A Foundation for Watermarking in Compressed Domain

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JPEG Compression

Image

DCT Transform → Quantizer → Entropy Coder

Encoder

Bit Stream

16	11	10	16	24	40	51	61
11	12	14	25	38	58	60	60
14	13	16	28	35	42	58	68
14	22	25	36	35	48	52	62
18	22	29	34	39	44	62	60
24	35	39	42	68	109	92	111
49	64	68	75	89	105	114	105
72	92	95	98	112	99	105	99

Quantization Table

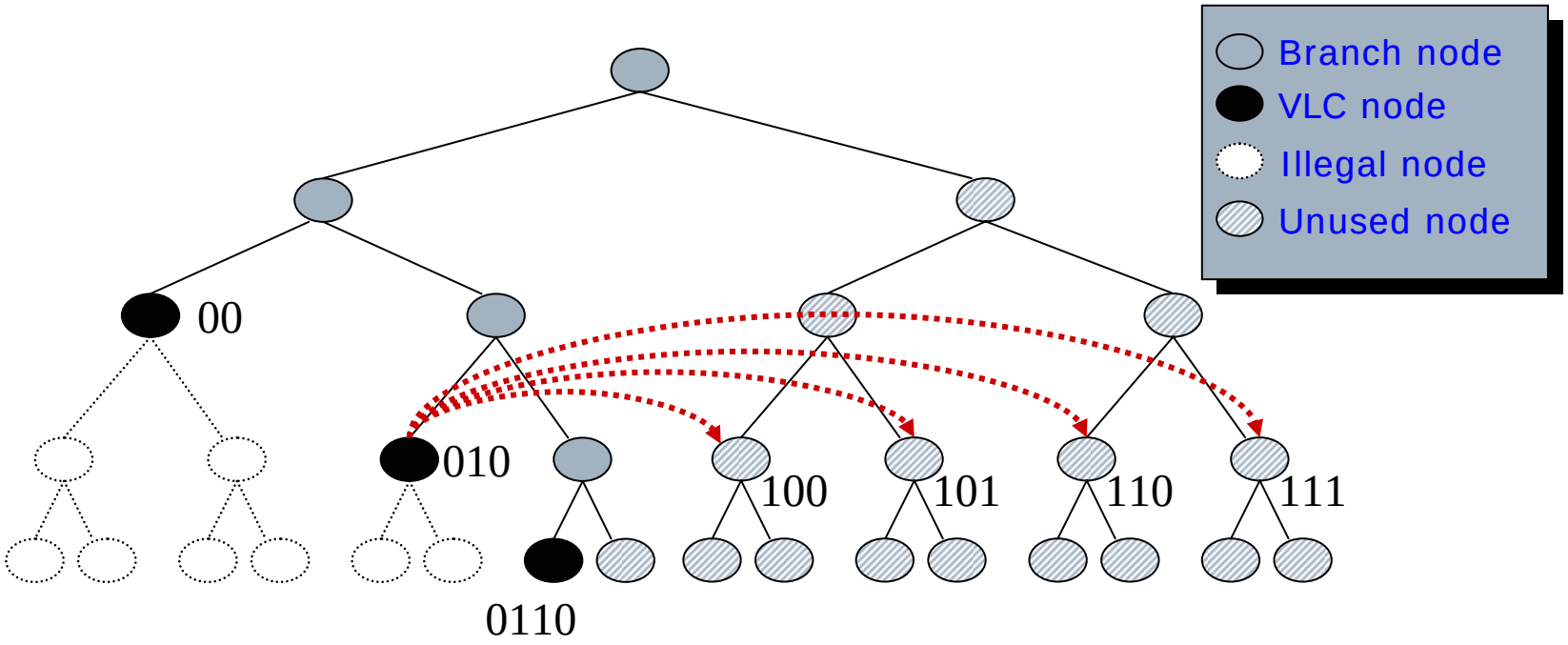
386	-29	-62	25	55	-20	-1	2
6	-21	-62	8	12	-7	-6	7
-46	8	77	-26	-30	10	6	-5
-49	12	34	-14	-10	6	1	1
11	-8	-12	-2	-1	1	-5	2
-10	1	3	-3	0	0	2	0
-3	-1	1	0	1	-4	2	-3
-1	-1	0	-3	0	0	-1	0

24	-3	-6	2	2	-1	0	0
1	-2	-4	0	0		0	0
-3	1		-1				0
-4	1						
1	0						0
0							0
0							0
0					0	0	0

Modify

Proposed scheme

- Code tree: $V = \{00, 010, 0110\}$
  - Step 1: Build a code tree of Huffman Coding

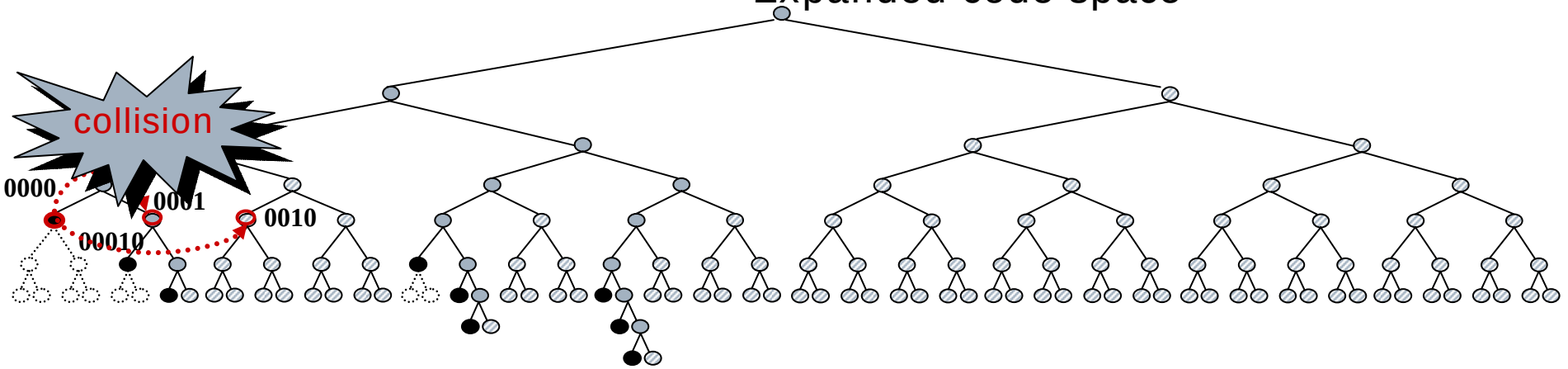


Map a VLC code to an *unused* codeword for watermarking.

Proposed scheme (cont.)

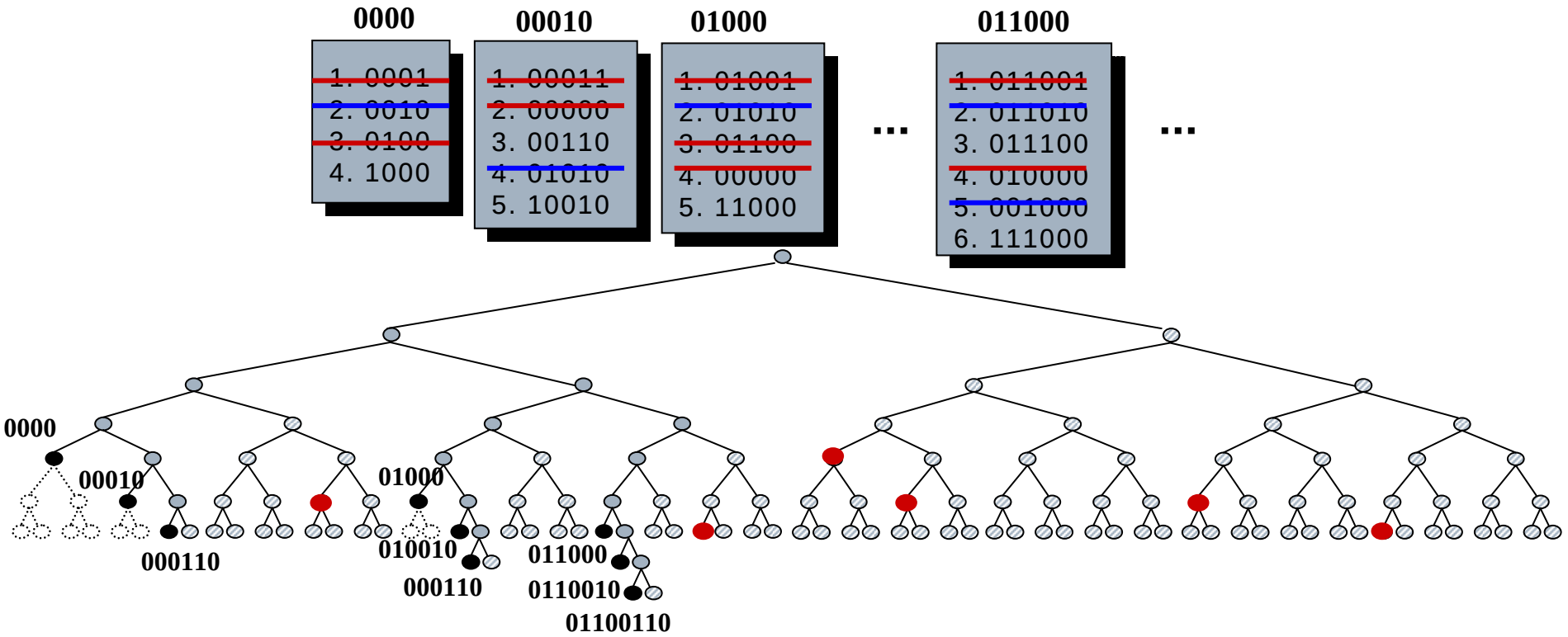
- Code tree: V={00, 010, 0110}
  - Step 2: Expand the total code space by pairing

1.(00 00) 2.(00 010) 3.(00 0110)
4.(010 00) 5.(010 010) 6.(010 0110)
7.(0110 00) 8.(0110 010) 9.(0110 0110)



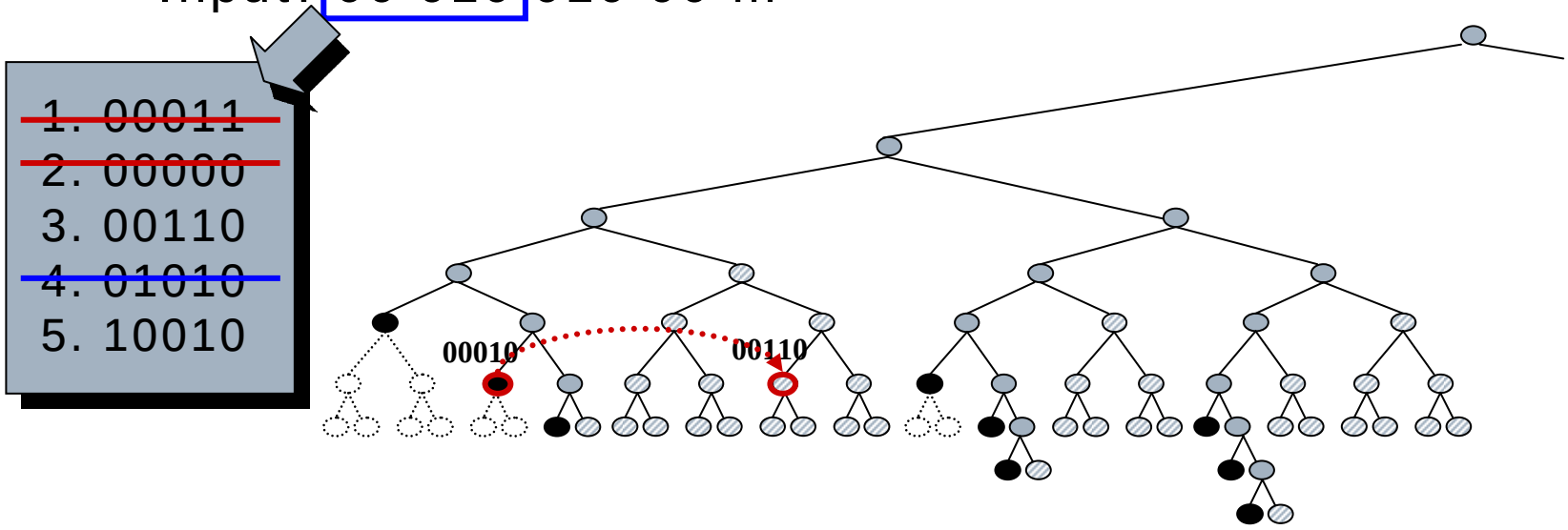
Proposed scheme (cont.)

- Code tree: $V=\{00, 010, 0110\}$
  - Step 3: Find all the possible mappings for each code



Proposed scheme (cont.)

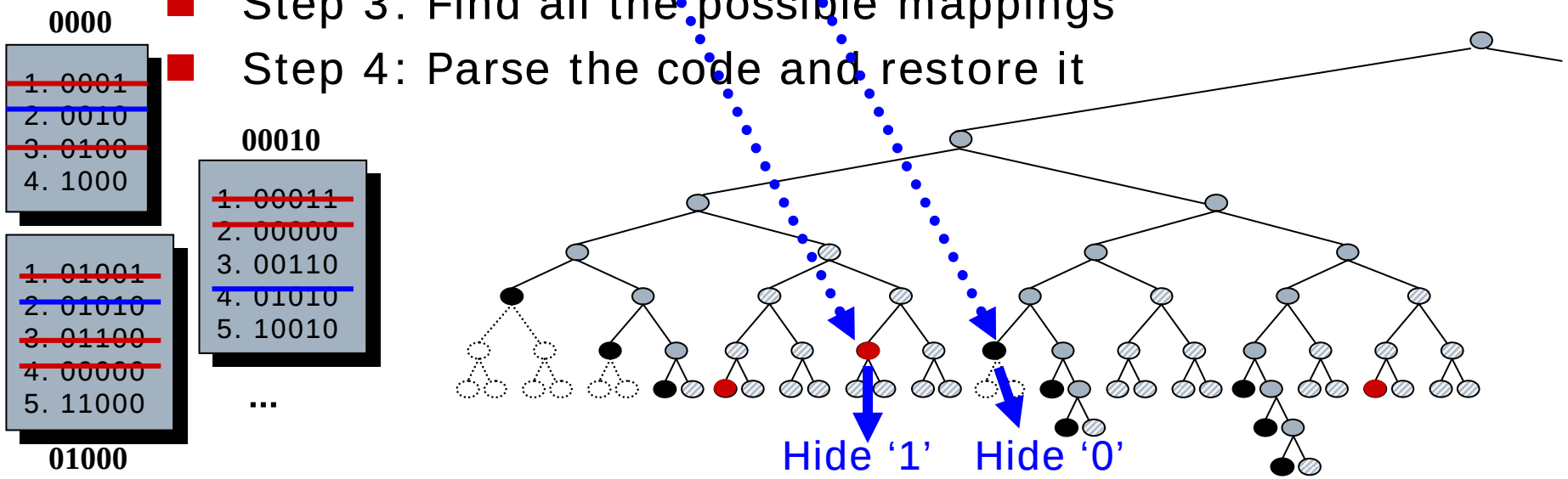
- Embedding:
  - Secret: 10...
  - Input: 00 010 010 00 ...



Output: 00 110 010 00 ...

Proposed scheme (cont.)

- Extracting:
  - Received: 00110 01000…
  - Step 1: Build the original code tree
  - Step 2: Build the expanded code tree
  - Step 3: Find all the possible mappings
  - Step 4: Parse the code and restore it



Experiment

TABLE I
WATERMARKING STATISTICS FOR *LENA.JPG* IMAGE

Total VLCs appearing in image	58
Watermarkable VLCs	31
File size for watermarking (bytes)	46,733
Payload (bits)	2300
Watermark capacity	0.61%

Conclusions

- Secret data is directly embedded into the compressed *bit stream*.
- The original compressed bit stream can be *restored*.
- It is applicable to any entropy-coded compression stream, provided that the total code space is not used.