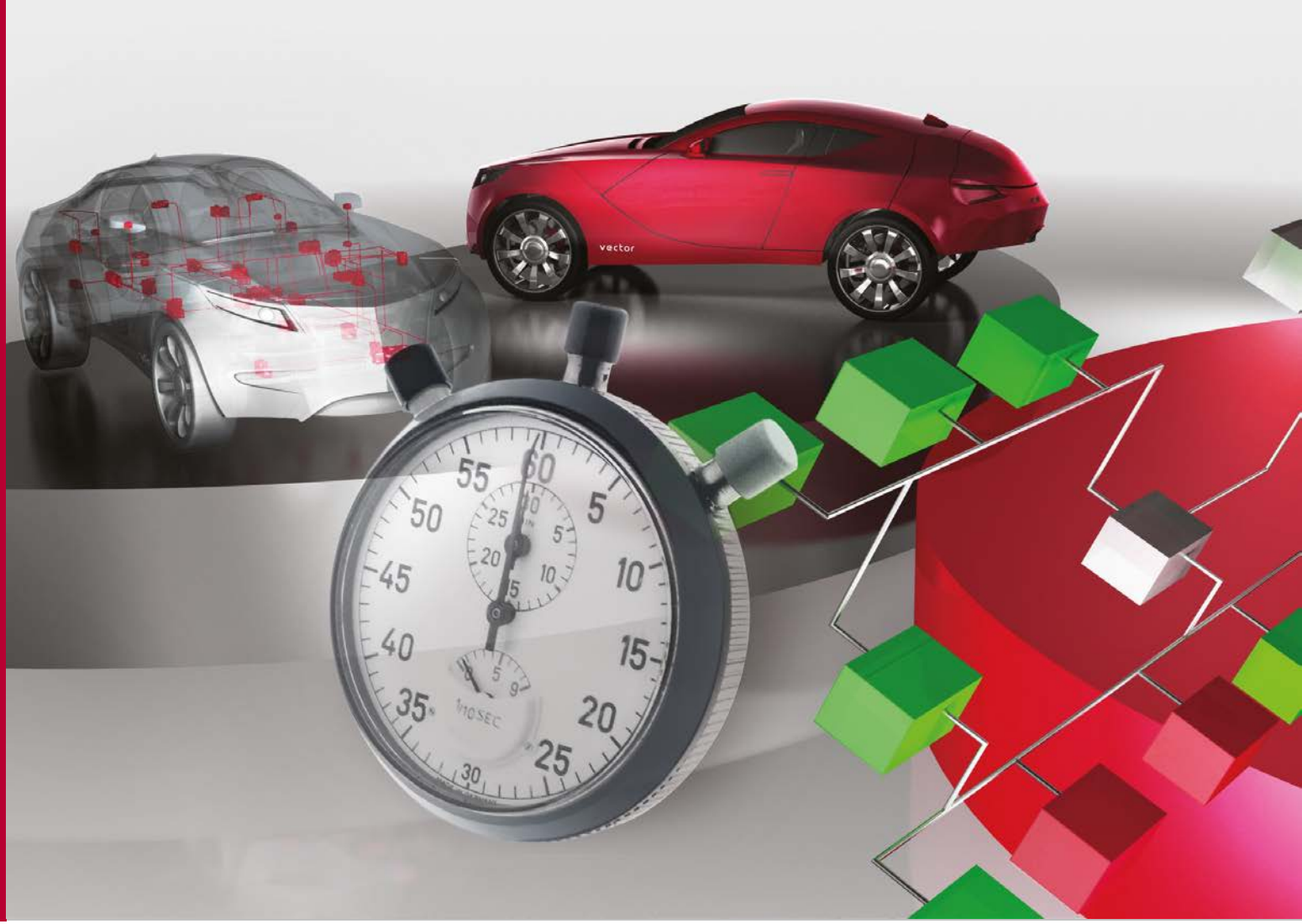


Ethernet@Automotive Webinar

Introduction of Audio/Video Bridging (AVB) over Ethernet in Vehicles – Embedded Software Architecture, Specifics and Use Cases

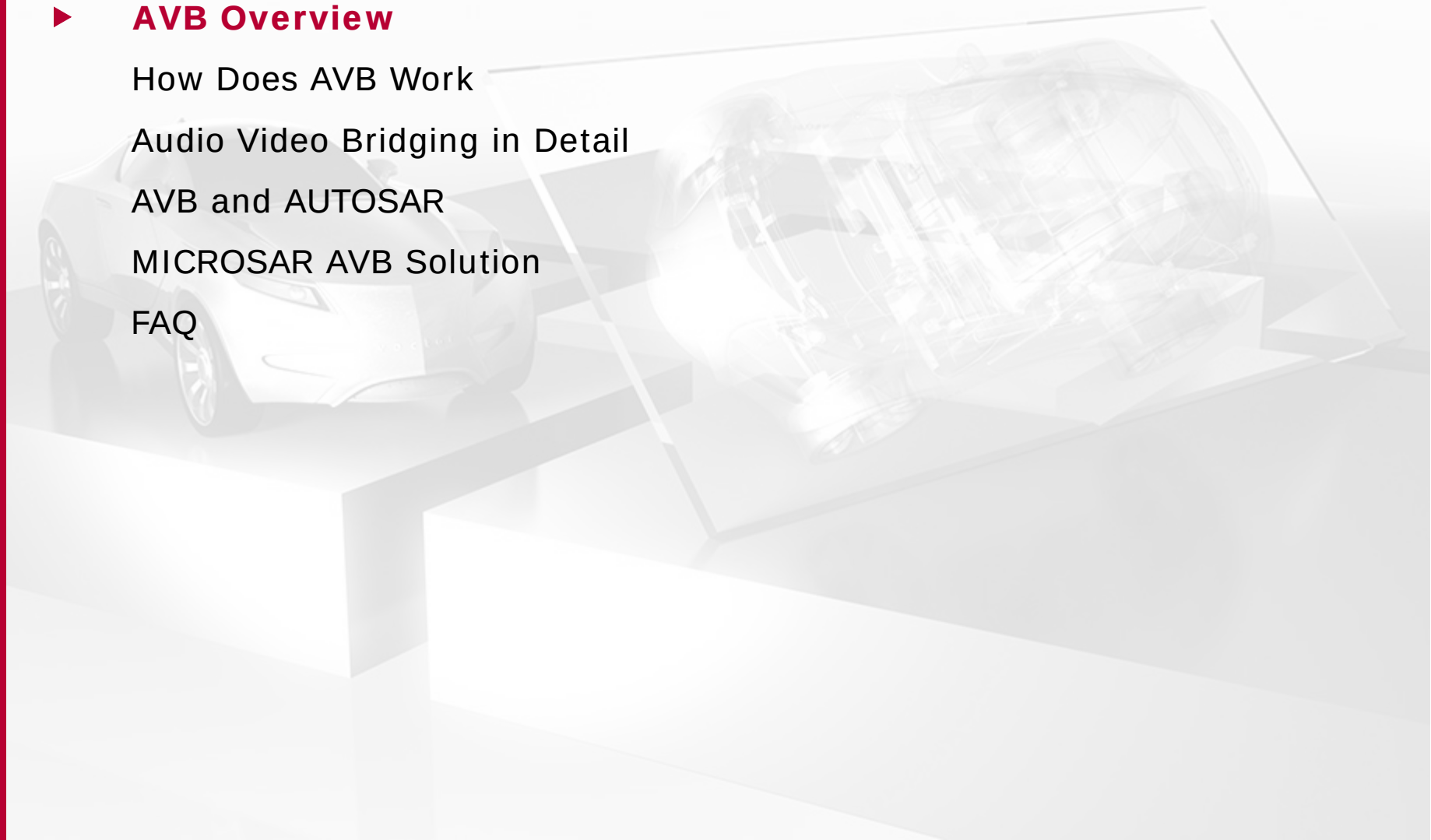
V2.00.02 | 2015-06-09

Ethernet@Automotive Webinar Series

- Part 1: Introduction of Ethernet and IP in Vehicles
  - Presenter: Jan Bossert
  - Wednesday, 6th of May 2015
- Part 2: The AUTOSAR Ethernet Stack and its Use Cases
  - Presenter: Marc Weber
  - Tuesday, 2nd of June 2015
- Part 3: Introduction of Audio/Video Bridging (AVB) over Ethernet in Vehicles – Embedded Software Architecture, Specifics and Use Cases
  - Presenter: Bernd Jesse
  - Friday, 12th of June 2015

Agenda

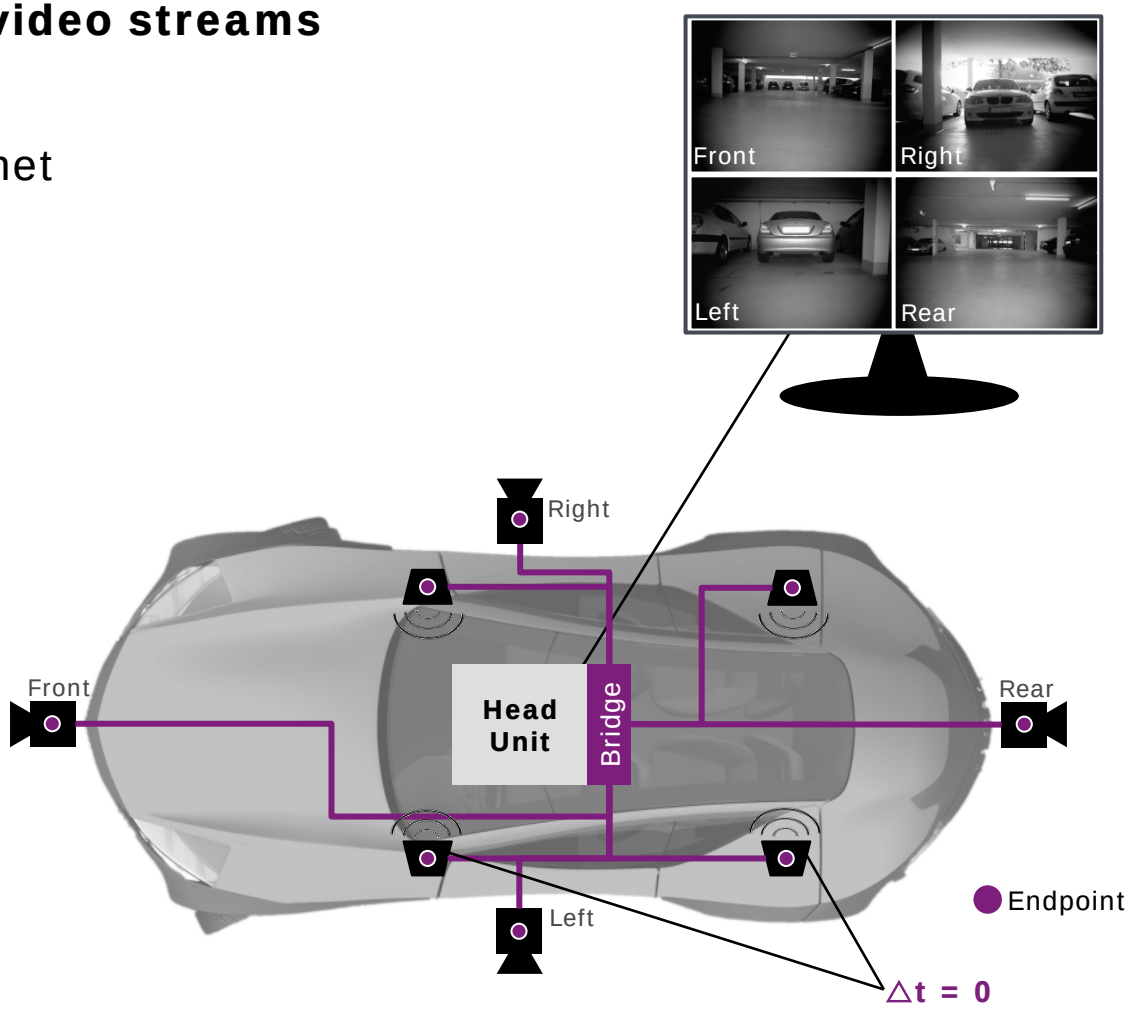
- **AVB Overview**
- How Does AVB Work
- Audio Video Bridging in Detail
- AVB and AUTOSAR
- MICROSAR AVB Solution
- FAQ



Audio Video Bridging - AVB

Transport of audio and video streams

- Through standard Ethernet network technology
- With simple cabling
- Fast and in real-time
- Well synchronized with a global time and prioritized compared to other streams and/or frames



Why AVB?

Significant increase of Audio / Video applications

- Camera devices (rear view, front view, side view)
  - Virtual surround view, accident avoidance, pre-crash preparation
- Infotainment

Significant increase for control data as well

- Fast backbone needed
- Consideration of time-data relation required

Guarantees for Quality of Service (QoS) required

- Fast-Ethernet (*Full-Duplex*)
  - No message priority consideration
  - Latency not defined
- vs. AVB (*Full-Duplex with Bandwidth Reservation*)
  - Time synchronization
  - Bandwidth reservation
  - Worst-case latency presetting

Important IEEE Specifications

Bridging & Management

- IEEE 802.1BA – Audio Video Bridging Systems
  - Intro and Overview
- IEEE 802.1AS – Timing and Synchronization for Time-Sensitive Applications
  - AVB key specification for global time synchronization and network setup
- IEEE 802.1Qav – Forwarding and Queuing Enhancements for Time-Sensitive Streams
  - FQTSS – Traffic shaping
- IEEE 802.1Qat – Stream Reservation Protocol
  - Dynamic stream announcement with admission control
  - Static implementation for automotive possible

AVTP

- IEEE 1722(a) – Layer 2 Transport Protocol for Time Sensitive Applications
  - (a) == automotive version in draft status
    - Covers encryption, simple A/V streams and formats, automotive message types within an A/V stream

Agenda

AVB Overview

How Does AVB Work

Audio Video Bridging in Detail

AVB and AUTOSAR

MICROSAR AVB Solution

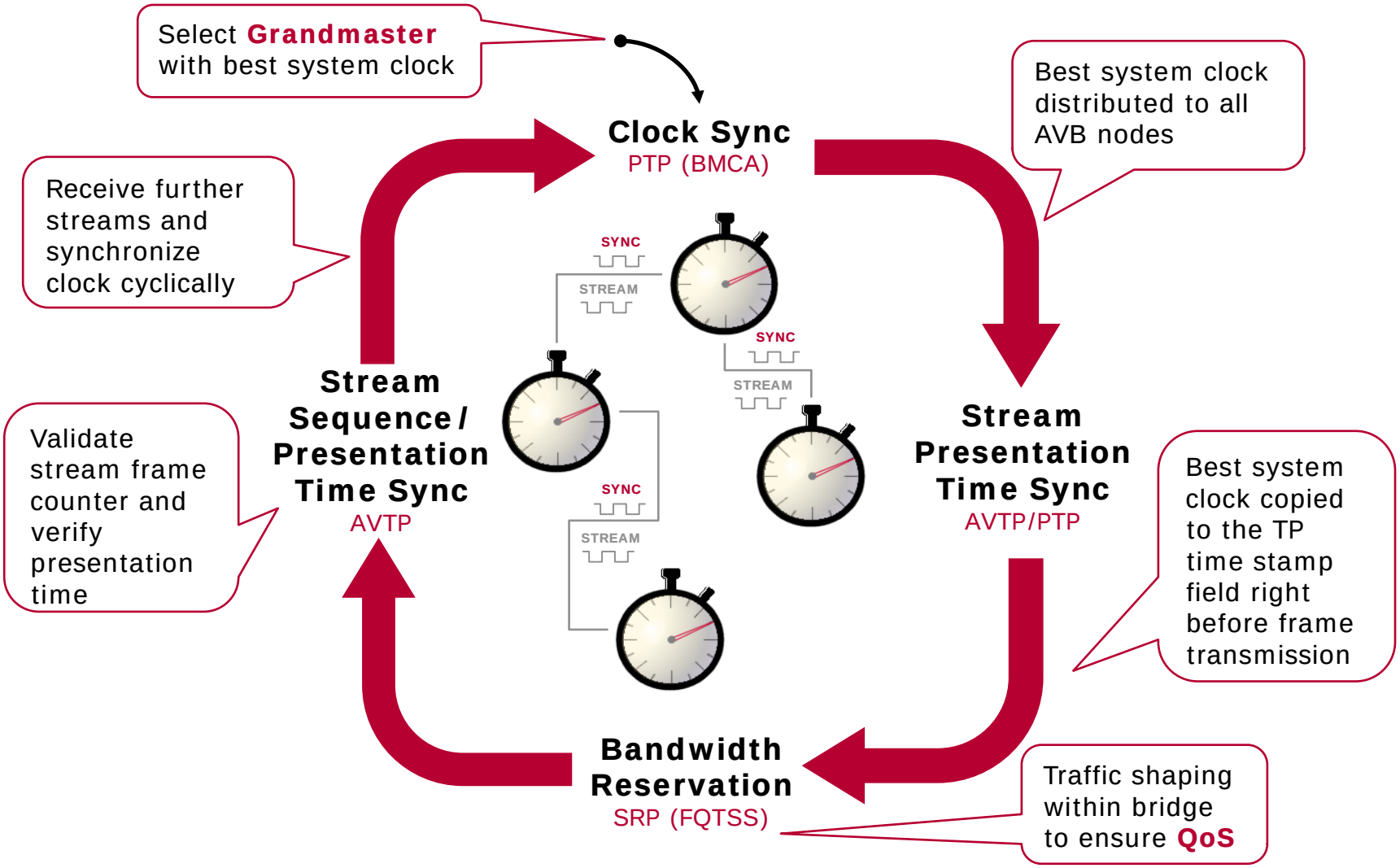
FAQ

Protocols and Methods defined by IEEE

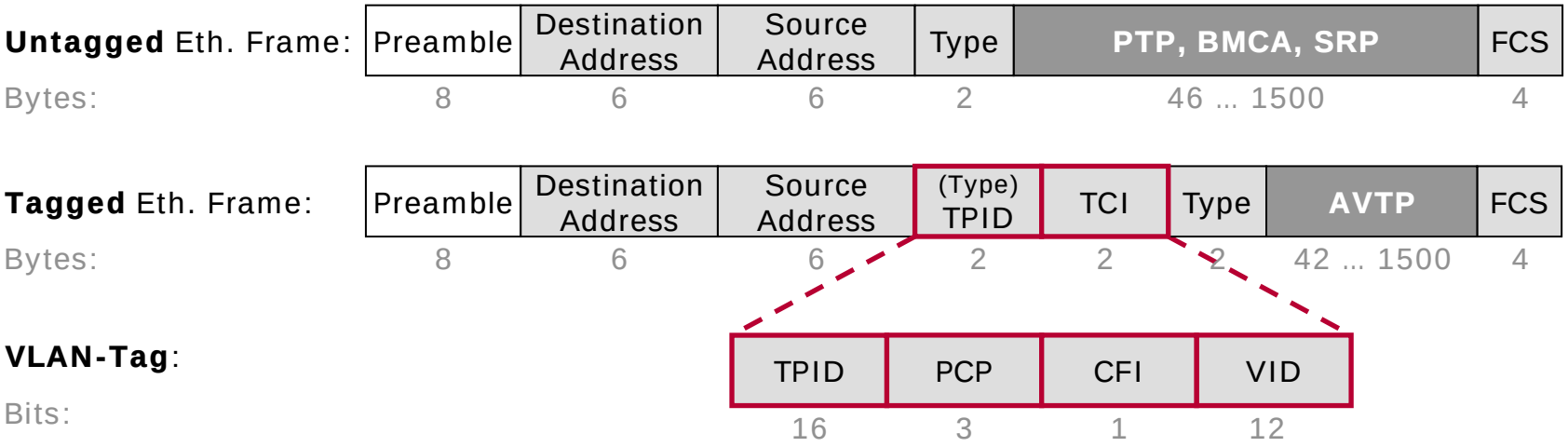
- A **Best Master Clock Algorithm** (**BMCA**) ensures, that all Bridges and Endpoints have the best clock reference to adjust their own time base.
  - 1st Pre-condition for time synchronous data transmission (streaming)
- A **Precision Time Protocol** (**PTP**) ensures, that the clocks in all Bridges and Endpoints are permanently synchronous.
  - 2nd Pre-condition for time synchronous data transmission (streaming)
- An **Audio/Video Transport Protocol** (**AVTP**) ensures, that real time audio/video streams could be handled across an AVB network.
  - 3rd Pre-condition for time synchronous data transmission (streaming)
- A **Stream Reservation Protocol** (**SRP**) ensures, that all Bridges reserve the appropriate bandwidth.
  - 1st Pre-condition for guaranteed transmission to ensure Quality of Service (**QoS**)
- A **Forwarding and Queuing Enhancement for Time Sensitive Streams** (**FQTSS**) ensures, that Bridges are able to distinguish priorities/credits of traffic classes.
  - 2nd Pre-condition for guaranteed transmission to ensure Quality of Service (**QoS**)

Dependencies acc. to IEEE

- All Pre-Conditions must match to ensure seamless operation



Basic Message Layout



- TPID – Tag Protocol Identifier; fix value of 0x8100 (Ethertype for VLAN)
- TCI – Tag Control Identifier
  - PCP – Priority Code Point (large value represents high priority)
  - CFI – Canonical Format Indicator
    - '0' == MAC addresses are sent LSB (always the case for Ethernet)
    - '1' == Token Ring use-cases
  - VID – VLAN Identifier

Definitions

- AVB Bridge:
  - A bridge that implements SRP, FQTSS and PTP.
- AVB Endpoint:
  - A station that is typically receiver/consumer of a stream and located at the end of an AVB network.
- AVB Talker:
  - An Endpoint that is the source/producer of a stream.
- AVB Listener:
  - An Endpoint that is the destination/consumer of a stream.
- Master Port:
  - Any port of the time-aware system that is closer to the root (Grandmaster) than any other port of the PTP communication path connected to this port.
- Slave Port:
  - The one port of the time-aware system that is closest to the root time-aware system.

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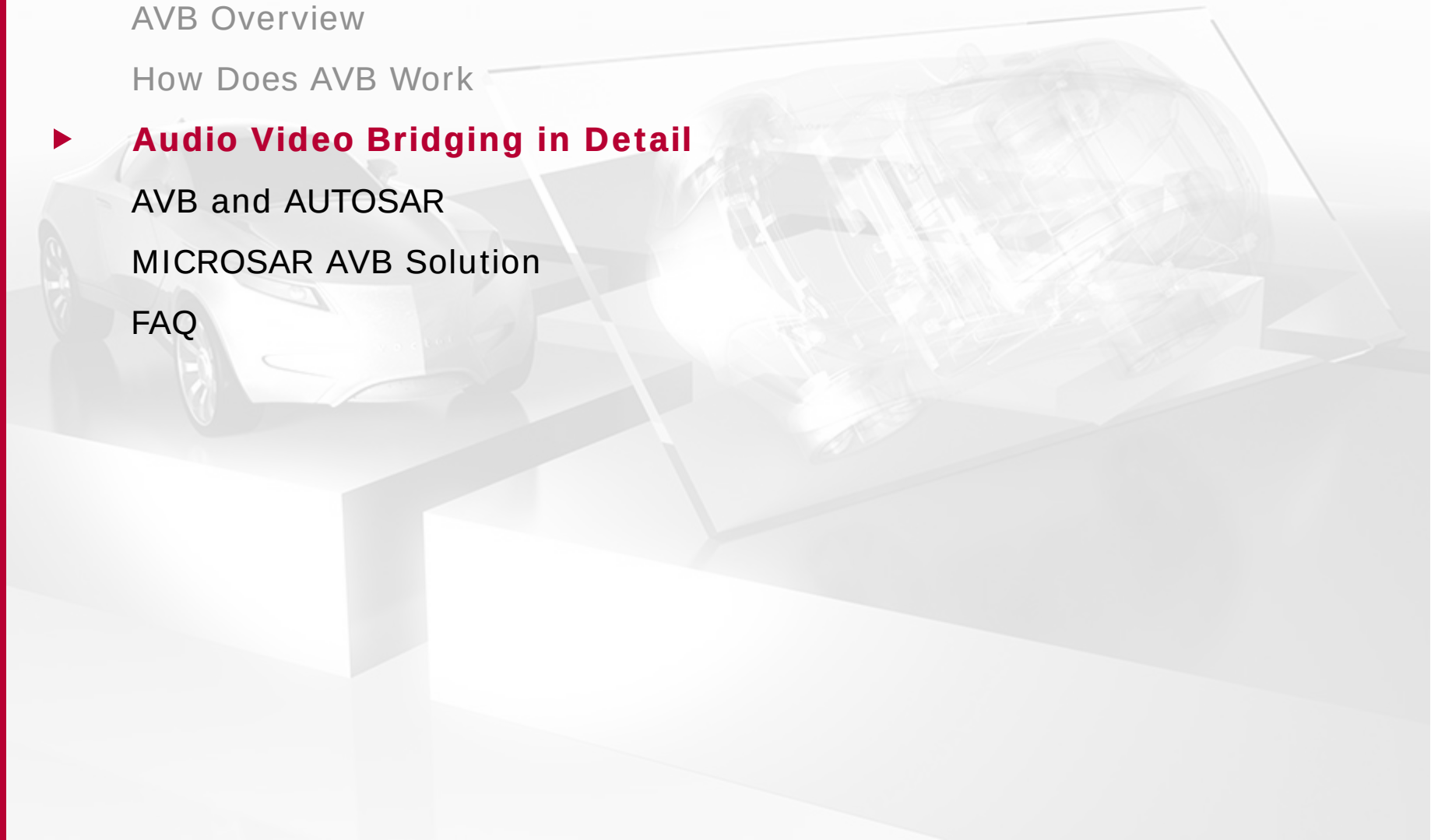
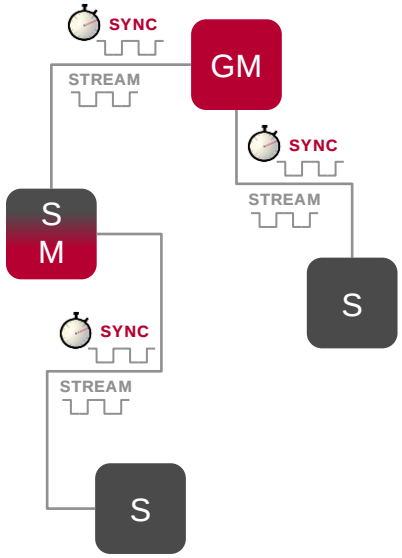


Best Master Clock Algorithm (BMCA)

The network structure follows a strict hierarchy to ensure

- Short distances between Bridges
- No loops
- No redundancies
- 1 Grandmaster per domain, number of bridges <= 7, ...



This will be ensured by

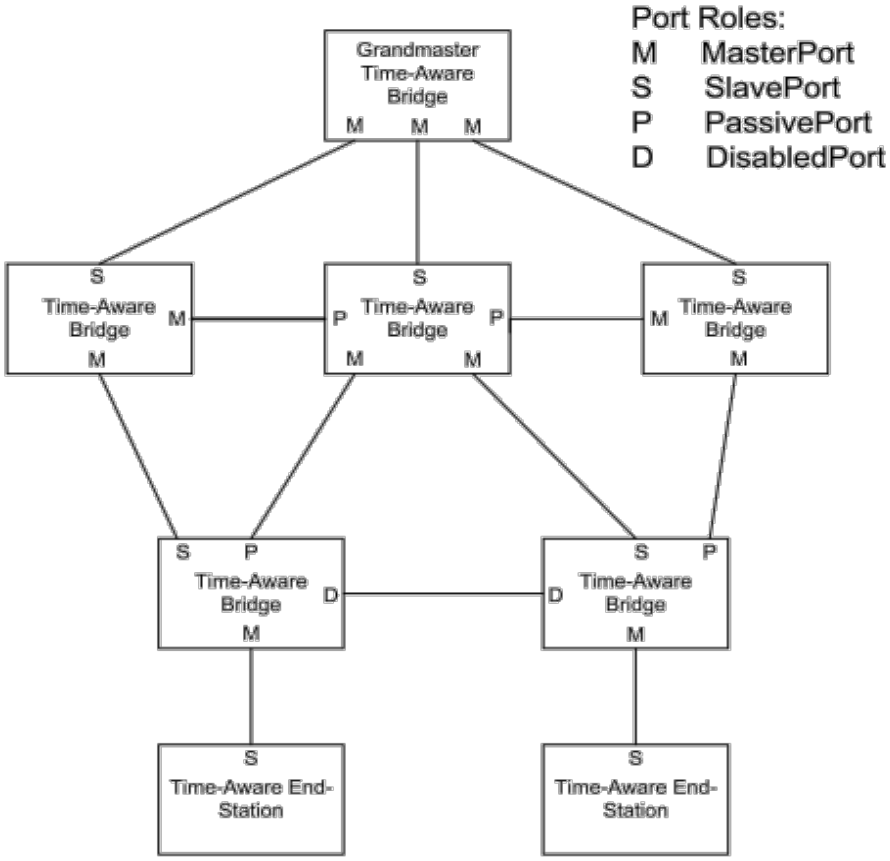
- Finding the better grandmaster-capable device based on configuration parameters named as "systemIdentity"
- Developing the network hierarchy by calculating the Priority Vector for each device. As lower the value, as closer is the position of the device to the Grandmaster.
- Gathering the Priority Vector by using BMCA state machine and protocol.
- Using propagation delay messages to figure out, if propagation delay meets the requirements and if the device is a part of the Time Aware System.

Best Master Clock Algorithm (BMCA)

Time-Synchronization Spanning Tree

The result of all BMCA measures is the "Time-Synchronization Spanning Tree" with

- well defined port roles
- well defined priority
- well defined position



Source: IEEE 802.1AS

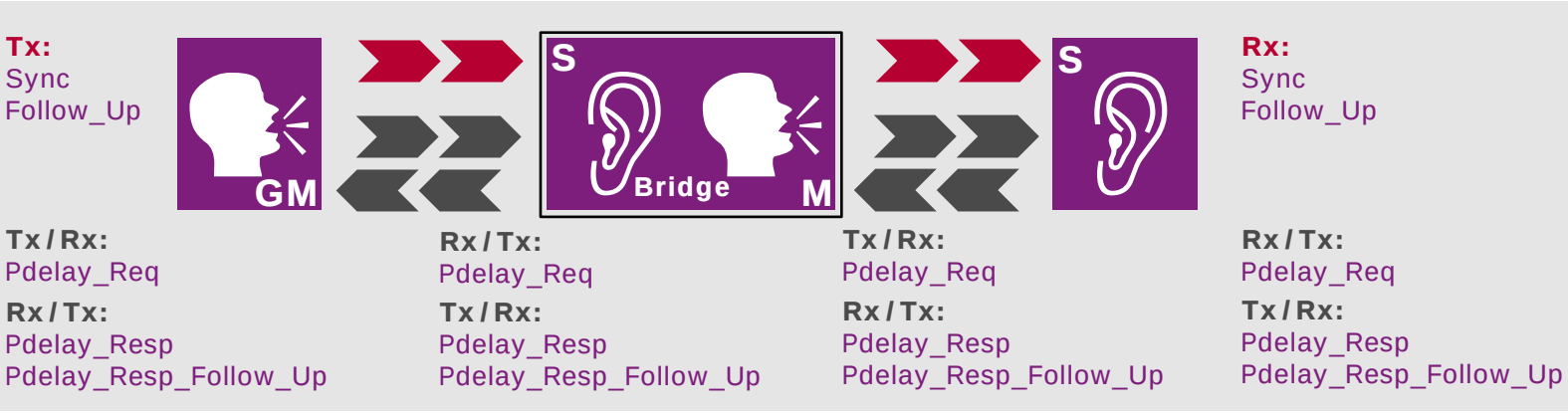
Precision Time Protocol (PTP)

Grandmaster (GM):

- Distributes the clock to the system – receiver adjust their clock
  - Sync (triggers the receiver to a time stamp) and
  - Follow_Up (contains the time stamp at Sync generation and the time correction value at Sync transmission)
- GM time aware messages will be forwarded by other bridges as well

Propagation Delay Measurement:

- Point-to-point measurement between two ports against each other
- Based on ingress and egress time stamping of Pdelay messages, the initiator computes propagation delay



Stream Reservation Protocol (SRP)

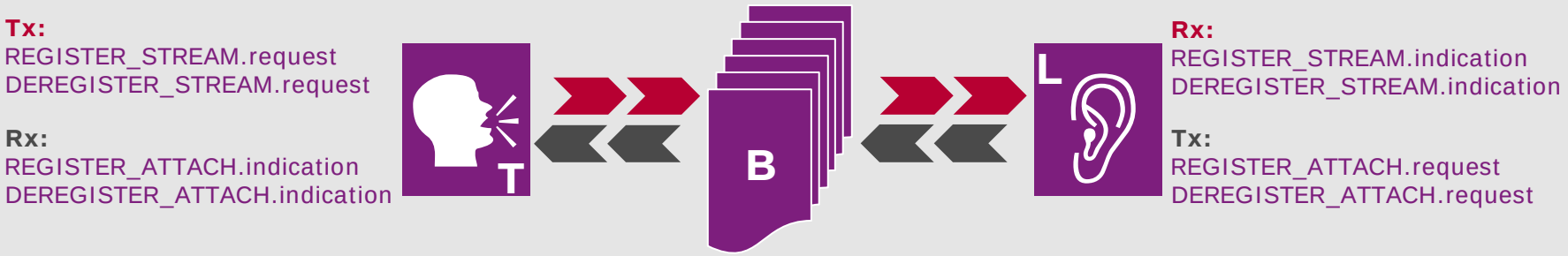
The SRP ensures bandwidth guaranties of an AVB network by

- Registration of streams by Talker/Listeners
- De-Registration of streams by Talker/Listeners
- Maintaining stream reservation information by Bridges

The SRP requires support of VLAN's where Endpoints declare their membership for. Un-registered streams will not pass the Bridge.

Importance decision based is on:

1. StreamRank (lower is better)
2. StreamAge (earlier registered/larger age is better) and
3. StreamID (lower is better)



Forwarding and Queuing Enhancements for Time-Sensitive Streams (FQTSS)

Purpose:

- For Bridges that provide performance guarantees for time-sensitive A/V stream traffic
- For Talkers, if Stream Reservation Classes are defined
- Defines handling of queues for AVB and Non-AVB traffic

By using:

- Priority information to determine the traffic classes to be used for time-sensitive streams
- One or more queues for a given Bridge Port
- Strict Priority Algorithm (simple) or
- Credit-based Shaper Algorithm (more complex)

Remark:

- Talkers use the priorities that the Bridges in the network recognize as being associated with Stream Reservation Classes exclusively for transmitting stream data.

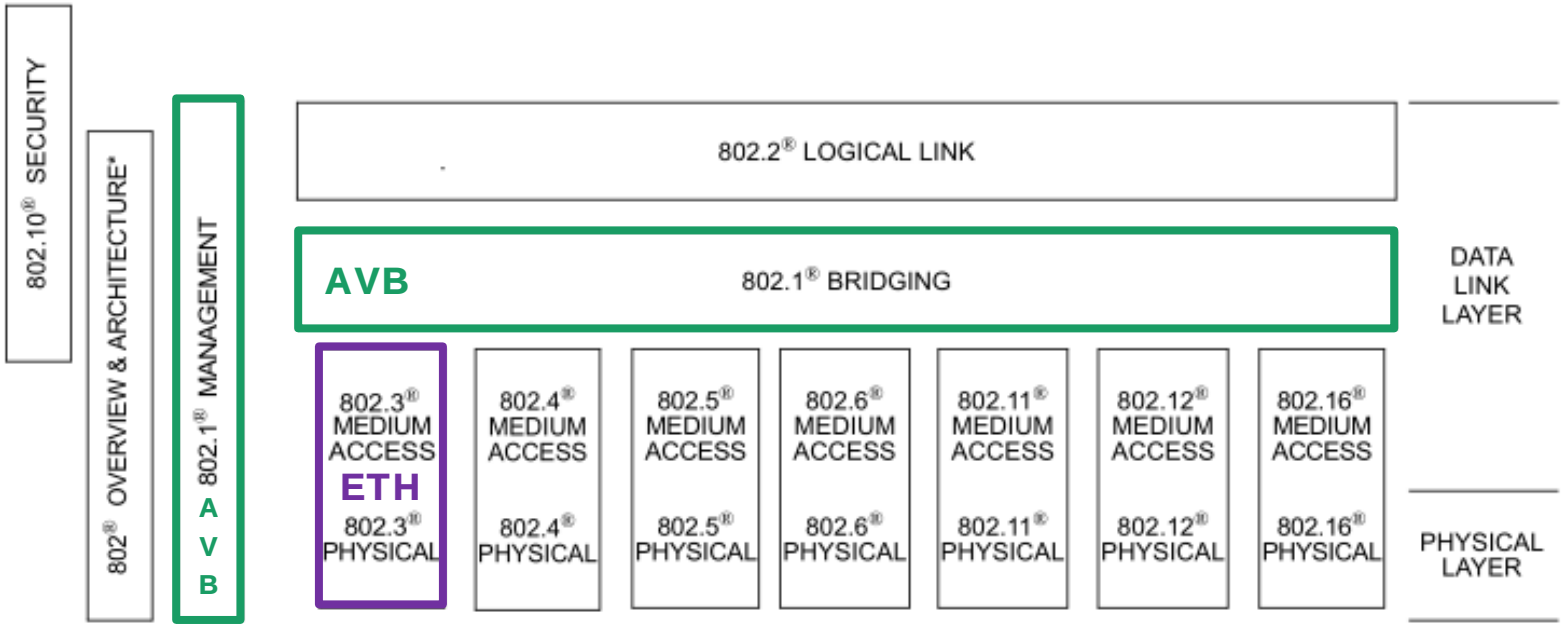
Audio Video Transport Protocol (AVTP)

- AVTP delivers the data stream from one Endpoint to another by carrying:
  - Stream and control data
  - Sequence number
  - Presentation time
  - Validation flags
  - Sub-protocols
  - Sub-protocol data

- Support of several A/V formats
- Presentation time synchronizes Talker and Listener

Architecture Specified by IEEE

- AVB is on top of the MAC Layer



Source: IEEE 802

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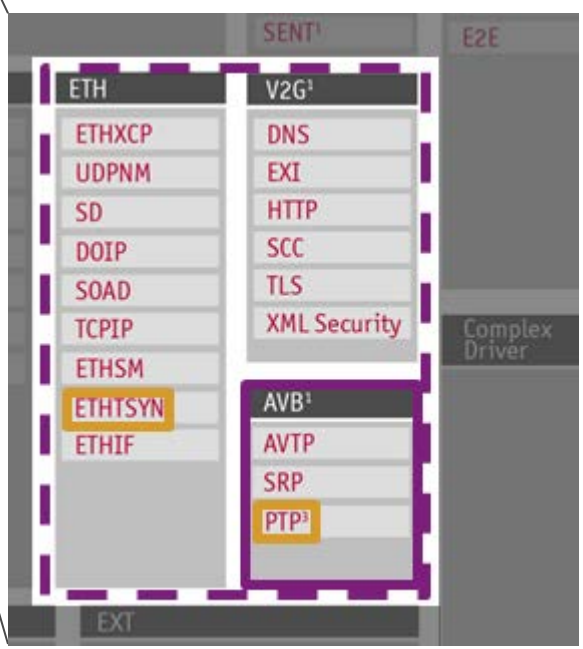
Specification Status

With AUTOSAR 4.2, the Ethernet communication cluster will be extended by the new module EthTSyn according to AUTOSAR_SWS_TimeSyncOverEthernet [ID 676].



EthTSyn is responsible for transmission and reception of time synchronization messages over Ethernet, like CanTSyn for CAN and FrTSyn for FlexRay.

EthTSyn includes PTP, slightly customized for automotive.

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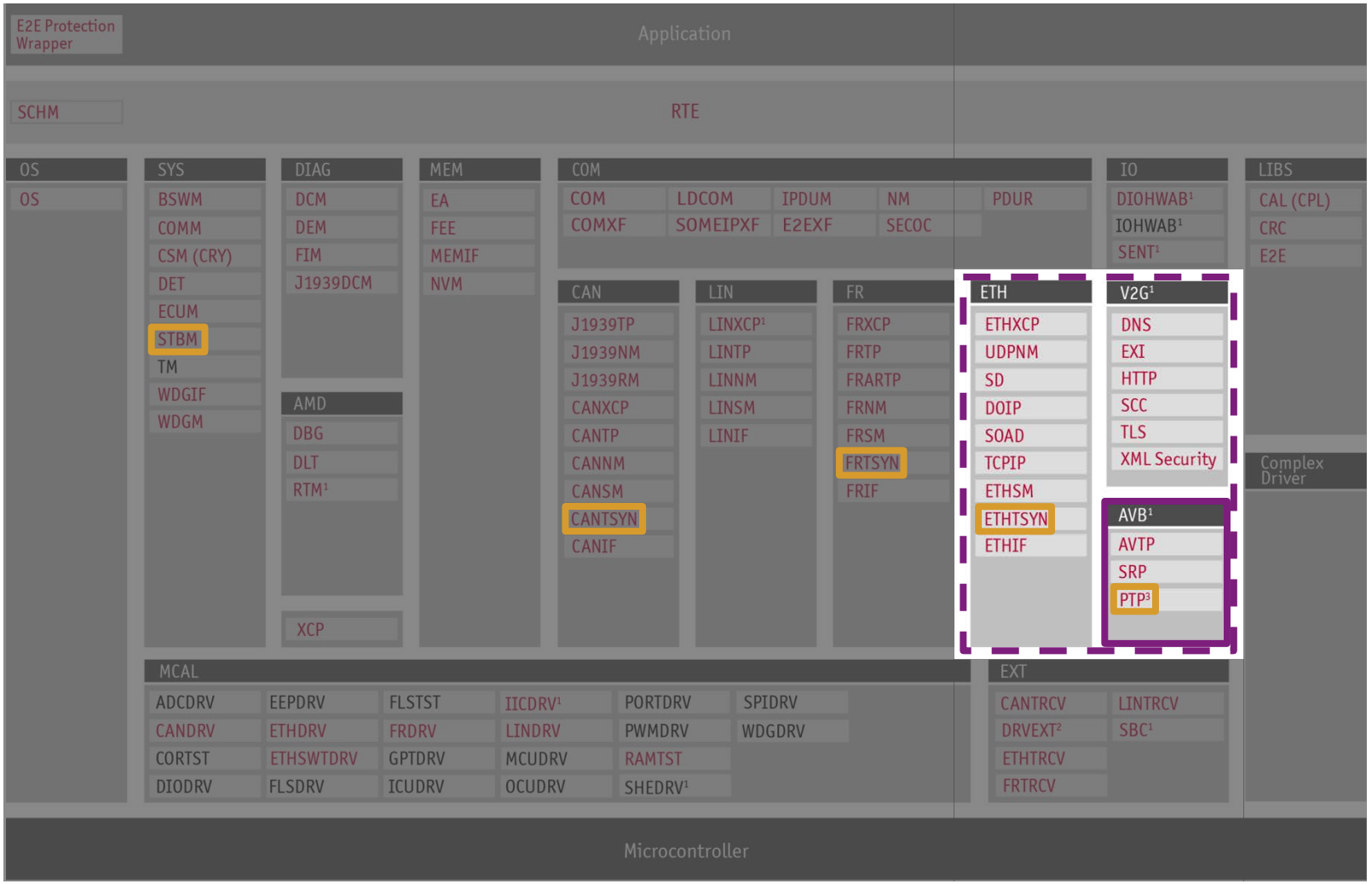
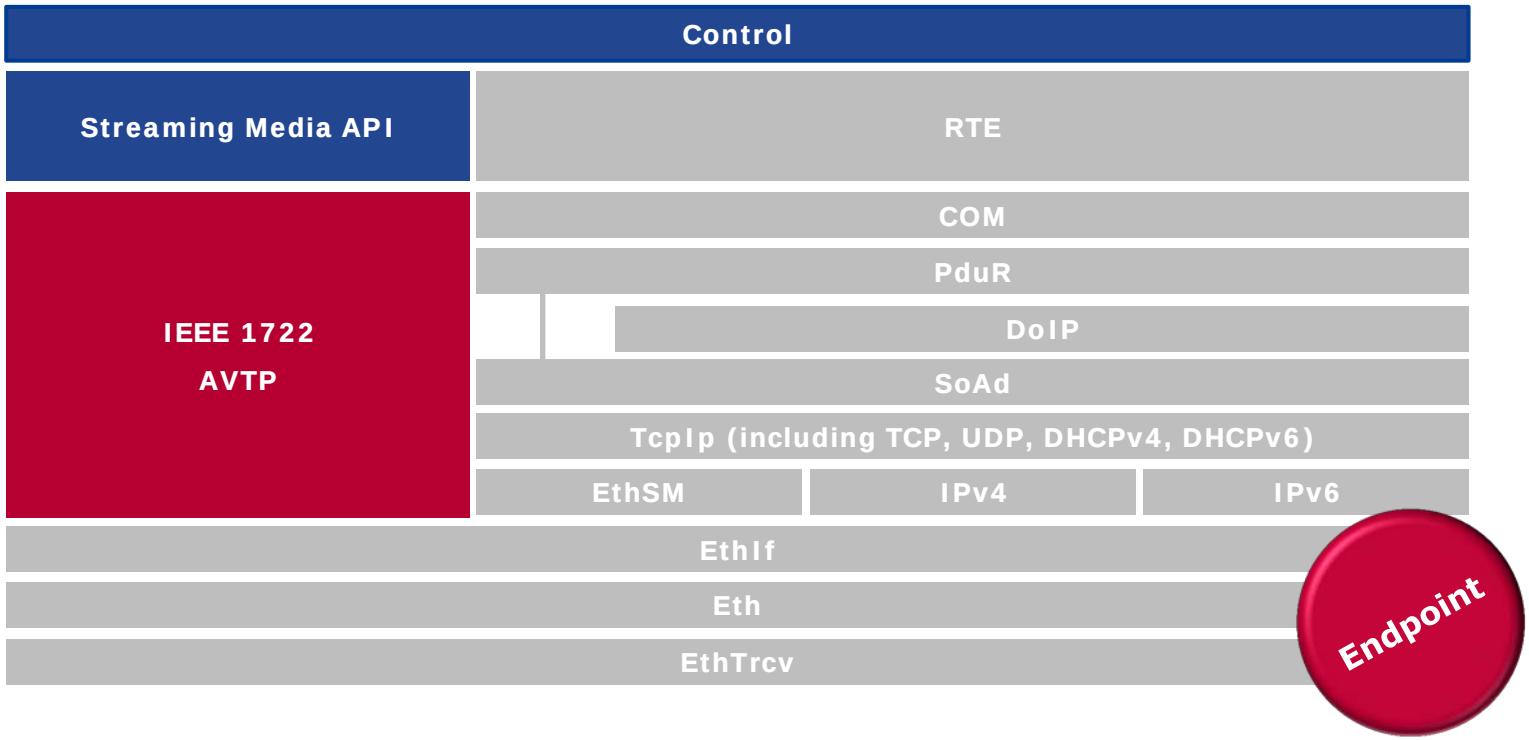
Location within our MICROSAR Software Architecture



Vector Standard Software | 3rd Party Software

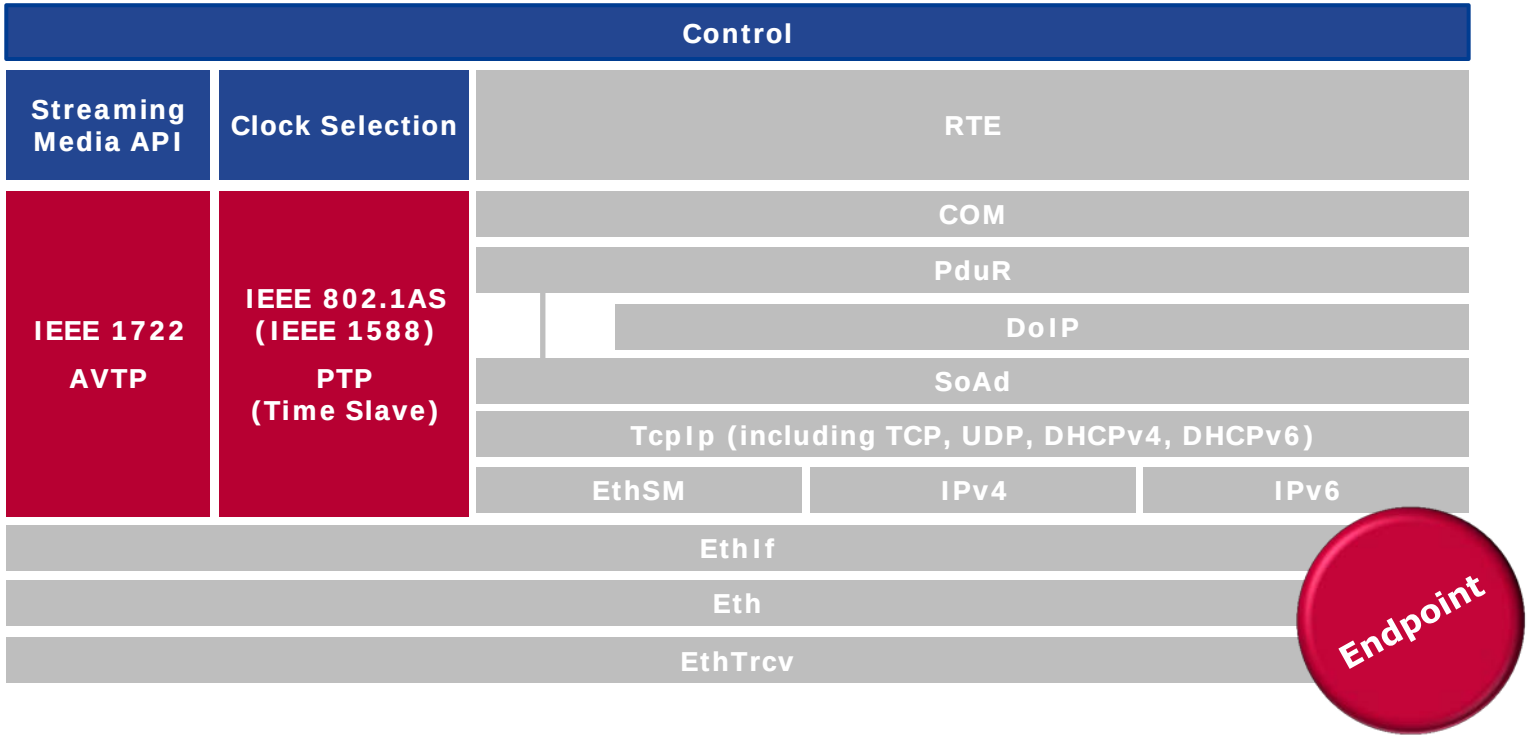
[1] Available extensions for AUTOSAR
[2] Includes EXTADC, EEPEXT, FLSEXT, ETHSWTEXT and WDGEXT
[3] Functionality represented in ETHTSYN and STBM

Step 1 – ECU with AVTP



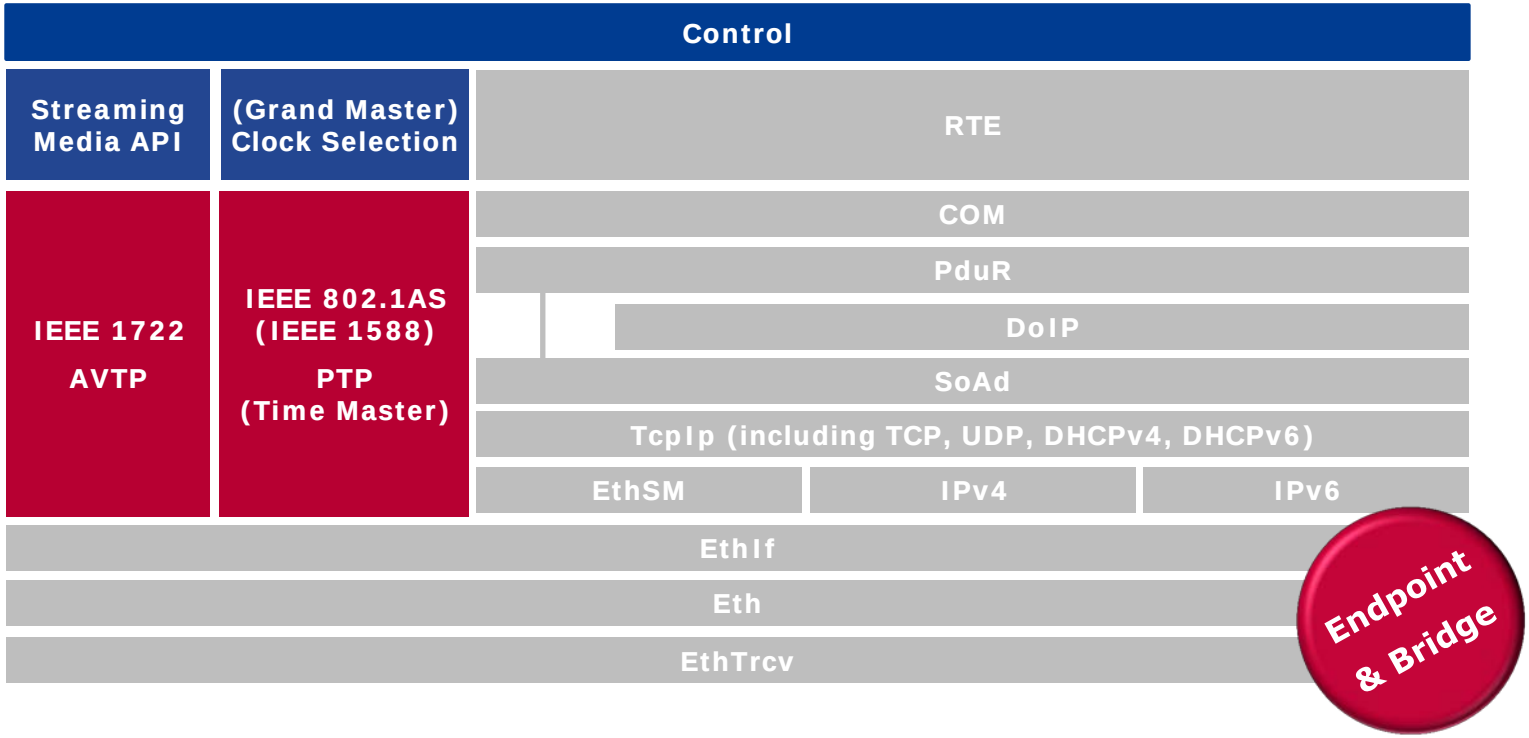
- Application / Customer SW
- MICROSAR Ethernet Stack + COM + RTE
- Not In AUTOSAR specified:
  MICROSAR AVTP (Audio/Video Transport Protocol)

Step 2 – ECU with AVTP and PTP (Time Slave)



- Application / Customer SW
- MICROSAR Ethernet Stack + COM + RTE
- Not In AUTOSAR specified:
  - MICROSAR AVTP (Audio/Video Transport Protocol)
  - MICROSAR PTP (Precision Time Protocol) – HW support required

Step 3 – ECU with AVTP and PTP (Time Master)



- Application / Customer SW
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Full Set of IEEE Specifications vs. Automotive Use Case

Criteria	IEEE Specification	Automotive Use Case
Network Topology	Dynamic	Static
SW Standard	None	AUTOSAR
Time Synchronization	PTP	EthTSyn and StbM
Network Clock Provider	Bridge with GM-Functionality	Central GW Module
Network Access	Dynamic (Devices Unknown)	Exclusive
Coexistence with other Ethernet Protocols	Possible	Required (e.g. TCP/IP)
Latency Presetting	Yes	Yes
Device Connection	Spanning Tree	Peer to peer

- Static network topology, exclusive network access and time synchronization requirements together with todays peer to peer endpoint connection concludes, that the implementation of AVTP and PTP are highly recommended for automotive.
- Depending on the network complexity and network setup requirements further protocol implementations might be required.
- DOIP in parallel is always possible.

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Why AVB if we have already IP ?

- AVB frames are separated from IP frames already on driver level, due to different Ethertype and VLAN-Tag. This ensures a high availability of AVB data, not interrupted and disturbed by IP protocol.

- The structure of the AVTP ensures a seamless flow of Audio/Video information such as timestamp and data on a fixed position in the packet.

- AVB was designed to allow a maximum of hardware support within DSP's/FPGA's due to no additional protocol overhead. This increases the availability in supporting Audio/Video streams at all.

- IP based RTP (Real Time TP) solution was designed for long Ethernet distances, e.g. Internet. AVTP is more suitable for short network distances.

- Mixed operation of IP and AVB on one physical Ethernet bus with pre-defined bandwidth due to usage of tagged VLAN and traffic shaping in Bridges always possible

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