

# Computer Networks

## COL 334/672

Application Layer: DNS and P2P

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*Slides adapted from KR*

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# Quiz

Password: dns

# Recap: Application Layer

- HTTP
- Email
- DNS
- P2P
- **Video streaming**

# Video Streaming

- Stream stored video traffic
  - E.g., Netflix, YouTube, Hotstar

live streaming | video conferencing



- Killer application over the Internet.
- Being able to stream video to large-scale users (say ~1B users) has been a North Star for Internet stakeholders
  - Handle client and network heterogeneity
  - Scale: Numbers and geography

# Video Streaming

Virtual Reality  
4K, 8K streaming

- stream stored video traffic: current

## Biggest Cricket World Cup ever smashes Broadcast and Digital records

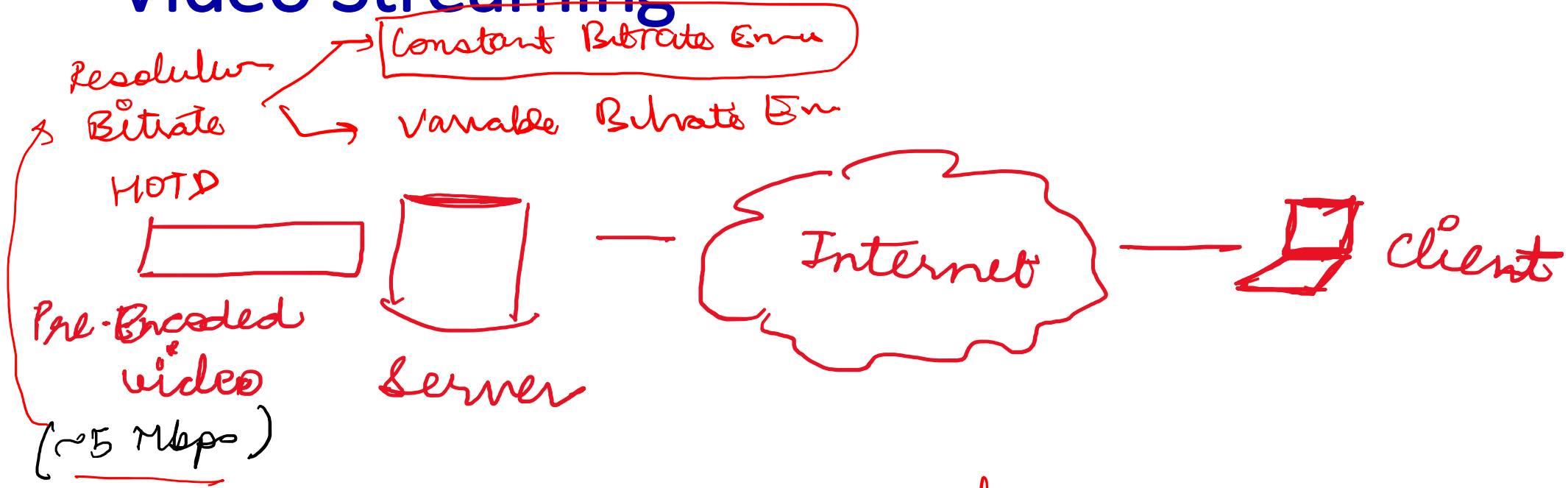
The decision to make coverage freely available for mobile users via Disney+ Hotstar in India led to a whopping 295 million LIVE Tournament viewers tuning in. Across the event, there were five world records broken on Disney+ Hotstar for digital peak concurrency, with the final attracting cricket's highest concurrent audience ever, having already made history at four other 2023 World Cup matches, demonstrating the appeal of cricket and the excitement the ODI format continues to offer:

- Enabling large-scale video streaming has been the North Star for Internet stakeholders

# Learning Goals

- What is <sup>stored</sup> video streaming?
- What are the protocols used for streaming video over the Internet

# Video Streaming



→ latency - sensitive to some extent

→ Streaming: Play video as it is being downloaded and don't save it

Q: What is the application performance metric for streaming video?

# Designing a video streaming system

Design Goals: *(Reliable delivery)*  
*→ All of the content to be delivered over the N/w*

- ① ■ No skipping of video content due to packet loss
- ② ■ Continuous playout of content, i.e., avoid video freezing *(Application performance requirement)*
- ③ ■ Interactivity: Pause, repositioning, fast-forwarding
- ④ ■ Scale to millions of users
- ⑤ ■ Client heterogeneity: different device types and network conditions

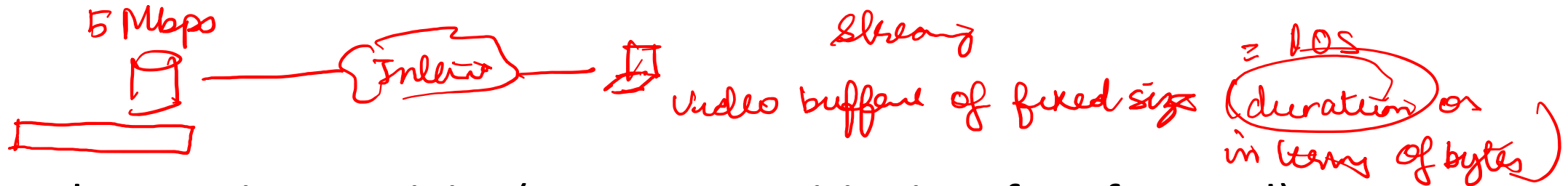


# Achieving Design Goals

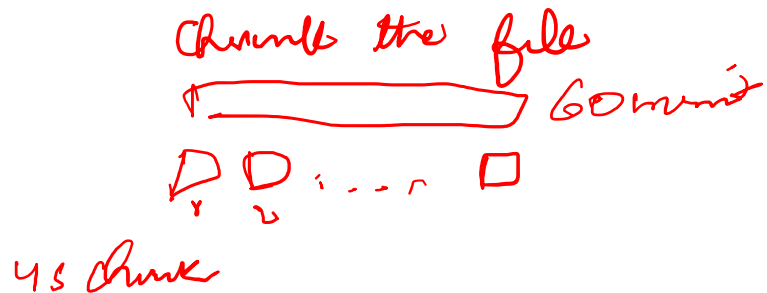
#1: No skipping of video content due to packet loss

→ Reliable transport (TCP)

#2: Continuous playout of content, i.e., avoid video freezing



#3: Implement interactivity (pause, repositioning, fast-forward)



# How to achieve scale?

RTSP servers → FLASH

Browser → HTTP

CDNS

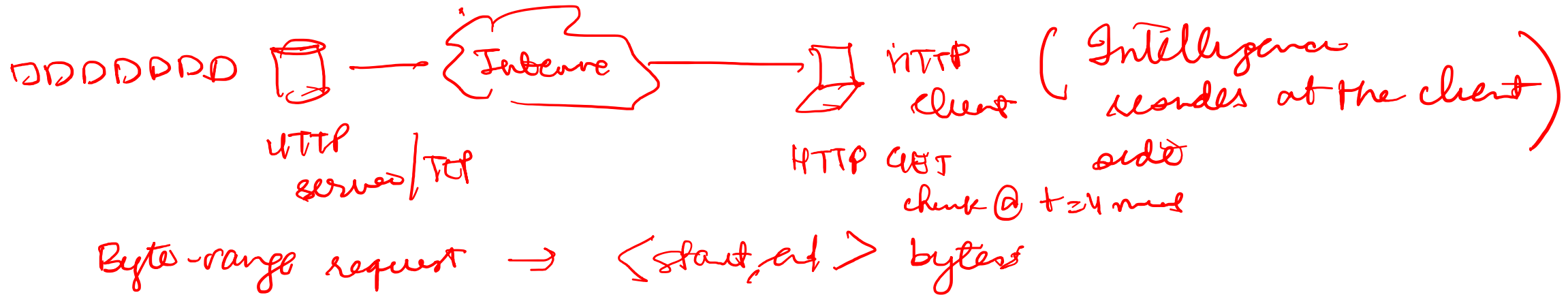
Web → HTTP

- Need geographically distributed video servers (special servers?)

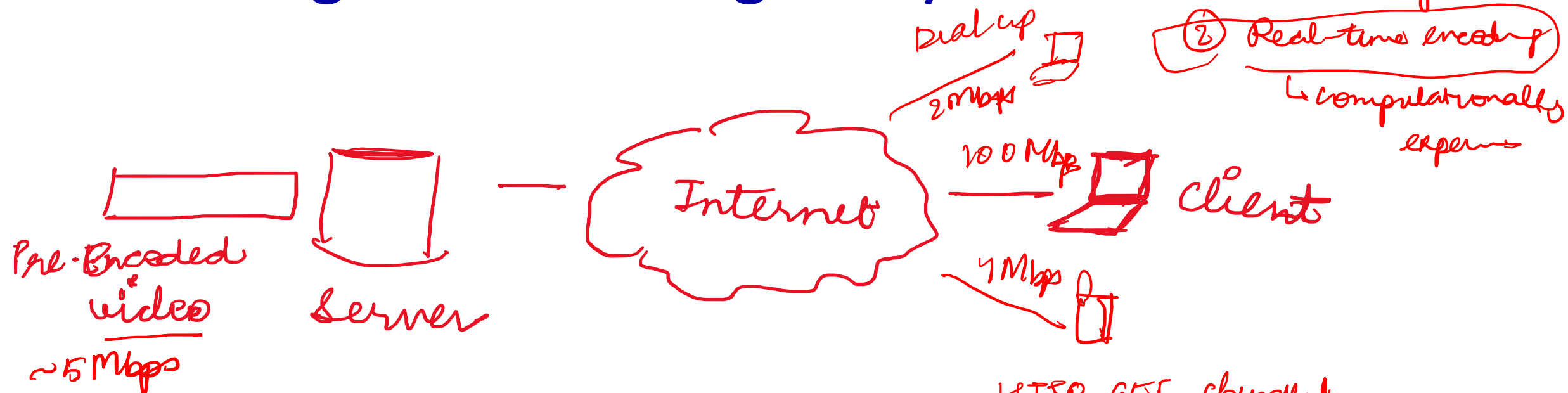
↳ Reuse existing infrastructure

↳ More firewall friendly

HTTP-based  
streaming



# Handling client heterogeneity



Q: What bitrate should we encode the video?

- Constraints: clients with diverse network conditions and device capabilities
- Network conditions are variables
- Real-time encoding [not efficient]
  - Pre-encode multiple versions
- Adapt the bitrate during the session
- 720p
- 480p
- 360p
- 240p
- 144p
- bitrate  $k_b$
- bitrate  $k_b$
- Adaptation

*Dynamically Adaptive Streaming over HTTP (DASH)*

# HTTP Adaptive Streaming (HAS)



HTTP GET  
"Seg1@360p"

720p	1	2	3	4
480p	1	2	3	4
360p	1	2	3	4

- "intelligence" at client: *HTTP GET* client determines  
*Seg 2 @ 480p*
  - *when* to request chunk (so that buffer starvation, or overflow does not occur)
  - *what encoding rate* to request (higher quality when more bandwidth available)

**Bitrate adaptation**

# When to request a new video chunk?

- Client keeps a maximum buffer threshold, i.e., the maximum amount of downloaded but not played video
  - Either expressed as duration or number of bytes
- If the current video buffer occupancy  $>$  max buffer threshold, wait for the video buffer to deplete to less than max buffer threshold
- Once video buffer occupancy  $<$  max buffer threshold, request a new chunk

**At what bitrate?**

*Bitrate  
Adap algo* → *Quali*

# Designing Bitrate Adaptation Algorithm

- **Design goal:** Maximize application performance
- **Q:** What does application performance depend on in adaptive streaming?
  - Video stalls
  - Video quality
  - Video smoothness

→ No stalls

→ highest quality

→ smoothness in video quality

Minimize stall duration



Maximize average bitrate



Minimize bitrate switches

