High Efficiency Image File Format

Session 513

Davide Concion, Apple/Image Compression Team

De facto standard for image compression—JPEG

Requirements for a new format

HEIF—The answer

HEIF anatomy

The codec of choice—HEVC

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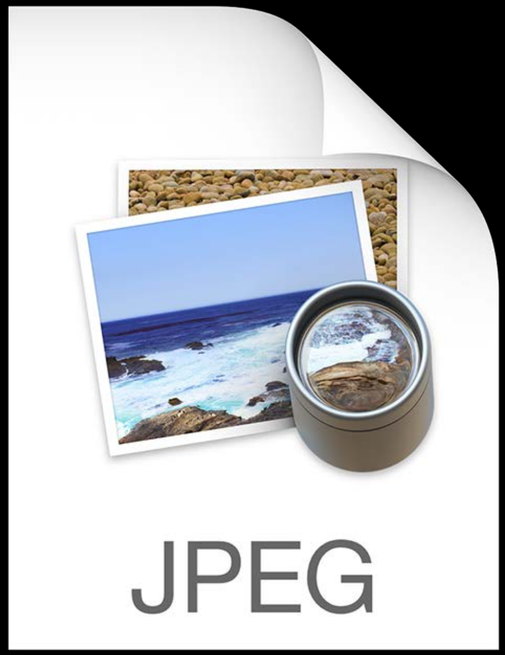
JPEG > De facto Standard for Image Compression

Hundreds of millions of JPEG images are
captured, created, uploaded, and shared daily



JPEG > De facto Standard for Image Compression

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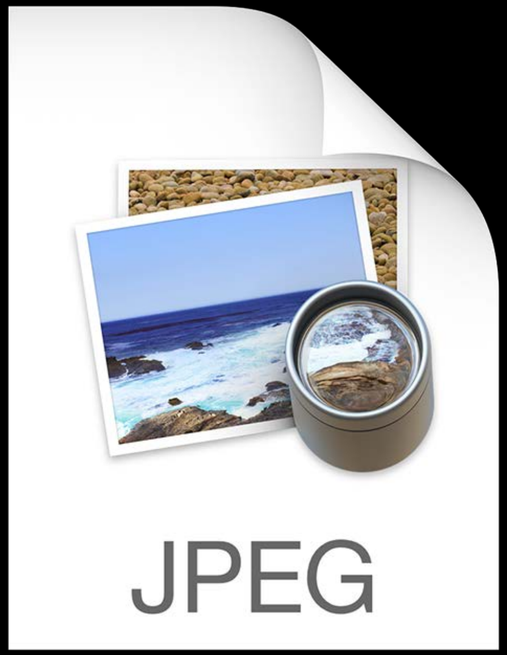
Limitations

- Compression
- Auxiliary images
- Animations



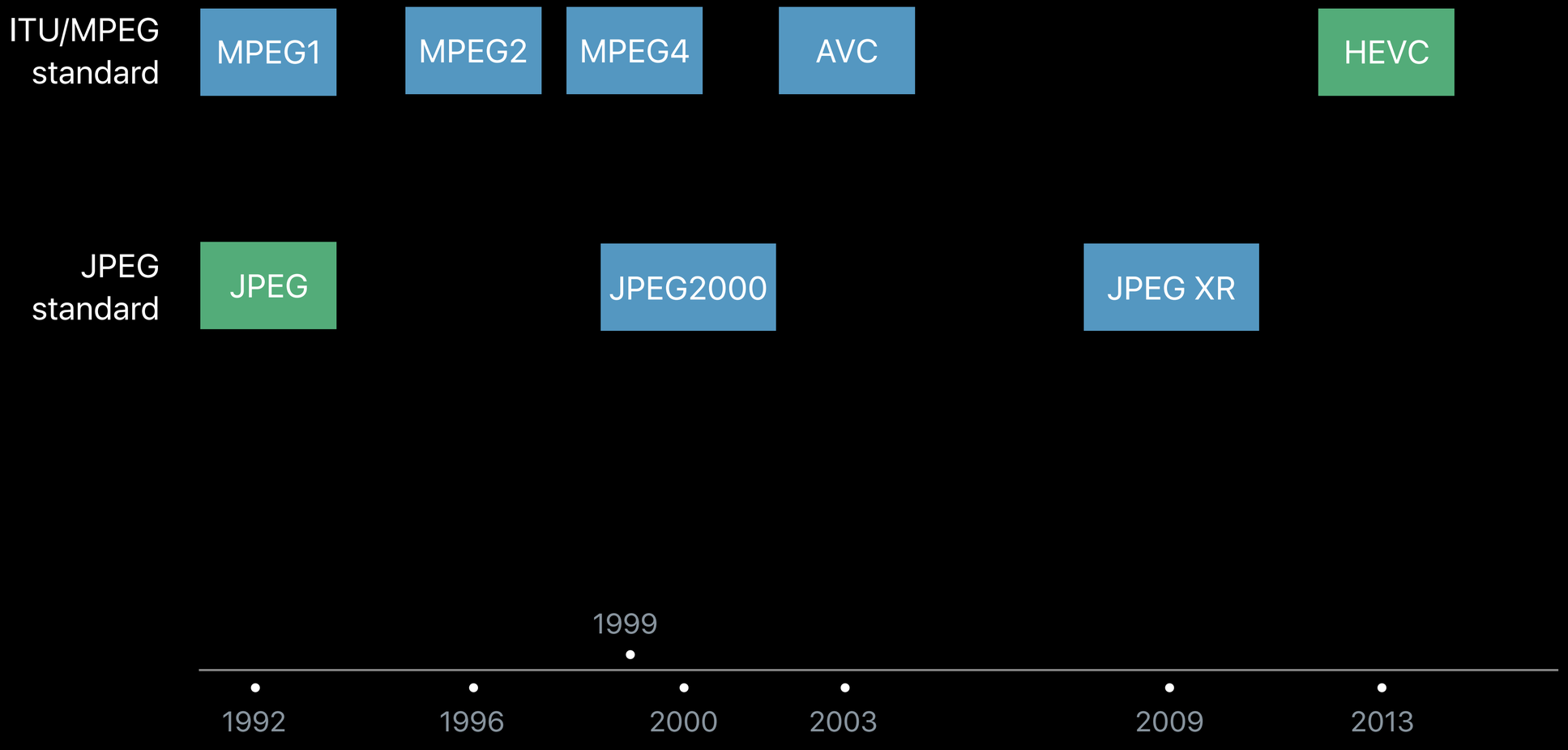
JPEG > 1992

ITU/MPEG standard

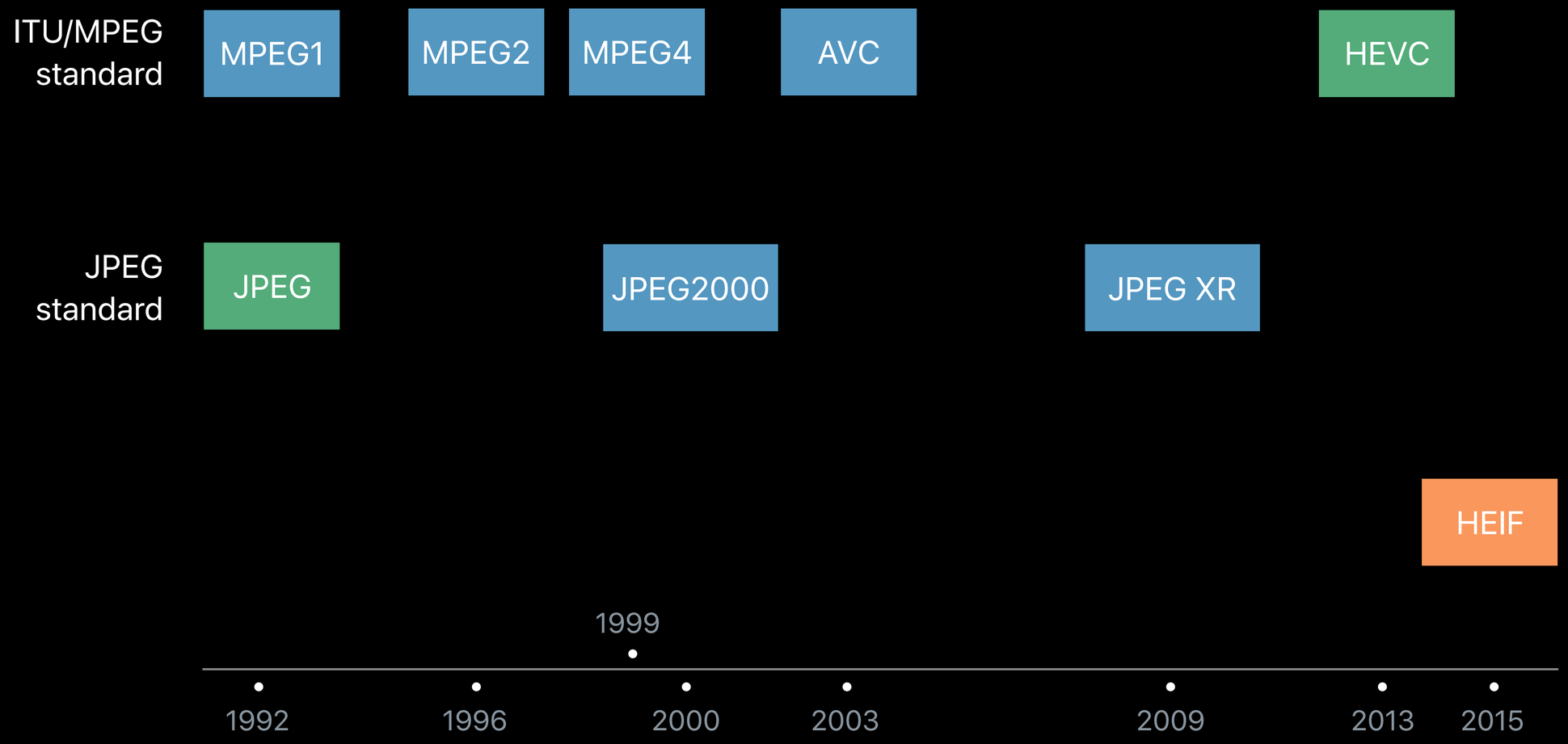
JPEG standard

1992

JPEG > 1992


ITU/MPEG standard
MPEG1
MPEG2
MPEG4
AVC
HEVC
JPEG standard
JPEG
JPEG2000
JPEG XR
1999
1992
1996
2000
2003
2009
2013

JPEG > 1992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Requirements for a New Format

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State-of-the-art compression

Requirements for a New Format

State-of-the-art compression

HW acceleration

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State-of-the-art compression

HW acceleration

Deep and wide color

Requirements for a New Format

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Deep and wide color

4:4:4 color sampling

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Auxiliary images

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Animation, burst, and playback intent

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Multiple-image

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Multiple-image

Multi-resolution

Requirements for a New Format

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HDR

Auxiliary images

Animation, burst, and playback intent

Multiple-image

Multi-resolution

Tiles

Requirements for a New Format

State-of-the-art compression

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Auxiliary images

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Multiple-image

Multi-resolution

Tiles

Rich metadata

Requirements for a New Format

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Multiple-image

Multi-resolution

Tiles

Rich metadata

Other media types

Requirements for a New Format

State-of-the-art compression

HW acceleration

Deep and wide color

4:4:4 color sampling

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Auxiliary images

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Other media types

Extensible

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HEIF > Standard

High Efficiency Image File Format

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High Efficiency Image File Format

ISO standard—ISO/IEC 23008-12 (June 2015—Version 1)

- http://mpeg.chiariglione.org/standards/mpeg-h/image-file-format

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Version 2 of the spec should be made public soon

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Reference model from MPEG

- http://mp4ra.org

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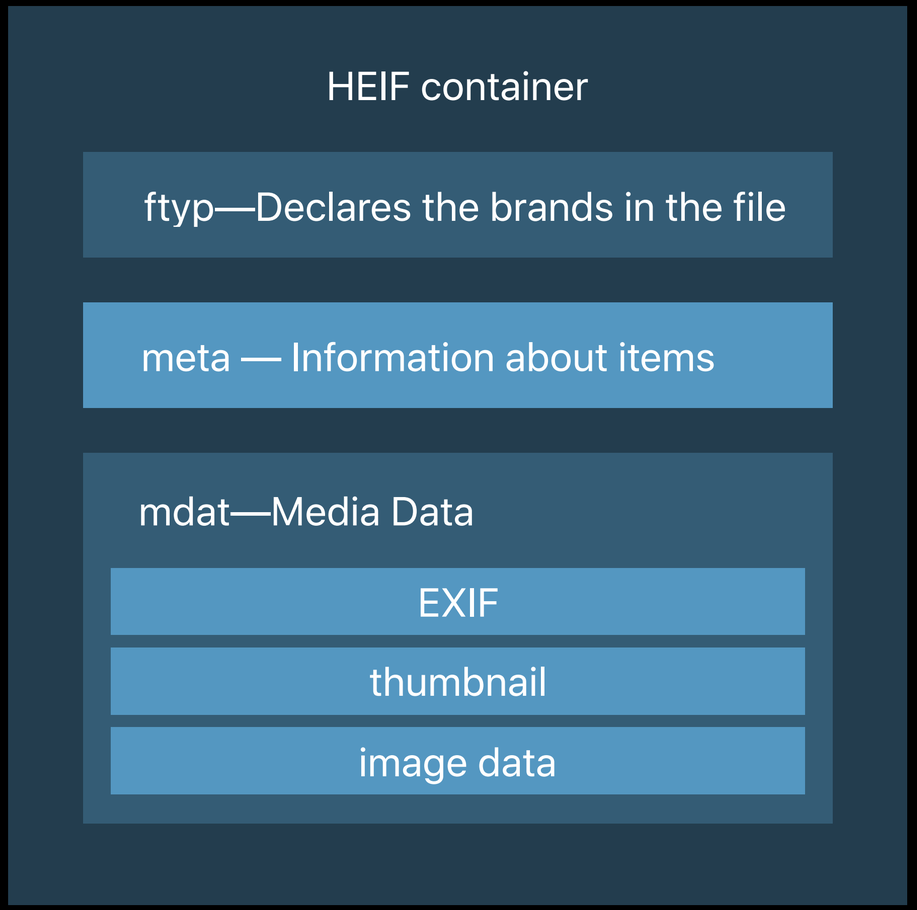
GPAC/MP4Box has recently added basic support for HEIF

- https://gpac.wp.imt.fr

HEIF > Container

HEIF specifies a structural format
(a “container”)

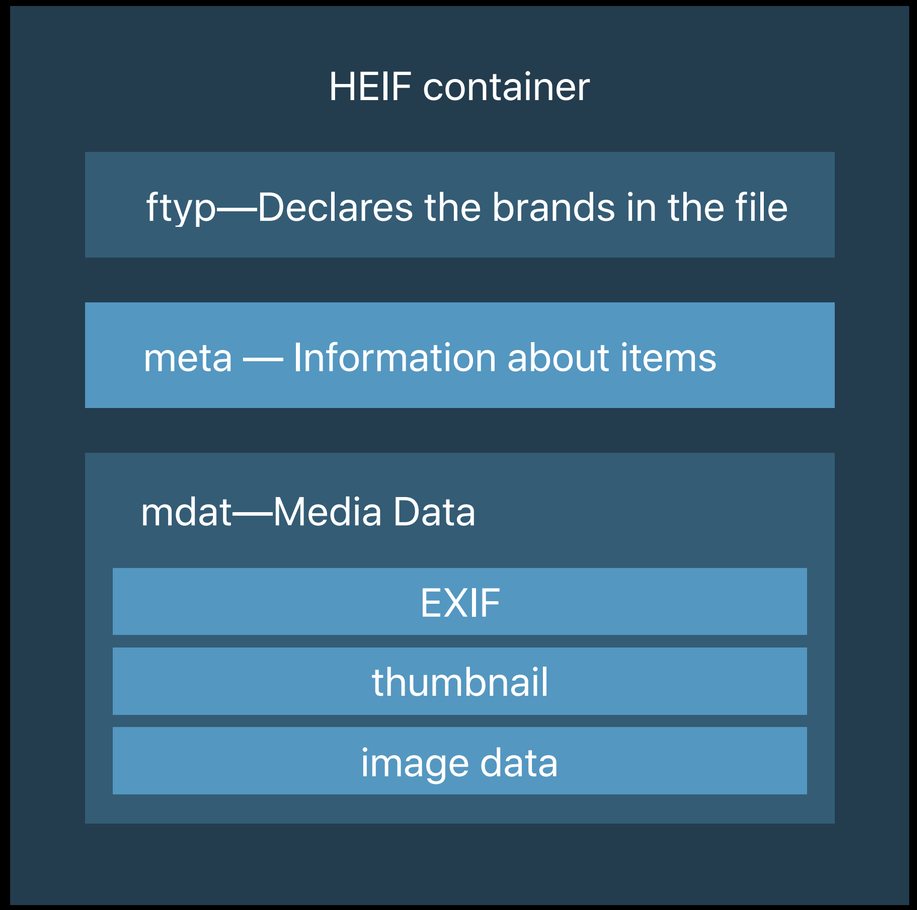


HEIF > Container

HEIF specifies a structural format
(a “container”)

Derived from ISO Base Media File Format
(ISOBMFF - ISO/IEC 14496-12),
based on Apple QuickTime

- MP4, timed media
- MPEG-21, digital items



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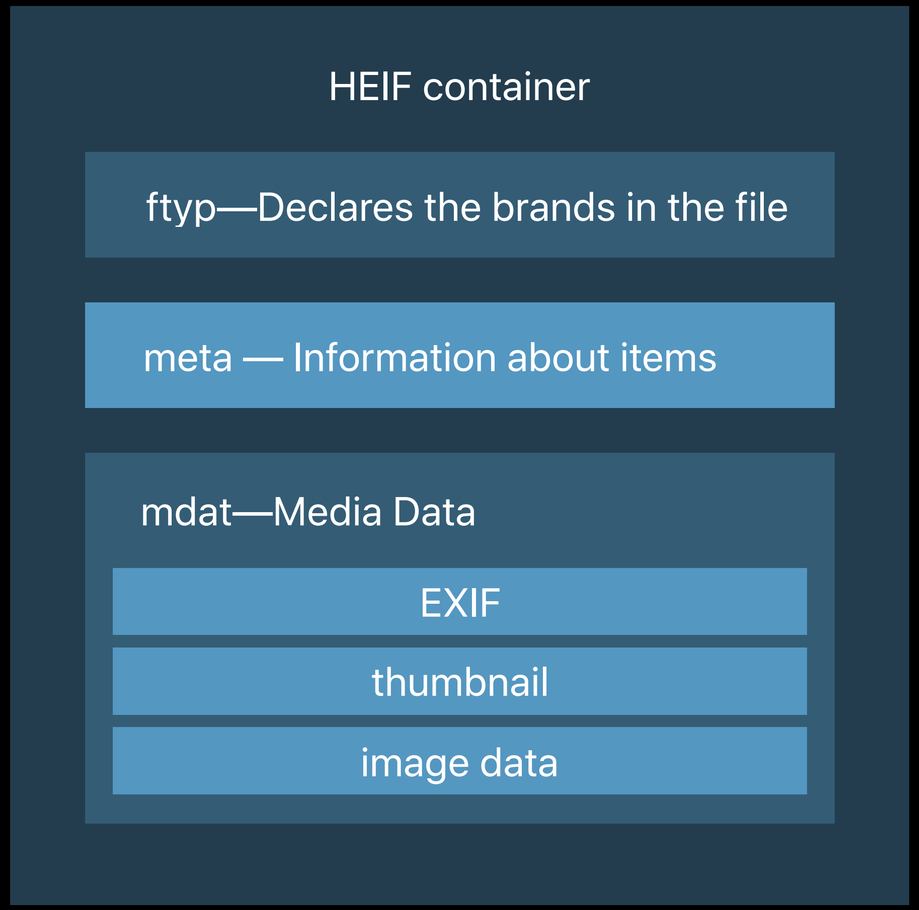

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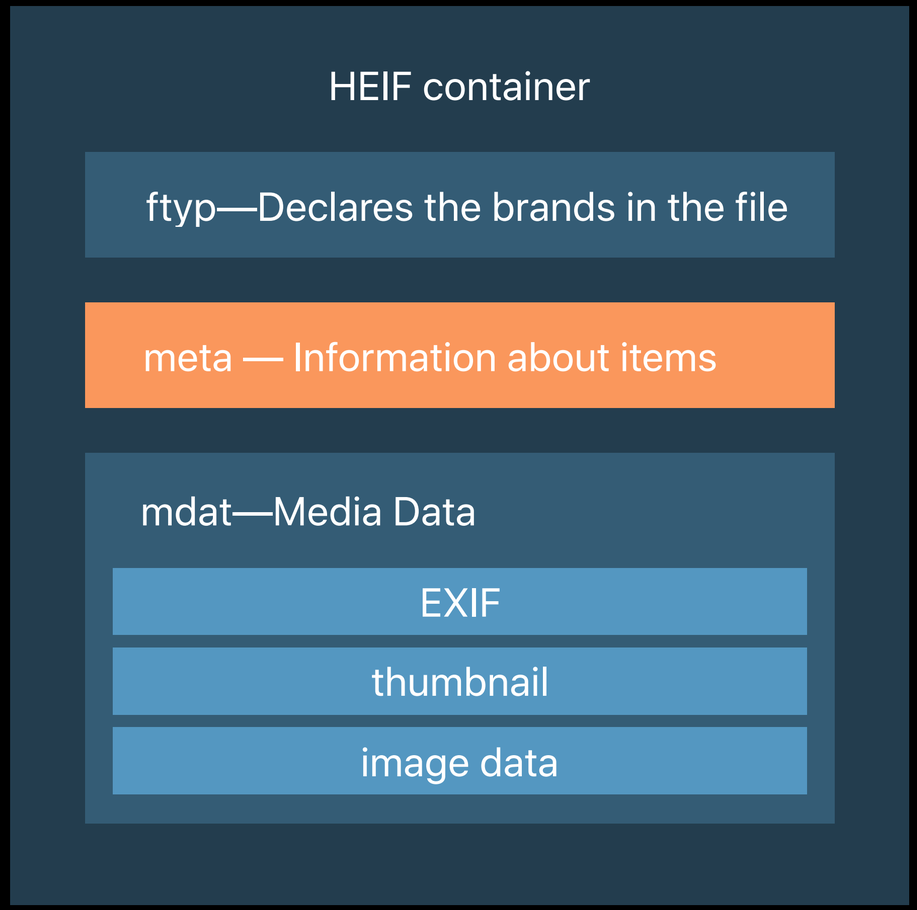

HEIF > File Extension

Payload	Extension—single image	Extension—sequence
HEVC	.HEIC	.HEICS
H.264	.AVCI	.AVCS
Any Codec	.HEIF	.HEIFS

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HEIF Anatomy

Items

Roles of images

Image properties

Properties association

Image sequences

Tiles

HEIF Anatomy > Items

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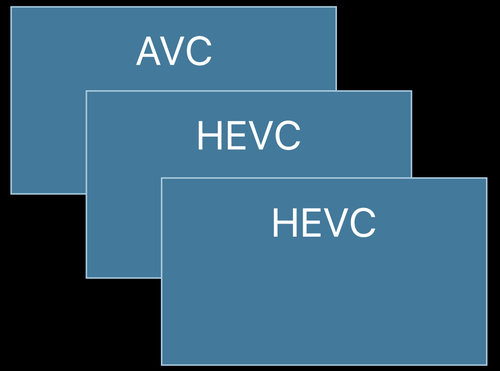
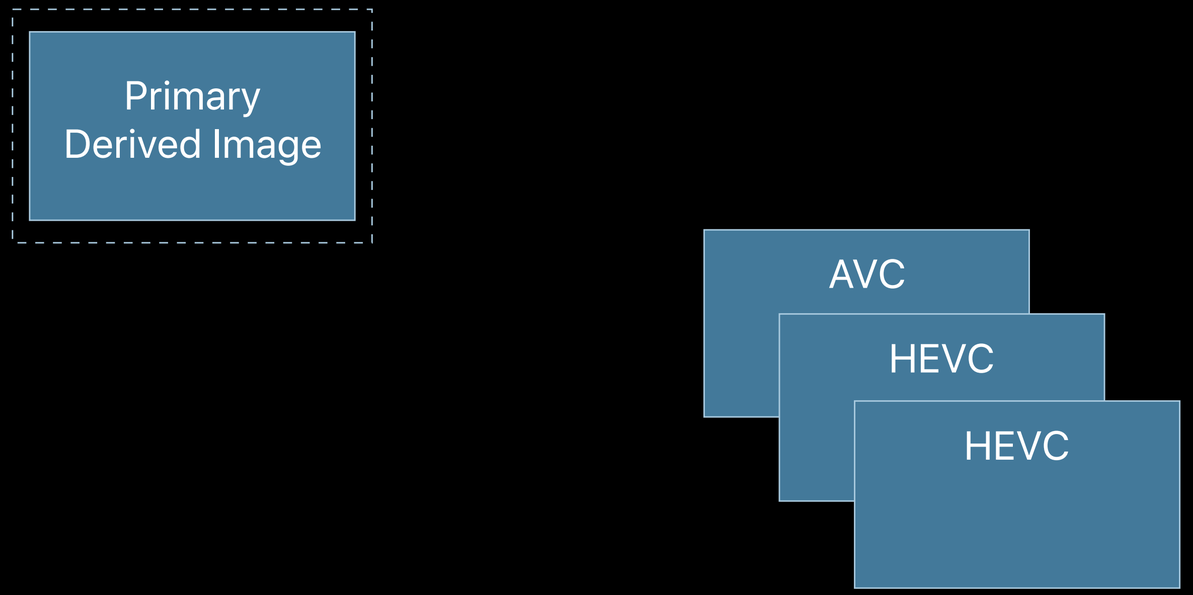


HEIF Anatomy > Items



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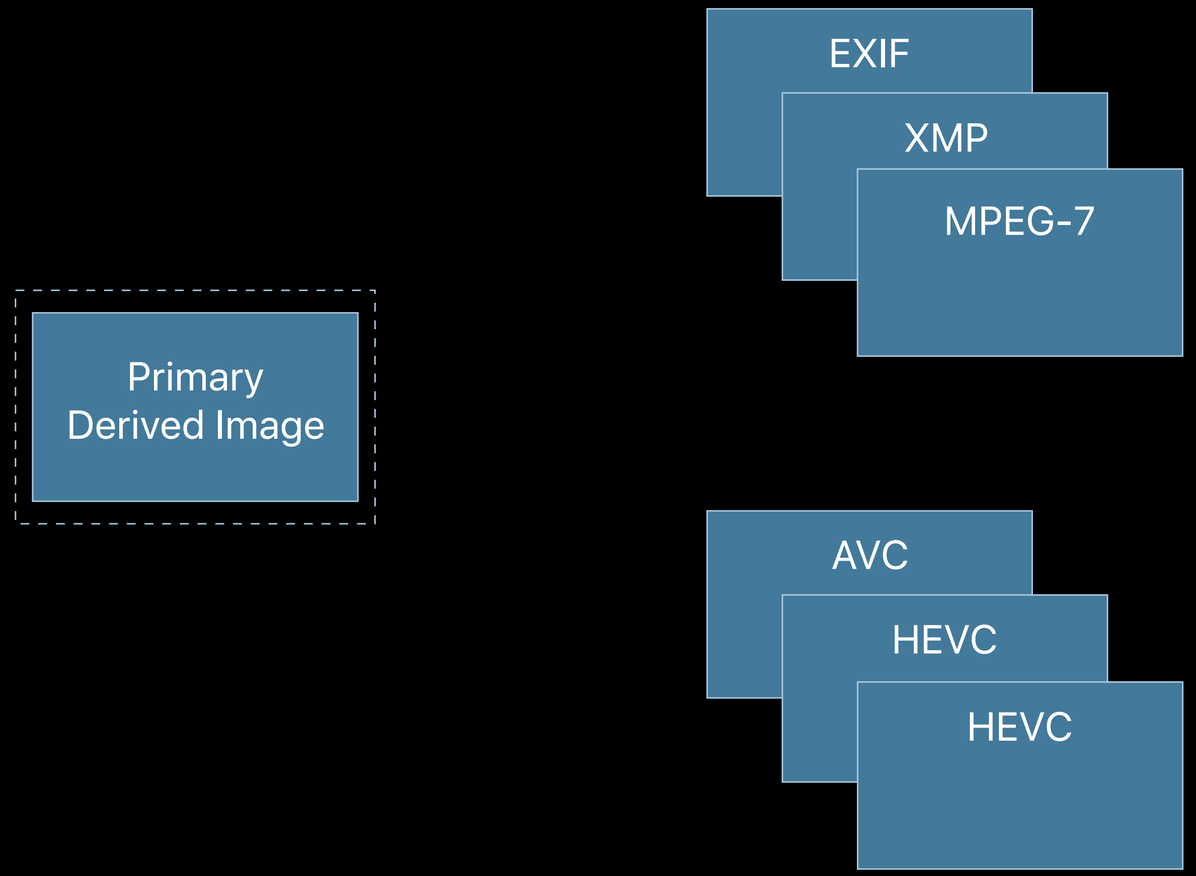
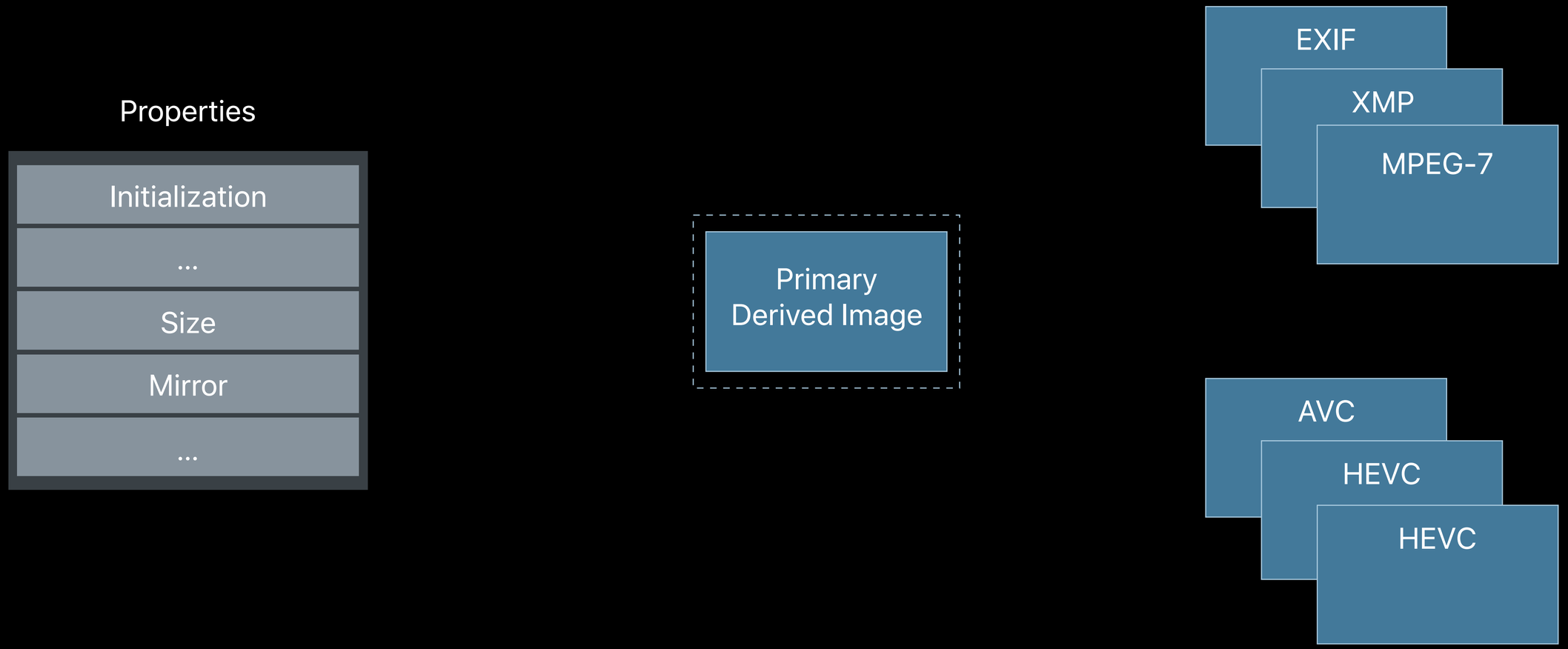


HEIF Anatomy > Items



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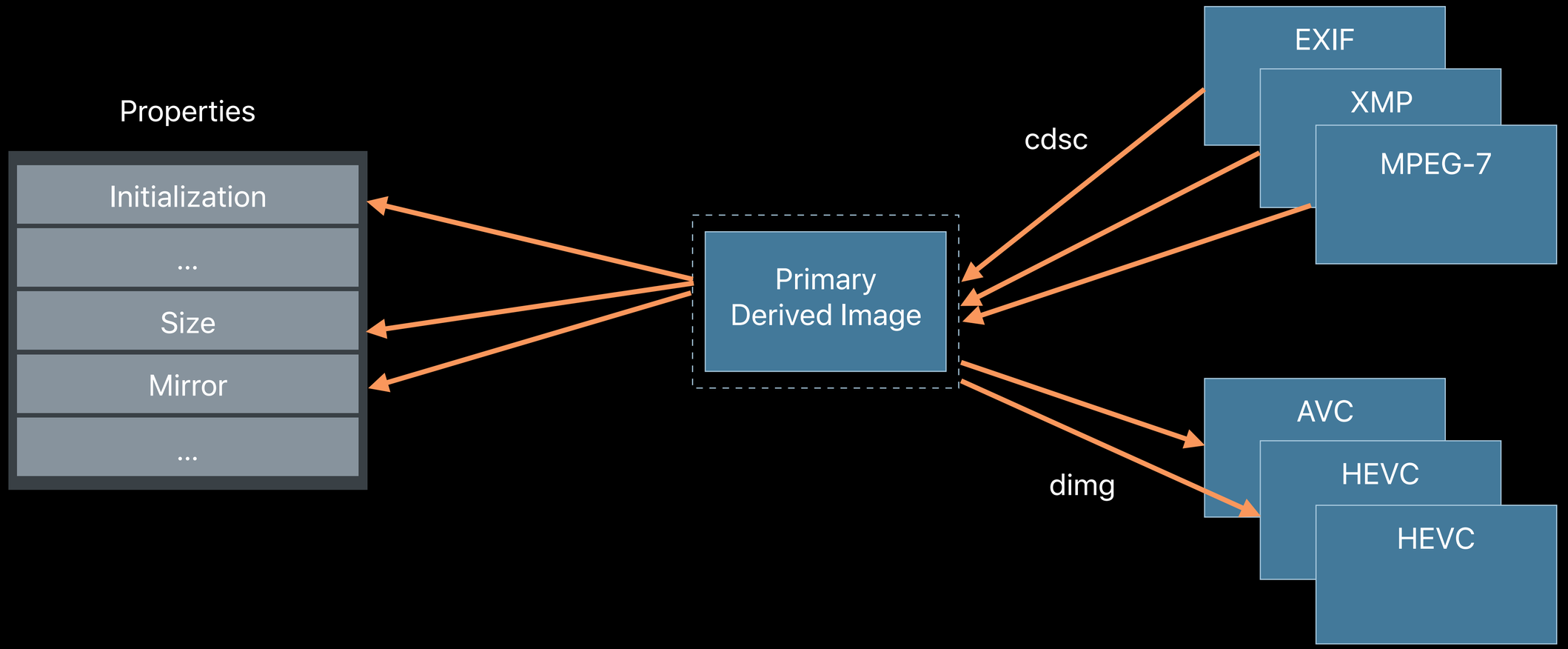

HEIF Anatomy

Items

Roles of images

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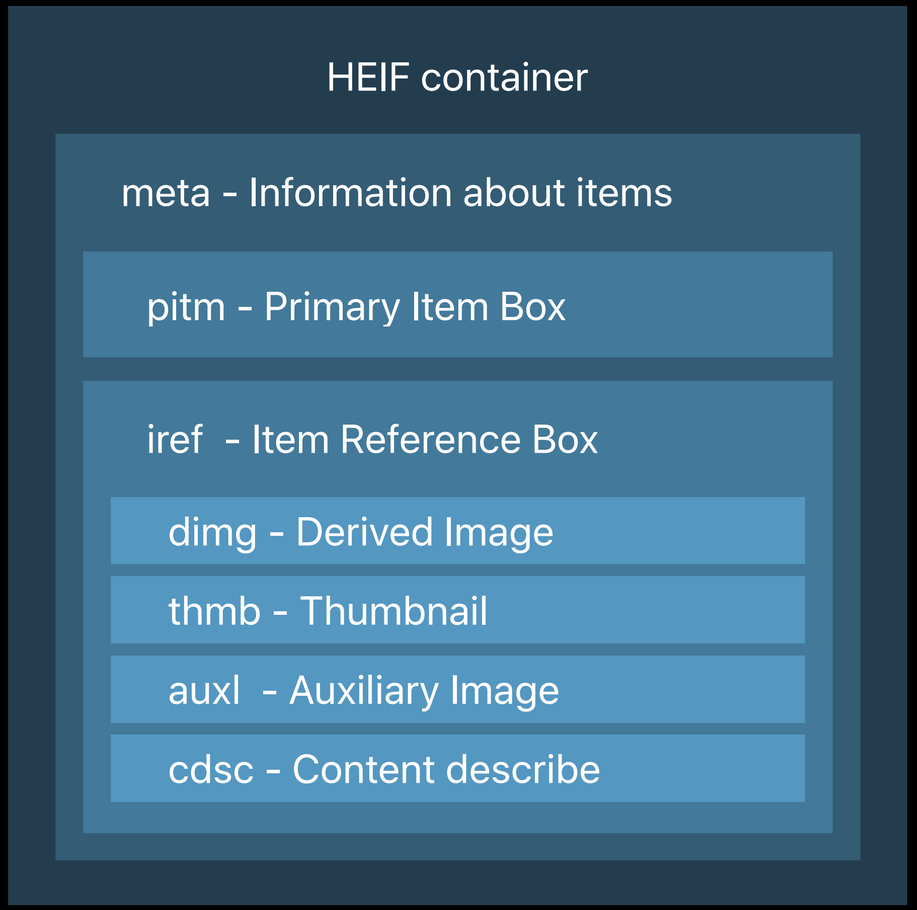
HEIF Anatomy > Roles of Images

Primary	Representative image
Master	Full-resolution displayable image
Thumbnail	Smaller resolution
Auxillary	Alpha plane or a depth map
Hidden	Not for display
Derived	‘grid’, ‘iden’, ‘iovl’
Equivalent	Alternative images



HEIF Anatomy

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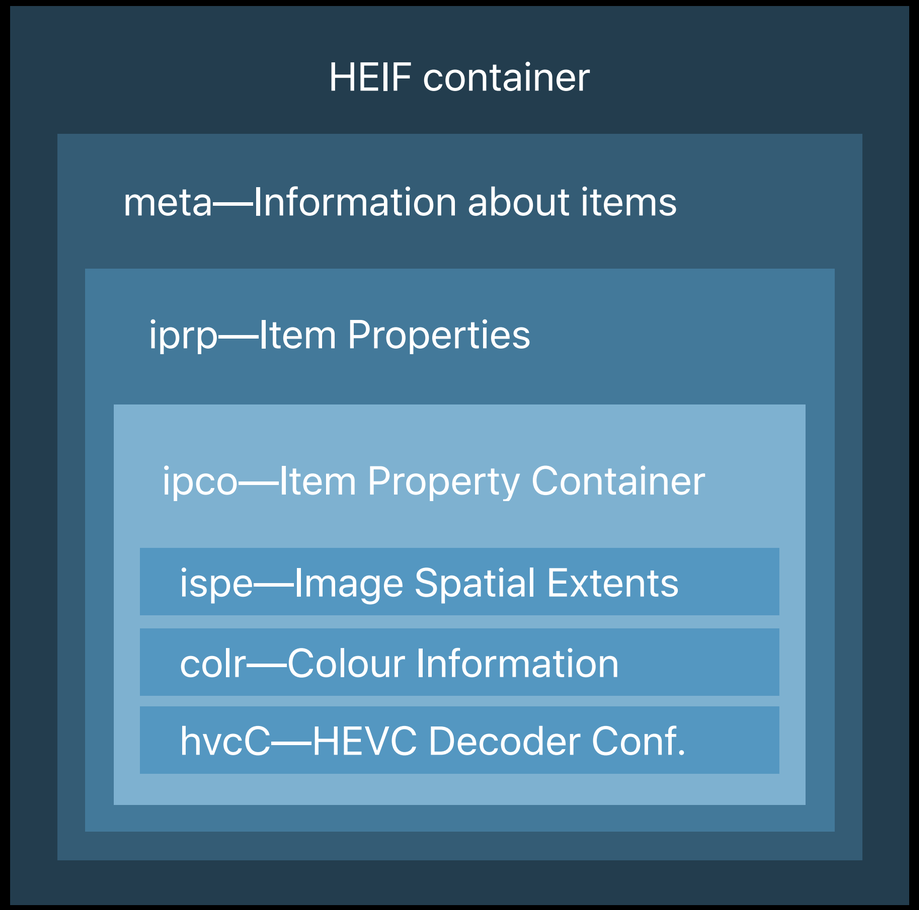
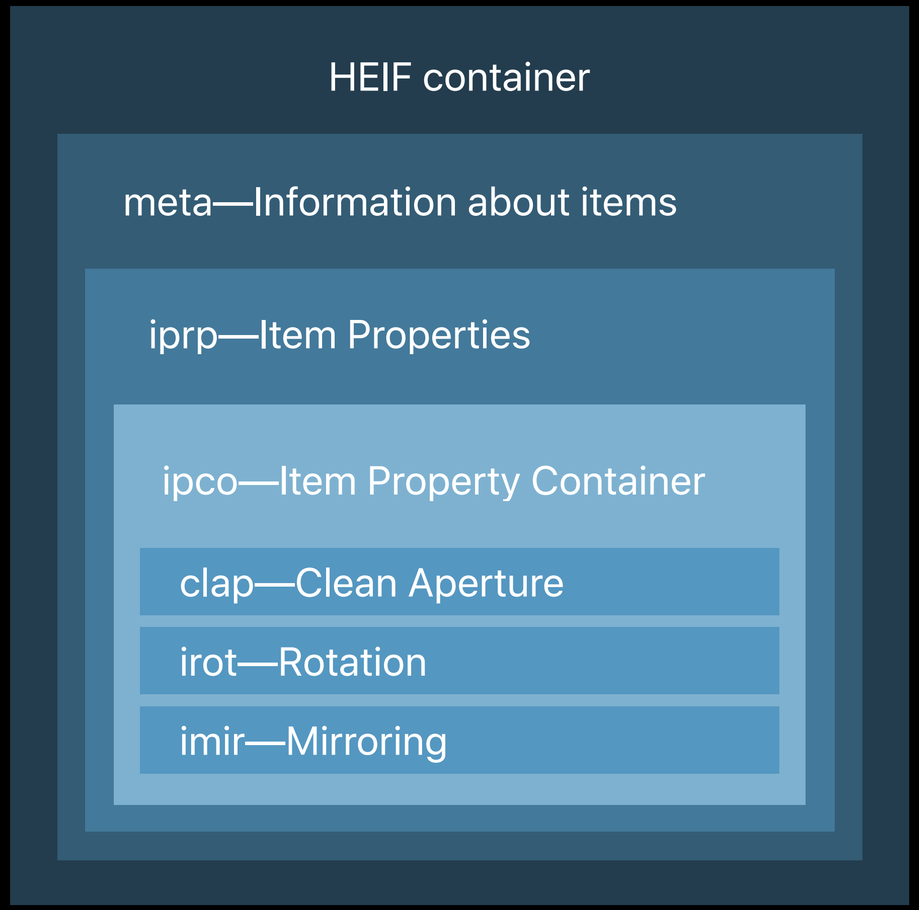
HEIF Anatomy > Image Properties > Descriptive

Decoder configuration	Codec initialization
Image spatial extents	Width and height
Pixel aspect ratio	Pixel aspect ratio
Colour information	ICC profile
Relative location	Position of the reconstructed image
Auxiliary images properties	Type of auxiliary image



HEIF Anatomy > Image Properties > Transformative

Clean aperture	Cropping of image
Image rotation	0, 90,180,270 degrees rotation
Image mirroring	Image mirroring



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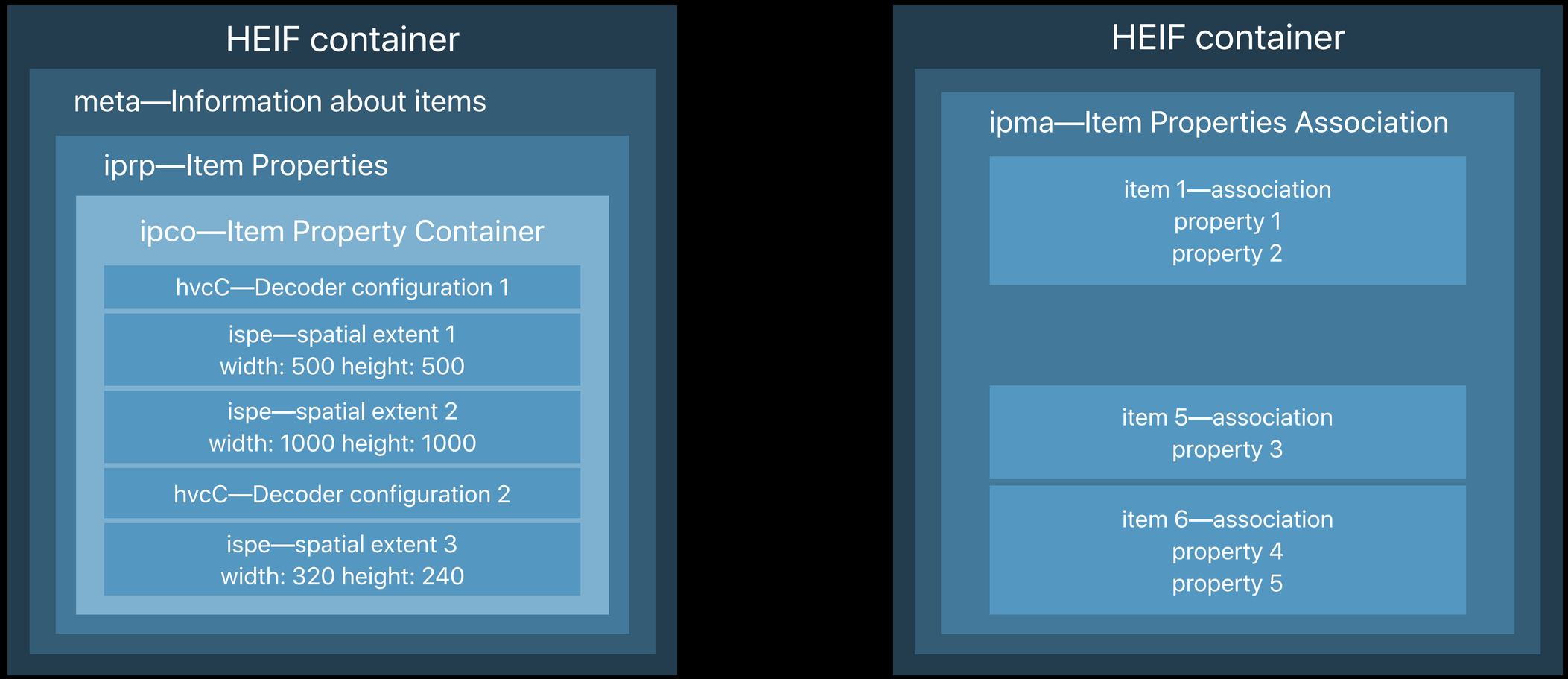
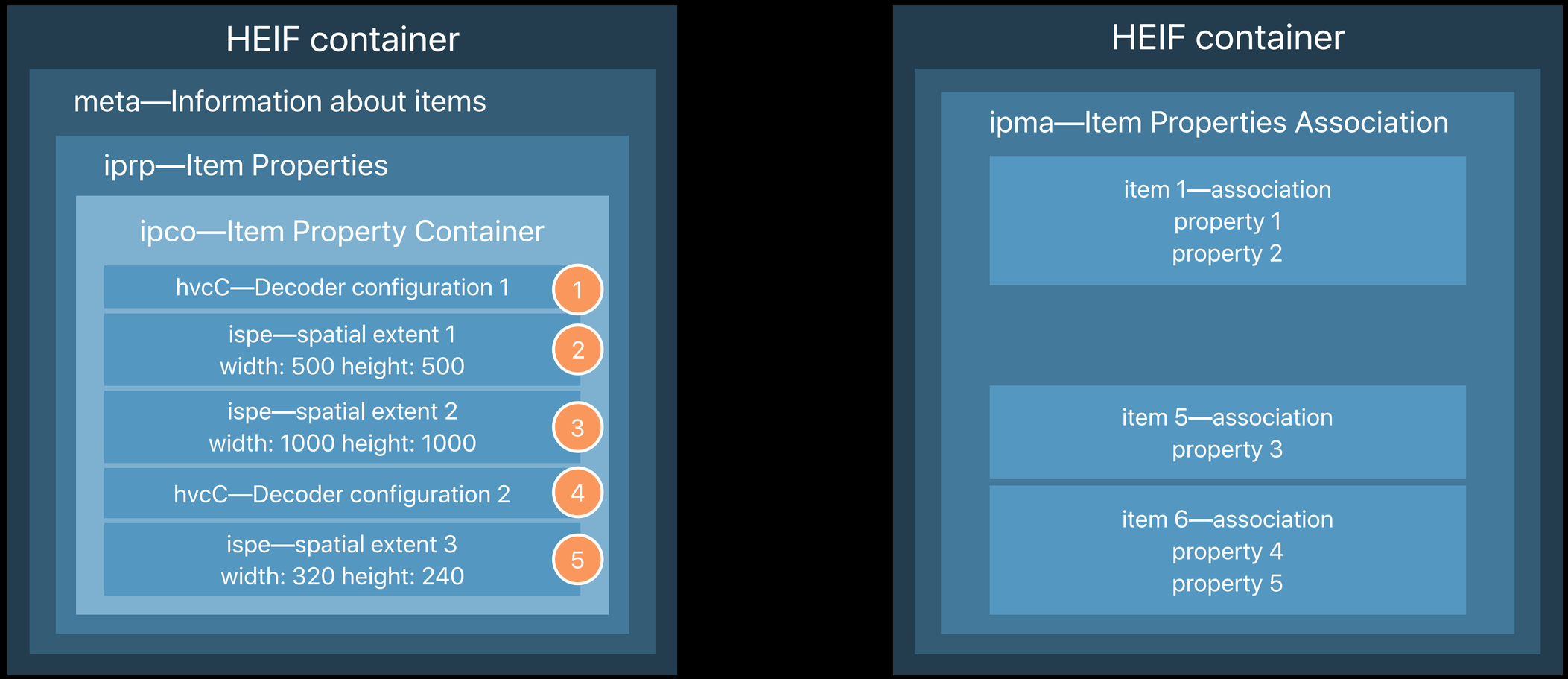
HEIF Anatomy > Image Properties > Association



HEIF Anatomy > Image Properties > Association



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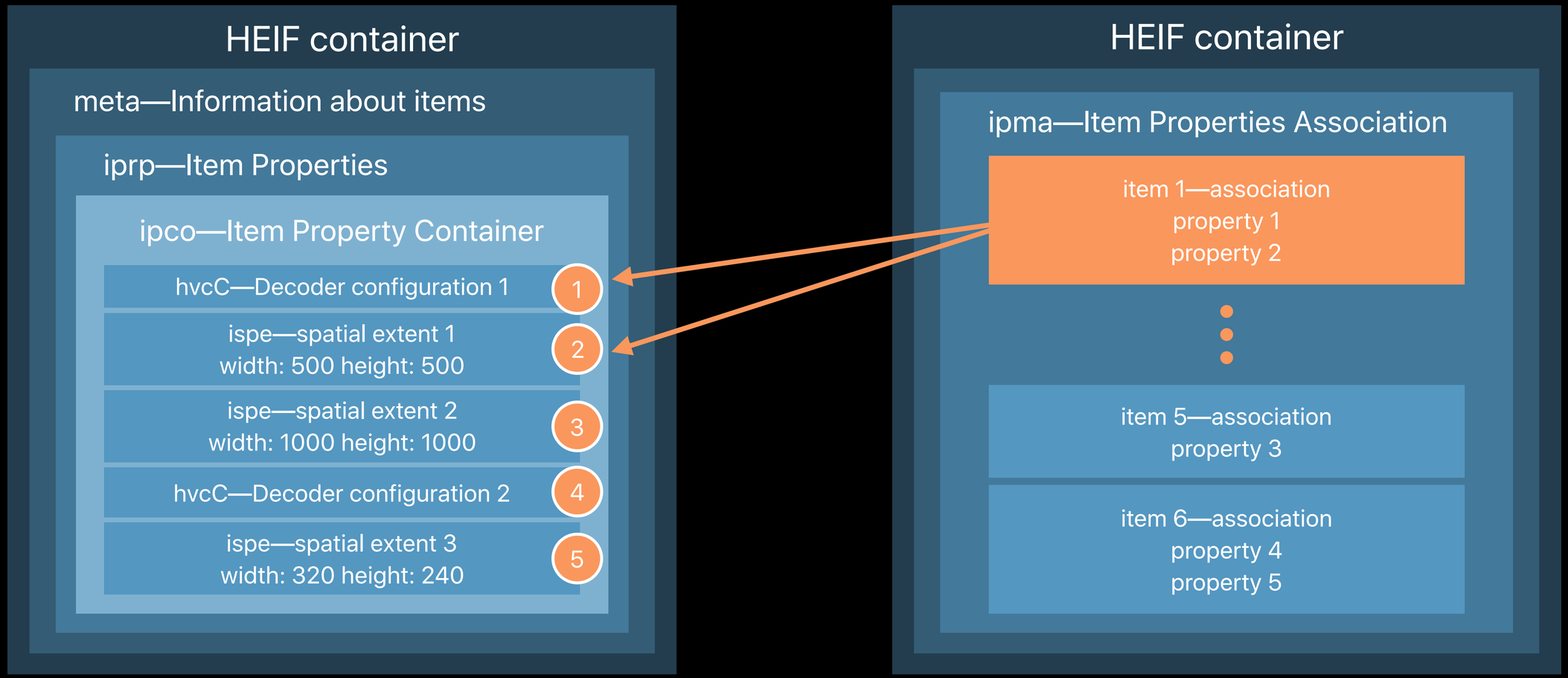

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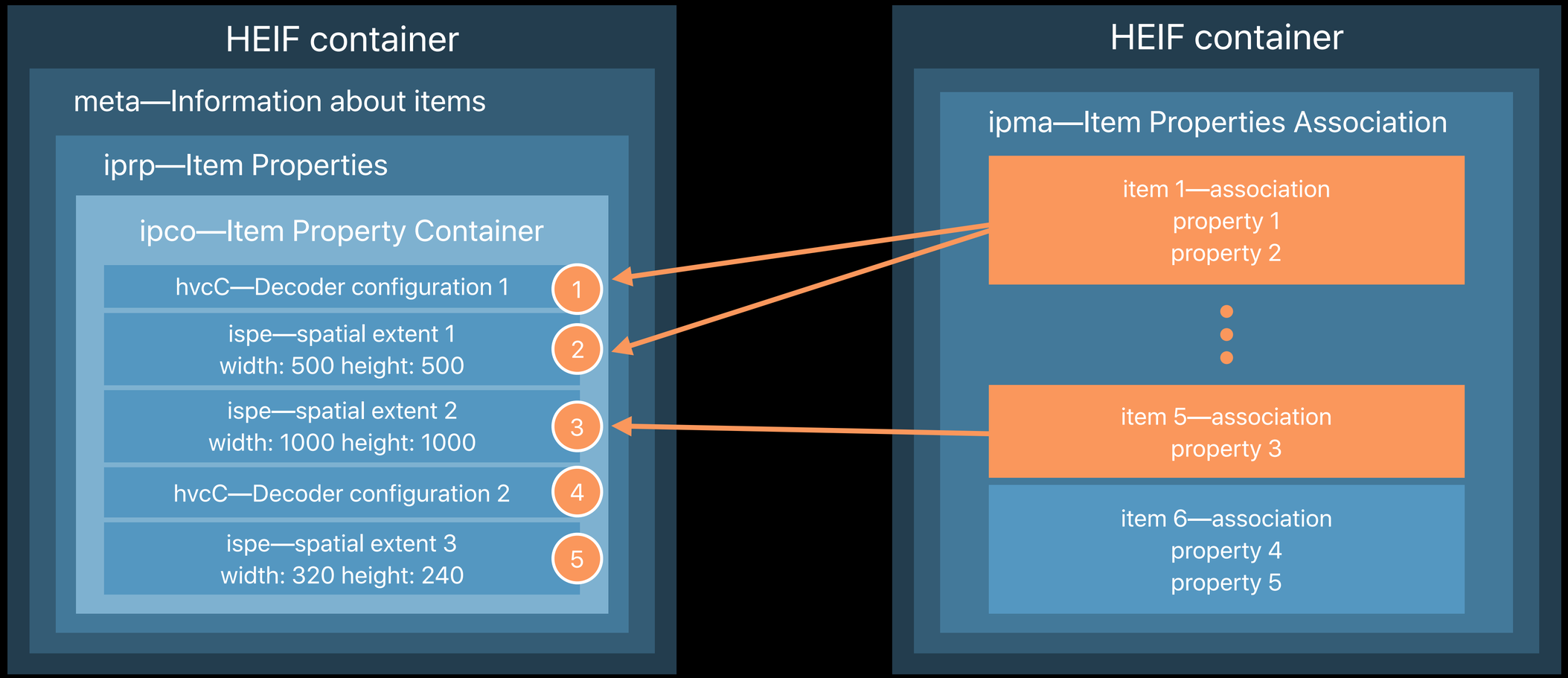

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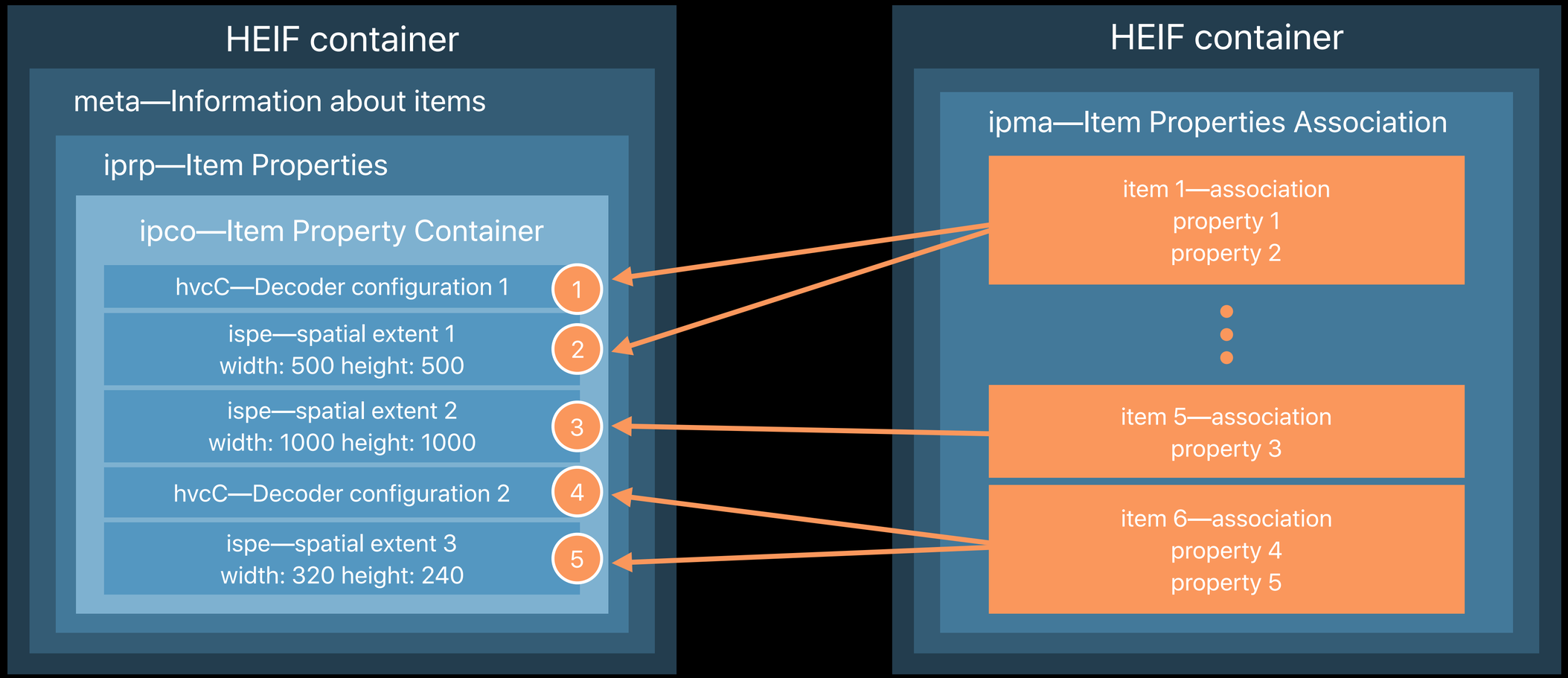

HEIF Anatomy

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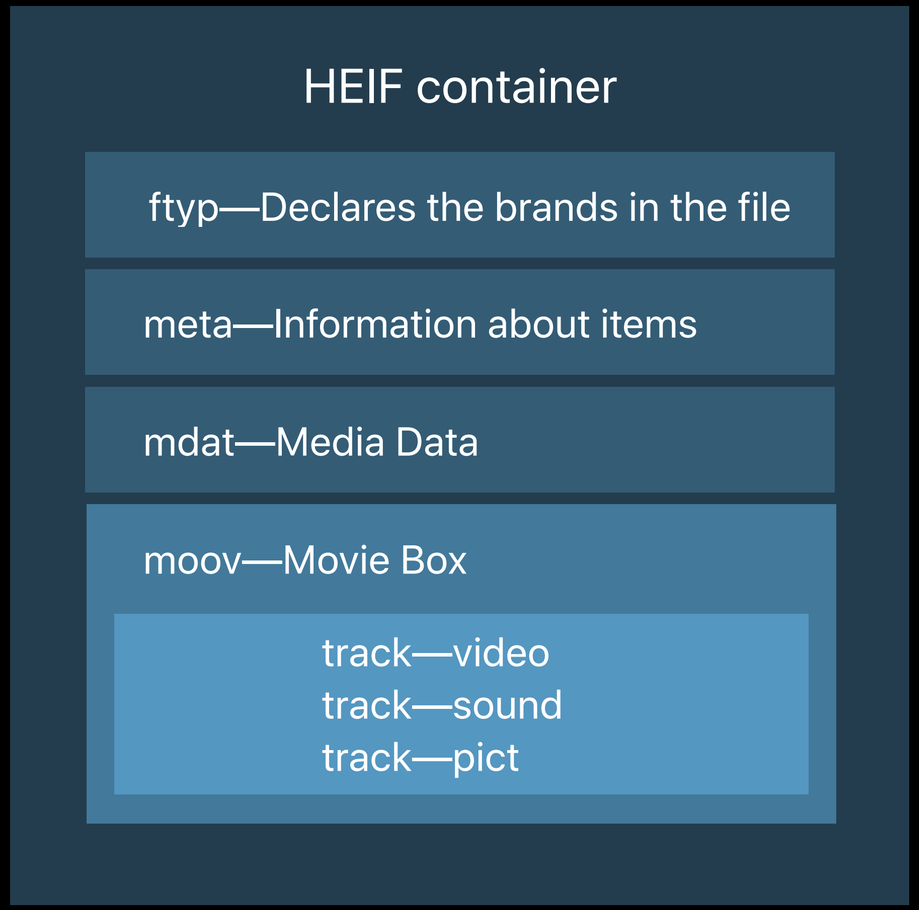
HEIF Anatomy > Sequences

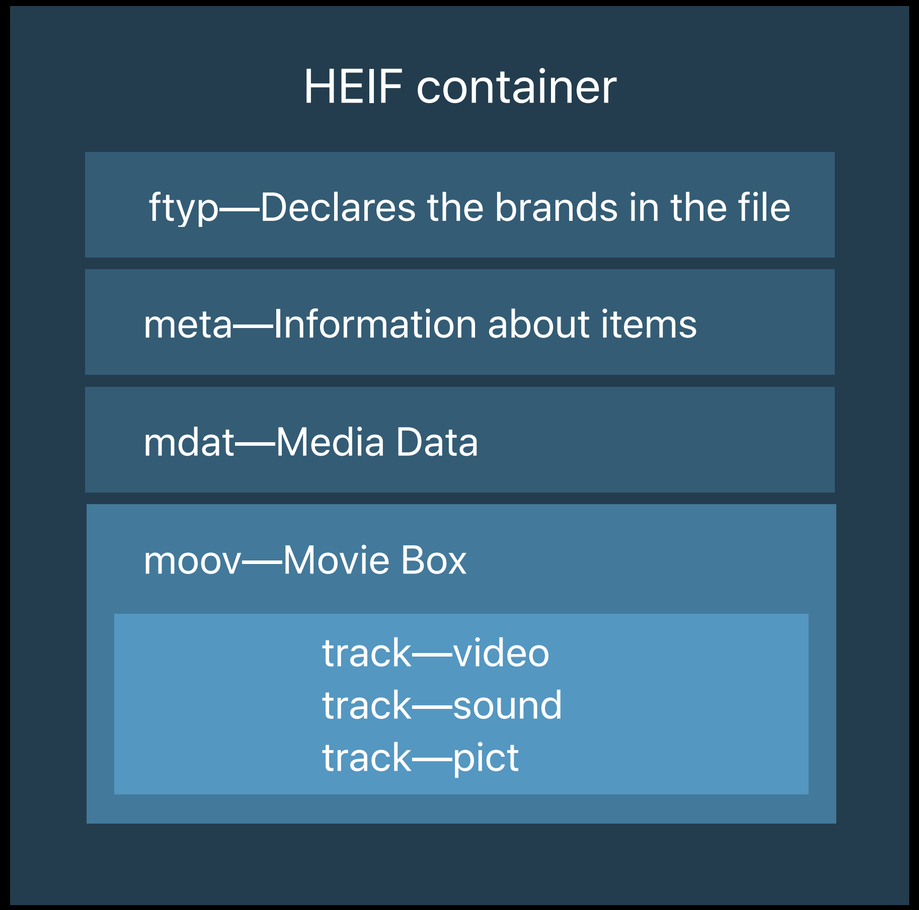
‘moov’ box—‘trak’ box—‘pict’ handler



HEIF Anatomy > Sequences

‘moov’ box—‘trak’ box—‘pict’ handler

Tracks have roles too



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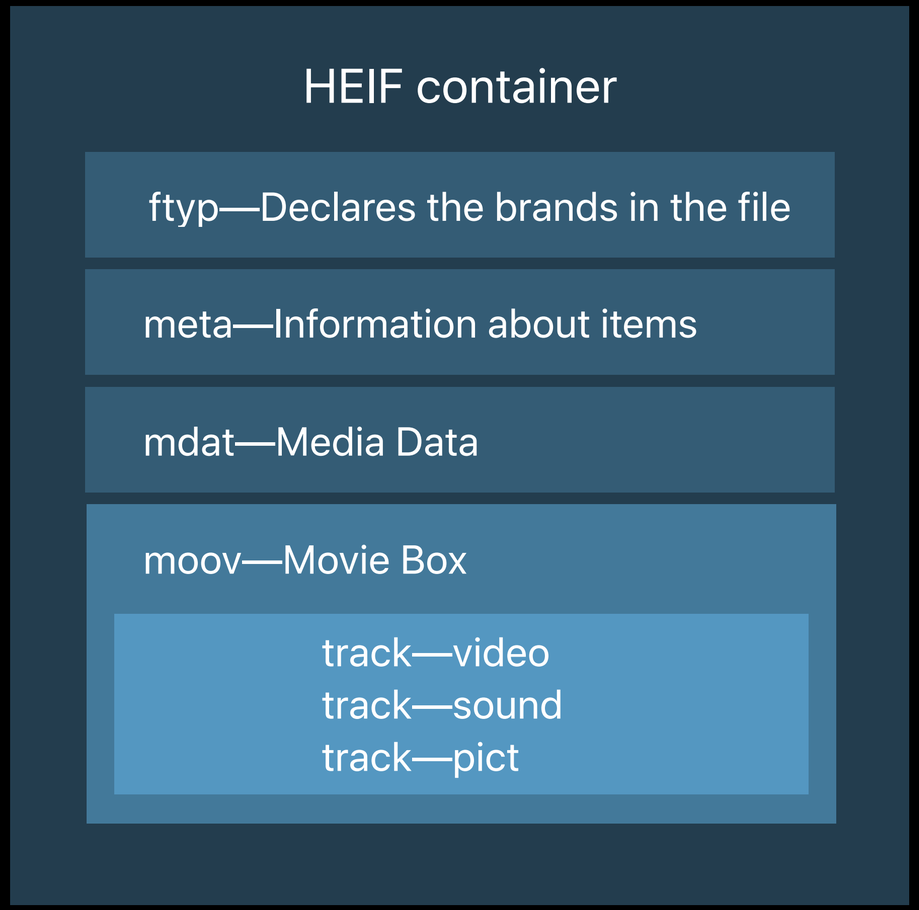
‘moov’ box—‘trak’ box—‘pict’ handler

Tracks have roles too

Controlling the playback

- Edit list
- Looping



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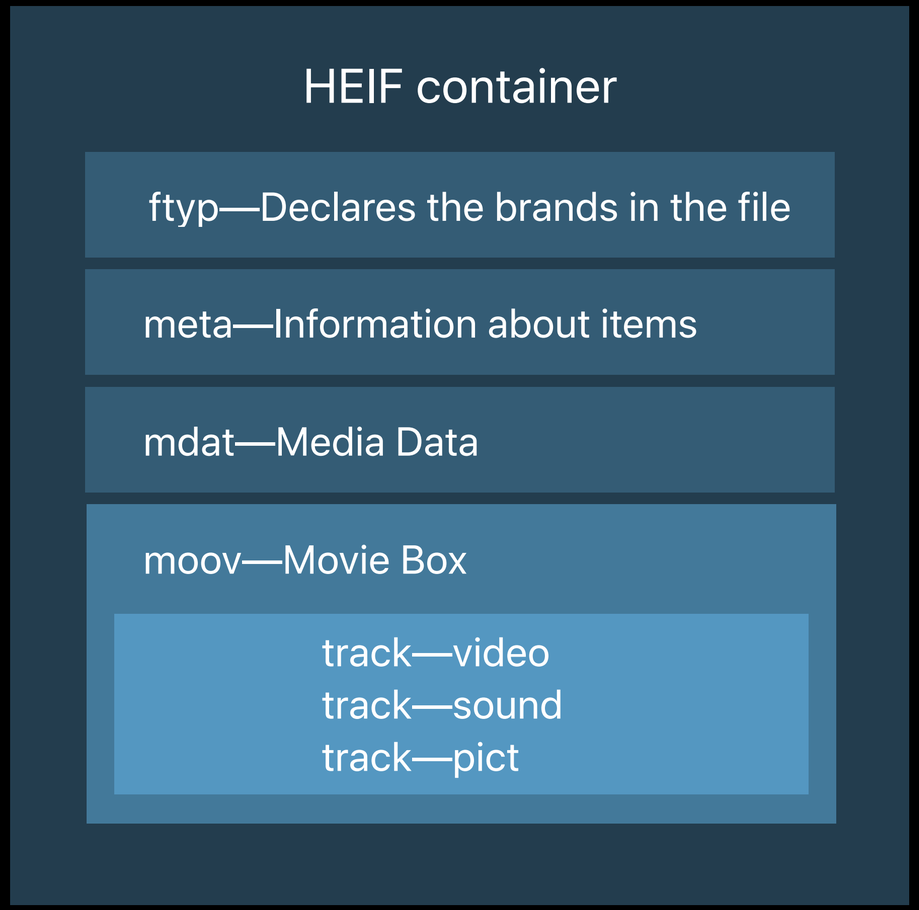
Inter prediction



HEIF Anatomy

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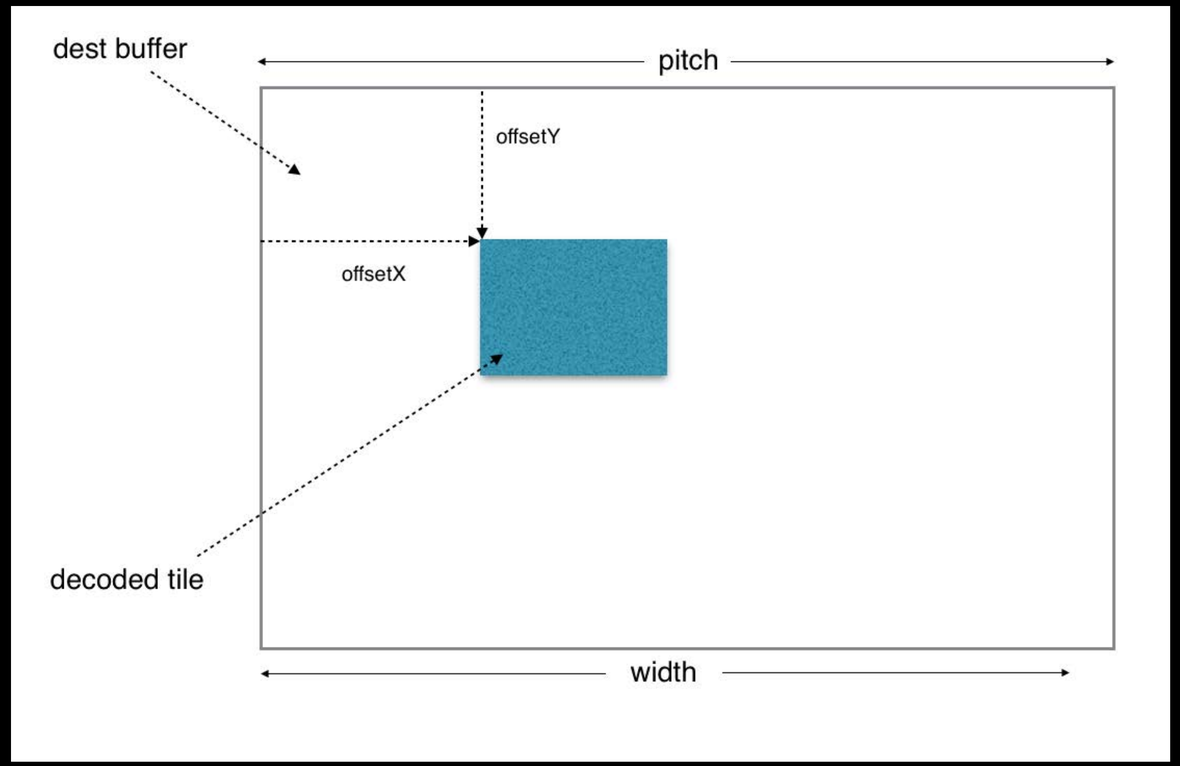
Tiles

HEIF Anatomy > Tiles

Tiles

- rloc
- grid



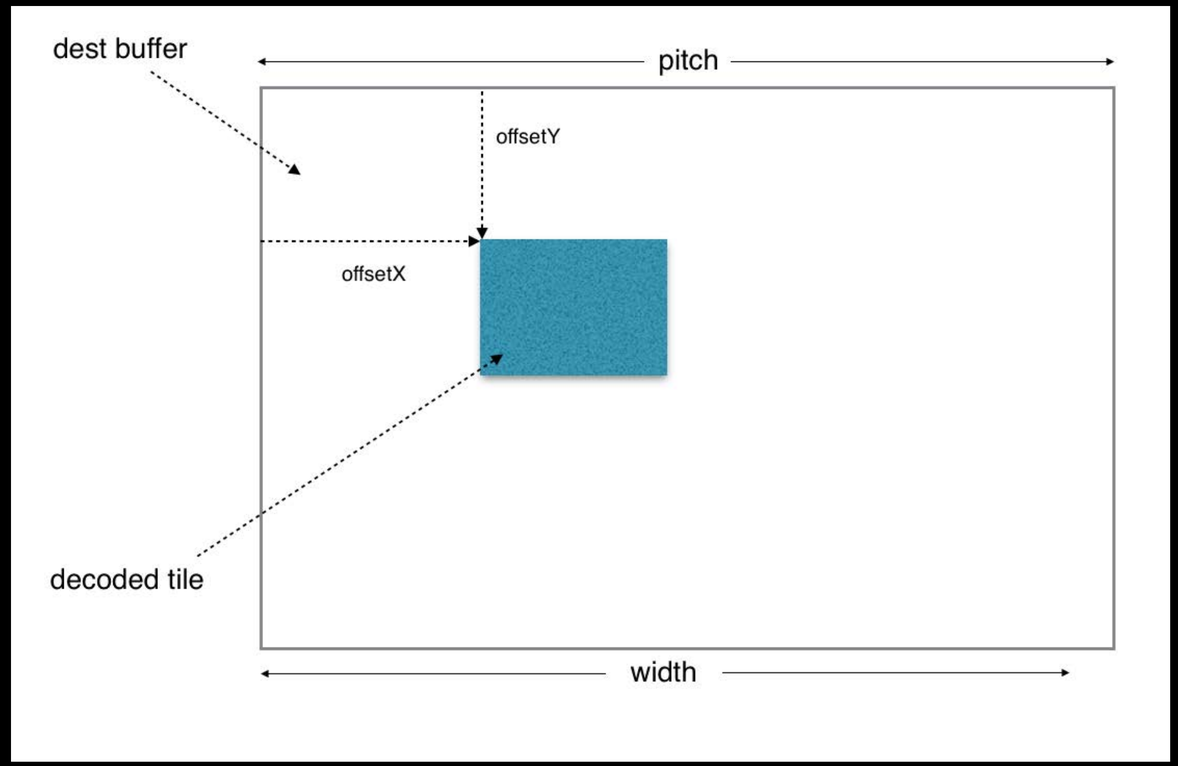
HEIF Anatomy > Tiles

Tiles

- rloc
- grid

Why tiles?

- Parallelism
- Memory
- Cropping



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- rloc
- grid

Why tiles?

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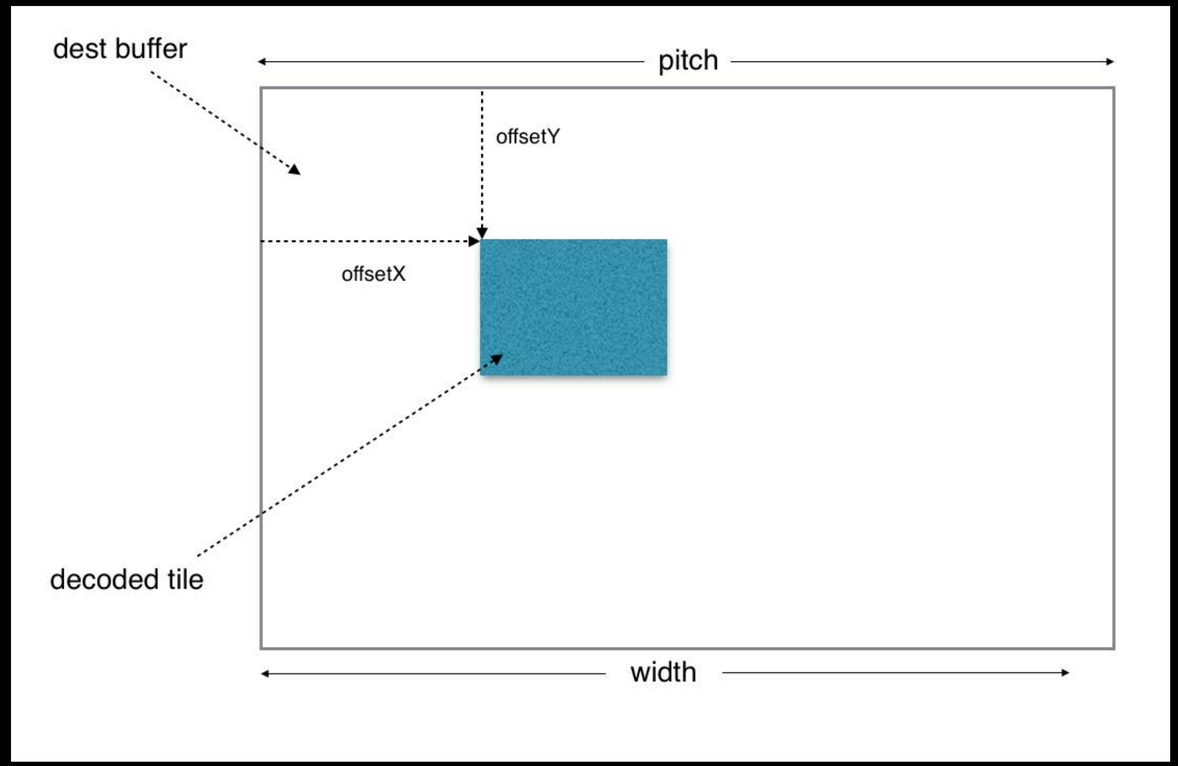
System tiles vs. HEVC tiles



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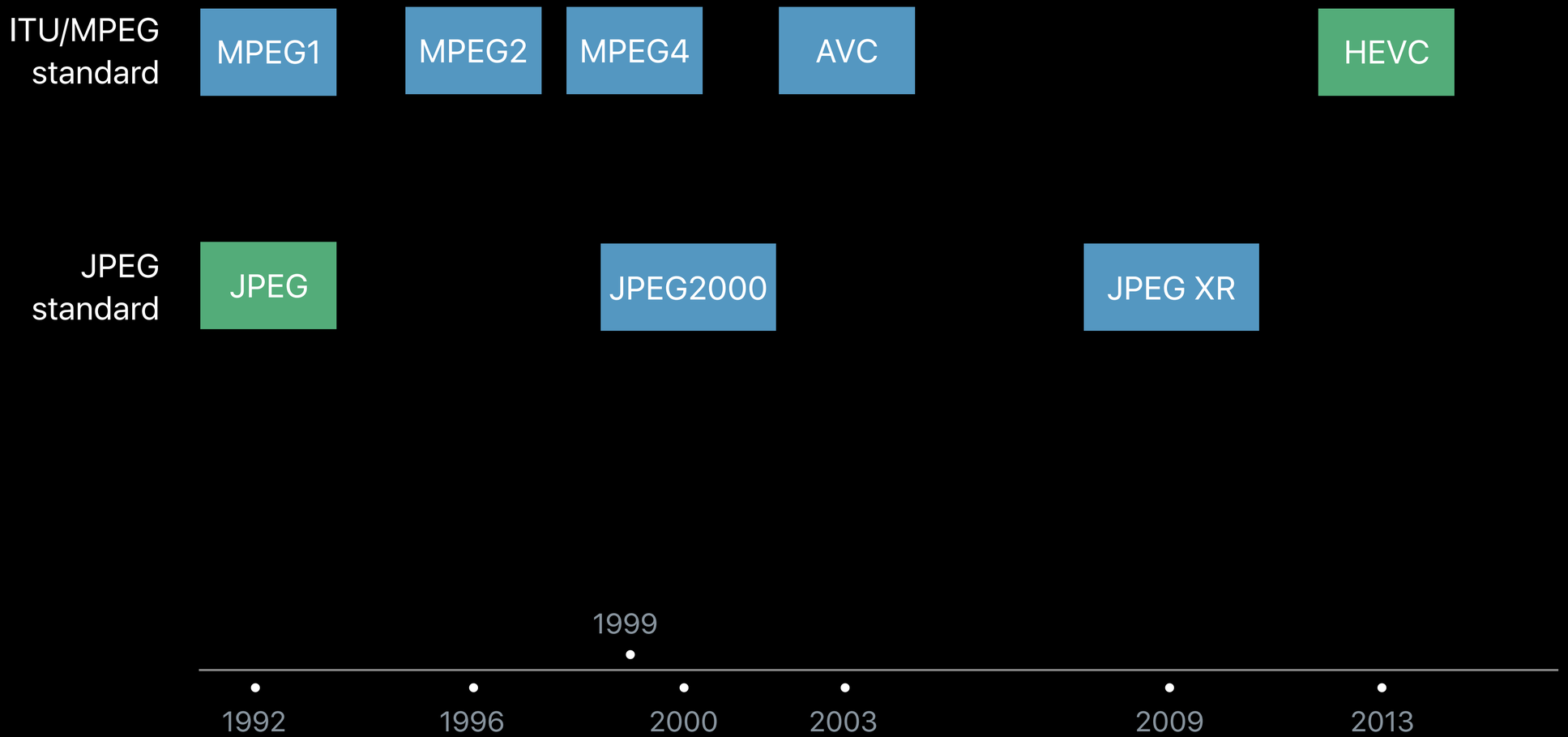
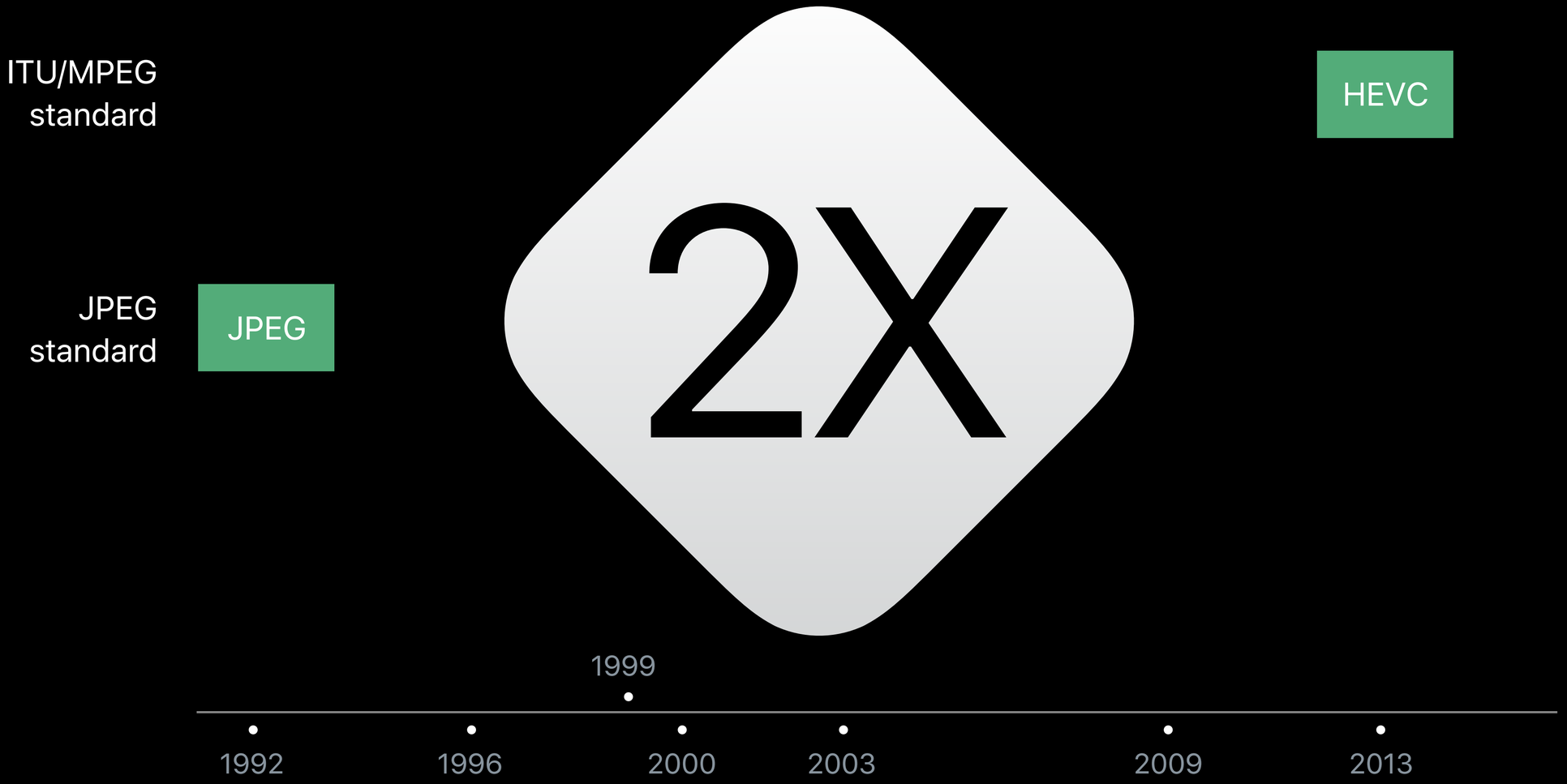


The Codec of Choice—HEVC



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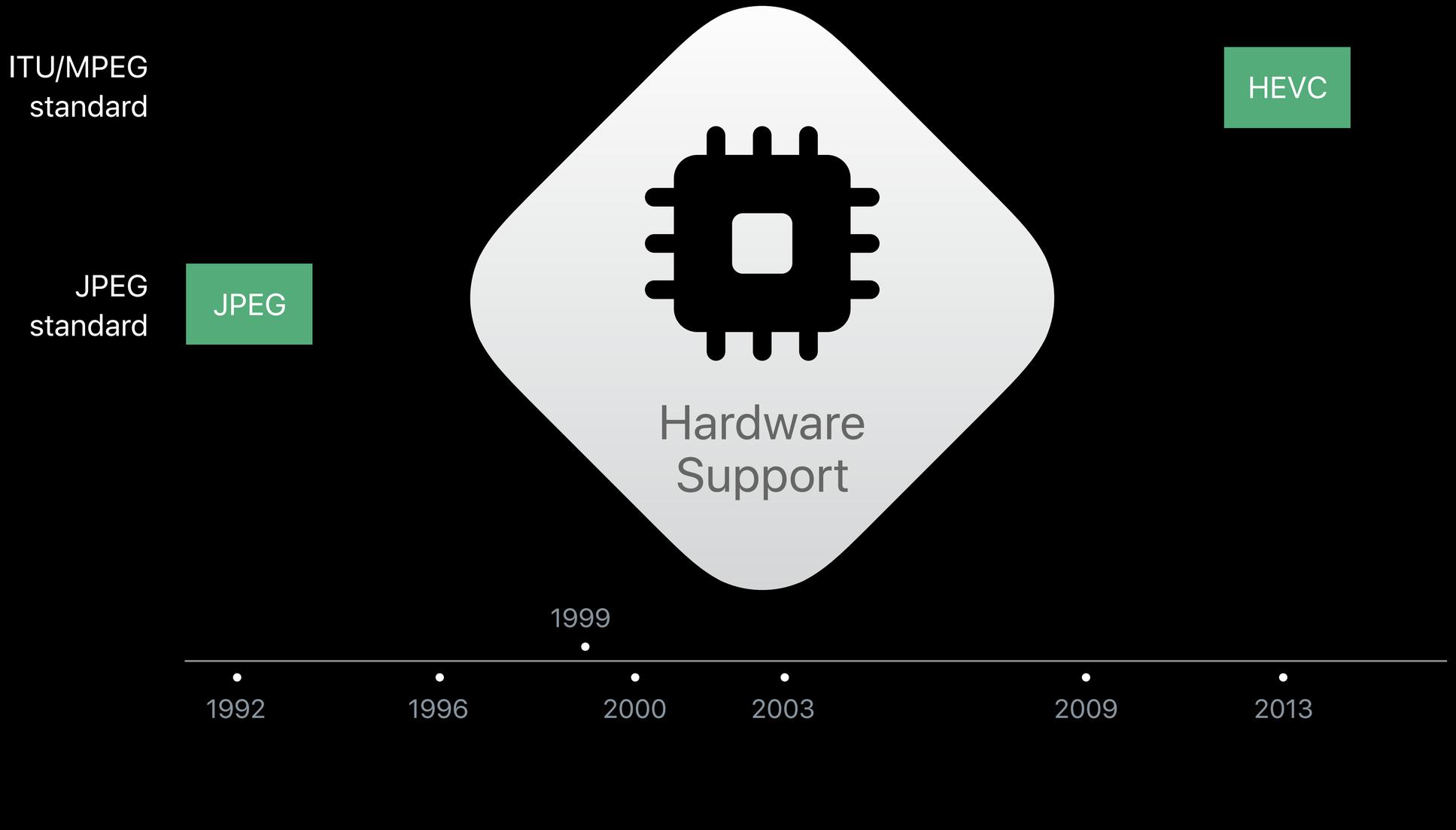


The Codec of Choice—HEVC

Coding tools that outperform JPEG

Block size

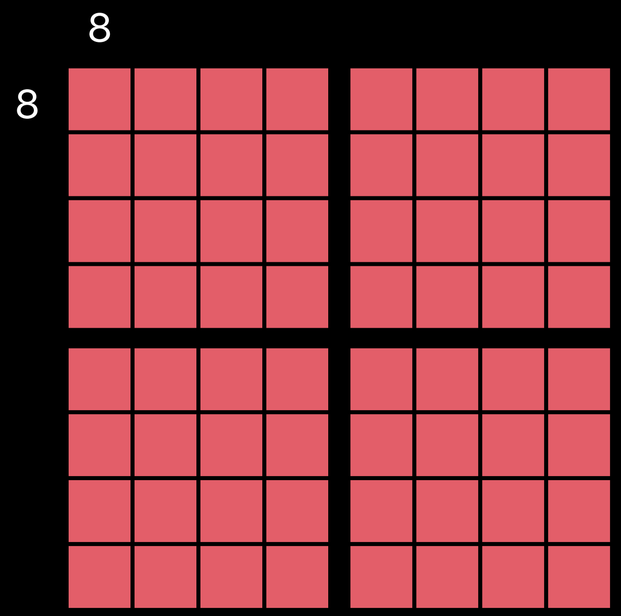
Angular prediction

Entropy coding

Adaptive quantization

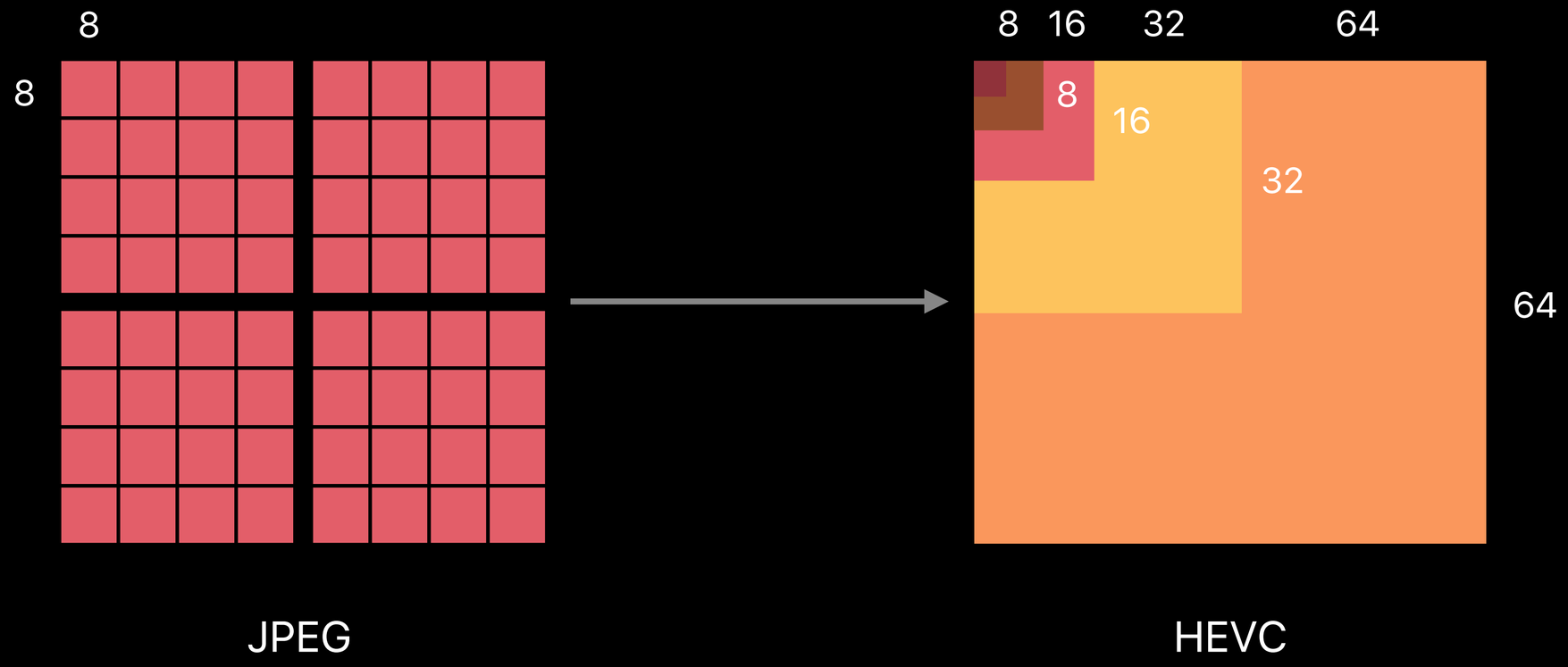
Deblocking, SAO

HEVC > Intra Coding Tools > Block Size

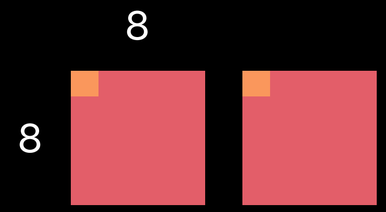


JPEG

HEVC > Intra Coding Tools > Block Size

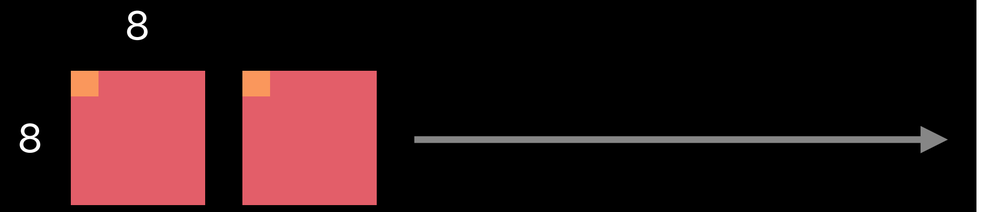


HEVC > Intra Coding Tools > Angular Prediction

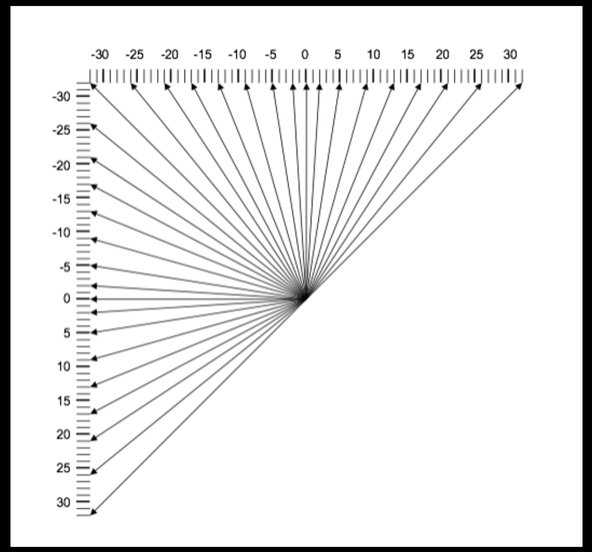


JPEG

HEVC > Intra Coding Tools > Angular Prediction



JPEG



HEVC

HEVC > Intra Coding Tools > Entropy Coding

Huffman

JPEG

HEVC > Intra Coding Tools > Entropy Coding

Huffman → **CABAC**

JPEG

HEVC

HEVC > Intra Coding Tools > Adaptive Quantization

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	36	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

JPEG

HEVC > Intra Coding Tools > Adaptive Quantization

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	36	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

JPEG

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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	36	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

HEVC

+ QP

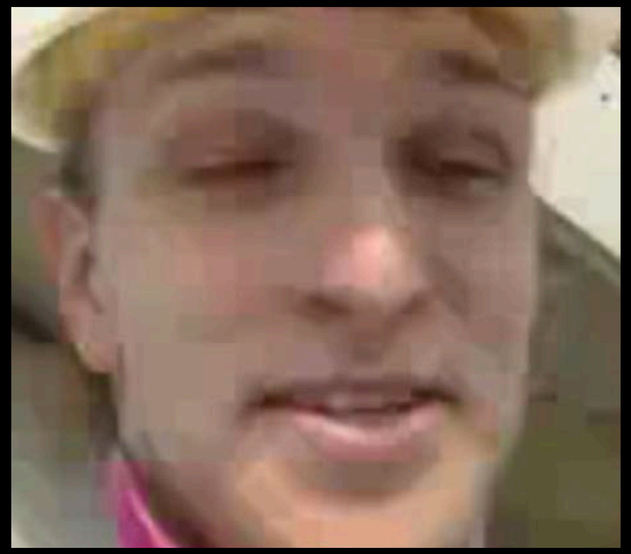
HEVC > Intra Coding Tools > Deblocking > SAO

Deblocking

- Global smoothing sharp edges

SAO

- Local smoothing



HEVC > Intra Coding Tools > Deblocking > SAO

Deblocking

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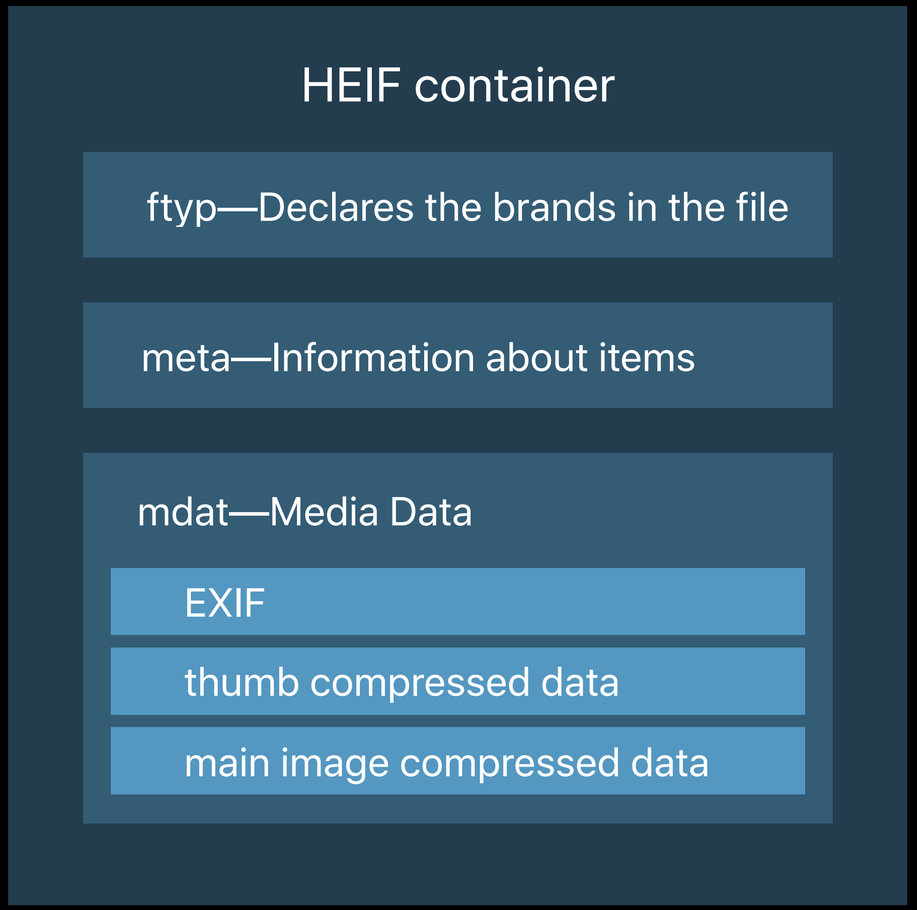
SAO

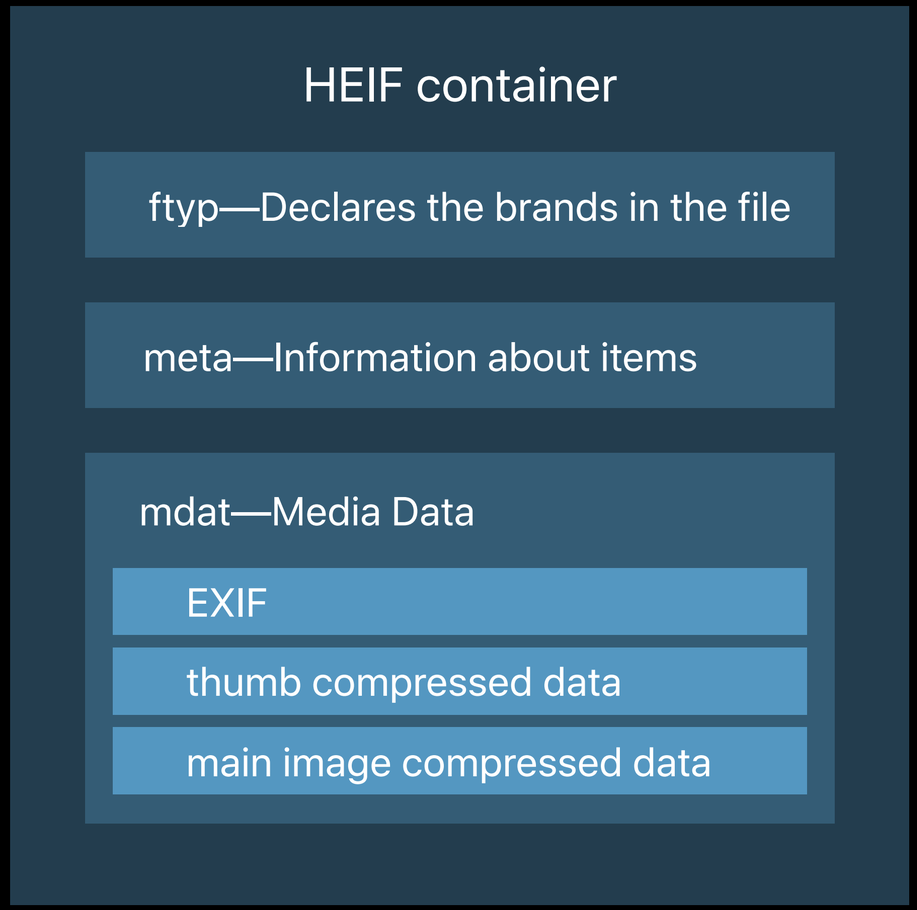
- Local smoothing

HEIF Configuration with Camera App



HEIF Configuration with Camera App

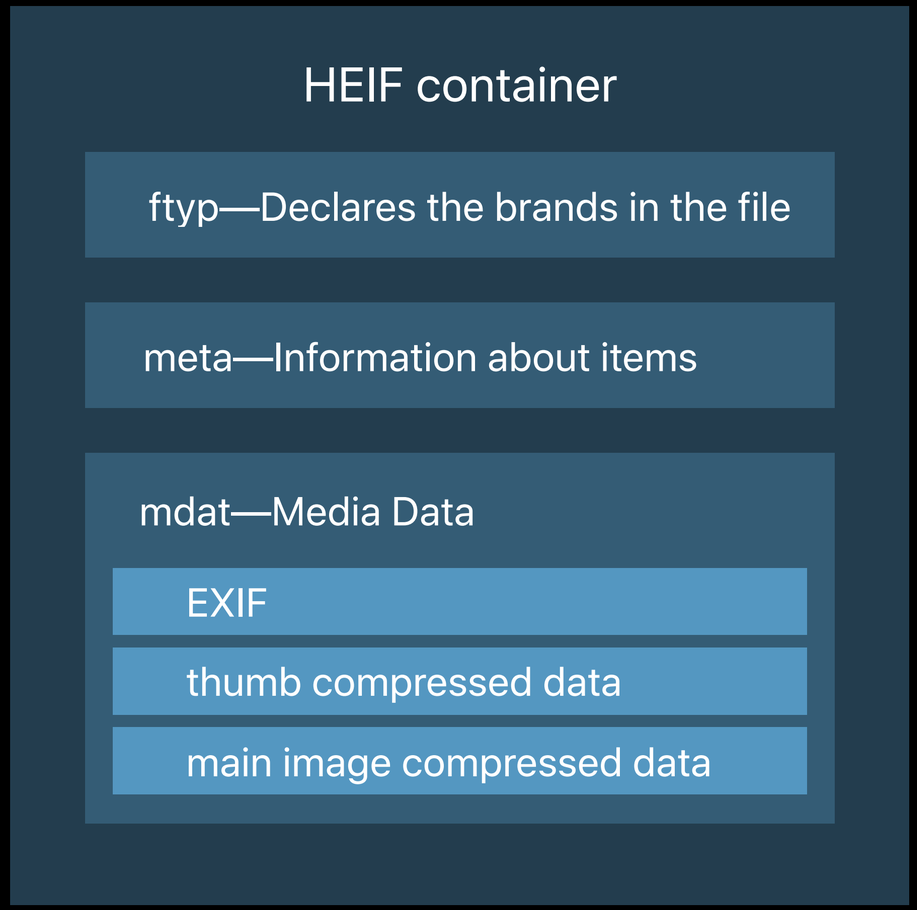
.HEIC



HEIF Configuration with Camera App

.HEIC

HEVC—main still profile

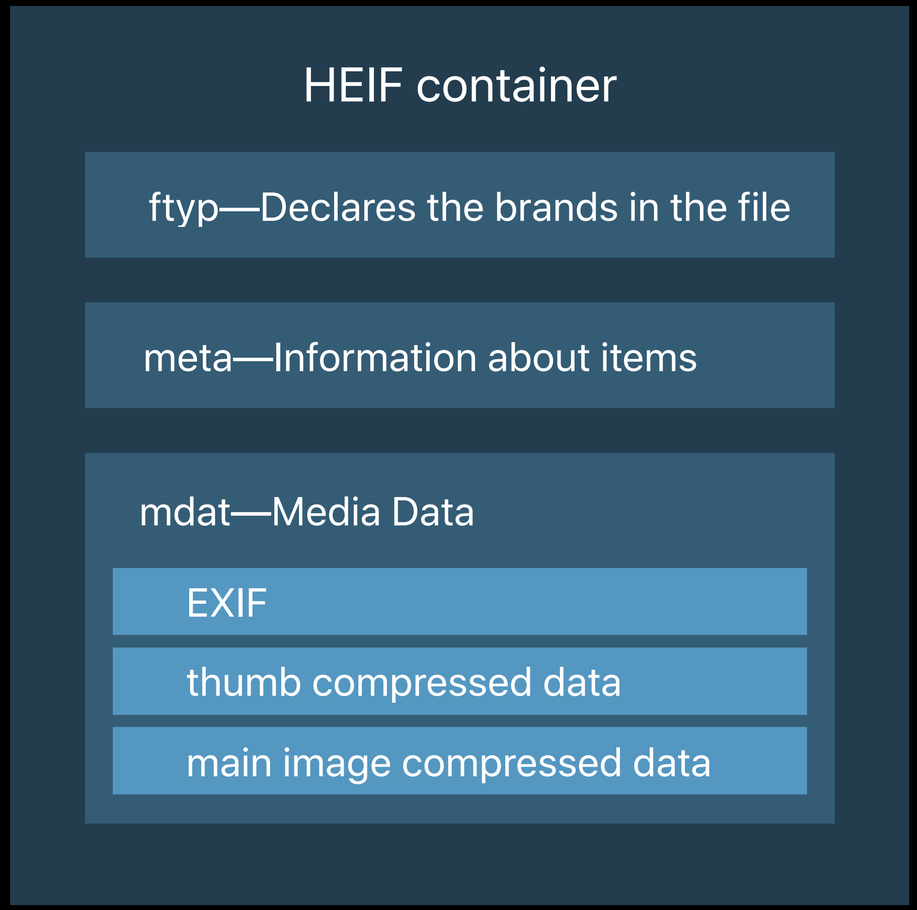


HEIF Configuration with Camera App

.HEIC

HEVC—main still profile

Images are encoded in 512x512 tiles



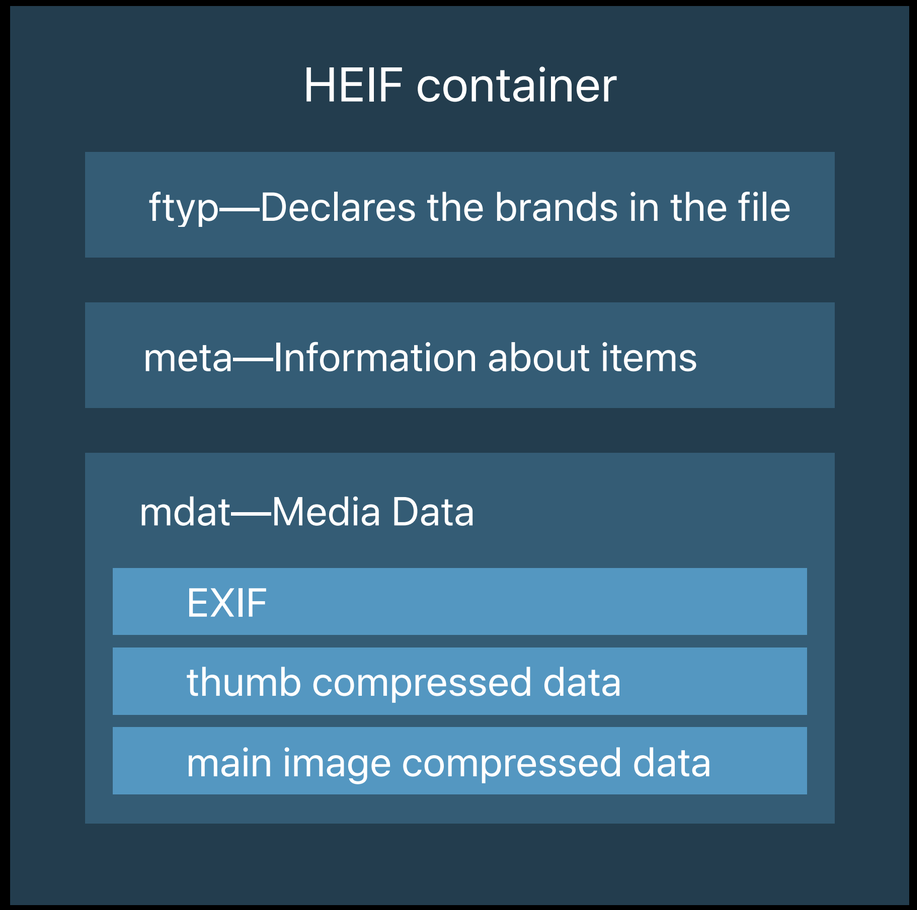
HEIF Configuration with Camera App

.HEIC

HEVC—main still profile

Images are encoded in 512x512 tiles

Thumb is 320x240



HEIF Configuration with Camera App

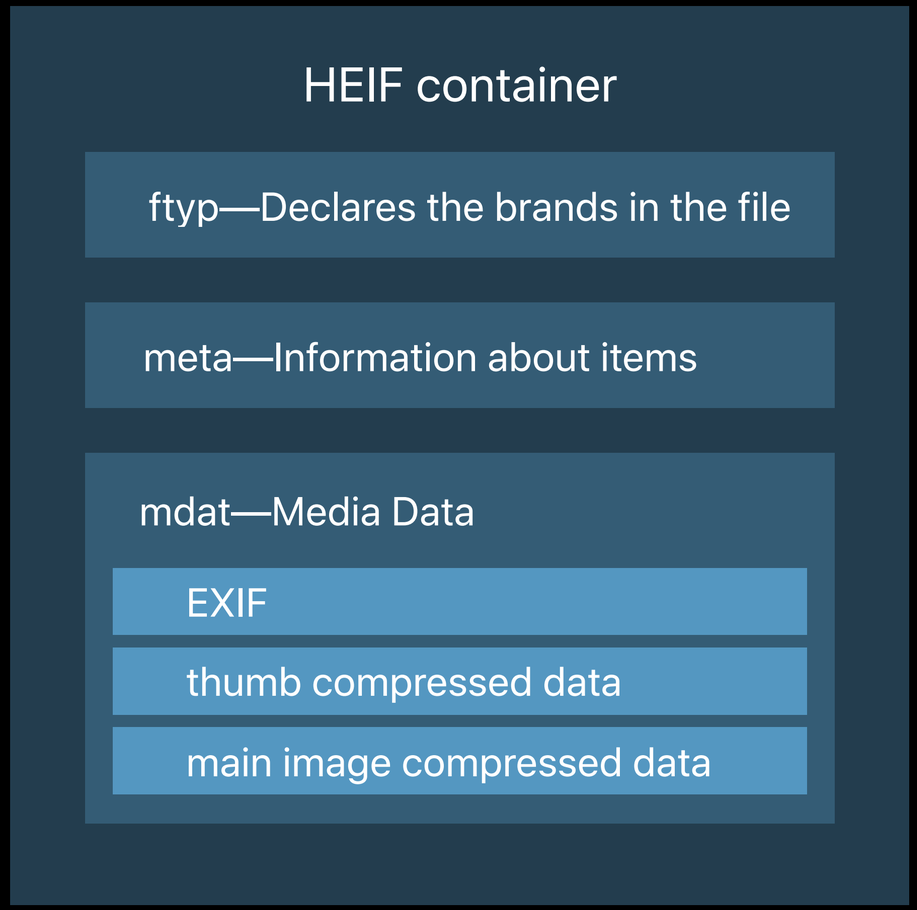
.HEIC

HEVC—main still profile

Images are encoded in 512x512 tiles

Thumb is 320x240

EXIF



HEIF Configuration with Camera App

.HEIC

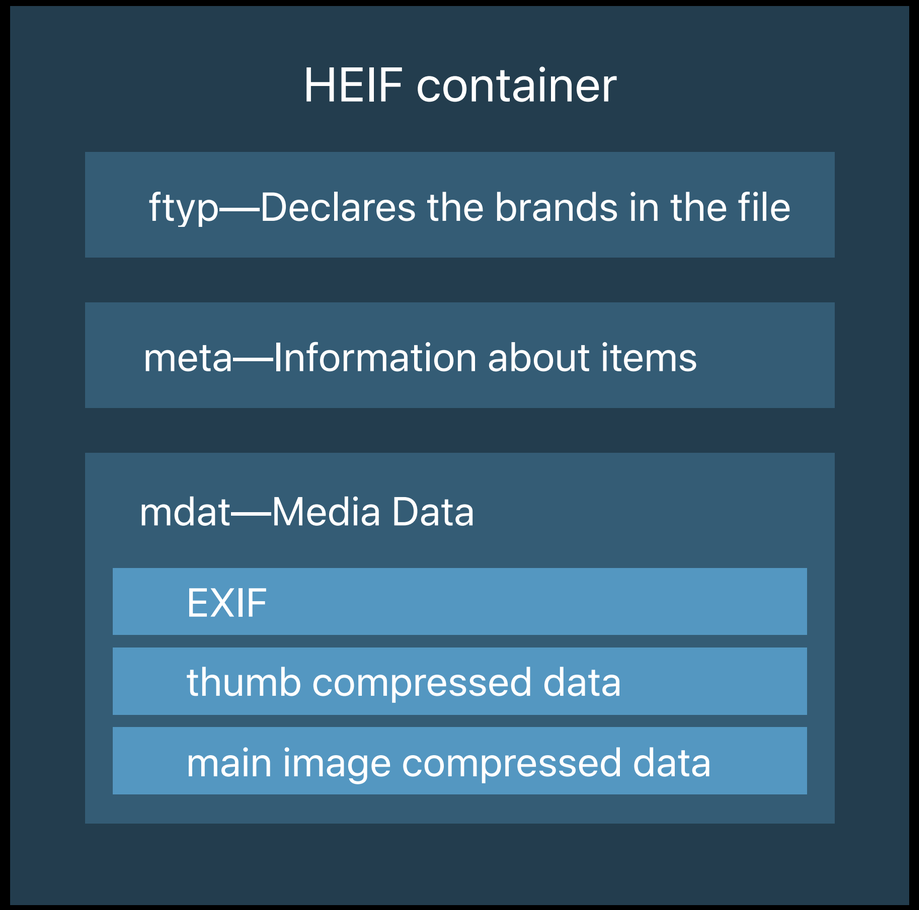
HEVC—main still profile

Images are encoded in 512x512 tiles

Thumb is 320x240

EXIF

Depth stored as auxiliary image + XMP



HEIF Configuration with Camera App

.HEIC

HEVC—main still profile

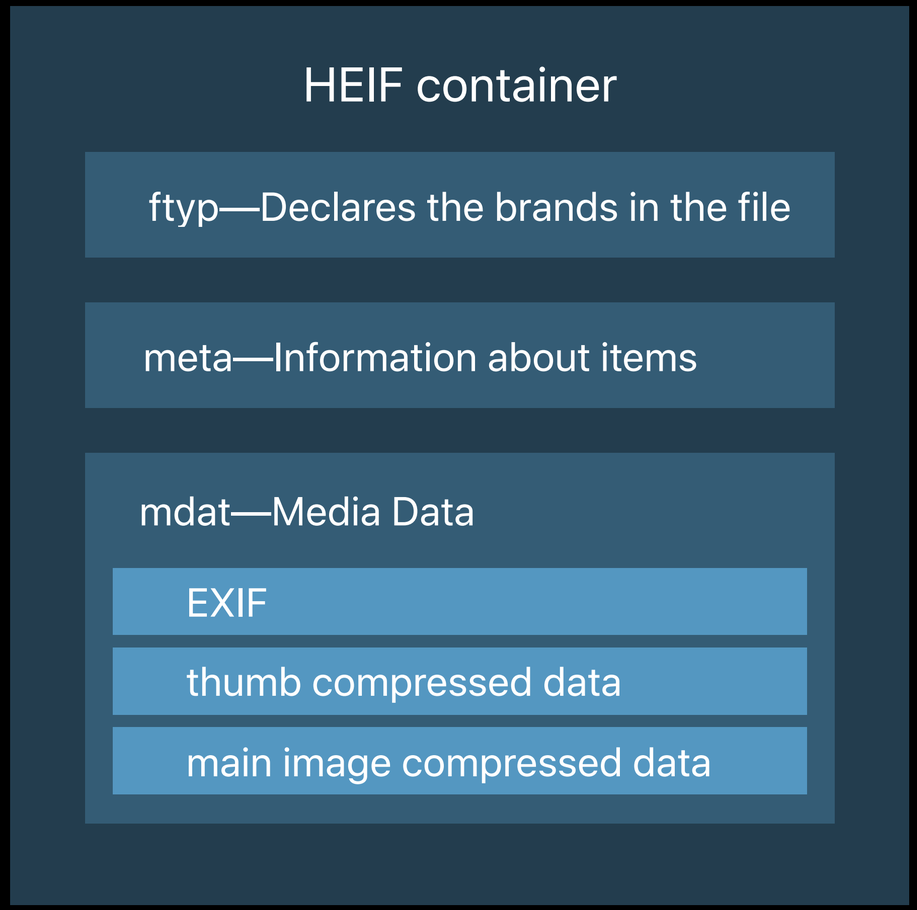
Images are encoded in 512x512 tiles

Thumb is 320x240

EXIF

Depth stored as auxiliary image + XMP

Meta first, then thumbs, then main image



HEIF Configuration with Camera App

.HEIC

HEVC—main still profile

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EXIF

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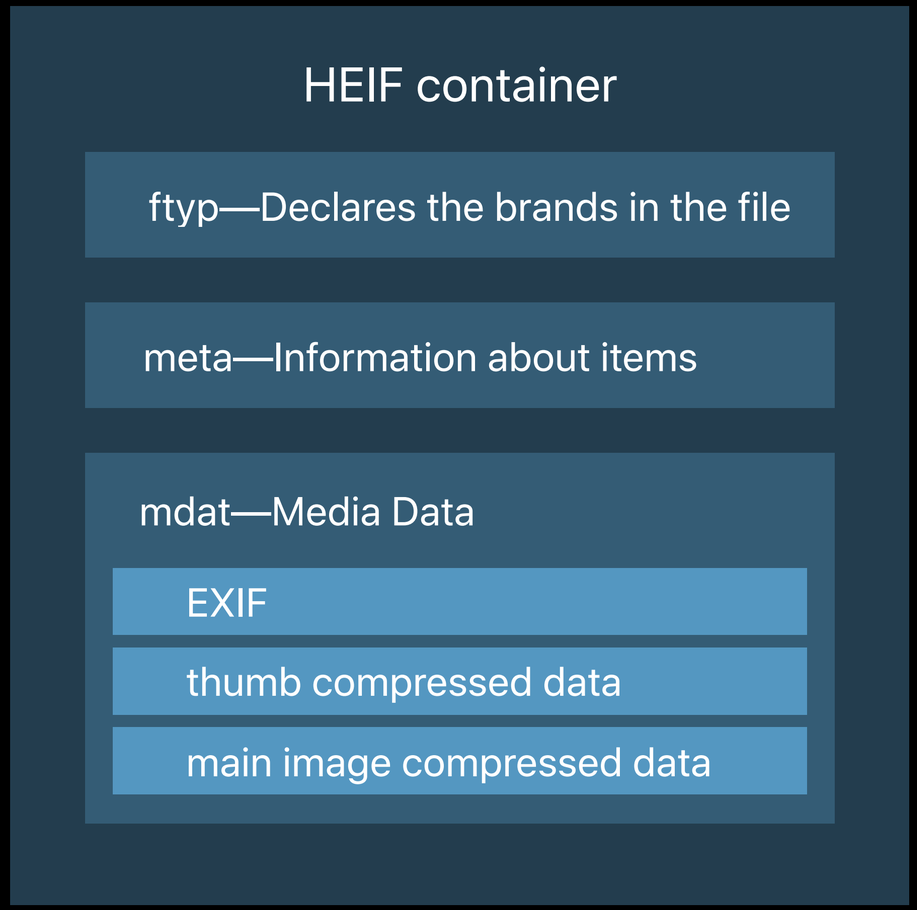
Meta first, then thumbs, then main image



Summary

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De facto image file format

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Format requirements

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HEIF

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De facto image file format

Format requirements

HEIF

HEIF in depth

Summary

De facto image file format

Format requirements

HEIF

HEIF in depth

HEVC

More Information

https://developer.apple.com/wwdc17/513

Related Sessions

Introducing HEIF and HEVC	Executive Ballroom	Tuesday 4:10PM
Working with HEIF and HEVC	Hall 2	Friday 11:00AM

Labs

HEIF and HEVC Lab	Technology Lab A	Wed 9:00AM–11:00AM
HEIF and HEVC Lab	Technology Lab F	Fri 12:00PM–1:50PM


WWDC17