

A large, stylized blue arrow pointing to the right, composed of various shades of blue and white geometric shapes, serving as a background for the title text.

ATSC 1.0 in an ATSC 3.0 world

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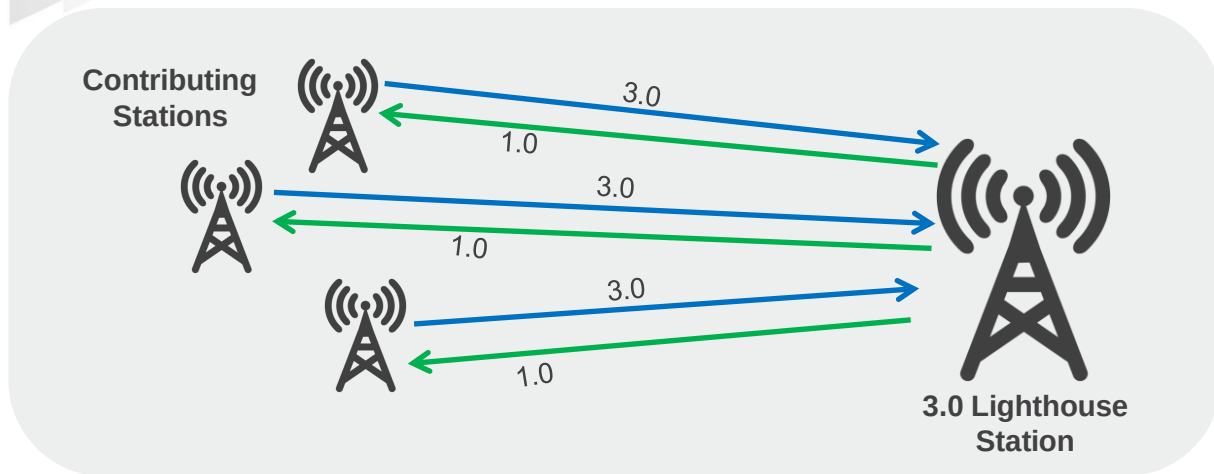
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Why worry about ATSC 1.0 in an ATSC 3.0 world?

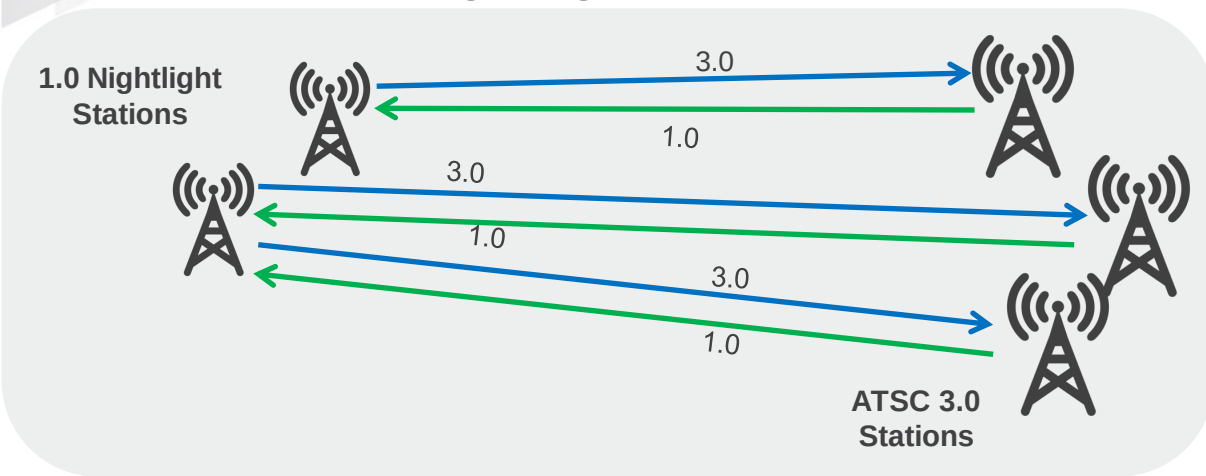
- **A Lighthouse is an ATSC 3.0 station(s) carry the primary channels in ATSC 3.0 for most of the stations in a market or DMA**
 - In return these other stations carry the ATSC 1.0 for the station(s) that became Lighthouse(s)
 - Each guest station must add one or more channels
- **Night Light(s) are stations who will carry the ATSC 1.0 channels for the other stations in the market when they switch to ATSC 3.0**
 - This is encoder limited, extremely good encoding is necessary to fit on the minimum number of transmitters
 - They will may be independent stations who can make more money as a Night Light than with other programming

CHANNEL SHARING: Lighthouse Stations



- Most stations will need to share twice,
 - Their ATSC 1.0 channels and Their ATSC 3.0 channels
 - A lighthouse gets all the ATSC 3.0 content from the others
 - and sends their ATSC 1.0 to the others
 - The contributing stations send out 3.0 and receive 1.0
- The FCC requires that stations retain ATSC 1.0 for at least 5 years

CHANNEL SHARING: Nightlights



- After the “Crossover” ATSC 1.0 service will be gradually decreased
- The channel sharing will reverse as stations convert to 3.0 and the remaining 1.0 stations move to “Nightlight” mode
- These will provide coverage for remaining legacy 1.0 TV’s
- This is likely a commercial decision, probably after the FCC mandated 5 year period

ATSC 1.0's role in the ATSC 3.0 world



- The conversion from analog to ATSC 1.0 took 11 years
 - Accelerated by government mandates: tuners, subsidized set top boxes, a mandate to turn off analog, plus giving every TV station a 2nd channel
- Timing
 - The average life of a TV in the US is about 7 years
 - The average household has 2.3 TV's
 - ATSC 3.0 TV's are not yet widely available
 - Manufacturers usually need 3 years to create new TV's, widespread presence in stores is probably 2025
 - 70% to 90% penetration of 3.0 TV's is not likely before 2032 and could be 2037 or later
- Eventually Primary Stations (ABC, CBS, NBC, PBS) will leave the lighthouse
 - Only one standard can be transmitted on a single transmitter or channel
 - Only if ATSC 3.0 is successful (defined mostly by increased revenue or a killer app)
 - Trend begins at ~70% penetration, ending at 90 to 95% penetration of new TV's to avoid disenfranchisement of viewers
- ATSC 1.0 (MPEG 2 encoding) future enhancements
 - ATSC 1.0 in the US is the only market for advanced HD MPEG 2 encoding
 - The value of ATSC 1.0 broadcasting over the next 10 years will be in excess of 100 Billion dollars by some estimates
 - ATSC 1.0 MPEG2 encoders with the efficiency necessary to fit a whole market on one or two transmitters will be completely unique, the ROI on these systems could be hours or days considering the size of the remaining 1.0 audience and the DMA
 - The required development is very expensive. MPEG 2 is a 37 year old standard. Current performance is 5-10 x what was anticipated

- Phase 1: Light House
 - 1.0 stations must carry the channels for the Light House stations
 - Generally within the capability of current new encoders
 - Some stations will be though if they are already heavily loaded
- Phase 2: Outgrow the Light House
 - Stations find profitable ATSC 3.0 use cases
 - Not everyone agrees what the profitable applications will be
 - UHD sports is a likely candidate
 - Paid programming is likely
 - The channel density increases on remaining 1.0 stations
 - This stage may be limited by achievable 1.0 density
- Phase 3: Night Light
 - Many stations are profiting from ATSC 3.0
 - Quite a few 1.0 only households still exist
 - Night Light stations take on 1.0 carriage to avoid disenfranchising viewers and to feed legacy cable
 - ATSC 1.0 performance is critical

A little ATSC 1.0 (MPEG 2) Encoding History

1st Generation “Window Pane” - The “6 Pack” 1997



- SD ASIC's or even separate boards or boxes
- Window Panes
- Little or no communication between the window panes
- Poor rate control
- No real motion vector search between panes
- Mullions show up under stress
- Poor efficiency, especially with complexity across the frame
- No lookahead
- Fixed GOP (usually)
- Limited programmable cycles
- Often “IBM” chipset
- Much of the R&D is lost when with new ASIC hardware

1st Generation “Slices” MV400, MV450, MV500 (1998)



- SD ASIC's on a common bus
- Slices
- Motion vector search across adjacent slices
- Better rate control
- Somewhat better filtering
- Adaptive variable GOP
- More ASICs yielded more programmable cycles
- Some FPGA enhancement
- Efficiency was better
- Single pass, or partial lookahead
- Useable but limited statistical multiplex performance
- Usually “C-Cube Chipset”
- Much of the R&D is lost when with new ASIC hardware

3rd Generation SD Encoding Single Slice (MV40, MV45, MV50, MV100) 1998



- Already available during the 1st generation of HD
- Single Slice (full frame)
- Multiple cascaded ASIC's for lookahead and filtering
- FPGA augmentation
- Motion Vector search limited only by ASIC complexity
- Motion Compensated Temporal Filtering (MCTF)
- Fully adaptable GOP
- Some picture recognition features
- New filter types, sometimes adaptive or dedicated to specific picture types or features
- Full two pass encoding (lookahead)
- Much better statistical multiplex performance
- Most basic features of “modern” encoding
- Much of the R&D is lost when with new ASIC hardware

3rd Generation HD – Single Slice (Electra 8000, 9000, EM4000) 2009



- Single slice in AVC or MPEG 2
- Triple pass encoding, dual lookahead
- “Universal” ASIC’s - AVC & MPEG2
- Multiple HD encodes on a single ASIC
- Lots of programmable cycles
- AVC creates some new approaches
- Great leap forward in efficiency
- First practical three HD TV stations
- New filter types, with intent driven filtering
- Much of the R&D is lost when with new ASIC hardware



Old limitations don't apply

- The new limit is CPU cycles
- Improvements come from spending CPU cycles to Improve quality or density
- Efficiency gains can provide more CPU cycles for quality
- Labor intensive
- Continuous improvement: no waiting for new ASIC's



Open source? From scratch?
Off the shelf code? GPU?

- **You must recreate all the ASIC hardwired features**
 - The basic functions: motion search, filtering etc.
 - CPU intensive: ASIC's use hardware logic
 - ASIC's come with reference designs and code
 - ASIC's can offer good quality with a minimum of programming
 - High end modern ASIC's offer programmability as well but its not efficient to code for basic functions
 - Ultimate quality is limited by the hardware functions which can't be changed
- **Pure software is very CPU intensive**
 - Efficient code is essential
 - The basic functions aren't fixed, they are open to innovation



- **Encoder code is available as open source, BUT**
 - But quality is limited
 - The basic architecture may limit possible architectures and enhancements
 - Open source is usually targets lower performance applications
- **GPU's offer high density**
 - Limitations are similar to ASIC's
 - The maximum quality is tends to be limited
 - Limitations of the GPU Chips create a possible loss of R&D with new generations
- **"From scratch" designs are extremely labor intensive**
 - Nothing is limited except the available CPU cycles
 - A good underling architecture can provide a platform for continued improvements
 - Improvements come from learning how to spend CPU cycles to improve quality
 - Efficiency improvements can increase density
 - Efficiency can provide additional CPU cycles for improved performance

Secret Sauce?

- **There isn't any magic bullet or secret sauce**
 - Good design, Hard Work, Detail, Detail and lots of man hours is what it takes to make a great encoder
 - It helps to have a large customer base to amortize the man hours
 - Fundamental Codec improvements are mostly already known, but still possible
 - Filters and statistical multiplex improvements are productive,
 - Typically yield 1% or less at a time
 - But over time accumulate to offer significant quality gains
 - Many techniques pioneered for non-real-time encoding can be applied in real-time with enough horsepower

- **Detect and react to picture types and features**

- Encoder actions:

- Rate control within the frame
 - Specific filter algorithms
 - Enhancement algorithms
 - Overall rate and buffer control
 - Statmux bitrate request modifications
 - GOP modification (I, P, B placement)
 - In loop quality feedback

- Statmux control

- Overall Pool loading controls adaptations
 - Multiple look ahead
 - Picture adaptations drive statmux estimations
 - Quality estimation
 - Quality goals: “best quality” and “constant quality”
 - Application specific adaptations
 - “Safe” vs. “Aggressive” statmux
 - MVPD’s are different from broadcasters
 - ATSC OTA is different than distribution

- **Examples**

- Scene change
 - Film cadence, cadence changes
 - Repeated fields and frames
 - Logo, other fixed graphics
 - Text
 - Crawl
 - Explosion
 - Pan
 - Zoom
 - Faces
 - Crowds
 - Grass
 - Floor
 - Detailed rapidly moving objects
 - Eyes
 - People on background
 - People in motion

- **ATSC 1.0 is uniquely difficult**

- It is the last worldwide market for HD MPEG 2
- Smallest video pool size of any application
 - cable is double, most satellite is triple
- Not enough programs to approach constant quality
 - The Statmux concept is based on the notion that with enough programs each can have constant quality
- Extreme prioritization is the norm: Not at all like MVPD's
- Mixed HD & SD pools are not common in other applications
- HD and SD programming and requirements are very different
 - SD content is often legacy with a mixture of film and analog tape
 - SD channels are intentionally bit starved
 - HD premium content is often sports, with clean sources
 - HD primetime is often 24 fps, but with disrupted cadence

- ATSC 1.0 density is now 2 to 4 times the first generation
- There is room to improve MPEG 2, but its very difficult
- A single SD today is 7% to 10% of the total
 - The real figure of merit for ATSC 1.0 is “How many SD’s can I do with that?”
 - Adding an SD involves Filters, Statmux and Codec improvements
 - Improvements tend to come 1% at a time
 - Fine tuning specific for ATSC 1.0 is critical
- MPEG 2 now runs well below the early AVC expectations
 - But AVC has improved at the same rate
 - ATSC 1.0 can arguably support AVC (on some TV’s)
- You must test with the actual content.....!!!
- MPEG 2 will be over 40 years old before it can be retired!
- I still listen to AM & FM radio.....But I don’t watch NTSC
- There are techniques developed for other applications that can still yield improvements

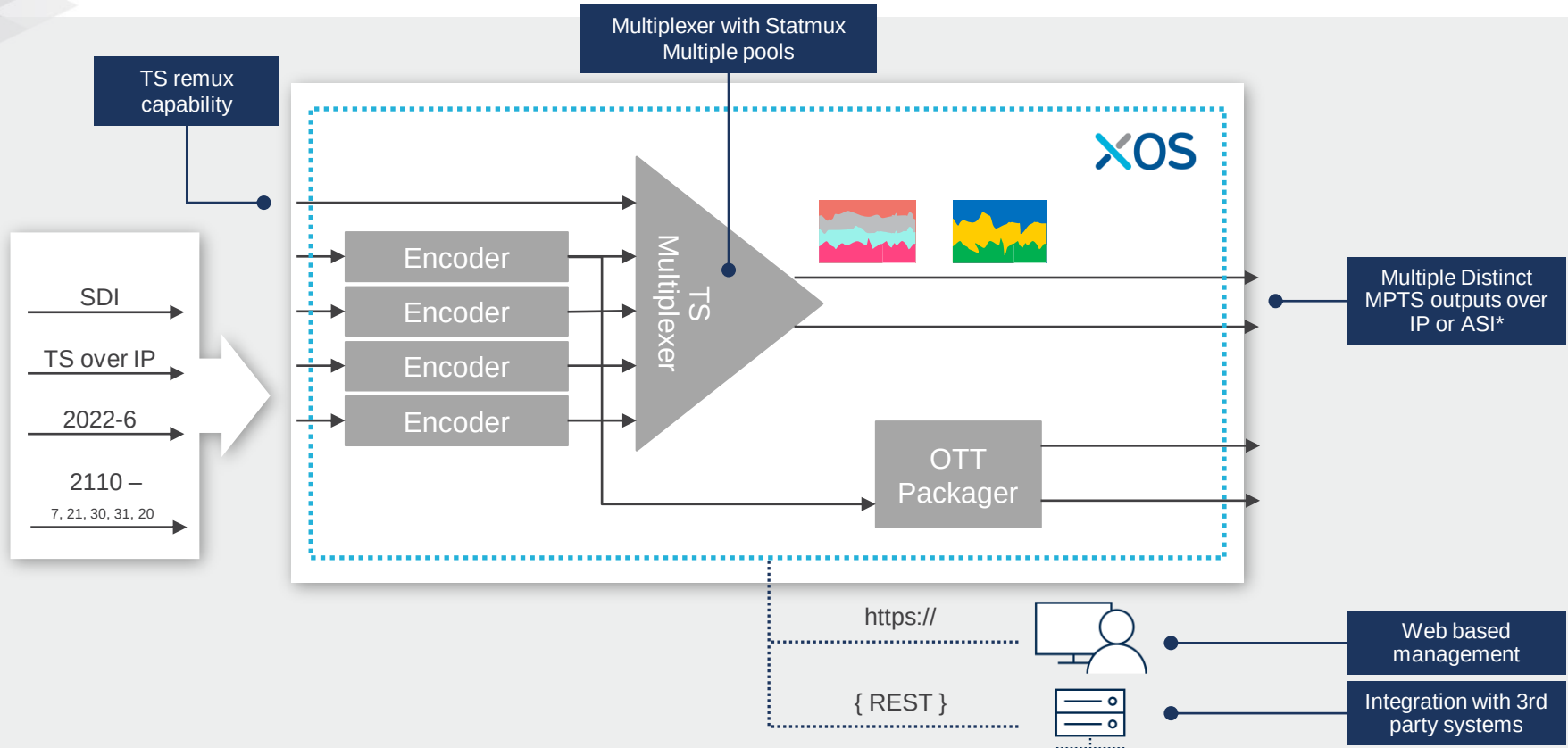
Thank You

XOS

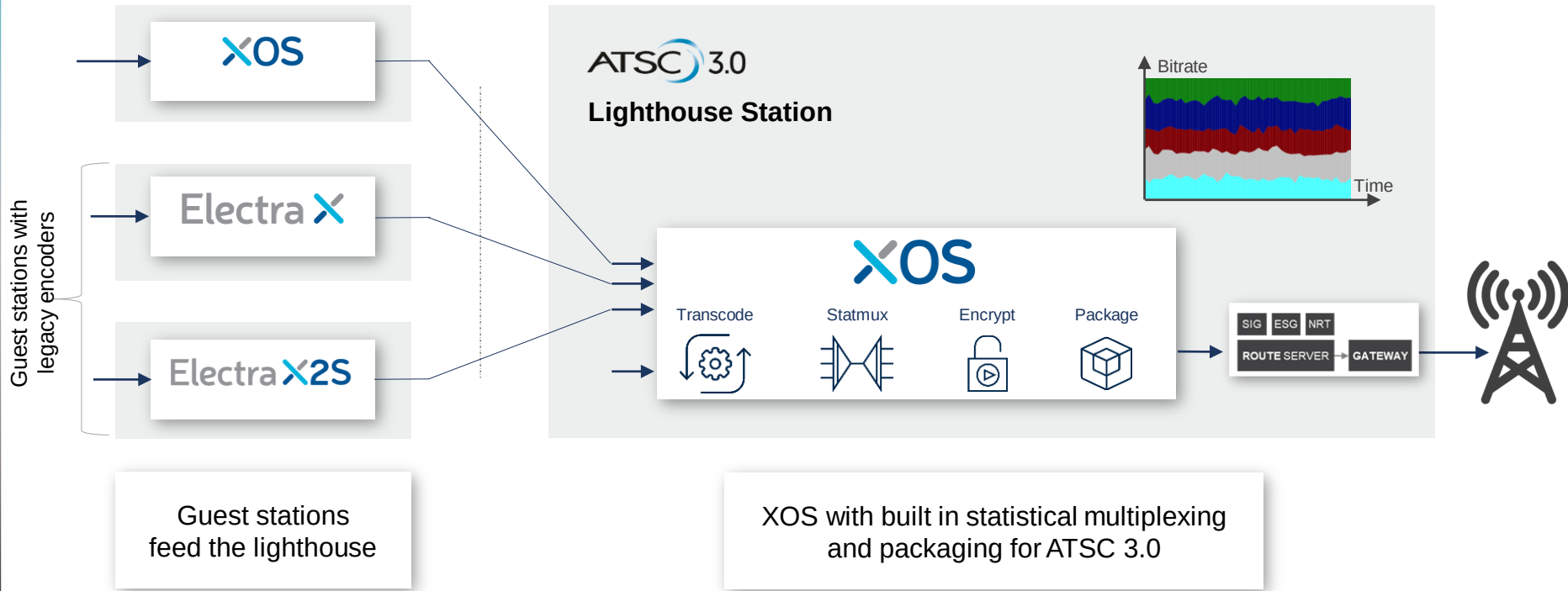
ADVANCED MEDIA PROCESSOR
Premier ATSC 3.0 solution



XOS APPLICATIONS SYSTEM IN A BOX



Typical Light House using Harmonic Products



Electra X2S ATSC 1.0



- **ATSC 1.0 Packages**

- all are expandable to 8 channels (24 with expansion chassis)
- 3HD + 3SD
- 2HD + 2SD
- 1HD + 4SD

- Largest selling ATSC 1.0 encoder ever
- More channels, better video quality than any previous generation
- Added SD channels often offer an positive ROI in days or weeks
- Capacity for multiple TV stations
- Capacity to feed lighthouses
- ATSC 3.0 capable

Thank You