

# JPEG 2000 for Digital Cinema Applications

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Eric Edwards

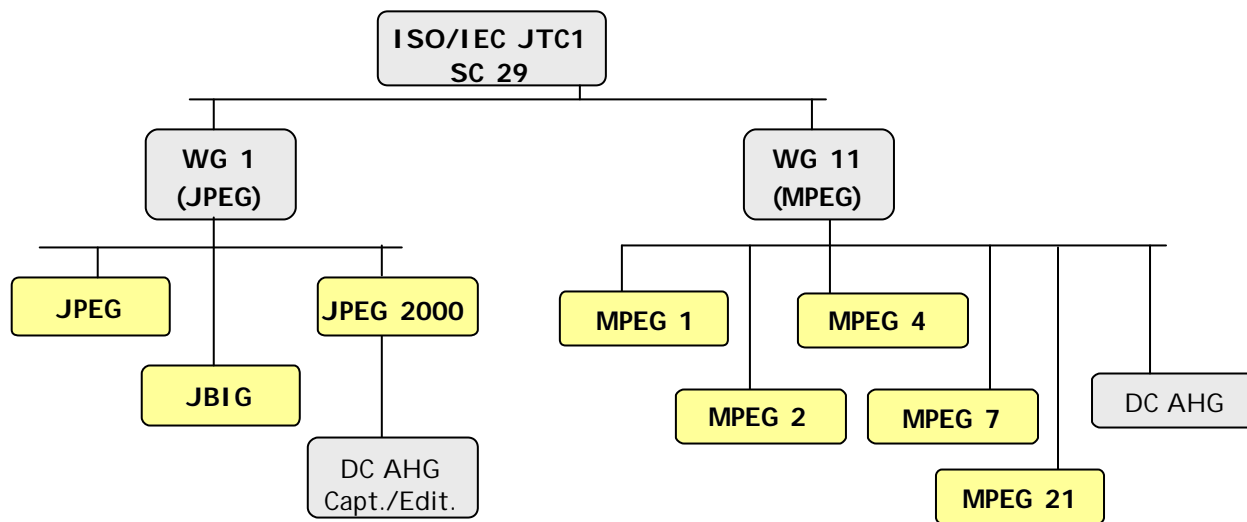
Sony Network and Software Technology Center of  
America

Siegfried Foessel

Fraunhofer Society for applied research,  
Fraunhofer IIS-A, Germany

# Introduction - JPEG

- JPEG is a compression standard that is used universally for digital photographic images. It is used in virtually all Digital Still Cameras (DSC) and for almost all Internet images. In addition, Motion JPEG is used in important applications from professional video editing to capture cards in a PC. The JPEG standard was produced by an international group of experts - the Joint Photographic Experts Group - under the ISO/IEC/ITU standards organizations. JPEG is a sister organization to MPEG.



# What is JPEG 2000

- JPEG 2000 is the successor of the JPEG standard.
  - In 1997 work on a new compression standard for photographic images was proposed. The approach to this new standard was an inspired one.
  - The experts decided to look at the » **overall environment** « in which images would be tasked in future and decided that a compression scheme that worked well in network environments was the most desirable. So the experts decided to depart from the block based DCT coding used by existing JPEG and MPEG standards in favor of wavelet based compression which delivered better quality than JPEG and allowed » **scalability** « without having to store redundant data.
  
- In addition to the benefits of scalability, JPEG 2000 delivers about 20% » **better compression** « than JPEG. And, at more extreme compression ratios, JPEG 2000 delivers significantly better quality.
  
- Another key benefit of JPEG 2000 is that it supports both » **lossless and lossy** « compression in a single codec – a very desirable feature in certain applications such as medical imaging.

# Scalability

- JPEG 2000 is scaleable in both SNR and resolution.
  - Example 1: Using JPEG 2000, a picture stored on a server has lower resolution versions embedded in the compressed data. If you wanted to view an image on a remote PDA, a lower resolution image would be extracted. No transcoding is required. If you wanted to zoom in on a part of the image, additional information would be downloaded from the image file. Resending a higher resolution version of the image is not required. Only the additional information needed to make a higher resolution version is extracted and added to the local image data.



Example of resolution progressive bit-stream ordering

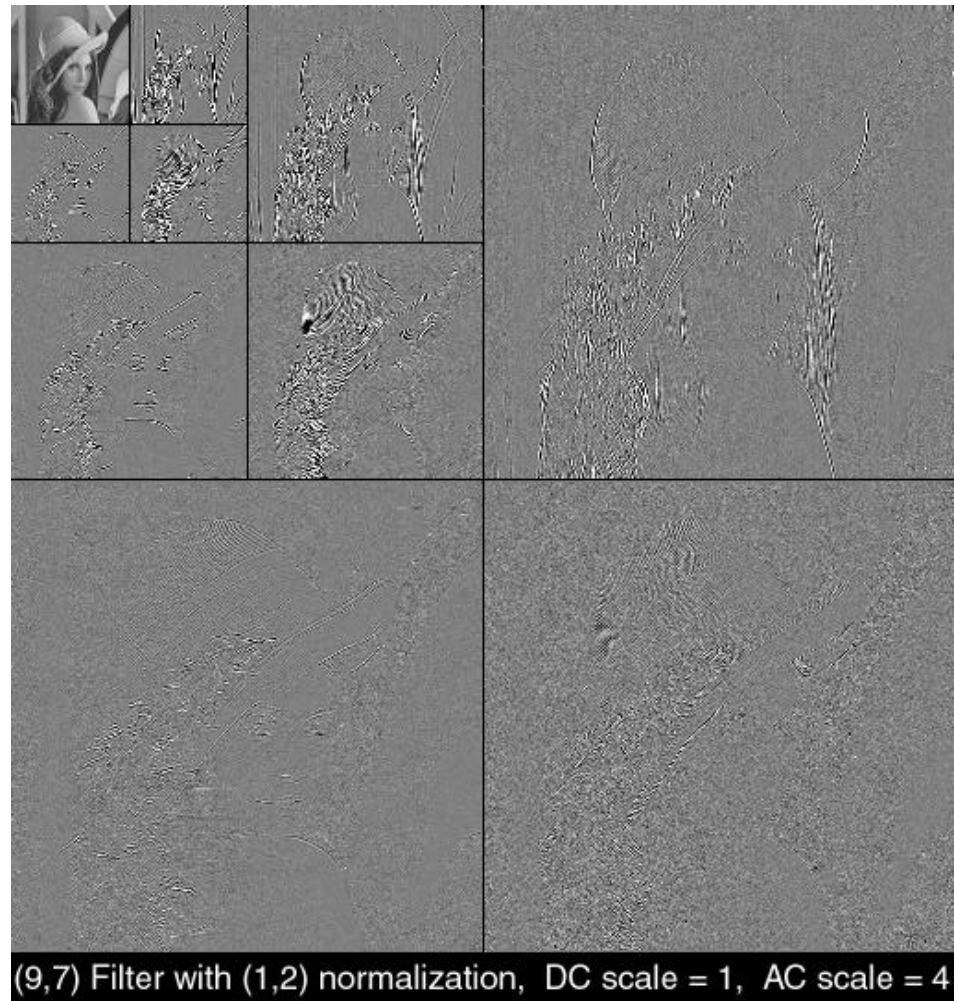
# Scalability

- JPEG 2000 is scaleable in both SNR and resolution.
  - Example 2: Using JPEG 2000, a picture stored on a server has lower quality levels embedded in the compressed data. If you wanted to preview an image, a lower quality would be extracted. No transcoding is required. If you wanted to see the best quality, additional information would be downloaded from the image file. Resending the full image information is not required.



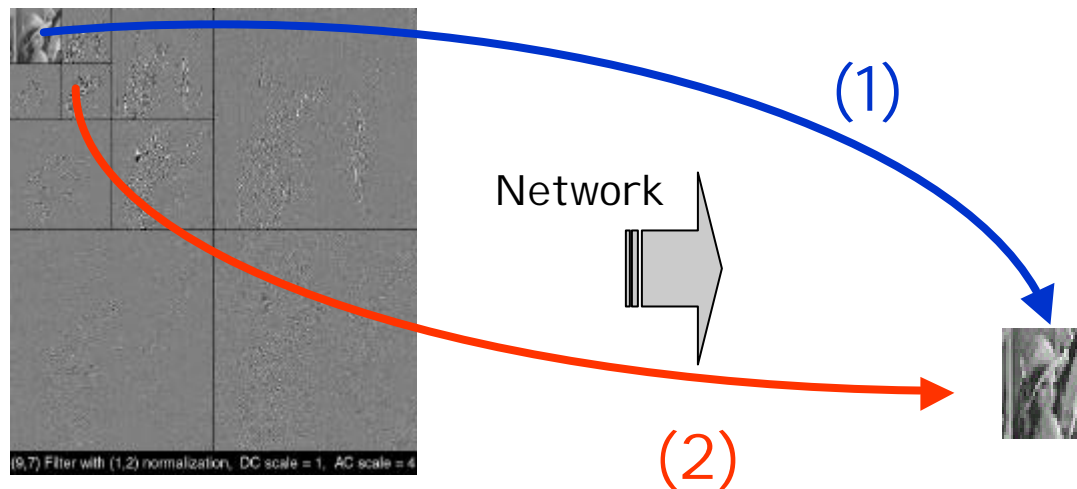
Example of layer progressive bit-stream ordering, (left) 0.125 bpp; (right) 0.50 bpp

# What is Wavelet compression



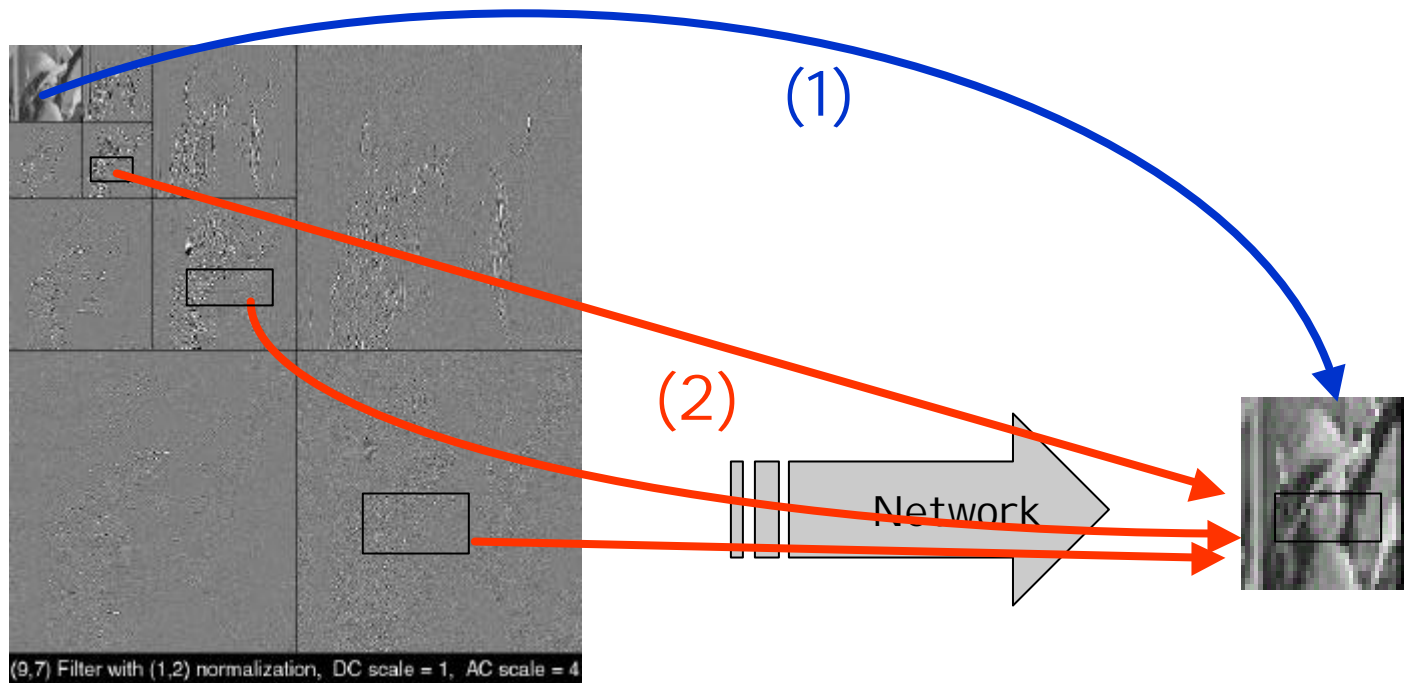
# JPEG 2000 Scalability

- With JPEG 2000 several levels of resolution or detail are coded in the compressed image file.
- When accessing a JPEG 2000 image across a network, a low resolution image (or a full resolution image with low detail) can be extracted from the compressed image stored on the server (1)
- If more quality is desired, more information can be extracted from the compressed file on the server to increase the resolution or detail locally (2)
- There is no data redundancy in the compressed image and therefore for this type of application JPEG 2000 is very efficient



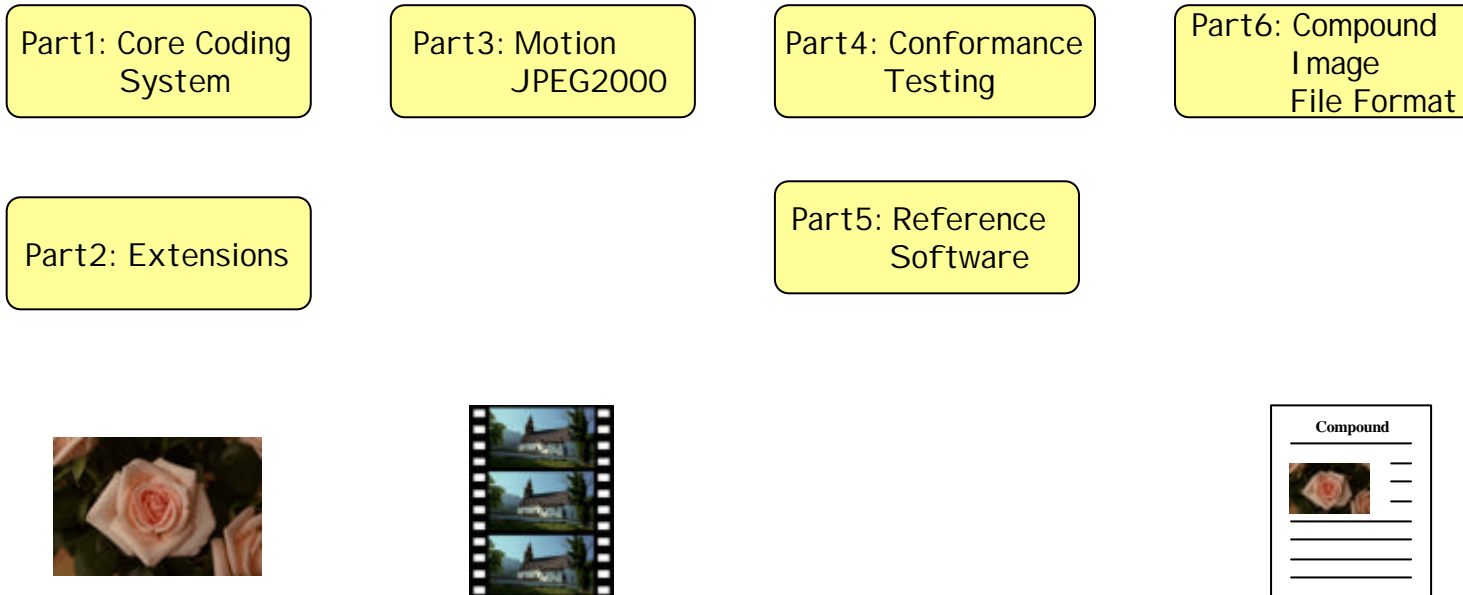
# JPEG 2000 Scalability

- JPEG 2000 also supports selective extraction of image data from a particular region.
- Use of this feature allows areas of interest to be viewed at higher quality while minimizing the amount of data needed to be transferred over the network
- This is particularly useful when viewing images on limited bandwidth networks and when using low power devices with limited display capabilities - such as mobile devices



# Parts in JPEG 2000

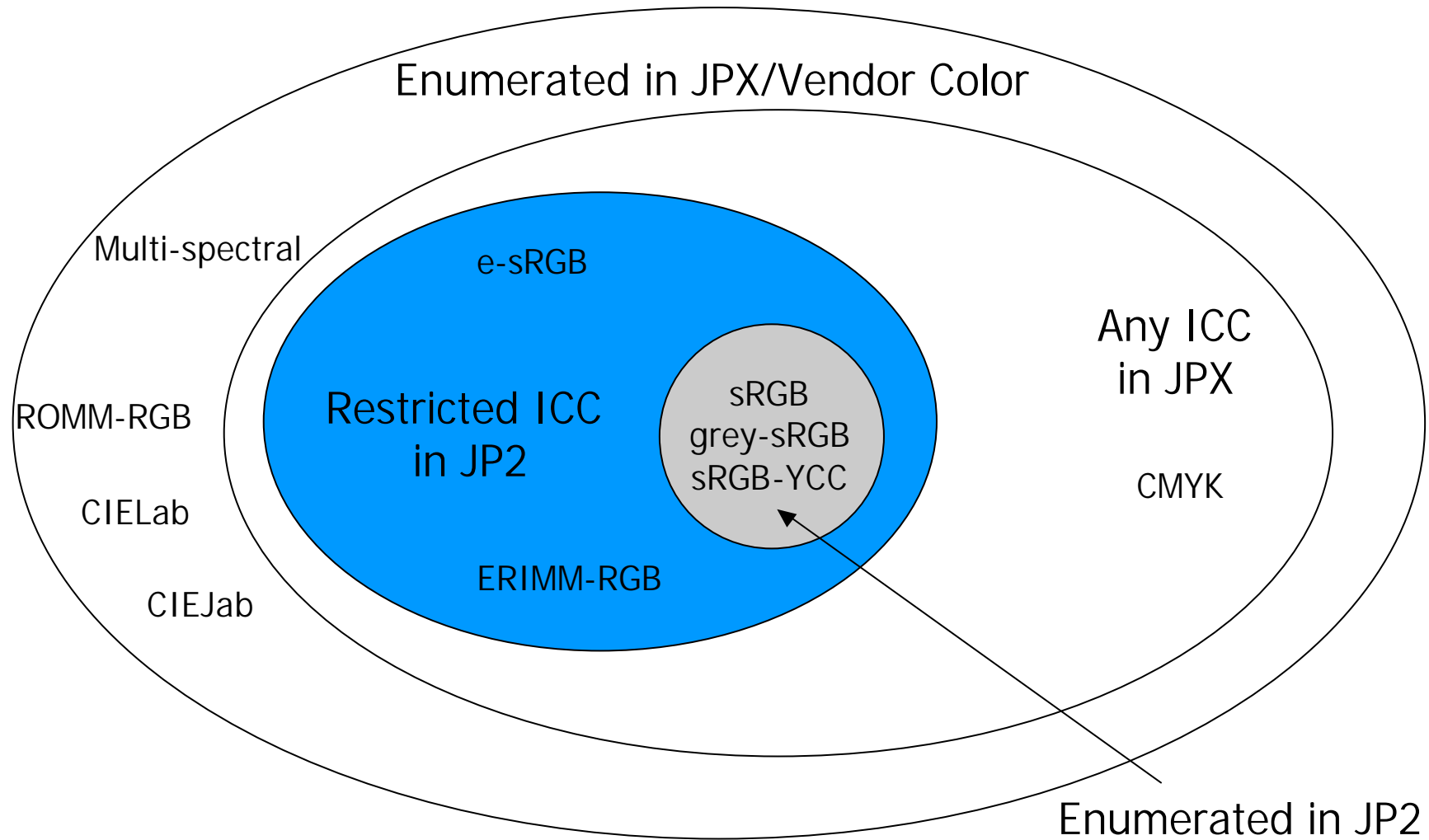
→ The JPEG 2000 standard consists of several parts



# Parts in JPEG 2000

- **Part 1** is the baseline compression standard with a minimal file format. The file extension is \*.jp2. It is intended that all JP2 readers will be able to read a \*.jp2 file. Part 1 is intended to be royalty free. **Status: *International Standard***.
- **Part 2** covers technology extensions and an extensive file format. The extension is \*.jpx. A JPX reader is not guaranteed to read any \*.jpx file. It must read a \*.jp2 file. Technology in part2 may require license and royalties. **Status: *International Standard***.
- **Part 3** is Motion JPEG 2000. Extension is \*.mj2 or \*.mjp2. It is intended to be royalty free. **Status: *International Standard***.
- **Part 4** is conformance. This part of the standard specifies how to judge if a reader is compliant to the standard. It will also specifies levels of compliance. Consequently, a low complexity hardware implementation will handle complex or large images in a limited fashion. **Status: *International Standard***.
- **Part 5** is reference software. **Status: *International Standard***
- **Part 6** specifies how to support multiple compression schemes in a single file – Multi-raster Content. It is targeted for scanner and fax applications. File extension is \*.jpm. **Status: *Final Committee Draft***

# Color levels in JPEG 2000



# Future of JPEG 2000

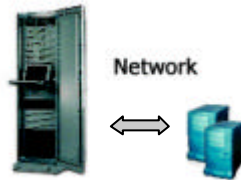
- The JPEG 2000 standard is continuing to evolve.
  - In 2002 work on new parts begin, which use the benefits of the overall approach and support the basic core system in special fields of application.

Part8: JPSEC  
(Secure JPEG2000)

Part9: JPIP  
(Interactive Prot.)

Part10: JP3D  
(3-D Extensions)

Part11: JPWL  
(Wireless)

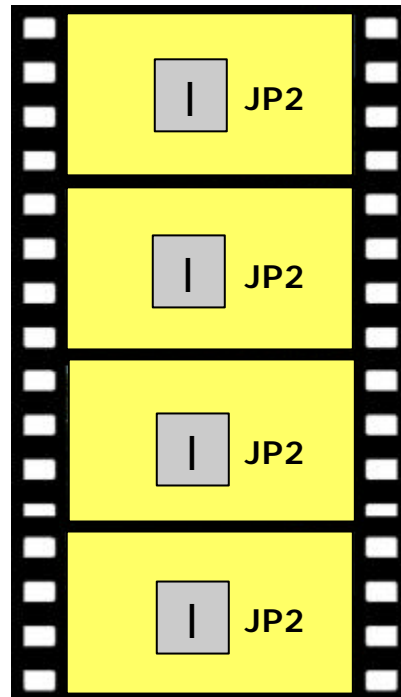


- Liaisons with other standardization committees make sure of compatibility.
  - MJ2 for Digital Cinema Archive - (MPEG)
  - Inter-frame coding (MPEG and JPEG)
  - Streaming for JPEG 2000 codestreams (IETF)

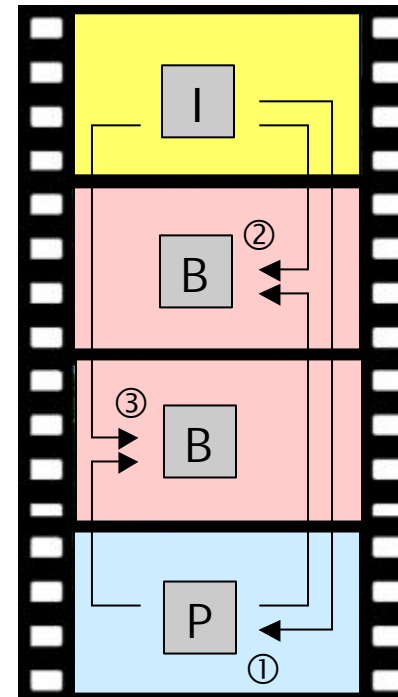
# Motion JPEG 2000

- Motion JPEG 2000 is developed for image sequences.
  - In Motion JPEG 2000 each frame is coded individually. **Intra-frame** coding allows for random access and reduced complexity. In MPEG the encoding uses a series of frames – **inter-frame** coding. This allows for improved compression efficiency but the coding technique is more complex.

**Intra-frame coding**  
(Motion JPEG2000 Structure)

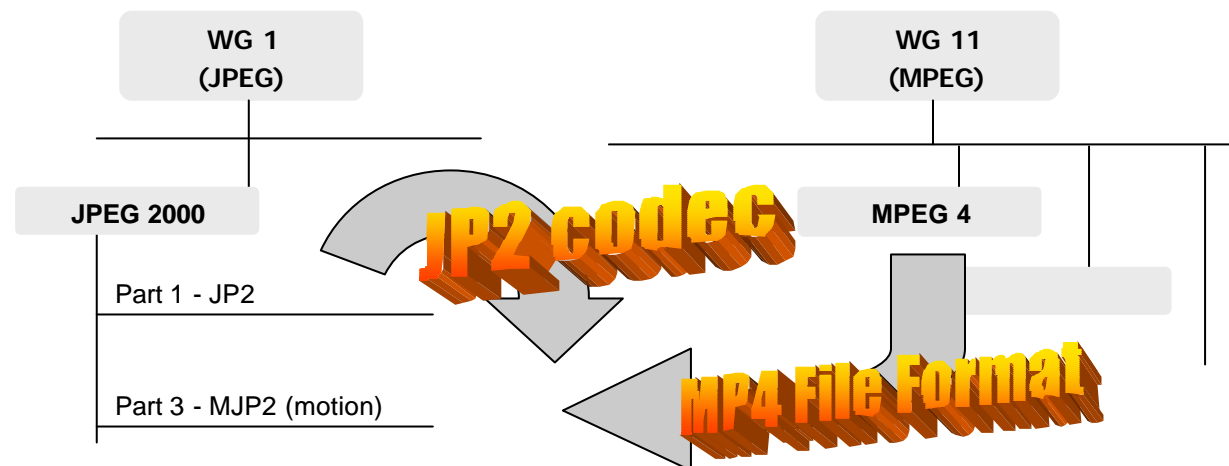


**Inter-frame coding**  
(MPEG-Structure)



# Motion JPEG 2000

- Motion JPEG will be used in application environments where scalability, high quality, lossless coding and error resilience are required – digital photography, security, medical imaging, image databases and mobile appliances. It is important to understand that in most cases Motion JPEG 2000 will not compete with the MPEG standards
- In order to maintain as much as possible areas of compatibility between MPEG and JPEG, the MP4 file format was chosen for Motion JPEG 2000. The MP4 file format is used in MPEG 4 and is derived from Quicktime.



# Motion JPEG 2000 – Key Features

## → Flexible File Format

- MJ2 File Format based on MP4/QuickTime file format.
- This allows for
  - easy synchronization with audio and other metadata
  - ISO File Format
  - future compatibility as the ISO File Format evolves
  - support for other audio codecs and metadata from the MPEG family
  - optional compatibility with JPEG 2000 codecs
  - implementations where image data can be related both temporally or spatially

# Motion JPEG 2000 – Key Features

## → Scalability

- Scalability is probably the most important feature of JPEG 2000 and Motion JPEG 2000. This manifests in several different ways. Bandwidth in networks is always precious. A MJ2 file stored on a server can be accessed across a network at a lower resolution there by limiting the amount of bandwidth used. When a sequence of interest is encountered the resolution or detail can be increased easily without any transcoding required. This is particularly useful in searching content databases, for security applications and in medical imaging. If a movie is encoded where distribution to different devices is desired - a PDA and a movie theater - a single file is created where the content can be extracted without transcoding required and no data redundancy. MJ2 files are scaleable in resolution, detail and temporally.

# Motion JPEG 2000 – Key Features

## → High compression

- MJ2 has improved compression efficiency over Motion JPEG implementations (DV is essentially Motion JPEG). MJ2 is about half the bit-rate of DV compression with same quality. MJ2 is not as compression efficient as the MPEG standards but has the advantages of lower complexity and random frame access.

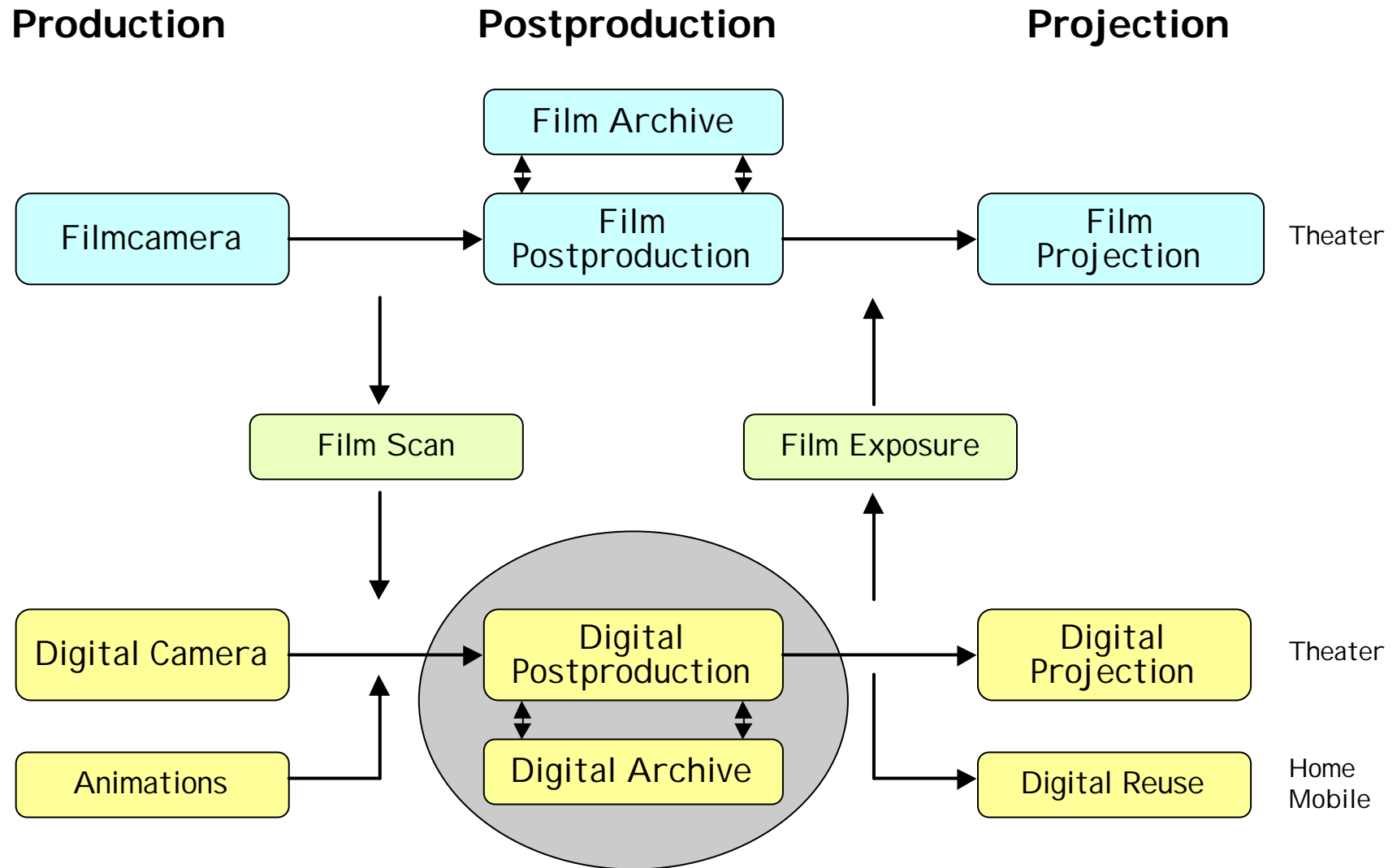
## → High quality

- MJ2 allows for lossless and visually lossless in the same bitstream. This feature is not available in MPEG and Motion JPEG implementations. It is particularly useful in medical applications and for Digital Cinema archive, editing and distribution.

# Application Digital Cinema

- For the foreseeable future both film and digital technologies will have to seamlessly coexist
- Image data from film and digital capture is very large and the scalability of Motion JPEG 2000 has tremendous advantages in working over networks and delivery to customers
- It is well suited for editing
- Resolution, color gamut and dynamic range exceed DC requirements
- The standardized color spaces allow for seamless interchange
- Image data can easily be retasked for other applications - graphic arts for example
- At the high bit rates required for Digital Cinema applications, the compression efficiency differences between MPEG and Motion JPEG 2000 are relatively small
- Low cost Motion JPEG 2000 chips are entering the market that can support these applications
- Motion JPEG 2000 can support compression domain processing
- Targeted to be royalty free.

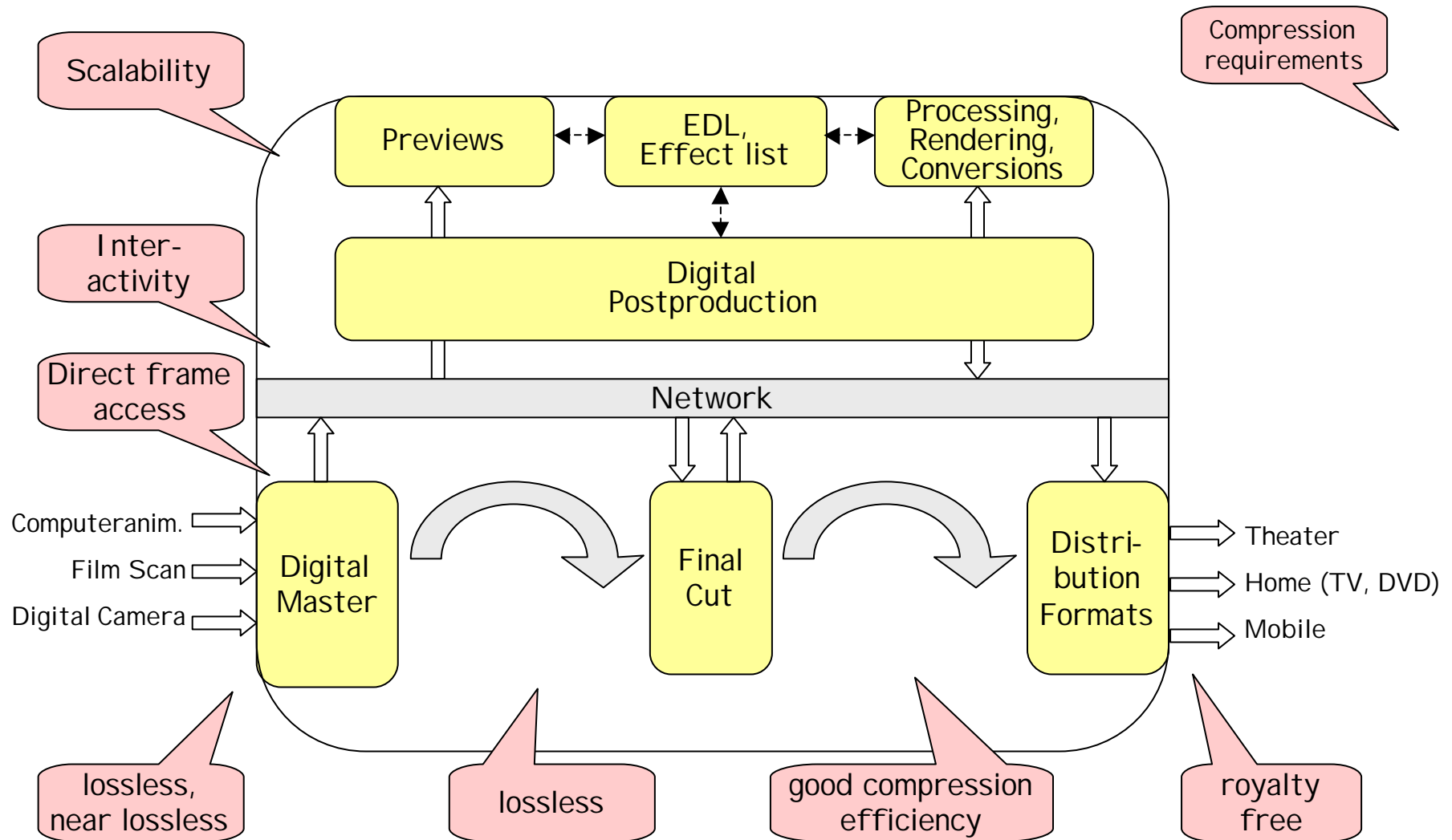
# Cinema chain



# Cinema chain

- Film is not the only way to create content. Also computer generated animations are widely used in movies. To integrate the animations into the movies film is scanned and after digital manipulation recorded back to film.
- So parts of the cinema chain are already digital.
- To improve movie quality the trend goes to a totally digital cinema chain.
- Developments in electronic cameras and projection will accelerate progress to digital.
- Reuse of the content for home and mobile applications is easier to realize.

# Postproduction



# Postproduction

## → Compression requirements:

- **Scalability:** For previews and fast forward during editing the client shall be able to receive lower resolutions or lower quality images out of the original sequence.
- **Interactivity:** During the editing process, the client shall be able to ask for missing data for increasing resolutions or qualities or requesting areas of interest.
- **Camera compression:** The compression in the camera shall be lossless or near lossless.
- **Archive compression:** In postproduction the compression shall be lossless.
- **Compression efficiency:** The compression efficiency shall be quite good.
- **Royalty free:** For distribution the compression shall be royalty free.

# New work on Digital Cinema

## → JPIP for Editing

- The new part JPIP offers the possibility to create complete new concepts for accessing archives with non-linear editing software.
- Fast access to archives for previews and fast forward/backward is no longer limited by the bandwidth of the network.

## → Metadata in MJ2

- The MJ2 file format based on the MP4 syntax is expandable to integrate additional data, like the SMPTE metadata directory or unique extensions.

# Conclusions

- The design of JPEG 2000 is innovative. It is inherently scaleable, unlike current JPEG and MPEG standards. JPEG 2000 will be the likely compression of choice in many networked and P2P applications.
- It is expected that Motion JPEG 2000 and MPEG will coexist. MPEG is more compression efficient than MJ2. MJ2 is scaleable and better suited to networked environments.
- Unlike current JPEG and MPEG standards, JPEG 2000 supports lossless and lossy compression in a single codec – an ideal design for high quality imaging.
- Motion JPEG 2000 is designed to take advantage of low cost jp2 baseline hardware implementations. In an attempt to maintain compatibility with emerging MPEG standards, the file format was derived from the mp4 file format – a Quicktime derivative.
- There are several manufacturers that have announced JPEG 2000 hardware will be available shortly. This should accelerate the adoption of jp2 and mj2.

# Conclusions

- In client-server and in peer-to-peer architectures content will need to be delivered to clients with vastly different capabilities. This can be achieved by storing multiple data sets on a server or transcoding data for each client or by using a scalable compression technology
- A scalable compression system is more efficient than one where multiple data sets or transcoding is required.
- JPEG 2000 is likely to become the technology of choice in image servers, medical imaging, digital cinema, security systems and digital photography.
- It is possible that JPEG 2000 will be used in other areas like mobile imaging and digital cinema applications.
- JP2 and MJP2 are targeted to be royalty free