How Video Streaming Works?

Xiangbo Li

Nov. 7, 2018

Let us get some motivation…


NETFLIX

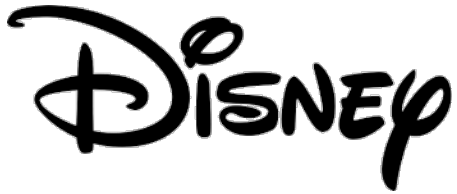

YouTube


amazon
Prime instant video


hulu


HBO GO


livestream


Disney


facebook


brightcove


BITMOVIN

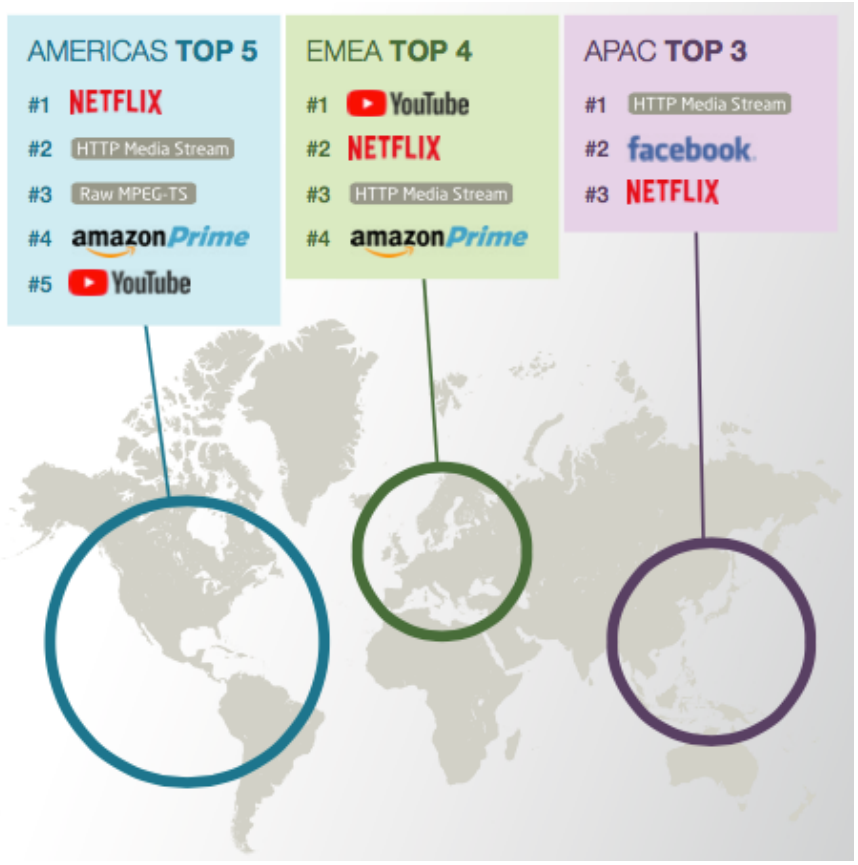

JWPLAYER


ELEMENTAL

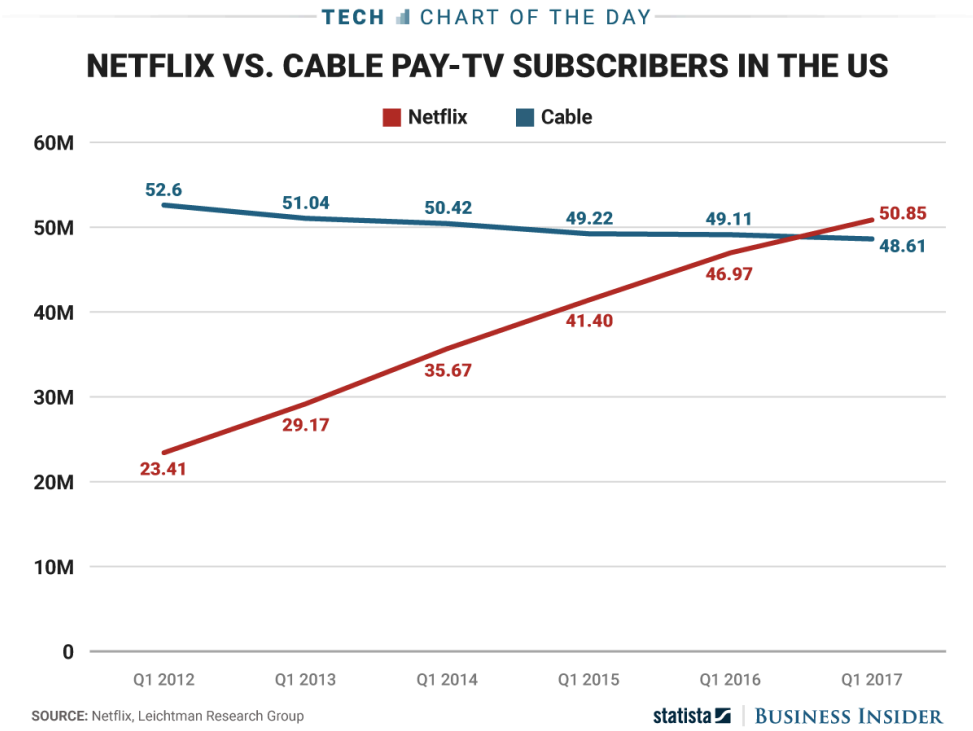

OOYALA


WOWZA
media systems

The Global Internet Phenomena Report, October 2018

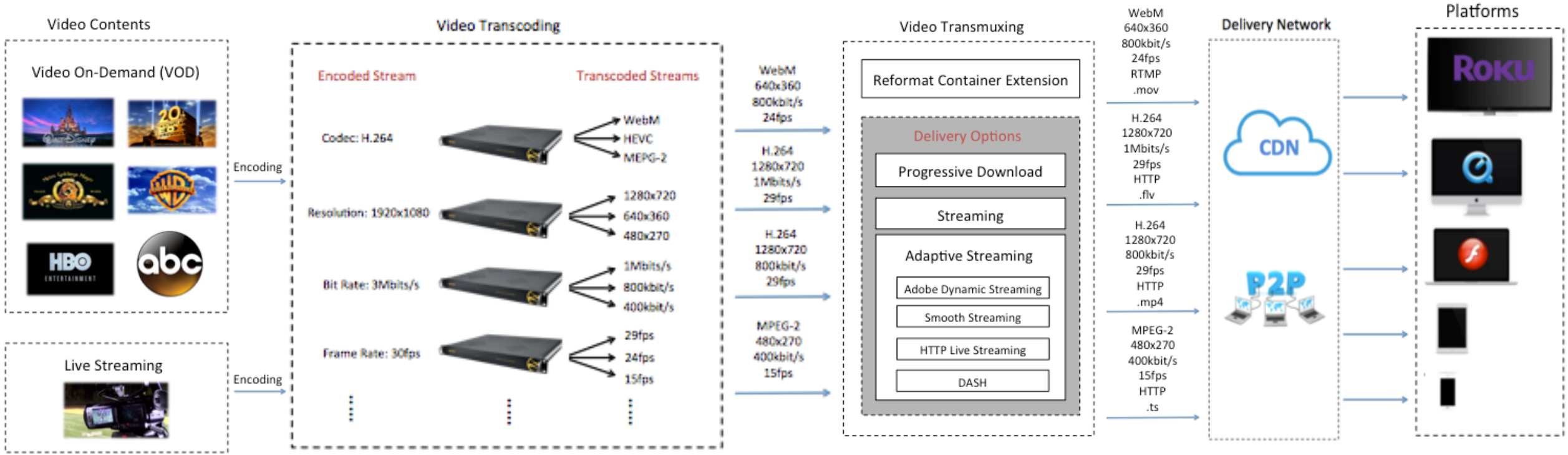


Video accounts for almost 60% Internet traffic



Streaming subscribers > Cable subscribers

So how video streaming works?


Video Contents
Video On-Demand (VOD)
HBO
abc
Live Streaming
Encoding
Encoding
Video Transcoding
Encoded Stream
Transcoded Streams
Codec: H.264
WebM
HEVC
MEPG-2
Resolution: 1920x1080
1280x720
640x360
480x270
Bit Rate: 3Mbits/s
1Mbits/s
800kbit/s
400kbit/s
Frame Rate: 30fps
29fps
24fps
15fps
WebM
640x360
800kbit/s
24fps
H.264
1280x720
1Mbits/s
29fps
H.264
1280x720
800kbit/s
29fps
MPEG-2
480x270
400kbit/s
15fps
Video Transmuxing
Reformat Container Extension
Delivery Options
Progressive Download
Streaming
Adaptive Streaming
Adobe Dynamic Streaming
Smooth Streaming
HTTP Live Streaming
DASH
WebM
640x360
800kbit/s
24fps
RTMP
.mov
H.264
1280x720
1Mbits/s
29fps
HTTP
.flv
H.264
1280x720
800kbit/s
29fps
HTTP
.mp4
MPEG-2
480x270
400kbit/s
15fps
HTTP
.ts
Delivery Network
CDN
P2P
Platforms
Roku

Topics

I. Video Encoding

II. Video Transcoding

III. Video Transmuxing/Packaging

IV. Digital Right Management (DRM)

V. Content Delivery Network (CDN) and P2P

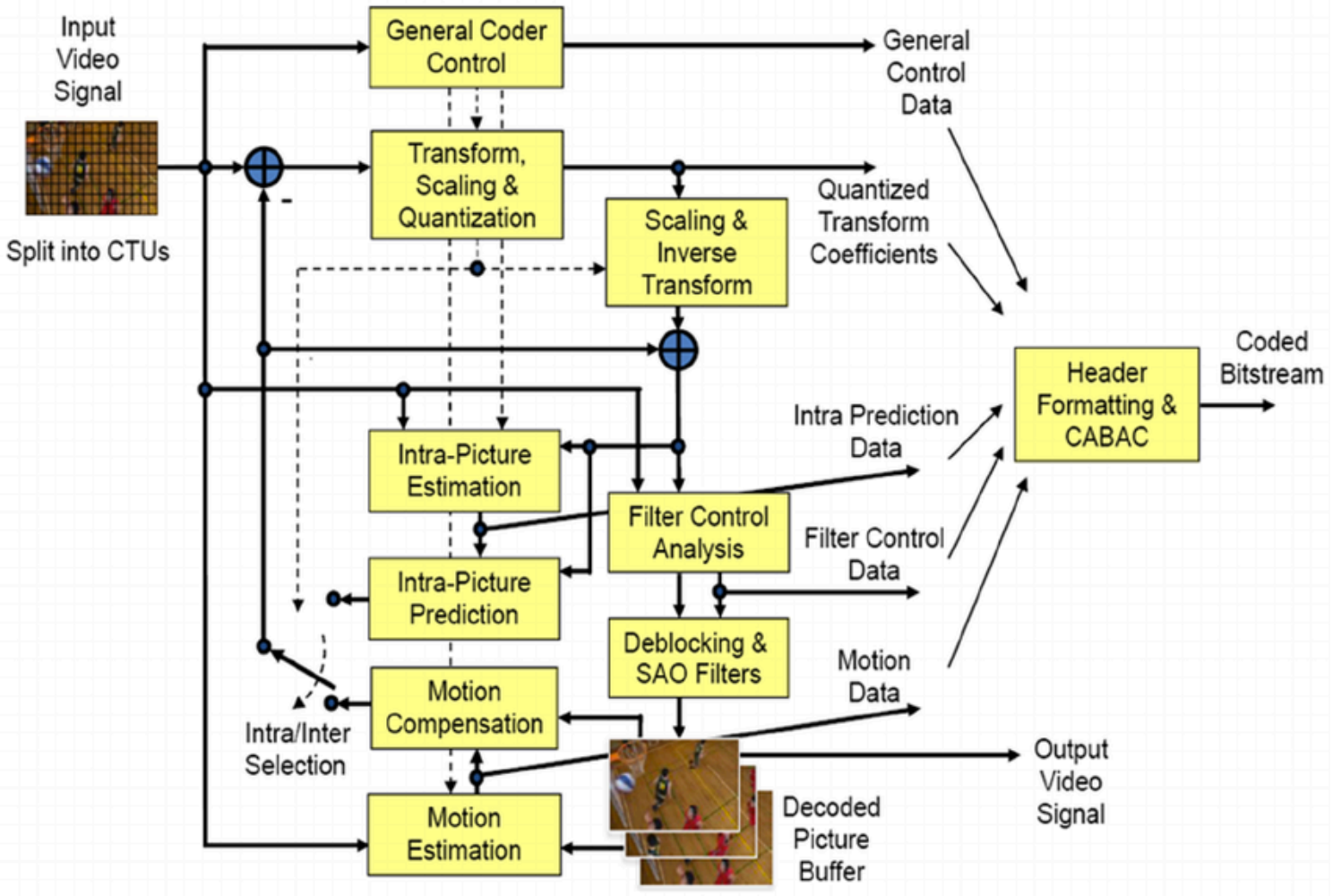
Why encode video?

$$\left(\frac{720\times1280\,pixels}{frame}\right)\left(\frac{60\,frames}{\text{sec}}\right)\left(\frac{3colors}{pixel}\right)\left(\frac{8bits}{color}\right)=1.3Gb/s$$

HDTV channel bandwidth: 20Mb/s

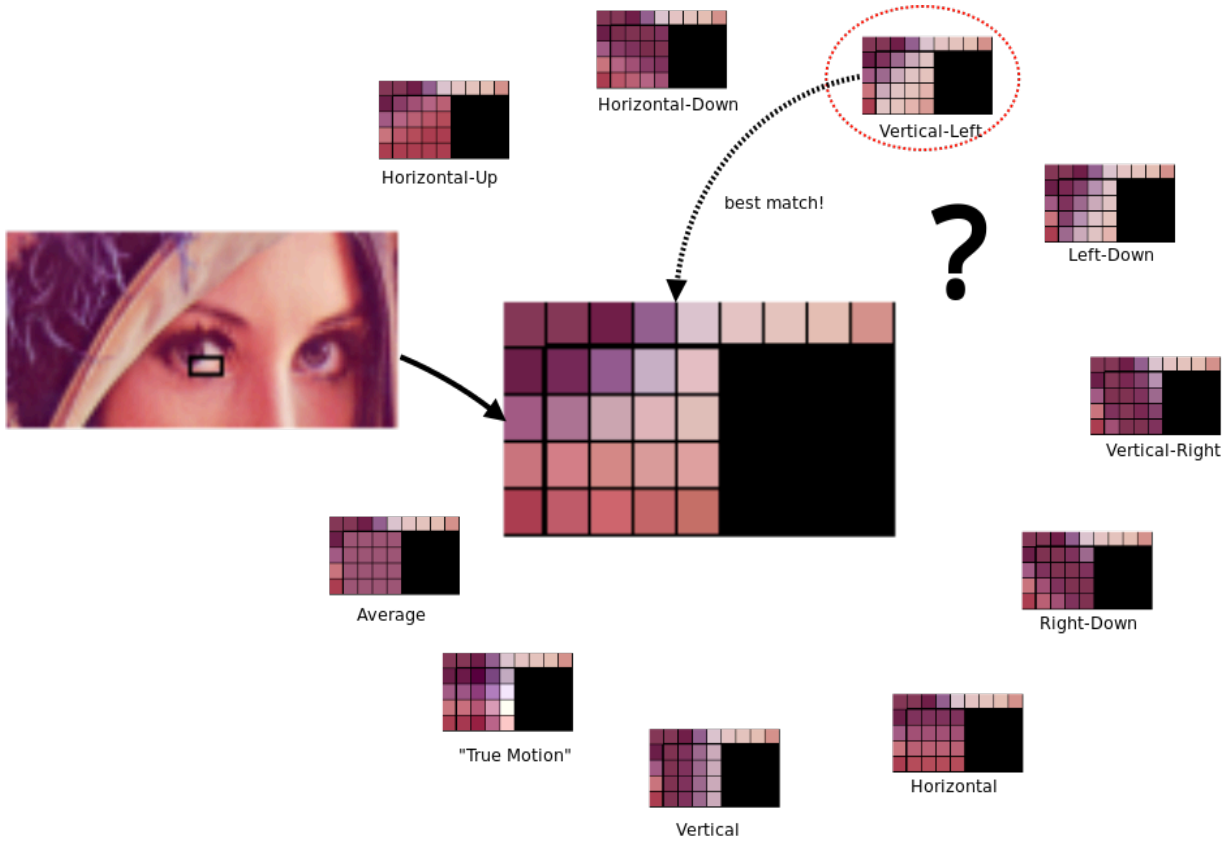
Common 720p video: 2GB

HEVC Encoder Architecture



- Intra Prediction
- Inter Prediction
- Transform & Quantization
- Entropy coding

Intra Prediction

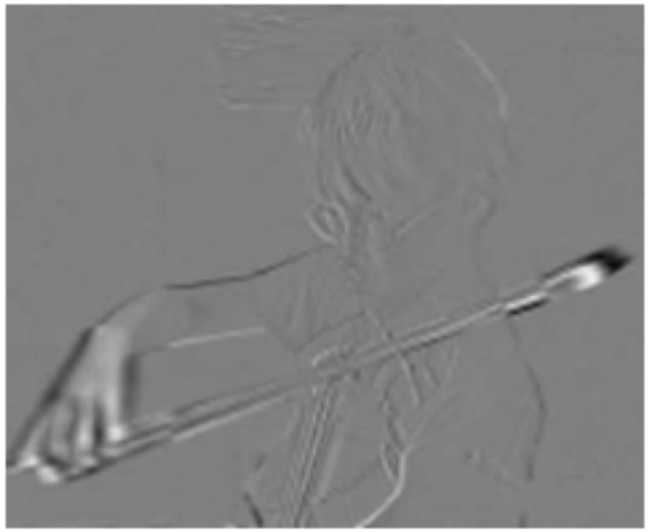


Remove spatial redundancy

Inter Prediction

Frame 2

Frame 1



Residue

Remove Temporal redundancy

Transform & Quantization

73 87 64 13 40 63 23 2 36 24 68 26 29 98 67 12 **Original block (4x4)**	181.3 47.4 –65.8 4.0 5.7 29.6 16.4 –2.2 40.3 18.3 –28.8 –13.8 13.1 –20.2 13.8 33.9 **Forward transform coefficients**
18 5 –7 0 1 3 2 0 4 2 –3 –1 1 –2 1 3 **Quantized coefficients (step size = 10)**	9 2 –3 0 0 1 1 0 2 1 –1 –1 1 –1 1 2 **Quantized coefficients (step size = 20)**

Entropy Coding

- Context-Adaptive Variable-Length Coding (VLC)
- Context-Based Adaptive Binary Arithmetic Coding (CABAC)
- GoLomb Coding

Why transcode video?

Video Codecs

MPEG2 video Codec

H.264 MPEG-4/AVC

H.265 HEVC

VP9

AV1

Client Devices

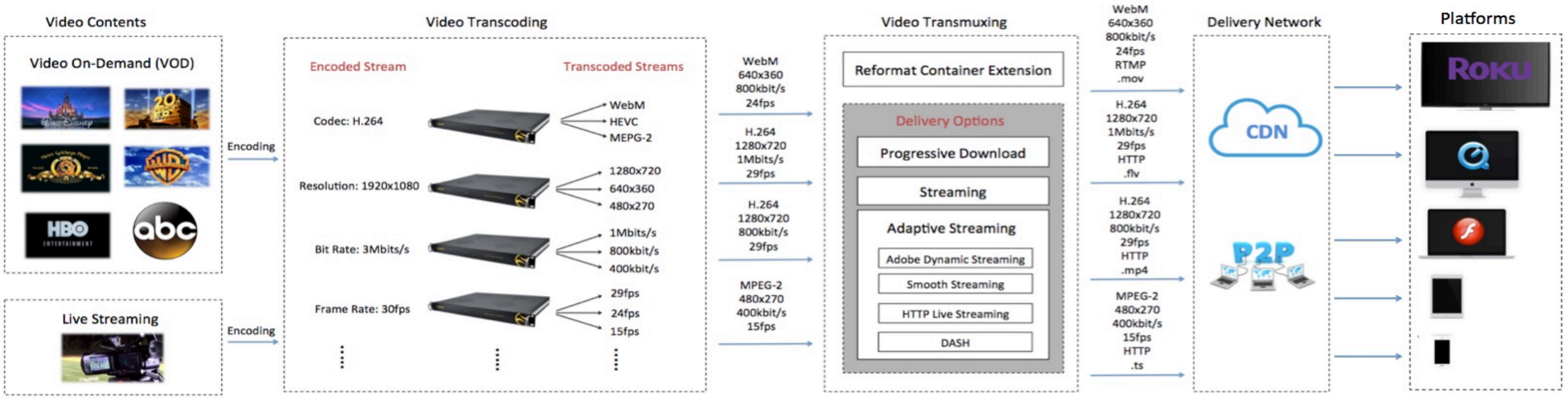
Network Bandwidth

Wifi

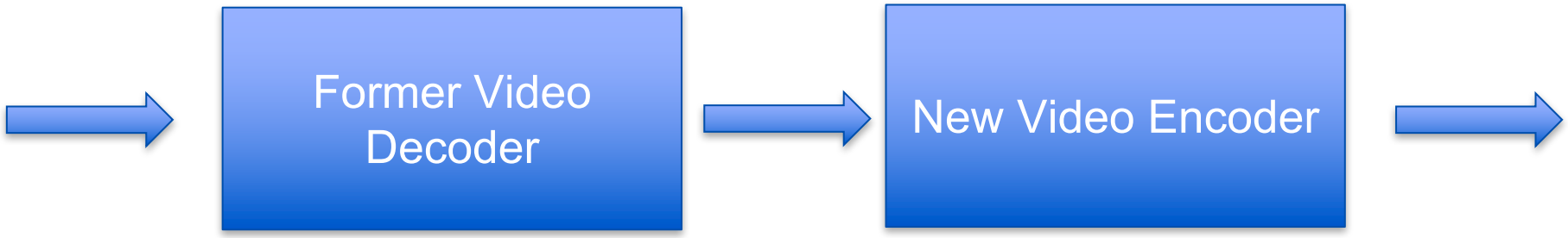
DSL

Google fiber

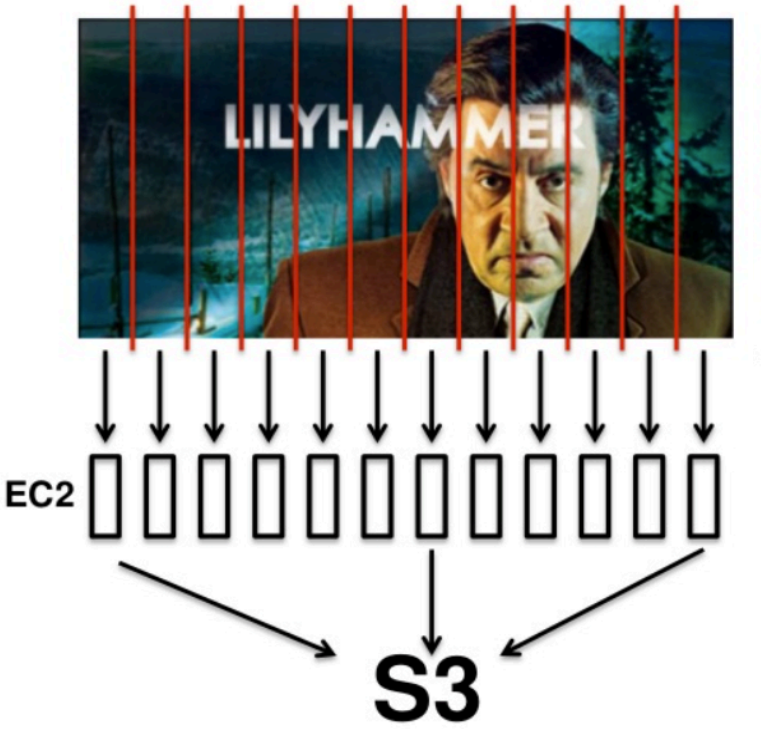
How Video Streaming Works?



2 codecs * 5 bit rate= 10



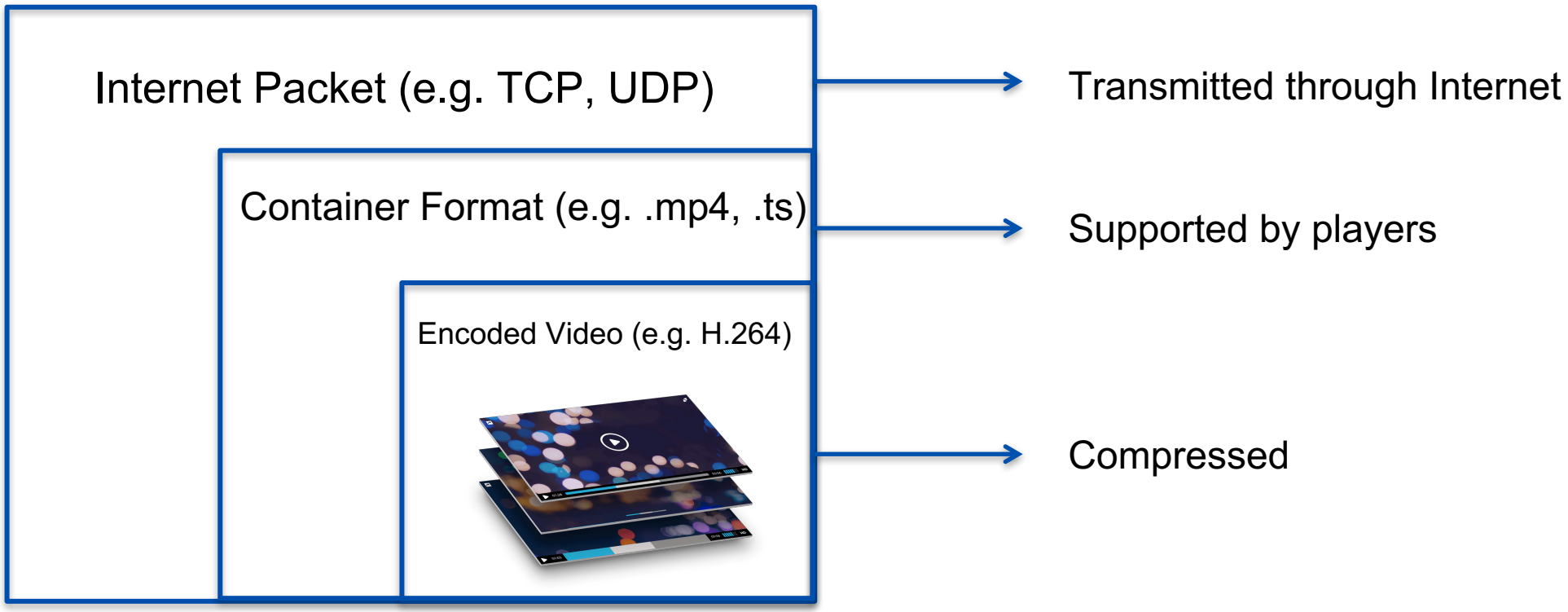
Video transcoding is computationally complex and time-consuming



- Traditional way takes **days** to transcode
- Cloud-based way only takes **hours/minutes**

Why transmux video?


The document "want-to-believe.avi" could not be opened. The movie is not in a format that QuickTime Player understands.
You may need to install additional software to open this type of file.
Tell Me More
OK

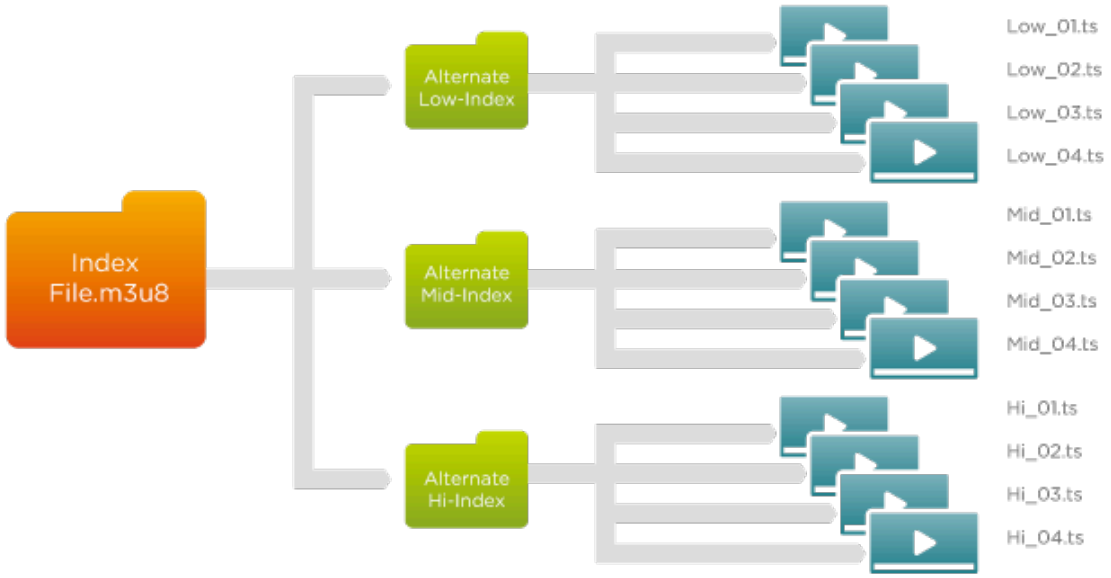

Internet Packet (e.g. TCP, UDP)
Container Format (e.g. .mp4, .ts)
Encoded Video (e.g. H.264)
Transmitted through Internet
Supported by players
Compressed

The evolution of streaming protocols…

Progressive Download

Streaming

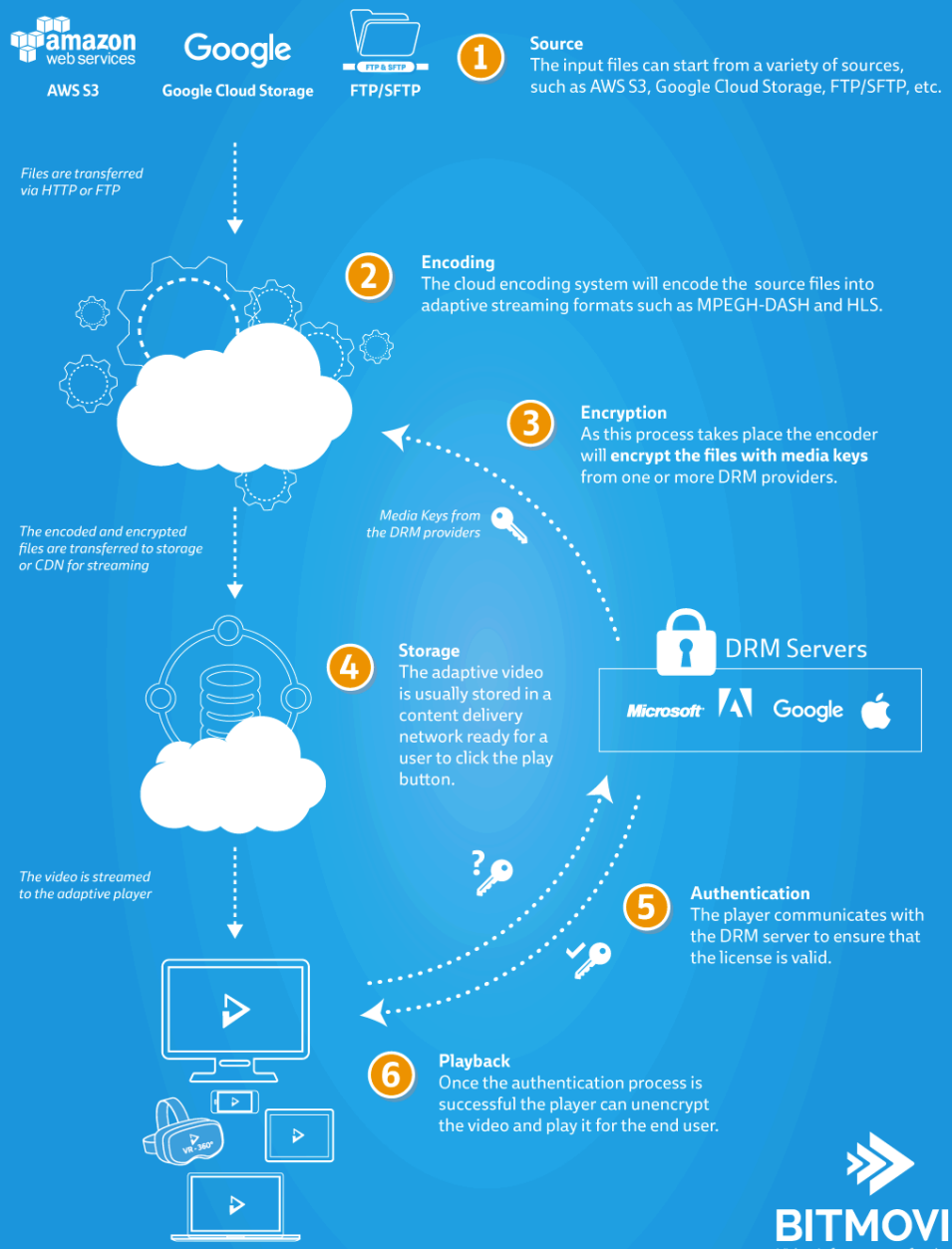
Adaptive Bitrate Streaming



	Desktop Player	Mobile Device Support	OTT Support
MPEG-DASH	dash.js, dash.as, GPAC	Windows, Android Phone	Google TV, Roku, Xbox 360
HTTP Dynamic Streaming (HDS)	Flash, AIR	Android/iOS(via AIR app)	None
Apple HTTP Live Streaming (HLS)	iOS, Mac OSX, Flash	iOS/Android3.0+	Apple TV, Boxee, Google TV, Roku
Smooth Streaming	Silverlight	Windows Phone	Google TV, Roku, Xbox 360

How to protect video?

How does DRM work?

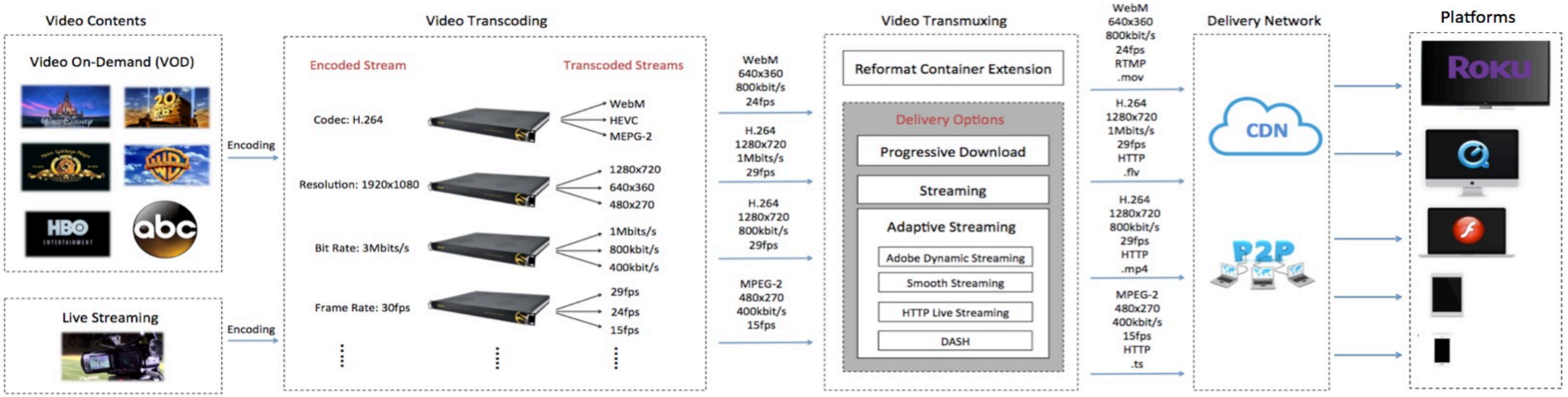


Google

Microsoft

Platform	Chrome	FireFox	IE 11	Safari	Android	iOS	Windows Phone	ChromeCast	Roku	Apple TV	Xbox
Fairplay				✓		✓				✓	
PlayReady			✓	✓			✓	✓	✓		✓
Widevine	✓	✓			✓			✓			

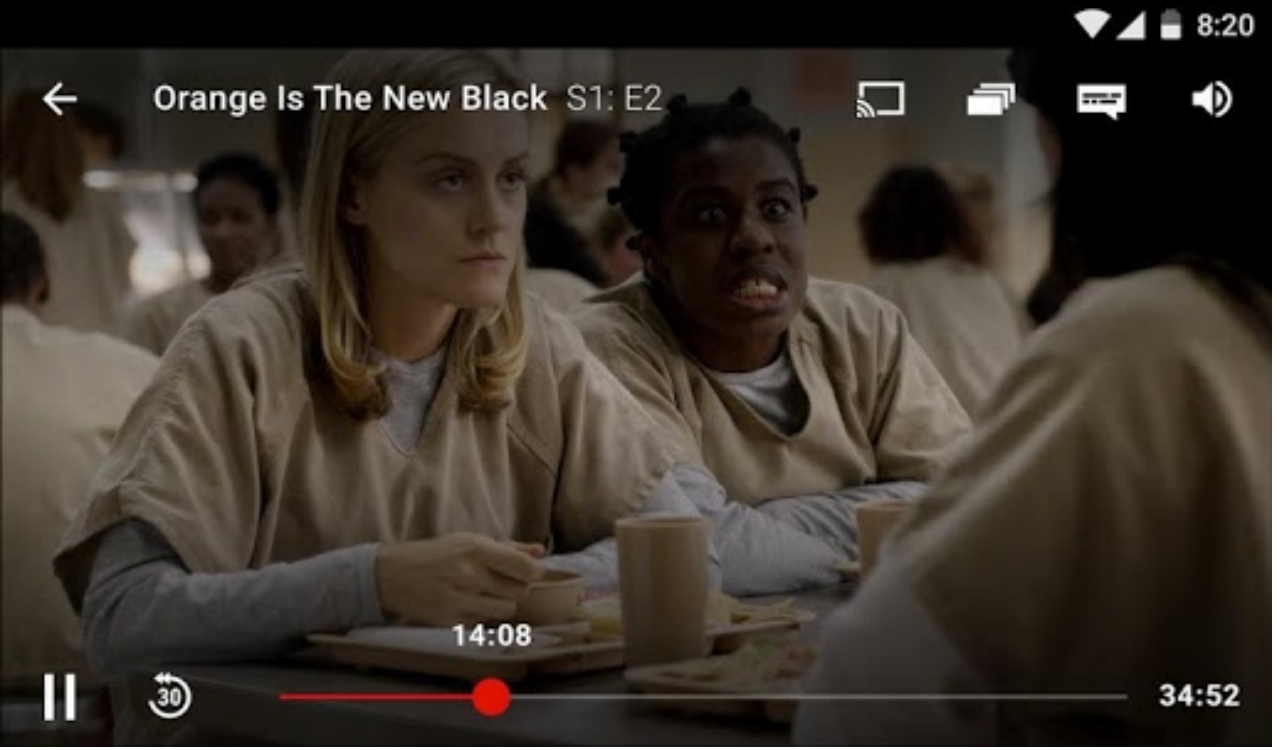
How Video Streaming Works?

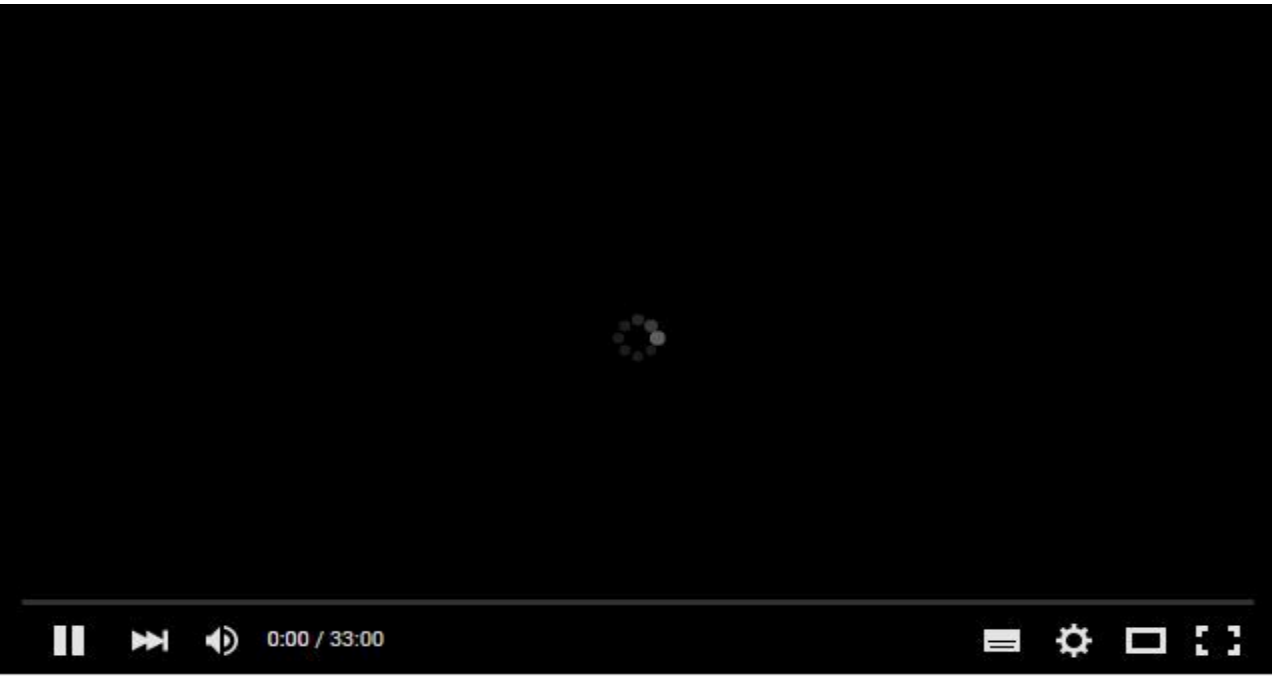


2 codecs * 5 bit rate= 10

10 * 3 protocols * 3 DRM = 90

Why Content Delivery Network (CDN)?



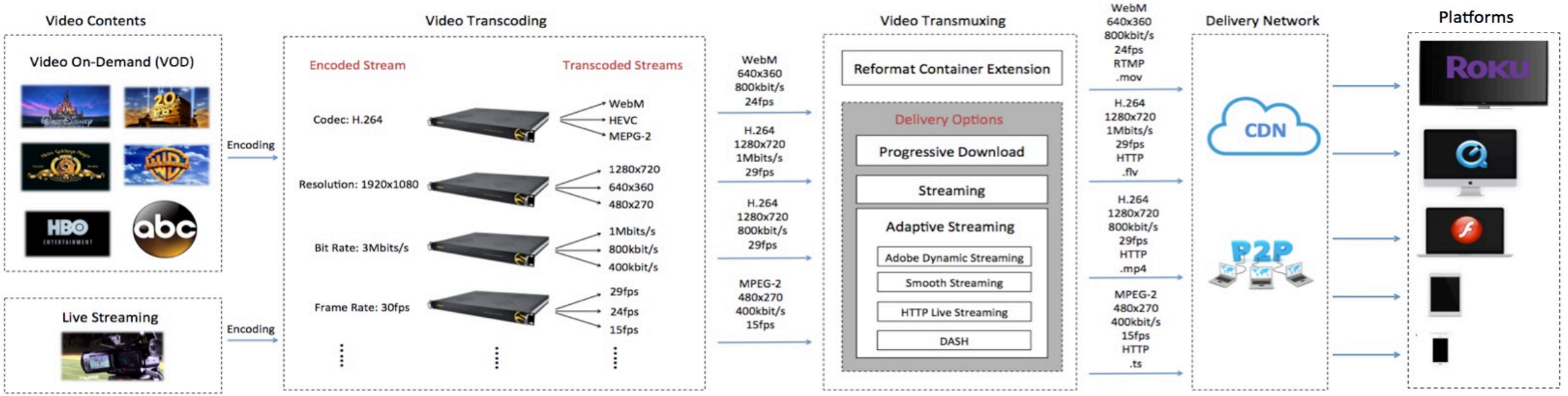


Customers in the US

Customers in Asia


CDN Provider A
CDN Provider B
CDN Provider C

How Video Streaming Works?



2 codecs * 5 bit rate= 10

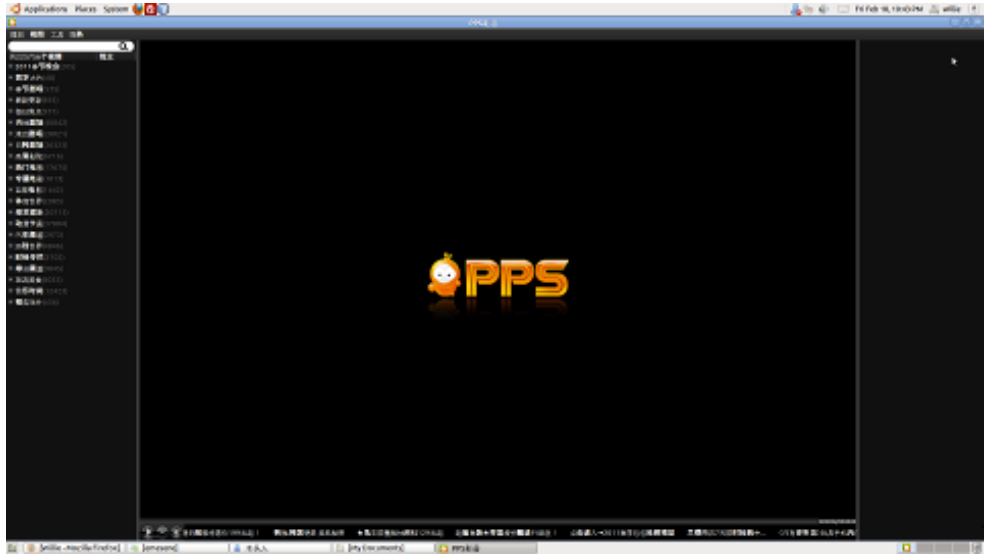
10 * 3 protocols * 3 DRM = 90

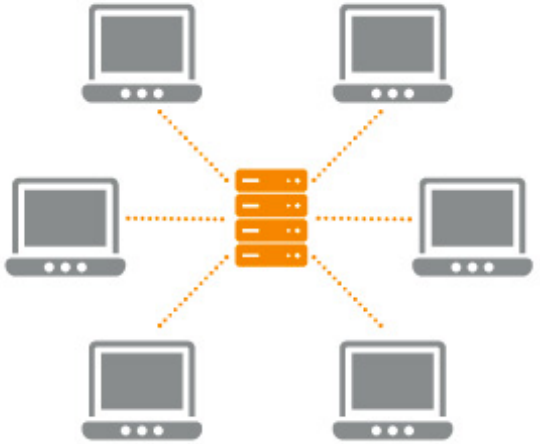
90 * 3 regional CDN = 270

Video is just cached, not stored forever…

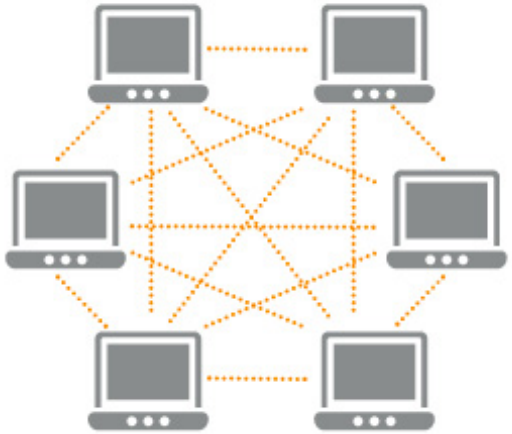
What is P2P then?

BitTorrent™



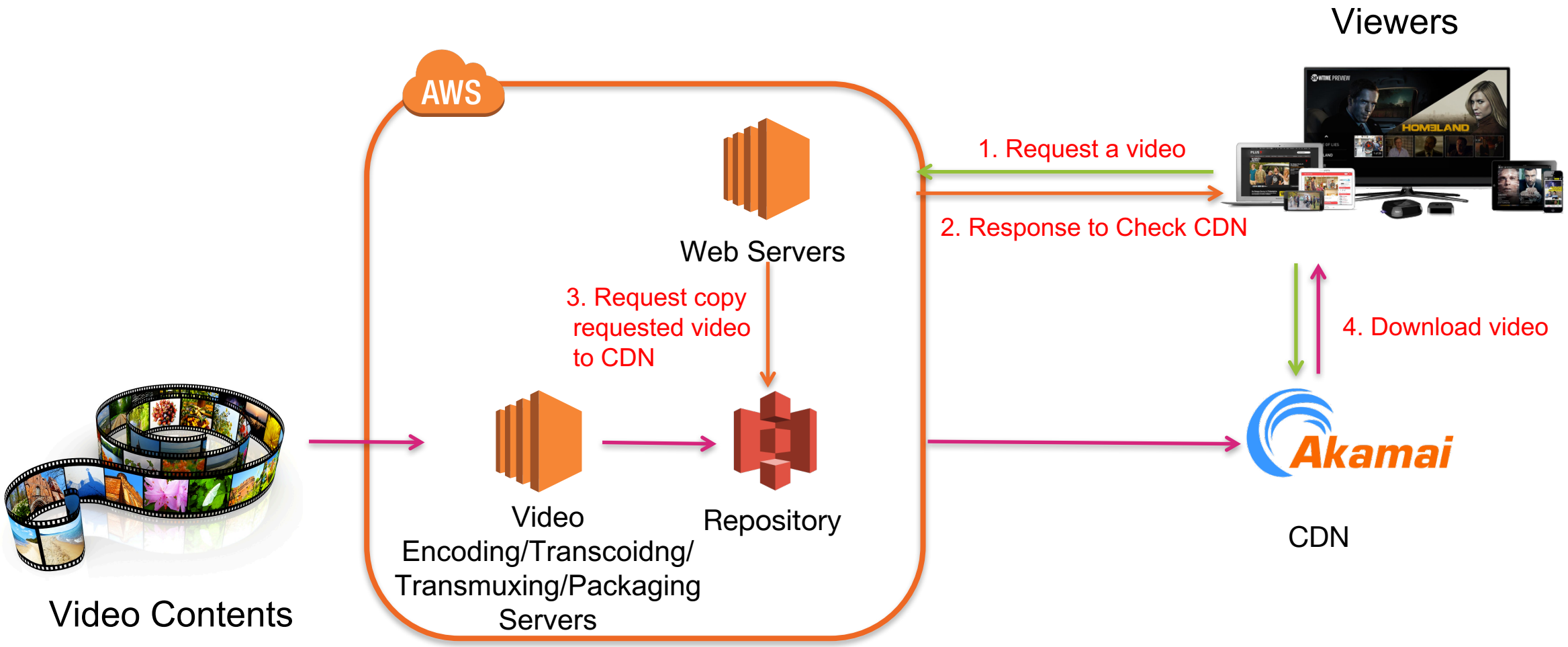


Server-Based



P2P

So how video streaming works?


Viewers
AWS
Web Servers
1. Request a video
2. Response to Check CDN
3. Request copy requested video to CDN
4. Download video
Video Encoding/Transcoidng/ Transmuxing/Packaging Servers
Repository
Akamai
CDN
Video Contents

Q & A