



Laboratoire  
d'Informatique  
de Robotique  
et de Microélectronique  
de Montpellier



# HYPER-CUBE WATERMARKING SCHEME

**Authors : Marc CHAUMONT**  
**Dalila GOUDIA**  
**William PUECH**

# OUTLINE

- Few words about high rate watermarking schemes
- The P-QIM algorithm [Li and Cox 2007]
- Improvements: Framework + Quality  
Improvement + ECC integration + Proof  
integration inside JPEG/H.264
- Experimental evaluations
- Conclusion

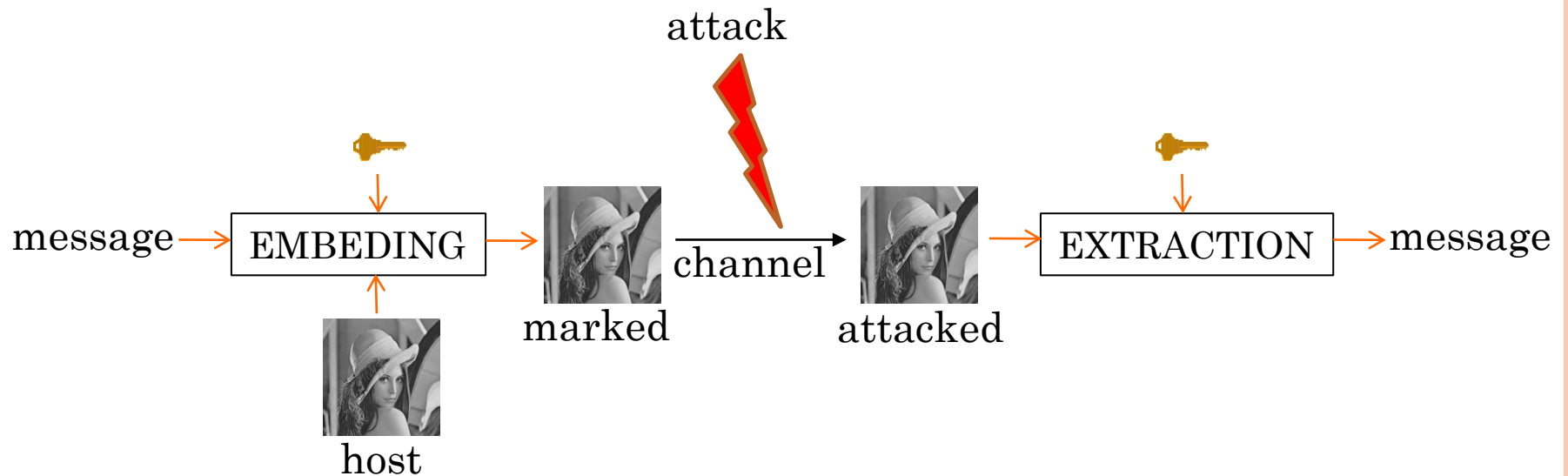


# FEW WORDS ABOUT HIGH RATE WATERMARKING SCHEMES

3

# HIGH RATE WATERMARKING SCHEMES

- General watermarking scheme



# HIGH RATE WATERMARKING SCHEMES

- Quantized-based:
    - DC-QIM, SCS, RDM, Perceptual-QIM...
  - Trellis-based:
    - DPTC
  - Mix of Quantized-based and Trellis-based:
    - T-TCQ
- ⇒ **payload  $\approx$  1 bit embedded for 64 pixels**  
(image  $256 \times 256 \Rightarrow 1024$  bits embedded)



# P-QIM ALGORITHM [LI AND COX 2007]

6

# P-QIM INTERESTING POINTS

- P-QIM [Li and Cox 2007] :
  - Quantized based  
use of QIM [Chen and Wornell 2001]
  - Robustness to valumetric attack  
use of RDM principle [Perez-Gonzalez et al. 2004]
  - Psychovisual masking  
use of a modified Watson Model [Watson 1993]

→ **A MATURE QUANTIZED BASED APPROACH**

# OUR PROPOSITION :

- There is not a clear Framework :
  - There is lots of incremental and experimental tests
  - Correcting codes are not enough evoked
  - **Give a clear and generic Framework**
- Non classical payload (2 bits in 64 pixels)
  - **Use a more realist payload  
and draw comparisons with known approaches**
- Possible block artifacts
  - **Suppress some block artifacts**
- **Proof of integration inside JPEG/H.264**

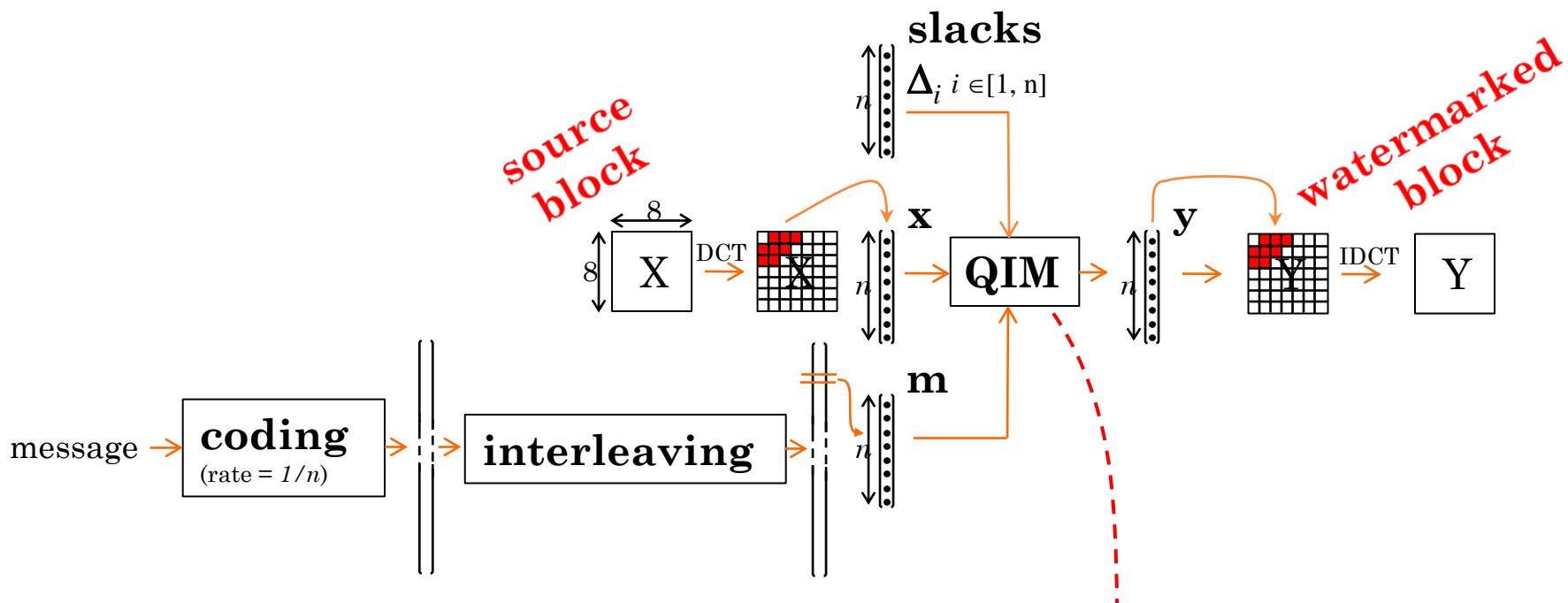




**IMPROVEMENTS: FRAMEWORK +  
QUALITY IMPROVEMENT + ECC  
INTEGRATION + PROOF  
INTEGRATION INSIDE JPEG/H.264**

# HYPER-CUBE WATERMARKING:

## → FRAMEWORK



$$Q_0(\mathbf{x}[i], \Delta_i) = 2\Delta_i \times \text{round} \left( \frac{\mathbf{x}[i]}{2\Delta_i} \right),$$
$$Q_1(\mathbf{x}[i], \Delta_i) = 2\Delta_i \times \text{round} \left( \frac{\mathbf{x}[i] - \Delta_i}{2\Delta_i} \right) + \Delta_i.$$

# HYPER-CUBE WATERMARKING: → PSYCHOVISUAL IMPROVEMENT



P-QIM, SSIM=98%  
payload = 1/64



Hyper-Cube, SSIM=98%  
payload = 1/64

# HYPER-CUBE WATERMARKING: → PSYCHOVISUAL IMPROVEMENT



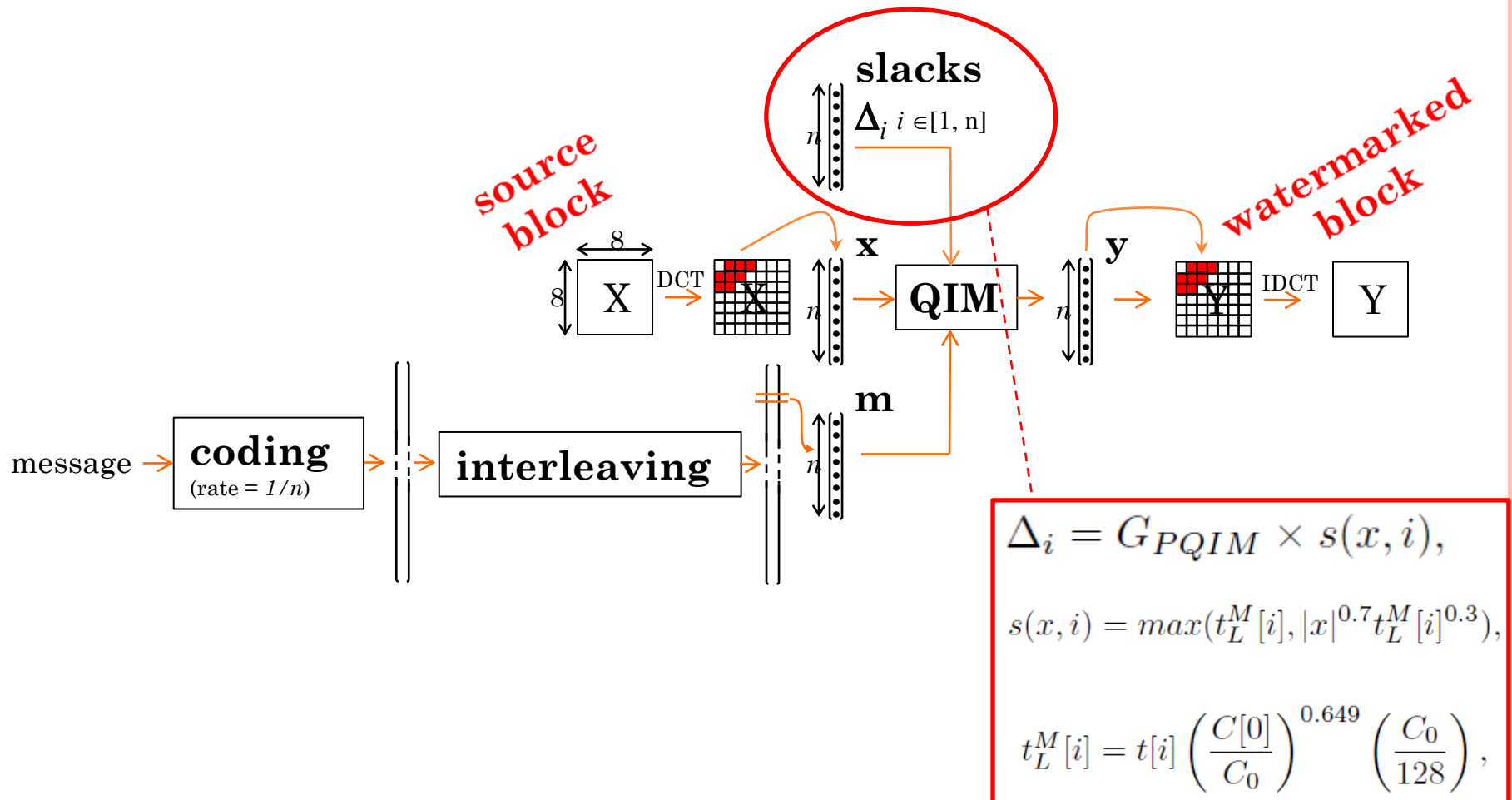
P-QIM



Hyper-Cube

# HYPER-CUBE WATERMARKING:

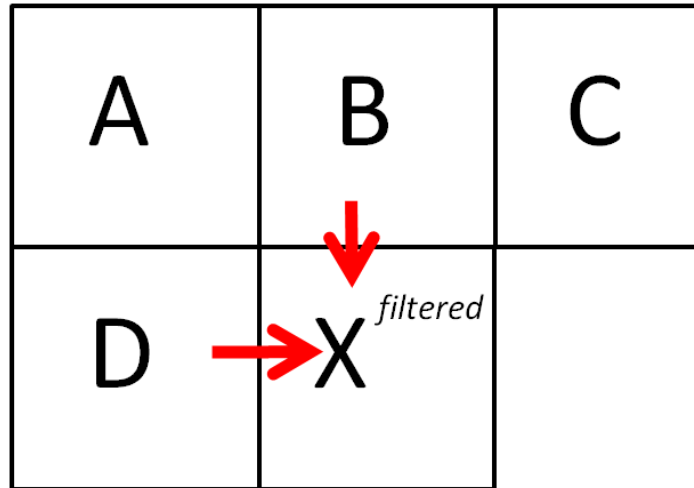
→ PSYCHOVISUAL IMPROVEMENT



# HYPER-CUBE WATERMARKING:

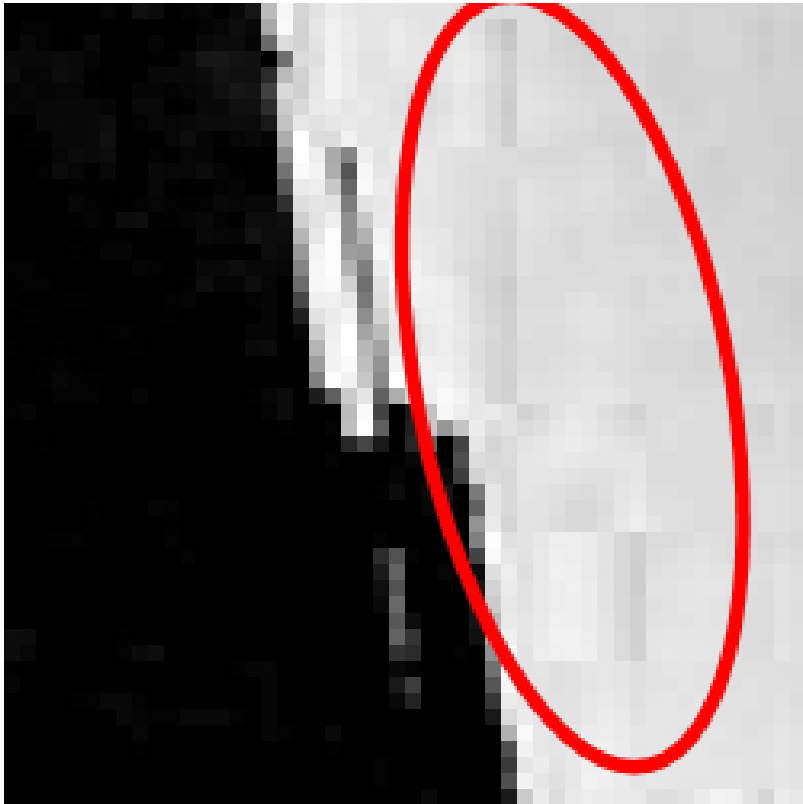
→ PSYCHOVISUAL IMPROVEMENT

- Slacks computed on a previously watermarked block B (top) or D (left) for current block X



- Selection of the spatially closest block B or D

# HYPER-CUBE WATERMARKING: → PSYCHOVISUAL IMPROVEMENT



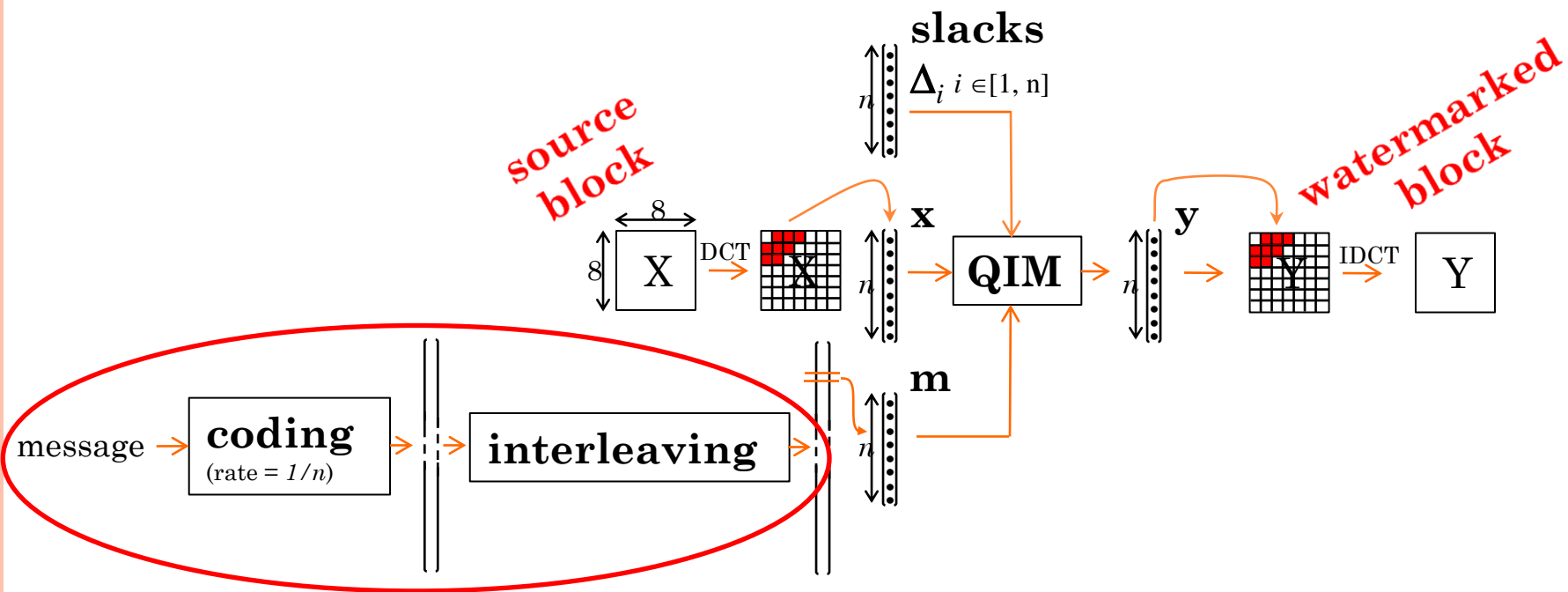
P-QIM



Hyper-Cube

# HYPER-CUBE WATERMARKING:

→ ECC INTEGRATION

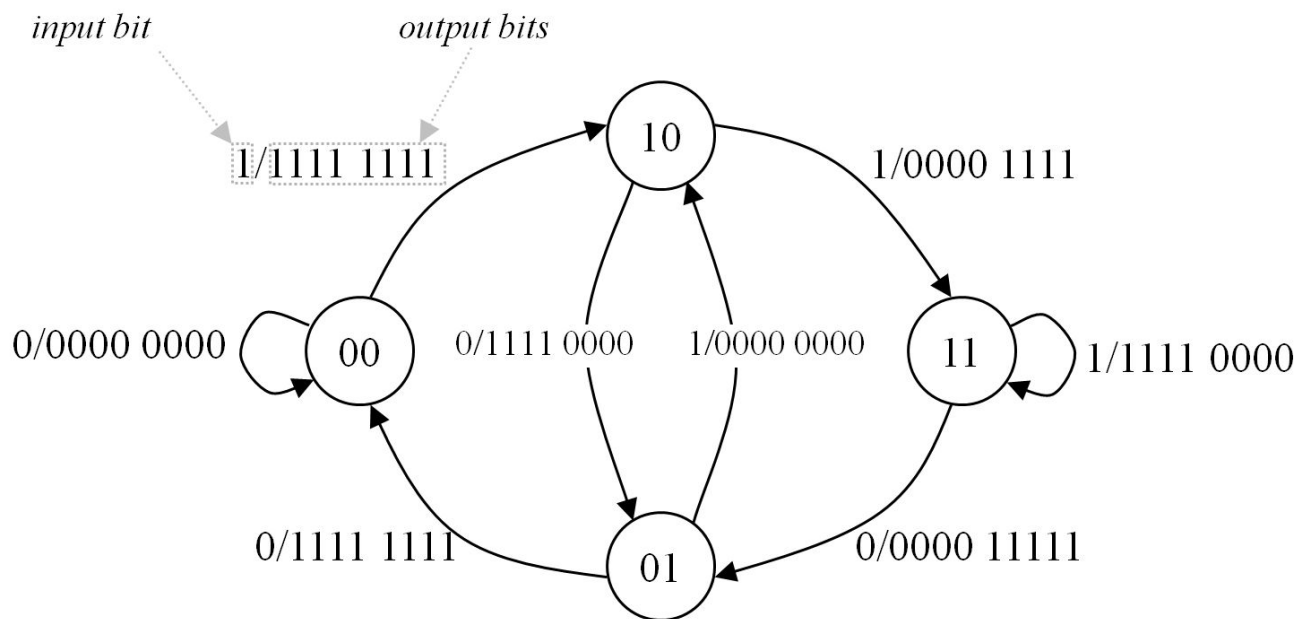




# HYPER-CUBE WATERMARKING:

→ ECC INTEGRATION

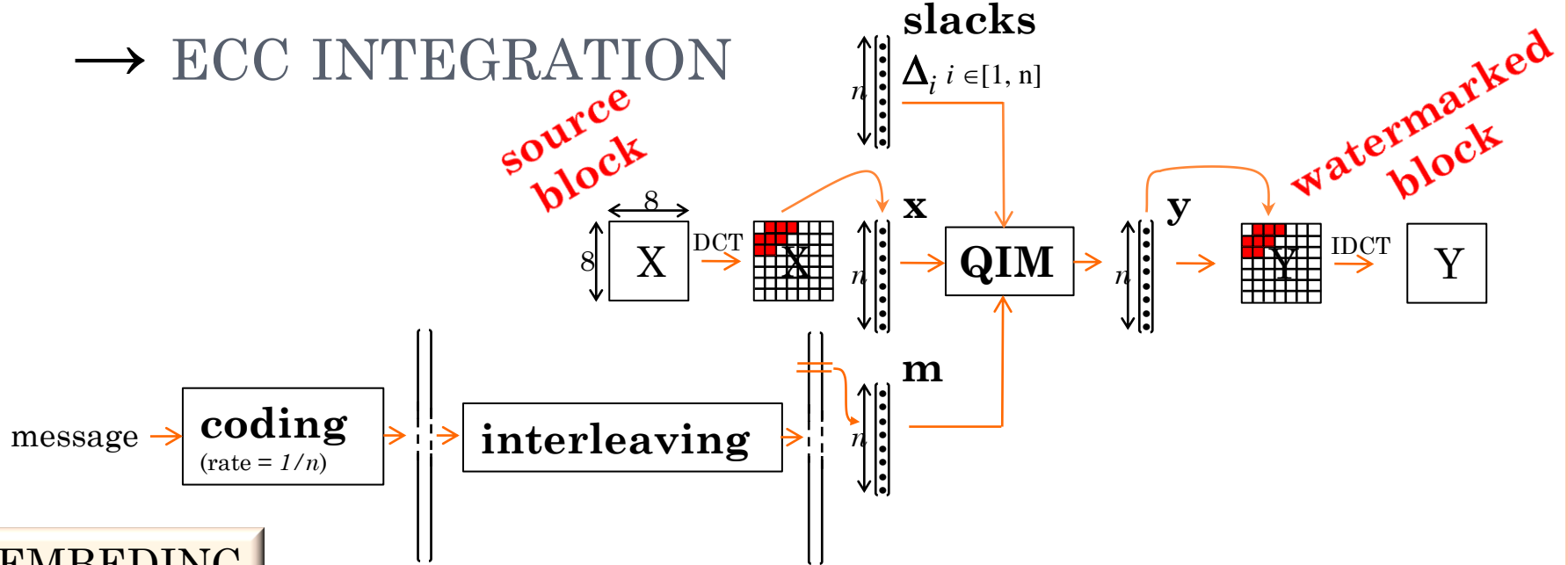
## ○ Convolutional Correcting code



State machine of the convolution code 1/8-rate 2-memory.

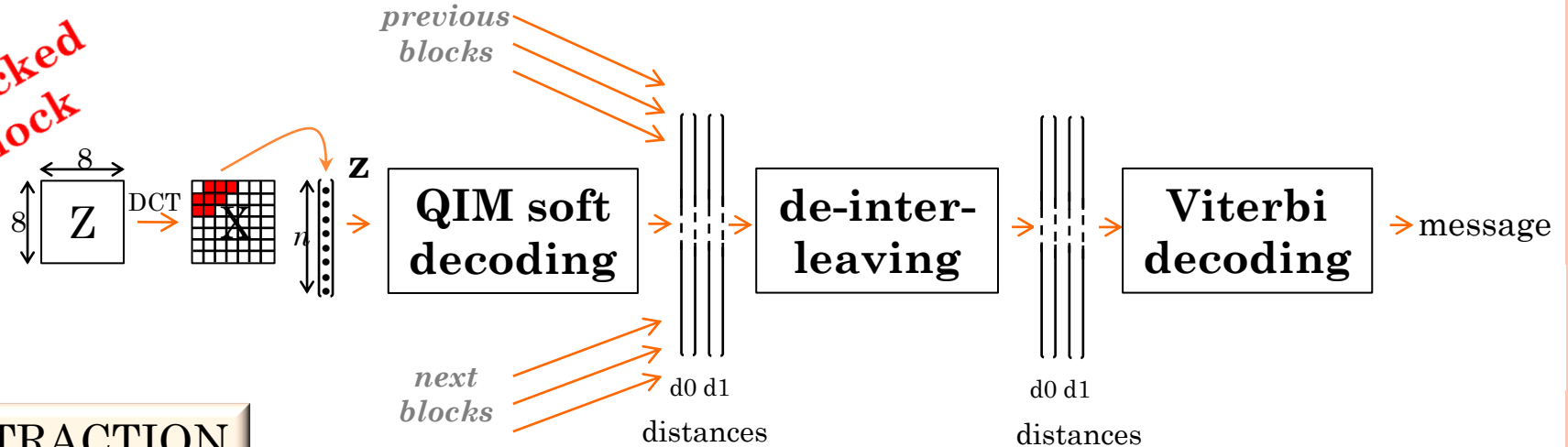
# HYPER-CUBE WATERMARKING:

→ ECC INTEGRATION



EMBEDDING

attacked block



EXTRACTION



# EXPERIMENTAL EVALUATIONS

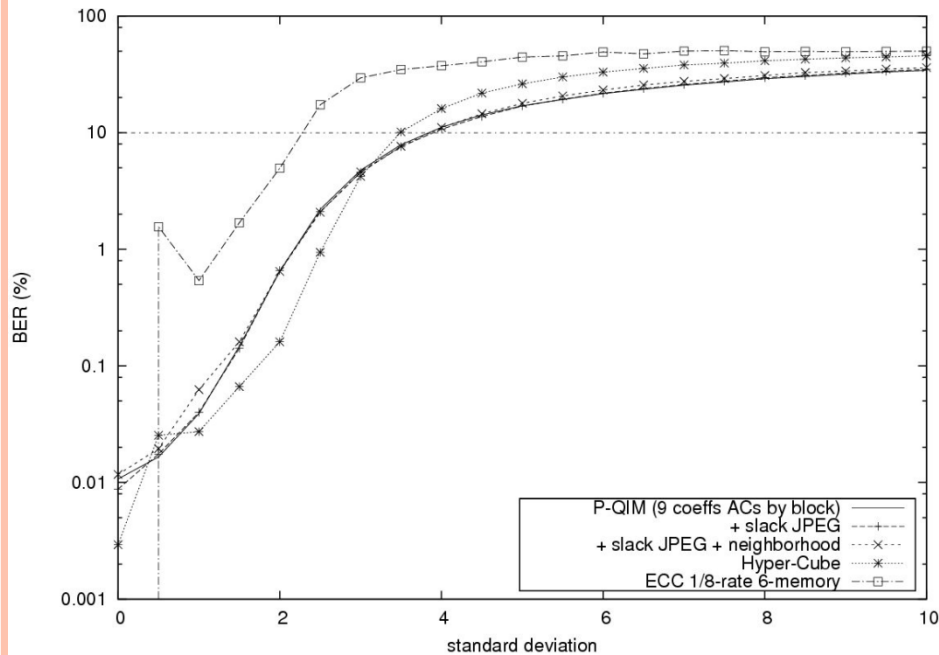


19

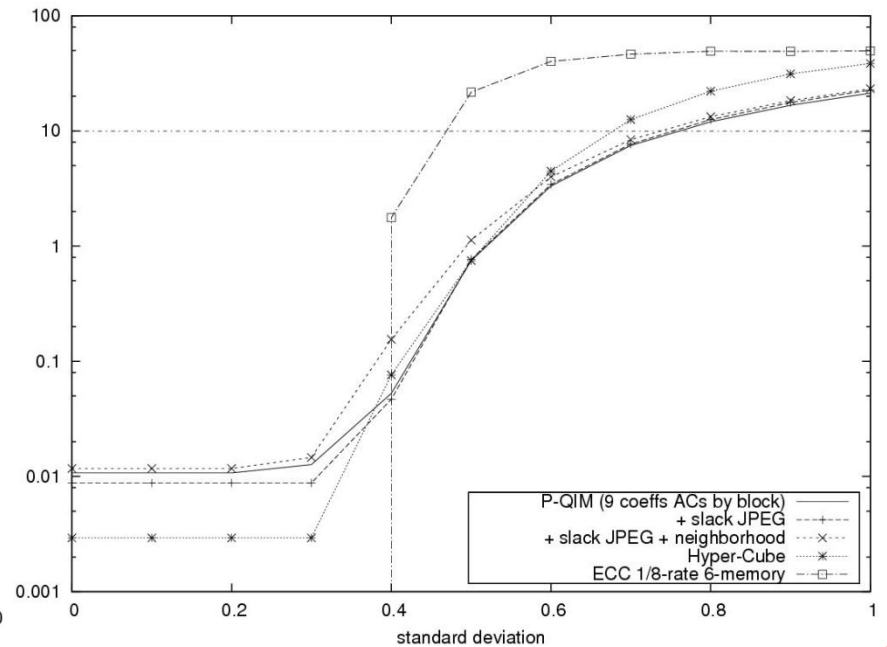
# EVALUATION & ALGORITHMS

- 100 images 256×256
- 5 different versions are competing with a fix SSIM = 98% and a fix payload = 1/64 :
  - P-QIM like approach with adapted parameters,
  - Version « + *slacks JPEG* », → **Scheme integrable inside JPEG/H.264**
  - Version « + *slacks JPEG + neighborhood* »,
  - Version « + *ECC 1/8-rate 6-memory* »,
  - Hyper-Cube (*slacks JPEG + neighborhood + ECC 1/8-rate 2-memory*).
- 4 attacks:
  - Gaussian noise,
  - Gaussian filtering,
  - Valumetric scaling,
  - Jpeg attack.

# ATTACKS (1) – FIXED SSIM = 98%

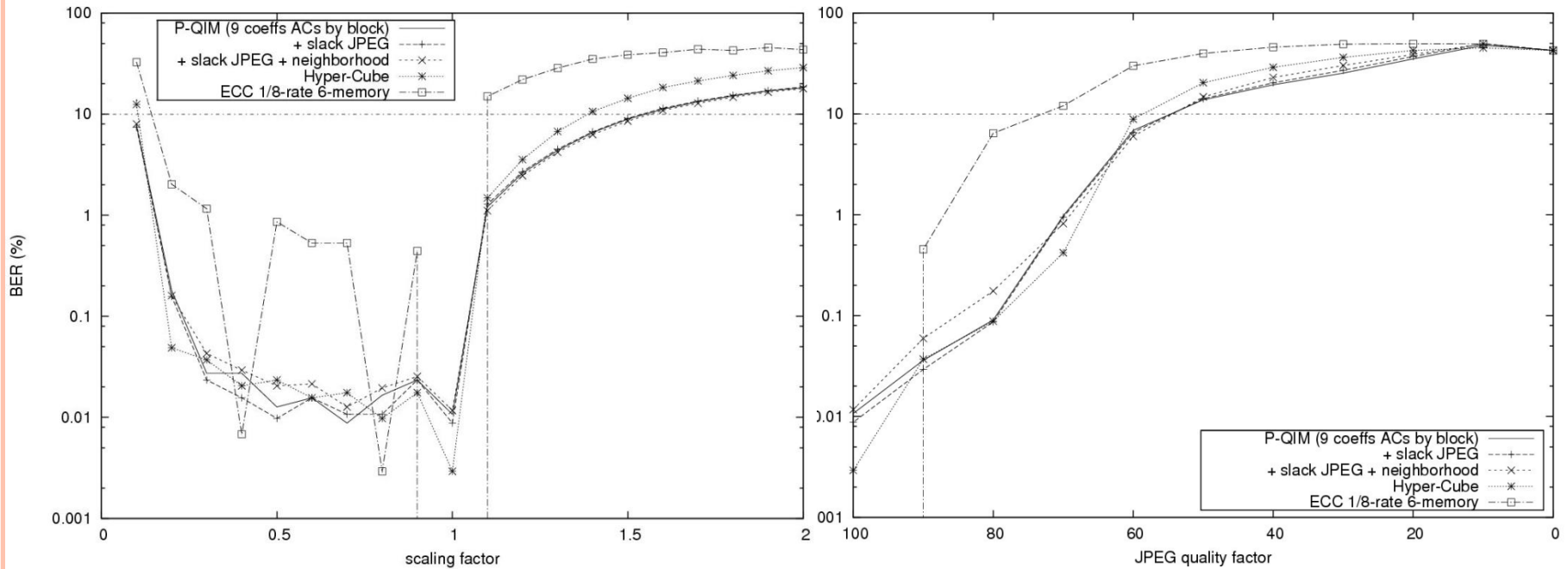


Gaussian noise attack



Gaussian Filtering attack

# ATTACKS (2) – FIXED SSIM = 98%



Valumetric scaling attack

Jpeg attack

A decorative vertical bar on the left side of the slide, featuring a gradient from dark blue to light orange. It is adorned with several orange circles of varying sizes. The largest circle is at the top, and smaller ones are scattered below it. The number '23' is centered within one of the circles.

# CONCLUSION & DISCUSSION

23

# CONCLUSION & DISCUSSION

- Practical framework,
- Better psychovisual results,
- Easy to improve using the framework (QIM + ECC + psychovisual models),
- Easy to integrate jointly to JPEG/H.264 (experimental proof).
  
- Future work:
  - Integration of the T-TCQ,
  - Use of lattices suitable for large dimension,
  - Robustness to additional attacks.





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Dalila GOUDIA (PhD Student - LIRMM)

William PUECH (LIRMM)

**[marc.chaumont@lirmm.fr](mailto:marc.chaumont@lirmm.fr)**

**PAPER downloadable at**

**<http://www.lirmm.fr/~chaumont/Publications.html>**