Content Distribution Networks (CDNs)

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Yesterday

End-User Mapping: Next Generation Request Routing for Content Delivery

Today at 1:45pm

Practical, Real-time Centralized Control for CDN-based Live Video Delivery

A Control-Theoretic Approach for Dynamic Adaptive Video Streaming over HTTP
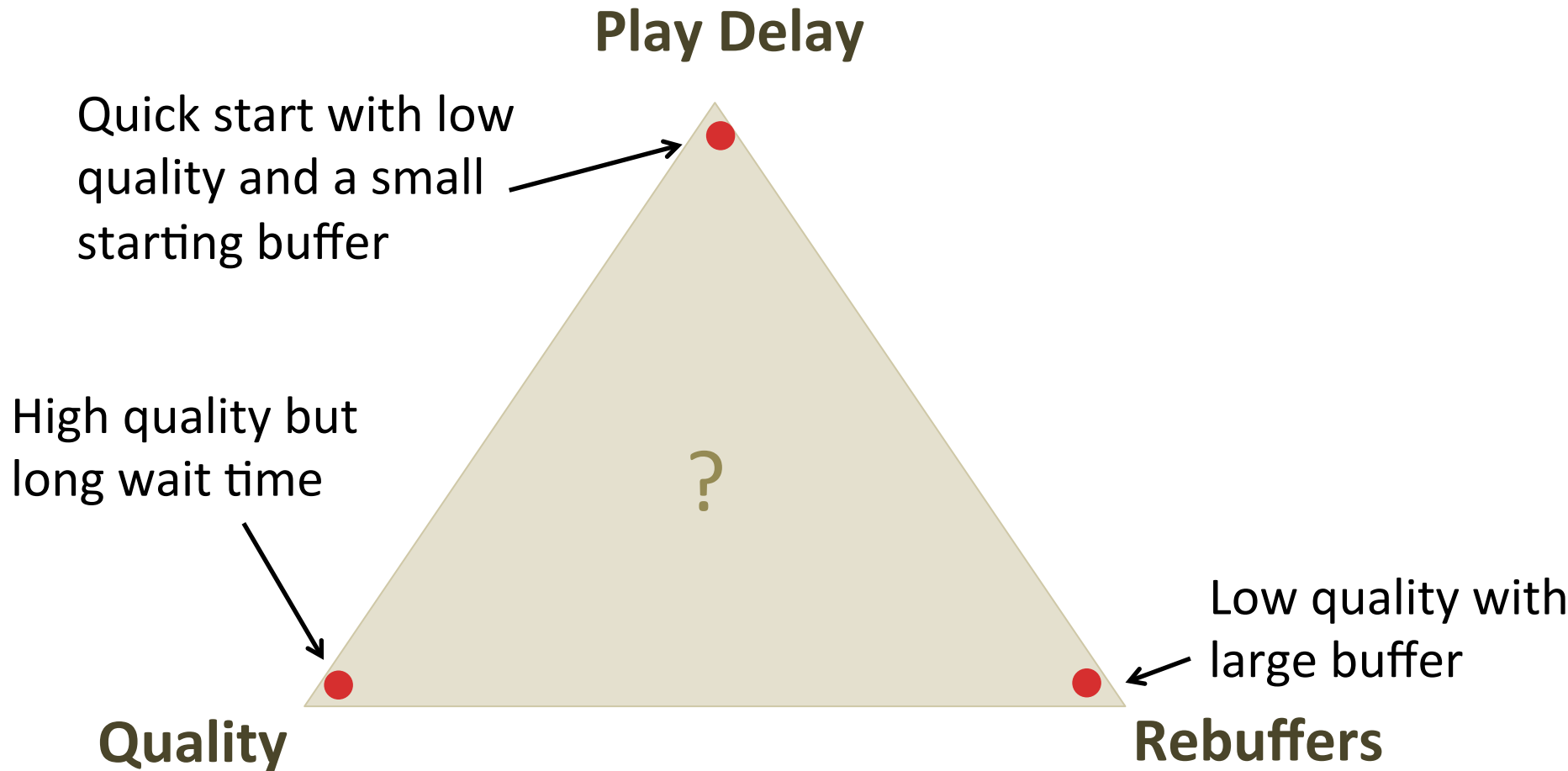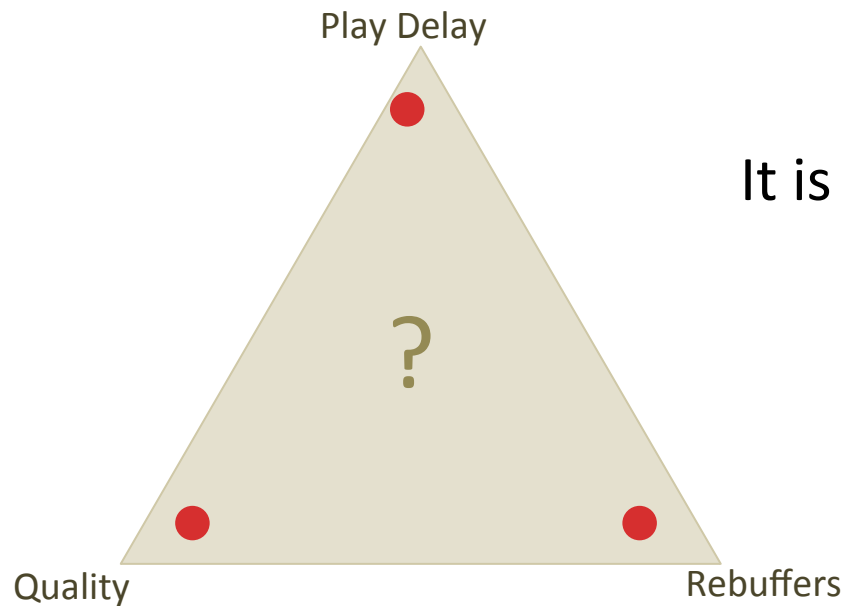
Welcome to the Video Session!

What makes a for good streaming experience?

- Quick start (small **play delay**)
- High Quality (high **video rate**)
- No interruption (no **rebuffer**)

Network conditions change & are hard to predict

so is hard to achieve all three goals!

QoE Metrics & Trade-Offs

Play Delay

Quick start with low quality and a small starting buffer

High quality but long wait time

?

Low quality with large buffer

Quality

Rebuffers

Play Delay

?

Quality   Rebuffers

It is a hard Problem!

Research Questions:

- Do humans weight one metric more than another?

  - QoE modeling, user studies
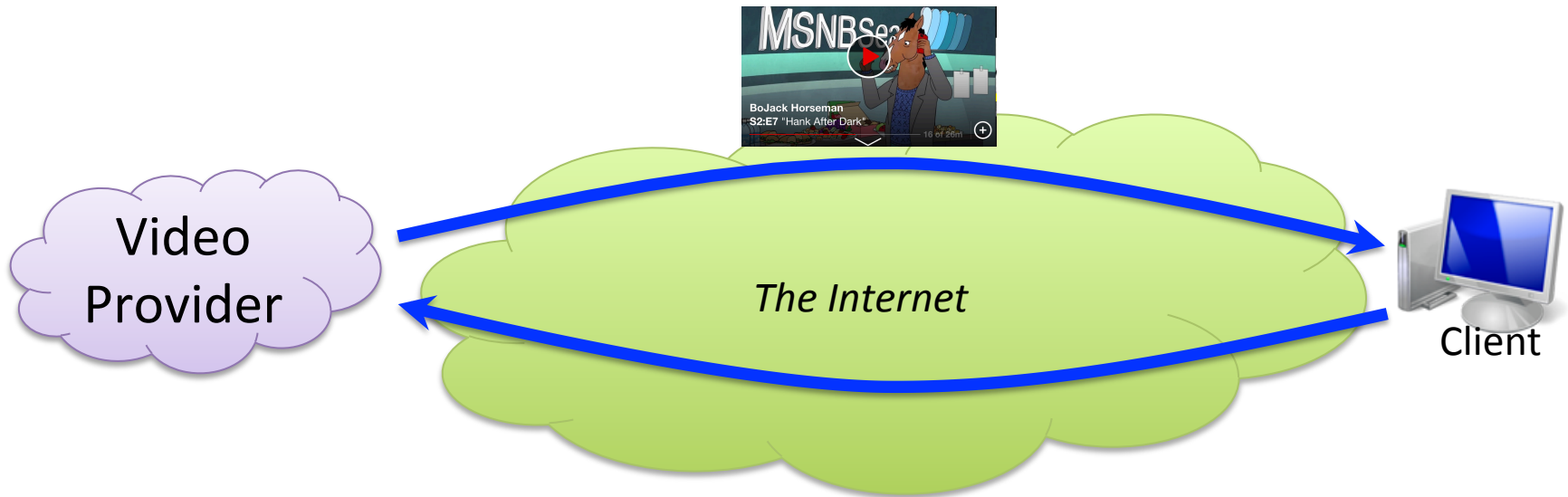
- How to better design a video delivery system?

What does a video delivery system look like?
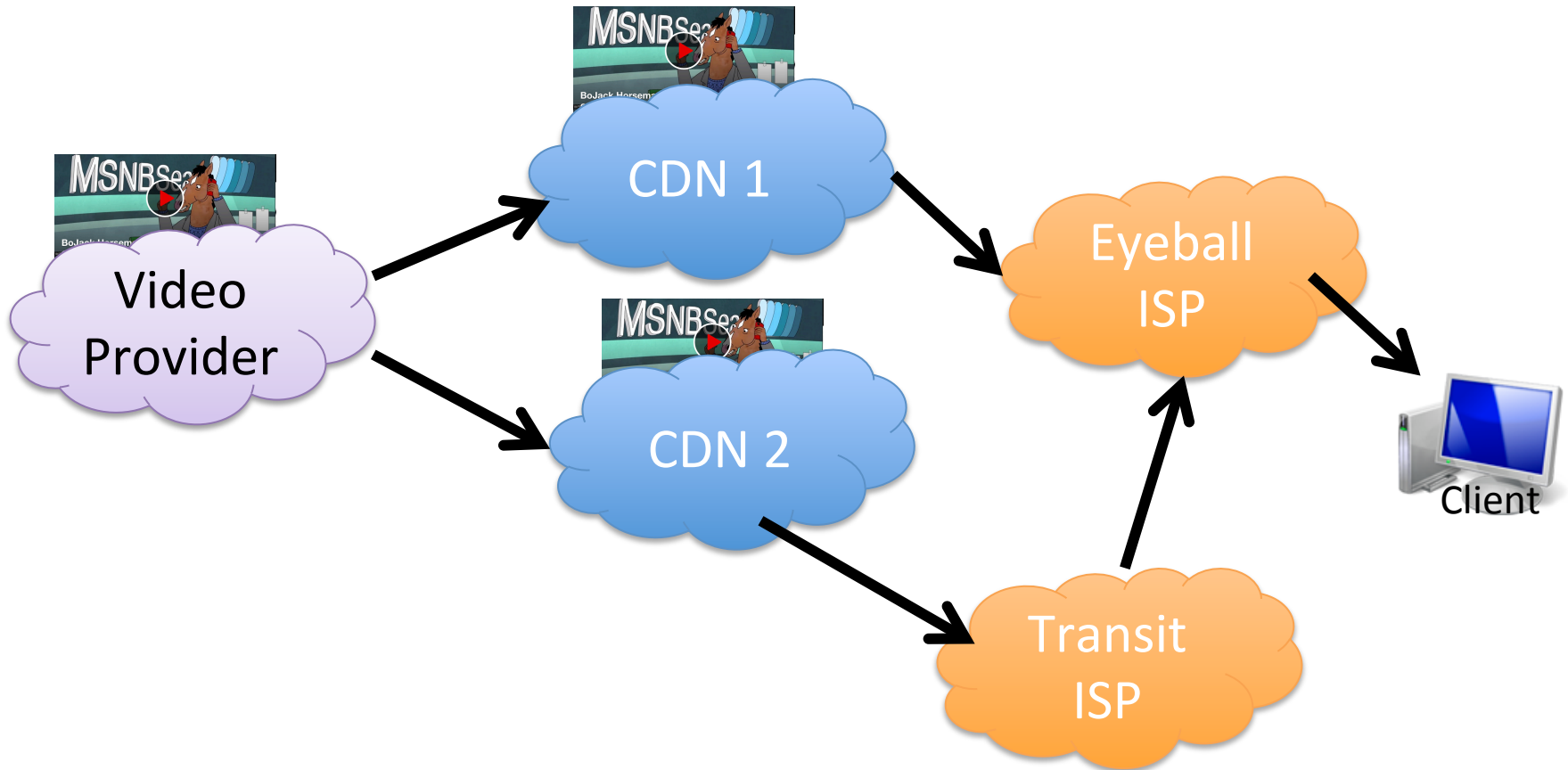
What a video delivery system looks like?

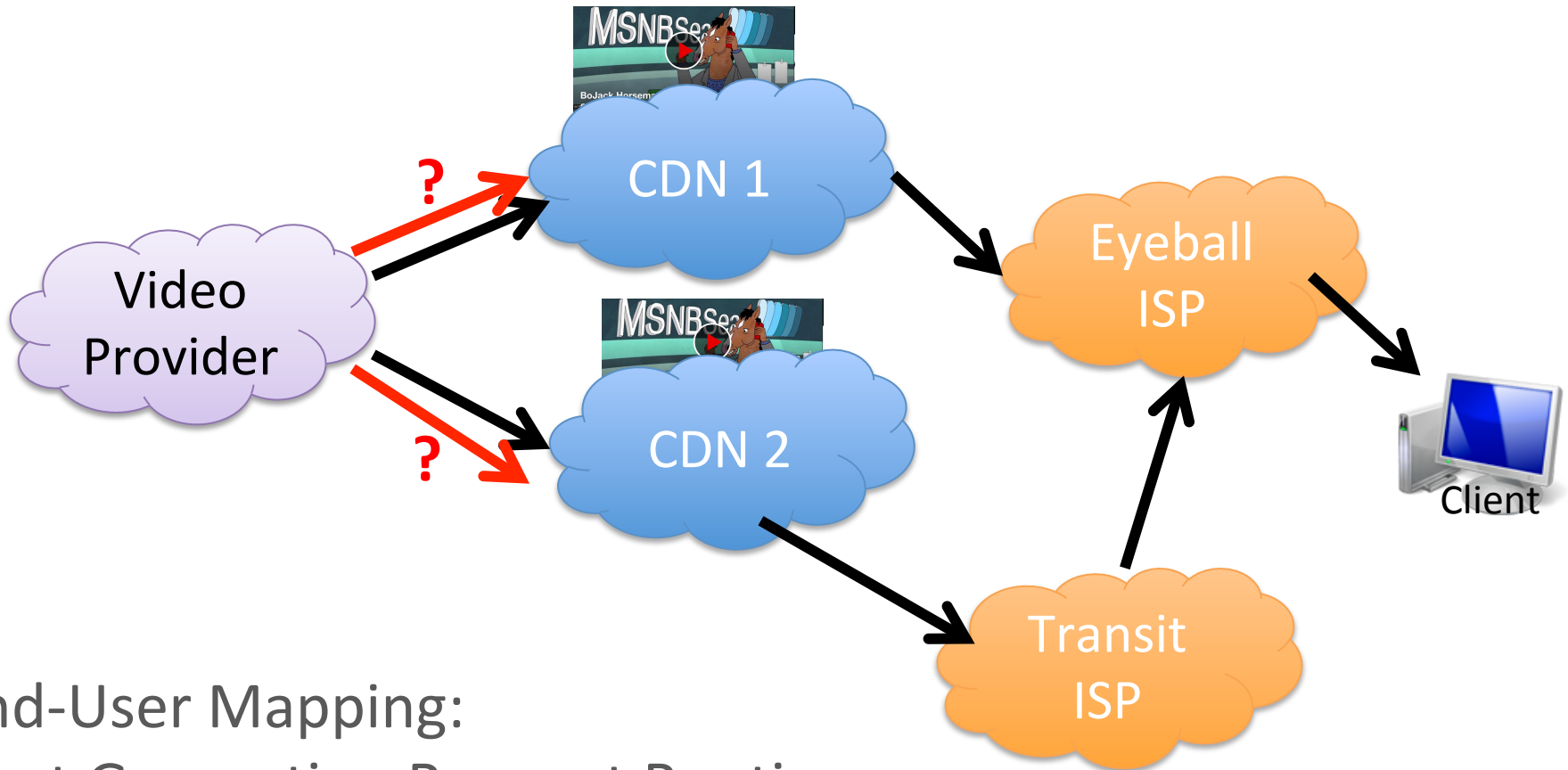## What happens when I click play?

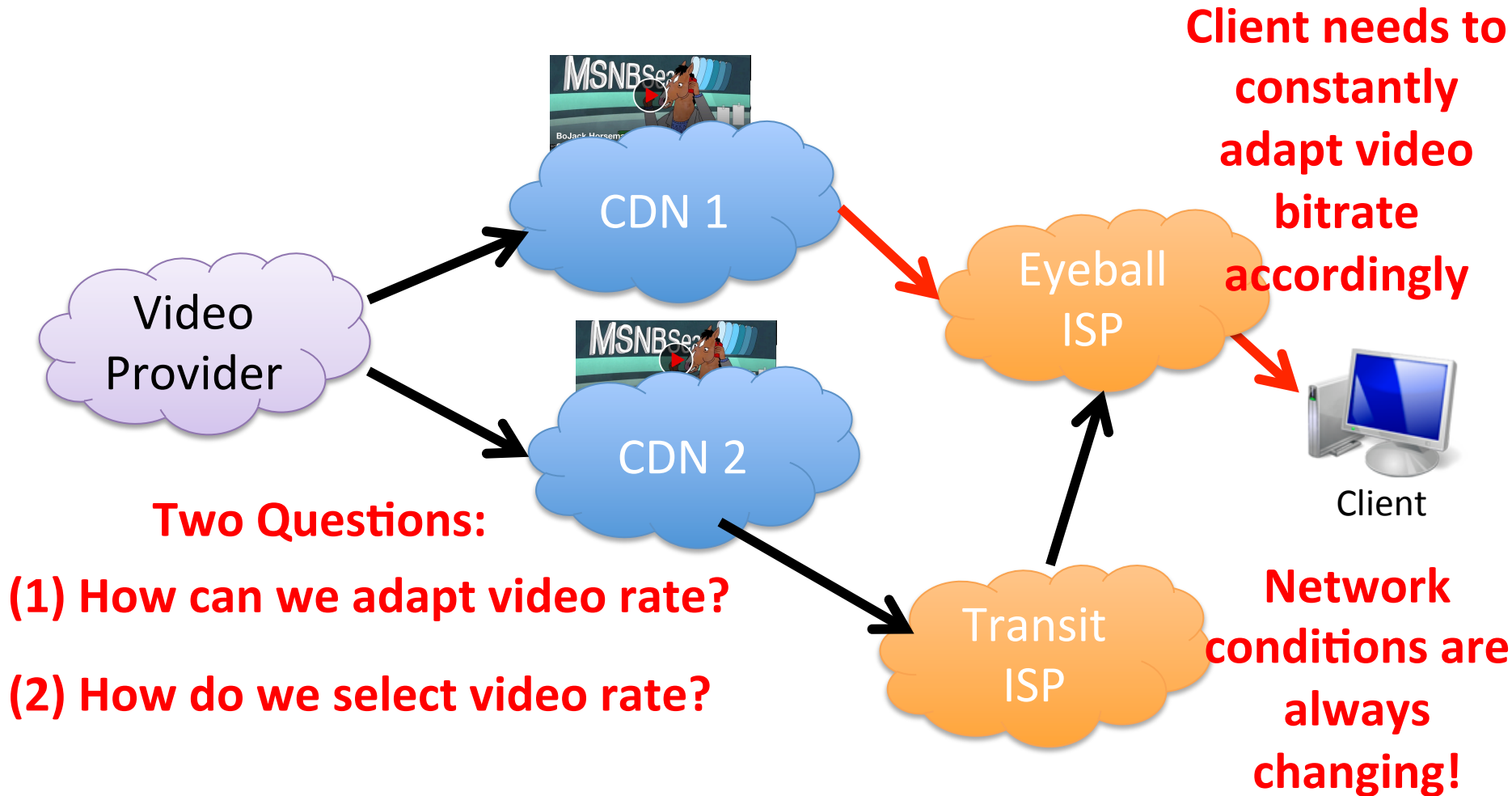# Video Streaming From 10,000 Feet

Video Streaming From 10,000 Feet

Which CDN to use?

End-User Mapping:
Next Generation Request Routing
for Content Delivery

Which Bitrate a Client Should Request?

Client needs to constantly adapt video bitrate accordingly

Video Provider

CDN 1

CDN 2

Eyeball ISP

Transit ISP

Client

Network conditions are always changing!

Two Questions:

(1) How can we adapt video rate?

(2) How do we select video rate?

How Video Bitrate is Adapted?

- Video is encoded into different quality streams

2 Mbps stream

| chunk 1 | chunk 2 | ··· |

1 Mbps stream

| chunk 1 | chunk 2 | chunk 3 | chunk 4 | chunk 5 |

500 Kbps stream

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

- Client selects video bitrate for each chunk

| 1 | 2 | 3 | 4 | 5 |

Which Video Bitrate to Select?

- Ideally, if we know the bandwidth
  - Select a video bitrate right under it
- Some people works on bandwidth prediction
  - Network conditions are changing
    - Prediction is hard to get perfectly right

Bandwidth (y-axis), Δt (x-axis), Connection Bandwidth, Video bitrate
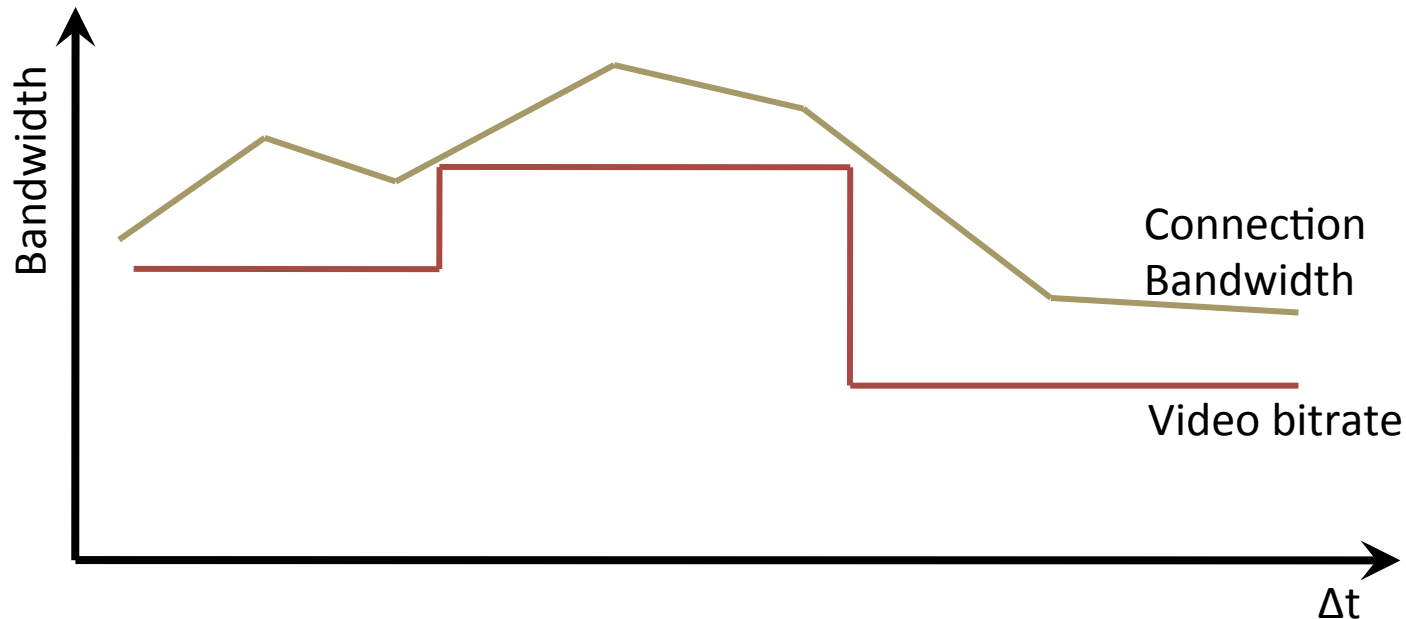
Which Video Bitrate to Select?

- Others work on using video buffer occupancy as a signal
  - Video buffer level is the state variable
  - When just started up,
    - No buffer is available
- Neither buffer or prediction is perfect
  - A Control-Theoretic Approach for Dynamic Adaptive Video Streaming over HTTP
    - Second paper of the session

Input (Fill) Rate

Buffer Level

Output (Drain) Rate
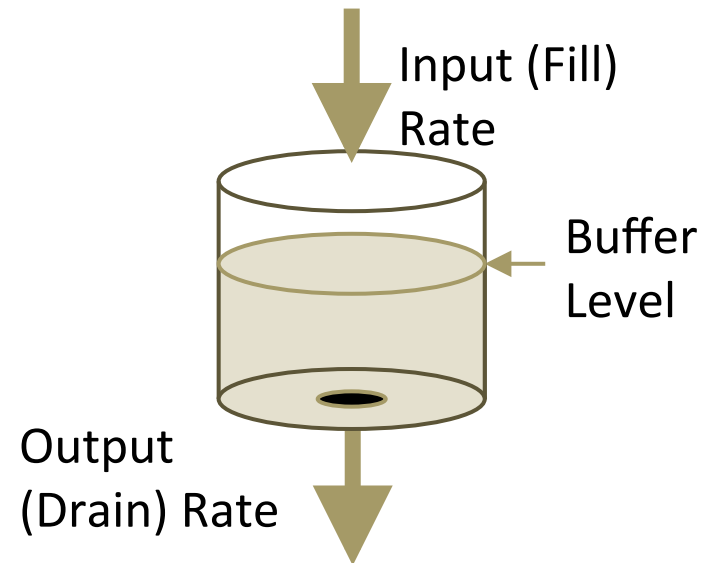
What about Live Streaming?

- Different challenge: concurrently serving the video to multiple users
  - Each user has different network condition & request a different bitrate
    - How to group users to best use of the resource?
      - Practical, Real-time Centralized Control for CDN-based Live Video Delivery
      - First paper of the video session

To Be Continued …

- Many more questions need to be answered:
  - Encoding & its interaction with adaptive streaming
  - Better transport
  - Home network … etc.

Exciting research area!   Real Impact!   Much to do!

- Any questions?
  - Come talk to Maria & TY!
- Want to know more?

Come to Netflix Industrial Demo Session!