The transition to ATSC 3.0

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Making the ATSC 3.0 transition

- The need for channel sharing
- ATSC 1.0 Channel Sharing
- ATSC 3.0 Channel Sharing
- The basics of statistical multiplexing
• ATSC 3.0 will require extensive channel sharing
• Most stations will need at least two shares: ATSC 1.0 and ATSC 3.0
• Bit rate agreements are difficult and often reflect a lack of knowledge of how statistical multiplexing works
• Fair agreements need to address time as well as rate
• The interconnection between stations is often overlooked until it's too late…..
  • The interconnection often drives both cost and video quality (for good or bad)
  • Reusing an ATSC 1.0 signal for ATSC 3.0 defeats the whole purpose of ATSC 3.0
  • Poor channel share implementations degrade quality and reduce useable channel count
How can we make ATSC 1.0 work for the nightlights?
ATSC 1.0 Channel Sharing

- The ATSC conversion is driven by channel sharing
- During each phase ATSC 1.0 will usually be the limiting factor
- The FCC requires that ATSC 1.0 coverage must retain 95% of the audience
  - Applies to the primary channel
  - This may eliminate some hosts if their coverage is less
- Most stations want to retain all of their existing channels
- ATSC 3.0 can (usually) carry more channels than ATSC 1.0
- Spreading shared ATSC 1.0 channels across several stations can optimize VQ
- A market wide approach is best
  - station pairing offers too little ATSC 1.0 capacity
- The ATSC 1.0 Nightlight will evolve as the 3.0 audience grows
MPEG 2 Efficiency Improvements

- MPEG codecs, MPEG2, AVC, HEVC all specify the decoder
- MPEG 2 encoders are still improving
- HD has improved more than SD
  - Within MPEG2
  - AVC and HEVC also favor higher resolutions
- MPEG 2 HD encoding efficiency is about double what it was in 1999
- Improvements generally fall into categories:
  - Codec, Statmux, Filtering
- Major leaps are rare, but there have been several:
  - Optimized Variable GOP (Codec)
  - Lookahead and multiple lookahead (Statmux & Filters)
  - MCTF (motion compensated temporal) (filter)
  - Single slice (codec)
- But….Most improvements are small but cumulative: 1% or 2% at a time
What bitrate do I need?

• There is no real answer!

• Basic parameters:
  • minimum
  • maximum
  • priority
  • total pool size / # of services

• The bitrate for a given quality level depends on:
  • Video format (1080i, 720p etc.)
  • Content: Sports, Entertainment, Film, Hand animated, Computer animated…
  • Your taste
  • The market size

• In ATSC 1.0 the number of channels considered to have acceptable quality (by their management) varies widely
  – Examples:
    • Small market channel share (3 way, 2 independent + Public TV): 3 HD + 7 SD
    • Large market (O&O): 2 HD + 5 SD (limited sports)
    • Large market (O&O): 2 HD + 2 SD (Sports on both HD’s)

• In the end the quality must be appropriate for the content
• It must serve the interests of the station(s) and the public
Making the ATSC 1.0 share work

• More stations = more opportunity to optimize the mix of channels on the 1.0 stations

• The primary HD channel shares represent opportunity for Public and Independent stations
  – These stations often don’t carry sports
  – Bitrate agreements are difficult, often its more productive to treat bitrates as a fallback
  – The primary agreement should allow optimization of the encoding system, i.e. maximize overall VQ first

• It is possible to fit two HD channels even with simultaneous sporting events
  – There are many examples from the spectrum auction
  – Controlling the rate of any accompanying SD channels is critical
  – HD sharing with HD is often more efficient than a mix of HD and SD

• Rather than try to specify SD bitrates, it is often better to treat them as equal, but with less priority than the primary channels
Things to consider in a contract

- Never specify a “minimum” bitrate. This = CBR
- Average is better
  - Average over what time frame?
    - Consider a day, or a week to allow for sporting events
    - Tools are available to log bitrates
    - It is possible to have deterministic average bitrates
      But letting the encoder decide often offers better performance
- Specifying equal settings is often more efficient than trying to specify bitrates
  - Equal settings should provide equal VQ if the encoder is well designed
  - The contract can contain language based on bitrates to settle disputes if necessary
- Split the channels into groups, settings for the primary channels, other settings for the secondary channels
- Bitrate logging with adjustment good faith agreement can allow higher quality for all
ATSC 3.0 Rollout
ATSC 3.0 transition over time

- The initial rollout period (2019 – late 2020)
  - Few 3.0 TV’s
  - Service is required to kick start the consumer market
  - Occasional UHD / HDR special programming will become available

- Full service (2021 2022)
  - Quality and services must clearly distinguish 3.0 as an improvement over 1.0
  - Network programming should be available 1080p HDR
  - SFN and OTT hybrid transmissions can improve quality and quantity of services

- Crossover
  - The number of 3.0 households will eventually crossover 1.0
  - MVPD’s will eventually carry 3.0 services
  - Some of the 1.0 stations will convert, placing new demands on the remaining nightlights
  - Eventually 1.0 service will be reduced as stations reach the 5 year timeout, assuming 3.0 is more profitable
PLP’s: A lot of choices

- **Physical Layer Pipes**
  - Use up to 4 PLP’s
  - Each PLP can have different modulation and bandwidth
  - The parameters for each PLP are chosen for specific services
  - Indoor, mobile, portable services require robust modulation
  - UHD or high channel count HD may require less robust modulation in order to carry enough bits
  - Single Frequency Networks may support different choices than a single transmitter
  - A robust PLP for service announcement can extend OTT availability

- A single PLP in the middle of the range will yield 24 to 26 Mb/s
• Assumptions:
  – 25 Mb/s
  – Stations transmit 1080p59.9
  – Statistical multiplexing is used
  – Capacity for a single transmitter will likely be 4 to 6 primary channels
  – 720p59.9 for some stations would increase this capacity

• In the initial rollout the goal is likely to replicate the primary ATSC 1.0 services
  – The goal should be to very quickly achieve better quality than the ATSC 1.0 services
  – This is the time to eliminate Interlace
  – Reusing the ATSC 1.0 transmission is only OK until there are TV's available

• UHD will be an issue
  – Useful bitrates for UHD are 2 to 3 times the 1080p rates
  – Typical transmitter configurations will not allow for UHD along with full carriage of 3 or 4 1080p59.9
Why you may need Hybrid sooner than later

- Some networks will have occasional UHD content as early as 2020
  - Consumer electronics manufacturers will advertise UHD TV’s
  - Local Electronics stores and chains will advertise with cooperative dollars
  - A shared transmitter will probably not have enough bandwidth for UHD, certainly not two
  - OTT delivery can provide the necessary bandwidth without equipment budget
- Many shared transmitters will not have space for secondary channels
  - These channels can be transmit OTT with **no** transmitter bandwidth
  - Secondary channels can be in HD when delivered via OTT
- Early adaptor consumers will set the tone for the rollout
  - Early adopters need to see a difference between ATSC 1.0 and 3.0
Hybrid Broadcast / Broadband

- A single Media Presentation Description (MPD) is used to signal A/V on broadcast and broadband
- The receiver can seamlessly switch between OTA and OTT
- OTT reception is only possible if OTA is present
- Examples of hybrid delivery of A/V streams:
  - Same service over broadcast and broadband but with different qualities (HD OTA, UHD OTT)
  - Enhanced tuning time
  - OTT error correction / recovery for OTA
  - Main service over broadcast: DVR, Pause, Start Over, Rewind OTT
About Statistical Multiplexing
Statistical Multiplexing

- Statistical Multiplexing is STATISTICAL
  - i.e. it’s not ALWAYS going to work the way you want
    - Constant Bitrate = Variable Quality
    - Variable Bitrate = Constant Quality
    - The actual instantaneous quality is determined by total pool complexity
    - The complexity varies continuously
    - It works because some channels have light complexity while others have high complexity
    - It doesn’t work when all channels have high complexity simultaneously
    - The more channels there are the more likely that the statistics will balance out for consistent quality
    - The quality will vary with time, one measure of quality is the percentage of time the picture is unacceptable
    - With few channels there is efficiency gain, but the quality will be more variable
Statistical Multiplexing

• The instantaneous bitrate for each channel is determined by the required bits to achieve the target quality
• The sum of the channel bitrates must equal a constant bitrate, otherwise null packets will be needed to fill between peaks
• The target quality is determined by:
  – Channels with equal priority should have equal quality
  – Channels with lower or higher priority will have adjusted quality, lower or higher
• It is possible to target a given bitrate, but the required bitrate is fundamentally determined by:
  – Video format: Pixels per second $H \times V \times FR$
  – HD uses fewer bits per pixel than SD, UHD less than HD…
  – Complexity: Motion $\times$ Detail
  – Nearby pictures: scene, transitions, pan, flash, fade, camera shake, film registration
  – Noise: camera noise, film grain, existing encode artifacts
Statistical Multiplex Example
Statistical Multiplex Example

Video Bitrate Line Chart

Program 1 PGM1
Program 2 PGM2
Program 3 PGM3
Program 4 PGM4
Program 5 PGM5
Program 6 PGM6
About Bitrates

• Factors which determine video quality:
  – Maximum bitrate that’s available to a channel
  – Average bitrate (pool / channels)
  – The content present on the other channels

• In a large pool the quality is more closely related to the maximum bitrate than the average
  – Max = Pool – (sum of mins) OR the max setting, whichever is lower

• The average bitrate should be determined by the encoder, not forced upon the channel
  – Modern encoders are smart, they will balance the channels naturally
  – Forcing an average per program reduces overall video quality
  – But a forcing an average makes contracts easier to write

• The minimum bitrate has very little to do with quality
  – High minimum bitrates will degrade other channels more than they improve the target channel
  – If every stream has a high minimum it is no longer a statmux: it will be CBR
  – Overall quality is improved when there are more bits that can be “moved”
  – A good encoder has lookahead to ensure there are enough bits available around scene change and transitions

• HD requires fewer bits per pixel, but SD allows for higher statmux gain
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Sample bitrate as Run (in Excel)
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- Of the original A53 formats, only 3 are widely used
- 2 currently unused formats have promise for reintroduction
- 720p30 offers HD at half the current HD bitrates
- 480p30 offers clearer pictures for SD, but at similar bitrates
Final Thoughts
• The ATSC 3.0 transition will require unsanctioned cooperation between broadcasters
• The greatest challenge is going to be channel sharing
• Getting a station on the air in 3.0 is less of a challenge than keeping 1.0 service alive
• The challenges are legal as well as technical
• There is intense focus on legal agreements based on bitrates
• BUT continuity and quality of service are not defined just by bitrates
Thank You

MPEG 2 VQ: Making the Nightlight work