TODAY, TOMORROW & BEYOND

Overview of the ATSC 3.0 Effort

What is the goal?

- To improve the television viewing experience
  - Higher audio and video quality, more accessibility
  - Personalization and Interactivity
- To address changing consumer behavior and preferences
  - TV content on all devices, both fixed and **mobile**
- To add value to broadcasting's service platform
  - Extending reach, adding possible new business models

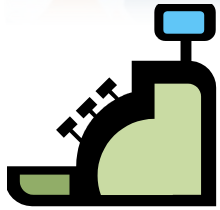
…All without the restriction of backward compatibility

Why is this change worth doing?

- Technology marches on
  - ATSC 1.0 is approaching 20 years old
- Audience expectations are growing
- New competition and disruptive forces
- Wiser use of spectrum
- Leveraging power of OTA+Online

Why should broadcasters care?

- Maintaining and building audience
- Putting content where viewers are
- Benefiting from new technologies
- Quantitative and qualitative growth
- Developing new revenue streams



Broadcaster Participation

- Many broadcast groups have joined ATSC and attend and participate in meetings of SG and AHG's
- Broadcast groups have hired experts to represent their views in specific areas
- NAB Labs is active and helping to lead

Broadcaster's Guidance

- OFDM PHY Layer
- IP Core
- Flexible and evolvable Application and Management Layers
- Cross Layer Control Channel

Broadcaster's Perspective

Platform

In order of Importance

- Robustness
- Mobile
- Flexible Use of Spectrum
- Advanced/Targeted Advertising
- Advanced Accessibility Services
- Advanced Emergency Alerting

Applications

All must be included

- Hybrid Services
- Ultra HD
- Personalization / Interactivity
- Multi-view/Multi-screen
- Enhanced / Immersive Audio
- 3D Content (Video)

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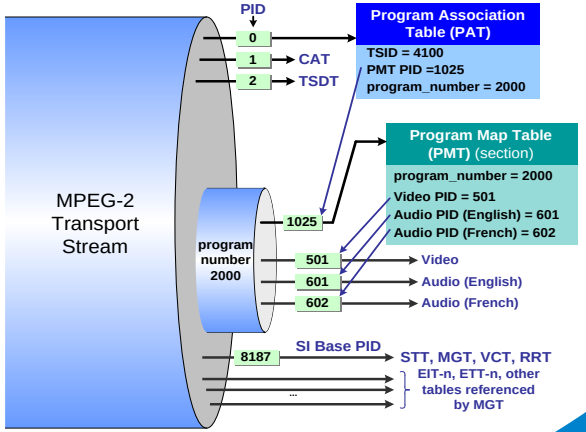
Overview of ATSC 3.0

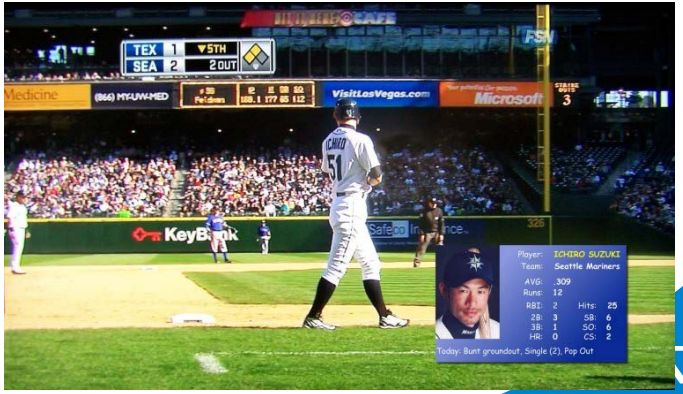
ATSC “1.0”

- Single 6MHz RF channel
  - Channel # ≠ Brand
- Digital – fit within 19.39 Mb/s
- Multiple “programs”
- One Video per program
  - SD & HD
- Multiple Audios
  - But > 2 problematic
  - Up to 5.1 surround
- Closed Captioning
- No new viewer training



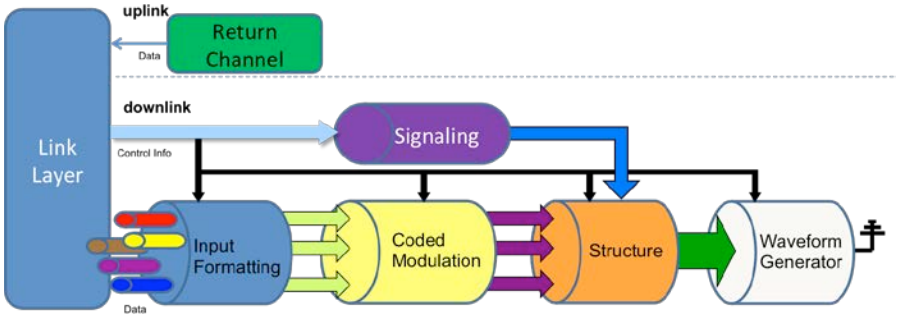
ATSC “1.0” + Mobile + 2.0

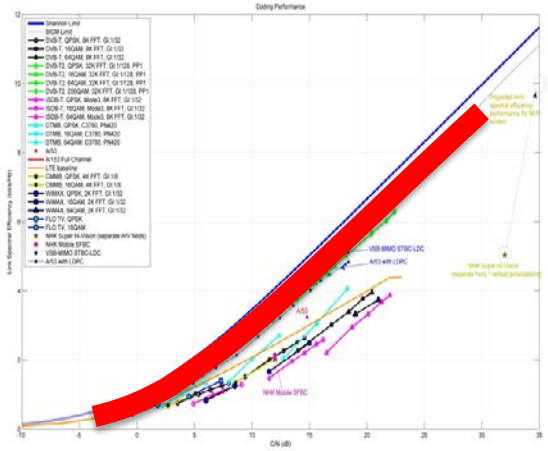
- Single 6MHz RF channel
  - + in-band Mobile
- Multiple “programs”
- One Video per program
  - SD & HD
- Multiple Audios
  - Up to 5.1 surround
  - + non-ideal mobile listening environment
- Closed Captioning
- Pushed Content
- Broadcaster Driven Interactivity



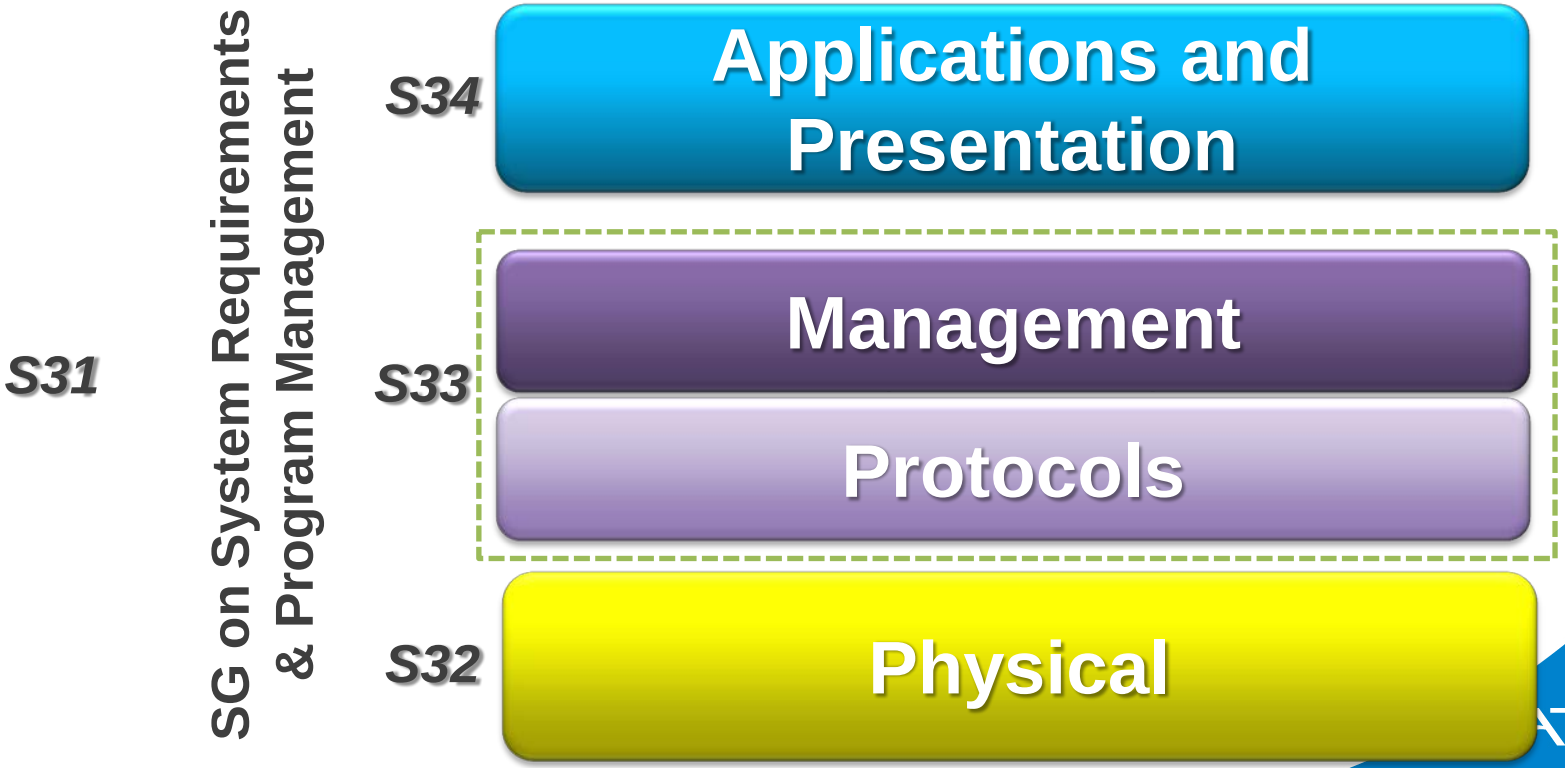
ATSC 3.0

- 6MHz RF channel
  - Scalable to other channel bandwidths
  - Flexible use – fixed or mobile or mix
- Broadband delivery part of mix
- Multiple services
- Wide range of viewing devices
- >1Video per service possible
  - SD & HD & UHD
- Multiple Audios
  - Personalizable
  - Immersive
- Closed Captioning
- Pushed Content
- Interactivity
- Flexibility
- Evolvability





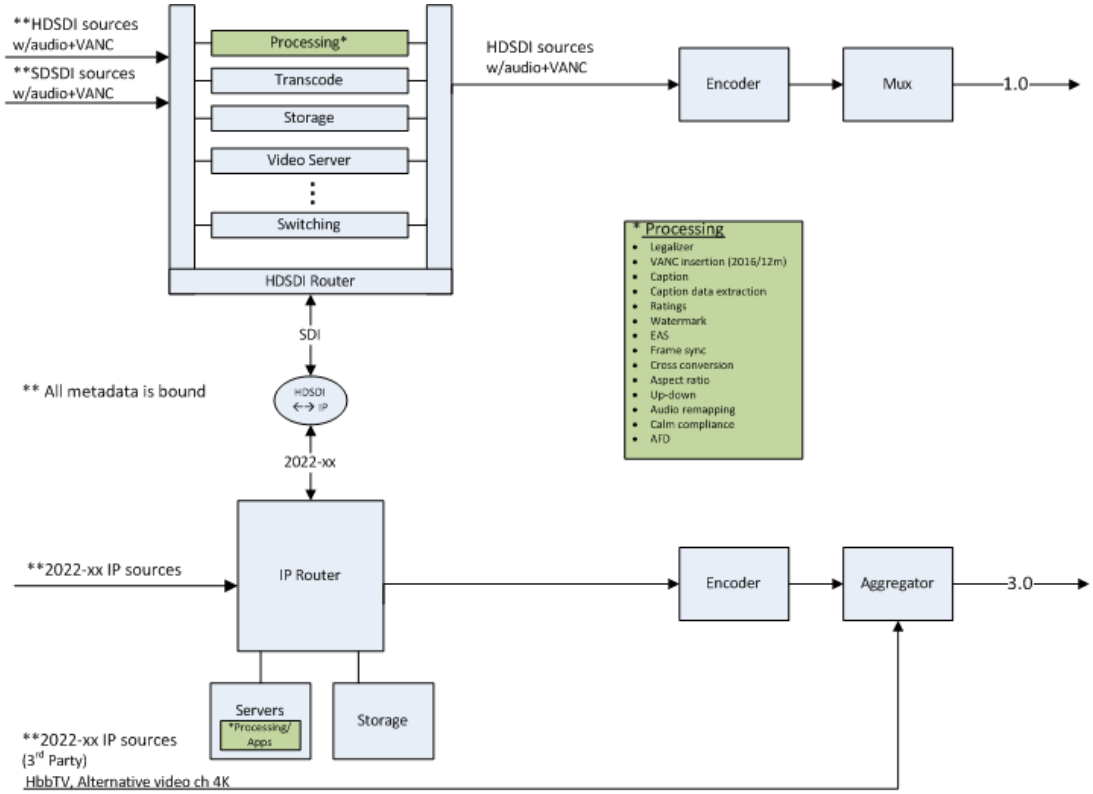
How to organize?



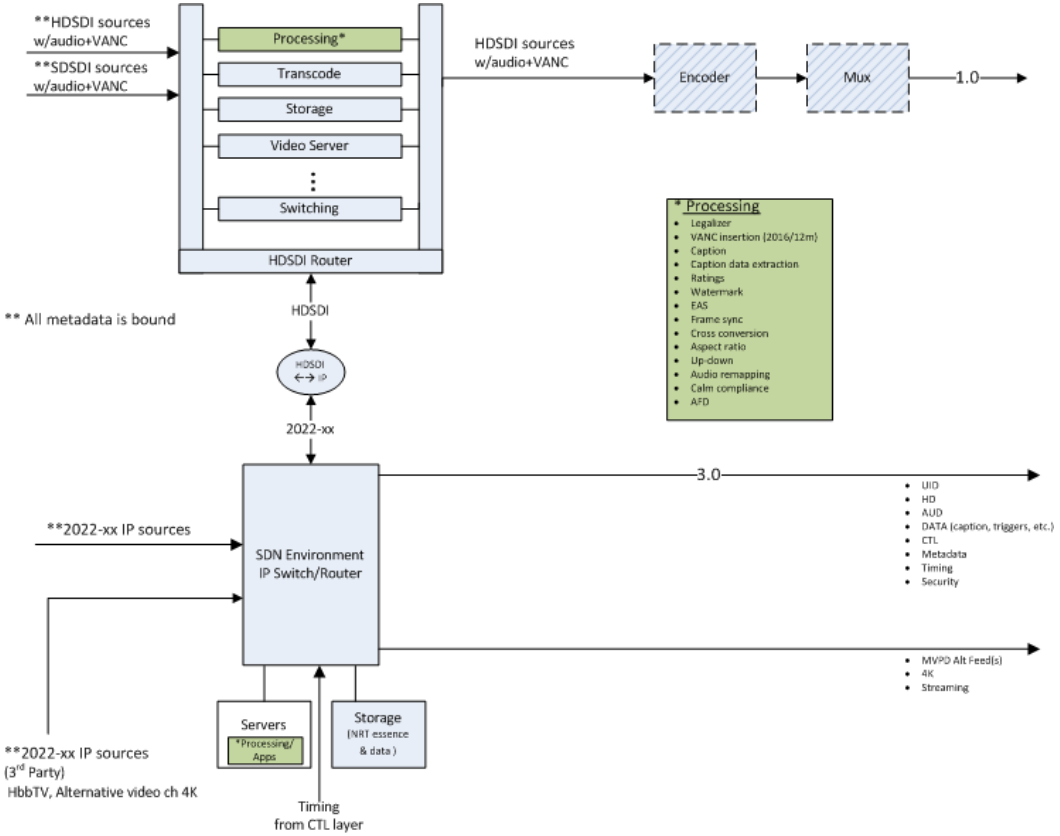
Putting It All Together

- ATSC TG3/S35 Specialist Group on ATSC 3.0 Ecosystem
  - Model and evaluate the environment for 3.0 deployment
  - Examine each type of content and functionality impacting a fully operational ATSC 3.0 system

Example – Video Streaming 1-5 Years



Example – Video Streaming Beyond 5 Years



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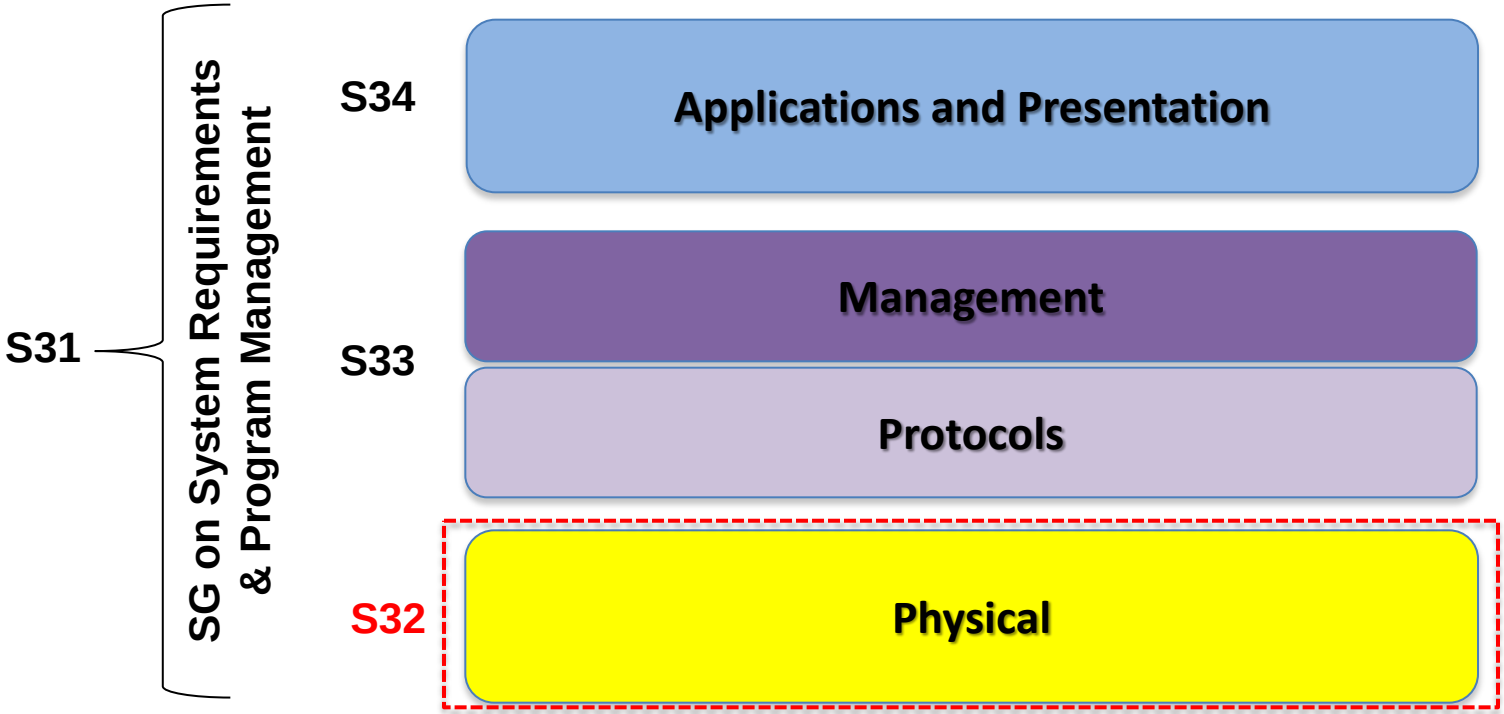
ATSC 3.0 Physical Layer Overview

Layers: System and Process

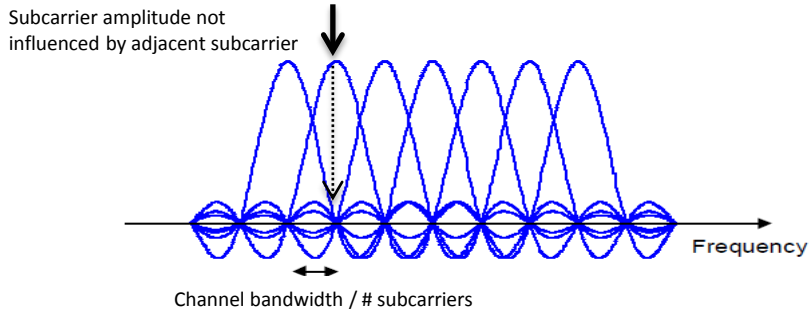


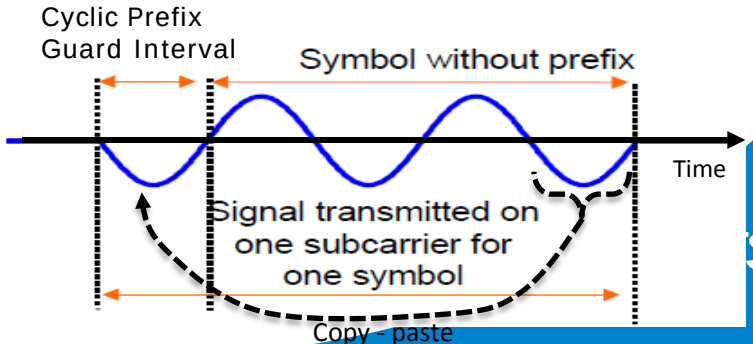
Basic Terminology

- What is OFDM?
- What is FEC?
- What is Shannon’s Theorem?
- What does BER mean?

Orthogonal Frequency Division Multiplexing (OFDM)

- Instead of modulating one carrier with all information, parse information into pieces and modulate those pieces on many carriers. This is frequency division multiplexing (FDM).
- Values at all other subcarriers of interest are zero at correct frequency (orthogonal FDM)
- Enables efficient usage of spectrum by dividing into a set of equally spaced subcarriers within a channel bandwidth
- Easy implementation by having IFFT at TX and FFT at RX chain
- Use of GI (Guard Interval) enables to remove ISI (Inter-Symbol Interference) caused by multipath fading, whose delay is shorter than guard interval



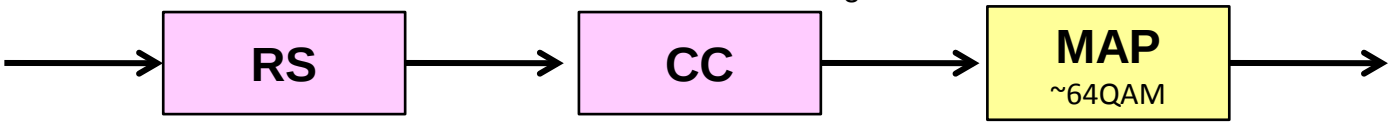


Forward Error Correction (FEC)

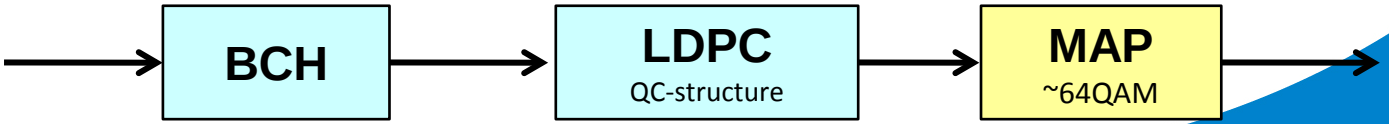
- Adds error correction capability to input data
- Typical FEC codes (combinations)
  - Reed Solomon + Convolutional Code
  - LDPC + BCH

	DVB-T2	DTMB	ISDB-T	ATSC
Inner FEC	LDPC 1/2, 3/5, 2/3, 3/4, 4/5, 5/6	LDPC 0.4, 0.6, 0.8	Convolutional Code 1/2, 2/3, 3/4, 5/6, 7/8	Convolutional Code 2/3
Outer FEC	BCH	BCH (762,752)	Reed Solomon (204,188)	Reed Solomon (207,187)

- Requirements
  - Error correcting capability, measured by closeness to theoretical Shannon limit
- EXAMPLE: Reed Solomon (RS) + Convolutional Code (CC)
  - RS codes to eliminate burst errors after Viterbi decoding of convolutional code



- EXAMPLE: Bose-Chaudhun-Hocquenghem (BCH) + Low Density Parity Check (LDPC)
  - BCH codes to reduce error floors after LDPC decoding



Shannon's Theorem

The relationship with system capacity C of a channel perturbed by AWGN is a function of the average received signal power S, the average noise power N, and the bandwidth W. The capacity relationship (Shannon-Hartley theorem) can be stated as

$$C = W \log_2\left(1 + \frac{S}{N}\right)$$

W = bandwidth (Hz)
S = $E_b C$ (Watts): average received signal power
$N = N_o W$ (Watt): average noise power

In consideration of bandwidth

$$N = N_0 W$$

$$\frac{C}{W} = \log_2\left(1 + \frac{S}{N_0 W}\right)$$

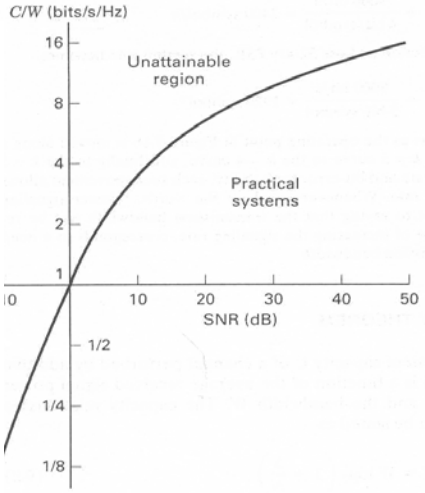


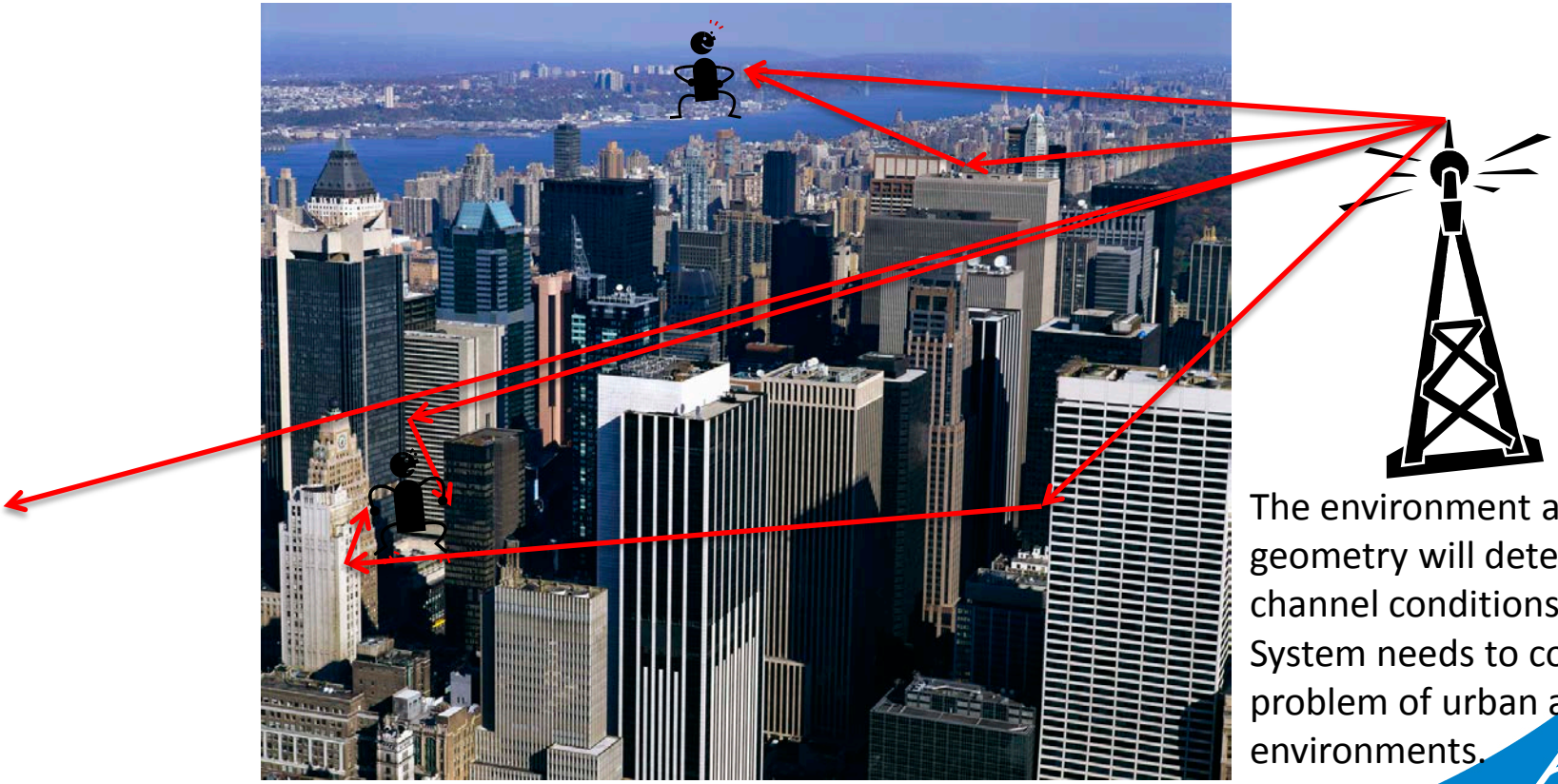
Figure 9.2 Normalized channel capacity versus channel SNR.

*Reference: "Digital Communications", Sklar, Chapter 9.

Bit Error Rate (BER)

- BER is a measure of how clean an output demodulated digital signal can be from the physical layer. Usually expressed as errors / second.
- For IP purposes, Packet Error Rate (PER) might be more useful as packets get dropped from a frame.

Real World concerns

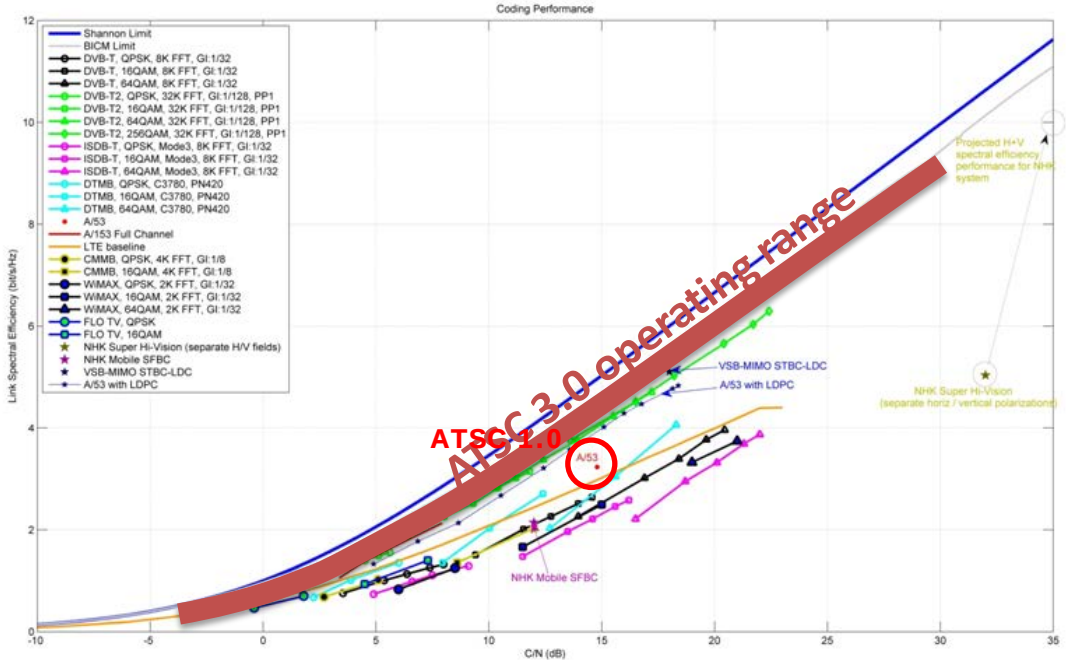


The environment and its geometry will determine channel conditions.
System needs to combat this problem of urban and rural environments.

Technology to combat concerns

- OFDM modulation with Guard Intervals to easily remove multipath effects
- Strong FEC coding to recover symbol errors
- Parameterization to account for strong Doppler, low signal strength and other channel impairments for each device type, mobile and fixed. (FFT size, Modulation and FEC selection, interleaver depths, aiding pilots, etc.)
- Single Frequency Networks to provide different angles of arrival for the broadcast signal
- Extensibility to account for future technology improvements

Spectral efficiency operation



Put the pieces together to give broadcasters operating options:

- **Flexible, robust and efficient operation**
- **Target mobile and fixed devices simultaneously**
- **Enable extensibility for future improvements**

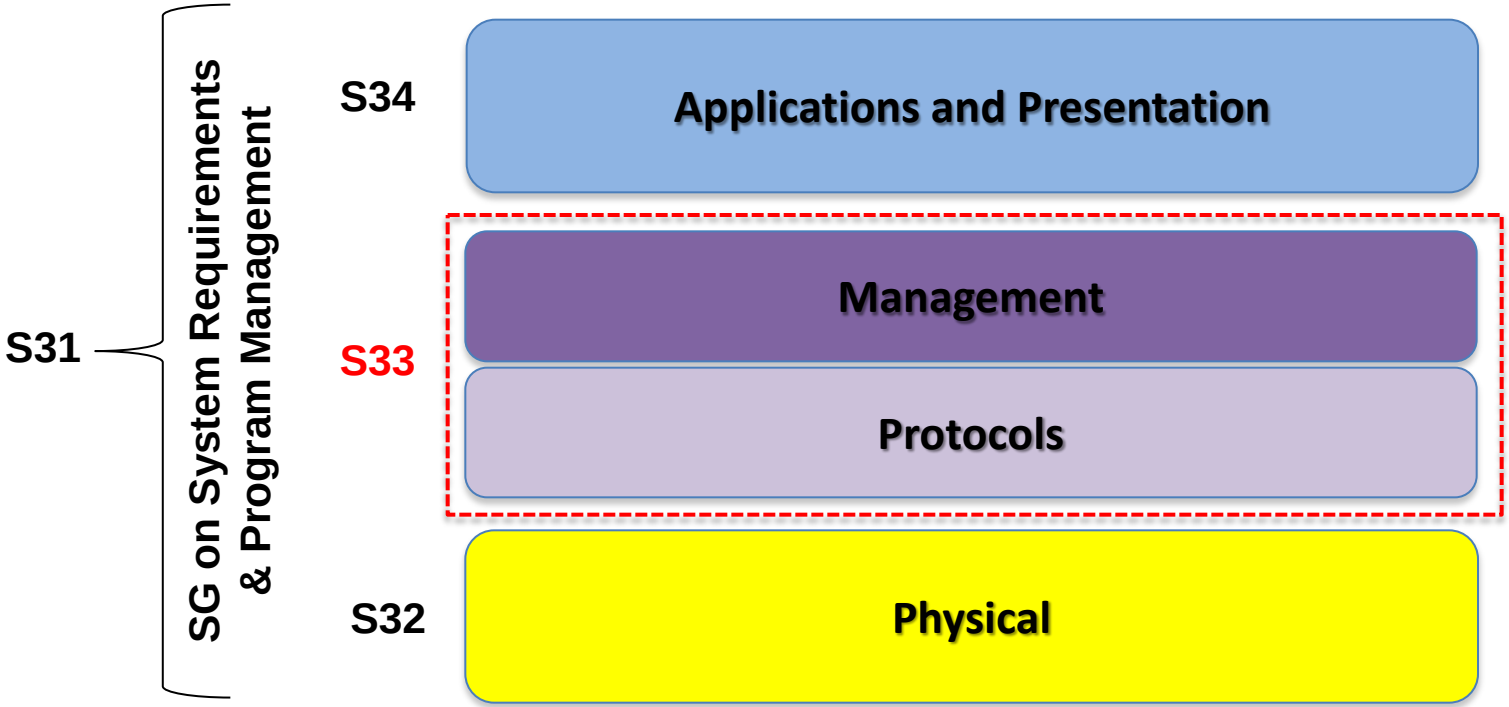
Specialist Group S-32 Organization

- Work divided in 4 Ad Hoc Groups
  - S32-1 AHG on Common System Elements
  - S32-2 AHG on Modulation and Coding
  - S32-3 AHG on Waveform
  - S32-4 AHG on Core Broadcast Services

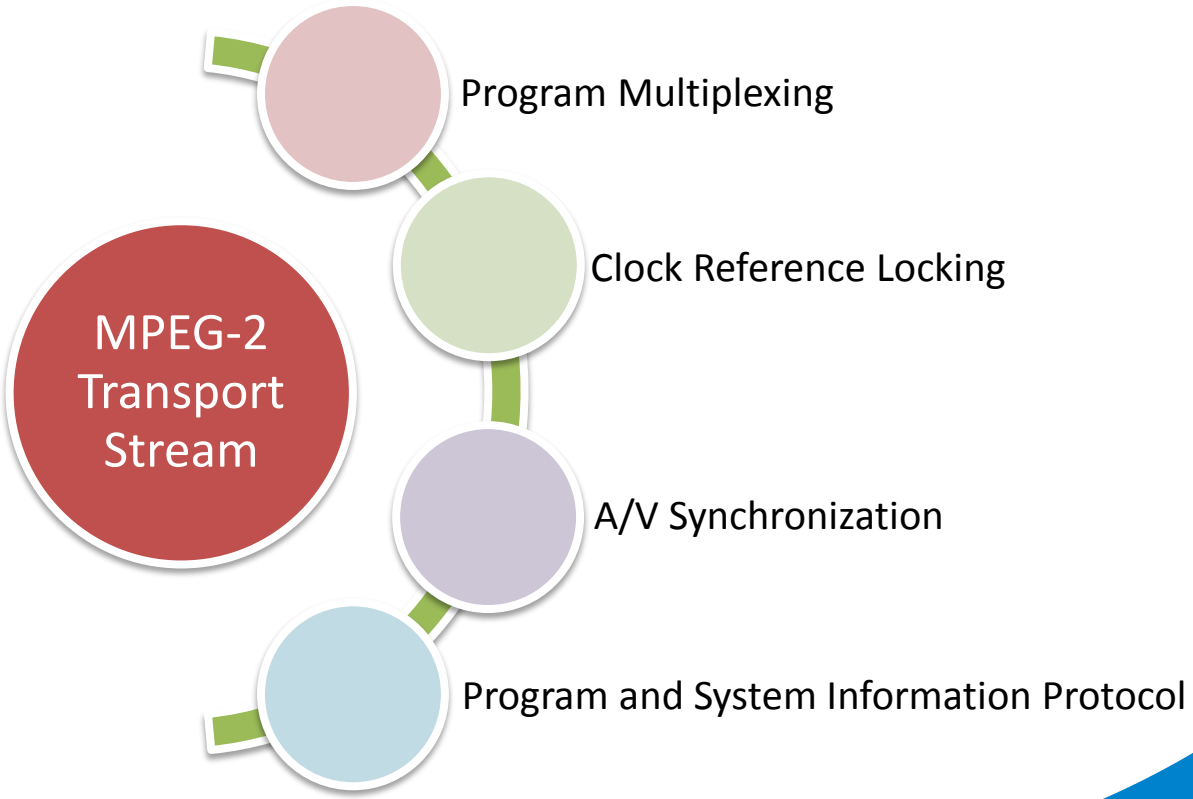
TODAY, TOMORROW & BEYOND

Management & Protocol Layer Overview

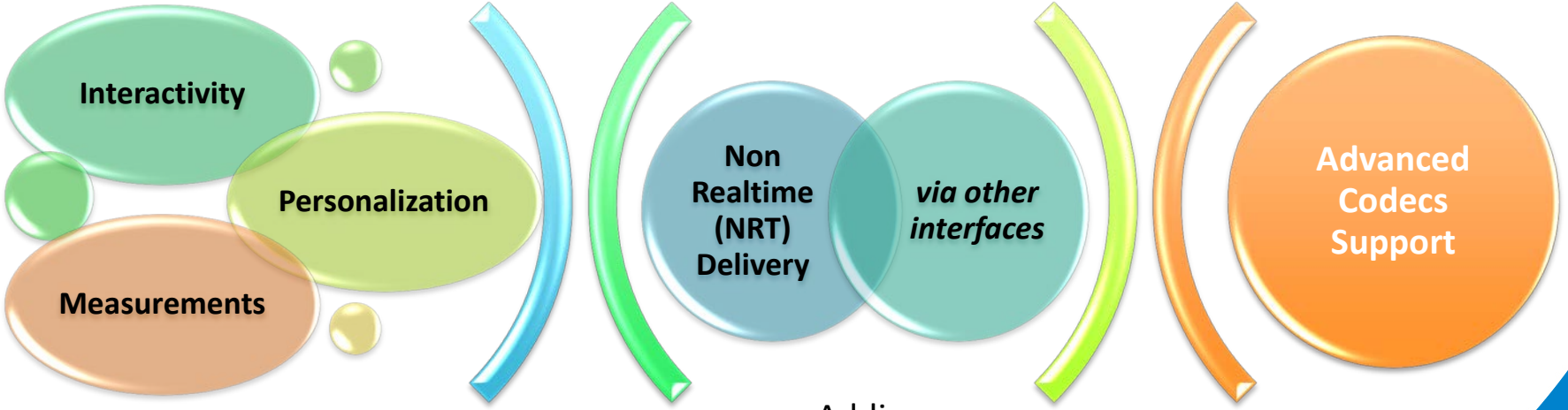
Layers: System and Process



Management & Protocol Layer of ATSC 1.0



Management & Protocol Layer of ATSC 2.0



Adding

use of Internet

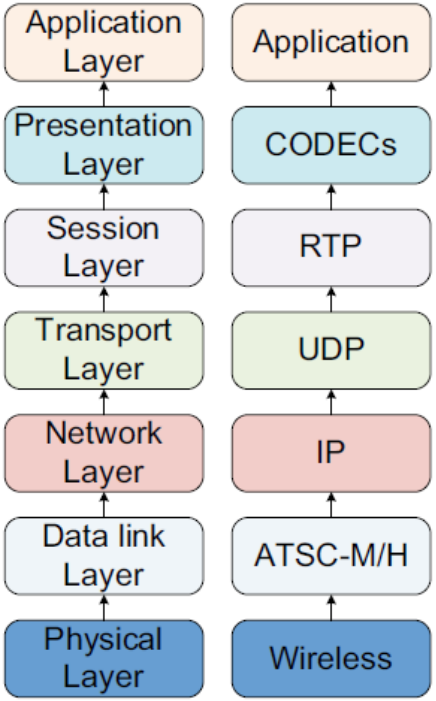
Adding

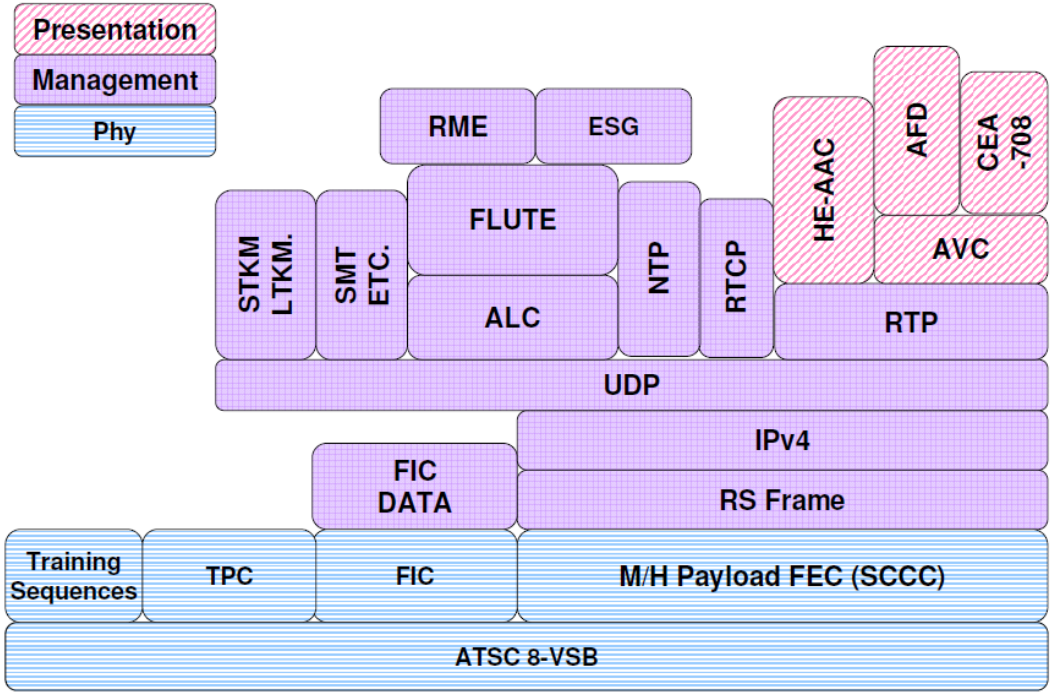
use of local storage & others

Adding

use of new codecs

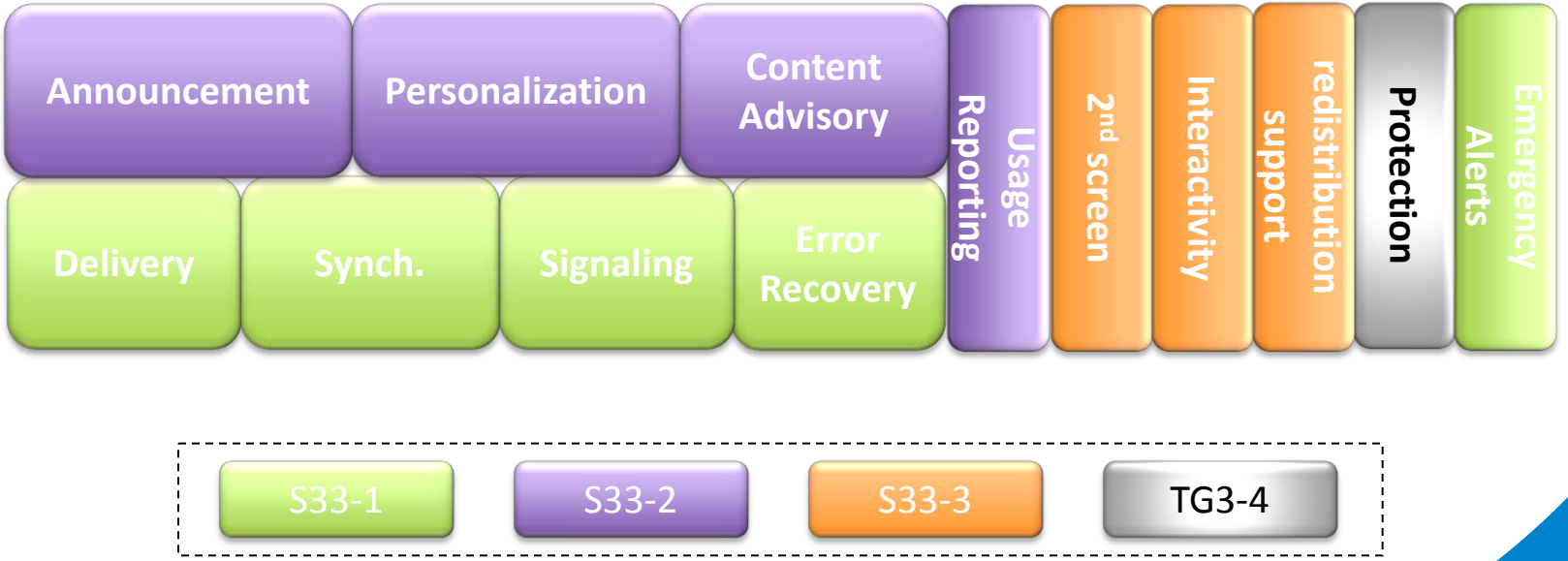
Management & Protocol Layer of ATSC MDTV



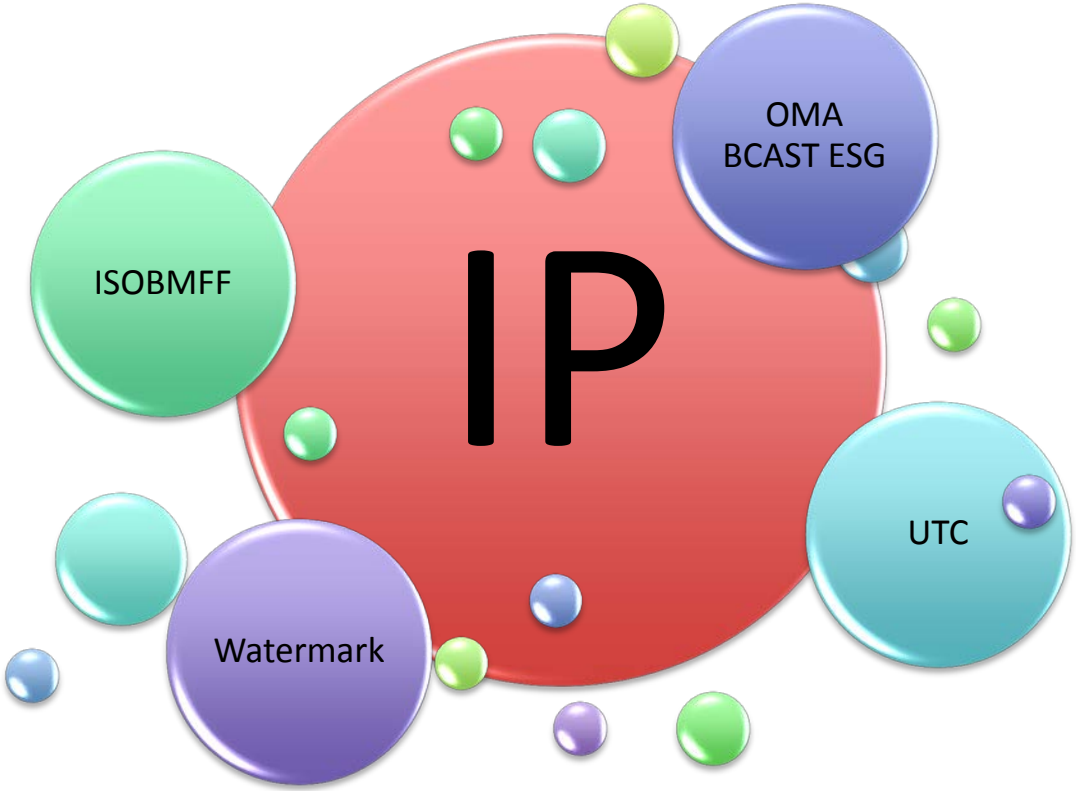


captured from http://www.atsc.org/cms/pdf/bootcamp/ATSC_MDTV_Bootcamp%20_10_13_11-Jay_Adrick.pdf

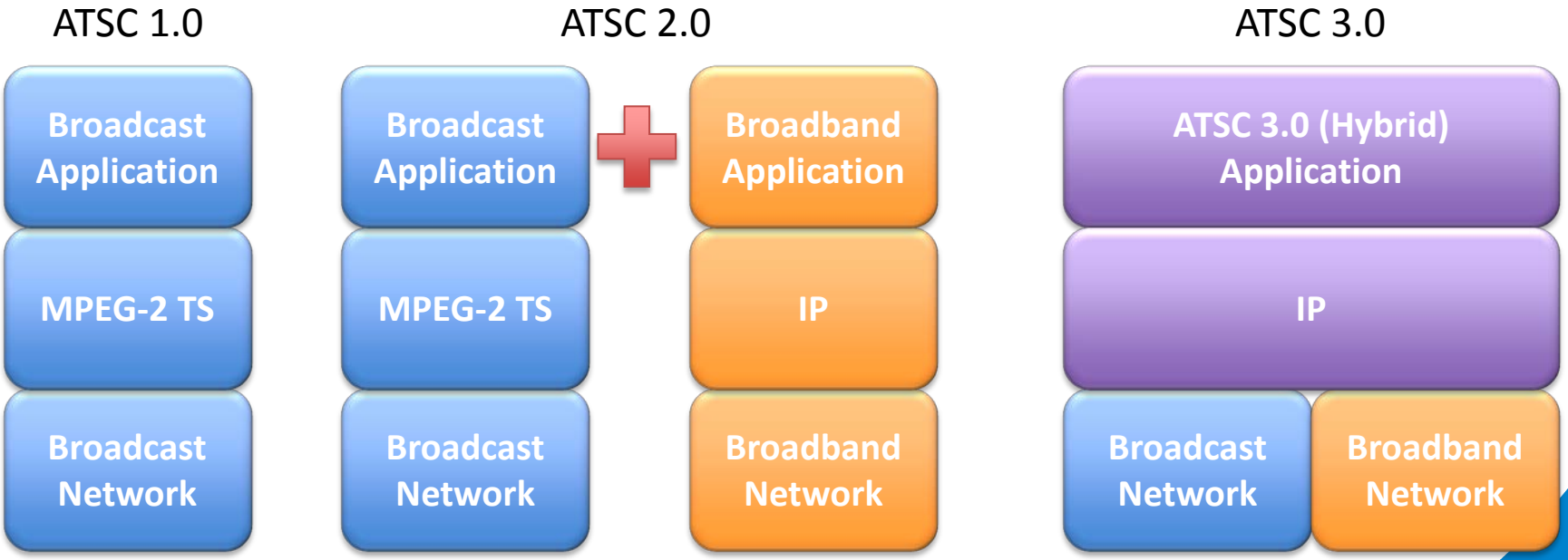
Management & Protocol Layer of ATSC 3.0



Toward Broadband & Mobile Standard



Summary


ATSC 1.0
Broadcast Application
MPEG-2 TS
Broadcast Network
ATSC 2.0
Broadcast Application
MPEG-2 TS
Broadcast Network
Broadband Application
IP
Broadband Network
ATSC 3.0
ATSC 3.0 (Hybrid) Application
IP
Broadcast Network
Broadband Network

Specialist Group S-33 Organization

- Work divided into 3 Ad Hoc Groups
  - S33-1 AHG on Service delivery & Synchronization
  - S33-2 AHG on Service Announcement & Personalization
  - S33-3 AHG on Interactive Services & Companion Screen

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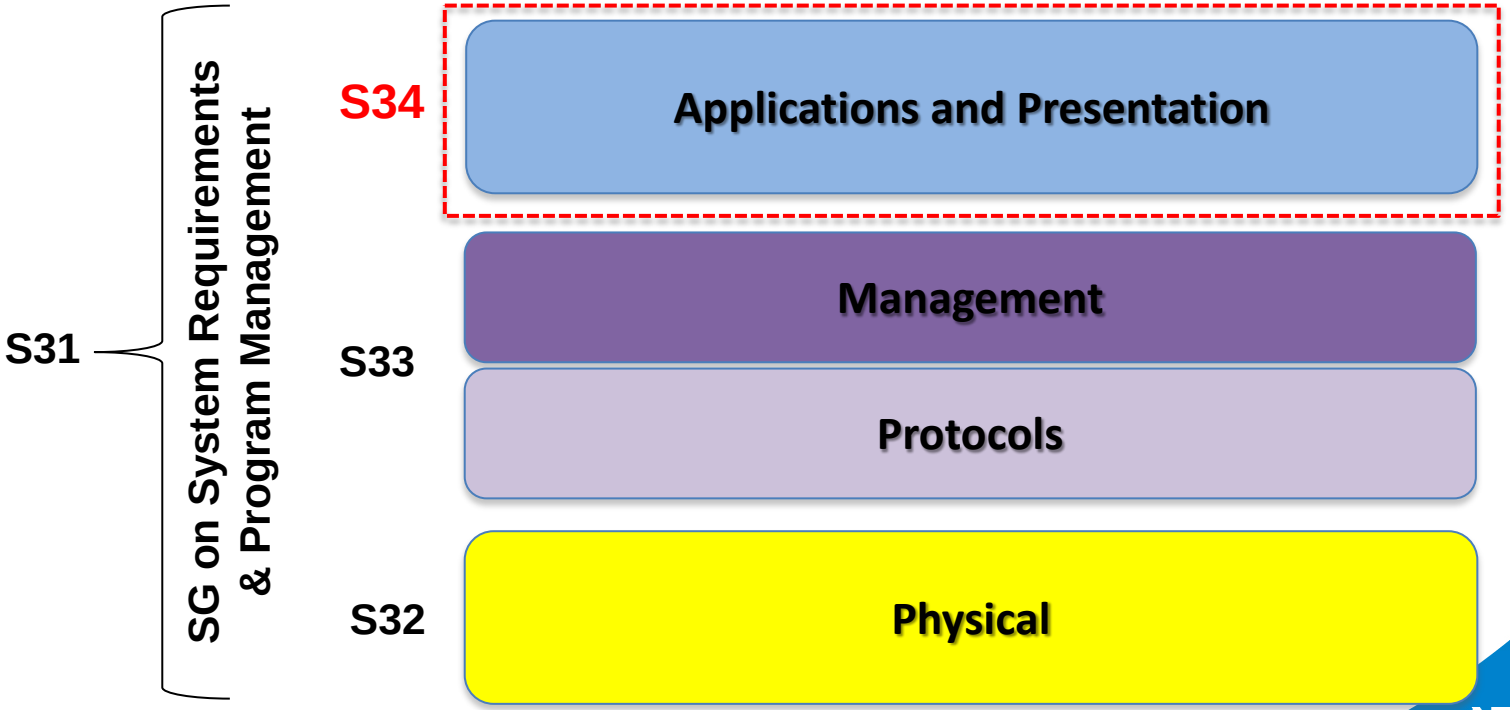
Applications & Presentation Layer Overview

ATSC 3.0 Layers



Applications & Presentation

- Essentially – what the consumer experiences
- Flexible Service Model
- Video
- Audio
- Closed Captions, Interactivity, Personalization, Advanced Emergency Alerts, Accessibility, and more

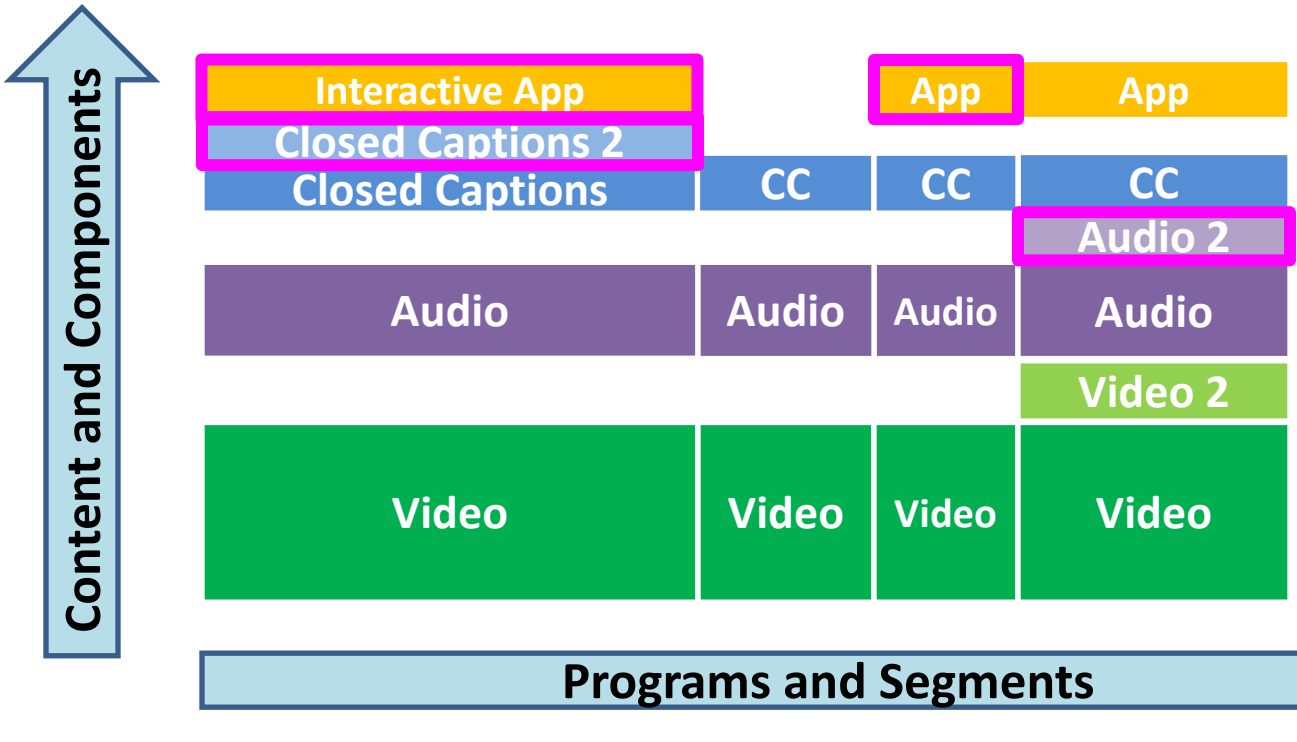
Flexible Service Model (1/3)

- Enhanced linear TV, plus on-demand support
- Subscription and PPV support
- Conditional access and DRM capabilities
- Mobile and fixed devices plus companion device support
- Hybrid delivery (broadcast and broadband)
- Automatic content recognition (ACR)
- Flexibility for future business opportunities

Flexible Service Model (2/3)

- Flexible component delivery mechanisms
  - Different delivery methods (broadcast, broadband)
  - Different levels of robustness (high robustness vs. high bitrate)
  - Different delivery times (NRT, real-time continuous stream)
- Components dynamically combined at receiver
  - Components can be selected automatically (e.g., low/high bit rate versions)
  - Components can be user-selected (e.g., optional alternative camera angle)
  - Signaling enables synchronization at the receiver

Flexible Service Model (3/3)



Hybrid broadcast/broadband delivery is possible

And components can be dynamically selected and combined at the receiver.

Video

- Enhanced HD and UHD
- Hybrid broadcast/broadband delivery support
- High efficiency compression
- Multiple, selectable video components
  - Alternate camera angles
  - Multi-view (e.g., picture-in-picture)
  - Multi-screen and companion device support

Audio

- New personalization features
- Enhanced immersive experience
- Targeted to various devices (fixed, mobile) and speaker set-ups
- Support for audio-only content as well as A/V content
- Hybrid broadcast/broadband delivery support
- High efficiency compression

Additional Services

- Interactivity
- Personalization and targeted advertising
- On-demand
- PPV and subscription models
- Closed Captions
- Audience measurement
- Advanced emergency alerts
- Advanced accessibility features

Specialist Group S-34 Organization

- Work divided into 4 Ad Hoc Groups
  - S34-1 AHG on Video for ATSC 3.0
  - S34-2 AHG on Audio for ATSC 3.0
  - S34-3 AHG on Presentation Logic & Framework
  - S34-4 AHG on Runtime Environment

ATSC

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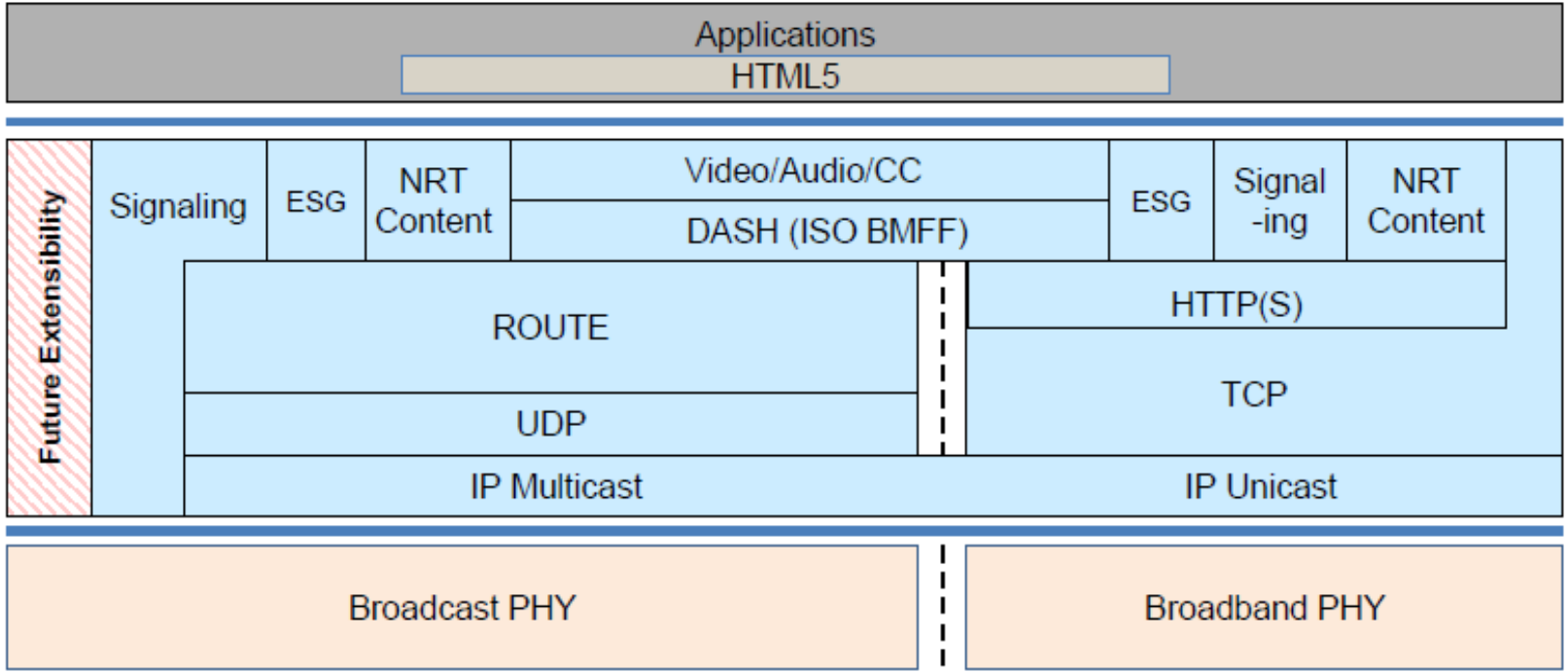
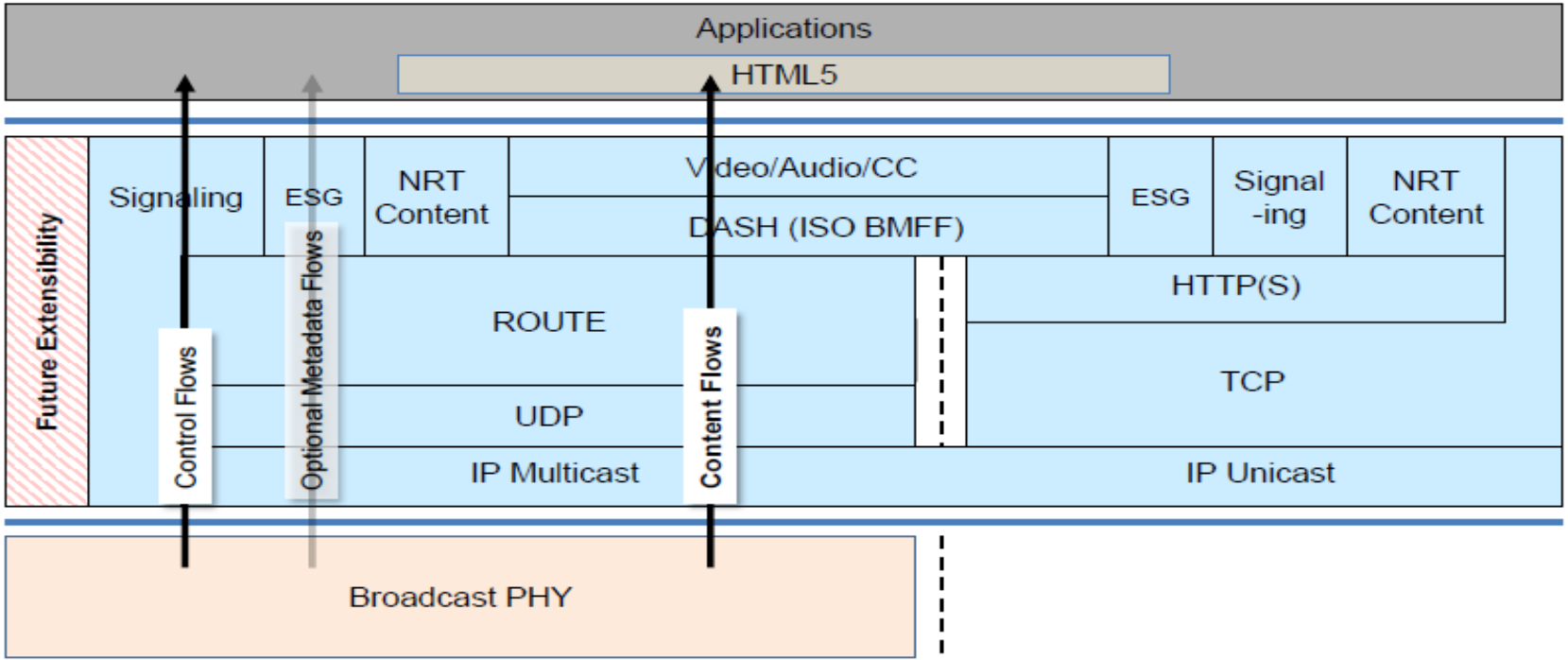
Content Delivery in an IP Based Broadcast – Broadband World

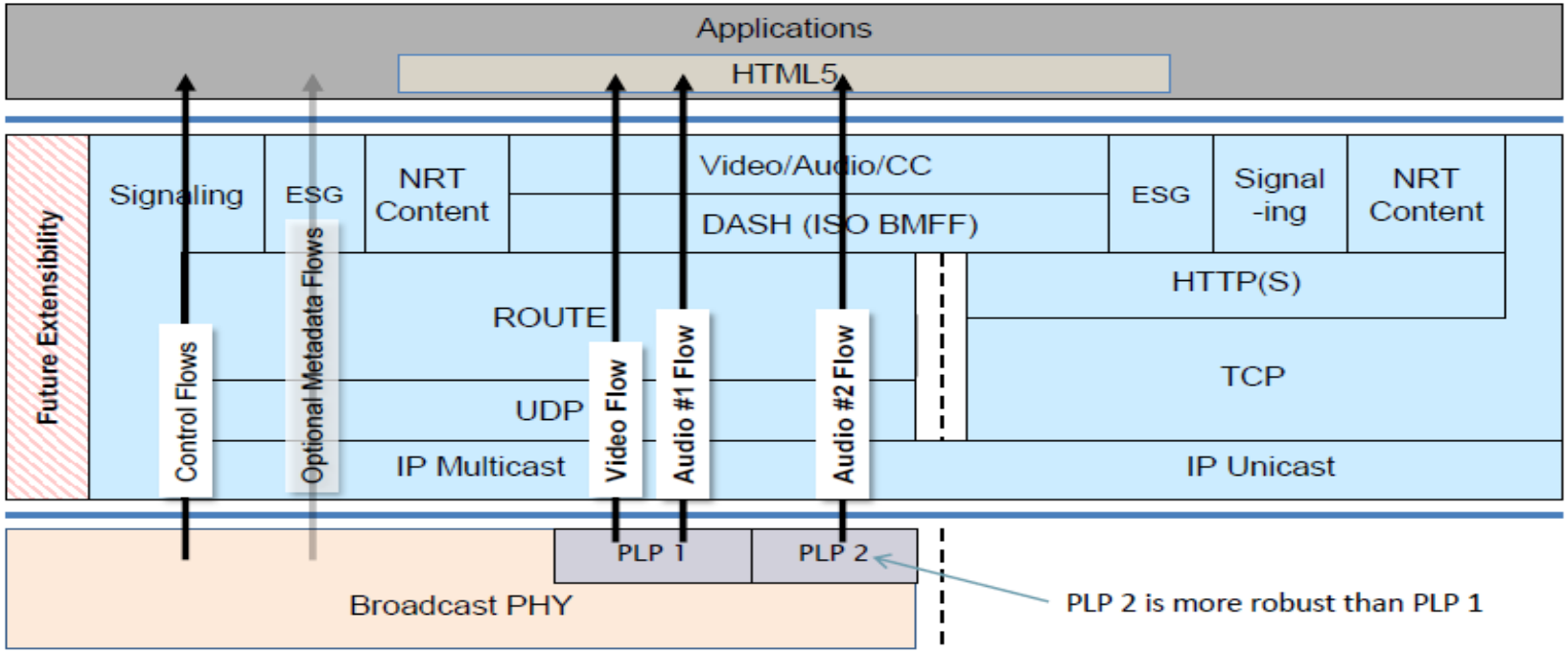
ROUTE/DASH IP-Centric Receiver Stack



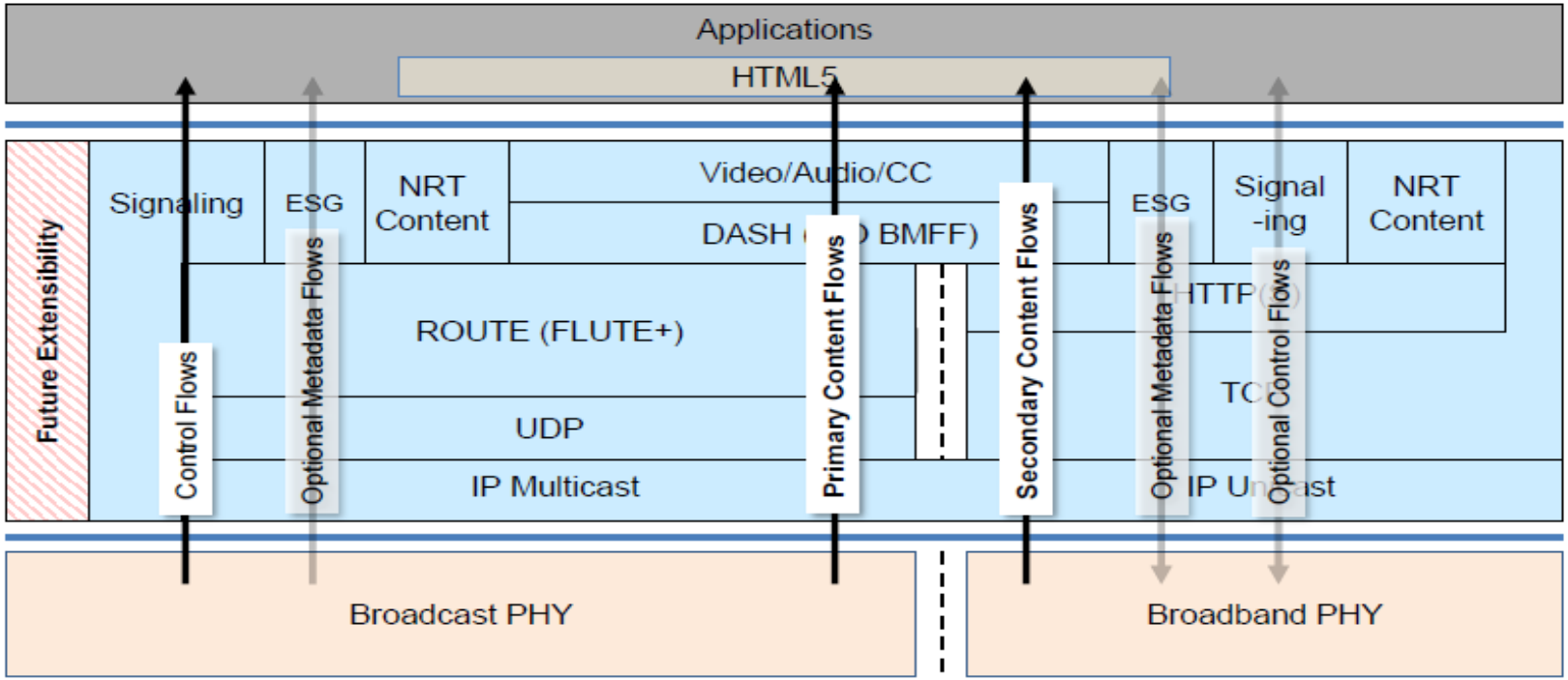
Basic ROUTE/DASH Broadcast Service



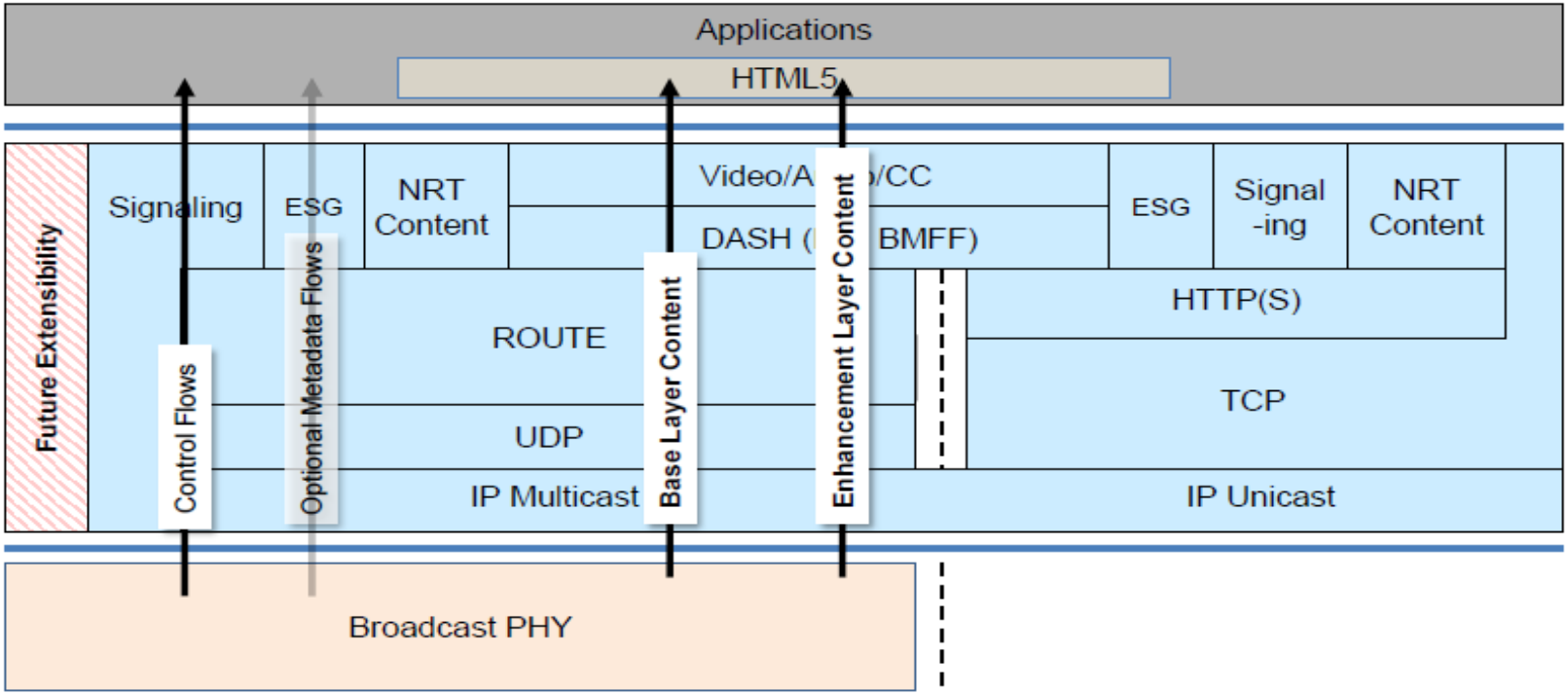
Robust Audio



Hybrid Service



Layered Coding



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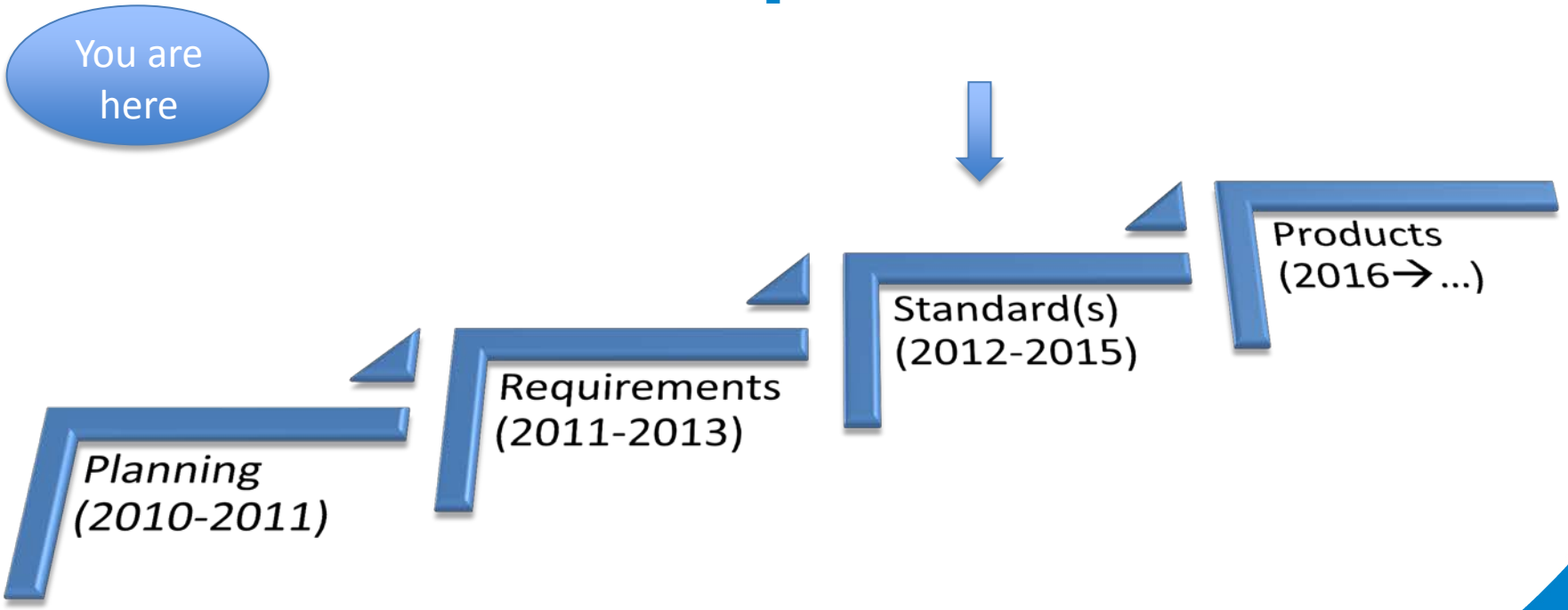
Transitioning & Deployment

ATSC 3.0 Development Timeline



Transitioning Challenges

- No additional spectrum for second service
  - Stations within a DMA could channel share to create a dual service during transition
- Receivers
  - Possible USB stick tuner for current flat panel TV's
  - Set-top converters
  - Industry driven campaign to include tuner in portable devices…tablets, lap tops, smart phones, etc.

Solving Coverage Problems

- AHG S32-4 is studying distributed transmission models
  - Likely scenario will be “Big Stick” supplemented by 4 smaller synchronized boosters surrounding the perimeter of the coverage area with directional antennas
  - Multiple stations may share the booster sites

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OK…But Does it Work?