Advanced Editing with AV Foundation

Session 612

Scott G. Johnston
AV Foundation Engineer

Agenda

- Custom video compositing
  - Existing architecture
  - New custom video compositing
  - Choosing pixel formats
  - Tweening
  - Performance
- Debugging compositions
  - Common pitfalls

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Existing Architecture

AV Foundation editing today

- Available since iOS 4.0 and OS X Lion
- Used in video editing apps from Apple and in the store
- Video editing
  - Temporal composition
  - Video composition
  - Audio mixing

Possible Today

Wipes, Dissolves, Transforms,…

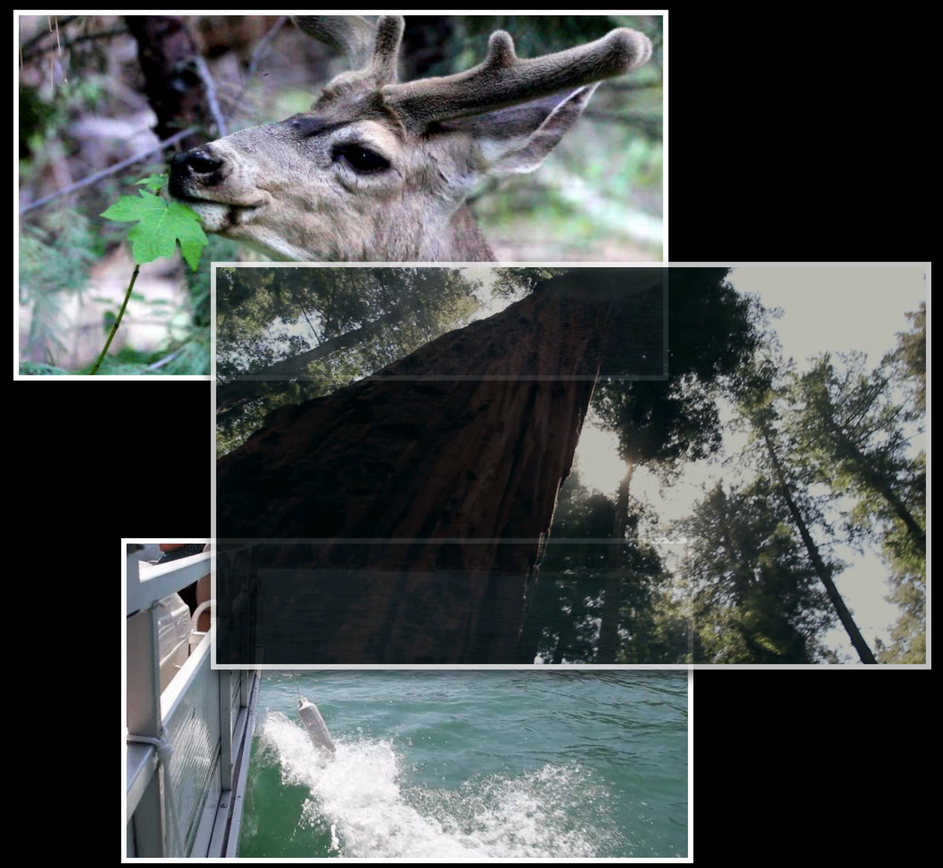
New Opportunities

OpenGL and Everything Else

Custom Video Compositor

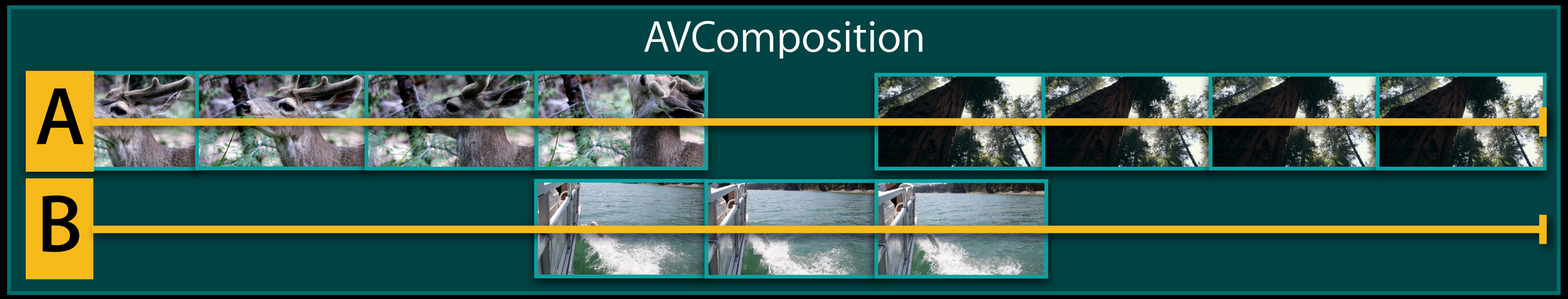
What Is a Video Compositor?

- Unit of video mixing code
- Receives multiple source frames
- Blends or transforms pixels
- Delivers single output frame
- Part of the composition architecture



Composition Model

Composition Model



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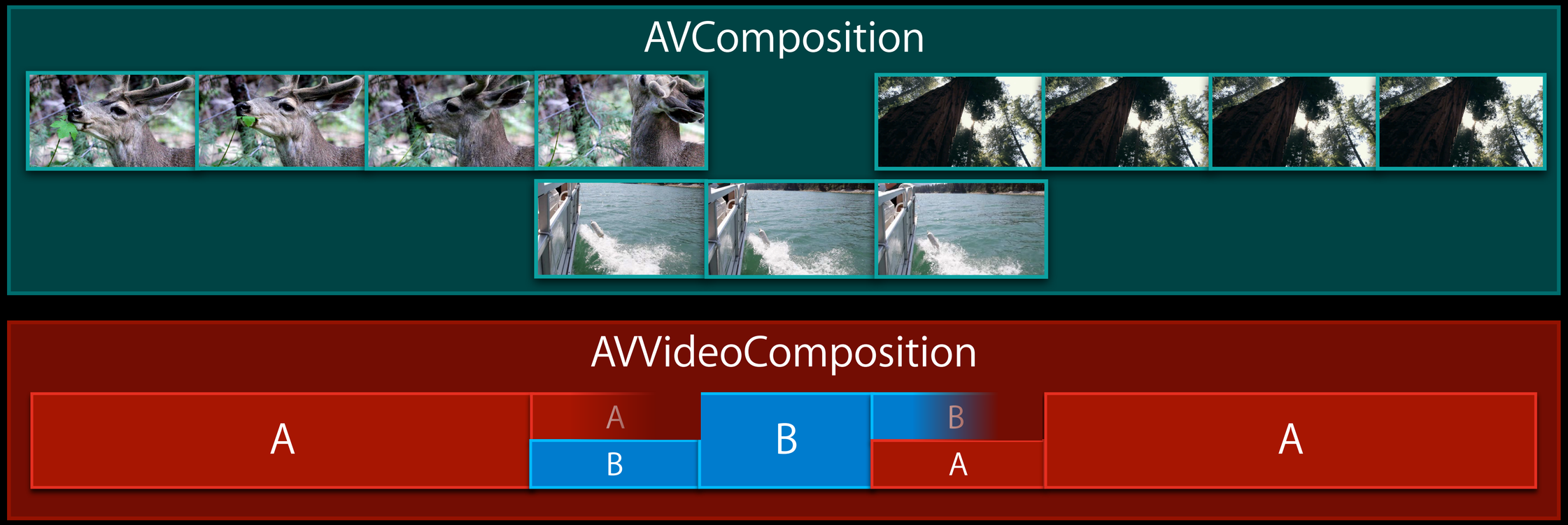
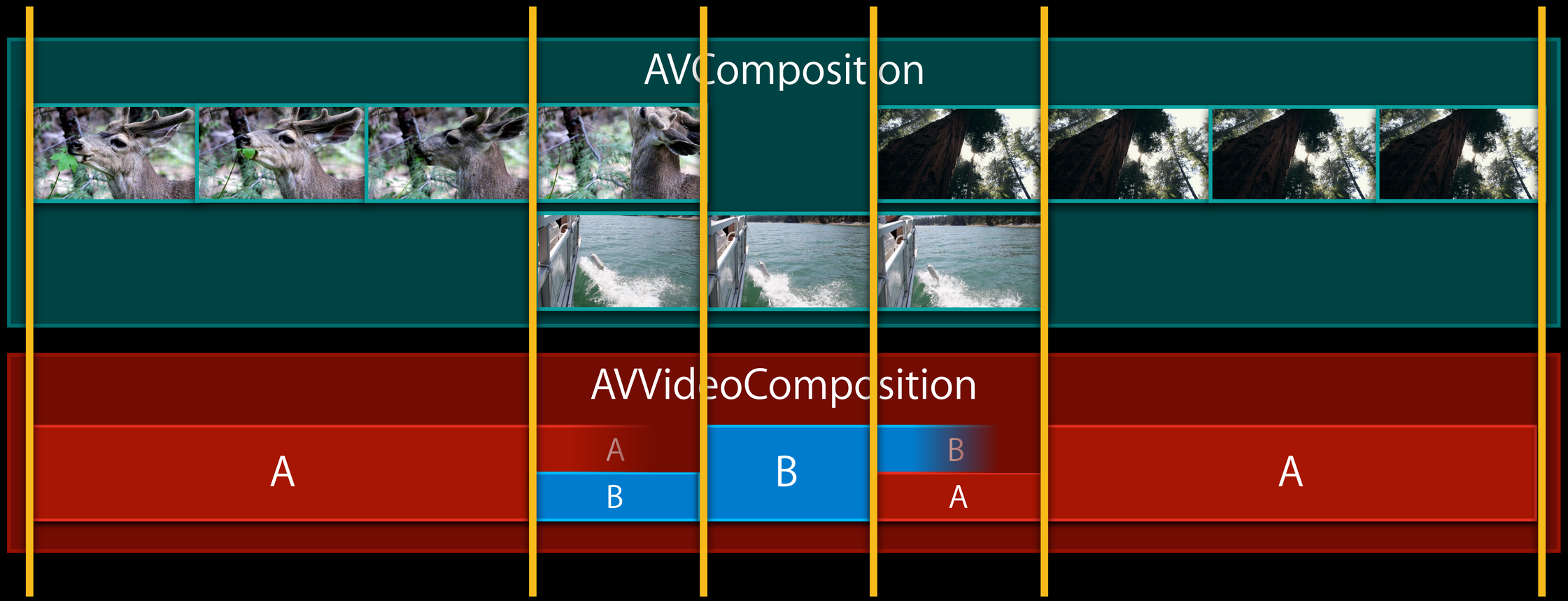
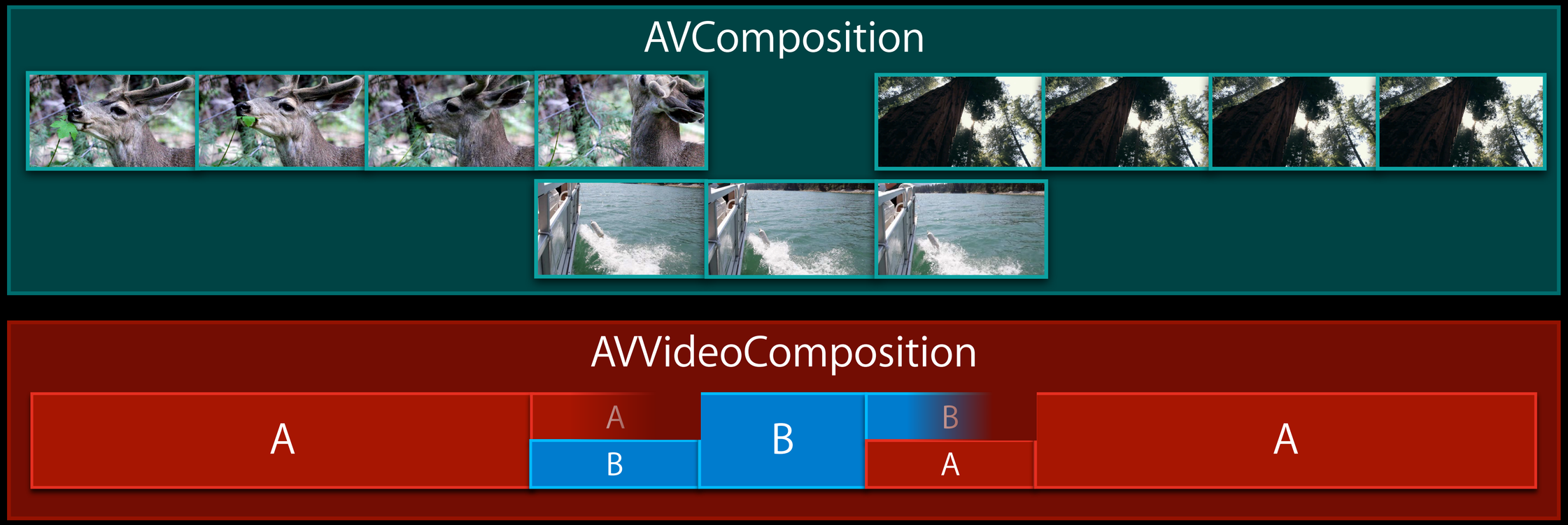


Composition Model

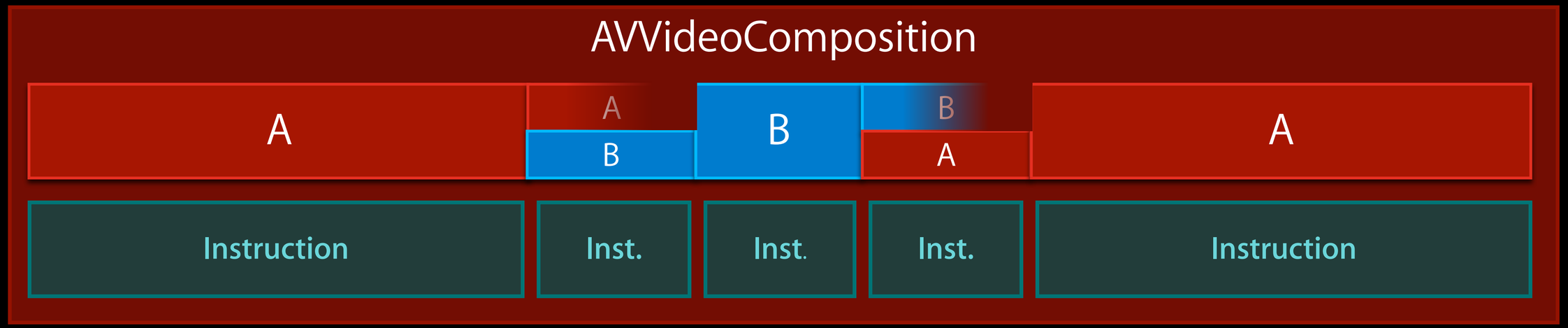


Composition Model

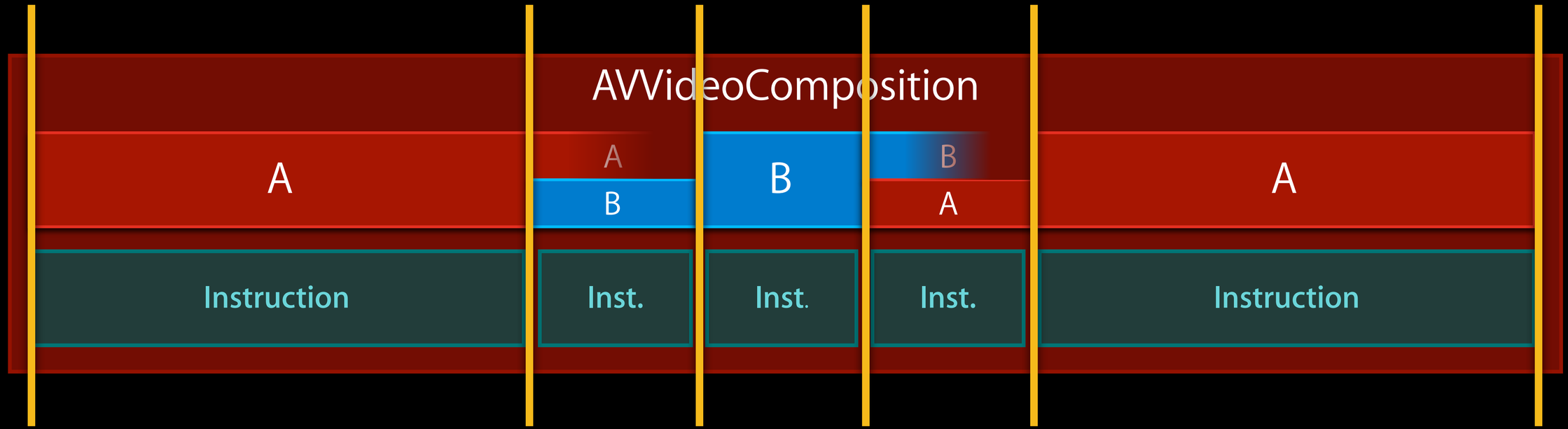


Composition Model

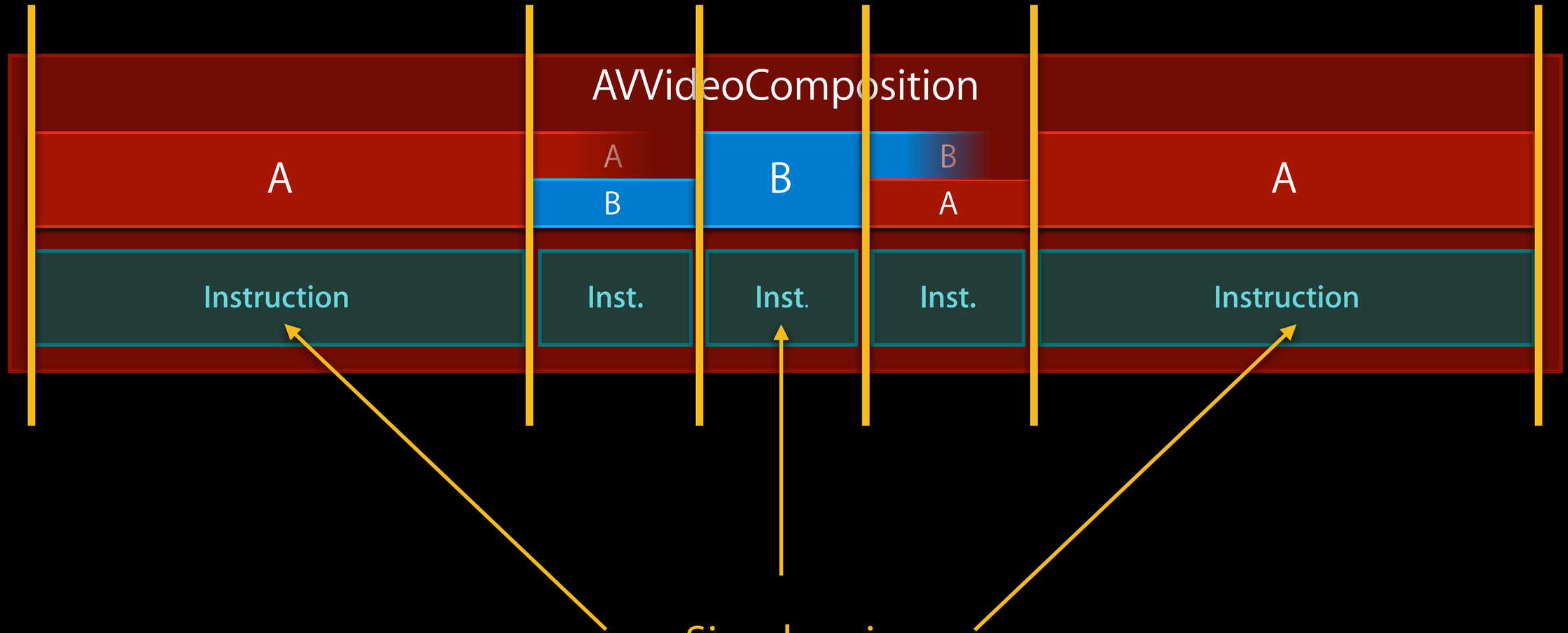
Video Instructions



Video Instructions

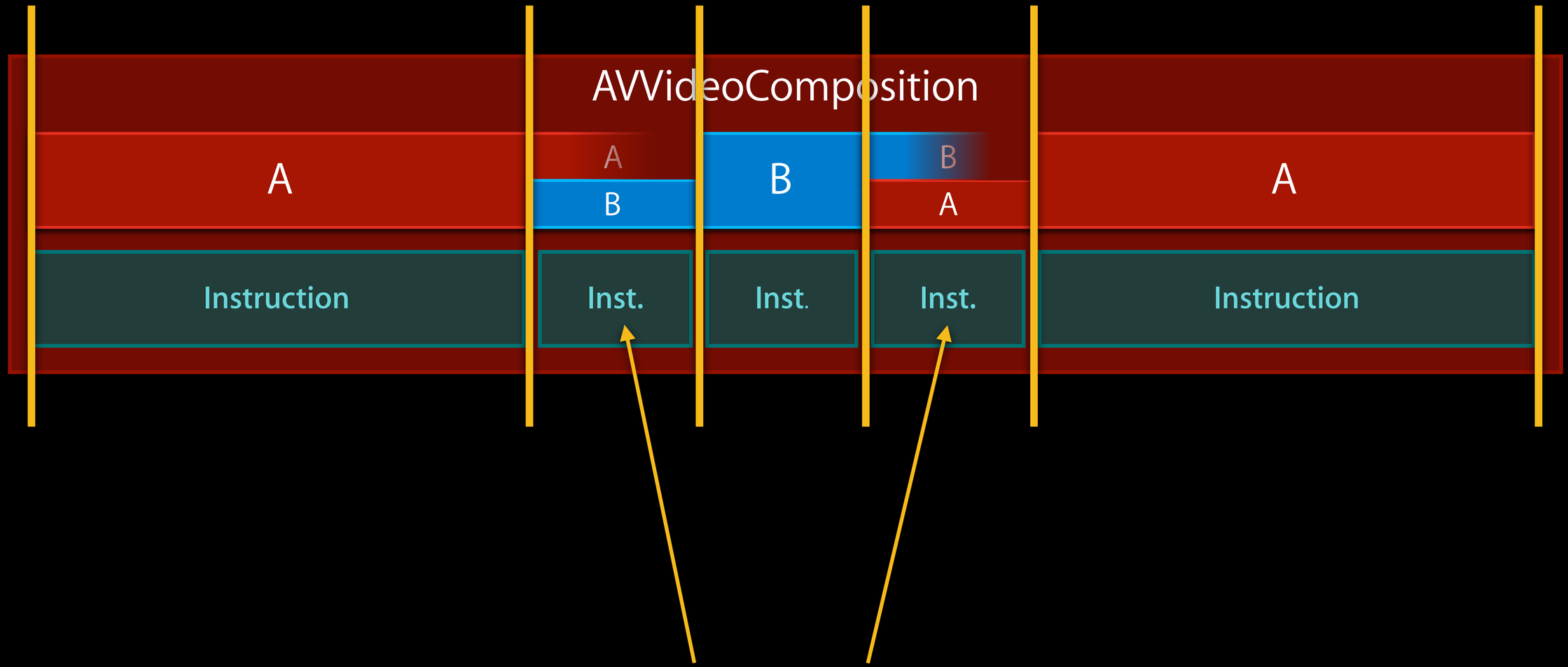


Video Instructions



Simple mix
1 source track

Video Instructions



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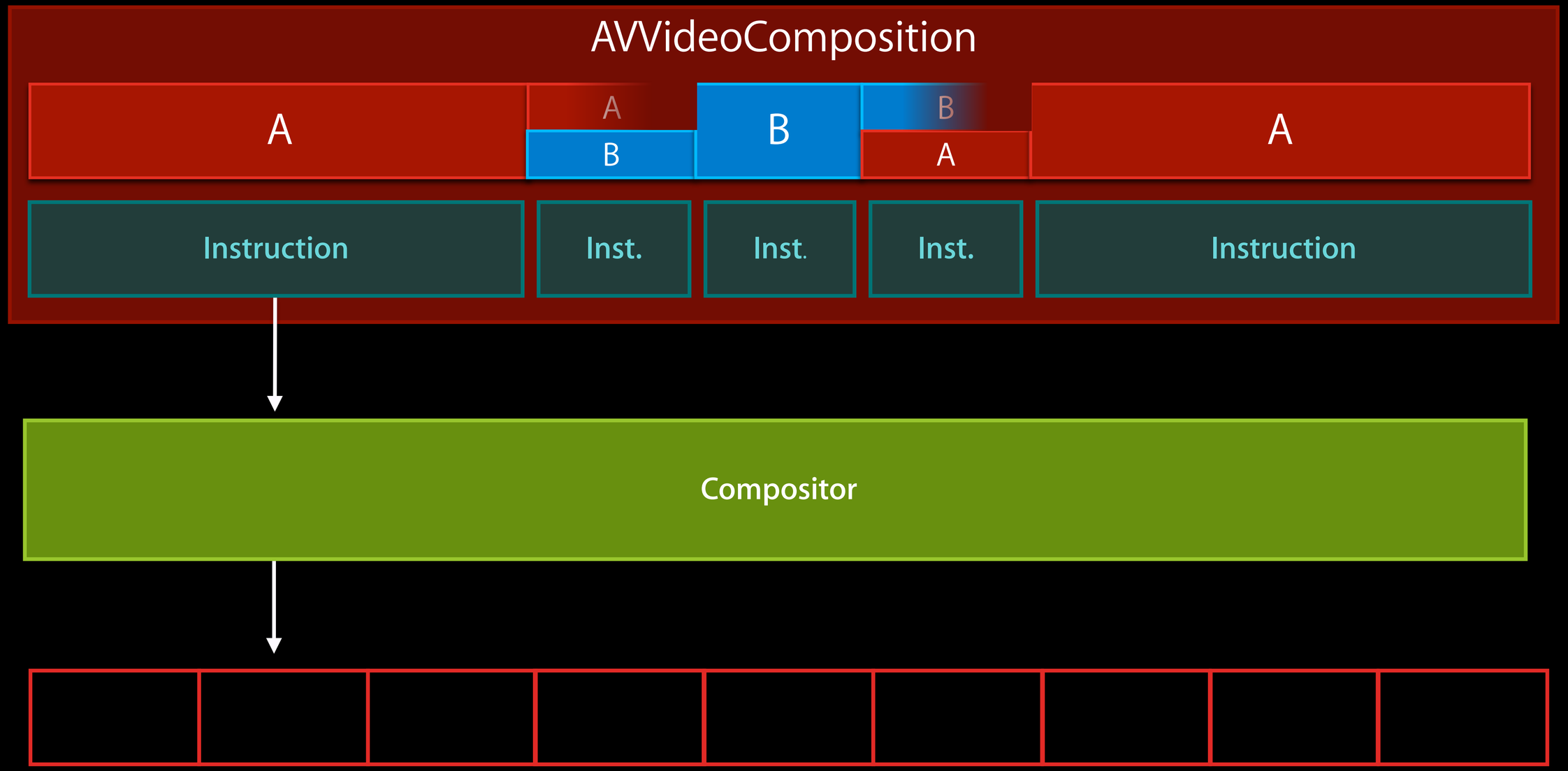

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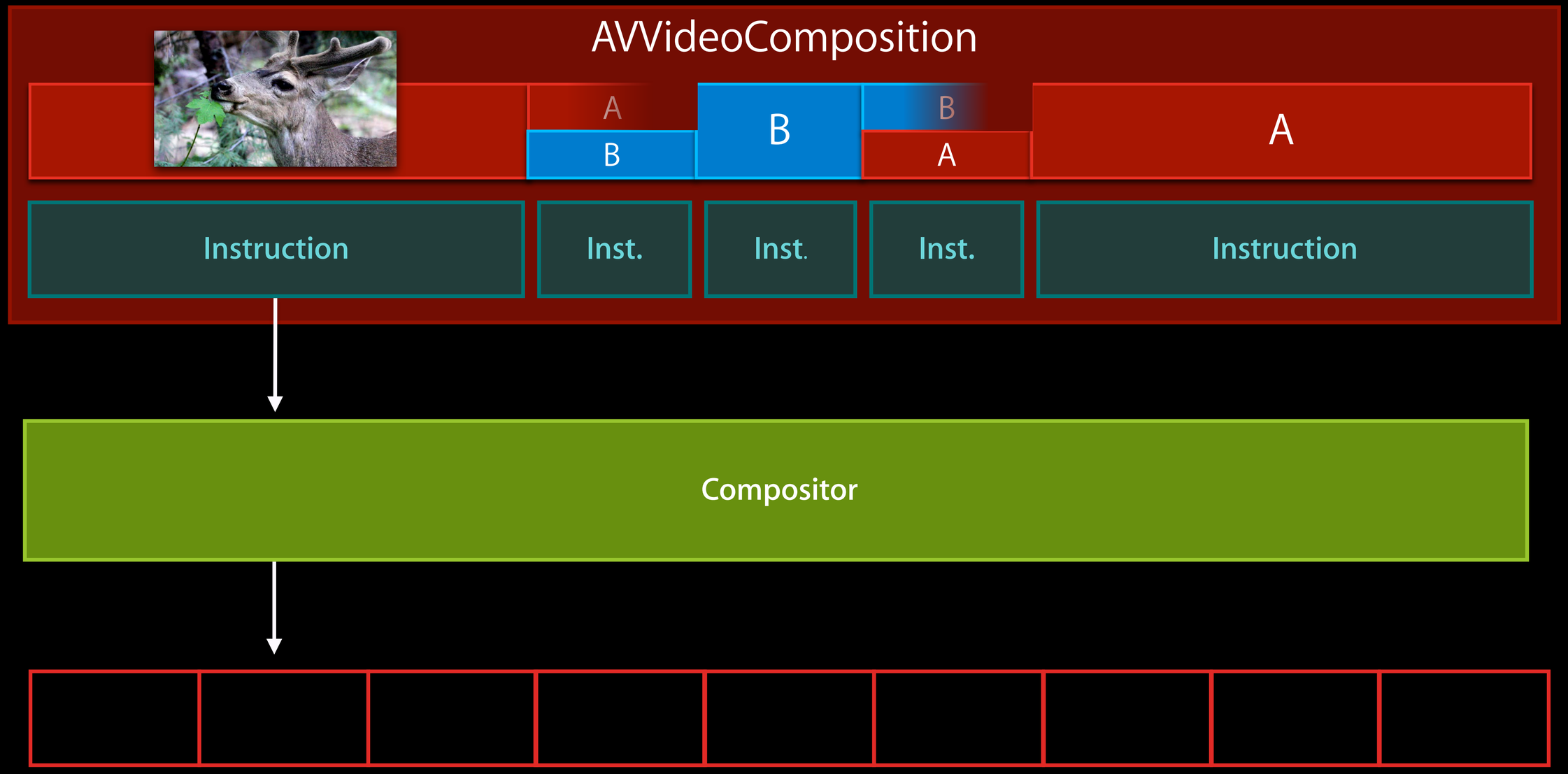

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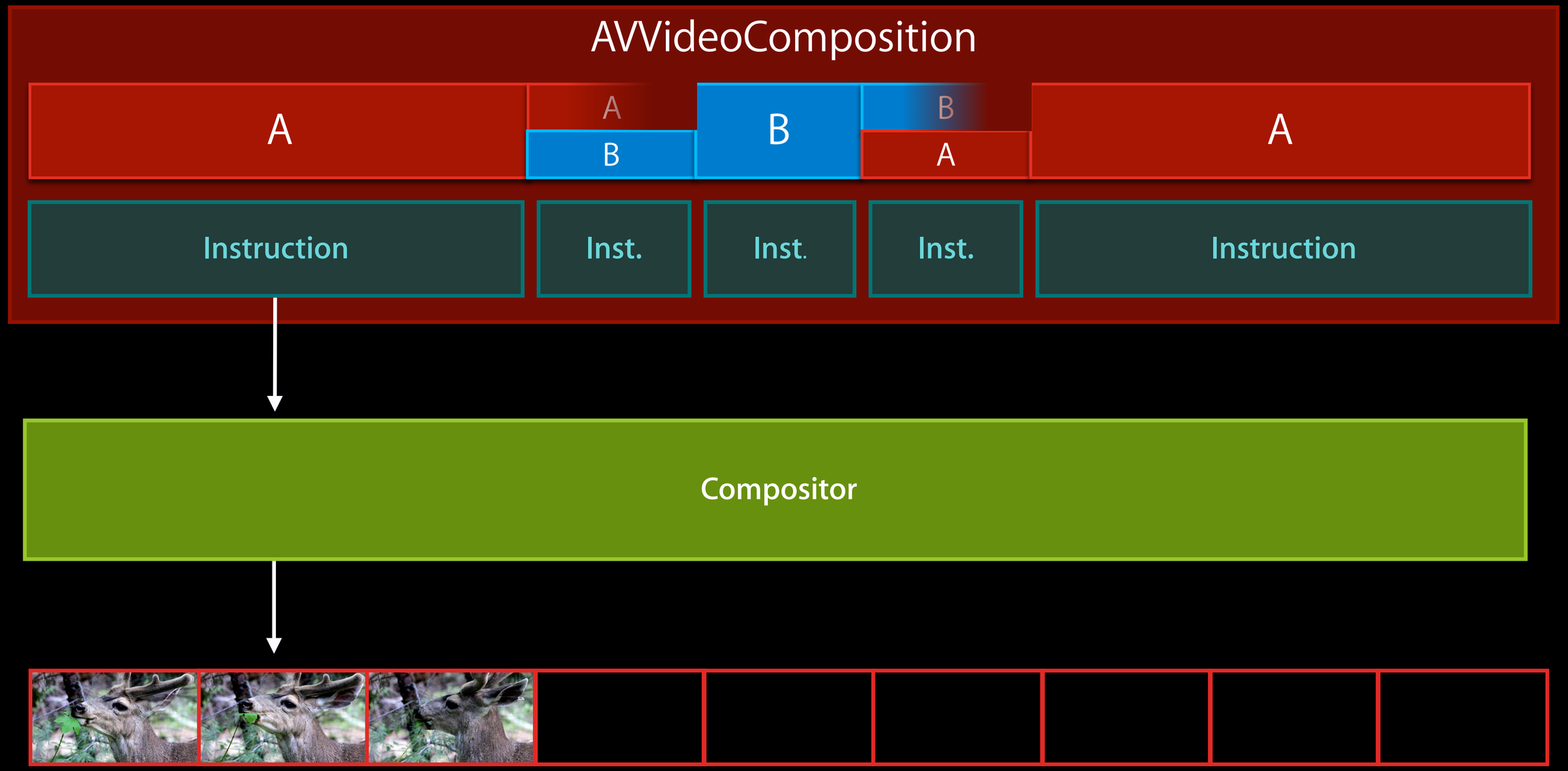
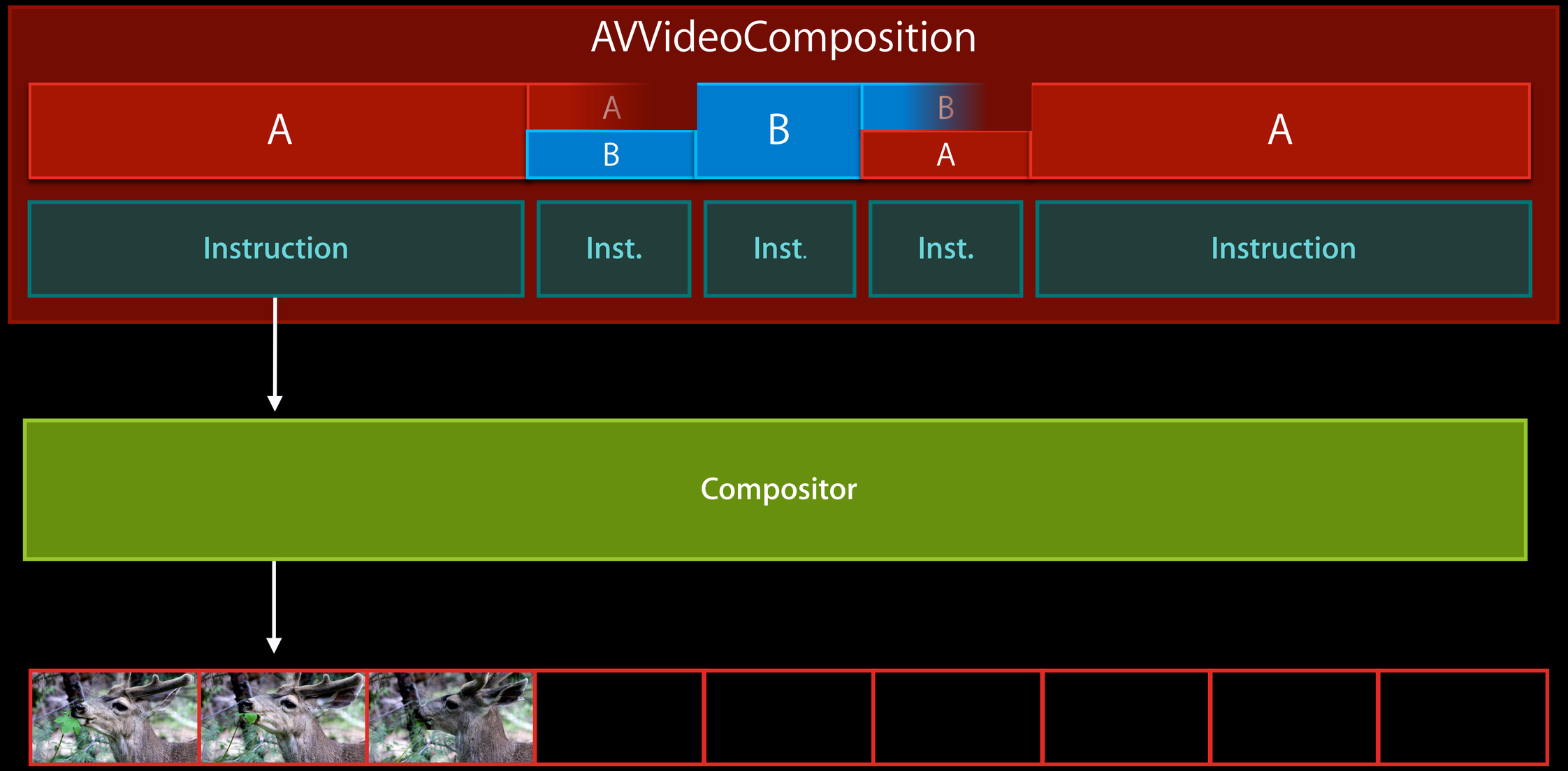
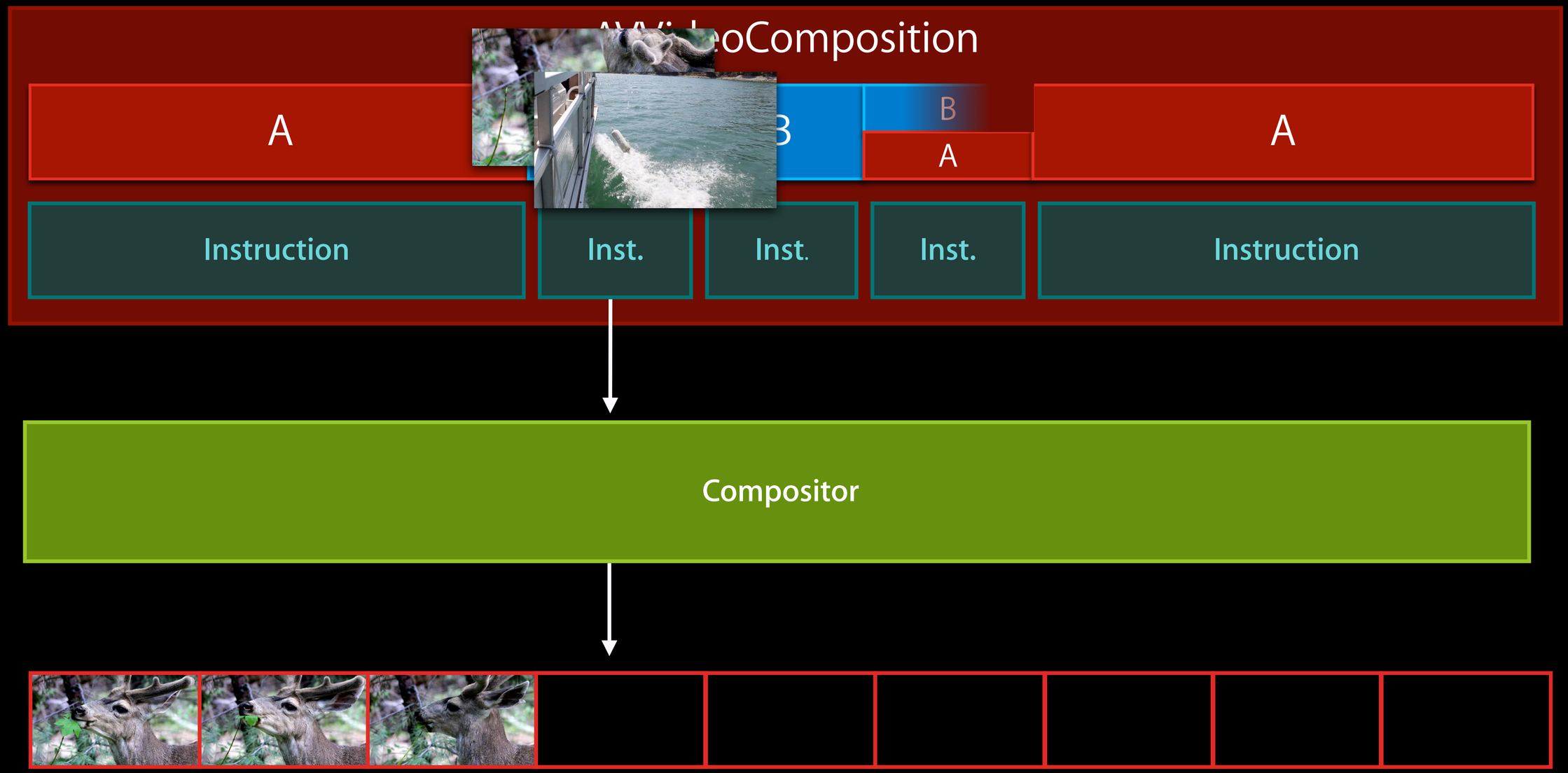


Video Instructions



Video Instructions



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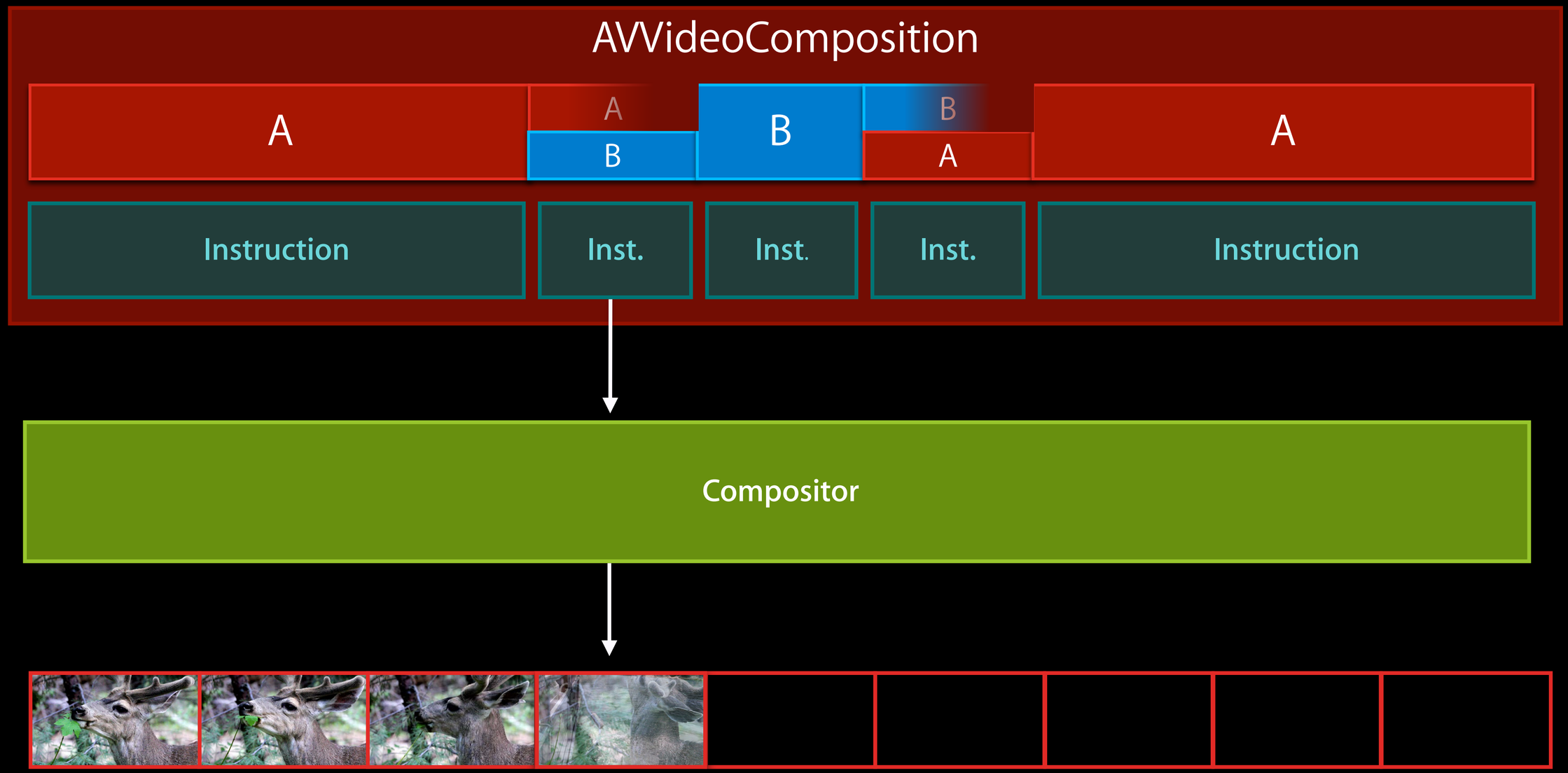

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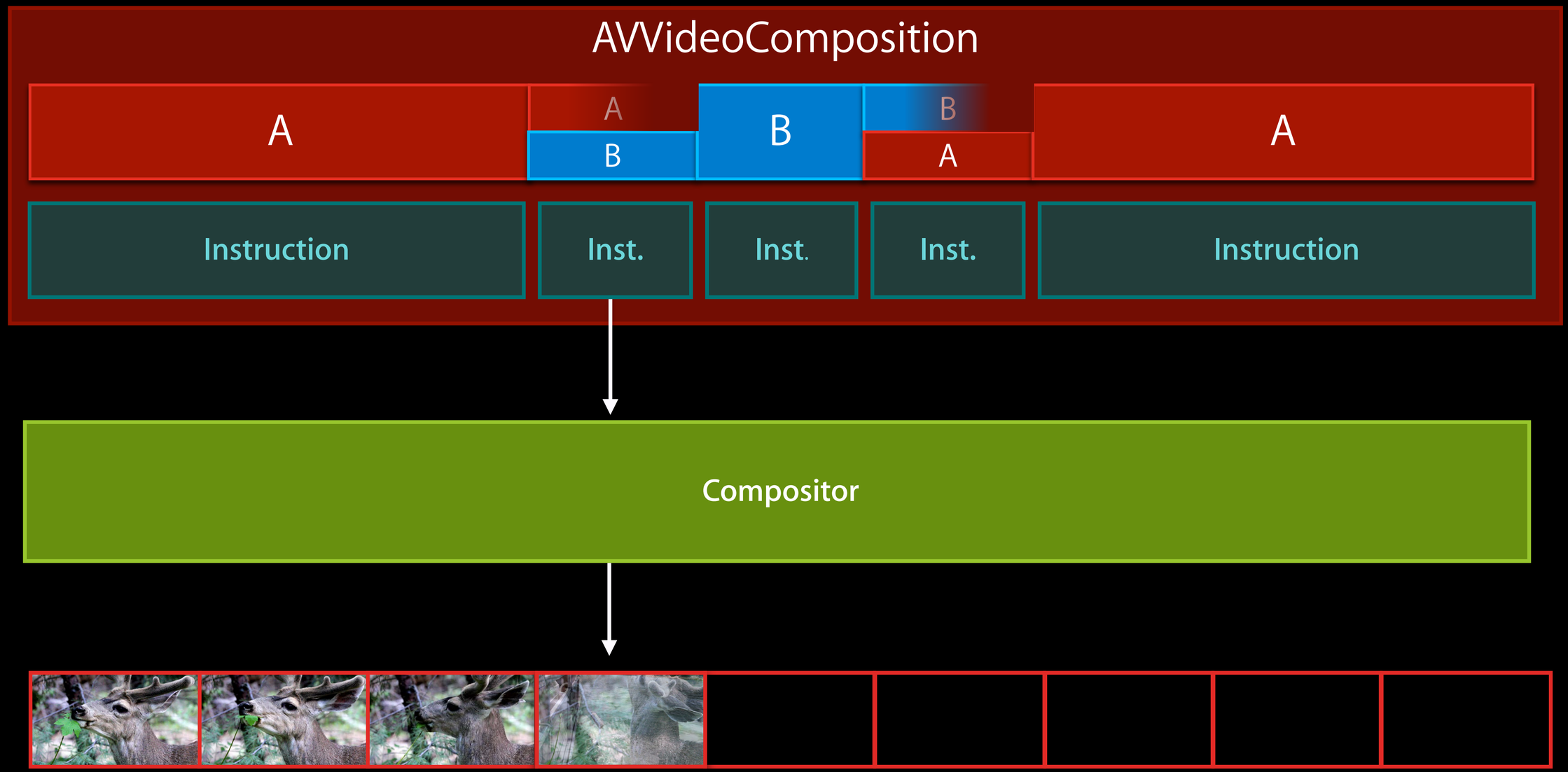

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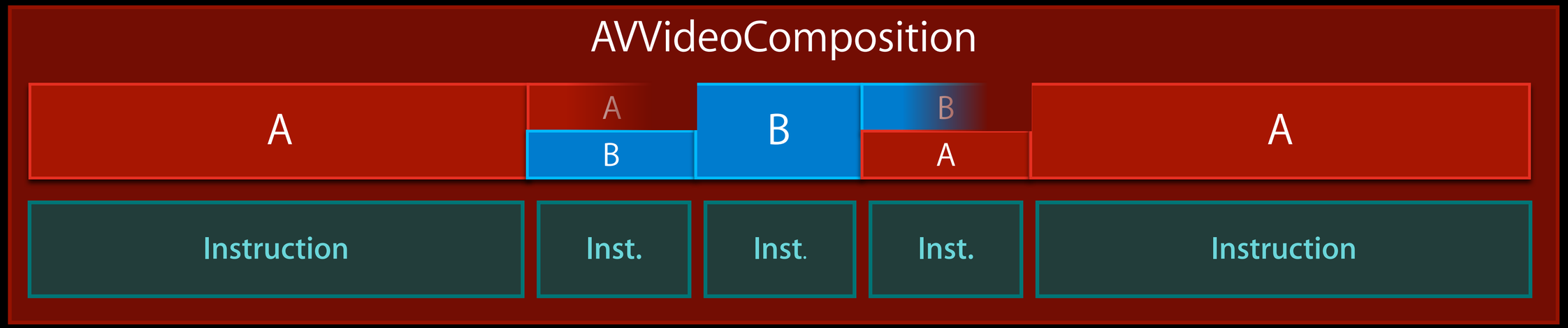

Compositor

Compositor

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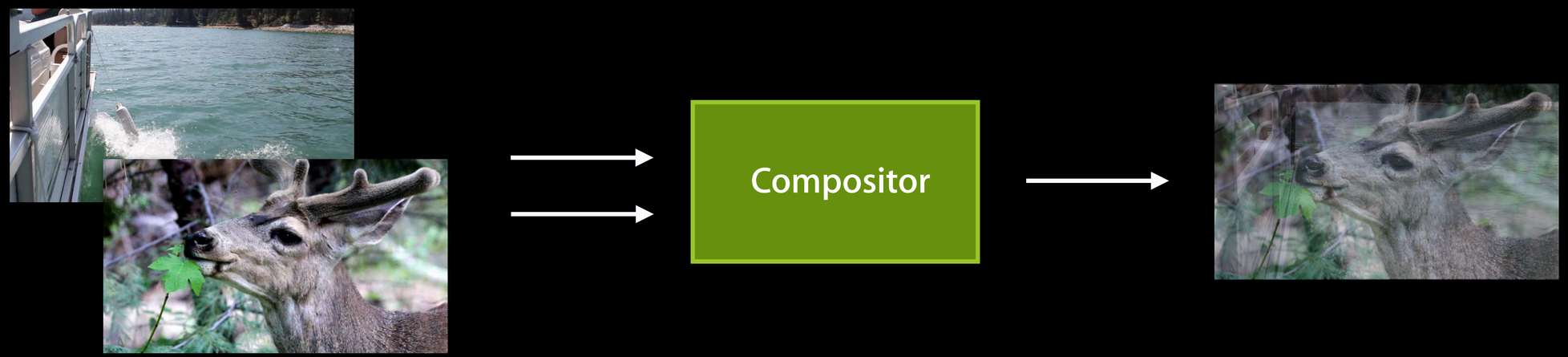
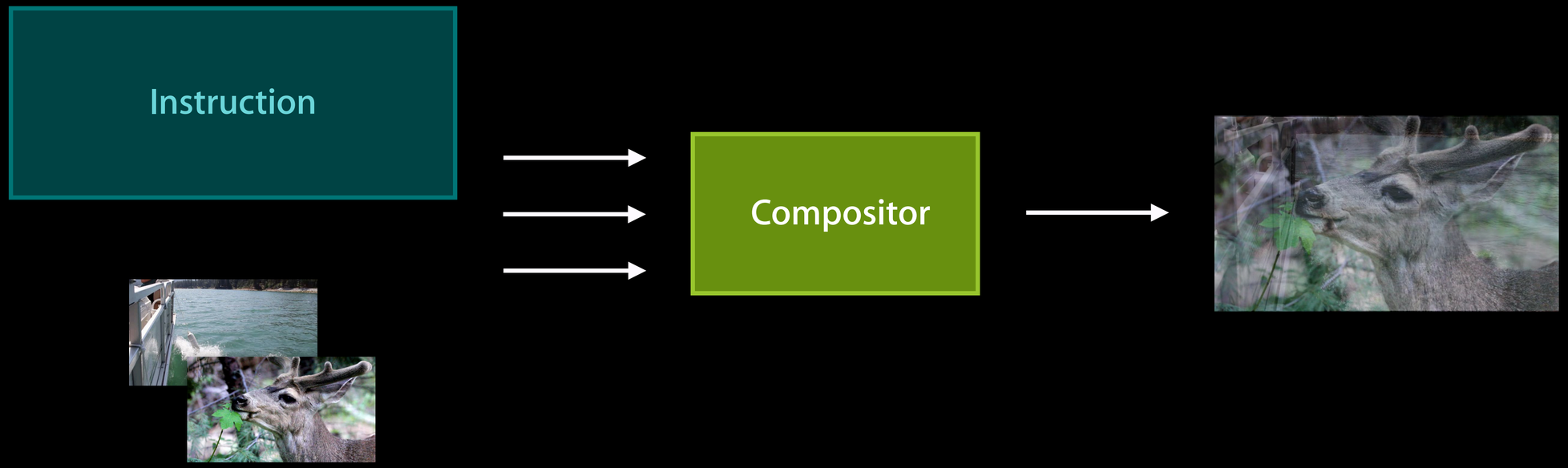
Video Compositor



Video Compositor



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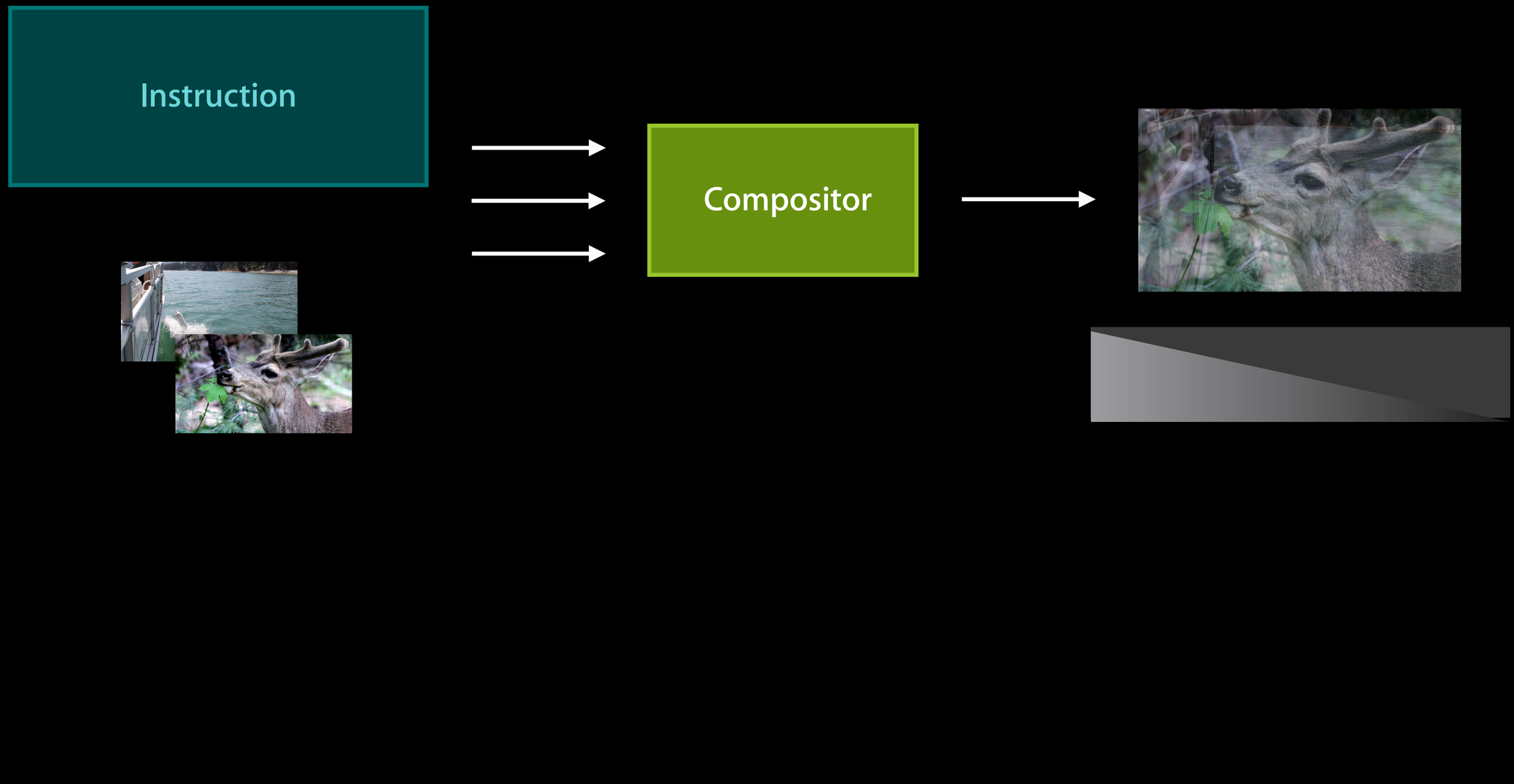

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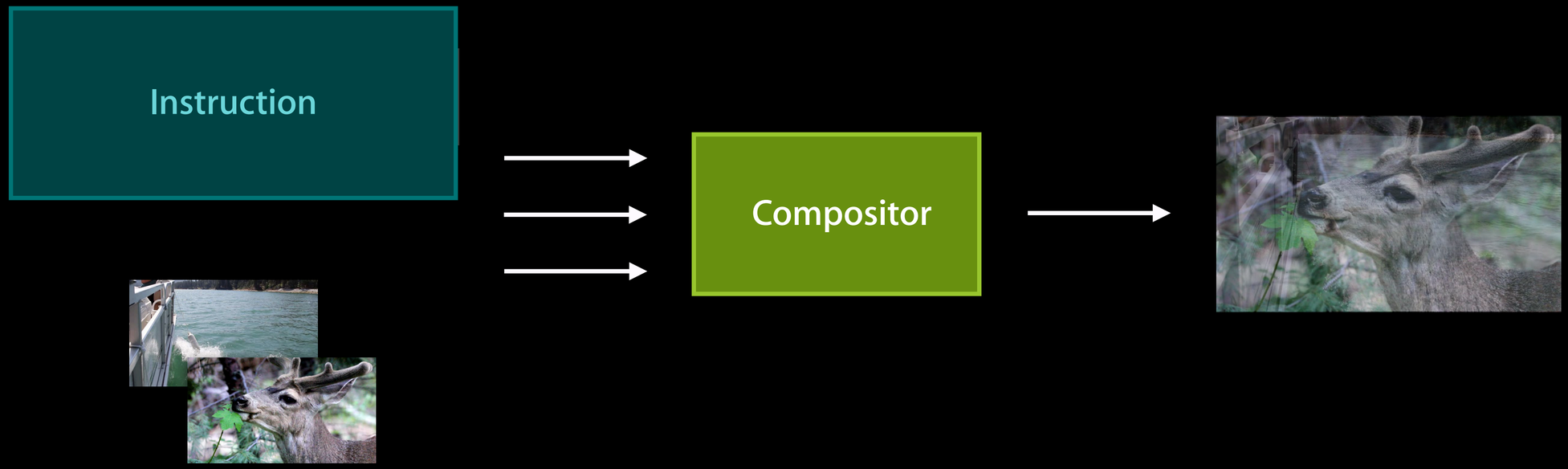
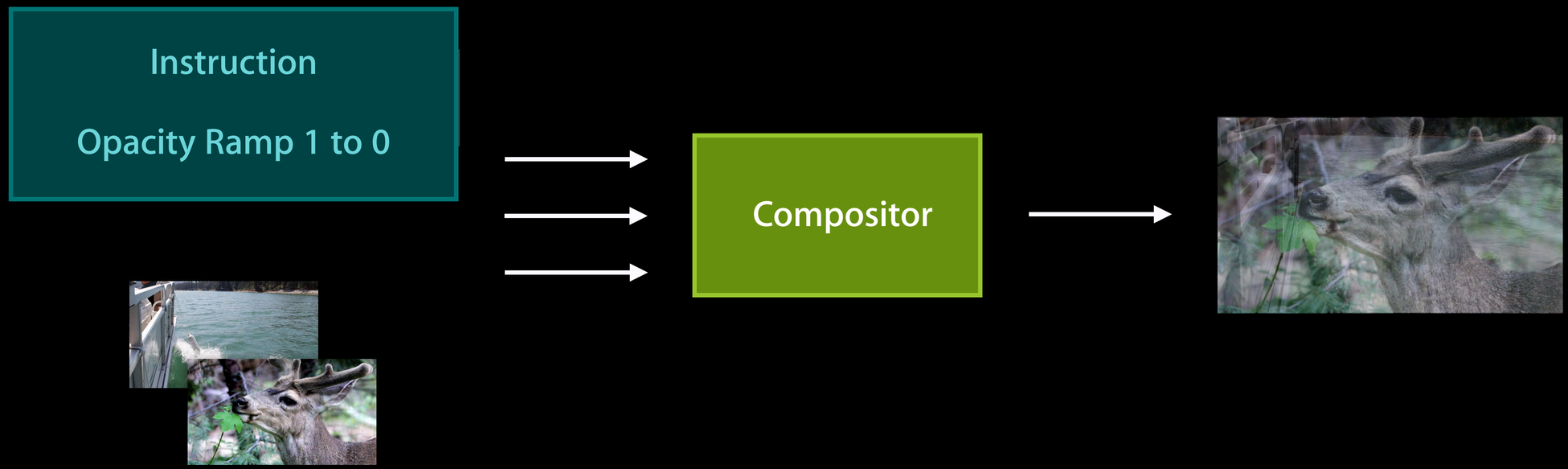


Video Compositor



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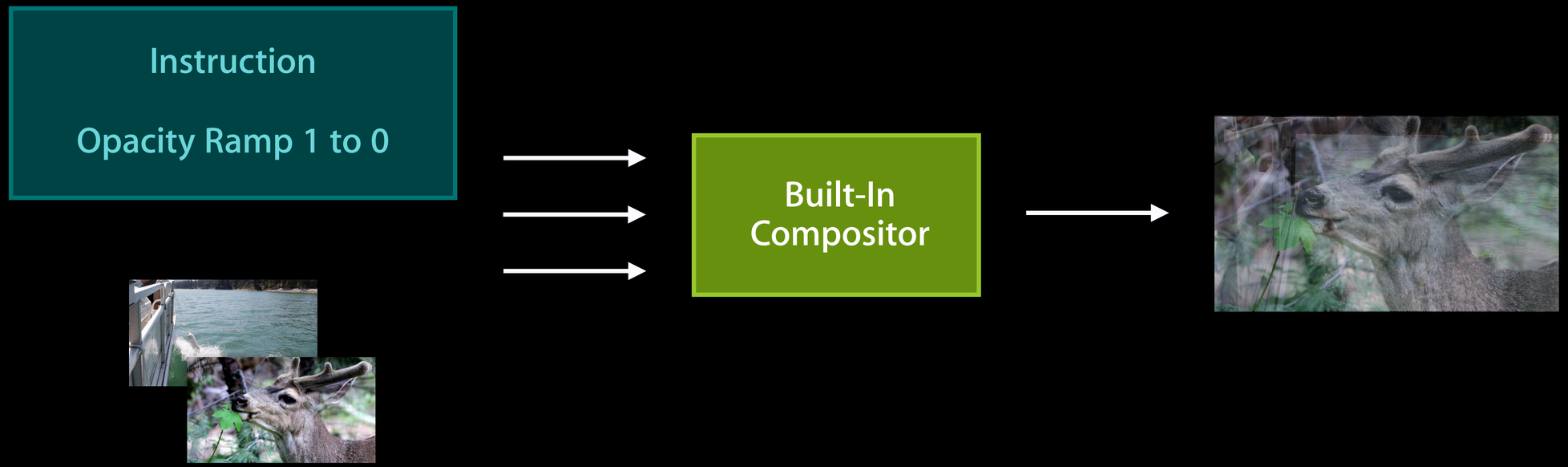
  - Common pitfalls

Video Compositor



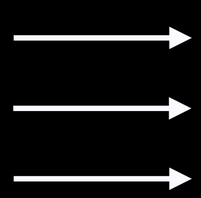
Video Compositor

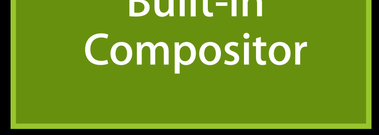
Instruction

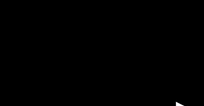
Opacity Ramp 1 to 0

Built-In Compositor

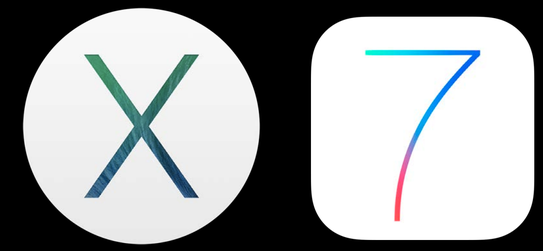
Video Compositor

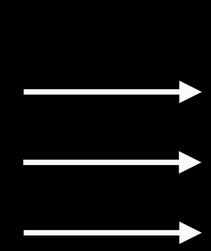






Custom Video Compositor





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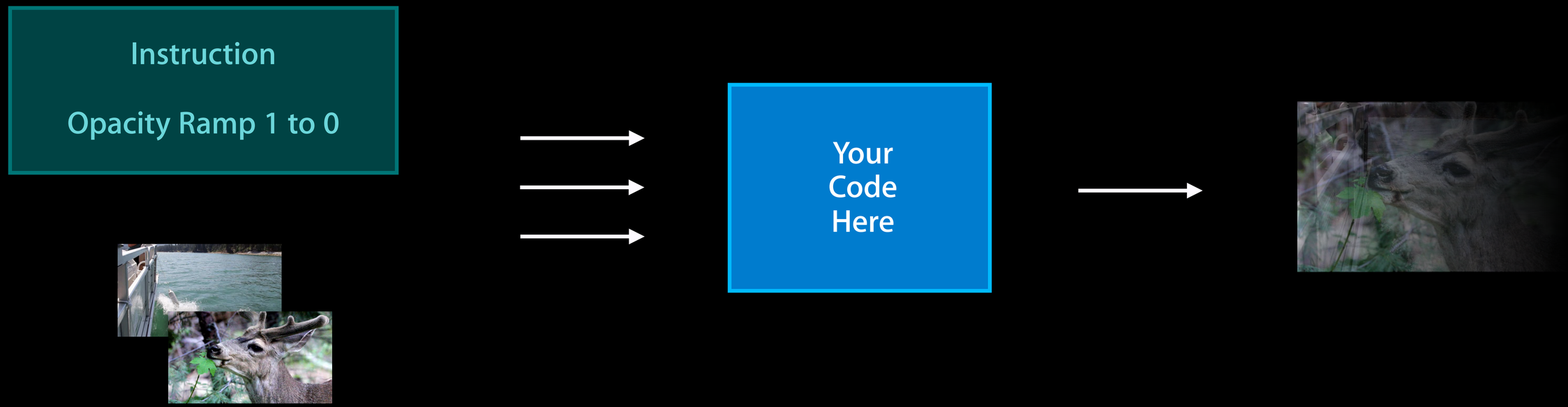

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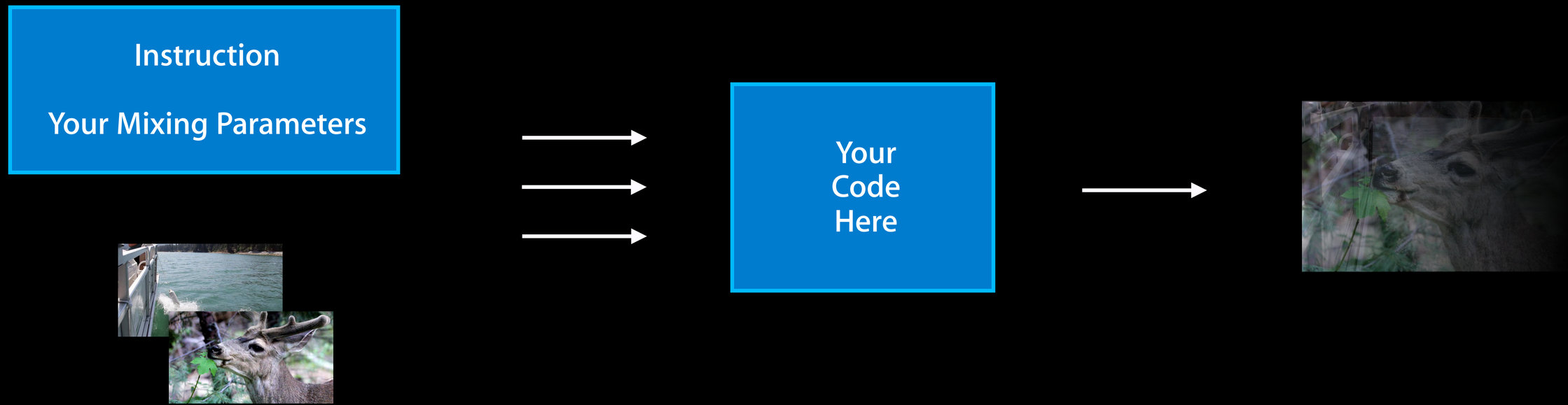

Custom Video Compositor

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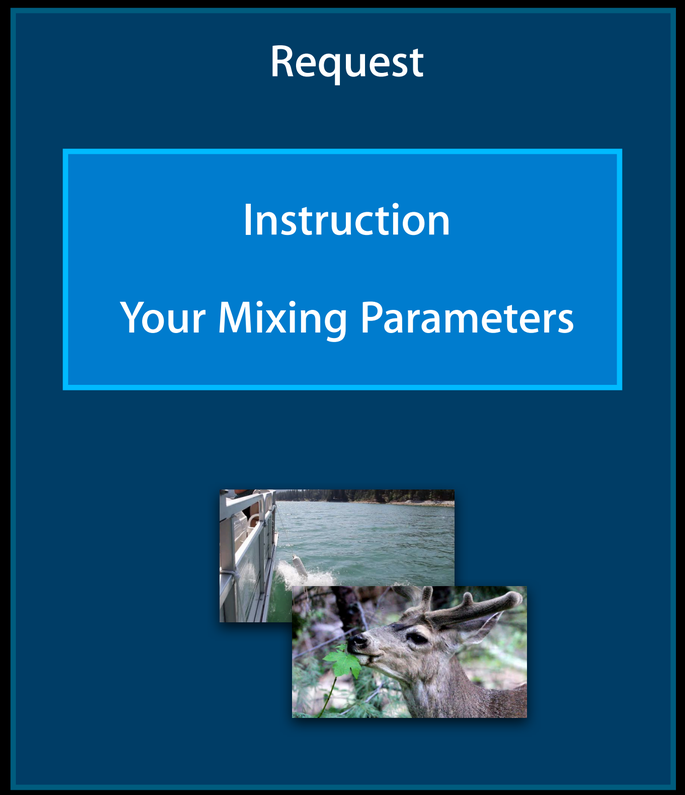

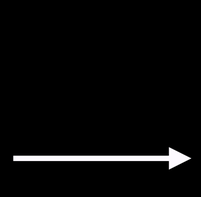

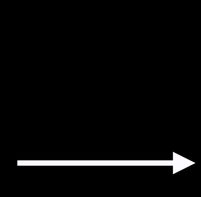

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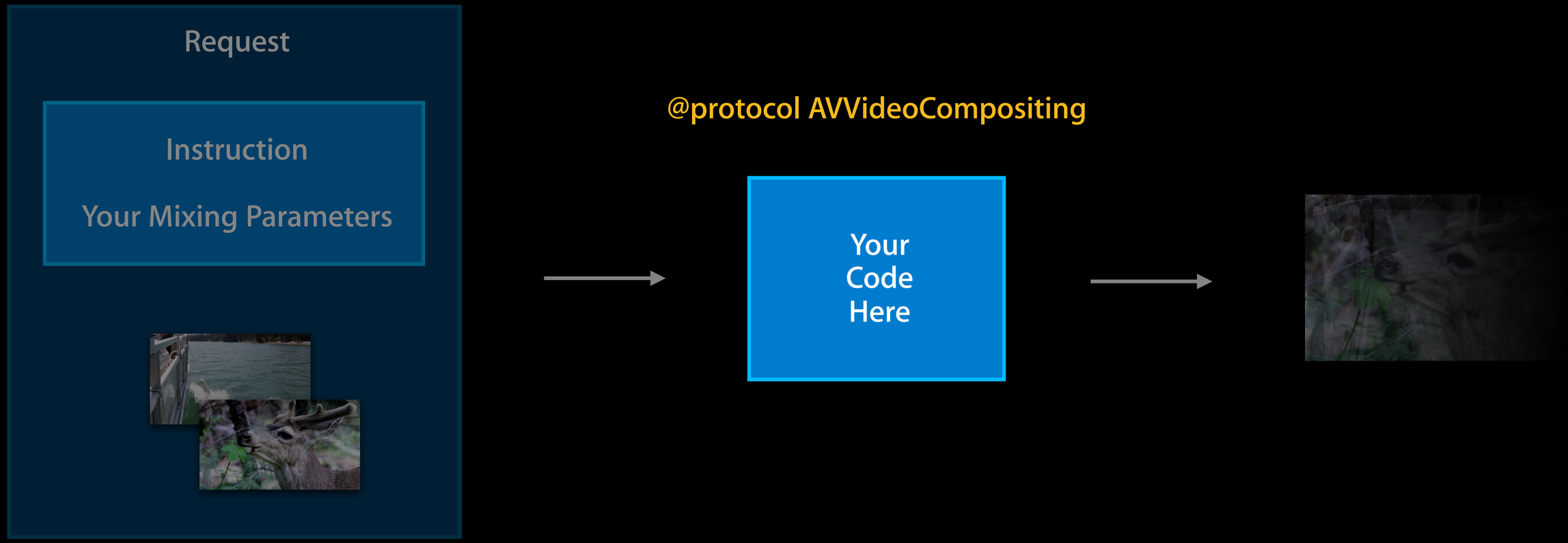
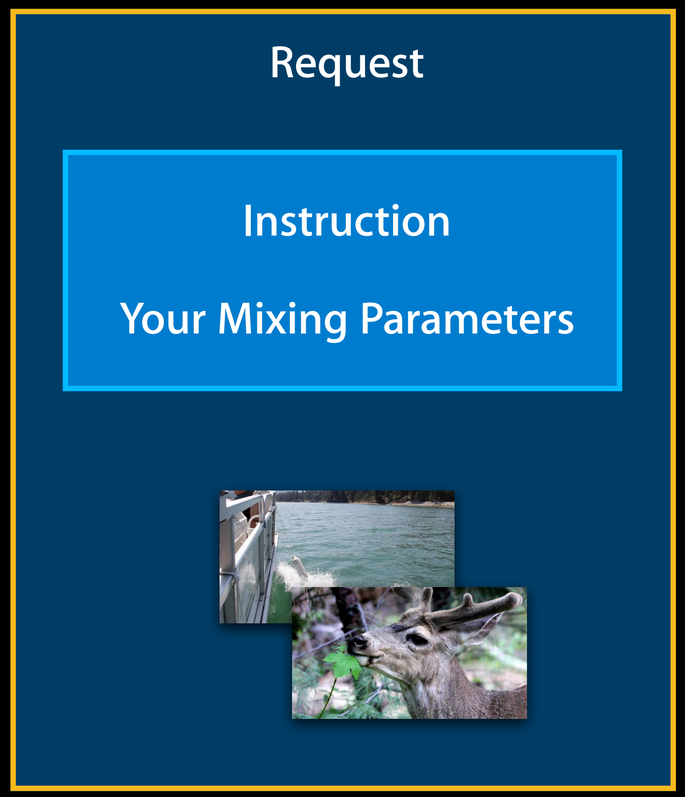


Custom Video Compositor

AVAsynchronousVideoCompositionRequest



@protocol AVVideoCompositing

Custom Video Compositor

AVAsynchronousVideoCompositionRequest

Request

@protocol AVVideoCompositionInstruction

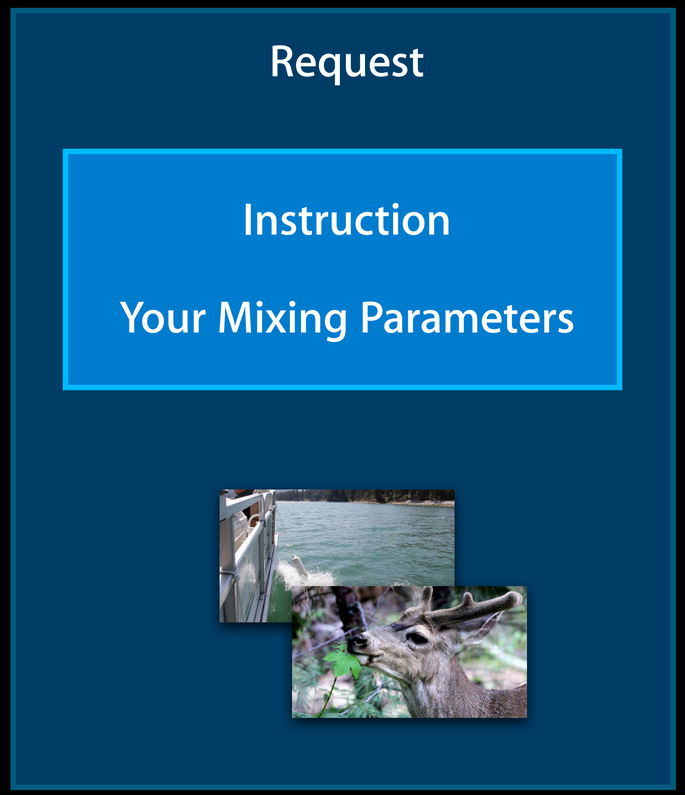
Instruction

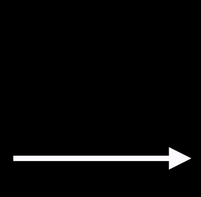
Your Mixing Parameters

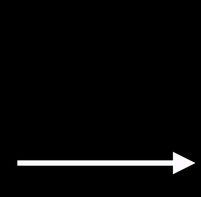
@protocol AVVideoCompositing

Your Code Here

Custom Video Compositor

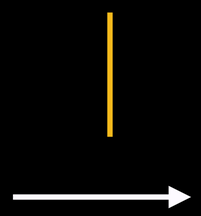


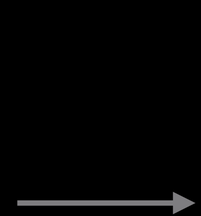




Custom Video Compositor

startVideoCompositionRequest:





Custom Video Compositor

Request

Instruction

Your Mixing Parameters

startVideoCompositionRequest:

Your Code Here

finishWithComposedVideoFrame:

Custom Video Compositor

Request

Instruction

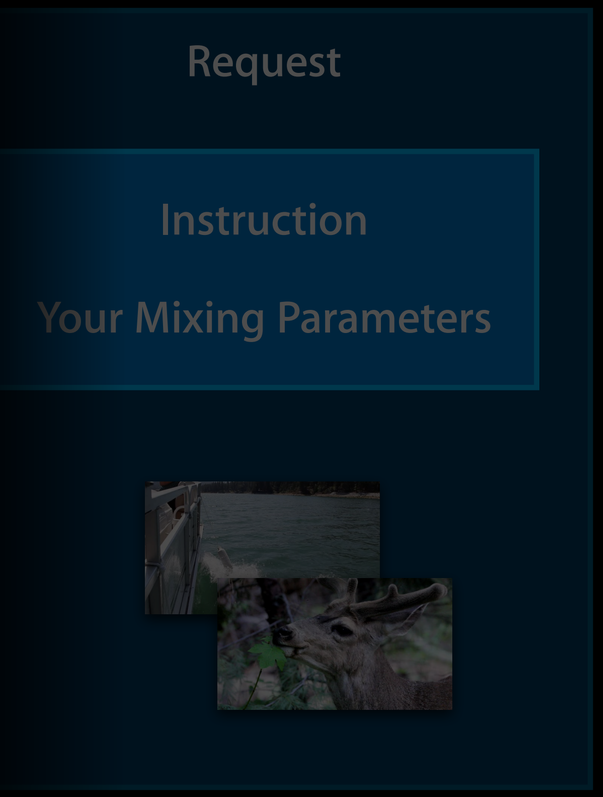
Your Mixing Parameters

startVideoCompositionRequest:

Your
Code
Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Custom Video Compositor



startVideoCompositionRequest:

Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Custom Video Compositor

Request

Instruction

Mixing Parameters

startVideoCompositionRequest:

Your Code Here

finishWithError:
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Custom Video Compositor

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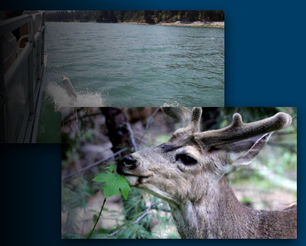
Mixing Parameters



startVideoCompositionRequest:

Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Request

Instruction

Mixing Paran

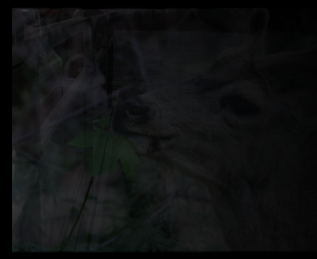
startVideoCompositionRequest:

Your
Code
Here

finishWithError:

finishCancelledRequest:

finishWithComposedVideoFrame:



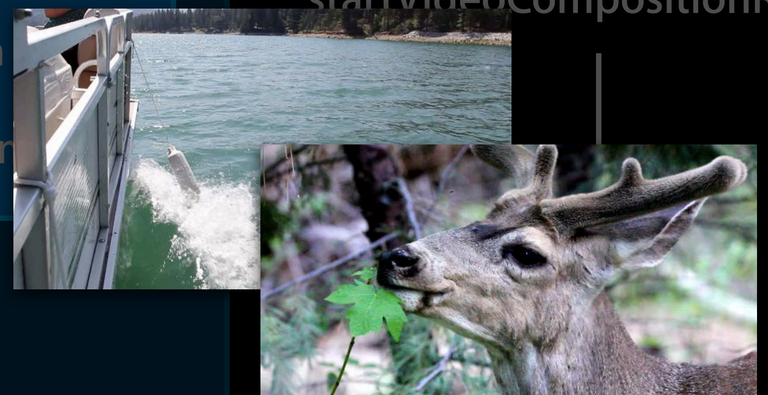
Choosing Pixel Formats

Request

Instruction

Mixing Paran

startVideoCompositionRequest:



Your Code Here

finishWithError:

finishCancelledRequest:

finishWithComposedVideoFrame:

Choosing Pixel Formats

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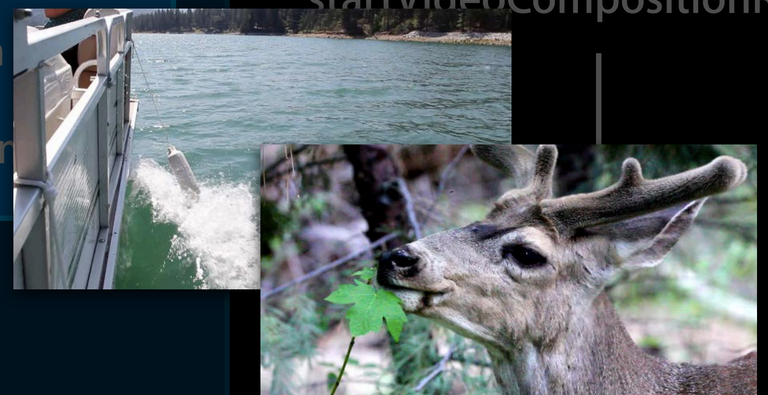
Instruction

Mixing Paran

startVideoCompositionRequest:



Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Source Pixel Format
YUV 8-bit 4:2:0
YUV 8-bit 4:4:4
YUV 10-bit 4:2:2
YUV 10-bit 4:4:4
RGB 24-bit
BGRA 32-bit
BGR 24-bit
ARGB 32-bit
ABGR 32-bit

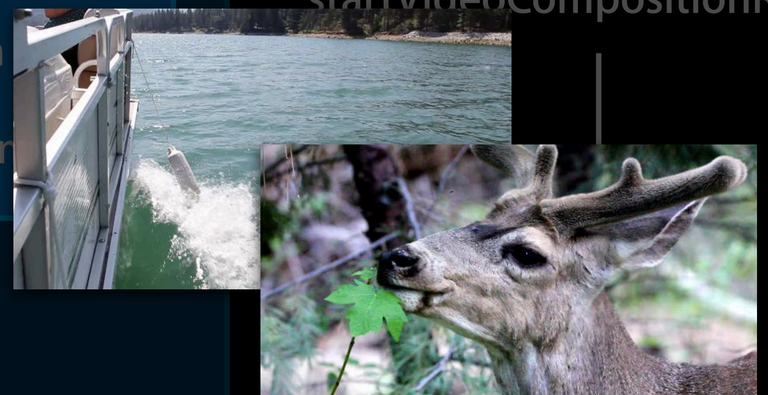
Choosing Pixel Formats

Request

Instruction

Mixing Paran

startVideoCompositionRequest:



Your Code Here

finishWithError:
finishCancelledRequest:
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Source Pixel Format
YUV 8-bit 4:2:0

Choosing Pixel Formats

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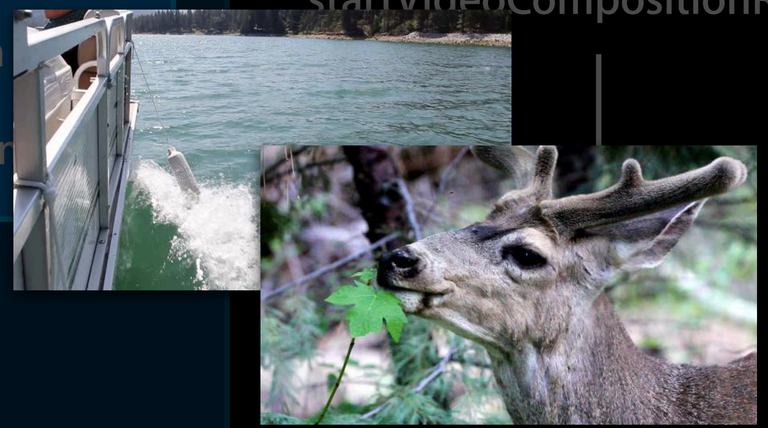


Source Pixel Format
YUV 8-bit 4:2:0

Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

```
(NSDictionary *) sourcePixelBufferAttributes
```

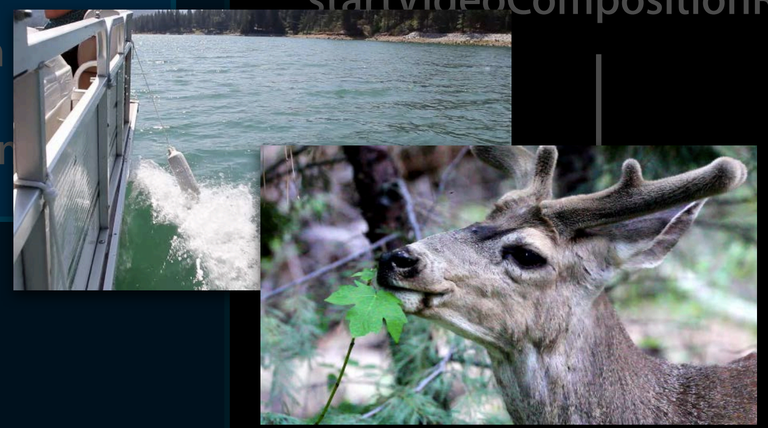
Choosing Pixel Formats

Request

Instruction

Mixing Paran

startVideoCompositionRequest:



Source Pixel Format
YUV 8-bit 4:2:0

Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

```
(NSDictionary *) sourcePixelBufferAttributes
                 kCVPixelFormatType_32BGRA,...
```

Choosing Pixel Formats

Request

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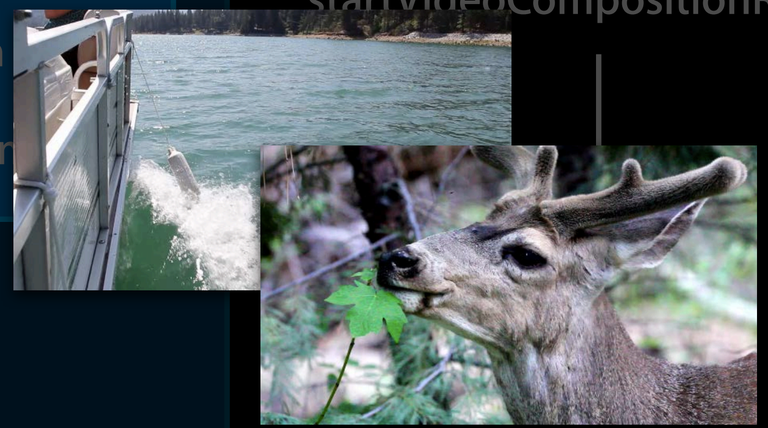
Mixing Paran

startVideoCompositionRequest:



Your Code Here

finishWithError:
finishCancelledRequest:
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Source Pixel Format

`kCVPixelFormatType_32BGRA,...`

```
(NSDictionary *) sourcePixelBufferAttributes
```

Choosing Pixel Formats

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Mixing Paran

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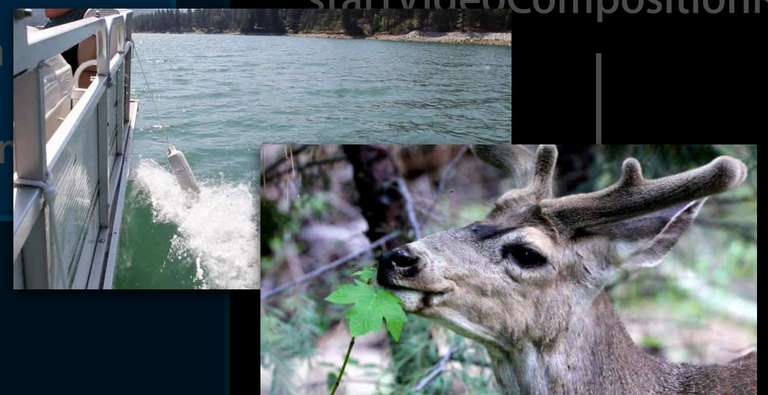

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Choosing Pixel Formats

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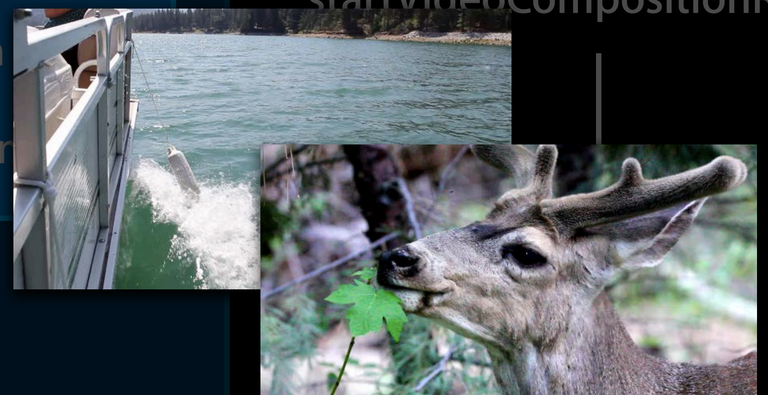
Mixing Paran

startVideoCompositionRequest:



Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Source Pixel Format
BGRA 32-bit

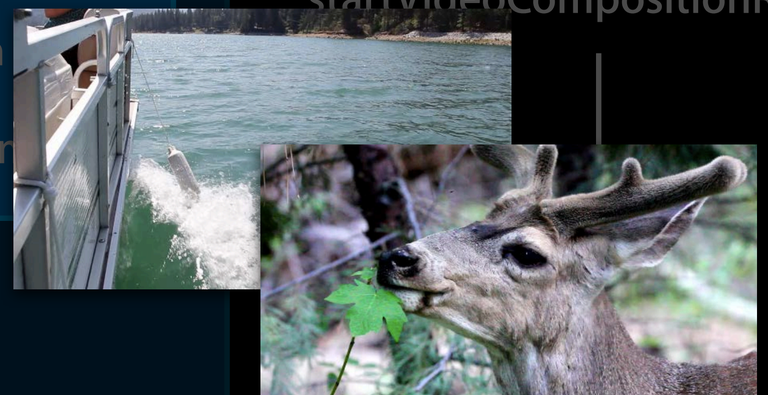
Choosing Pixel Formats

Request

Instruction

Mixing Paran

startVideoCompositionRequest:



Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Source Pixel Format
BGRA 32-bit

Choosing Pixel Formats

Request

Instruction

Mixing Parameters

startVideoCompositionRequest:

Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Source Pixel Format
BGRA 32-bit

Choosing Pixel Formats

Request

Instruction

Mixing Parameters

startVideoCompositionRequest:

Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Source Pixel Format
BGRA 32-bit

Output Pixel Format

Choosing Pixel Formats

Request

Instruction

Mixing Parameters

startVideoCompositionRequest:

Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Output Pixel Format

```
(NSDictionary *) requiredPixelBufferAttributesForRenderContext
```

Choosing Pixel Formats

Request

Instruction

Mixing Parameters

startVideoCompositionRequest:

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Your Code Here

Output Pixel Format

```
(NSDictionary *) requiredPixelBufferAttributesForRenderContext
kCVPixelFormatType_32BGRA,...
```

Choosing Pixel Formats

Request

Instruction

Mixing Parameters

startVideoCompositionRequest:

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

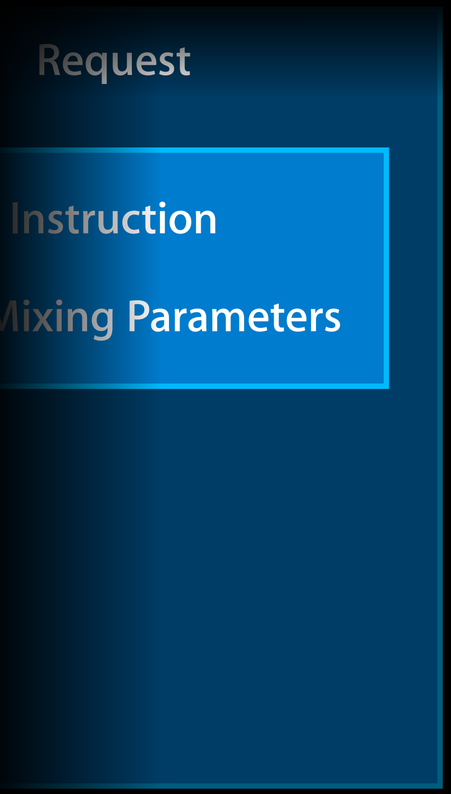
Your Code Here

Output Pixel Format

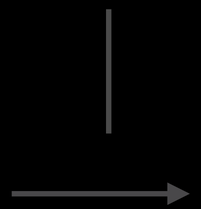
kCVPixelFormatType_32BGRA,...

(NSDictionary *) requiredPixelBufferAttributesForRenderContext

Choosing Pixel Formats

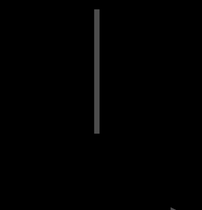


startVideoCompositionRequest:



Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:



Output Pixel Format

Choosing Pixel Formats

Request

Instruction

Mixing Parameters

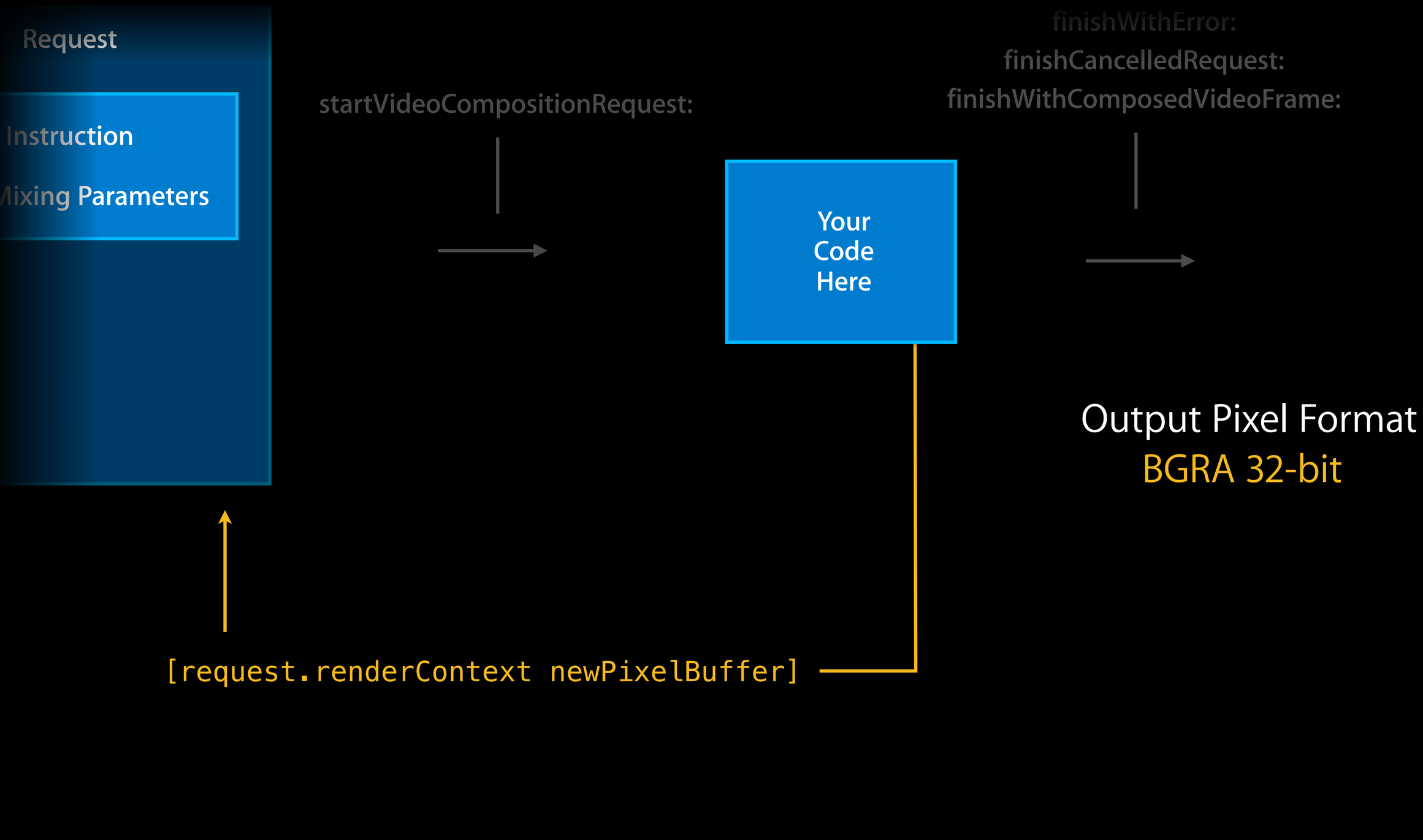
startVideoCompositionRequest:

Your Code Here

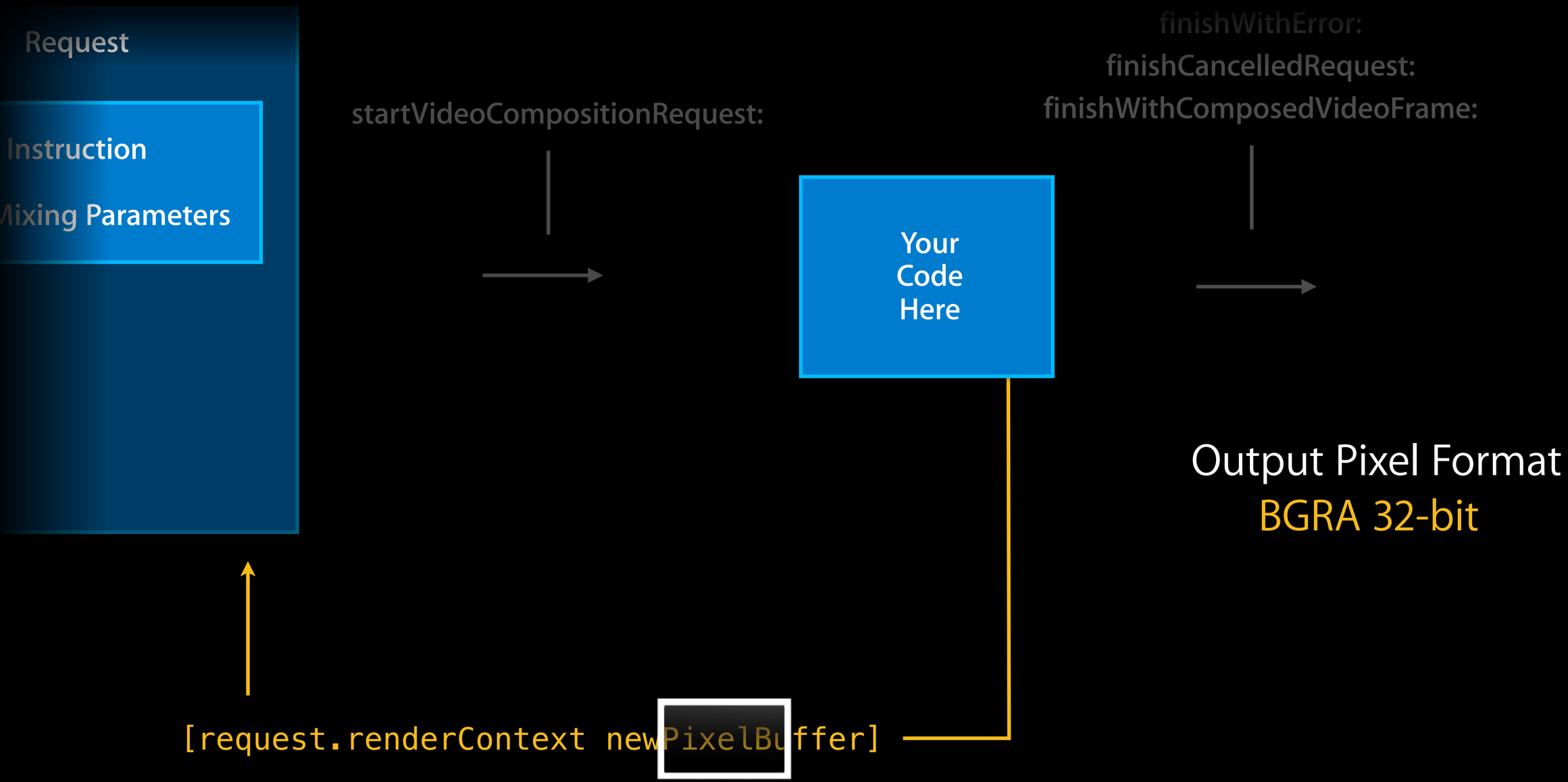
finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Output Pixel Format
BGRA 32-bit

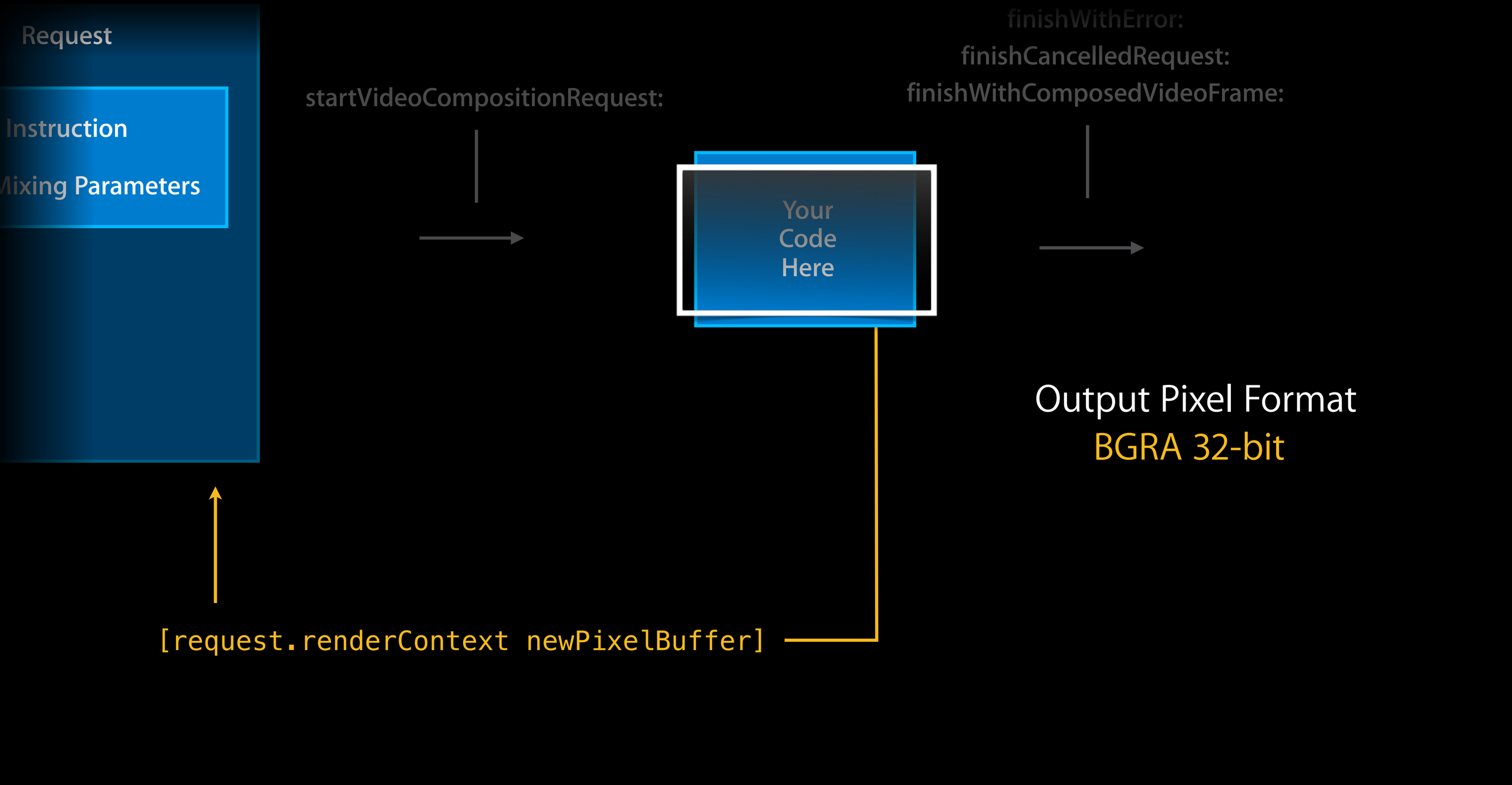
Choosing Pixel Formats



Choosing Pixel Formats



Choosing Pixel Formats



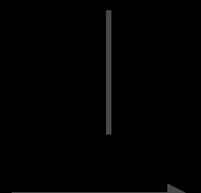
Choosing Pixel Formats

Request

Instruction

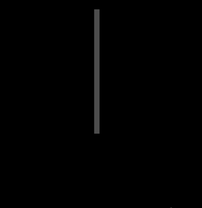
Mixing Parameters

startVideoCompositionRequest:



Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:



Output Pixel Format
BGRA 32-bit

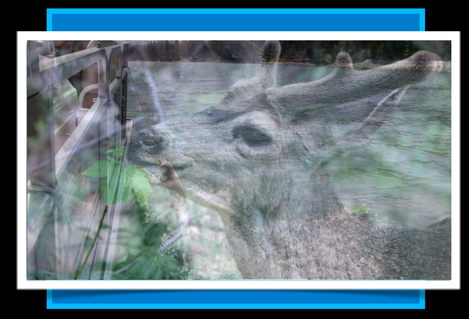
Choosing Pixel Formats

Request

Instruction

Mixing Parameters

startVideoCompositionRequest:



finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Output Pixel Format
BGRA 32-bit

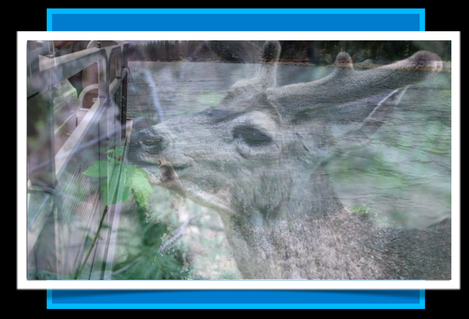
Choosing Pixel Formats

Request

Instruction

Mixing Parameters

startVideoCompositionRequest:



finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Output Pixel Format
BGRA 32-bit

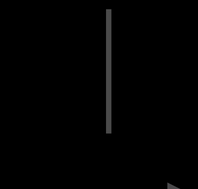
Choosing Pixel Formats

Request

Instruction

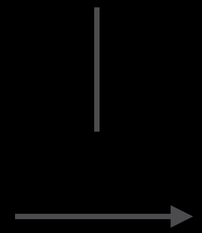
Mixing Parameters

startVideoCompositionRequest:



Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:



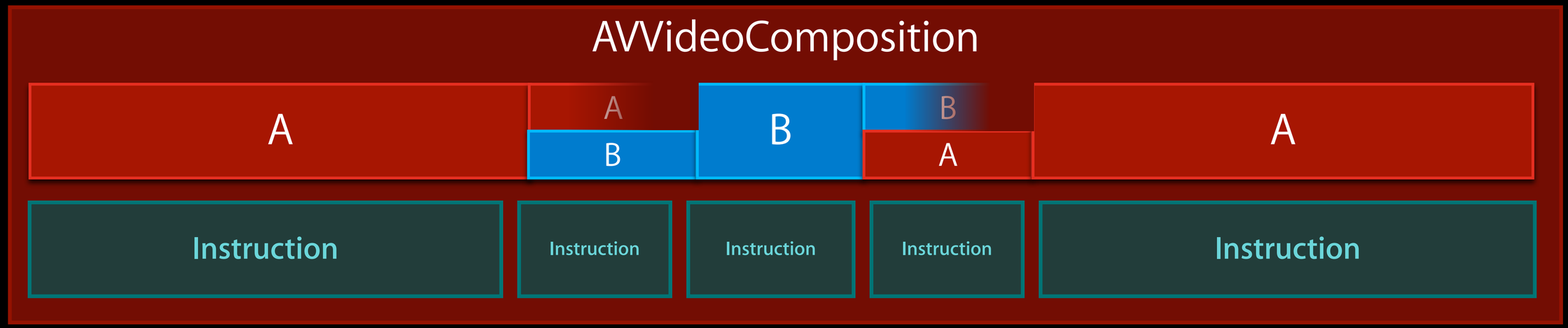
Demo

CPU and GPU custom compositors

Agenda

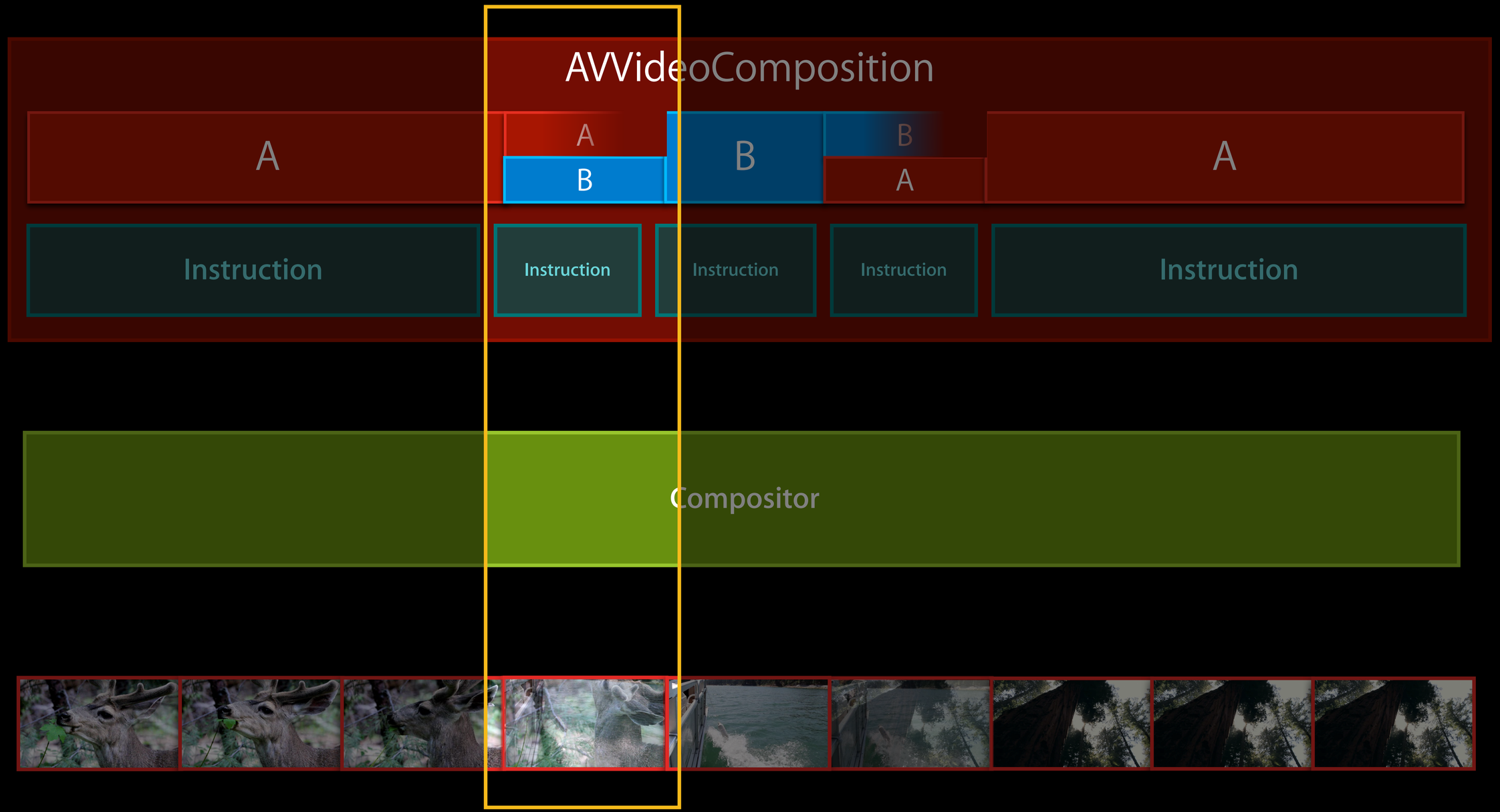
- Custom video compositing
  - Existing architecture
  - New custom video compositing
  - Choosing pixel formats
  - Tweening
  - Performance
- Debugging compositions
  - Common pitfalls

Tweening

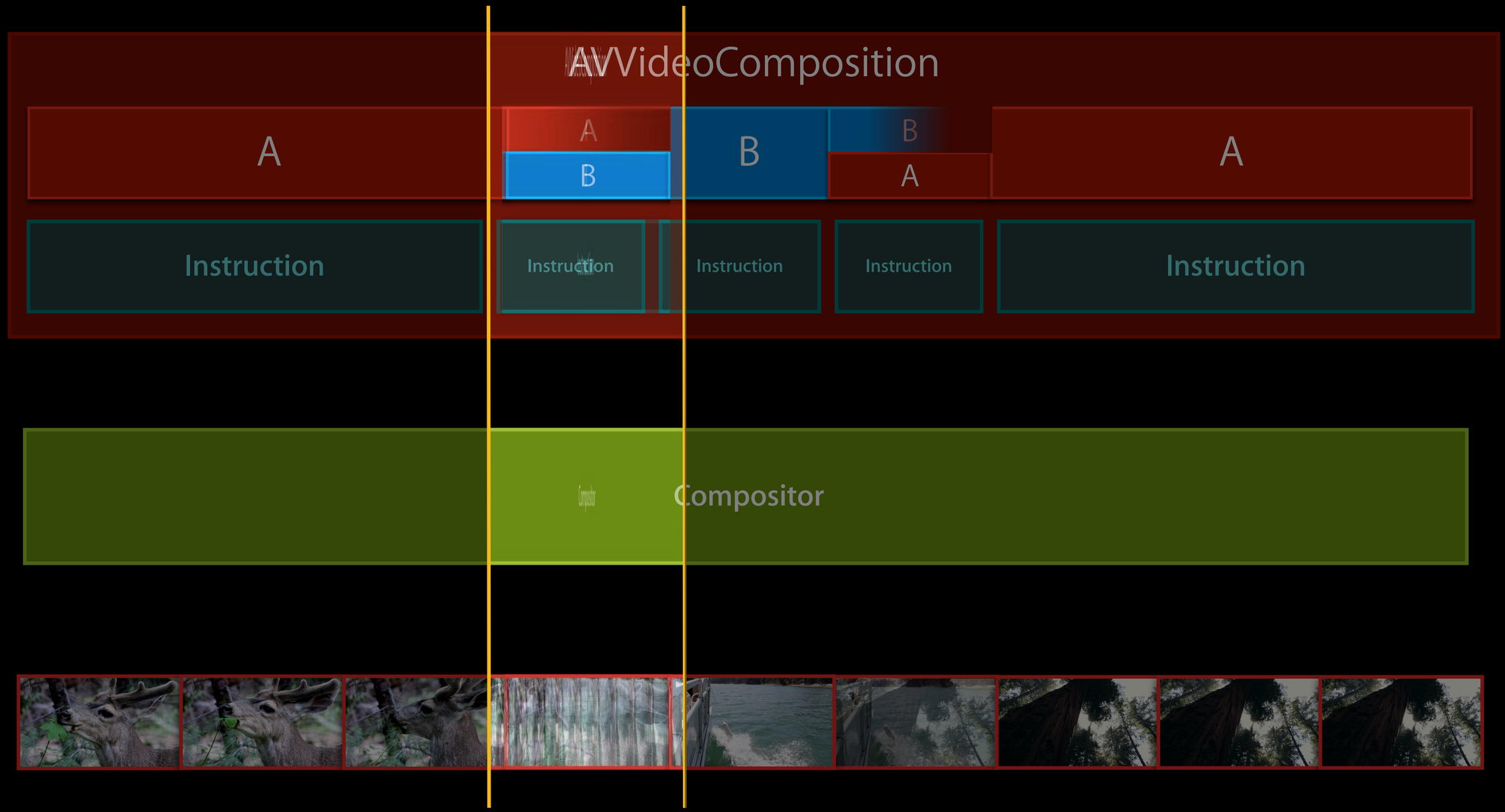


Compositor

Tweening

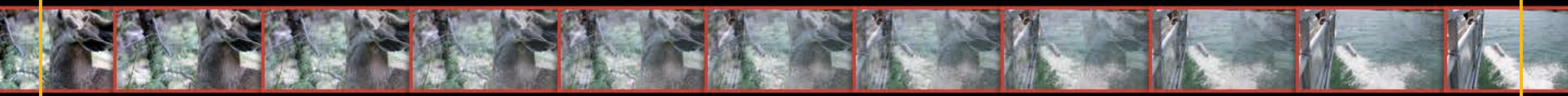

AVVideoComposition
A
A
B
B
B
A
A
Instruction
Instruction
Instruction
Instruction
Instruction
Compositor

Tweening


AVVideoComposition
A
A
B
B
B
A
A
Instruction
Instruction
Instruction
Instruction
Instruction
Compositor

Tweening

Compositor



Tweening

AVVideoComposition

A

B

Instruction

Compositor

Tweening

AVVideoComposition

A

B

Compositor

Tweening

AVVideoComposition

A

B

Opacity Ramp 100% to 0%

Compositor

Tweening

AVVideoComposition

A

B

Opacity Ramp 100% to 0%

```
MyInstruction.timeRange = { start 5, duration 10/30 secs }
MyInstruction.opacityRamp = { 100% to 0% }
```

Compositor

Tweening

elapsed = 0 secs

AVVideoComposition

A

B

Opacity Ramp 100% to 0%

Compositor

Tweening

elapsed = 0 secs

AVVideoComposition

A

B

opacity = 100%

Opacity Ramp 100% to 0%

Compositor

Tweening

elapsed = 0 secs

AVVideoComposition

A

B

opacity = 100%

Opacity Ramp 100% to 0%

tween = elapsed / duration = 0.0

Compositor

Tweening

elapsed = 1/30 secs

AVVideoComposition

A

B

opacity = 90%

Opacity Ramp 100% to 0%

tween = elapsed / duration = 0.1

Compositor

Calculate how far through the animation we are;
Subtract the start time, divide by the duration

Tweening

elapsed = .. secs

AVVideoComposition

A

B

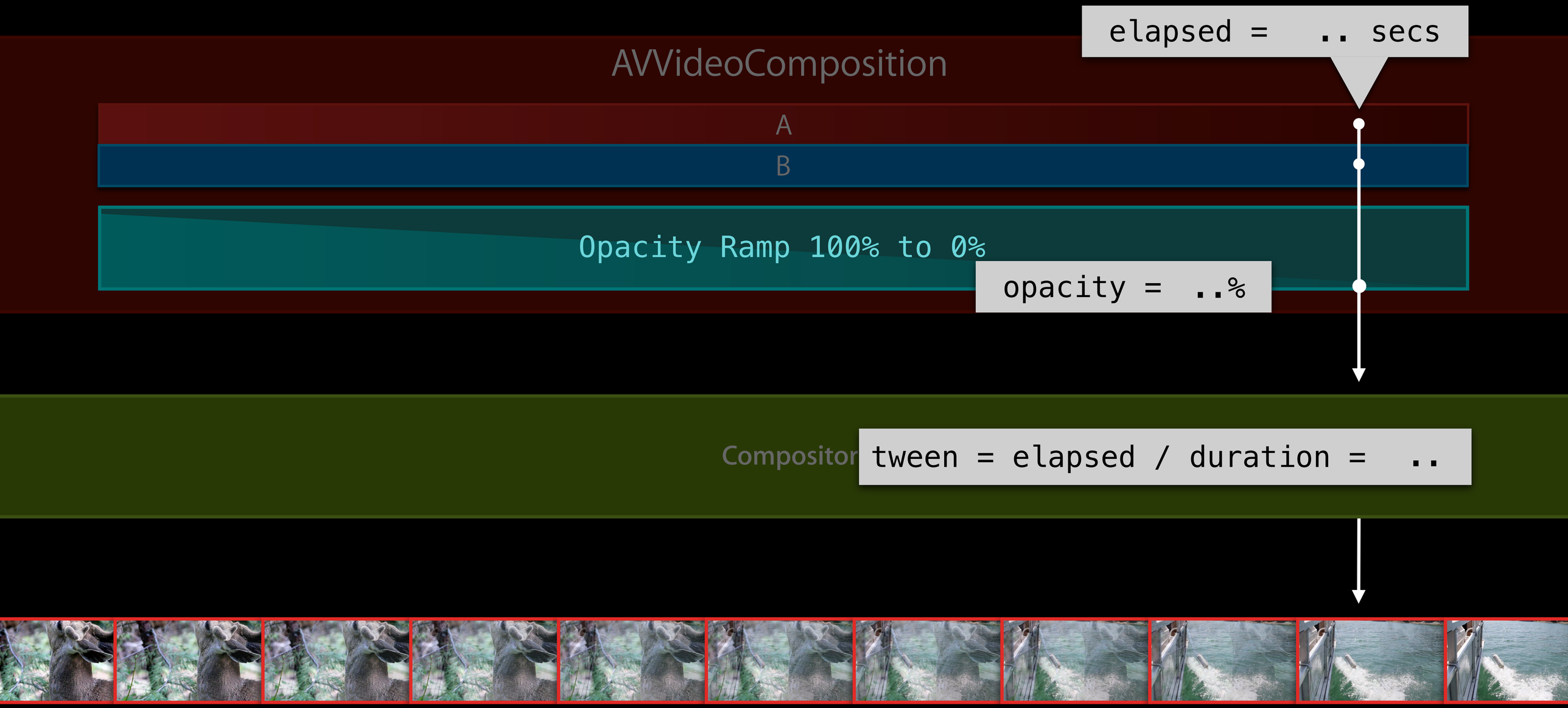
opacity = ..%

Opacity Ramp 100% to 0%

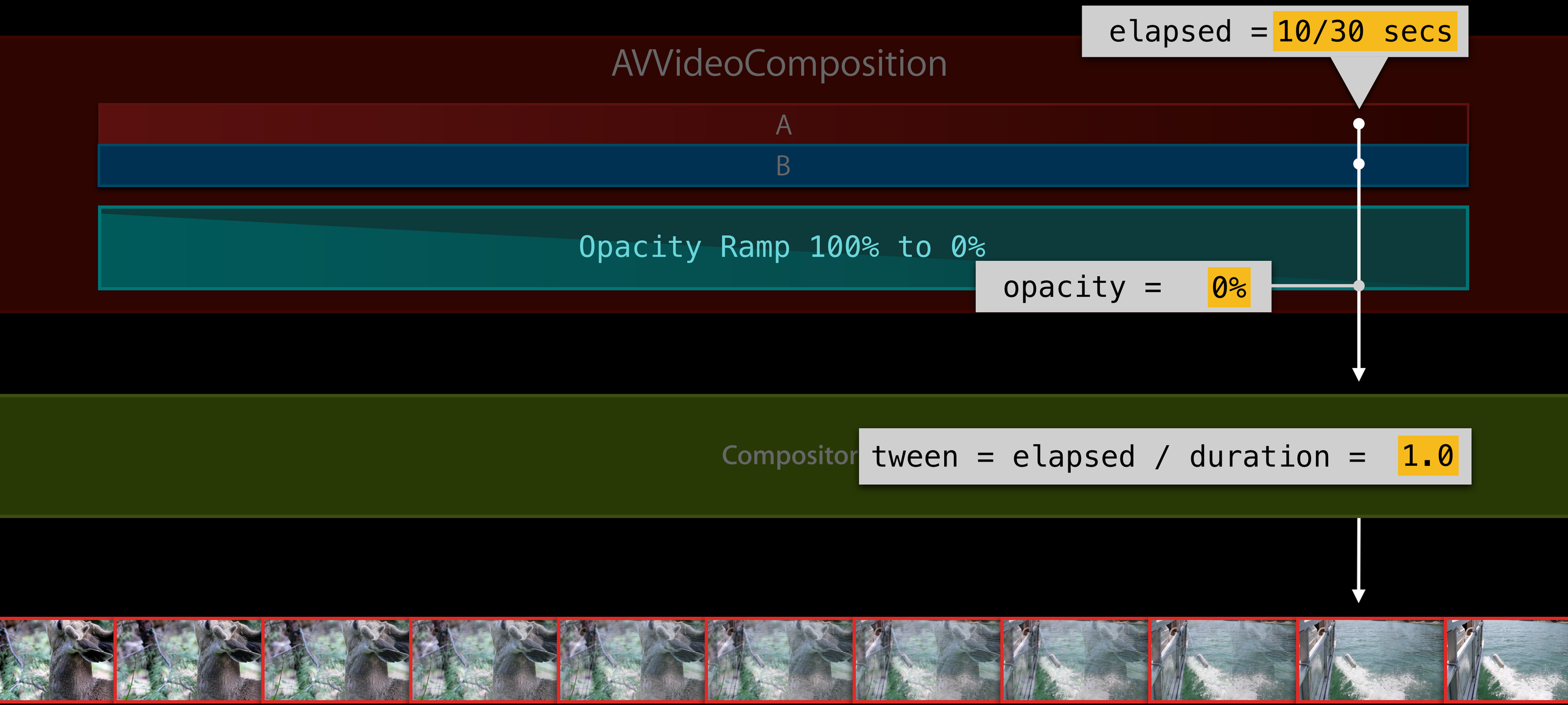
tween = elapsed / duration = ..

Compositor

Tweening


elapsed = .. secs
AVVideoComposition
A
B
Opacity Ramp 100% to 0%
opacity = ..%
Compositor
tween = elapsed / duration = ..

Tweening


elapsed = 10/30 secs
AVVideoComposition
A
B
Opacity Ramp 100% to 0%
opacity = 0%
Compositor
tween = elapsed / duration = 1.0

Agenda

- Custom video compositing
  - Existing architecture
  - New custom video compositing
  - Choosing pixel formats
  - Tweening
  - Performance
- Debugging compositions
  - Common pitfalls

iOS Apps

Foreground	Background
CPU	CPU
OpenGL ES	—

Performance

Instruction properties

```
@protocol AVVideoCompositionInstruction<NSObject>
{
   @property CMPersistentTrackID passthroughTrackID;
   @property NSArray *requiredSourceTrackIDs;
   @property BOOL containsTweening;
}
```

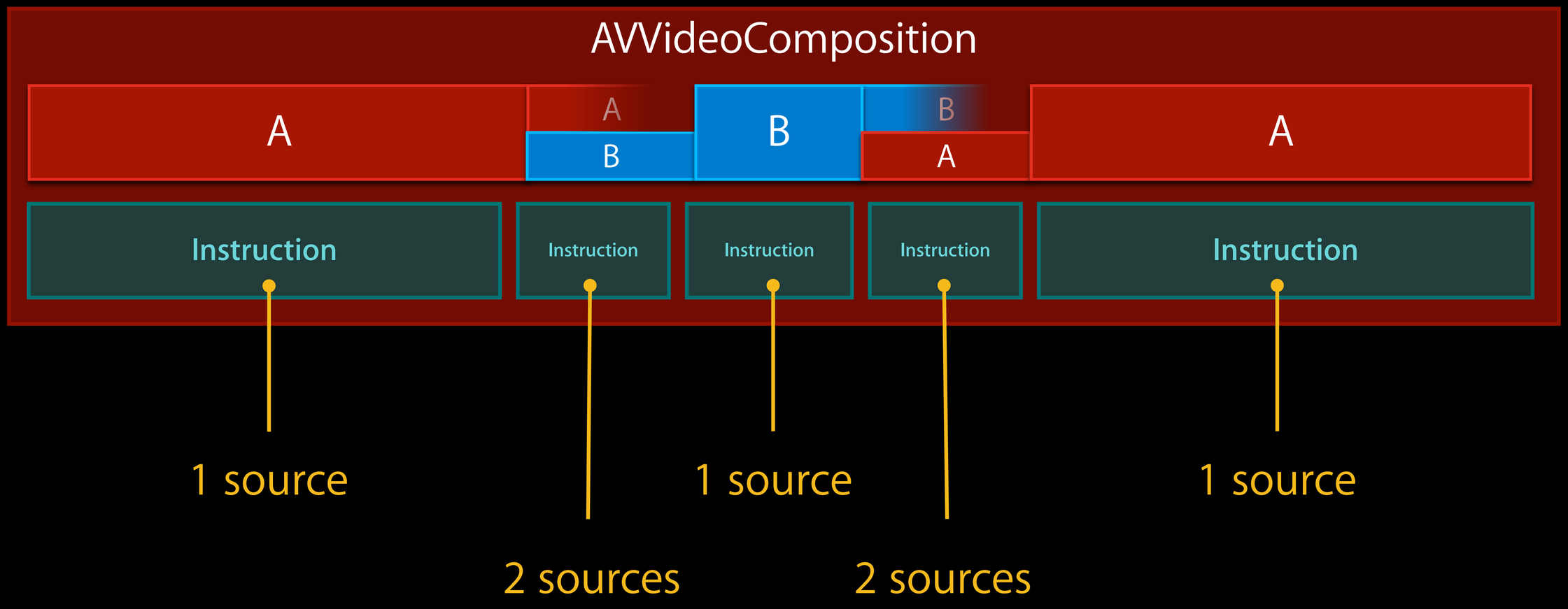
Performance

Instruction properties

```
@protocol AVVideoCompositionInstruction<NSObject>
{
    @property CMPersistentTrackID passthroughTrackID;
    @property NSArray *requiredSourceTrackIDs;
    @property BOOL containsTweening;
}
```

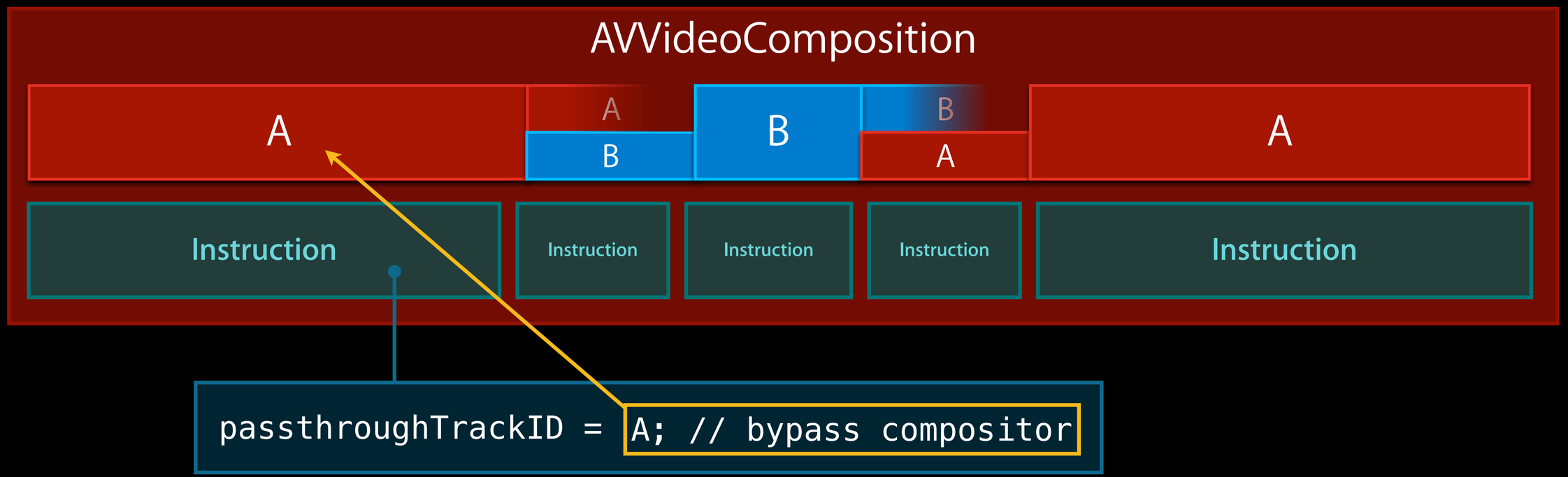
Performance

passthroughTrackID



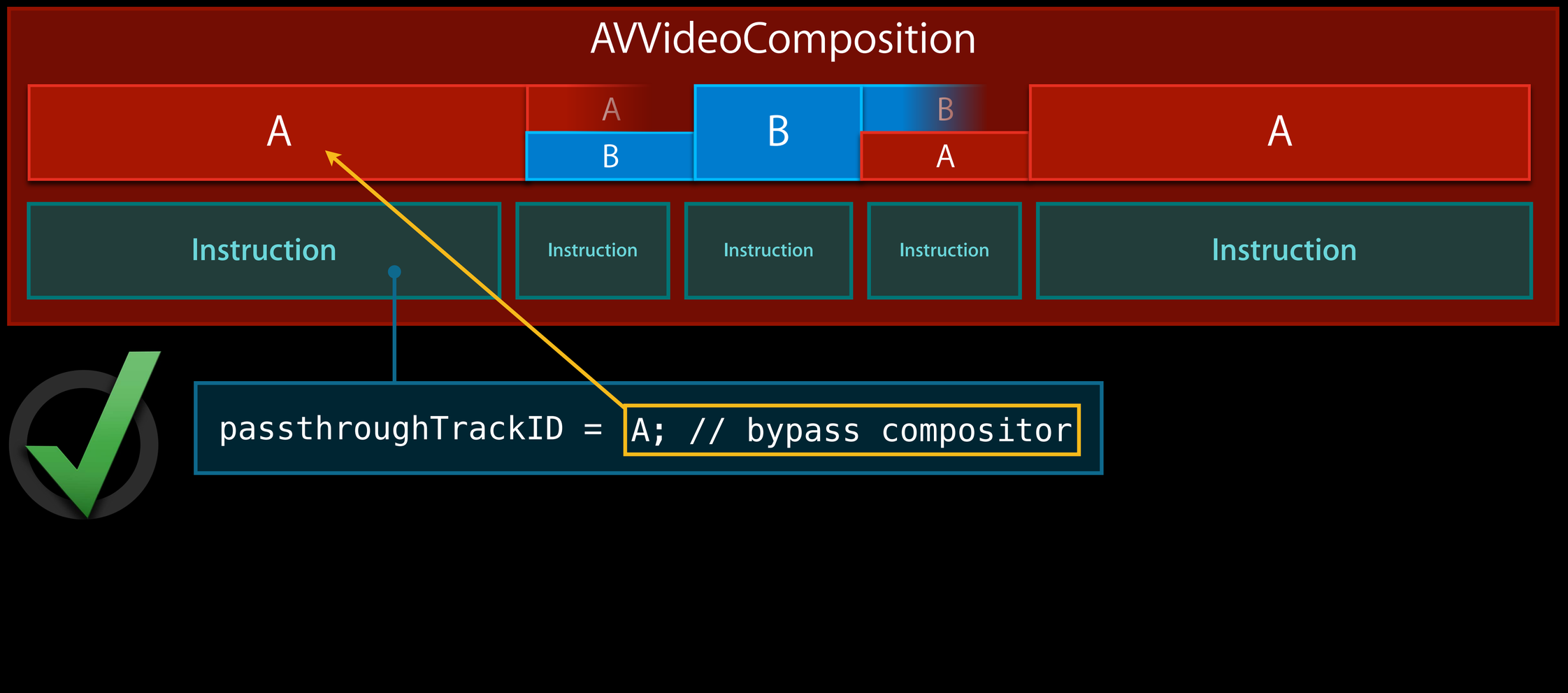
Performance

passthroughTrackID



Performance

passthroughTrackID



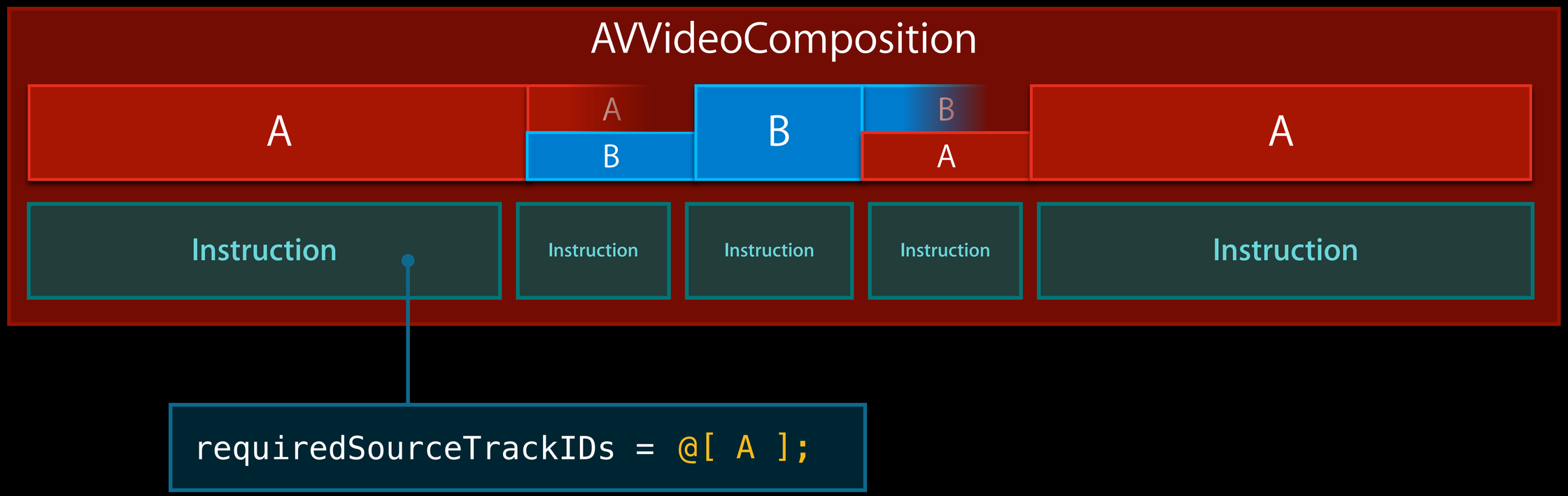
Performance

Instruction properties

```
@protocol AVVideoCompositionInstruction<NSObject>
{
    @property CMPersistentTrackID passthroughTrackID;
    @property NSArray *requiredSourceTrackIDs;
    @property BOOL containsTweening;
}
```

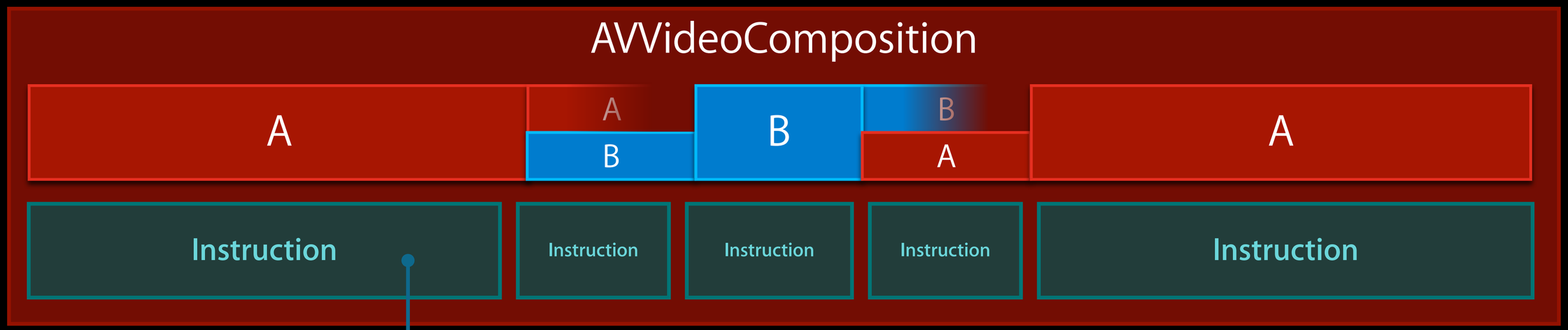
Performance

`requiredSourceTrackIDs`



Performance

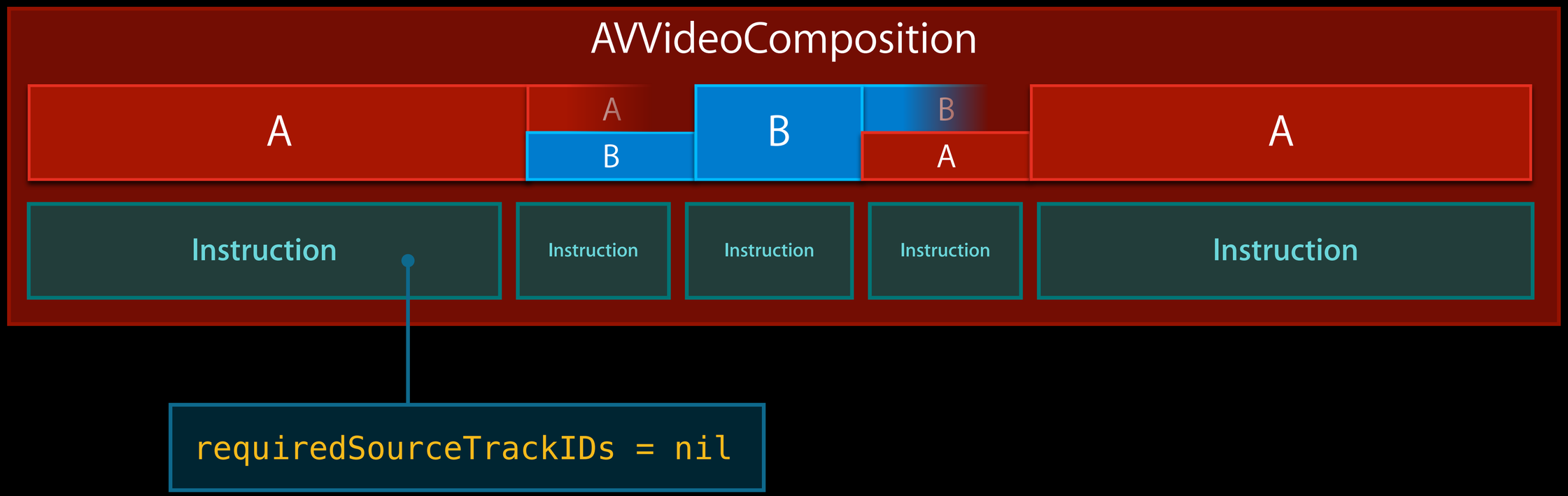
`requiredSourceTrackIDs`



```
requiredSourceTrackIDs = @[ A ];
```

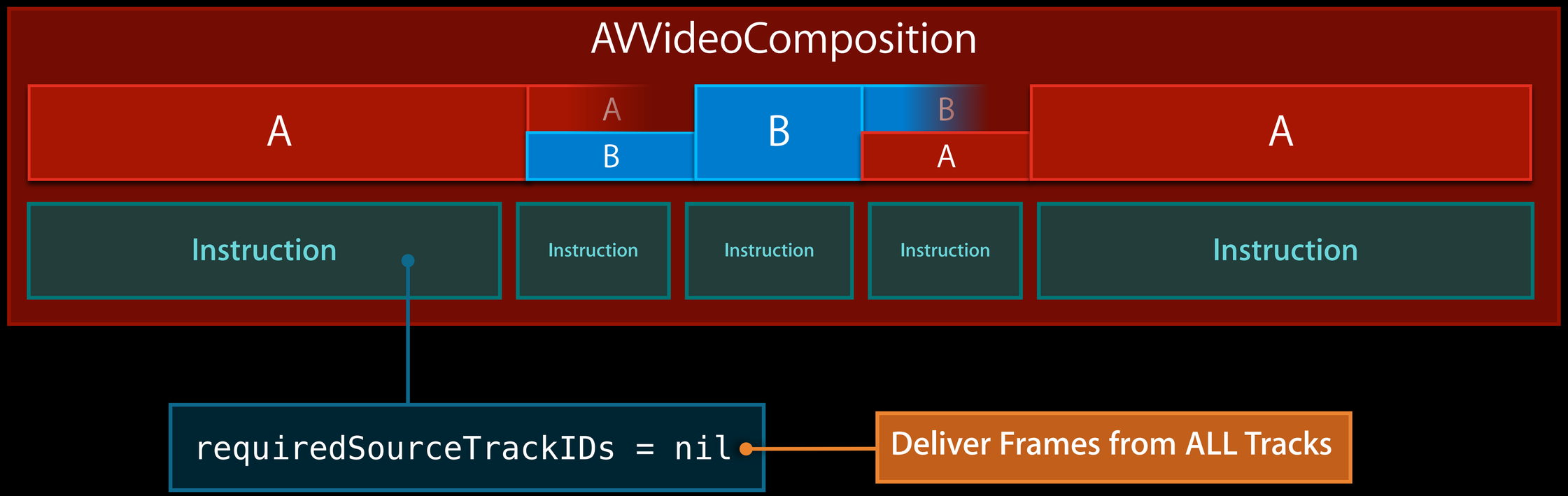
Performance

`requiredSourceTrackIDs`



Performance

`requiredSourceTrackIDs`



Performance

Instruction properties

```
@protocol AVVideoCompositionInstruction<NSObject>
{
    @property CMPersistentTrackID passthroughTrackID;
    @property NSArray *requiredSourceTrackIDs;
    @property BOOL containsTweening;
}
```

Performance

`containsTweening`

Moving picture-in-picture,
same source frames every time

Performance

containsTweening

```
containsTweening = YES;
```

Moving picture-in-picture,
same source frames every time

Performance

containsTweening

```
containsTweening = YES;
```

Performance

containsTweening

```
containsTweening = YES;
```

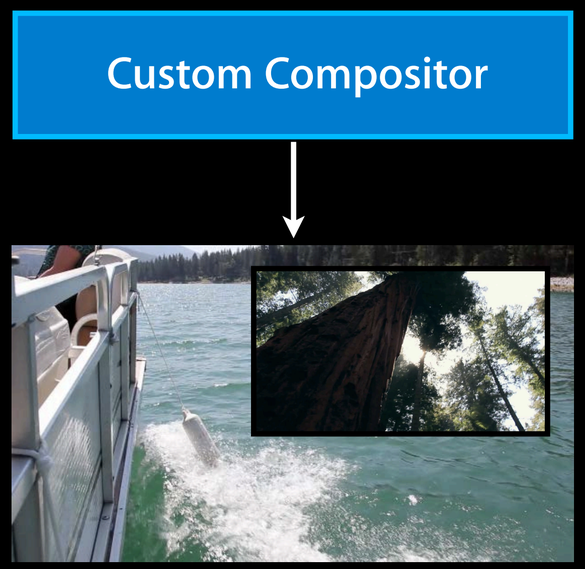
Static picture-in-picture,
same source frames every time

Performance

containsTweening

```
containsTweening = YES;
```

Frame #0



Static picture-in-picture,
same source frames every time

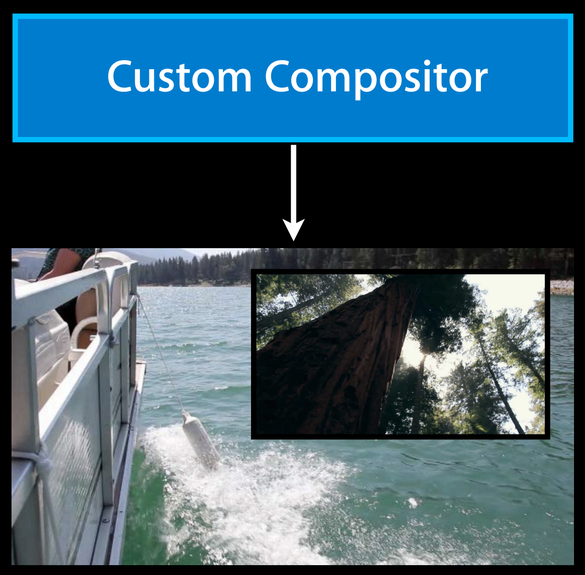
Performance

containsTweening

```
containsTweening = YES;
```

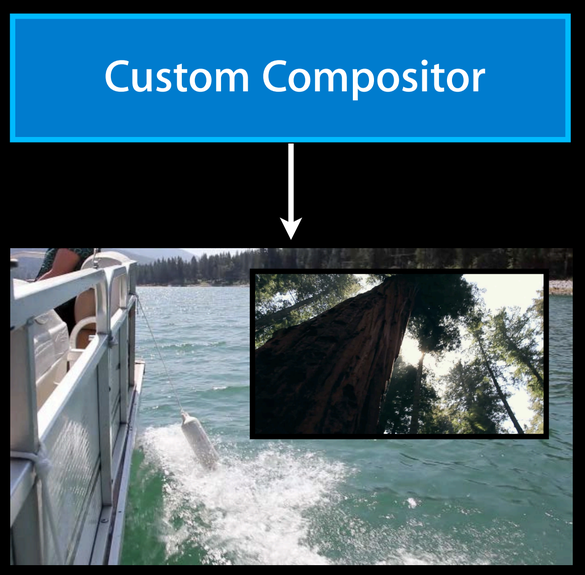
Frame #0

Custom Compositor



Frame #1

Custom Compositor



Static picture-in-picture,
same source frames every time

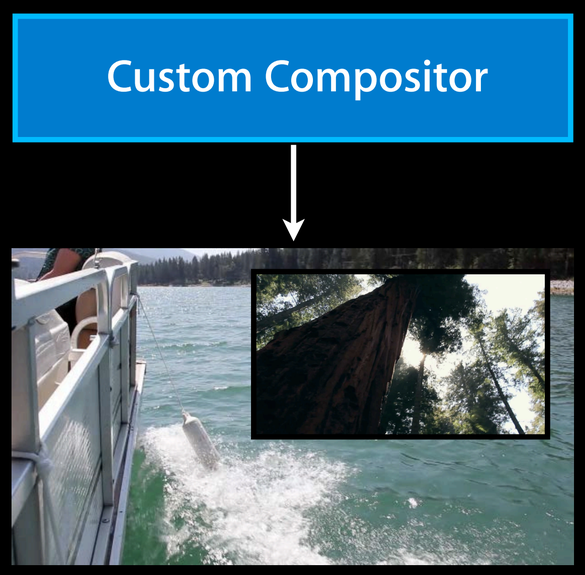
Performance

containsTweening

```
containsTweening = YES;
```

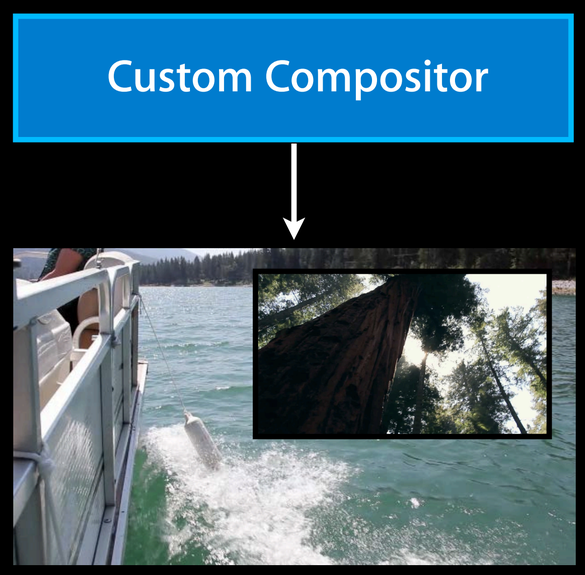
Frame #0

Custom Compositor



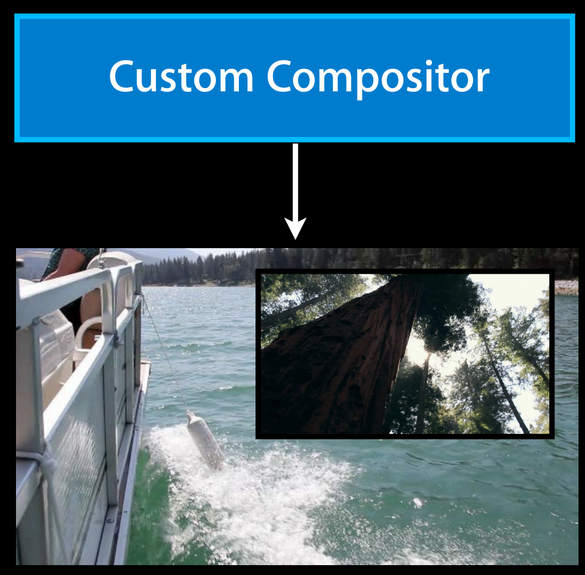
Frame #1

Custom Compositor



Frame #2

Custom Compositor



Static picture-in-picture,
same source frames every time

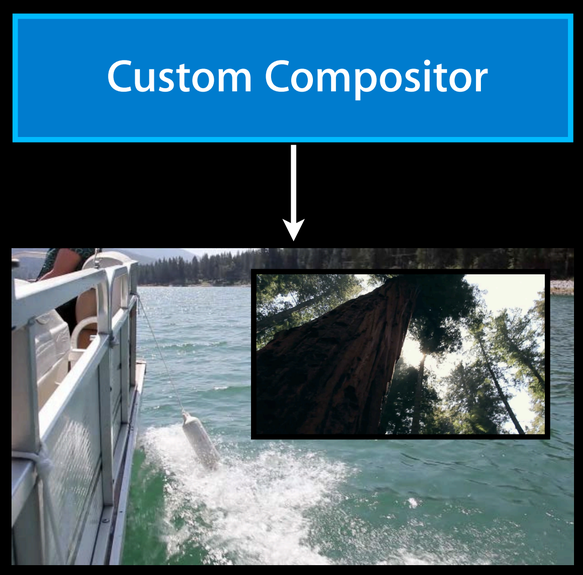
Performance

containsTweening

```
containsTweening = YES;
```

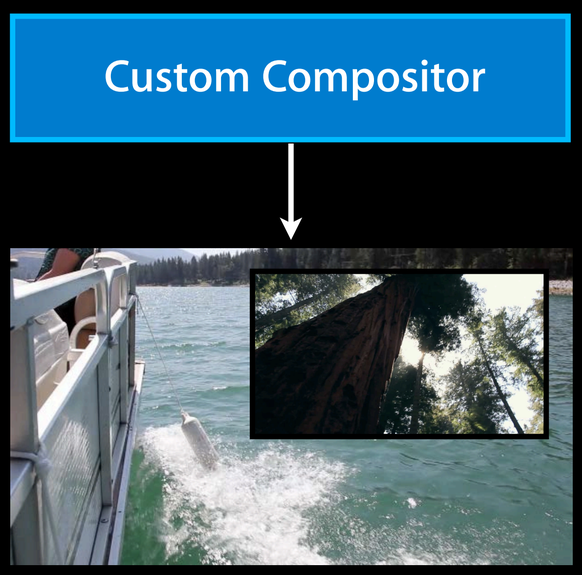
Frame #0

Custom Compositor



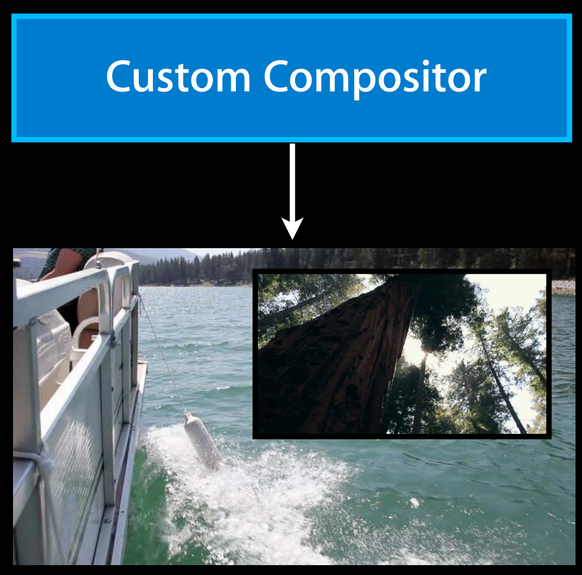
Frame #1

Custom Compositor



Frame #2

Custom Compositor



Static picture-in-picture,
same source frames every time

Performance

containsTweening

Re-render identical output!

```
containsTweening = YES;
```

Frame #0

Custom Compositor

Frame #1

Custom Compositor

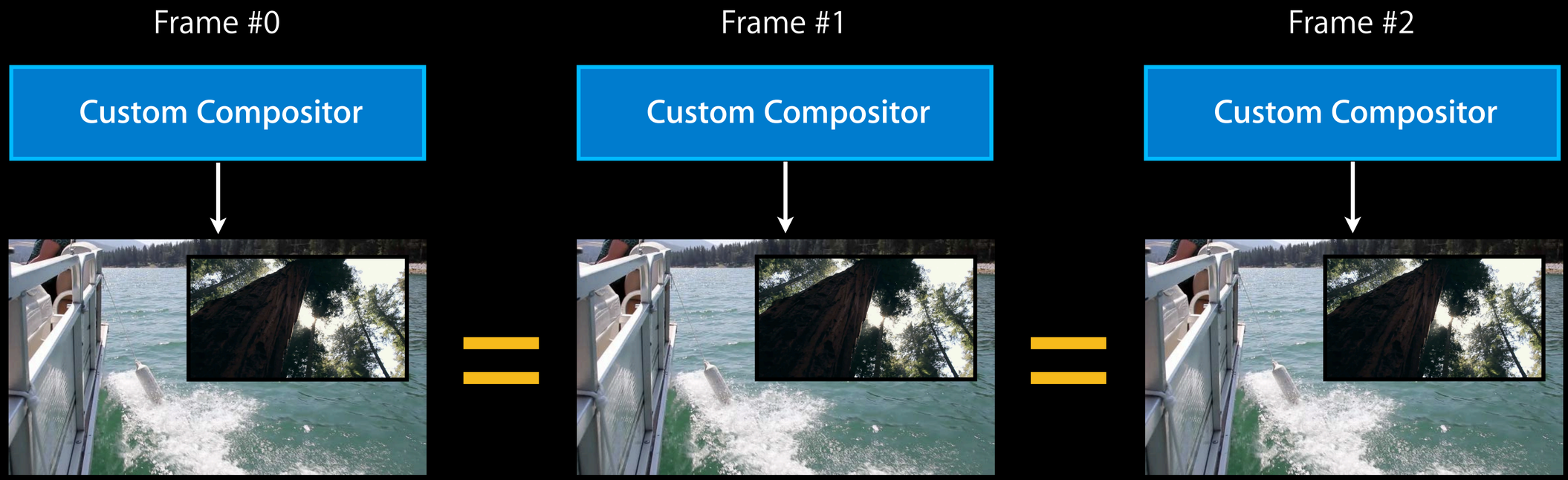
Frame #2

Custom Compositor

Static picture-in-picture,
same source frames every time

Performance

`containsTweening`



Static picture-in-picture,
same source frames every time

Performance

containsTweening

I'm not animating

```
containsTweening = NO;
```

Frame #0

Frame #1

Frame #2

Custom Compositor

Custom Compositor

Custom Compositor

Static picture-in-picture,
same source frames every time

Performance

containsTweening

```
containsTweening = NO;
```

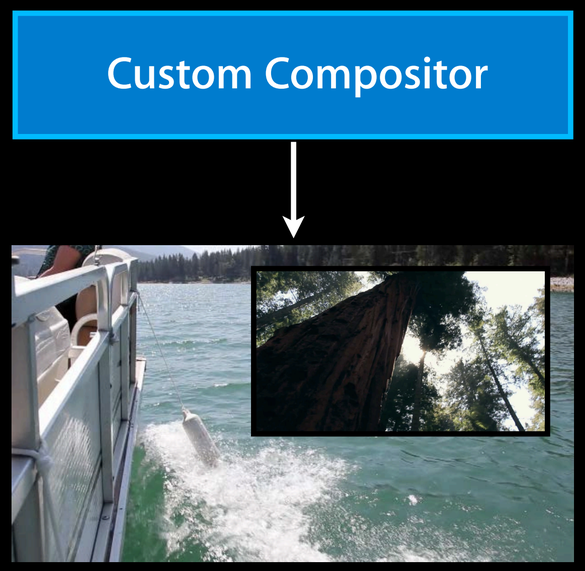
Static picture-in-picture,
same source frames every time

Performance

containsTweening

```
containsTweening = NO;
```

Frame #0

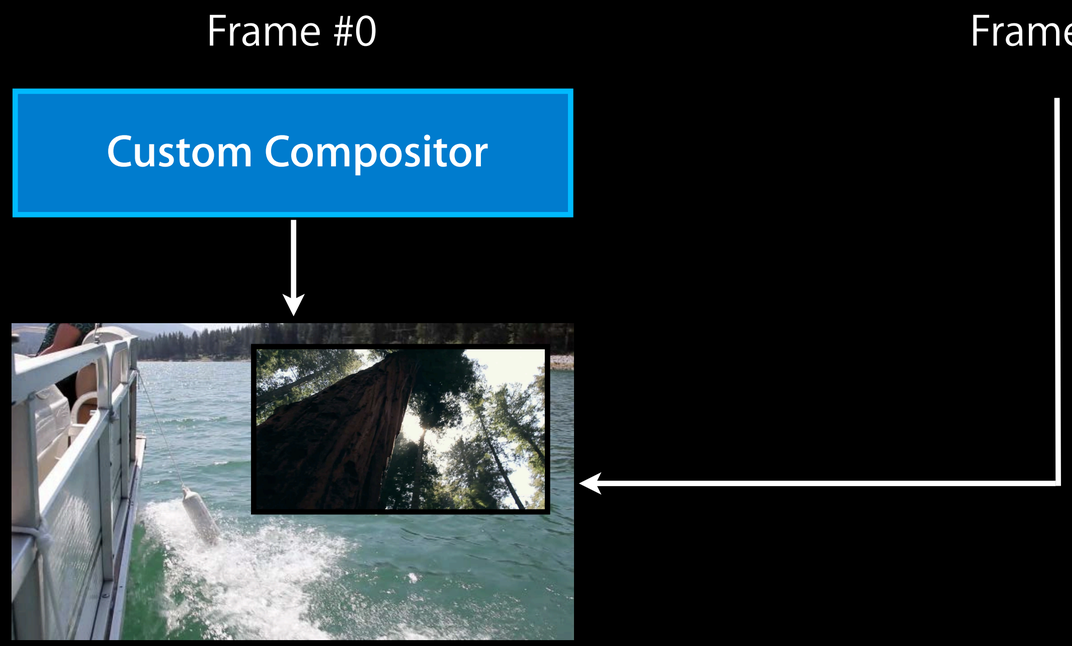


Static picture-in-picture,
same source frames every time

Performance

containsTweening

```
containsTweening = NO;
```

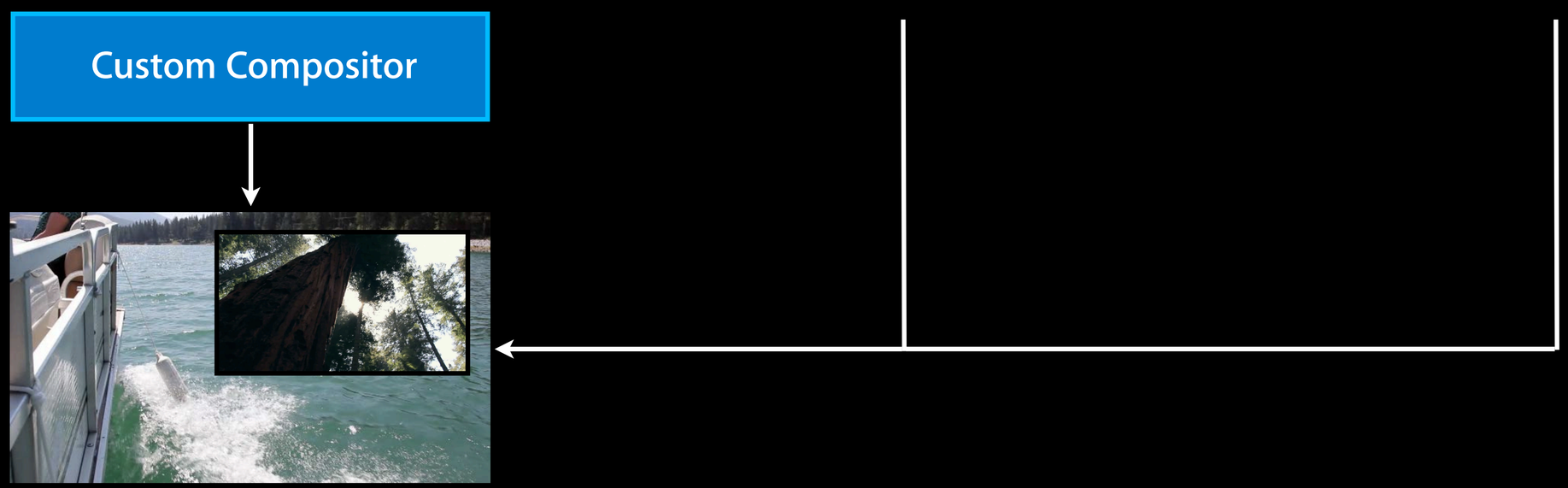


Static picture-in-picture,
same source frames every time

Performance

containsTweening

```
containsTweening = NO;
```



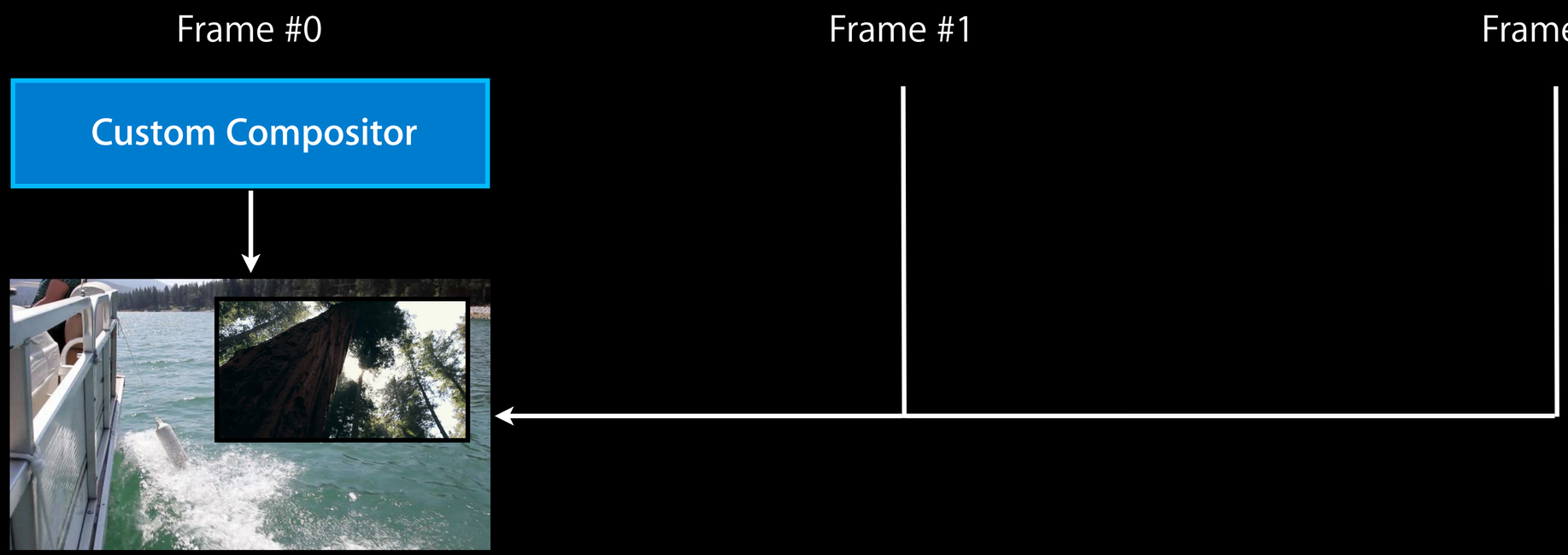
Static picture-in-picture,
same source frames every time

Performance

containsTweening

Reuse identical output

```
containsTweening = NO;
```



Static picture-in-picture,
same source frames every time

Performance

Pixel buffer formats

- Performance hit converting sources
  - H.264 decodes to YUV 4:2:0
  - Best performance, work in YUV 4:2:0
- Output format less critical
  - BGRA or YUV 4:2:0 out

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Sample Code

Custom compositor

- AVCustomEdit
- GPU compositor
- Materials available at:
  https://developer.apple.com/wwdc/schedule/details.php?id=612

Agenda

- Custom video compositing
  - Existing architecture
  - New Custom video compositing
  - Choosing pixel formats
  - Tweening
  - Performance
- Debugging compositions
  - Common pitfalls

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- Gaps between segments
- Misaligned track segments
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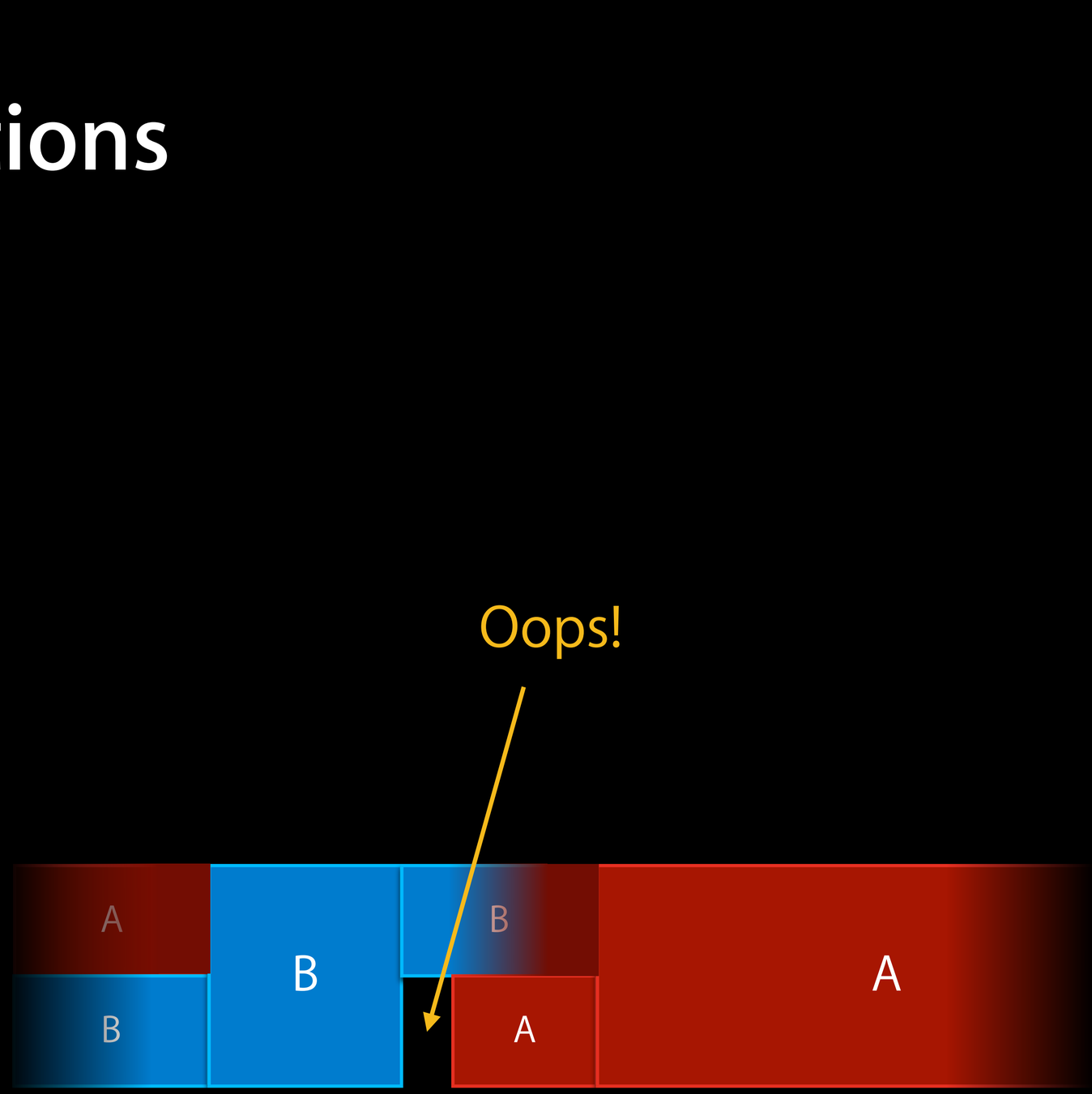

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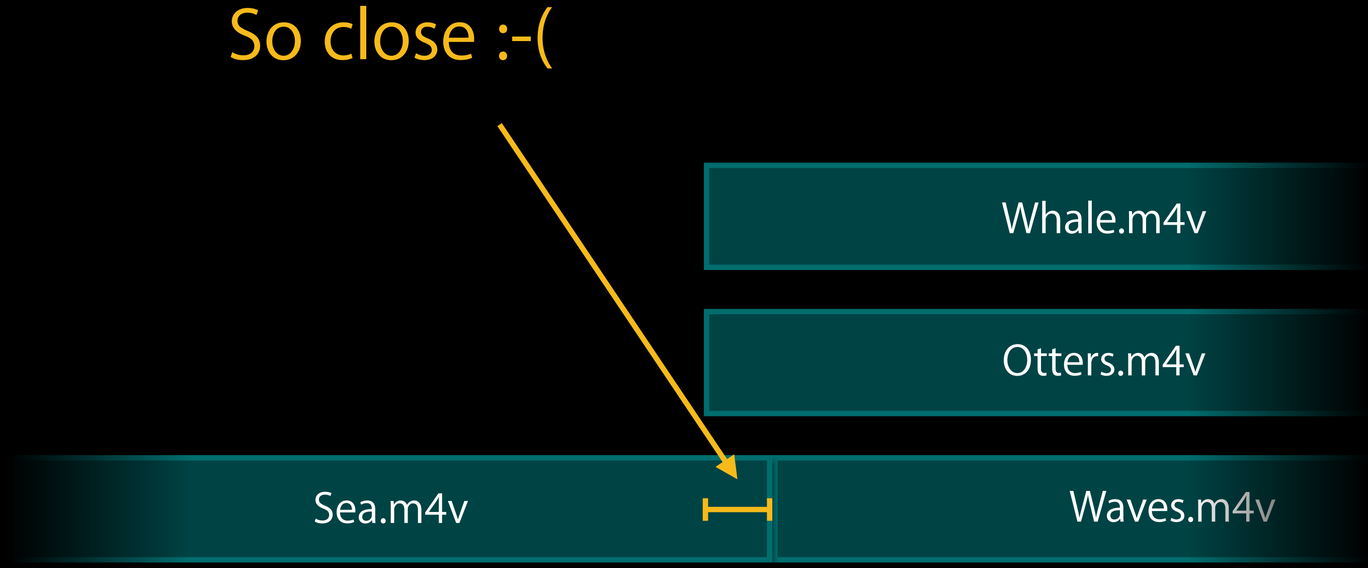

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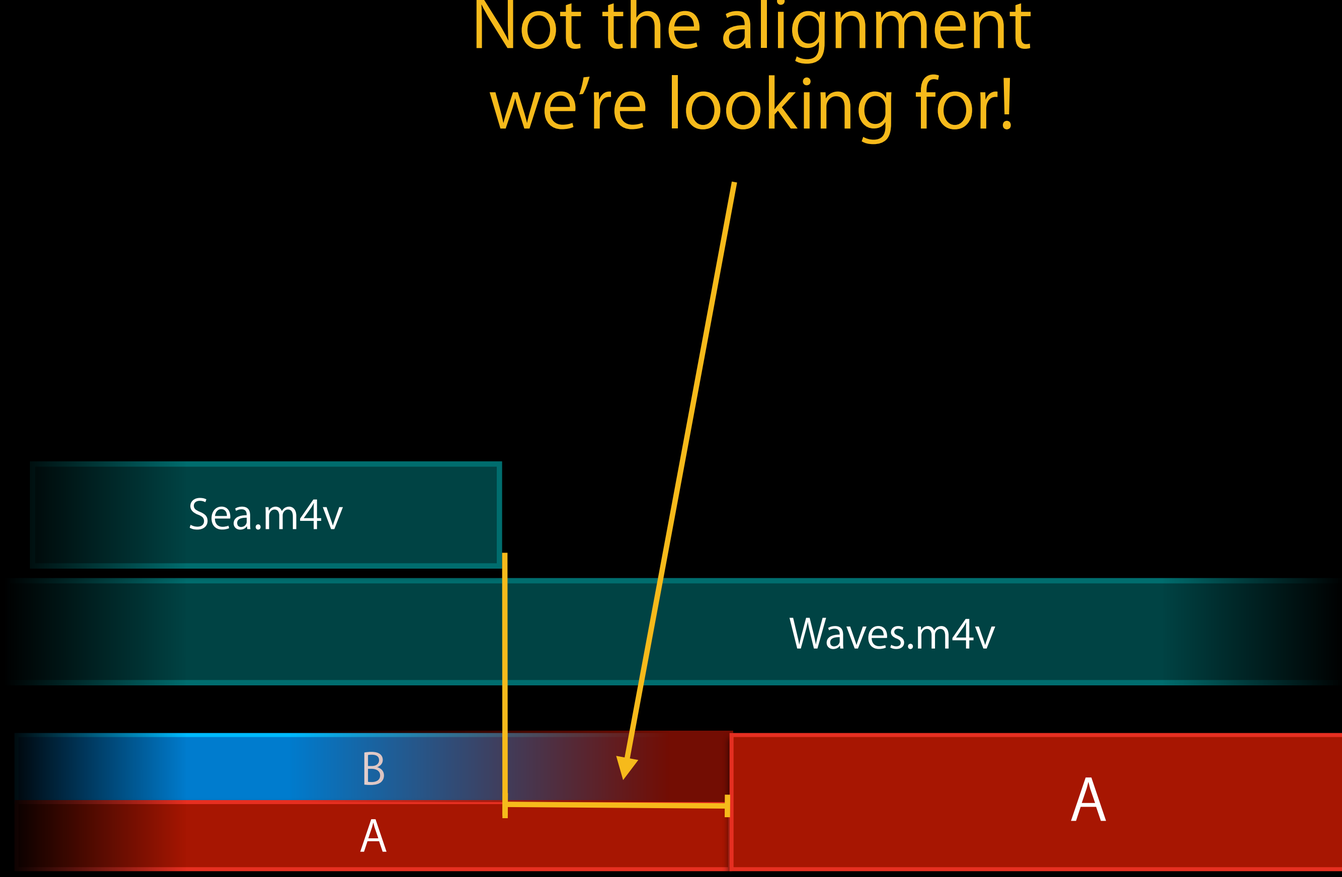

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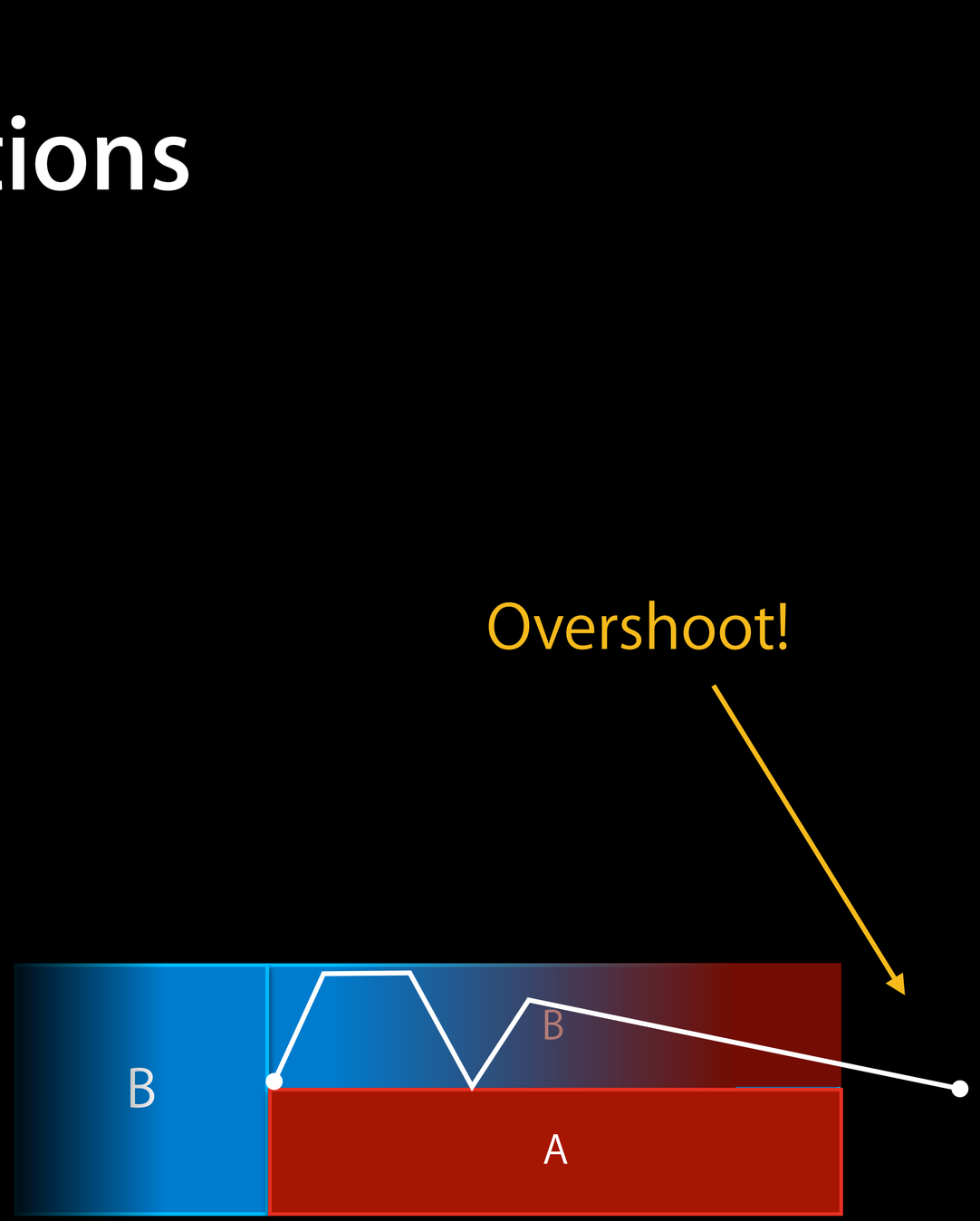

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?*#!

Demo

AVCompositionDebugViewer

Sample Code

Debugging compositions

- `AVCompositionDebugViewer`
- Materials available at:
  https://developer.apple.com/wwdc/schedule/details.php?id=612

Debugging Compositions

- Drop `AVCompositionDebugView` into your own app
- Extend it to draw your own video instructions
- Spot overlaps and gaps; tracks, video instructions, and audio mix
- Don’t forget the composition validation API
  - `@protocol AVVideoCompositionValidationHandling`

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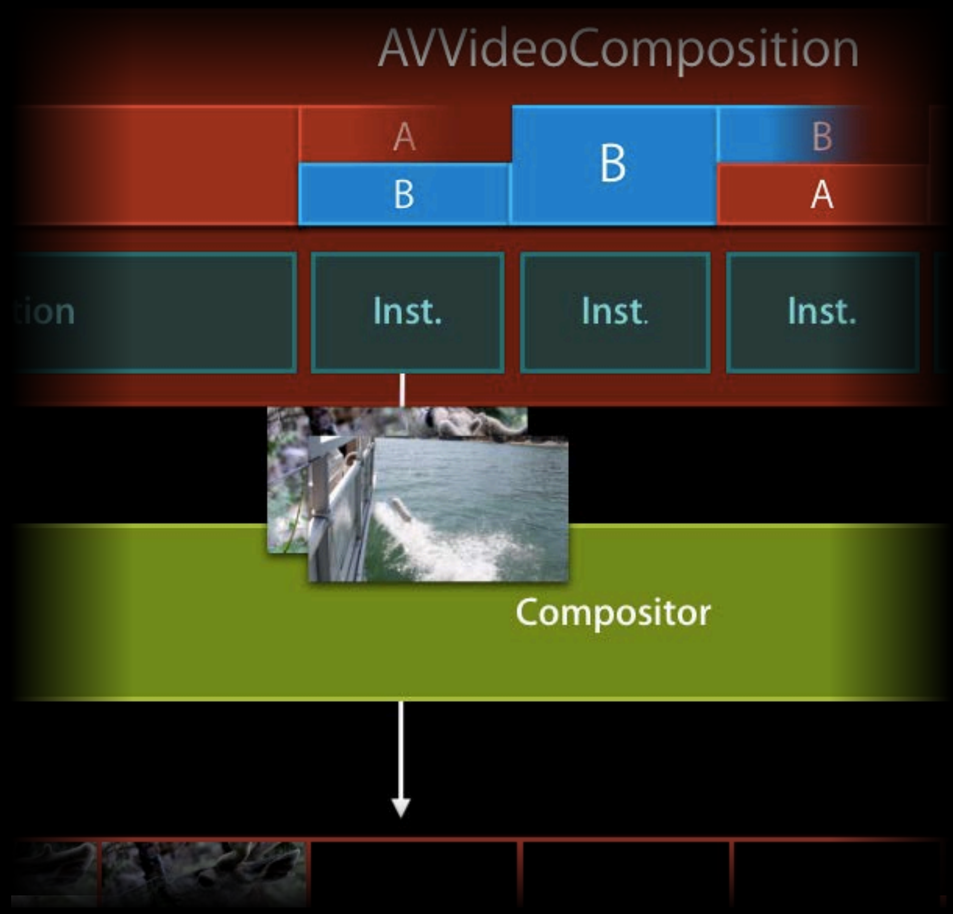

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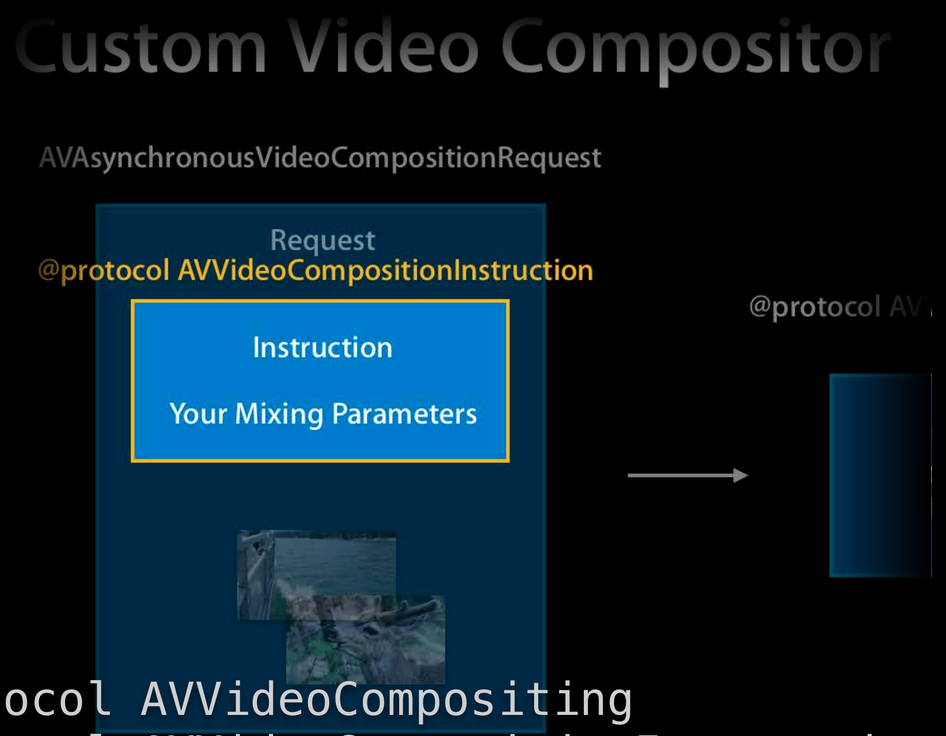


```
@protocol AVVideoCompositing
@protocol AVVideoCompositionInstruction
AVAsynchronousVideoCompositionRequest
```

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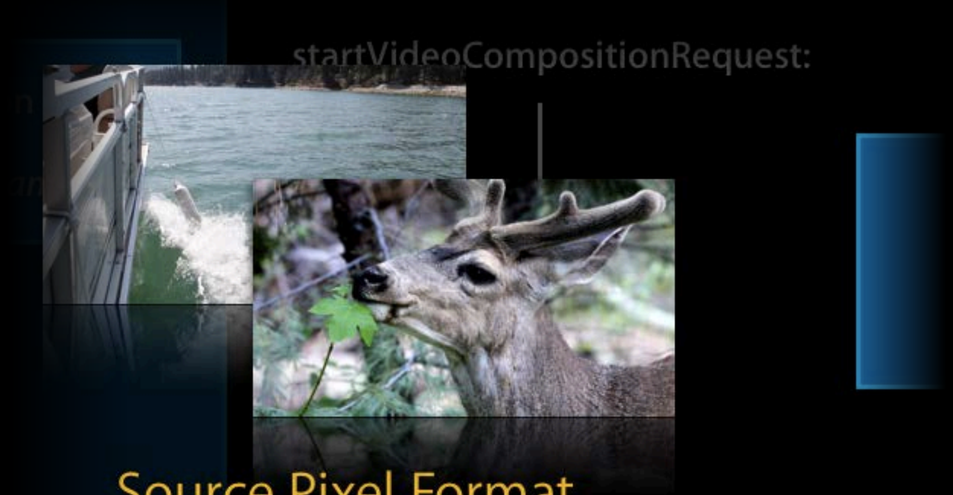

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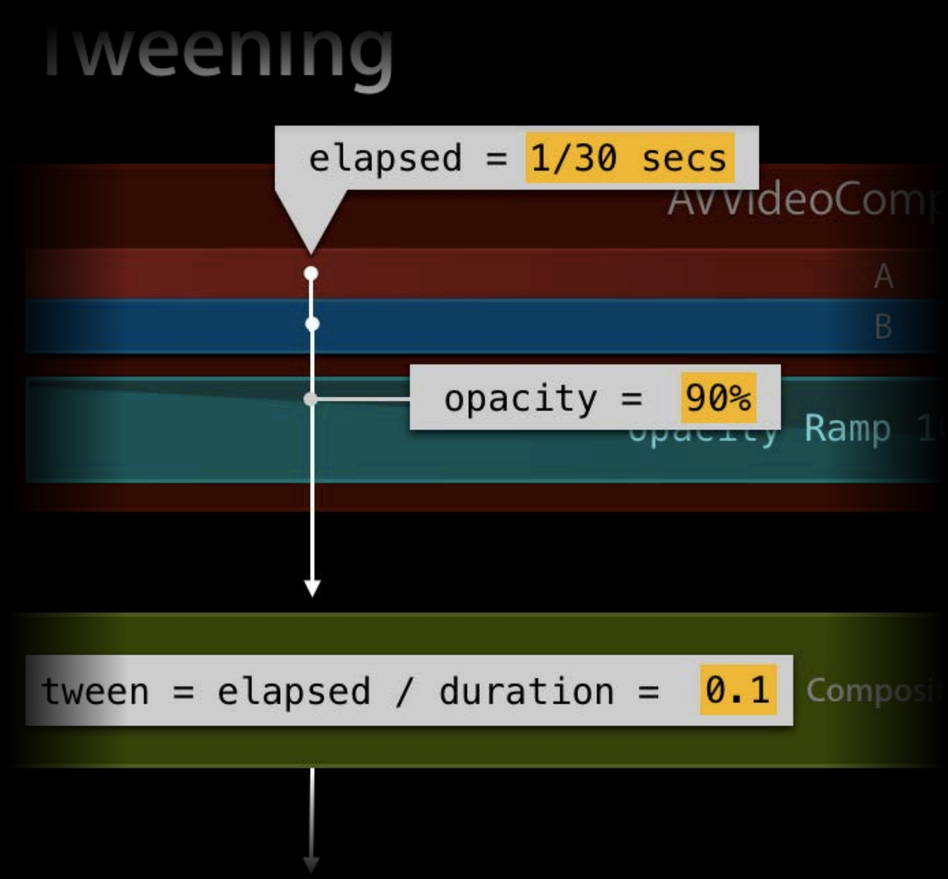

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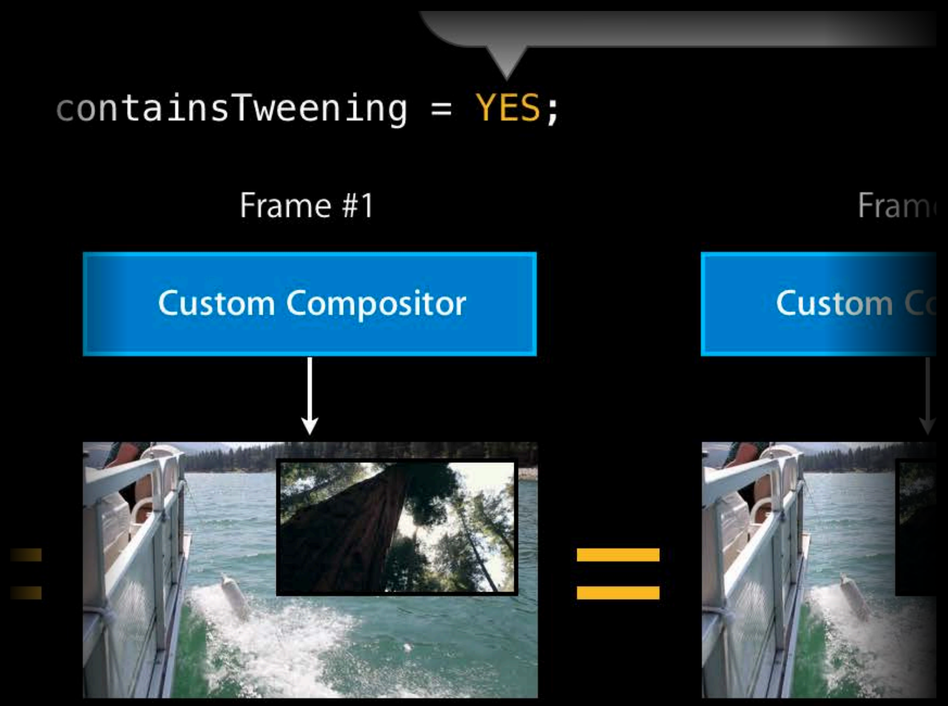

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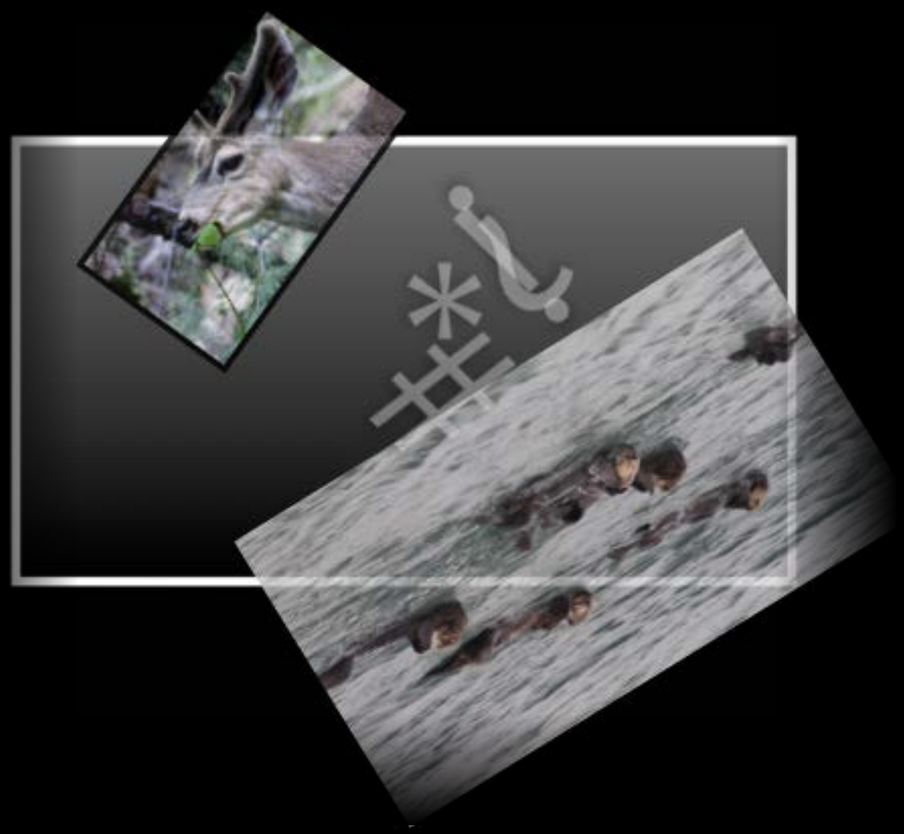

Custom Compositors

Effects, Transitions, Generators

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More Information

John Geleynse
Director, Technology Evangelist
geleynse@apple.com

Documentation
AVFoundation
http://developer.apple.com/library/ios/#documentation/AudioVideo/Conceptual/AVFoundationPG

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

Related Sessions

Moving to AV Kit and AV Foundation	Pacific Heights Tuesday 4:30PM	
Preparing and Presenting Media for Accessibility	Nob Hill Wednesday 10:15AM	
What's New in Camera Capture	Nob Hill Wednesday 11:30AM	

Labs

OS X and iOS Capture Lab	Media Lab B Thursday 9:00AM
AV Foundation Lab	Media Lab B Thursday 2:00PM
AV Foundation Lab	Media Lab B Friday 9:00AM

WWDC2013