AUTOSAR Time Sync over Ethernet

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Goals for this Presentation

- Provide overview of AUTOSAR time sync over Ethernet
  - Perspective of how automotive views that Ethernet topic
- Compare AUTOSAR time sync to 1588 and 802.1AS
  - Suggest opportunities for future alignment
- No recommendations for 802.1DG
  - This presentation is not a use case or requirement
  - TSN profile has normative references to time sync standard(s)
    - E.g. 802.1BA refs 802.1AS; 802.1CM refs ITU-T profiles for 1588
    - This presentation might help as input to that decision for 802.1DG

AUTOSAR Standards in these Slides

- Specification of Synchronized Time-Base Manager, Classic Platform (CP) v4.4.0
  - "StbM" in these slides
- Time Synchronization Protocol Specification, Foundation (FO) v1.5.1
  - "TSprot" in these slides
- Specification of Time Synchronization over Ethernet, Classic Platform (CP) v4.4.0
  - "EthTSyn" in these slides
- Publicly published standards as of this presentation
  - No draft work is mentioned in this presentation
  - Note that AUTOSAR publishes with a fast cadence relative to IEEE

StbM: AUTOSAR Syncs More than Ethernet

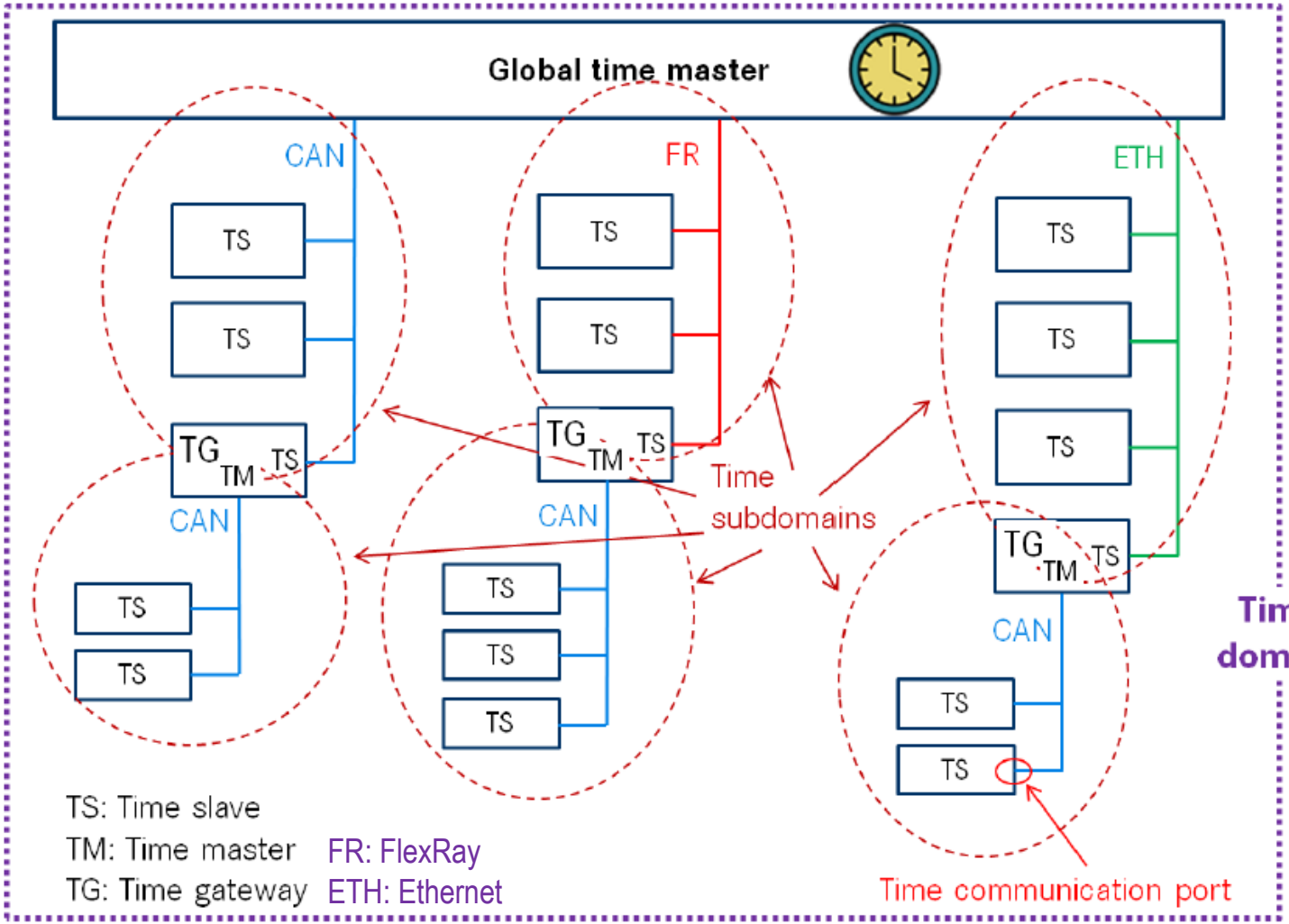
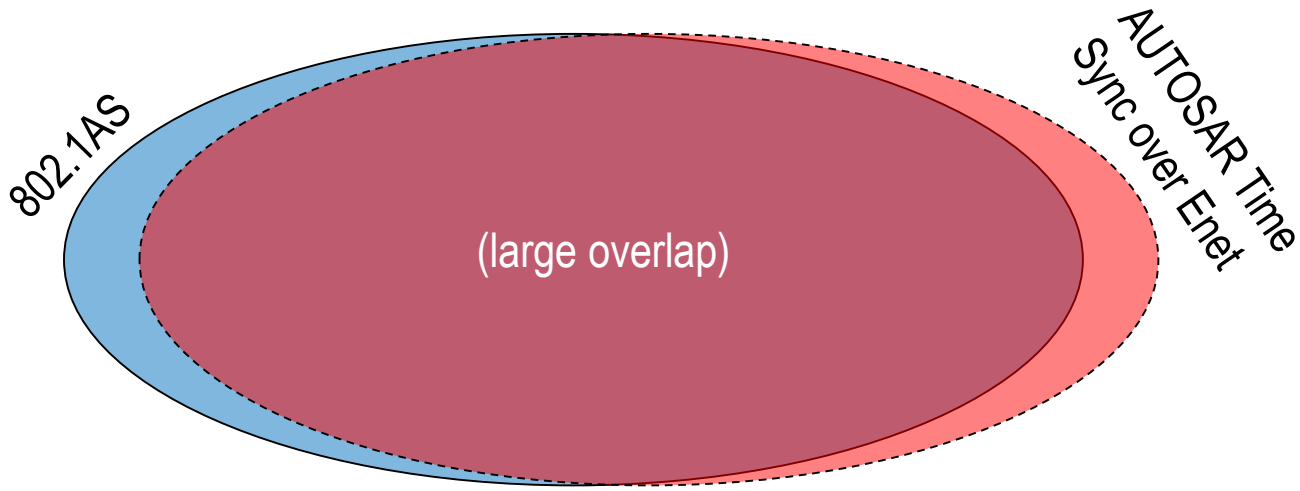


Figure 3: Terminology Example

Overall Impressions



- Architectural overlap is significant
- Conformance issues in next slides are arguably minor
  - Nevertheless, improved alignment will be helpful

Conformance to 1588 / 802.1AS

- TSprot: "based on existing PTP mechanisms that are described in standards like IEEE 1588 and IEEE 802.1AS"
  - Neither listed as a normative reference
  - AUTOSAR's time sync is a standalone standard
    - Formal conformance to 1588 or 802.1AS is not claimed
    - Nevertheless, alignment with 802.1AS is clearly intended
- TSprot: "neither IEEE 1588 nor IEEE 802.1AS have been developed considering automotive requirements"
  - This is true
  - Developed from requirements for test&measurement, industrial, telecom, power, audio/video, financial, ...
    - ... and future participation from automotive is welcomed

Why So Many Applications in 1588?

- Benefits are the same as with any standard
  - Leverage hardware across applications
  - Leverage software across applications (e.g. open-source)
- Another less-known benefit: Time sync expertise
  - Time sync is a relatively small topic in each application's standard organization (e.g. ITU, SMPTE, AUTOSAR)
  - Time sync is a narrow specialty in each affiliated company
  - Time sync experts participate in 1588 (and 802.1AS)
    - In that context, time sync is the primary topic
    - Share knowledge across applications and companies
    - Specific application meets its requirements, but learns from others

Assumptions for Future Work

- Time sync specs are not fixed documents
  - All standards evolve to meet new requirements
- Let's assume that AUTOSAR time sync experts are willing to participate in IEEE time sync discussions
  - Bring automotive requirements to 802.1AS (and/or 1588)
  - Short-term benefit: Sharing of expertise
  - Long-term benefit: Future AUTOSAR publications can be conformant to future publications of 1588 / 802.1AS

Format of Subsequent Slides

Based on the assumptions for future, in subsequent slides...

- Title: Describes an issue
- First bullet: References an issue in AUTOSAR standards
- Second bullet: Summarizes current specs for the issue in 1588-rev and/or 802.1AS-rev
- Third bullet: Describes possible future changes in AUTOSAR, 1588, or 802.1AS to improve alignment
  - Suggested changes are for future projects, not ongoing revisions
  - This is the opinion of the presenter, and does not represent consensus in any of the three standardization groups

Disable BMCA

- TSprot 1.2.2 Limitations
  - "No support of BMCA protocol"
- Current 1588/802.1AS revision specs
  - No issue
  - Industrial brought this requirement to both revisions
    - Incorporated as externalPortConfiguration feature
- Possible future changes
  - AUTOSAR
    - Reference 1588-rev or 802.1AS-rev
    - Specify that externalPortConfiguration=TRUE
      - fixed value... no management protocol needed

No Signaling

- TSprot 1.2.2 Limitations
  - "No support of Signaling messages"
- Current 1588/802.1AS revision specs
  - 1588: No issue
    - 1588 does not require Signaling
  - 802.1AS: Signaling is required
    - To change data set members, and to negotiate compatibility
    - Presenter submitted comments to make Signaling optional (rejected)
- Possible future changes
  - 802.1AS
    - Make Signaling optional in future publication

No Announce (1 of 2)

- TSprot 1.2.2 Limitations
  - "No support of Announce messages"
- Current 1588/802.1AS revision specs
  - Reasons why 1588 requires Announce
    1. BMCA
       - Not applicable to AUTOSAR
    2. Transfer of TLVs from Grandmaster through network to Slaves
       - Applicable to AUTOSAR: TLVs currently on Follow_Up message

No Announce (2 of 2)

- Possible future changes
  - AUTOSAR
    - Transmit Announce after Follow_Up
    - Attach existing TLVs to Announce instead of Follow_Up
      - Gain benefits of the other Grandmaster info in Announce header
      - If use same interval, implementation is same except for extra message header
      - If Announce interval is multiple of Follow_Up interval (e.g. every 4), bandwidth usage is reduced, since TLVs don't transfer as often

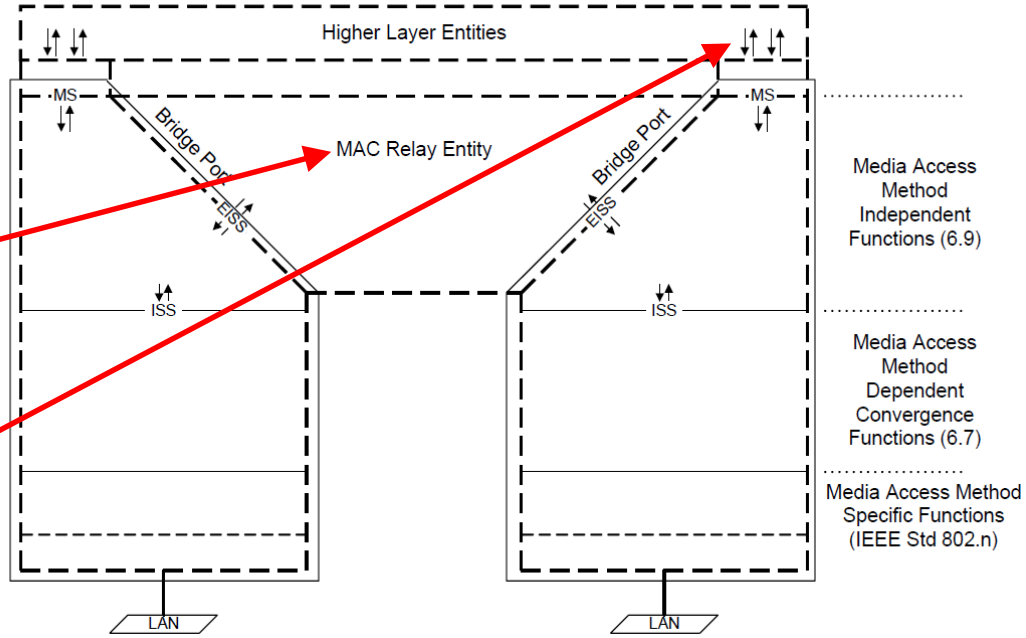
VLAN Tagging (1 of 3)

- TSprot 1.2.2 Limitations
  - "Time synchronization protocol would allow Time Synchronization on VLANs under the condition, that the switch HW supports forwarding of reserved multicast addresses using the range of 01:80:C2:00:00:00 .. 0F"
- TSprot 1.3.2 Dependencies on other standards
  - "For VLAN characteristics refer to [2, IEEE 802.1Q-2011]."
- EthTSyn 10.2.6 (config parameter EthTSynFramePrio)
  - "If this optional parameter is not present, frames are sent without a priority and VLAN field."
- Current 1588/802.1 revision specs
  - 1588: Not applicable since 1588 is transport-independent
  - 802.1AS: VLAN tagging is prohibited (see next slide)

VLAN Tagging (2 of 3)

- 802.1Q-2018, 8.2 and 8.6.3

Nearest Bridge group address (used by 802.1AS, in TSprot range) shall not forward through MAC Relay. VLAN applies to this relay (typically handled by hardware).



All time sync protocols are Higher Layer Entities, typically handled by software. The Nearest Bridge group address is received on a single port, and software decides if/how to transmit on other ports. 802.1AS uses the 1588 domainNumber field for that decision, because VLAN is incorrect for time sync.

VLAN Tagging (3 of 3)

- Possible future changes
  - AUTOSAR
    - Destination MAC address
      - The "switch HW" of TSprot 1.2.2 is not an 802.1Q switch
        - » Contradicts TSprot 1.3.2
        - » Difficult to implement as Ethernet usage grows
      - Suggestion: Remove statement on switch HW forwarding; Recommend Nearest Bridge group address
    - VLAN tagging
      - All 1588/802.1AS source code uses domainNumber
        - » VLAN not used: data topology is distinct from time sync topology
      - AUTOSAR uses 802.1AS headers, so domainNumber is available
        - » If domainNum's port state is not configured to MASTER, no "forward"
      - Suggestion: Recommend use of domainNumber (not VLAN option)

MessageCompliance flag

- TSprot 5.3.1.2
  - "If MessageCompliance is set to FALSE, the Follow_Up shall contain an AUTOSAR TLV, depending on configuration."
- Current 1588/802.1AS revision specs
  - 1588-rev: No issue... profiles can add organization TLV
  - 802.1AS-rev: No issue... aligns with 1588-rev
- Possible future changes
  - AUTOSAR
    - Clarify that MessageCompliance=FALSE is a compliant message
    - Future discussion: What is the fundamental reason for the choice?
      - Is TRUE really intended as "I am using 802.1AS source code?"

pDelay Optional

- TSprot 1.2.2 Limitations
  - "... does not require the Pdelay mechanism"
- Current 1588/802.1AS revision specs
  - 1588: No issue

    portDS.delayMechanism=NO_MECHANISM
  - 802.1AS: pDelay exchange is required in both directions
- Possible future changes
  - 802.1AS
    - Allow NO_MECHANISM as an option
    - Add data set member to statically configure portDS.meanLinkDelay
    - Integrate in asCapable, to support transmit of Sync without Pdelay

Future Discussion (No Suggestion)

- TSprot 1.2.2: pDelay rate ratio (neighborRateRatio) optional
  - 802.1AS-rev requires, but can turn off with management (semi-optional)
- TSprot 5.3: Cannot add CRC TLV to pDelay (.1AS prohibits)
  - 1588-rev allows, 802.1AS-rev allows: AUTOSAR can add CRC TLV
- TSprot 5.3.1.2: OFS sub-TLV for domain that is offset from another
  - 1588-rev has similar Alternate Time Offset Indicator TLV (ATOI)
    - Might be simpler to implement (2 timescales but only 1 domain)
- TSprot 5.7-5.10, EthTSyn 7.3 & 7.7: hardware timestamping
  - Optional in AUTOSAR; 802.1AS assumes it is ubiquitous
- EthTSyn 7.7.1.3: Immediate time sync
  - Application on Master can trigger immediate transmit of Sync (outside interval)
  - Single Sync exchange does not always achieve stable synchronization
  - Helpful to discuss use cases; Interval speed control might solve this better

Thank You