

# Chapter 2

## Application Layer

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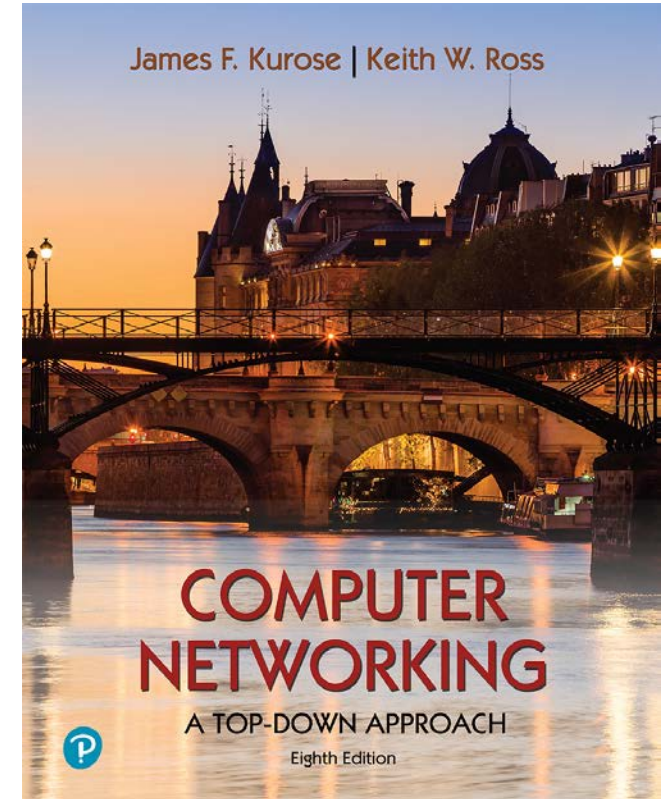
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## *Computer Networking: A Top-Down Approach*

8<sup>th</sup> edition  
Jim Kurose, Keith Ross  
Pearson, 2020

# Video Streaming and CDNs: context

- stream video traffic: major consumer of Internet bandwidth
  - Netflix, YouTube, Amazon Prime: 80% of residential ISP traffic (2020)
- *challenge*: scale - how to reach ~1B users?
- *challenge*: heterogeneity
  - different users have different capabilities (e.g., wired versus mobile; bandwidth rich versus bandwidth poor)
- *solution*: distributed, application-level infrastructure

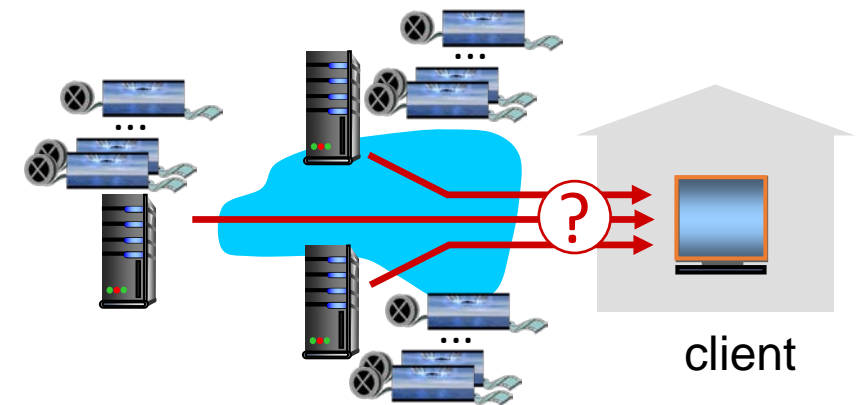


# Streaming multimedia: DASH

*D*ynamic, *A*daptive  
*S*teaming over *H*TTP

## server:

- divides video file into multiple chunks
- each chunk encoded at multiple different rates
- different rate encodings stored in different files
- files replicated in various CDN nodes
- *manifest file*: provides URLs for different chunks

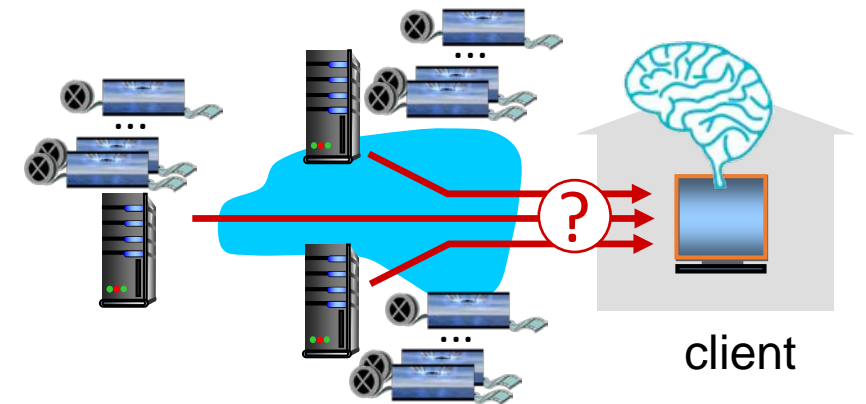


## client:

- periodically estimates server-to-client bandwidth
- consulting manifest, requests one chunk at a time
  - chooses maximum coding rate sustainable given current bandwidth
  - can choose different coding rates at different points in time (depending on available bandwidth at time), and from different servers

# Streaming multimedia: DASH

- “*intelligence*” at client: client determines
  - *when* to request chunk (so that buffer starvation, or overflow does not occur)
  - *what encoding rate* to request (higher quality when more bandwidth available)
  - *where* to request chunk (can request from URL server that is “close” to client or has high available bandwidth)



Streaming video = encoding + DASH + playout buffering

# Content distribution networks (CDNs)

*challenge:* how to stream content (selected from millions of videos) to hundreds of thousands of *simultaneous* users?

- *option 1:* single, large “mega-server”
  - single point of failure
  - point of network congestion
  - long (and possibly congested) path to distant clients

....quite simply: this solution *doesn't scale*

# Content distribution networks (CDNs)

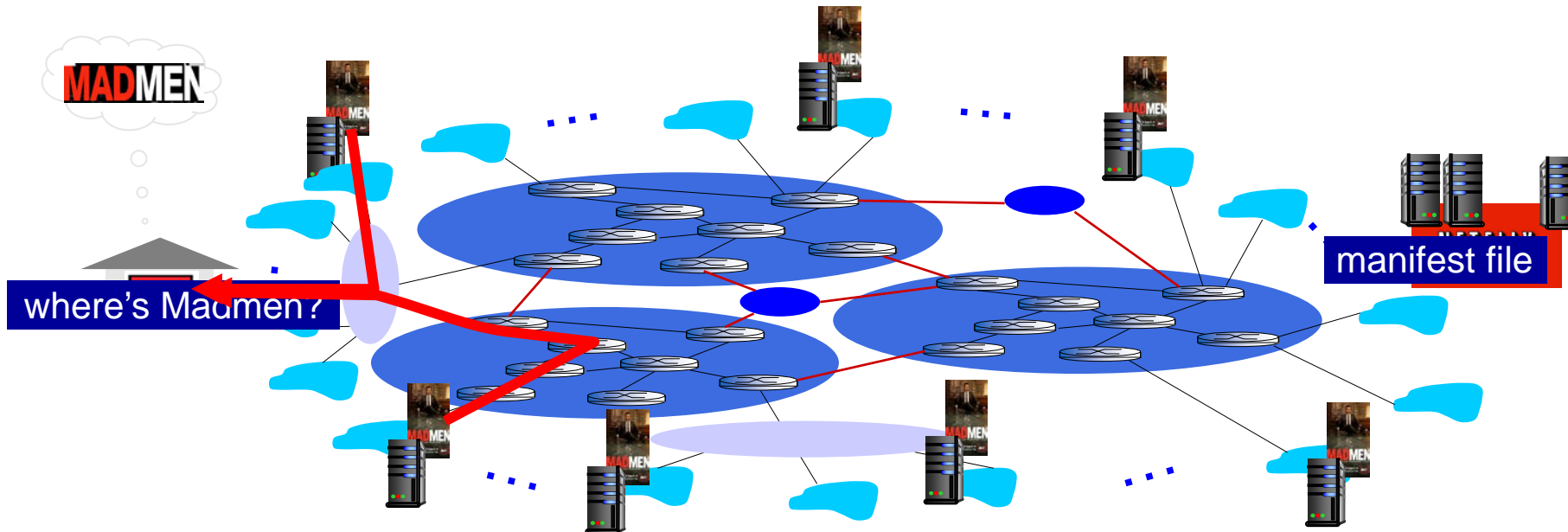
*challenge:* how to stream content (selected from millions of videos) to hundreds of thousands of *simultaneous* users?

- *option 2:* store/serve multiple copies of videos at multiple geographically distributed sites (*CDN*)
  - *enter deep:* push CDN servers deep into many access networks
    - close to users
    - Akamai: 240,000 servers deployed in > 120 countries (2015)
  - *bring home:* smaller number (10's) of larger clusters in POPs near access nets
    - used by Limelight



# Content distribution networks (CDNs)

- CDN: stores copies of content (e.g. MADMEN) at CDN nodes
- subscriber requests content, service provider returns manifest
  - using manifest, client retrieves content at highest supportable rate
  - may choose different rate or copy if network path congested



# Content distribution networks (CDNs)

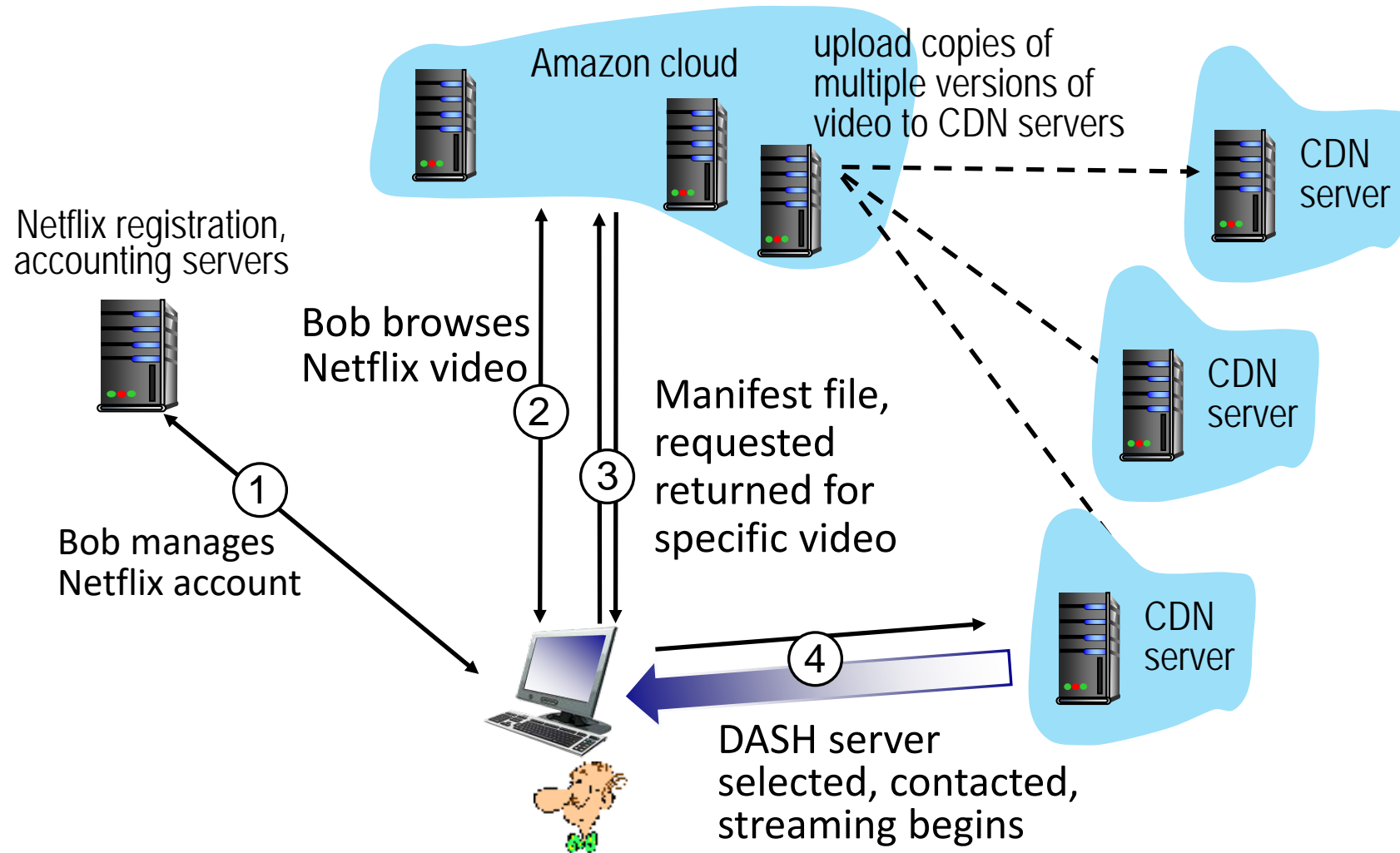


*OTT challenges:* coping with a congested Internet from the “edge”

- what content to place in which CDN node?
- from which CDN node to retrieve content? At which rate?



# Case study: Netflix



# CDN content access: a closer look

Bob (client) requests video `http://netcinema.com/6Y7B23V`

- video stored in CDN at `http://KingCDN.com/NetC6y&B23V`

