Navigating Advanced Features of PTP to Enable Higher Timing Accuracy and Security in Complex Networks

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

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Agenda

- Why is improving accuracy and security for PTP important
- What tools are the latest PTP standards releases enabling
- Accuracy enhancements and implementations
- Security enhancements and implementations
- Conclusions and future direction

Why is Improving Accuracy and Security for PTP Important

- **Our collective mission is to <u>generate</u>, <u>distribute</u>, and <u>apply</u> timing and synchronization**
- **IEEE® 1588 PTP is primarily a <u>distribution</u> technology**
- **Critical application questions:**
  1. Is it accurate enough
  2. Is it secure enough

IEEE® 1588 PTP Standards

- **IEEE® 1588-2019 Precision Time Protocol (PTP)**
  - IEEE 1588a-2023 Amendment introduces a new TLV to enable increased timing accuracy in complex networks
  - IEEE 1588 four-prong security model for PTP network deployments

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IEEE 1588a-2023 Amendment Highlights

- **TLV Extension for Enhanced Accuracy Metrics**
  - Improved path selection for BMCA
- **Error models for quantifying path error components**
  - Quantifies total path error for TLV Extension

Why Is the Enhanced Accuracy TLV Needed?

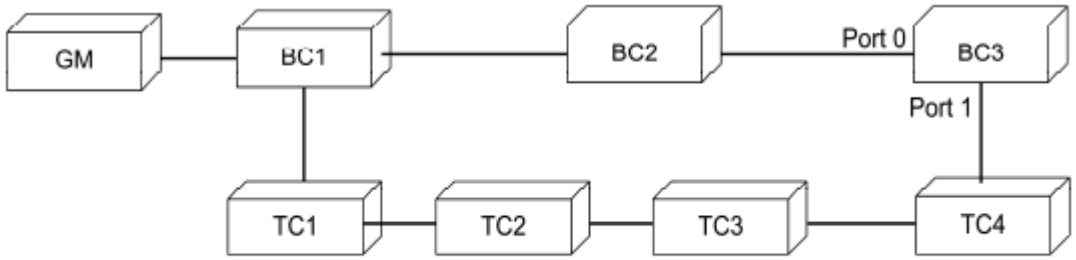

Figure P2.1—Behavior of the default BMCA in a network with a chain of TCs

- **Issue 1: The default BMCA does not count TCs as a hop**
  - BC3 sets port 1 as slave even though the path goes through a larger number of element hops (TCs)

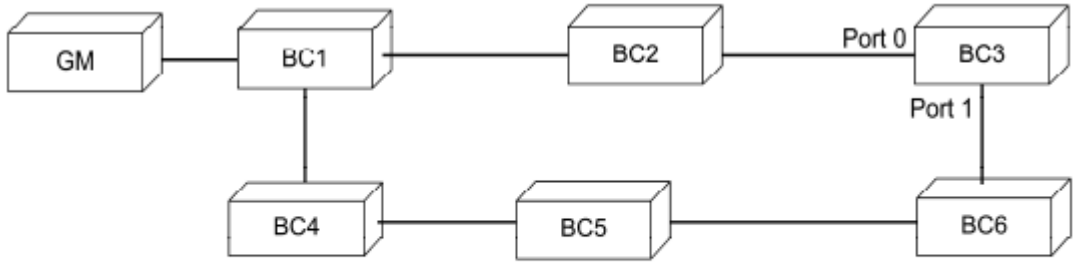

Figure P2.2—Behavior of the default BMCA in a network with chains of BCs providing different synchronization performance.

Source IEEE Std 1588a-2023

- **Issue 2: The default BMCA picks the lowest hop count, but not all BCs are equal**
  - BC4/BC5/BC6 path has lower total error than the BC2 path, but BC3 sets port 0 as slave due to lower hop count

BMCA – Best Master Clock Algorithm
TC – Transparent Clock
BC – Boundary Clock

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Enhanced Accuracy TLV Error Components

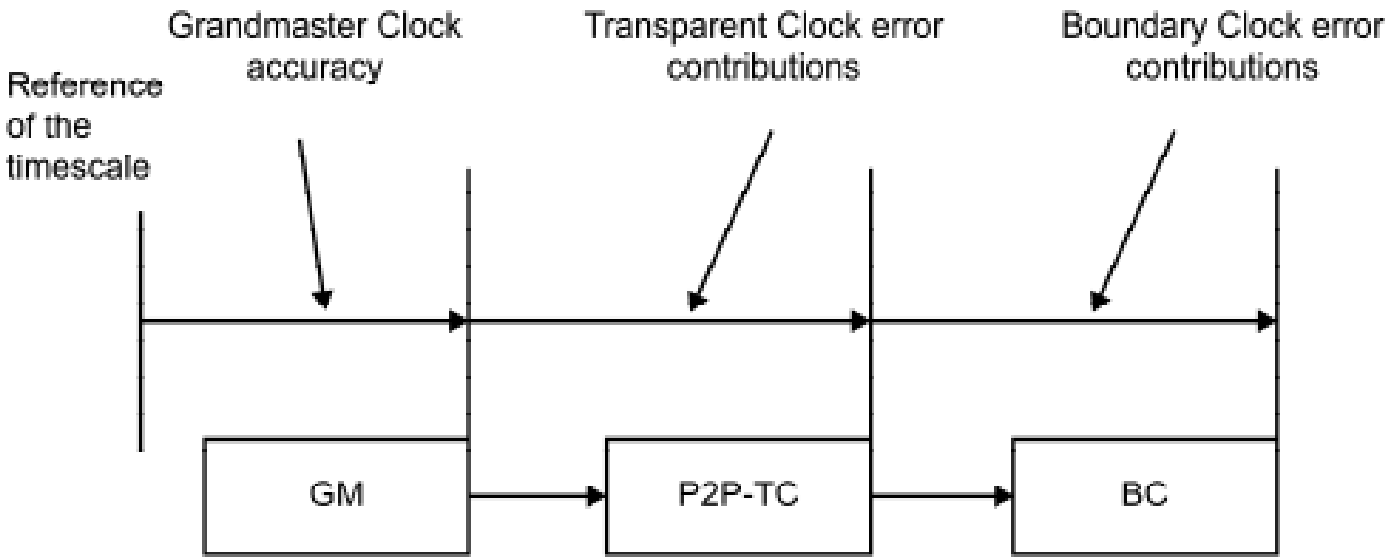

Figure 46—Contribution of the various PTP Instances to metrics in the TLV

Source IEEE Std 1588a-2023

- **The TLV includes two groups of components**
  - GM component
  - Distribution components
- **Error components are categorized as transient or steady state (dynamic and static)**

Enhanced Accuracy TLV Format

- **Enhanced Accuracy TLV is included in the GM announce message**
  - Adds TC hop count and various transient, dynamic, and static error estimate fields
  - TLV aware distribution elements update as the TLV message is propagated forward

Table 130 —ENHANCED_ACCURACY_METRICS TLV format

Bits								Octets	TLV offset
7	6	5	4	3	2	1	0		
tlvType								2	0
lengthField								2	2
bcHopCount								1	4
tcHopCount								1	5
exclusionFlags ~~Reserved~~								2	6
maxGmInaccuracy								8	8
varGmInaccuracy								8	16 [a]
maxTransientInaccuracy								8	24 [a]
varTransientInaccuracy								8	32 [a]
maxDynamicInaccuracy								8	40 [a]
varDynamicInaccuracy								8	48 [a]
maxStaticInstanceInaccuracy								8	56 [a]
varStaticInstanceInaccuracy								8	64 [a]
maxStaticMediumInaccuracy								8	72 [a]
varStaticMediumInaccuracy								8	80 [a]

Source IEEE Std 1588a-2023

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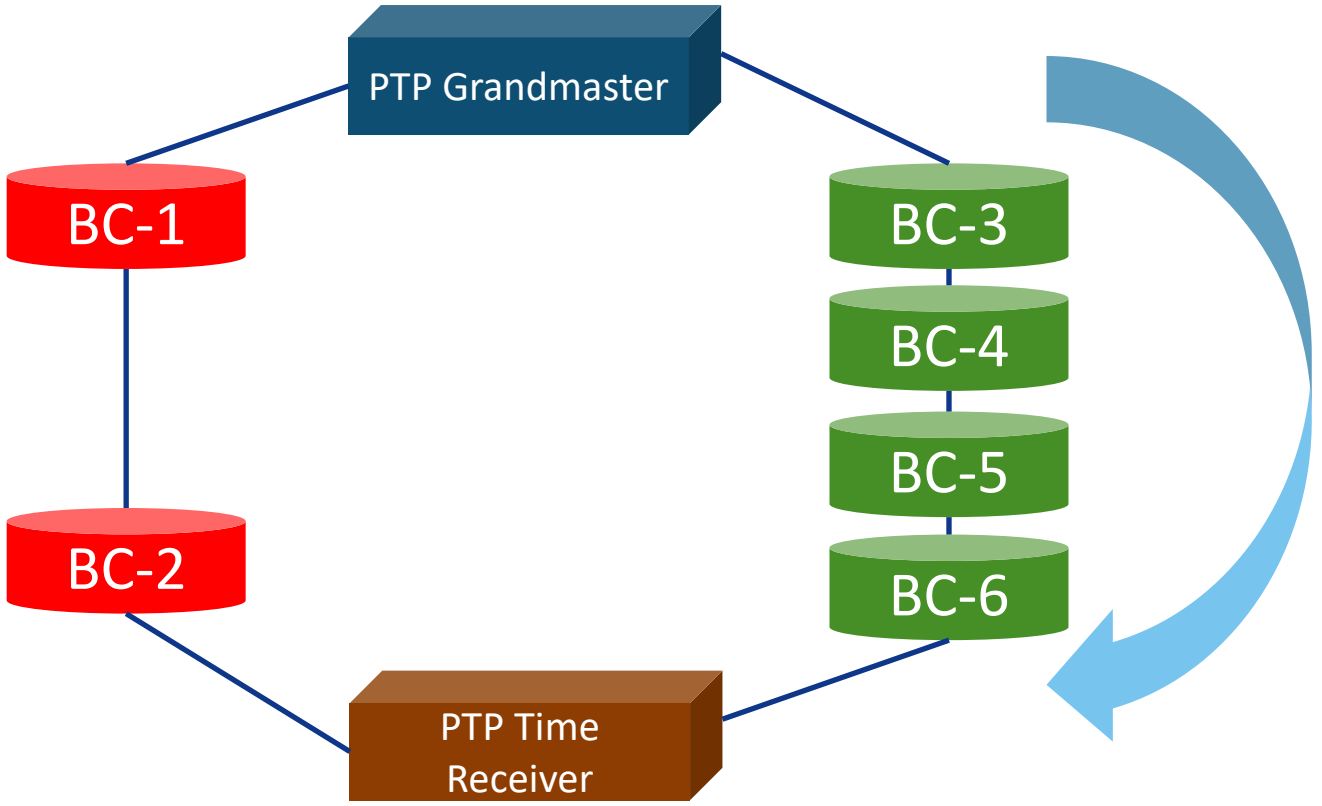
Key Benefit of the Enhance Accuracy TLV

Low precision class A BCs provide the less accurate path (100ns per hop)



High precision class D BCs provide the most accurate path (5ns per hop)

Enables the BMCA to select the most accurate path rather than the path with the fewest hops.

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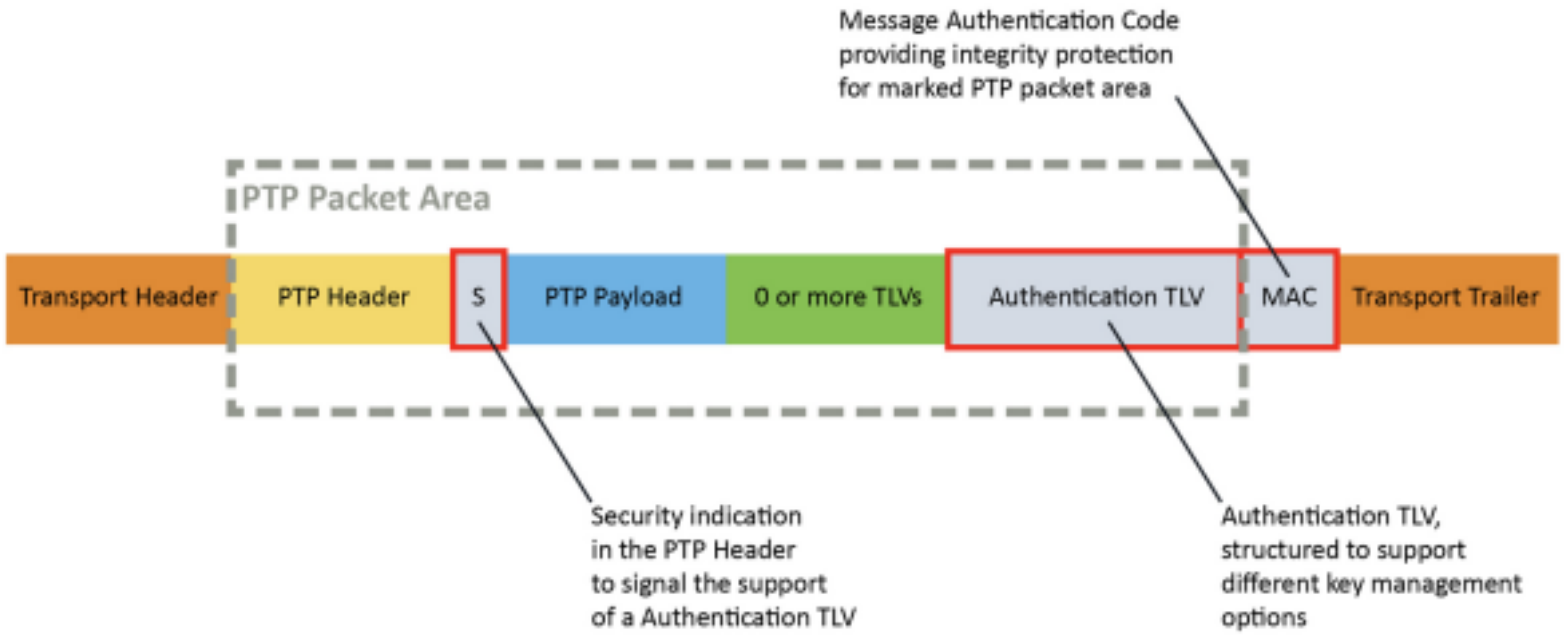
Four Prong Security Model

PTP Security Enhancements

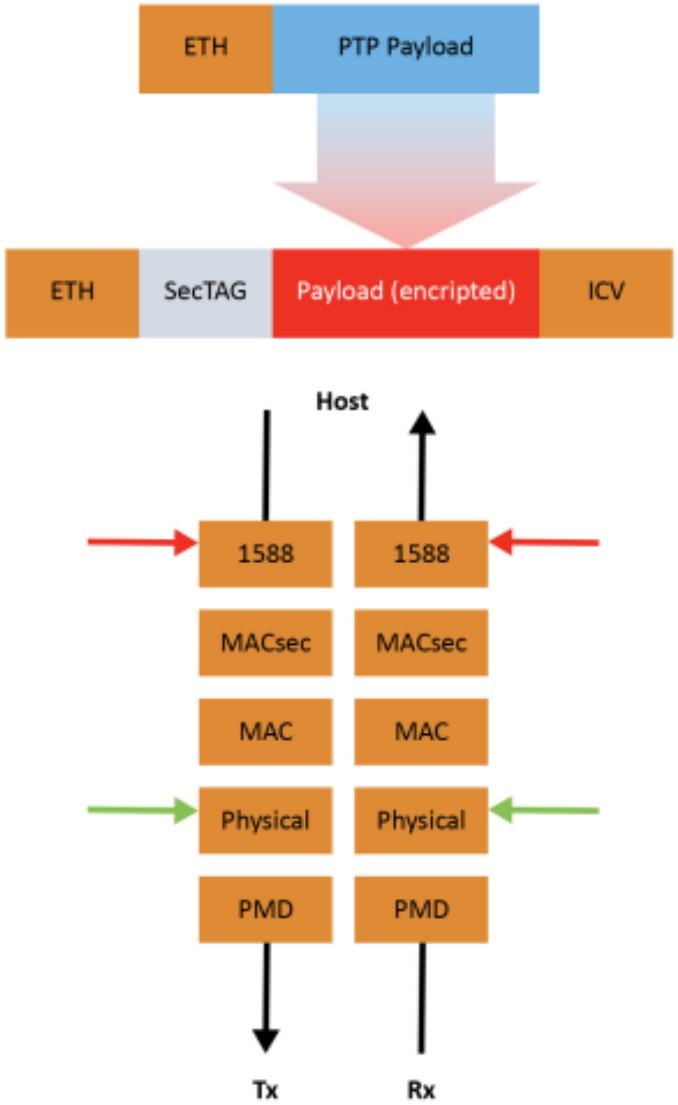
- IEEE® 1588 2019 introduces a four-prong security model
  - Prong A – Integrated Security Mechanism
  - Prong B – External Security Mechanisms
  - Prong C – Architecture Guidance
  - Prong D – Monitoring and Management

Prong A – Integrated Security Mechanism



- **Key challenge to implement Prong A is that security key distribution for the Authentication TLV has not been finalized**
- **There are proposals to use Network Time Security Key Exchange (NTS-KE) for both NTP and PTP**

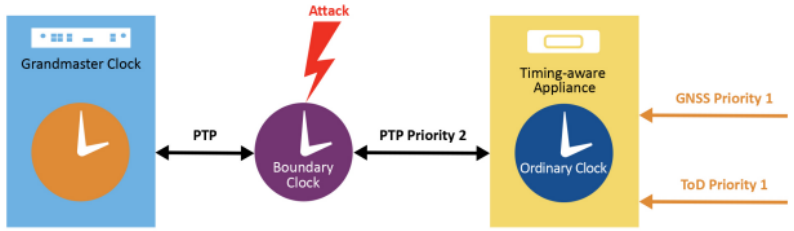
Prong B – External Security Mechanisms



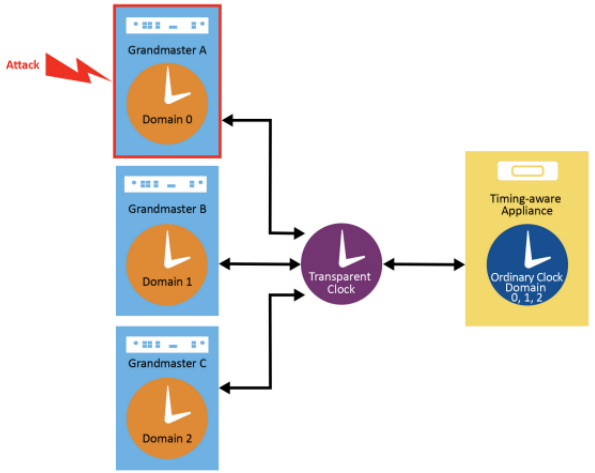
Encompasses using well known transport security mechanisms such as MACsec (Media Access Control Security) and IPsec (IP Security) for securing PTP

- MACsec implementations lagging because they require HW upgrades.
- IPsec accuracy concerns remain as a barrier

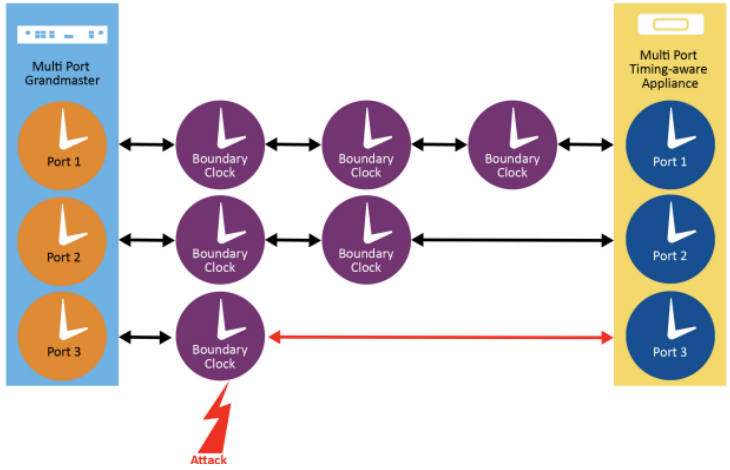
Prong C – Architecture Guidance: Widely Deployed Today



Multiple Inputs using various timing systems



Multiple PTP Grandmasters with Different Domains



Timing Appliance Using Multiple Paths

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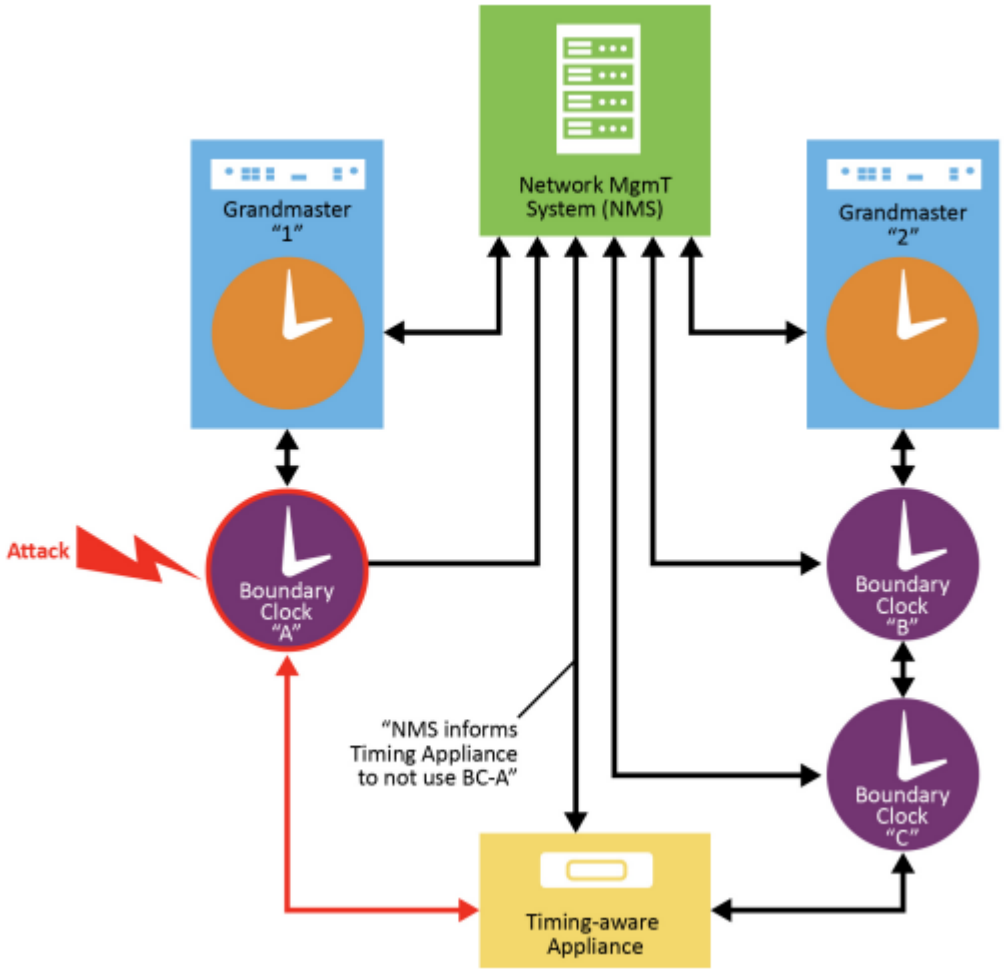
Prong D – Monitoring and Management



Monitoring and management provides a higher view of the network topology and can monitor all devices and network changes. Upon detection of an attack on grandmaster or path, it can inform a timing appliance to stop using the grandmaster or path for time synchronization

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Conclusions and Future Direction

- **PTP accuracy**
  - Enhanced Accuracy TLV as defined in IEEE 1588a-2023 Amendment support in various industry PTP profiles to drive adoption and deployment
- **PTP Security**
  - Start with Prong C and D for security today – widely deployed
  - Prong A and B will come as future standards activities progress

Thank You