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# Wireless Video

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## Presentation Outline

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

## Current ISO & ITU Standards do not measure up!

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Aren't error robust !

- Suffer from spatial and temporal error propagation

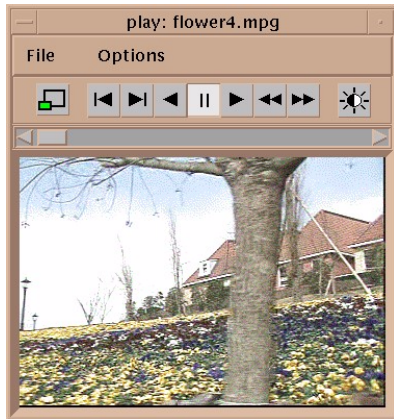
Aren't network friendly !

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

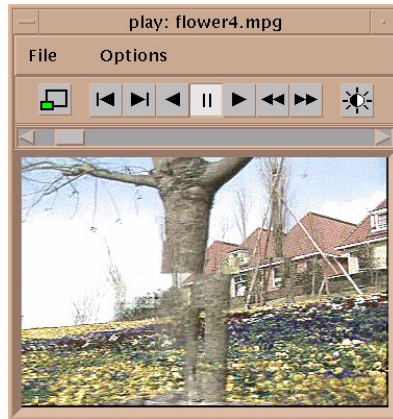
Aren't application friendly !

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

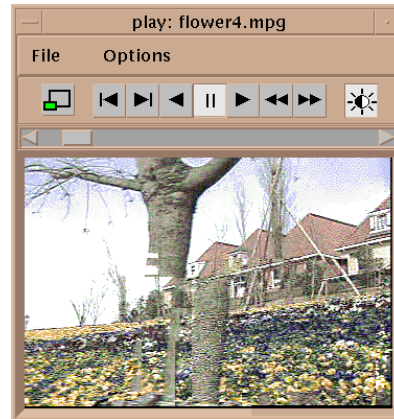
# Example -- Transmission Errors (MPEG-1, MPEG-2, H.261, H.263)



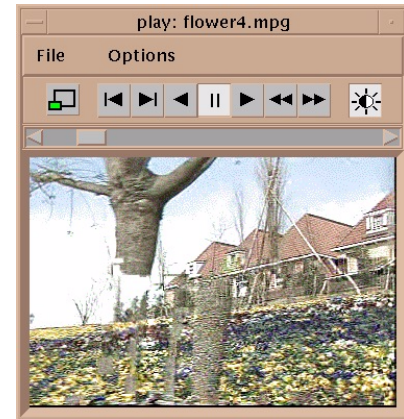
Frame 16



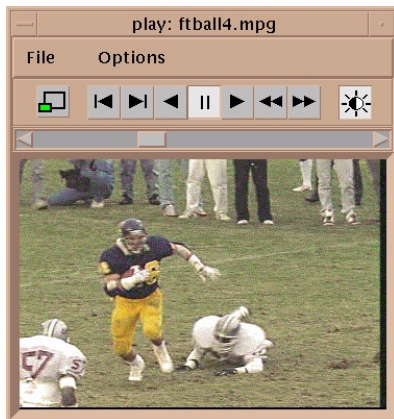
Frame 20



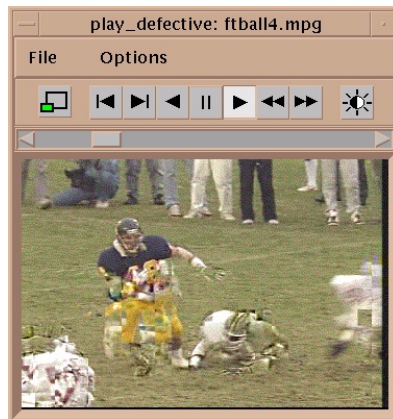
Frame 26



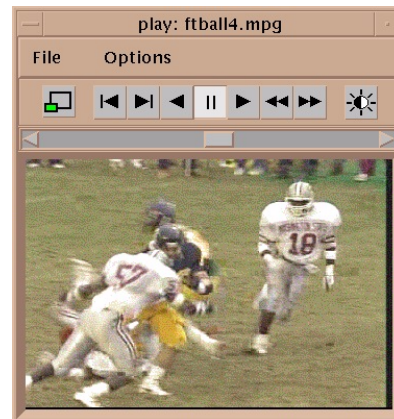
Frame 31



Original



Motion Vectors Corrupted



Original



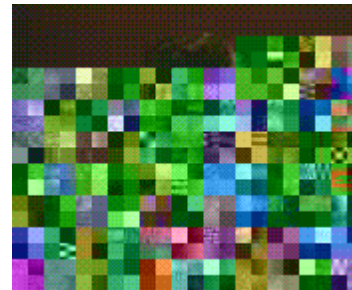
Headers Corrupted

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

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Original



Errors in VLC



Frame 266



Frame 267



Frame 268

## Summary -- Effect of Transmission Errors

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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

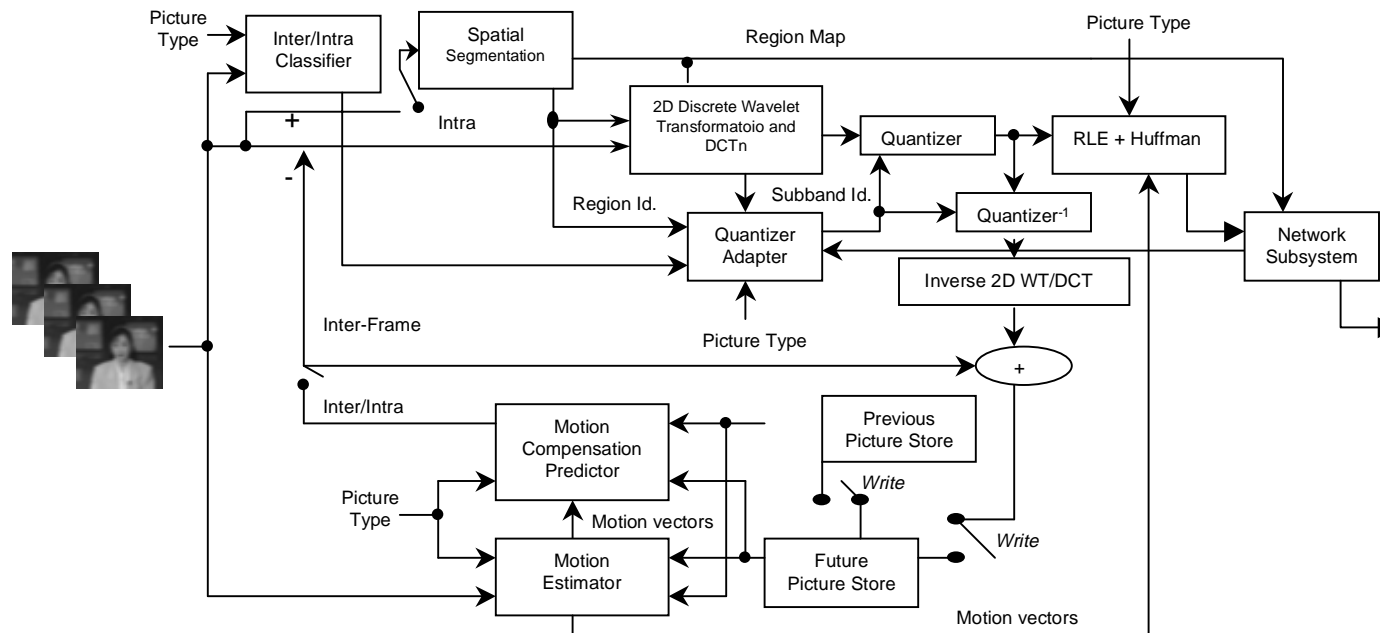
Errors in high frequency DCT coefficients have little impact on the video quality

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# Content Sensitive Video Codec



Encoder



## Segmentation -- Split and Merge Algorithm

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

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

Where  $T$  (Threshold) is calculated as:

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

# Example -- Intra-Frame Segmentation

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Miss America



Threshold = 0.278

Akiyo

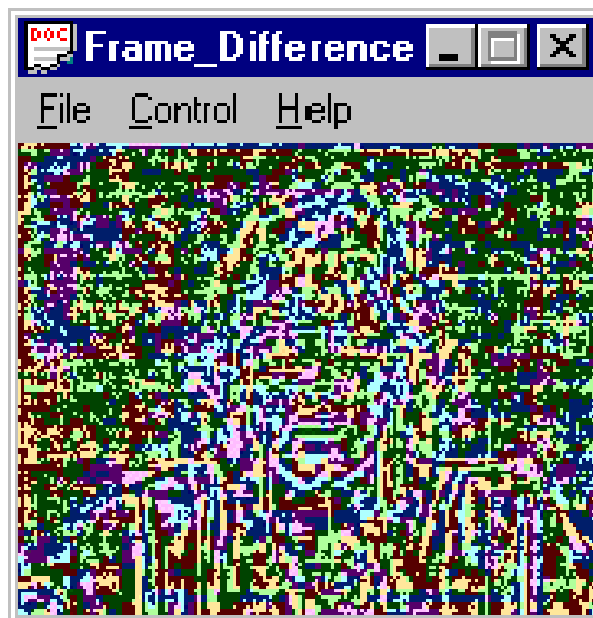


Threshold = 0.278

## Example -- Inter-Frame Segmentation

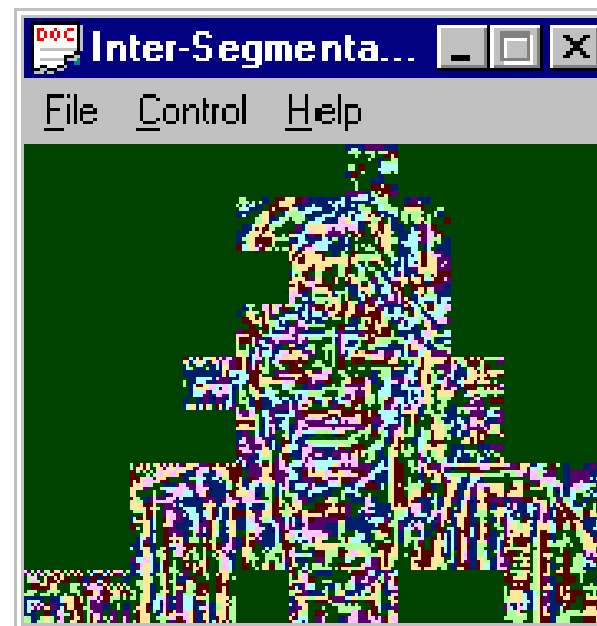
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Miss America



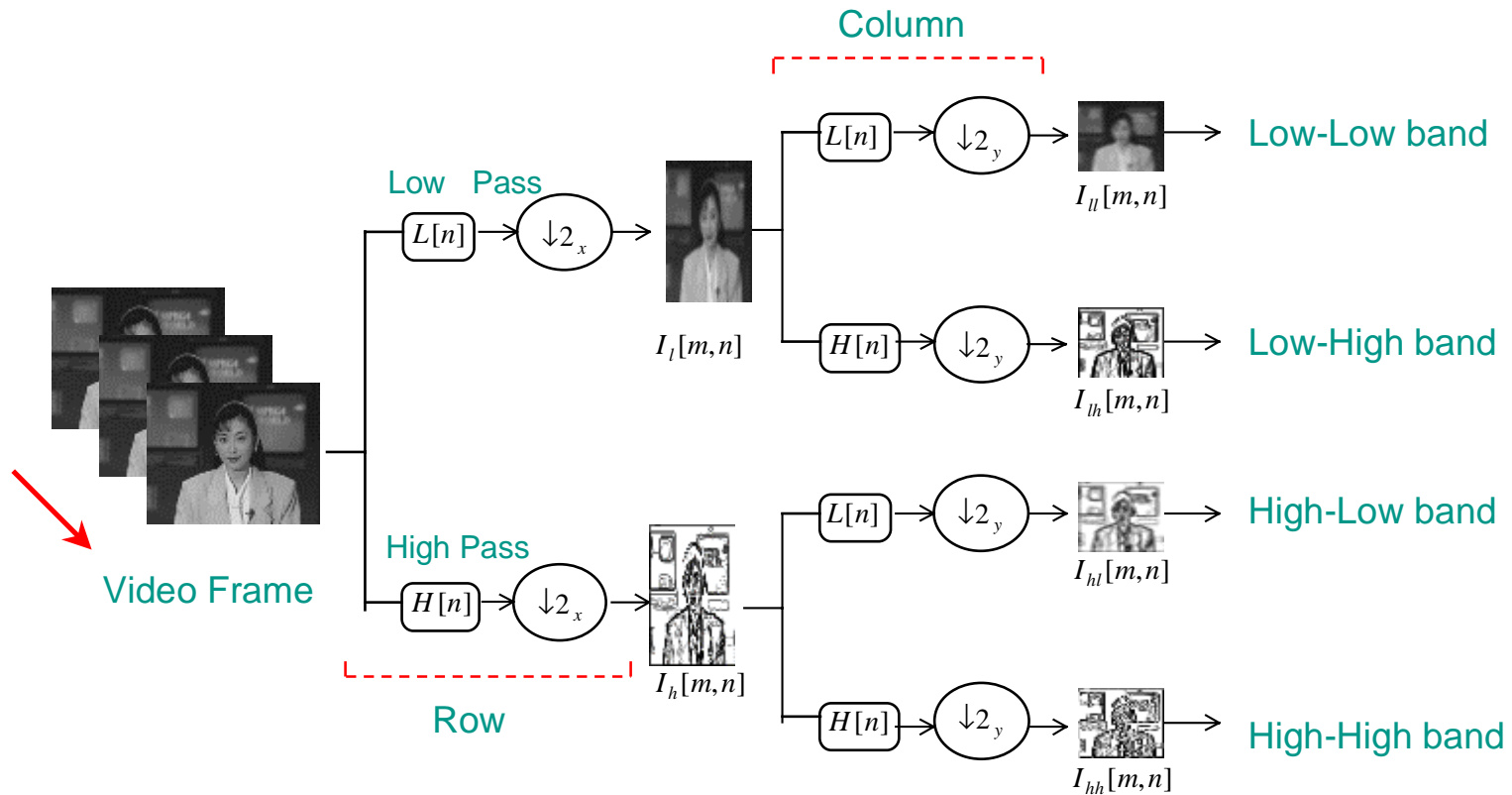
Frame Difference between the 9th and 10th Frame

Miss America



Threshold = 20

# Subband Decomposition



## Example -- Wavelet Decomposition of Primary Region

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Two-Tap Haar Filter  
applied to the Luminance  
Component



4-Level Decomposition of *Miss America*

## Example -- Effect of Insufficient Bandwidth

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Akiyo



Foreman



Mother & Daughter



Original 48 Kbit/sec

Missing one Subband

Missing three Subbands

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# Lego Transmission

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Transmitter

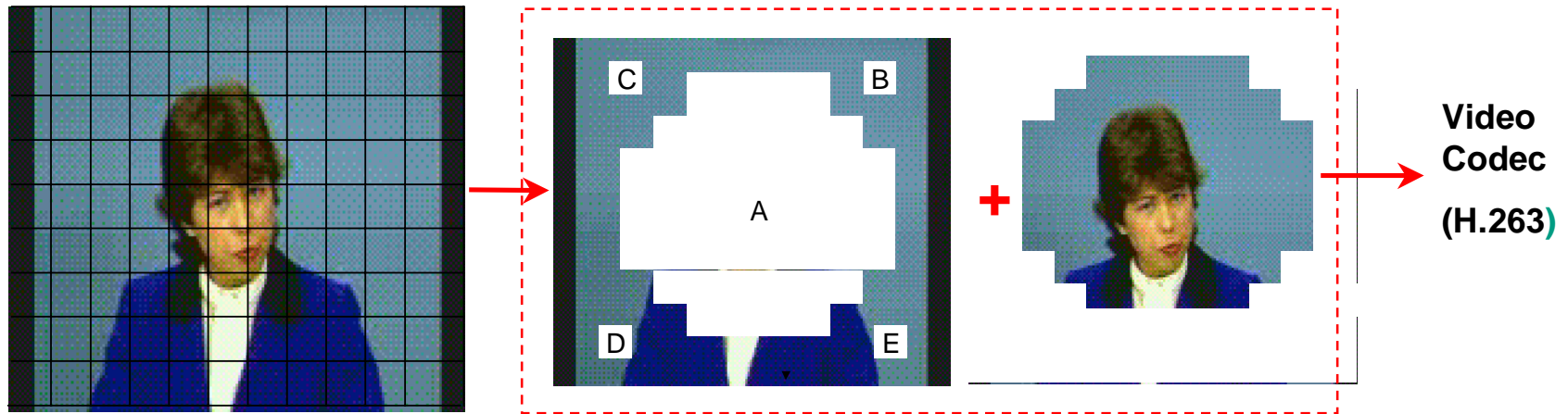


Image Segmentor

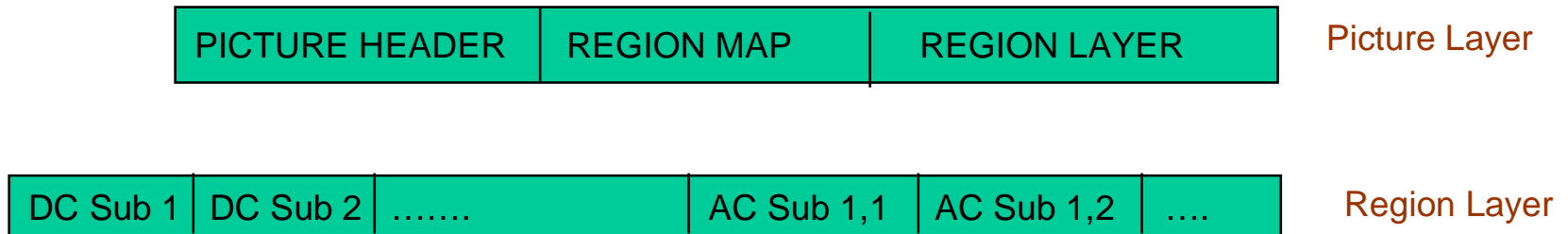


# Bit Stream Syntax

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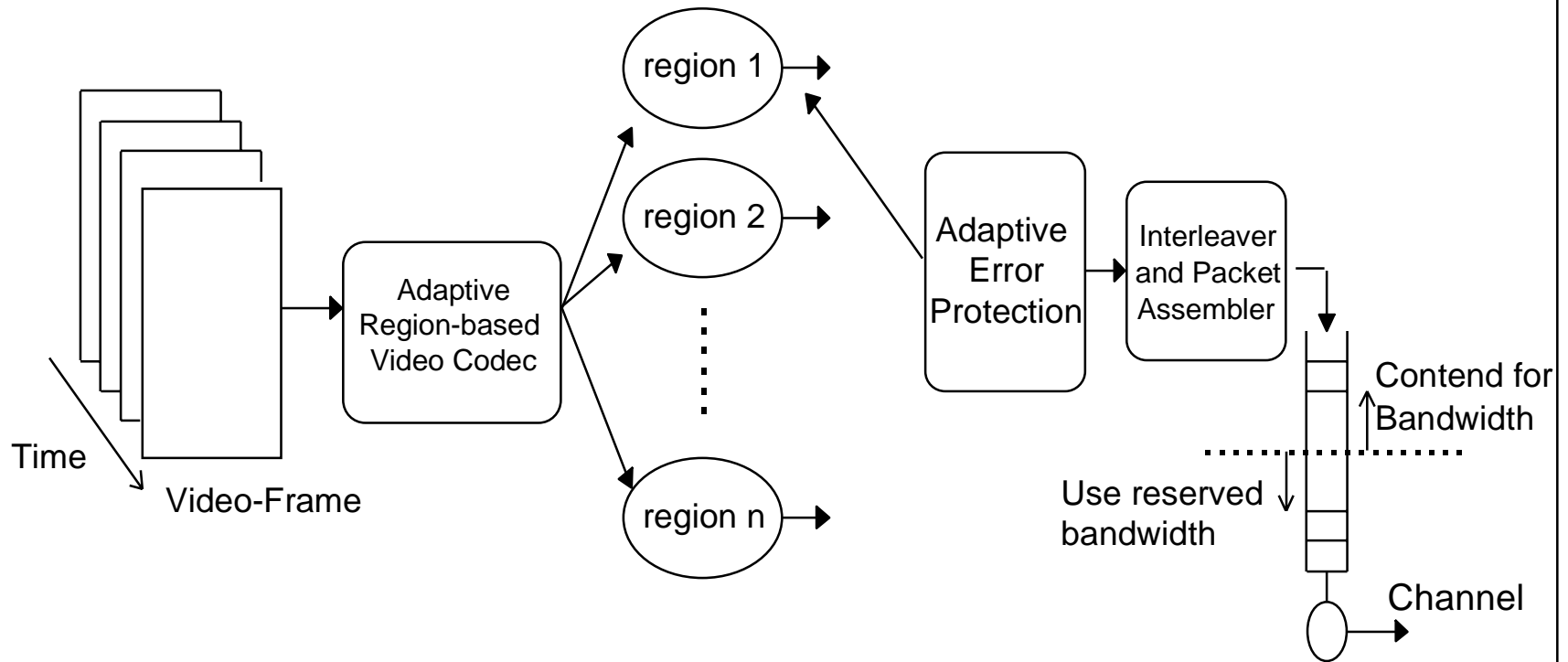
## Picture Layer

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

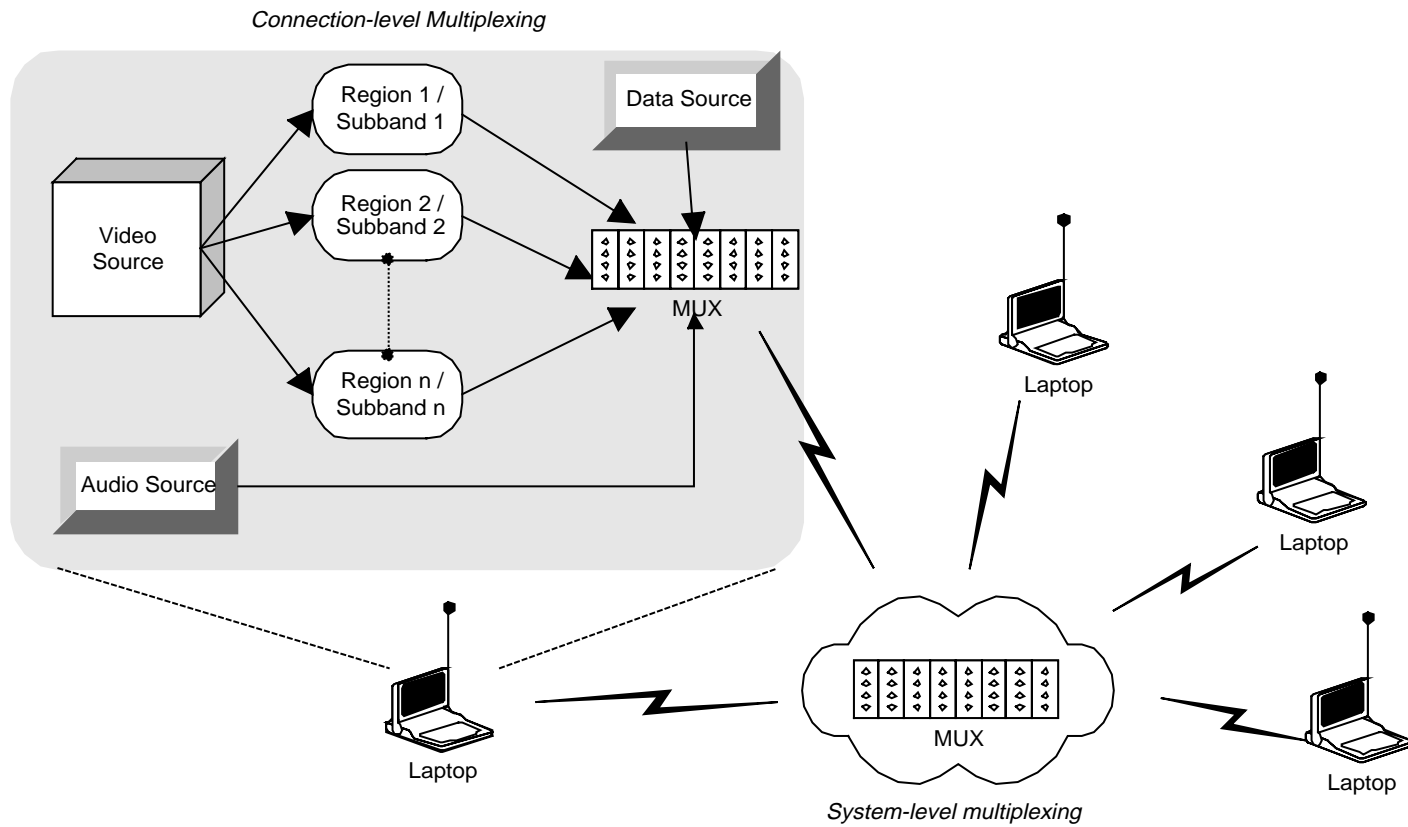


# Bandwidth Reservation

Reserve peak demand of the primary subband or main region

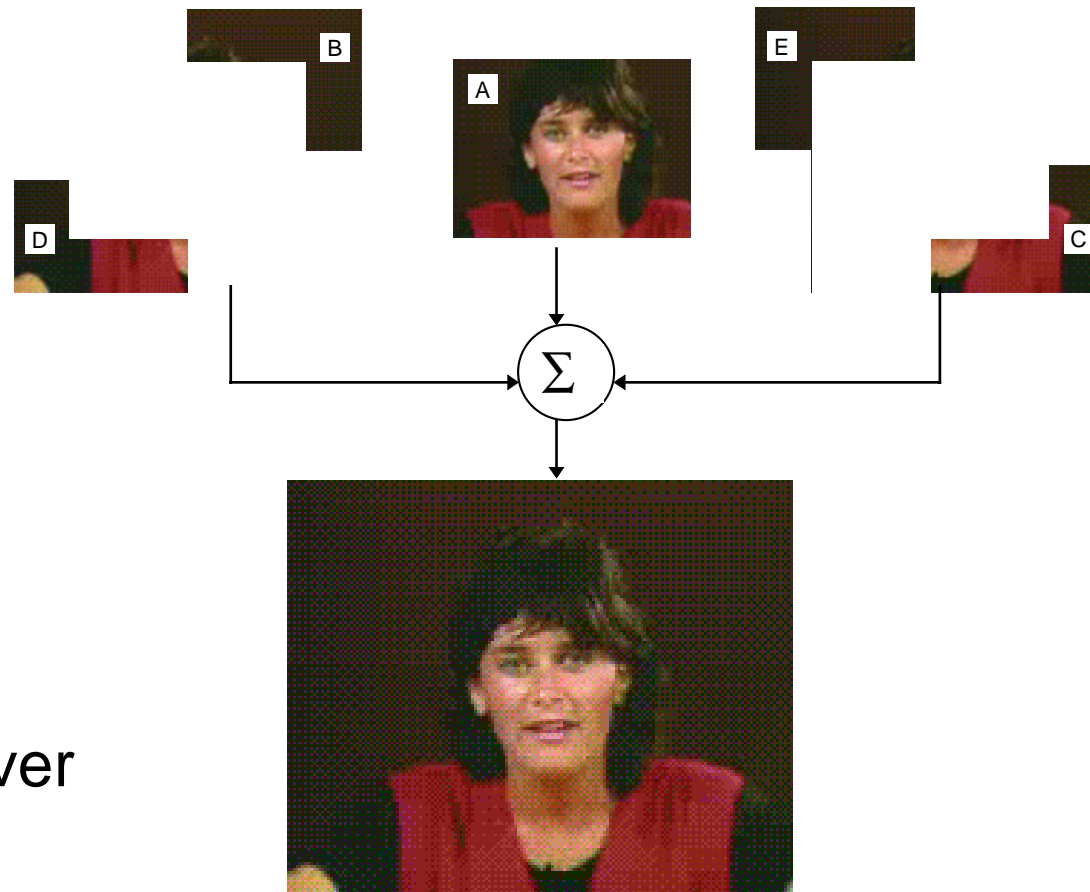


# Statistical Multiplexing: Connection Level .vs. System Level



# Lego Reconstruction

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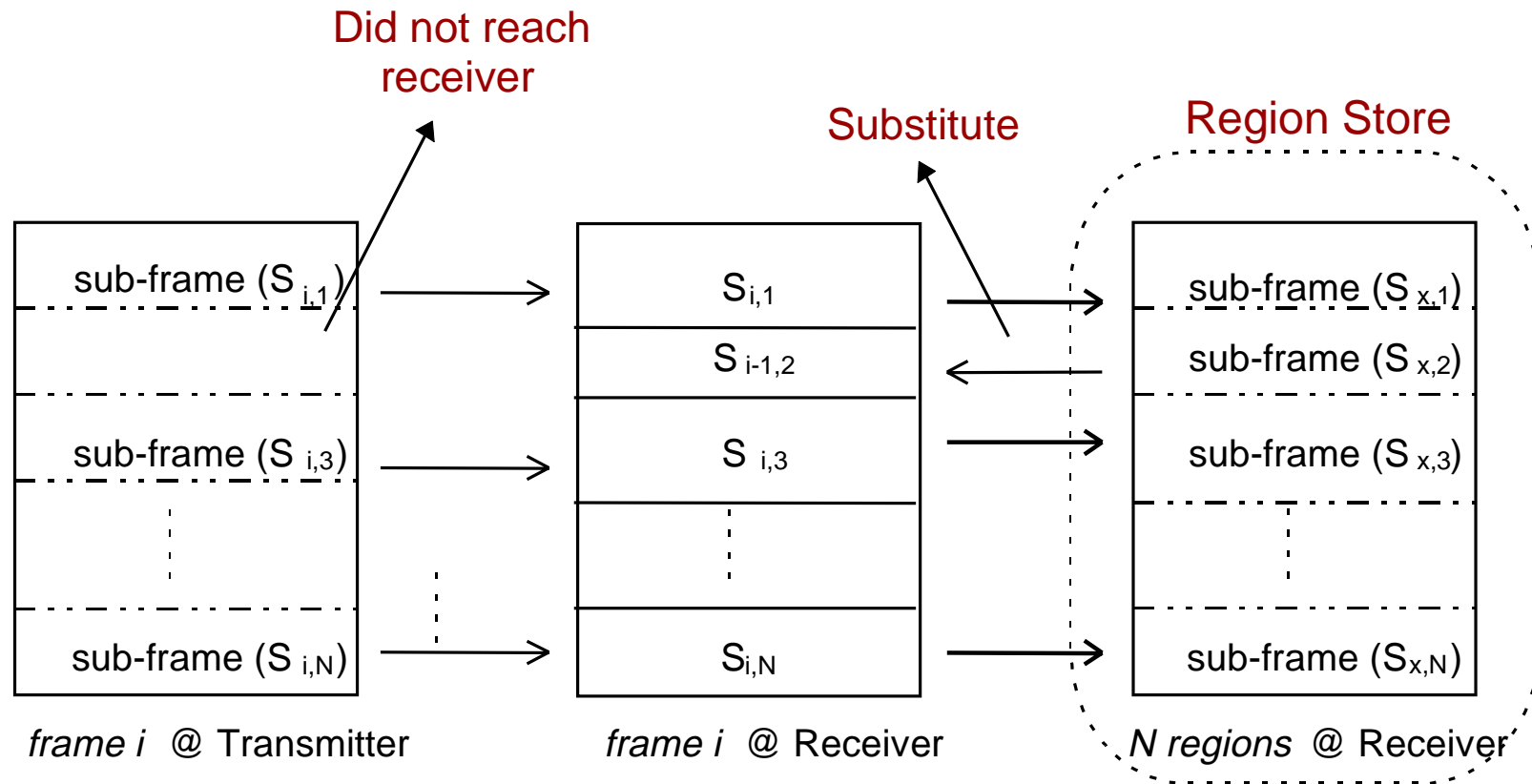


Receiver

January 1997

Victor Bahl

# Lego Reconstruction (Error Concealment)

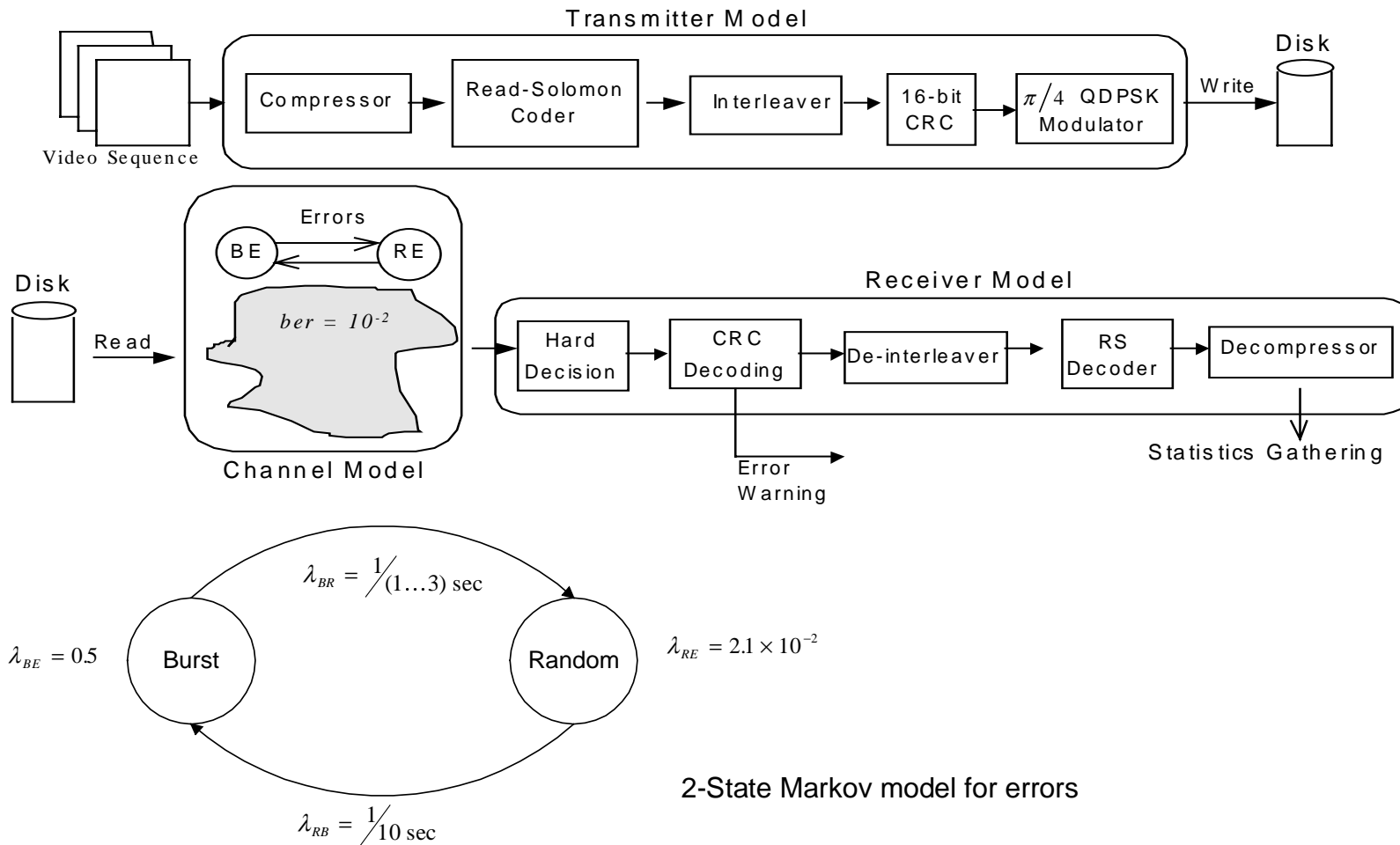


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# Simulation Methodology



## Properties -- Robustness Against Noise

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Reconstruction with corrupted  
AC Subbands - 25.34 dB



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

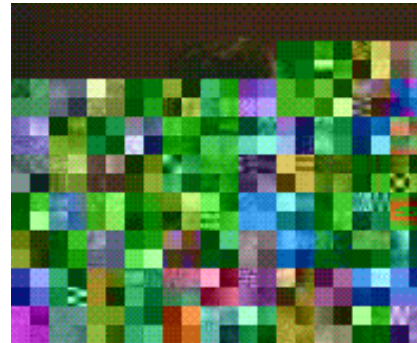


## Properties -- Restricted Error Propagation

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Original (16 Kbit/sec)



Without Segmentation



With Segmentation



Original (16 Kbit/sec)

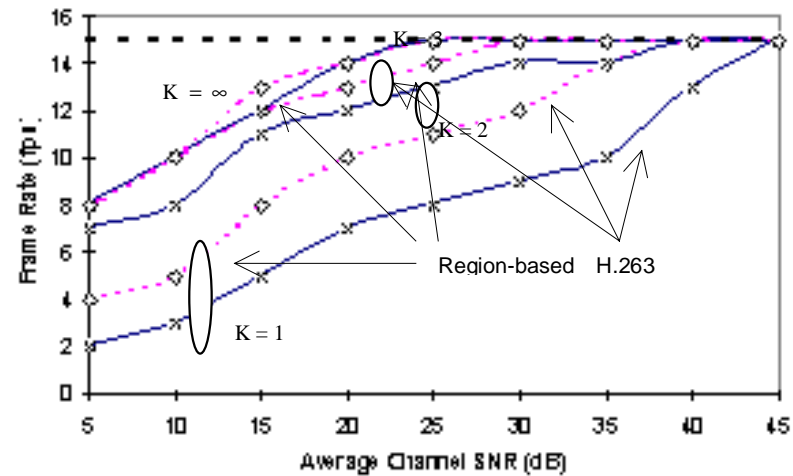
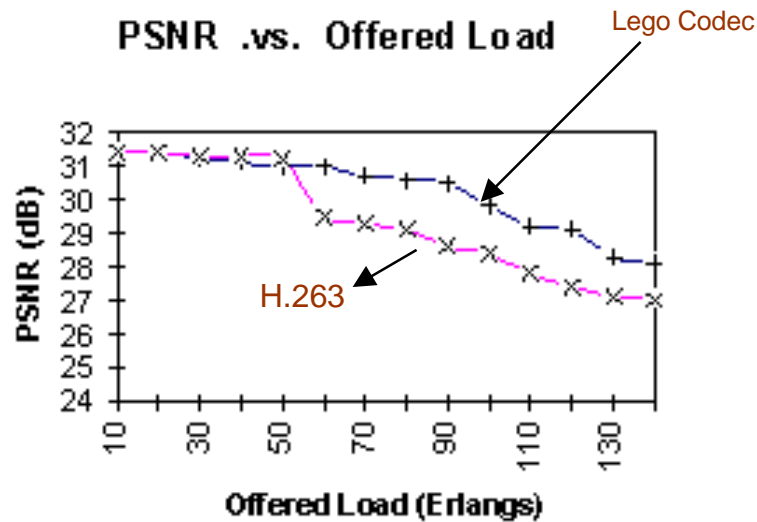


Without Segmentation

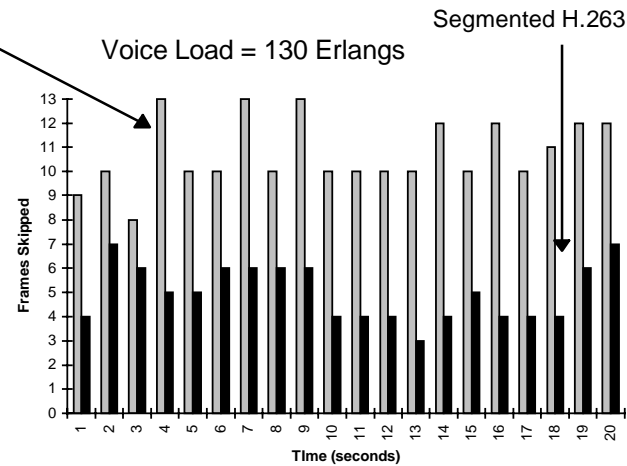
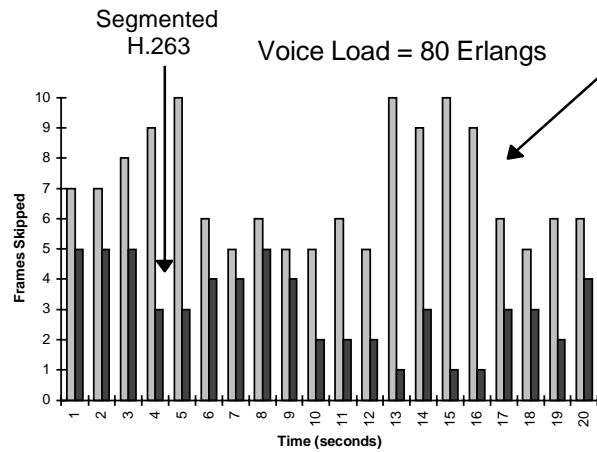


With Segmentation

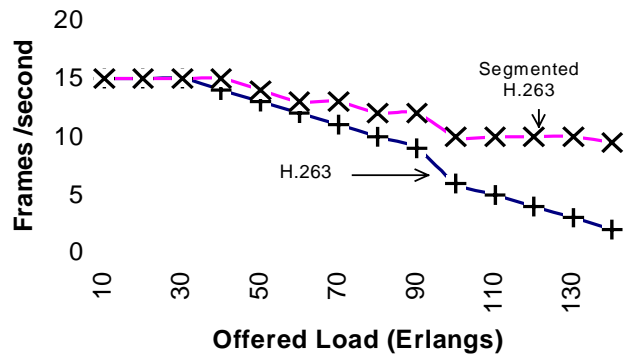
# Results -- Improved Temporal Resolution - Changing Error Patterns



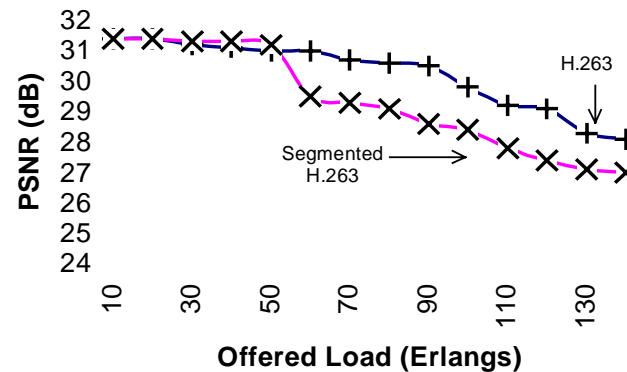
# Results -- Improved Temporal Resolution - Changing Bandwidth



**Frame Rate .vs. Offered Load**



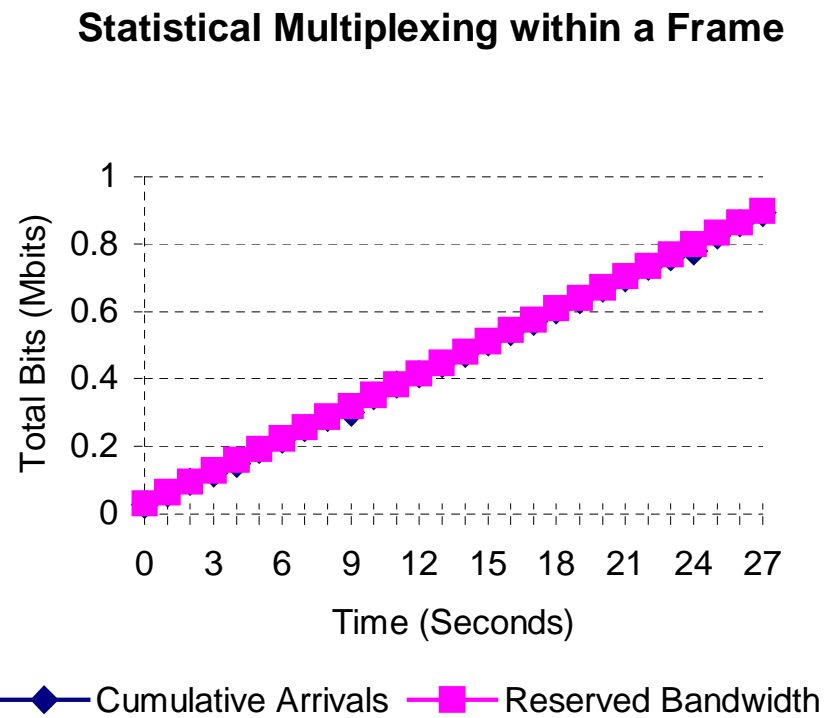
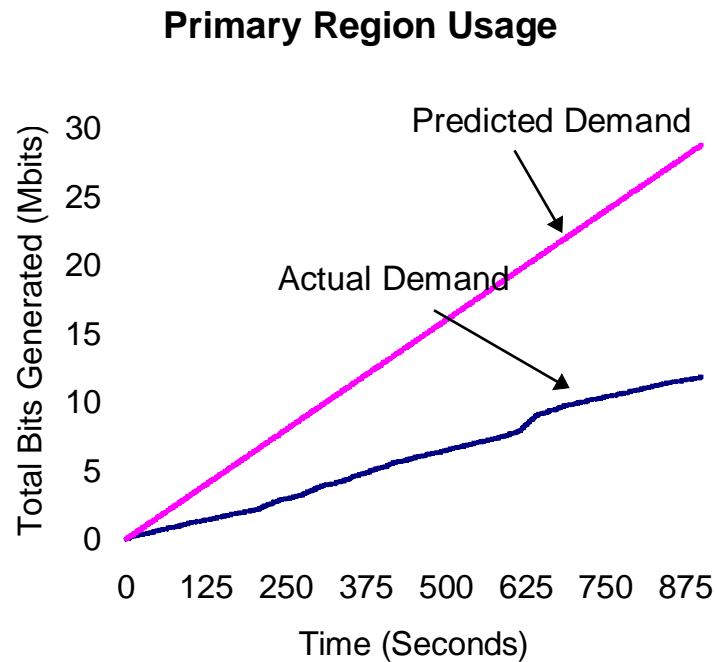
**PSNR .vs. Offered Load**



**Changing Load (Bandwidth)**

# Results - Improved Bandwidth Utilization

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*Bandwidth usage with and without intra-frame statistical multiplexing*

## Presentation Outline

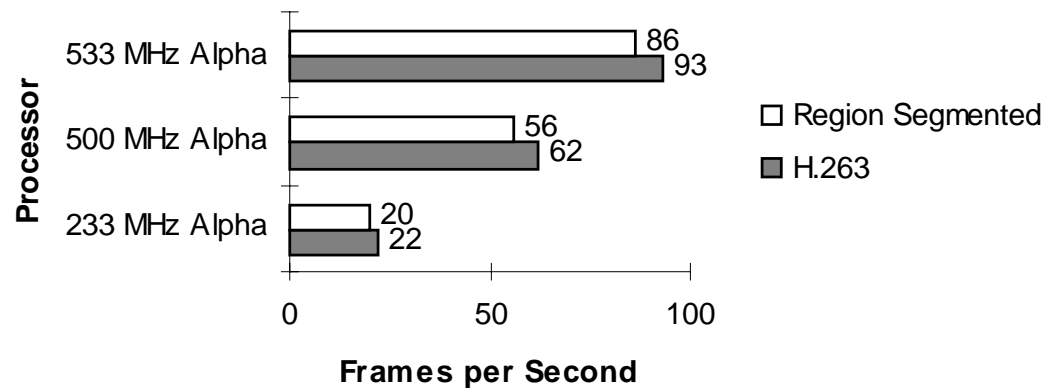
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# Software Performance

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

Encoding Rate Comparison



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## Conclusions

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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