# Direct Access to Video Encoding and Decoding

Session 513

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Tech Lead, Frameworks with “Video” in their names

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# Introduction

Hardware encode and decode can improve user experience

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Hardware encode and decode can improve user experience

- Better performance

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- Better performance
- Increased efficiency

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Hardware encode and decode can improve user experience

- Better performance
- Increased efficiency
- Extend battery life

# What You Will Learn

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Case Studies

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1. Displaying an H.264 stream in a layer in your application

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2. Decoding an H.264 stream and accessing the decoded buffers

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Using multi-pass encoding in AVFoundation and Video Toolbox

# Media Interfaces Overview

## With a focus on video

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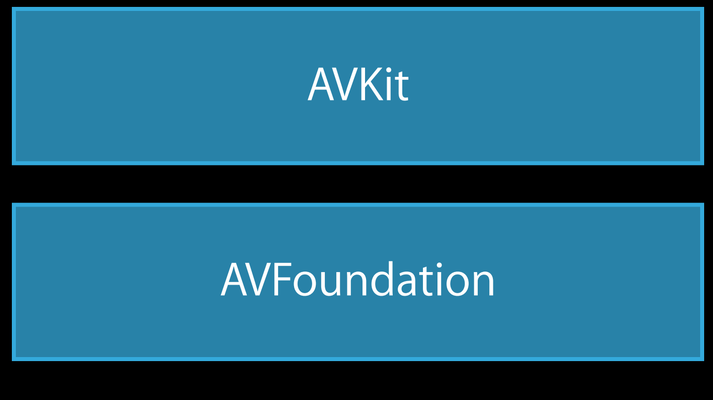
## With a focus on video

AVKit

# Media Interfaces Overview

## With a focus on video



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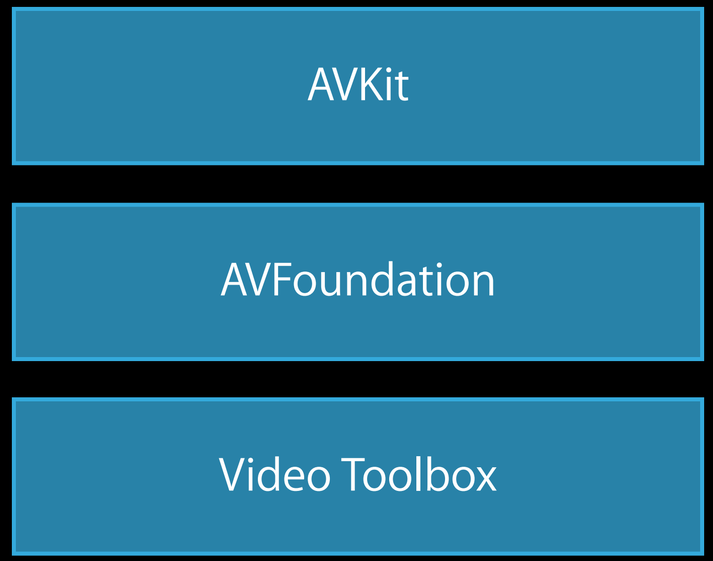

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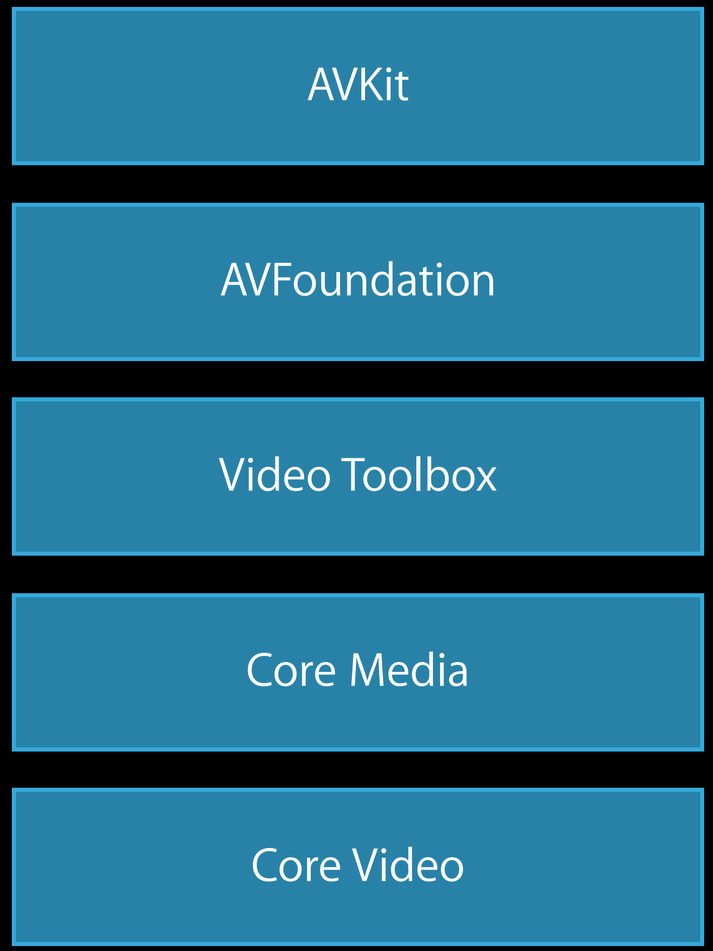
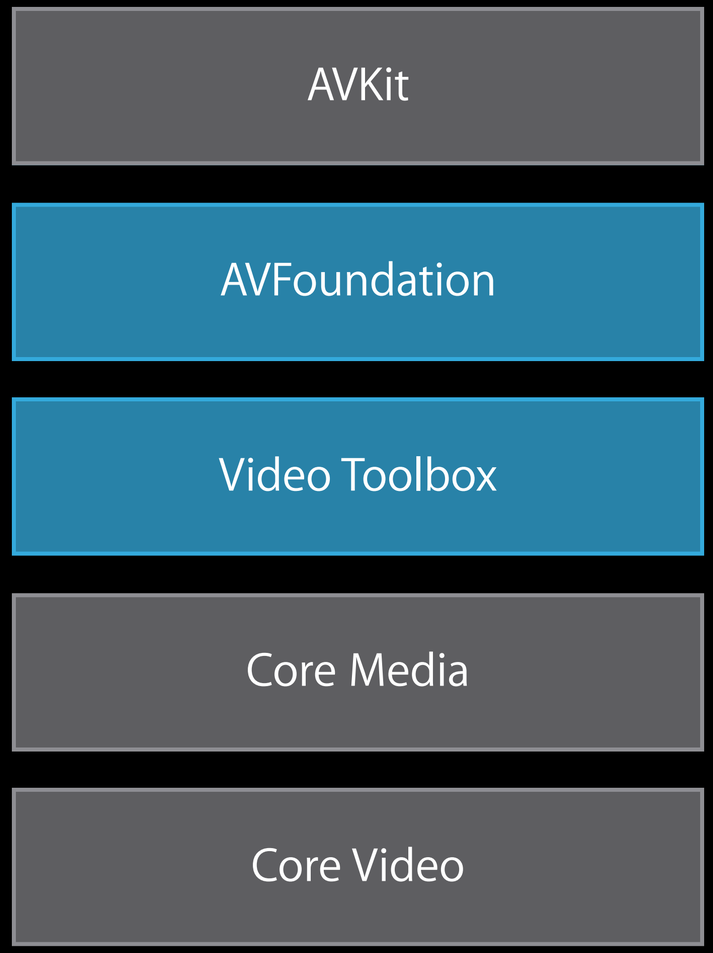


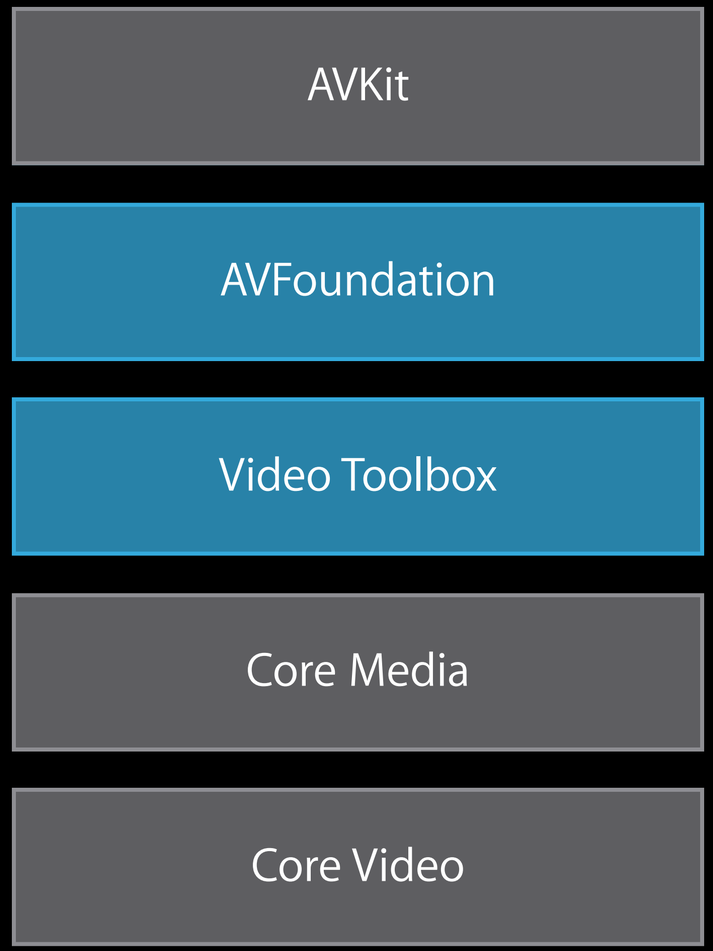
# Media Interface Focus



# Media Interface Focus

AVFoundation

- Decompress direct to display
- Compress directly to file



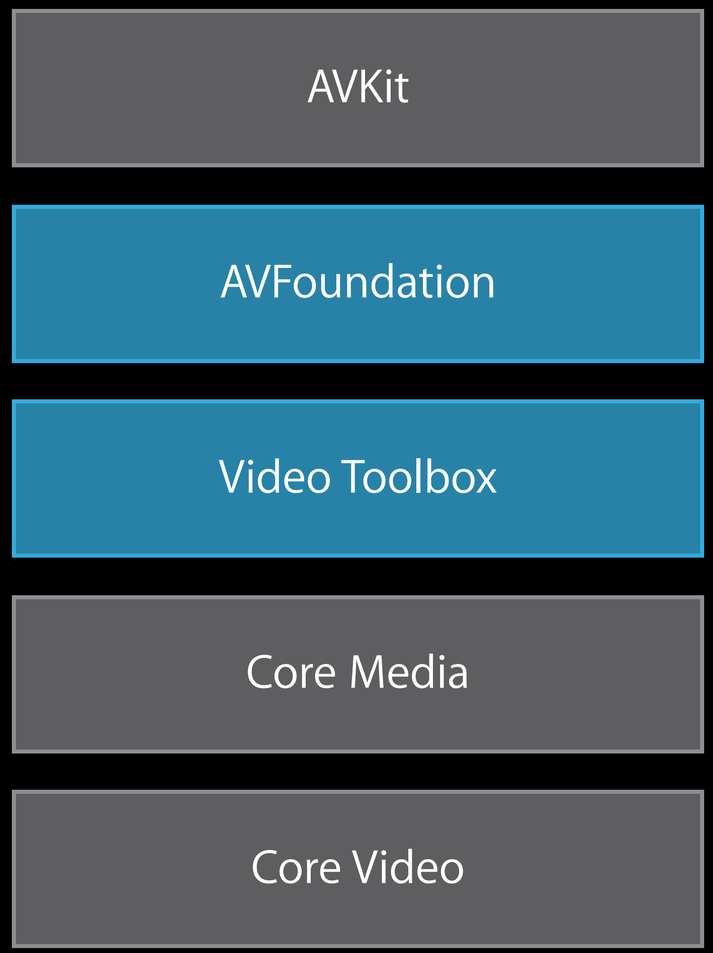
# Media Interface Focus

AVFoundation

- Decompress direct to display
- Compress directly to file

Video Toolbox

- Decompress to CVPixelBuffer
- Compress to CMSampleBuffer



# Media Interface Focus

AVKit

AVFoundation

Video Toolbox

# Hardware Codec Usage

AVKit

AVFoundation

Video Toolbox

# Hardware Codec Usage

| | iOS | OS X |
|---|---|---|
| AVKit | Always | When Available |
| AVFoundation | Always | When Available |
| Video Toolbox | Always | When Available and Requested |

# The Cast of Characters

CVPixelBuffer
CVPixelBufferPool
pixelBufferAttributes
CMTime
CMVideoFormatDescription
CMBlockBuffer
CMSampleBuffer
CMClock
CMTimebase

# The Cast of Characters

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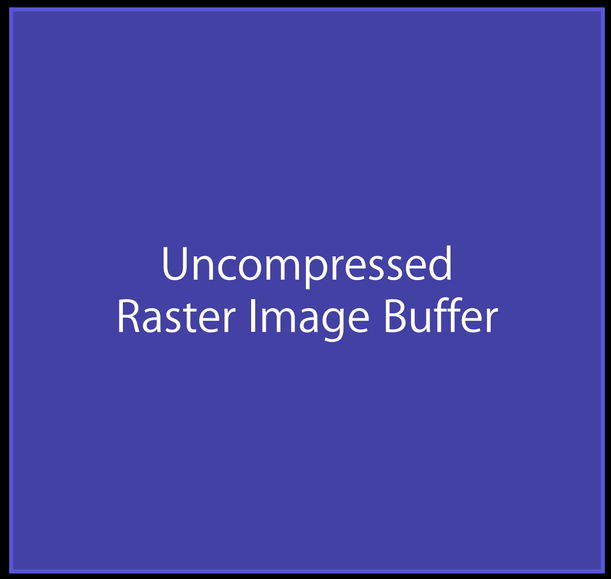

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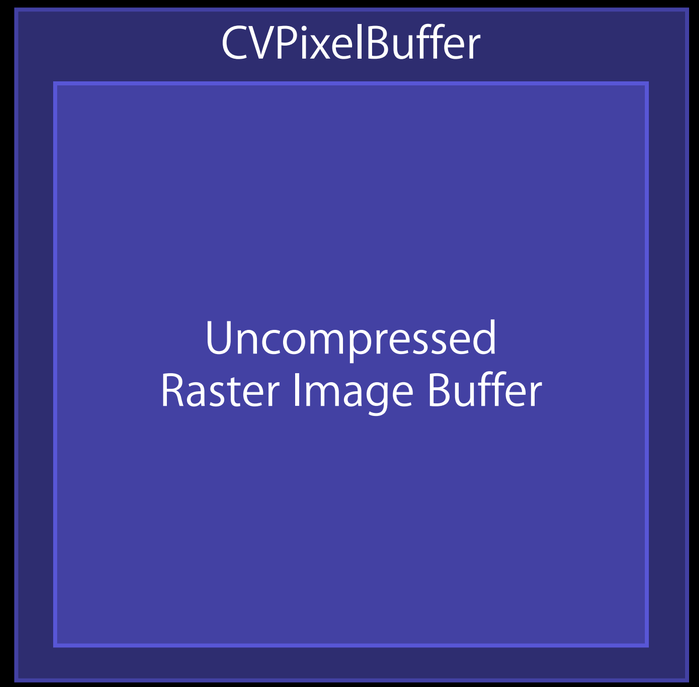

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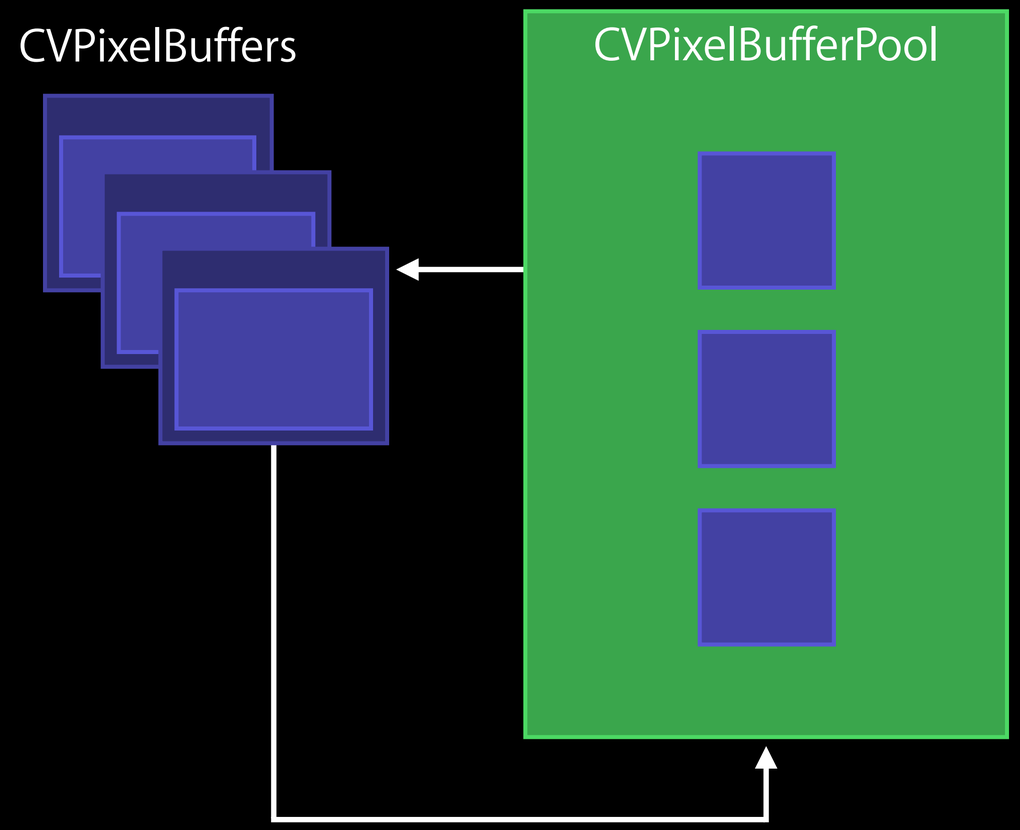

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`CFDictionary` of requirements;
May Include:

- Width/height
- Pixel format type (e.g., 32BGRA, YCbCr420)
- Compatibility (e.g., OpenGL ES, Core Animation)

# The Cast of Characters

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64-bit Time Value (Numerator)
32-bit Time Scale (Denominator)

# The Cast of Characters

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Width/Height

Format Type—(kCMPixelFormat_32BGRA, kCMVideoCodecType_H264,…)

Extensions—(Pixel Aspect Ratio, Color Space,…)

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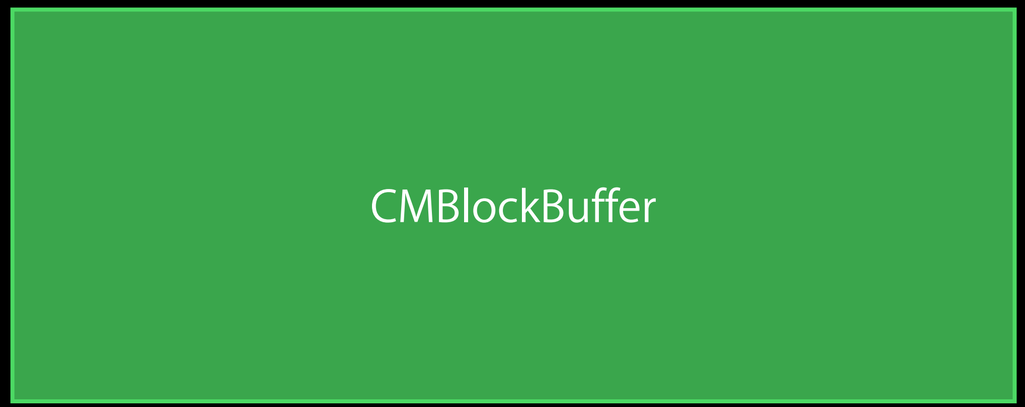

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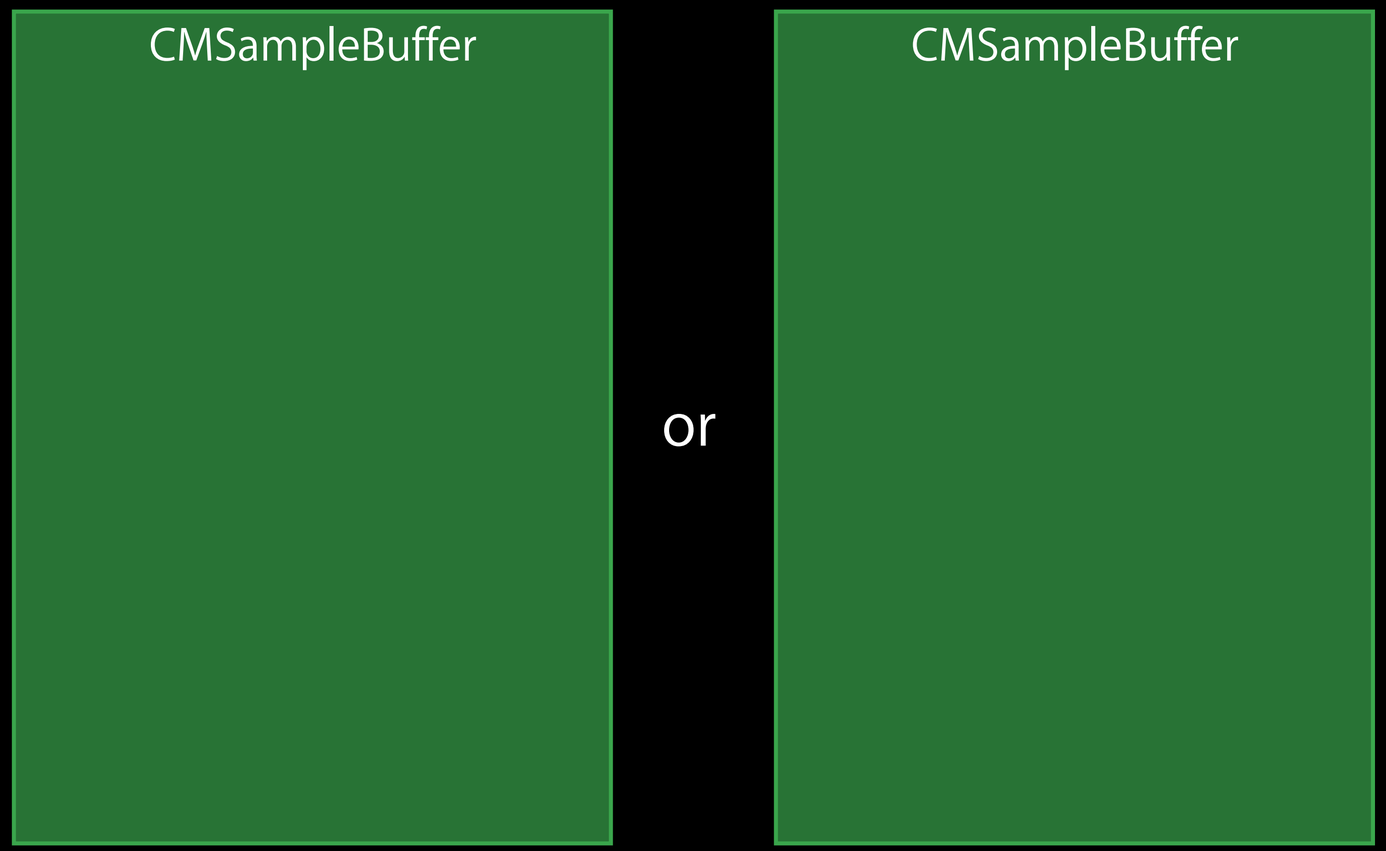

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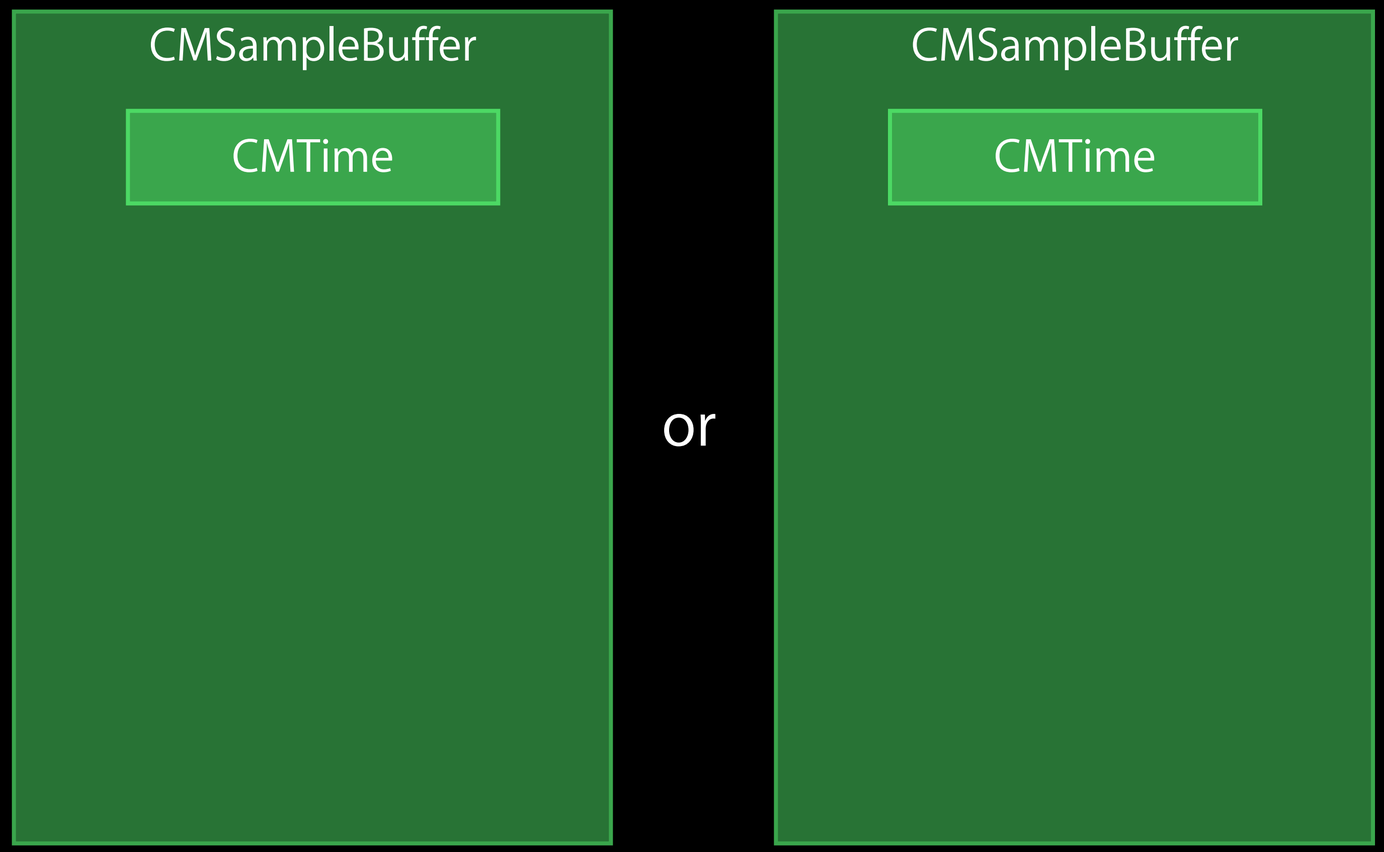

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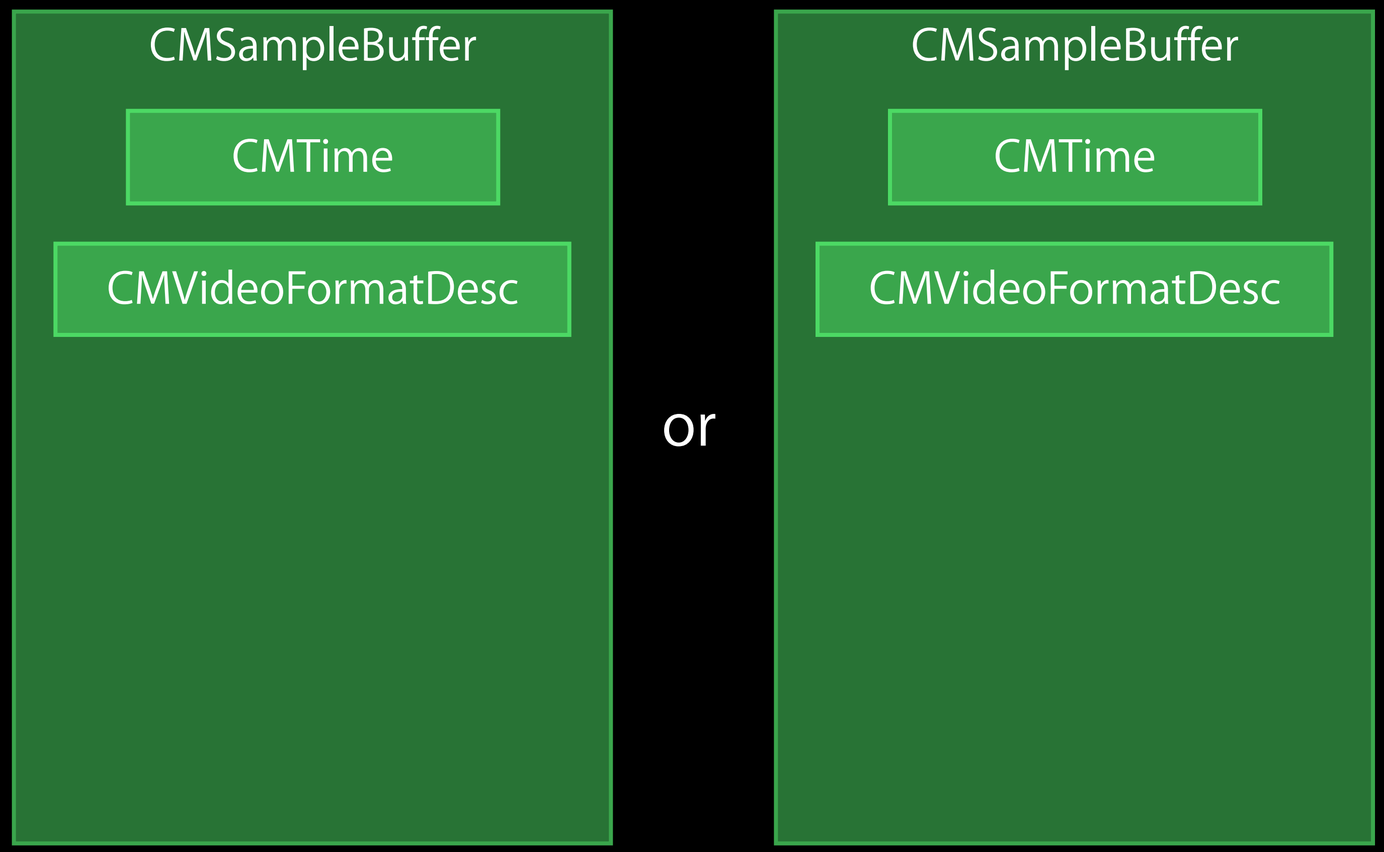

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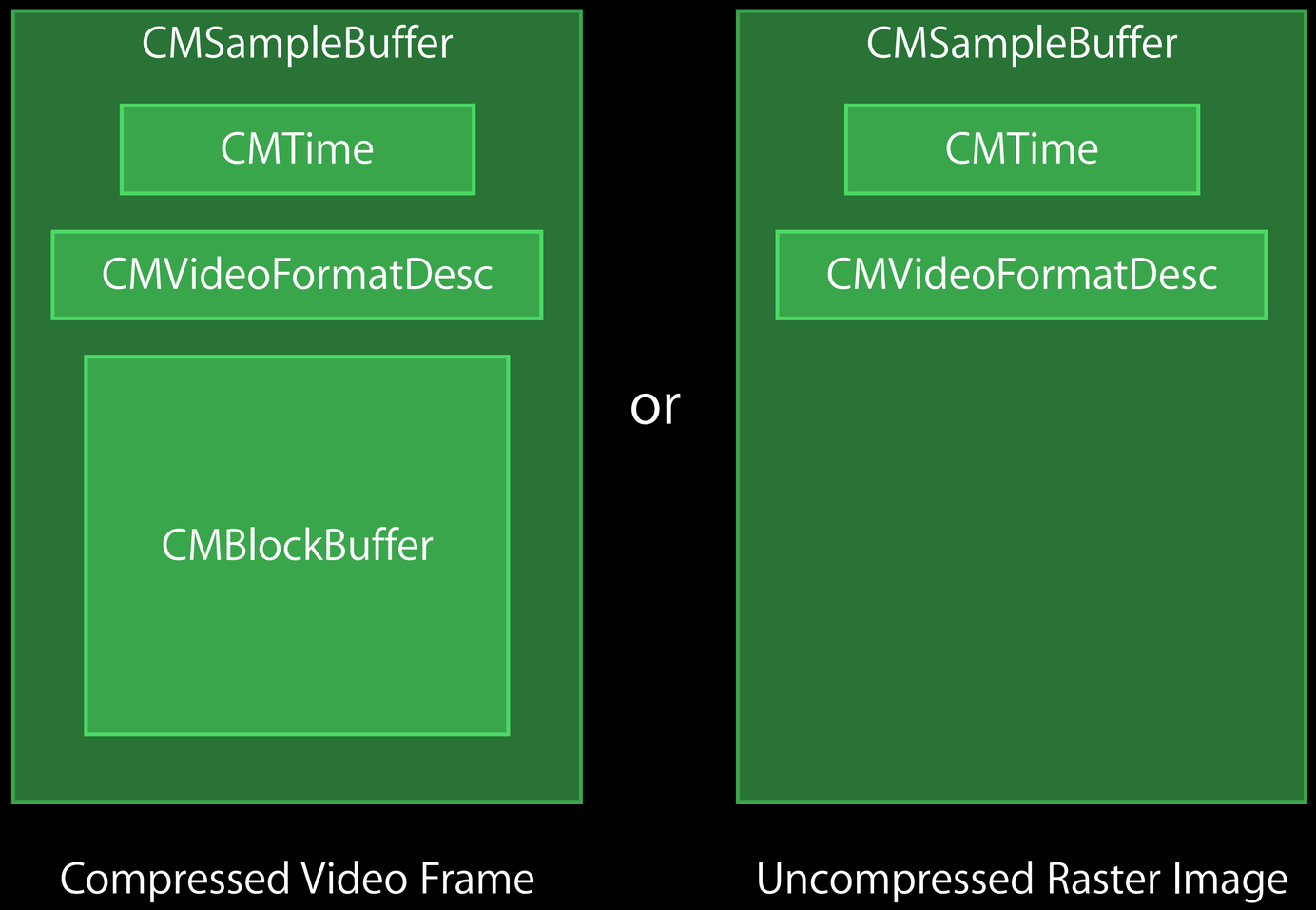

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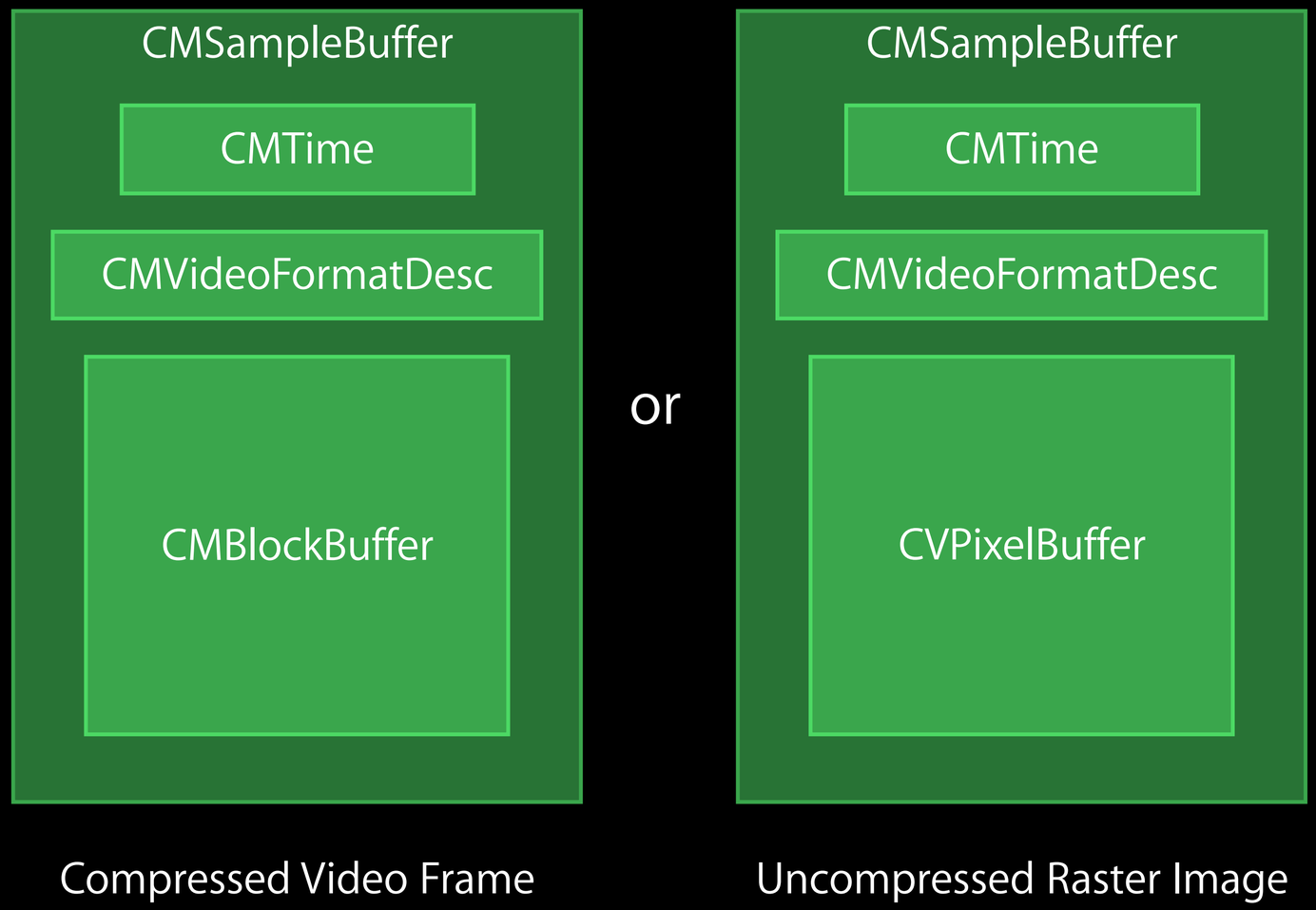

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# The Cast of Characters

Wraps a source of time

A clock's time always increases

`CMClockGetHostTimeClock() wraps mach_absolute_time()`

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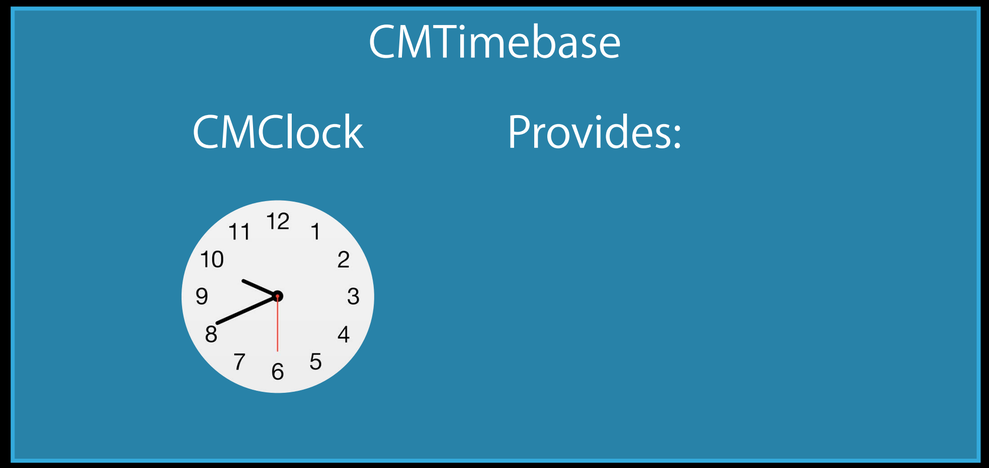
CMClock

# The Cast of Characters

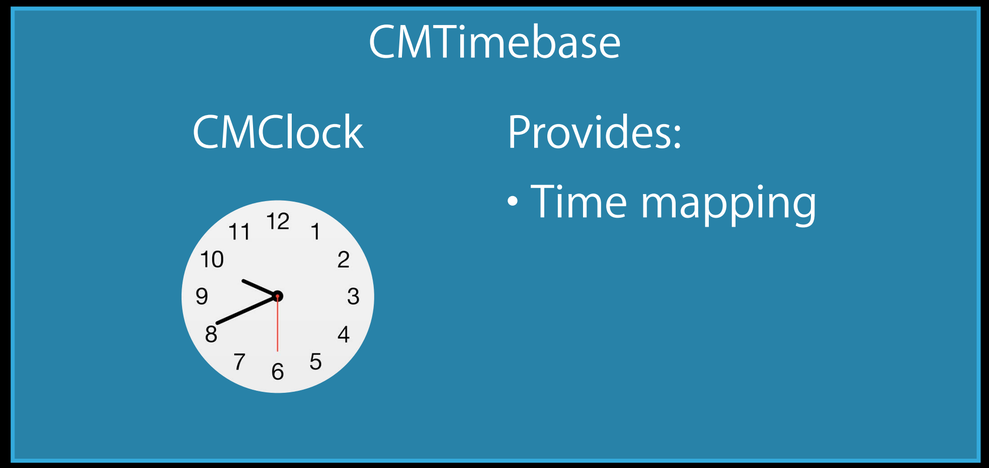
A controlled view onto a CMClock



# The Cast of Characters

A controlled view onto a CMClock

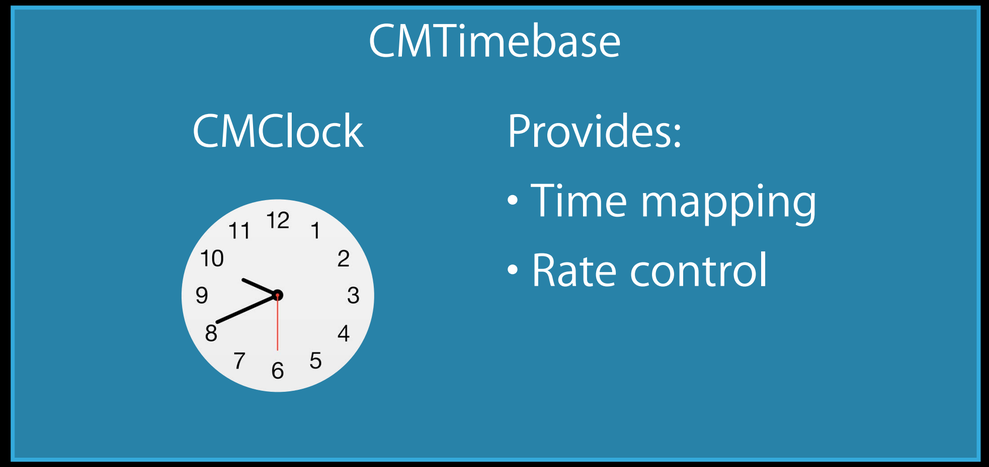
```
CMTimebaseSetTime(timebase, kCMTimeZero);
```



# The Cast of Characters

A controlled view onto a CMClock

```
CMTimebaseSetTime(timebase, kCMTimeZero);
CMTimebaseSetRate(timebase, 1.0);
```



# Case One

## Displaying video from a network stream

# Case One Overview

# Case One Overview

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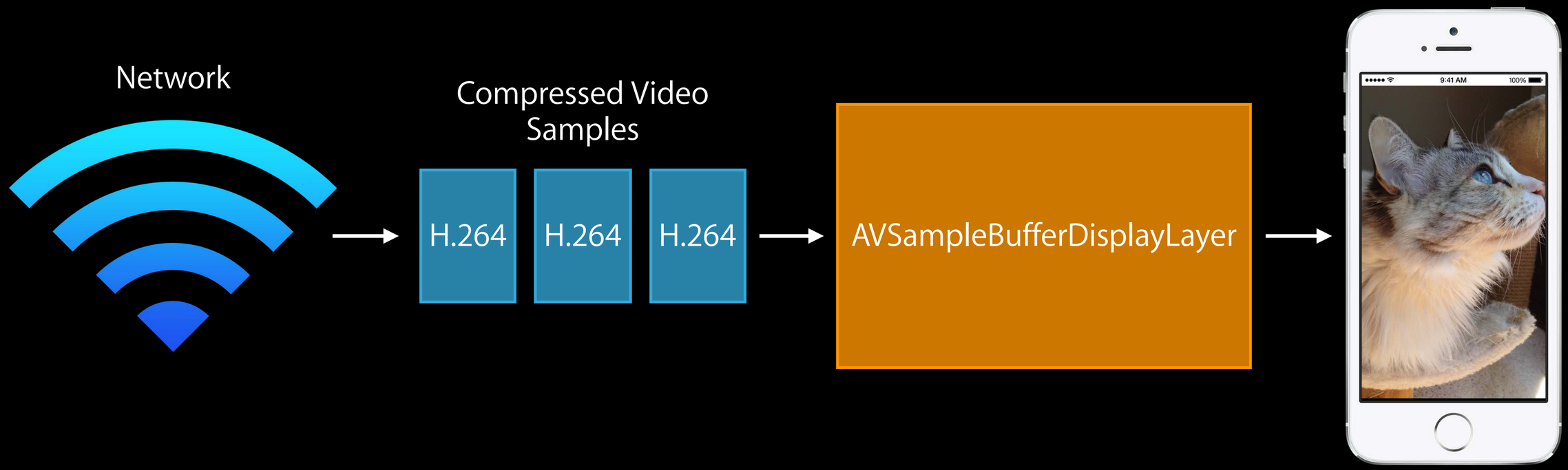
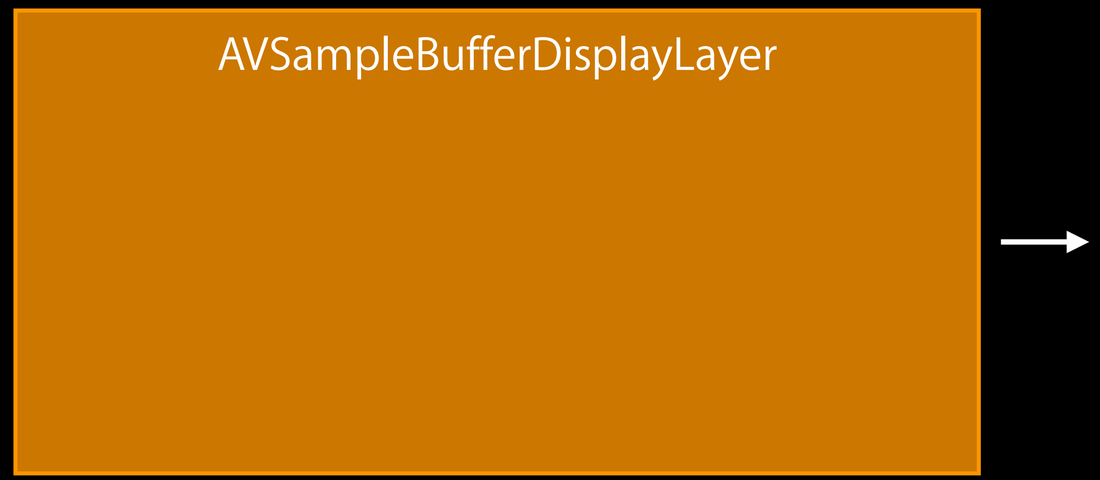


# AVSampleBufferDisplayLayer

## A closer look



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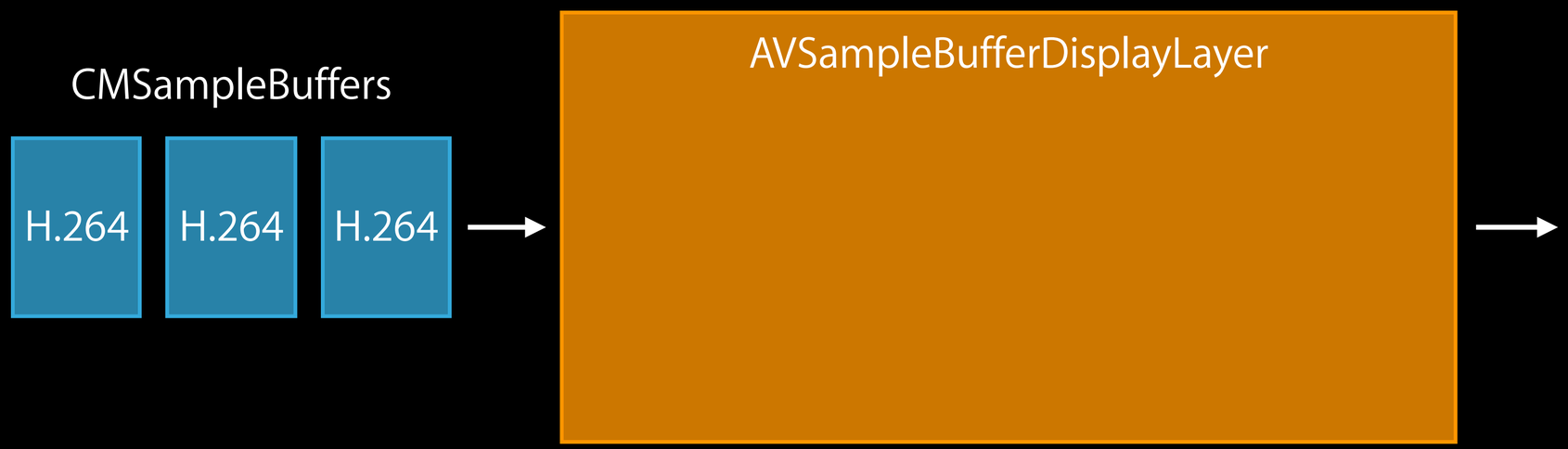

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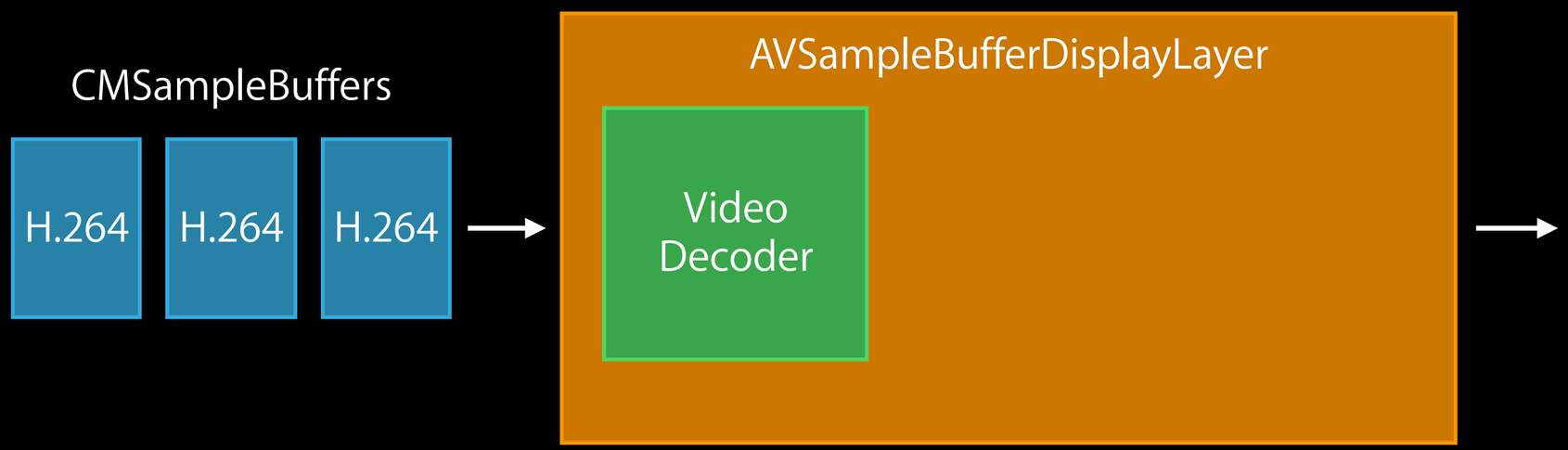

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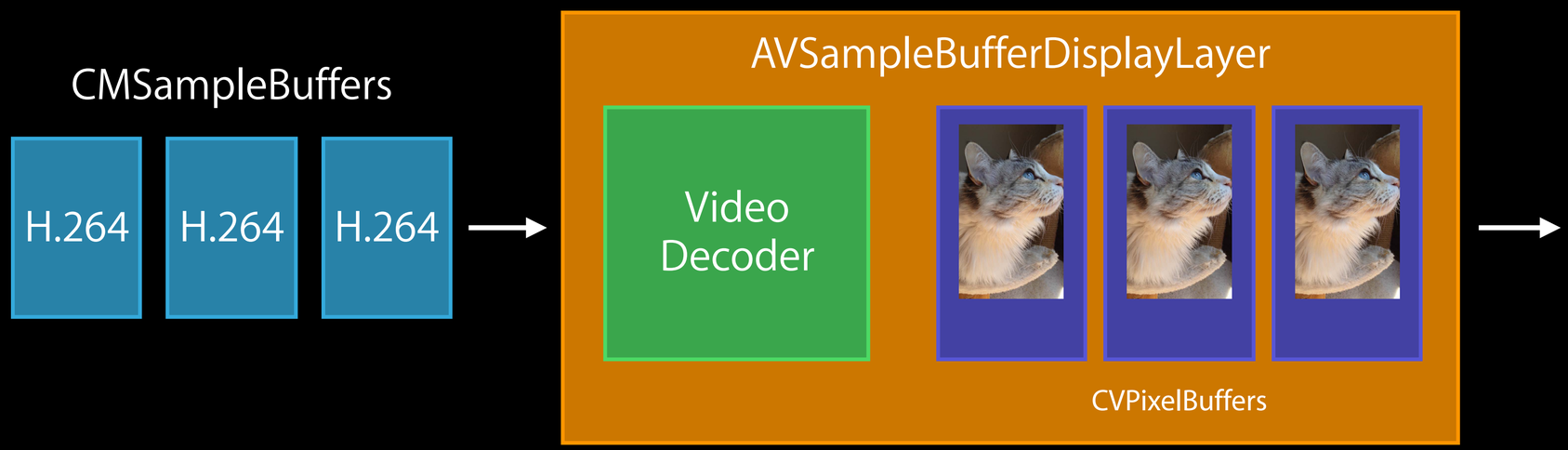

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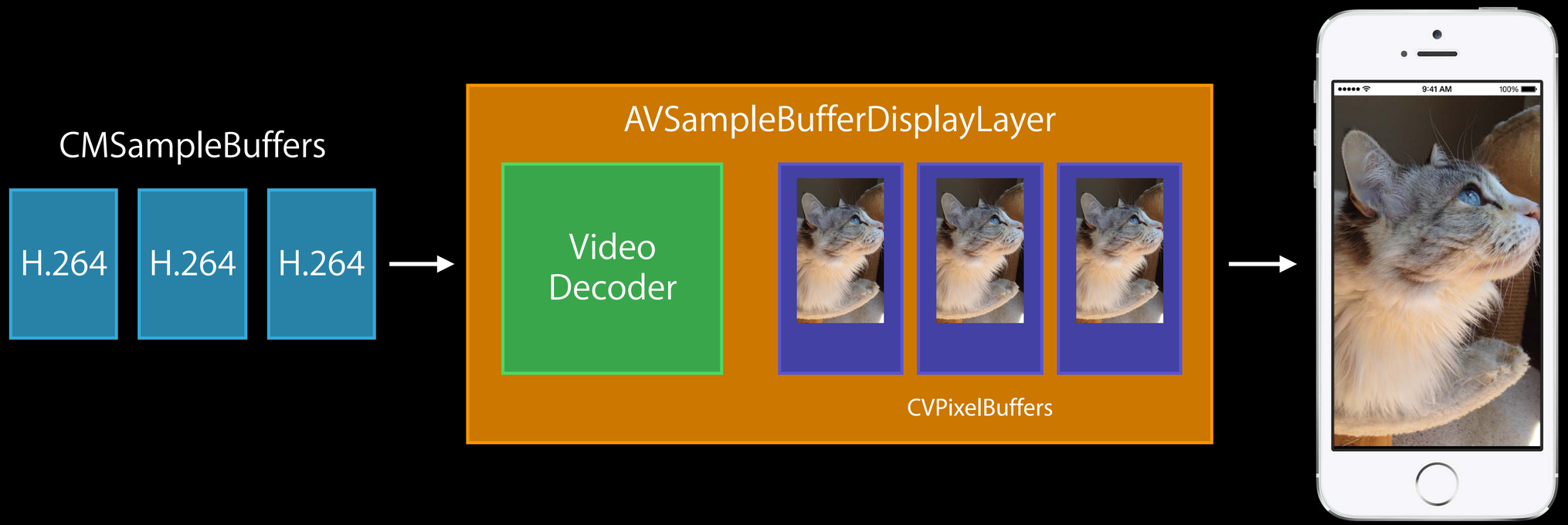
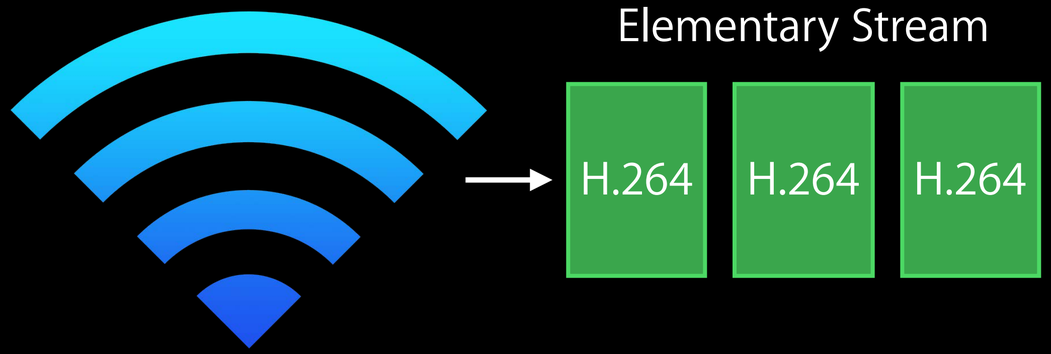


# AVSampleBufferDisplayLayer Input



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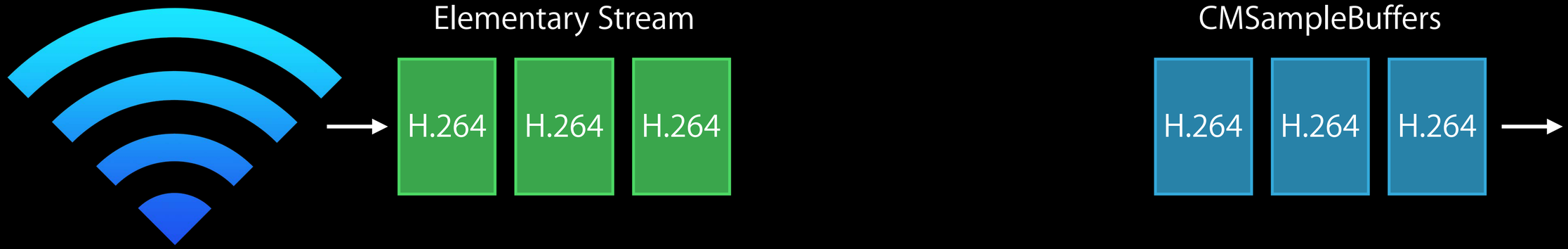

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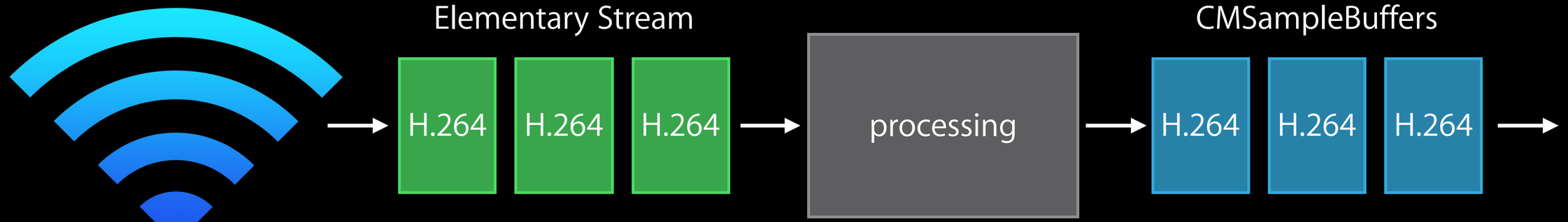

# H.264 Syntax

Elementary Stream

MPEG-4

# H.264 Syntax

Elementary Stream

MPEG-4

# H.264 Syntax

## Network Abstraction Layer (NAL)

# H.264 Syntax

## Network Abstraction Layer (NAL)

H.264 stream consists of a sequence of NAL Units (NALUs)

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NAL Units may contain

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H.264 stream consists of a sequence of NAL Units (NALUs)


NAL Units may contain

- Video frame (or slice of video frame)

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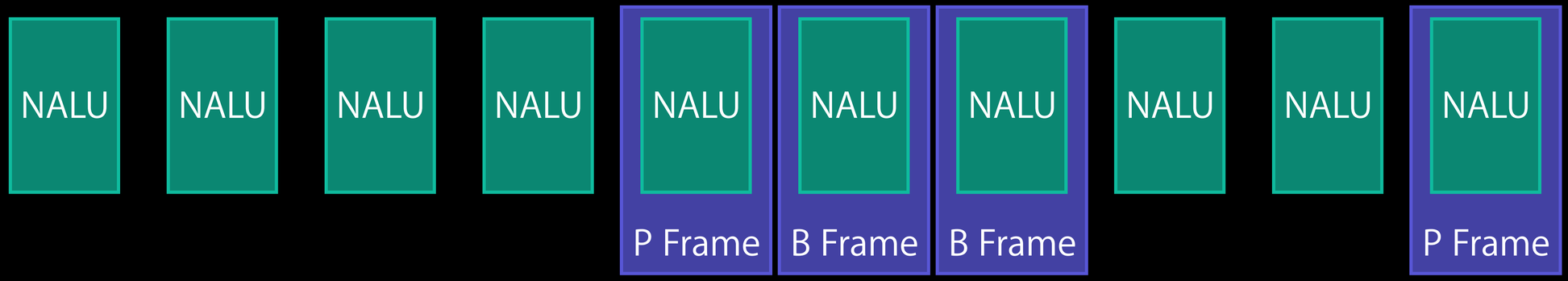


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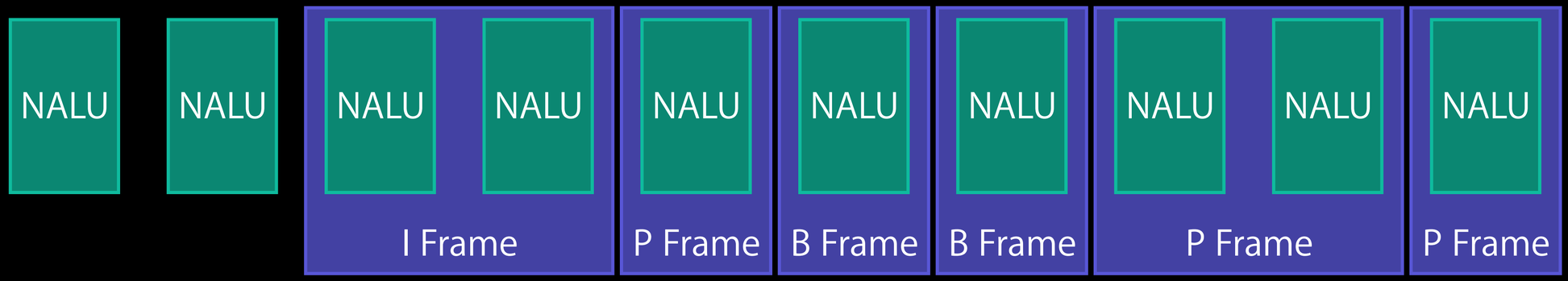


NAL Units may contain

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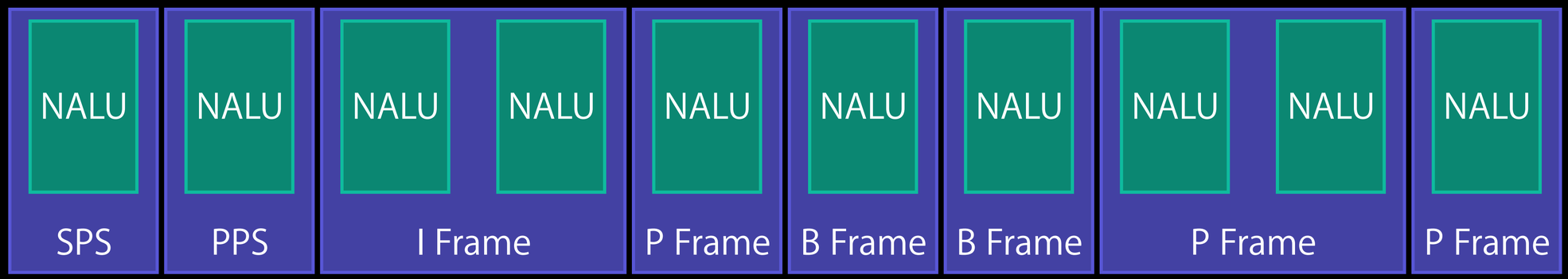



NAL Units may contain

- Video frame (or slice of video frame)
- H.264 parameter sets
  - Sequence Parameter Set (SPS) and Picture Parameter Set (PPS)

# H.264 Syntax

## Parameter sets: SPS and PPS

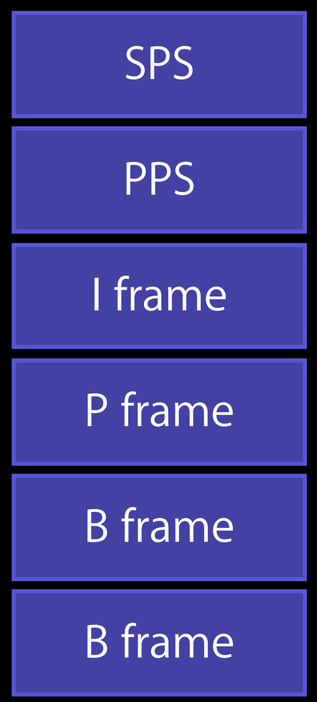
Elementary Stream

MPEG-4

# H.264 Syntax

## Parameter sets: SPS and PPS

Elementary Stream



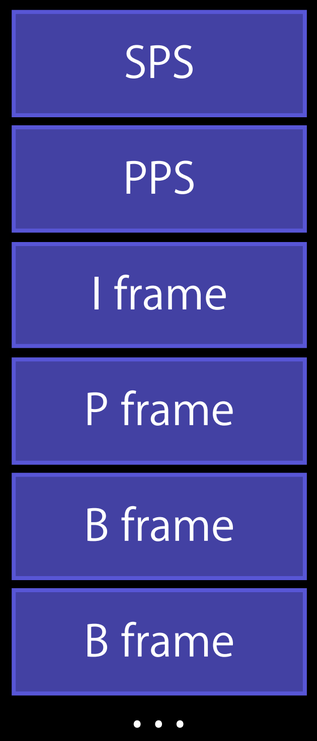

Parameter Sets in Stream

MPEG-4

# H.264 Syntax

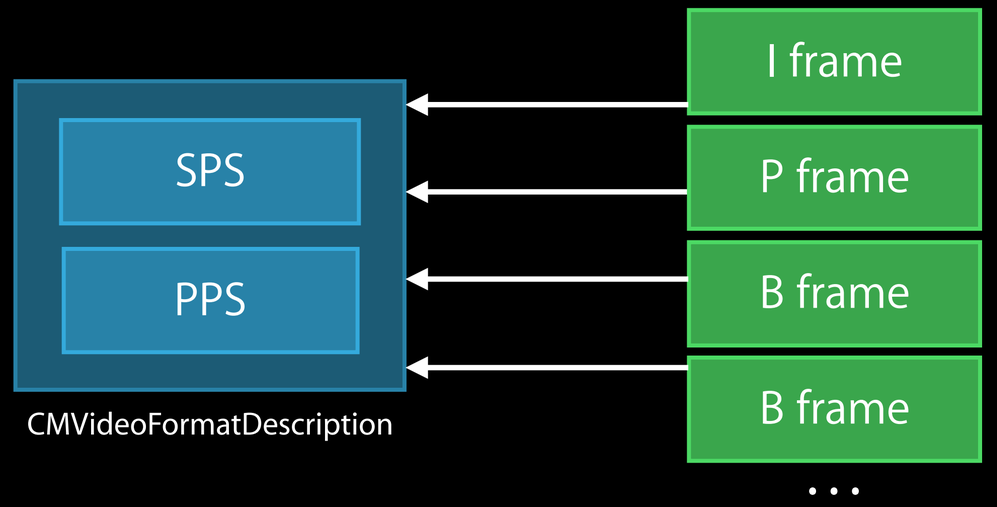
## Parameter sets: SPS and PPS

Elementary Stream




Parameter Sets in Stream

MPEG-4




Parameter Sets in Format Description

# H.264 Syntax

## Conversion

Elementary Stream

MPEG-4

# H.264 Syntax

## Conversion

Elementary Stream

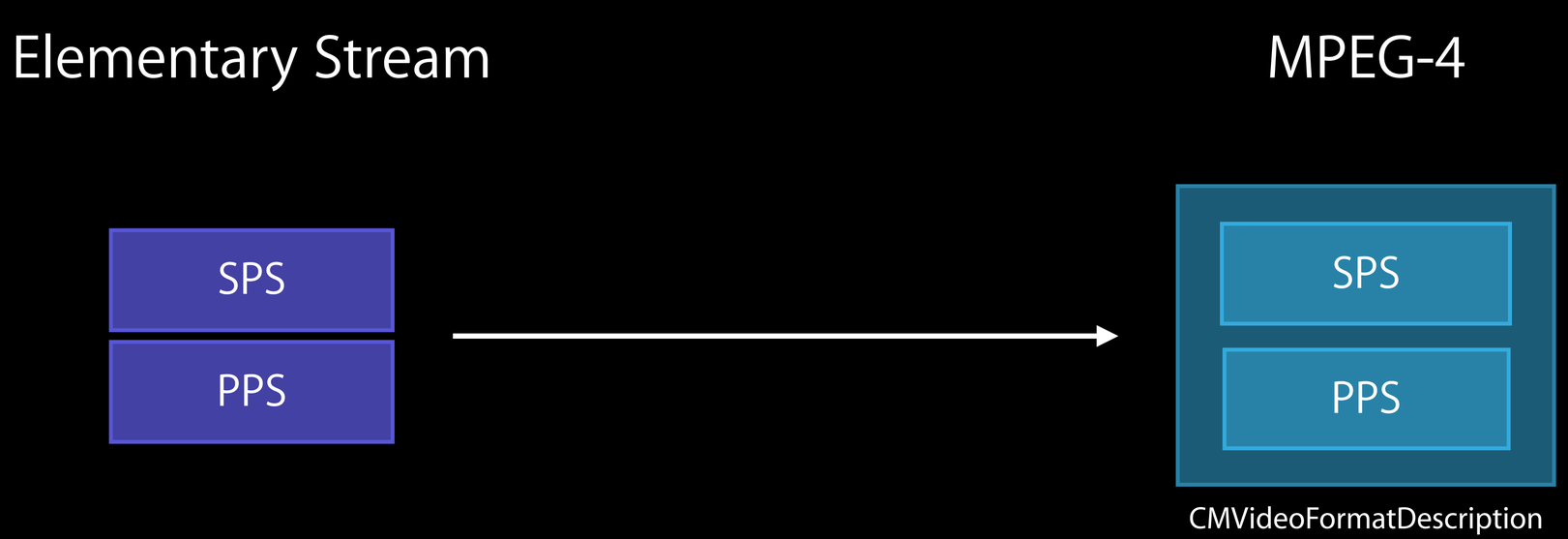
MPEG-4

SPS

PPS

# H.264 Syntax

## Conversion



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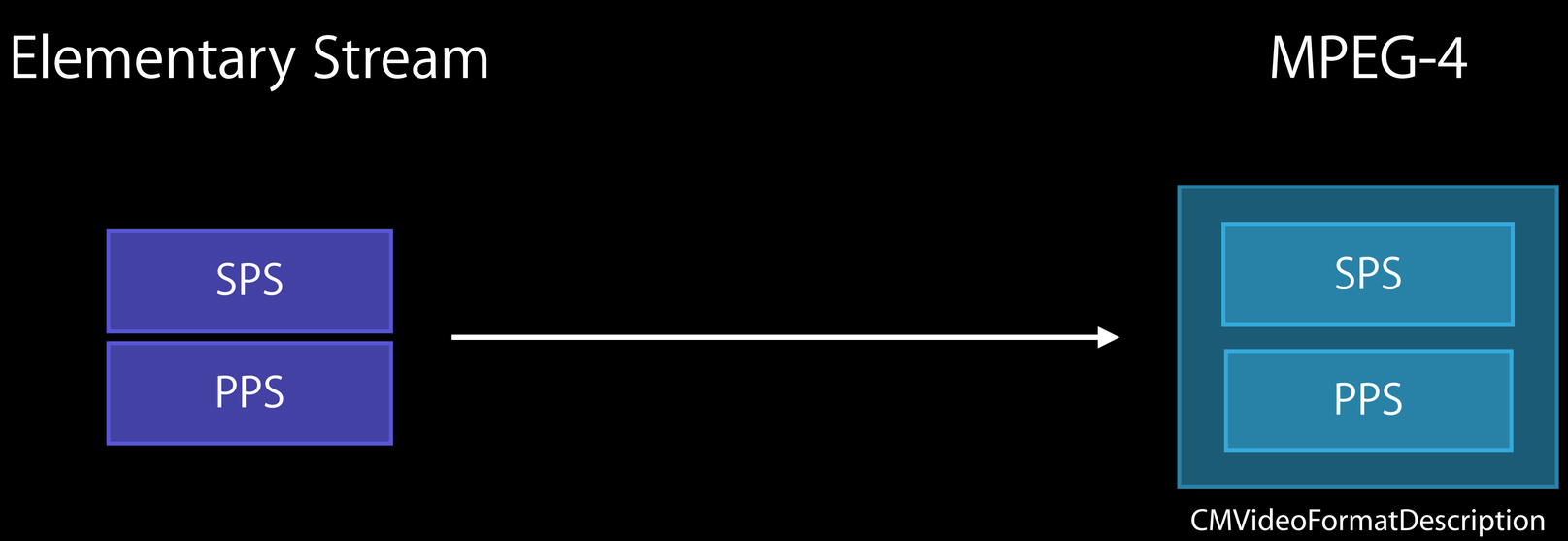


```
CMVideoFormatDescriptionCreateFromH264ParameterSets
```

# H.264 Syntax

## NAL Unit headers

Elementary Stream

MPEG-4

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## NAL Unit headers

Elementary Stream

MPEG-4

```
00 00 01
```


3- or 4-Byte Header:
Start Code

# H.264 Syntax

## NAL Unit headers

### Elementary Stream

```
00 00 01
```


3- or 4-Byte Header:
Start Code

### MPEG-4

```
00 00 80 00
```


4-Byte Header:
Length

# Building a CMSampleBuffer

## NAL Unit conversion

00 00 01

# Building a CMSampleBuffer

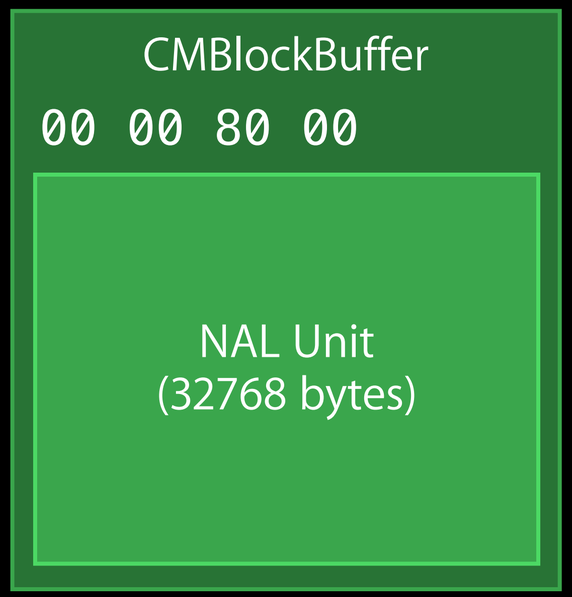
## NAL Unit conversion

00 00 80 00

NAL Unit
(32768 bytes)

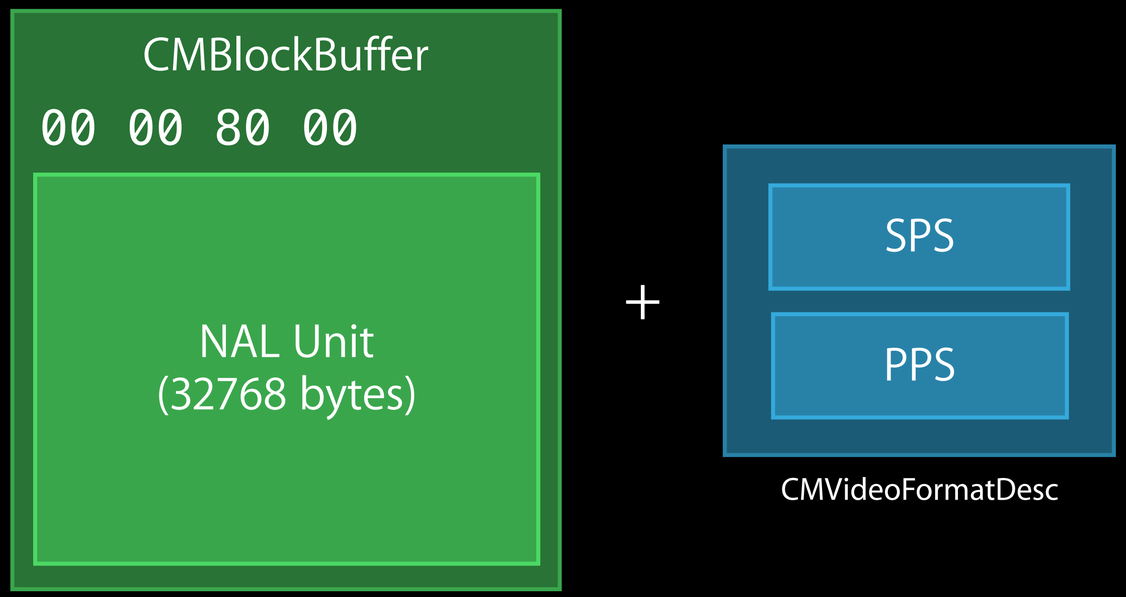
# Building a CMSampleBuffer

## NAL Unit conversion



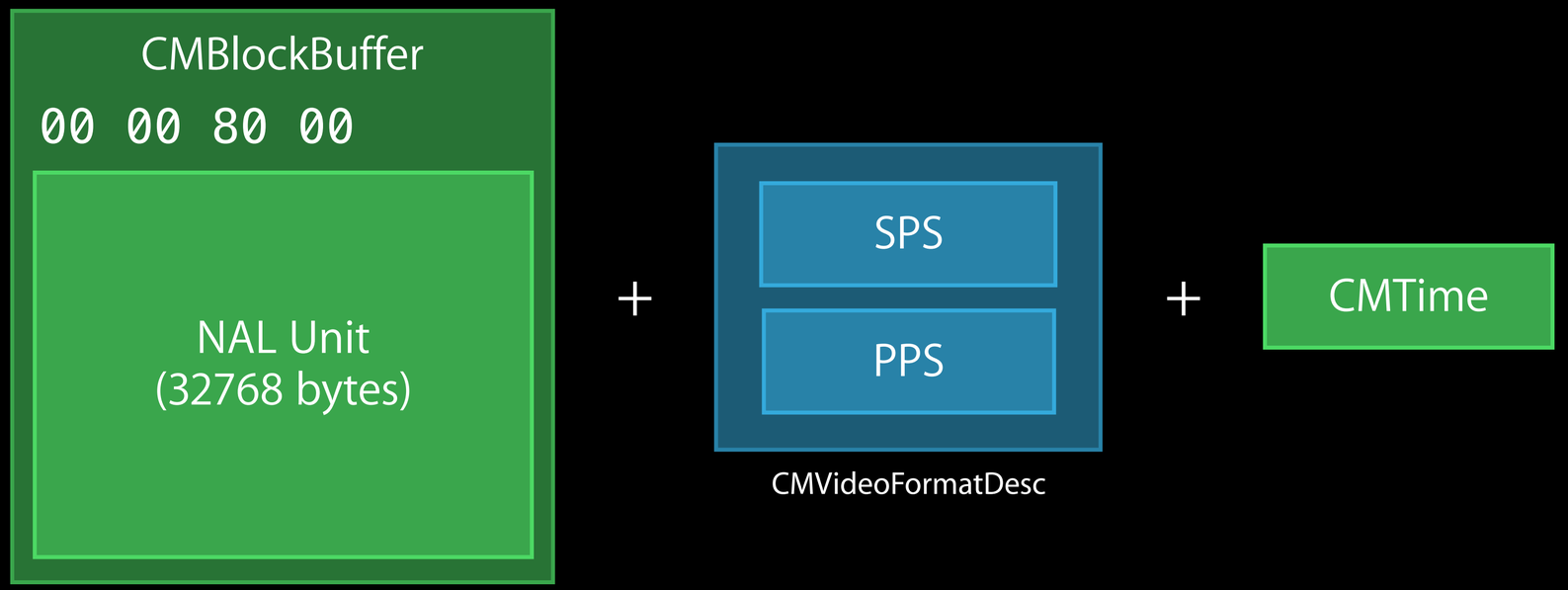
# Building a CMSampleBuffer

## NAL Unit conversion



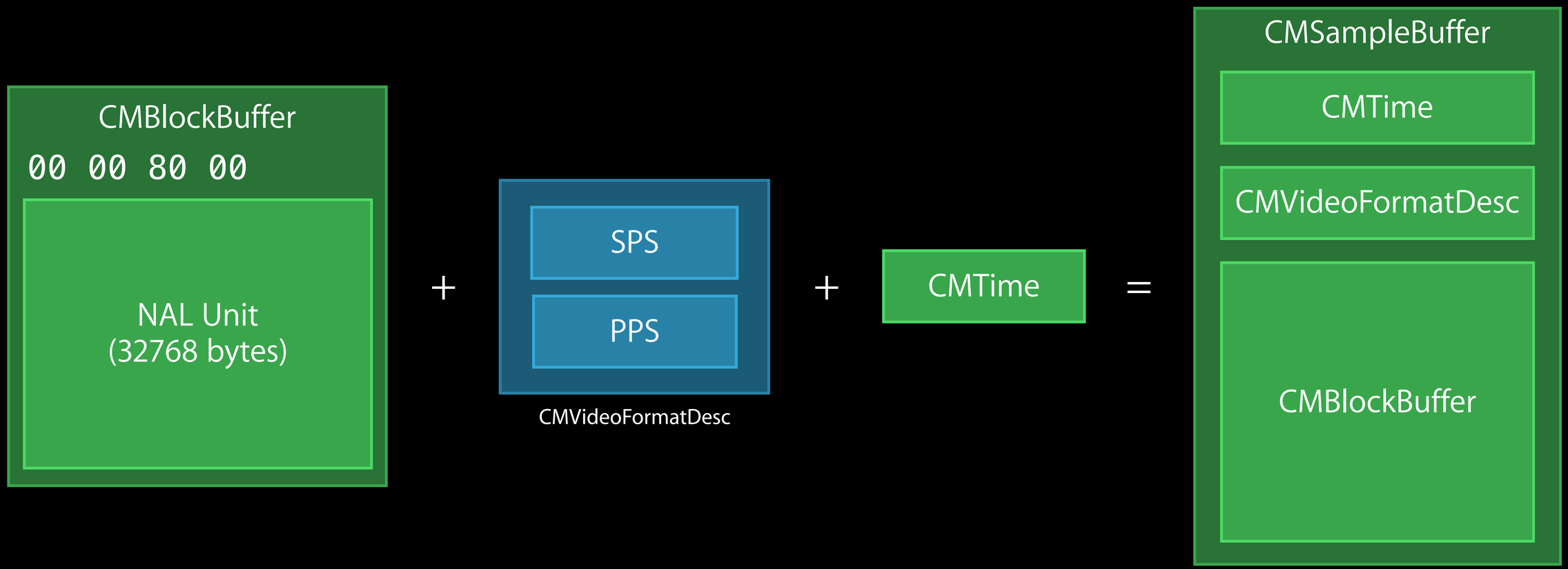
# Building a CMSampleBuffer

## NAL Unit conversion



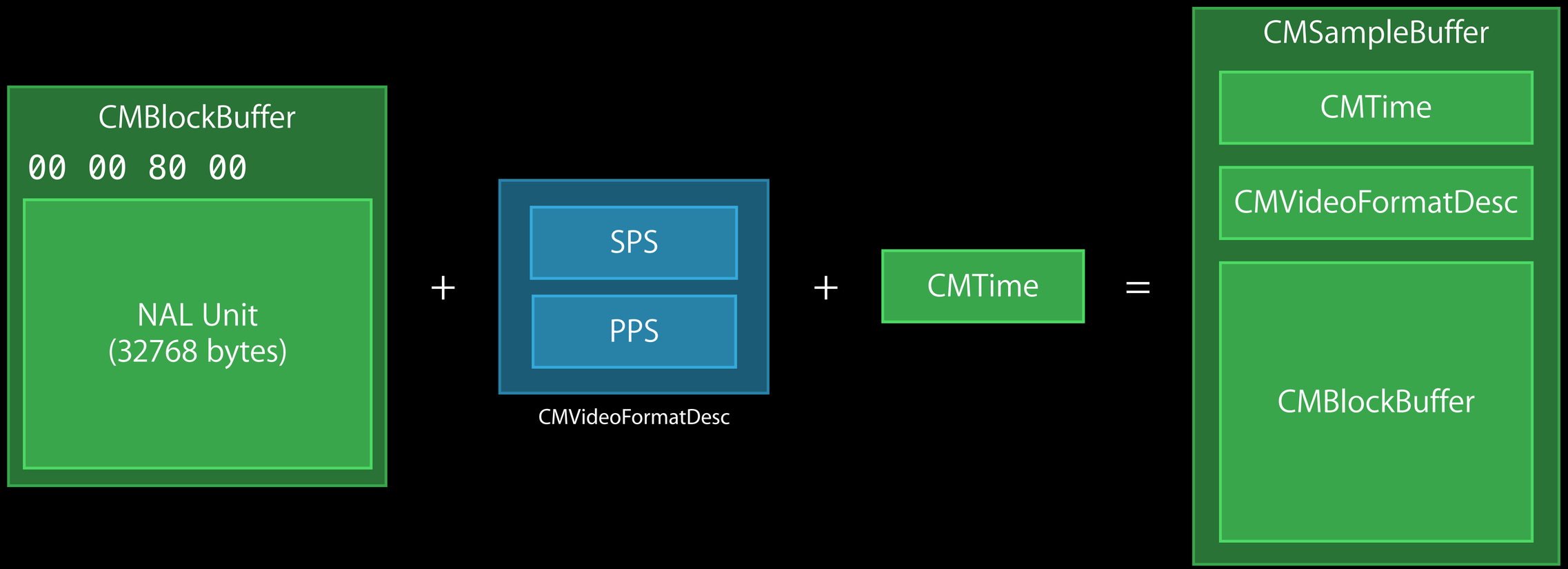
# Building a CMSampleBuffer

## NAL Unit conversion



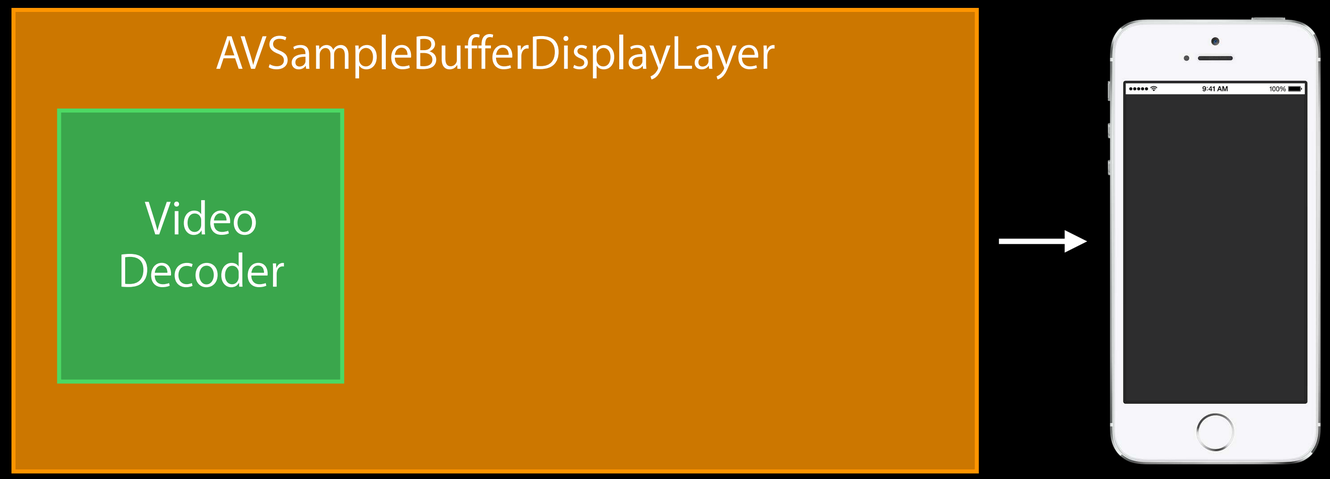
# Building a CMSampleBuffer

## NAL Unit conversion

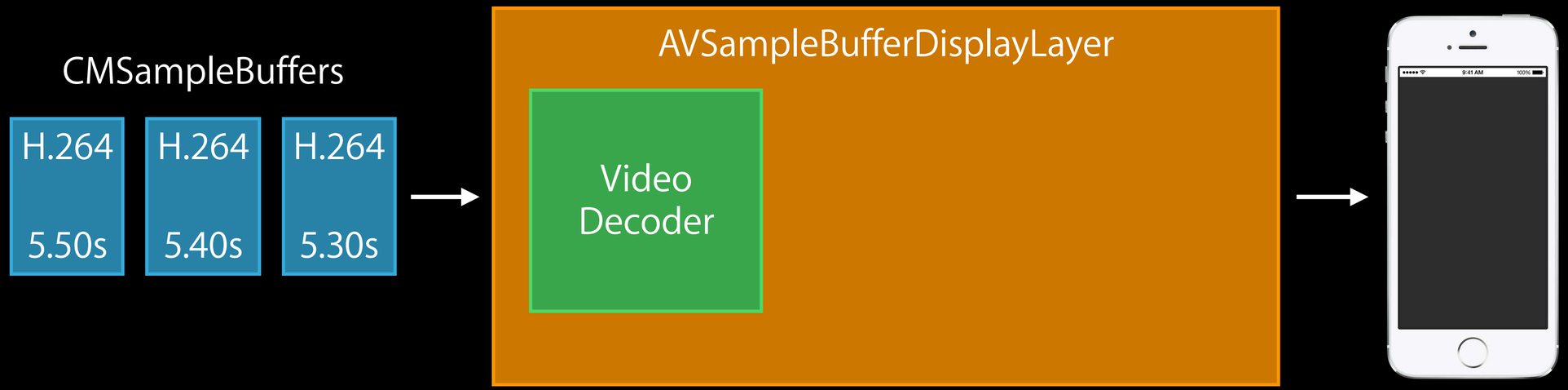



`CMSampleBufferCreate`

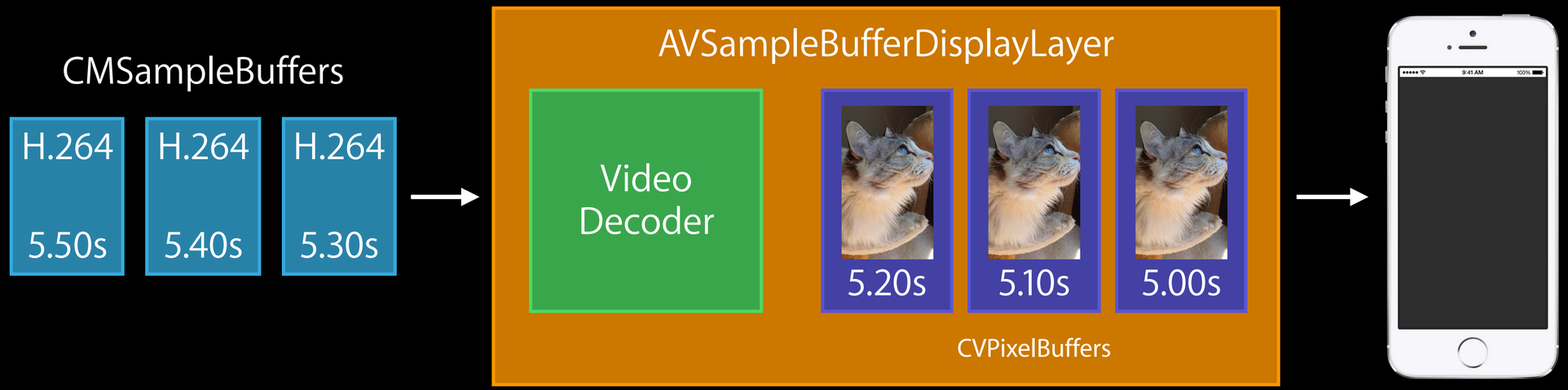
# AVSampleBufferDisplayLayer and Time



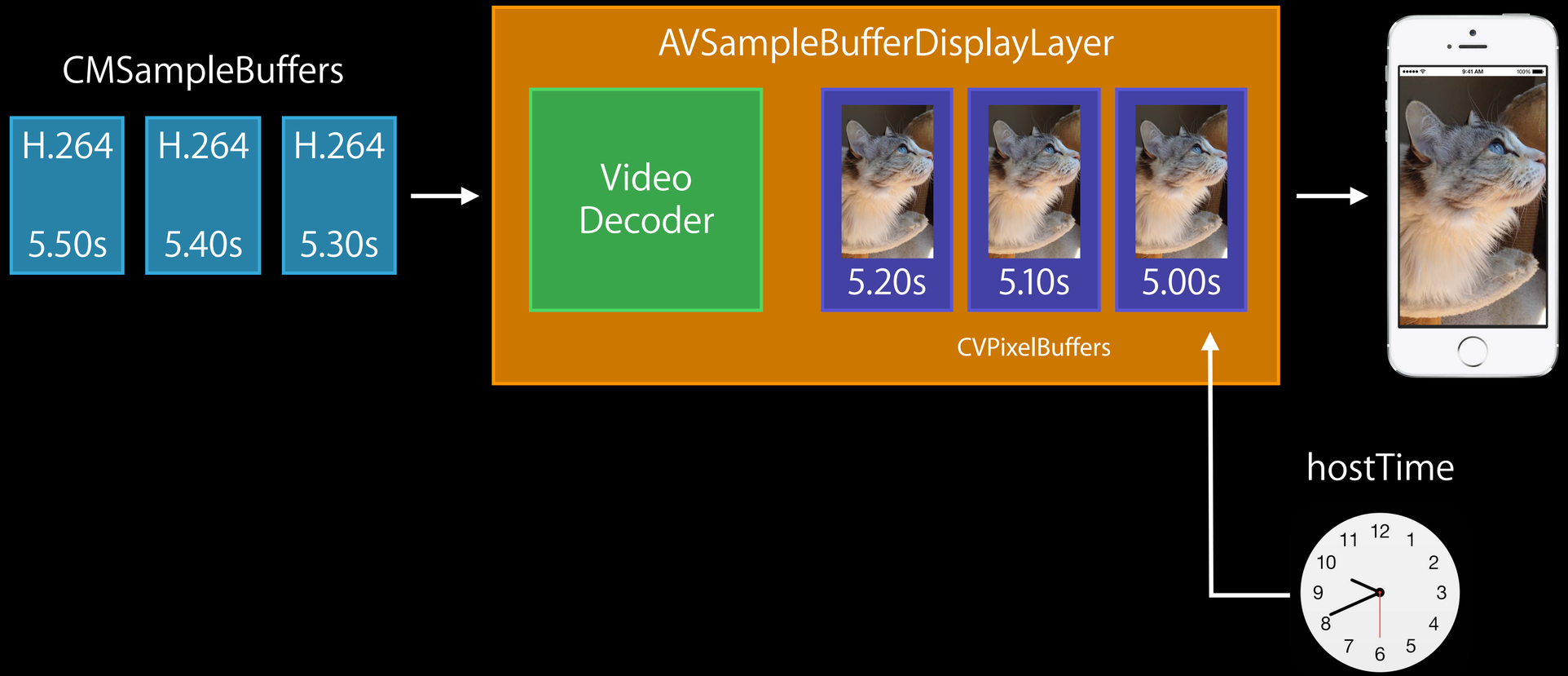
# AVSampleBufferDisplayLayer and Time



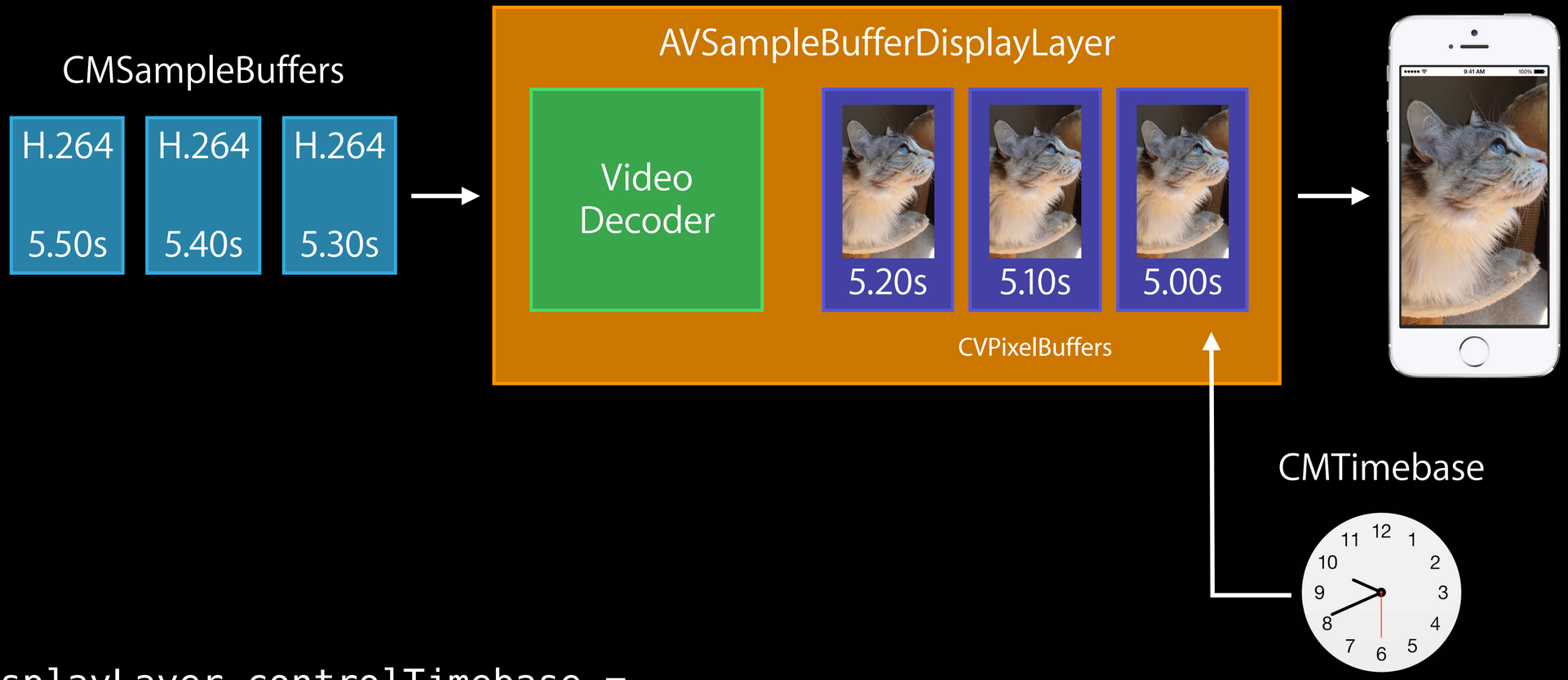
# AVSampleBufferDisplayLayer and Time



# AVSampleBufferDisplayLayer and Time



# AVSampleBufferDisplayLayer and Time




```
sbDisplayLayer.controlTimebase =
    CMTimebaseCreateWithMasterClock(CMClockGetHostTimeClock());
CMTimebaseSetTime(sbDisplayLayer.controlTimebase, CMTimeMake(5, 1));
CMTimebaseSetRate(sbDisplayLayer.controlTimebase, 1.0);
```

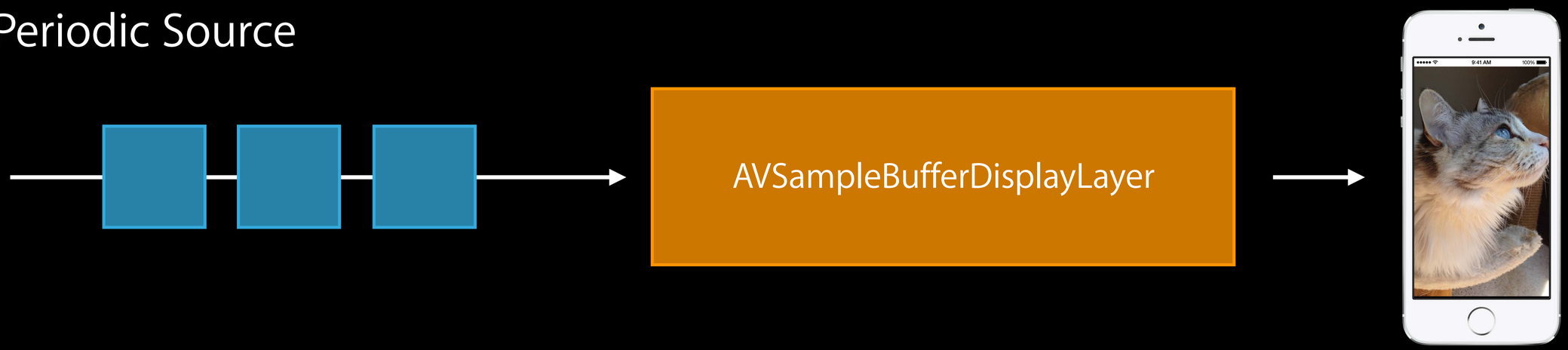
# Feeding AVSampleBufferDisplayLayer

Two scenarios

# Feeding AVSampleBufferDisplayLayer

## Two scenarios

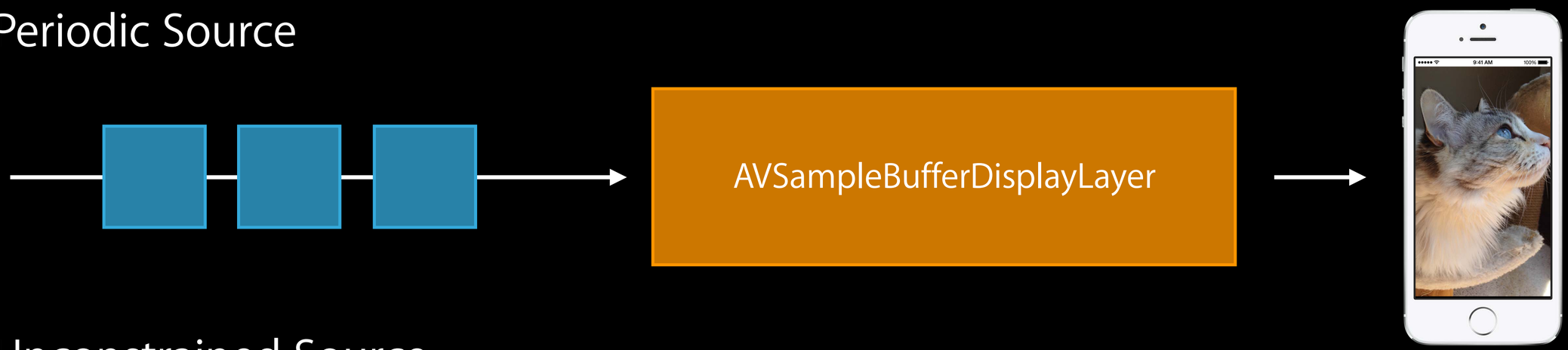
Periodic Source



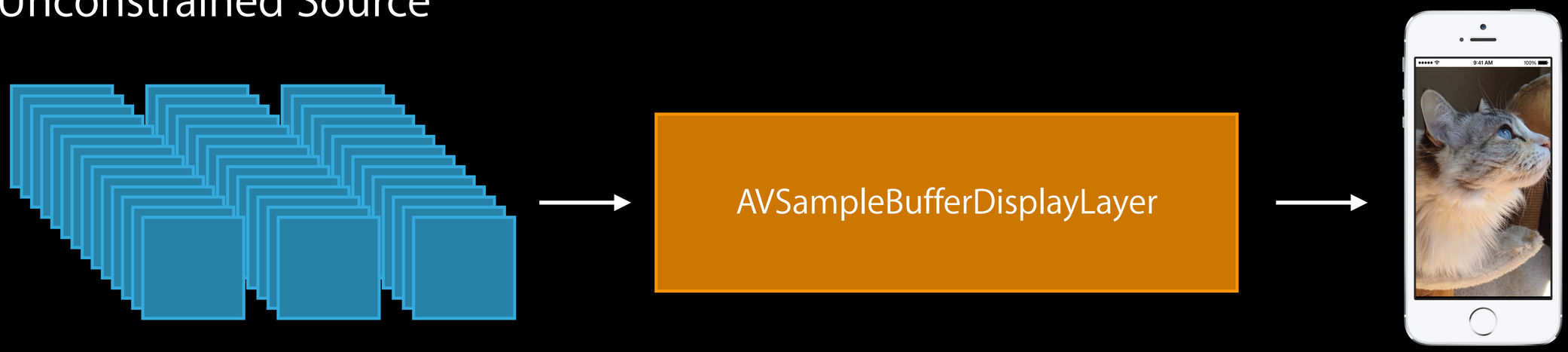
# Feeding AVSampleBufferDisplayLayer

## Two scenarios

Periodic Source




Unconstrained Source



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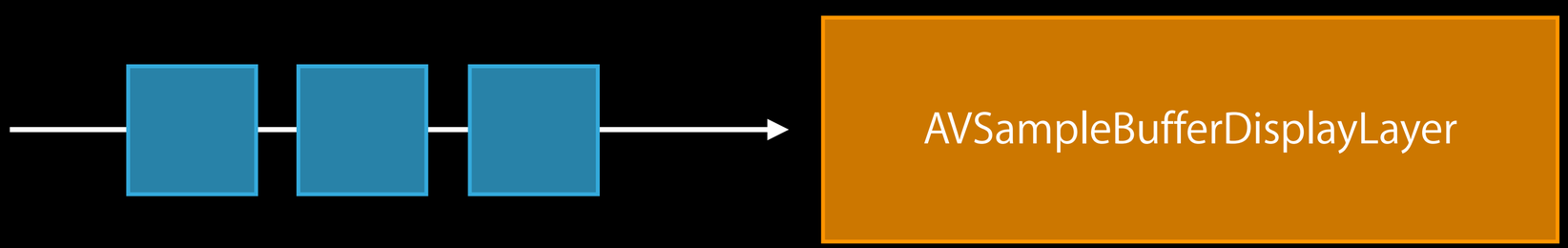

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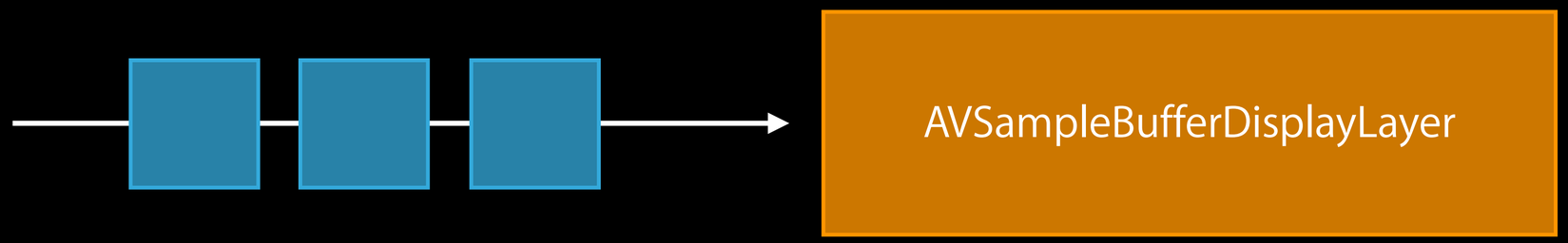


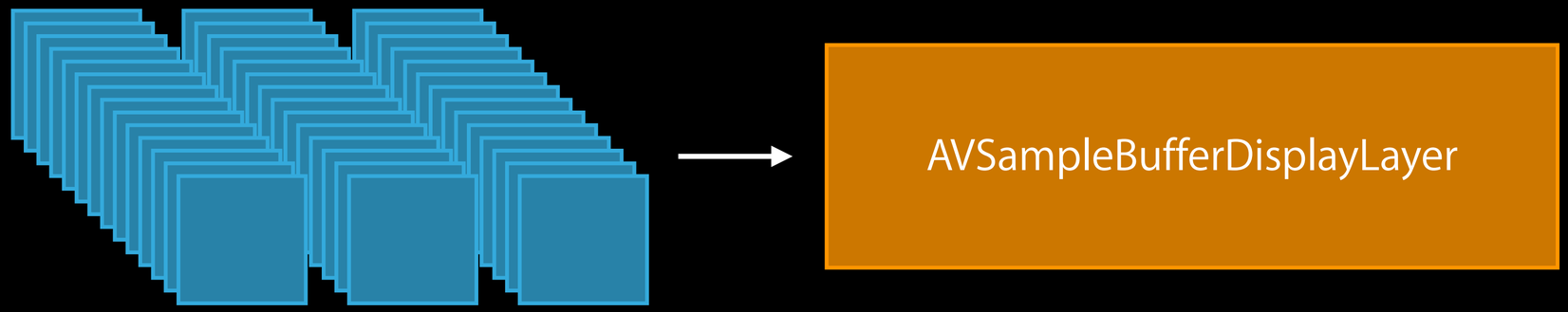

Frame arrival corresponds to display frequency

Enqueue with:

```
[sbDisplayLayer enqueueSampleBuffer:sbuf];
```

# Feeding AVSampleBufferDisplayLayer

## Unconstrained source



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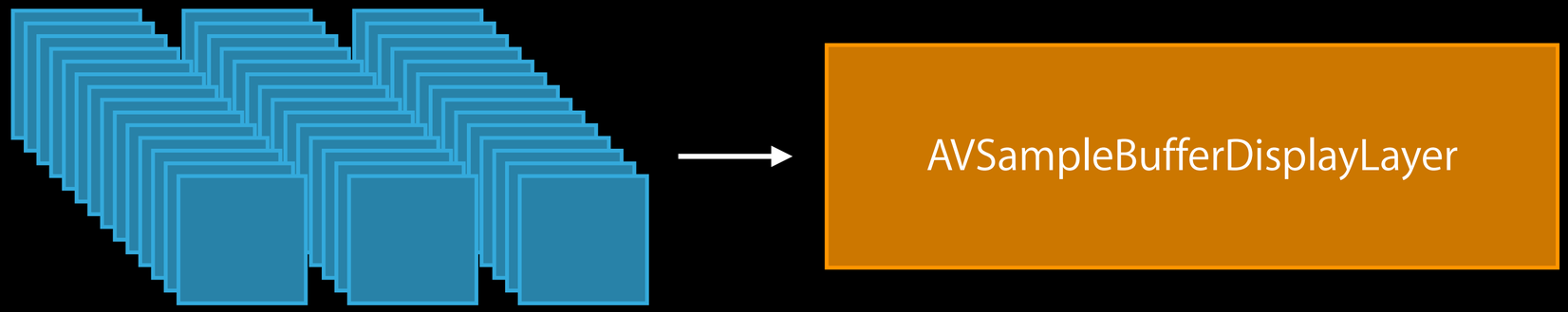


AVSampleBufferDisplayLayer throttles input:

```
[sbDisplayLayer requestMediaDataWhenReadyOnQueue:dispatchQueue usingBlock:^{
    while ([sbDisplayLayer isReadyForMoreMediaData]) {
        CMSampleBuffer sbuf = copyNextSBuf();
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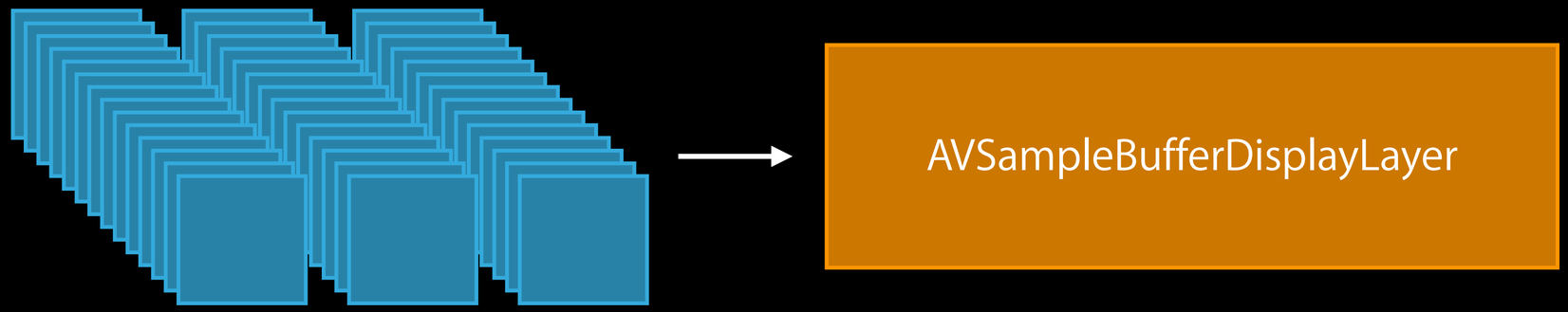
        CFRelease(sbuf);
    }
}];
```

# Feeding AVSampleBufferDisplayLayer

## Unconstrained source

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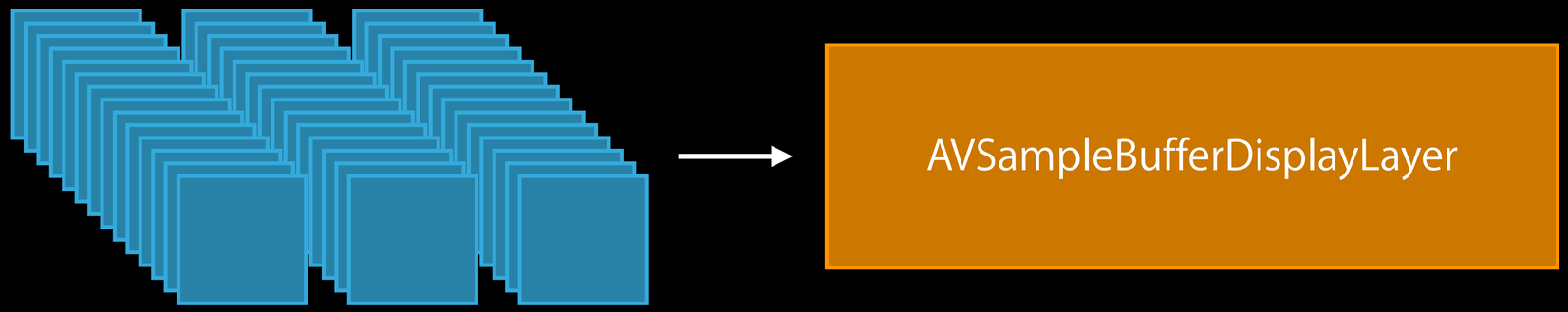


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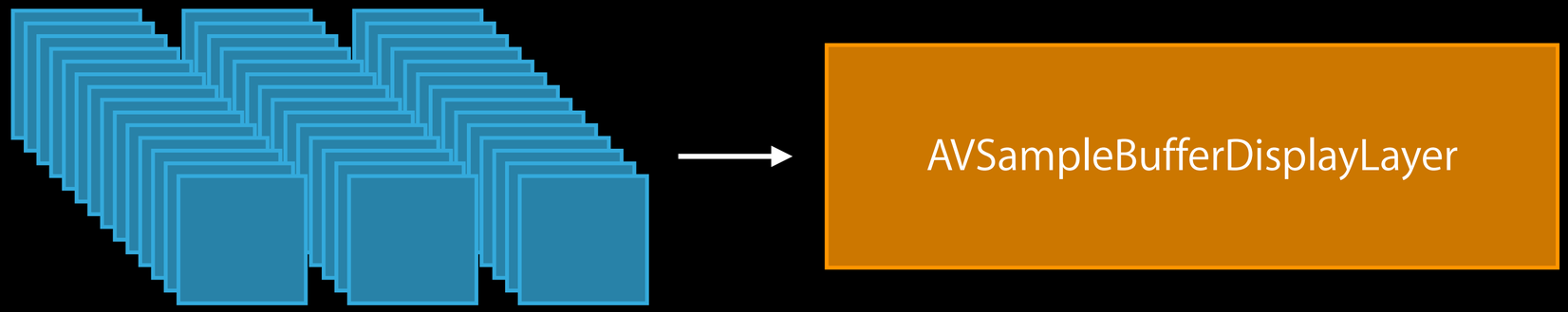


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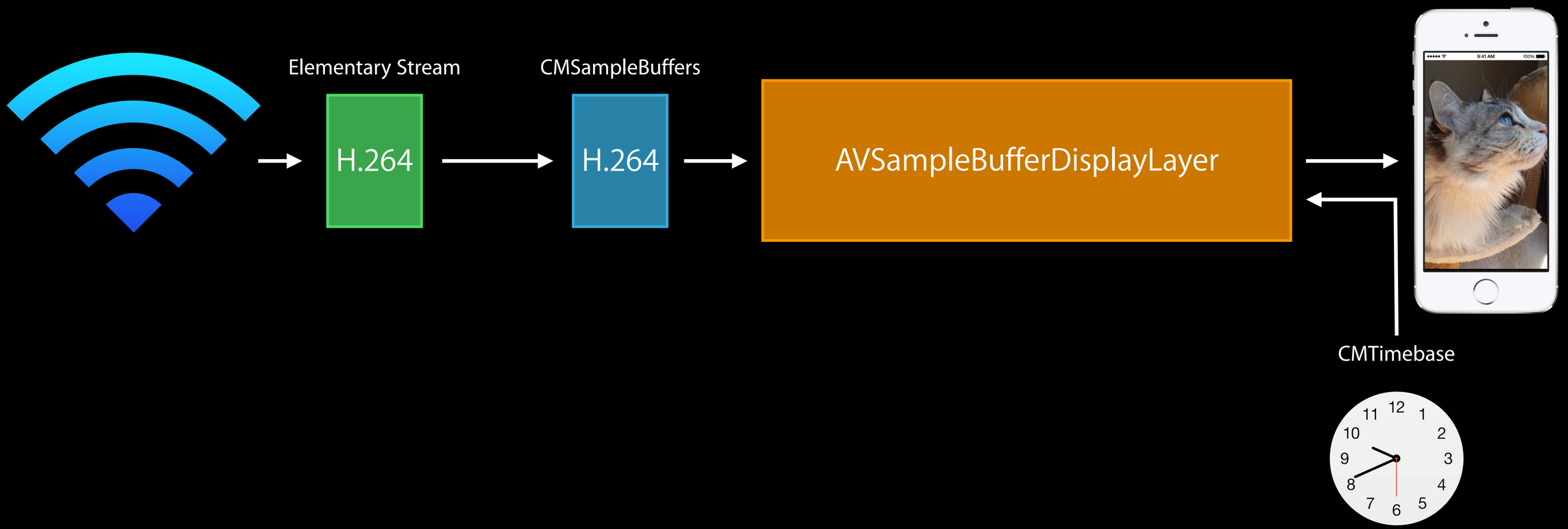
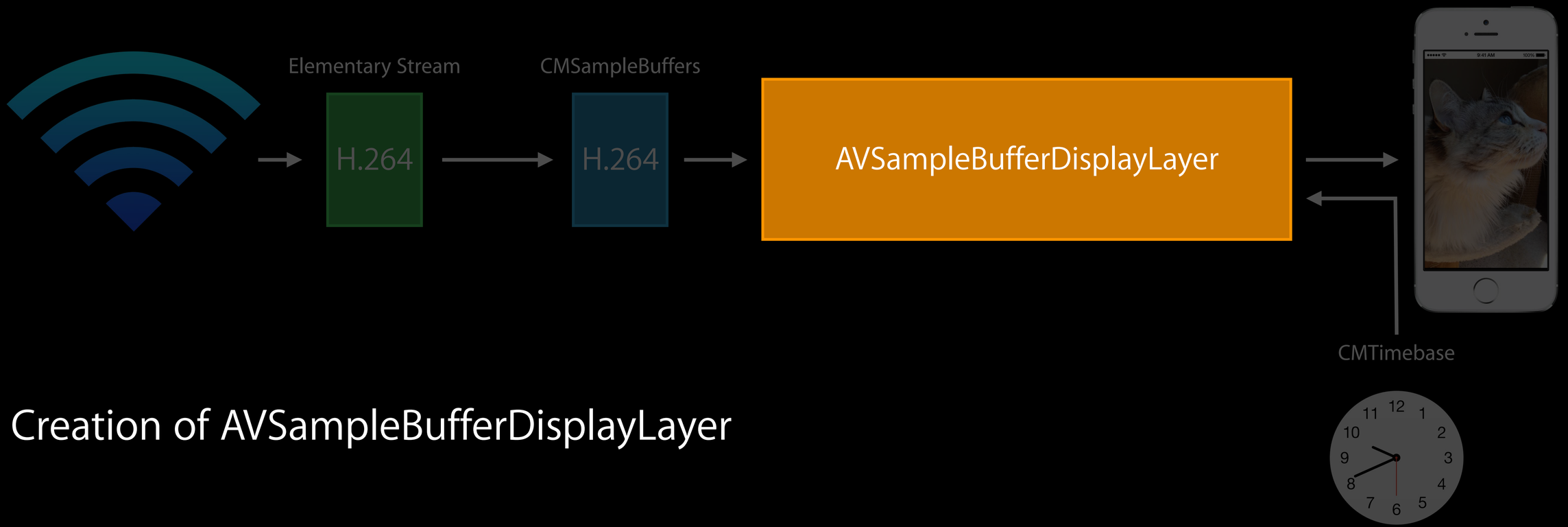
# AVSampleBufferDisplayLayer Summary

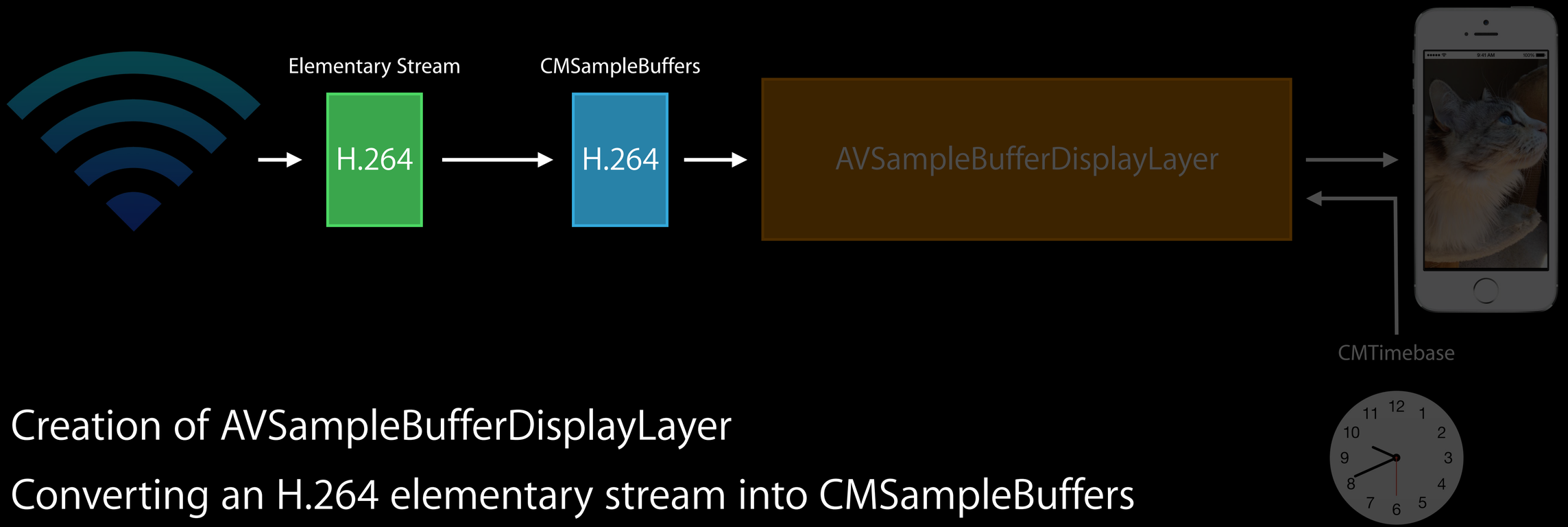


# AVSampleBufferDisplayLayer Summary




## Creation of AVSampleBufferDisplayLayer

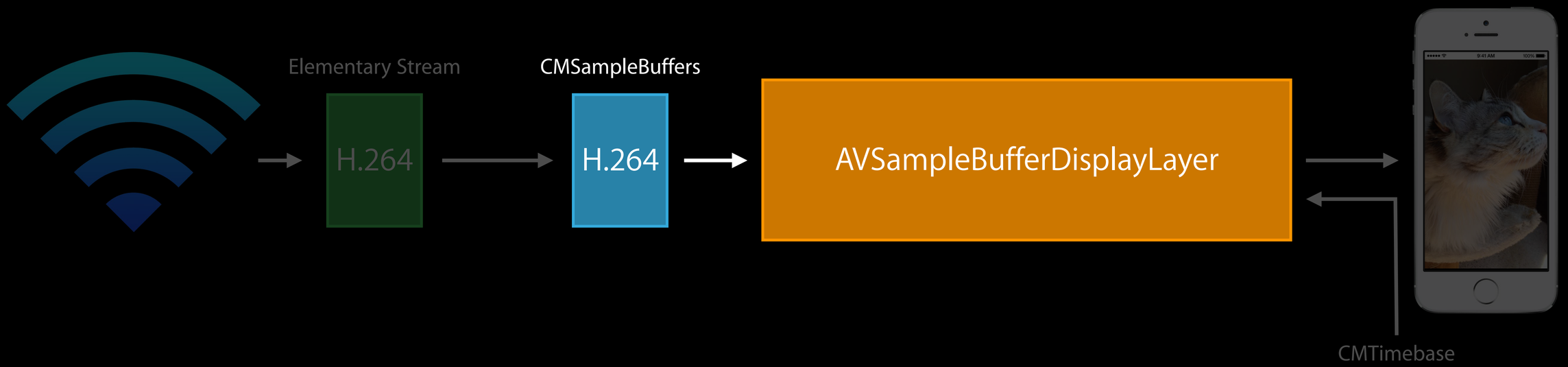
# AVSampleBufferDisplayLayer Summary




Creation of AVSampleBufferDisplayLayer

Converting an H.264 elementary stream into CMSampleBuffers

# AVSampleBufferDisplayLayer Summary

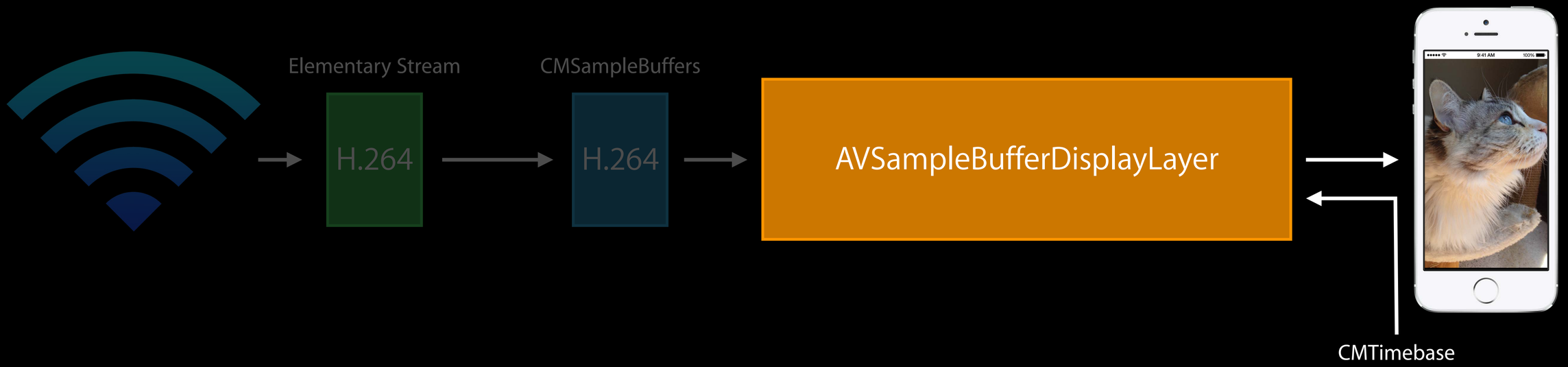



Creation of AVSampleBufferDisplayLayer

Converting an H.264 elementary stream into CMSampleBuffers

Providing CMSampleBuffers to AVSampleBufferDisplayLayer

# AVSampleBufferDisplayLayer Summary




Creation of AVSampleBufferDisplayLayer

Converting an H.264 elementary stream into CMSampleBuffers

Providing CMSampleBuffers to AVSampleBufferDisplayLayer

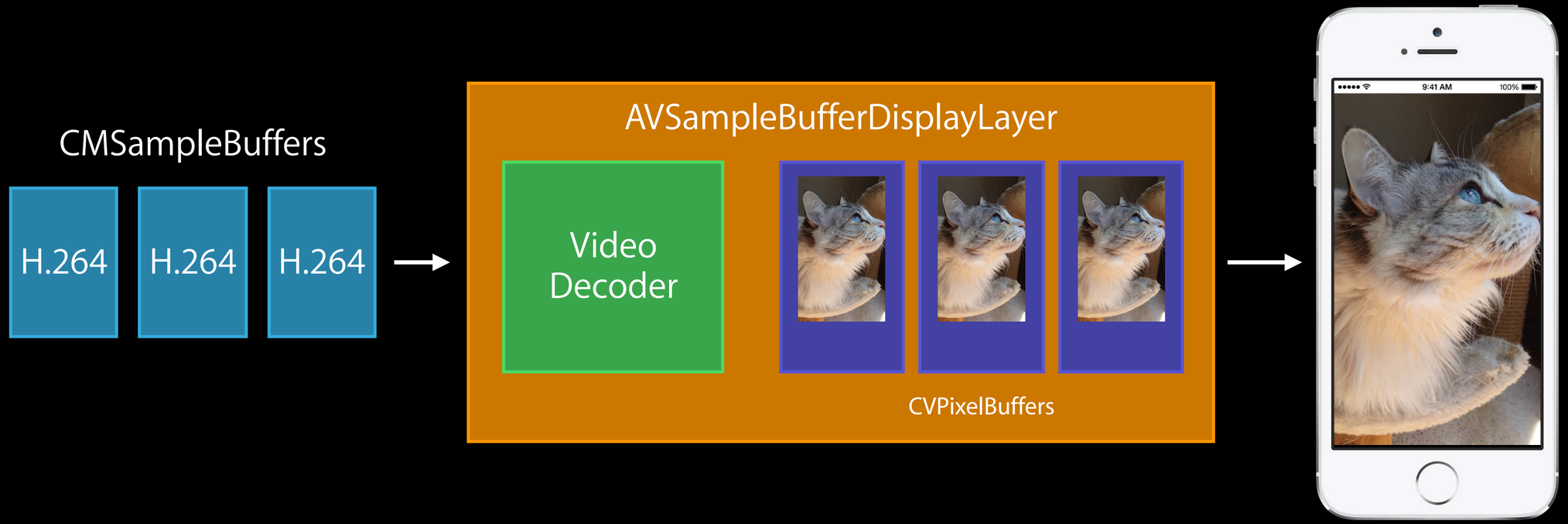
Using a custom CMTimebase with AVSampleBufferDisplayLayer

# Case Two

## Getting CVPixelBuffers from a compressed stream

# AVSampleBufferDisplayLayer

# AVSampleBufferDisplayLayer



# VTDecompressionSession

## Getting access to the decoder

# VTDecompressionSession

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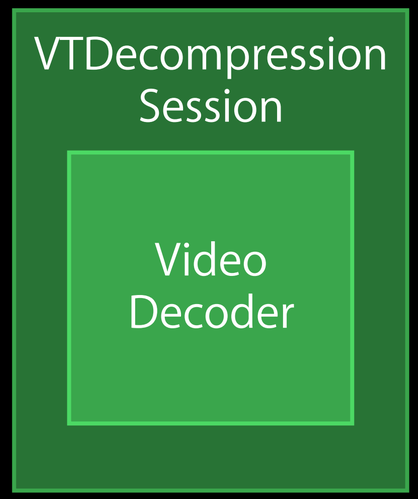
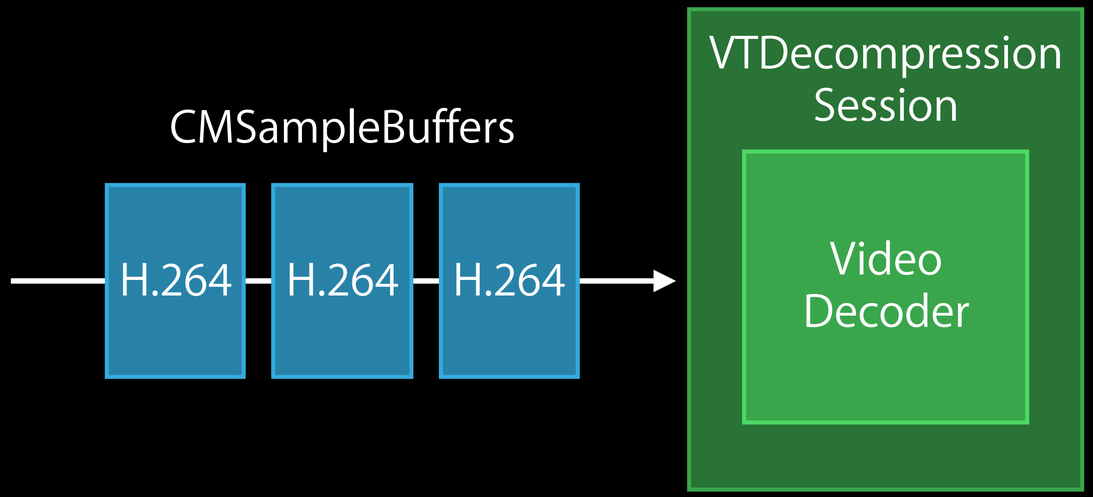


# VTDecompressionSession

## Getting access to the decoder



# VTDecompressionSession

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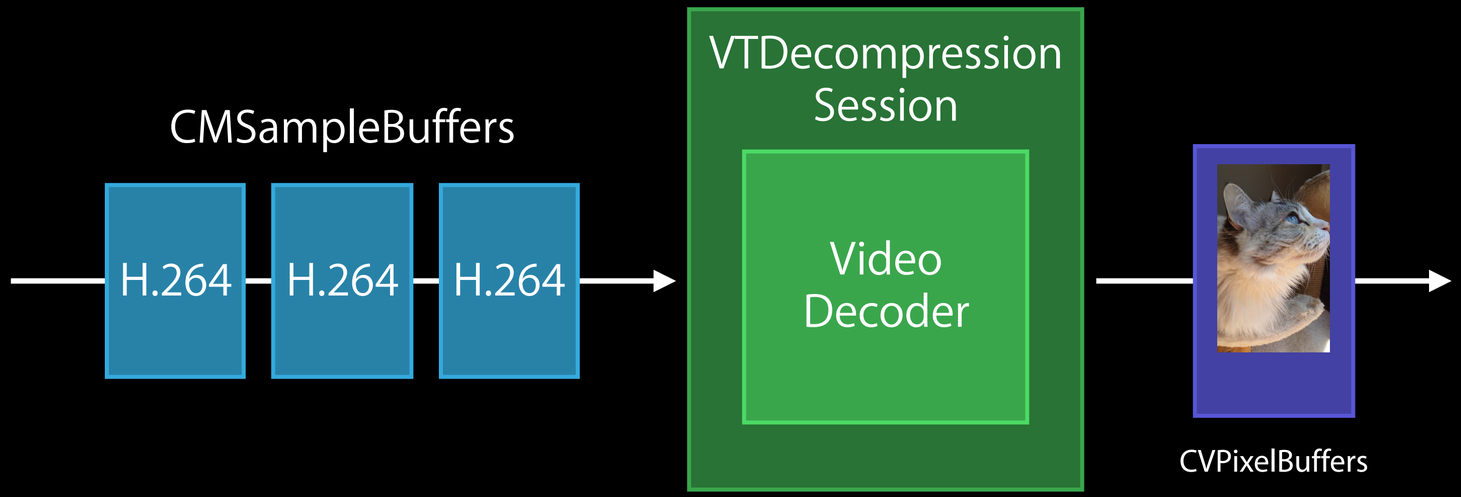
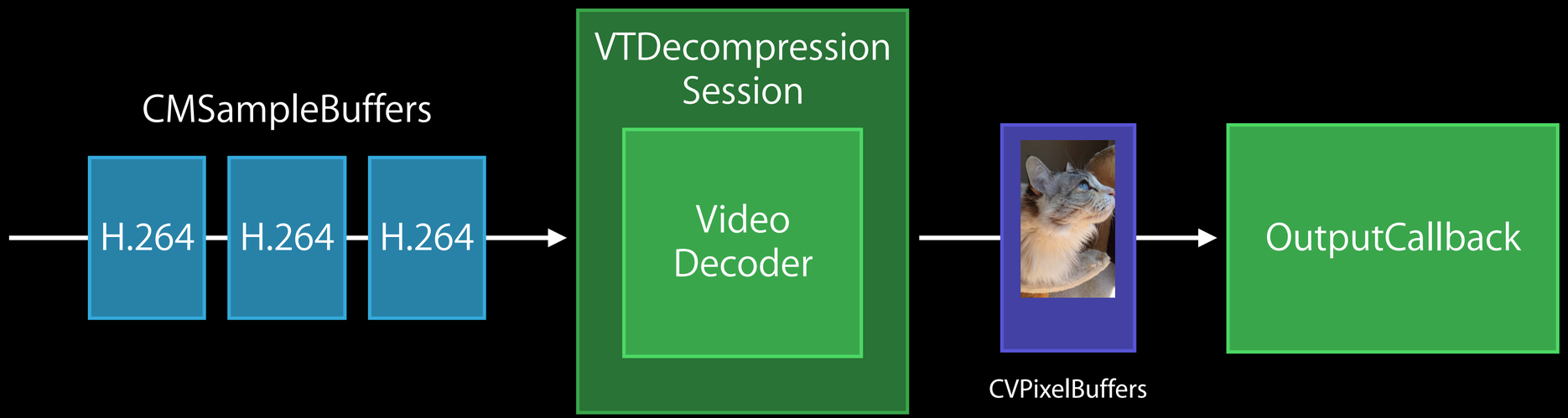


# VTDecompressionSession

## Getting access to the decoder



# Creating a VTDecompressionSession

What you need

# Creating a VTDecompressionSession

What you need

- Description of source data—CMVideoFormatDescription

# Creating a VTDecompressionSession

What you need

- Description of source data—CMVideoFormatDescription
- Requirements for output buffers—pixelBufferAttributes

# Creating a VTDecompressionSession

What you need

- Description of source data—CMVideoFormatDescription
- Requirements for output buffers—pixelBufferAttributes
- A VTDecompressionOutputCallback

# Requirements for Output CVPixelBuffers

## Creating a pixelBufferAttributes dictionary

# Requirements for Output CVPixelBuffers

## Creating a pixelBufferAttributes dictionary

Example: OpenGL ES render pipeline

# Requirements for Output CVPixelBuffers

## Creating a pixelBufferAttributes dictionary

Example: OpenGL ES render pipeline


To require OpenGL ES compatibility—

```
NSDictionary *destinationImageBufferAttributes =
    [NSDictionary dictionaryWithObjectsAndKeys:
     [NSNumber numberWithBool:YES],(id)kCVPixelBufferOpenGLESCompatibilityKey,
     nil];
```

# Requirements for Output CVPixelBuffers

## Creating a pixelBufferAttributes dictionary

Example: OpenGL ES render pipeline


To require OpenGL ES compatibility—

```
NSDictionary *destinationImageBufferAttributes =
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```

# Optimizing Output

## Do not over specify

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kCVPixelBufferOpenGLESCompatibilityKey requested

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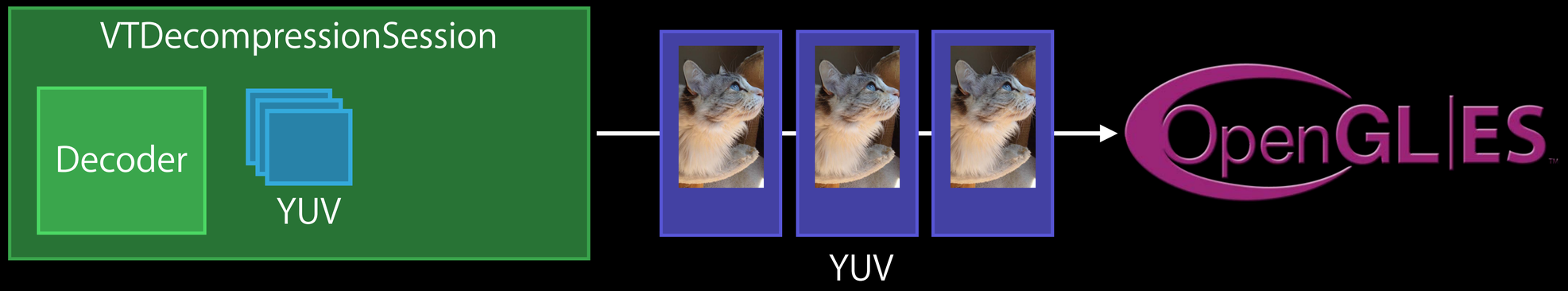
kCVPixelBufferOpenGLESCompatibilityKey requested




kCVPixelBufferOpenGLESCompatibilityKey and ‘BGRA’ pixel format required

# Optimizing Output

## Do not over specify

kCVPixelBufferOpenGLESCompatibilityKey requested


kCVPixelBufferOpenGLESCompatibilityKey and ‘BGRA’ pixel format required

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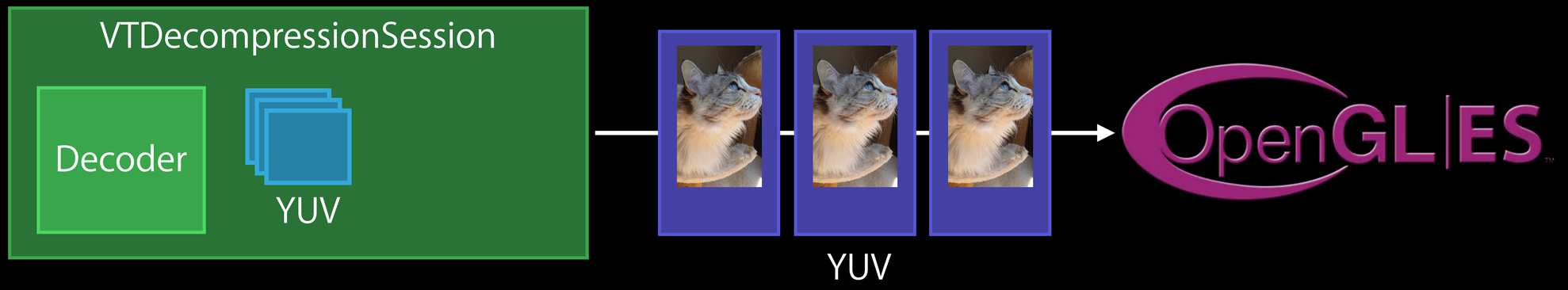


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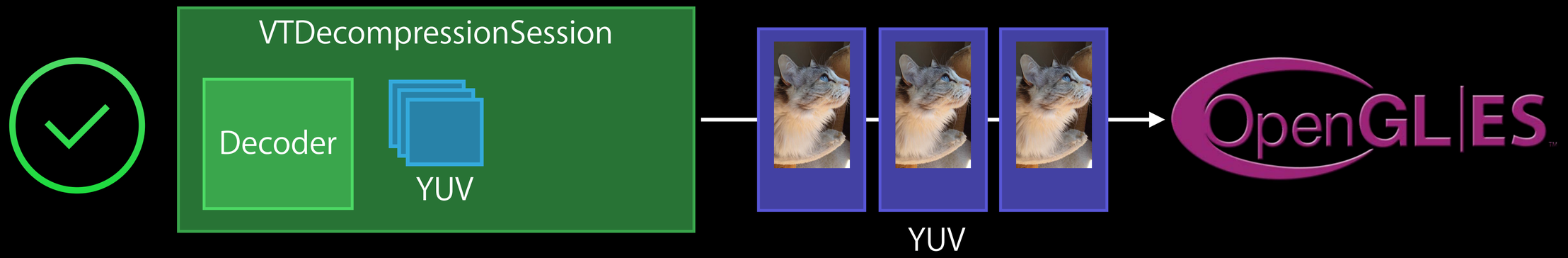


kCVPixelBufferOpenGLESCompatibilityKey and ‘BGRA’ pixel format required

# VTDecompressionOutputCallback

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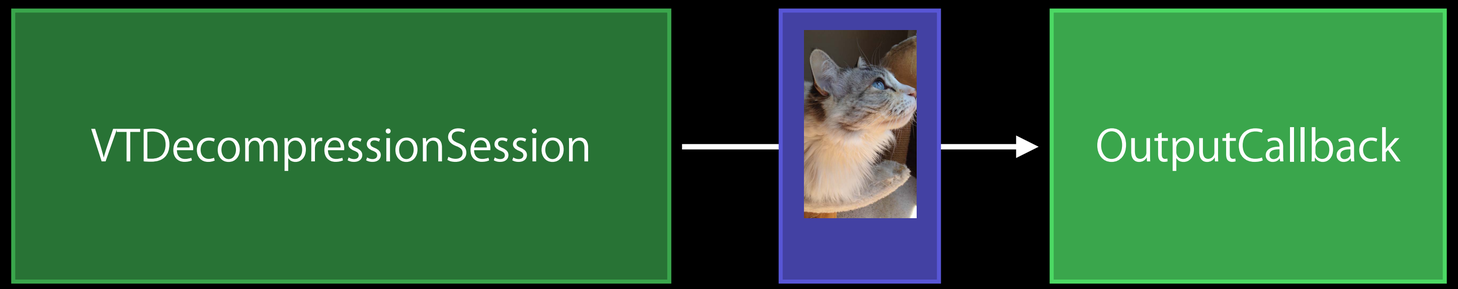
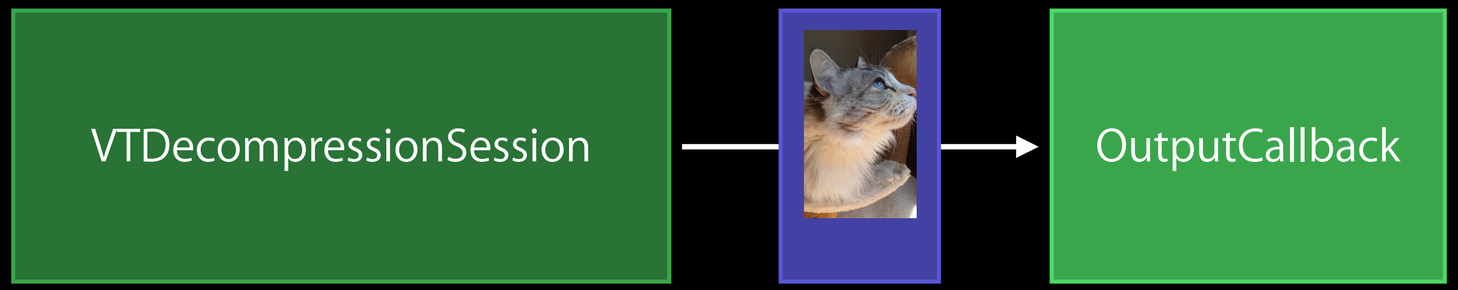
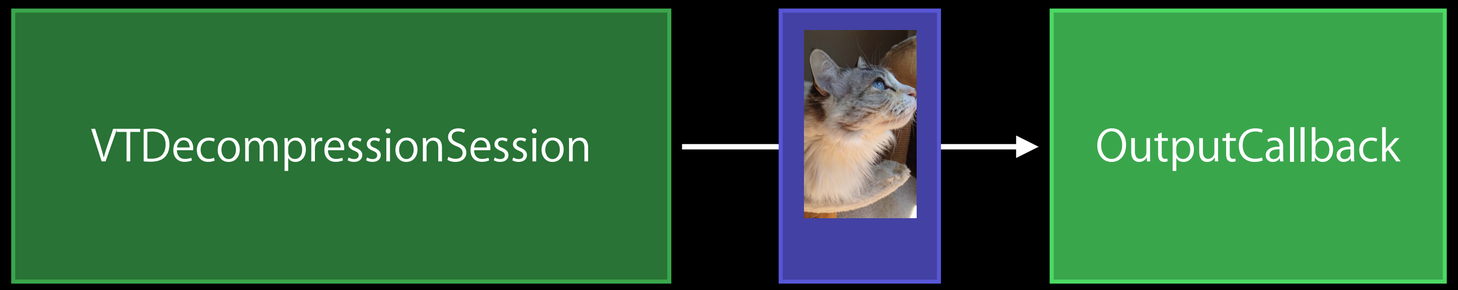


# VTDecompressionOutputCallback




VTDecompressionOutputCallback receives

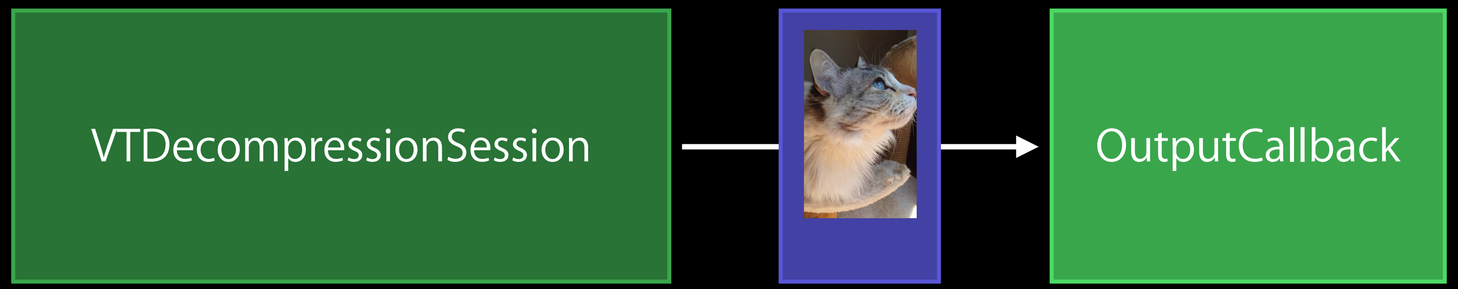
# VTDecompressionOutputCallback




VTDecompressionOutputCallback receives

- Output CVPixelBuffer

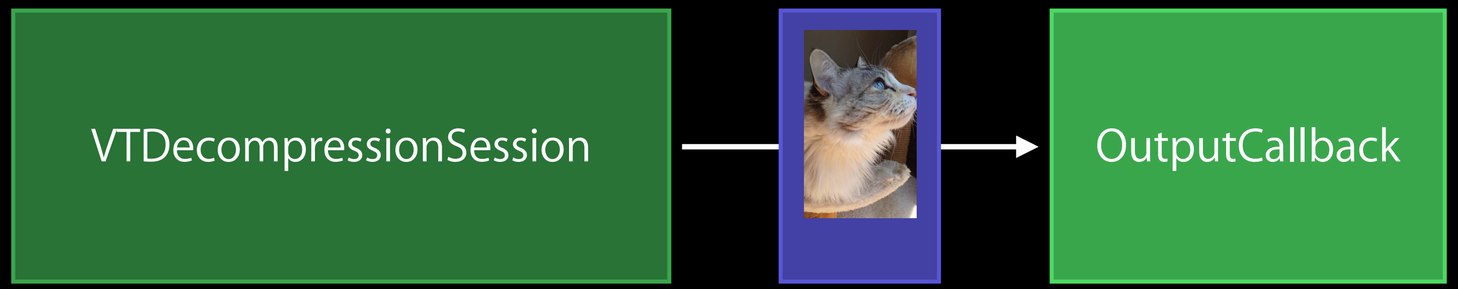
# VTDecompressionOutputCallback




VTDecompressionOutputCallback receives

- Output CVPixelBuffer
- Presentation time stamp

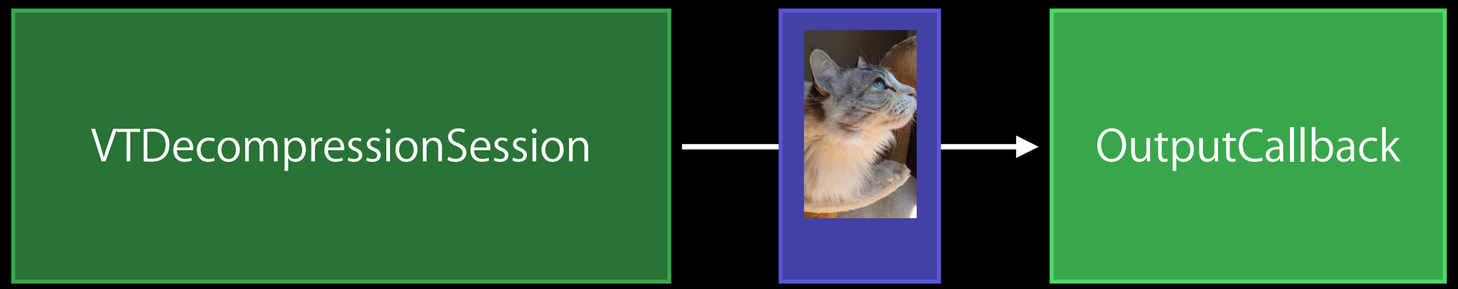
# VTDecompressionOutputCallback




VTDecompressionOutputCallback receives

- Output CVPixelBuffer
- Presentation time stamp
- Decompression error codes

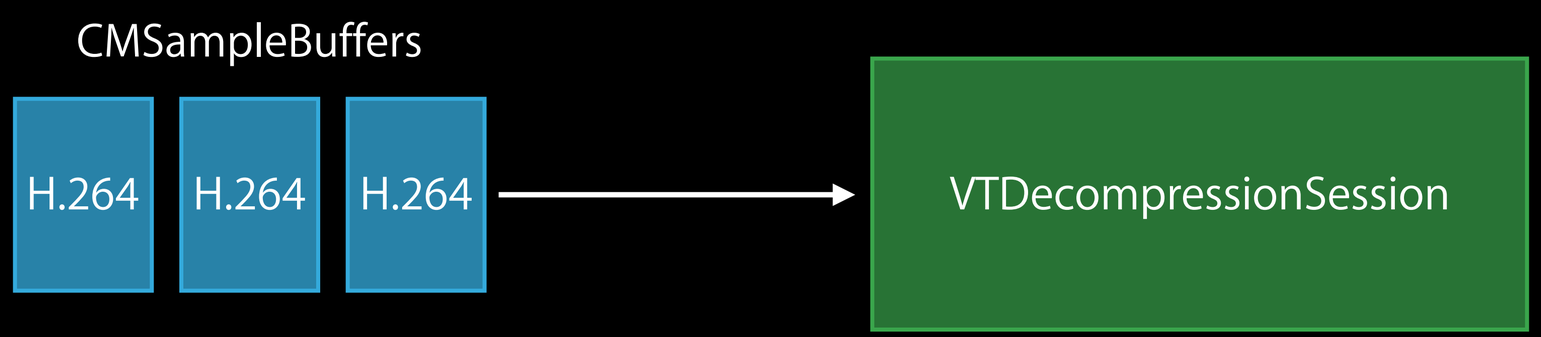
# VTDecompressionOutputCallback



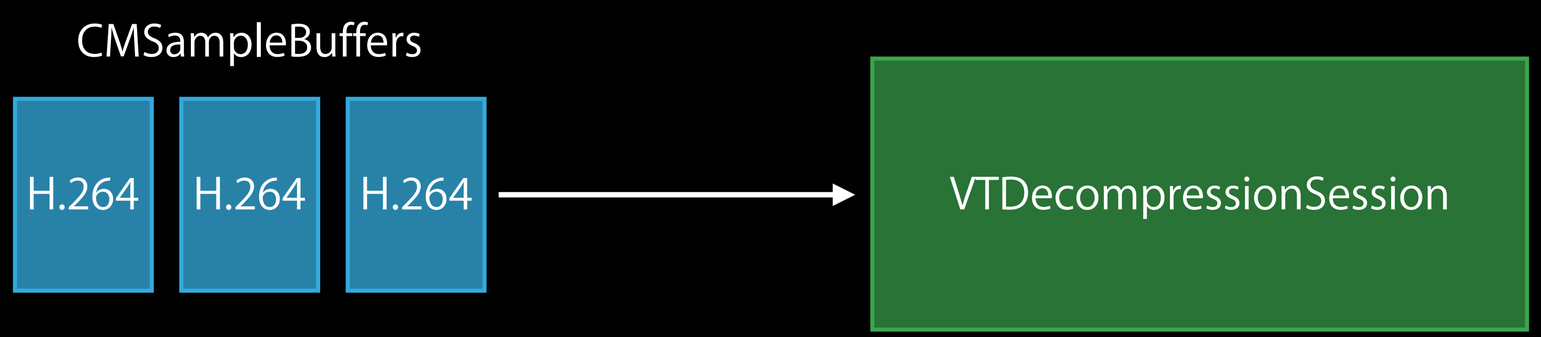

VTDecompressionOutputCallback receives

- Output CVPixelBuffer
- Presentation time stamp
- Decompression error codes
- Dropped frames

# Feeding VTDecompressionSession

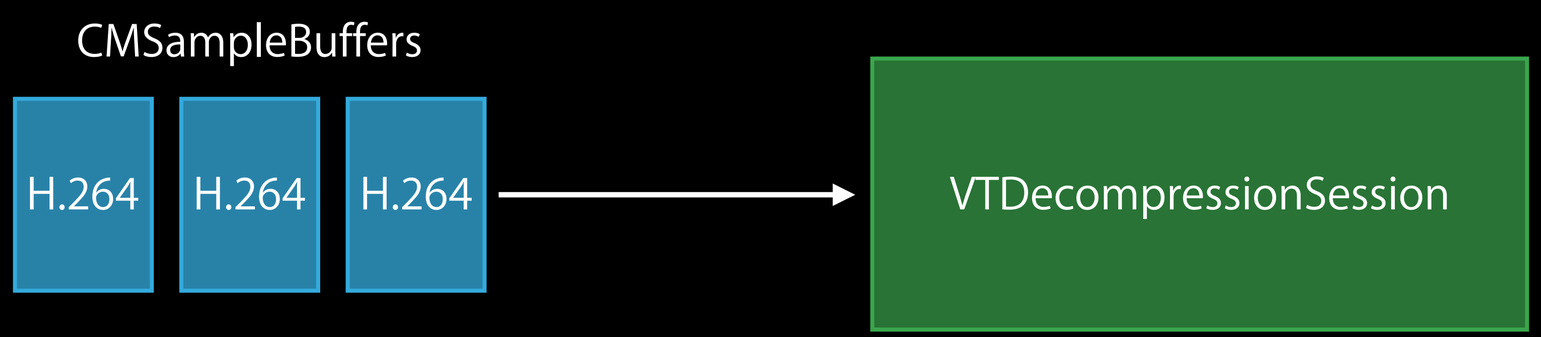


# Feeding VTDecompressionSession




```
err = VTDecompressionSessionDecodeFrame( session, sbuf,
          inFlags, refCon, &outFlags );
```

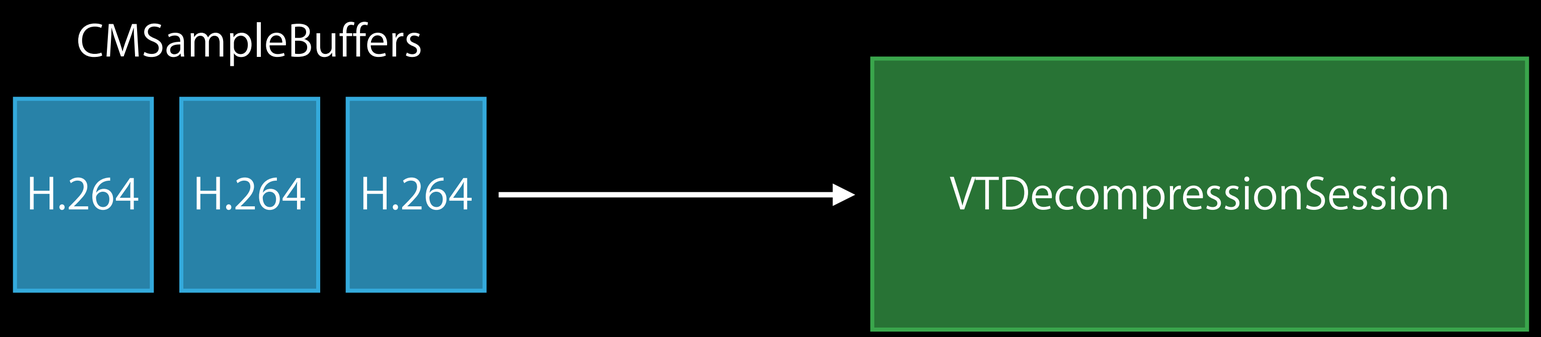
# Feeding VTDecompressionSession




```
err = VTDecompressionSessionDecodeFrame( session, sbuf,
          inFlags, refCon, &outFlags );
```

Wants CMSampleBuffers

# Feeding VTDecompressionSession

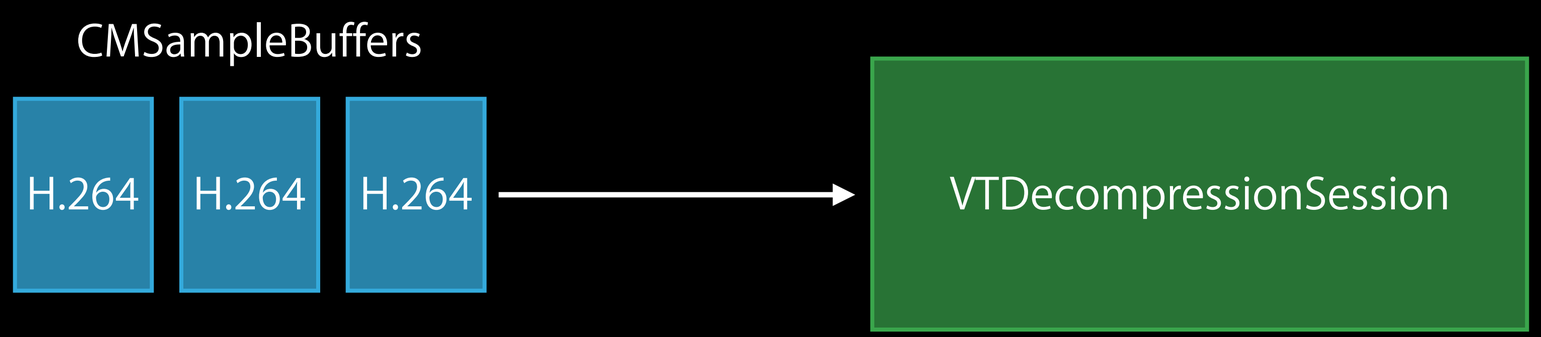



```
err = VTDecompressionSessionDecodeFrame( session, sbuf,
          inFlags, refCon, &outFlags );
```

Wants CMSampleBuffers

Decode order

# Feeding VTDecompressionSession



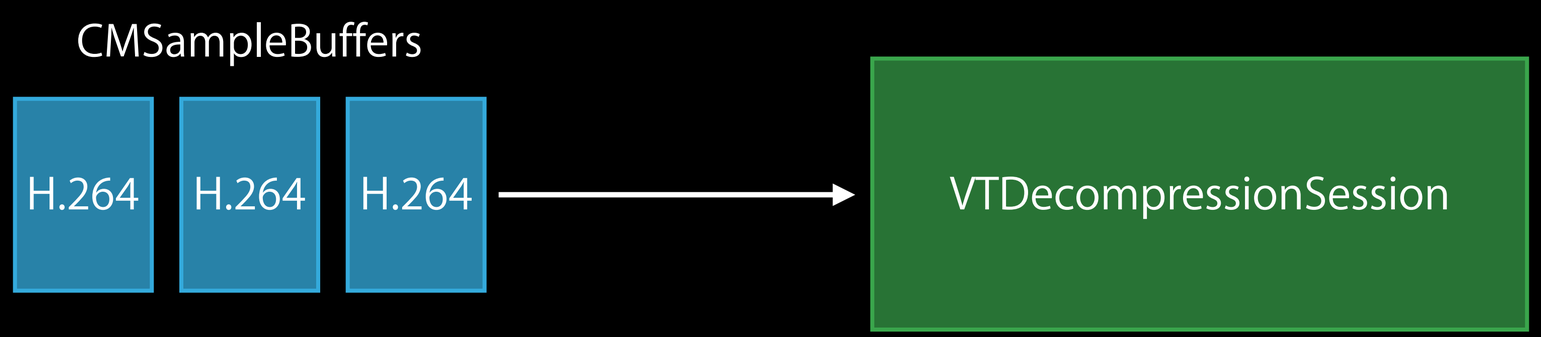

```
err = VTDecompressionSessionDecodeFrame( session, sbuf,
          inFlags, refCon, &outFlags );
```

Wants CMSampleBuffers

Decode order

Synchronous by default

# Feeding VTDecompressionSession




```
err = VTDecompressionSessionDecodeFrame( session, sbuf,
          inFlags, refCon, &outFlags );
```

Wants CMSampleBuffers

Decode order

Synchronous by default

Set kVTDecodeFrame_EnableAsynchronousDecompression for async

# Async Decompression

# Async Decompression

Decoder blocks when full—Decoder back pressure

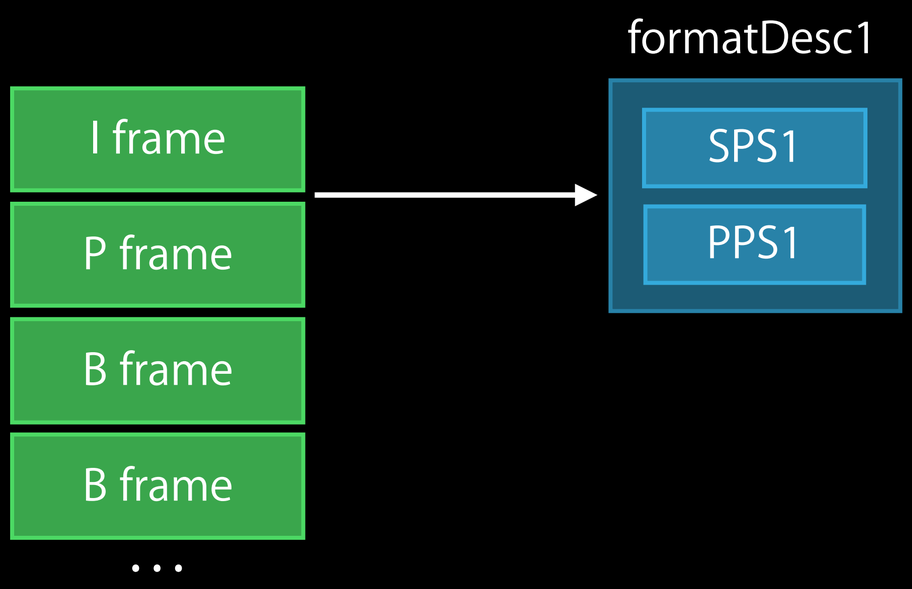
# Async Decompression

Decoder blocks when full—Decoder back pressure

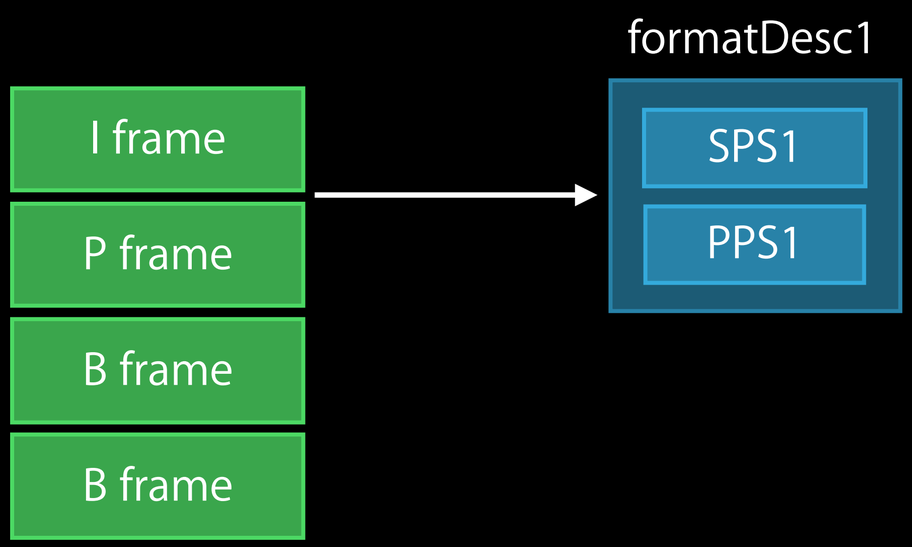
Finish async frames with VTDecompressionSessionWaitForAsynchronousFrames

# Changing CMVideoFormatDescription

# Changing CMVideoFormatDescription

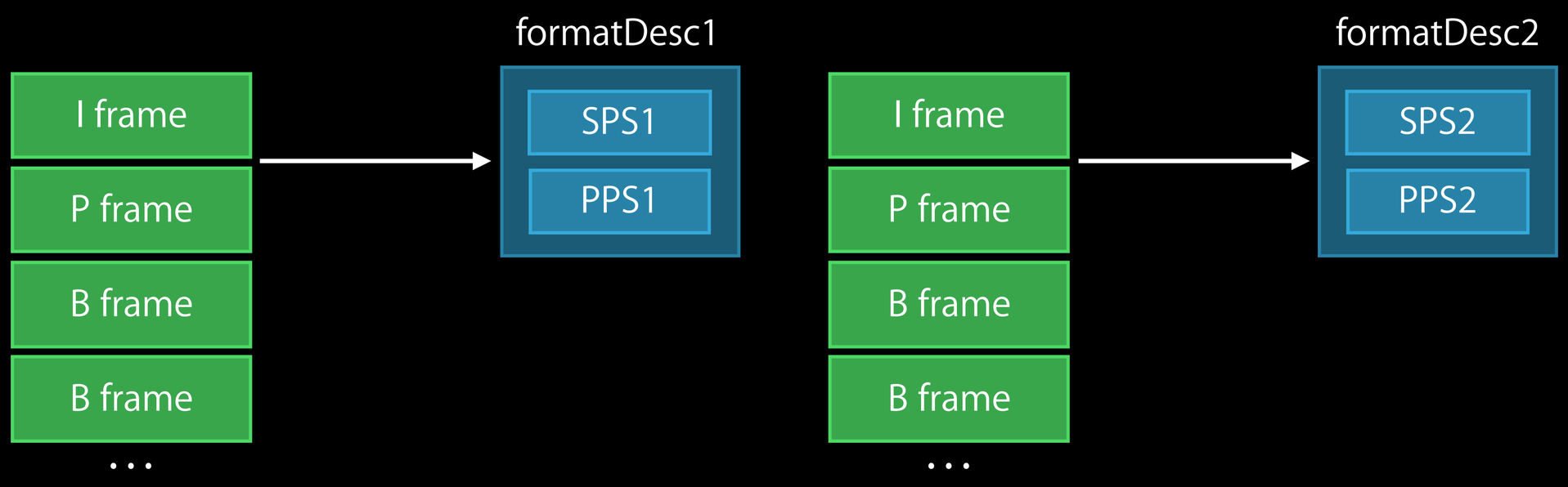


# Changing CMVideoFormatDescription



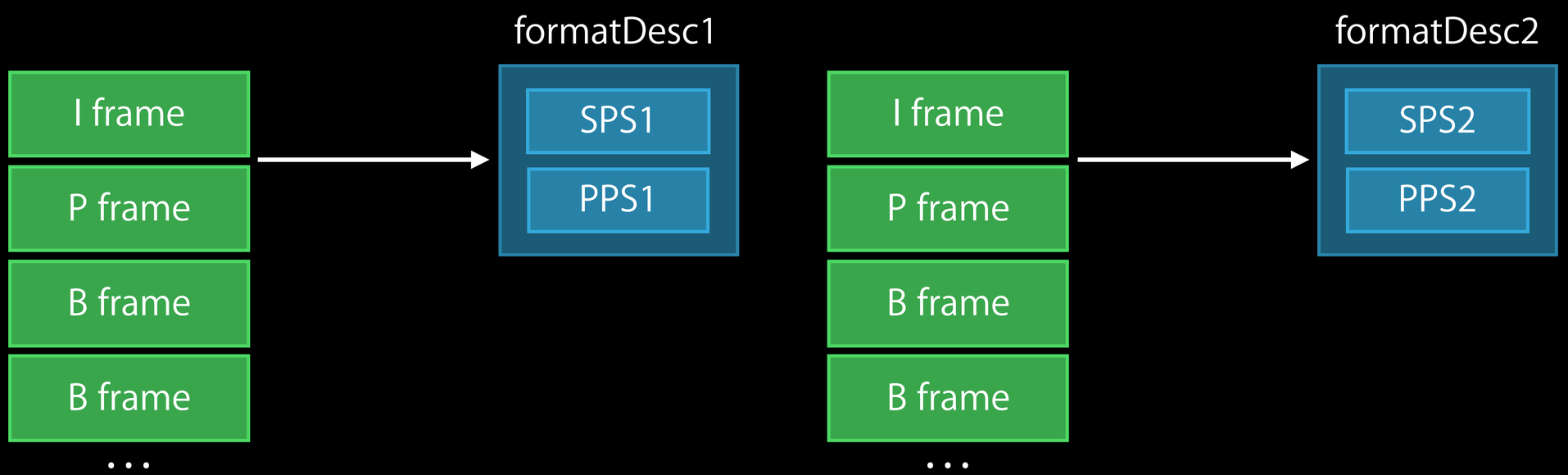

```
err = VTDecompressionSessionCreate( kCFAllocatorDefault, formatDesc1, … ,
                                    &session );
```

# Changing CMVideoFormatDescription




```
err = VTDecompressionSessionCreate( kCFAllocatorDefault, formatDesc1, … ,
                                    &session );
```

# Changing CMVideoFormatDescription




```
err = VTDecompressionSessionCreate( kCFAllocatorDefault, formatDesc1, … ,
                                    &session );

Boolean needNewSession = ( VTDecompressionSessionCanAcceptFormatDescription(
                                    session, formatDesc2 ) == false);
```

# VTDecompressionSession Summary

# VTDecompressionSession Summary

Creation of VTDecompressionSession

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Creation of VTDecompressionSession

Make optimal decisions about output requirements

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Make optimal decisions about output requirements

Run your VTDecompressionSession synchronously and asynchronously

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Creation of VTDecompressionSession

Make optimal decisions about output requirements

Run your VTDecompressionSession synchronously and asynchronously

Handling changes in CMVideoFormatDescription

# Case Three

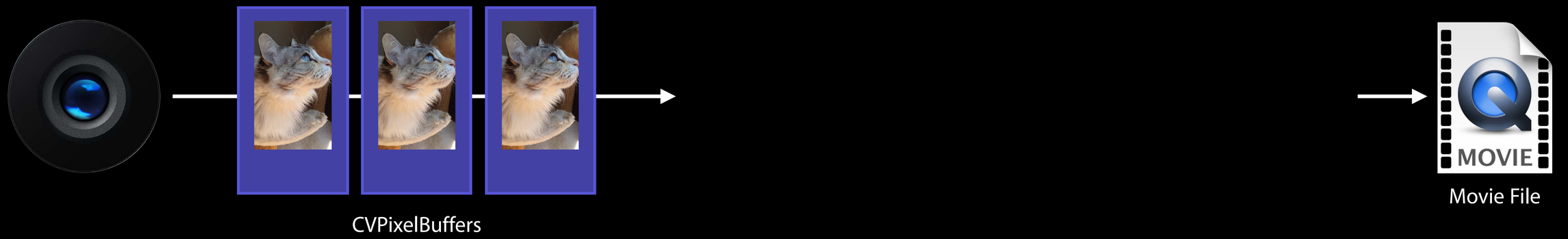
Compressing CVPixelBuffers into a file

# Compressing Video into a File

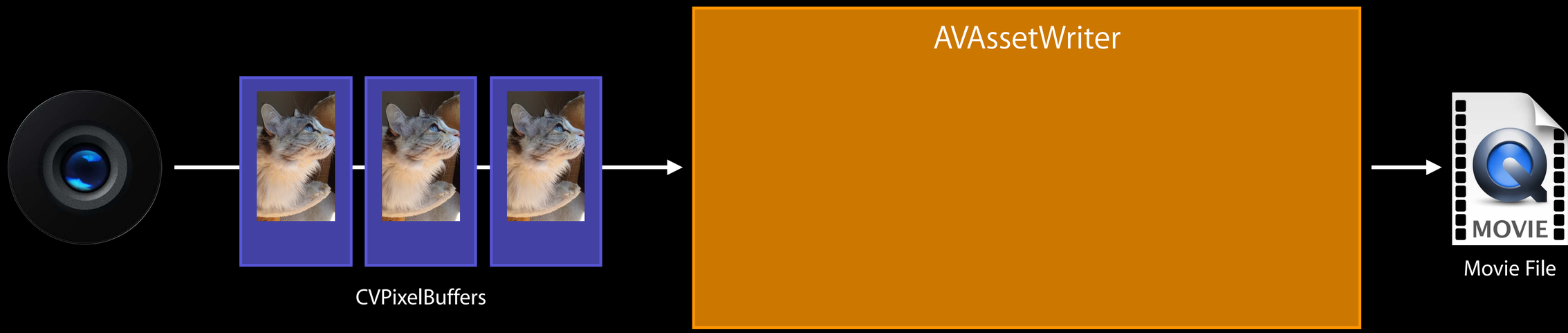
# Compressing Video into a File

CVPixelBuffers

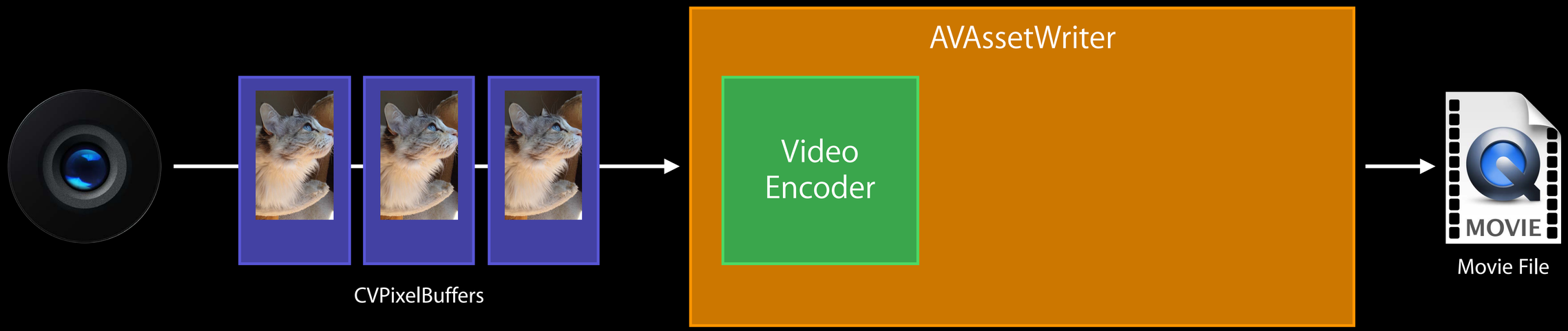
# Compressing Video into a File



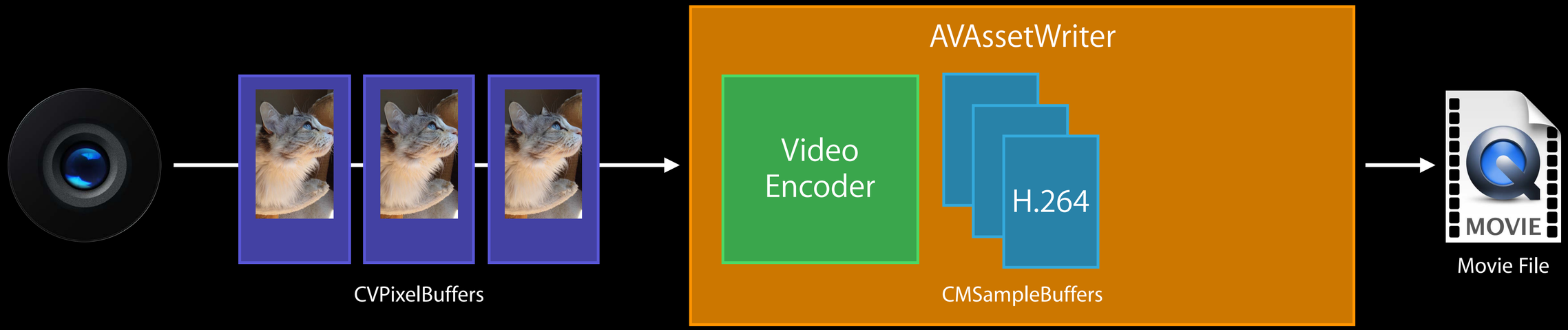
# Compressing Video into a File



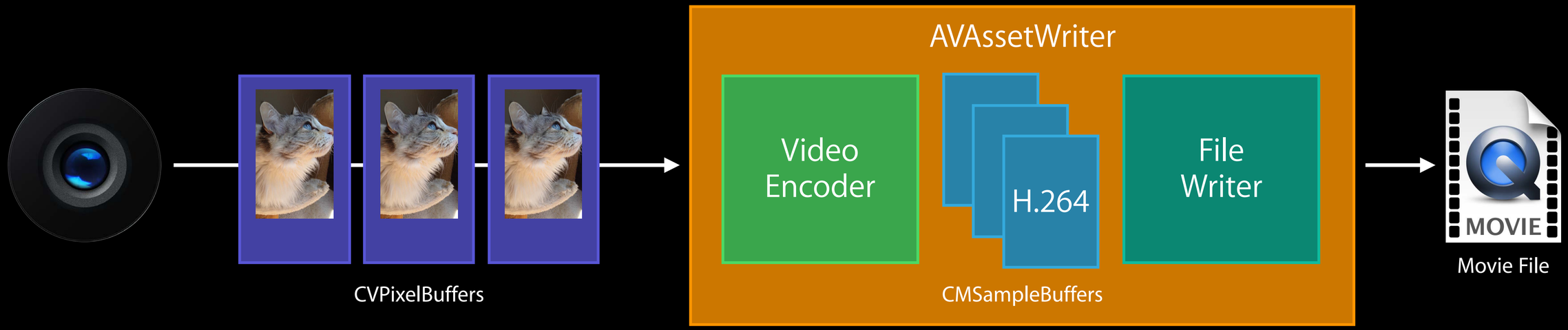
# Compressing Video into a File



# Compressing Video into a File



# Compressing Video into a File



# For More Details on AVAssetWriter

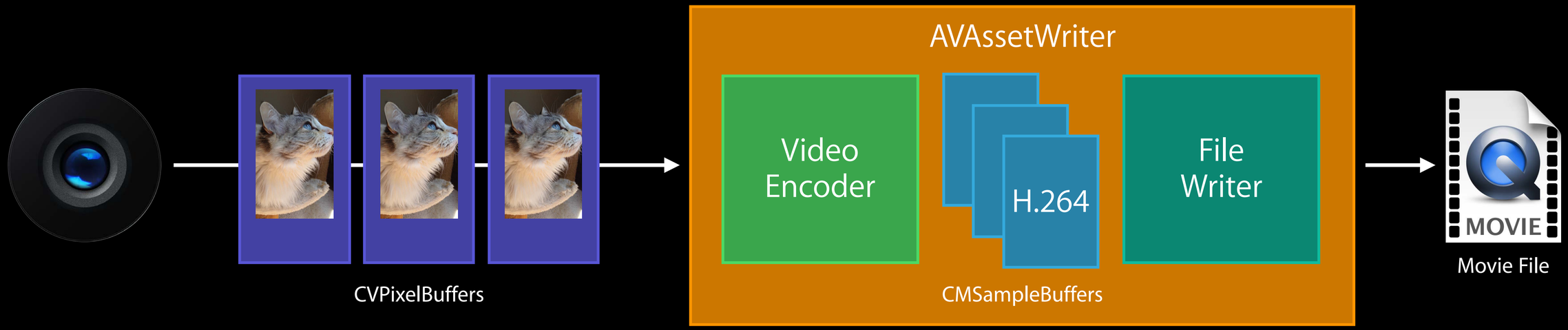
WWDC 2013—Moving to AVKit and AVFoundation

WWDC 2011—Working with Media in AVFoundation

# Case Four

Compressing CVPixelBuffers for the network

# Back Inside AVAssetWriter



# VTCompressionSession

## Getting access to the encoder

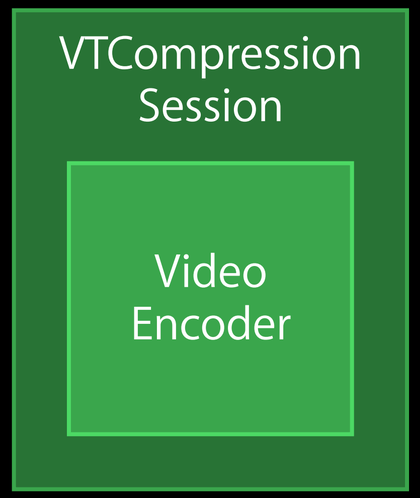
# VTCompressionSession

## Getting access to the encoder

Video
Encoder

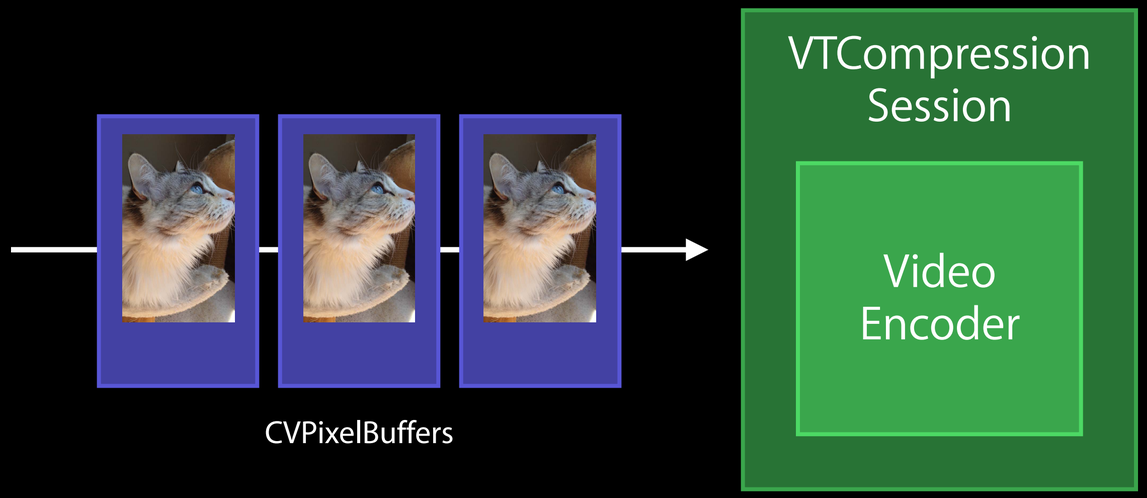
# VTCompressionSession

## Getting access to the encoder



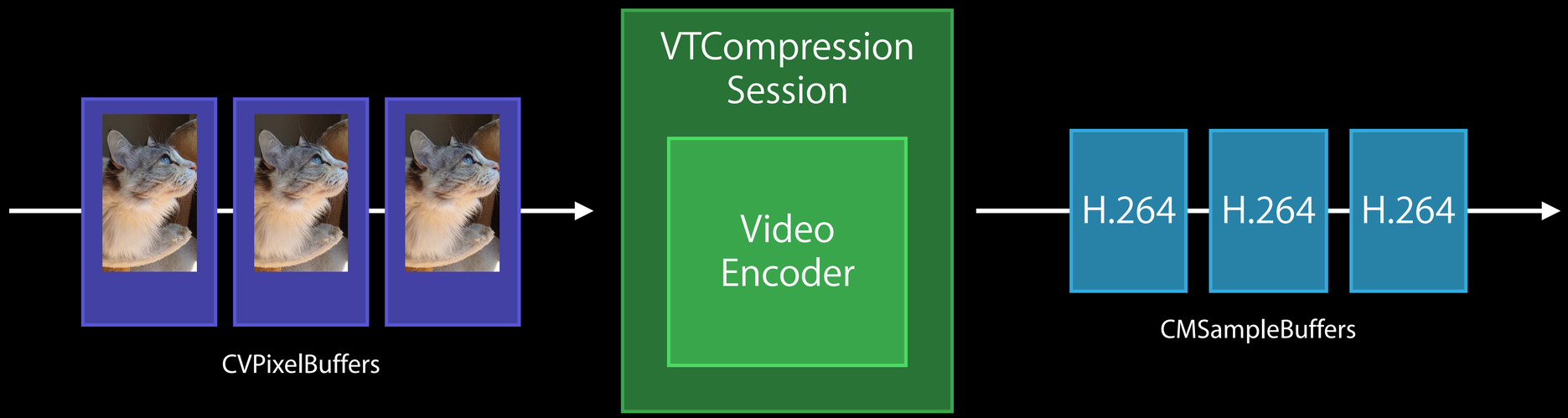
# VTCompressionSession

## Getting access to the encoder



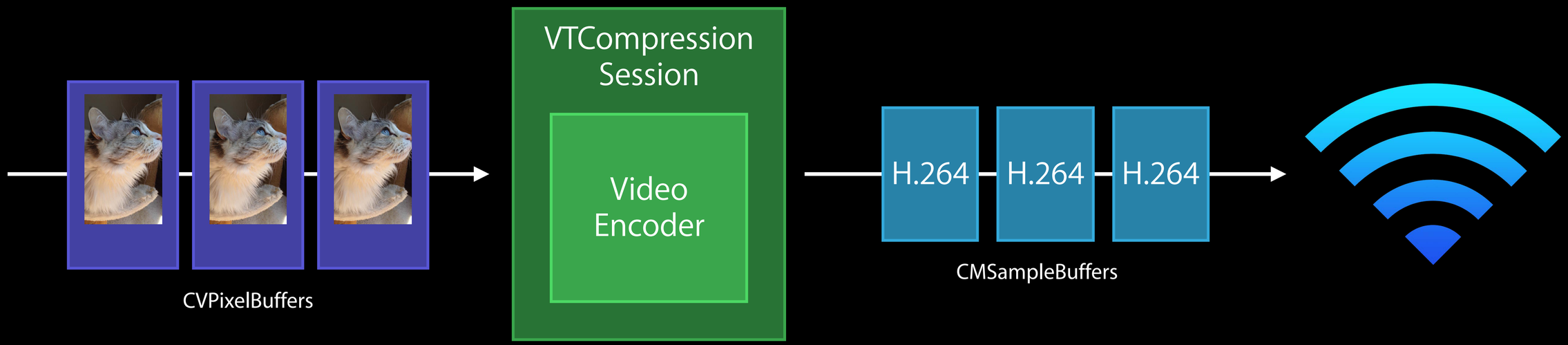
# VTCompressionSession

## Getting access to the encoder



# VTCompressionSession

## Getting access to the encoder



# Creating a VTCompressionSession

What you need:

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What you need:

- Dimensions for compressed output

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- Format for compression (e.g., kCMVideoCodecType_H264)

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- PixelBufferAttributes describing source buffer requirements (optional)

# Creating a VTCompressionSession

What you need:

- Dimensions for compressed output
- Format for compression (e.g., kCMVideoCodecType_H264)
- PixelBufferAttributes describing source buffer requirements (optional)
- A VTCompressionOutputCallback

# Configuring VTCompressionSession

# Configuring VTCompressionSession

Configure compression using VTSessionSetProperty() calls

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Configure compression using VTSessionSetProperty() calls

`kVTCompressionPropertyKey_AllowFrameReordering`

# Configuring VTCompressionSession

Configure compression using VTSessionSetProperty() calls

```
kVTCompressionPropertyKey_AllowFrameReordering
kVTCompressionPropertyKey_AverageBitRate
```

# Configuring VTCompressionSession

Configure compression using VTSessionSetProperty() calls

```
kVTCompressionPropertyKey_AllowFrameReordering
kVTCompressionPropertyKey_AverageBitRate
kVTCompressionPropertyKey_H264EntropyMode
```

# Configuring VTCompressionSession

Configure compression using VTSessionSetProperty() calls

```
kVTCompressionPropertyKey_AllowFrameReordering
kVTCompressionPropertyKey_AverageBitRate
kVTCompressionPropertyKey_H264EntropyMode
kVTH264EntropyMode_CAVLC/kVTH264EntropyMode_CABAC
```

# Configuring VTCompressionSession

Configure compression using VTSessionSetProperty() calls

```
kVTCompressionPropertyKey_AllowFrameReordering
kVTCompressionPropertyKey_AverageBitRate
kVTCompressionPropertyKey_H264EntropyMode
    kVTH264EntropyMode_CAVLC/kVTH264EntropyMode_CABAC
kVTCompressionPropertyKey_RealTime
```

# Configuring VTCompressionSession

Configure compression using VTSessionSetProperty() calls

```
kVTCompressionPropertyKey_AllowFrameReordering
kVTCompressionPropertyKey_AverageBitRate
kVTCompressionPropertyKey_H264EntropyMode
    kVTH264EntropyMode_CAVLC/kVTH264EntropyMode_CABAC
kVTCompressionPropertyKey_RealTime
kVTCompressionPropertyKey_ProfileLevel
```

# Configuring VTCompressionSession

Configure compression using VTSessionSetProperty() calls

```
kVTCompressionPropertyKey_AllowFrameReordering
kVTCompressionPropertyKey_AverageBitRate
kVTCompressionPropertyKey_H264EntropyMode
    kVTH264EntropyMode_CAVLC/kVTH264EntropyMode_CABAC
kVTCompressionPropertyKey_RealTime
kVTCompressionPropertyKey_ProfileLevel
    for example: kVTProfileLevel_H264_Main_AutoLevel
```

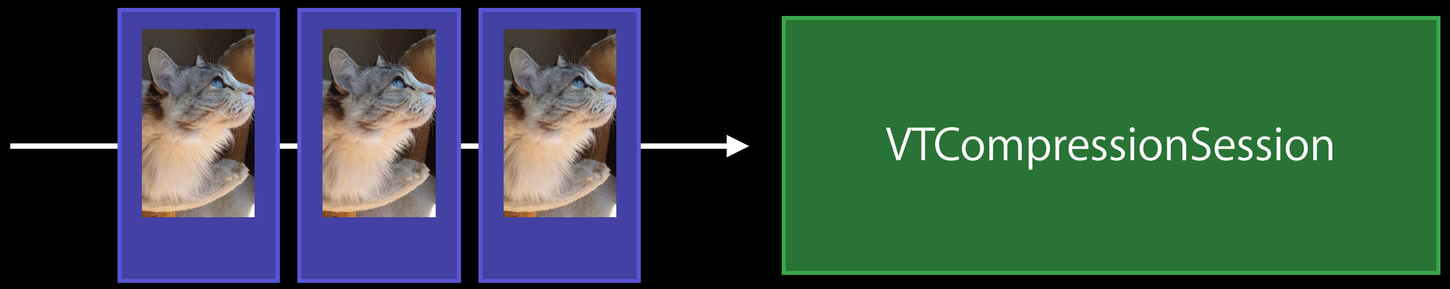
# Configuring VTCompressionSession

Configure compression using VTSessionSetProperty() calls

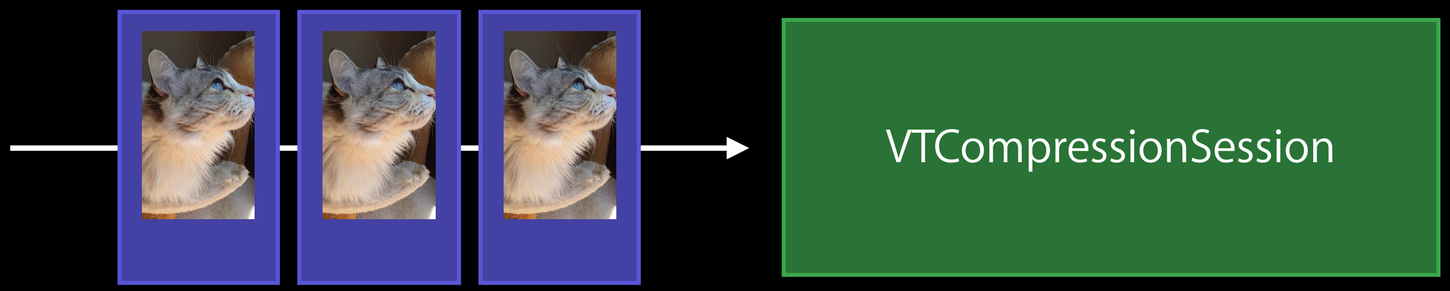
```
kVTCompressionPropertyKey_AllowFrameReordering
kVTCompressionPropertyKey_AverageBitRate
kVTCompressionPropertyKey_H264EntropyMode
    kVTH264EntropyMode_CAVLC/kVTH264EntropyMode_CABAC
kVTCompressionPropertyKey_RealTime
kVTCompressionPropertyKey_ProfileLevel
    for example: kVTProfileLevel_H264_Main_AutoLevel
```

...and many more

# Feeding VTCompressionSession

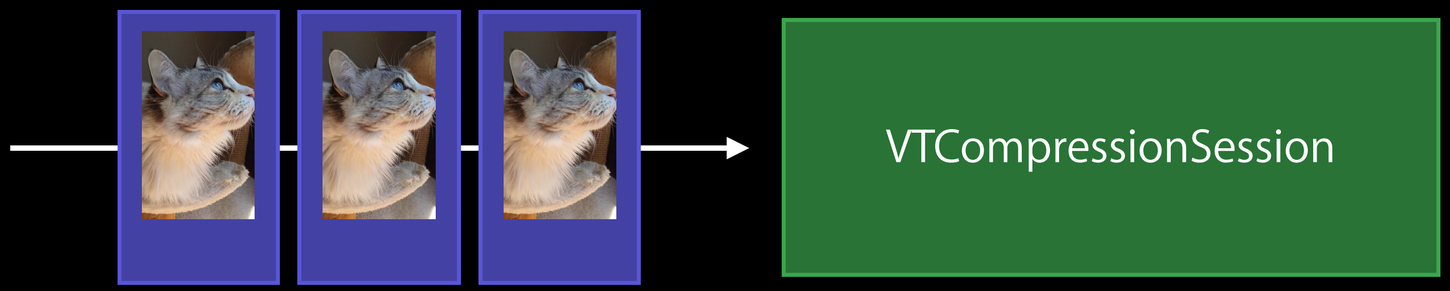


# Feeding VTCompressionSession




```
err = VTCompressionSessionEncodeFrame( session, pixelBuffer,
          presentationTime, … );
```

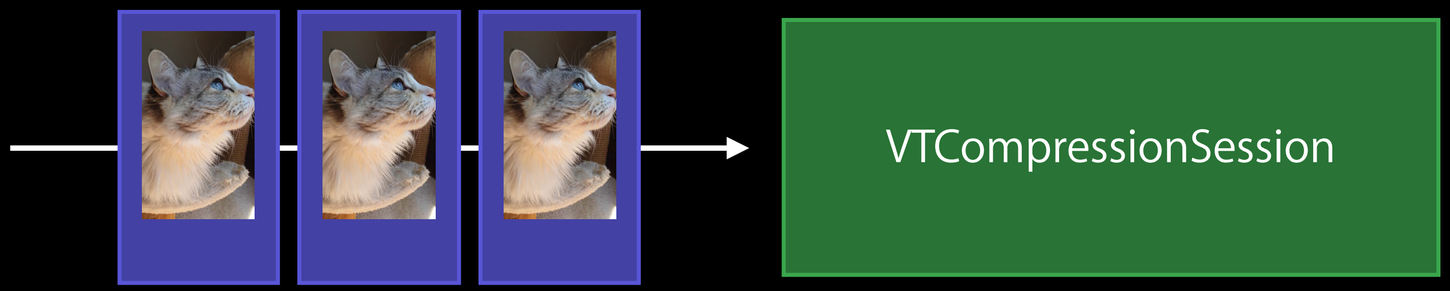
# Feeding VTCompressionSession




```
err = VTCompressionSessionEncodeFrame( session, pixelBuffer,
          presentationTime, … );
```

- Source frames as CVPixelBuffers with presentation time

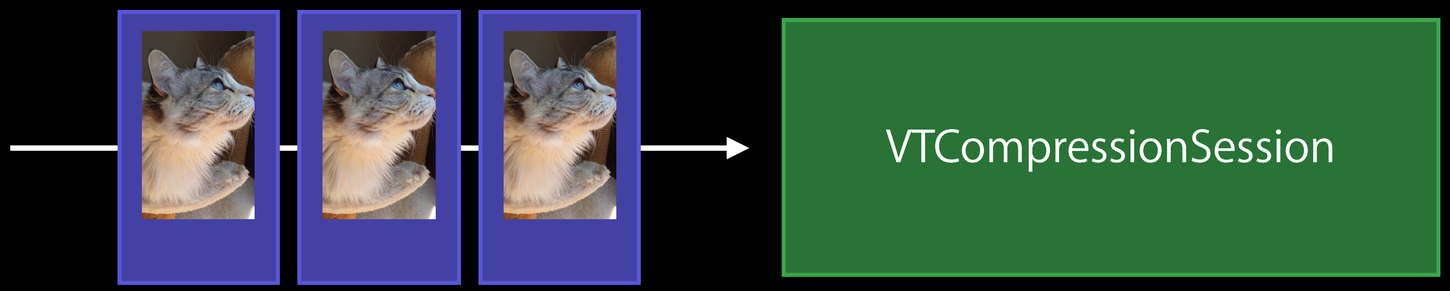
# Feeding VTCompressionSession




```
err = VTCompressionSessionEncodeFrame( session, pixelBuffer,
          presentationTime, … );
```

- Source frames as CVPixelBuffers with presentation time
- Presentation order

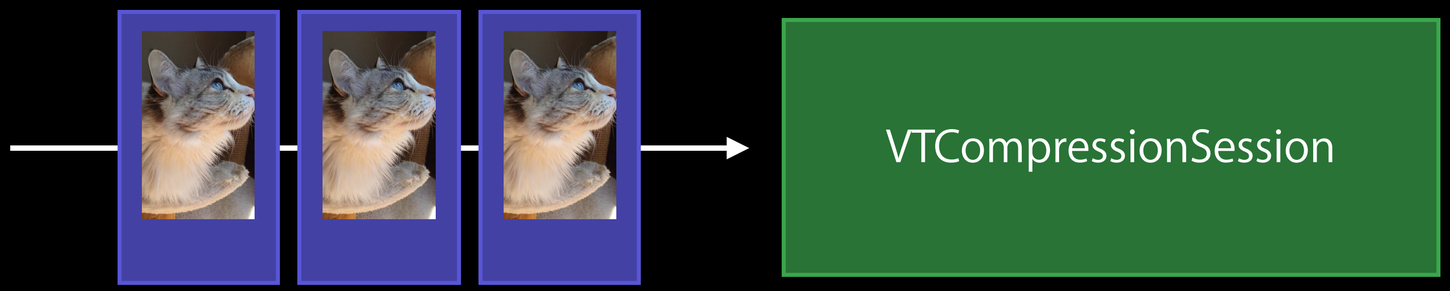
# Feeding VTCompressionSession




```
err = VTCompressionSessionEncodeFrame( session, pixelBuffer,
          presentationTime, … );
```

- Source frames as CVPixelBuffers with presentation time
- Presentation order
- Output may be delayed

# Feeding VTCompressionSession



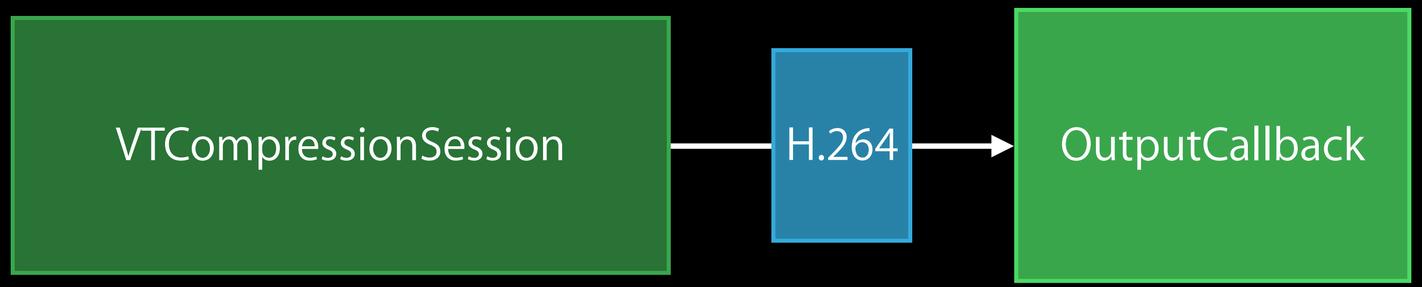

```
err = VTCompressionSessionEncodeFrame( session, pixelBuffer,
          presentationTime, … );
```

- Source frames as CVPixelBuffers with presentation time
- Presentation order
- Output may be delayed
- Use `VTCompressionSessionCompleteFrames()` to finish pending frames

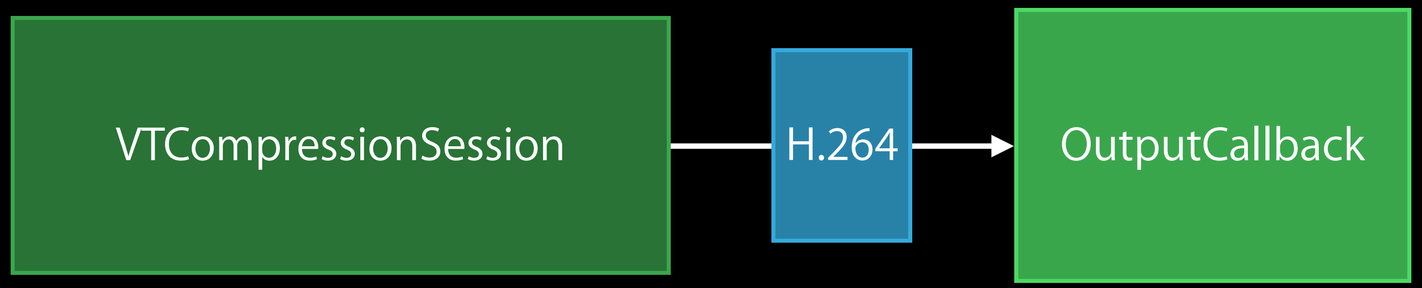
# VTCompressionOutputCallback

VTCompressionSession

# VTCompressionOutputCallback

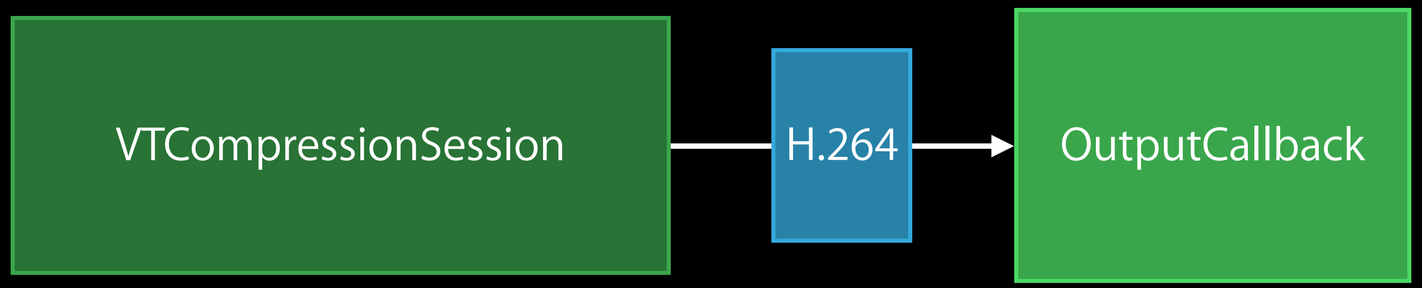


# VTCompressionOutputCallback




VTCompressionOutputCallback:

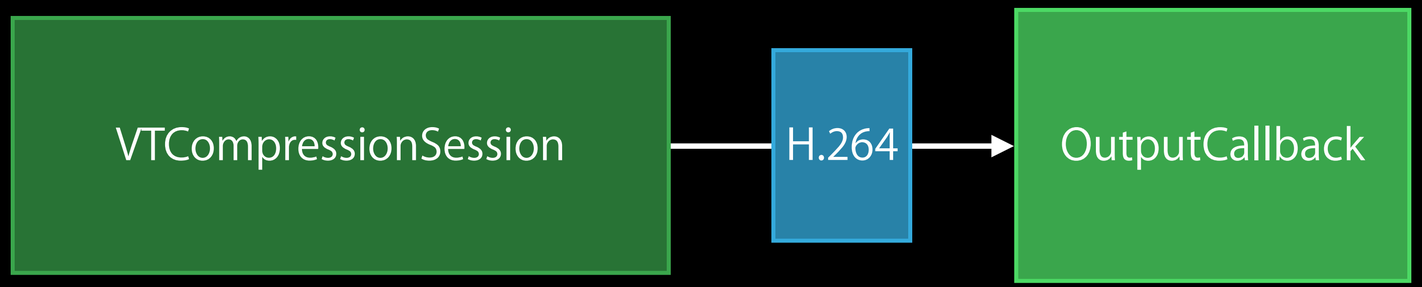
# VTCompressionOutputCallback




VTCompressionOutputCallback:

- Output CMSampleBuffer

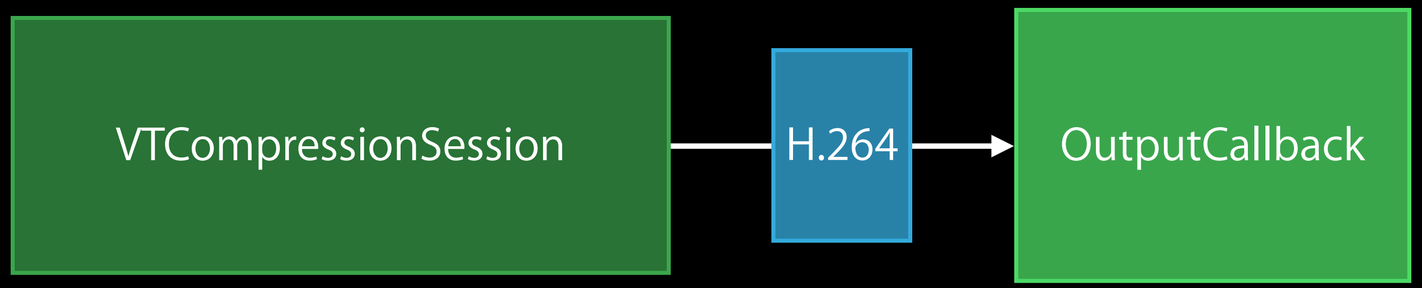
# VTCompressionOutputCallback




VTCompressionOutputCallback:

- Output CMSampleBuffer
- Compression error codes

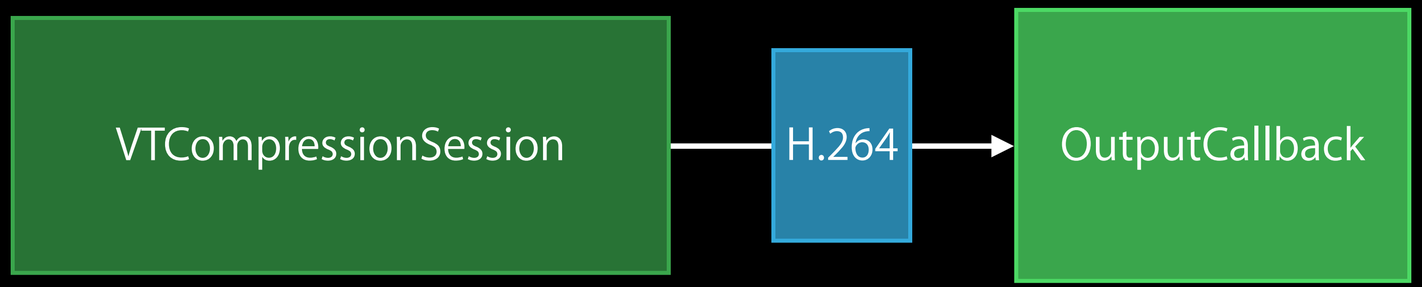
# VTCompressionOutputCallback




VTCompressionOutputCallback:

- Output CMSampleBuffer
- Compression error codes
- Dropped frames

# VTCompressionOutputCallback

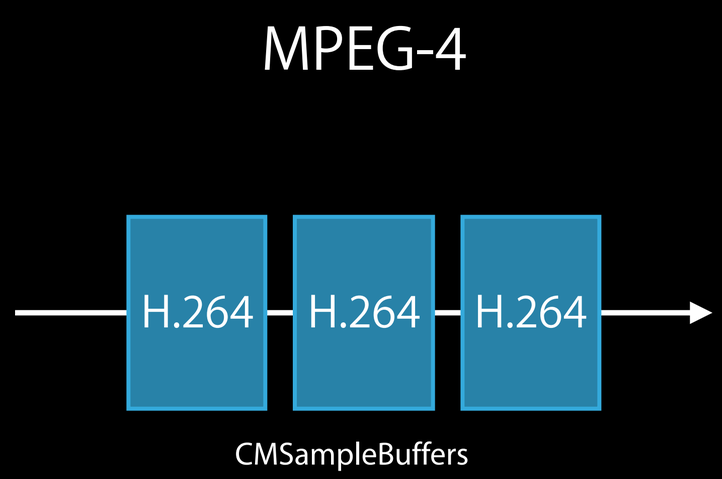



VTCompressionOutputCallback:

- Output CMSampleBuffer
- Compression error codes
- Dropped frames
- Frames emitted in decode order

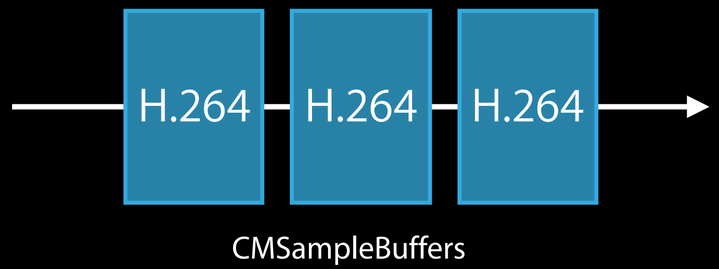
# CMSampleBuffers and Elementary Streams

# CMSampleBuffers and Elementary Streams



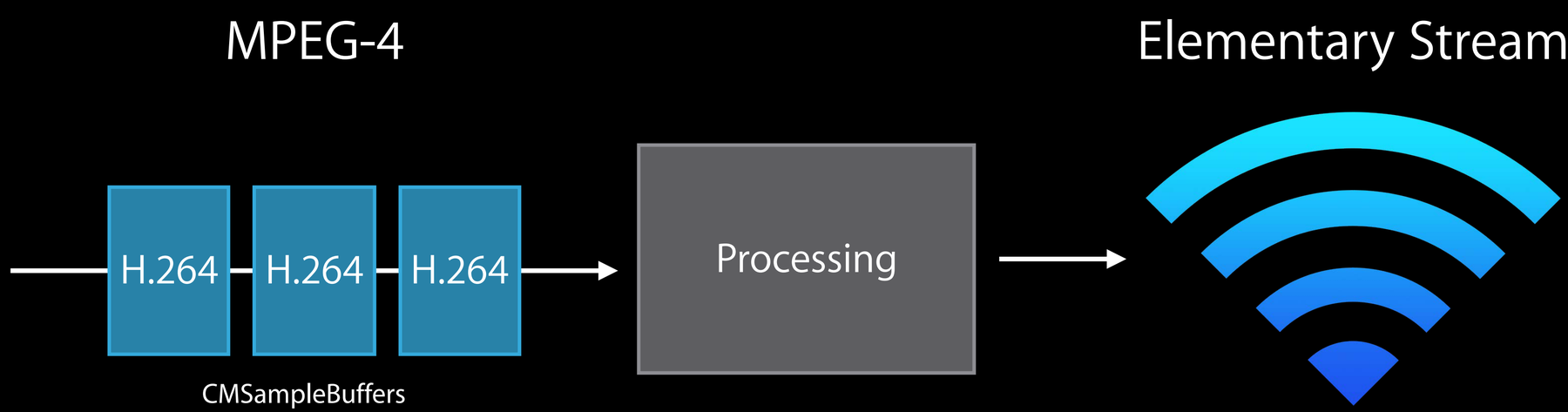
# CMSampleBuffers and Elementary Streams

MPEG-4




Elementary Stream

# CMSampleBuffers and Elementary Streams



# H.264 Syntax

## Conversion of parameter sets

MPEG-4

Elementary Stream

# H.264 Syntax

## Conversion of parameter sets

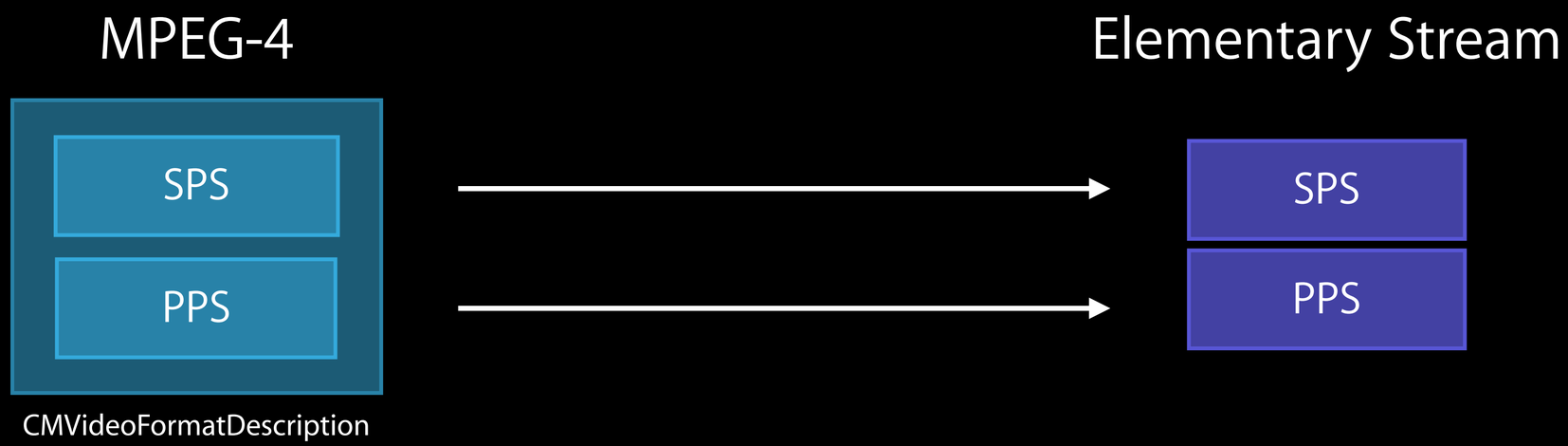
MPEG-4


CMVideoFormatDescription

Elementary Stream

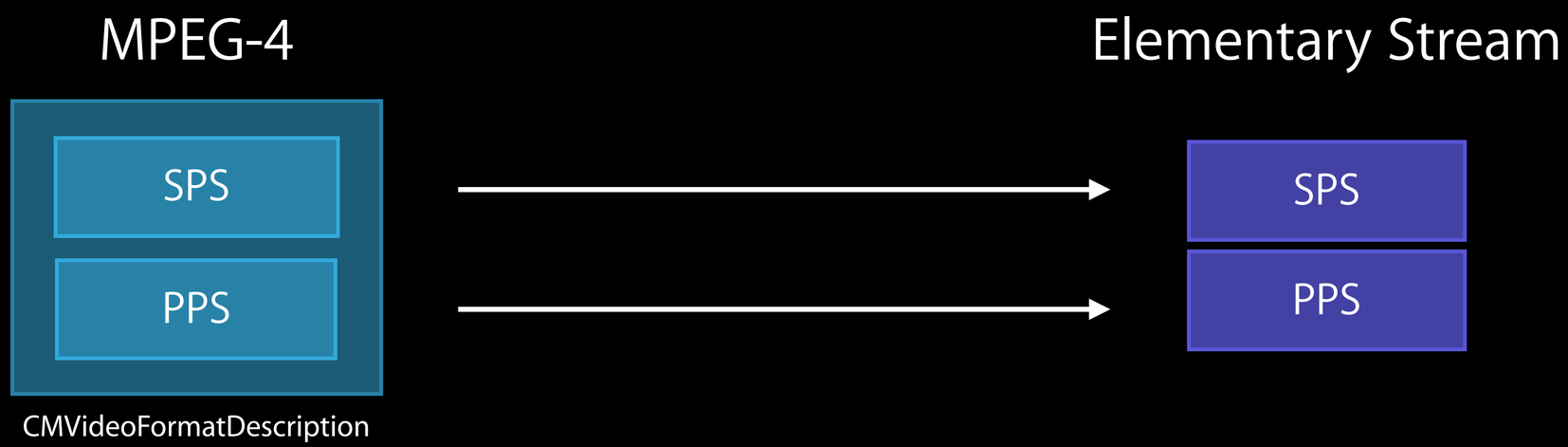
# H.264 Syntax

## Conversion of parameter sets



# H.264 Syntax

## Conversion of parameter sets




```
CMVideoFormatDescriptionGetH264ParameterSetAtIndex
```

# H.264 Syntax

## NAL Unit headers

MPEG-4

Elementary Stream

# H.264 Syntax

## NAL Unit headers

MPEG-4

Elementary Stream

00 00 80 00

I Frame
(32768 bytes)

4-Byte Header:
Length

# H.264 Syntax

## NAL Unit headers

MPEG-4

00 00 80 00

I Frame
(32768 bytes)

4-Byte Header:
Length

Elementary Stream

00 00 01

I Frame

3- or 4-Byte Header:
Start Code

# VTCompressionSession Summary

# VTCompressionSession Summary

Creation of VTCompressionSession

# VTCompressionSession Summary

Creation of VTCompressionSession

Configuring the compressor

# VTCompressionSession Summary

Creation of VTCompressionSession

Configuring the compressor

Providing CVPixelBuffers to VTCompressionSession

# VTCompressionSession Summary

Creation of VTCompressionSession

Configuring the compressor

Providing CVPixelBuffers to VTCompressionSession

Converting CMSampleBuffers into H.264 elementary stream packaging

# Multi-Pass Encoding

Erik Turnquist
Core Media Engineer

# Quality vs. Bit Rate

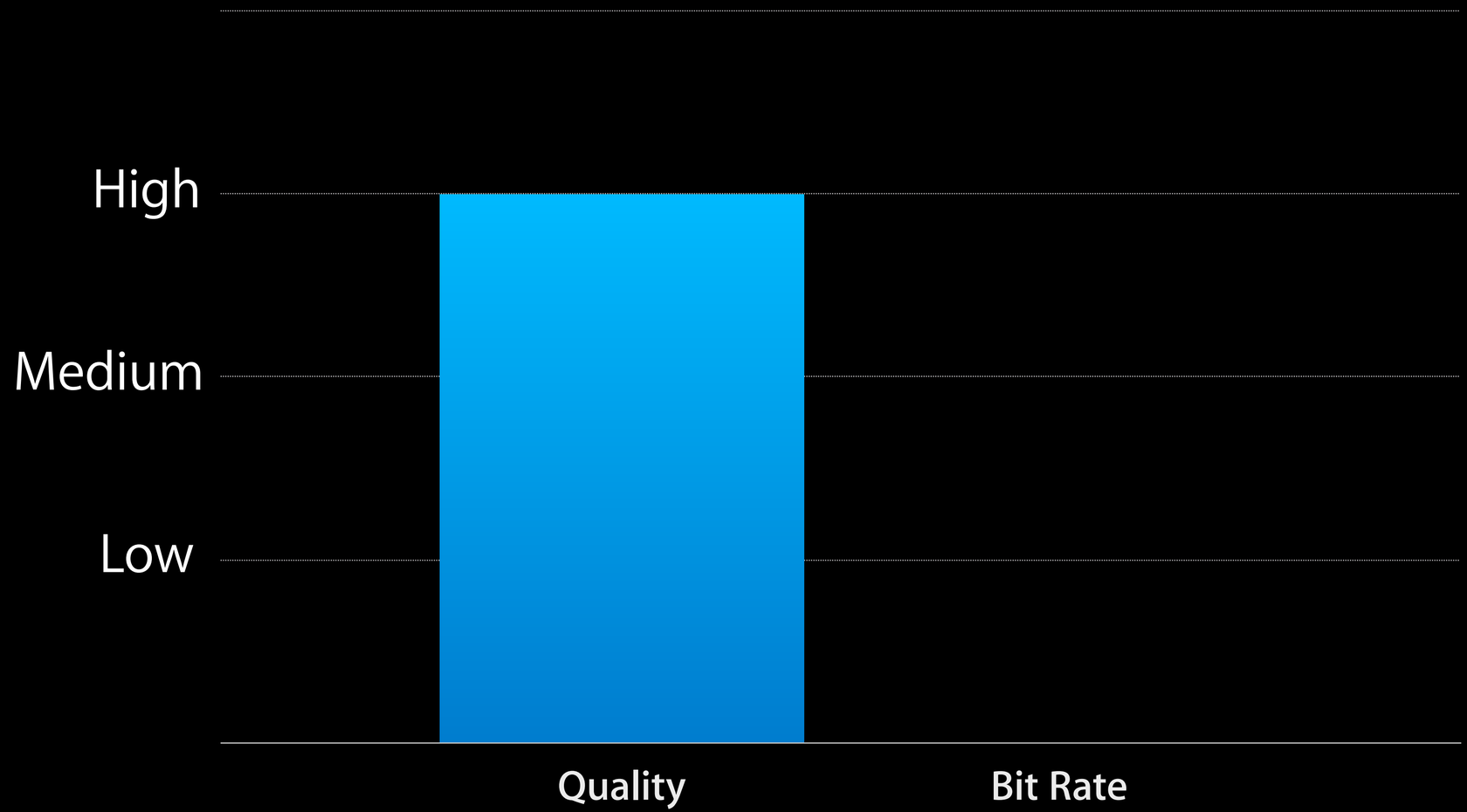
High

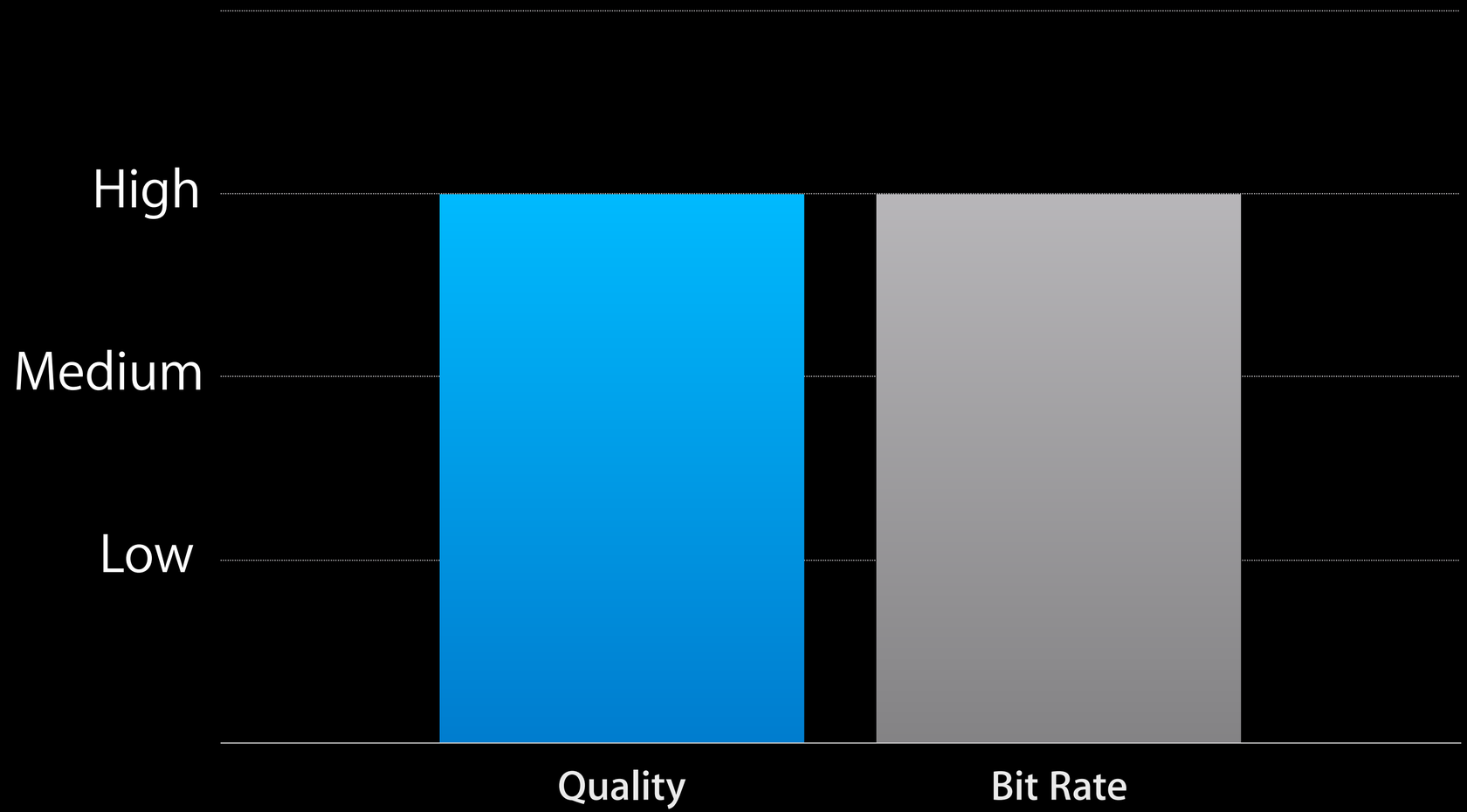
Medium

Low

Quality

Bit Rate


High
Medium
Low
Quality
Bit Rate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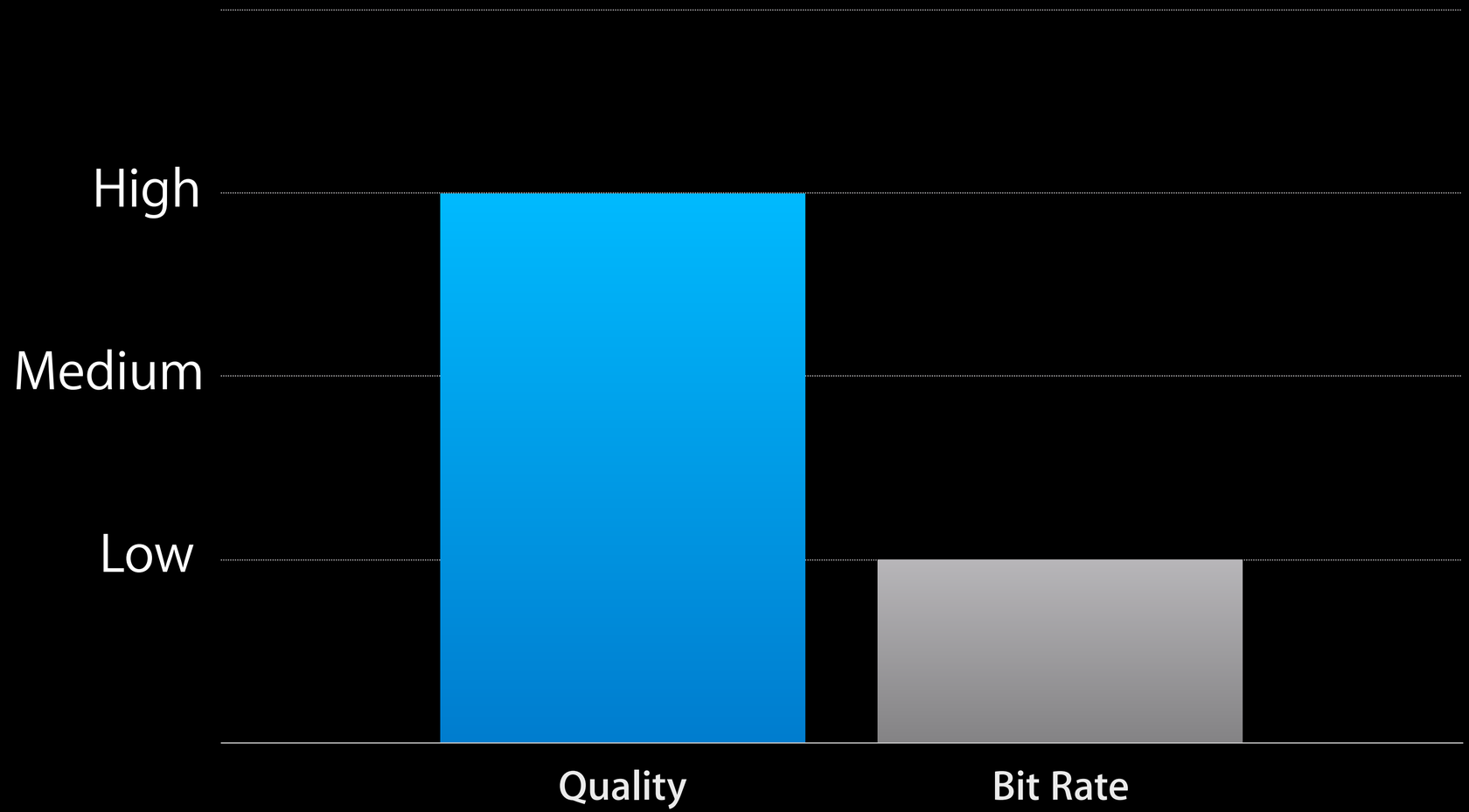
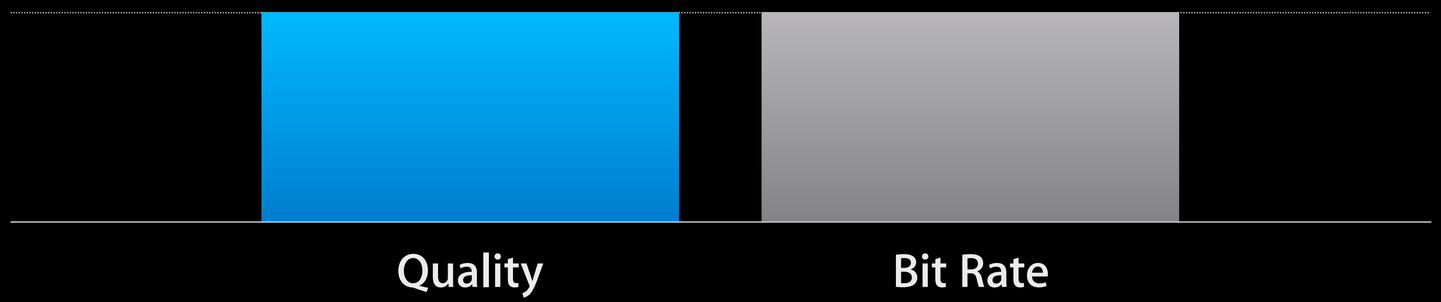
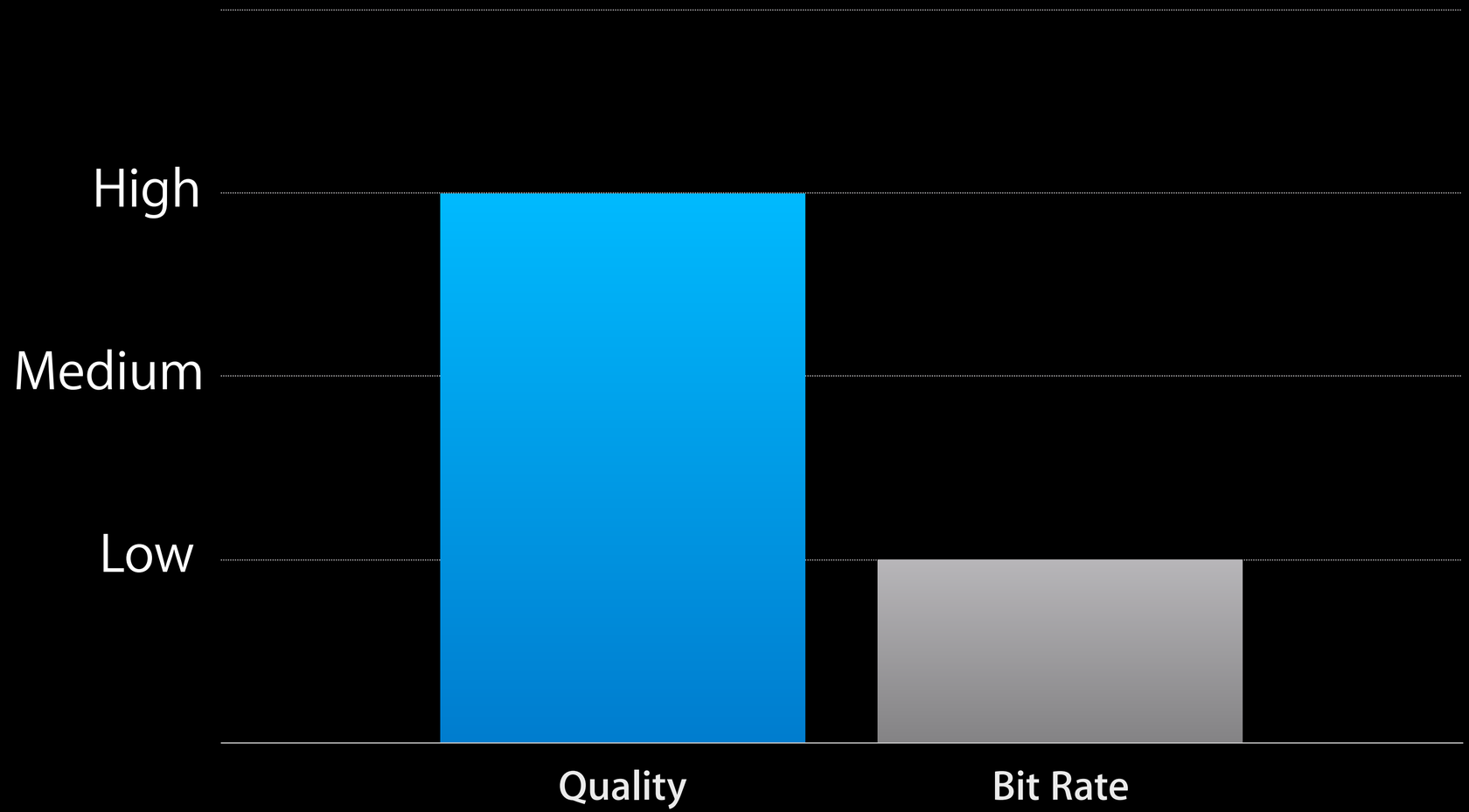

High
Medium
Low
Quality
Bit Rate

High

Medium

Low

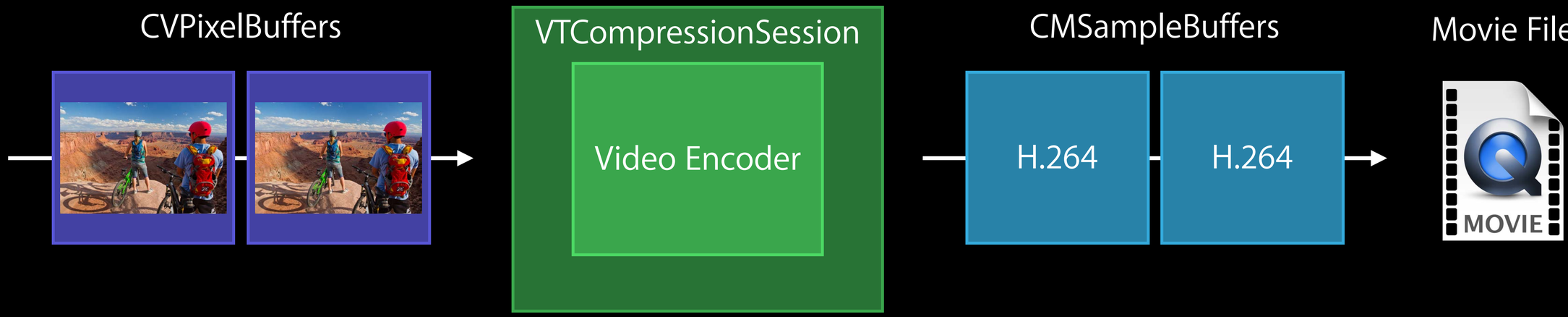



High
Medium
Low
Quality
Bit Rate

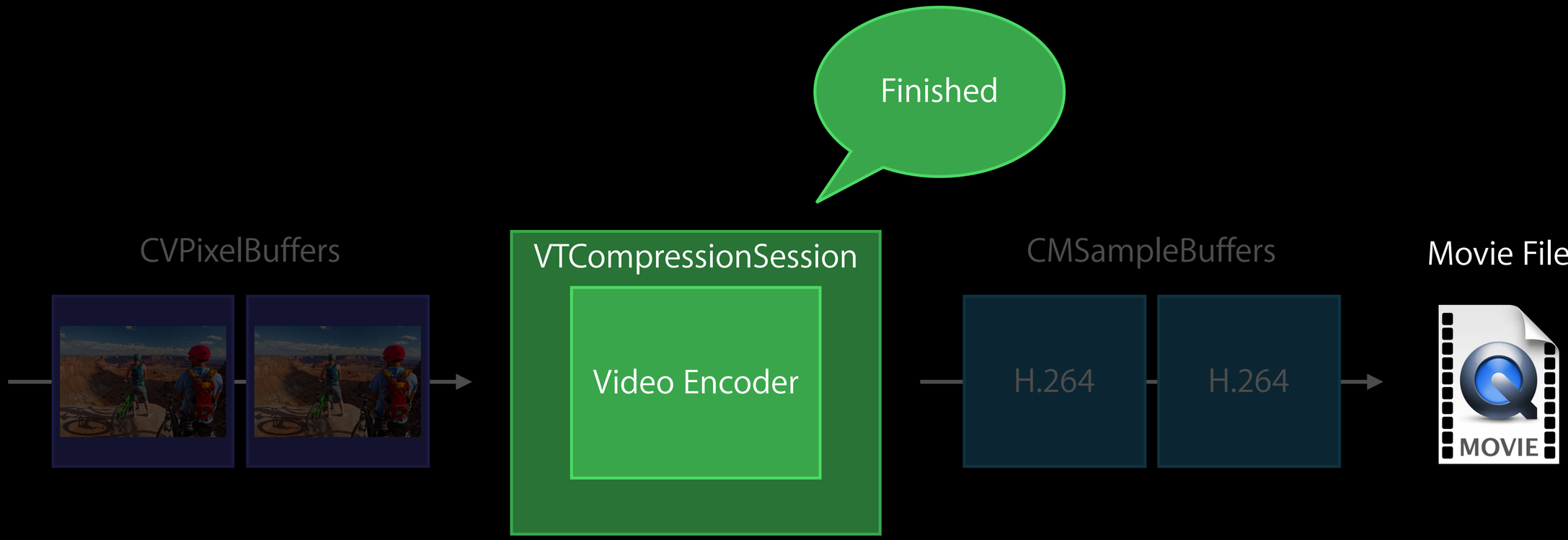
# What Is Multi-Pass Encoding?

# Single-Pass Encoding

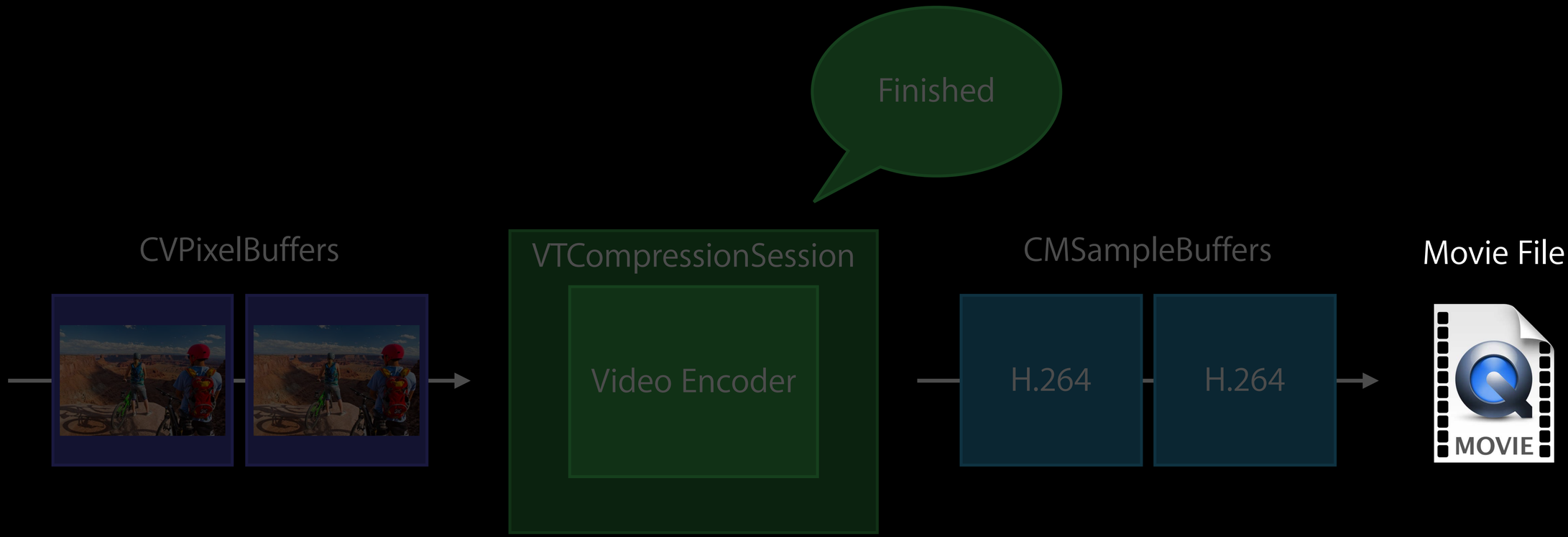
# Single-Pass Encoding



# Single-Pass Encoding

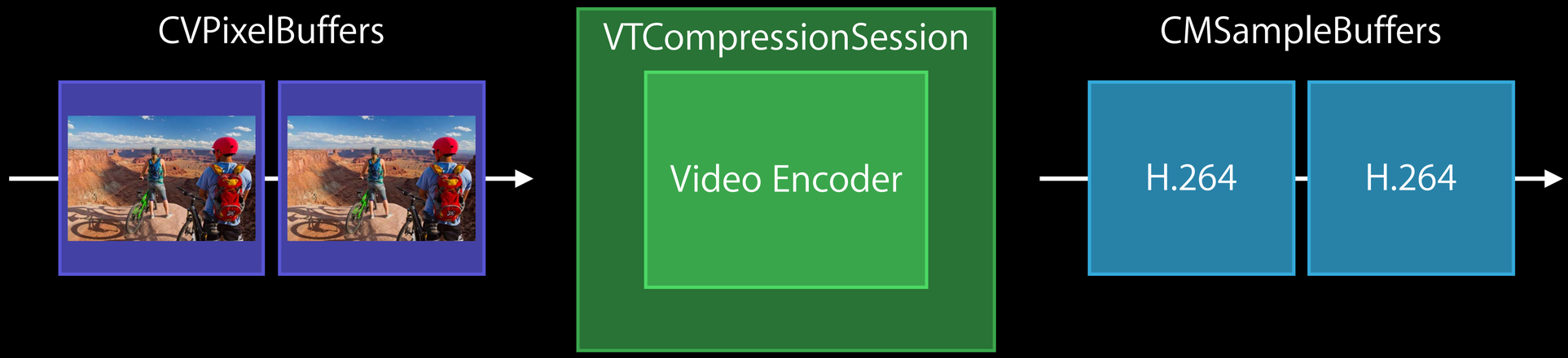


# Single-Pass Encoding

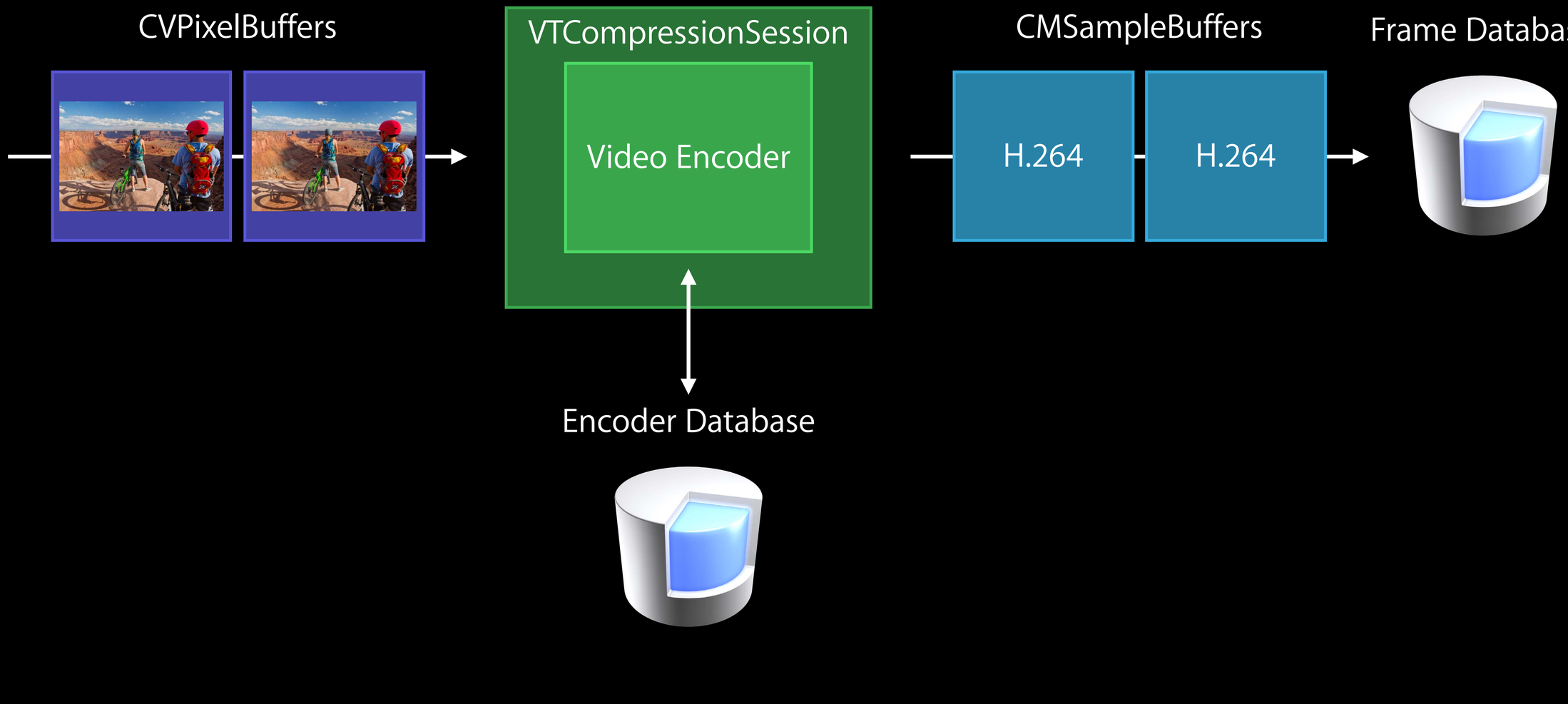


# Multi-Pass Encoding

# Multi-Pass Encoding



# Multi-Pass Encoding



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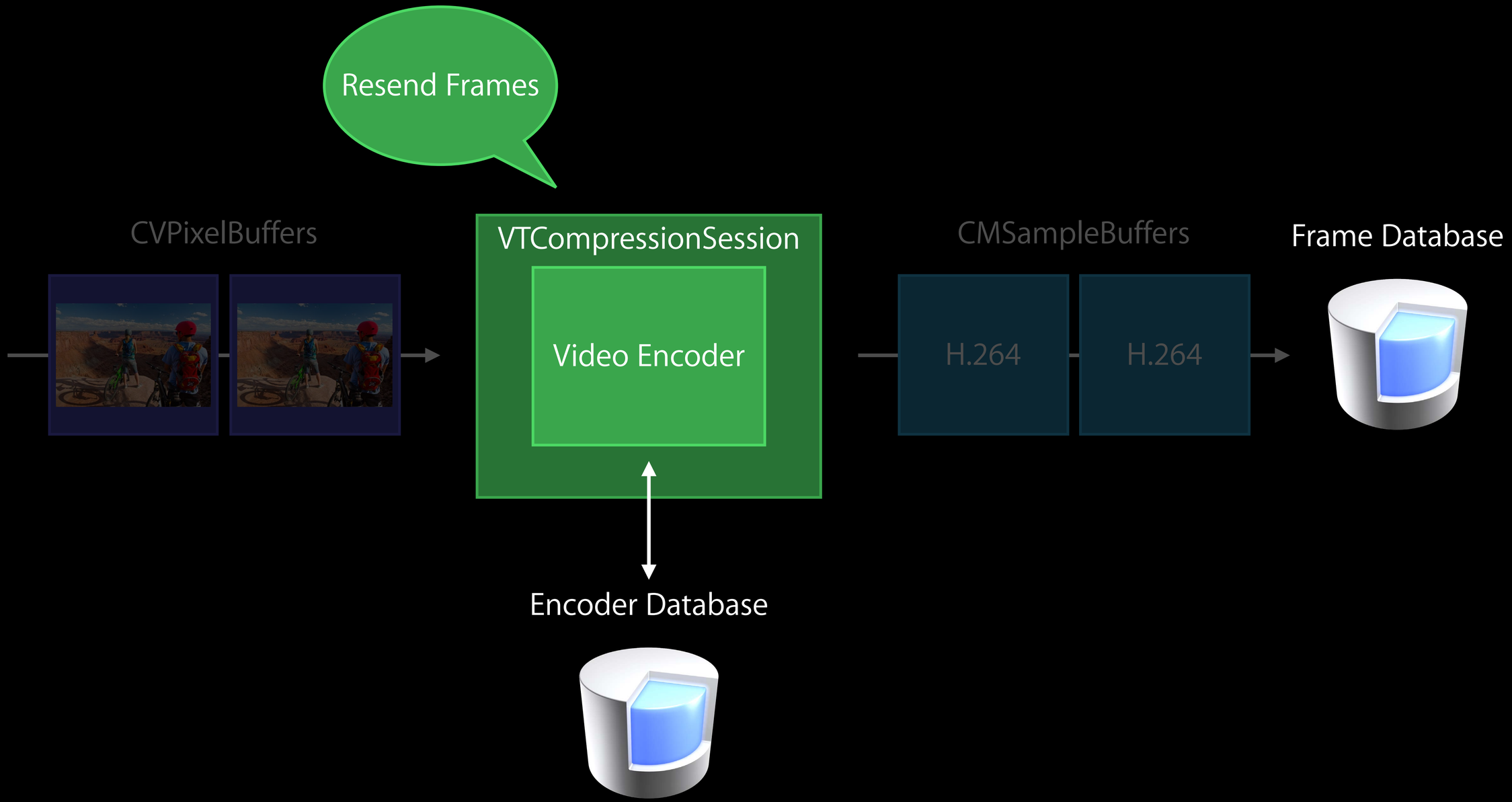
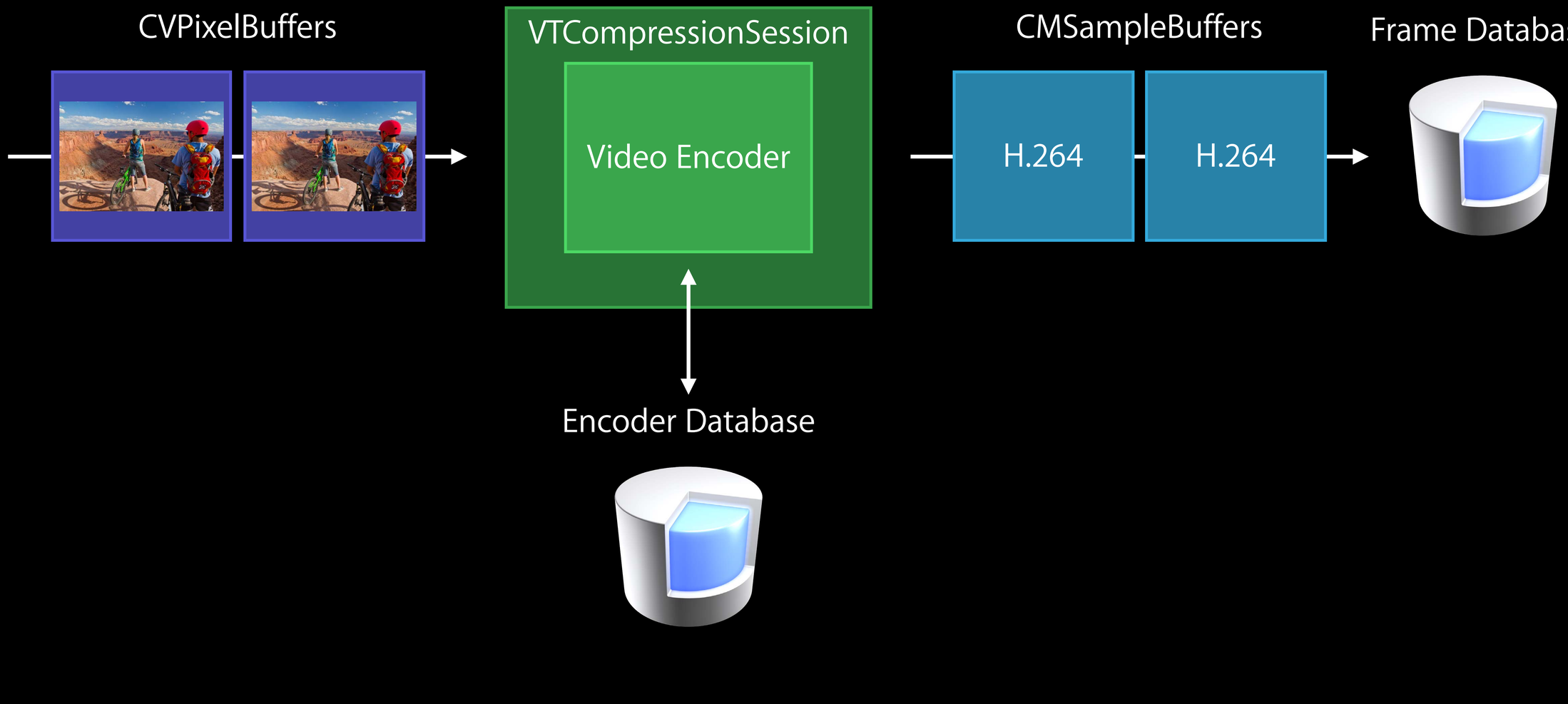


# Multi-Pass Encoding



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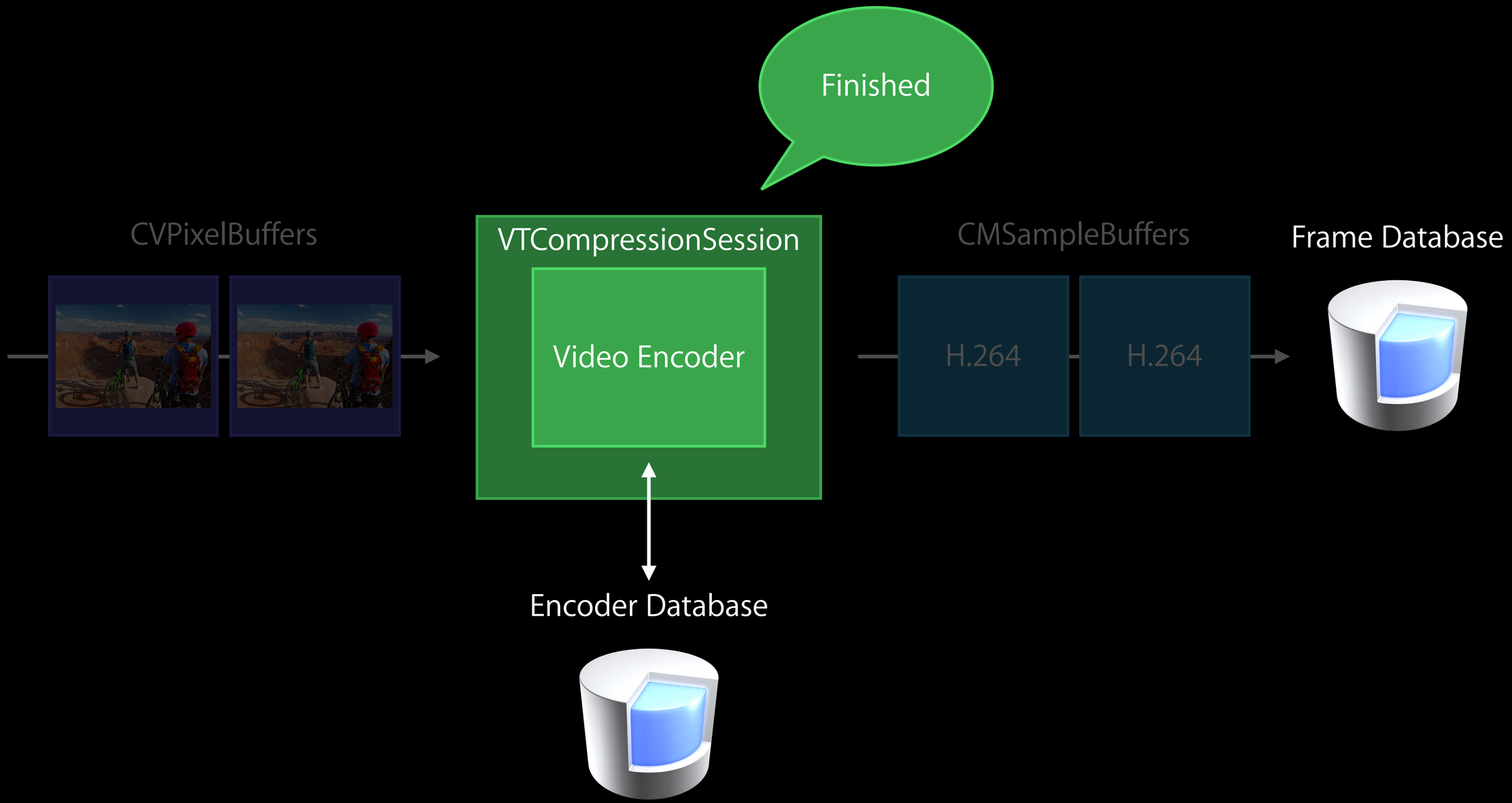

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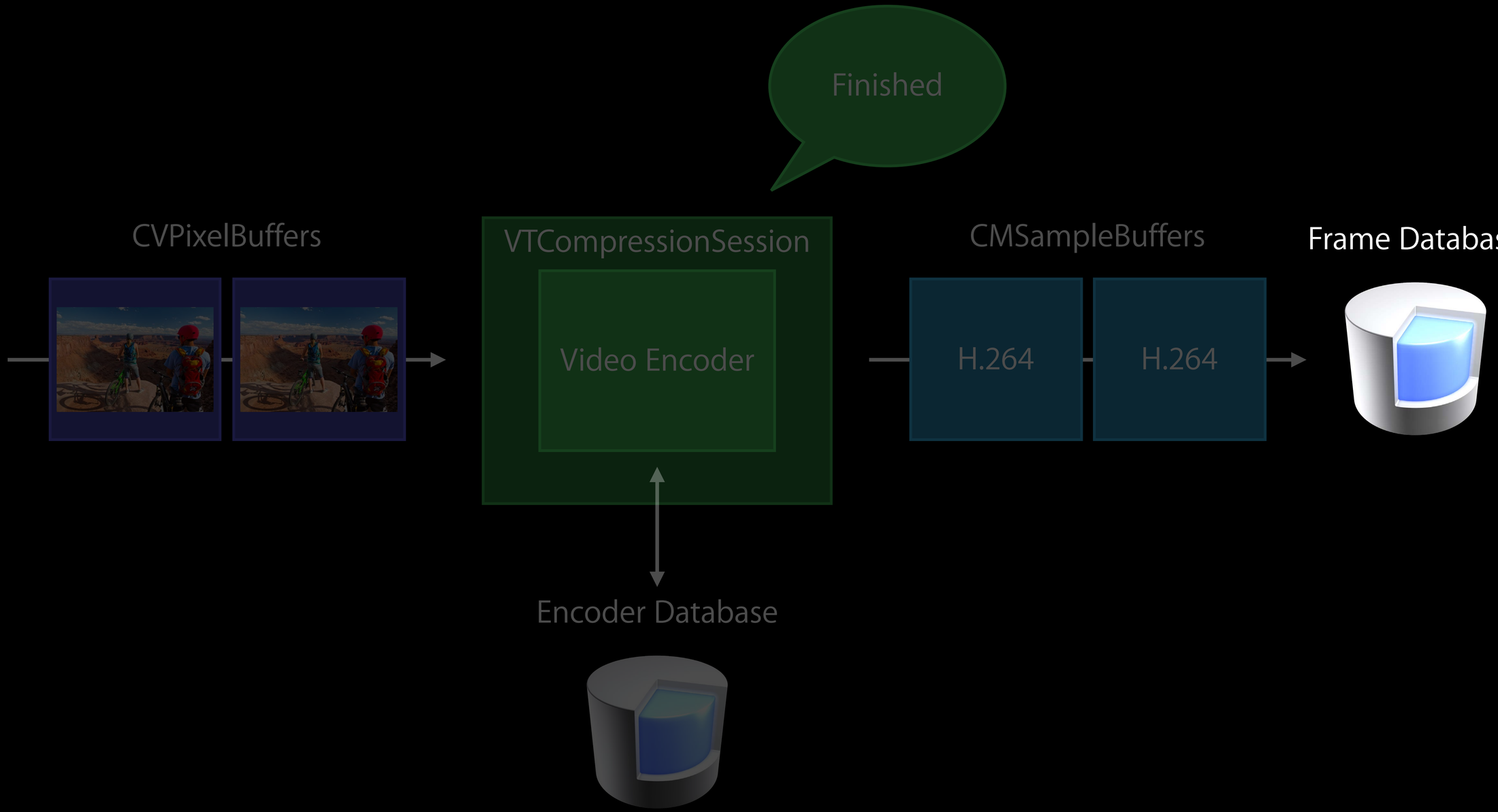
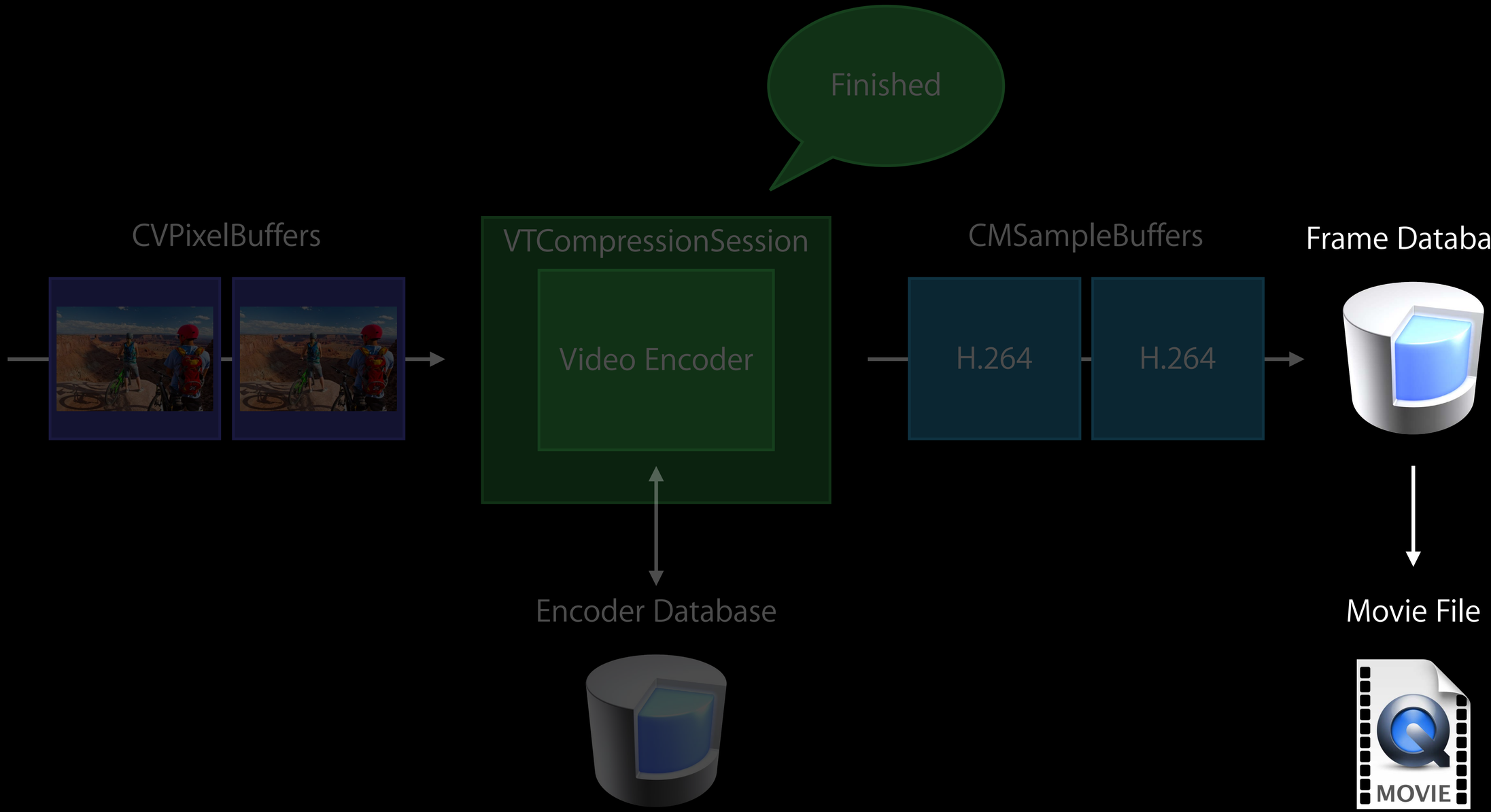
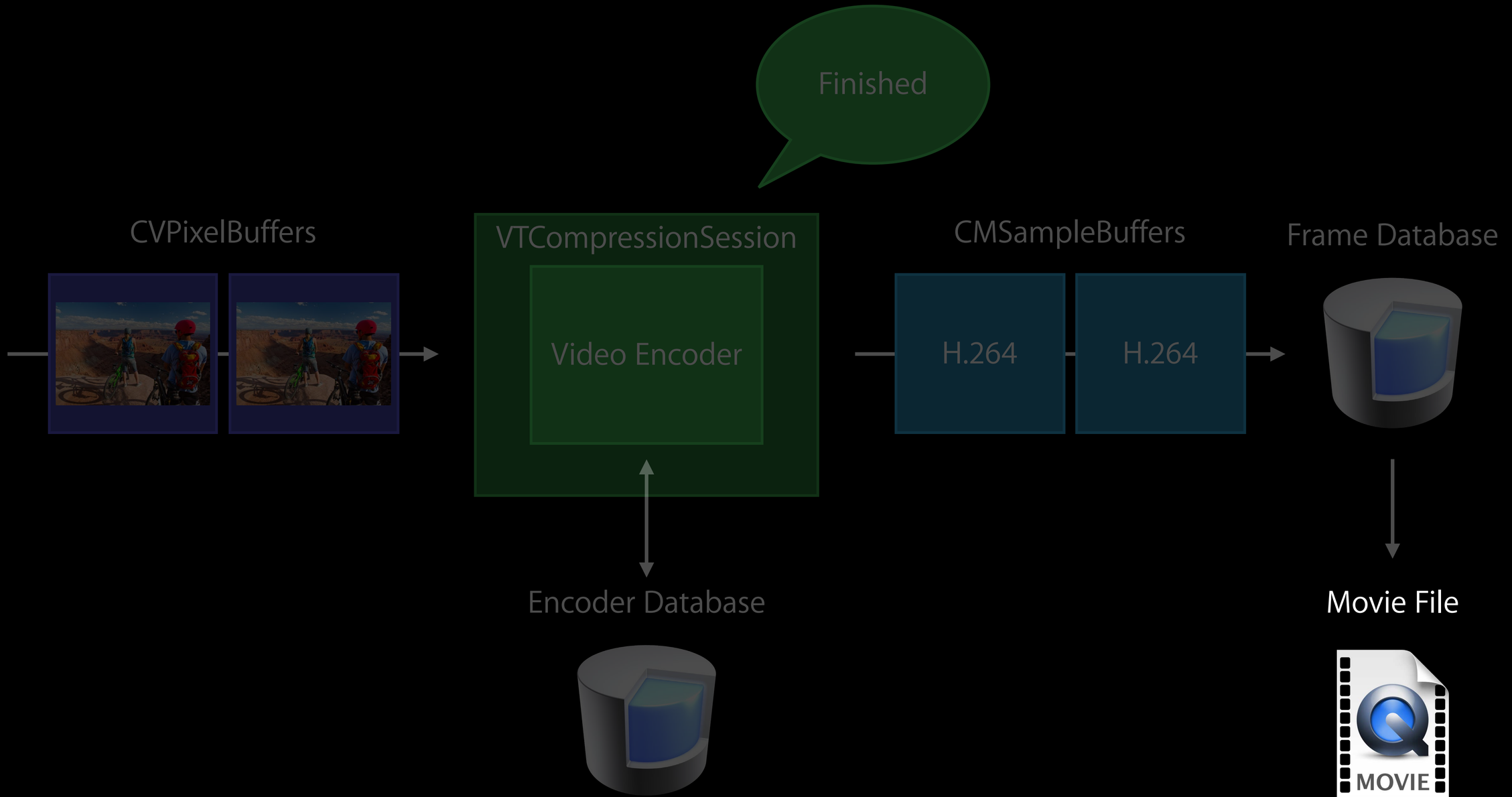


# Multi-Pass Encoding



# Multi-Pass Encoding



# Multi-Pass Encoder Features

| | Single-Pass | Multi-Pass |
|---|---|---|

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| | Single-Pass | Multi-Pass |
|---|---|---|
| Hardware Accelerated | ✓ | ✓ |

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| Hardware Accelerated | ✓ | ✓ |
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# Multi-Pass Encoder Features

| | Single-Pass | Multi-Pass |
|---|---|---|
| Hardware Accelerated | ✓ | ✓ |
| Knowledge of Future | ✗ | ✓ |
| Change Decisions | ✗ | ✓ |
| Optimal Quality per Bit | ✗ | ✓ |

# New APIs

AVKit

AVFoundation

Video Toolbox

Core Media

Core Video

# AVFoundation

New AVAssetExportSession property

Pass descriptions for AVAssetWriterInput

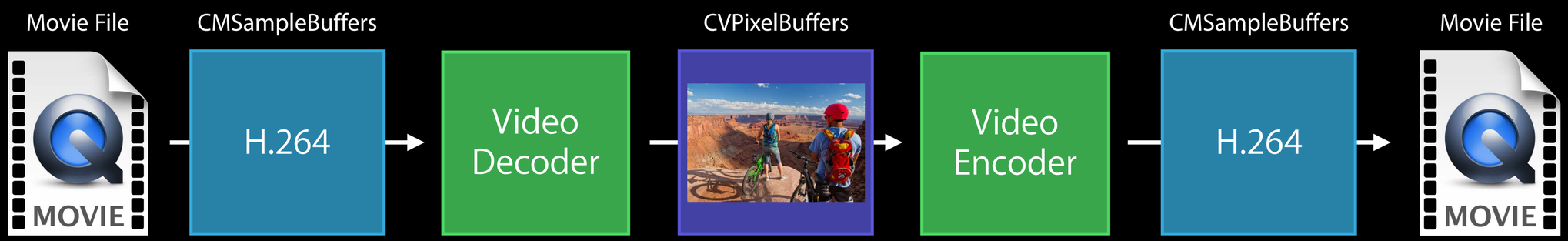
Reuse of AVAssetReaderOutput

# AVAssetExportSession

## Overview

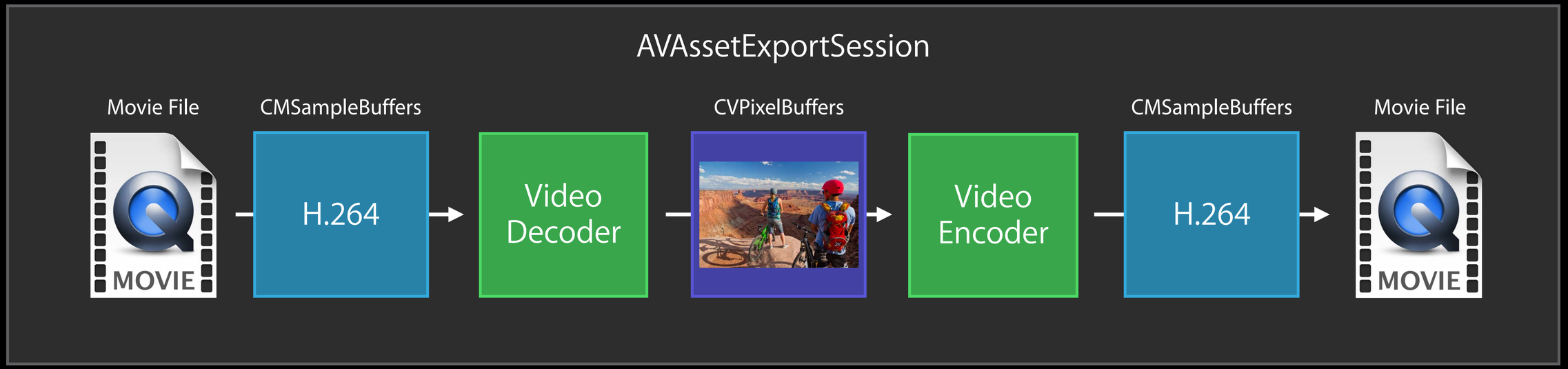
# AVAssetExportSession

## Overview



# AVAssetExportSession

## Overview



# AVAssetExportSession

## New APIs

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## New APIs


Multiple passes are taken care of automatically

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Multiple passes are taken care of automatically

- Falls back to single-pass if not supported

# AVAssetExportSession

## New APIs


Multiple passes are taken care of automatically

- Falls back to single-pass if not supported

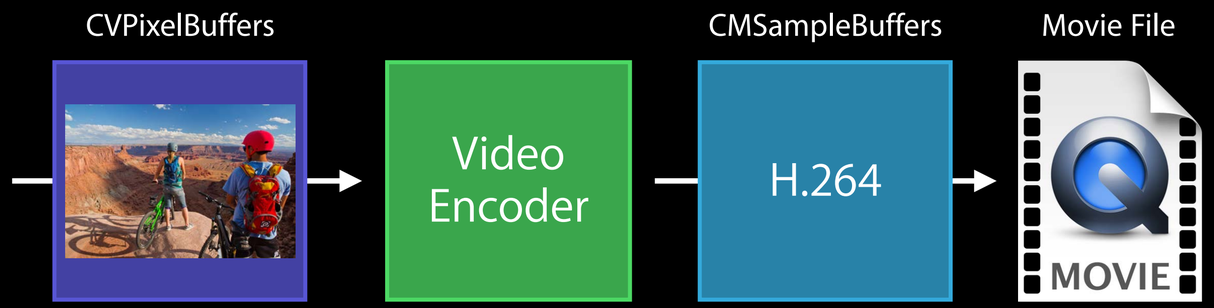
```
@property (nonatomic) BOOL canPerformMultiplePassesOverSourceMediaData;
```

# AVAssetWriter

## Overview

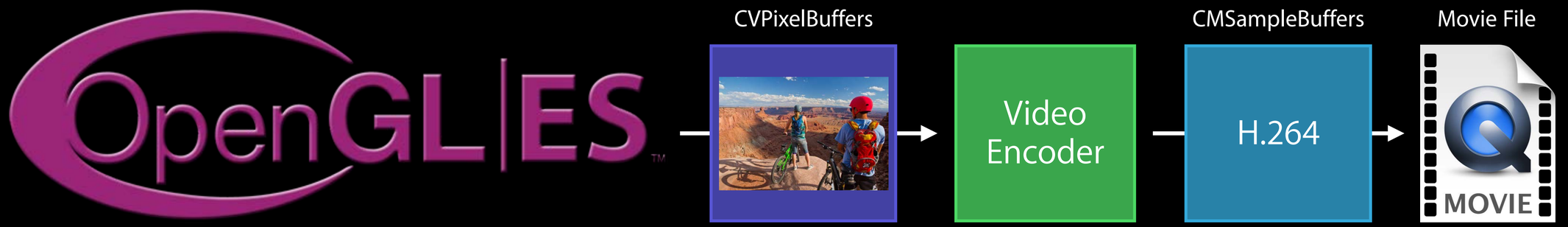
# AVAssetWriter

## Overview



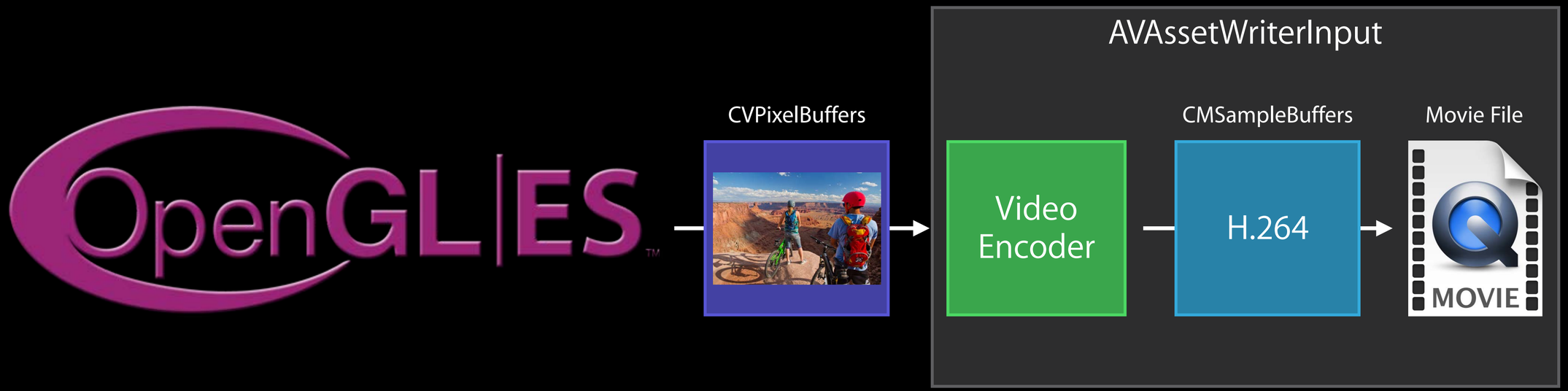
# AVAssetWriter

## Overview



# AVAssetWriter

## Overview



# AVAssetWriter

## Overview

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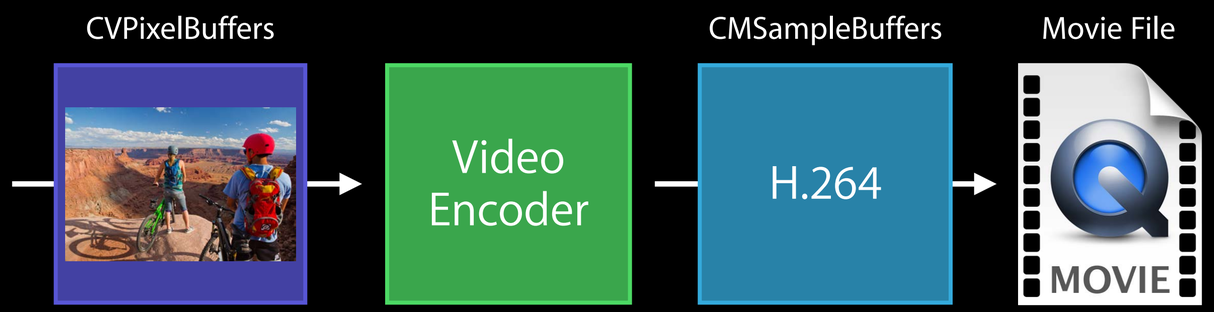
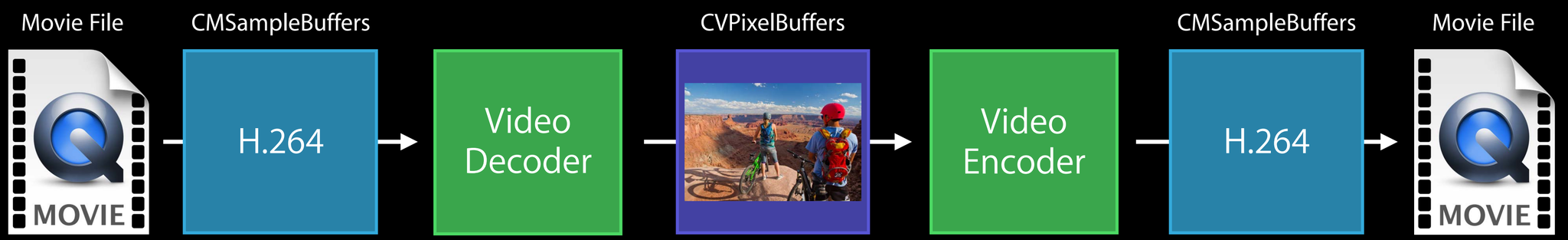
## Overview



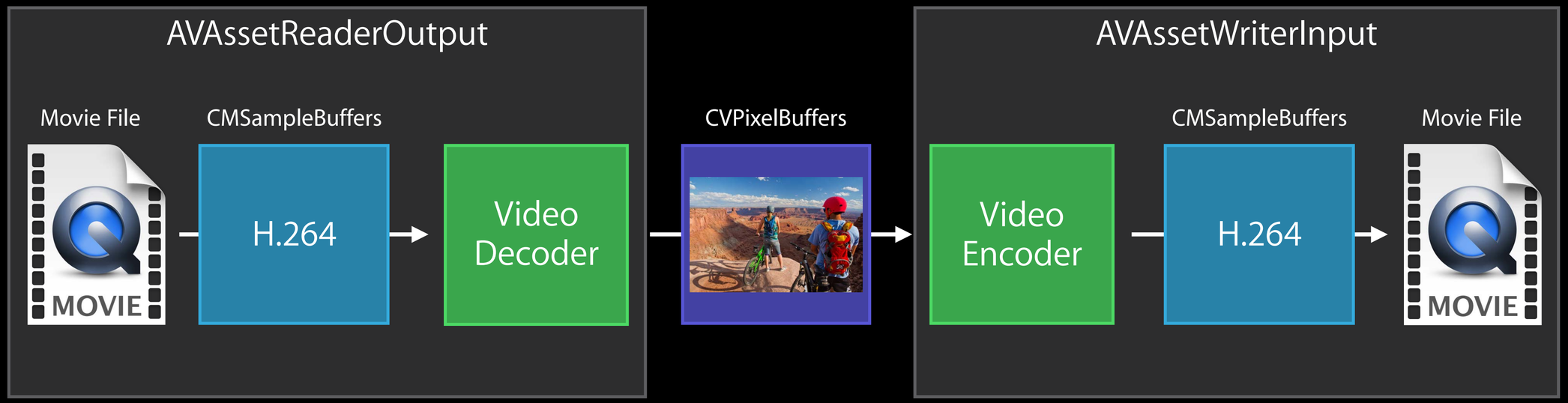
# AVAssetWriter

## Overview



# AVAssetWriter

## Overview



# AVAssetWriterInput

## New APIs

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## New APIs


Enable multi-pass encoding if supported

```
@property (nonatomic) BOOL performsMultiPassEncodingIfSupported;
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# AVAssetWriterInput

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End current pass after appending samples

```
- (void)markCurrentPassAsFinished;
```

# AVAssetWriterInput

## New APIs


Enable multi-pass encoding if supported

```
@property (nonatomic) BOOL performsMultiPassEncodingIfSupported;
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Triggers encoder analysis

# AVAssetWriterInput

## New APIs


Enable multi-pass encoding if supported

```
@property (nonatomic) BOOL performsMultiPassEncodingIfSupported;
```

End current pass after appending samples

```
- (void)markCurrentPassAsFinished;
```

Triggers encoder analysis

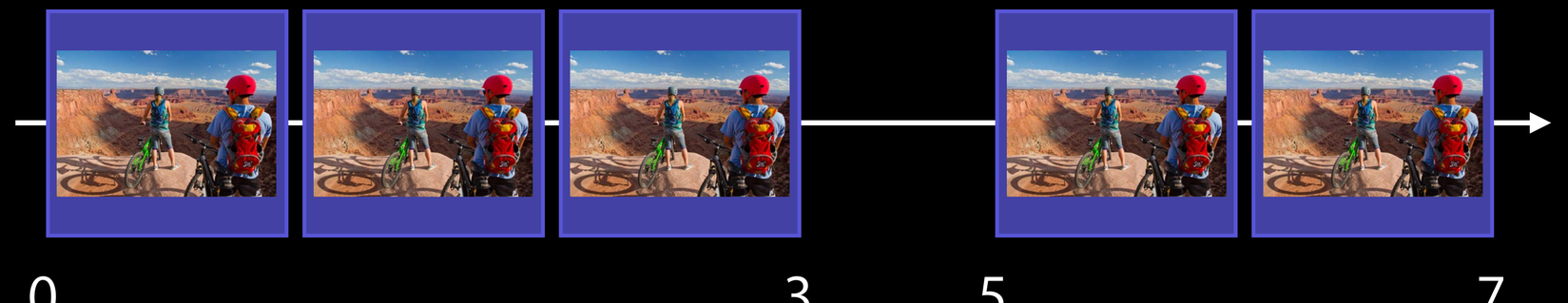
Encoder decides if it wants more passes and what time ranges

# AVAssetWriterInputPassDescription

NEW

# AVAssetWriterInputPassDescription

NEW

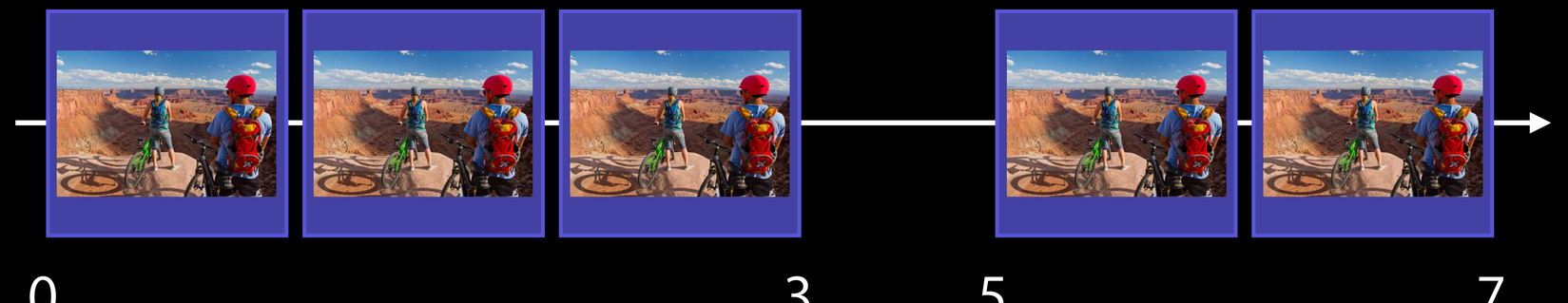



Encoder's request for samples in next pass

- May contain subsets of entire sequence

# AVAssetWriterInputPassDescription

NEW




Encoder's request for samples in next pass

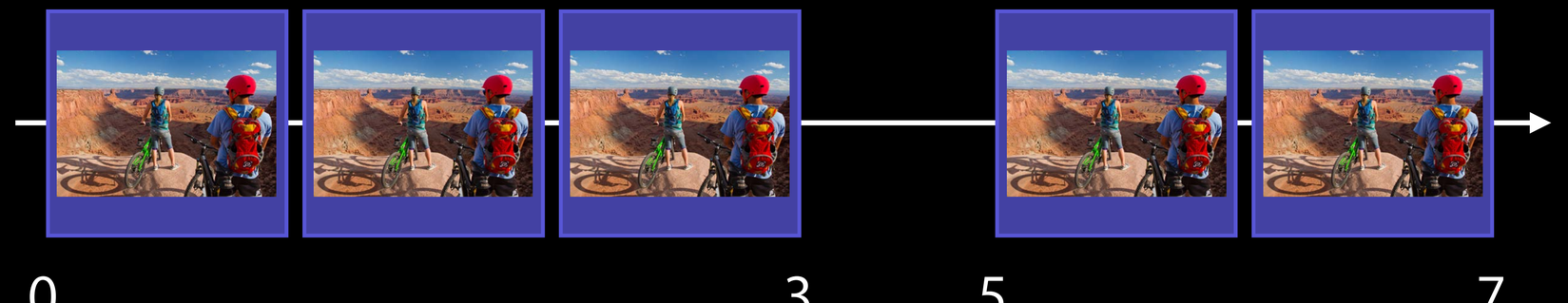
- May contain subsets of entire sequence

Query pass description time ranges

```
@property (nonatomic, readonly) NSArray *sourceTimeRanges;
```

# AVAssetWriterInputPassDescription

NEW




Encoder's request for samples in next pass

- May contain subsets of entire sequence

Query pass description time ranges

```
@property (nonatomic, readonly) NSArray *sourceTimeRanges;
```

Array of CMTimeRanges as NSValues

# AVAssetWriterInput

## Pass descriptions

# AVAssetWriterInput

## Pass descriptions


Block is called when encoder makes decision about next pass

```
– (void)respondToEachPassDescriptionOnQueue:(dispatch_queue_t)queue
                                 usingBlock:(dispatch_block_t)block;
```

# AVAssetWriterInput

## Pass descriptions


Block is called when encoder makes decision about next pass

```
– (void)respondToEachPassDescriptionOnQueue:(dispatch_queue_t)queue
                                 usingBlock:(dispatch_block_t)block;
```

Get the new description

```
@property (readonly) AVAssetWriterInputPassDescription *currentPassDescription;
```

# AVAssetWriterInput

## Sample

# AVAssetWriterInput

## Sample

```
[assetWriterInput respondToEachPassDescriptionOnQueue:queue usingBlock:^{
    AVAssetWriterInputPassDescription *pass = [assetWriterInput currentPassDescription];
    if (pass != nil) {
        // Reconfigure source to deliver samples
        [source deliverSamplesFromPassDescription:pass];

        // Ready to start next pass
        [assetWriterInput requestMediaDataWhenReadyOnQueue:queue usingBlock:block];
    } else {
        // Finished
        [assetWriterInput markAsFinished];
    }
}];
```

# AVAssetWriterInput

## Sample

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}];
```

# AVAssetReaderOutput

## New APIs

# AVAssetReaderOutput

## New APIs


Prepare source for multi-pass

```
@property (nonatomic) BOOL supportsRandomAccess;
```

# AVAssetReaderOutput

## New APIs


Prepare source for multi-pass

```
@property (nonatomic) BOOL supportsRandomAccess;
```

Reconfigure source to deliver samples in time ranges

```
- (void)resetForReadingTimeRanges:(NSArray *)timeRanges;
```

# AVAssetReaderOutput

## New APIs


Prepare source for multi-pass

```
@property (nonatomic) BOOL supportsRandomAccess;
```

Reconfigure source to deliver samples in time ranges

```
- (void)resetForReadingTimeRanges:(NSArray *)timeRanges;
```

All passes have completed

```
- (void)markConfigurationAsFinal;
```

# AVAssetReader and AVAssetWriter

# AVAssetReader and AVAssetWriter

Enable AVAssetReaderOutput if AVAssetWriterInput support multi-pass

```
readerOutput.supportsRandomAccess = writerInput.canPerformMultiplePasses;
```

# AVAssetReader and AVAssetWriter

Enable AVAssetReaderOutput if AVAssetWriterInput support multi-pass

```
readerOutput.supportsRandomAccess = writerInput.canPerformMultiplePasses;
```

Reconfigure source to deliver samples for an AVAssetWriterInput

```
[readerOutput resetForReadingTimeRanges:passDescription.sourceTimeRanges];
```

# AVAssetReaderOutput

Sample

# AVAssetReaderOutput

## Sample

```
[assetWriterInput respondToEachPassDescriptionOnQueue:queue usingBlock:^{
    AVAssetWriterInputPassDescription *pass = [assetWriterInput currentPassDescription];
    if (currentPass != nil) {
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        [assetWriterInput requestMediaDataWhenReadyOnQueue:queue usingBlock:block];
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```

AVKit

AVFoundation

Video Toolbox

Core Media

Core Video

# Video Toolbox

Encoder frame analysis database

- VTMultiPassStorage

Additions to VTCompressionSession

Compressed frame database

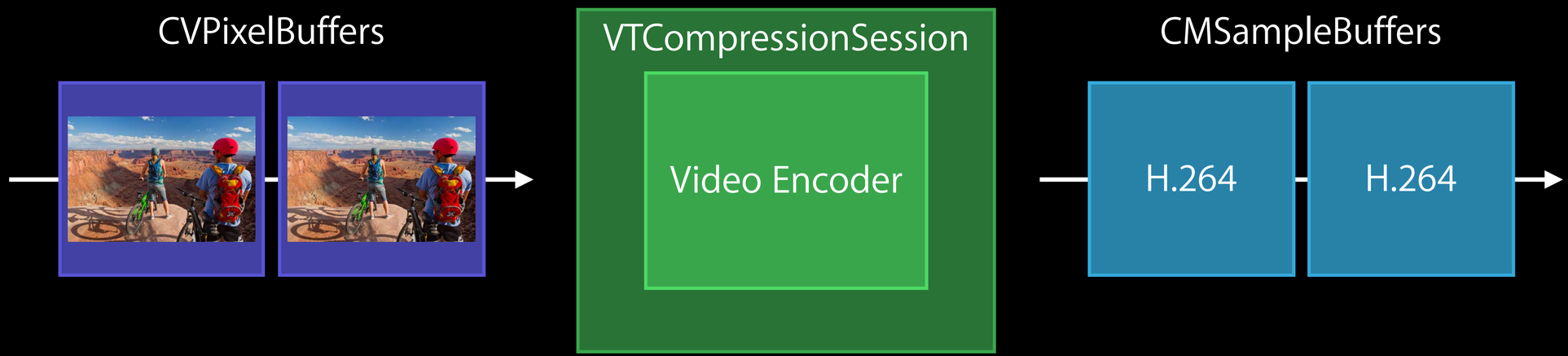
- VTFrameSilo

# Video Toolbox Multi-Pass

## Architecture

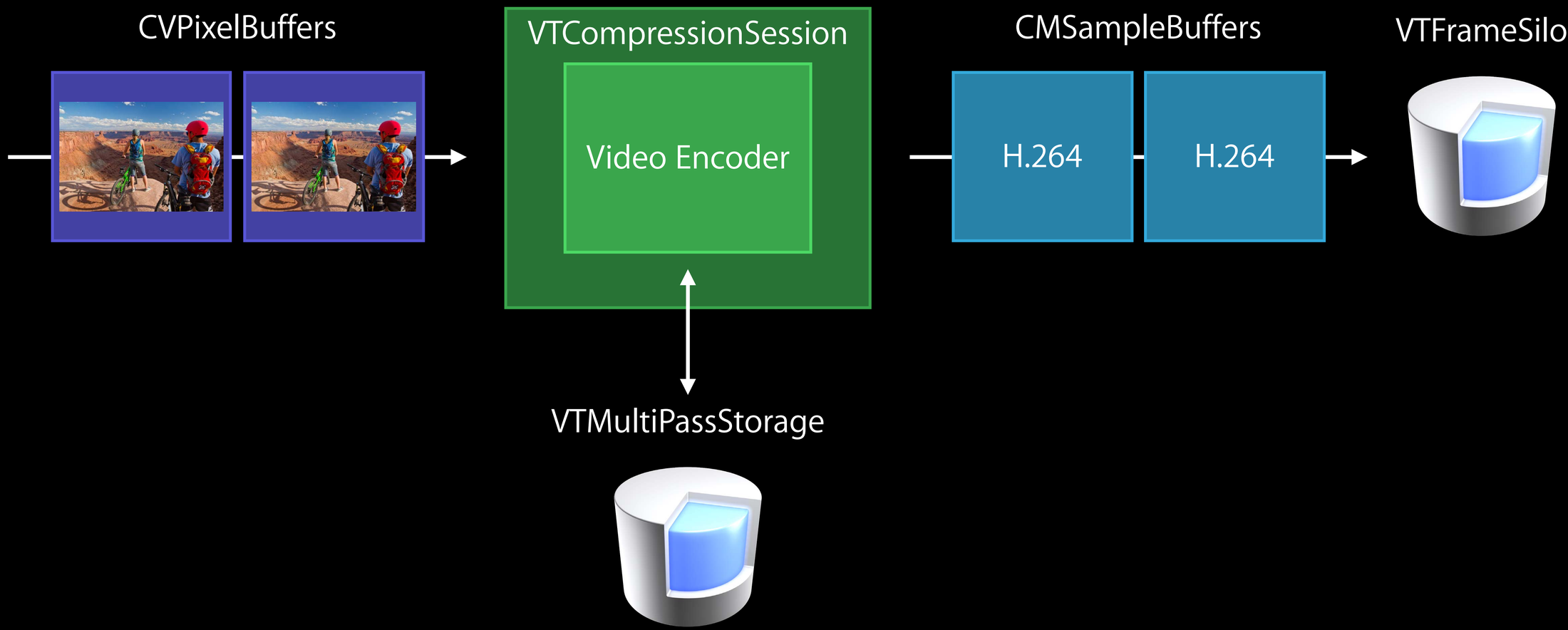
# Video Toolbox Multi-Pass

## Architecture



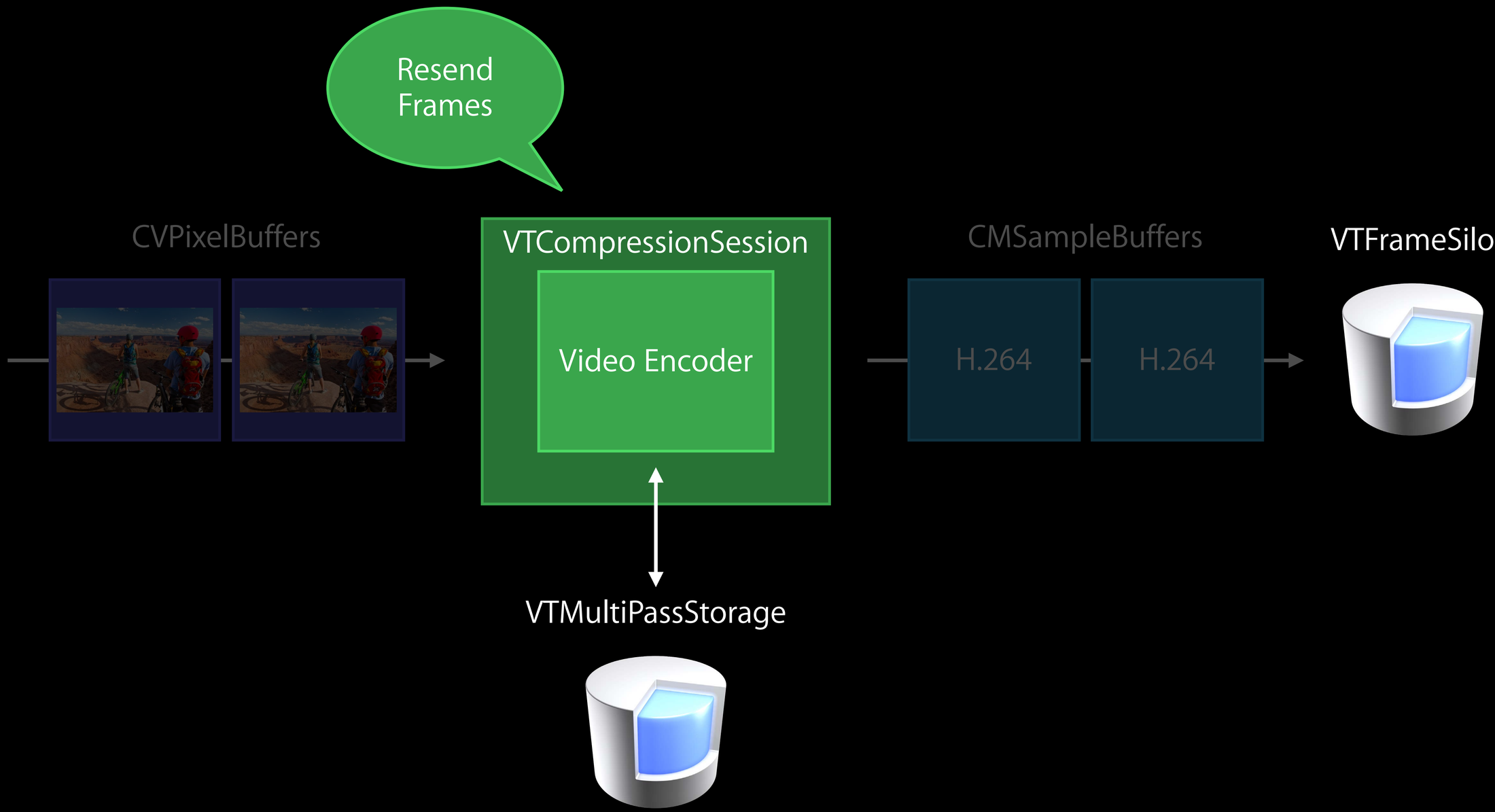
# Video Toolbox Multi-Pass

## Architecture



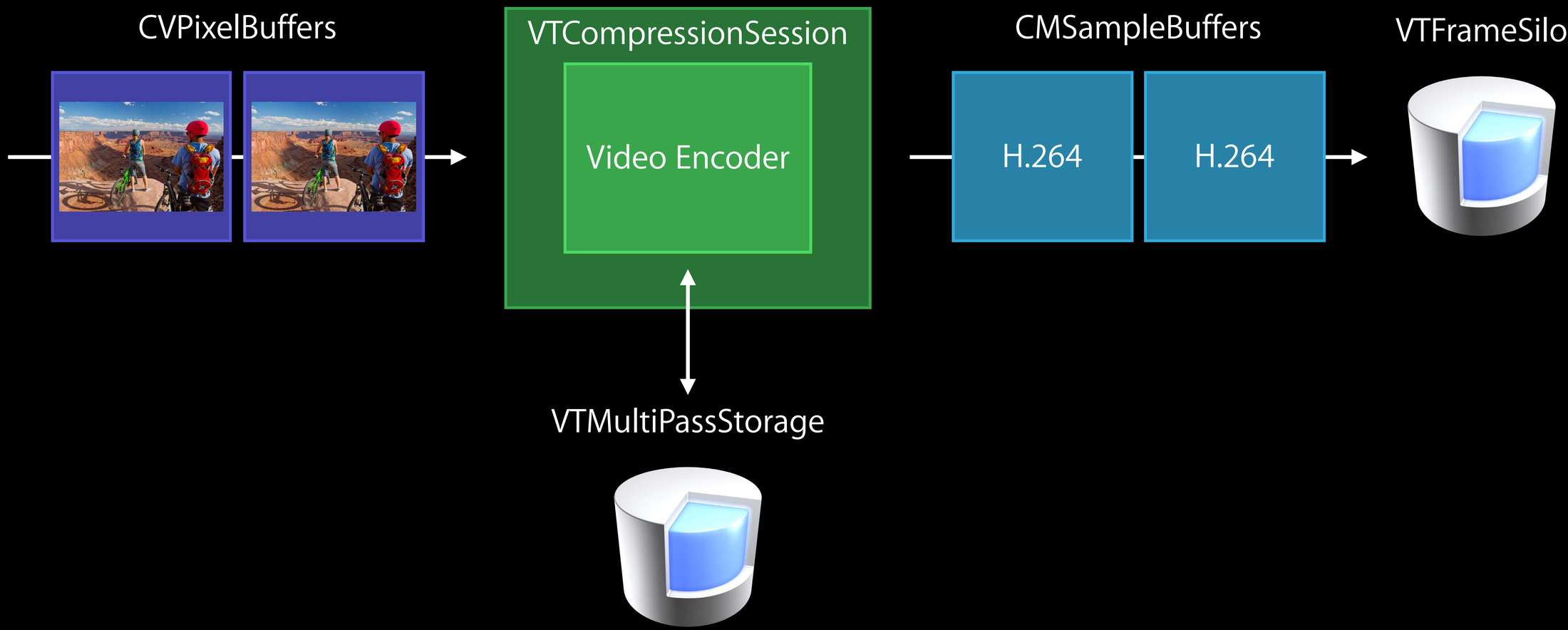
# Video Toolbox Multi-Pass

## Architecture



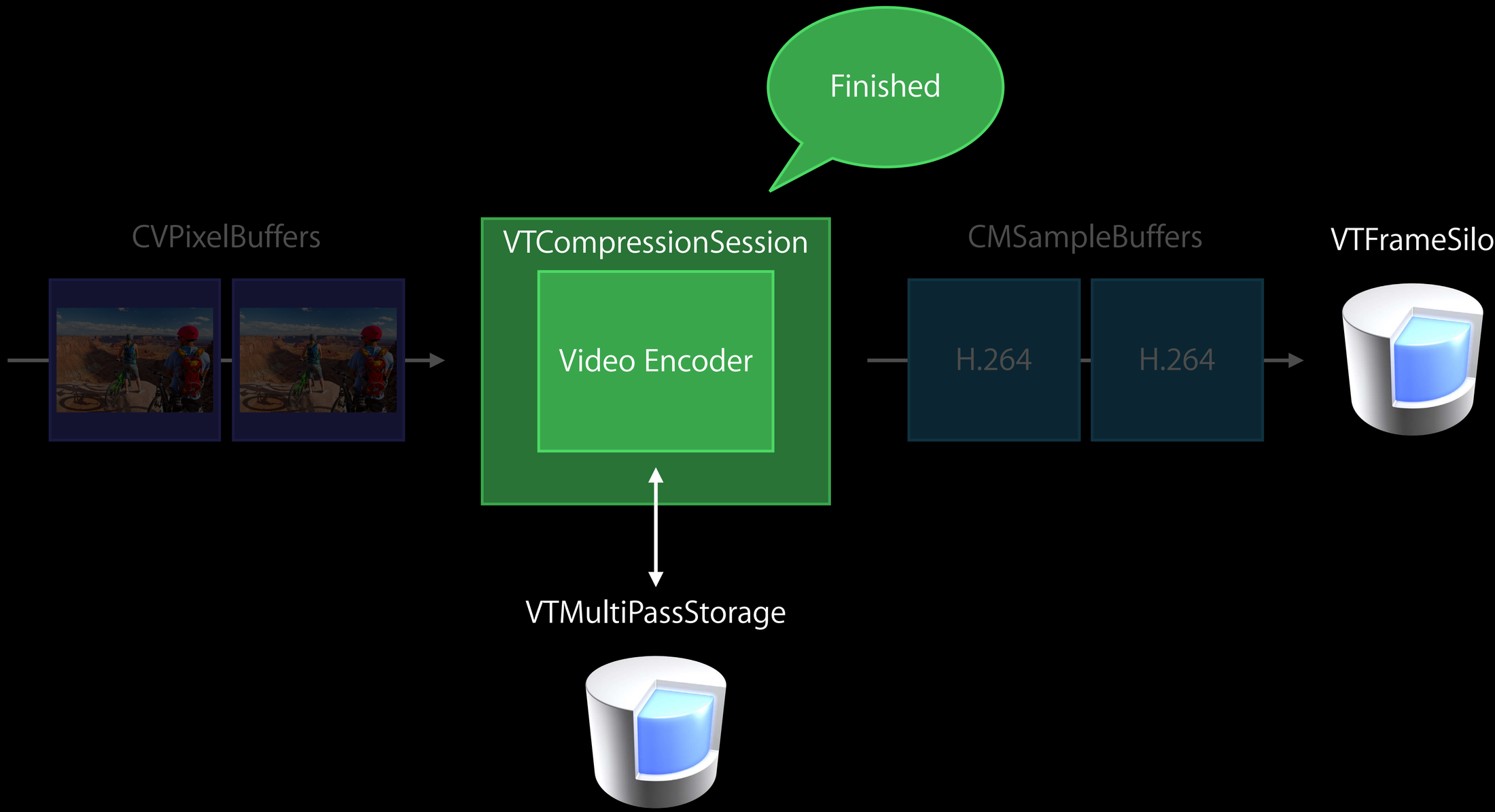
# Video Toolbox Multi-Pass

## Architecture



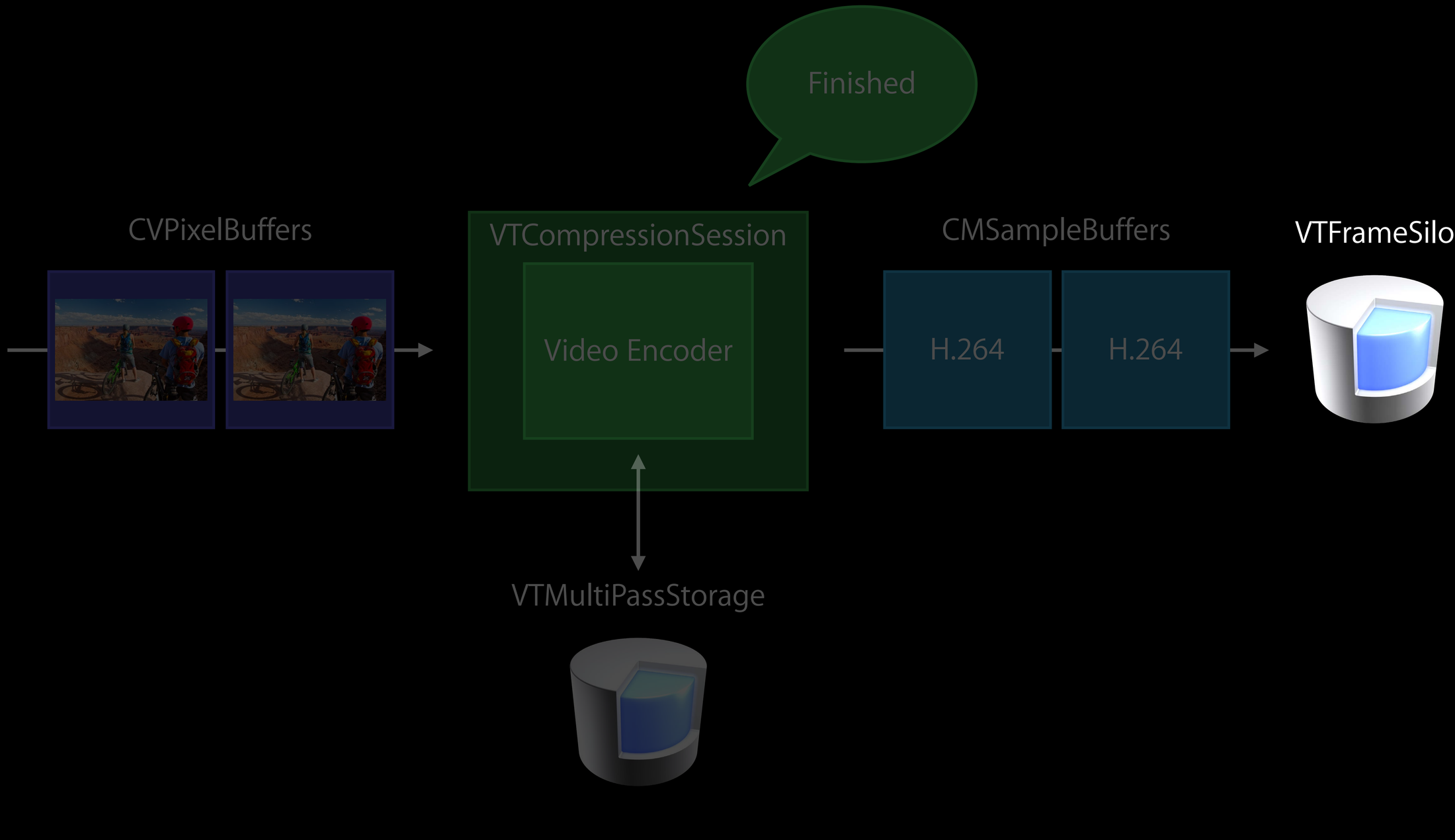
# Video Toolbox Multi-Pass

## Architecture



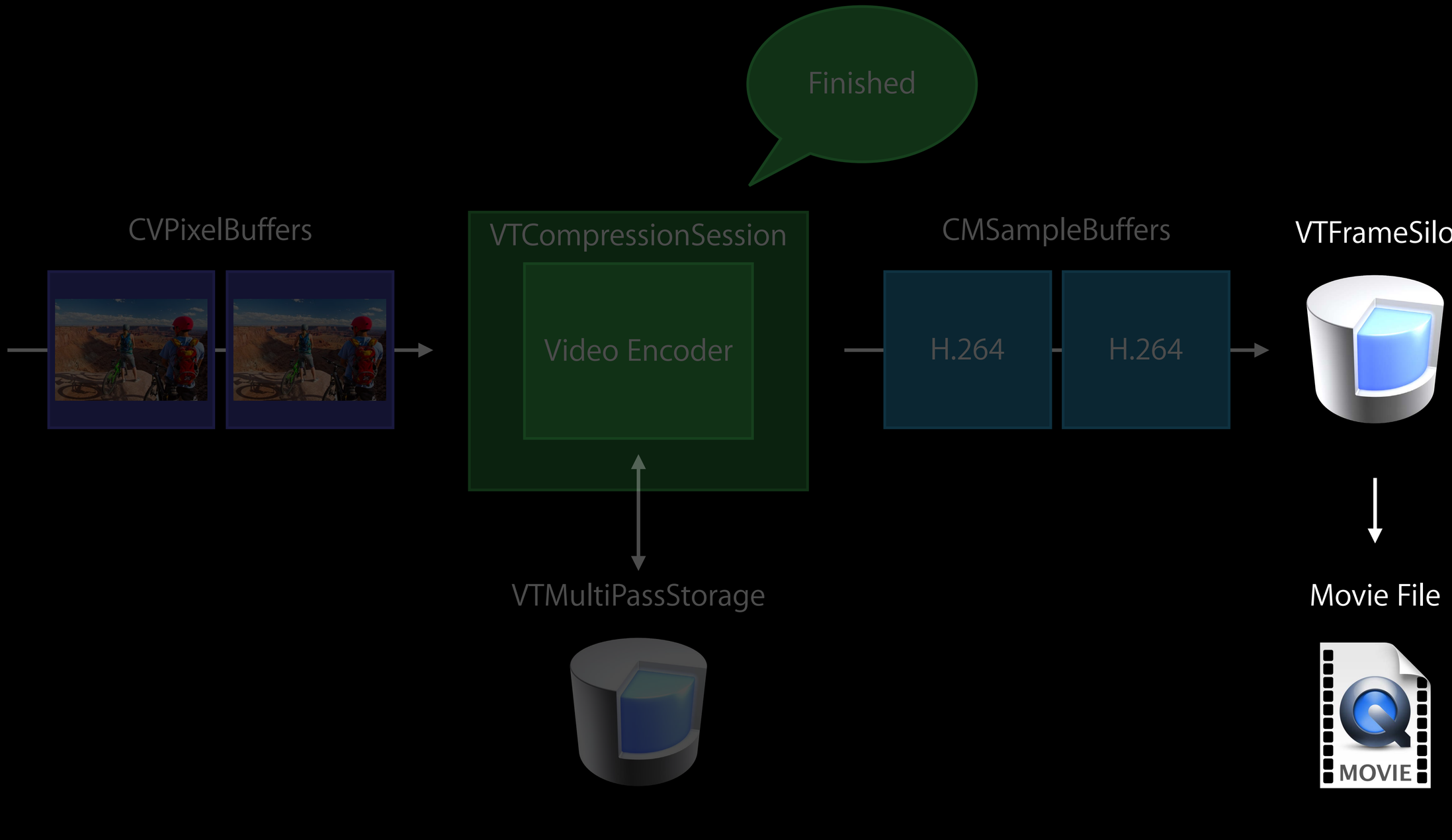
# Video Toolbox Multi-Pass

## Architecture



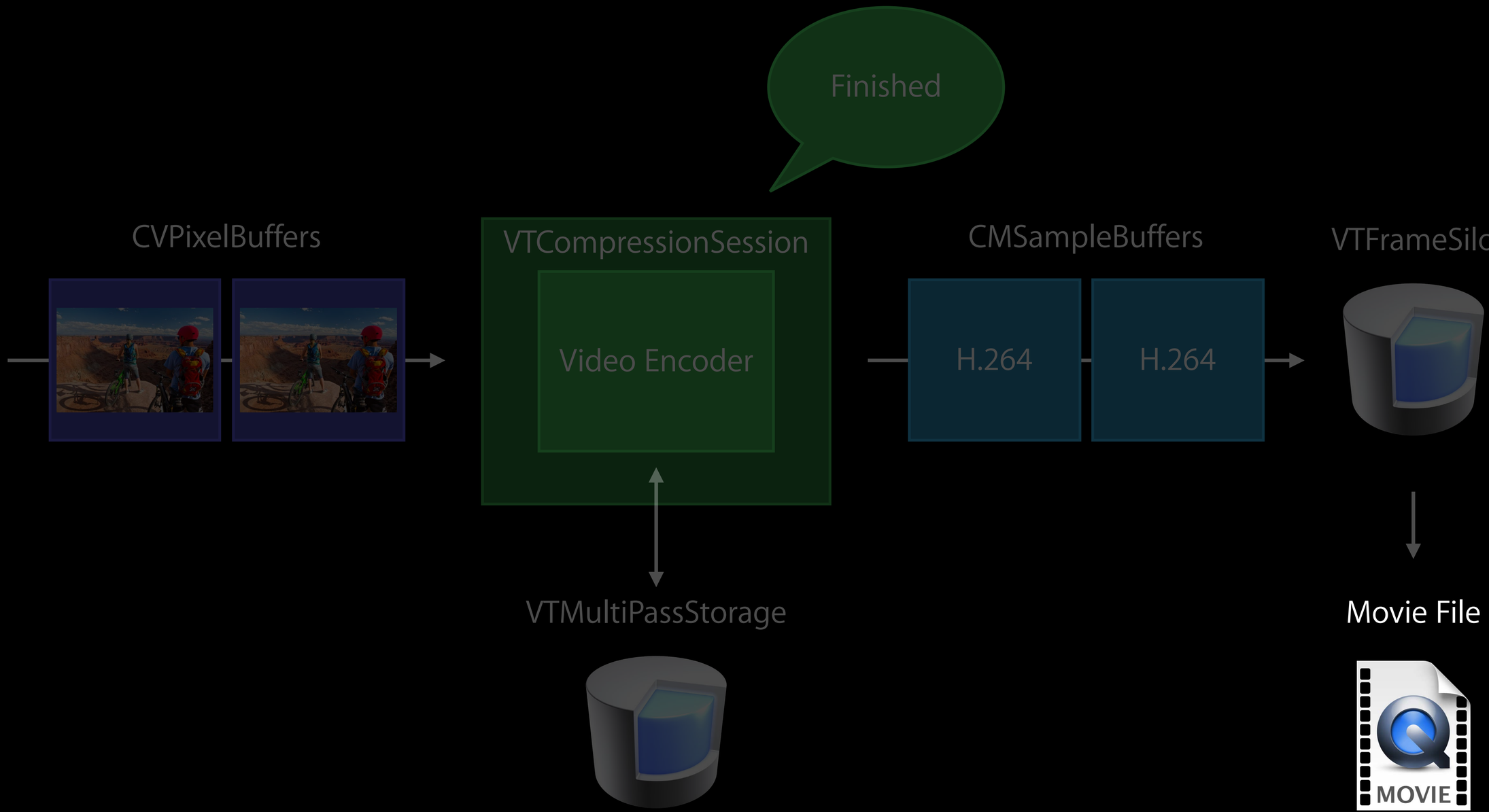
# Video Toolbox Multi-Pass

## Architecture

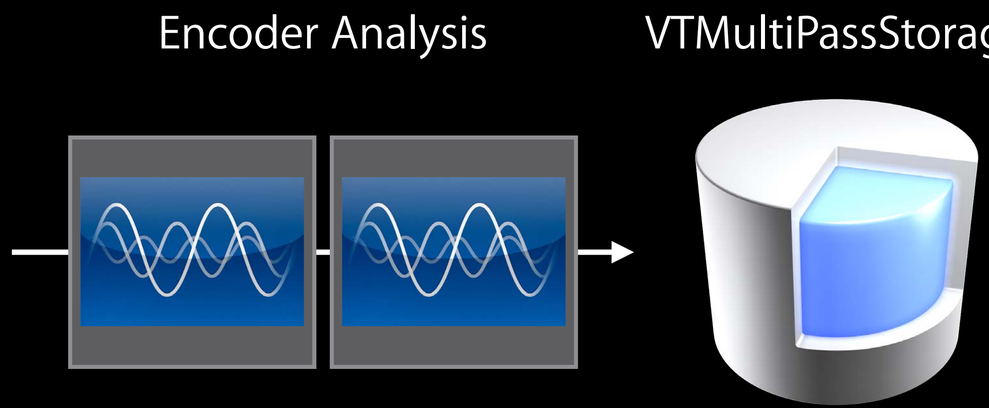


# Video Toolbox Multi-Pass

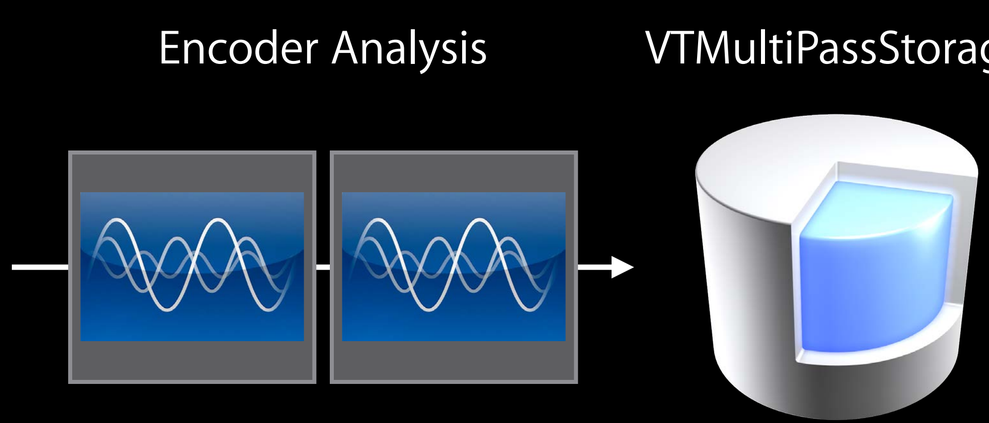
## Architecture



# VTMultiPassStorage



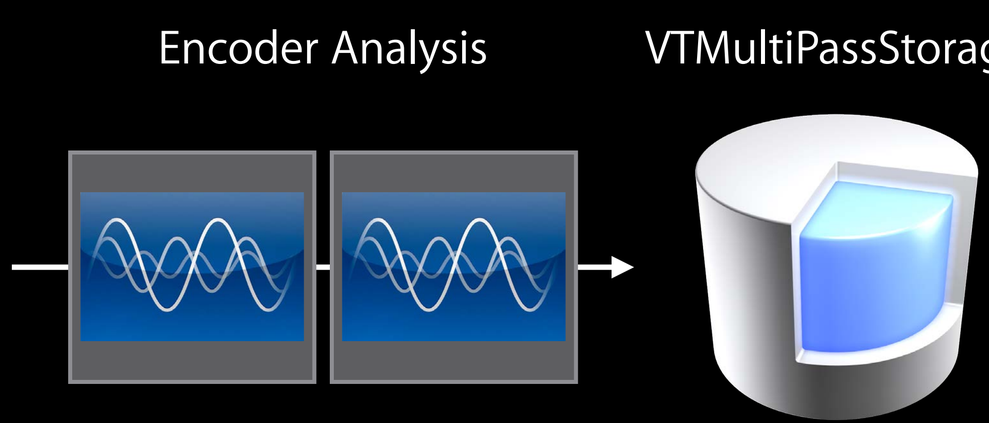
# VTMultiPassStorage




Create the encoder analysis storage

```
error = VTMultiPassStorageCreate( allocator, fileURL, timeRange,
                                  options, &storage );
```

# VTMultiPassStorage



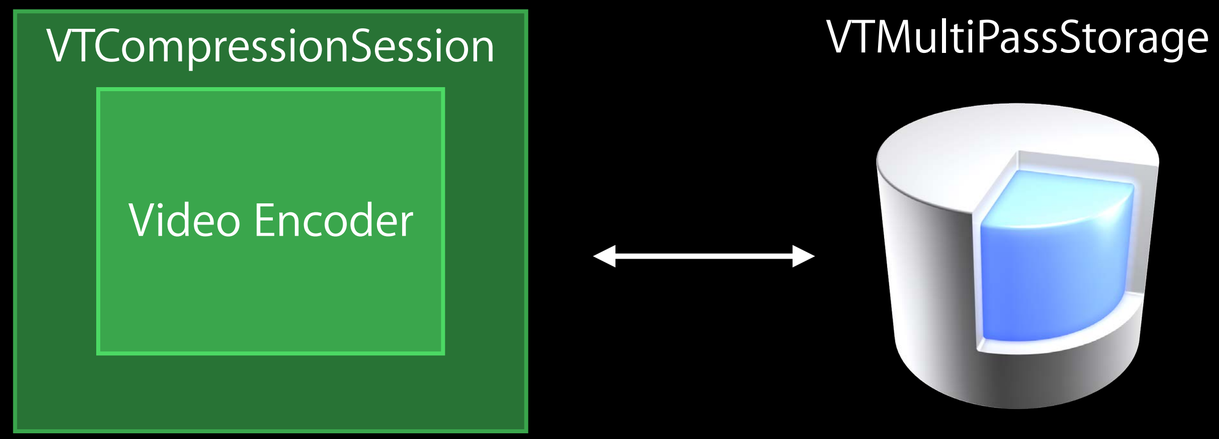

Create the encoder analysis storage

```
error = VTMultiPassStorageCreate( allocator, fileURL, timeRange,
                                  options, &storage );
```

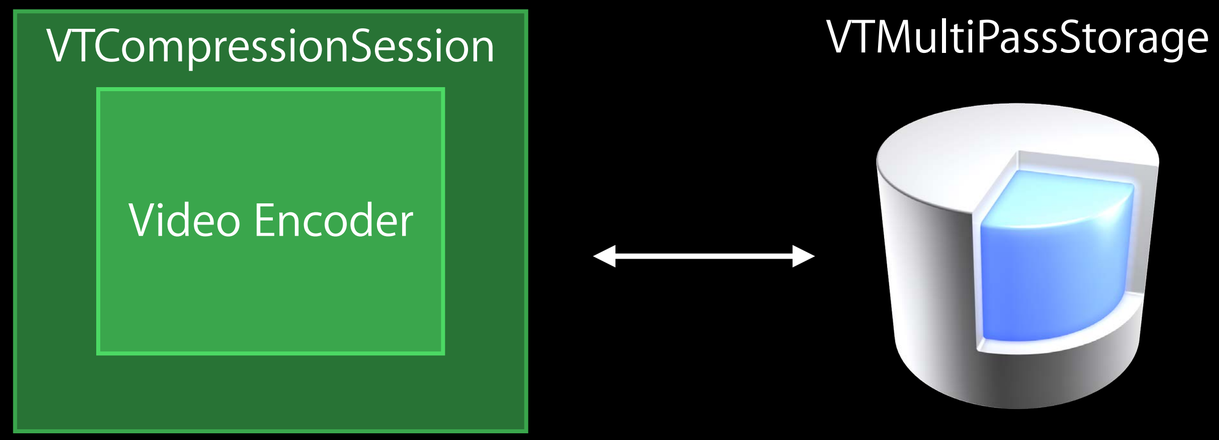
Close the file

```
error = VTMultiPassStorageClose( storage );
```

# VTCompressionSession



# VTCompressionSession




Enable multi-pass

```
error = VTSessionSetProperty( session,
            kVTCompressionPropertyKey_MultiPassStorage, multiPassStorage );
```

# VTCompressionSession

# VTCompressionSession

Begin a pass

```
error = VTCompressionSessionBeginPass( session, 0, NULL );
```

# VTCompressionSession

Begin a pass

```
error = VTCompressionSessionBeginPass( session, 0, NULL );
```

End a pass

- Asks the encoder if another pass can be performed

```
error = VTCompressionSessionEndPass( session,
                                     &furtherPassesRequested, NULL );
```

# VTCompressionSession

Begin a pass

```
error = VTCompressionSessionBeginPass( session, 0, NULL );
```

End a pass

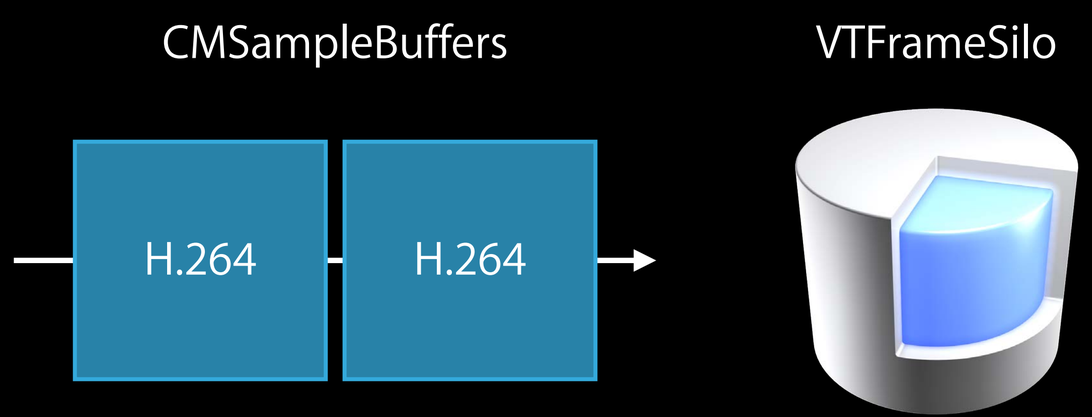
- Asks the encoder if another pass can be performed

```
error = VTCompressionSessionEndPass( session,
                                     &furtherPassesRequested, NULL );
```

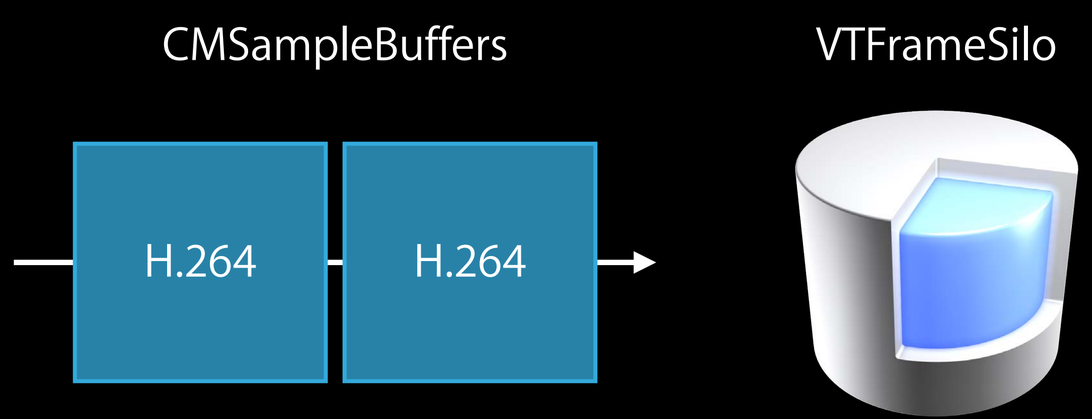
Retrieve time ranges for next pass

```
error = VTCompressionSessionGetTimeRangesForNextPass( session,
                                     &timeRangesCount, &timeRangeArray );
```

# VTFrameSilo



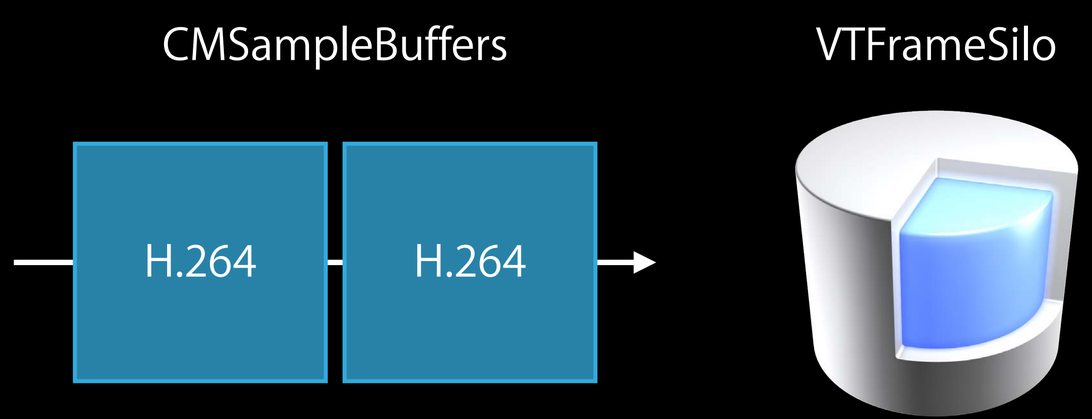
# VTFrameSilo




Create compressed frame storage

```
error = VTFrameSiloCreate( allocator, fileURL, timeRange, options, &silo );
```

# VTFrameSilo



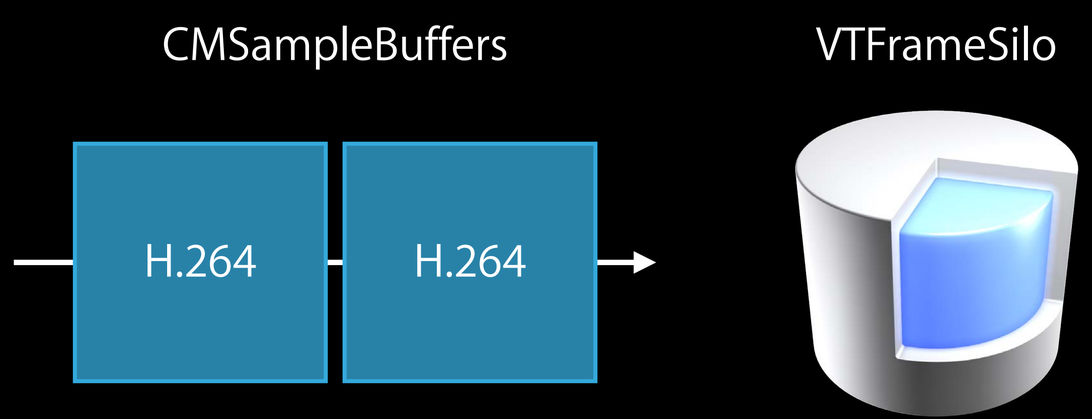

Create compressed frame storage

```
error = VTFrameSiloCreate( allocator, fileURL, timeRange, options, &silo );
```

Add a sample in VTCompressionOutputCallback

```
error = VTFrameSiloAddSampleBuffer( silo, sampleBuffer );
```

# VTFrameSilo




Create compressed frame storage

```
error = VTFrameSiloCreate( allocator, fileURL, timeRange, options, &silo );
```

Add a sample in VTCompressionOutputCallback

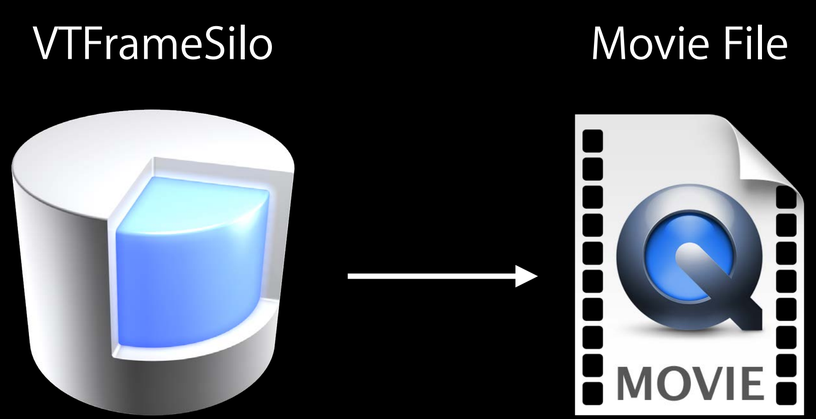
```
error = VTFrameSiloAddSampleBuffer( silo, sampleBuffer );
```

Prepare for next pass

```
error = VTFrameSiloSetTimeRangesForNextPass( silo,
                                             timeRangeCount, timeRangeArray );
```

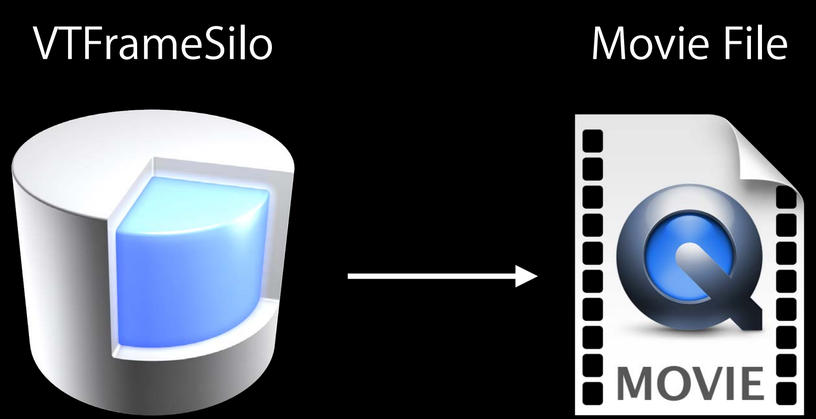
# VTFrameSilo

## File output



# VTFrameSilo

## File output




Retrieve samples for time range

```
error = VTFrameSiloCallBlockForEachSampleBuffer( silo,
            timeRange, ^(CMSampleBuffer sampleBuffer) {
      // append sampleBuffer to movie file
 });
```

# Considerations

# Use Case Considerations

Best Choice

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |
| Best Quality | |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |
| Best Quality | Multi-Pass |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |
| Best Quality | Multi-Pass |
| Closer to Target Bit Rate | |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |
| Best Quality | Multi-Pass |
| Closer to Target Bit Rate | Multi-Pass |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |
| Best Quality | Multi-Pass |
| Closer to Target Bit Rate | Multi-Pass |
| Okay to Take Longer | |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |
| Best Quality | Multi-Pass |
| Closer to Target Bit Rate | Multi-Pass |
| Okay to Take Longer | Multi-Pass |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |
| Best Quality | Multi-Pass |
| Closer to Target Bit Rate | Multi-Pass |
| Okay to Take Longer | Multi-Pass |
| Your App | |

# Use Case Considerations

| | Best Choice |
|---|---|
| Real Time | Single-Pass |
| Minimum Power Use | Single-Pass |
| Minimum Temporary Storage | Single-Pass |
| Best Quality | Multi-Pass |
| Closer to Target Bit Rate | Multi-Pass |
| Okay to Take Longer | Multi-Pass |
| Your App | Experiment |

# Content Considerations

Best Choice

# Content Considerations

| | Best Choice |
|---|---|
| Low Complexity | |

# Content Considerations

| | Best Choice |
|---|---|
| Low Complexity | Single/Multi |

# Content Considerations

| | Best Choice |
|---|---|
| Low Complexity | Single/Multi |
| High Complexity | |

# Content Considerations

| | Best Choice |
|---|---|
| Low Complexity | Single/Multi |
| High Complexity | Single/Multi |

# Content Considerations

| | Best Choice |
|---|---|
| Low Complexity | Single/Multi |
| High Complexity | Single/Multi |
| Varying Complexity | |

# Content Considerations

| | Best Choice |
|---|---|
| Low Complexity | Single/Multi |
| High Complexity | Single/Multi |
| Varying Complexity | Multi-Pass |

# Content Considerations

| | Best Choice |
|---|---|
| Low Complexity | Single/Multi |
| High Complexity | Single/Multi |
| Varying Complexity | Multi-Pass |
| Your Content | |

# Content Considerations

| | Best Choice |
|---|---|
| Low Complexity | Single/Multi |
| High Complexity | Single/Multi |
| Varying Complexity | Multi-Pass |
| Your Content | Experiment |

# Summary

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AVFoundation provides powerful APIs to operate on media

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Video Toolbox APIs provide direct codec access

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AVFoundation provides powerful APIs to operate on media

Video Toolbox APIs provide direct codec access

Multi-pass can provide substantial quality improvements

# More Information

Evangelism
evangelism@apple.com

AVFoundation Documentation
AVFoundation Programming Guide
https://developer.apple.com/library/ios/documentation/AudioVideo/Conceptual/AVFoundationPG/

Apple Developer Forums
http://devforums.apple.com

# Related Sessions

| | | |
|---|---|---|
| • Mastering Modern Media Playback | Mission | Tuesday 11:30AM |
| • Harnessing Metadata in Audiovisual Media | Pacific Heights | Tuesday 2:00PM |
| • Camera Capture: Manual Controls | Marina | Wednesday 11:30AM |
| • Introducing the Photos Frameworks | Nob Hill | Thursday 10:15AM |

# Labs

| | | |
|---|---|---|
| • AVFoundation and Camera Capture Lab | Media Lab A | Thursday 2:00PM |

WWDC14