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File Formats 101

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File Formats 101

Kathryn Lybarger

Paul Revere's Ride

Listen my children and
you shall hear
Of the midnight ride of
Paul Revere,
On the eighteenth of
April, in Seventy-five;
Hardly a man is
now alive
Who remembers that
famous day and year.

Paul Revere's Specification

… If the British march

By land or sea from the town to-night,

Hang a lantern aloft in the belfry arch

Of the North Church tower, as a signal light, --

One, if by land, and two, if by sea

THE BRITISH ARE COMING BY SEA

A better signal

How many signals?

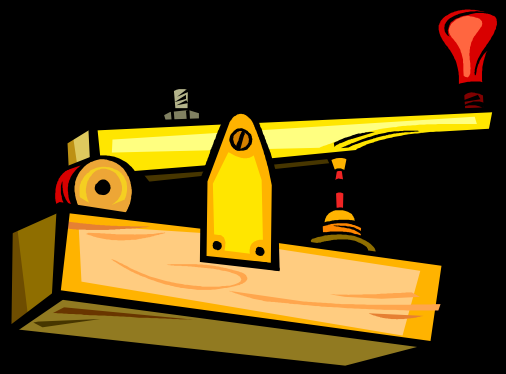
- The British are not coming (yet).
- The British are coming by land.
- The British are coming by sea.

More options

- The British are coming in some other way – look out!

- There is some other problem – come see.

Western Union “92 code” (1859)



- 1 Wait a minute.
- 7 Are you ready?
- 27 Priority, very important.
- 73 Best Regards.
- 88 Love and kisses.

More than one tower?

- (0 0 0) The British are not coming (yet).
- (0 0 1) The British are coming by land.
- (0 1 0) The British are coming by sea.
- (0 1 1) The British are coming!!
- (1 0 0) Love and kisses.
- (1 0 1) We are out of tea.
- (1 1 0) We are out of milk.
- (1 1 1) We are out of lanterns.

Binary numbers

- Each position represents a power of two:

  128 64 32 16 8 4 2 1

- 7 = 4 + 2 + 1 → 00000111

- 20 = 16 + 4 → 00010100

Binary is compact

- All numbers between 0 and 255 can be represented using 8 bits (one byte).

- 255 = 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 =

  11111111

- 128 = 128 + 0 + 0 + 0 + 0 + 0 + 0 + 0 =

  10000000

Binary is flexible

- 0, 1 written as text
- negative/positive polarity on magnetic media
- low voltage / high voltage on a wire
- lanterns not lit / lanterns lit in towers

File formats

A **file format** is a specification for interpreting a bitstream as meaningful data.

Examples:

- 0 = black, 1 = white (bitmap image)
- Group as binary numbers -> letters (ASCII)
- “Executable” code

File formats are interpreted by software.

Do not trust file name extensions

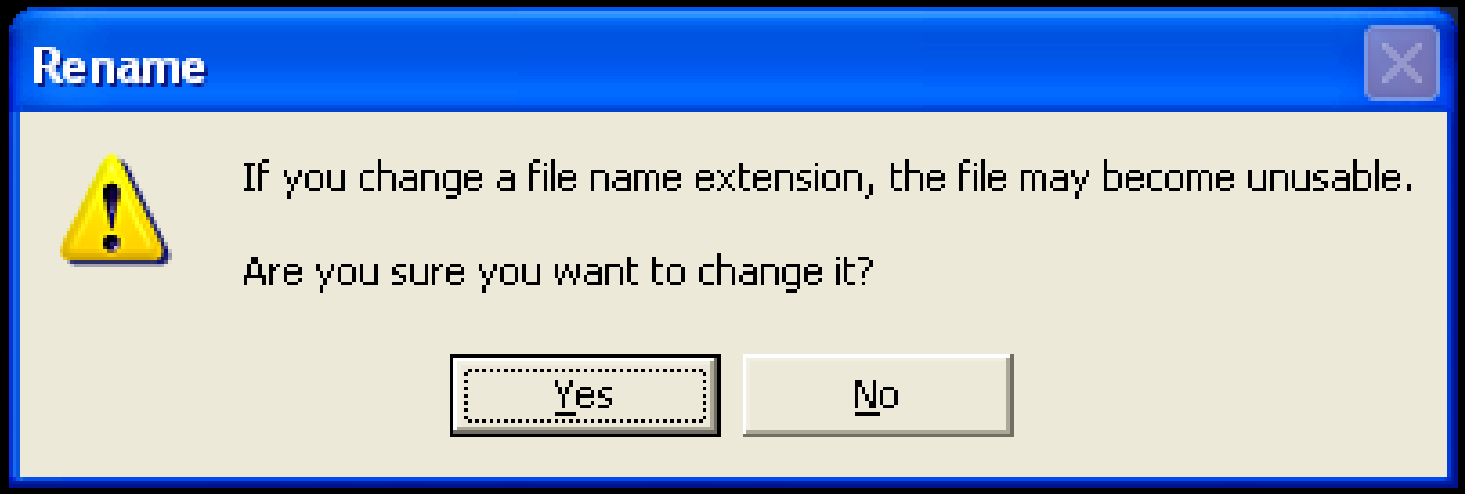


photo.jpg

photo.mp3

Preservation file formats

A **preservation file format** is a file format which stores data in a way such that it can be faithfully rendered by computer systems now and in the future.

The same file format forever?

- Example: Project Gutenberg (1970's)
- Now allows XHTML, images, audio
- Insists on plain ASCII copy

Format migration

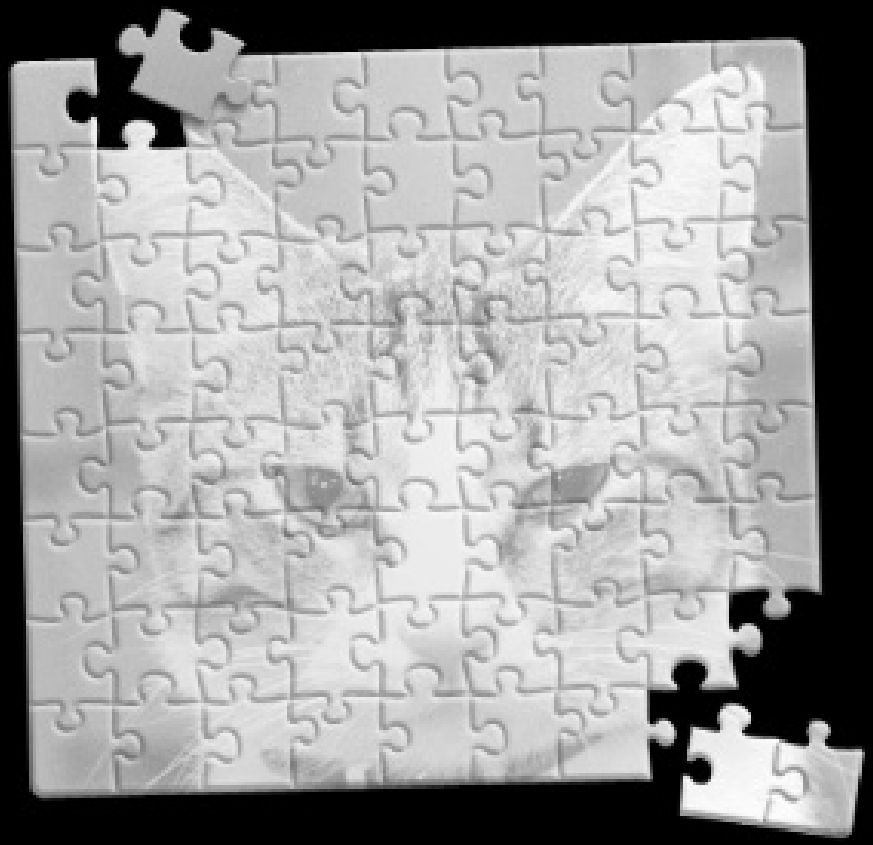
- You need not use the same file format forever
- Must have sufficient data and context to migrate data to other formats
- Those formats should similarly be preservation file formats

Preservation file formats should be lossless

- All analog to digital conversions are lossy.
- A **lossless** format is one such that conversion of digital data into this format loses no more data.

Lossless / lossy formats

- Files in lossy formats do not (typically) lose data when you view them
- They might if you SAVE them as you close them, even if you save in the same format



JPG → JPG → JPG → JPG …

Preservation file formats should be open

An open format is one where the mode of presentation of the data is transparent, or the format specification is publically available.

-- from openformats.org

Transparent presentation of data

HTML code:

My favorite show is Quantum Leap.

Renders as:

My **favorite** show is *Quantum Leap*.

Format specification

A TIFF file begins with an 8-byte image file header, containing the following information:

Bytes 0-1: The byte order used within the file. Legal values are:

"II" (4949.H)

"MM" (4D4D.H)

In the "II" format, byte order is always from the least significant byte to the most significant byte, for both 16-bit and 32-bit integers This is called *little-endian* byte order. In the "MM" format, byte order is always from most significant to least significant, for both 16-bit and 32-bit integers. This is called *big-endian* byte order.

Bytes 2-3 An arbitrary but carefully chosen number (42) that further identifies the file as a TIFF file.

The byte order depends on the value of Bytes 0-1.

Bytes 4-7 The offset (in bytes) of the first IFD. The directory may be at any location in the file after the header but *must begin on a word boundary*. In particular, an Image File Directory may follow the image data it describes. Readers must follow the pointers wherever they may lead.

Preservation file formats should be unencumbered

- Formats may require royalties to use the format.
- Licenses may disallow reverse-engineering
- Leads to “lock-in”

Example: LZW compression

- Used in GIF, compressed TIFF
- Subject to multiple patents (now expired)

Example: EndNote

- Academic reference manager
- An open-source alternative, Zotero, allowed importing EndNote files
- EndNote brought a lawsuit against Zotero
- Case was dismissed

Preservation file formats should be resistant to corruption

- Physical media degrades
- File systems become corrupt
- Files do not always transfer correctly

File corruption

File corruption

File corruption

Location of corruption is important

- Many file formats have a “magic number”
  - PDF %PDF
  - GIF GIF87a or GIF89a
  - Java CAFEBABE or CAFED00D
  - TIFF II or MM followed by 42 in binary
- Corrupted magic number may make a file “unrecognizeable”

Not all software handles corruption the same way

- Some may not notice it
- Some may refuse to open the file
- Some may help you salvage the file

Preservation file formats should allow embedded metadata

- File name / directory structure is insufficient
- Files may be stored in different ways
- File names are not part of files

QE^TQE^TE^TQE^TQE^T'Qlih¢(¢(¢l^DP:RNE^TQE^T§^T(sKE^TQE^TQE^TQE^TQE^TQE^TQE^TQE
TQE^TQE^TQE^TQE^TQE^TQE^TQE^TQE^TQE^TQE^TQE^TQE^TQE^TQIE-^TQE^TQE^TQE^TQE^TQE^T
E^TQE^T^AKE^TQE^TQE^TQE^Téh¢(¢(¢(¢(¢ÿ^@tÔ^Q¸ñV)h¢))h¤=)^GZu^TQE^TQE^TQE^TQE%^B(
(¢(¢ÿ^@tÔqO¢(¢(¢(¢Ý)GJZ(¢(¤=)÷@(¢(¢(¢(¢JZ(¢(¢:Ó¨¢cÓJ)h¢(¤=(¥¢J^GJZ(¢cÓJZ(¢3m^TQ
^TQE^TQE^TQE^TQE^TS^ ¥8t¥¢(¢(¢(¢(¢(¢>(¦·jZZ(¢(¢(¢(¤¥¢(¢(¢(¢(¢(¢(¢(¢(¢(¢(¢(¢(¢(¢
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Preservation file formats

- Lossless
- Open
- Unencumbered
- Resilient to corruption
- Allow metadata

File formats need not be perfect

- Have a realistic view of how your data is being stored
- Respond accordingly
- Migrate when new formats are adopted

Using preservation file formats

- Not always possible
- Not sufficient to keep data safe forever
- Important part of complete preservation strategy

Any questions?