Wireless Video

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Presentation Outline

- Problem Identification
- Video Codec
  - Encoding / Decoding
  - Transmission and Reconstruction
- Simulation Methodology and Results
- Software Performance
- Conclusions

Current ISO & ITU Standards do not measure up!

Aren't error robust !

- Suffer from spatial and temporal error propagation

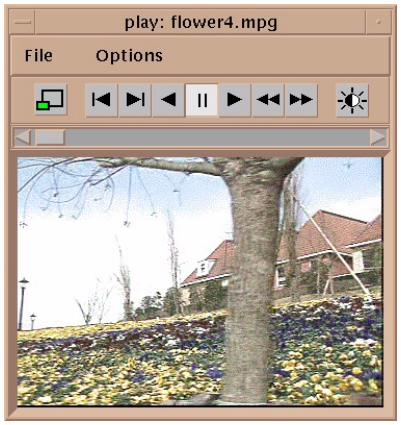
Aren't network friendly !

- How much bandwidth to reserve for VBR bitstreams ?
- How do you guarantee delay if bandwidth is not reserved?

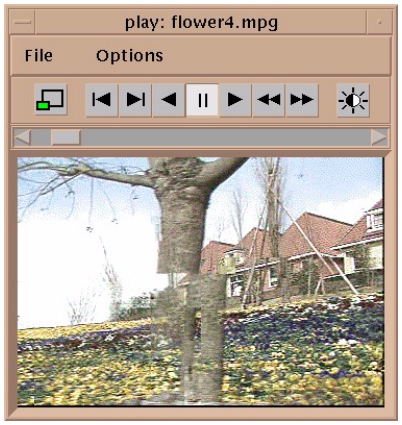
Aren't application friendly !

- Poor error concealment properties
- Do not allow for graceful degradation. In the absence of bandwidth
  - Loose frames -- Choppy video
  - Loose synchronization

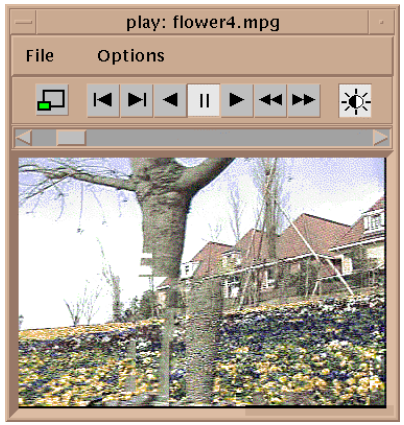
Example -- Transmission Errors (MPEG-1, MPEG-2, H.261, H.263)



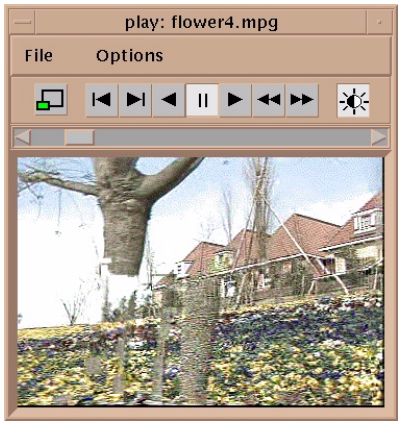
Frame 16



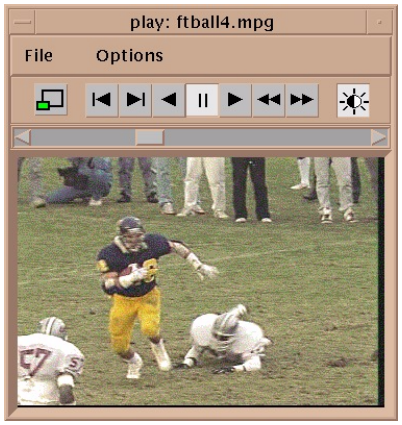
Frame 20



Frame 26

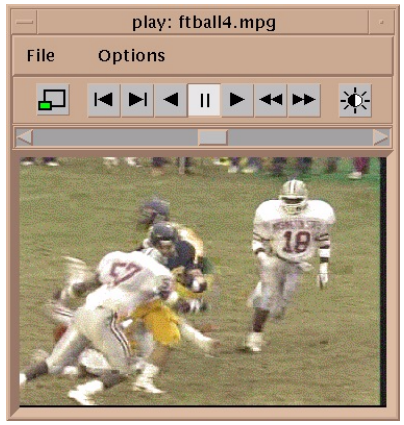


Frame 31



Original

Motion Vectors Corrupted

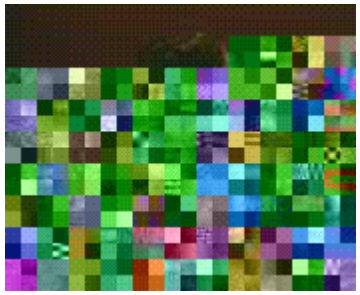


Original

Headers Corrupted

Example -- Transmission Errors (H.261, M-JPEG)

Original



Errors in VLC

Frame 266

Frame 267

Frame 268

Summary -- Effect of Transmission Errors

The impact of bit errors on video quality depends on their **spatial** and **temporal** location

A single bit error may destroy a major part of a GOB in spatial domain due to VLC

- Picture and GOB headers stop error propagation in spatial domain

Errors propagate among P, PB, and B pictures in the temporal domain

- I-Pictures stop error propagation in the temporal domain

Errors in headers or motion vectors could cause major damage

Errors in high frequency DCT coefficients have little impact on the video quality

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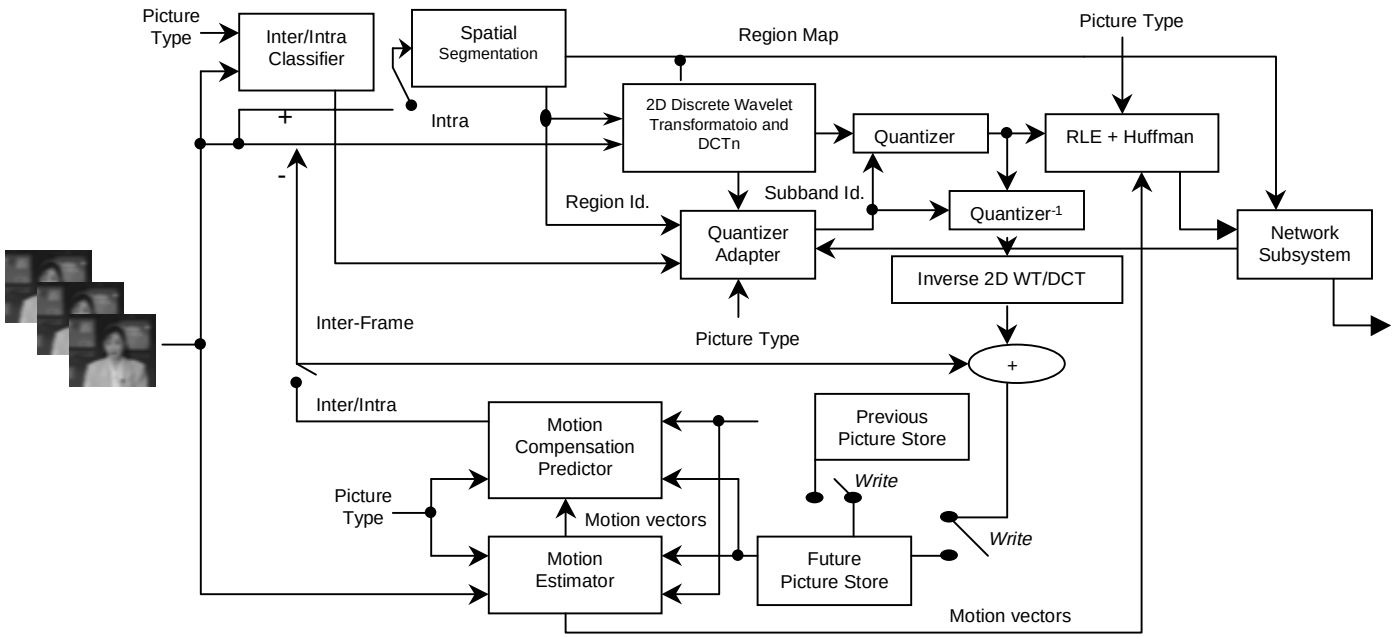
Content Sensitive Video Codec



Encoder

Segmentation -- Split and Merge Algorithm

Merge the macro-block *i* with *j* whenever:

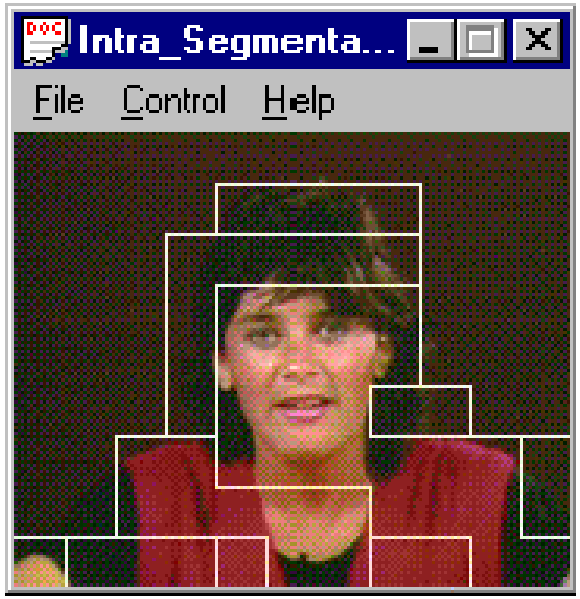
$$\left| \log\left(\sigma_i^2 / \sigma_j^2 \right) \right| \quad < \quad T$$

Where T (Threshold) is calculated as:

$$T \quad = \quad \log\left(\sigma_{\max}^2 / \sigma_{\min}^2 \right) / N \quad + \quad \eta$$

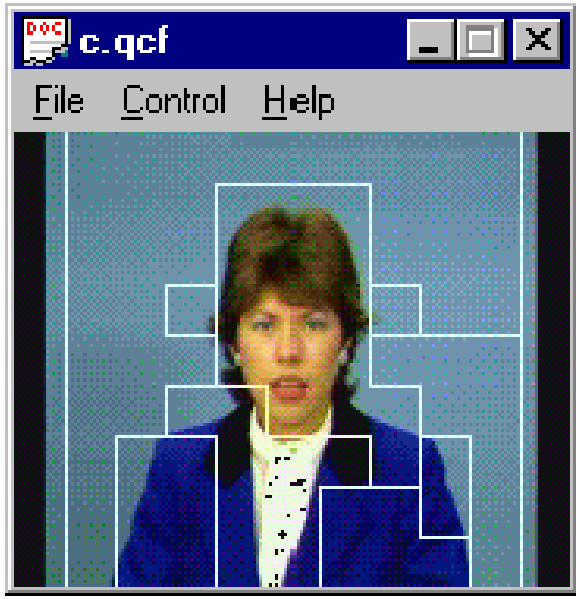
Example -- Intra-Frame Segmentation

Miss America



Threshold = 0.278

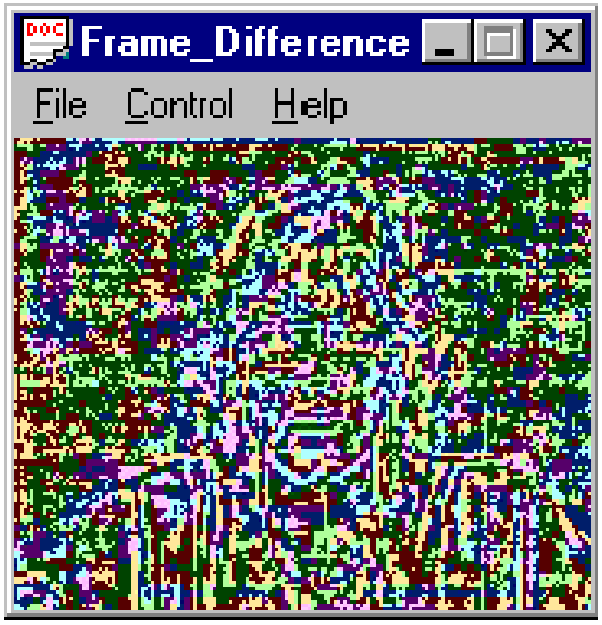
Akiyo



Threshold = 0.278

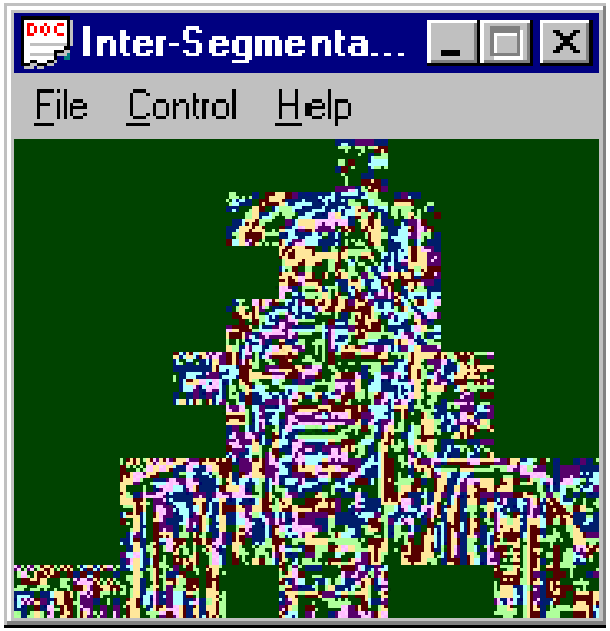
Example -- Inter-Frame Segmentation

Miss America



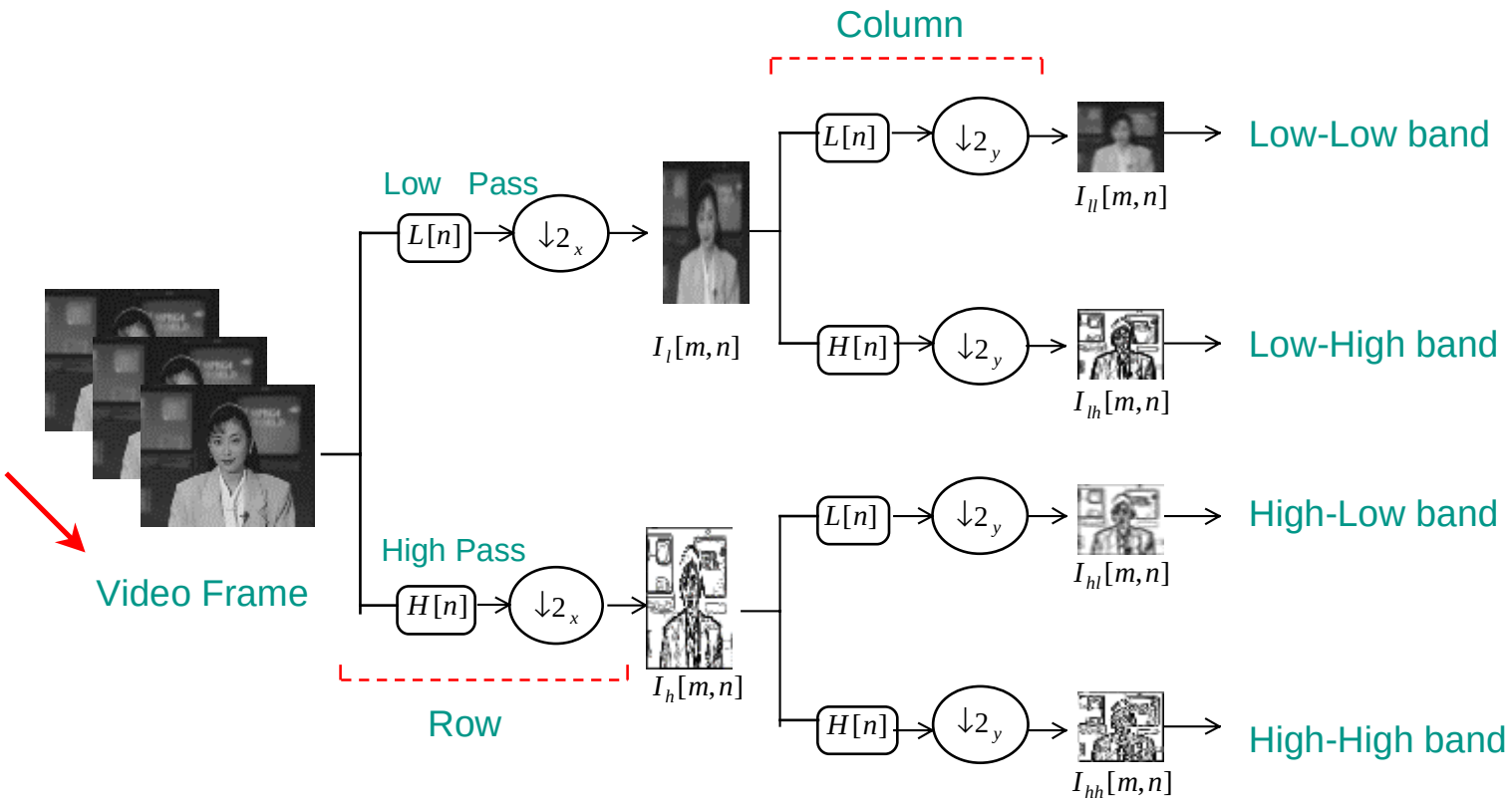
Frame Difference between the 9th and 10th Frame

Miss America



Threshold = 20

Subband Decomposition



Example -- Wavelet Decomposition of Primary Region

Two-Tap Haar Filter applied to the Luminance Component

4-Level Decomposition of *Miss America*

Example -- Effect of Insufficient Bandwidth

Akiyo



Foreman



Mother & Daughter



Original 48 Kbit/sec | Missing one Subband | Missing three Subbands

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Lego Transmission

Transmitter

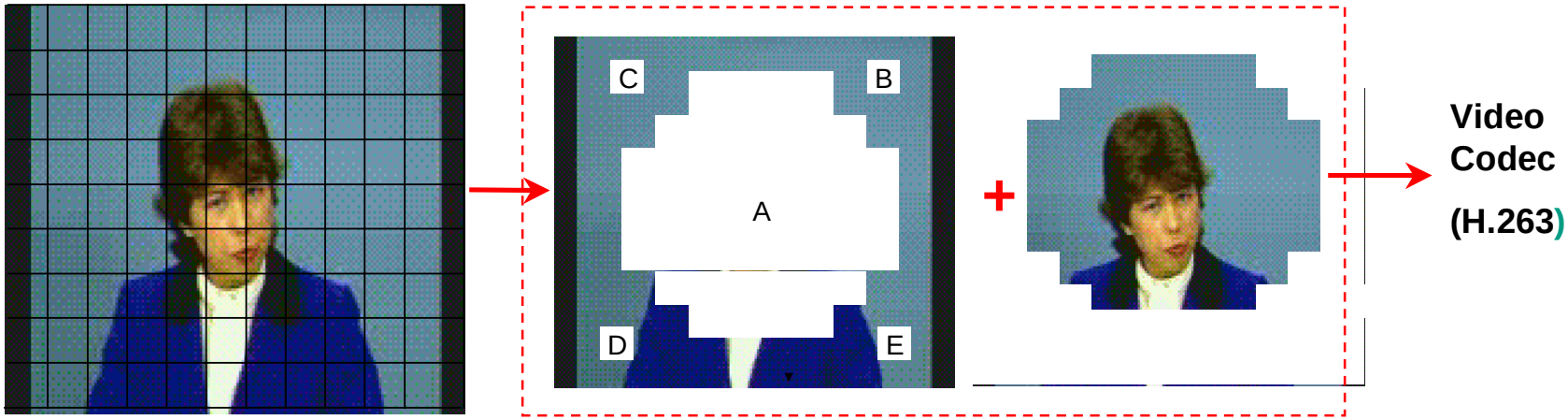
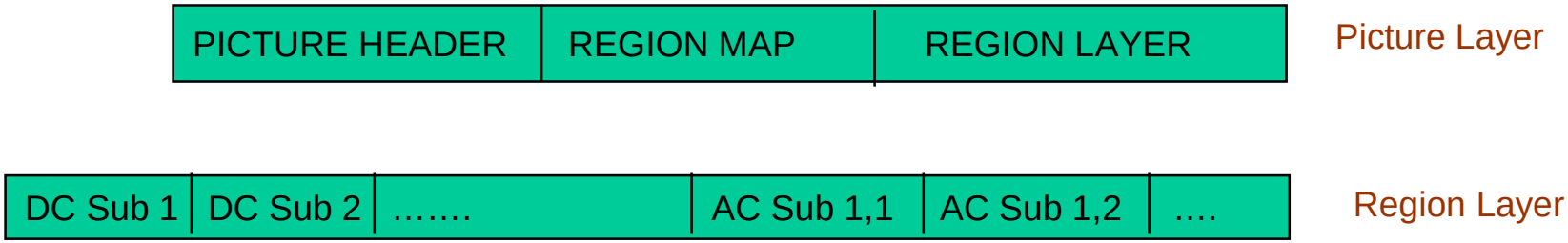


Image Segmentor

Bit Stream Syntax

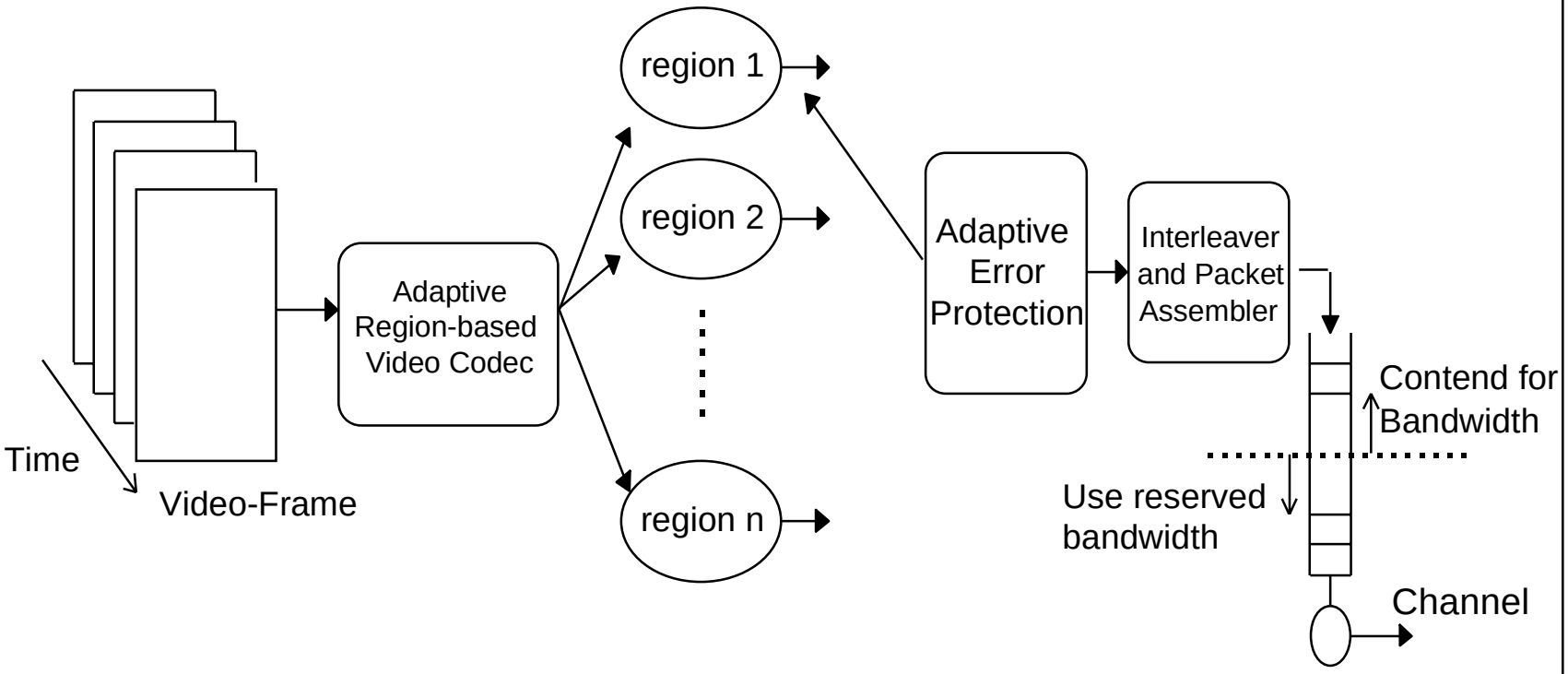
Picture Layer

- Region Layer (RL) (instead of the GOB Layer)
  - Subband Layer (SL)
    - Macroblock Layer (MBL)
      - Block Layer

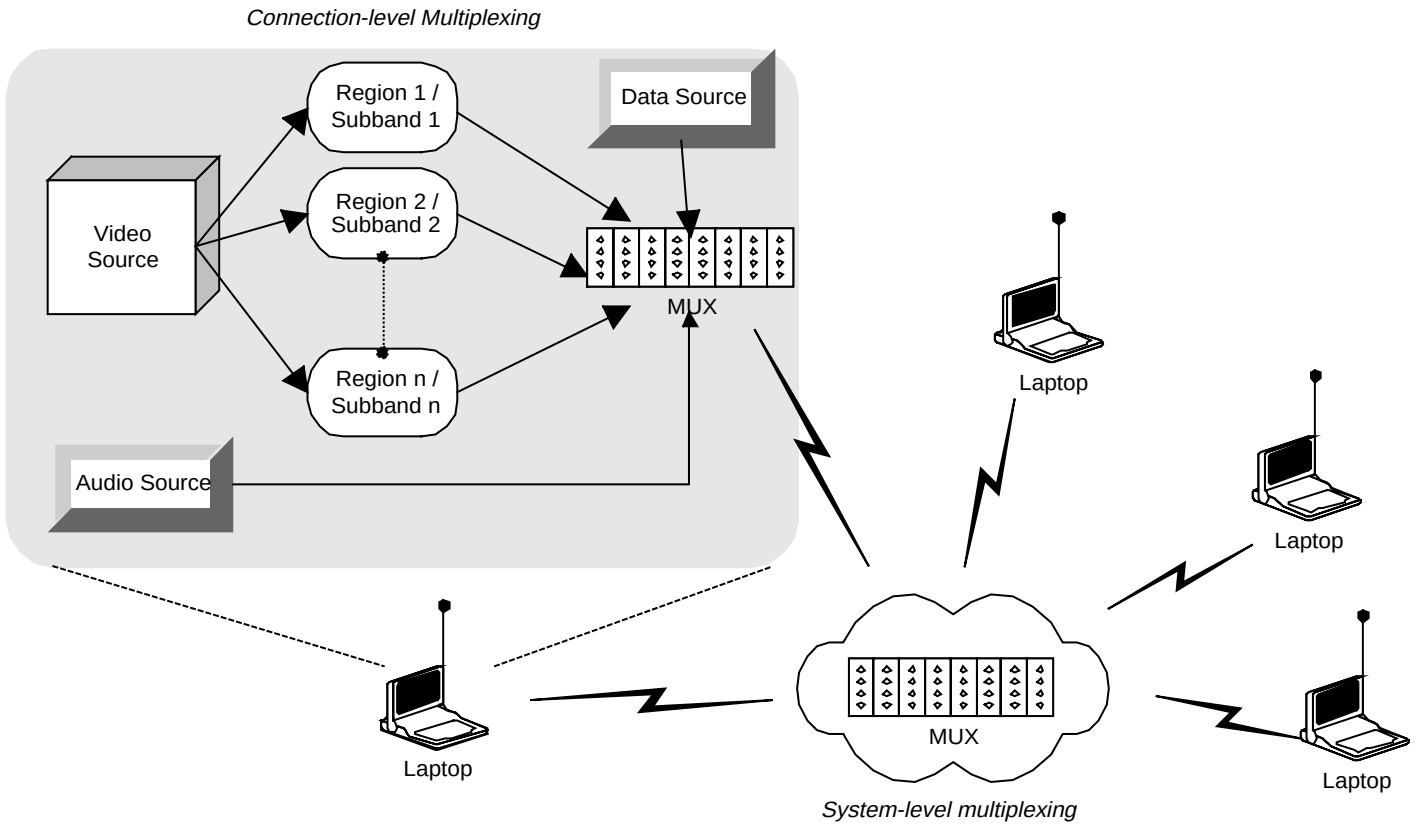


Bandwidth Reservation

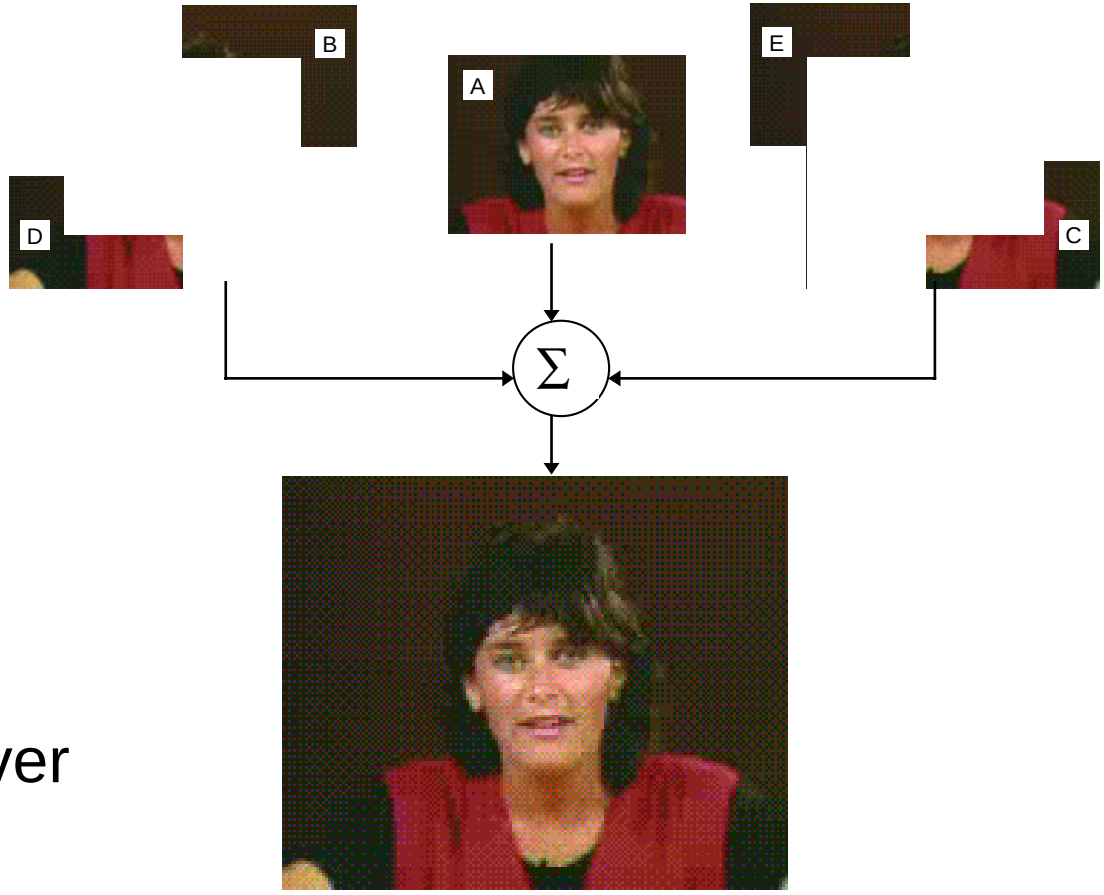
Reserve peak demand of the primary subband or main region



Statistical Multiplexing: Connection Level .vs. System Level

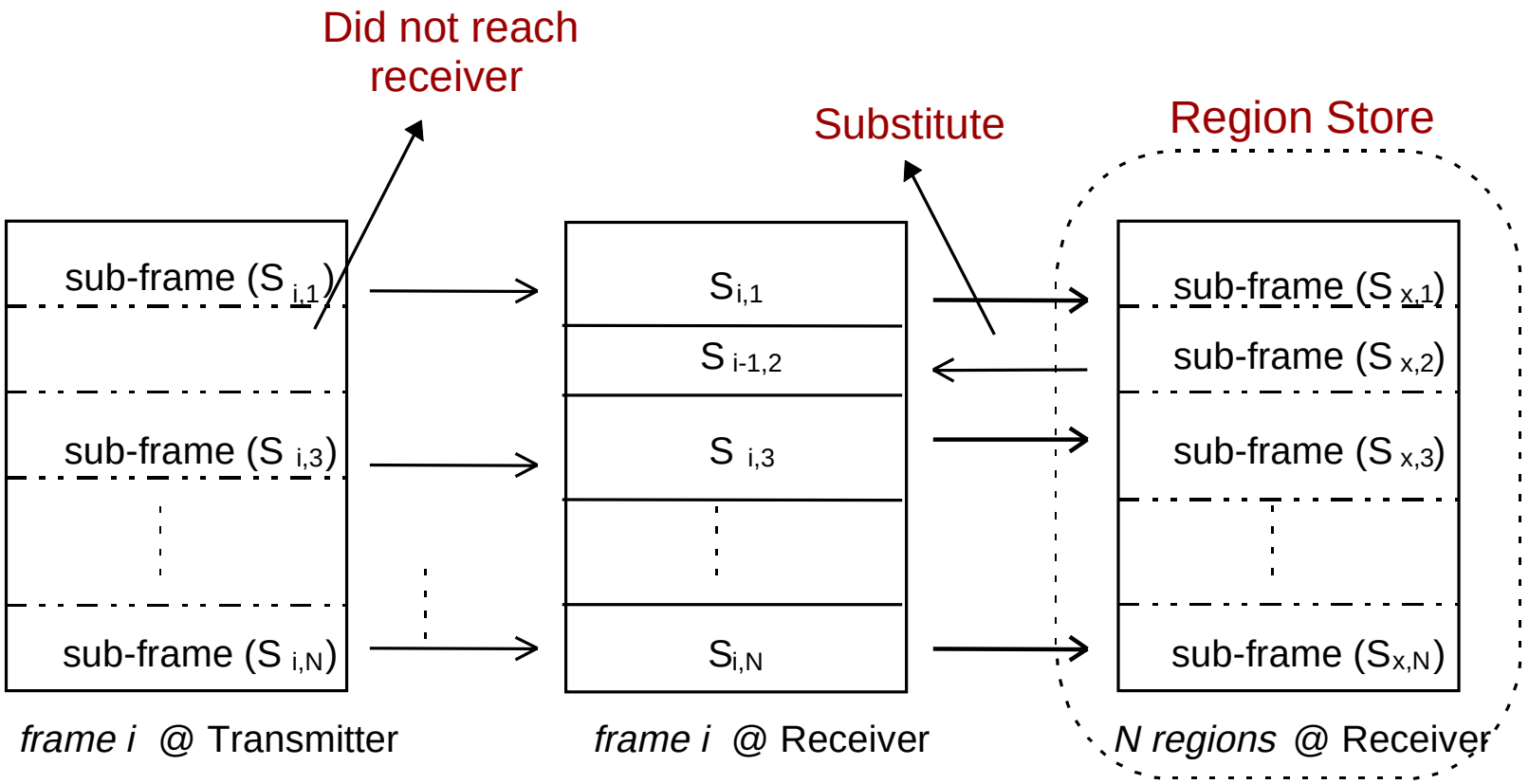


Lego Reconstruction



Receiver

Lego Reconstruction (Error Concealment)



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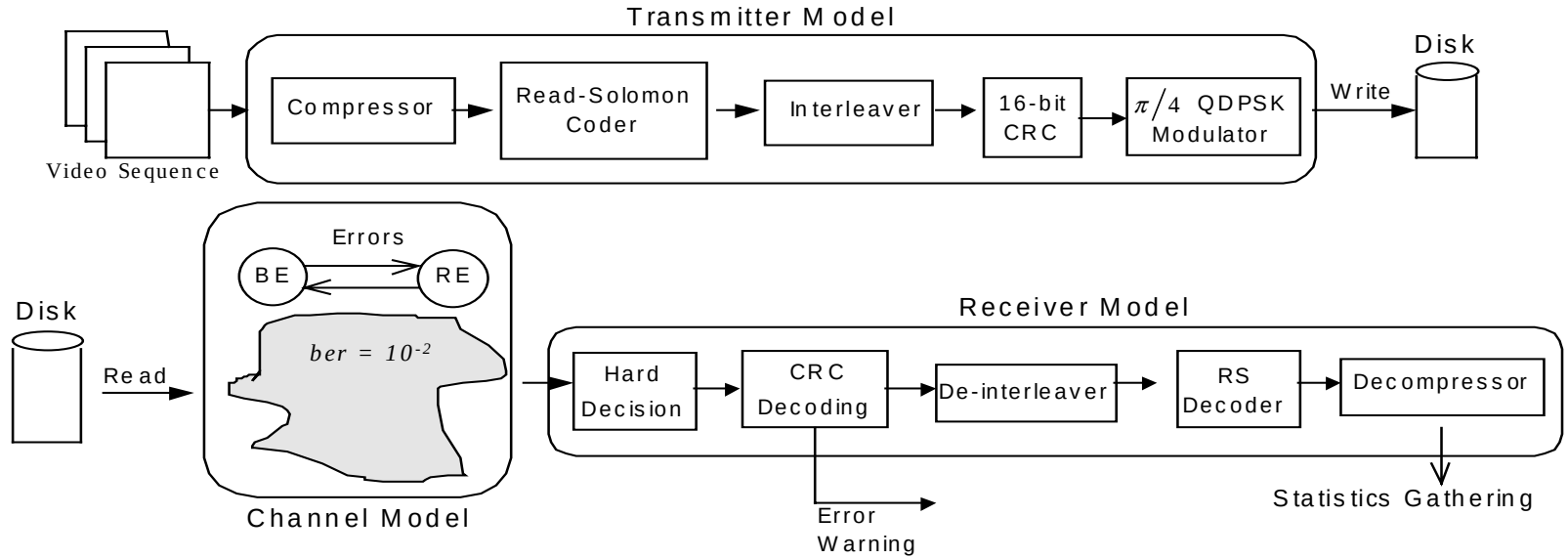
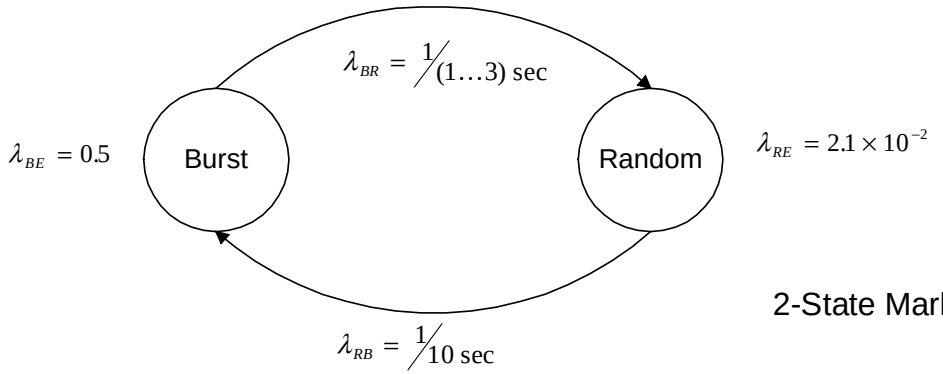
Simulation Methodology





2-State Markov model for errors

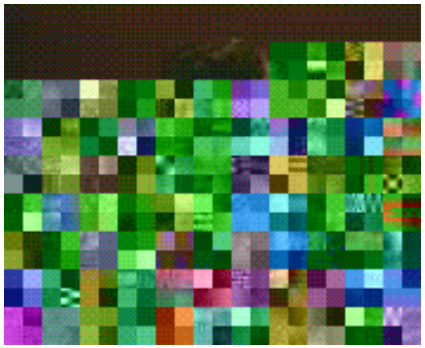
Properties -- Robustness Against Noise

Reconstruction with corrupted AC Subbands - 25.34 dB

Reconstruction from Protected Coefficients (ignoring all Corrupted Regions - 35.43 dB

Properties --
Restricted Error Propagation

Original (16 Kbit/sec)



Without Segmentation

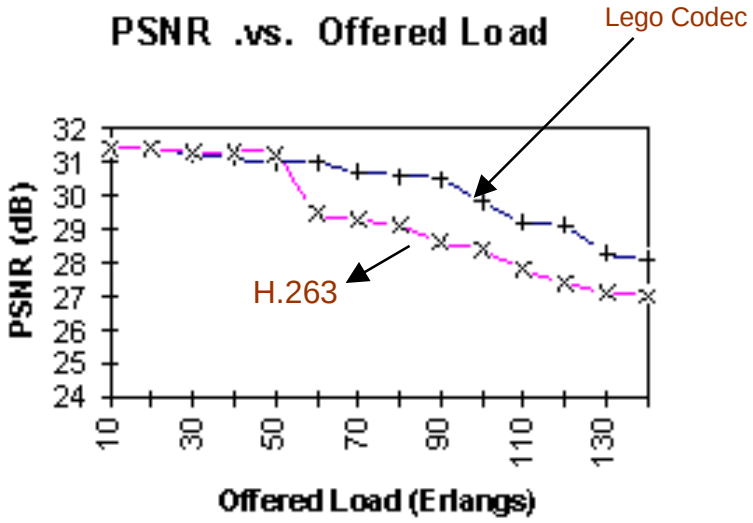
With Segmentation

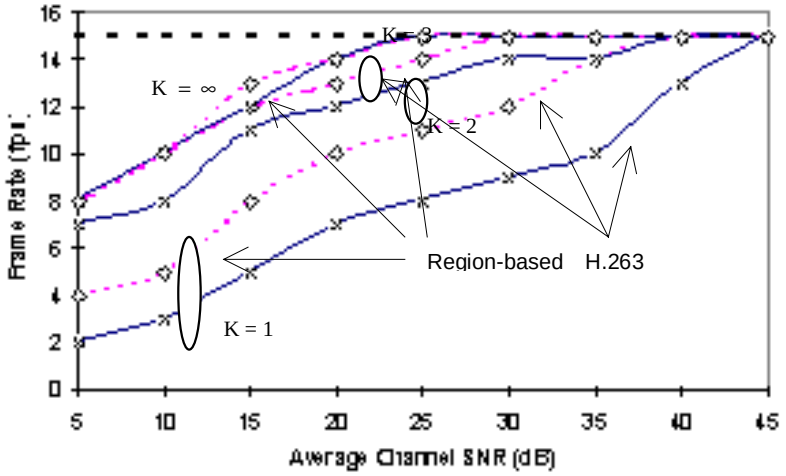
Original (16 Kbit/sec)

Without Segmentation

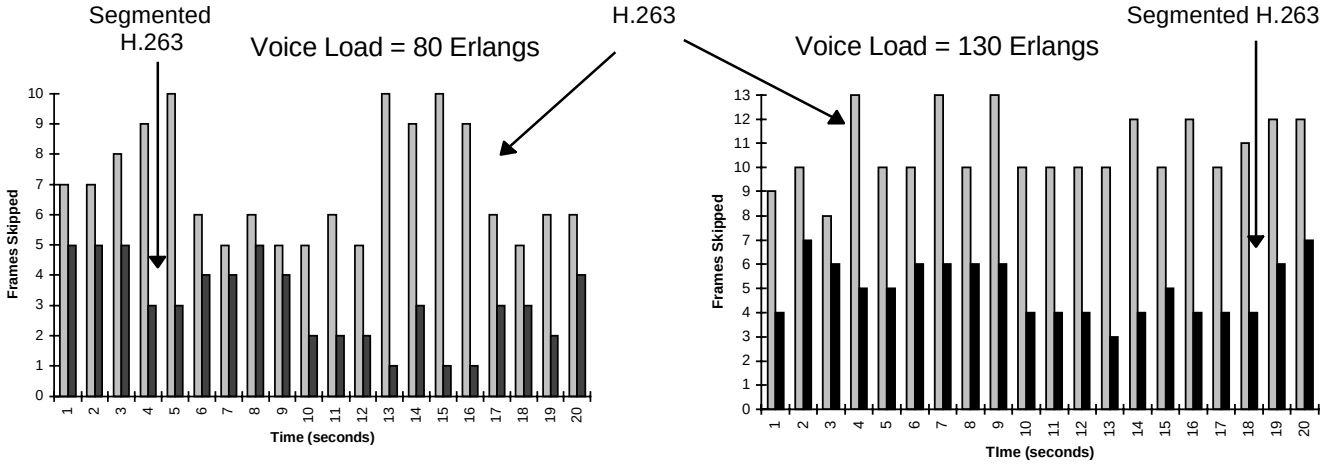
With Segmentation

Results --
Improved Temporal Resolution - Changing Error Patterns



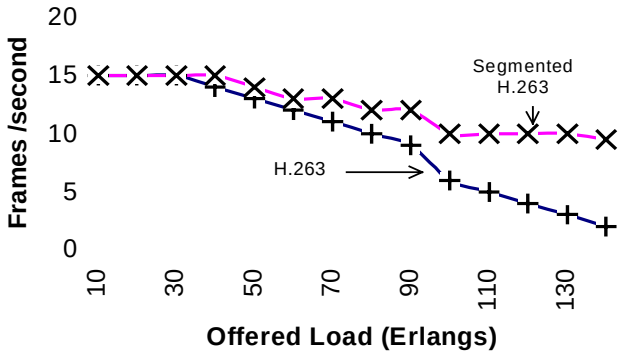


Results --
Improved Temporal Resolution - Changing Bandwidth

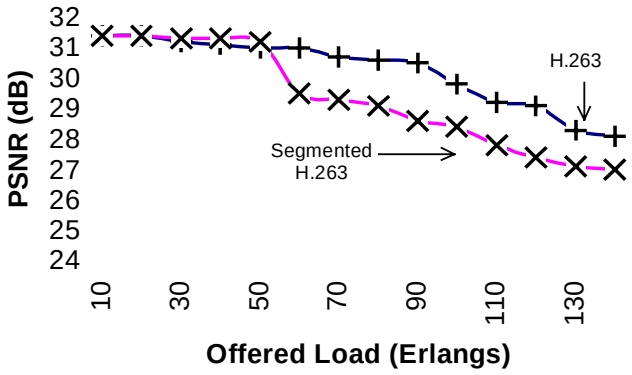


Changing Load (Bandwidth)

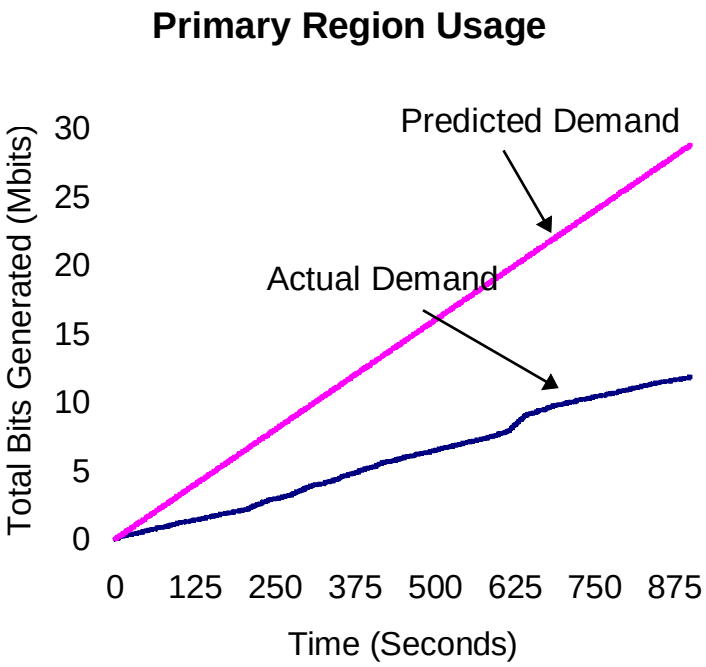
Frame Rate .vs. Offered Load

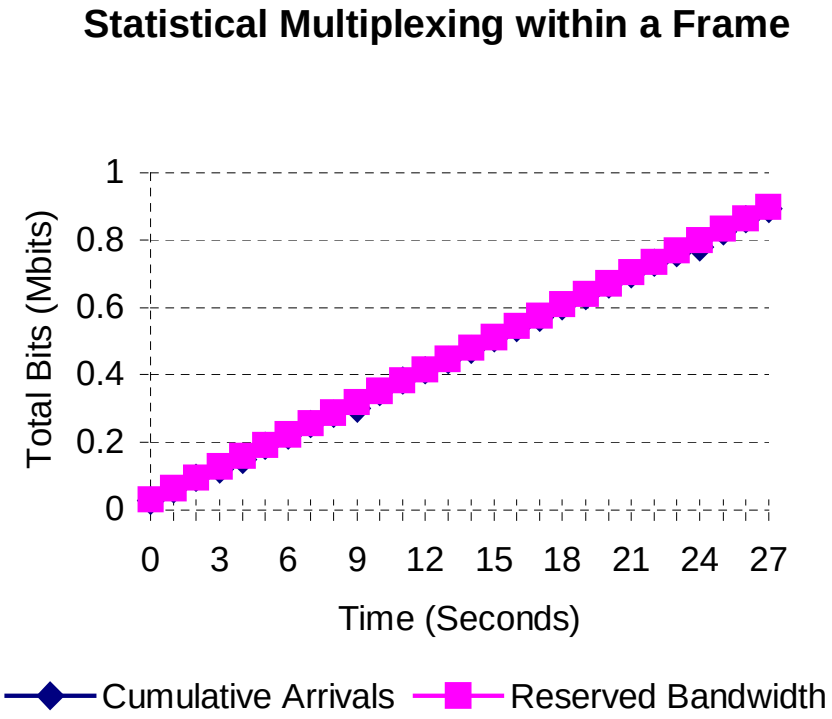


PSNR .vs. Offered Load



Results - Improved Bandwidth Utilization





Bandwidth usage with and without intra-frame statistical multiplexing

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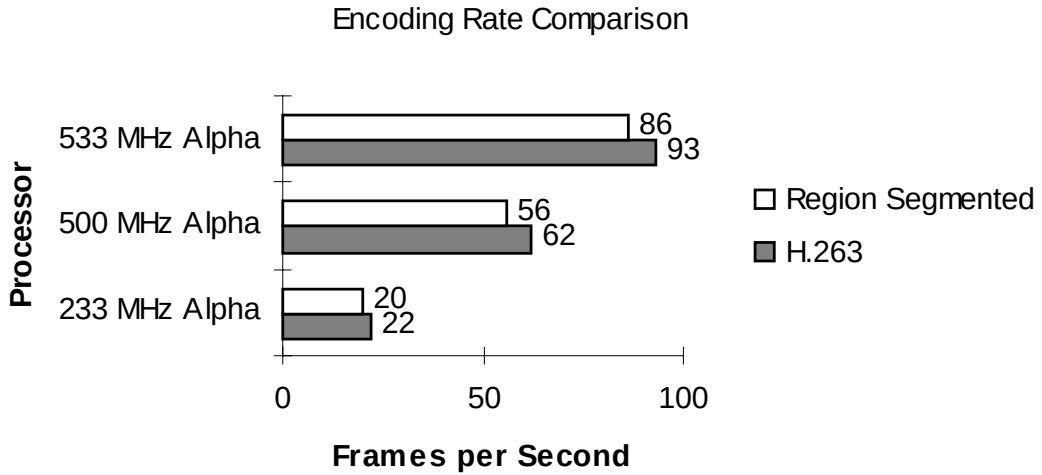
Software Performance

Function Name	Lego Video Codec	ITU's H.263 Codec
Segmentation	11	--
DWT / IDWT	1.8	--
DCT / IDCT	4.7	5.3
Motion Estimation	55.3	62.8
FindHalfPel	9.9	11.3
Quant / DeQuant	2.4	2.7
Clip	1.5	1.7
Interpolate Image	1.1	1.2
Predict_P	2.2	2.5
MB_Reconstruction	1.1	1.3
Miscellaneous	9	11.2



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Conclusions

Region segmented, content sensitive video codec works better than all current ISO and ITU video coding standards

- Robust against errors
- Bounds both spatial and temporal error propagation
- Improves perceptual temporal resolution
  - when available bandwidth is changing
  - when error characteristics are changing
- Good for QoS
  - Can be used with near optimum reserved bandwidth utilization
- Software performance comparable to H.263