Multimedia

Outline

- Compression
- RTP
- Scheduling

Compression Overview

- Encoding and Compression
  - Huffman codes
- Lossless
  - data received = data sent
  - used for executables, text files, numeric data
- Lossy
  - data received does not != data sent
  - used for images, video, audio

Lossless Algorithms

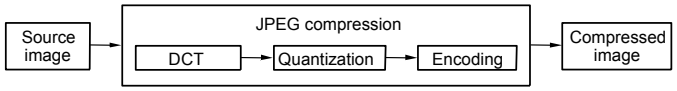
- Run Length Encoding (RLE)
  - example: AAABBCDDDD encoding as 3A2B1C4D
  - good for scanned text (8-to-1 compression ratio)
  - can increase size for data with variation (e.g., some images)
- Differential Pulse Code Modulation (DPCM)
  - example AAABBCDDDD encoding as A0001123333
  - change reference symbol if delta becomes too large
  - works better than RLE for many digital images (1.5-to-1)

Dictionary-Based Methods

- Build dictionary of common terms
  - variable length strings
- Transmit index into dictionary for each term
- Lempel-Ziv (LZ) is the best-known example
- Commonly achieve 2-to-1 ratio on text
- Variation of LZ used to compress GIF images
  - first reduce 24-bit color to 8-bit color
  - treat common sequence of pixels as terms in dictionary
  - not uncommon to achieve 10-to-1 compression (x3)

Image Compression

- JPEG: Joint Photographic Expert Group (ISO/ITU)
- Lossy still-image compression
- Three phase process



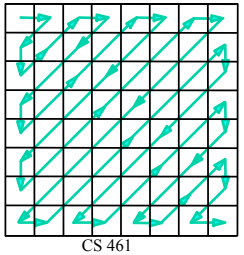
  - process in 8x8 block chunks (macro-block)
  - grayscale: each pixel is three values (YUV)
  - DCT: transforms signal from spatial domain into and equivalent signal in the frequency domain (loss-less)
  - apply a quantization to the results (lossy)
  - RLE-like encoding (loss-less)

Quantization and Encoding

- Quantization Table

3	5	7	9	11	13	15	17
5	7	9	11	13	15	17	19
7	9	11	13	15	17	19	21
9	11	13	15	17	19	21	23
11	13	15	17	19	21	23	25
13	15	17	19	21	23	25	27
15	17	19	21	23	25	27	29
17	19	21	23	25	27	29	31

- Encoding Pattern

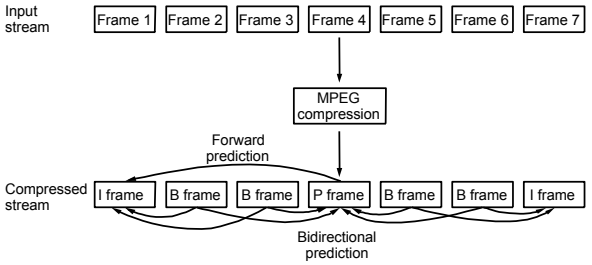


MPEG

- Motion Picture Expert Group
- Lossy compression of video
- First approximation: JPEG on each frame
- Also remove inter-frame redundancy

MPEG (cont)

- Frame types
  - I frames: intrapicture
  - P frames: predicted picture
  - B frames: bidirectional predicted picture



- Example sequence transmitted as I P B B I B B

MPEG (cont)

- B and P frames
  - coordinate for the macroblock in the frame
  - motion vector relative to previous reference frame (B, P)
  - motion vector relative to subsequent reference frame (B)
  - delta for each pixel in the macro block
- Effectiveness
  - typically 90-to-1
  - as high as 150-to-1
  - 30-to-1 for I frames
  - P and B frames get another 3 to 5x

MP3

- CD Quality
  - 44.1 kHz sampling rate
  - 2 x 44.1 x 1000 x 16 = 1.41 Mbps
  - 49/16 x 1.41 Mbps = 4.32 Mbps
- Strategy
  - split into some number of frequency bands
  - divide each subband into a sequence of blocks
  - encode each block using DCT + Quantization + Huffman
  - trick: how many bits assigned to each subband

RTP

- Application-Level Framing
- Data Packets
  - sequence number
  - timestamp (app defines “tick”)
- Control Packets (send periodically)
  - loss rate (fraction of packets received since last report)
  - measured jitter

Transmitting MPEG

- Adapt the encoding
  - resolution
  - frame rate
  - quantization table
  - GOP mix
- Packetization
- Dealing with loss
- GOP-induced latency

Layered Video

- Layered encoding
  - e.g., wavelet encoded
- Receiver Layered Multicast (RLM)
  - transmit each layer to a different group address
  - receivers subscribe to the groups they can “afford”
  - Probe to learn if you can afford next higher group/layer
- Smart Packet Dropper (multicast or unicast)
  - select layers to send/drop based on observed congestion
  - observe directly or use RTP feedback

Real-Time Scheduling

- Priority
- Earliest Deadline First (EDF)
- Rate Monotonic (RM)
- Proportional Share
  - with feedback
  - with adjustments for deadlines