IEEE Standards Update

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Agenda

- IEEE-802.1AS, "Standard for Local and Metropolitan Area Networks - Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks"
- P802.3bf, “Ethernet Support for the IEEE P802.1AS Time Synchronization Protocol Study Group”
- IEEE P802.3az, “Energy-efficient Ethernet Task Force”
- IEEE-1588™, “IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems”

IEEE-802.1AS

- Specifies the protocol and procedures used to ensure that the synchronization requirements are met for time sensitive applications
  - Audio and video application across Bridged and Virtual Bridged Local Area Networks consisting of LAN media (e.g. used for Digital Home Media distribution)
- IEEE 802.1AS is based on IEEE 1588v2, and includes a Precision Time Protocol (PTP) profile
  - Bridge acts as a boundary clock
  - End station acts as ordinary clock
- Synchronization is transported over a maximum of 7 hops (1 LAN = 1 Hop) based on expected applications
- Status
  - PAR approved May 25th, 2006
  - Task Group ballot
  - Planned to be finished in 2009

P802.3bf

- DRAFT Objective
  - "Provide an accurate indication of the transmission and reception initiation times of certain packets as required to support IEEE P802.1AS"
- The main objective is to add synchronization capability to Ethernet
  - IEEE P802.1AS, Audio-Video Bridging is the main driver
  - Other potential new applications include, wireless backhaul, industrial control, and SmartGrid
- Support for the time synchronization will be limited to the full-duplex operation mode of the IEEE Std 802.3-2008 MAC
- PAR has been drafted for an Amendment to existing IEEE Standard 802.3-2008
  - Conformance with IEEE 802.1 Overview and Architecture, IEEE Std 802.1D, IEEE 802.1Q, and it will complement IEEE P802.1AS
- Status
  - Criteria and Objective were approved at the September 2009 802.3 Interim meeting
  - Projected Completion Date: June 2011

IEEE P802.3az

- Scope
  - "The proposed standard will include a symmetric protocol to facilitate transition to and from lower power consumption in response to changes in network demand. The transition will not cause loss of link as observed by higher layer protocols. The project will also specify PHY enhancements as required for a selected subset of PHY types to improve energy efficiency."

- It defines a Low Power Idle mode
  - No need to consume power if the link is idle
  - Potentially can affect Synchronous Ethernet, as there is an idle period

- Status
  - PAR has been approved for an Amendment to existing IEEE Standard 802.3-2008
  - Projected Completion Date: September 2010

IEEE-1588™

IEEE 1588 – Status and History

- IEEE Std 1588™-2002 (version 1) was published November 8, 2002
  - Title "IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems"
  - Defines a Precision Time Protocol (PTP), therefore is also referenced as PTP
  - IEEE 1588 synchronizes real-time clocks in the nodes of a distributed networked system.

- IEEE Std 1588™-2008 (version 2) was approved March 27, 2008 and published July 24, 2008
  - Title "IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems"
  - It is available for purchase from the IEEE web site
    http://www.ieee.org/web/standards/home/index.html

- Applications
  - Industrial Automation, Test and Measurement, Military, Power generation and distribution, Consumer electronics, and Telecommunications

IEEE-1588 Version 1

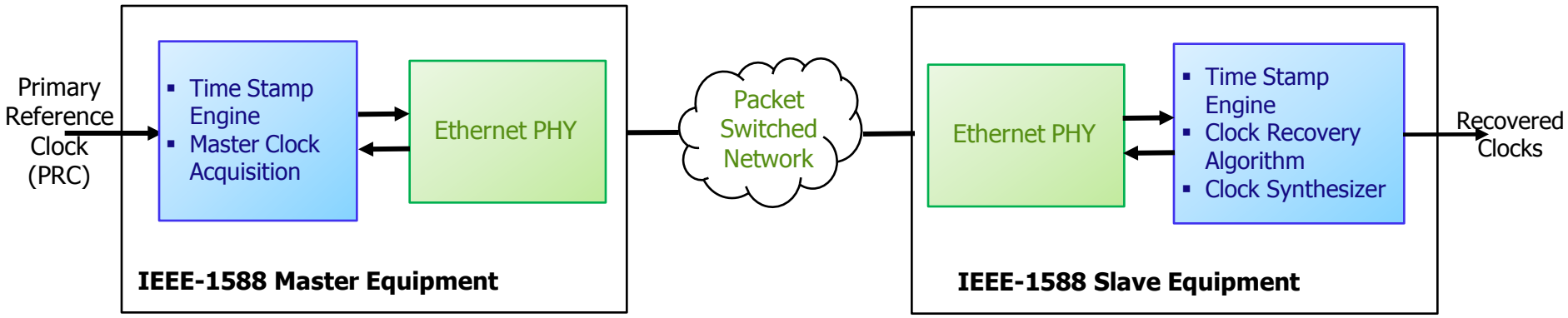
- IEEE Std 1588™-2002 (version 1)
  - It was developed for the Industrial Automation and Test and Measurement applications
  - Addressed Local Area Networks inside a building or a factory

- Issues with Version 1 for Telecom applications
  - Only used multicast
    - Unicast is needed for Telecom
  - The maximum rate for the sync messages was 1 packet per second
    - Need higher message rate to meet the requirements of the Telecom networks
  - Bandwidth consumption was very high due to delay-req/delay_resp were sent in multicast
    - The bandwidth consumption would increase with the number of slaves in the network
  - Frame format was too big
  - Time To Live in the header of the messages was set to 1
    - The messages could not transverse more than one router

Version 2 New Features

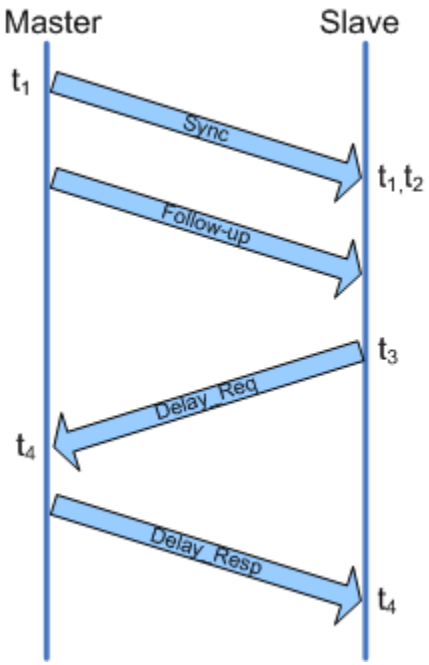
- Mappings to UDP/IPv6, DeviceNet™, Ethernet (direct mapping), PROFINET, ControlNet™
- TLV (type, length, value) for message extensions
- Transparent clocks
- Clock redundancy and fault tolerance
- New management capabilities and options
- Higher sync message rate compared to V1;
- Possibility for asymmetry corrections
- Optional unicast messaging (in addition to multicast)
- PTP profiles
- Smaller Frame format

IEEE-1588 without support from Network



- IEEE-1588 is a time protocol to deliver Time of Day
- The timing requirements (jitter, wander, time synchronization) of a particular application that uses the PTP clock are not specified in IEEE-1588 standard
  - For Telecom applications, the requirements are specified at ITU
  - Clock recovery algorithm is not defined in the IEEE 1588 standard and it is proprietary
- The quality of the clock delivered to the application depends on several factors
  - The quality of the oscillator at the slave
  - The packet delay variation of the network
  - The number of timing packets per second
- ITU-T is working on a PTP profile for IEEE-1588 for Frequency Synchronization to be consented in June 2010. Another profile for time of Day/phase synchronization is also working in progress

PTP Basic Synchronization



- Slave synchronizes to its master using Sync, possibly Follow_Up, Delay_Req, and Delay_Resp messages exchanged between master and its slave
- Assuming a Symmetric Network
  - Offset = $[(t_2 - t_1) - (t_4 - t_3)]/2$
  - Propagation time = $[(t_2 - t_1) + (t_4 - t_3)]/2$

PTP Version 2 Messages

- Two types of messages are defined
  - Event Messages - an accurate timestamp is generated at egress and ingress
  - General Messages - do not require accurate timestamps

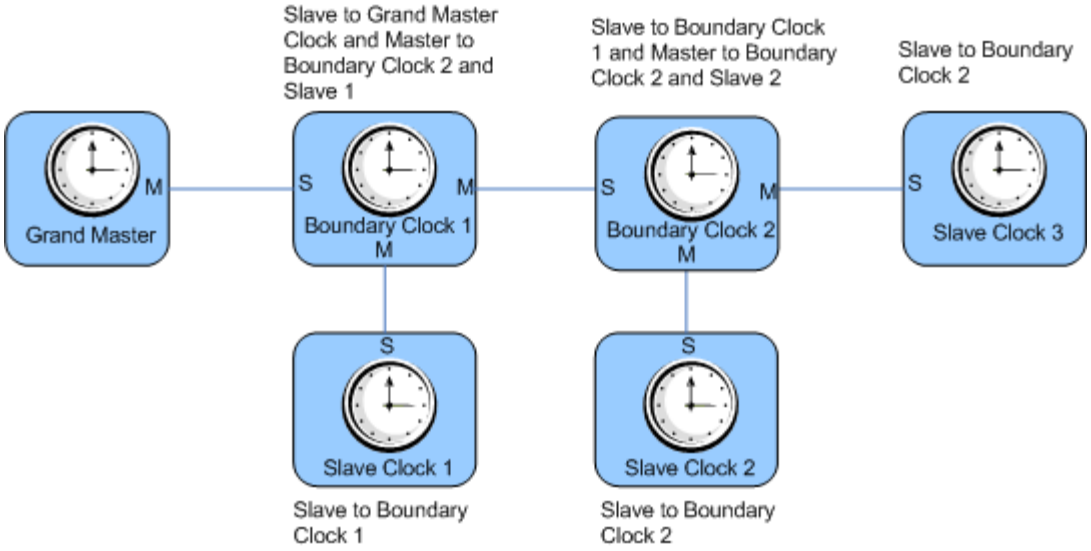
- Event Messages
  - Sync
  - Delay_Req
  - Pdelay_Req
  - Pdelay_Resp

- General Messages
  - Follow_Up
  - Delay_Resp
  - Pdelay_Resp_Follow_Up
  - Announce
  - Management
  - Signaling

IEEE-1588 Basic Concepts

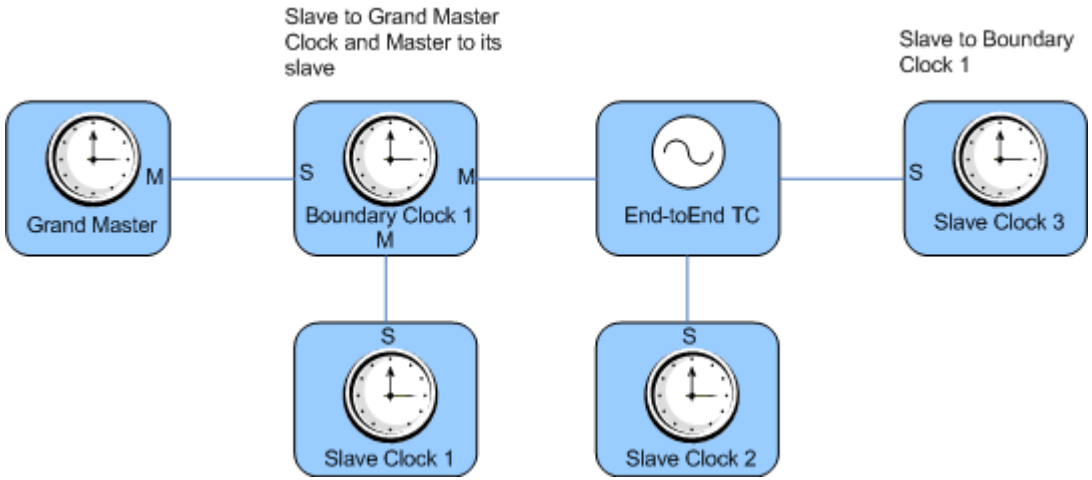
- Ordinary Clocks was specified in version 1 and it is carried over to version 2
  - It has a single port in a domain it may be a master clock, or a slave clock
- Boundary Clock (BC) was specified in version 1 and it is carried over to version 2
  - It has multiple PTP ports in a domain, its ports can be a master or a slave
- Transparent clock (TC) is new in version 2
  - It measures the time taken for an event message to transit the device and provides this information to clocks receiving this event message
  - There are 2 types of Transparent Clock, End-to-end transparent clock (E2E TC) and Peer-to-peer transparent clock (P2P TC)
- Two-step Clock
  - It provides time information using the combination of an event message (sync) and a subsequent general message (follow-up)
- One-step Clock
  - It provides time information using a single event message (sync message), so it does not use follow-up messages
- Grandmaster clock:
  - A clock that is the ultimate source of time for clock synchronization within a domain

Boundary Clock



- BC terminates Sync, Follow_Up, Delay_Req, or Delay_Resp messages
- Each BC is affected by the preceding clock
  - Care must be taken with the quality of the local oscillator

End-to-End Transparent Clock



- An E2E TC does not synchronize to the grandmaster (GM), it forwards Sync and corresponding Follow_Up messages
- The messages exchanged are Sync, Follow_Up, Delay_Req, or Delay_Resp messages
- The E2E TC time stamps the Sync message on ingress and egress, and computes the residence time (the time taken for the message to traverse the node)

End-to-End Transparent Clock

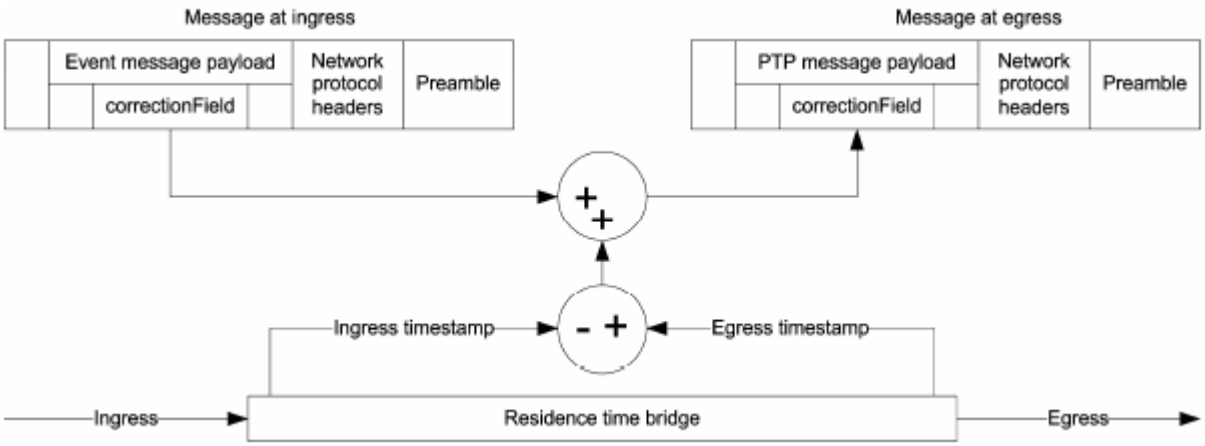
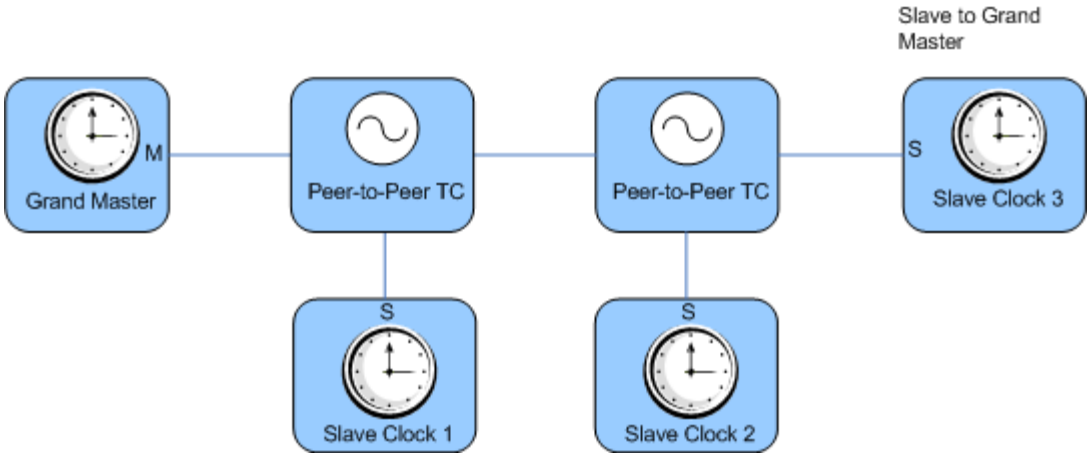


Figure 5 of IEEE Std 1588™-2008 – End-to-end residence time correction model*

- The residence time is accumulated in the correction field of the Sync or Follow_Up messages

* IEEE Std 1588-2008 IEEE Standard for a Precision Clock Synchronization Protocol, copyright 2008 IEEE. All right reserved.

Peer-to-Peer Transparent Clock



- An P2P TC does not synchronize to the grandmaster (GM), it forwards Sync and corresponding Follow_Up messages
- The messages exchanged are Sync, Follow_Up, Pdelay_Req, Pdelay_Resp, and Pdelay_Resp_Follow_Up messages
- The P2P TC time stamps the Sync message on ingress and egress, and computes the residence time (the time taken for the message to traverse the node)
- It calculates the link delay time using the Pdelay mechanism

Peer-to-Peer Transparent Clock

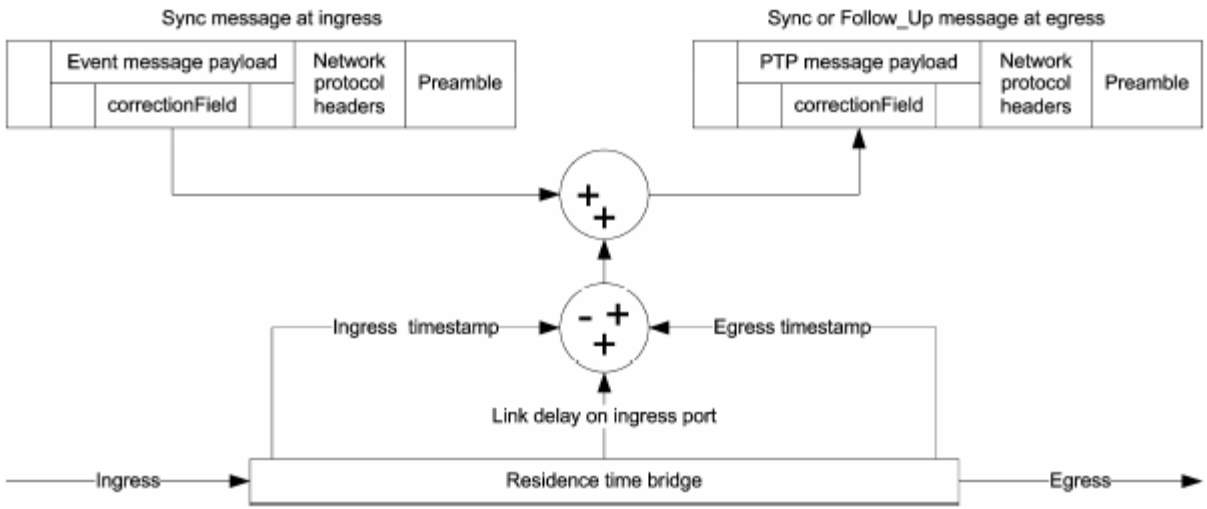


Figure 8 of IEEE Std 1588™-2008 – Peer-to-peer residence time and link delay correction model*

- The residence time and link delay is accumulated in the correction field of the Sync or Follow_Up messages
- The peer delay mechanism is used to calculate the link delay. Pdelay_Req, Pdelay_Resp, and possibly Pdelay_Resp_Follow_Up messages are exchanged with the link peer

Best Master Clock Algorithm (BMCA)

- All the clocks that are part of the same domain will organize themselves into a master-slave hierarchy based on the BMCA
- IEEE 1588 V2 uses a default Best Master Clock algorithm (BMCA) that is similar to the V1 BMCA
- BMCA uses Announce messages to establish the synchronization hierarchy
- IEEE 1588 IEEE 1588 V2 also allows an alternate best master clock algorithm specified by a profile

Profiles*

- IEEE Std 1588-2008 defines Profile
  - The set of allowed Precision Time Protocol (PTP) features applicable to a device
  - The purpose of a PTP profile is to allow organizations to specify specific selections of attribute values and optional features of PTP that, when using the same transport protocol, inter-work and achieve a performance that meets the requirements of a particular application.
  - A PTP profile is a set of required options, prohibited options, and the ranges and defaults of configurable attributes.
  - An IEEE 1588 profile may be developed by external organizations including:
    a) A recognized standards organization with jurisdiction over the industry, e.g. IEC, IEEE, IETF, ANSI, ITU, or;
    b) An industry trade association or other similar organization recognized within the industry as having standards authority for the industry;
    c) Other organizations as appropriate."

- ITU-T PTP Profile
  - ITU-T is working on a PTP profile for IEEE-1588 without support from Network to be consented in June 2010. Another profile for time of Day/phase synchronization is also working in progress

References

- IEEE-802.1AS - http://www.ieee802.org/1/pages/802.1as.html
- Don Pannell and Michael Johas Teener, *Audio/Video Bridging (AVB) Assumptions, July, 2008 – Denver, CO (annotated Sept 2008 – Seoul,* Korea) (available at http://www.ieee802.org/1/files/public/docs2008/avbpannell-mjt-assumptions-0908-v17.pdf)
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- IEEE Std 1588™-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

QUESTIONS ???

THANK YOU!