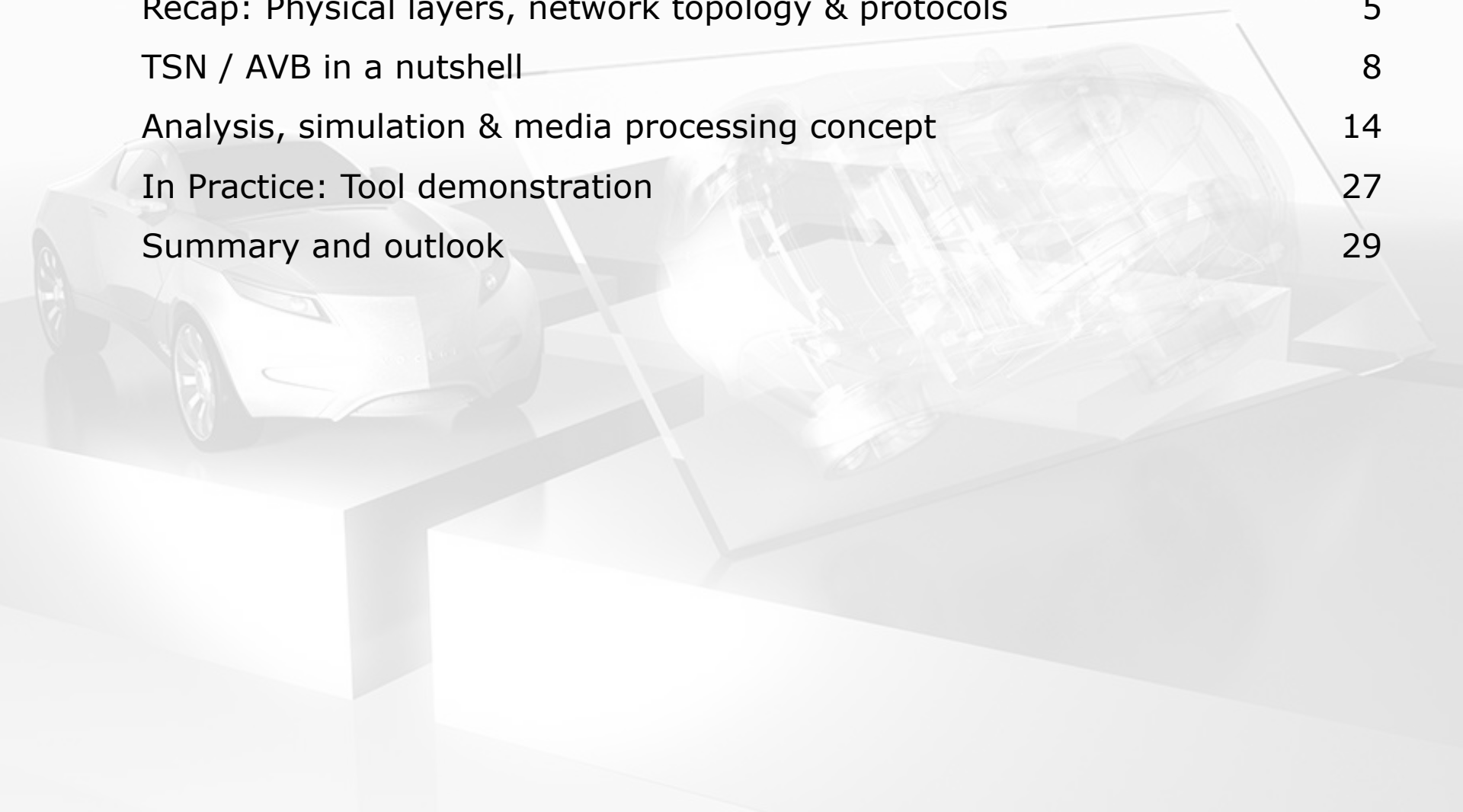


Ethernet@Automotive webinar series

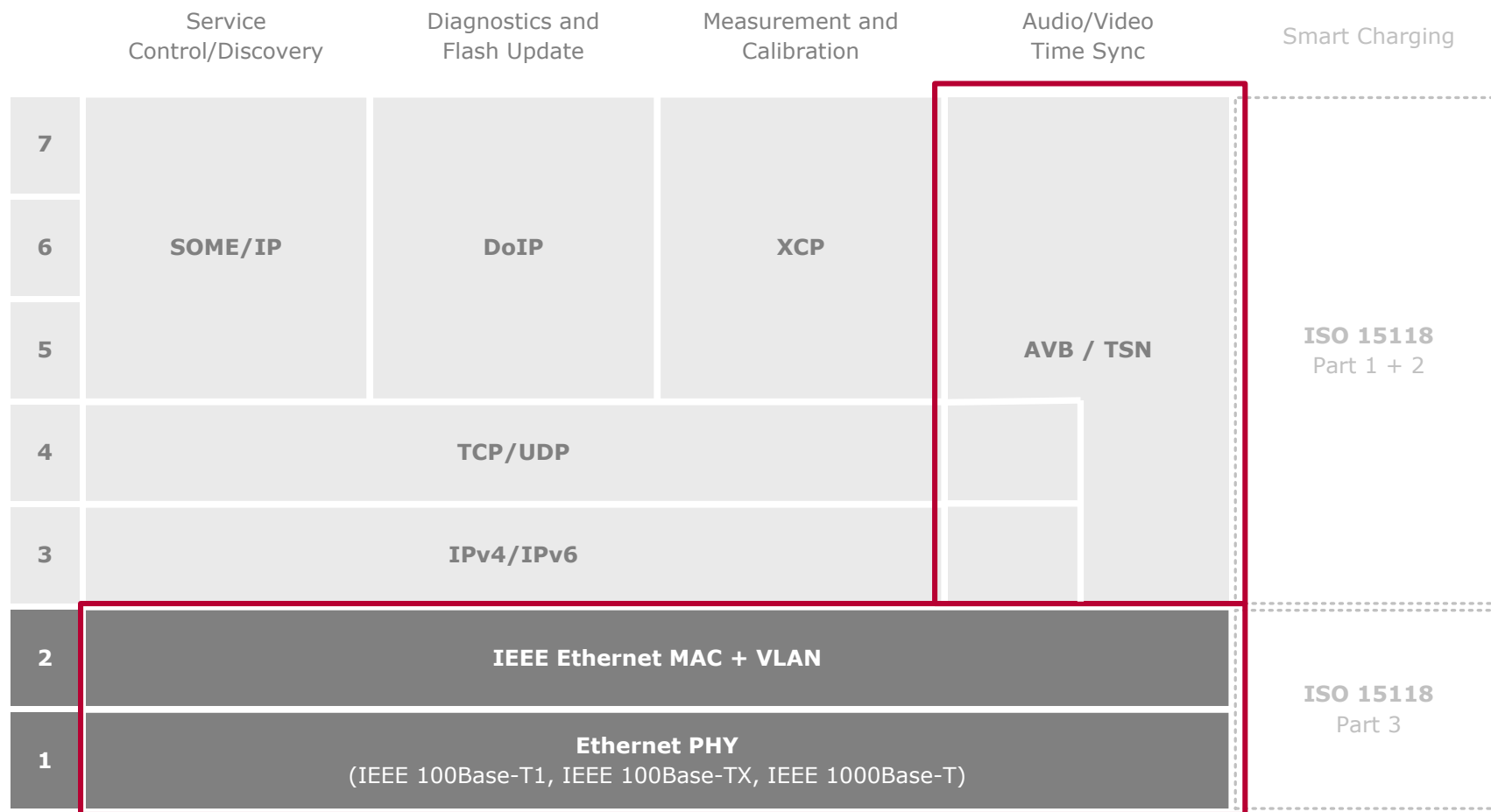
Moving Forward: Tool Supported Development for Automotive Ethernet in Time Sensitive Networks

Agenda

► Introduction	3
Recap: Physical layers, network topology & protocols	5
TSN / AVB in a nutshell	8
Analysis, simulation & media processing concept	14
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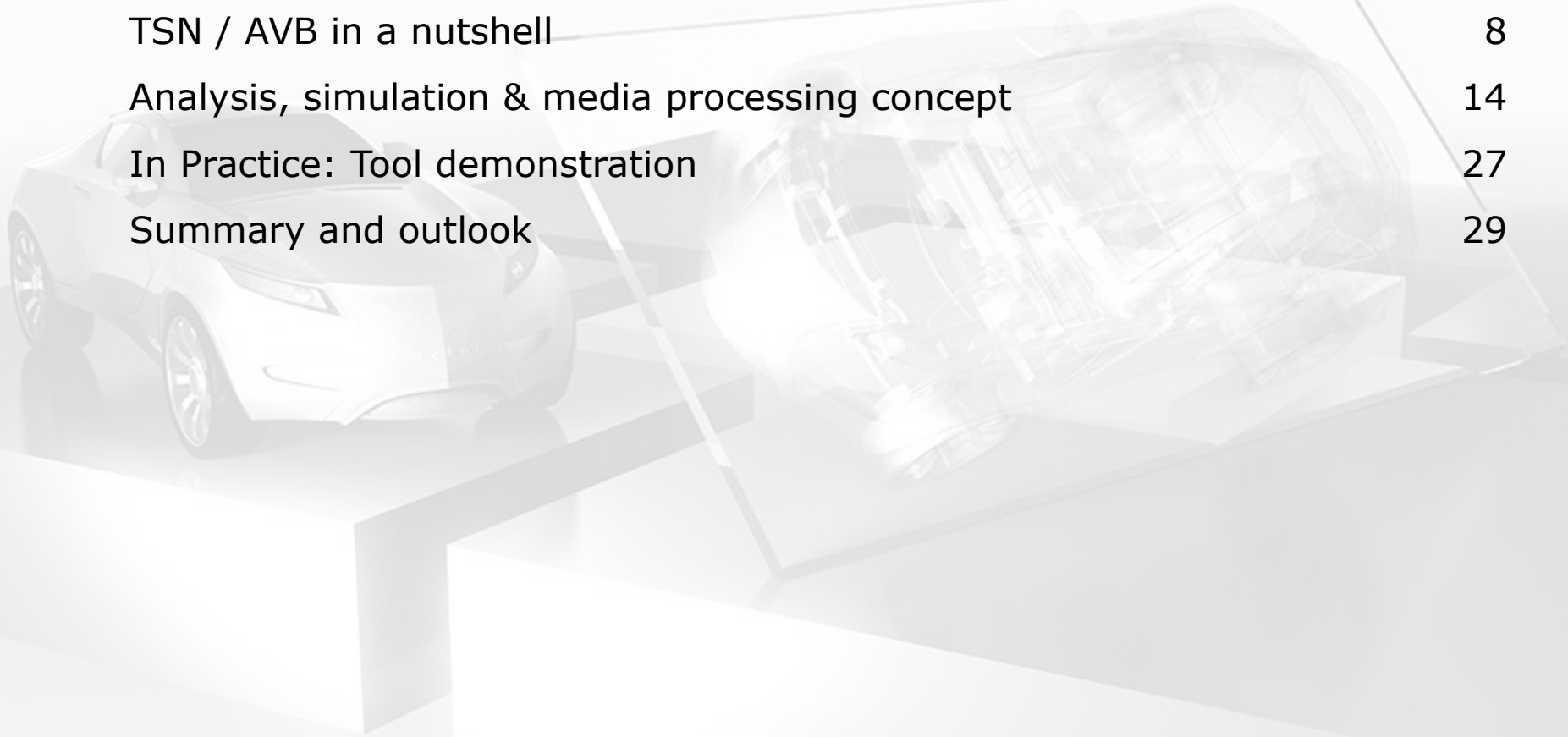


Application area



Agenda

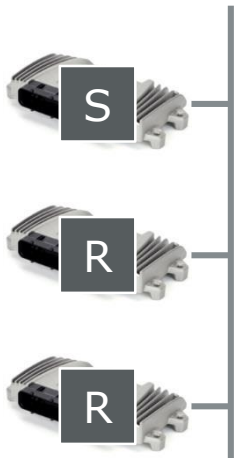
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Network Characteristics

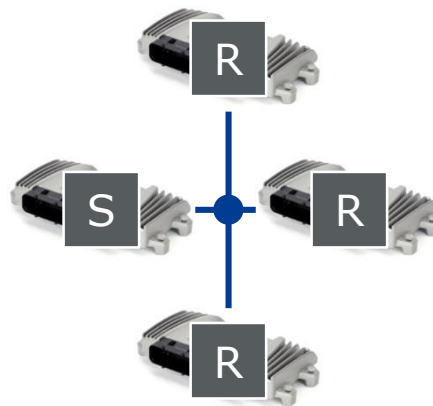
CAN (FD)

- ▶ Bus
- ▶ Broadcast



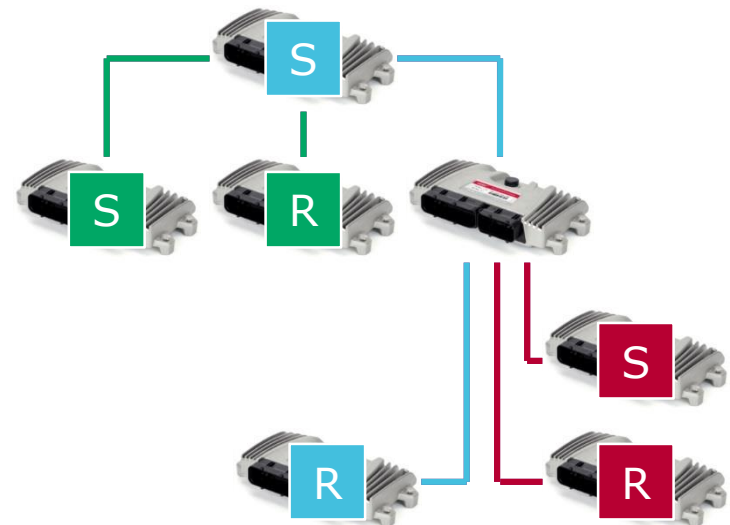
FlexRay

- ▶ Active Star
- ▶ Broadcast

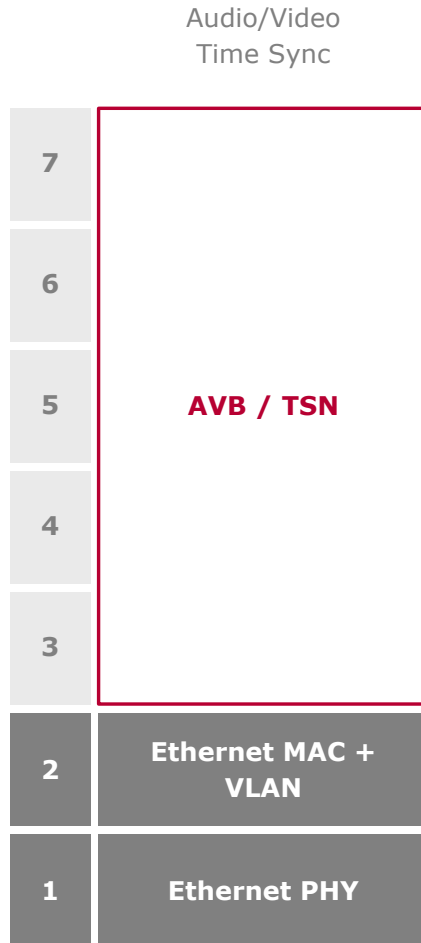


Ethernet

- ▶ Fully switched network (point-to-point)
- ▶ Unicast
- ▶ Multicast and broadcast



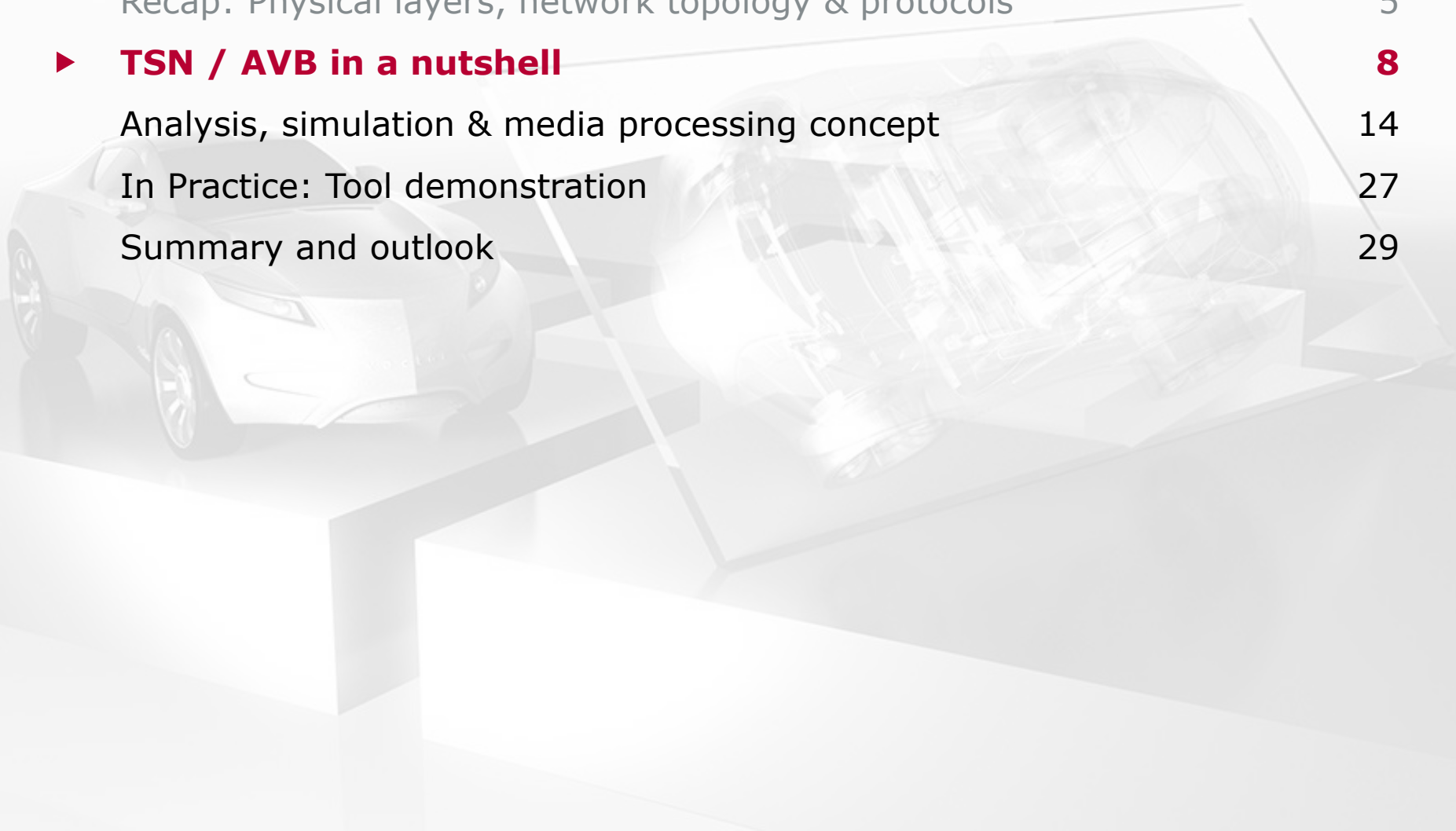
AVB/TSN: Audio Video Bridging / Time Sensitive Networking



- ▶ Application area:
 - > Time synchronous data transmission
 - > Assured worst case latency for data transmission
 - > Priority controlled data transmission
- ▶ Needs Ethernet Frames or VLAN Frames:
 - > Various Ethernet Types: e.g. 0x88F7 (**gPTP**)
- ▶ Standards surrounding AVB:
 - > **IEEE 802.1AS**: Timing and synchronization
 - > **IEEE 802.1Qav/Qat**: Forwarding and queuing, stream reservation (QoS)
 - > **IEEE 1722**: **A**udio/**V**ideo **T**ransport **P**rotocol

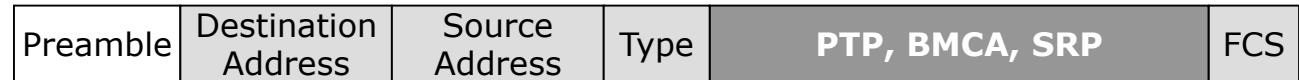
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Basic Message Layout

Untagged Eth. Frame:



Bytes:

8

6

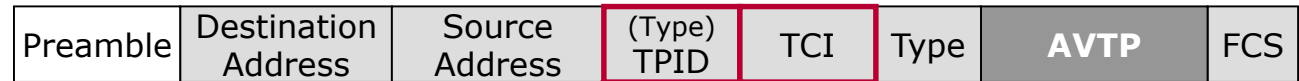
6

2

46 ... 1500

4

Tagged Eth. Frame:



Bytes:

8

6

6

2

2

2

42 ... 1500

4

VLAN-Tag:

Bits:

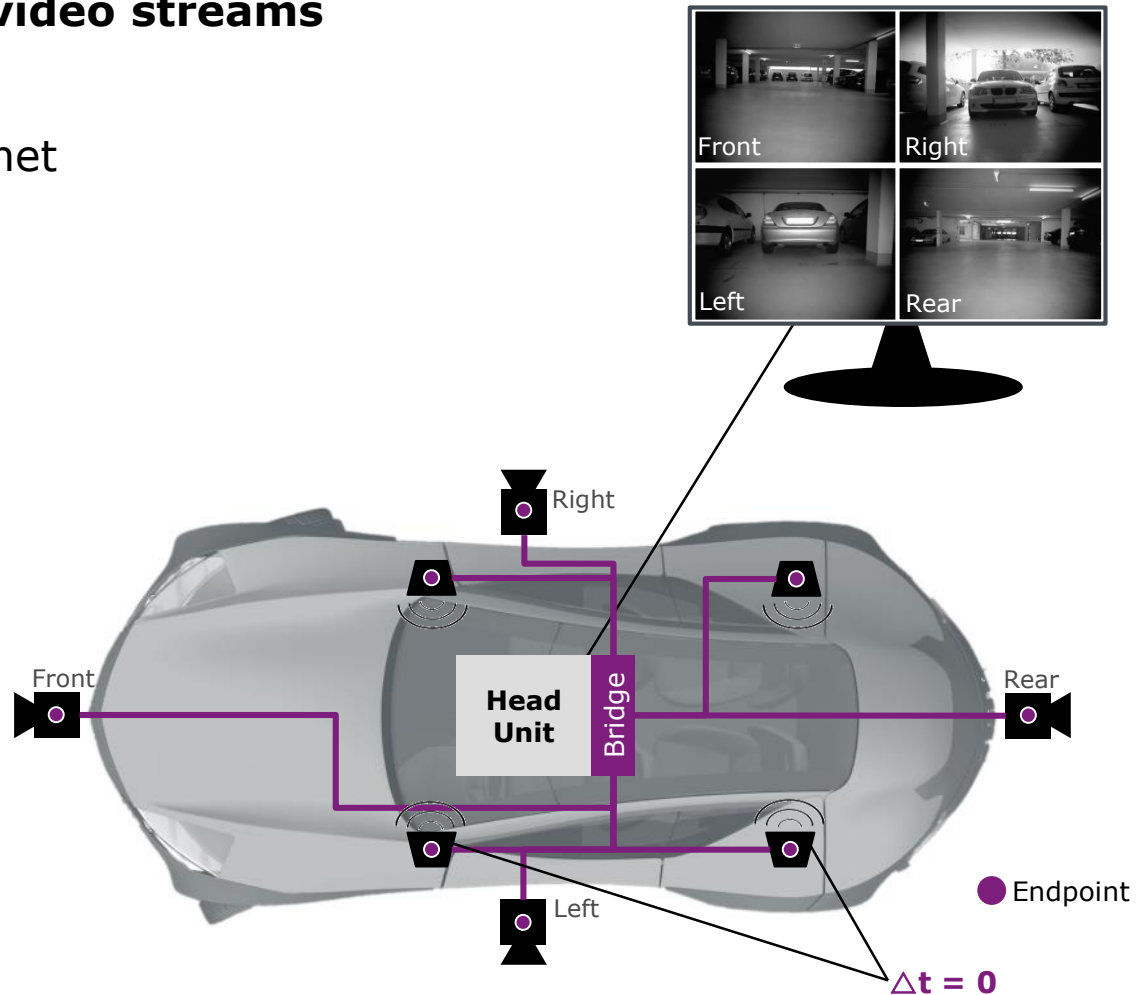


- ▶ TPID – Tag Protocol Identifier; fix value of 0x8100 (Ethernet for VLAN)
- ▶ TCI – Tag Control Identifier
 - > PCP – Priority Code Point (large value represents high priority)
 - > CFI – Canonical Format Indicator
 - > VID – VLAN Identifier

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

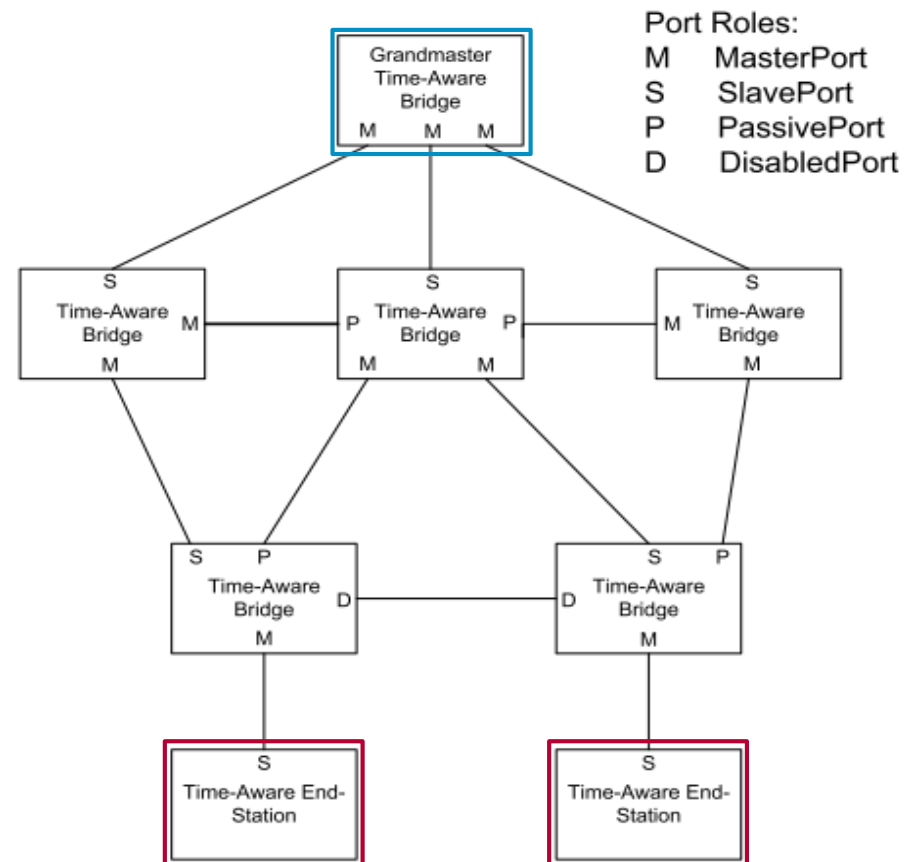
- ▶ Fast-Ethernet (*Full-Duplex*)
 - ▶ No message priority consideration
 - ▶ Latency not defined
- ▶ vs. AVB (*Full-Duplex with Bandwidth Reservation*)
 - ▶ Time synchronization
 - ▶ Bandwidth reservation
 - ▶ Worst-case latency presetting

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



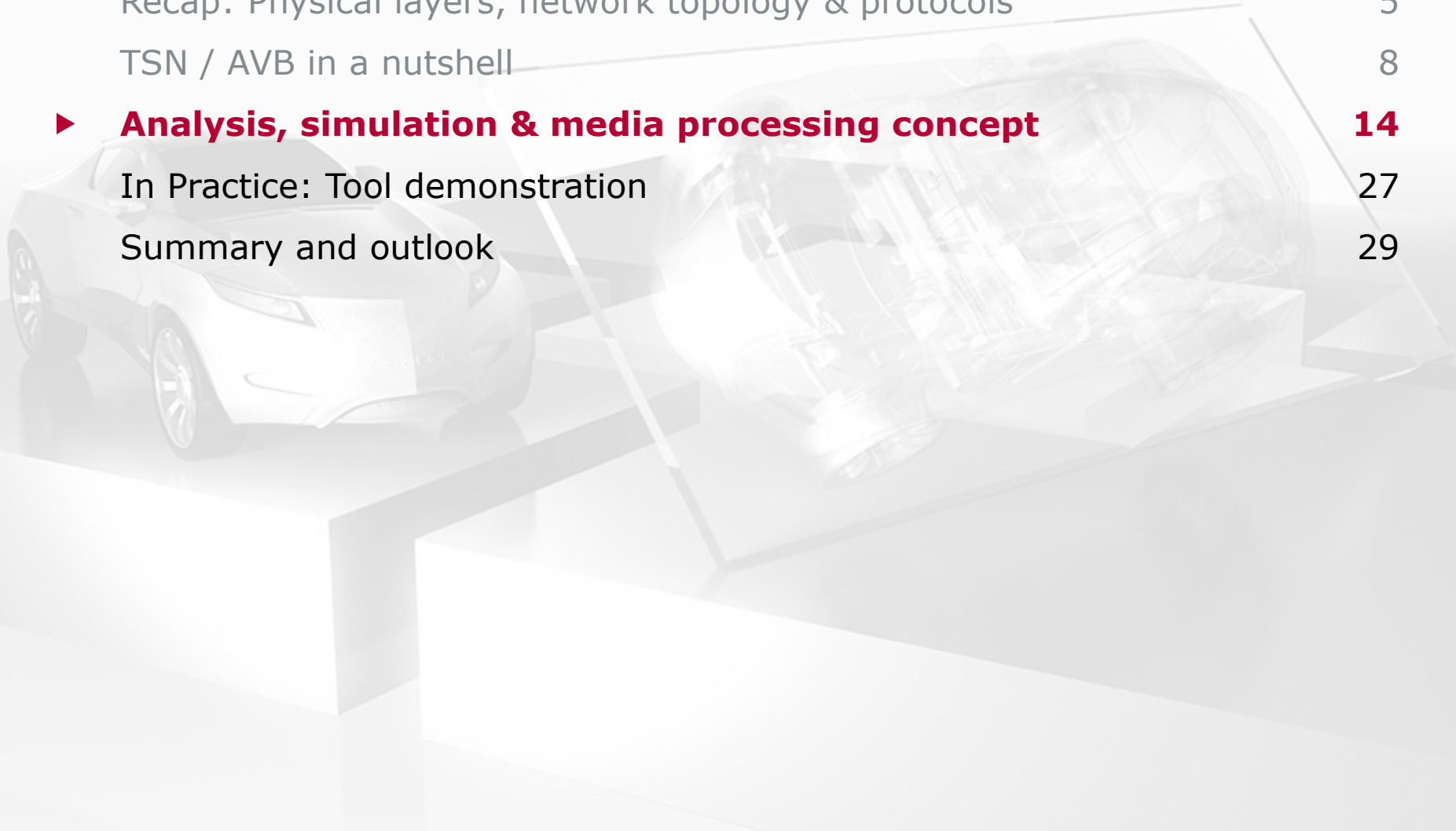
Source: IEEE 802.1AS

Audio Video Transport Protocol (AVTP)

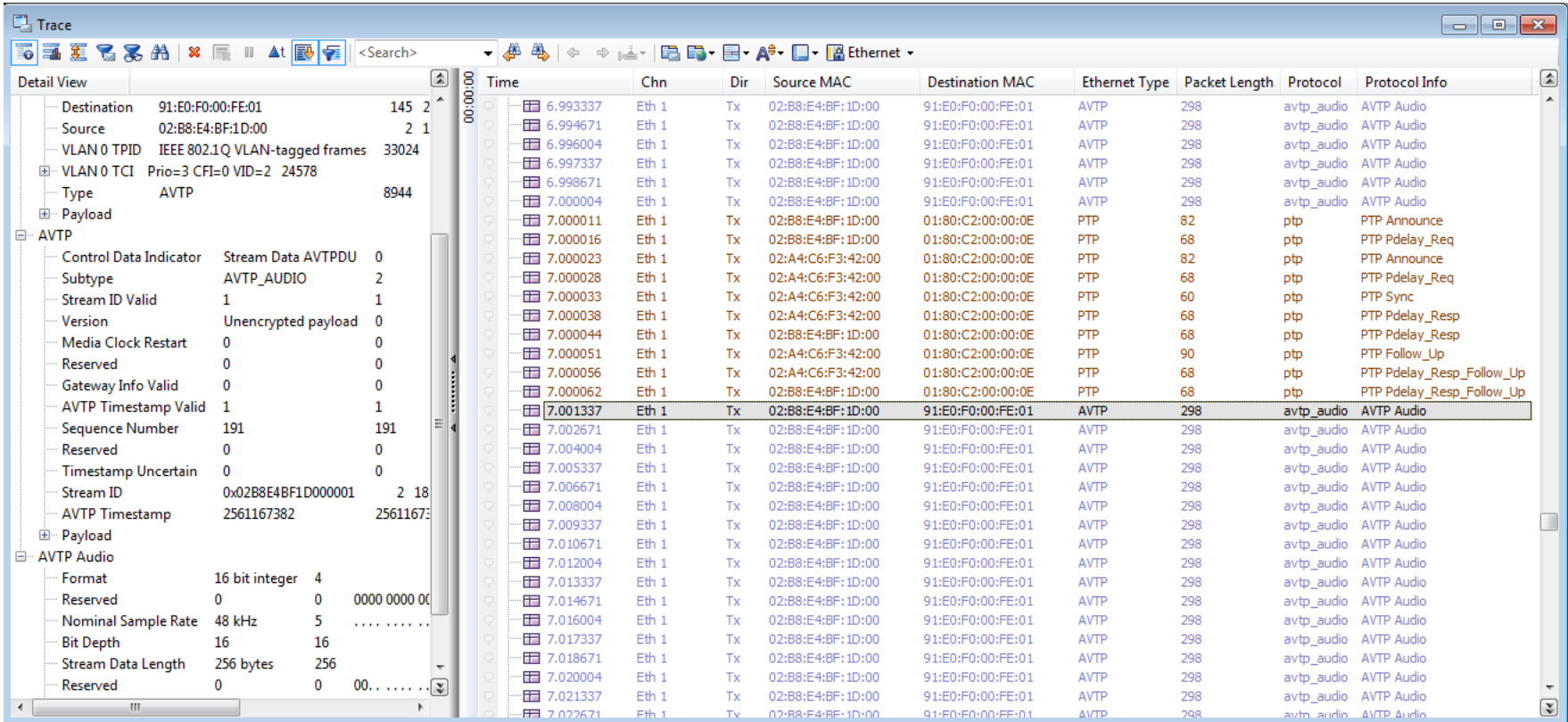
- ▶ AVTP delivers the data stream from one **Endpoint** to another by carrying:
 - ▶ Stream and control data
 - ▶ Sequence number
 - ▶ Presentation time
 - ▶ Validation flags
 - ▶ Sub-protocols
 - ▶ Sub-protocol data
- ▶ Support of several A/V formats
- ▶ Presentation time synchronizes Talker and Listener

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Trace Window



Trace Window

Detail View

- Destination: 91:E0:F0:00:FE:01 145 2
- Source: 02:B8:E4:BF:1D:00 2 1
- VLAN 0 TPID: IEEE 802.1Q VLAN-tagged frames 33024
- VLAN 0 TCI: Prio=3 CFI=0 VID=2 24578
- Type: AVTP 8944
- Payload:
 - AVTP
 - Control Data Indicator: Stream Data AVTPDU 0
 - Subtype: AVTP_AUDIO 2
 - Stream ID Valid: 1 1
 - Version: Unencrypted payload 0
 - Media Clock Restart: 0 0
 - Reserved: 0 0
 - Gateway Info Valid: 0 0
 - AVTP Timestamp Valid: 1 1
 - Sequence Number: 191 191
 - Reserved: 0 0
 - Timestamp Uncertain: 0 0
 - Stream ID: 0x02B8E4BF1D000001 2 18
 - AVTP Timestamp: 2561167382 25611673
 - Payload:
 - AVTP Audio
 - Format: 16 bit integer 4
 - Reserved: 0 0 0000 0000 00
 - Nominal Sample Rate: 48 kHz 5
 - Bit Depth: 16 16
 - Stream Data Length: 256 bytes 256
 - Reserved: 0 0 00... 00

Packet List

Time	Chn	Dir	Source MAC	Destination MAC	Ethernet Type	Packet Length	Protocol	Protocol Info
6.993337	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
6.994671	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
6.996004	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
6.997337	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
6.998671	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.000004	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.000011	Eth 1	Tx	02:B8:E4:BF:1D:00	01:80:C2:00:00:0E	PTP	82	ptp	PTP Announce
7.000016	Eth 1	Tx	02:B8:E4:BF:1D:00	01:80:C2:00:00:0E	PTP	68	ptp	PTP Pdelay_Req
7.000023	Eth 1	Tx	02:A4:C6:F3:42:00	01:80:C2:00:00:0E	PTP	82	ptp	PTP Announce
7.000028	Eth 1	Tx	02:A4:C6:F3:42:00	01:80:C2:00:00:0E	PTP	68	ptp	PTP Pdelay_Req
7.000033	Eth 1	Tx	02:A4:C6:F3:42:00	01:80:C2:00:00:0E	PTP	60	ptp	PTP Sync
7.000038	Eth 1	Tx	02:A4:C6:F3:42:00	01:80:C2:00:00:0E	PTP	68	ptp	PTP Pdelay_Resp
7.000044	Eth 1	Tx	02:B8:E4:BF:1D:00	01:80:C2:00:00:0E	PTP	68	ptp	PTP Pdelay_Resp
7.000051	Eth 1	Tx	02:A4:C6:F3:42:00	01:80:C2:00:00:0E	PTP	90	ptp	PTP Follow_Up
7.000056	Eth 1	Tx	02:A4:C6:F3:42:00	01:80:C2:00:00:0E	PTP	68	ptp	PTP Pdelay_Resp_Follow_Up
7.000062	Eth 1	Tx	02:B8:E4:BF:1D:00	01:80:C2:00:00:0E	PTP	68	ptp	PTP Pdelay_Resp_Follow_Up
7.001337	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.002671	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.004004	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.005337	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.006671	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.008004	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.009337	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.010671	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.012004	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.013337	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.014671	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.016004	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.017337	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.018671	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.020004	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.021337	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio
7.022671	Eth 1	Tx	02:B8:E4:BF:1D:00	91:E0:F0:00:FE:01	AVTP	298	avtp_audio	AVTP Audio

AVB IL

- ▶ Simulation of Stream Talker
 - ▶ Provides media data
 - > Direct access to media source files (audio, video*) to simplify streaming
 - ▶ Protocol handling (e.g. gPTP, AVTP, ...)
 - ▶ AVTP
 - > Support various media protocol formats (AAF, CVF, ...)
 - > Clock Reference Format
 - ▶ Quality of Service
 - > Support Forwarding and Queueing of Time Sensitive Streams (FQTSS)

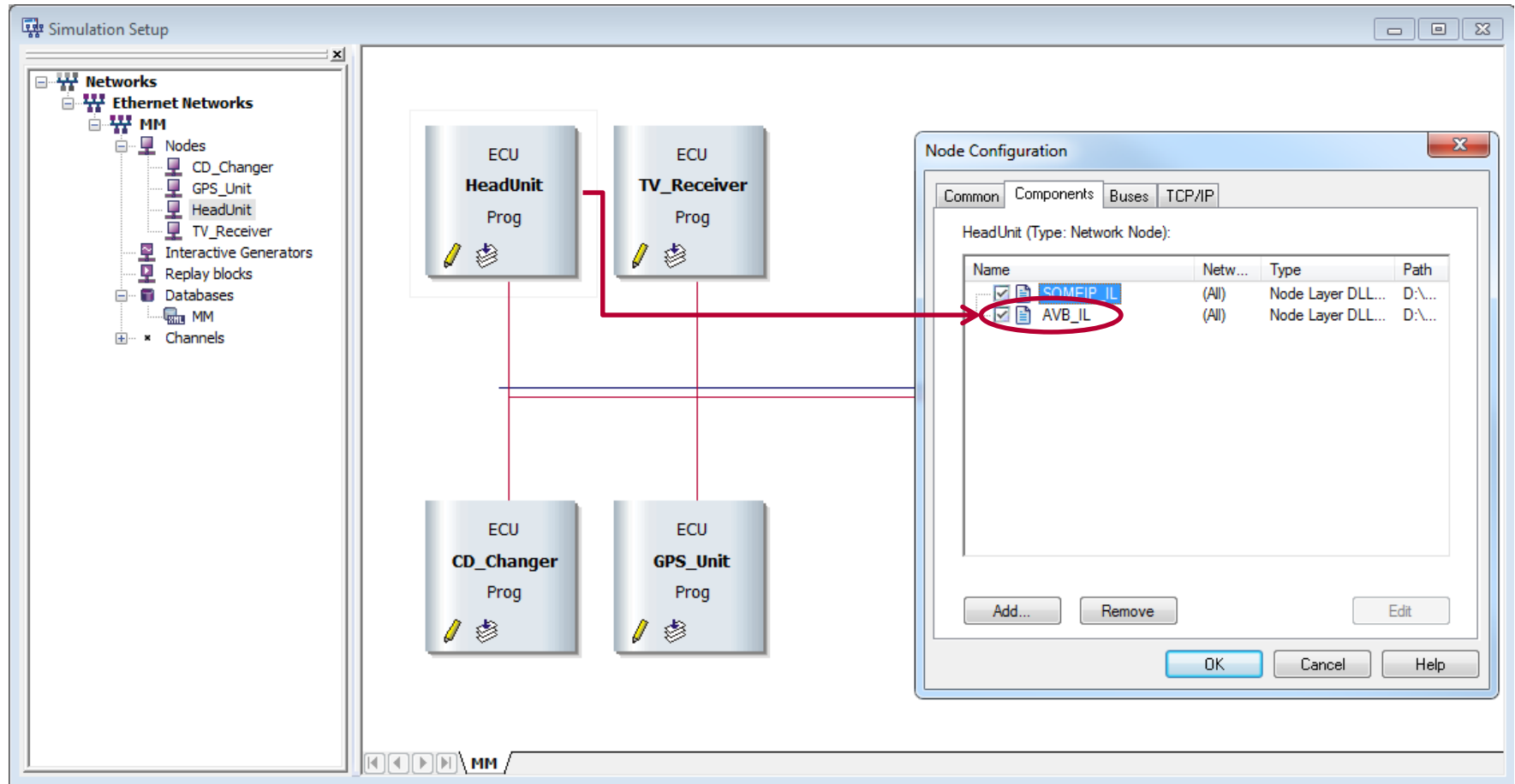
- ▶ Simulation of Stream Listener
 - ▶ Counterpart to talker
 - > Enable communication (e.g. when SRP is used)
 - ▶ Protocol handling (gPTP, AVTP)
 - ▶ Register to stream(s)
 - > Easy access to media data and protocol information

AVB IL

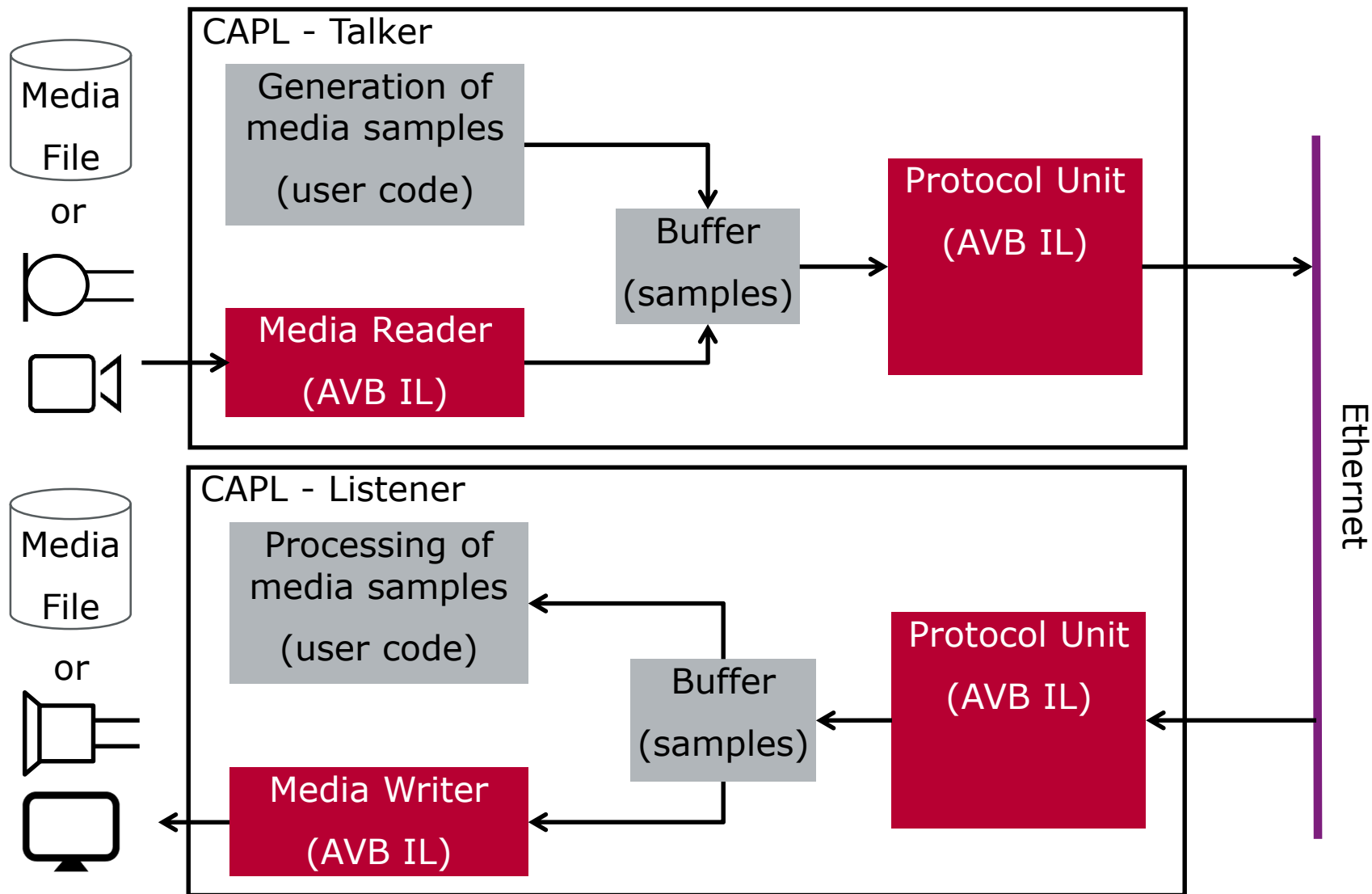
- ▶ Simulation of Clock Master
 - ▶ Best Master Clock Selection Algorithm (BMCA)
 - ▶ Support IEEE 802.1AS
 - > Clock synchronization for phase and frequency
 - ▶ gPTP
 - > Precise gPTP time due to interface hardware time stamps
 - > gPTP is equal to CANoe simulation time
- ▶ Simulation of Clock Slave
 - ▶ Precise gPTP time due to interface hardware time stamps
- ▶ Stream Reservation Protocol*

* Not used in automotive profile (defined by AVnu Alliance)

AVB IL

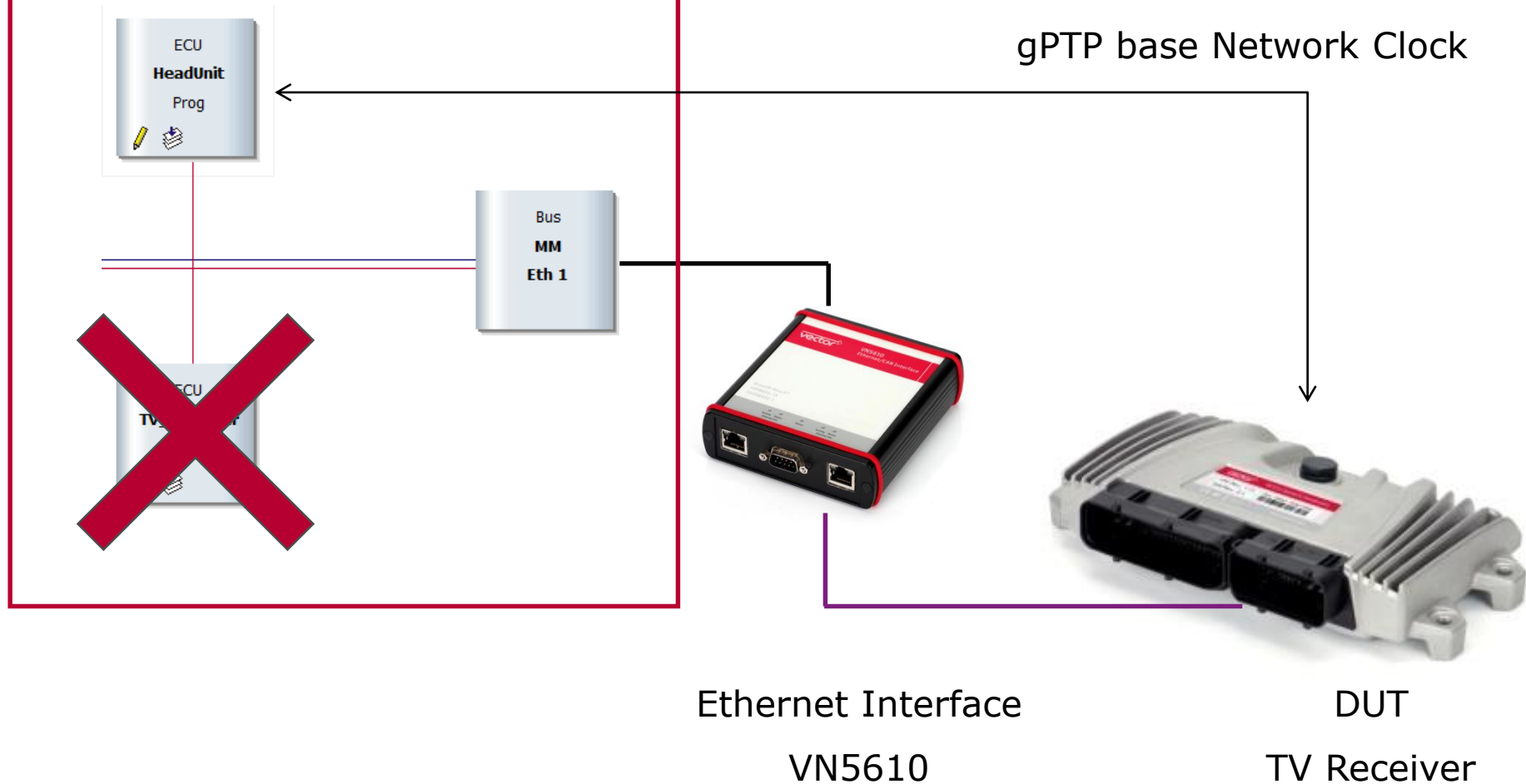


AVB IL

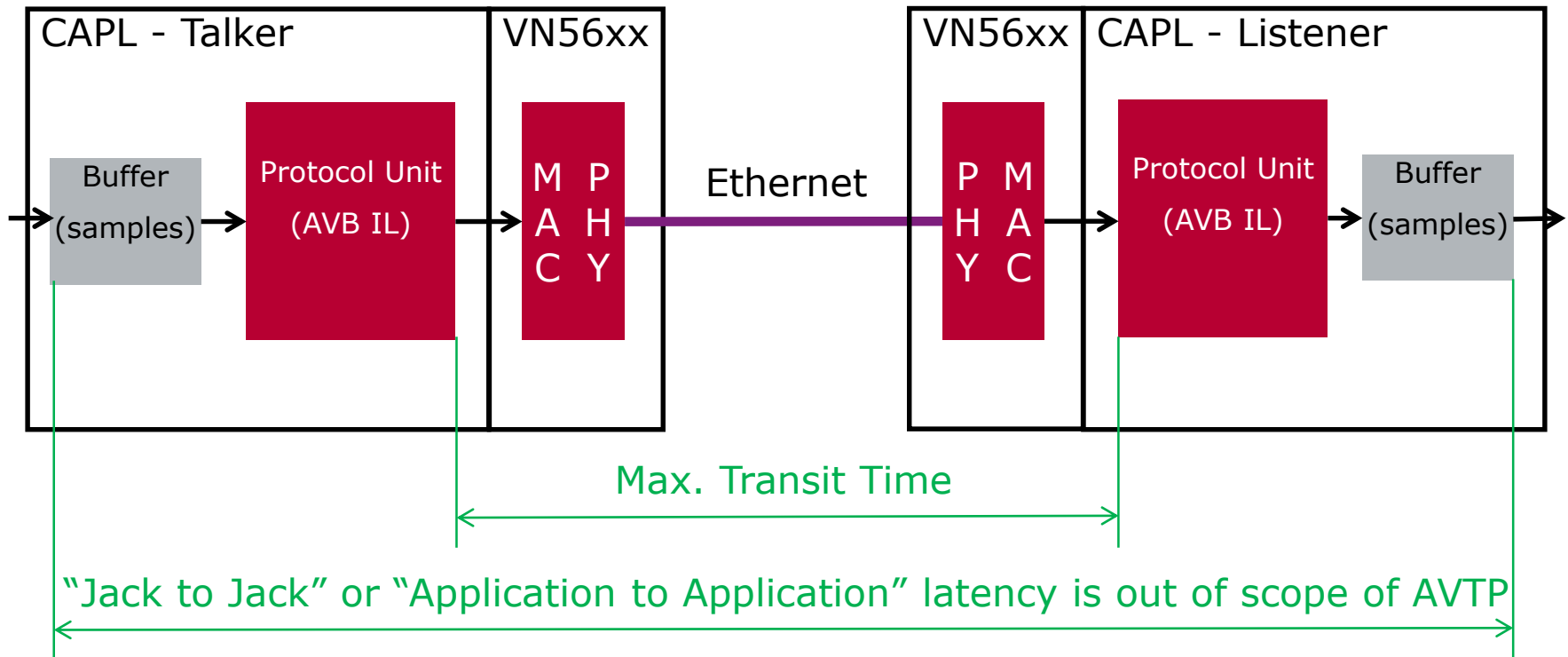


AVB IL – Time Synchronization

CANoe Simulation



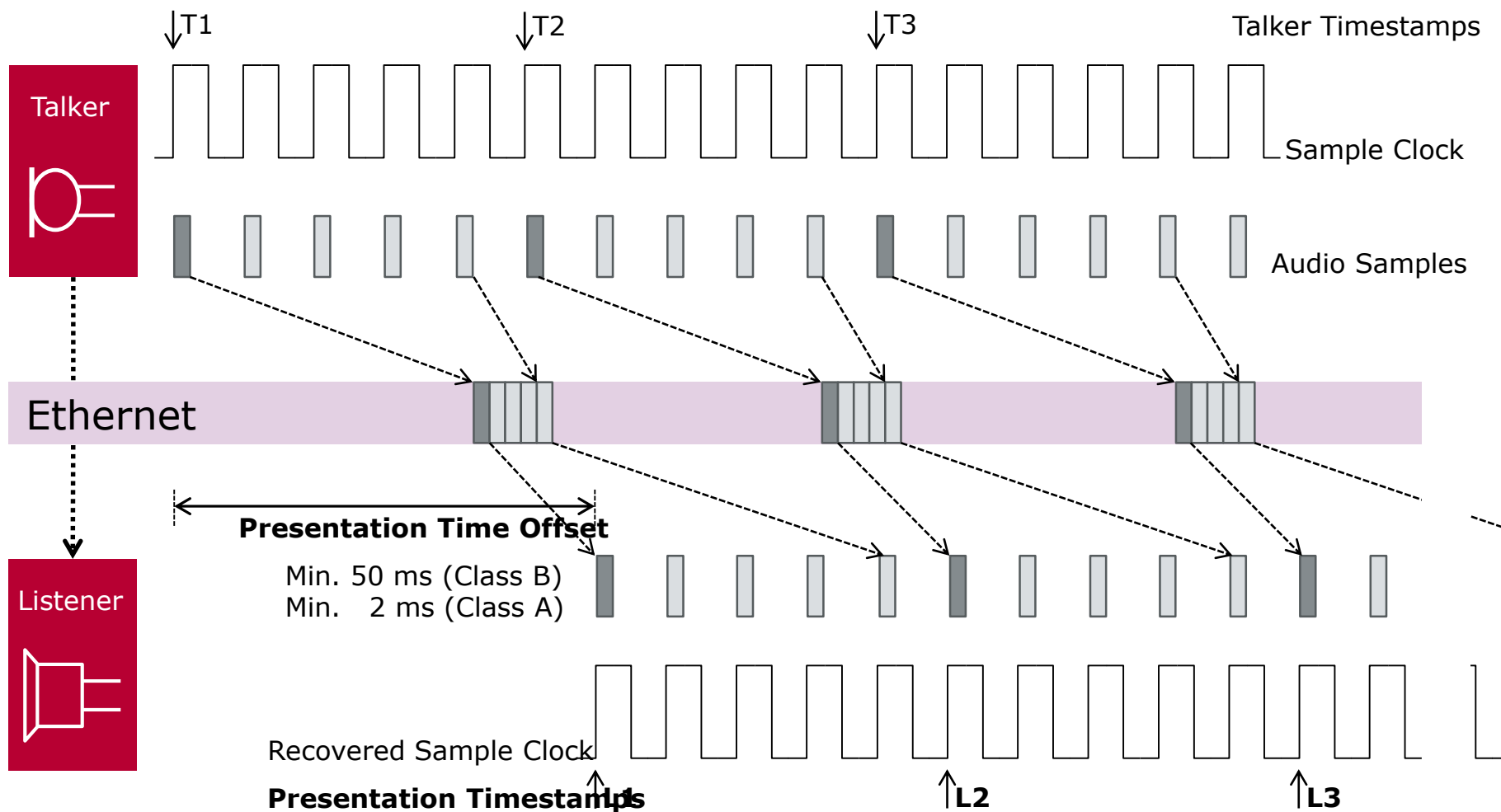
AVB IL – AVTP Timing



- ▶ Max. Transit Time Class A Network < 2 ms
- ▶ Max. Transit Time Class B Network < 50 ms

— IEEE Definition

AVB IL – AVTP Audio Packetization (FQTSS)

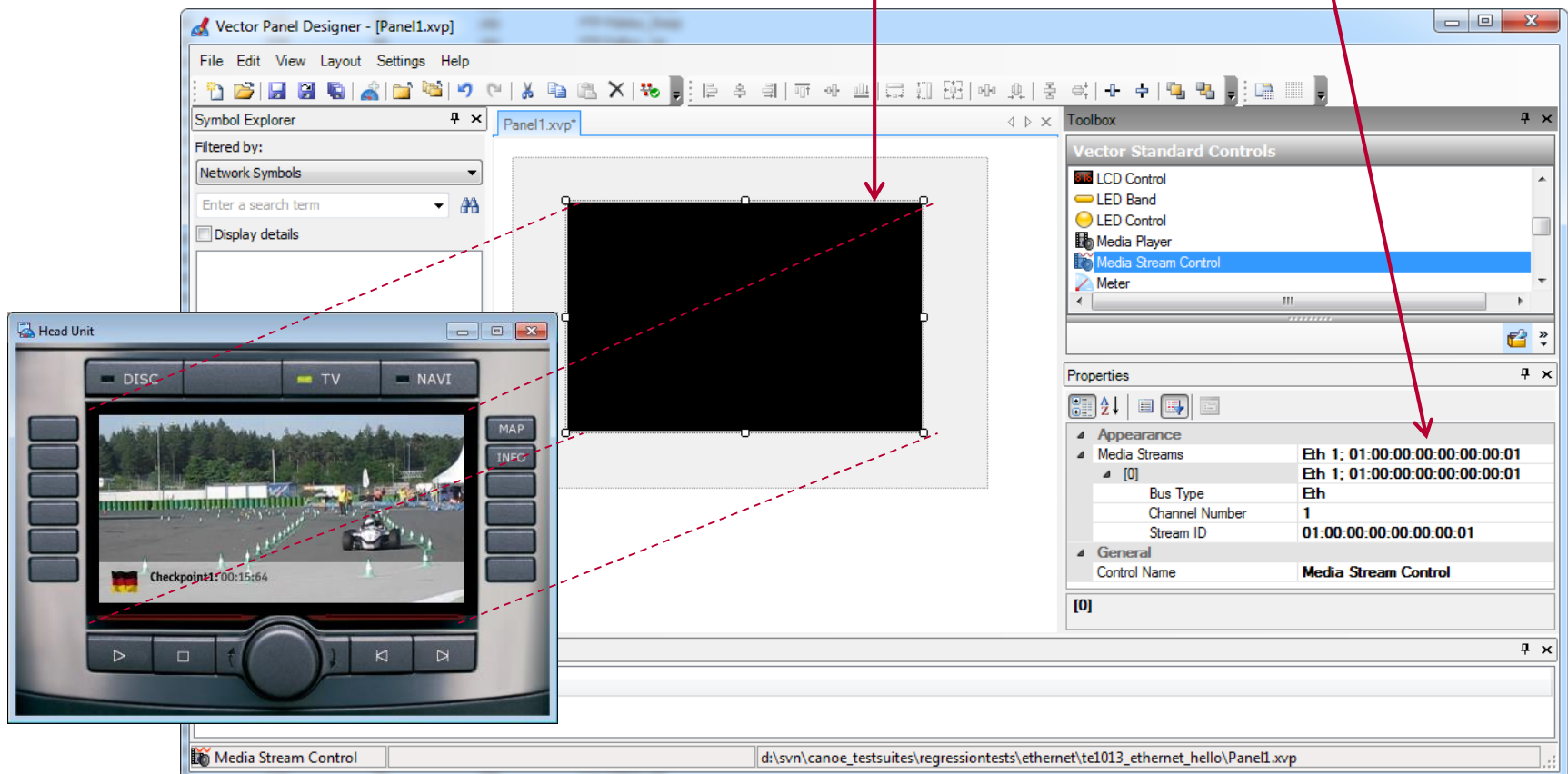


Audio / Video

Media Stream Control for Panels

Customizable layout

Stream ID configurable



Ethernet Interface VN5610



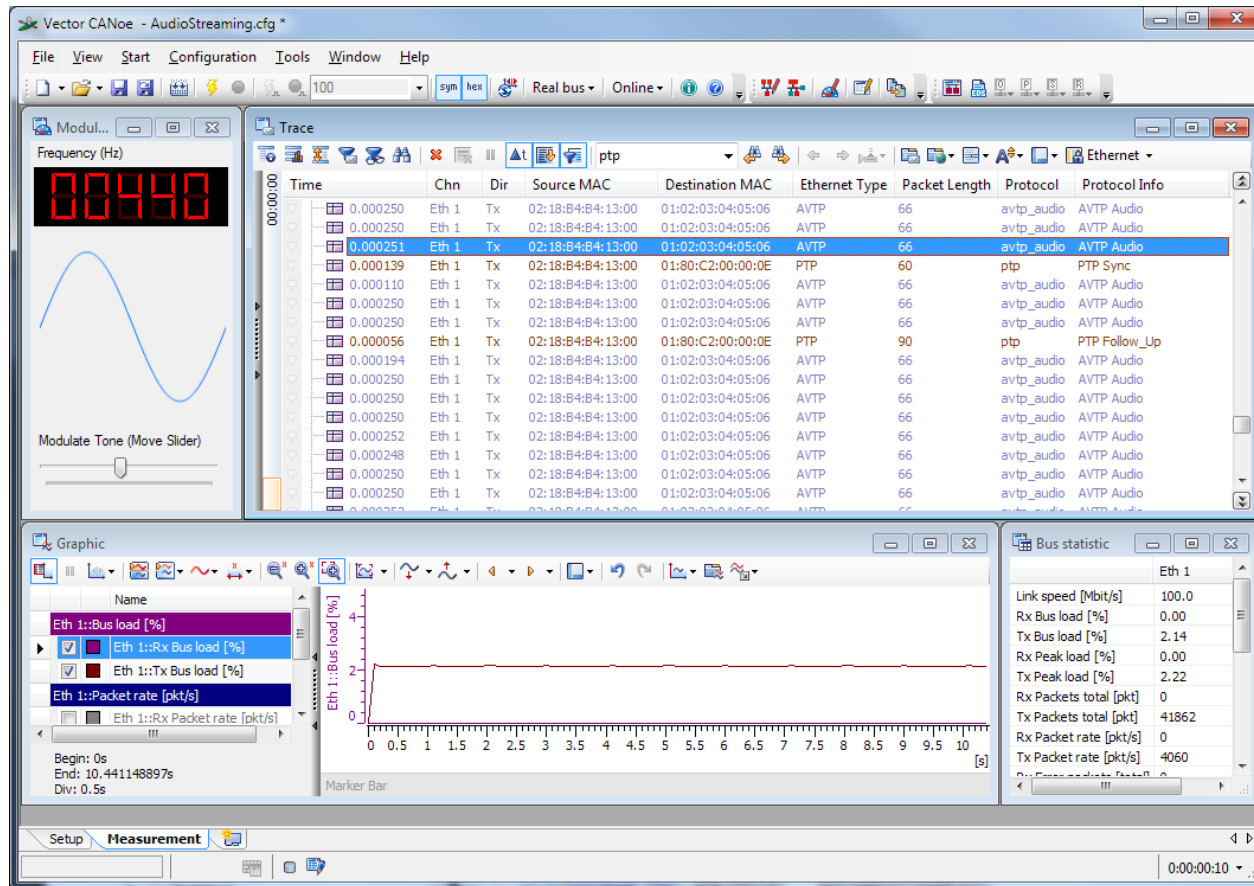
- ▶ 2 x RJ45 for IEEE802.3 (100BASE-TX and 1000BASE-T) physical layer
- ▶ 1 x D-Sub9 for 2 Channel BroadR-Reach
- ▶ 1 x USB2.0 (connection to PC)
- ▶ 2 x Binder (Hw-Sync + ext. Power)
- ▶ D-Sub9 for 2 Channel CAN/CAN-FD
- ▶ 1 x RJ45 (reserved)

Ethernet Interface VN5640



- ▶ New member of the Ethernet interface family
 - ▶ Supported starting CANalyzer / CANoe 9.0 SP3
 - ▶ 16 Ethernet channels for efficient network access (12 x BR; 4 X IEEE)
 - ▶ TAP and switch capabilities
 - ▶ One I/O port for DoIP activation line trigger
 - ▶ Seamless integration into tool chain
 - ▶ Two high speed CAN/CAN-FD channels
 - ▶ USB3.0 (connection to PC)

Expected AVTP timing with hardware supported transmission

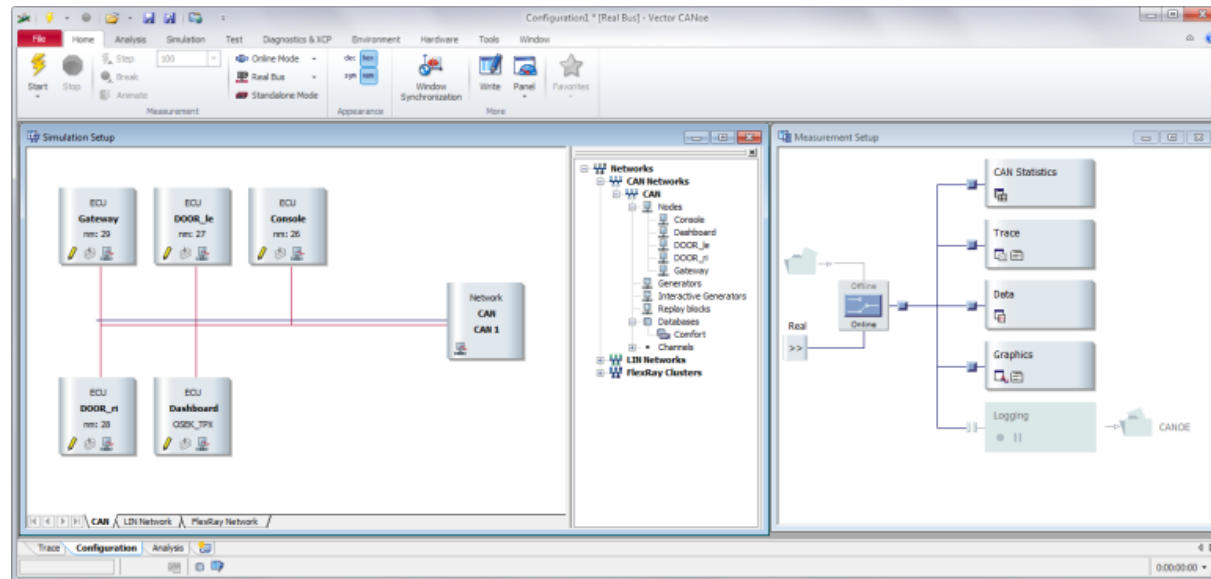


- ▶ Repetition rate $\pm 20\mu\text{s}$
- ▶ Guaranteed repetition rate $\pm 50\mu\text{s}$

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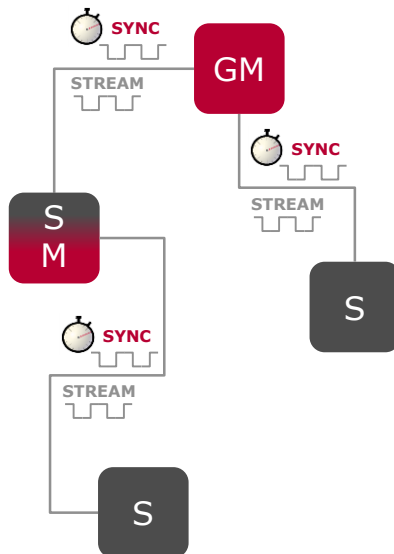
Summary

- AVB / TSN provides mechanisms for the **synchronization** of network participants for **reliable, low-latency** media transmission.

- „Lip-sync“ is achieved

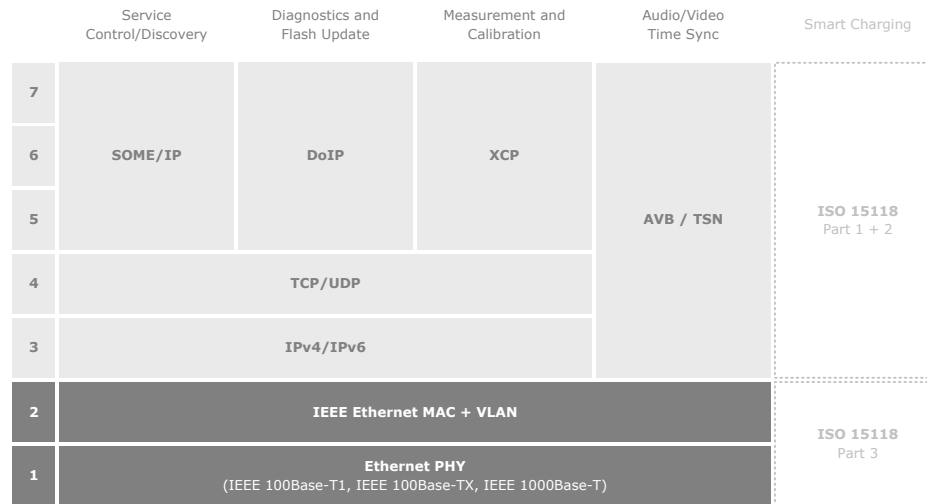


- A **common time base** is shared amongst all network components

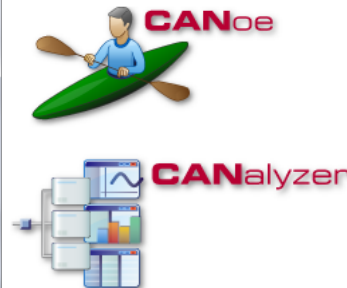
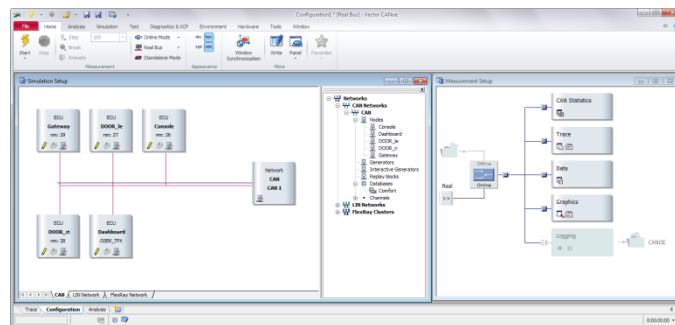


Summary

- A well defined **protocol set** is described to fulfil the requirements



- Mature **PC tools & hardware** for analysis & simulation purposes are available



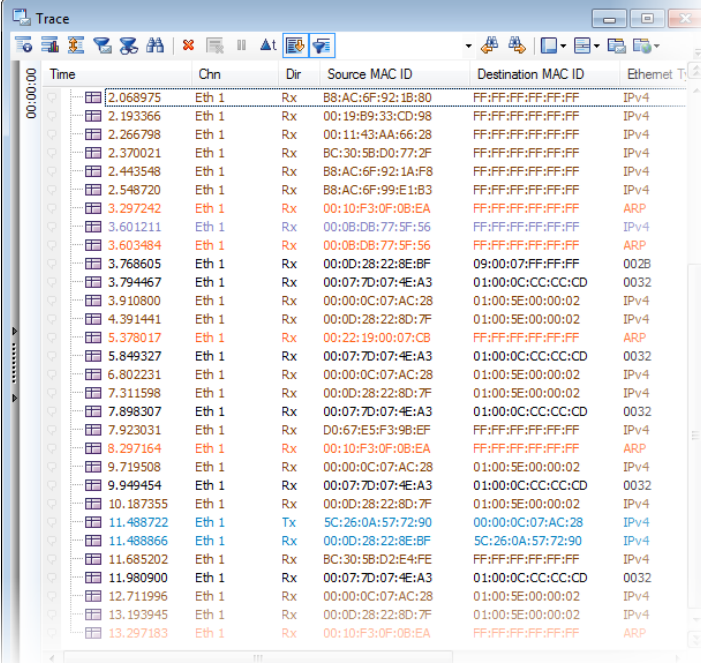
CANoe/CANalyzer.Ethernet

► CANoe/CANalyzer Demo including Ethernet:

- > Measuring, analyzing, simulation, testing of Ethernet and IP based communication
- > Free demo version:

www.vector.com/vi_downloadcenter_de.html

Products: CANoe, Categories: Demos



Time	Chn	Dir	Source MAC ID	Destination MAC ID	Ethernet Type
2.068975	Eth 1	Rx	B8:AC:6F:92:18:80	FF:FF:FF:FF:FF:FF	IPv4
2.193366	Eth 1	Rx	00:19:B9:33:CD:98	FF:FF:FF:FF:FF:FF	IPv4
2.266798	Eth 1	Rx	00:11:43:AA:66:28	FF:FF:FF:FF:FF:FF	IPv4
2.370021	Eth 1	Rx	BC:30:5B:D0:77:2F	FF:FF:FF:FF:FF:FF	IPv4
2.443548	Eth 1	Rx	B8:AC:6F:92:1A:F8	FF:FF:FF:FF:FF:FF	IPv4
2.548720	Eth 1	Rx	B8:AC:6F:99:E1:B3	FF:FF:FF:FF:FF:FF	IPv4
3.297242	Eth 1	Rx	00:10:F3:0F:0B:EA	FF:FF:FF:FF:FF:FF	ARP
3.601211	Eth 1	Rx	00:0B:DB:77:5F:56	FF:FF:FF:FF:FF:FF	IPv4
3.603484	Eth 1	Rx	00:0B:DB:77:5F:56	FF:FF:FF:FF:FF:FF	ARP
3.768605	Eth 1	Rx	00:0D:28:22:8E:8F	09:00:07:FF:FF:FF	002B
3.794467	Eth 1	Rx	00:07:7D:07:4E:A3	01:00:0C:CC:CC:CD	0032
3.910800	Eth 1	Rx	00:00:0C:07:AC:28	01:00:5E:00:00:02	IPv4
4.391441	Eth 1	Rx	00:0D:28:22:8D:7F	01:00:5E:00:00:02	IPv4
5.378017	Eth 1	Rx	00:22:19:00:07:CB	FF:FF:FF:FF:FF:FF	ARP
5.849327	Eth 1	Rx	00:07:7D:07:4E:A3	01:00:0C:CC:CC:CD	0032
6.802231	Eth 1	Rx	00:00:0C:07:AC:28	01:00:5E:00:00:02	IPv4
7.311598	Eth 1	Rx	00:0D:28:22:8D:7F	01:00:5E:00:00:02	IPv4
7.898307	Eth 1	Rx	00:07:7D:07:4E:A3	01:00:0C:CC:CC:CD	0032
7.923031	Eth 1	Rx	D0:67:E5:F3:98:EF	FF:FF:FF:FF:FF:FF	IPv4
8.297164	Eth 1	Rx	00:10:F3:0F:0B:EA	FF:FF:FF:FF:FF:FF	ARP
9.719508	Eth 1	Rx	00:00:0C:07:AC:28	01:00:5E:00:00:02	IPv4
9.949454	Eth 1	Rx	00:07:7D:07:4E:A3	01:00:0C:CC:CC:CD	0032
10.187355	Eth 1	Rx	00:0D:28:22:8D:7F	01:00:5E:00:00:02	IPv4
11.488722	Eth 1	Tx	5C:26:0A:57:72:90	00:00:0C:07:AC:28	IPv4
11.488866	Eth 1	Rx	00:0D:28:22:8E:8F	5C:26:0A:57:72:90	IPv4
11.685202	Eth 1	Rx	BC:30:5B:D2:E4:FE	FF:FF:FF:FF:FF:FF	IPv4
11.980900	Eth 1	Rx	00:07:7D:07:4E:A3	01:00:0C:CC:CC:CD	0032
12.711996	Eth 1	Rx	00:00:0C:07:AC:28	01:00:5E:00:00:02	IPv4
13.193945	Eth 1	Rx	00:0D:28:22:8D:7F	01:00:5E:00:00:02	IPv4
13.297183	Eth 1	Rx	00:10:F3:0F:0B:EA	FF:FF:FF:FF:FF:FF	ARP

CANoe/CANalyzer.Ethernet

For more information about Vector
and our products please visit

www.vector.com

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