Ground-to-Cloud Media Transport Integration - Standards and Approaches

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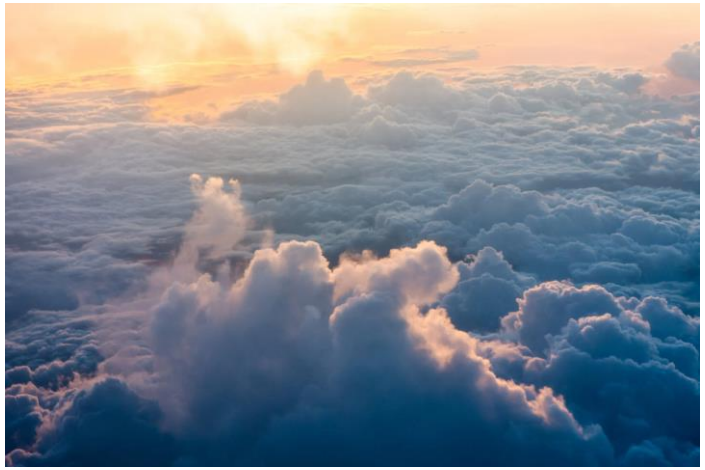
What is Ground-cloud-cloud-ground (GCCG)?

- Pandemic showed the power of the cloud to scale-up compute-heavy services on demand:
  - Zoom, Cloud-hosted email, Social Media, Amazon, Netflix etc…
- **But television broadcast production still mainly on-premise – nearly all mid/high end production is some variant of in-person.**
- Cloud economics (scale-up/scale down) seems a great alternative to paying for resources that stay idle most of the time – what is stopping us?

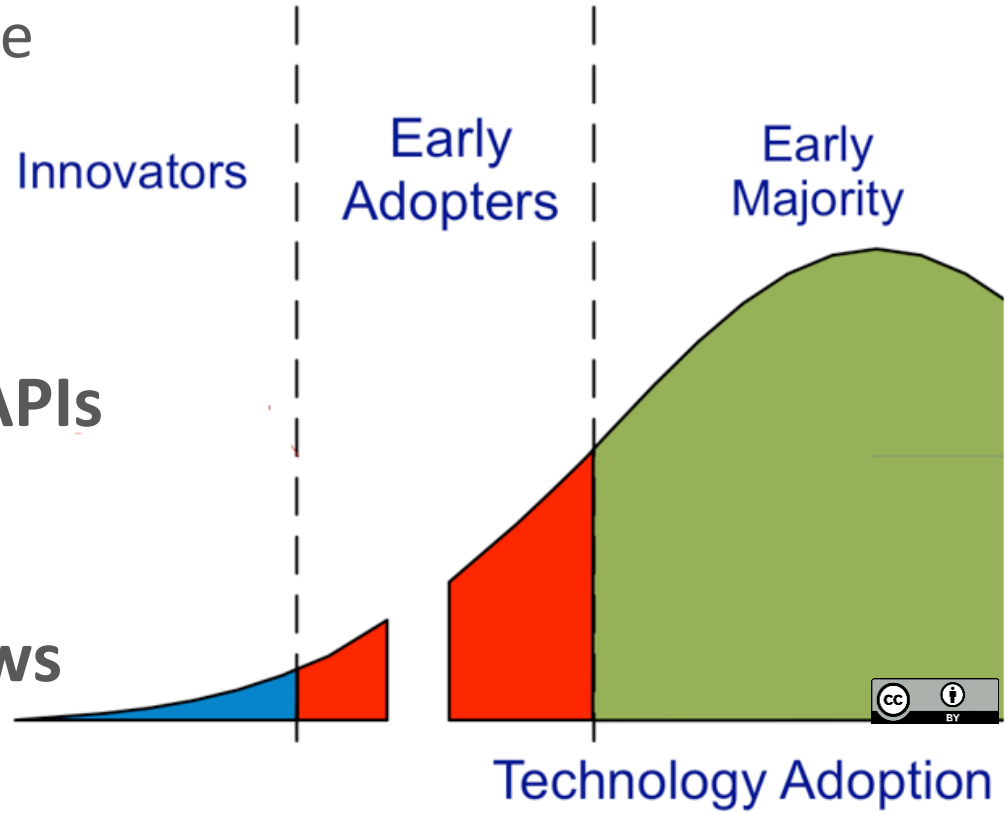


Moving Cloud production to the next level

"But I've been doing live cloud production" – Yes and No

- Single Vendor Monolithic applications such as Channel-in-a-box, playout server, cloud switchers, use the cloud as a home, but not necessarily as a scalable architecture
- Proprietary Transports stifle innovation

- **To get widespread adoption we must have:**
  - **Multi-vendor interoperation via standard APIs**
  - **Appropriate-to-task picture quality levels**
  - **Standards for Ground-Cloud-Cloud-Ground**
  - **Agreed mechanism(s) for building workflows**



Cloud production – What makes it difficult?

- Integration with the ground – both ways
  - Must work into existing workflows
  - SDI, ST 2110, satellite, cable, OTA
- Legacy Workflows have well-defined linear timing models (e.g SDI, ST 2110-21, MPEG-TS VBV)
- Without a proper timing model, you end up with variable (undefined) latency
  - One reason web streams are 20-30 seconds behind broadcast – They don't have a timing model!
  - What are my neighbors cheering about?
- Inter-cutting ground and cloud requires timing

I'll just do 2110 in the cloud

- Some people claiming to have 2110 in public cloud
- But it's not possible right now in any public cloud:
  - **No (full) PTP in the cloud – all clouds handle time their own way**
  - Cloud networks are shared and have packet loss
  - No real access to network card capabilities (e.g packet pacing) for 2110
- ***Is this even a good idea?***
  - We don't actually want time-linear processing in cloud any more
  - Allow cloud instances to process data non-linearly, sometimes faster or slower than real-time but on average real-time – known worst case
- How to handle "synthetic" sources (e.g clips, graphics) played out from cloud?

Cloud-vendor specific transport

- To get the benefits of cloud, we also must trust the cloud
  - Depend on cloud provider bulk-transport protocols
  - Throughput with Reliability - all my data arrives correctly
  - Latency - all my data will arrive on time

- The Big Data community has similar needs for large data transfers
  - Application may not have visibility of the internals of protocol (“black box”)
- Amazon Scalable Reliable Datagram (SRD) such an example
- Used in Amazon CDI

Amazon CDI

- How does the Amazon CDI protocol compare?
  - Handles many of the challenges discussed
  - An agreed way to exchange data between Amazon cloud instances. Defined pixel data structures, metadata (e.g HDR) etc
- Amazon guarantees throughput, reliability and bounds latency
- **A big step forward for the industry**

- Some parts need GCCG input, more detailed timing model
- GCCG could leverage CDI for applications where available (in Amazon)

What is the VSF GCCG working group

- The GCCG working group is Addressing this set of problems

- The last difficult problem in broadcast production (personal view):
- How can I do a complex multichannel production in the cloud, with comparable latency to on-premises and get it to the viewer?
- Numerous technical challenges

- https://vsf.tv/Ground-Cloud-Cloud-Ground.shtml

Orchestration and Control

- The boring but important part – on Ground and Cloud
- How do cloud instances expose their capabilities (max resolution, frame rate etc.)?
- Is there an orchestration layer that connects the pieces together?
- Handling changes in signal flow (resolution/framerate, audio channels)
- Connection status (Am I ready?)

- Control of Ground to Cloud (and vice-versa) elements

What are the "operating points" we see today (for TV)

- Uncompressed (2022-6 or 2110-20) (already defined)
- **"PremiumCompressed" – super low latency, super high quality**
  - **JXS for (1080i @ 200m?) (UHD @ 1000-1500M)**
  - **Dual-path reliability model for super-good reliability @ *minimum latency***
- J2K-ULL (sunnest) @200
- J2K (full-frame) @120
- AVCI @ 100
- **Interactive Latency ~20Mbit(HD) (ULL restricted VBV buffer) $$**
  - **ARQ/RIST or dual-path model or FEC? (Typical 4:2:2/10 profile)**
- **Rate Optimized (longer latency @ lower rate) (HD@3-10 Mbits, more delay)**
  - **ARQ/RIST or dual-path model or FEC? (Typical 4:2:0/8 profile)**
- Zoom / GoToMeeting / Webex – whatever gets a picture on the screen
  - Internet best-effort reliability work

Focus on these

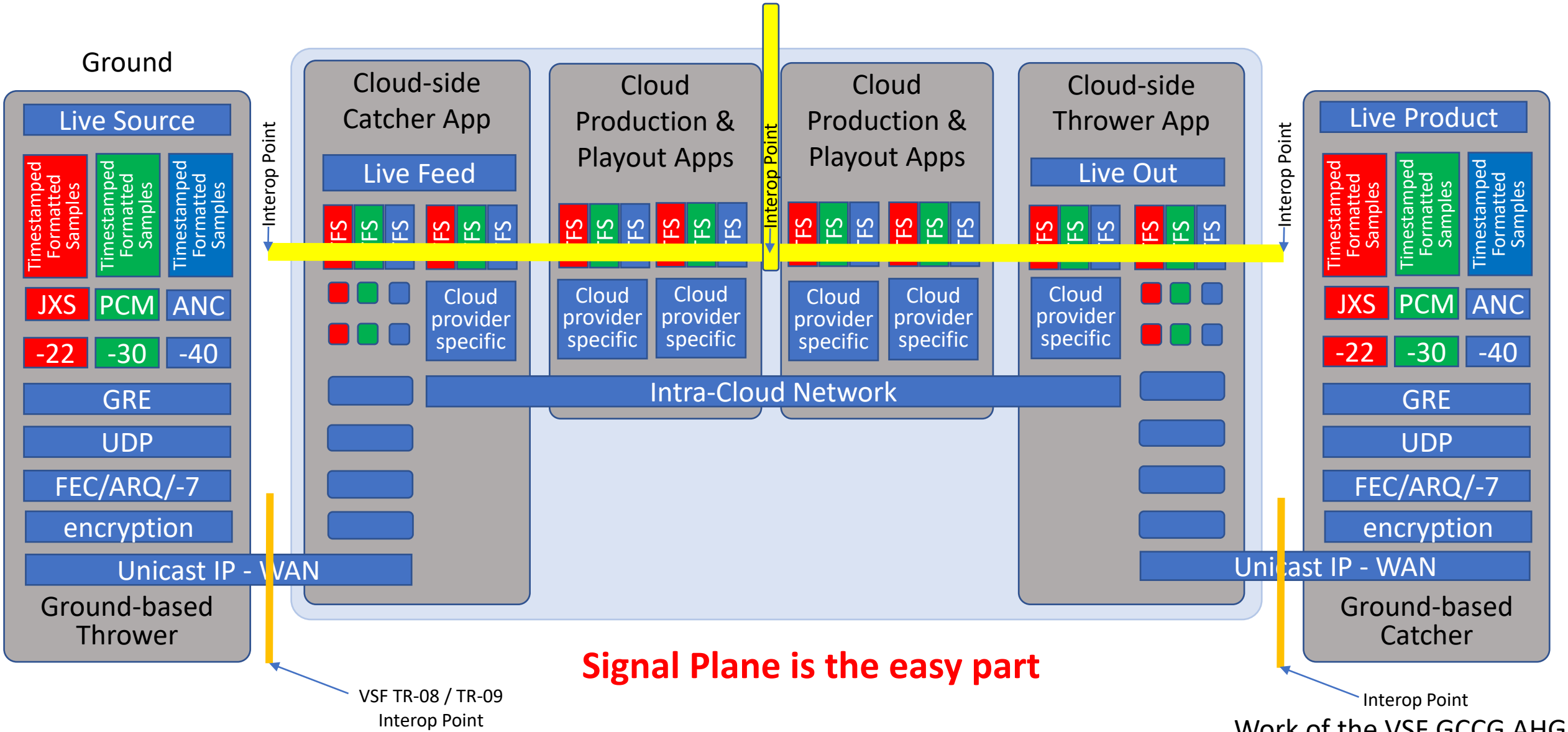
Premium Compressed (JPEG XS)
VSF TR-08: codec & LAN 2110-22 base
VSF TR-09: WAN 2110-x extension
*** reference TR-08**
*** opt: with 2022-7**
*** opt: with FEC (small intl, 1D)**
*** opt: GRE Tunnel (ref RIST)**
*** opt: encryption (ref RIST)**

Interactive Latency (small GOP or Prog Refresh)
- **(HD) H264 (constrained VBV, 4:2:2, 10bit)**
- **(UHD) H265 (constrained for latency)**
- **2022-2(TS-RTP)**
- **RIST-FEC (+/- multi-path)**

Bandwidth Optimized
- **(HD) H264 (420/8 standard vbv)**
- **(UHD) H265 ()**
- **2022-2(TS-RTP)**
- **ARQ or FEC**
- **Opt: encryption (ref RIST)**

Work of the VSF GCCG AHG

Where are the points-of-interoperability?



Work of the VSF GCCG AHG

VSF and other Related Work In Progress

- **Document the "Premium Compressed" use case for G-C and C-G: TR-08 & TR-09**
  - **TR-07 & 08 published**. JPEG-XS over TS and over 2110-22 with interop points and capability sets
  - **TR-09 is publishing soon**. Defines the data encapsulation plane, plus NMOS-like Control plane

- Is there something more to document about the TS/IP/H.26x case? Or is it good enough?
  - Can the TR-09 (ARQ, FEC, -7) control plane be applied to this class of streams ? (yes, probably)

- Time-Flow / Time-Transport / Time-Tagging model
  - How do we treat time in the concatenated virtualized systems
  - How do we integrate "real-time" on the ground with "floating time" in the cloud?
  - This requires a vocabulary and some modeling/specification effort
  - Define how to catch up / manage drift / manage change / re-integration to timeline

- The Media Containers / Object Format structures for hand-off from application to application
  - The AWS CDI structures are defined on github
  - Need to document how this handoff interacts with latency and latency accumulation

Work of the VSF GCCG AHG

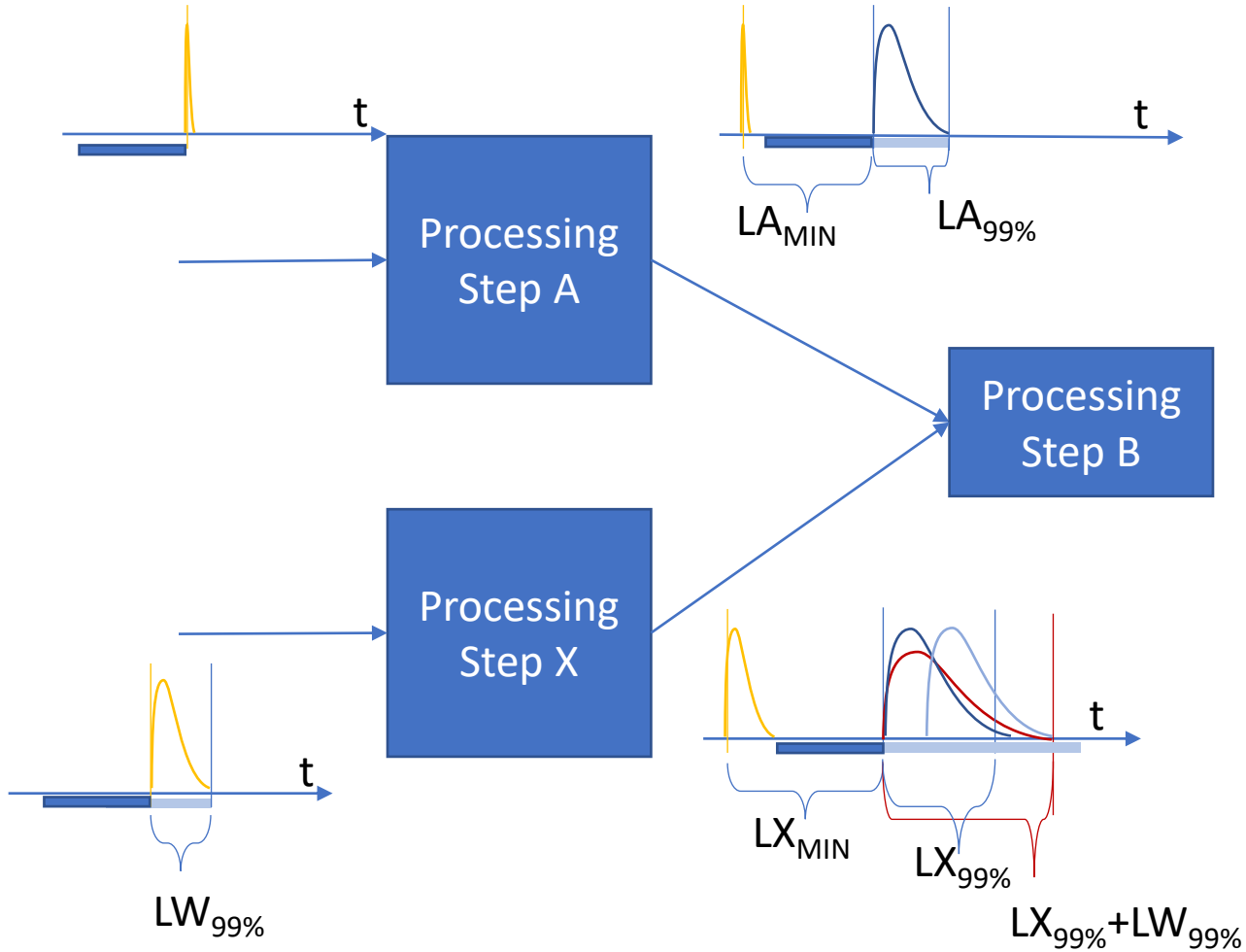
The “time variability / time floating” work

How do we avoid re-creating our frame-sync pipeline in the cloud, and let software work well?

- Allow variability in the handoffs, but with an ability to predict the outcome
- Some processes must reconcile the variable inputs into a consistent output
  - Must bound the input buffering (latency) yet accommodate the variability
- What are the sources of delivery (arrival) variability?
  - Network-induced (probably small)
  - Processing-induced (upstream process steps with variable latency)
- Vocabulary (about each process step in the datacenter)
  - TX Variability – bound on how early/late the signal may egress, variance above baseline
  - TX Planning Delay – the baseline in the above statement – the smallest value of delay
  - Actual delay is planning delay plus some amount of variability

What is the "spec" of latency and variability?

- Push model (not backpressured)
- Based on (uniform?) content "chunks"
  - might be frames, fields, stripes
  - might be blocks of audio samples
- L_{MIN} = the soonest/shortest amount of time from input to output
  - Input time = buffer 100% arrived to me
  - Output time = buffer left me 100%
  - Includes the egress transit time
- $L_{99\%}$ = the amount of variability *beyond* the L_{MIN} for 99th percentile case
- What about continuity? Do processing steps need to maintain cadence if input not there?
  - Maybe not – only if it "has to" for its own processing purposes. Otherwise best to just be late or missing and let downstream do the best it can with what it gets when it gets it.



Variability on the input accumulates into the output!!!

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Summary of Consensus Views and path forward

For ***Ground-to-Cloud*** and ***Cloud-to-Ground***, target TR08/TR09 for high-quality, and H.264/265 TS for intermediate quality

For ***inter-instance*** (intra-cloud) coordinated handoff (a “virtual facility”)

- Identify senders and receivers (use NMOS extended, similar to TR-09)
- Initiate connections (IS-05 extended) (WIP in AMWA BCP-06-x)
  - What is the content description lingo? (VSF to recommend additions to AMWA)
  - What are the transport params for CDI? for other clouds? (VSF will recommend to AMWA)
  - What is the timing description specification? (document our WIP)
- What is the data format of the buffer-style handoff between instances in cloud?
  - Canonical format = 2110 pgroup concatenated schema
  - Other buffer formats can exist and may be more perfect, i.e. https://vsf-tv.github.io/cef/
  - Canonical audio-only format including timing relationship and transport suggestion (TBD)
  - Canonical metadata format including timing relationship and transport suggestion (TBD)
- For inter-envelope (arms-length) handoffs within/between cloud(s)
  - Essentially this is like the ground-to-cloud case

Where do we go from here?

- The VSF GCCG group has some WIP to document, and some actions to document/forward to AMWA
- AMWA is extending NMOS to other stream types
- VSF already published TR-08
- VSF is publishing TR-09 very soon

- Be sure to attend other talks this week about the sub-topics in here
- Join the VSF and AMWA and help move this work forward

Any Questions?

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