

The Rise and Evolution of Gateways and Vehicle Network Processing

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SECURE CONNECTIONS
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Agenda

- What is a Automotive Gateway?
- Gateway Evolution
 - Overview, Market Trends, Architecture
- NXP Gateway Reference Solutions
- Summary
- For More Information

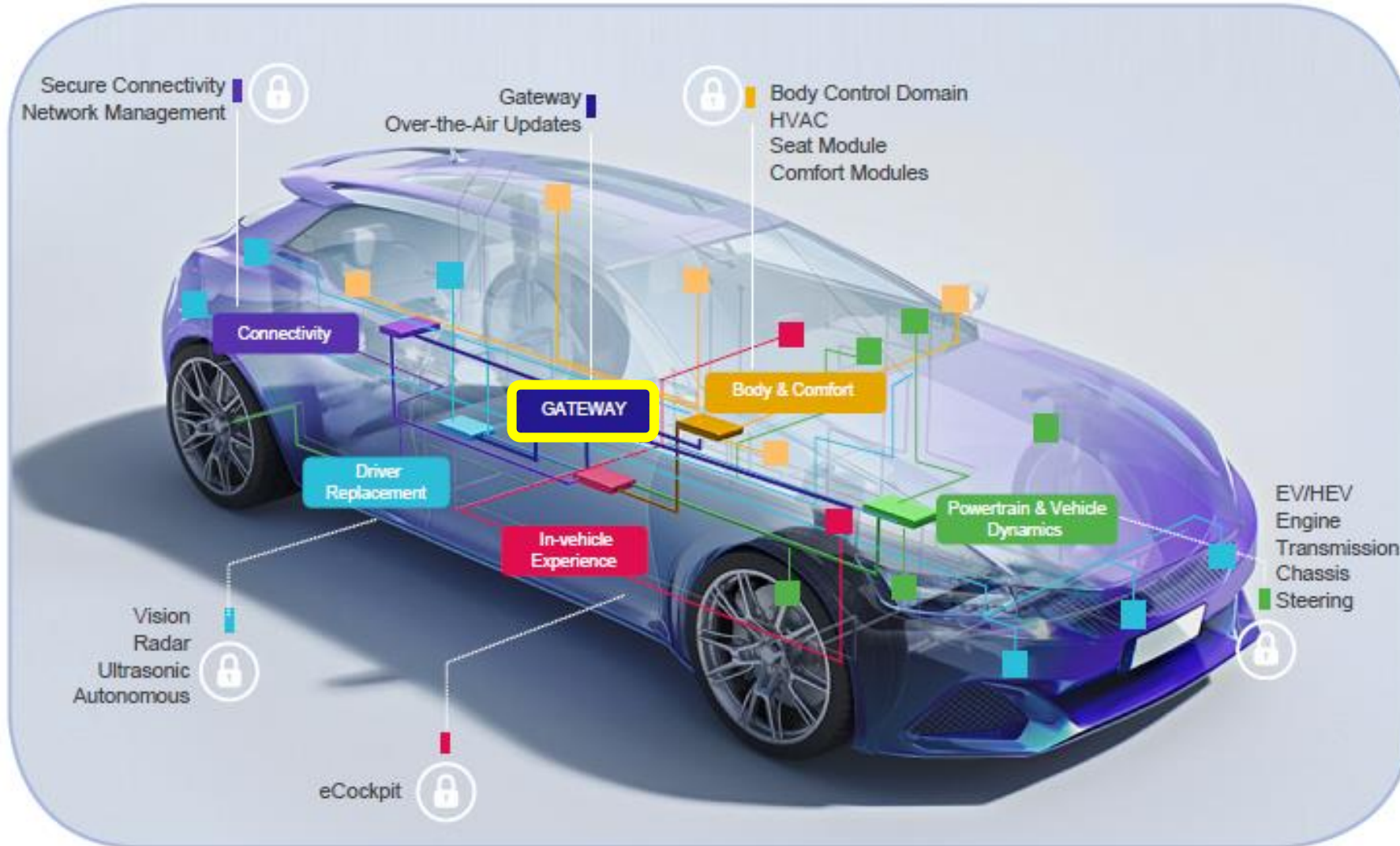
What is an Automotive Gateway?



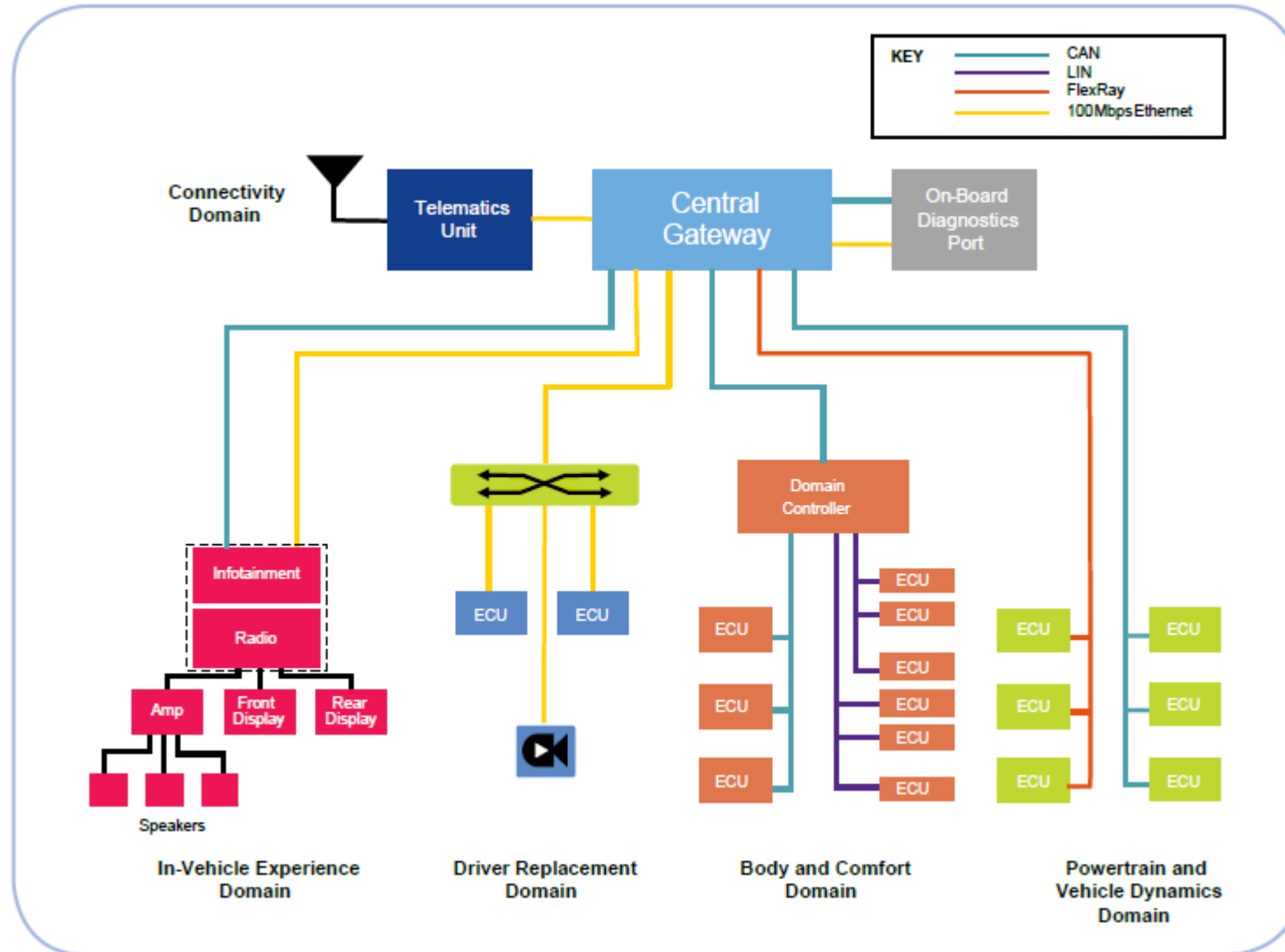
<https://www.nxp.com/video/:AUTOMOTIVE-GATEWAY-VID>

Local Video

The Automotive Gateway is Central to the Vehicle



Automotive Gateway is Central for Vehicle Communications



Key Gateway Functions

Gateway Capability	Description
Protocol Translation	Translating data and control information to/from incompatible networks to enable communications between them
Data Routing	Routing of data on a path to reach its intended destination. It may be on different networks requiring protocol translation.
Diagnostic Routing	Routing of diagnostic messages between external diagnostic devices and ECUs which may involve translation between diagnostic protocols such as DoIP and UDS.
Firewall	Filtering inbound and outbound network traffic based on rules, disallowing data transfers from unauthorized sources. Advanced firewalls may include context-aware filtering.
Message Mirroring	Capturing data from received interfaces to transmit over another interface for diagnostics or data logging (storage)
Intrusion Detection	Monitoring network traffic for anomalies that may indicate intrusion
Network Management	Manages the states and configuration of the network and ECUs connected to network, and support diagnostics
Key Management	Secure processing and storage of network keys and certificates
OTA Management	Managing remote OTA firmware updates of ECUs within the vehicle that are accessible from the gateway

Gateway Evolution – Overview



Automotive Industry Megatrends



Autonomy

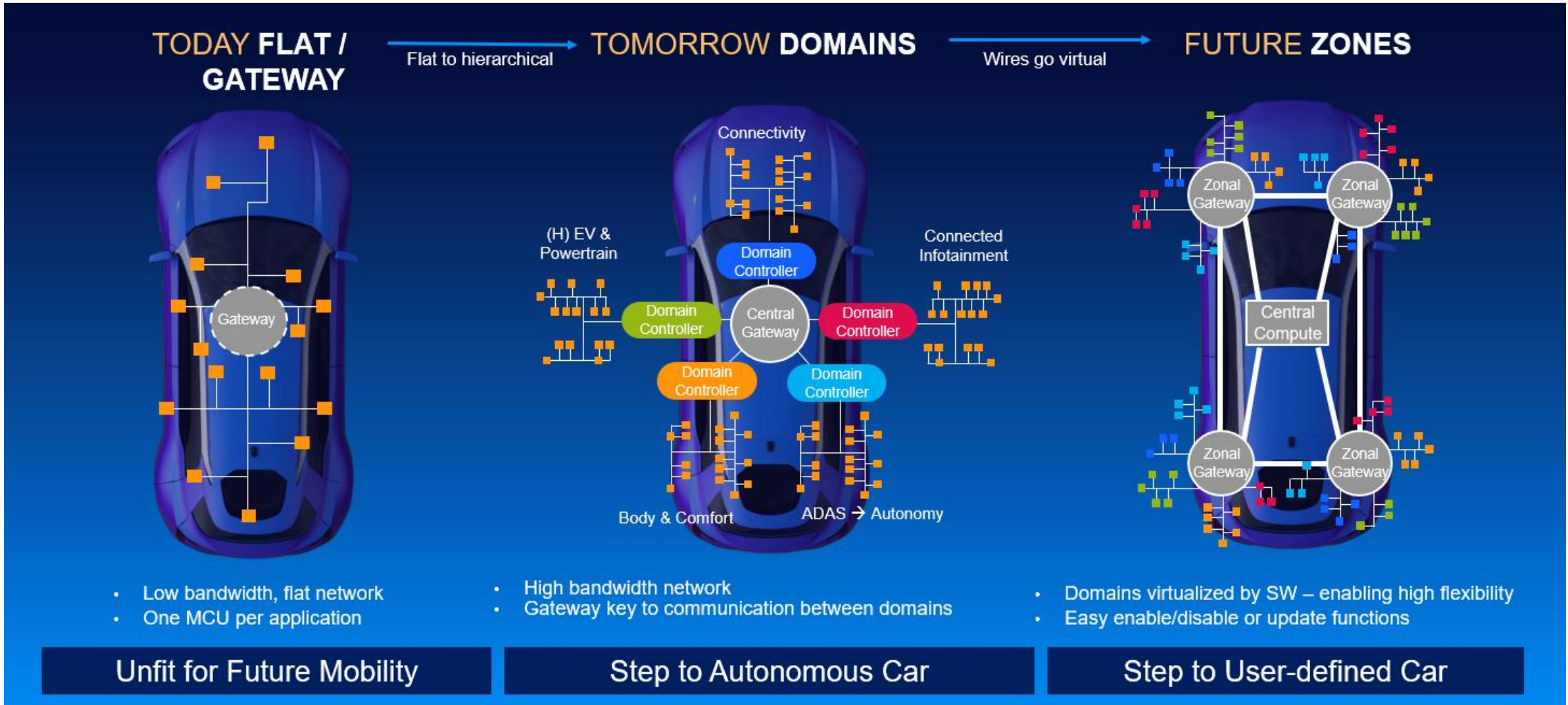


Electrification

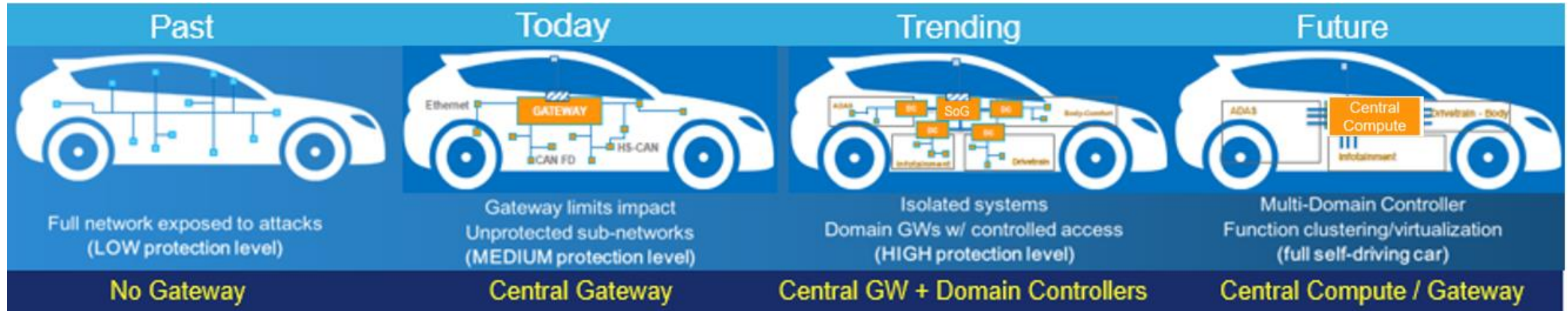


Connectivity

Megatrends Force Vehicle Architecture Transformation



Gateway Rise and Evolution



- No or limited connectivity



- High-speed wireless interfaces (4G→5G, Wi-Fi)

- No or limited security



- High security, isolation, public key crypto, contextual firewall, intrusion detection

- Basic routing



- Advanced routing, vehicle OTA, analytics, ECU consolidation, new services

- Limited bandwidth / scalability
(kilobit / Megabit interfaces)



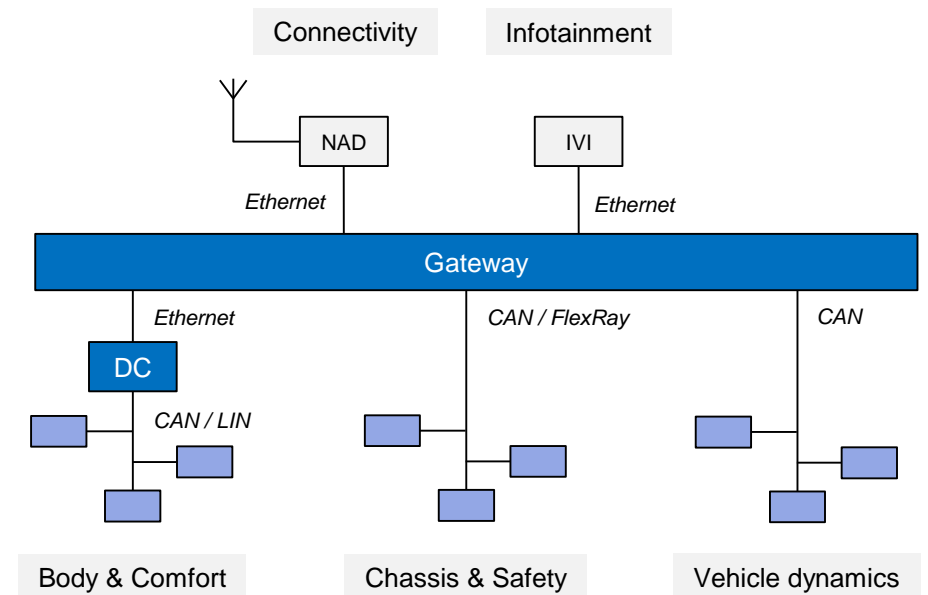
- High-bandwidth, scalable architectures
(Gigabit interfaces)

Key Gateway Use Cases

- **The Gateway is becoming the central, critical component in vehicle architectures**
 - System security, OTA management, applications/services, analytics, vehicle compute, and more
- **Gateways are shifting to software-centric solutions → introducing new services**
 - Enables OEM differentiation, operational efficiency, and new revenue generation
 - Improves customer satisfaction
- **Protocol and Data Translation**
 - Network protocol-to-protocol translation
 - Raw data-to-contextual information
- **Network Security**
 - High-performance contextual firewall
 - Intrusion Detection and Prevention System
 - Authentication and Secure Messages
 - Network Key Management
- **Over-the-Air (OTA) Updates Management**
 - Remote upgrades (new features, safety/security patches...)
- **Apps Processing / Services**
 - ECU consolidation
 - Analytics (edge processing and edge-to-cloud)
 - Remote monitoring and condition-based maintenance (prognostics / vehicle health monitoring)
 - Centralized functions (vehicle identity, power strategy...)
 - Agile deployment of future functionality

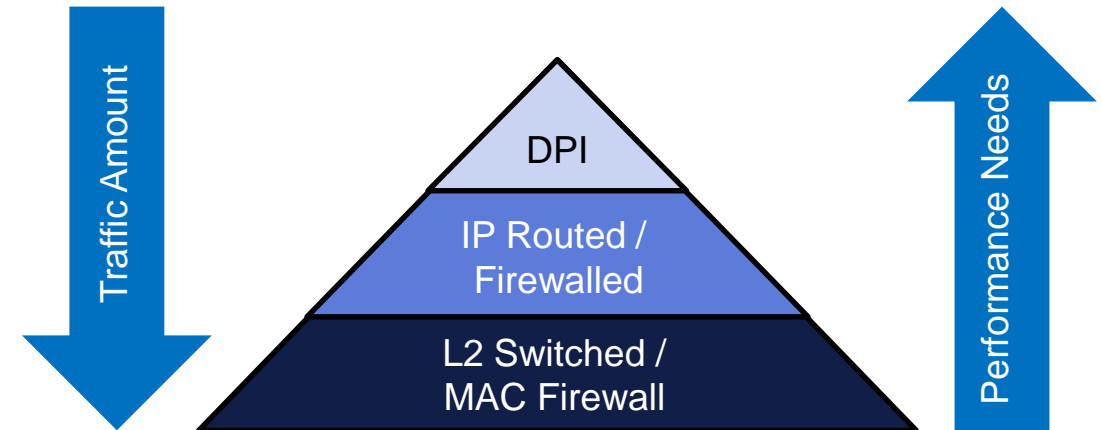
Market Trends: Networking

- Move to a predominately **Ethernet backbone**
 - Bandwidth needs – autonomous driving platforms, infotainment
 - Domain controller approach – domain isolation; simplifies logistics of deploying vehicle platform
 - **IP Routing, VLAN & >L3 firewalling** to isolate & protect Ethernet domains
 - Diagnostics over IP (DoIP) usage widespread
- Hybrid Approach during 2020 to 2025
 - Typical: **3-5 Ethernet domains + 10+ CAN**
- # of CAN channels increasing
 - Isolation of increasing number of ECUs
 - Up to ~175 ECUs in some high-end vehicles!



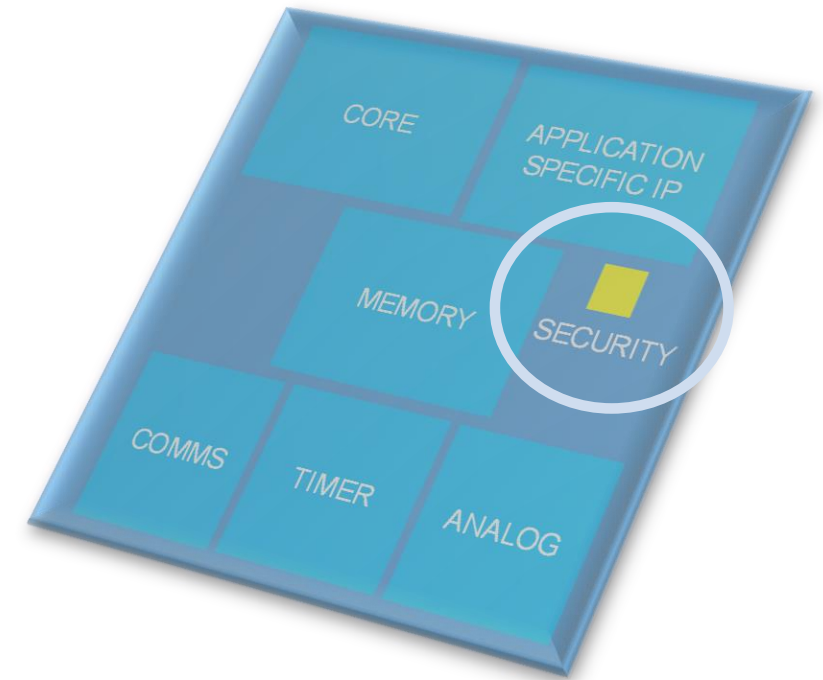
Market Trends: Network Security

- Gateway is considered as a **central location for security**
 - Policing vehicle information, monitoring traffic between networks, security key management
- **Growth of Ethernet**
 - Wider range of known attacks
 - Ways to protect:
 - Layered network hierarchy
 - Contextual firewalls, deep packet inspection (DPI), etc...
 - Firewalling & Security brings **significantly greater performance requirements** than CAN
 - Need for a processor with **network security in mind**



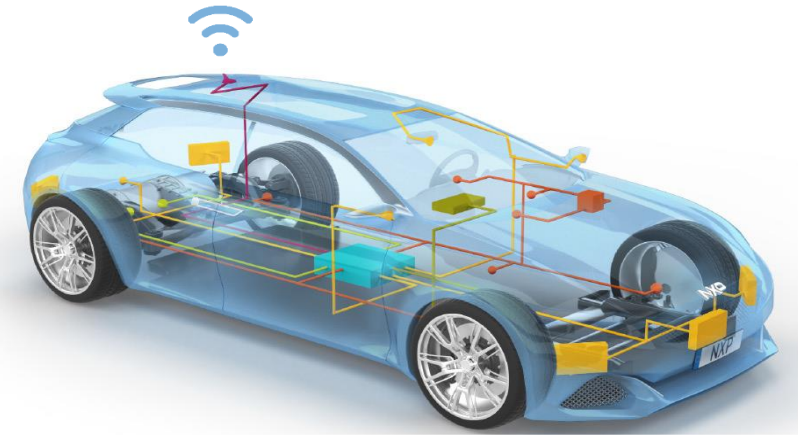
Market Trends: Processor Security

- Industry attention after security hacks publicized in 2015
- Need to secure gateway processors from malicious attacks
 - Taking control of the ECU
 - Stealing Intellectual Property
- Connected services driving additional layers of security in the gateway
 - Public Key handling acceleration, connecting through internet
 - Physical protection of keys guaranteed strong root of trust. Extremely high value keys that need protected



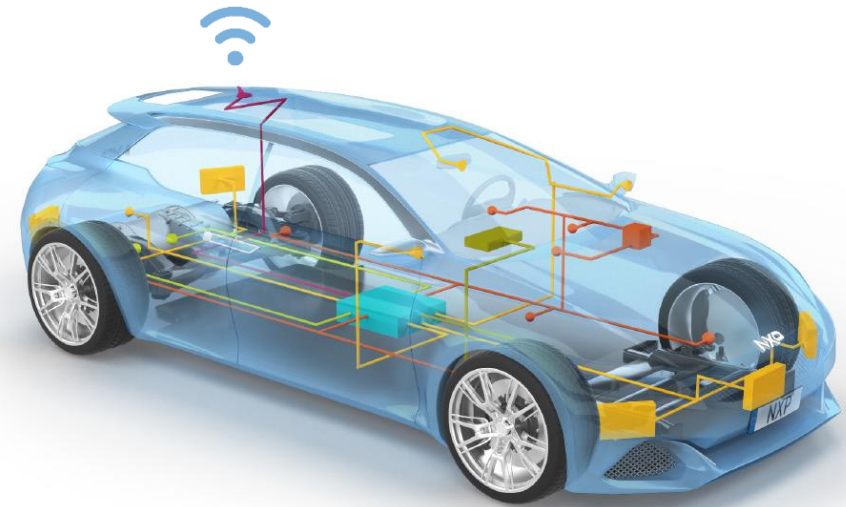
Market Trends: Over-The-Air (OTA)

- Over-the-Air firmware/software updates is a key trend in the industry
- Trend to move OTA Management function in Gateway ECU
 - Centralized management of OTA deployment in-vehicle
 - Interface to OEM servers
 - Security is paramount
- Utilizing OTA mechanism to **deploy new features via SW in field** (Agile SW deployment)
 - Build performance overhead into hardware
 - In-field, test & deploy new customer features as use cases emerge



Market Trends: Connectivity

- **Trusted & untrusted connectivity**
 - Untrusted infotainment (IVI) system
 - Connected car vs In-Vehicle Network
 - New services being introduced to vehicles (e.g., OTA)
- **Move to separation of connectivity**
 - Trusted: Gateway
 - Untrusted/Consumer: IVI
- **Enabling new features**
 - OTA Updates
 - Remote Diagnostics - Tester in gateway (Diagnostics over IP)
 - IoT Connectivity - Translation of raw data into rich information
 - Cloud Offload – e.g., Analytics, Modelling vehicle behaviour



Market Trends: Processing

- 1000's of DMIPS performance needed to support future service-oriented gateway providing new capabilities and services
- ECU consolidation: Feature deployment by SW package rather than new ECU
- Data Analytics: Descriptive / Diagnostics / Predictive
 - Edge analytics
 - Cloud connectivity
 - Machine Learning (ML)

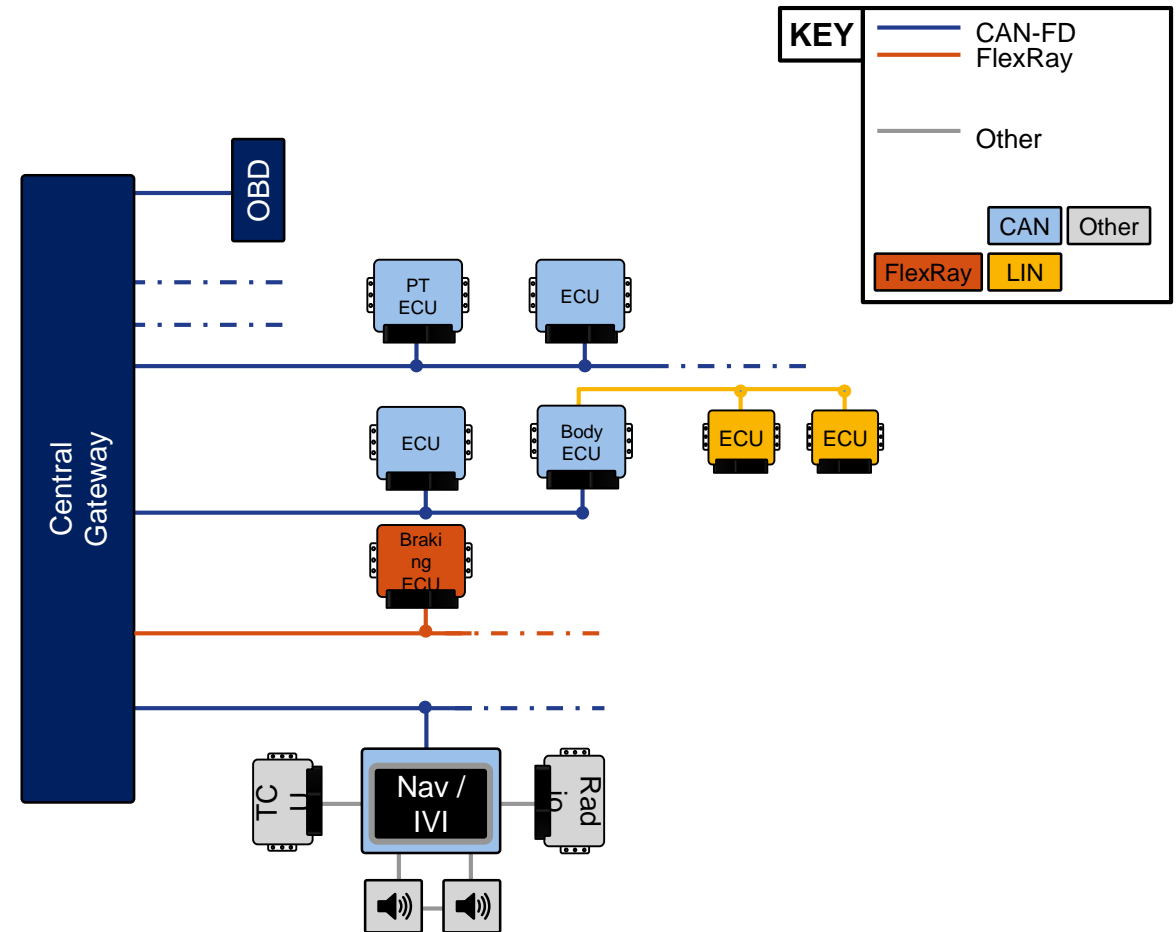


Gateway Evolution – Architectures



CAN Central Gateway Architecture

- **Legacy Automotive Networks**
 - Typically 3-8 CAN networks
 - Typically 1-2 FlexRay networks
- **Increased Bandwidth**
 - but, small compared to consumer / networking world
 - Proprietary protocols for higher bandwidth
- **Physical Isolation**
 - Functional domains
 - Safety / Non-safety
- **Gateway Role**
 - Firewall internal traffic
 - Protocol translation



Hybrid Ethernet Architecture

- Legacy + Ethernet Networks

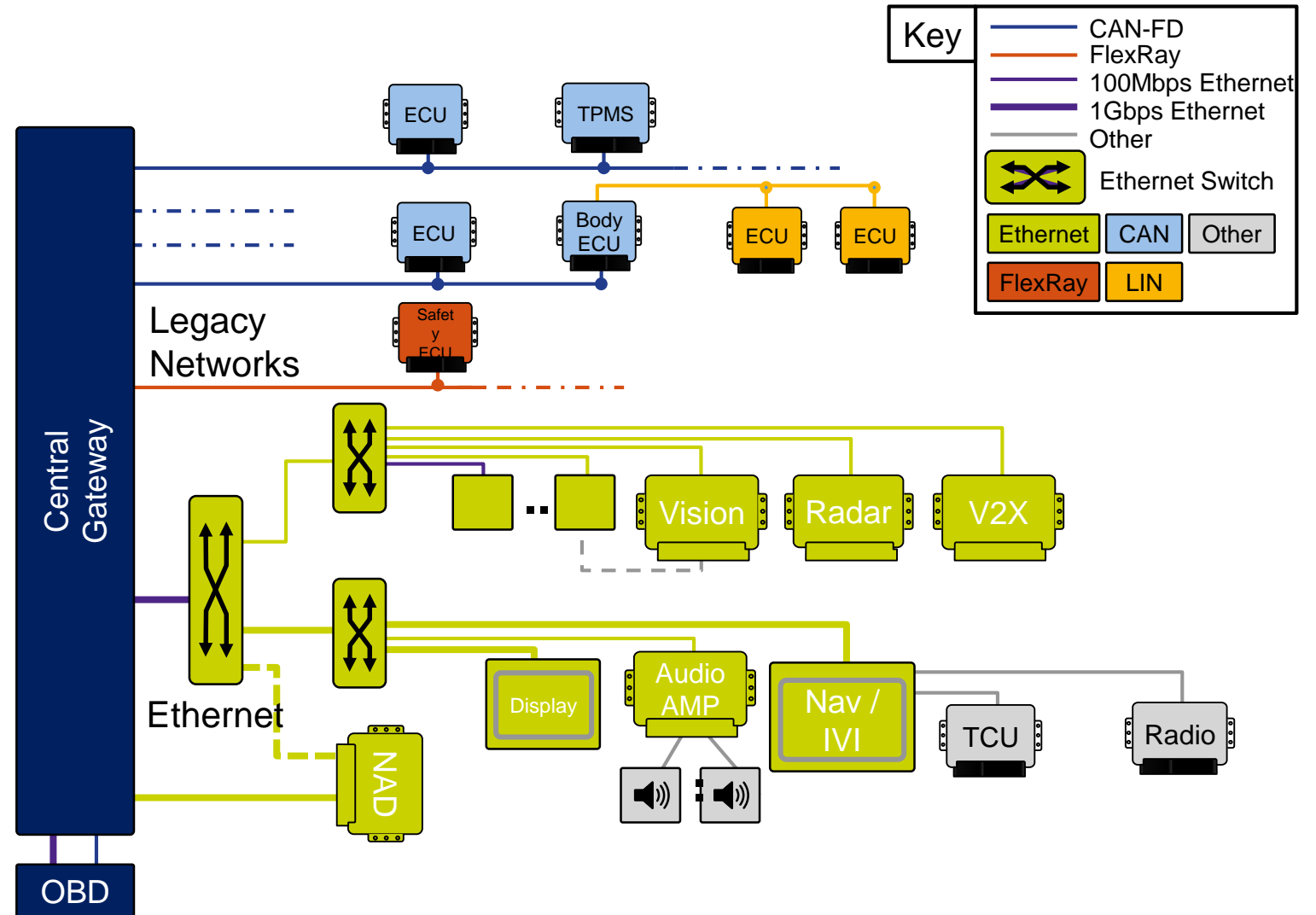
- CAN, FlexRay & Ethernet

- High-bandwidth Data

- 100Mbit → 1Gbit Ethernet
- ADAS and Infotainment drive higher data rates
- Improved ECU program time in factory

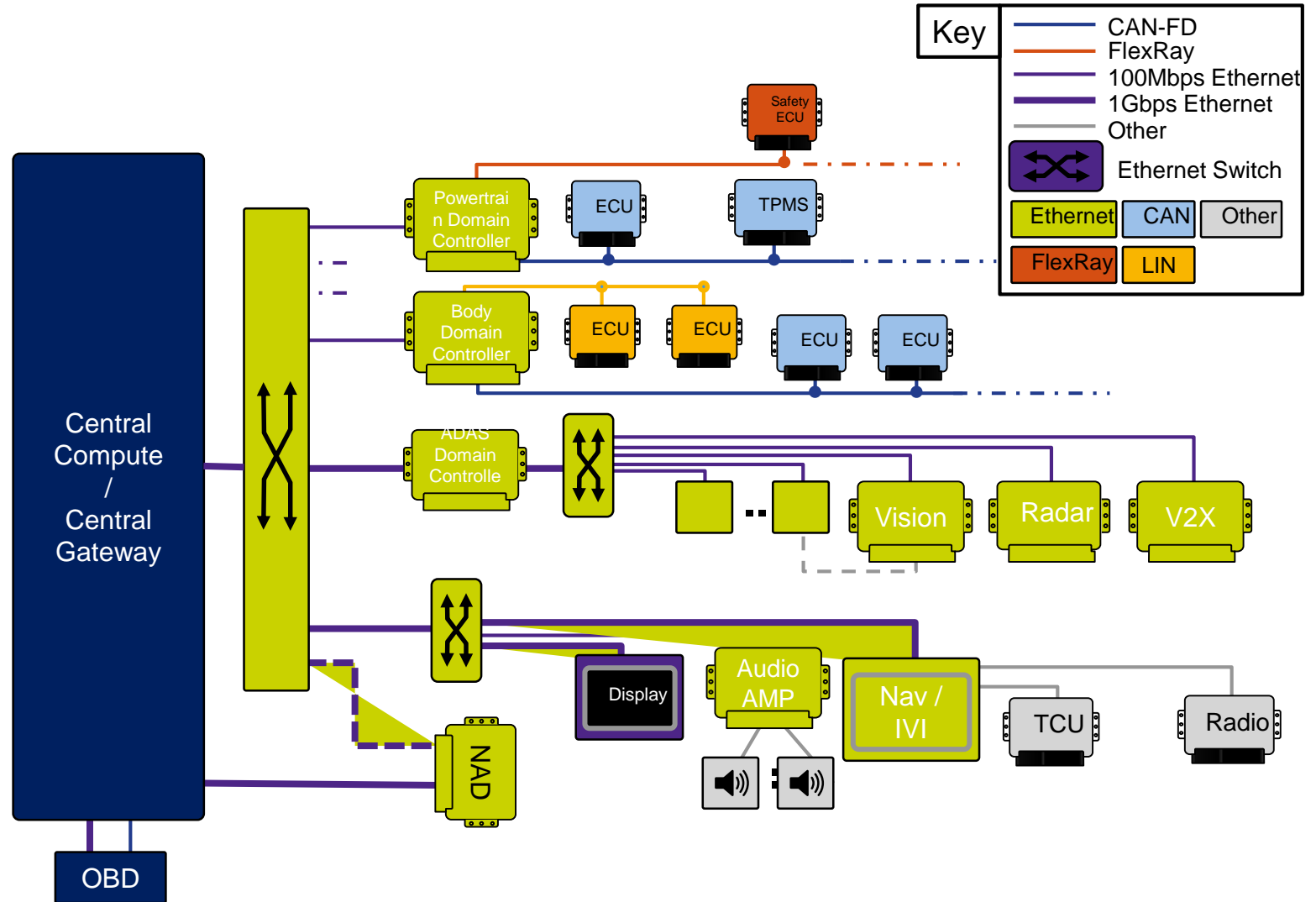
- Gateway role

- Firewall internal & external
- Efficient protocol translation
- ECU consolidation
- New apps & services



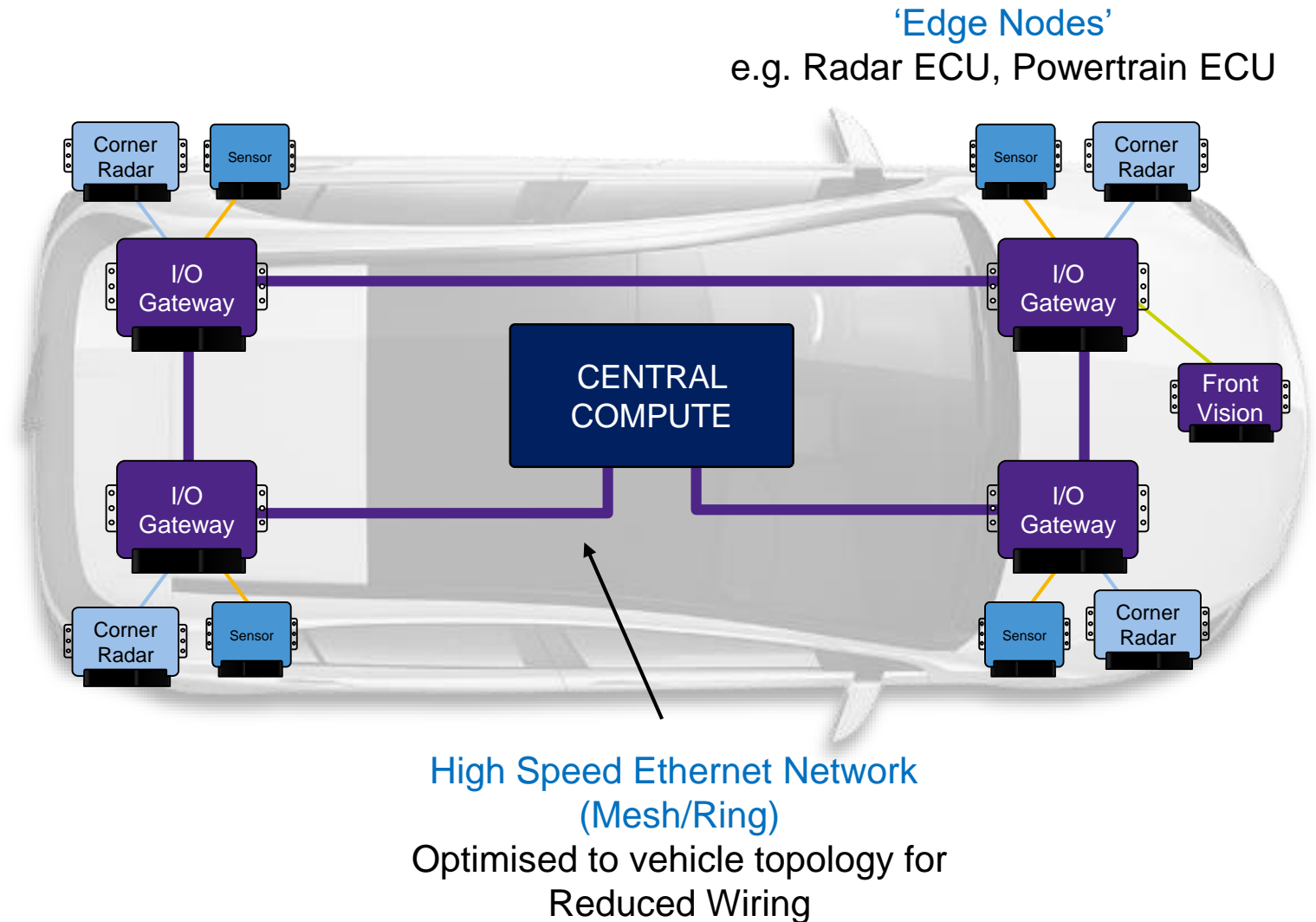
Ethernet Backbone with Domain Controllers

- Ethernet Backbone with Domain Controllers
 - ECU consolidation
 - Distributed gateway
- Central Compute
 - Strategy / Decision making
 - Distributed vs Centralized



Central Compute Architecture

- **Central Compute + I/O Gateways**
 - No functional domains
 - Strategy for vehicle fully owned by Central Compute
- **I/O Gateways Connect Edge Nodes to Central Compute**
 - Distributed processing
 - Optimize network utilization
- **Benefits:**
 - Network architecture optimised to vehicle topology
 - Less wires (less weight, power, cost)



Moving Towards Central Compute: “Server in the Car”

- Network Security
 - Intrusion Detection and Prevention
 - Firewall
- Applications Server
- Integration of Cloud and Fog Services into the Vehicle Architecture
- Proliferation of PHY Technologies
 - 100Base-T1 -> 1000Base-T1, 10 Mbps, 10 Gbps, 25 Gbps, 10GBASE-KR (802.3ap), ...
- Communication Paradigms Evolve
 - Service-based versus signal-based
 - Authentication
 - Encryption

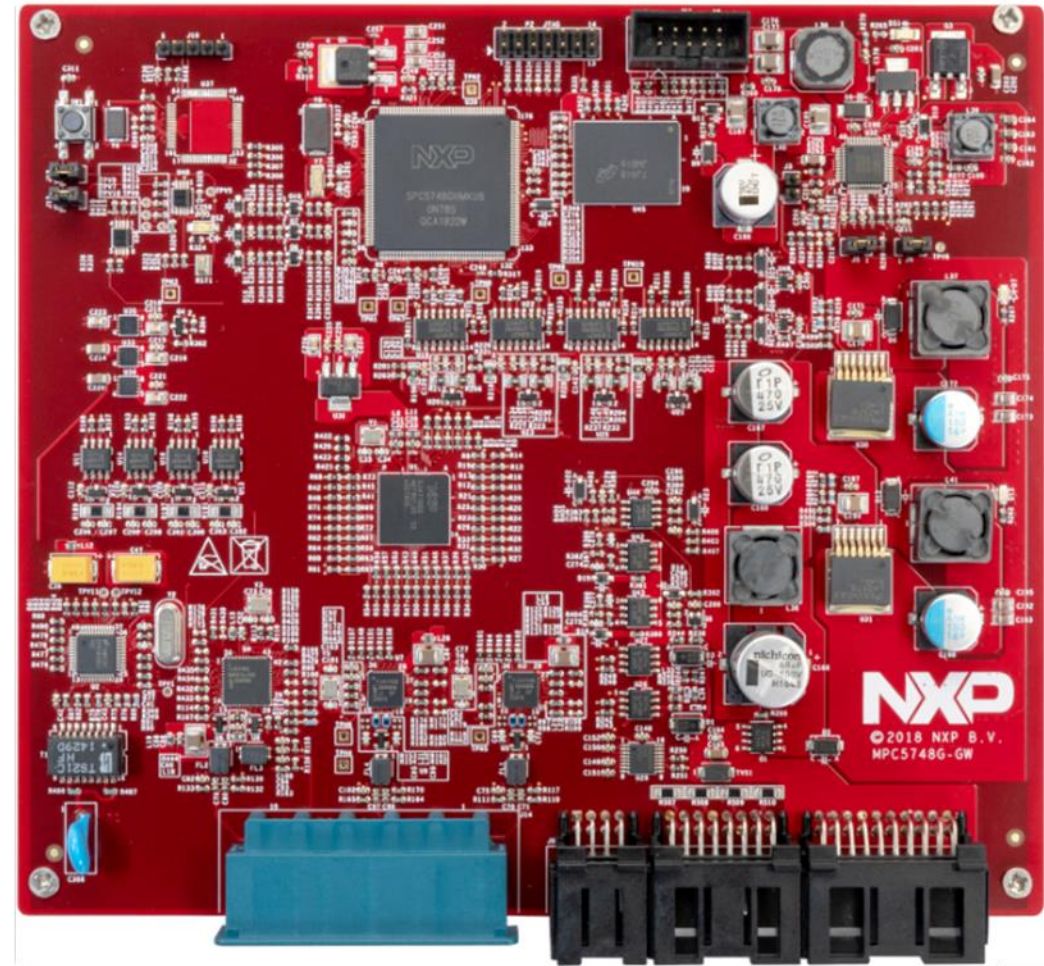
NXP Gateway Reference Solutions



NXP Secure Ethernet Gateway Reference Design

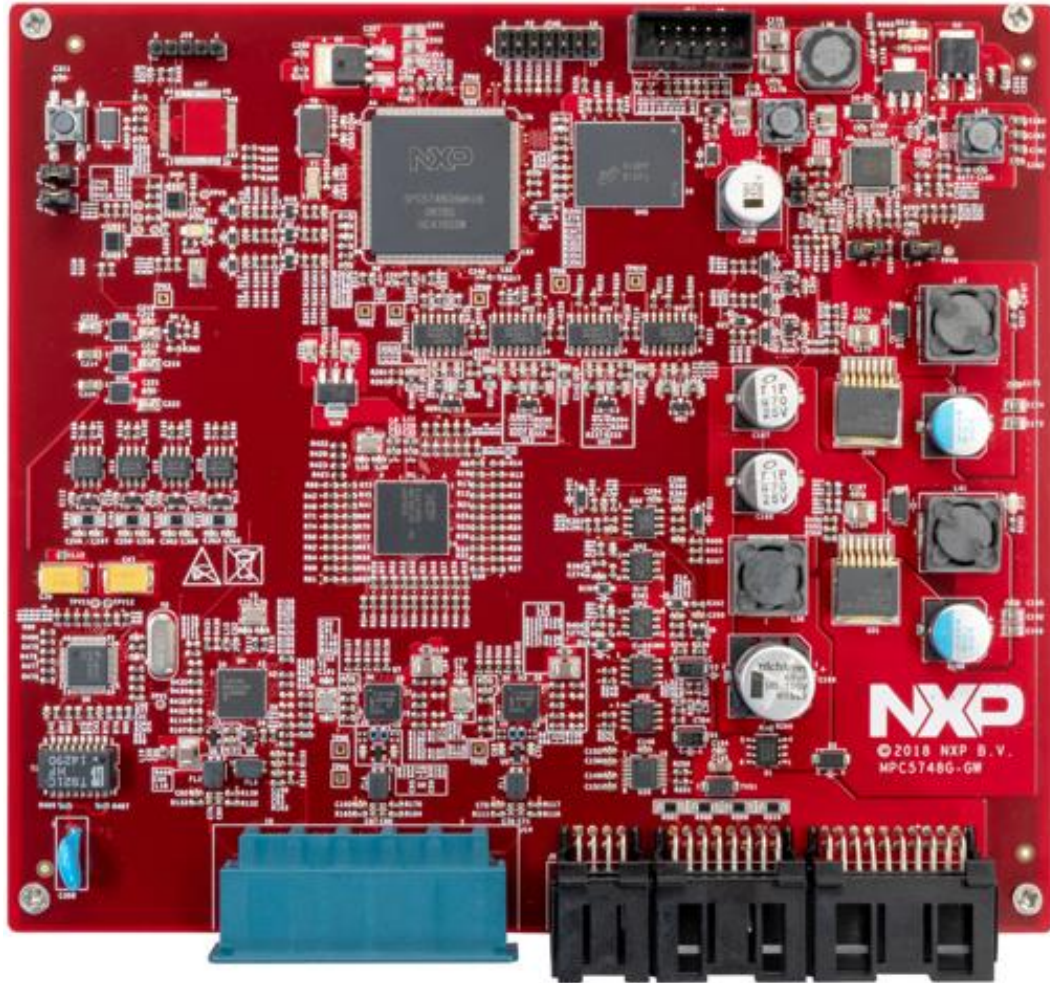
Hardware Features

- 5 x 100Mbit/s Ethernet
 - 4x100Base-T1
 - 1x100Base-TX for Diagnosis/SW Update
- 8 x CAN (CAN-FD compatible)
- 2 x LIN
- eMMC (4GB)
- 3 x PWM / Digital IN
- 2 x Analog IN
- 2 x HS Switch OUT
- Wake IN/Wake OUT
- 1 x RS232 (option)
- JTAG Debug



Based on NXP MPC5748G Gateway Microcontroller

MPC5748G-GW-RDB



Information:

[MPC5748G-GW-RDB Secure Ethernet Gateway](#)

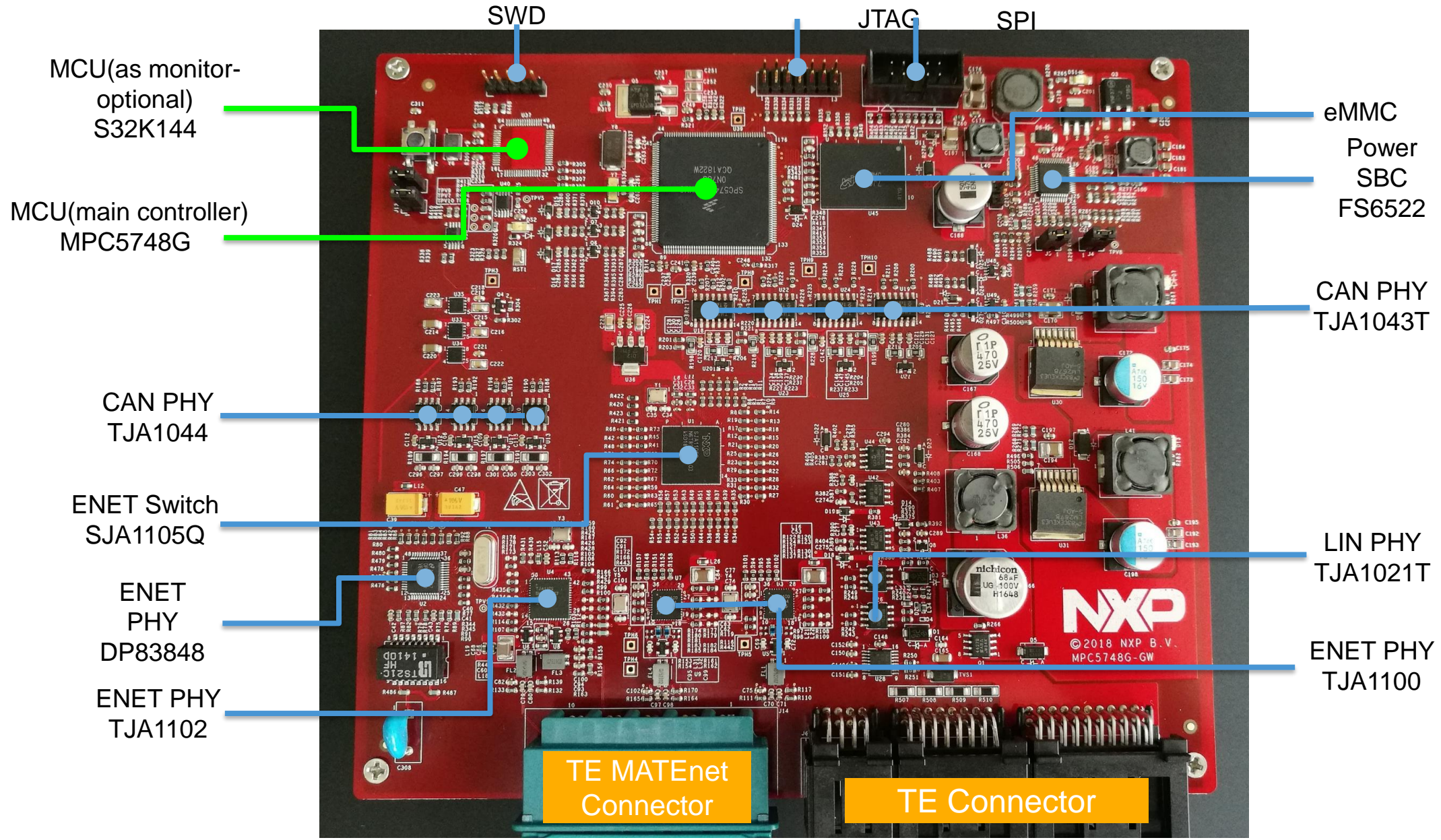
NXP Components:

MPC5748G (Gateway MCU), S32K144 (Monitor MCU), FS6522 (Power SBC), SJA1105Q (5-Port Ethernet switch), TJA1044 (CAN PHY), TJA1043 (CAN PHY), TJA1021T (LIN PHY), TJA1102 (Ethernet PHY), TJA1100 (Ethernet PHY)

Cost: \$449

How to buy: [NXP.com](https://www.nxp.com)

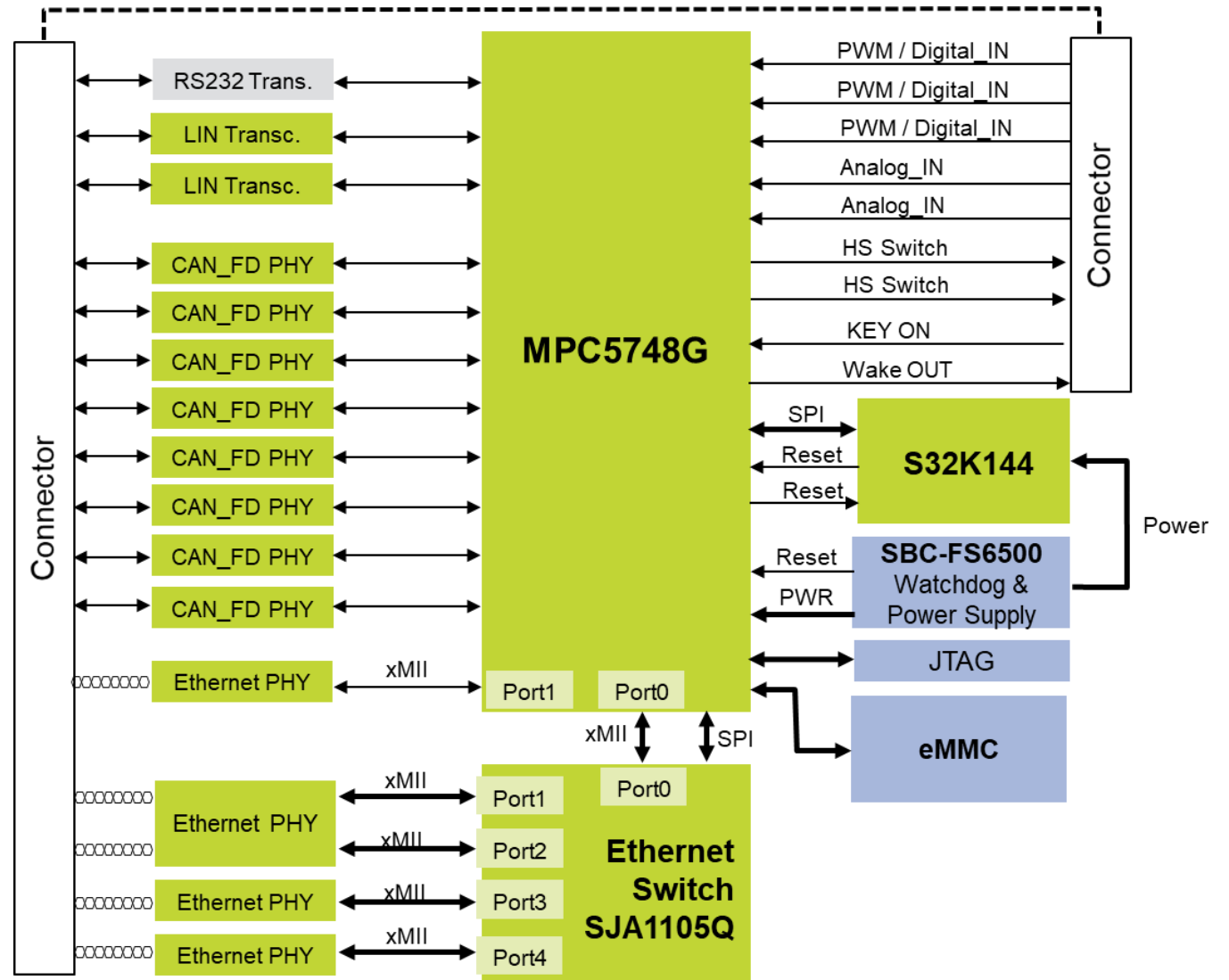
Get to Know the MPC5748G-GW-RDB



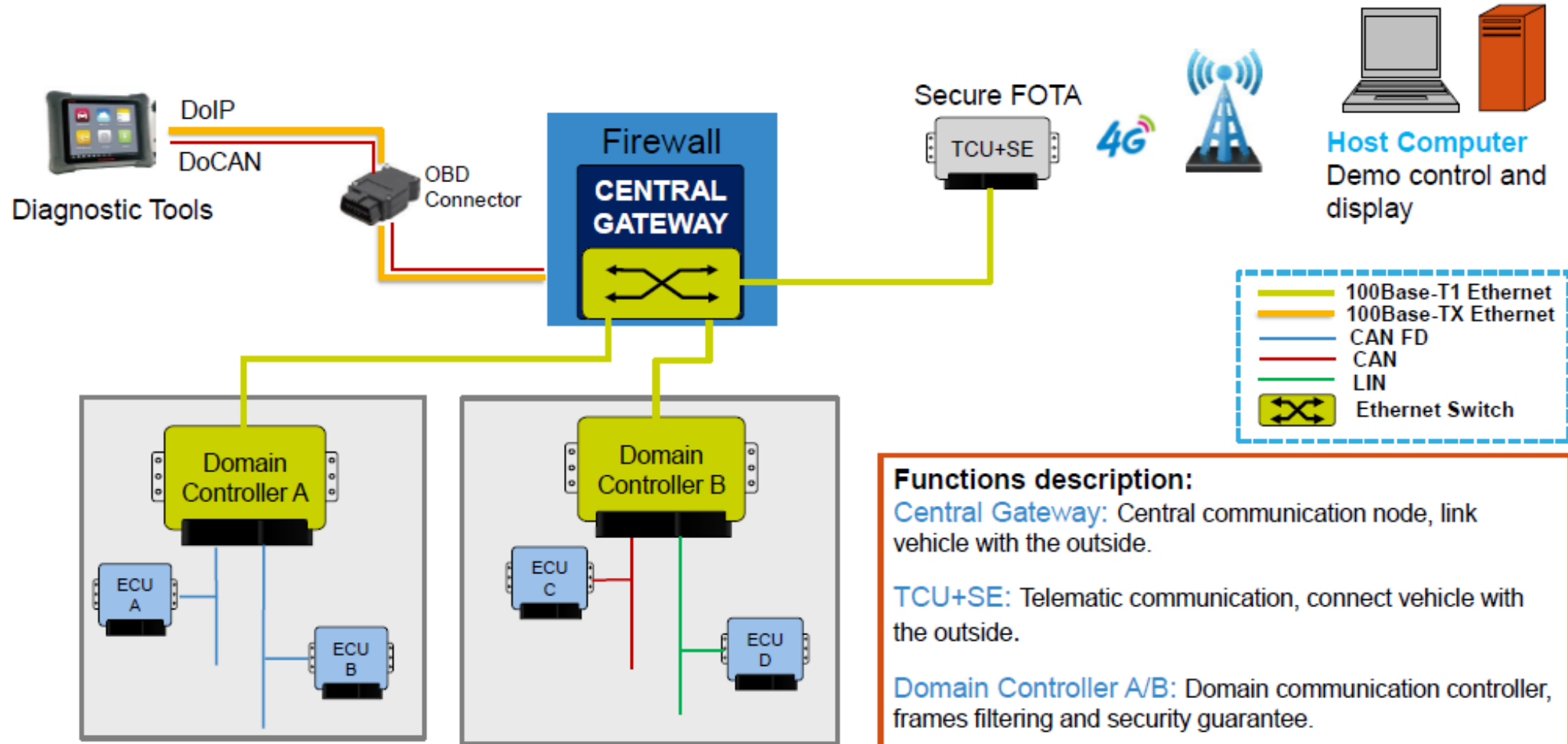
NXP Secure Ethernet Gateway Block Diagram

Hardware Resources:

- 5 x 100Mbit/s Ethernet
 - 4x100Base-T1
 - 1x100Base-TX for DoIP
 - 8 x CAN(CAN-FD compatible)
 - 2 x LIN
 - eMMC (4GB)
 - 3 x PWM / Digital IN
 - 2 x Analog IN
 - 2 x HS Switch OUT
 - Wake IN/Wake OUT
 - 1 x RS232
 - JTAG Debug
- Support ISO26262 functional safety features:
- ASIL D Safety power SBC FS65xx
 - ASIL B MPC5748G as main MCU
 - ASIL B S32K144 as sub-MCU for monitoring/supervising
 - ASIL A SJA1105Q 5-ports Ethernet Switch
 - Fault management and reset logic circuit



Gateway Demo Architecture



MPC-LS Vehicle Network Processing Solution

- Enables Next-gen VNP Solutions

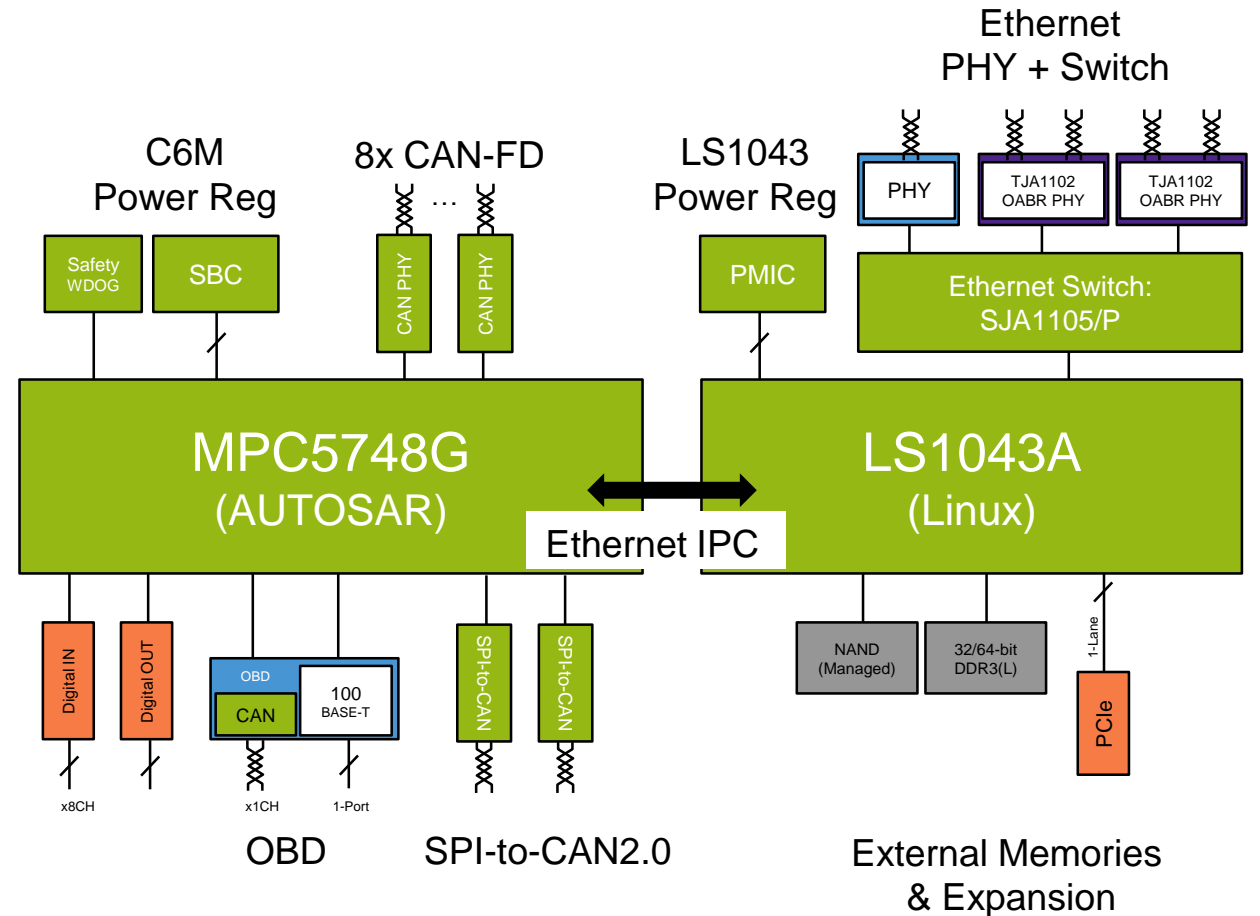
- Automotive Microcontroller + Network Processing
- (Gigabit Ethernet Packet Routing) + Applications
- MPC5748G + LS1043A (MCU + MPU)
- Available today

- Feature Set

- CAN Signal Gateway (ASIL B)
- 4x Arm Cortex-A53 (LS1043A)
- Packet Forwarding Engine

- OS Support

- AUTOSAR: Real-time CAN gateway
- FreeRTOS: limited support
- Linux: Ethernet routing, applications processing



MPC-LS Vehicle Network Processing (VNP)

Reference Design Board (RDB)

- Real-time Gateway Processing
- Applications Processing
- Gigabit Ethernet Acceleration
- Embedded Security

Part Number: [MPC-LS-VNP-RDB](#)

- Price: \$749 Available: July'19 for approved customers
- Reference Design: 90% of BOM is Automotive Grade
- Includes SW enablement and demonstrations

NXP Components:

- MPC5748G (MCU), LS1043A (Comms Processor), SJA1105SEL (5-port Ethernet switch), PF8200 (Power Management IC)
- TJA1081TS (FlexRay), TJA1024HG (Quad LIN), TJ1102HN (Dual Ethernet PHY), TJA1048T (Dual CAN Transceiver)
- NTS0102 (Dual Supply Transceiver), NX5P3090UK (USB Power Switch)



www.nxp.com/MPC-LS-VNP-RDB

MPC-LS VNP Reference Design Board Key Components

LS1043A Console connector

Dual-stacked USB connector

RGMII EC1 and EC2 connector

Aquantia 10G connector

Auto Ethernet Port 1

Auto Ethernet Port 2

RGMII Ethernet Phy connected to SJA1105 switch

LS1043A

Power

Fault/Power LEDs

M.2 connector (PCIe)
for SSD, peripherals

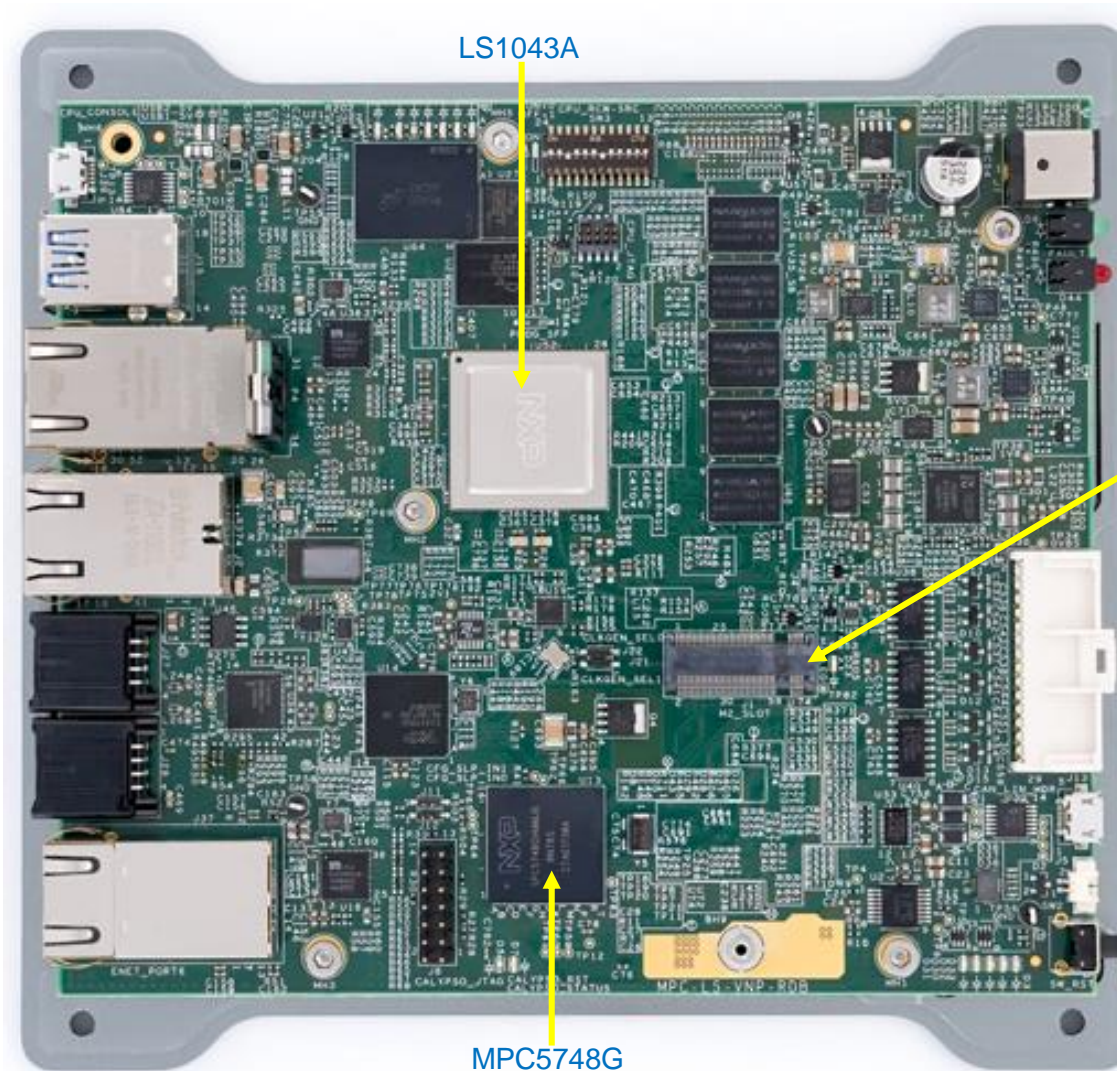
CAN
connector

LIN connector

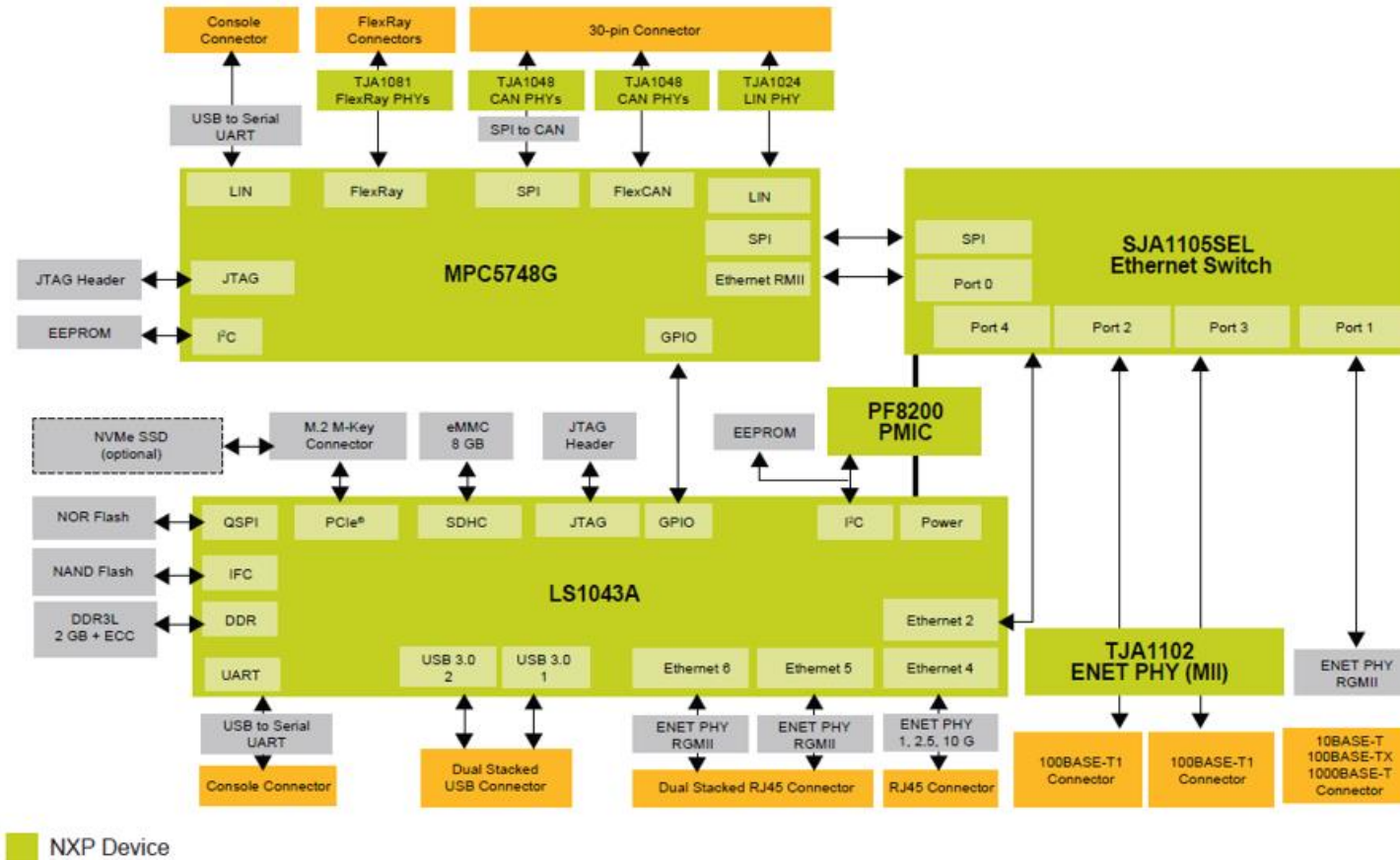
MPC5748G
Console connector

Reset button

MPC5748G



MPC-LS-VNP-RDB Block Diagram



Processors

- MPC5748G Automotive Microcontroller
- LS1043A Communications Processor

Memory

- 2 GB DDR3L @ up to 1.6 GT/s
- 1 GB NAND flash
- 64 MB Serial NOR flash
- 8 GB eMMC

Storage

- M.2 M-Slot for optional PCIe SSD

NXP Support Devices

- PF8200 Power Management IC
- SJA1105SEL Ethernet Switch
- TJA1024 LIN PHY
- TJA1048 CAN PHY
- TJA1081 FlexRay PHY
- TJA1102 100 Mbps Ethernet PHY

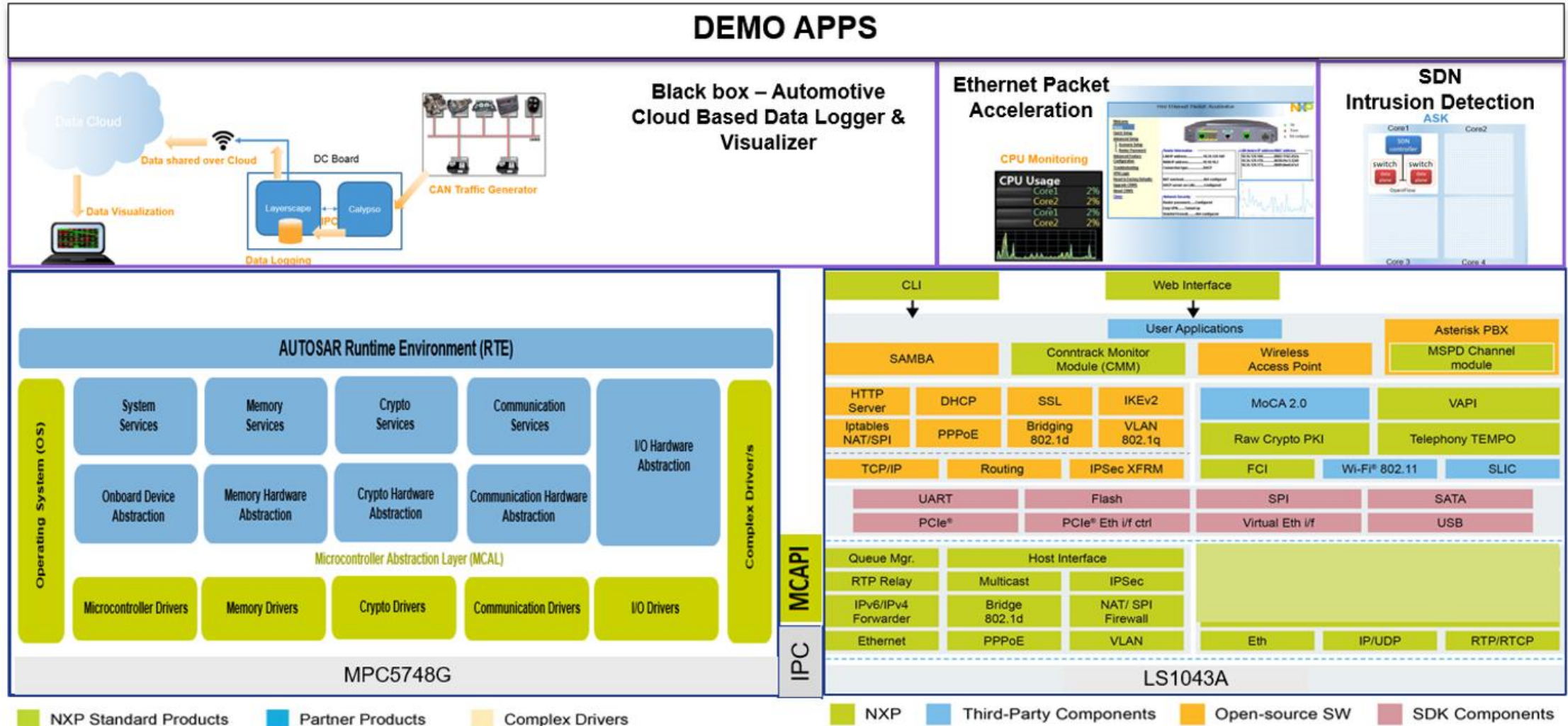
PCB

- Single 6-layer board ~ 6.1 x 6.4 inches
- 90% of BOM Automotive Grade

Demonstration Software



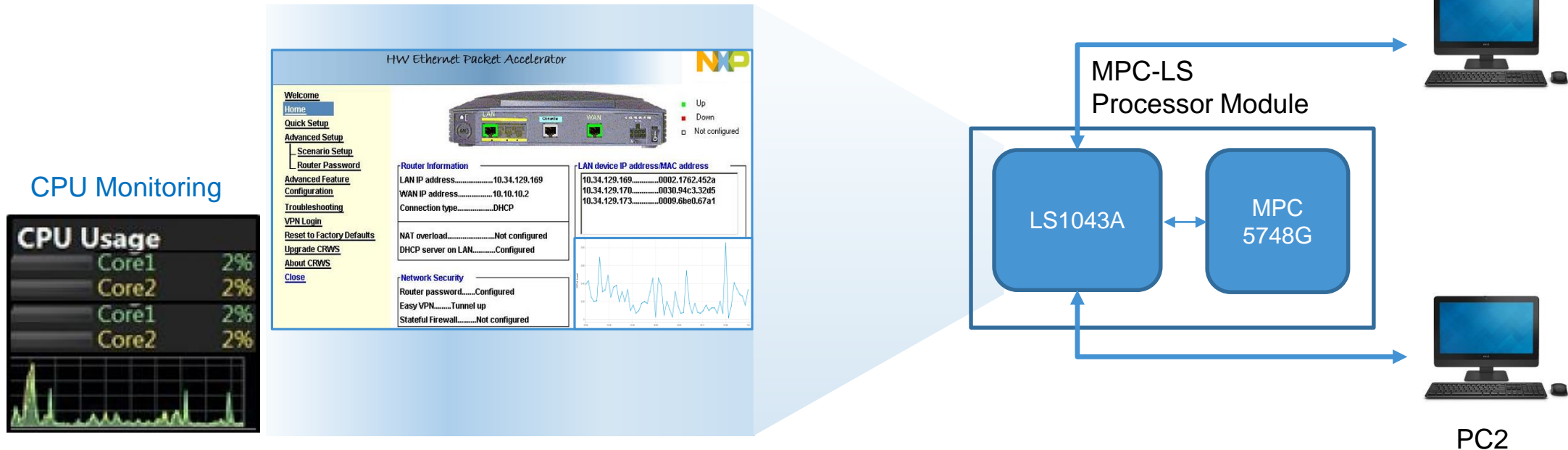
MPC-LS Demo Applications Software



Value Proposition:

- Ethernet Packet Acceleration vs SW-based competition

Ethernet Packet Acceleration



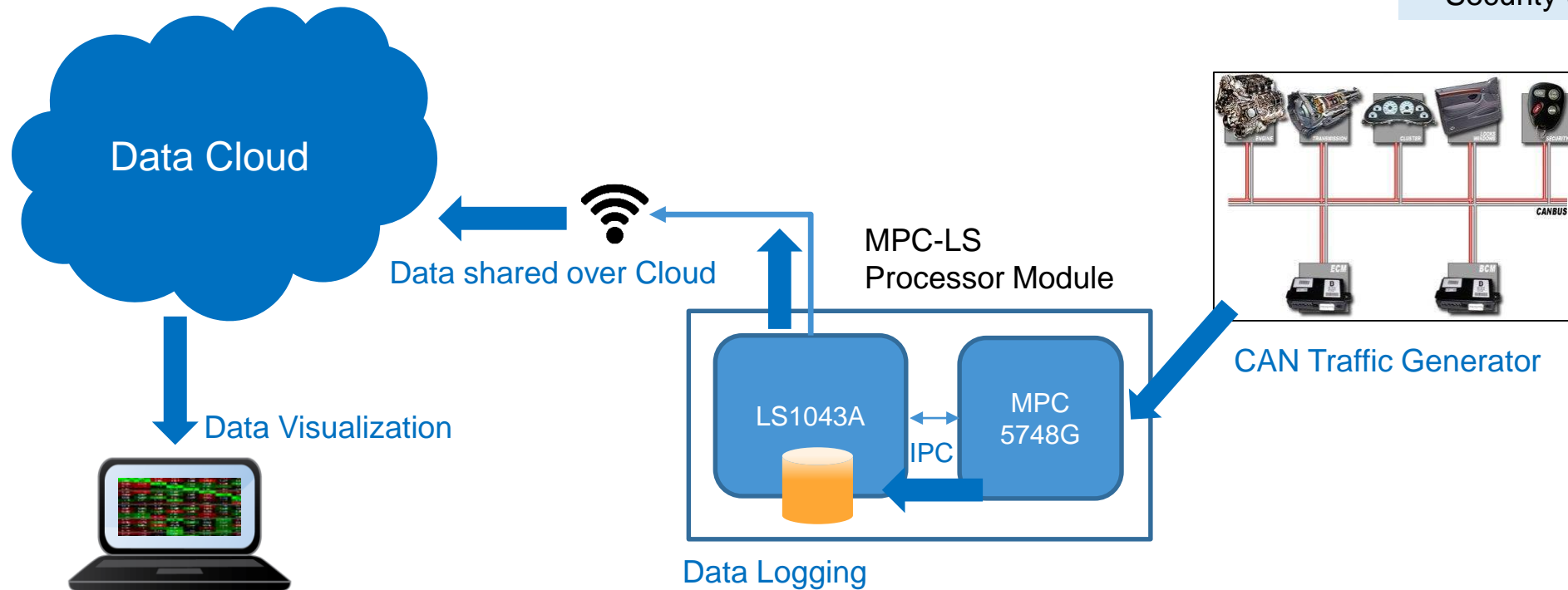
Web-based Application with below functionalities:

- ❑ Demonstrating packet acceleration during network load
- ❑ Enabling and disabling of HW acceleration (Slow Path/Fast path with load on primary cores)
- ❑ Realtime CPU Load monitoring
- ❑ Router setup/configuration connecting two PCs

Automotive Data Logger

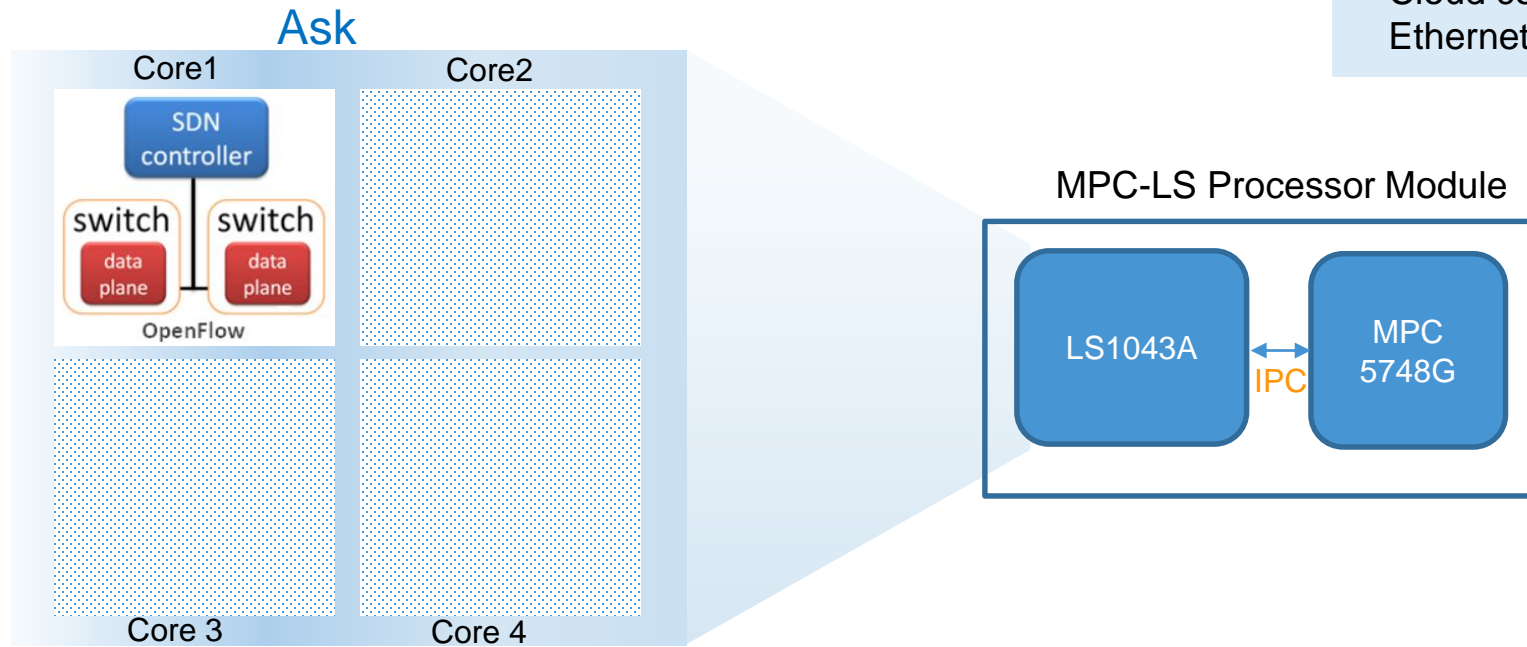
Value Propositions:

- Cloud connectivity (Apps Processing)
- PCIe memory
- MCU to MPU (CAN-Eth)
- Security (CAN, Eth & Cloud)



- ❑ Vehicle Health Parameters recorder - "relevant" data from Vehicle logged into a mass storage.
- ❑ Calypso receiving the CAN data from an external CAN traffic generator.
- ❑ Data transmitted via IPC to Layerscape for logging.
- ❑ Logged Data shared over cloud
- ❑ Data fetched from cloud for monitoring.

Software Defined Network (SDN) in Vehicular Networks



Value Propositions:

- Cloud controlled firewall: Connectivity, Ethernet, Apps Processing.

Full functional SDN Stack showcased on one Arm Cortex-A53 core in Layerscape

Summary



Summary

- Automotive Gateways are critical for providing secure communications between vehicle domains, but are evolving to provide more capabilities:
 - Over-the-Air Updates, Intrusion Detection, Analytics, Vehicle Health/Prognostics, Apps/Services...
- Multiple approaches to In-Vehicle Network architectures across carmakers and over the next decade:
 - No gateways → Central Gateway
 - Central Gateways + Domain Controllers
 - Central Compute → Server in the Car
- Gateways are evolving quickly to meet new demands driven by vehicle electronics: connected car, infotainment, ADAS/autonomous driving,...
 - More performance, security, connectivity, higher bandwidth, safety
- NXP is leading the way in / vehicle network processors to help drive the Gateway Evolution and enable carmakers' innovations

For More Information

- **NXP.com resources:**
 - [NXP Central Gateway Site](#)
 - [NXP Secure Gateway & In-Vehicle Networking](#)
- **NXP Connects Sessions and Demo:**
 - AMF-AUT-T3662 - “Layerscape in Automotive—Multi-Arm Processors for Telematics, Gateway and AD Sensor Fusion”
 - AMF-AUT-T3657 - “Service-Oriented Architecture— Design and Implementation Using Automotive Linux BSP”
 - AMF-AUT-T3697 - “PF81/PF82 PMICs for High-Performance Applications Processors”
 - Demonstration – Technology Lab Kiosk #209 - “Unlocking Vehicle Data with the MPC-LS Chipset”



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