Automotive Electronic Systems

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Outlines

- Developing Trends of Automotive Electronic Systems
- Emerging In-Vehicle Networks

Developing Trends of Automotive Electronic Systems

Automotive Electronic Systems Today

VW Phaeton:

- 11.136 electrical parts in total

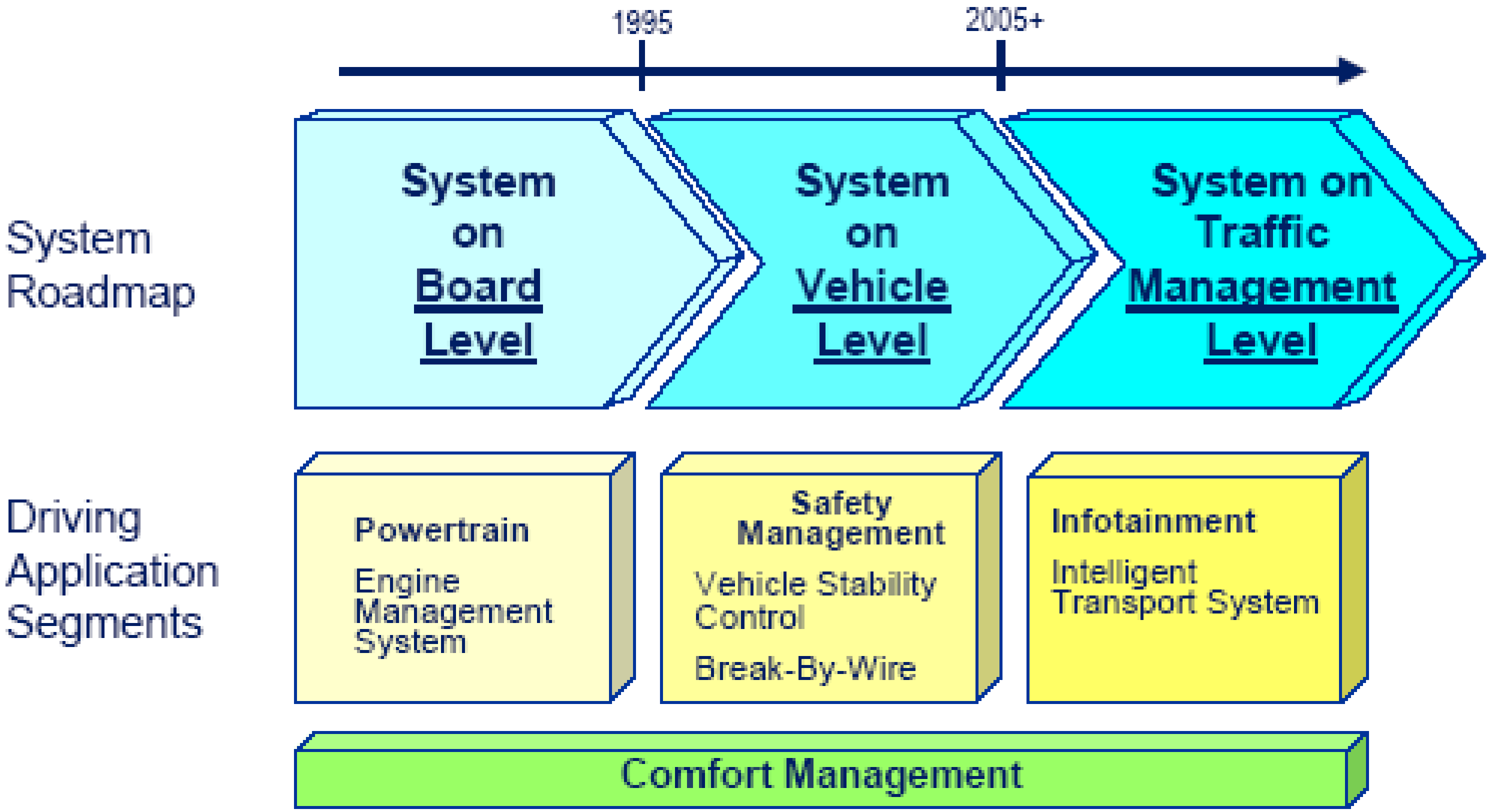
communication:

- **61 ECUs in total**
- external diagnosis for 31 ECUs via serial communication
- optical bus for high bandwidth Infotainment-data
- **sub-networks** based on proprietary serial bus
- **35 ECUs** connected by **3 CAN-busses**

sharing

- appr. **2500 signals**
- in **250 CAN messages**

Expanding Automotive Electronic Systems



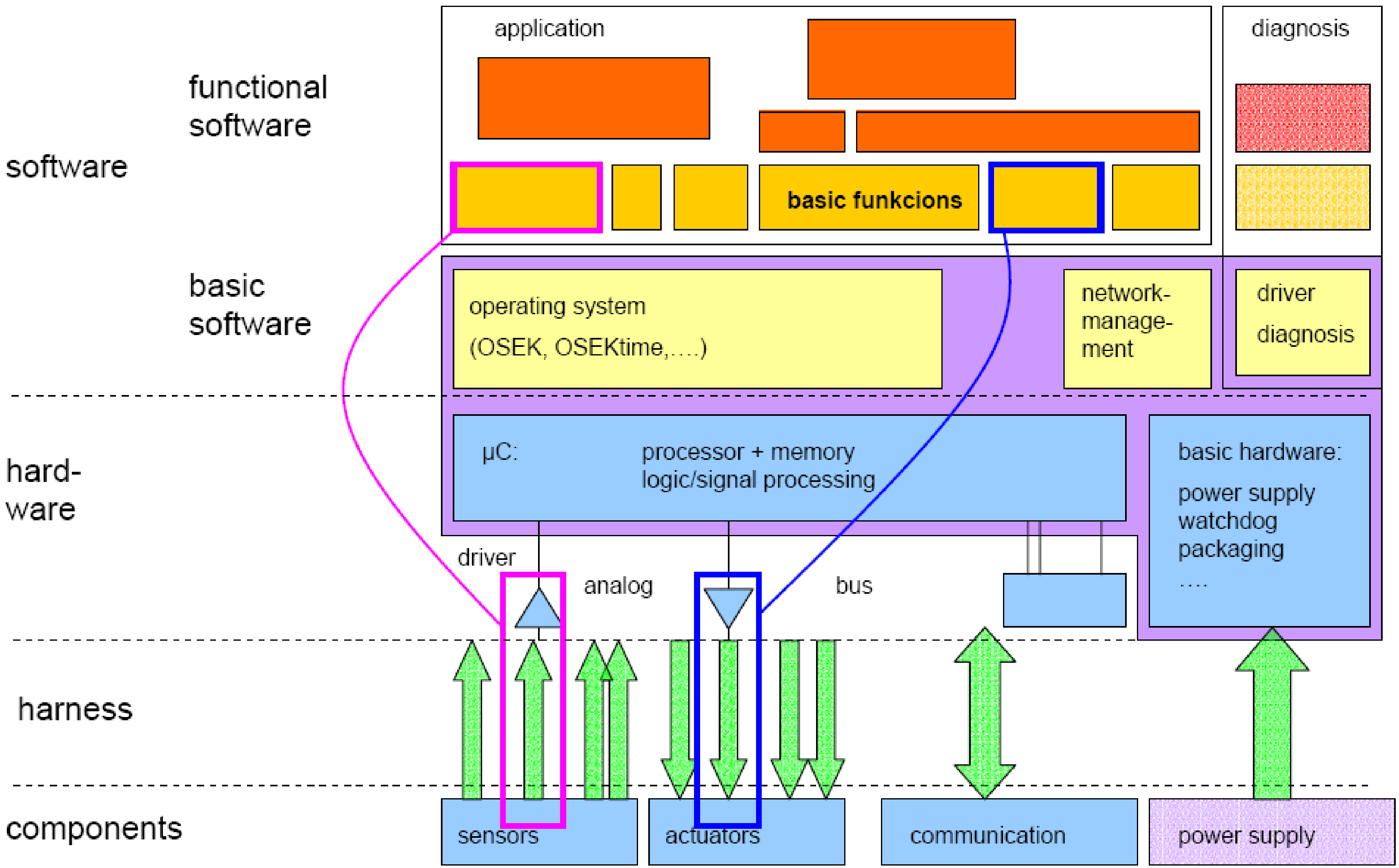
Expanding Automotive Electronic Systems

- The mature subsystems of automotive electronic systems
  - Powertrain/Body control—EMS, ABS, …
- Themes of current stage
  - X-by-wire—an ongoing revolution in vehicle electronics architecture
- Themes of next stage
  - Infotainment= Entertainment + Communication + Information

Expanding Automotive Electronic Systems

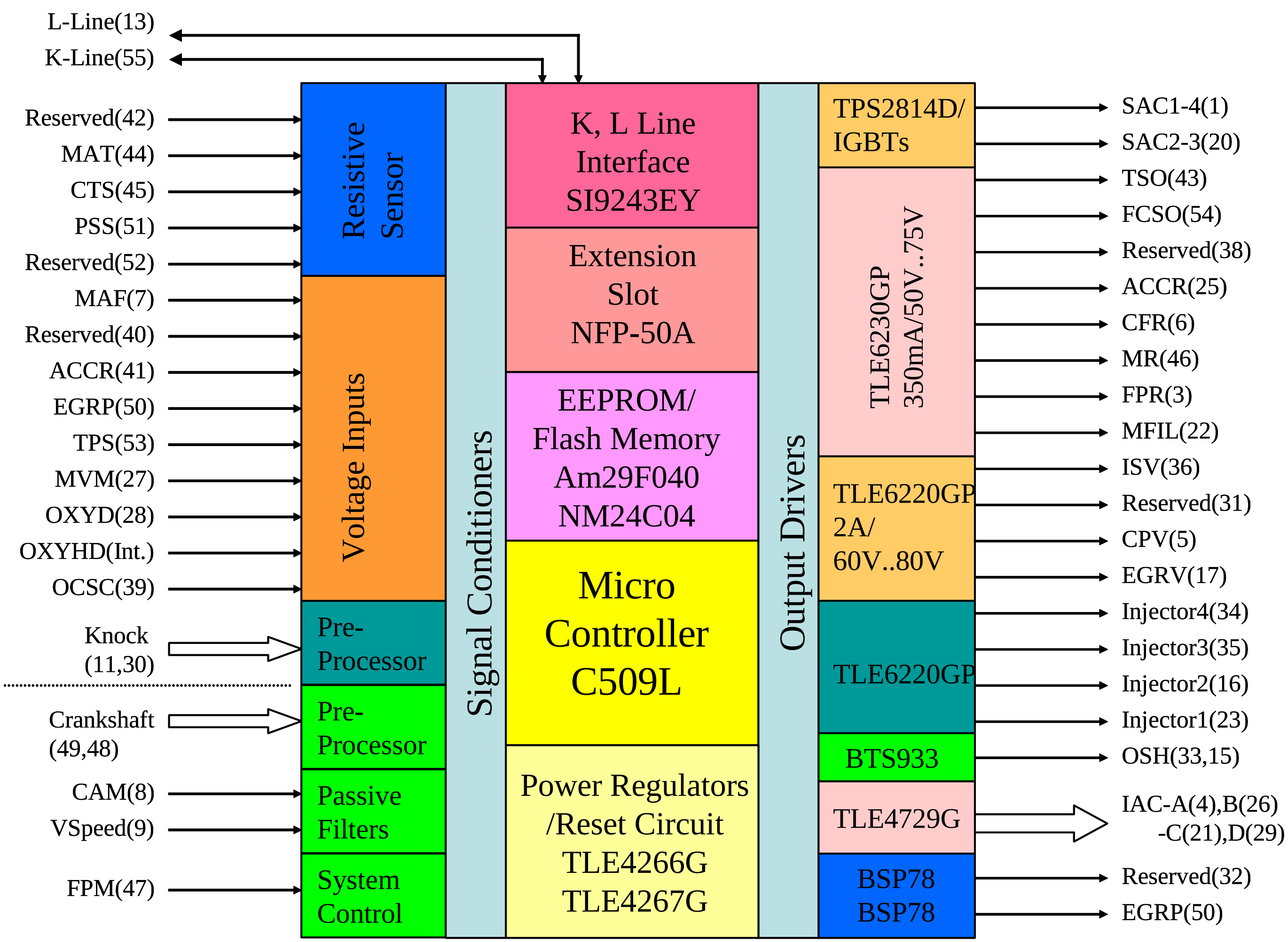
- Analysts estimate that more than 80 percent of all automotive innovation now stems from electronics
- To embedded the electronic systems and silicon components—such as transistors, microprocessors, and diodes—into motor vehicles is the developing trend of automotive electronic systems

System Structure of ECU



System Structure of ECU

- Example



Developing Trends of Automotive Electronic Systems

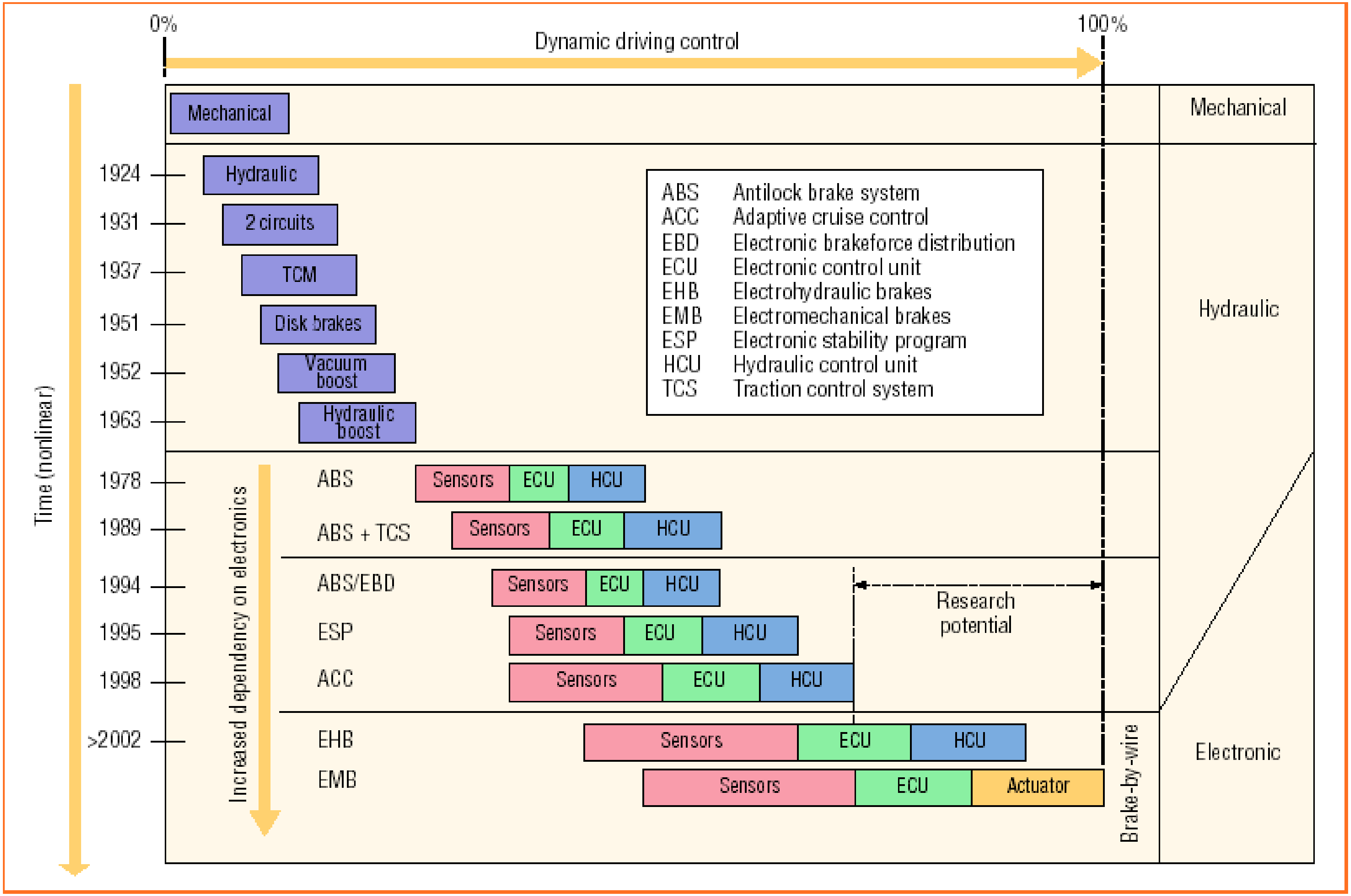
- System requirements
  - Standardization of functional interfaces
  - Share and reuse the existing components
  - Comprehensive safety
  - A high degree of comfort
  - Low energy consumption, and
  - Minimal pollutant emission

Developing Trends of Automotive Electronic Systems

- Issues of system development
  - Integrate and reuse the software and hardware cores from multiple vendors
  - Innovative functionality realized through interaction of formerly autonomous units (reconfigurable distributed systems/mechatronics)
  - Scalability to different vehicle and platform variants

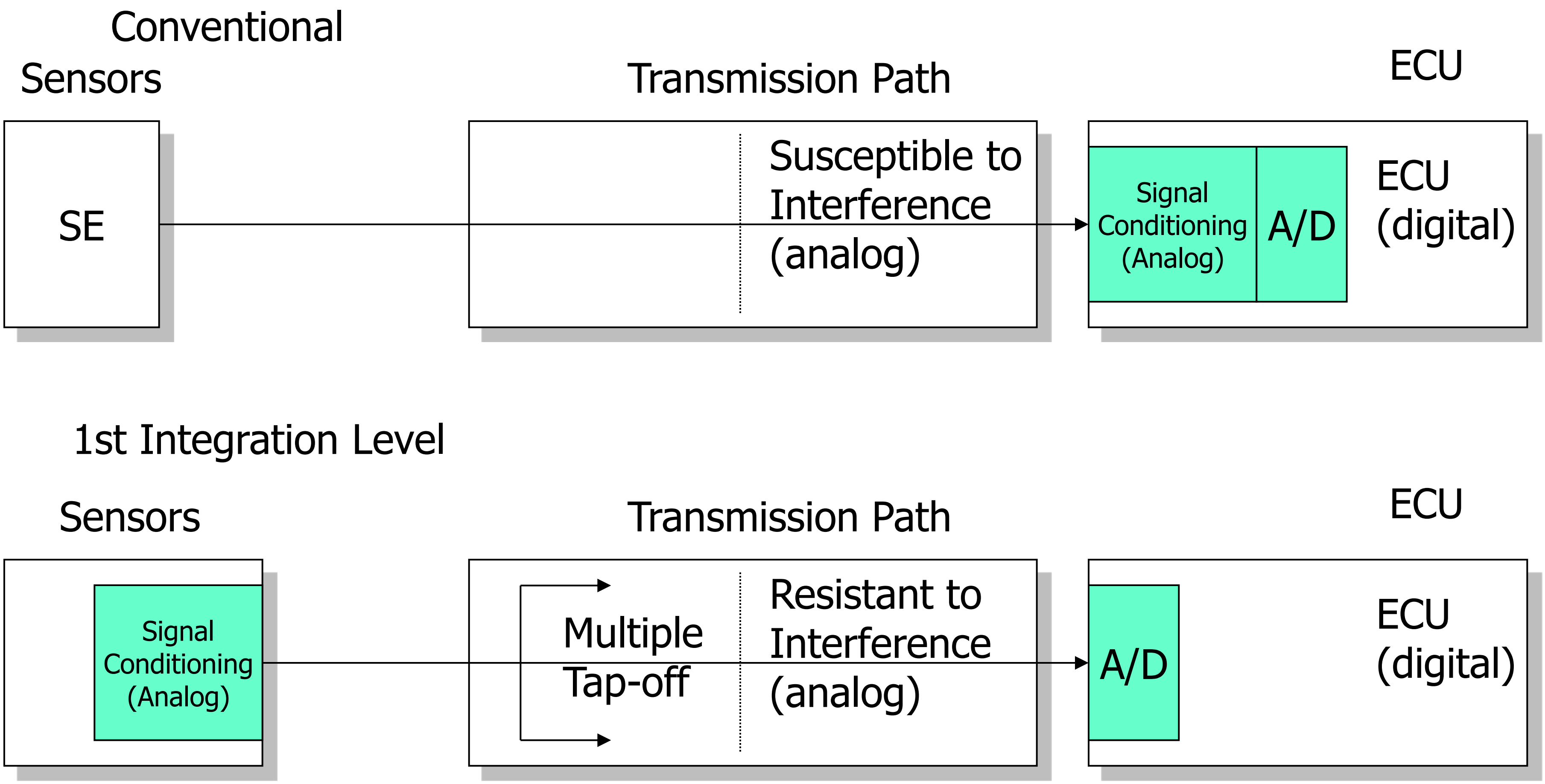
Developing Trends of Automotive Electronic Systems

– Design Toolkits
– Digital Transmission Capability
– Transferability of functions throughout network
– Maintainability throughout the whole “Product Life Cycle“



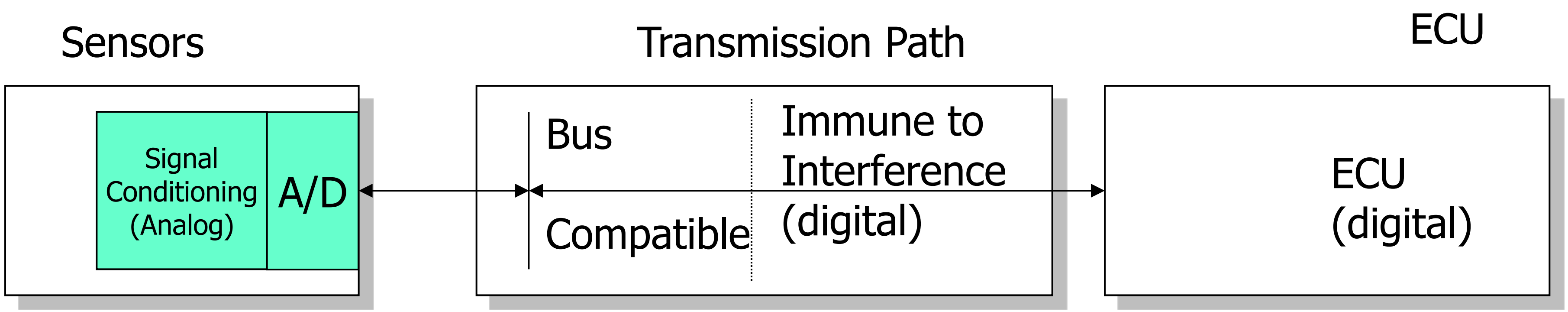
referring to: G. Leen and D. Heffernan,"Expanding Automotive Electronic Systems"

Developing Trends of Automotive Electronic Systems

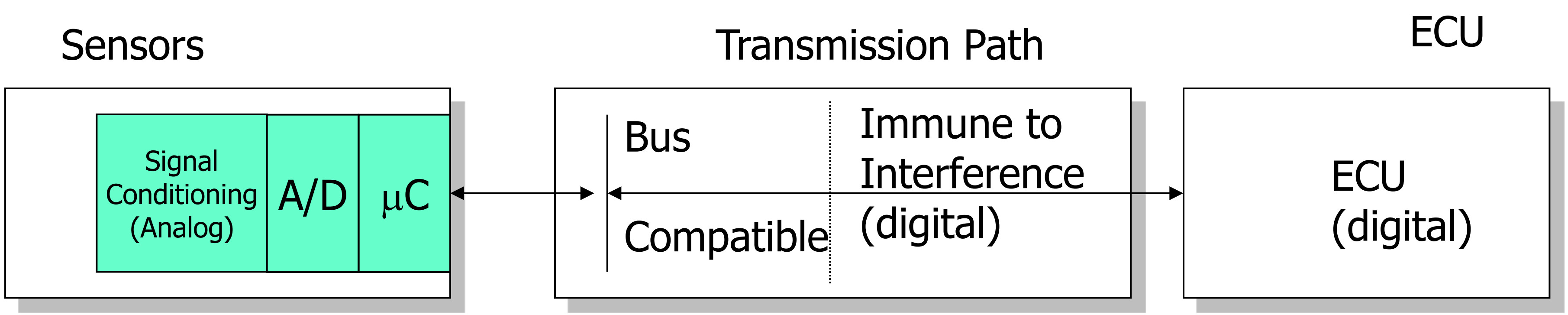


Developing Trends of Automotive Electronic Systems

2nd Integration Level



3rd Integration Level

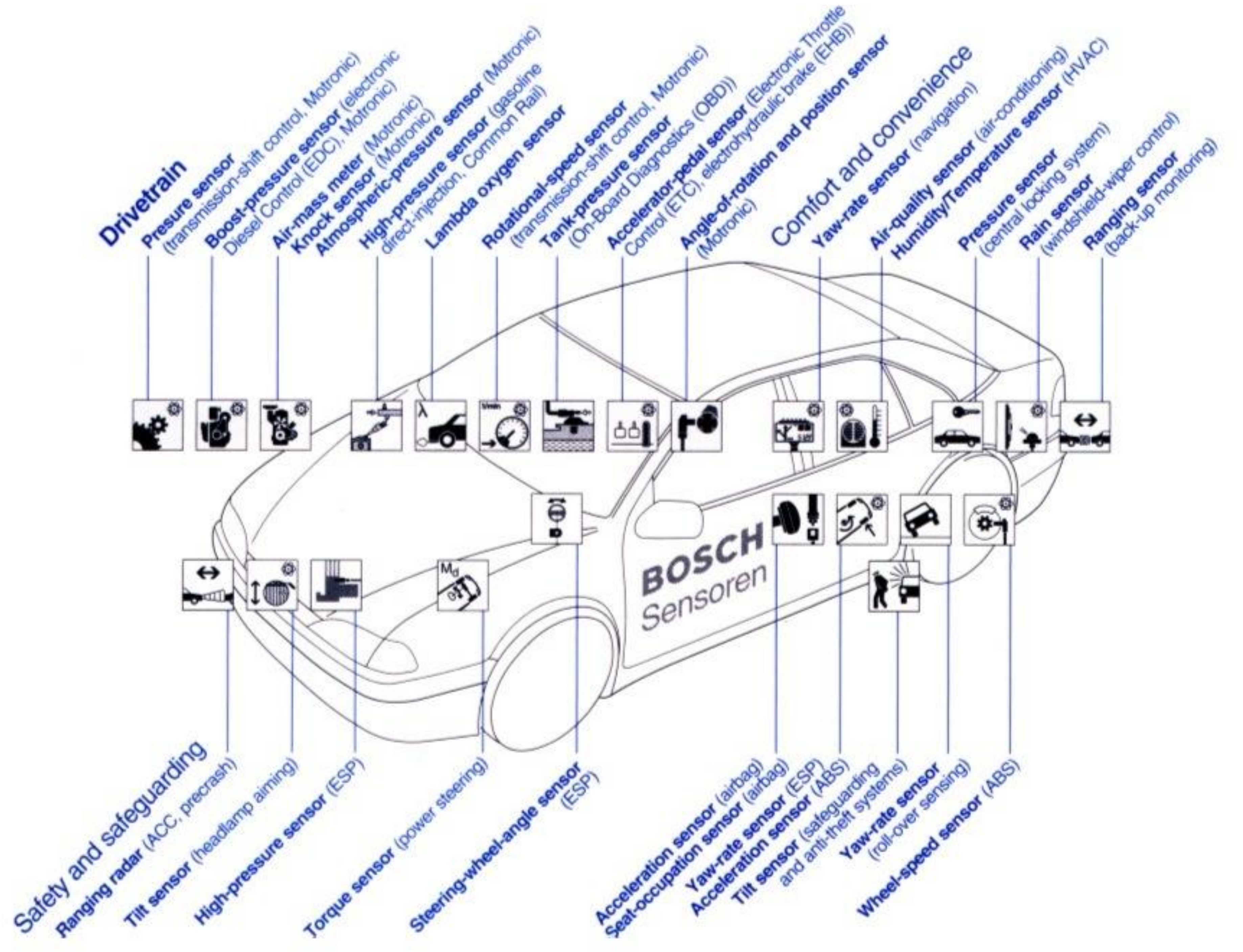


Developing Trends of Automotive Electronic Systems

- Mechatronics

Developing Trends of Automotive Electronic Systems

- Issues of hardware development
  – Exhibit immunity from radio emissions
  – Reducing the hardware cost and size
  – With high computing power
  – Transient faults well be tolerated
  – Embedded network
  – A variety of sensor/actuator interface capabilities



Drivetrain
Presure sensor (transmission-shift control, Motronic)
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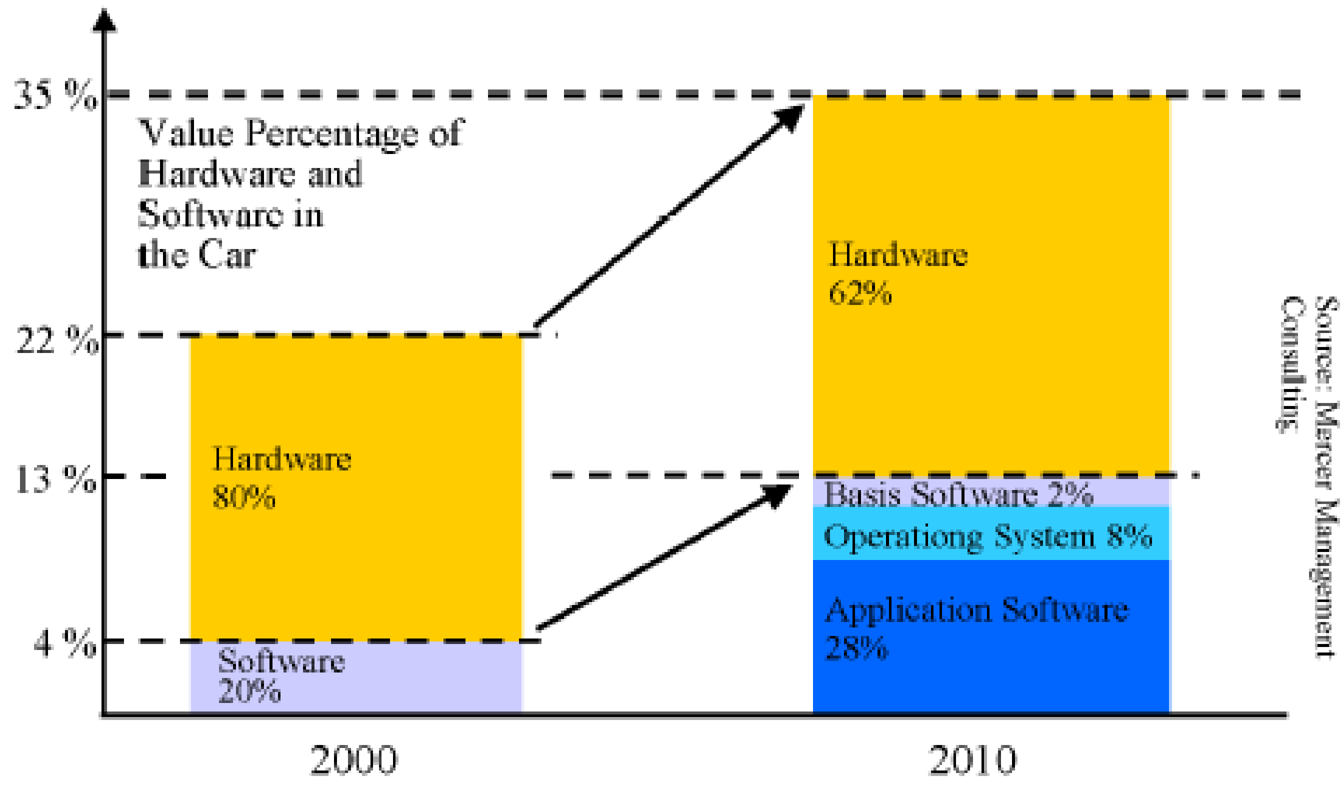
Wheel-speed sensor (ABS)

Developing Trends of Automotive Electronic Systems

- Issues of software development
  - Real-time operating system
  - Software component paradigm
  - Software updates and upgrades over vehicle lifetime
  - Minimizing the cost and execution time of software components
  - Uniform data format and seamless software component interface

Developing Trends of Automotive Electronic Systems

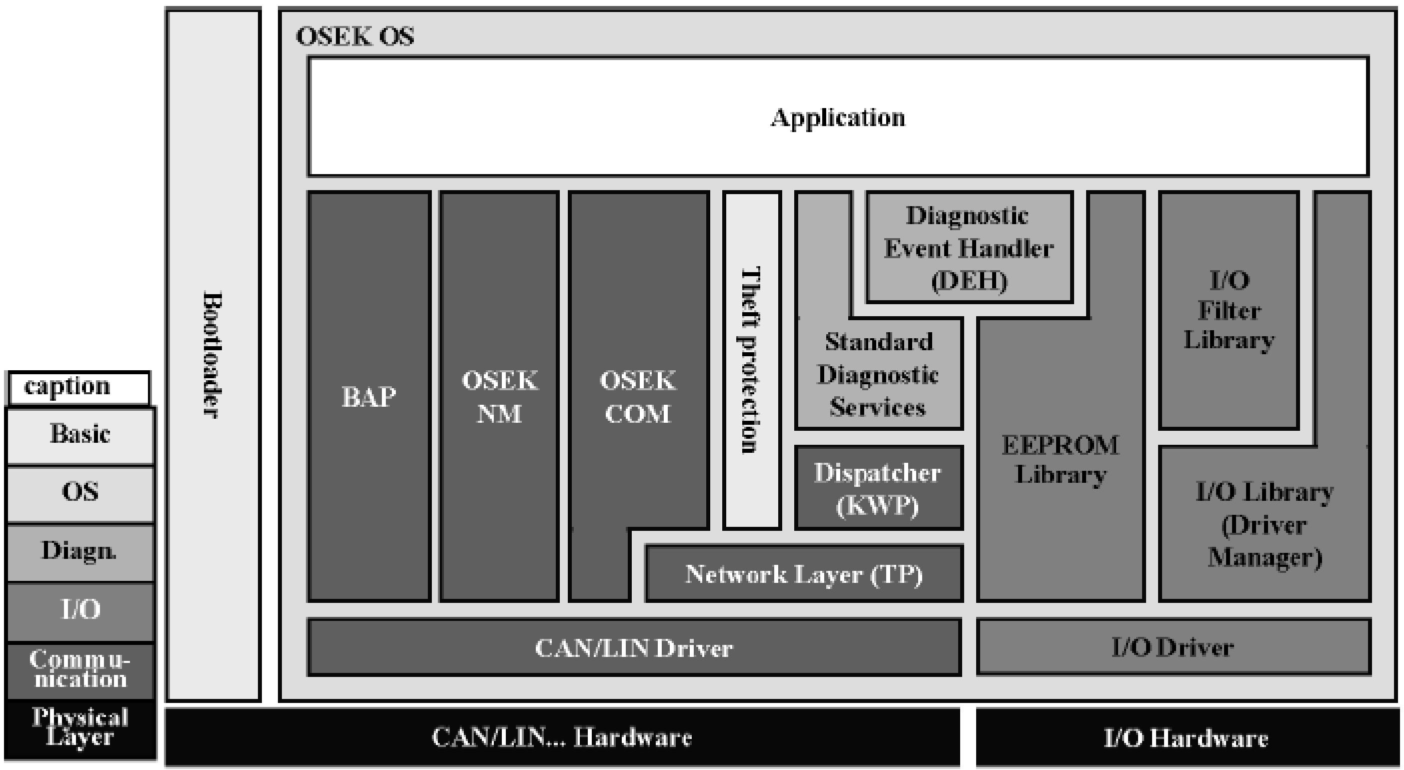
- Rise of importance of software in the Car



Refer to:B. Hardung, T. Kolzow, and A. Kruger, "Reuse of Software in Distributed Embedded Automotive Systems"

Developing Trends of Automotive Electronic Systems

- Example of software cores (components)



Developing Trends of Automotive Electronic Systems

- Standardized systems (Open systems)
  - Management of automotive electronic systems complexity associated with growth in functional scope
  - Flexibility for product modification, upgrade and update
  - Scalability of solutions within and across product lines
  - Improved quality and reliability of automotive electronic systems

Developing Trends of Automotive Electronic Systems

- OSEK/VDX
  - OSEK/VDX is a joint project of the automotive industry (1993)
  - It aims at an industry standard for an open-ended architecture for distributed control units in vehicles

Developing Trends of Automotive Electronic Systems

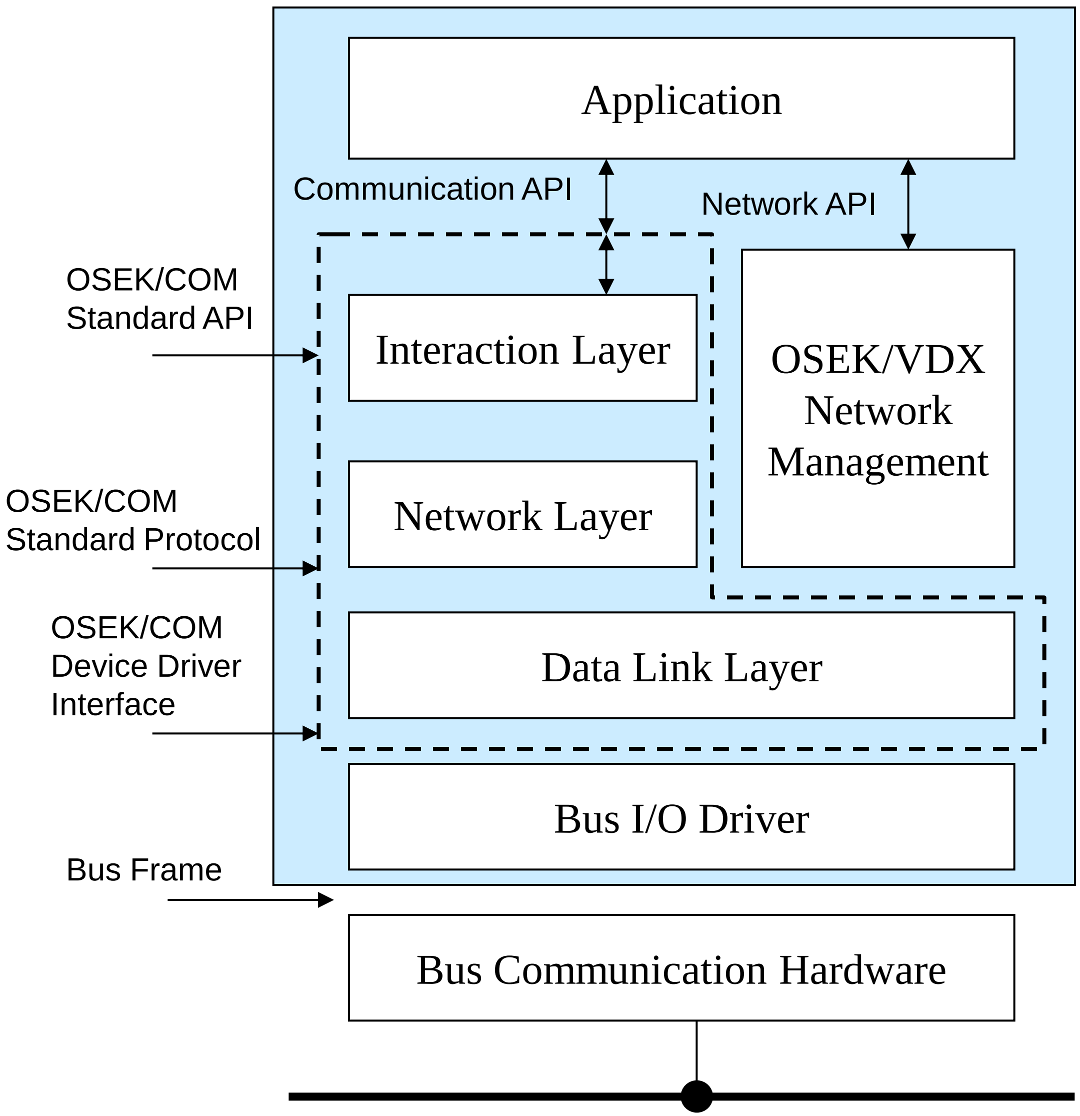
– The term OSEK means ”Offene Systeme und deren Schnittstellen für die Elektronik im Kraftfahrzeug” (Open systems and the corresponding interfaces for automotive electronics).

– The term VDX means „Vehicle Distributed eXecutive“

Developing Trends of Automotive Electronic Systems

- The OSEK/VDX specifies
  - Real-time operating system
  - Software interfaces and functions for communication, and
  - Software for network management

Developing Trends of Automotive Electronic Systems



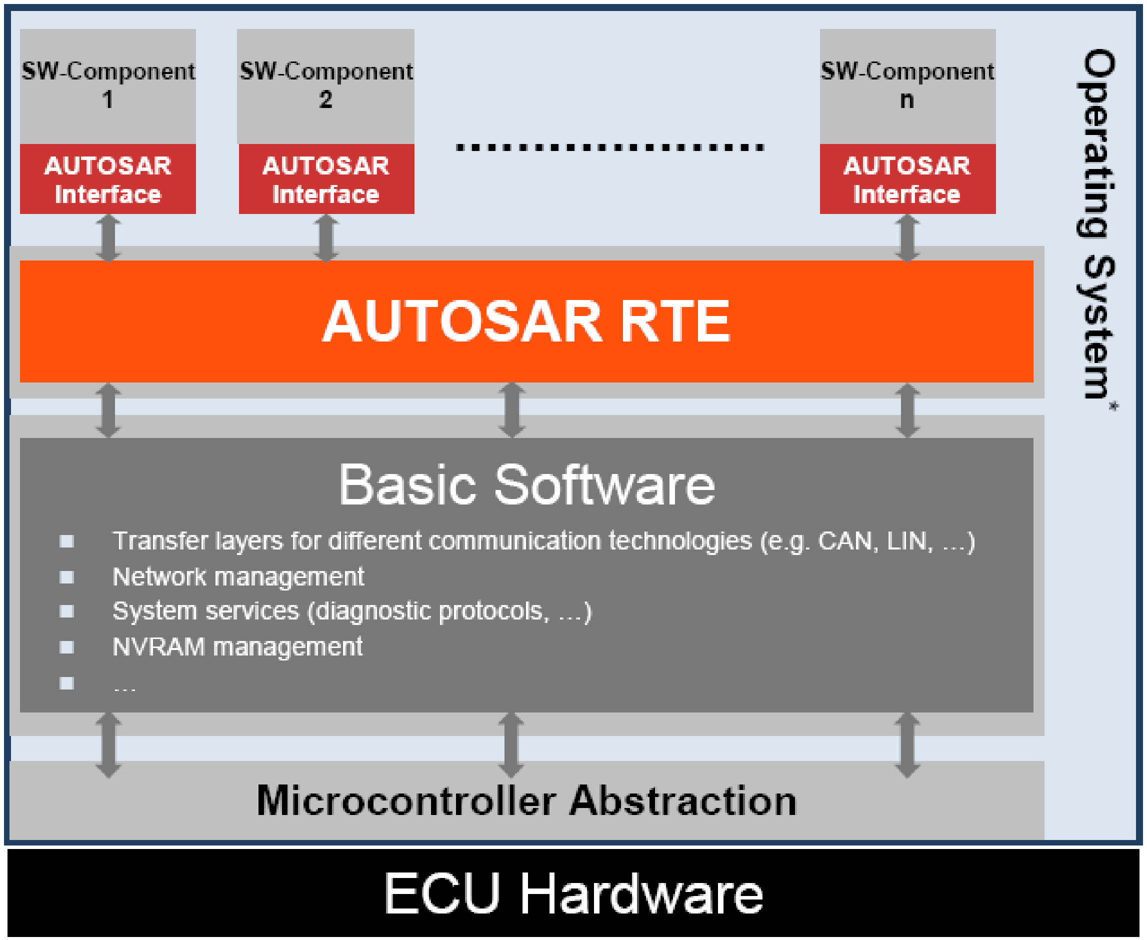
Developing Trends of Automotive Electronic Systems

- Automotive Open System Architecture (AUTOSAR):
  - Standardization of different APIs to separate the AUTOSAR software layers
  - Encapsulation of functional software-components
  - Definition of the data types of the software-components

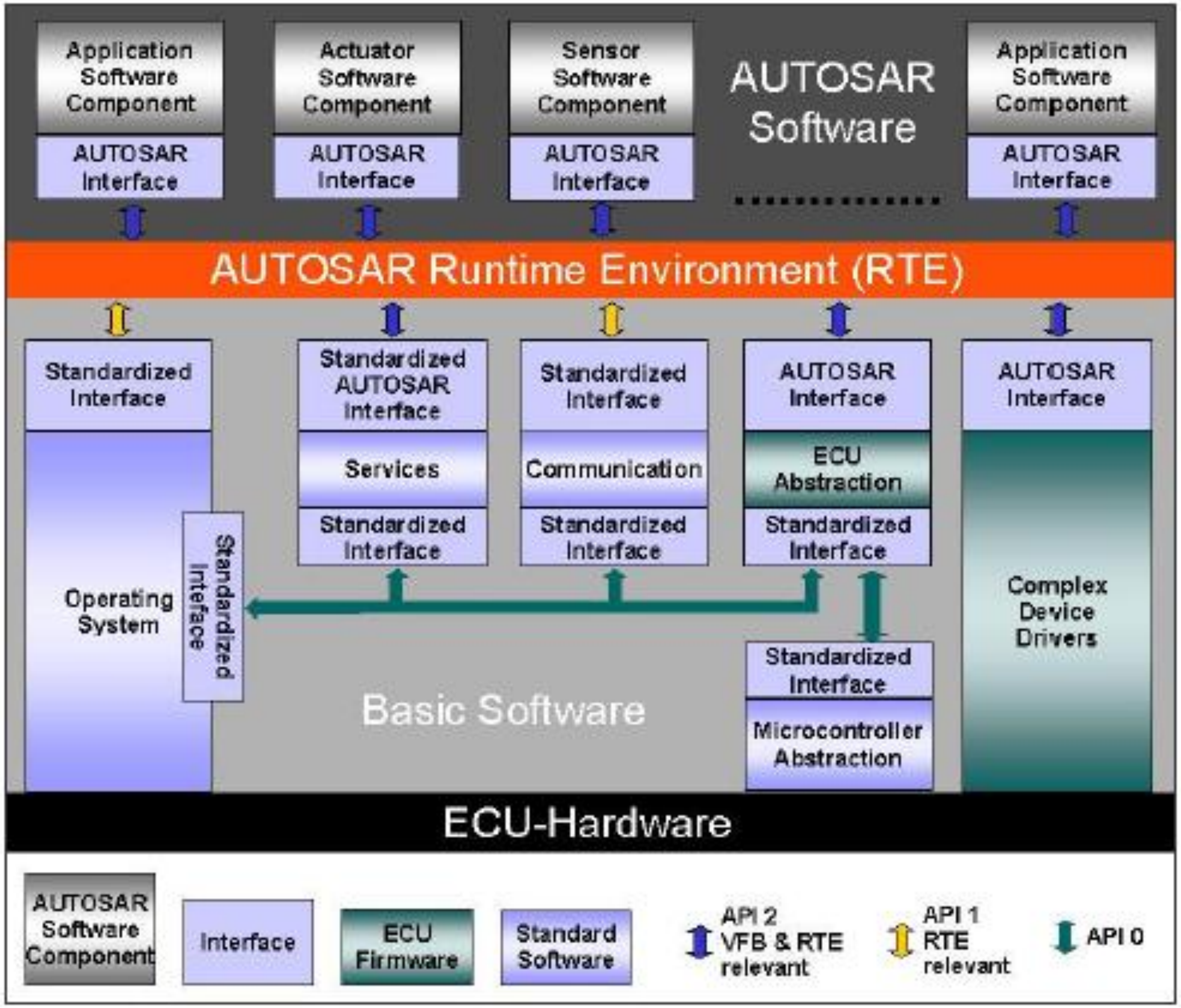
Developing Trends of Automotive Electronic Systems

– Identification of basic software modules of the software infrastructure and standardize their interfaces

Developing Trends of Automotive Electronic Systems

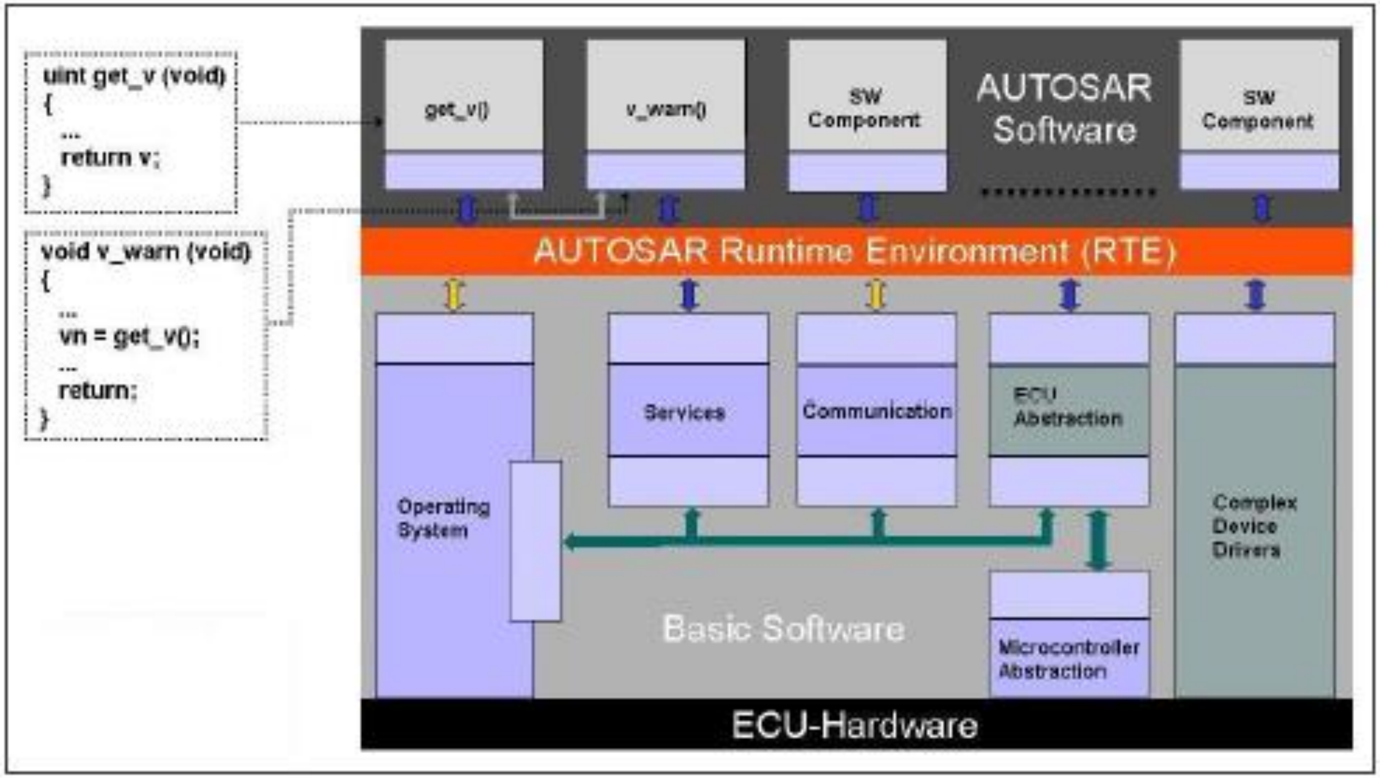


Developing Trends of Automotive Electronic Systems



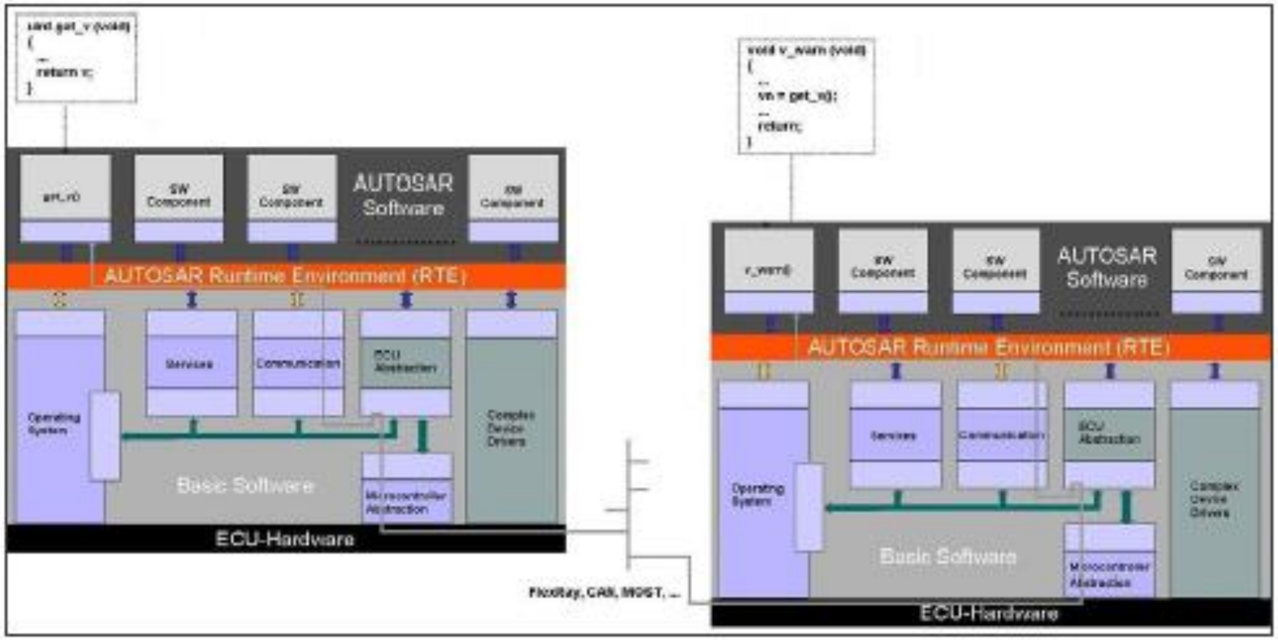
Developing Trends of Automotive Electronic Systems

- One ECU example



Developing Trends of Automotive Electronic Systems

- Two ECUs example



Emerging In-Vehicle Networks

Introduction

- In-vehicle networks
  - Connect the vehicle's electronic equipments
  - Facilitate the sharing of information and resources among the distributed applications
  - These control and communications networks are based on serial protocols, replacing wire harnesses with in-vehicle networks
  - Change the point-to-point wiring of centralized ECUs to the in-vehicle networking of distributed ECUs

Introduction

- Aims of In-Vehicle Network
  - Open Standard
  - Ease to Use
  - Cost Reduction
  - Improved Quality

Introduction

- Benefits of In-Vehicle Network
  - More reliable cars
  - More functionality at lower price
  - Standardization of interfaces and components
  - Faster introduction of new technologies
  - Functional Extendibility

Introduction

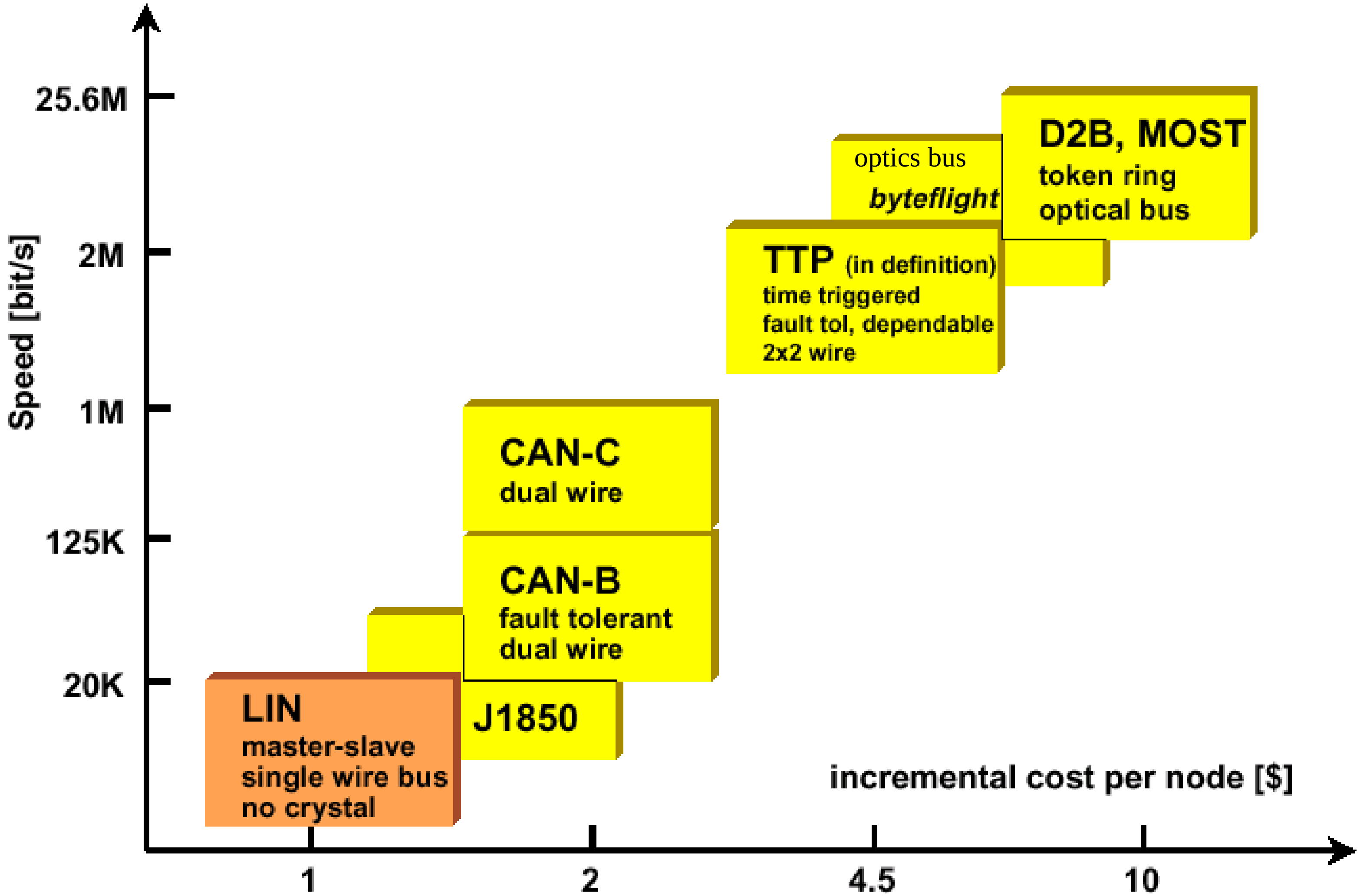
– Decreasing wiring harness weight and complexity
– Electronic Control Units are shrinking and are directly applied to actuators and sensors

Introduction

modern automobile's networks

Buses	Speed	Origin
D2B(5Mbit/s, electrical or optical mainly for digital audio)	High	Auto
MOST(22.5Mbit/s, audio, video,control)	High	Auto
FlexRay(10Mbit/s, x-by-wire, safety-critical control)	High	Auto
Byteflight(10Mbit/s, constant latencies, airbag, sear-belt)	High	Auto
TTP(5~25Mbit/s, real-time distributed/fault-tolerant apps)	High	Auto
Bluetooth(10Mbits/s, wireless for infotainment equipments)	High	Consumer
CAN(50-1000kbit/s control only)	Low	Auto
J1850(10.4kbit/s and 41.6kbit/s, control)	Low	Auto
LIN(20kbps, control)	Low	Auto

Roadmap of in-vehicle networks



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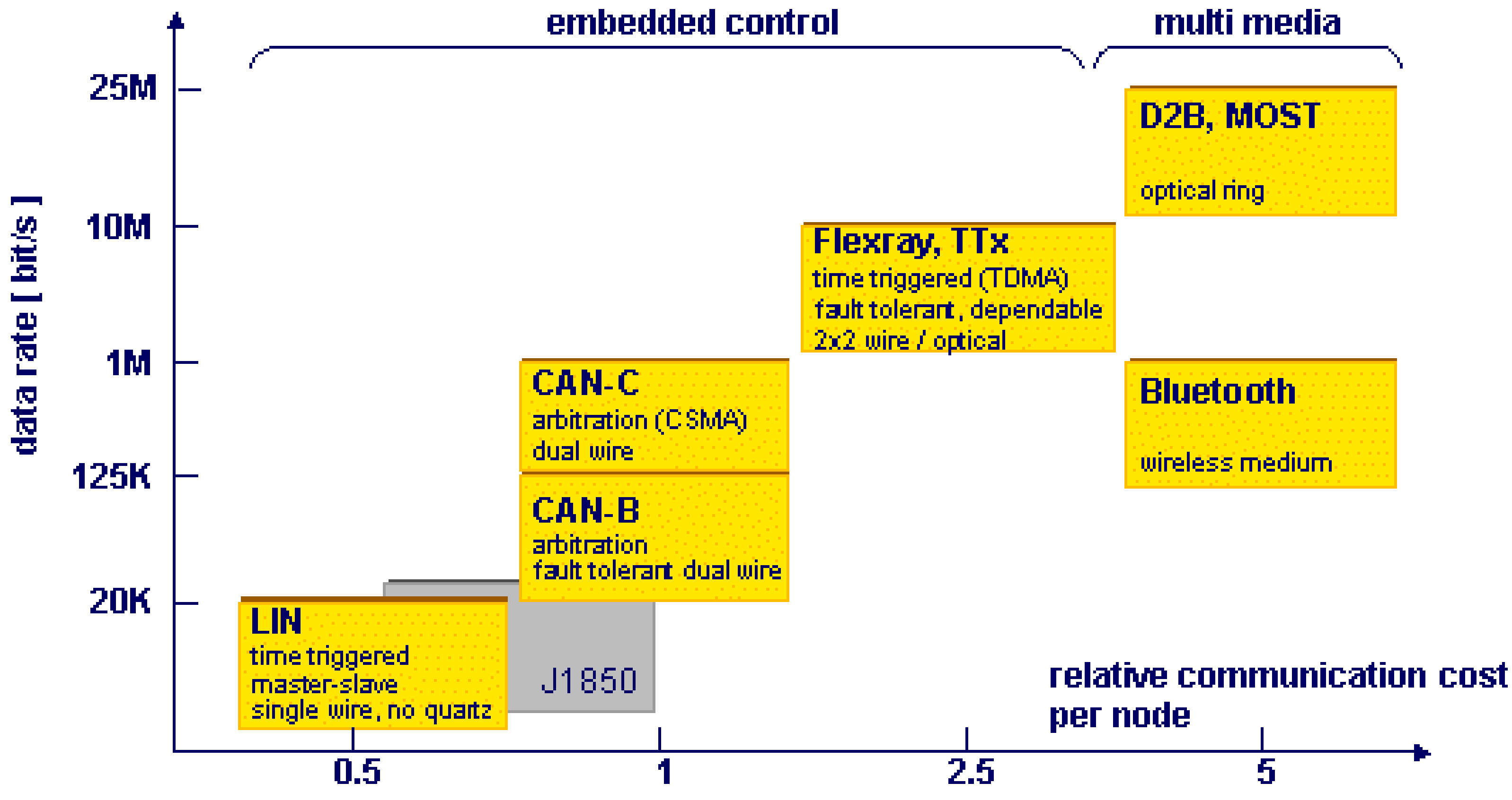
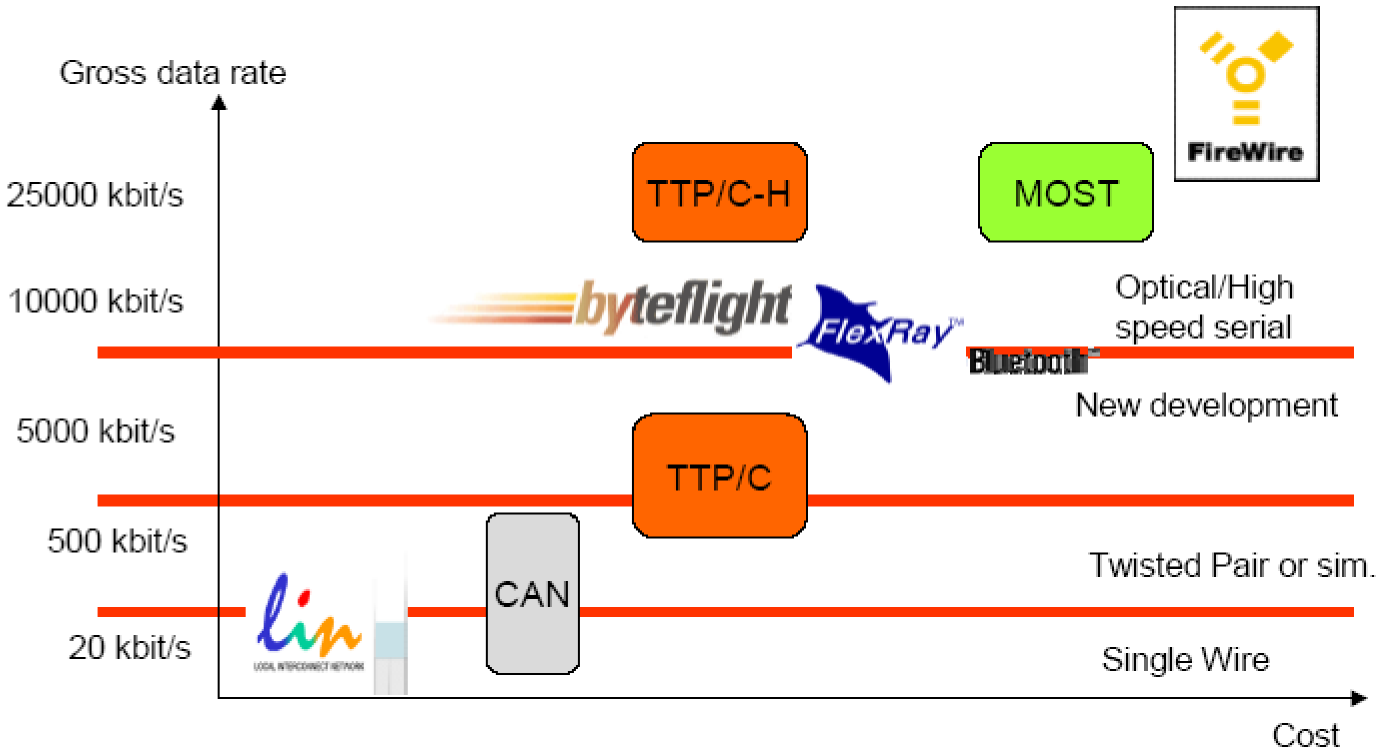


source: www.lin-subbus.org

Protocol Comparison



Protocol Comparison

- Class A (<20 kbit/s) : LIN, CAN
- Class B (50-500 kbit/s) : CAN, J1850
- MMedia (> 20 Mbit/s) : MOST, Firewire
- Wireless : GSM, Bluetooth
- Safety : Byteflight, TTP/C, Flexray

Overview of In-Vehicle Networks

- D2B (Domestic Data Bus)
  - Matsushita and Philips jointly developed
  - Has promoted since 1992
  - D2B was designed for audio-video communications, computer peripherals, and automotive media applications
    - The Mercedes-Benz S-class vehicle uses the D2B optical bus to network the car radio, autopilot and CD systems
    - The Tele-Aid connection, cellular phone, and Linguatronic voice-recognition application

Overview of In-Vehicle Networks

- Media-Oriented Systems Transport (MOST)
  - It was initiated in 1997
  - Supports both time-triggered and event-triggered traffic with predictable frame transmission at speeds of 25Mbps
  - Using plastic optic fiber as communication medium

Overview of In-Vehicle Networks

- The interconnection of telematics and infotainment such as video displays, GPS navigation systems, active speaker and digital radio
- More than 50 firms—including Audi, BMW, Daimler-Chrysler, Becker Automotive, and Oasis Silicon Systems—developed the protocol under the MOST Cooperative

Overview of In-Vehicle Networks

- Time-triggered protocol (TTP)
  - It was released in 1998
  - It is a pure time-triggered TDMA protocol
  - Frames are sent at speeds of 5-25Mbps depending on the physical medium
  - Designed for real-time distributed systems that are hard and fault tolerant
  - It is going on to reach speeds of 1Gbps using an Ethernet based star architecture

Overview of In-Vehicle Networks

- FlexRay
  - FlexRay is a fault-tolerant protocol designed for high-data-rate, advanced-control applications, such as X-by-wire systems (high-speed safety-critical automotive systems)
  - Provides both time-triggered and event-triggered message transmission
  - Messages are sent at 10Mbps

Overview of In-Vehicle Networks

- Both electrical and optical solutions are adopted for the physical layer
- The ECUs are interconnected using either a passive bus topology or an active star topology
- FlexRay complements CAN and LIN being suitable for both powertrain systems and XBW systems

Overview of In-Vehicle Networks

- Byteflight
  - Developed from 1996 by BMW
  - A flexible time-division multiple access (TDMA) protocol using a star topology for safety-related applications
  - Messages are sent in frames at 10Mbps support for event-triggered message transmission

Overview of In-Vehicle Networks

- Guarantees deterministic (constant) latencies for a bounded number of high priority real-time message
- The physical medium used is plastic optical fiber
- Byteflight can be used with devices such as air bags and sear-belt tensioners
- Byteflight is a very high performance network with many of the features necessary for X-by-wire

Overview of In-Vehicle Networks

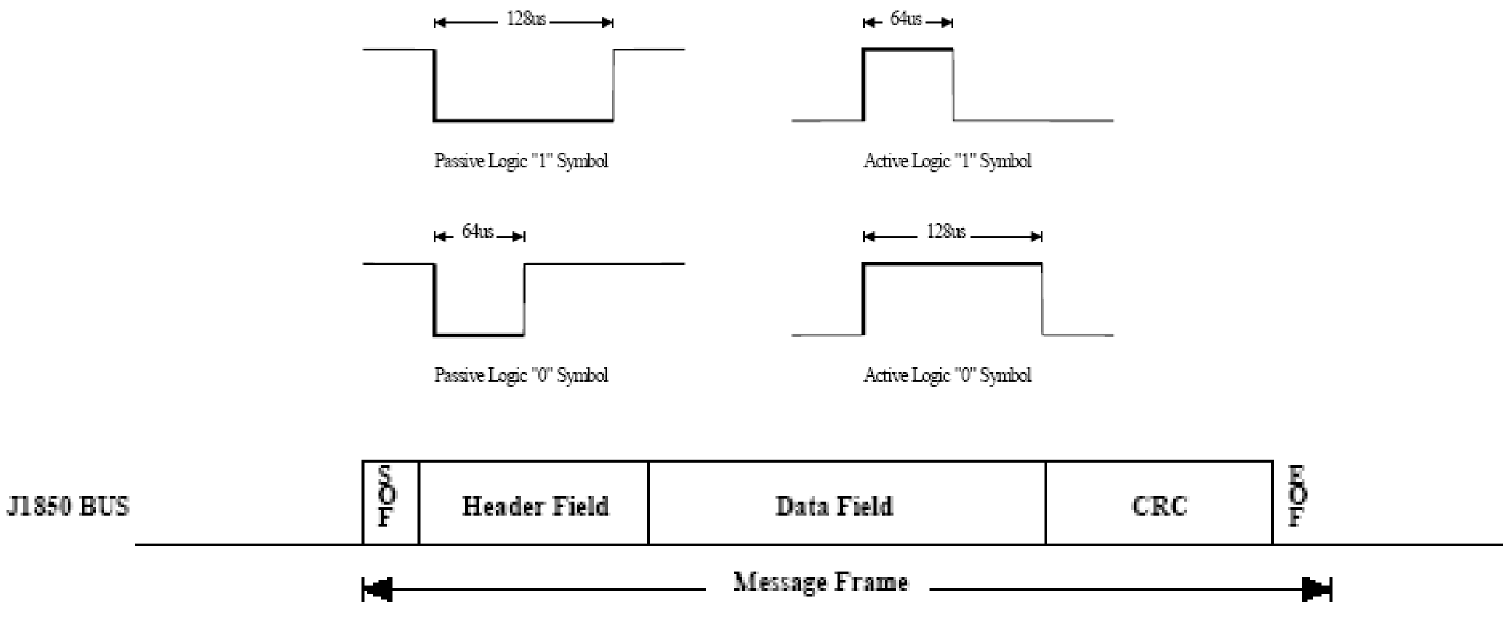
- Bluetooth
  - An open specification for an inexpensive, short-range (10-100 meters), low power, miniature radio network.
  - Easy and instantaneous connections between Bluetooth-enabled devices without the need for cables
    - vehicular uses for Bluetooth include hands-free phone sets; portable DVD, CD, and MP3 drives; diagnostic equipment; and handheld computers

Overview of In-Vehicle Networks

- Controller area network (CAN)
  - Was initiated in 1981 and developed by Bosch developed the controller
  - Message frames are transmitted in an event-triggered fashion
  - Up to 1Mbps transmission speed
  - It is a robust, cost-effective general control network, but certain niche applications demand more specialized control networks.

Overview of In-Vehicle Networks

- The SAE J1850 Standard
  - supports two main alternatives, a 41.6 kbps PWM approach (dual wires), and a 10.4kbps VPW (single wire) approach.



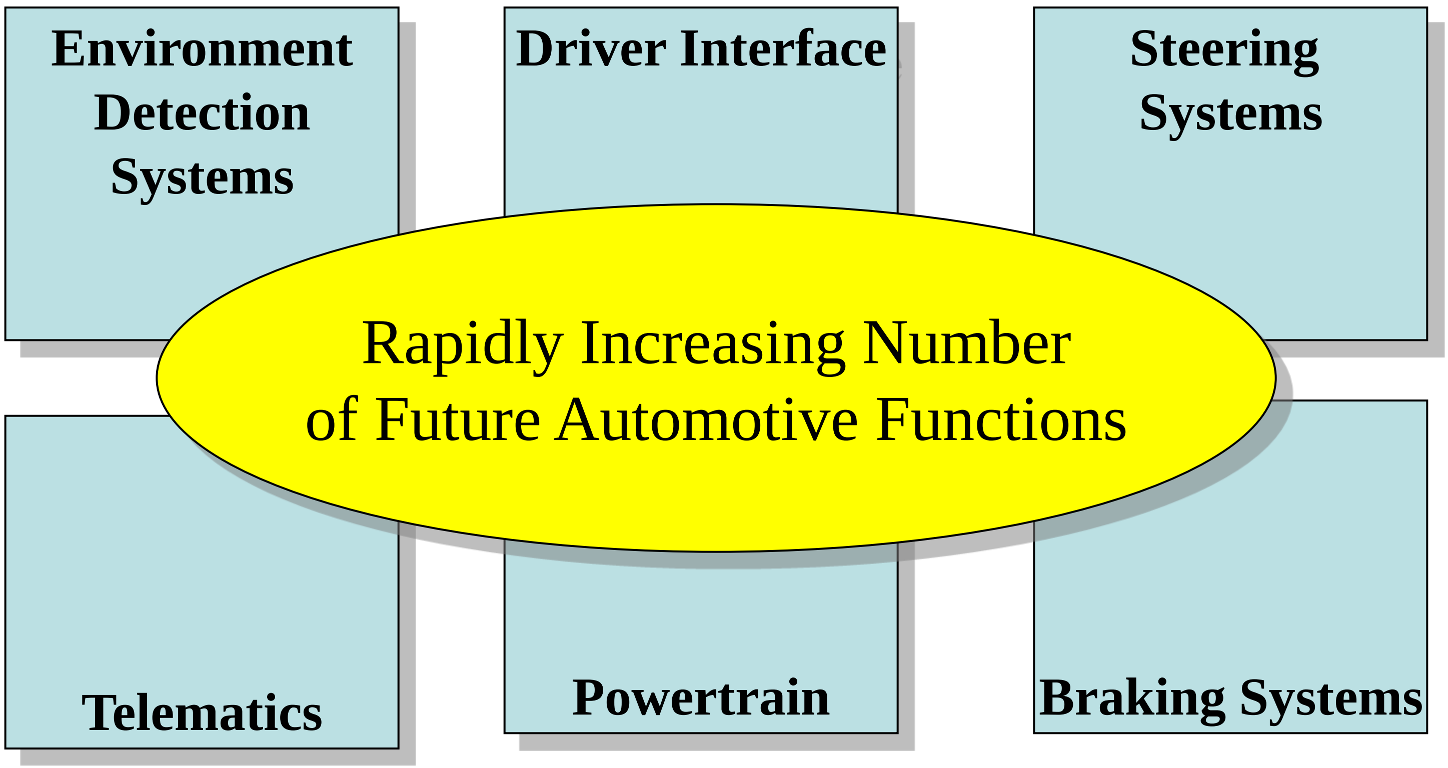
Overview of In-Vehicle Networks

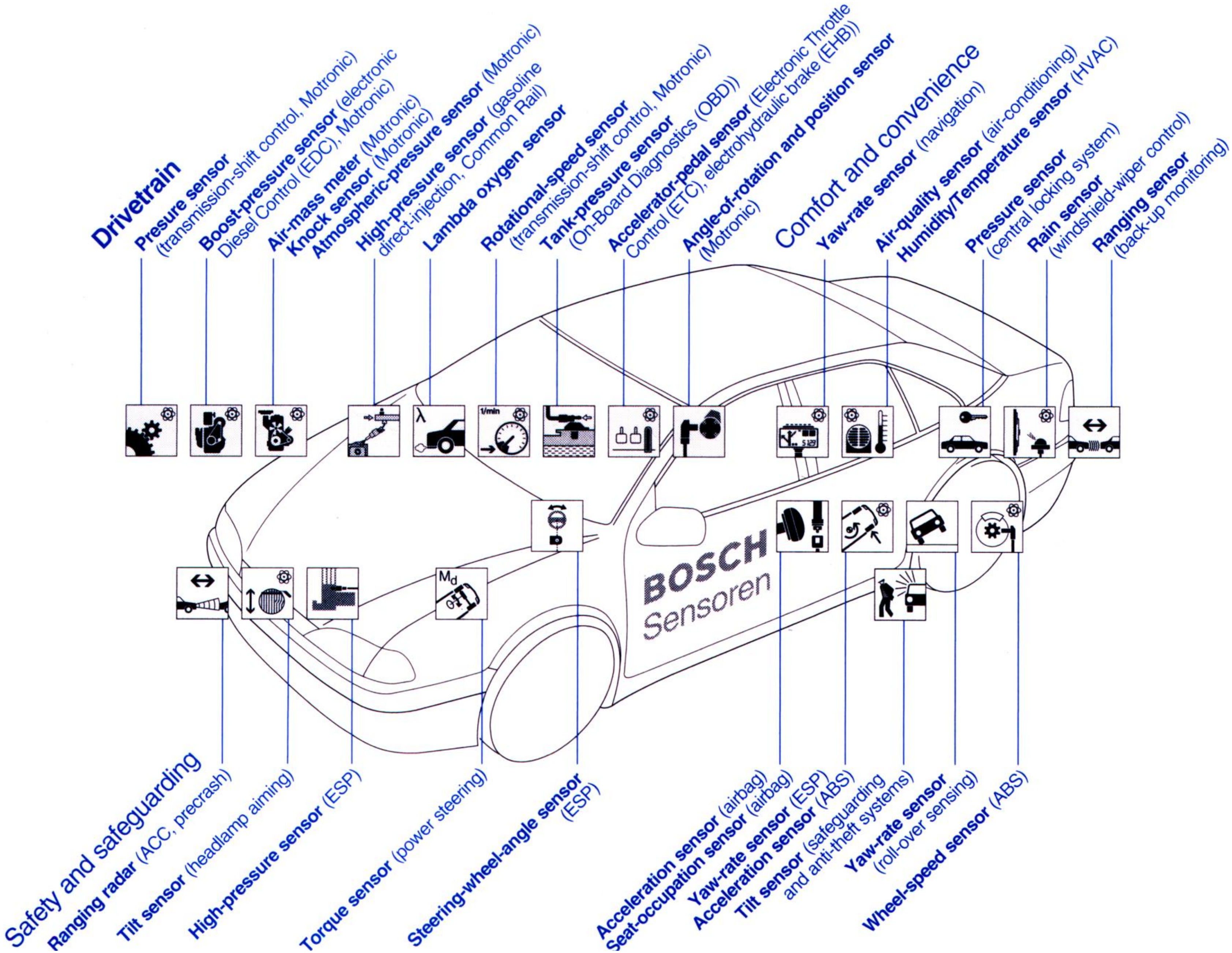
- Local interconnect network (LIN)
  - A master-slave, time-triggered protocol
  - As a low-speed (20kbps), single-wire
  - LIN is meant to link to relatively higher-speed networks like CAN
  - LIN reveals the security of serial networks in cars

Overview of In-Vehicle Networks

– network is used in on-off devices such as car seats, door locks, sunroofs, rain sensors, and door mirrors

Future Needs for Networking





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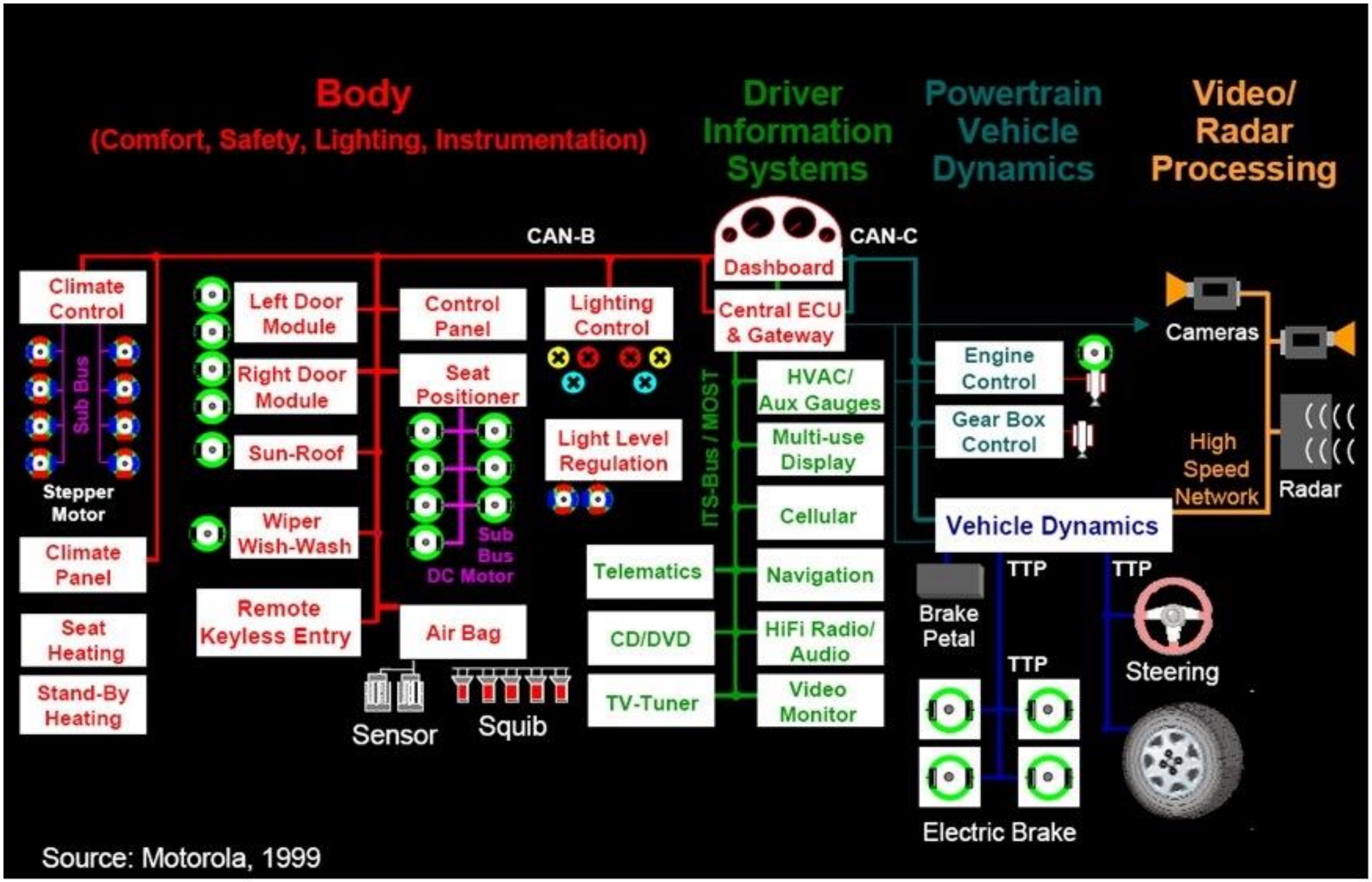
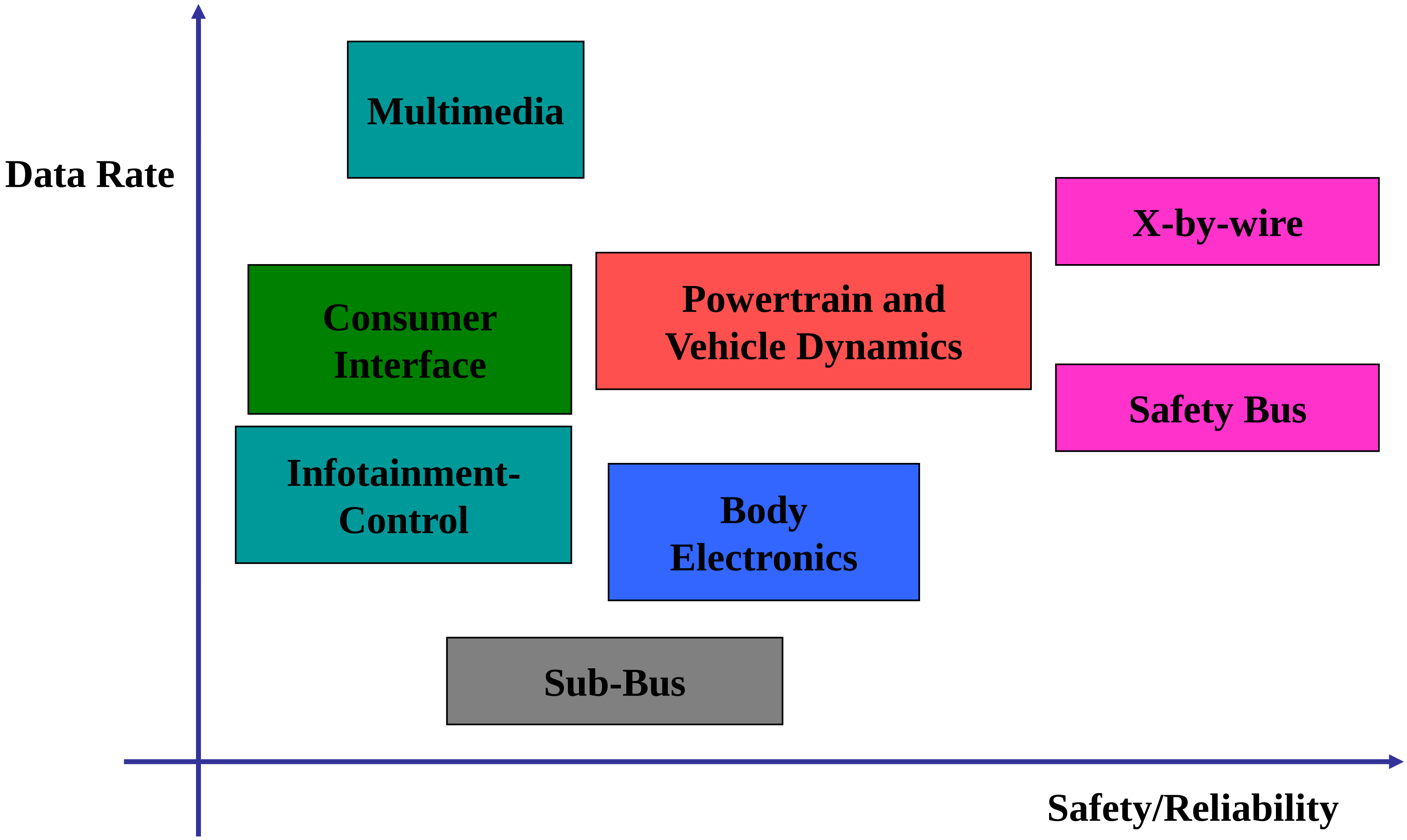
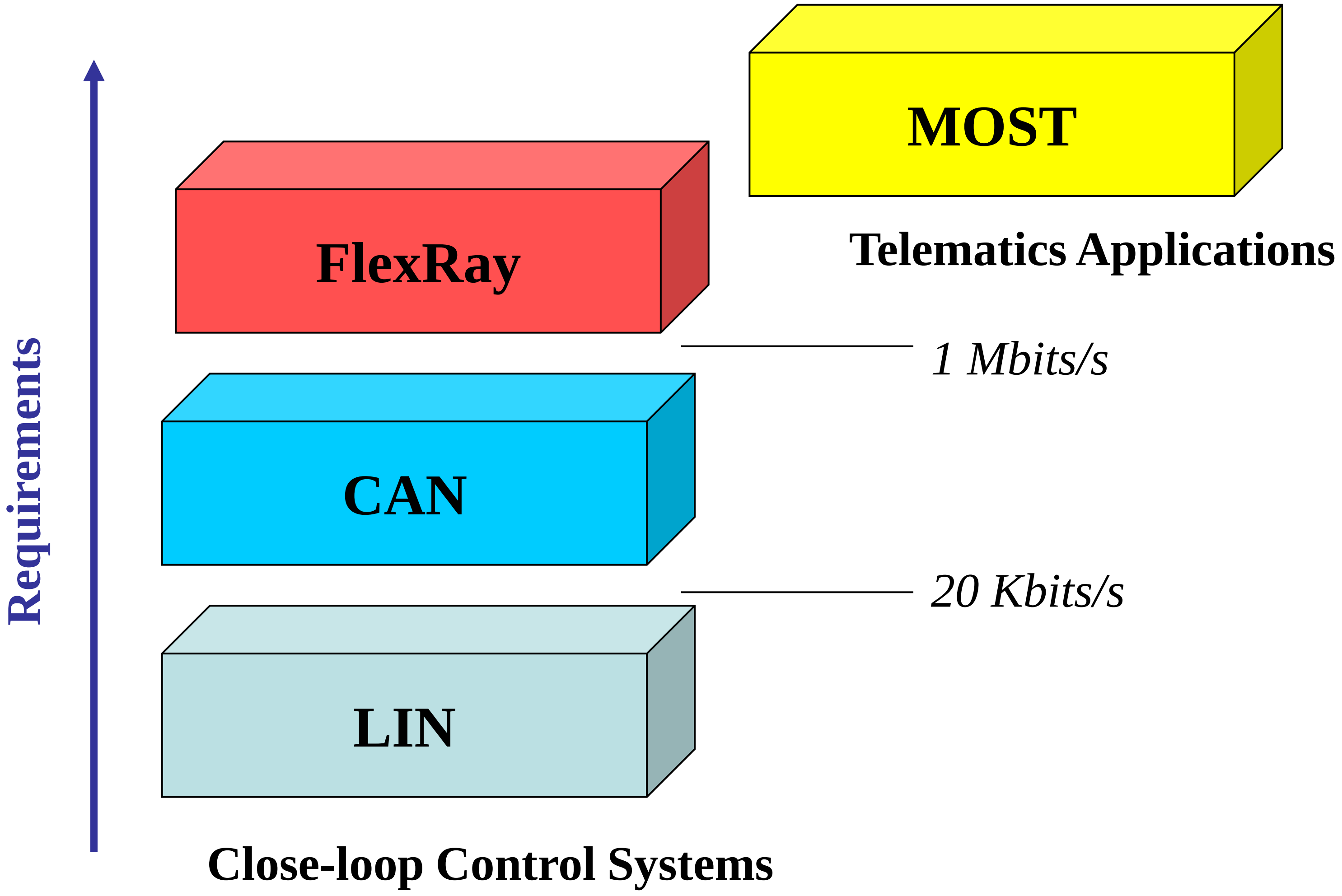
Interconnections in the Vehicle



Functional Applications



Strategic Technical Considerations



Thank you for your attention!

Discussion