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Why Time Synchronization essential in IP-based Media

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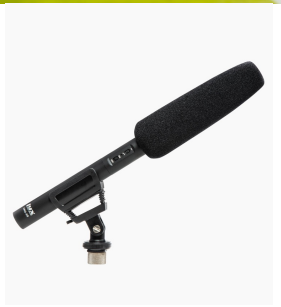
Meinberg

Why Time Synchronization is essential in IP- based Media?

- In many applications multiple audio, video and metadata essence are captured on separate equipment
  - Multi- cameras covering an event- requiring smooth transitions
  - Multi- microphones capturing various audio sources
  - Metadata - Closed caption, and color grading



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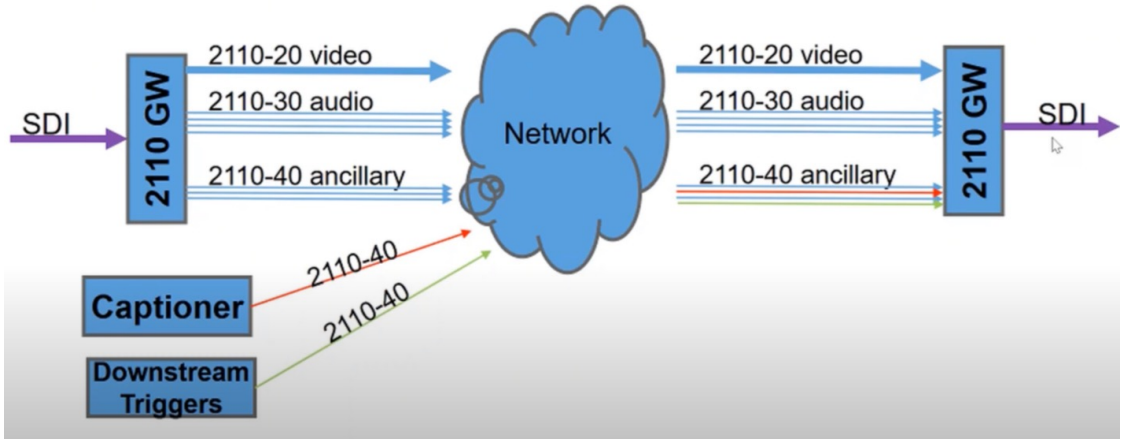
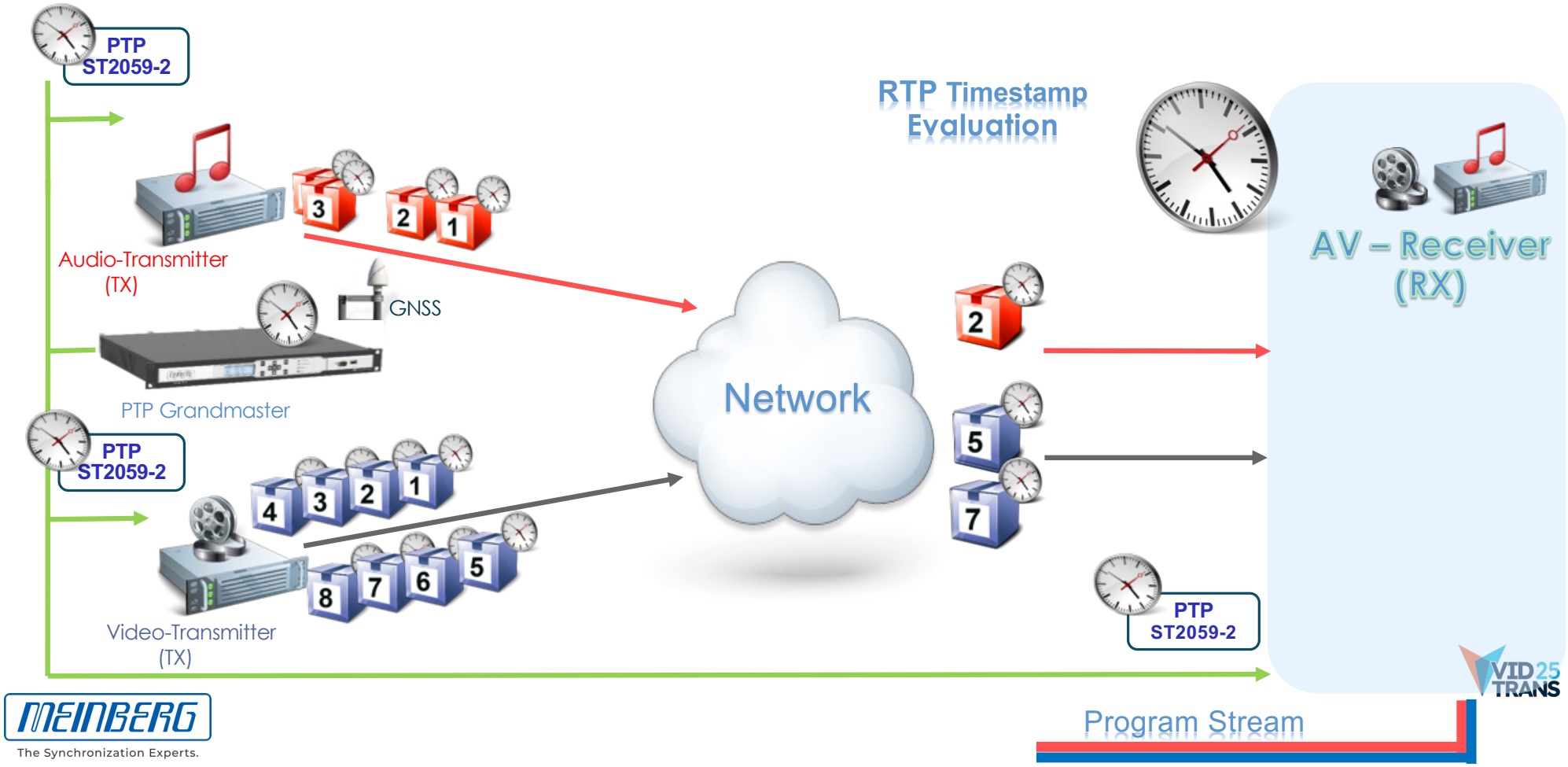
Why Time Synchronization essential in IP- based Broadcast Media?

- In Hybrid applications (SDI ➡ ST-2110 and visa versa), the Audio, Video and Metadata Essence are separated and Must be re-combined for Broadcast and streaming:
  - based on audio and video and metadata packet stamps:
    - Synchronizing video, audio, and Ancillary Essence streams
    - Generating ST-2110 RTP timestamps
    - Generating time code labels



Let's examine PTP in IP based TV Studio



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What Key challenges are solved using Time Synchronization in IP- based Media?

- Smooth video transitions among multi cameras, playback devices and other video sources
  - Prevent jitter and artifacts
  - Solves black frame / drop sync (Δ phase, Δ frequency)

- Audio- allows for proper lip-sync and phase alignment
  - Solves lip-sync issues (Δ timestamp)
  - Prevents audio dropout during switching
  - Prevents audio drifting
  - Prevents Pops and Crackling artifacts

- Metadata- Keeps Closed Caption and Subtitles in sync with the video
  - Color accuracy

Without Time Synchronization on the network…

- The result can be a combination of dropped video frames (black frames).
  - Video frames received out of order or out of alignment – causing Jitter
    - Caused by Network switch- packet optimization and network topology
      - Packets loss, buffering and latency
        - Side effect of Multicast- No acknowledgement or delivery guarantee

- Audio can completely drop during switching
  - Caused by Packets loss and network latency
- Audio drift (run-away)
  - Improper nodes buffering - (Constant bit- rate – ST 2110-22)
- Closed Caption will be out of sync with Video scenes
  - Colors mis-match between camera and sources

Types of Time Synchronization

Types of Time Synchronization

	*IRIG	NTP	PTP
Typical accuracy	1µs	1-10 > ms	<1µs
Network characteristics	Dedicated coaxial cables	LAN, WAN	LAN
Self-calibrating	No	Yes	Yes
Specialized hardware	Yes	No	Yes

*Inter-Range Instrument Group timecodes- Standards created by the Telecommunications Working group of the US Military

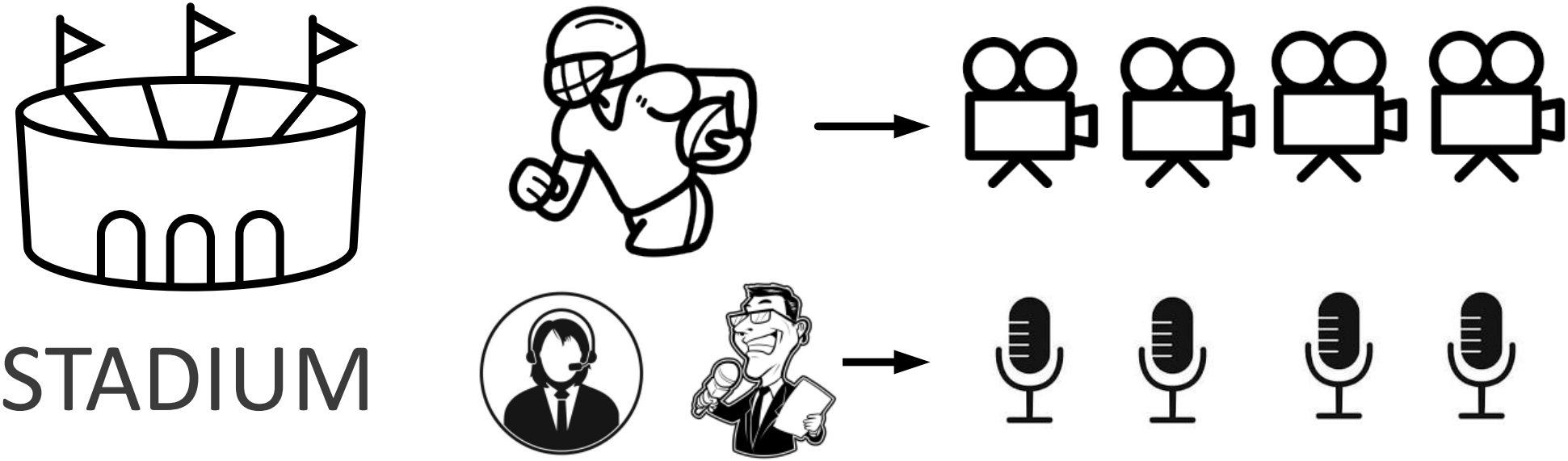
Timing accuracy
Specifications for the Broadcast Media

Timing and Synchronization requirements per SMPTE 2059-2 and JT-NM

(Joint Task force Network Media)

- For video and Mono audio: **~10ms**
- For Stereo audio : **~10µs**
  - **~ 1µs** – as recommended by Joint Task force Network Media Reference JT-NMReferenceArchitecturev1.0%20150904%20FINAL.pdf
- For multi camera synchronization raster sampling within = **~ 2 µs**
  - Reference JT-NMReferenceArchitecturev1.0%20150904%20FINAL.pdf
- Error budgeted to Network time distribution is typically **1µs**

Let’s look at a Super Bowl event example



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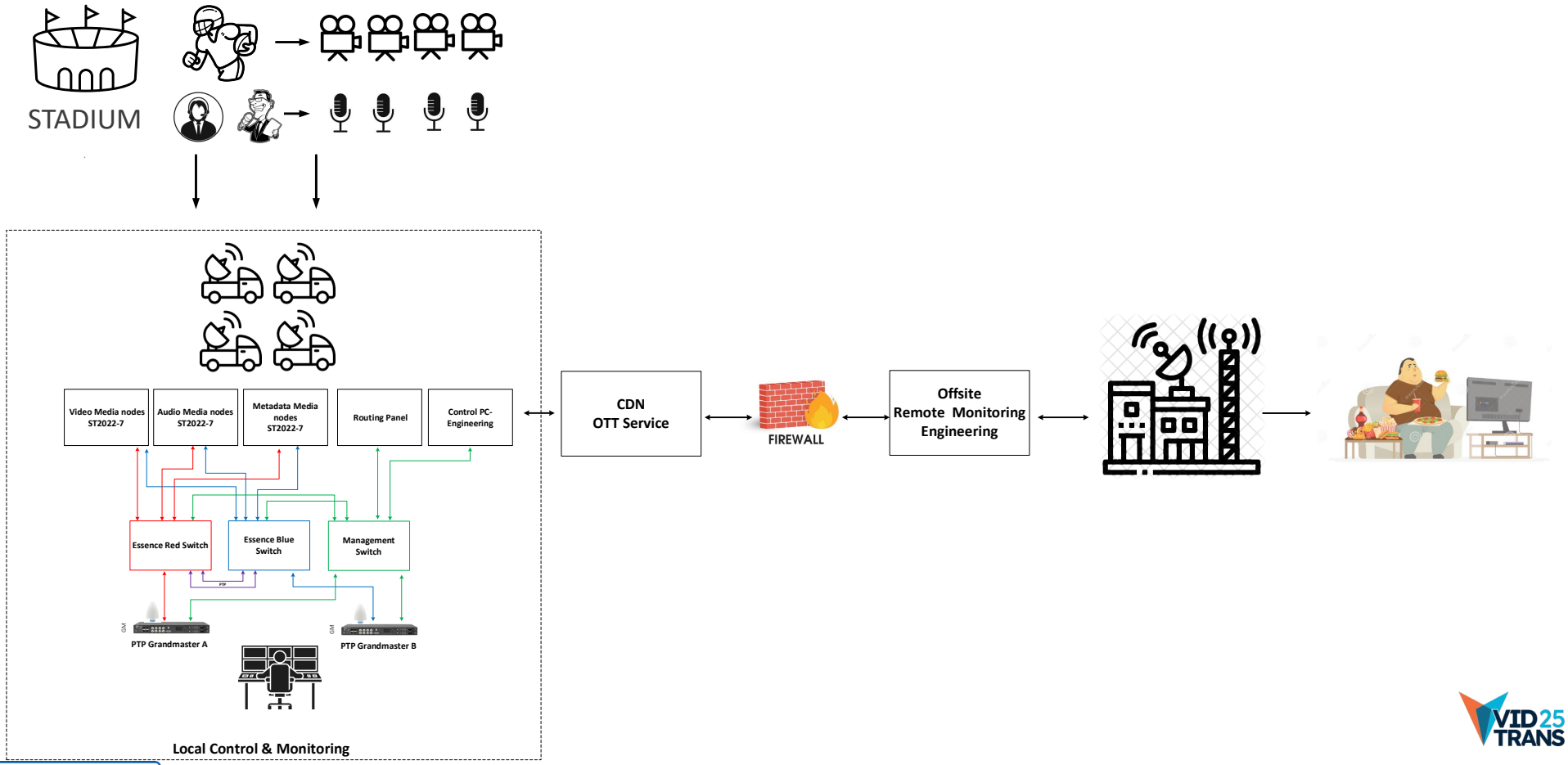
Super Bowl Game



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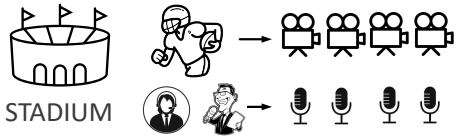
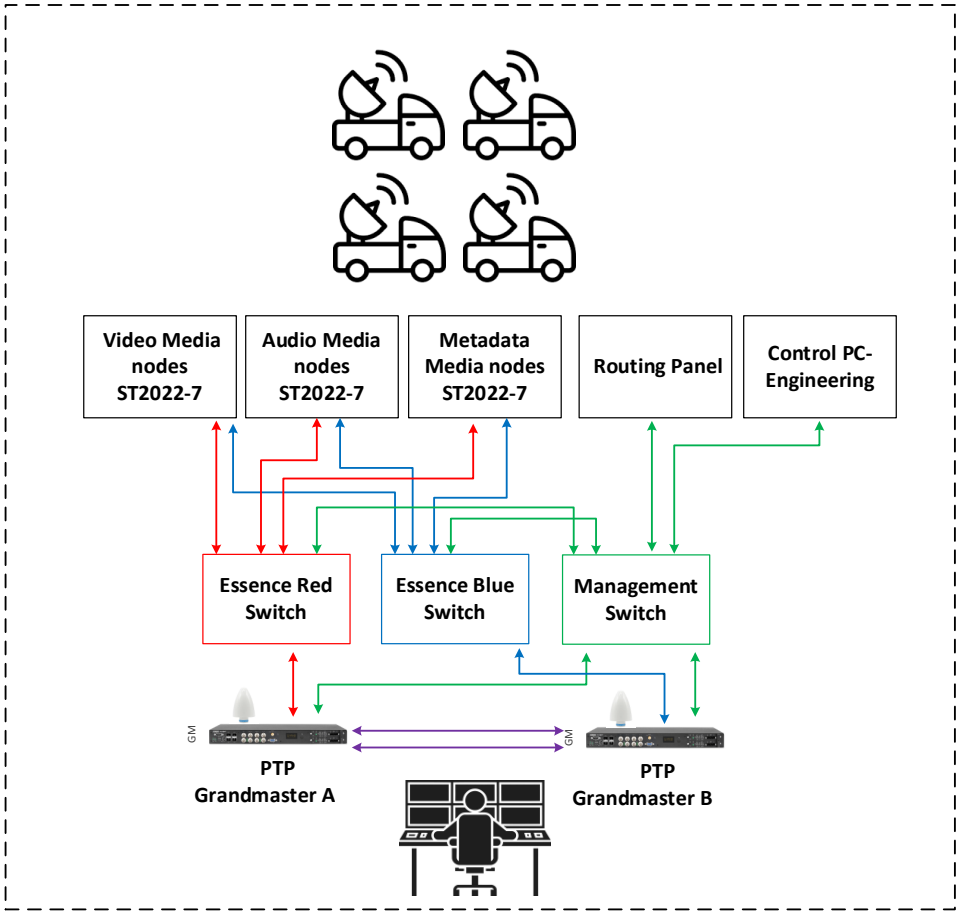
Super Bowl Game





Local Control & Monitoring

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High accuracy precision with PTP

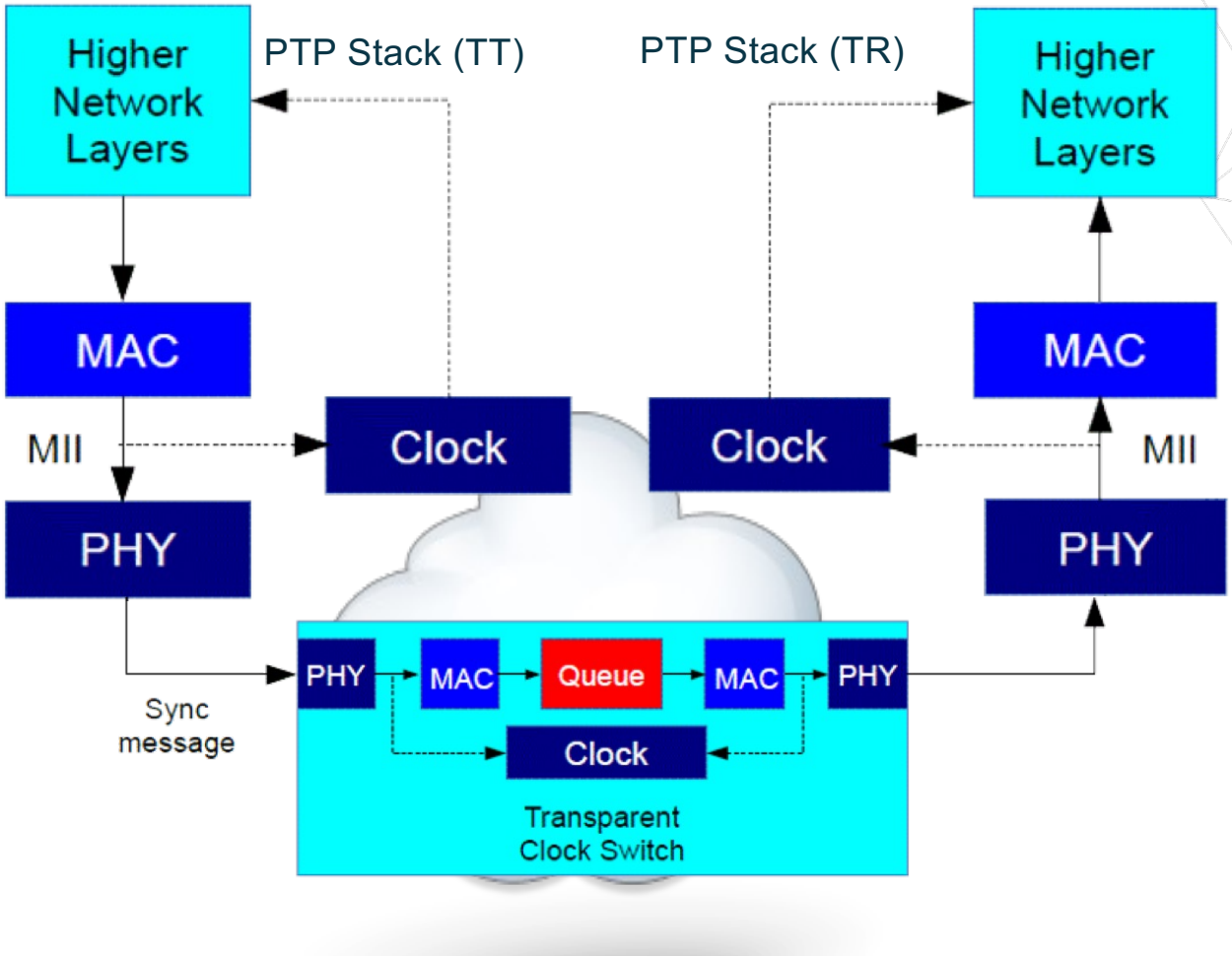
How is high accuracy ensured with PTP?

Answer:

Hardware time stamps

Network Interface Card

MII = Media Independent Interface



SMPTE 2059-2 Timing sequence

PTP Flow works – PTP Messages

“Announce”

+ Used to establish the synchronization hierarchy- BMCA
+ Provides the Clock status and Clock criteria used to determine which clock becomes the Grandmaster

“Sync and Follow up”

+ Transmitted by the Grandmaster and used by the Follower to derive the time

“Delay Request”

+ Request for timing information sent from the Follower to the Grandmaster in order to determine the propagation delay between the Follower and the Grandmaster

“Delay Response”

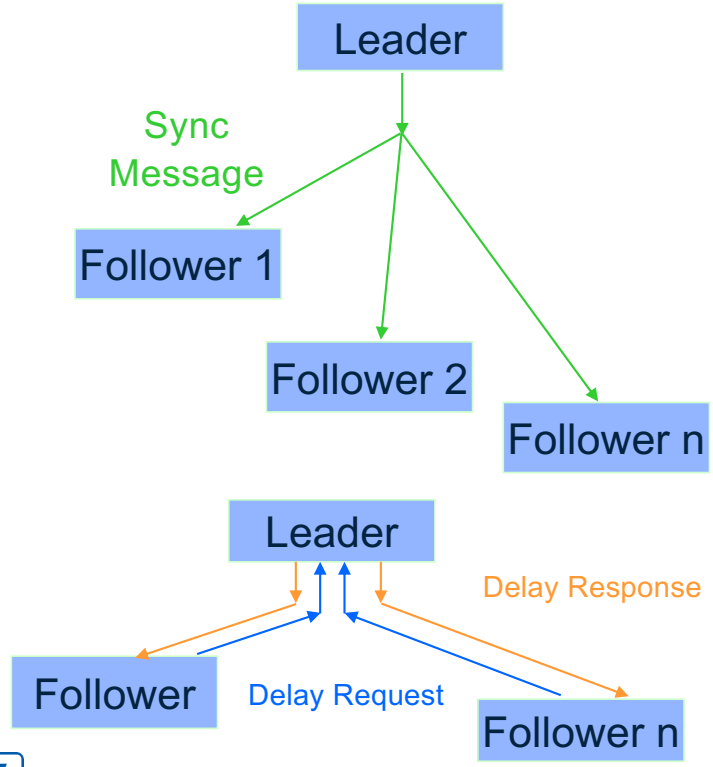
+ Time of receipt of Delay Request message sent by the Grandmaster back to the Follower.
    * Also known as end-to-end (E2E)

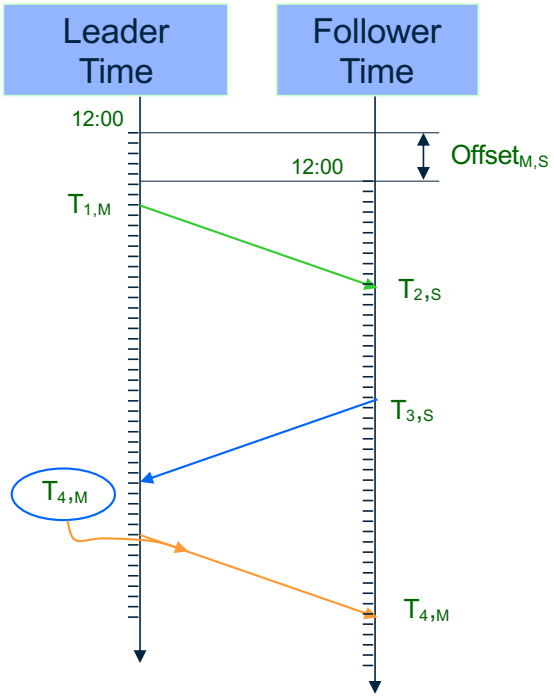
PTP Message Types

Name	Event Msg.	Purpose	Sent by
Announce		Advertise GM clock properties	Ports in master state
Sync	✓	Send time	Ports in master state
Follow-up		Precise timestamp for sync	Ports in master state
Peer Delay Request	✓	Delay measurement	All Peer delay ports
Peer Delay Response	✓	Delay measurement	All Peer delay ports
Peer Delay Response Follow-up		Delay measurement	All "two-step" Peer delay ports
Delay Request	✓	Delay measurement	"End-to-End" ports in slave state
Delay Response		Delay measurement	"End-to-End" ports in master state
Signaling		Unicast Negotiation	Unicast Ports
Management		Management, Monitoring	All Ports

PTP – Synchronization Principle

How does PTP ST-2059-2 timestamps, message sequence and synchronization principal work?





$$T_{2,S} - T_{1,M} = T_{2,1}$$
$$T_{4,M} - T_{3,S} = T_{4,3}$$

$$Offset = \frac{T_{2,1} - T_{4,2}}{2}$$

$$Delay = \frac{T_{2,1} + T_{4,3}}{2}$$

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What does a PTP Sequence look like?

1. M → S : SYNC

„It is 12:03:45.6653776“

2. M → S : FOLLOW-UP

„When I told you it is12:03:45.6653776, it really was 12:03:45.6658994 already!“ (521.8 µs later)

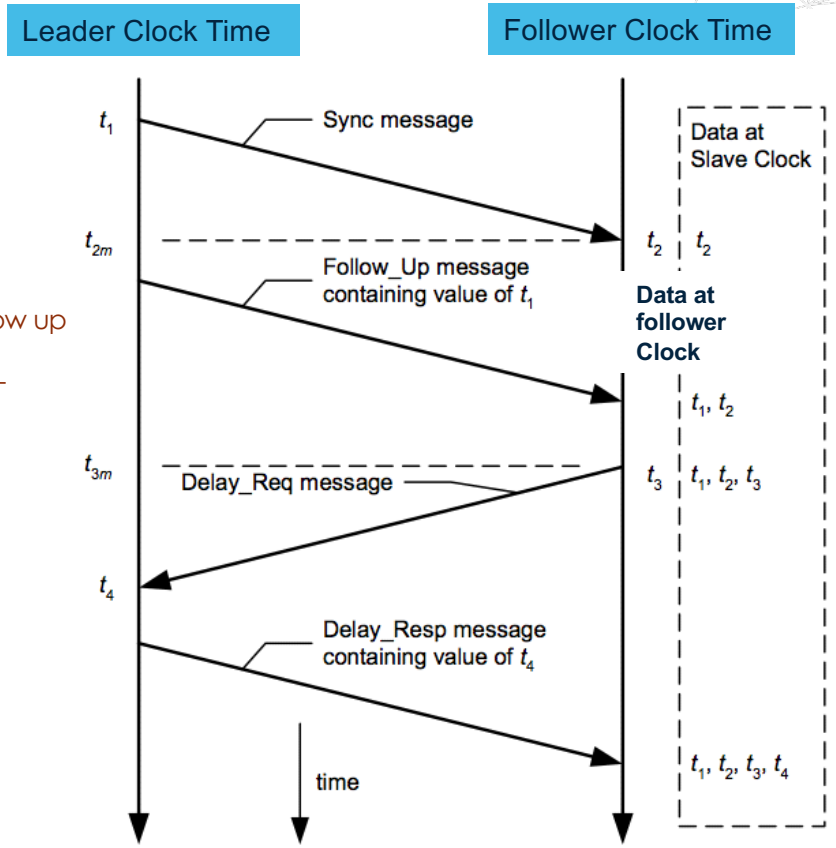
3. S → M : Delay Request

„Tell me, when you received this!“

4. M → S : Delay Response

„I got your message at 12:03:48.6726323“ (180.44ms later)!

Notes:
1. Announce, Sync and (optionally) Follow up are also sent from TT port to TR port
2. Peer delay messages are sent as non-forwardable, layer two frames



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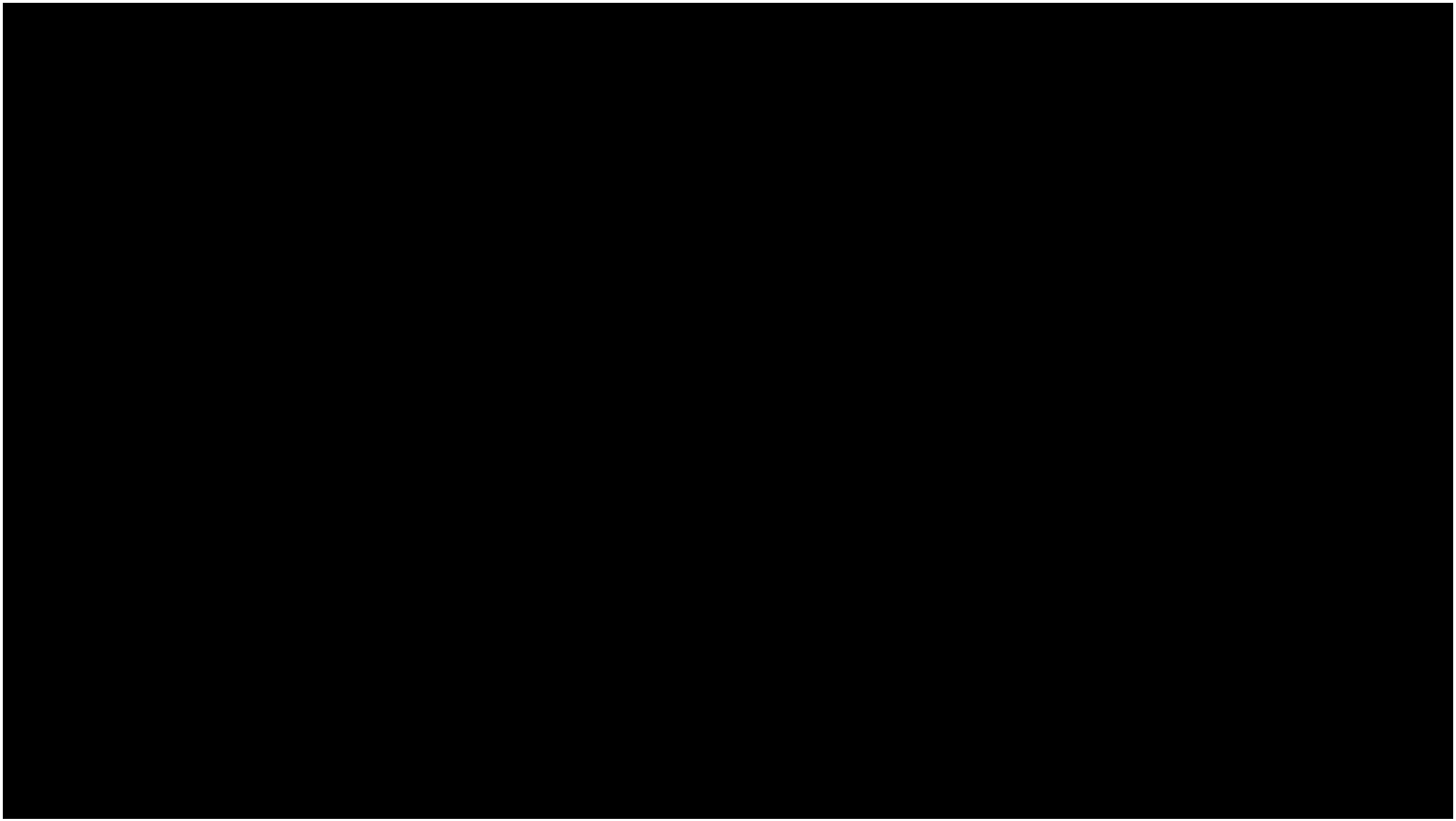

Questions?

Thank you

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