Multimedia

- Outline
  - Compression
  - RTP
  - Scheduling

Compression Overview

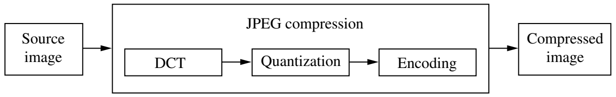
- Encoding and Compression
  - Huffman codes
- Lossless
  - data received = data sent
  - used for executables, text files, numeric data
- Lossy
  - data received $\neq$ data sent
  - used for images, video, audio

Loss-Less Compression Algorithms

- Run Length Encoding (RLE)
  - example: AAABBCDDDD encoded 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 encoded 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) compression is the best-known example
  - commonly achieve 2-to-1 ration on text
  - variation of LZ used to compress GIF images
    - first reduce 24-bit color to 8-bit color
    - treat common sequences of pixels as terms in dictionary
    - not uncommon to achieve 10-to-1 compression ($\times 3$)

Image Compression

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



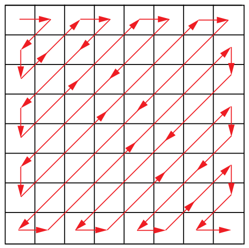
  - process in 8$\times$8 block chunks (macroblock)
  - greyscale: each pixel is a single value
  - color: each pixel is three values (YUV)
  - DCT: transforms signal from spatial domain into an equivalent signal in the frequency domain (loss-less)
  - apply a quantization to the results (lossy)
  - RLE-like encoding (loss-less)

Quantization and Encoding Phases

- Example Quantization Table

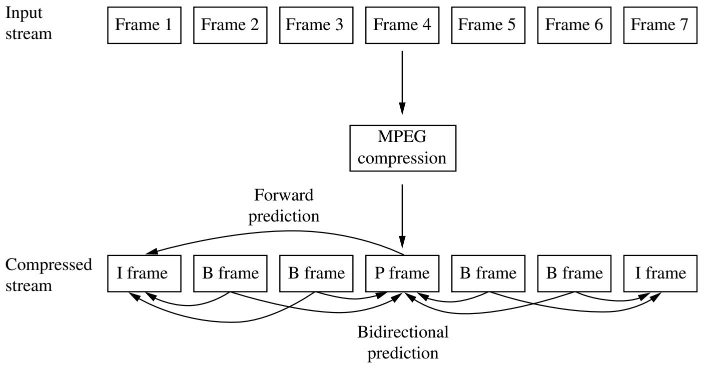
$$
\begin{bmatrix}
3 & 5 & 7 & 9 & 11 & 13 & 15 & 17 \\
5 & 7 & 9 & 11 & 13 & 15 & 17 & 19 \\
7 & 9 & 11 & 13 & 15 & 17 & 19 & 21 \\
9 & 11 & 13 & 15 & 17 & 19 & 21 & 23 \\
11 & 13 & 15 & 17 & 19 & 21 & 23 & 25 \\
13 & 15 & 17 & 19 & 21 & 23 & 25 & 27 \\
15 & 17 & 19 & 21 & 23 & 25 & 27 & 29 \\
17 & 19 & 21 & 23 & 25 & 27 & 29 & 31
\end{bmatrix}
$$

- Encoding Pattern



Video Compression

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

- B and P frames
  - coordinate for the macroblock in the frame
  - motion vector relative to previous reference frame
  - motion vector relative to subsequent reference frame (B only)
  - 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 & B frames get another 3 to 5×

RTP

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

Real-Time Scheduling

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