

NETFLIX

A Brief History of Netflix Streaming

May 2013

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Introduction

- Netflix started streaming in 2007 with IE-plugin hosting Windows Media Player
- Today, > 80 million active Netflix devices phones, tablets, game consoles, and TV's

Overview

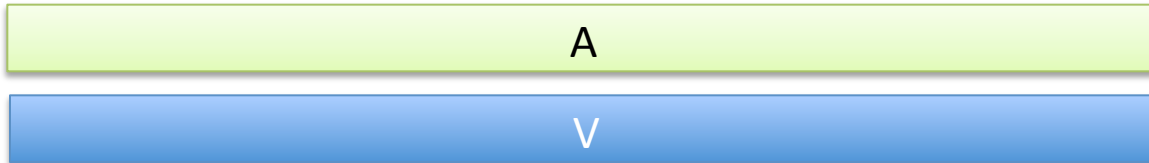
- Major milestones of our streaming evolution
- Key codec and packaging decisions
- The evolution of our adaptive streaming model
- How we did iPad in < 60 days
- Move to standards-based streaming

Terminology

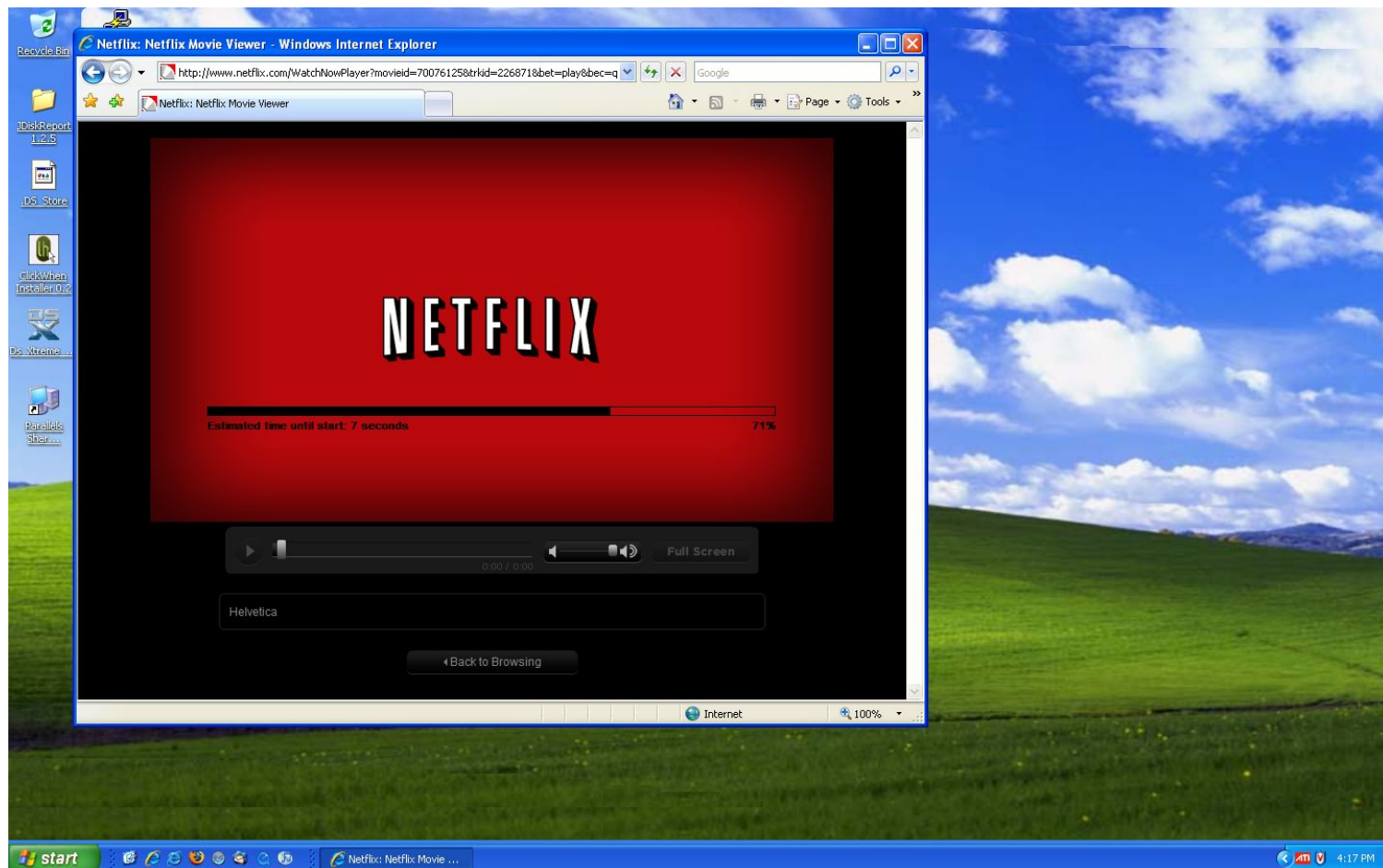
- Muxed (multiplexed) Stream: A/V interleaved in one stream



- Unmuxed (non-multiplexed) Stream: Separate A/V Streams

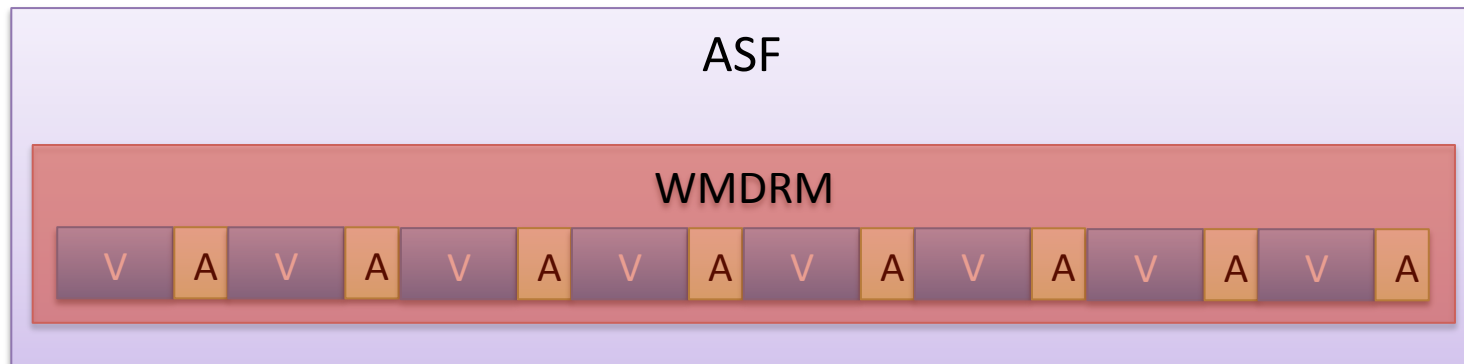


A Humble Beginning



The Streaming Client 1.0

- IE ActiveX Plugin
- Hosted Windows Media Player
- Muxed A/V: VC-1 Video, WMA Audio
- WMDRM
- ASF Container



CE 1 SDK



Microsoft and Netflix Unveil Partnership to Instantly Stream Movies and TV Episodes to the TV via Xbox LIVE

July 14, 2008

Exclusive agreement creates game-changing home entertainment experience; more than 10,000 movies and TV episodes will be available to watch instantly at no additional cost to paying subscribers.

The Netflix Player by Roku

Support

The Player Easy Set Up Easy to Use FAQs Order Now

Netflix Now Gives You More:
Movies and TV Episodes
In Your Living Room

INSTANTLY.

instant streaming ready

NETFLIX

\$99.99
One-time purchase

Order Now

Small as a paperback book.
Fills any room with instant entertainment.
30-day money back guarantee

- Over 10,000 movies and TV episodes instantly
- No change in monthly Netflix costs and you continue to get your DVDs by mail
- Easily connects directly to your TV
- Pause, rewind or play anytime - just like a DVD
- Guaranteed to work with your TV

What's Being Said...

"The Netflix Player by Roku revolutionizes the way entertainment is delivered. It's the best new benefit a Netflix member could have."
Reed Hastings
CEO, Netflix

The Netflix Player

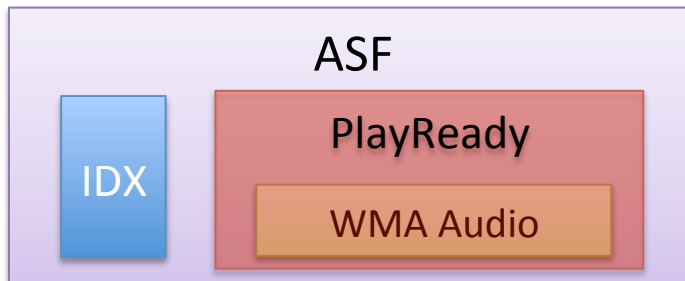
The Netflix Player makes it easy to instantly watch movies and TV episodes over the Internet on your living room TV, or anywhere you have a TV and an Internet connection. Compact and lightweight, inexpensive but powerful, simple to set up and use (it's the perfect answer for people who just can't get enough Netflix).

Choose Movies on Your TV

Movies and TV episodes in your Netflix Instant Queue appear right on your TV screen. Use the included remote control to browse through the items you've added to your Instant Queue and pick something to watch —

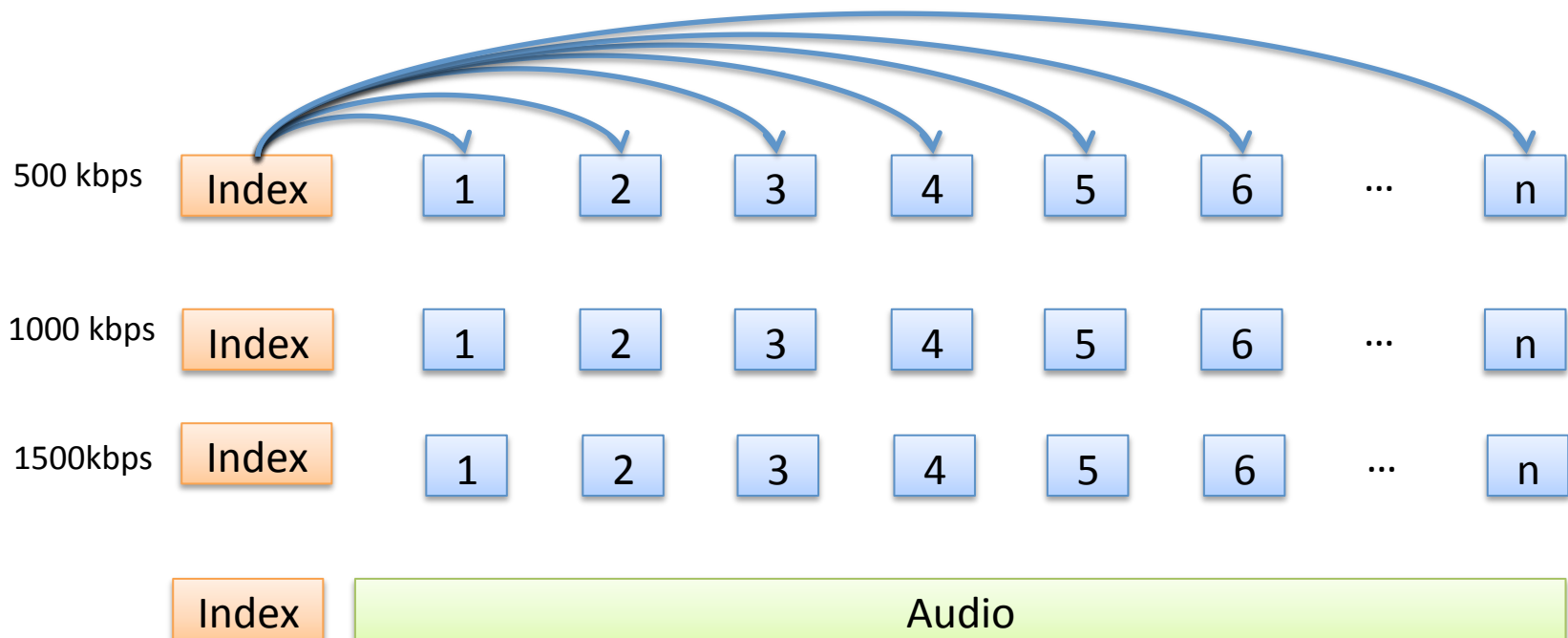
The Silverlight Player

- PC/Mac
- A/B Testing
- Adaptive Streaming
- Unmuxed A/V Streams
- PlayReady DRM
- ASF Container
- Chunk Index



Adaptive Streaming Silverlight Style

- Fixed size closed-GOP Chunks, same for all bit rates
- Per Stream Index in ASF Header Object
- One audio stream selected based on initial BW
- Client varies video bitrate to manage buffer



The Silverlight Player Hack

- Silverlight 2.0 did not allow HTTP 1.1 Range headers (needed for range requests)
- Chunked download requires range request
- The Solution: “Range Request in URL”
 - Client inserts range request byte range into URL
 - CDN translates to Range Request

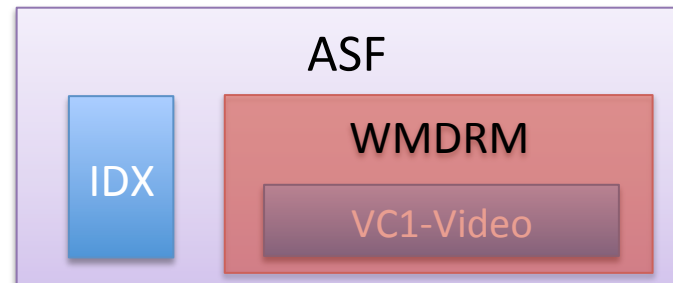
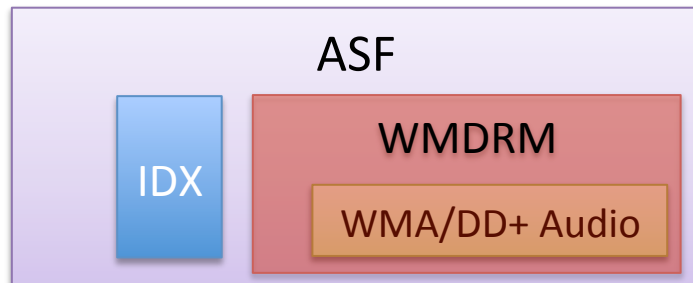
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Silverlight Innovations

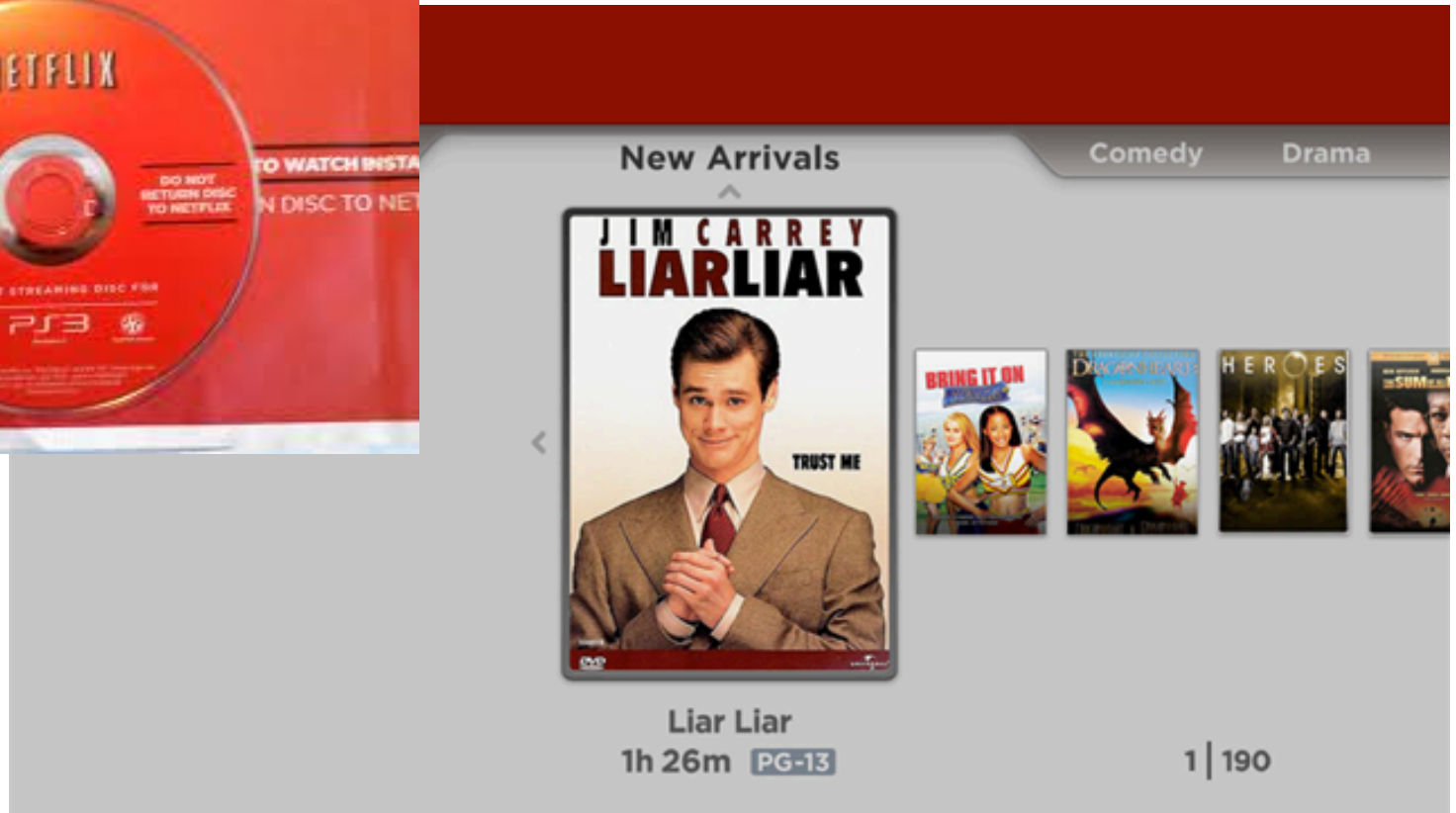
- 2-get rule
 - Max 2 http gets to pull stream headers
 - Index at front of file
- A/B testable client
- Heuristics-driven adaptive streaming
 - Metric is re-buffer rate
 - A/B test to maximize quality and minimize re-buffers

CE2 SDK

- Flash UI
- Adaptive Streaming
- Unmuxed A/V Streams
- VC1/WMA/DD+
- WMDRM
- ASF Container
- Chunk Index



PS3 V1 (Vega)

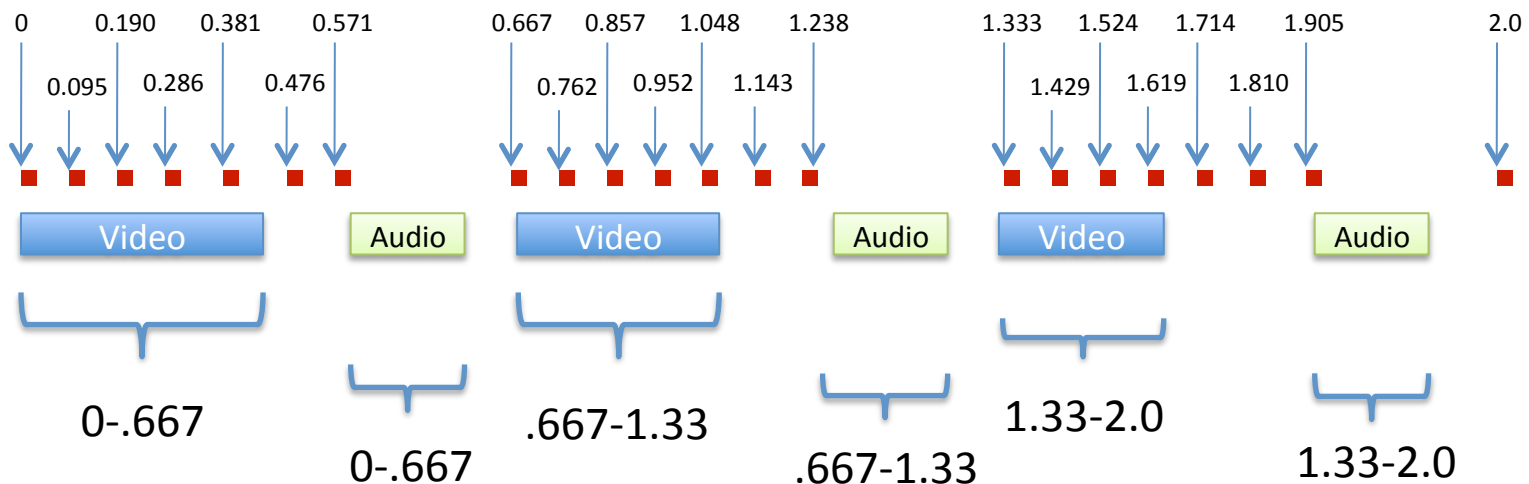


Vega: A Blu-Ray Hack

- PS3 is a very powerful BD Player
- BD-Live application (BD-Java)
- Progressive Playlist playback
- Adaptive Streaming: client-side muxing
- AVC Video, AC3 Audio
- AACs DRM
- First LOLOMO UI

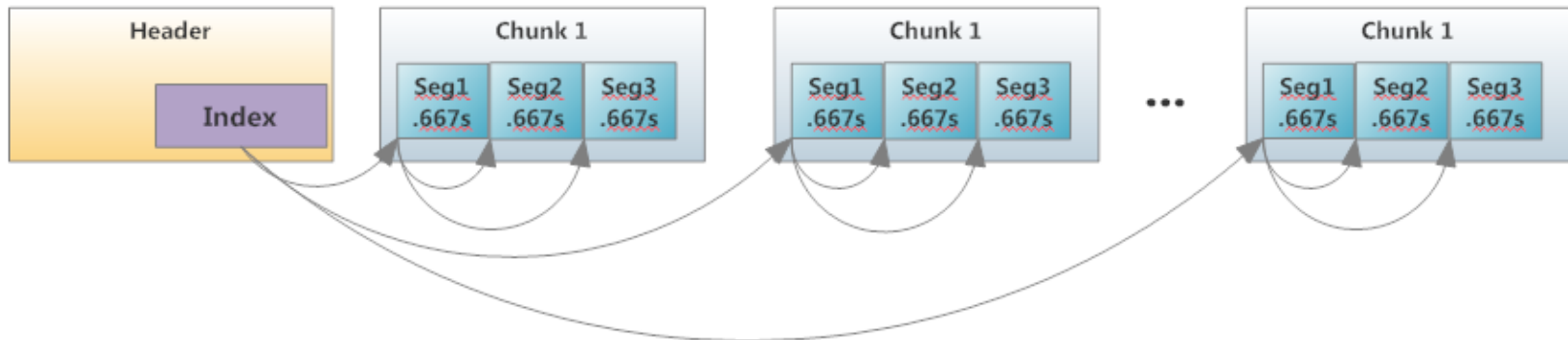
Vega Streaming Model

- Lazy TDM M2TS Transport Stream Muxing
- From the Spec
 - PSI arrival interval 100ms max
 - Min 20 PSI sets for 2-second GOP (we used 21)
 - 1-second max audio buffer
- Allows for “coarse” audio interleaving



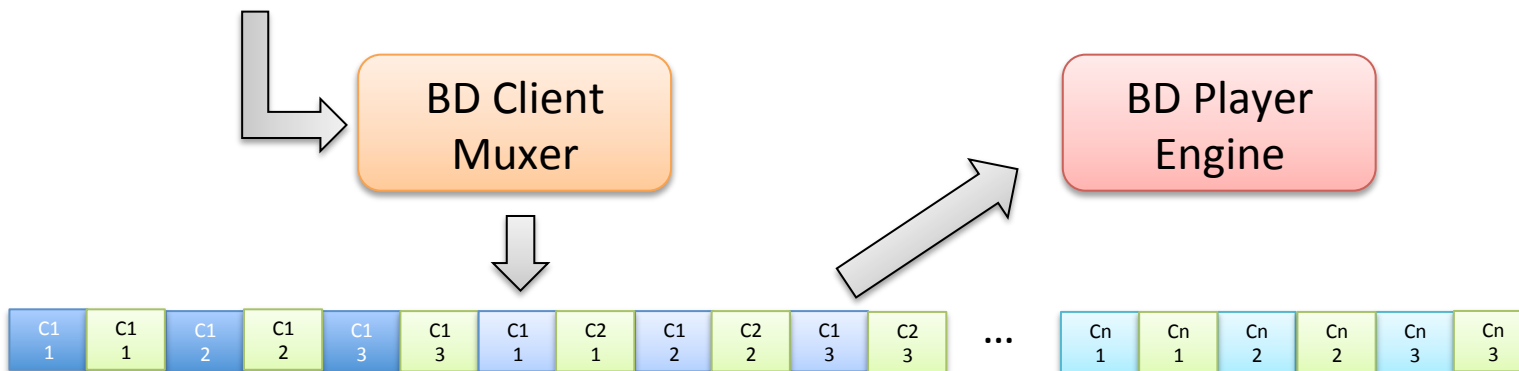
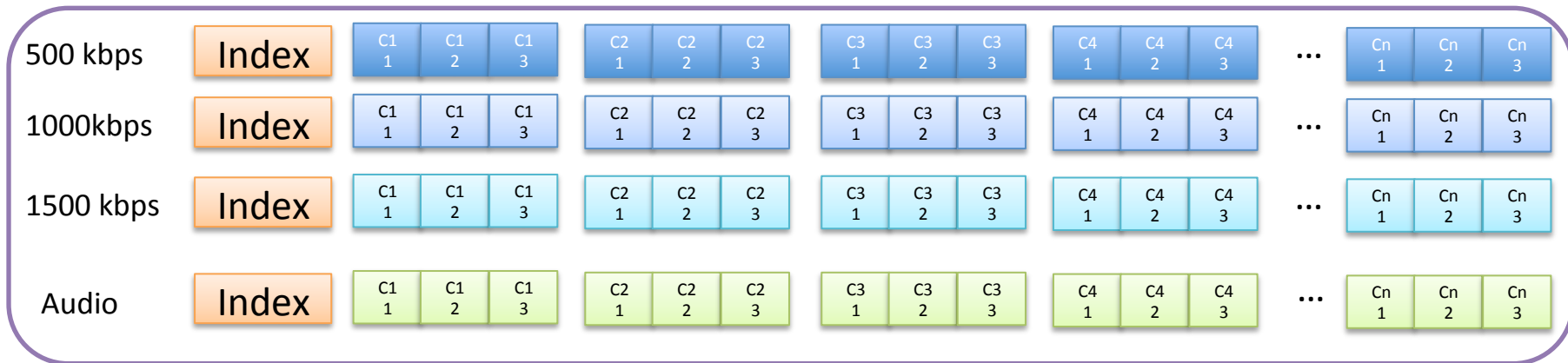
Vega Stream Format

- Single file with 2-second chunks
- Each chunk divided into 3 segments of .667s
- Each M2TS file has header with index
- Same model for A & V
- Client pulls all stream headers at startup



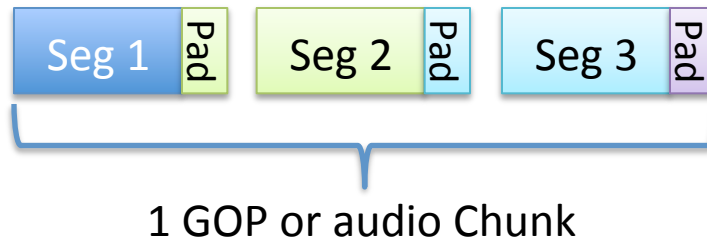
Vega Adaptive Client

- Client produces local muxed files
- Files are fed to BD engine with Progressive Playlist
- Padding to AACs encryptionblock boundry

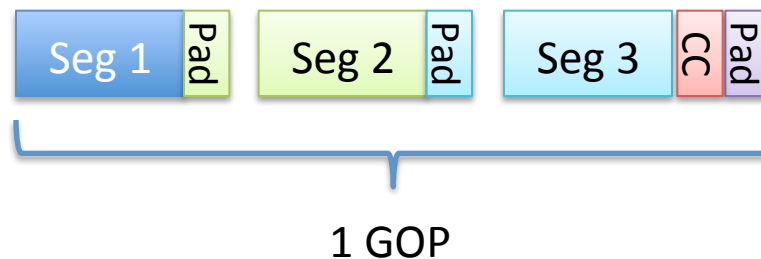


Vega Hacks

- Need to mux encrypted streams
- Solution all chunk segments padded to 6K block
 - Segments 1 & 2 padded with packets from “borrowed” from next segment
 - Segment 3 padded with Null Packets



- M2TS Continuity count aligned across all video streams
 - Solution: Each video chunk starts with $cc == 0$.
 - Add video filler packets to get CC to 15



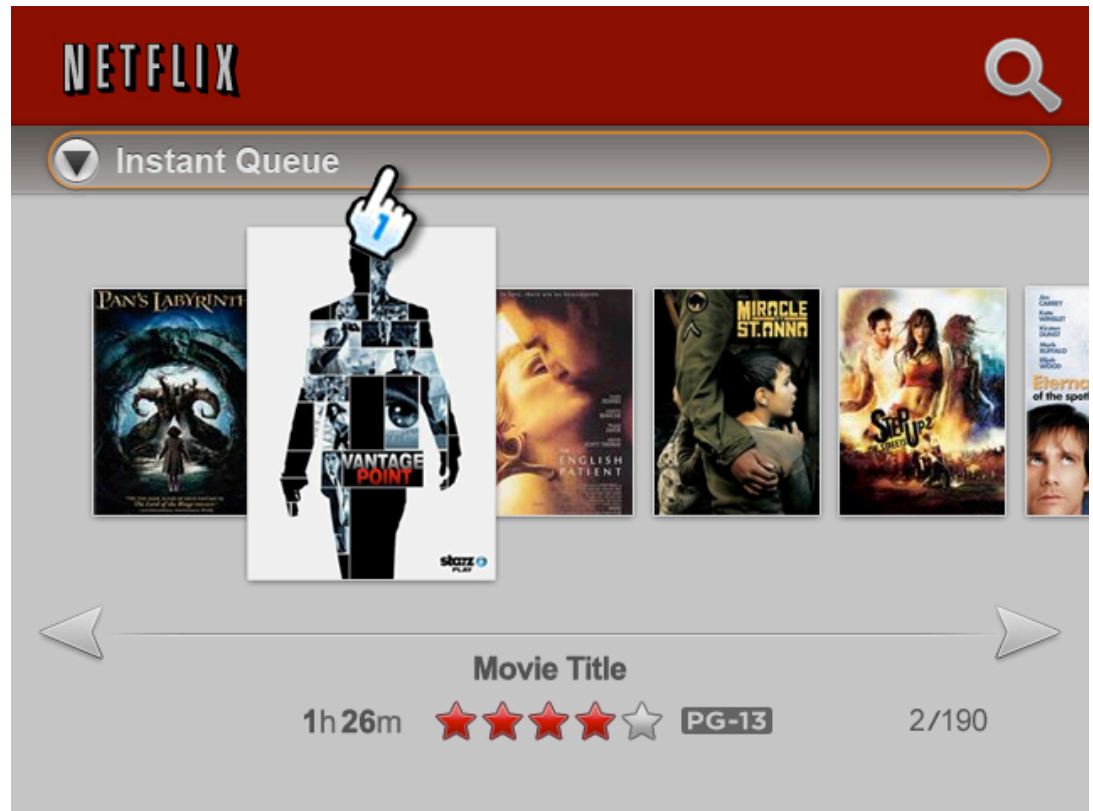
Vega Encoding Challenge

- Highly complex streams
- Unusual Netflix model, no OTS tools available
- Non-conformed streams would crash BD system
- Tight schedule for encoding, packaging, and deploying assets

The Vega Encoding Solution

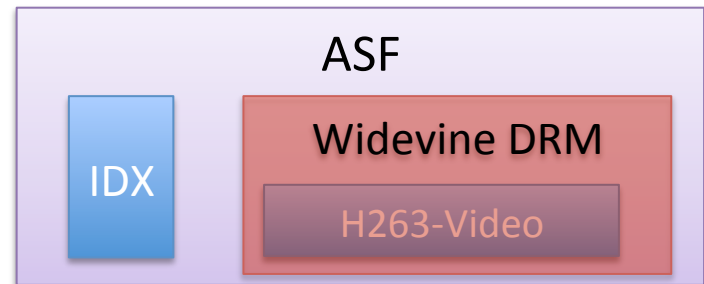
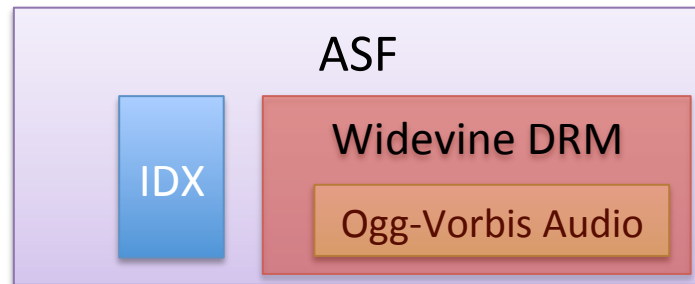
- Custom tools for BD packaging
- Custom tools for BD Stream verification.
- First Netflix project to use EC2-based encoding
- Encoding Tools team is started
- Media Pipeline team comes of age

Wii V1 (aka Link)



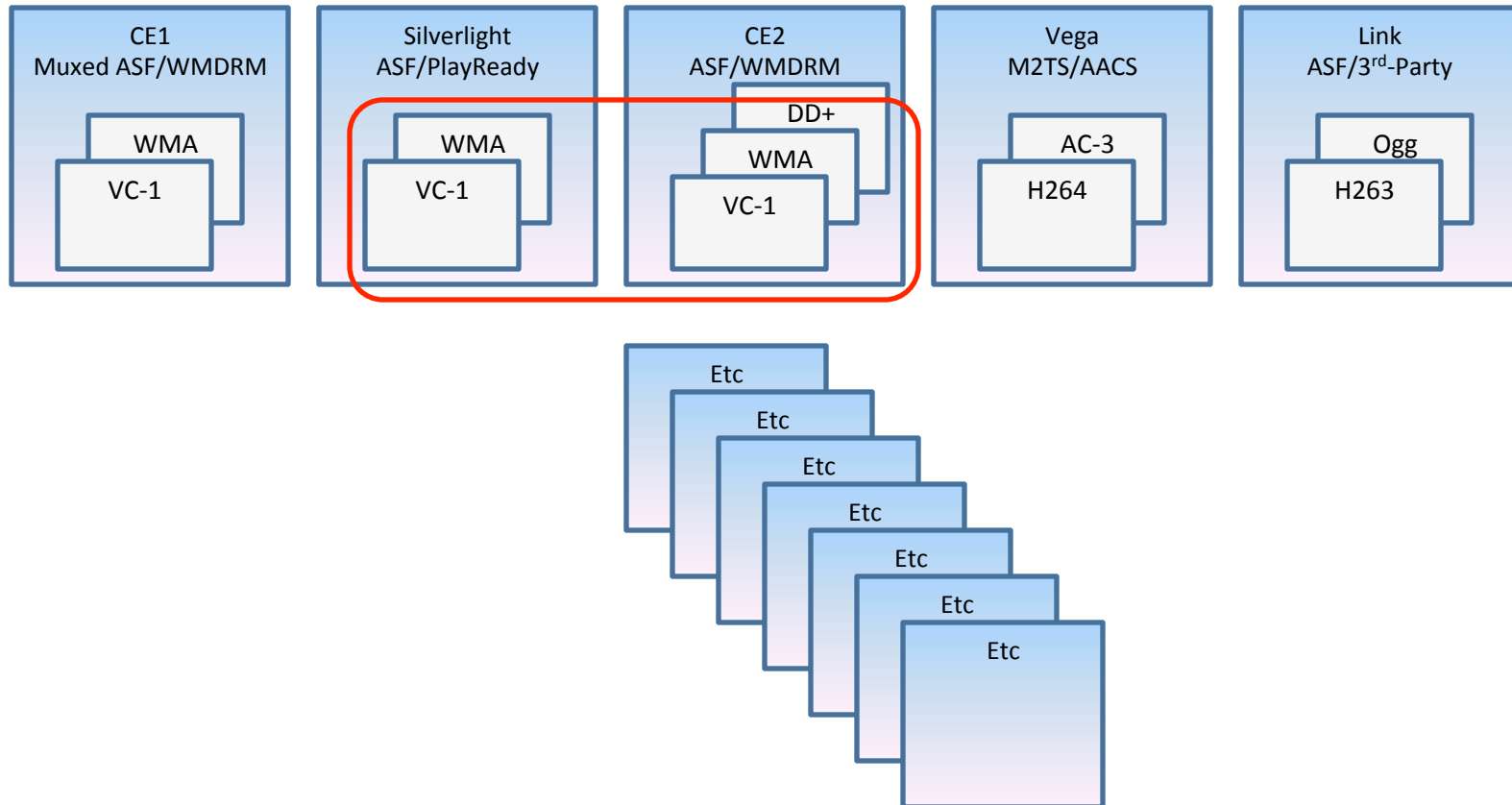
Link Streaming Model

- H263-Advanced Simple Video
- Ogg-Vorbis Audio
- Widevine DRM
- ASF Container
- Chunk Index



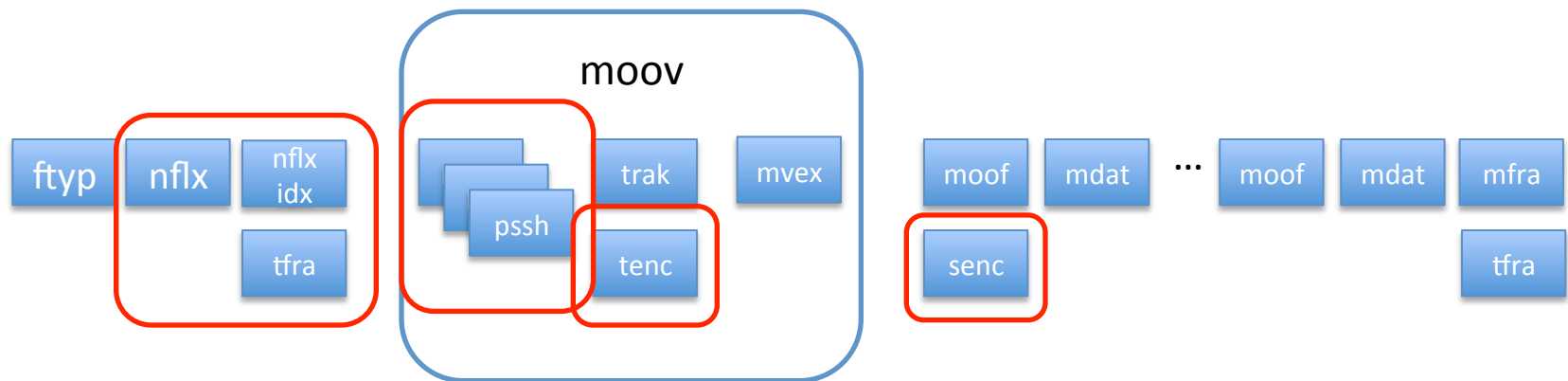
Issue: Profile Bloat

- Overlapping profiles necessitated by DRM
- Assume 40,000,000 customers == 120,000+ viewables (6X)
- 25-50 TB per profile (late 2009)

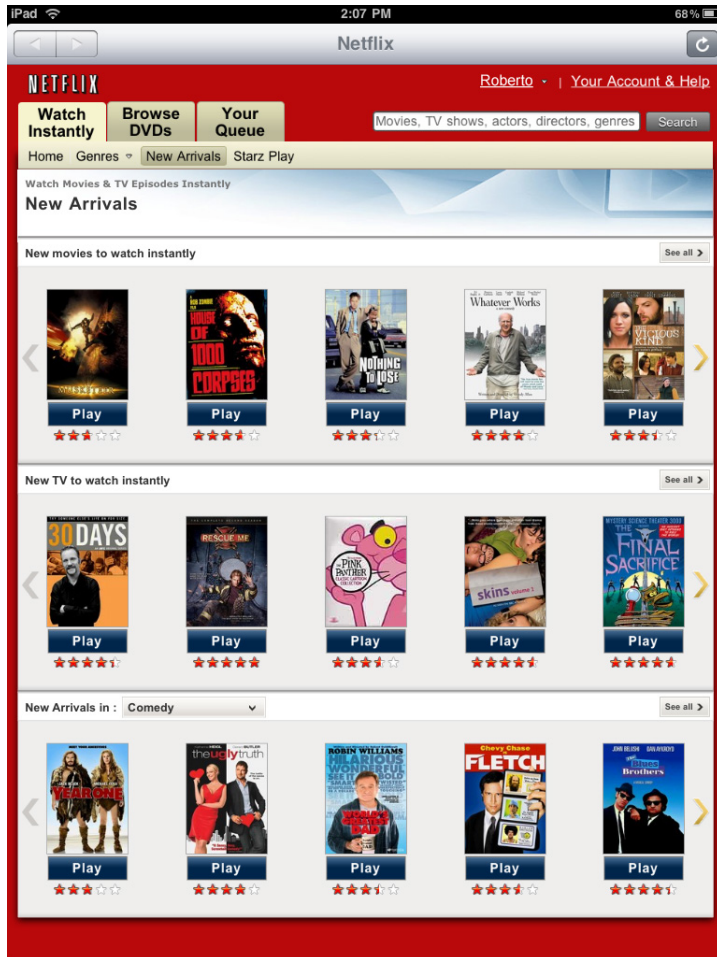


CE3 Profile (V1)

- H264 Baseline & Main
- AAC/DD+
- Fragmented ISO container
- Microsoft Piff
- Multi-DRM
- Internal packaging tools



iPad/iPhone (NATO)



The Challenge

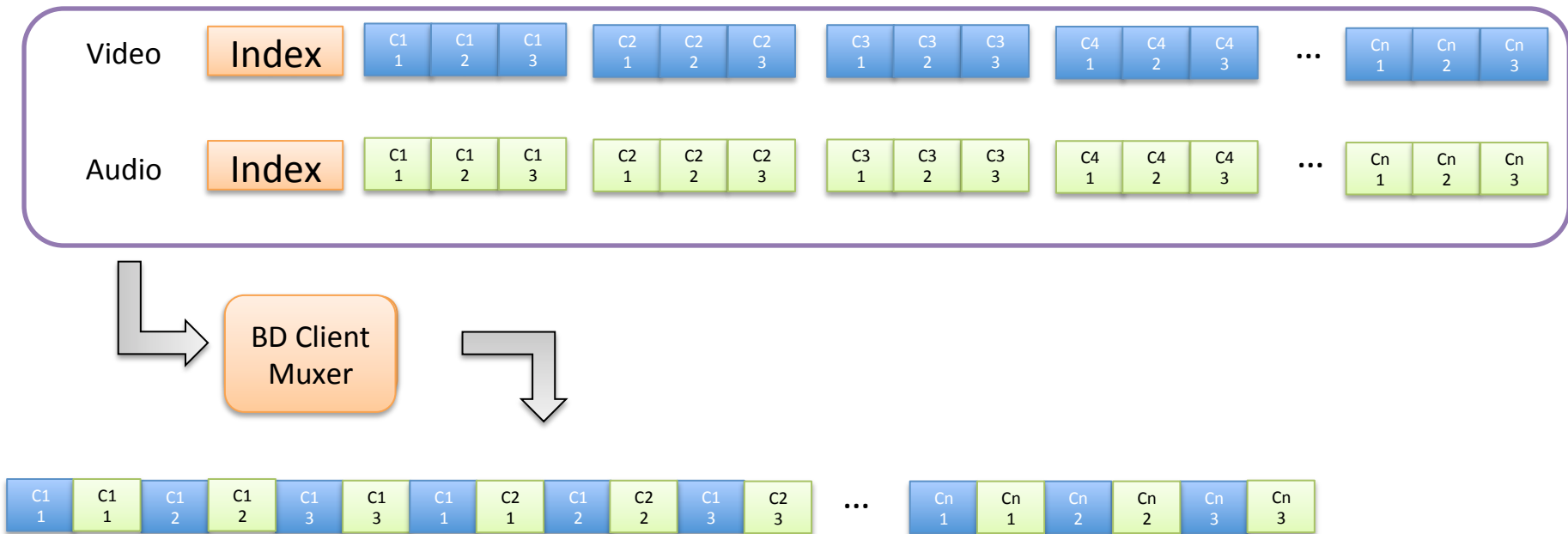
- On February 6, 2010, Apple invited Netflix to be part of the iPad launch (April 3, 2010)
- HTTP Live Streaming (HLS) model incompatible with Netflix systems in most every way
- 1.5 weeks later, we had HLS adaptive working
- 4/3/2010 Netflix was live on iPad with ~ 20,000 titles (2 bitrates each)

Http Live Streaming Issues

- Expiring URLs complicate M3U playlist
- DRM (or lack thereof)
- M2TS vs. fragmented ISO
- Physical vs. virtual chunked files
- Muxed vs. unmuxed
- Precise audio alignment across chunks

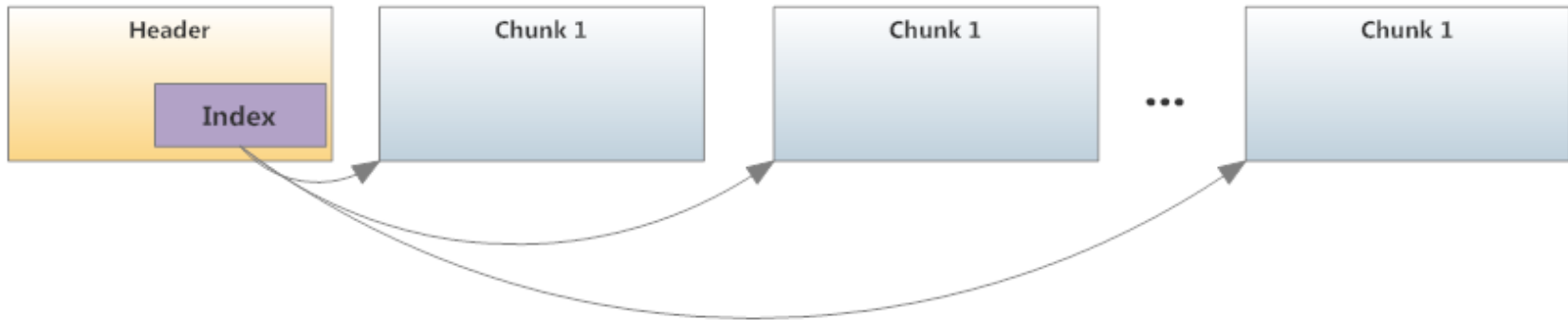
HLS Muxed M2TS (Vega Revisited)

- Audio and video muxed using index
- Precise Audio alignment
- Move muxing to backend
- About 1 day to convert tools



M3U Playlists

- Playlist management difficult with expiring URLs
- Add Index to muxed files
- Move Playlist generation to client



Physical Chunking (billion files model)

- NCCP Service not designed for chunked files
- Troublesome for CDNs (at Netflix scale)
- Solution: range-request in URL (from Silverlight)
- Virtual chunking looks like physical chunking

Sample M3U PlayList

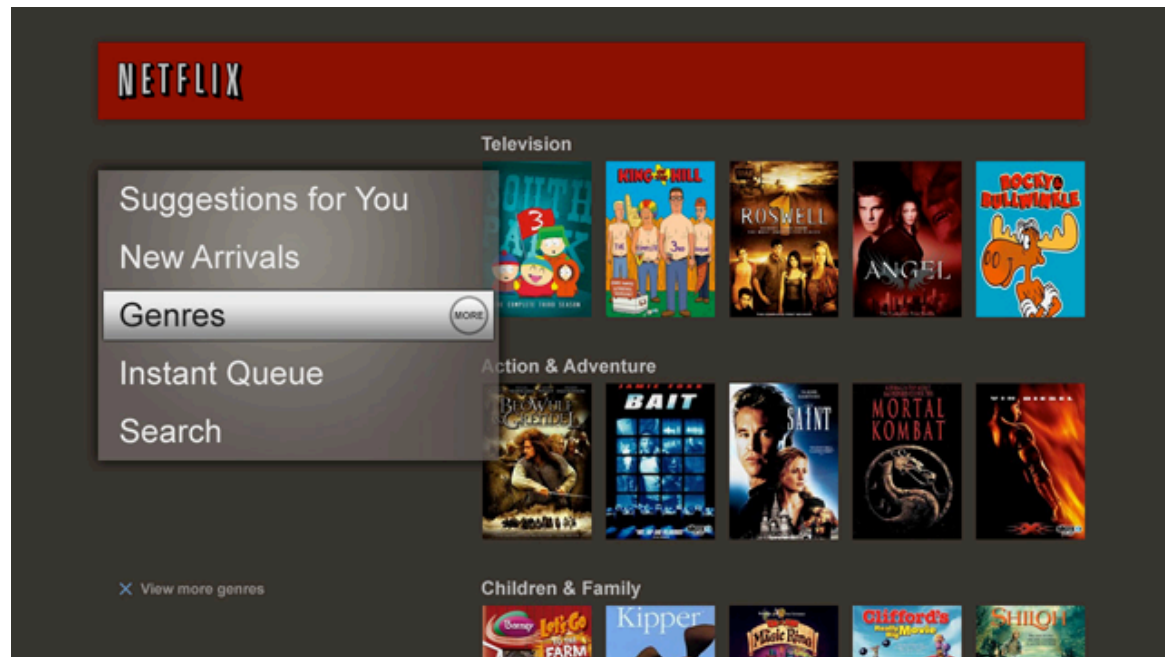
```
playlist "http://netflix-532.vo.llnwd.net/s/s11/904/1377925904.ts.prdy?  
p=60&e=1296814051&h=673020a1f218df112dde1a403c5163f4"  
#EXTM3U  
#EXT-X-TARGETDURATION:10.010000  
#EXT-X-MEDIA-SEQUENCE:0  
#EXT-X-KEY:METHOD=AES-128,URI="https://ihost.netflix.com:4343/keys/crypt0.key"  
#EXTINF:10.010000  
http://netflix-532.vo.llnwd.net/s/s11/904/1377925904.ts.prdy/range/31020-304763?  
p=60&e=1296814051&h=673020a1f218df112dde1a403c5163f4  
#EXTINF:10.010000  
http://netflix-532.vo.llnwd.net/s/s11/904/1377925904.ts.prdy/range/304764-496715?  
p=60&e=1296814051&h=673020a1f218df112dde1a403c5163f4  
#EXTINF:10.010000  
http://netflix-532.vo.llnwd.net/s/s11/904/1377925904.ts.prdy/range/496716-676827?  
p=60&e=1296814051&h=673020a1f218df112dde1a403c5163f4  
#EXTINF:10.010000
```


iPad Summary

- Vega tools adapted to HLS M2TS model
- Client-side playlist generation
- Range-request-in-URL for virtual chunking
- Encoding started ~2 weeks before launch
- Live on 4/3 with ~22,000 titles
- 2 bitrates per title
- iPhone followed in fall 2010

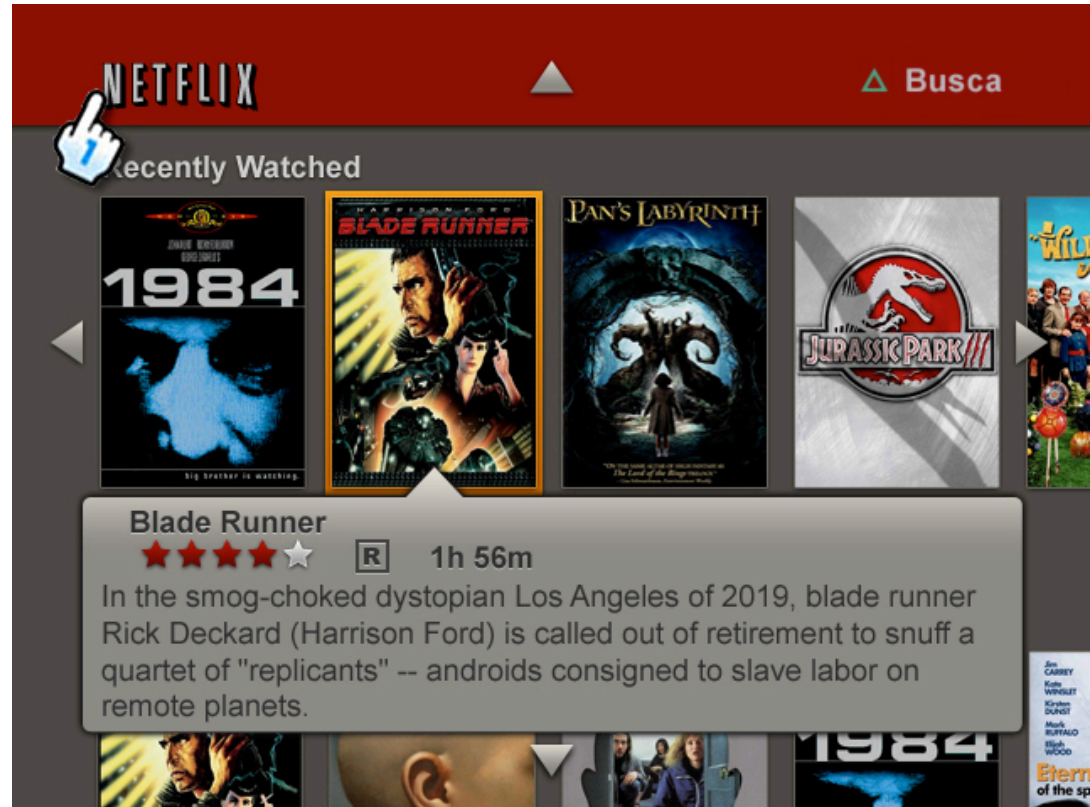
PS3 V2 (Rigel)

- Native PS3 Application
- Vega end-of-life
- CE3 Profile
- PlayReady DRM



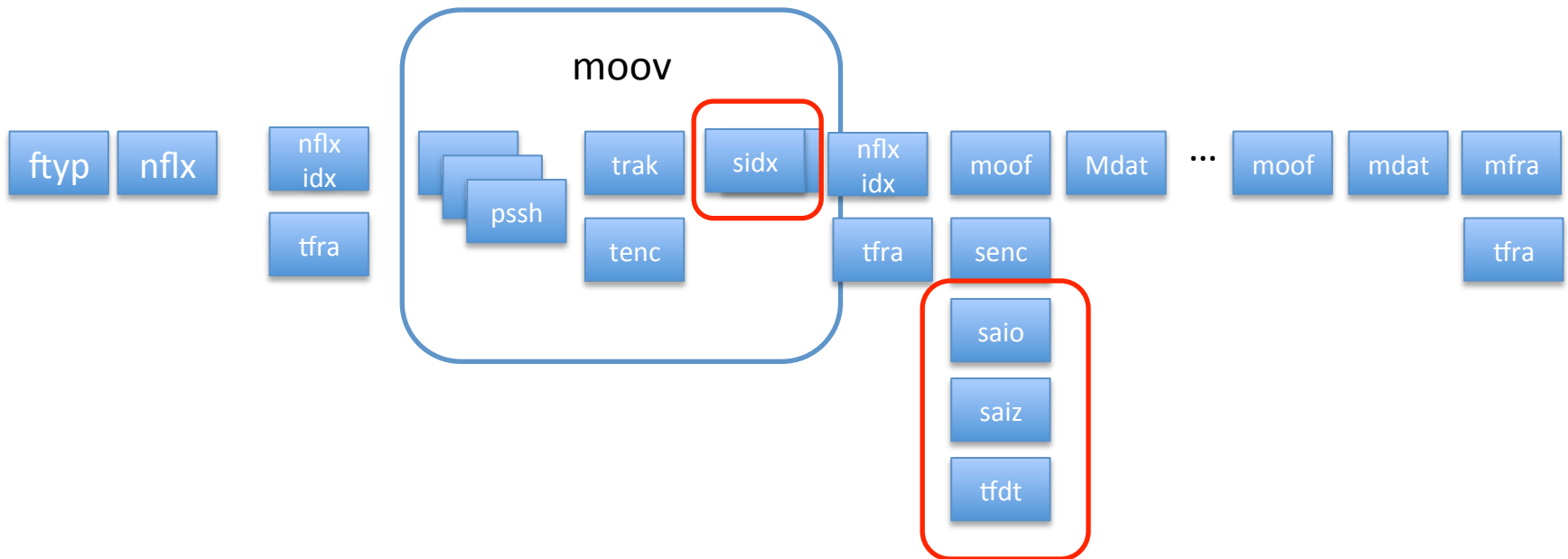
Wii V2 (Kirby)

- Wii Store App
- H263/OggVorbis
- FMP4-Piff
- PlayReady DRM



CE3 Profile V2 (DASH)

- In 2010, Netflix joined the DASH committee
- One motivation, PIFF-DASH compatibility
- DASH streams also PIFF compatible

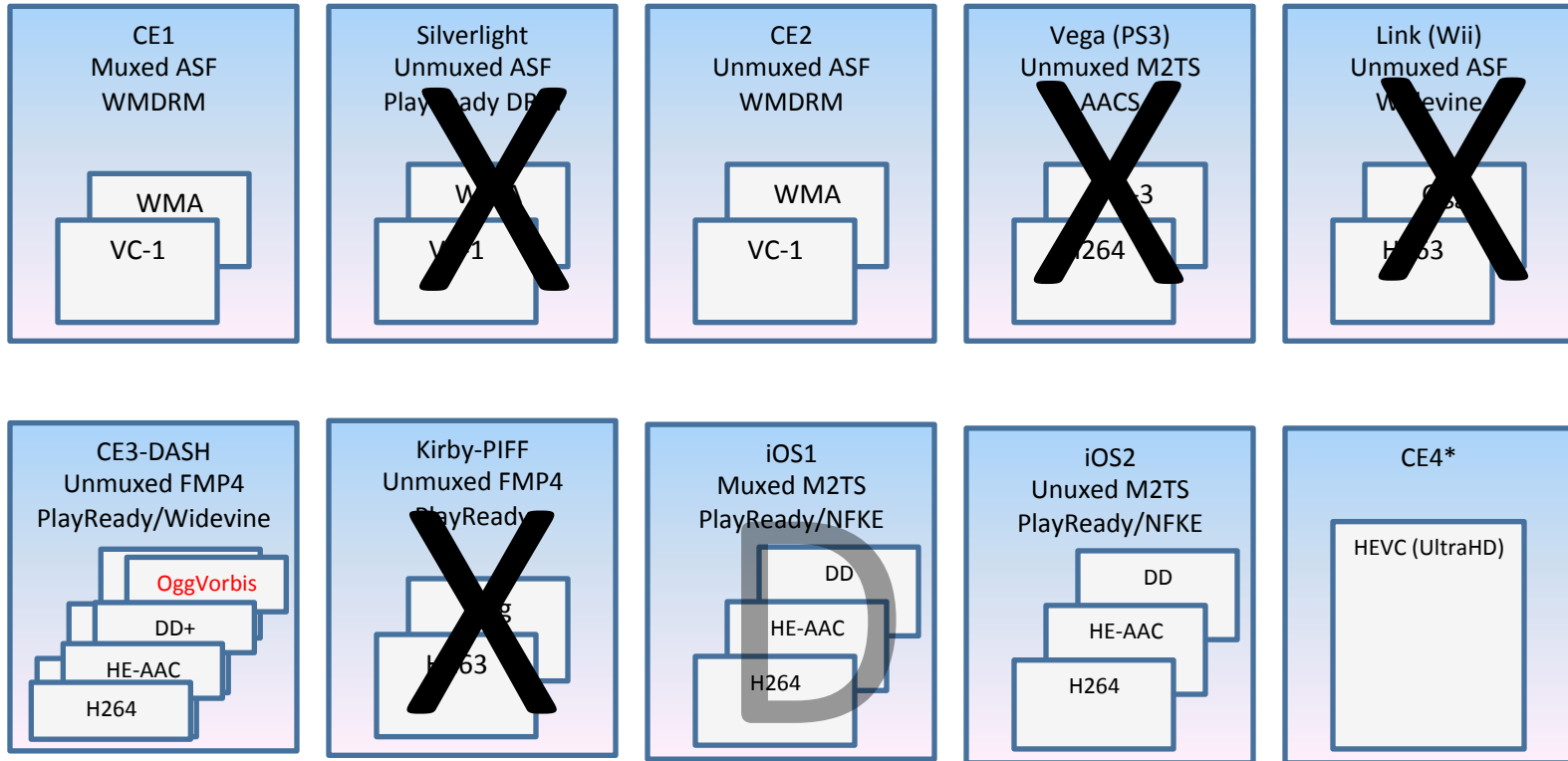


CE3 Profile V2 (DASH)

- Android Devices
- Roku 2
- xBox, PS/3, Wii, WiiU



Profile Summary



* Planned

Summary

- Netflix streaming started very simple
- Incremental evolution
- Silverlight was platform for early innovation
- Early development model: “go to device”
- Now standards-based
- Agile development
- Hack when necessary
- Innovation in other areas such as UI, heuristics, etc.

Questions?

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