



Laboratoire  
d'Informatique  
de Robotique  
et de Microélectronique  
de Montpellier



# HYPER-CUBE WATERMARKING SCHEME

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# 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

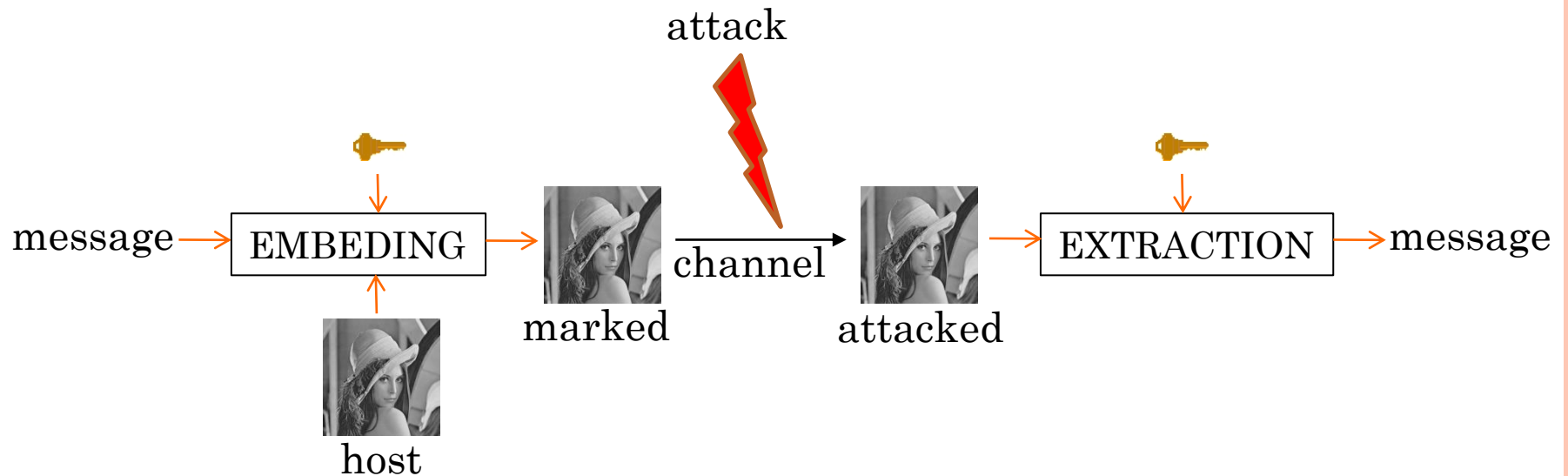


# FEW WORDS ABOUT HIGH RATE WATERMARKING SCHEMES

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 :

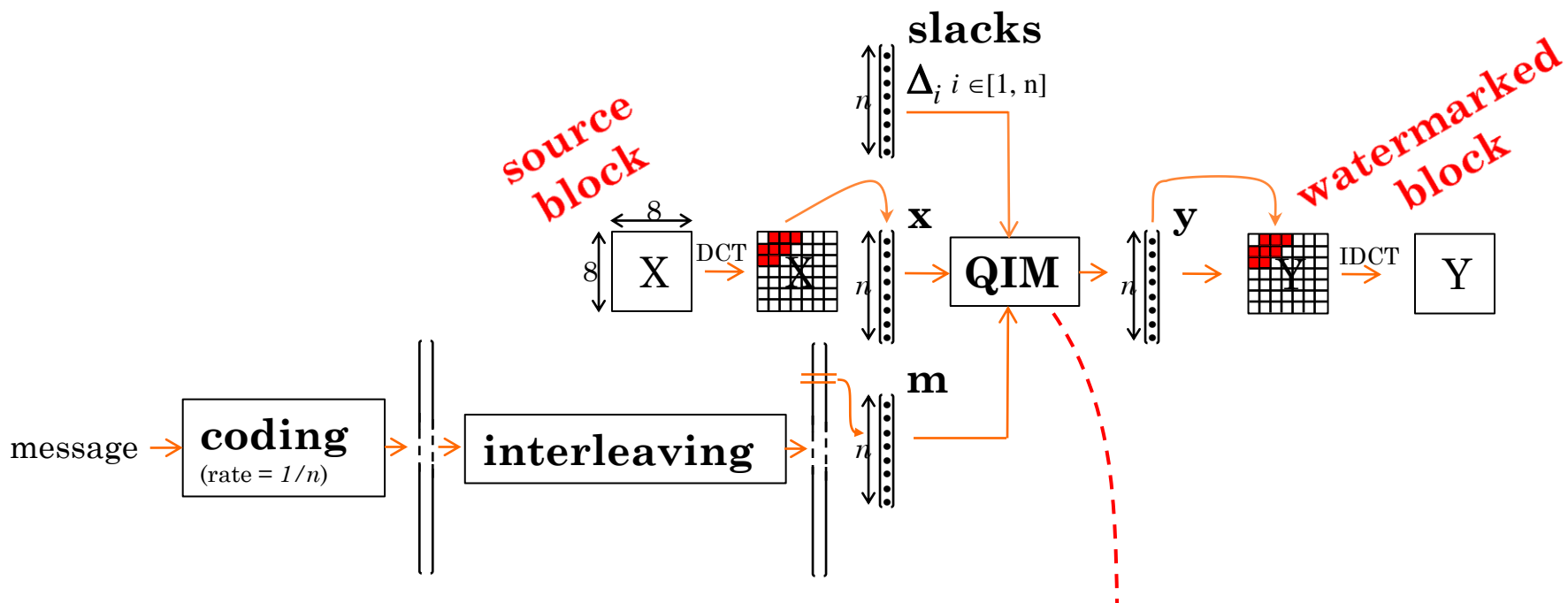
- There is not a clear Framework :
  - There is lots of incremental and experimental tests
  - Correcting codes are not enough evoked
  - **Give a clear and generic Framework**
- Non classical payload (2 bits in 64 pixels)
  - **Use a more realist payload  
and draw comparisons with known approaches**
- 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



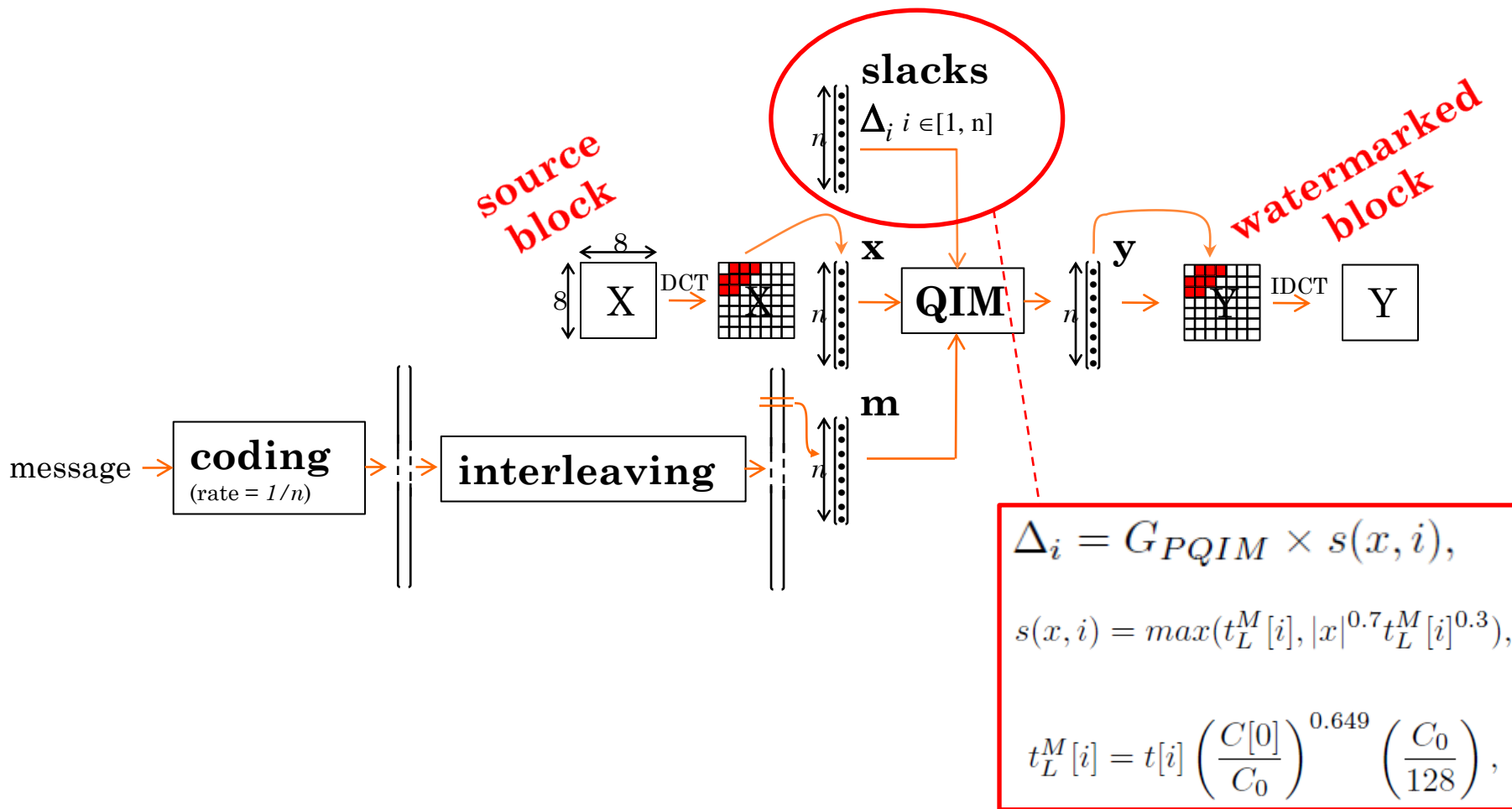
P-QIM



Hyper-Cube

# HYPER-CUBE WATERMARKING:

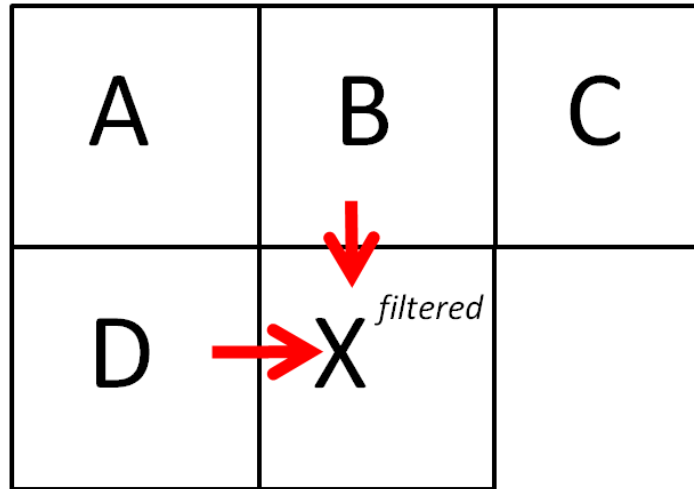
→ PSYCHOVISUAL IMPROVEMENT



# 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



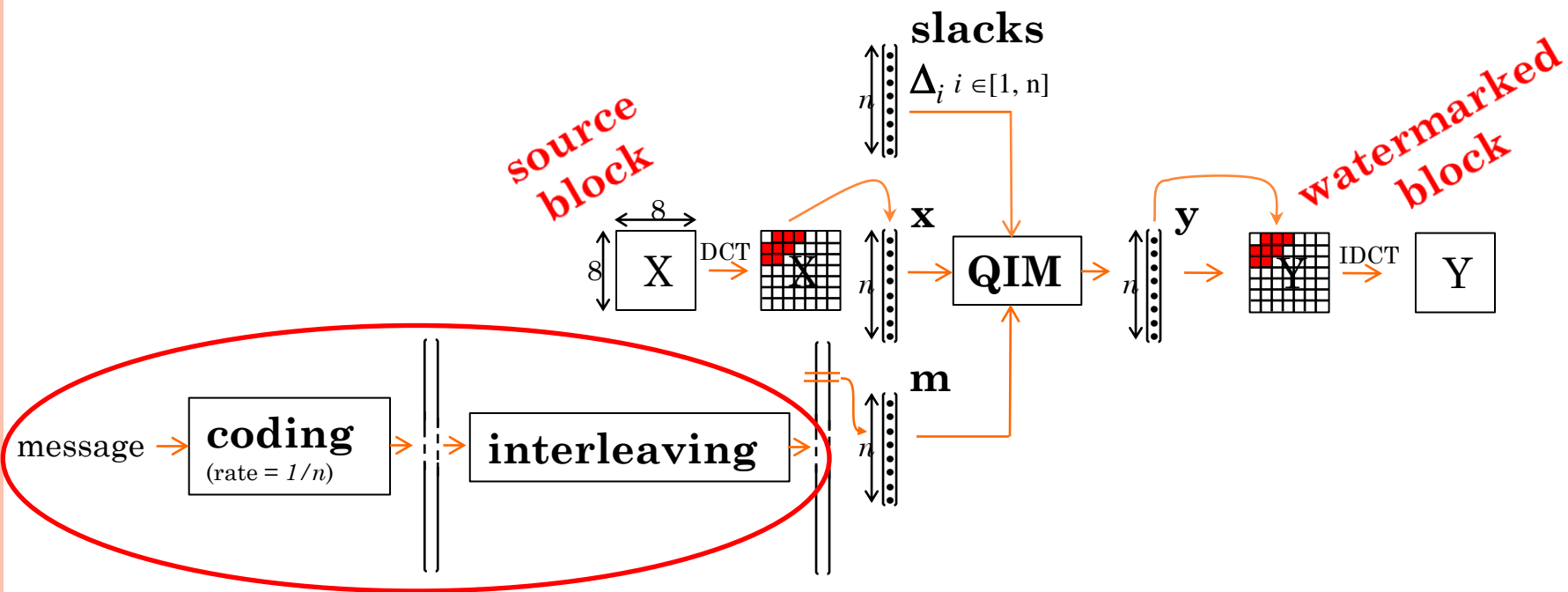
P-QIM



Hyper-Cube

# HYPER-CUBE WATERMARKING:

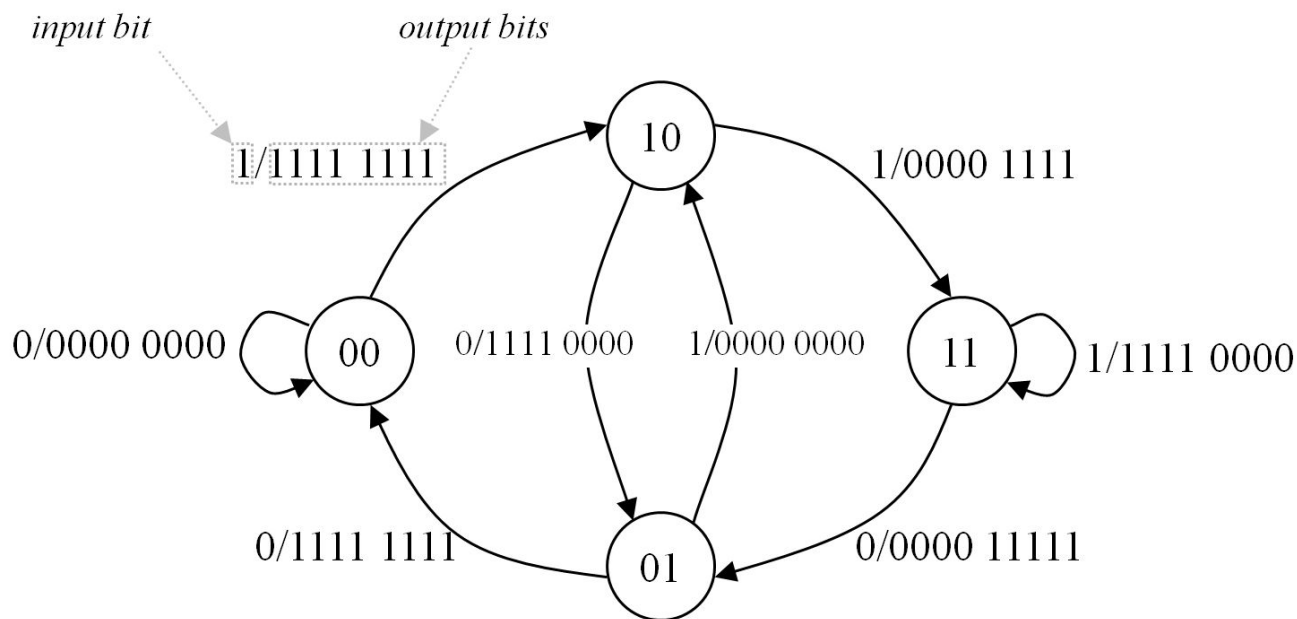
→ ECC INTEGRATION



# HYPER-CUBE WATERMARKING:

→ ECC INTEGRATION

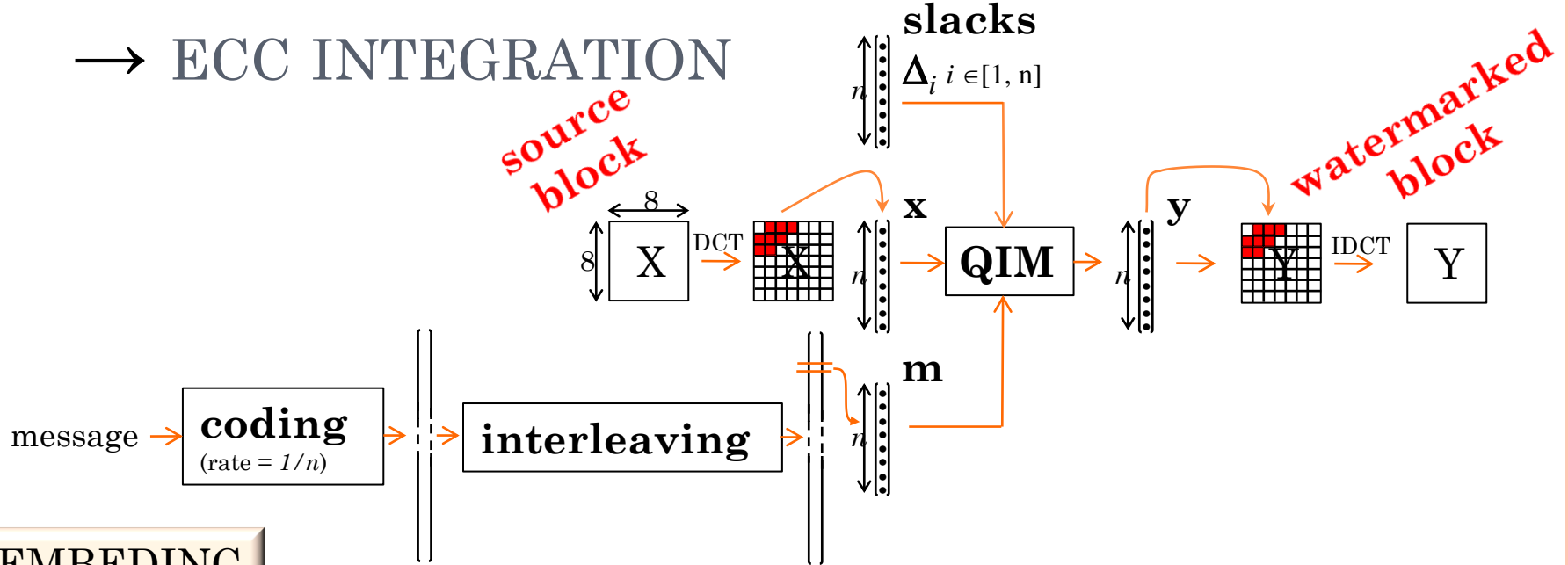
## ○ Convolutional Correcting code



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

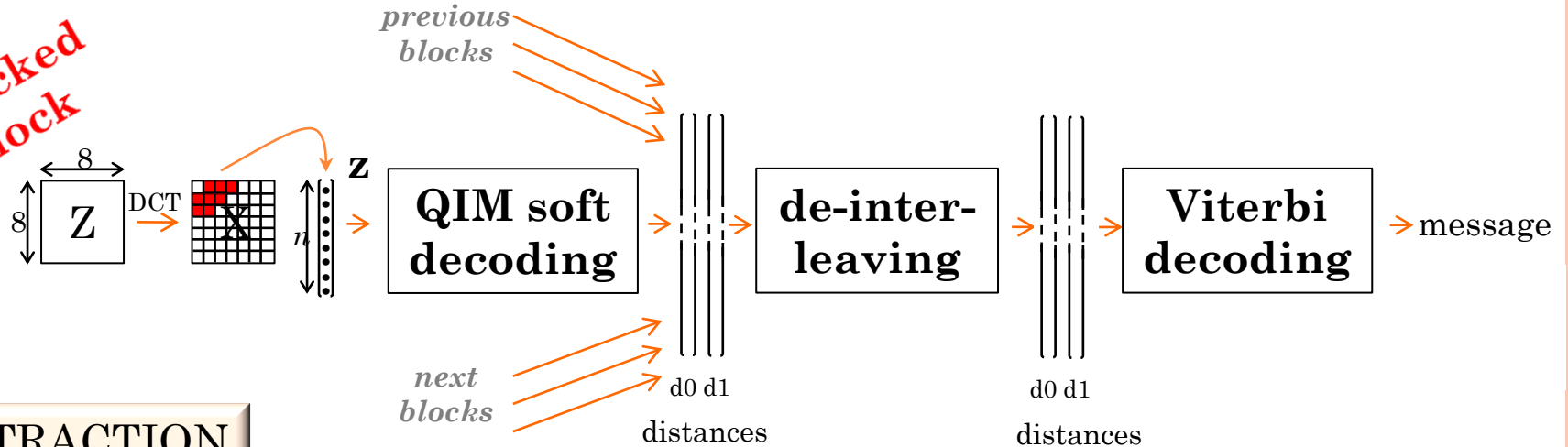
# HYPER-CUBE WATERMARKING:

→ ECC INTEGRATION



EMBEDDING

attacked block



EXTRACTION



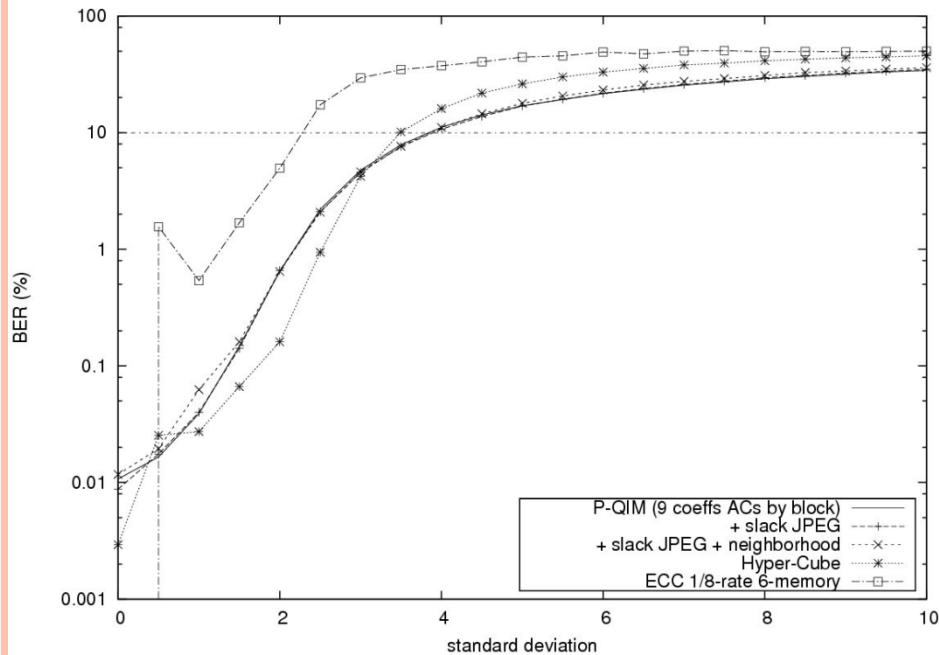
# EXPERIMENTAL EVALUATIONS

19

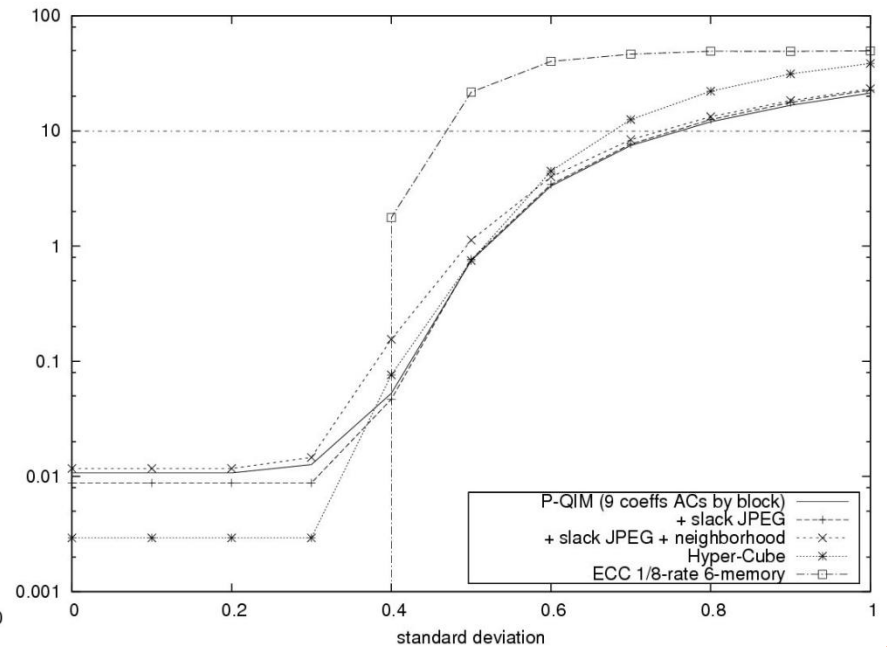
# EVALUATION & ALGORITHMS

- 100 images  $256 \times 256$
- 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%

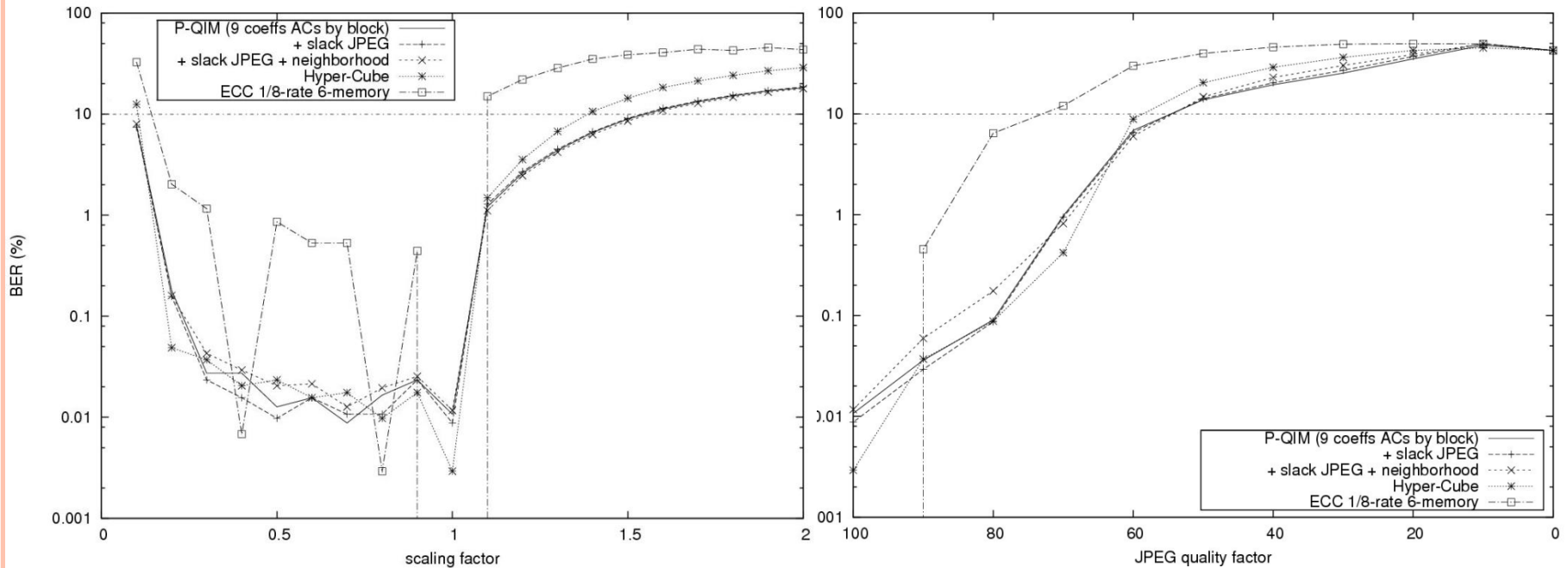


Gaussian noise attack



Gaussian Filtering attack

# ATTACKS (2) – FIXED SSIM = 98%



Valumetric scaling attack

Jpeg attack



# 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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**PAPER downloadable at**

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