Timing Requirements in Broadcast Applications - the Reasoning behind AES67 & SMPTE ST 2059 PTP Profiles

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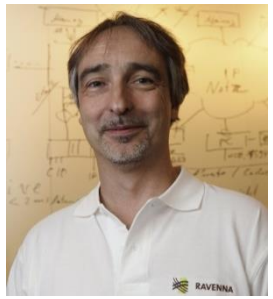


Andreas Hildebrand, RAVENNA Technology Evangelist

- more than 25 years in the professional audio / broadcasting industry
- graduate diploma in computer science
- R&D, project & product management experience
- member of AES67 TG and ST2110 DG

ALC NetworX GmbH, Munich / Germany

- established 2008
- R&D center
- developing & promoting RAVENNA
- Partnerships with > 40 manufacturers

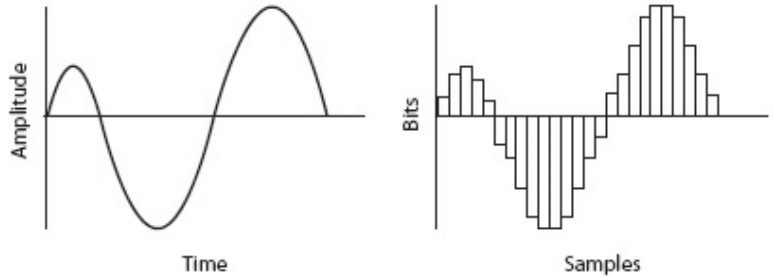
RAVENNA

- IP media networking technology
- designed to meet requirements of professional audio / broadcasting applications
- open technology approach, license-free
- fully AES67- and SMPTE ST2110-compliant

Timing & Synchronization – General Requirements

- Media bit-transparency
  - → no sample rate conversion
  - → streams need to run on same media clock
- Concurrent operation of different sample rates on same network

Media clock = Sampling rate



- Determinable (low) end-to-end latency
- Time alignment between media streams

- Replacement for “house clock” distribution (word clock, black burst etc.)

⇨ Clock reassembly from stream data not appropriate
⇨ Distribution of master clock beats not sufficient
⇨ Common understanding of absolute time required (“wall clock”)

Timing & Synchronization – Accuracy Requirements

- Audio applications have highest time accuracy & precision demands:

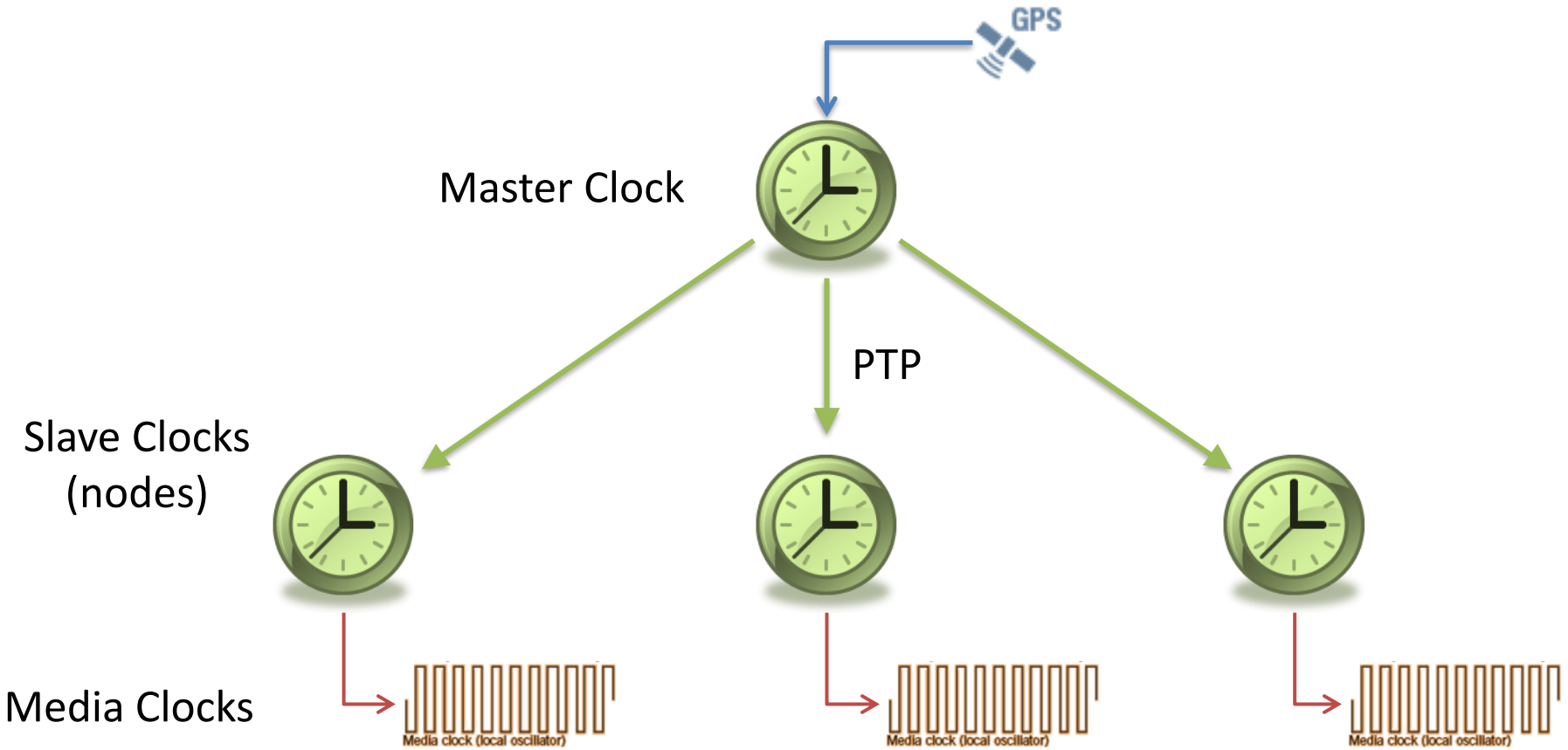
  ⇨ Sample accurate alignment of streams (± ½ sample)
  - @ 48 kHz: ± 10 µs
  - @ 96 kHz: ± 5 µs
  - @ 192 kHz: ± 2.5 µs

  ⇨ "Distribution" of word clock reference
  (AES11 calls for ± 5% max jitter / wander):
  - @ 48 kHz: ± 1 µs
  - @ 96 kHz: ± 500 ns
  - @ 192 kHz: ± 250 ns

Synchronization & Media Clocks

- All nodes are running local clocks
- Local clocks are precisely synchronized to a common wall clock via PTP
- Media clocks are generated locally from synchronized local clock

Synchronization & Media Clocks



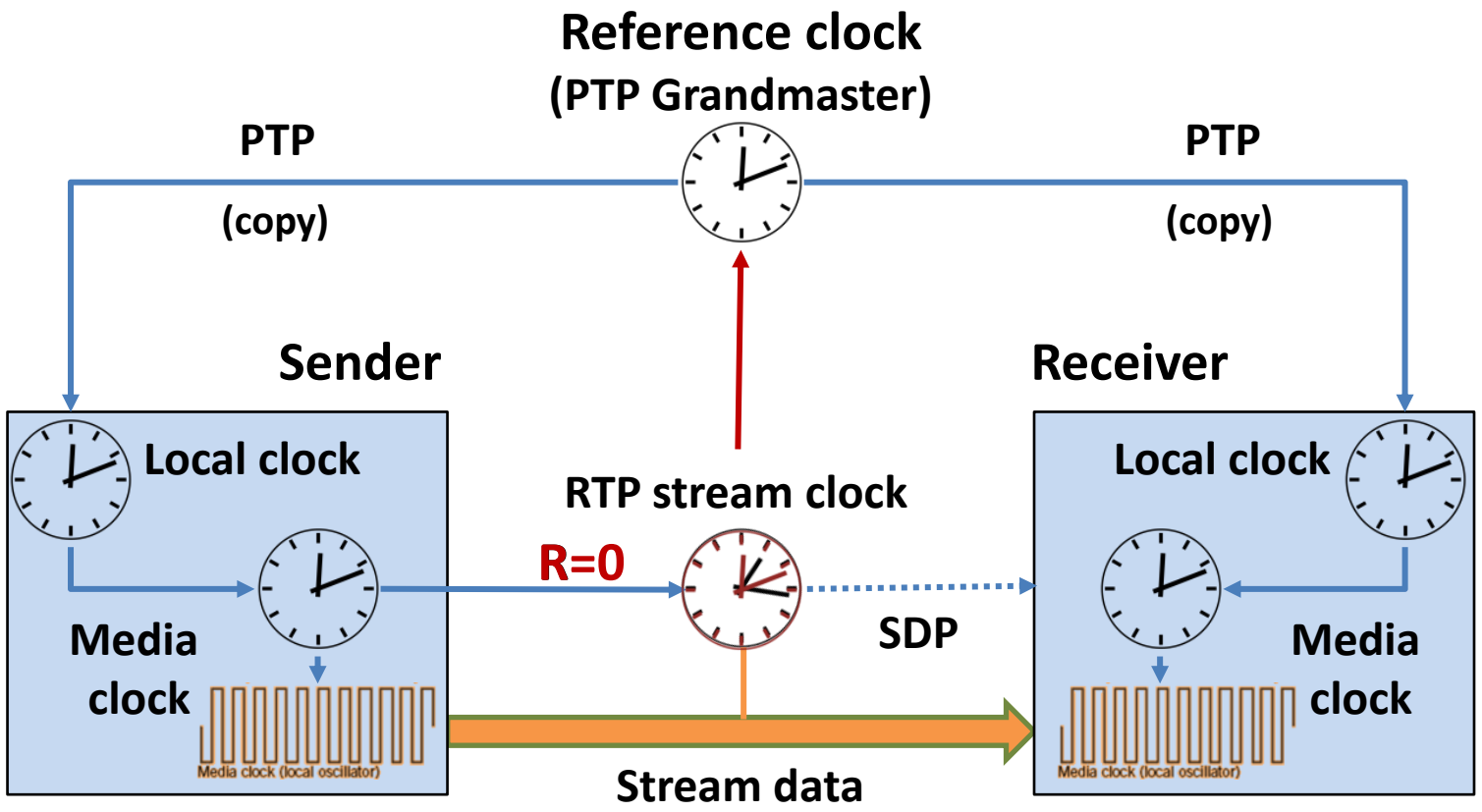
Synchronization & Media Clocks

- All nodes are running local clocks
- Local clocks are precisely synchronized to a common wall clock via PTP
- Media clocks are generated locally from synchronized local clock
- Generation of any desired media clock (sample rate) possible
- Concurrent operation of different media clocks possible
- Phase accuracy of AES 11 (± 5% of sample period) achievable by deployment of PTP-aware switches (BC or TC)
- Synchronization across facilities possible by reference to absolute time (TAI / GPS)
- Essence data (audio samples or video frames) is related to the media clock upon intake - essentially receiving a generation “time stamp” with respect to the media clock

Synchronization & Media Clocks – "time stamping"

- 3 type of clocks in the system:
  - Wall clock - provided by Grandmaster
    - local copy of the wall clock in each node
  - Media clock – derived from the local clock (i.e. 48 kHz for audio, 90 kHz for video)
  - RTP clock (stream clock) – derived from the media clock

Synchronization & Media Clocks

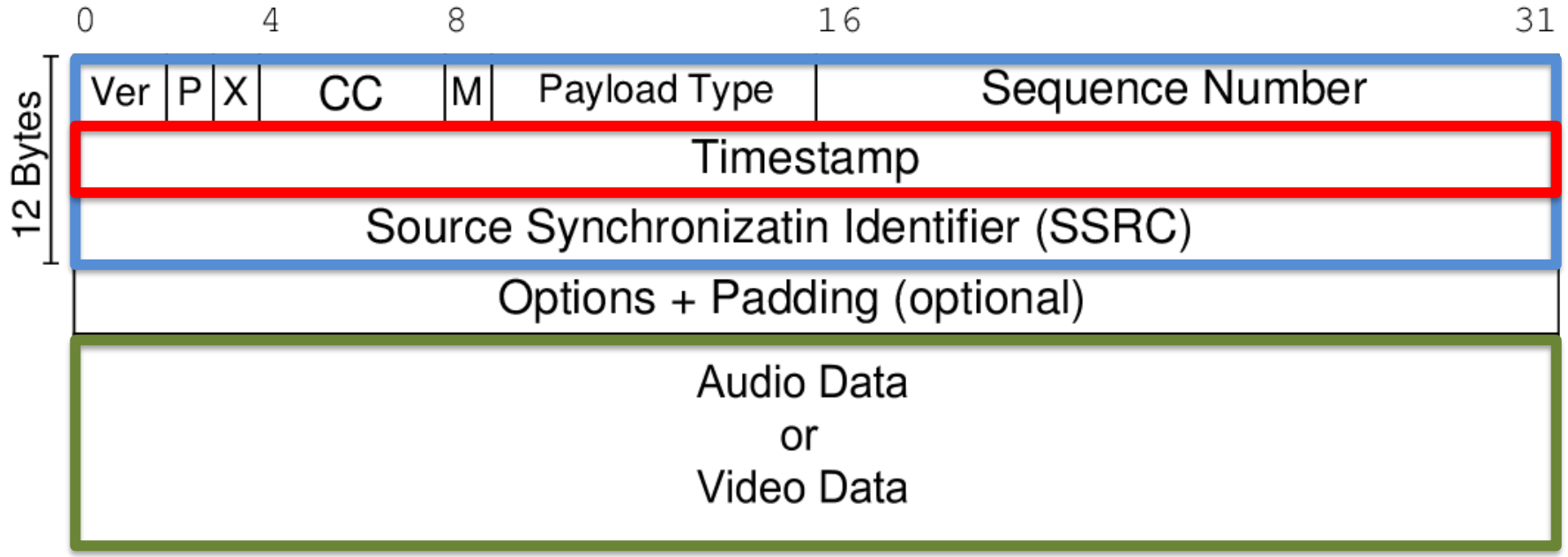


- Offset **R** is established on stream start-up
- **R** may be random to defeat crypto-text attacks
- This offset will be constant throughout the stream's lifetime

- The offset (**R**) will be conveyed via SDP (a=mediaclk:direct=<offset>) **– must be "0" in ST2110**

RTP Packets (Layer 5)

- Consist of RTP header, optional payload headers and the payload itself
- **RTP header** (overhead) = 12 bytes, **RTP payload** (linear audio data) = up to 1440 bytes
- **RTP Timestamp** = **media clock counter** (for linear PCM audio) = 32 bits (4 bytes)
  - ⇨ @ 48 kHz a rollover will occur roughly once per day (~ 1d, 51m, 19s)



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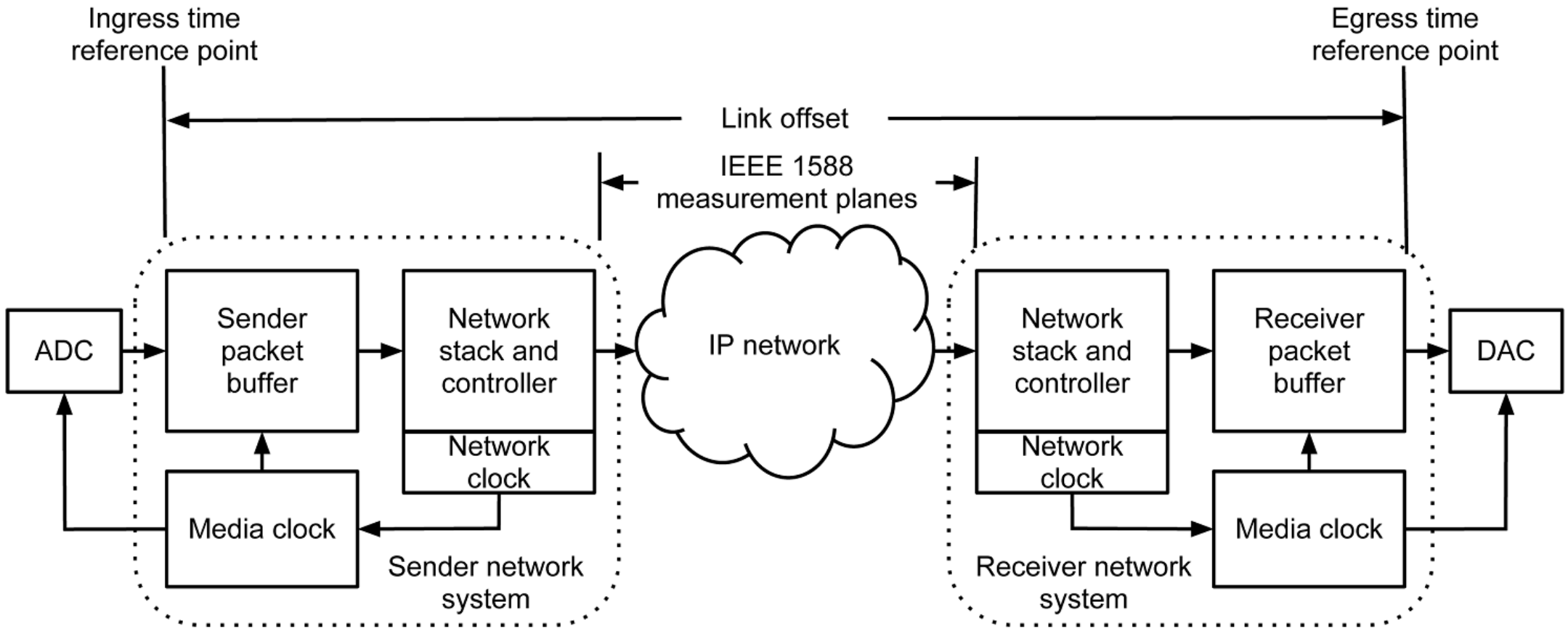
- Fixed / determinable latency by configuring a suitable link offset (“playout delay”)

AES67 synchronization - link offset (latency)



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- Inter-stream alignment by comparing and relating the time stamps of individual essence data

Production Workflow Timing

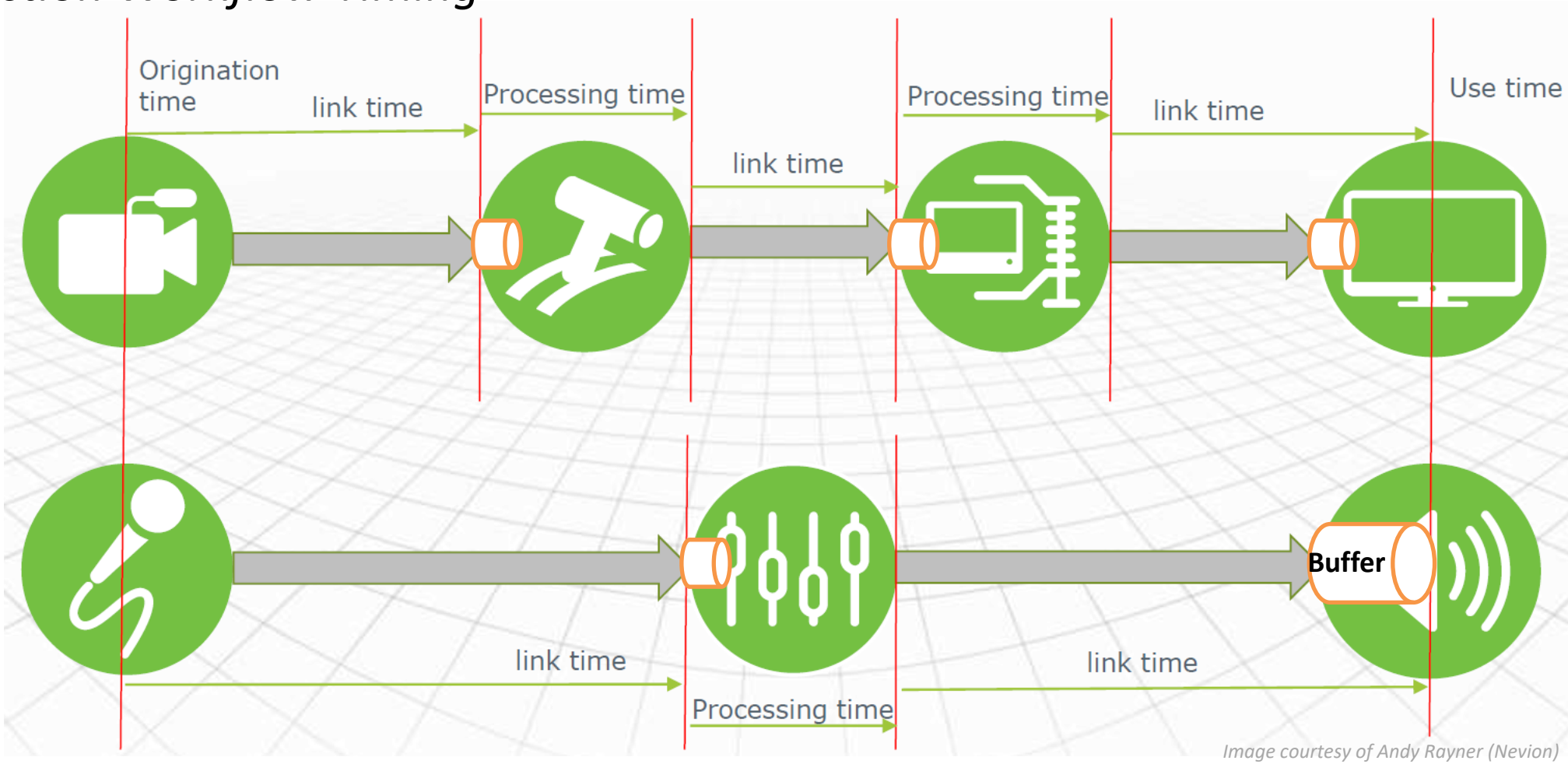

Image courtesy of Andy Rayner (Nevion)

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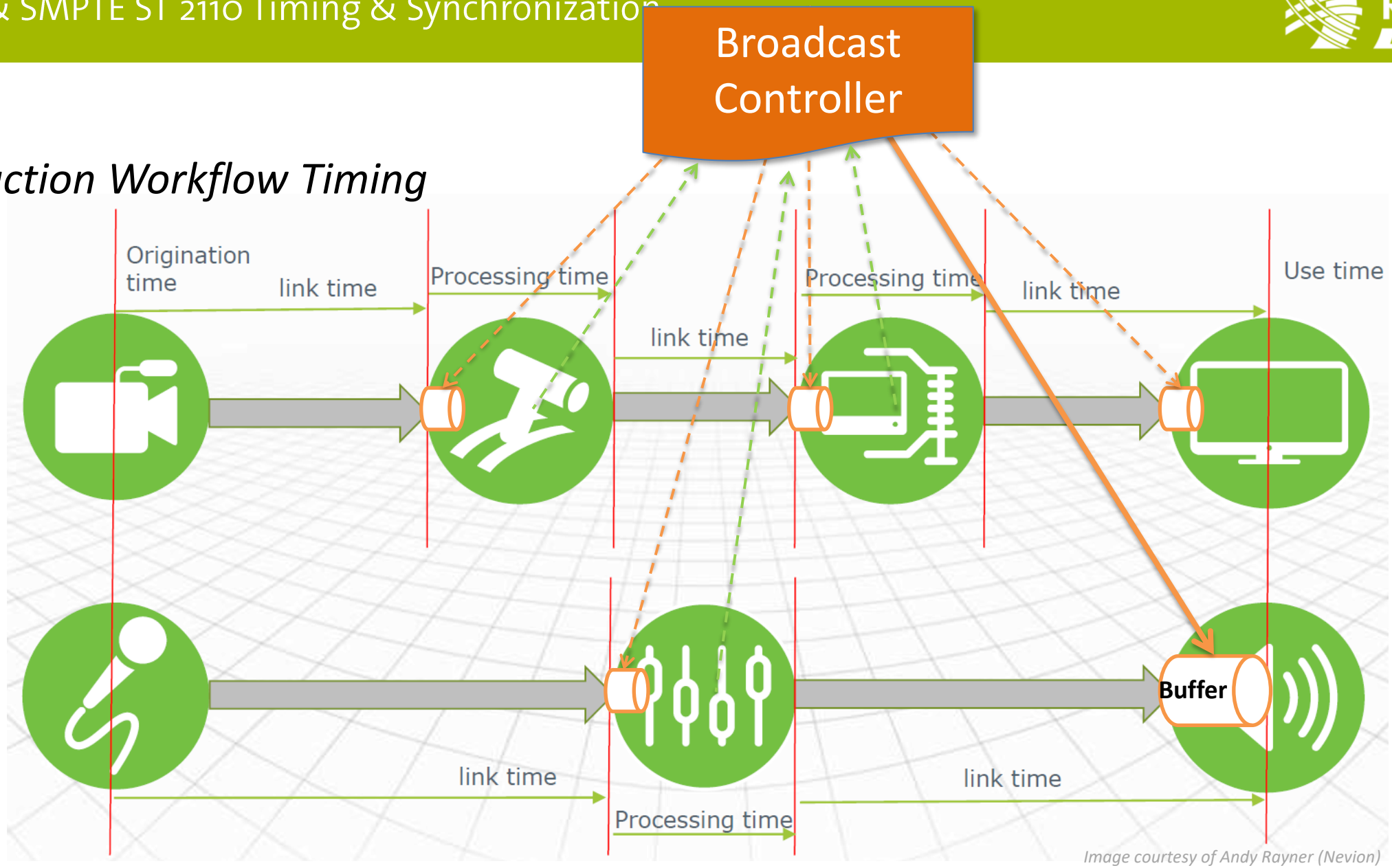

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AES67 PTP Media profile & SMPTE ST 2059-2 PTP profile

"**AES67 Media profile**" (Annex to AES67)

- Normative, but optional (PTP Default profile req'd)
- Reduced msg intervals for improved startup and accuracy
- Physical clock requirements (AES11)
- Add'l clock classes (to signal AES11 DARS grade)

Overview on message rates:*

Parameter	Default	Minimum	Maximum
Domain number	0	0	127
Announce interval	2 s	1 s	16 s
Sync interval	125 ms	$^1/_{16}$ s	2 s
Delay request interval	1	125 ms	32 x Sync interval

SMPTE ST 2059-2 - "**SMPTE PTP Profile**"

- Normative, mandatory for SMPTE ST 2110
- Further reduced msg intervals for improved startup and accuracy
- Specific PTP rules and clock constraints required by SMPTE application
- SMPTE-specific TLV metadata

Parameter	Default	Minimum	Maximum
Domain number	127	0	127
Announce interval	250 ms (1 s)*	125 ms	2 s
Sync interval	125 ms	$^1/_{128}$ s	500 ms
Delay request interval	Sync interval	Sync interval	32 x Sync interval

* AES-R16-2016 summarizes differences & commonalities between ST 2059 / AES67 & PTP Default profiles

More information…

RAVENNA / AES67 / SMPTE ST 2110 Resources:

RAVENNA AES67 & ST 2110 built-in

www.ravenna-network.com/resources

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