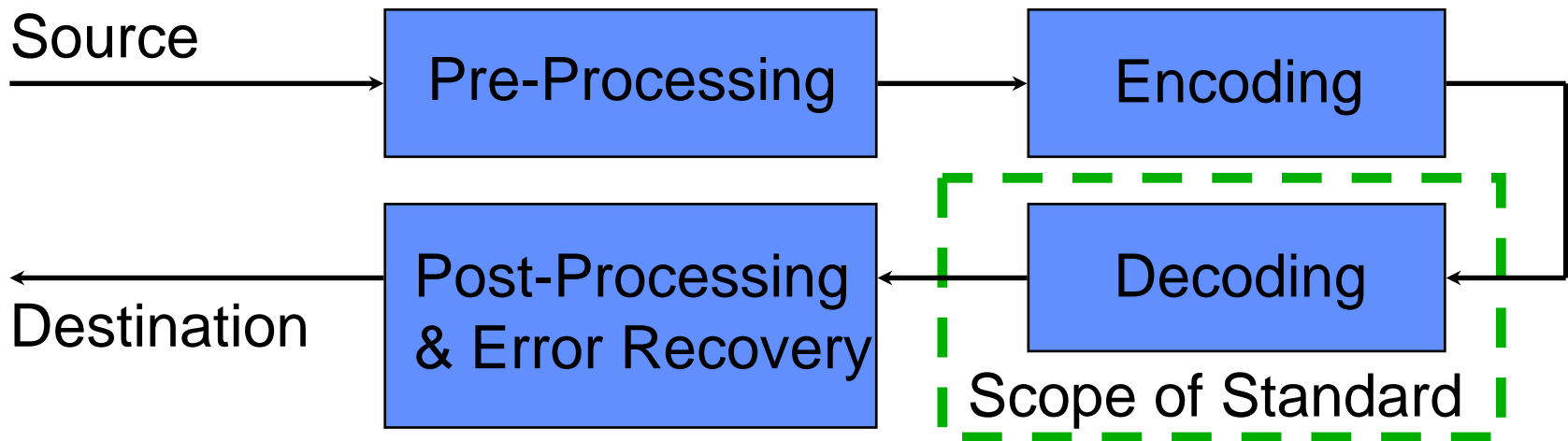

JPEG Image Coding Standard

- International Standardization of Image Coding
- JPEG

The Scope of Picture and Video Coding Standardization

- **Only Restrictions on the *Bitstream*, *Syntax*, and *Decoder* are standardized:**
 - Permits optimization beyond the obvious
 - Permits complexity reduction for implementability
 - Provides *no* guarantees of Quality



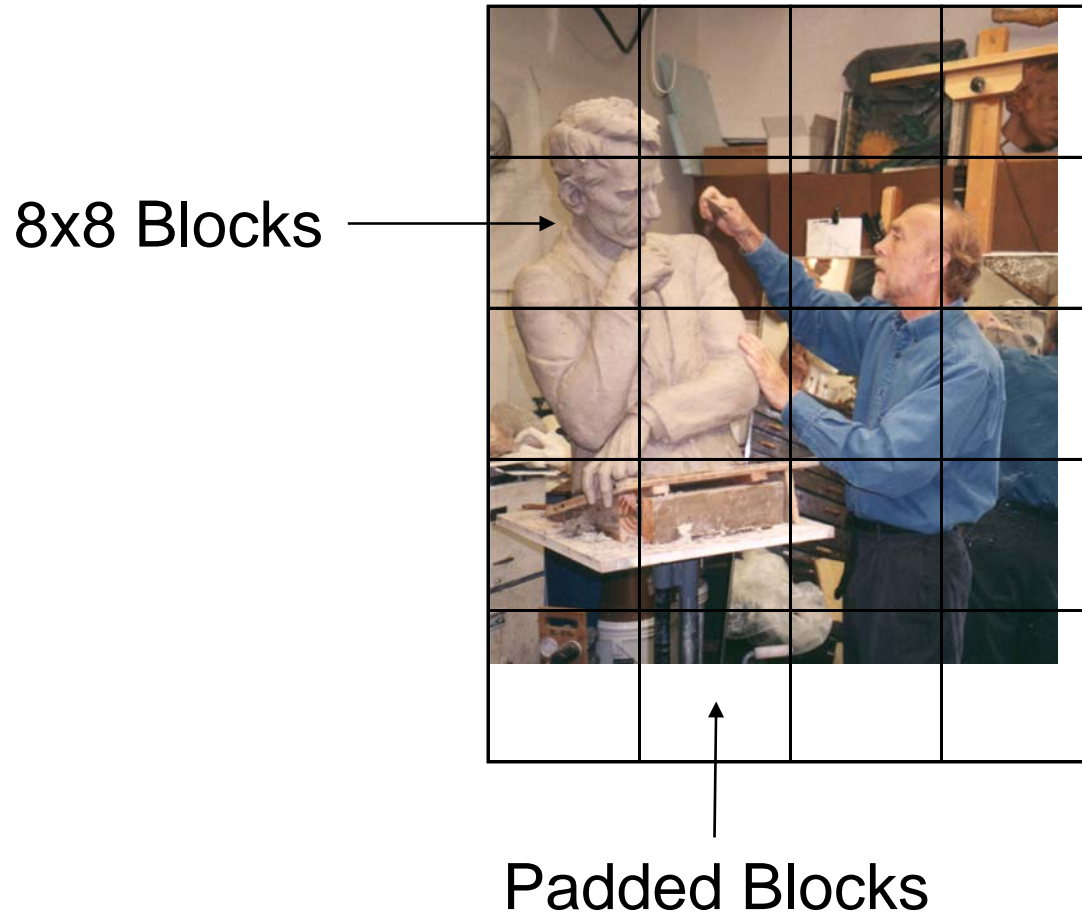
Why Do We Need Standards ?

- Image (and video) coding standards provide *interoperability* between codecs built by different manufactures
 - Basis for most products in communication technology
 - Standards based products can be build with common software and hardware tools
 - Only syntax and decoder specified
- Standards provide state-of-the-art technology that is developed by a group of experts in the field
 - Actual performance depends on implementation of standard regarding error resilience, delay, display
 - Encoder is not standardized and its optimization is left to the manufacturer

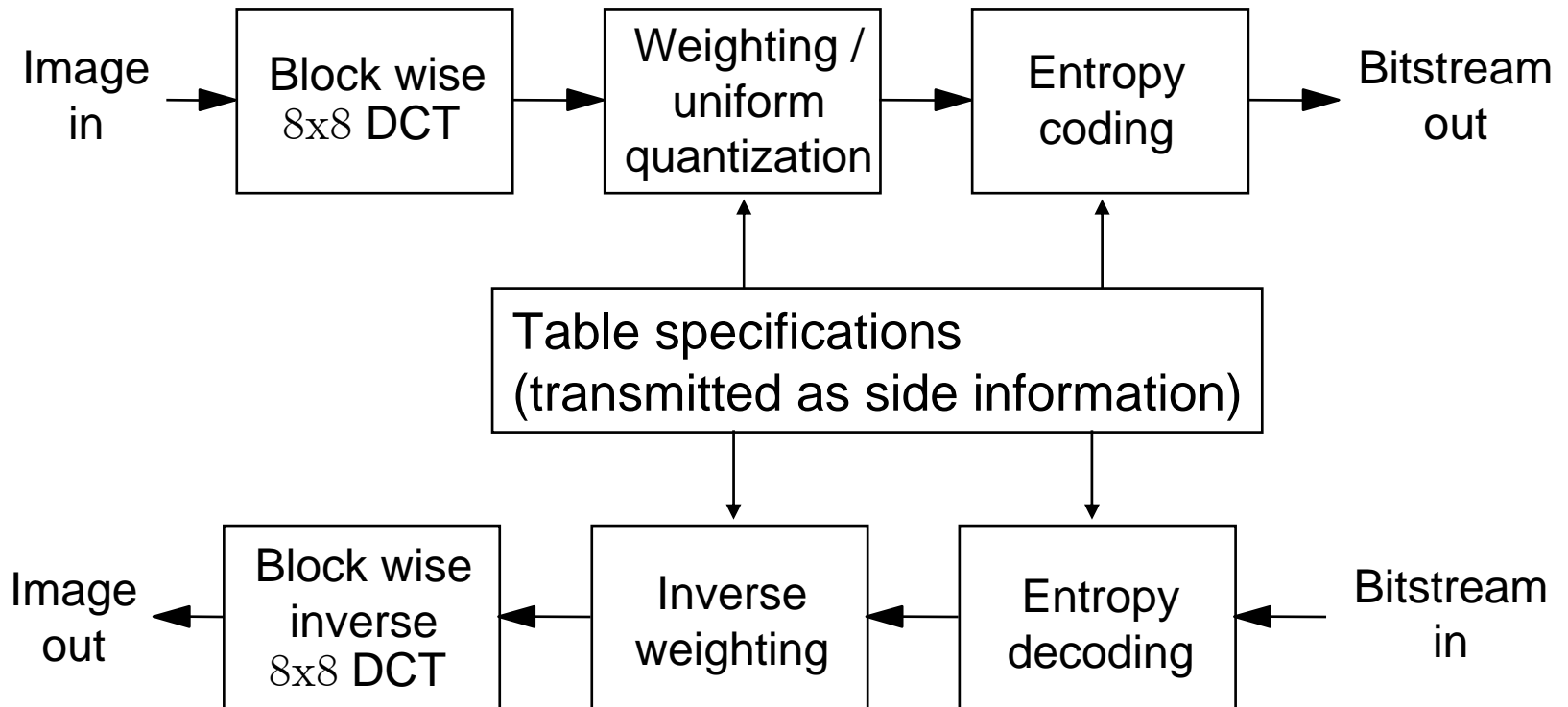
Standardization of Image Coding

- **ITU-R Radiocommunications (www.itu.int/ITU-R)**
 - SG 6 - Broadcasting Service (terrestrial and satellite)**
 - Standards for digital high definition television
 - Objective picture quality parameters and associated measurement and monitoring methods for television images
- **ITU-T Telecommunication Standardization (www.itu.int/ITU-T)**
 - SG 9 - Integrated broadband cable networks and television and sound transmission**
 - Objective and subjective methods for evaluating conversational audiovisual quality in multimedia services
 - Digital transmission of television signals for contribution
 - SG 16 – Multimedia services, systems and terminals**
 - Video and data conferencing using Internet-supported services
 - Advanced video coding
- **ISO/IEC JTC1 SC29 Coding of audio, picture, multimedia and hypermedia information (www.iso.ch/meme/JTC1SC29.html)**
 - WG 1 - Digital compression and coding of still pictures (JPEG)**
 - WG 11 - Generic coding of moving pictures and associated audio information (MPEG)**

JPEG: Image Partitioning



JPEG: Baseline Algorithm



JPEG: Quantizer Step Size

- Different weighting matrices are standardized, adapted to human visual contrast sensitivity
- Example: Inverse weighting for ITU-R 601 images

Luminance

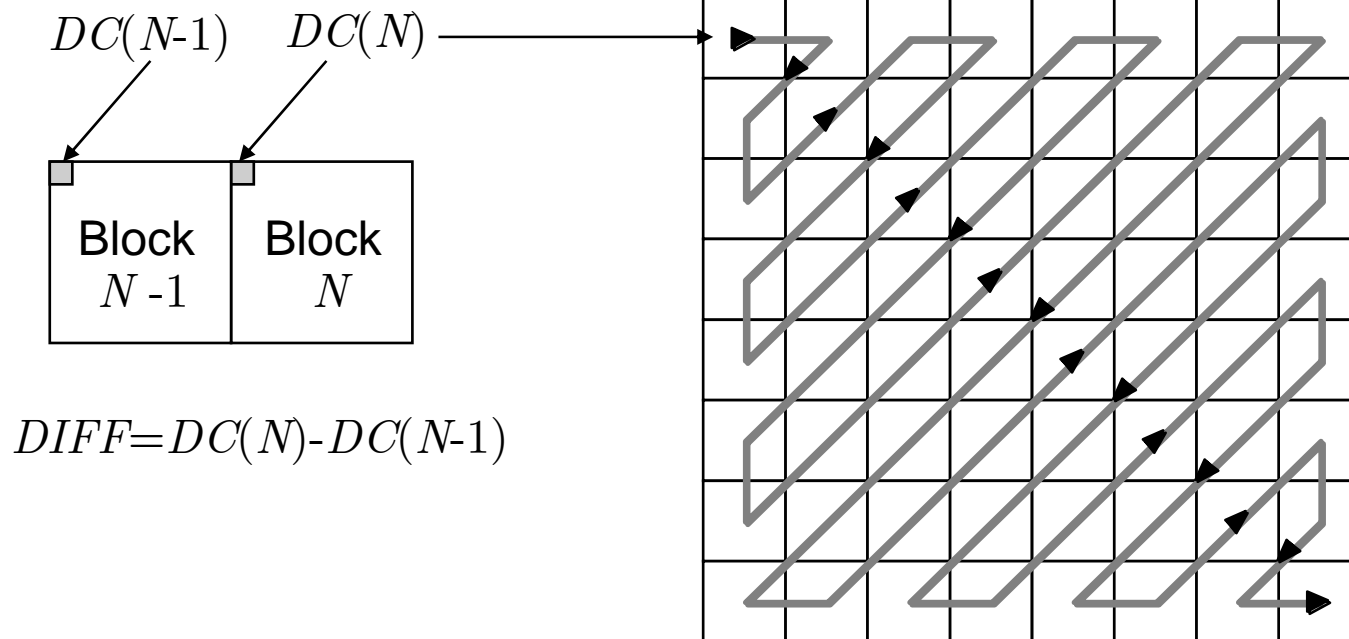
16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

Chrominance

17	18	24	47	99	99	99	99
18	21	26	66	99	99	99	99
24	26	56	99	99	99	99	99
47	66	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99

Quantization of DCT Coefficients

- Differential coding of DC coefficient: DPCM using previous quantized DC coefficient as predictor
- Zig-zag scan of AC coefficients



JPEG

- **Features of the JPEG “baseline system”**
 - Represents a minimum of capabilities
 - Compression of digital images with 8-bit representation
 - Sequential processing of blocks, i.e. starting from upper left corner moving to right side
 - Transform coding using 8x8 block DCT
 - Scalar quantization of transform coefficients with weighting matrix
 - Zig-zag scan and successive entropy coding with prefix-free codes
- **Extended DCT-based system**
 - Digital images with 8 and 12-bit representation
 - Sequential as well as progressive block handling
 - Prefix-free or arithmetic codes

JPEG – Beyond Baseline

- **Lossless mode**

- DPCM-based (no DCT)
- Compression of digital images with 2 – 16 bits representation
- Sequential processing of blocks
- Prefix-free codes

- **Hierarchical mode**

- Multiple pictures encoded differentially as well as non-differentially
- Employs extended DCT-based or lossless JPEG mode

Entropy Coding

- Two methods for entropy coding defined
 - Prefix-free coding
 - Arithmetic coding

- Two options for Prefix-free coding of run-level pairs
 - Predefined code tables (one-pass system)
 - Code tables optimized for individual image (two-pass system)

- Arithmetic coding
 - Binary coder
 - Default conditioning table
 - Adaptive to actual symbol statistics

Coding Results

Original



Coded at rate 1:150



Coding Results: Detail

Original



Coded at rate 1:150



Summary

- International Standardization of Image Coding is conducted to achieve inter-operability and to provide state-of-the-art technology
- Only syntax and decoder are specified
- JPEG started in 1986 and is a well established image coding standard
- JPEG still provides competitive performance for the medium bit-rate range