Time and timing
- the 2021 update!

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Time flies - update!

Andy: 42.5 billion frames (25fps) since his epoch!

Esther: now 1.8 billion frames!

Esther

Hope

Judah

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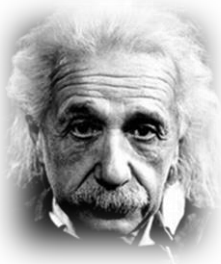
"How did it get so late so soon?"
— Dr. Seuss



"Time is an illusion."
— Albert Einstein

"You may delay, but time will not."
—Benjamin Franklin

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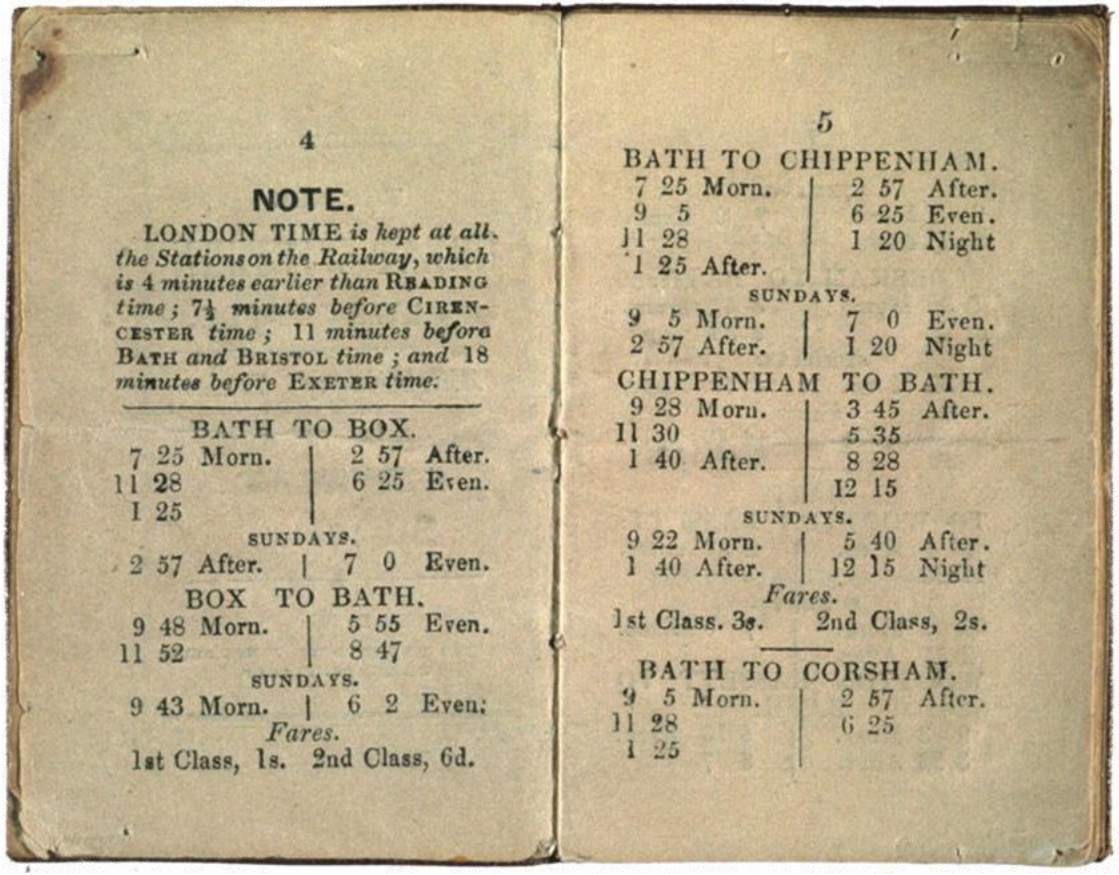
When timing started really mattering
1840 – coordinated railway time → GMT



4

NOTE.

LONDON TIME *is kept at all the Stations on the Railway, which is 4 minutes earlier than* READING *time; 7½ minutes before* CIRENCESTER *time; 11 minutes before* BATH *and* BRISTOL *time; and 18 minutes before* EXETER *time.*

BATH TO BOX.

7 25 Morn.	2 57 After.
11 28	6 25 Even.
1 25	

SUNDAYS.

2 57 After.	7 0 Even.

BOX TO BATH.

9 48 Morn.	5 55 Even.
11 52	8 47

SUNDAYS.

9 43 Morn.	6 2 Even.

Fares.

1st Class, 1s. 2nd Class, 6d.

5

BATH TO CHIPPENHAM.

7 25 Morn.	2 57 After.
9 5	6 25 Even.
11 28	1 20 Night
1 25 After.	

SUNDAYS.

9 5 Morn.	7 0 Even.
2 57 After.	1 20 Night

CHIPPENHAM TO BATH.

9 28 Morn.	3 45 After.
11 30	5 35
1 40 After.	8 28
	12 15

SUNDAYS.

9 22 Morn.	5 40 After.
1 40 After.	12 15 Night

Fares.

1st Class. 3s. 2nd Class, 2s.

BATH TO CORSHAM.

9 5 Morn.	2 57 After.
11 28	6 25
1 25	

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Setting the time on my watch

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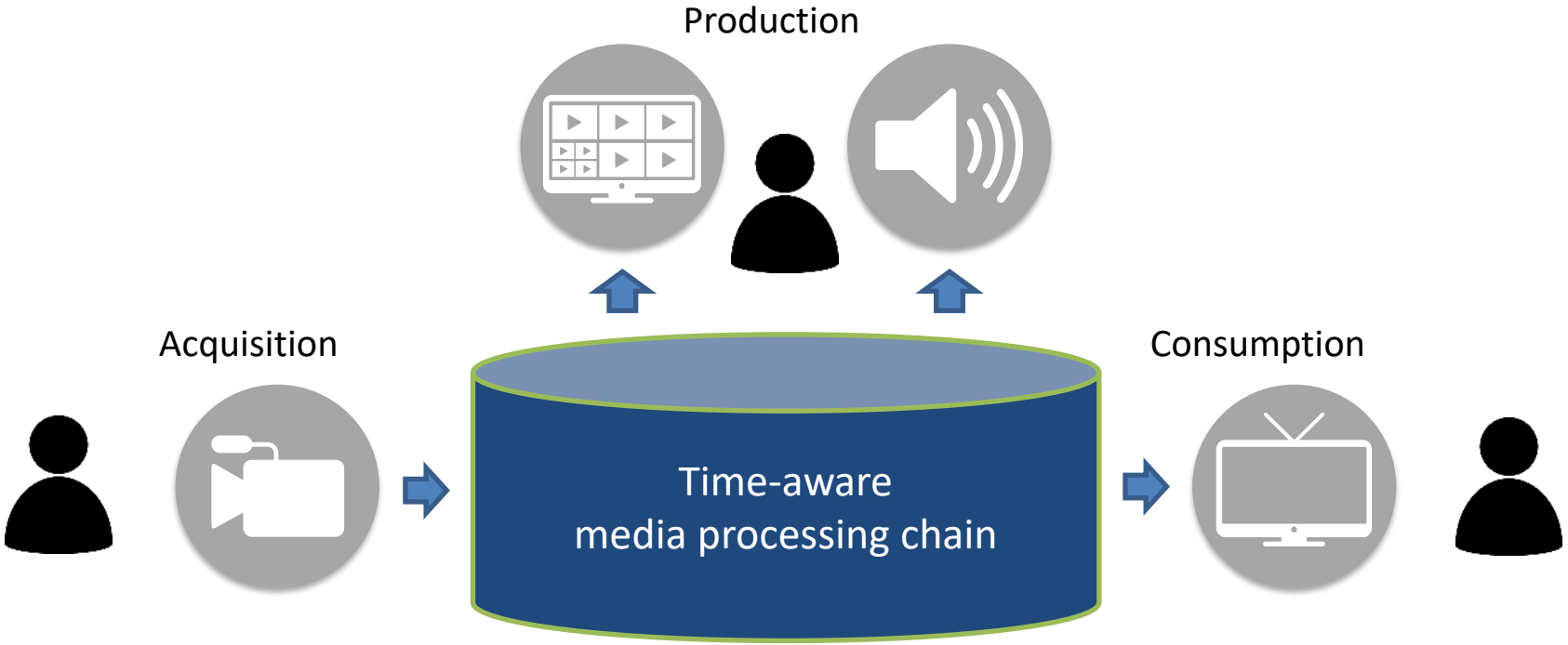
Where time really matters……



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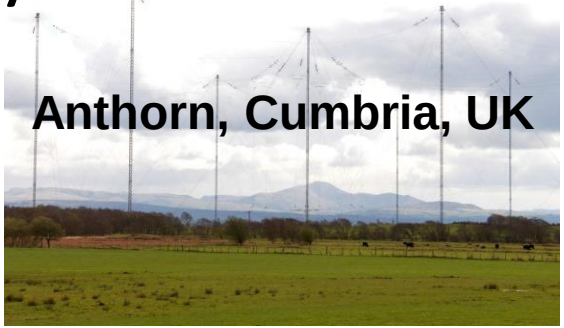
We have been putting a lot of effort into keeping everything in sync….

GNSS

GPS

GALILEO

GLONASS



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PTP Master

Boundary Switch

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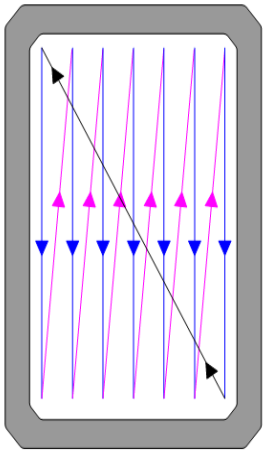
In the beginning……1932

Betty Bolton



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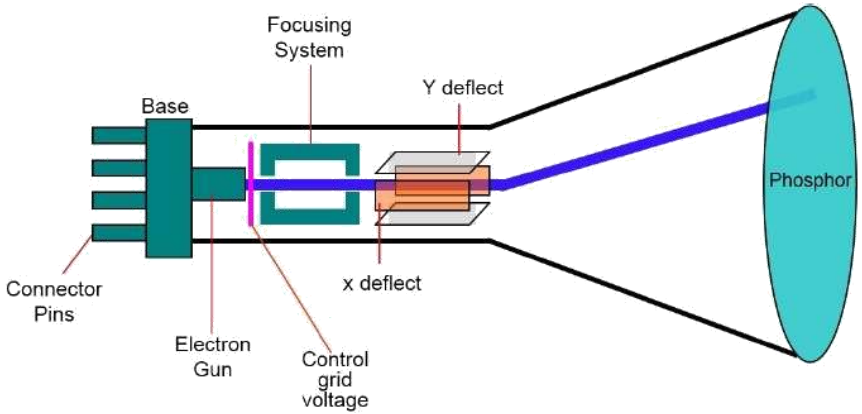
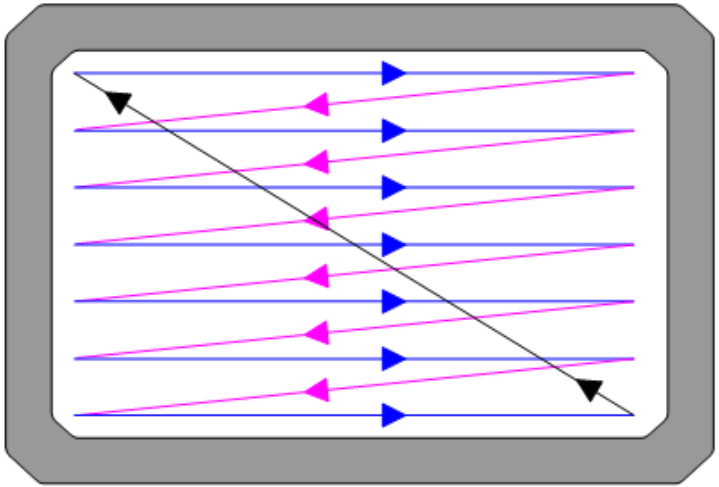
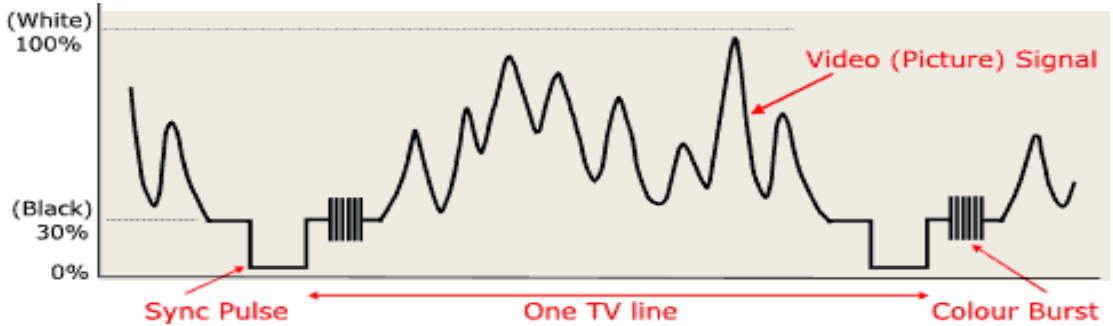
In the beginning…..the raster scan







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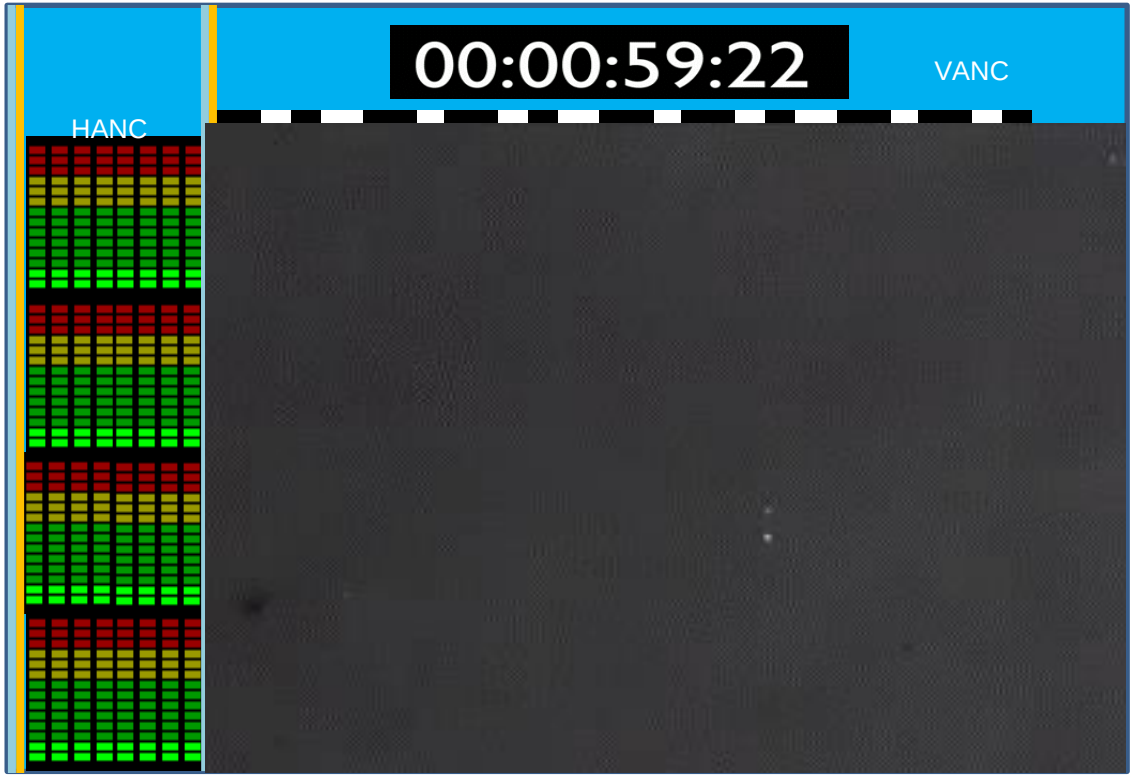
SDI 1987

Production timing - VITC



Me in 1987 – look, I had hair!

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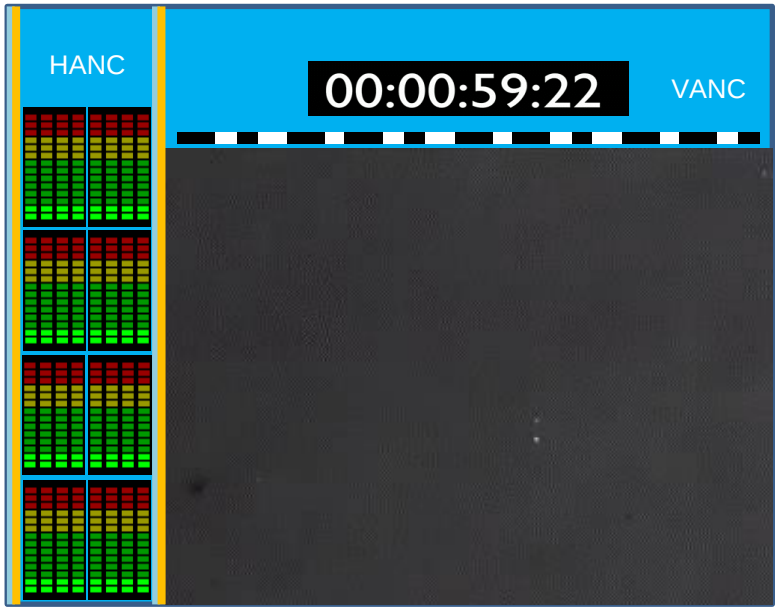
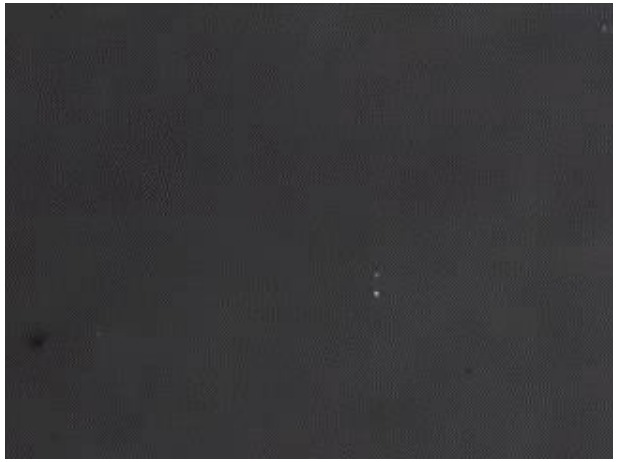
‘Composite’ SDI → ST 2110 **Essence** in production - now + absolute timing in RTP





00:00:59:22

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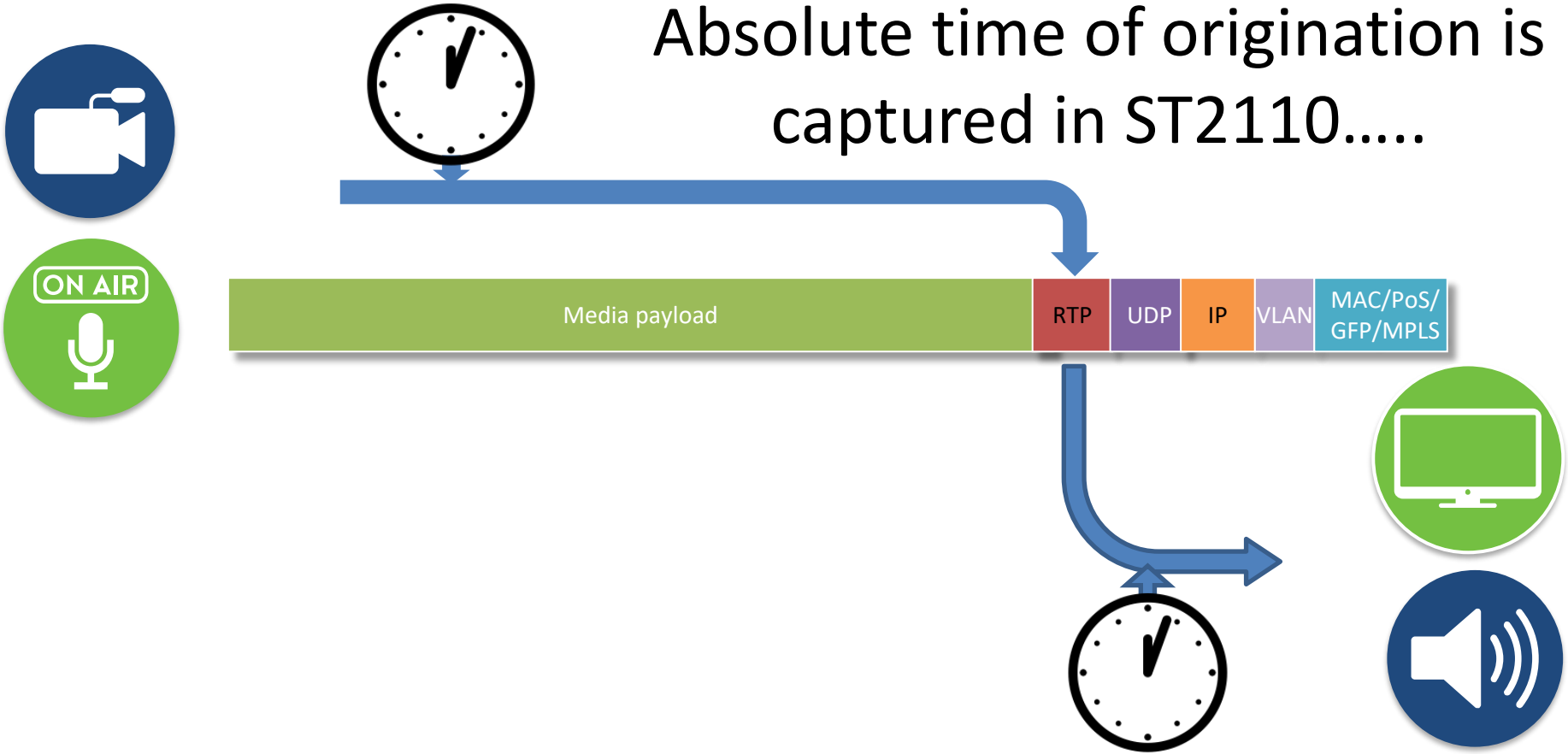
Absolute time of origination is captured in ST2110…..



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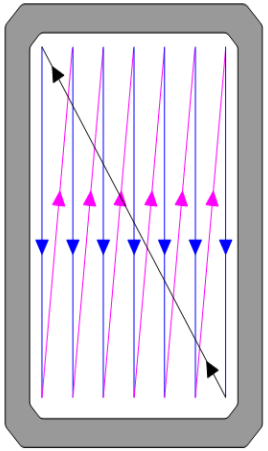
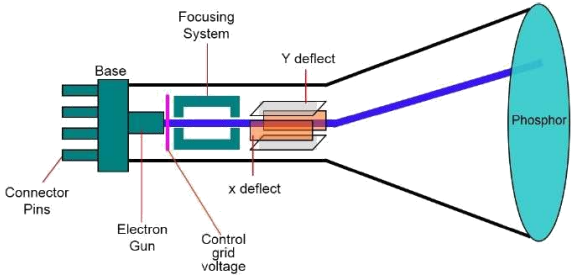
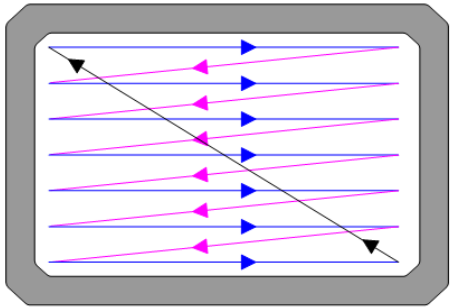
Time of acquisition

Spread image time (CRT, CMOS RS)
→ point image time (CCD, CMOS GS)







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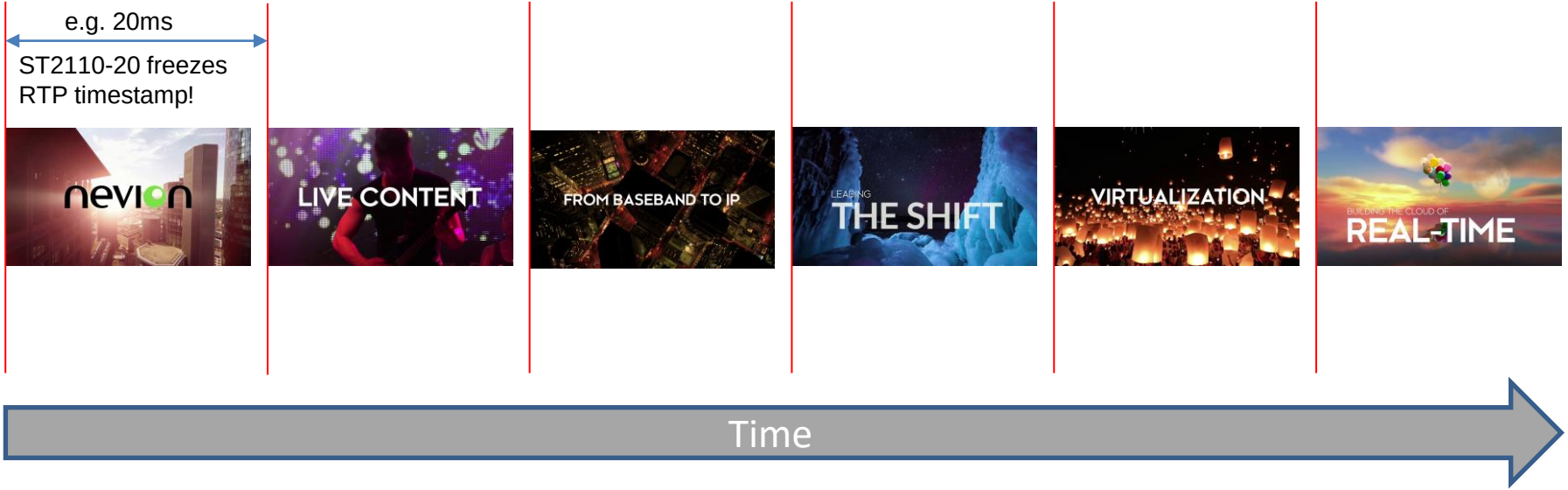
An image at a moment in time



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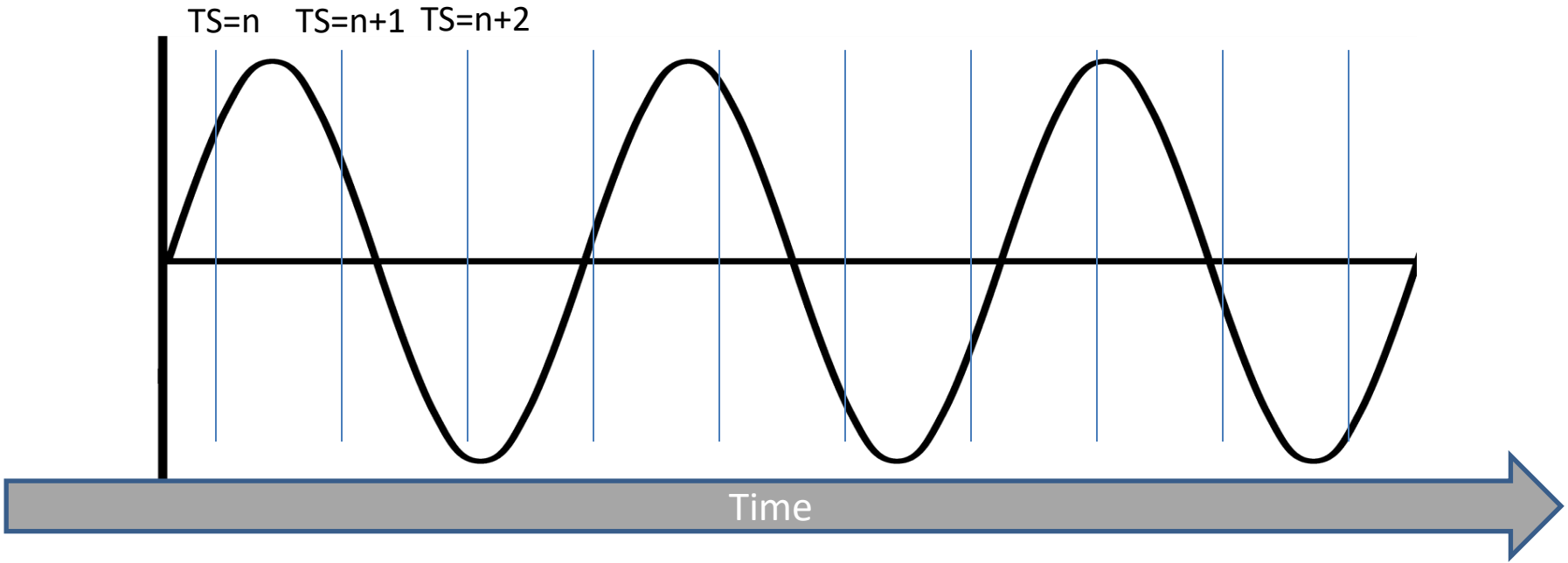
Audio per-sample timing



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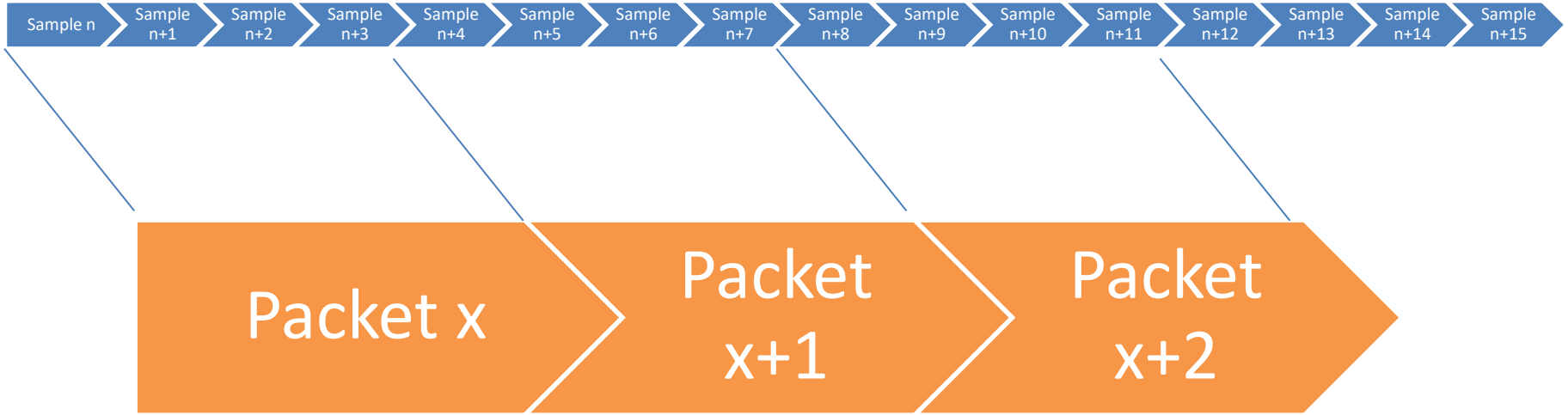
Linear stream flows –
our raster & hardware heritage



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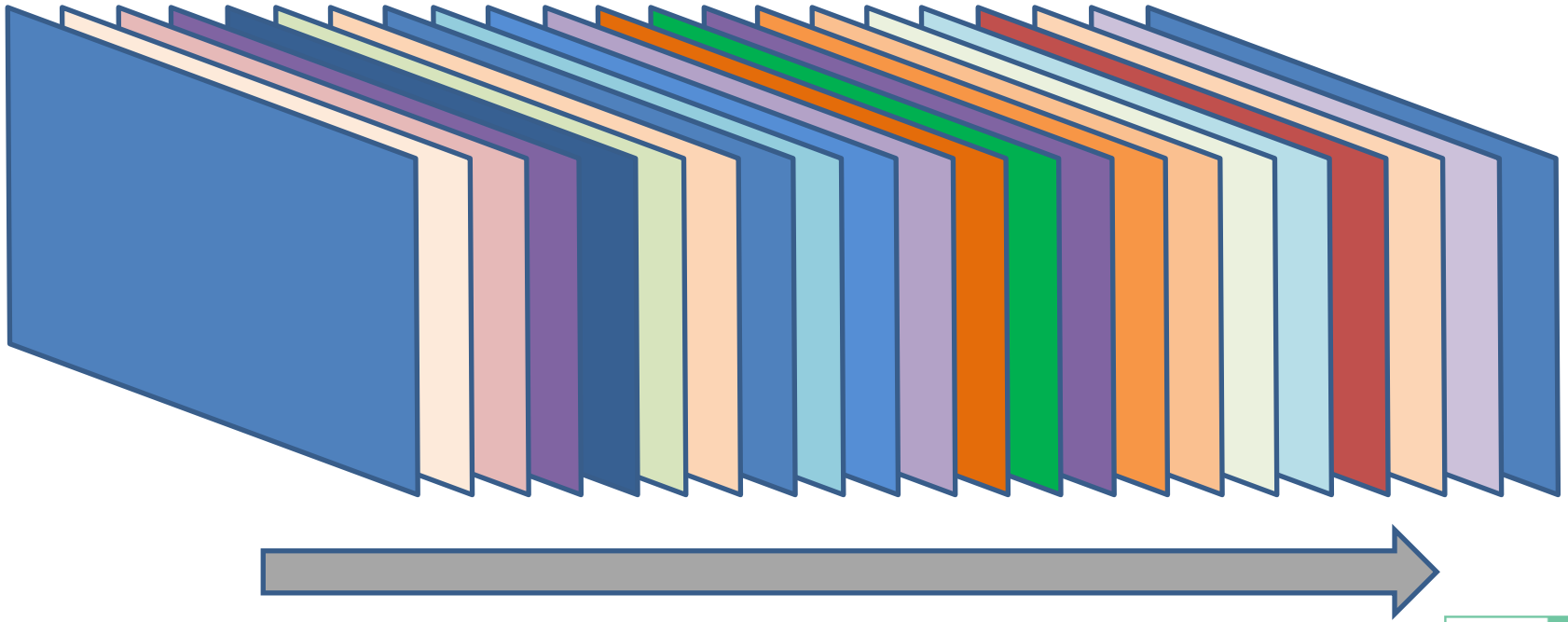
Linear video



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ST2110 senders

N ✓

Narrow (gapped)
Typically hardware based
Linked to linear active-raster-based video
Small buffering requirement
Capable of low latency chaining

NL ✓

Narrow linear
Image based – not active raster
Small buffering requirement
Low latency when not raster interfaced
Containerised software can achieve this

W ✓

Wide
Typically software based using NIC
Not linear raster related
Larger buffering required
Low latency when not raster interfaced

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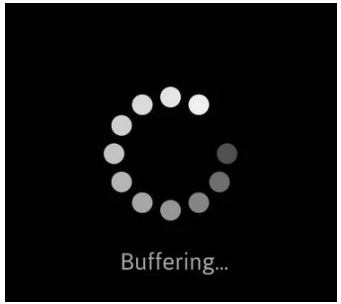
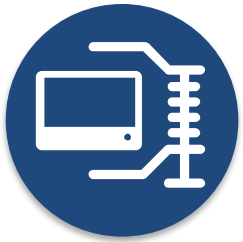
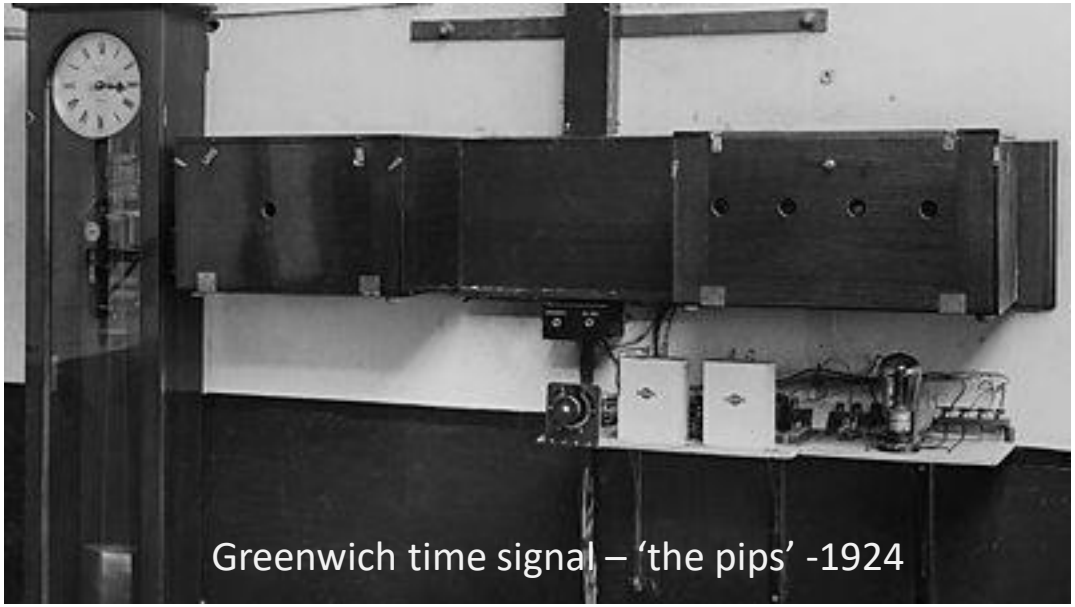
What now constitutes real time ‘live’?

Internet rx ~15s





DTH encoding ~5s



Traditional broadcast distribution contract: ‘no more than 100ms end to end delivery latency’

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What maters about time to the content consumer…

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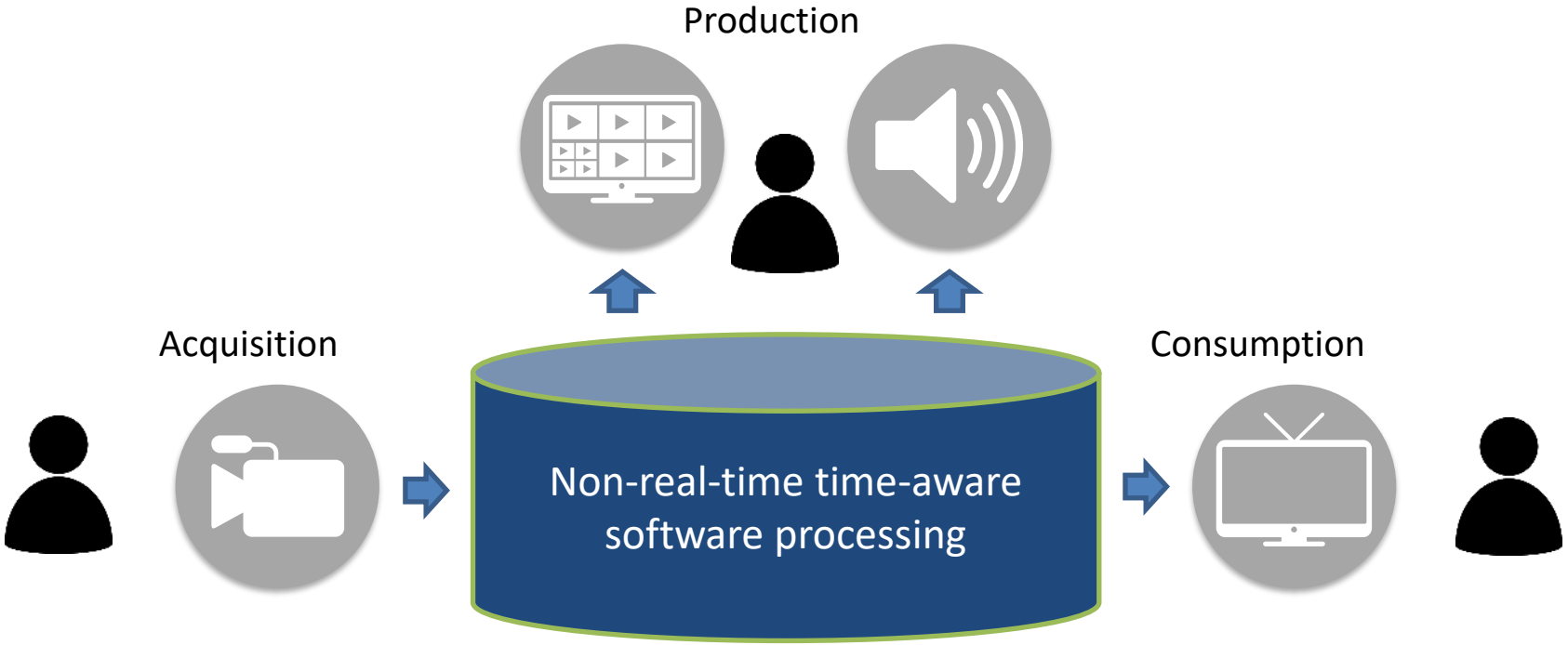
What matters to the content producer…



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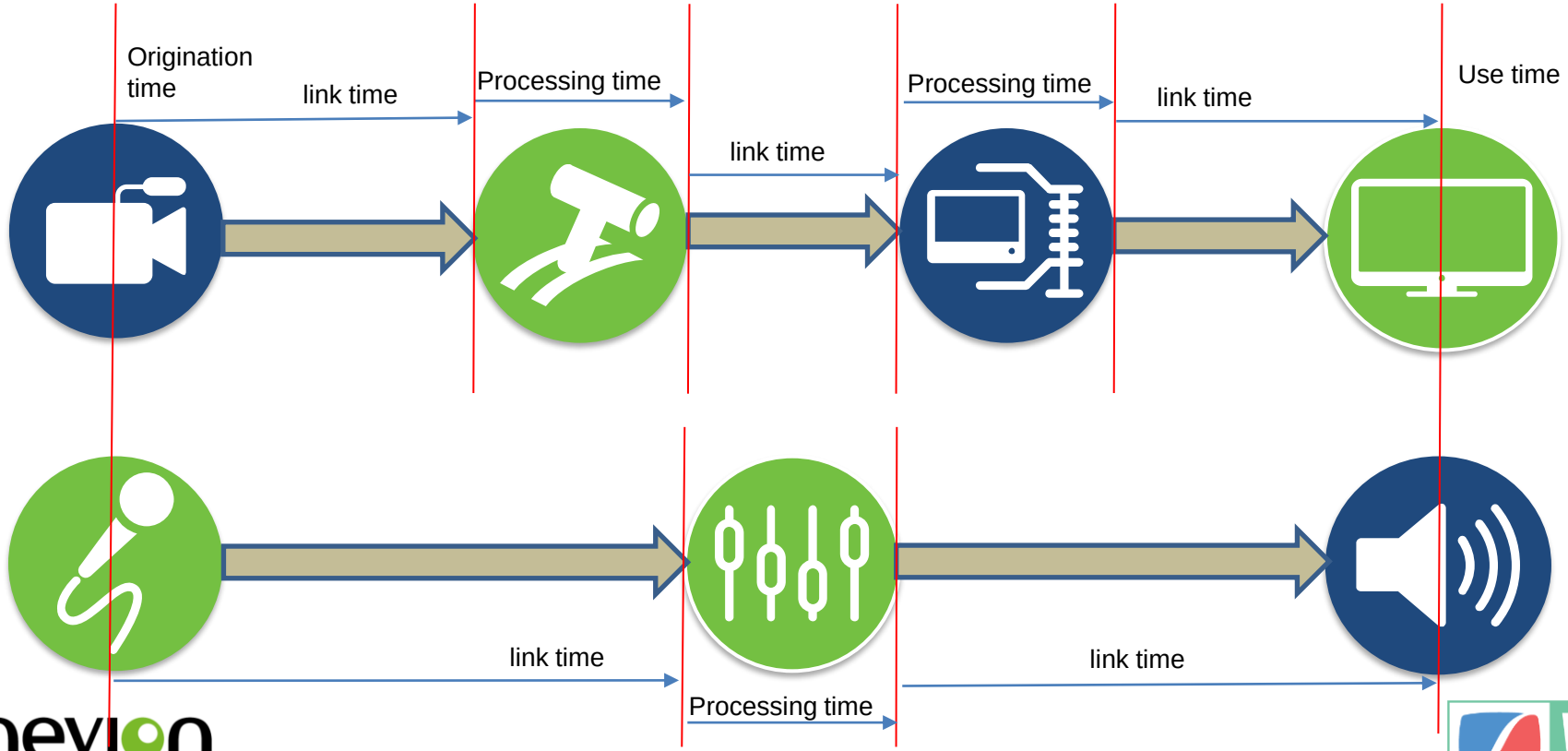
Live video – November 2, 1936

Tracking time through a production workflow



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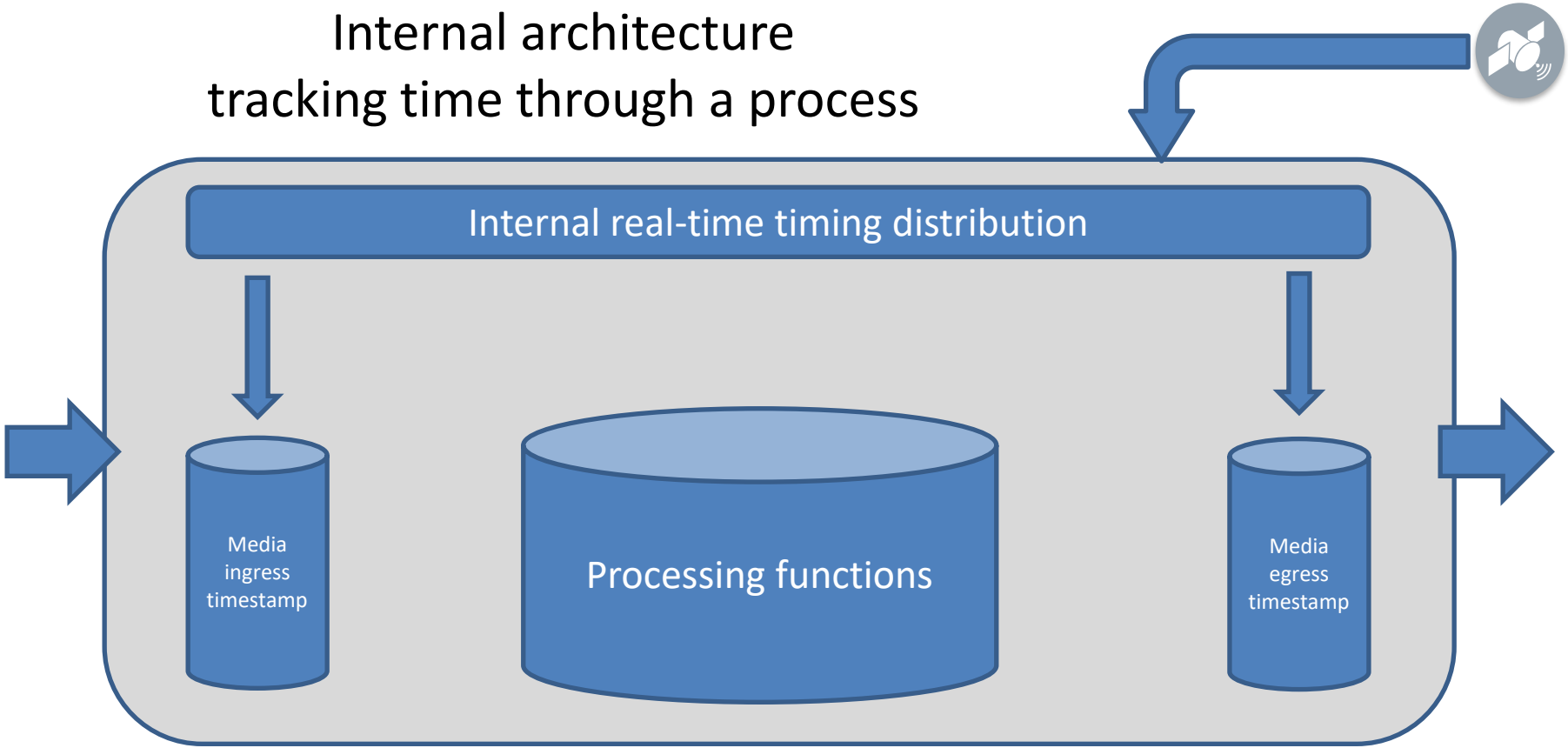
Internal architecture
tracking time through a process



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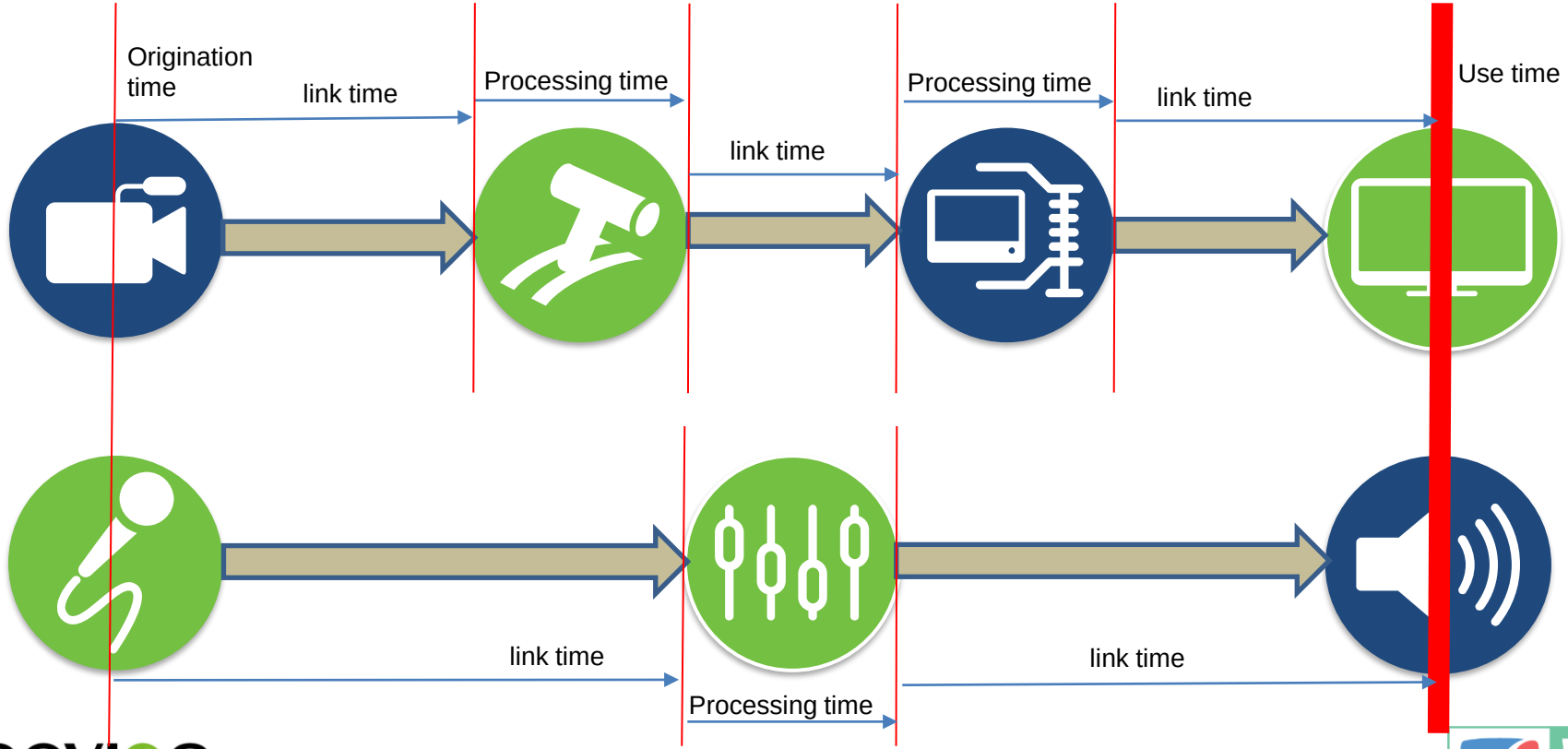
Reconciling essence timings for use



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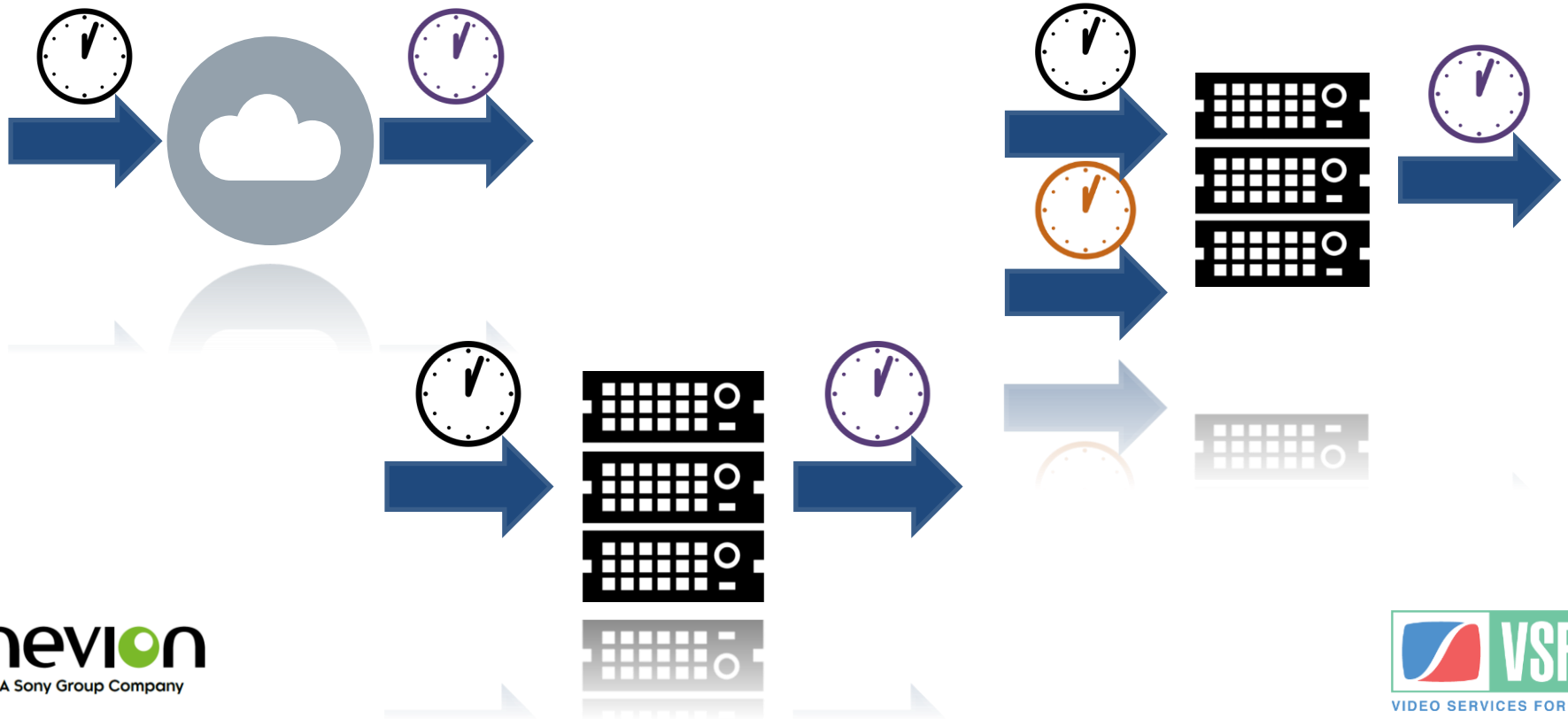
Transit & processing time through system



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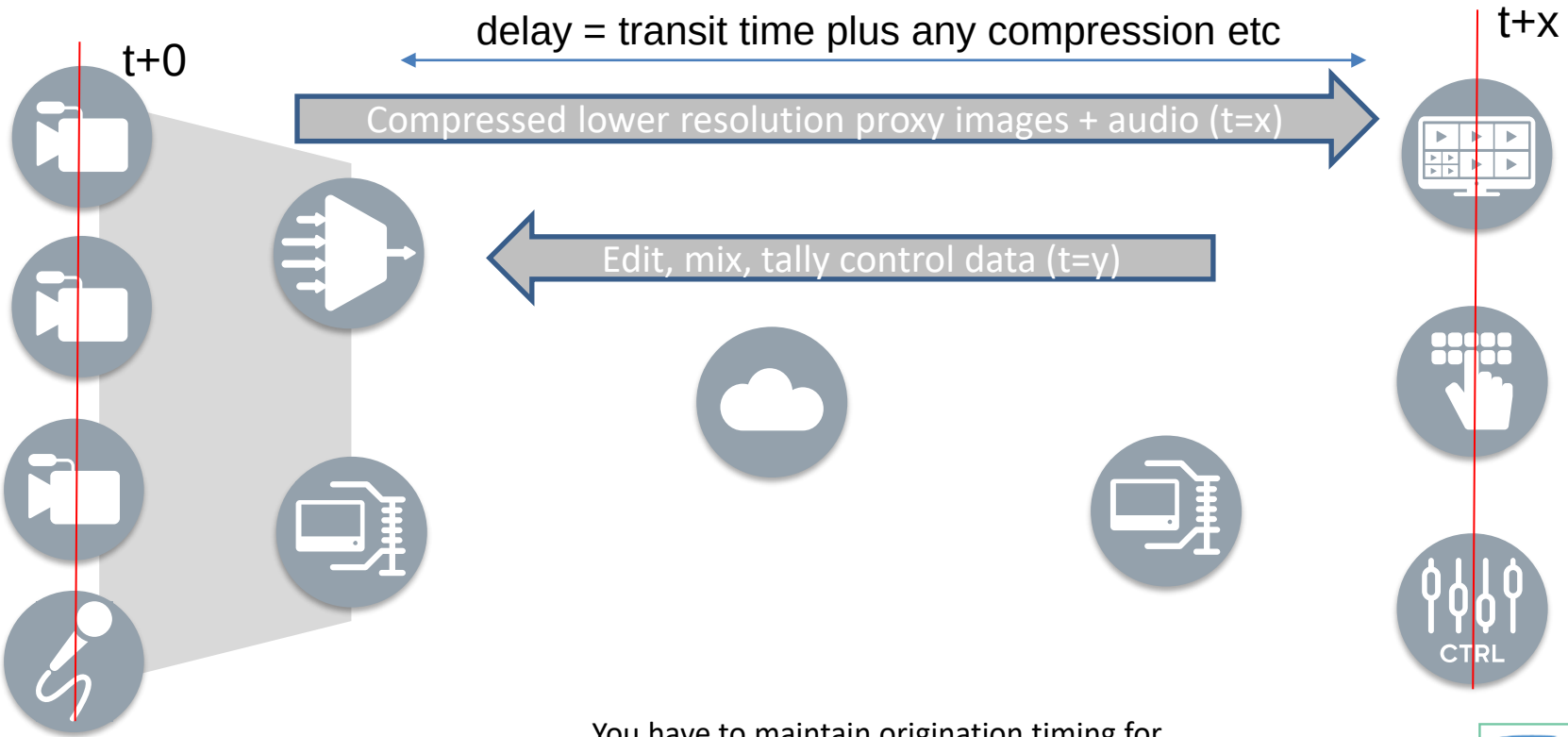
Proxy remote production timing



You have to maintain origination timing for all elements for this to solution to work

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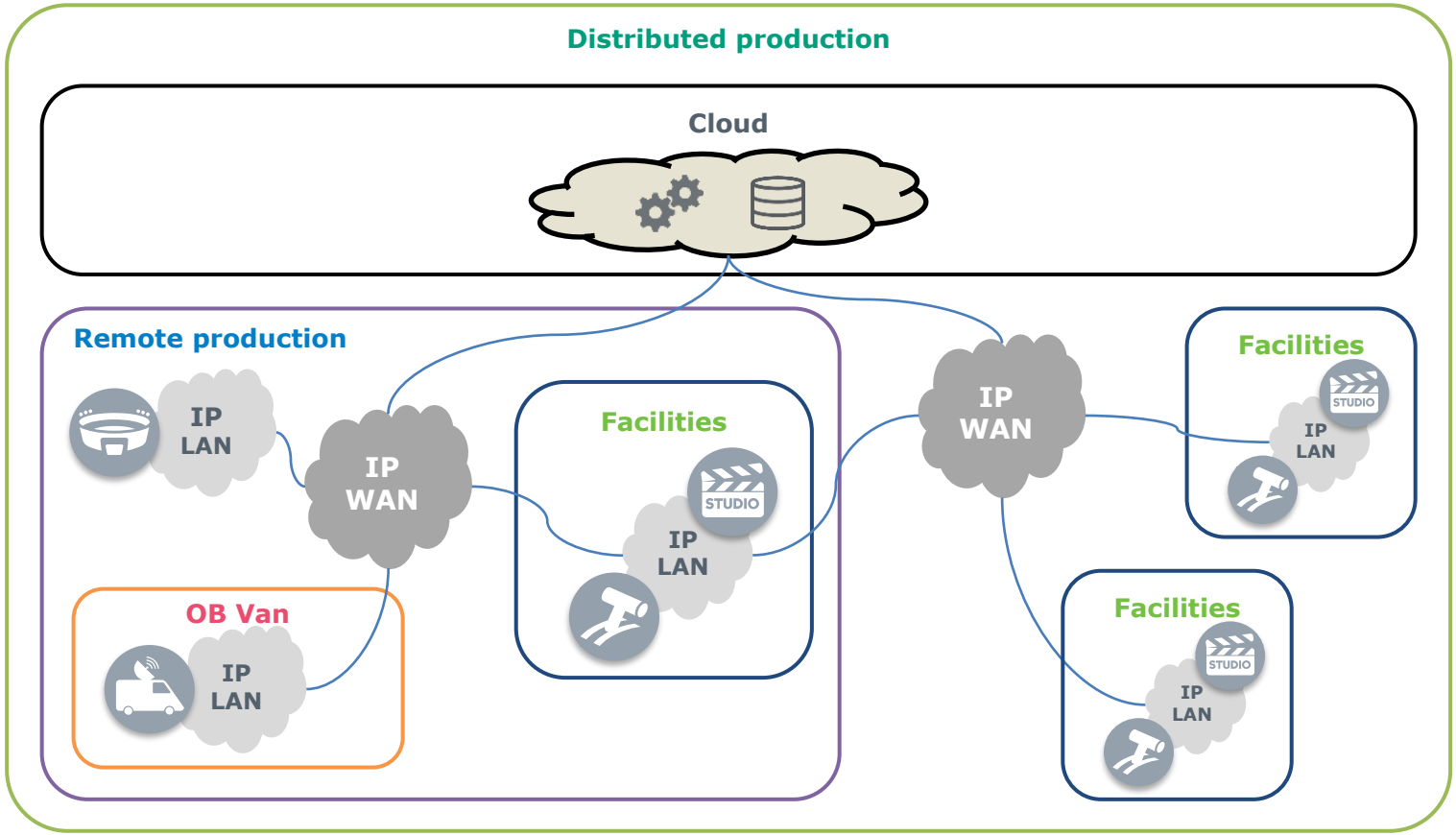

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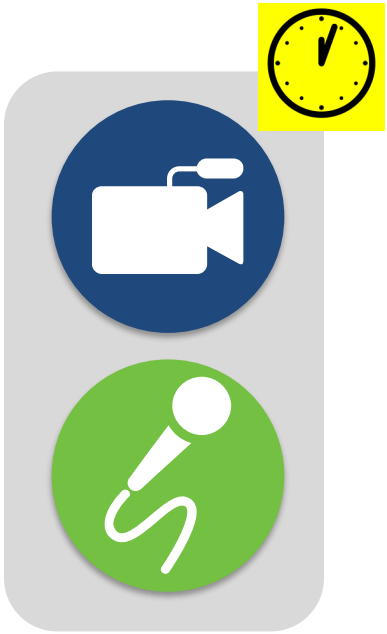
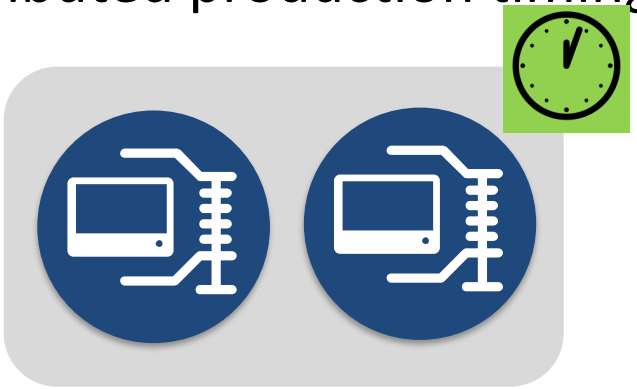
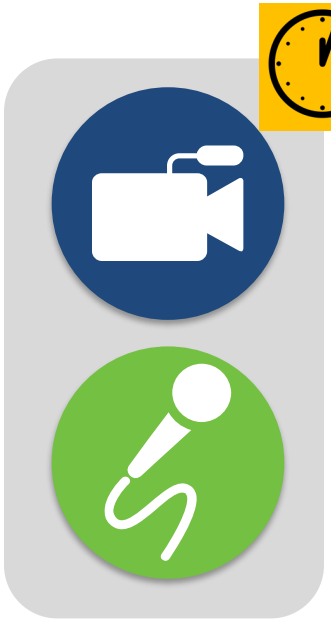
Distributed production timing







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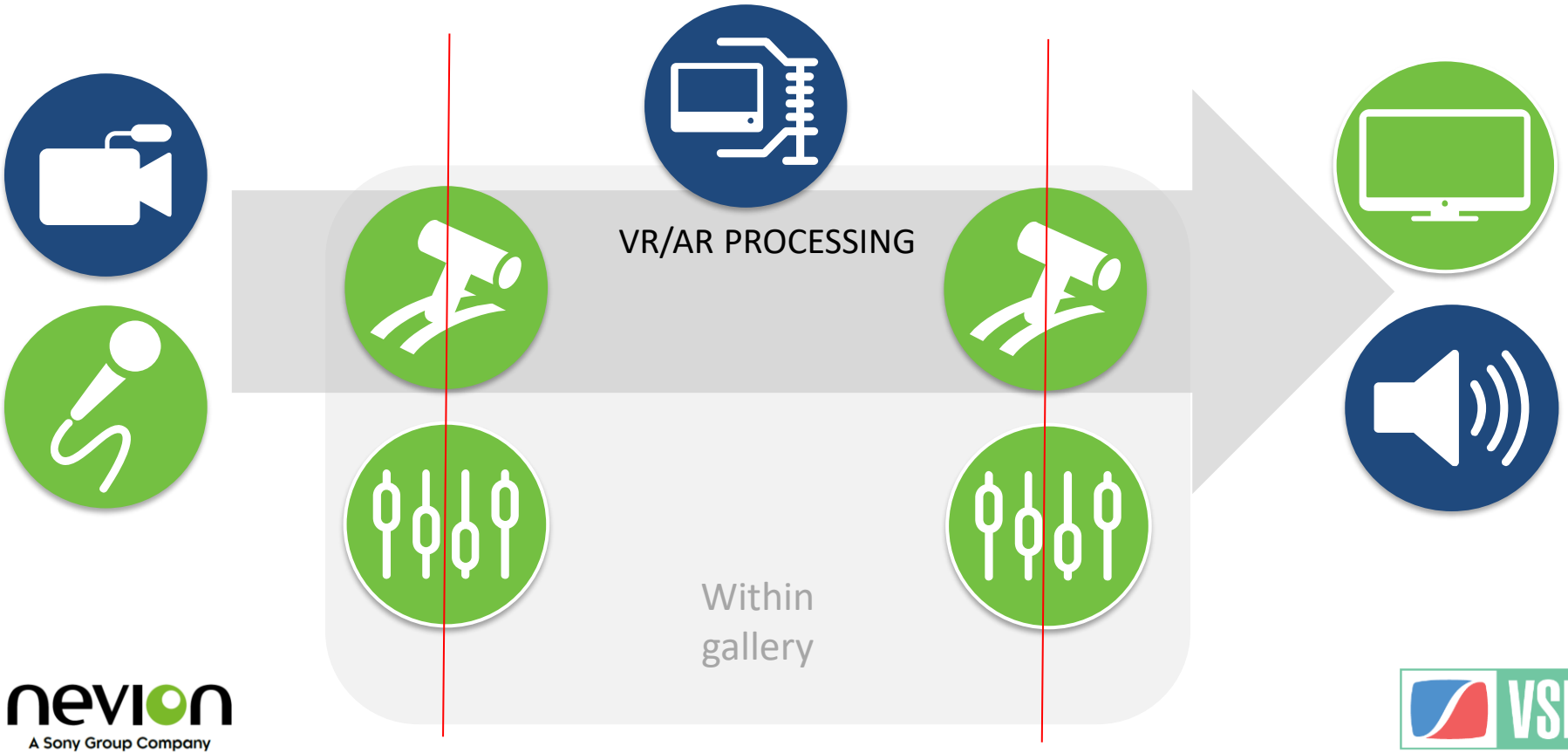
Living with split timing domains in ‘local’ production



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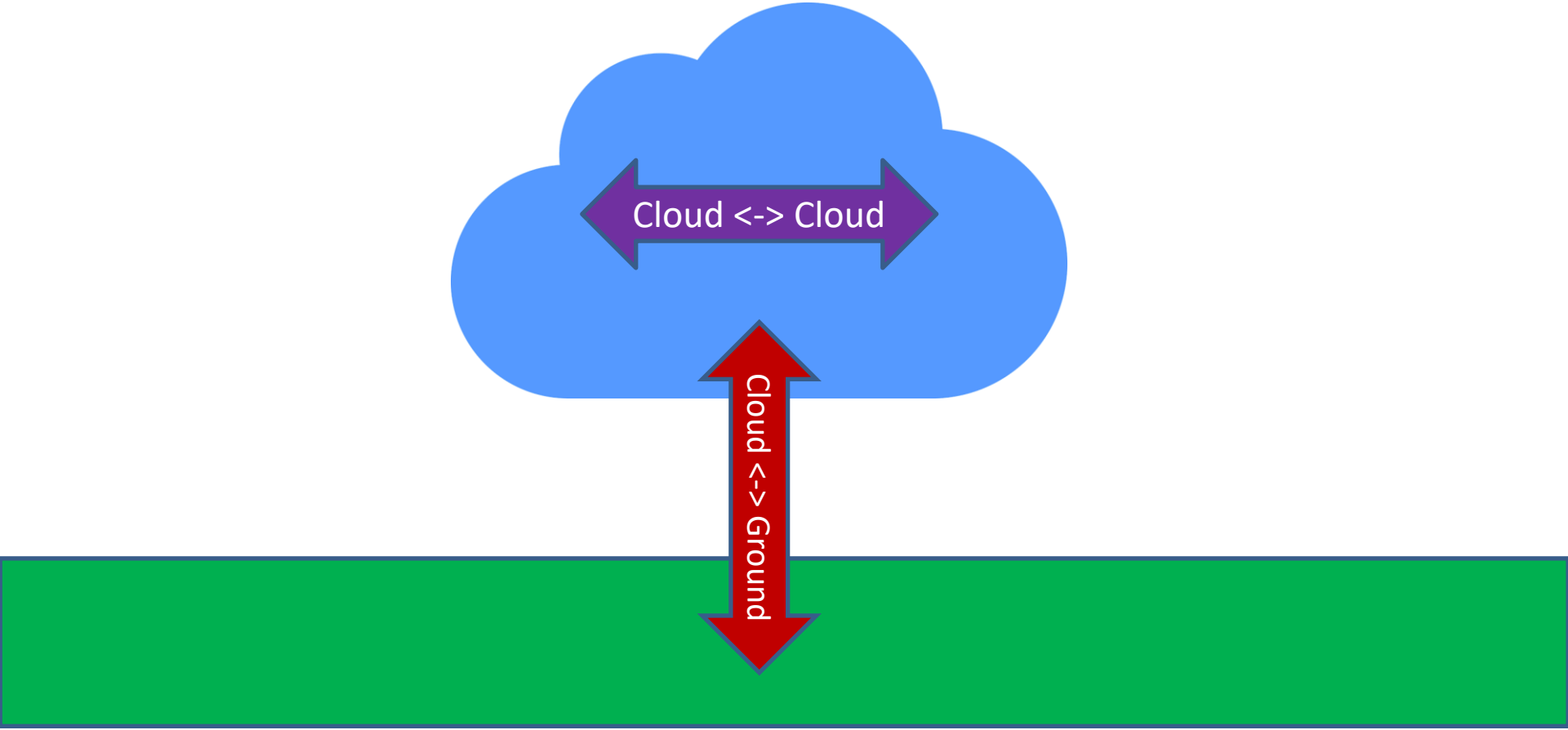
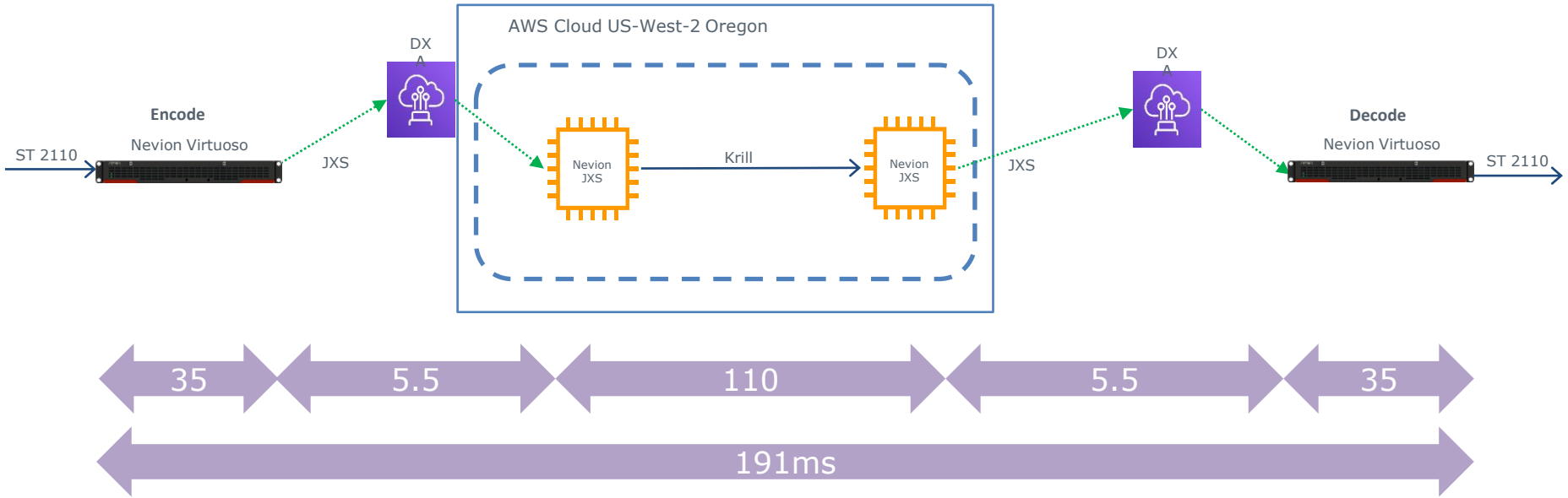

Cloud <-> Cloud
Cloud <-> Ground

Worlds first CDI G-C-C-G JXS latency test – May 2020



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Which time matters?

Relative time

Production time

Wall clock time

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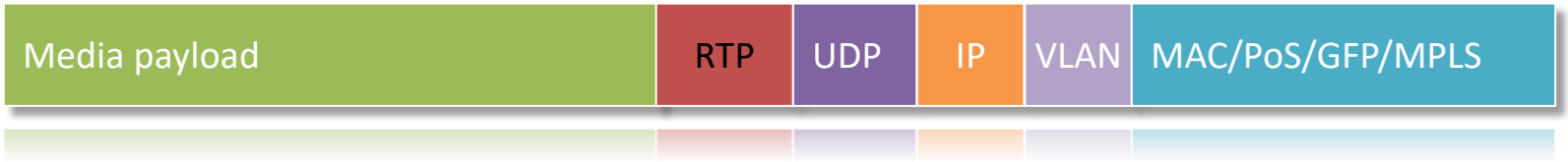
Once we get inside a compute environment…..



?

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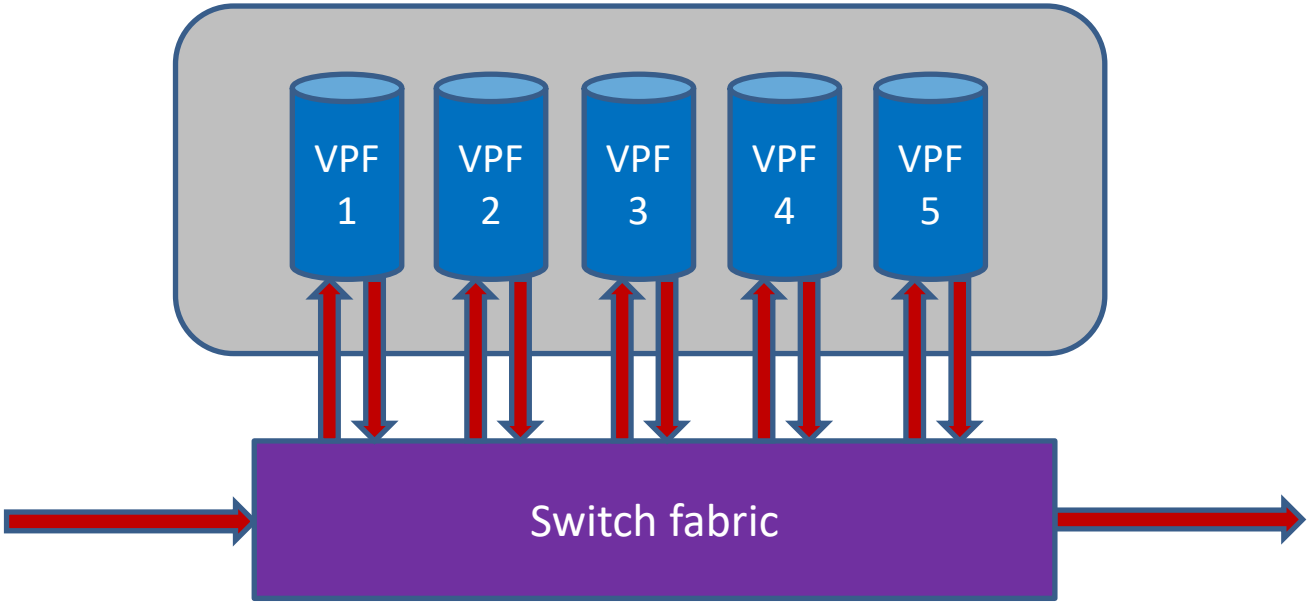
Separate virtual processing functions connected in ‘real time IP’ (e.g. ST2110) via external fabric



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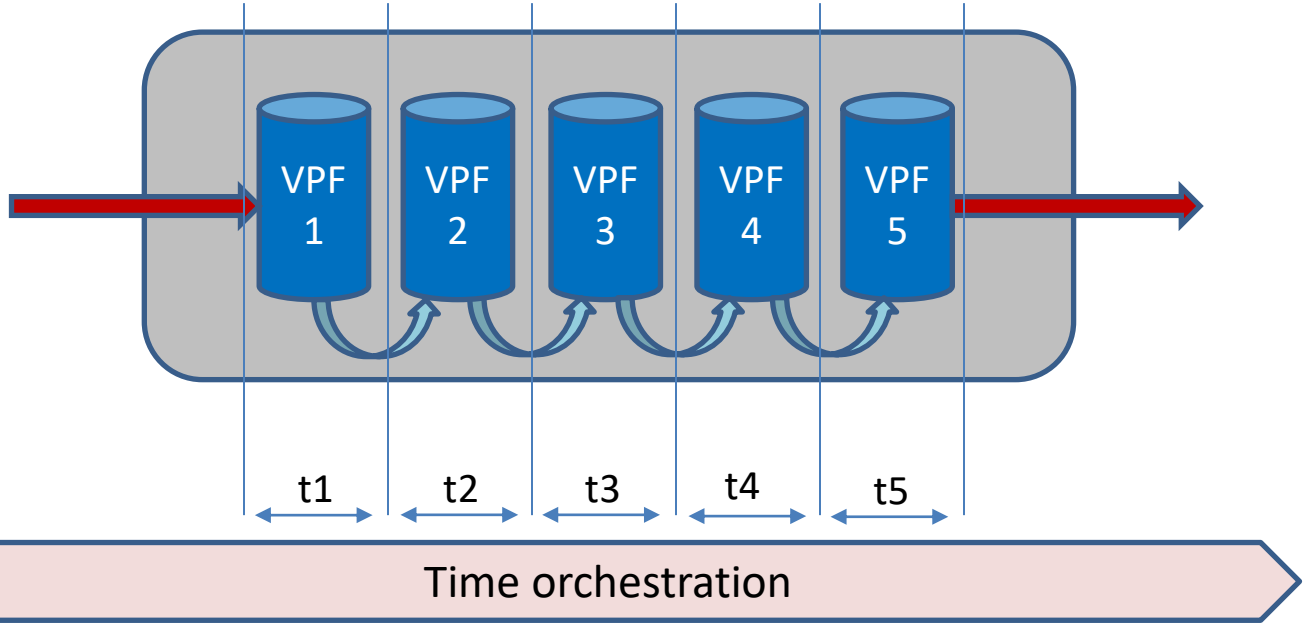
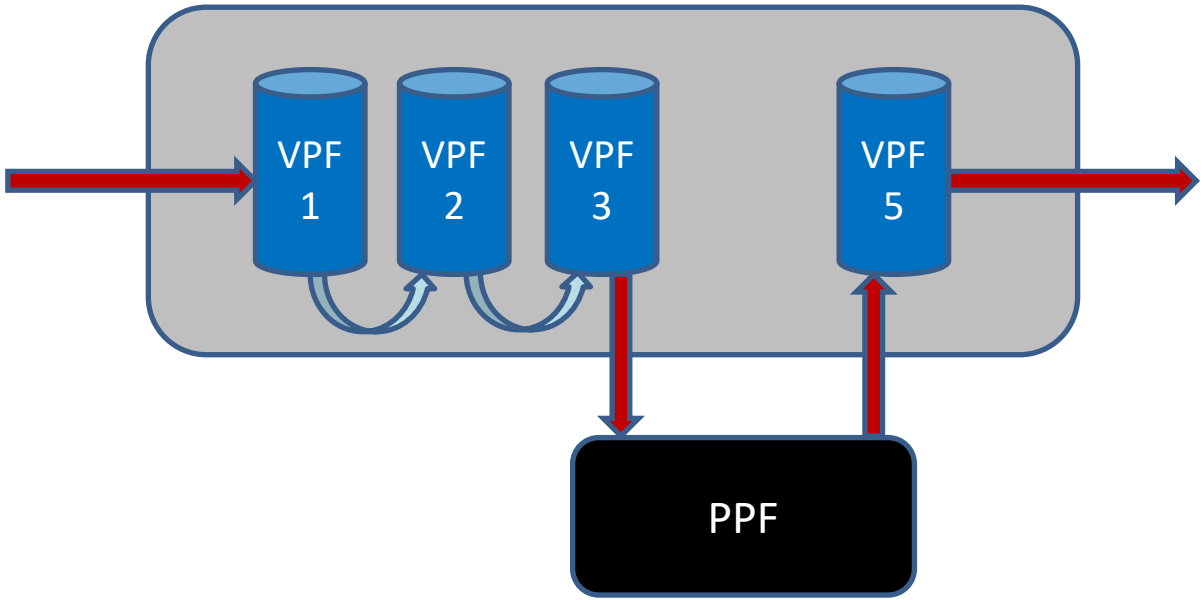
Concatenated virtual processing functions, each with defined (max) execution time



A hybrid of virtual and physical processing functions



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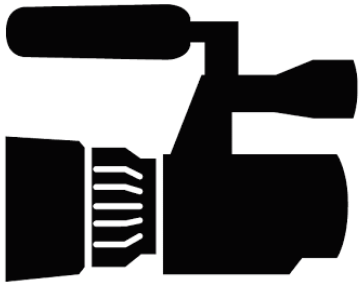
Time on ground and in cloud

~~PTP~~ NTP

- Physical and synthetic sources on ground
- Synthetic sources in the cloud



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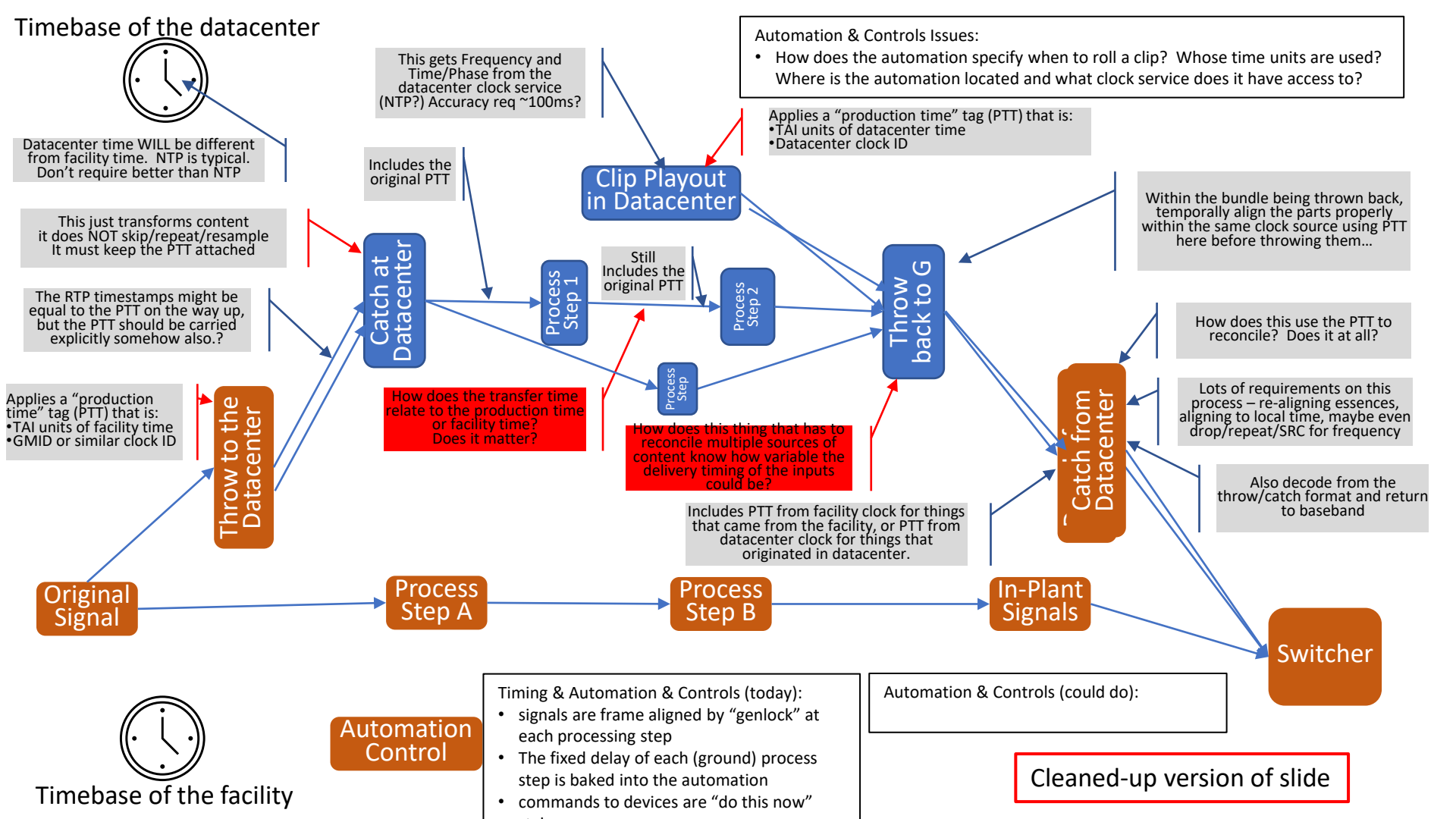
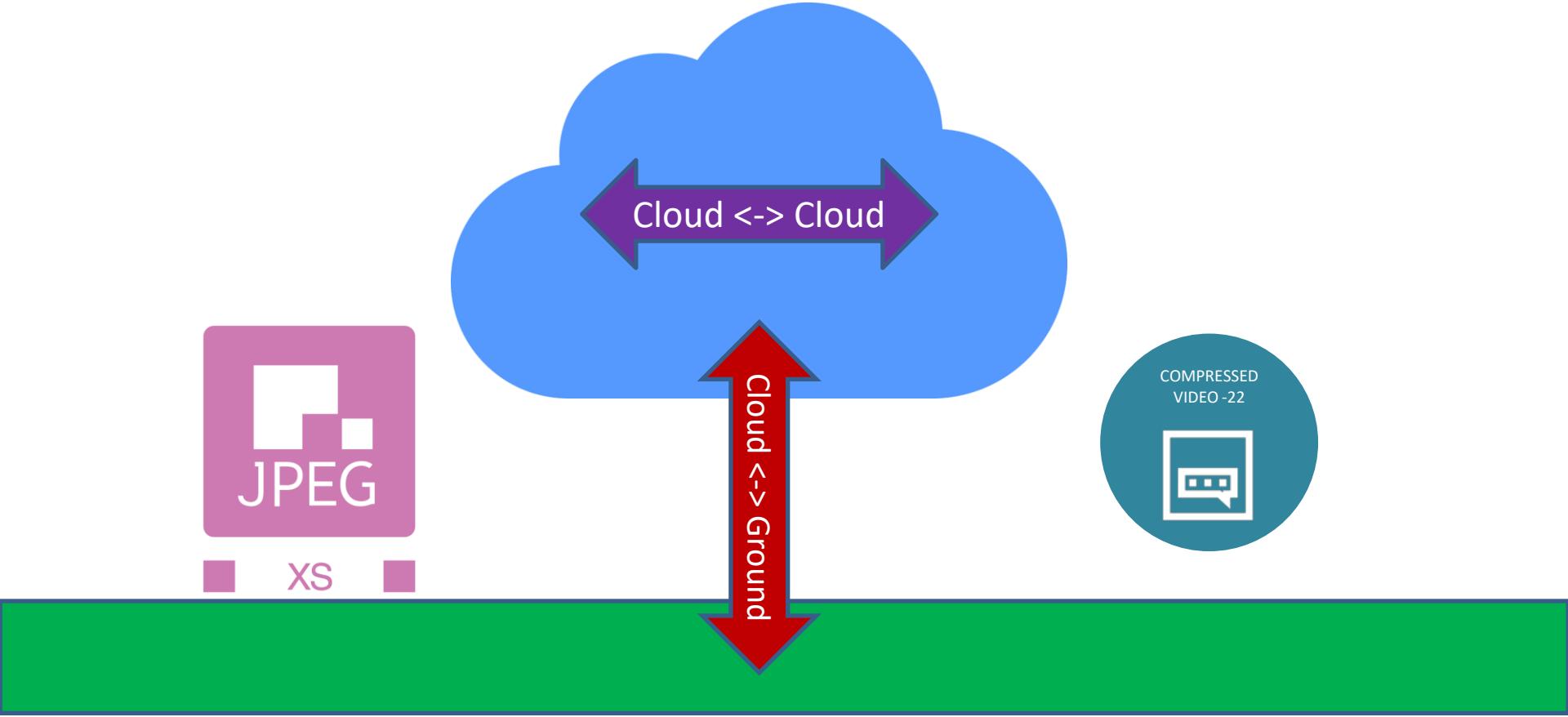
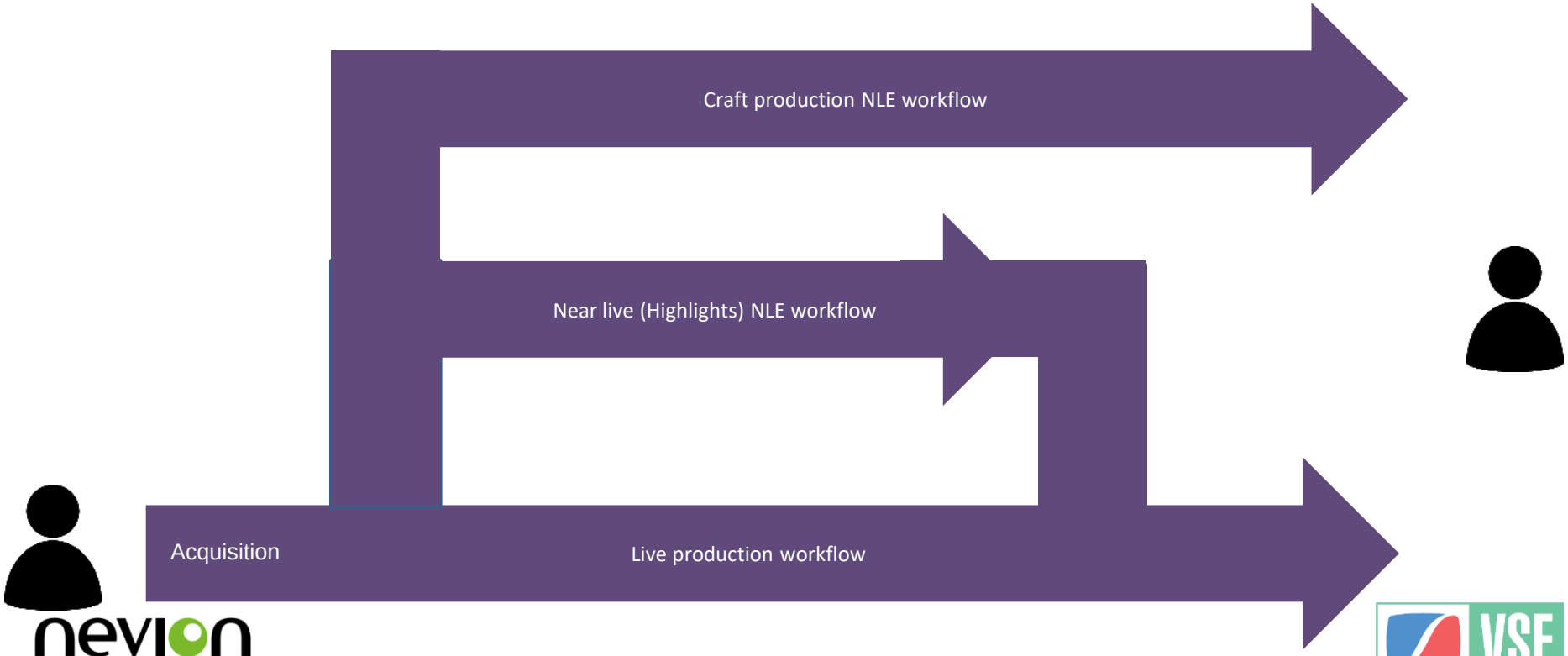

Timebase of the datacenter
Automation & Controls Issues:
• How does the automation specify when to roll a clip? Whose time units are used? Where is the automation located and what clock service does it have access to?
This gets Frequency and Time/Phase from the datacenter clock service (NTP?) Accuracy req ~100ms?
Applies a "production time" tag (PTT) that is:
•TAI units of datacenter time
•Datacenter clock ID
Datacenter time WILL be different from facility time. NTP is typical. Don't require better than NTP
Includes the original PTT
Clip Playout in Datacenter
Within the bundle being thrown back, temporally align the parts properly within the same clock source using PTT here before throwing them…
This just transforms content it does NOT skip/repeat/resample It must keep the PTT attached
Catch at Datacenter
Process Step 1
Still Includes the original PTT
Process Step 2
Throw back to G
The RTP timestamps might be equal to the PTT on the way up, but the PTT should be carried explicitly somehow also.?
How does this use the PTT to reconcile? Does it at all?
Process Step
Applies a "production time" tag (PTT) that is:
•TAI units of facility time
•GMID or similar clock ID
Throw to the Datacenter
How does the transfer time relate to the production time or facility time? Does it matter?
How does this thing that has to reconcile multiple sources of content know how variable the delivery timing of the inputs could be?
Catch from Datacenter
Lots of requirements on this process – re-aligning essences, aligning to local time, maybe even drop/repeat/SRC for frequency
Also decode from the throw/catch format and return to baseband
Includes PTT from facility clock for things that came from the facility, or PTT from datacenter clock for things that originated in datacenter.
Original Signal
Process Step A
Process Step B
In-Plant Signals
Switcher
Timebase of the facility
Automation Control
Timing & Automation & Controls (today):
• signals are frame aligned by "genlock" at each processing step
• The fixed delay of each (ground) process step is baked into the automation
• commands to devices are "do this now"
Automation & Controls (could do):
Cleaned-up version of slide


Cloud <-> Cloud
Cloud <-> Ground
JPEG
XS
COMPRESSED
VIDEO -22

Media production convergence



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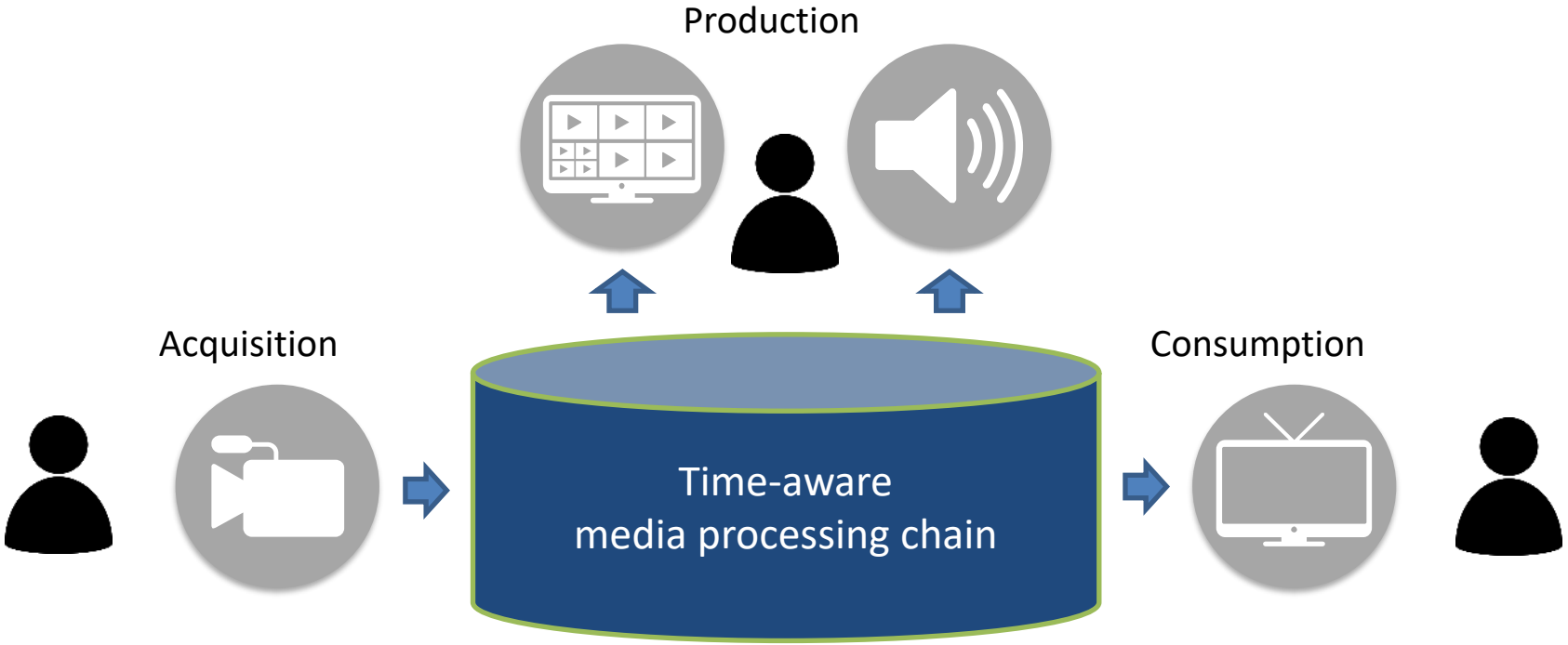
Where time really matters……



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Thank you!

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