IV.1 Overview of Video Adaptation

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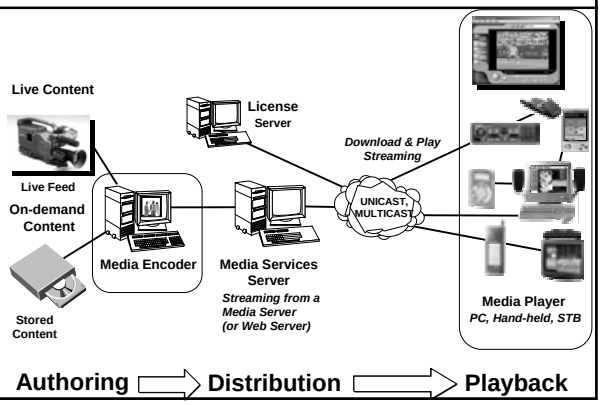
Outline

- Introduction
- Video Adaptation Tools
  - Dynamic Bitstream Switching
  - Scalable Coding
  - Video Transcoding
- Summary

Components of Networked Multimedia



Issues in Networked Multimedia

- Real-time constraints: delay, delay jitter
- Bandwidth requirement, VBR or CBR, symmetrical or asymmetrical
- Quality of Service (QoS): delay, delay jitter, packet loss, bit-error-rate, burst-error-rate, burst error length...
- Synchronization of video, audio, data, applications...
- Error robustness: error resilience, error concealment
- Cost

Problems in Video Streaming

- No QoS Guaranteed for current Network
  - No bandwidth reservation;
  - No delay guarantee;
  - No packet loss guarantee
- Heterogeneity
  - network: different users, different packet loss / delay
  - receiver: different latencies / visual quality requirements / processing powers / display formats

Video Adaptation

Video adaptation is an emerging field that includes a body of knowledge and techniques responding to the pervasive media applications

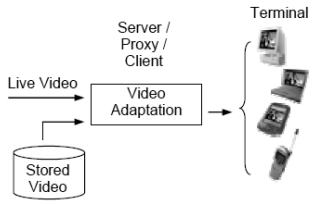


Figure 1 The role of video adaptation in pervasive media environments to support heterogeneous terminals and networks.

Conceptual Framework for Video Adaptation

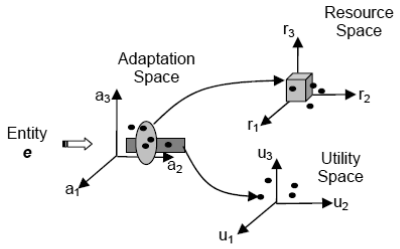


Figure 2 A general conceptual framework for video adaptation and associated concepts of resources and utility.

Conceptual Framework for Video Adaptation (Cont.)

- Entity
  - is defined to refer to the basic unit of video that undergoes the adaptation process
- ***adaptation space***
  - The space of feasible adaptations for a given video entity
- Resource space
- Utility space
  - ***utility value*** represents the quality or users' satisfaction of the video content

Given a video entity, the relationships among the adaptation space, the resource space, and the utility space represent critical information for designing content adaptation solutions

Systematic Procedure for Video Adaptation

1) Identify the adequate entities (e.g., frame, shot, sequence of shots, etc.)
2) Identify the feasible adaptation operators (e.g., requantization, frame dropping, shot dropping, replacement, etc.)
3) Develop models for measuring and estimating the resource and utility values
4) Given user preferences and constraints on resource or utility, develop strategies to find the optimal adaptation operator satisfying the constraints.

Systematic Procedure for Video Adaptation (Cont.)

- Many video adaptation problems can be formulated as MAX-UTILITY and MIN-RESOURCE
  - Given a content entity (**e**), user preferences, and resource constraints ($\mathbf{C_R}$), find the optimal adaptation operation ($\mathbf{a_{opt}}$) within the feasible adaptation region so that the utility of the adapted entity (**e'**) is maximized
  - exploring the utility-constrained region to find the optimal adaptation operator to satisfy utility constraints while requiring minimal resources

Video Adaptation Taxonomy

- Transcode
- Select/Reduce
  - to trade some components of the entity for saving of some resources
  - implemented by selection and reduction of some elements in a video entity
- Replace
  - replaces selected elements in a video entity with less expensive counterparts, while aiming at preserving the overall perceived utility
- Synthesize
  - synthesizing new content presentations based on analysis results
  - The goal is to provide a more comprehensive experience or a more efficient tool for navigation

Video Adaptation Taxonomy

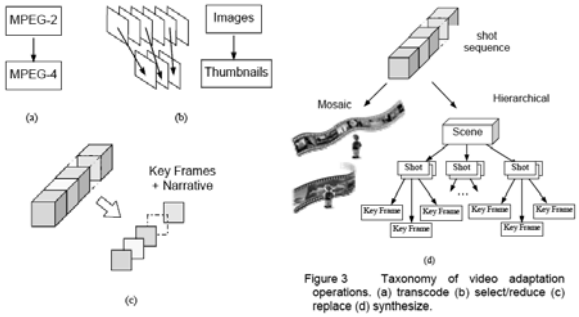
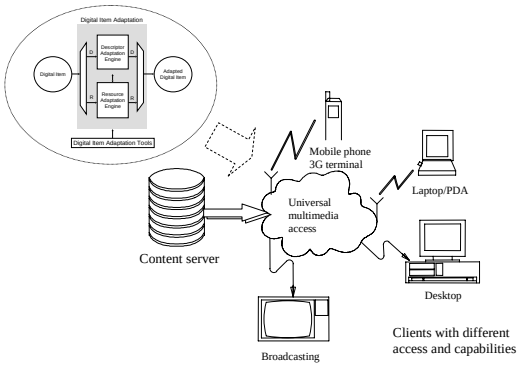


Figure 3 Taxonomy of video adaptation operations. (a) transcode (b) select/reduce (c) replace (d) synthesize.

MPEG-21 DIA for Universal Multimedia Access

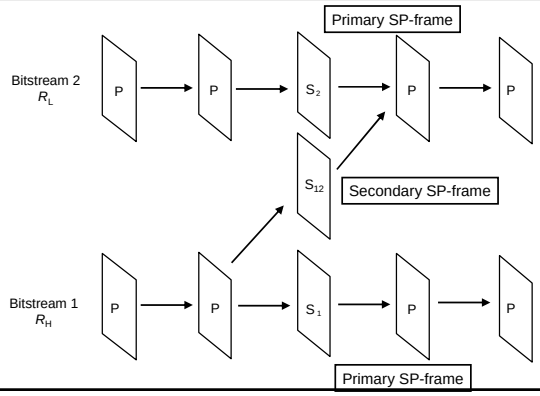


Video Adaptation - Tools

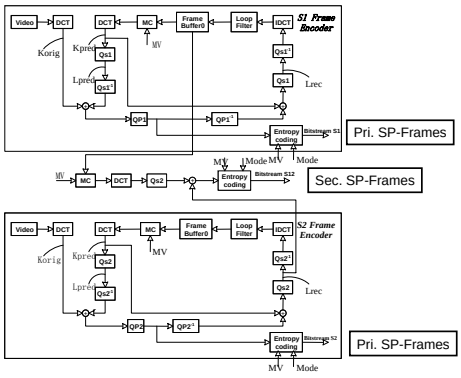
Tools for Future MPEG-21 RAE (Resource Adaptation Engine)

- Multiple Bit-streams pre-encoded with different bit-rates
  - Large storage
  - Drift problem
  - Complexity in bit-streams management and switching
  - H.264/MPEG-4 AVC SP/SI-frames (seamless switching)
- Real-time Transcoder
  - Relatively higher complexity in the streaming sever
  - Highest flexibility and performance
- Scalable video
  - Degree of scalability
  - MPEG-4 FGS (Fine Granularity Scalability), MPEG-21 SVC (Scalable Video Coding)

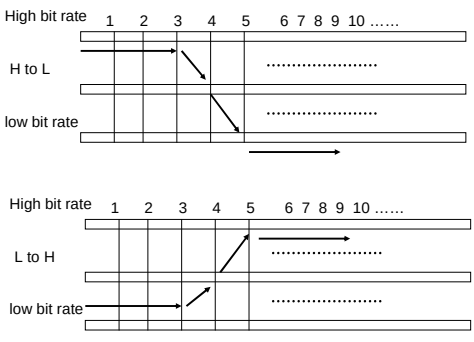
H.264 Bitstream Switching (SP-Frames)



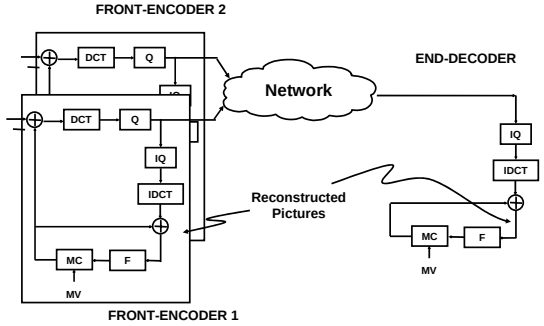
H.264/MPEG-4 AVC SP-Frames



Bitstream Switching with Switching Frames

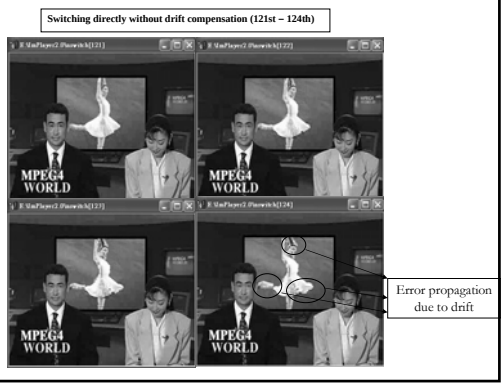


Drift Caused by Direct Switching

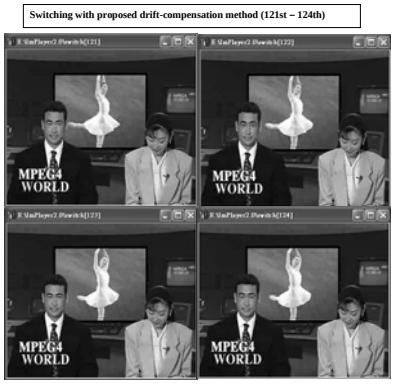


- The reconstructed pictures in encoder and decoder have to be **exactly same** to prevent "drift"

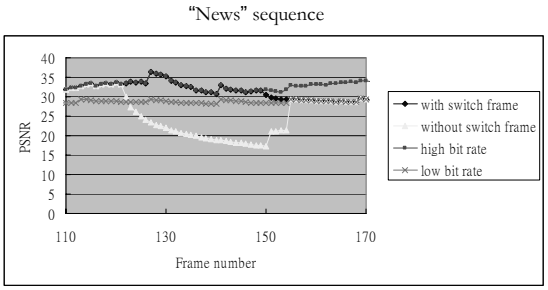
Bitstream Switching with Direct Switching



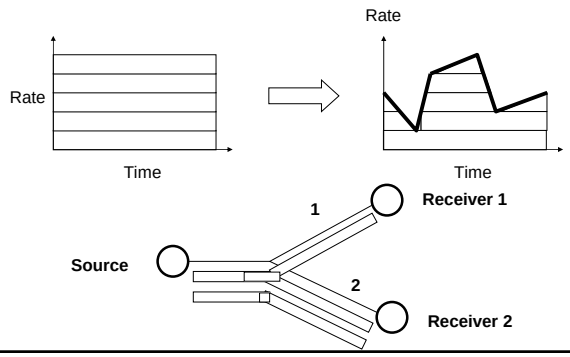
Bitstream Switching with Switching Frames



Performance Comparison

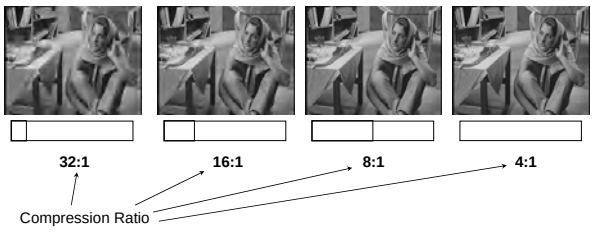


Scalable Coding

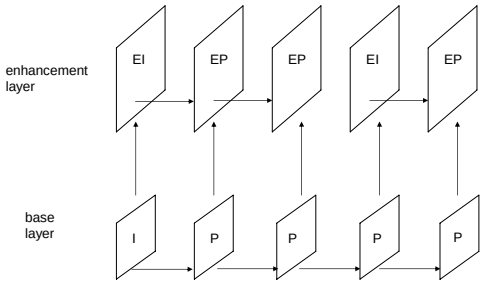


Quality (SNR) Scalability

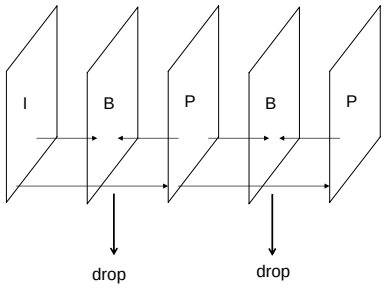
- Improve decoding quality as receiving more bits:



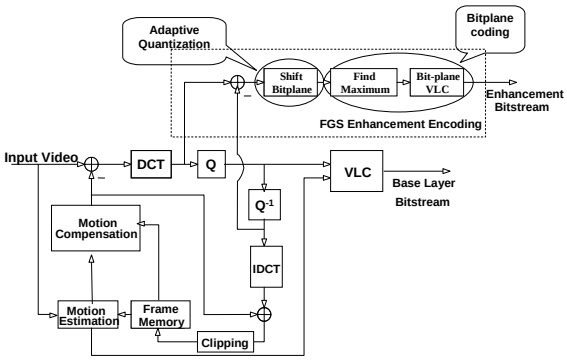
Spatial Scalability



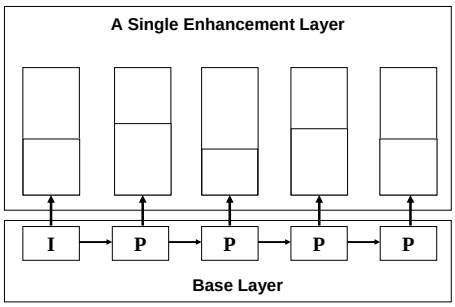
Temporal Scalability



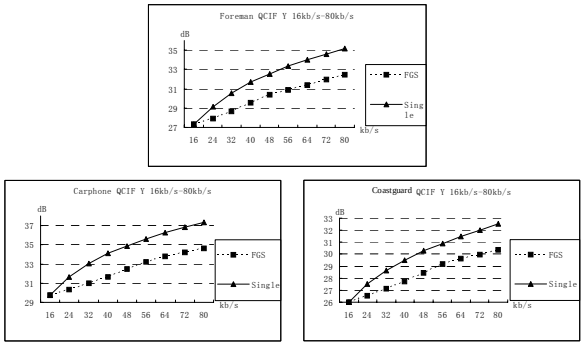
MPEG-4 Fine Granularity Scalability



SNR Scalability with MPEG-4 FGS

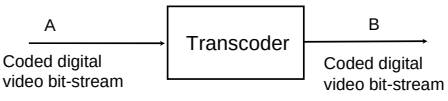


Performance of MPEG-4 FGS



1.5~2.5 dB degradation was observed

Video Transcoding



- Bit-rate adaptation
- Spatial/temporal resolution conversion
- Multipoint video conferencing
- Watermarking
- Error resilience
- Encryption
- Video multicast over heterogeneous networks

Video Transcoding

- Signal level adaptation
  - involving various manipulations of coded representations and issues of bit allocation
- Spatial dimension
  - change spatial resolution, i.e., frame size
- Precision dimension
  - change the bit plane depth, color depth, or the step size for quantizing the transform coefficients
- Temporal dimension
  - change the frame rate
- Object dimension
  - transmit a subset of objects

Heterogeneous Video Transcoding

- Adapting video streams to different types of terminals with different terminal capabilities such as screen size, amount of available memory, processing power and type of network access