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Leading the world in precise time solutions.

Profile for Use of IEEE 1588™ Precision Time Protocol in Power System Applications

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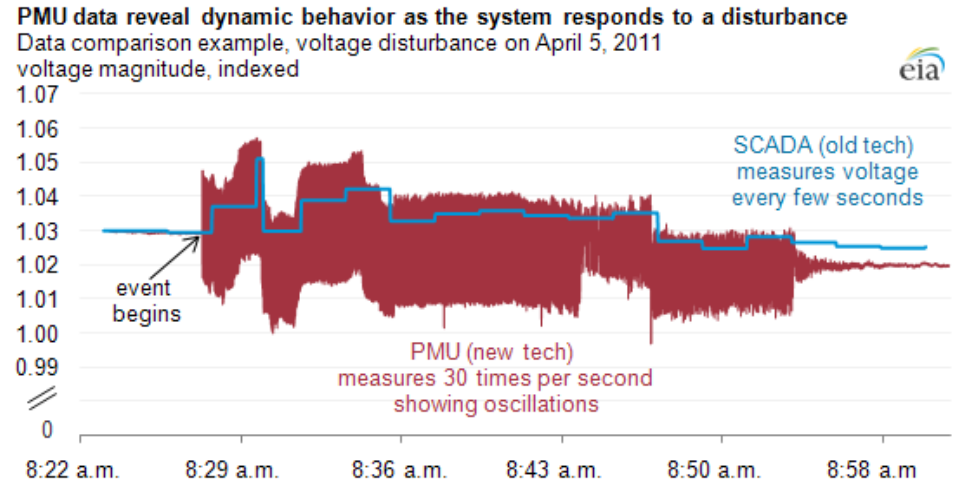
March 26, 2013

Agenda

1. Precise time in Power Systems
2. Introduction the Precision Time Protocol
3. Profile for PTP in Power Systems
4. Summary

Why are Synchrophasors Needed?



High-speed precision measurements provide information that SCADA data cannot provide.

SCADA → Synchrophasor

=

X-Ray → MRI

SCADA - Supervisory Control and Data Acquisition

Why are Synchrophasors Needed?

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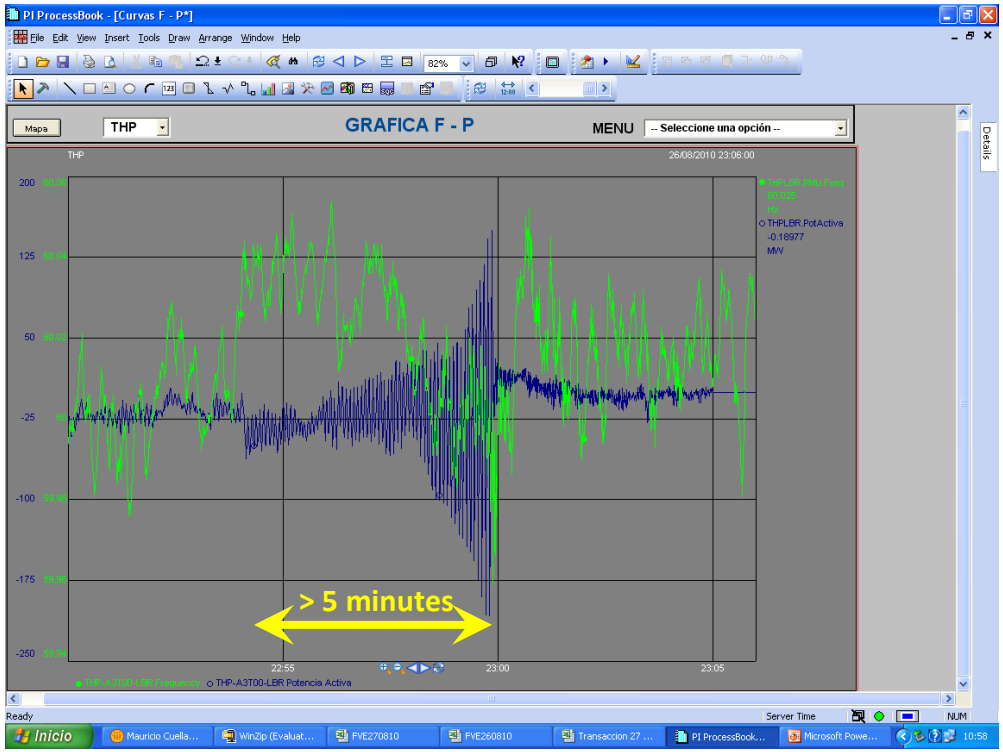
Actual Mexico-Guatemala Tie Line Event



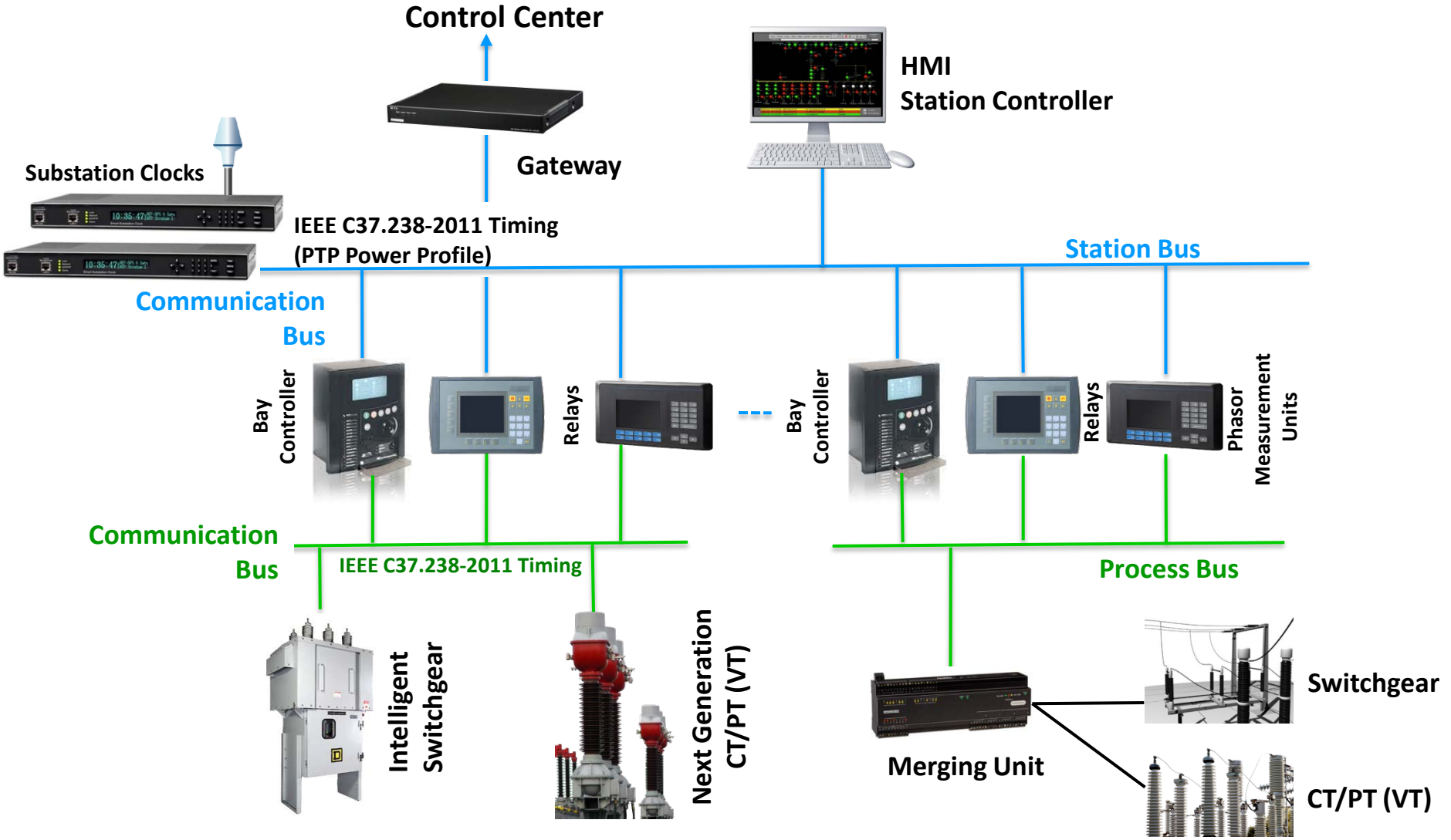
If the data can be transformed into information that enables operators to make faster more accurate decisions, the benefits to reliability are tremendous.

Precise **time synchronized** measurements are **essential** to transforming the data into information

SISCO SYSTEMS INTEGRATION SPECIALISTS

IEC 61850 Smart Substation: Industrial Ethernet Infrastructure With PTP

NO INDEPENDENT TIMING DISTRIBUTION



Synchrophaser Timing Requirements

From IEEE C37.118.1-2011, IEEE Standard for Synchrophasor Measurements for Power Systems

A phase error of 0.57 degrees (0.01 radian) will by itself cause 1% Total Vector Error (TVE) … This corresponds to a time error of **±26 µs** for a **60 Hz** system and **±31 µs** for a **50 Hz** system.

A time source that reliably provides time, frequency, and frequency stability **at least 10 times better** than these values corresponding to 1% TVE is highly recommended.

Bottom line: **±2.6 µs** for 60 Hz and **±3.1 µs** for **50 Hz**

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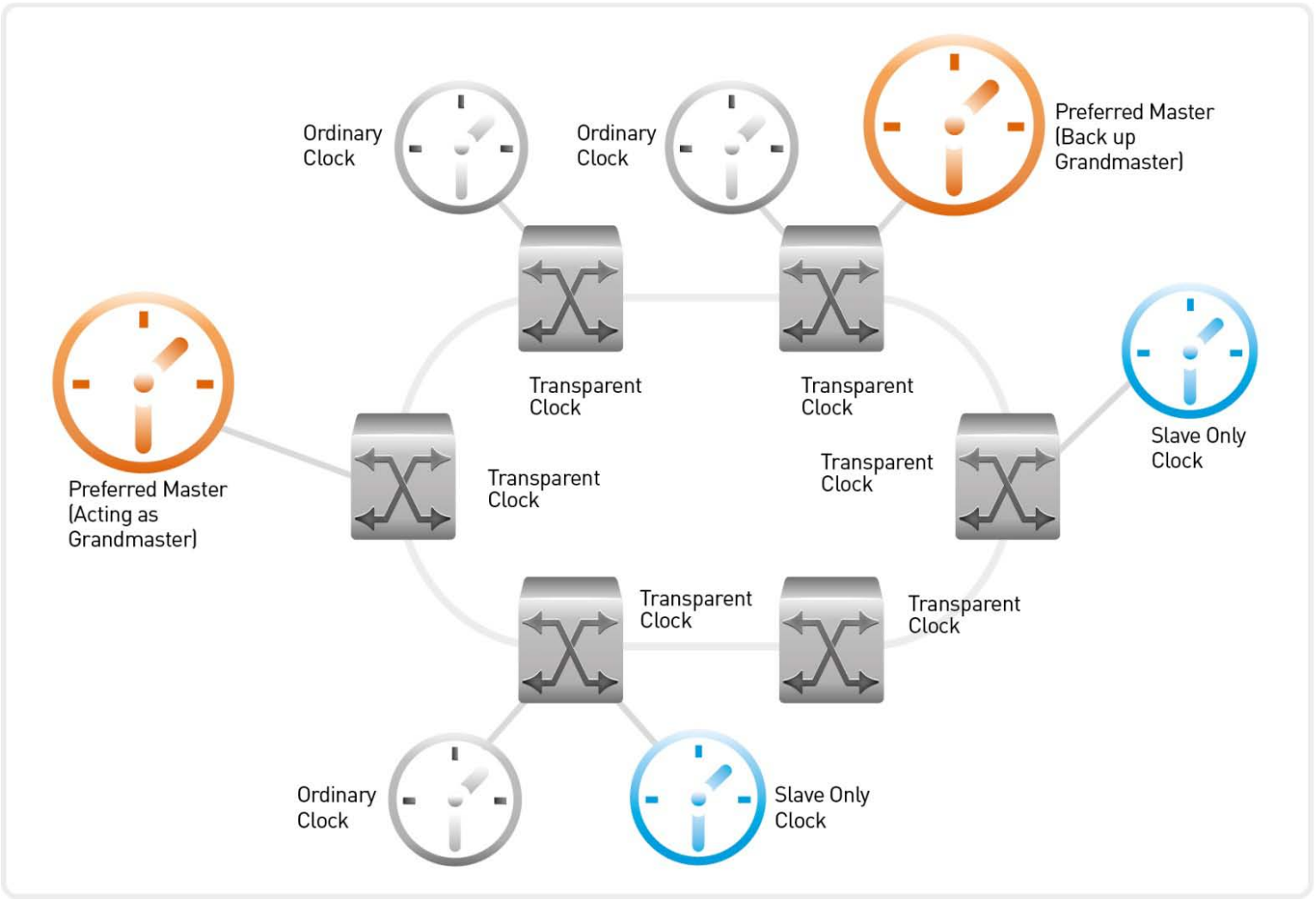
Time Transfer Technologies

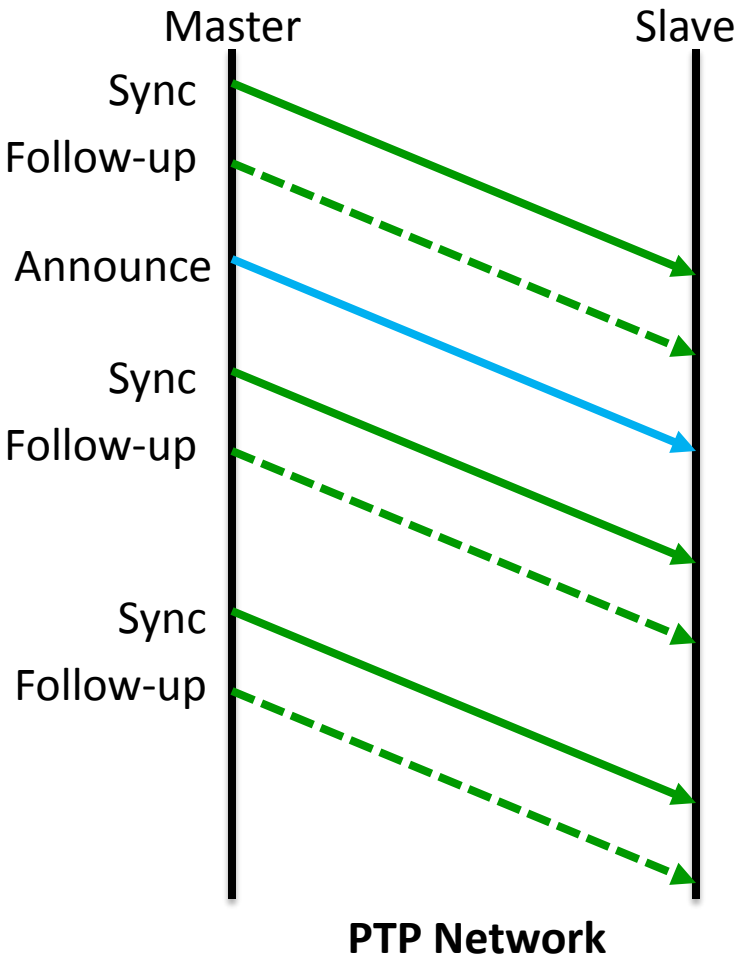
	IRIG-B	(S)NTP	PTP
Accuracy (typical)	1-10µs	1ms – 10 ms	100ns-1µs
Transport media	Dedicated cables	Ethernet cables	Ethernet cables
Protocol style	Master-slave	Client-server	Master-slave
Built in latency correction	No	Yes	Yes
Set-up	Configured	Configured	Self-organizing, or configured
Update intervals	1 second	Minutes	1 second
Specialized hardware	Required	No	Required
Redundant masters for N-1 contingency	No	Yes	Yes

What a network looks like to PTP

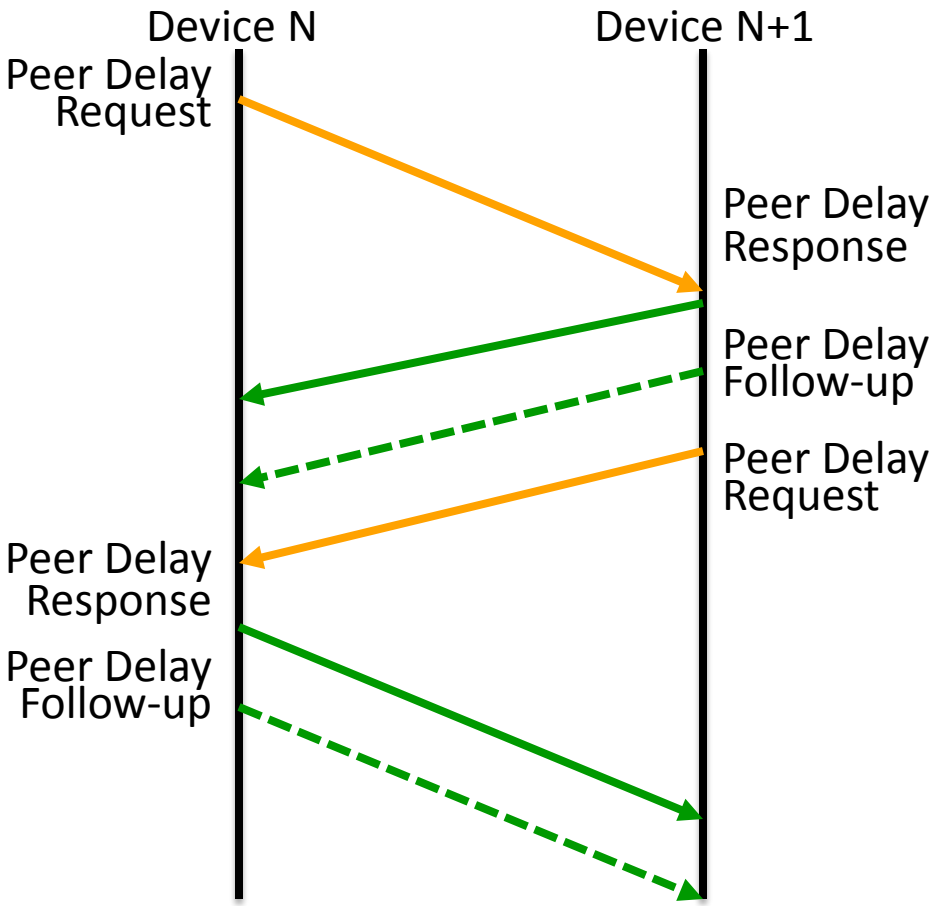


PTP Message Sequence

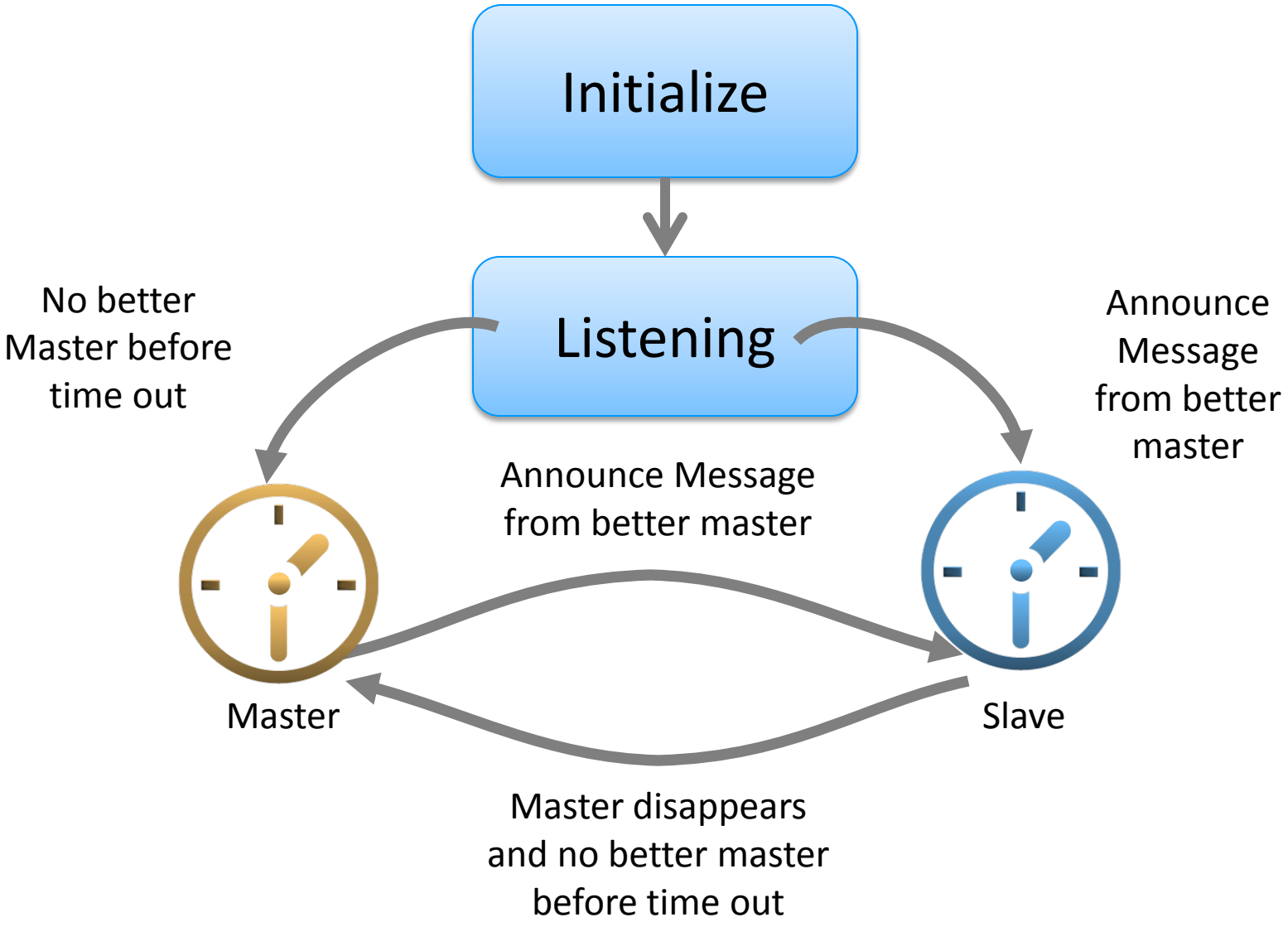
Master to Slave



Adjacent Devices



An Ordinary Clock Wakes Up



Selecting the Best

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National Football League Division Champion Tie Breakers

1. Head-to-head (best won-lost-tied percentage in games between the clubs).
2. Best won-lost-tied percentage in games played within the division.
3. Best won-lost-tied percentage in common games.

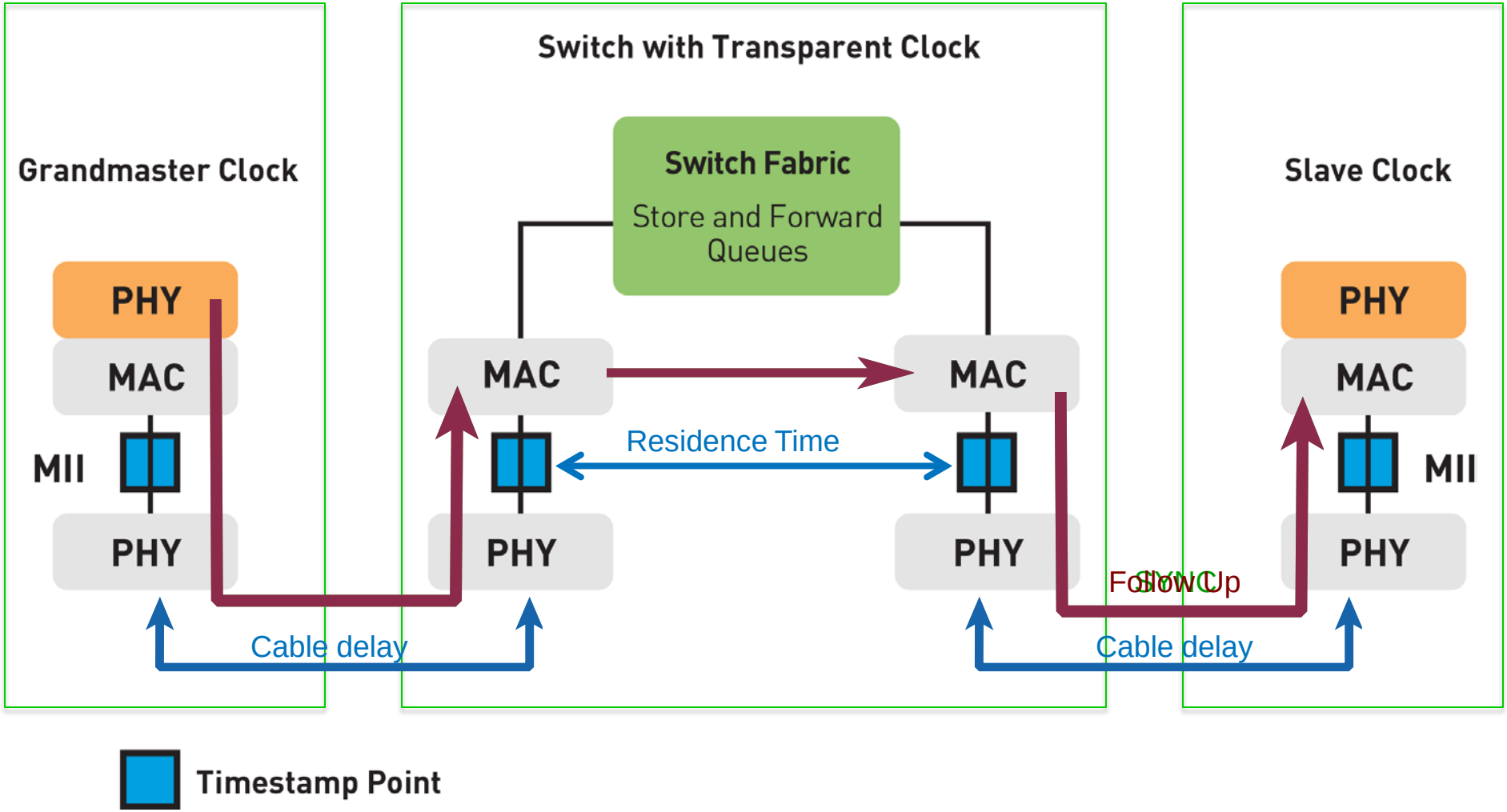
…

10. Best net points in all games.
11. Best net touchdowns in all games.
12. Coin toss

Best Master Clock in PTP

1. Priority 1 Field
   - User configurable
2. Clock Class
   - Got GPS?
3. Clock Accuracy
   - E.g. 100 ns
4. Clock Variance
   - Frequency Stability
5. Priority 2 Field
   - User Configurable
6. Clock ID
   - Must be unique
   - Often MAC address

Transparent Clock



Total delay = cable delays + switch residence time

PTP Profiles

- PTP options
  - Many optional features
  - Works over many network types
  - Used in several different industries
  - Interoperability between PTP enabled devices is not guaranteed!
- Profiles
  - More restrictive set of rules for specific application
  - Specifies:
    - Required options
    - Allowed options
    - Forbidden options
    - Network topology limitations

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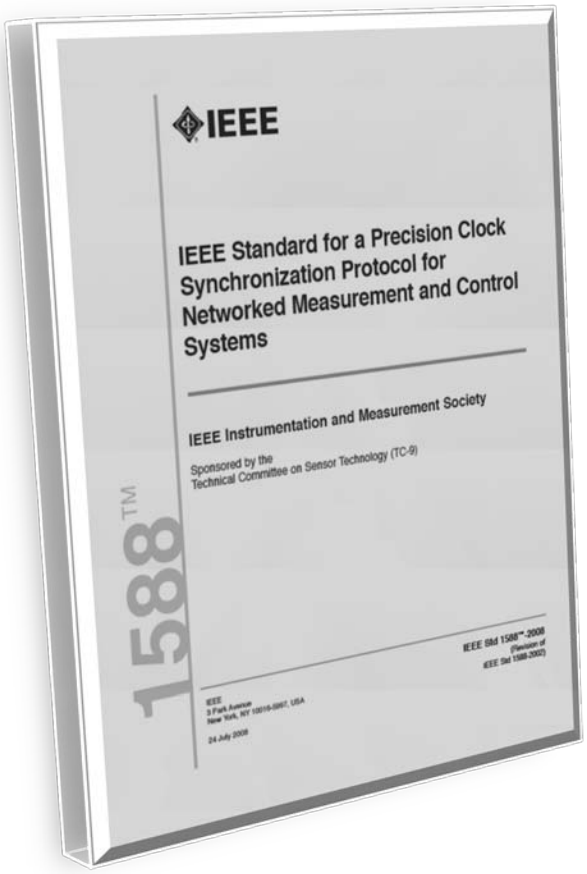
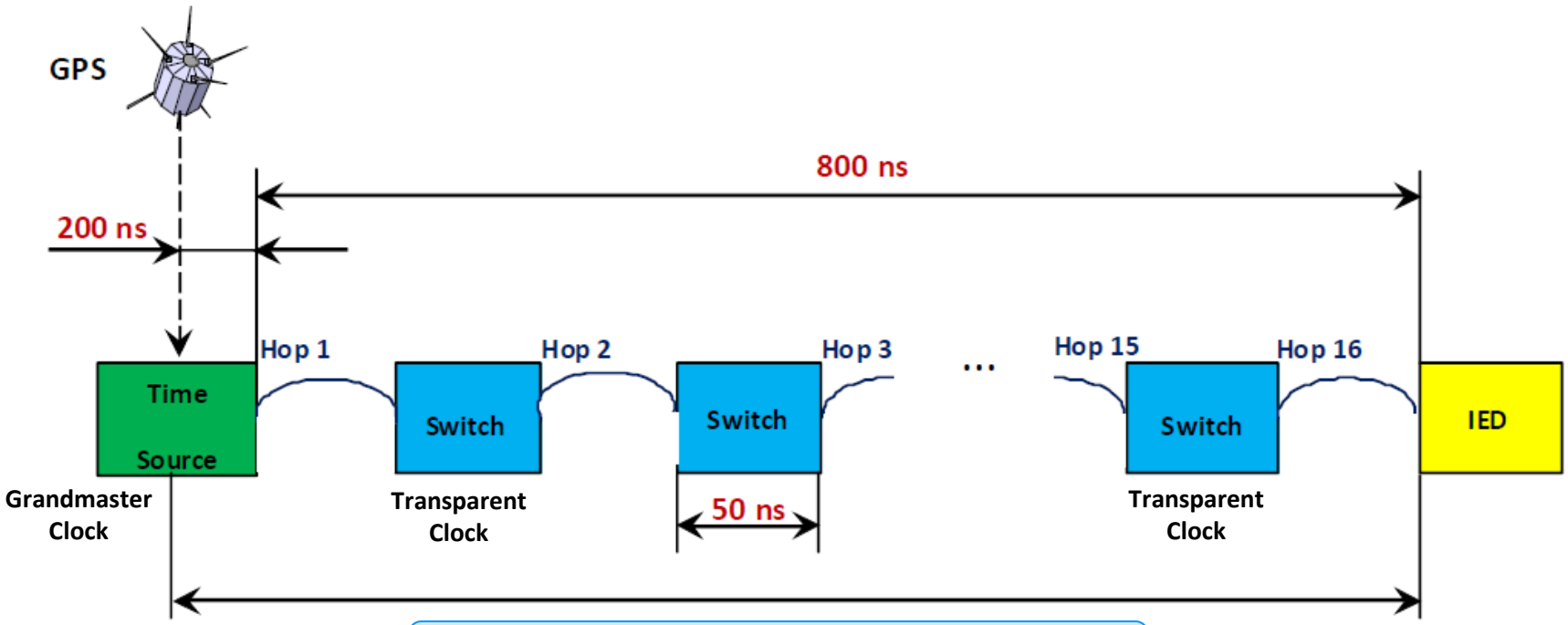
IEEE 1588 Power Profile Standard 2011



- IEEE C37.238-2011 Standard
  - Profile for IEEE 1588 Precision Time Protocol in power system applications
- Profile Characteristics:
  - LAN (Layer 2 Ethernet Mapping)
  - Multicast addressing only
  - Peer-to-peer delay measurement
  - Switches are Transparent Clocks
  - Time transfer accuracy and holdover time defined
- IEC 61850 will add C37.238-2011 as a requirement in the future.
- http://standards.ieee.org/findstds/standard/C37.238-2011.html

PTP Power Profile



1 microsecond time accuracy, < 16 hops

PTP Power Profile delivers microsecond timing in the Smart Substation

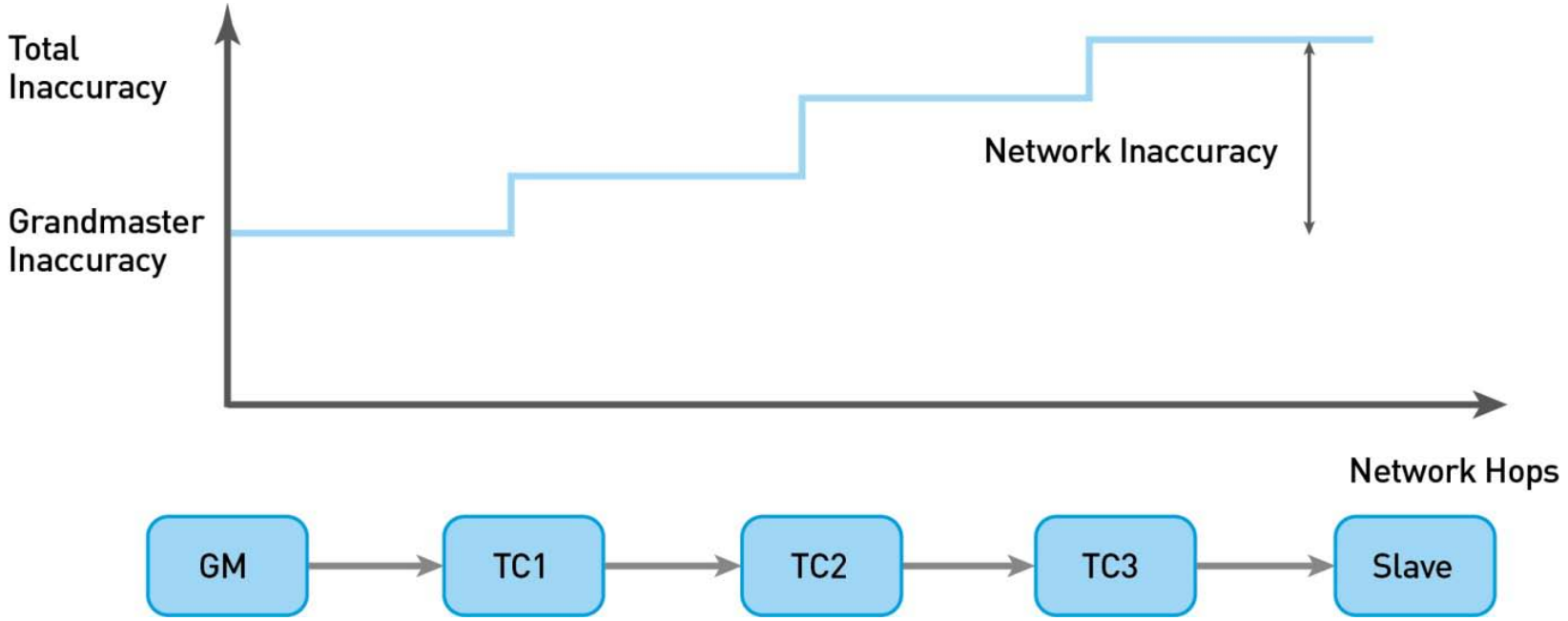
The Rules

- Required:
  - Ethernet Layer 2
    - HSR, PRP allowed
  - All switches support peer to peer timing mechanism
    - Usually transparent clocks
  - Priority fields set to 128 for GM capable devices
  - Power Profile TLV
  - SNMP MIB for GM capable devices
  - 802.1Q VLAN tags
- Allowed:
  - Clock types
    - Preferred Master clocks
    - Ordinary clocks
    - Slave only clocks
    - Transparent clocks
    - Boundary clocks
  - One step and two step clocks
- Forbidden:
  - Internet Protocol (Layer 3)
  - End to end delay measurement
  - Alternative time scales

Message Rates

Message	Interval or trigger
Announce	1 second
Sync	1 second
Follow-up (2-step clocks only)	Triggered by Sync Message
Peer Delay Request	1 second
Peer Delay Response	Triggered by Peer Delay Request
Peer Delay Response Follow-up (2-step clocks only)	Triggered by Peer Delay Response

Inaccuracy



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Future of Power Profile

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- IEEE 1588
  - Study Group formed to craft requirements for revision
  - New optional features
  - New network mappings
    - Explicit support for HSR and PRP?
- C37.238 Addendum
  - Clean up minor errors
  - SNMP MIB and VLAN tags optional?

- Significant investment by equipment manufacturers and silicon vendors means that **maintaining backwards compatibility will be top priority**

Take Aways

- PTP Power profile designed to meet the time synchronization needs of PMUs and other IEDs
  - 1 us over 16 switches.
- Key benefits of PTP (IEEE 1588)
  - Time over the data network
  - Cable delays automatically calibrated
  - Self-organizing
  - Fault tolerant
- Power Profile
  - Switches are Transparent clocks
    - Using peer to peer delay measurements
  - Message rates of once per second
  - Message carry 802.1Q Ethernet tags
  - Announce message carries maximum inaccuracy information

SGC-1500 Smart Grid Clock

- Multiple GigE ports
- GPS timing receiver
- PTP Power Profile GM
- PTP Telecom Profile slave*
- Secure management
- NERC CIP compliance
- IRIG-B, DCF-77, pulse rates, 10MPPS output timing ports
- T1/E1, Fiber optic, Open collector outputs
- Rubidium oscillator option
- IEC 61850-3, IEEE 1613 hardened

**Additional information on the PTP Telecom Profile is available on the Symmetricom website (recorded webinar and white paper.)*

Thank you.

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