UNIVERSITÀ PARTHENOPE
DiST
Dipartimento di Scienze e Tecnologie

Intelligent Signal Processing

Streaming

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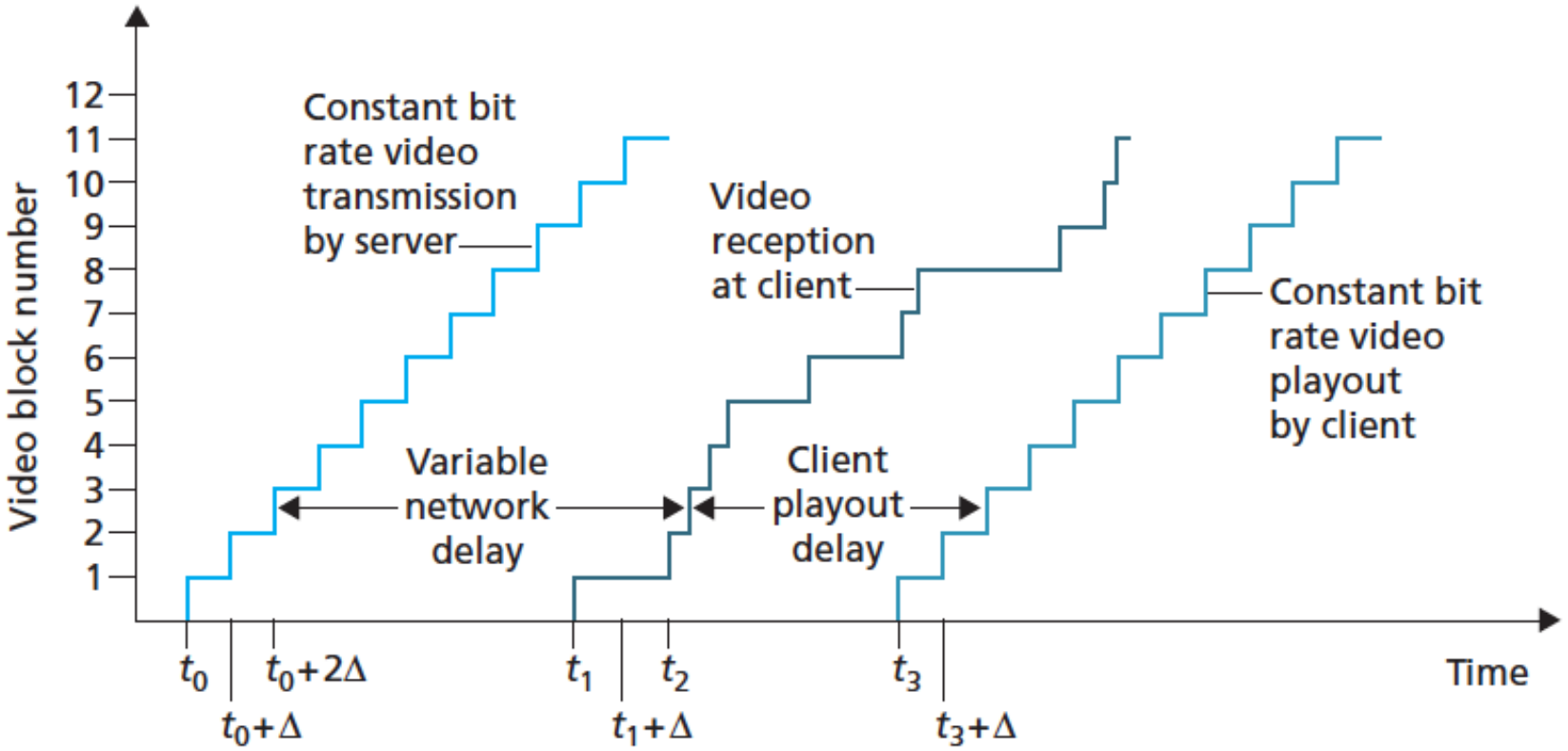
Introduction

- Streaming Stored Video
  - prerecorded videos are placed on servers
  - users send requests to these servers to view the videos on demand
- Streaming Video Systems categories
  - UDP streaming
  - HTTP streaming
  - adaptive HTTP streaming
- Common characteristics
  - client-side application buffering
    - to mitigate the effects of varying end-to-end delays
    - varying amounts of available bandwidth between server and client

Buffering



Client playout delay in video streaming

UDP Streaming

- UDP Streaming
  - server transmits video at a rate that matches the client's video consumption rate
  - chunks over UDP at a steady rate
    - 3 Mbps Video, 8000 bits of Video, transmission on the socket each 4 msec
  - UDP does not employ a congestion-control mechanism
  - before UDP the server will encapsulate the Video chunks within Real-Time Transport Protocol (RTP)

UDP Streaming

- Drawbacks
  - constant-rate UDP streaming can fail to provide continuous playout
  - it requires a media control server, such as an RTSP server, to process client-to-server interactivity requests and to track client state
  - many firewalls are configured to block UDP traffic

HTTP Streaming

- HTTP Streaming
  - the Video is simply stored in an HTTP server as an ordinary file with a specific URL
  - client establishes a TCP connection with the server and issues an HTTP GET request for that URL
  - Server ends the Video file, within an HTTP response message
  - on the client side, the bytes are collected in a client application buffer
  - once the number of bytes in this buffer exceeds a predetermined threshold, the client application begins playbak
    - it periodically grabs Video frames from the client application buffer, decompresses the frames, and displays them on the user's screen

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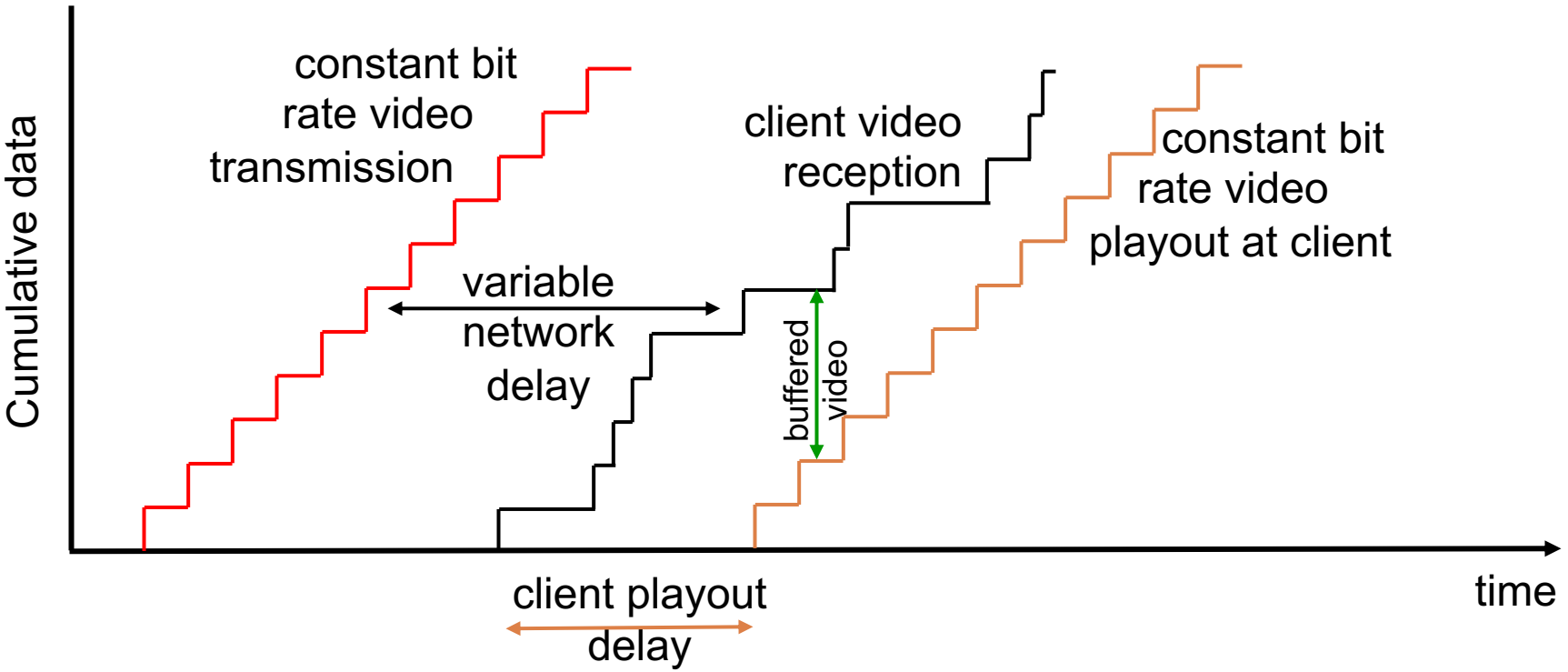
HTTP Streaming

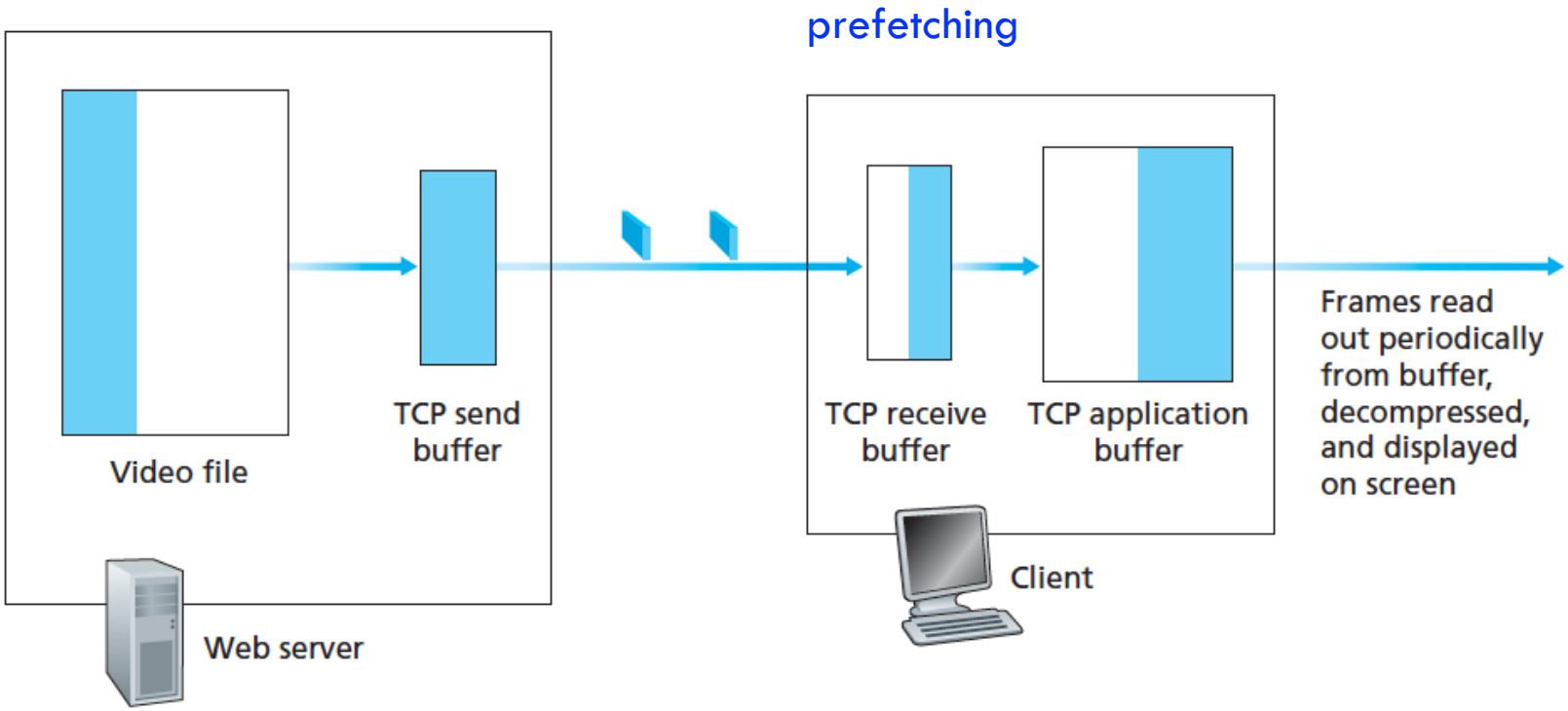
- Characteristics
  - allows the Video to traverse firewalls
  - obviates the need for a media control server, such as an RTSP server
  - most Video streaming applications today
    - YouTube
    - Netflix
    - …

Streming stored Video



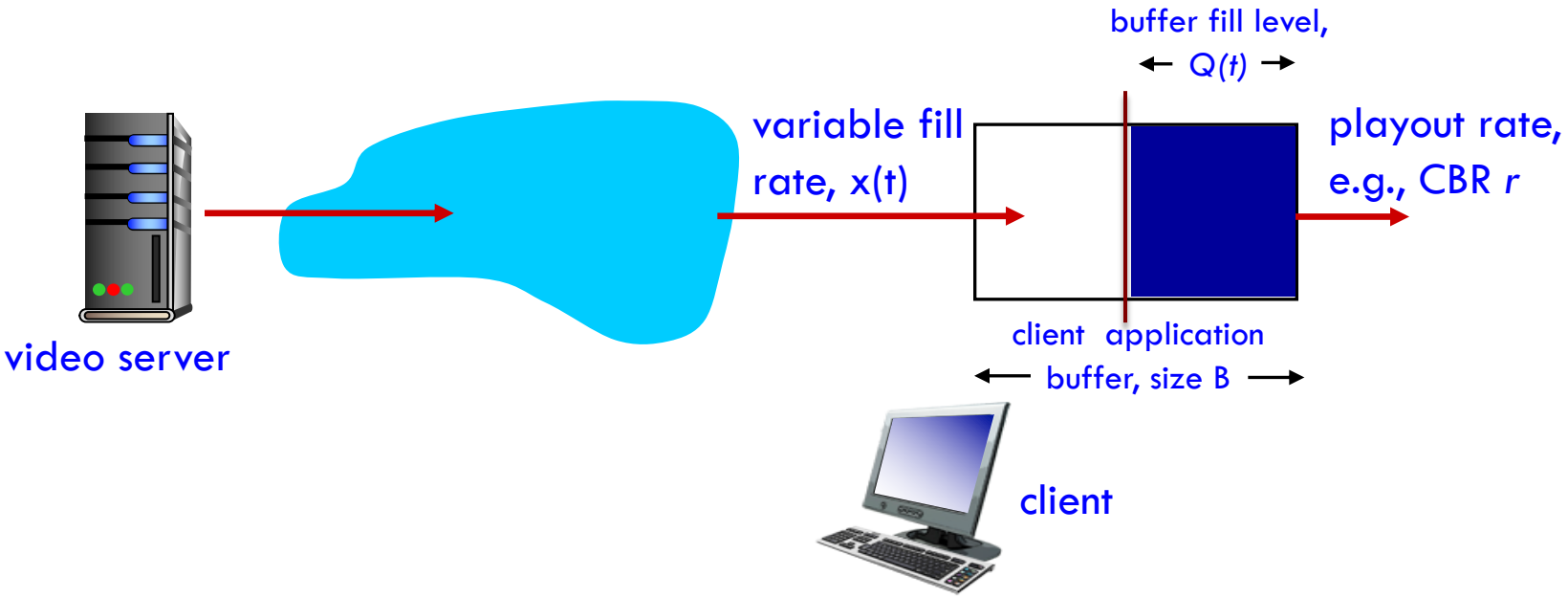
Streaming stored Video over HTTP/TCP

Streming stored Video



Buffering in streaming stored Video over HTTP/TCP

Prefetching and Buffering



- when the available rate in the network is less than the video rate, playout will alternate between periods of continuous playout and periods of freezing

- when the available rate in the network is more than the video rate, after the initial buffering delay, the user will enjoy continuous playout until the video ends

Adaptive Streaming and DASH

- Dynamic Adaptive Streaming over HTTP (DASH)
  - the video is encoded into several different versions
  - each version having a different bit rate and, correspondingly, a different quality level
    - bandwidth is high
      - selects chunks from a high-rate version
    - bandwidth is low
      - selects from a low-rate version
  - clients with different Internet access rates to stream in video at different encoding rates

Adaptive Streaming and DASH

- Dynamic Adaptive Streaming over HTTP (DASH)
  - each Video version is stored in the HTTP server, each with a different URL
  - the HTTP server has a manifest file
    - provides a URL for each version along with its bit rate
  - while downloading chunks, the client also measures the received bandwidth and runs a rate determination algorithm to select the chunk to request next
    - freely switch among different quality levels
  - for many implementations also separately stores many versions of the Audio

Real Time Streaming Protocol

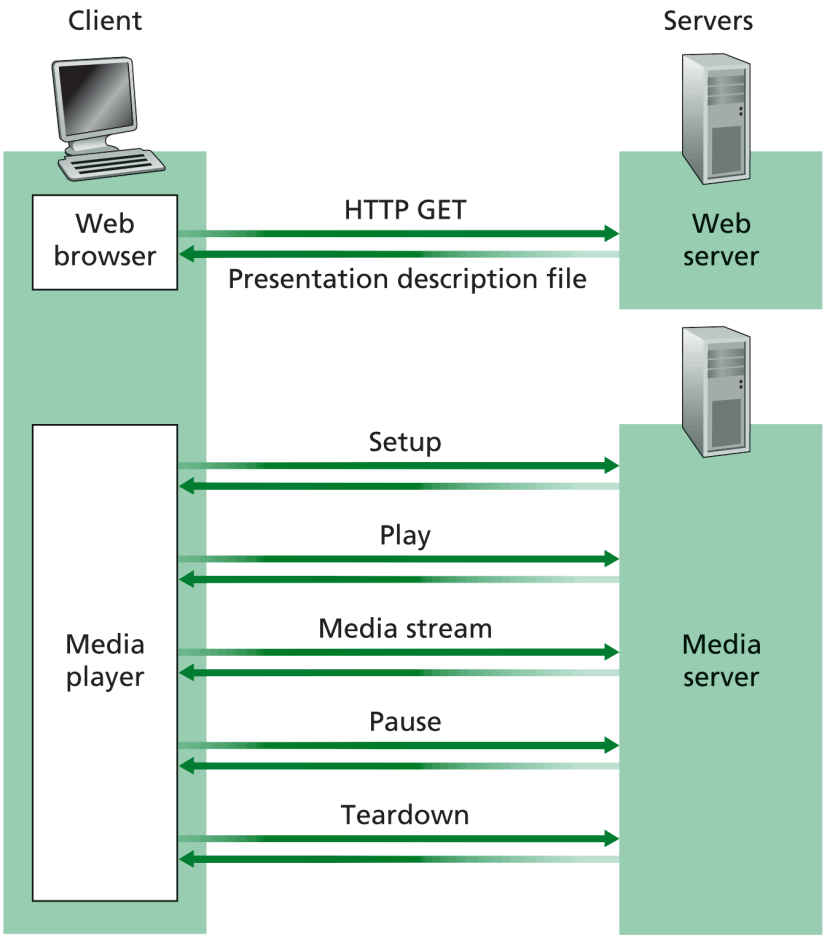


Figure 7.5 ♦ Interaction between client and server using RTSP.

RTSP scheme

Metafile

```
<title>Twister</title>
<session>
        <group language=en lipsync>
                <switch>
                    <track type=audio
                           e="PCMU/8000/1"
                           src =
  "rtsp://audio.example.com/twister/audio.en/lofi">
                <track type=audio
                           e="DVI4/16000/2" pt="90
  DVI4/8000/1"

  src="rtsp://audio.example.com/twister/audio.en/hifi">
                </switch>
            <track type="video/jpeg"

  src="rtsp://video.example.com/twister/video">
        </group>
</session>
```


RTSP session

C: SETUP rtsp://audio.example.com/twister/audio RTSP/1.0
Transport: rtp/udp; compression; port=3056; mode=PLAY

S: RTSP/1.0 200 1 OK
Session 4231

C: PLAY rtsp://audio.example.com/twister/audio.en/lofi RTSP/1.0
Session: 4231
Range: npt=0-

C: PAUSE rtsp://audio.example.com/twister/audio.en/lofi RTSP/1.0
Session: 4231
Range: npt=37

C: TEARDOWN rtsp://audio.example.com/twister/audio.en/lofi RTSP/1.0
Session: 4231

S: 200 3 OK

Streaming example

Example of streaming (see e-learning platform)

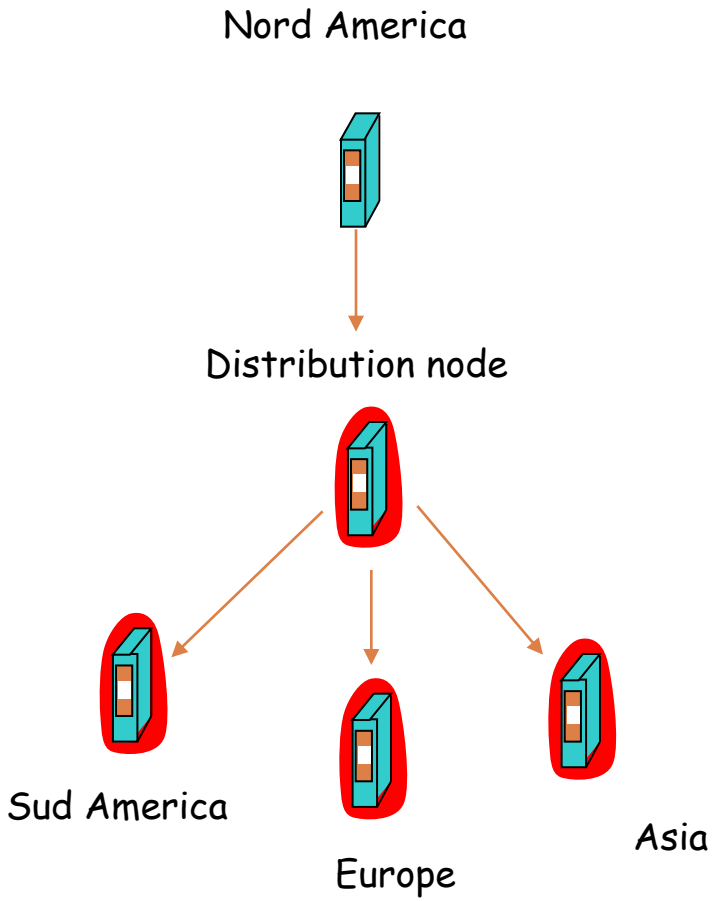
Content Distribution Networks

- Content Distribution Networks (CDNs)
  - massive amounts of Video data
  - manages servers in multiple geographically distributed locations, stores copies of the videos
  - may be
    - private
      - Google's CDN distributes YouTube videos
    - third-party
      - Akamai's distributes Netflix and Hulu content, among others

Server placement

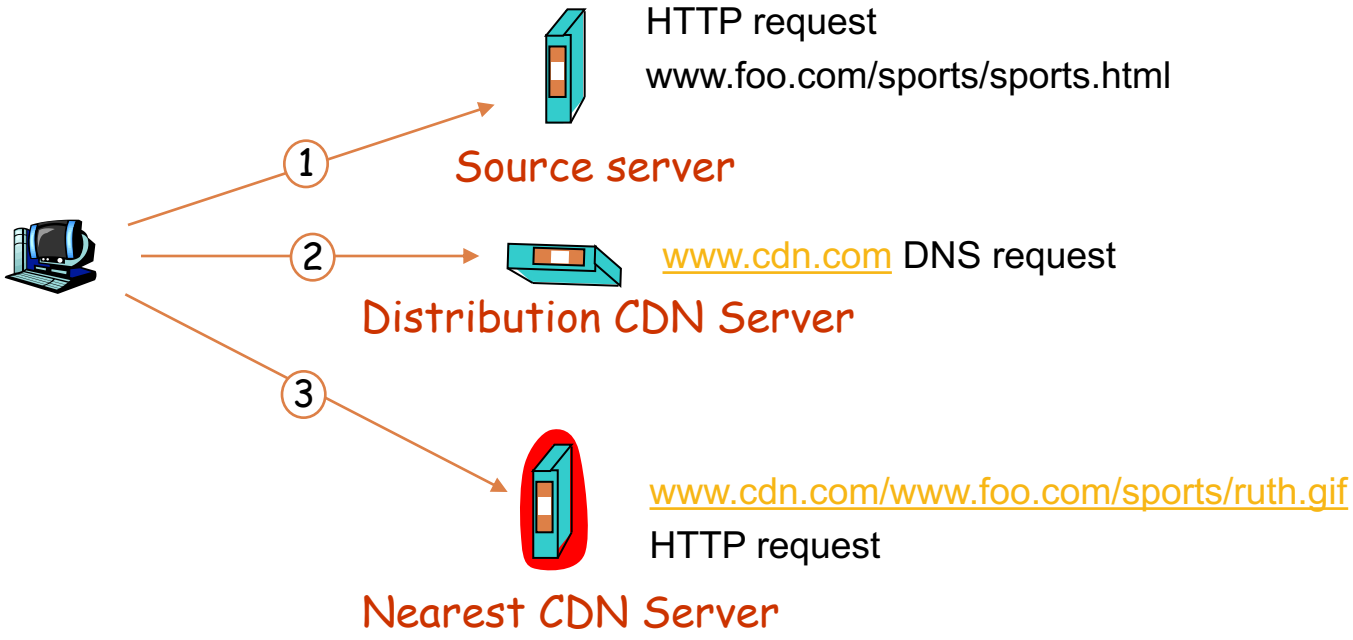
- server placement philosophies
  - enter deep
    - enter deep into the access networks of Internet Service Providers, by deploying server clusters in access ISPs all over the world
    - Akamai
  - bring home
    - building large clusters at a smaller number (for example, tens) of key locations and connecting these clusters using a private high-speed network
    - Limelight

Server placement



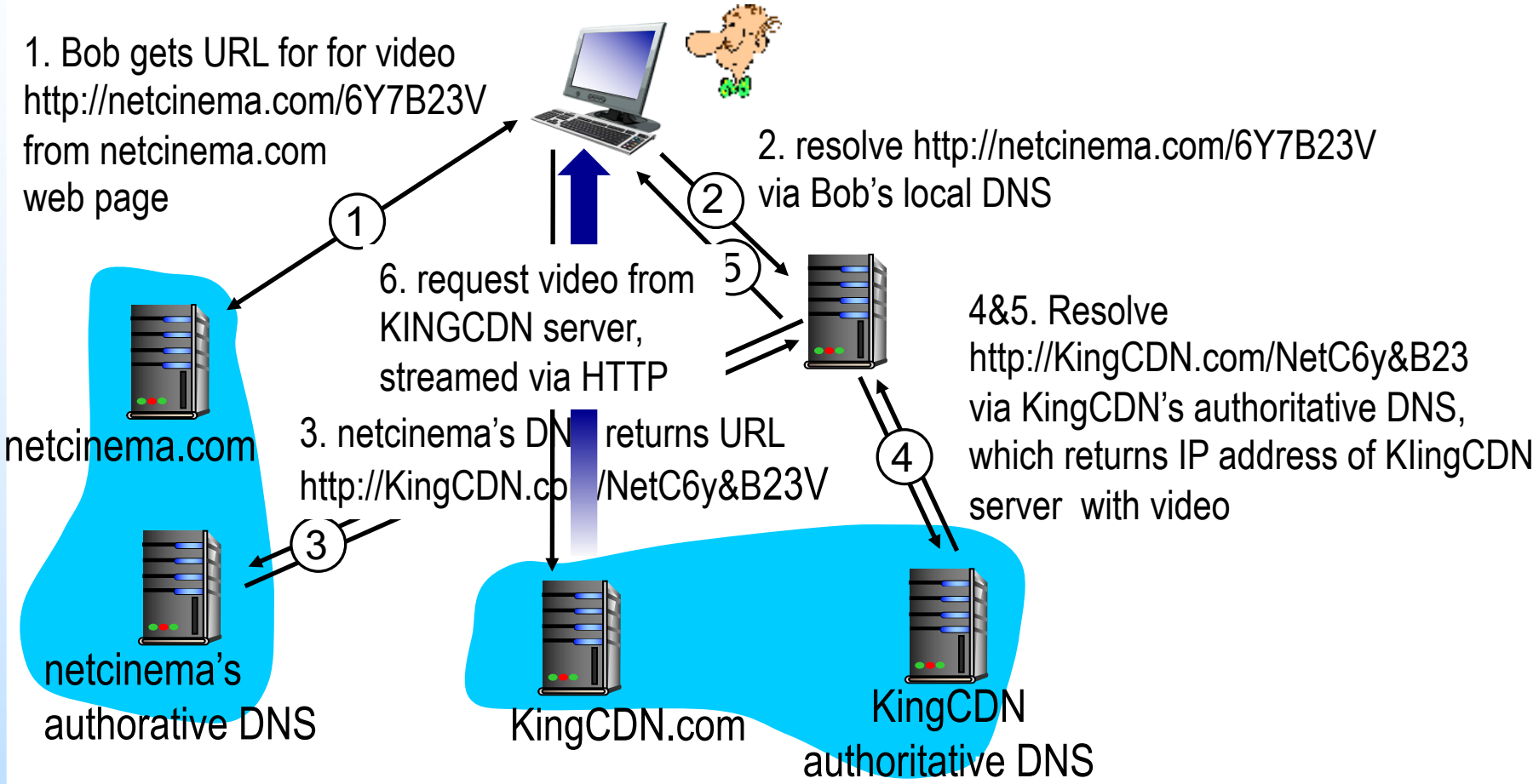
Server placement example

Server placement



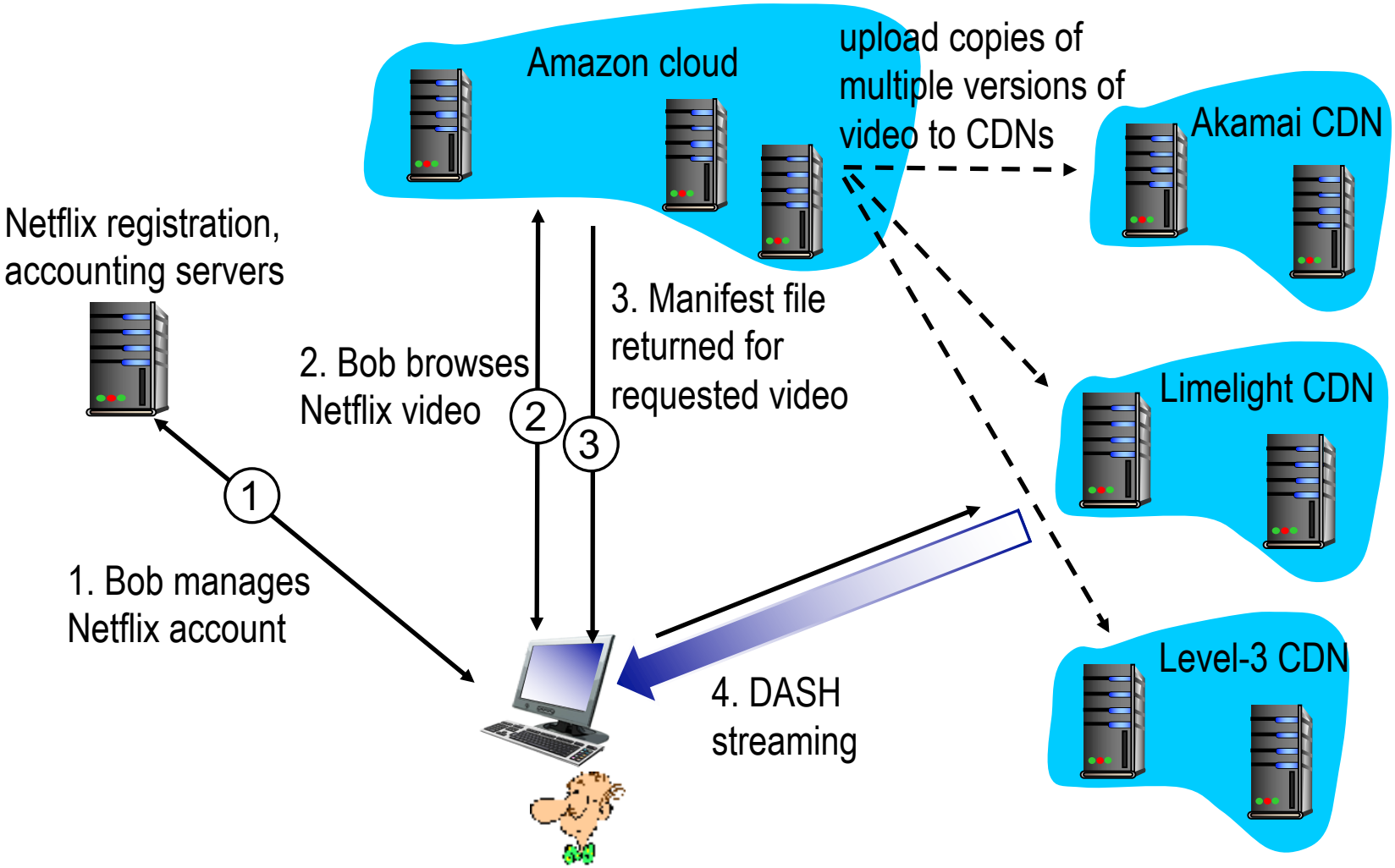
Video request example

Server placement



Server placement example

Netflix

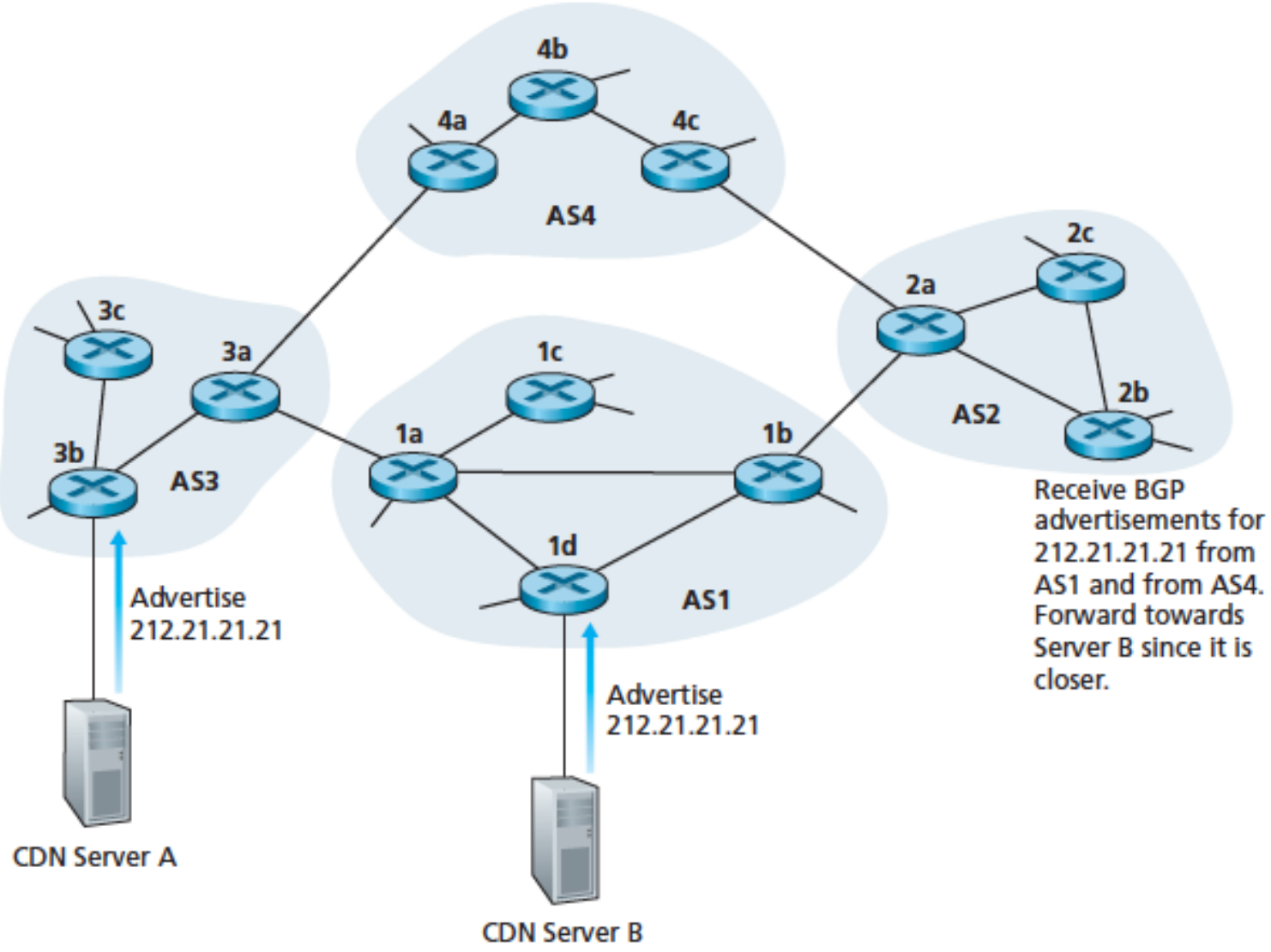


Netflix server placement example

Cluster selection

- Cluster Selection Strategies
  - geographically closest
  - based on the current traffic onditions
  - IP anycast
    - BGP protocol

Cluster selection



Using IP anycast to route clients to closest CDN cluster

Cluster selection

- Case studies
  - Netflix
  - YouTube
  - Kankan

- See
  - *Computer Networking*, A top-down Approach, J.F. Kurose and K.W. Ross, Pearson, 6-th edition, 2012