Streaming Learning Center

(realeyes)

C202: How To Build Your Own Cloud Encoder With FFmpeg

Jan Ozer, Principal - Doceo Publishing

Phil Moss, Senior Developer - RealEyes

About Your Speakers

- Jan Ozer,
    - Contributing Editor, *Streaming Media* Magazine
    - Author, *Learn to Produce FFmpeg in 30 Minutes or Less*, Doceo Press, 2017
    - www.streaminglearningcenter.com
- Phil Moss
    - Senior Developer, RealEyes
    - Consultancy, developer for exceptional video experiences to desktop, mobile, and OTT set-top devices
    - Clients include NBCS, Oracle, Adobe, MLBAM, Lionsgate
    - www.realeyes.com

INTRO

The WIIFM

WHO IS THIS PRESENTATION FOR?

- You have lots of video to transcode
- You distribute via one or more adaptive bitrate technologies
- You’re familiar with concepts like codecs and packaging
- You’re familiar with creating command line executions and JavaScript doesn’t offend you
- You understand some very basics of servers and how to work with them

Streaming Learning Center

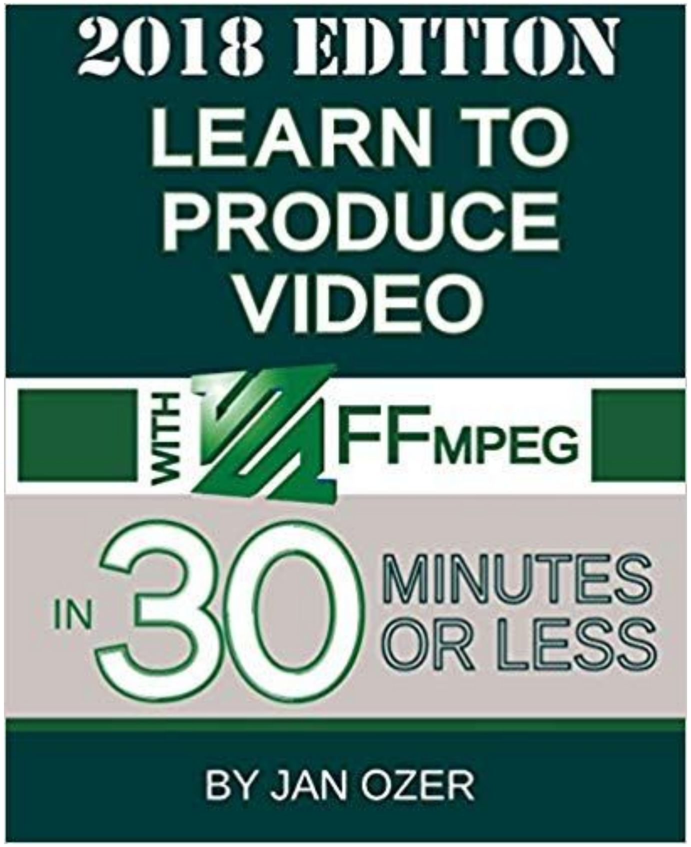
(realeyes)

Intro to FFmpeg

Jan Ozer
@janozer

Book from Which Some Materials Derived

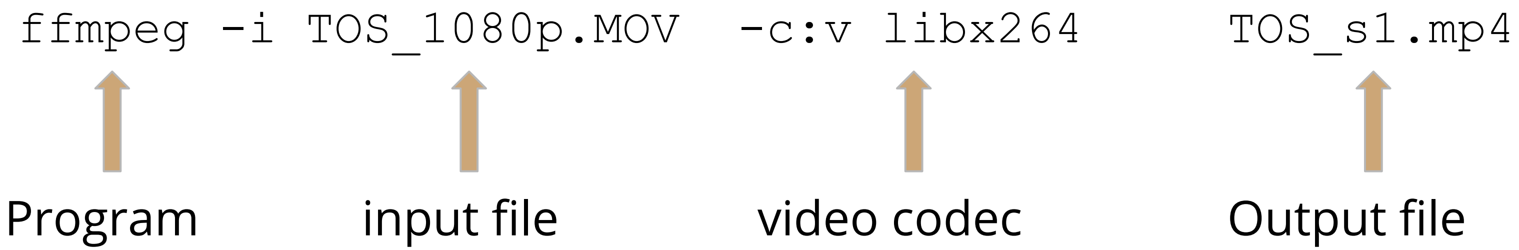
- Includes H.264/H.265
- Creation of variant playlists with FFmpeg
- Variant/master playlists with Apple tools
- Show special:
  - - Buy book
  - - Email receipt to janozer@gmail.com
  - - get free copy of PDF ($24.95 value
  - - Valid till 11/30



Introduction

- There are always multiple ways; seldom is there a single correct “one”
- We’re showing minimum necessary commands; there are lots more configuration options
- Location of configuration option in string typically doesn’t matter
- If you don’t choose a configuration option, FFmpeg uses the default
- Configurations in command line override defaults

Script 1: Choosing Codec



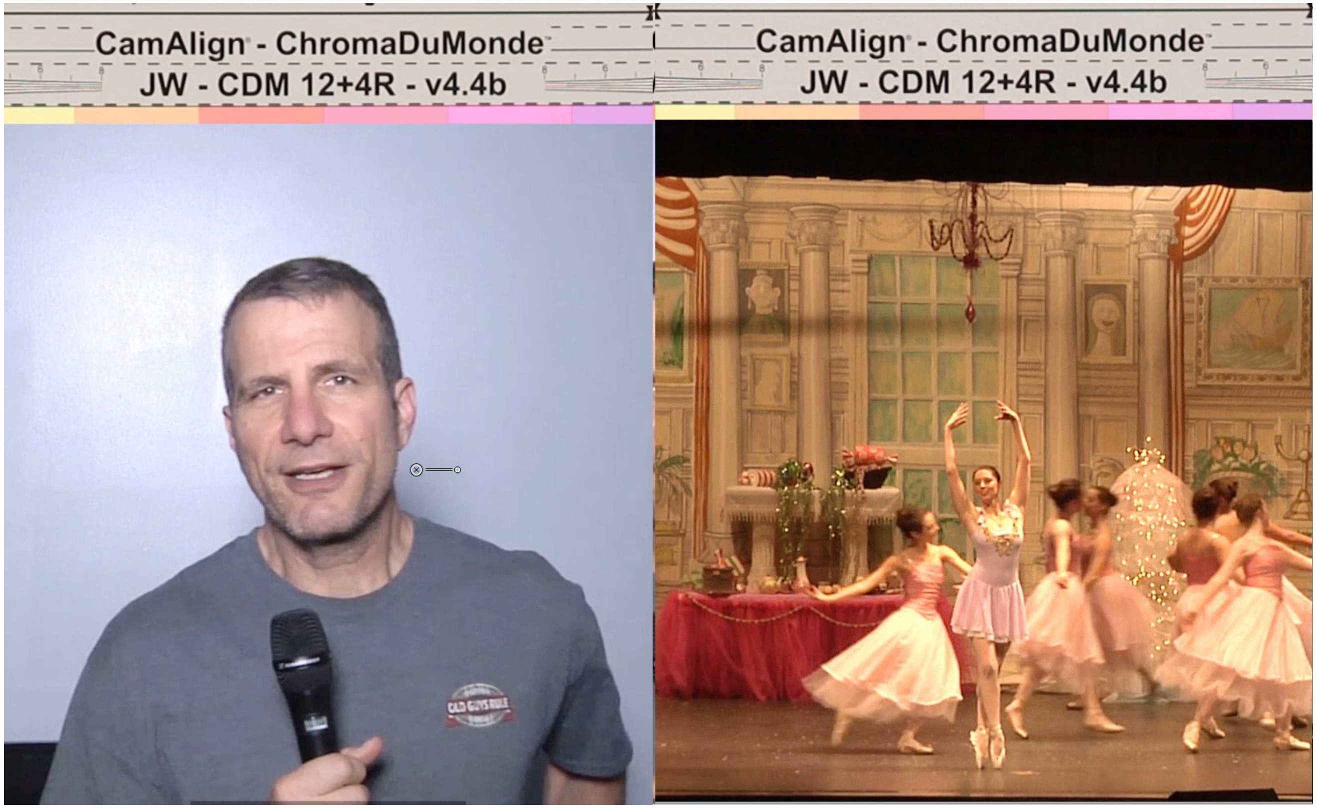
```
ffmpeg -i TOS_1080p.MOV  -c:v libx264     TOS_s1.mp4
```

- Input file: 1080p file in MOV format
  - YUV video
  - PCM audio
- Simple script means that you accept all FFmpeg defaults
- Generally acceptable for home movies; not acceptable for streaming, particularly adaptive streaming

Encoding Output - Default

- Codec: x264
  - Data rate: 15 Mbps
  - Bitrate control: average bitrate
  - Key frame: 250
  - Scene change: Yes
  - Resolution: same (1080p)
  - Frame rate: same (24)
  - Profile: High
  - CABAC: Yes
  - x264 preset: Medium
  - B-frames: preset (3)
  - B-adapt: preset (1)
  - Reference frames preset (3)
- Audio codec: AAC
  - Audio channels: 2
  - Audio samples: 48 khz
  - Audio bitrate: 2277 b/s
- Other Topics
  - Encoding multiple files
  - Converting to HLS

Bitrate Control



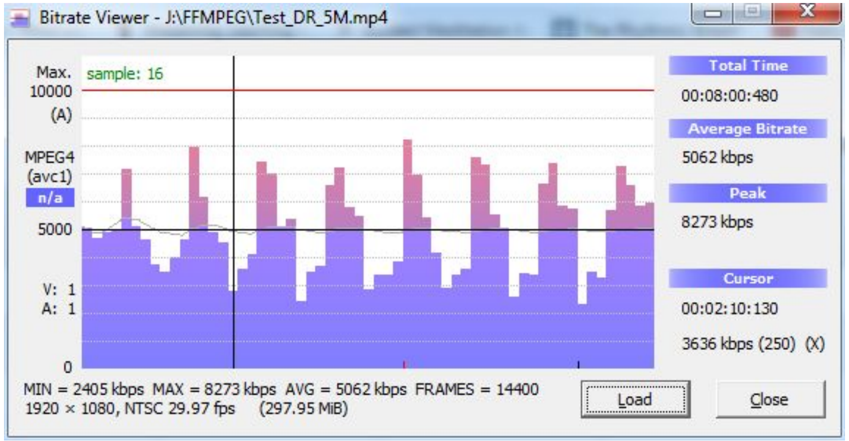
30 seconds talking head/30 seconds ballet

Setting Data Rate-Video

```
-b:v 5000k
```

bitrate video

- Sets video bitrate to 5 mbps



Bitrate Viewer - J:\FFMPEG\Test_DR_5M.mp4

Total Time
00:08:00:480

Average Bitrate
5062 kbps

Peak
8273 kbps

Cursor
00:02:10:130
3636 kbps (250) (X)

```
MIN = 2405 kbps  MAX = 8273 kbps  AVG = 5062 kbps  FRAMES = 14400
1920 × 1080, NTSC 29.97 fps    (297.95 MiB)
```

- No real bitrate control
- Spikes may make file hard to play

Images from Bitrate Viewer

Setting Data Rate-Two-Pass

```
ffmpeg -y -i Test_1080p.MOV -c:v libx264 -b:v 5000k -pass 1  -f mp4 NUL && \

ffmpeg -i  Test_1080p.MOV -c:v libx264 -b:v 5000k -pass 2   Test_1080p_2P.mp4
```

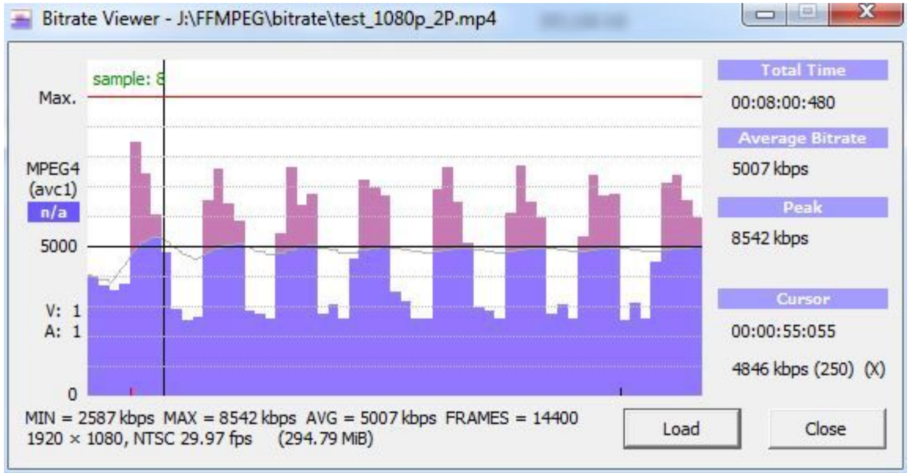
Line 1:

- `-y` - overwrite existing log file
- `- pass 1` - first pass, no output file
- `-f mp4` - output format second pass
- `NUL` - creates log file cataloguing encoding complexity (can name log file if desired)
- `&& \` - run second pass if first successful

Line 2:

- `-pass 2` - find and use log file for encode
- `Test_1080p_2P.mp4` - output file name
- Note - all commands in first pass must be in second file; can add additional commands in second line (more later)

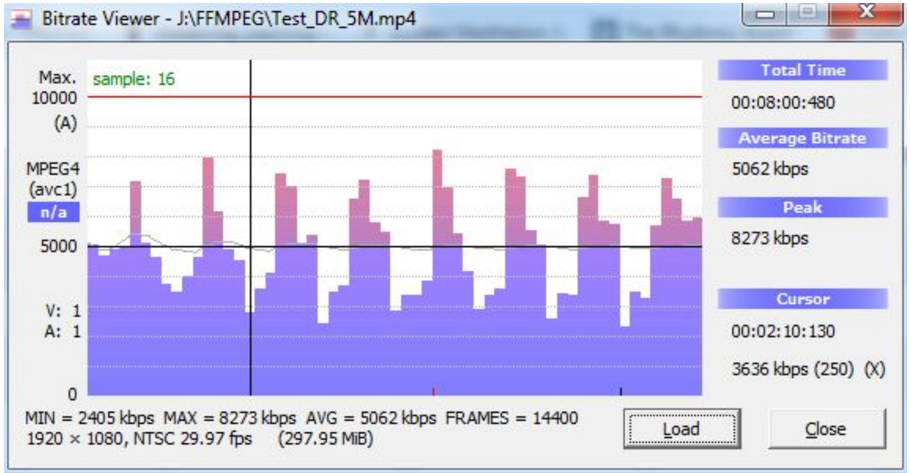
Setting Data Rate-Two-Pass



```
Bitrate Viewer - J:\FFMPEG\bitrate\test_1080p_2P.mp4

Total Time
00:08:00:480
Average Bitrate
5007 kbps
Peak
8542 kbps
Cursor
00:00:55:055
4846 kbps (250) (X)

MIN = 2587 kbps  MAX = 8542 kbps  AVG = 5007 kbps  FRAMES = 14400
1920 × 1080, NTSC 29.97 fps    (294.79 MiB)
```



```
Bitrate Viewer - J:\FFMPEG\Test_DR_5M.mp4

Total Time
00:08:00:480
Average Bitrate
5062 kbps
Peak
8273 kbps
Cursor
00:02:10:130
3636 kbps (250) (X)

MIN = 2405 kbps  MAX = 8273 kbps  AVG = 5062 kbps  FRAMES = 14400
1920 × 1080, NTSC 29.97 fps    (297.95 MiB)
```

- Two-Pass Encode
  - Improved bitrate control (5007 kbps)
  - Higher peak!

- Single-Pass Encode
  - Poor data rate control (5062 kbps)

Setting Data Rate-CBR

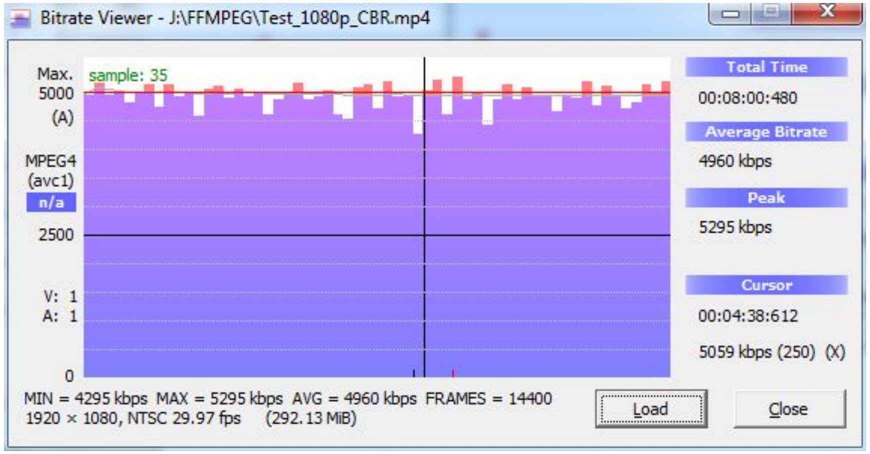
```
ffmpeg -y -i  test_1080p.MOV -c:v libx264  -b:v 5000k -pass 1  -f mp4 NUL && \
(same)

ffmpeg -i  test_1080p.MOV -c:v libx264   -b:v 5000k -maxrate 5000k -bufsize 5000k
-pass 2  test_1080p_CBR.mp4
```

Line 2:

- `- maxrate 5000k` - maximum rate same as target
- `- bufsize 5000k` - VBV (Video Buffering Verifying) buffer set to one second of video (limits stream variability)

Setting Data Rate-Two-Pass


Bitrate Viewer - J:\FFMPEG\Test_1080p_CBR.mp4

Total Time
00:08:00:480

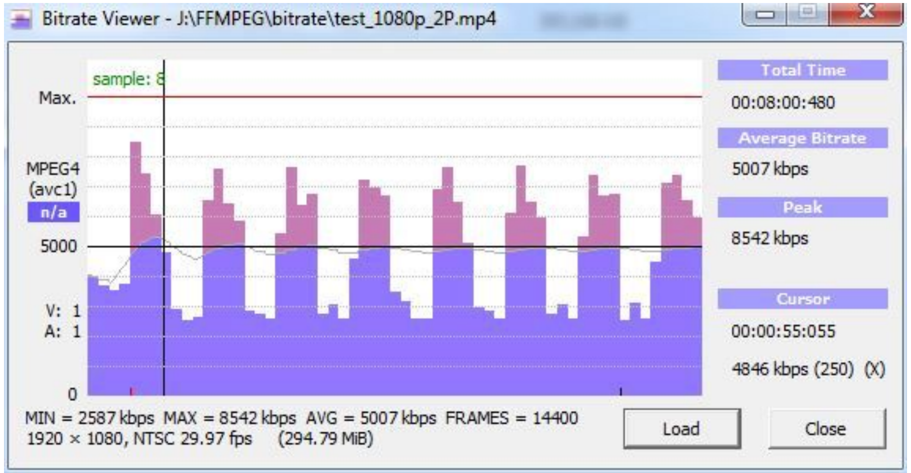
Average Bitrate
4960 kbps

Peak
5295 kbps

Cursor
00:04:38:612

5059 kbps (250) (X)

MIN = 4295 kbps MAX = 5295 kbps AVG = 4960 kbps FRAMES = 14400
1920 × 1080, NTSC 29.97 fps (292.13 MiB)


Bitrate Viewer - J:\FFMPEG\bitrate\test_1080p_2P.mp4

Total Time
00:08:00:480

Average Bitrate
5007 kbps

Peak
8542 kbps

Cursor
00:00:55:055

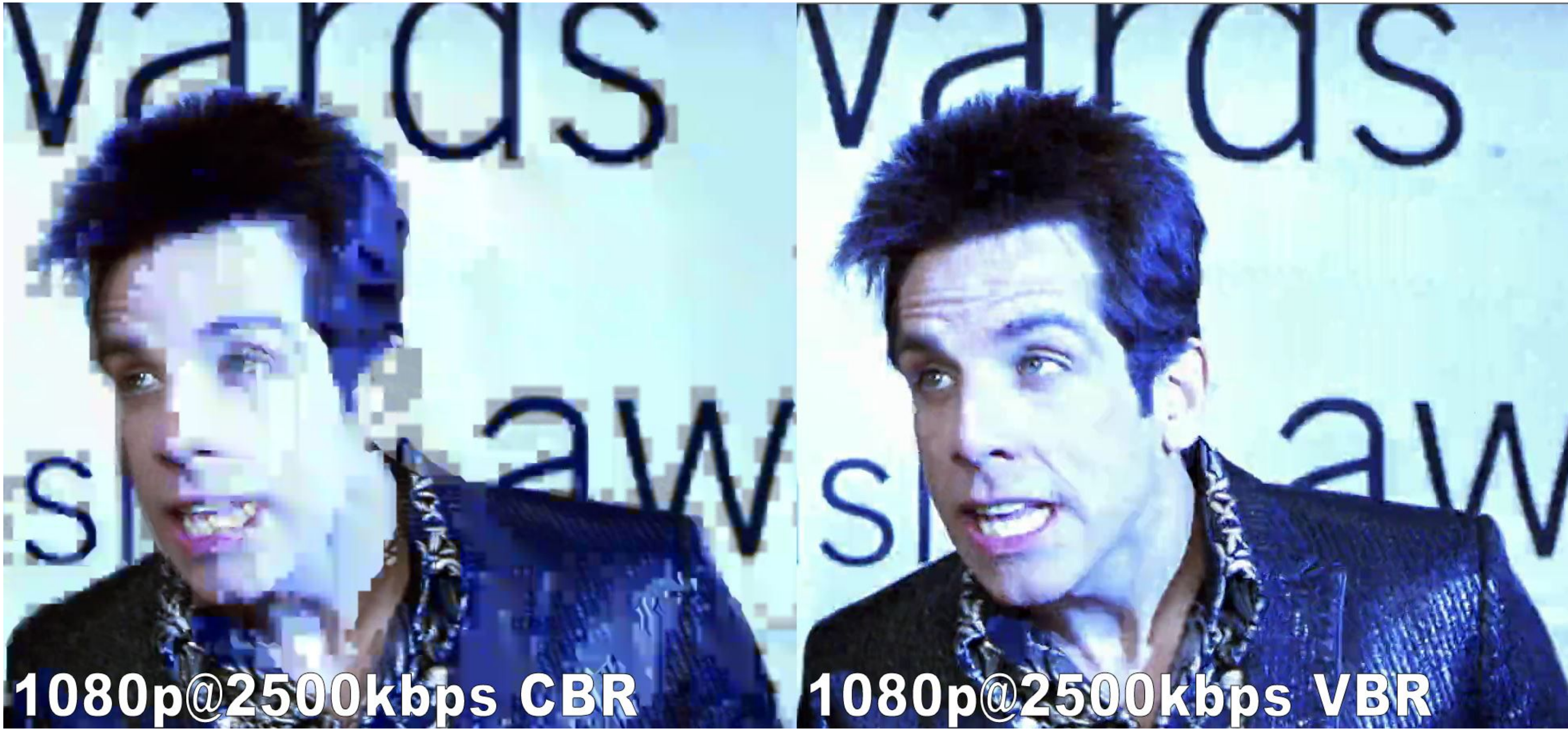
4846 kbps (250) (X)

MIN = 2587 kbps MAX = 8542 kbps AVG = 5007 kbps FRAMES = 14400
1920 × 1080, NTSC 29.97 fps (294.79 MiB)

- CBR - not flat line
  - Peak is 5295
  - Much less variability
  - Lower overall quality (not much)
  - Can show transient quality issues

- Two-pass ABR
  - Poor data rate control
  - Better overall quality

CBR Can Show Transient Quality Issues



- http://bit.ly/vbr_not_cbr

Setting Data Rate-Constrained VBR

```
ffmpeg -y -i  Test_1080p.MOV -c:v libx264  -b:v 5000k -pass 1  -f mp4 NUL && \
(same)

ffmpeg -i  Test_1080p.MOV -c:v libx264  -b:v 5000k -maxrate  10000k -bufsize 10000k
-pass 2  Test_1080p_200p_CVBR.mp4

ffmpeg -i  Test_1080p.MOV -c:v libx264  -b:v 5000k -maxrate  5500k -bufsize 5000k
-pass 2  Test_1080p_110p_CVBR.mp4
```

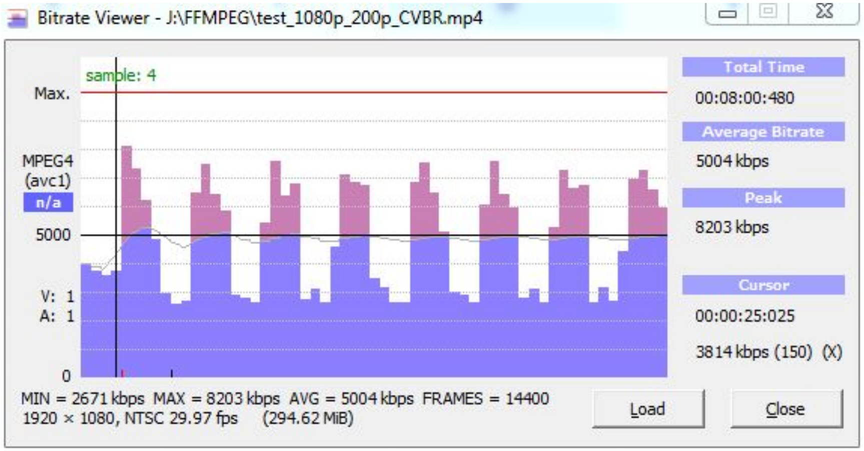
Line 2: 200% Constrained VBR

- `- maxrate 10000k` - 200% of target
- `- bufsize 10000k` - VBV buffer set to two seconds of video (more variability)

Line 2: 110% Constrained VBR

- `- maxrate 5500k` - 110% of target
- `- bufsize 10000k` - VBV buffer set to one second of video (less variability)

Setting Data Rate-Constrained VBR



Bitrate Viewer - J:\FFMPEG\test_1080p_200p_CVBR.mp4

Total Time: 00:08:00:480

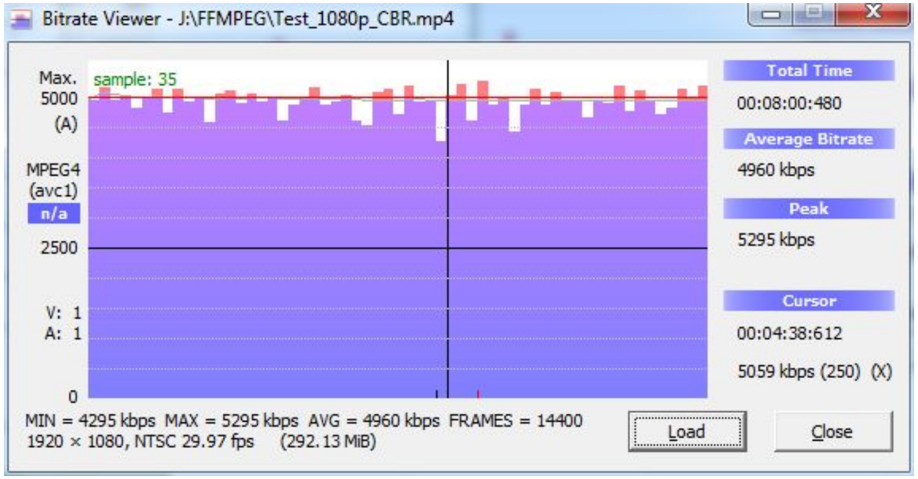
Average Bitrate: 5004 kbps

Peak: 8203 kbps

Cursor: 00:00:25:025

3814 kbps (150) (X)

MIN = 2671 kbps MAX = 8203 kbps AVG = 5004 kbps FRAMES = 14400
1920 × 1080, NTSC 29.97 fps   (294.62 MiB)



Bitrate Viewer - J:\FFMPEG\Test_1080p_CBR.mp4

Total Time: 00:08:00:480

Average Bitrate: 4960 kbps

Peak: 5295 kbps

Cursor: 00:04:38:612

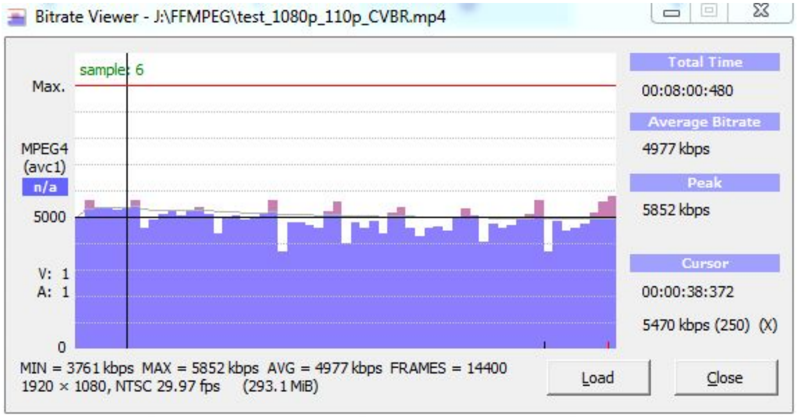
5059 kbps (250) (X)

MIN = 4295 kbps MAX = 5295 kbps AVG = 4960 kbps FRAMES = 14400
1920 × 1080, NTSC 29.97 fps   (292.13 MiB)

- 200% Constrained VBR - more stream variability
  - Slightly higher quality
  - Avoids transient problems
- Too much variability

- Peak is 5295
- Much less variability
- Lower overall quality (not much)
- Can show transient quality issues

Setting Data Rate-Constrained VBR



00:08:00:480

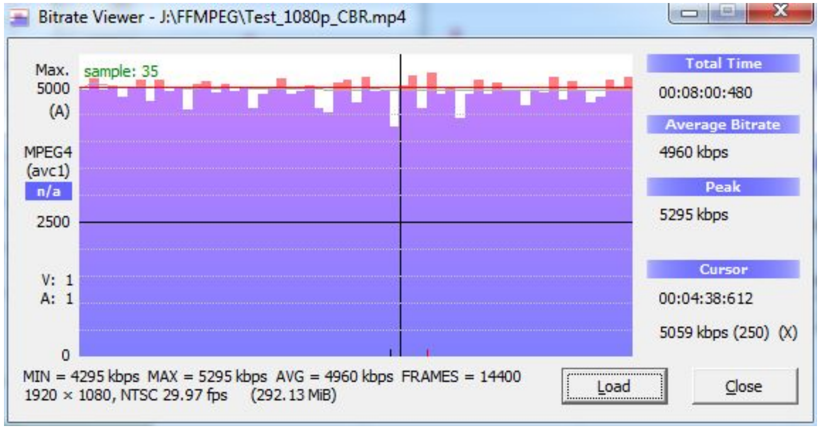
4977 kbps

5852 kbps

00:00:38:372

5470 kbps (250) (X)

MIN = 3761 kbps MAX = 5852 kbps AVG = 4977 kbps FRAMES = 14400
1920 × 1080, NTSC 29.97 fps (293.1 MiB)



00:08:00:480

4960 kbps

5295 kbps

00:04:38:612

5059 kbps (250) (X)

MIN = 4295 kbps MAX = 5295 kbps AVG = 4960 kbps FRAMES = 14400
1920 × 1080, NTSC 29.97 fps (292.13 MiB)

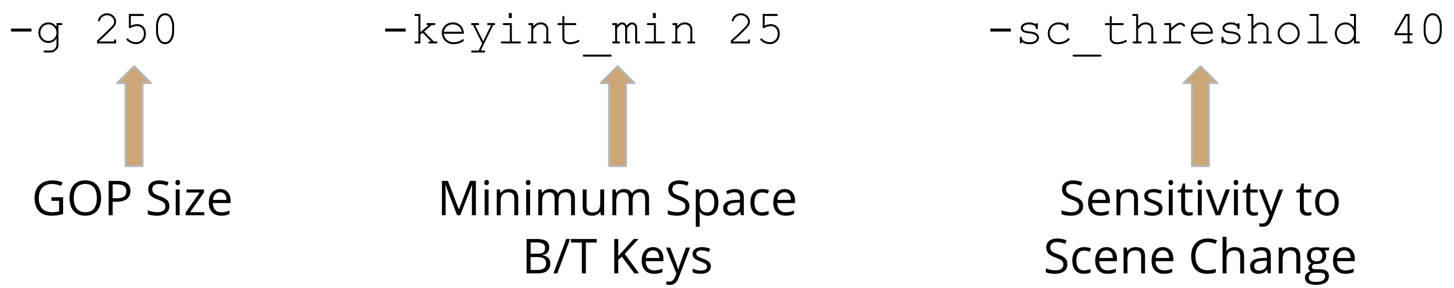
- 110 Constrained VBR
    - Slightly higher quality than CBR
    - Slightly higher peak
    - Avoids transient frame issues
    - More easily deliverable than 200% constrained
    -

- Peak is 5295
- Much less variability
- Lower overall quality (not much)
- Can show transient quality issues

Bottom Line

- Technique is pretty simple
- My tests
    - CBR delivers best QoE (http://bit.ly/BRC_QOE)
    - CBR can introduce transient quality issues (http://bit.ly/vbr_not_cbr)
    - Bottom line: recommend 110% Constrained VBR
        - Very deliverable
        - Avoids transient quality issues

Keyframe/Scene Change - Single File



`-g 250`

GOP Size

`-keyint_min 25`

Minimum Space
B/T Keys

`-sc_threshold 40`

Sensitivity to
Scene Change

- Default is:
  - Interval of 250
  - Scene change enabled
  - Minimum interval between 25
  - Sensitivity of 40
- Don’t have to do add anything; FFmpeg will deliver these defaults with or without entries

Key Frame/Scene Change - Single File

`-g 250`

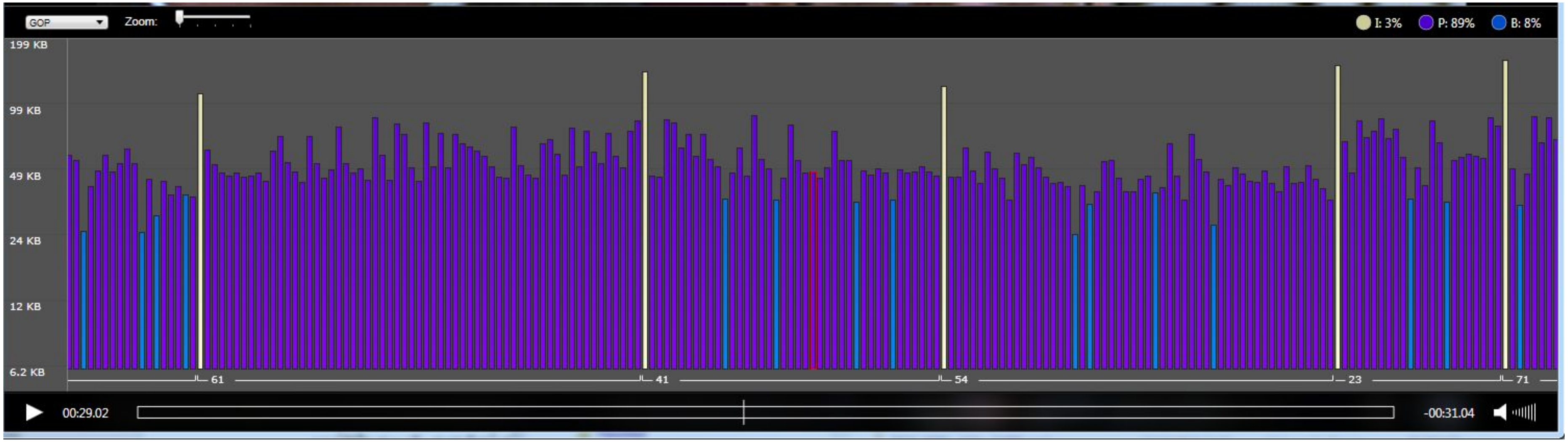
GOP Size

`-keyint_min 25`

Minimum Space B/T Keys

`-sc_threshold 40`

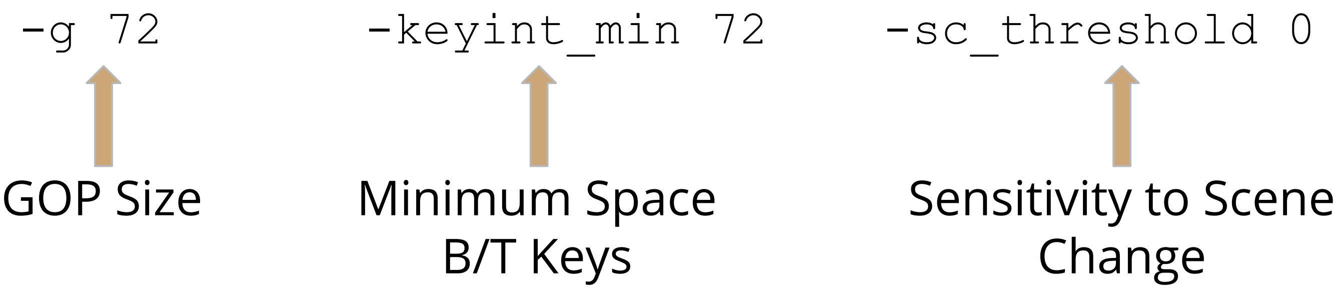
Sensitivity to Scene Change



Images from Telestream Switch

Irregular Keyframes

Key Frame/Scene Change - ABR - Alt 1



```
-g 72          -keyint_min 72     -sc_threshold 0
```

GOP Size

Minimum Space B/T Keys

Sensitivity to Scene Change

- ABR
  - Need smaller GOP so can switch to different streams much faster
  - Need consistent keyframe interval
    - Have to be at the start of all segments

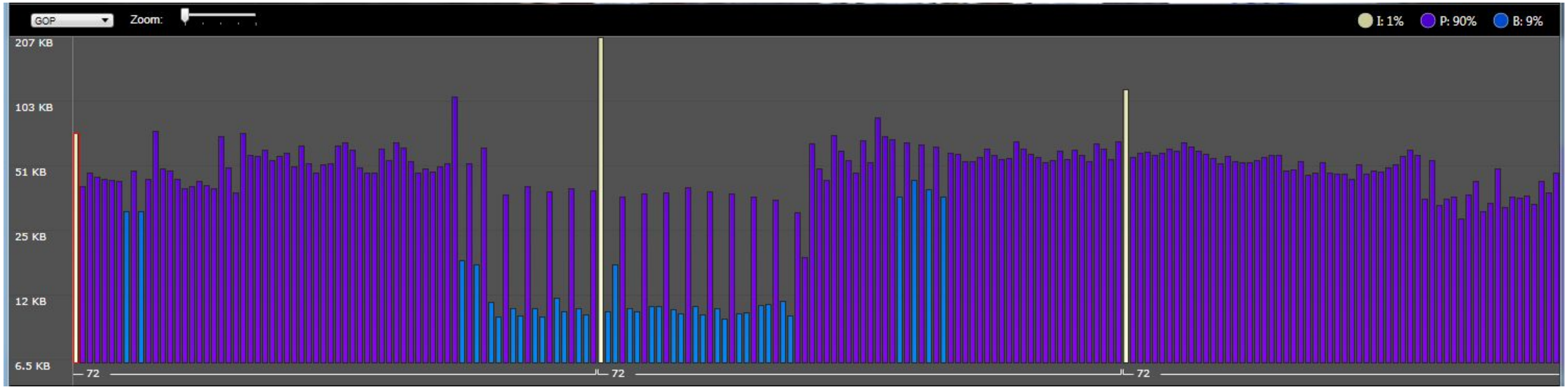
- GOP 72 (3 seconds)
  - 72 is about the longest; many use 2-seconds
  - Adjust for frame rate
- Minimum 72 e.g. no scene changes
- -sc_threshold 0 - no scene changes
- Need in Pass 1 and Pass 2

Key Frame/Scene Change - ABR - Alt 1

`-g 72` — GOP Size

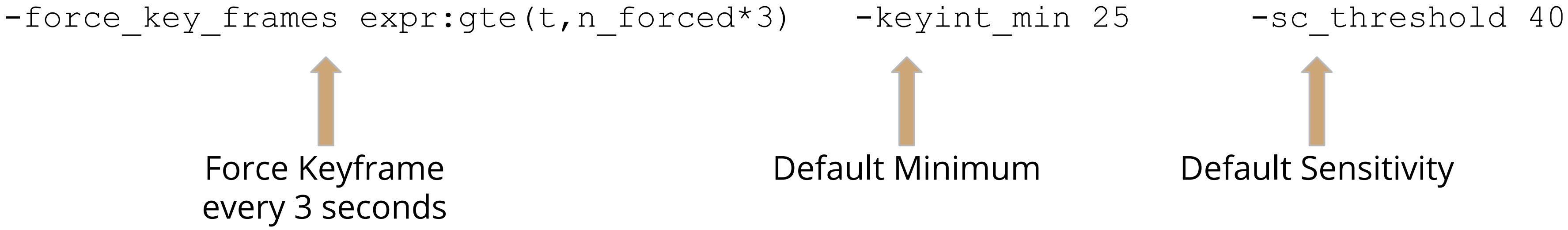
`-keyint_min 72` — Minimum Space B/T Keys

`-sc_threshold 0` — Sensitivity to Scene Change



Regular Keyframes but none at scene changes

Key Frame/Scene Change - ABR - Alt 2



```
-force_key_frames expr:gte(t,n_forced*3)    -keyint_min 25        -sc_threshold 40
```

Force Keyframe every 3 seconds

Default Minimum

Default Sensitivity

- Should deliver
  - Keyframe every 72 frames

- Second two are defaults
  - Don’t really need to be there

Key Frame/Scene Change - ABR - Alt 2

`-force_key_frames expr:gte(t,n_forced*3)`

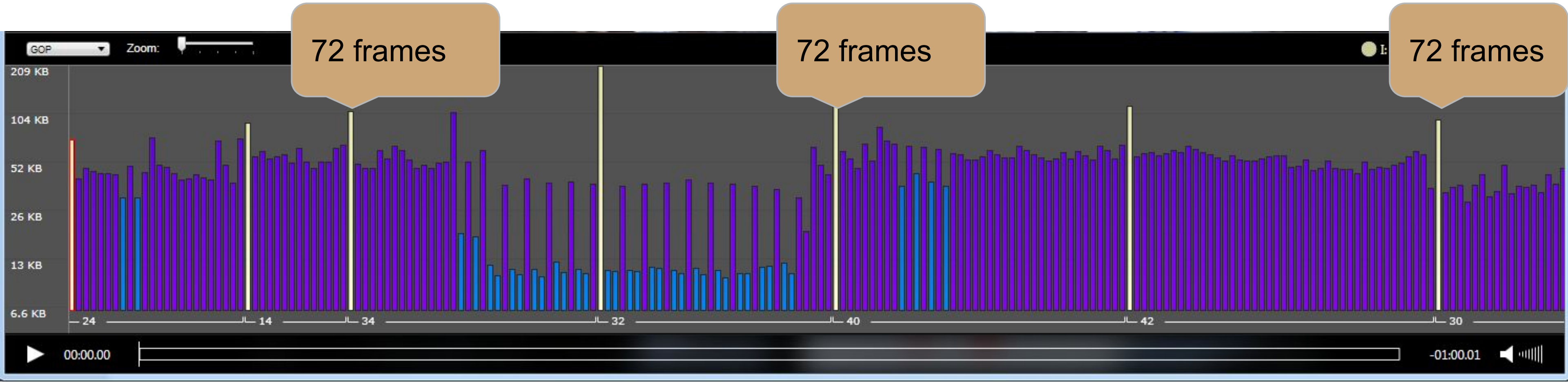
Force Keyframe every 3 seconds

`-keyint_min 25`

Default Minimum

`-sc_threshold 40`

Default Sensitivity



Regular Keyframes, and keyframes at scene changes

Which Alternative is Better?

Static (no scene change)

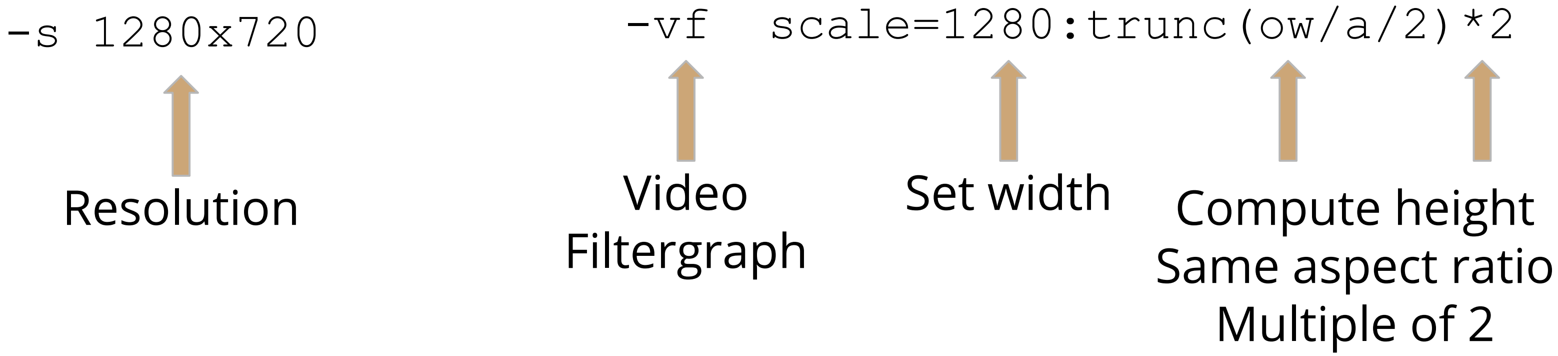
PSNR - 41.22207

Scene Change Detection

PSNR - 41.25565

.08% better

Resolution



```
-s 1280x720
```

Resolution

```
-vf  scale=1280:trunc(ow/a/2)*2
```

Video Filtergraph

Set width

Compute height
Same aspect ratio
Multiple of 2

Simple

- Default is same as original; if not changing resolution can leave out
- Set size directly
- Simple and easy
- Will distort if aspect ratio changes

More Complex

- More flexible approach
- Preserves aspect ratio
- Makes sure height is multiple of 2 (mod 2)
  - If odd value can cause encoding problems

Frame Rate

```
-r 12
```

- Don’t need to include
  - Default is use source frame rate
  - Typically used to cut frame rate on lower quality streams
    - 480x270@12 fps

Profile/Level

```
-profile:v Baseline, Main or
              High
     -profile:v Baseline
```

- Default is High; need to use baseline for files created for Android and older iOS devices

```
-level:v number
 -level:v 4.2
```

- Use when encoding for constrained devices (mobile)
- Simply inserts level in file metadata; does not restrict encode to level parameters

x264 Preset/Tuning

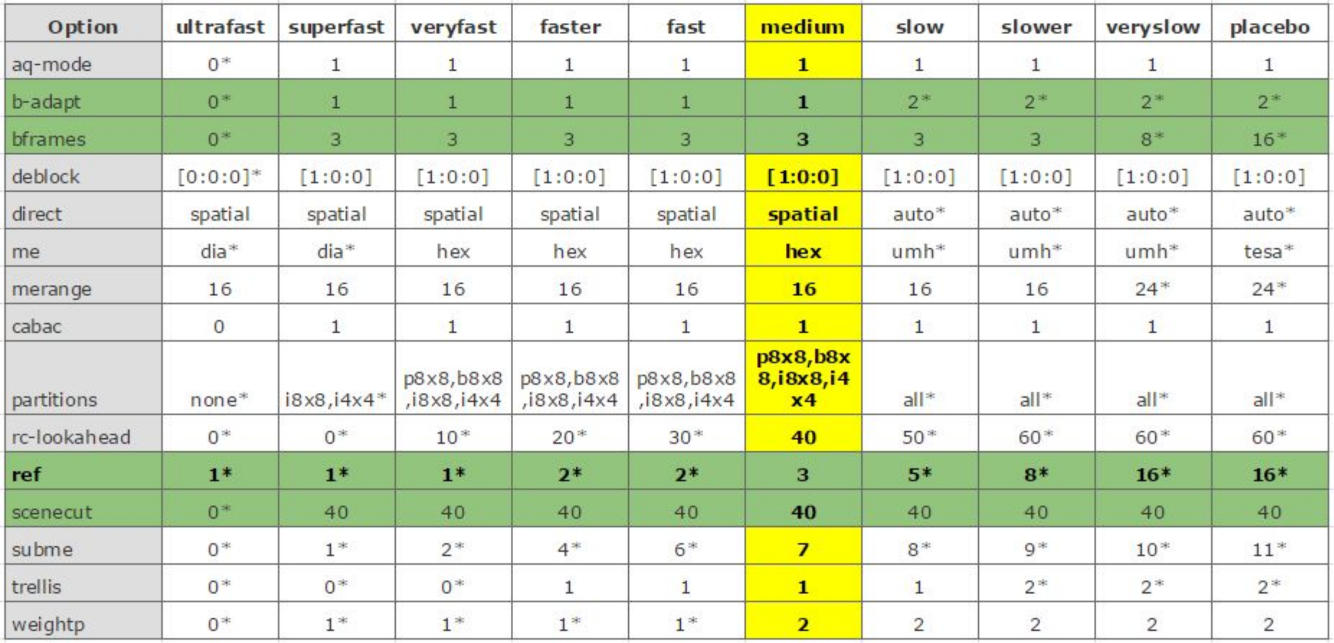
```
-preset preset name (slow)
      - preset slow
```

- x264 has collections of encoding parameters called presets
    - Ultrafast to placebo
    - Trade encoding speed against quality (see next page)
- Default is medium - if no entry, medium parameters are applied

```
-tune tune name (animation)
     - tune animation
```

- Tune encoding parameters for different footage types
    - Animation, film, still images, PSNR, SSIM, grain
- My experience - animation works pretty well, the rest not so much
- Default is no tuning

x264 Preset



Option	ultrafast	superfast	veryfast	faster	fast	medium	slow	slower	veryslow	placebo
aq-mode	0*	1	1	1	1	**1**	1	1	1	1
b-adapt	0*	1	1	1	1	**1**	2*	2*	2*	2*
bframes	0*	3	3	3	3	**3**	3	3	8*	16*
deblock	[0:0:0]*	[1:0:0]	[1:0:0]	[1:0:0]	[1:0:0]	**[1:0:0]**	[1:0:0]	[1:0:0]	[1:0:0]	[1:0:0]
direct	spatial	spatial	spatial	spatial	spatial	**spatial**	auto*	auto*	auto*	auto*
me	dia*	dia*	hex	hex	hex	**hex**	umh*	umh*	umh*	tesa*
merange	16	16	16	16	16	**16**	16	16	24*	24*
cabac	0	1	1	1	1	**1**	1	1	1	1
partitions	none*	i8x8,i4x4*	p8x8,b8x8,i8x8,i4x4	p8x8,b8x8,i8x8,i4x4	p8x8,b8x8,i8x8,i4x4	**p8x8,b8x8,i8x8,i4x4**	all*	all*	all*	all*
rc-lookahead	0*	0*	10*	20*	30*	**40**	50*	60*	60*	60*
ref	**1***	**1***	**1***	**2***	**2***	**3**	**5***	**8***	**16***	**16***
scenecut	0*	40	40	40	40	**40**	40	40	40	40
subme	0*	1*	2*	4*	6*	**7**	8*	9*	10*	11*
trellis	0*	0*	0*	1	1	**1**	1	2*	2*	2*
weightp	0*	1*	1*	1*	1*	**2**	2	2	2	2

- Yellow - default
- Green - ones that you may adjust with

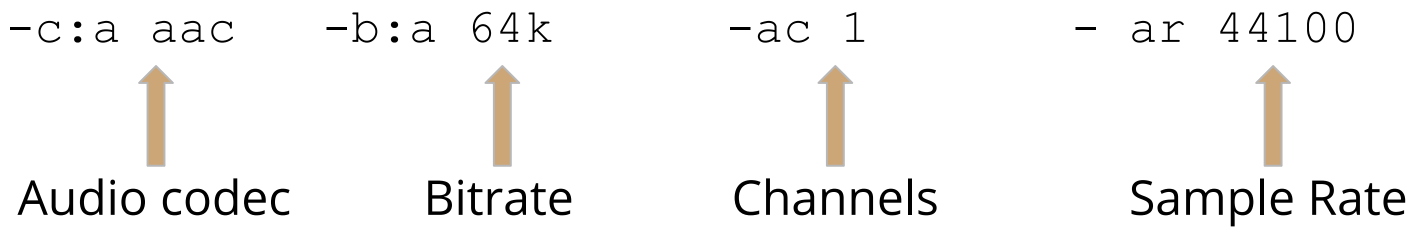
* - are differing values from medium.

excerpted from http://dev.beandog.org/x264_preset_reference.html

x264 Preset

- Medium is default; works well in most cases
- If capacity becomes an issue, consider switching to Faster
  - Slightly lower quality
  - 58% of encoding time

Audio



```
-c:a aac   -b:a 64k      -ac 1       - ar 44100
```

Audio codec

Bitrate

Channels

Sample Rate

- Default:
    - AAC for MP4
    - Channels: source
    - Sample rate: source
    - Data rate: inconsistent

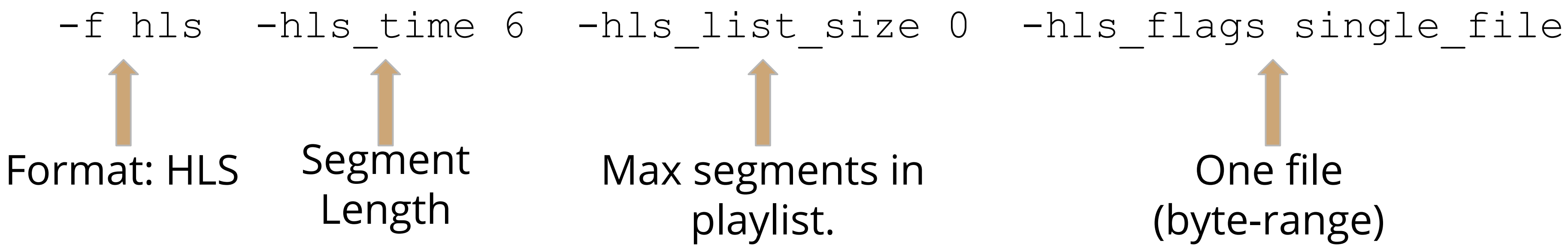
- HE, HE2 are different codecs
- Channels
    - 1 = mono
    - 2 - stereo

Multipass Encoding ABR Streams

- Can run first pass once, and apply to multiple encodes;
- **Can** reuse for different rez and bitrates
- **Can't reuse if change:**
  - frame rate
  - Keyframe interval
  - Profile

- Which config options must be in first pass?
  - Frame settings (B-frame/Key frame)
  - Target data rate
  - Some say audio settings
    - My tests haven't shown this is true

HLS Packaging



```
-f hls  -hls_time 6  -hls_list_size 0  -hls_flags single_file
```

Format: HLS

Segment Length

Max segments in playlist.

One file (byte-range)

- Format: Must be in first and second pass
- Segment length
    - Keyframe interval must divide evenly into segment size
    - Shorter improves responsiveness
- -HLS_list_size
    - Typically set to 0 which means all
- HLS_Flags
    - When single_file, one TS file with byte-range requests
    - When left out, individual .ts segments
- Creates individual .m3u8 files; you have to create master

HLS Command Line for Three Files

Pass 1:
```
ffmpeg -y -i Test_1080p.mov -c:v libx264 -s 1280x720 -preset medium -g 48
-keyint_min 48 -sc_threshold 0  -bf 3  -b_strategy 2 -b:v 3000k -c:a aac -b:a 128k -ac 2
-ar 48000 -pass 1  -f HLS -hls_time 6 -hls_list_size 0 -hls_flags single_file NUL && \
```

Pass 2:
```
ffmpeg -i Test_1080p.mov -c:v libx264 -preset medium -g 48 -keyint_min 48
-sc_threshold 0  -bf 3  -b_strategy 2   -b:v 7800k -maxrate 8600k -bufsize 7800k -c:a aac
-b:a 128k -ac 2 -ar 48000 -pass 2 -f hls -hls_time 6 -hls_list_size 0 -hls_flags single_file
Test_1080p.m3u8
```

Pass 2:
```
ffmpeg -i Test_1080p.mov -c:v libx264 -s 1280x720 -preset medium -g 48
-keyint_min 48 -sc_threshold 0  -bf 3  -b_strategy 2   -b:v 6000k -maxrate 6500k -bufsize
6000k -c:a aac -b:a 128k -ac 2 -ar 48000 -pass 2 -f hls -hls_time 6 -hls_list_size 0
-hls_flags single_file Test_720p_H.m3u8
```

Pass 2:
```
ffmpeg -i Test_1080p.mov -c:v libx264 -s 1280x720 -preset medium -g 48
-keyint_min 48 -sc_threshold 0  -bf 3  -b_strategy 2   -b:v 4500k -maxrate 5000k -bufsize
4500k -c:a aac -b:a 128k -ac 2 -ar 48000 -pass 2 -f hls -hls_time 6 -hls_list_size 0
-hls_flags single_file Test_720p_M.m3u8
```

HEVC Encoding

```
ffmpeg -y -i TOS_1080p.mov -c:v libx265 -preset slow-x265-params
profile=main:keyint=48:min-keyint=48:scenecut=0:ref=5:bframes=3:b-adapt=2:bitrate=4000
:vbv-maxrate=4400:vbv-bufsize=4000:pass=1 -an -f mp4 NUL && \

ffmpeg -i TOS_1080p.mov -c:v libx265 -preset slow  -x265-params
profile=main:keyint=48:min-keyint=48:scenecut=0:ref=5:bframes=3:b-adapt=2:bitrate=4000
:vbv-maxrate=4400:vbv-bufsize=4000:pass=2 -an TOS_1080p_h.mp4

ffmpeg -i TOS_1080p.mov -c:v libx265-s 1280x720 -preset slow  -x265-params
profile=main:keyint=48:min-keyint=48:scenecut=0:ref=5:bframes=3:b-adapt=2:bitrate=1000
:vbv-maxrate=1100:vbv-bufsize=1000:pass=2 -an TOS_720p_l.mp4
```

- Integrate x265 commands into FFmpeg

-x265-params – start of x265 commands, in x265 syntax

- http://x265.readthedocs.io/en/default/
- One string of commands, separated by colon, no spaces until finished

- Preset, an (audio no), format, and Null outside of this structure
- Scaling commands outside of –x265-params structure

Download free chapter - http://bit.ly/jo_freechap

Intro to Bento4

MP4 SWISS ARMY KNIFE: HLS & DASH

What can I do with Bento4?

https://www.bento4.com/

- HLS generation, including master manifests, stream level manifests, mpeg-2 ts files, and fMP4 (fragmented MP4)
- MP4 to fMP4 conversion
- DASH generation
- Parsing and multiplexing of H.264 and AAC streams
- Support for DRM (Marlin, PlayReady, Widevine and FairPlay).
- Support for H.264, H.265, AAC, AC3, eAC3, DTS, ALAC, and other codec types.
- Dual generation of HLS and DASH from fragmented MP4
- Atom/box editing, and stream/codec information
- A lot more… https://www.bento4.com/

Bento4 vs FFMPEG

- Bento4 focuses on MP4 based content: Packaging & Transmuxing
- FFMPEG is a broad spectrum tool for media conversion, encoding & packaging

HLS options

- Master playlists
- Single file output with byte range requests
- I-Frame only playlists
- AES encryption
- DRM
- Audio stream sidecar
- Subtitle sidecar
- fMP4

Create Multiple Bitrate Assets

```
mp4hls --hls-version 4 input_7000kb.mp4 input_5000kb.mp4 input_3500kb.mp4
```

Outputs:

Master.m3u8

Stream.m3u8 for each bitrate

Iframe.m3u8 for each bitrate

ts fragments for each bitrate

Multiple Audio Streams

```
mp4hls video.mp4 spanish_audio.m4a (different audio file)
```

```
mp4hls video.mp4 [+language=es]audio.m4a (multiplexed audio file, getting the
spanish stream)
```

Outputs:

Master.m3u8

Stream.m3u8 for video and audio

Iframe.m3u8 for video and audio

ts fragments

Audio.m3u8 and aac fragments

WebVTT Subtitles

```
mp4hls video.mp4 [+format=webvtt,+language=en]english.vtt
```

Outputs

Master.m3u8

Stream.m3u8

Webvtt manifest and .vtt file

Encryption and Single Segment

```
mp4hls --hls-version 4 --output-single-file --segment-duration 6
--encryption-mode AES-128 --encryption-key abaa09cd8c75abba54ac12dbcc65acd7
--encryption-url http://getmyKey?token=token video.mp4
```

Outputs

All HLS assets (master, stream with byterange requests, iframe, single ts file)

Assets are encrypted with AES-128, and encryption URL is added to the stream manifests

Segment duration will be set to 6 seconds, but will only segment at the closest i-frame

Dual HLS and DASH From fMP4

```
mp4fragment input.mp4 output.mp4 (converts mp4 to fmp4)
```

```
mp4dash --force --hls --no-split --use-segment-timeline output.mp4 (without
--no-split it will output .m4s segments)
```

Outputs

Master.m3u8

Audio.m3u8

Video.m3u8

Stream.mpd (DASH manifest)

Example master playlist for single bitrate

```
#EXTM3U

#EXT-X-VERSION:6

# Media Playlists

# Audio

#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="audio/mp4a",LANGUAGE="en",NAME="English",AUTOSELECT=YES,DEFAULT=YES,URI="audio-en-mp4a.m3u8"

# Video

#EXT-X-STREAM-INF:AUDIO="audio/mp4a",AVERAGE-BANDWIDTH=3454711,BANDWIDTH=4209761,CODECS="avc1.640020,mp4a.40.2",RESOLUTION=1280x720 video-avc1.m3u8
```

Other Info

- Bento will only segment at an i-frame
- Creates HLS assets faster than ffmpeg or shaka packager
- Gathers its metadata while segmenting, so codecs, average bandwidth, bandwidth, and resolution are automatically added to the manifests
- A full set of DASH and metadata options

List of all Bento4 binaries: https://www.bento4.com/

Cloud Encoding (The Server)

TIME FOR SYSADMIN

OVERVIEW

- Choose your Cloud:
  - AWS
  - Azure
  - RackSpace
  - IBM SoftLayer

- Or don’t (On-prem)

- Or a hybrid (e.g. - On-prem and S3)

SIZING YOUR SERVER

- General
  - What general bitrates are you dealing with?
- Live
  - How many concurrent live streams?
  - Are you also transcoding optional renditions for ABR?
- VOD
  - How many concurrent videos being processed?
  - Is it transcoding or just transmuxing?
  - Do you need to create sidecar assets?

OUR EXPERIENCE

- In AWS we’ve found m3.large to be a pretty cost effective, decently performant and reliable instance size
- We made our decision in Azure based on AWS and went with as similar a match we could find, DS2_V2
- We use Linux as our base since it’s friendlier with our software stack. Mostly RHEL.

STARTING POINT

- Get started with ec2 instances: http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EC2_GetStarted.html
- Get started with Azure VMs: https://azure.microsoft.com/en-us/documentation/articles/virtual-machines-linux-quick-create-portal/

GPU PIPELINE

Offload processing from CPU to dedicated hardware

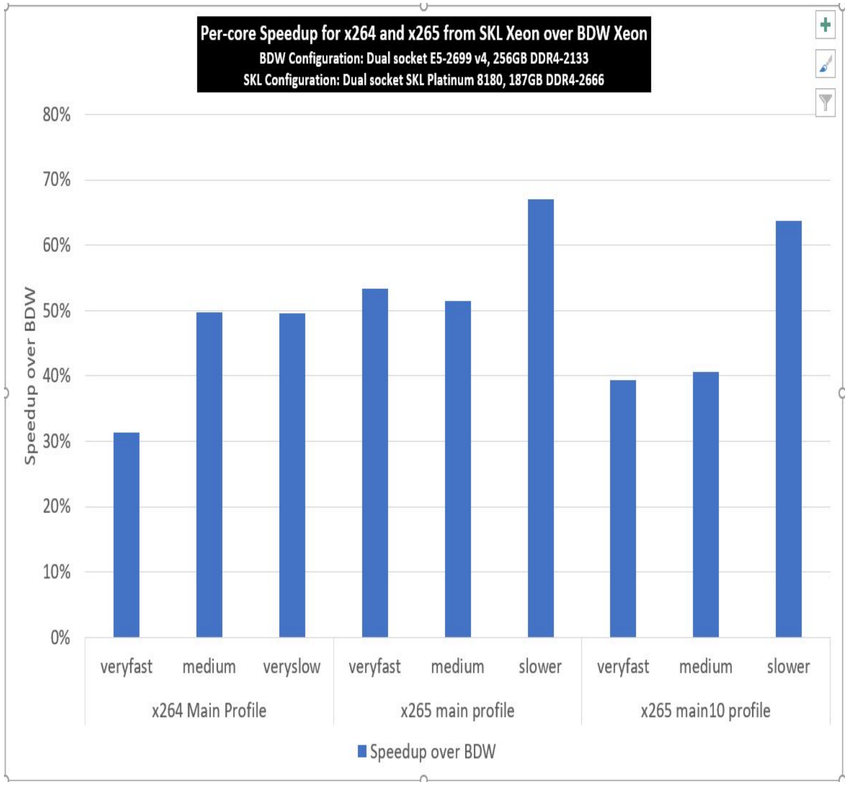
- FFmpeg has some support for GPU Acceleration
- You need to have specific supported hardware
  - Example: AWS EC2 g2.2xlarge + CUDA + FFmpeg with -hwaccel option specified

HEVC Live – Intel Scalable Processor Family

- x265 Boost from Intel Xeon Scalable Processor Family

- x265 show a 67% average per-core gain for encoding using HEVC Main profile

- 50% average gain with Main10 profile across different presets



GETTING THE SOFTWARE

You’ll need to download and install software

- Our preferred toolset:
  - **FFmpeg** (Video processing and Static Builds are easy install)
  - **Bento4** (Video packaging and MP4 manipulations)
  - **ImageMagick** (spritesheets, thumbnails and image manipulation)
  - **Node.js** (You need an application server wrapper)
  - **MongoDB** (You need some data persistence)
  - **Cloud Provider SDK** (e.g. AWS SDK for JavaScript in Node.js)

DIRECT LOADING

Getting started with FFmpeg

1. Select your static build: https://ffmpeg.org/download.html
2. Download, extract, and verify:

```
jheider@manage:~$ wget https://johnvansickle.com/ffmpeg/releases/ffmpeg-release-64bit-static.tar.xz

jheider@manage:~$ tar xf ffmpeg-release-64bit-static.tar.xz

jheider@manage:~$ cd ffmpeg-3.1.5-64bit-static/

jheider@manage:~/ffmpeg-3.1.5-64bit-static$ ./ffmpeg

ffmpeg version 3.1.5-static http://johnvansickle.com/ffmpeg/  Copyright (c) 2000-2016 the FFmpeg
developers
  built with gcc 5.4.1 (Debian 5.4.1-2) 20160904
```

Cloud Workflow

MAKING IT HAPPEN

DESIGNING A WORKFLOW - API

You need a good workflow architecture

- Similar to AWS Simple Workflow Service for logical and atomic chunks:
  - Workflow (End to End Execution)
  - Steps (Ingestion, Processing, Transfer)
  - Tasks (Create alternate bitrate rendition, Thumbnails)
  - Adapters (We added this to be agnostic.
    E.g. AWS S3 vs. Azure Blob vs. On-prem)

WORKFLOW: FILE TRANSFER

Try to leverage any performance enhancements available

- Day to Day Ingestion
    - AWS Multipart Upload
    - Azure Streaming Put a BlockBlob

- Initial Content Migration
    - AWS Import/Export Snowball
    - Azure Import/Export Service

WORKFLOW: QUEUE

Gracefully handle all your users

- Processing takes time. You need to line up requests.
- Queuing w/persistence also lets you keep track of job status and what’s pending in case of restart.

SAMPLE CODE

Check out the demo: https://github.com/realeyes-media/demo-encoder

- Here’s a snippet

```
input.inputOptions = options.inputOptions;
output.outputOptions = ["-hls_time 8", "-hls_list_size 0", "-bsf:v
h264_mp4toannexb", "-threads 0"];
input.inputURI = path.join(__dirname, '../../' + options.inputURI);
output.outputURI = directory + '/' + options.fileName + options.timestamp + '_' +
bitrate + '.' + options.outputType;
options.outputURI = output.outputURI;
output.outputOptions.push('-b:v ' + bitrate + 'k', '-r ' + options.fps);

// Use options to call ffmpeg executions in parallel
executeFfmpeg(input, output)
```

Scaling

TIME TO GROW

SCALING & CONCURRENCY

How high can we go?

- FFmpeg will not error when the CPU is busy, just takes longer to process.
- First - Determine the Scenario:
  - The volume of files you need to simultaneously process
  - The average size of the files you need to process
  - The processing time that’s acceptable for you org
  - The kinds of operations that need to occur (e.g. Just transmux? Transcode to 4 renditions?)
- Second - Run Performance Tests

SCALING - MULTIPLE INSTANCES

Bigger instance or more instances?

- Bigger Instance
  - PRO: Handles more concurrency
  - CONS: Can be more costly

- More Instances
  - PRO: Cheaper - Can be scaled up and down to only pay when needed
  - CONS: More complicated to manage

MULTI INSTANCE BALANCING

Scale Horizontally Transparently

- Clients hit a load balancer
- You can add more instances as needs grow in a transparent and simple way
- If your architecture is sound there’s no need for session stickiness between the clients and the transcoding system
- AWS Elastic Load Balancer: https://aws.amazon.com/elasticloadbalancing/
- Azure Load Balancing: https://azure.microsoft.com/en-us/documentation/articles/virtual-machines-linux-load-balance/

AUTO-SCALING

Leverage Auto Scaling Features

- Automate the spin up/down of instances based on a number of criteria:
  - Instance Load
  - Periodic Need for Faster Processing
  - Time of Day
  - Specific Events
- AWS Auto Scaling: https://aws.amazon.com/autoscaling
- Azure Auto Scale: https://azure.microsoft.com/en-us/documentation/articles/cloud-services-how-to-scale-portal/

CONTAINER SWARMS

Docker is all the rage. Swarms and Service Discovery

- Create a swarm of Docker containers for a highly repeatable processing server snapshot that utilizes system resources efficiently
- Further increase automation through service discovery
- Implement “auto scaling” on steroids
- AWS Elastic Container Service

Encoding and Review Demos

- Demo Encoder Demo
- Manifest Viewer Demo

Conclusion

THINGS TO TAKE AWAY

THANK YOU!

- Jan Ozer
  - Principal - Doceo Publishing
  - jozer@mindspring.com
  - @janozer

- Phil Moss
  - Senior Developer - RealEyes Media
  - phil@realeyes.com
  - http://bit.ly/realeyes2018 [Presentation Resources]