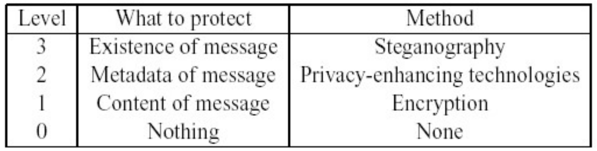
Steganography

What to protect



Level	What to protect	Method
3	Existence of message	Steganography
2	Metadata of message	Privacy-enhancing technologies
1	Content of message	Encryption
0	Nothing	None

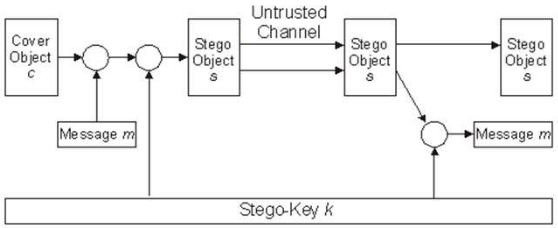
Table by I.A. Goldberg

Metadata of message here is: the sender, the recipient, the time the message was sent, or the length of the message, etc

Steganography and information hiding

- **Steganography,** derived from “covered writing” in Greek
- It includes the methods of secure communications that conceal the **very existence** of the message
- Examples (non-digital): invisible ink, microdots, etc

Steganography in digital world



Picture by C.Shoemaker

Digital watermarking

- **Digital watermarking**:
- aim is to embed an amount of information that could not be removed or altered without making the cover object entirely unusable
- adds additional requirement of **robustness** as compared **with** steganography
- Can be used for copyright protection

Texts as cover objects

- Text as a cover object:

- *Apparently neutral's protest is thoroughly discounted*
- *and ignored. Isman hard hit. Blockade issue affects*
- *pretext for embargo on by products, ejecting suets*
- *and vegetable oils.*

- *(Real example of the text sent by a spy in WWII)*

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- *and vegetable oils*

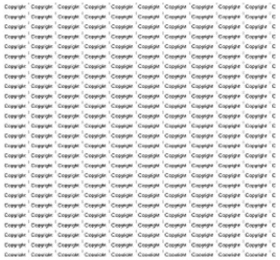
- Taking the second letter in each word gives the message: Pershing sails from NY June 1

Images as cover objects

- LSB (Least Significant Bit) substitution method:
- Least significant bits used to store characteristics of particular pixels of an image (cover object) are modified to store a message
- Colours and lightness of pixels of obtained image may differ slightly from original cover image, but both images looks identically to human eye.
- Easy to implement, but not too robust methods
- Transformations of images may easily destroy the message (watermark)

Images as cover objects

Watermarked image (LSB substitution)



Watermark recovered

Note: watermark is embedded as the image, not the plain text to improve robustness

Advantages and disadvantages of LSB

- **Advantages of LSB**
- easy to implement
- has high capacity
- **Disadvantages of LSB**
- is not robust
- message is easy to detect:
  - A message insertion introduces distortion to the statistical properties of image which never naturally appear

Stochastic modulation method

- **Simple variant**:
- Before embedding a message a randomly chosen pixels are altered by changing their intensities (= a number between 0 and 255) by +1 or –1;
- For a parameter **p** in [0;1] a pixel intensity is increased/decreased by 1 with probability p; it is left unchanged with probability 1-2p;
- Then LSB method is used
- Provide more protection against detection of the message

Stochastic modulation method

- **Improved method (J.Fridrich, M.Goljan):**
- The idea:
- take a cover image and add a “noise” modulated by a message bits
- “noise” actually means pseudo-noise here , that is a sequence of pseudo-random values, which can be generated deterministically given a secret initial value (key)
- If initial value (key) is known then generation of pseudo-noise can be repeated (used for extraction of the message)

Stochastic modulation

- Simple implementation;
- High capacity;
- Low embedding and extraction complexity
- Embedding noise can have arbitrary characteristics and may approximate the noise of a given device => high security

Transform space algorithms

- **Jsteg** algorithm (D.Upham) uses specifics of JPEG image format
- For each colour component JPEG image format uses *discrete cosine transform* (DCT)
- DCT is used by JPEG to transform consecutive 8 by 8 pixel blocks of the image to 64 DCT coefficients each:

$$F(u,v) = \frac{1}{4}C(u)C(v)\left[\sum_{x=0}^{7}\sum_{y=0}^{7} f(x,y) * \cos\frac{(2x+1)u\pi}{16}\cos\frac{(2y+1)v\pi}{16}\right],$$

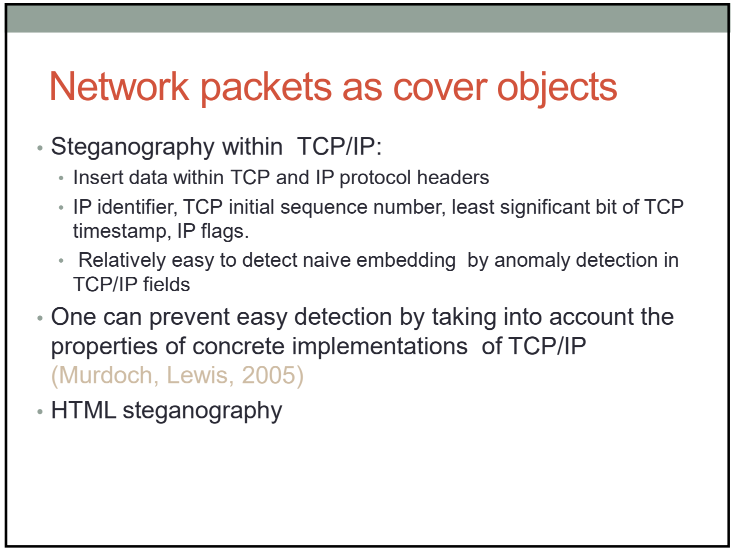
- where $C(x) = 1/\sqrt{2}$ if x = 0 and $C(x) = 1$ otherwise

Transform space algorithms

- JPEG: after quantization DCT coefficients are stored;
- Jsteg algorithm:
  - Replace sequentially the least-significant bit of discrete cosine transform coefficients with the message data
- Gives better protection (as many others TS algorithms) against visual attacks

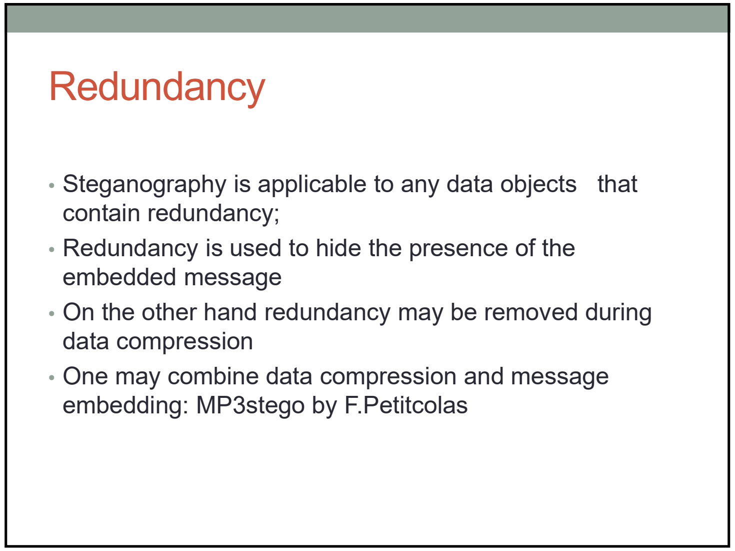
Audio (video) files as cover objects

- LBS can be used, but it introduces a significant noise to audio data ;
- A message may be encoded in audio signal *phase*, replacing original phase with a reference phase representing a hidden message;more difficult to implement;
- *Spread spectrum* method: encoded data spread across the maximum range of frequencies; difficult to detect hidden message;
- Video objects (files, streams) can be used for hiding information as well;



Network packets as cover objects

- Steganography within TCP/IP:
  - Insert data within TCP and IP protocol headers
  - IP identifier, TCP initial sequence number, least significant bit of TCP timestamp, IP flags.
  - Relatively easy to detect naive embedding by anomaly detection in TCP/IP fields
- One can prevent easy detection by taking into account the properties of concrete implementations of TCP/IP (Murdoch, Lewis, 2005)
- HTML steganography



Redundancy

- Steganography is applicable to any data objects that contain redundancy;
- Redundancy is used to hide the presence of the embedded message
- On the other hand redundancy may be removed during data compression
- One may combine data compression and message embedding: MP3stego by F.Petitcolas