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Innovation in IP Video

ATSC TELEVISION

ATSC 3.0 Transition Architectures

New Opportunities and Channel Sharing Options

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Agenda

ATSC 1.0 – Quick Overview

ATSC 3.0 – Core components

Consumer Landscape

Broadcast Infrastructure

Moving Between ATSC 1.0 and 3.0

3.0 Options and Opportunities

System Architecture Scenarios

Summary

ATSC 1.0 Overview

The move from analog to digital…

The Paradigm Shift

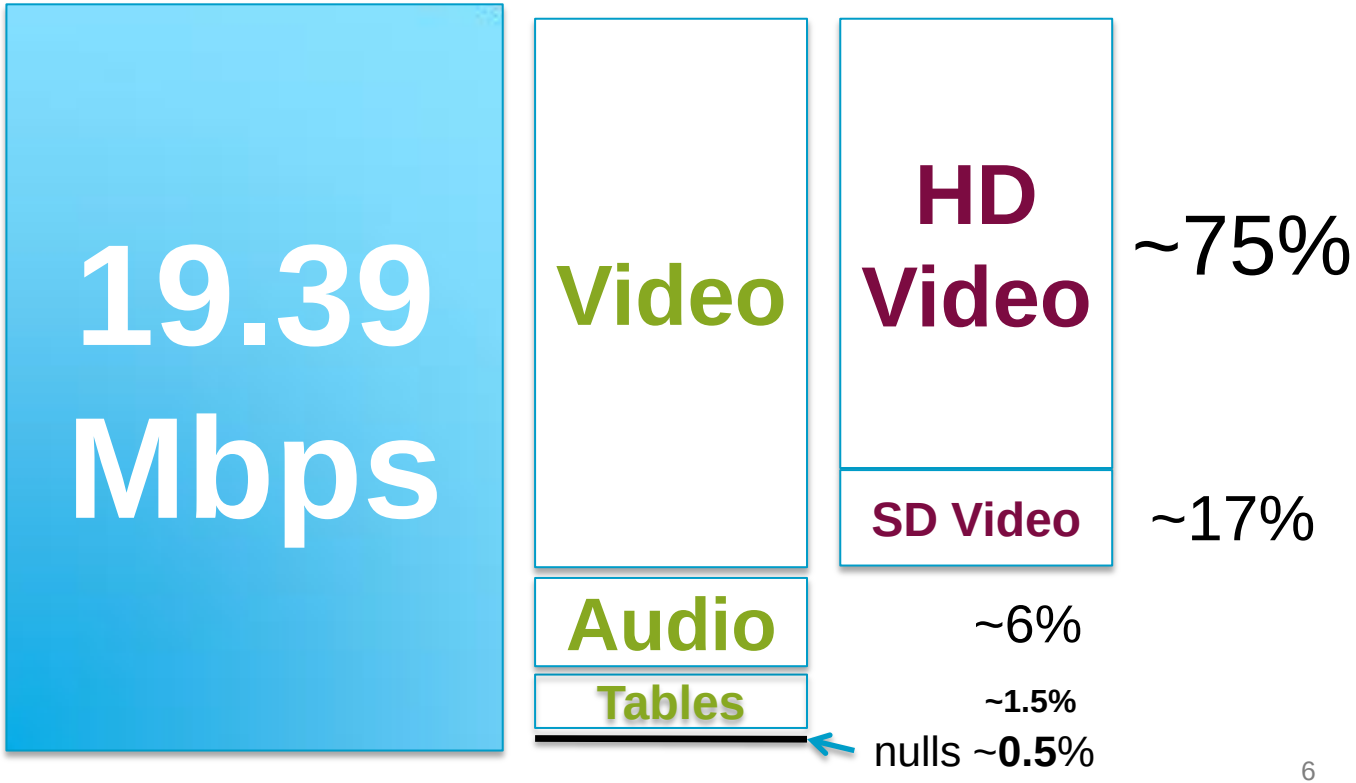
- ATSC broadcasters built systems based on the state of the art.
- Ushered in 4 distinct technologies which didn't exist before…
  - **Real Time Media Compression**
    - Video (MPEG 2)
    - Audio (AC-3)
  - **Multiplexing** (MPEG 2 TS)
    - Metadata (PSIP)
  - **Digital STL** (ASI / SMPTE 310M)
  - **Digital Modulation** (8VSB)

Compression

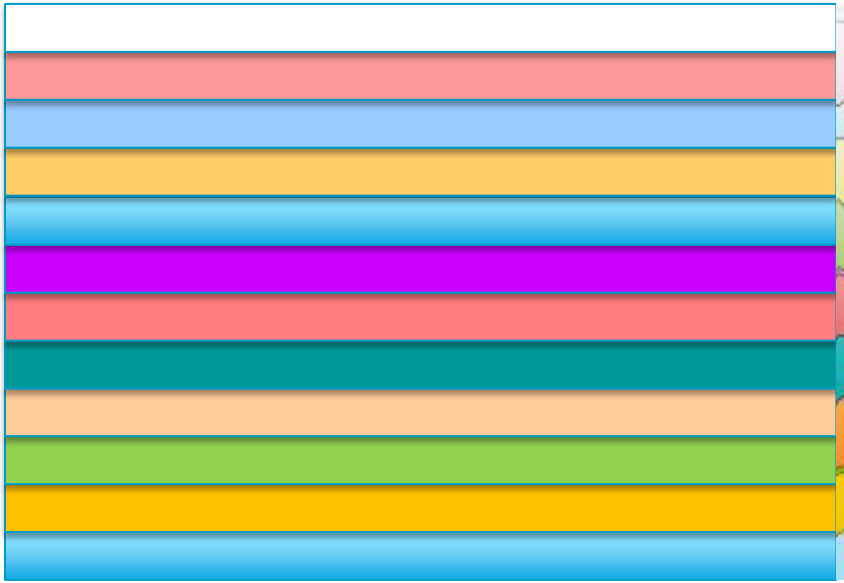
The ATSC Transport Stream

Multiplexing

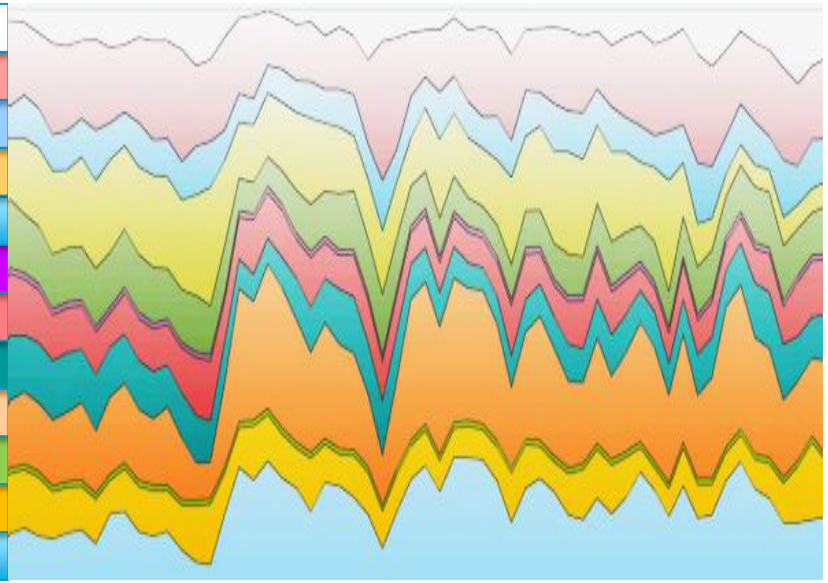
The ATSC Transport Stream



Constant vs. Variable Bitrate



CBR — Variable VQ (lower average)



VBR — Constant VQ (higher average)

CBR = Less Efficiency when running multiple channels

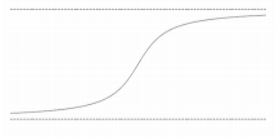
Look-ahead metrics are used to compensate faster than a eye can perceive.

ATSC 1.0 Historical

HD was the attraction but struggled w/ 1080i HD at 18Mb/s

Statmux allowed systems to combine multiple SD to their multiplex

MPEG-2 performance improved asymptotically over time, slowly tapering off



Coding and filter techniques for AVC & HEVC trickled down to benefit MPEG-2 processing

Statmuxing, along with filter tools & coding techniques supported MUCH higher channel densities

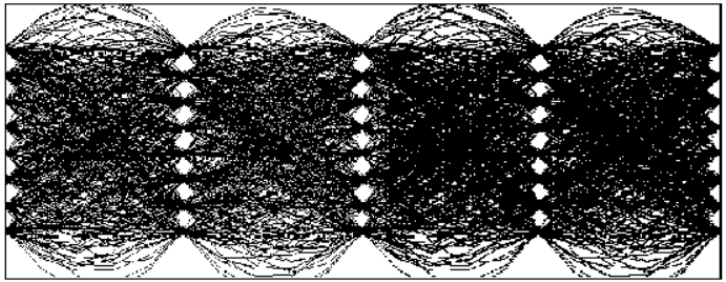
ATSC 1.0 STL and Modulation (8VSB)

The digital STL was needed to move the MPEG 2 Transport Stream from the studio to the transmitter

The digital modulator is a form of digital to analog converter to allow the conversion of the bit stream to be converted into a waveform

MPEG 2 TS

8VSB Eye Pattern



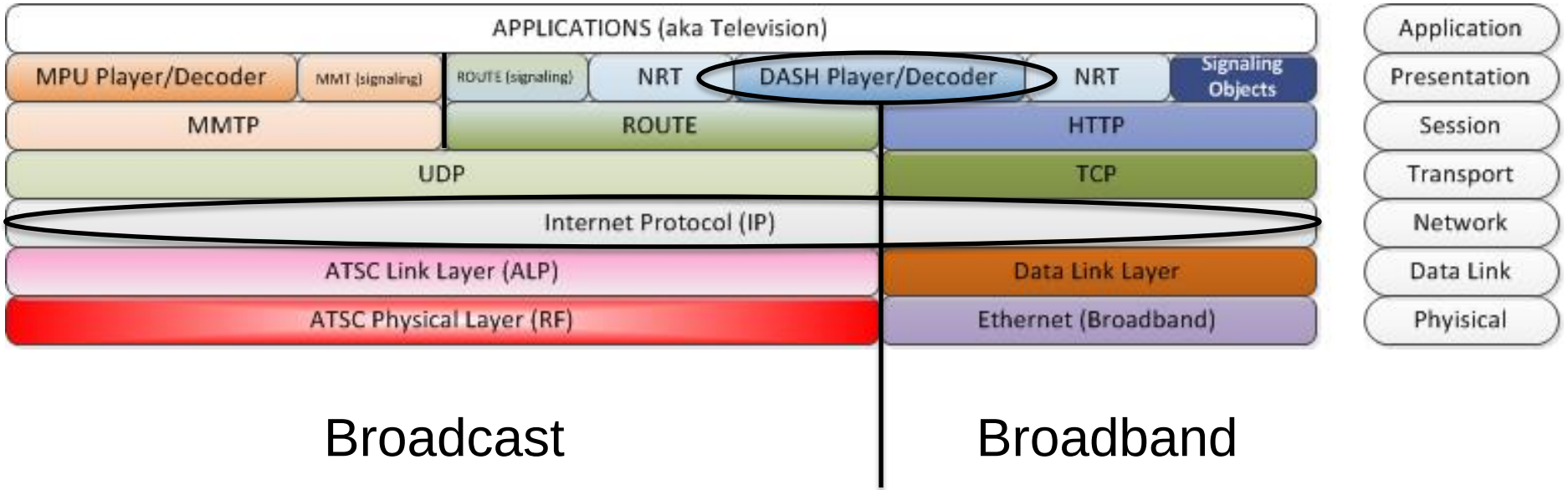
Receiver silicon evolved improving the lock and track performance

The Core Components
…(including the kitchen sink)

The Next Paradigm Shift

- The ATSC 3.0 system is the next level of state of the art…
- Ushers in 4 distinct technologies which didn't exist before…
  - **Real Time Media** Compression
    - Video (HEVC)
    - Audio (AC-4)
  - **Packaging / Streaming** (DASH / MMT)
    - Metadata (ROUTE, MMTP)
  - **Digital STL** (IP)
  - **Digital Modulation** (A3P)

The ATSC 3.0 Protocol Stack



The ATSC 3.0 Documents

A/321	**SYSTEM DISCOVERY AND SIGNALLING (final)**
A/322	PHYSICAL LAYER PROTOCOL
A/330	LINK LAYER PROTOCOL
A/331	SIGNALING, DELIVERY, SYNCHRONIZATION & ERROR PROTECTION
A/332	SERVICE ANNOUNCEMENT
A/333	SERVICE USAGE REPORTING
A/334	AUDIO WATERMARK EMISSION
A/335	VIDEO WATERMARK EMISSION
A/336	CONTENT RECOVERY IN REDISTRIBUTION SCENARIOS
A/338	COMPANION DEVICE
A/341	VIDEO (H.265)
A/342	AUDIO (AC-4 {US})
A/343	CAPTIONS AND SUBTITLES

ATSC 3.0 Physical Layer (A3P)

- Supported bit rate ranges in a 6MHz channel are …
  - Minimum **0.83 Mb/s** using QPSK, coderate 2/15, 8K FFT, 300usec GI
  - Maximum **56 Mb/s** using 4096 QAM, coderate 13/15, 32K FFT, 28usec GI
- A ~28Mbps service in 6 MHz is considered a “comparable” use case to a 8VSB – **represents a 70% boost**
- Receivers must support as many as 4 PLP’s

Linear TV++

- **Service Types** – Enhanced linear services including multiple, alternative components and interactive application enhancements, pre-load application-based VoD services, audio-only services, push style data-only services
- **Hybrid Delivery** – Delivery of programs, program elements and triggers via broadcast to announce additional products or services available to those with broadband connectivity
  - 1) Main program delivered via broadcast and alternate components or interstitials delivered via broadband
  - 2) Trigger delivered in broadcast and preloaded content delivered via broadband
  - 3) Temporary “hand-off” from broadcast to broadband and back for brief fades in reception
- **Real-Time and Non-Real-Time Delivery** – Content can be streamed in real-time (i.e., linear or streaming on-demand content) via both broadcast and broadband. Content can also be delivered in non-real-time and cached locally via both broadcast and broadband.

New Ecosystems

- **Security –** Security-enabled business models such as subscription services, “freemium” services (i.e., if the user registers and then the content is provided free), subscription for alternate components, and pay-per-view programs.
- **Interactivity** – The interactive application environment for ATSC 3.0 will enable interoperability between the receiver runtime environment and apps that producers and broadcasters author, based on WC3 technologies. The goal is to align with the web as much as possible.

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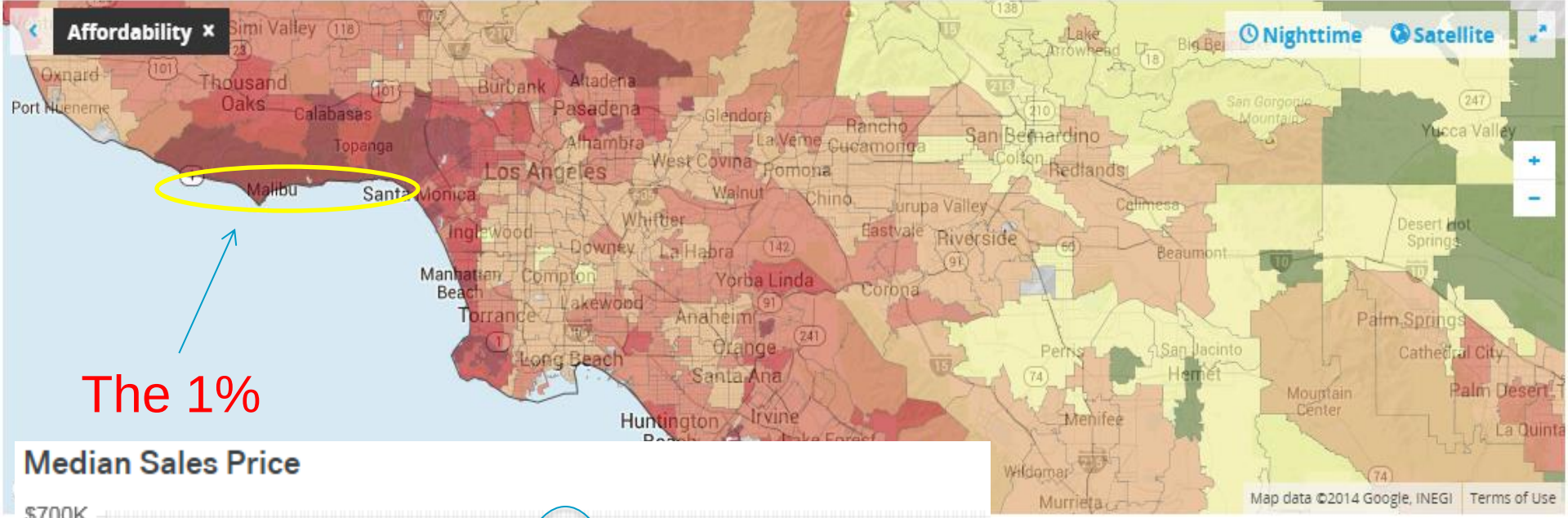
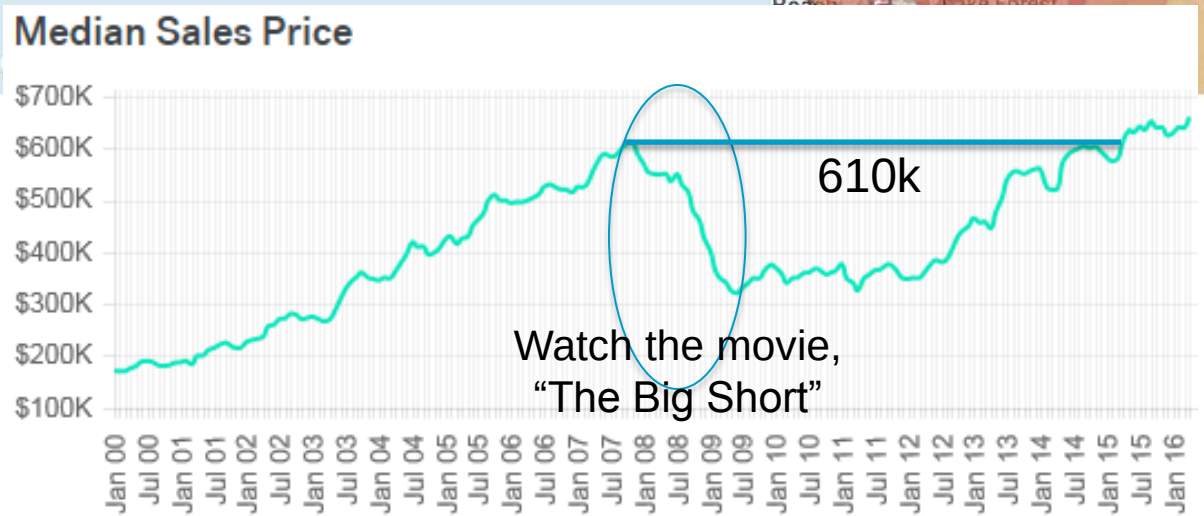
Consumer Landscape


Affordability ×
Nighttime
Satellite
Oxnard
Port Hueneme
Simi Valley
Thousand Oaks
Calabasas
Topanga
Malibu
Santa Monica
Burbank
Altadena
Pasadena
Glendora
La Verne
Rancho Cucamonga
San Bernardino
Colton
Redlands
Yucca Valley
Ahambra
West Covina
Los Angeles
Pomona
Walnut
Chino
Jurupa Valley
Eastvale
Riverside
Colimesa
Beaumont
Desert Hot Springs
Inglewood
Whittier
Downey
La Habra
Manhattan Beach
Compton
Yorba Linda
Corona
Torrance
Lakewood
Anaheim
Palm Springs
Cathedral City
Long Beach
Orange
Santa Ana
Perris
San Jacinto
Hemet
Mountain Center
Palm Desert
La Quinta
Huntington
Irvine
Menifee
Wildomar
Murrieta
Map data ©2014 Google, INEGI
Terms of Use

The 1%


Median Sales Price
$700K
$600K
$500K
$400K
$300K
$200K
$100K
610k
660k
Watch the movie,
“The Big Short”
Jan 00
Jul 00
Jan 01
Jul 01
Jan 02
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Jul 15
Jan 16

Household Income (based on L.A. data)

The income status of residents was as follows…

- Median household income: $48,610
- Mean household income: $76,557
- Median family income: $53,008
- Mean family income: $83,965
- Median non-family income: $38,227
- Mean non-family income: $61,155

Take-home pay for a typical household is ~$2,250

(Calculation based on a typical 26 pay periods, less typical withholding)

Wikipedia – factfinder.census.gov

The racial/ethnic/cultural composition of Los Angeles as of the 2005-2009 American Community Survey:[2]

White: 41.3% (Non-Hispanic Whites: 29.4%)

Hispanic or Latino (of any race): **47.5%**

Black or African American: 9.8%

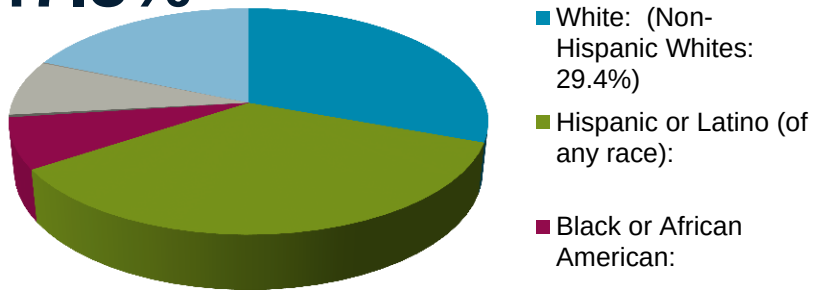
Native American: 0.5%

Asian: 10.7%

Native Hawaiian and Other Pacific Islander: 0.2%

Other: 25.2%

Two or more races: 2.8%



Languages

- The linguistic composition of Los Angeles out of a population of 3,473,790 people over the age of 5 [4]
  - English only: 40.2% (1,397,555)
  - **Language other than English: 59.8%** (2,076,235)
    - Speak English less than "very well": 30.5% (1,058,358)
  - Spanish: **43.6% (1,513,106)**
    - Speak English less than "very well": 23.2% (806,252)
  - Other Indo-European languages: 7.0% (242,461)
    - Speak English less than "very well": 2.8% (98,907)
  - Asian languages and Pacific Islander languages: 7.9% (275,109)
    - Speak English less than "very well": 4.0% (140,058)
  - Other languages: 1.3% (45,559)
    - Speak English less than "very well": 0.4% (13,141)

The Economy

- The US economy has slowly recovered in most sectors…
- Household income has not increased much for the middle class
- Cord cutting trends continue since disposable income is greatly affected because of fluctuation commodity costs (gas $5/gal)
- Discretion says keep the 4G-LTE, but drop the pay TV
  - Cable TV prices went up 4x the rate of inflation in the last 3 years
  - DBS is still in high churn mode, and big DSL just bought big satellite
  - Second screen is growing rapidly as pay TV (ESPN, HBO) losses continue to erode

The Consumer Television

- The average TV screen size has increased (~150%) as the average sale price has decreased on the larger models
- 4K Screen prices range (45” – 65”) **$499 – $7899**

  (based on a range of 6 manufacturers of 2 specific models available at 3 major stores)
- The motivation - the new displays have…
  - FOTA tuners – including the big 4k UHD TVs
  - Better processors/ up-scalers ASICs
  - Better display / backlight technology
  - Better power consumption, slim or curved profile, UI...
  - Built in AVC decoders – Thank you NetFlix, YouTube!

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Broadcast Infrastructure

Flexibility and Diversity

- Multi channel service per carrier is more common (12SD or 3HD)
- Viewers are more comfortable with picture artifacts (YouTube)
- By 2020 we see a number of significant changes …
  - **OTA** – broadcaster **will** be sharing bandwidth
  - **OTT** – forcing trends in spending (a-la cart) and viewing habits (binge)
  - **MVPD** – will be chasing dwindling content contracts moving to all IP
- The number of ethnic channels will continue to increase …
- More 2k (Full HD) & 4k delivery is already predicted …
  - HEVC will be needed to make it survive

HEVC versus H.264

- Both Codecs…
  - Came to the market with a lot of buzz
  - Promise better pictures at half the bandwidth when compared with the predecessor
- But H.264…
  - Needed several years to deliver pictures at half the rate
  - Took a very long time to become a “common” decoder
  - Will never fully displace MPEG-2

HEVC versus H.264

- Both timed with consumption shift
  - H.264 = HDTV
  - HEVC = Internet TV and 4k
- MPEG-2 limited HD's market penetration
  - High bandwidth "cost" meant fewer channels
  - Not viable for Internet delivery
- H.264 is limiting Internet TV via "compromises"
  - Reduced frame rates, 720p**30** vs 720p**60**
  - Video Quality vs. Accessibility, HD @ 1.5Mbps

Technology Snapshot

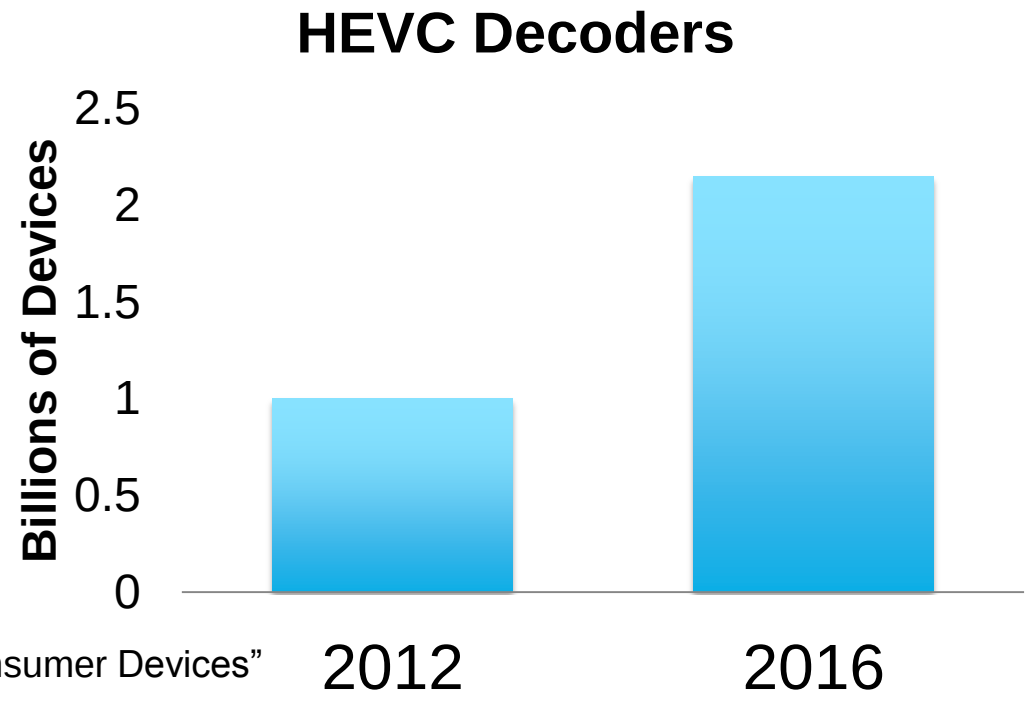
- Early Silicon
  - H.264 decode was hard to do, encoder was even harder
  - Not enough devices to decode the video
- Device eco-system
  - In 2004, computers lacked the horsepower to decode
  - Set top boxes required a new generation of silicon
- Internet Connectivity
  - No wireless data of any meaningful speed
  - Home broadband was still anemic

What changed in 10 years?

- Early Silicon
  - H.26[A6] de was h[Core i7 900 Extreme] encode[NVIDIA TEGRA 3] harder
  - Not enough devices to decode the video
- Device eco system
  - In [tablets] mput [phone] ked [tablets] powe[TV]
  - Set top boxes required a new generation of silicon
- Internet Connectivity
  - [4G LTE] eless data of any meaningful[PING 31 ms | DOWNLOAD SPEED 19.21 Mbps | UPLOAD SPEED 2.53 Mbps | SHARE THIS RESULT] [VERIZON 4G LTE]
  - Home broadband was still anemic

Is the World ready for HEVC?

For the 1st time a codec will launch with an installed base of capable consumption devices



Source: MRG 2012 "HEVC Decoding in Consumer Devices"

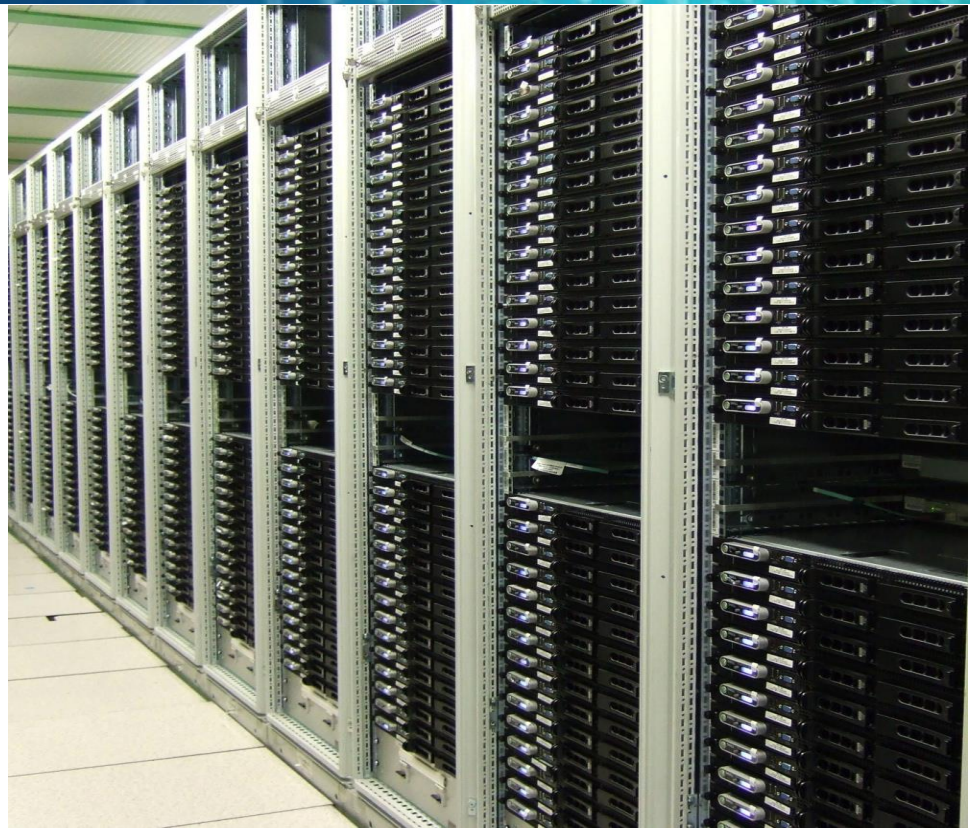
Impact on video infrastructure

Data Centers

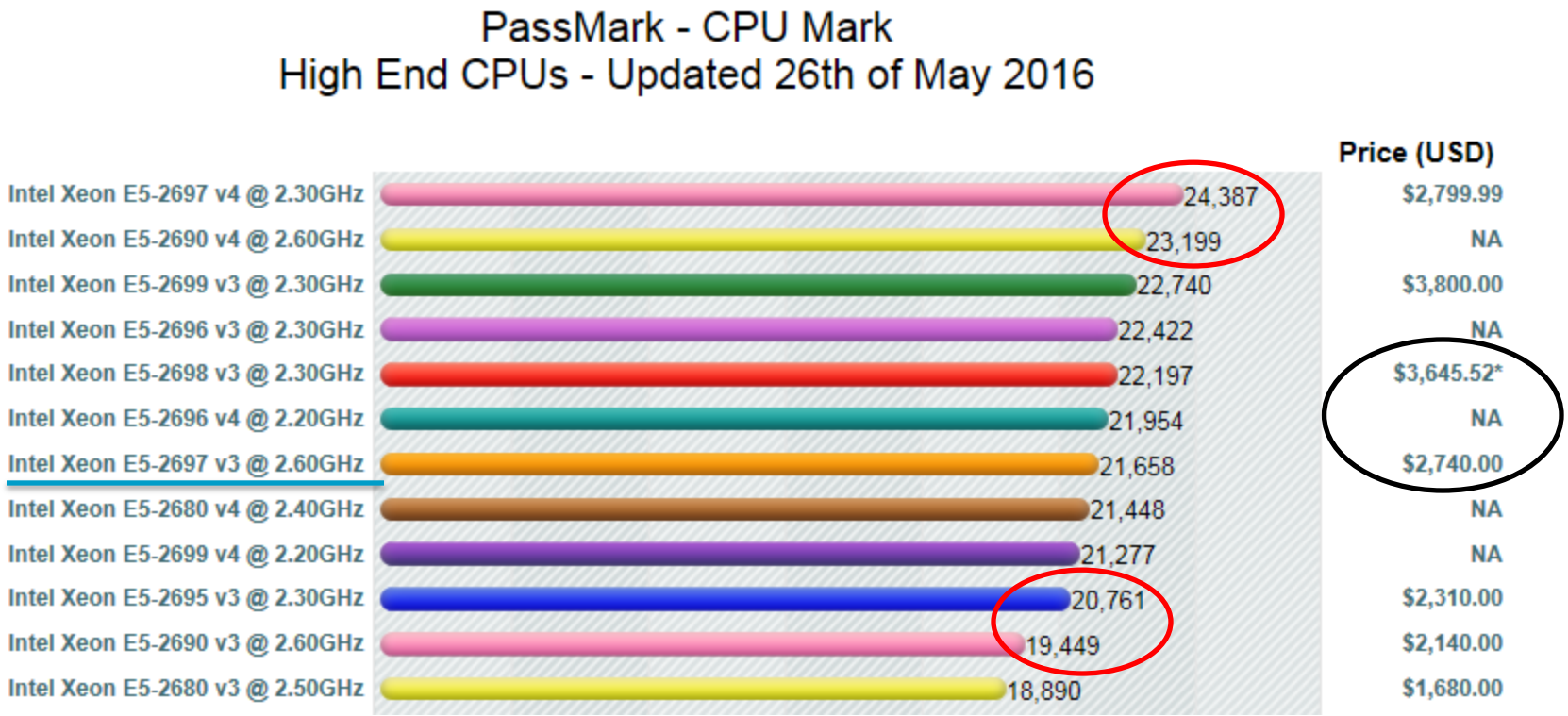
- Unified infrastructure
- Efficient networking
- Elastic capabilities

Opportunity?

- Is it possible to move the broadcast/playout facility to IT infrastructure?
- Can we really get the flexibility and reliability?



Tracking the High End CPU Market

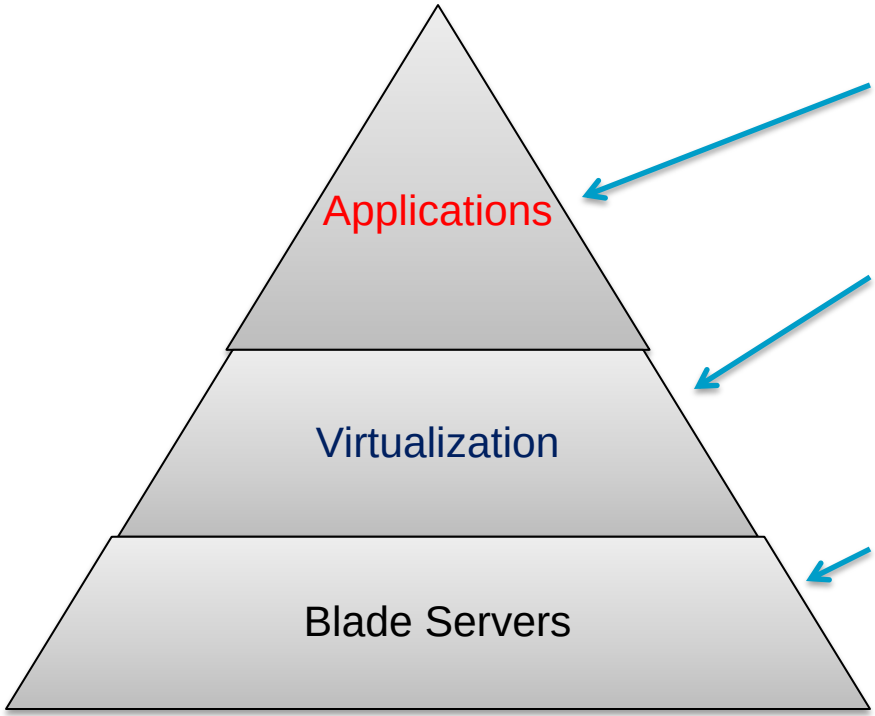


Source - http://www.cpubenchmark.net/high_end_cpus.html

COTS Blade Server Advantages

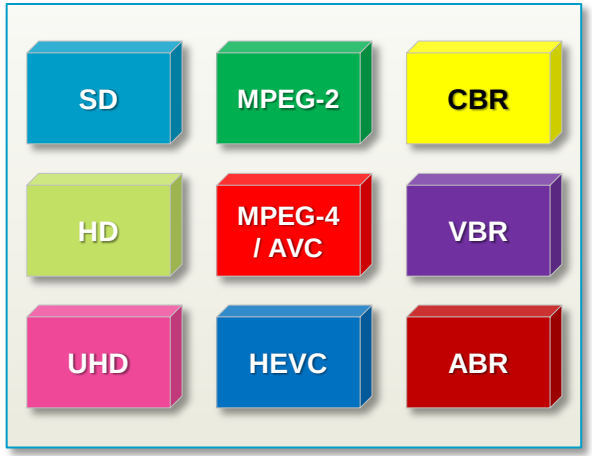
- 70-80% less networking
- Hardware de-coupled from encoding technology
- Common compute across all applications
- Simplified servicing

Software Versatility



- Faster rate of innovation
- Dynamically balance efficiency and resource utilization
- Application investment outlives underlying infrastructure

Virtualized Video Infrastructure



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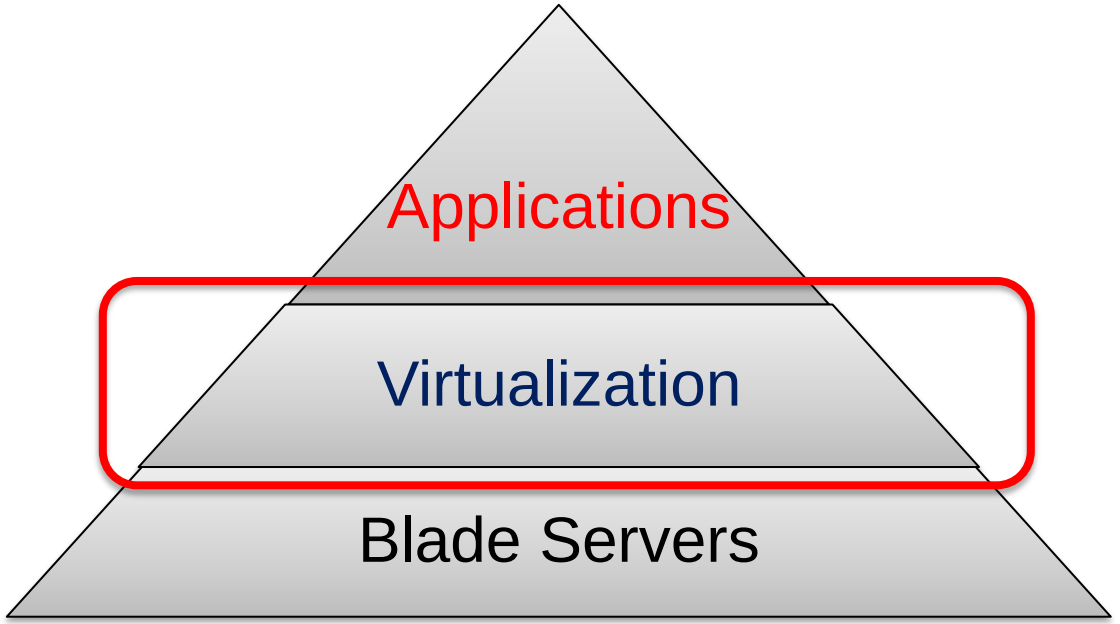
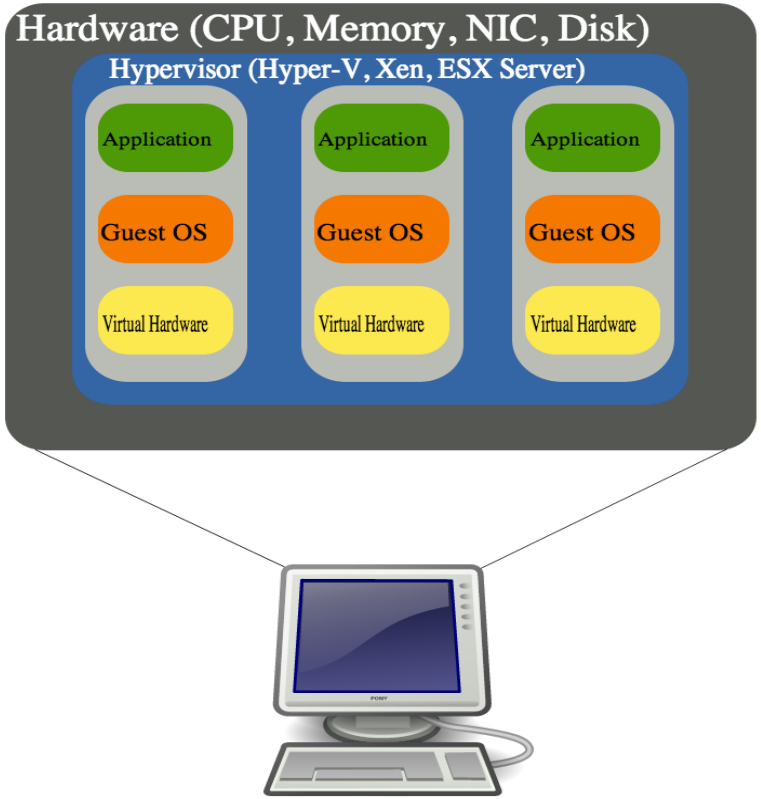
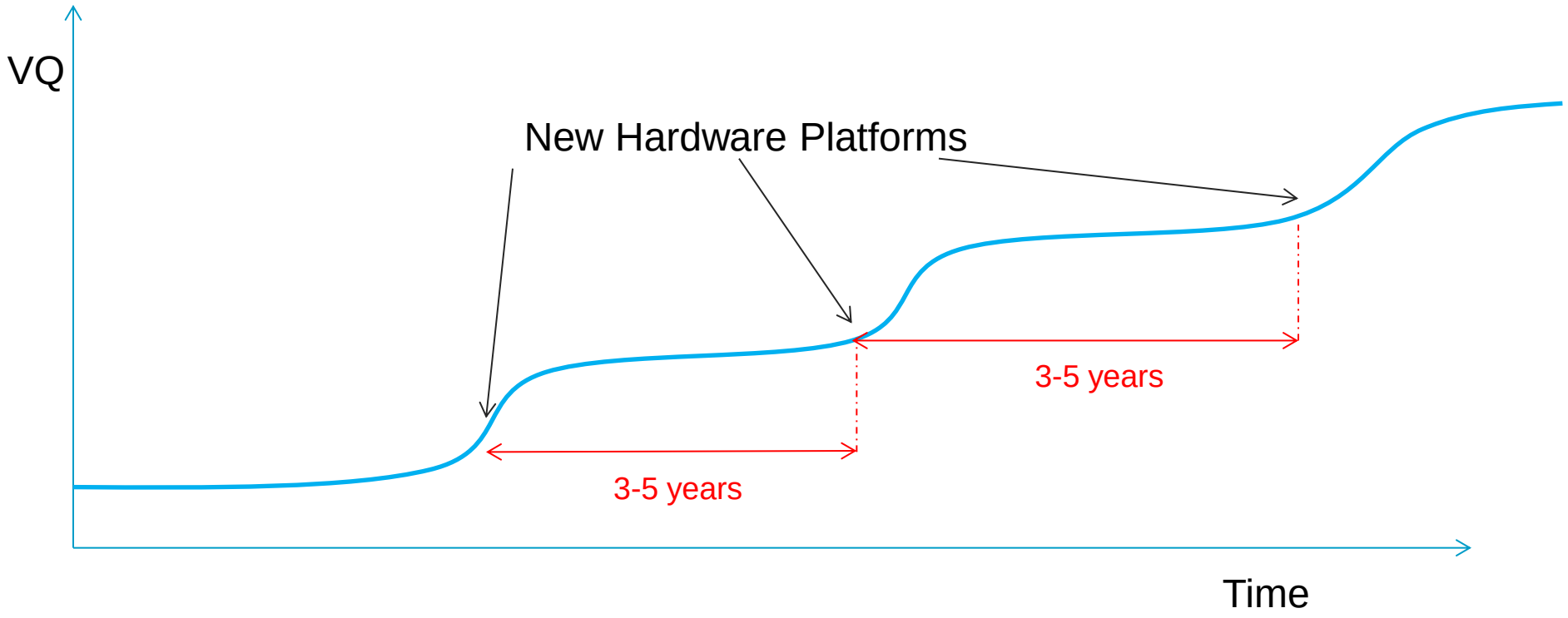


Virtualization Advantages

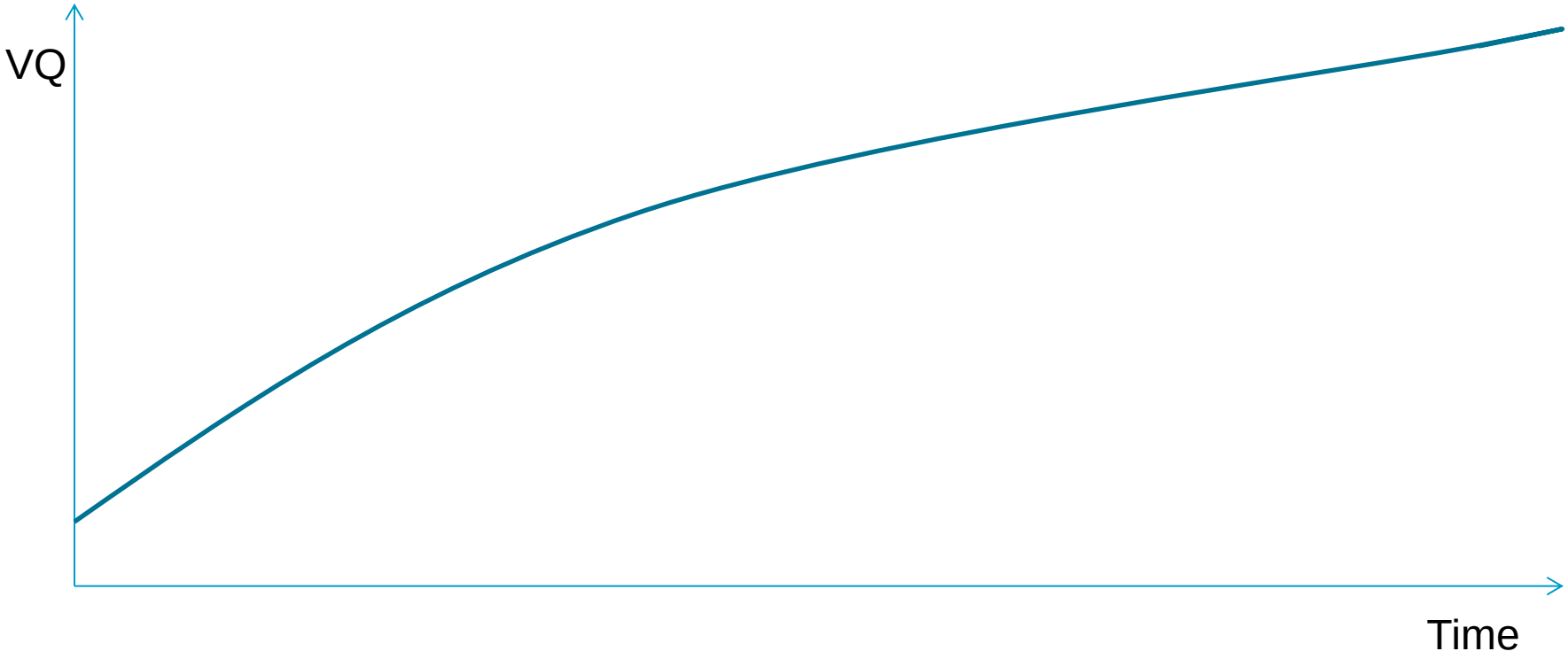


- Easily upgrade underlying hardware
- Rapid deployment and scalability
- Applications can share compute cycles
- Enables expanded commercial terms for encoding technology

Typical H/W VQ Improvement Rate



Typical SW VQ Improvement Rate



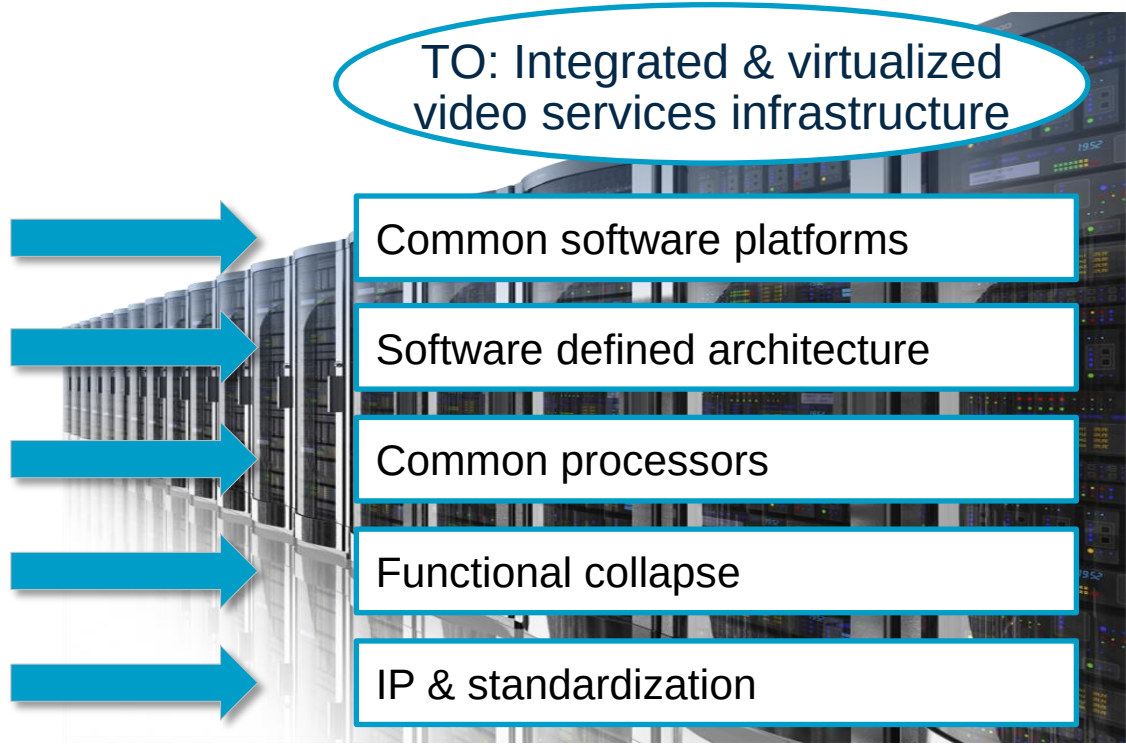
Virtualized Video Infrastructure

FROM:
Discrete proprietary video appliances

- Device specific software
- Hardware defined architecture
- Bespoke processors / ASICs
- Fixed functional devices
- Custom video technologies

TO: Integrated & virtualized video services infrastructure

- Common software platforms
- Software defined architecture
- Common processors
- Functional collapse
- IP & standardization



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Moving Between ATSC 1.0 to 3.0

1.0 – Was Analog to Digital…
3.0 – Is Broadcasting + Streaming…

Decision Time

- Come September…
  - We will know more about the broadcast landscape
    - Who stays and who moves
    - **In Los Angles** – somebody is likely to loose
  - The petition from the consortium has gone out to the FCC
    - “We are ready to move on with 3.0, let’s go…”
    - DA-16-451 “… Authorize Permissive Use of the Next Gen TV”
  - Standards work will continue to progress
    - HDR momentum will come to a head
    - Lab and Pilot systems are already been built

Optimizing MPEG-2 Statmux Density

4x HD (720p) CHANNELS

Good results for secondary content like S@H, movies, legacy programming; limited sports

3x HD CHANNELS (MIXED)

Mainstream video quality and not going to get much better without severe softening or compromise

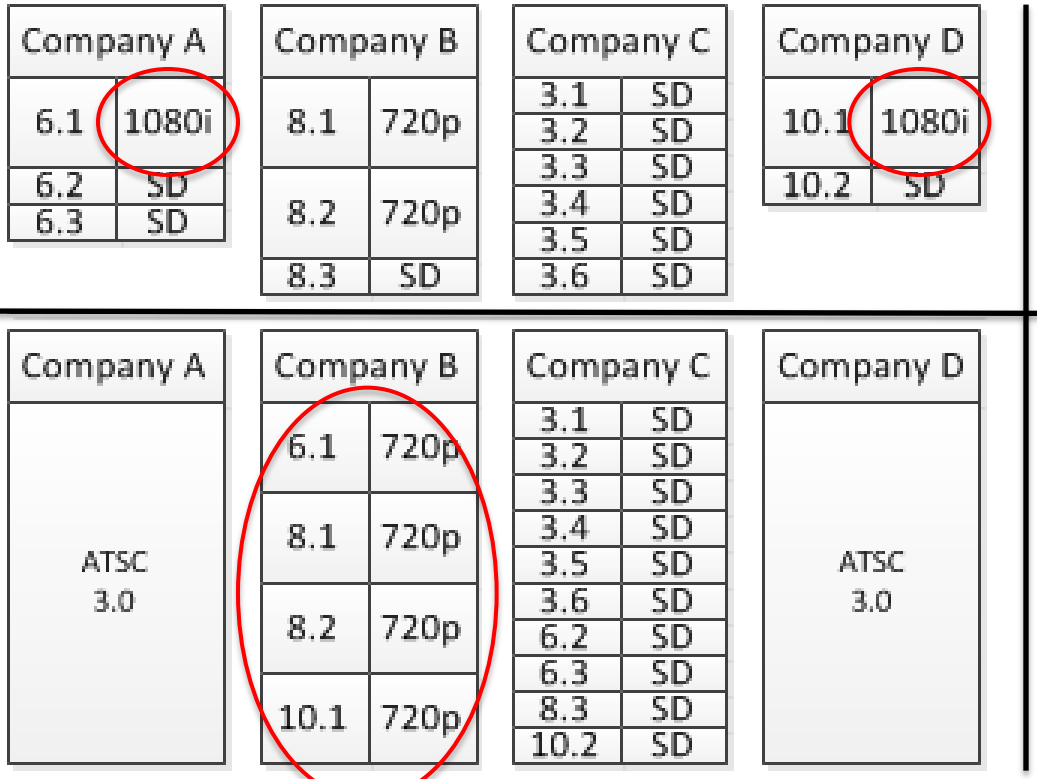
10-12x SD CHANNELS

- Good video quality for any “dot-two” channels of multiple stations

WITH 3 RF CHANNELS

- Can off-load 5 to 6 stations…
- 6x HD (mixed) in 2 pools and a single pool of 10 SD in the 3rd

Rearranging the channels…



In a typical ATSC market, each station will have deployed their channels in a mixed profile statmux

By setting all the HD profiles to 720p, the statmux pools can be reorganized into similar profiles and liberate two carriers

A Whole ATSC Market in 15 Carriers

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RF 1	RF 2	RF 3	RF 4	RF 5	RF 6	RF 7	RF 8	RF 9	RF 10	RF 11	RF 12	RF 13	RF 14	RF 15
1080i	SD	720p	SD	1080i	SD	720p	SD	1080i	720p	1080i	SD	720p	SD	1080i
	SD		SD		SD		SD				SD		SD	
	SD		SD		SD		SD				SD		SD	
	SD		SD		SD		SD				SD		SD	
	SD		SD		SD		SD				SD		SD	
1080i	SD	720p	SD	1080i	SD	720p	SD	1080i	720p	1080i	SD	720p	SD	1080i
	SD		SD		SD		SD				SD		SD	
	SD		SD		SD		SD				SD		SD	
	SD		SD		SD		SD				SD		SD	
	SD		SD		SD		SD				SD		SD	

MPEG 2
1080i – 10
720p – 12
480i – 60

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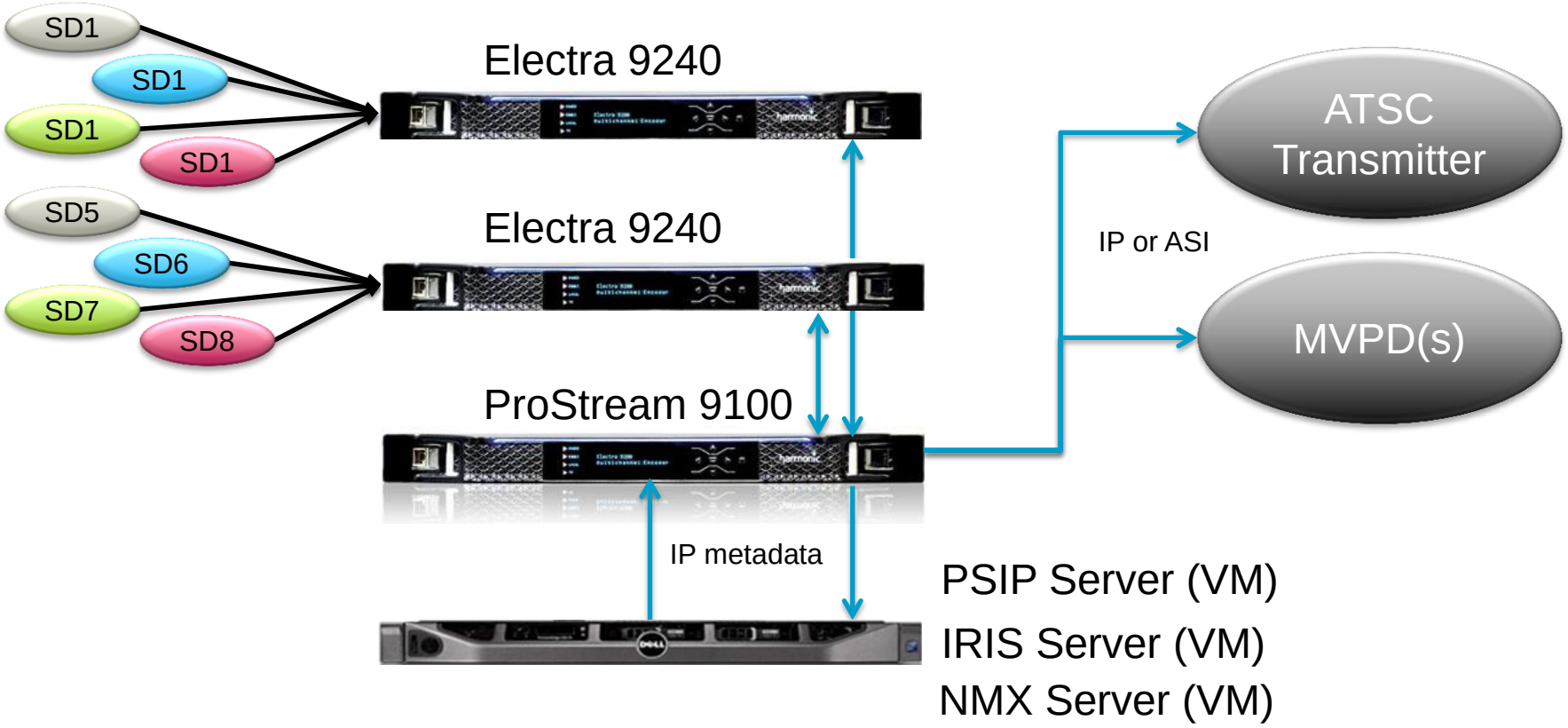
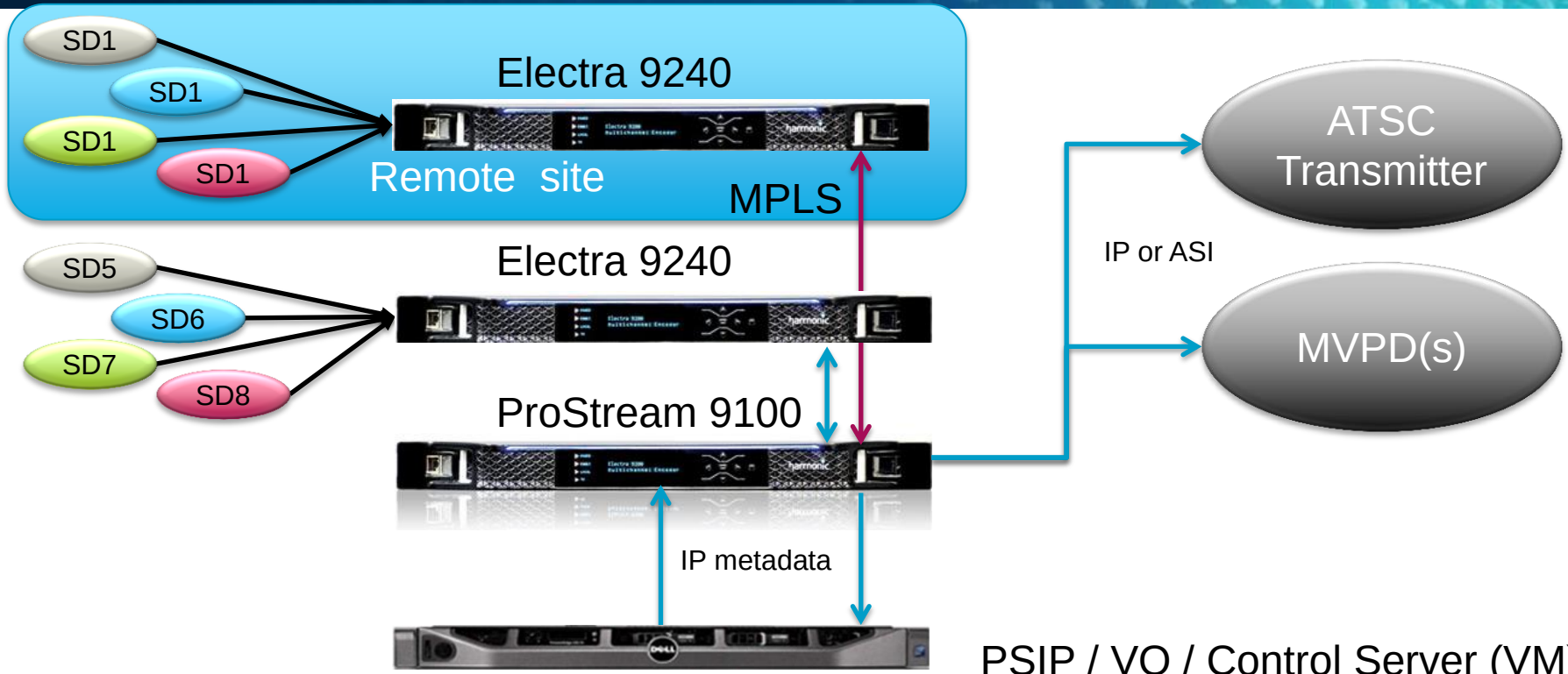
System Solutions

From ATSC 1.0

TYPICAL SOLUTION



STATMUX over WAN - SOLUTION



ATSC 1.0 Density Options

- Make the case to be a single profile operator to maximize the density
  - Mixed pools work but are biased to create a balance
  - Some stations are ALREADY aligned

- Transition **AIR** services to lower profiles 1080i->720p->480p (16:9)
- BUT!!! Maintain the MVPD profiles and channel characteristics as is

- **A/72 (ATSC 2.0)**
  - Is now a reality – but controversial (field of dreams)
    - Start a simulcast a channel today – promote it – market push
    - No way to know the market penetration of capable receivers

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System Solutions

For ATSC 3.0

ATSC 3.0 E/E Solution

NAB LABS FUTURES PARK

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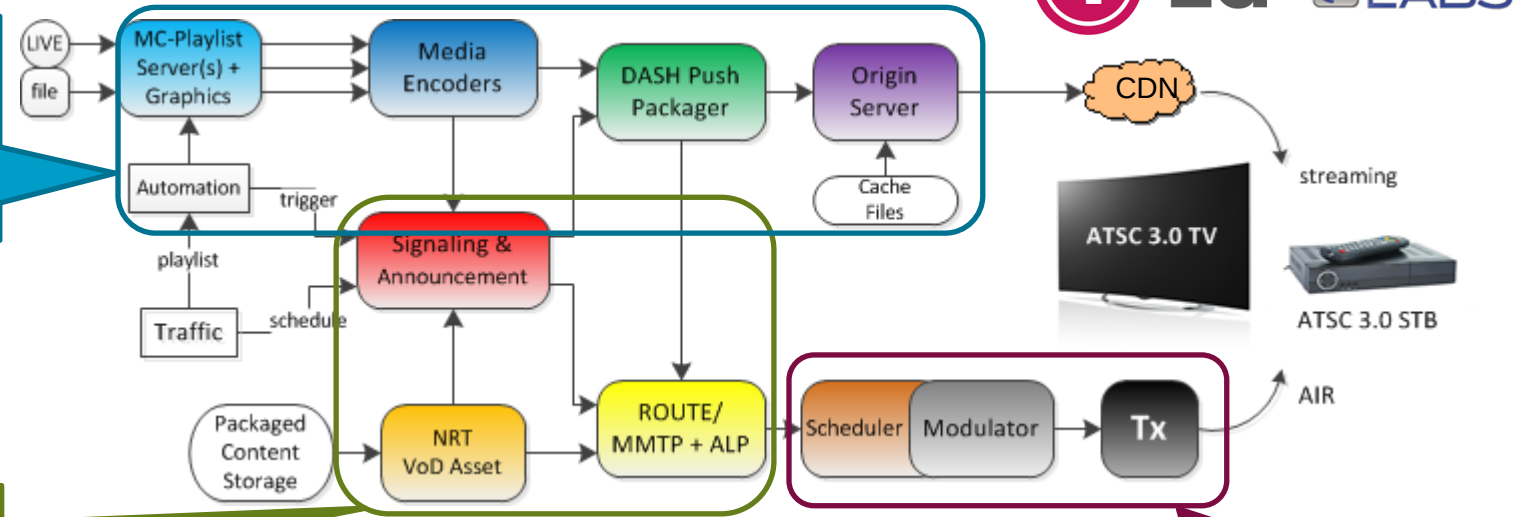
Playout
Encoder
Packager
Origin



LG NAB LABS

triveni DIGITAL

Signaling
NRT Data
Scheduler
Router

GATESAIR

PLP Scheduler
Modulation
HPA

Broadcasters are now Multicasters

- The ATSC 3.0 station output is …
  - UDP – user datagram protocol
  - MULTICAST (broadcast)
  - IP – internet protocol
  - PACKETS – payload for bits

Broadcasters are now Multicasters

- The business opportunities built into ATSC 3.0 are based on both broadcast and streaming capabilities…
- The definition of TV delivery is about to get blurry
  - Turn the tables, streaming delivery for broadcast
  - Broadband file delivery offload fail back to broadcast
  - Application delivery services, s/w upgrades!!!
  - Triggered NVoD delivery service
  - And many more…

ATSC 3.0 Over The Air Options

- **Single Carrier**
  - Single PLP - just like ATSC 1.0 is one level of robustness
  - Multiple PLP – Allows various size pipes
    - Each PLP is a set to carry a collection of specific parts
- **Multiple Carrier**
  - Multiple PLP are bonded across two or more carriers to make an aggregate pipe for multi tuner operation
  - The carriers don’t need to be concurrent in spectrum
    - One carrier can be a LoV with very robust coding to deliver the smaller circuits, Audio, ESG, triggers, etc. (lower data rates)
    - Other carrier can be HiV or U and run higher data rate (lower robustness) to carry the videos

ATSC 3.0 SFN

- **Single Carrier – SFN**
  - Same model but with a distributed transmission system to operate from multiple low power, low tower locations to raise the signal level with tightly coupled synchronous transmitters, a Low VHF stands a better chance of surviving in the noise

- **Multiple Carrier – SFN**
  - The data rate possible running on one or more carriers is approaching the rate available on small CABLE systems
    - Assume ATSC 3.0 rates of 28 - 50 Mb/s each…
    - QAM 256 ~ 38.7 Mb/s

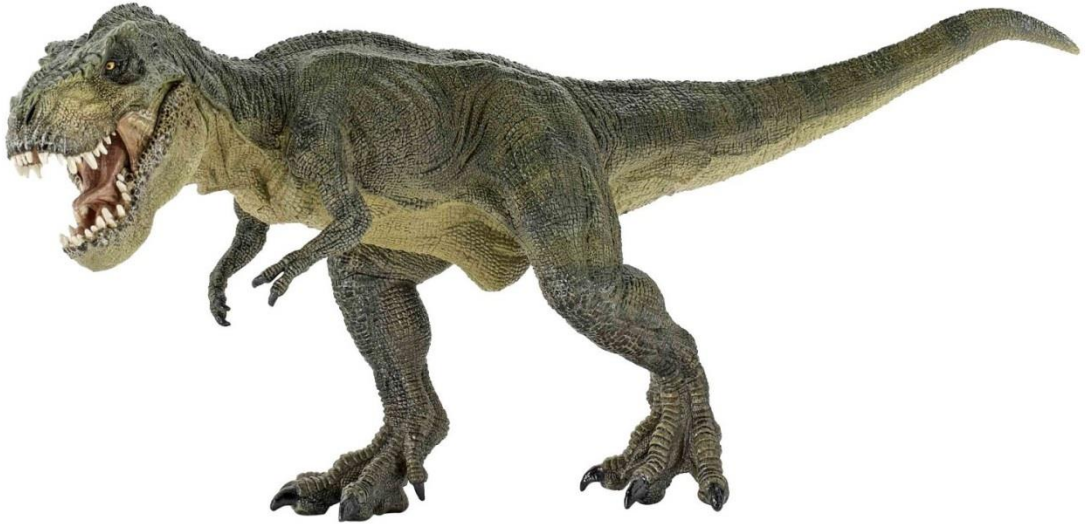
ATSC 3.0 Broadband

- Broadcast services must announce the products available in the streaming services (geo fencing)
- Streaming services can provide… (but not stand alone)
  - Diverse, Unlimited, Extra/Bonus and bidirectional
  - Alternate content, Alternate endings, Continued interviews
  - Off load VoD materials,
    - previous season
    - older episodes
    - Ad split

Summary

Digital Broadcasting in the US

- Broadcasters *must* change, since 2009 many things have changed …
- The motivations to change are very simple to understand



Forced Flash-Cut

- ATSC 3.0 currently does not have US government support
- There is no new spectrum available for a transition

Scalable Transition Plan Options

- ATSC 3.0 is a scalable standard **unlike** ATSC 1.0
- A range of selectable options are built into the layers…

New Business Models

- ***The principles of cooperation, sharing and creating the strongest business case for broadcasting are universal around the world but the applications are hyper-local since no two markets are alike. Broadcasters must quickly recognize their real competition is NOT the other broadcasters in their market.***

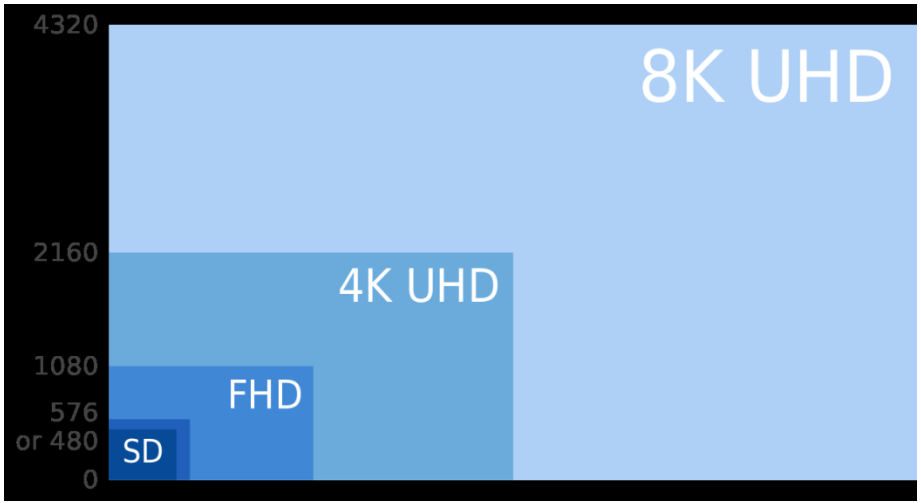
- Groups/consortiums will form to actively participate to manage changes where they have historically not cooperated in the past
- These groups will decide best how to share the spectrum, facilities and infrastructure associated with this transition

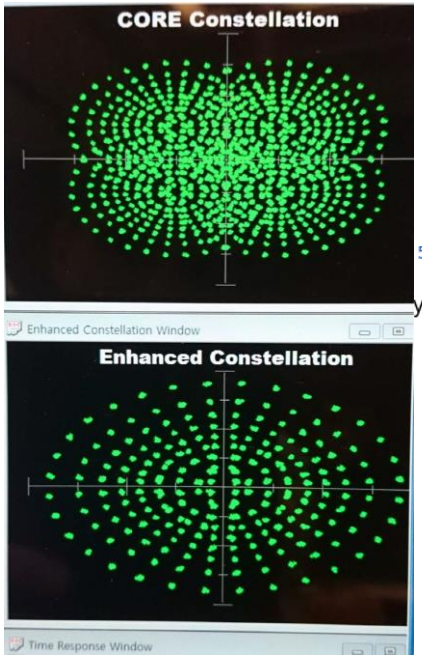
Coordination

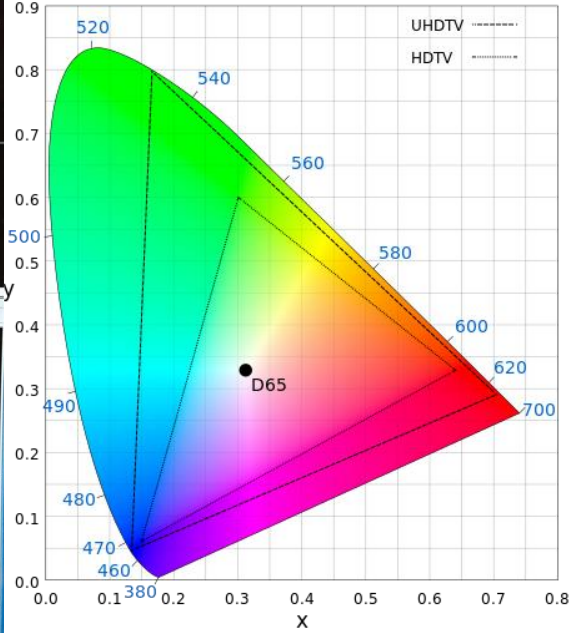
- The next transition will most likely happen market-by-market with the broadcaster engineers in each market determining how best to manage those changes
- Some stations will continue operation in ATSC 1.0 mode for many years (2021) while others move and change
- Other stations will offer MPEG 2 and AVC in 8VSB for channel sharing or to improve channel density/coverage

How Big is This?

- ATSC 3.0 has the potential to expand into markets outside of the US
- **Receivers** will support a wide range of capability not just UHD
- **Receivers** WILL leverage home IP







In Conclusion

1. *The number of broadcast channels available post auction? -* ***Aug-Sept?***
2. *The number of transmission facilities capable of upgrading to 3.0? –* ***Most***
   The Real question is when and where first/next …
3. *The number of stations in a market …*
   I. *…staying in 1.0 operation –* ***depends on consumer adoption rate***
   II. *…shifting to 3.0 operation –* ***depends on the production house sched***
4. *The number of stations which can be moved into a cloud plant?*
   1. ***Will depend on the available connectivity (uW/ Fiber/ MPLS/ etc.)***
   2. ***Links between studios and transmitters over IP is a key tenant of the 3.0 standard – IP has a habit of being networked***
   3. ***Uncompressed or mezzanine compressed (<5 frames) links over IP will be more common place as the shift to move some production and operations elements into the cloud take shape***

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Questions?

Thank you.

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