Project Details

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CS 179i: Project in Computer Science (Networks)

Lectures: Monday 3:10-4pm in Spieth 1307

http://www.cs.ucr.edu/~jiasi/teaching/cs179i_winter16/

Outline

- Virtual reality
- Video streaming
- Download booster
- Proposal

Virtual Reality
Using Commodity Hardware

Two Different Platforms

- Google Cardboard
  - $20 cardboard viewer to use any smartphone as a VR display

- Samsung Gear VR
  - Only certain Samsung phones (Galaxy S6, Note5)
  - Better motion-tracking, higher resolution screens
  - Passthrough-camera enabled
- Resources
  - Cardboard Android API: https://developers.google.com/cardboard/android/
  - Gear VR Android development: http://www.gearvrf.org/

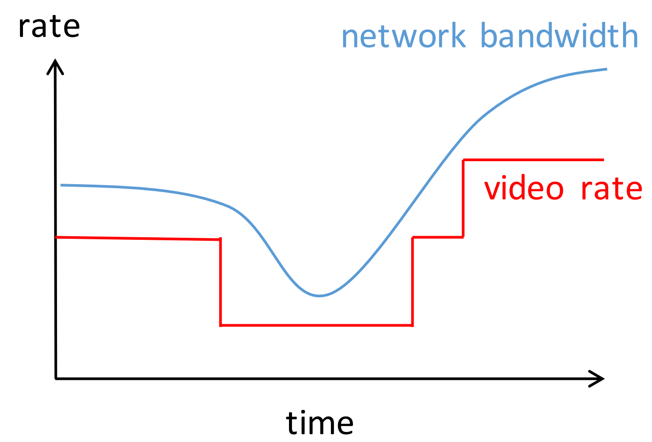
Virtual Reality Project Ideas

- StreetView
  - Create a virtual tour of a location
- Live streaming
  - Stream the scene from your VR device to another user
- Augmented reality with the Samsung Gear VR
  - Has passthrough camera, but not powerful enough for augmented reality [1]
  - What if some processing could be offloaded to nearby devices?

MPEG-DASH Video Streaming

MPEG-DASH Protocol

- MPEG-DASH
  - APP-layer protocol for adapting video quality to network conditions
  - Client-driven: client estimates network conditions and requests appropriate video quality
  - Standard doesn't specify adaptation algorithm, just the communication protocol between client and server



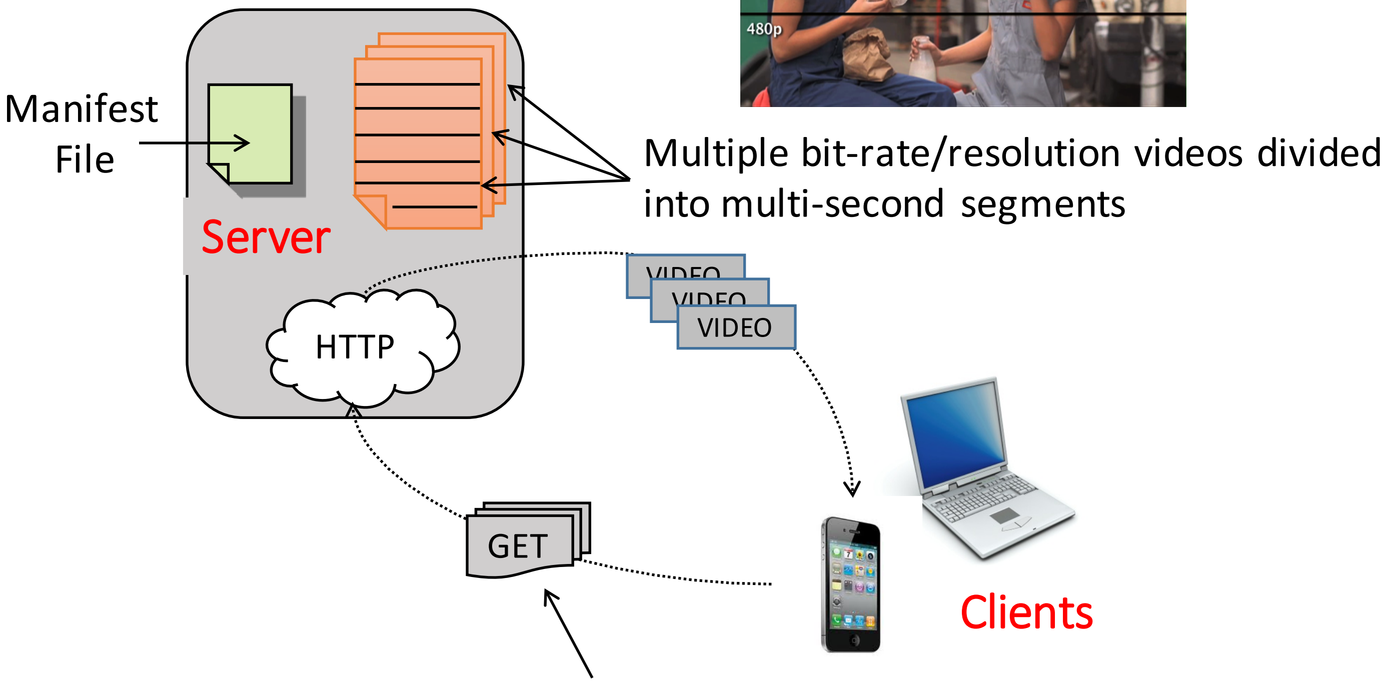
- Who uses it?

Project Goal

- Current approaches
  - Numerous approaches proposed in research literature and in practice
  - Need a apples-to-apples comparison under common set of test conditions

- Resources
  - MPEG-DASH video player:
    https://github.com/Dash-Industry-Forum/dash.js/wiki

How DASH Works



- Clients request a new video segment every ***X*** seconds.
- The bit-rate of the requested segment is based on the average TCP throughput of last ***Y*** segments.

General Video Rate Adaptation Algorithm

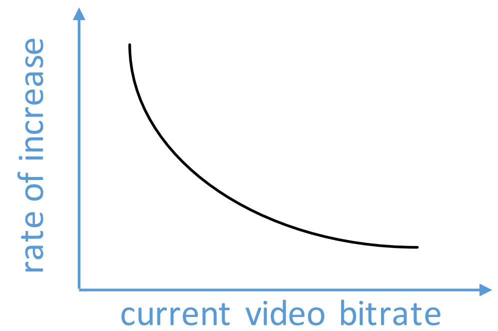
1. Estimate bandwidth
   1. Update bandwidth estimate of i^{th} chunk, B[i]
   2. Based on previous bandwidth estimates B[1], B[2], ..., B[i], predict new bandwidth B[i+1]
2. Make new video rate selection
   1. Pick the new video rate R = f(video bitrate, network bandwidth, buffer size)
   2. t++
3. Go to step 1

Current Approach 1: Bandwidth-based

- Default approach: R[t+1] = max {r : r < B[t+1]}

- Problem: higher bitrates → higher bandwidth estimate → unfair competition between clients
  - Lower overhead for higher bitrates

- R = f(previous video bitrate, bandwidth estimate)
  = f(R[t], B[t+1])

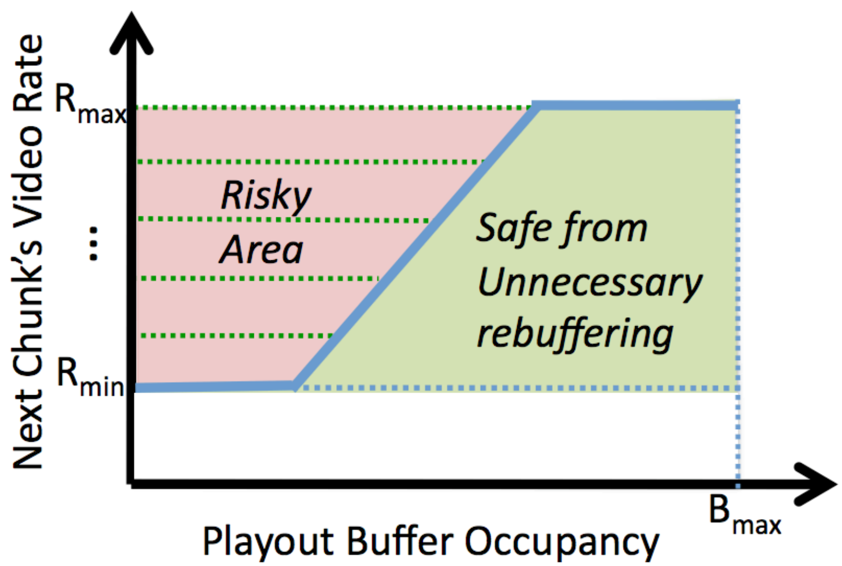


- Compensate by ramping up quickly for lower bitrates, ramping up slowly for higher bitrates

Reference: http://conferences.sigcomm.org/co-next/2012/eproceedings/conext/p97.pdf

Current Approach 2: Buffer-based

- In steady state, R = f(buffer size)



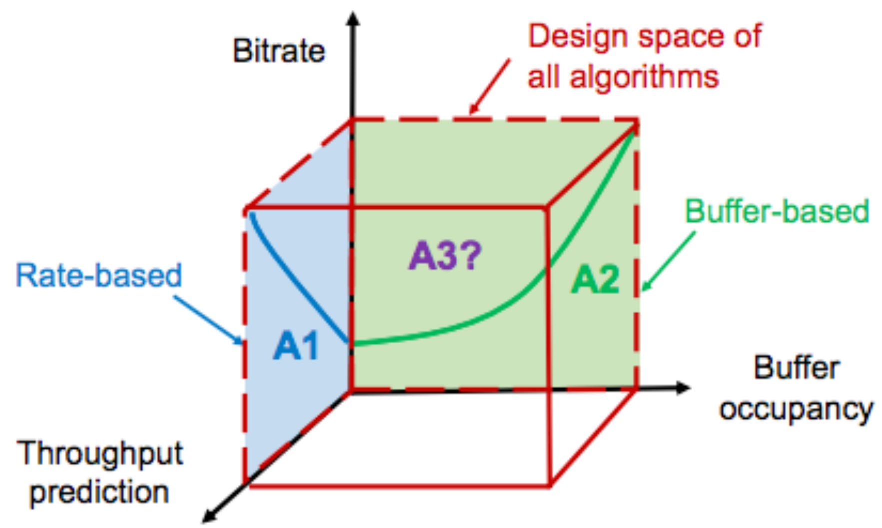
Reference: http://yuba.stanford.edu/~nickm/papers/sigcomm2014-video.pdf

Current Approach 3: Bandwidth + Buffer-based

- Look into the future: make bandwidth predictions for the next N time slots

- R = f(previous video bitrate,
  bandwidth estimate, buffer)
  = f(R[t], B[t], …, B[t+N], buffer size)

- Markov decision process with online table lookup
    - Multi-criterion objective



Reference: http://conferences.sigcomm.org/sigcomm/2015/pdf/papers/p325.pdf

Download Booster

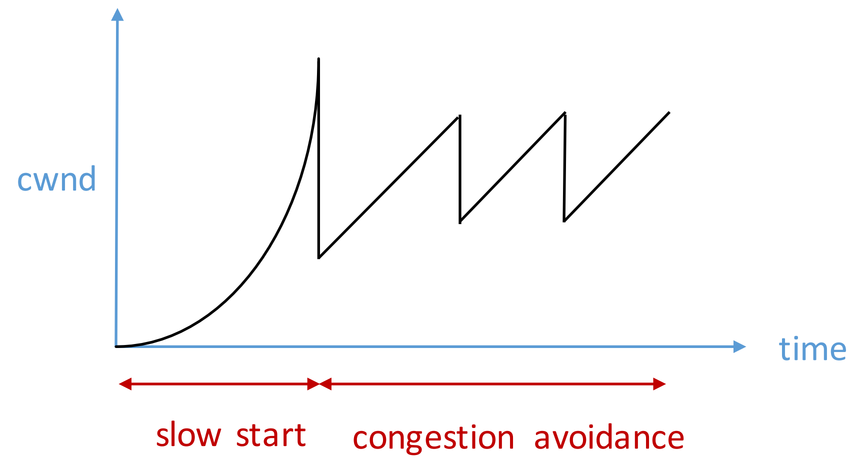
Download Booster

- Want to speed up downloads of large files by using multiple interfaces simultaneously (e.g., WiFi, 4G, Ethernet)
- Samsung introduced Download Booster, but it got blocked by major carriers
- Multipath-TCP is another major standardization effort to enable multiple networks

Review of TCP Throughput

- Control transmission rate by setting windowsize
  - Window size = min {cwnd, rwnd}
  - cwnd = congestion window (set by sender)
  - rwnd = receive window (set by receiver)

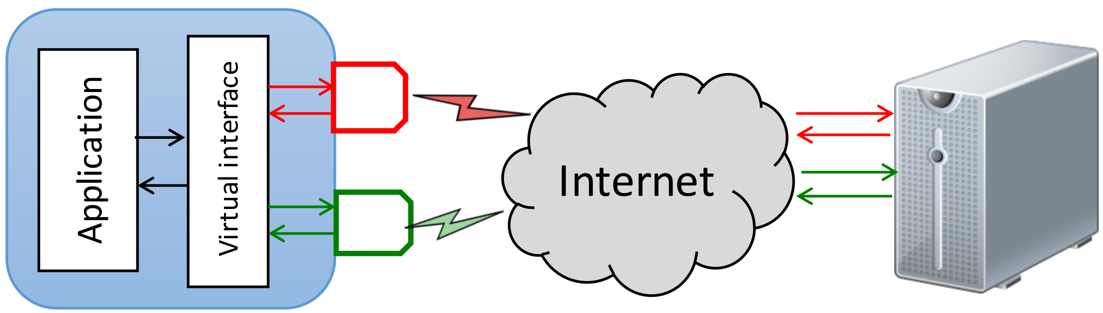
- Scheduler (multiple networks only)
  - If # of pkts to send < window size, which pipe should I send the pkts on?



TCP congestion avoidance:

If ACK received:
cwnd ← cwnd + 1/cwnd
If loss:
cwnd ← cwnd/2

Transport and Application Layer Approaches



Transport layer: multipath-TCP

- MPTCP congestion control + (default, round robin) scheduler
- Fine-grained scheduler control (operate on packets)

Application layer: HTTP proxy

- TCP congestion control + your scheduler
- Coarse-grained scheduler control (operate on chunks)

Multipath-TCP

- Congestion control
  - Separate congestion window for each subflow *r*

MPTCP default [1]

If ACK received:

$$cwnd_r \leftarrow cwnd_r + \frac{\max_i \left\{\frac{cwnd_i}{RTT_i^2}\right\}}{\left(\sum_i cwnd_i/RTT_i\right)^2}$$

If loss:

cwnd ← cwnd/2

Pareto-optimal [2]

If ACK received:

$$cwnd_r \leftarrow cwnd_r + \frac{cwnd_r/RTT_r^2}{\left(\sum_i cwnd_i/RTT_i\right)^2} + \frac{a_r}{cwnd_r}$$

If loss:

cwnd ← cwnd/2

- Scheduler
  - Default: Send packets on the pipe with the lowest RTT
  - Round-robin: May leave space open in congestion window

[1] https://www.eecs.berkeley.edu/~sylvia/cs268-2014/papers/mptcp.pdf
[2] http://conferences.sigcomm.org/co-next/2012/eproceedings/conext/p1.pdf

HTTP Proxy

- Congestion control
  - Standard TCP congestion control on each pipe

```
If ACK received:
        cwnd ← cwnd + 1/cwnd
If loss:
        cwnd ← cwnd/2
```

- Scheduler
  - How to schedule packets onto each pipe? Your design!
  - E.g., schedule packets proportional to estimated bandwidth

Proposal

- 2-page summary and plan of your project
  - Worth 10% of your grade

- Sections
  - Executive summary
  - Comparison against other approaches
    - e.g., startups, research papers, commercial products
  - Target features
    - Milestone 0 (oral progress update on 2/16/16)
    - Milestone 1
  - Methodology (e.g., tools, programming languages)
  - Evaluation (e.g., testbed, metrics)

Proposal

- Make sure to address
  - What makes your project interesting? Does it fulfil some unmet need? Who is it useful for?
  - At least one figure showing system design/architecture
- If you're choosing an existing project (MPEG-DASH or MPTCP)
  - Read the references, compare them, and discuss what you expect to find/improve
- If you're choosing your own project
  - Why should someone invest in your "startup"?
- Written feedback by 1/22/16

Conclusions

- Next class
  - Design tips
- Lab this week
  - Work on your proposal
- To do by next Monday (1/18)
  - Submit proposal via iLearn by 3:10pm (one per group)