Standards & Specifications for Carriage of JPEG XS in RTP for IP Networks

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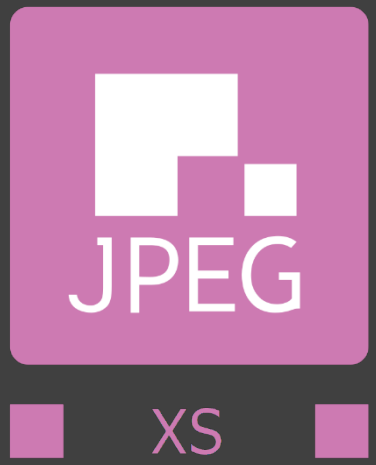
JPEG XS: Low-complexity, low-latency, high quality codec

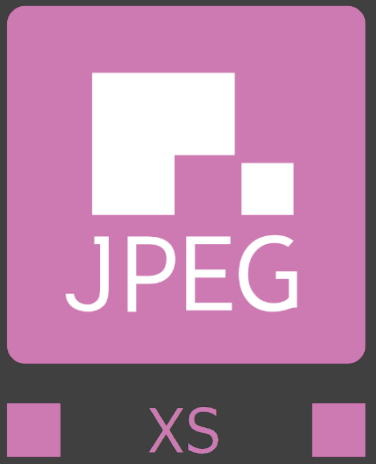
- “JPEG” joint working group of International Standardization Organization (ISO) & International Electrotechnical Commission (IEC)
- Standardized as ISO/IEC 21122
- It’s neither JPEG nor JPEG 2000
- “XS” = “eXtra speed” & “eXtra small”
- Wavelet-based codec
- Low complexity – 4K 60p on i7 in real time
- Royalty required for use



ISO/IEC 29170-2 “Flicker” Testing

- Reference on one side
- Flicker back and forth between reference & compressed on other
- Which image seems to “flicker”?

JPEG XS: Low-Latency, High Quality



- End-to-end latency as low as 32 lines
    - Real-world & software more like 1 frame
- Low multi-generation loss (<1 dB PSNR / 10 cycles)
- My view: JPEG XS needs 175 Mbps for “visually lossless” HD
    - +1 bpp over J2K
- Customer view:
    - Networks – 10:1 (720p60 @ 110 Mbps)
    - Sports – 5:1 (720p60 @ 220 Mbps)
- More Info:
  http://ds.jpeg.org/whitepapers/jpeg-xs-whitepaper.pdf

JPEG XS & ST 2110

ST 2110

Emmy Award Winning

ST 2110-22

Use CBR RTP Payload defined by IETF

IETF®

+

JPEG XS

=

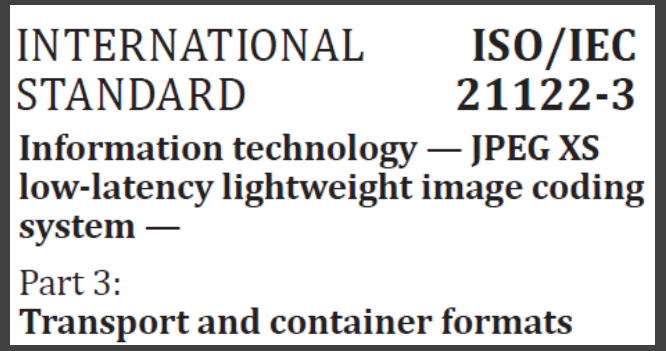
AIMS IPMX

Use ST 2110-22 with JPEG XS

IPMX
IP MEDIA EXPERIENCE

JPEG XS RTP Defining Documents

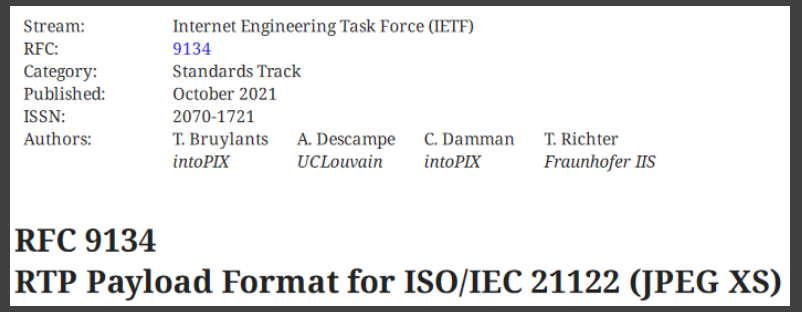
- ISO/IEC 21122-3
  - Specifies metadata “boxes”
- IETF RFC 9134
  - RTP payload format for JPEG XS
- SMPTE ST 2110-22
  - How CBR compressed video works in 2110 systems
- VSF TR-08
  - JPEG XS constraints for television signal interoperability


INTERNATIONAL STANDARD

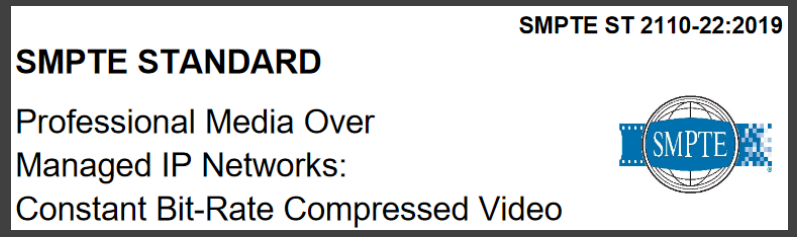
ISO/IEC 21122-3

Information technology — JPEG XS low-latency lightweight image coding system —

Part 3:
Transport and container formats


Stream: Internet Engineering Task Force (IETF)
RFC: 9134
Category: Standards Track
Published: October 2021
ISSN: 2070-1721
Authors: T. Bruylants (intoPIX), A. Descampe (UCLouvain), C. Damman (intoPIX), T. Richter (Fraunhofer IIS)

RFC 9134
RTP Payload Format for ISO/IEC 21122 (JPEG XS)


SMPTE ST 2110-22:2019

SMPTE STANDARD

Professional Media Over Managed IP Networks:
Constant Bit-Rate Compressed Video

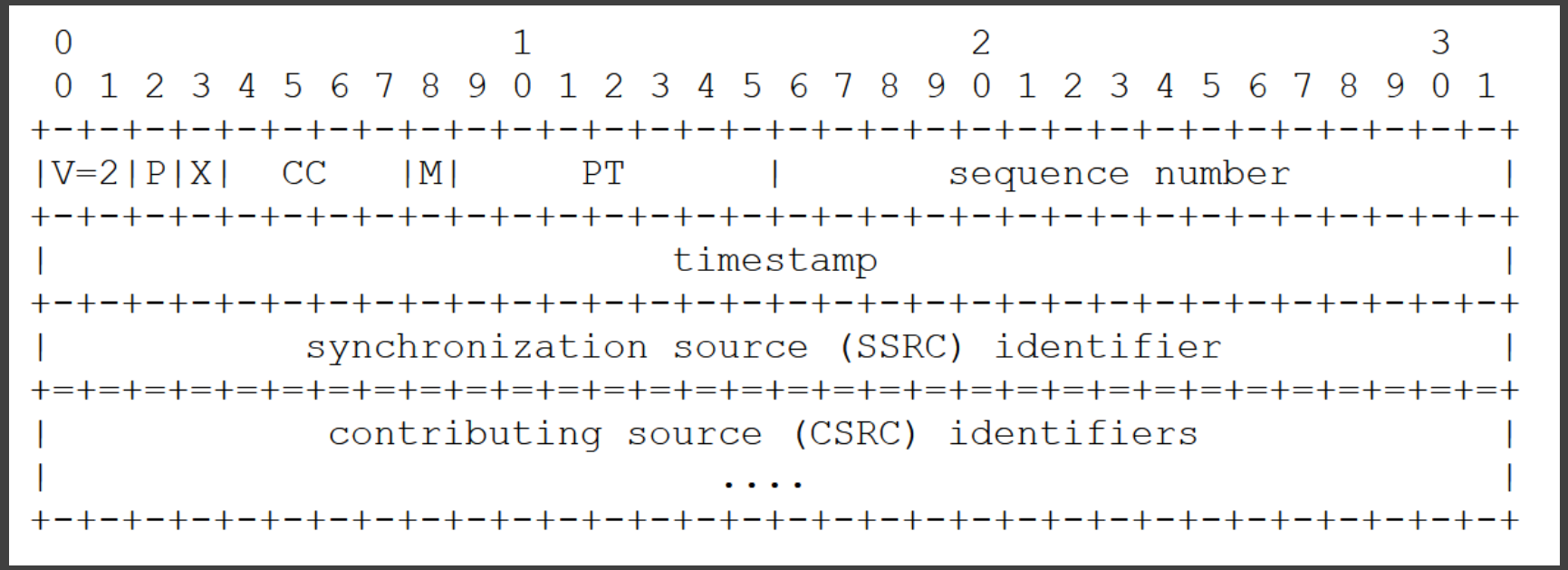

Video Services Forum (VSF)
Technical Recommendation TR-08

Transport of JPEG XS Video in ST 2110-22

Important Vocabulary!

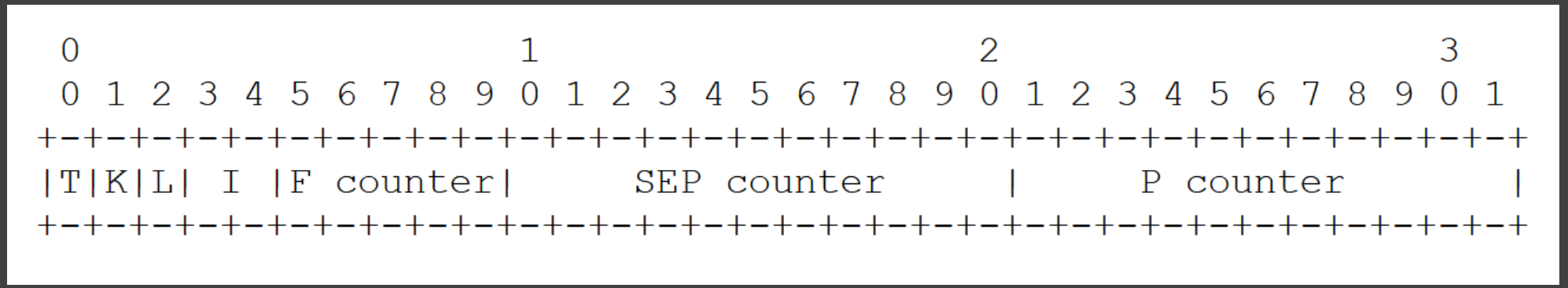
- ADU: Application Data Unit, made up of several…
- Packetization units, in “codestream packetization mode”, a…
- JPEG XS picture segment, made up of:
  - Video Support Box
  - Color Support Box
  - JPEG XS codestream of one field/frame
- VSF TR-08 only allows codestream packetization mode
  - *I’ll skip slice packetization mode…*

RFC 9134: RTP Header – no surprises



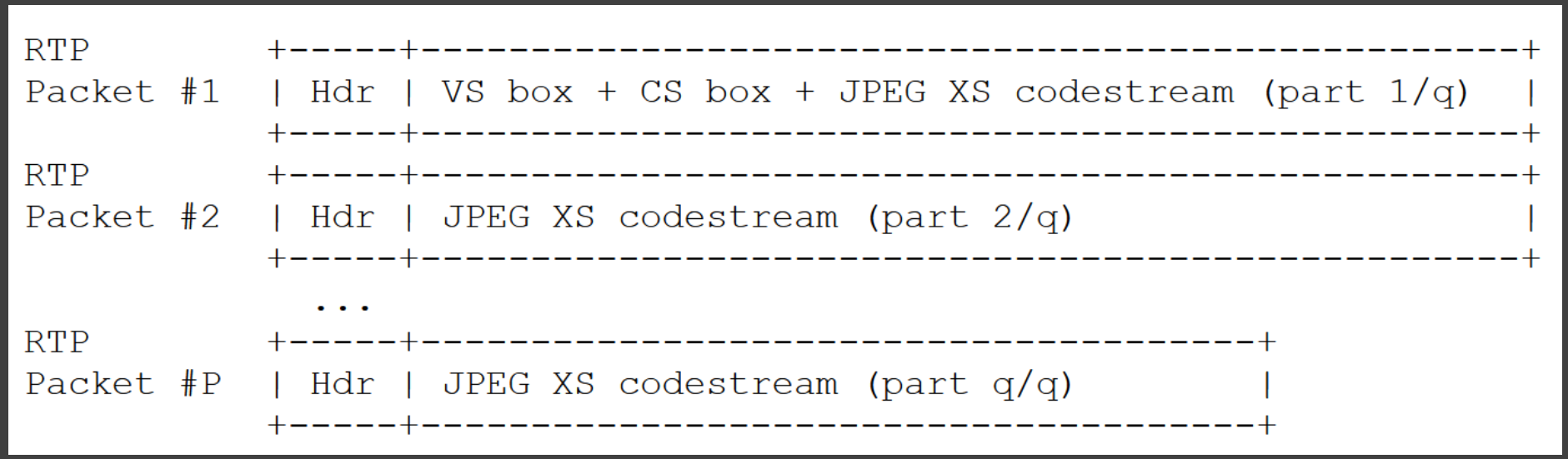
- **V**ersion, **P**adding, e**X**tension, CSRC count (**CC**), sequence number, synchronization source & contributing source identifiers as per RFC 3550
- **M**arker Bit – last packet of field/frame
- Timestamp – 90 kHz

RFC 9134: JPEG XS Payload Header



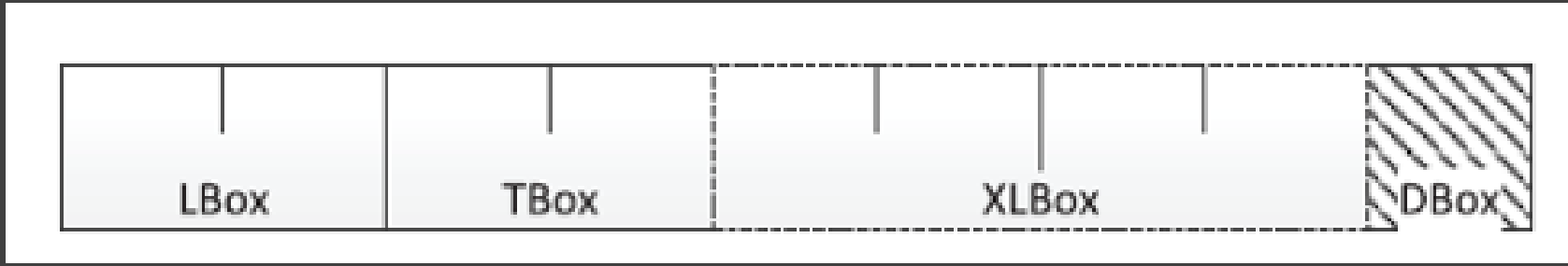
- **T**ransmission mode: 1=sequentially, 0=may be out of order
- pac**K**etization mode: 0=codestream, 1=slice
- **L**ast: last packet of a packetization unit (in codestream mode, end of field/frame, and same as **M**arker bit)
- **I**nterlaced: 00=progressive, 10=first field, 11=second field
- **F**rame counter (modulo 32)
- Slice and Extended Packet (**SEP**) counter: resets when Packet counter resets & increments by 1 when Packet counter overruns
- **P**acket counter: Reset to 0 at start of packetization unit (codestream mode, beginning of field/frame), modulo 2048

RFC 9134: Payload Data



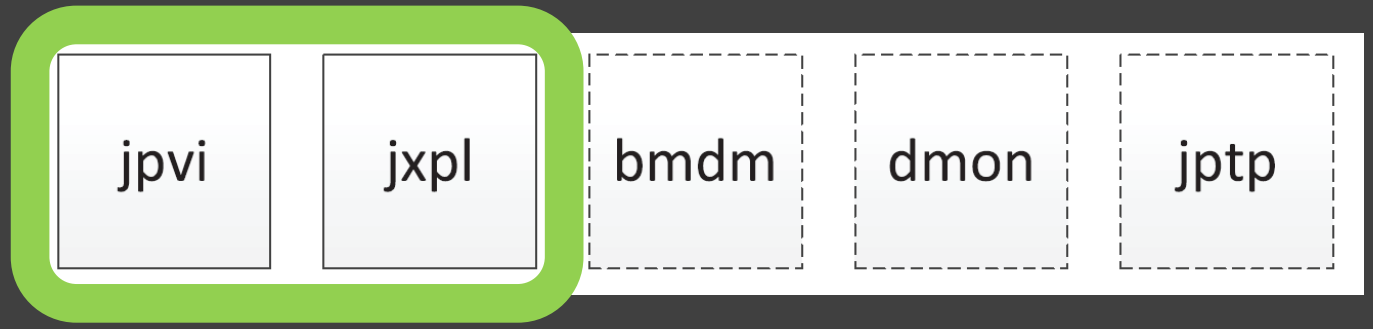
- Boxes defined in ISO/IEC 21122-3
- Video Support (**VS**) Box
  - A “superbox”, a box that contains other Boxes
  - Contains “video information”
  - e.g. frame rate, field coding, time code, profile/level
- Color Specification (**CS**) Box
  - e.g., color primaries, transfer characteristics, “full” range

ISO/IEC 21122-3: Boxes



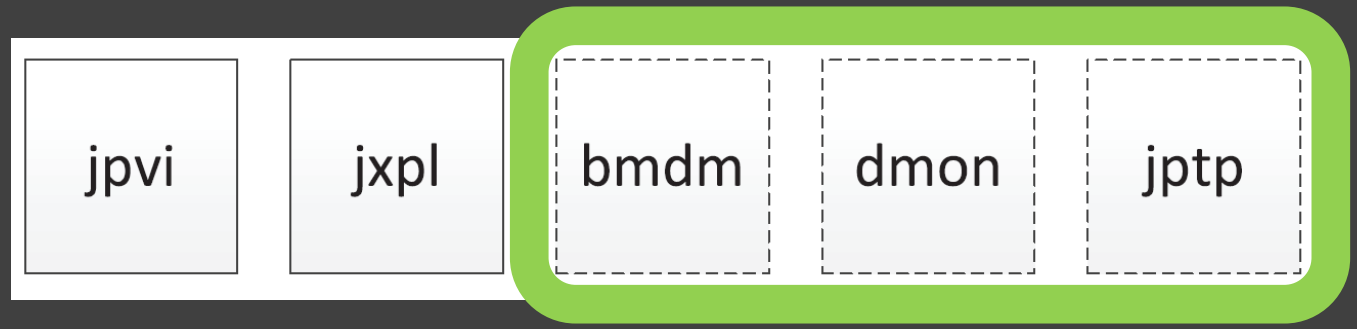
- “Derived from” atoms from ISO/IEC 14496-12 ISOBMFF / QuickTime, but are specifically defined for JPEG XS
- LBox: 4 byte length field
- TBox: 4 byte box type
  - 'jpvs' (0x6A70 7673): JPEG XS Video Support Box
  - 'colr' (0x636F 6C72): Color Specification Box
- XLBox: 8 byte extended length field (if LBox=1)
- DBox: box contents

ISO/IEC 21122-3: Video Support Box, mandatory sub-boxes



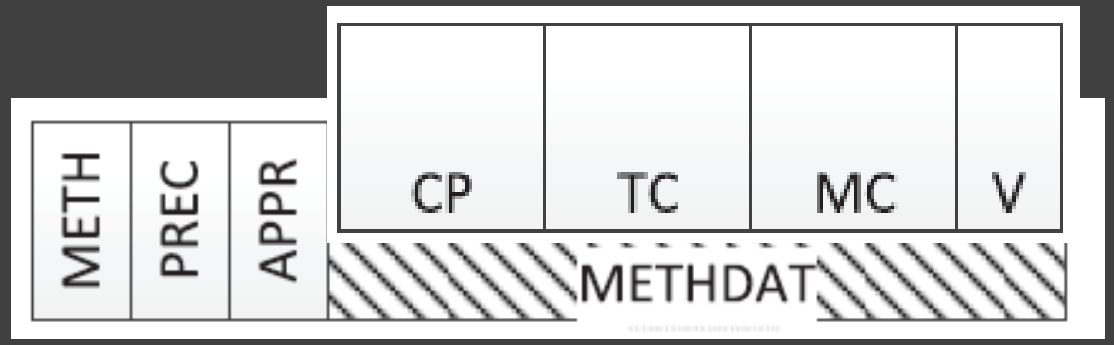
- 'jpvi' (0x6A70 7669): JPEG XS Video Information Box
  - brat [32 bits]: max bitrate
  - frat [32 bits]: frame rate including interlace mode, numerator, denomerator
  - schar [16 bits]: sample characteristics, bit depth, sampling
  - tcod [32 bits]: timecode HHMMSSFF
- 'jxpl' (0x6a78 706c): JPEG XS Profile and Level Box
  - Ppig [16 bits]: profile
  - Plev [16 bits]: level

ISO/IEC 21122-3: Video Support Box, optional sub-boxes



- 'bmdm' (0x626d 646d): Buffer Model Description Box
  - Tmbd: buffer model from ISO/IEC 21122-2
  - Either the buffer model with limited transmission latency
  - …or full use of decoder smoothing buffer (variable transmission latency)
  - # coefficient groups of horizontal & vertical blanking periods
- 'dmon' (0x646d 6f6e): Mastering Display Metadata Box
  - SMPTE ST 2086 metadata
  - MCLL, MFALL as per CTA 861-G
- 'jptp’ (0x646d7370): JPEG XS Video Transport Parameter box
  - Suggestions to the decoder on how many slices assigned to processing units, how many parallel decoding units, size of decoder packet reordering buffer

ISO/IEC 21122-3: Color Specification Box



- 'colr' (0x636F 6C72): Color Specification Box
  - METH [8 bits]: 5=Coding Independent Code Points (CICP) of Rec. ITU-T H.273
  - PREC [8 bits]: Precedence, undefined, should =0
  - APPR [8 bits]: Colorspace approximation, currently =0
- METHDAT: Method data for CICP
  - CP [16 bits]: Color primaries
  - TC [16 bits]: Transfer characteristics
  - MC [16 bits]: Matrix coefficients
  - V [8 bits]: Video Full Range Flag (1=full range)

Color Specification Box Commonly Used METHDAT

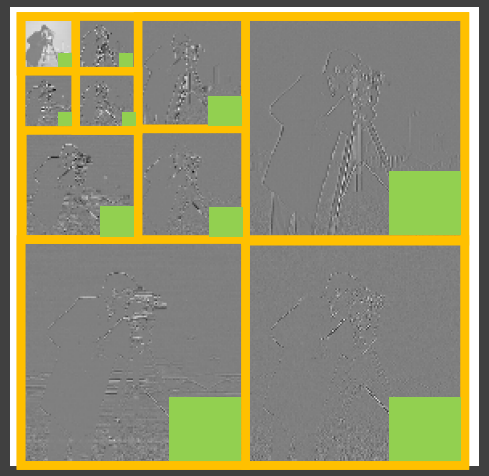
Color space	Color primaries code	Transfer characteristics code	Matrix coefficients code	Video full range flag	Notes
Rec. ITU-R BT.709-6	1	1	1	0	BT 709 SDR
Rec. ITU-R BT.2100-2	9	16	9 (Y'CbCr)	0	PQ HDR with BT 2020
Rec. ITU-R BT.2100-2	9	18	9 (Y'CbCr)	0	HLG with BT 2020

ISO/IEC 21122-1: JPEG XS Codestream

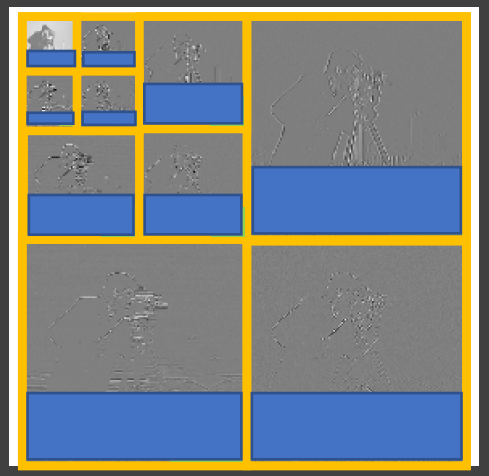
- Markers:
  Identify structural parts of codestream
- Marker segments:
  Marker followed by length field and data parameters
- Entropy coded data:
  Wavelet coefficients that have been entropy coded
- Precincts:
  Entropy coded data of wavelet coefficients contributing to spatial region of the image
- Slices:
  integral number of precincts over the full width of the image.

Image

Precinct



Slice



JPEG XS Codestream Syntax

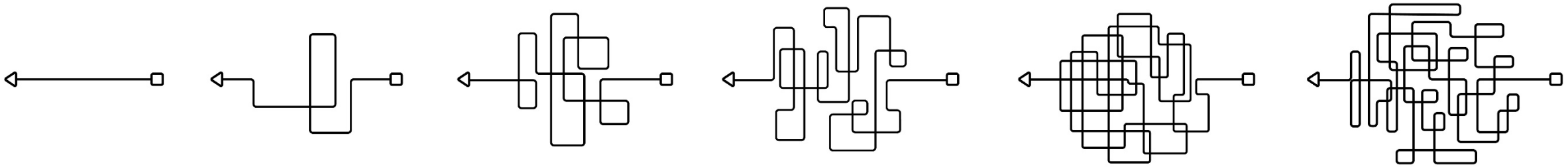
Syntax Element	Syntax Type	Code (if marker)
Start of Codestream (SOC)	marker	0xff10
Capability Marker	marker segment	0xff50
Picture Header	marker segment	0xff12
Component Table	marker segment	0xff13
Weights Table	marker segment	0xff14
Extension Marker	marker segment	0xff15
Loop over Slices {		
Slice Header	marker segment	0xff20
Loop over Precincts {		
Precinct Header	entropy coded data	
Loop over Packets {		
Packet Header	entropy coded data	
Packet Body }	entropy coded data	
Fill()		
}} End of Codesteam (EOC)	marker	0xff11

VSF TR-08 Constraints

- Codestream Packetization Mode
- JPEG XS profile “High444.12”
- 5 horizontal & 2 vertical wavelet transforms
- Only use uniform quantizer
- 4 bpp minimum and 1.5 bpp maximum compression
- # bytes in Payload Data multiple of 8 bytes
- Senders/receivers must support “configurations”
  - Combinations of Conformance Level & Capability Set
  - Includes audio & video
  - Intra-facility, interfacility, and intra-campus IPMX Capability Sets

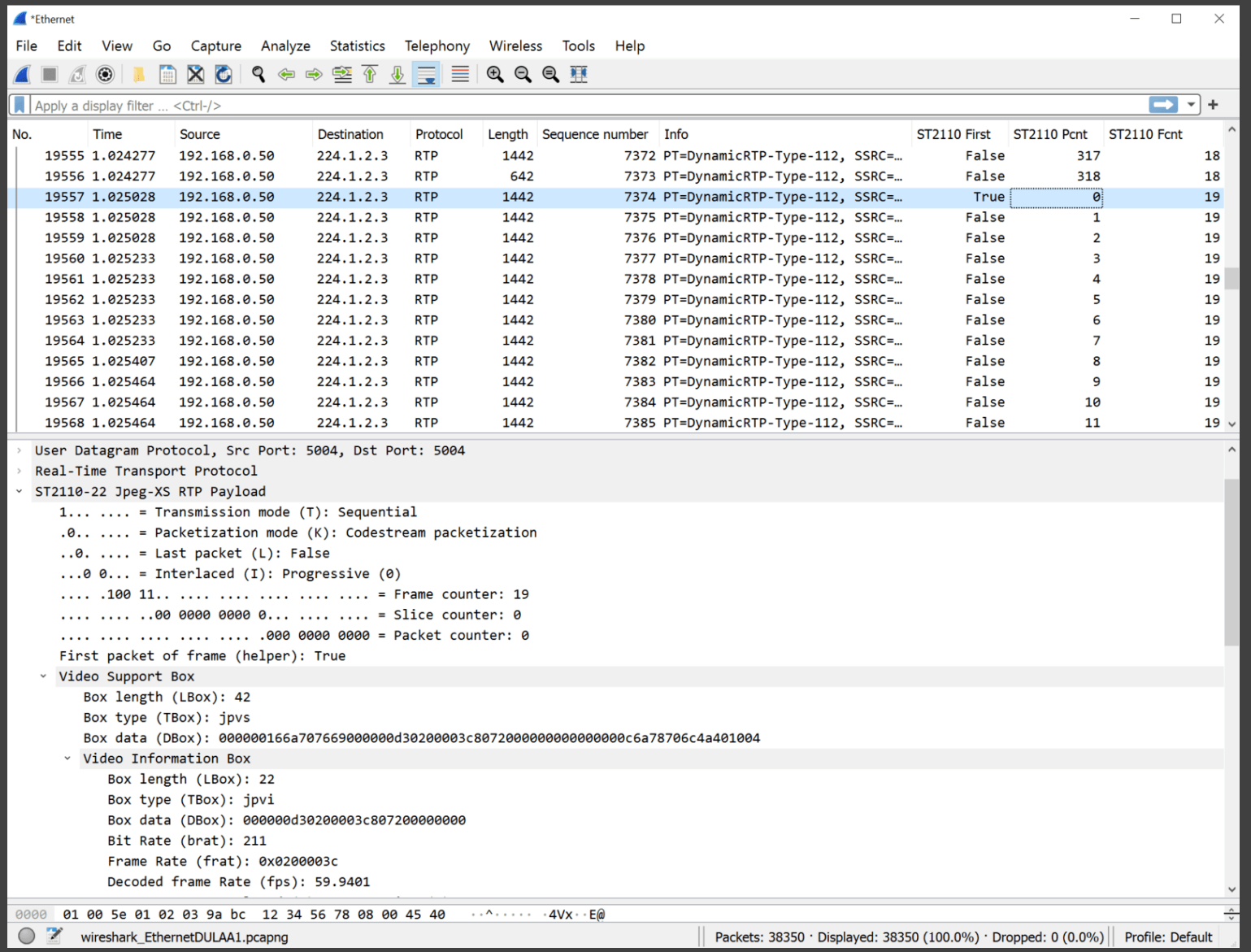
Important Note

- RFC 9134 took 3 ½ years to develop
- Internet-draft versions significantly different than RFC
- Fielded devices may use -0 or -3 version of I-D



JPEG XS RTP Wireshark Dissectors from intoPIX

Available for free from:
https://www.intopix.com/blogs/post/Deep-dive-into-SMPTE-ST2110-22-with-Wireshark-Dissector



Conclusions

- JPEG XS – a software friendly, high-quality, low-latency codec, great for on-prem or the cloud
- Several different documents must be read to understand the carriage of JPEG XS over RTP/IP
- Broadcast industry now beginning to explore the use cases of JPEG XS over IP, and we’ve got Wireshark dissectors to help!

Thank you!

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