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Chair of Future Communication
Faculty of Computer Science
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050069

# VO Netzwerktechnologie für Multimedia Anwendungen

## Lecture 3: Review of Networking Concepts, Multimedia Networking

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# Chapter 2: Revision of Networking Concepts


- Overview:
- Protocol layering and Internet protocol stack
- Circuit switching vs. packet switching
- Connectionless vs. connection-oriented networks, routing, forwarding, and switching
- Transport layer protocols
- Application layer
  - Sockets
  - Client-server and peer-to-peer communication
- Web services

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# Sockets 1/2


- Process
  - Program running within a host
  - Processes within same host communicate using inter-process communication (defined by OS).
  - Processes in different hosts communicate by exchanging messages
  - Application: process in a hosts
  - Client process: process that initiates communication
  - Server process: process that waits to be contacted

- Several processes running on the same host
  - Identification through 16 bit port numbers
  - Example port numbers:
    - HTTP server: 80
    - Mail server: 25

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# Sockets 2/2


- Host
  - Identification through unique 32 bit IP address
- Socket
  - End-point of an Internet Protocol-based communication
  - Components
    - Protocol (TCP, UDP, raw IP)
    - Local IP address
    - Local port
    - Remote IP address
    - Remote port
  - The remote address can be either
    - any valid IP address, or
    - 0.0.0.0 for listening sockets, or
    - 255.255.255.255 for broadcasting sockets
  - Process sends/receives messages to/from its socket

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# Application Layer Protocols 1/2


- Application layer protocols
  - Run on different end systems
  - Communicate over a network
  - e.g., Web: Web server software communicates with browser software
  - No interaction from core network devices required
  - New software only in end-points needed: rapid deployment possible
- Public-domain protocols
  - defined in RFCs
  - allows for interoperability
  - E.g., HTTP, SMTP
- Proprietary protocols
  - E.g., KaZaA

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# Application Layer Protocols 2/2


- Application layer protocols define
  - Types of messages exchanged
    - E.g., request & response messages
  - Syntax of message types
    - What fields in messages & how fields are delineated
  - Semantics of the fields
  - State machines
    - Rules for when and how processes send & respond to messages
  - Preferred transport protocol for msgs
  - Preferred port numbers to be contacted
    - E.g., http on port 80

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# Network Applictions

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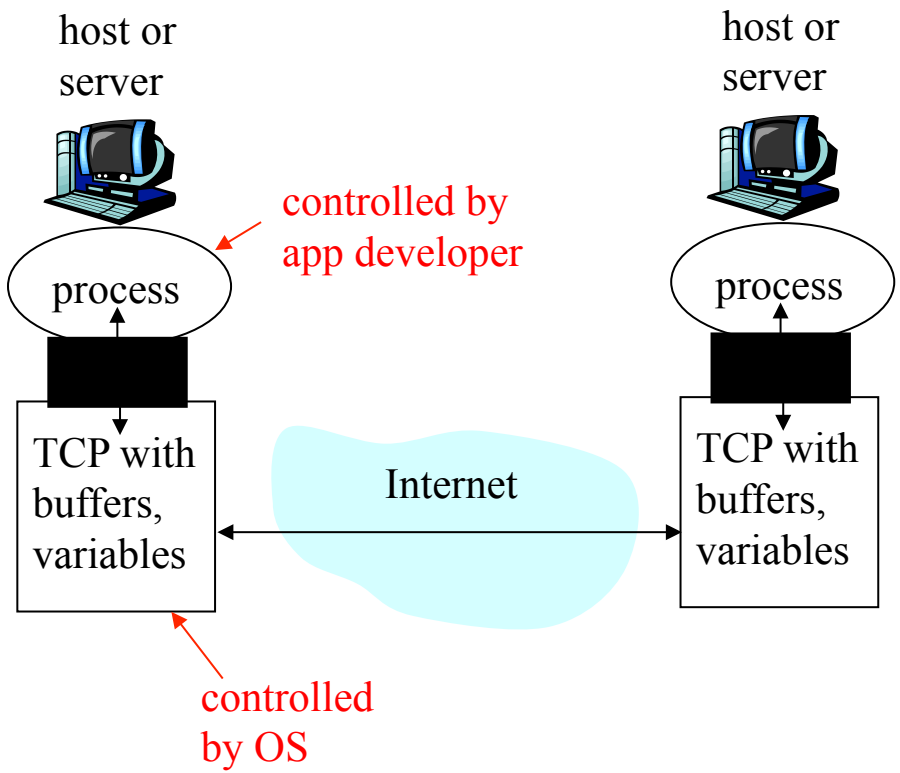
- Create a new network application
  - Define new protocol
  - Deploy software and start it
  - Start communication by contacting those hosts on the right port
- Some network applications
  - E-mail
  - Web
  - Instant messaging
  - Remote login
  - P2P file sharing
  - Multi-user network games
  - Streaming stored video clips
  - Internet telephone
  - Real-time video conference
  - Massive parallel computing



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# Client-Server Architecture

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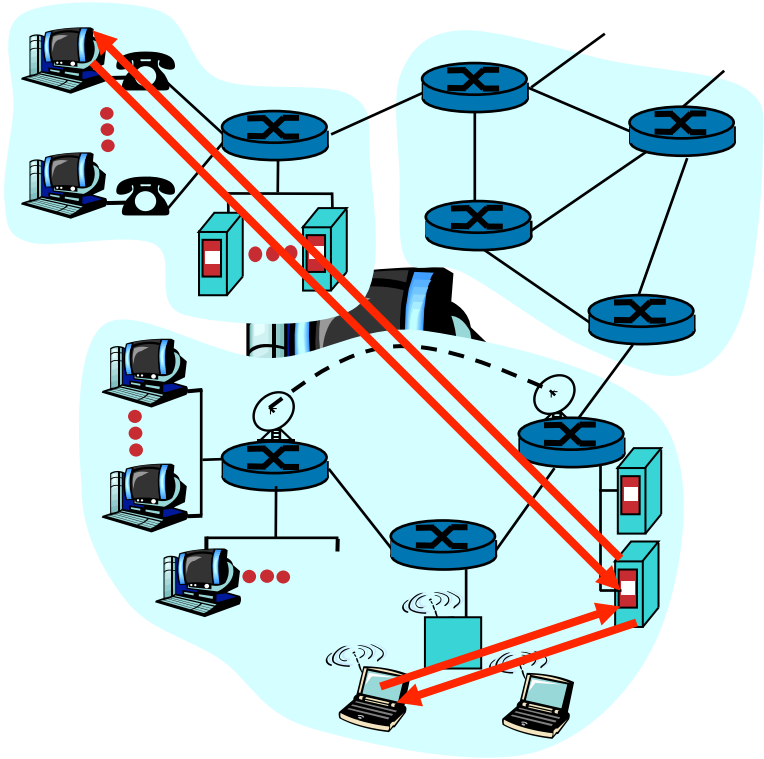
Server

- Always-on host
- Permanent IP address
- Server farms for scaling

Clients

- Communicate with server
- May be intermittently connected
- May have dynamic IP addresses
- Do not communicate directly with each other



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# P2P Architecture

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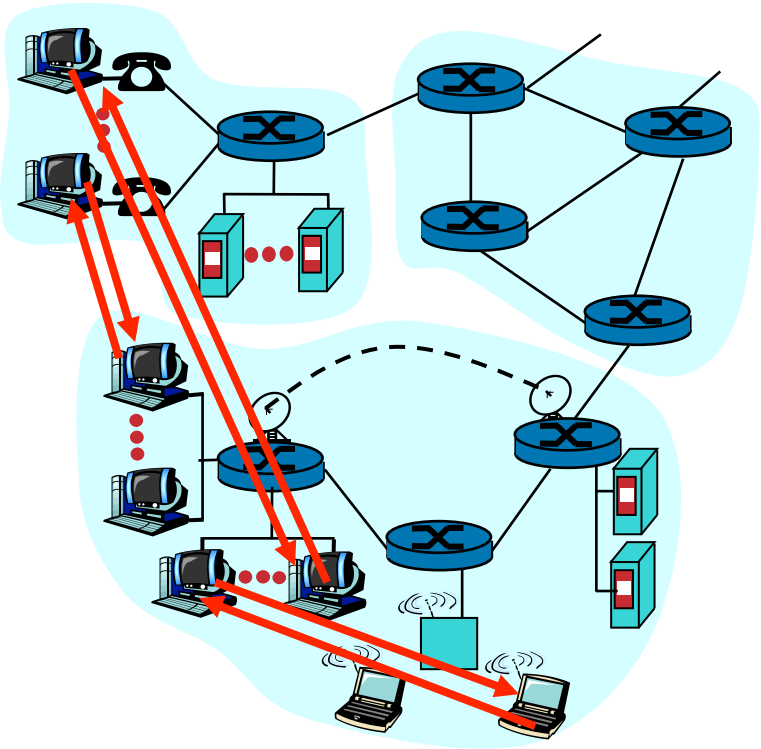
- Arbitrary end systems directly communicate
- Peers are intermittently connected and change IP addresses
- Note: applications with P2P architectures have client processes & server processes
- Highly scalable
- But difficult to manage



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# Was ist P2P?

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- Def.: Ein Peer-to-Peer System ist ein selbstorganisierendes, verteiltes System aus miteinander verbundenen, gleichen und autonomen Knoten, zur gemeinsamen Nutzung von verteilten Ressourcen in einem Netzwerk ohne eine zentrale Instanz.

- Peer (engl. Gleichgestellter)
- Peer-to-Peer vs. Server-Client Prinzip
- Charakteristika von P2P Systemen:
  - Peers sind sowohl Clients als auch Server
  - Dezentralisierung
  - Nutzung nicht benötigter Ressourcen
  - Transient Connectivity
  - Autonomie der Peers
  - Keine Globale Sicht

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# Bewertung von P2P



- Vorteile:
  - Skalierbarkeit
  - Gemeinsame Nutzung von Ressourcen
  - Robuster gegen den zufälligen Ausfall einzelner Komponenten
- Probleme:
  - Peers und Verbindungen sind nicht zuverlässig
  - Hoher Kommunikationsaufwand

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# Anwendung von P2P


- Aktuelle Anwendungsbereiche
  - Filesharing (Bittorrent, KaZaa, Napster, eDonkey)
  - Instant-Messaging (Skype, CSpace)
  - Data Storage (PAST, OceanStore, FarSite)
  - Grid/Distributed Computing (Seti@Home, Folding@Home)
  - Collaboration / Groupware (Groove)
  - Kontrolle von Netzen (Tutschku et al., 2003 – )

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# P2P Overlay Network

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- Overlay Network ist ein logisches Netz
- Setzt auf einem physikalische Netz (Internet) auf
- Besteht aus allen teilnehmenden Peers (Knoten)
- Jeder Knoten speichert eine Liste von Nachbarknoten
- Knoten sind durch (virtuelle) Kanten miteinander verbunden

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# P2P Klassifikation



| Client-Server | Peer-to-Peer | | | |
|---|---|---|---|---|
| | Unstructured P2P | | | Structured P2P |
| | 1. Generation | | 2. Generation | 3. Generation |
| | Centralized P2P | Pure P2P | Hybrid P2P | DHT-based |
| *www* | *Napster* | *Gnutella 0.4, Freenet* | *Gnutella 0.6* | *Cord, CAN, Pastry* |

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# Chapter 3: Multimedia Networking


Overview

- 3.1 Multimedia Networking Applications
- 3.2 Streaming stored audio and video
- 3.3 Real-time Multimedia: Internet Phone study
- 3.4 Protocols for Real-Time Interactive Applications
  - RTP,RTCP
- 3.5 IP Telefony, SIP, and H.323
- 3.6 Distributing Multimedia: content distribution networks

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# Multimedia, Quality of Service: What is it?

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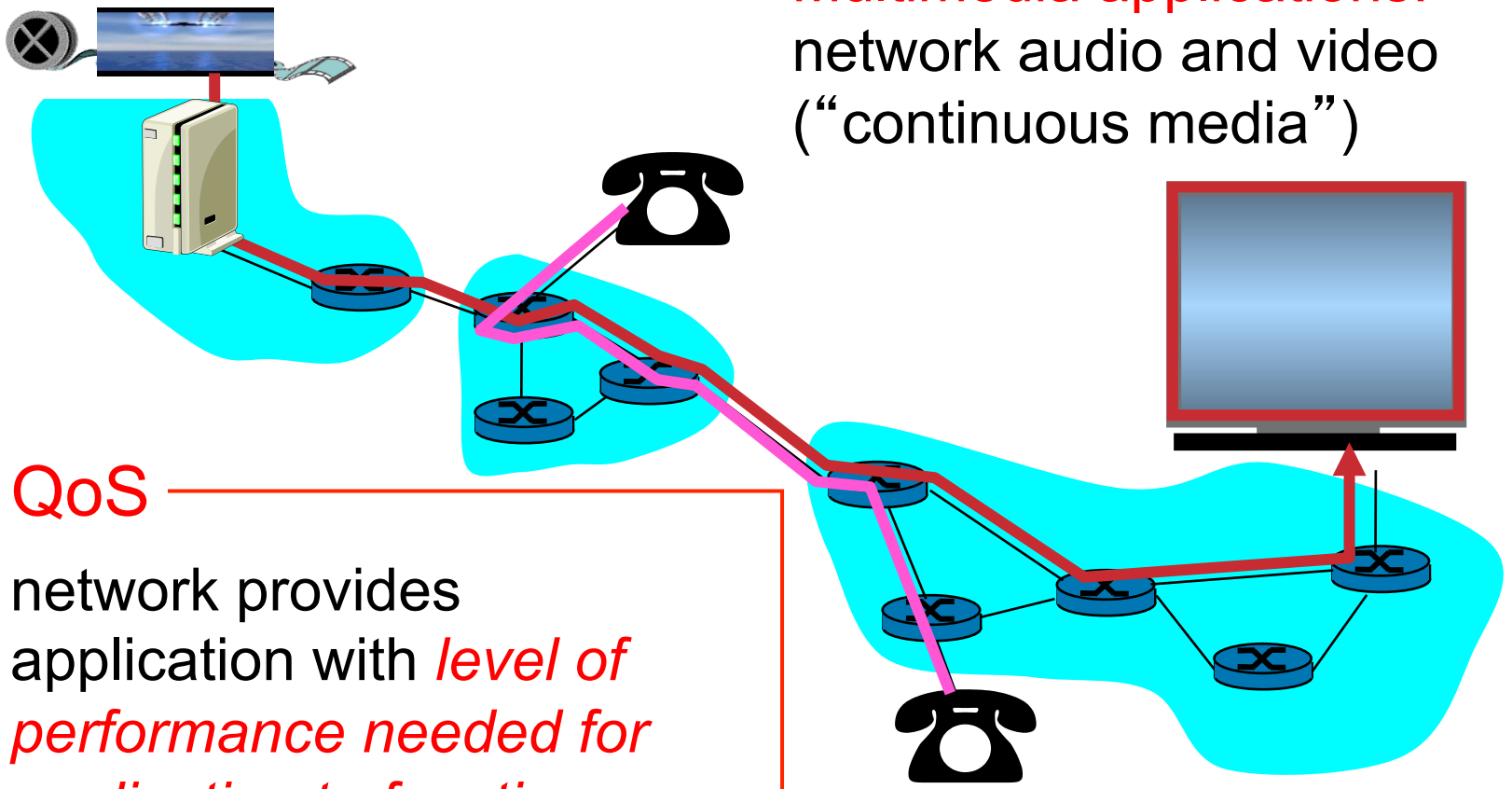
Multimedia applications:
network audio and video
("continuous media")



## QoS

network provides application with *level of performance needed for application to function.*

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# MM Networking Applications



Classes of MM applications:

- Streaming stored audio and video
- Streaming live audio and video
- Real-time interactive audio and video

Fundamental characteristics:

- Typically delay sensitive
  - end-to-end delay
  - delay jitter
- But loss tolerant: infrequent losses cause minor glitches
- Antithesis of data, which are loss intolerant but delay tolerant

Jitter is the variability of packet delays within the same packet stream

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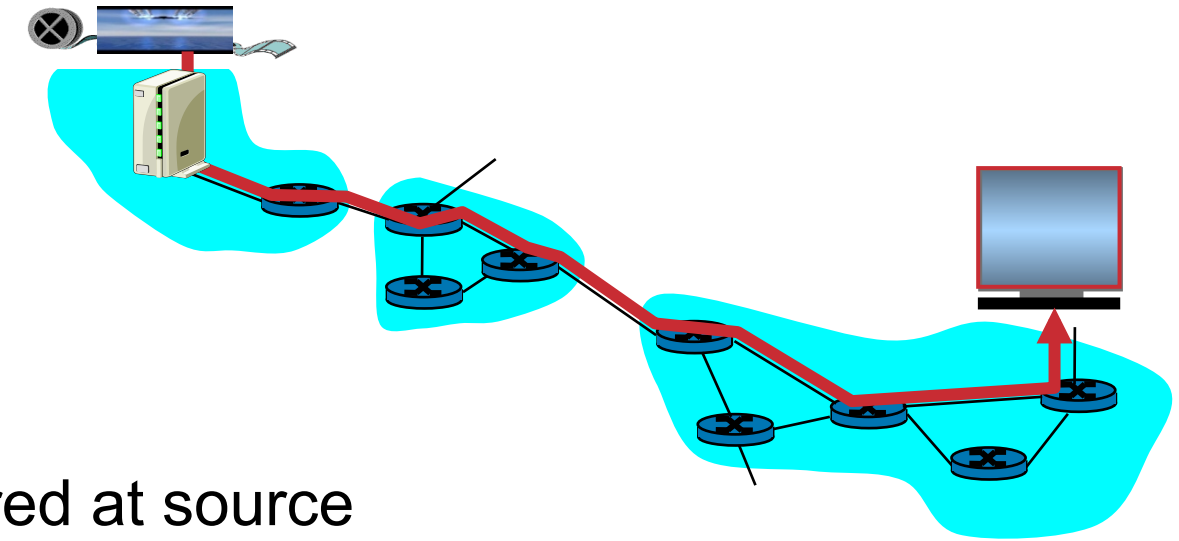
# Streaming Stored Multimedia



Streaming:

- media stored at source
- transmitted to client
- streaming: client playout begins *before* all data has arrived
- timing constraint for still-to-be transmitted data: in time for playout

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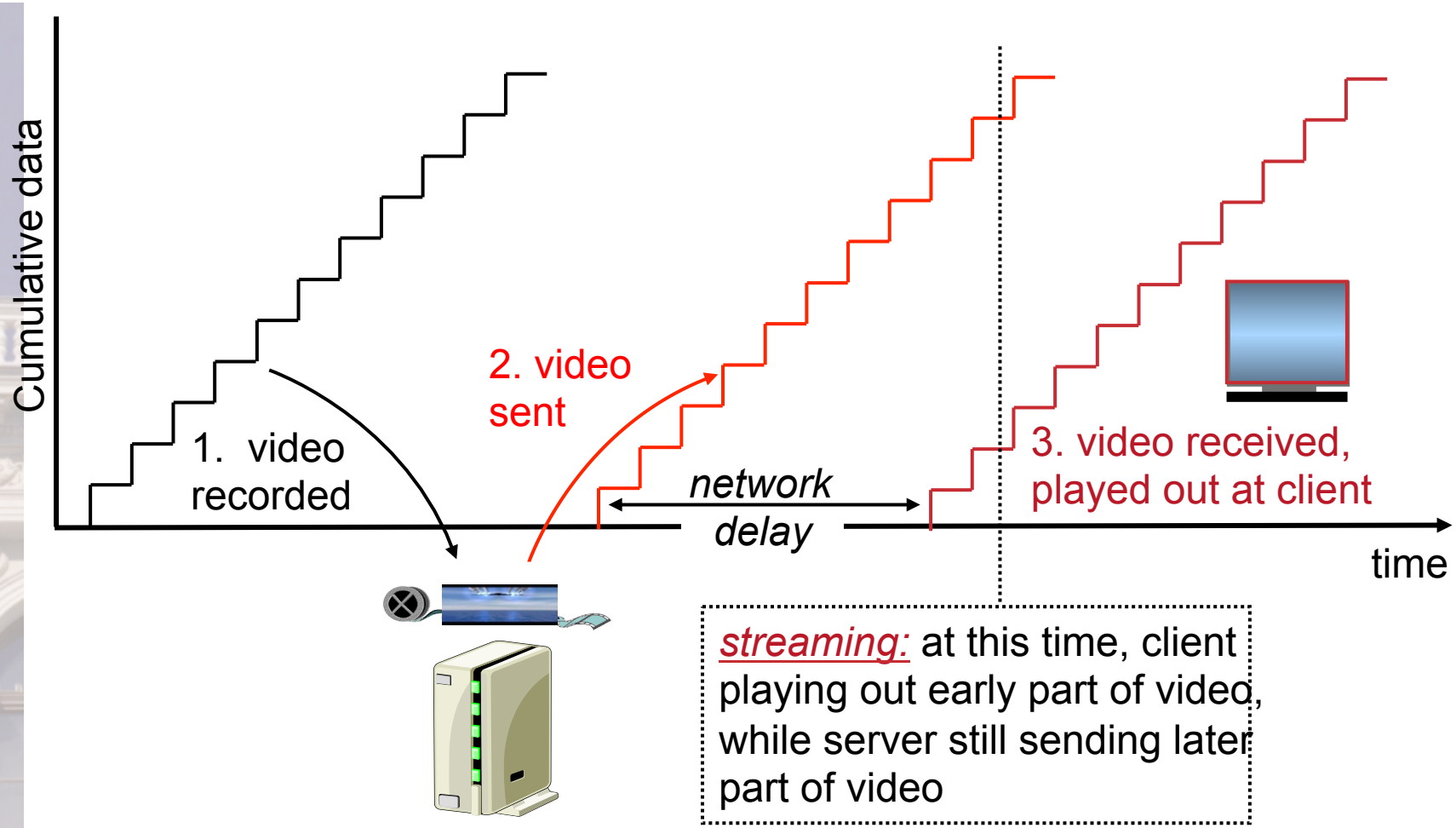
# Streaming Stored Multimedia: What is it?

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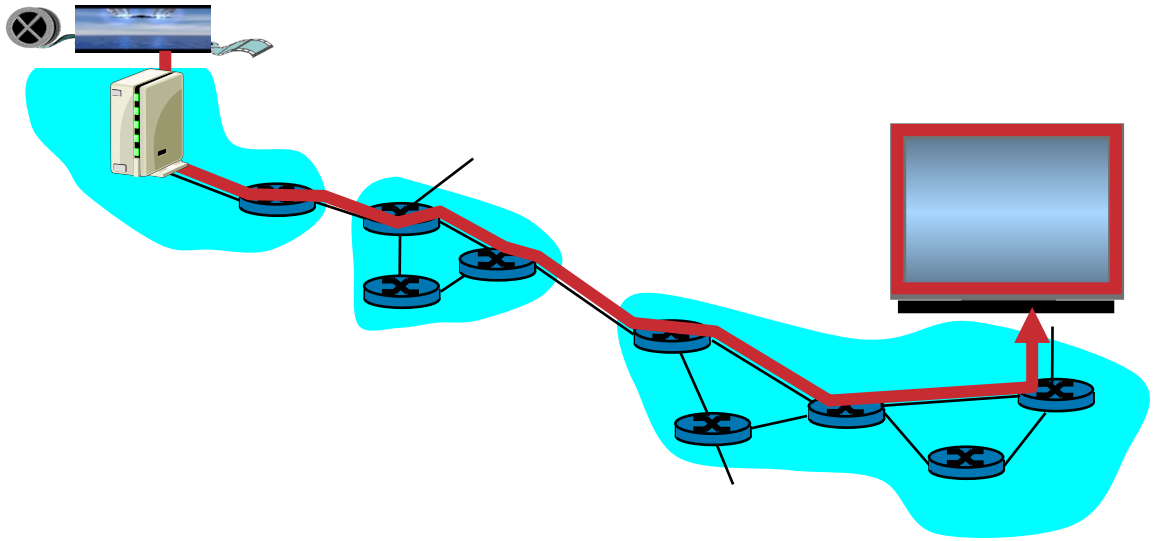
# Streaming Stored Multimedia: Interactivity



- *VCR-like functionality:* client can pause, rewind, FF, push slider bar
  - 10 sec initial delay OK
  - 1-2 sec until command effect OK
  - RTSP often used (more later)
- timing constraint for still-to-be transmitted data: in time for playout

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# Streaming Live Multimedia


## Examples:

- Internet radio talk show
- Live sporting event

## Streaming

- playback buffer
- playback can lag tens of seconds after transmission
- still have timing constraint

## Interactivity

- fast forward impossible
- rewind, pause possible!

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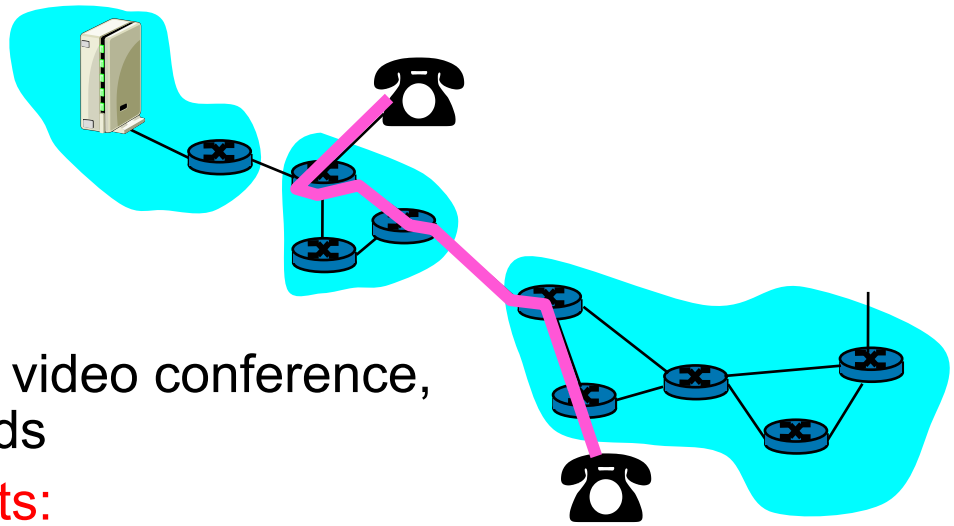
# Interactive, Real-Time Multimedia



- applications: IP telephony, video conference, distributed interactive worlds
- end-end delay requirements:
  - audio: < 150 msec good, < 400 msec OK
    - includes application-level (packetization) and network delays
    - higher delays noticeable, impair interactivity
- session initialization
  - how does callee advertise its IP address, port number, encoding algorithms?

# Multimedia Over Today's Internet

TCP/UDP/IP: "best-effort service"

- *no* guarantees on delay, loss

But you said multimedia apps requires QoS and level of performance to be effective!

Today's Internet multimedia applications use application-level techniques to mitigate (as best possible) effects of delay, loss

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# How should the Internet evolve to better support multimedia?

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Integrated services philosophy:

- Fundamental changes in Internet so that apps can reserve end-to-end bandwidth
- Requires new, complex software in hosts & routers

Laissez-faire

- no major changes
- more bandwidth when needed
- content distribution, application-layer multicast
  - application layer

Differentiated services philosophy:

- Fewer changes to Internet infrastructure, yet provide 1st and 2nd class service.

What's your opinion?

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# A few words about audio compression


- Analog signal sampled at constant rate
  - telephone: 8,000 samples/ sec
  - CD music: 44,100 samples/ sec
- Each sample quantized, i.e., rounded
  - e.g., $2^8$=256 possible quantized values
- Each quantized value represented by bits
  - 8 bits for 256 values

- Example: 8,000 samples/sec, 256 quantized values --> 64,000 bps
- Receiver converts it back to analog signal:
  - some quality reduction

Example rates

- CD: 1.411 Mbps
- MP3: 96, 128, 160 kbps
- Internet telephony: 5.3 - 13 kbps

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# A few words about video compression

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- Video is sequence of images displayed at constant rate
  - e.g. 24 images/sec
- Digital image is array of pixels
- Each pixel represented by bits
- Redundancy
  - spatial
  - temporal

Examples:

- MPEG 1 (CD-ROM) 1.5 Mbps
- MPEG2 (DVD) 3-6 Mbps
- MPEG4 (often used in Internet, < 1 Mbps)

Research:

- Layered (scalable) video
  - adapt layers to available bandwidth

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# Generation of MPEG Video Sequences



- Given: sequence of digital images
- MPEG compression is combination of
  - Intra-frame compression (spatial redundancy reduction)
    - Discrete-Consine Transformation (DCT):
      8x8 pixel blocks ⇒ DCT ⇒ 8x8 DC coefficients
    - Quantization
    - Zig-zag entropy encoding
  - Inter-frame compression (temporal redundancy reduction)
    - Block-based motion compensation

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# Inter-Frame Dependencies



- Frame types
  - Intracoded frames (I-frame)
    - Does not depend on any other frames
    - Most important information, largest frame size
  - Predicted frames (P-frame)
    - Depends on preceding I- or P-frame
    - Medium frame size
  - Bidirectional frames (B-frame)
    - Depends on preceding and succeeding I- or P-frame
    - Small frame size, no other frame depends on it
- Group of Pictures (GoP)
  - All frames following and depending on a specific I-frame

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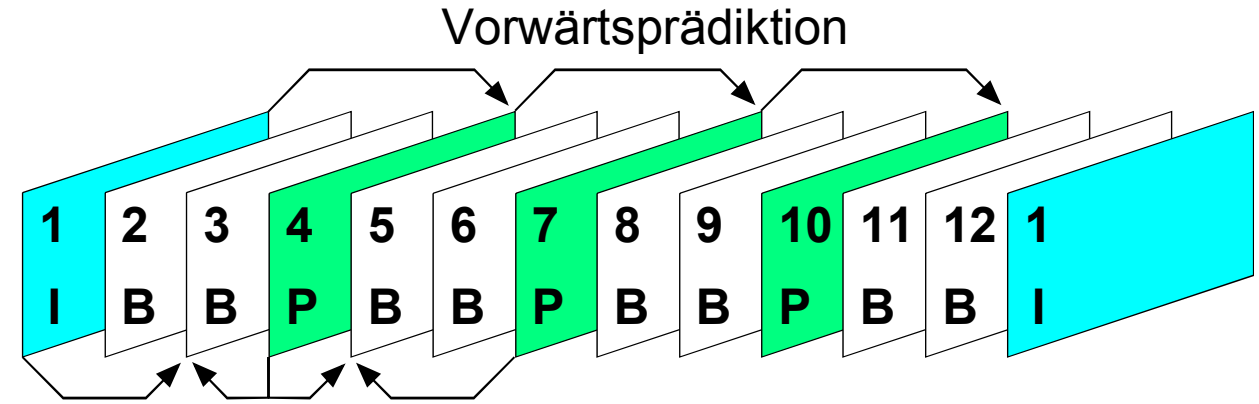
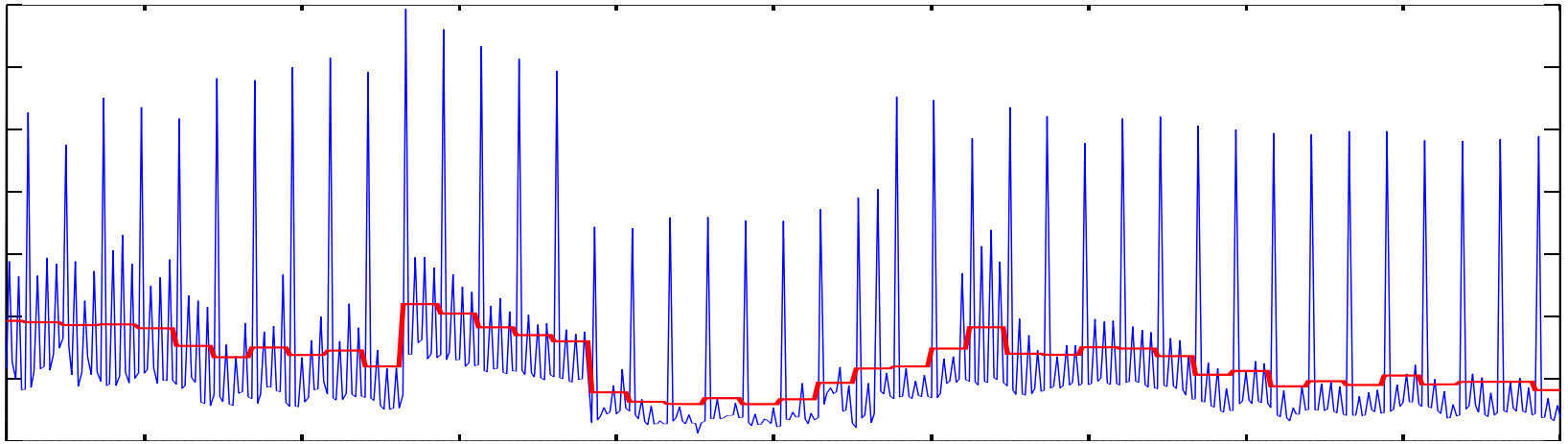
# Measured Time Series of MPEG Frame Sizes



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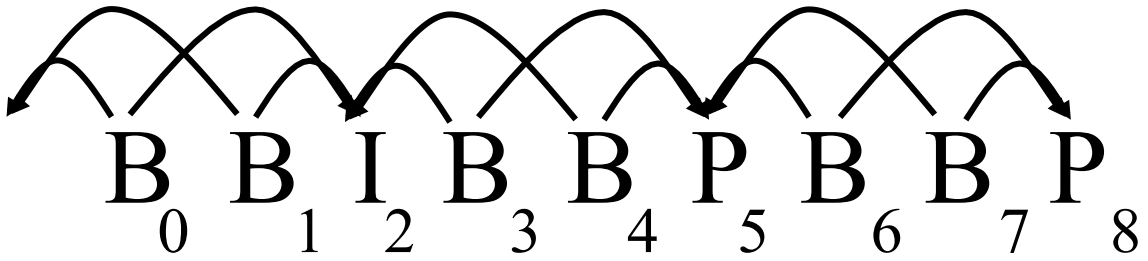
# Display and Bitstream Order



- Display order




- Bitstream order