Bit Rate Reduction Video Transcoding with Distributed Computing

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Introduction

- Clients may have different devices with different screen resolution and processing power.
  - TV, computer, Mobile device
- Different Network Bandwidths
  - Local Area Network
  - Wireless Local Area Network
  - Wide Area Network
  - Metropolitan Area Network
Compressed video is decoded

- A video is stored and transmitted in compressed form
- Different Decoders (eg. MPEG 1, 2, 4 H.263, H.264, Quicktime… etc.)
  - A device may not have all these decoder
Solution

• Multiple copies.
  – Simple and fast
  – Waste of storage
• Transcoding
  – Convert a compressed video into another compressed video with lower bit rate or in other formats.
Video Transcoding

- In video transcoding the compressed video needs to be processed to produce another compressed video with different characteristics.
- The new video can have different bit rate, frame rate, frame resolution, or any combination of these.
- It is also possible to transcode a video in an entirely different video format.
Decoding

VLD : Variable length decoding
MC : Motion compensation
IQ : Inverse quantization
FM : Frame memory
R₁(n) : Input compressed video
x(n) : Uncompressed video

Encoding

VLC : Variable length coding
MC : Motion compensation
ME : Motion estimation
IQ : Inverse quantization
Q : Quantization
FM : Frame memory
R₂(n) : Output compressed video
x(n) : Uncompressed video
Transcoding

VLD : Variable length decoding
VLC : Variable length coding
MC : Motion compensation
ME : Motion estimation
IQ : Inverse quantization
Q  : Quantization
FM : Frame memory
R_1(n) : Input compressed video
R_2(n) : Output compressed video
x(n) : Uncompressed video
MPEG stream frame types

- A MPEG stream consists of 3 types of frames
  - I Frames
    - The original picture represented can be reconstructed without reference to other frames
  - P Frames
    - The original picture has to be reconstructed with reference to the past constructed I or P frames
  - B Frames
    - The original picture has to be reconstructed with reference to the past and future constructed I or P frames
MPEG video stream

- Seq1, Seq2, Seq3, SeqN
- Video stream
- GOP Header,GOP1, GOP2, GOPN
- Video sequence
- Frame1, Frame2, FrameN
- Group of Pictures
- M pels
- GOB 1, GOB 2, GOB 3, GOB 4, GOB 5, GOB 6, GOB N
- N lines
- Frame Pictures
- MB 1, MB 2, MB 3, MB 4, MB 5, MB 6
- Group of Blocks (GOB)
- Y1, Y2, Y3, Y4, Cb, Cr
- Macroblock
- 8x8 Block
Bit rate reduction video transcoding

- Video resolution and frame rate are unchanged
- Video quality is degraded
- Less bit rate is achieved by applying inverse quantization and then again quantization with increased quantization step at the encoder side in the transcoder
- Some DCT coefficients become zero after coarser quantization

\[ Q_1^{-1} \quad Q_2 \]

Input Stream

\[ Q_1^{-1} \quad Q_2 \]

Output Stream
Video segmentation

- To segment the source video into smaller parts, there must be an Intra frame at the beginning of every segment.
- An intra frame followed by a sequence of P and B frames is termed a group of pictures (GOP).
- We segmented video with:
  - equal number of group of pictures (GOP) segmentation,
  - equal size segmentation (in mega bytes, kilo bytes, etc.)
Video Transcoding with Message Passing Interface

- To segment the source video into smaller parts, there must be an Intra frame at the beginning of every segment.
- We have chosen the MPI (message passing interface) for our transcoder.
- This standard is flexible, efficient, portable, practical and easy for application development.
- The MPI is used for MIMD (multiple instructions multiple data) systems.
- The MPI standard is open source.
Video Transcoding with Message Passing Interface

- In the MPI model the computation can be done on a set of machines.
- Every machine will get its part of the work and communication among different machines is possible through sending and receiving messages.
- The data transfer among two machines will be done through send and receive messages.
Video sequence used for experiments

• The big buck bunny video is used as source video.
  – 4CIF (704x576) resolution
  • 24fps,
  • 79.9 MB size
  • 00:09:56 play time
  • 14314 total frames
Profiling Results (ffmpege)

Ffmpeg was used for transcoding. The MPI based version of ffmpeg can execute on
1. Cluster of computers
2. Multi-core systems
3. Multi-processor based workstations

Video encoding 79.46%  
Video decoding 19.82%

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Results

- MPI based transcoder has 10 to 20% overheads (It includes video segmentation time).
- It can provide 3 to 5 times speed up using 7 worker nodes.
- Video segmentation with equal number of Intra frames is more efficient than equal size segmentations.
Analysis

- Peak Signal to Noise Ratio is used to measure the quality of images.
- PSNR for individual frames is shown below

\[
PSNR = 10 \times \log_{10}\left(\frac{\text{MaxErr}^2 \times W \times H}{\sum_{i=1,j=1}^{W,H} (x_{ij} - y_{ij})^2}\right)
\]
Analysis

- Average Peak Signal to Noise Ratio is used to measure the quality of video.
- If the value of APSNR is above 30 it means the video quality is acceptable.
- Maximum value for APSNR is 100
Conclusion

- Message passing based video transcoder can provide significant speed up
- Among two segmentation methods, equal number of Intra frames segmentation is more efficient than equal size segmentation.
- Same transcoder can also be used for other type of transcoding such as
  - Spatial resolution reduction transcoding
  - Temporal resolution reduction transcoding
  - Spatiotemporal resolution reduction transcoding