Encoding at Netlfix

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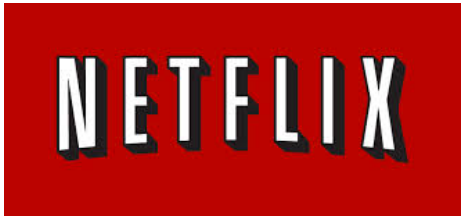
Introduction

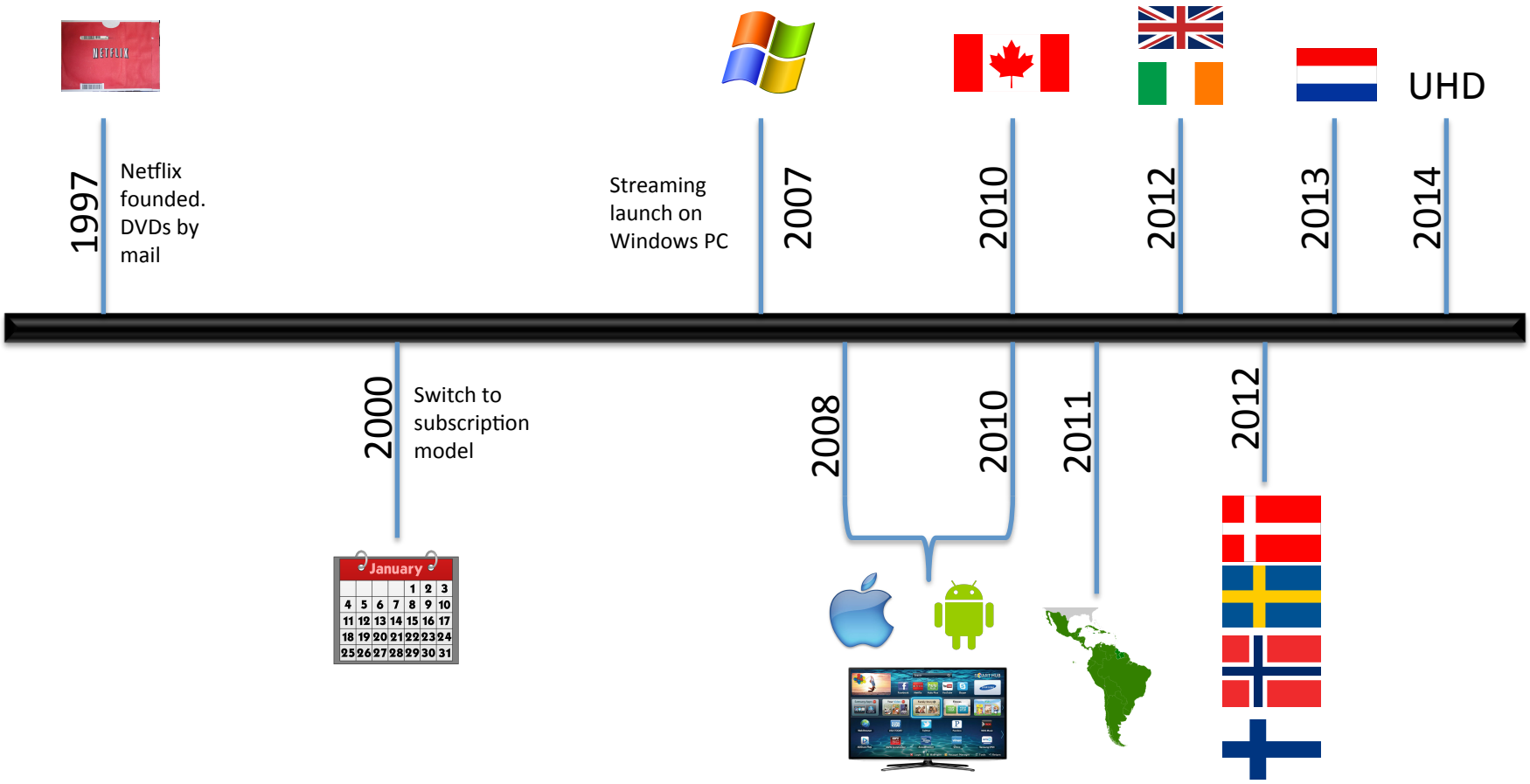
Netflix started streaming in 2007 with IE-plugin hosting Windows Media Player and ~2000 titles

Today …

- Award-winning Netflix Originals
- Tens of millions of active Netflix devices
- Billions of hours of content streamed
- International
- Recently launched 4K UHD service



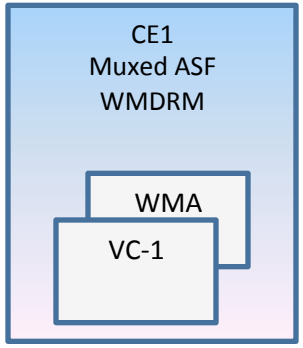
Netflix Timeline

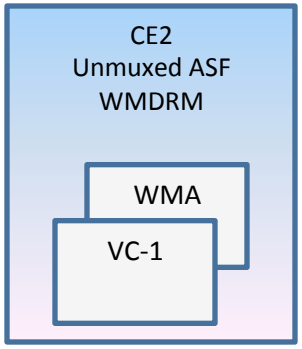


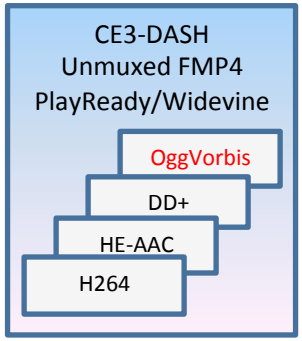
Discussion Topics

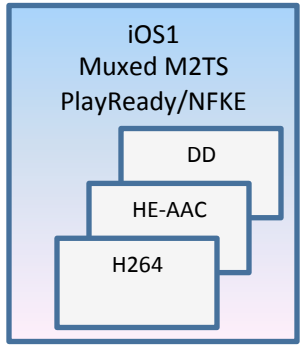
- Brief Historical look at our encoding workflows
- Robust and scalable encoding in the cloud
- Our 4K Solution
- Netflix Source Format Roadmap

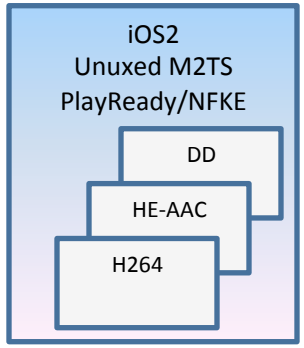
Streaming Profile Review

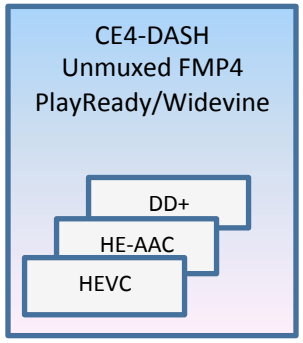




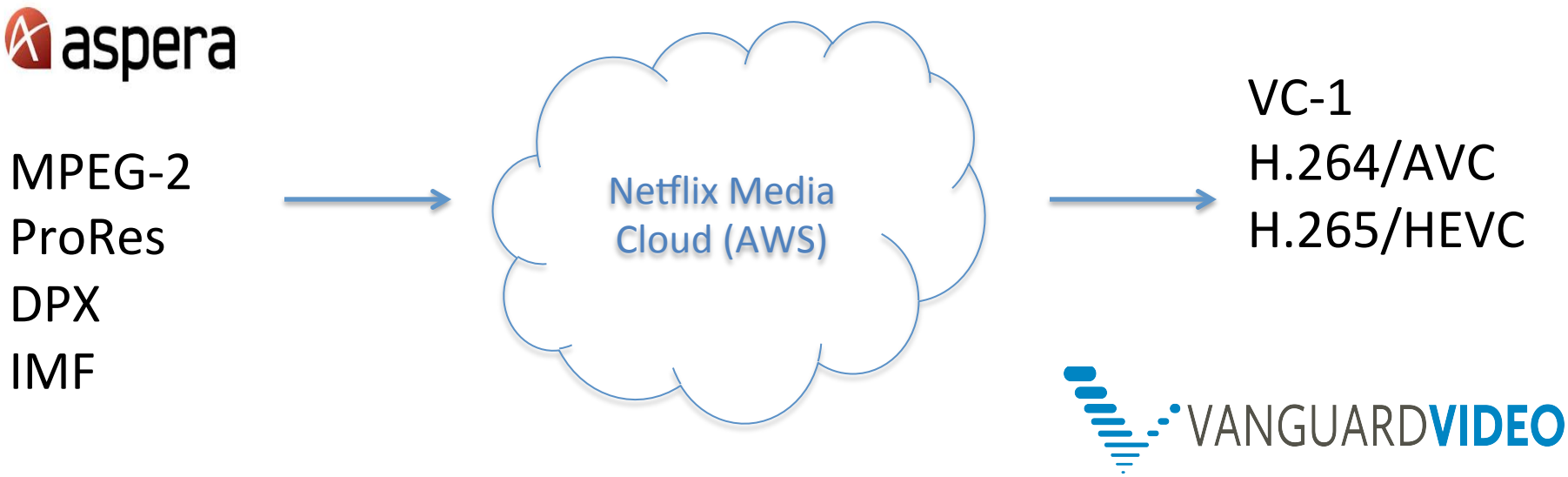








Netflix Media Processing At A Glance



- Distributed architecture
- Elastic
- 100% Cloud
- Thousands of EC2 instances

Netflix Encoding V1 (2007)

- Script files running on servers in data center
- 100% MSFT: WMV, WMDRM
- Encoding framework built on AviSynth and VFW
- Scale to a few thousand titles

Netflix Encoding V2 (Matrix, 2009)

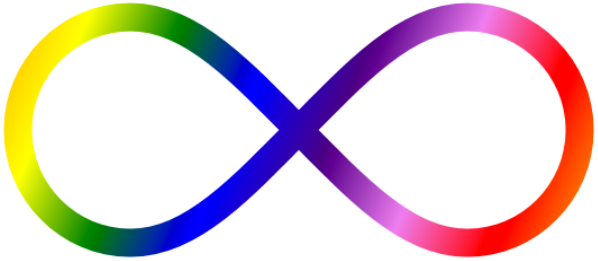
- Move to EC2 (elastic)
- Written in Java
- Same video framework (AviSynth and VFW)
- Scale to tens of thousands of titles
- Added H264, AAC, DD+, etc.
- Production for all encode profiles starting with “Vega” BD-Live

Matrix Encoding Limitations

- Very long encode times (10-40x play time)
- Inadequate source inspections
  - Loose tolerances
  - Unreliable duration
  - Few source problems detected early
  - Problem source == problem encodes
- Source problems delivered to customers
- Inability to scale sufficiently for growing business

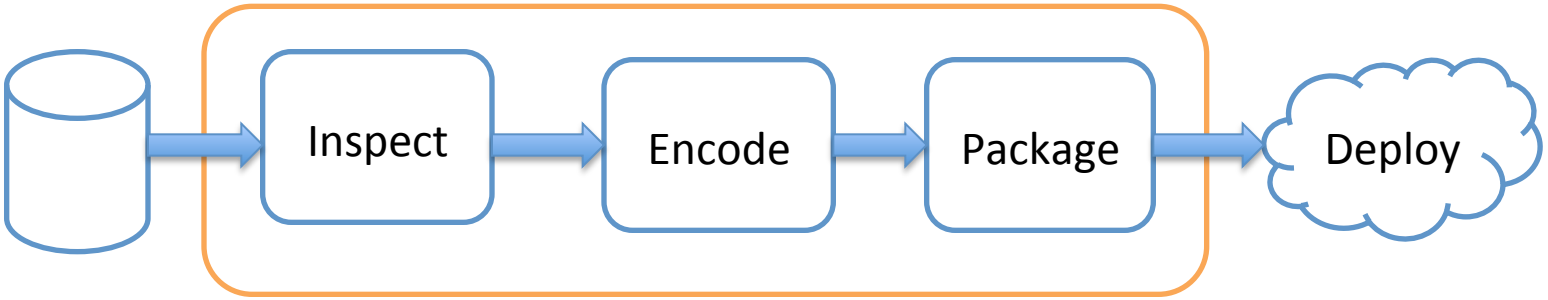
Netflix Encoding V3 (Reloaded, 2013)

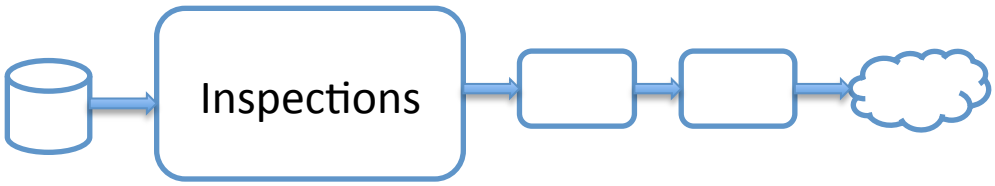
- Linux & ffmpeg
- Designed for infinite scaling
- Robust source inspections
- Parallel video encoding
- Very large source files (i.e. 4K)



Designing for Scale

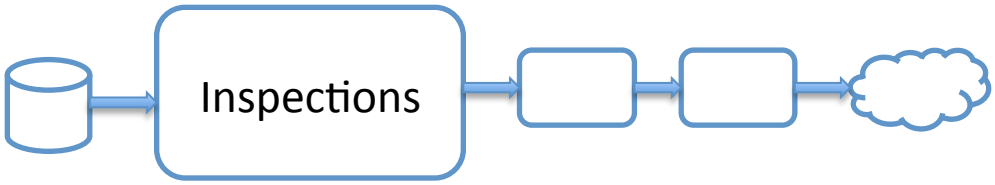
- Thorough inspection of all incoming assets
- Issues detected at point of failure
- Robust and failure tolerant
- Progressive model for long processes
- Parallelization where needed
- Highly predictable output





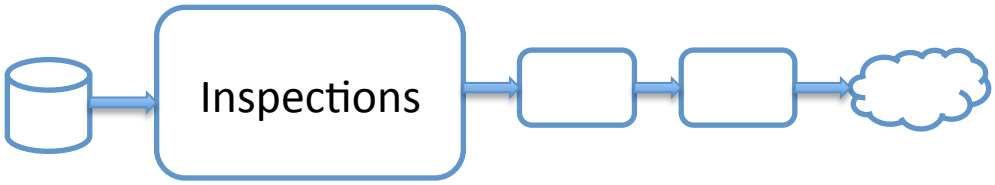
A predictable encoding system requires good input

- Verify source conformance to delivery specification
- Auto-route failures with actionable error messages
- System layer and decode inspections
- Fully index elementary streams
- Multiple sources of truth



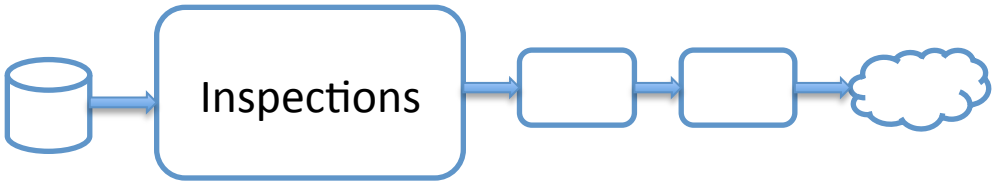
System layer inspections

- Verify conformance to relevant system specification (M2TS, MP4, etc.)
- Example: M2TS
  - Packet inspections: synch, continuity
  - Timing: PCR, buffer, STD delay, etc.



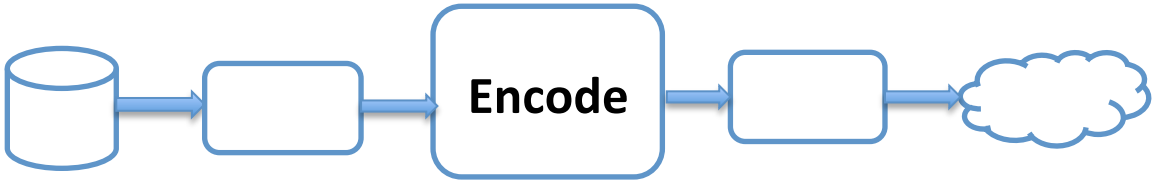
Decode Inspections

- Full decode of source, no errors allowed
- Decoded picture analysis
  - Telecine detection
  - Commercial Black detection
  - Crop detection
- Audio decode: drop out, channel map, etc.

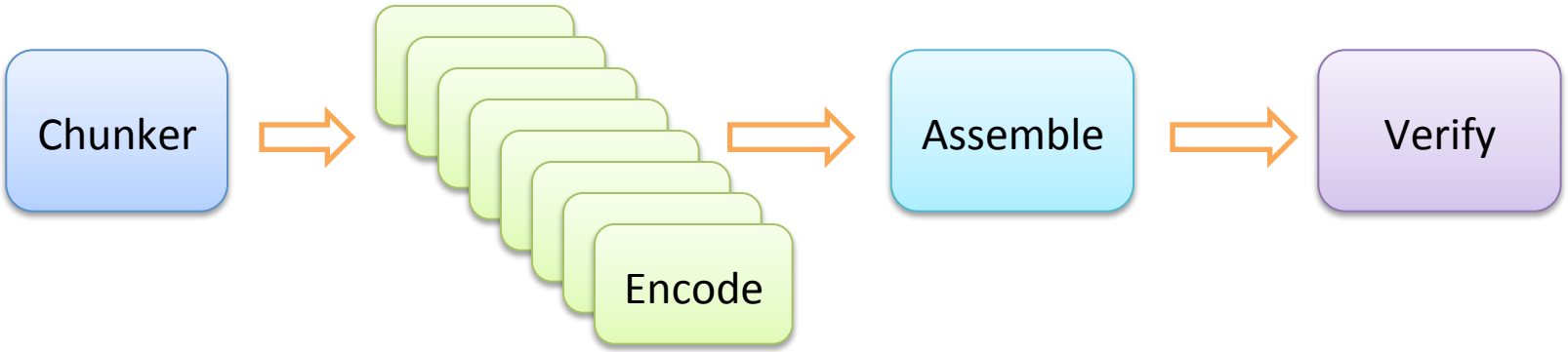


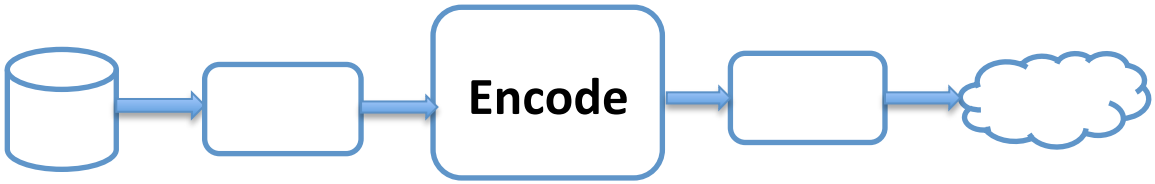
Multiple Sources of Truth

- Each of the major inspections yields A & V sample counts
  - System inspection
  - Decode
  - Index
- All counts must match exactly
- Encoding conformed sources highly predictable



- MAPLE: MAssively ParalleL Encoding
- Video job chunked across multiple EC2 instances
- Progressive model for efficient handling of transient errors
- Post-encode verification detects most encoder issues

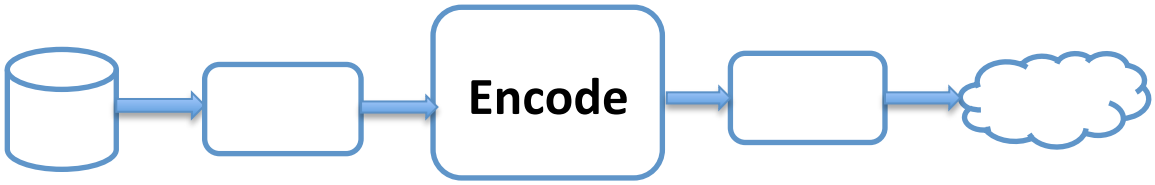




MAPLE in Action: UK Day-after-broadcast

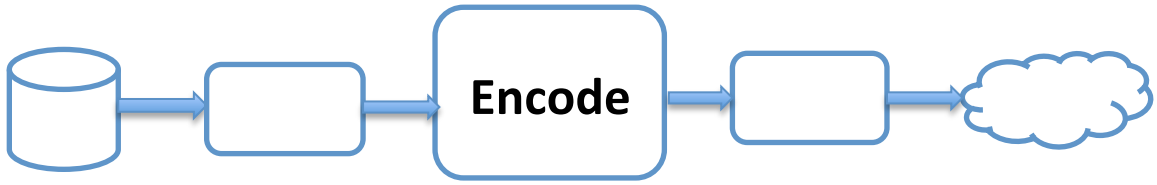
Title	Package ID	Arrived_Date	Inspection Duration Time	Encoding Start Time	Encoding Duration Time (Does not include the waiting time in the queues)	Packaging End Time	Ingest to MPL complete time (hours)
Episode 1	xxxxxx	8/9/13 13:24	3 hours, 11 minutes	8/9/13 17:42	Longest Required ~1 hour Longest - 1 hours 50 minutes	8/9/13 20:47	7.38
Episode 2	xxxxxx	8/12/13 13:58	1 hour, 24 minutes	8/12/13 15:24	Longest Required ~1 hour 10 min Longest - 3 hours 4 minutes	8/12/13 21:05	7.13

- Average time to ingest and encode all bitrates is ~7 hours (~2.5 hours to encode all profiles)
- Compare to Matrix encode ~46 hours for 5.8Mbps 1080p



MAPLE in Action: Worst-Case Encode

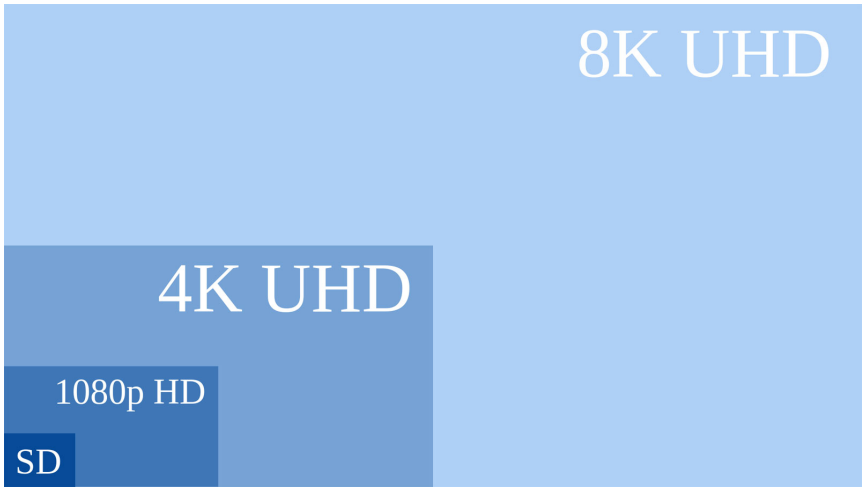
- 4.95 hour title
- 96 hours to encode 1080p in Matrix
- ~900 compute hours before encode completed (due to various transient errors)
- MAPLE encode time ~3 hours.

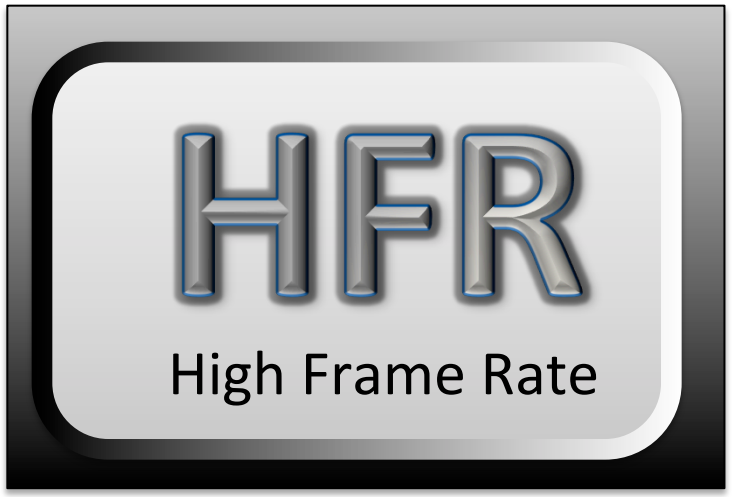


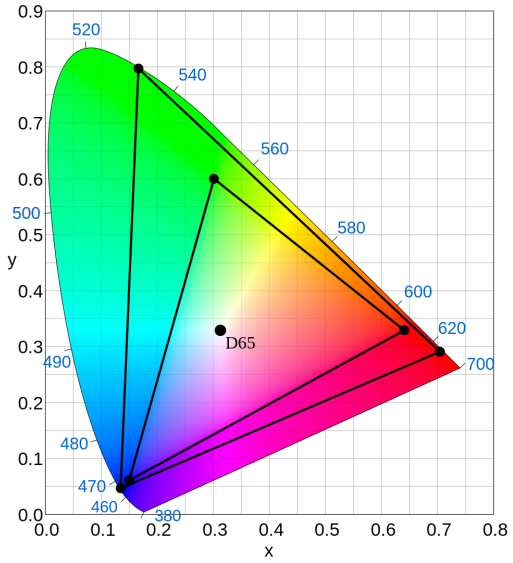
MAPLE Summary

- Able to deliver Day-After-Broadcast at all bitrates
- Tight system tolerances (+/- 1 frame)
- High confidence in quality of encodes
- Progressive model minimizes impact of transient errors
- Still much opportunity to improve performance
- Conclusion: MAPLE is sweet!

Ultra HD 4K


8K UHD
4K UHD
1080p HD
SD


HFR
High Frame Rate


520
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0.5
0.6
0.7
0.8
x

Ultra HD 

Challenges

- Emerging standards (HEVC, HDR, etc.)
- Bitstream analyzer immaturity
- Few decoders
- Large Source files (DPX ~2TB/hour)

Ultra HD 

Working with 2TB file

- Too big to land on one EC2 drive for inspection
- Downloading could take 24 hours
- Difficulty dealing with transient errors
- Solution: Chunked inspections

Ultra HD 4K

Chunked Inspections

- Able to manage large files efficiently
- Parallel inspections run faster
- Progressive model to minimize transient errors
- Initially DPX, now includes IMF/MXF and ProRes
- Ingest and encode DPX and IMF/MXF at scale

Source Format Roadmap

Supported Formats

- MPEG2 Transport Stream
- Apple ProRes
- DPX
- IMF/MXF (new)

Source Format Roadmap

M2TS

- Well supported but…
- Not really a file format
- Serial inspections
- Video quality not great

Source Format Roadmap

ProRes

- High Quality
- Parallel & Progressive processing
- But … Proprietary format

Source Format Roadmap

DPX

- Very High Quality
- Parallel & Progressive processing
- But … really big
- ~2TB/hour
- S3 5TB Object size limit
- Not practical for scale

Source Format Roadmap

IMF/MXF (JPEG 2000)

- Very High Quality
- Parallel & Progressive processing
- Emerging standard
- Ability to deliver incremental revisions, localized playlists, etc.
- First 4K IMF/MXF assets ingested in Feb. 2014

Source Format Roadmap

Summary

- MPEG2 TS is legacy and not suitable for UHD
- ProRes is proprietary
- DPX is unwieldy
- IMF/MXF is the future
  - Netflix heavily investing in IMF
  - Currently the preferred source format
  - Eventually, may be required format

HEVC Thoughts

- Evaluated many HEVC encoders, currently we see
- No efficiency gain vs. x264 (non-realtime, <=1080p)
- Quality about same as x264
- Much longer encode time (~10x)
- But … very early in HEVC lifecycle
- In ~2 years, we expect
  - 20%-30% encoding efficiency vs. x264
  - Encode time near x264
- We are very excited about HEVC
- Most all new dev is in 4K/HEVC

Random Trivia

- Reloaded transition: every AAC & DD asset was re-encoded …
- 50+ encodes per video (codecs, packaging, bit rates)
- Currently C1M, no GPU acceleration
- 4K DPX workflow stood up in 2 months
- Initial IMF/MXF workflow stood up in 2 months

Questions?

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