Adaptive Video Streaming

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Problem Statement

- The design, implementation, and evaluation of an *adaptive streaming protocol* for MPEG-4.
- “adaptive streaming protocol” – negotiation between client and server of optimal **bitrate** and **error resilience** based on observation of network conditions, resulting in dynamic adjustment of the video bitstream which is transmitted

Motivation

- Rising demand for streaming multimedia over the Internet
- Significant variation in network conditions over time
- Ability for user to specify allocation of bandwidth (prioiritization of various portions of the bitstream)

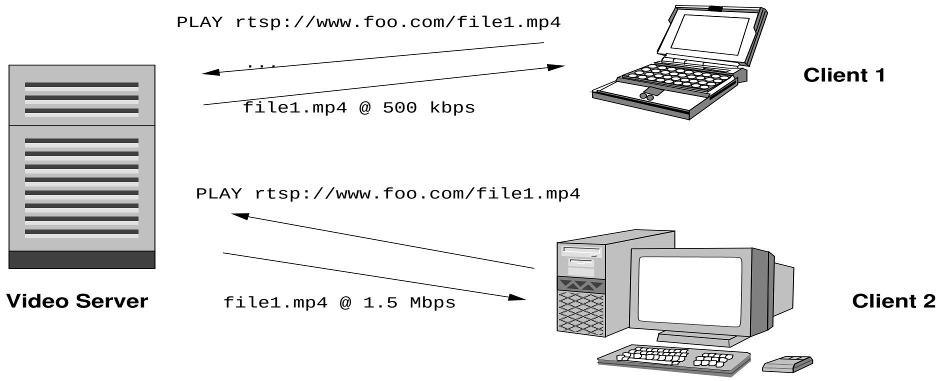
Traffic Patterns are Changing

- **The Past** – Internet traffic dominated by applications which require reliable data delivery (FTP, HTTP, SMTP, etc.) which use TCP connections
- **Streaming Media** – Low and predictable latency, often high data rates.

The Internet, however, is characterized by large variations in available network bandwidth and host processing power, resulting in potentially high variance in latency!

The Goal

- Transmission of video over networks
- A protocol which allows a client/server system to adaptively stream video, responding appropriately to:
  - variable network conditions
  - application and user-controlled adaptation



Related Work

- **Rate-based Control:** sender attempts to send at a relatively constant end-to-end transmission rate, using callbacks from receiver as feedback (Berkeley's MPEG Player)
  Issue: does not take into account congestion which might occur at intermediate nodes
- **RTP/RTSP:** services for data "with real-time characteristics"
  Issue: need a mechanism for timely delivery and QoS guarantees

Related Work

- **Streaming Control Protocol:** set of rules for adjusting congestion window size
  Issue: control is not at the application layer

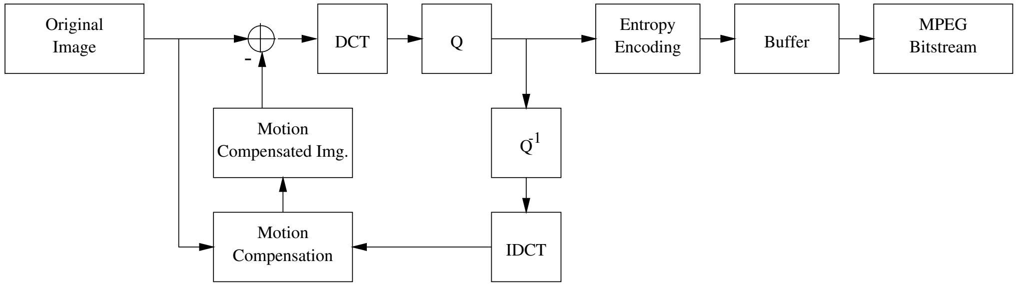
- **Modified TCP:** TCP without retransmission (RealPlayer)
  Issue: AIMD still makes transmission inherently bursty

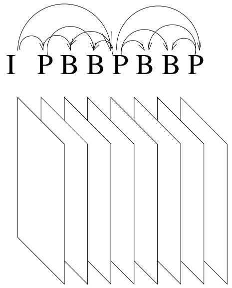
- **Smoothing Algorithms:** attempt to smooth the bitrate of MPEG over time (MPEG has an inherently non-constant bitrate)

MPEG-4 Overview

The original objective of MPEG-4 was to allow for very-low bitrate (VLBR) coding (< 64 kbps). Its ultimate purpose will be to be a superset of MPEG-2.

Overview of MPEG Video Compression



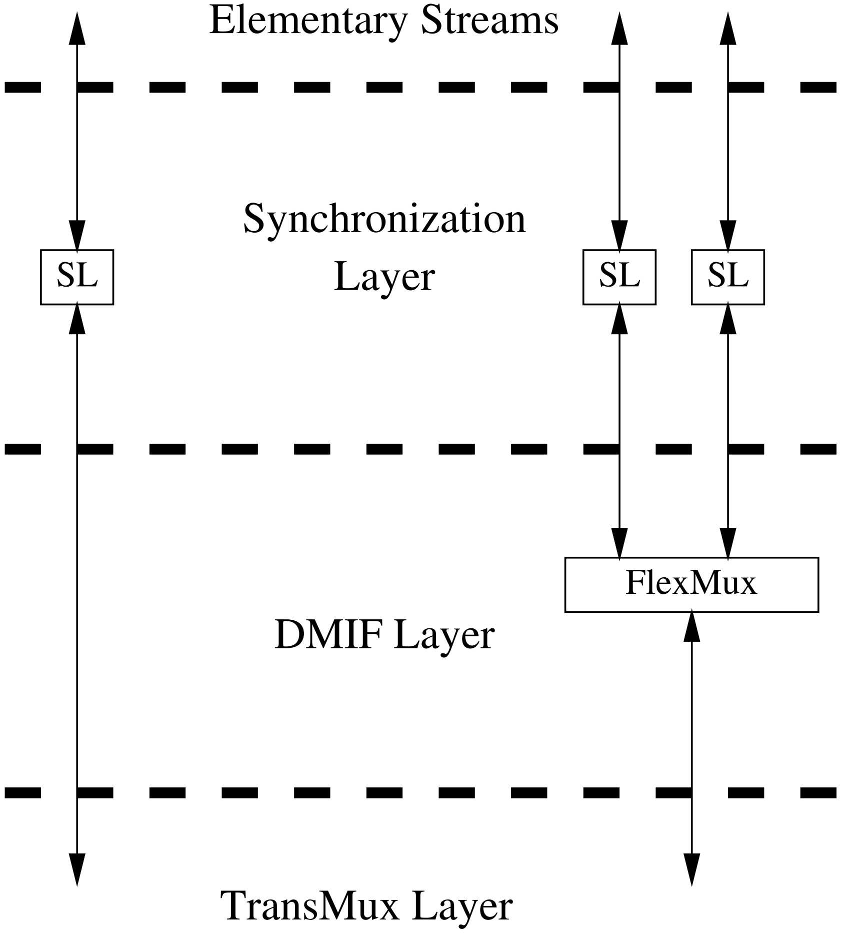


Features of MPEG-4

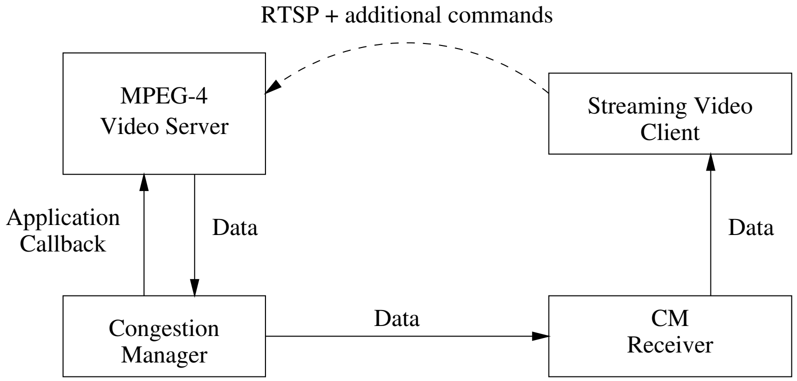
Manipulation of video bitstreams on an object-based level.

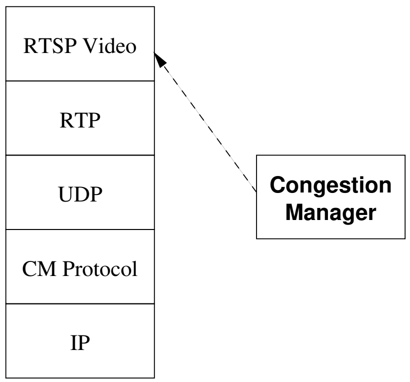
- **Media objects:** frames may be composed of still images, video (sprite, background), audio, etc.
- **Scene descriptions:** binary language for composing a set of multiple media objects, coded independently from elementary streams
- **Multiplexing/synchronization of streams:** functionality to ensure multiple streams which compose a scene are properly synchronized
- **Scalability of textures, images, and video:** spatial and temporal scalability, scalability in video quality (PSNR)

MPEG-4 System Layers



System Architecture





System Design Overview

- Client/server system
- Two channels for communication:
  - TCP control channel – RTSP client/server control
  - ITP/UDP data – transmit bitstream from server to client
- Network Monitoring: CM callbacks to application provide information about network conditions

System Design Overview

- User Interaction
  - Absolute bitrate specification
  - Relative bitrate specification
  - Area of interest
- CM separates choice of transport protocol from congestion control

CM Overview

Congestion Manager: Management of network congestion from an end-to-end perspective.

Features:

- application-specific congestion management policy
- separation of congestion control from transport protocol

Data Transport

- TCP is undesirable because of potentially long and highly variable latency.
- UDP is better, but would like:
  - client to be able to request retransmission of packets
  - reconstruction of out-of-order arrival into sensible data units
- *solution:* variant of “image transport protocol” (ITP), which allows for variably reliable, client-controlled transmission of data units which are larger than the MTU of ethernet

Interesting Issues and Other Ideas

- Implementation of dynamic bitrate adjustment
- Alternatives to offline coding, e.g., exploiting bitstream scalability
- Security issues: anyonymity and authentication in the context of video-conferencing
- Potential exploitation of VBR-encoded bistream (multiplexing, etc.) ?

Current State

`[To be filled in at appropriate time.]`