# Timing in Broadcast, Finance and Power

WSTS 2021

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# Agenda

1. The need for packet timing in industry
2. Broadcast
3. Finance
4. Power
5. Industrial Automation
6. Automotive

Bonus Industries!

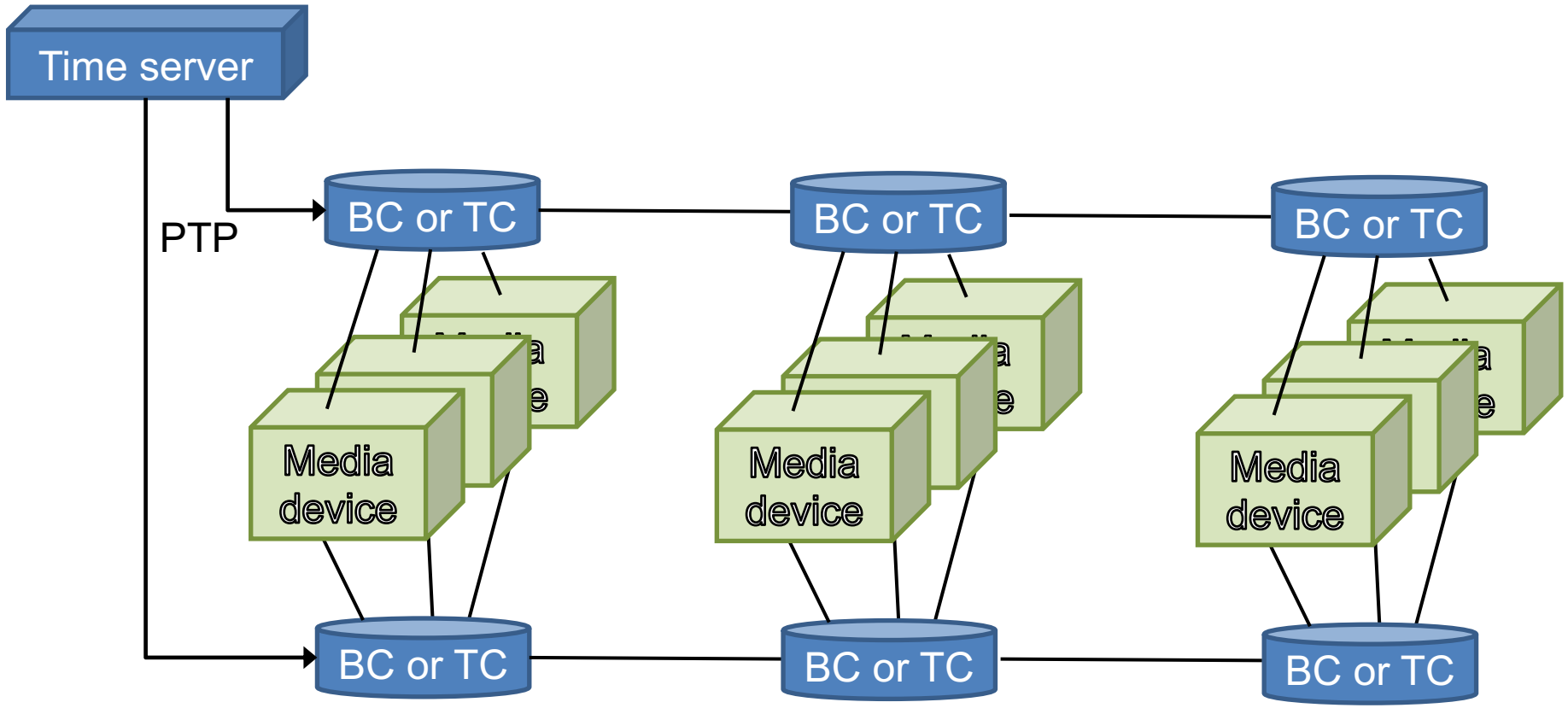
# Every technical industry

- Timing is always needed in distributed control systems and/or communication systems
- History
  - Industry specific network technology
  - Industry specific timing signals, usually in dedicated timing networks
- Present and future
  - Datacom based networks
    - Ethernet, Wifi, IP
    - NTP and PTP for timing
    - Driven by cost

# Need for timing in Broadcast

- Audio and video captured separately
  - Audio and visual captured separately
- Broadcast audio visual presentation built from files on multiple servers
  - One or more audio streams (15 $\mu$s requirement)
  - One or more video streams
- Need ~ 1 $\mu$s from packet timing

# Redundant Broadcast networks



# PTP Profiles for Broadcast

- SMPTE ST2059-2 Profile
  - Society of Motion Picture and Television Engineers
  - Mapping: IPv4 or IPv6
  - Multicast
  - Delay request-response
  - Master ports send signalling message with timing meta data needed by legacy timing infrastructure
- AES67 Media Profiles for PTP timing
  - Audio Engineering Society
  - Similar to SMPTE ST2059-2
  - Does not have timing metadata message

One of the SPMTE Defined test patterns

# Finance Industry

- Enterprise IT technical viewpoint
  - IETF is where standards come from
  - Comfortable with non-standard approaches (Especially HFT firms)
- Regulatory compliance is mission critical
- Need time at software layer in standard hardware
  - PCIe cards
  - Software slaves/clients

# 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 µs by exchanges
  - To UTC:NIST
- To trade in the Europe (MiFID II)
  - Financial transactions need to be timestamped to 100 µs
  - To UTC
  - Most trading firms do business all over the world, so they will need to meet the strictest time accuracy for
- HFT
  - 50 ns – 500 ns
  - To measure network performance, not for regulation

# MiFID II

- Timestamp accuracy (100 µs)
  - Allows government regulators to identify illegal trading activity
  - Standard NTP software can barely meet this with a local timeserver
  - PTP or Specialized NTP preferred
- Archive data
  - Need to prove compliance on past dates
  - Government audits
- Measurements
  - Desire to prove timing accuracy of slaves/clients

# Timing Protocols in Finance

- Default Profile PTP
- Enterprise Profile PTP
  - Draft RFC in IETF
  - Mixed multicast/unicast operation (hybrid mode)
- Specialized NTP
  - High message rates
  - Lucky packet filters
  - Hardware timestamping

# Challenges of Today's Power Grids

- Clean energy sources: power generation varies with weather
  - solar
  - wind
- Grid operators often required to buy excess energy from customers with clean energy production
  - These sites sometimes generate energy, sometimes need energy
- Demand response
  - Balance energy flows
  - Turn generators on and off
  - Turn large loads on and off, e.g. air conditioning

# Timing in the Power Grid

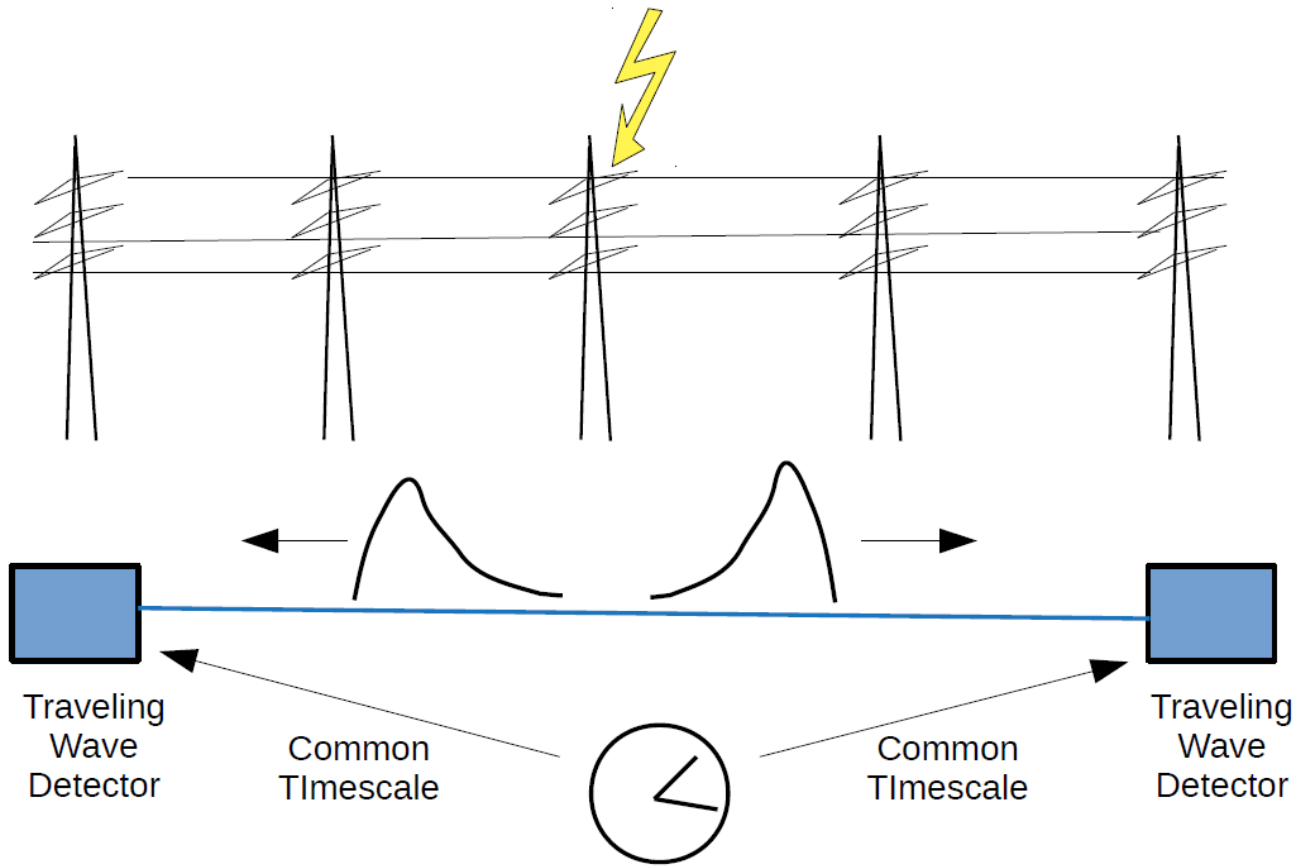
| Function | Purpose of timing | Accuracy required |
|---|---|---|
| Control Room | Log file coordination | 1 second |
| SCADA system | Grid wide monitoring and control | 1 ms |
| Synchrophasors | Measurements more precise than SCADA system. Monitor grid stability. Predict faults | 1 $\mu$s |
| Travelling wave fault detection | Location of faults to within 100s of meters Improves maintenance efficiency | 300 -1000 ns |

The use of precise timing in power system networks reduces blackouts and allows the grid to be more efficiently monitored and controlled.

Timing used in:

- Intelligent Electronic Devices (IEDs)
- Synchrophasors, also called Phase Measurement Units (PMUs)
- Merging units
- Protective Relays

# Travelling Wave Fault Detection

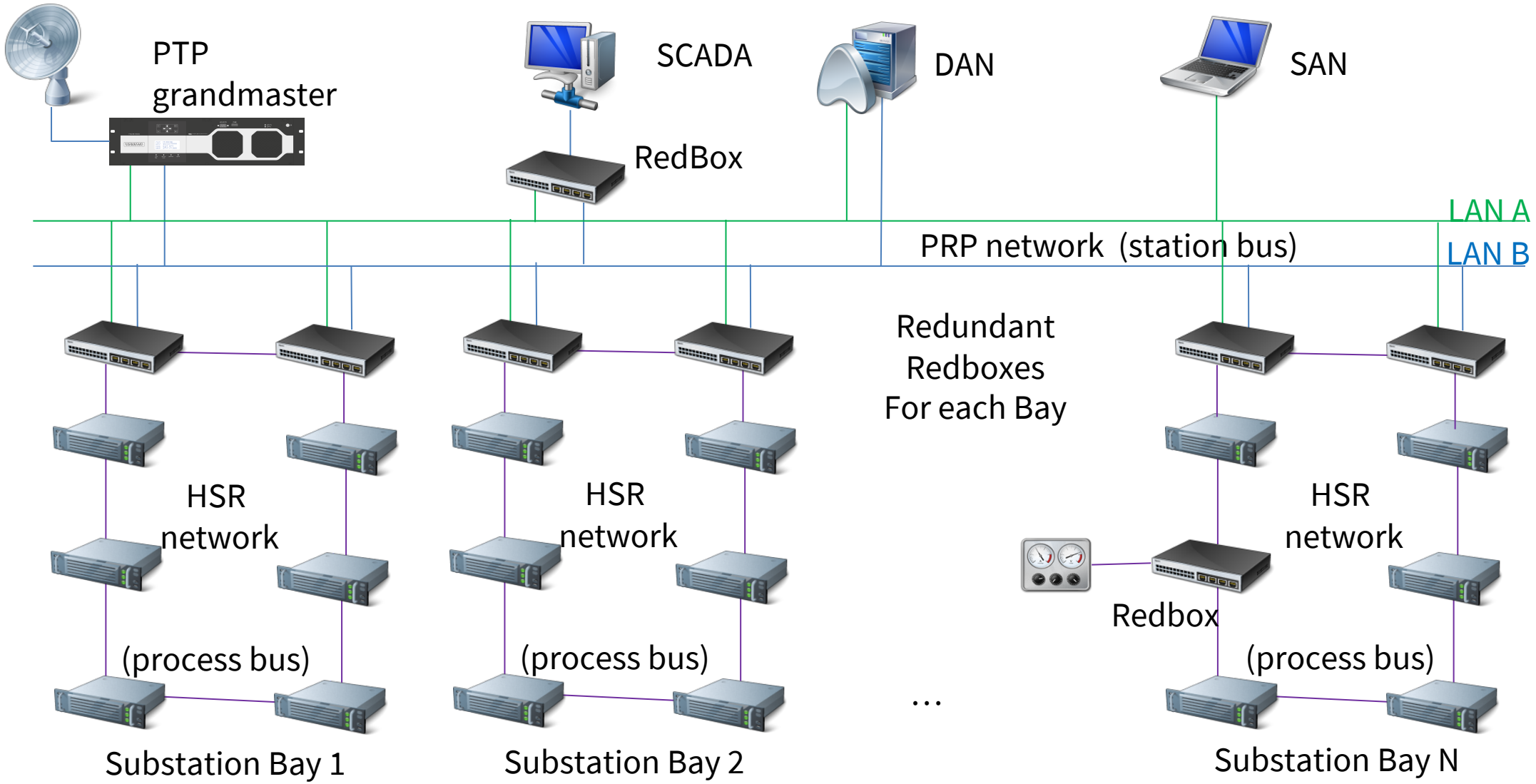



- 300 ns precision ~ 100 m location error
- Repair crews can spend less time finding the damaged equipment

# Power Industry Standards

- IEC 61850-9-3, Utility Profile
  - Layer 2
  - peer delay
  - Defines mappings for HSR and PRP (redundant layer 2 networks)
- IEEE C37.238, Power profile
  - Utility profile ++
  - Inaccuracy TLV, so PTP slaves can know received time accuracy
    - Requires support  by BCs and TCs (optional in standard)
  - Uses reserved domain number 254
    - Achieves isolation from other PTP profiles
    - Violates IEEE 1588

# Combined HSR and PRP network in a substation



# Bonus Industries:
# Timing in Industrial Automation and Automotive

Thanks to Rodney Cummings for help with these industries

# Industrial Automation

- Timing needed to coordinate cyber physical system
  - Sensors -> Controller -> Actuators
  - For example, assembly line robots
- Networks
  - Legacy CAN bus, RS45
  - Ethernet
  - Order of 1000 nodes
  - Many sensors and actuators are simple two port switches
  - Up time critical
  - Integration with 5G networks in near future

# Industrial Automation timing requirements

- Timing agreement ~ 1 us
  - No need for standard time, often no GNSS
  - Redundant PTP domains
- Standards
  - Profile IEEE 802.1AS
    - Layer 2, peer delay, Non filtering BCs with cumulative rate ratio
  - IEC/IEEE P60802
    - Time sensitive network profile for Industrial Automation
    - Profile of IEEE 802.1 TSN standards

# Automotive

- Timing needed to coordinate ~ 100 controllers in car
- Networks
  - Moving away from CAN bus and flexRay to Ethernet
  - Moving away from multiple networks to one network
  - Interact with 5G in future
- Timing
  - No need for standard time until 5G communications added
  - Want simplified PTP
    - No BMCA
    - Fixed port states
- Standards
  - 802.1DG PTP Profile and traffic shaping


# Thank you for your attention

For more information please feel free to contact:
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