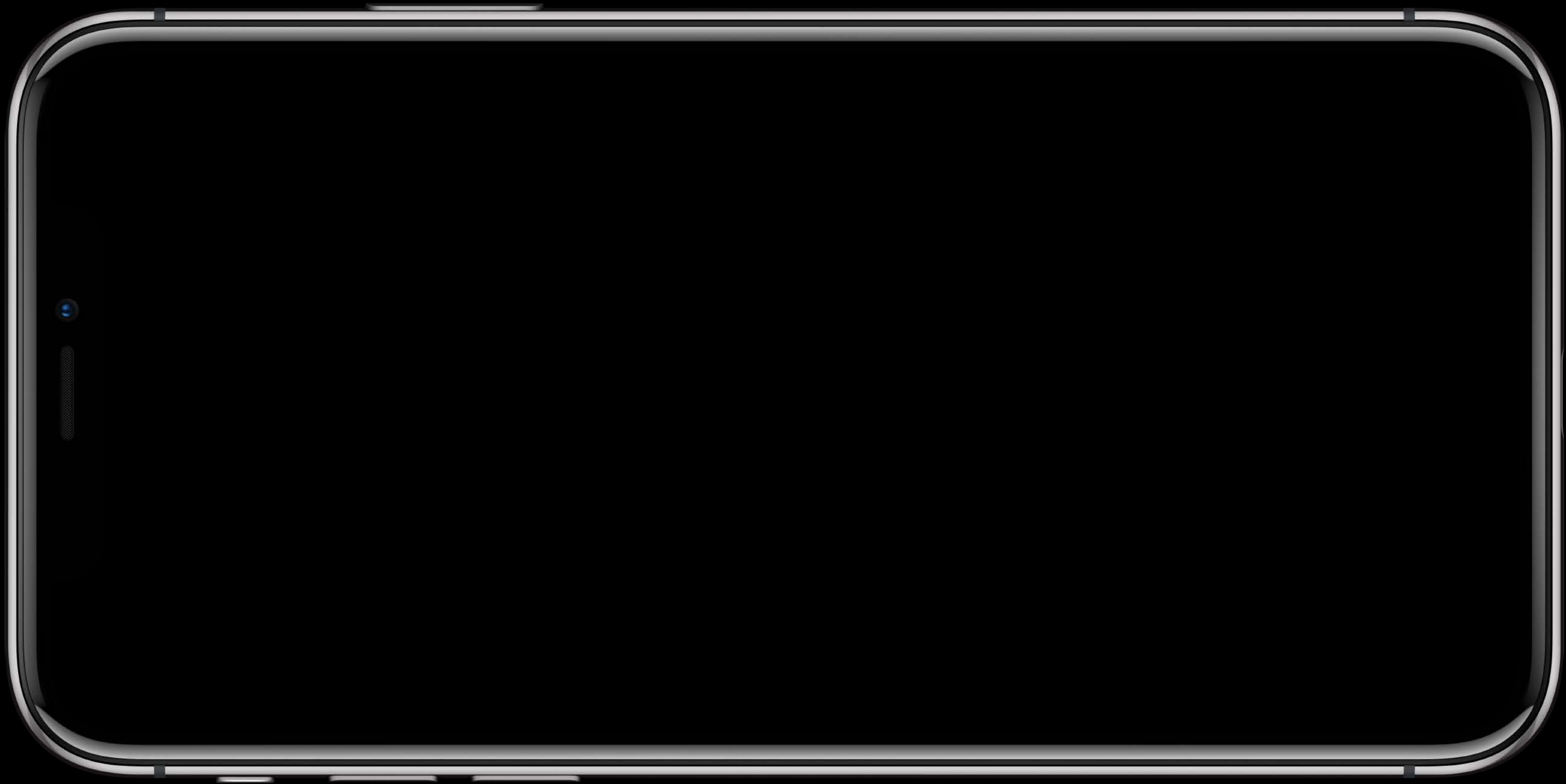


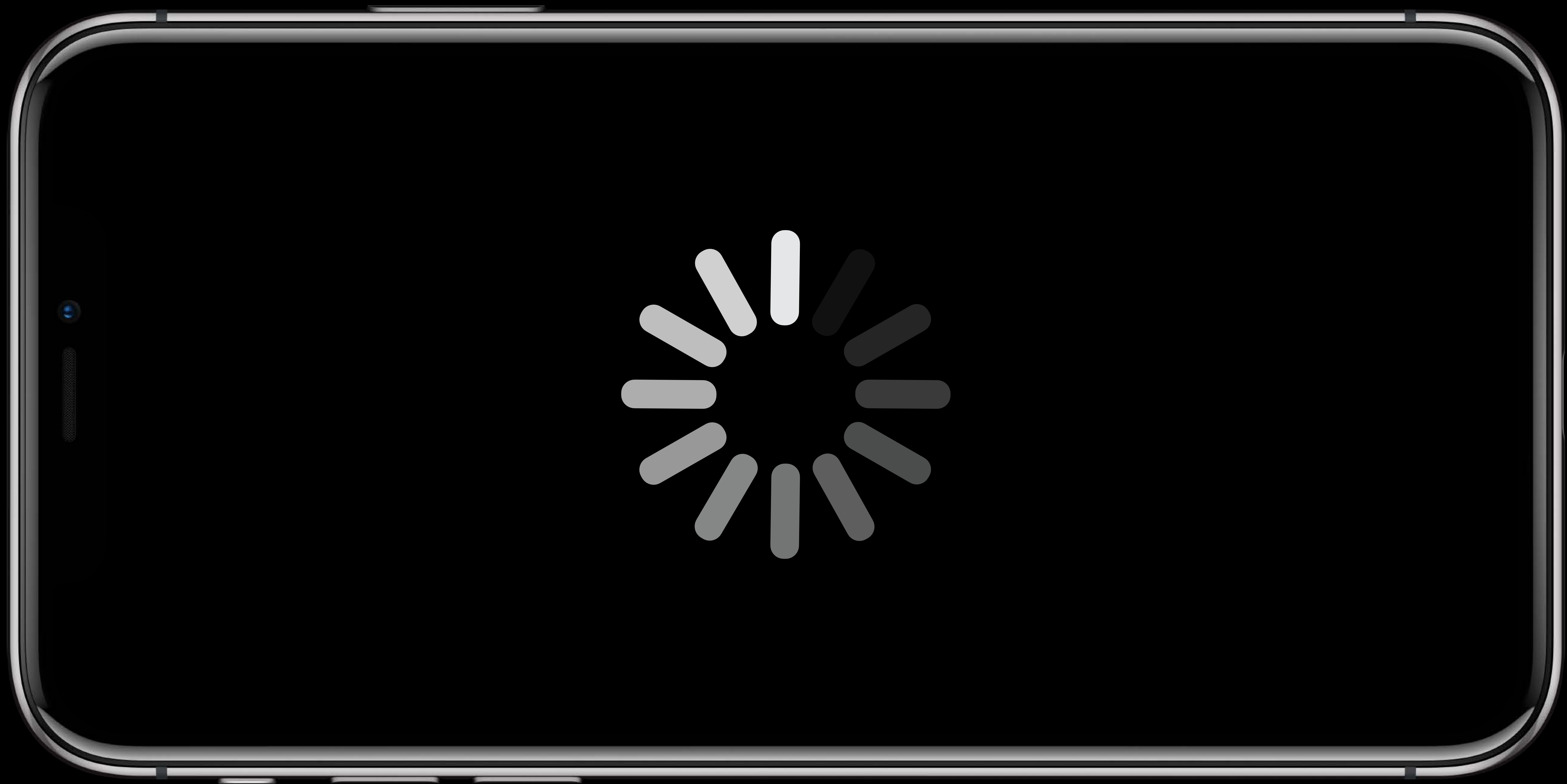
#WWDC18

# Measuring and Optimizing HLS Performance

Session 502

Emil Andriescu, Media Streaming Engineer









# Best User Experience for HLS

# Best User Experience for HLS

Content authoring → playlist authoring, media formats, codecs

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Content authoring → playlist authoring, media formats, codecs

Application design → using the AVFoundation API



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Application design → using the AVFoundation API

Delivery → server configuration and performance

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Understand and quantify user experience in conjunction with your changes

# Best User Experience for HLS

Content authoring → playlist authoring, media formats, codecs

Application design → using the AVFoundation API

Delivery → server configuration and performance

Understand and quantify user experience in conjunction with your changes

Measure to find the optimal configuration

# What Is This Session About?

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Establish a common language for streaming Quality of Service

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Objectively measure the streaming QoS

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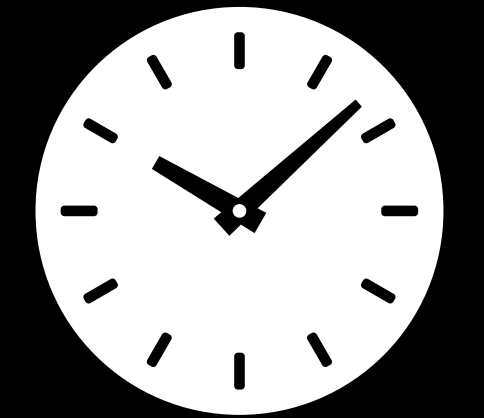
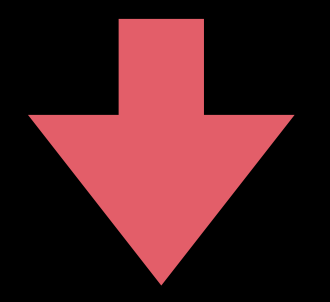
Objectively measure the streaming QoS

Identify and solve problems that impair QoS

Get master playlists right

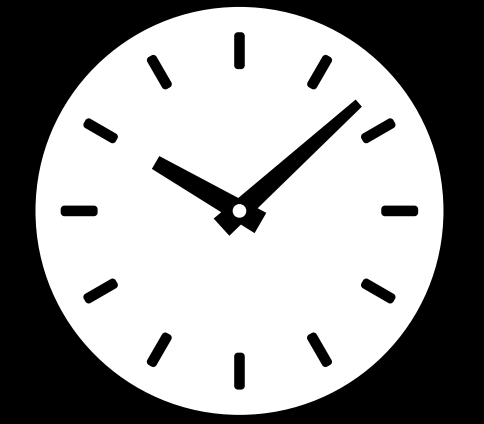
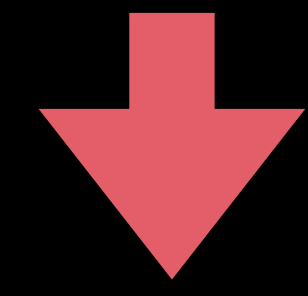


# Anatomy of an HLS Playback Session



Not playing  
Loading playlist  
2 Mbps download  
1 Mbps download  
Playout duration

# Anatomy of an HLS Playback Session



m  
3  
u  
8

Not playing  
Loading playlist  
2 Mbps download  
1 Mbps download  
Playout duration

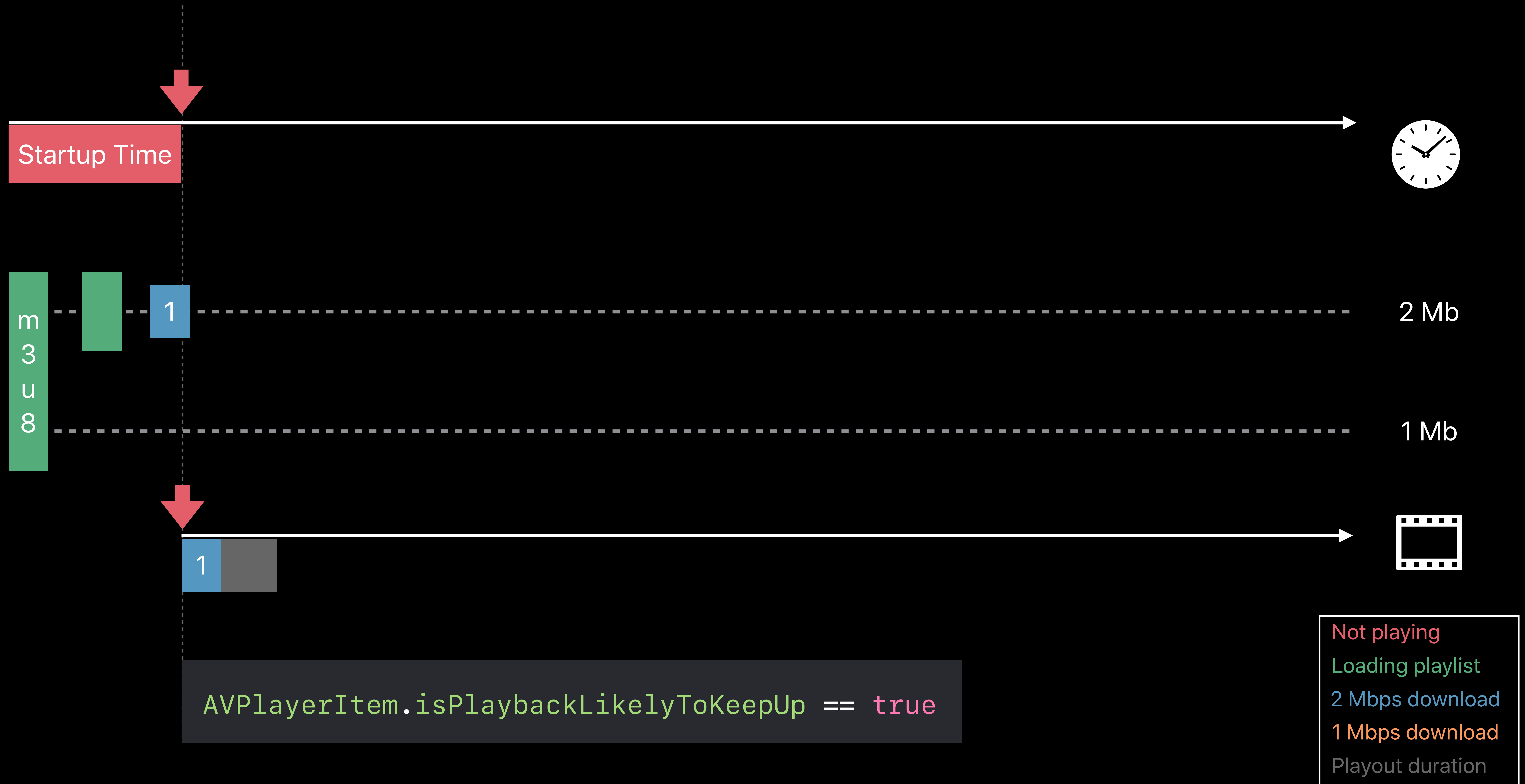
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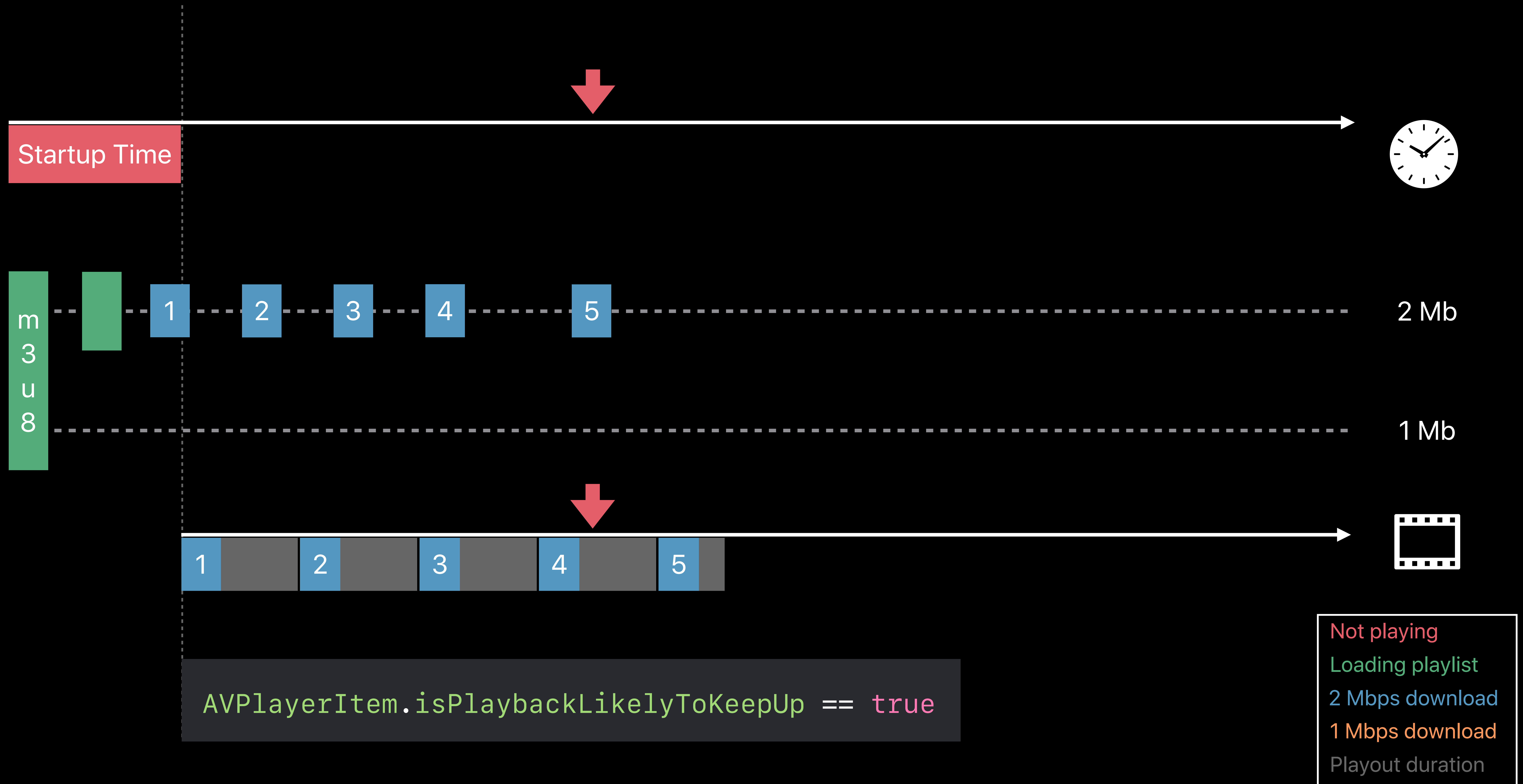
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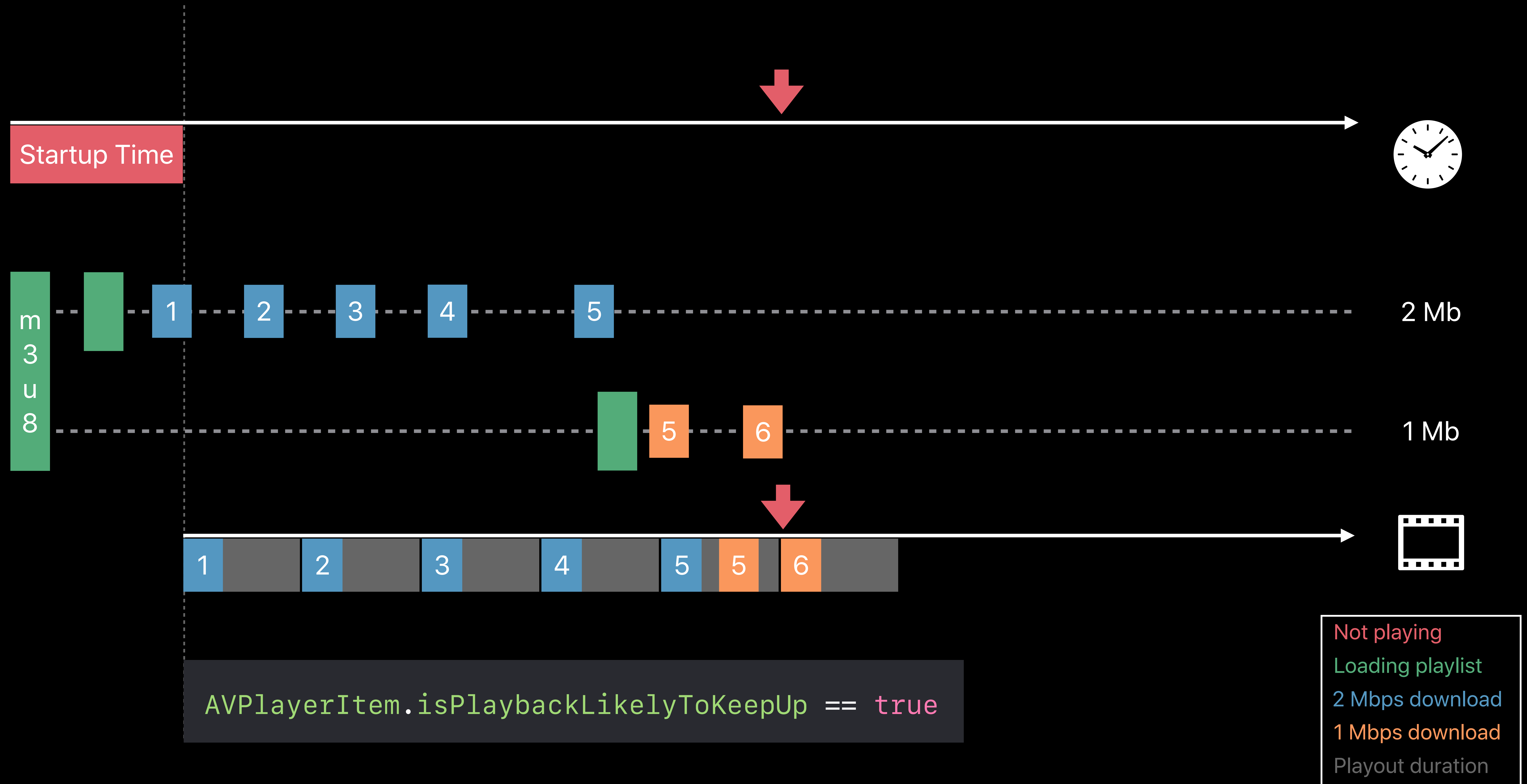
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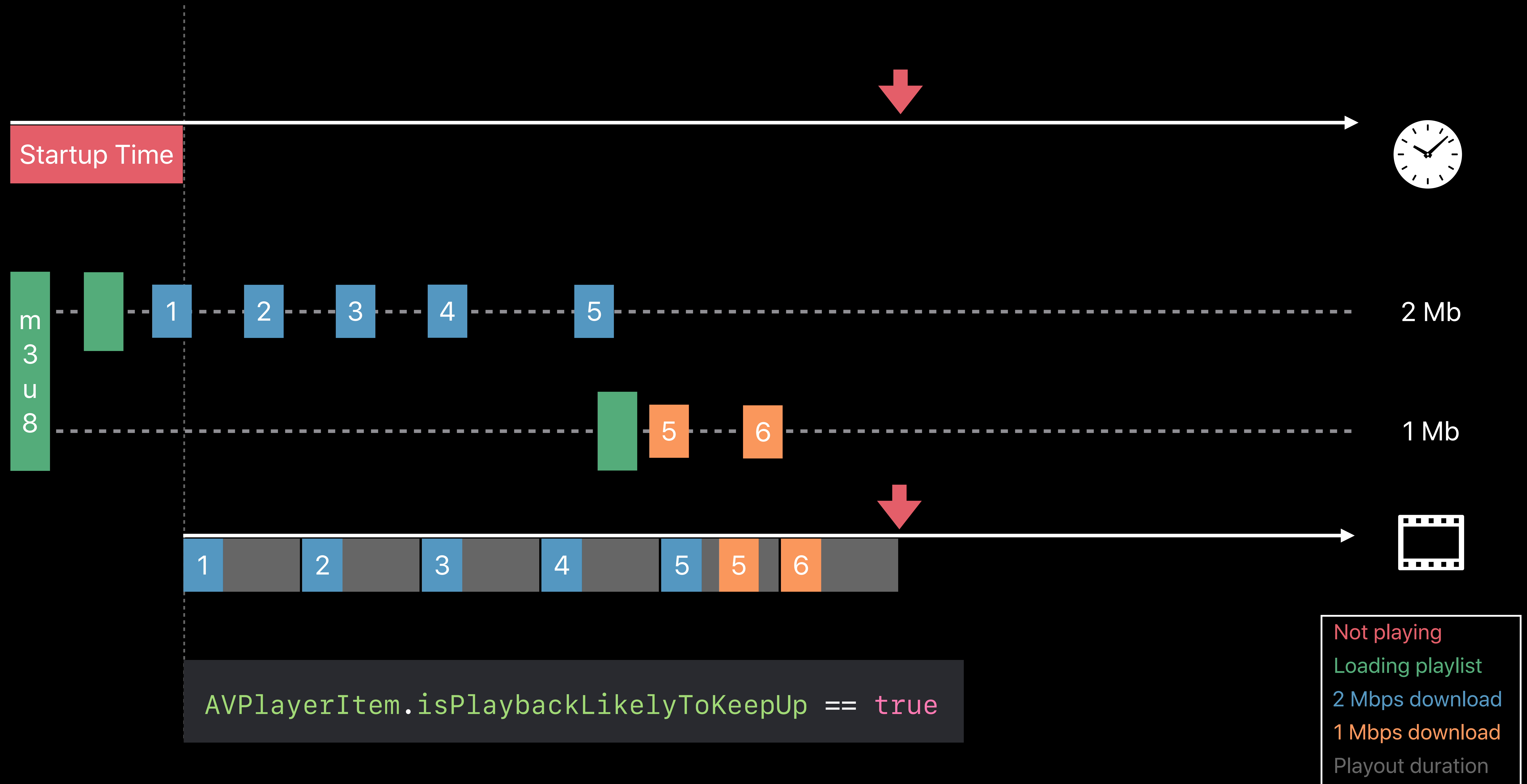
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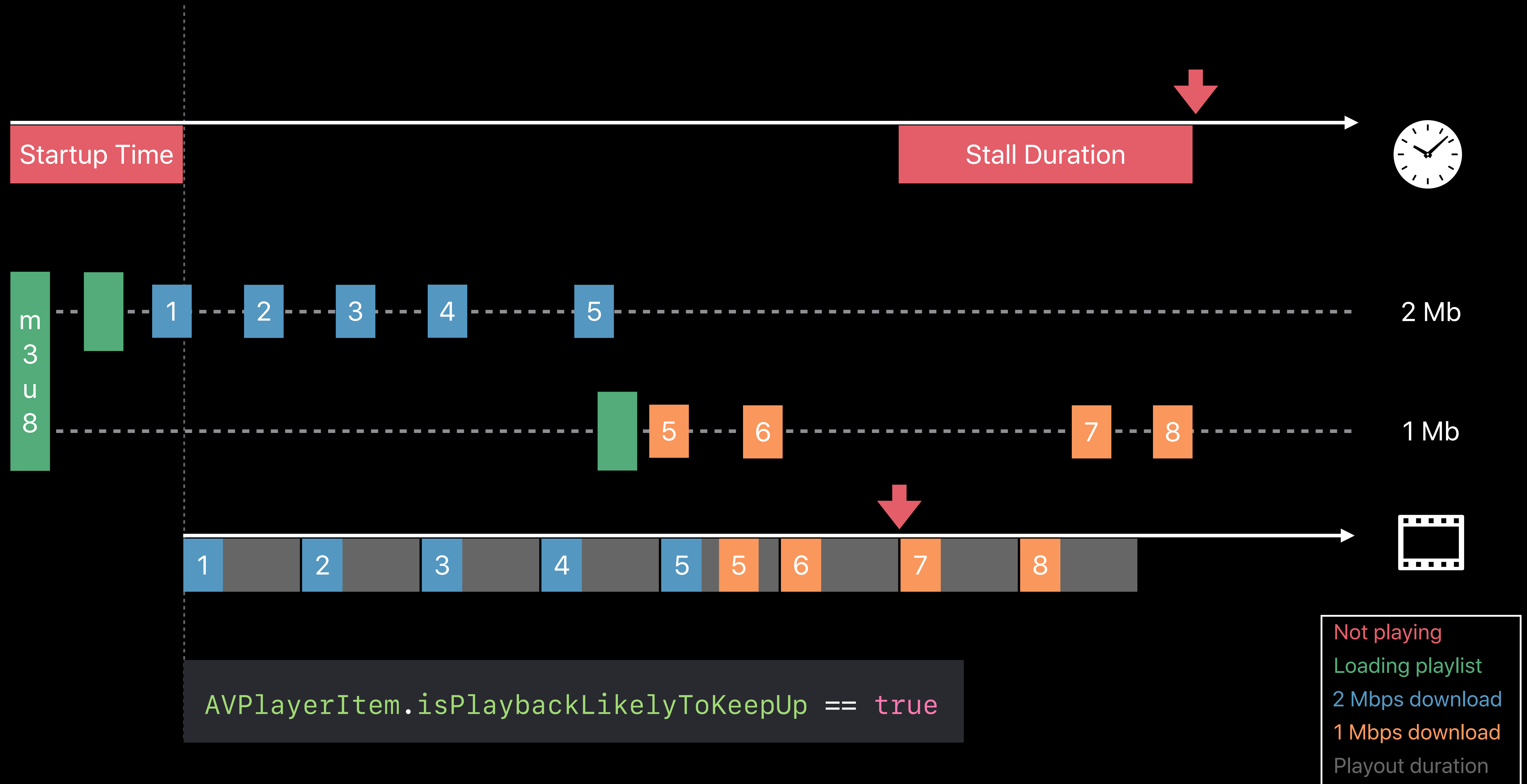


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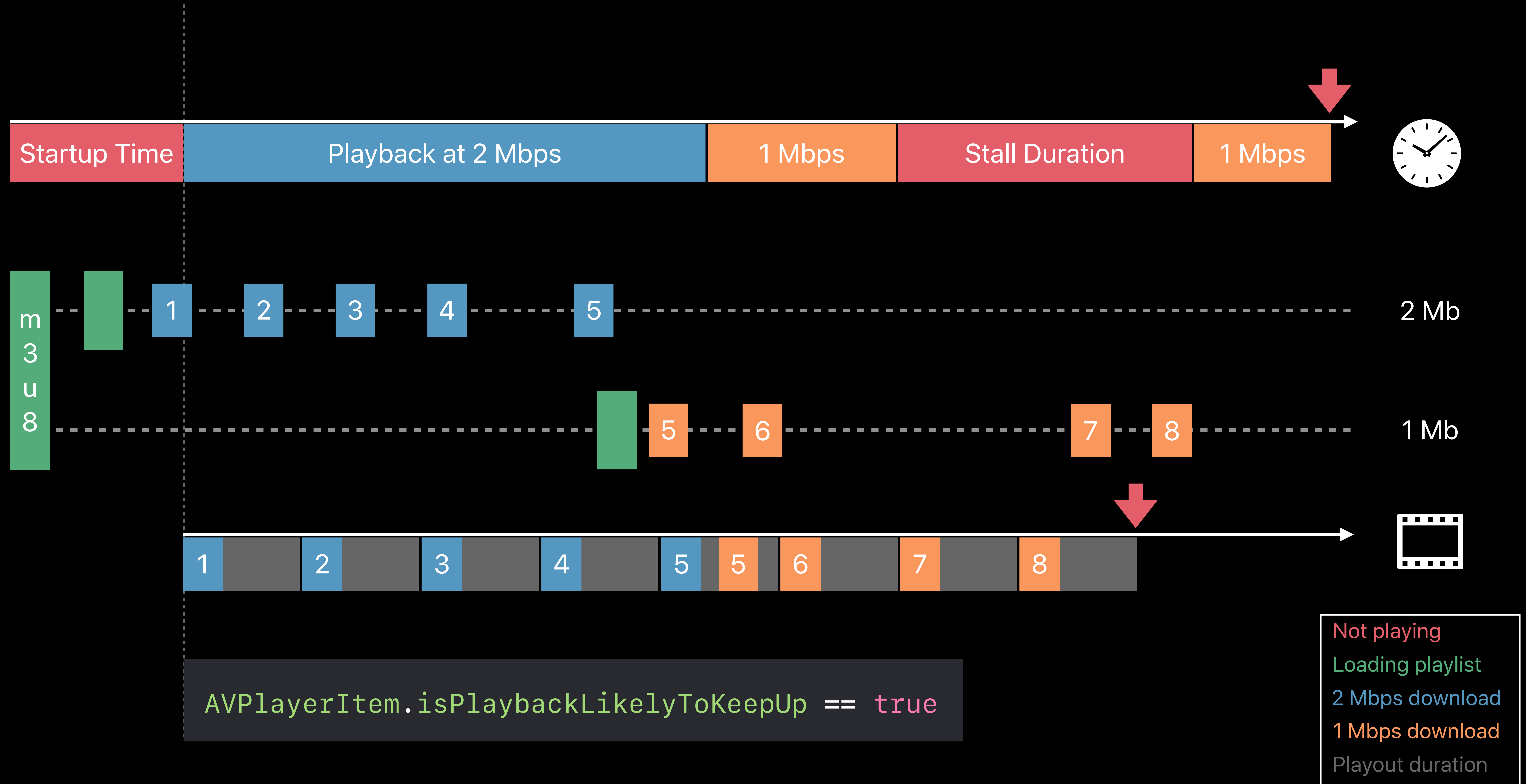




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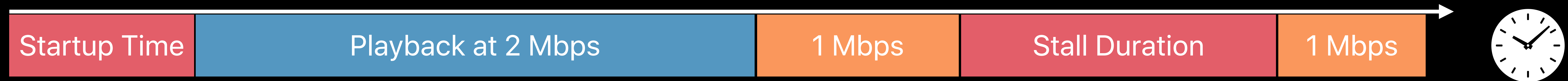


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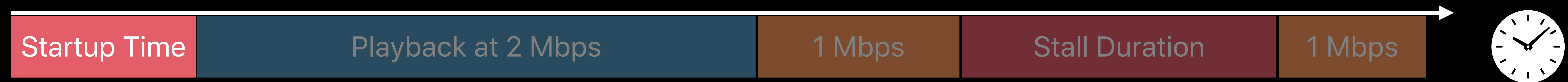
# Quantifying the User Experience

Key Performance Indicators (KPIs) for HLS



# Quantifying the User Experience

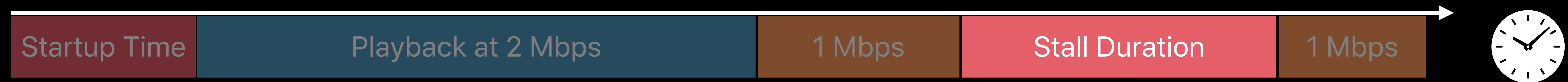
## Key Performance Indicators (KPIs) for HLS



How much time did the user spend waiting for playback to start?

# Quantifying the User Experience

## Key Performance Indicators (KPIs) for HLS



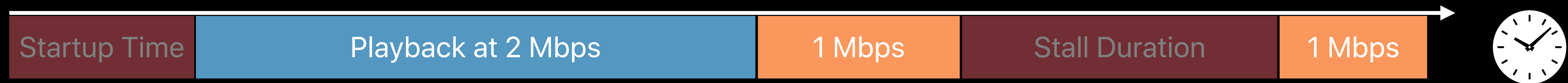
How much time did the user spend waiting for playback to start?

How often was playback interrupted?

How long was playback interrupted?

# Quantifying the User Experience

## Key Performance Indicators (KPIs) for HLS



How much time did the user spend waiting for playback to start?

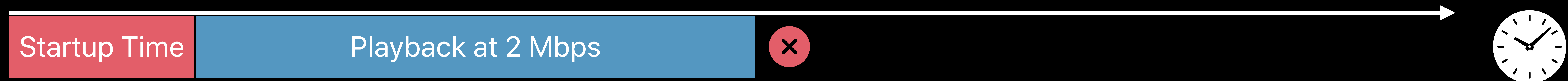
How often was playback interrupted?

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What was the overall media quality?

# Quantifying the User Experience

## Key Performance Indicators (KPIs) for HLS



How much time did the user spend waiting for playback to start?

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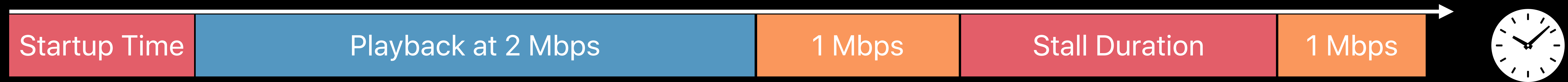
How long was playback interrupted?

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How often did the stream end due to an error?

# Startup Time

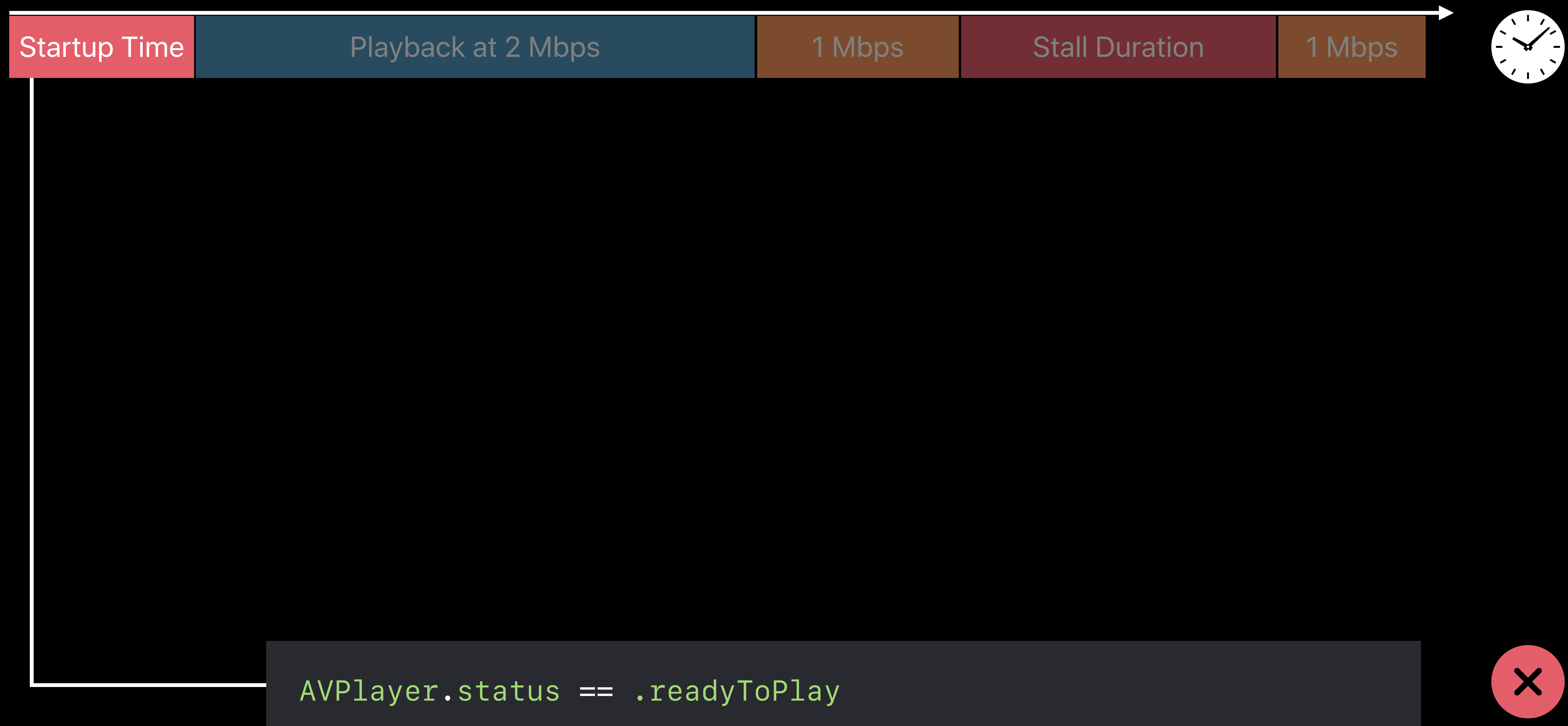
How much time did users spend waiting for playback to start?





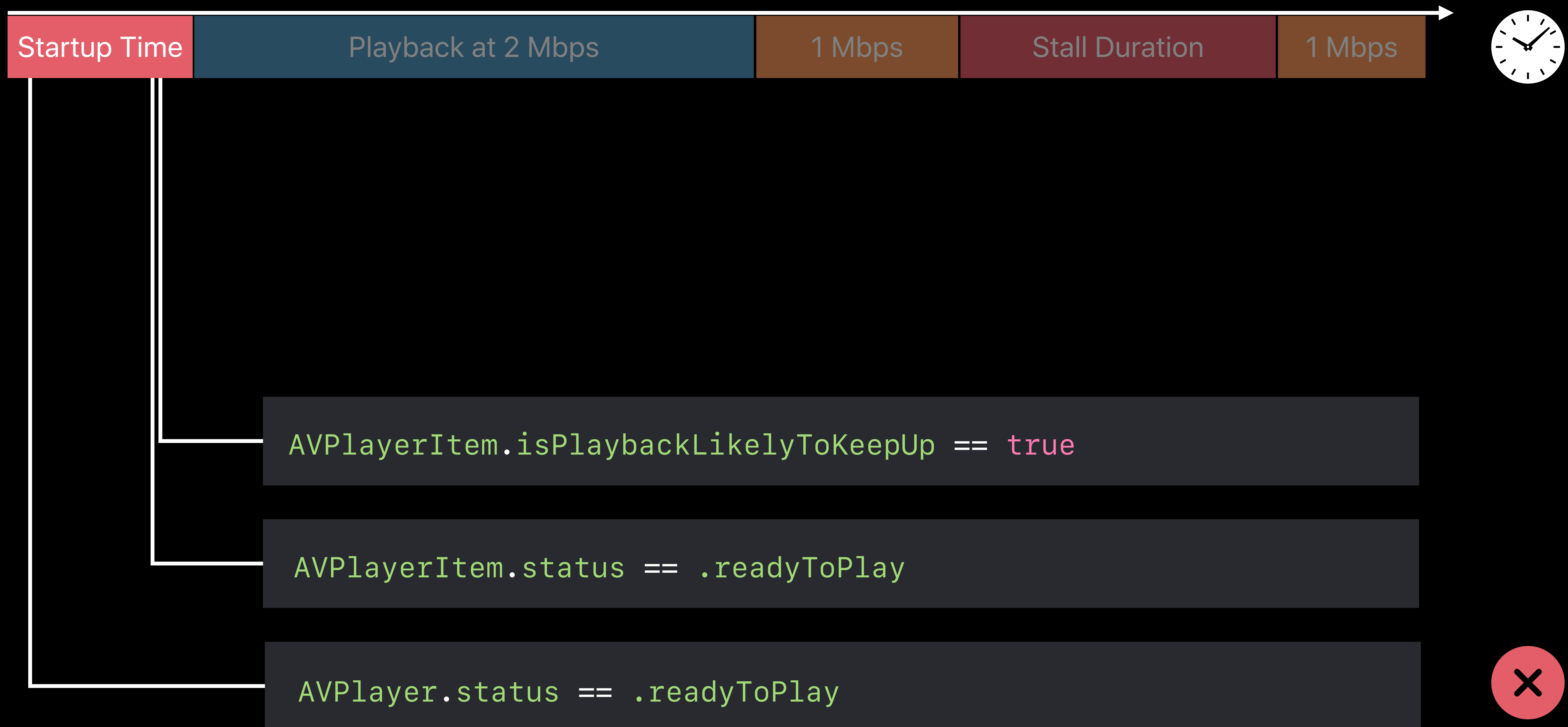
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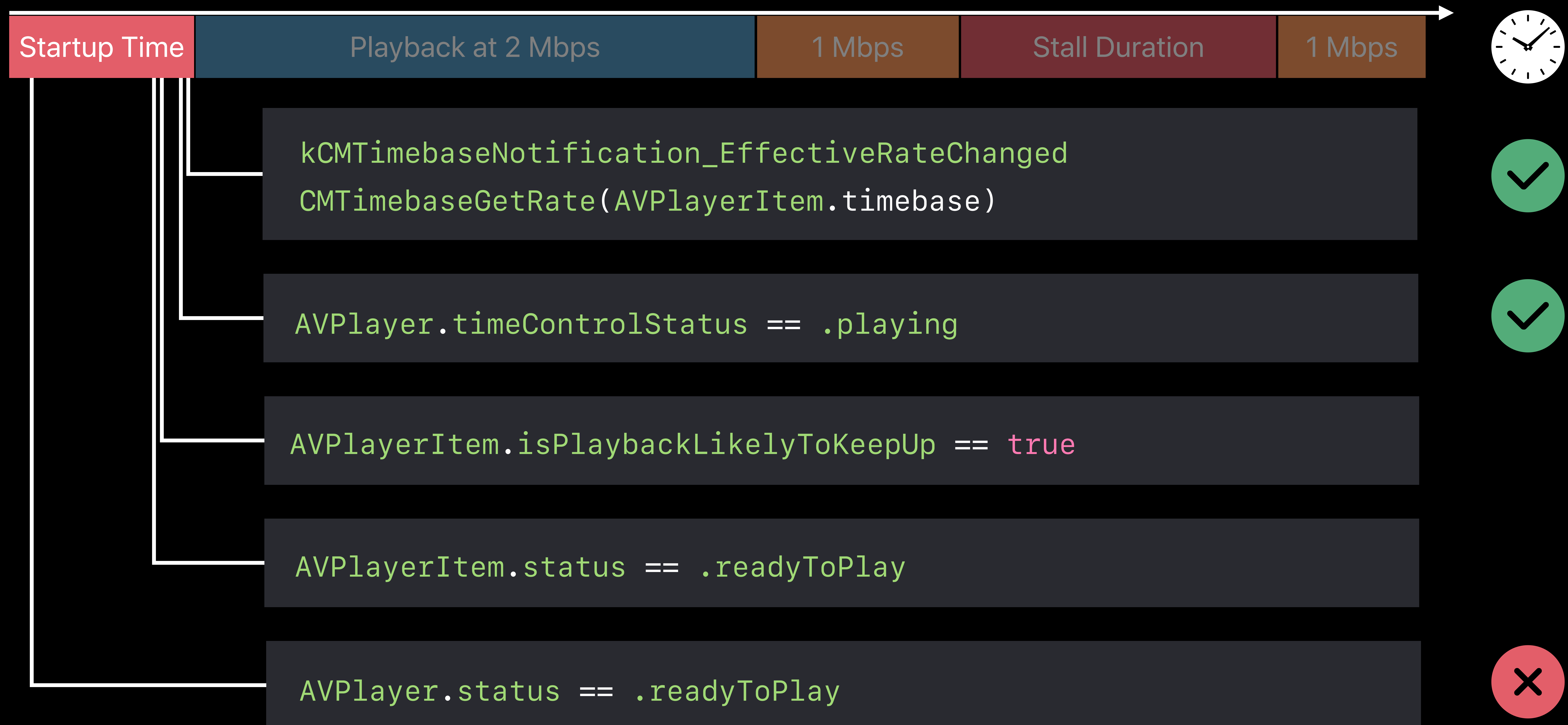
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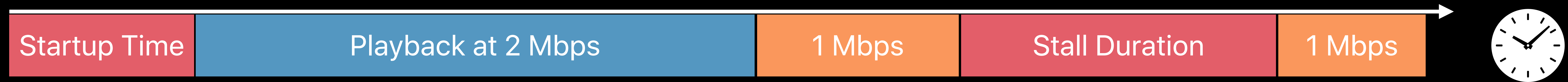
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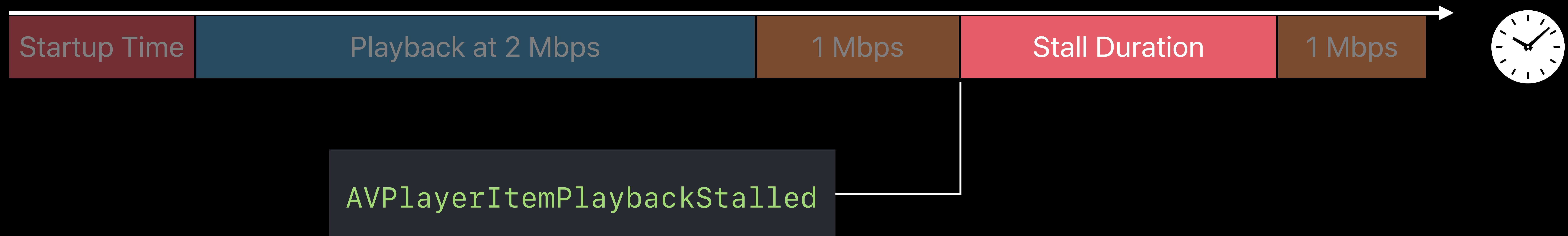
# Stall Rate

How often was playback interrupted?



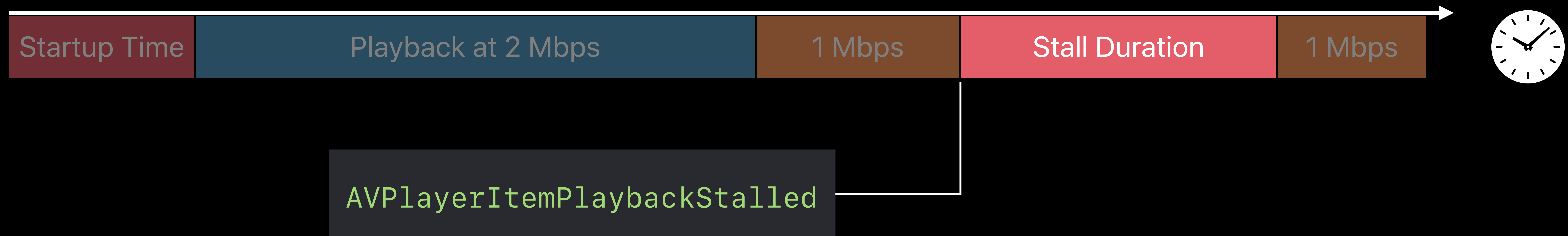
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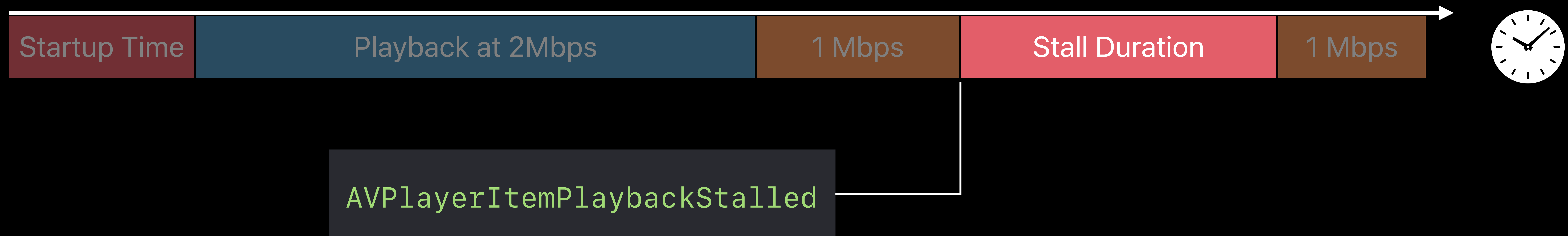
How often was playback interrupted?



| KPI                                         | Unit                  |
|---------------------------------------------|-----------------------|
| Stall rate (normalized to duration watched) | stalls / hour watched |

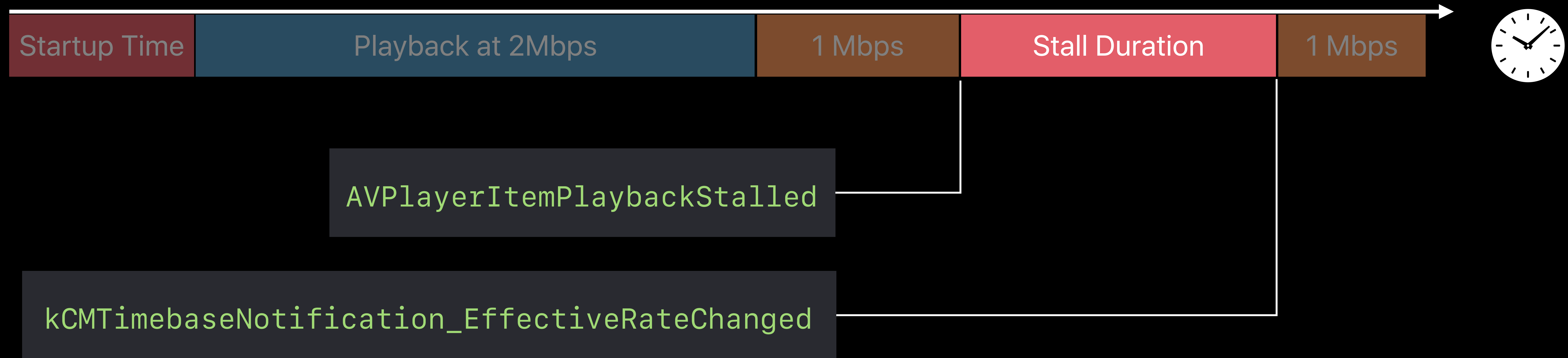
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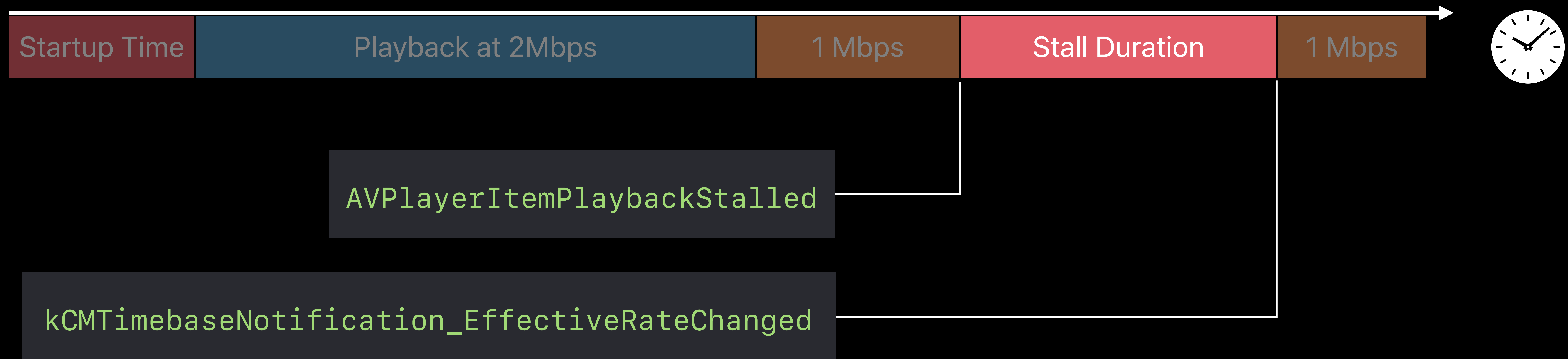
How long was playback interrupted?





# Stall Duration

How long was playback interrupted?



**KPI**

Stall duration to duration watched ratio

**Unit**

total stall duration / total duration watched

```
//Computing total duration watched from AVPlayerItem's access log
```

```
var totalDurationWatched = 0.0
```

```
if let accessLog = playerItem.accessLog() {
```

```
    for event in accessLog.events {
```

```
        if event.durationWatched > 0 {
```

```
            totalDurationWatched += event.durationWatched
```

```
        }
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```
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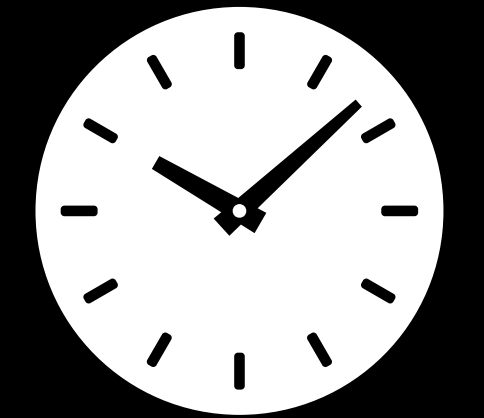
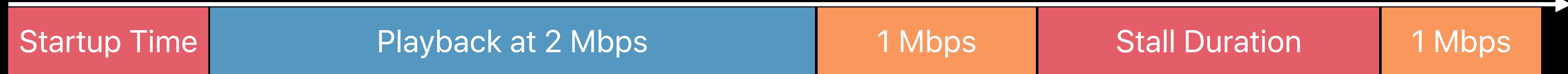
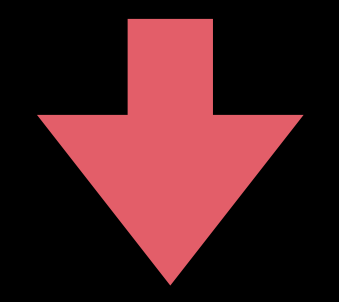
```
        }
```

```
    }
```

```
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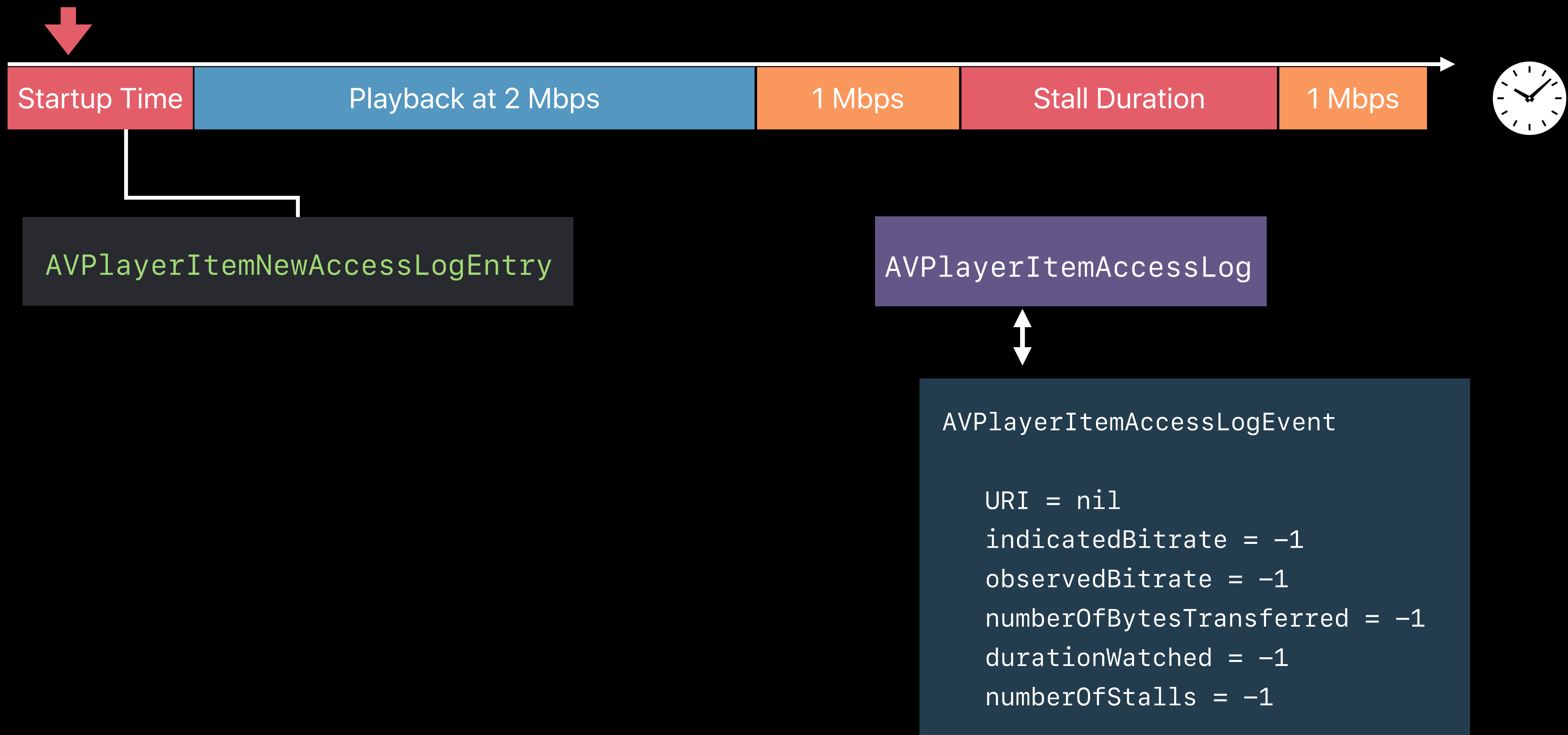
# AVPlayerItemAccessLog

Provides a history of the playback session



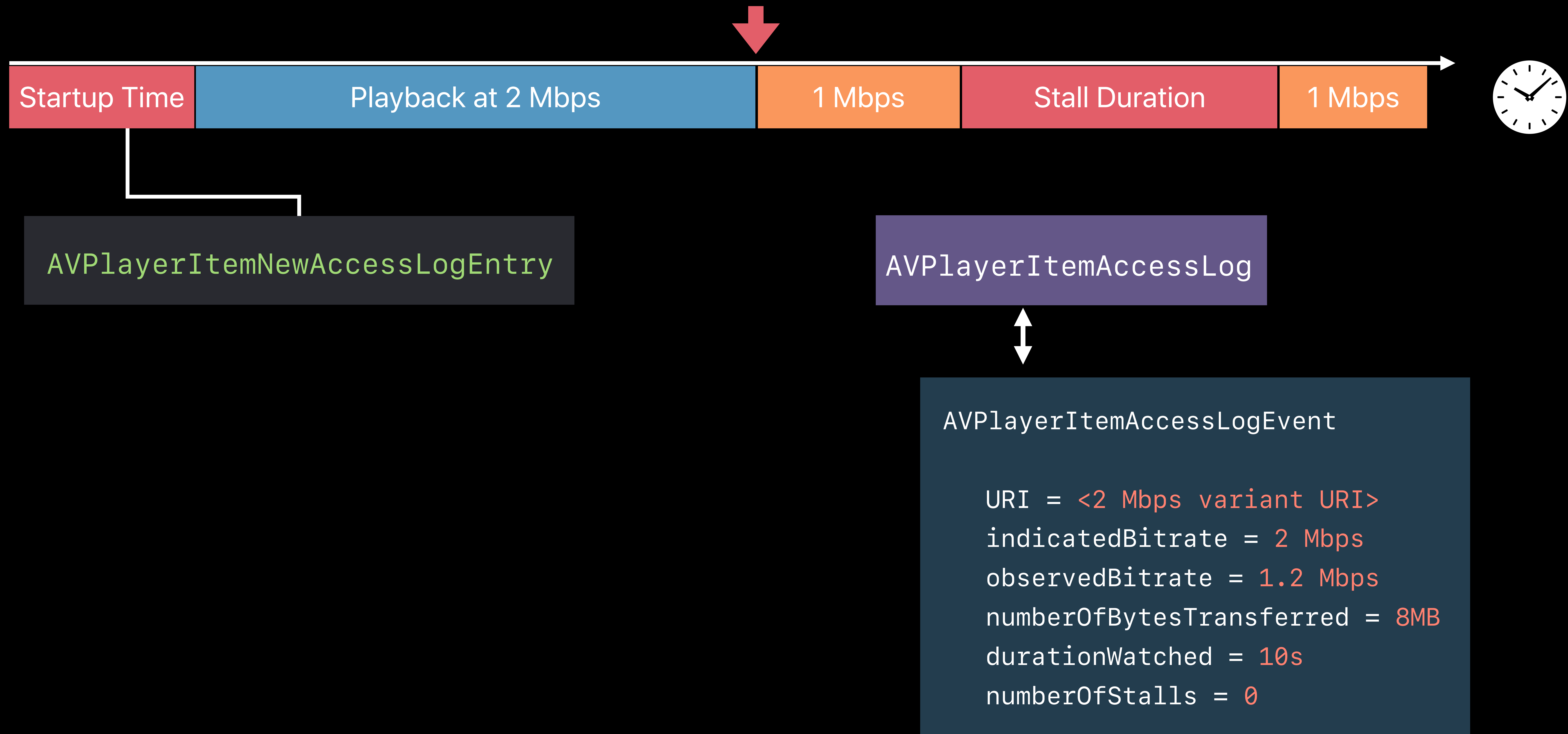
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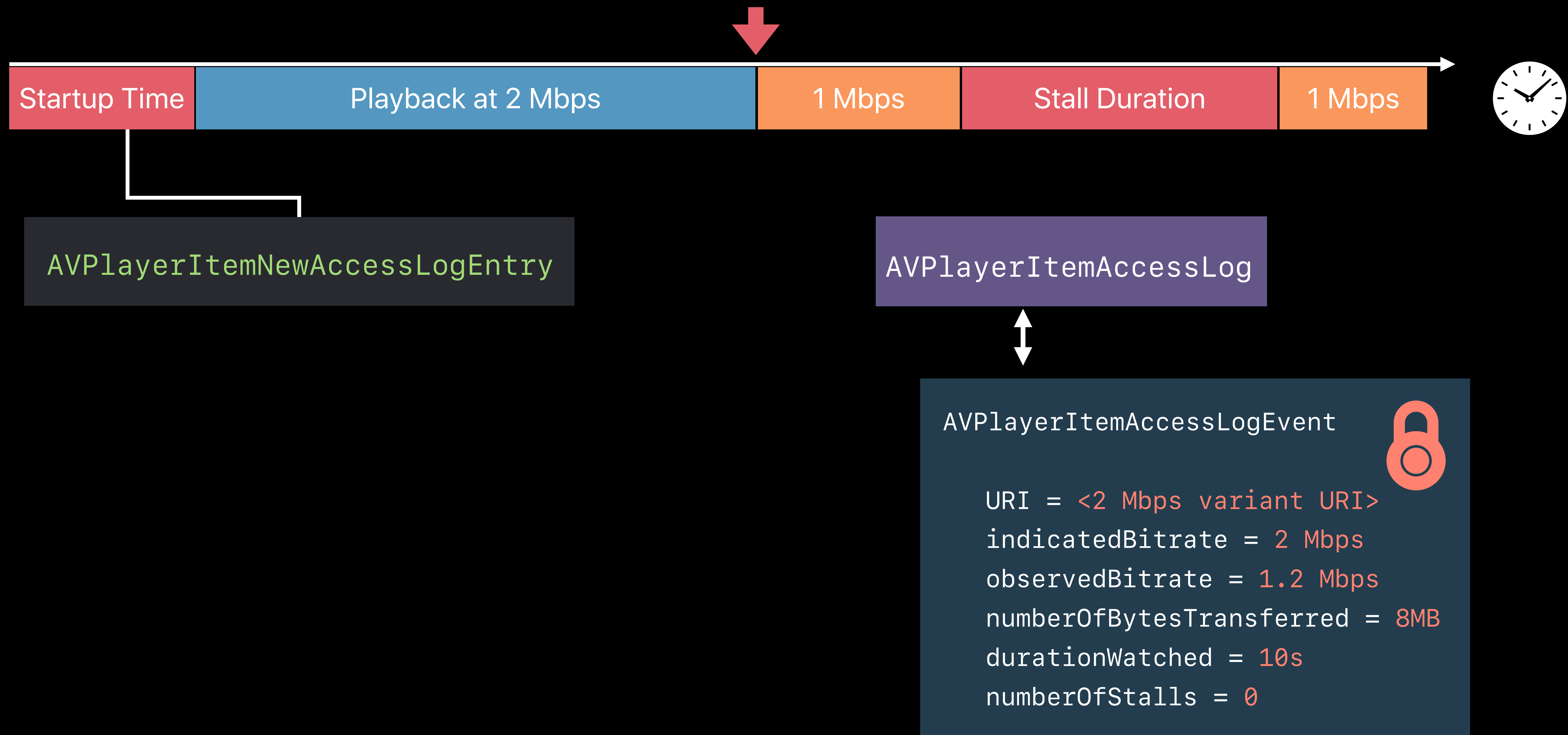
Provides a history of the playback session





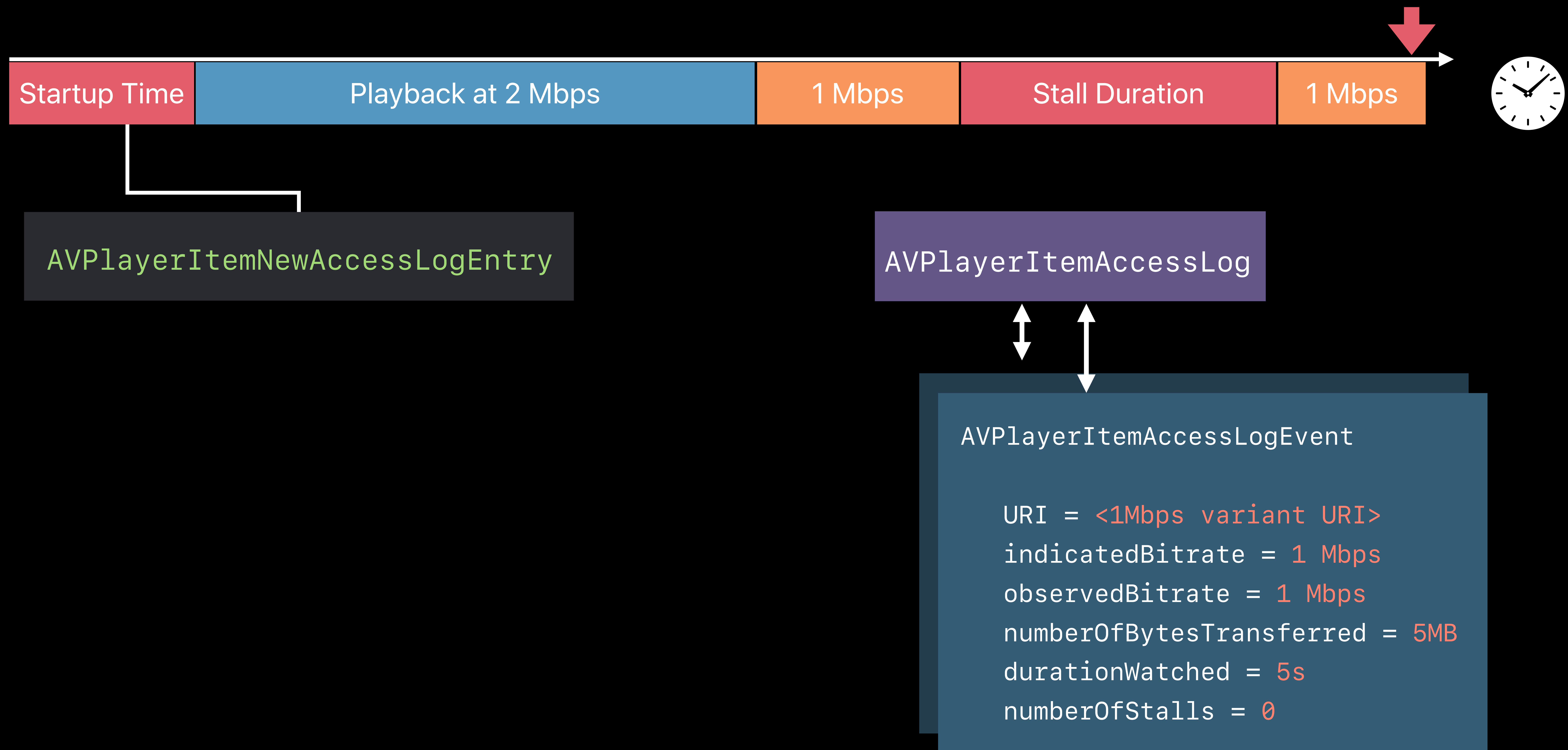
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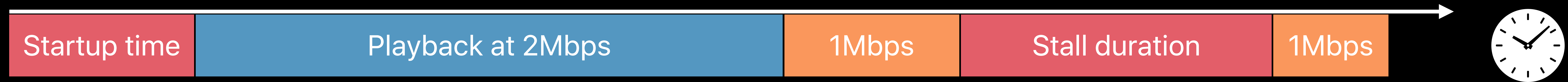
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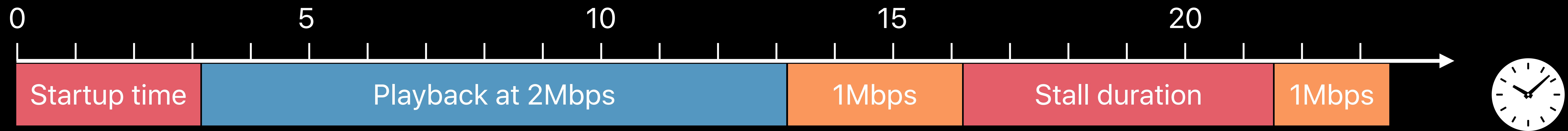
# Time-Weighted Indicated Bitrate

What was the overall media quality?



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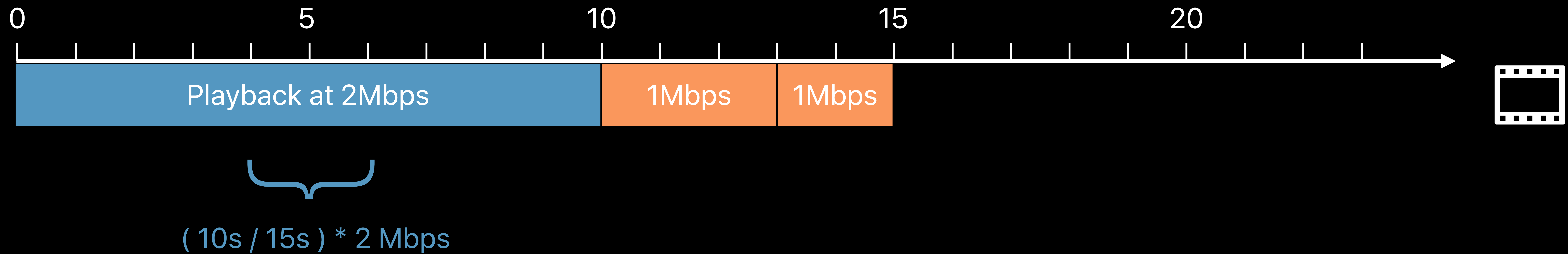
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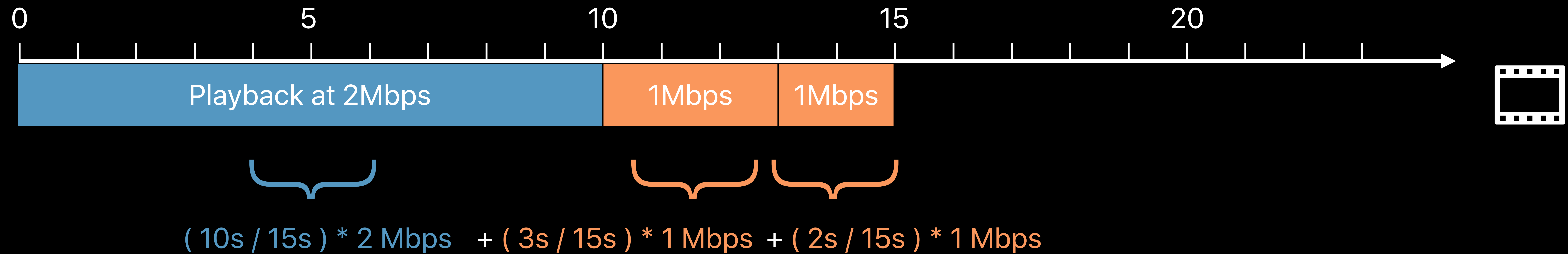
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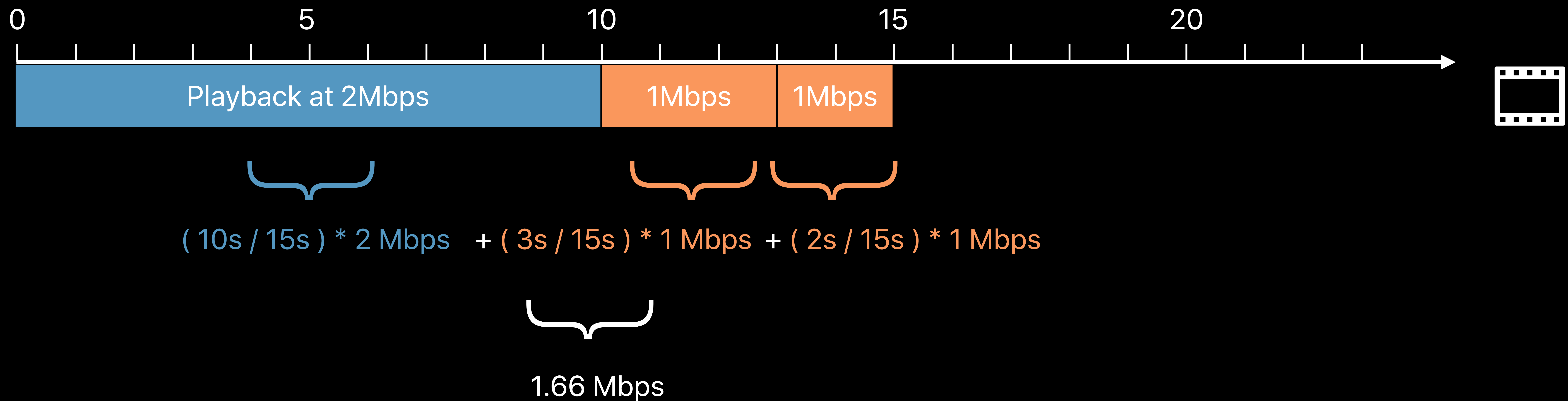
$$\underbrace{\hspace{10em}}_{(10s / 15s) * 2 \text{ Mbps}} + \underbrace{\hspace{2em}}_{(3s / 15s) * 1 \text{ Mbps}} + \underbrace{\hspace{2em}}_{(2s / 15s) * 1 \text{ Mbps}}$$

$$\underbrace{\hspace{10em}}_{1.66 \text{ Mbps}}$$



# Time-Weighted Indicated Bitrate

What was the overall media quality?



| KPI                             | Unit |
|---------------------------------|------|
| Time-weighted indicated bitrate | Mbps |

```
//Computing time-weighted indicated bitrate from AVPlayerItem's access log

var timeWeightedIBR = 0.0
if let accessLog = playerItem.accessLog(), totalDurationWatched > 0 {
    for event in accessLog.events {
        if event.durationWatched > 0 && event.indicatedBitrate > 0 {
            let eventTimeWeight = event.durationWatched / totalDurationWatched
            timeWeightedIBR += event.indicatedBitrate * eventTimeWeight
        }
    }
}
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# Playback Failure Percentage

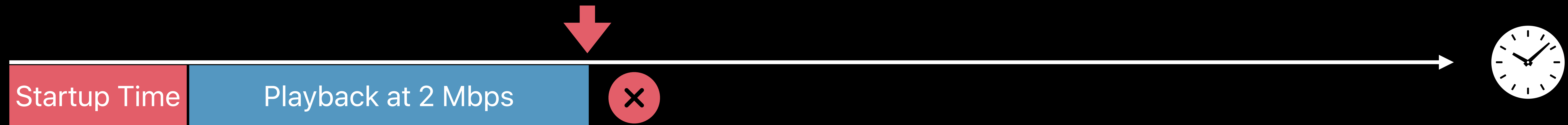
How often did the stream end due to an error?





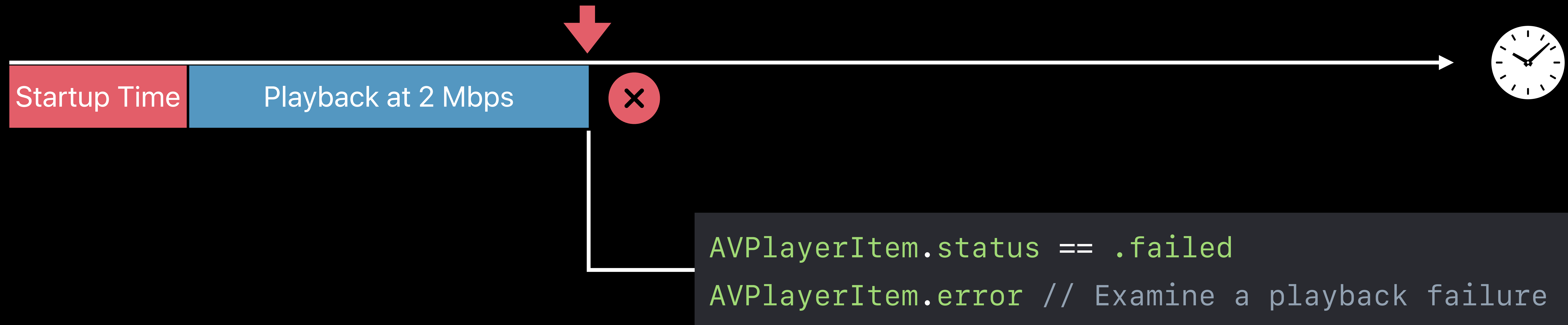
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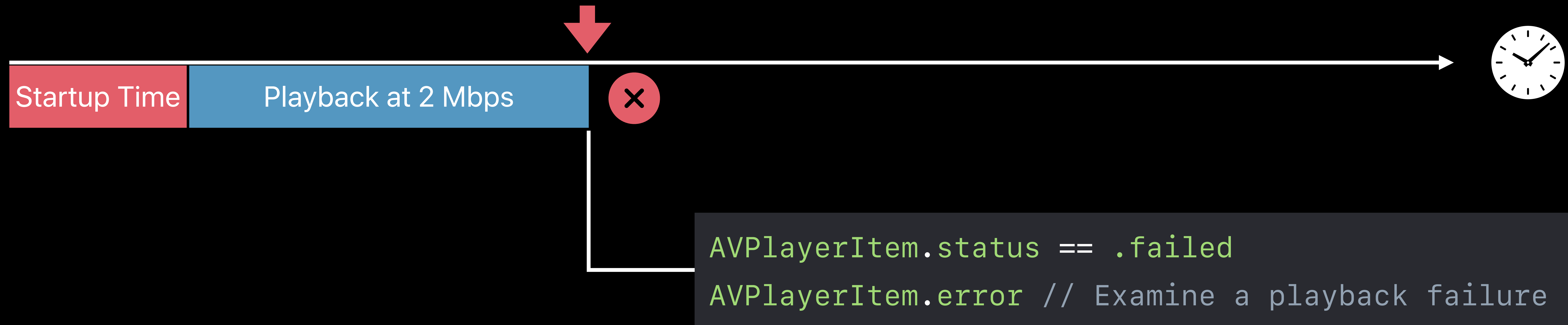
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How often did the stream end due to an error?



# Playback Failure Percentage

How often did the stream end due to an error?



**KPI**

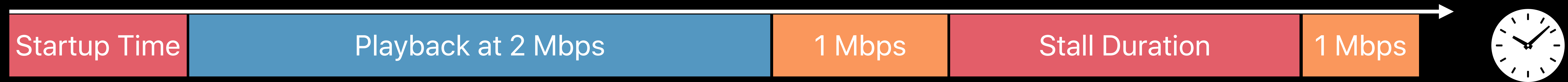
Playback failure percentage

**Unit**

Percent of total sessions

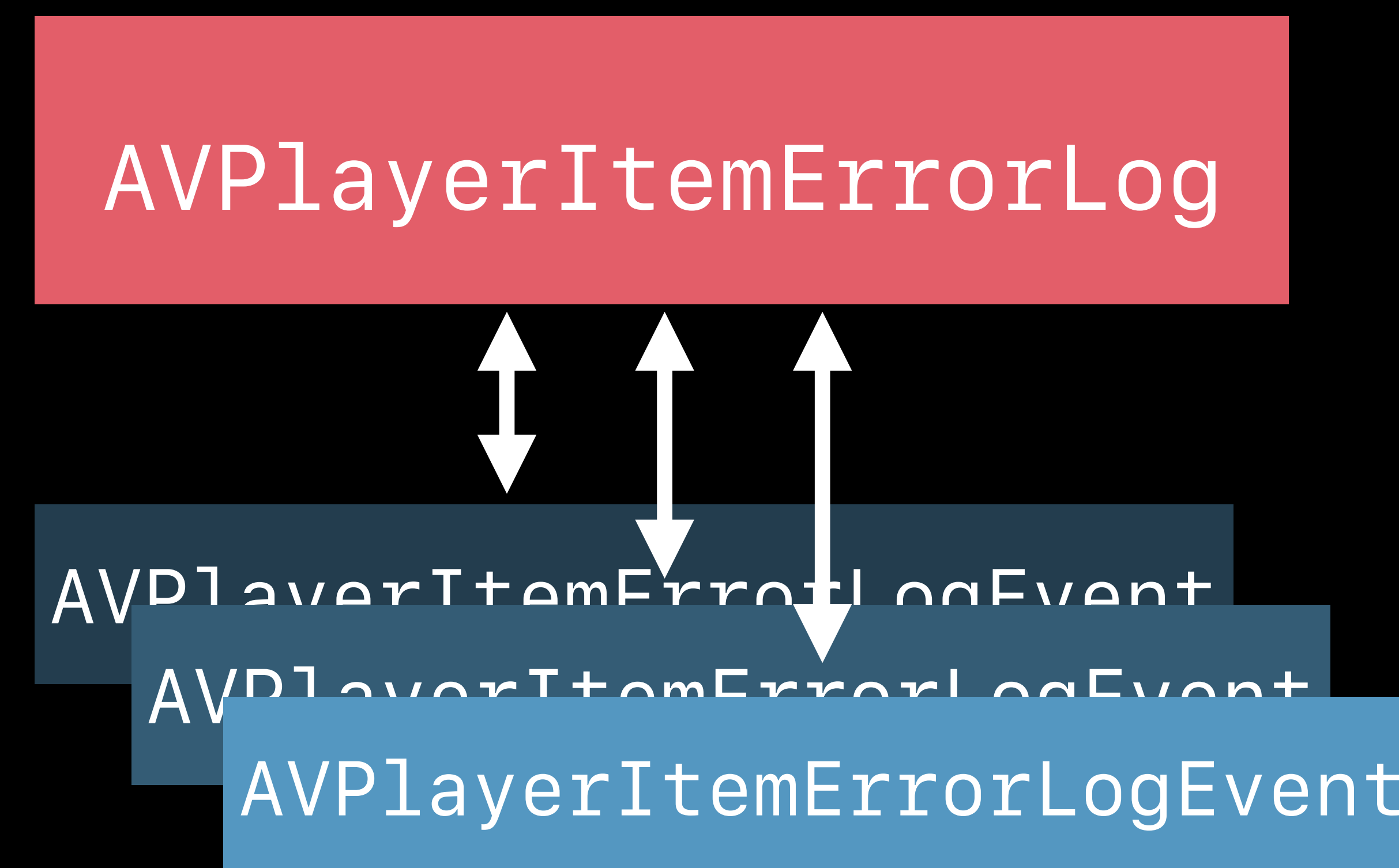
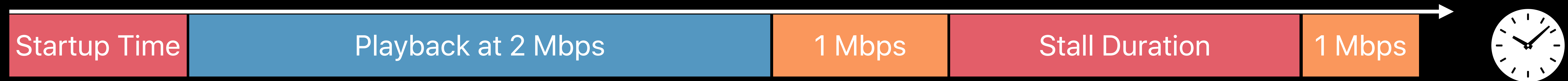
# AVPlayerItemErrorLog

Conveys failures with varying degrees of user impact



# AVPlayerItemErrorLog

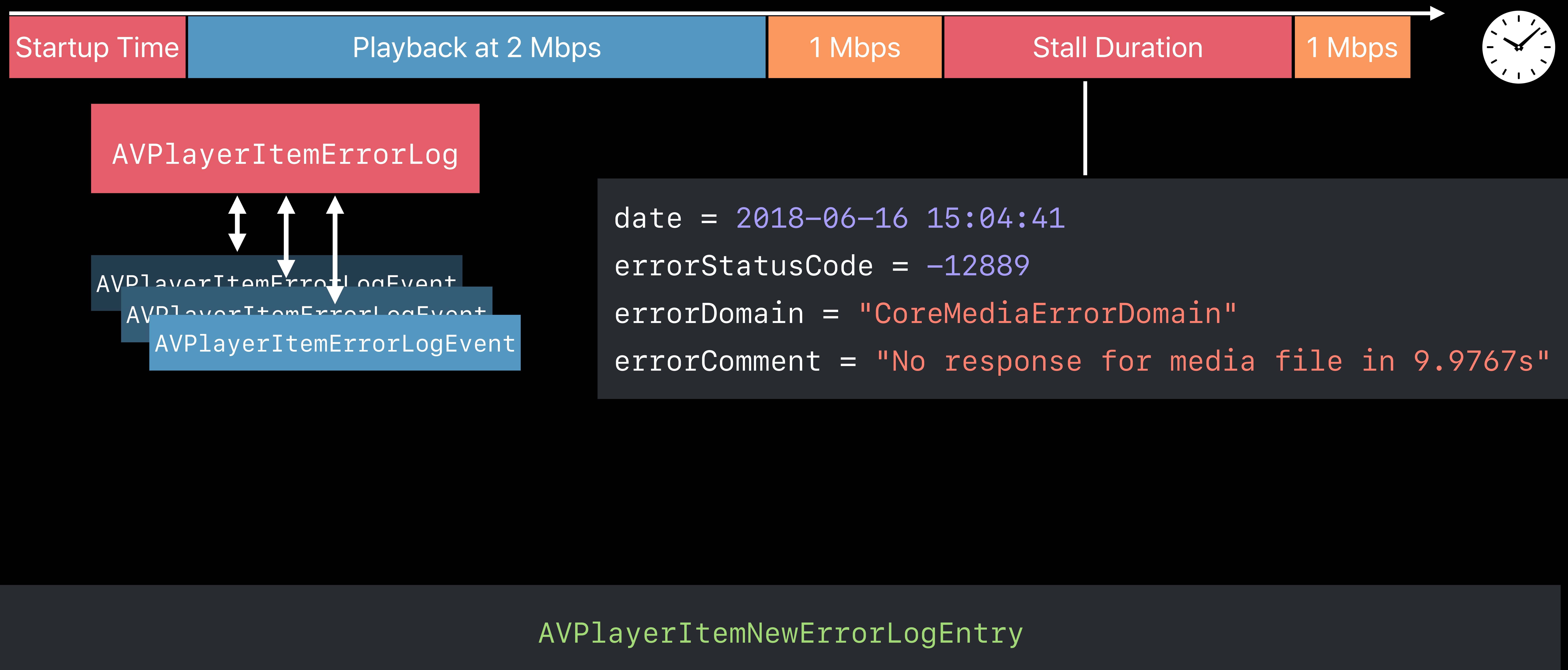
Conveys failures with varying degrees of user impact



`AVPlayerItemNewErrorLogEntry`

# AVPlayerItemErrorLog

Conveys failures with varying degrees of user impact



# The User Experience

Key performance indicators for HLS

---

| User Experience | Metric | KPI |
|-----------------|--------|-----|
|-----------------|--------|-----|

---

# The User Experience

Key performance indicators for HLS

---

| User Experience               | Metric       | KPI                      |
|-------------------------------|--------------|--------------------------|
| Waiting for playback to start | Startup time | Startup time per session |

---



# The User Experience

Key performance indicators for HLS

---

| User Experience               | Metric       | KPI                                         |
|-------------------------------|--------------|---------------------------------------------|
| Waiting for playback to start | Startup time | Startup time per session                    |
| Playback stalls               | Stall count  | Stall rate (normalized to duration watched) |

---

# The User Experience

Key performance indicators for HLS

| User Experience                | Metric         | KPI                                         |
|--------------------------------|----------------|---------------------------------------------|
| Waiting for playback to start  | Startup time   | Startup time per session                    |
| Playback stalls                | Stall count    | Stall rate (normalized to duration watched) |
| Waiting for playback to resume | Stall duration | Stall duration to duration watched ratio    |

# The User Experience

Key performance indicators for HLS

| User Experience                | Metric            | KPI                                         |
|--------------------------------|-------------------|---------------------------------------------|
| Waiting for playback to start  | Startup time      | Startup time per session                    |
| Playback stalls                | Stall count       | Stall rate (normalized to duration watched) |
| Waiting for playback to resume | Stall duration    | Stall duration to duration watched ratio    |
| Overall stream quality         | Indicated bitrate | Time-weighted indicated bitrate             |

# The User Experience

Key performance indicators for HLS

| User Experience                | Metric            | KPI                                         |
|--------------------------------|-------------------|---------------------------------------------|
| Waiting for playback to start  | Startup time      | Startup time per session                    |
| Playback stalls                | Stall count       | Stall rate (normalized to duration watched) |
| Waiting for playback to resume | Stall duration    | Stall duration to duration watched ratio    |
| Overall stream quality         | Indicated bitrate | Time-weighted indicated bitrate             |
| Playback fails                 | Error             | Playback failure percentage                 |

# The User Experience

Key performance indicators for HLS

KPIs are not always comparable between device models and usage scenarios

# The User Experience

Key performance indicators for HLS

KPIs are not always comparable between device models and usage scenarios

Gather context information along with your streaming metrics

# The User Experience

Key performance indicators for HLS

KPIs are not always comparable between device models and usage scenarios

Gather context information along with your streaming metrics

Partition your playback sessions in classes that make sense for your application

# More Information

<https://developer.apple.com/library/content/navigation/>



# Improving HLS Performance

Zhenheng Li, Media Streaming Engineer

# Ways to Improve User Experience

Reduce startup time

Investigate stalls

Investigate errors

# What Can Delay Start of Playback?



----- Network Activities

- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

# What Can Delay Start of Playback?



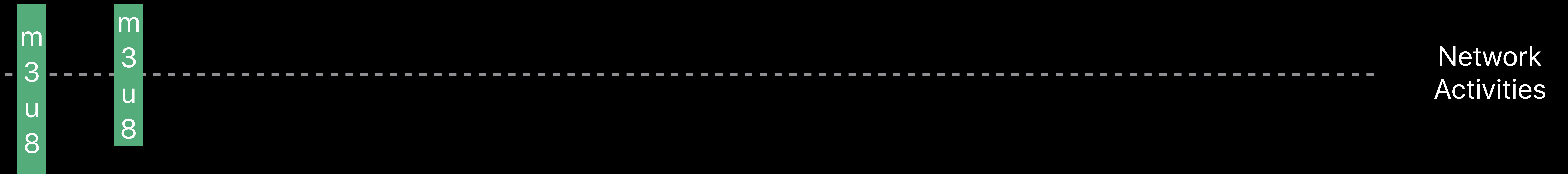
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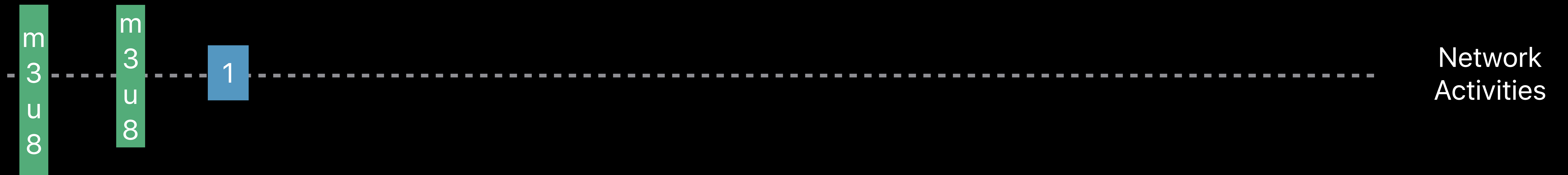


# What Can Delay Start of Playback?



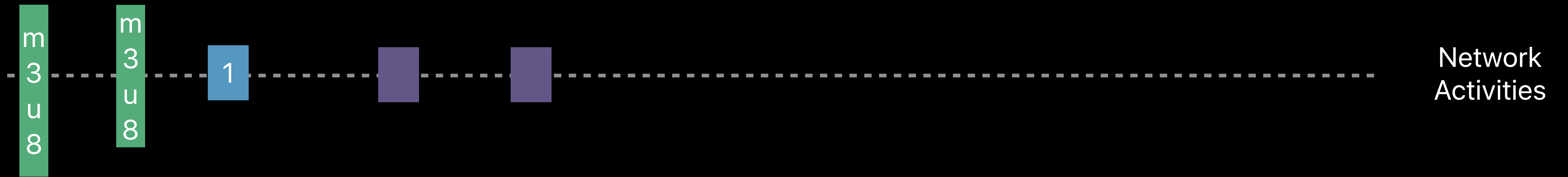
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# What Can Delay Start of Playback?



- Playlists
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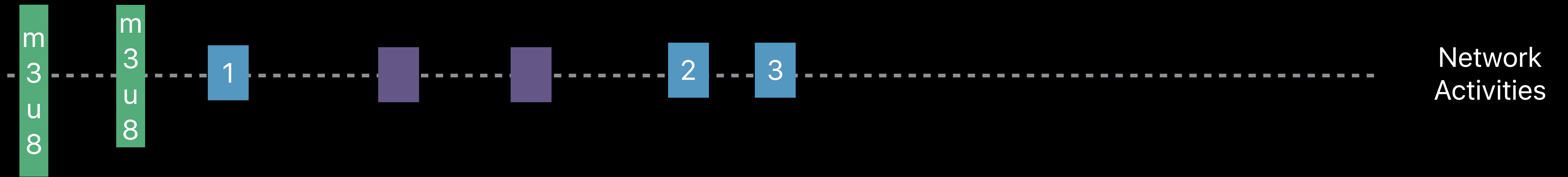
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- Decryption keys
- Spanish audio

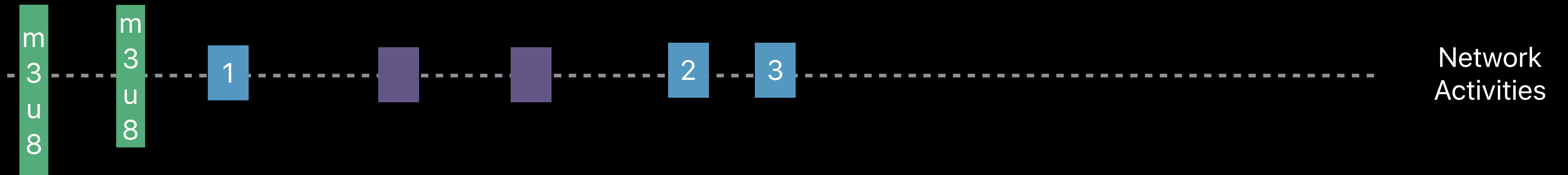
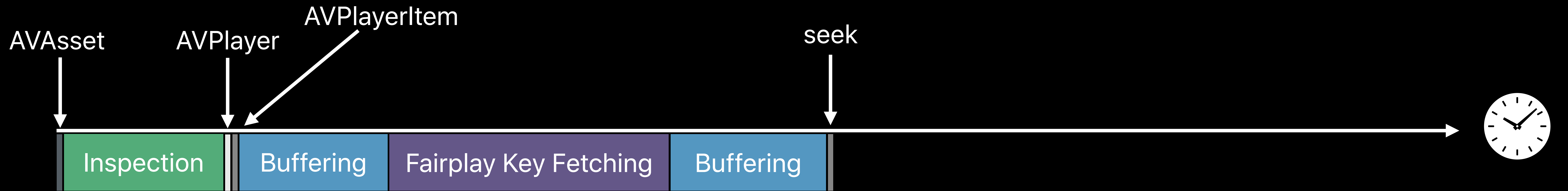


# What Can Delay Start of Playback?



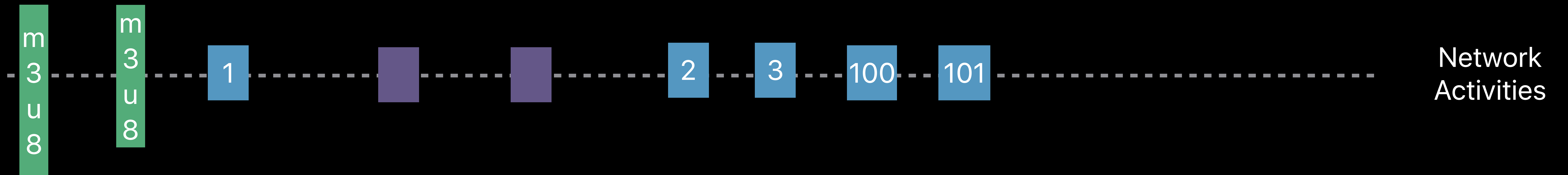
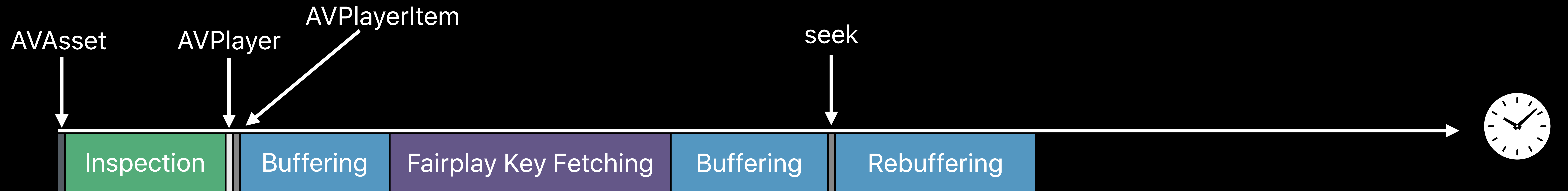
- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

# What Can Delay Start of Playback?



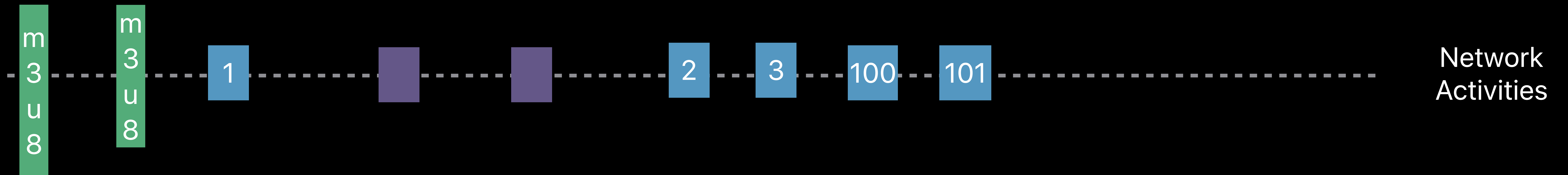
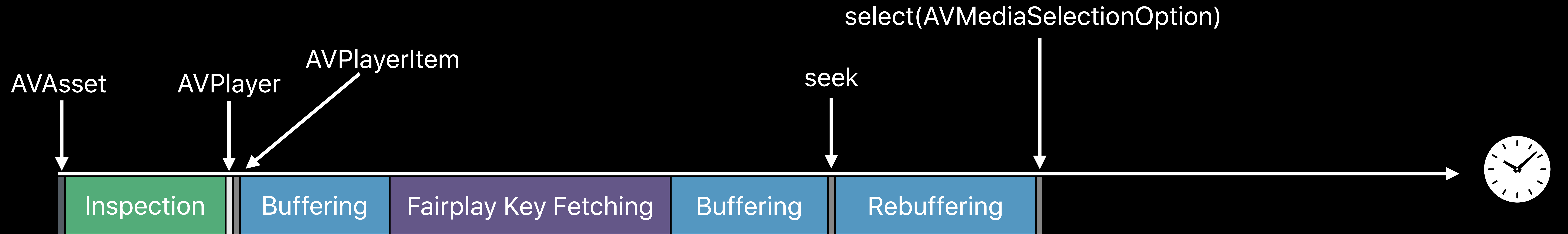
- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

# What Can Delay Start of Playback?



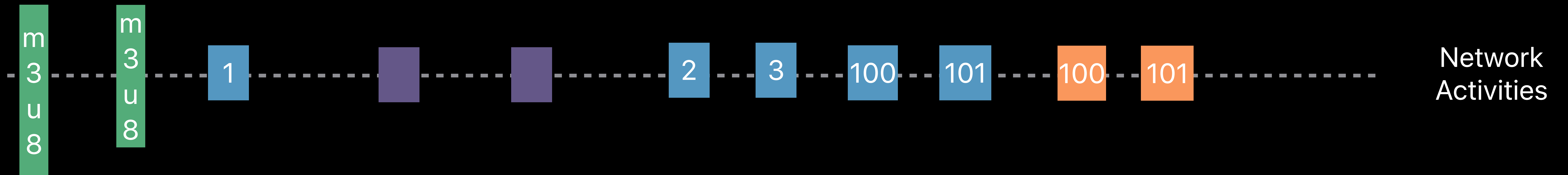
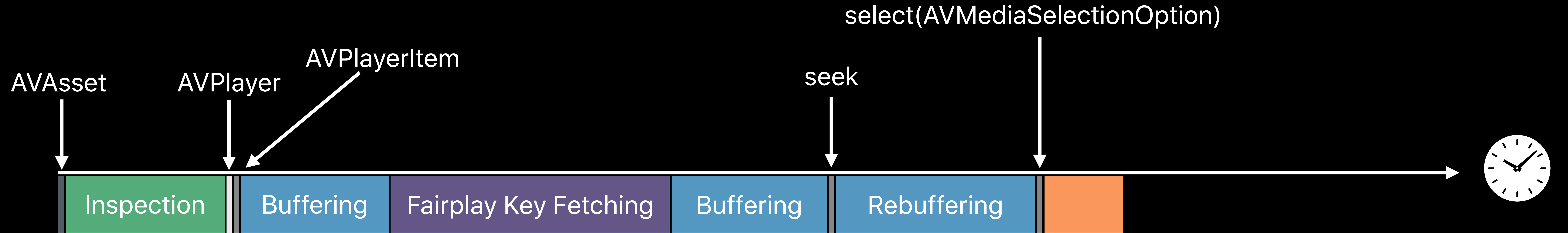
- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

# What Can Delay Start of Playback?



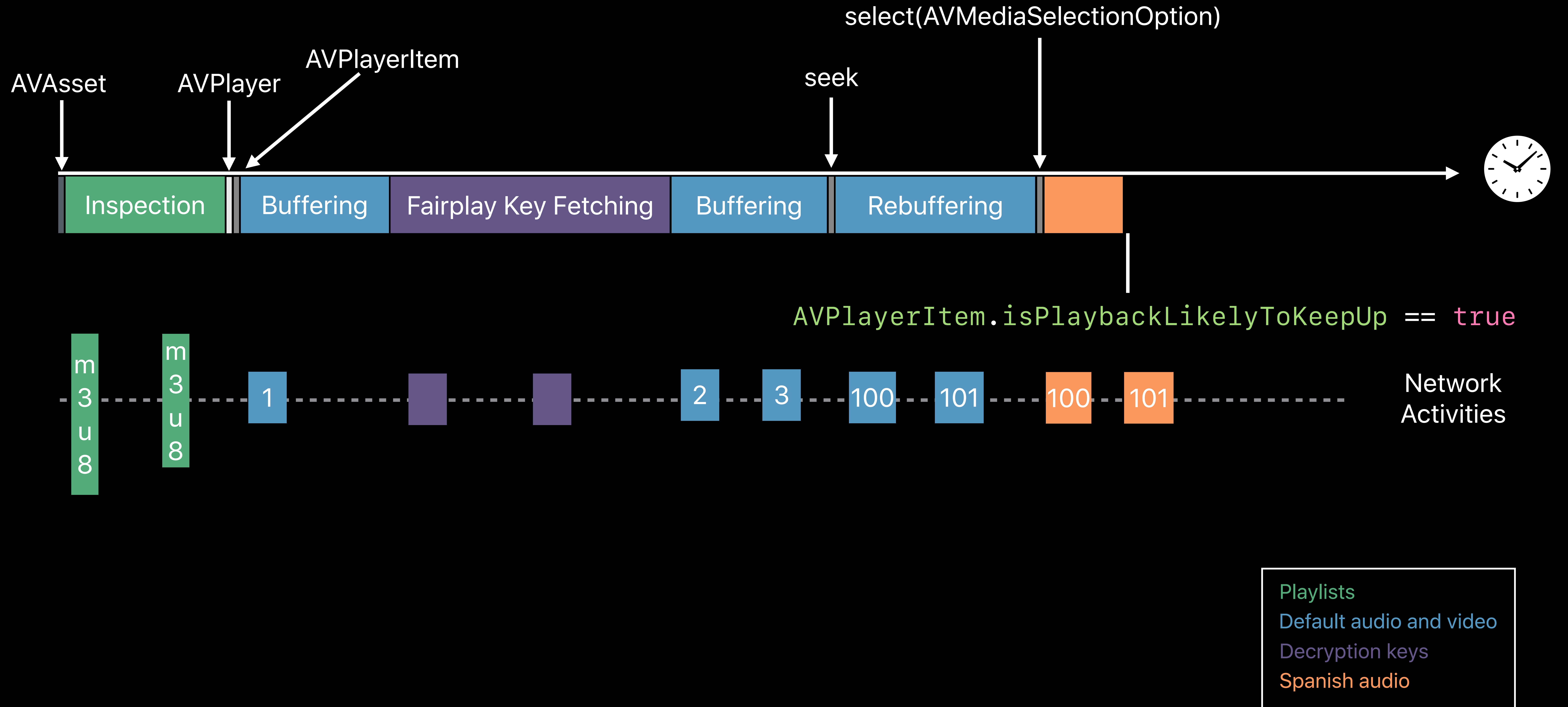
- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

# What Can Delay Start of Playback?

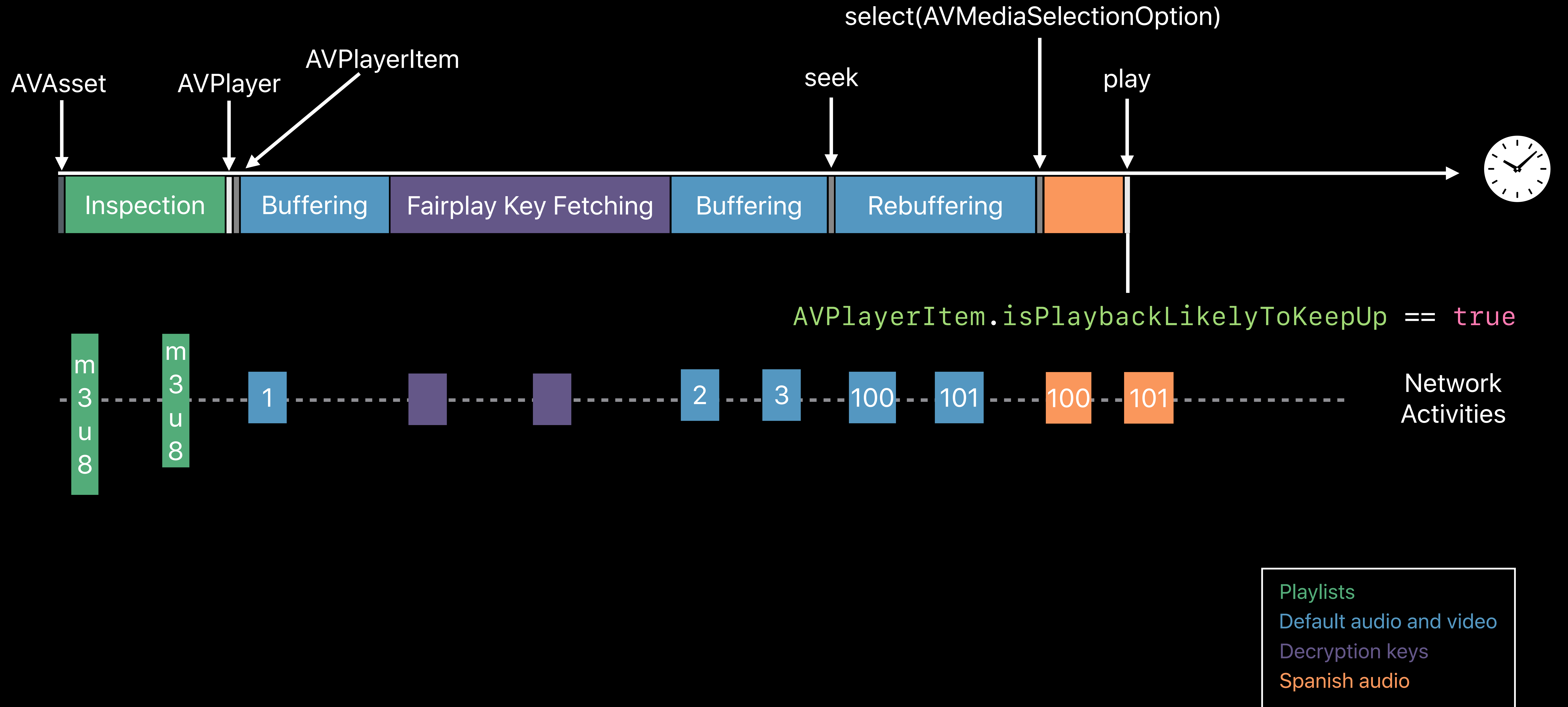


- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

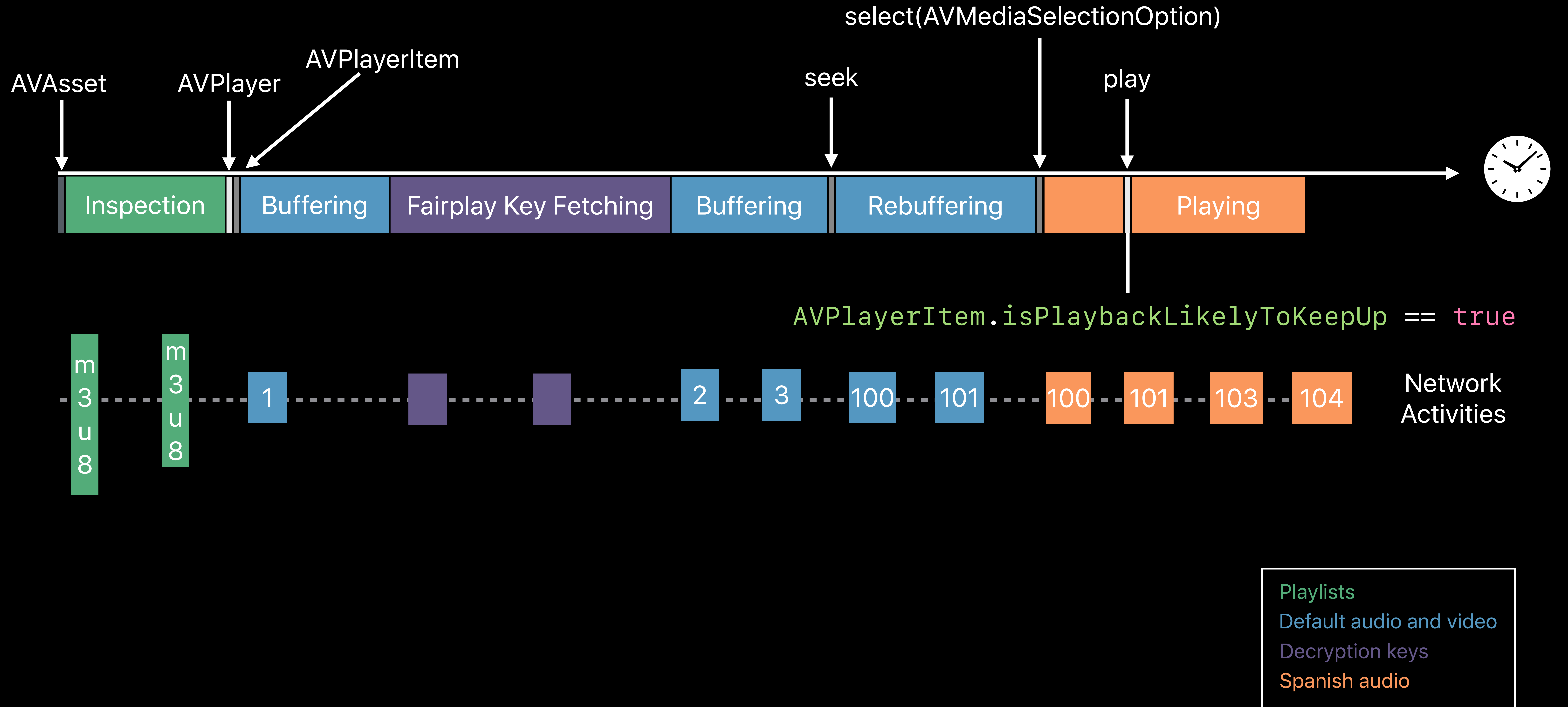
# What Can Delay Start of Playback?



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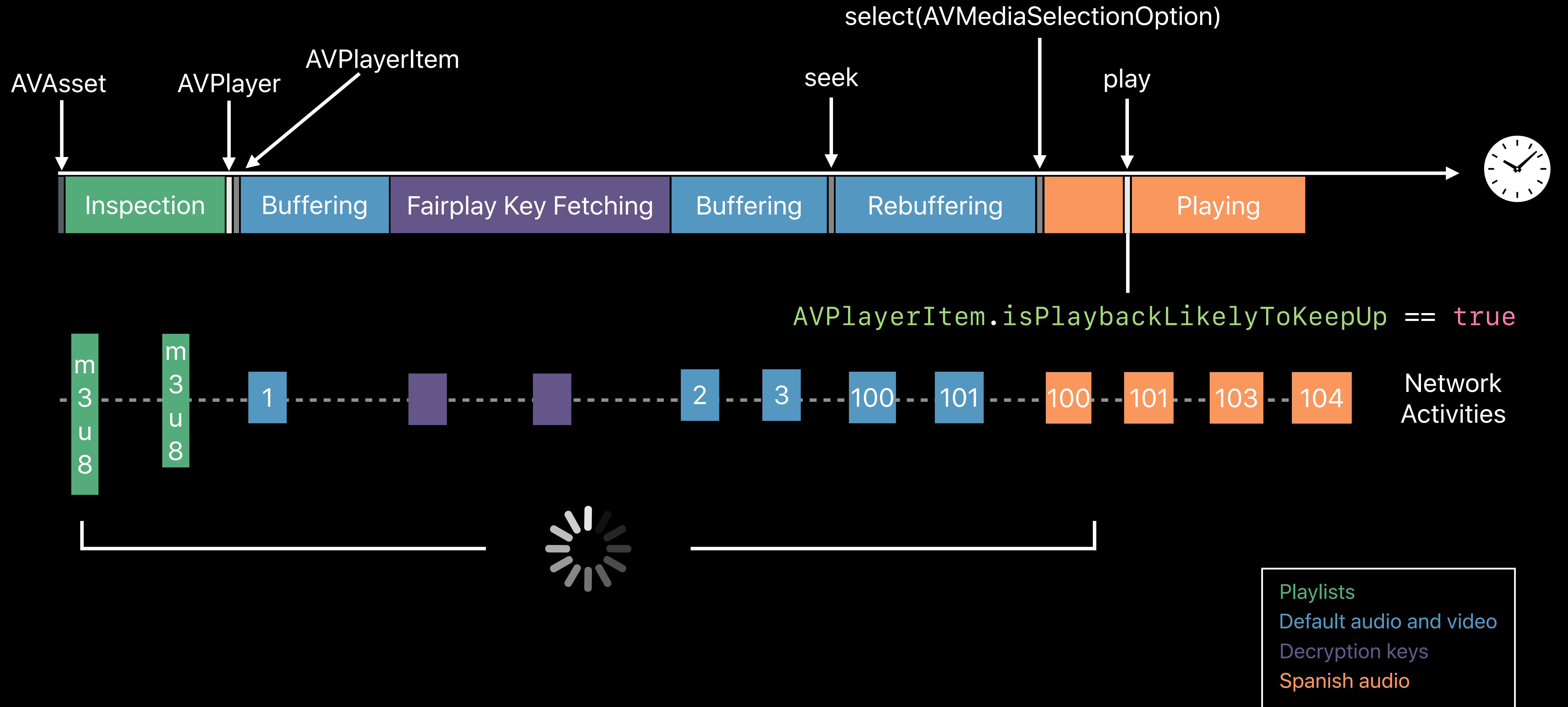


# What Can Delay Start of Playback?





# What Can Delay Start of Playback?



# How Do I Reduce Startup Time?

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Multiple time-consuming operations

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Measure time cost

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- Time spent between API calls and Player/PlayerItem status change notifications

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Multiple time-consuming operations

Measure time cost

- Time spent between API calls and Player/PlayerItem status change notifications
- `AVPlayerItemAccessLogEvent.startupTime`

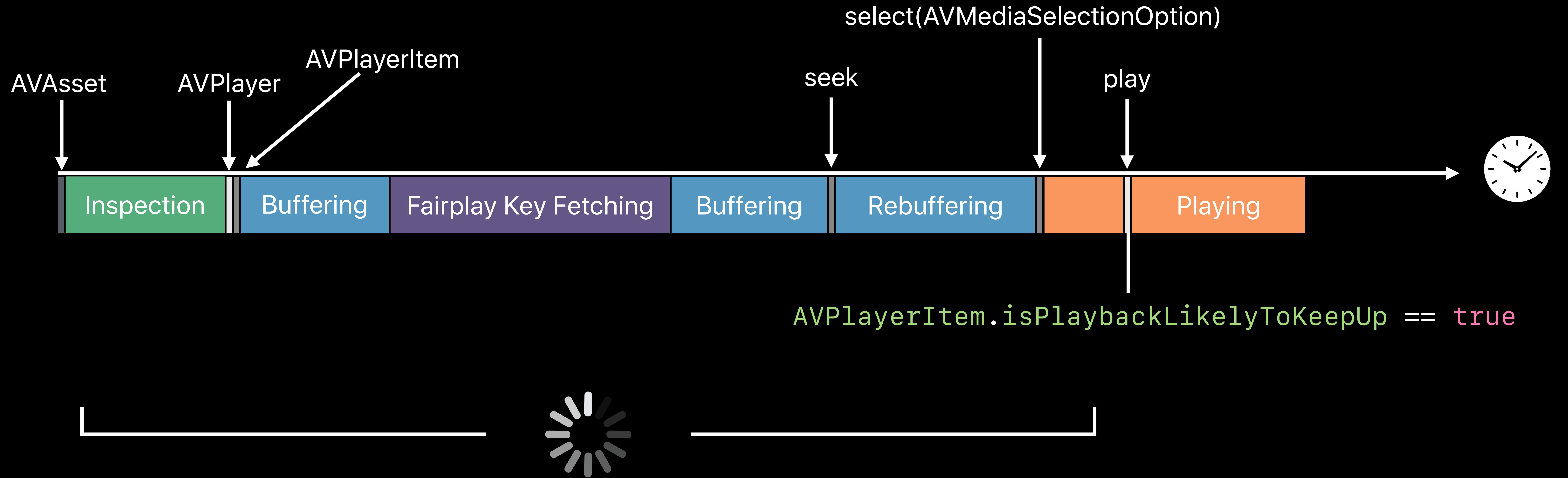
# How Do I Reduce Startup Time?

Multiple time-consuming operations

Measure time cost

- Time spent between API calls and Player/PlayerItem status change notifications
- `AVPlayerItemAccessLogEvent.startupTime`
- Time from starting media download to the first `isPlaybackLikelyToKeepUp == true`

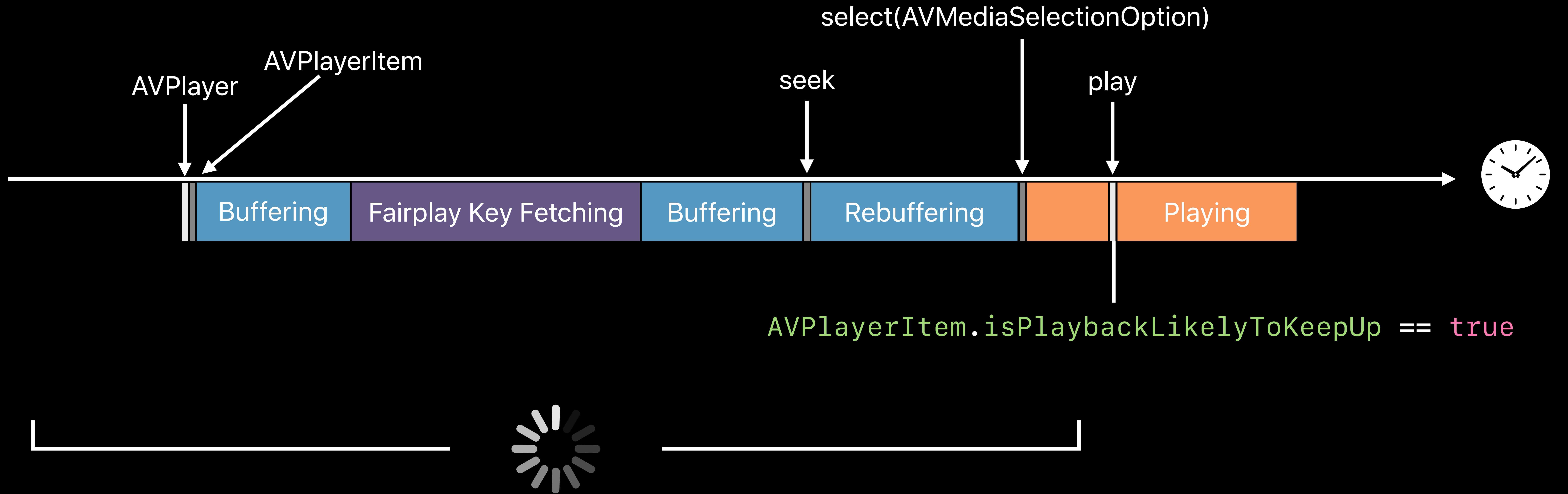
# Reduce Startup Time—AVAsset



- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

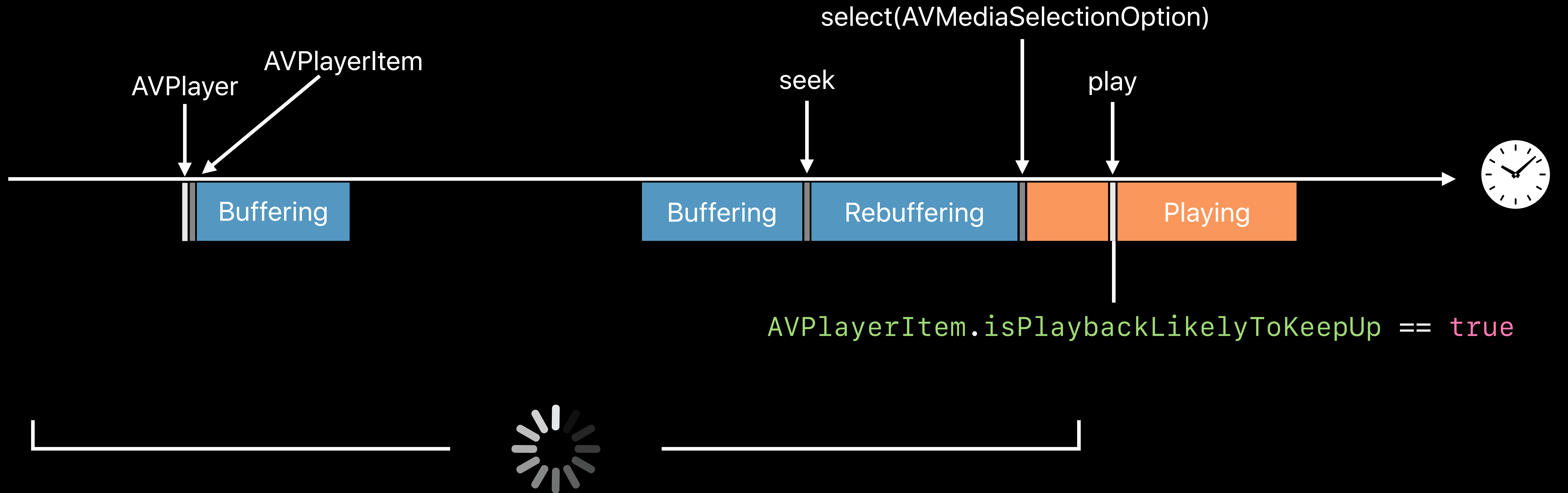


# Reduce Startup Time—AVAsset



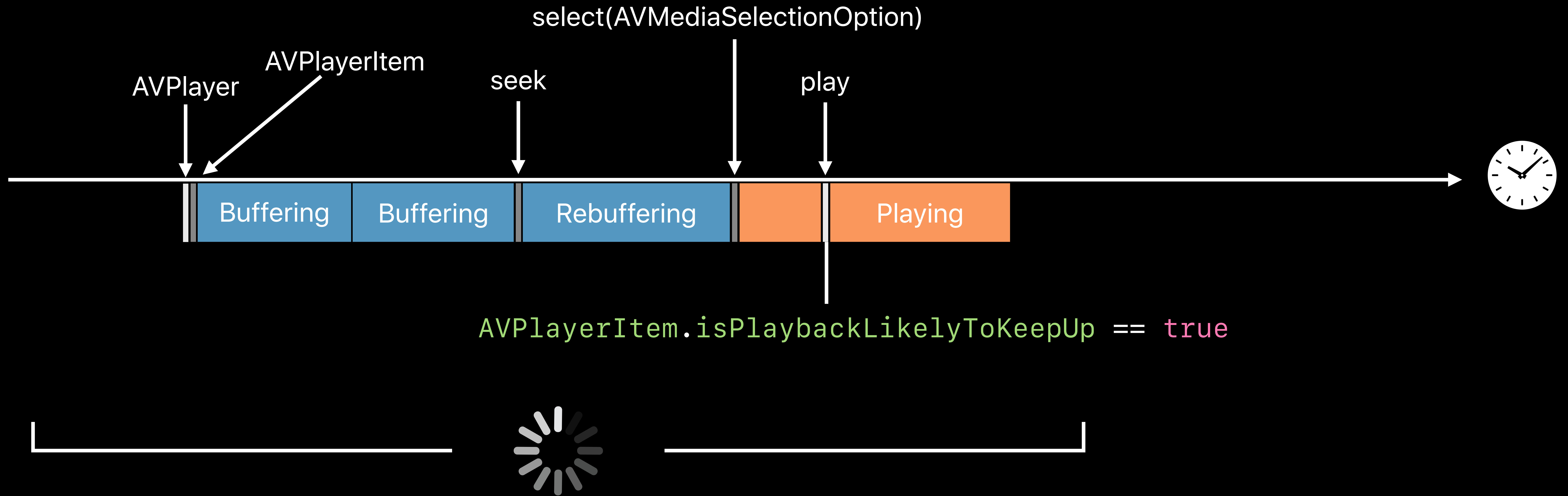
- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

# Reduce Startup Time—AVAsset



- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

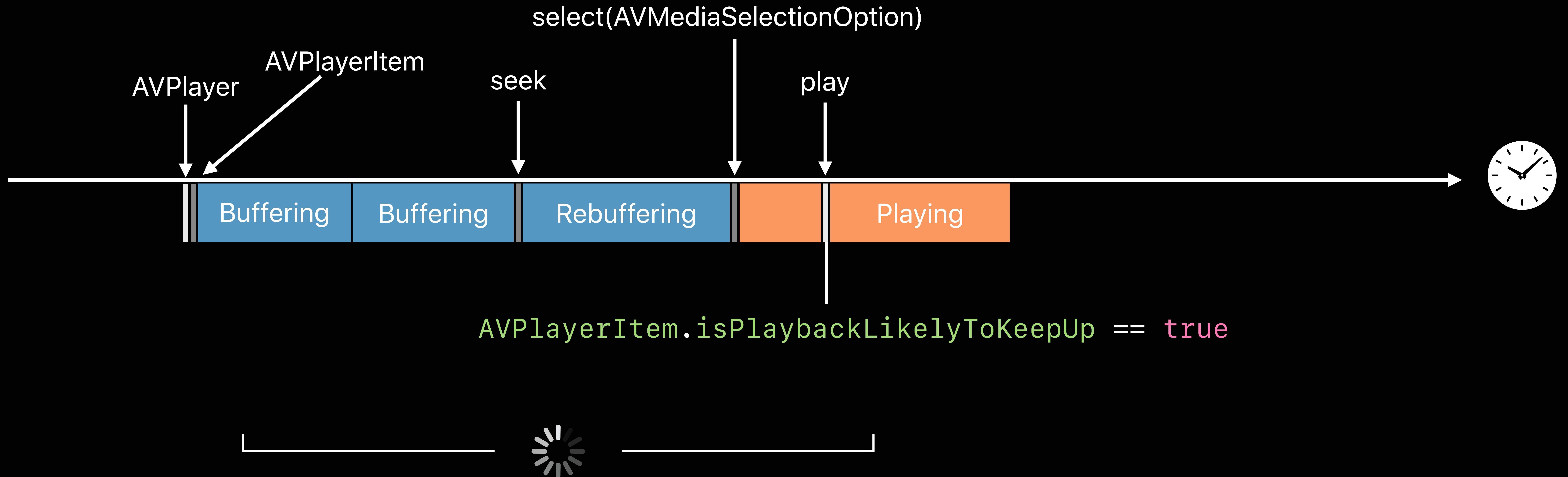
# Reduce Startup Time—AVAsset



`AVPlayerItem.isPlaybackLikelyToKeepUp == true`

- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

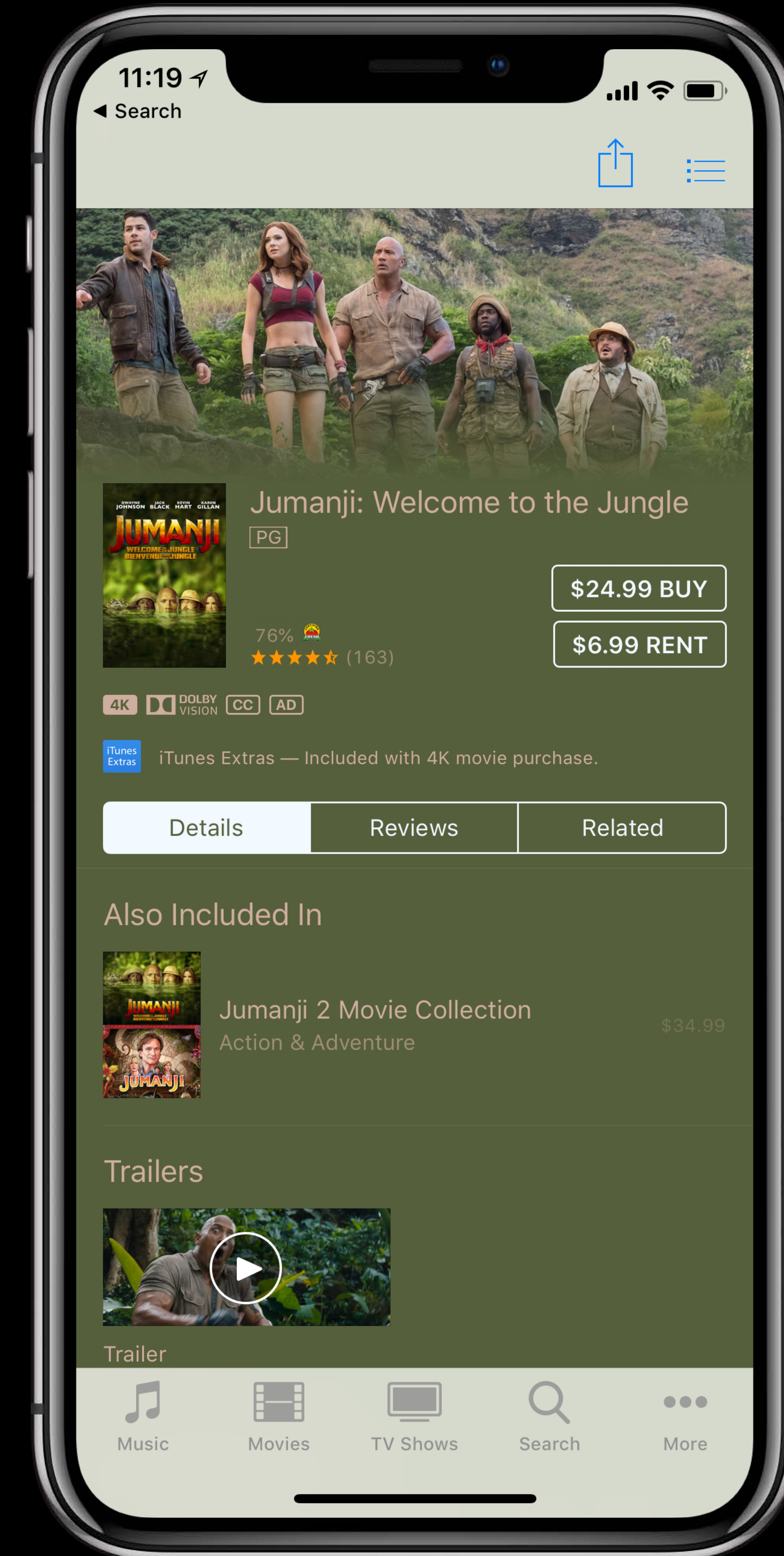
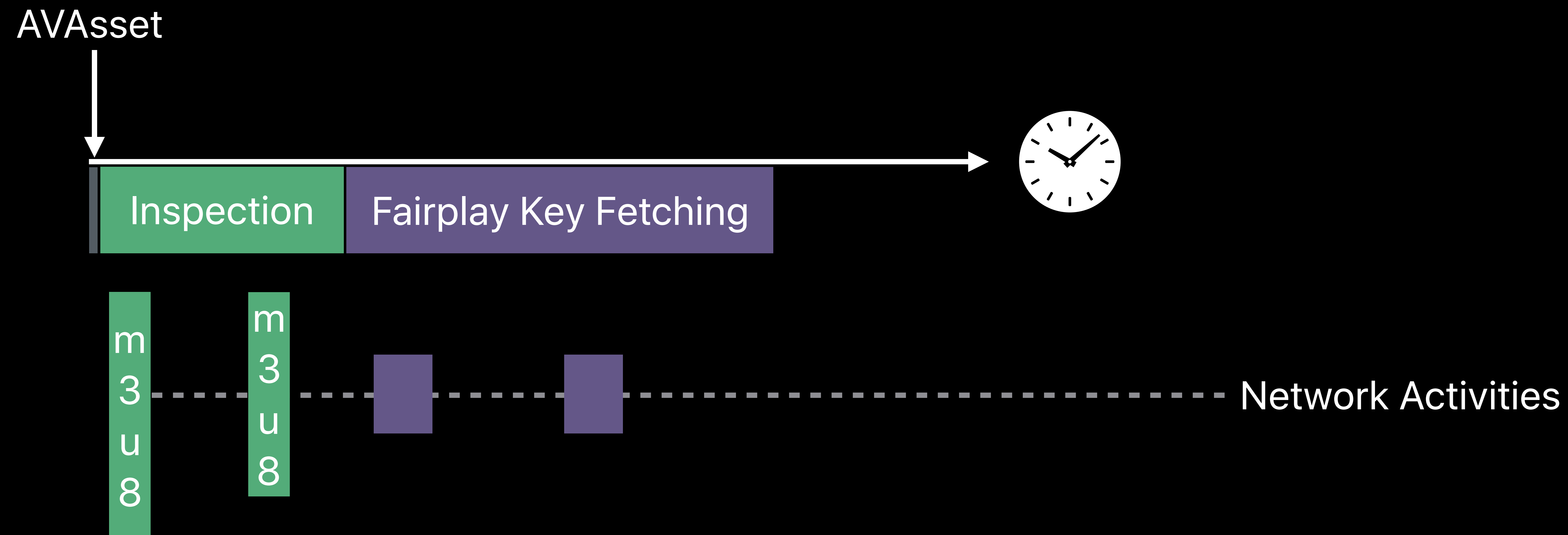
# Reduce Startup Time—AVAsset



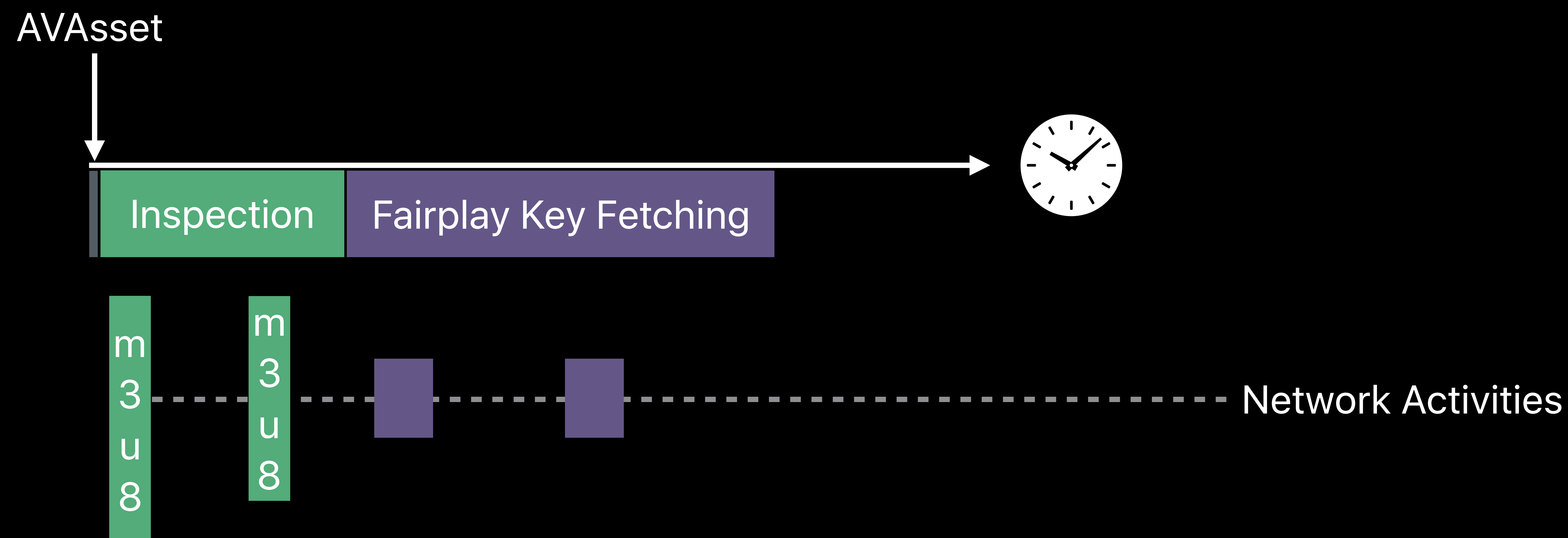
`AVPlayerItem.isPlaybackLikelyToKeepUp == true`

- Playlists
- Default audio and video
- Decryption keys
- Spanish audio

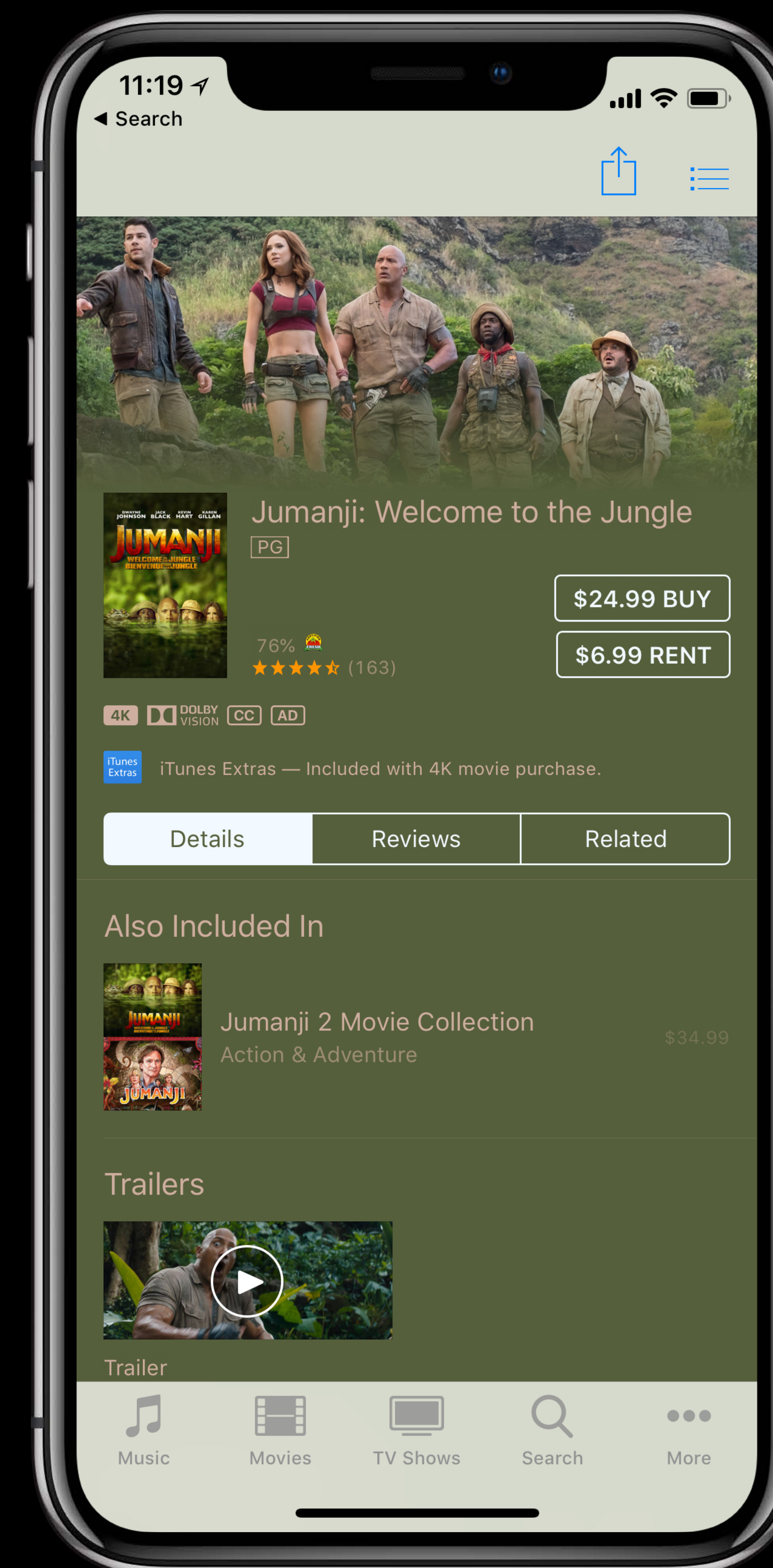
# Reduce Startup Time—AVAsset



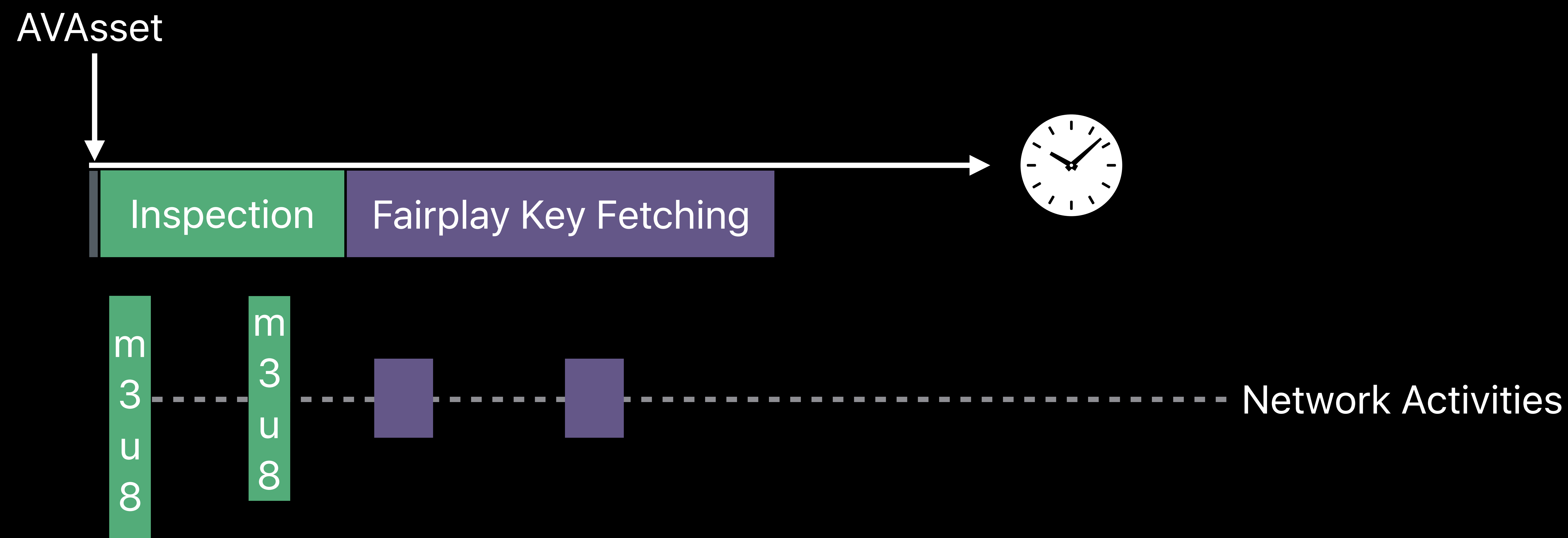
# Reduce Startup Time—AVAsset



Create and inspect AVAsset before user decides to play



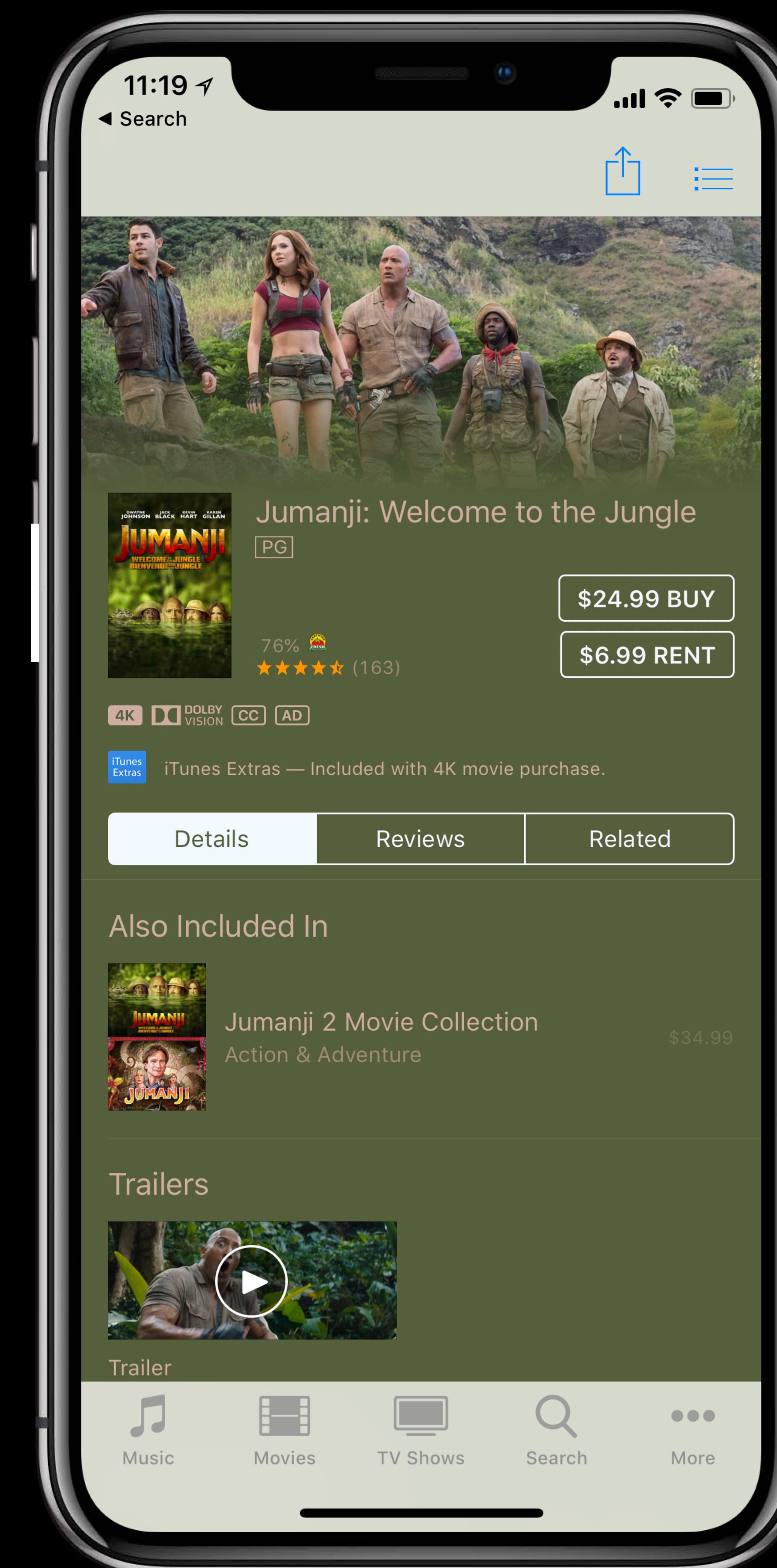
# Reduce Startup Time—AVAsset



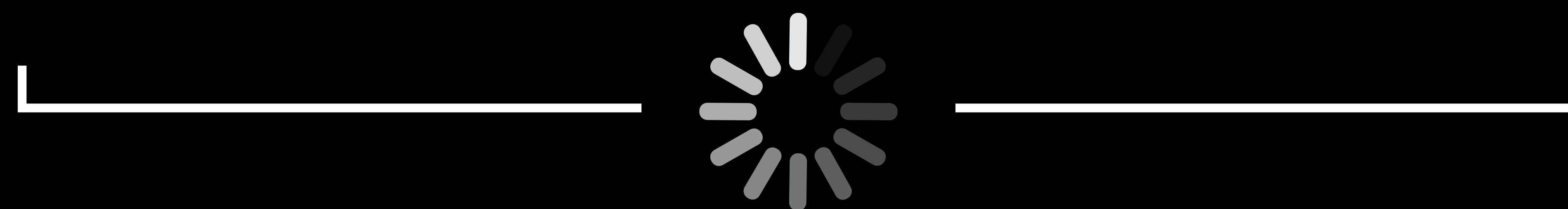
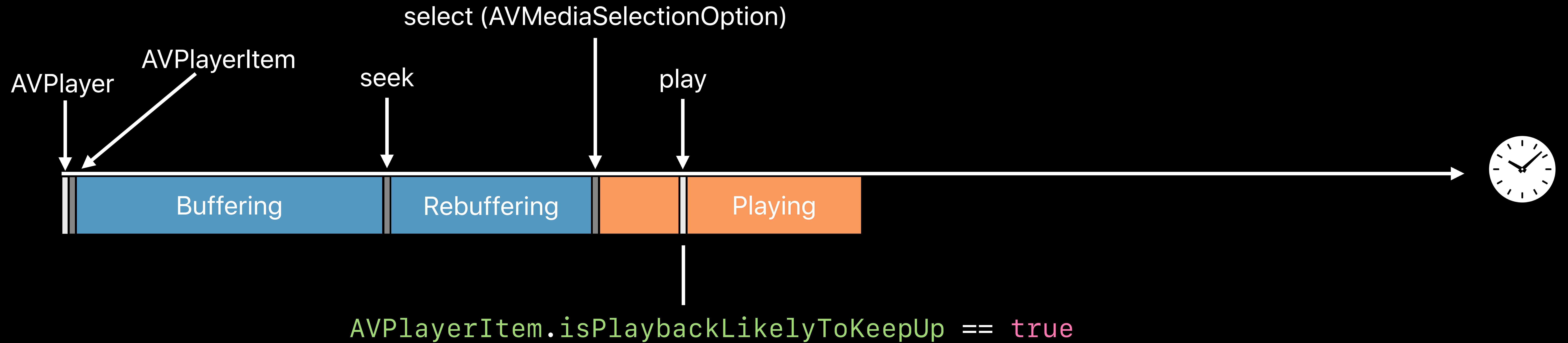
Create and inspect AVAsset before user decides to play

Prefetch decryption keys

- Adopt AVContentKeySession!



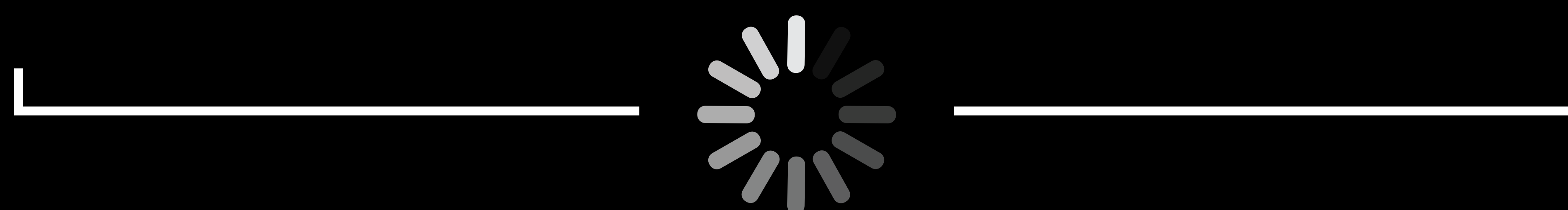
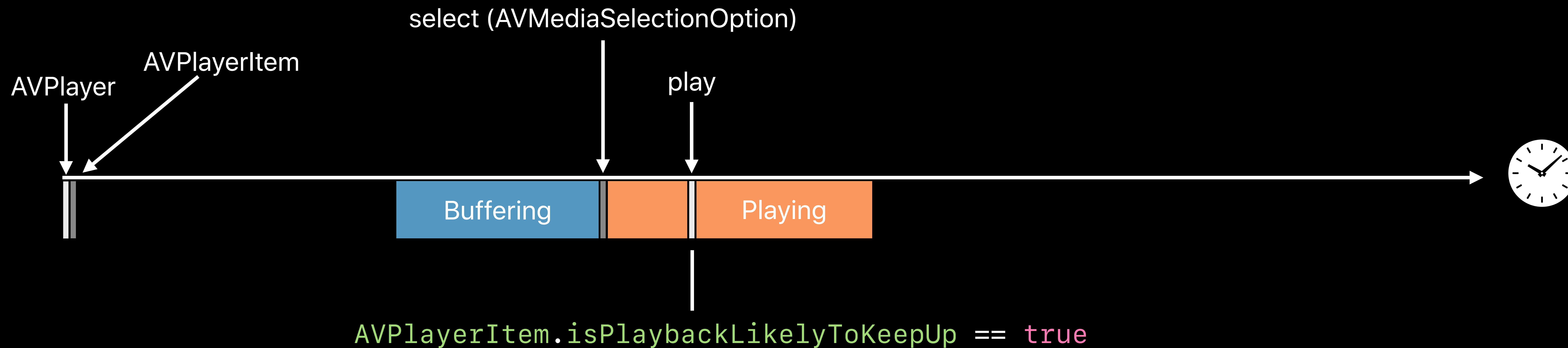
# Reduce Startup Time—AVPlayer and AVPlayerItem



Default audio and video  
Spanish audio

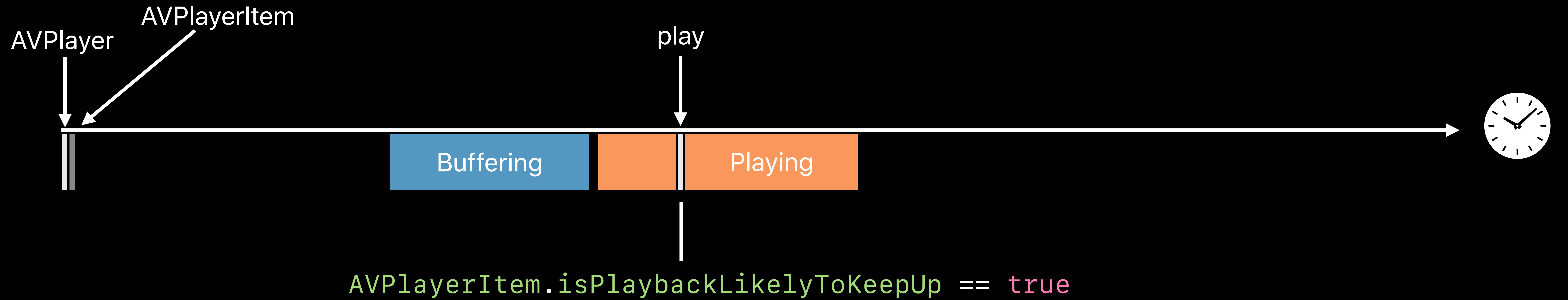


# Reduce Startup Time—AVPlayer and AVPlayerItem

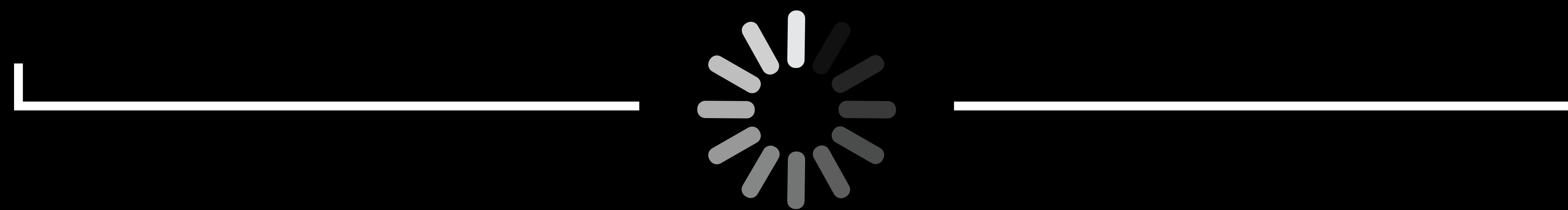


Default audio and video  
Spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem

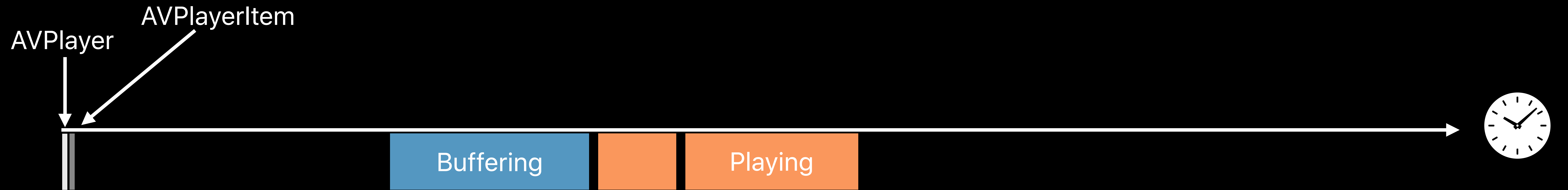


```
AVPlayerItem.isPlaybackLikelyToKeepUp == true
```

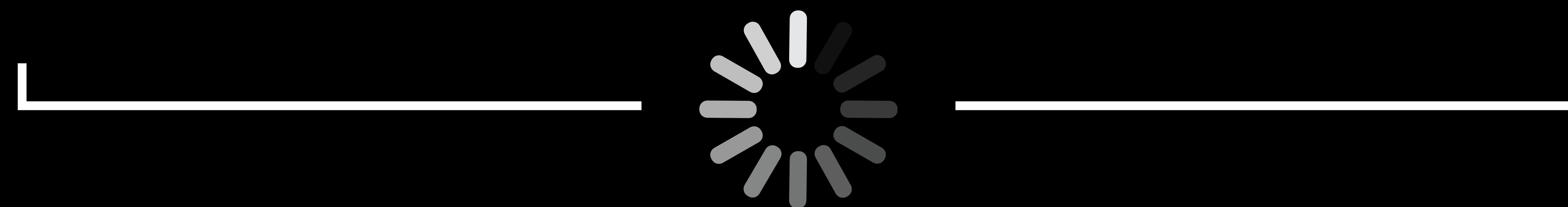


Default audio and video  
Spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



```
AVPlayerItem.isPlaybackLikelyToKeepUp == true
```

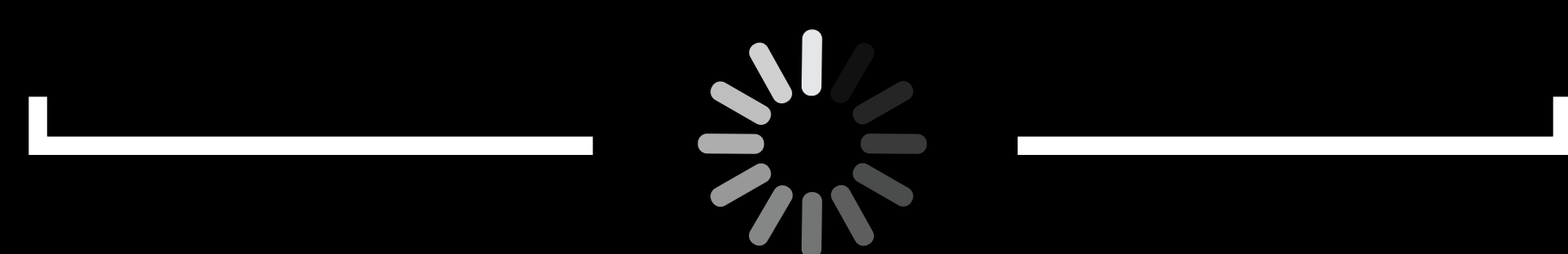


Default audio and video  
Spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



`AVPlayerItem.isPlaybackLikelyToKeepUp == true`

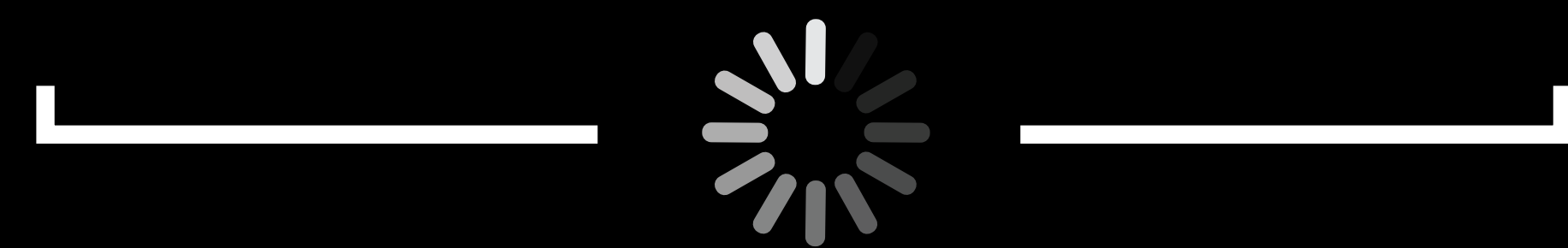


Default audio and video  
Spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem

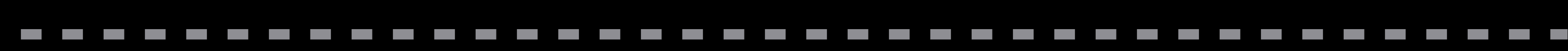


`AVPlayerItem.isPlaybackLikelyToKeepUp == true`



Default video and spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



Network Activities

Default video and spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem

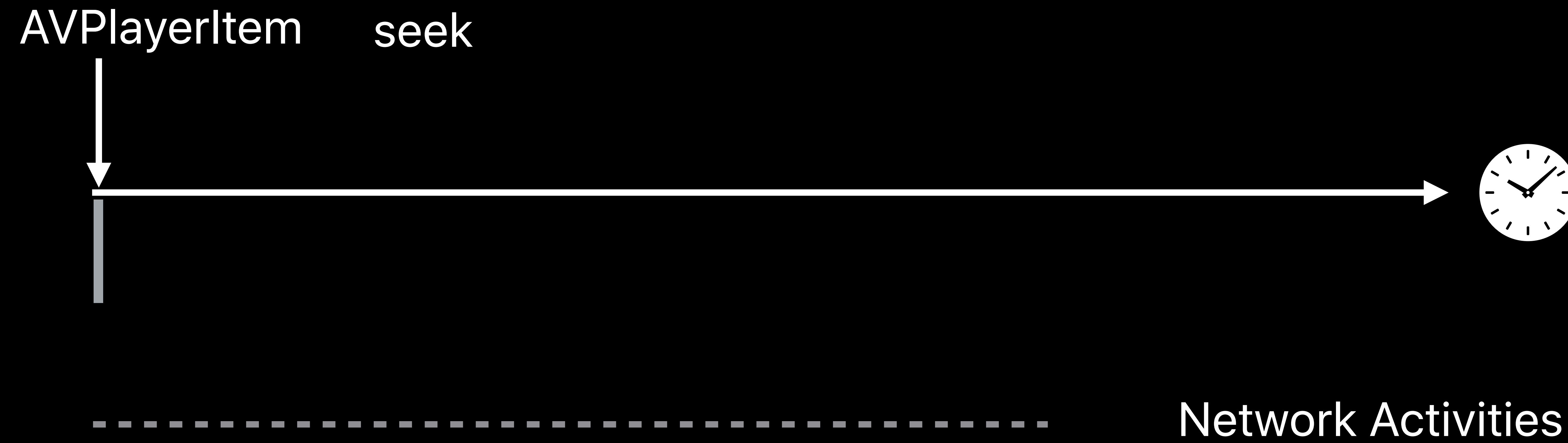
AVPlayerItem



----- Network Activities

Default video and spanish audio

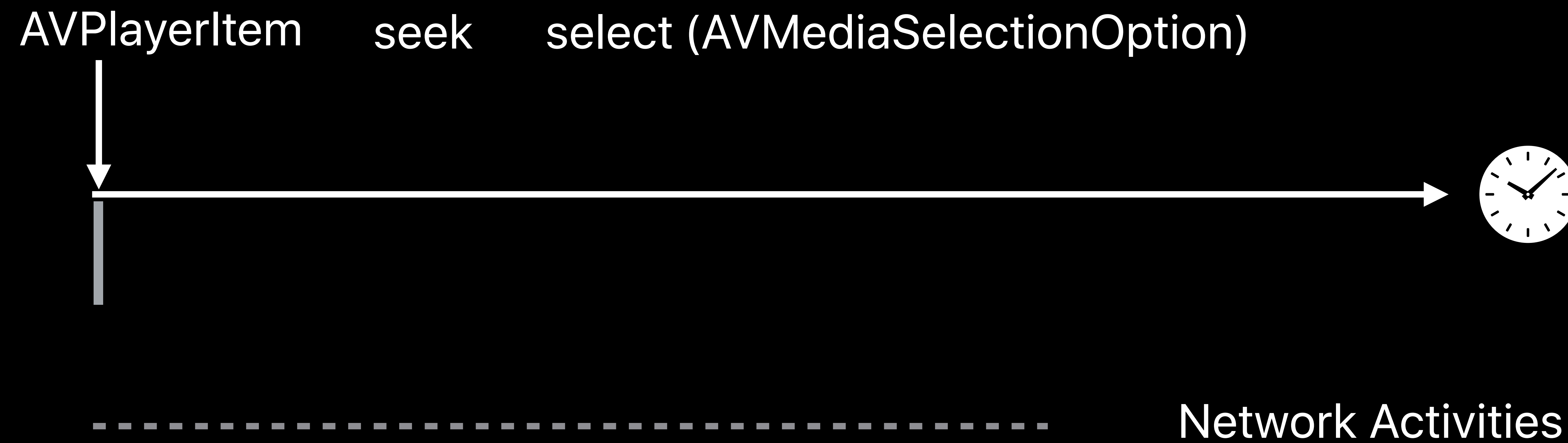
# Reduce Startup Time—AVPlayer and AVPlayerItem



Default video and spanish audio

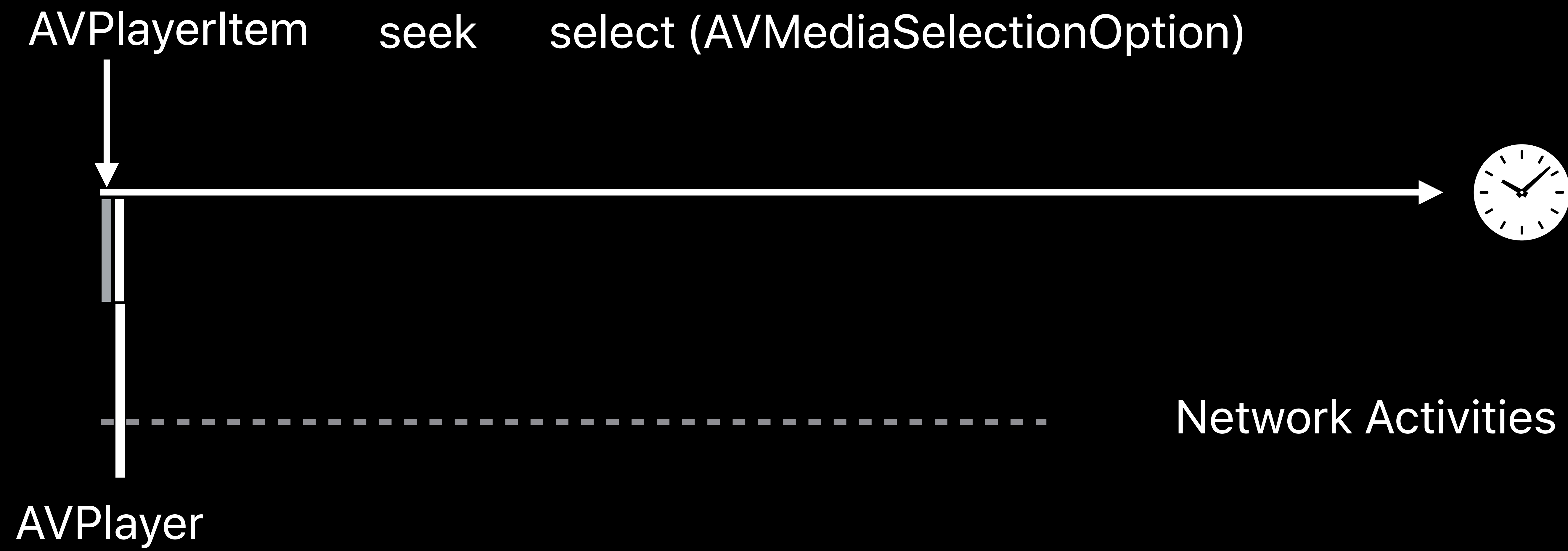


# Reduce Startup Time—AVPlayer and AVPlayerItem



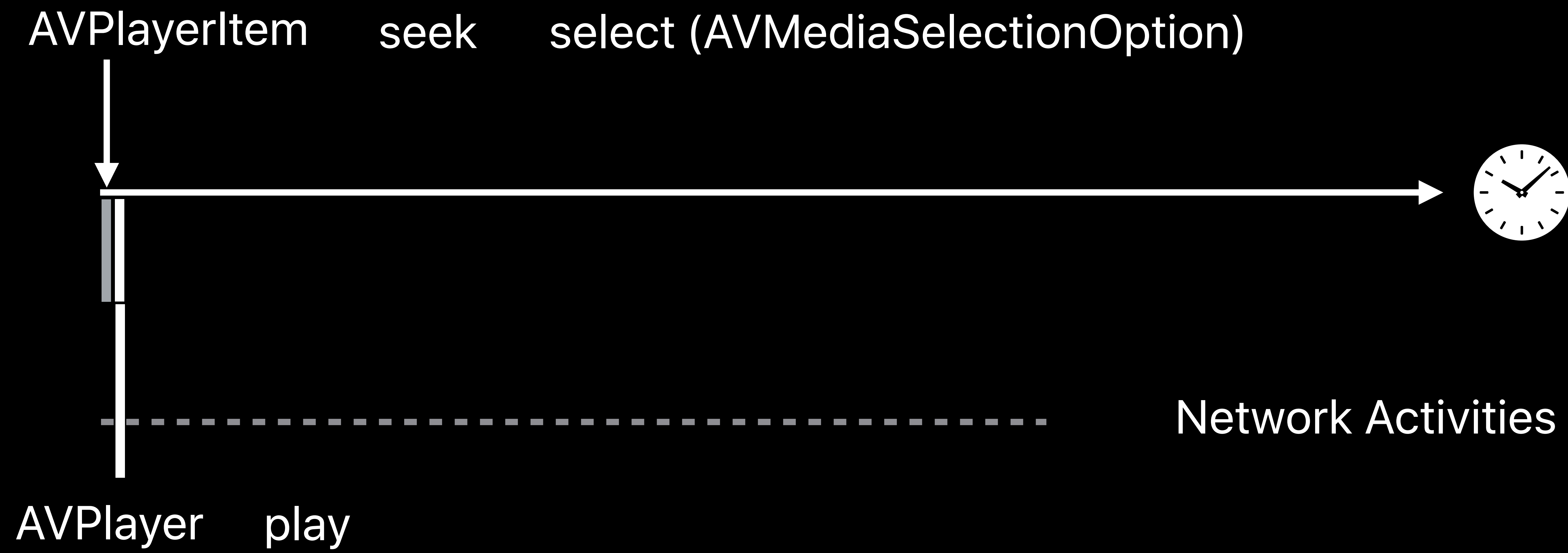
Default video and spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



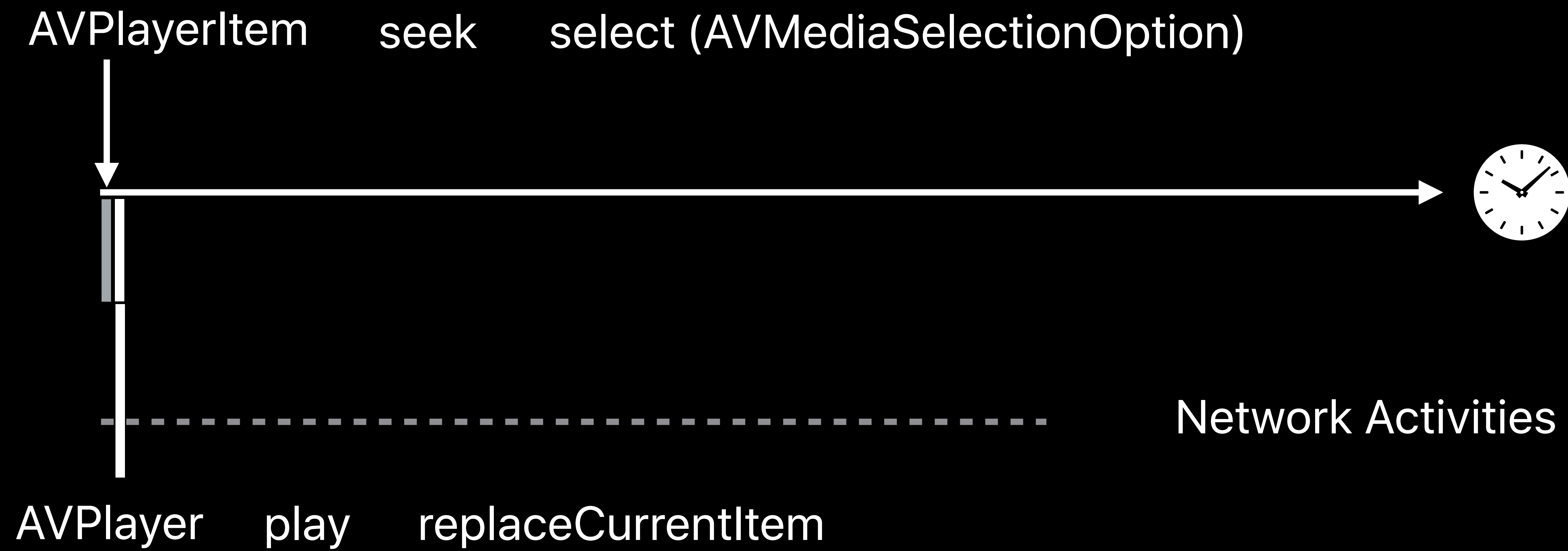
Default video and spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



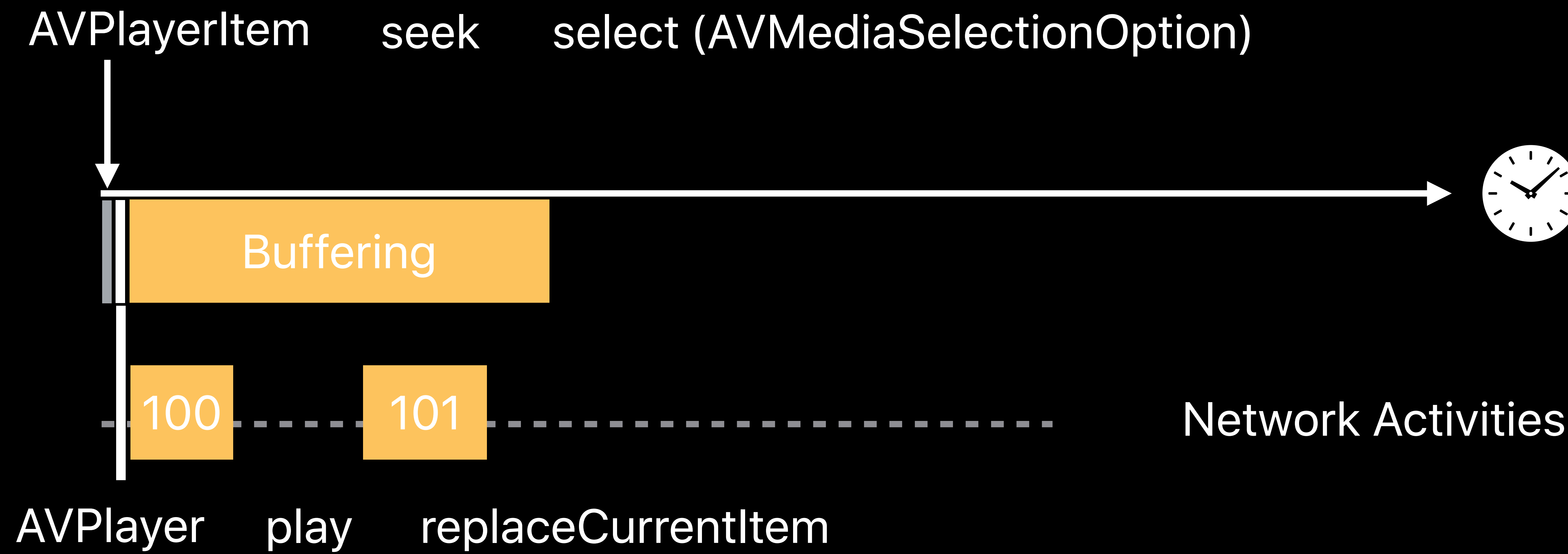
Default video and spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



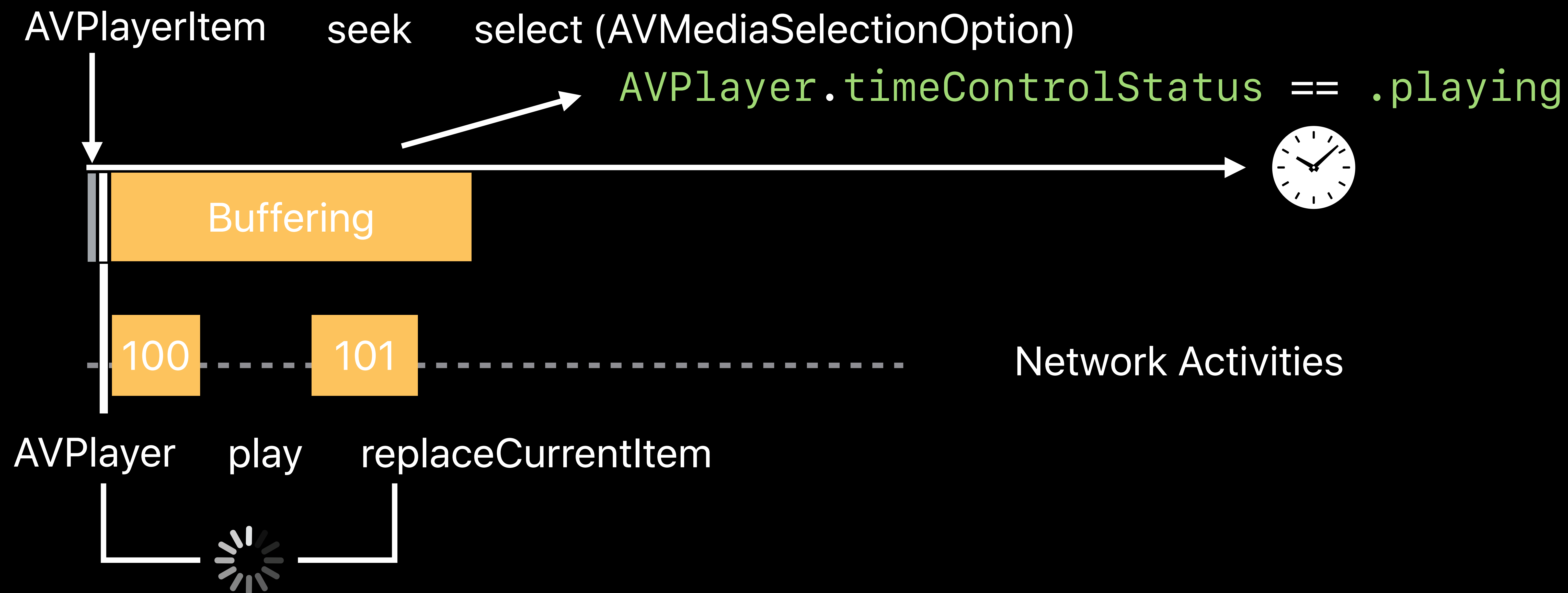
Default video and spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



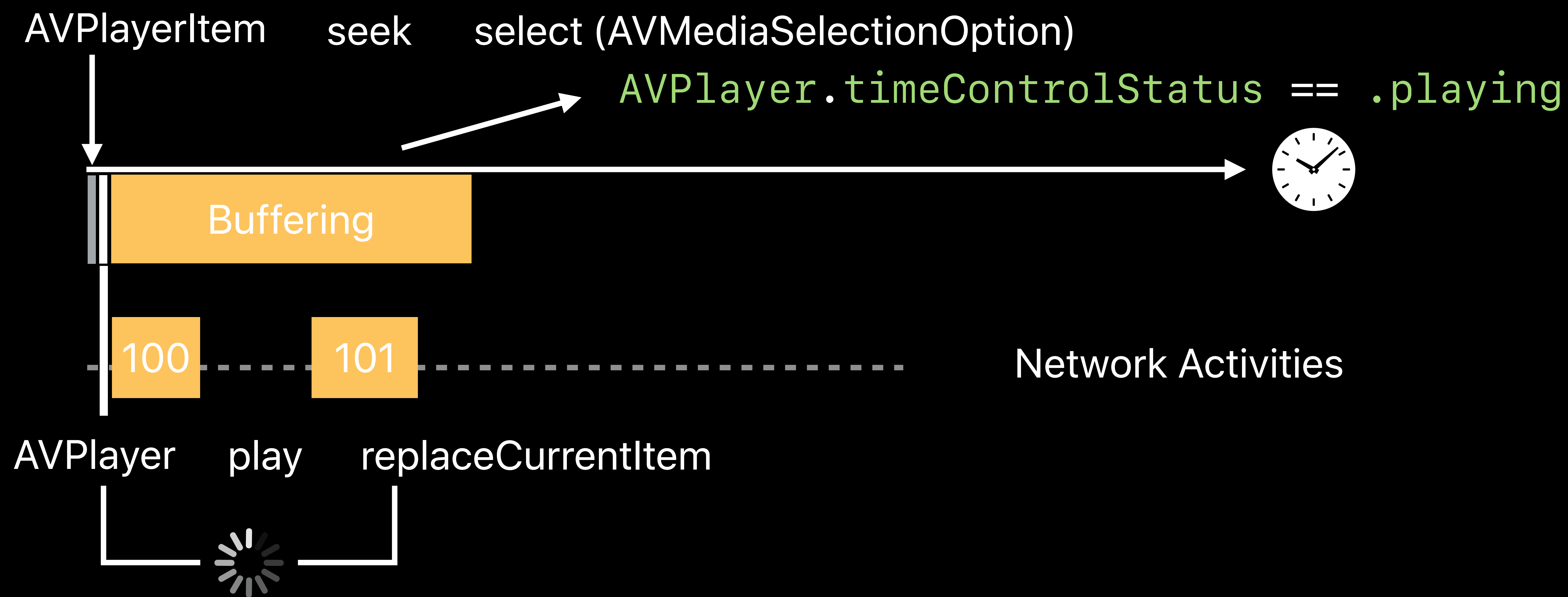
Default video and spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



Default video and spanish audio

# Reduce Startup Time—AVPlayer and AVPlayerItem



Default video and spanish audio

Set up `AVPlayerItem` before buffering

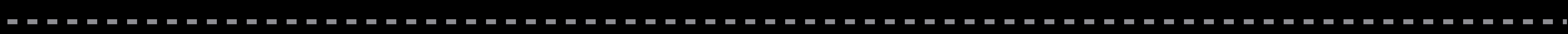
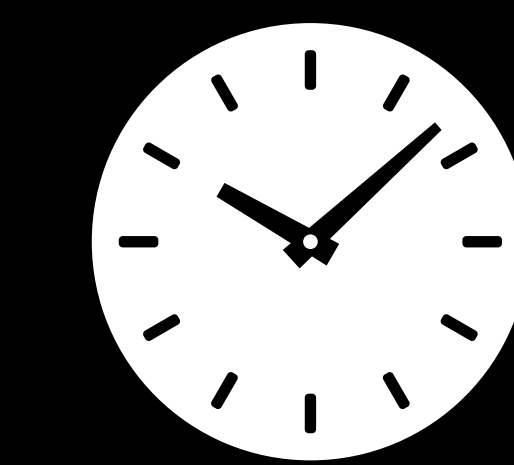
Set `AVPlayer` rate before setting player item

# Reduce Startup Time—AVPlayerItem Transition

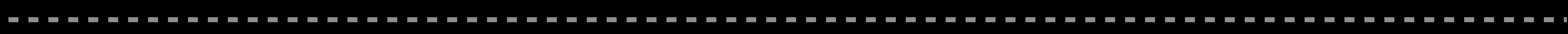


# Reduce Startup Time—AVPlayerItem Transition

AVQueuePlayer



Network Activities



Network Activities

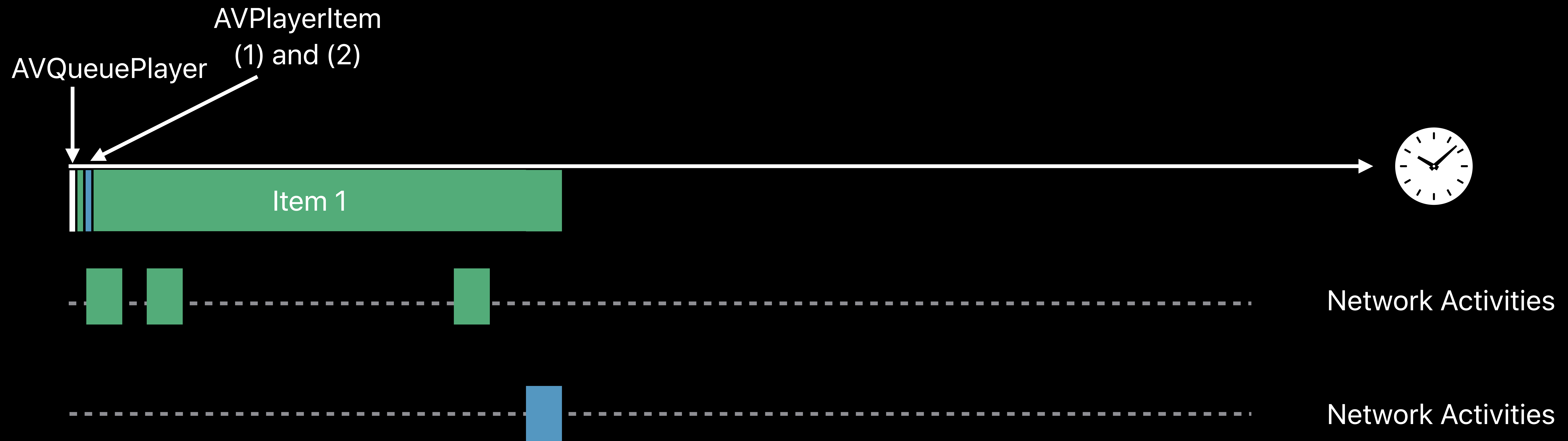
# Reduce Startup Time—AVPlayerItem Transition



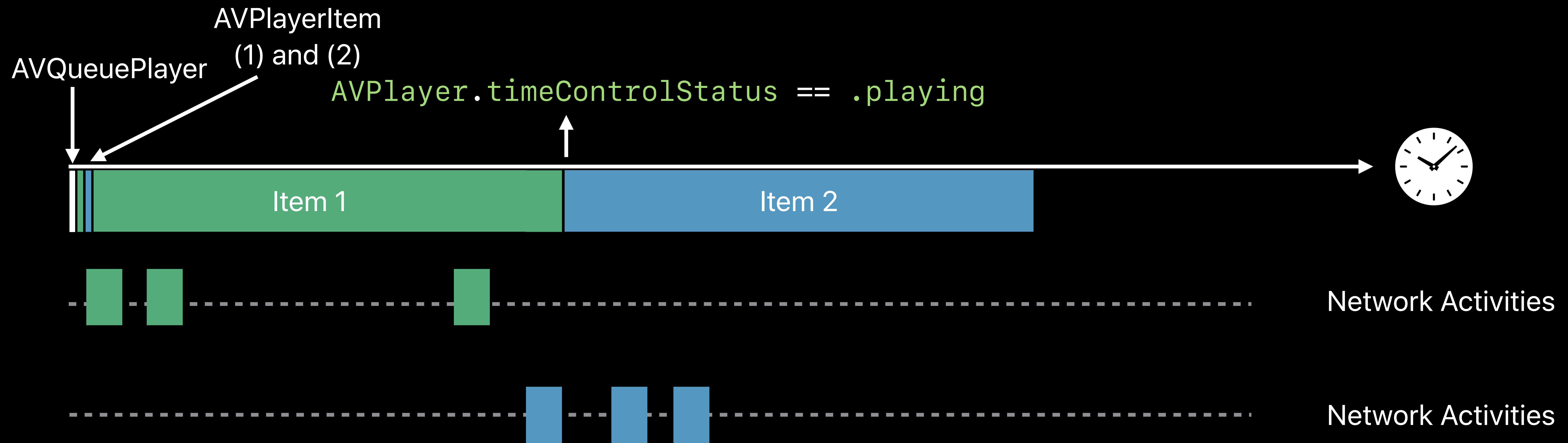
# Reduce Startup Time—AVPlayerItem Transition



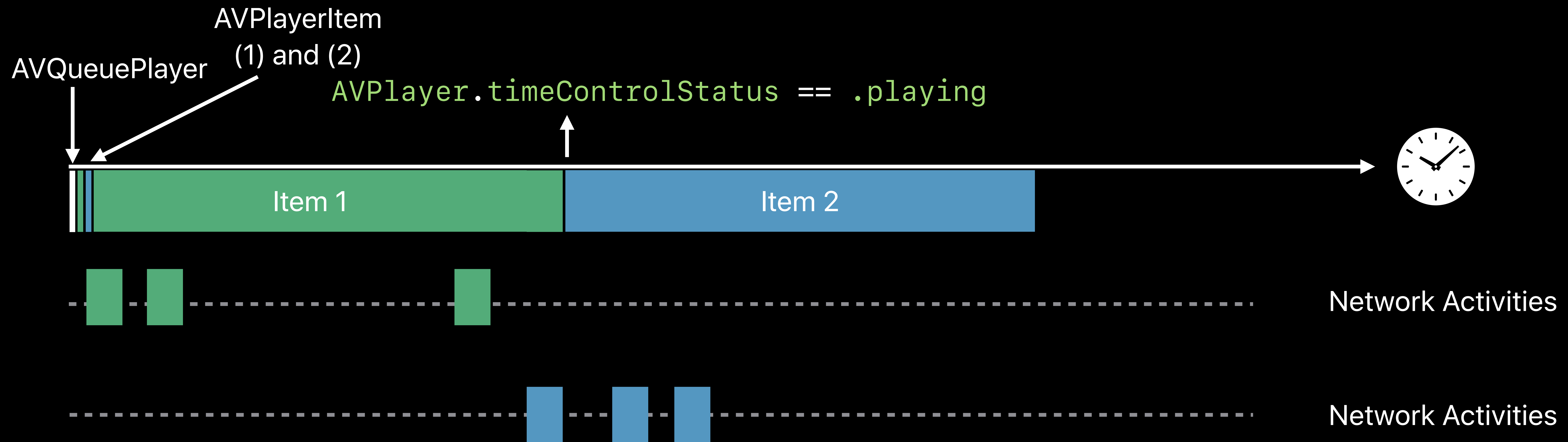
# Reduce Startup Time—AVPlayerItem Transition



# Reduce Startup Time—AVPlayerItem Transition



# Reduce Startup Time—AVPlayerItem Transition



Use `AVQueuePlayer` to play multiple items

Enqueue second `AVPlayerItem` well in advance

# What Determines Network Buffering Time?

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Choice of variant



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Choice of variant

Content bitrate

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Choice of variant

Content bitrate

Playlist target duration

# What Determines Network Buffering Time?

Choice of variant

Content bitrate

Playlist target duration

Network bandwidth

# Network Buffering Time—Typical Case

```
#EXTM3U
```

```
#EXT-X-VERSION:7
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.
```

```
40.2",RESOLUTION=1920x1080
```

```
video_high.m3u8
```

# Network Buffering Time—Typical Case

```
#EXTM3U
#EXT-X-VERSION:7
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.
40.2",RESOLUTION=1920x1080
video_high.m3u8
```

Network bandwidth: avg 6Mbps

Target duration: 10s

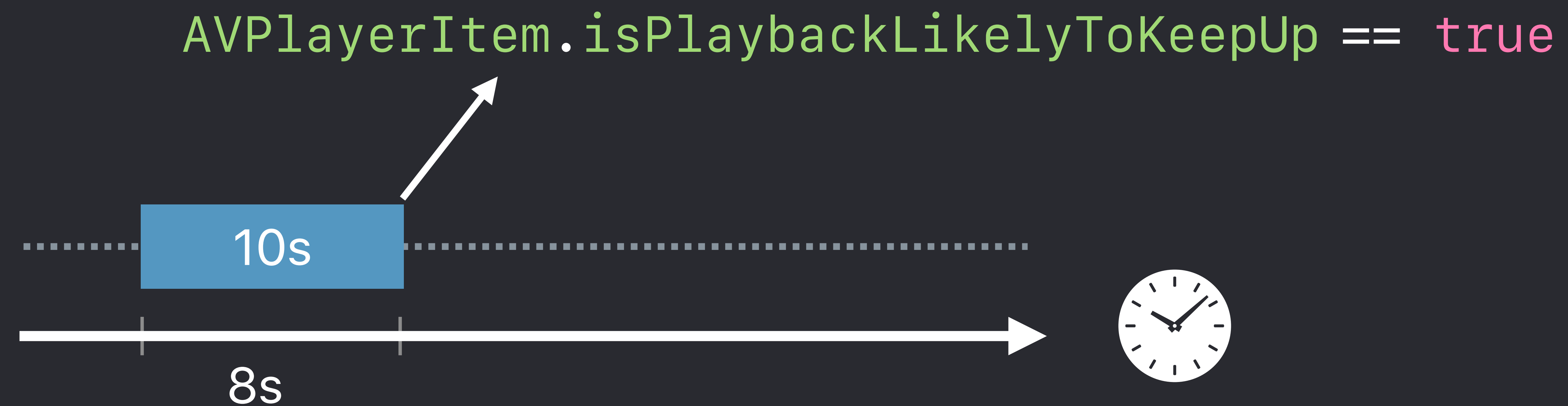
Initial tier: avg 4972158

Video quality: 1080p

# Network Buffering Time—Typical Case

```
#EXTM3U
#EXT-X-VERSION:7
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.40.2",RESOLUTION=1920x1080
video_high.m3u8
```

Network bandwidth: avg 6Mbps  
Target duration: 10s  
Initial tier: avg 4972158  
Video quality: 1080p



# Network Buffering Time—Download Slower Than 1x

```
#EXTM3U
#EXT-X-VERSION:7
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.
40.2",RESOLUTION=1920x1080
video_high.m3u8
```

Network bandwidth: avg 6Mbps

Target duration: 10s

Initial tier: avg 4972158

Video quality: 1080p

# Network Buffering Time—Download Slower Than 1x

```
#EXTM3U
```

```
#EXT-X-VERSION:7
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.
```

```
40.2",RESOLUTION=1920x1080
```

```
video_high.m3u8
```

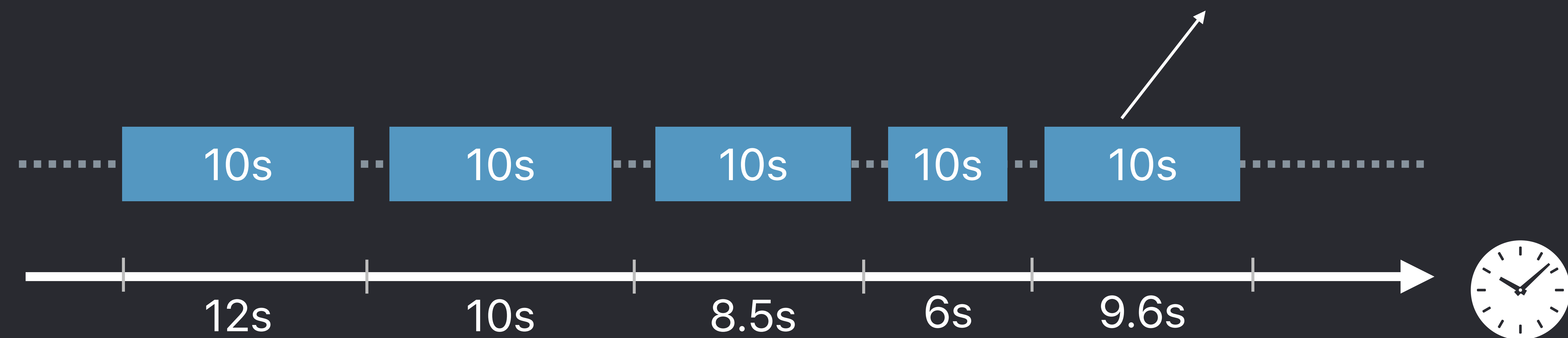
Network bandwidth: avg 6Mbps

Target duration: 10s

Initial tier: avg 4972158

Video quality: 1080p

```
AVPlayerItem.isPlaybackLikelyToKeepUp == true
```





# Network Buffering Time—Download Slower Than 1x

```
#EXTM3U
```

```
#EXT-X-VERSION:7
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.
```

```
40.2",RESOLUTION=1920x1080
```

```
video_high.m3u8
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=2884141,BANDWIDTH=4125794,CODECS="avc1.64001f,mp4a.
```

```
40.2",RESOLUTION=1280x720
```

```
video_mid.m3u8
```

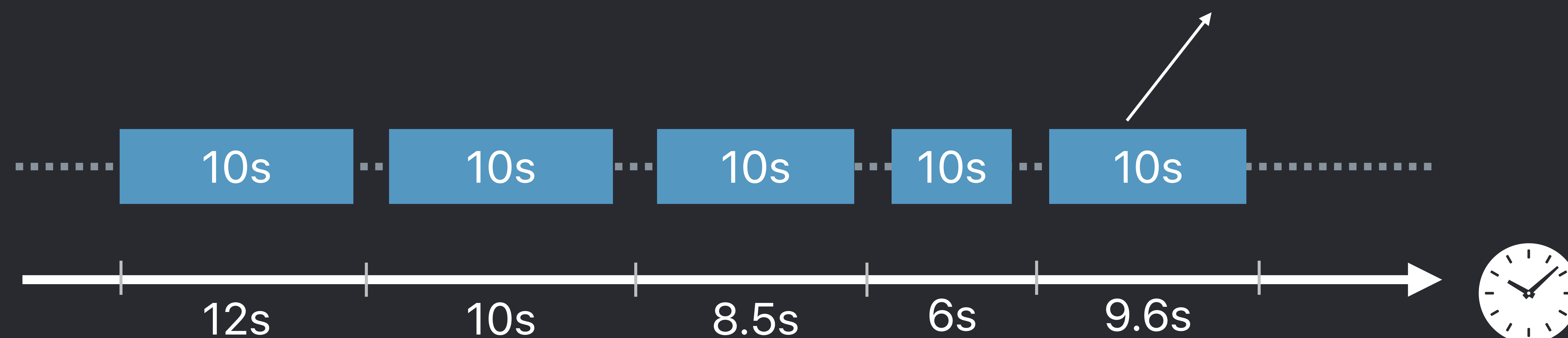
```
AVPlayerItem.isPlaybackLikelyToKeepUp == true
```

Network bandwidth: avg 6Mbps

Target duration: 10s

Initial tier: avg 4972158

Video quality: 1080p



# Network Buffering Time—Download Slower Than 1x

```
#EXTM3U
```

```
#EXT-X-VERSION:7
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.40.2",RESOLUTION=1920x1080
```

```
video_high.m3u8
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=2884141,BANDWIDTH=4125794,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=1280x720
```

```
video_mid.m3u8
```

```
AVPlayerItem.isPlaybackLikelyToKeepUp == true
```

Network bandwidth: avg 6Mbps

Target duration: 10s

Initial tier: avg 4972158

Video quality: 1080p



# Network Buffering Time—Initial Variant Choice

```
#EXTM3U
```

```
#EXT-X-VERSION:7
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=2884141,BANDWIDTH=4125794,CODECS="avc1.64001f,mp4a.
```

```
40.2",RESOLUTION=1280x720
```

```
video_mid.m3u8
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.
```

```
40.2",RESOLUTION=1920x1080
```

```
video_high.m3u8
```

# Network Buffering Time—Initial Variant Choice

```
#EXTM3U
```

```
#EXT-X-VERSION:7
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=2884141,BANDWIDTH=4125794,CODECS="avc1.64001f,mp4a.
```

```
40.2",RESOLUTION=1280x720
```

```
video_mid.m3u8
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.
```

```
40.2",RESOLUTION=1920x1080
```

```
video_high.m3u8
```

```
Network bandwidth: avg 6Mbps
```

```
Target duration: 10s
```

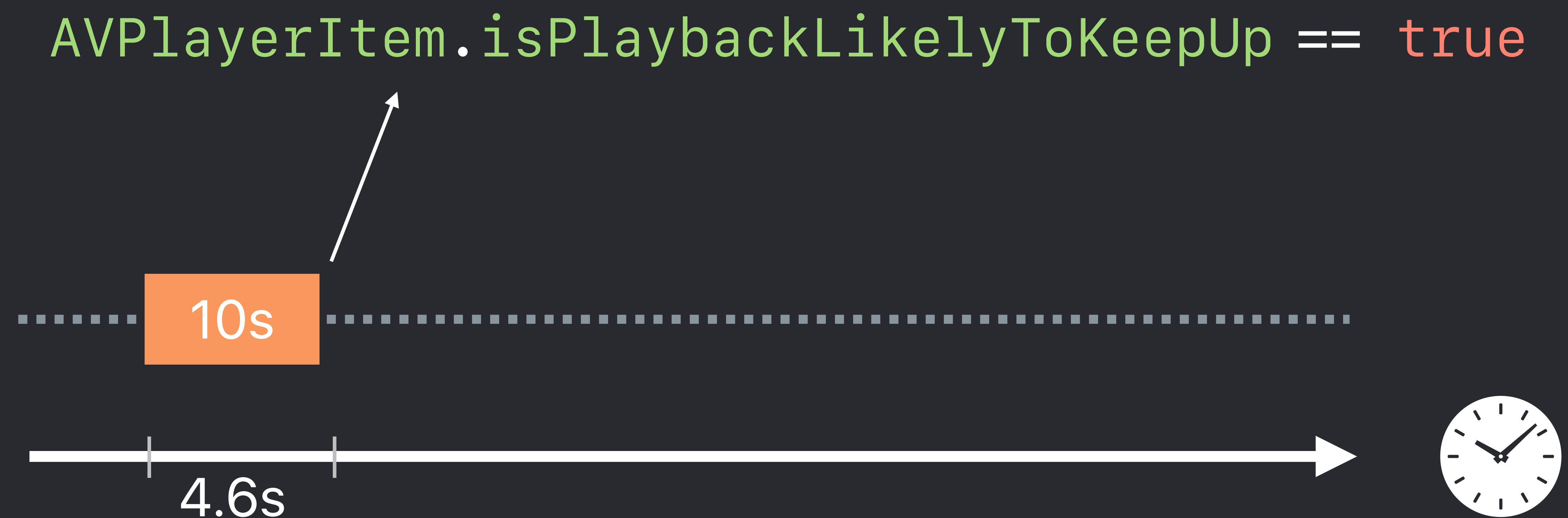
```
Initial tier: avg 2884141
```

```
Video quality: 720p
```

# Network Buffering Time—Initial Variant Choice

```
#EXTM3U
#EXT-X-VERSION:7
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=2884141,BANDWIDTH=4125794,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=1280x720
video_mid.m3u8
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.40.2",RESOLUTION=1920x1080
video_high.m3u8
```

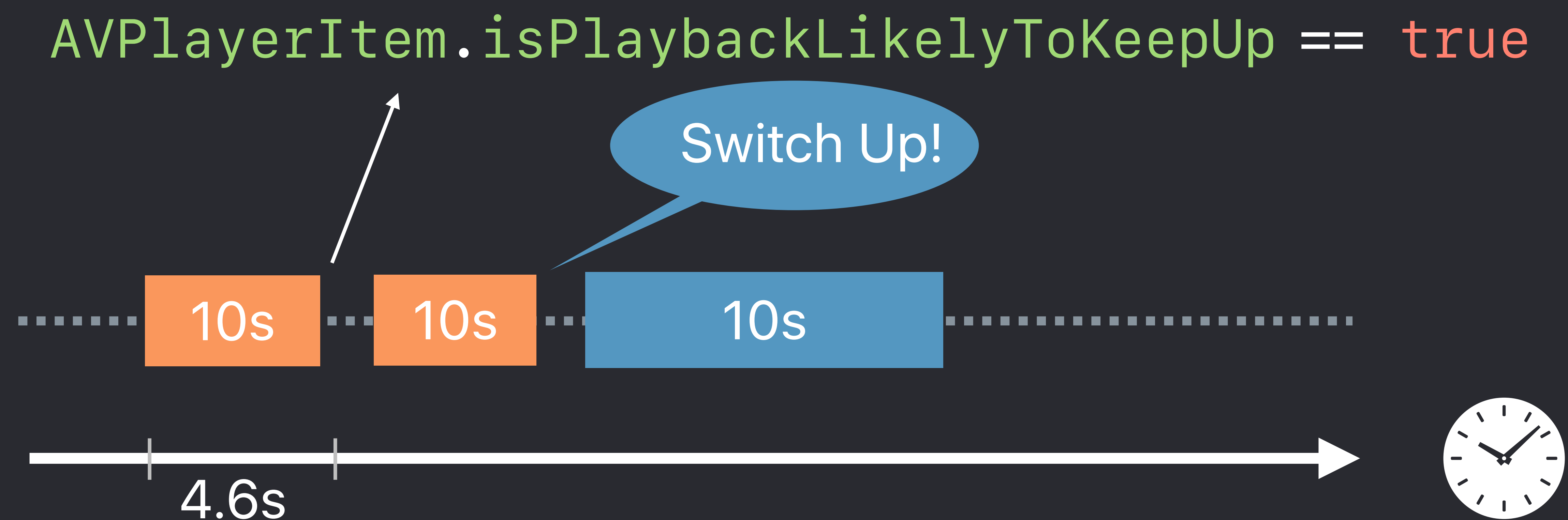
Network bandwidth: avg 6Mbps  
Target duration: 10s  
Initial tier: avg 2884141  
Video quality: 720p



# Network Buffering Time—Initial Variant Choice

```
#EXTM3U
#EXT-X-VERSION:7
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=2884141,BANDWIDTH=4125794,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=1280x720
video_mid.m3u8
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=4972158,BANDWIDTH=7365128,CODECS="avc1.640028,mp4a.40.2",RESOLUTION=1920x1080
video_high.m3u8
```

Network bandwidth: avg 6Mbps  
Target duration: 10s  
Initial tier: avg 2884141  
Video quality: 720p



# Reducing Network Buffering Time

# Reducing Network Buffering Time

Wise choice of initial variant

- Lower content bitrate means shorter buffering time for startup
- But it is a tradeoff of initial video quality



# Reducing Network Buffering Time

Wise choice of initial variant

- Lower content bitrate means shorter buffering time for startup
- But it is a tradeoff of initial video quality

Be mindful of all media formats

- Consider initial variant for each flavor of media format
- HDR / SDR, HEVC / H.264, Stereo / DD / DD+

# Why Does the Playback Stall?

# Why Does the Playback Stall?

Stalls can happen!

# Why Does the Playback Stall?

Stalls can happen!

How to investigate stalls

# Why Does the Playback Stall?

Stalls can happen!

How to investigate stalls

How to avoid stalls

# Stall Investigation

# Stall Investigation

Listen to stall notifications

# Stall Investigation

## Listen to stall notifications

```
notificationCenter.addObserver(self,  
    selector: #selector(handlePlaybackStalled(_:)),  
    name: .AVPlayerItemPlaybackStalled,  
    object: playerItem)
```



# Stall Investigation

## Listen to stall notifications

```
notificationCenter.addObserver(self,  
    selector: #selector(handlePlaybackStalled(_:)),  
    name: .AVPlayerItemPlaybackStalled,  
    object: playerItem)
```

## Check AVPlayerItem status

# Stall Investigation

## Listen to stall notifications

```
notificationCenter.addObserver(self,  
    selector: #selector(handlePlaybackStalled(_:)),  
    name: .AVPlayerItemPlaybackStalled,  
    object: playerItem)
```

## Check AVPlayerItem status

```
AVPlayerItem.isPlaybackLikelyToKeepUp
```

# Stall Investigation

## Listen to stall notifications

```
notificationCenter.addObserver(self,  
    selector: #selector(handlePlaybackStalled(_:)),  
    name: .AVPlayerItemPlaybackStalled,  
    object: playerItem)
```

## Check AVPlayerItem status

```
AVPlayerItem.isPlaybackLikelyToKeepUp
```

## AVPlayerItemErrorLog

# Stall Investigation

## Listen to stall notifications

```
notificationCenter.addObserver(self,  
    selector: #selector(handlePlaybackStalled(_:)),  
    name: .AVPlayerItemPlaybackStalled,  
    object: playerItem)
```

## Check AVPlayerItem status

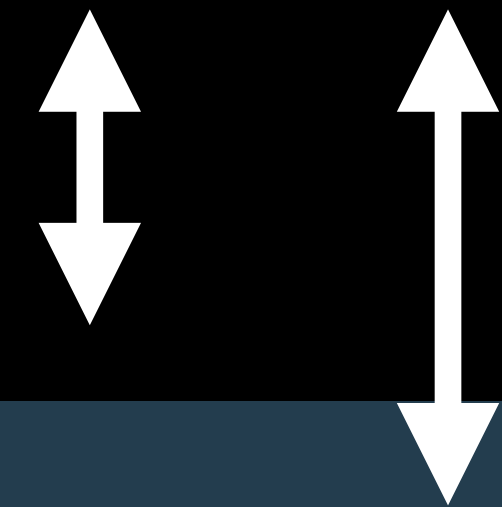
```
AVPlayerItem.isPlaybackLikelyToKeepUp
```

AVPlayerItemErrorLog

AVPlayerItemAccessLog

# Stall Example—Network Bandwidth Condition

AVPlayerItemErrorLog

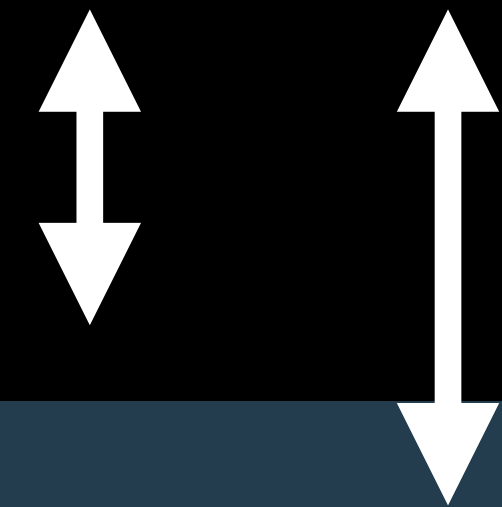


AVPlayerItemErrorLogEvent

```
URI = http://example.com/VOD/4k/prog_index.m3u8  
errorStatusCode = -16830  
errorDomain = CoreMediaErrorDomain  
errorComment = "Media file not received in 15s"
```

# Stall Example—Network Bandwidth Condition

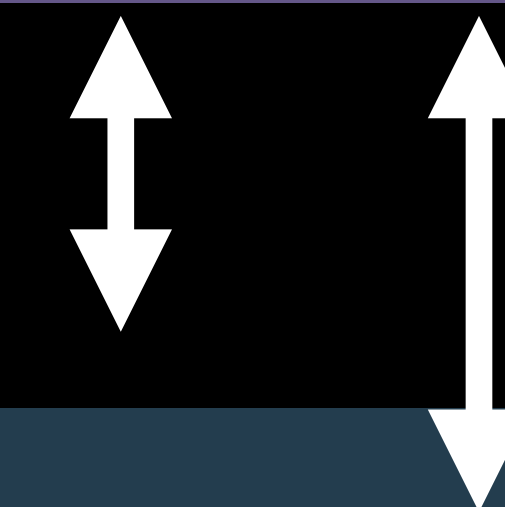
AVPlayerItemErrorLog



AVPlayerItemErrorLogEvent

```
URI = http://example.com/VOD/4k/prog_index.m3u8
errorStatusCode = -16830
errorDomain = CoreMediaErrorDomain
errorComment = "Media file not received in 15s"
```

AVPlayerItemAccessLog



AVPlayerItemAccessLogEvent

```
playbackType = VOD
URI = http://example.com/VOD/4k/prog_index.m3u8
indicatedBitrate = 36 Mbps
observedBitrate = 2.8 Mbps
```

# Reducing Stalls—Dealing With Variable Networks

# Reducing Stalls—Dealing With Variable Networks

Provide a full set of bit rate tiers



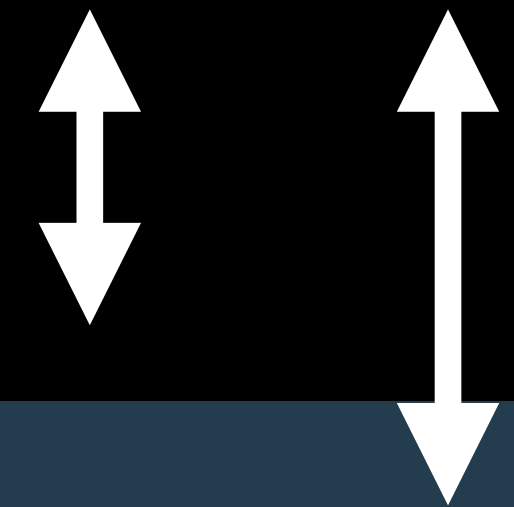
# Reducing Stalls—Dealing With Variable Networks

Provide a full set of bit rate tiers

- Each codec combination needs its own set of tiers

# Stall Example—Content Authoring / Delivering

AVPlayerItemErrorLog

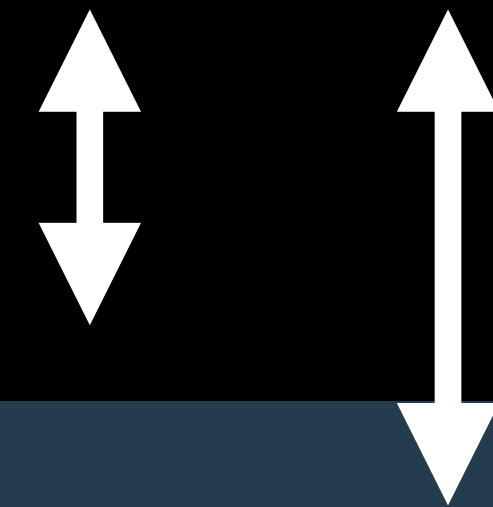


AVPlayerItemErrorLogEvent

```
URI = http://example.com/LIVE/prog_index.m3u8
errorStatusCode = -12888
errorDomain = CoreMediaErrorDomain
errorComment = "Playlist File unchanged for
                2 consecutive reads"
```

# Stall Example—Content Authoring / Delivering

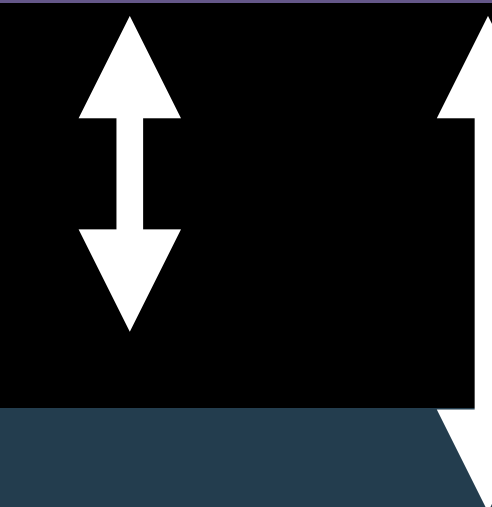
AVPlayerItemErrorLog



AVPlayerItemErrorLogEvent

```
URI = http://example.com/LIVE/prog_index.m3u8
errorStatusCode = -12888
errorDomain = CoreMediaErrorDomain
errorComment = "Playlist File unchanged for
                2 consecutive reads"
```

AVPlayerItemAccessLog



AVPlayerItemAccessLogEvent

```
playbackType = LIVE
URI = http://example.com/LIVE/prog_index.m3u8
indicatedBitrate = 404 kbps
observedBitrate = 3.7 Mbps
```

# Reducing Stalls—Content Delivery

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Your content server and CDN must

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# Reducing Stalls—Content Delivery

Your content server and CDN must

- Deliver media playlists, segments, and keys without delay
- Update live playlists at least every target duration
- Synchronize discontinuity sequence numbers between playlists
- Indicate server-side failures clearly

# How to Investigate Errors

# How to Investigate Errors

Error and access logs

# How to Investigate Errors

Error and access logs

Error properties

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Error and access logs

Error properties

Media validation

# Streaming Errors—AVPlayerItemErrorLog

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Can be triggered by problems with the network or content format

May be nonfatal

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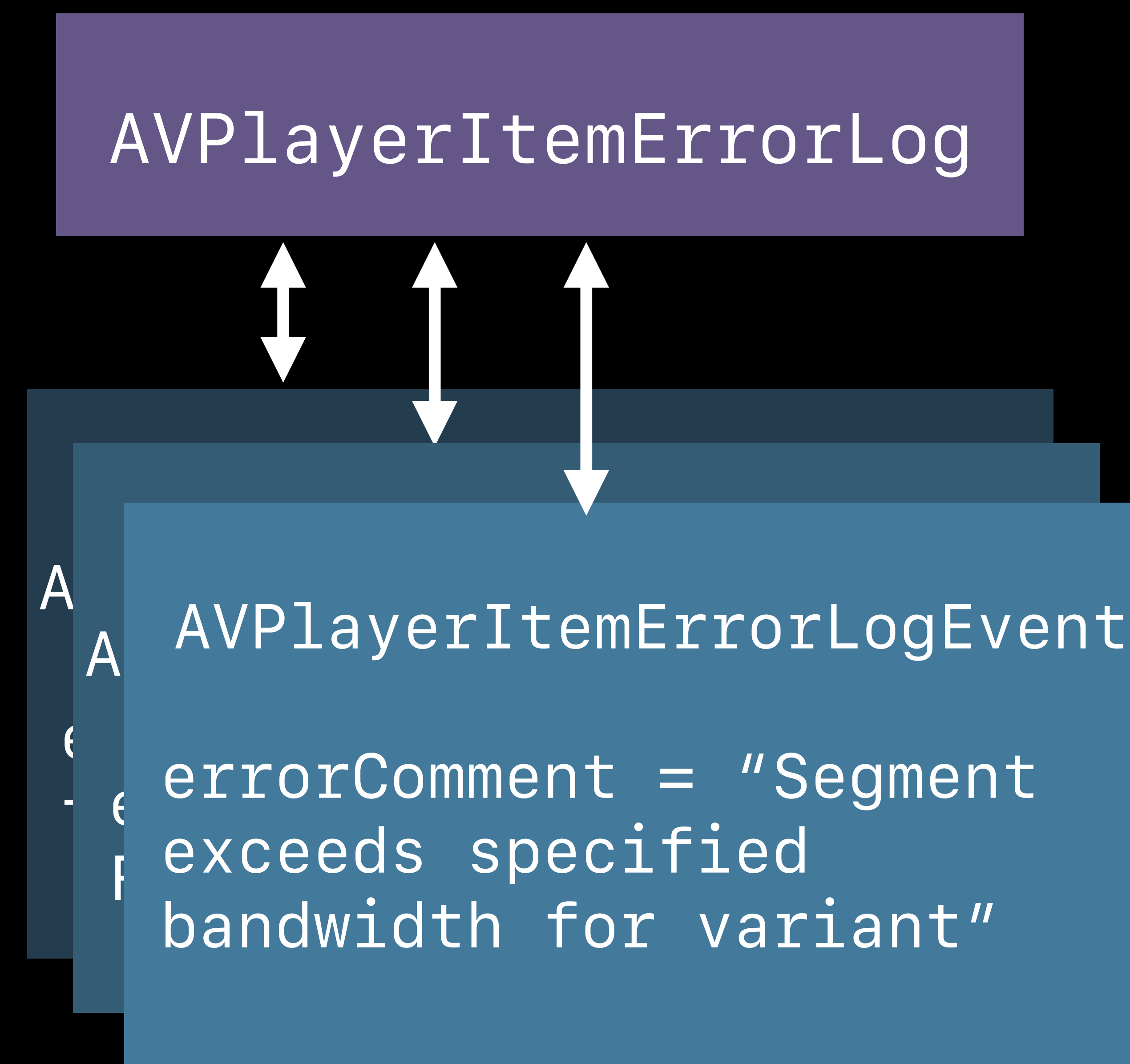


# Streaming Errors—AVPlayerItemErrorLog

Can be triggered by problems with the network or content format

May be nonfatal

Details are in the error comments

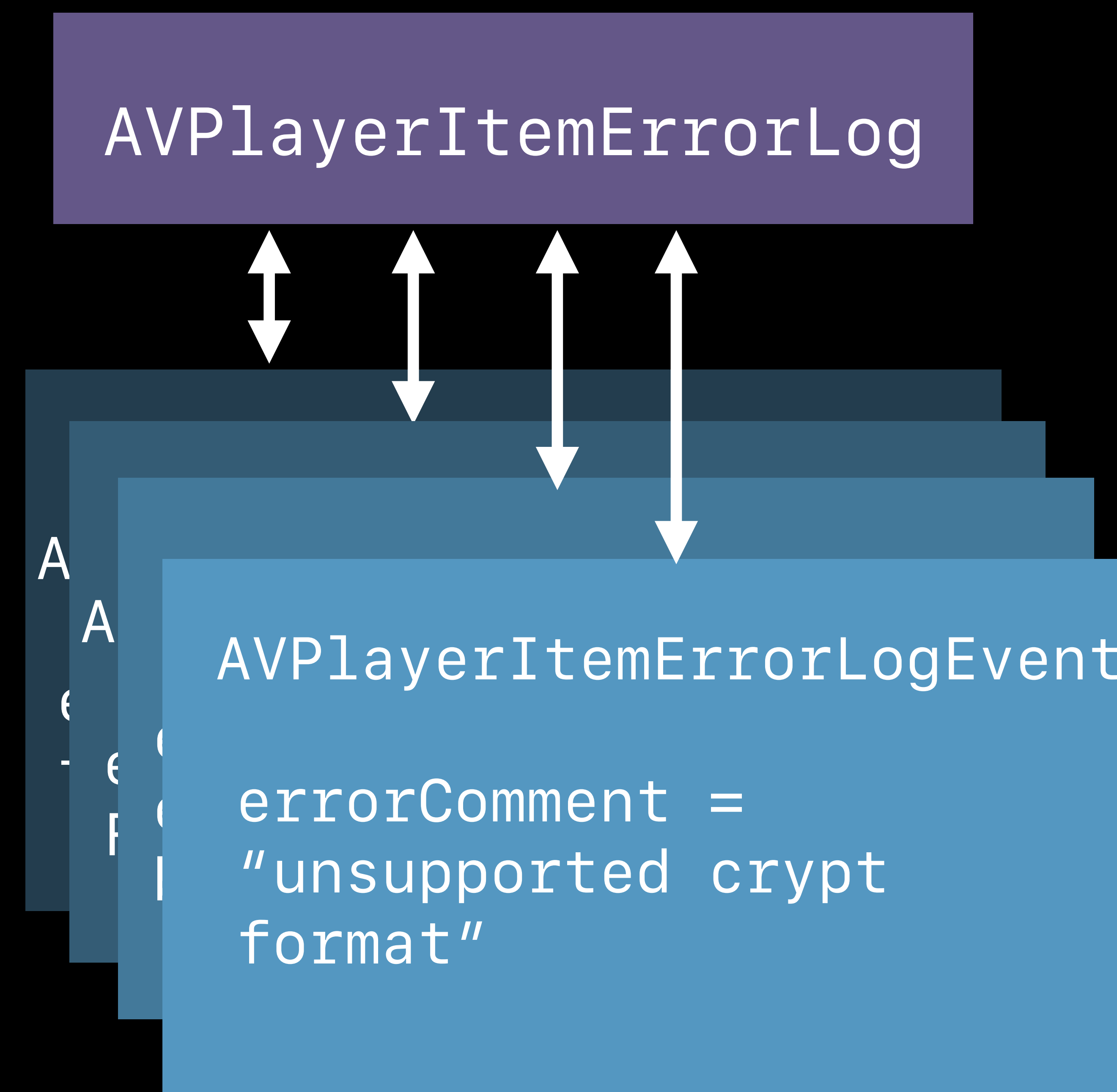


# Streaming Errors—AVPlayerItemErrorLog

Can be triggered by problems with the network or content format

May be nonfatal

Details are in the error comments



# Streaming Errors—AVPlayerItemErrorLog

Can be triggered by problems with the network or content format

May be nonfatal

Details are in the error comments

```
AVPlayerItemErrorLogEvent  
  
errorComment = "Media  
file not received in 15s"
```

```
AVPlayerItemErrorLogEvent  
  
errorComment = "HTTP 404:  
File Not Found"
```

```
AVPlayerItemErrorLogEvent  
  
errorComment = "Segment  
exceeds specified  
bandwidth for variant"
```

```
AVPlayerItemErrorLogEvent  
  
errorComment =  
"unsupported crypt  
format"
```

# Streaming Errors—AVPlayer, AVPlayerItem

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Observe `AVPlayerItem.status` and `AVPlayerItem.error`

# Streaming Errors—AVPlayer, AVPlayerItem

Observe `AVPlayerItem.status` and `AVPlayerItem.error`

`AVPlayerItem` errors end playback, remove item from player queue



```
//Streaming Errors : AVPlayer, AVPlayerItem

playerItemObserver = playerItem?.observe(\AVPlayerItem.status, options: [.new, .initial])
{ [weak self] (item, _) in
    guard let strongSelf = self else { return }
    if item.status == .failed {
        let error = item.error
        print("AVPlayerItem Error: \(String(describing: error?.localizedDescription))")
        let errorLog = item.errorLog()
        let lastErrorEvent = errorLog?.events.last
        print("ErrorLog: \(String(describing: lastErrorEvent?.description))")
    }
}
```

```
//Streaming Errors : AVPlayer, AVPlayerItem

playerItemObserver = playerItem?.observe(\AVPlayerItem.status, options: [.new, .initial])
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    }
}
```

```
//Streaming Errors : AVPlayer, AVPlayerItem

playerItemObserver = playerItem?.observe(\AVPlayerItem.status, options: [.new, .initial])
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    }
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```

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    }
}
```

```
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playerItemObserver = playerItem?.observe(\AVPlayerItem.status, options: [.new, .initial])
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        let errorLog = item.errorLog()
        let lastErrorEvent = errorLog?.events.last
        print("ErrorLog: \(String(describing: lastErrorEvent?.description))")
    }
}
```

```
//Streaming Errors: AVPlayer, AVPlayerItem
```

```
Error Domain=AVFoundationErrorDomain Code=-11800 "See -[AVPlayerItem errorLog] for 2 events"
```

```
UserInfo= {
```

```
    NSLocalizedDescription=The operation could not be completed,
```

```
    NSUnderlyingError=0x108342ba0 {
```

```
        Error Domain=NSOSStatusErrorDomain Code=-12645
```

```
    },
```

```
    NSDebugDescription=See -[AVPlayerItem errorLog] for 2 events,
```

```
    NSLocalizedFailureReason=An unknown error occurred (-12645)
```

```
}
```

```
//Streaming Errors: AVPlayer, AVPlayerItem
```

```
Error Domain=AVFoundationErrorDomain Code=-11800 "See -[AVPlayerItem errorLog] for 2 events"
```

```
UserInfo= {
```

```
    NSLocalizedDescription=The operation could not be completed,
```

```
    NSUnderlyingError=0x108342ba0 {
```

```
        Error Domain=NSOSStatusErrorDomain Code=-12645
```

```
    },
```

```
    NSDebugDescription=See -[AVPlayerItem errorLog] for 2 events,
```

```
    NSLocalizedFailureReason=An unknown error occurred (-12645)
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```
}
```

```
//Streaming Errors: AVPlayer, AVPlayerItem
```

```
Error Domain=AVFoundationErrorDomain Code=-11800 "See -[AVPlayerItem errorLog] for 2 events"
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```
UserInfo= {
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```

```
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```

```
    },
```

```
    NSDebugDescription=See -[AVPlayerItem errorLog] for 2 events,
```

```
    NSLocalizedFailureReason=An unknown error occurred (-12645)
```

```
}
```



```
//Streaming Errors: AVPlayerItemErrorLog
```

```
ErrorLog: <AVPlayerItemErrorLog: 0x10832d370>
```

```
#Version: 1.0
```

```
#Software: AppleCoreMedia/1.0.0.15F79 (iPhone; U; CPU OS 11_0 like Mac OS X; en_us)
```

```
#Date: 2018/05/23 11:34:34.034
```

```
#Fields: date time uri status domain comment cs-iftype
```

```
2018/05/23 11:34:34.034 http://example.com/master.m3u8 -12885
```

```
"CoreMediaErrorDomain" "unsupported crypt format." wifi-infra
```

```
//Streaming Errors: AVPlayerItemErrorLog
```

```
ErrorLog: <AVPlayerItemErrorLog: 0x10832d370>
```

```
#Version: 1.0
```

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#Software: AppleCoreMedia/1.0.0.15F79 (iPhone; U; CPU OS 11_0 like Mac OS X; en_us)
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2018/05/23 11:34:34.034 http://example.com/master.m3u8 -12885
```

```
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```

# Streaming Errors—HDCP

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```
AVPlayer.isOutputObscuredDueToInsufficientExternalProtection == true
```

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AVPlayer.isOutputObscuredDueToInsufficientExternalProtection == true
```

Current item requires external protection

Device does not meet protection level

User observes video loss

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AVPlayer.isOutputObscuredDueToInsufficientExternalProtection == true
```

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Device does not meet protection level

User observes video loss

Have a variant which doesn't require HDCP protection

App user interface should reflect property value changes



# Streaming Errors—HDCP

```
AVPlayer.isOutputObscuredDueToInsufficientExternalProtection == true
```

Current item requires external protection

Device does not meet protection level

User observes video loss

Have a variant which doesn't require HDCP protection

App user interface should reflect property value changes



# Streaming Errors—Media Validation

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Media stream validator

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Media stream validator

Available on developer website

# Master Playlists

Getting it right

Eryk Vershen, Media Streaming Engineer

“The right thing to do is to give us everything you’ve got.”

Roger Pantos, in a meeting

How do I make sure the player  
chooses the right stream?

```
# The simplest possible master playlist. Don't do this!
```

```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000
```

```
http://example.com/video.m3u8
```





```
# Slightly better master playlist. Still, don't do this!
```

```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000
```

```
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000
```

```
http://example.com/video2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=3500000
```

```
http://example.com/video3.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=6500000
```

```
http://example.com/video4.m3u8
```



# Attributes For Variants

EXT-X-STREAM-INF tag

---

|                   |                         |                                     |
|-------------------|-------------------------|-------------------------------------|
| BANDWIDTH         | Peak bits per second    | Worst case data rate                |
| AVERAGE-BANDWIDTH | Average bits per second | Expected data rate                  |
| CODECS            | Media formats used      | Will I be able to decode this?      |
| RESOLUTION        | Video resolution        | Is this an appropriate size?        |
| HDCP-LEVEL        | NONE, TYPE-0, or TYPE-1 | Will this play on my output device? |
| VIDEO-RANGE       | SDR or PQ               | Will this play on my output device? |
| FRAME-RATE        | Maximum frame rate      | Will this play on my output device? |

---

```
# Simple master playlist with attributes
```



```
#EXTM3U
```

```
#EXT-X-VERSION:4
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976  
http://example.com/video2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=3500000,AVERAGE-BANDWIDTH=3000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=1280x720,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976  
http://example.com/video3.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=6500000,AVERAGE-BANDWIDTH=6000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=1920x1080,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976  
http://example.com/video4.m3u8
```

Why don't I see images in fast-forward  
or in the Apple TV scrubber bar?



Advances in HTTP Live Streaming  
Session 504  
Rugil Partha, AVFoundation Engineer  
And Kati, AVFoundation Engineer

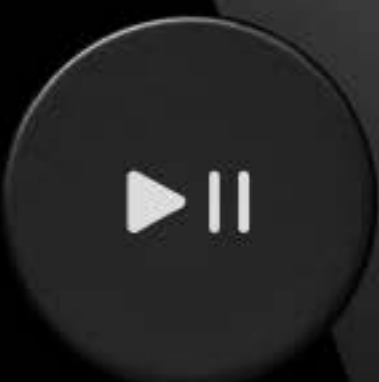
0:17

26:47

-54:34

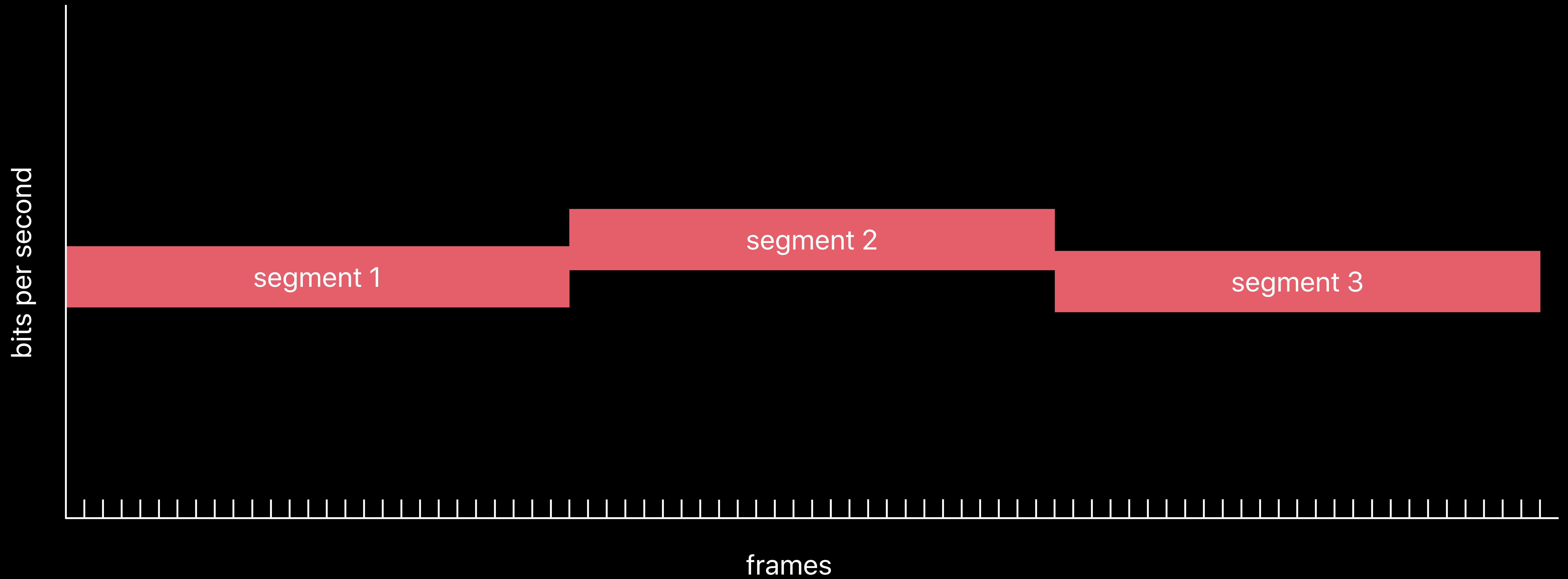


MENU



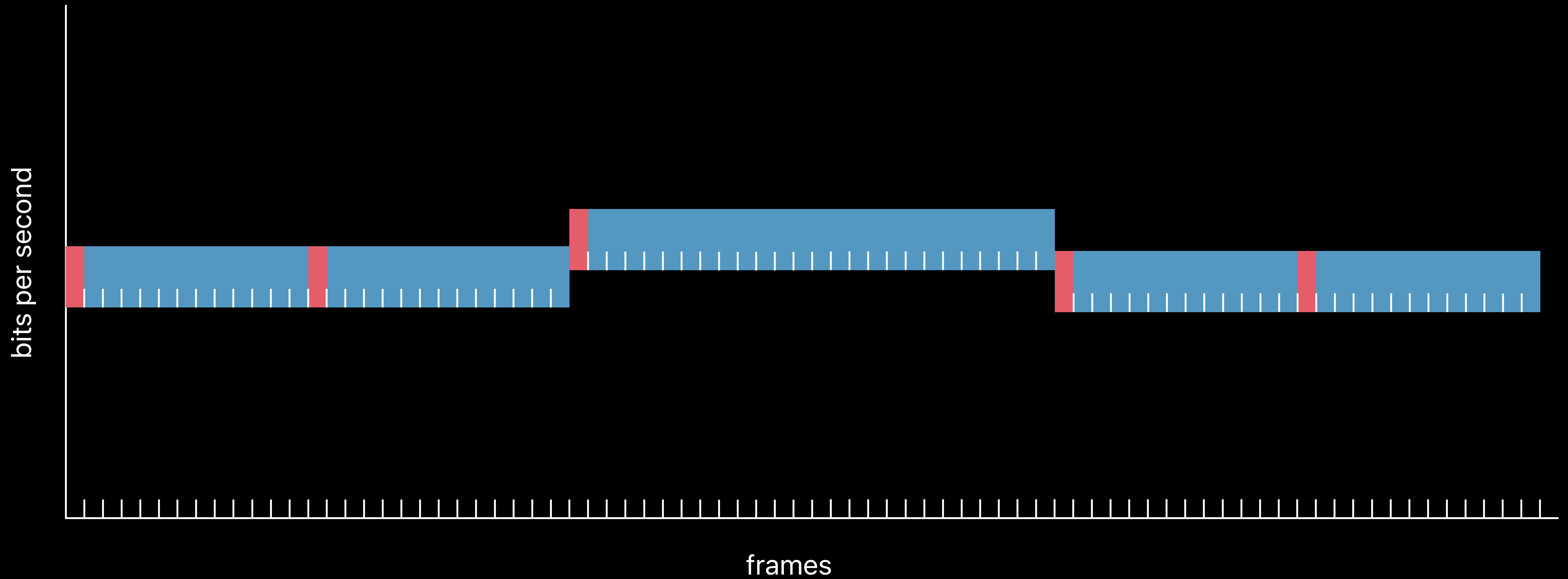
# What's an I-frame?

Normal (full) video segments



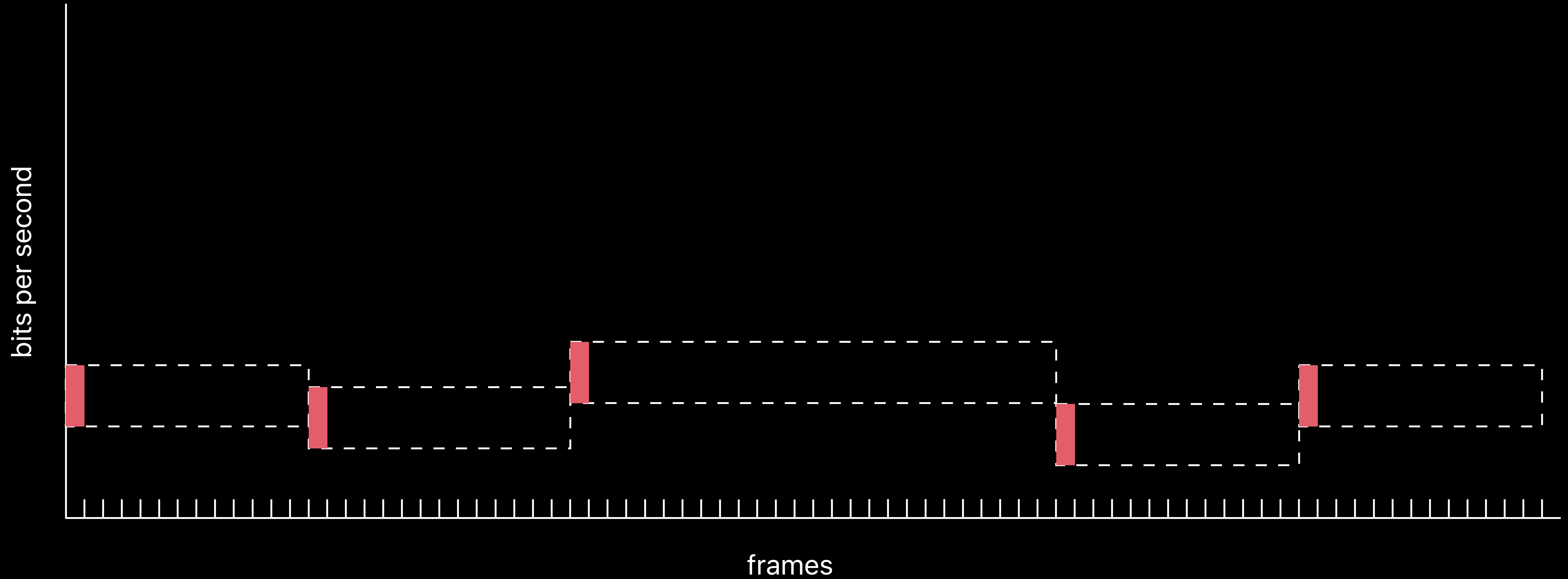
# What's an I-frame?

Independently decodable frames



# I-frame Video Segments

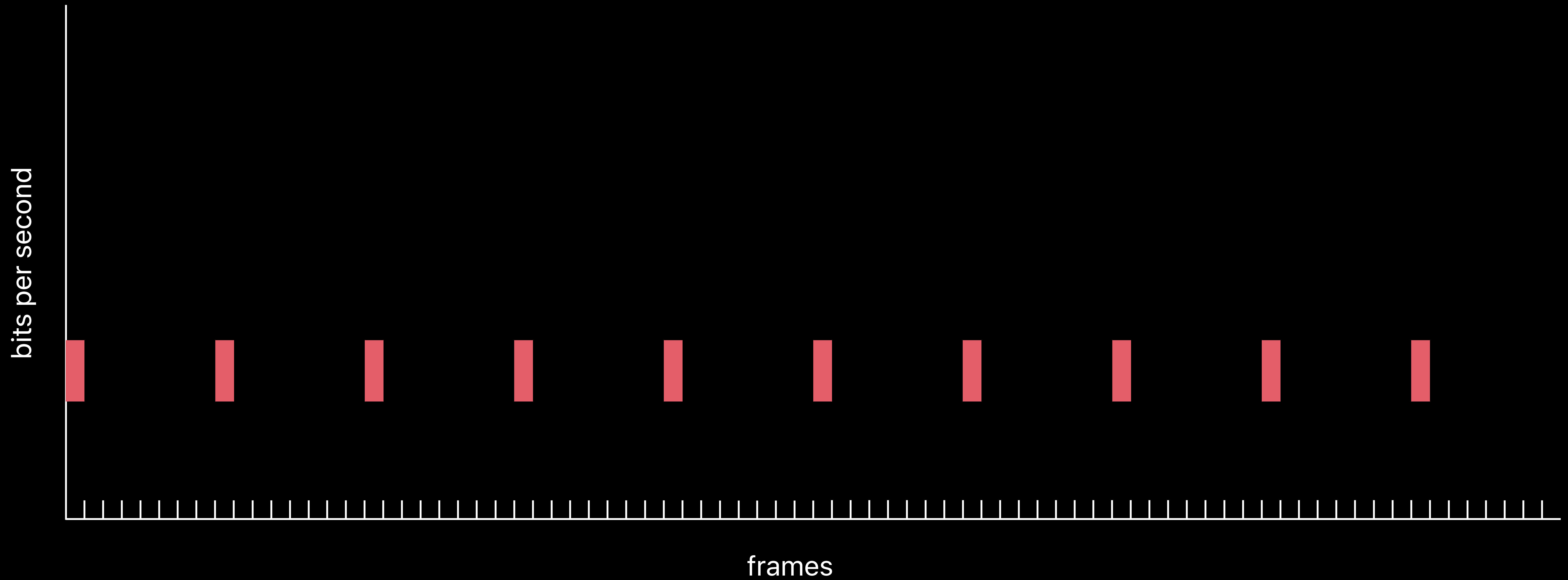
Consist of a single frame





# High Density I-frames

Evenly spaced, closer together, better user experience



```
# Master Playlist with I-frame playlists
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976
```

```
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976
```

```
http://example.com/video2.m3u8
```

```
#EXT-X-I-FRAME-STREAM-INF:BANDWIDTH=187500,AVERAGE-BANDWIDTH=125000,CODECS="avc1.64001f",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,URI="http://example.com/iframe1.m3u8"
```

```
#EXT-X-I-FRAME-STREAM-INF:BANDWIDTH=312500,AVERAGE-BANDWIDTH=250000,CODECS="avc1.64001f",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,URI="http://example.com/iframe2.m3u8"
```

```
# Master Playlist with I-frame playlists
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976
```

```
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976
```

```
http://example.com/video2.m3u8
```

```
#EXT-X-I-FRAME-STREAM-INF:BANDWIDTH=187500,AVERAGE-BANDWIDTH=125000,CODECS="avc1.64001f",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,URI="http://example.com/iframe1.m3u8"
```

```
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```

```
# Master Playlist with I-frame playlists
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976
```

```
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976
```

```
http://example.com/video2.m3u8
```

```
#EXT-X-I-FRAME-STREAM-INF:BANDWIDTH=187500,AVERAGE-BANDWIDTH=125000,CODECS="avc1.64001f",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,URI="http://example.com/iframe1.m3u8"
```

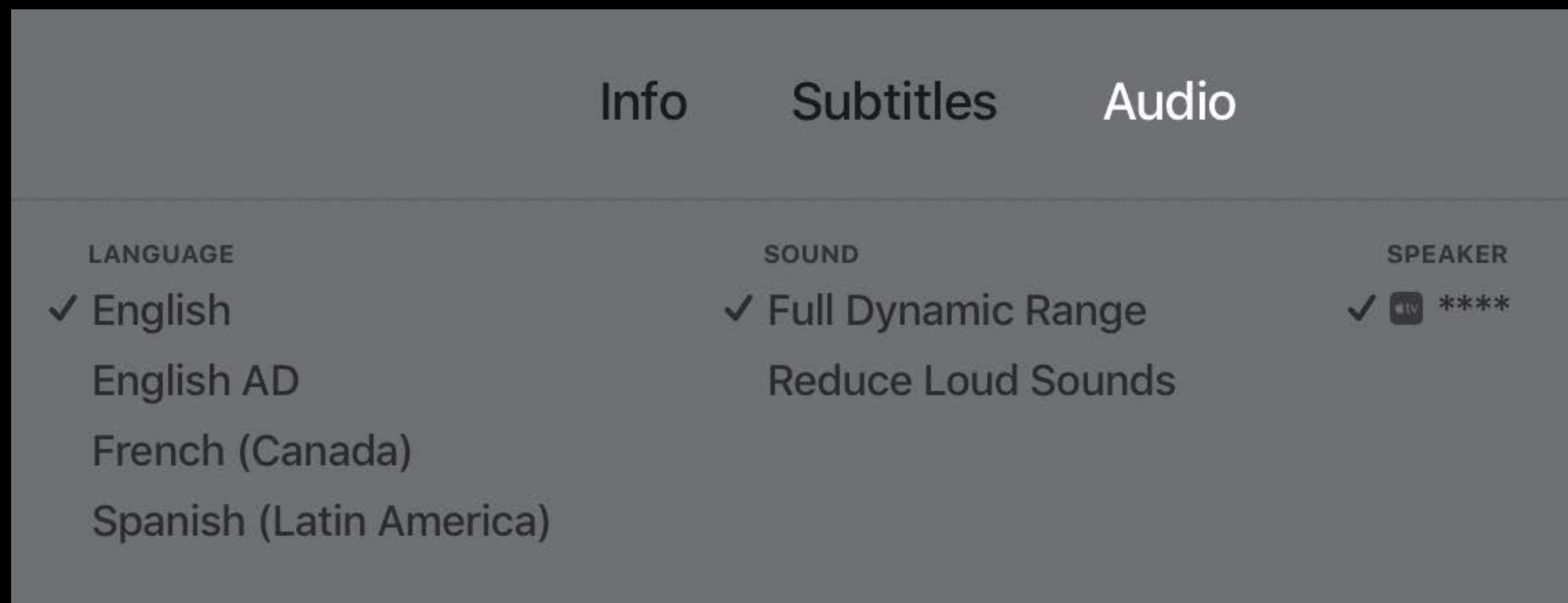
```
#EXT-X-I-FRAME-STREAM-INF:BANDWIDTH=312500,AVERAGE-BANDWIDTH=250000,CODECS="avc1.64001f",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,URI="http://example.com/iframe2.m3u8"
```

“The peak segment bit rate of a Media Playlist is the largest bit rate of any contiguous set of segments whose total duration is between 0.5 and 1.5 times the target duration.”

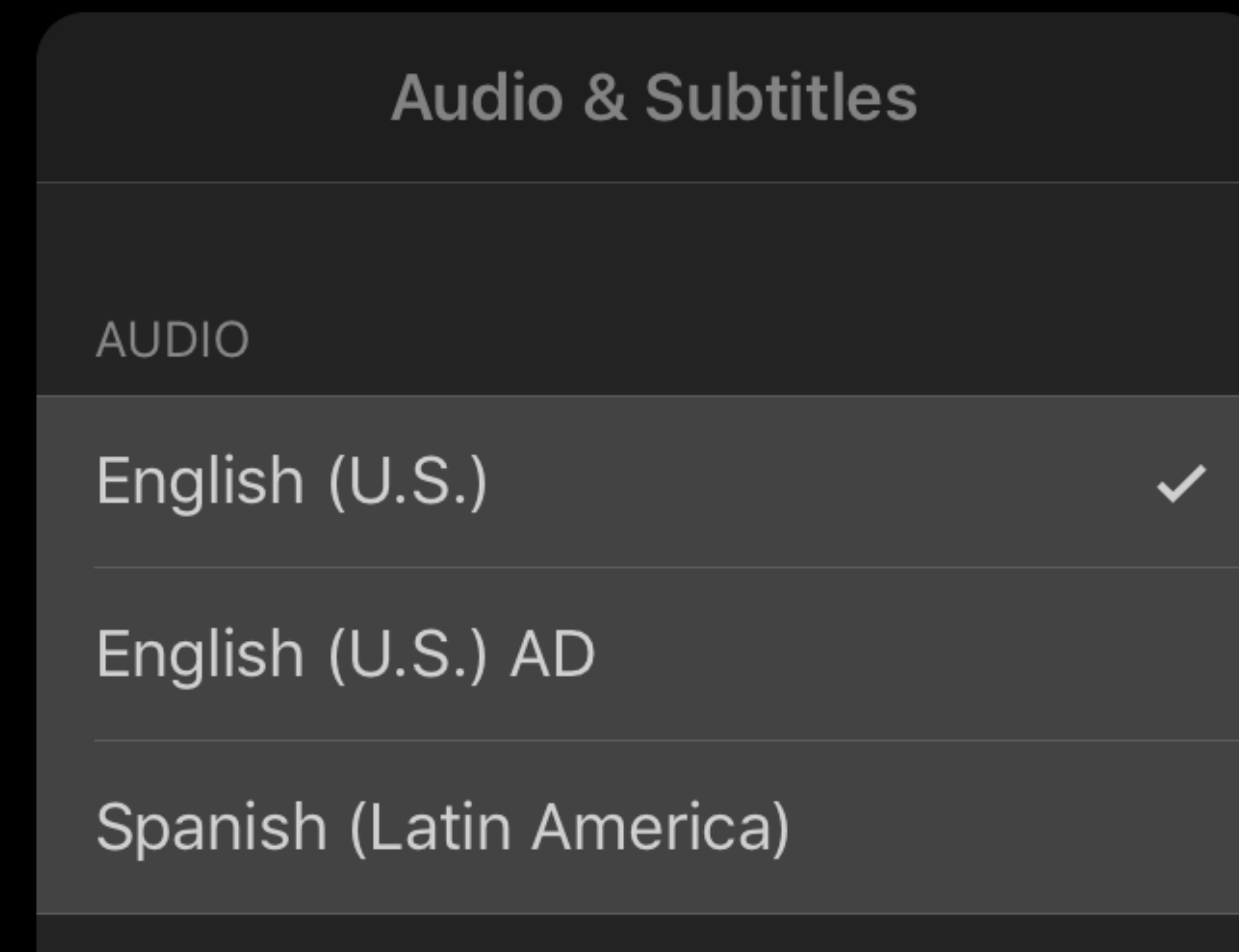
*HTTP Live Streaming 2nd Edition, draft-pantos-hls-rfc8216bis*  
(Also RFC8216)

How do I support multiple languages?

# Multiple Languages



tvOS



iOS

```
# Master Playlist with audio in two languages
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=3500000,AVERAGE-BANDWIDTH=3000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=1280x720,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video3.m3u8
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aud",NAME="English",LANGUAGE="en",DEFAULT=YES,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/en_audio.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aud",NAME="Français",LANGUAGE="fr",DEFAULT=NO,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/fr_audio.m3u8"
```



```
# Master Playlist with audio in two languages
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=3500000,AVERAGE-BANDWIDTH=3000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=1280x720,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video3.m3u8
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aud",NAME="English",LANGUAGE="en",DEFAULT=YES,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/en_audio.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aud",NAME="Français",LANGUAGE="fr",DEFAULT=NO,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/fr_audio.m3u8"
```

```
# Master Playlist with audio in two languages
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=3500000,AVERAGE-BANDWIDTH=3000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=1280x720,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aud"  
http://example.com/video3.m3u8
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aud",NAME="English",LANGUAGE="en",DEFAULT=YES,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/en_audio.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aud",NAME="Français",LANGUAGE="fr",DEFAULT=NO,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/fr_audio.m3u8"
```

What's the difference between  
DEFAULT and AUTOSELECT?

# AUTOSELECT

This rendition can be automatically selected

Generally you want this set to YES

Set to NO for things like a commentary track

# DEFAULT

Player chooses this rendition unless the user chooses something else

Only one member of a group can be DEFAULT=YES

Must have AUTOSELECT=YES

Has nothing to do with the default variant

How do I support multichannel audio?

# Multichannel Audio

Gives us stereo also

Group 1

Group 2

English

English stereo

English 5.1

French

French stereo

French 5.1

Chinese

Chinese stereo

Chinese 5.1

# Multichannel Audio

Gives us stereo also

Group 1

Group 2

English

English stereo

English 5.1

French

French stereo

Chinese

Chinese stereo

Chinese 5.1



# Multichannel Audio

Gives us stereo also

Group 1

Group 2

English

English stereo

English 5.1

French

French stereo

French Stereo

Chinese

Chinese stereo

Chinese 5.1

```
# Master Playlist with audio in two languages, two formats
```

```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aac"
```

```
http://example.com/video1.m3u8
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aac",NAME="English",LANGUAGE="en",DEFAULT=YES,AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/en_audio.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aac",NAME="Français",LANGUAGE="fr",DEFAULT=NO,AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/fr_audio.m3u8"
```



```
# Master Playlist with audio in two languages, two formats
```

```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aac"  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1700000,AVERAGE-BANDWIDTH=1200000,  
CODECS="avc1.64001f,ac-3,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,  
FRAME-RATE=23.976,AUDIO="ac3"  
http://example.com/video1.m3u8
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aac",NAME="English",LANGUAGE="en",DEFAULT=YES,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/en_audio.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aac",NAME="Français",LANGUAGE="fr",DEFAULT=NO,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/fr_audio.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="ac3",NAME="English",LANGUAGE="en",DEFAULT=YES,  
AUTOSELECT=YES,CHANNELS="6",URI="http://example.com/en_surround.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="ac3",NAME="Français",LANGUAGE="fr",DEFAULT=NO,  
AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/fr_audio.m3u8"
```





```
# Master Playlist with audio in two languages, two formats
```

```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="aac"
```

```
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1700000,AVERAGE-BANDWIDTH=1200000,CODECS="avc1.64001f,ac-3,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="ac3"
```

```
http://example.com/video1.m3u8
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aac",NAME="English",LANGUAGE="en",DEFAULT=YES,AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/en_audio.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="aac",NAME="Français",LANGUAGE="fr",DEFAULT=NO,AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/fr_audio.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="ac3",NAME="English",LANGUAGE="en",DEFAULT=YES,AUTOSELECT=YES,CHANNELS="6",URI="http://example.com/en_surround.m3u8"
```

```
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="ac3",NAME="Français",LANGUAGE="fr",DEFAULT=NO,AUTOSELECT=YES,CHANNELS="2",URI="http://example.com/fr_audio.m3u8"
```

How do I support *several* audio bit rates?

# Multiple Audio Bit Rates

Give us every language in every bit rate

HE-AAC  
32 kb

AAC-LC  
96 kb

English

English low bit rate stereo

English stereo

French

French low bit rate stereo

French stereo

Chinese

Chinese low bit rate stereo

Chinese stereo

# Multiple Audio Bit Rates and Formats

Always fill out the whole matrix

|         | HE-AAC<br>32 kb             | AAC-LC<br>96 kb | AC-3<br>384 kb |
|---------|-----------------------------|-----------------|----------------|
| English | English low bit rate stereo | English stereo  | English 5.1    |
| French  | French low bit rate stereo  | French stereo   | French 5.1     |
| Chinese | Chinese low bit rate stereo | Chinese stereo  | Chinese 5.1    |

```
# Master Playlist with multiple bit rate audio
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.5",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="low"
```

```
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="high"
```

```
http://example.com/video2.m3u8
```



```
# Master Playlist with multiple bit rate audio and multiple formats
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.5",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="low"  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="high"  
http://example.com/video2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1800000,AVERAGE-BANDWIDTH=1300000,CODECS="avc1.64001f,ac-3",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="ac3"  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2700000,AVERAGE-BANDWIDTH=2200000,CODECS="avc1.64001f,ac-3",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="ac3"  
http://example.com/video2.m3u8
```

```
# Master Playlist with multiple bit rate audio and multiple formats
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.5",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="low"  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2500000,AVERAGE-BANDWIDTH=2000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="high"  
http://example.com/video2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1800000,AVERAGE-BANDWIDTH=1300000,CODECS="avc1.64001f,ac-3",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="ac3"  
http://example.com/video1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2700000,AVERAGE-BANDWIDTH=2200000,CODECS="avc1.64001f,ac-3",RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="ac3"  
http://example.com/video2.m3u8
```

How do I want HEVC or Dolby Vision?

# Video Formats

Don't skimp on variants

|                | H.264           | HEVC           | Dolby Vision           |
|----------------|-----------------|----------------|------------------------|
| Video (tier 1) | 540p SDR H.264  | 540p SDR HEVC  | 540p HDR Dolby Vision  |
| Video (tier 2) | 720p SDR H.264  | 720p SDR HEVC  | 720p HDR Dolby Vision  |
| Video (tier 3) | 1080p SDR H.264 | 1080p SDR HEVC | 1080p HDR Dolby Vision |
| Video (tier 4) |                 | 2160p SDR HEVC | 2160p HDR Dolby Vision |

```
# Master Playlist with multiple video formats (part 1 of 3)
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=2259085,AVERAGE-BANDWIDTH=1477534,CODECS="avc1.64001f,ac-3",  
RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="audio-ac3"
```

```
http://example.com/video_a1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=4860763,AVERAGE-BANDWIDTH=3175979,CODECS="avc1.640020,ac-3",  
RESOLUTION=1280x720,HDCP-LEVEL=TYPE-0,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="audio-ac3"
```

```
http://example.com/video_a2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=6463929,AVERAGE-BANDWIDTH=4165530,CODECS="avc1.640028,ac-3",  
RESOLUTION=1920x1080,HDCP-LEVEL=TYPE-0,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="audio-ac3"
```

```
http://example.com/video_a3.m3u8
```

# Master Playlist with multiple video formats (part 2 of 3)



#EXT-X-STREAM-INF:BANDWIDTH=1856750,AVERAGE-BANDWIDTH=1194136,CODECS="hvc1.2.4.L123.B0,ac-3",  
RESOLUTION=960x540,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="audio-ac3"

[http://example.com/video\\_h1.m3u8](http://example.com/video_h1.m3u8)

#EXT-X-STREAM-INF:BANDWIDTH=3955841,AVERAGE-BANDWIDTH=2488906,CODECS="hvc1.2.4.L123.B0,ac-3",  
RESOLUTION=1280x720,HDCP-LEVEL=TYPE-0,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="audio-ac3",

[http://example.com/video\\_h2.m3u8](http://example.com/video_h2.m3u8)

#EXT-X-STREAM-INF:BANDWIDTH=3954219,AVERAGE-BANDWIDTH=2487757,CODECS="hvc1.2.4.L123.B0,ac-3",  
RESOLUTION=1920x1080,HDCP-LEVEL=TYPE-0,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="audio-ac3",

[http://example.com/video\\_h3.m3u8](http://example.com/video_h3.m3u8)

#EXT-X-STREAM-INF:BANDWIDTH=8545569,AVERAGE-BANDWIDTH=5269090,CODECS="hvc1.2.4.H150.B0,ac-3",  
RESOLUTION=3840x2160,HDCP-LEVEL=TYPE-1,VIDEO-RANGE=SDR,FRAME-RATE=23.976,AUDIO="audio-ac3",

[http://example.com/video\\_h4.m3u8](http://example.com/video_h4.m3u8)

# Master Playlist with multiple video formats (part 3 of 3)



```
#EXT-X-STREAM-INF:BANDWIDTH=2208349,AVERAGE-BANDWIDTH=1394149,CODECS="dvh1.05.01,ac-3",
RESOLUTION=960x540,HDCP-LEVEL=TYPE-1,VIDEO-RANGE=PQ,FRAME-RATE=23.976,AUDIO="audio-ac3",
http://example.com/video_d1.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=4662645,AVERAGE-BANDWIDTH=2926283,CODECS="dvh1.05.01,ac-3",
RESOLUTION=1280x720,HDCP-LEVEL=TYPE-1,VIDEO-RANGE=PQ,FRAME-RATE=23.976,AUDIO="audio-ac3",
http://example.com/video_d2.m3u8
```

```
#EXT-X-STREAM-INF:BANDWIDTH=4659386,AVERAGE-BANDWIDTH=2929051,CODECS="dvh1.05.03,ac-3",
RESOLUTION=1920x1080,HDCP-LEVEL=TYPE-1,VIDEO-RANGE=PQ,FRAME-RATE=23.976,AUDIO="audio-ac3",
http://example.com/video_d3.m3u8
```

```
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=6327675,BANDWIDTH=10277026,CODECS="dvh1.05.06,ac-3",
RESOLUTION=3840x2160,HDCP-LEVEL=TYPE-1,VIDEO-RANGE=PQ,FRAME-RATE=23.976,AUDIO="audio-ac3",
http://example.com/video_d4.m3u8
```

How do I handle subtitles?



```
# Master Playlist with subtitles and closed captions
```



```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,SUBTITLES="subtitles",CLOSED-CAPTIONS="cc"  
http://example.com/video1.m3u8
```

```
#EXT-X-MEDIA:TYPE=SUBTITLES,GROUP-ID="subtitles",LANGUAGE="cmn-Hans",NAME="中文 (简体",AUTOSELECT=YES,FORCED=NO,URI="http://example.com/subtitles_cmn-Hans.m3u8"
```

```
#EXT-X-MEDIA:TYPE=SUBTITLES,GROUP-ID="subtitles",LANGUAGE="es-419",NAME="Español (Latinoamérica) (forced)",AUTOSELECT=YES,FORCED=YES,URI="http://example.com/subtitles_es-419_forced.m3u8"
```

```
#EXT-X-MEDIA:TYPE=CLOSED-CAPTIONS,GROUP-ID="cc",NAME="English (US)",LANGUAGE="en-US",AUTOSELECT=YES,INSTREAM-ID="CC1",CHARACTERISTICS="public.accessibility.transcribes-spoken-dialog"
```



```
# Master Playlist with subtitles and closed captions
```

```
#EXTM3U
```

```
#EXT-X-STREAM-INF:BANDWIDTH=1500000,AVERAGE-BANDWIDTH=1000000,CODECS="avc1.64001f,mp4a.40.2",RESOLUTION=768x432,HDCP-LEVEL=NONE,VIDEO-RANGE=SDR,FRAME-RATE=23.976,SUBTITLES="subtitles",CLOSED-CAPTIONS="cc"  
http://example.com/video1.m3u8
```

```
#EXT-X-MEDIA:TYPE=SUBTITLES,GROUP-ID="subtitles",LANGUAGE="cmn-Hans",NAME="中文 (简体",AUTOSELECT=YES,FORCED=NO,URI="http://example.com/subtitles_cmn-Hans.m3u8"
```

```
#EXT-X-MEDIA:TYPE=SUBTITLES,GROUP-ID="subtitles",LANGUAGE="es-419",NAME="Español (Latinoamérica) (forced)",AUTOSELECT=YES,FORCED=YES,URI="http://example.com/subtitles_es-419_forced.m3u8"
```

```
#EXT-X-MEDIA:TYPE=CLOSED-CAPTIONS,GROUP-ID="cc",NAME="English (US)",LANGUAGE="en-US",AUTOSELECT=YES,INSTREAM-ID="CC1",CHARACTERISTICS="public.accessibility.transcribes-spoken-dialog"
```

“The right thing to do is to give us everything  
you’ve got.”

Roger Pantos, in a meeting

# Summary

Measure key performance indicators (KPIs)

Reduce startup time

Investigate and resolve stalls and errors

Tell us everything you can in your master playlists

# More Information

<https://developer.apple.com/wwdc2018/502>

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HTTP Live Streaming Lab

Technology Lab 3

Tuesday 2:00PM

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HTTP Live Streaming Lab

Technology Lab 4

Thursday 9:00AM

---

 **WWDC18**