Advances in HTTP Live Streaming

Session 504

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But First

HLS Has Been Approved for Publication as an RFC!

draft-pantos-http-live-streaming-23 will be published by the IETF as an RFC

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Watch for a new Internet-Draft containing future updates

NEW

New Video Format: HEVC

Benefits of HEVC

NEW

Better encoding efficiency than AVC / H.264

- Reduce segment sizes by up to 40% with same visual quality

On a given network link, this translates to:

- Faster video start at reasonable quality
- Better quality overall

HEVC Will Be Widely Supported

	iOS	macOS
8-bit Hardware Decode (includes FairPlay Streaming)	A9 chip	6th Generation Intel Core processor
10-bit Hardware Decode (includes FairPlay Streaming)		7th Generation Intel Core processor
8-bit Software Decode	All iOS Devices	All Macs
10-bit Software Decode		

HEVC Support in HLS

For Apple clients, HEVC must be packaged as fMP4

- No support for HEVC in MPEG-2 TS

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Same encryption format — 'cbcs' ISO/IEC 23001:7 Common Encryption

Mark your Media Playlists as HEVC with the CODECS attribute

- `CODECS= "hvc1.2.4.L123.B0,…"`
- See ISO/IEC 14496-15 for the string format

Mixing HEVC and H.264

HEVC and H.264 variants can appear in the same Master playlist

- I-frame playlists too

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- Label your Media Playlists with correct CODECS attributes!

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HEVC and H.264 variants can appear in the same Master playlist

- I-frame playlists too
- HEVC must be fMP4
- H.264 can be TS or fMP4
- Label your Media Playlists with correct CODECS attributes!

HLS Authoring guidelines have been updated for HEVC

- See the on-demand talk "HLS Authoring Update"

NEW

New Subtitle Format: IMSC1

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IMSC1 is a profile of TTML that has been optimized for streaming delivery

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Better control over styling, compared to VTT

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Better control over styling, compared to VTT

Baseline subtitle format for the Common Media Application Format (CMAF)

- Part of a wider effort to support CMAF features

IMSC1 in HLS

Carried as XML text inside fMP4 Segments

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Mark your Media Playlists as IMSC1 with the CODECS attribute

- `CODECS="stpp.TTML.im1t, …"`

IMSC1 in HLS

Carried as XML text inside fMP4 Segments

HLS defines support for the IMSC1 Text profile

Mark your Media Playlists as IMSC1 with the CODECS attribute

- `CODECS="stpp.TTML.im1t, …"`

Note that IMSC1 does not depend on HEVC, or vice-versa

```
//IMSC1 alongside WebVTT in a Master Playlist

#EXTM3U

#EXT-X-MEDIA:TYPE=SUBTITLES,GROUP-ID="vtt",LANGUAGE="eng",NAME="English",URI="vtt.m3u8"
#EXT-X-STREAM-INF:BANDWIDTH=90000,CODECS="avc1.4d001e,ac-3",SUBTITLES="vtt"
bipbop_gear1/prog_index.m3u8

#EXT-X-MEDIA:TYPE=SUBTITLES,GROUP-ID="imsc",LANGUAGE="eng",NAME="English",URI="imsc.m3u8"
#EXT-X-STREAM-INF:BANDWIDTH=90000,CODECS="avc1.4d001e,ac-3,stpp.TTML.im1t",SUBTITLES="imsc"
bipbop_gear1/prog_index.m3u8
```

IMSC1 in a Media Playlist

```
# WebVTT
#EXTM3U
#EXT-X-TARGETDURATION:6
#EXTINF 6,
segment1.vtt
#EXTINF 6,
segment2.vtt
…
```

```
# IMSC1
#EXTM3U
#EXT-X-TARGETDURATION:6
#EXT-X-MAP:URI="header.mp4"
#EXTINF 6,
segment1.mp4
#EXTINF 6,
segment2.mp4
…
```

You Might Switch Your HLS Streams to IMSC1 if …

You want more control over text styling than VTT alone provides

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You produce VTT by translating TTML

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You produce IMSC1 anyway

- Reduce the number of overall streams you produce

You Might Switch Your HLS Streams to IMSC1 if …

You want more control over text styling than VTT alone provides

You produce VTT by translating TTML

- TTML-to-IMSC1 translation is simpler, and may have higher fidelity

You produce IMSC1 anyway

- Reduce the number of overall streams you produce

Sticking with VTT is fine, too

Is There an IMSC2?

Not yet. It is currently being defined.

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We expect it to add advanced styling features for Japanese text

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Not yet. It is currently being defined.

We expect it to add advanced styling features for Japanese text

Stay tuned

New Streaming Features

EXT-X-GAP: A New m3u8 Tag

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:7
#EXT-X-MEDIA-SEQUENCE:9
#EXTINF:9.34267,
fileSequence9.ts
#EXTINF:9.75975,
fileSequence10.ts
#EXTINF:9.63462,
fileSequence11.ts
#EXTINF:9.34267,
fileSequence12.ts
```

EXT-X-GAP: A New m3u8 Tag

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:7
#EXT-X-MEDIA-SEQUENCE:10
#EXTINF:9.75975,
fileSequence10.ts
#EXTINF:9.63462,
fileSequence11.ts
#EXTINF:9.34267,
fileSequence12.ts
#EXTINF:9.75975,
fileSequence13.ts
```

EXT-X-GAP: A New m3u8 Tag

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:7
#EXT-X-MEDIA-SEQUENCE:11
#EXTINF:9.63462,
fileSequence11.ts
#EXTINF:9.34267,
fileSequence12.ts
#EXTINF:9.75975,
fileSequence13.ts
#EXTINF:9.84317,
fileSequence14.ts
```

EXT-X-GAP: A New m3u8 Tag

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:7
#EXT-X-MEDIA-SEQUENCE:12
#EXTINF:9.34267,
fileSequence12.ts
#EXTINF:9.75975,
fileSequence13.ts
#EXTINF:9.84317,
fileSequence14.ts
#EXTINF:8.75875,
#EXT-X-GAP
missing-Sequence15.ts
```

EXT-X-GAP: A New m3u8 Tag

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:7
#EXT-X-MEDIA-SEQUENCE:13
#EXTINF:9.75975,
fileSequence13.ts
#EXTINF:9.84317,
fileSequence14.ts
#EXTINF:8.75875,
#EXT-X-GAP
missing-Sequence15.ts
#EXTINF:9.88487,
#EXT-X-GAP
missing-Sequence16.ts
```

EXT-X-GAP: A New m3u8 Tag

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:7
#EXT-X-MEDIA-SEQUENCE:14
#EXTINF:9.84317,
fileSequence14.ts
#EXTINF:8.75875,
#EXT-X-GAP
missing-Sequence15.ts
#EXTINF:9.88487,
#EXT-X-GAP
missing-Sequence16.ts
#EXTINF:9.09242,
fileSequence17.ts
```

EXT-X-GAP: A New m3u8 Tag

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:7
#EXT-X-MEDIA-SEQUENCE:15
#EXTINF:8.75875,
#EXT-X-GAP
missing-Sequence15.ts
#EXTINF:9.88487,
#EXT-X-GAP
missing-Sequence16.ts
#EXTINF:9.09242,
fileSequence17.ts
#EXTINF:9.63462,
fileSequence18.ts
```

EXT–X–GAP Tag Semantics

Gap tag indicates that a Media Segment is missing

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- Player will not attempt to download the segment URL

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- If all variants have the same gap, silence will be played until gap ends

EXT–X–GAP Tag Semantics

Gap tag indicates that a Media Segment is missing

- Player will not attempt to download the segment URL
- Player will attempt to find another variant without a gap to play
- If all variants have the same gap, silence will be played until gap ends

See the WWDC HLS beta spec for details

Variable Support in m3u8 Playlists

NEW

Simple variable substitution in m3u8 playlists

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PHP-style syntax for variables: `{$filename}.ts`

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PHP-style syntax for variables: `{$filename}.ts`

`EXT-X-DEFINE` tag defines a variable

- Or imports it from master playlist

All variables must be defined, or playlist will not parse

Variable Support in m3u8 Playlists

NEW

Simple variable substitution in m3u8 playlists

PHP-style syntax for variables: `{$filename}.ts`

`EXT-X-DEFINE` tag defines a variable

- Or imports it from master playlist

All variables must be defined, or playlist will not parse

Allows media playlists to depend on values defined in master playlist

- Media Playlist must explicitly import each variable

Variables in Master Playlists

```
#EXTM3U

#EXT-X-DEFINE:NAME="auth",VALUE="?auth_token=/aazv/54334:pp2"

#EXT-X-STREAM-INF:BANDWIDTH=1156000,RESOLUTION=640x480,CODECS="avc1.4d001e,mp4a.40.2"
bipbop_gear1/prog_index.m3u8{$auth}
```

Variables in Media Playlists

```
#EXTM3U
#EXT-X-TARGETDURATION:6

#EXT-X-DEFINE:NAME="path",VALUE="/media/encoded/asset127-a/1MB/"
#EXT-X-DEFINE:IMPORT="auth"

#EXT-X-MEDIA-SEQUENCE:44
#EXTINF 6,
{$path}segment44.mp4{$auth}
```

See the WWDC HLS beta spec for details

Synchronized Playback of Live Streams

NEW

Playback is synchronized using shared `EXT-X-PROGRAM-DATE-TIME` tags

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Use `-[AVPlayer setRate:time:atHostTime:]` to start second player in sync

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NEW

Playback is synchronized using shared `EXT-X-PROGRAM-DATE-TIME` tags

Use `-[AVPlayer setRate:time:atHostTime:]` to start second player in sync

- Sample code available, "SyncStartTV"

Demo

Synchronized live stream playback

Resolution Cap: preferredMaximumResolution

NEW

Companion to existing bandwidth cap (`preferredPeakBitRate`)

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Companion to existing bandwidth cap (`preferredPeakBitRate`)

Programmatically specify the maximum desired content resolution

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Useful for video thumbnails and multi-stream presentations

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Companion to existing bandwidth cap (`preferredPeakBitRate`)

Programmatically specify the maximum desired content resolution

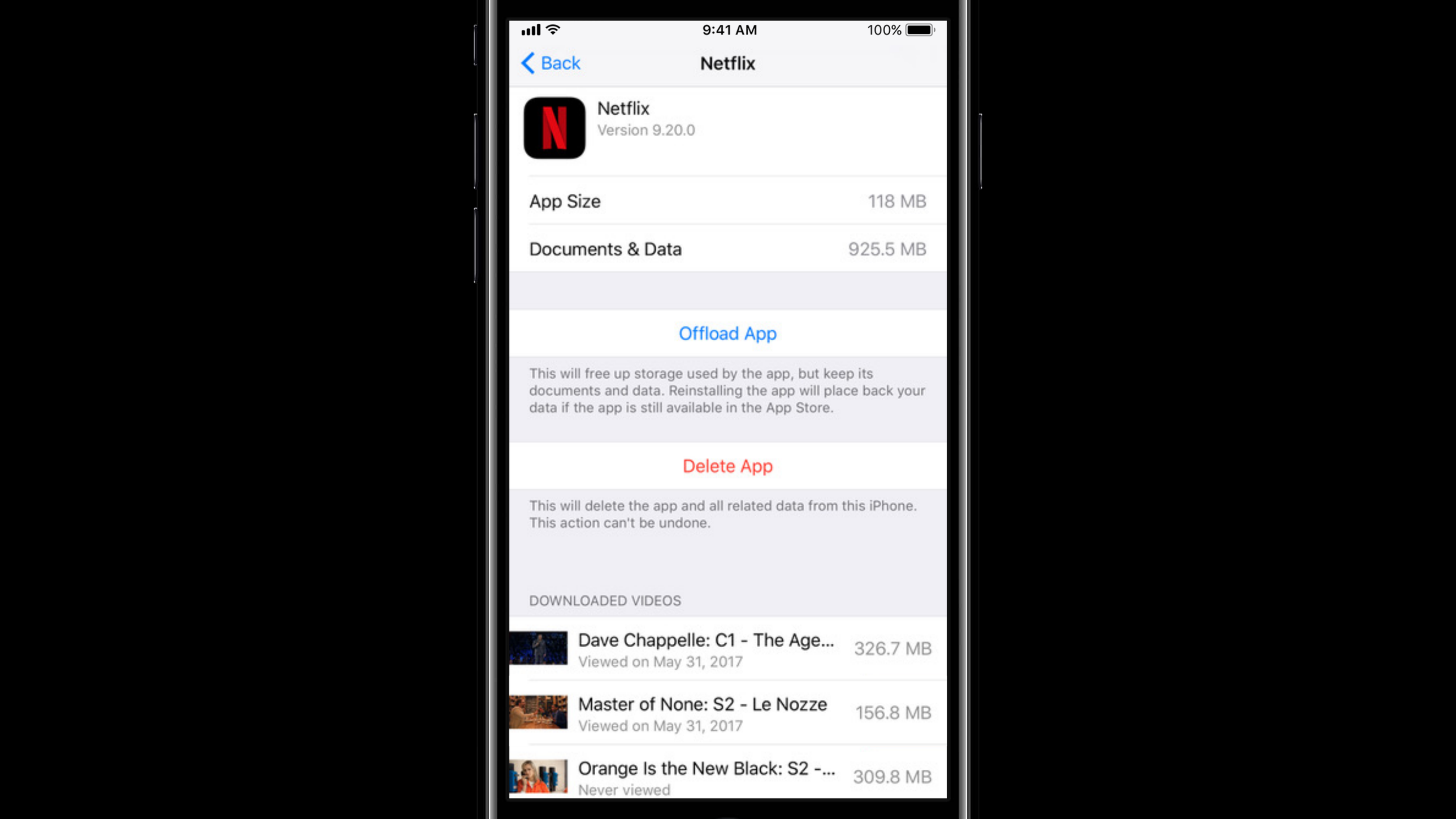
Useful for video thumbnails and multi-stream presentations

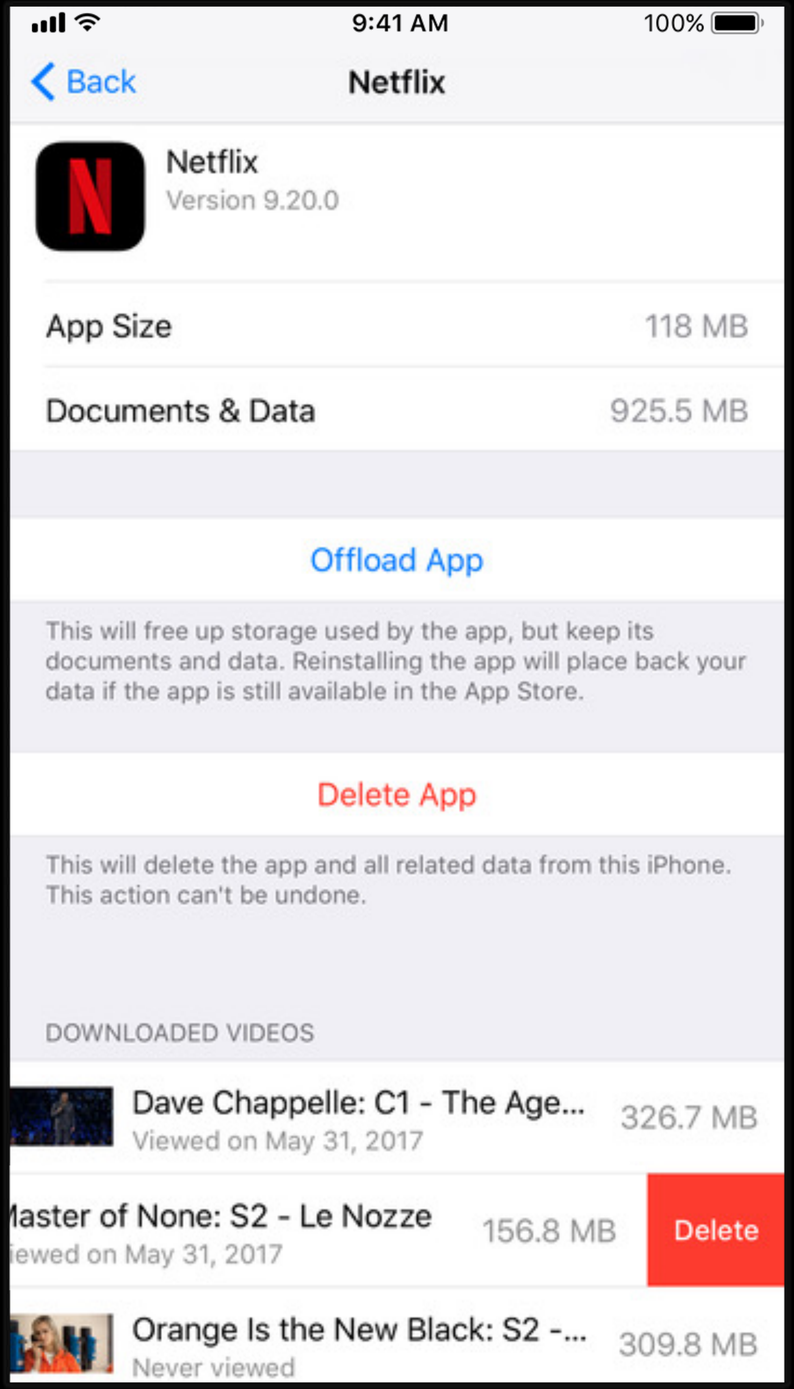
If there is no playable variant below the resolution cap, the lowest-resolution variant is chosen

Resolution Cap Example

```
func configureMyPlayerItem(item: AVPlayerItem) {
    item.preferredMaximumResolution = CGSize(height: 640, width: 480)
    . . .
}
```

HLS Offline Storage Management


9:41 AM
100%
Back
Netflix
Netflix
Version 9.20.0
App Size
118 MB
Documents & Data
925.5 MB
Offload App
This will free up storage used by the app, but keep its documents and data. Reinstalling the app will place back your data if the app is still available in the App Store.
Delete App
This will delete the app and all related data from this iPhone. This action can't be undone.
DOWNLOADED VIDEOS
Dave Chappelle: C1 - The Age...
Viewed on May 31, 2017
326.7 MB
Master of None: S2 - Le Nozze
Viewed on May 31, 2017
156.8 MB
Orange Is the New Black: S2 -...
Never viewed
309.8 MB


9:41 AM
100%
Back
Netflix
Netflix
Version 9.20.0
App Size
118 MB
Documents & Data
925.5 MB
Offload App
This will free up storage used by the app, but keep its documents and data. Reinstalling the app will place back your data if the app is still available in the App Store.
Delete App
This will delete the app and all related data from this iPhone. This action can't be undone.
DOWNLOADED VIDEOS
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HLS Offline Storage Management

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The OS can delete offline assets while the app is not running

- Via Settings, or when space is required for a software update

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`AVAssetDownloadStorageManager`

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`AVAssetDownloadStorageManager`

Sets the policy for automatic purging of downloaded AVAssets

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`AVAssetDownloadStorageManager`

Sets the policy for automatic purging of downloaded AVAssets

- `AVAssetDownloadStorageManagementPolicy` has two properties:

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`AVAssetDownloadStorageManager`

Sets the policy for automatic purging of downloaded AVAssets

- `AVAssetDownloadStorageManagementPolicy` has two properties:
  - Expiration date

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`AVAssetDownloadStorageManager`

Sets the policy for automatic purging of downloaded AVAssets

- `AVAssetDownloadStorageManagementPolicy` has two properties:
  - Expiration date
  - Priority (important, default)

```
// AVAssetDownloadStorageManager

// Get the singleton
let storageManager = AVAssetDownloadStorageManager.shared()
```

```
// AVAssetDownloadStorageManager

// Get the singleton
let storageManager = AVAssetDownloadStorageManager.shared()

// Set the policy
let newPolicy = AVMutableAssetDownloadStorageManagementPolicy()
newPolicy.expirationDate = myExpiryDate
newPolicy.priority = .important
storageManager.setStorageManagementPolicy(newPolicy, forURL: myDownloadStorageURL)
```

```
// AVAssetDownloadStorageManager

// Get the singleton
let storageManager = AVAssetDownloadStorageManager.shared()

// Set the policy
let newPolicy = AVMutableAssetDownloadStorageManagementPolicy()
newPolicy.expirationDate = myExpiryDate
newPolicy.priority = .important
storageManager.setStorageManagementPolicy(newPolicy, forURL: myDownloadStorageURL)

// Get the policy
let currentPolicy = storageManager.storageManagementPolicy(forURL: myDownloadStorageURL)
```

Batching up Your Offline Downloads

NEW

`AVAggregateAssetDownloadTask`

- Specify multiple media selections prior to initiating download

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NEW

`AVAggregateAssetDownloadTask`

- Specify multiple media selections prior to initiating download

```
let task = myDownloadSession.aggregateAssetDownloadTask(with: AVURLAsset,
    mediaSelections: AVMediaSelection[],
    assetTitle: String,
    assetArtworkData: Data?,
    options: [String:Any]?)
```

Key Management Enhancements

FairPlay Streaming

FairPlay Streaming

FairPlay Streaming introduced in 2015

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Protects HLS content

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Protects HLS content

Enhancements to

- Simplify workflow

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Protects HLS content

Enhancements to

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- Scale adoption

FairPlay Streaming

FairPlay Streaming introduced in 2015

Protects HLS content

Enhancements to

- Simplify workflow
- Scale adoption
- Support new features

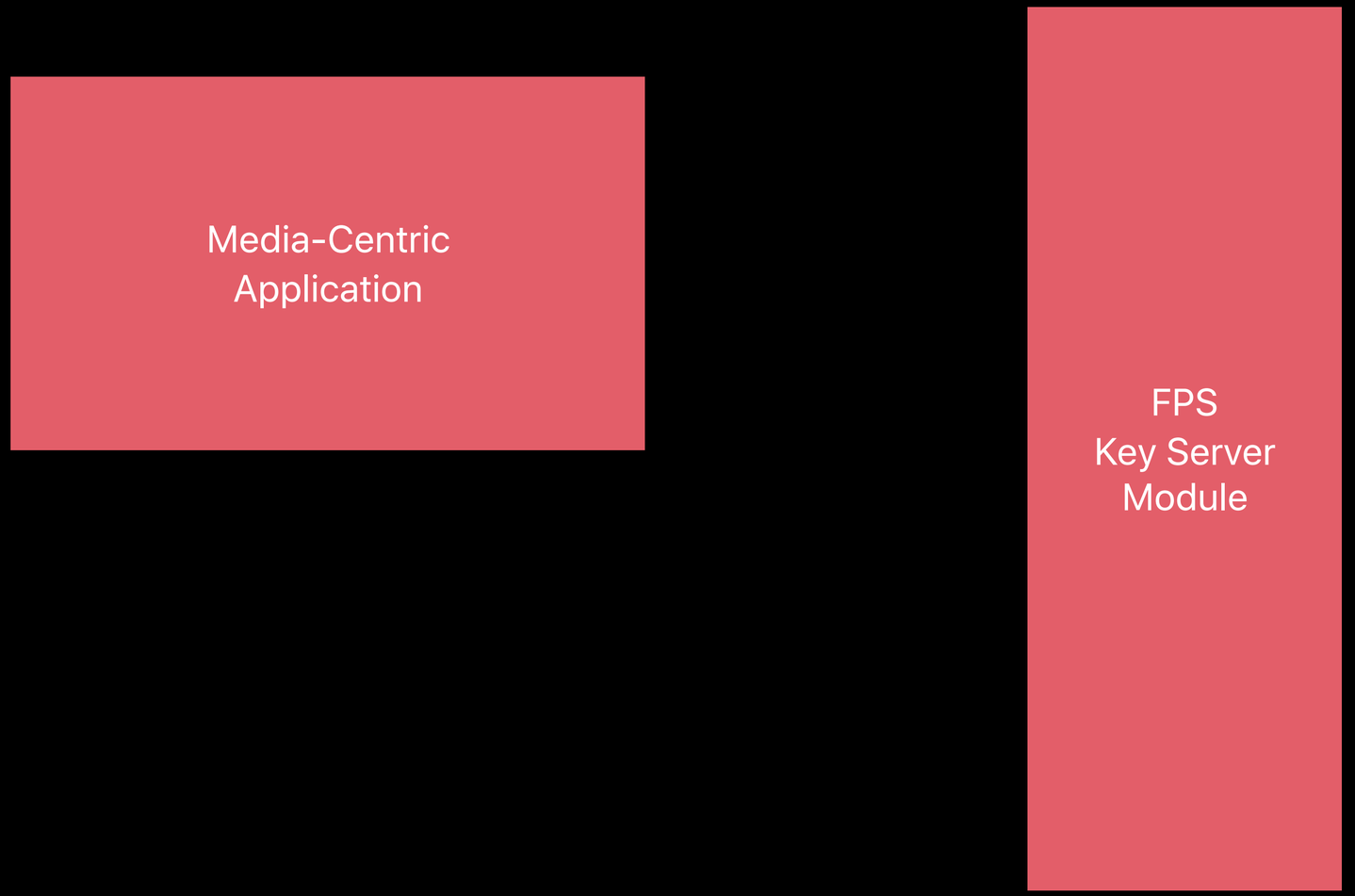
FairPlay Streaming Overview

FairPlay Streaming Overview

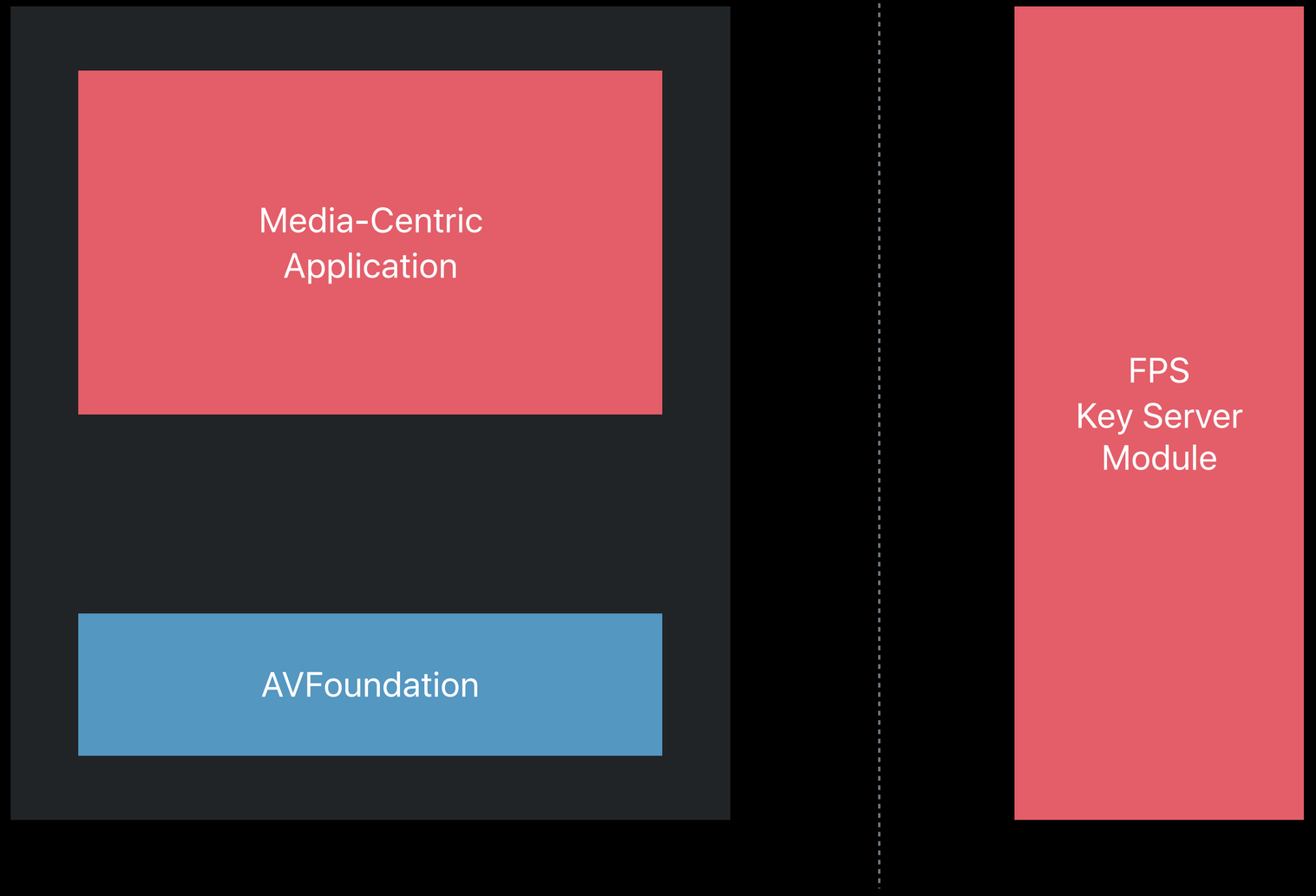
Securely deliver Content Decryption Keys

FairPlay Streaming Overview

FairPlay Streaming Overview

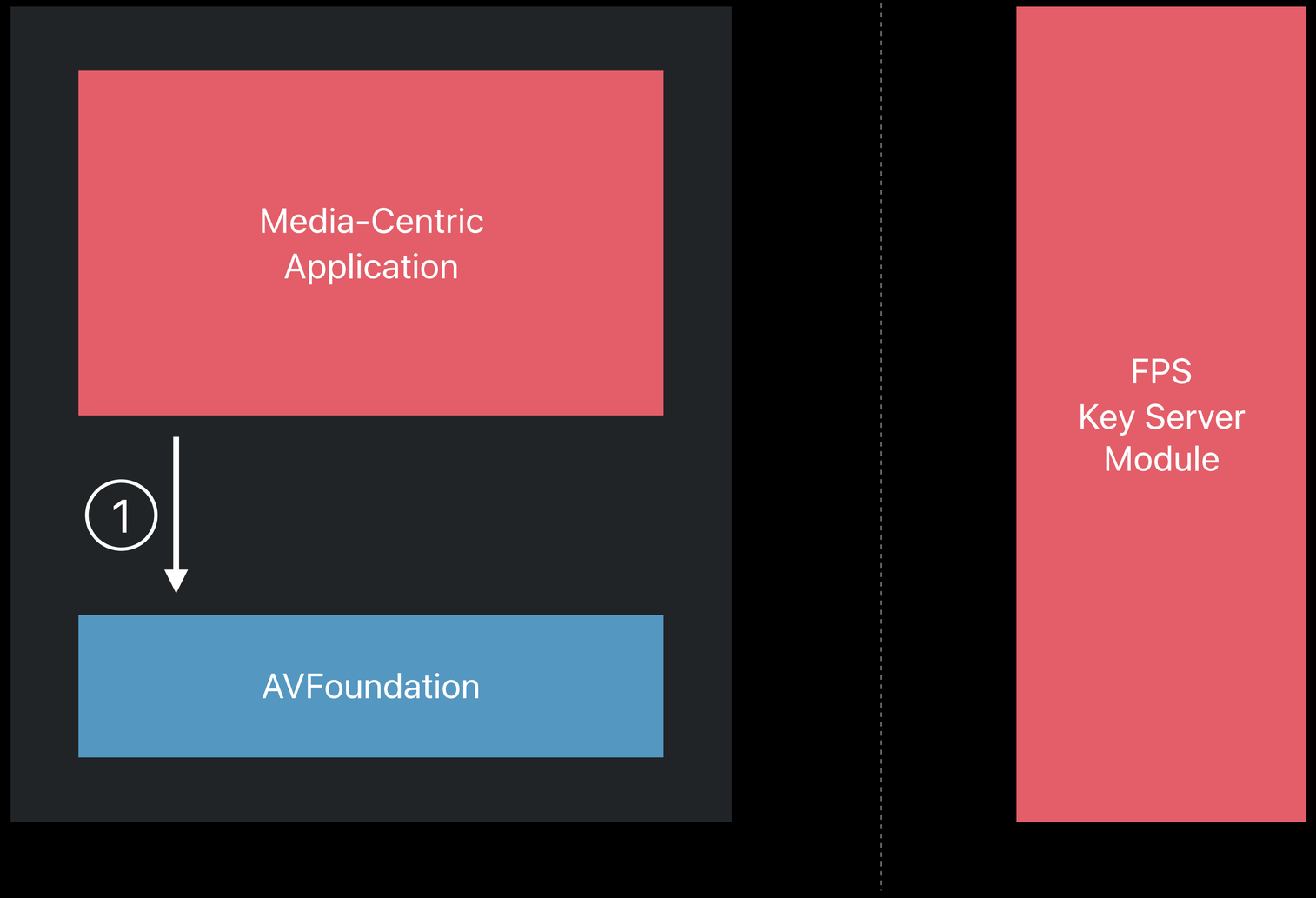


FairPlay Streaming Overview



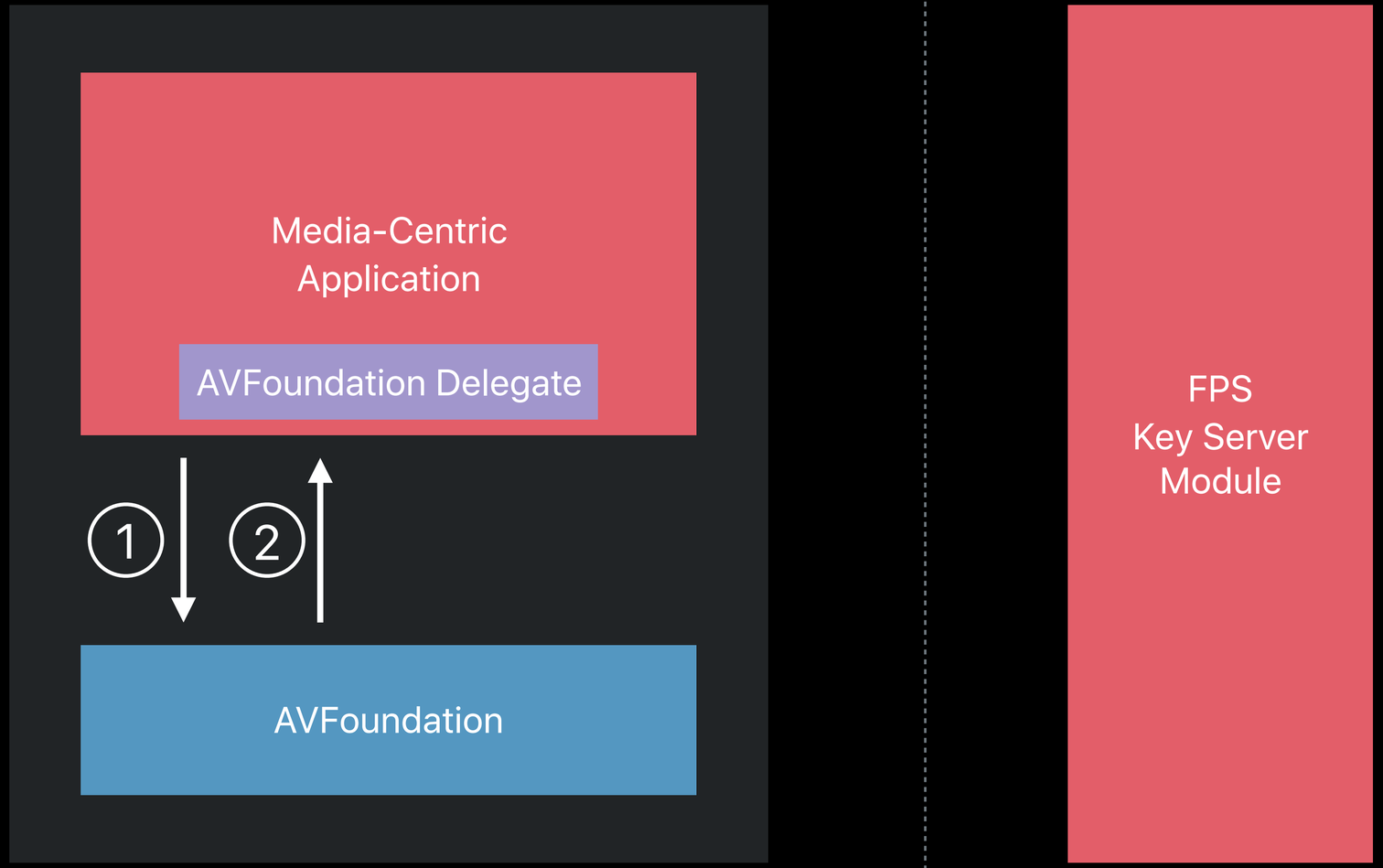
FairPlay Streaming Overview

1. Request Playback



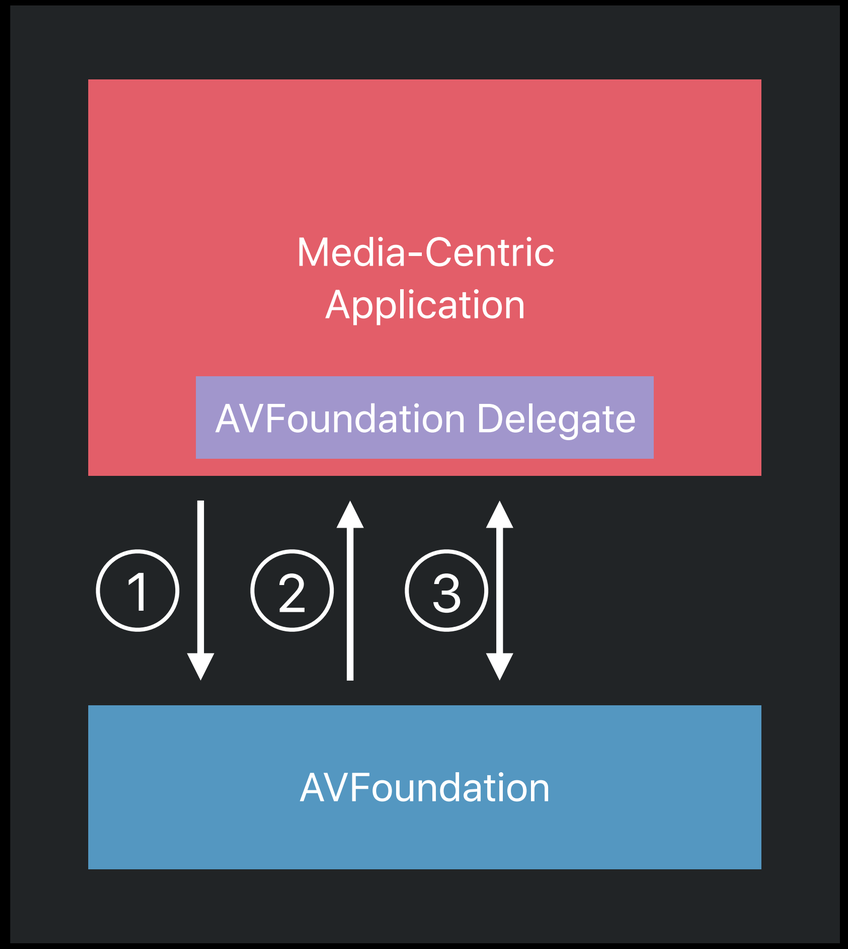
FairPlay Streaming Overview

1. Request Playback
2. Request key



FairPlay Streaming Overview

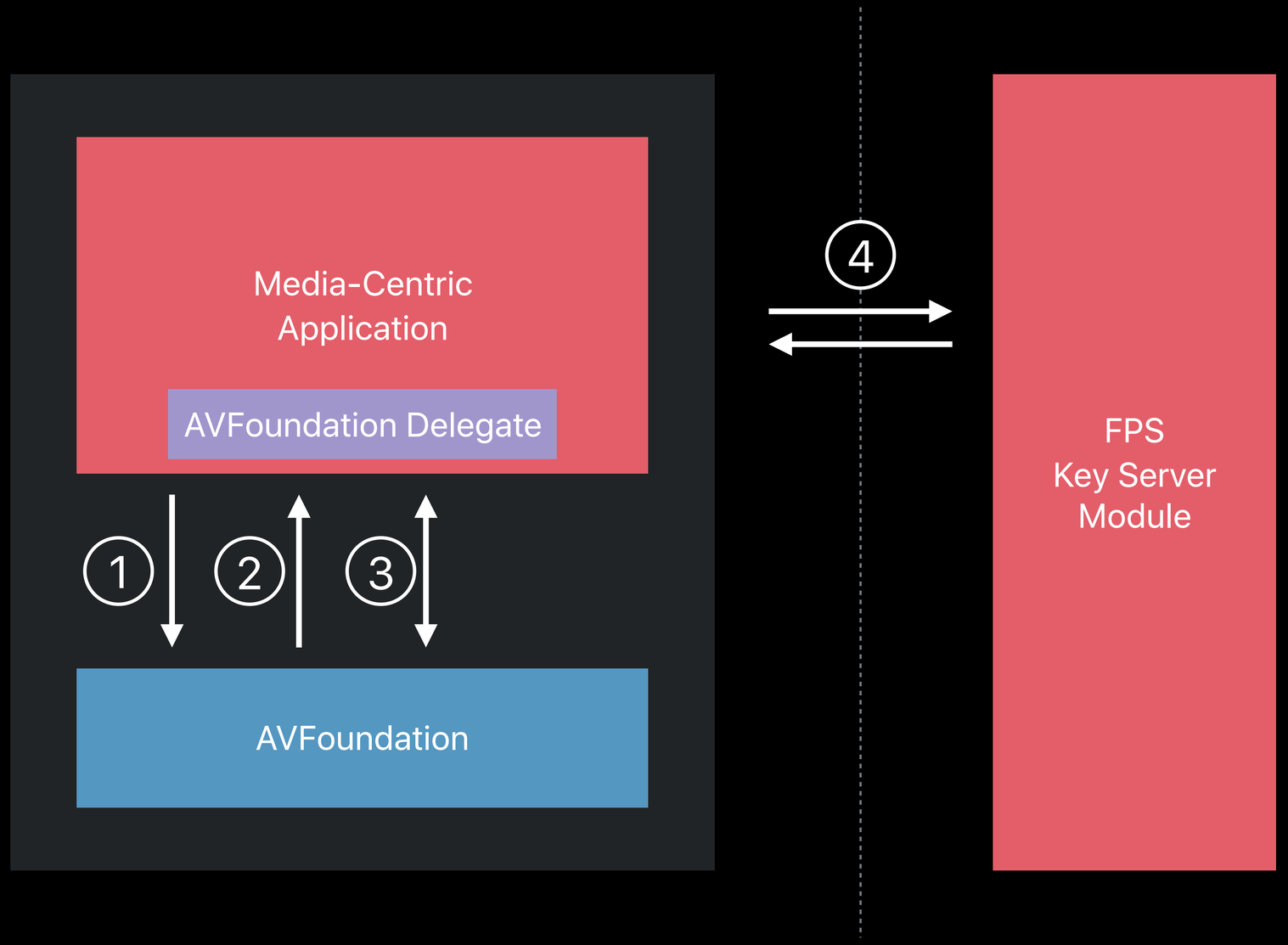
1. Request Playback
2. Request key
3. Create SPC



FPS
Key Server
Module

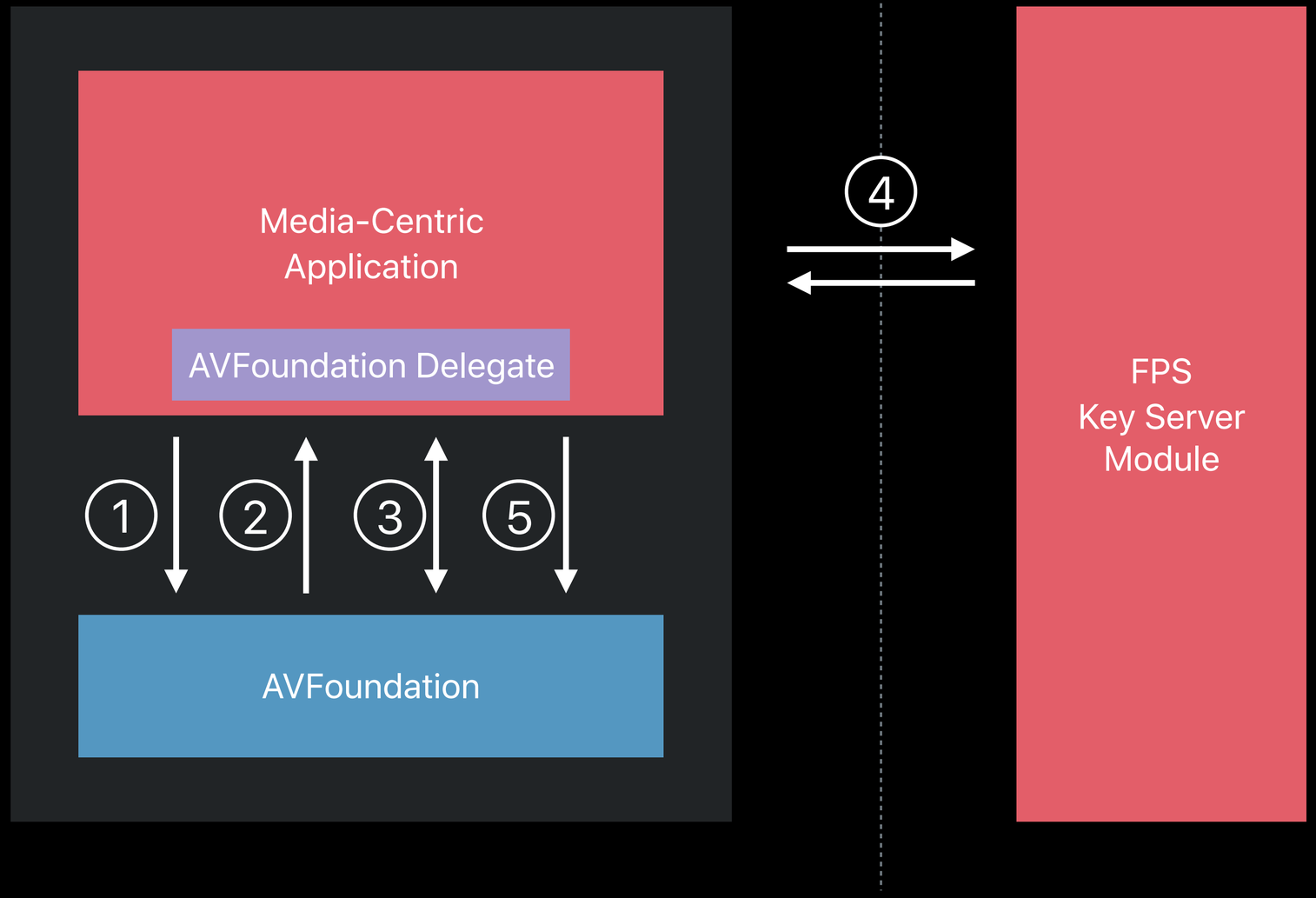
FairPlay Streaming Overview

1. Request Playback
2. Request key
3. Create SPC
4. Send SPC; Get CKC

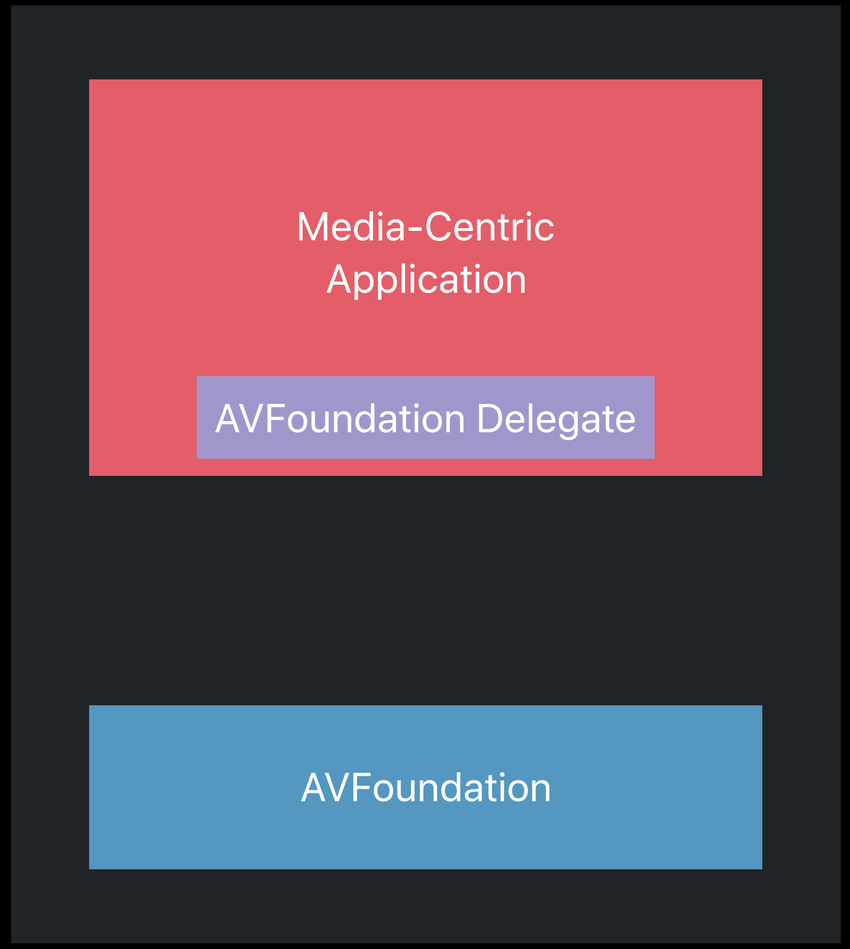


FairPlay Streaming Overview

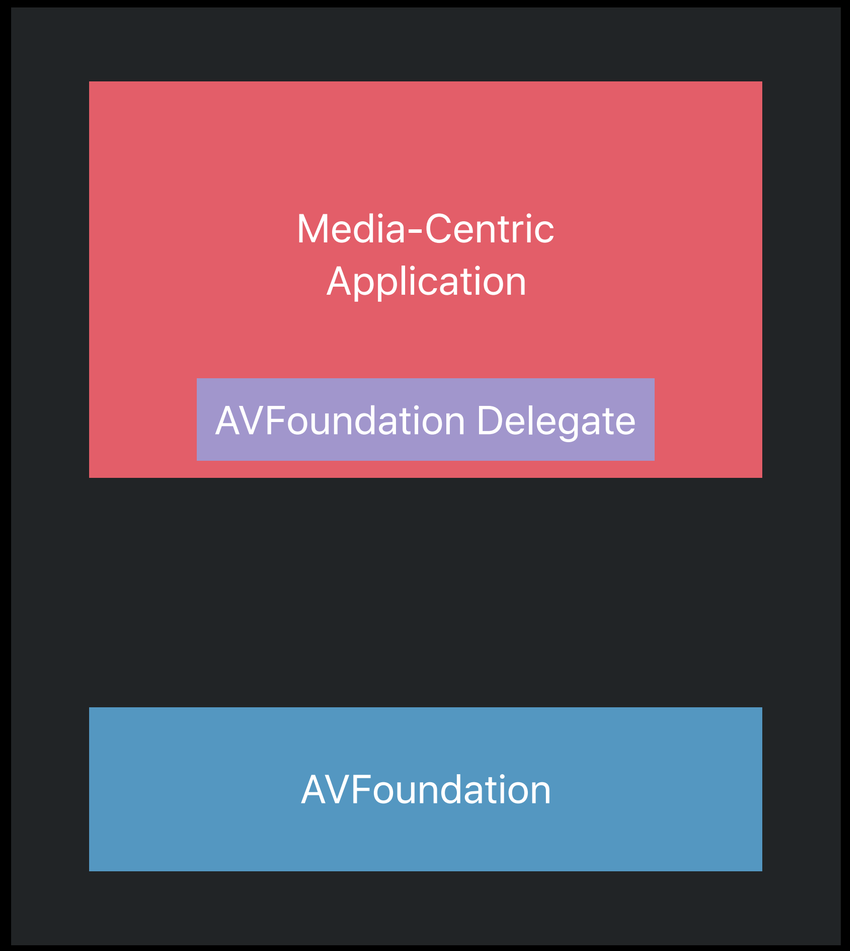
1. Request Playback
2. Request key
3. Create SPC
4. Send SPC; Get CKC
5. Respond with CKC

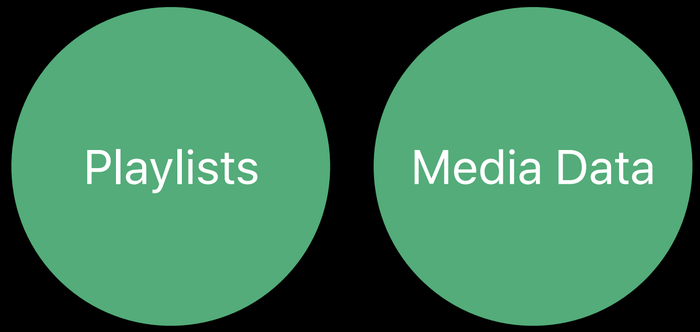


FairPlay Streaming Keys

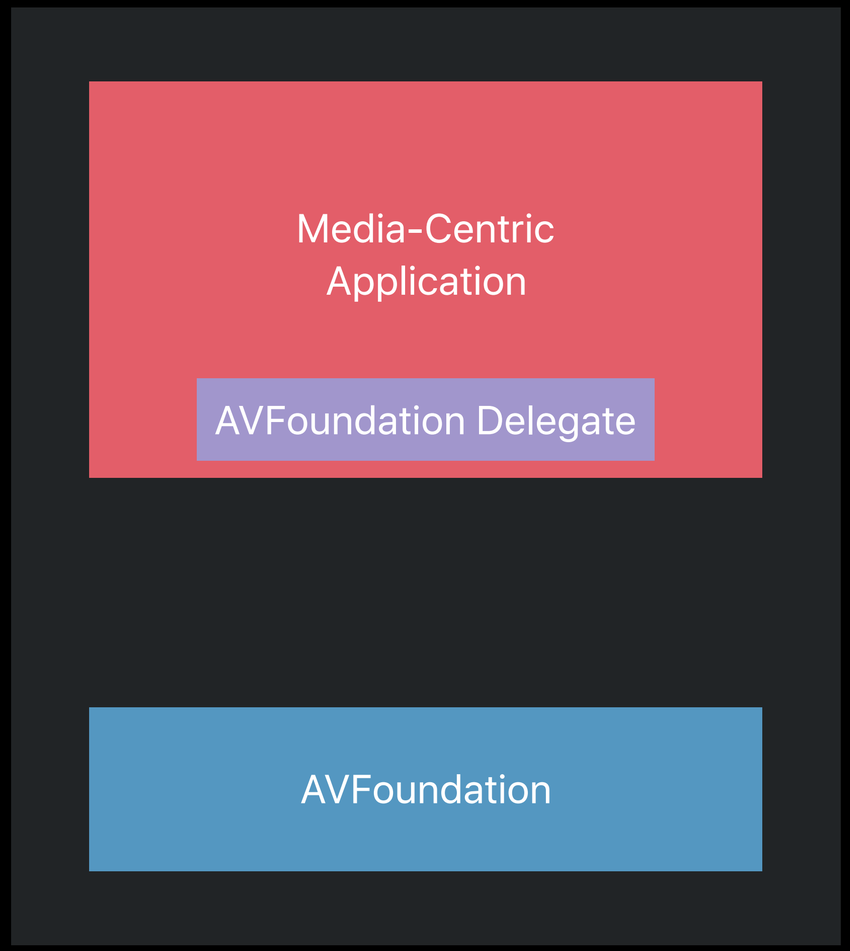


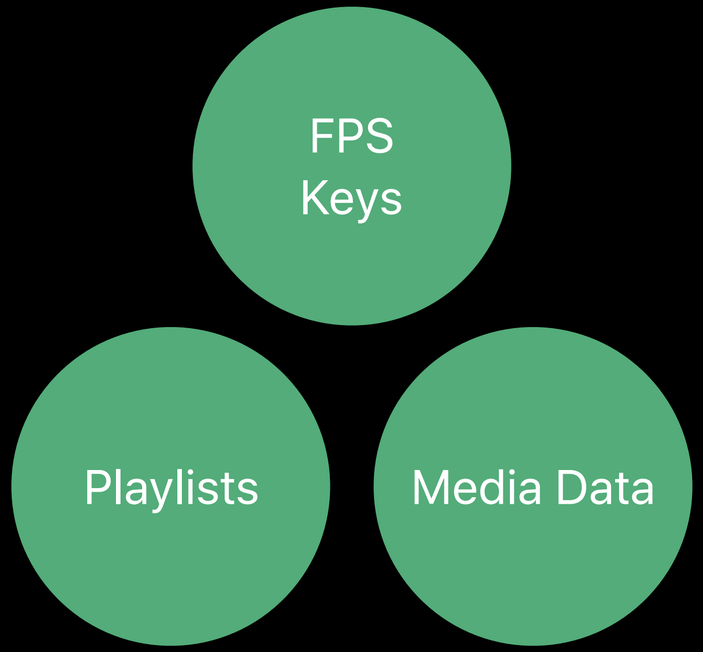
FairPlay Streaming Keys





FairPlay Streaming Keys





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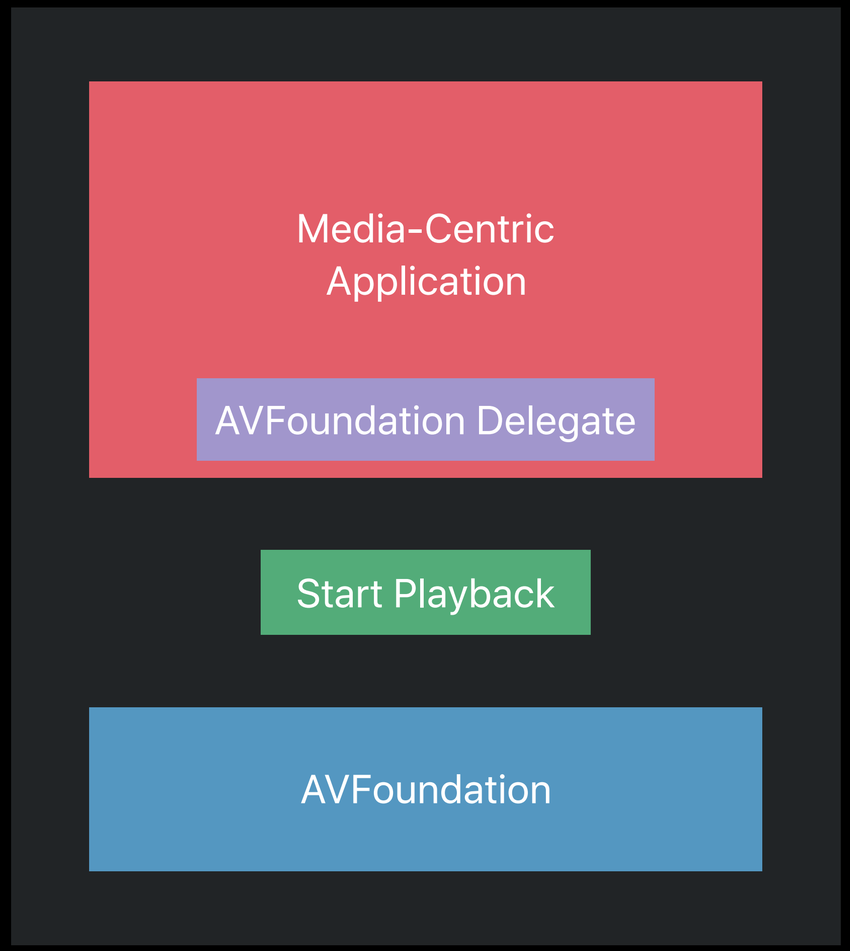
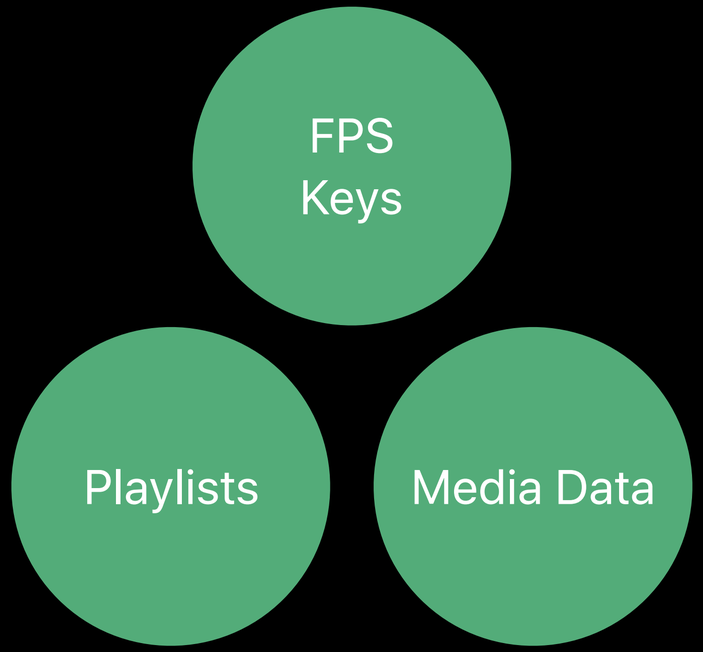
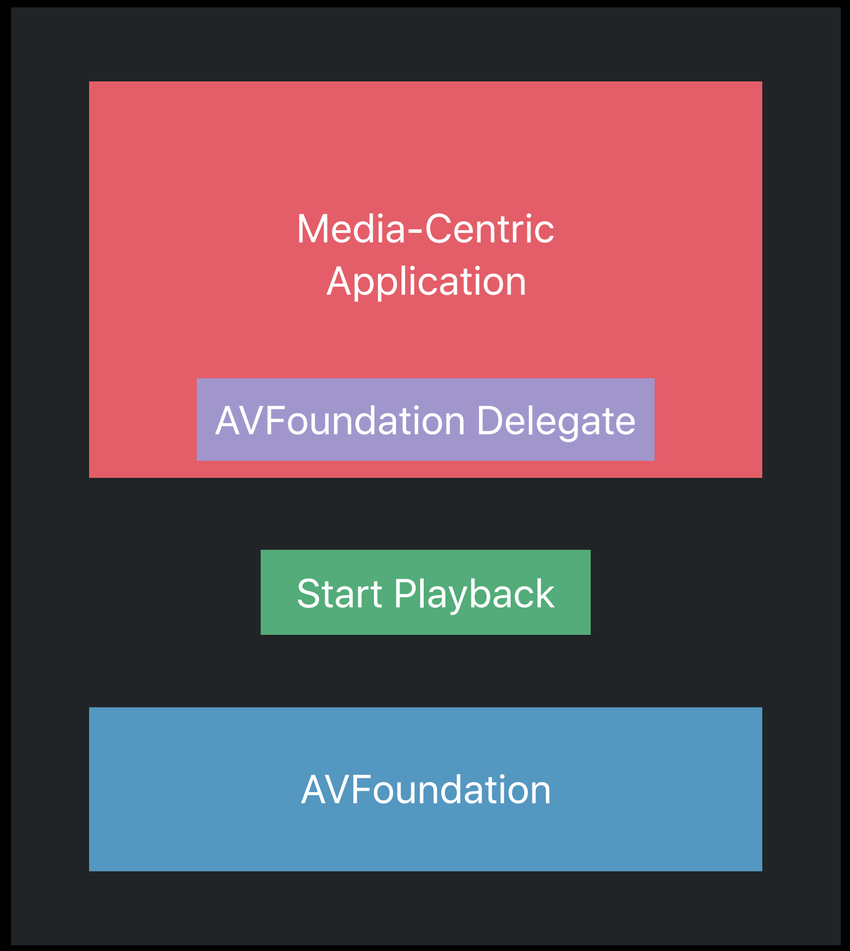
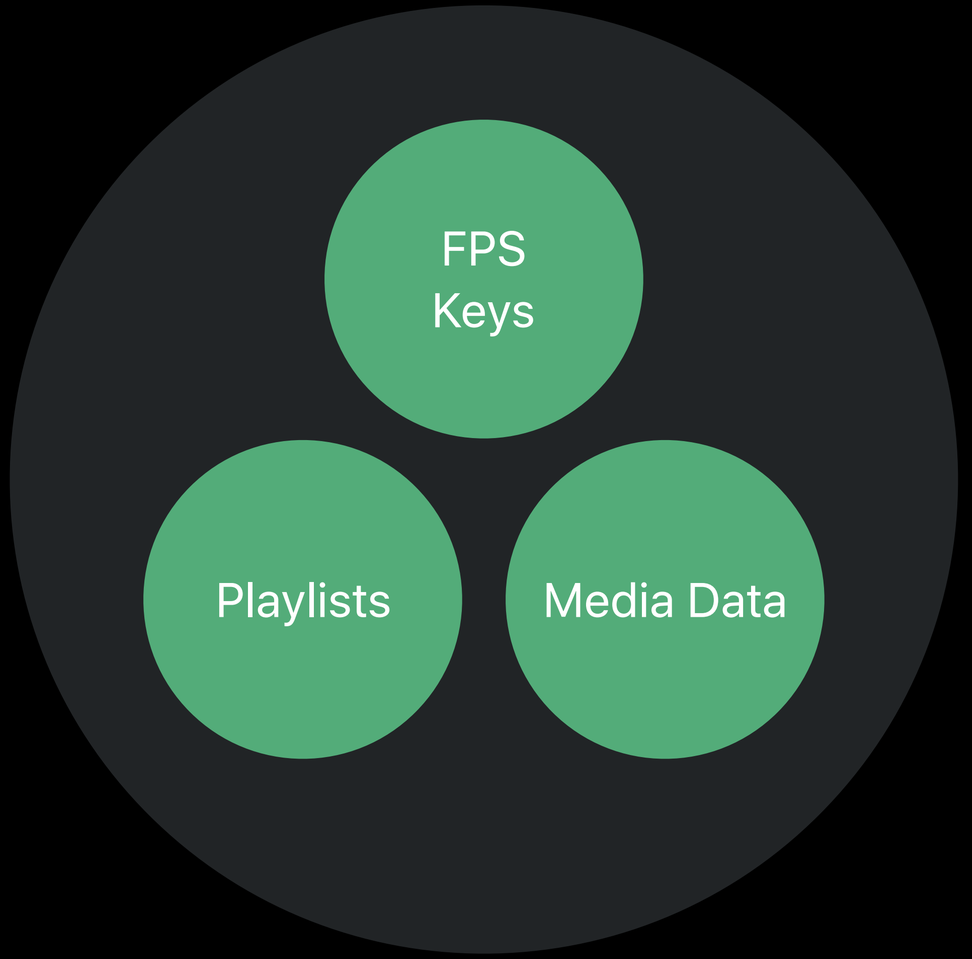


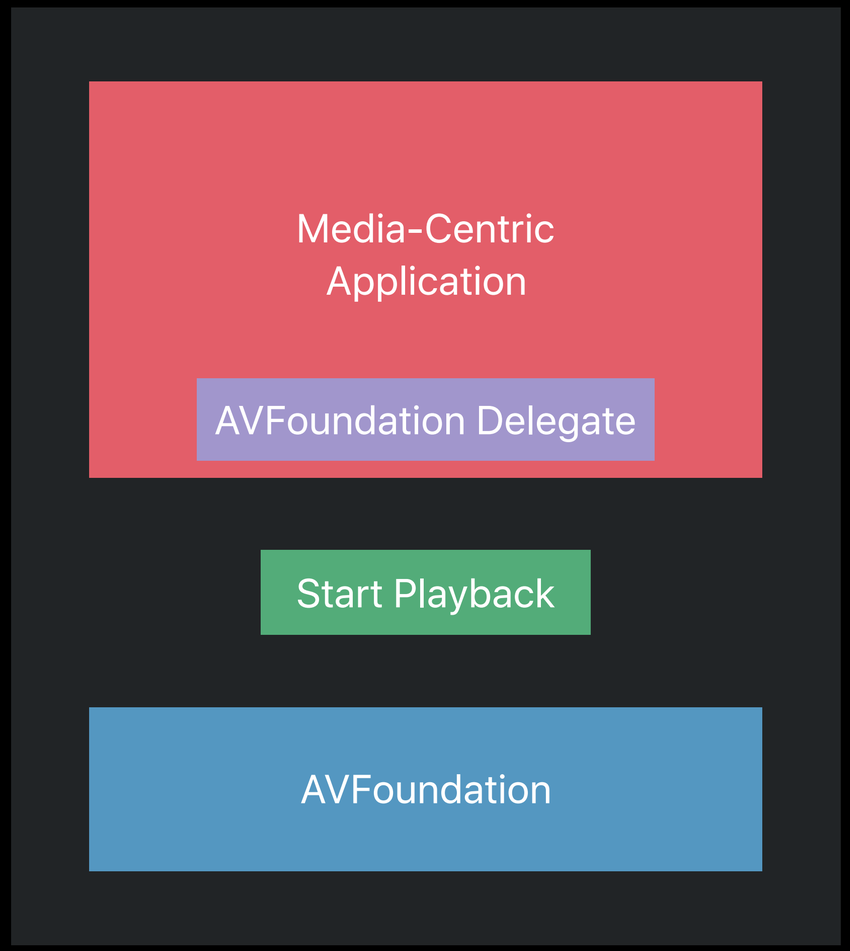


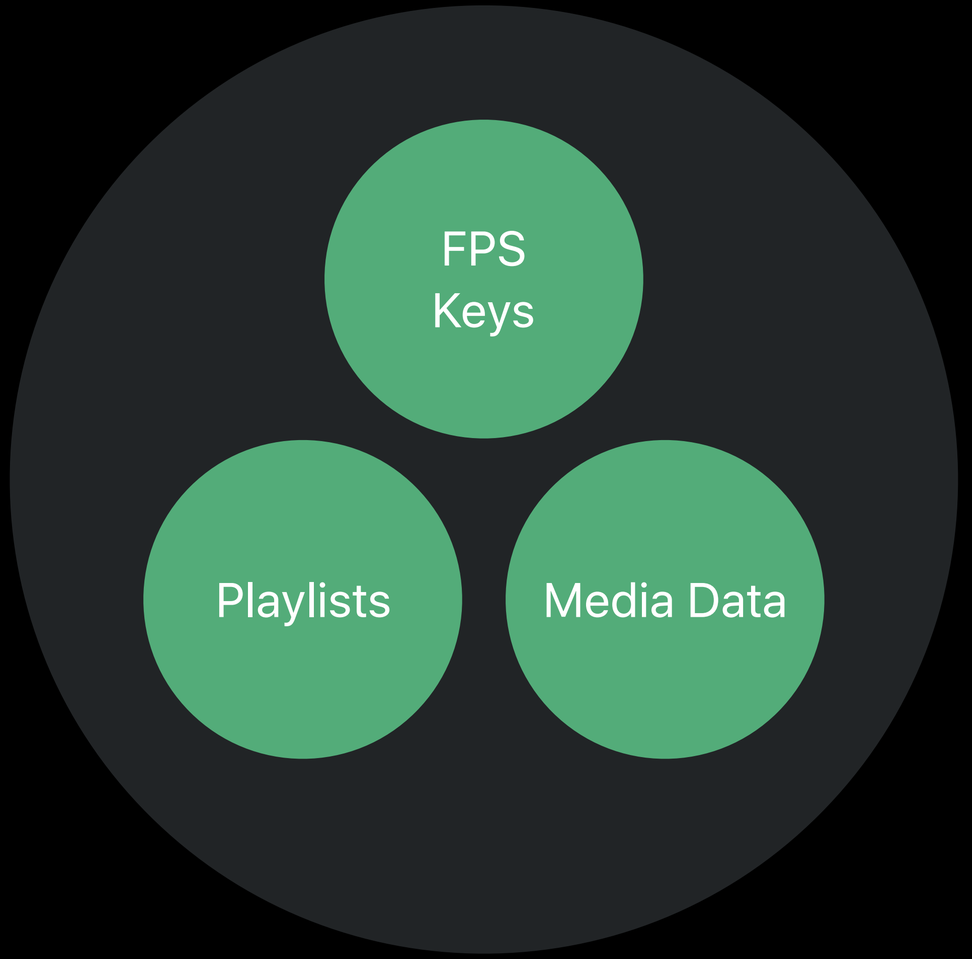
FairPlay Streaming Keys





FairPlay Streaming Keys





`AVAssetResourceLoader`

FairPlay Streaming Keys

NEW

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FPS keys are more specialized resources

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- Freeze dry for future use (offline playback)

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New API to manage and deliver decryption keys

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FPS keys can be loaded independently of assets

New API to manage and deliver decryption keys

`AVContentKeySession`

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AVFoundation class for decryption keys

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Two ways key loading process is triggered:

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Two ways key loading process is triggered:

Application

Using
`AVContentKeySession`

AVContentKeySession

AVFoundation class for decryption keys

- Decouples key loading from media loading or playback
- Better control over lifecycle of keys

Allows you to load keys at any time

Two ways key loading process is triggered:

Application

Using `AVContentKeySession`

AVFoundation

After playback starts
(content is encrypted)

Improve Playback Startup

Improve Playback Startup

Key load time can significantly impact startup

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Key load time can significantly impact startup

Keys are normally loaded on-demand

Improve Playback Startup

Key load time can significantly impact startup

Keys are normally loaded on-demand

Use `AVContentKeySession` to

- Predictively load keys before requesting playback (key preloading)

Scale Live Playback

Scale Live Playback

Huge growth in live content

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Huge growth in live content

Extra protection with key rotation and lease renewal

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Extra protection with key rotation and lease renewal

Impulse load on key server

Scale Live Playback

Huge growth in live content

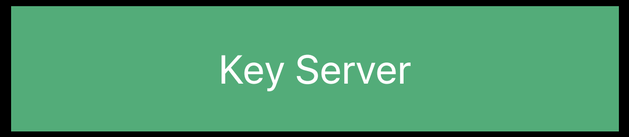
Extra protection with key rotation and lease renewal

Impulse load on key server

Use `AVContentKeySession` to

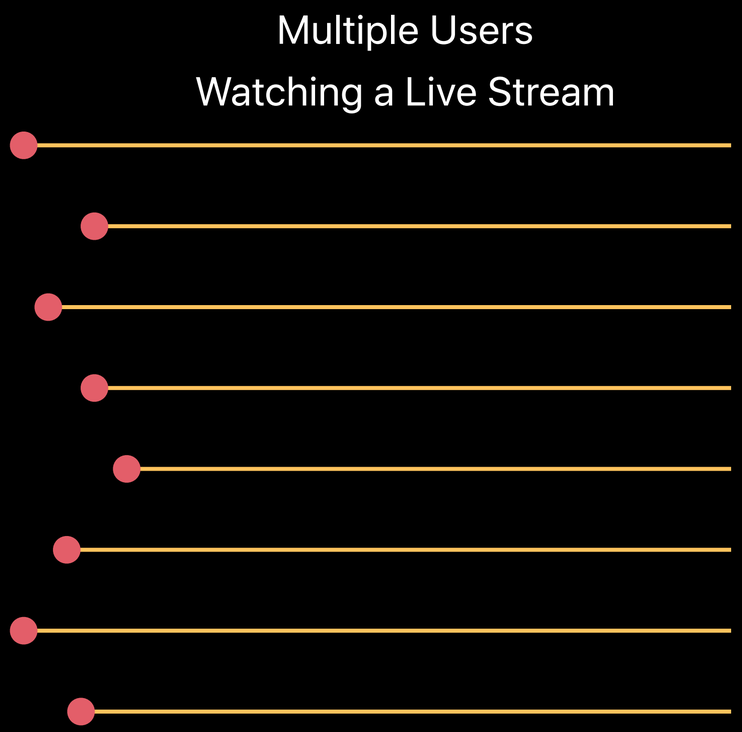
- Load balance key requests at the point of origin

Scale Live Playback



Scale Live Playback

Key Server



Scale Live Playback

Key Server

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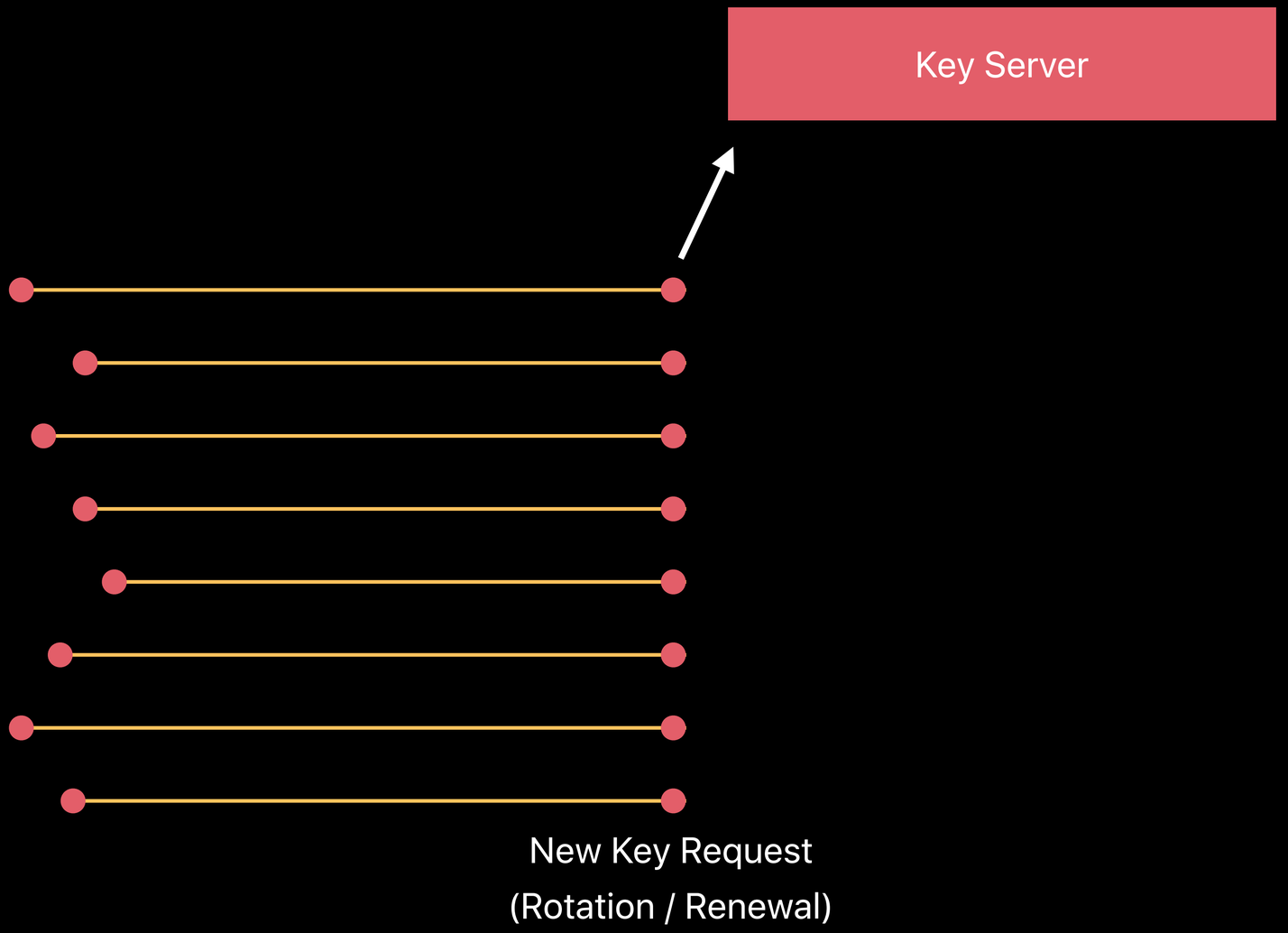

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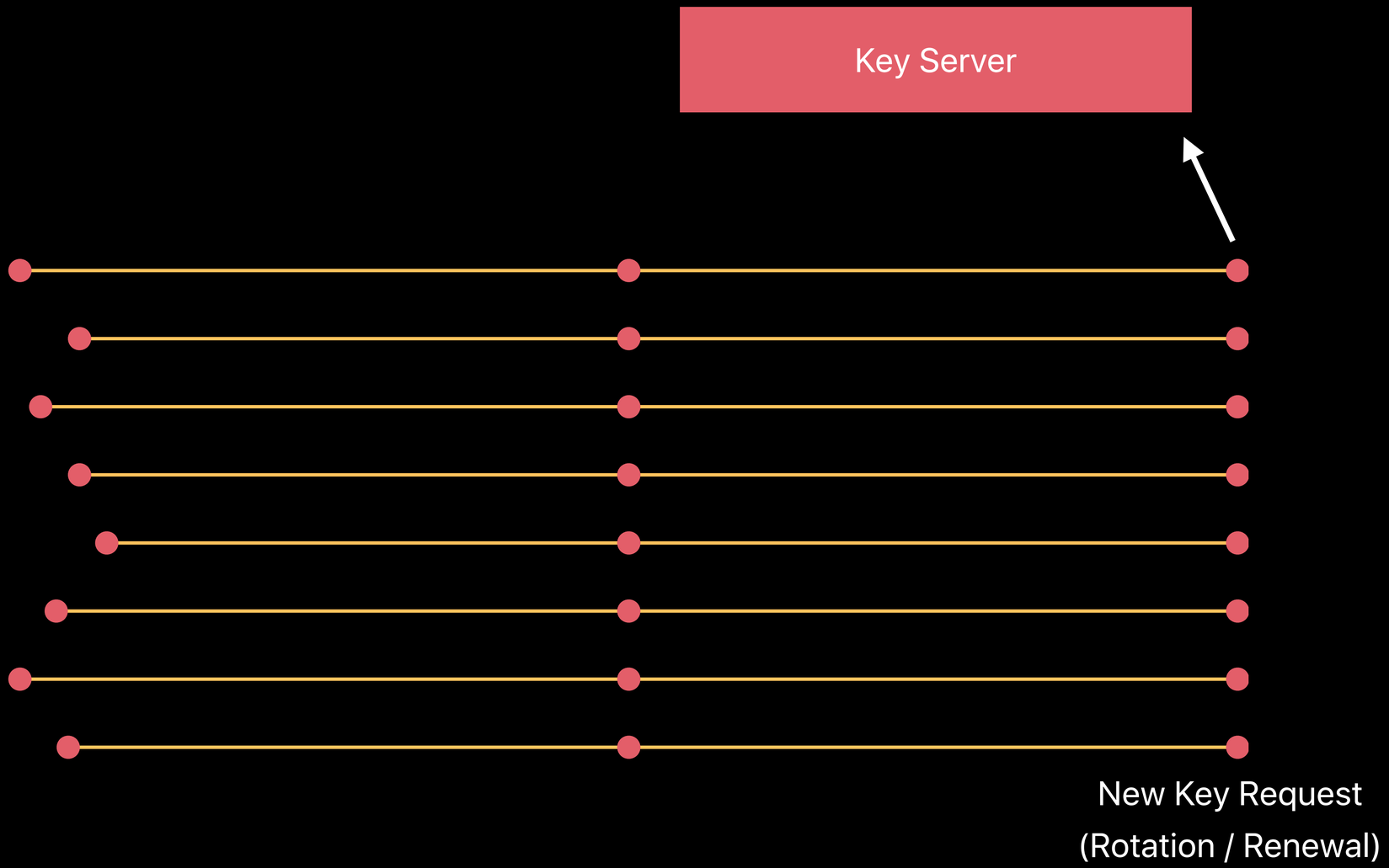

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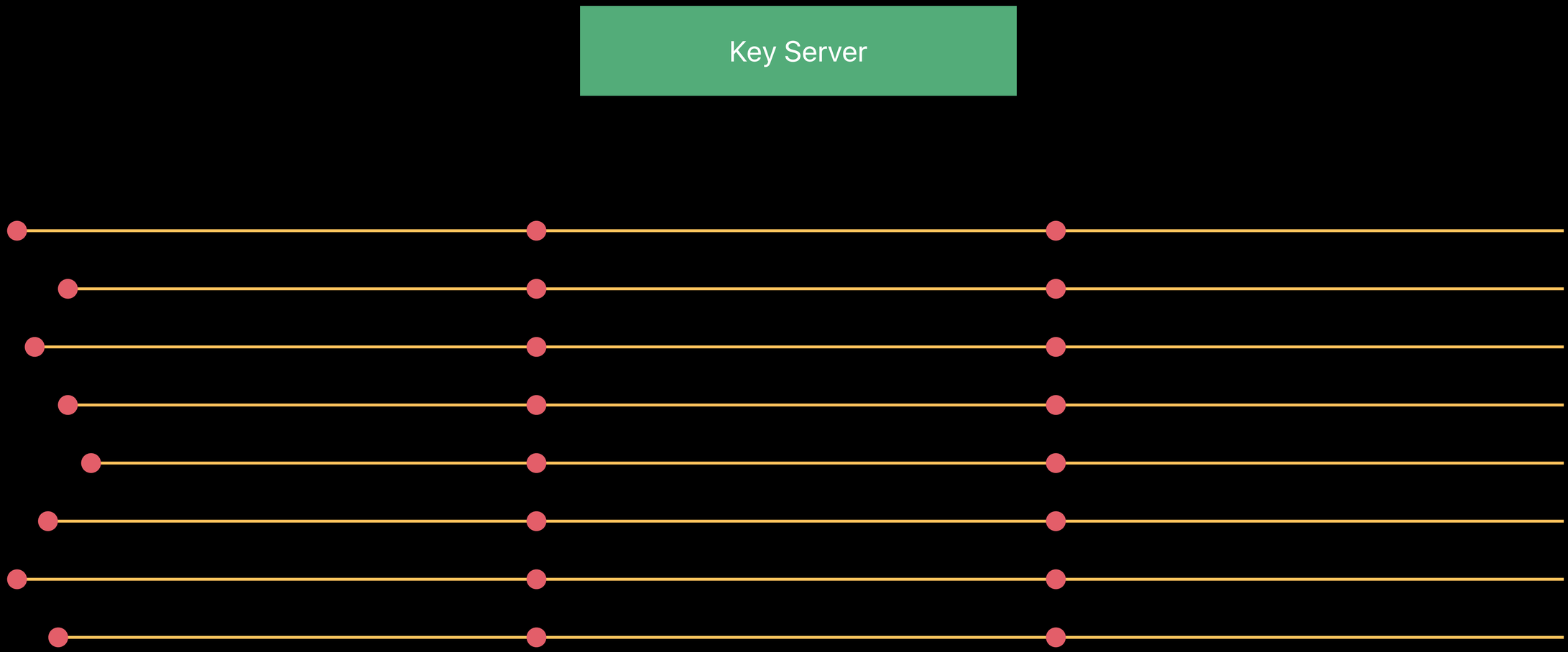

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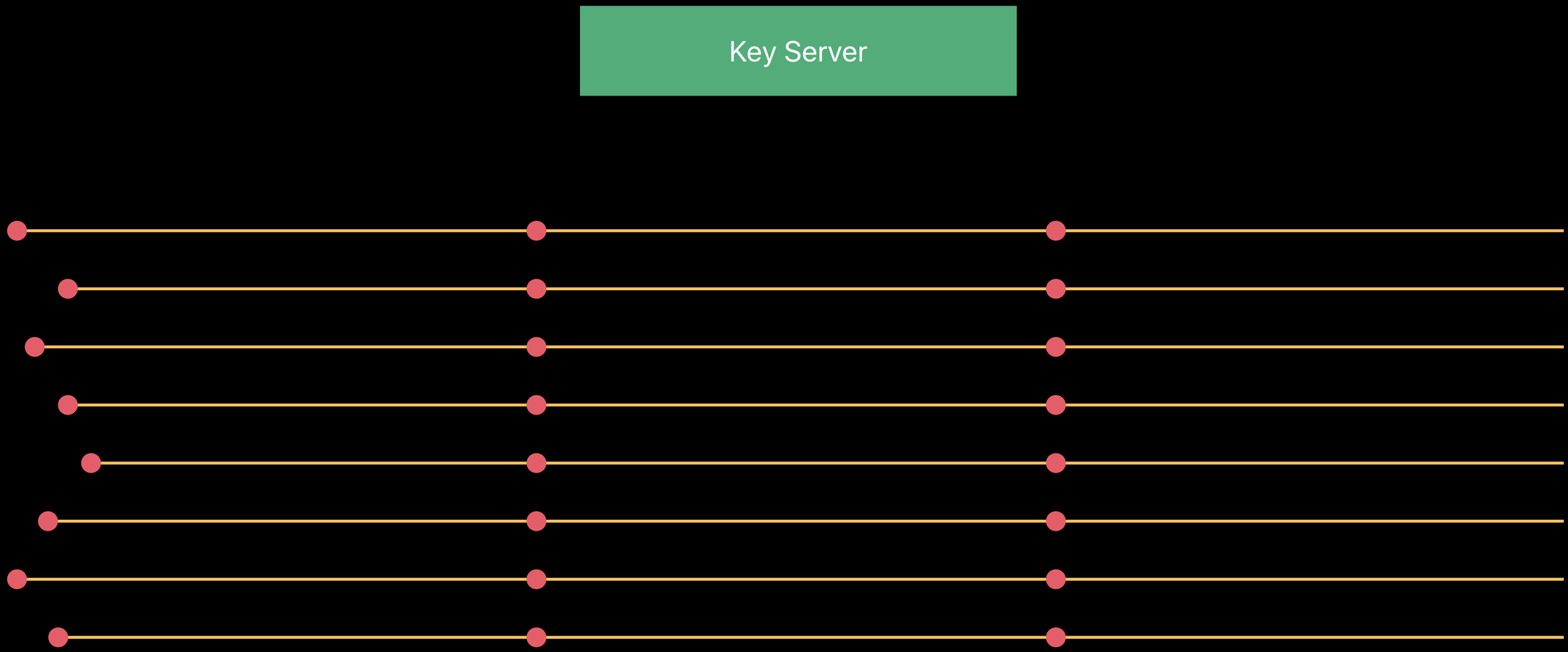

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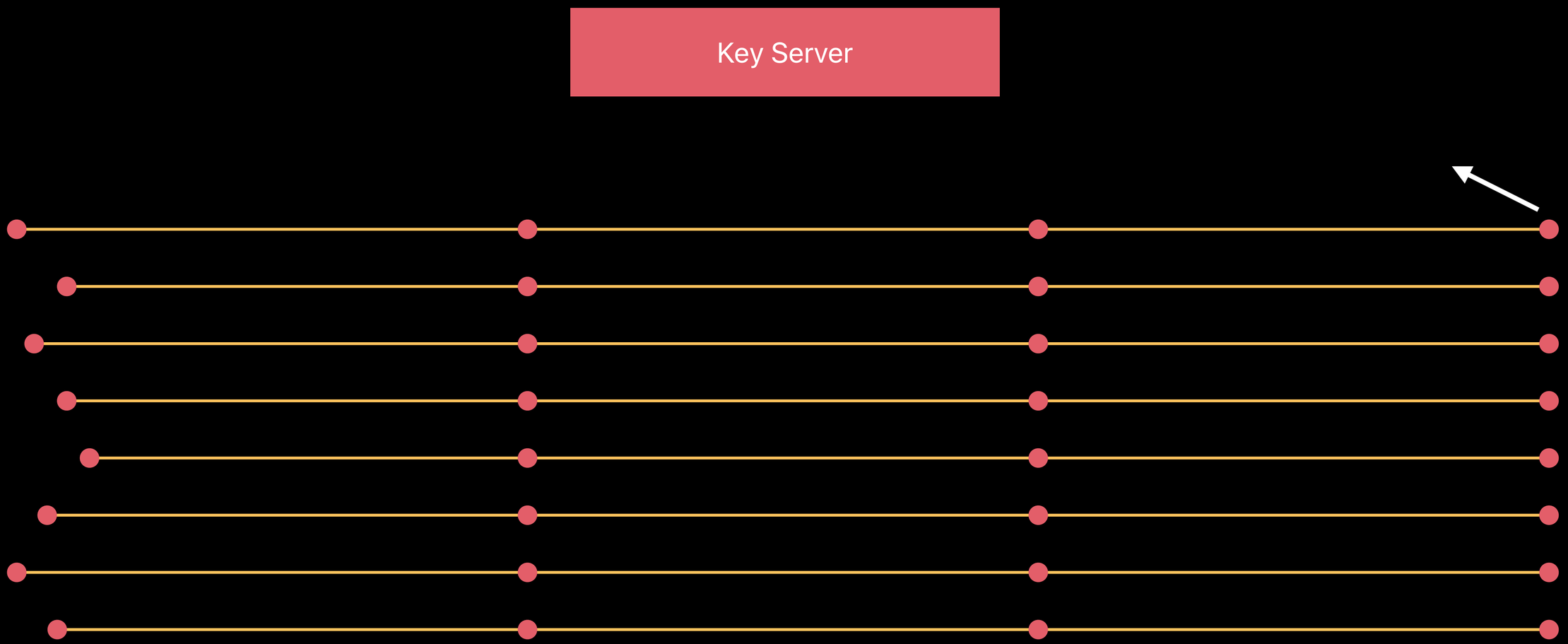

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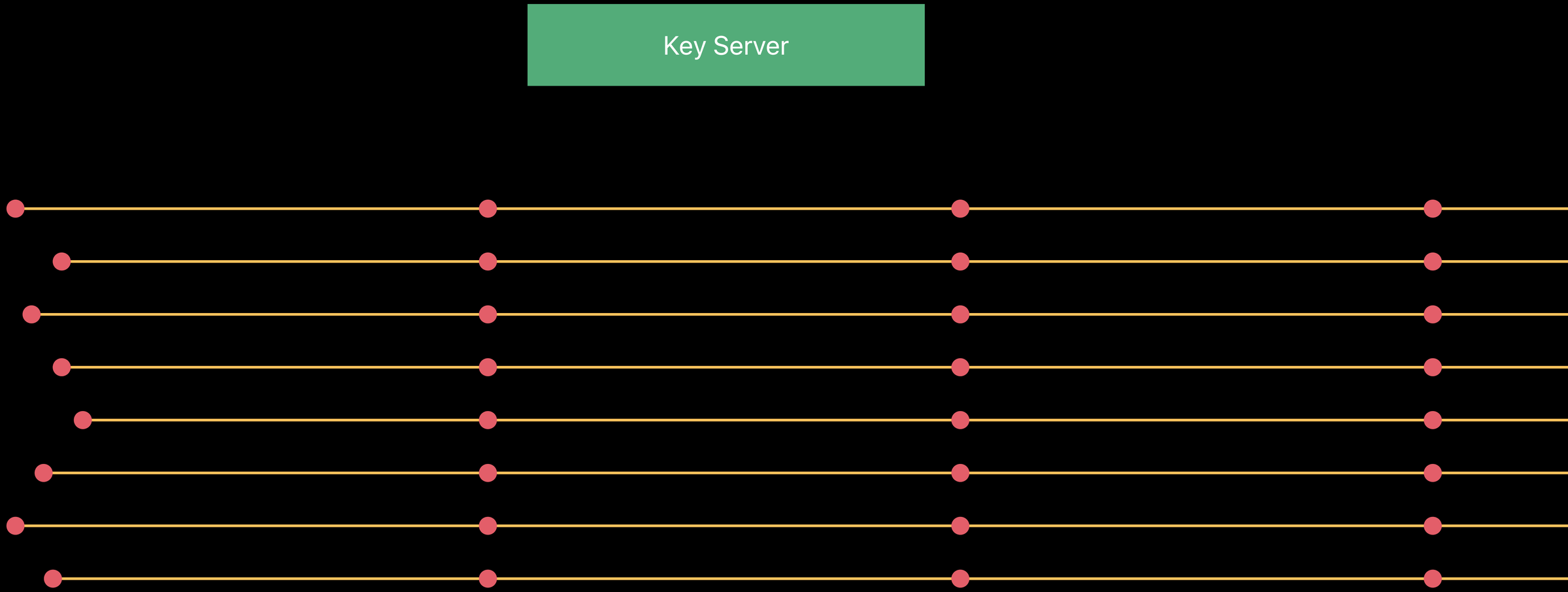

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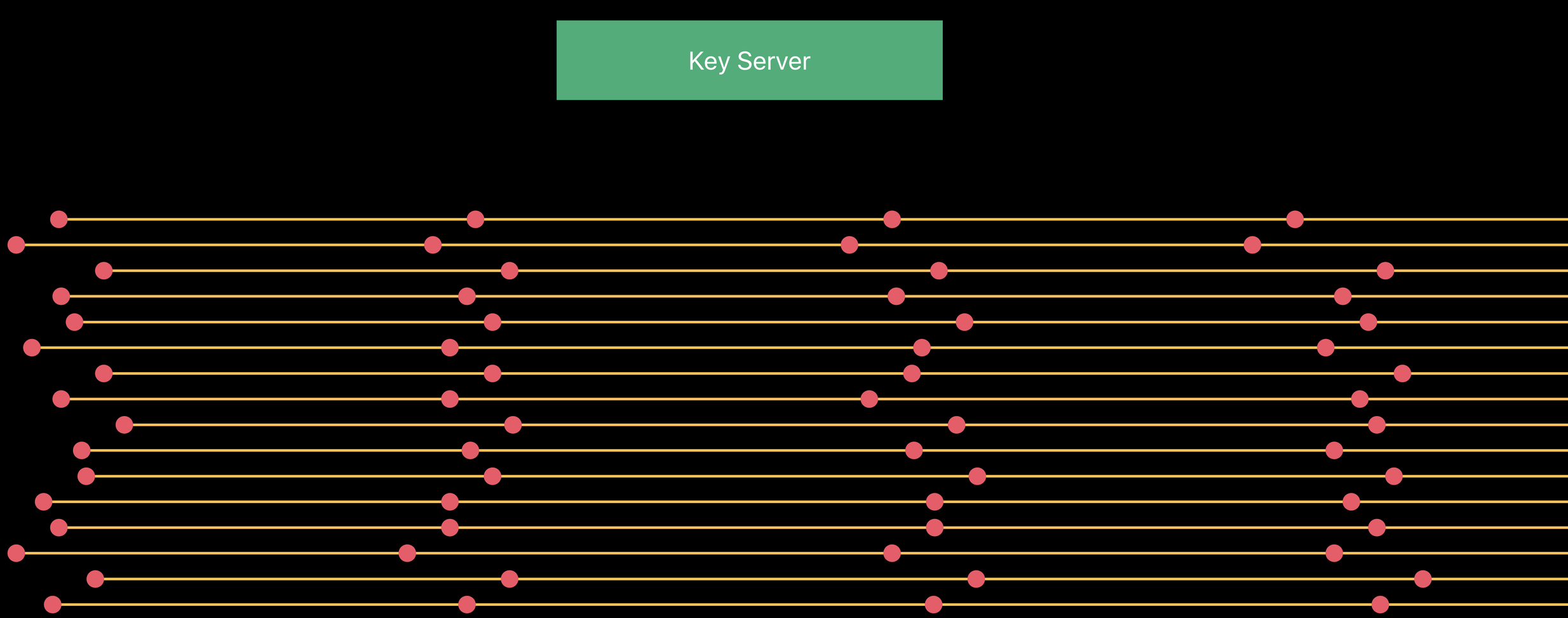

```
//Using AVContentKeySession to initiate Key Loading Process

//Create AVContentKeySession instance for FairPlay Streaming Key Delivery
let contentKeySession = AVContentKeySession(keySystem: .fairPlayStreaming)

//Register self as Delegate
contentKeySession.setDelegate(self, queue: DispatchQueue(label: "DelegateQueue"))

//Initiate Key Loading Process
contentKeySession.processContentKeyRequest(withIdentifier: "skd://myKey", initializationData:
nil, options: nil)
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```
//Tag in your Media Playlist
#EXT-X-KEY:METHOD=SAMPLE-AES,URI="skd://myKey",KEYFORMAT="com.apple.streamingkeydelivery",
KEYFORMATVERSIONS="1"
```

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//Delegate callback that delivers AVContentKeyRequest
func contentKeySession(_ session: AVContentKeySession, didProvide keyRequest:
AVContentKeyRequest) {









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    //Request SPC
    keyRequest.makeStreamingContentKeyRequestData(forApp: appCertificate, contentIdentifier:
assetID, options: keyRequestOptions) {
        (spcBytes: Data?, spcCreationError: Error?) in
        //Send SPC to Key Server and obtain CKC
        if let ckcBytes = getCKCFromKeyServer(forSPC: spcBytes) {
            //Create Response using the CKC you obtained from Key Server
            let response = AVContentKeyResponse(fairPlayStreamingKeyResponseData: ckcBytes)
            //Set Response on the Key Request object when you are about to start playback
            keyRequest.processContentKeyResponse(response)
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Responding to Key Requests

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Be mindful while responding to key requests

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- Respond to key requests just before requesting playback

Persistent FPS Keys

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Persistent FPS keys protect offline HLS assets

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Use `AVContentKeySession` to

- Create persistent keys before requesting HLS asset download

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Use `AVContentKeySession` to

- Create persistent keys before requesting HLS asset download

Simpler and cleaner workflow

Persistent FPS Keys

Persistent FPS keys protect offline HLS assets

Use `AVContentKeySession` to

- Create persistent keys before requesting HLS asset download

Simpler and cleaner workflow

Work with `AVPersistableContentKeyRequest`

```
//Delegate callback that delivers AVContentKeyRequest
func contentKeySession(_ session: AVContentKeySession, didProvide keyRequest:
AVContentKeyRequest) {
    //Check if you are creating a Persistent Decryption Key
    if (creatingPersistentDecryptionKey(keyRequest.identifier)) {
        //Request a Persistable Key Request
        keyRequest.respondByRequestingPersistableContentKeyRequest()
        return
    }
    //Continue with AVContentKeyRequest while loading non-Persistent Decryption Key
}
```

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            //Request Persistent Decryption Key by providing the CKC
            let persistentKey = try? keyRequest.persistableContentKey(fromKeyVendorResponse:
ckcBytes!, options: nil)

            //Stow persistentKey data blob for future use
        }
    }
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```
//Delegate callback that delivers AVPersistableContentKeyRequest
func contentKeySession(_ session: AVContentKeySession, didProvide keyRequest:
AVPersistableContentKeyRequest) {
    //Create Response using the Persistent Key that was created earlier
    let response = AVContentKeyResponse(fairPlayStreamingKeyResponseData: persistentKey)
    //Set Response on the Persistable Key Request Object
    keyRequest.processContentKeyResponse(response)
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AVContentKeySession

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Works similarly to `AVAssetResourceLoader`

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`AVAssetResourceLoadingRequest` → `AVContentKeyRequest`

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Except not tied to `AVURLAsset` at the time of creation

Create `AVContentKeySession` at any time

Add asset as a content key recipient before requesting playback

- Using `addContentKeyRecipient()`

Recommended Usage

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`AVContentKeySession` for

- Content decryption keys

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`AVContentKeySession` for

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`AVAssetResourceLoader` for

- Playlists, media data, and metadata

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What if `AVURLAsset` has both delegates installed?

Recommended Usage

`AVContentKeySession` for

- Content decryption keys

`AVAssetResourceLoader` for

- Playlists, media data, and metadata
- Key loading is still supported

What if `AVURLAsset` has both delegates installed?

- `AVAssetResourceLoader` delegate should defer key requests to `AVContentKeySession`

```
func resourceLoader(_ resourceLoader: AVAssetResourceLoader,
shouldWaitForLoadingOfRequestedResource loadingRequest: AVAssetResourceLoadingRequest) ->
Bool
{
    //Check if the resource loading request is for Content Decryption Key
    if (requestIsForContentDecryptionKey(request: loadingRequest)) {
        //Defer loading of Content Decryption Key to AVContentKeySession
        loadingRequest.contentInformationRequest?.contentType =
AVStreamingKeyDeliveryContentKeyType
        loadingRequest.finishLoading()
        return true
    }

    //Continue loading all other resources (playlists, media data & metadata)

    return true
}
```

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    }

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        loadingRequest.finishLoading()
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    }

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    return true
}
```

```
func resourceLoader(_ resourceLoader: AVAssetResourceLoader,
shouldWaitForLoadingOfRequestedResource loadingRequest: AVAssetResourceLoadingRequest) ->
Bool
{
    //Check if the resource loading request is for Content Decryption Key
    if (requestIsForContentDecryptionKey(request: loadingRequest)) {
        //Defer loading of Content Decryption Key to AVContentKeySession
        loadingRequest.contentInformationRequest?.contentType =
AVStreamingKeyDeliveryContentKeyType
        loadingRequest.finishLoading()
        return true
    }

    //Continue loading all other resources (playlists, media data & metadata)

    return true
}
```

Dual Expiry Windows for Persistent Keys

NEW

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NEW

Support dual expiry windows for persistent FPS keys

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Dual expiry window model for rentals

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Works for both online and offline playback

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- Playback expiry

Dual Expiry Windows for Persistent Keys

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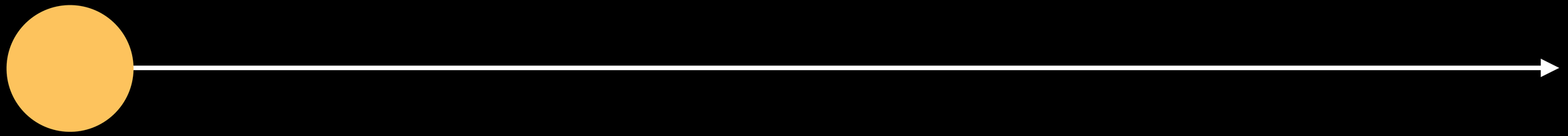
Dual Expiry Windows for Persistent Keys



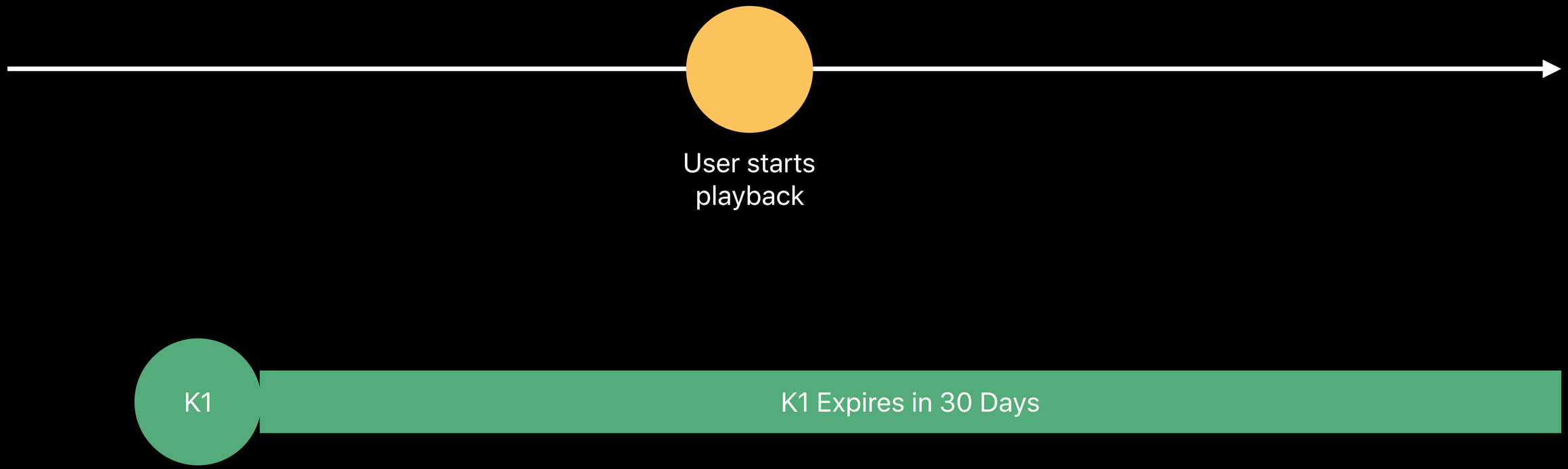
User rents content

Dual Expiry Windows for Persistent Keys

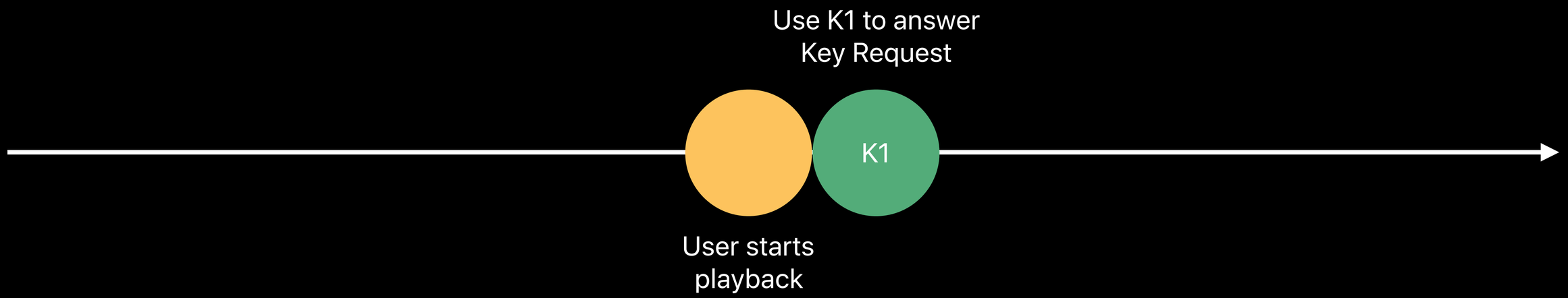
Dual Expiry Windows for Persistent Keys

Dual Expiry Windows for Persistent Keys

Dual Expiry Windows for Persistent Keys

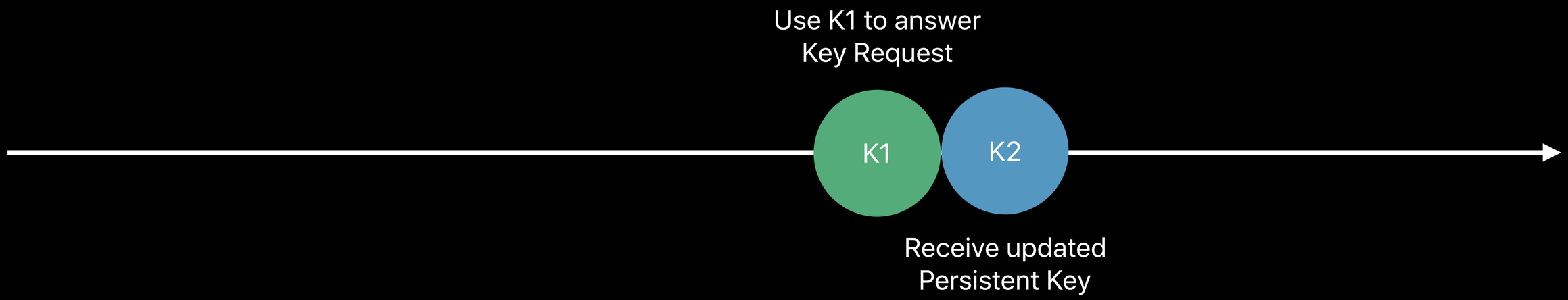


Dual Expiry Windows for Persistent Keys



K1 Expires in 30 Days

Dual Expiry Windows for Persistent Keys



Dual Expiry Windows for Persistent Keys

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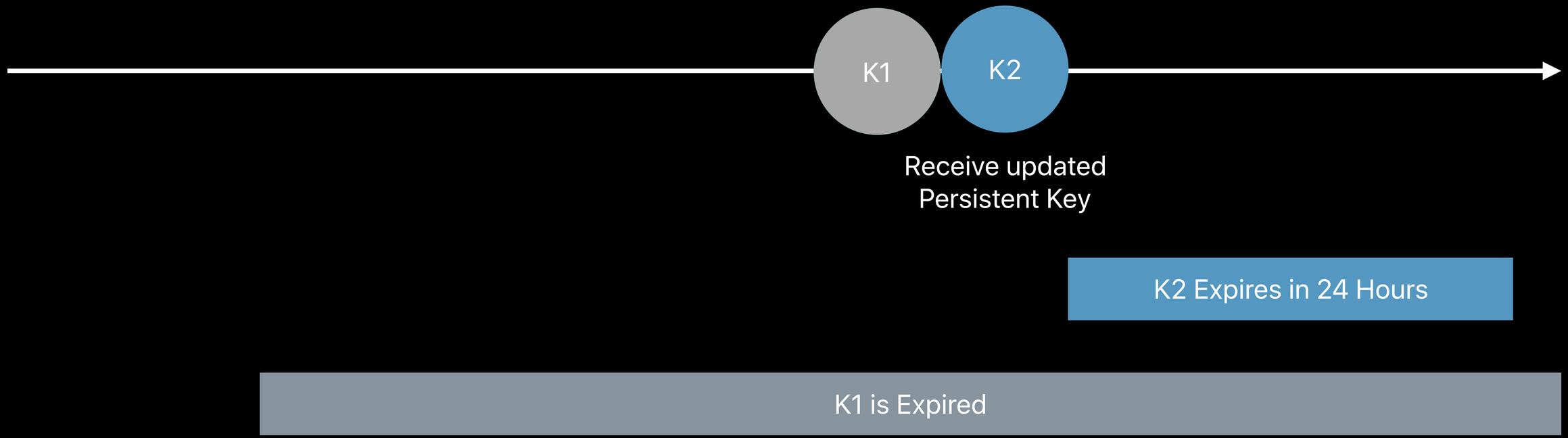
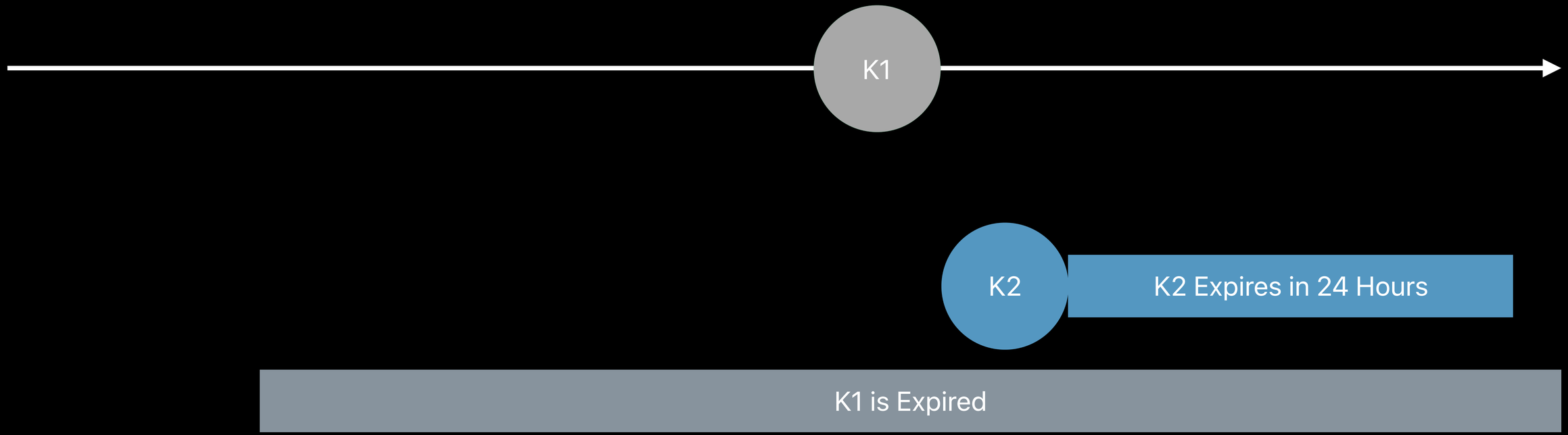


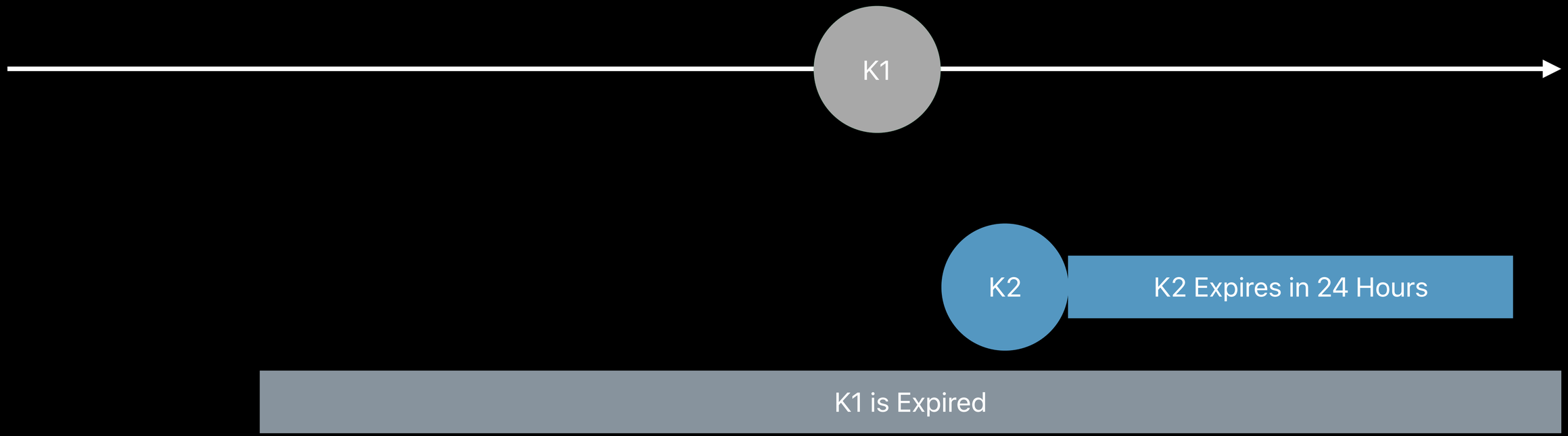
Dual Expiry Windows for Persistent Keys



Dual Expiry Windows for Persistent Keys

Updated Persistent Key sent through delegate callback:

`didUpdatePersistableContentKey`



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`AVContentKeySession` API to manage and deliver content keys

Rental support for persistent FPS keys

More Information

https://developer.apple.com/wwdc17/504

Related Sessions

Error Handling Best Practices for HTTP Live Streaming		WWDC 2017 Video
HLS Authoring Update		WWDC 2017 Video
Introducing HEIF and HEVC	Executive Ballroom	Tuesday 4:10PM
Media and Gaming Accessibility	Grand Ballroom A	Wednesday 3:10PM
Introducing AirPlay 2	Executive Ballroom	Thursday 4:10PM
Working with HEIF and HEVC	Hall 2	Friday 11:00PM

Labs

AVFoundation Lab 1	Technology Lab F	Tue 1:00 - 4:10 PM
HTTP Live Streaming Lab 1	Technology Lab F	Wed 9:00 - 11:00 AM
AVFoundation Lab 2	Technology Lab G	Wed 11:00 AM - 1:00 PM
AVFoundation Lab 3	Technology Lab F	Thur 12:00 - 3:00 PM
HTTP Live Streaming Lab 2	Technology Lab G	Thur 3:10 - 6:00 PM

Labs (continued)

AVKit Lab 1	Technology Lab F	Tue 1:00 - 4:10 PM
HEIF/HEVC Lab 1	Technology Lab A	Wed 9:00 - 11:00 AM
AirPlay Lab 1	Technology Lab A	Wed 11:00 AM - 1:00 PM
AVKit Lab 2	Technology Lab G	Wed 11:00 AM - 1:00 PM
AirPlay Lab 2	Technology Lab A	Fri 9:00 - 11:00 AM
HEIF/HEVC Lab 2	Technology Lab F	Fri 12:00 - 1:50 PM


WWDC17