

# N+1 redundant GOP based FEC algorithm for Error Resilient real-time video communication

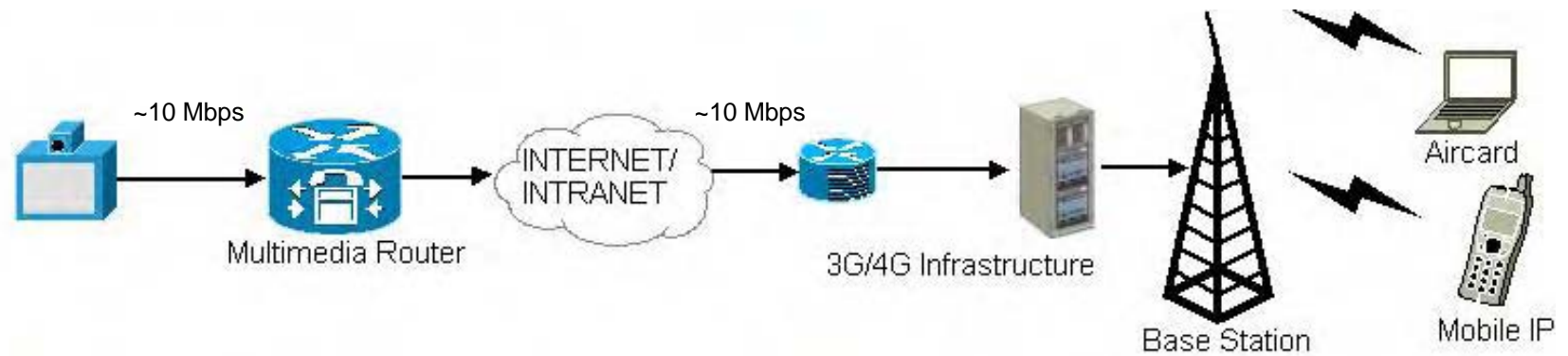
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# Synopsis

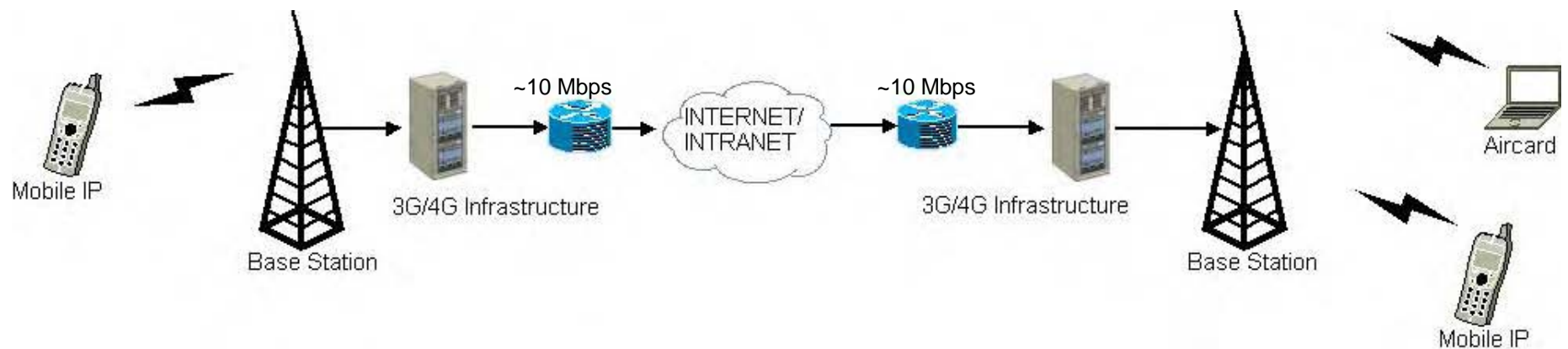
- The advent of Broadband 3G/4G Cellular Technologies bring the boon of Multimedia over Wireless.
- Inherent nature of the transmission medium makes the problems of Packet Loss and Delay variance (jitter) are more severe in Wireless/Cellular networks.
- This methodology is utilized to study a redundancy based Video coder, which can be more resilient to Error propagation. Results are shown indicating better performance than previous implementation.

# Typical 3G/4G Network Applications



CDMA 2000 1X: 144 kbps  
 EVDO Rev A: 500-700kbps  
 WiMAX: >3.1Mbps

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# A Packet Loss Model

courtesy: [Feamster, Balakrishnan](#)

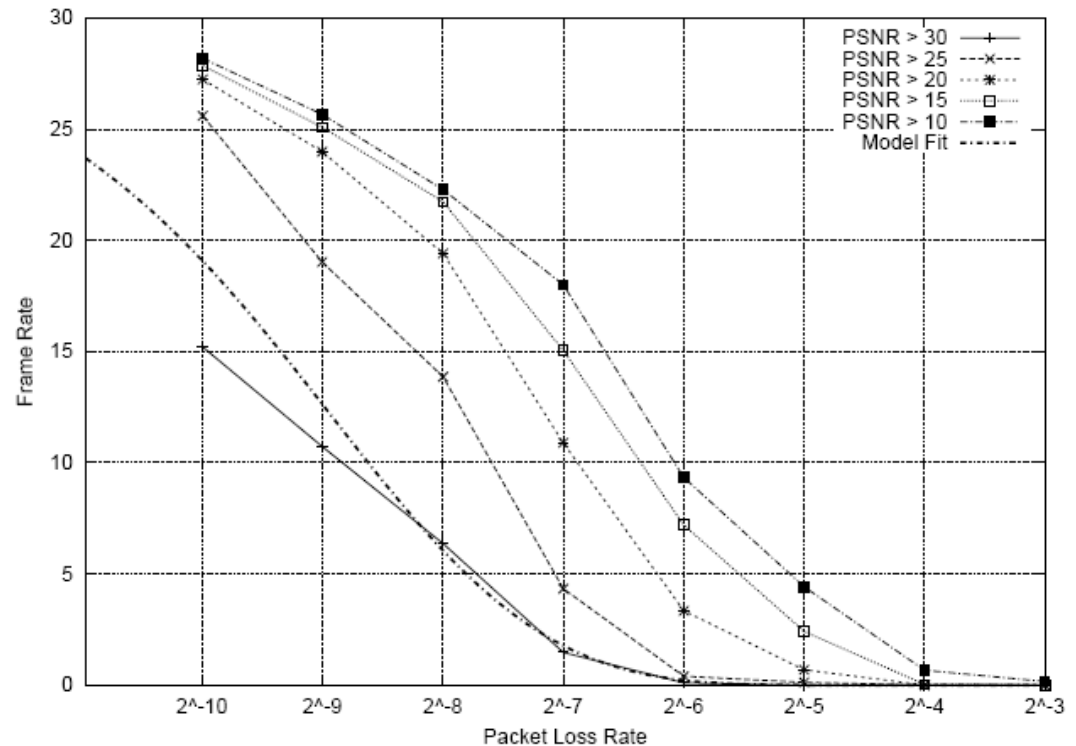
$$PL_T = p = 1 - \frac{n_{T_{recv}}}{n_{T_{sent}}}$$

where T: Particular Type of data in packet (header, I, P, B, S).

$n_{T_{sent}}$  : number of type  $T$  packets sent

$n_{T_{recv}}$  : number of type  $T$  packets received

This plot shows the relationship between Packet Loss Rate and Frame Rate (or Perceived Video Quality) for Videos of different original PSNR.



## Packet Loss Model contd.

Effects of Packet Loss on observed frame rate at the receiver.

- Using selective reliability of specific frames can improve the over all received Video quality
- The graph shows that as the packet loss rate  $p$  increases, the frame rate/quality degrades roughly as [9]:

$$f(p) = \alpha(1 - p)^c$$

Let  $P(\overline{F}|f_i)$  be the conditional probability that a frame was successfully decoded at the receiver. Defining it as a Bernoulli random variable:

$$P(\overline{F}|I) = 1 - (1 - p)^{S_I}$$

Successful decoding of a P frame depends on all I and P frames that precede it in the GOP:

$$P(\overline{F}|P) = \frac{1}{N_P} \sum_{k=1}^{N_P} \left( 1 - (1 - p)^{S_I + kS_P} \right)$$

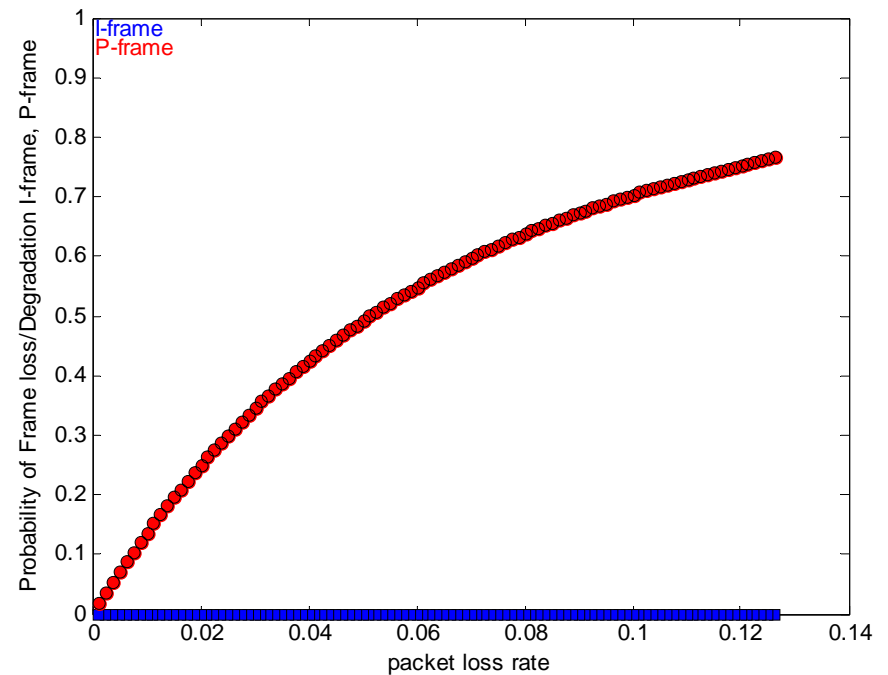
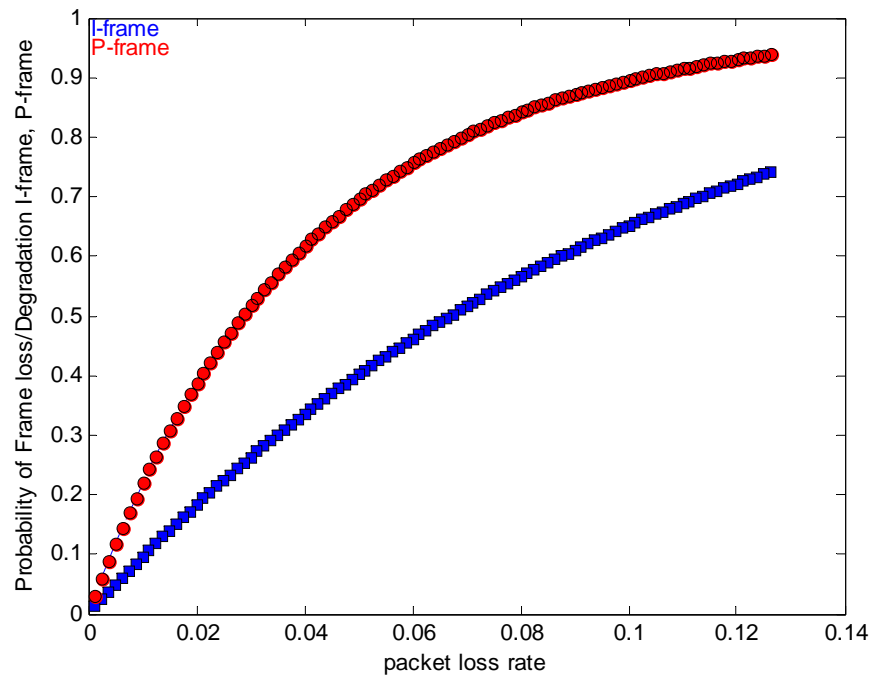
Where  $p$  = packet loss rate

$S_I$  and  $S_P$  is the average Number of packets in an I and P frame respectively

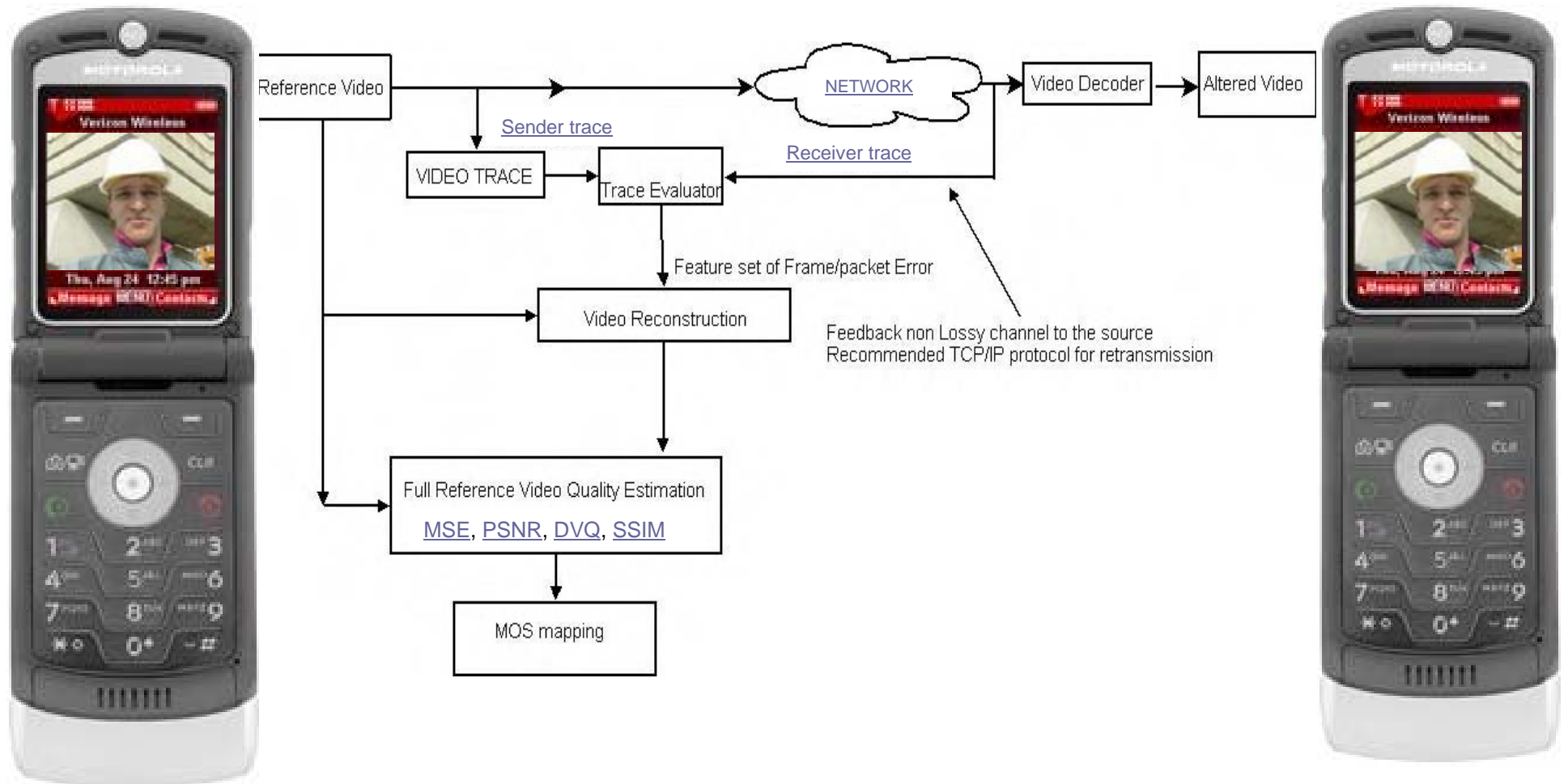
$N_P$  = Number of P frames in a GOP

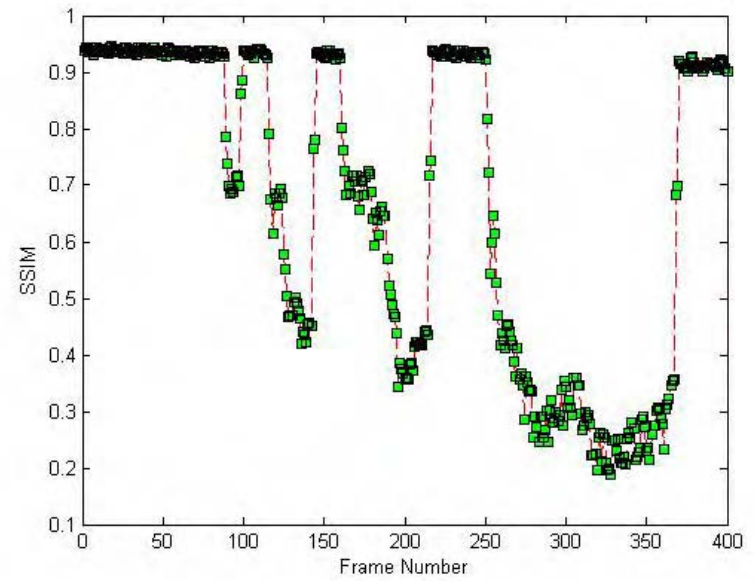
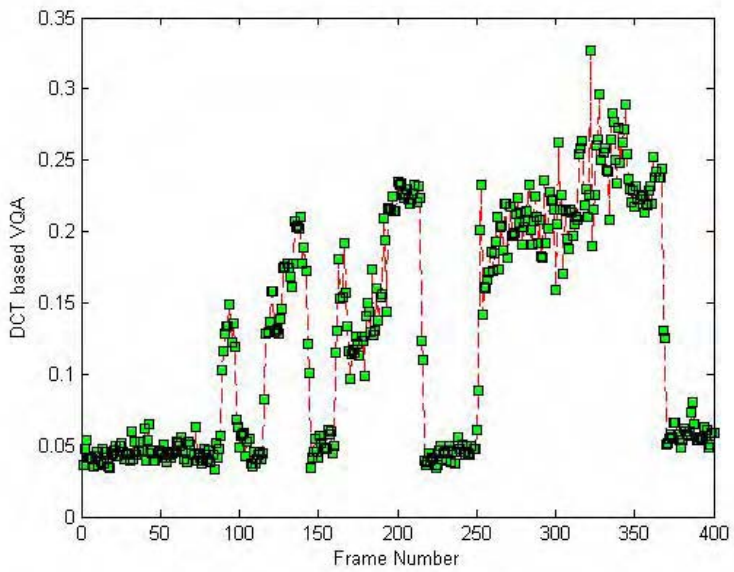
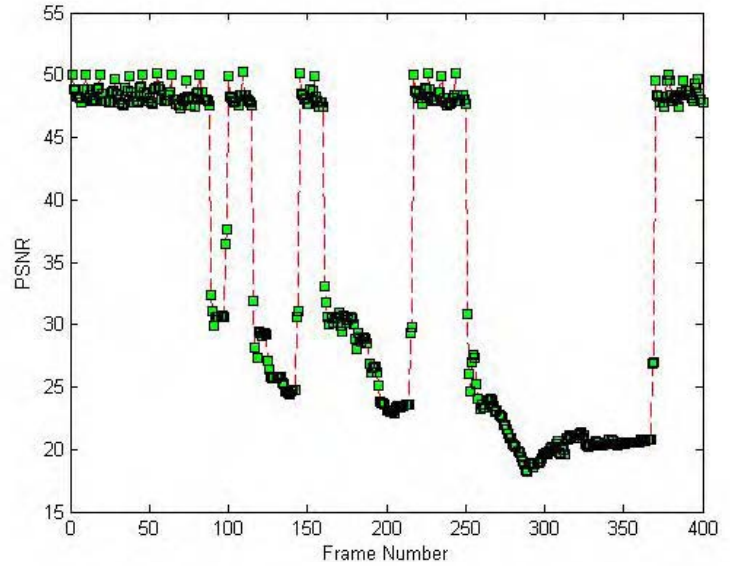
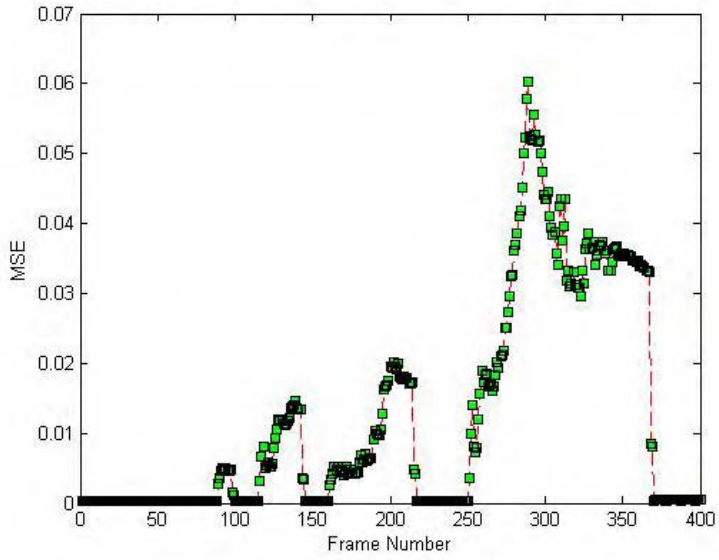
# Probability of frame loss of I-frames and P-frames

- Following plots show the dependence of the Probability of frame loss of typical Predicted frames.
- I-frames have been proven by the model to result in the highest number of dependencies and Probability of error propagation.
- If the probability of degradation/loss of I-frames is decreased, it decreases the probability of degradation/loss of P-frames.

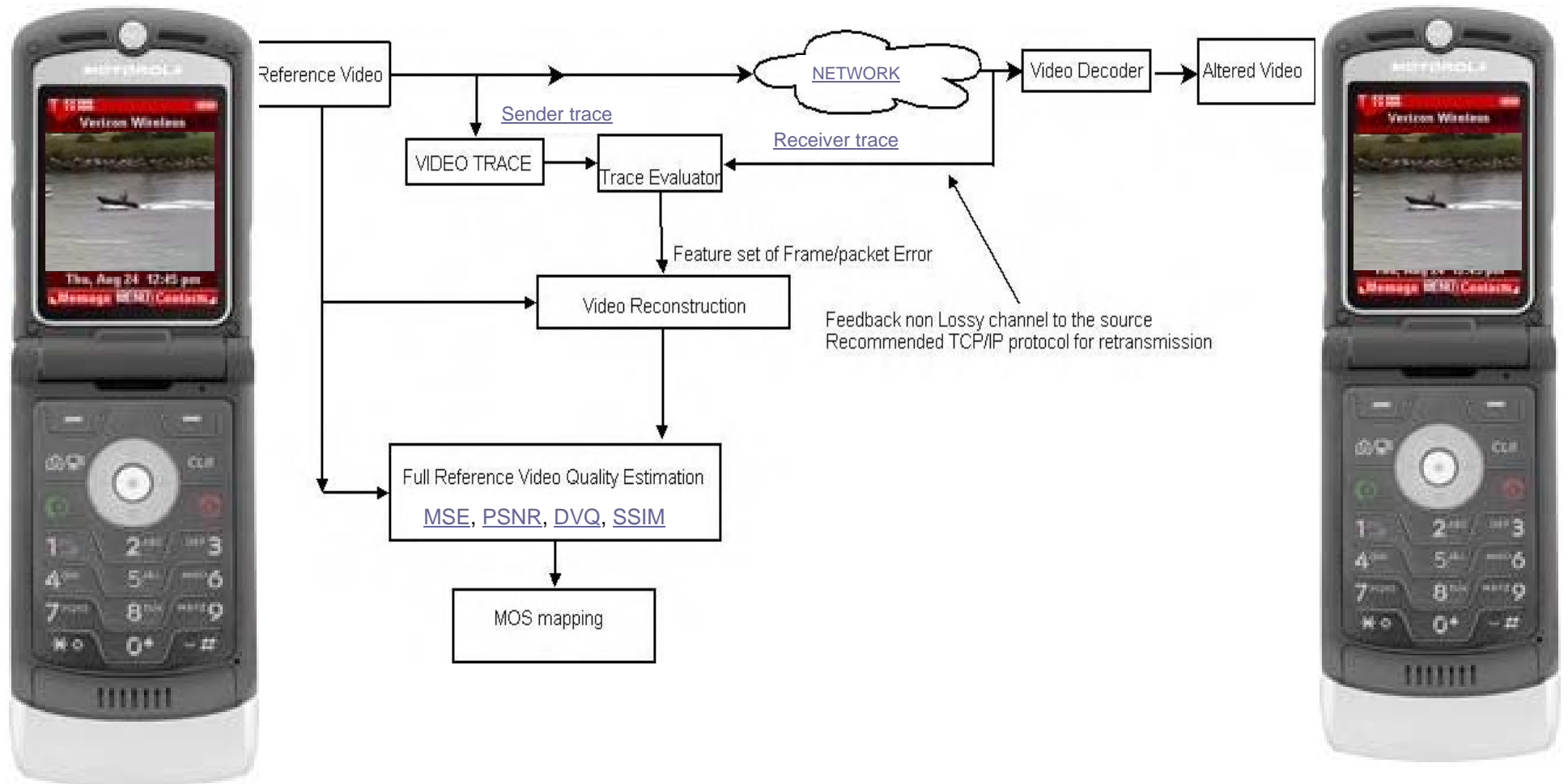


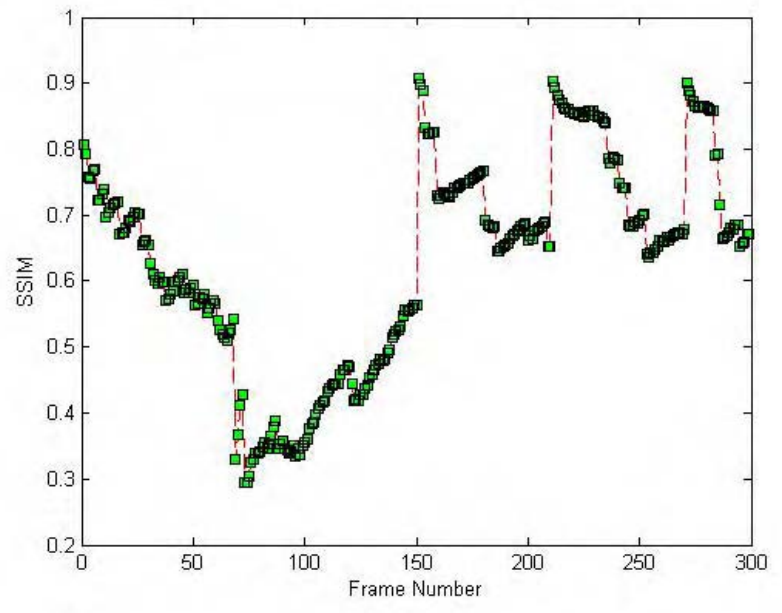
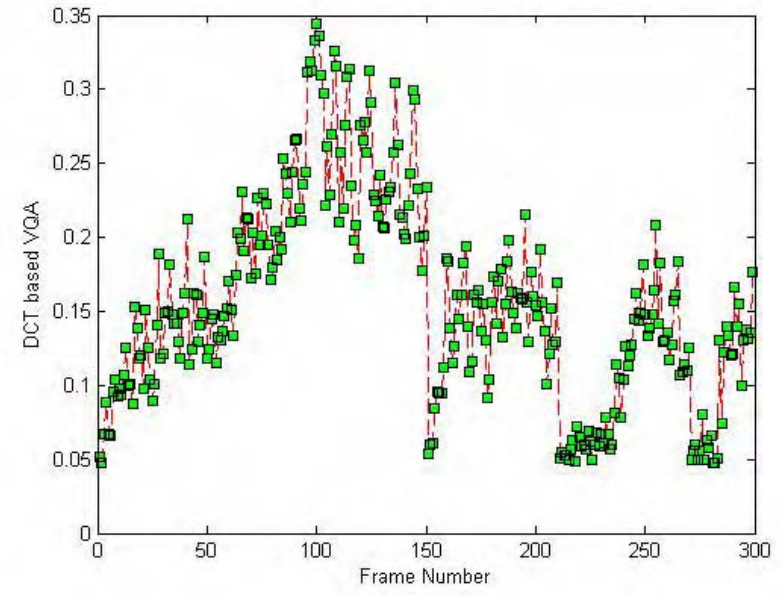
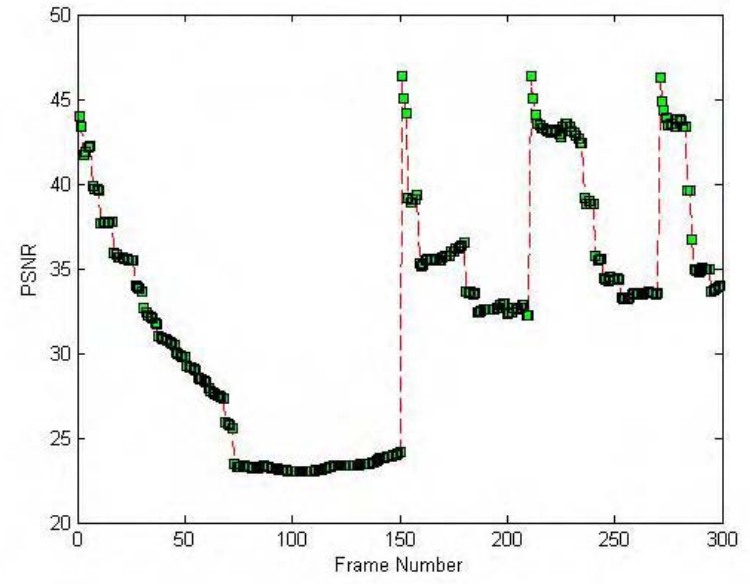
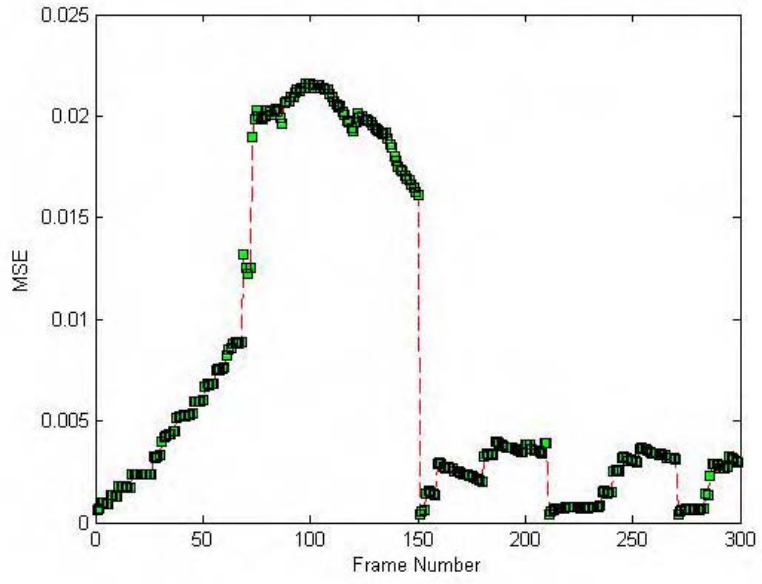
# Mobile to Mobile QCIF Clips



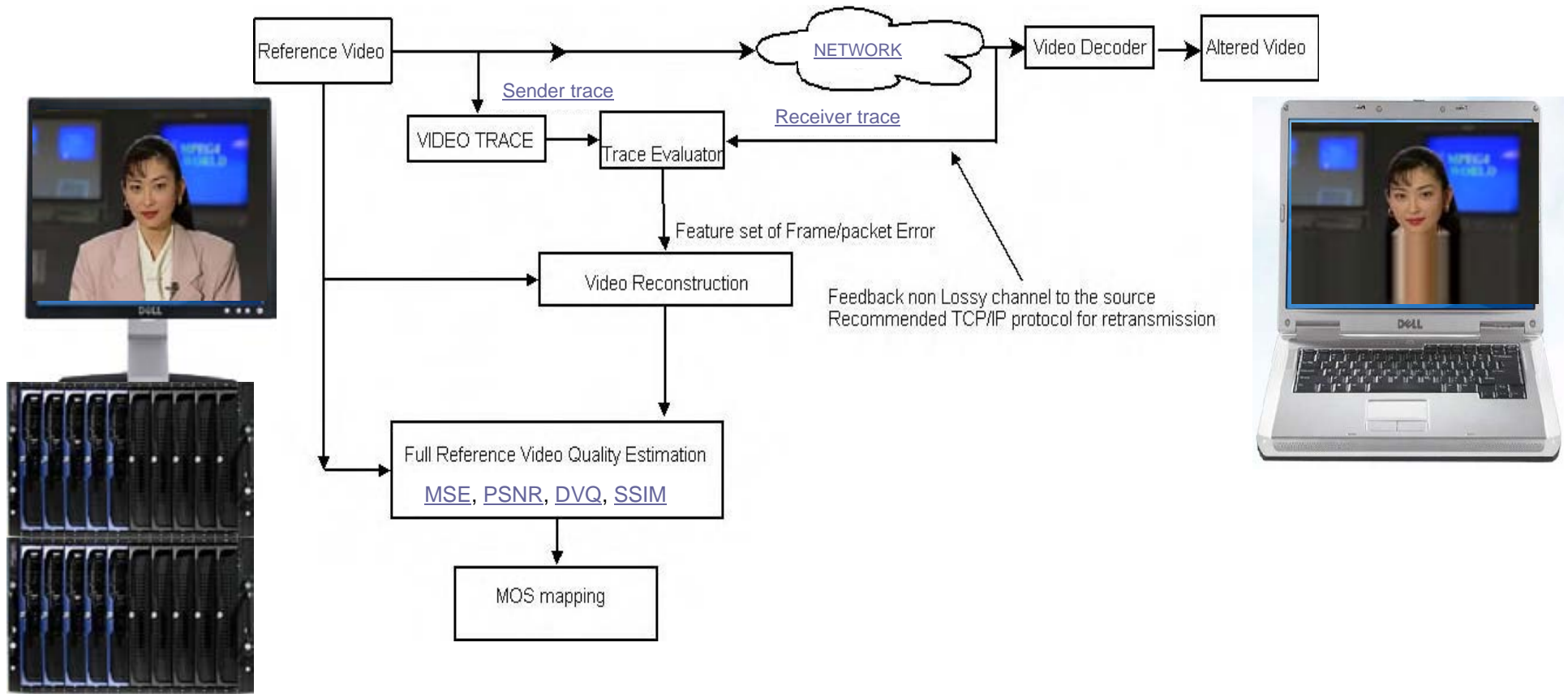


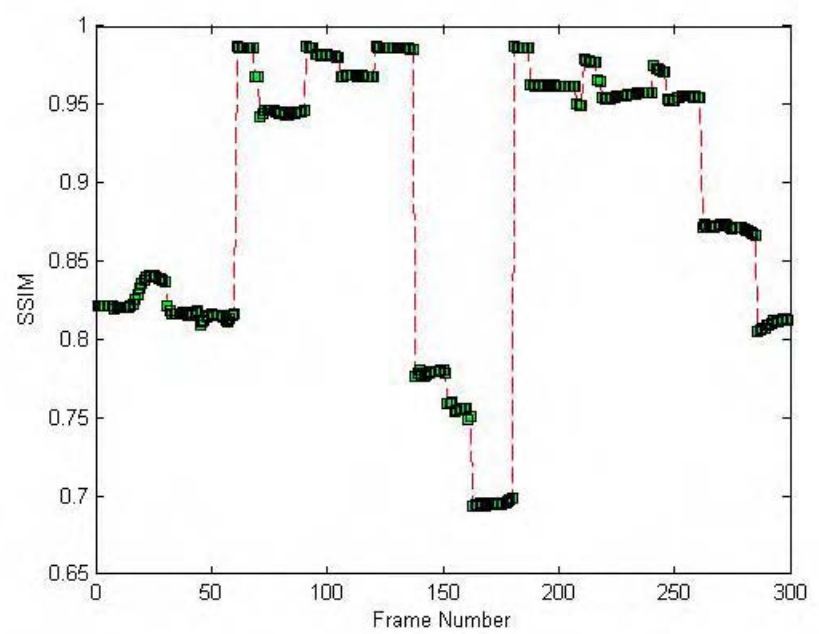
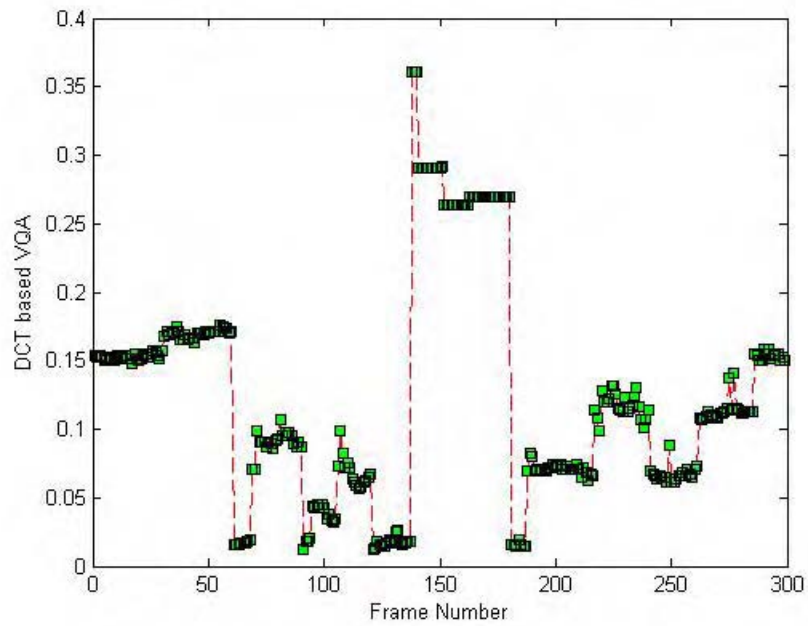
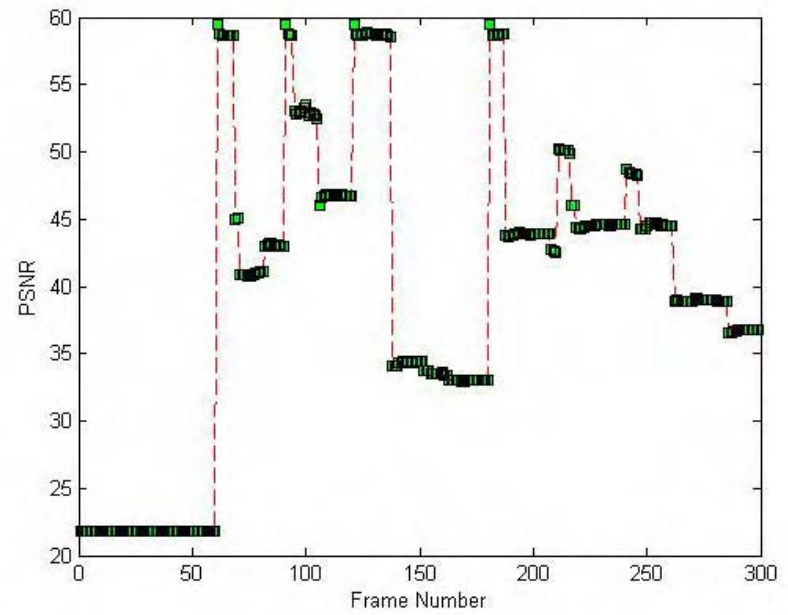
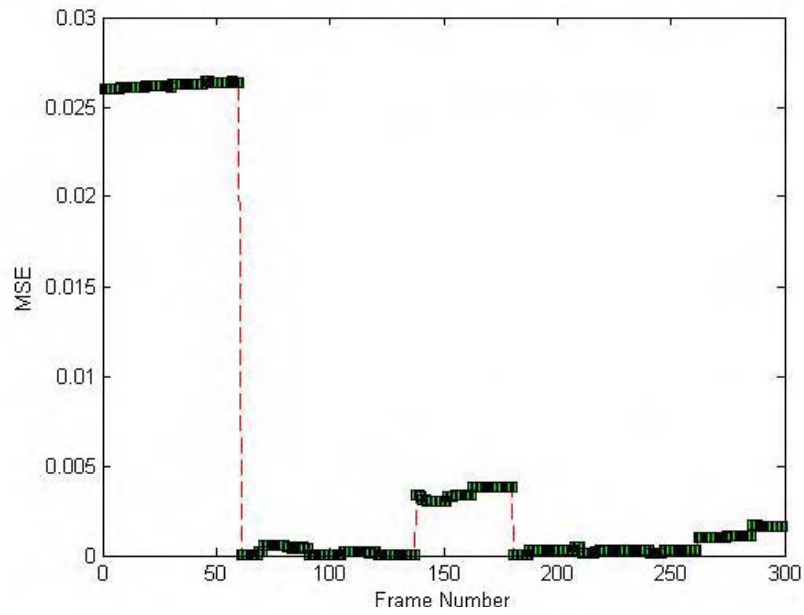
# Mobile to Mobile QCIF Clips





# PDSN to Mobile Aircard CIF Clips







# Need for Error Resilience for Video Communication

- Current prevalent Network architecture uses UDP over TCP/IP.
- A single bit-error results in packet checksum error.
- A packet of 1024-1500 bytes MTU is dropped (causing packet loss) or requested for retransmission (causing packet delay).
- Current prevalent MPEG-2/MPEG-4 decoders are designed to drop a frame if a packet loss occurred in it.
- The decoder copies the last frame into the current frame location, on the assumption that temporal information is preserved within consecutive frames.
- Tests reveal that the slight variation between consecutive frames gets not only propagated, but amplified in future P or B-frames.
- The I-frame has the highest dependency. Corruption of an I-frame will result in error propagation through all the frames in the GOP.
- Wireless networks using the 3gpp2 protocol use a GOP size  $> 30$ . The corruption of an I-frame would result in a degraded video sequence of  $> 1$  sec.



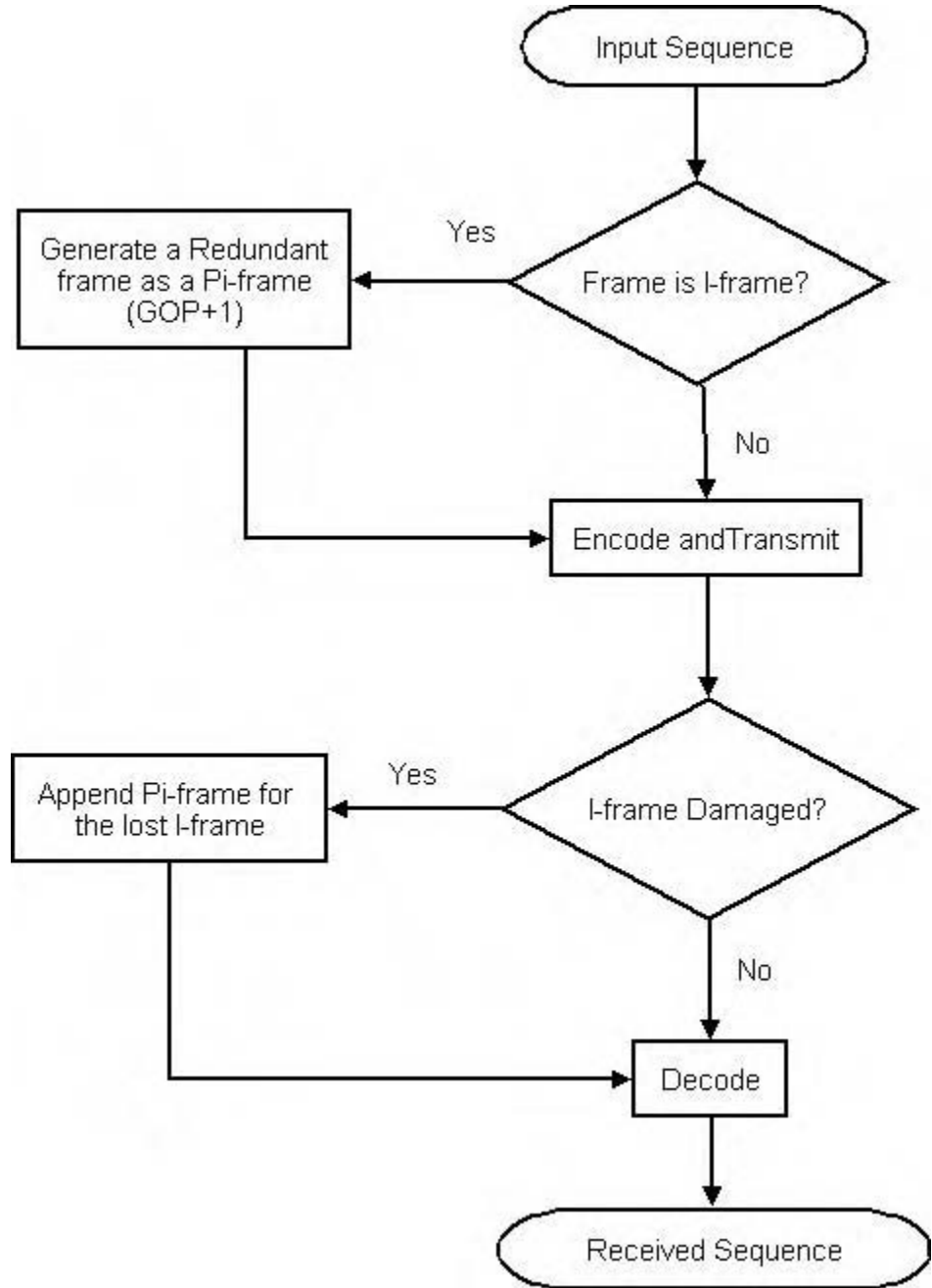
## A Redundancy based decoder

- Liu and Claypool [[10](#)] propose a piggy-backing redundant video frames within the transmitted video stream in order to repair lost frames.
- At the sender, frames are compressed into two versions, one with high quality and the other with a low quality hence a smaller frame size. (Q1 and Q25) The ratio of frame sizes is 19k:3k bytes.
- In case the primary frame is lost, the corresponding redundant low quality frame is used to replace it.
- A different approach is introduced to provide redundancy of I-frames only, because I-frames have been proven by the model to result in the highest number of dependencies and Probability of error propagation. The size of the redundant frame is kept equal to the size of the low quality redundant frame in the previous approach.

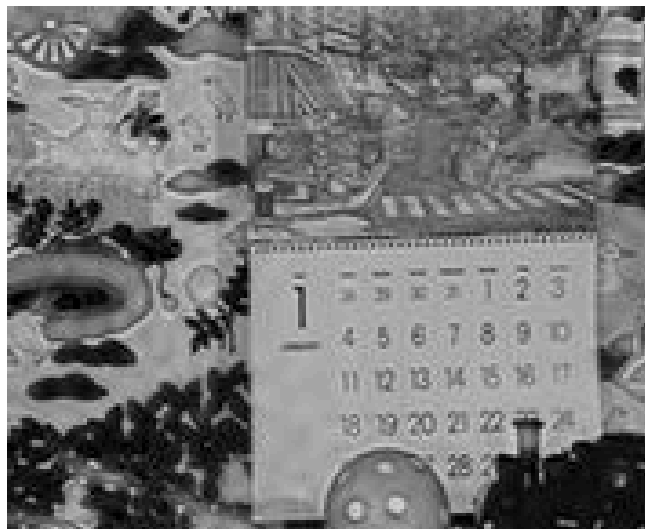
# The Proposed Flow Diagram

## Experimental implementation

- The GOP size is limited to 5 frames with only I and P frames:  
I P P P P
- The encoding and decoding is done according to MPEG-2 standard.
- Only Luminance (Gray scale) frames are used in the current implementation.
- An extra P-frame called a 'Pi-frame' is sent at the end of the actual GOP, which is a redundant Predicticted encoded next I-frame. Hence making it N+1 Redundant GOP.



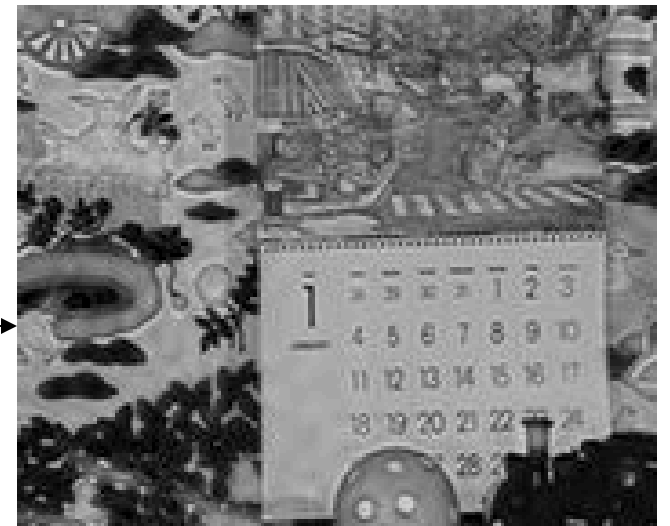
Original Sequence



Commercial Decoder



Proposed Decoder





Original Sequence



Commercial  
Decoder

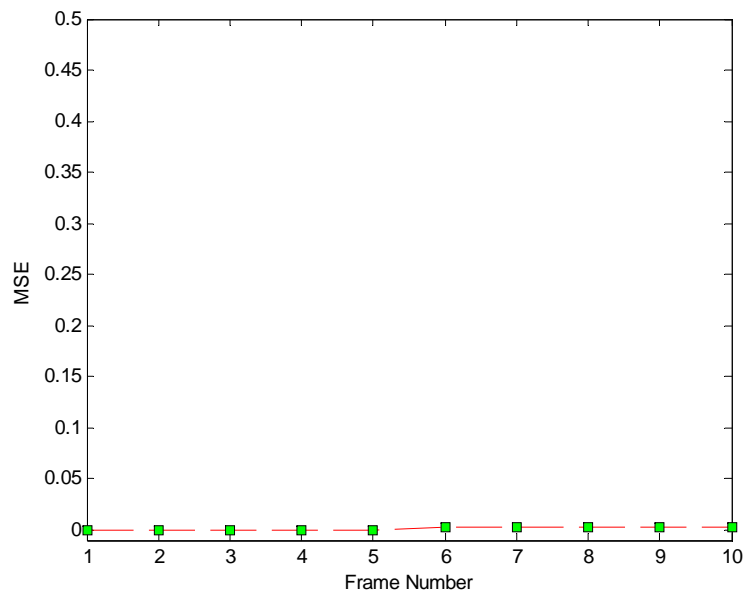


Proposed  
Decoder

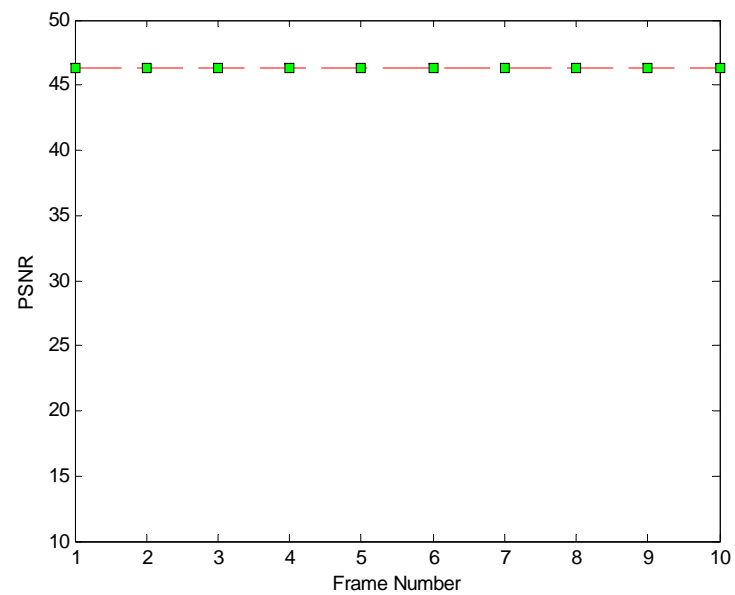
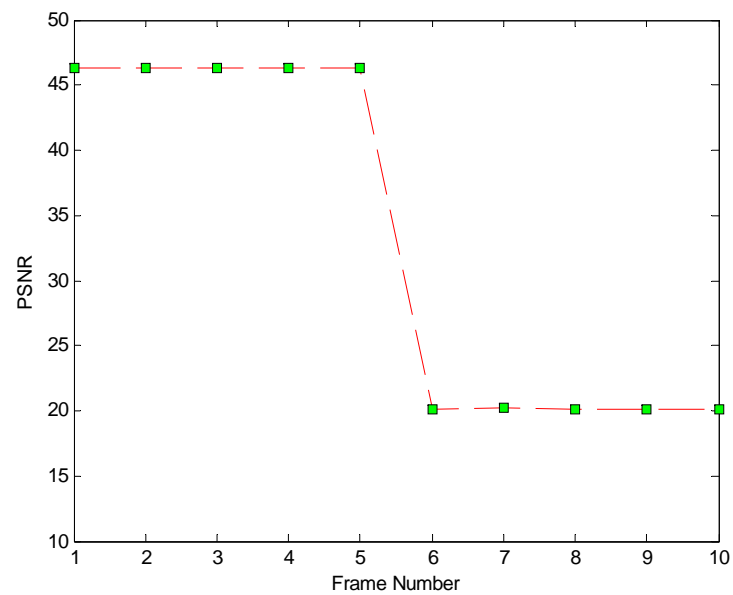
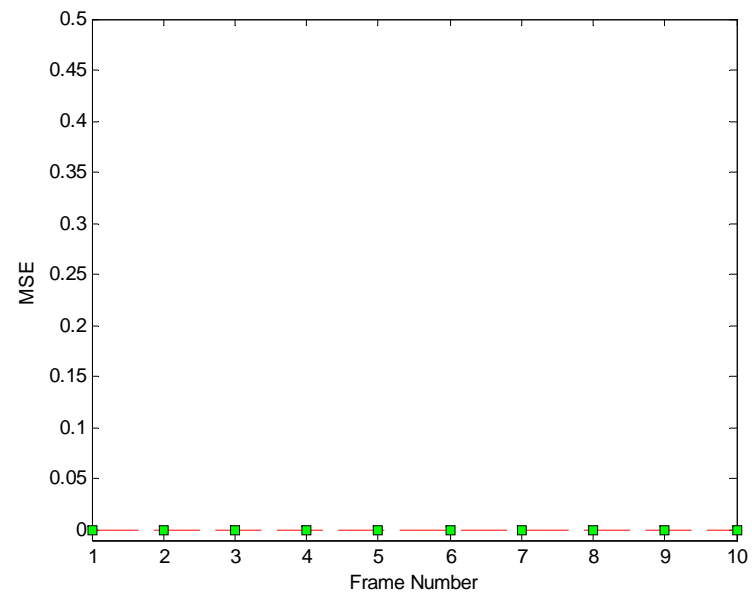


# VQA

## Original vs MPEG-2 Decoder

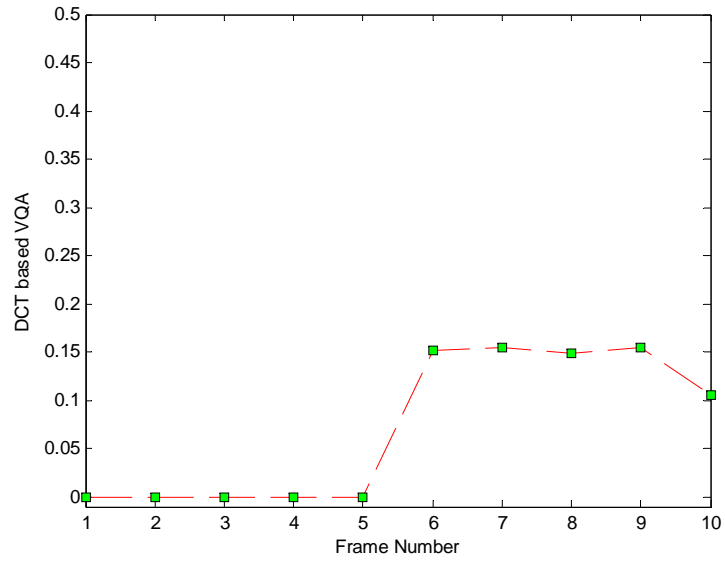


## Original vs Proposed Decoder

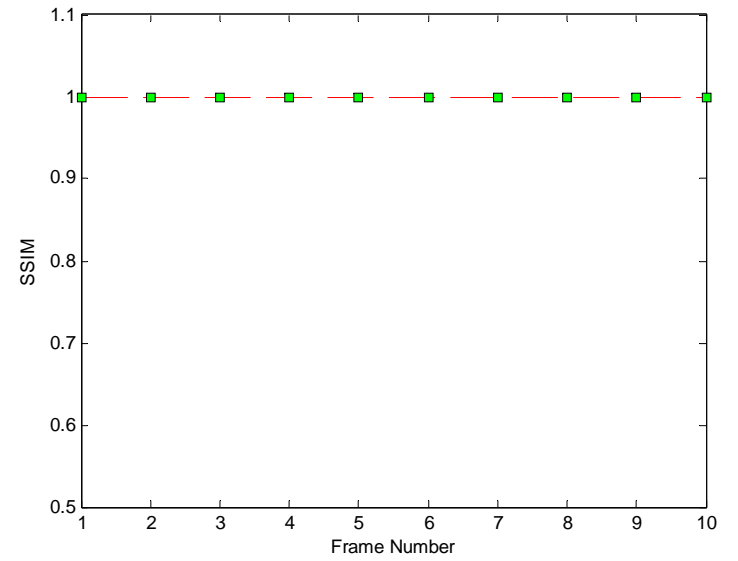
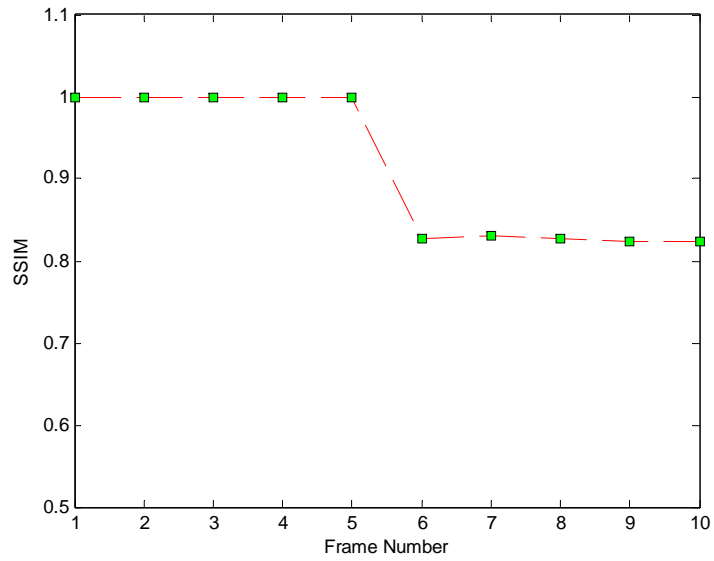
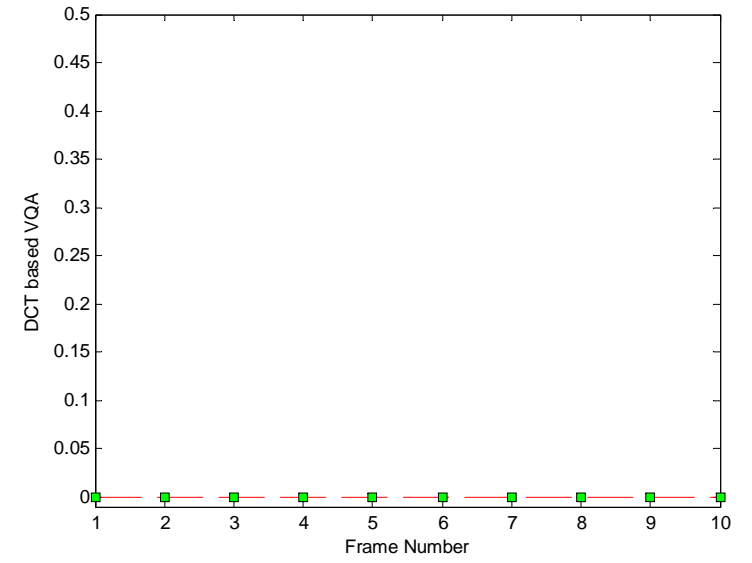


# VQA

## Original vs MPEG-2 Decoder



## Original vs Proposed Decoder



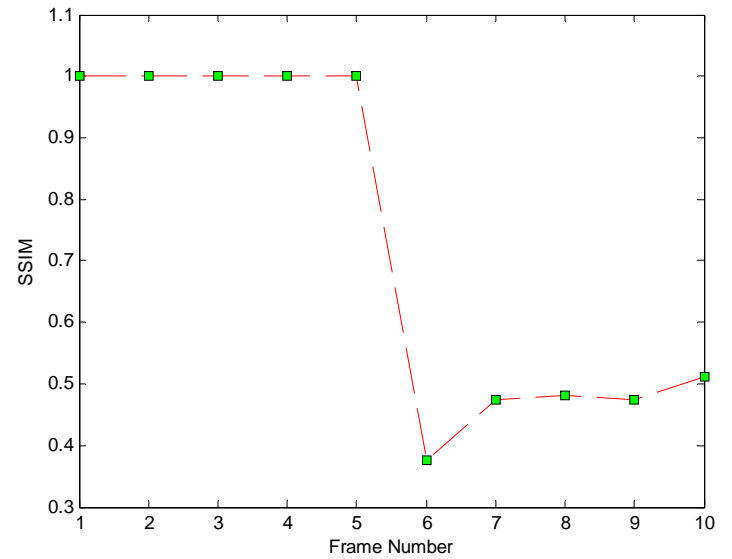
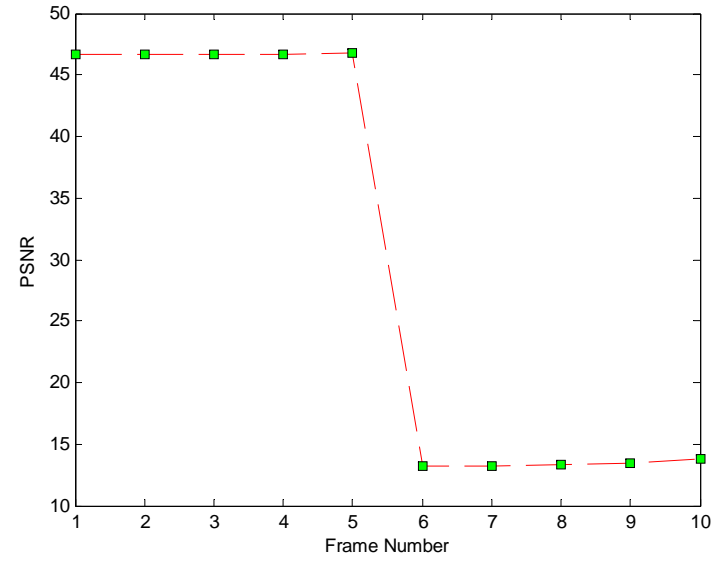
Original CIF Sequence



Commercial Decoder



Objective Video Quality



# Comparison of Proposed Scheme vs Previous method [[10](#)]

Proposed Scheme

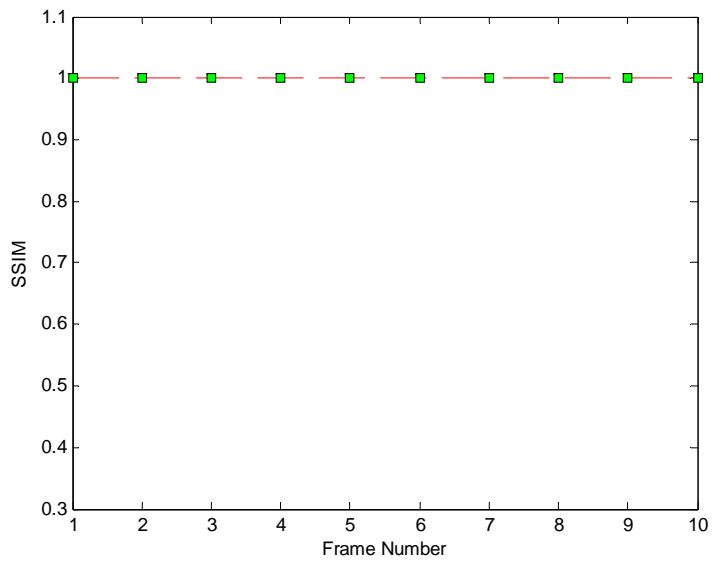
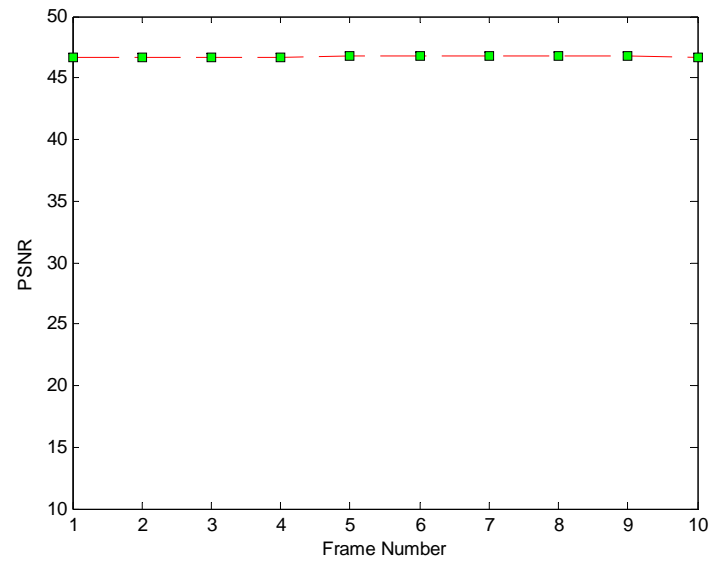


Proposed by [Liu et al.](#)

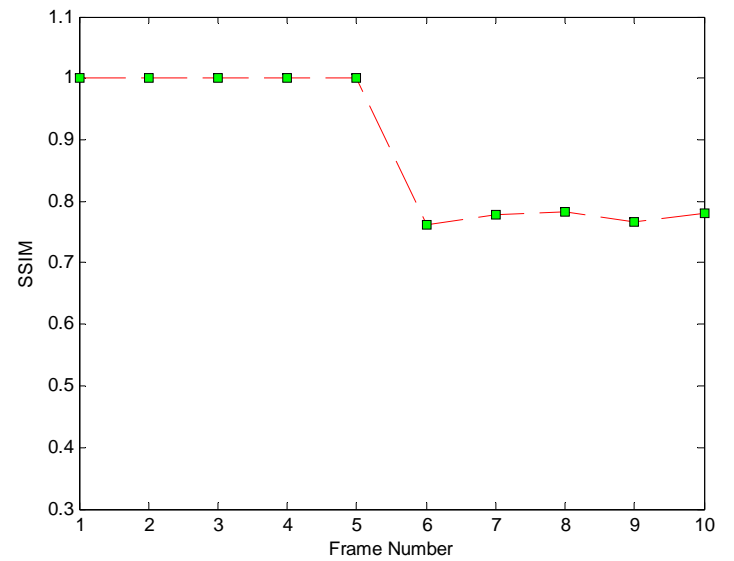
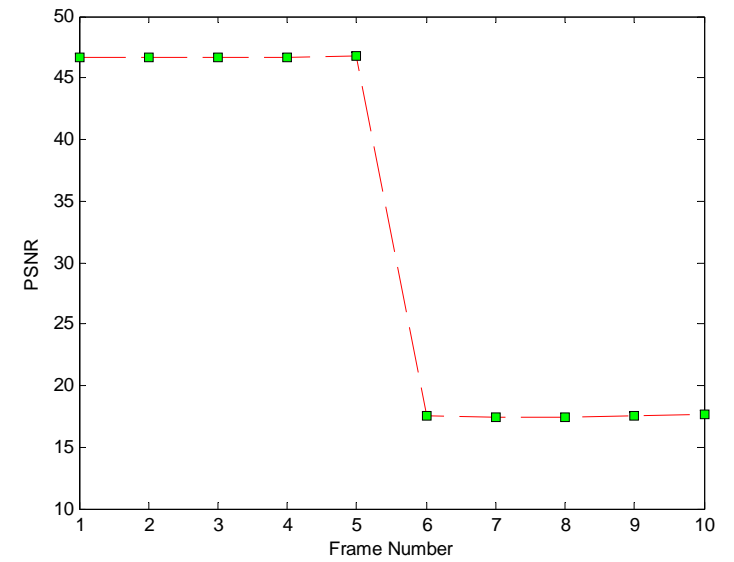


# Objective Video Quality

## Proposed Scheme



## Proposed by Liu et al.





# Conclusions

- A Packet Loss model is used to explain the advantages of I-frame resilience on video transmissions.
- A new Packet Loss Recovery mechanism is proposed, which adds a small overhead but increases the error-resilience of the real-time video transmission by providing redundancy to I-frames.
- Redundancy based methods show better Video Quality at the receiver in case of an I-frame loss, than non-redundancy based (commercial) methods.
- The proposed scheme provides better results in terms of video quality than a preceding method [\[10\]](#).
- MSE and PSNR did not prove to be good Objective VQA methods to differentiate between the different methods.



# Applications and Future Work

- Study the effects of applying this methodology to new protocols specifically designed for error prone networks, like UDP-lite, that avoid checksum checks on packet payloads.
- Future work can include adding error resilience to P and B-frames as well.
- Study the future of Error resilience schemes using the ‘UDP-lite’ protocol.
- A Matlab<sup>®</sup> based implementation of MPEG-2 standard encoder and decoder was done as part of this project . This implementation can be further enhanced to construct a toolbox to evaluate the newest standards like AVS/H.264.



# References

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