Chapter 8

Multimedia Security

Digital Watermarks for Multimedia

Digital Watermarking

- Watermarking is a method to hide secret information in a multimedia content
- The signal may be audio, pictures or video
- If the signal is copied, then the information is also carried in the copy

- Roots in *Steganography*

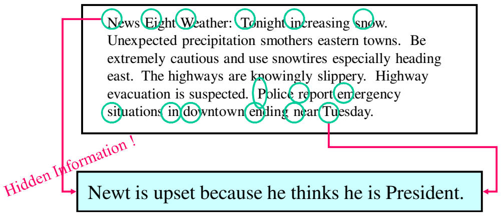
  Stegano for *"covered"* and
  graphos "to write"

Steganography - Hiding Information

- Goal
  - hide secret communication
  - hide secret messages in regular messages
  - attacker should not see second secret message
  - secret messages are “invisible”
  - “invisible writing”

Simple Example 1

Taking the first letter in each word

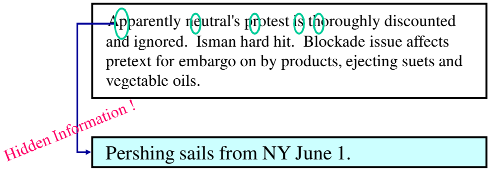


News Eight Weather: Tonight increasing snow. Unexpected precipitation smothers eastern towns. Be extremely cautious and use snowtires especially heading east. The highways are knowingly slippery. Highway evacuation is suspected. Police report emergency situations in downtown ending near Tuesday.

Newt is upset because he thinks he is President.

Simple Example 2

Taking the second letter in each word
(actually sent by a German Spy in WWII)

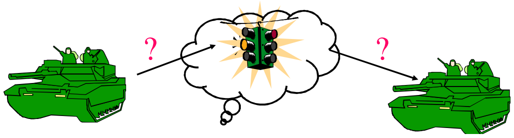


Apparently neutral's protest is thoroughly discounted and ignored. Isman hard hit. Blockade issue affects pretext for embargo on by products, ejecting suets and vegetable oils.

Pershing sails from NY June 1.

Information Hiding

- Distinguished but imperceptible marks
  - Contain a hidden copyright notice or serial number
  - Help to prevent unauthorized copying directly
- Example
  - Military Communications System
    - Conceal its sender, its receiver or its very existence
  - Mobile Phone System, DVD Player, Digital Election, Cash



Definition of Digital Watermarking

– Digital Watermarking technology

allows users to embed some data into digital contents such as

still image,
movie and
audio data.

– When data is embedded,

it is not written at header part but embedded directly into digital media itself by changing media contents data.

Multimedia and security

– Video Conferencing:

Only allowed participants in a video conferencing session

– Pay-TV (Pay per View)

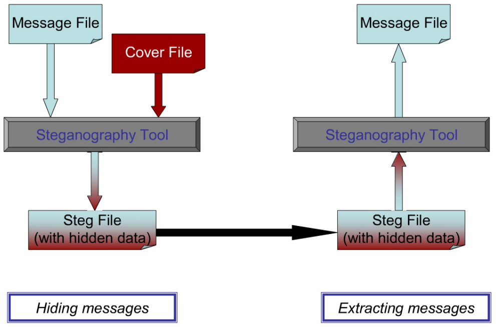
Only allowing paying customers to listen to a live broadcast

– Video on Demand

Only allowing paying customers to listen to a recording or file

– Restricting where, when or how a recording is accessed

How It Works?



Message File

Cover File

Steganography Tool

Steg File (with hidden data)

Message File

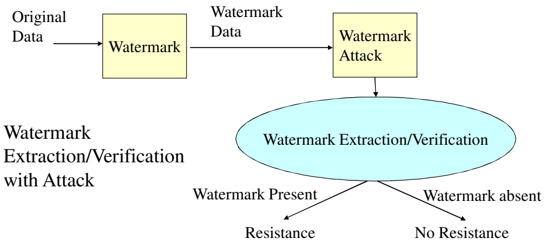
Steganography Tool

Steg File (with hidden data)

Hiding messages

Extracting messages

Overall Model



Original Data

Watermark

Watermark Data

Watermark Attack

Watermark Extraction/Verification with Attack

Watermark Extraction/Verification

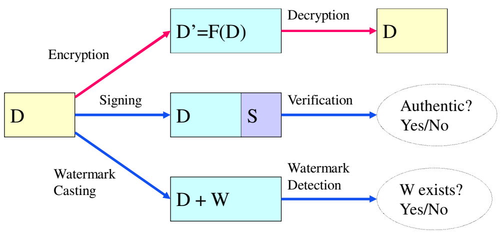
Watermark Present

Watermark absent

Resistance

No Resistance

Crypto & Digital Watermarking



Encryption

D'=F(D)

Decryption

D

D

Signing

D S

Verification

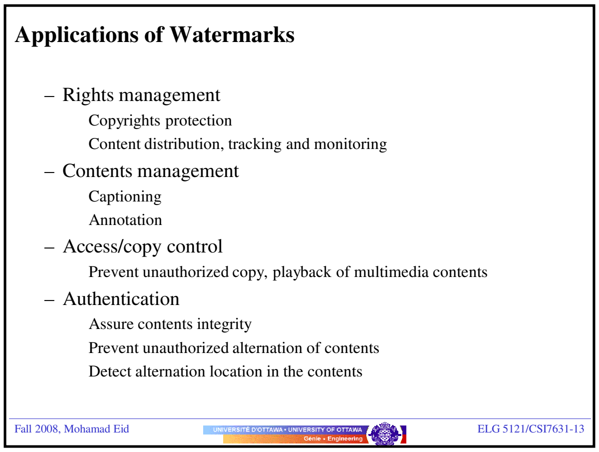
Authentic? Yes/No

Watermark Casting

D + W

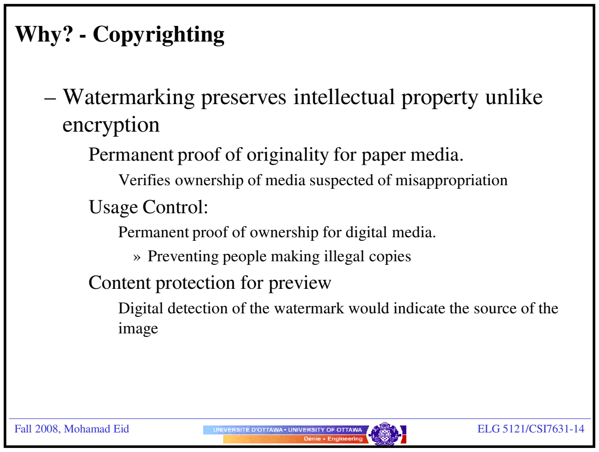
Watermark Detection

W exists? Yes/No



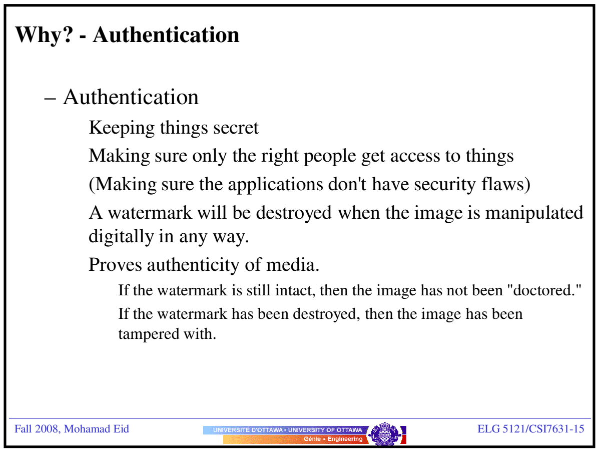
Applications of Watermarks

- Rights management
  - Copyrights protection
  - Content distribution, tracking and monitoring
- Contents management
  - Captioning
  - Annotation
- Access/copy control
  - Prevent unauthorized copy, playback of multimedia contents
- Authentication
  - Assure contents integrity
  - Prevent unauthorized alternation of contents
  - Detect alternation location in the contents



Why? - Copyrighting

- Watermarking preserves intellectual property unlike encryption
  - Permanent proof of originality for paper media.
    - Verifies ownership of media suspected of misappropriation
  - Usage Control:
    - Permanent proof of ownership for digital media.
      - » Preventing people making illegal copies
  - Content protection for preview
    - Digital detection of the watermark would indicate the source of the image



Why? - Authentication

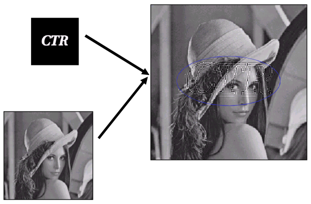
- Authentication
  - Keeping things secret
  - Making sure only the right people get access to things
  - (Making sure the applications don't have security flaws)
  - A watermark will be destroyed when the image is manipulated digitally in any way.
  - Proves authenticity of media.
    - If the watermark is still intact, then the image has not been "doctored."
    - If the watermark has been destroyed, then the image has been tampered with.

Types of Watermarks (I)

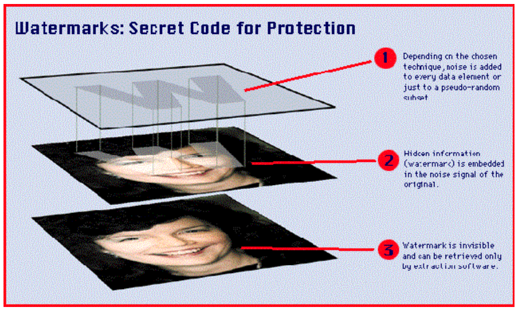
- Visible
  - A visible translucent image which is overlaid on the primary image
    - Example: Visible corporate logo to protect copyrights
- Invisible
  - An overlaid image which cannot be seen, but which can be detected algorithmically
  - Embedding level is too small to notice
  - Can be retrieved by extraction software
  - Applications:
    - Authentication
    - Copyrighting

Visible Watermark

- Logo or seal of the organization which holds the rights to the primary image, it allows the primary image to be viewed, but still marks it clearly as the property of the owning organization.
- Overlay the watermark in a way which makes it difficult to remove, if the goal of indicating property rights is to be achieved.



Invisible Watermark



Watermarks: Secret Code for Protection

1 Depending cn the chosen technique, noise is added to every data element or just to a pseudo-random subset

2 Hidcen information (watermark) is embedded in the noise signal of the original.

3 Watermark is invisible and can be retrieved only by extraction software.

Types of Watermarks (II)

- Robust watermarks:
  - There should be no way of removing the embedded information without rendering the cover object unusable
  - Visible watermarks
  - Unperceivable watermarks
  - Fingerprinting:
    - a unique watermark in each object
  - Applications:
    - To resolve original owner/creator disputes
    - Detect copies copyrighted material
    - Fingerprinting
      - Traitor tracing – detect who leaked a copy

Types of Watermarks (II)

- Fragile watermarks
  - Any manipulation of the cover object removes the watermark
  - Can detect changed objects, compressed copies, etc.
  - Also useful with fingerprinting
  - Applications:
    - Only allow devices to play watermarked objects
      - No copies
    - Fingerprinting
      - Only allow objects to be played on one, unique device

Properties/Features of Digital Watermarks

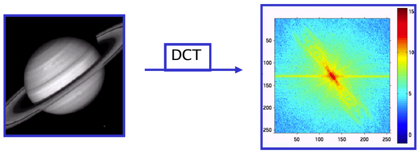
- Invisible/Inaudible
  - Information is embedded without digital content degradation, because of the level of embedding operation is too small for human to notice the change.
- Inseparable
  - The embedded information can survive after some processing, compression and format transformation.
- Unchanging data file size
  - Data size of the media is not changed before and after embedding operation because information is embedded directly into the media.

Image watermark

- Spatial Watermarks
  - Watermark is inserted in the spatial domain
  - Has low bit capacity
  - Not robust to geometric distortions
- Spectral Watermarks
  - Watermark is inserted in the frequency domain
  - Watermark is generated using the principle of Direct Sequence Spread Spectrum (DS-SS)
    - » Image Adaptive DCT Watermarking
    - » Image Adaptive DWT Watermarking

Invisible Watermarking for Multimedia

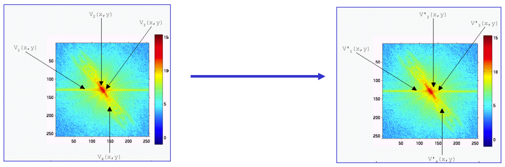
- E.g. Secure Spread Spectrum
- Non-visible watermarking using random vector
- Computation of spectral components using DCT
  - Discrete cosinus transformation
- Computation of various frequency bands according to luminance and chroma values

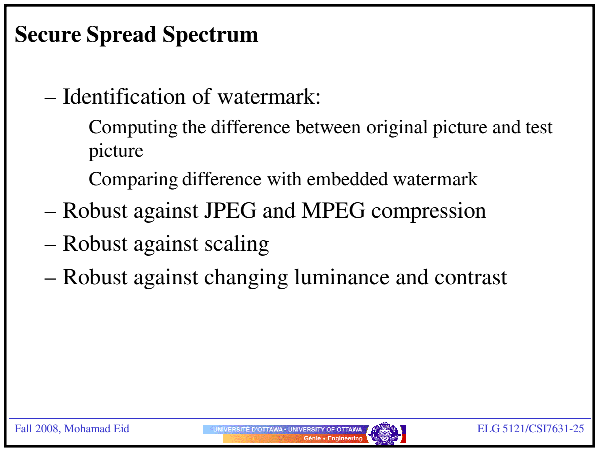


Secure Spread Spectrum

- Selection of n significant points
- Change values of these points by adding watermark

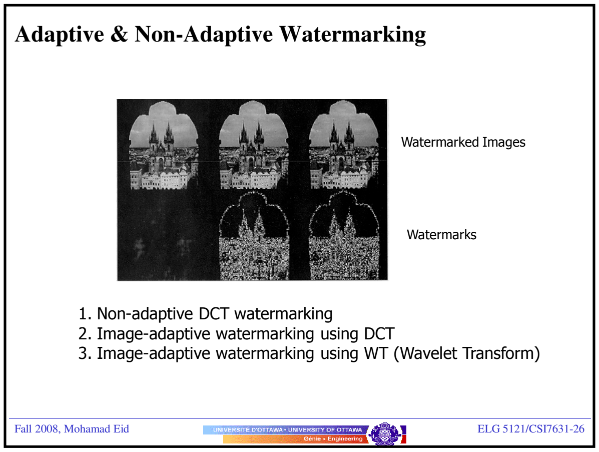
  E.g. $v'_i = v_i + \alpha x_i$





Secure Spread Spectrum

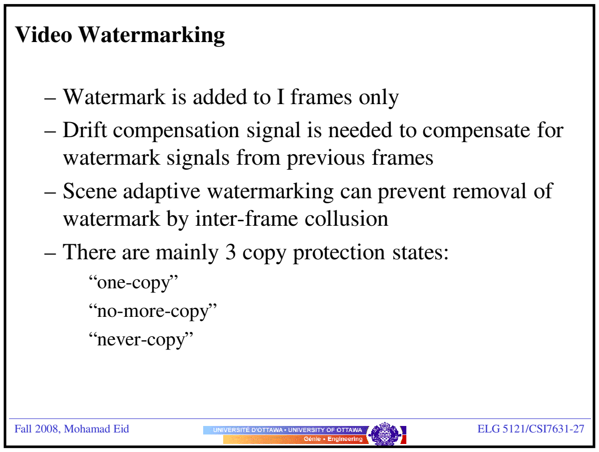
- Identification of watermark:
  - Computing the difference between original picture and test picture
  - Comparing difference with embedded watermark
- Robust against JPEG and MPEG compression
- Robust against scaling
- Robust against changing luminance and contrast



Adaptive & Non-Adaptive Watermarking

Watermarked Images
Watermarks

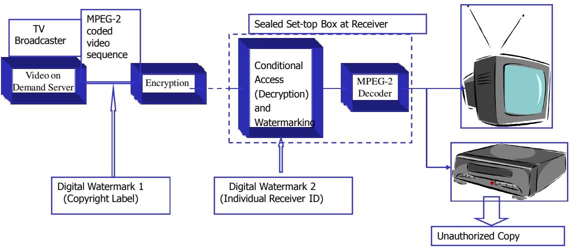
1. Non-adaptive DCT watermarking
2. Image-adaptive watermarking using DCT
3. Image-adaptive watermarking using WT (Wavelet Transform)



Video Watermarking

- Watermark is added to I frames only
- Drift compensation signal is needed to compensate for watermark signals from previous frames
- Scene adaptive watermarking can prevent removal of watermark by inter-frame collusion
- There are mainly 3 copy protection states:
  - "one-copy"
  - "no-more-copy"
  - "never-copy"

Broadcasting of Video with Watermarking

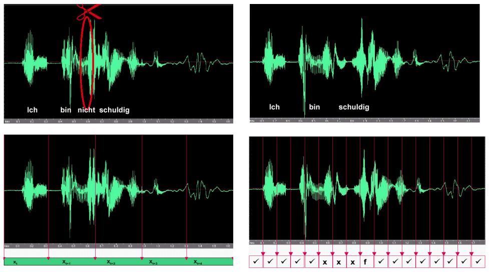

TV Broadcaster
MPEG-2 coded video sequence
Video on Demand Server
Encryption
Sealed Set-top Box at Receiver
Conditional Access (Decryption) and Watermarking
MPEG-2 Decoder
Digital Watermark 1 (Copyright Label)
Digital Watermark 2 (Individual Receiver ID)
Unauthorized Copy

Audio Watermarking

- Watermarking in audio signal is a challenge due to Human Auditory System (HAS)
- Two main areas considered for modification,
  - Digital representation
    - WAV, AIFF or low quality μ-law format, etc
  - Signal’s transmission pathway
    - Digital, resampled, analog and over the air
- Watermarking
  - Low bit coding
  - Phase coding
  - Spread spectrum, etc

Audio - Watermarking - Integrity

Spread spectrum: Direct Sequence Spread Spectrum encoding (DS-SS)



Watermarking 3D Objects

- Research on digital watermarking of 3D objects is becoming important as more and more 3D data is entering the World Wide Web.
- Problems:
  - One must deal with low volume of data.
  - Handling and editing may involve a variety of complex geometrical or topological operations.
  - No unique representation of model data exists.
- The embedded watermark should be robust and resist all/most of the following modifications:
  - Rotation
  - Translation
  - Uniform Scaling
  - Polygon simplification
  - Randomization of points
  - Re-meshing
  - Mesh smoothing operation
  - Shearing

Requirements for 3D Object Watermarking

- Geometry is the best candidate for watermarking, being the least likely to be removed
- List of embedding primitives invariant to different geometrical transformations:

Altered by all transformations	coordinates of a point
Invariant to translation & rotation	length of line, area of polygon, volume of polyhedron
Invariant to rotation, uniform-scaling & translation	angles, ratio of areas of two polygons
Invariant to affine transformation	ratio of lengths of 2 segments of a line, ratio of volumes of 2 polyhedrons

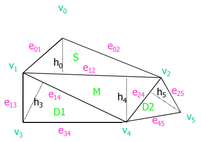
Triangle Similarity Quadruple (TSQ) Embedding

Tetrahedral Volume Ratio (TVR) Embedding

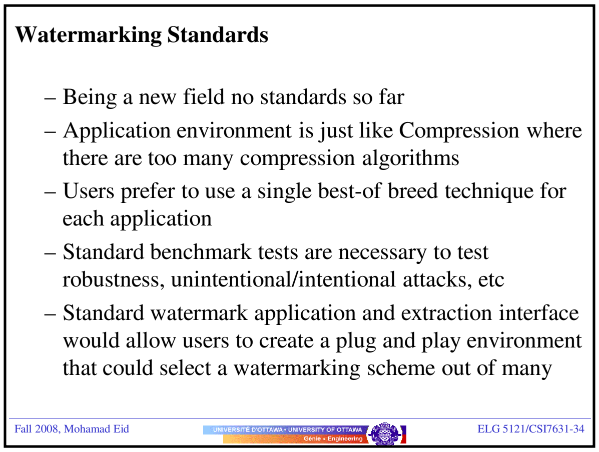
Mesh Density Pattern Embedding

TSQ Algorithm

- TSQ (Triangle Similarity Quadruple)Watermark Embedding

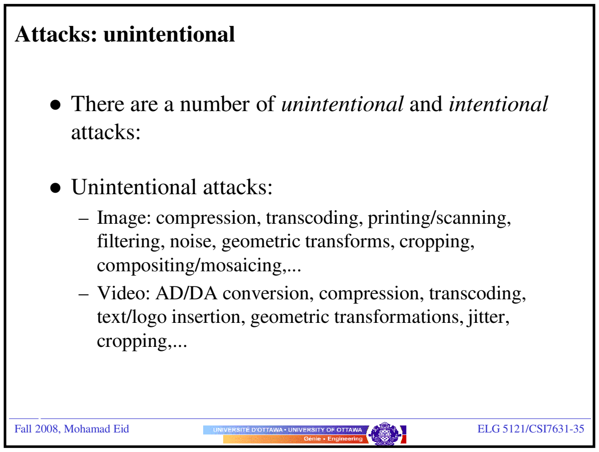


1. Find a set of triangles to be used as a Macro-Embedding Primitive (MEP)
2. Embed Marker value pair in the center triangle by changing $\{e_{14}/e_{24}, h_4/e_{12}\}$
3. Embed Subscript in the pair$\{e_{02}/e_{01}, h_0/e_{12}\}$ by displacing vertex v_0
4. Embed the two Data symbols similarly, displacing v_3 and v_5
5. Repeat steps 1-4 until all data symbols of the message are embedded



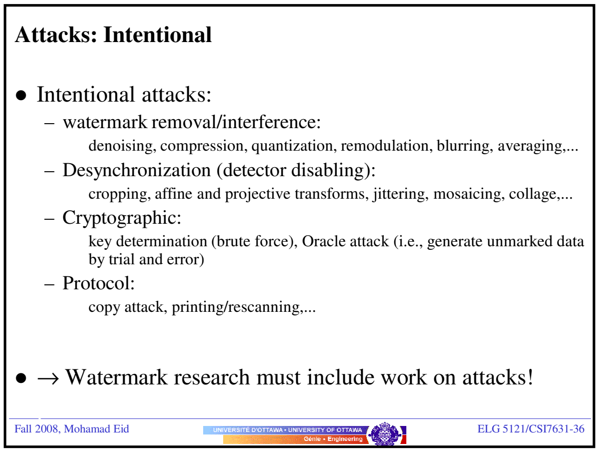
Watermarking Standards

- Being a new field no standards so far
- Application environment is just like Compression where there are too many compression algorithms
- Users prefer to use a single best-of breed technique for each application
- Standard benchmark tests are necessary to test robustness, unintentional/intentional attacks, etc
- Standard watermark application and extraction interface would allow users to create a plug and play environment that could select a watermarking scheme out of many



Attacks: unintentional

- There are a number of *unintentional* and *intentional* attacks:
- Unintentional attacks:
  - Image: compression, transcoding, printing/scanning, filtering, noise, geometric transforms, cropping, compositing/mosaicing,...
  - Video: AD/DA conversion, compression, transcoding, text/logo insertion, geometric transformations, jitter, cropping,...



Attacks: Intentional

- Intentional attacks:
  - watermark removal/interference:
    denoising, compression, quantization, remodulation, blurring, averaging,...
  - Desynchronization (detector disabling):
    cropping, affine and projective transforms, jittering, mosaicing, collage,...
  - Cryptographic:
    key determination (brute force), Oracle attack (i.e., generate unmarked data by trial and error)
  - Protocol:
    copy attack, printing/rescanning,...
- → Watermark research must include work on attacks!

LAW

– DMCA - Digital Millennium Copyright Act

– EU copyright directive

... "Member States shall provide adequate legal protection against the circumvention of any effective technological measures, which the person concerned carries out in the knowledge, or with reasonable grounds to know, that he or she is pursuing that objective." ..

"..."technological measures" means any technology, device or component that, in the normal course of its operation, is designed to prevent or restrict acts, in respect of works or other subject-matter..."

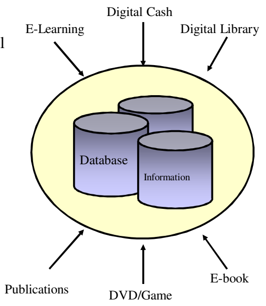
Summary

- Watermarking
  - Image, Video, 3-D models, Audio and Text
  - No watermarking technique is proven robust so far
  - Study of attacks leads to intensive evaluations of different watermarking techniques
  - Need for a standard to make watermarking systems interoperable
- Who is Interested:
  - Military and intelligence agencies
  - Criminals
  - Law enforcement and counter intelligence
  - Secret communication without encryption
  - Media companies

Case studies

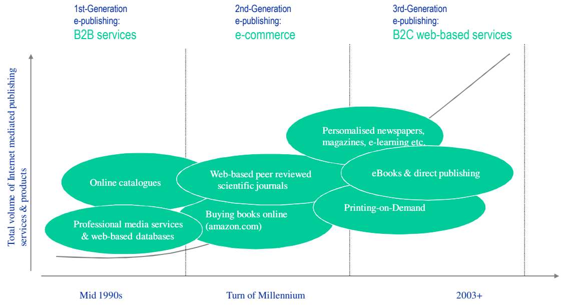
Case Study - Example (I)

- Digital Commerce
  - Publications
  - Digital TV, DVD
  - Digital Information(Digital Library)
  - Game
  - Music/Image/Movie
  - E-Book(Digital Book)
  - Cyber Education(E-Learning)
  - Digital Cash(Electronic Payment Protocol)
- Core
  - Digital Contents (eContents)



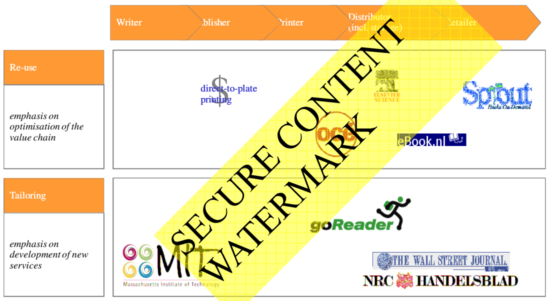
Case Study - Example (I)

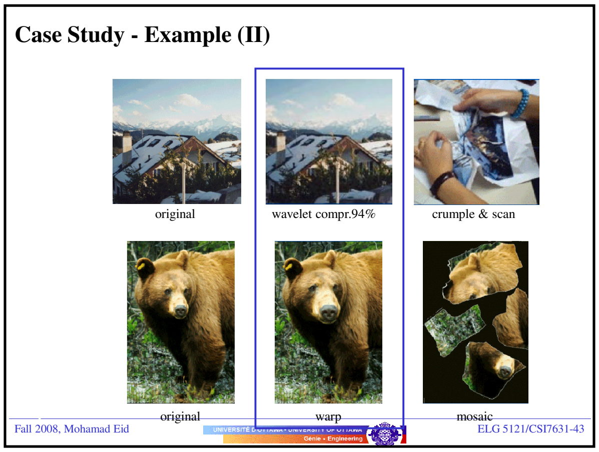
- Nevertheless, the evolution from traditional publishing towards multimedia rich web-based publishing is underway



Arthur D. Little, GigaPort

Case Study - Example (I)





Case Study - Example (II)

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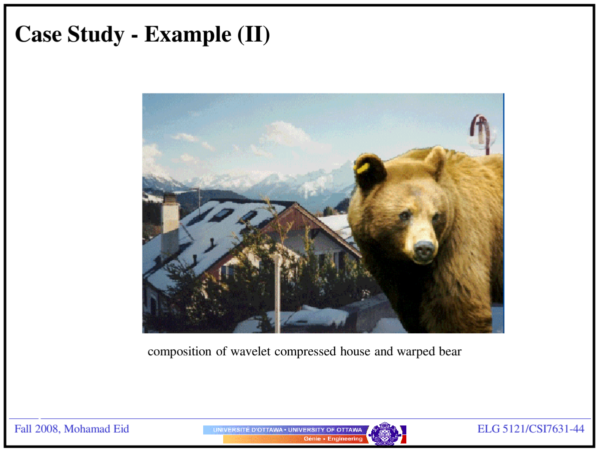

Case Study - Example (II)

composition of wavelet compressed house and warped bear

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