



International Telecommunication Union

The First Joint ITU | ISO/IEC Still Image Compression Standards

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Outline

- o About the History
- o Continuous color still picture coding
 - JPEG1 (ITU-T T.81 | ISO/IEC 10918)
 - JPEG2000 (ITU-T T.800 Series) not discussed here
- o Bi-level image coding standards
 - JBIG-1 (ITU-T T.82)
 - JBIG-2 (ITU-T T.88)
- o Conclusions
- o Back-up slides (for more technical details)



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History

- o Both CCITT SGVIII and ISO TC97 SC2 WG8 had standardization groups for image coding in the mid 1980s
- o Historically both were targeted on image communication (such as Photovideotex)
- o In 1986 it was decided to create JPEG, the Joint (CCITT/ISO) Photographic Expert Group for cont. tone color image coding
- o In 1988 it was decided to create JBIG, the Joint (CCITT/ISO) Bi-level Image Group for b/w image compression and coding



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What is JPEG-1?

- o Basically a „color-blind“ image compression engine



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22-23 July 2005, ITU Headquarter, Geneva



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What is JPEG-1?

- o „Tool-Box“ type of standard for cont. tone color images.
- o It standardizes „common image components“ needed to create cont. tone color application standards
- o „Tool-Box“ is strictly separated from the application standard („bricks“ versus „building“ concept)
- o Therefore: originally no file format, no color space, no protocols (this was left to application standards)



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What is JPEG-1?

- 0 “Baseline” sequential (lossy)
 - 1. 8 bits/sample
 - 1. 8x8 DCT
 - 2. Huffman coding only
 - 3. Required in all JPEG-1 decoders
- 0 Extended sequential (lossy) option
 - 1. 8 or 12 bits/sample
 - 2. 8x8 DCT
 - 3. Huffman /Arithmetic coding (QM)



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What is JPEG-1? Cont.

- 0 Progressive (lossy)
 1. 8 or 12 bits/sample
 2. 8x8 DCT
 3. Huffman /Arithmetic coding (QM)
 4. SA, SS, and/or hierarchical
- 0 Lossless option
 1. 2-16 bits/sample
 2. Predictive based (DPCM)
 3. Huffman or arithmetic coding (QM)
 4. Sequential and/or hierarchical



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Progressive vs sequential

- 0 Sequential: 1 pass to final quality
- 0 Progressive : Multiple passes
 1. DC always separate pass(es)
 2. Spectral selection (SS): band of coefficients
 3. Successive approximation (SA)
 - 1st pass missing some lsb
 - 1 bit added per later pass(es)
 4. Can mix SS and SA
- 0 Following images by W.B. Pennebaker



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DC without l_{sb} (0.088 b/p)



progressive

2889 bytes



sequential

Entropy coder is QM.
Sequential to nearest 8 line boundary



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+1-63 AC w/o 3 lsb (0.283 b/p)



progressive



sequential

9282 bytes



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+1-63 AC 3rd Isb (0.482 b/p)



progressive



sequential

15796 bytes



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+1-63 2nd Isb (0.796 p/p)



progressive



sequential

26091 bytes



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DC + 1-63 AC lsb (1.379 p/b)



progressive



sequential

45172 bytes

Original = 512 x 512 bytes



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IPR Status JPEG-1

- o Royalty Free Baseline (this is challenged in practice)
- o RAND Options (Arithmetic Coding, Hierarchical)



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JPEG awards

- o Technical Emmy (with MPEG) 1996
- o Lawrence D. Eicher Leadership Award of ISO/IEC 2003



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Proposed enhancement to JPEG-1

- o Optional alternative arithmetic coders
 1. Fee-free Q-15 (in alternative baseline)
 2. MQ-coder from JPEG2000 & JBIG-2
- o DCT precision 8 through 16 bits/sample
- o Start of Image (SOI) marker replaced with JPG extension marker plus parameters
- o Converts into baseline with no loss if DCT-based



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History of Bi-level Image Coding Standard

- 1st. Gen. MH /MR(T.4) ; MMR (T.4/T.6) 1980, 1984 [Text, Lineart] **ITU-T Recommendations only**
One/Two-dimensional Runlength coding
- 2nd Gen. JBIG or JBIG1 (ISO/IEC 11544, T.82) 1993
[Text, Lineart, Halftone]
Markov-model coding +Res. Reduction
- 3rd Gen. JBIG2 (ISO/IEC 14492, T.88) 2000
[Text, Lineart, Halftone, Visually-lossless Text; Multi-page, Generated]
Pattern-matching + Markov-model coding /MMR



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What is JBIG1?

- Title: PROGRESSIVE BI-LEVEL IMAGE COMPRESSION
- The 1st Bi-level Image Coding Standard Developed by Joint Bi-level Image Experts Group [ISO/IEC JTC 1/SC29/WG1 (JBIG SG) & ITU-T SG8/Q.6] (WG9 & WG10 were merged into WG1 on Nov.1993)
- Published as :ISO/IEC 11544 | ITU-T Rec. T.82 (ITU-T FAX Profile : Rec.T.85) in 1993



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Bi-level image types

- Bi-level image typically consists of text, lineart and halftone
- Robustness to image types is achieved by Markov Model Coding (Context-base coding) with
 - Adaptive Templates
 - by a floating pixel
 - Adaptive Arithmetic Coding (QM-Coder)
 - built-in state transition rule for learning statistics (Common to JPEG Arithmetic)



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JBIG1 compression improvements from MMR

- o Also „tool-box“ type standard
- o **Breakthrough** improvement for *halftone* compression
 1. Periodical halftones: 10-30 times
 2. Non-periodical halftones: 3-5 times
- o **Enhanced** improvement for *text / line art* compression
 1. 20-50% improvement (**much in CG**)



IPR Status JBIG-1 (RAND)

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1. Arithmetic Coding

- IBM, AT&T ->Lucent, Mitsubishi
- One-time fee of \$5,000-\$15,000 to each

2. Image Reduction

- Canon, KDD, Mitsubishi

3. Adaptive adjusting of AT pixel

- AT&T -> Lucent



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What is JBIG2?

- Title: LOSSY/LOSSLESS CODING OF BI-LEVEL IMAGES
- The Second Bi-level Image Coding Standard
Developed by: ISO/IEC JTC 1/SC29/WG1 (JBIG SG) & ITU-T SG8/Q.6
[Joint Bi-level Image Experts Group]
- Published as :ISO/IEC 14492 & ITU-T Rec. T.88 (ITU-T FAX Profile T.89)
- Also „tool-box“ type standard



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JBIG2 compression

- o Improves all combinations of text, halftones, line art / input (scanned, generated)/# of pages/lossy or lossless



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JBIG2 Improvements

- o Breakthrough ***text*** compression (3-5)
 1. **Visually-lossless** for *scanned* text pages
 2. **Lossless** for *generated* text pages
 3. **Visually-lossless for *multi-page***
(another factor of 2 or more)
- o Enhanced ***text*** compression (20%)
 1. For **lossless** *scanned* pages
- o Enhanced ***halftone*** compression (20%)
 1. Extends earlier JBIG1 breakthrough for **lossless** halftone



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IPR status JBIG-2

- License-fee free patents: Arithmetic Coder (IBM, Mitsubishi)

Supposed IPR-Fee Free Profile(#6,#7)

- Decoder
- No Mixed Region
- At least two stripes per page

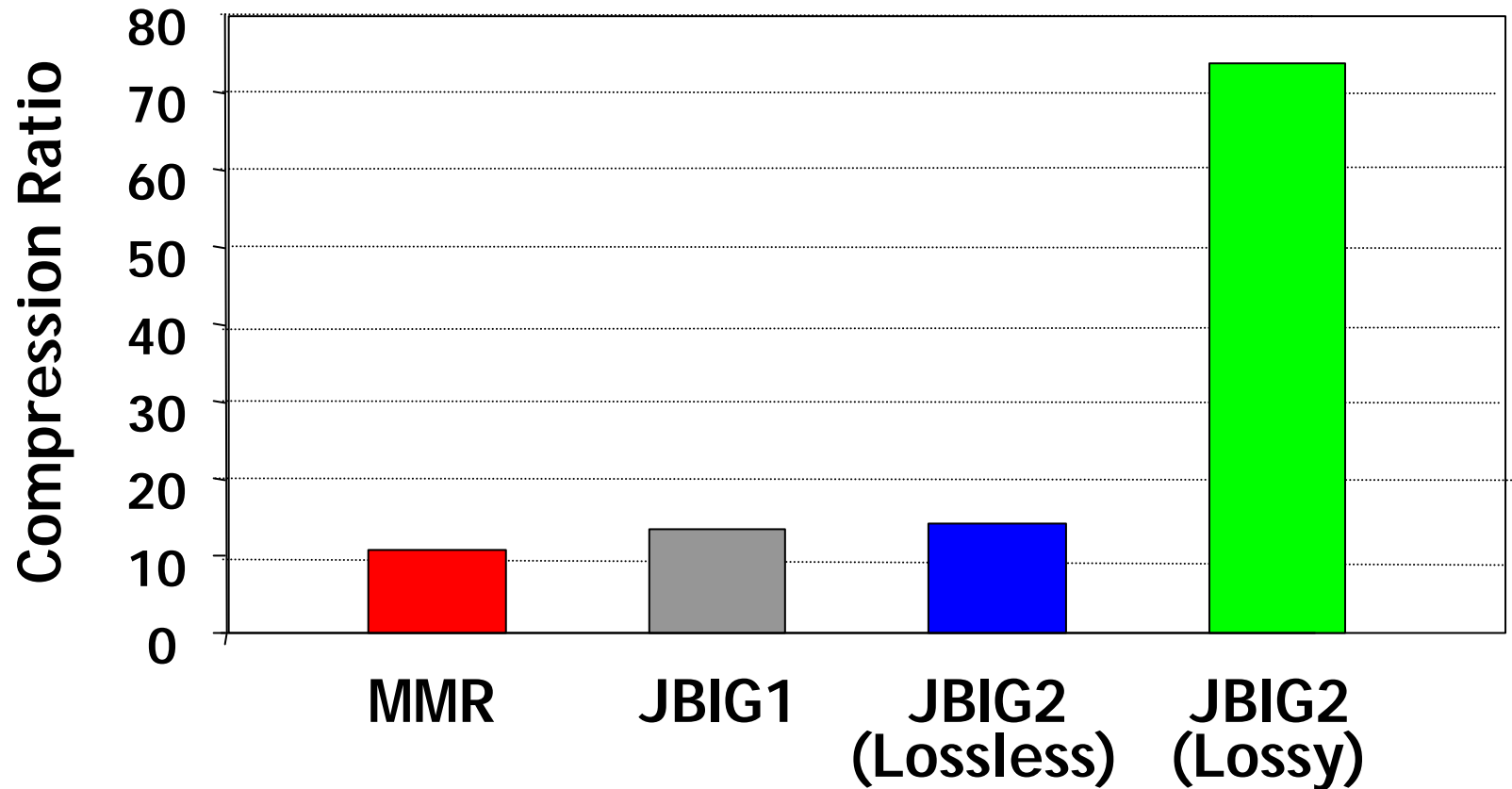
Other profiles RAND



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Breakthrough text compression

1 page memo (scanned)

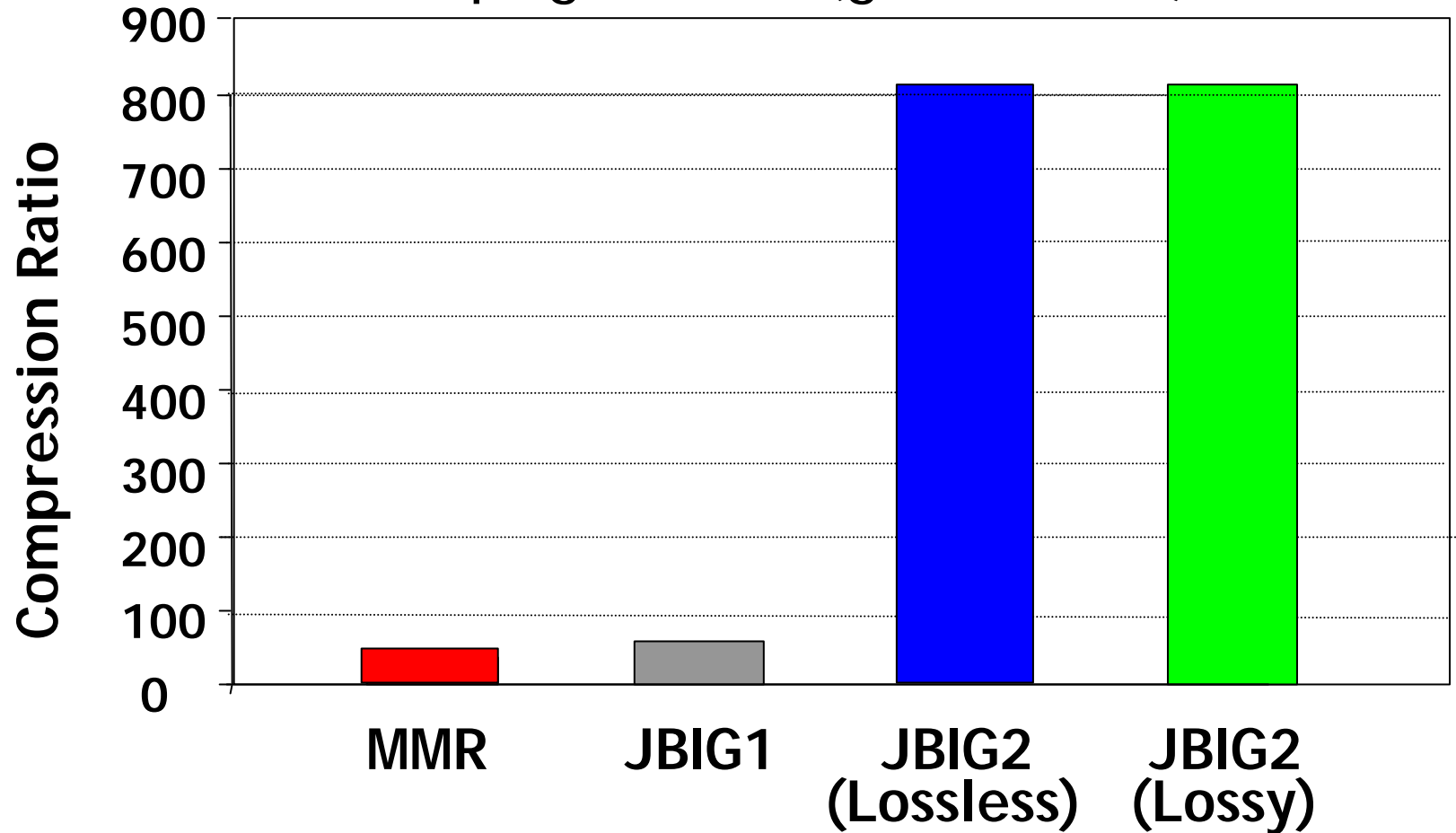




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Breakthrough text compression plus multi-page compression

512 page book (generated)





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Bi-level compression summary

- o Lossless compression ratios:
 1. MH:7
 2. MR:10
 3. MMR:15
 4. JBIG1:18
 5. JBIG2:21

- o Visually Lossless compression ratio:
 1. JBIG2:100



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Conclusions

- o Excellent co-operation between ISO/IEC and ITU-T
- o Technical Breakthrough both in bi-level and color still picture compression technology and standards
- o Huge Market breakthrough for JPEG-1 - one of the most successful standards ever
- o JPEG-1 like market breakthrough for JBIG-1 and JBIG-2 yet to come



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Thanks!

o Questions?



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Back up slides



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Abstract

- o ISO and ITU (then known as CCITT) joined forces in 1986 to create the Joint Photographic Experts Group (JPEG) committee to establish a still image continuous-tone data compression standard. This cooperation extended to a sister organization, the Joint Bi-Level Image Experts Group (JBIG), when it split off from JPEG in 1988 to focus on two-tone (e.g. binary facsimile) images. The first joint standard (nicknamed JPEG-1) is widely used in cameras and on the internet. The JBIG-1 and JBIG-2 standards are included as fax standards. The first JPEG standard together with another sister organization's, the Moving Picture Experts Group (MPEG), standard were award a technical Engineering Emmy in 1996, a first Emmy presented for any standard, and in October 2003 it was honored with first Lawrence D. Eicher Leadership Award of ISO/IEC. This talk will briefly review these standards and point out their strengths.



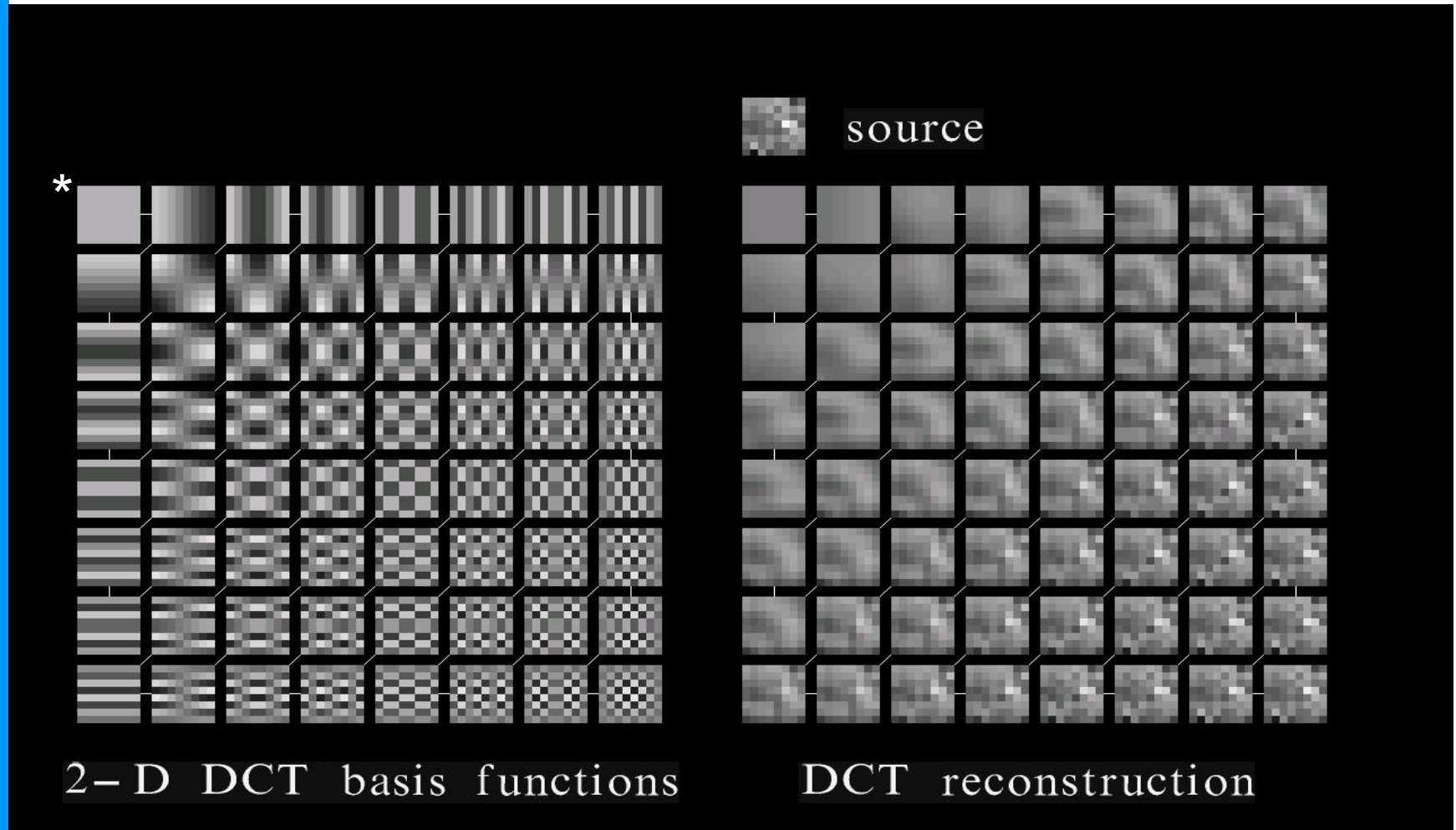
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Back-up Slides JPEG-1



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DCT transform

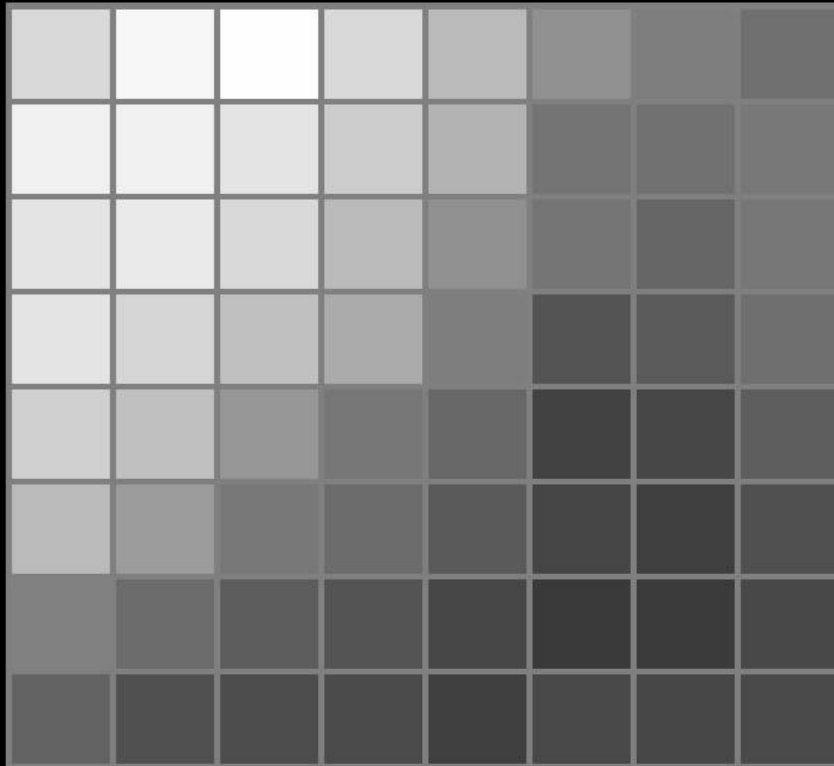


* DC term. Other 63 are AC terms

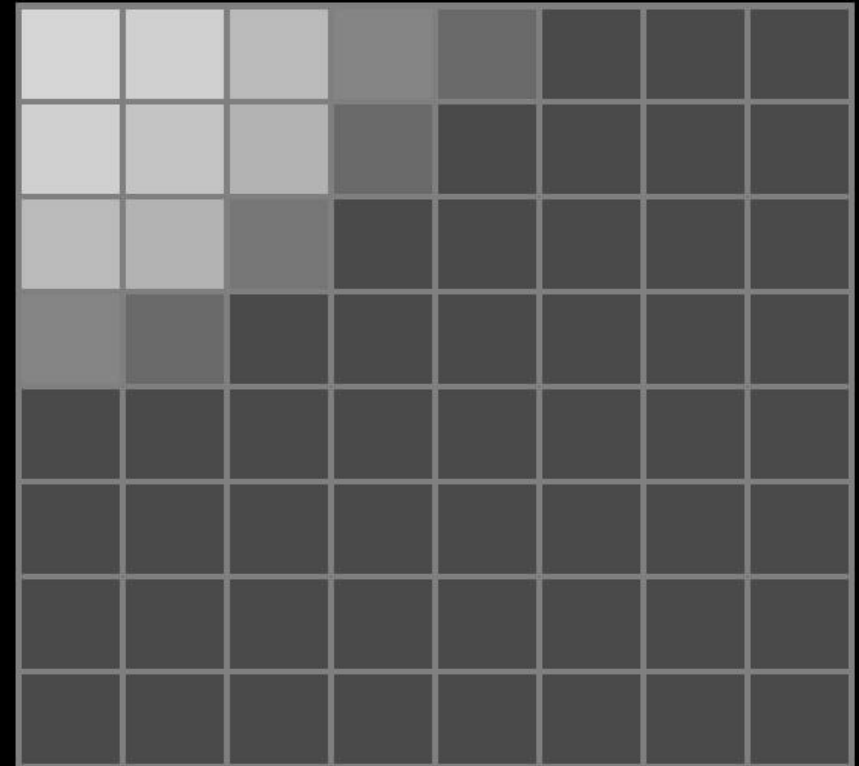


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Example quantization tables



luminance quantization



chrominance quantization

(Larger values are darker)



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Proposed enhancement to JPEG-1

- Alternative baseline sequential (lossy)
 1. 8 bits/sample
 2. 8x8 DCT
 3. Q-15 arithmetic coding only
 4. Required in all DCT-based decoders
- Extended sequential (lossy) option
 1. 8-16 bits/sample
 2. 8x8 DCT
 3. Arithmetic coding (Q-15 or MQ)



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Proposed enhancement to JPEG-1

- Progressive (lossy)
 1. 8-16 bits/sample
 2. 8x8 DCT
 3. Arithmetic coding (Q-15 / MQ)
 4. SA, SS, and/or hierarchical
- Lossless option
 1. 2-16 bits/sample
 2. Predictive based (DPCM)
 3. Arithmetic coding (Q-15 / MQ)
 4. Sequential and/or hierarchical



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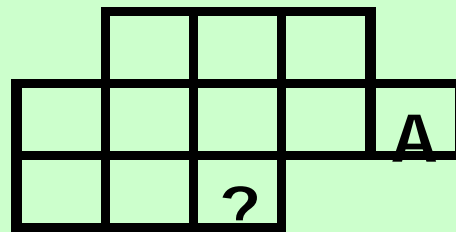
Back-up Slides JBIG-1



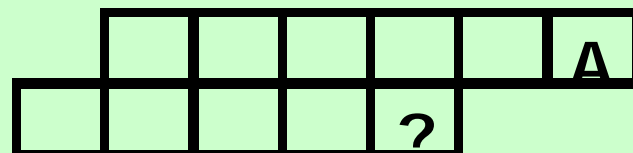
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Two kinds of First Layer Template

3 line 10 pels



2 line 10 pels





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Arithmetic Entropy Coding

- o QM-coder
 - multiplication-free
 - MPS/LPS conditional exchange
 - renormalization-driven update
 - 113 state transition model
 - Byte-stuffing for carry propagation prevention



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FAX Application

- 0 ITU-T T.85
 - 1. Single-progression sequential coding **only**
 - 2. Horizontal offset allowed for AT pel: 0-127
 - 3. Vertical offset allowed for AT pel: 0
 - 4. Periodic resynchronization allowed



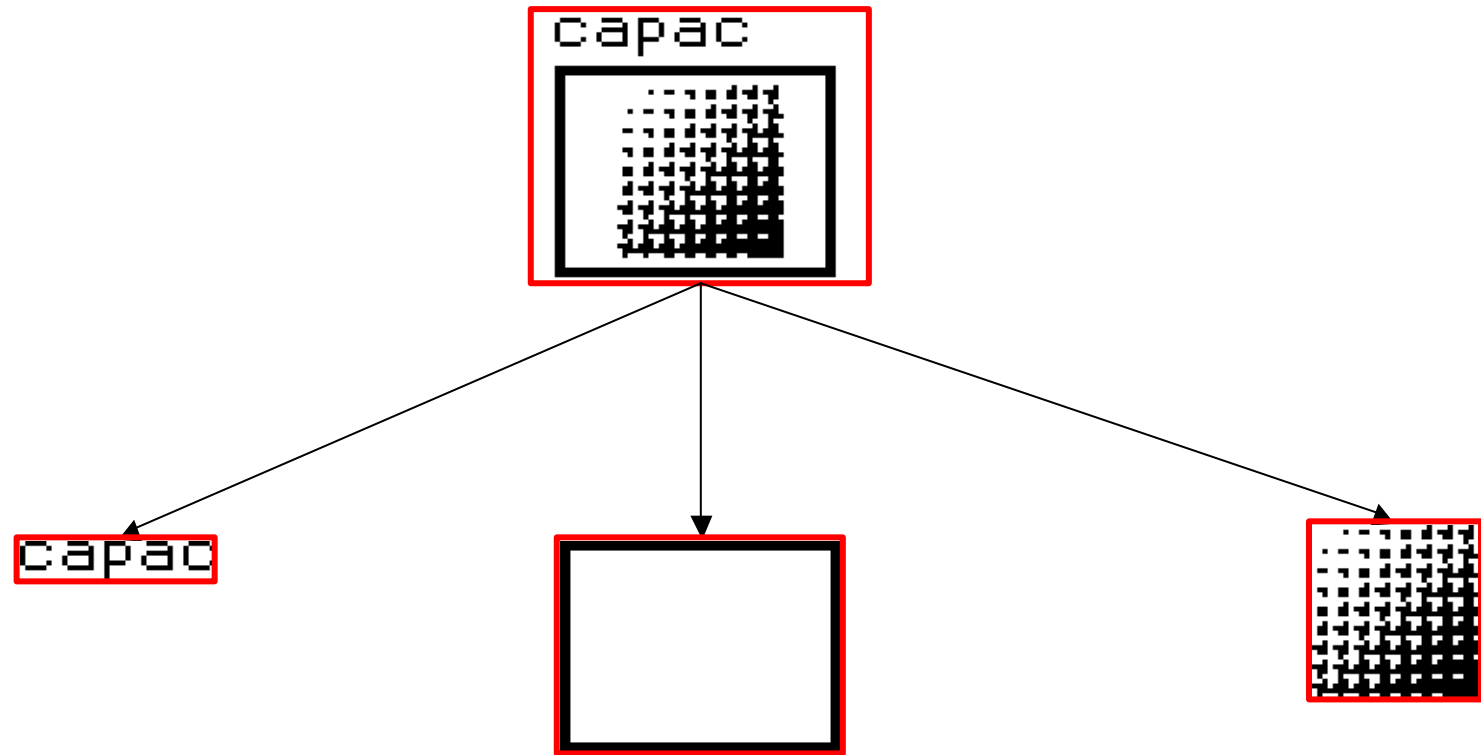
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Back-up Slides JBIG-2



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Segmentation Example



Text region:
Use symbol
coding

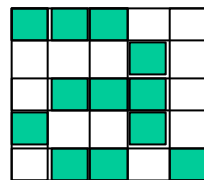
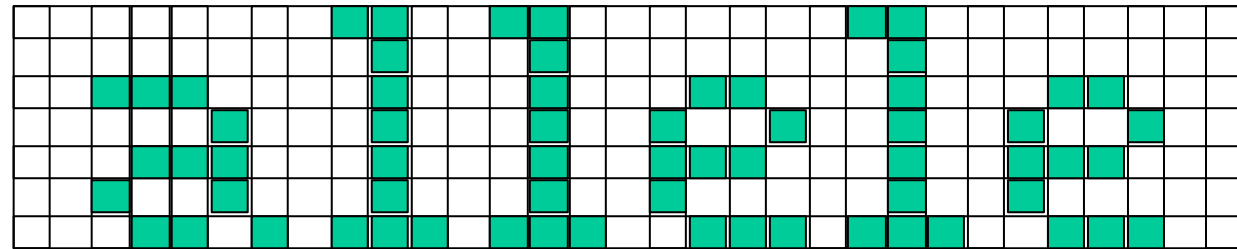
Generic region:
Use generic (MMR
or JBIG1-like)
coding

Halftone region:
Use pattern
coding

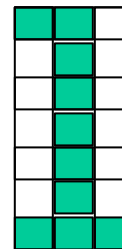


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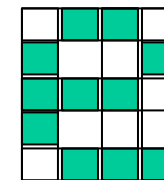
Symbol Extraction



(2,2)



(8,0)
(12,0)
(21,0)



(16,2)
(25,2)



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Context-base Arithmetic coding Compared to JBIG1

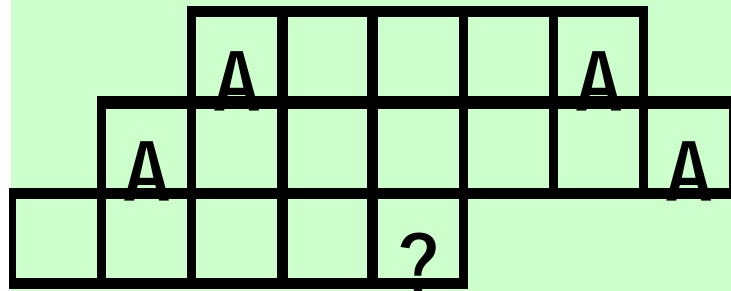
- Number of template pels (Adaptive Pel)
JBIG2:16(4AP); 13(1AP); 10(1AP)
JBIG1:10(1AP)
- Adaptive arithmetic coder
JBIG2:MQ(47states, bit-stuffing)
common to JPEG2000
JBIG1:QM(113 states, byte-stuffing)
common to JPEG



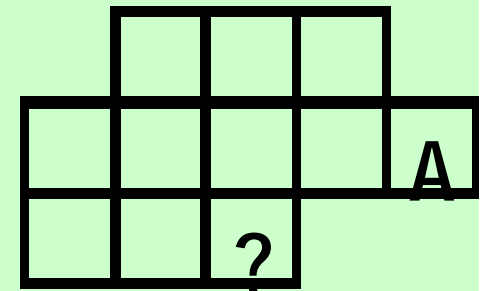
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Direct Templates

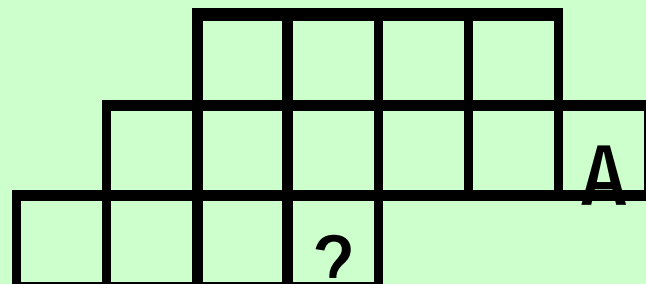
16 nels



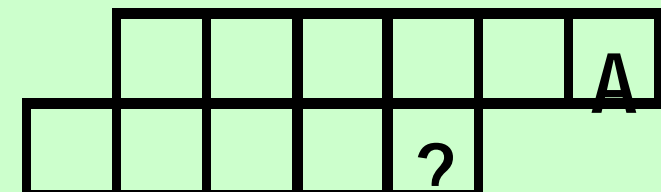
10 nels



13 nels



10 nels





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Compression performance

| Image | Pages | MMR | JBIG1 | JBIG2 (exact) | JBIG2 (lossy) |
|---------|-------|----------------|--------------------|--------------------|--------------------|
| F04_300 | 1 | 95.9 KB (1) | 77.7 KB (0.81) | 73.4 KB (0.77) | 14.2 KB (0.15) |
| Report | 23 | 1.2 MB (1) | 926.2 KB (0.74) | 842.9 KB (0.67) | 184.5 KB (0.15) |
| Book | 512 | 45.7 MB (1) | 34.7 MB (0.76) | 2.6 MB (0.06) | N/A |



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Context-base arithmetic coding JBIG2 compared to JBIG1

- o Number of template pels (Adaptive Pels)
 1. JBIG2:16(4AP); 13(1AP); 10(1AP)
 2. JBIG1:10(1AP)

- o Adaptive arithmetic coder
 1. JBIG2:MQ (47states, bit-stuffing)
common to JPEG2000
 2. JBIG1:QM (113 states, byte-stuffing)
common to JPEG



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JBIG2 Additional Work

- **AMD1: Encoder (Published Dec.2004)**
 - JBIG2 standardized a *code-stream* and *decoding* functions
 - Based on request to provide one or more normative, but non-mandatory, complete JBIG2 *encoding* methods
- **AMD2: Extension of Adaptive Template for halftone coding (Published Dec.2003)**
 - Based on request from high resolution printing market
 - At high resolutions, extending the number of AT pixels from 4 to 12 may achieve 20% compression improvement
 - Improvements used 'Genetic' AT pixel placement method



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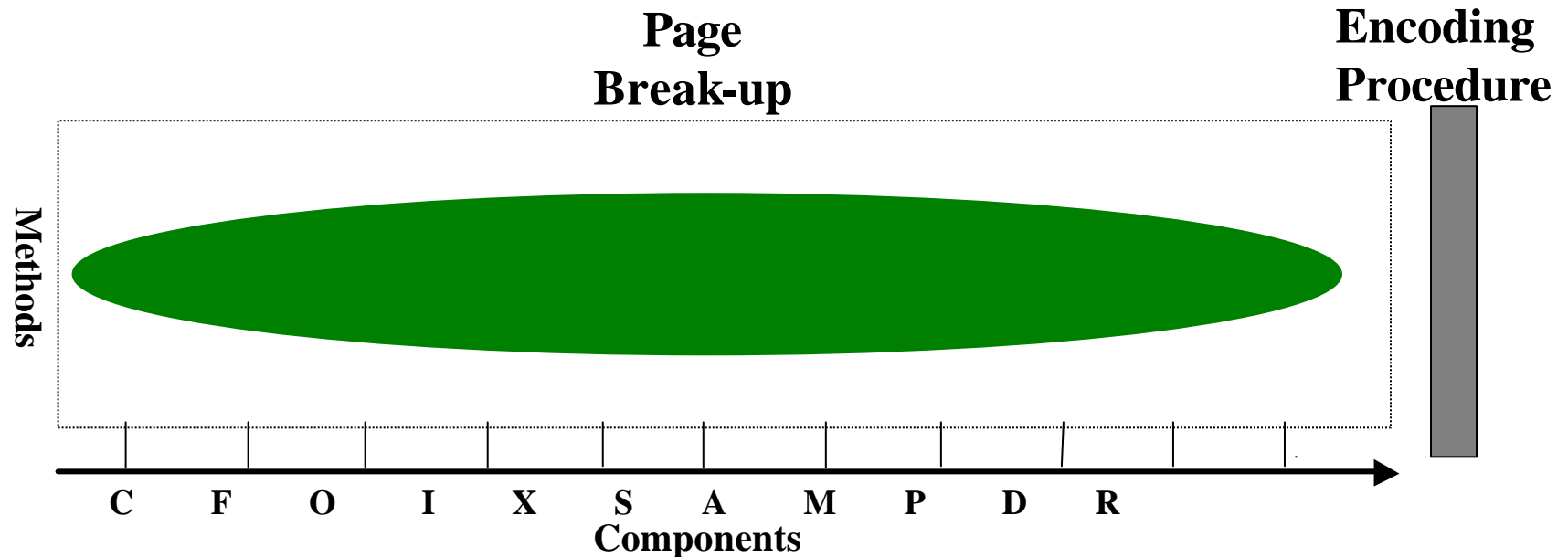
JBIG2-AMD1 Content

- **Encoding functions to mirror decoding functions (normative)**
 - *entropy-encoding* as exact inverse of *entropy-decoding*
 - *control-encoding* as exact inverse of *control-decoding*
 - *page-breakup* as analogous inverse of *page-makeup*
(many-to-one *architecture* with optional *components*)
- **Examples for all page-breakup components (non-normative)**
 - based on journal publications, book and expired patent
- **Updates to the List of Patents annex (non-normative)**
 - revises existing patent lists with latest additions and changes
 - adds additional list - - patents identified in JBIG2, for which patent statements weren't obtained (with notes of explanation)



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JBIG2-AMD1 Diagram



- **Encoding Procedure:** defined using conventional *specifications*
- **Page Break-up:** defined using an *architecture*, consisting of -
 - any sequence of *components (each optional)*, from the set: {Capture, Filter, Orient, Identify, Extract, Screen, Match, Post-Match, Dictionary, and Refine} Align,
 - a user-specified *method* to perform each component
(choice of each method is open, hence non-normative)
- **Ellipse:** represents wide variety of components and methods



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Conclusion

- JBIG2 Offers unprecedented compression
As a Rule of Thumb
Lossless compression ratio:
MH:7, MR:10, MMR:15, JBIG1:18, JBIG2:21
Visually Lossless:
JBIG2:100
- AMD1(RF Encoding) is also available