Advances in HTTP Live Streaming

Roger Pantos
iPhone Engineer


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Advances in HTTP Live Streaming

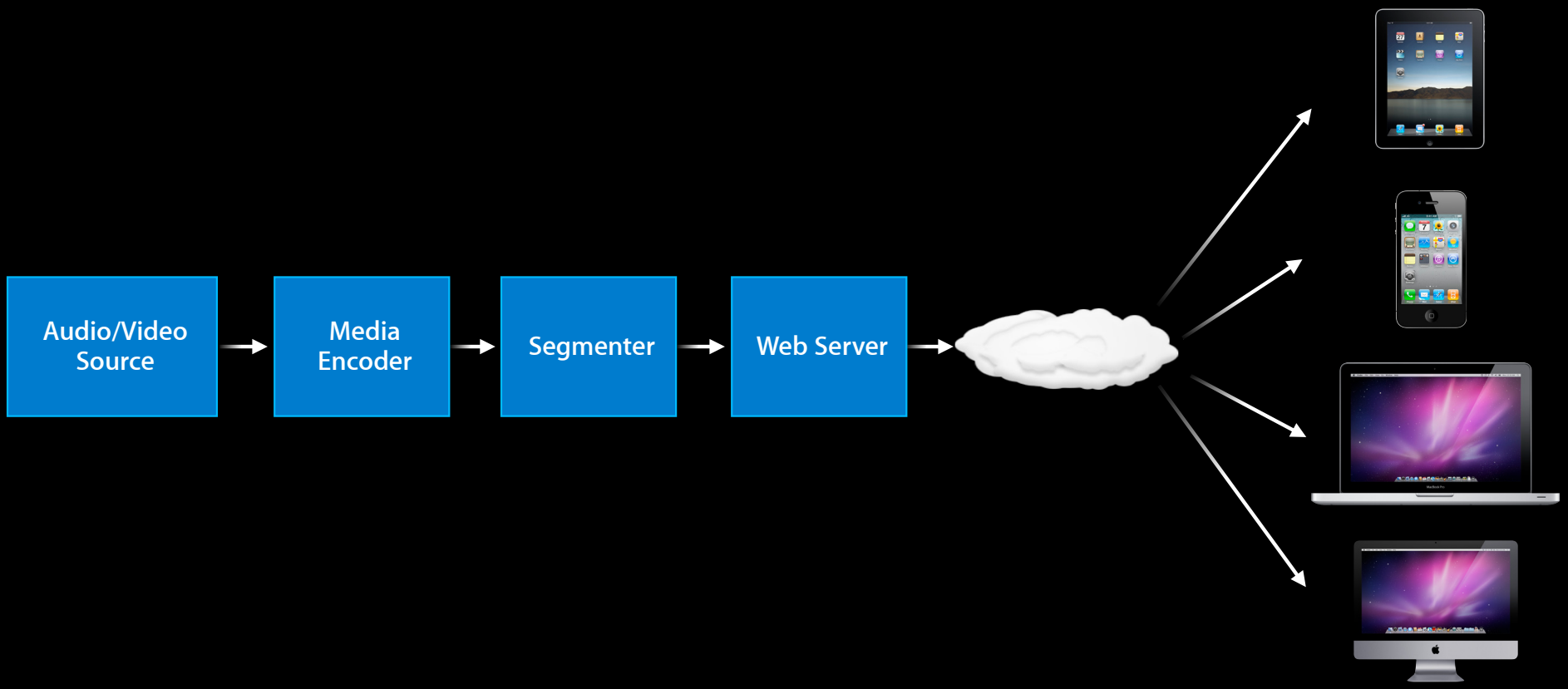
Eryk Vershen
Media Technologies Evangelist

Outline

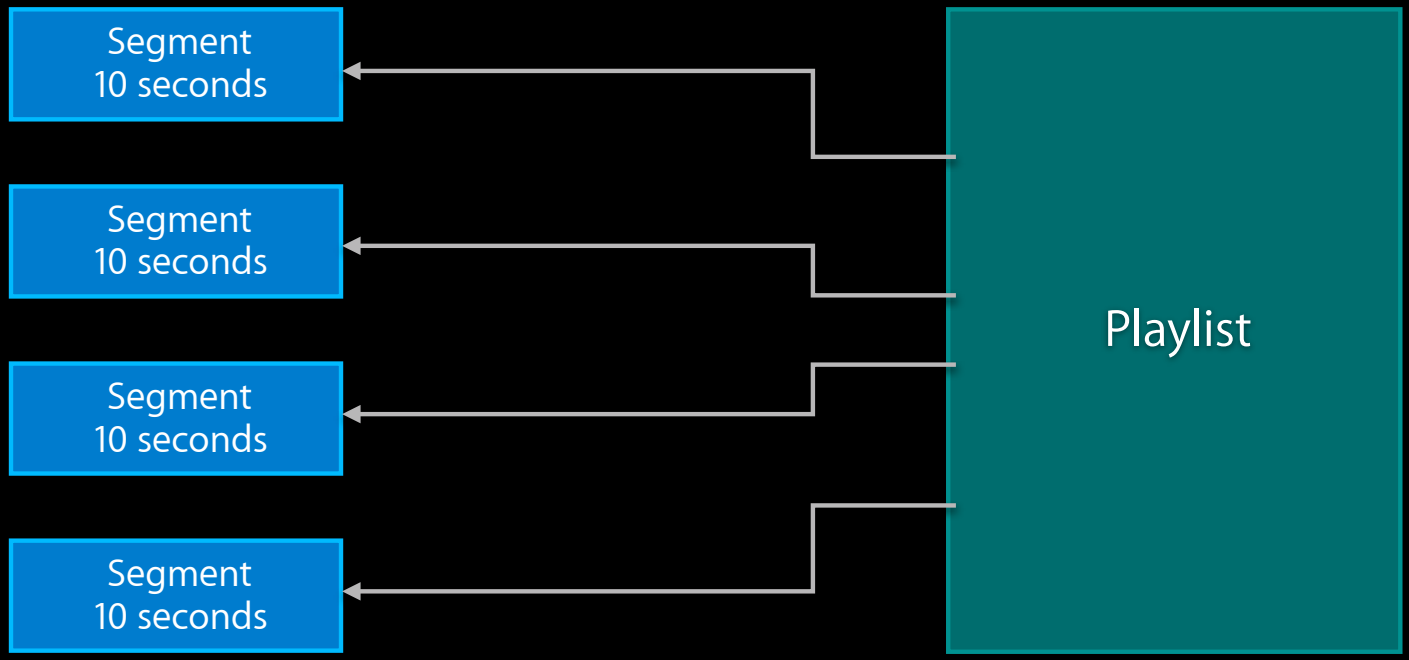
- Technology walk-through
- New features
- Tools
- Tips and tricks

Technology Walk-Through

Workflow



Segments and Playlists



Playlist

- Lists the segments in playback order
  - In live streams this defines the playback window
- Defines keys for encrypted segments
- Can specify multiple variants of the content

Video on Demand Playlist

Video on Demand Playlist

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:0
#EXTINF:10,
http://example.com/movie1/fileSequenceA.ts
#EXTINF:10,
http://example.com/movie1/fileSequenceB.ts
#EXTINF:10,
http://example.com/movie1/fileSequenceC.ts
#EXTINF:10,
http://example.com/movie1/fileSequenceD.ts
#EXT-X-ENDLIST
```

Video on Demand Playlist

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:0
#EXTINF:10,
fileSequenceA.ts
#EXTINF:10,
fileSequenceB.ts
#EXTINF:10,
fileSequenceC.ts
#EXTINF:10,
fileSequenceD.ts
#EXT-X-ENDLIST
```

Live Playlist

Live Playlist

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:1
#EXTINF:10,
fileSequence1.ts
#EXTINF:10,
fileSequence2.ts
#EXTINF:10,
fileSequence3.ts
#EXTINF:10,
fileSequence4.ts
#EXTINF:10,
fileSequence5.ts
```

Live Playlist

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:2
#EXTINF:10,
fileSequence2.ts
#EXTINF:10,
fileSequence3.ts
#EXTINF:10,
fileSequence4.ts
#EXTINF:10,
fileSequence5.ts
#EXTINF:10,
fileSequence6.ts
```

Live Playlist

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:3
#EXTINF:10,
fileSequence3.ts
#EXTINF:10,
fileSequence4.ts
#EXTINF:10,
fileSequence5.ts
#EXTINF:10,
fileSequence6.ts
#EXTINF:10,
fileSequence7.ts
```

Live Playlist

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:4
#EXTINF:10,
fileSequence4.ts
#EXTINF:10,
fileSequence5.ts
#EXTINF:10,
fileSequence6.ts
#EXTINF:10,
fileSequence7.ts
#EXTINF:10,
fileSequence8.ts
```

Live Playlist

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:5
#EXTINF:10,
fileSequence5.ts
#EXTINF:10,
fileSequence6.ts
#EXTINF:10,
fileSequence7.ts
#EXTINF:10,
fileSequence8.ts
#EXTINF:10,
fileSequence9.ts
```

Event Playlist

Event Playlist

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:1
#EXTINF:10,
fileSequence0.ts
#EXTINF:10,
fileSequence1.ts
#EXTINF:10,
fileSequence2.ts
#EXTINF:10,
fileSequence3.ts
#EXTINF:10,
fileSequence4.ts
...
#EXT-X-ENDLIST
```

Encrypted Segments

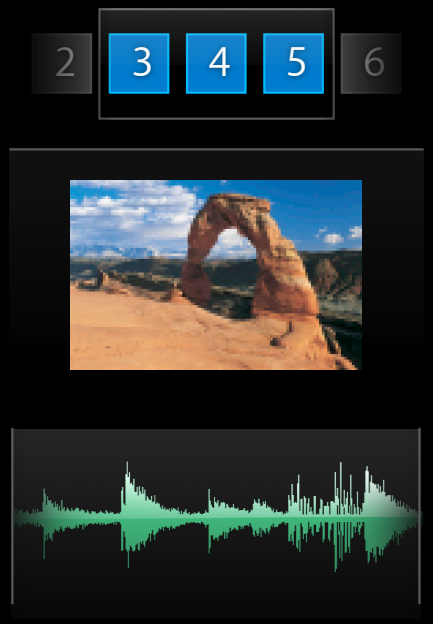
Encrypted Segments

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:39
#EXT-X-KEY:METHOD=AES-128,URI="https://example.com/1.key"
#EXTINF:10,
http://media.example.com/segment39.ts
#EXTINF:10,
http://media.example.com/segment40.ts
#EXT-X-KEY:METHOD=AES-128,URI="https://example.com/2.key"
#EXTINF:10,
http://media.example.com/segment41.ts
#EXTINF:10,
http://media.example.com/segment42.ts
```

Variant Playlist

- A variant is a version of the stream at a particular bit rate
  - Each variant is a separate playlist
- The variant playlist describes all of the available variants
- Client will switch to most appropriate variant based on measured bit rate
- Client's player is tuned to minimize stalling of playback

Variant Playlist



Variant Playlist

- Not re-read, endlist on individual variant ends the stream

```
#EXTM3U
#EXT-X-STREAM-INF:PROGRAM-ID=1,BANDWIDTH=150000
http://example.com/low/index.m3u8
#EXT-X-STREAM-INF:PROGRAM-ID=1,BANDWIDTH=240000
http://example.com/lo_mid/index.m3u8
#EXT-X-STREAM-INF:PROGRAM-ID=1,BANDWIDTH=440000
http://example.com/hi_mid/index.m3u8
#EXT-X-STREAM-INF:PROGRAM-ID=1,BANDWIDTH=640000
http://example.com/high/index.m3u8
#EXT-X-STREAM-INF:PROGRAM-ID=1,BANDWIDTH=64000
http://example.com/audio/index.m3u8
```

Playback

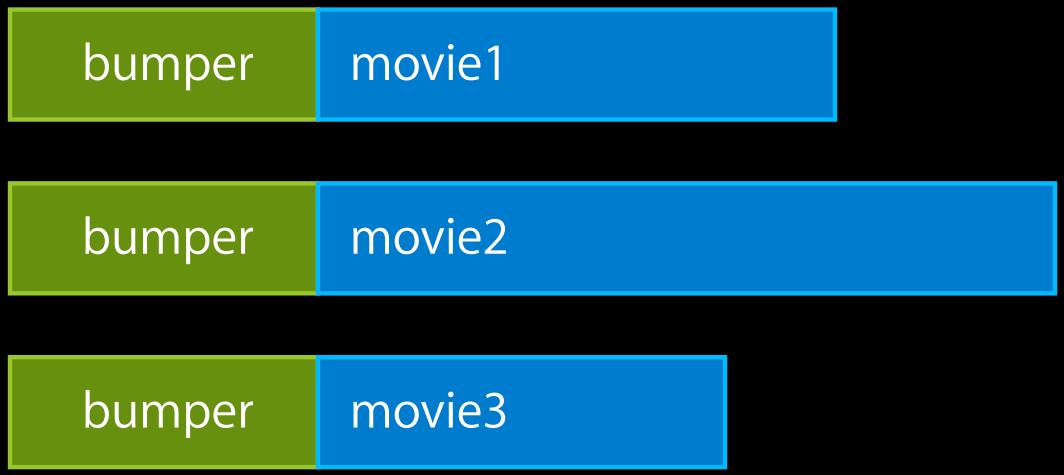
- Safari
  - HTML5 <video> element
- iPhone OS
  - UIWebView
  - MPMoviePlayerController
  - AVPlayerItem

New Features

New Features

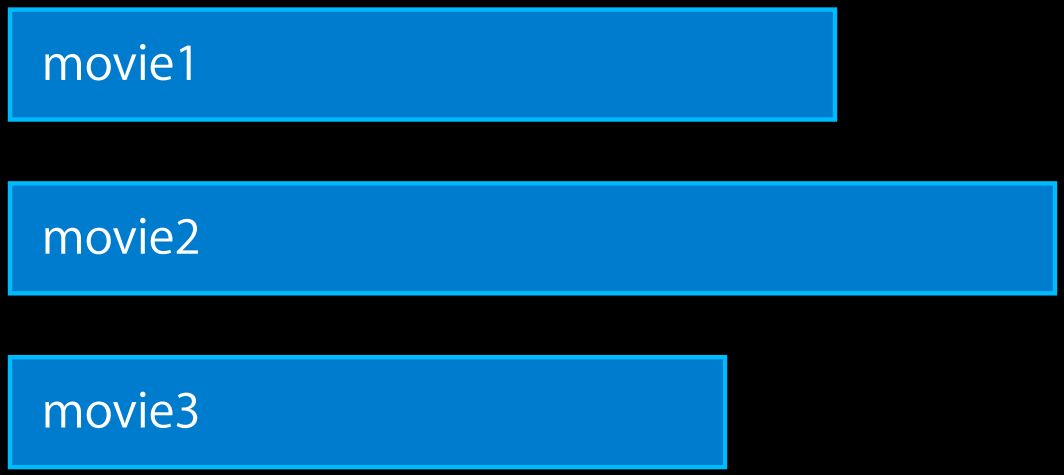
- Stream discontinuities
- Timed metadata
- Custom protocols for keys
- Performance improvements

Discontinuity



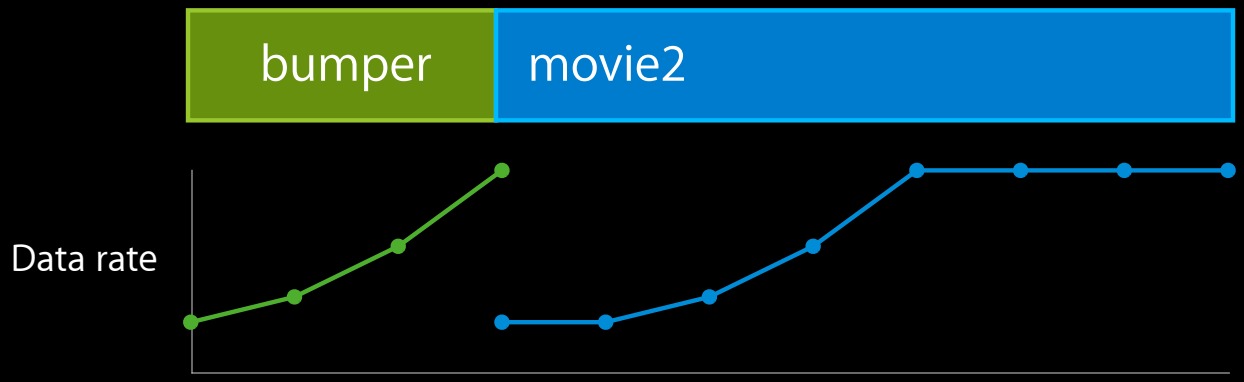
Discontinuity

Merge?



Discontinuity

As separate movies?



Discontinuity

- Streams can change
  - Timecode break
  - Encoding parameters
- Let the client know
  - EXT-X-DISCONTINUITY

Discontinuity

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:1
#EXT-X-MEDIA-SEQUENCE:0
#EXTINF:10,
bumper0.ts
#EXTINF:8,
bumper1.ts
#EXT-X-DISCONTINUITY
#EXTINF:10,
movieA.ts
#EXTINF:10,
movieB.ts
```

Discontinuity

Default initialization vector for encryption is sequence number

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:1
#EXT-X-MEDIA-SEQUENCE:0
#EXT-X-KEY:METHOD=AES-128,URI="crypt0.key"
#EXTINF:10,
bumper0.ts
#EXTINF:8,
bumper1.ts
#EXT-X-DISCONTINUITY
#EXT-X-KEY:METHOD=AES-128,URI="cryptA.key"
#EXTINF:10,
movieA.ts
#EXTINF:10,
movieB.ts
```

What's an Initialization Vector

And why do I care?

- Encryption tries to make a segment look like random data
- This doesn't work so well in the beginning of the segment
- An Initialization Vector makes the first part more random-like
- Ideally an IV is a truly random sequence of bits that changes often enough

Discontinuity

Default initialization vector for encryption is sequence number

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:1
#EXT-X-MEDIA-SEQUENCE:0
#EXT-X-KEY:METHOD=AES-128,URI="crypt0.key"
#EXTINF:10,
bumper0.ts          sequence number 0 initialization vector 0x00000000000000000000000000000000
#EXTINF:8,
bumper1.ts          sequence number 1 initialization vector 0x00000000000000000000000000000001
#EXT-X-DISCONTINUITY
#EXT-X-KEY:METHOD=AES-128,URI="cryptA.key"
#EXTINF:10,
movieA.ts           sequence number 2 initialization vector 0x00000000000000000000000000000002
#EXTINF:10,
movieB.ts           sequence number 3 initialization vector 0x00000000000000000000000000000003
```

Discontinuity

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:2
#EXT-X-MEDIA-SEQUENCE:0
#EXT-X-KEY:METHOD=AES-128,URI="crypt0.key",IV=0xbe326869034ca49333acace46d5cd56f
#EXTINF:10,
bumper0.ts          initialization vector 0xbe326869034ca49333acace46d5cd56f
#EXTINF:8,
bumper1.ts          initialization vector 0xbe326869034ca49333acace46d5cd56f
#EXT-X-DISCONTINUITY
#EXT-X-KEY:METHOD=AES-128,URI="cryptA.key",IV=0x5b13747cdbb9d76998fba9e7e1e72ba7
#EXTINF:10,
movieA.ts           initialization vector 0x5b13747cdbb9d76998fba9e7e1e72ba7
#EXTINF:10,
movieB.ts           initialization vector 0x5b13747cdbb9d76998fba9e7e1e72ba7
```

Initialization Vectors

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-VERSION:2
#EXT-X-MEDIA-SEQUENCE:0
#EXT-X-KEY:METHOD=AES-128,URI="crypt0.key",IV=0x9c7db8778570d05c3177c349fd9236aa
#EXTINF:10,
movie1.ts
#EXTINF:10,
movie2.ts
#EXT-X-KEY:METHOD=AES-128,URI="crypt0.key",IV=0xc055ee9f6c1eb7aa50bfab02b0814972
#EXTINF:10,
movie3.ts
#EXT-X-KEY:METHOD=AES-128,URI="crypt0.key",IV=0xdfe1ede5280608a25fe9731cc18a62a3
#EXTINF:10,
movie4.ts
```

What Is Timed Metadata?

- Data about the video
- Occurs at a specific movie time

Timed Metadata

- Want to communicate info
  - About this moment in movie
  - To a dedicated player app
- Independent channels are hard to synchronize
  - Even harder to rewind/seek/replay properly

- Add a time stamped information stream

Timed Metadata

Timed Metadata

- We use it to timestamp audio-only streams
- Add pictures to audio-only streams
- Images to overlay
- Text to display
- Mark points in the movie
- Mix in a slide deck
  - While slides show movie becomes picture in picture

Timed Metadata

- Uses ID3
- Separate elementary stream
  - Except for audio only—added to audio stream
- Can add with mediafilesegmenter
- Supported in MPMoviePlayerController and AVPlayerItem
  - timedMetadata property

Encryption Keys

- Tricky to get certificates to work right
- Wanted more secure key delivery

- Private protocols for keys

Encryption Keys

- Custom URL scheme (with an app)
  - Uses NSURLProtocol class
  - See “URL Loading System Programming Guide”

```
#EXTM3U
#EXT-X-TARGETDURATION:10
#EXT-X-MEDIA-SEQUENCE:39
#EXT-X-KEY:METHOD=AES-128,URI="myprotocol://key1234"
#EXTINF:10,
http://media.example.com/segment39.ts
#EXTINF:10,
http://media.example.com/segment40.ts
```

Performance Improvements

- Faster stream switching
- Faster startup on fast connections
- Compressed (gzip) playlists

Failover

```
#EXTM3U
#EXT-X-STREAM-INF:PROGRAM-ID=1, BANDWIDTH=240000
http://one.example.com/lo/index.m3u8
#EXT-X-STREAM-INF:PROGRAM-ID=1, BANDWIDTH=240000
http://two.example.com/lo/index.m3u8

#EXT-X-STREAM-INF:PROGRAM-ID=1, BANDWIDTH=440000
http://one.example.com/md/index.m3u8
#EXT-X-STREAM-INF:PROGRAM-ID=1, BANDWIDTH=440000
http://three.example.com/md/index.m3u8
```

Program Date-Time

- EXT-X-PROGRAM-DATE
  - Associates a wall clock date and time with the start of a segment
- AVPlayerItem lets you seek to dates

```
– (BOOL)seekToDate:(NSDate *)date;
```

- If you use EXT-X-PROGRAM-DATE, add it after every discontinuity

Demo

StitchedStreamPlayer

Roger Pantos
iPhone Engineer

Tools

HTTP Live Streaming Tools

- mediafilesegmenter
- variantplaylistcreator
- mediastreamsegmenter
- mediastreamvalidator
- id3taggenerator

- Available at:

http://connect.apple.com in Downloads -> iPhone

Media File Segmenter

- Easy to use

```
mediafilesegmenter  my_movie_file.mp4
```

mediafilesegmenter Options

- Main options
- Names and locations
- Encryption
- Metadata

```
-target-duration duration
-audio-only
-generate-variant-plist
-base-url <url>
-file-base path
-index-file fileName
-base-media-file-name name
-encrypt-iv [random | sequence]
-key-rotation-period period
-encrypt-rotate-iv-mbytes numberMBytes
-encrypt-key file-or-path
-encrypt-key-url <url>
-base-encrypt-key-name name
-meta-file file
-meta-type [picture | text | id3]
-meta-macro-file file
```

Variant Playlist Creator

Variant Playlist Creator

```
mkdir normal
mediafilesegmenter  -generate-variant-plist \
    -file-base normal  movie1.mp4

mkdir cell
mediafilesegmenter  -generate-variant-plist \
    -file-base cell  movie1-cell.3gp

variantplaylistcreator  -o all.m3u8 \
    normal/prog_index.m3u8  movie1.plist \
    cell/prog_index.m3u8  movie1-cell.plist
```

generates movie1.plist

generates movie1-cell.plist

Media Stream Segmenter

- Similar to mediafilesegmenter
- Can take input from pipe or UDP port

mediastreamsegmenter Options

- Main options
- Names and locations
- Encryption
- Metadata
- Playlist structure
- Actions

```
-program
-program-duration durationMins
-sliding-window-entries entries
-start-index-file-count entries
-initial-sequence-number num
-delete-files
-reuse-media-entry-name num
-receive-data-timeout duration
-exit-on-receive-data-timeout
-file-complete-command command
-file-delete-command command
-crypt-file-complete-command command
-crypt-file-delete-command command
```

Media Stream Validator

- Parse
- Validate

ID3 Tag Generator

- Creates ID3 files
- Use with mediafilesegmenter -meta-macro-file option

- Sample macro-file:

```
1.2  id3      /tmp/title.id3
10   picture  /tmp/picture.jpg
```

Tips and Tricks

Variant Playlists

- First alternative will play initially
- Create one variant playlist for cellular and one for Wi-Fi
  - In an app use the Reachability APIs to determine connection type
    - http://developer.apple.com/iphone/library/samplecode/Reachability/
- For web delivery use makerefmovie
  - makerefmovie can target cellular vs. Wi-Fi
  - makerefmovie can target desktop vs. iPhone vs. iPad

Encoding

- File size is VERY important over mobile
- Don’t forget container overhead
- No need to encode at full screen dimensions
  - Take advantage of video scaling on the device
  - You can trade off frames per second vs. image quality
- Use multiple keyframes per segment
- Audio should be identical across the variants
- With QuickTime Player 7 use the Movie to MPEG-4 exporter

Takeaways

- Continuing to evolve
- Stay current
- Your feedback is important

Related Sessions

Discovering AVFoundation	Presidio Tuesday 2:00PM
Discovering AVFoundation (Repeat)	Nob Hill Thursday 4:30PM
Delivering Audio and Video Using Web Standards, Part 1 (Repeat)	Nob Hill Friday 10:15AM
Delivering Audio and Video Using Web Standards, Part 2 (Repeat)	Nob Hill Friday 11:30AM

Labs

HTTP Live Streaming Lab	Graphics and Media Lab B Wednesday 9:00AM
AVFoundation Lab	Graphics and Media Lab C Wednesday 9:00AM
AVFoundation Lab (Repeat)	Graphics and Media Lab B Friday 11:30AM
HTML5 Audio and Video Lab	Internet and Web Lab A Tuesday 2:00PM

More Information

Eryk Vershen
Media Technologies Evangelist
evershen@apple.com

Documentation

HTTP Live Streaming Overview
http://developer.apple.com/iphone/library/documentation/NetworkingInternet/Conceptual/StreamingMediaGuide

Best Practices for Creating and Deploying HTTP Live Streaming Media for the iPhone and iPad
http://developer.apple.com/iphone/library/technotes/tn2010/tn2224.html

Public Specification—Version 3
http://tools.ietf.org/html/draft-pantos-http-live-streaming

Apple Developer Forums

http://devforums.apple.com


WWDC10