Multimedia Networking Introduction

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

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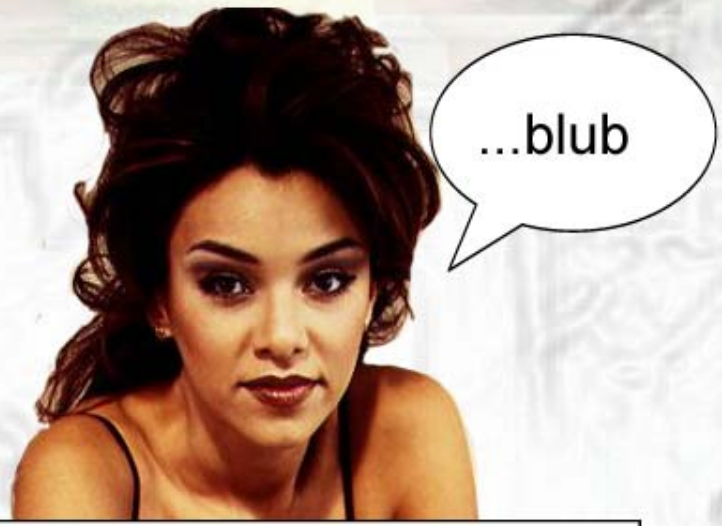
What is Multimedia?



- Text
- Sound
- Images
- Video

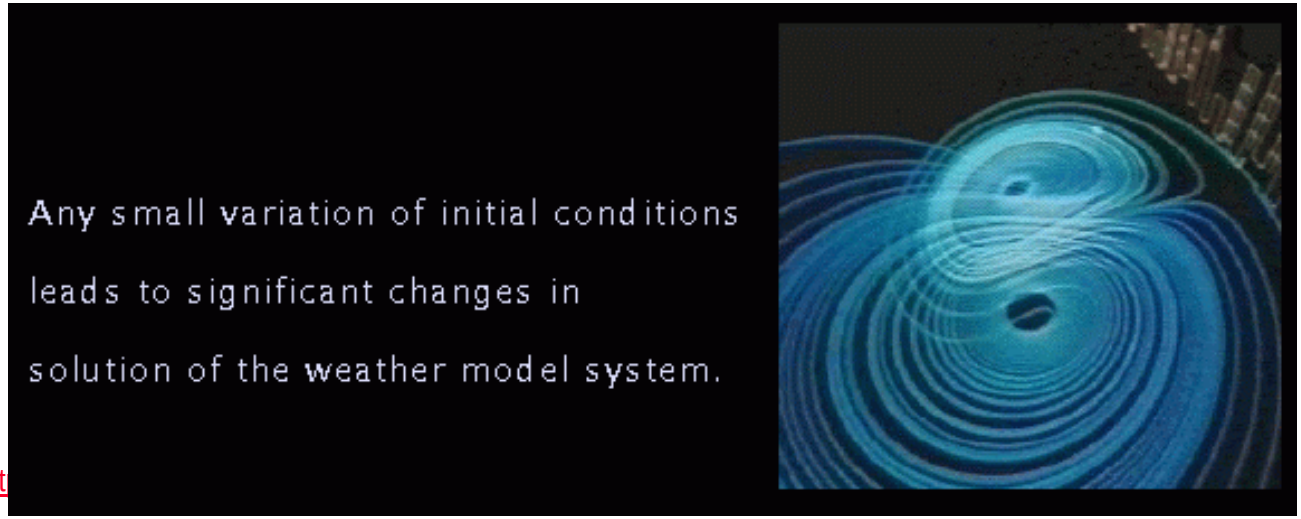
News>> ... today: Iglo announces new Nemo fish finger..... <<News

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

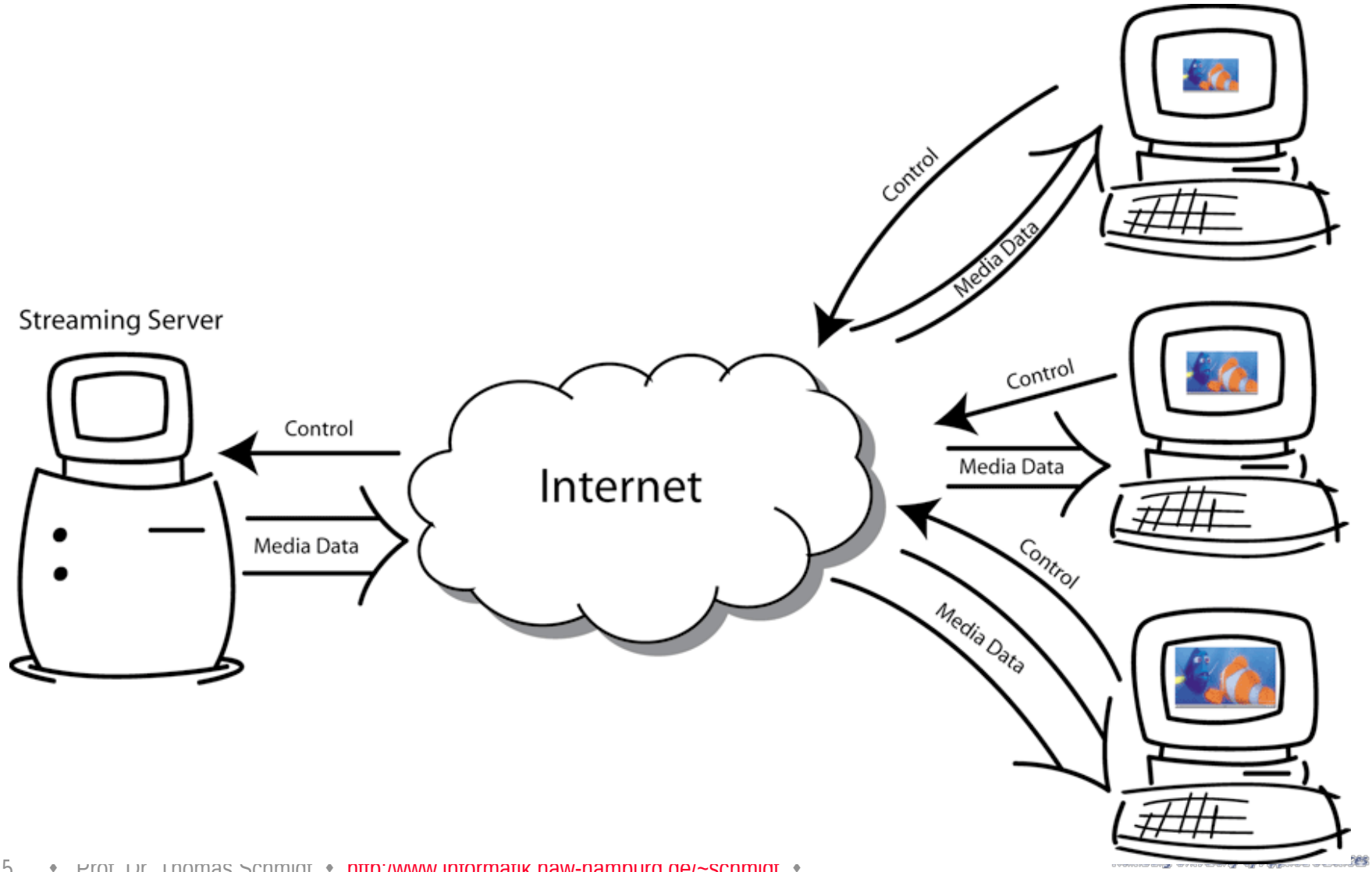


Networked Multimedia Applications

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

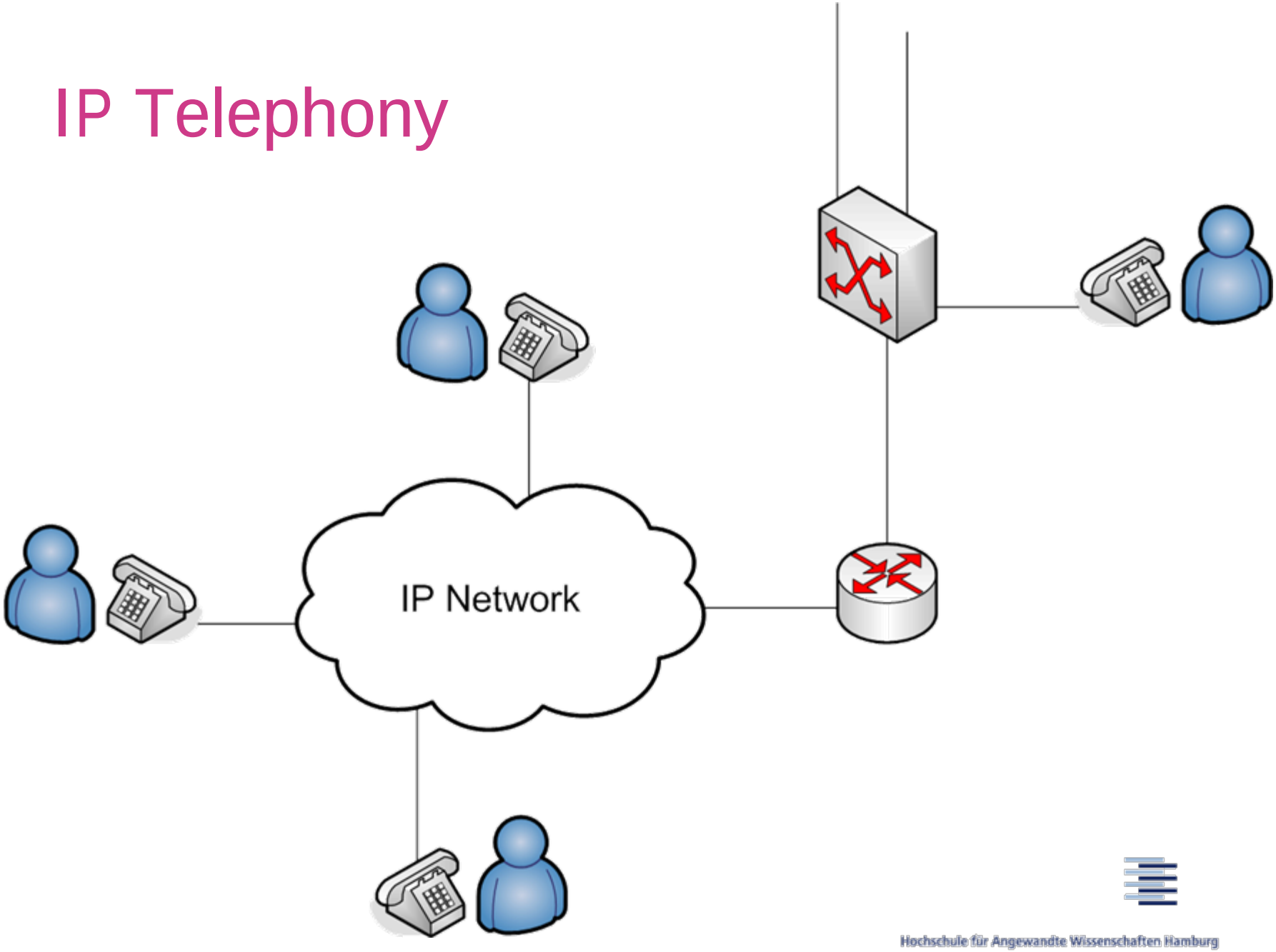
- Image Distribution
- Telephony
- Radio
- Jukebox Services
- Document Archives

Video Streaming



Video-Conferencing

IP Telephony



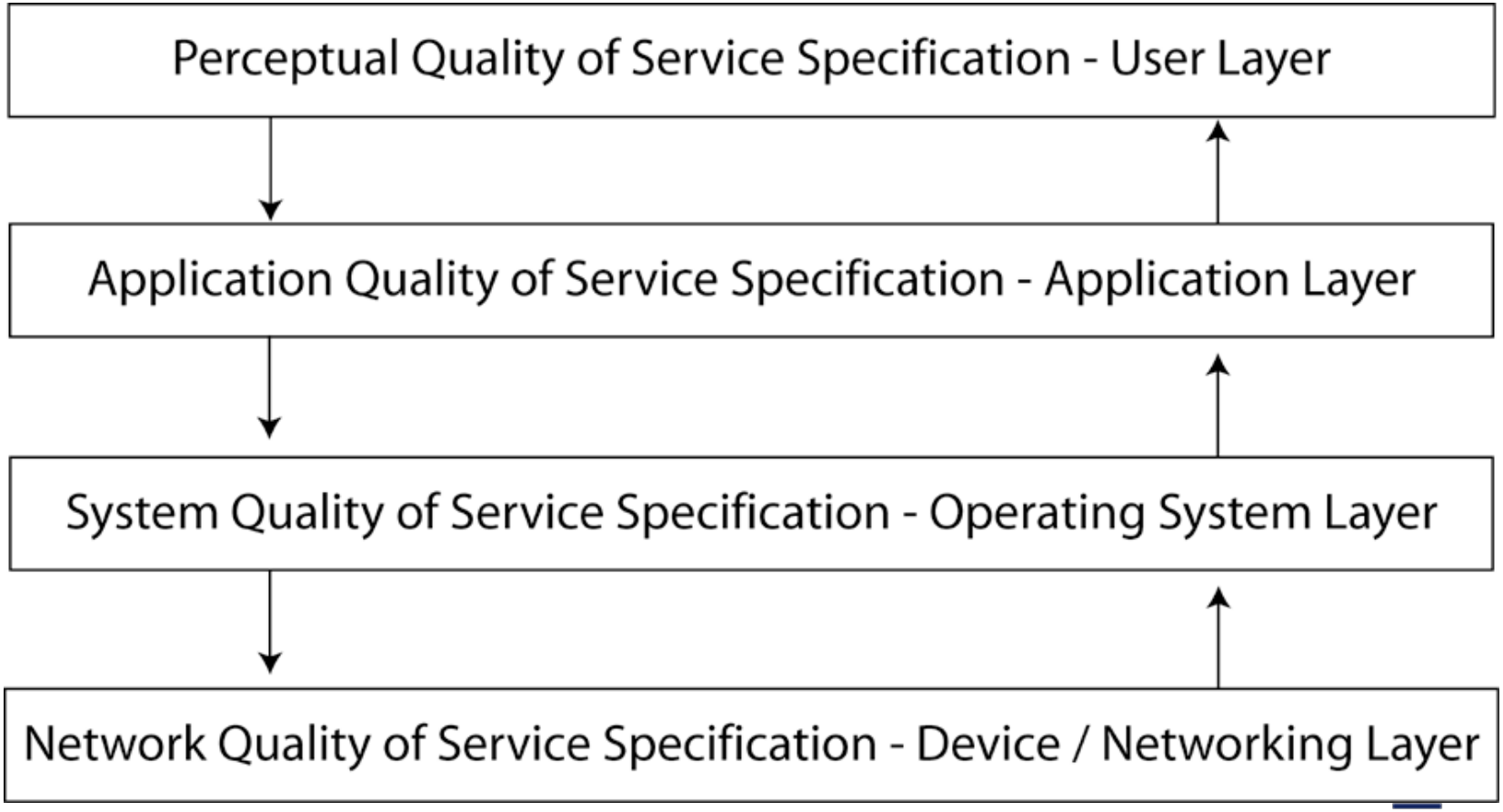
How does Multimedia Communication Differ?

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

Distinctive Issues

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

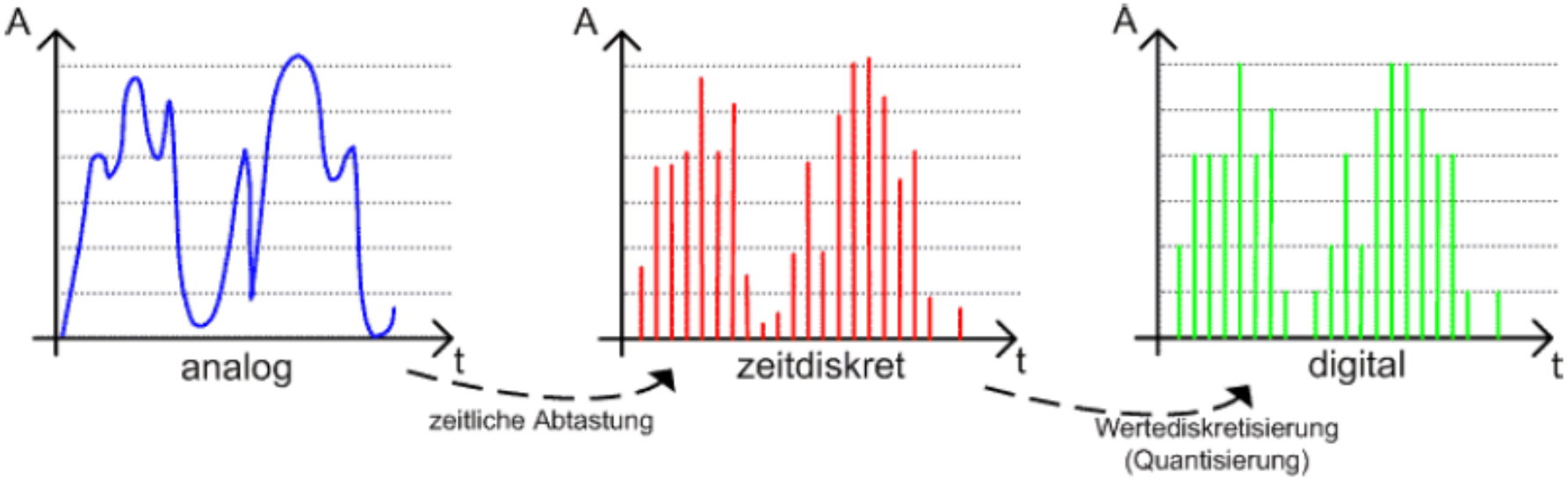
Sampling & Quantisation

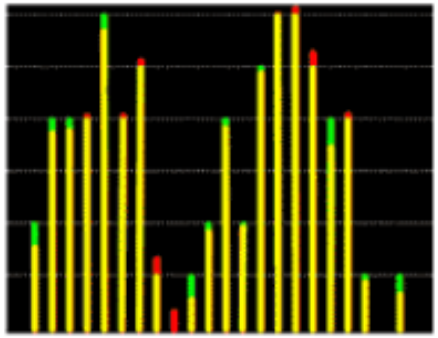
⇒ Apply Compression by

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

Objective: Minimal Data for Given Play-Out Quality

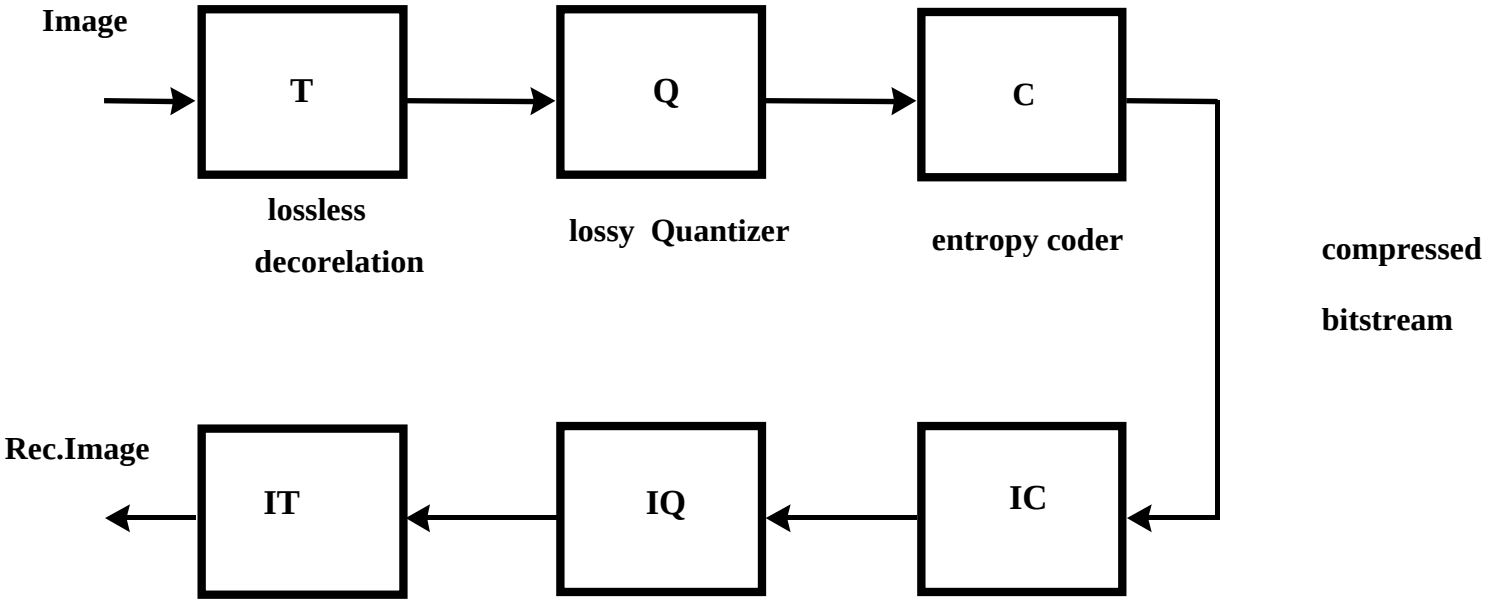
Sampling & Quantisation





Differenz

Transform Coding Decoding (DCT- or Wavelet- based)



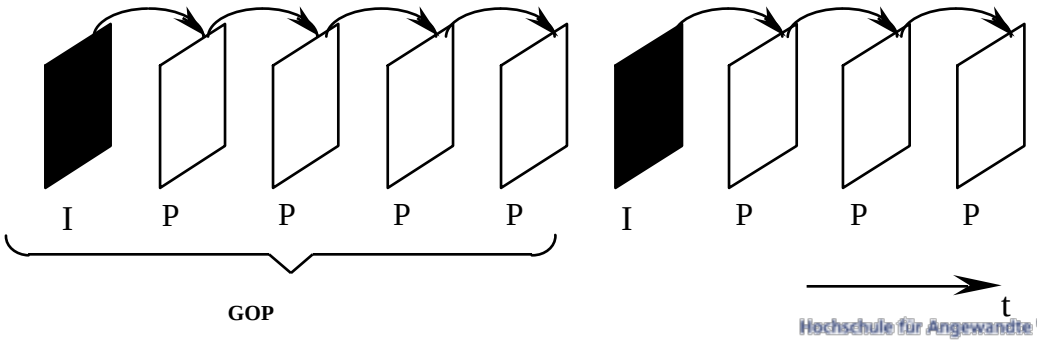
Temporal Decorrelation for Video: Difference Coding

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 (≈ 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:

- MPEG-7: Multimedia Content Description Interface
  - Meta data standard
  - Goal: describe multimedia data for search, retrieval and (combined/synchronized) play out
- MPEG-21: Multimedia Framework (just finishing)
  - Meta data standard for multimedia applications
- Signalling: Technical Metadata for content processing
  - For end-to-end content handling
  - For stream management at network and nodes

Multimedia Data Exchange

- Media specific data encoding results in many different formats
- Formats represent media data specific intelligence (e.g. compression)
- Media types require classes of applications (e.g. viewers, players)
- Applications must understand the media data formats
- Format processing forms major application intelligence
- Media types, formats and applications open for new development
- 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

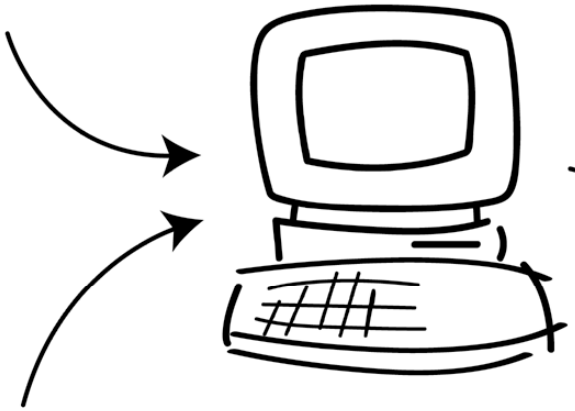
New Mime-Types are appointed continuously.

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/jpg
.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

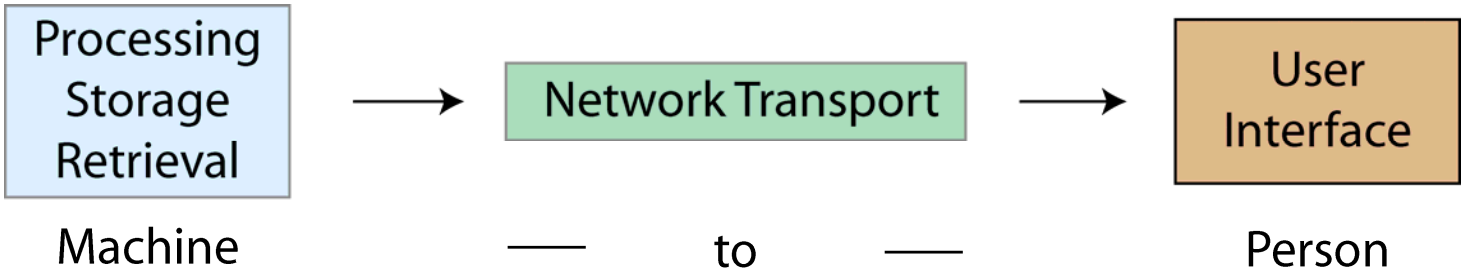
Pseudo-Synchronous

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

MM Communication Aspects

Type: Distribution

- Audio/Video Broadcast, Web, Archives



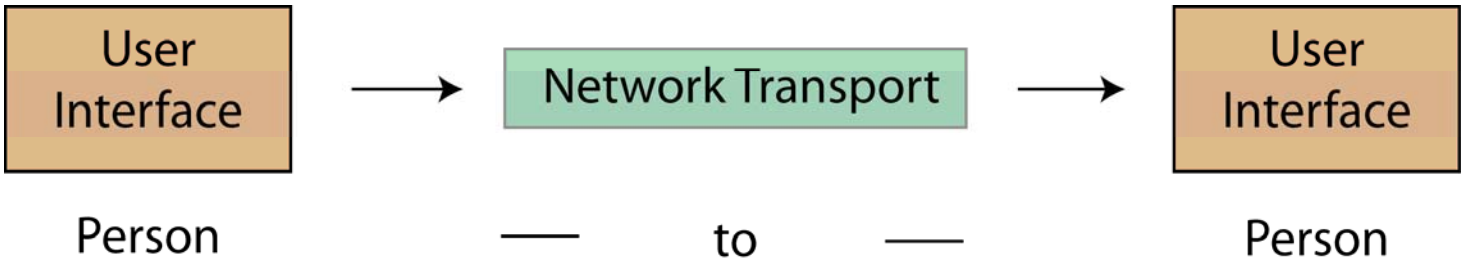
Typical Aspects

- 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



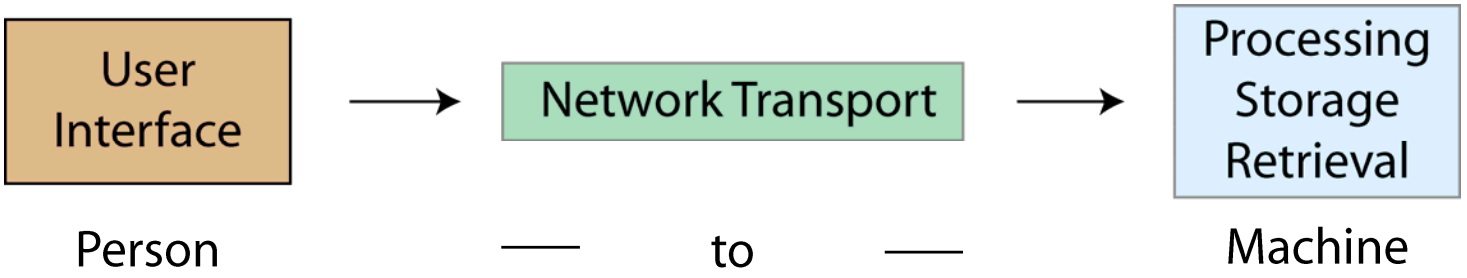
Typical Aspects

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

MM Communication Aspects

Type: Production

- Multimedia authoring, recording, (Email)



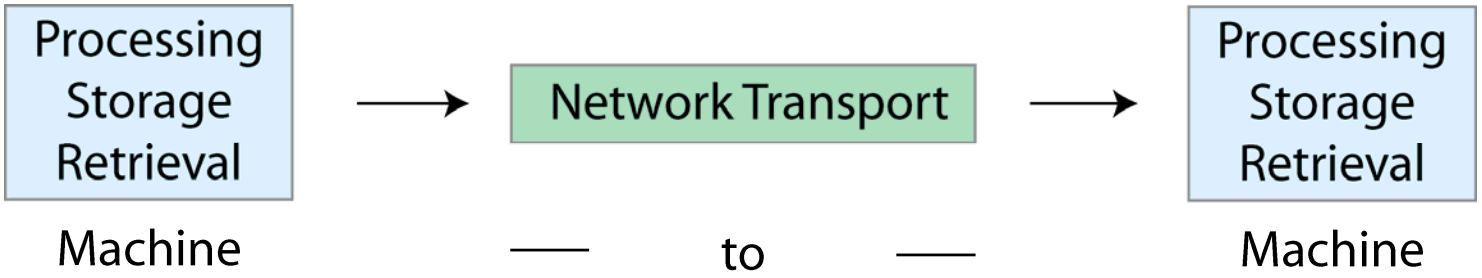
Typical Aspects

- 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

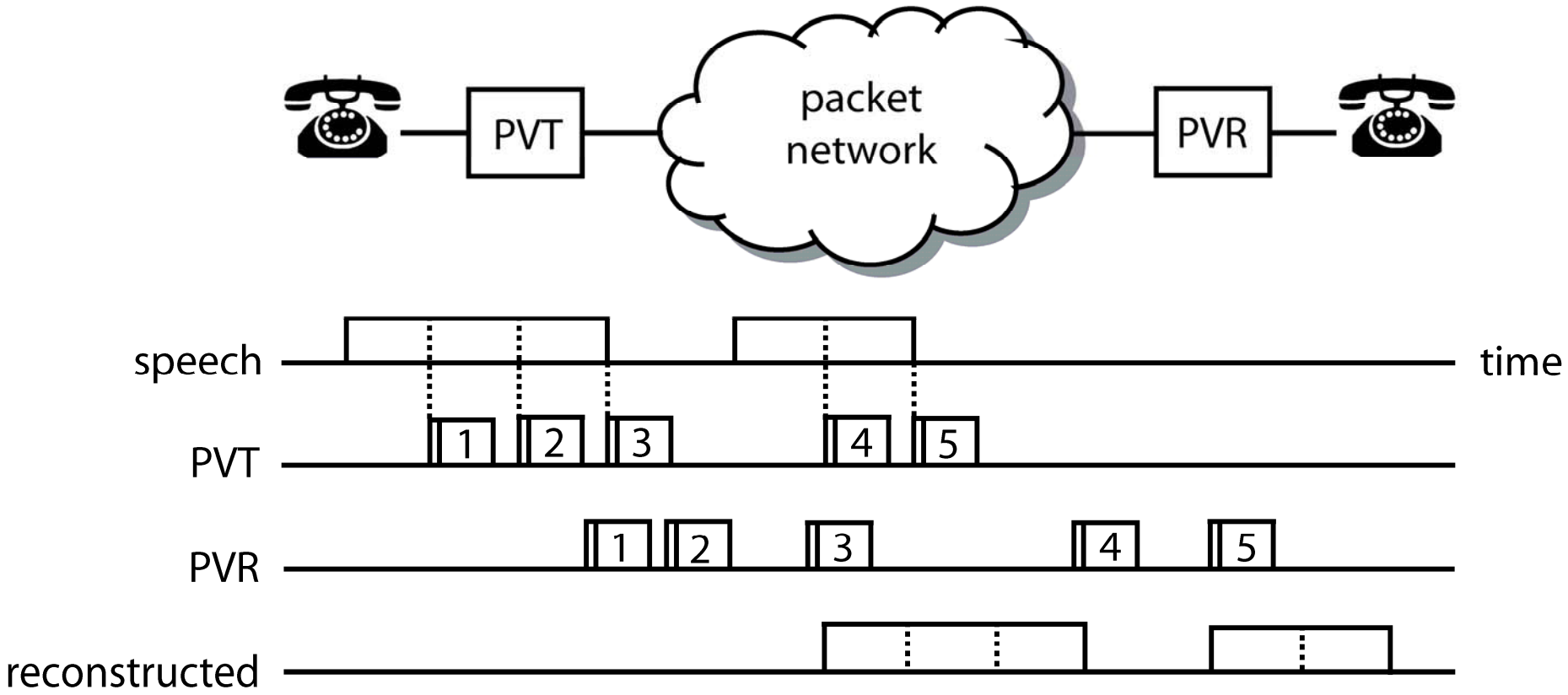
- o Sustained availability of NW bandwidth
- o Predefined reliability and performance of transport
- o Group communication support
- o Availability of media-aware middleware
- o Availability and performance of applications

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 $0 < u < 1$

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

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

$J'_i = (1 - u)\, J'_{i-1} + u\,|\,(r_i - t_i) - (r_{i-1} - t_{i-1})|$ (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 $\approx$ 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:

- Reliable Jitter compensation: conform each data unit to maximum delay

  ⇒ Increase of total delay ↗ critical for interactivity

- Binding applications to fixed processing times (coding)
- Replay buffers and proxies
- Over provisioning in end-nodes and network nodes (memory, processing)
- Traffic classification & priority queuing
- Traffic decrease/adaptation conformal to network capacities
- 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 .
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