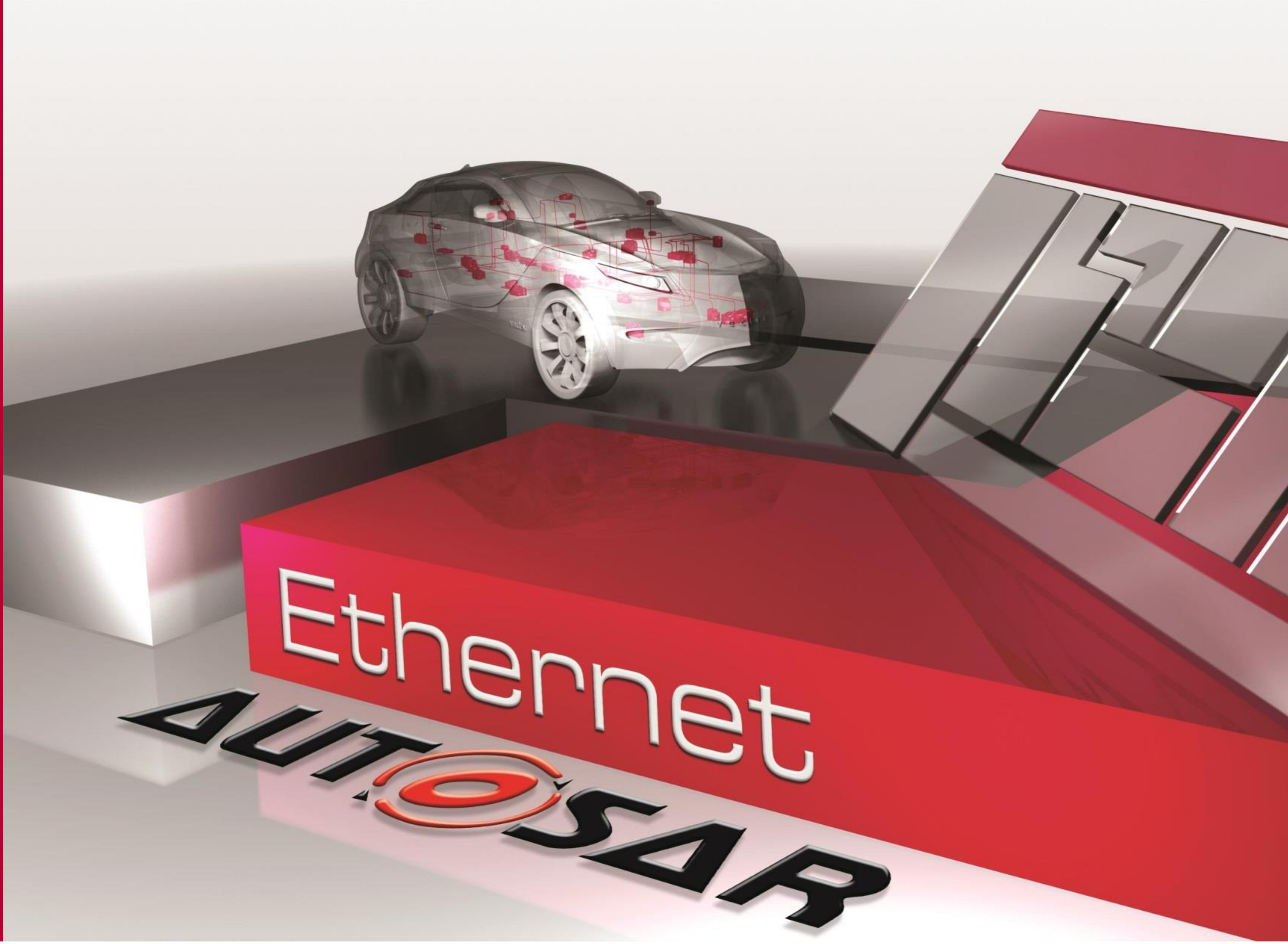


PES Solution Ethernet

The Vector Embedded Ethernet-Stack and its Use-Cases

PES Solution Ethernet Overview

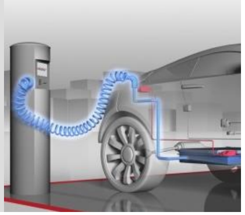
The **PES Solution Ethernet** comprises:

▶▶ Ethernet – MICROSAR.ETH

- Service Discovery, SOME/IP
- UDP Network Management
- Signal- and PDU-based communication
- Diagnostics over Internet Protocol, Flashbootloader
- XCP on Ethernet, XCP Routing
- Mirroring

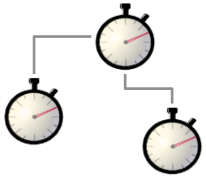
▶▶ Vehicle-to-Grid – MICROSAR.V2G

- Smart Charge Communication
- Customer-specific functions



▶▶ Audio/Video Bridging – MICROSAR.AVB

- Audio/Video Transport Protocol
- Generalized Precision Time Protocol / Best Master Clock Algorithm



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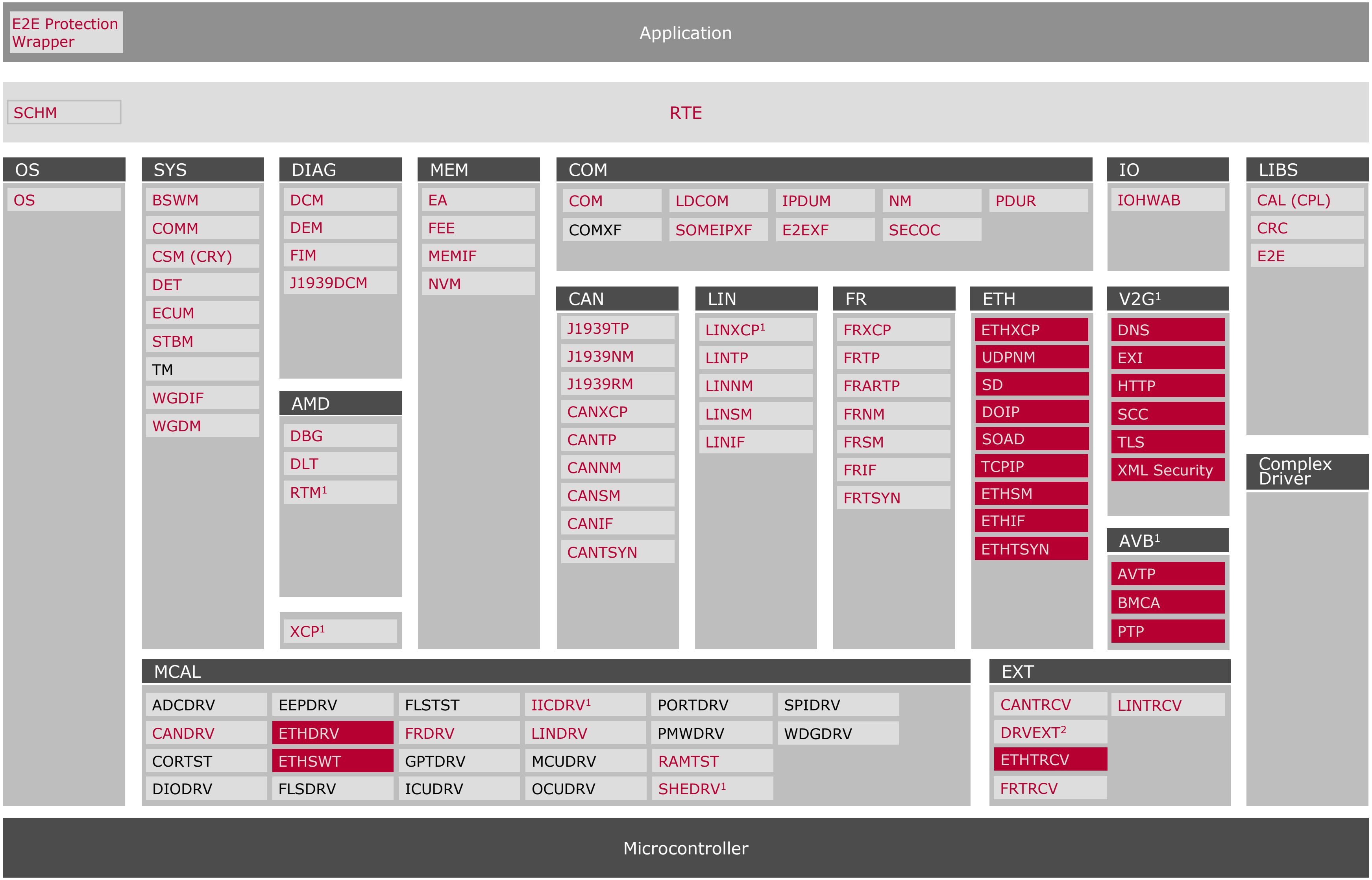
AUTOSAR and MICROSAR Software Architecture



E2E Protection Wrapper

Application

SCHM

RTE

OS
- OS

SYS
- BSWM
- COMM
- CSM (CRY)
- DET
- ECUM
- STBM
- TM
- WGDIF
- WGDM

DIAG
- DCM
- DEM
- FIM
- J1939DCM

AMD
- DBG
- DLT
- RTM[1]

XCP[1]

MEM
- EA
- FEE
- MEMIF
- NVM

COM
- COM
- LDCOM
- IPDUM
- NM
- PDUR
- COMXF
- SOMEIPXF
- E2EXF
- SECOC

CAN
- J1939TP
- J1939NM
- J1939RM
- CANXCP
- CANTP
- CANNM
- CANSM
- CANIF
- CANTSYN

LIN
- LINXCP[1]
- LINTP
- LINNM
- LINSM
- LINIF

FR
- FRXCP
- FRTP
- FRARTP
- FRNM
- FRSM
- FRIF
- FRTSYN

ETH
- ETHXCP
- UDPNM
- SD
- DOIP
- SOAD
- TCPIP
- ETHSM
- ETHIF
- ETHTSYN

IO
- IOHWAB

V2G[1]
- DNS
- EXI
- HTTP
- SCC
- TLS
- XML Security

AVB[1]
- AVTP
- BMCA
- PTP

LIBS
- CAL (CPL)
- CRC
- E2E

Complex Driver

MCAL
- ADCDRV
- CANDRV
- CORTST
- DIODRV
- EEPDRV
- ETHDRV
- ETHSWT
- FLSDRV
- FLSTST
- FRDRV
- GPTDRV
- ICUDRV
- IICDRV[1]
- LINDRV
- MCUDRV
- OCUDRV
- PORTDRV
- PMWDRV
- RAMTST
- SHEDRV[1]
- SPIDRV
- WDGDRV

EXT
- CANTRCV
- DRVEXT[2]
- ETHTRCV
- FRTRCV
- LINTRCV

Microcontroller

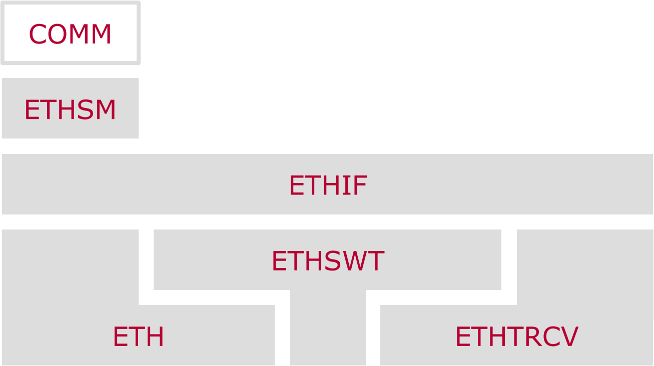
Vector Standard Software

3rd Party Software

[1] Available extensions for AUTOSAR
[2] Includes EXTADC, EEPEXT, FLSEXT, ETHSWTEXT and WDGEXT

AUTOSAR and MICROSAR Software Architecture

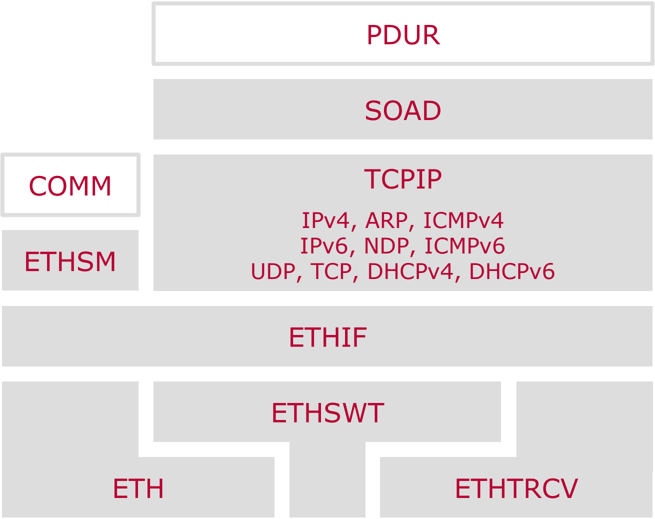
Ethernet Communication Stack



- ETH – Ethernet Driver
  - Uniform API to access all Ethernet controllers of the same type
- ETHTRCV – Ethernet Transceiver Driver
  - Uniform API to access all Ethernet transceivers of the same type
- ETHSWT – Ethernet Switch Driver
  - Configuration of Ethernet switches – e.g. Virtual Local Area Networks (VLANs) and routing tables
  - Uniform API to access all Ethernet switches of the same type (ETHSWTEXT for external switches which are configured e.g. via SPI)
- ETHIF – Ethernet Interface
  - Hardware independent interface to access all Ethernet drivers and Ethernet transceiver drivers
  - Handling of different VLANs
- ETHSM – Ethernet State Manager
  - Enabling and disabling of Ethernet controller and Ethernet transceiver to switch on or off Ethernet communication

AUTOSAR and MICROSAR Software Architecture

Ethernet Communication Stack



- TCPIP – TCP/IP stack
  - IPv4/IPv6 – Internet Protocol version 4/version 6 (IPv4 and IPv6 can be used in parallel on the same ECU)
  - ARP – Address Resolution Protocol (IPv4)
  - NDP – Neighbor Discovery Protocol (IPv6)
  - ICMPv4/v6 – Internet Control Message Protocol
  - UDP – User Datagram Protocol
  - TCP – Transmission Control Protocol
  - DHCPv4/v6 – Dynamic Host Configuration Protocol
    - v4: Client and Server
    - v6: Client only
- SOAD – Socket Adaptor
  - Transformation of socket-based into AUTOSAR PDU-oriented communication

AUTOSAR and MICROSAR Software Architecture

Supported Hardware

- Microcontrollers / Ethernet controllers
  - MPC (FEC and ENET)
  - TriCore, Aurix
  - V850, RH850
  - Jacinto 6 (incl. switch functionality)
  - AR7000 (Powerline communication)
  - CANoeEmu (Simulating an Ethernet controller within a CANoe DLL)
- Ethernet transceivers
  - BCM89810 (BroadR-Reach)
  - DP83848 (100BASE-TX)
  - AR7000 (Powerline communication)
  - CANoeEmu (Simulating an Ethernet transceiver within a CANoe DLL)
  - Generic (Support of all transceivers which have a MII interface)
- Ethernet switches
  - BCM89501 (BroadR-Reach)

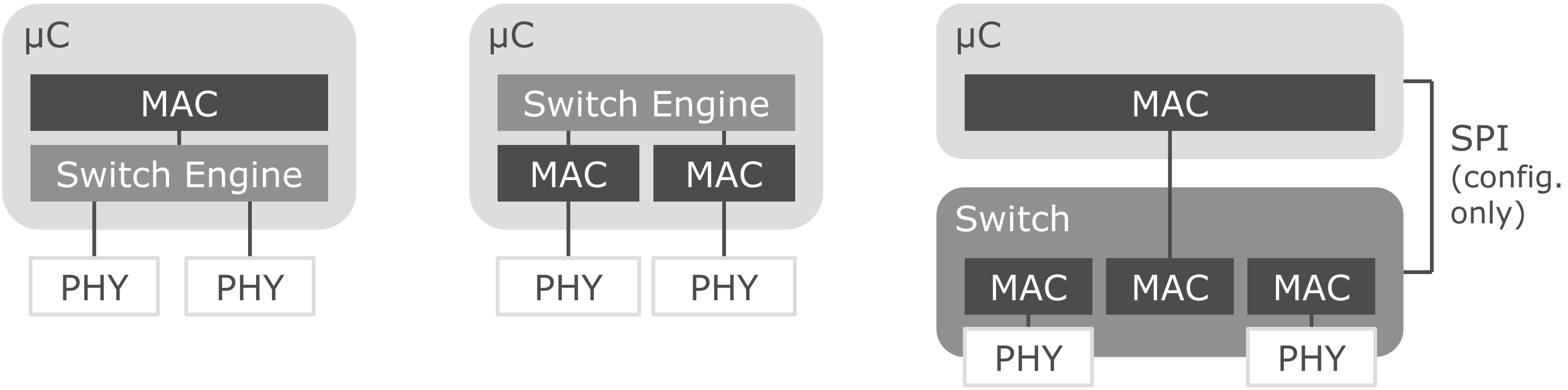
Further controllers, transceivers and switches can be supported on request!

AUTOSAR and MICROSAR Software Architecture

Supported Hardware

Ethernet Switches

- Automotive Ethernet switches offer different configuration possibilities
  - VLAN
  - Forwarding tables
  - Queuing mechanisms
  - …
- AUTOSAR architecture fits to all known Ethernet switch architectures



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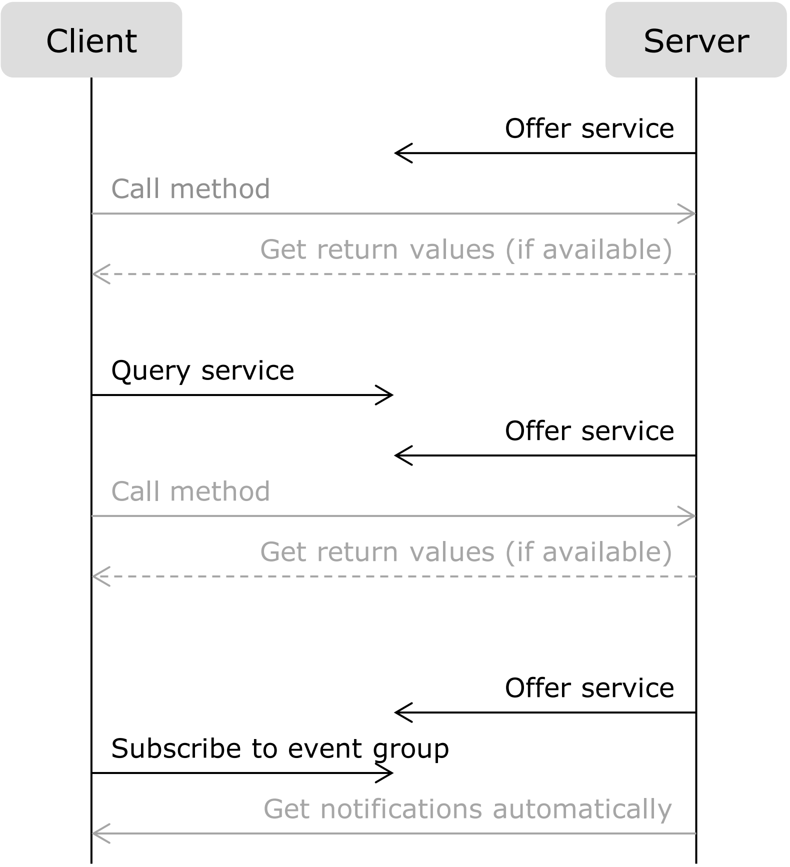
Service Discovery (SD)

- Service-oriented communication scheme instead of a classical signal-oriented approach
- What is a “Service”?
  - A Service can contain “Methods” which can be called by other ECUs, this mechanism is known as Remote Procedure Call (RPC)
  - A Service can contain “Events” to which other ECUs can subscribe to be informed about changes or updates
  - There are Service providers (servers) and Service consumers (clients)
- What is the purpose of Service Discovery?
  - A provider announces the availability and implicitly the location of a Service via Service Discovery to other ECUs
  - A consumer knows the availability of a Service, can call Methods and can subscribe to offered Event groups
- Service Discovery was first specified in AUTOSAR 4.1.1

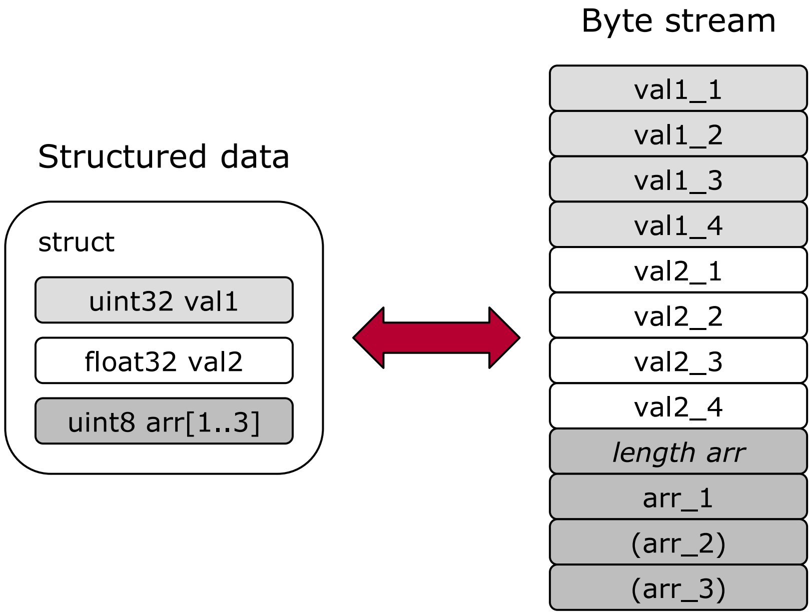
In-Vehicle Ethernet Communication

- Advantages
  - Avoid sending of invalid signals
    - Save bandwidth
  - Avoid sending multi- and broadcasts but use unicast
    - Save bandwidth on alternative communication paths (use advantage to Ethernet as a switched network)
  - Reduce CPU load
  - Dynamic relocation of Services possible
- Modes
  - Announce on startup
  - Query/Announce
  - Publish/Subscribe



Scalable Service-Oriented Middleware over IP (SOME/IP)

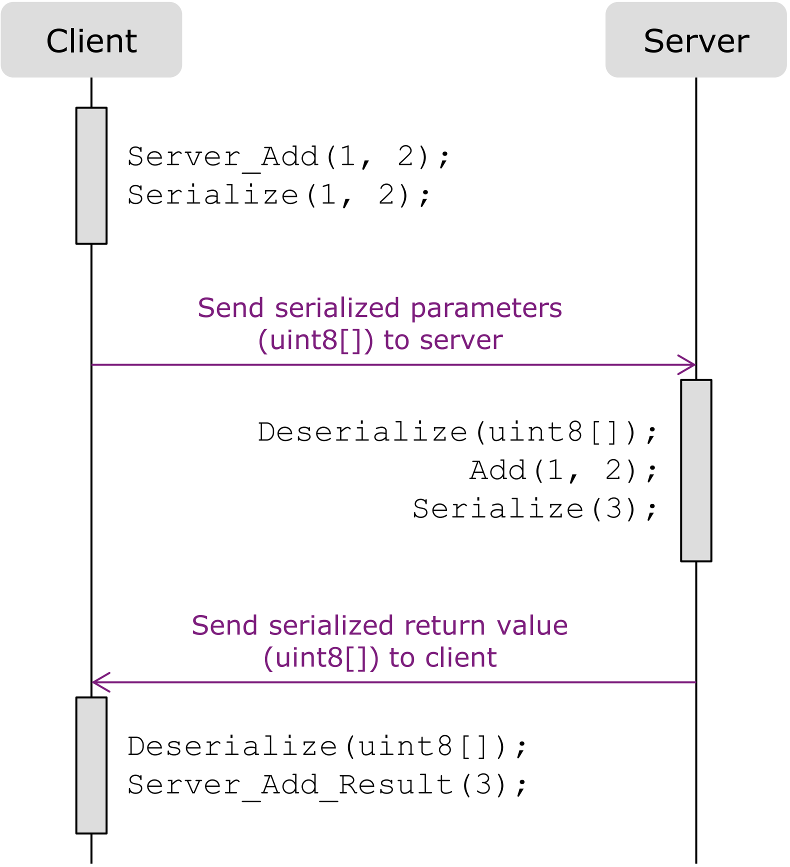
- SOME/IP is an automotive serialization protocol
  - Definition of a header format which supports RPCs, i.e. calling a function on a remote server ECU like it would be executed on the own ECU
  - Definition how application data shall be serialized to the on-the-wire payload
    - Support of basic data types, complex data types (e.g. C-struct), static and dynamic array data types
    - Independent on endianness
  - Designed for AUTOSAR and non-AUTOSAR ECUs



MICROSAR.ETH

In-Vehicle Ethernet Communication

- SOME/IP does not require Service Discovery and vice versa; however, they are designed to work together
  - Methods calls can be performed via SOME/IP messages
  - Event notifications can be sent via SOME/IP messages
  - Service Discovery messages like ‘Offer’ and ‘Query’ use the SOME/IP header
- SOME/IP was specified by BMW
  - Auxiliary document in AUTOSAR 4.1.1
  - SOME/IP will be specified in AUTOSAR 4.2.1



Client

Server

```
Server_Add(1, 2);
Serialize(1, 2);
```

Send serialized parameters (uint8[]) to server

```
Deserialize(uint8[]);
         Add(1, 2);
       Serialize(3);
```

Send serialized return value (uint8[]) to client

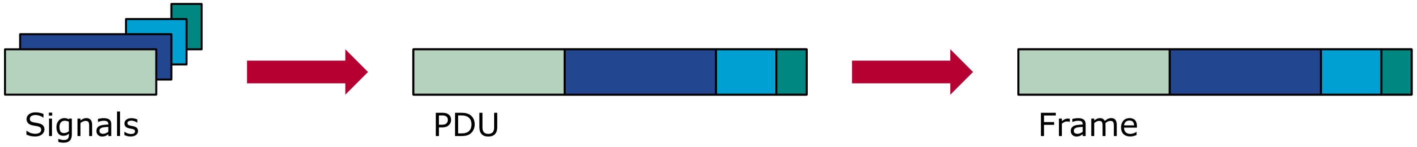
```
Deserialize(uint8[]);
Server_Add_Result(3);
```

UDP Network Management (UDPNM)

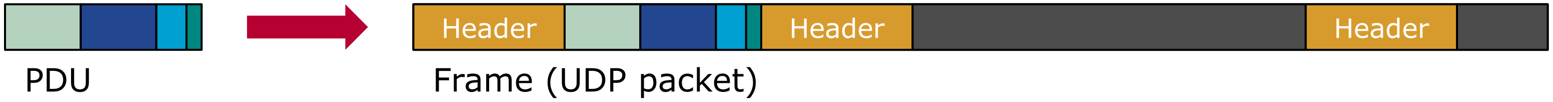
- Coordination of the transition between normal operation and bus-sleep mode of an Ethernet network
  - Periodic broadcast messages are sent by nodes which want to keep the NM-cluster awake
  - No master node
  - Node detection (detect all present nodes in a network)
  - Ready sleep detection (detect if all nodes in a network are ready for bus-sleep mode)
  - Partial Networking support added with AUTOSAR 4.1.1
  - Similar to network management on CAN
- No wake-up based on Ethernet communication possible
  - Additional bus connection or wake-up line necessary
  - Transceiver support missing
    - Power consumption in sleep mode is too high (all switches have to be powered up)
    - New transceivers will be available soon (2014)

Signal-/PDU-based communication

- Mapping of Signals onto a PDU and a PDU onto a frame
  - Similar to classical communication on CAN

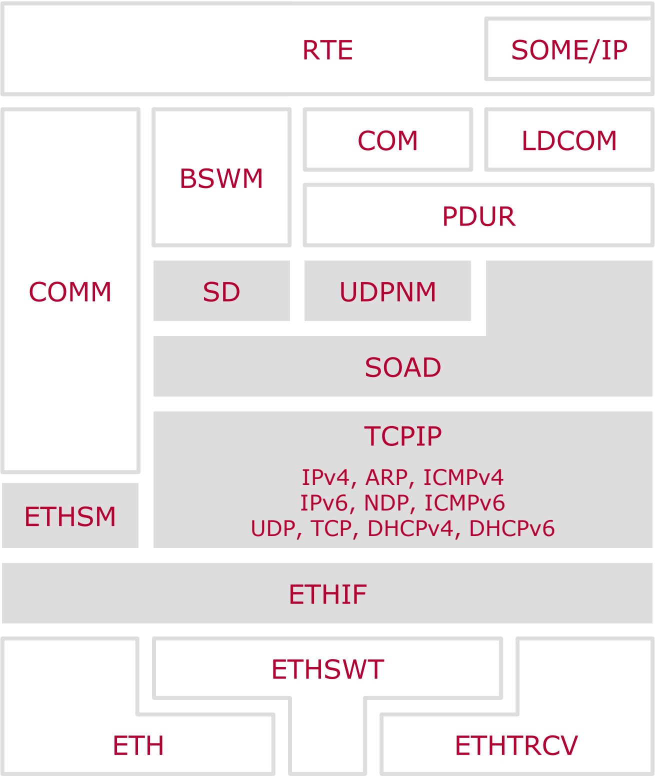


- Transmission and reception of multiple PDUs in one Ethernet frame to save resources
  - Fan-out mechanism allows to transmit one PDU to several destinations via unicast
  - Location of a PDU within a frame is dynamic
    - Socket Adaptor adds and removes a small header to differentiate between PDUs which comprises a PDU identifier and a length field
    - Different frame triggering mechanisms available



MICROSAR.ETH

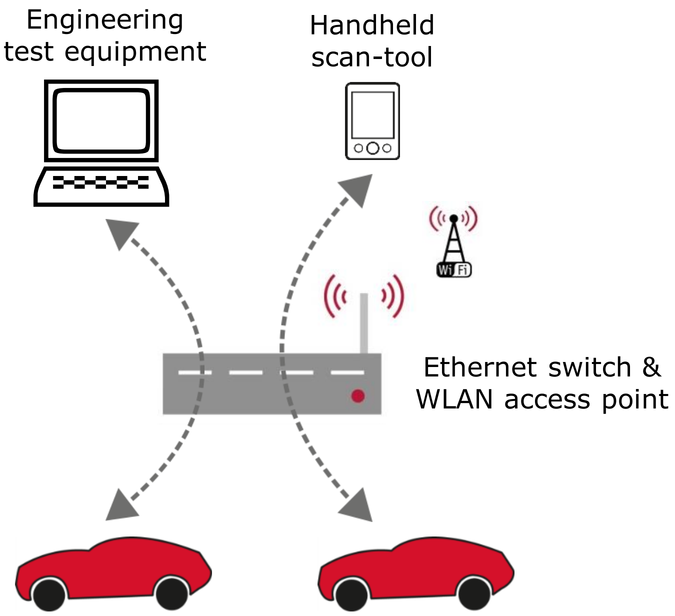
In-Vehicle Ethernet Communication



- SD – Service Discovery
  - > Management of service states
  - > Configuring communication paths over the Socket Adaptor e.g. disable routing if service is not available
- SOME/IP – Scalable Service-Oriented Middleware over Internet Protocol
  - > Serialization of application data and deserialization of received data
  - > Since AUTOSAR 4.2.1 specified as RTE transformer
  - > Large Data COM (LDCOM) can be used to save resources
- UDPNM – UDP Network Management
  - > Coordinated shut down of Ethernet ECUs
  - > Connection to NMIF is not shown in the figure

Diagnostics over Internet Protocol (DoIP)

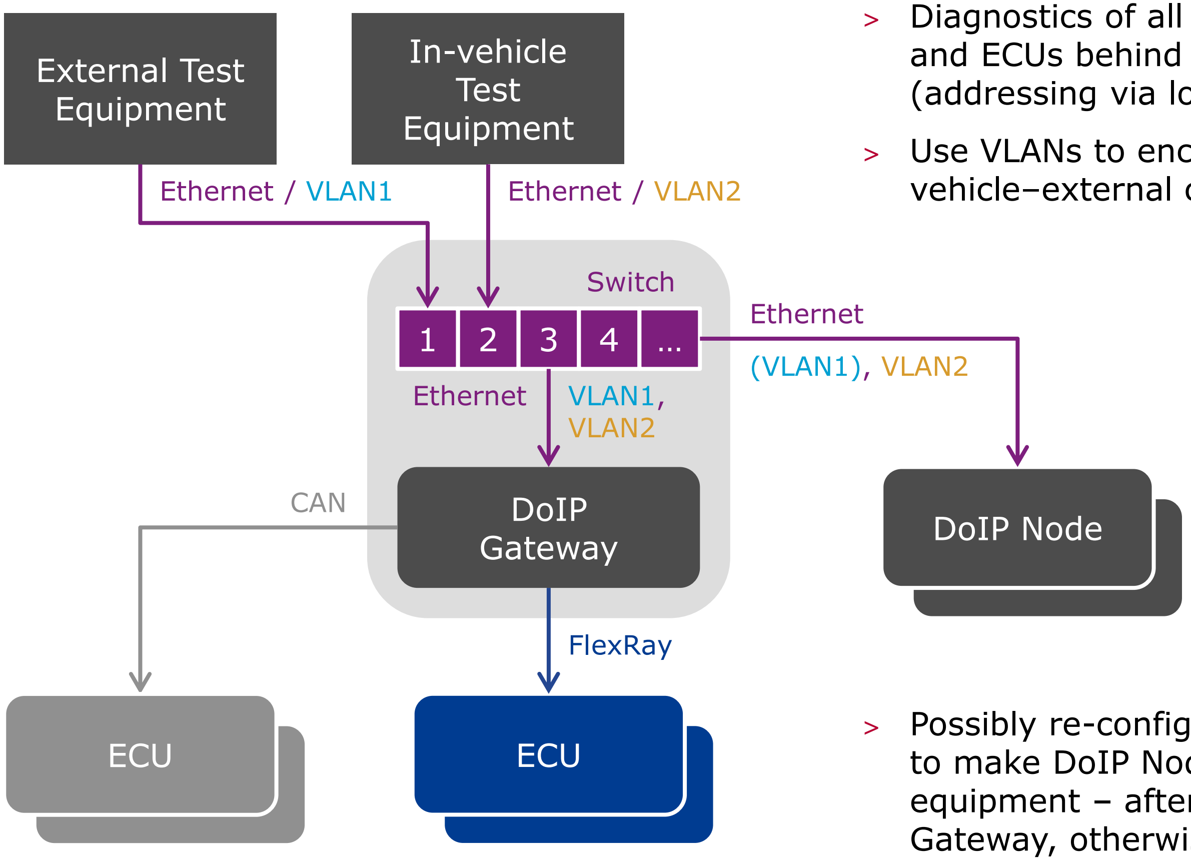
- Use-cases
  - Diagnostics (repair shop, legislator)
  - ECU re-programming
    Manufacturer: End of line programming
    Repair shop: Software update
- Advantages
  - High-speed access to vehicle ECUs
  - Gateway to existing bus systems like CAN and FlexRay
  - Parallel flash download
  - Ethernet, TCP/IP as well-known technology
  - New possibility for production and repair shop infrastructure (WLAN)


Engineering test equipment
Handheld scan-tool
Wi Fi
Ethernet switch & WLAN access point

DoIP Diag. Message	Eth	IP	TCP	DoIP	UDS	...	...	Eth

MICROSAR.ETH

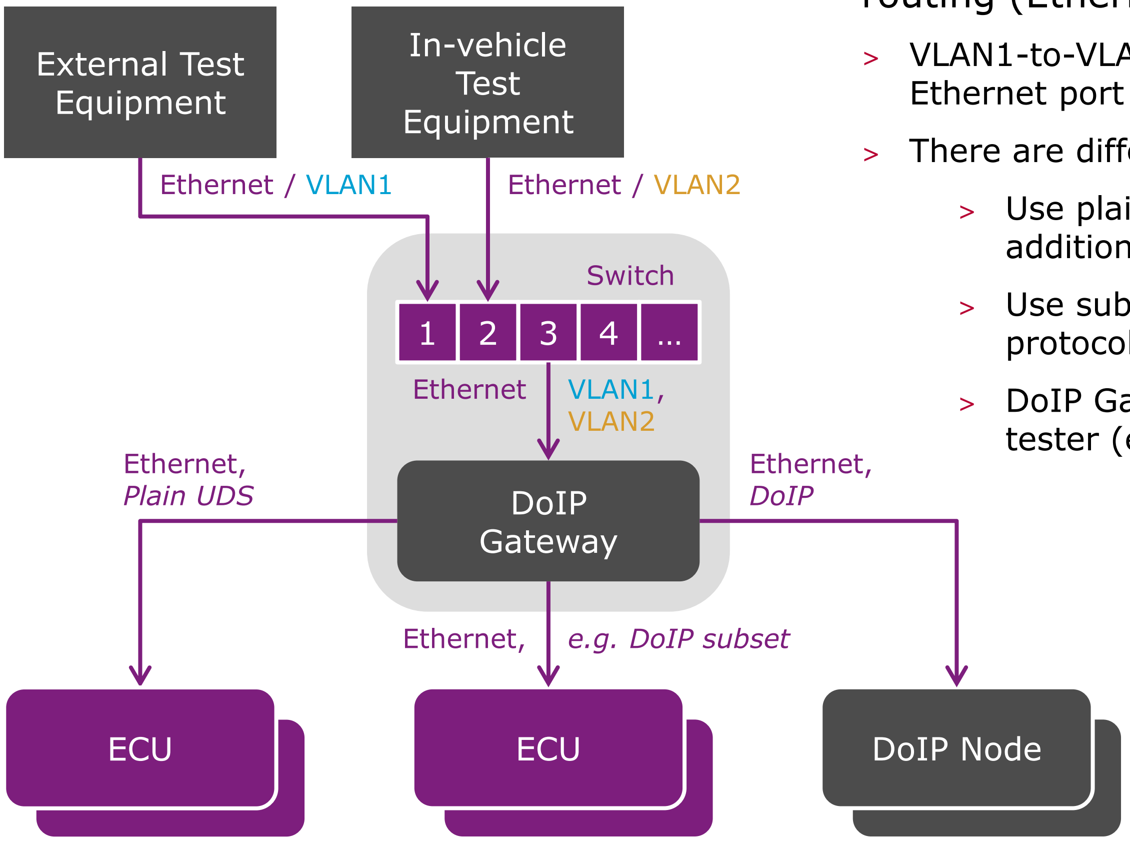
Diagnostics, Measurement and Calibration



- ISO 13400
  - Diagnostics of all DoIP Nodes, DoIP Gateways and ECUs behind the DoIP Gateways (addressing via logical DoIP address)
  - Use VLANs to encapsulate vehicle-internal from vehicle–external communication
  - Possibly re-configure the switch during runtime to make DoIP Nodes visible to the external test equipment – after authentication to the DoIP Gateway, otherwise the DoIP Gateway has to route messages

MICROSAR.ETH

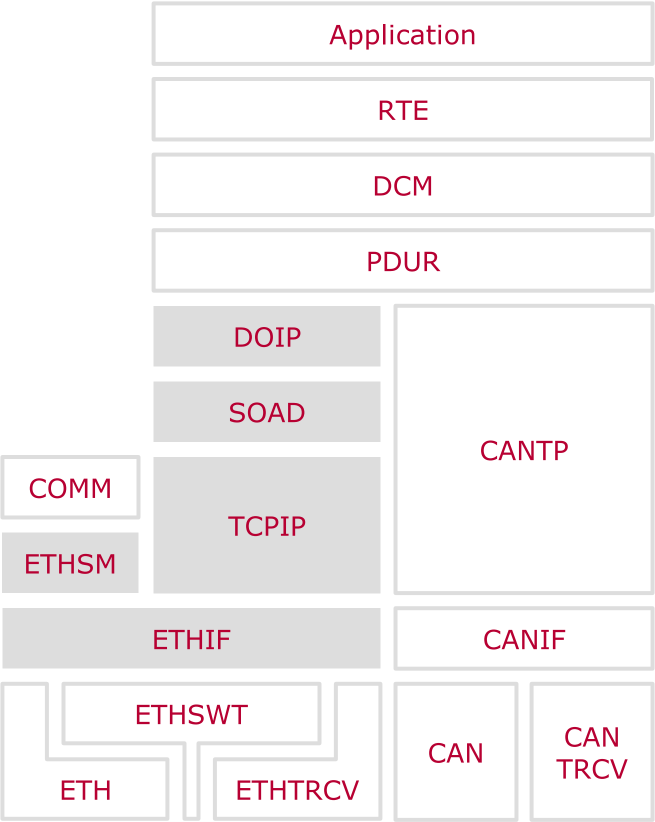
Diagnostics, Measurement and Calibration



- ISO 13400 does not specify DoIP-to-DoIP routing (Ethernet behind the gateway)
  - VLAN1-to-VLAN2 conversion on the same Ethernet port is also considered as routing
  - There are different possible solutions
    - Use plain UDS over TCP/IP without additional protocol
    - Use subset of DoIP or other OEM-specific protocol
    - DoIP Gateway implements a diagnostic tester (emulation)

MICROSAR.ETH

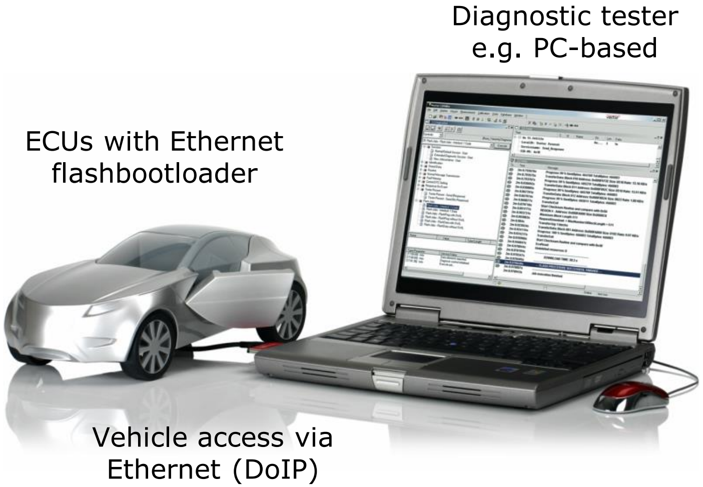
Diagnostics, Measurement and Calibration



- DOIP – Diagnostics over Internet Protocol
  - Implementation of ISO 13400-2
  - The handling of the DoIP protocol was specified as Socket Adaptor plug-in in AUTOSAR 4.0.x and became a separate module in AUTOSAR 4.1.x
- PDUR – PDU Router
  - Central module for PDU forwarding and routing e.g. DoIP <-> Dcm and DoIP <-> CanTp
- DCM – Diagnostic Communication Manager
  - Implementation of the diagnostic protocol (UDS)
  - Interaction with the Diagnostic Event Manager (DEM) to get diagnostic event information
  - Interaction with the application over the RTE to query diagnostic information and execute procedures

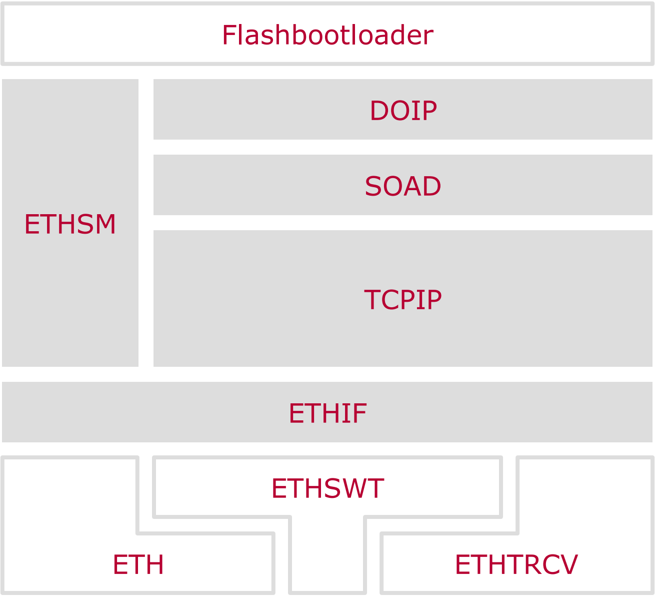
Ethernet Flashbootloader (FBL)

- Fast ECU (re-)programming over Ethernet via DoIP
  - 100MBit/s instead of max. 1MBit/s with CAN
- Use-cases
  - End-of-line (EOL) ECU programming
  - After-sales ECU re-programming
  - ECU development
- Properties
  - Independent application which remains permanently in the ECU
  - The FBL is based on the MICROSAR.ETH BSW modules, but the source code cannot be shared between FBL and normal application
  - Because of the special flash driver, the FBL is a hardware dependent application
- Offered as additional service



MICROSAR.ETH

Diagnostics, Measurement and Calibration



- Flashbootloader
  - Communication (COMM and PDUR) wrapper
  - Flash/EEPROM driver
  - FBL security module
  - FBL diagnostics
  - FBL application

Universal (X) Measurement and Calibration Protocol (XCP)

- Successor of CCP – CAN Calibration Protocol
- Used for measurement, calibration, bypassing and ECU re-programming
- The XCP protocol is split into transport and protocol layer
  - The protocol layer is identical for all network technologies i.e. CAN, FlexRay, Ethernet, USB
  - The transport layer is specific for each network technology (different header and trailer data)
- ASAM AE MCD-1 XCP V1.1.0
  - ASAM AE MCD-1 XCP V1.2.0 only adds CAN-FD as new transport layer, no functional changes

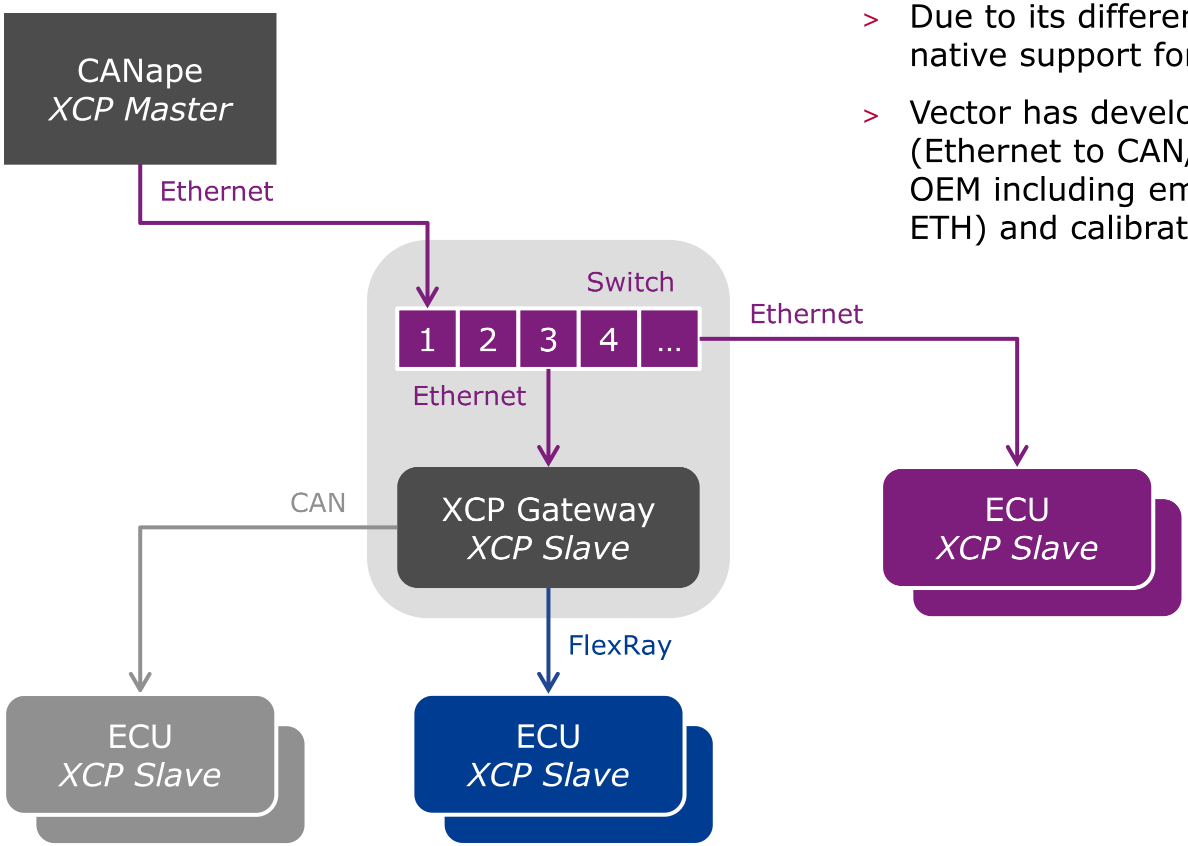
XCP on Ethernet	Eth	IP	UDP/TCP	XCP H.	XCP P.	…	…	Eth

XCP H. = XCP Header (transport layer specific)

XCP P. = XCP Packet (protocol layer)

MICROSAR.ETH

Diagnostics, Measurement and Calibration

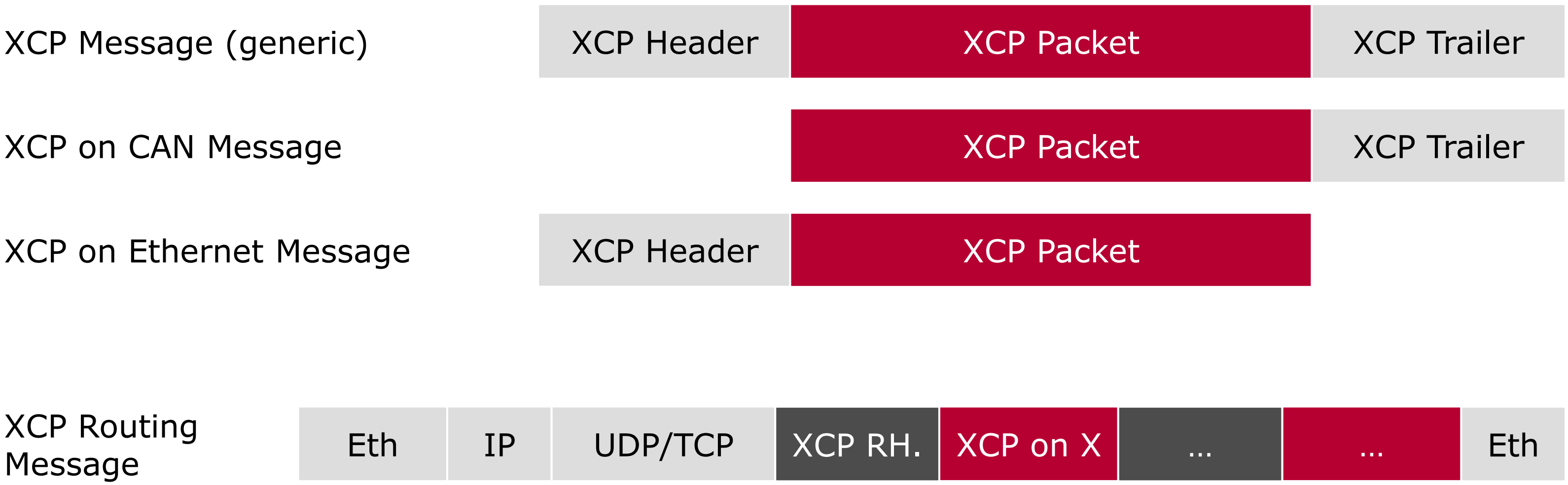


- XCP Routing
  - Due to its different transport layers, XCP has no native support for routing
  - Vector has developed a solution for XCP routing (Ethernet to CAN/FlexRay) together with an OEM including embedded software (MICROSAR ETH) and calibration tool (CANape)

MICROSAR.ETH

Diagnostics, Measurement and Calibration

- XCP Routing
  - Route XCP data from a XCP master over a gateway to multiple ECUs and back
    - Send XCP on CAN/FlexRay messages over Ethernet from a XCP master to the gateway
    - UDP or TCP can be used as transport protocol
    - Cascading of XCP on X messages possible

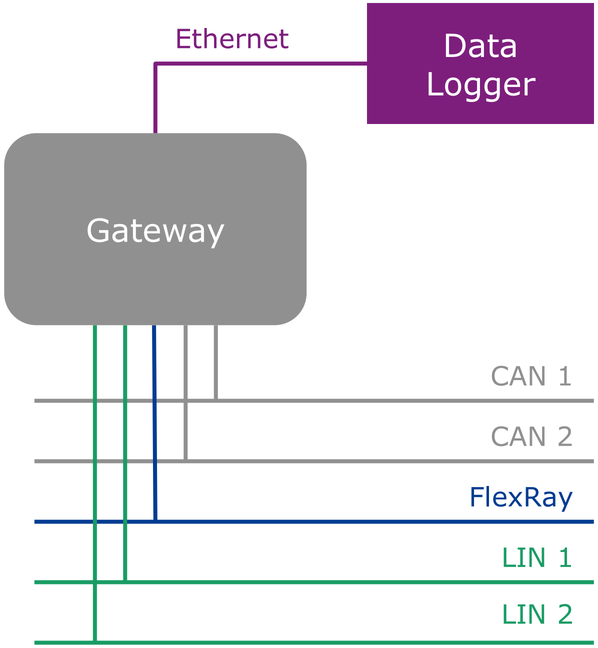


XCP RH. = XCP Routing Header (Vector-specific extension)

XCP on X = XCP on CAN/FlexRay message

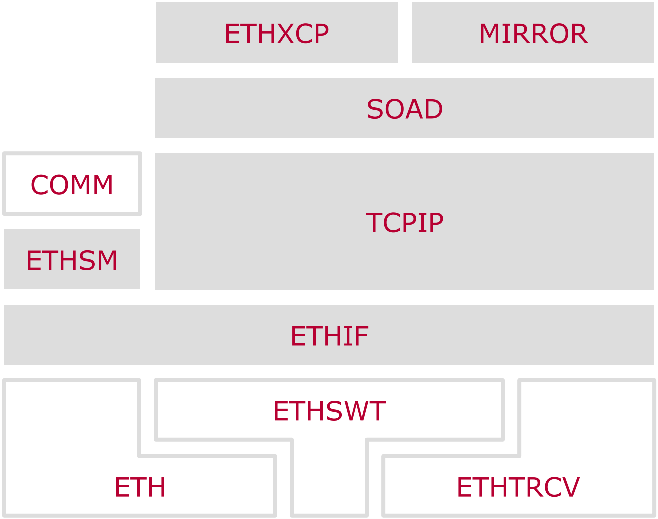
Mirroring

- How can vehicle internal bus traffic be logged and analyzed if Ethernet is the only access point to the vehicle and without additional logging equipment?
- Solution: Mirroring of CAN/LIN/FlexRay bus traffic to Ethernet
  - Mirroring of complete communication
  - Simultaneous mirroring of all connected busses possible
  - Multiple CAN/LIN/FlexRay messages are packed in one Ethernet packet
  - Additional information is added to the mirrored messages
  - Mirror functionality can be switched on/off e.g. by a diagnostic command
  - Implementation as CDD above the Socket Adaptor with direct access to bus drivers
- Analysis of mirrored data in CANoe



MICROSAR.ETH

Diagnostics, Measurement and Calibration



- ETHXCP – XCP on Ethernet
  - Ethernet specific transport layer of
    ASAM AE MCD-1 XCP V1.1.0
- SOAD – Socket Adaptor
  - Vector specific extensions to the AUTOSAR specification
    to support XCP routing and Mirroring
- MIRROR – Mirroring
  - Complex Driver above the Socket Adaptor with direct access to communication drivers

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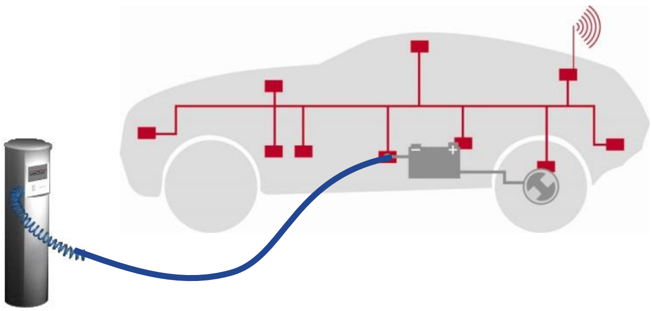
MICROSAR.V2G

Smart Charge Communication (SCC)

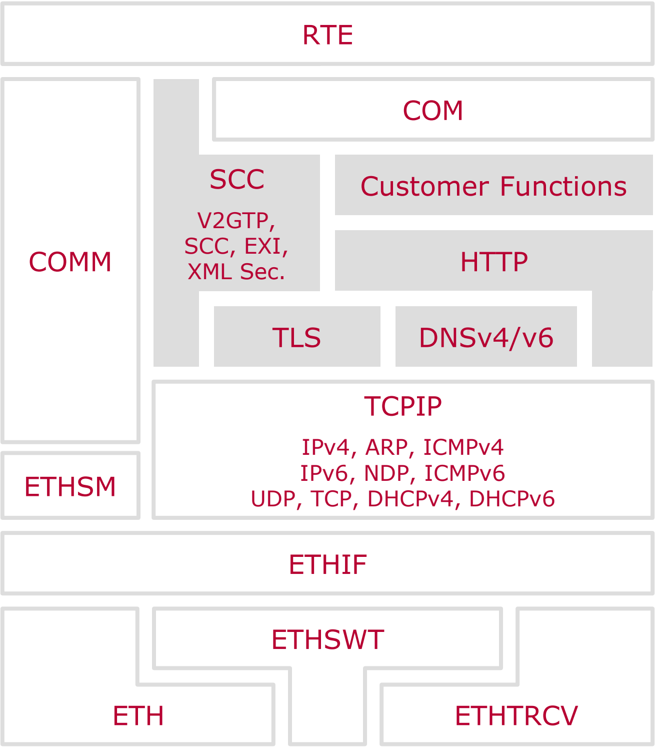


- When and how to charge an electric vehicle?
  - How much energy is available/required?
  - How to pay?
- ISO 15118
  - AC and DC charging
  - Profile: Plug and Charge (PnC) – charging in a public environment with billing
  - Profile: External Identification Means (EIM) – “simple” charging
  - Value Added Services (VAS)
- DIN 70121
  - DC charging (similar to ISO DC EIM – no encryption, no payment)

Customer Specific Functions

- If the vehicle is connected to the Internet e.g. via a charge spot, additional web-services may be available or implemented by using e.g. HTTP

MICROSAR.V2G



- TLS – Transport Layer Security
  - Encryption and decryption of TCP streams
- SCC – Smart Charge Communication
  - Implementation of the V2GTP (Vehicle-to-Grid transport protocol)
  - Efficient XML Interchange (EXI) and XML Security are implemented in separate modules
- DNSv4/v6 – Domain Name Service
  - Resolver only: Resolution of URLs into IP addresses (IPv4/IPv6)
- HTTP – Hypertext Transfer Protocol
  - String-based communication with a server
- Customer Functions
  - Customer specific functions, which e.g. are based on HTTP communication
  - An implementation of XML Engine and JSON (JavaScript Object Notation) is also available

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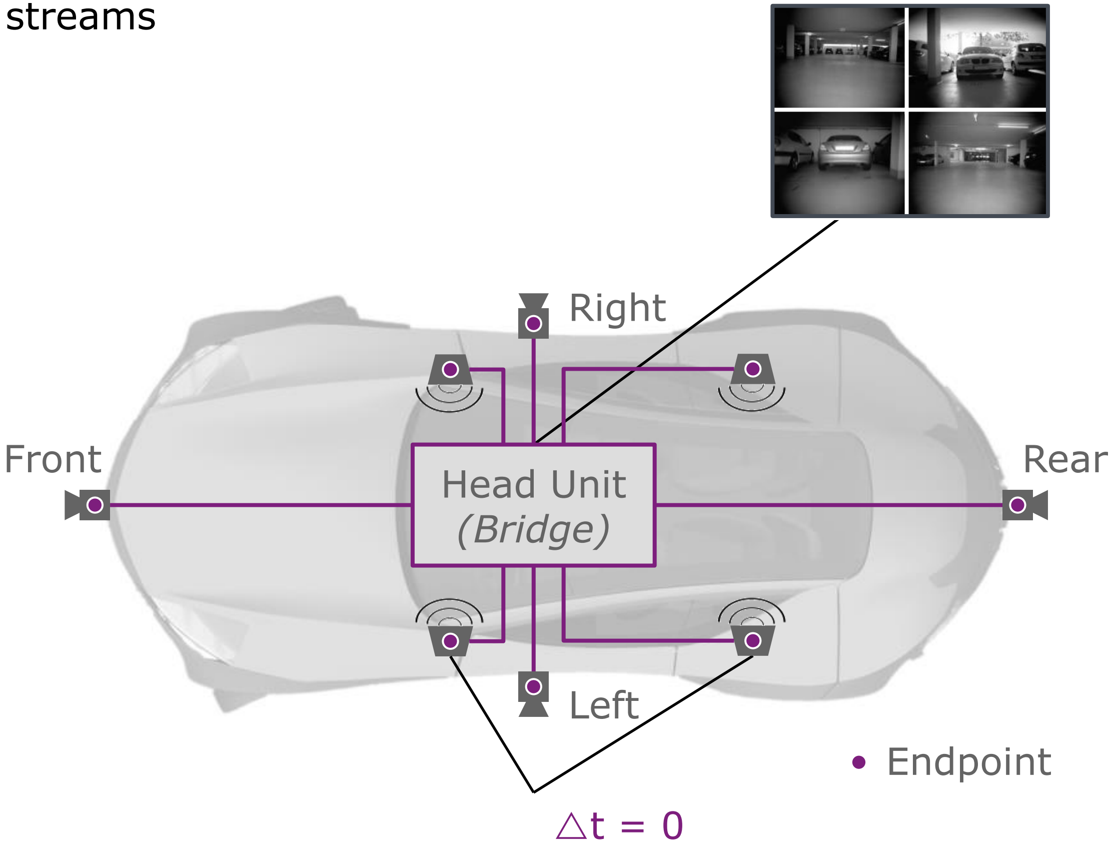
MICROSAR.AVB

Audio/Video Bridging (AVB)

- Transport audio and video streams
  - Through standard Ethernet network technology
  - With simple cabling
  - Fast and in real-time
  - Well synchronized and prioritized

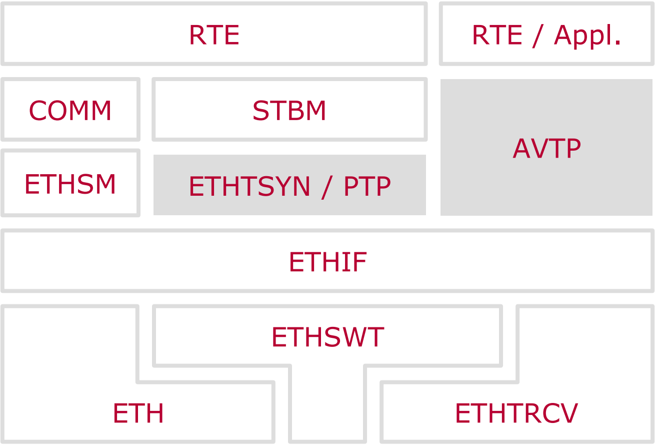


MICROSAR.AVB

- Important IEEE specifications for bridging & management
  - Introduction and Overview
    - IEEE 802.1BA – Audio Video Bridging (AVB) Systems
  - Generalized Precision Time Protocol (gPTP) and Best Master Clock Algorithm (BMCA)
    - IEEE 802.1AS – Timing and Synchronization for Time-Sensitive Applications
    - References IEEE 1588
  - Traffic shaping
    - IEEE 802.1Qav – Forwarding and Queuing Enhancements for Time-Sensitive Streams
  - Stream management
    - IEEE 802.1Qat – Stream Reservation Protocol (SRP)
    - Dynamic stream announcement with admission control
    - Static implementation for automotive possible

- Audio/Video data transmission and reception
  - Audio/Video Transport Protocol (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

MICROSAR.AVB



- ETHTSYN – Ethernet Time Synchronization
  - Time synchronization between Ethernet ECUs
  - The Synchronized Time Base Manager (STBM) acts as coordinator between different networks
    - ETHTSYN can also be used without STBM
  - Implements the Generalized Precision Time Protocol (gPTP)
    - IEEE 802.1AS
  - Is specified by AUTOSAR 4.2
  - Is part of MICROSAR.ETH but because it implements gPTP, it is explained in context of MICROSAR.AVB
  - Best Master Clock Algorithm (BMCA) to determine the best clock in the system
    - Can be provided on request
- AVTP – Audio/Video Transport Protocol
  - Transmission and reception of audio and video streams
  - IEEE 1722(a)

Agenda

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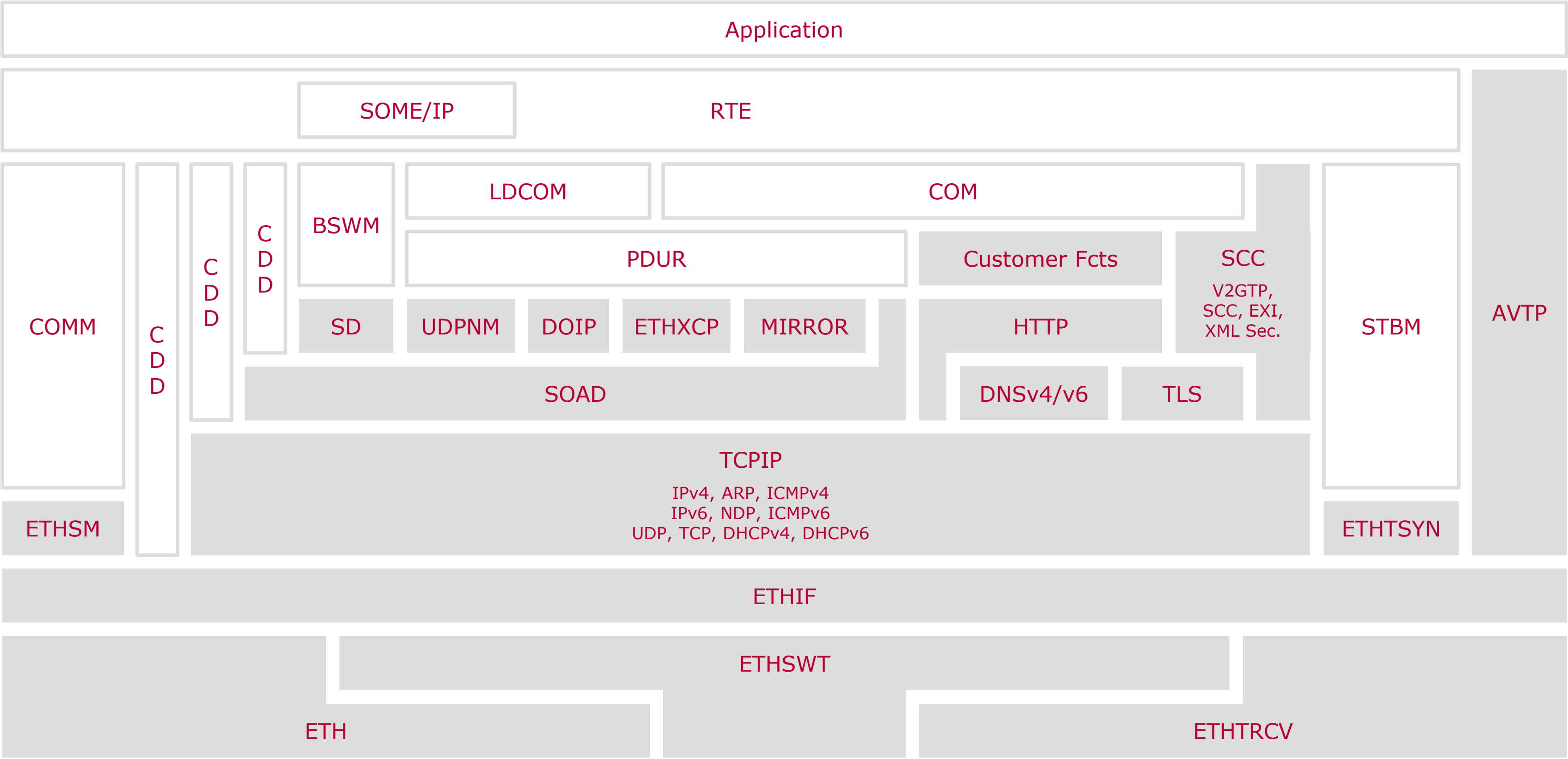
Summary

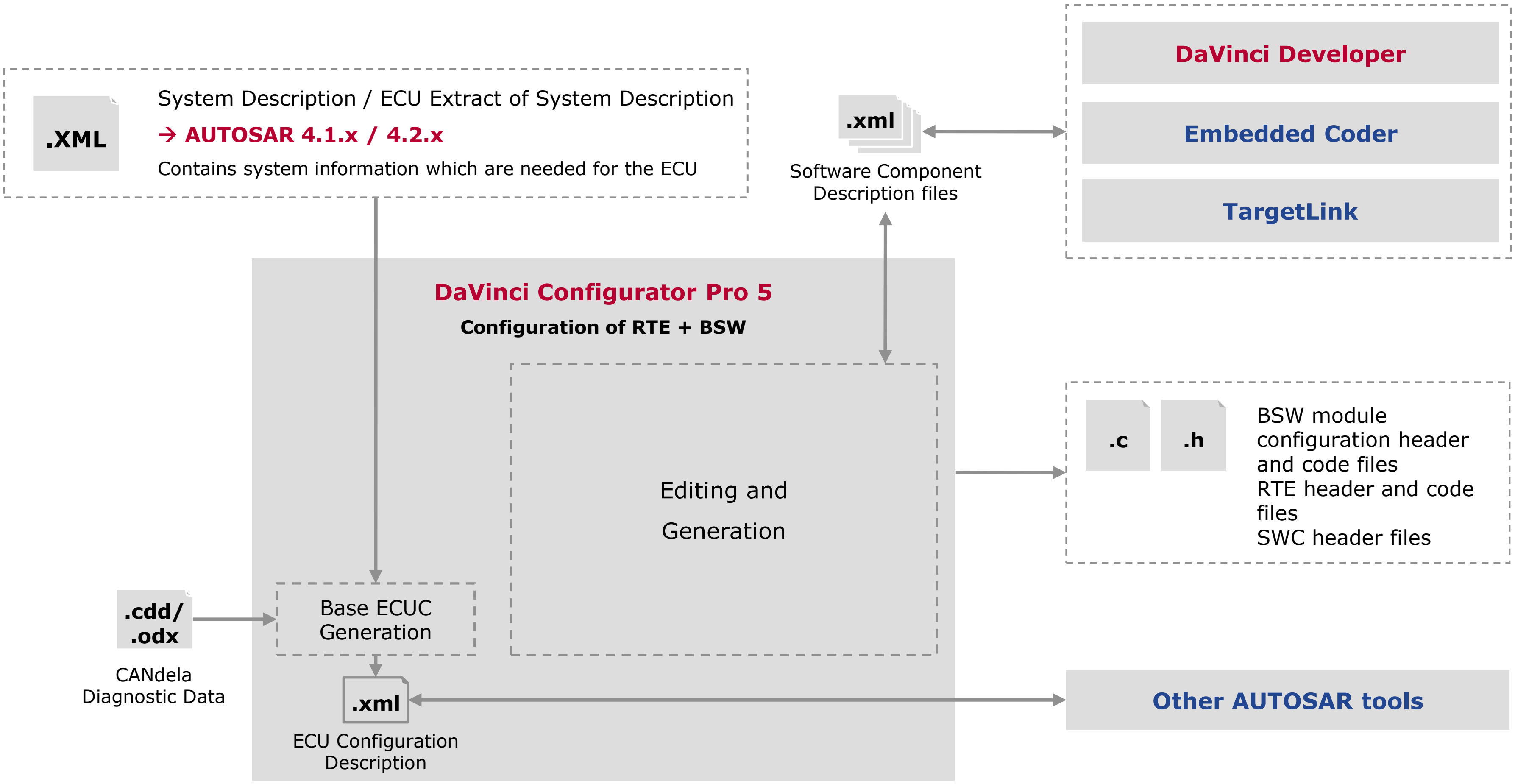
Overall MICROSAR Ethernet Architecture



- MICROSAR.ETH is the basis of MICROSAR.V2G and MICROSAR.AVB
  - All clusters and use-cases can run in parallel
  - Figure does not show ETHSWTEXT and the flashbootloader

Summary

ECU Configuration Flow for MICROSAR.ETH



.XML

System Description / ECU Extract of System Description

→ **AUTOSAR 4.1.x / 4.2.x**

Contains system information which are needed for the ECU

.xml

Software Component Description files

DaVinci Developer

Embedded Coder

TargetLink

DaVinci Configurator Pro 5

Configuration of RTE + BSW

Editing and Generation

.c .h

BSW module configuration header and code files
RTE header and code files
SWC header files

.cdd/ .odx

CANdela Diagnostic Data

Base ECUC Generation

.xml

ECU Configuration Description

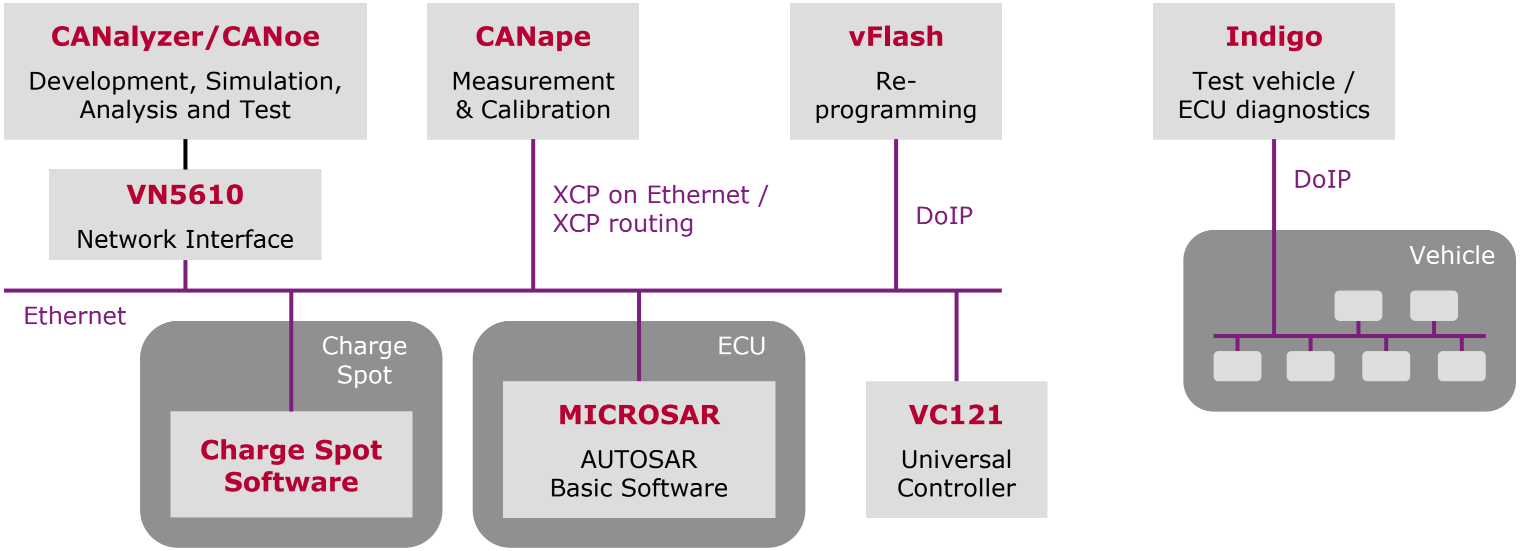
Other AUTOSAR tools

Summary

Vector Ethernet Solution

Ethernet and TCP/IP in Vehicles

- Ethernet and TCP/IP technologies have made their way into the vehicle and they are expected to extend into new application areas
- Automotive OEMs and suppliers are facing diverse challenges here
- Vector supports you in meeting these challenges with professional tools, embedded software and services



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