

Multimedia Networking

Introduction

- o What is Multimedia?
- o How does Multimedia Communication Differ?
- o Media Data and Metadata
- o Multimedia Communication Aspects
- o Multimedia Network Requirements



What is Multimedia?

Text

Sound

Images

Video

...blub

News>> ... today: Iglo announces new Nemo fish finger..... <<News

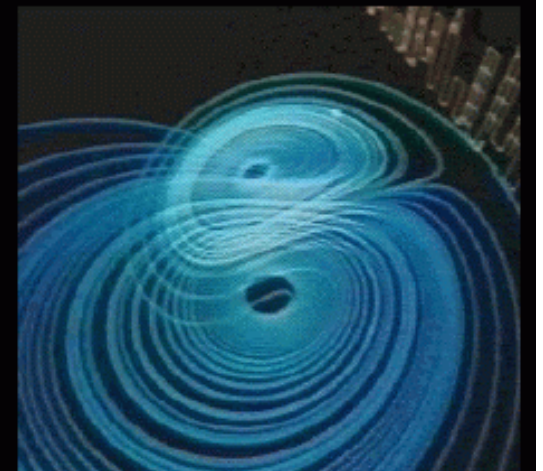
Simultaneous deployment of various media

Networked Multimedia Applications

- o Multimedia Extended Email
- o World Wide Web
- o Video Distribution Services
- o Video Conferencing
- o Interactive Distributed Games
- o Virtual Reality
- o Distant Learning
- o Instant Messaging

Alignment of
Media requires
Synchronisation

Any small variation of initial conditions
leads to significant changes in
solution of the weather model system.



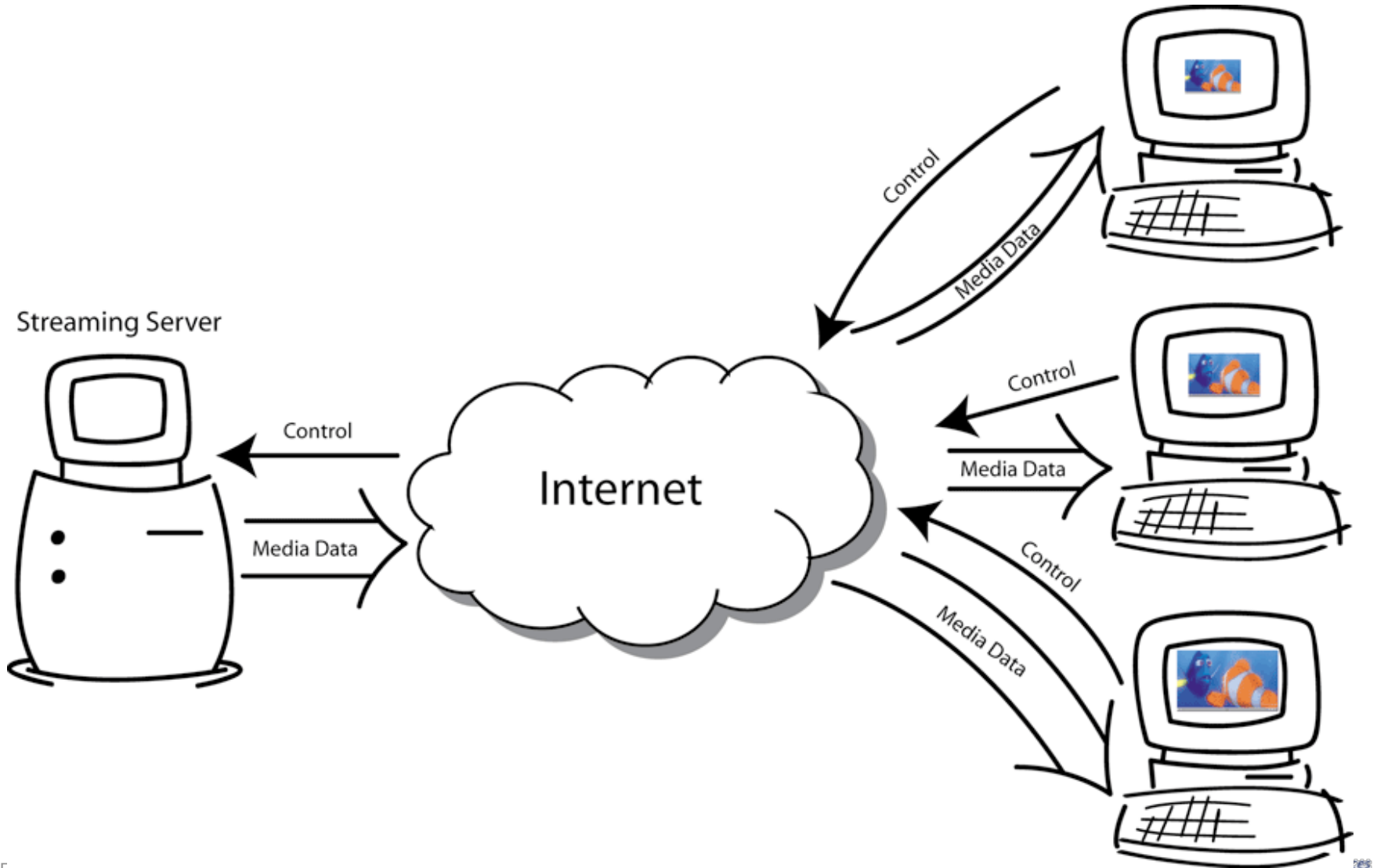
Networked Multimedia Applications

Sometimes there may be only one media,
but similar requirements:

- o Image Distribution
- o Telephony
- o Radio
- o Jukebox Services
- o Document Archives



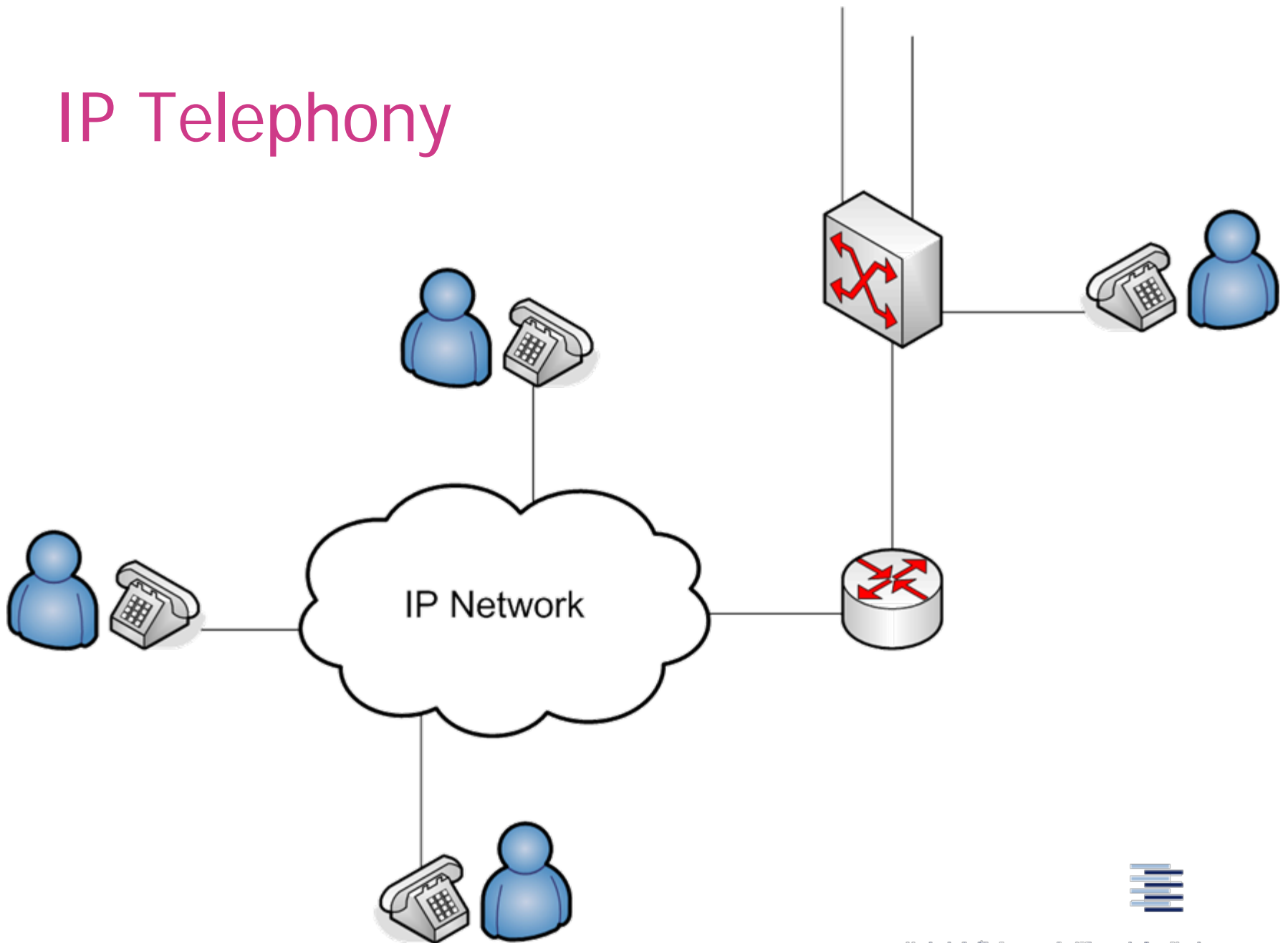
Video Streaming



Video-Conferencing



IP Telephony



How does Multimedia Communication Differ?

- o Data Formatting
 - ... the only universal data standard is ASCII ...
- o Data Volume
 - ... many times there are several fat chunks ...
- o Data Delivery Demands
 - ... synchronisation & real-time requirements ...
- o Interactive Data Exchange
 - ... user sensitive to response time ...
- o Complex Communication Scenarios
 - ... additional meta-communication needed ...

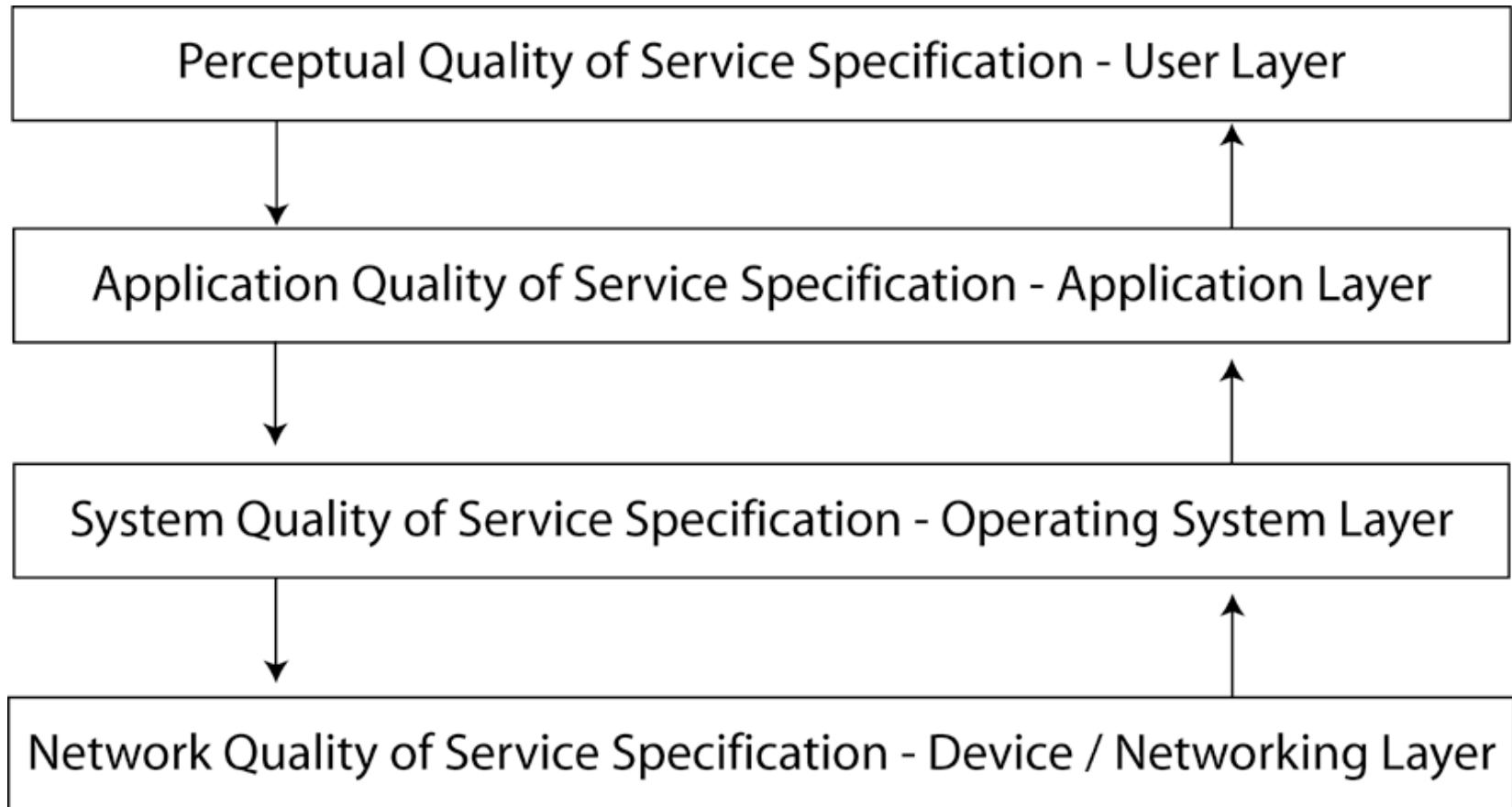


Distinctive Issues

- o Media Specific Formats
- o Partitioning of Complex Information into Media Types
- o Data Compression
- o Continuous Flows of Data
- o Data Bound to Real-Time Playout
- o Interactivity Burdened with Data Complexity
- o Limited Loss Toleration
- o Media & Communication Specific Signalling



QoS – Layered Model



Types of Media

Timeless

- Text with or without formatting (ASCII, HTML, XML, PDF, ...)
- Images with or without animation (GIF, PNG, JPEG, TIFF, ...)
- Vector graphics (SVG, Vendor Formats)
- Animation Scripts (Java-/ECMAScript, Flash, ...)

Time-based

- Audio (PCM, GSM, G.7xx, MP3, WAV, ...)
- Synthesised Audio (MIDI)
- Video (MPEG1/2/4, AVC, H.26x, ...)
- Synchronised Media Streams (SMIL, Lingo)



Media Formats & Bandwidths

Video (raw)

Formats	Lines	Columns	Fps [Hz]	Size [kB]	Data Rate [Mb/s]
QCIF	176	144	5-15	38	1-4
CIF	352	288	10-30	152	10-36
CCIR601 (TV)	720	576	25	829	166

Audio (raw)

Formats	Sampling Rate [kHz]	Size [bit]	Data Rate [kb/s]
G.711 (Speech)	8	8	64
Music CD (Stereo)	44,1	16	1411

Countermeasure on Bandwidth: Compressive Coding

Media Coding:

Sampling & Quantisation

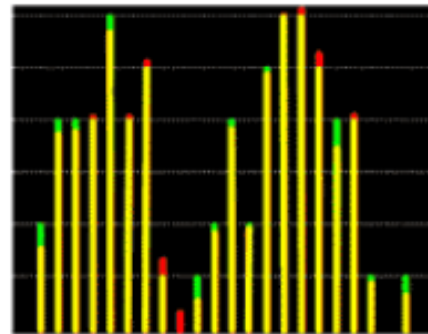
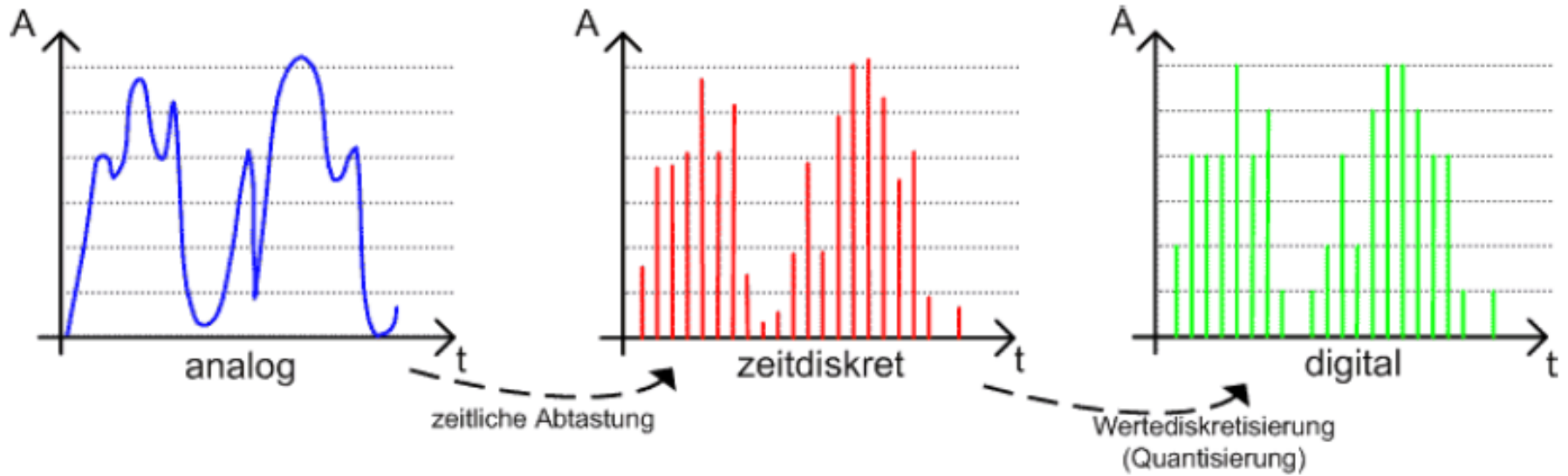
⇒ Apply Compression by

- o Redundancy Elimination
- o Data Reduction of 'Unnoticeable' Information
- o Statistical Reduction (Entropy Coding)
- o Lossy Adaptation to Bandwidth Limitations

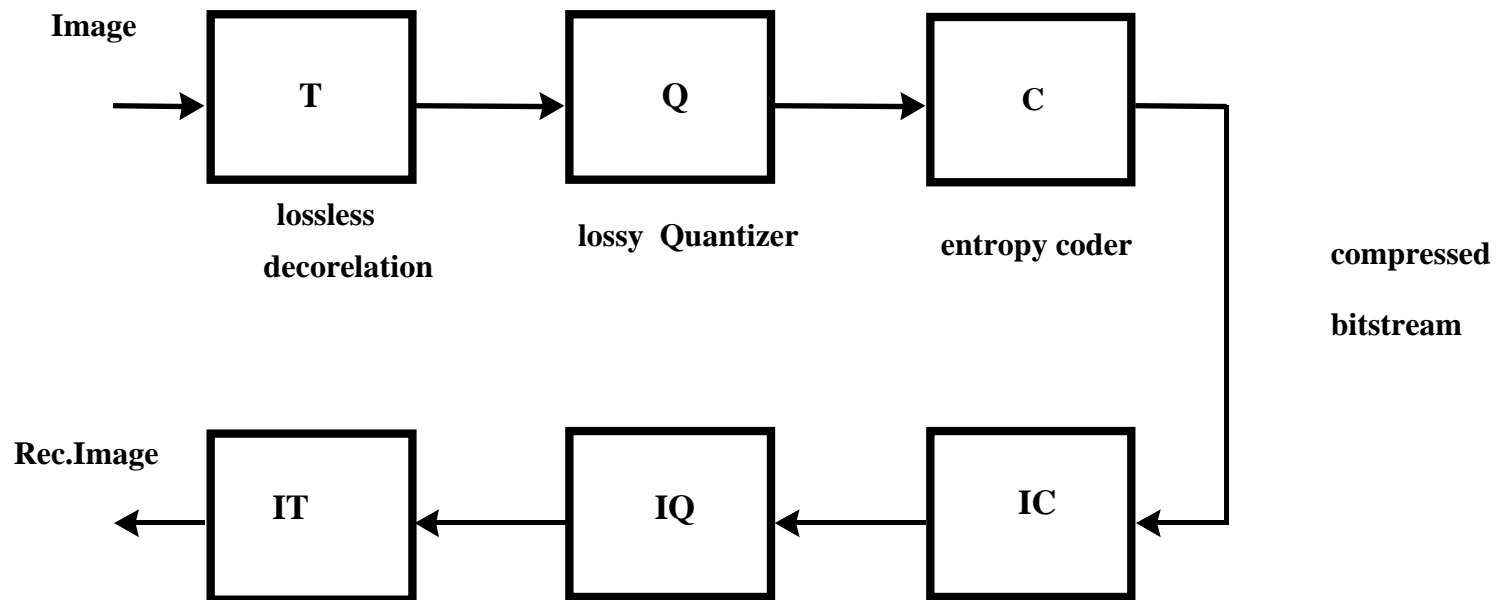
Objective: Minimal Data for Given Play-Out Quality



Sampling & Quantisation



Transform Coding Decoding (DCT- or Wavelet- based)

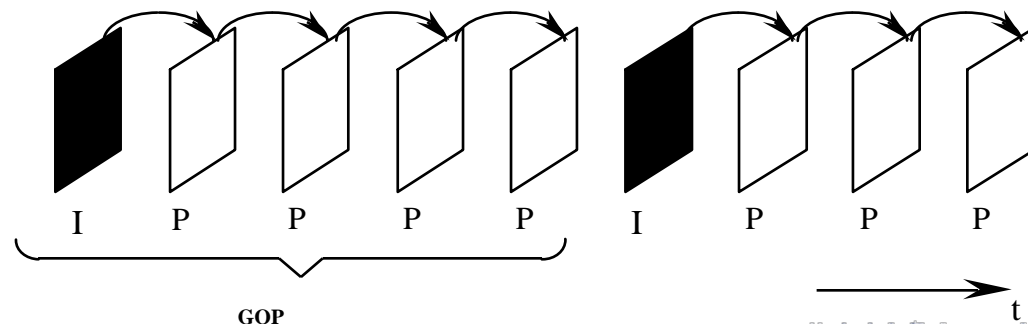


Temporal Decorrelation for Video: Difference Coding

In slow moving scenes many subsequent images are nearly alike:

- **Temporal Redundancy** is eliminated by coding only the difference of subsequent images (Inter-Frames).
- To limit accumulating errors full images (Intra-Frames) are coded regularly (\approx one of 50 frames)

I = Intra
P = Inter



Coding

Video Data: Compression Rates of 1 : 300 up to 1 : 1500 needed ...

Choice of Coding depends on:

- o Strength of Algorithms
- o Resource availability in the Network
- o Compute capabilities at End-nodes
- o Types of application: Live (real-time) or Store & Retrieve
- o Quality requirements at End-nodes



Metadata

We need assistance to examine media content:

- o MPEG-7: Multimedia Content Description Interface

- Meta data standard
- Goal: describe multimedia data for search, retrieval and (combined/synchronized) play out

- o MPEG-21: Multimedia Framework (just finishing)

- Meta data standard for multimedia applications

- o Signalling: Technical Metadata for content processing

- For end-to-end content handling
- For stream management at network and nodes



Multimedia Data Exchange

- o Media specific data encoding results in many different formats
 - o Formats represent media data specific intelligence (e.g. compression)
 - o Media types require classes of applications (e.g. viewers, players)
 - o Applications must understand the media data formats
 - o Format processing forms major application intelligence
 - o Media types, formats and applications open for new development
 - o Data exchange in heterogeneous environments requires standards
- ⇒ Any rigid scheme of standards offends innovation & communication



Mime Signalling

Multipurpose Internet Mail Extensions (RFCs 2045-49 et al.) define an extensible meta-communication scheme on media types, formats and applications.

Key component:

Definition of media specific Tags

Content-Type: type/subtype (* = wildcard)

Example

Content-Type: application/msword
 image/gif
 audio/mp3

New **Mime-Types** are appointed continuously.

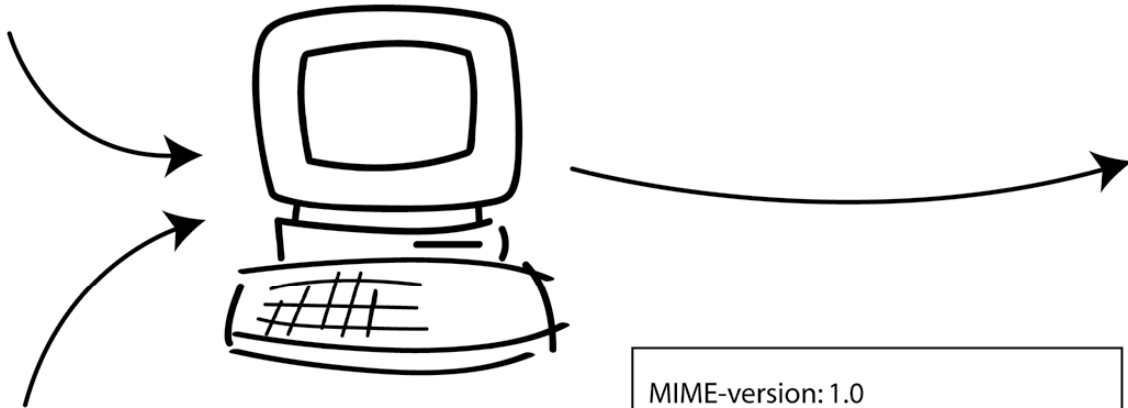
Mime Signalling (2)

Snoopy.gif



Hello.html

```
<html>
<head>
<title></title>
</head>
<body>
<h1>Hello Snoopy</h1>
</body>
</html>
```



mime.types

```
.gif : image/gif
.jpeg : image/jpeg
.html : text/html
.
.
.
```

```
MIME-version: 1.0
Content-Type: multipart/mixed

Content-Type: text/html

    <h1>Hello Snoopy</h1>

Content-Type: image/gif

    data: Snoopy.gif
    [encoded gif image]
```



mailcap

```
.
text/html: /bin/mozilla.exe
.
.
.
```

More Signalling

Temporal Synchronisation

- Real-Time Transport (Control) Protocol (RTP/RTCP)
- Real-Time Streaming Protocol (RTSP)

Session Handling

- H.323/H.225/H.245 (POTS compatible)
- Session Initiation Protocol SIP
- Session Description Protocol SDP

Session Announcement

- Session Announcement Protocol SAP
- Internet Media Guides (IMG)



MM Transmission Modes

Asynchronous

- No temporal restriction in data delivery

Synchronous

- Maximal end-to-end delivery delay

Isochronous

- Maximal and minimal end-to-end delivery delay

Pseudo-Synchronous

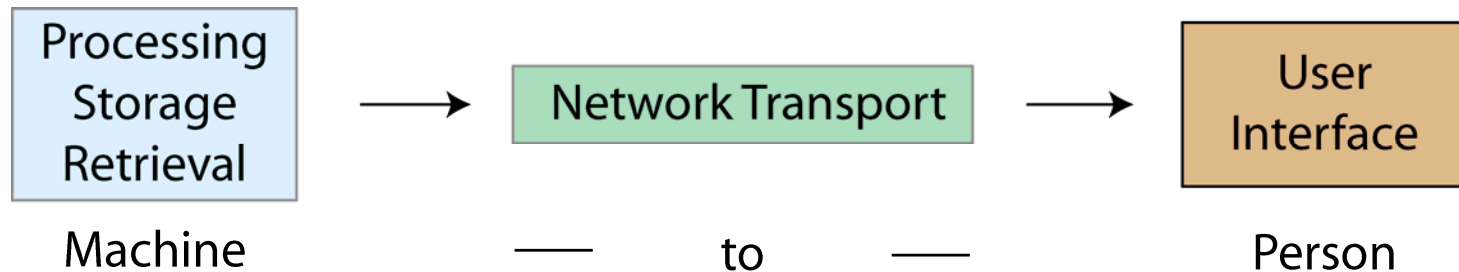
- Simulated or weakly bound end-to-end delivery delay



MM Communication Aspects

Type: Distribution

- Audio/Video Broadcast, Web, Archives



Typical Aspects

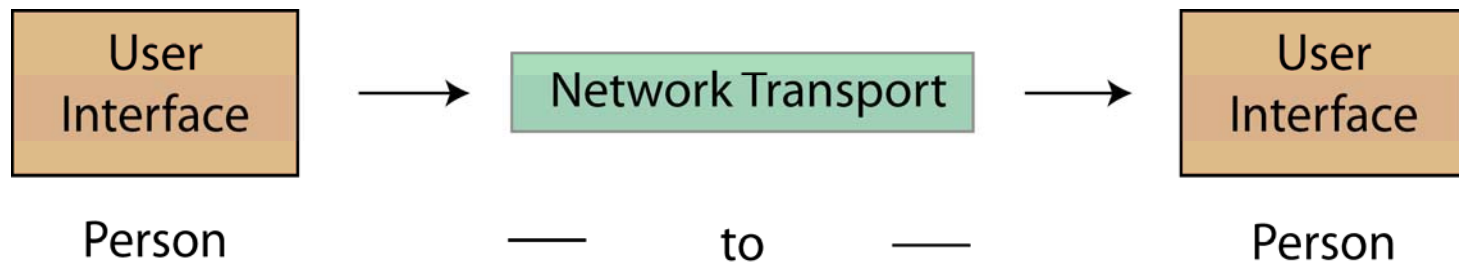
- Asynchronous or pseudo synchronous transmission
- Client/Server Model, one to many (concurrent)
- Unidirectional, low interactivity



MM Communication Aspects

Type: Exchange

- Audio/Video Conferencing, Telelearning, Collaboration Tools



Typical Aspects

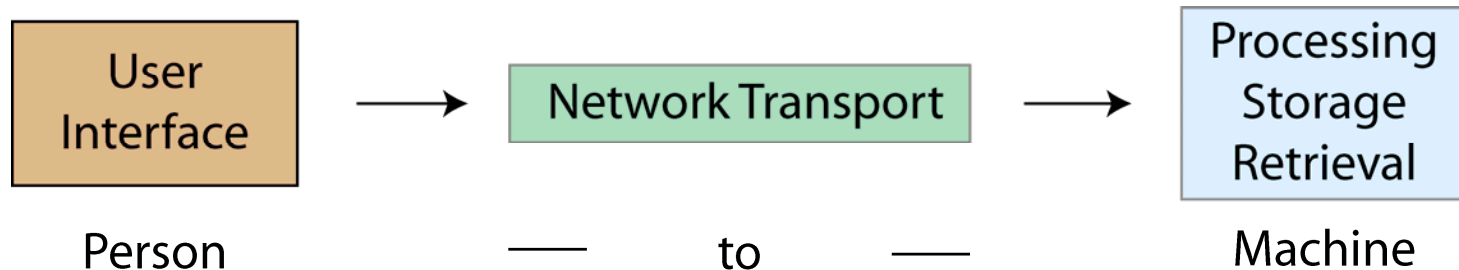
- Synchronous or isochronous transmission
- Peer-to-peer, one to one (or multipoint)
- Bidirectional, highly interactive



MM Communication Aspects

Type: Production

- Multimedia authoring, recording, (Email)



Typical Aspects

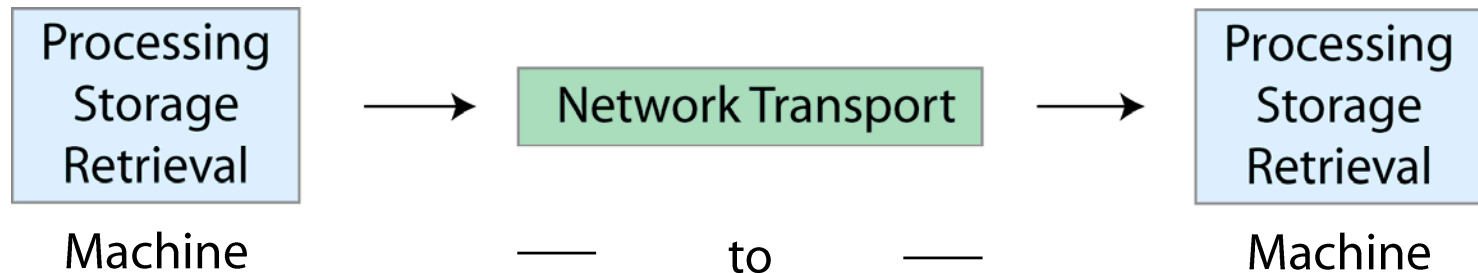
- Synchronous or pseudo synchronous transmission
- Client/Server Model, one to many (competitive)
- Unidirectional, highly interactive



MM Communication Aspects

Type: Synchronisation

- Data synchronisation, (synchronised) multi-archive retrieval, software distribution



Typical Aspects

- Any mode of transmission
- Client/Server Model, one to one or many
- Uni- or bidirectional, low interactivity



Requirements in Multimedia Networking

- o Sustained availability of NW bandwidth
- o Predefined reliability and performance of transport
- o Group communication support
- o Availability of media-aware middleware
- o Availability and performance of applications

Expected strength of performance strongly (e.g. non-linearly)
depends on media quality!



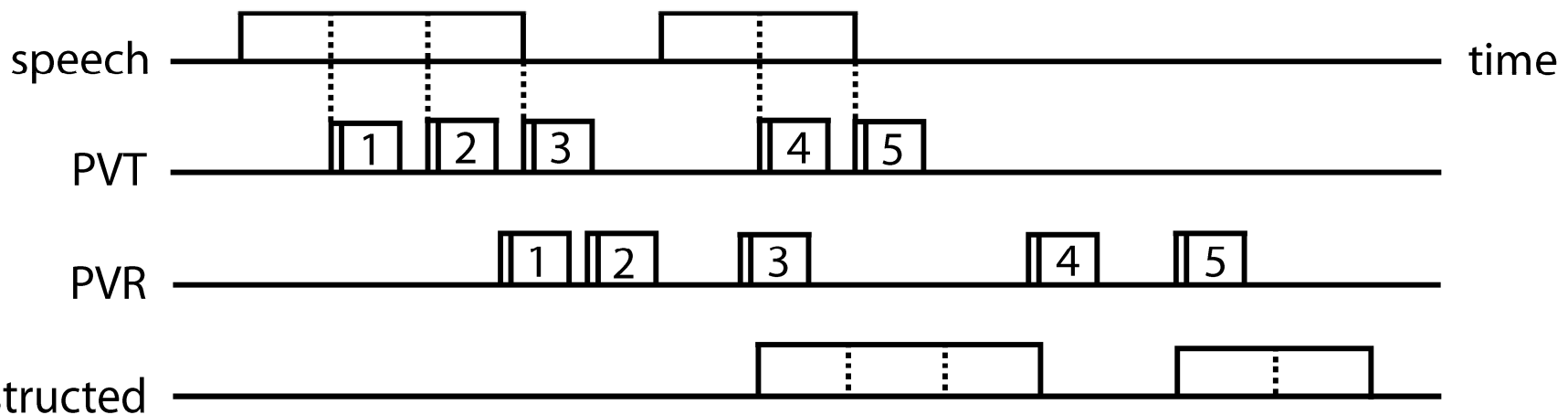
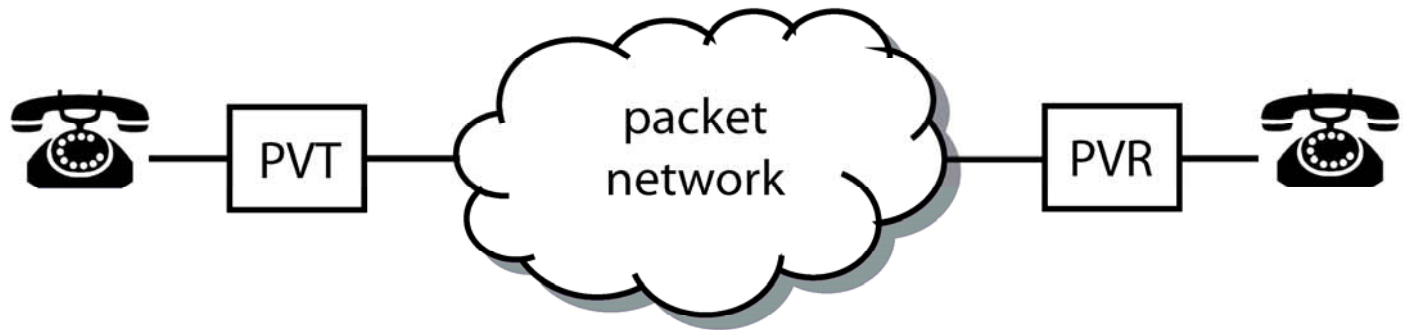
Network Performance

Terms and Definitions

- **Bandwidth (sustained)** - Average throughput capacity of the network
- **Packet Loss** - Measure of network reliability with respect to loss or de-sequencing of (unreliable) packet transport, taken in %
- **End-to-End Latency** - Time needed for a packet to travel between application end-points
- **Network Delay** - Transit time for a packet within the network
- **Inter-stream Latency** - Relative latencies between synchronised streams (e.g. audio and video)
- **Jitter** - Delay variation in packet arrival



Critical Issue: Jitter



Constant Bit-Rate cells transmitted over packet networks:
From Packet Voice Transmitter (PVT) to Receiver (PVR)
encounter packet-wise random delays

Estimators

How to evaluate delay and jitter?

Let

t_i = Timestamp of the i -th packet

r_i = Time of reception for the i -th packet

Then for appropriate weight $0 < u < 1$

$$d_i = (1 - u) d_{i-1} + u (r_i - t_i) \quad (\text{Delay Estimator})$$

$$J_i = (1 - u) J_{i-1} + u | r_i - t_i - d_i | \quad (\text{Jitter Estimator}) \text{ or}$$

$$J'_i = (1 - u) J'_{i-1} + u | (r_i - t_i) - (r_{i-1} - t_{i-1}) | \quad (\text{Interarrival Jitter Estimator})$$

are smoothed temporal averages



VoIP/VCoIP

Real-Time Requirements

! Latency $\approx < 100$ ms

! Inter-stream Latency $\approx < 30/40$ ms audio ahead/behind

! Jitter $\approx < 50$ ms

! Packet loss $\approx < 1$ %

! Interruption: 100 ms ≈ 1 spoken syllable

! Packet reordering may cause loss & jitter



Multimedia Transport

Single files (Images, Documents, Video/Audio Scenes, etc):
just large chunks for regular (TCP-) transport ...

... but real-time streams are **incompatible with TCP** due to
retransmission timing:

↓ Originally lost or corrupted packets eventually are useless upon arrival
because retransmission took too long

→ **UDP** used for real-time applications **at transport layer**



Multimedia Transport: Annoyance to Networks

TCP adapts to traffic conditions (per connection states: window sizes)

UDP ignores traffic conditions (no connection state)

o Multimedia real-time streams may flood networks and routers and harm

- other data intensive flows, but
- in particular TCP traffic, which is “polite”

o Introduction of multimedia traffic may misbalance well provisioned networks

→ Traffic segregation, policing or bandwidth shaping/engineering



Countermeasures on Delay

Delay is added by applications, end-node systems, network nodes and distances

... possible preventions depend on application:

- o Application performance (real-time en-/decoding or pre-encoding)
- o Overprovisioning in end-nodes and network nodes
- o Large transmission resources (nw capacity, wire speed routing and switching)
- o Priorised forwarding
- o Delay hiding techniques (pre-fetches, buffers, proxies) in applications



Countermeasures on Jitter

Delay Variation (Jitter) is the most offending disturbance ...

... due to queuing/multiplexing, host and network overload:

- o Reliable Jitter compensation: conform each data unit to maximum delay
 - ⇒ **Increase of total delay ⚡ critical for interactivity**
- o Binding applications to fixed processing times (coding)
- o Replay buffers and proxies
- o Over provisioning in end-nodes and network nodes (memory, processing)
- o Traffic classification & priority queuing
- o Traffic decrease/adaptation conformal to network capacities
- o Decrease of overall delay scales



Group Communication

o Multicast transmission service

- Allows to send a single packet to a group
- Needs Multicast routing support
- Interactive applications are typically sender & receiver

o Server with reflector functionality/Multipoint Conference Unit

- Introduces additional delay and jitter
- Limited scaling



Quality of Service: Problem

“The ability of networks to guarantee and maintain certain performance levels for each application according to the specified needs of each user”

IETF

“QoS is a managed unfairness”

F.Baker, former IETF Chair

In Multimedia Networking QoS is mainly about

- Reservation of bandwidth
- Predefined delay
- Absence of jitter or congestion
- Predefined rate of reliability



Quality of Service: Support

Adaptation to network capabilities at application:

→ Layered Coding, Adaptive Buffers

Traffic Classification:

→ Based on Service Level Agreements

Resource Reservation:

→ RSVP based on Flows, Priority Classes

Router Scheduling:

→ Priority Queuing, Selective Dropping

Service Architectures:

→ DiffServ, IntServ



Reading

- Rao, Bojkovic, Milovanovic: **Introduction to Multimedia Communications**, Wiley & Sons, Hoboken, NJ, 2006 .
- Stallings: **High-Speed Networks and Internets**, 2nd Ed., Prentice-Hall, Upper Saddle River, NJ, 2002.
- Künkel: **Streaming Media**, Wiley & Sons, Chichester, 2003.
- Steinmetz: **Multimedia-Technologie**, 3rd Ed., Springer, Berlin 2000.
- IETF Documents: www.rfc-editor.org, www.w3c.org .
- ITU Documents: www.itu.int .

