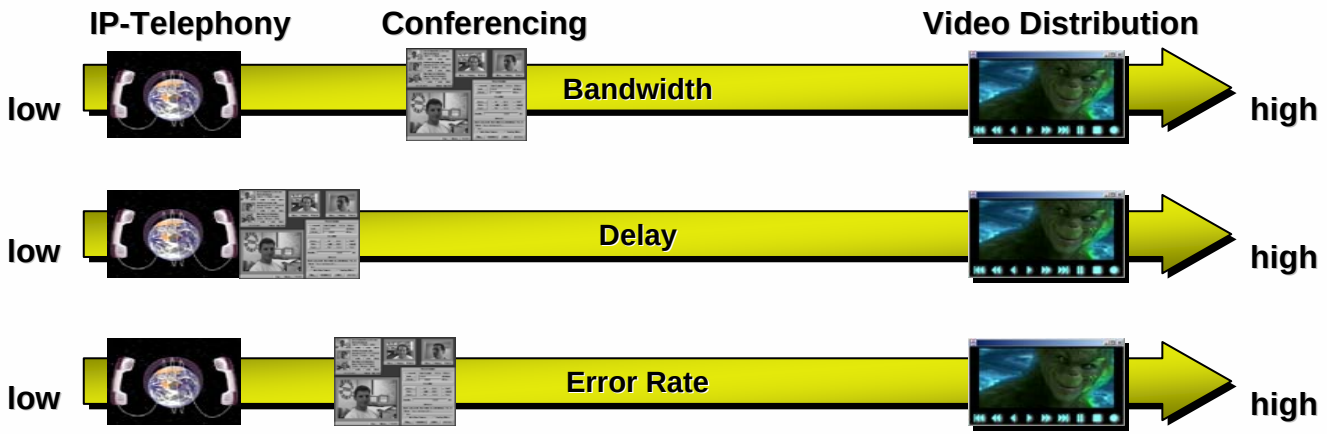
Media Adaptation

Motivation

- Heterogeneous ***Multimedia Applications/Services***
  - Varying requirements
    - interactive versus non-interactive usage
    - realtime versus non-realtime characteristics
    - unicast versus multicast (group communication scenarios)
    - etc.
  - VoIP (voice-over-IP) needs low delay
  - VoD (video-on-demand) needs high bandwidth



Motivation

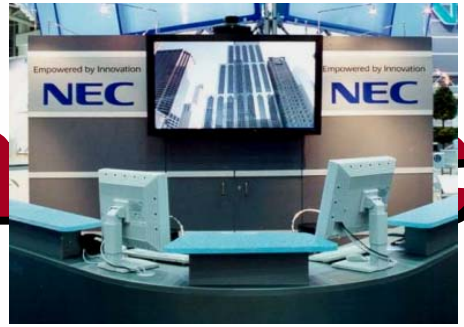
- Heterogeneous ***Devices***
  - Varying screen sizes, CPUs, memory, power supplies, interfaces, etc.

Wall Displays

Flat Info Terminals

Mobile Communicators

Video Projectors



Plasma Displays

Java Mobile Devices

Image Source: http://www.nec.com

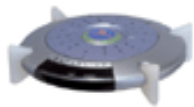
Motivation

- Heterogeneous ***Access Networks***
  - Varying characteristics for loss, bandwidth, reliability, etc.

Wired Links

Modem

ISDN



xDSL

Ethernet

...

10kbps **Bandwidth** **155Mbps**

Wireless Links

GSM/GPRS

UMTS

IEEE 802.11

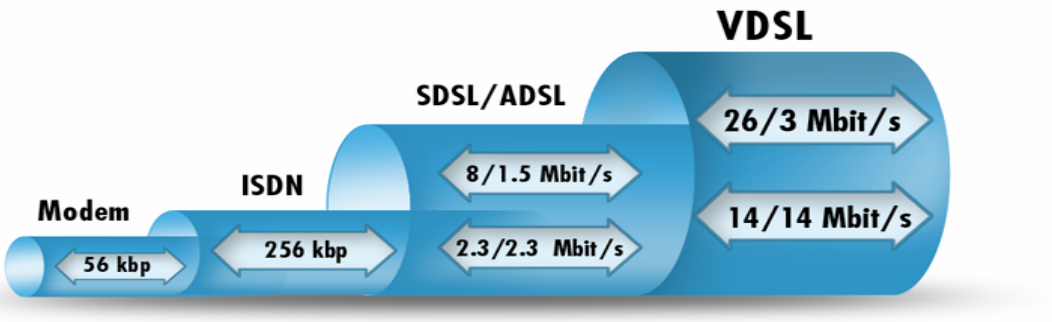
HIPERLAN

...

Bandwidth range of ~ 1:15000

Motivation

- QoS in heterogeneous network technologies
  - Broad spectrum of different transmission characteristics
  - Modem, ISDN, XDSL (56kbps-15Mbps)
  - Ethernet (10/100/1000Mbps, quasi lossless)
  - GSM/GPRS (few kbps, fluctuating losses)
  - UMTS (up to 2Mbps, theoretical, aggregated, strongly fluctuating losses)



Motivation

- Heterogeneous ***User Policies***

‚Normal User‘

likes to have an ‚on/off‘ button

‚Cyborg‘

wants to specify the importance of certain parameters

Motivation

- Future usage cases are mostly mobile

  - ***Terminal Mobility***
    - Supports physically moving the device and eventually connecting 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

The personalized mobile end-device will provide the necessary platform for a number of essential multimedia services for voice, video and data

Motivation

- Additional challenges in ***Mobile Networks***

Challenge: Heterogeneity

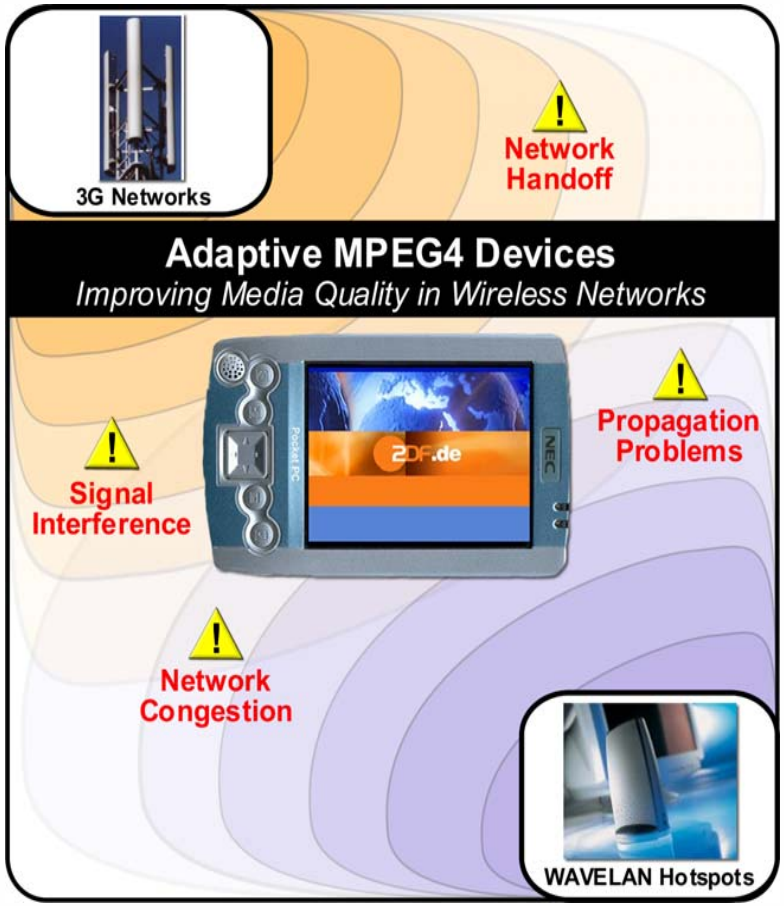
- Differing access technologies
- Differing network characteristics
- Differing device capabilities
- Java performance issues

Challenge: Network Congestion

- Shared network scenarios
- Unpredictable join / leave
- Fluctuating network load

Challenge: Radio Access

- Signal interference
- Propagation problems
- Uneven network coverage
- Network handoff

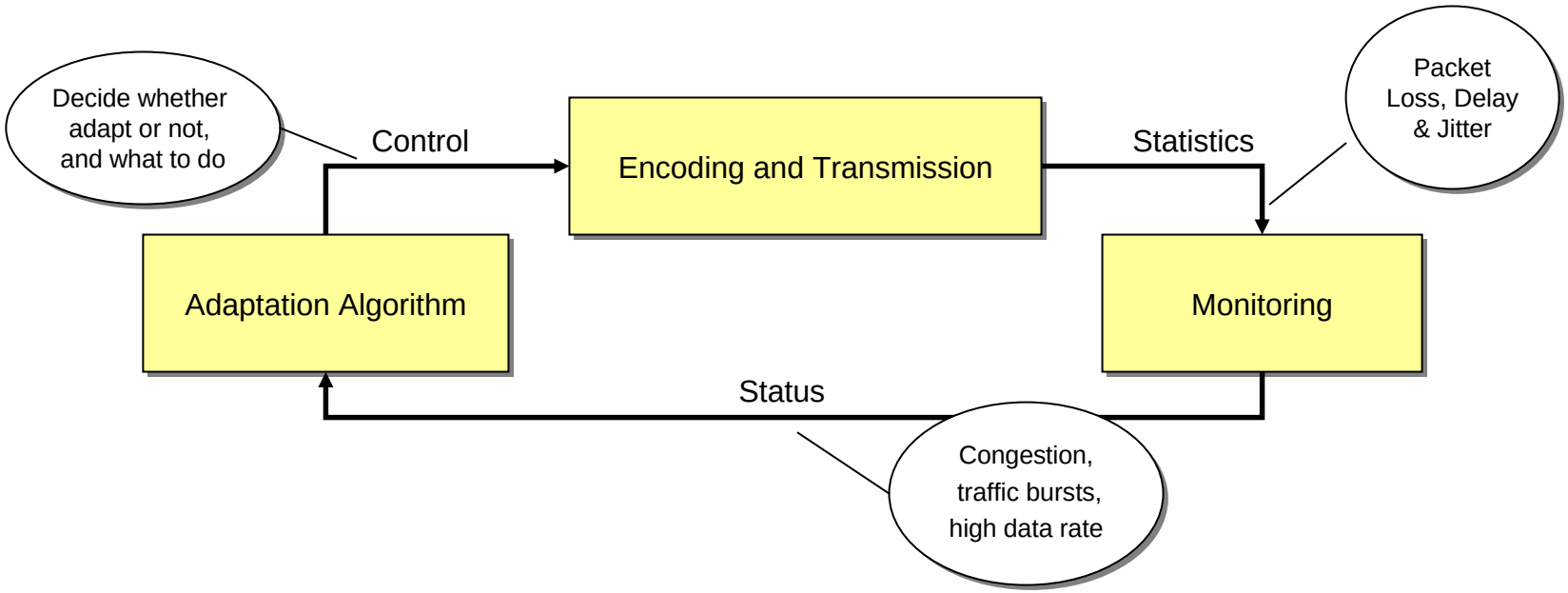


Media Adaptation

- Adaptive Streaming
  - Goals
    - Avoid overloading congestion points
    - Graceful Quality Adaptation
  - Mechanisms:
    - Adapt media stream in realtime
    - Match system load to resource availability
      - Endsystem (CPU, Memory, Battery, ...)
      - Network (Datarate, Packet Loss Rate, ...)
    - Stream adaptation is complementary to resource reservation
  - ***Media Scaling***
    - Tailor the streaming parameters for each customer
  - ***Media Filtering***
    - Remove parts of the stream at certain locations

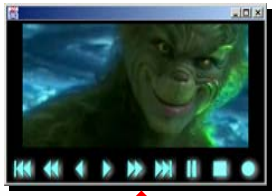
Media Adaptation

- ***How*** can we adapt the media stream?
  - Stream monitoring
  - Adaptation algorithms
  - Control of encoding and transmission entities



Media Adaptation

- ***Where*** should media adaptation be performed?



Adaptive Applications

+ Specific requirements of the Applications are well-known
- Adaptivity mechanism has to be ‚re-invented' by each application
- No global view for fairness, no inter-operability

Middleware

Adaptive Middleware

+ Combines advantages of both
  Allows for fairness as well as application-specific treatment

Operating System

Adaptive Operating Systems

+ Global view allows for optimized utilization and fairness
- Application semantic is unknown

Network

Adaptive QoS (Networks)

Active power control on the physical layer
Error control and adaptive reservation at the data link layer
Dynamic re-routing at the network layer
Dynamic re-negotiation of connection parameters at transport layer (IntServ, DiffServ)

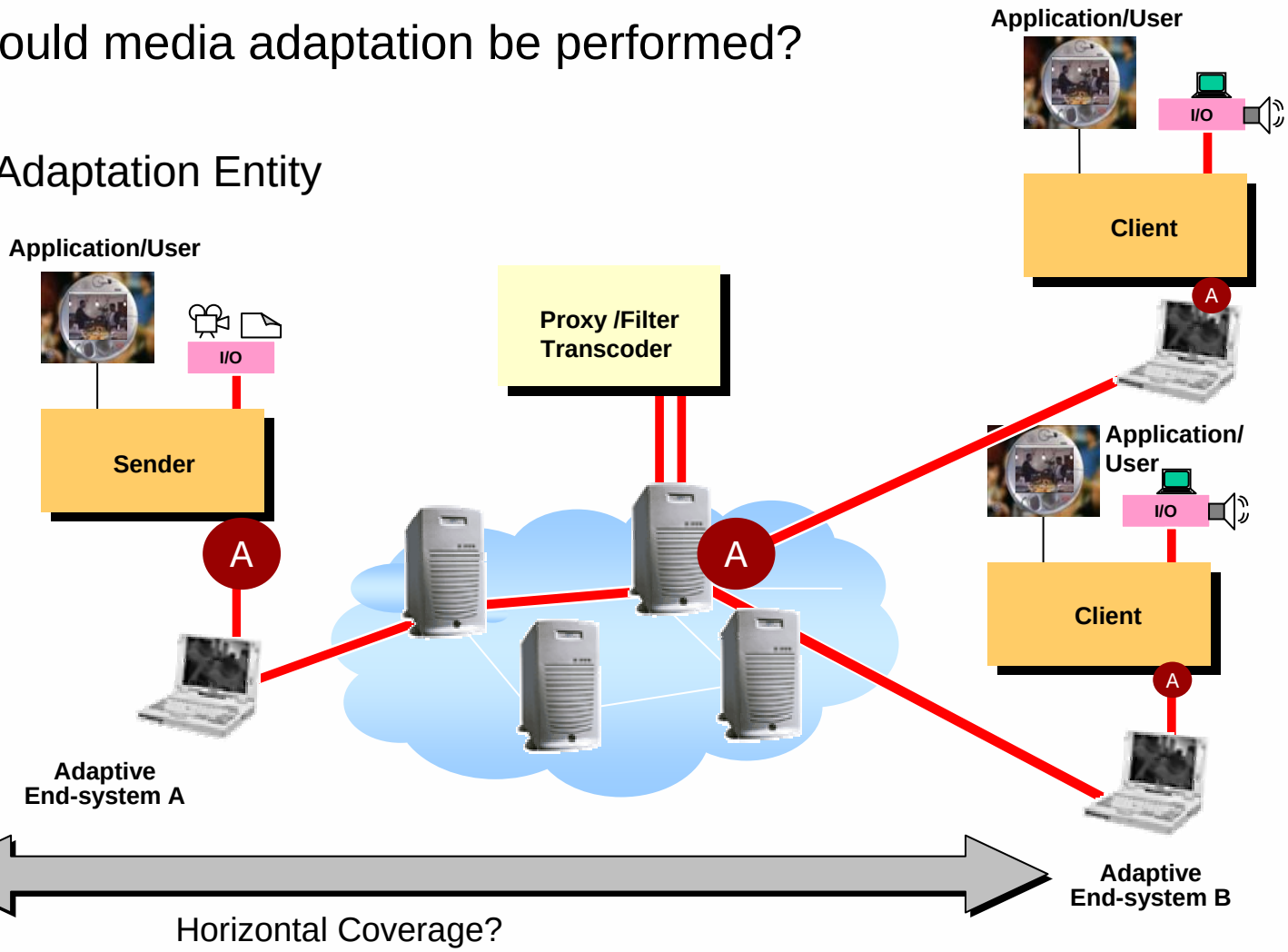
Vertical Coverage?

Optimal Strategy covers ***all layers***

Media Adaptation

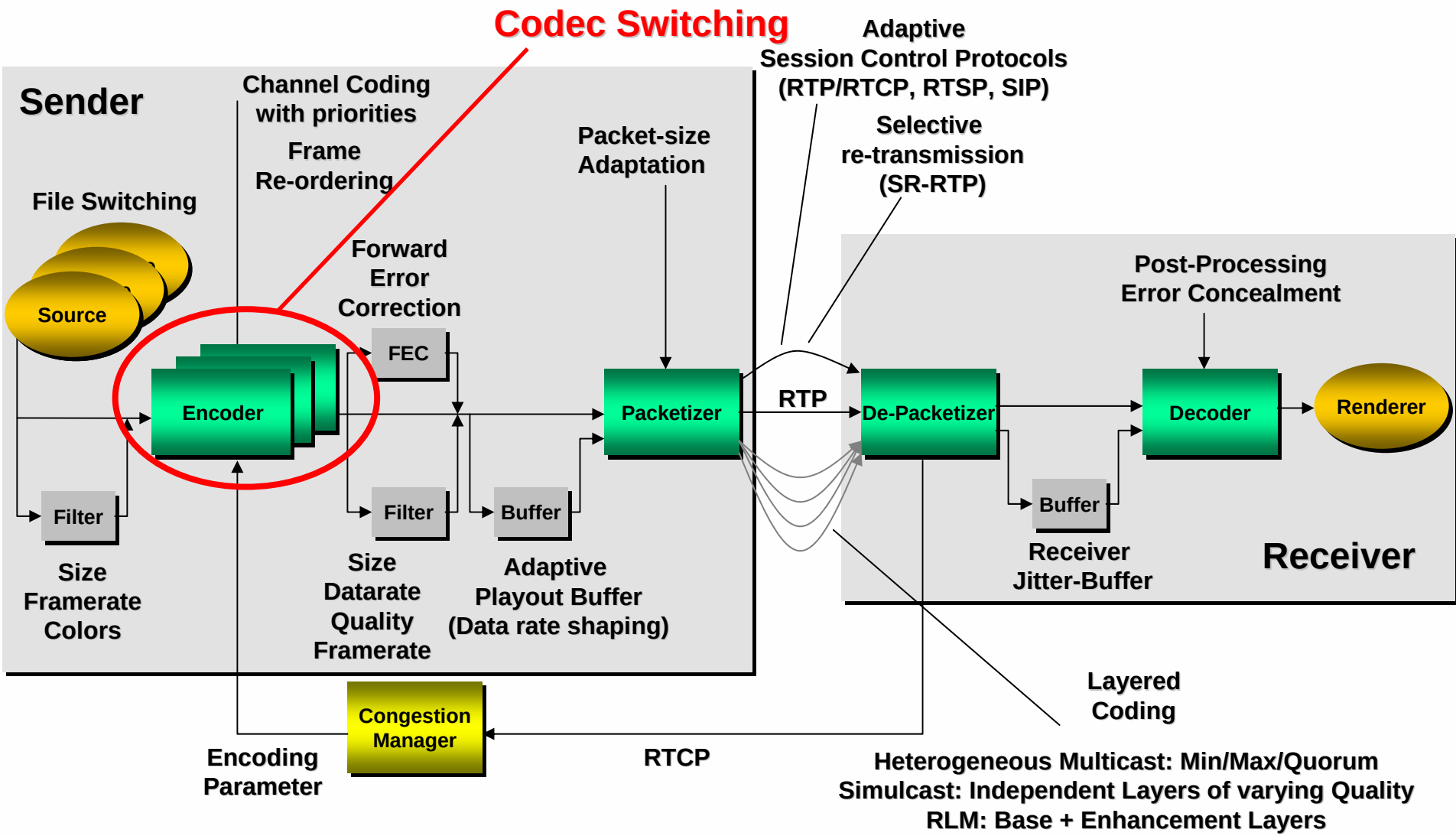
- ***Where*** should media adaptation be performed?

A Media Adaptation Entity



Optimal Strategy is ***end-to-end***

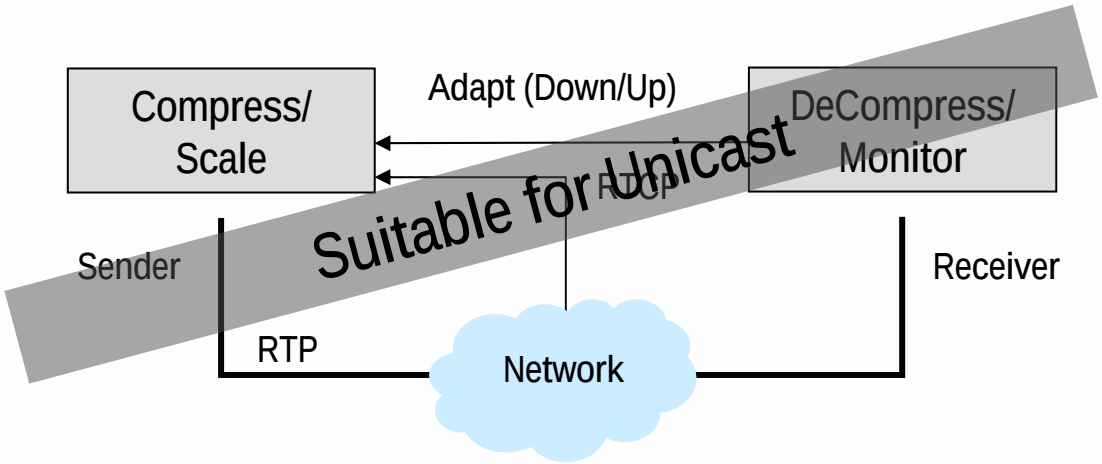
Adaptation Mechanisms



Media Scaling

Media Scaling

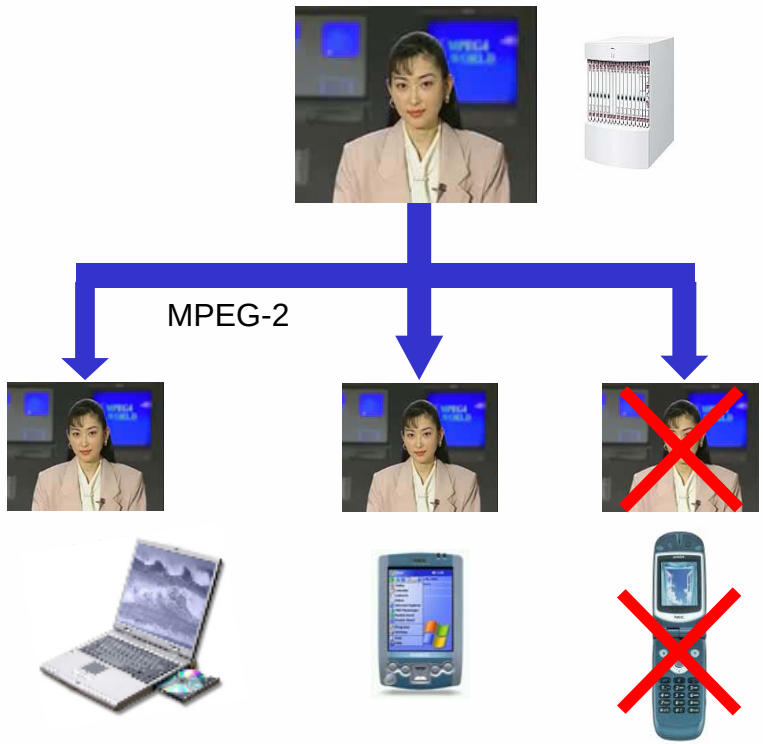
- Monitoring network/system load, use feedback information from receiver
- If necessary
  - Receiver informs sender about problems
  - Overloaded network element informs sender (implicitly via congestion notification)
  - Sender adapts itself by scaling media
    - Change compressor settings (e.g. adapt Mquant)
    - Stream switching (e.g. real networks)
    - Add/drop layers



Media Scaling

- ***Heterogeneous Multicasting***
  - Max/Min/Quorum client Bandwidth
    - Ignore some receivers
    - Send at high bandwidth
      → ignore low bandwidth receivers

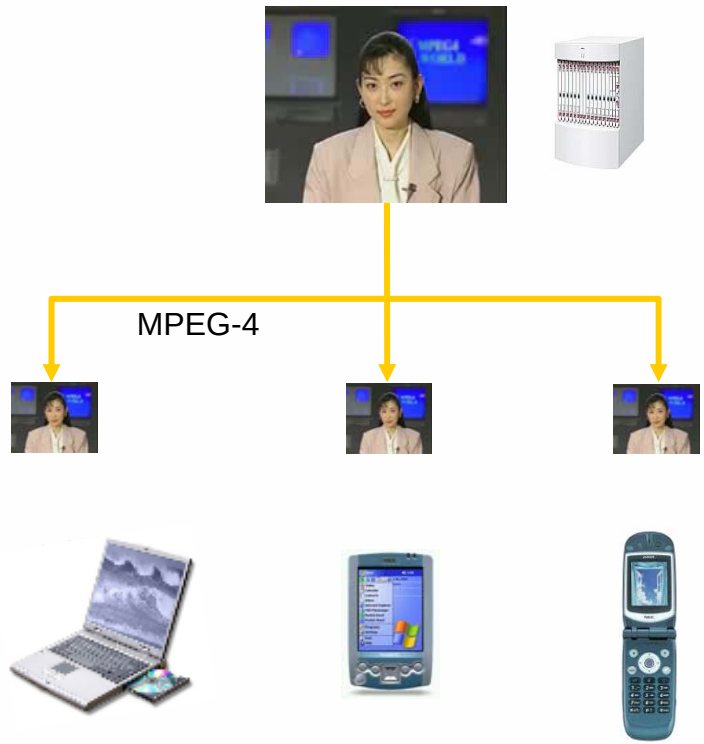
Static



Media Scaling

- ***Heterogeneous Multicasting***
  - Max/Min/Quorum client Bandwidth
    - Ignore some receivers
    - Send at high bandwidth
      → ignore low bandwidth receivers
    - Send at low bandwidth
      → force high bandwidth receivers to use low quality

Static



Media Scaling

- ***Heterogeneous Multicasting***
  - Max/Min/Quorum client Bandwidth
    - Ignore some receivers
    - Send at high bandwidth
      → ignore low bandwidth receivers
    - Send at low bandwidth
      → force high bandwidth receivers to use low quality
    - Let a quorum decide
      → force high bandwidth receivers to use medium quality, ignore some low bandwidth receivers
  - Disadvantages:
    - Does not take congestions into account
    - unfair, not very flexible

Static

Media Scaling

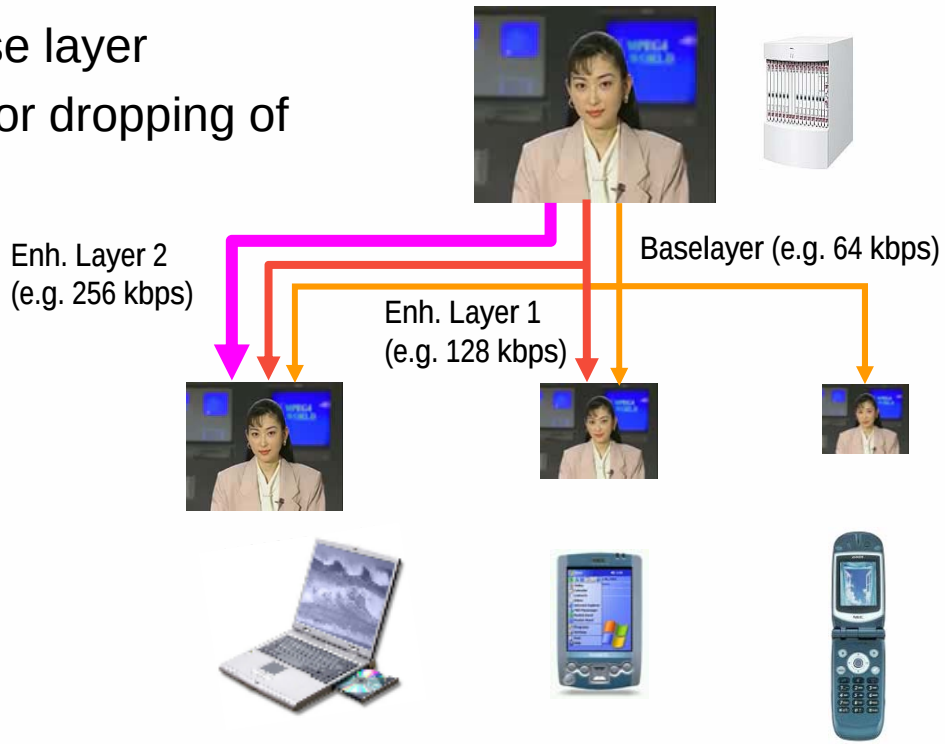
- ***Simulcast***
  - Send same stream with different encodings
  - Each receiver gets its own quality
  - Receiver can decide
  - Disadvantages:
    - Does not take congestion into account
    - Wastes bandwidth on shared links
    - Increased CPU usage on sender

Static

Media Scaling

- ***Receiver driven layered Multicast (RLM)***
  - Each hierarchical layer is transmitted as separate stream (to its own multicast-@)
  - Video encoded in additive layers
  - Each receiver subscribes to base layer
  - Adaptation by join experiments or dropping of multicast groups

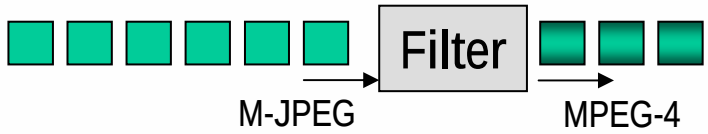
Dynamic



  - Disadvantages:
    - Support limited number of layers/streams
    - join/leave overhead → slow adaptation
    - How to detect congestion? → Not TCP friendly!
    - Codec must be supported

Media Filtering

- ***Media Filtering***
  - *Filtering = transparent scaling*
- Idea
  - Source sends at maximum Quality
  - Quality and datarate changed by filter



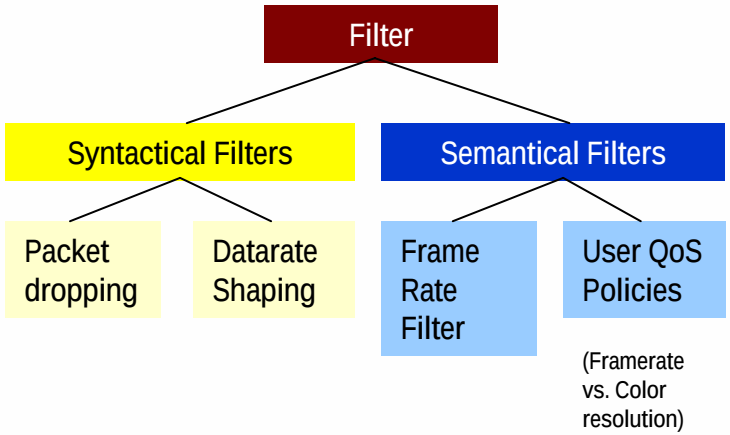
- ***General Filter***
  - Arbitrary functions at arbitrary locations (sender/receiver/network)
    - E.g. transcoding
    - Uses semantical information
  - Problems
    - Potentially high performance requirement
    - Additional end-to-end delay
    - Security aspects?
    - How to implement at application layer within the network? Active Networks?

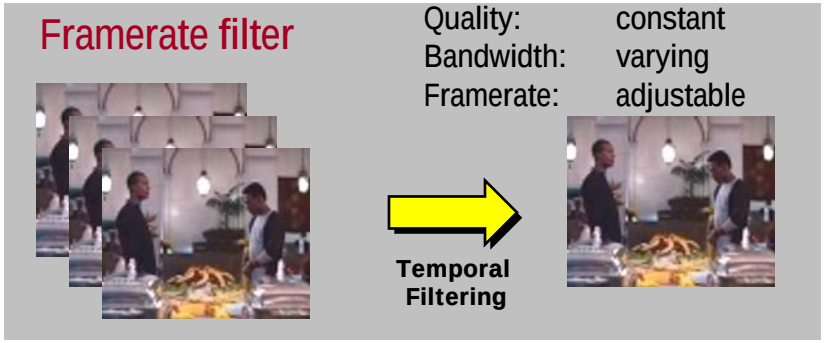
Media Filtering

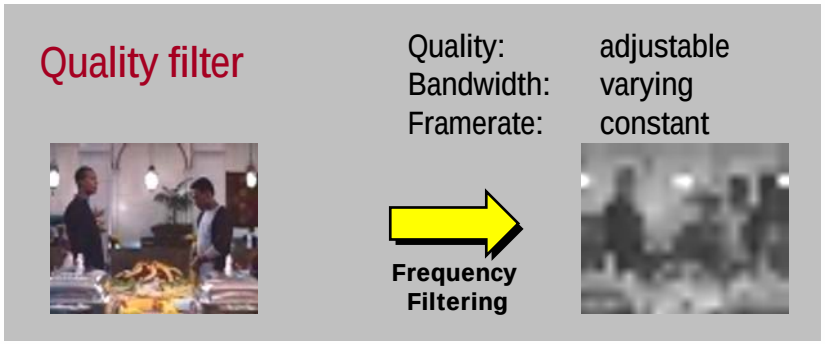
- ***Filtering with Priority Packet Discard (PPD)***
- Principle:
  - Remove parts of the stream by selective packet discarding
    - Depends on codec and packetization strategy (ALF)
    - Usable with layered (hierarchical) encoded (Sub-)Streams
    - Only necessary information is forwarded → all other packets are dropped
    - Best Quality only, when no packets are dropped
  - Applicable at different layers
    - Network Layer
    - Transport Layer
    - Application Layer → Content adaptation network

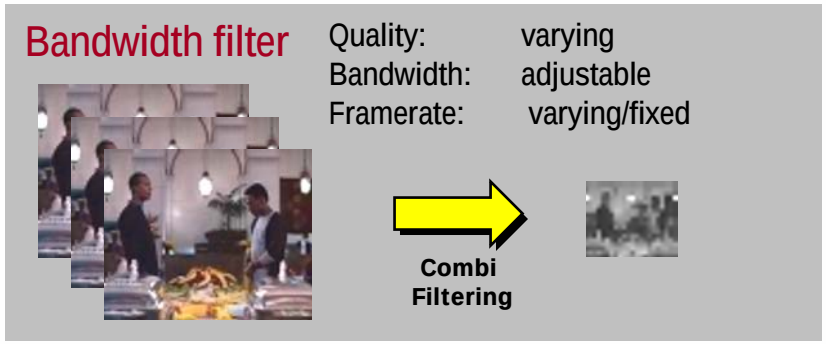
Media Filtering

- ***Media Filtering*** allows for
  - dynamically adjustments
  - local adaptation
  - codec independence
  - bandwidth efficiency
  - etc.



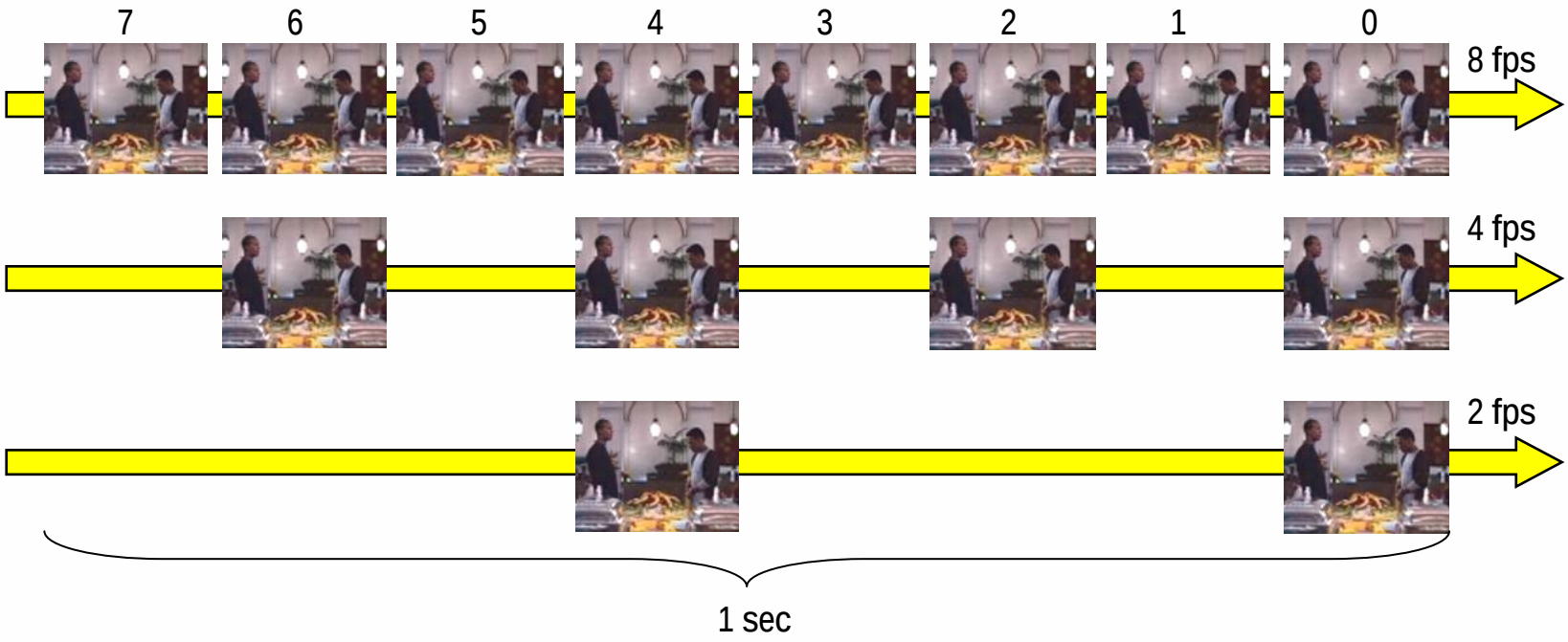






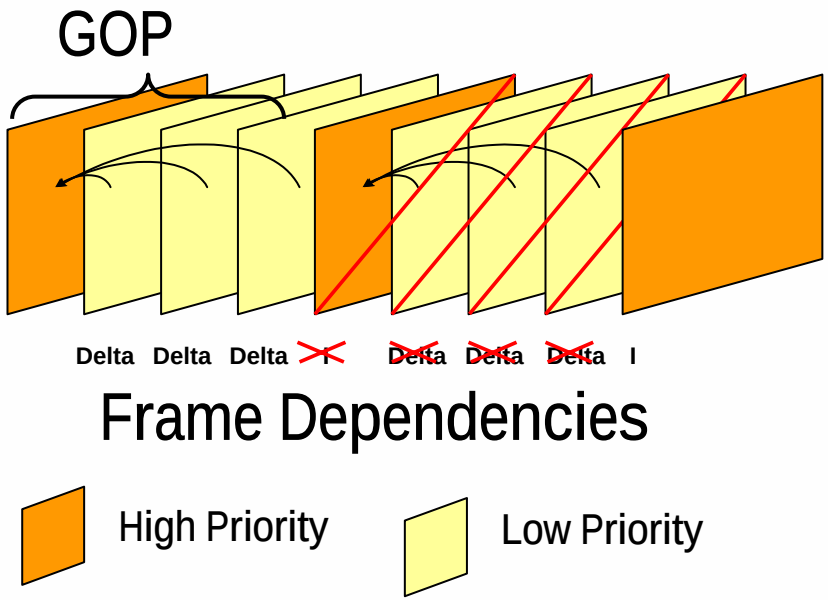
Media Filtering

- Framerate Filter
  - Two Modes
    - Adapt Videostream to available bandwidth
    - Match a given traget frame rate
  - Use frame number for packet drop decisions
  - Does not change quality of forwarded frames



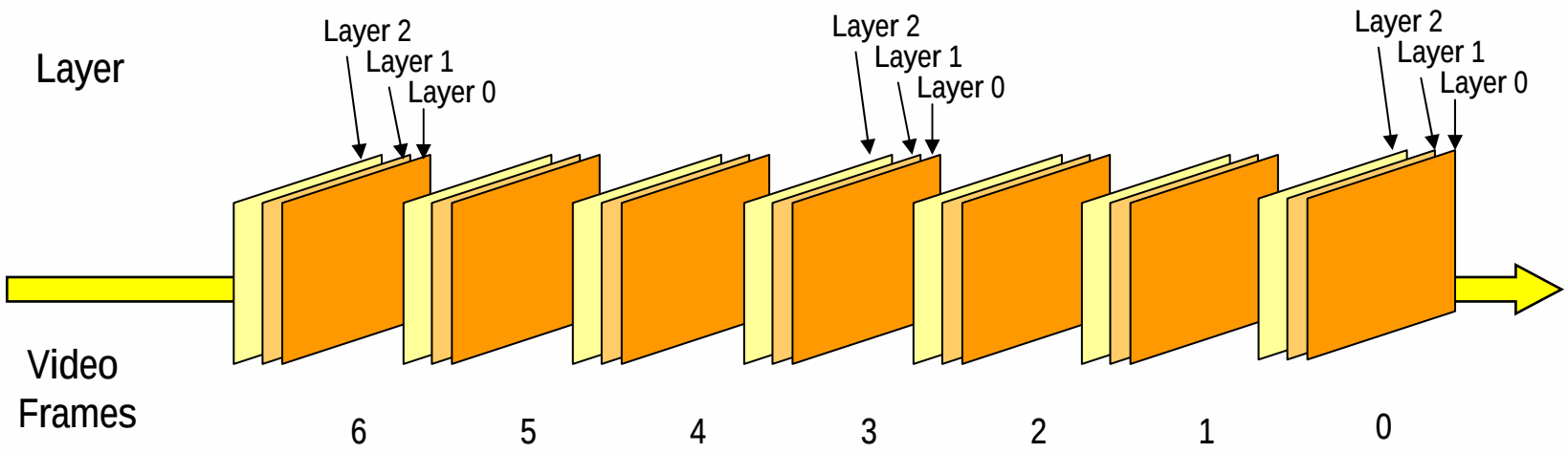
Media Filtering

- Problems with Framerate Filter
  - Inter-coded Frame depends on previous intra-coded Frame
  - Motion artefacts, if referenced I (intra coded) Frame was dropped
  - Inter Frame dependencies must be considered in packet drop priority



Media Filtering

- Filter Domains
  - Temporal Domain
  - Spatial Domain
  - Frequency Domain
  - Color Domain
  - Combinations…
  - Requires Layered Codec, z.B. MPEG-II, MPEG-4, Wavelet based, …



Adaptive streaming