arm TechCon

The Service and Software-oriented Vehicle

The in-vehicle Micro-cloud Platform

GuardKnox
Dionis Teshler

Guard KNOX Cyber Technologies

2019

#ArmTechCon

Agenda

1. Modern Car 101
2. The Service Oriented Car Concept
3. Key Components in SOA
4. Implementation
5. Key Benefits

arm TechCon

Modern Car 101

Current status of automotive E/E architecture

MODERN CAR

Approx. 50-150 ECUs

Approx. 5-10 networks

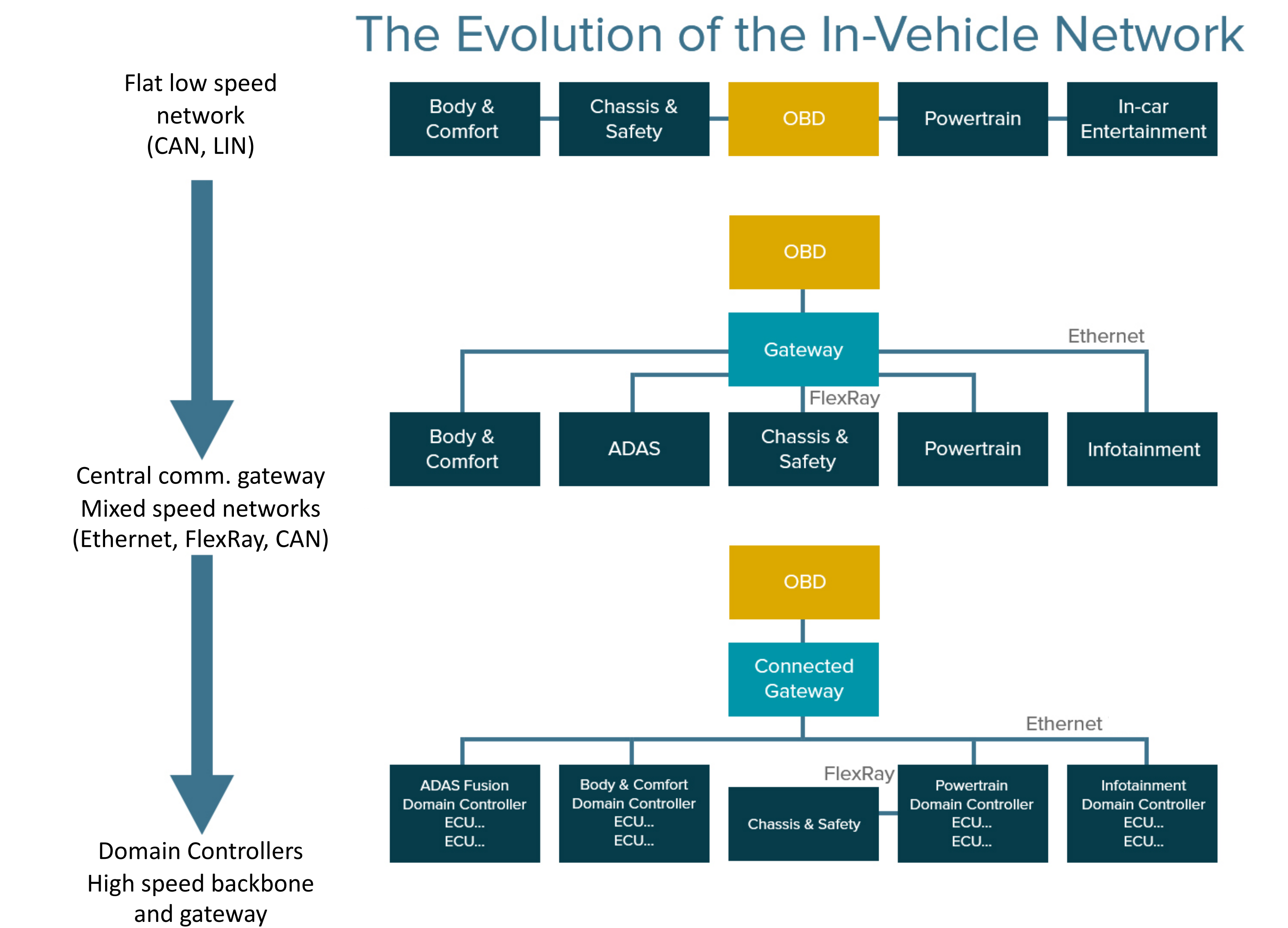
145,000 lines of code

40,000,000 lines of code

100,000,000 lines of code

300,000,000 lines of code

Evolution of Automotive Electrical/Electronic Architecture



The Evolution of the In-Vehicle Network

Flat low speed network (CAN, LIN)

Body & Comfort — Chassis & Safety — OBD — Powertrain — In-car Entertainment

Central comm. gateway
Mixed speed networks
(Ethernet, FlexRay, CAN)

OBD

Gateway

Ethernet

FlexRay

Body & Comfort — ADAS — Chassis & Safety — Powertrain — Infotainment

Domain Controllers
High speed backbone and gateway

OBD

Connected Gateway

Ethernet

FlexRay

ADAS Fusion Domain Controller ECU... ECU...

Body & Comfort Domain Controller ECU... ECU...

Chassis & Safety

Powertrain Domain Controller ECU... ECU...

Infotainment Domain Controller ECU... ECU...

Example Domain Controller Specifications

Category	Requirement	Comment
Processing Power	15-45K DMIPS 1-3K DMIPS safety critical	Quad A53 @ 1.2 GHz = ~11KDMIPS
Interfaces	10 Ethernet 100/1000Mbps interfaces	Automotive Ethernet
	15 Ethernet 100 interfaces	Automotive Ethernet
	15 CAN-FD interfaces	
	10 LIN interfaces	
Comm. Performance	1Gb Ethernet routing with <1ms latency	
	CAN operational <100ms cold start	
	Ethernet operational <200ms cold start	
Memory	Up to 8 GB RAM	
	Up to 128GB flash	
Runtime	Type 1 hypervisor support Multi domain and OS support	Linux, Andriod AUTOSAR – safety/realtime

arm TechCon

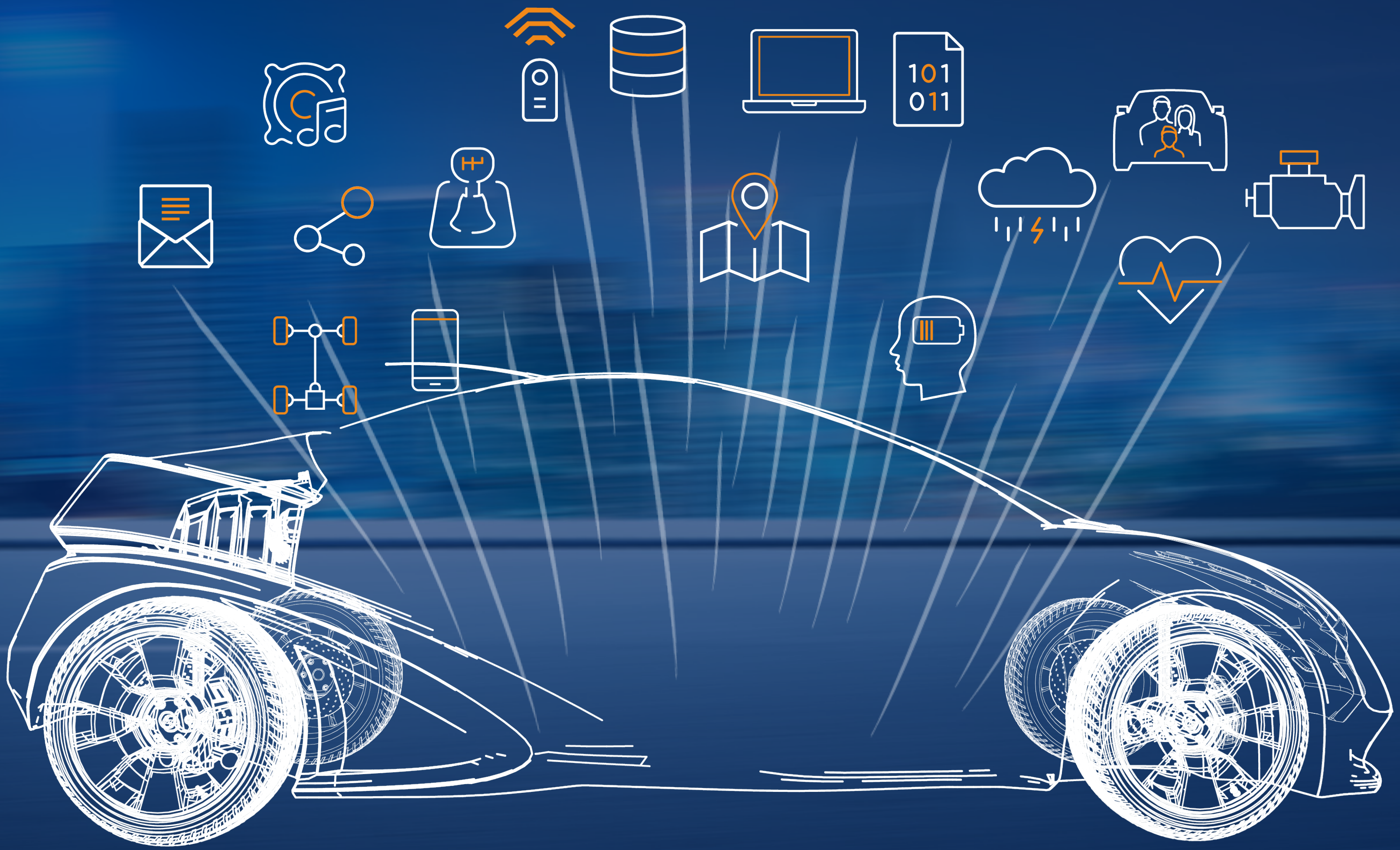
Service Oriented Car

The future of automotive user experience

Service-Oriented Architecture

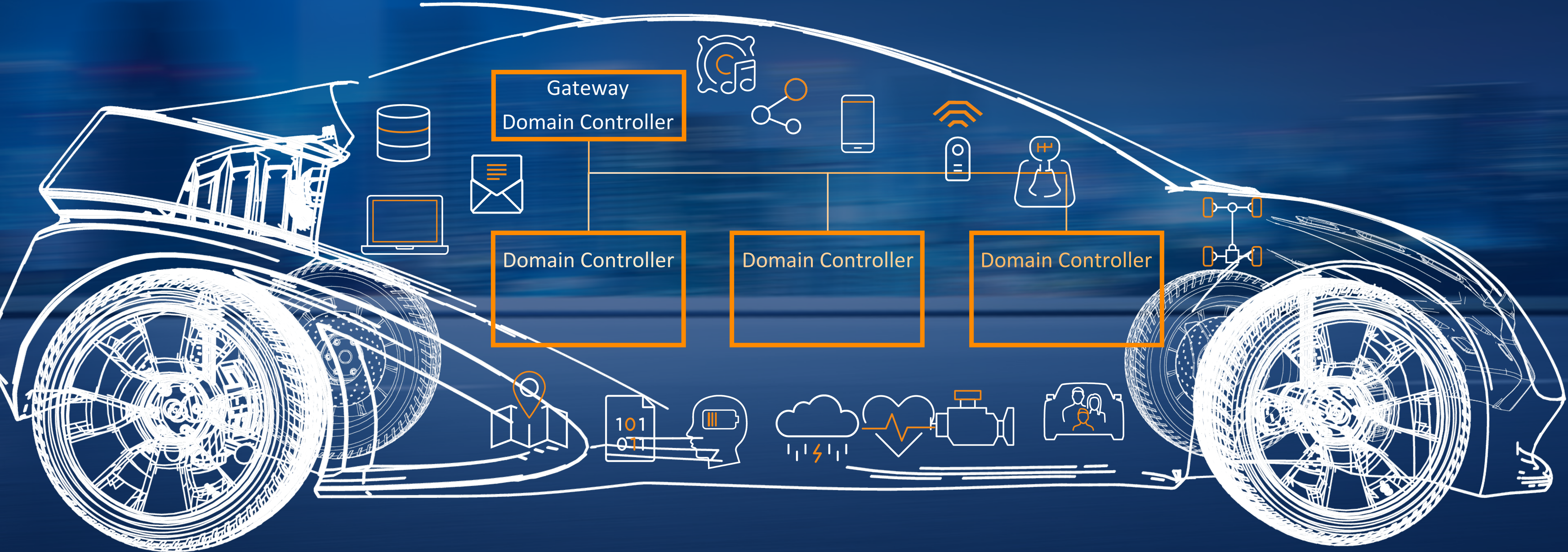
Basis for full vehicle personalization

Service oriented vehicle requires realtime remote deployment of capabilities

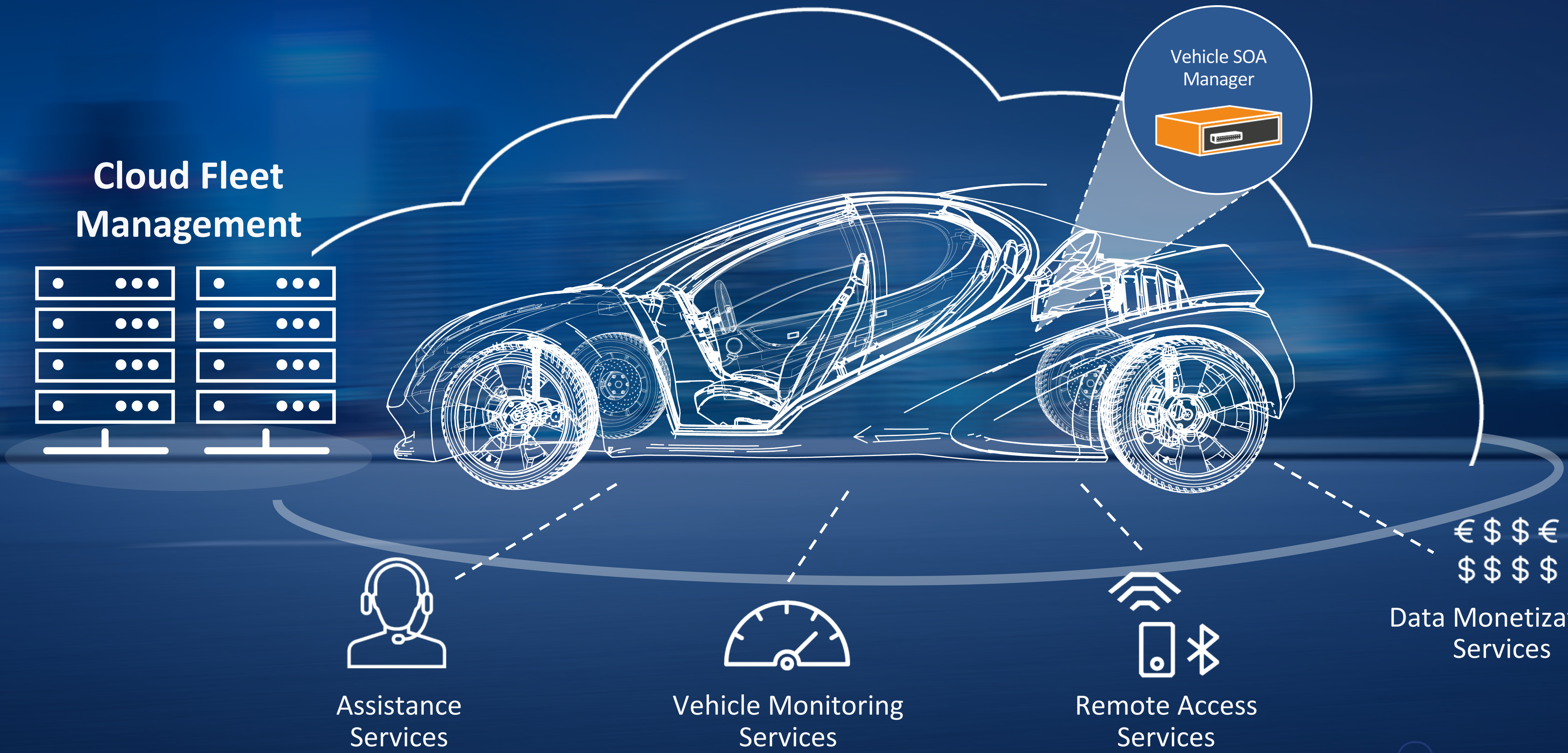


Drivers can *personalize* and *customize* their entire vehicle and travel experience

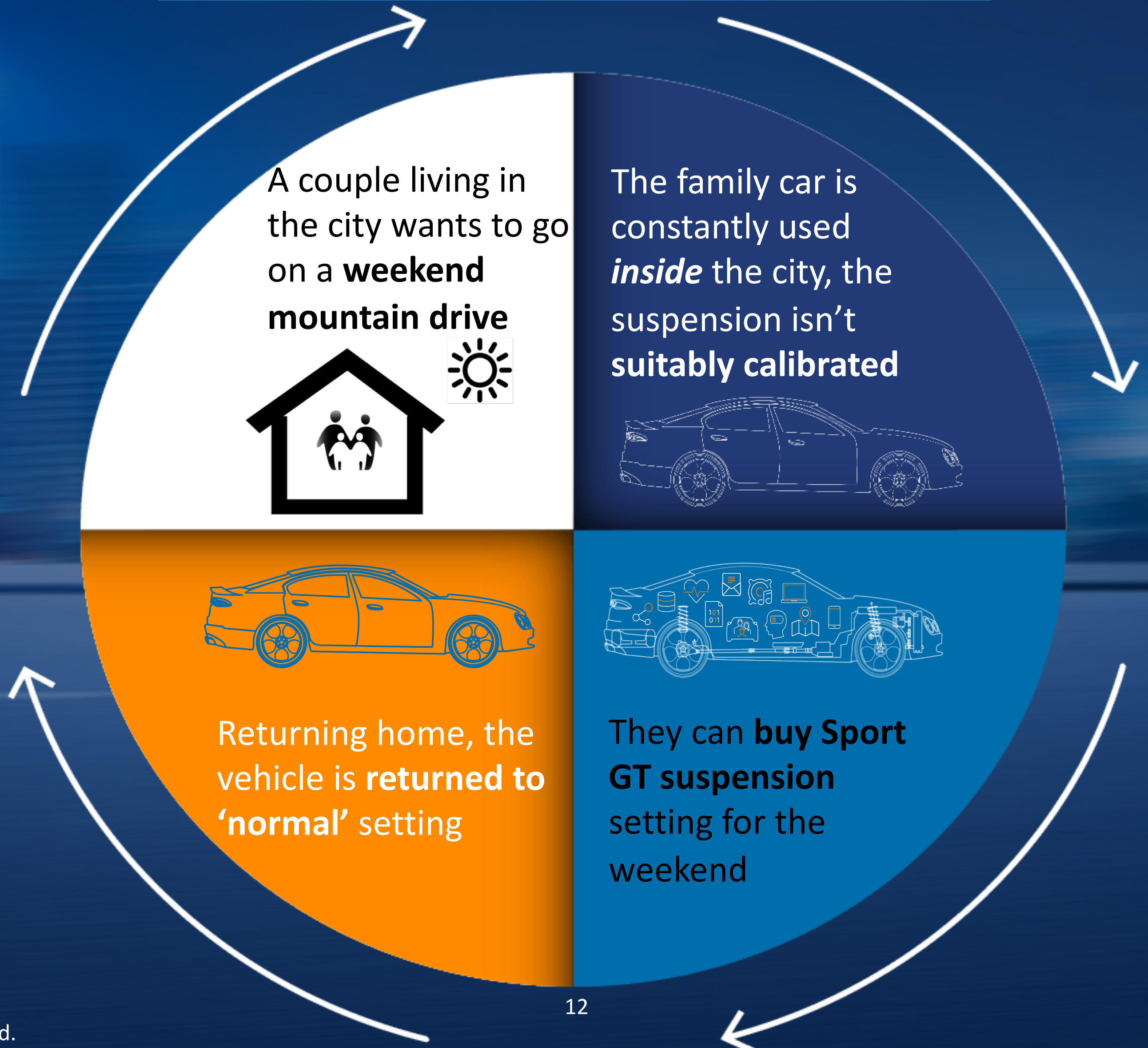
Services need a suitable host ECU(s) within the vehicle



Management is required on vehicle level and fleet level



Leading to new business models and revenue streams – turning Drivers into Subscribers



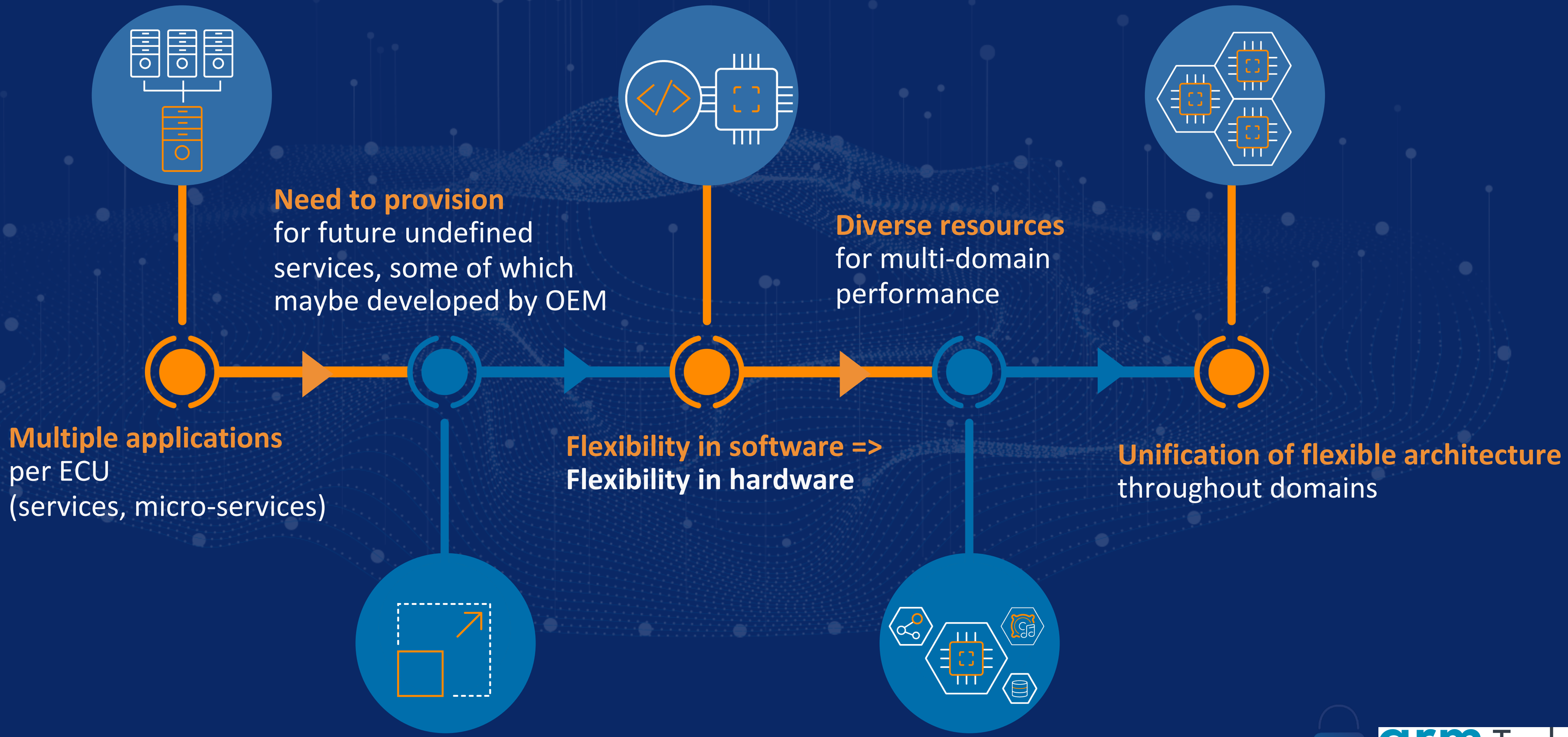
A couple living in the city wants to go on a **weekend mountain drive**

The family car is constantly used ***inside*** the city, the suspension isn't **suitably calibrated**

They can **buy Sport GT suspension** setting for the weekend

Returning home, the vehicle is **returned to 'normal'** setting

IMPLICATIONS ON E/E ARCHITECTURE



Multiple applications per ECU (services, micro-services)

Need to provision for future undefined services, some of which maybe developed by OEM

Flexibility in software => Flexibility in hardware

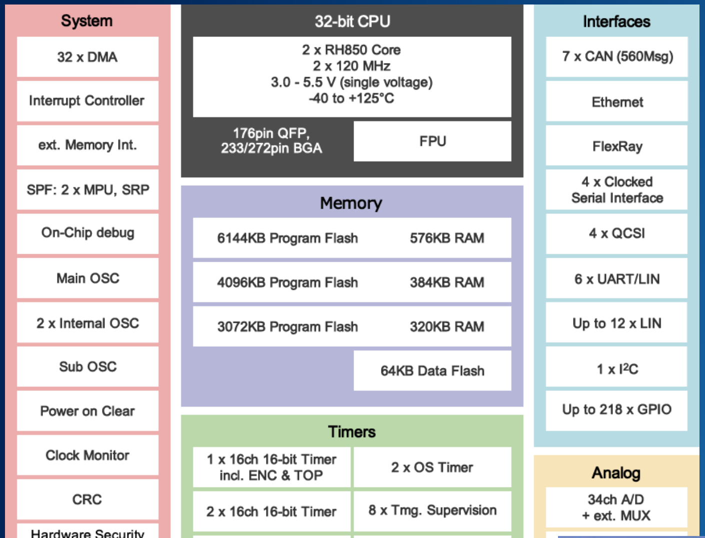
Diverse resources for multi-domain performance

Unification of flexible architecture throughout domains

Key Components

To create the Service Oriented Vehicle

Flexible domain controller ECU(s)



System
32 x DMA
Interrupt Controller
ext. Memory Int.
SPF: 2 x MPU, SRP
On-Chip debug
Main OSC
2 x Internal OSC
Sub OSC
Power on Clear
Clock Monitor
CRC
Hardware Security Module (ICU-M)

32-bit CPU
2 x RH850 Core
2 x 120 MHz
3.0 - 5.5 V (single voltage)
-40 to +125°C
176pin QFP, 233/272pin BGA
FPU

Memory
6144KB Program Flash | 576KB RAM
4096KB Program Flash | 384KB RAM
3072KB Program Flash | 320KB RAM
64KB Data Flash

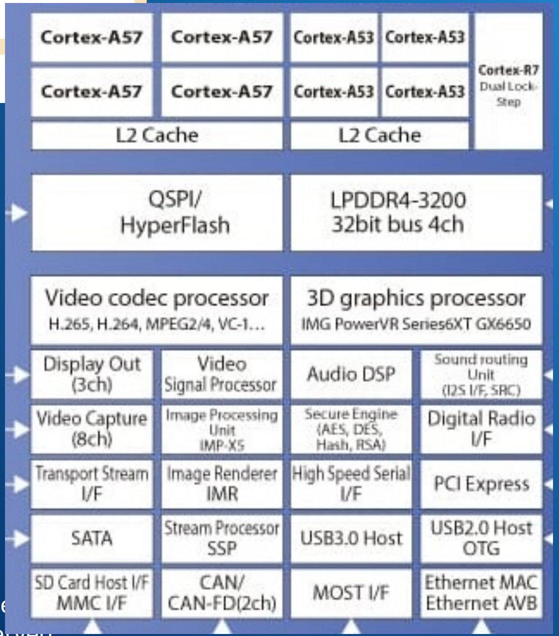
Timers
1 x 16ch 16-bit Timer incl. ENC & TOP
2 x OS Timer
2 x 16ch 16-bit Timer
8 x Tmg. Supervision
2 x 4ch 32-bit Timer
3 x WDT
Up to 96 x 12-bit PWM incl. Diag & Delay
RTC (Real Time Clock)

Interfaces
7 x CAN (560Msg)
Ethernet
FlexRay
4 x Clocked Serial Interface
4 x QCSI
6 x UART/LIN
Up to 12 x LIN
1 x I²C
Up to 218 x GPIO

Analog
34ch A/D + ext. MUX

Interface Focus

Non-Flexible



Cortex-A57 | Cortex-A57 | Cortex-A53 | Cortex-A53
Cortex-A57 | Cortex-A57 | Cortex-A53 | Cortex-A53
L2 Cache | L2 Cache
Cortex-R7 Dual Lock-Step

QSPI/ HyperFlash
LPDDR4-3200 32bit bus 4ch

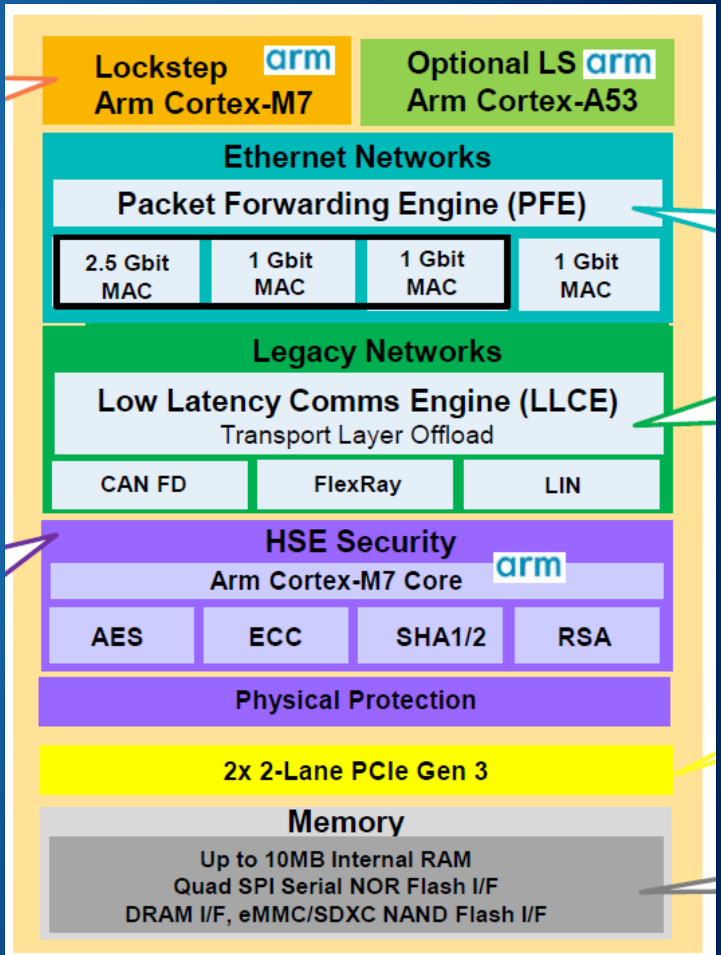
Video codec processor
H.265, H.264, MPEG2/4, VC-1…
3D graphics processor
IMG PowerVR Series6XT GX6650

Display Out (3ch)
Video Signal Processor
Audio DSP
Sound routing Unit (I2S I/F, SRC)
Video Capture (8ch)
Image Processing Unit IMP-X5
Secure Engine (AES, DES, Hash, RSA)
Digital Radio I/F
Transport Stream I/F
Image Renderer IMR
High Speed Serial I/F
PCI Express
SATA
Stream Processor SSP
USB3.0 Host
USB2.0 Host OTG
SD Card Host I/F MMC I/F
CAN/ CAN-FD(2ch)
MOST I/F
Ethernet MAC Ethernet AVB

Performance Focus

VS

Multi-Purpose
Partially Flexible
(2020)



Lockstep Arm Cortex-M7 arm
Optional LS Arm Cortex-A53 arm

Ethernet Networks
Packet Forwarding Engine (PFE)
2.5 Gbit MAC
1 Gbit MAC
1 Gbit MAC
1 Gbit MAC

Legacy Networks
Low Latency Comms Engine (LLCE)
Transport Layer Offload
CAN FD
FlexRay
LIN

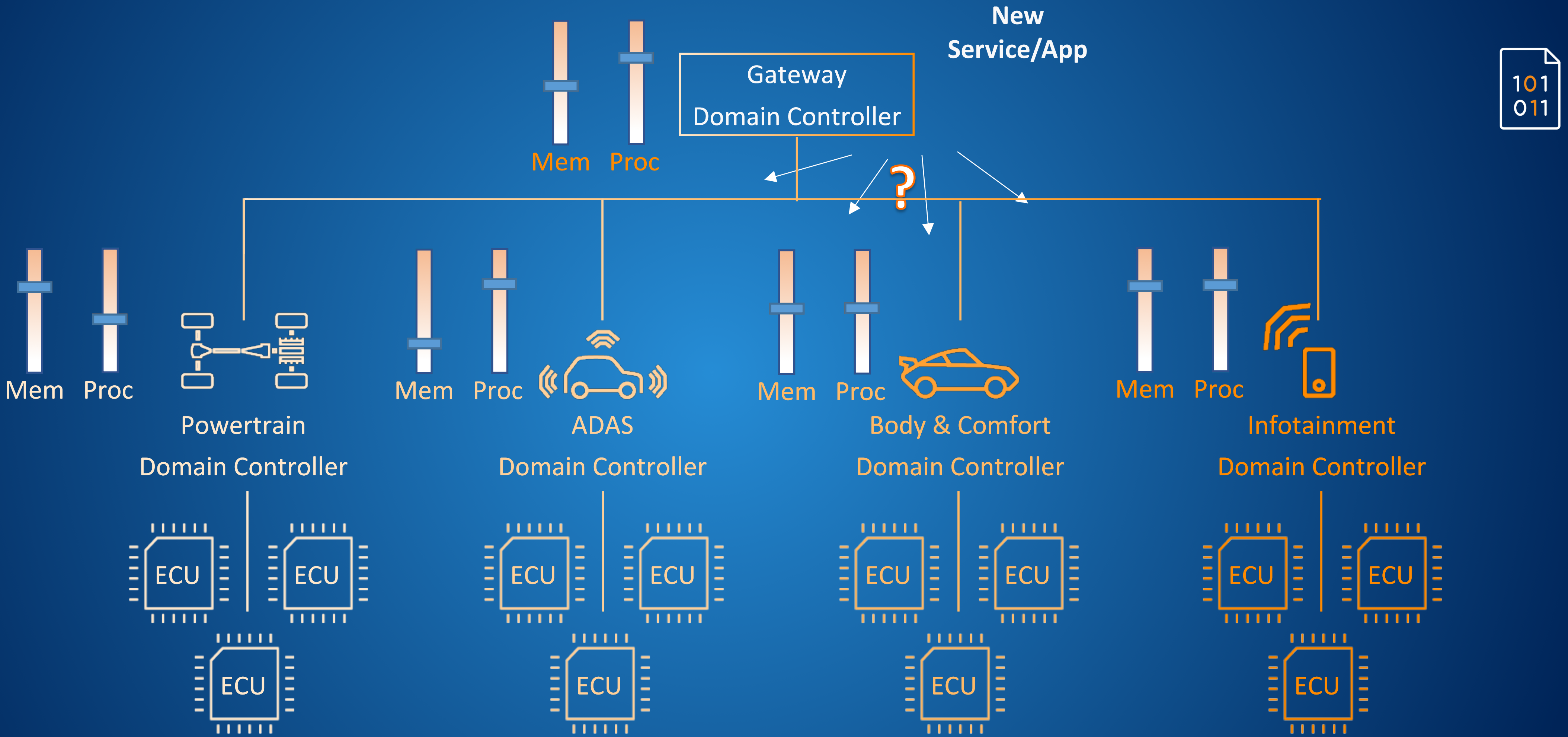
HSE Security
Arm Cortex-M7 Core arm
AES
ECC
SHA1/2
RSA

Physical Protection

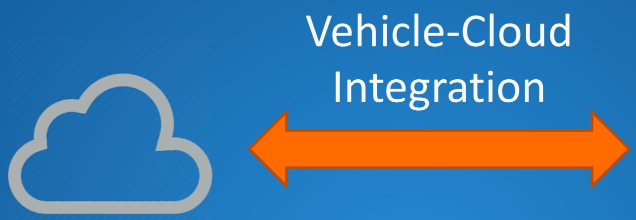
2x 2-Lane PCIe Gen 3

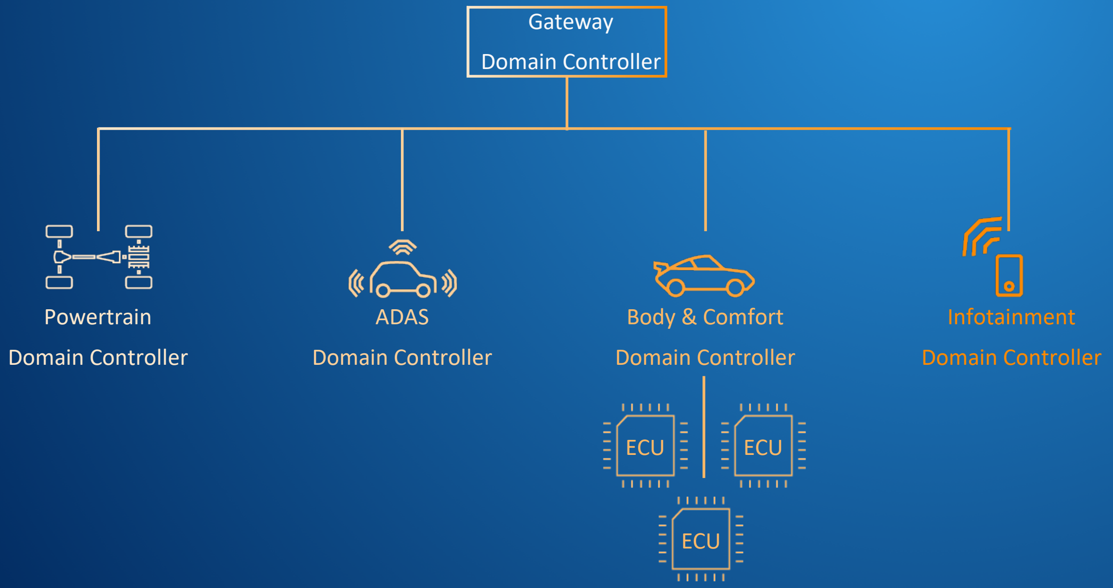
Memory
Up to 10MB Internal RAM
Quad SPI Serial NOR Flash I/F
DRAM I/F, eMMC/SDXC NAND Flash I/F

In vehicle service and resource management



Cloud fleet management – fully automated down to the ECU and application level





Fleet Management Services

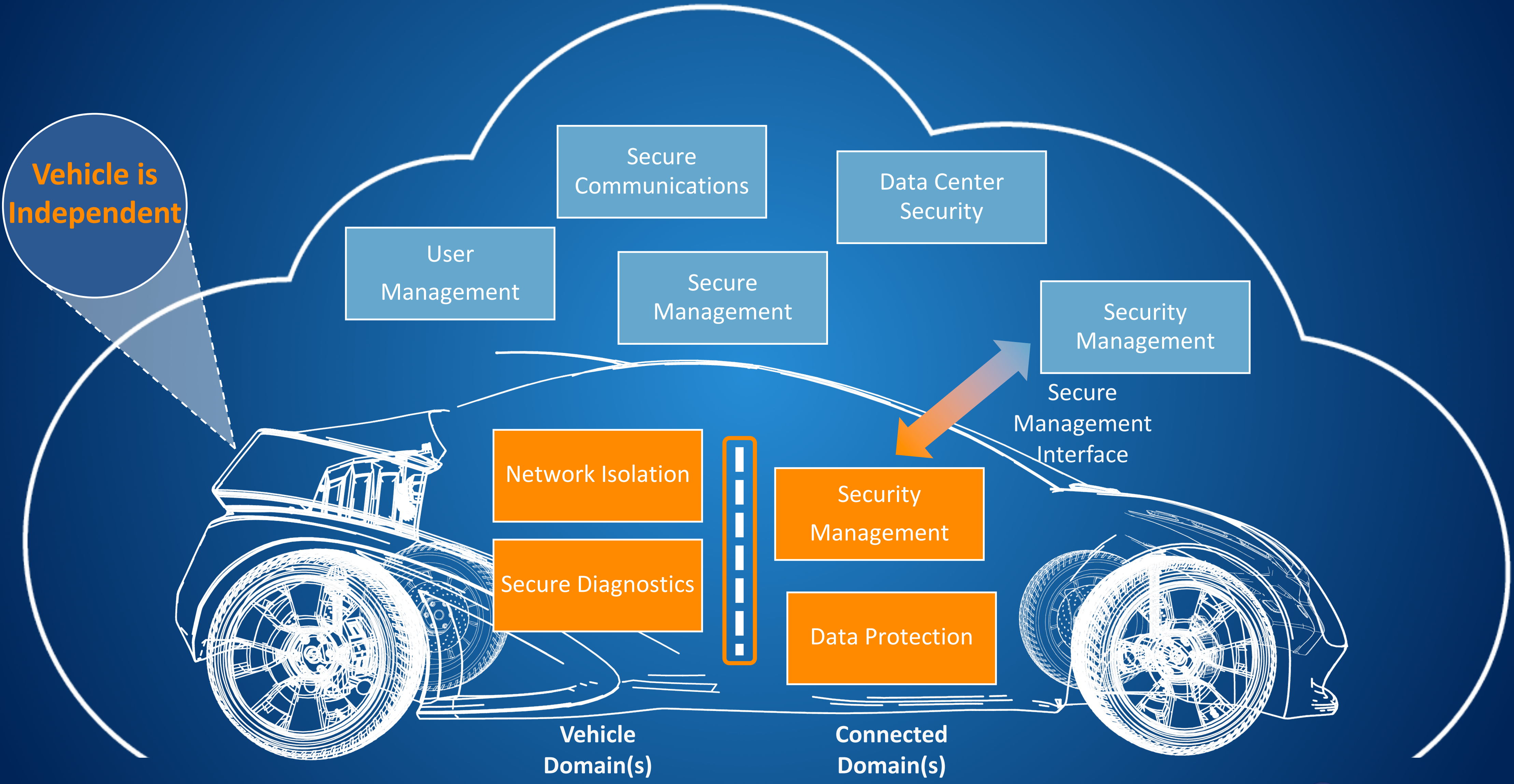
Service Deployment Management

Monetization and Service Utilization

Fleet Health Management

Cyber Security Management and Monitoring

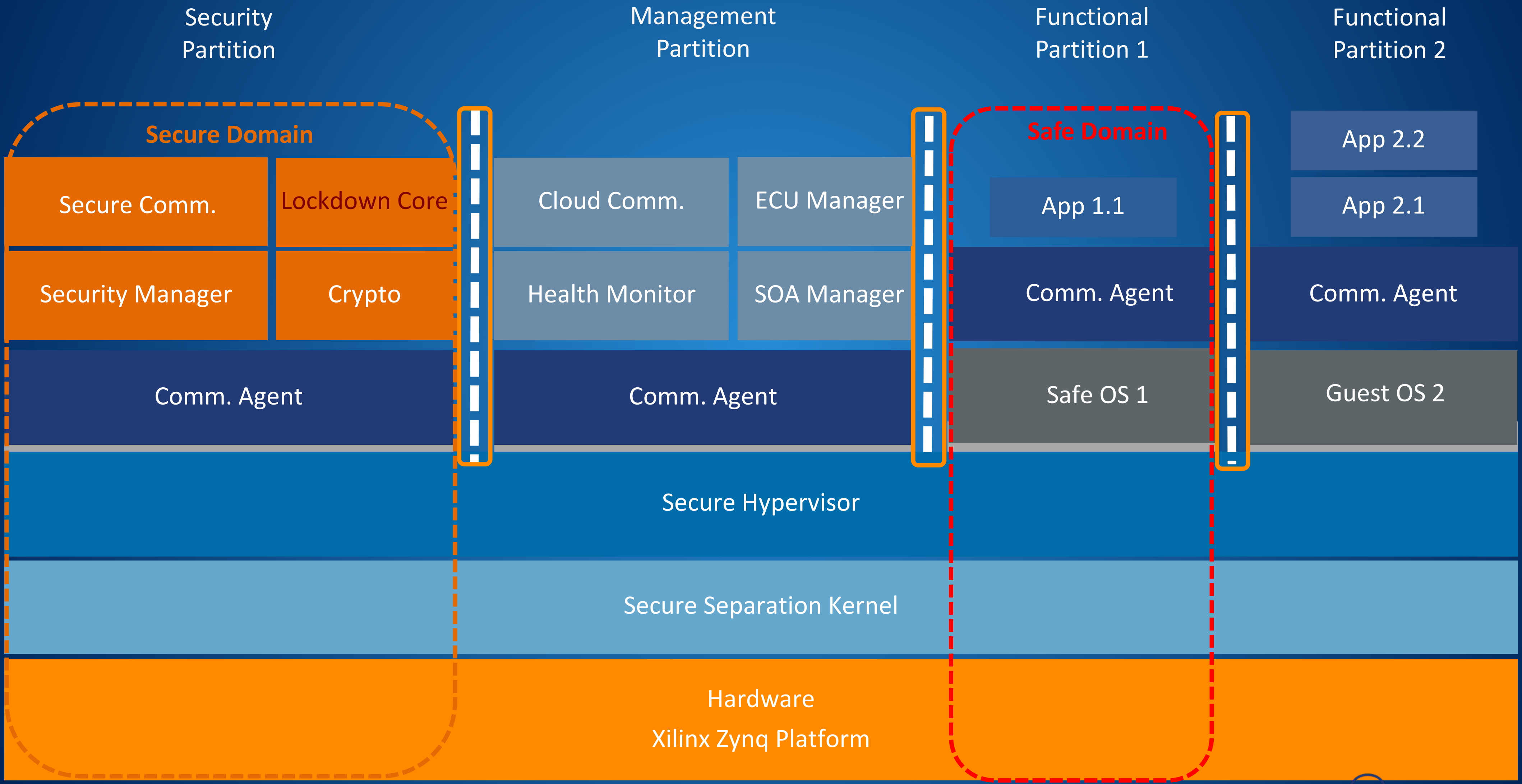
Hybrid security model – vehicle + cloud



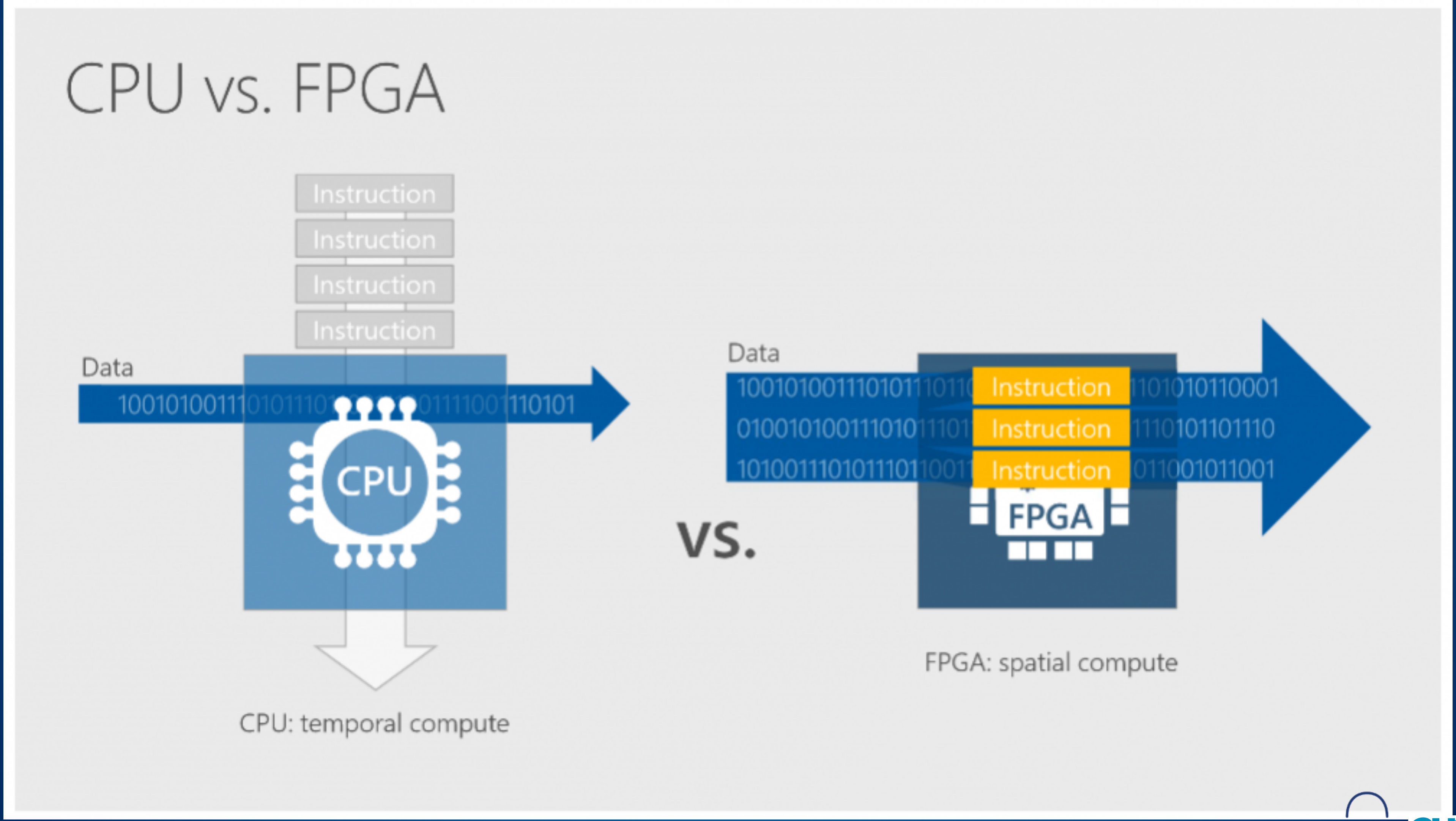
SOA Implementation

In Automotive Environment

Flexible SOA software stack



FPGAs as a flexible high performance compute and communication engine



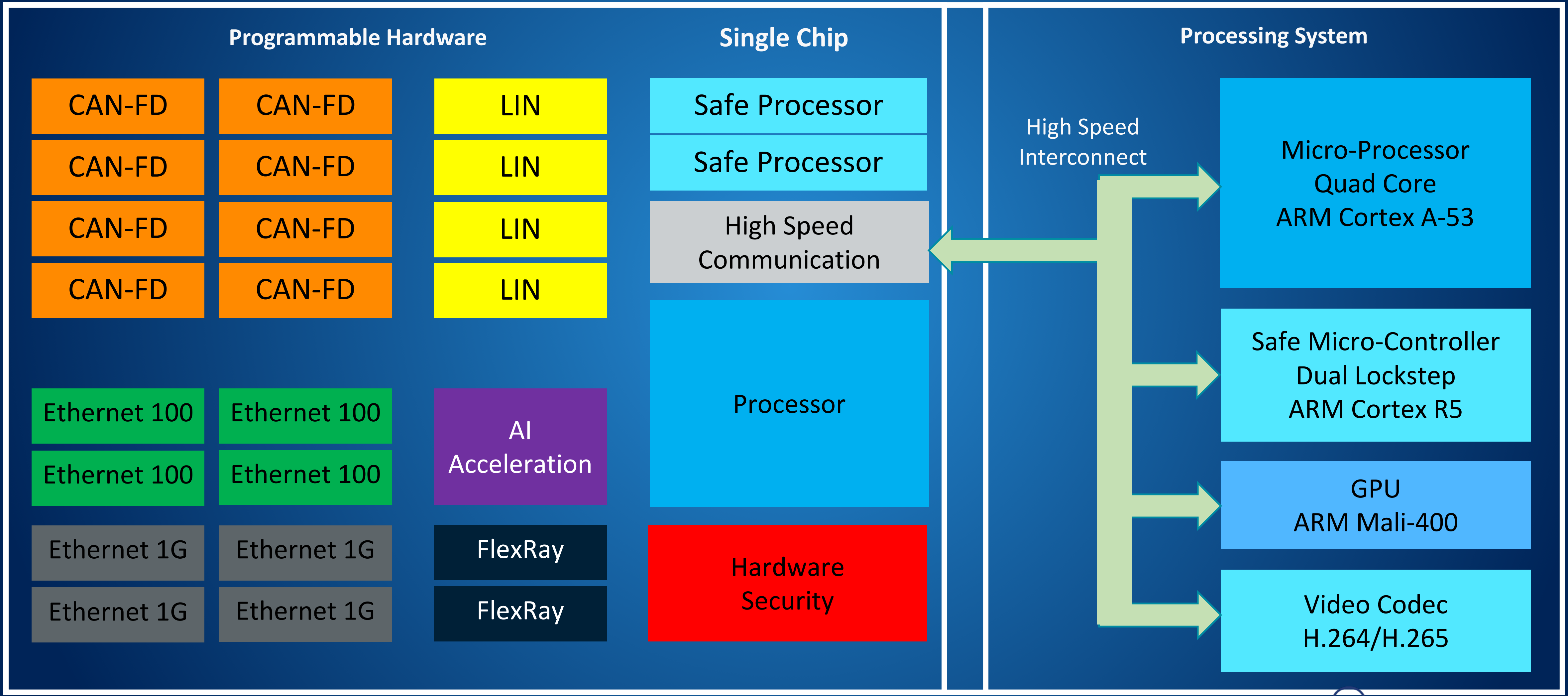
CPU vs. FPGA

Instruction
Instruction
Instruction
Instruction
Data
10010100111010111010111100111001110101
CPU
vs.
Data
1001010011101011101110 Instruction 1101010110001
0100101001110101110111 Instruction 1110101101110
1010011101011101100111 Instruction 011001011001
FPGA

CPU: temporal compute

FPGA: spatial compute

Flexible software isn't enough – it needs to run on **flexible hardware**



Programmable Hardware

Single Chip

Processing System

CAN-FD
CAN-FD
CAN-FD
CAN-FD
CAN-FD
CAN-FD
CAN-FD
CAN-FD

LIN
LIN
LIN
LIN

Ethernet 100
Ethernet 100
Ethernet 100
Ethernet 100

AI Acceleration

Ethernet 1G
Ethernet 1G
Ethernet 1G
Ethernet 1G

FlexRay
FlexRay

Safe Processor
Safe Processor

High Speed Communication

Processor

Hardware Security

High Speed Interconnect

Micro-Processor
Quad Core
ARM Cortex A-53

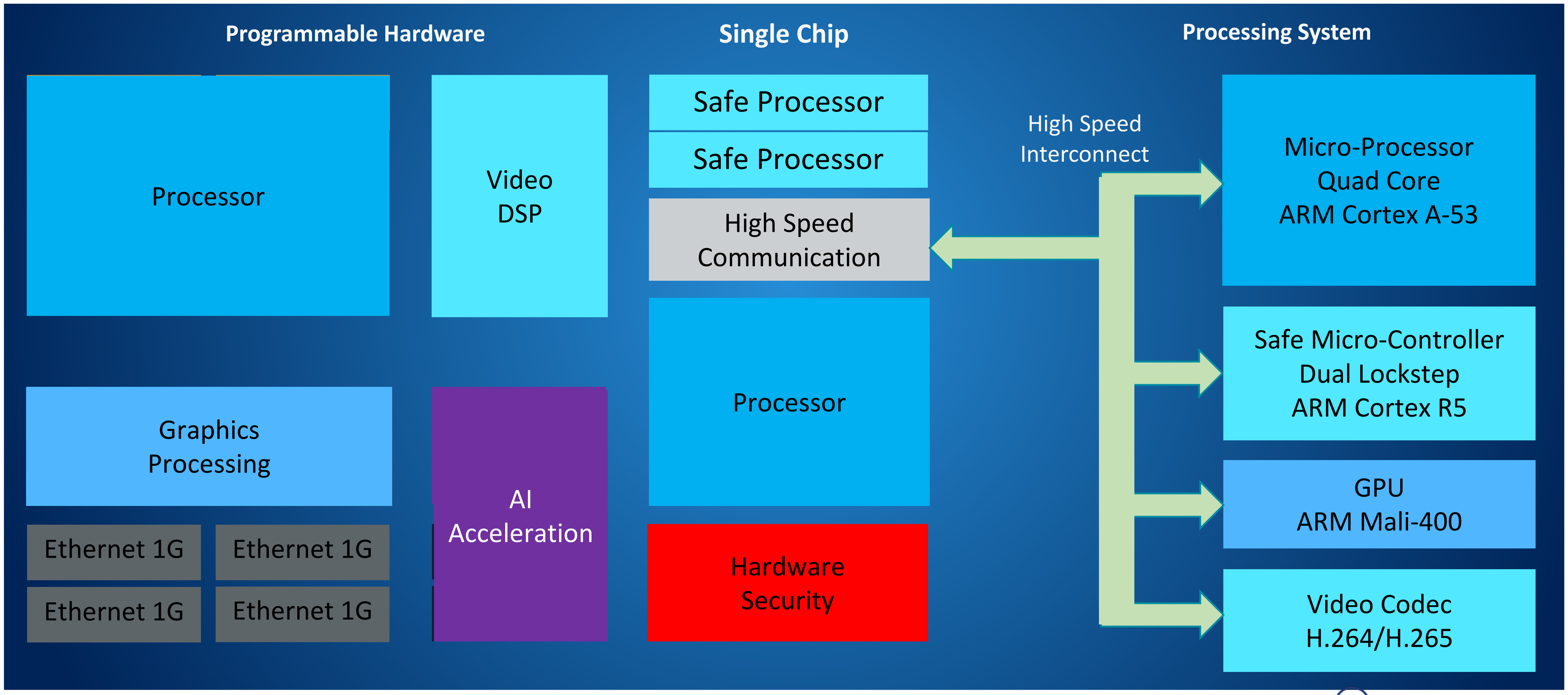
Safe Micro-Controller
Dual Lockstep
ARM Cortex R5

GPU
ARM Mali-400

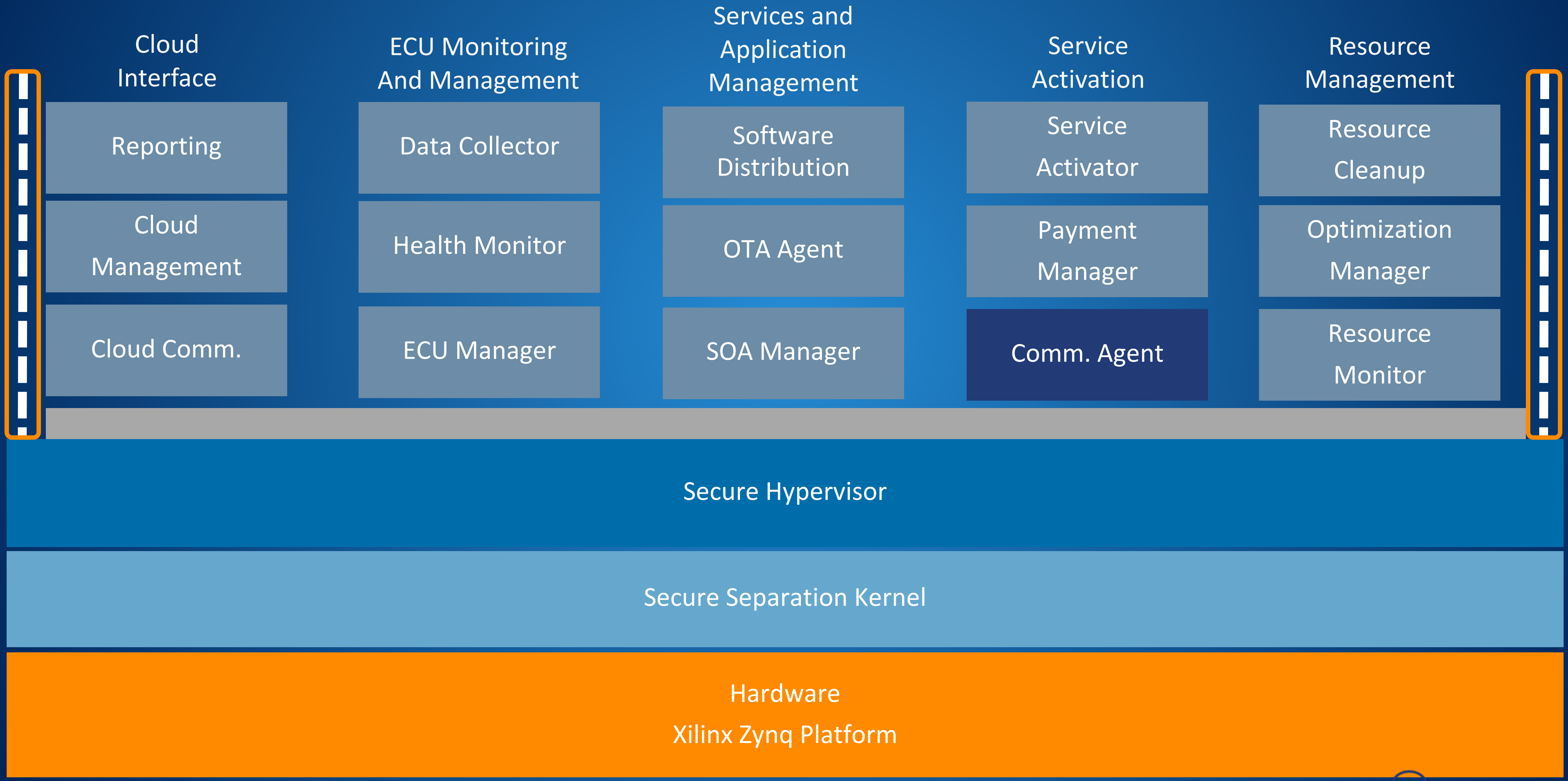
Video Codec
H.264/H.265

arm TechCon

Flexible software isn’t enough – it needs to run on **flexible hardware**



SOA is based on management of **all ECU aspects**



Cloud Interface

- Reporting
- Cloud Management
- Cloud Comm.

ECU Monitoring And Management

- Data Collector
- Health Monitor
- ECU Manager

Services and Application Management

- Software Distribution
- OTA Agent
- SOA Manager

Service Activation

- Service Activator
- Payment Manager
- Comm. Agent

Resource Management

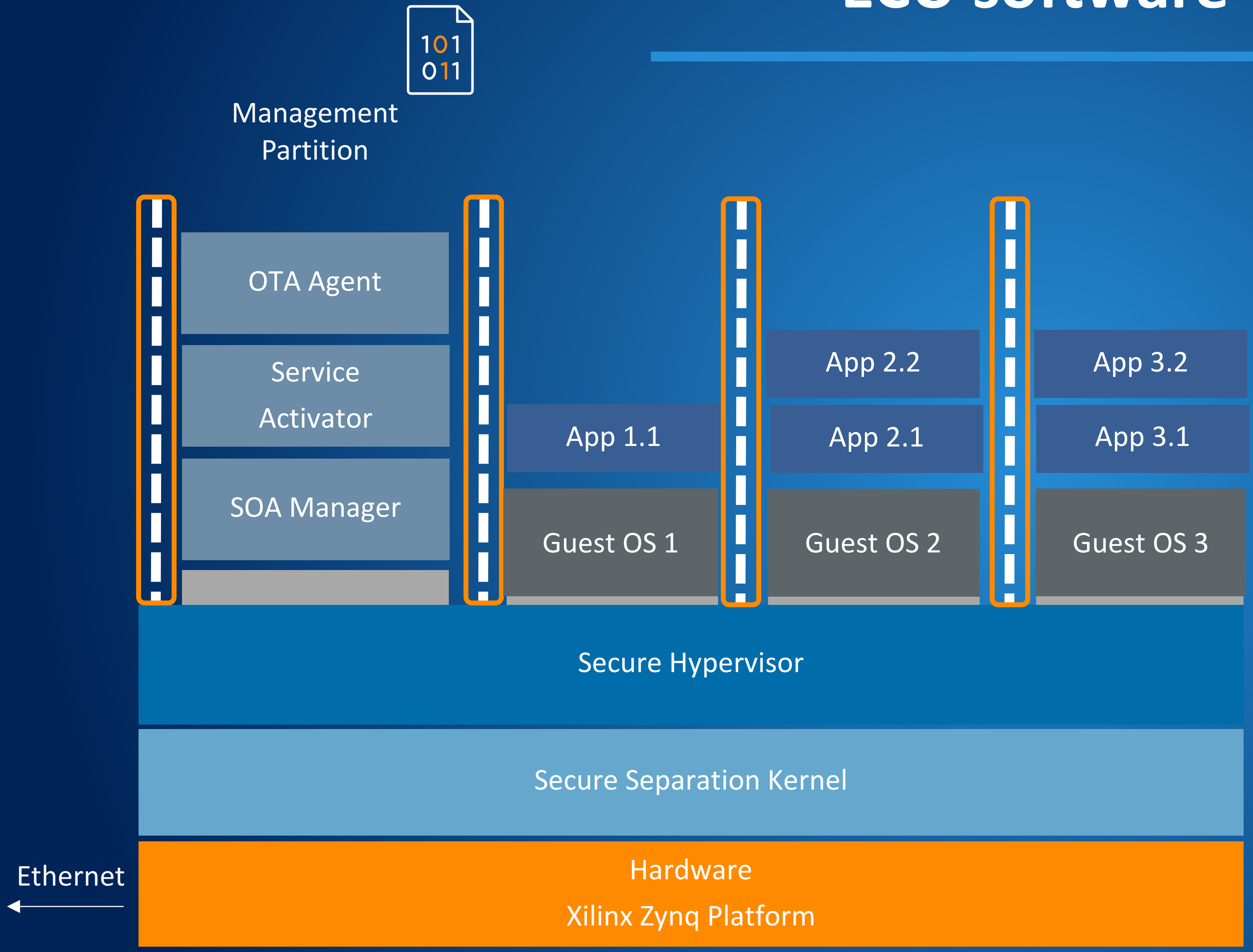
- Resource Cleanup
- Optimization Manager
- Resource Monitor

Secure Hypervisor

Secure Separation Kernel

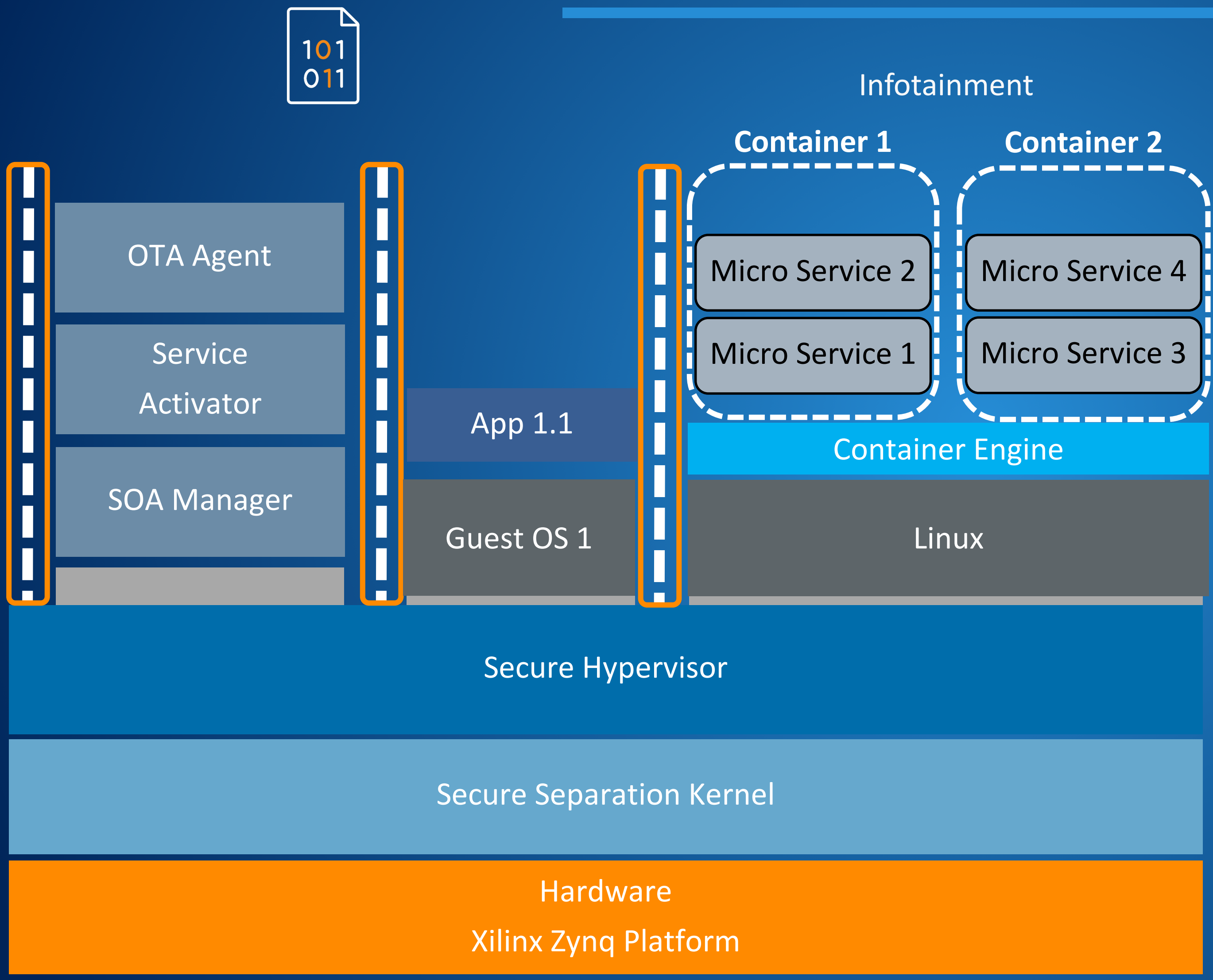
Hardware
Xilinx Zynq Platform

SOA for centralized deployment and management of **all vehicle ECU software**



1. Receive software OTA, through secure communications.
2. Validate and activate software (cryptographically). Activation may require license from Cloud Management Server.
3. Alert SOA management service of new service deployment
4. At the proper time, load new service into appropriate partition and start it
5. If new software is meant for an external ECU, initiate session and send software

SOA mechanisms which are designed for **cloud integration** – micro services with in-vehicle lightweight micro-cloud



101
011

Infotainment

Container 1

Micro Service 2

Micro Service 1

Container 2

Micro Service 4

Micro Service 3

OTA Agent

Service Activator

SOA Manager

App 1.1

Guest OS 1

Container Engine

Linux

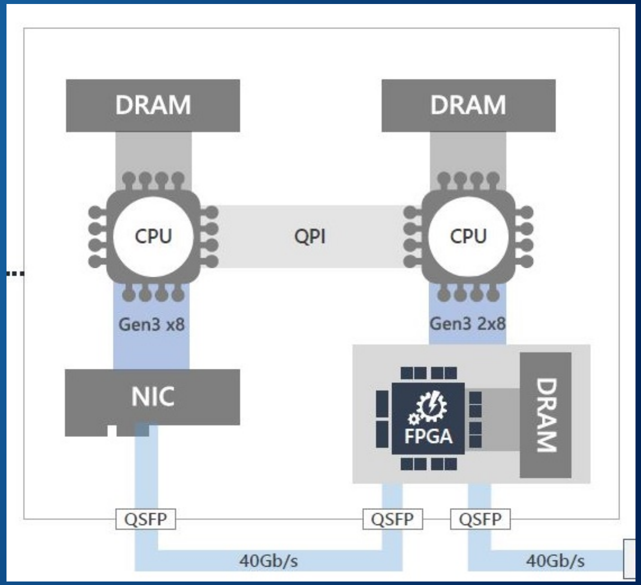
Secure Hypervisor

Secure Separation Kernel

Hardware
Xilinx Zynq Platform

Similar Approach

Cloud Hardware Instance of FPGA backed Cloud Infrastructure

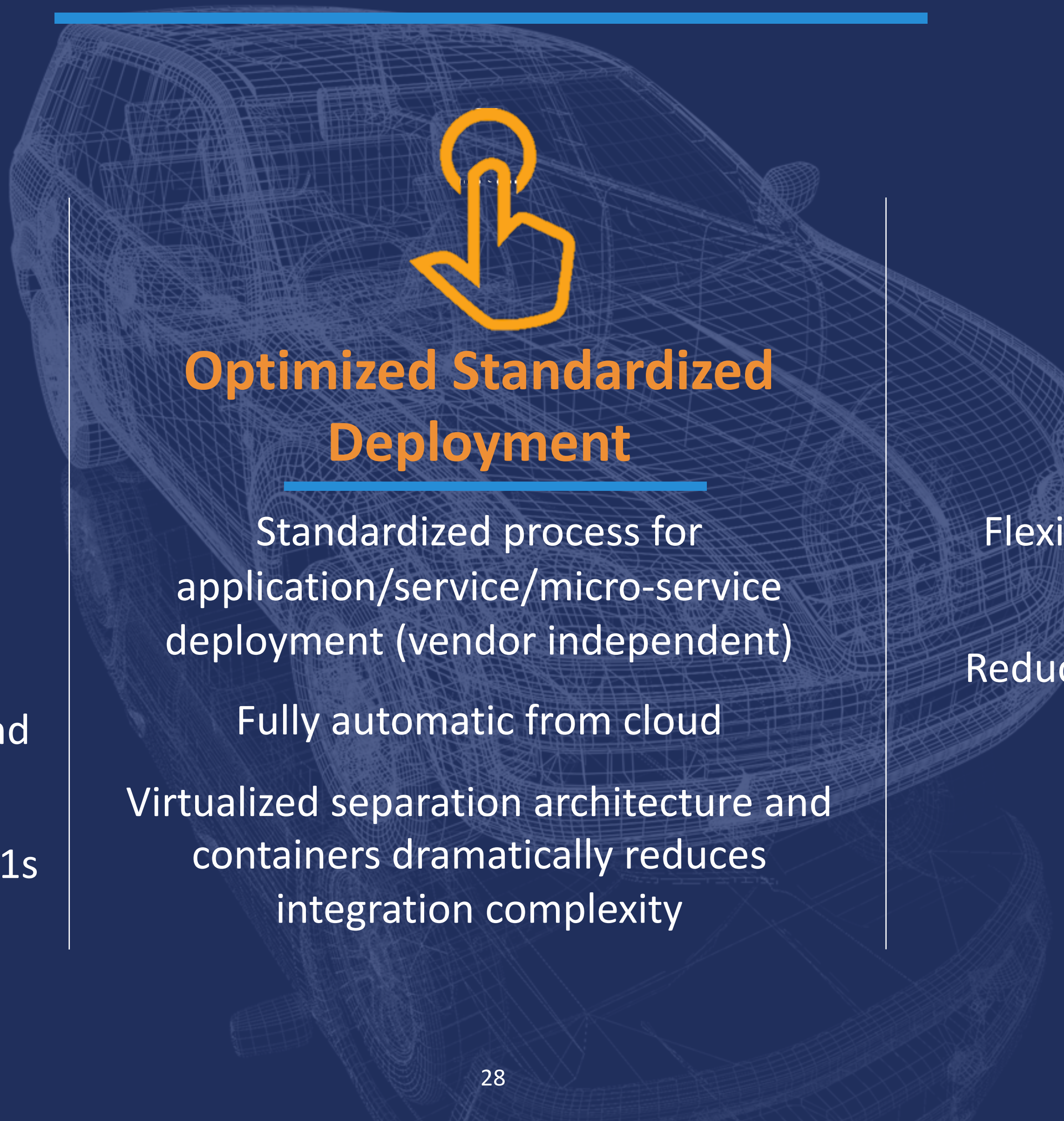


arm TechCon

Key Benefits of SOA

For automotive development and vehicle life cycle

Reduction of software development and deployment costs



Unified Architecture

Same hypervisor for all domain controllers

Predictable performance (same architecture) – easier deployment

Can run same version of Guest OS and same container management

More communality for software Tier 1s

Optimized Standardized Deployment

Standardized process for application/service/micro-service deployment (vendor independent)

Fully automatic from cloud

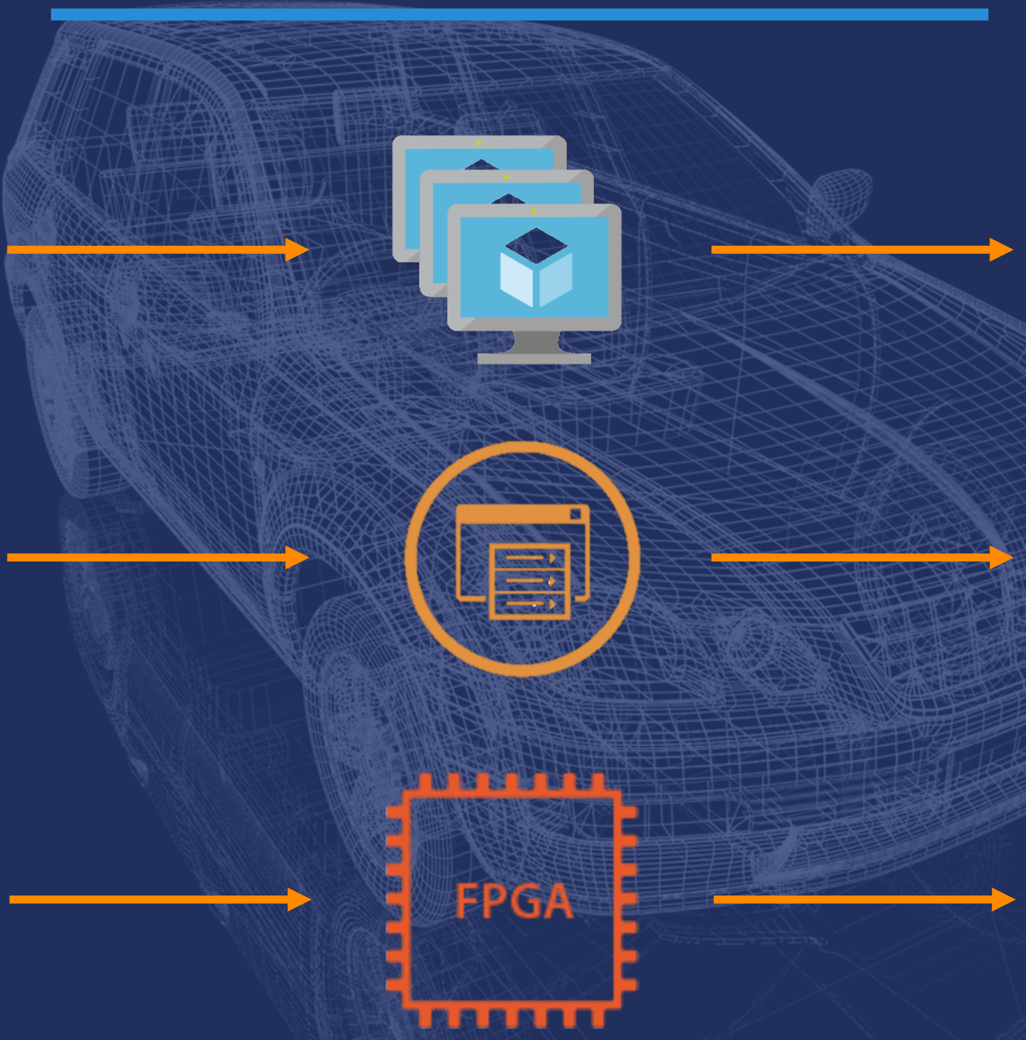
Virtualized separation architecture and containers dramatically reduces integration complexity

Flexible Hardware Acceleration

Flexible hardware to support high performance needs

Reduces need for complex software optimization

Reduce E/E architecture lifecycle costs



E/E Architecture Cost Drivers

Hardware Facelift

Can’t handle new app requirements

Software Integration Lifecycle

Very expensive to reliably integrate new apps

Increasing Communication Requirements

Higher Bandwidth Interfaces

More Interfaces

Cost Reduction Measure

Flexible Compute Hardware

Add compute resources OTA

Add dedicated logic OTA

Partitioning and Isolation

Isolated environment for app/service

No need for system level integration

No need for cross-vendor integration

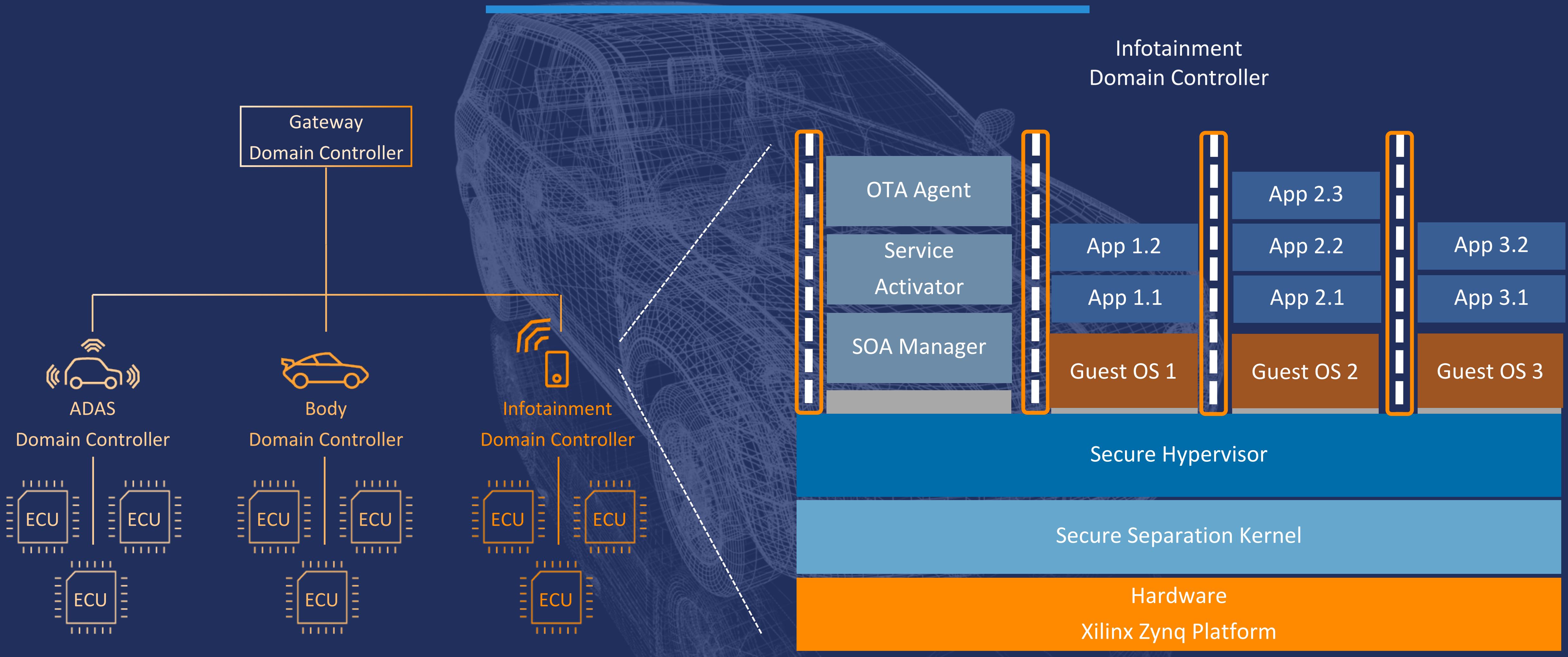
Flexible Comm. Hardware

Isolated environment for app/service

No need for system level integration

No need for cross-vendor integration

Reduce E/E architecture lifecycle costs



Gateway Domain Controller

ADAS Domain Controller

Body Domain Controller

Infotainment Domain Controller

ECU ECU ECU

ECU ECU ECU

ECU ECU ECU

Infotainment Domain Controller

OTA Agent

Service Activator

SOA Manager

App 1.2

App 1.1

Guest OS 1

App 2.3

App 2.2

App 2.1

Guest OS 2

App 3.2

App 3.1

Guest OS 3

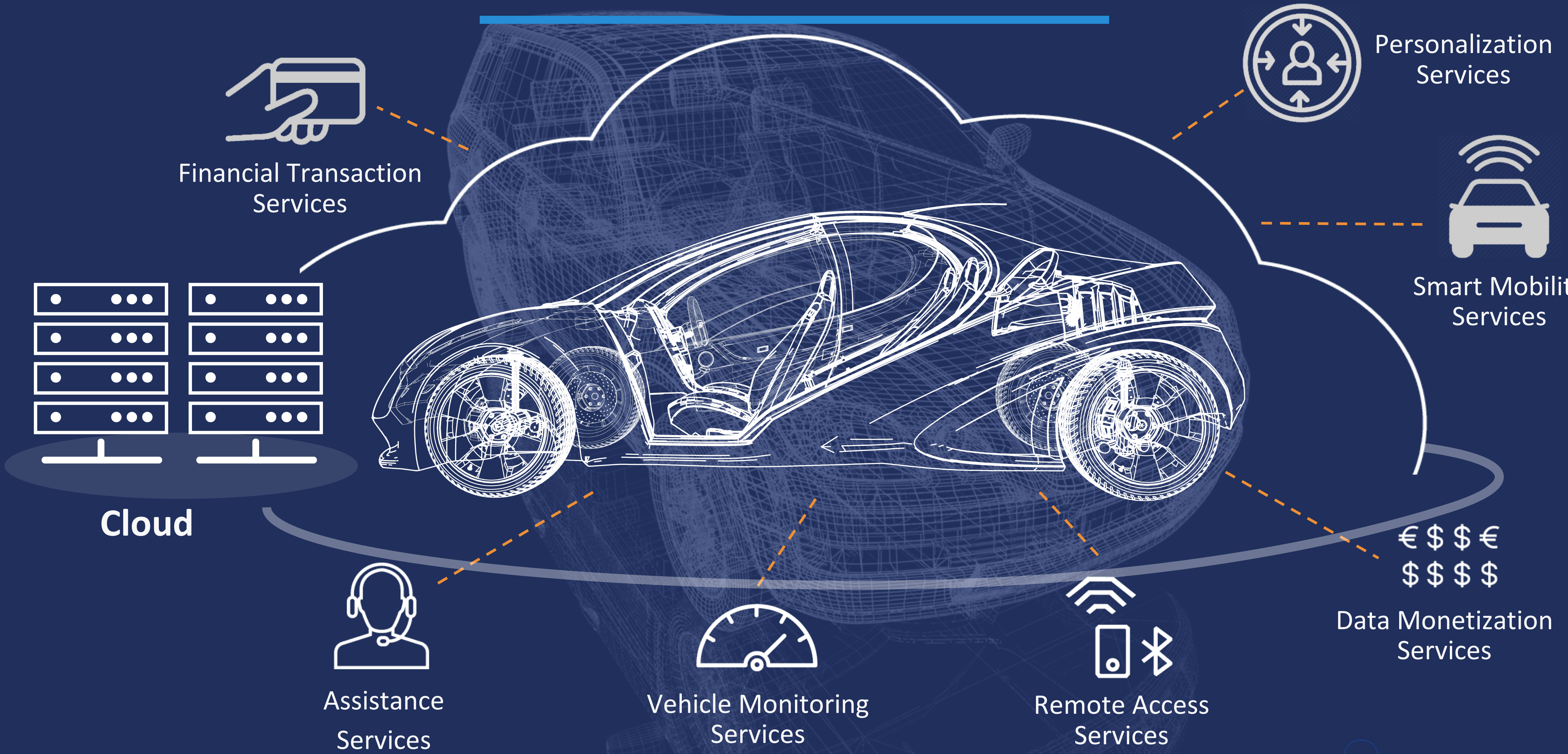
Secure Hypervisor

Secure Separation Kernel

Hardware

Xilinx Zynq Platform

Impose the **least possible constraints** on business models and processes



Financial Transaction Services

Personalization Services

Smart Mobility Services

Cloud

€ $ $ €
$ $ $ $

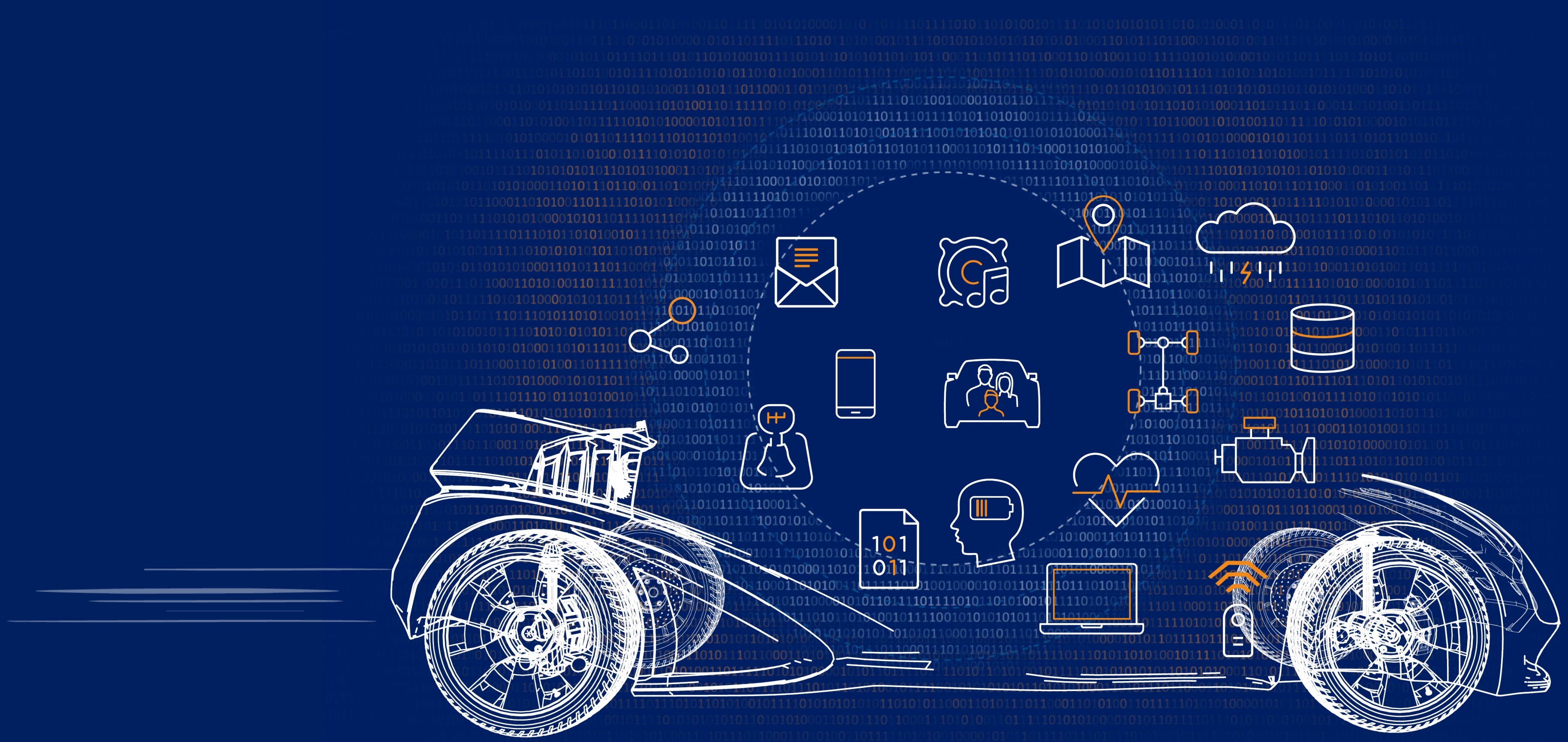
Data Monetization Services

Assistance Services

Vehicle Monitoring Services

Remote Access Services

Provide to the **end customer** with the opportunity to make their vehicle **as unique as they desire**



Thank You!

Dionis Teshler, CTO
dionis@guardknox.com
+1-213-599-6261