

Timing and Synchronization in the Professional Broadcast TV Industry

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Overview

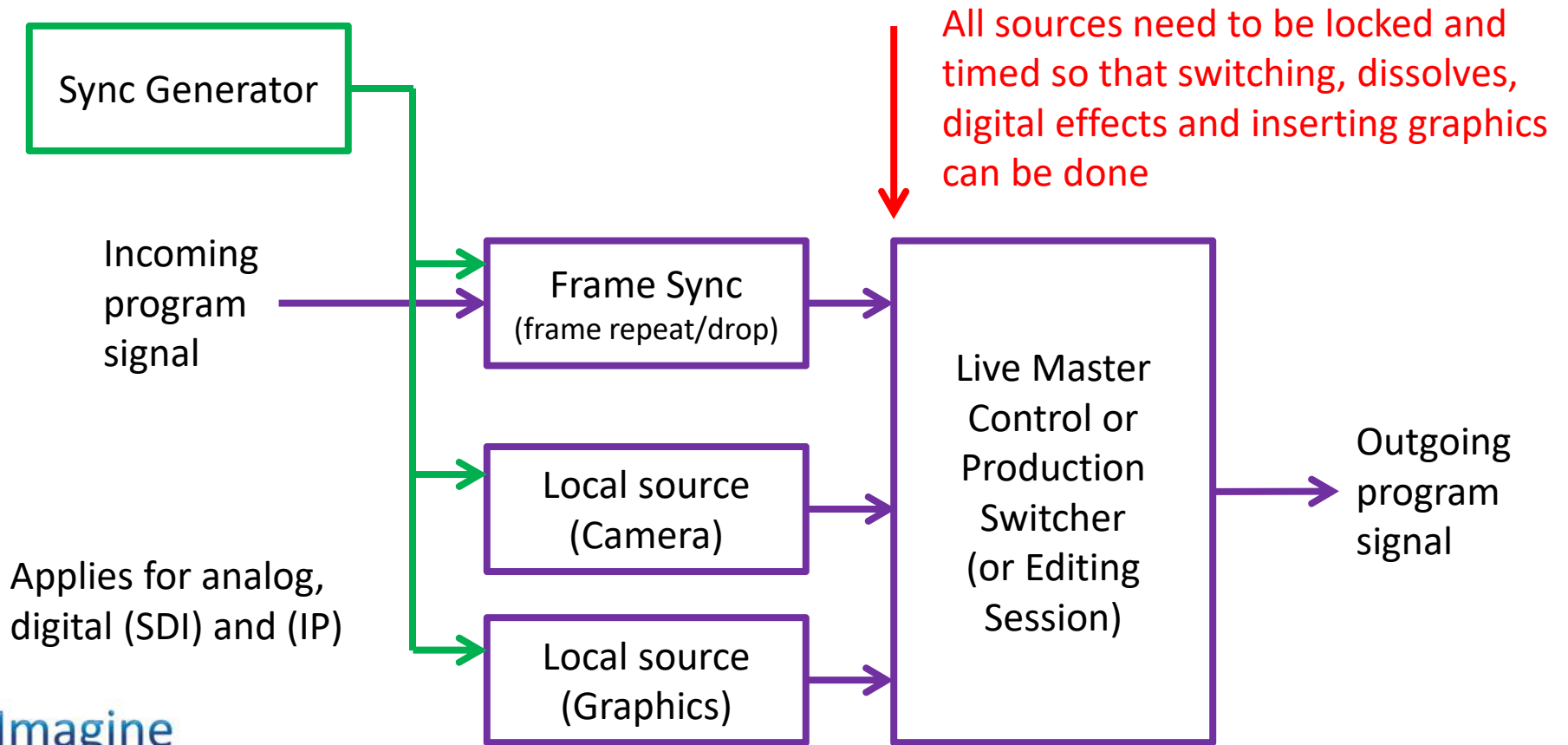
- Timing requirements of the Professional Broadcast TV Industry
- Using time for SDI and SMPTE ST 2110
- SMPTE ST 2059-2 PTP Profile
- Professional Broadcast Networks
- Recent work in the Professional Broadcast TV Industry
- Active work in the Professional Broadcast TV Industry

SMPTE

- Society of Motion Picture and Television Engineers®
- Creates the standards/RP for the Profession Broadcast TV industry
- Founded in 1916
- www.smpte.org
- SMPTE Digital Library on IEEE Xplore



What is Genlock ?

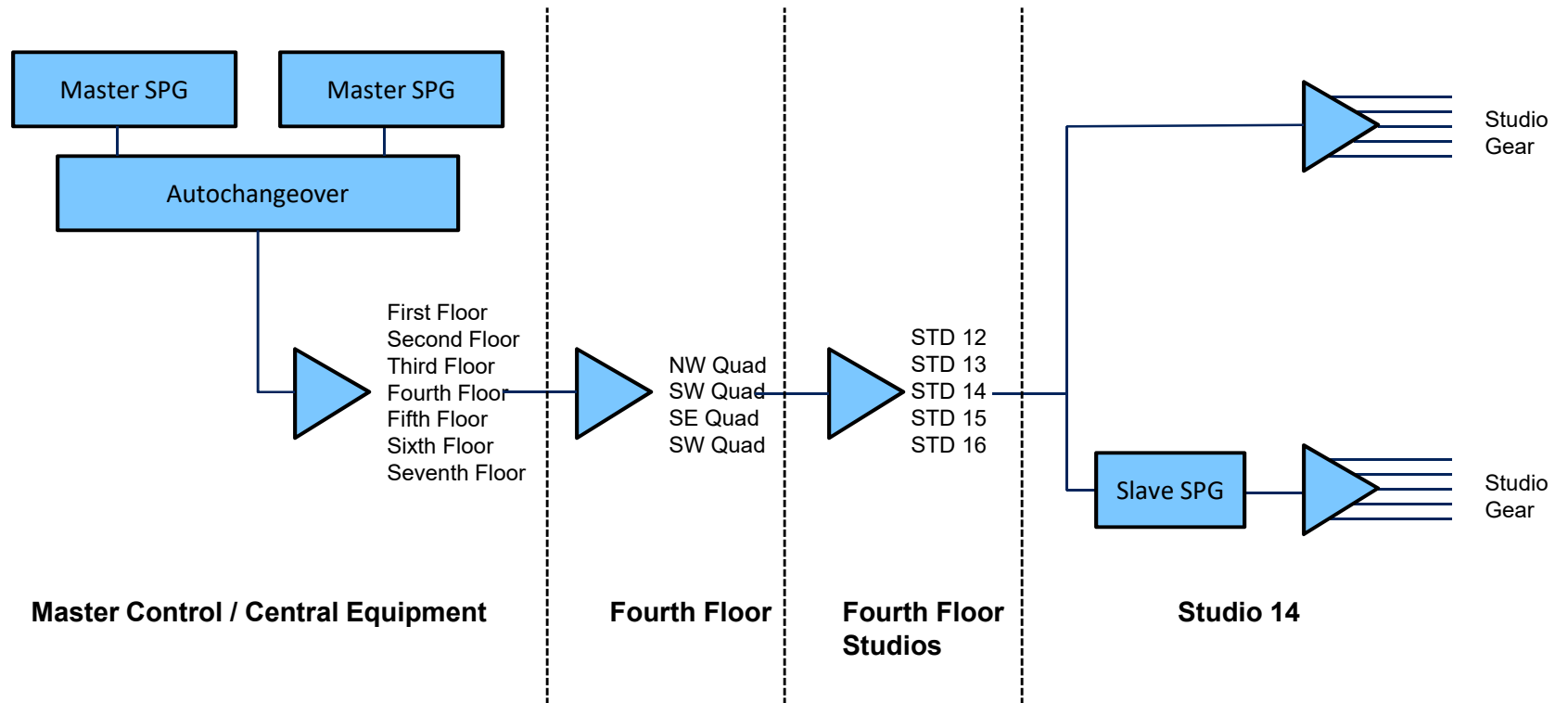


What is Genlock ?

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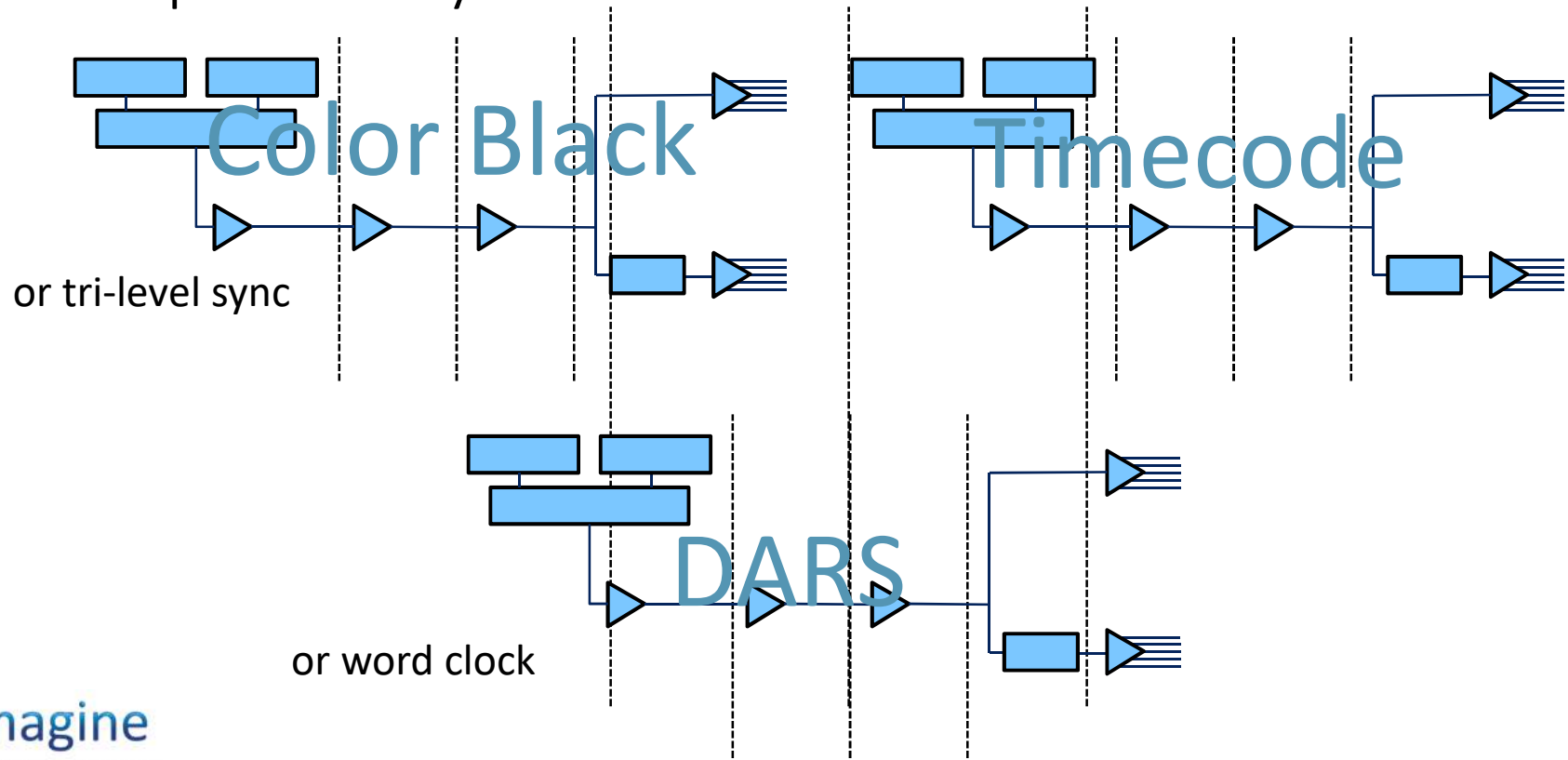
- System that allows source signals to be aligned to a common reference
- Fundamental frequencies for video, audio and time code must be derived from reference signal
 - Signal edge timing
 - E.g. for video - vertical, horizontal
- Enables independent sources to be frequency and phase locked so that they can be processed without any impairments

Non-IP Reference System



Non-IP Reference System

- Multiple Parallel Systems



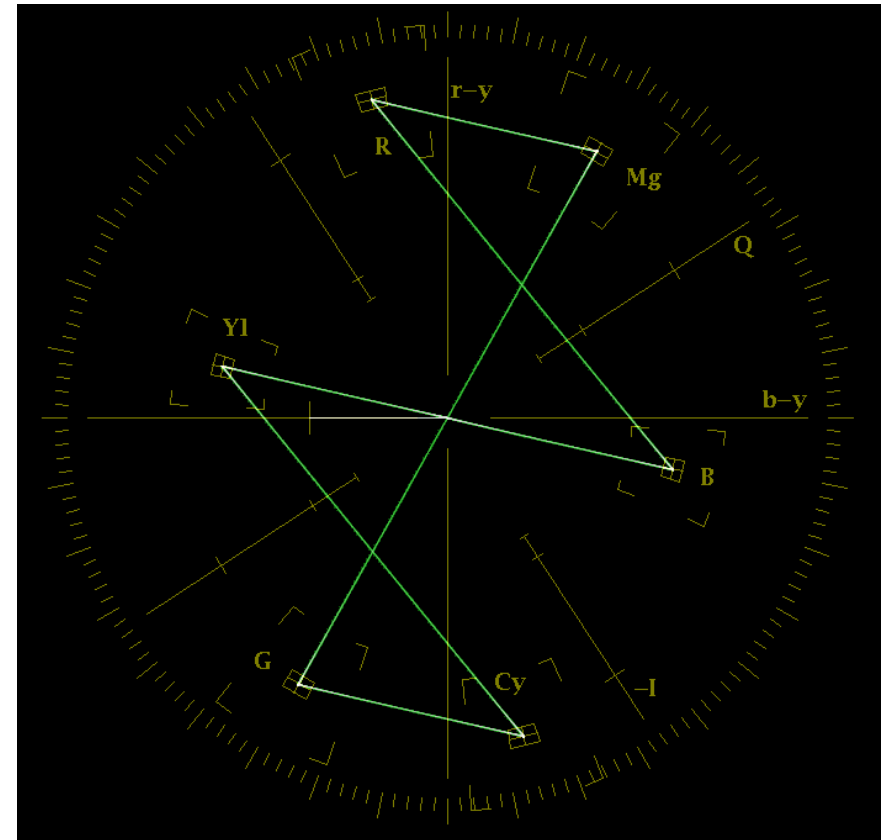
SMPTE ST 12-1 Timecode

- Frame label
- Drifts because of 59.94Hz
 - “Leap Year” rules
 - “Jam Sync” to correct 86ms daily drift



Timing Requirements of the Professional Broadcast TV Industry

- Absolute phase (time) accuracy
 - With analog video, <100 ps
 - With SDI video, <few us
 - IP video, < few more us
- Target is 1us



Requirements of the Professional Broadcast TV Industry

- Quick lock time
 - Approx. <5 seconds
- Wide range of processing capabilities and network interfaces
 - Microphones and speakers to high end custom hardware
 - 100Mbps to 100Gbps
- Media Nodes (End devices) support “Slave Only” mode
- +/- 100ms to TAI
- Free-run accuracy <2 ppm
- Internally need 27MHz, 148.5MHz, 148.5 x 1000/1001 MHz, 90KHz, 48Khz

SMPTE ST 2110 Family of Standards

- Standards for Professional Media Over Managed IP Networks
- Splits each essence type into separate RTP streams
 - Active video, audio and ancillary data
- RTP Timestamps

Key Concepts of a Network Based Genlock

1. Getting the time
Getting accurate time to each device
2. Using the time
Using the time to generate output signals

1. “Getting the time”

- Using IEEE-1588:2008 as the core
- Add on
 - SMPTE ST 2059-2:2015 “SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications”
 - SMPTE ST 2110-10:2017 “Professional Media Over Managed IP Networks: System Timing and Definitions”
 - JT-NM TR-1001-1:2018 “System Environment and Device Behaviors For SMPTE ST 2110 Media Nodes in Engineered Networks-Networks, Registration and Connection Management”

ST 2059-2 SMPTE Profile

- IEEE 1588 profile specific for Broadcast/Media applications
- Parameter ranges to enable fast lock times
- Adds metadata for generating SMPTE ST 12-1 timecode
 - E.g. When last and next Jam Sync
- Adds some restrictions to simplify implementations

2. “Using the time”

- SMPTE ST 2059-1:2015 “Generation and Alignment of Interface Signals to the SMPTE Epoch”
 - Based on Patent #6191821 “Method and apparatus for synchronization of periodic signals” 1998
 - Epoch
 - Phase at the Epoch
 - Converting time from the epoch to signal phase
- SMPTE ST 2110 “Professional Media Over Managed IP Networks”
 - RTP Timestamps and stream alignment

ST 2059-1 Time to Phase Conversion

Table 2 – Signal Generation – Digital Standard Definition Television

Television System	Frame Rate [Hz]	Reference Standard	Horizontal Alignment (Y Sample) P	Vertical Alignment Line L	Y samples per total line H	Y Samples per active line HA	Total Lines V	Sample Clock Frequency SR [Hz]
525 line Interlaced 13.5 MHz Sampling	30/1.001	SMPTE ST 125	736	4	868	720	625	13.5×10^6
625 line Interlaced 13.5 MHz Sampling	25	SMPTE ST 125	732	1	864	720	625	13.5×10^6
525 line Interlaced 18 MHz Sampling	30/1.001	SMPTE ST 125	981.5	4	1144	960	525	18×10^6
625 line Interlaced 18 MHz Sampling	25	SMPTE ST 125	976	1	1152	960	625	18×10^6
525 Line Progressive 27 MHz Sampling	60/1.001	SMPTE ST 293 ITU-R BT.1358-1	736	7	868	720	525	27×10^6
625 Line Progressive 27 MHz Sampling	50	ITU-R BT.1358-1	732	1	864	720	625	27×10^6

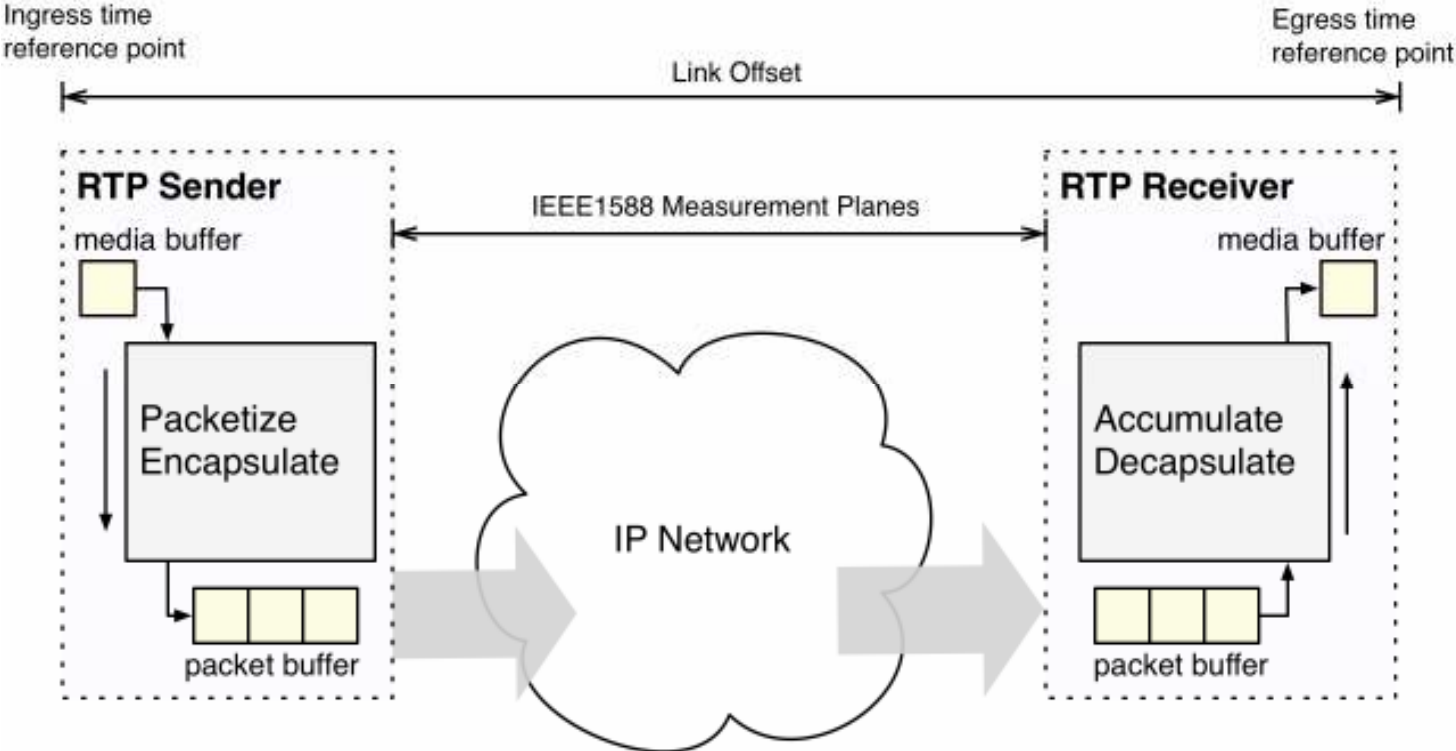
$$T = \frac{1}{SR}$$

$$NextAlignmentPoint = \left(\text{int} \left(\frac{t}{H \times V \times T} + 1 \right) \times (H \times V \times T) \right)$$

$$SampleWordNumber = \left(\text{int} \left(\frac{t}{T} \right) + P \right) \% H$$

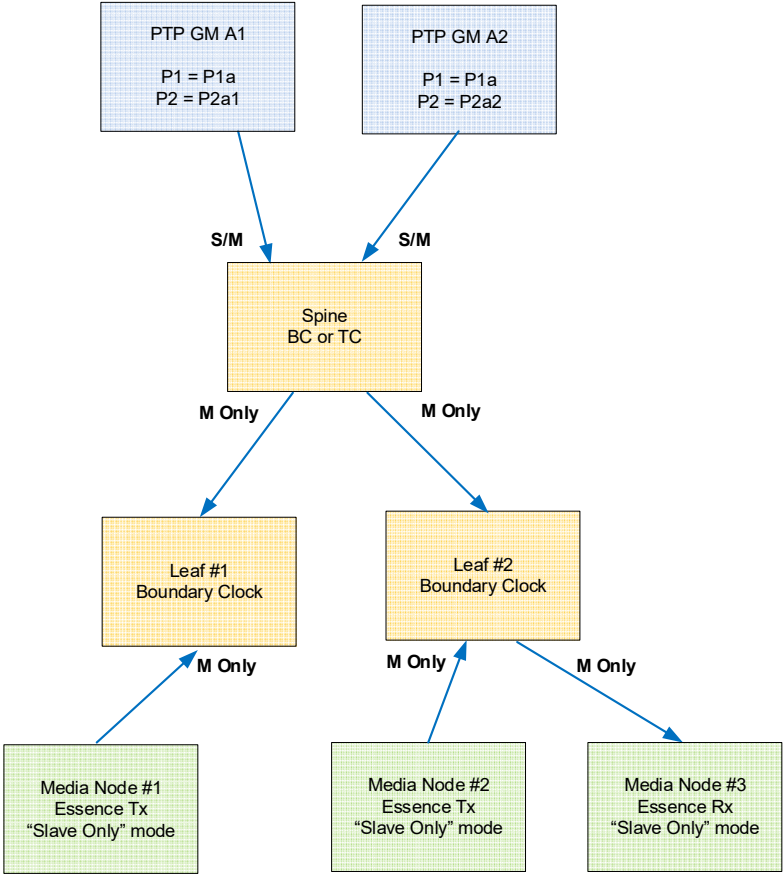
$$LineNumber = \left(\left(\text{int} \left(\frac{\left(\frac{t}{T} + P - HA \right)}{H} \right) + (L - 1) \right) \% V \right) + 1$$

SMPTE ST 2110



Source: Video Services Forum (VSF) Technical Recommendation TR-03

Professional Broadcast Network Topology



Recent Work in the Professional Broadcast Industry

- Joint Task Force on Networked Media (JT-NM) Technical Recommendation TR-1001-1 “System Environment and Device Behaviors For SMPTE ST 2110 Media Nodes in Engineered Networks-Networks, Registration and Connection Management” 29 November 2018
 - www.jt-nm.org/documents/JT-NM_TR-1001-1:2018_v1.0.pdf
 - System Resource to get critical PTP parameter
- “Dirty Hands” Workshop - Feb. 2019
 - Testing system level concerns such as does power cycling the entire network have unexpected behaviors
 - 84 media nodes devices from 42 vendors plus 4 switch vendors

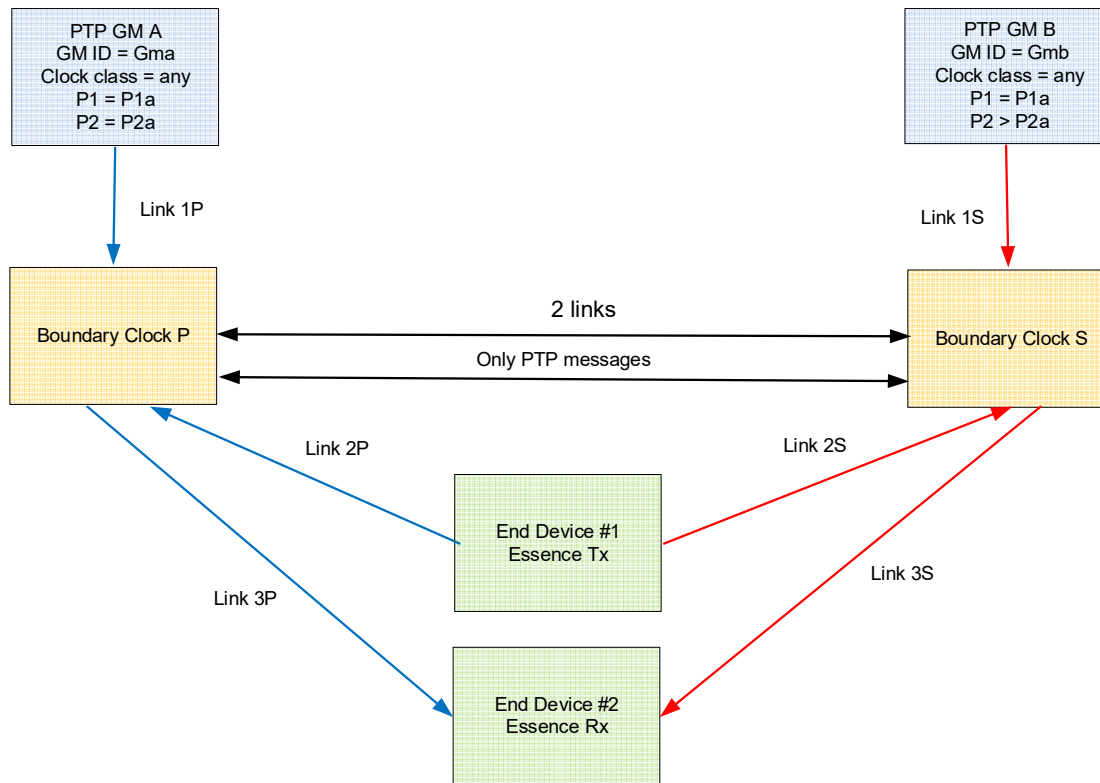
Recent Work in the Professional Broadcast Industry

- “JT-NM Tested” Event – March 2019
 - Some PTP and SMPTE 2059 tests

Active work in the Professional Broadcast Industry

- 1-year reviews of the ST 2059 and ST 2110 suit standards
- PTP over a ST 2022-7 Redundant network

ST 2022-7 Redundant Networks



For ST 2022-7

With the failure of 1 link,
1 switch or 1 GM, Rx can
still receive from Tx

All devices must lock to
same GM-ID

ST 2022-7 Redundant Networks

Media Node Requirements

- 2 or more interfaces
- Both interfaces are active
- Cannot have bridging between the interfaces
- Support ST 2022-7 for essence redundancy
- All devices must lock to same GM-ID

System Requirements

- Connections between the switches are allowed

Active work in the Professional Broadcast Industry

- PTP Security
 - SMPTE has an active Study Group
 - Gathering information from the other industries
- PTP in the cloud and VM
 - Both private and public cloud
- ST 2059 Workshop in Fall 2019
- ST 2110 PIC document
 - Is there/should there be a PTP PIC document?

Conclusions

- Professional Broadcast TV Industry is starting to adopt PTP
 - SMPTE ST 2059-1 and -2 Define PTP in the TV industry
 - SMPTE ST 2110 Define Essence Over IP
 - JT-NM TR-1001-1 Define Device Behaviors
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- Active work in the Professional Broadcast Industry
 - PTP over ST 2022-7 Redundancy Networks
 - Security
 - Cloud/VM
 - ST 2059 Workshop in Fall 2019



Thank You

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