

## Compression Fundamentals

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### Example 1. Facsimile image transmission

A4 page = 8.5 x 11 inches in 200dpi  
digitized to 3.74 Mbits  
for 14.4 kbits/s modem needs 5.62 minutes

### Example 2. Video-based CD-ROM

30 fps 720 x 480 resolution  
generates data at 20.736 Mbytes/sec  
only 31 seconds of video be stored on 650MByte CD-ROM



## Why Compression

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1. Large storage requirements
  - encyclopedia
2. Relatively slow storage devices
  - CD-ROM (300KB/sec transfer rate)
3. Network's bandwidth
  - Ethernet, token ring (tens of Mb/sec)
  - ATM, FDDI (hundreds of Mb/sec)



## Storage Requirements for Multimedia applications

|                    | TEXT              | IMAGE                                                                                                              | AUDIO                                                                                                                                 | ANIMATION                                                                        | VIDEO                                                                            |
|--------------------|-------------------|--------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| OBJECT TYPE        | -ASCII<br>-EBCDIC | -Bit-mapped graphics<br>-Still photos<br>-Faxes                                                                    | Non-coded stream of digitized audio or voice                                                                                          | Synched image and audio stream at 15-19 frames/s                                 | TV analog or digital image with synched streams at 24-30 frames/s                |
| SIZE AND BANDWIDTH | 2 KB per page     | -Simple (grayscale)<br>77KB per image (320x240x8bits)<br><br>-Detailed (color)<br>3 MB per image (1100x900x24bits) | Voice/Phone<br>8KHz/8 bits- (mono)<br>6-44 KB/s<br><br>Audio CD<br>44.1 KHz,<br>16 bits/stereo<br>176 KB/s (44.1KHz x 2 ch x 16 bits) | 16 bit color,<br>16 frames/sec<br><br>6.5 MB/s (32 x640 x16bits x 16 frames/sec) | 24 bit color,<br>30 frames/sec<br><br>27.6 MB/s (640X480X24bits x 30 frames/sec) |

Table 4.1 Storage requirements for various media types.

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## Applications for image, video, and audio compression

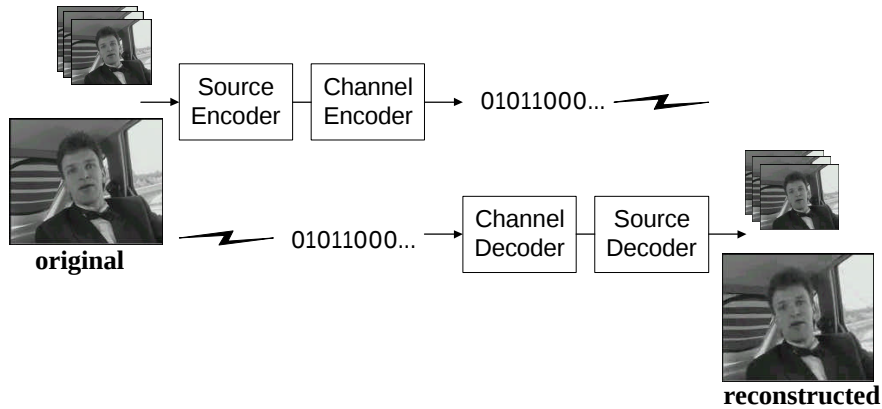
| Application                                                              | Data Rate    |             |
|--------------------------------------------------------------------------|--------------|-------------|
|                                                                          | Uncompressed | compressed  |
| <b>Voice</b> 8k samples/s, 8bits/sample 64kbps                           | 2-4 kbps     |             |
| <b>Slow-motion video</b> (10fps)<br>framesize 176x120, 8bits/pixel       | 5.07Mbps     | 8-16 kbps   |
| <b>Audio conference</b><br>8 ksample/s, 8 bits/sample                    | 64kbps       | 16-64 kbps  |
| <b>Video conference</b> (15 fps)<br>framesize 352x240, 8bits/pixel       | 30.41Mbps    | 64-768kbps  |
| <b>Digital audio</b> (stereo)<br>44.1 ksamples/s, 16 bits/sample         | 1.5Mbps      | 128-1.5Mbps |
| <b>Video file transfer</b> (15fps)<br>framesize 352x240, 8bits/pixel     | 30.41Mbps    | 384 kbps    |
| <b>Digital video on CD-ROM</b> (30fps)<br>framesize 352x240, 8bits/pixel | 60.83Mbps    | 1.5-4 Mbps  |
| <b>Broadcast video</b> (30fps)<br>framesize 720x480, 8bits/pixel         | 248.83Mbps   | 3-8 Mbps    |
| <b>HDTV</b> (59.94 fps)<br>framesize 1280x720, 8bits/pixel               | 1.33 Gbps    | 20 Mbps     |

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## Compression Concepts



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## Considerations for Compression

- Picture quality vs. bitrate
- Variable bit rate versus constant bit rate
- Robustness - noisy channels
- Interactivity - algorithm that operates on a small group of pels
- Compression and packetization delay: more efficient algorithm introduces more compression and packetization delay

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## Considerations for Compression

- Multiple encoding - higher quality is required for multiple codings
- Symmetry: the analysis phase of encoding makes the encoder more expensive
- Scalability - different resolutions (in space, time, amplitude, ...)
  - algorithms with highest compression efficiency usually are not very scalable

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## The Measure of Compression

- Compression ratio
  - $Cr = \text{source coder input size} / \text{source coder output size}$
- Signal Quality
  - $SNR = 10 \log_{10}(\text{encoder input signal energy} / \text{noise signal energy})$
  - or  $= 10 \log_{10}(255 / \text{noise signal energy})$
  - mean opinion score (very annoying, annoying, slightly annoying,  
» perceptible but not annoying, imperceptible)

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# Compression Technology

- Theorem:
  - Spatial redundancy      - DPCM, DCT, Subband, wavelet
  - Temporal redundancy    - DPCM, MC/ME
  - Statistical redundancy    - RLC, VLC
  - Perceptual redundancy   - SQ, VQ, fractal
- Compression → remove redundancy
  - Statistical redundancy
    - lossless
    - depend on the probabilistic characterization of signal
  - Perceptual redundancy
    - lossy, irreversible
    - complex, depends on context and application

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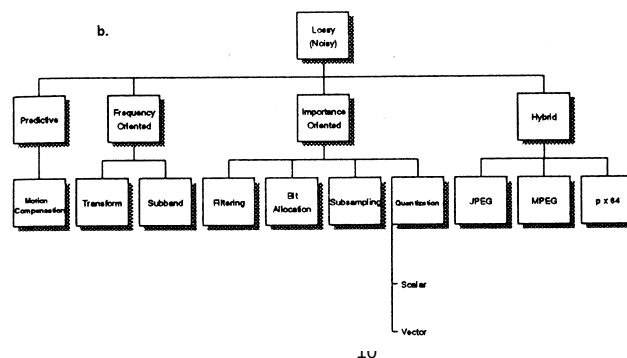
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# Compression Technology

Lossless compression:

Huffman, Run length, Arithmetic, Lempel Ziv

Lossy compression:



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## ITU Image standards

- JBIG (Joint Binary Image Experts Group)
- ITU-T Rec. T.6
- JPEG (Joint Photographic Experts Group)
- JPEG2000

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## ITU Visual Communication Standards

| Standard     | H.310                             | H.320                   | H.321                   | H.322                   | H.323                                     | H.324           |
|--------------|-----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------------------------|-----------------|
| Network      | ATM LAN                           | ISDN                    | ATM LAN                 | (QoS) LAN               | Ethernet                                  | GSTN (POTS)     |
| Video        | MPEG-2 (H.262)<br>H.261           | H.261 (H.263)           | H.261 (H.263)           | H.261<br>H.263+         | H.261<br>H.263+                           | H.261<br>H.263+ |
| Audio        | G.711<br>G.722<br>G.728<br>MPEG-2 | G.711<br>G.722<br>G.728 | G.711<br>G.722<br>G.728 | G.711<br>G.722<br>G.728 | G.711<br>G.722<br>G.728<br>G.729<br>G.723 | G.723           |
| Multiplexing | H.222.0<br>H.222.1 (MPEG)         | H.221                   | H.221                   | H.221                   | H.225.0                                   | H.223           |
| Control      | H.245                             | H.230<br>H.242          | H.242                   | H.242                   | H.245                                     | H.245           |
| Multi-point  |                                   | H.231<br>H.243          | H.231<br>H.243          | H.231<br>H.243          | H.323                                     |                 |
| Data         | T.120                             | T.120                   | T.120                   | T.120                   | T.120                                     | T.120           |

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## ISO Video Standards

### ISO/IEC MPEG-1

- 11172-1 : Systems
- 11172-2 : Video
- 11172-3 : Audio
- 11172-4 : Conformance
- 11172-5 : Software

### ISO/IEC MPEG-2

- 13818-1 : Systems
- 13818-2 : Video
- 13818-3 : Audio
- 13818-4 : Conformance
- 13818-5 : Software
- 13818-6 : Digital Storage Media command and Control (DSM-CC)

### ISO/IEC MPEG-4

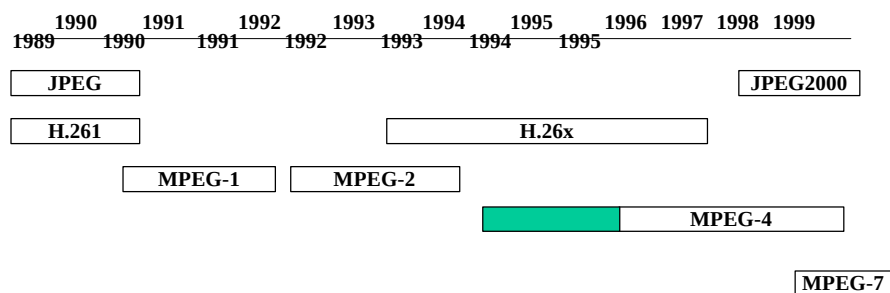
### ISO/IEC MPEG-7

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## Schedule of video standards



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