POWER TRAIN OVERVIEW

Agenda

1. Car ECU architecture

2. Power Train: What is it and what for?

3. Vehicle communication

4. ECU SW Architecture (AUTOSAR)

Agenda

1. **Car ECU architecture**

2. Power Train: What is it and what for?

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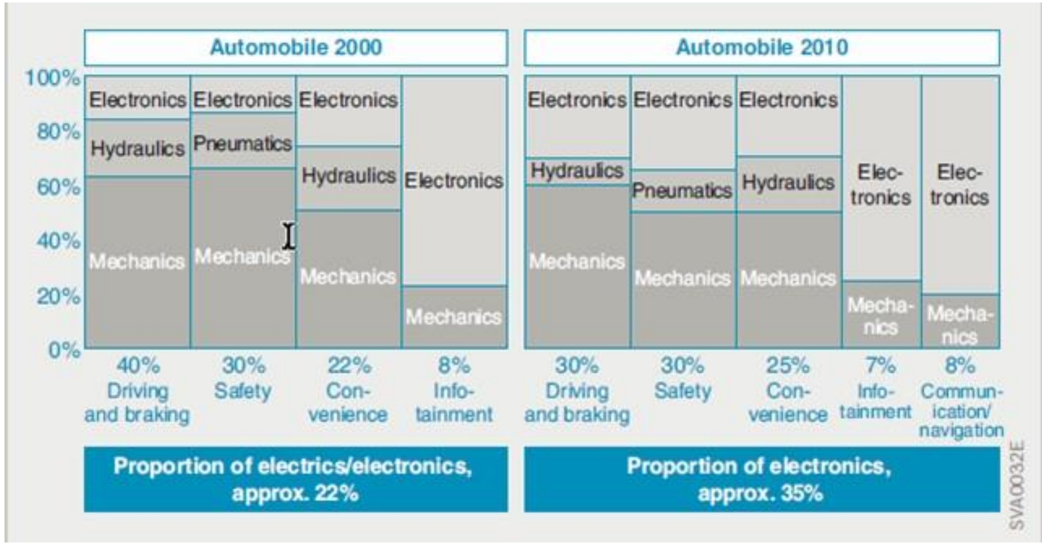
4. ECU SW Architecture (AUTOSAR)

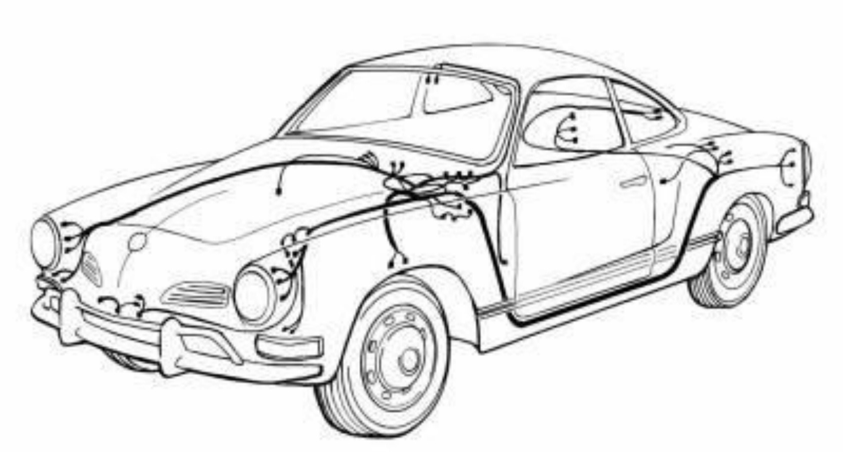
1. Car ECU architecture

History

- In 1950 electrical network comprised approx. 40 lines (battery, starter, ignition and the lighting and signalling systems)
- Today in a premium-class vehicle, there may be up to 80 control units performing their duties.
- A modern car can have over 200 microcontrollers



1. Car ECU architecture
Feature comparison



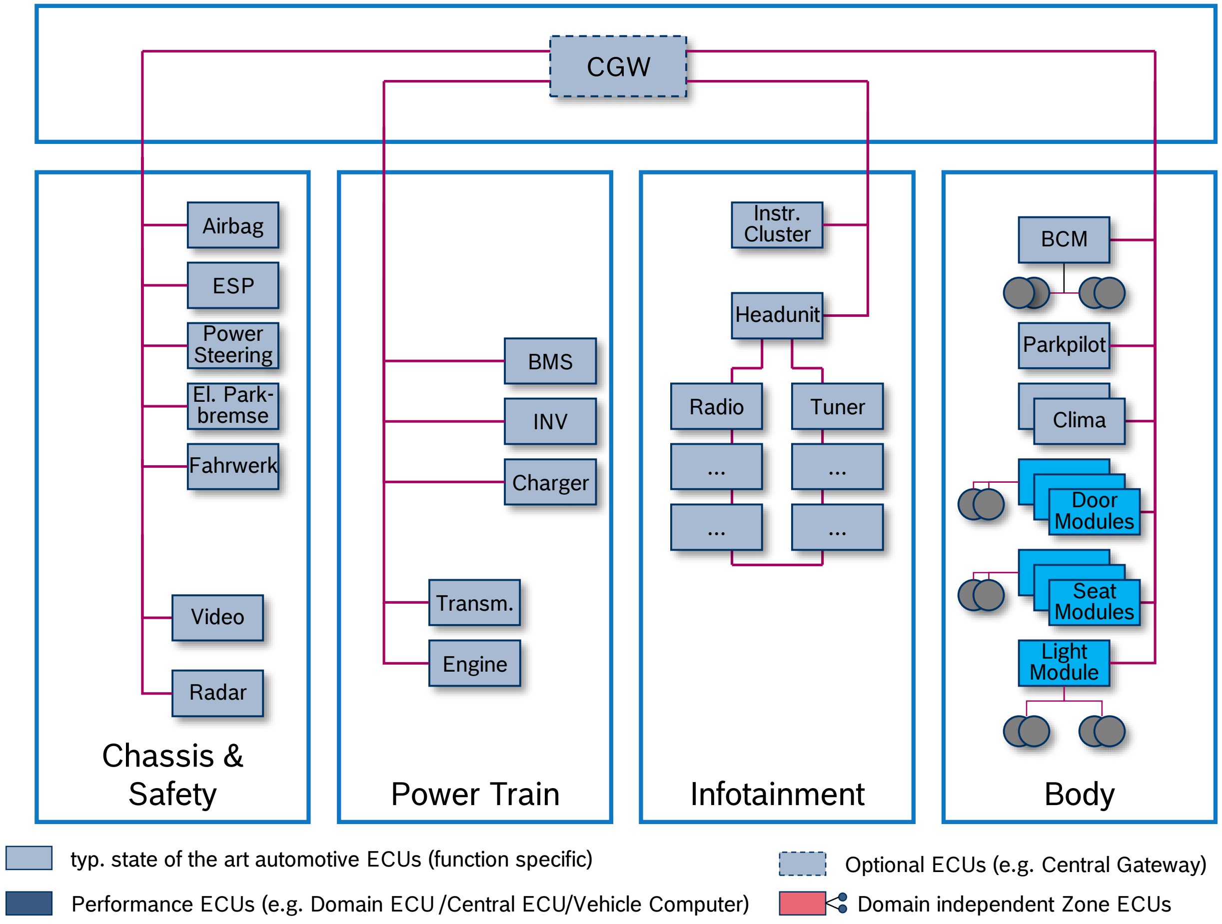
Vintage

Modern

- Aprox. 40 wires
- Headlights and backlights
- Horn
- Electric wipers
- Radio
- Seatbelts

- 800 to 1000 wires.
- Traction control
- Dynamic torque distribution
- Hill decent assist
- Hill start assist
- Launch control
- Regenerative braking
- Start-stop
- Pre-tensioning seatbelts
- ABS
- ESP
- Park pilot
- ACC
- Lane assist
- Adaptive headlights
- 4 zone AC
- Infotaiment
- Internet connectivity
- Tire pressure monitoring
- Heated and cooled seats
- Heated steering wheel
- Voice commands
- Airbags
- Emergency braking
- Soft close doors
- Automatic boot
- ...

1. Car ECU architecture
ECU Domains



Main properties & characteristics

- mainly encapsulated E/E architecture structure
- each function has his “own” ECU
- partly merge of ECUs
  - examples:
    - Parking-Assist ECU into Body Control Module (BCM)
    - APB into ESP

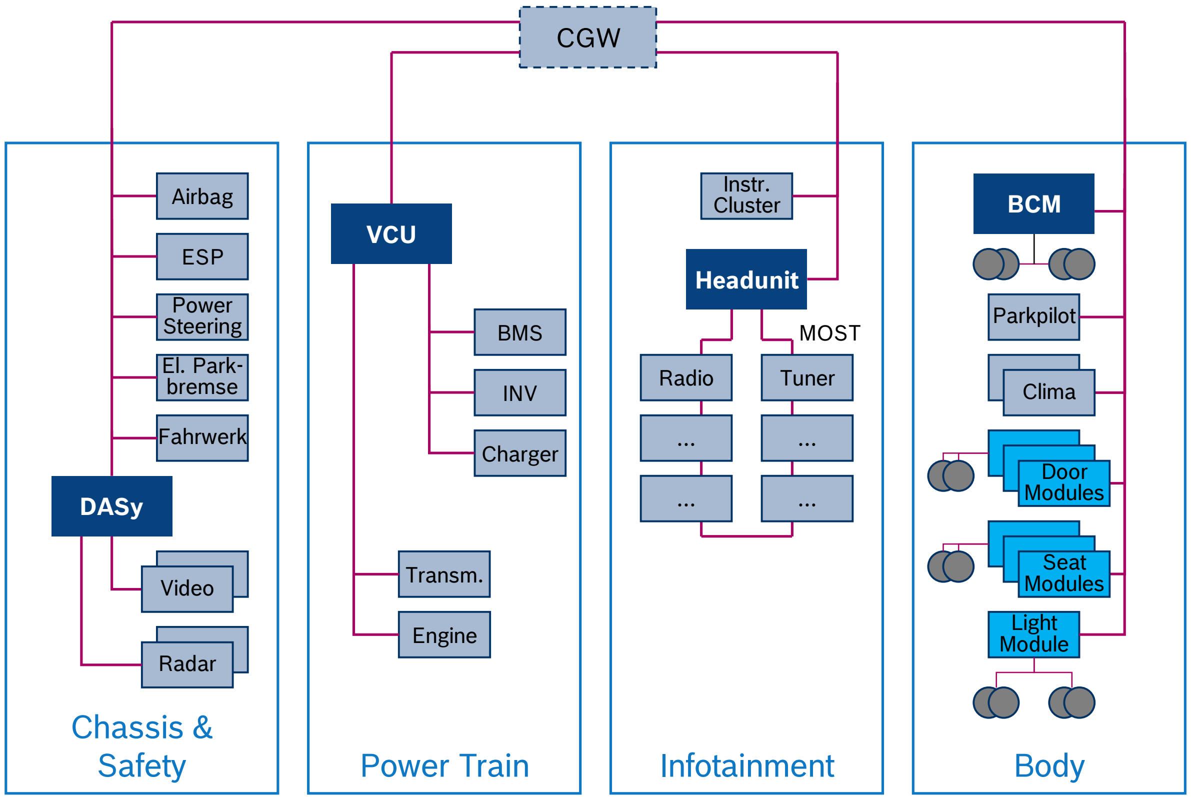
Nomenclature

- “Function Specific ECUs”
  e.g. ESP = stability functions, Engine ECU = engine functions
- “Domain Specific Zone ECUs”
  e.g. Body-Domain Door/Roof/Light-ECU

Options / Variants

- CGW as stand alone ECU or pot. integrated in e.g. BCM

ECU architecture
Domains 2



Main properties & characteristics

- Mainly domain centralized E/E architecture
- Domain centralized ECUs as "master" of the domain for intra-domain functions (integration platform for each domain)
- Motivation: Higher performance requirements and standardization of sensor/actuator ECUs

Nomenclature

- "Domain specific Central ECUs"
  e.g. DASy, VCU, HU
- "Function Specific ECUs"
  e.g. ESP = stability functions, Engine ECU = engine functions
- "Domain Specific Zone ECUs"
  e.g. Body-Domain Door/Roof/Light-ECU

Options / Variants

- Not every domain will have a domain specific "Central ECUs"
- Not every domain specific "Central ECUs" will have the same performance requirements

typ. state of the art automotive ECUs (function specific)
Performance ECUs (e.g. Domain ECU /Central ECU/Vehicle Computer)
Optional ECUs (e.g. Central Gateway)
Domain independent Zone ECUs
Sensors/Actuators
Domain specific Zone ECUs (e.g. todays Door ECU)

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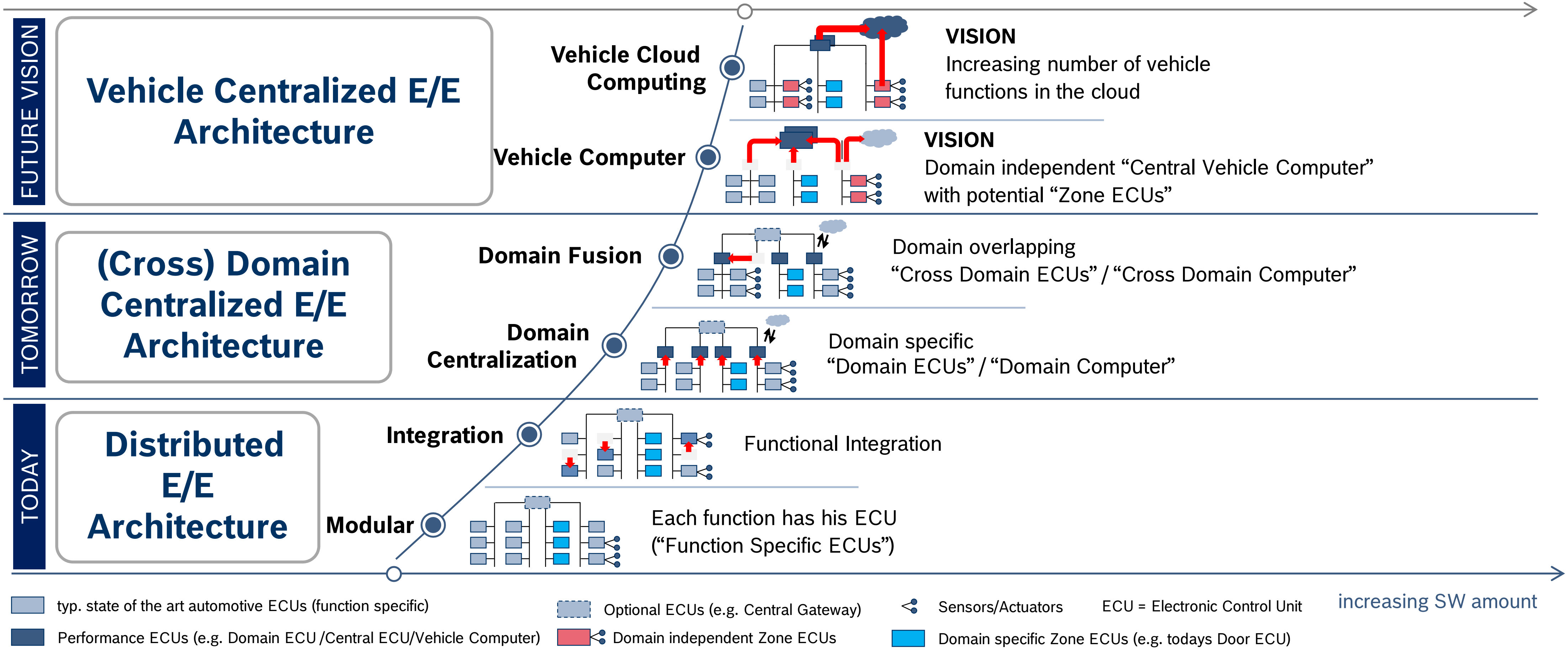
ECU architecture
Next steps



Agenda

1. Car ECU architecture

2. Power Train: What is it and what for?

3. Vehicle communication

4. ECU SW Architecture (AUTOSAR)

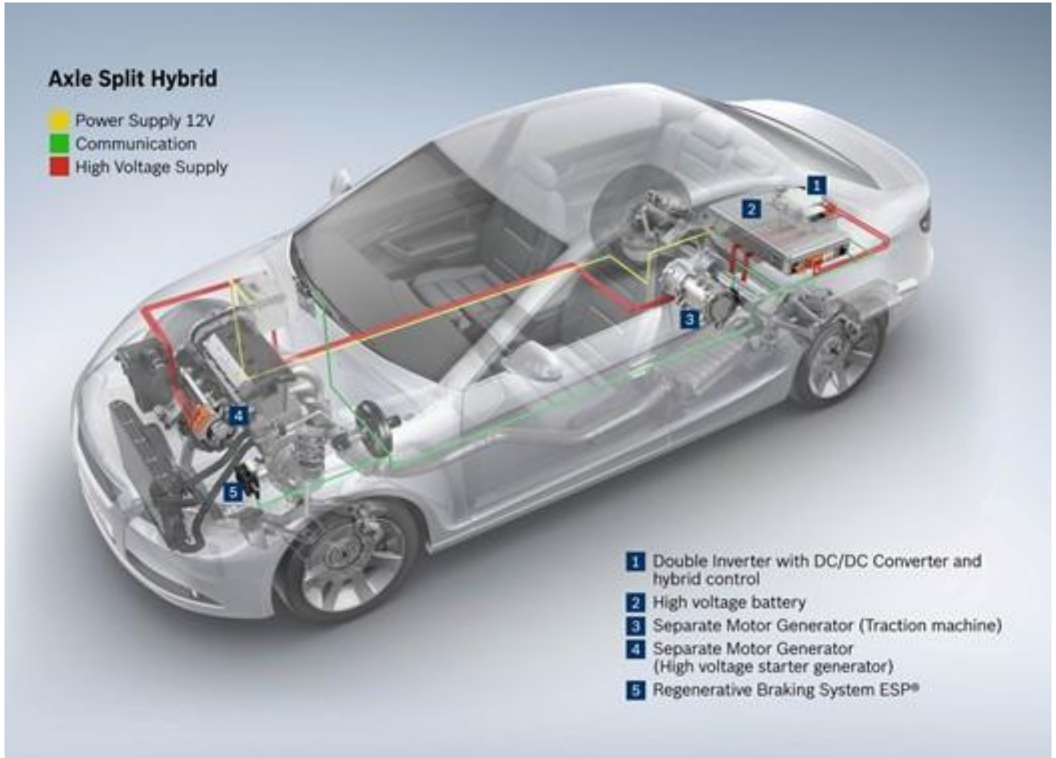
2. Power train
Overview

- The term **power train** or **power plant** describes the main components that generate power and deliver it to the road surface, water, or air.

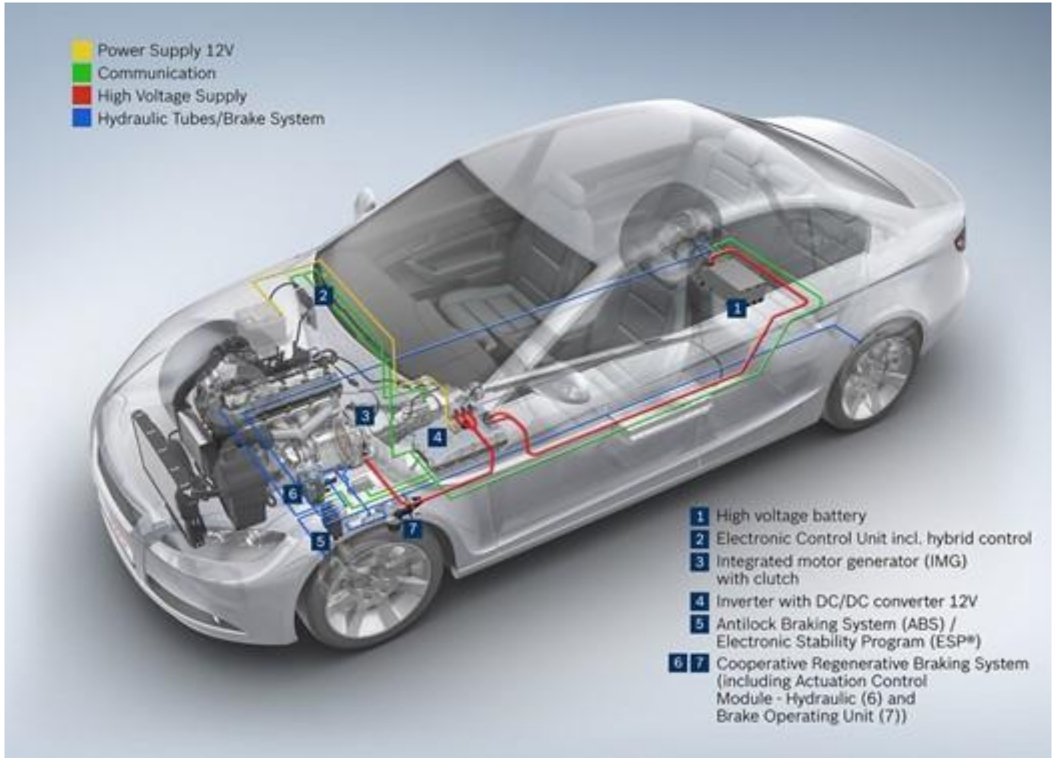
- This includes the engine, transmission, drive shaft, differentials, and the final drive (dive wheels, continuous track as in caterpillar tractors).

- Types of powertrain available:
    - Internal combustion
    - Hybrid
        - Plug-in hybrids
        - Non Plug-in hybrids
    - Full Electric

2. Power train
Hybrid drive



Plug-in Hybrid



Hybrid

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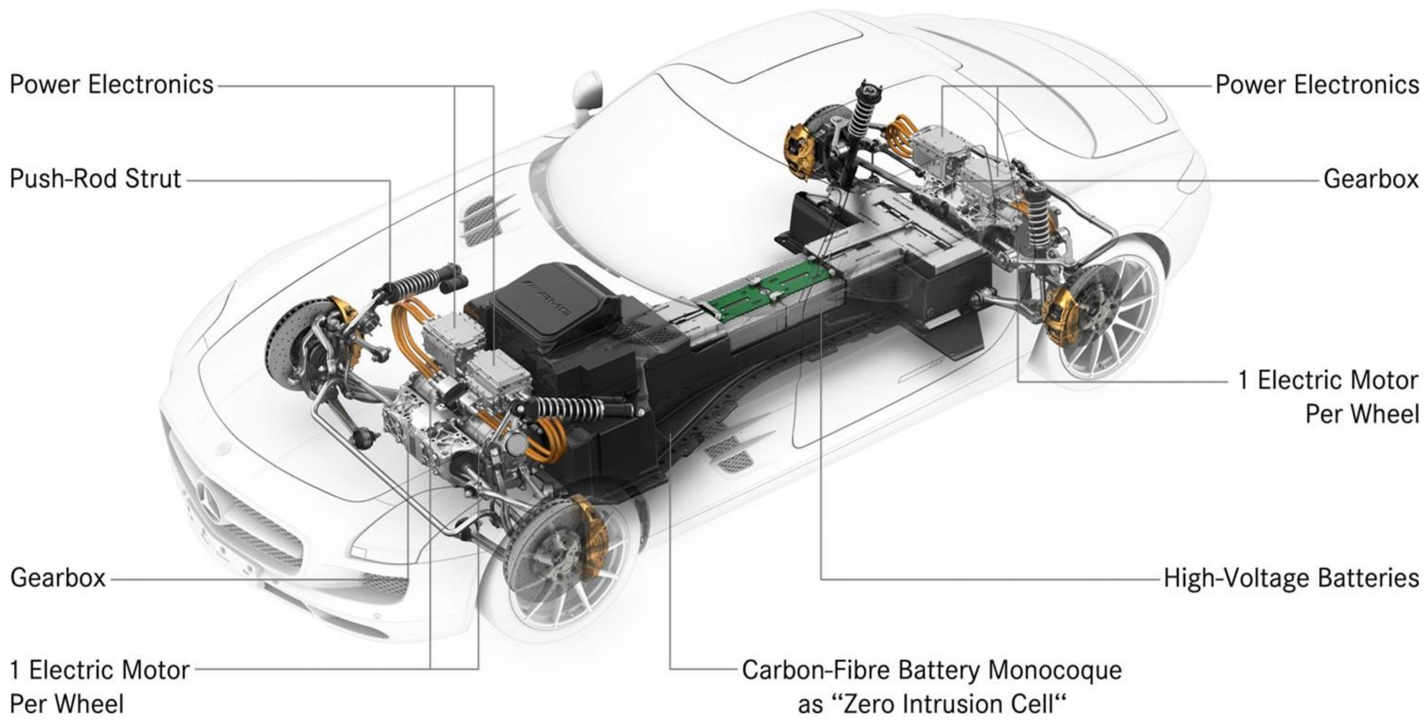
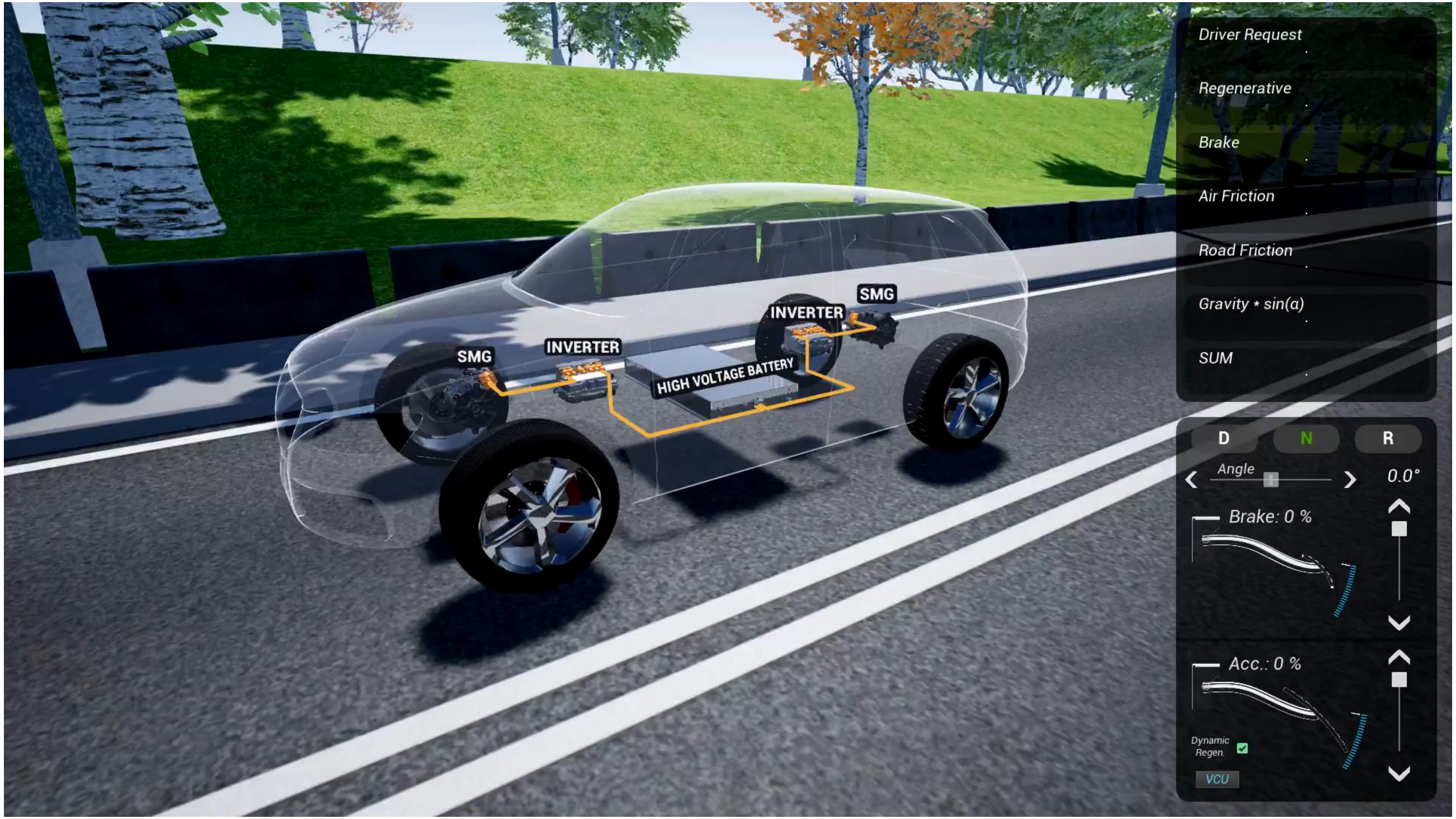
2.Power train
Electric drive

- Main components:
  - Electric motor
  - Invertor
  - Battery management
  - Battery (20 – 100 kWh)

- Functionalities
  - Traction control
  - Torque vectoring
  - Dynamic power distribution
  - Regenerative braking



2. Power train
Regenerative Braking



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Agenda

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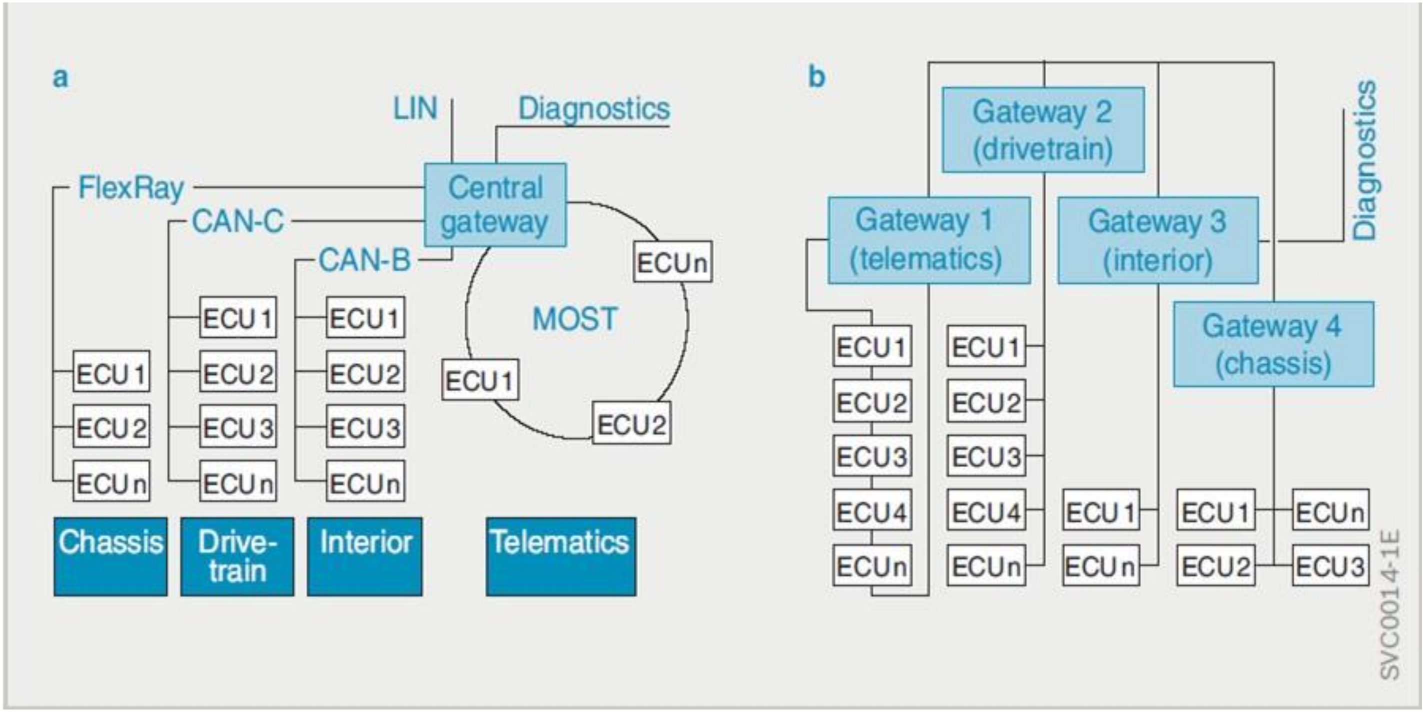
3. Vehicle communication
Overview

- Chassis/ Safety domain:
  - Bus type: Flexray
  - Topology: Star topology
  - Data rates: Max. 20 Mbit/s
  - Standard: Flexray consortium
  - SAR Classification: Drive-by-wire
- Powertrain/ Drivetrain domain:
  - Bus type: High Speed CAN
  - Topology: Linear Bus
  - Data rates: 10kbit/s – 1Mbit/s
  - Standard: ISO 1198
  - SAR Classification: Class C
- Body/ Interior domain:
  - Bus type: Low Speed CAN
  - Topology: Linear Bus
  - Data rates: Max. 125 kbit/s
  - Standard: ISO 11519-2
  - SAR Classification: Class B
- Infotainment / Telematics domain:
  - Bus type: MOST
  - Topology: Ring topology
  - Data rates: Max. 22.5 Mbit/s
  - Standard: MOST cooperation
  - SAR Classification: Mobile Media



a. Central Gateway topology

b. Distributed Gateway topology

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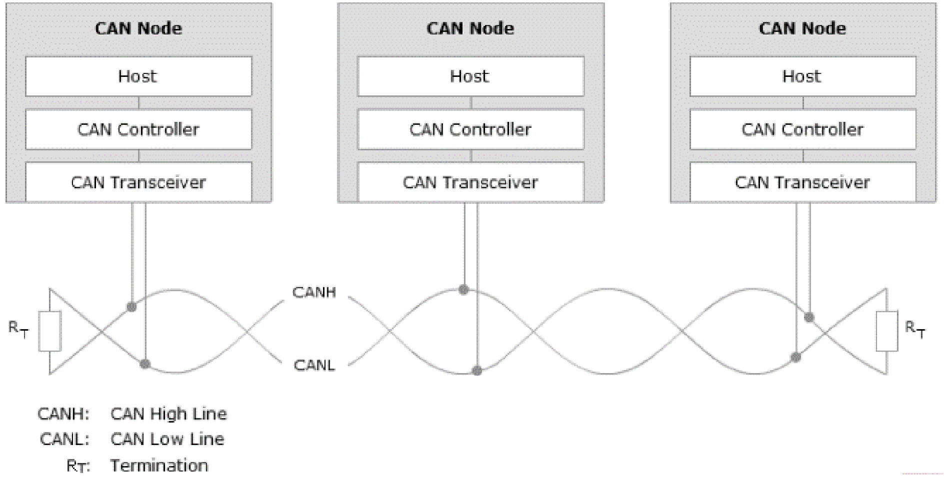
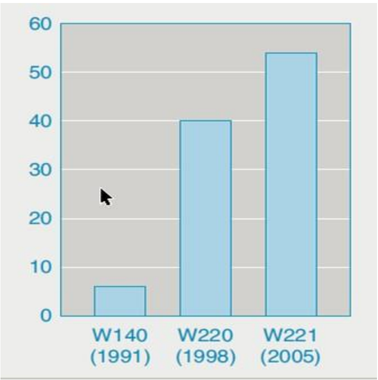
3. Vehicle communication
CAN Overview

- Development of the CAN bus started in 1983 at Robert Bosch GmbH.
- The first CAN controller chips, produced by Intel and Philips, came on the market in 1987
- In 1991 the CAN bus (Controller Area Network) was the first bus system to be introduced to a motor vehicle in mass production

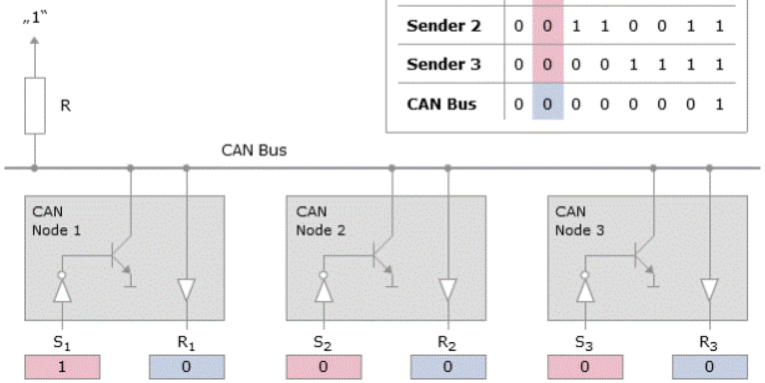
- ISO 11898 specifies
  - 1 MBits/s for 40 m (specified)
  - 500 kBits/s up to 100 m (recommendation)
  - 250 kBits/s up to 250 m
  - 125 kBits/s up to 500 m
  - 40 kBits/s up to 1,000 m



ECU connection

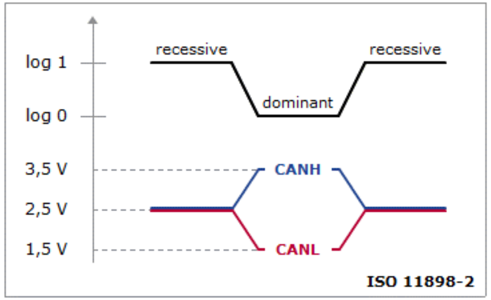


No. of ECU

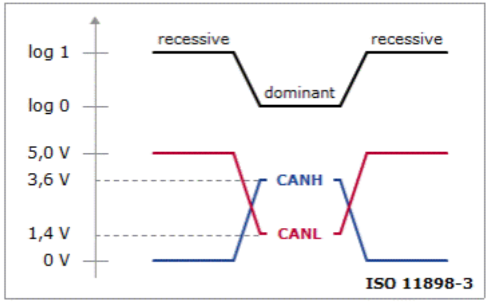


Sender 1	0	1	0	1	0	1	0	1
Sender 2	0	0	1	1	0	0	1	1
Sender 3	0	0	0	0	1	1	1	1
CAN Bus	0	0	0	0	0	0	0	1

CAN Arbitration



High speed CAN



Low speed CAN

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3. Vehicle communication

CAN Frame

- Standardized in accordance with
ISO 11898
- Prioritized communication
- Data transfer rates: up to 1 MBits/s
- Data capacity: up to 8 bytes per message
- Real-time response
- Very high reliability of data transfer
- Fault detection and signaling
Short-circuit resistance

Frame types:

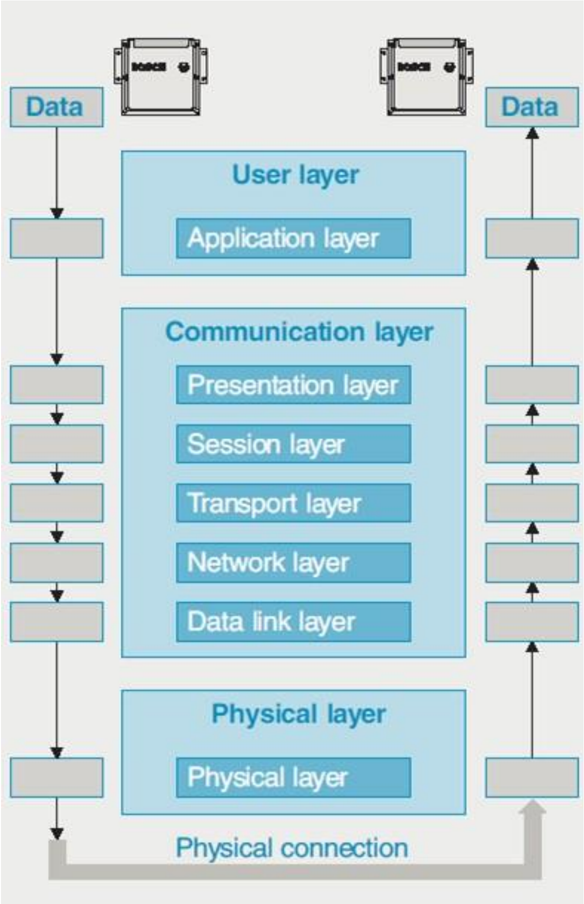
- Data frame
- Remote frame
- Error frame

Error detection

- *Cyclic redundancy check*
- *Frame check*
- *ACK check*
- *Monitoring*

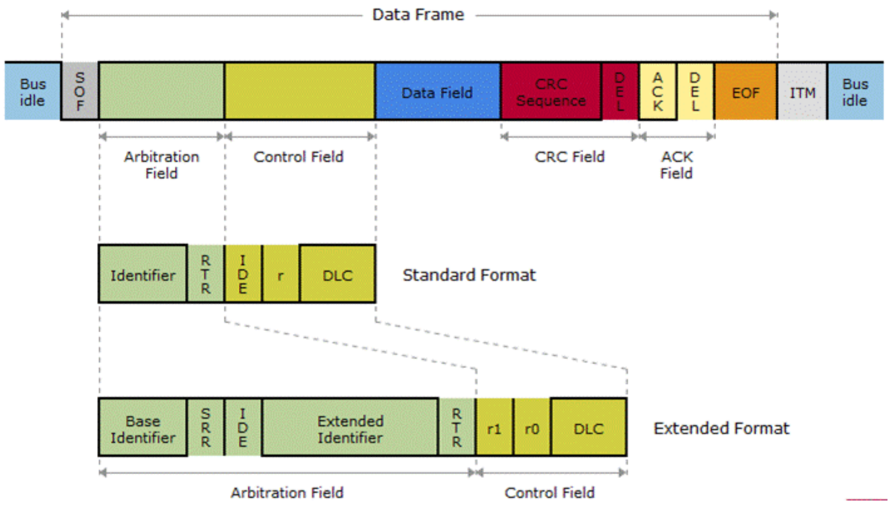
ISO OSI reference model (Open Systems Interconnection) used to describe the protocol communicate:

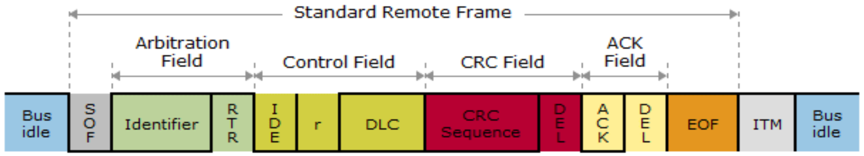
- Application layer
- Communication Layer
- Physical layer

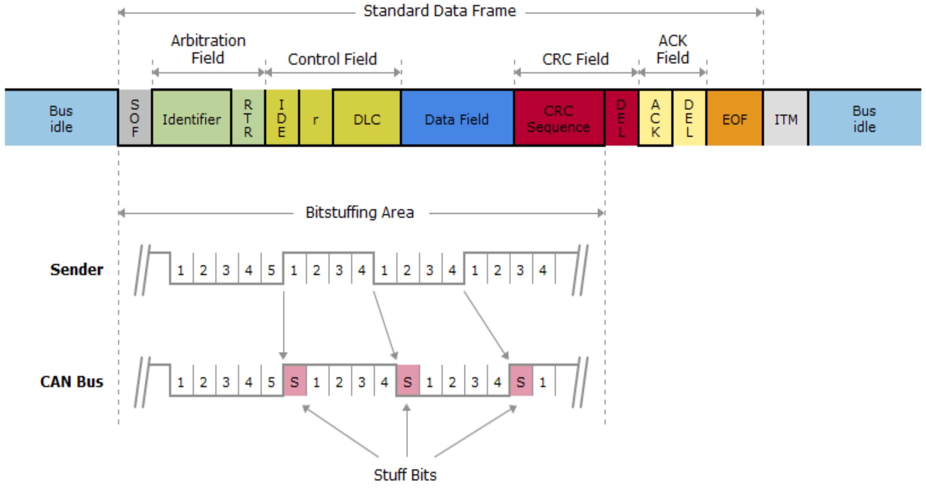


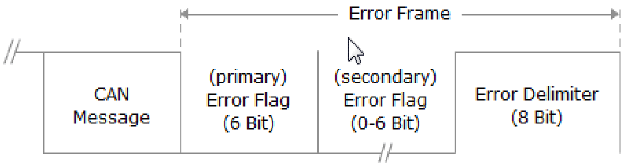
CAN OSI Model

3. Vehicle communication
CAN Frame Types









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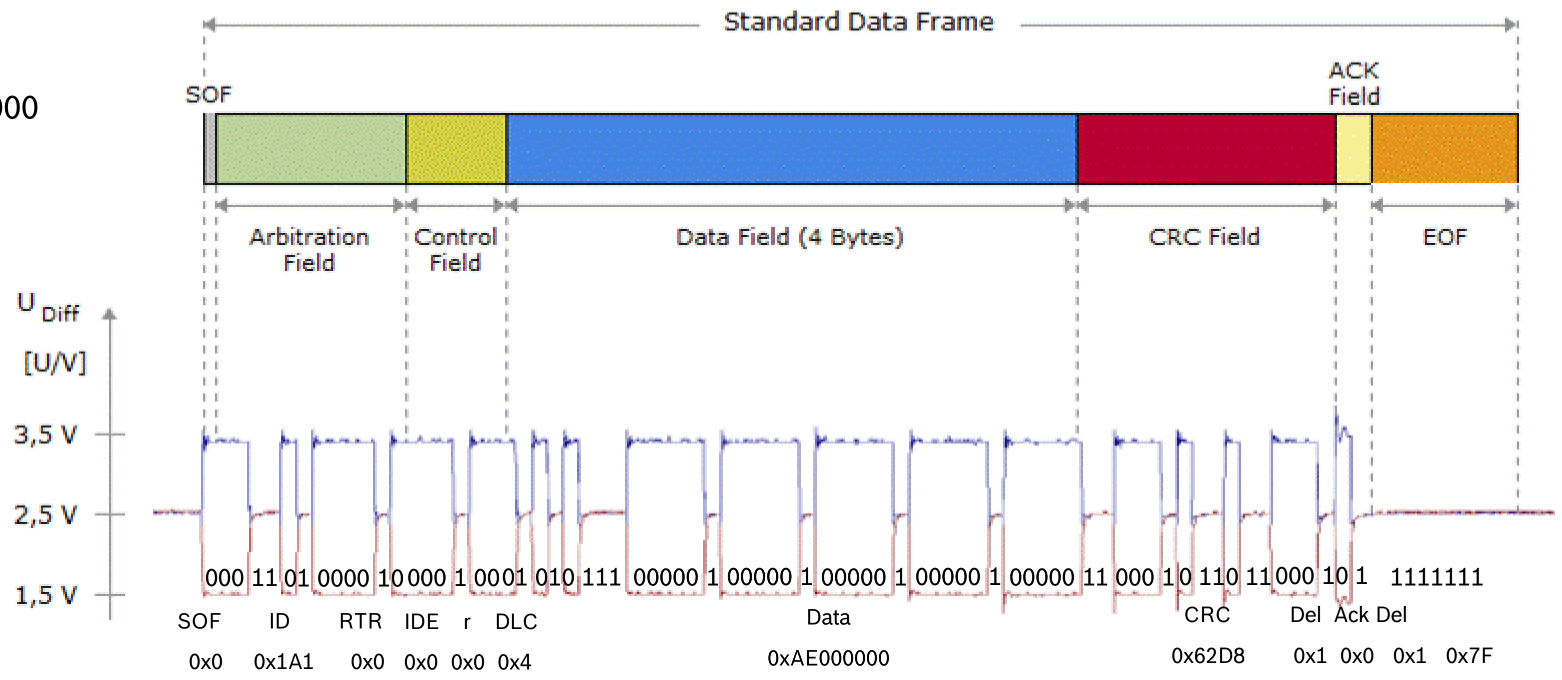
3. Vehicle communication
CAN Example

Send standard data frame:

- ID – 0x1A1
- DLC – 0x4
- Data – 0xAE000000

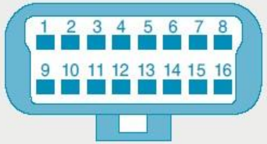


3. Vehicle communication
Diagnostics protocols

- Emissions diagnostics functionality is mandatory by legislation CARB (California Ari Resource Board) and EOBD (European On board diagnostics)

- CAN baud rates are 500 kBd or 1 MBd.
- Addressing and message types
Tester communication on the CAN bus is defined by ISO 15765.
- The communication
services of ISO 15765-3 or 14 229-1 are defined in a similar way to those of ISO 14230-3

- OEM and workshops use the OBD port for troubleshooting, calibration and maintenance



Pin 2: Bus line (high) from SAE J1850
Pin 10: Bus line (low) from SAE J1850
Pin 7: K line in accordance with ISO 9141-2 and ISO 14230-4
Pin 15: K line in accordance with ISO 9141-2 and ISO 14230-4
Pin 6: CAN_H from ISO 15765-4
Pin 14: CAN_L from ISO 15765-4
Pin 1, 3, 8, 9, 11, 12, 13 Not used by OBD
Pin 4: Vehicle ground
Pin 5: Signal ground
Pin 16: Battery positive

UWT0106-1E

OBD connector

a

Layer	CARB			
	K line			CAN
7	ISO 15031-5	ISO 15031-5	ISO 15031-5	ISO 15031-5
6				
5				ISO 15765-4
4				
3				ISO 15765-2 ISO 15765-4
2	ISO 9141-2	ISO 14230-2 ISO 14230-4	SAE J1850	ISO 11898 ISO 15765-4
1	ISO 9141-2	ISO 14230-1 ISO 14230-4	SAE J1850	ISO 11898 ISO 15765-4

b

Layer	Manufacturer-specific	
	K line: KWP 2000	CAN / UDS
7	ISO 14230-3	ISO 15765-3 ISO 14229-1
6		
5		ISO 15765-3
4		
3		ISO 15765-2
2	ISO 14230-2	ISO 11898-1
1	ISO 14230-1	ISO 11898

SVA0018E

Diagnostic protocols

a CARB communication
b Customer-specific communication

Layers of the OSI reference model
7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data link
1 Physical

UDS Unified Diagnostic Services

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3. Vehicle communication

UDS (Unified diagnostics services)

- A diagnostic communication protocol in the electronic control unit (ECU) environment within the automotive electronics, which is specified in the ISO 14229-1.It is derived from ISO 14230-3 (KWP2000) and ISO 15765-3 (Diagnostic Communication over Controller area network (DoCAN)

SID (hex)	Service
0x10	**Diagnostic Session Control service**
0x11	**ECU Reset service**
0x27	**Security Access service**
0x28	**Communication Control service**
0x3E	**Tester Present service**
0x83	Access Timing Parameter service
0x84	Secured Data Transmission service
0x85	**Control DTC Setting service**
0x86	Response On Event service
0x87	Link Control service

UDS Diagnostic services

Hex	Sub-function
0x00	Not defined
0x01	Hard reset
0x02	Key Off On Reset
0x03	Soft reset
0x04	Enable Rapid Power Shutdown
0x05	Disable Rapid Power Shutdown
0x06 – 0x3F	Not defined
0x40 – 0x5F	Vehicle Manufacturer Specific
0x60 – 0x7E	System Supplier Specific
0x7F	Not defined

Available subservices for

ECU Rest Service

Tx (transit message)

0.	1.	2.	3.	4.	5.	6.	7.
Length	SID	sub-service	Padding	Padding	Padding	Padding	Padding

Rx (received message)

Case 1: Positive response

0.	1.	2.	3.	4.	5.	6.	7.
Length	SID+0x40	sub-service	Padding	Padding	Padding	Padding	Padding

Case 2: Negative response

0.	1.	2.	3.	4.	5.	6.	7.
Length	0x7F	SID	NRC	Padding	Padding	Padding	Padding

Request and responsee frames

3. Vehicle communication

CAN UDS request example

- Using service ID 0x10 – Diagnostics session control
- Change diagnostics session to Extended Diagnostics Session (Sub service 0x03)

Tx

0.	1.	2.	3.	4.	5.	6.	7.
0x02	0x10	0x03	x	x	x	x	x

Rx Positive response

0.	1.	2.	3.	4.	5.	6.	7.
0x02	0x50	0x03	x	x	x	x	x

Rx Negative response:

0.	1.	2.	3.	4.	5.	6.	7.
0x03	0x7F	0x10	NRC	x	x	x	x

NRC	Description	Mnemonic
0x12	sub Function Not Supported	SFNS
0x13	incorrect Message Length Or Invalid Format	IMLOIF
0x22	conditions Not Correct	CNC
0x24	request Sequence Error	RSE
0x31	request Out Of Range	ROOR
0x33	security Access Denied	SAD
0x35	invalid Key	IK
0x36	exceeded Number Of Attempts	ENOA
0x37	required Time Delay Not Expired	RTDNE
0x38 – 0x4F	reserved By Extended Data Link Security Document	RBEDLSD
0x70	upload Download Not Accepted	UNDNA
0x71	transfer Data Suspended	TDS
0x72	general Programming Failure	GFP
0x73	wrong Block Sequence Counter	WBSC
0x93	voltage Too High	VTH
0x93	voltage Too Low	VTL

Negative response code (NRC) Table

Agenda

1. Car ECU architecture

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4. ECU SW Architecture (AUTOSAR)

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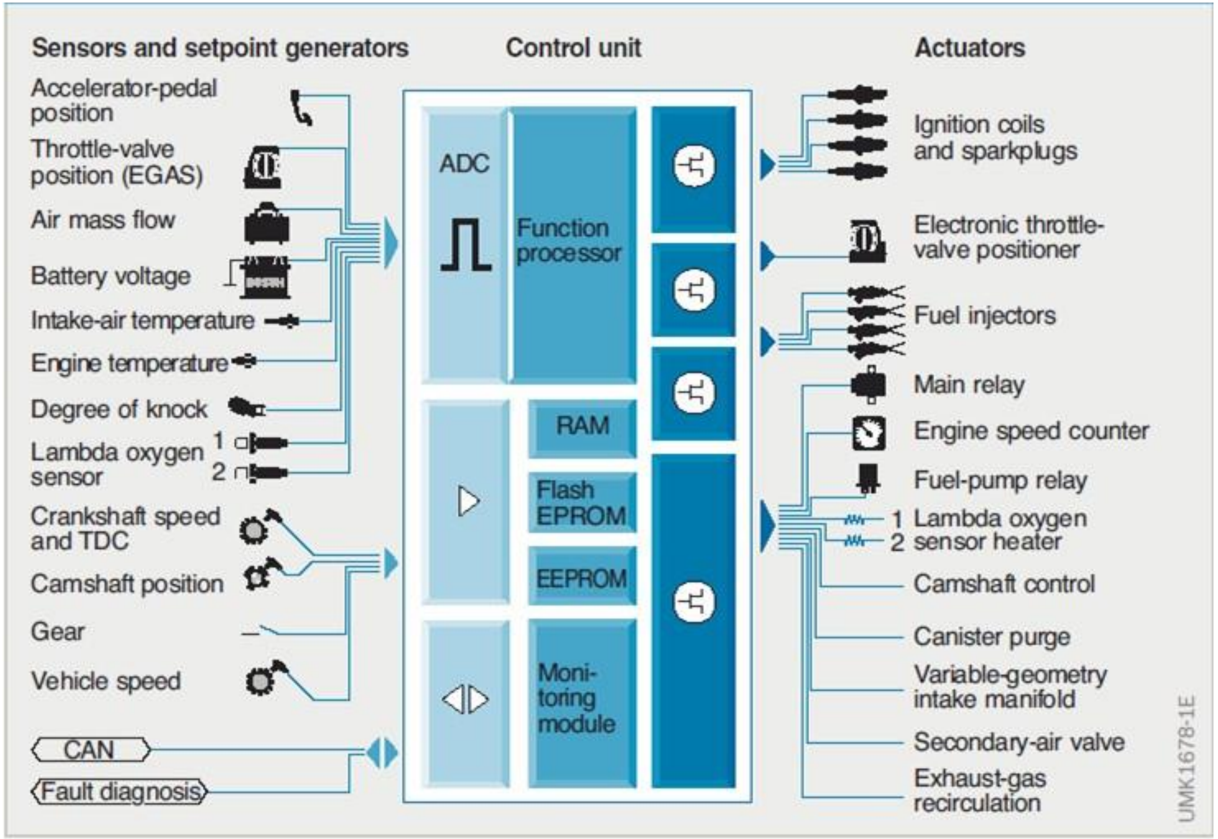
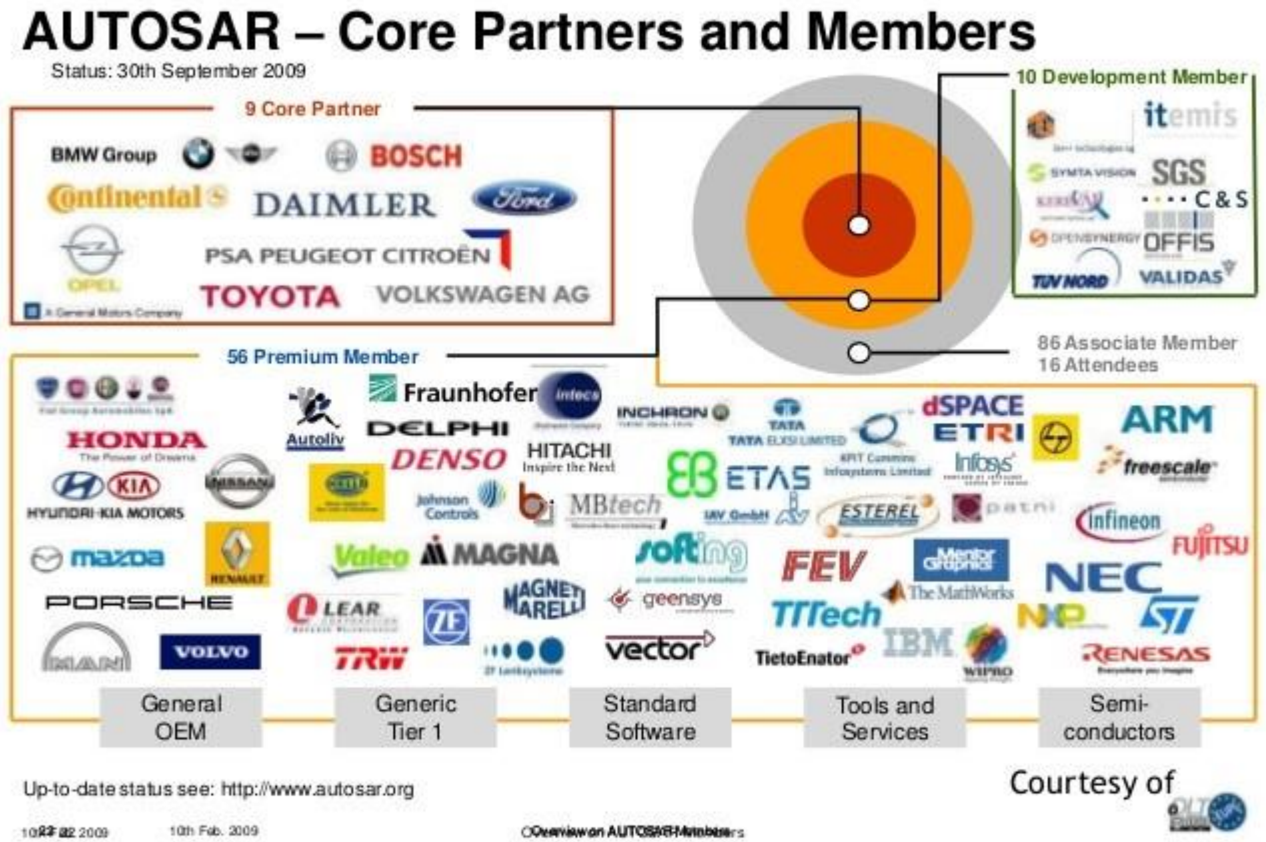
4. ECU SW Architecture
Why a standard SW Arch.?



Engine control unit block diagram

4. ECU SW Architecture
AUTOSAR Overview

- ▶ AUTomotive Open System Architecture

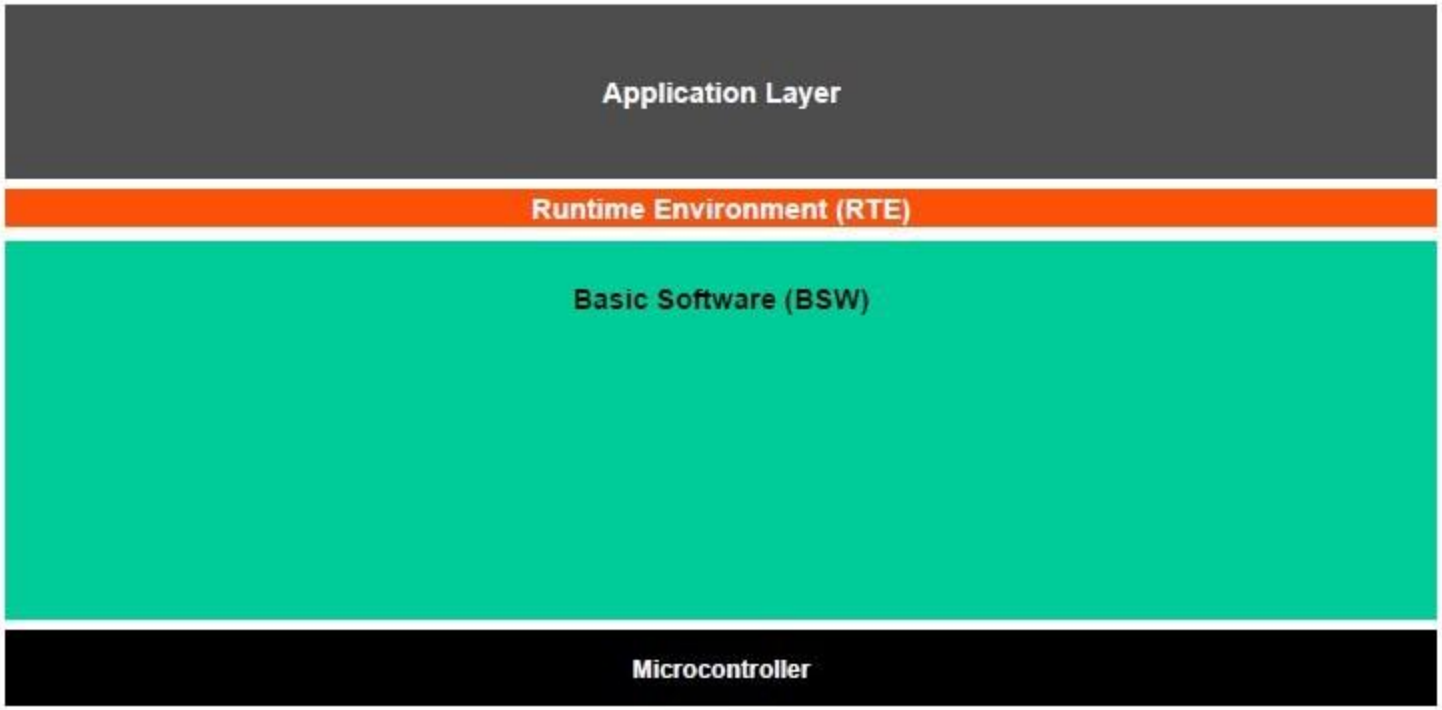


4. ECU SW Architecture

Motivation and Goals

- Scalability and re-use of Basic SW across OEMs and vehicle platforms
- Support integration of 3rd party Basic SW during design time
- Support integration of 3rd party Application SW Components during design time
- Support relocate ability of Application SW Components during design time
- Validation of Application SW Interfaces on vehicle level

4. ECU SW Architecture
SW Structure



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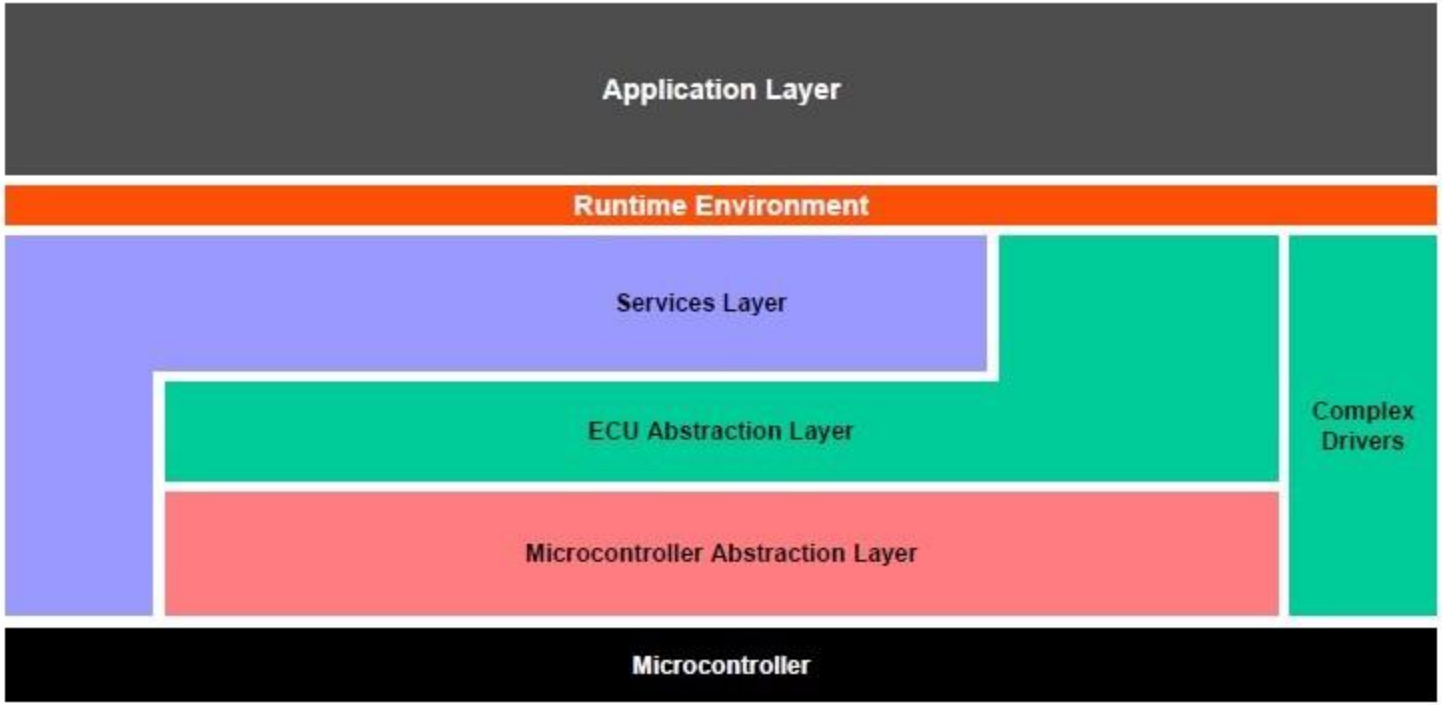
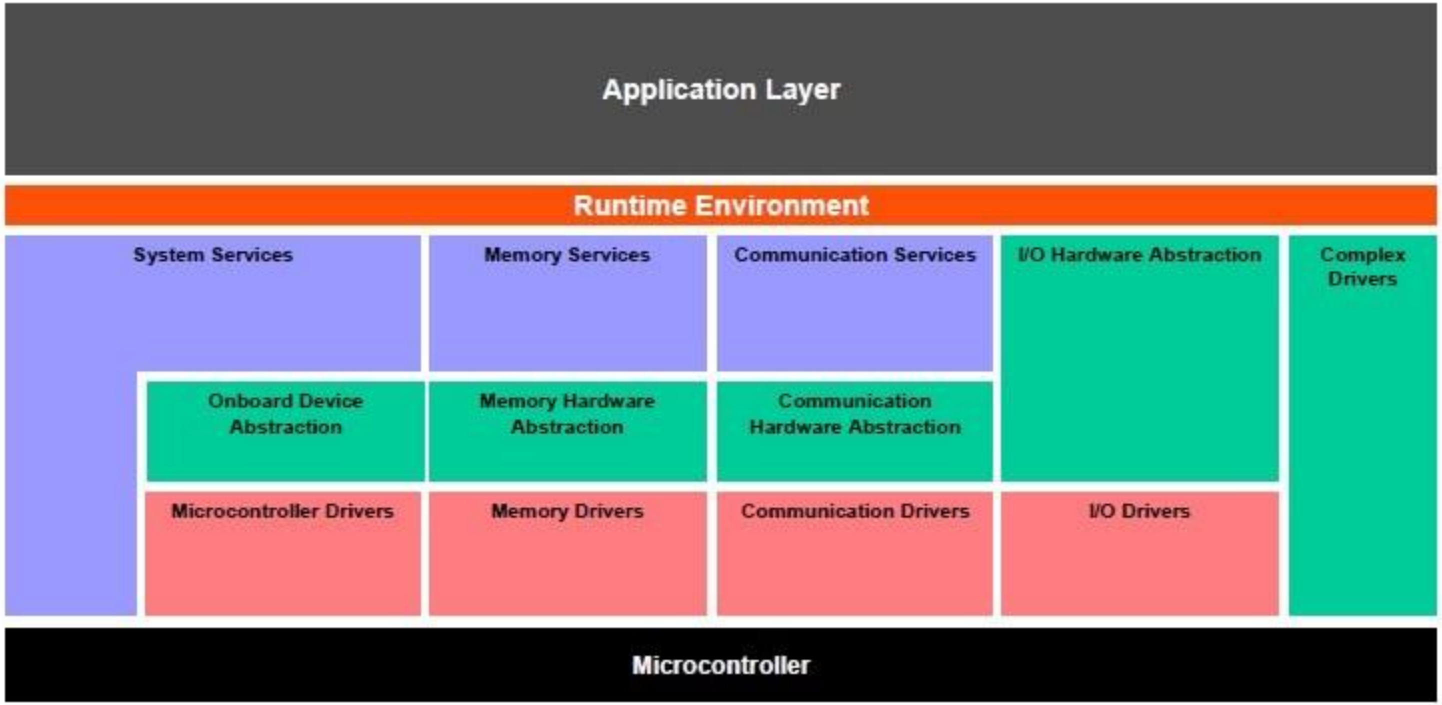
4. ECU SW Architecture
SW Structure



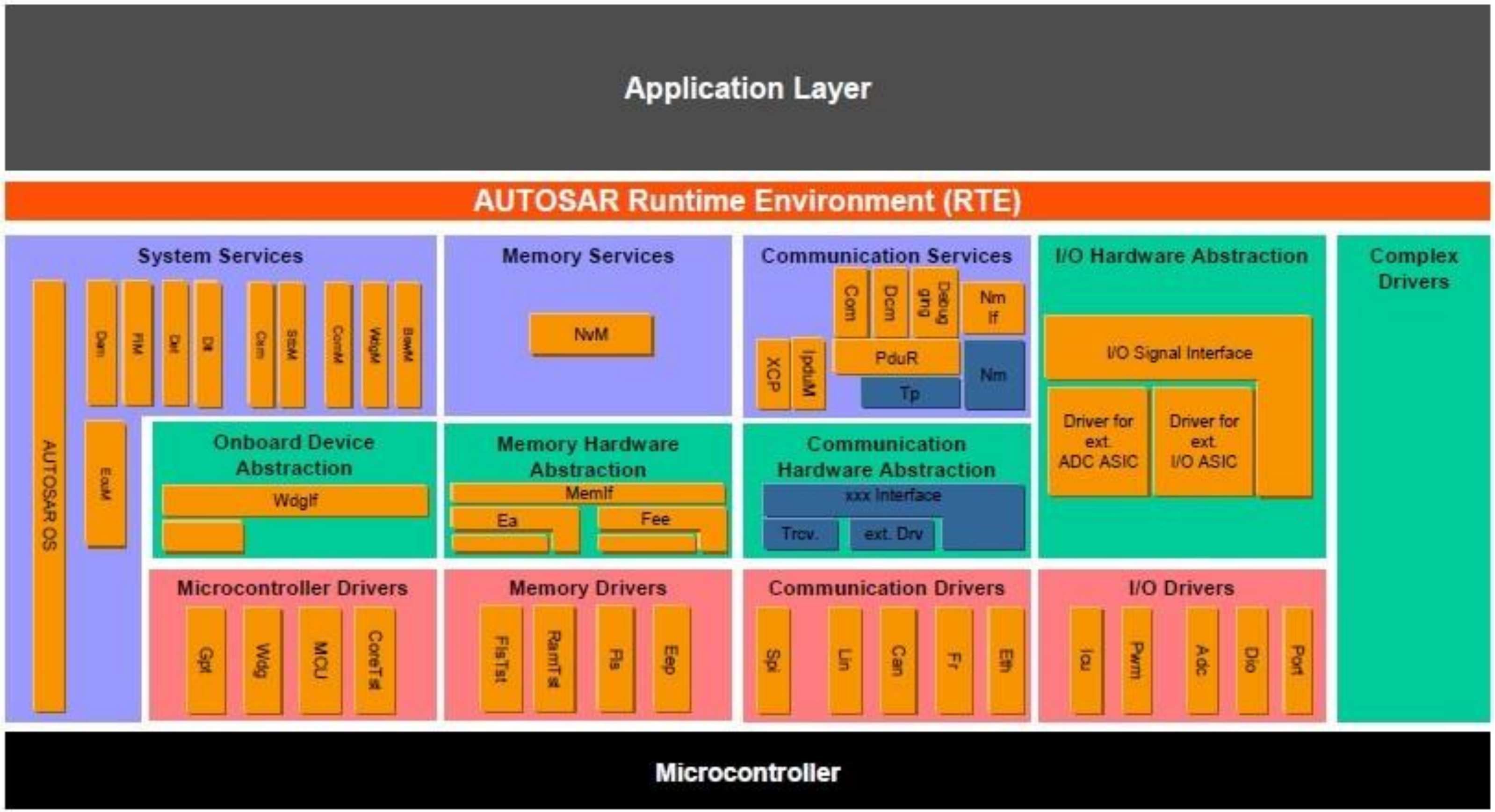
4.ECU SW Architecture

SW Structure

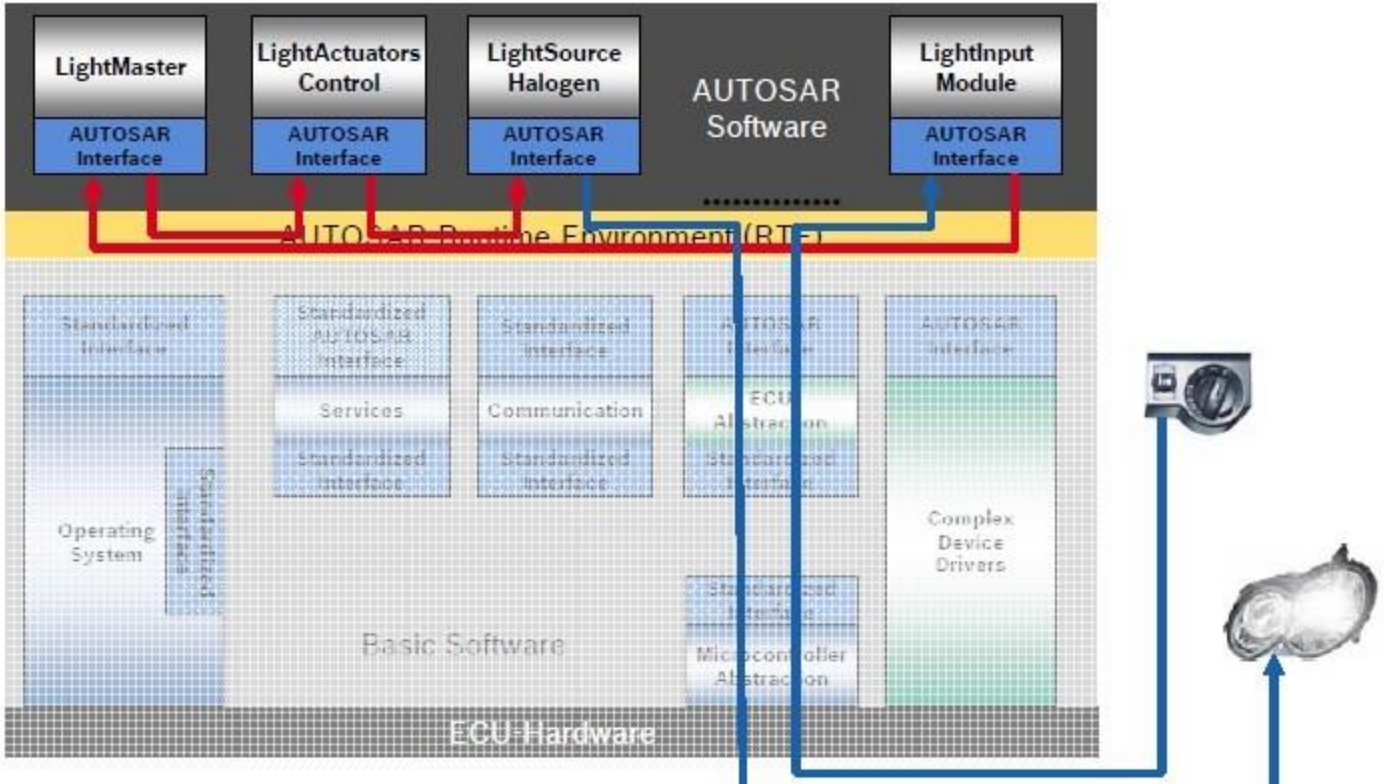


AUTOSAR Overview

SW Structure



4. ECU SW Architecture
SW Structure



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RBRO/ENG8 | 10/3/2017

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