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title: Assignment 1

subtitle: Computer performance, reliability, and scalability calculation

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1.2

a. Data Sizes

Data Item	Size per Item
128 character message.	128 Bytes
1024x768 PNG image	1.5 MB
1024x768 RAW image	1.127 MB
HD (1080p) HEVC Video (15 minutes)	160.18 MB
HD (1080p) Uncompressed Video (15 minutes)	160,181 MB
4K UHD HEVC Video (15 minutes)	641 MB
4k UHD Uncompressed Video (15 minutes)	640,723 MB
Human Genome (Uncompressed)	0.6 GB

- 128 character message = 128 *1 = 128, since 1 Character = 8 bits(1 byte).
- PNG Image: Formula for PNG Image Size in bytes: PNG Image Size (bytes) = (Width x Height x Bits per pixel) / Compression Ratio

  Bits per pixel = 16 bit

  pixel count = width of image in pixels × height of image in pixels

  pixel count = 1024 * 768 = 786432.

  image file size = pixel count × bit depth

  imaage file size = 786432 * 16 = 12,582,912

  image file size = 12,582,912 × (1 byte / 8 bits) × (1/1024) = 2304 KB * (1/1024) => 1.5 MB (uncompressed).

  This can change based on the compression ratio.
- The size of a RAW image depends on the bit depth and sensor resolution.

  Let's assume: Bit Depth: 12 bits per channel (common for many RAW formats) and No compression.

  pixel count = 1024 * 768 = 786432.

  impage file size = 786432 * 12 = 9,437,184

9,437,184 × (1 byte / 8 bits) × (1/1024) = 1152 KB x (1/1024) = 1.125 MB

- HD (1080p) HEVC Video (15 minutes) :

  Uncompressed Video Size (bytes) = (Width x Height x Bit Depth x Frame Rate) x Duration (seconds)

  Raw Video Bitrate = 30 fps x 1920 pixels x 1080 pixels x 24 bits = 1,492,992,000 bps (bits per second)

  Uncompressed Video Size = Raw Video Bitrate x Duration (seconds) / 8 => 1,492,992,000 x 900 seconds/8 = 167,961,600,000

  Apply the compression ratio of 1000:

  Compressed Video Size (GB) = Uncompressed Video Size (GB) / Compression Ratio

  Compressed Video Size = 167,961,600,000 / 1000 = 167,961,600 => 167,961,600 *(1/1024)* (1/1024) = 160.18 MB

- HD (1080p) Uncompressed Video (15 minutes):

  Uncompressed Video Size (bytes) = (Width x Height x Bit Depth x Frame Rate) x Duration (seconds)

  Raw Video Bitrate = 30 fps x 1920 pixels x 1080 pixels x 24 bits = 1,492,992,000 bps (bits per second)

  Uncompressed Video Size (GB) = Raw Video Bitrate (Gbps) x Duration (seconds) / 8

  => 1,492,992,000 x 900 seconds/8 = 167,961,600,000

  Uncompressed Video Size = 160,180.6640625 MB = ~ 160,181 MB

- 4K UHD HEVC Video (15 minutes):

  Video file size = Time (second) x Frames per Second (FPS) x Pixels per Frame (Resolution) x Bit Depth

  Video Resolution: 3840x2160 pixels (4K UHD)

  Bit Depth: 24 bits

  Frame Rate: 30 fps

  Duration: 900 seconds (15 minutes)

  Uncompressed Video Size (bytes) = 30 *(3840 x 2160)* 24 = 5,971,968,000

  Uncompressed Video Size (GB) = Raw Video Bitrate (Gbps) x Duration (seconds) / 8
  => 5,971,968,000 * 900 / 8 = 671,846,400,000 => 671,846,400,000

  Apply the compression ratio of 1000:

  Compressed Video Size = Uncompressed Video Size / Compression Ratio

  Compressed Video Size = 671,846,400,000 / 1000 => 671,846,400 => 640.722 MB = ~641 MB

- 4k UHD Uncompressed Video (15 minutes):

  Video file size = Time (second) x Frames per Second (FPS) x Pixels per Frame (Resolution) x Bit Depth

Video Resolution: 3840x2160 pixels (4K UHD)

Bit Depth: 24 bits

Frame Rate: 30 fps

Duration: 900 seconds (15 minutes)

Uncompressed Video Size (bytes) = 30 *(3840 x 2160)* 24 = 5,971,968,000 Uncompressed Video Size (GB) = Raw Video Bitrate (Gbps) x Duration (seconds) / 8
=> 5,971,968,000 * 900 / 8 = 671,846,400,000 => 671,846,400,000 = 640,722.6 MB = ~ 640,723 MB

- Uncompressed Genome Size (bytes) = Number of Base Pairs x Size per Base Pair

  The human genome, which is typically measured in base pairs (bp), consists of approximately 3.2 billion base pairs. This

  measurement includes all the DNA in a complete human genome. In terms of file size, DNA base pairs are typically represented

  using two bits per base pair (A, T, G, C), which translates to 0.2 bytes per base pair (since 1 byte = 8 bits).

  Uncompressed Genome Size (bytes) = 3,200,000,000 base pairs x 0.2 bytes/base pair => 640,000,000 bytes => 640 MB => 0.6 GB

b. Scaling

	Size	# HD
Daily Twitter Tweets (Uncompressed)	64 GB	1
Daily Twitter Tweets (Snappy Compressed)	42.6 GB	1
Daily Instagram Photos	113 TB	34
Daily YouTube Videos	461 TB	138
Yearly Twitter Tweets (Uncompressed)	23 TB	7
Yearly Twitter Tweets (Snappy Compressed)	15 TB	5
Yearly Instagram Photos	41245 TB	12374
Yearly YouTube Videos	168192 TB	50458

- Total Size (bytes) = Number of Tweets (X) x Average Tweet Length (Y) x Bytes per character (UTF-8 variable-length encoding)

  On an average, there are around 500 million tweets per day. Assuming thetweet length is 128 characters long.

  500,000,000 *128* 1 (byte) = 64,000,000,000 bytes / (1024 MB/GB) / 1024 = 64 GB

- Snappy typically achieves compression ratios in the range of 1.5x to 1.7x for plain text data, meaning the compressed size is about 50% to 70% of the original uncompressed size. Using 1.5, 64 GB / 1.5 = 42.66 GB

- Daily Instagram photos:

Average Photo Size = 1.5 MB

Daily Photo Size (bytes) = Daily Photo Uploads x Average Photo Size (1024 * 768)

Daily Photo Size (bytes) = 75,000,000 photos x 1.5 MB/photo #Calculating for the 75% alone.

Daily Photo Size ≈ 112,500,000 MB = 112.5 TB = ~113TB 112.5 * 0.3 = 33.75 HDD

- Daily YouTube Videos: 500 hours of video is uploaded to YouTube every minute.

  500 hours *60 mins = 30000 mins 15 mins - 160.18 MB (30000 mins* 160.18)/15 = 320,360MB = 320 GB 320 *24* 60 = 460800 GB in a day = 460.8 TB

  About 720000 *4* 160.18 MB = 461,318,400 MB (439.94 GB).

- 64 GB * 365 = 23,360 GB = 23 TB.
- 43 GB * 365 = 15,695 GB = 15 TB.
- 113 TB * 365 = 41,245 TB.
- 460.8 TB * 365 = 168,192 TB.

c. Reliability

	# HD	# Failures
Twitter Tweets (Uncompressed)	7	0.8617
Twitter Tweets (Snappy Compressed)	5	0.6155
Instagram Photos	12374	1523
YouTube Videos	50458	6211

The failure rate used is 12.31% AFR for 10TB drives Q2 2023 Failures = HD * Failure_Rate

7 0.1231 = 0.8617 5 0.1231 = 0.6155 12374 *0.1231 = 1,523.2394 50458* 0.1231 = 6,211.3798

d. Latency

	One Way Latency
Los Angeles to Amsterdam	30 ms
Low Earth Orbit Satellite	40 ms
Geostationary Satellite	240 - 280 ms
Earth to the Moon	1.3 s
Earth to Mars	21 minutes

- The distance between LA and Amsterdam is 8934 km/5551 mi, and the speed of light is about 300,000 km/sec. Time = 8934 * 1000/300000 = 29.78 ms = ~30 ms. 153.186ms -> https://wondernetwork.com/pings
- Low Earth Orbit Satellite = 40ms https://www.omniaccess.com/leo/#:~:text=MEO%20latency%20is%20180%20milliseconds,if%20you%20are

- Geostationary Staellite latency = 240 - 280 ms https://www.satsig.net/latency.htm
- Earth to moon latency today - 1.3 s https://www.spaceacademy.net.au/spacelink/commdly.htm
- Earth to Mars Latency today - 3 - 21 minutes
  https://www.spaceacademy.net.au/spacelink/commdly.htm