Impact of Video Content on Video Quality for Video over Wireless Networks

ADAMANTIUM

Information & Communication Technologies
COOPERATION

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Presentation Outline

- Background
  - Current status and motivations
  - Impact of video content on quality for wireless networks
  - Aims of the project
- Main Contributions
  - Classification of video content into three main categories.
  - Impact of packet loss on video contents in terms of PSNR and Q-value[1] and over the entire duration of the sequence
  - Identify the minimum Send Bitrate to meet QoS requirement in terms of PSNR.
- Conclusions and Future Work

Current Status and Motivations (1)

- Multimedia services are becoming commonplace across different transmission platforms such as 802.11 standards, UMTS, Wi-Max, etc.
- Current trends in the development and convergence of wireless internet applications and mobile systems are seen as the next step in mobile/wireless broadband evolution
- User’s demand of the quality of streaming multimedia is very much content dependent
- The future internet architecture will need to support various applications with different QoS requirements

Current Status and Motivations (2)

- Little work is done on the impact of different content types on end-to-end quality.
- Both the application (e.g. Send bitrate, etc) and network level (e.g. Packet loss, etc) parameters impact on quality.
- Over-provisioning as initial video quality requirements not well understood.

Hence the motivation of our work – to find the impact of both application and network level QoS parameters on video quality.

Video Quality for Wireless Networks (1)

Impact of Video Content on Quality

- Streaming video quality is dependent on the intrinsic attribute of the content
- Fast moving content has greater QoS requirements than slower moving contents

QoS Factors that affect video quality

- QoS of multimedia is affected by both the Application level and network level parameters
- Looked at the impact of Send Bitrate (SBR) in the application and Packet Error Rate (PER) in the network level

Video Quality for Wireless Networks (2)

Video Quality Measurement

- ❑ Subjective method (Mean Opinion Score – MOS [2])
- ❑ Objective methods
  - ➢ Intrusive methods (e.g. PSNR, Q value[1])
  - ➢ Non-intrusive methods (e.g. ANN-based models)

Video quality metrics used

PSNR - measures the difference between the reconstructed video file and the original video trace file.

$$PSNR(s,d) = 20\log\frac{MAX}{\sqrt{MSE(s,d)}}$$

Where MAX is the maximum pixel value of the image, which is 255 for 8 bit samples. Mean Square Error (MSE) is the cumulative square between compressed and the original image.

Q [1] value - Decodable frame rate (Q) is defined as the number of decodable frames over the total number of frames sent by a video source

Aims of the project

<u>Evaluate video quality in terms of PSNR and Q[1] *for …*</u>

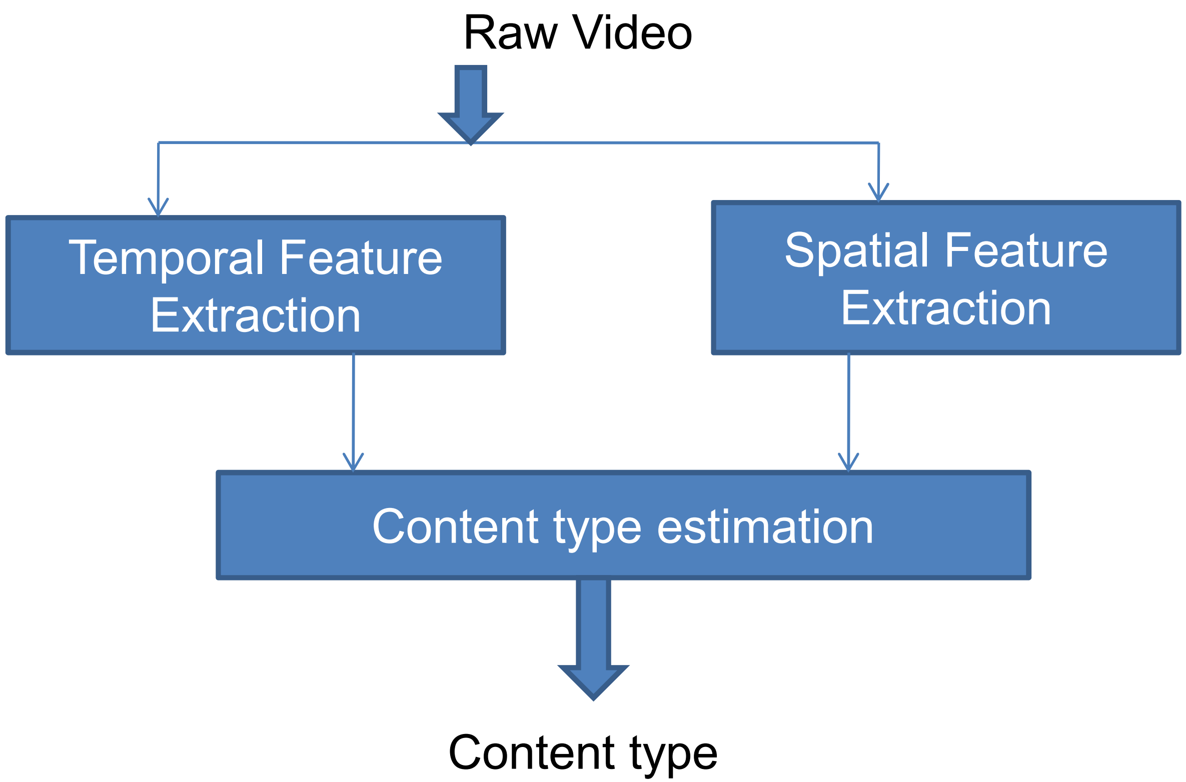
Q1. What is the acceptable packet error rate for all content types for streaming MPEG4 video and hence, find the threshold in terms of upper, medium and lower quality boundary at which the users' perception of quality is acceptable?

Q2. What is the minimum send bitrate for all content types to meet communication quality for acceptable QoS (PSNR >27 dB) as it translates to a MOS of greater than 3.5?

To address these two questions –

<u>First classified the video contents objectively.</u>

Classification of video contents (1)



Classification of video contents (2)

Temporal Feature Extraction

The movement in a video clip given by the SAD value (Sum of Absolute Difference). The SAD values are computed as the pixel wise sum of the absolute differences between the two frames being compared and is given by:

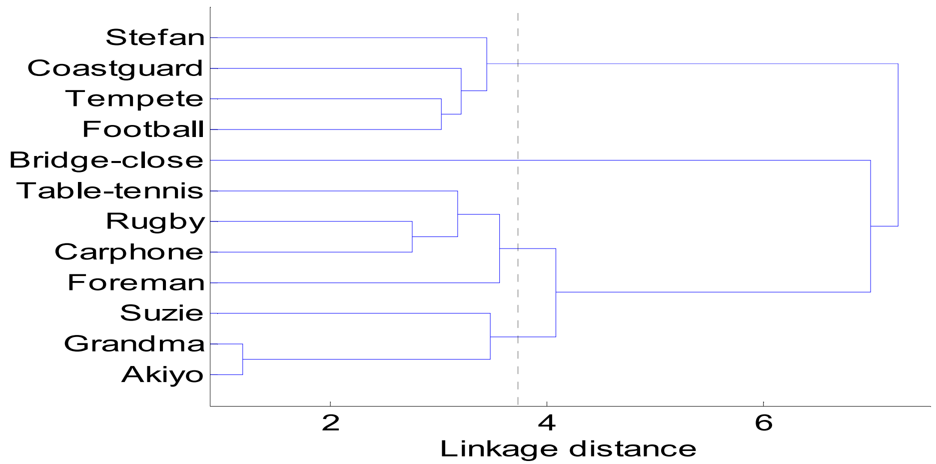
$$SAD_{n,m} = \sum_{i=1}^{N} \sum_{j=1}^{M} \left| B_n(i,j) - B_m(i,j) \right|$$

Where B_n and B_m are the two frames of size N X M, and i and j denote pixel coordinates.

Spatial Feature Extraction

The spatial features extracted were the edge blocks (blockiness), blurriness and the brightness between current and previous frames. Brightness is calculated as the modulus of difference between average brightness values of previous and current frames.

Classification of video contents (3)



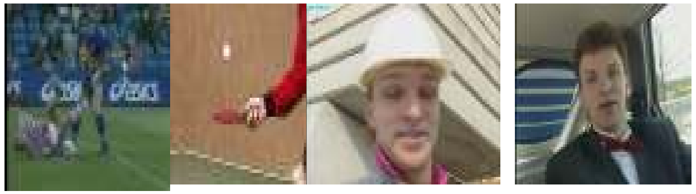
- Data split at 38%
- Cophenetic Coefficient C ~ 80%
- Classified into 3 groups as a clear structure is formed

Classification of Video Contents (4)

<u>Test Sequences Classified into 3 Categories of:</u>

1. Slow Movement(SM)
   (news type of videos)

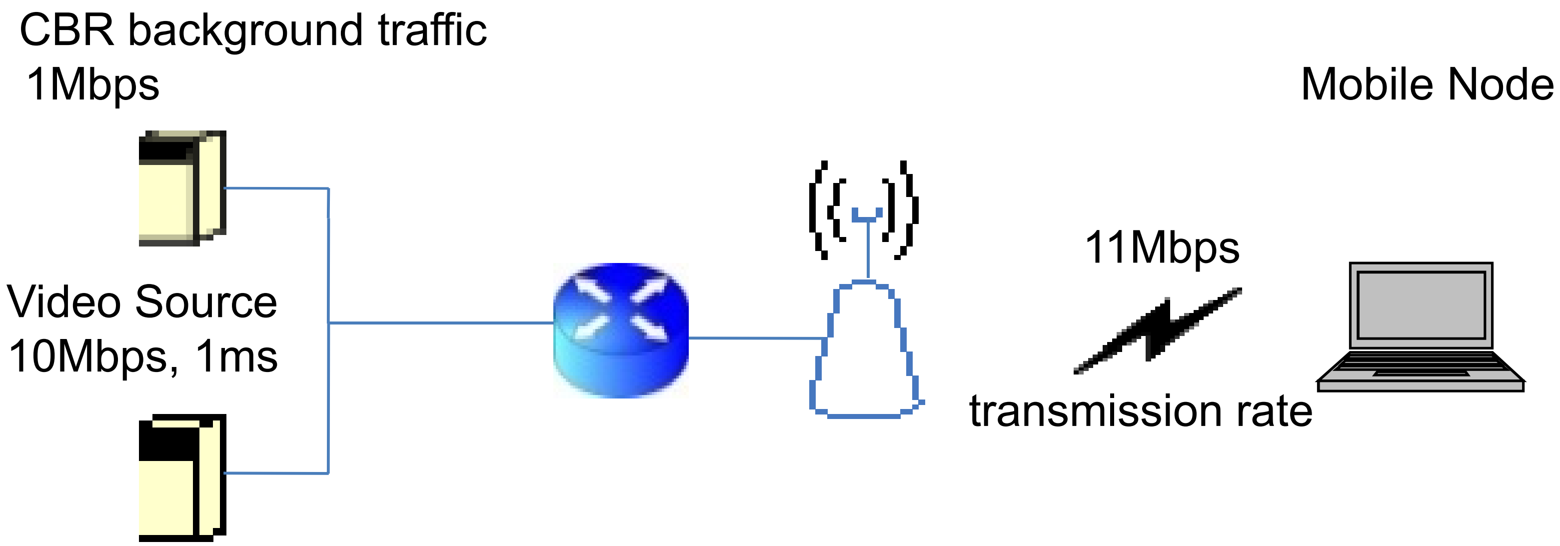
2. Gentle Walking(GW)
   (wide-angled clips in which both background and content is moving)



3. Rapid Movement(RM) –
   (sports type clips)

All video sequences were in the qcif format (176 x 144), encoded with MPEG4 video codec[3] with a frame rate of 10f/s

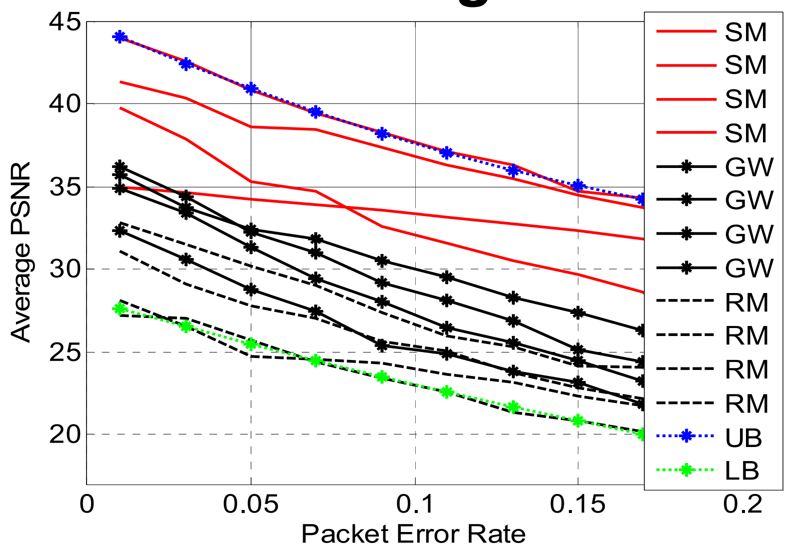
Simulation Set-up



- All experiments conducted with open source Evalvid [4] and NS2 [5]
- Random uniform error model
- No packet loss in the wired segment

Experiments (1)

Experiment 1 – Average PSNR Vs PER



SM: PSNR= 122.3$(PER)^2$-88.36(PER)+42.6; PER≤20%
GW: PSNR= 64.9$(PER)^2$-73.75(PER)+34.43; PER≤10%
RM: PSNR= 76.8$(PER)^2$-68.87(PER)+31.43; PER≤6%

All videos encoded at 256kb/s. Frame rate fixed at 10f/s

Goodness of fit (R^2)
R^2 ~ 99.71%
RMSE ~ 0.3235

Experiments (2)

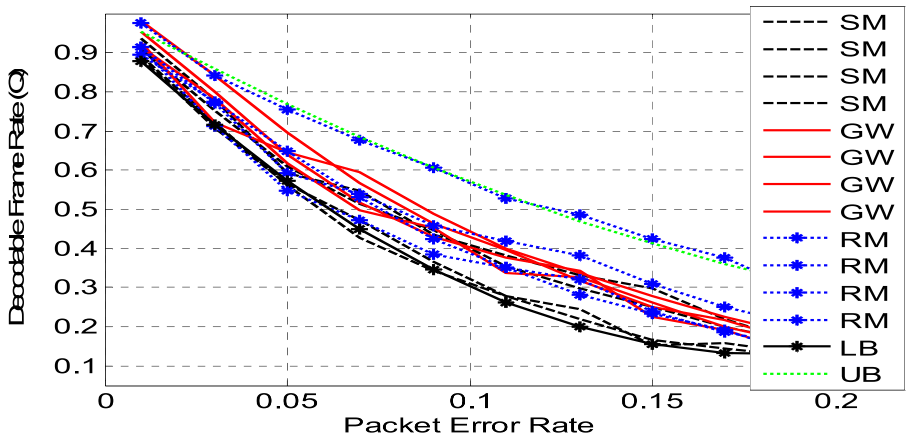
Experiment 1 – Average PSNR Vs PER

Avg. PSNR more tolerant to PER for SM compared to GW And RM

- For SM the acceptable PER to maintain minimum QoS requirement of 27dB is ≤ 20%
- For GW the acceptable PER to maintain minimum QoS requirement of 27dB is ≤ 10%
- For RM the acceptable PER to maintain minimum QoS requirement of 27dB is ≤ 6%

Experiments (3)

Experiment 2 – Q Vs PER



All videos encoded at 256kb/s. Frame rate fixed at 10f/s

Goodness of fit (R^2)

$R^2 \sim 99.71\%$

RMSE ~ 0.0117

SM: $Q = 19.89(PER)^2 - 8.03(PER) + 0.967$; $PER \leq 20\%$

GW: $Q = 18.09(PER)^2 - 7.88(PER) + 1.02$; $PER \leq 10\%$

RM: $Q = 13.84(PER)^2 - 6.5(PER) + 0.975$; $PER \leq 6\%$

Experiments (4)

Experiment 2 – Q Vs PER

Q more tolerant to PER for SM compared to GW

And RM as expected

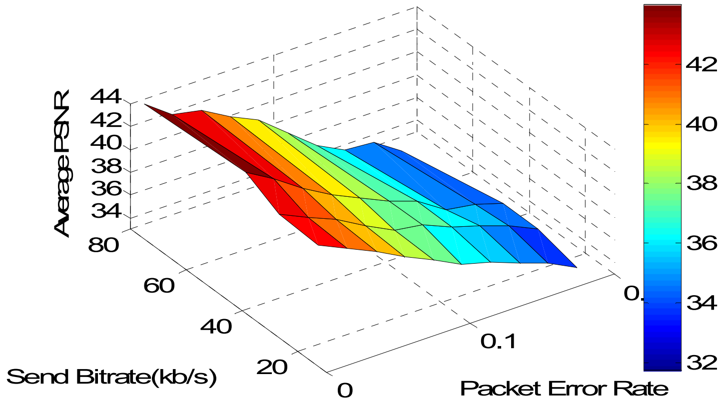
- For SM the acceptable PER to maintain minimum QoS requirement of 27dB is ≤ 20%
- For GW the acceptable PER to maintain minimum QoS requirement of 27dB is ≤ 10%
- For RM the acceptable PER to maintain minimum QoS requirement of 27dB is ≤ 6%

Experiments (5)

Experiment 3 – Average PSNR Vs PER Vs SBR

SBR ranged from 18kb/s – 80kb/s

PER 0-20%, FR 10f/s

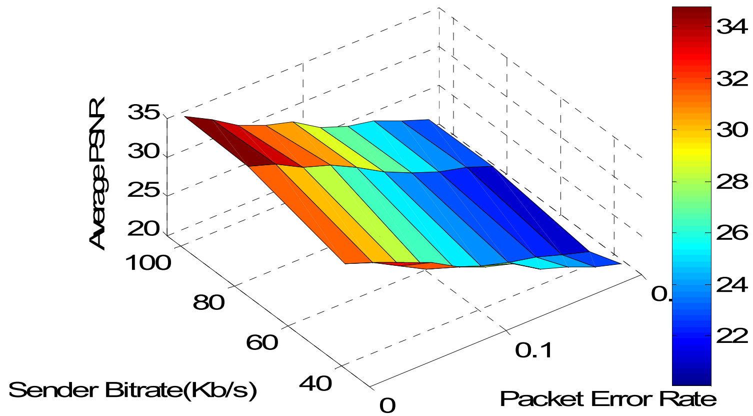


SM

For SM an SBR of 18kb/s gives acceptable QoS of 30dB (>27dB).

SBR ranged from 32kb/s – 104kb/s

PER 0-20%, FR 10f/s



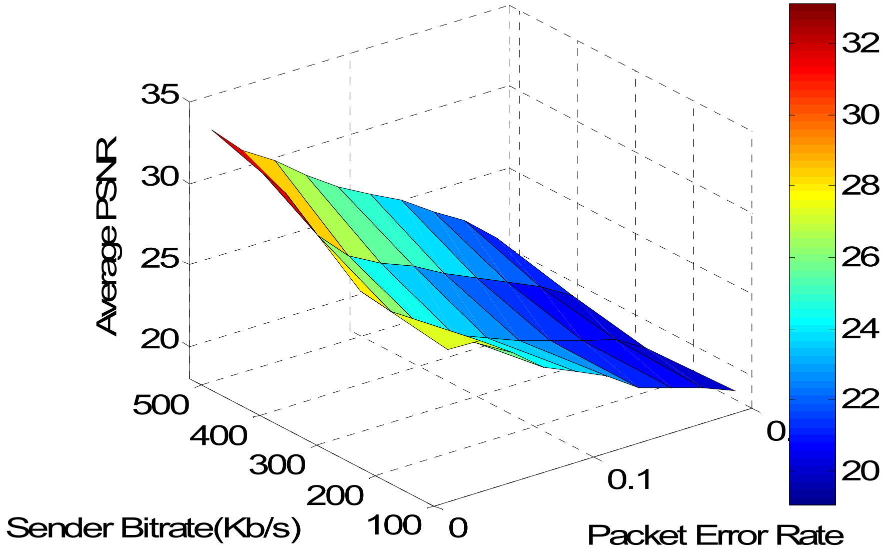
GW

For GW an SBR of 32kb/s gives acceptable QoS of 29dB (>27dB).

Experiments (6)

Experiment 3 - PSNR vs PER vs SBR for RM

SBR ranged from 80kb/s – 384kb/s
PER 0-20%,   FR 10f/s



For RM an SBR of 256kb/s gives acceptable PSNR of 30dB

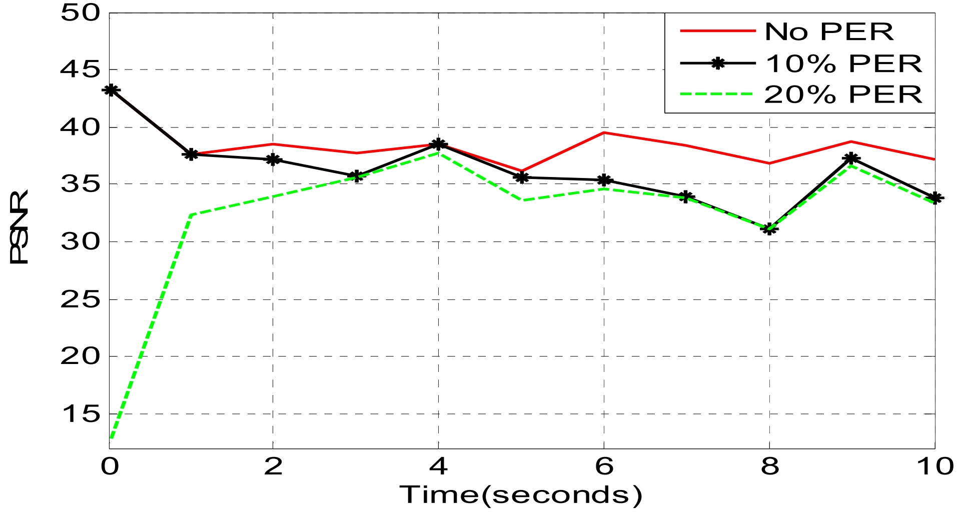
Increasing the SBR does not compensate for higher packet loss due to network congestion

Experiments (7)

Experiment 4 – PSNR Vs Time

Investigated the effects of packet loss on the entire duration of the video sequence

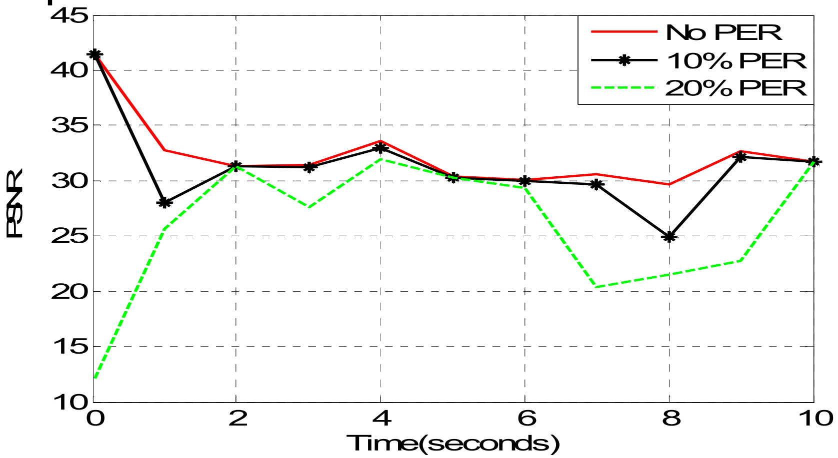
SM @ 32kb/s



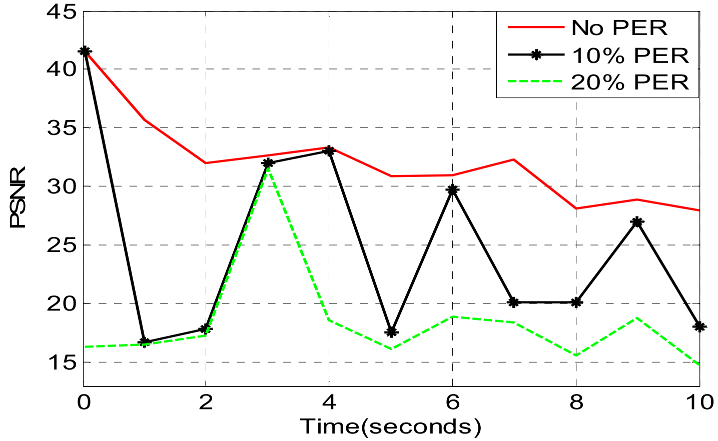
With increasing the PER errors more B-frames Are lost. However, as the number of I-frames lost is low the quality is acceptable upto 20% loss

Experiments (8)

Experiment4 – PSNR Vs Time
Investigated the effects of packet loss on the entire duration of the video sequence



GW @ 80kb/s



RM @ 384kb/s

With increasing the PER errors more I-frames Are lost degrading the quality Very rapidly for both GW and RM

Experiments (9)

Impact of SBR

- SBR exhibits a great influence on quality.
- Increasing the SBR increases the video quality.
- However it does not compensate for higher packet loss.
- Content category of SM very low SBR of 18kb/s gives acceptable video quality (PSNR > 27dB) for communication standards

Impact of PER

- Quality still acceptable for up to 20% PER for SM
- Quality reduces drastically with the increase of PER for GW and RM

Hence shows the importance of the impact of different content types on quality

Conclusions

- Classified the video content into three categories.
- Investigated and analyzed the combined effects of application and network parameters on end-to-end perceived video quality based on PSNR and Q value[1].
- PER have a great impact on video quality for faster moving content (e.g. GW and RM compared to SM).
- Increasing the SBR improves quality up to a point due to network congestion.
- Encoding video at a higher SBR than required wastes useful resources.
- Quality degradation increases with the duration of the sequence due to propagation of errors

Future Work

- Extend to Gilbert Eliot loss model.
- Propose one model for all contents.
- Currently limited to simulation only
- Extend to test bed based on IMS
- Use subjective data for evaluation.
- Propose adaptation mechanisms for QoS control.

References

Selected References

1. C. Lin, C. Ke, C. Shieh and N. Chilamkurti, "The packet loss effect on MPEG video transmission in wireless networks", *Proc. of the 20th Int. Conf. on Advanced Information Networking and Applications (AINA).*Vol. 1, 2006, pp. 565-72.
2. ITU-T. Rec P.800, Methods for subjective determination of transmission quality, 1996.
3. Ffmpeg, http://sourceforge.net/projects/ffmpeg
4. J. Klaue, B. Tathke, and A. Wolisz, "Evalvid – A framework for video transmission and quality evaluation", *In Proc. Of the 13th International Conference on Modelling Techniques and Tools for Computer Performance Evaluation,* Urbana, Illinois, USA, 2003, pp. 255-272.
5. NS2, http://www.isi.edu/nsnam/ns/.

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- Any questions?

Thank you!