IP, 4K/UHD & HDR
test & measurement challenges explained

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SDI → IP transition

Test and measurement challenges
What’s to be covered

- What’s driving IP?
- What’s happening with the key IP standards?
- Key compliance & signal quality challenges?
- What’s needed for test & measurement?
Many drivers behind IP: real momentum

- Larger systems, new business models to compete with OTT
- Agile workflows & accessible content
- Simplified cabling & new modular truck designs
- COTS speed of development & economies of scale
- Push for Cloud & Virtualisation
IP standards (RFC)

- RFC 768  "User Datagram Protocol"
- RFC 791  "Internet Protocol"
- RFC 2250 "RTP Payload Format for MPEG1/MPEG2 Video"
- RFC 2327 "SDP: Session Description Protocol"
- RFC 2431 "RTP Payload Format for BT.656 Video Encoding"
- RFC 2460 "Internet Protocol, Version 6 (IPv6)"
- RFC 3190 "RTP Payload Format for 12-bit DAT Audio and 20- and 24-bit Linear Sampled Audio"
- RFC 3376 "Internet Group Management Protocol, Version 3"
- RFC 3497 "RTP Payload Format for SMPTE 292M Video"
- RFC 3550 "RTP: A Transport Protocol for Real-Time Applications"
- RFC 3551 "RTP Profile for Audio and Video Conferences with Minimal Control"
- RFC 4175 "RTP Payload Format for Uncompressed Video"
- RFC 4421 "RTP Payload Format for Uncompressed Video: Additional Colour Sampling Modes"
- RFC 4445 "A Proposed Media Delivery Index (MDI)"
- RFC 4566 "SDP: Session Description Protocol"
- RFC 4604 "Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast"
and more …..

- RFC 4607 "Source-Specific Multicast for IP"
- RFC 5285 "A General Mechanism for RTP Header Extensions"
- RFC 5888 "The Session Description Protocol (SDP) Grouping Framework"
- RFC 6308 "Overview of the Internet Multicast Addressing Architecture"
- RFC 6410 "Reducing the Standards Track to Two Maturity Levels"
- RFC 7104 "Duplication Grouping Semantics in the Session Description Protocol"
- RFC 7273 "RTP Clock Source Signalling"

**SMPTE standards**

- ST 2022-6 “Transport of High Bit Rate Media Signals over IP Networks”
- ST 2022-7 “Seamless Protection Switching of SMPTE ST 2022 IP Datagrams”
- ST 2110-10 “System Timing and Definitions”
- ST 2110-20 “Uncompressed active video”
- ST 2110-30 “PCM Digital Audio”
- ST-2110-40 “Ancillary data”
- ST-2210-21 “Timing Model for Uncompressed Active Video”
- ST-2210-31 “AES3 Transparent Transport”
- ST-2210-50 “Interoperation of ST 2022-6 streams”
Protocol supports bridging between SDI-based and IP-based equipment by describing how SDI payloads are embedded in an IP RTP (Real-time Transport Protocol) stream.

Redundant stream variant 2022-7 for increased resilience.
TR-03 and TR-04

**TR-04**: developed by the Video Services Forum (VSF), it maintains the SDI-over-IP capability for video within SMPTE ST 2022-6, while defining an AES67-based option for transporting and processing discrete IP audio streams.

**TR-03**: another VSF technical recommendation which defines how separate uncompressed essences/stream of IP video, audio and metadata are packetized for mapping into RTP. This enables independent processing, while retaining the ability through synchronization to treat them as a whole in production workflows.
Evolution of IP standards: focusing on SMPTE 2110
SMPTE ST 2110 – Previous standards combined

SMPTE 2022-6

Packetised SDI style data

~ 100 deployments - effective for **playout applications** but packaging makes audio processing challenging

SMPTE 2110

Video stream

Audio stream

Individually routable essences better fit for **production applications**

Metadata stream
IP physical interconnections: significant near term changes

- **10GbE**  SFP28, common standard today – good for HD/3G payloads
- **40GbE**  QSFP28, 4x 10G, not so popular

- **25GbE**  SFP28, popular emerging standard – great for UHD applications
- **100GbE** QSFP28, 4x 25G, emerging standard

- **50GbE**  SFP28, future technology, 2-3 years away!
- **200GbE** QSFP28, 4x 50G, future technology, 2-3 years away!
Where are technology vendors with SMPTE 2110?

**NAB 2107 IP Showcase**
- 41 companies operating to SMPTE ST 2110 Final Draft (before published)
- Unprecedented industry cooperation

**AIMS April 2017 member survey**
- 72% shipping 2110 products in 2017 (not alpha, beta or POC)
What are the test & measurement challenges?
What are the test & measurement challenges with IP?

- Monitoring video network congestion
- Measurement of packet jitter
- Identifying signals within streams
- Stress testing as systems evolve
- Data logging & integration with system diagnostics
Congestion is the big problem
Video network problems: congestion & jitter issues

Ideal, steady video packet flow, 1080p60 payload in 10GbE pipe
Video network problems: congestion & jitter issues

Typical video packet flow between switches: 3x 1080p60 + audio + PTP in 10GbE pipe
Video network problems: congestion & jitter issues

BURST OF VIDEO PACKETS

VOID OF VIDEO PACKETS

10GbE

40GbE

10GbE

Video Stream

Audio Stream

Timing (PTP)
Video network problems: Packet Jitter is a major issue

- Excessive jitter means large variances in inter packet arrival times
  - Sustained jitter can mean bursts or voids of packets

- If packets are excessively delayed (a void), the receiver is starved
  - Receive buffers are drained and the stream cannot be sustained

- If packets are excessively bunched (a burst), the receiver is overloaded
  - Receive buffers are filled and video data must be discarded

- Use PHABRIX Inter Packet Arrival Time tool to visualise packet jitter
Jitter measurement: Inter Packet Arrival Time

Stream health reporting
Histogram presents distribution of packet arrival times
What does an ideal video network stream look like?

Perfect stream with low jitter
All IPAT values the same – zero Jitter
What does a problematic video network stream look like?

‘Idealised’ higher jitter stream
High occurrence of long & short IPATS
Network Jitter analysis tool: capturing Jitter problems

Tracks max/min PAT for all packets against the common reference clock
Determining signal types: stream analysis tool

<table>
<thead>
<tr>
<th>ID</th>
<th>Protocol</th>
<th>Bit Rate</th>
<th>Src IP</th>
<th>Ssrc</th>
<th>Dist IP</th>
<th>SSRC</th>
<th>Packets</th>
<th>Seq errors</th>
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<td>3.10 Gb/s</td>
<td>192.168.3.20</td>
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Table identifies all streams in 10GbE pipe

Presents protocol & bitrate
Stress testing networks & individual components

- Need to test component and network jitter resistance
  - Creating new networks
  - Changing existing networks
  - Checking suspect components

- Use PHABRIX tools to test resistance to jitter profiles
  - Video generator with IP encapsulation
  - Shape traffic using Jitter/Inter Packet Transmission time profiles
Stress testing: IP Packet Transmission tool

IP stream generation using uniform & narrow band jitter
(Inter Packet transmission Timing)
Stress testing: IP Packet Transmission tool

IP stream generation with high jitter (bursts & voids)
Stress testing: Inter Packet Transmission Profiling

Different Jitter Profiles available
Questions?