ATSC 3.0

Overview and Technical presentation

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Key covered topics

- **Overview**
  - Why ATSC3.0
  - Key advantages for Broadcasters
  - Key advantages for End Users
  - Broadcast & Broadband convergence

- **Technical**
  - Audo and Video compression
  - Air interface: OFDM, SFN, MultiPLP
  - Linear TV delivery: DASH/MPU -> ROUTE/MMTP and Signaling
  - Architectures

ATSC 1.0 – where we are

- **Built on 4 new technologies (AT The Time)**
  - Real Time Media Compression
    - Video (MPEG 2)
    - Audio (AC-3)
  - Multiplexing (MPEG 2 TS)
    - Metadata (PSIP)
  - Digital STL (ASI / SMPTE 310M)
  - Digital Modulation (8VSB)

ATSC 3.0 - introduction

- **The same 4 layers in ATSC 3.0**
  - New Compression codec's
    - Video (HEVC)
    - Audio (AC-4)
  - Packaging / Streaming (DASH / MMT)
    - Metadata (ROUTE, MMTP)
  - IP Digital STL
  - Digital Modulation (A3P)

Objectives

Introduction

- **Merge Broadcast and Broadband services**
  - Offering capability to ATSC 3.0 receiver to receive broadband services
  - Delivering services to existing home devices
- **Using Advanced Video and Audio compression for**
  - More channels
  - 4K UHD Services with HDR
  - Multichannels Immersive Audio
- **Advanced modulation**
  - More robust, SFN, PLPs, LDM
  - Better indoor reception and mobile reception

Objectives

Introduction

- **Interactives features, application (NRT)**
  - Advance Emergency Alert
  - Audience measurement
  - Data delivery (push data) to any devices (including cars, billboard advertising)
  - Targeted Ad Insertion
- **Flexible for future extension**

CES 2018

Completion of ATSC 3.0 Standard

Broadcaster

Broadcaster Advantages

- **Additional capacity = More channels**
- **Better reception = Indoor, Mobility…**
- **New business models**
  - Advanced and Targeted Advertising
  - Datacasting
  - Subscription services
  - Usage reporting
- **OTA and OTT Convergence**
  - Full IP standard
  - OTT based content for linear TV

Broadcaster Advantages

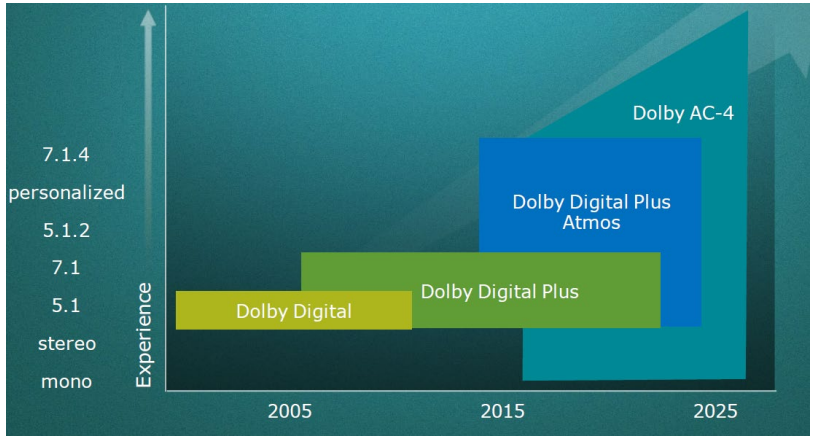
SMPTE DETROIT

- **Better end user experience:**
  - Improve audio & video quality
    - Video = HEVC (H265)
    - Audio = AC4 or MPEG-H
  - Interactivity
- **Using less bandwidth**

Video Comparison (1080p @ 23,976)

Video Codec	Distribution	Bitrate (Mbps)	2 hrs (GB)	Qf
MPEG2	DVD (typical)	32.0	26.8	.64
	Online (max.)	16.7	14.0	.34
H.264	Blu-Ray (typical)	25.0	21.0	.50
	Online (max.)	10.0	8.4	.20
	Broadcast (typ.)	6.0	5.0	.12
H.265	Online (max.)	6.0	5.0	.12
	Broadcast (typ.)	4.0	3.4	.08

Audio Comparison

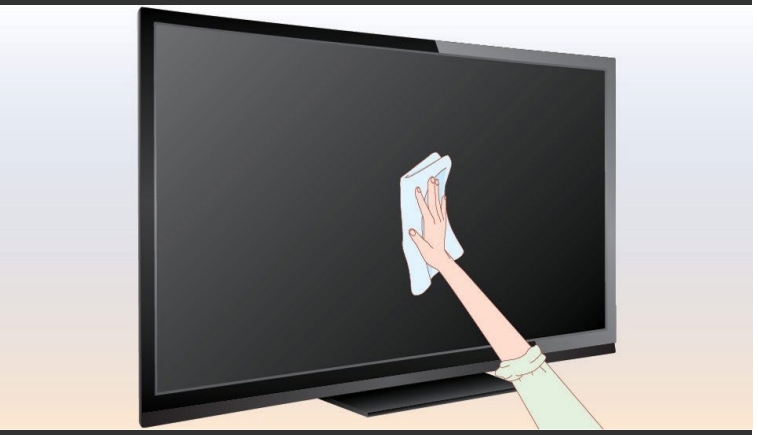


Dolby

Enhancements to Linear TV

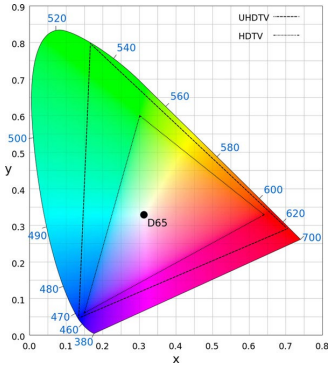
- **Service Types –** Enhanced linear services include alternative components and interactive application enhancements, pre-load application-based VoD services, audio-only services, push style data-only services
- **Hybrid Delivery –** Delivery of programs, program elements and triggers via broadcast to announce additional products or services available to those with broadband connectivity
- **Main program delivered via broadcast and alternate components or interstitials delivered via broadband**
- **Trigger delivered in broadcast and preloaded content delivered via broadband**
- **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.

End User



End User Advantages

- **Video = Better image quality**
  - SD, HD and UHD using HEVC
  - High Frame rate
  - High Dynamic Range & Wide Color Gamut



HDR (High Dynamic Range)

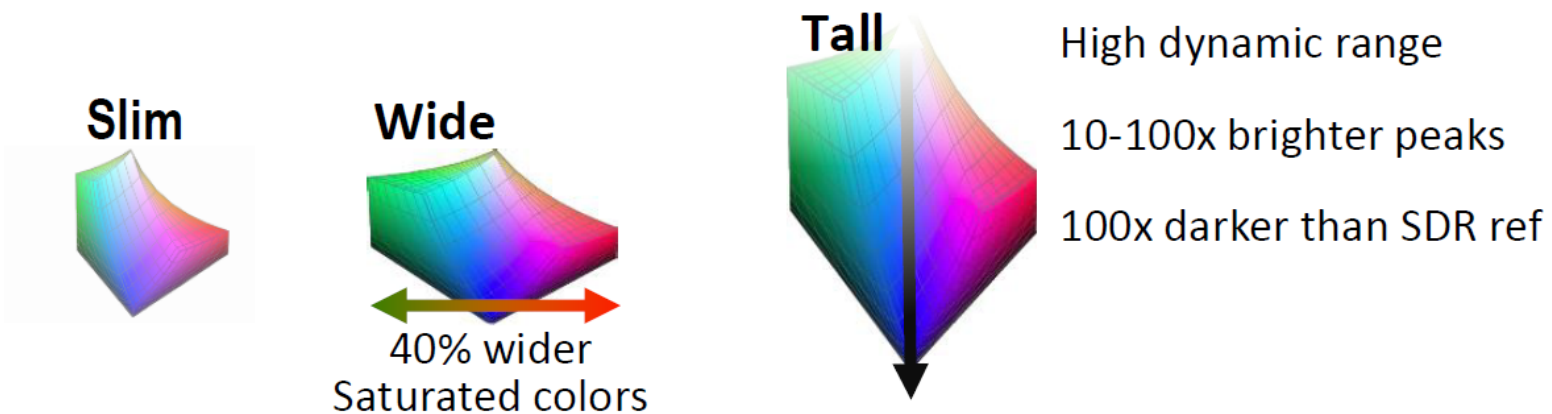
On the left is macroblocking as done by AVC/H.264. As you can see on the right, there's a lot more flexibility, not to mention larger sizes, for the HEVC/H.265 encoder to work with.

HDR (High Dynamic Range)

High Dynamic Range - Slim, Wide, Tall Volumes

TV System	*ITU Std*	*Image Size*	*Color Volume*
HD	**BT.709**	1920 x 1080 "2K"	Slim (**SDR**)
UHD 1	**BT.2020**	3840 x 2160 "4K"	Slim **or** Wide Color Gamut (**WCG**)
UHD 2	**BT.2020**	7680 x 4320 "8K"	Wide Color Gamut (**WCG**)
HDR	**BT.2100**	2K, 4K, 8K	Wide & Tall (**HDR**)

Professional Development Academy
Enabling Global Education



High dynamic range

10-100x brighter peaks

100x darker than SDR ref

End User

End User Advantages

- **Audio with Dolby AC4 or MPEG-H**
  - Immersive audio: sound from any directions
  - Object based:
    - User choose what he want to listen
    - Sound is restituted at home according to user audio system
    - Efficiently transmitted: no audio / sound duplications

Dolby

Broadcaster Advantages

Braodcaster

MPEG-2 TS: Audio Elementary Stream

Signaling Information	Audio Programme Components				
	M&E	Dialogue EN	Dialogue IT	AD IT	Team Radio
Default Preselection (English)	**M&E**	**Dialogue EN**	Dialogue IT	AD IT	Team Radio
Italian Preselection	**M&E**	Dialogue EN	**Dialogue IT**	AD IT	Team Radio
Italian Audio Description Preselection	**M&E**	Dialogue EN	**Dialogue IT**	**AD IT**	Team Radio
English Team Radio Preselection	**M&E**	Dialogue EN	Dialogue IT	AD IT	**Team Radio**
M&E Only Preselection	**M&E**	Dialogue EN	Dialogue IT	AD IT	Team Radio

Franhauffer

MME = Main or Music & Effects

AC4 Audio

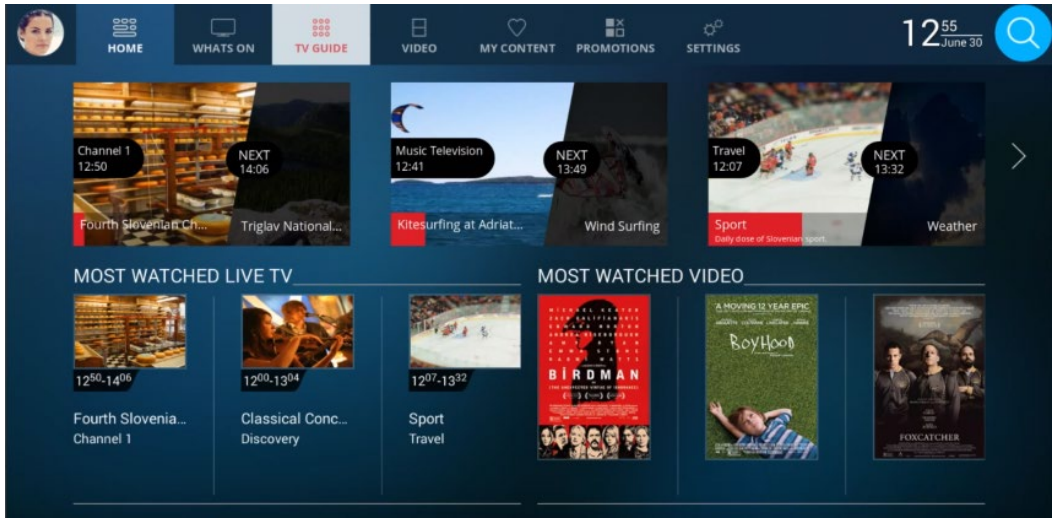
Dolby AC-4 capabilities include

- Greatly improved compression efficiency, up to 50 percent better than current broadcast-standard technologies
- Native support for dialogue enhancement, intelligent loudness, and advanced dynamic range control
- The most efficient support for multiple languages and descriptive services
- Delivery of optimum playback across all use cases and devices
- Immersive audio, enabling sound to move around the audience in three-dimensional space
- Personalized audio streams that enable broadcasters to provide customized presentations and elements that consumers can select to enjoy audio that matches their interests
- You can transfer information more reliably. Built-in self-configuration and automation will improve reliability and help you lower your operational costs. And Dolby AC-4 gives you the flexibility to deliver future services and experiences—on your timetable.
- Dolby AC-4 provides the tools. You decide how and when to use them.

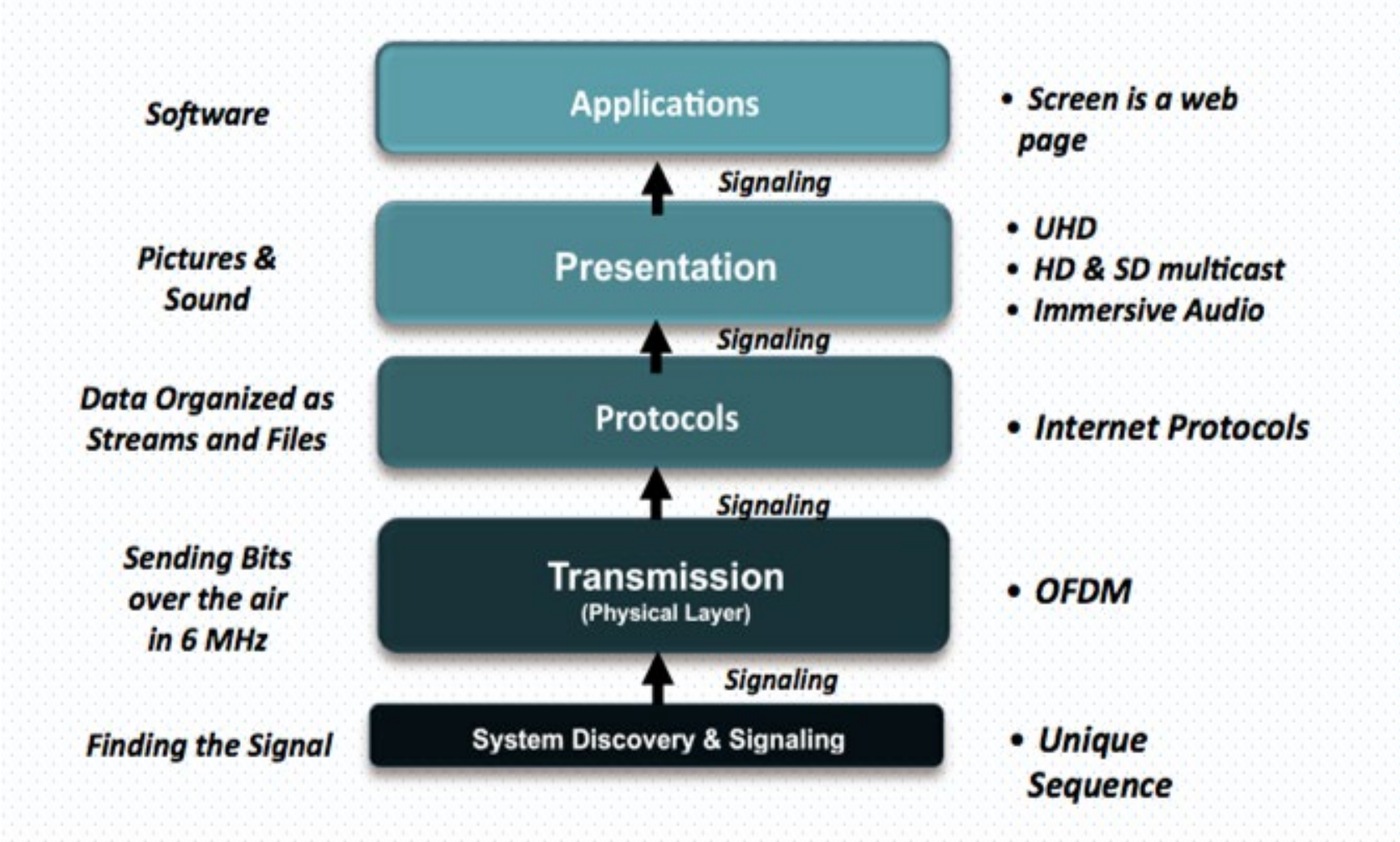
End User

End User Advantages

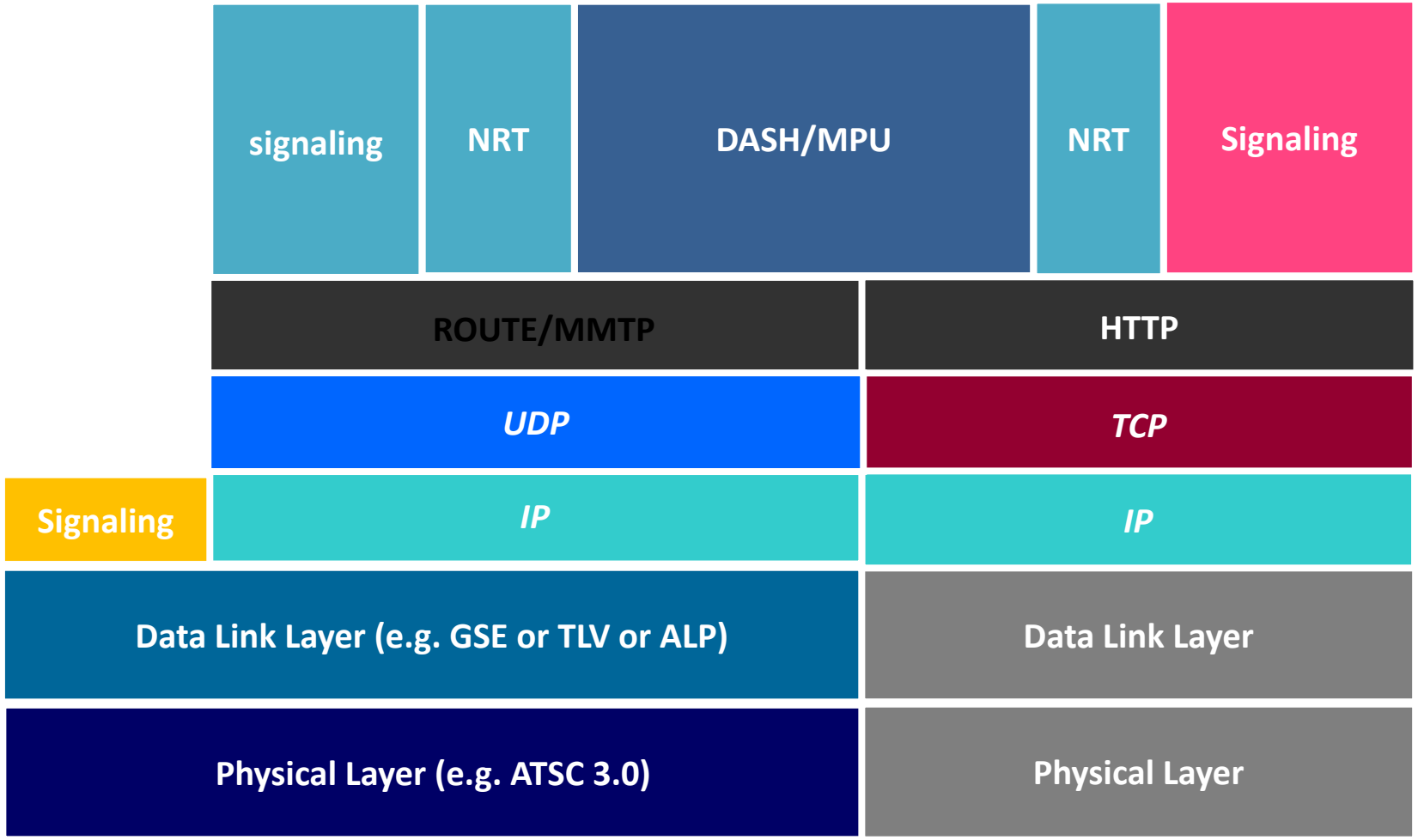
- **Interactivity**
  - HTML5 & Java script based
  - With dedicated TV Service API
- **Mix OTA, OTT, VOD on same device**
- **Include additional information and videos around primary Live TV services**
- **On the main display or on the second screen**

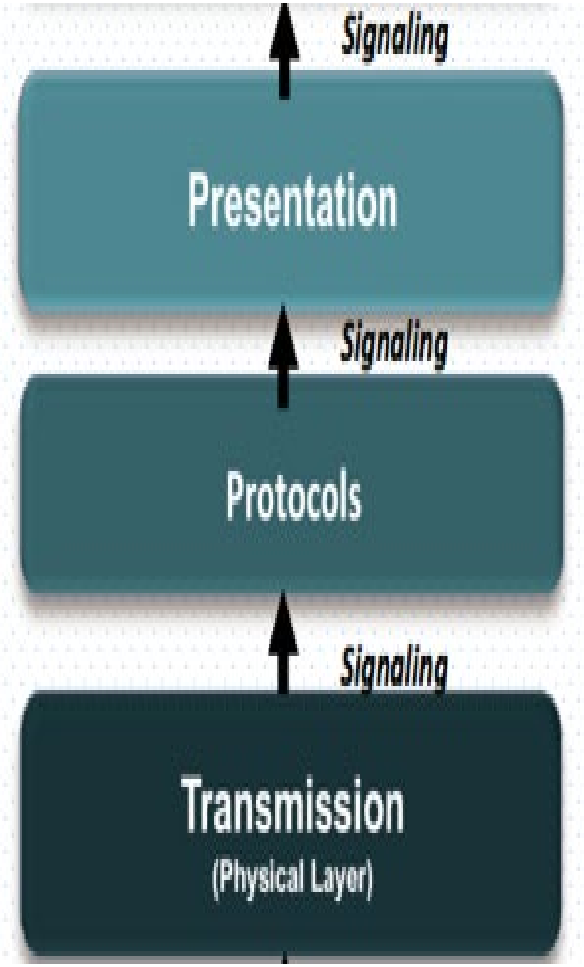


ATSC3.0 System Layers overview



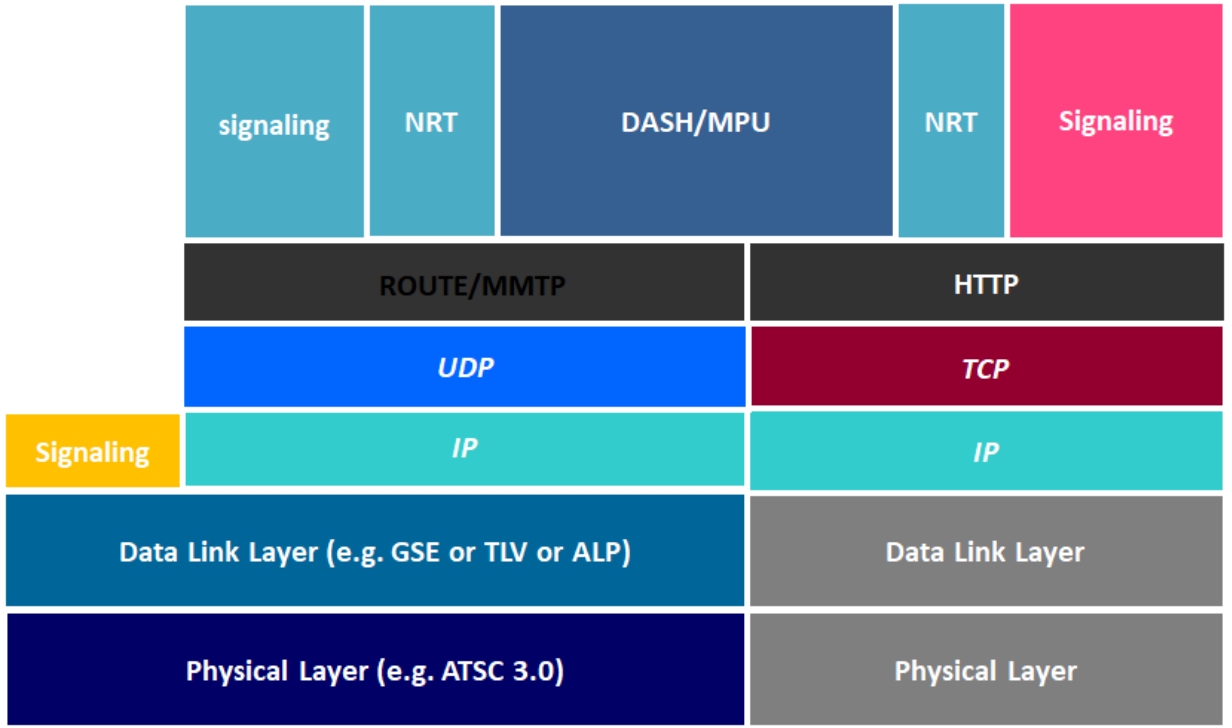
ATSC3.0 Protocol stack





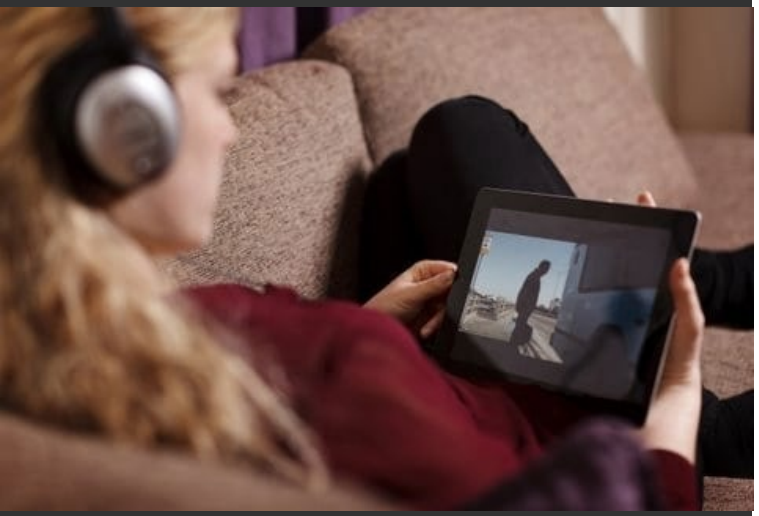
ATSC 3.0 = IP network

- IP is the delivery transport for all content in ATSC 3.0
- IP datagrams can contain any kind of content



OTA OTT Convergence

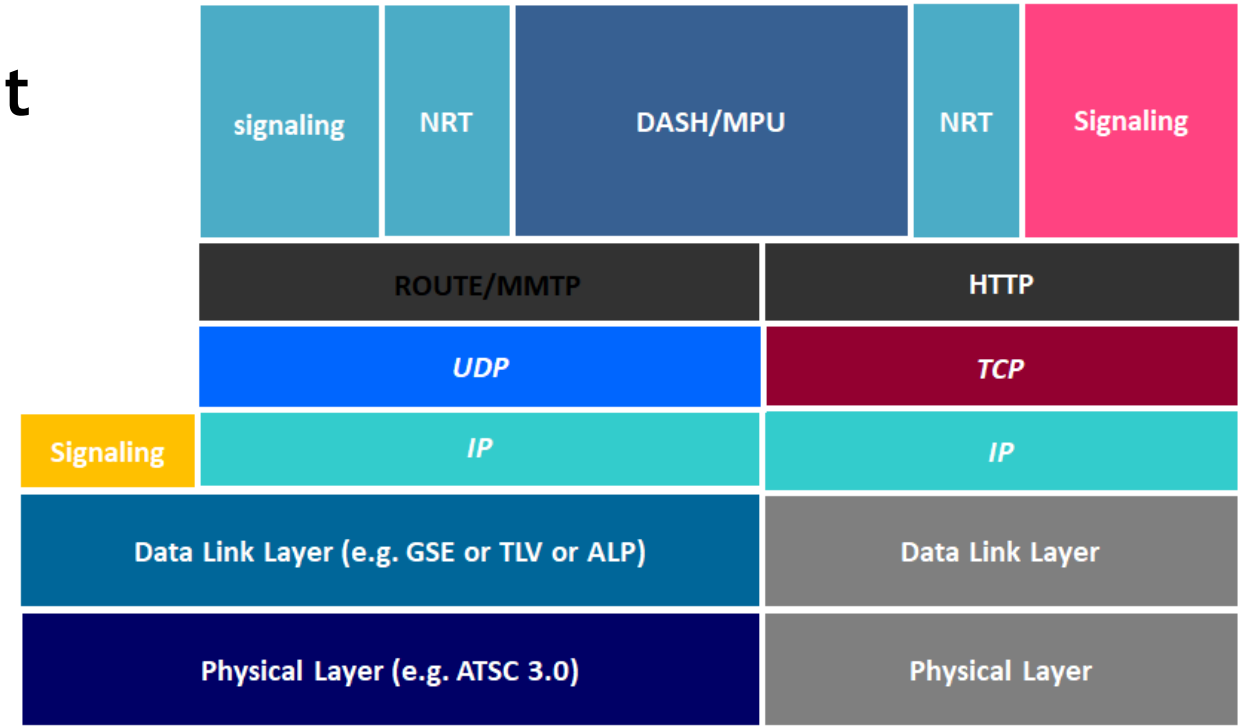
Linear TV delivery



- **ATSC 3.0 decided that the linear TV will be**
  - Package as OTT
  - Using ISO BMMF Segments: DASH or MPU
- **CE devices will receive segments**
  - That could be decoded by any OTT player
  - Embeded in the CE devive
  - Or store localy and acesse using any OTT local player
- **CE device could then receive content through**
  - ATSC 3.0 air interface
  - And / or through Broadband connection

Content delivery

- **ATSC3.0 propose 2 mechanisms to deliver Linear TV**
  - MPU segments delivered over MMTP
  - DASH segments delivered over ROUTE
- **ROUTE only for Non real time content delivery**
  - Electronic Service Guide
  - Interactive Applications
  - Push of content

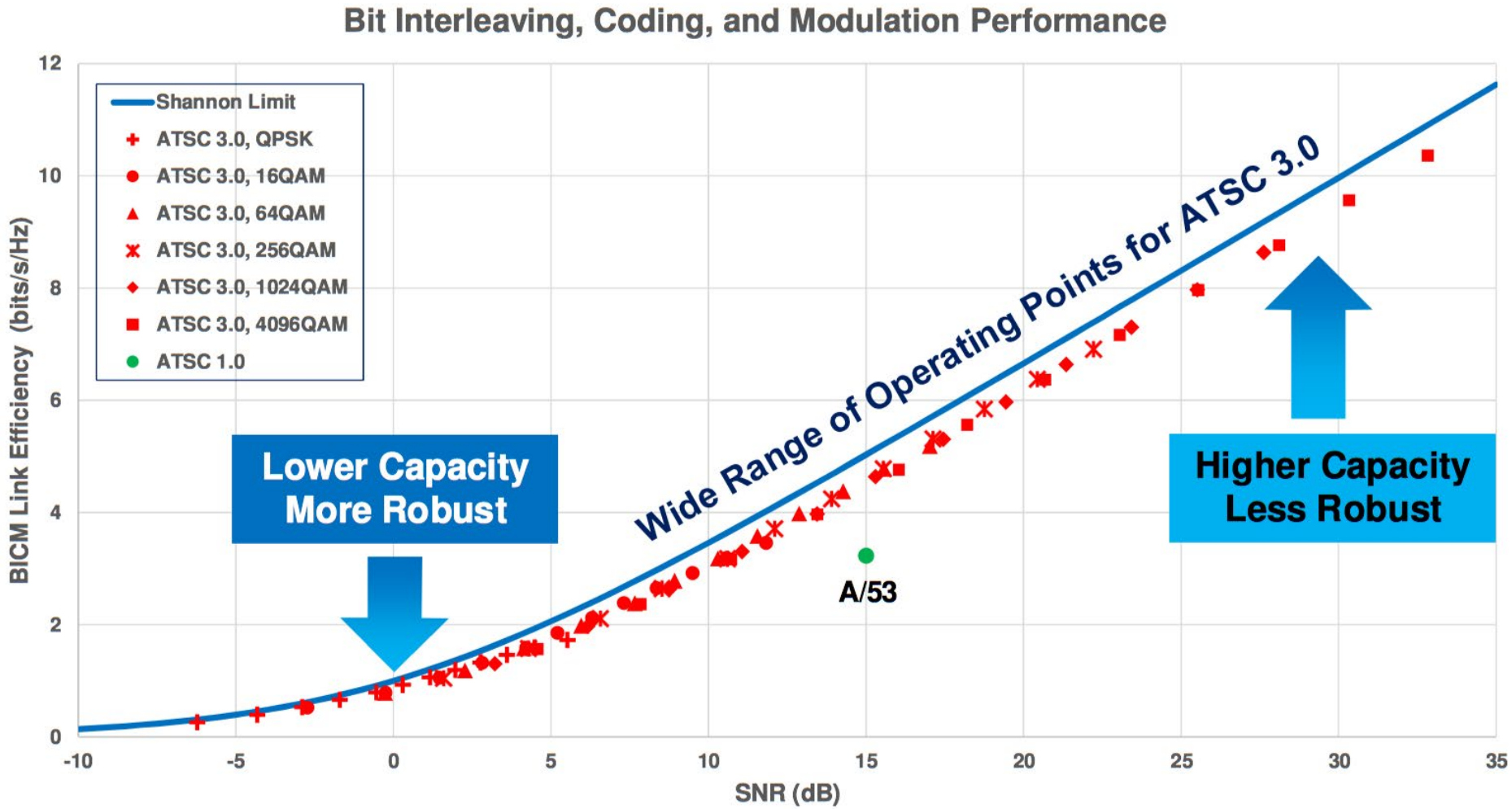


ATSC 3.0 Physical Layer (A3P)

Air Interface

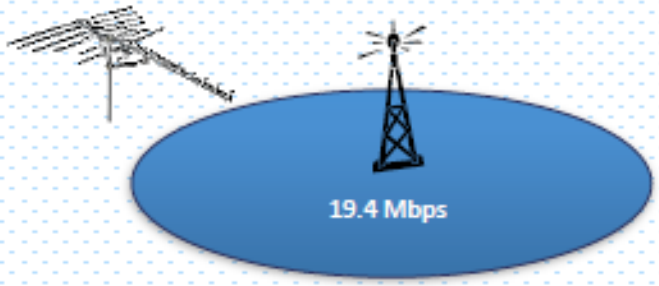
- Supported bit rate ranges in a 6MHz channel are …
- Minimum 0.83 Mb/s using QPSK, coderate 2/15, 8K FFT, 300usec GI
- Maximum 56 Mb/s using 4096 QAM, coderate 13/15, 32K FFT, 28usec GI
- A ~28Mbps service in 6 MHz is considered a “comparable” use case to a 8VSB
- Receivers must support at least 4 PLP’s
- Multiple PLP’s allow mixing different combinations of bits vs. robustness

Modulation Performance



Air interface ATSC3.0 vs ATSC1

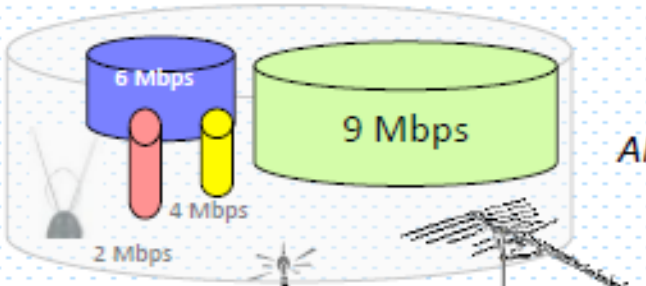
ATSC 1.0



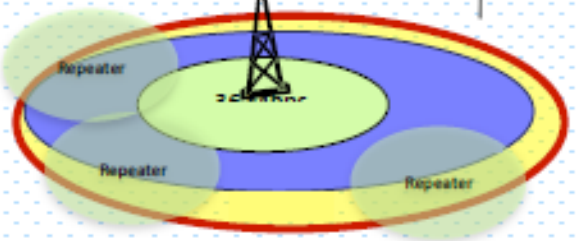
8-VSB

- One bit rate – 19.39 Mbps
- One coverage area – 15 db CNR (rooftop)
- Service flexibility – HDTV, multicast, data

ATSC 3.0



AND



OR

OFDM with variable-rate LDPC

- More bits/Hz – spectrum efficiency near theoretical limit
- Flexible bit rate & coverage area choices
- Multiple simultaneous "bit pipes" – different choices for different broadcast services
  - Physical Layer Pipes (time)
  - Layer Division Multiplexing (power)
  - Channel Bonding

Air interface ATSC3.0 vs ATSC1

ATSC

- **Fixe modulation:**
  - Fix robustness
  - Fix bitrate
- **One ‘multiplex’ per frequency**

ATSC 3.0

- **Different possible modulations:**
  - Different robustness
  - Different bitrate
- **Multiple ‘multiplexes’ per frequency using Physical Layer Pipe (PLP)**
- **SFN capability**

VSB vs OFDM

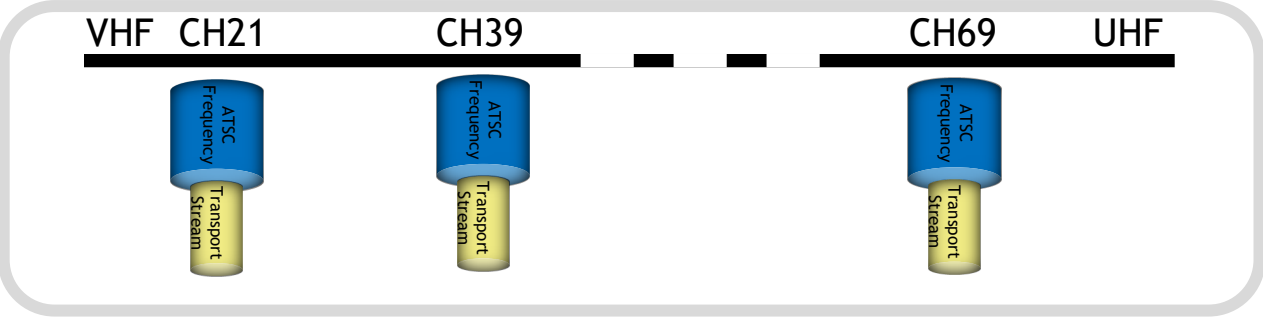
- **ATSC 1.0**
  - 8VSB is a single carrier modulation
  - Peak to average ratio is 6-7dB typical
  - Typical HPA building block rating is 25kW rms (after the mask filter, aka TPO)
- **ATSC 3.0**
  - OFDM is used for ATSC 3.0, multicarrier modulation
  - Peak to average ratio is 10dB typical, PAPR is employed
  - Typical 25kW HPA needs to be de-rated by 15-20% (i.e. 25 → 20kW TPO)

PARALLAX

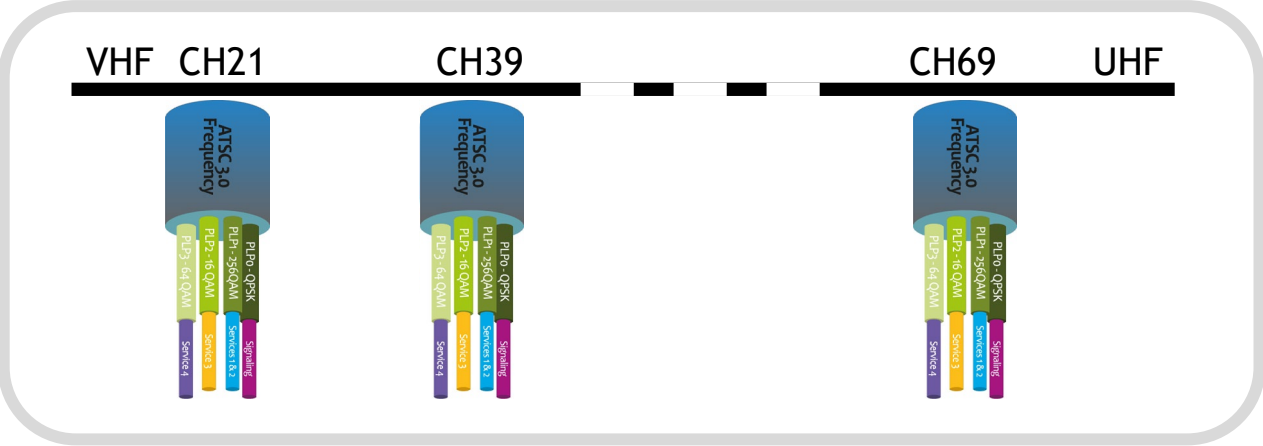
- The PARALLAX is designed around the BLF888E device:
  - ✓ The 888E has been optimized with higher class C peaking amp capacity via Asymmetrical Doherty design
  - ✓ Asymmetrical Doherty design actually increases operating efficiency in ATSC 1.0 mode
  - ✓ The 888E is ideal for waveforms with higher peak to rms (i.e. OFDM)
- The 2kW PARALLAX Power Amplifier module provides the same RF output power in ATSC 1.0 (8VSB) and ATSC 3.0 (OFDM)

Physical Layer Pipe

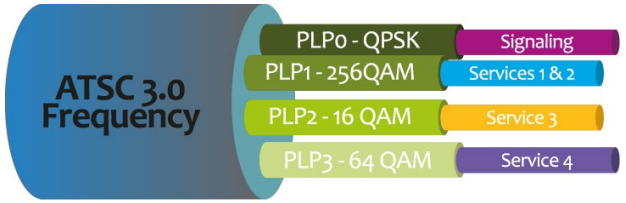
Main concept



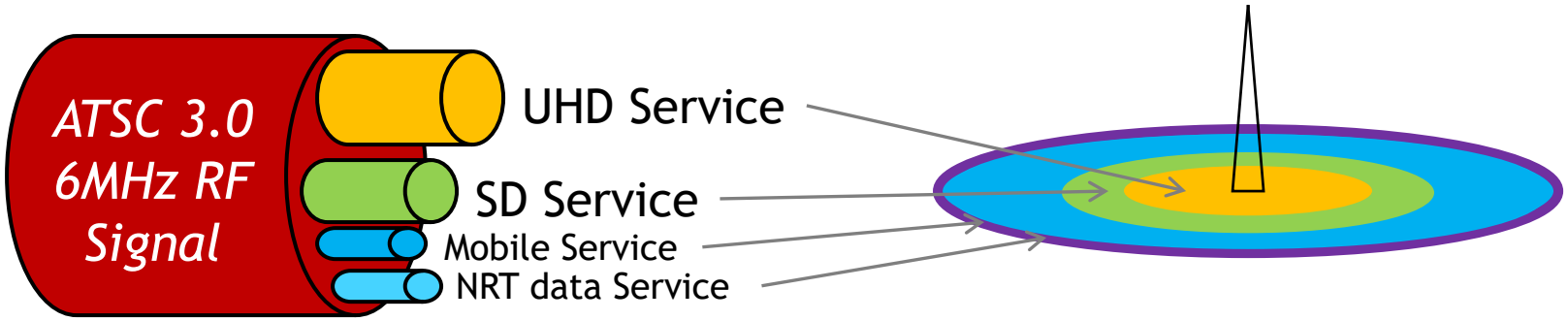
➔ ATSC1 =
1 Multiplex / TS per RF chanel



➔ ATSC3.0 MPLP =
several Multiplexes per RF channel



PLPs

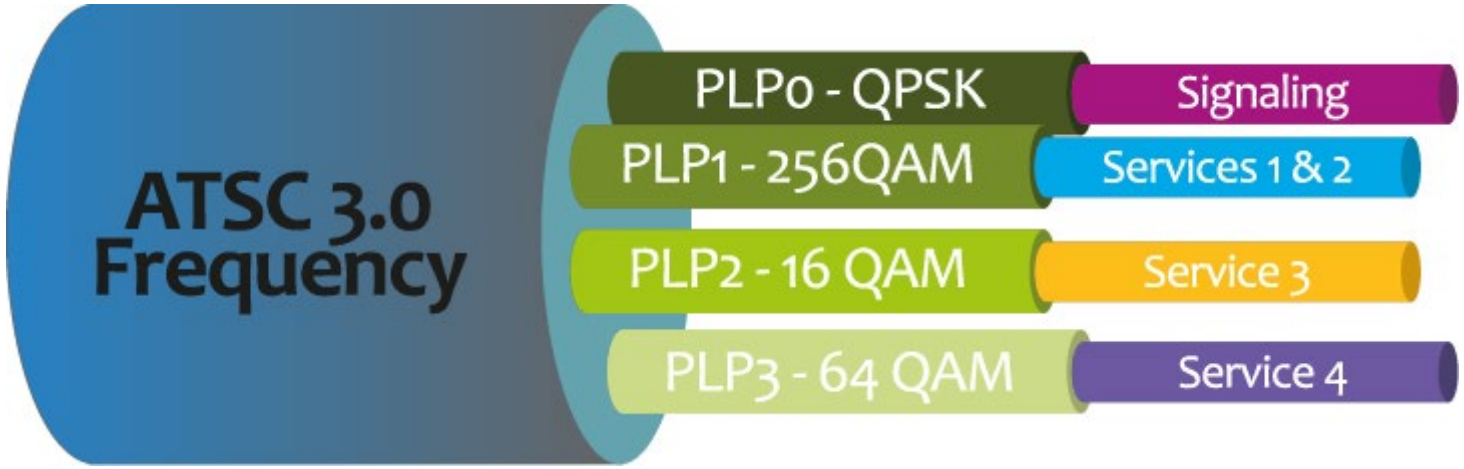


Service	PLP#	FFT	GI	Mod	Cod	Outer FEC	Inner FEC	Frame
UHD	PLP1	32k	148µS	256 QAM	13/15	BCH	64800	250mS
SD	PLP2	32k	148µS	64 QAM	10/15	BCH	64800	250mS
Mobile	PLP3	8k	148µS	QPSK	5/15	BCH	16200	100mS
NRT	PLP4	8k	148µS	QPSK	3/15	BCH	16200	100mS

Service	PLP#	% Channel	PLP Capacity	AGWN SNR	Rayleigh SNR	Doppler
UHD	PLP1	45%	17.3Mb/s	22.2 dB	26.6dB	49 mph
SD	PLP2	25%	5.5Mb/s	12.9dB	15.8dB	49 mph
Mobile	PLP3	20%	0.58Mb/s	-1.3dB	-0.1dB	180 mph
NRT	PLP4	10%	0.17Mb/s	-3.7dB	-3.0dB	180 mph
Total		100%	23.6Mb/s			

Physical Layer Pipe pamareters

- Every PLP have its own robustness and bit rate based on Modulation, FEC and interleaving parameters
- Some modulation parameters are PLP specific to allow specific service robustness and bandwidth



Common parameters

- Central Frequency
- SFN
- Frequency Bandwidth
- FFT mode
- Guard interval
- Scattered pilot patterns
- Frequency Interleaver

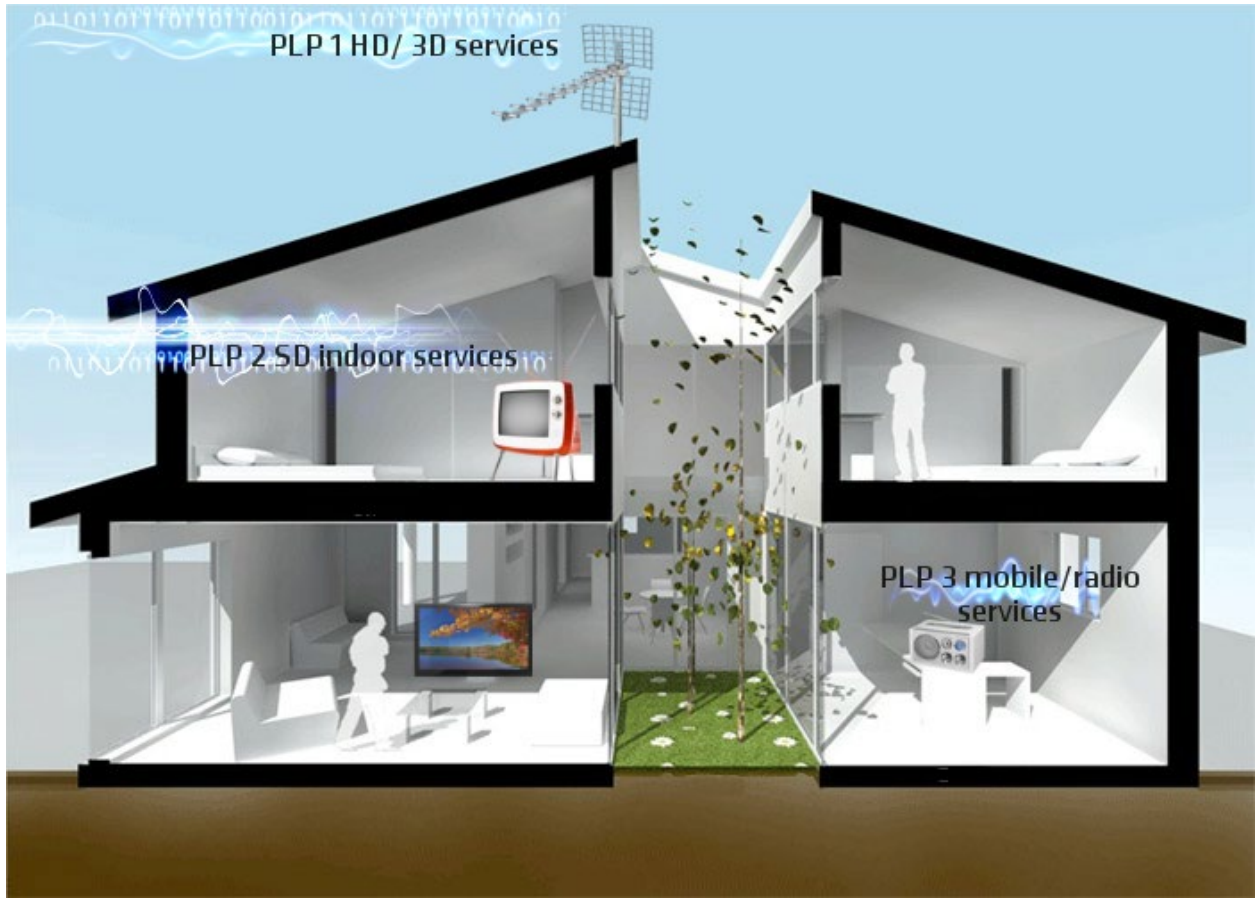
Specific PLP parameters

- Constellation
- Code rate
- FEC
- Time interleaving depth

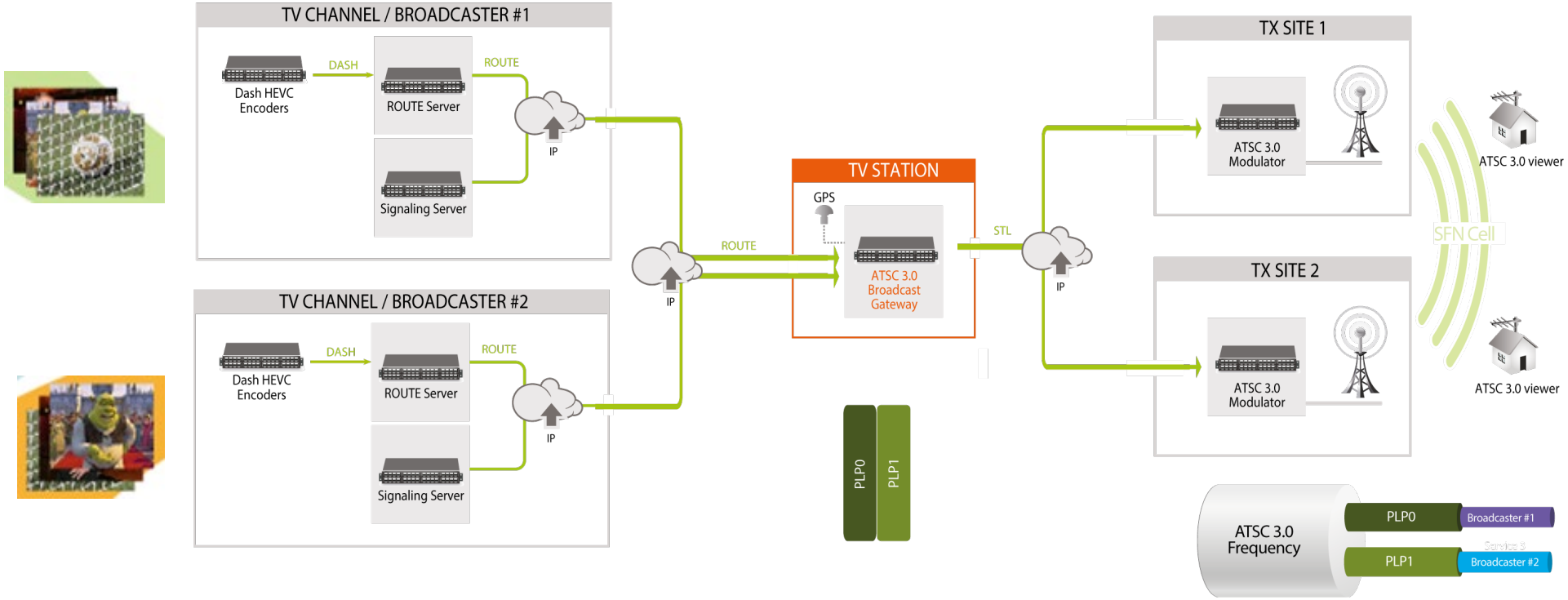
- ATSC3.0 standard request receivers to be able to decode a minimum of 4 PLPs in parallel
- PLP is not optional and could be used without any constrain or problematics

MultiPLP - QoS classes scenario

- 3D/HD/SD services : One PLP can carry 3D or HD services with low robustness (to increase the bandwidth), while another PLP could carry SD services with high robustness.
- TV/Radio services : Radio services are delivered on different PLP on a higher robustness to support in-door or mobile reception.

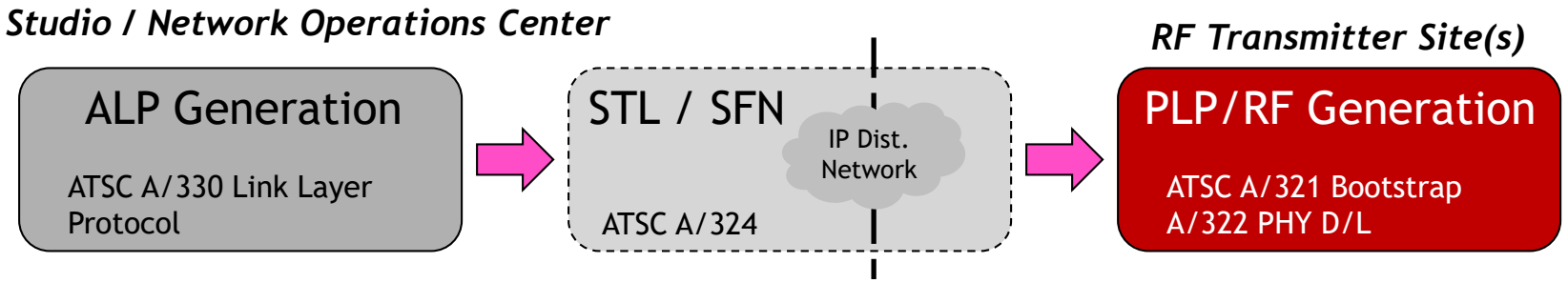


MPLP – Frequency sharing



Tall Tower vs SFN

- **High Power / High Tower DTV provides decent coverage for fixed reception:**
  - 30’ outside antenna, towards the extents of coverage radius
  - Indoor antenna, close in to tower
- **How can we improve coverage in the service area?**
  - More transmitters within a given coverage area – all on the same channel
  - Utilize elliptical polarization – more RF power density
- **Single Frequency Networks (SFN) employs multiple transmitters to cover a service area:**
  - Each transmitter is on the same RF frequency
  - Each transmitter is fed the same “IP” signal via STL, Fiber, etc (contribution network)
  - Transmitters are “adjusted” to compensate for contribution timing differences and to minimize self-interference

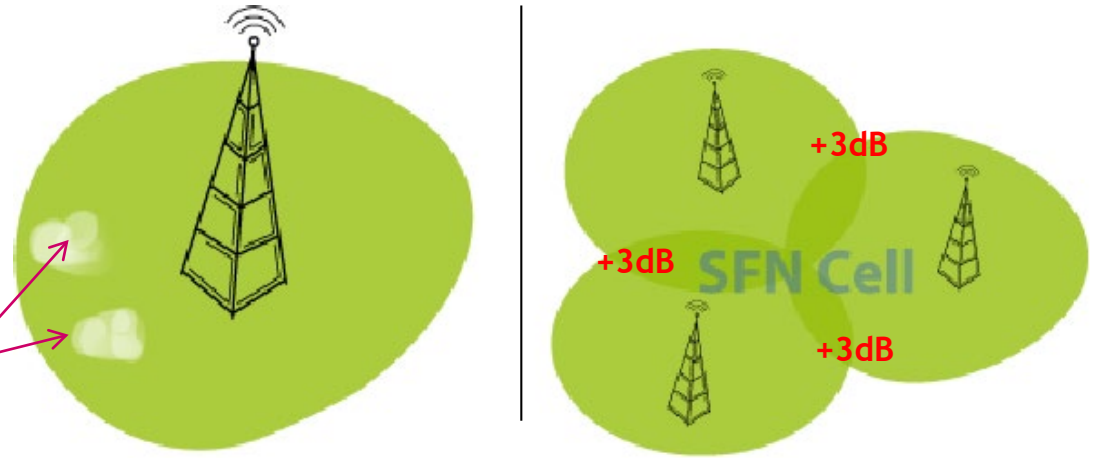


SFN topology advantages

- **Better RF coverage**
  - Several lower amplifiers instead of only one highly powered transmitter
- **Increase power reception**

One high building may create shadowed RF reception area (bad, or no reception)

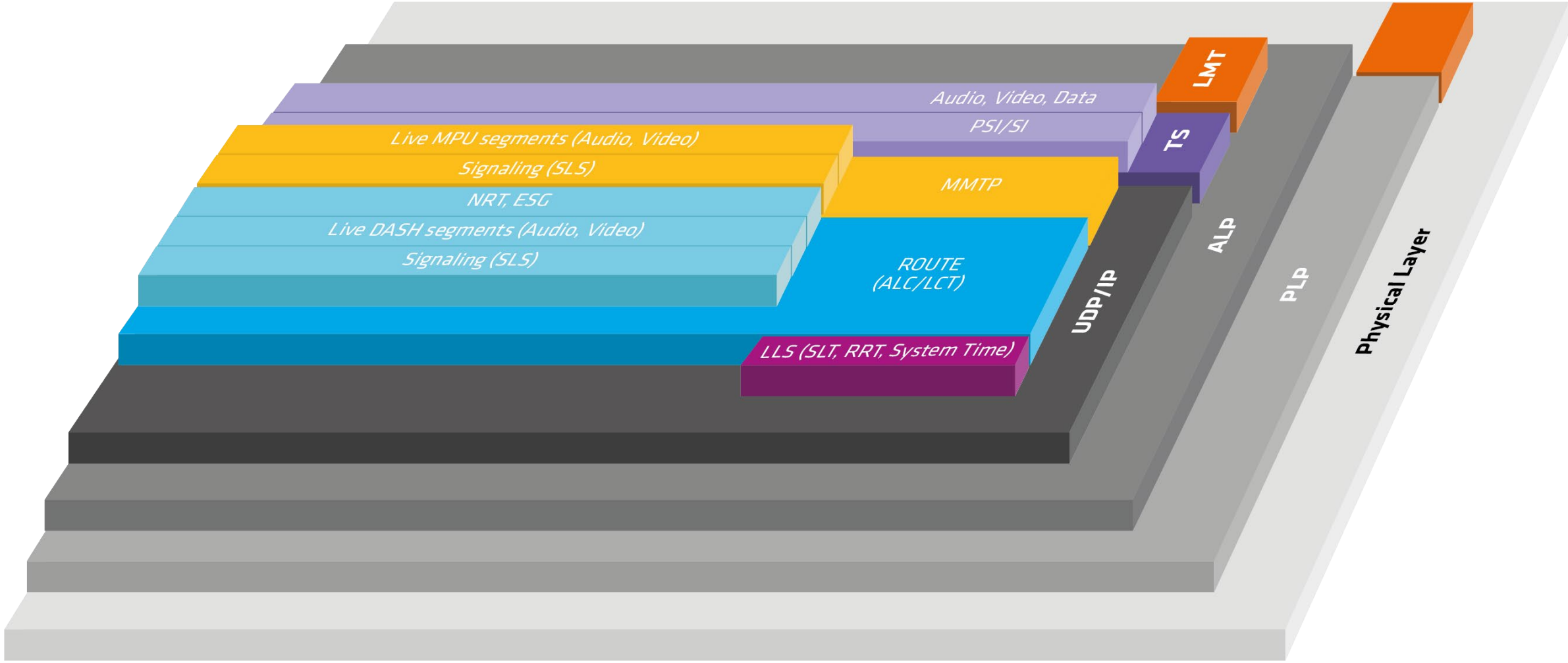
Bad reception



Transmission from all these lower powered amplifiers enable better RF coverage

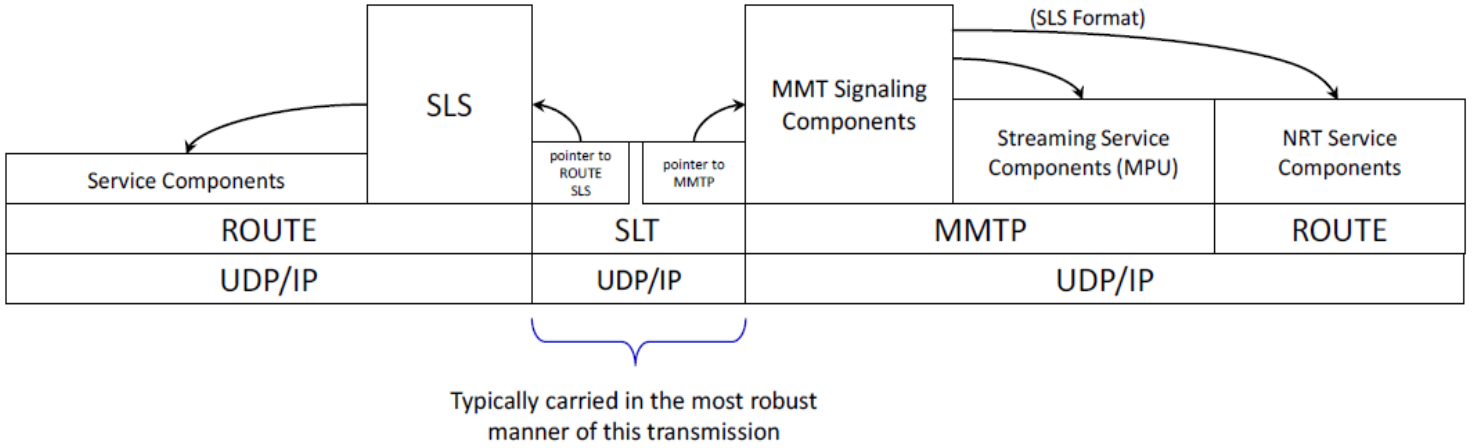
- **OFDM is more tolerant to multipath and echos compare to 8VSD**

ATSC 3.0 – Protocol stack

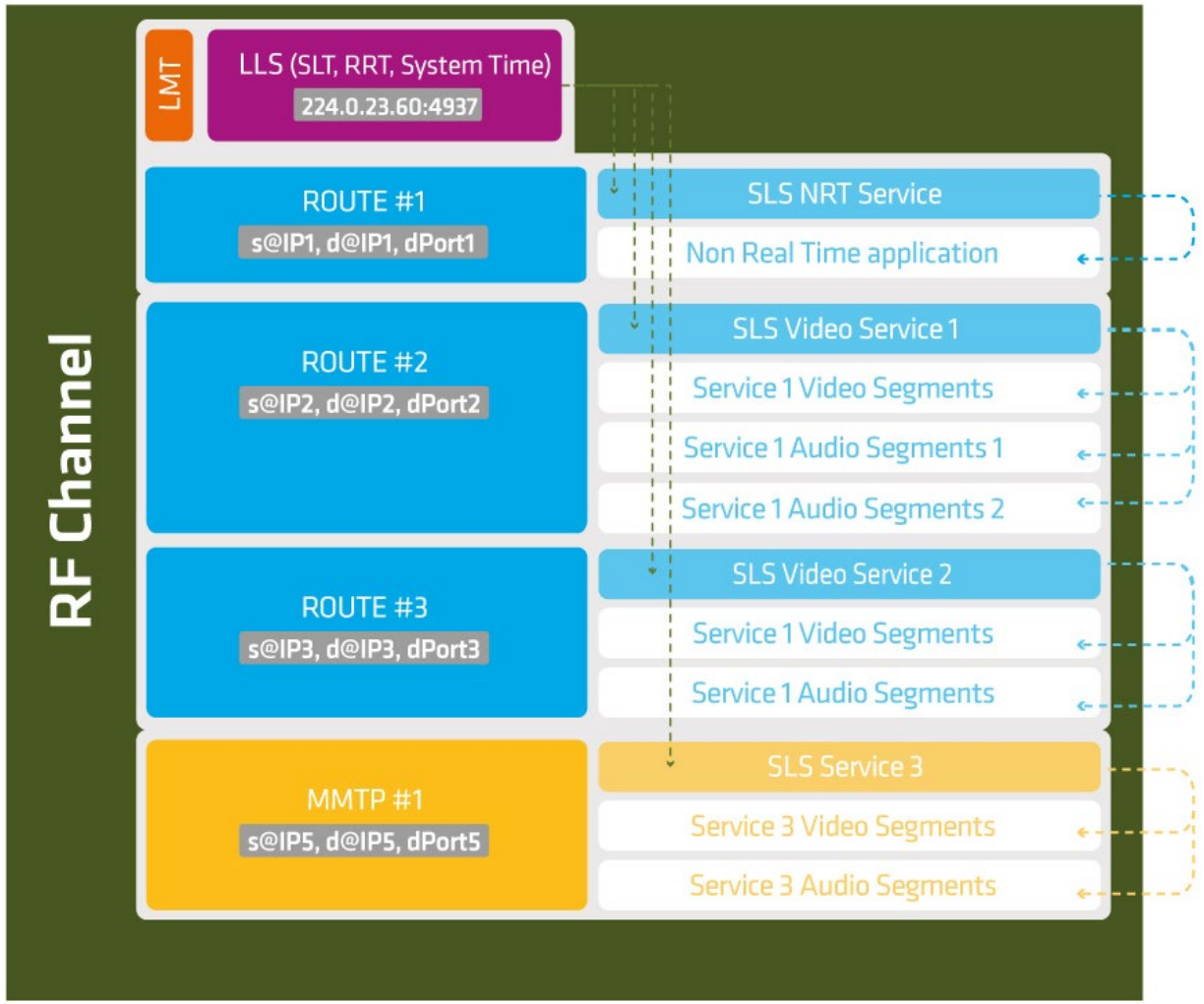


ATSC3.0 Signaling

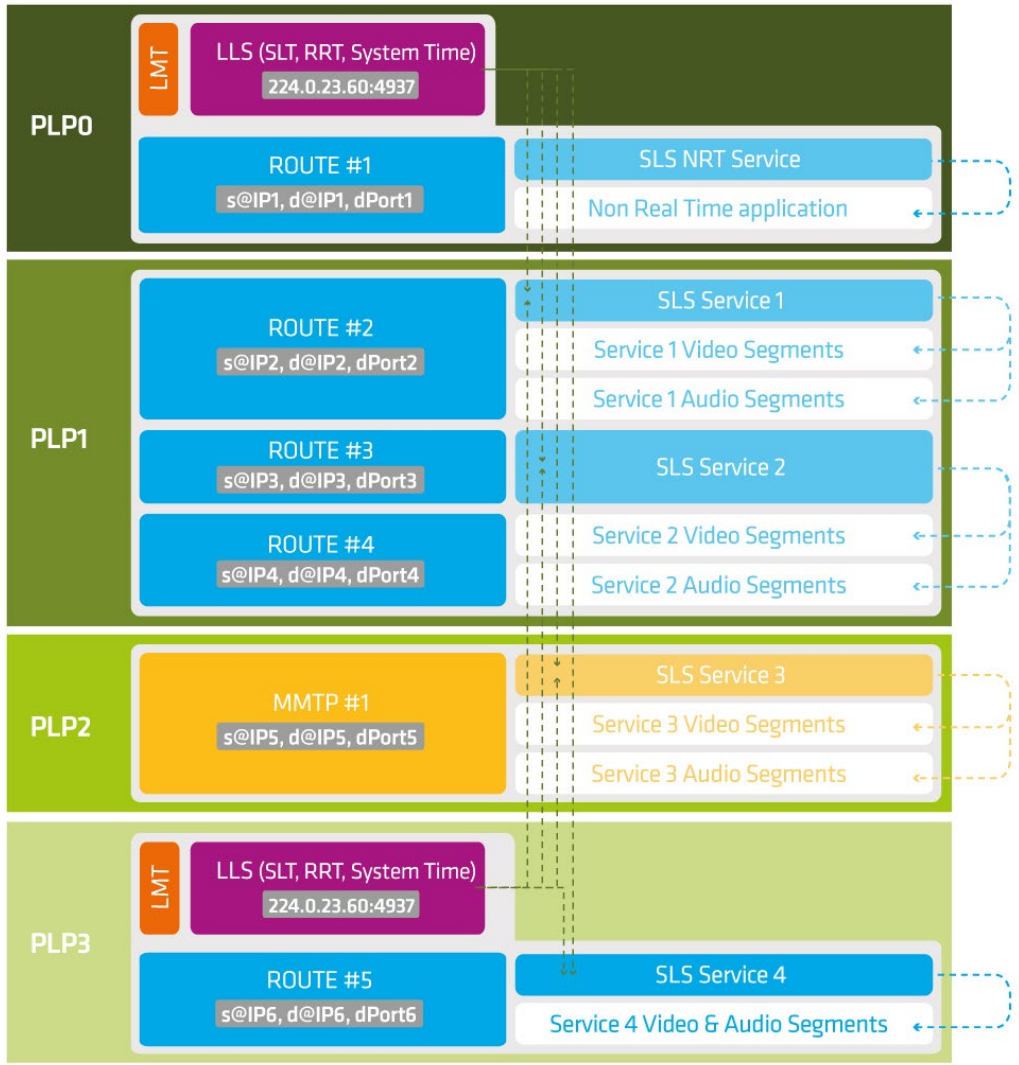
- **Services signaling generation and delivery**
  - **LLS/SLT tables** to enable the receiver to build a basic service list, and bootstrap the discovery of the SLS for each ATSC 3.0 service. The SLT can enable very rapid acquisition of basic service information.
  - **SLS fragments** to enable the receiver to discover and access ATSC 3.0 services and their content components



ATSC3.0 Signaling – Mono PLP



ATSC3.0 Signaling – Multi PLP

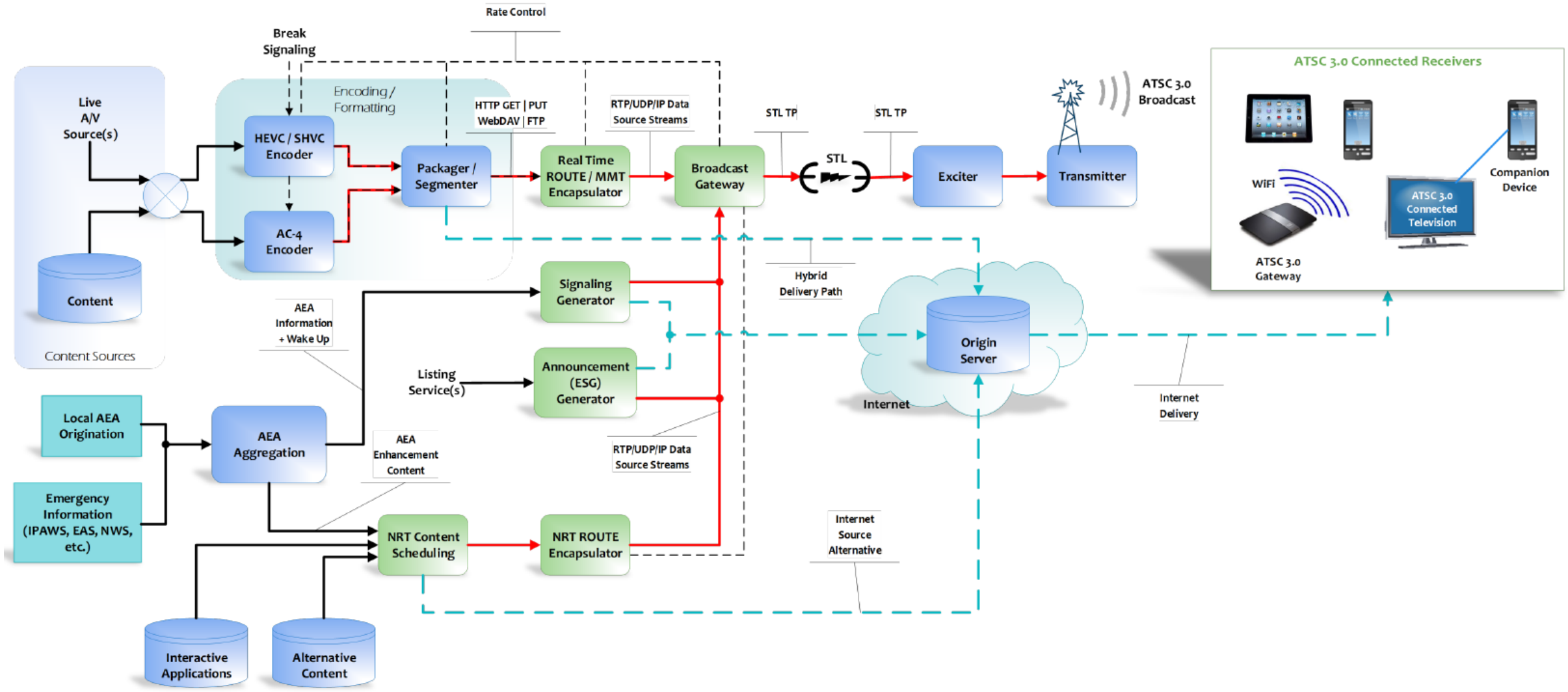


Possible Sharing Plan for Simulcast

As possible conclusion

- **Imagine a Market with 24 SD, 7 720p, 6 1080i across 12 RF channels**
- **ATSC-1 total 8 RF channels**
  - 2 transmitters with 10 SD
  - 2 transmitters with 2 x 720p + 2 SD
  - 1 transmitter with 3 x 720p
  - 3 transmitter with 2 x 1080i
- **ATSC-3 3 RF channels:**
  - 2 transmitter with 24 SD mostly 480p
  - 2 transmitters with 2 x 1080p HDR + 5 720p
- **Over time some ATSC 1 programming will be dropped to allow more ATSC 3, driven by viewership**

Big Picture


Rate Control
Break Signaling
Encoding / Formatting
Live A/V Source(s)
HEVC / SHVC Encoder
AC-4 Encoder
Packager / Segmenter
HTTP GET | PUT WebDAV | FTP
RTP/UDP/IP Data Source Streams
Real Time ROUTE / MMT Encapsulator
Broadcast Gateway
STL TP
STL
STL TP
Exciter
Transmitter
ATSC 3.0 Broadcast
ATSC 3.0 Connected Receivers
WiFi
ATSC 3.0 Gateway
ATSC 3.0 Connected Television
Companion Device
Content
Content Sources
Signaling Generator
AEA Information + Wake Up
Hybrid Delivery Path
Origin Server
Internet
Internet Delivery
Listing Service(s)
Announcement (ESG) Generator
Local AEA Origination
AEA Aggregation
AEA Enhancement Content
RTP/UDP/IP Data Source Streams
Emergency Information (IPAWS, EAS, NWS, etc.)
NRT Content Scheduling
NRT ROUTE Encapsulator
Internet Source Alternative
Interactive Applications
Alternative Content