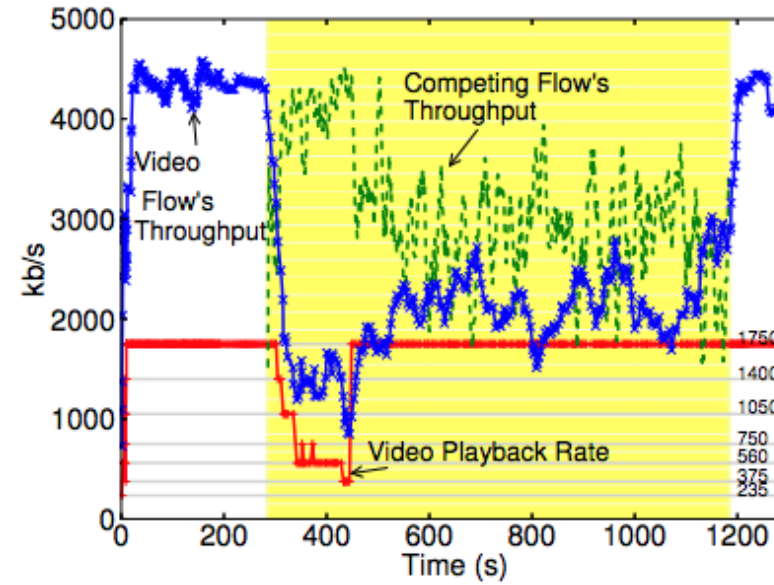
(d) Service C SD. Network bottleneck set to 5Mb/s.

Figure 4: The downward spiral effect is visible in all three services.

Sanity Check?



(a) Service A. Network bottleneck set to 5Mb/s.



- ✓ Problem
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Follow the spiral down

Monitor everything:

- TCP throughput
- Buffer size
- Request interval
- Congestion window



Where do these algorithms go wrong?

Client Network Behavior

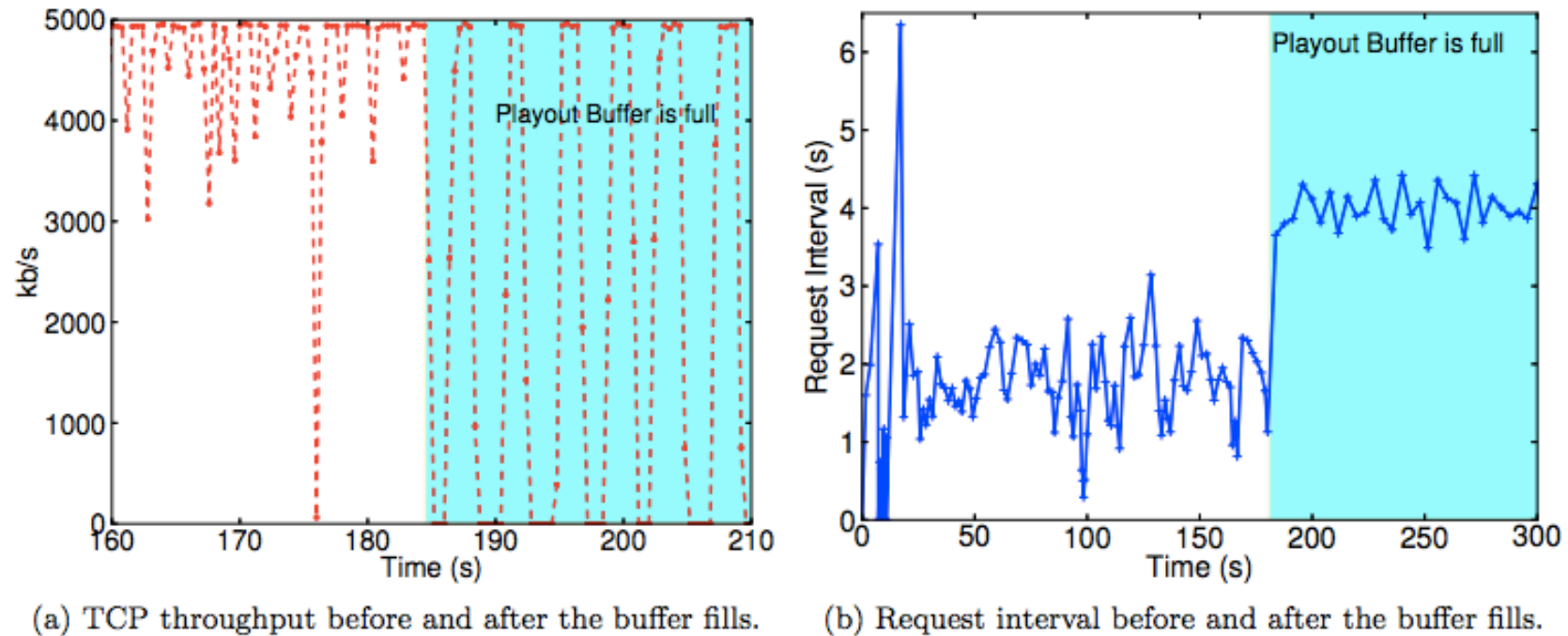
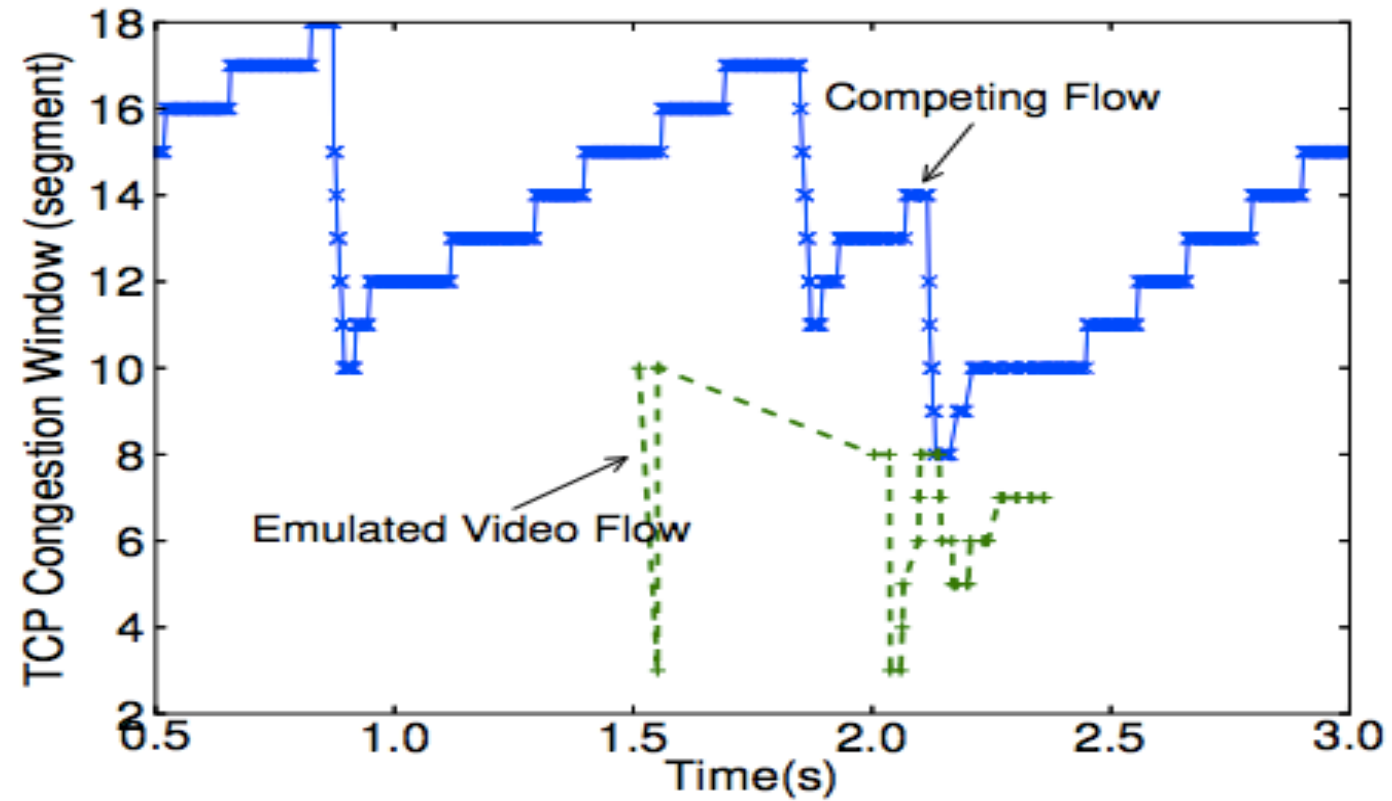


Figure 6: (Service A) Before and after the playback buffer fills at 185 seconds.

TCP Congestion Window

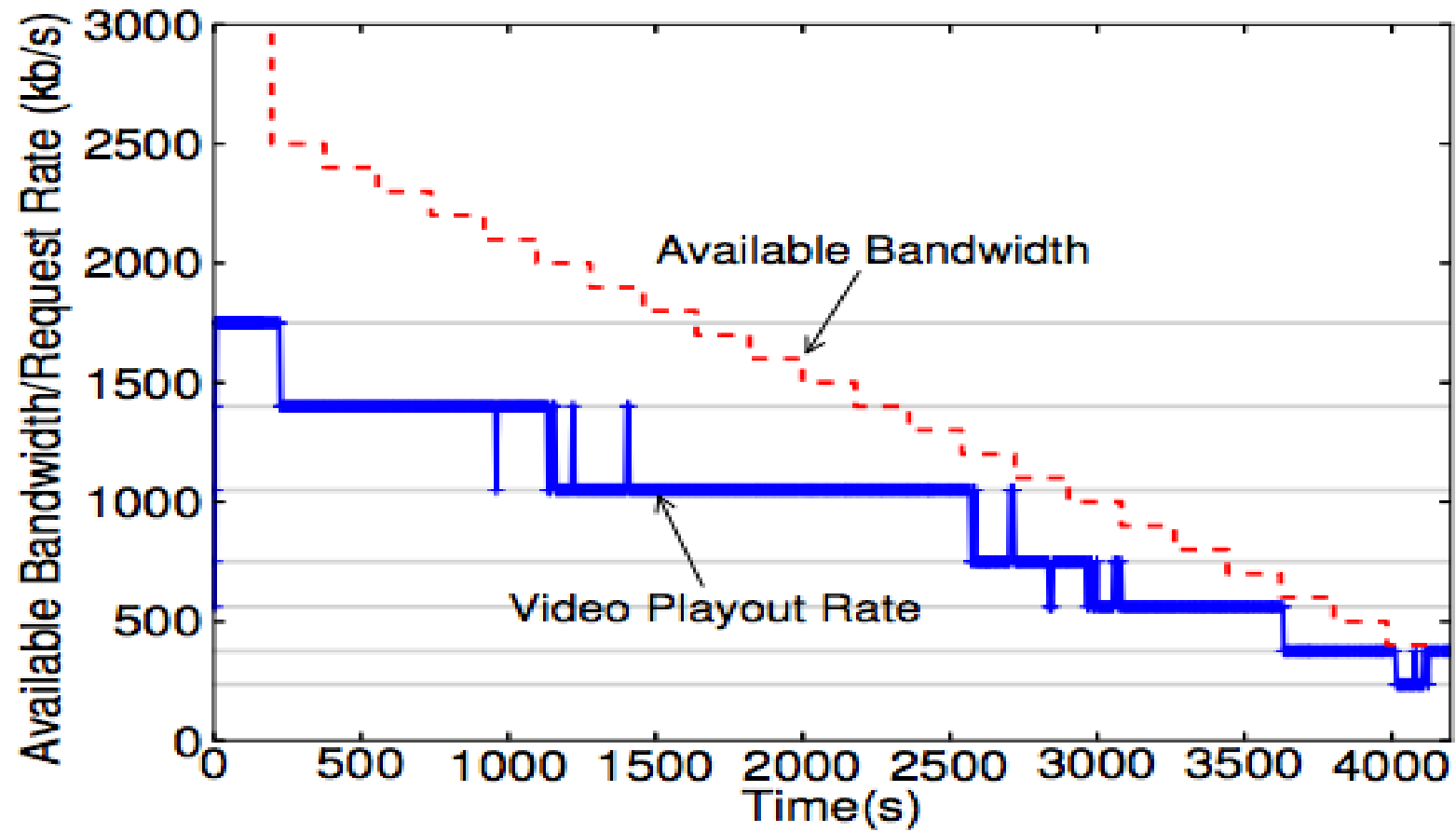
- Times out in 4s OFF period
- Reset to initial value of 10 packets, every time
- Single persistent connection
- Ramp up from slow start for each segment anyway
- No competing flow? No problem

Completely Squashed



(a) A 235kbps Segment.

Rational Behavior



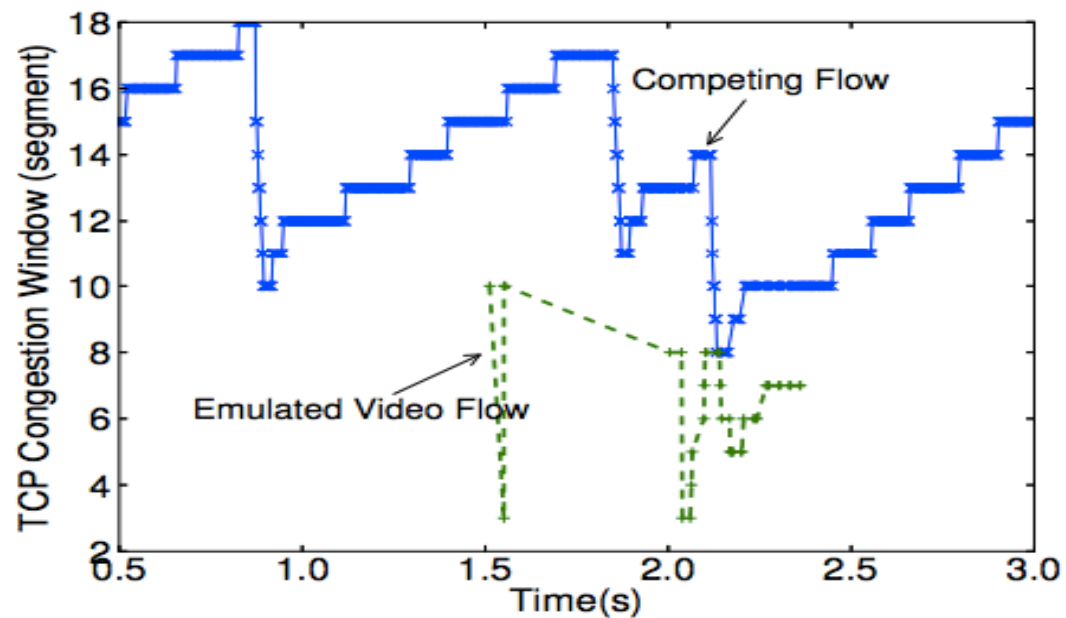
A More Complete Picture

- Playback buffer fills – starts periodic ON-OFF
- During OFF period:
 - Video stream congestion window idle resets
 - Competing flow is still going, filling the routers buffer
- ON period starts:
 - Very high initial packet loss
 - Estimate artificially low bandwidth
 - Lower playback rate

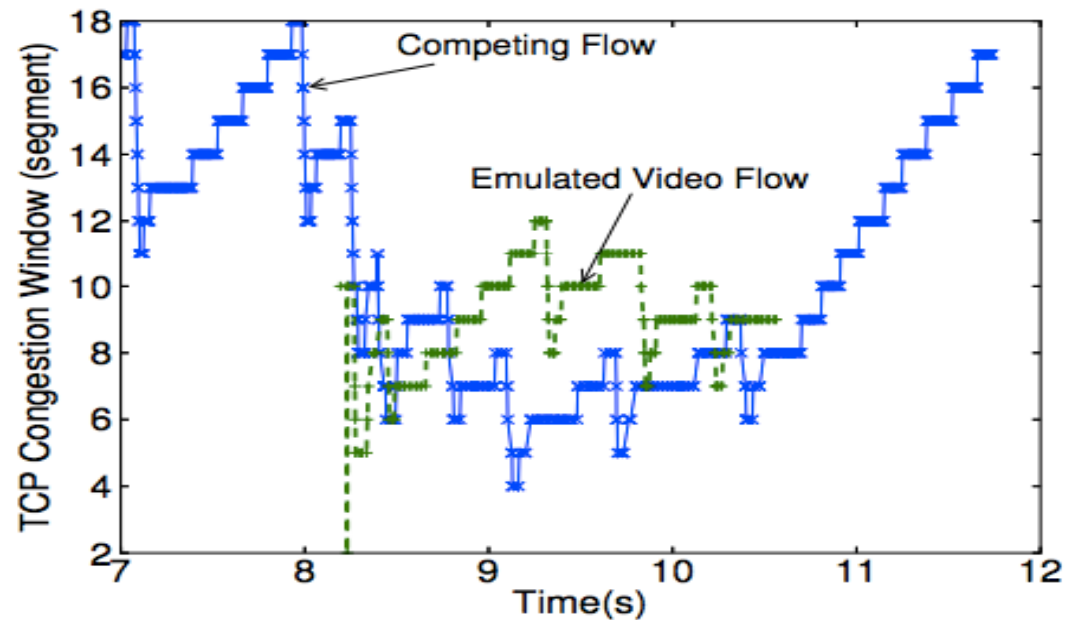
The “Spiral” Part

- ON period starts:
 - Very high initial packet loss
 - Estimate artificially low bandwidth
 - Lower playback rate – which means *shorter* segments
- Each estimate is ever lower than the previous
- Spiral down until you can't play lower quality

Another Thing - Timing



(a) A 235kbps Segment.



(b) Five contiguous 235kbps segments concatenated into one.

Figure 8: (Service A) The evolution of *cwnd* for different segment sizes.

- ✓ Problem
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Mimic Service A

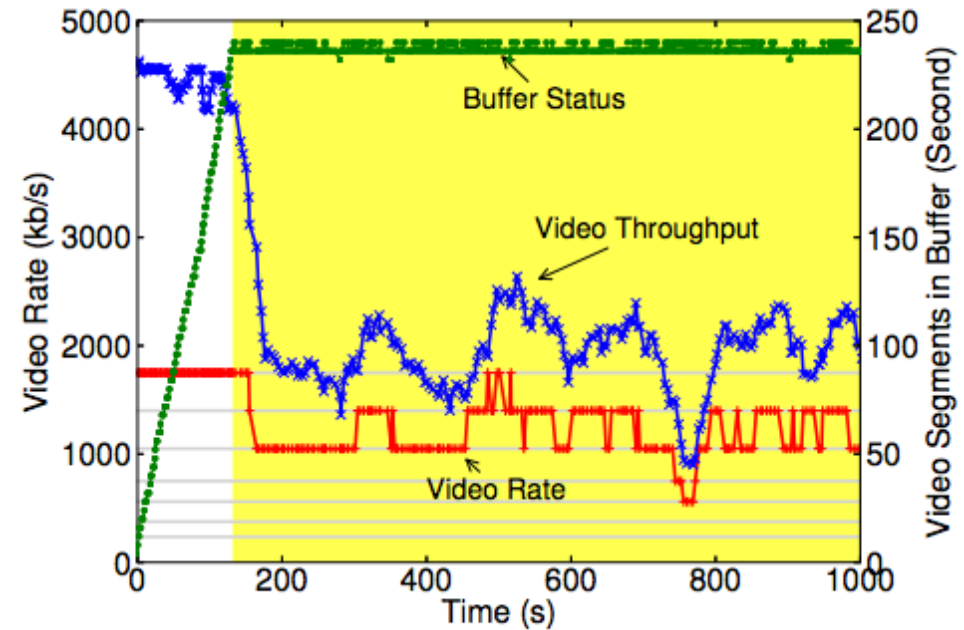
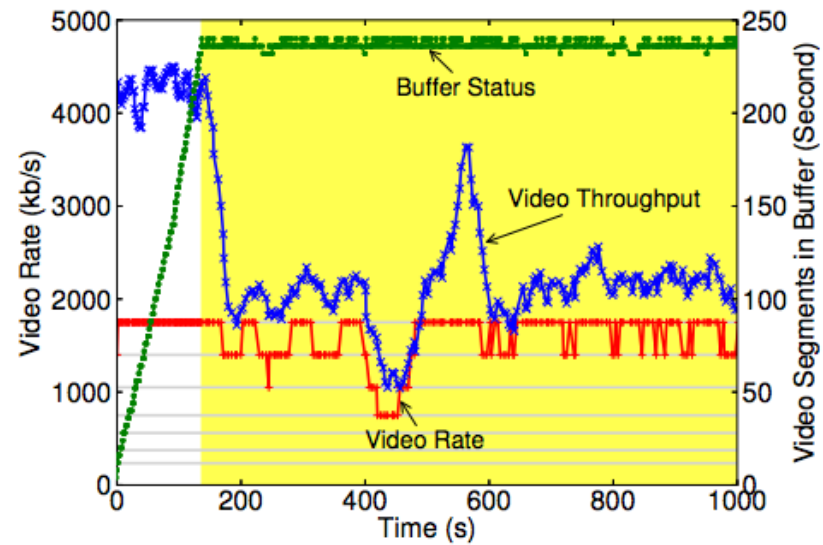


Figure 20: Custom client, similar to Service A – equally conservative, with a 10-sample moving average filter – displays the downward spiral.

Less Conservative

- Service A ~40%
- Try out 10%



Better Filtering

- Service A: ten sample moving average
- Try: 80th percentile

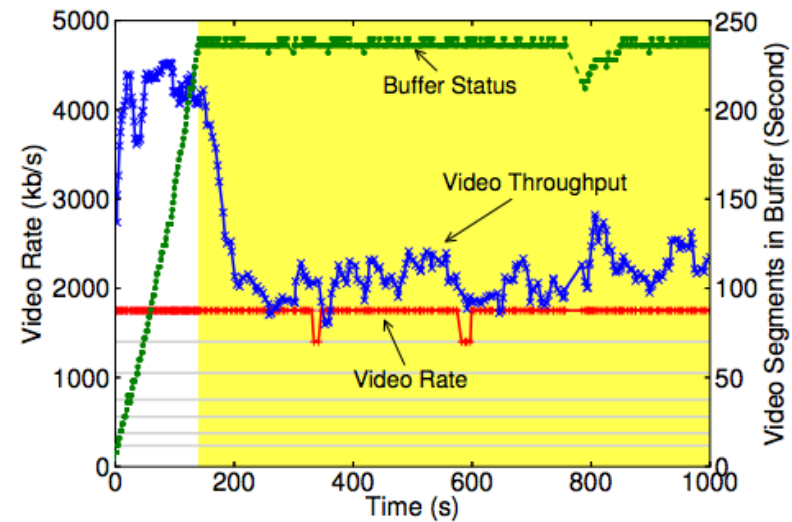


Figure 22: Custom client – with 10% conservatism, and with an 80th-percentile filter.

Finally: Bigger Segments

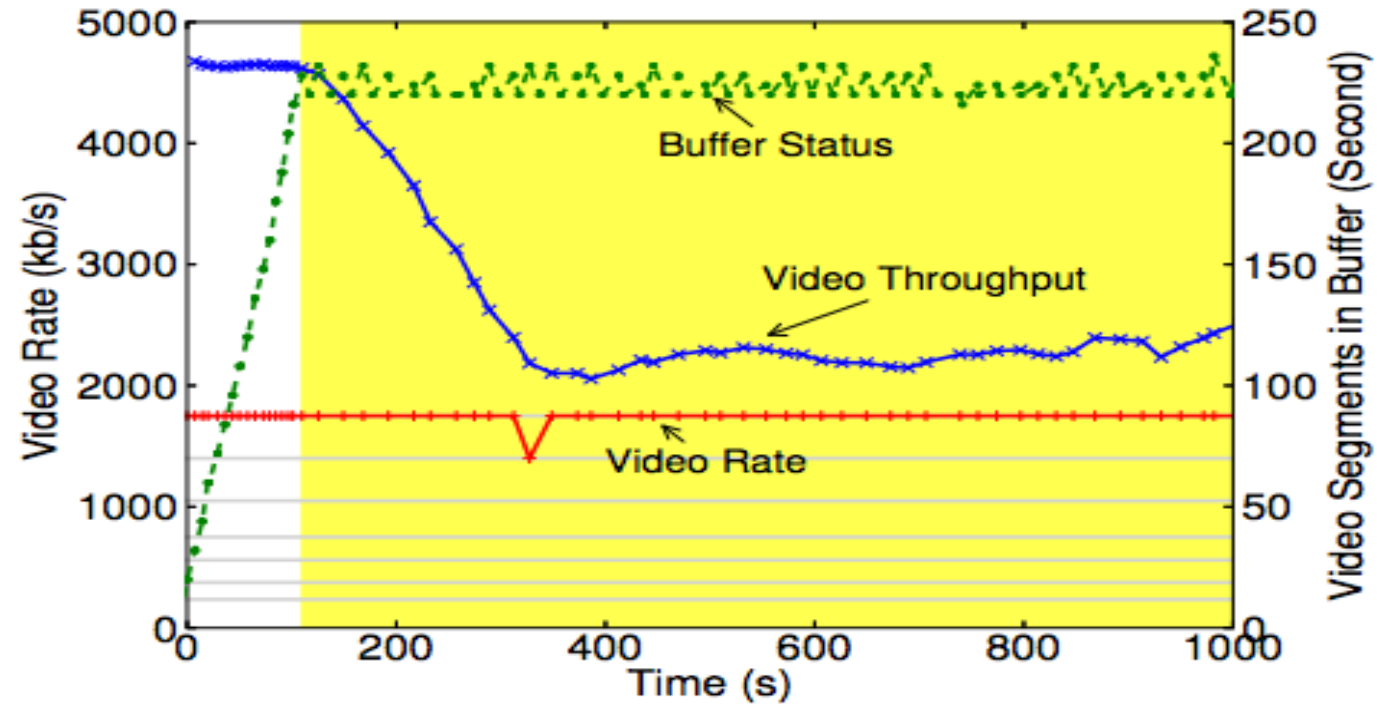
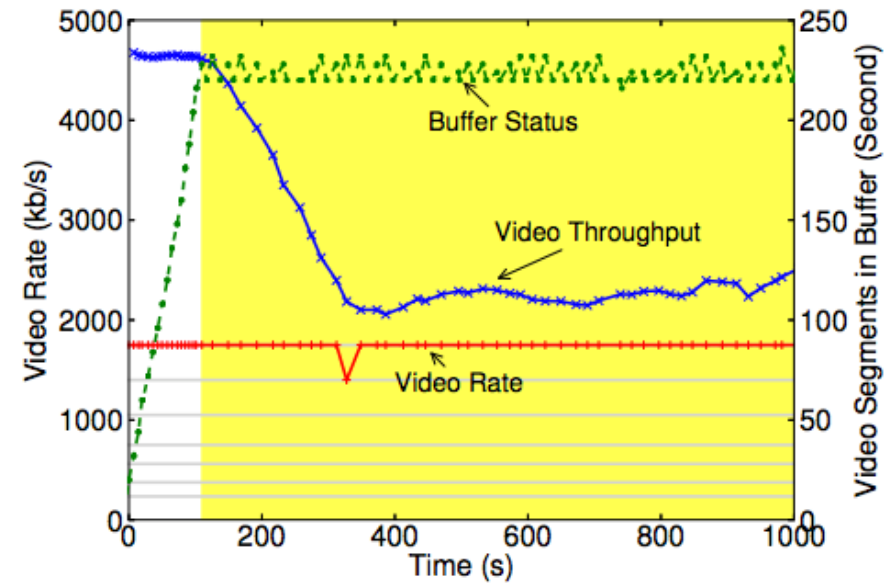
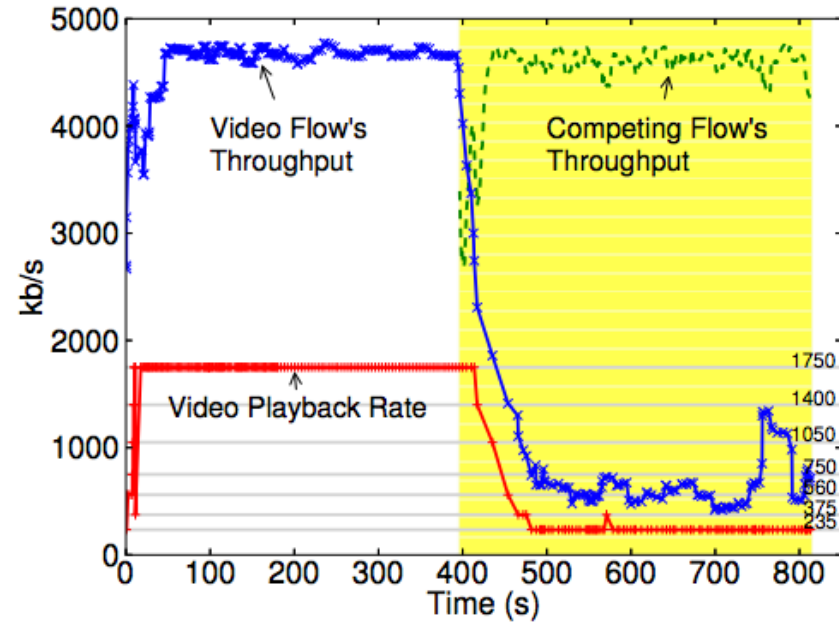


Figure 23: Custom client with increased segment size (5x).

- ✓ Problem
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- ✓ Research Motivation
- ✓ Experimental Setup
- ✓ First Results
- ✓ Downward Spiral
- ✓ Intervention
- Before, After



To Conclude

- On the one hand, there are changes to how the client estimates bandwidth which can improve its interplay with TCPs congestion control
- A more radical solution:
 - Don't attempt to estimate bandwidth at all
 - Competing goals: highest bitrate, and no underruns
 - Goal is NOT “keep the buffer full”
 - Goal is “don't let the buffer get empty”
 - Increase the playback bitrate when the buffer is high
 - Decrease the playback bitrate when the buffer is low
- Perfect layer of separation:
 - TCP responsible for delivering fair share bandwidth
 - Video player responsible for showing the highest rate it can

Questions

Thank you for listening