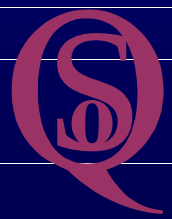
End Device and Network Adaptation of WaveVideo Streams



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Motivation

Observation (1):
Future Multimedia Communication will be performed in a very static/dynamic heterogeneous environment:

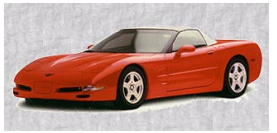
Devices

Screen Sizes, Processors, Memory, Power Supplies, Interfaces, etc.

Motivation

Network Access Technologies

- Modem, ISDN, xDSL, Ethernet, ATM, GSM/GPRS, UMTS, etc.
- Different characteristics for loss rate, bandwidth, etc.



Applications

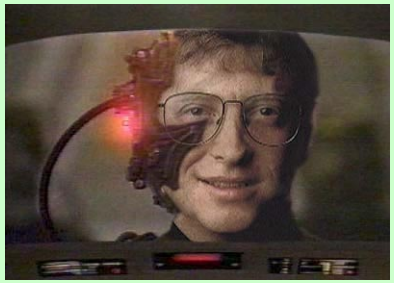
- Interactive/non-interactive, realtime/non-realtime, unicast/multicast etc.
- E.g. IP Telephony needs low delay, Video-on-Demand needs bandwidth

Users

- Different technology background and QoS requirements

‚Normal User‘

likes to have an ‚on/off‘ button



‚Cyborg‘

wants to specify the importance of certain parameters

Motivation

Observation (1):
In future networks,
Mobility will be essential

Terminal Mobility

- supports to physically move the device and eventually to connect to a foreign network

User Mobility

- supports to change the device and to have access on personal set of services in foreign networks

Session Mobility

- supports to maintain ongoing multimedia sessions during user and terminal movements

MASA

Mobility and Service Adaptation in Heterogeneous Mobile Networks

SIEMENS

Information and
Communication Networks
Communication On Air
ICN CA MS MA 1
Corporate Technology
ZT SE 2

University of Ulm
Department for Computer Science
Distributed Systems

NEC

NEC Europe Ltd.
Computer & Communications
Research Laboratories
Heidelberg

Outline of the Presentation

- The MASA QoS Framework
  - Architecture
  - Support for Heterogeneous Receivers
  - Adaptive Endsystem Architecture
- Media Adaptation and JMF
- QoS Filters
  - Syntactical
    - Priority
    - Data Rate Shaper
  - Semantical
    - Simple Frame Rate Filter
    - Advanced Frame Rate Filter
  - Evaluation
- Conclusion / Future Work

MASA QoS Framework

- A comprehensive end-to-end QoS architecture to support QoS for real-time multimedia streaming applications in a heterogeneous mobile wireless environment

- Application Separation
- Adaptive Multimedia
- Group Conferencing
- Heterogeneous Environments
- Network Layer QoS Mechanisms
- Wireless Networks
- Terminal/User/Session Mobility
- User Profiles
- Open APIs

- Plugable-Components
- Design Principles
- Admission Control
- Charging/Billing/Accounting
- Fairness
- Network Independence
- Operating System Independence
- Intuitive User Interfaces

Main Research Areas

- **Mobility Management**
  - to support seamless Handoffs in heterogeneous mobile environments
  - To support different access technologies

    (e.g. UMTS FDD, WirelessLAN, GSM/GPRS, Ethernet, etc.)

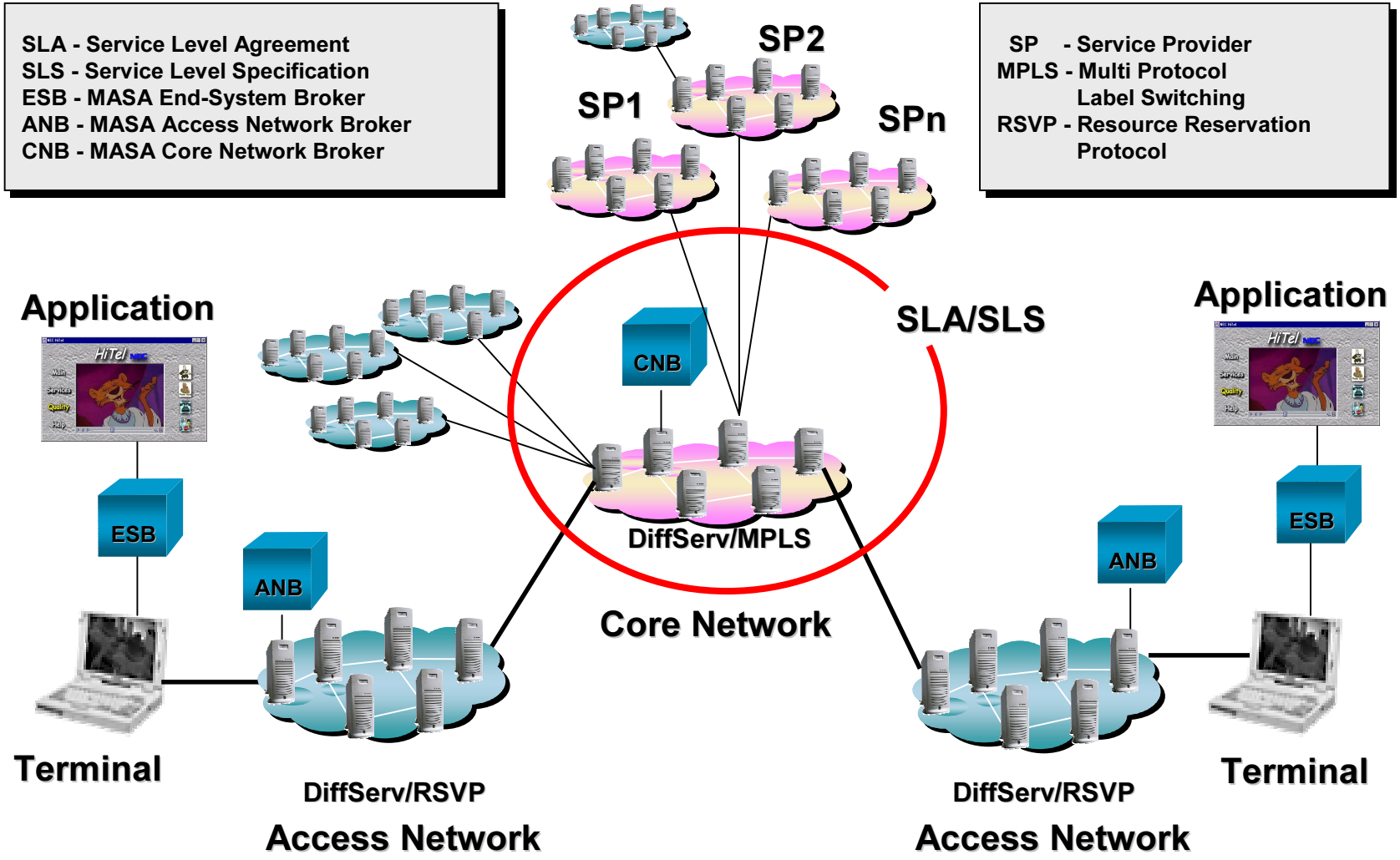
- **Media Management**
  - to support dynamic adaptable, high-quality, real-time media streaming
  - Separate Media Management from the Application
  - Pure IP-solution

- **QoS Management**
  - to manage QoS end-to-end in a co-operative way
  - Integrate and Orchestrate Resource Management
    - Locally (e.g. CPU, Memory, …)
    - Peer (e.g. CPU, Memory, …)
    - Network (e.g. DiffServ, IntServ,…)

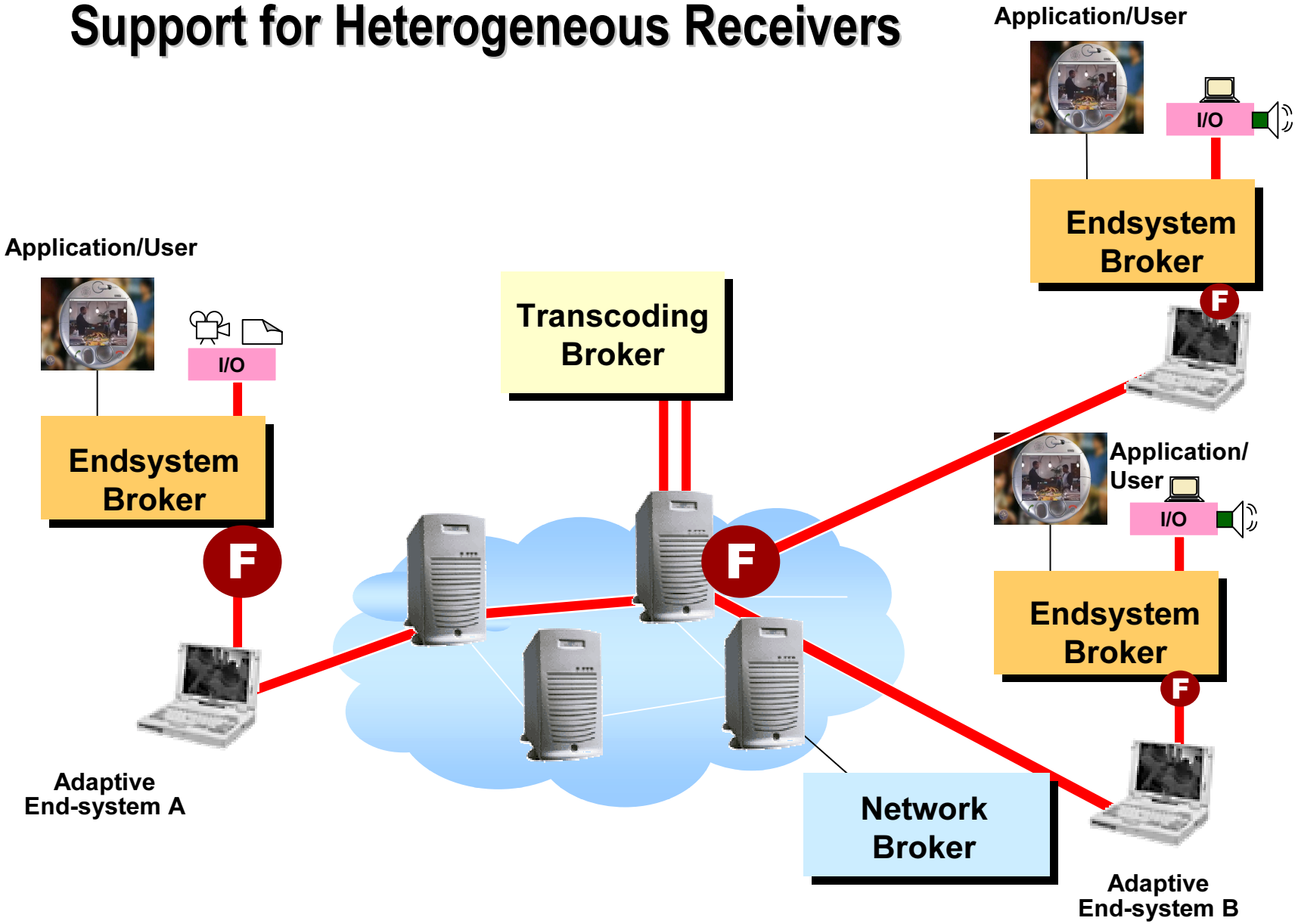
Overall Architecture

SLA - Service Level Agreement
SLS - Service Level Specification
ESB - MASA End-System Broker
ANB - MASA Access Network Broker
CNB - MASA Core Network Broker

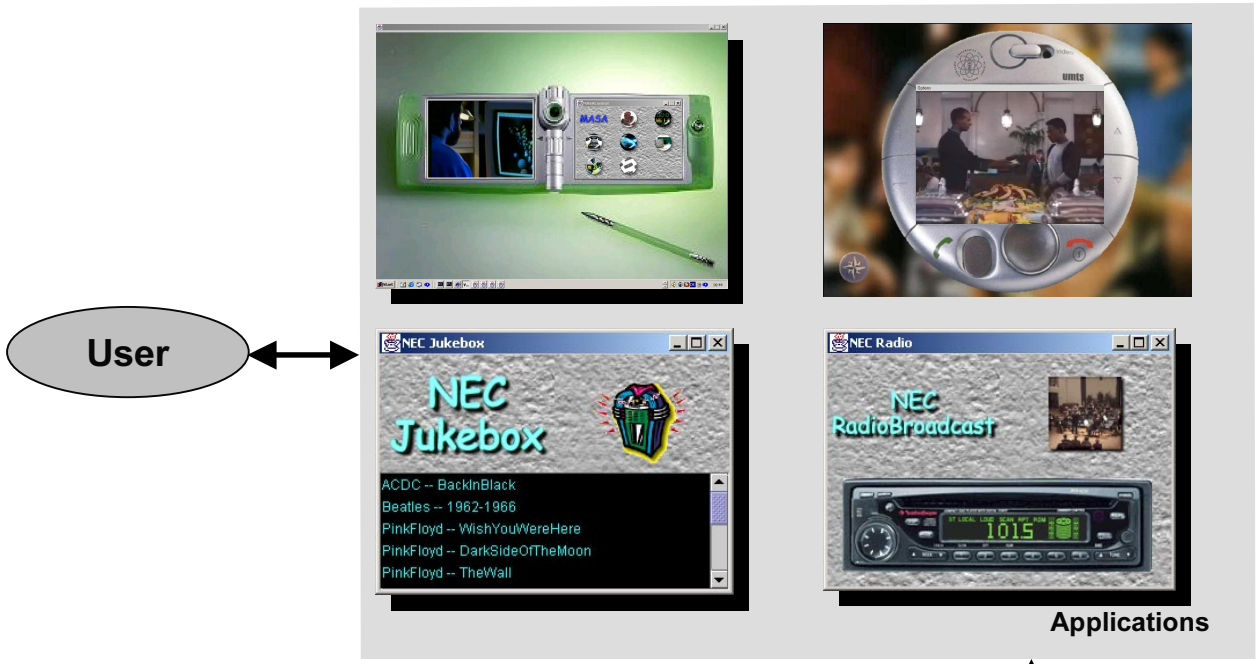
SP - Service Provider
MPLS - Multi Protocol Label Switching
RSVP - Resource Reservation Protocol



Support for Heterogeneous Receivers



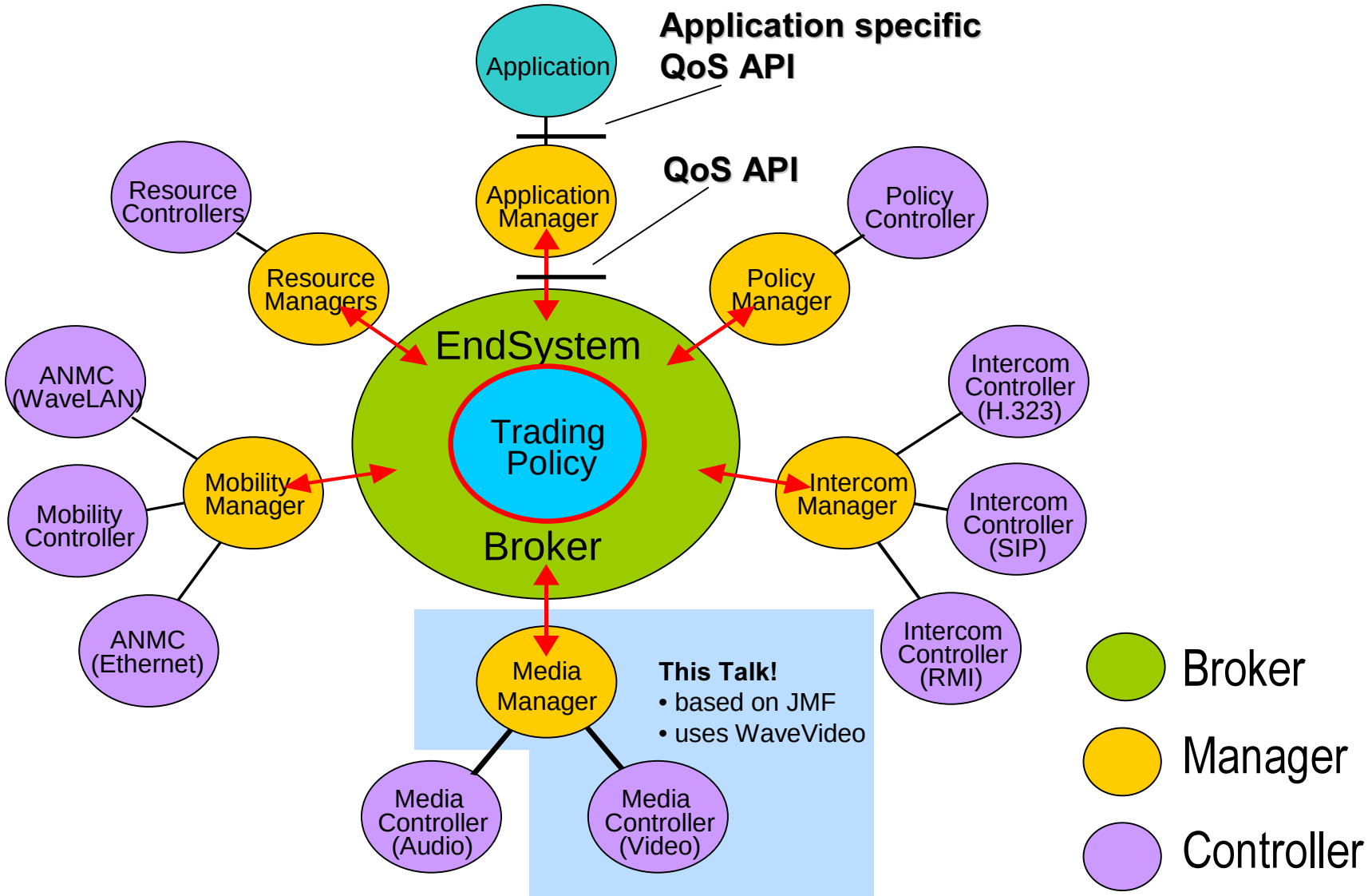
The Adaptive Endsystem Architecture



Separation of media processing and applications:

- ✓Media-independent application development
- ✓Hiding complex media details by high-level API
- ✓Future-proof technology
- ✓Dynamic downloading mechanisms
- ✓Operating-System independent applications
- ✓Generic QoS support

Generic Software Structure



Media Management

Media Manager orchestrates the whole process

- Administration of QoS hierarchy (User-Session-Stream-Flow)
- Aggregation of monitoring parameters on all hierarchy levels
- Broker support by hiding the Controller details
- Media adaptation orchestration
- Media synchronization

Media Controller supports specific tasks

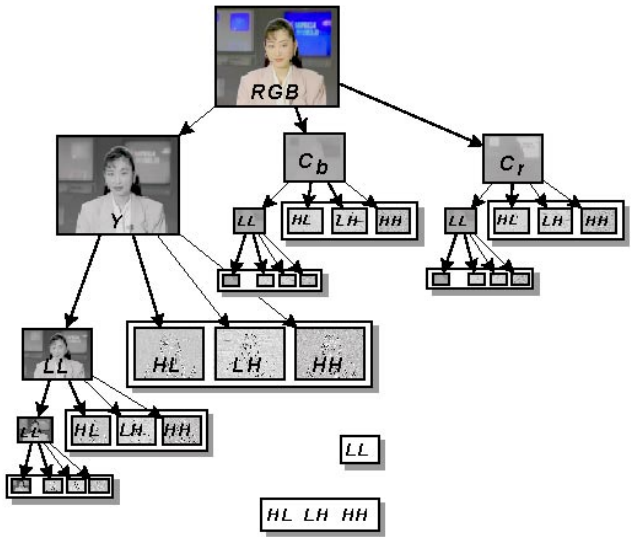
- Processing and transmission of real-time multimedia data (RTP)
- Instantiation of codecs, processors, effects, filters, etc.
- Monitoring of transmission parameters (RTCP)
- Monitoring of local performance
- Control of Media Handlers (Camera, Microphone, File, Loudspeaker,…)
- Media Adaptation Implementation

WaveVideo and JMF

WaveVideo

- Developed in 1998 by the ETH Zürich
- Video compression algorithm based on wavelet transformation
- Very robust and error tolerant, symmetric and low complexity codec
- No block building effects and scalable

Well suited for mobile networks !

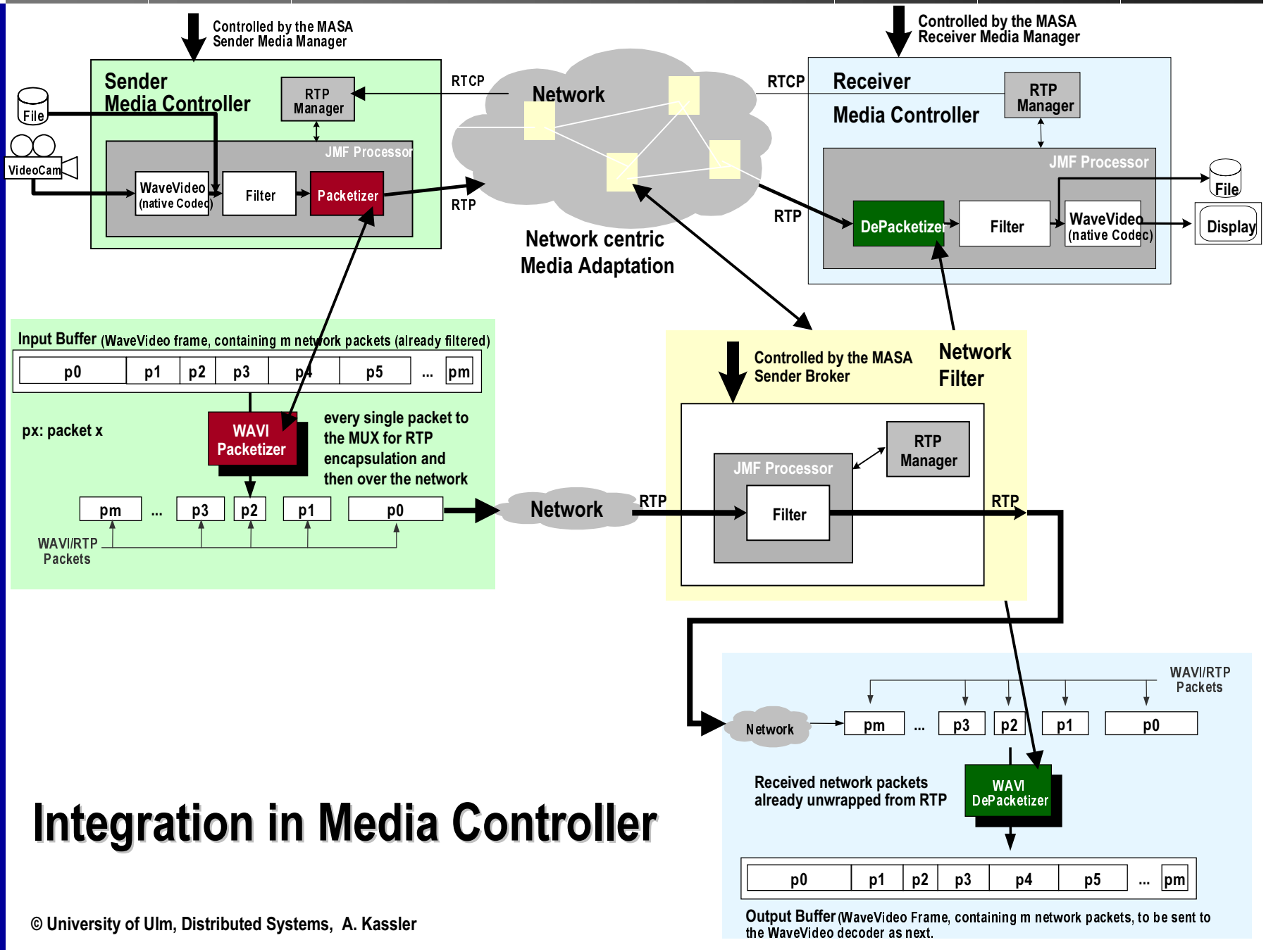


JMF (Java Media Framework)

- **Java extension to handle multi-media and time-based media data.**
- **JMF is able to manipulate and transmit several audio and video data.**
- **Plug-in architecture to extend JMF to handle new codecs or effects.**
- **Problem**: Video codecs supported by JMF don‘t offer adequate adaptation support or have a too high datarate

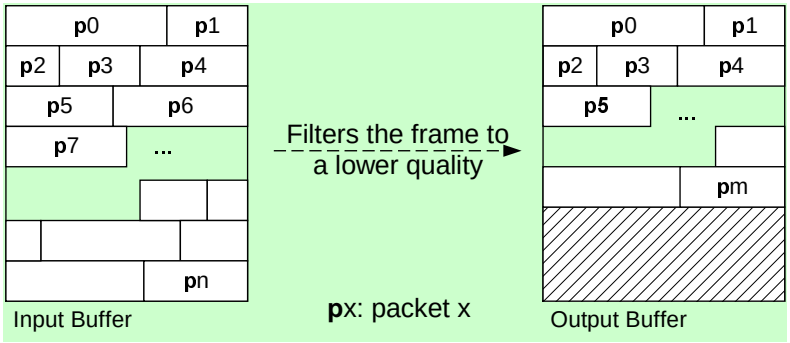
Integration WaveVideo/JMF?
Usage of RTP

- **The raw video signal is encoded to single frames with Wavelet Transformation and then compressed with Huffman and Run length Encoding (RLE).**
- **Every frame consits of n network packets with different lengths.**
- **Tags describe the content of each packet**



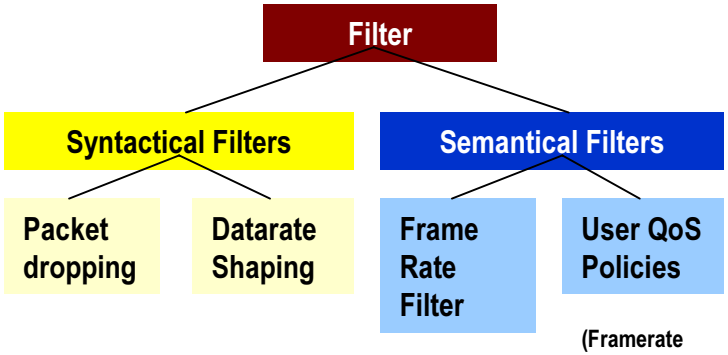
Integration in Media Controller

The QoS Filters



Filters as JMF plugin

- allows simple quality adaptation
- higher layer packets of a video frame in order to the selected quality are dropped.
- reduce the quality of the video and thus the necessary bandwith.



Bandwidth filter

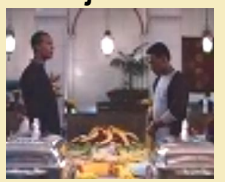
Quality: varying
Bandwidth: adjustable
Framerate: varying/fixed

Combi Filtering

Framerate filter

Quality: constant
Bandwidth: varying
Framerate: adjustable

Temporal Filtering



Quality filter

Quality: adjustable
Bandwidth: varying
Framerate: constant

Frequency Filtering

Syntactical filters

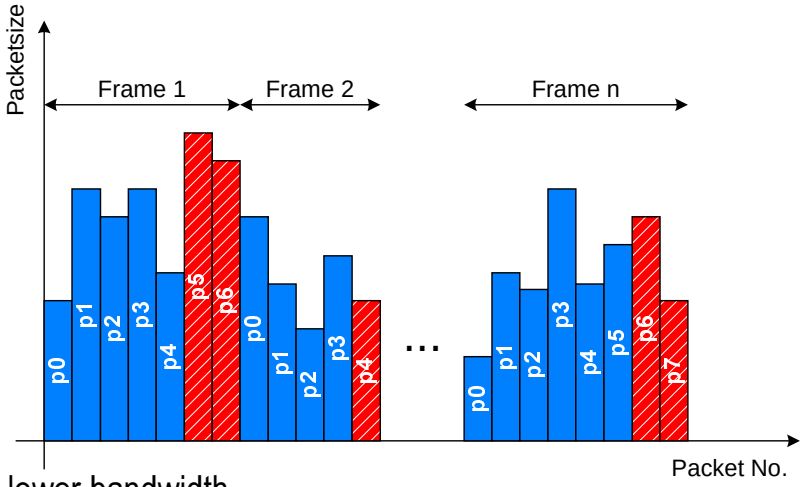
Priority Based Packet Dropping

$$m = trunc(n * q)$$

n: number of WaveVideo packets of input frame

m: number of WaveVideo packets for output

q: quality factor in [0,1], whereas 1 is the best quality



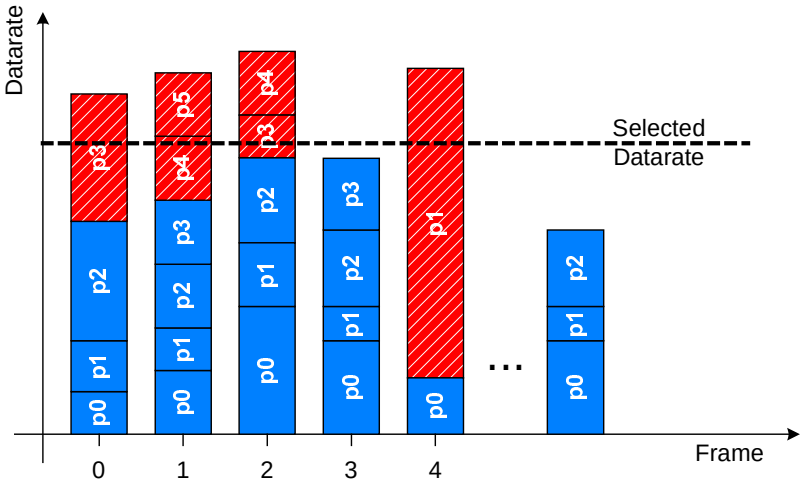
- In congestion, routers start early to drop packets and to adapt to a lower bandwidth.
- Degradation of the quality of the picture, but the stream won‘t be lost and no anoying artefacts will be visible.

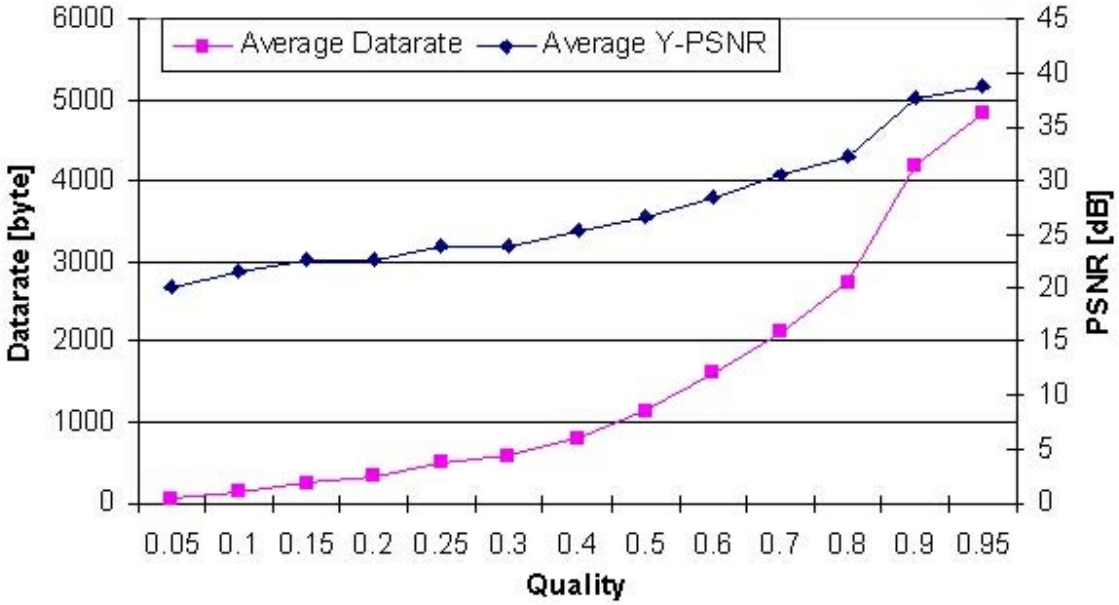
Data Rate Shaper

$$m < numberOfPackets(frame_k)$$

and

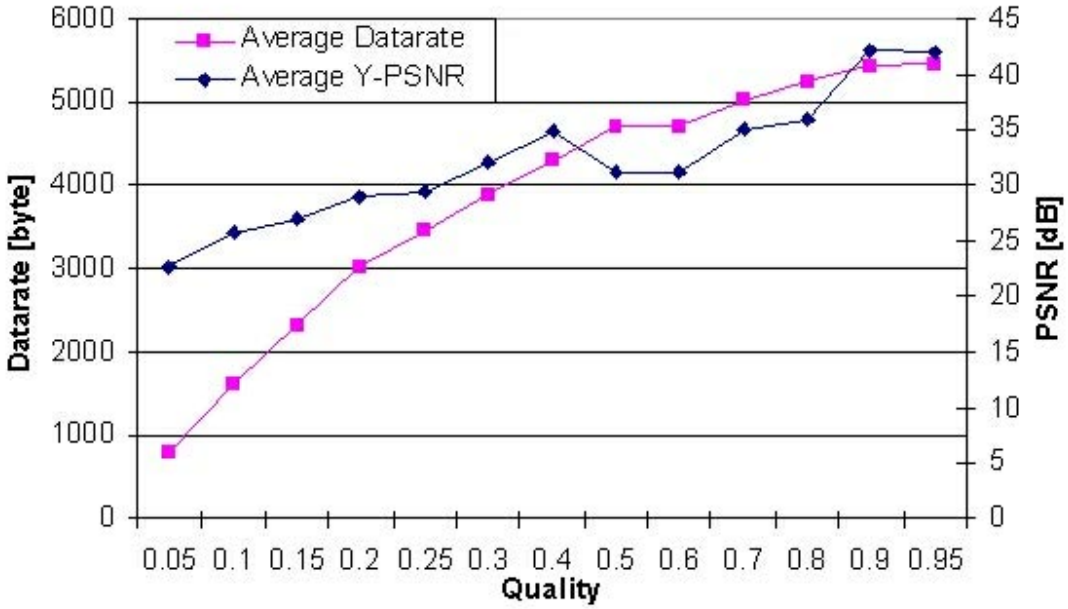
$$\sum_{i=0}^{i=m} size(p_i) < datarate_{selected}$$



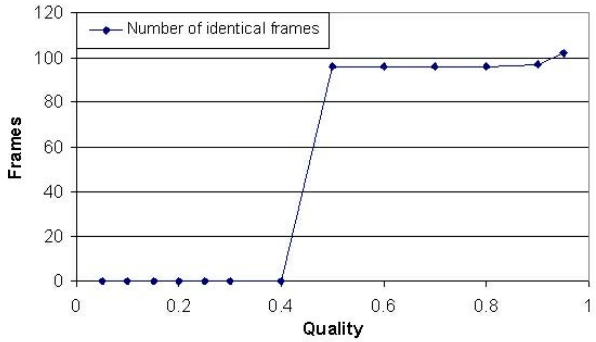


Priority Packet Dropper

Data rate Shaper



Identical Frames for DRS



Visual Quality

q=1.0

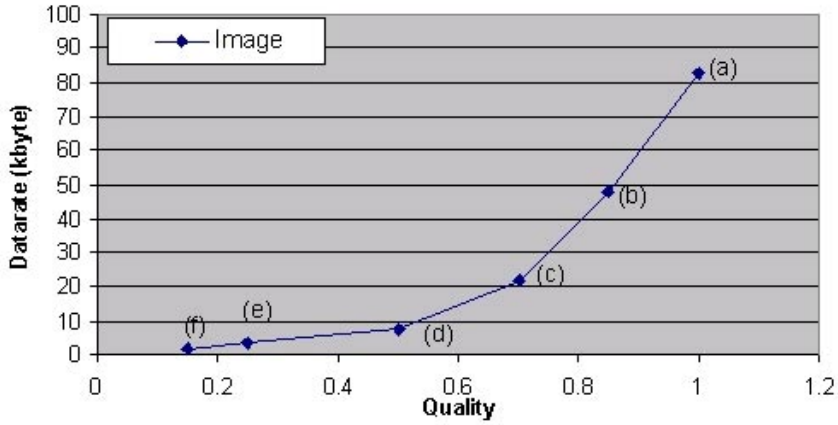
q=0.85

q=0.7

q=0.5

q=0.25

q=0.15



Q-factor	Datarate (byte)	Compression factor
1.0	82800	1:1
0.85	47959	1:2
0.7	21775	1:4
0.5	7697	1:11
0.25	3455	1:24
0.15	1583	1:52

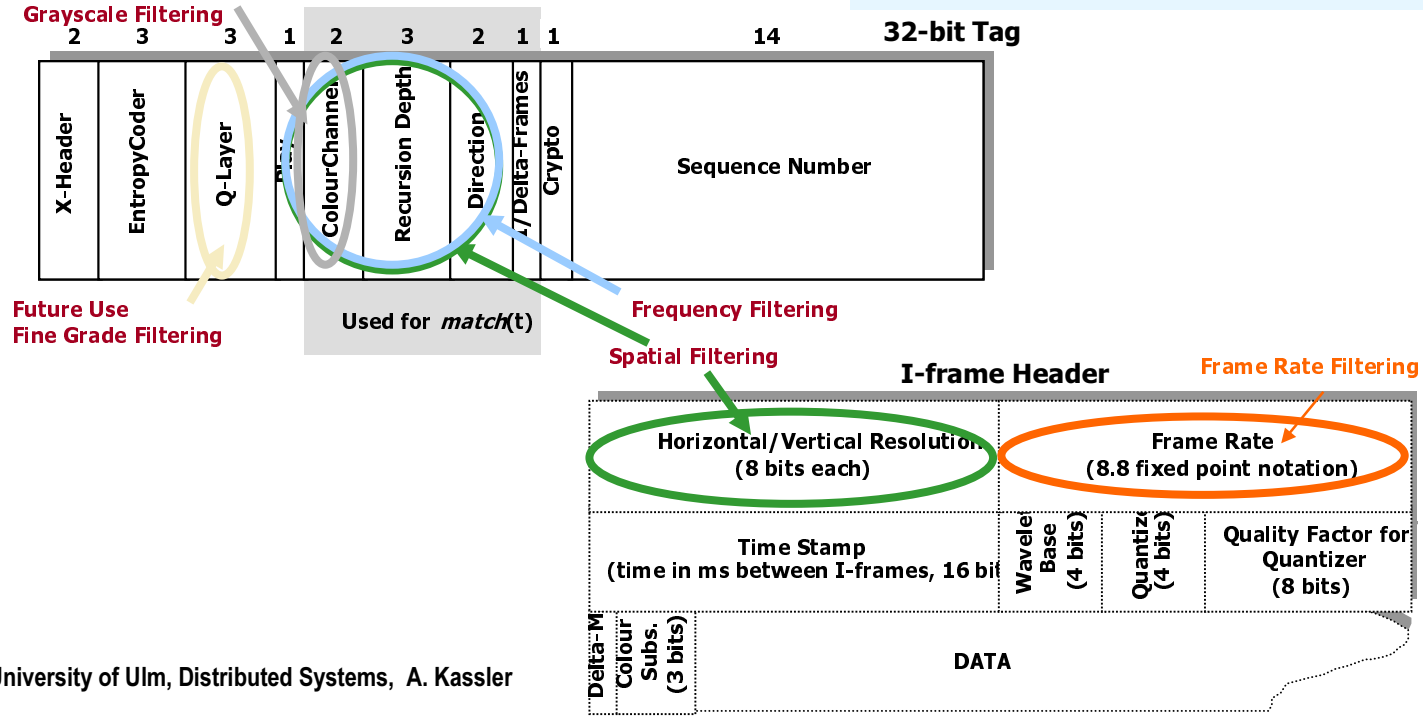
Semantical Filters

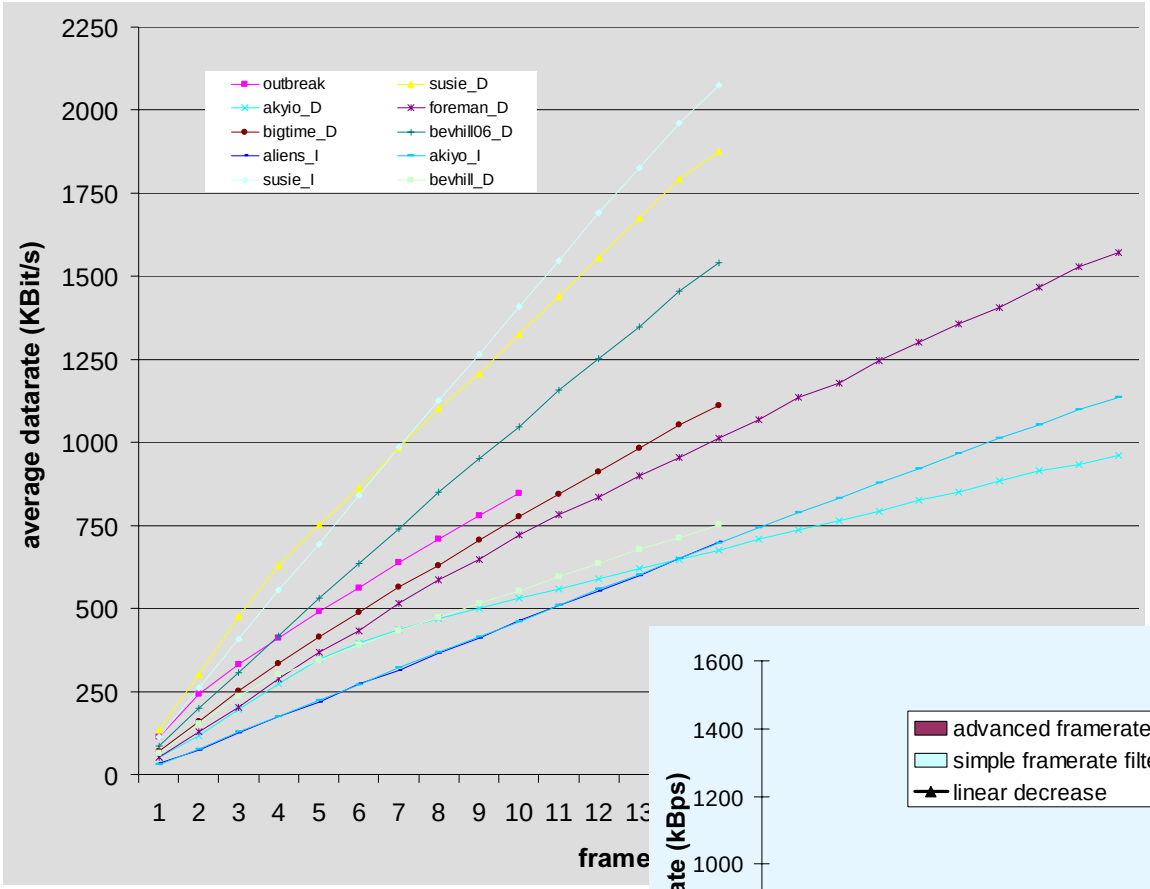
Simple Frame Rate Filter

- source rate specified in I-frame header
- $r := r_{src} / r_{dest}$
- for each frame f_i the next frame f_{fwd} to be forwarded
  - **if f_i was forwarded, $f_{fwd} = f_i + r$**
- all other frames are dropped
- adjust in all packets $r_{src} = r_{dest}$
- all Delta-frames referring to a dropped I-frame are dropped

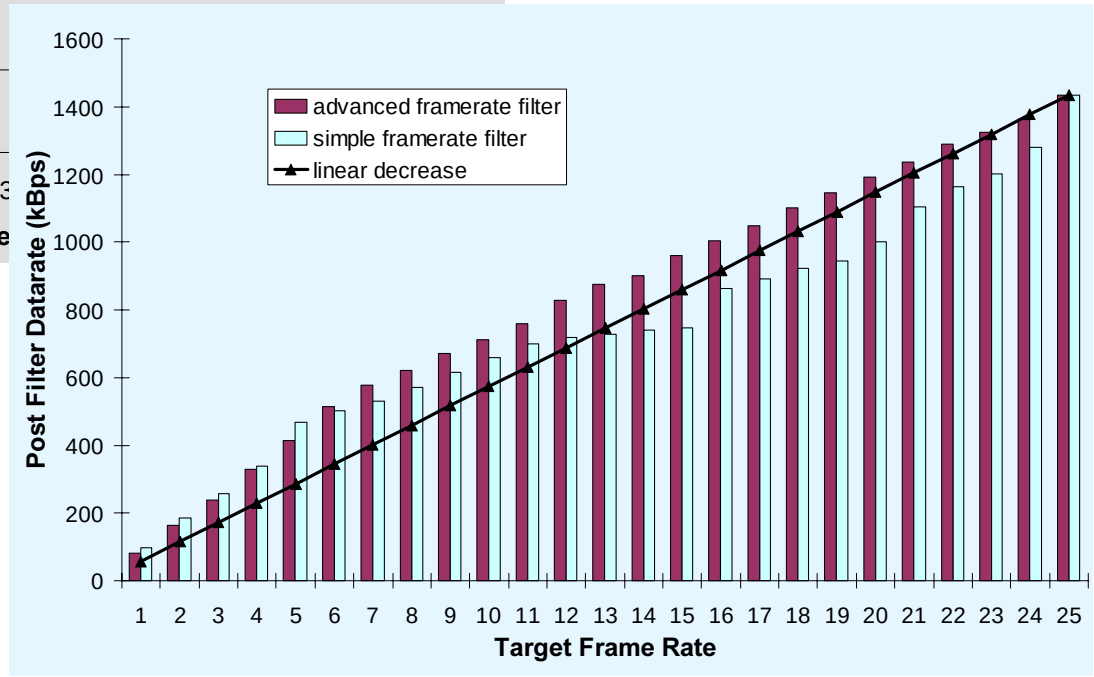
Advanced Frame Rate Filter

- Estimate r_{src} and r_{src_I}
  - $r_{src} = a\, r_{src} + (1-a)\, r_{\_max} / (frameNr - lastFrameNr)$
  - $r_{src\_I} = b\, r_{src\_I} + (1-b)\, r_{\_max} / (frameNr - last\_I\_FrameNr)$
- If $r_{src\_I} > r_{dest}$ the actual I-frame is forwarded only if the output frame rate does not exceed r_{dest}
- Otherwise, Delta-frames have to be forwarded, only if the post filtered frame rate does not exceed r_{dest} when forwarding the next expected I-Frame.





Advanced Frame Rate Filter
Applied to several clips



Comparison of Simple and
Advanced Frame Rate Filter

Conclusion and Future Work

- **We developed different filter types for JMF.**
  - They allow simple quality adaptation of WaveVideo streams.
  - Filters can be applied in endsystems as well as network nodes.
  - Syntactical/Semantical Filtering
- **JMF was extended to use this filters and to transmit WaveVideo with RTP over networks.**
- **WaveVideo well suited for filtering.**

Don‘t forget the Demos

Thank You!

- **Optimization of filter modules and packetizer as well as depacketizer modules (for the transmission)**
- **Support of multiple user QoS policies like frame-rate vs. color depth.**
- **Further Work on QoS Framework and Adaptation**
  - Resource Management
  - Policy Management
  - Mobility Management
  - RTP/RTCP statistics