Next-Generation Diagnostics for HPC-based Connected Vehicles

Automotive
Autos, Hybridfahrzeuge und Elektroautos

Landmaschinen
Selbstfahrende und gezogene Maschinen

Nutzfahrzeuge
Transporter, Busse und Lastkraftwagen

The vehicle is being re-invented

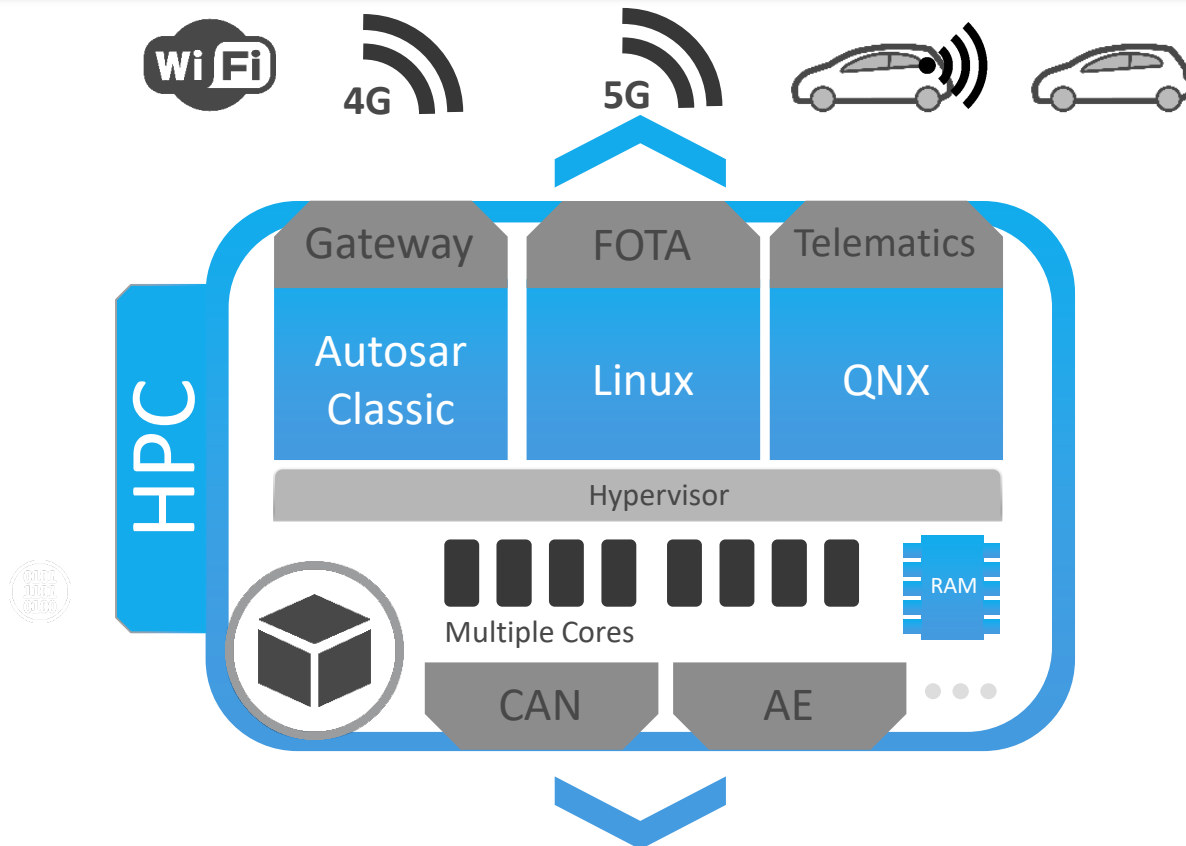Service / Remote Diagnostics

Autonomous Driving

E-Call
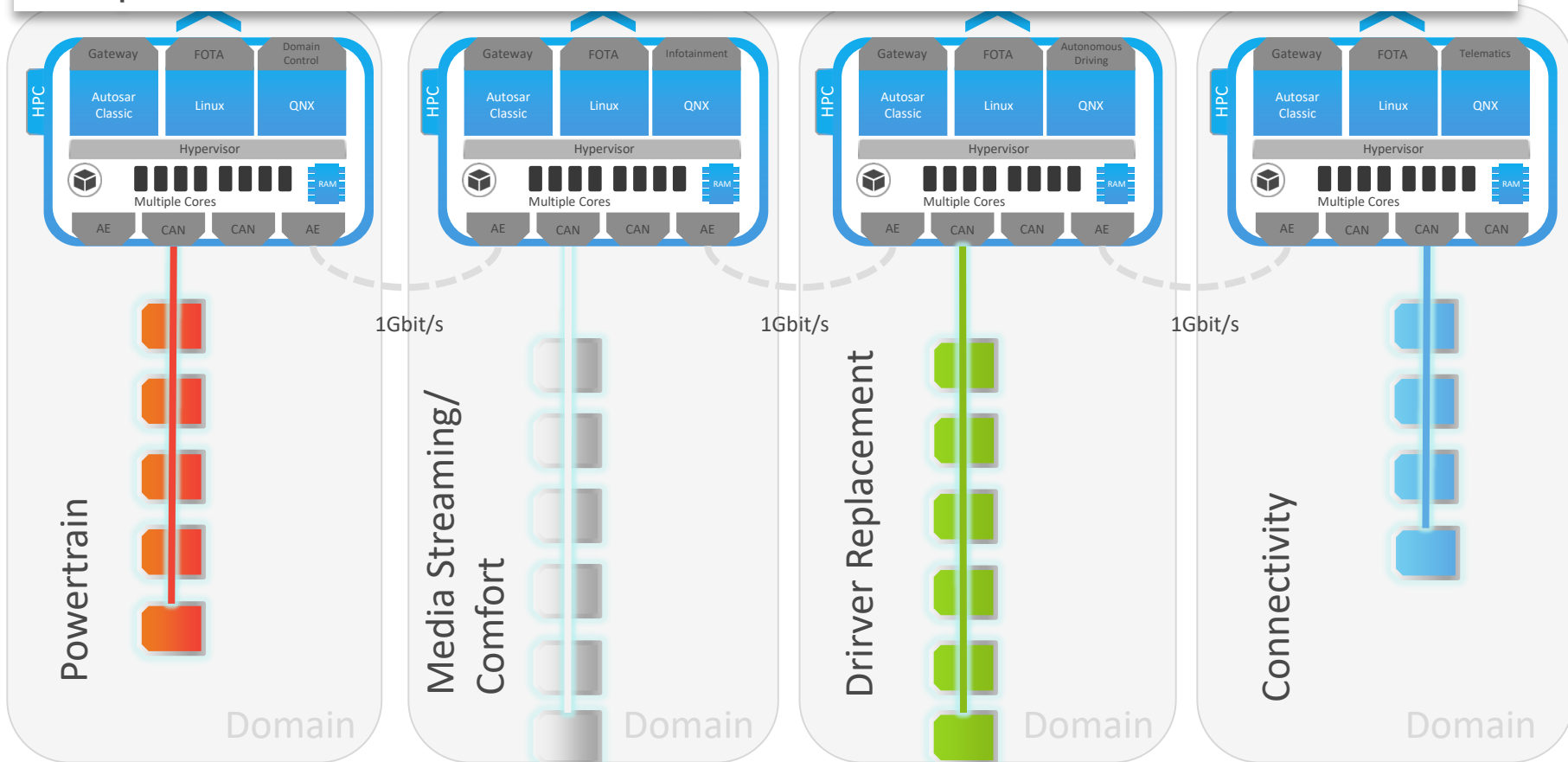

User Experience

FOTA

Extension of the vehicle with HPCs*

*High-Performance Computer

Next-Generation HPC Diagnostics

Multiple HPCs as domain controllers, connected via Automotive Ethernet

HPC

Gateway	FOTA	Domain Control
Autosar Classic	Linux	QNX

Hypervisor

Multiple Cores | RAM

AE | CAN | CAN | AE

1Gbit/s

HPC

Gateway	FOTA	Infotainment
Autosar Classic	Linux	QNX

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HPC

Gateway	FOTA	Autonomous Driving
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HPC

Gateway	FOTA	Telematics
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Powertrain

Domain

Media Streaming/ Comfort

Domain

Drirver Replacement

Domain

Connectivity

Domain

ECU vs. HPC

Electronic Control Units

Traditional open- and closed-loop control functions

Master of sensors and actuators

Processor	1 Core, 32 bit, 300 Mhz
Memory	512 KB RAM 128 KB Data Flash 4 MB Program Flash
Network	Ethernet (10/100 BaseT) FlexRay, 4xCAN
OS	OSEK, AUTOSAR classic

VS.

HPC (High-Performance Computer, MPSoC)

Complex, computing- and data-intensive Tasks (e.g. Autonomous Driving), Sensor data fusion, Image Processing, AI, neuronal networks
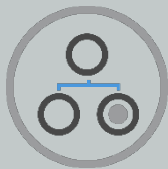
Prozessor	4 to 12 Cores, RISC, DSP, Security
Speicher	8-16 GB RAM >100 GB Flash
Network	Ethernet (100BASE-T1, 1000BASE-T1), 4G / (5G), WiFi, 4xCAN(-FD)
OS	Adaptive AUTOSAR, Linux, QNX

Network Technologies

CAN-Bus (ISO 11898)

Automotive Ethernet (IEEE 100(0)BASE-T1)

Signal Exchange between ECUs, Diagnostic and Reprogramming Communication

Data Exchange between HPCs (Image data, Radar data, Computation results), media streaming, UI

VS.

|	CAN-Bus	Automotive Ethernet
Cabling	Twisted Pair	Twisted Pair, Cat6 Kabel
Bandwidth	1 Mbit/s	100 Mbit/s (1000 Mbit/s)
Payload	8 Byte per Frame	64 bis 1518 Byte (like 802.3 Ethernet)
Layer	Physical & Data Link (1 & 2)	1 & 2

Today's Diagnostics (1)

> Allows diagnosis of the **electronics** of a mechatronic system

- Errors of sensors or their circuits
- Errors of actuators or their circuits
- Errors in the bus communication
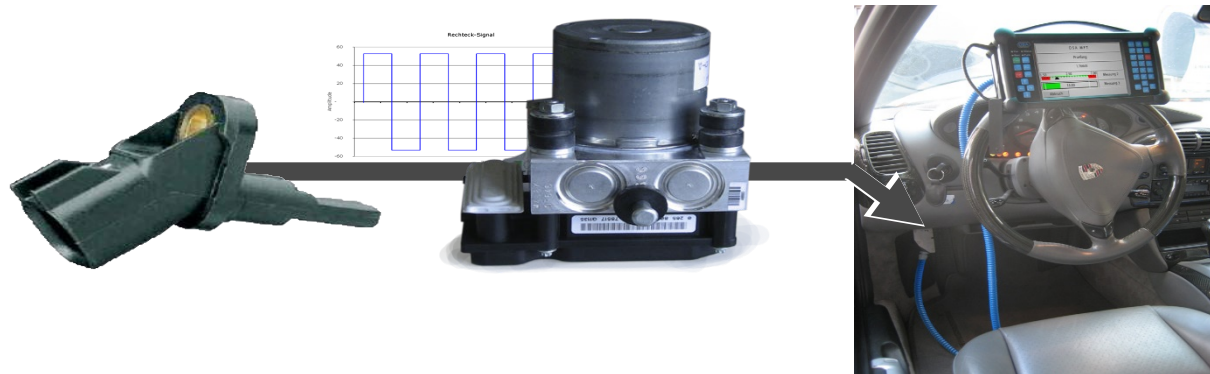
Todays's Diagnostics (2) – Core Services / UDS

ReadDTCInformation

Requesting results of ECU self diagnosis of connected circuits and the bus communication / Requesting historical sensor data as environment data (freeze frames)
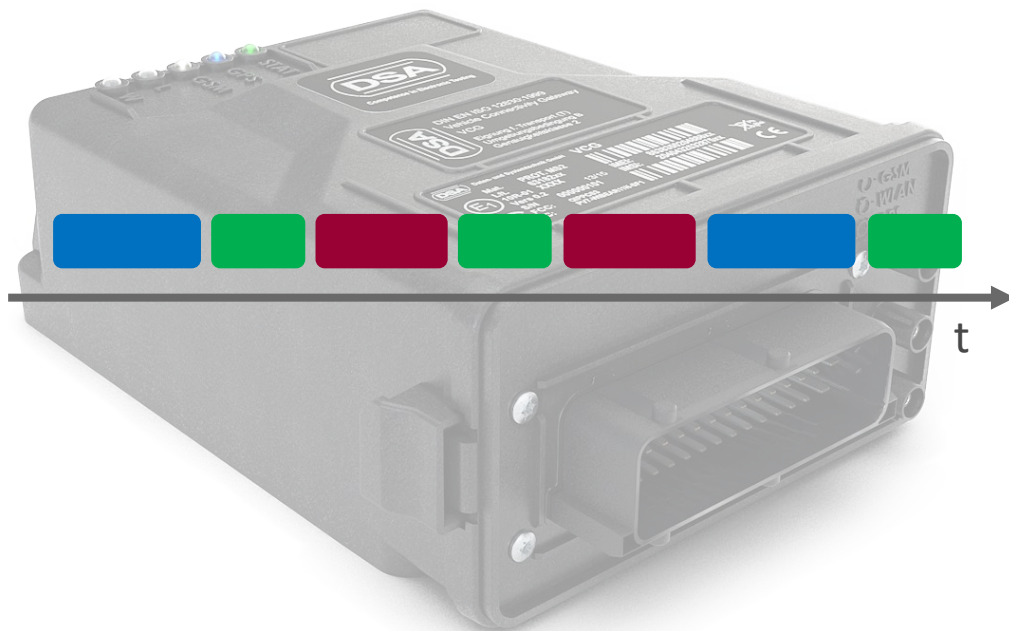
ReadDataByIdentifier

Requesting current values of sensors / static values of ECUs

InputOutputControl ByIdentifier

Excecution of actuator tests and tests of actuator circuits
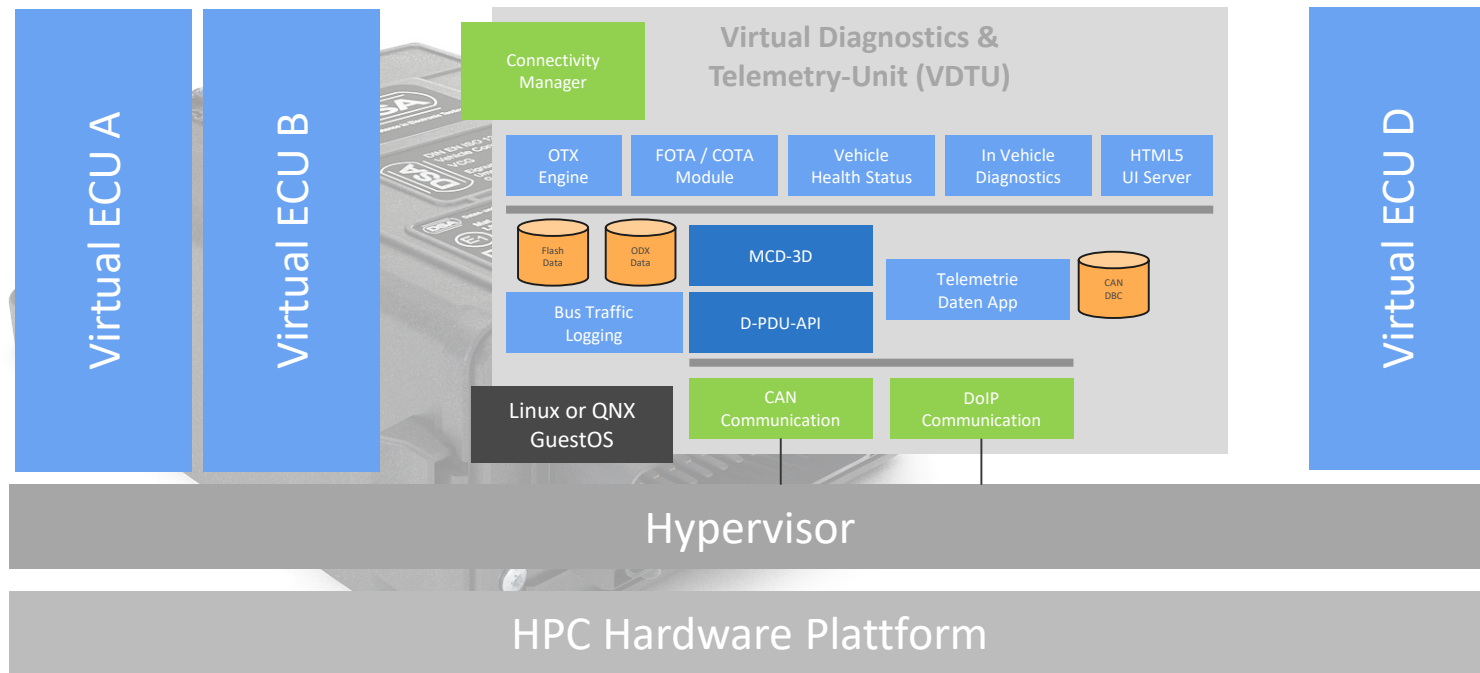
ECU Software

ECU Software is statically scheduled (time sliced Tasks)

Most Tasks are control functions

Tasks are considered „perfect" wrt. Diagnostics

t

In contrast: HPC Software

Virtual ECU A

Virtual ECU B

Connectivity Manager

Virtual Diagnostics & Telemetry-Unit (VDTU)

| OTX Engine | FOTA / COTA Module | Vehicle Health Status | In Vehicle Diagnostics | HTML5 UI Server |

Flash Data

ODX Data

MCD-3D

Telemetrie Daten App

CAN DBC

Bus Traffic Logging

D-PDU-API

Linux or QNX GuestOS

CAN Communication

DoIP Communication

Virtual ECU D

Hypervisor

HPC Hardware Plattform

HPC is a „new world" from a diagnostics perspective
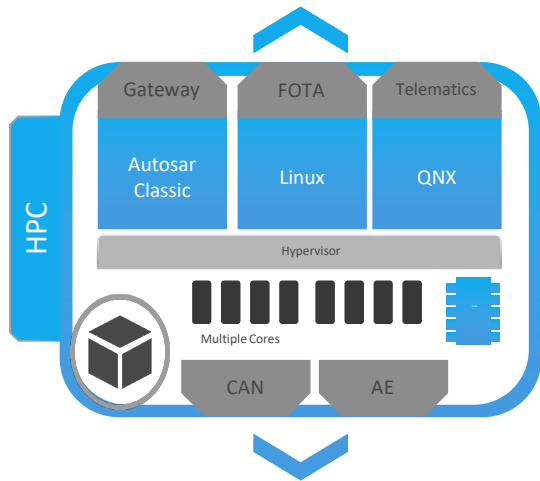
„resembles"

> Virtual Machines

> Guest Operating Systems

> Parallel Processes

> High Availability Requirements

> Multi-/Many-Core Systems (MPSoC)

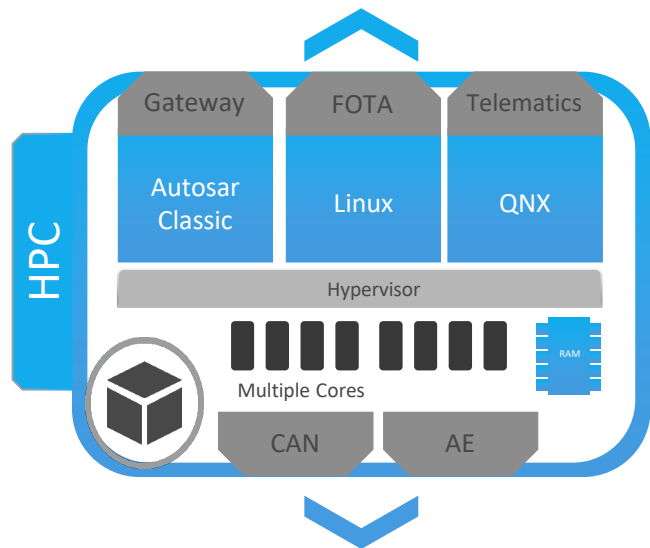# UDS is not sufficient to fully diagnose HPCs

Gateway | FOTA | Telematics

HPC

Autosar Classic | Linux | QNX

Hypervisor

Multiple Cores

RAM

CAN | AE

Possibility to make use of modern communication Technology for Use Cases like
Diagnostics, Flash-Update, Variant Coding etc.

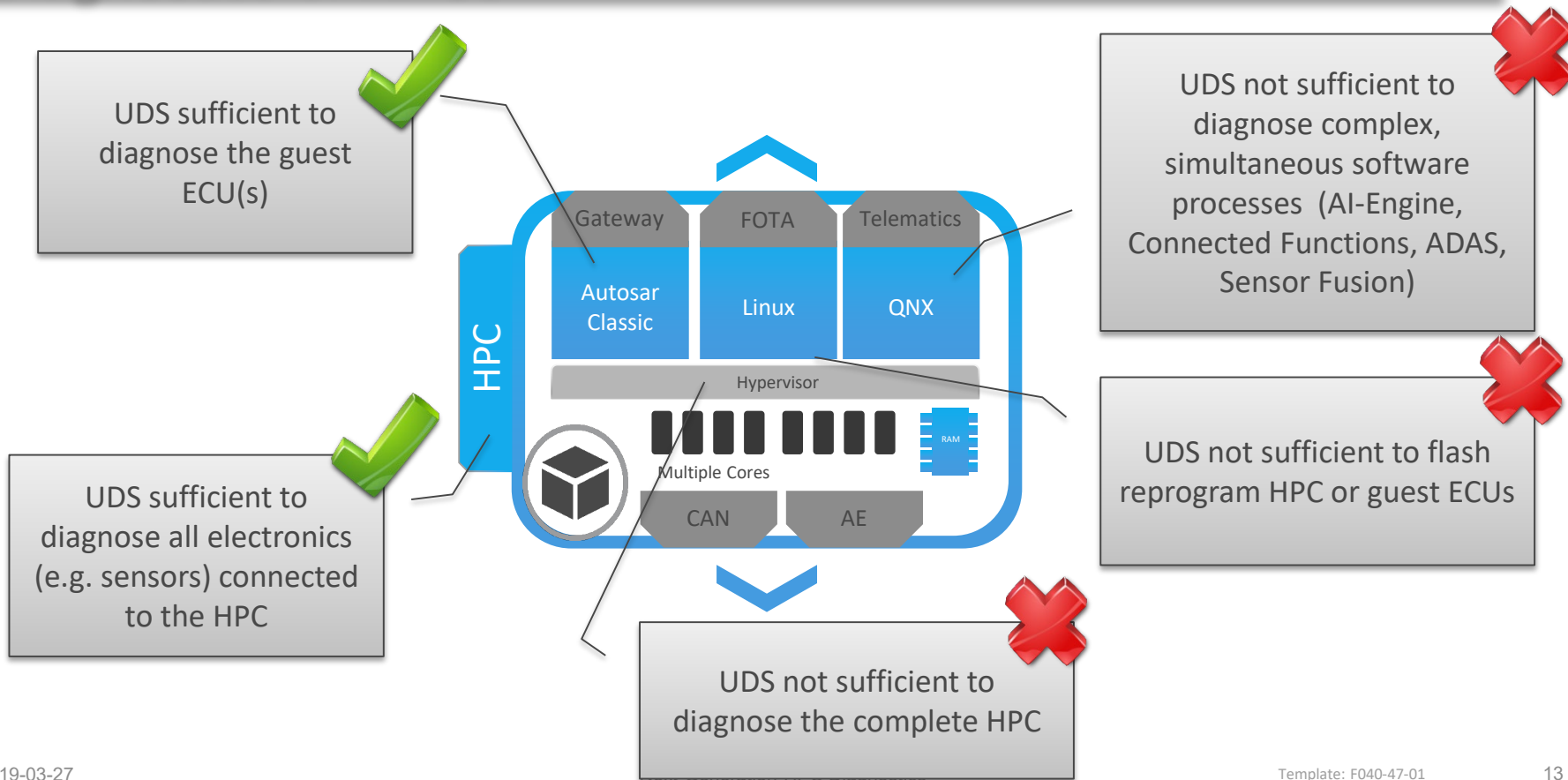Microservices, JSON, Some/IP, REST, Cloud, …

$\Rightarrow$ Analysis / Diagnosis of multi-threaded Systems
$\Rightarrow$ Similar to Analysis / Diagnosis in large IT centers

vs.

`0x00000710  03 22 f1 88 aa aa aa aa`

Today's Diagnostics analyse the electronic system under the assumption that the software of an ECU has no bugs.

Diagnostics of HPCs

UDS sufficient to diagnose the guest ECU(s)

UDS sufficient to diagnose all electronics (e.g. sensors) connected to the HPC

UDS not sufficient to diagnose complex, simultaneous software processes (AI-Engine, Connected Functions, ADAS, Sensor Fusion)

UDS not sufficient to flash reprogram HPC or guest ECUs

UDS not sufficient to diagnose the complete HPC

HPC

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Hypervisor

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Key Question

How to analyze erroneous vehicle behavior
when the root cause is in the software?

Race Conditions

Access Violations

Load

Deadlocks

...

Firmware Over-The-Air

Life Cycle Management

Remote Diagnostics

Customer Binding

BUT

?

Today's legislation relies on OBD

> **EUR 5/6 / CARB**
>   - Emissions Regulation
>   - Market Regulation for independent after market

> **Legislation for periodical technical inspection in Europe**
>   - Check of safety-relevant electronics within the vehicle

> **BUT: Today's vehicles are connected.**

$\Rightarrow$ New concepts and businesses are being defined

$\Rightarrow$ A new standard has to create options beyond OBD

Important concepts for a New Diagnostic Standard

> Standardization Efforts today focus on a specific usage scenario

> However, at minimum, 3 usage scenarios have to be supported by a future standard:
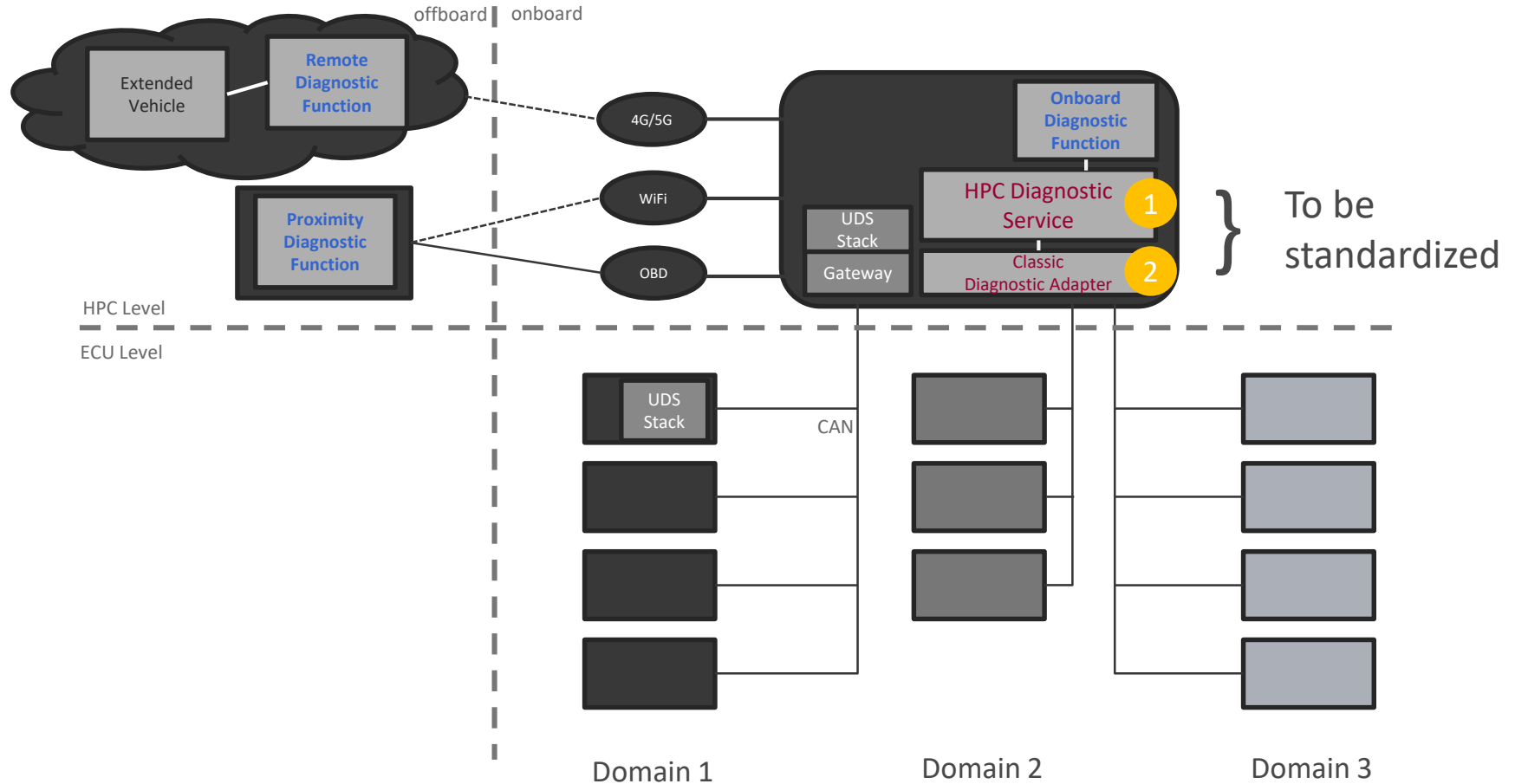
On-Board   Proximity   Remote

offboard | onboard

Extended Vehicle

Remote Diagnostic Function

Proximity Diagnostic Function

4G/5G

WiFi

OBD

Onboard Diagnostic Function

HPC Diagnostic Service ①

UDS Stack

Gateway

Classic Diagnostic Adapter ②

} To be standardized

HPC Level

ECU Level

UDS Stack

CAN

Domain 1

Domain 2

Domain 3

SOHD

Service-**O**riented **H**PC **D**iagnostics

We are about to begin! Join us!

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