

Timing in Broadcast, Finance, Datacenters

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Agenda

- The need for packet timing in industry
- Broadcast (media)
- Finance
- Data centers



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Every technical industry

- Timing is always needed in distributed control systems and/or communication systems
- Moving to datacom/telecom networks for cost reasons

Past

- Industry specific network technology
- Industry specific timing signals, usually in dedicated timing networks

Present

- Mixture of past and future
- Datacom networks with legacy timing signals

Future

- Ethernet, WIFI, IP, 5G
- NTP and PTP for timing
- Driven by cost



Why time is essential in Broadcast and Media

- Multiple audio and video files captured on separate equipment
 - Must be recombined for broadcast or steaming based on audio/visual file timestamps
 - Need smooth transitions among cameras, playback devices and other audio-visual sources
 - Color accuracy
 - Prevent jitter and artifacts
- Timing requirements
 - For video and mono audio: ~ 10 ms
 - For stereo audio: $\sim 10 \mu\text{s}$
 - Error budgeted to network time distribution is typically $1 \mu\text{s}$.



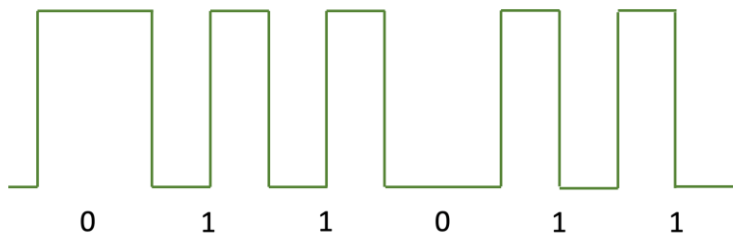
NBC Nightly News. Photo by Jeff Maurone

Legacy Broadcast timing signals

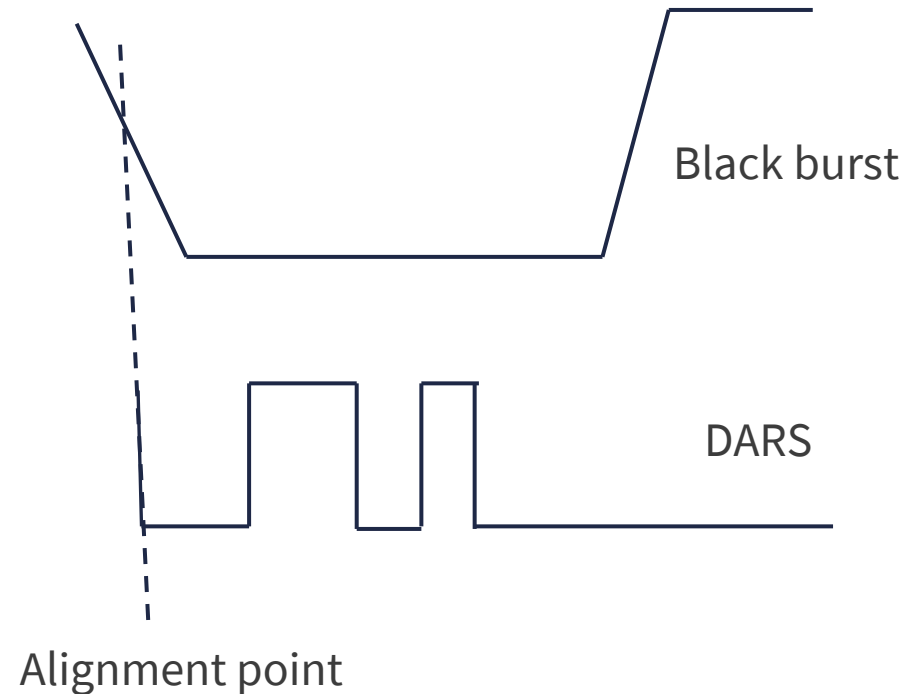
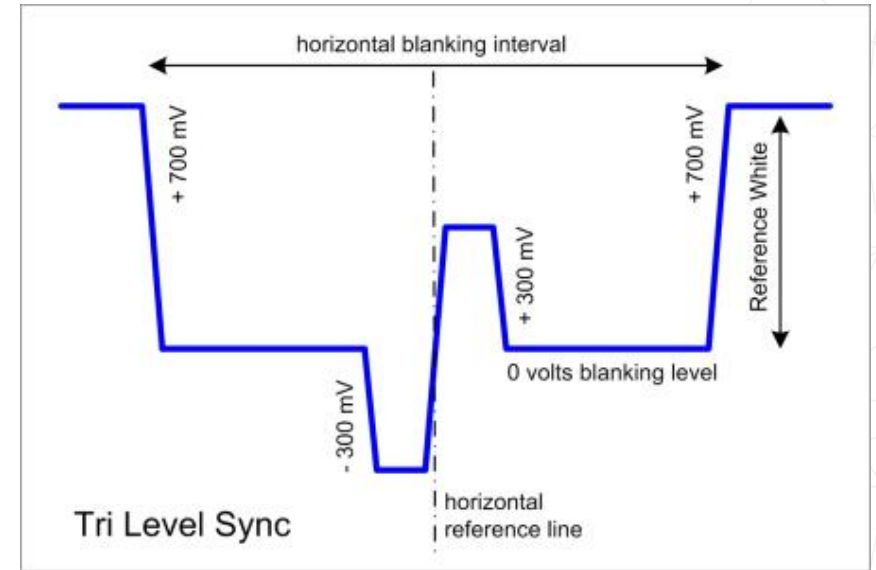
- Video signals
 - Black burst
 - Tri-level sync (supports HDTV)
- Audio signals
 - Word clock (square wave)
 - Digital Audio Reference Signal (DARS)

Genlock

- Linear time code
 - Used to insert timestamps in captured media



Linear timecode



Broadcast standards



- AES67: includes PTP Profile
 - Layer 3, E2E
 - Can be compatible with SMPTE ST2059-2



Image by RTFMASAP



- Society of Motion Picture and Television Engineers
- ST2059-2: PTP Profile
 - Layer 3, E2E
 - Announce TLV with timing metadata
 - Master/slave replaced by Leader/Follower, Grandmaster still Grandmaster

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Image by ZUMAPRESS.com/Newscom

IT in Finance Industry

- Enterprise IT technical viewpoint
 - IETF is where standards come from
 - Comfortable with non-standard approaches (Especially HFT firms)
 - Sometimes use non-standard NTP rather than PTP
- Regulatory compliance is mission critical
- Need time at software layer in standard hardware
 - PCIe cards
 - Software timeReceivers/clients
- HFT algorithms often implemented in FPGAs on PCIe cards

Timing Requirements in Finance

- To trade in the United States (Consolidated Audit Trail)
 - Financial transactions need to be timestamped to 50 ms by traders
 - 100 μ s by exchanges
 - To UTC:NIST
- To trade in the Europe (MiFID II)
 - Financial transactions need to be timestamped to 100 μ s
 - To UTC
 - Most trading firms do business all over the world, so they will need to meet the strictest time accuracy for
- HFT
 - To measure network performance, not for regulation
 - 1-50 ns



Image from QuoteInspector.com

Timing Protocols in Finance

- Default PTP Profile
- Enterprise PTP Profile
 - IETF RFC 9760
 - Mixed multicast/unicast operation (hybrid mode)
- Specialized NTP
 - High message rates, Lucky packet filters, Hardware timestamping
- High Accuracy PTP for HFT
 - For example, White Rabbit Project implementations



Image by FMT

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Timing Requirements in Data Centers

- To make data synchronization in distributed databases more efficient
 - Fewer messages needed required to harmonize DB copies if time sync < latencies between copies
 - Commit-wait time reduced, increasing storage bandwidth
 - Typically want $\sim 10 \mu\text{s}$
 - Future requirements will be tighter
- Other distributed applications might need timing
 - For example, distributed AI training
- Cloud vendors starting to host infrastructure for finance
 - Must meet CAT and MiFID II requirements



Image by cloudwatt

Timing technology in Data Centers

- PTP or NTP
 - PTP with or without on path support
 - Often engage in leap smeared NTP
 - Add inserted second gradually by slowing down clocks for a period of time
 - Easier or more efficient to mess up time then change DB software to handle leap seconds



Image by Bob Mical

- Open Compute Project (OCP)
 - Industry consortium for sharing open software, hardware and best practices
 - OCP-TAP: time appliance project (open timecard design)
- Stateless client-server PTP
 - Works similar to NTP
 - Standards project: IEEE 1588.1

Thank You!

If you have questions:

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The Synchronization Experts.