

# The Rise and Evolution of Automotive Gateways

Brian Carlson

Product Management  
AMP Connectivity & Security PL

September 2018 | AMF-AUT-T3190



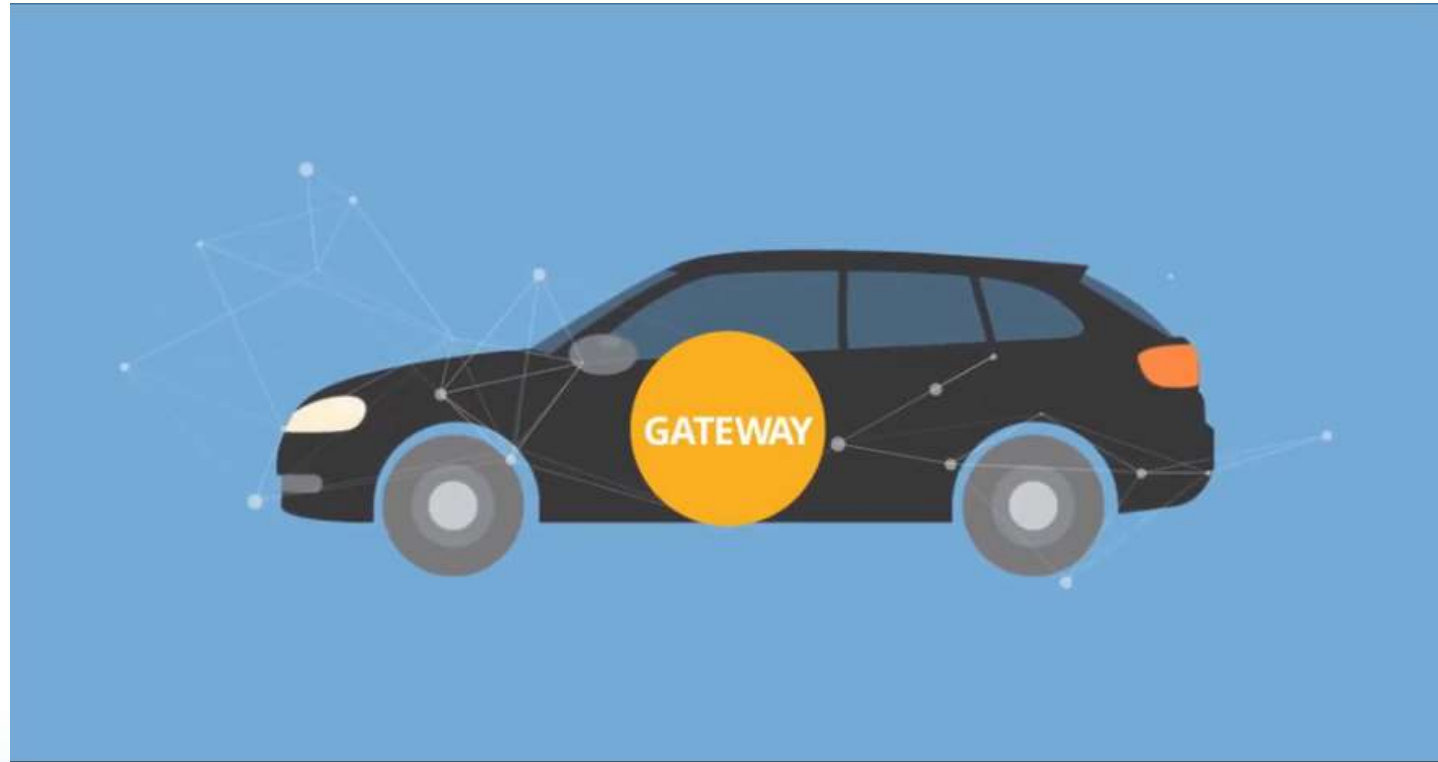
CONNECTS

# Agenda

---

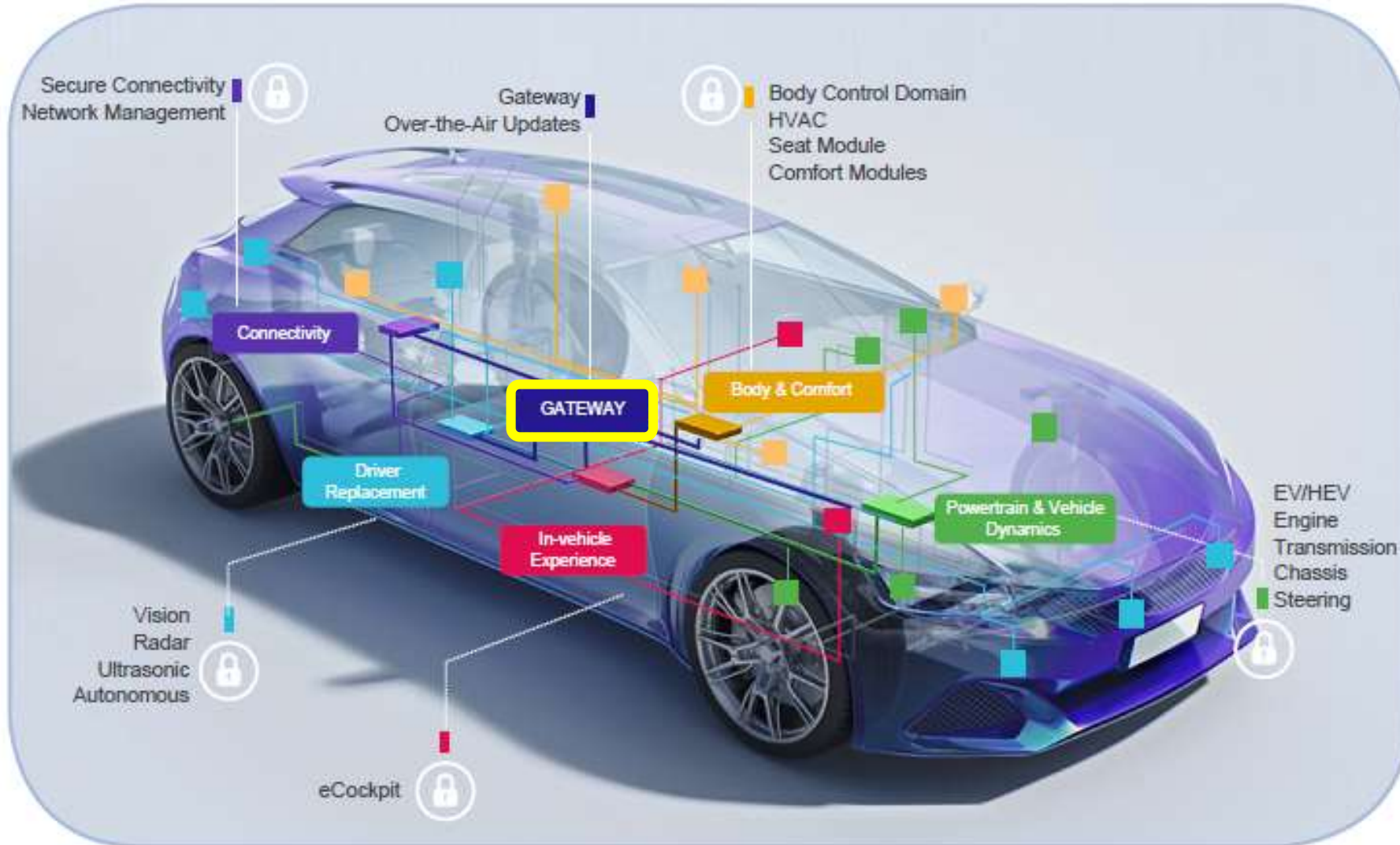
- What is an Automotive Gateway?
- Gateway Evolution
  - Overview, Market Trends, Architecture
- NXP Gateway Reference Solutions
- Summary
- For More Information

# What is an Automotive Gateway?

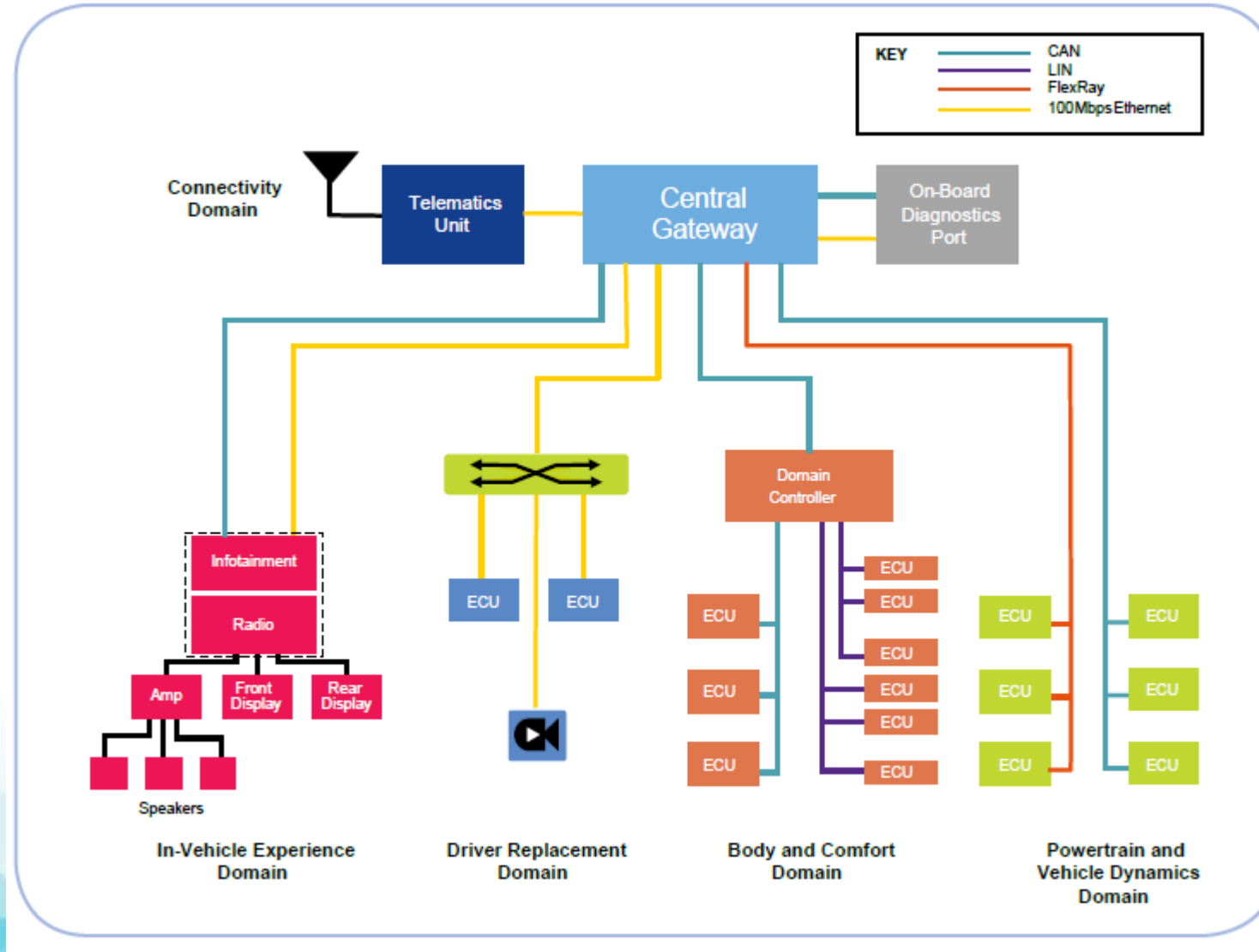


<https://www.nxp.com/video/:AUTOMOTIVE-GATEWAY-VID>

# The Automotive Gateway is Central to the Vehicle



# Automotive Gateway is Central for Vehicle Communications



# Key Gateway Functions

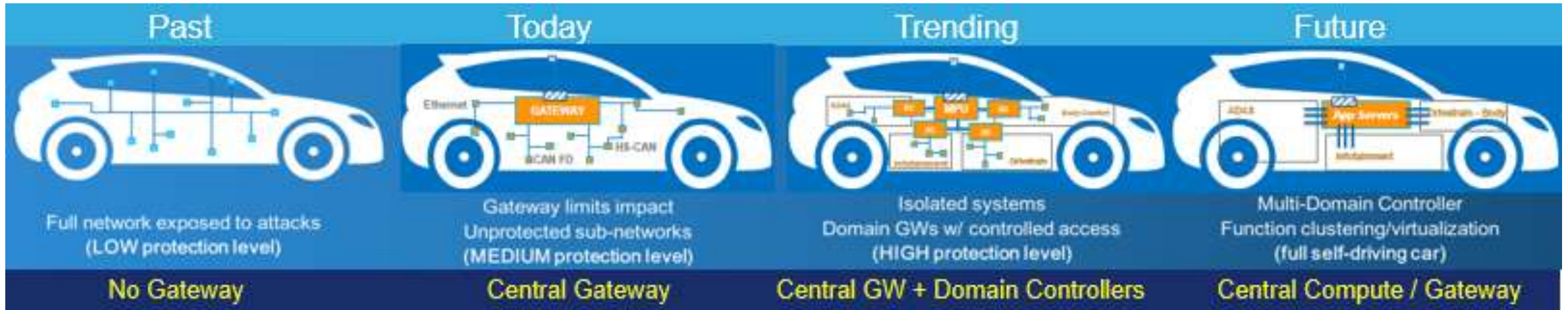
Gateway Capability	Description
Protocol Translation	Translating data and control information to/from incompatible networks to enable communications between them
Data Routing	Routing of data on a path to reach its intended destination. It may be on different networks requiring protocol translation.
Diagnostic 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



# Gateway Rise and Evolution



- No or limited connectivity

**Connectivity**

- No or limited security

**Security**

- Basic routing

**Processing**

- Limited bandwidth / scalability  
(kilobit / Megabit interfaces)

**Networking**

- Up to ASIL B with fail safe

**Functional Safety**

- High-speed wireless interfaces

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

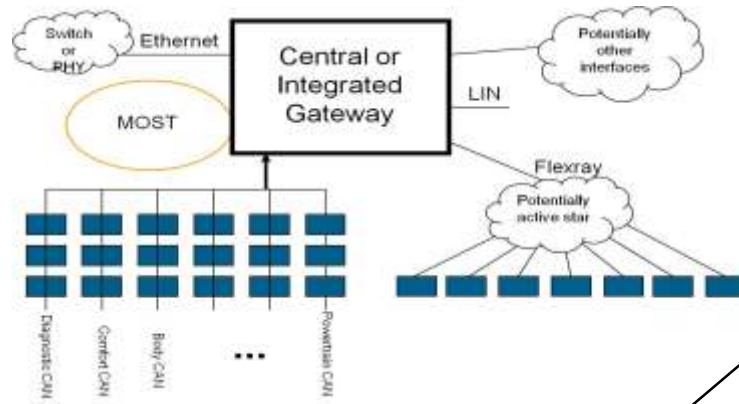
- Advanced routing, vehicle OTA, analytics, ECU consolidation, services

- High-bandwidth, scalable architectures  
(Gigabit interfaces)

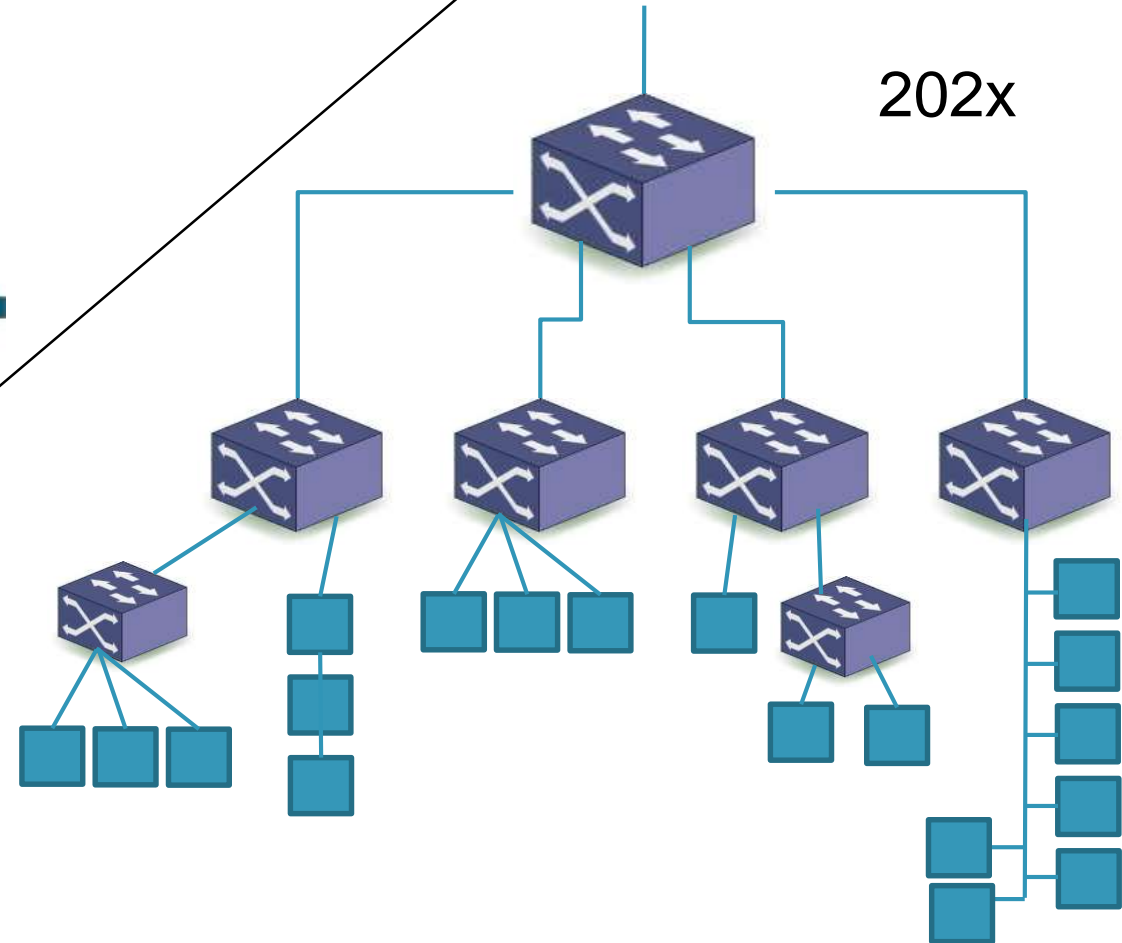
- Up to ASIL D with fail operational



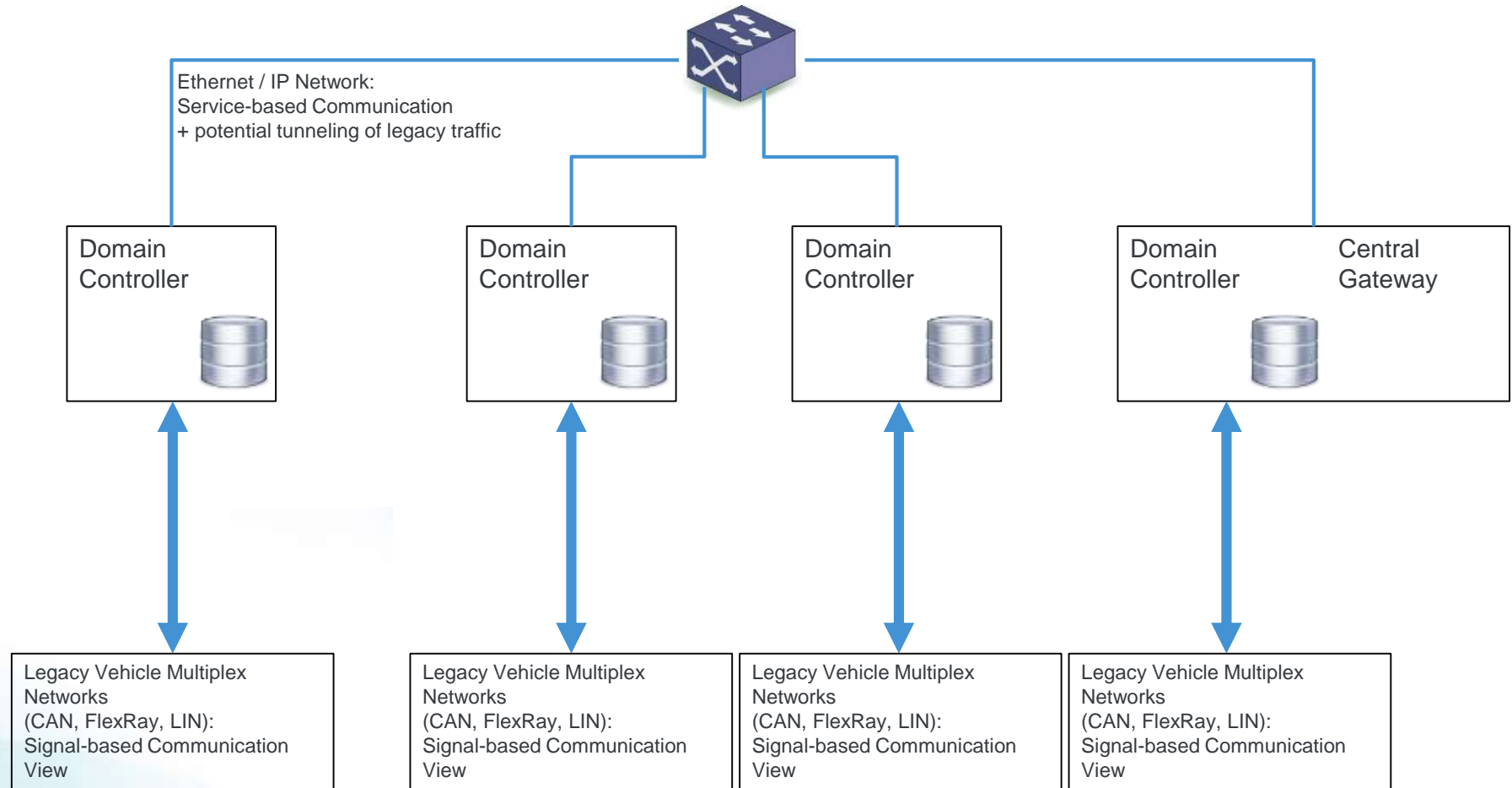
# Evolution from Central Gateway to Distributed Architecture



Today

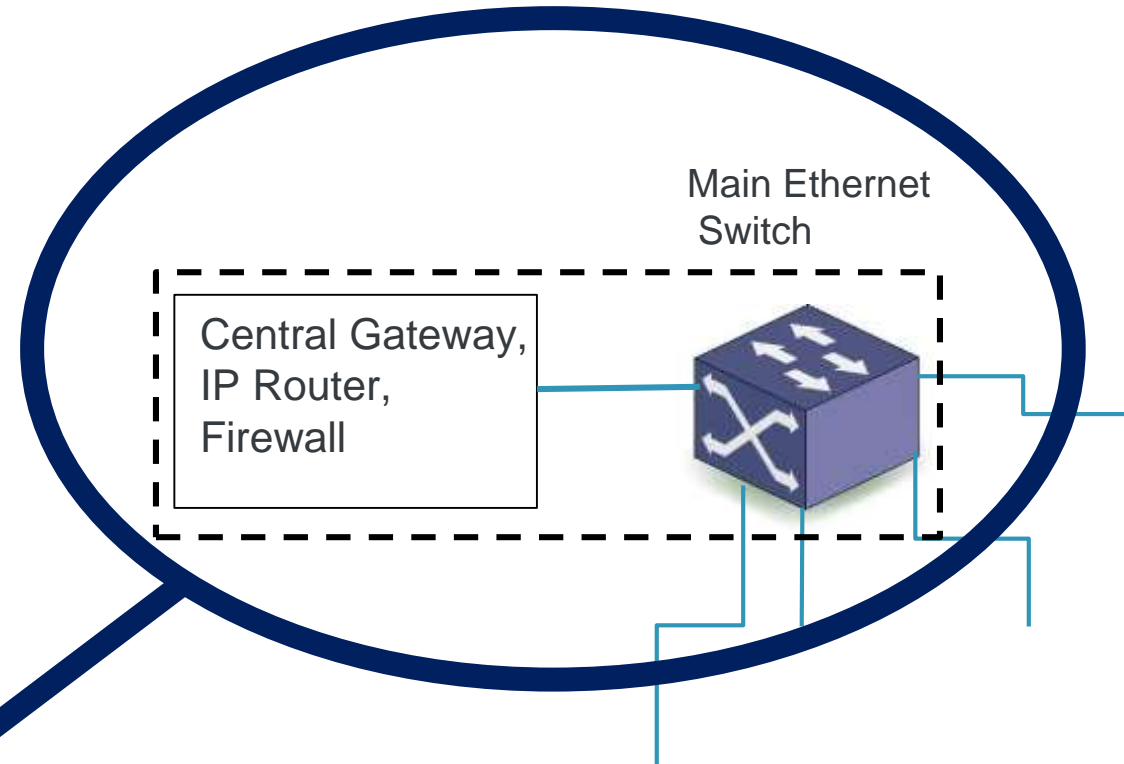


# Pure Domain Network Communications Flow



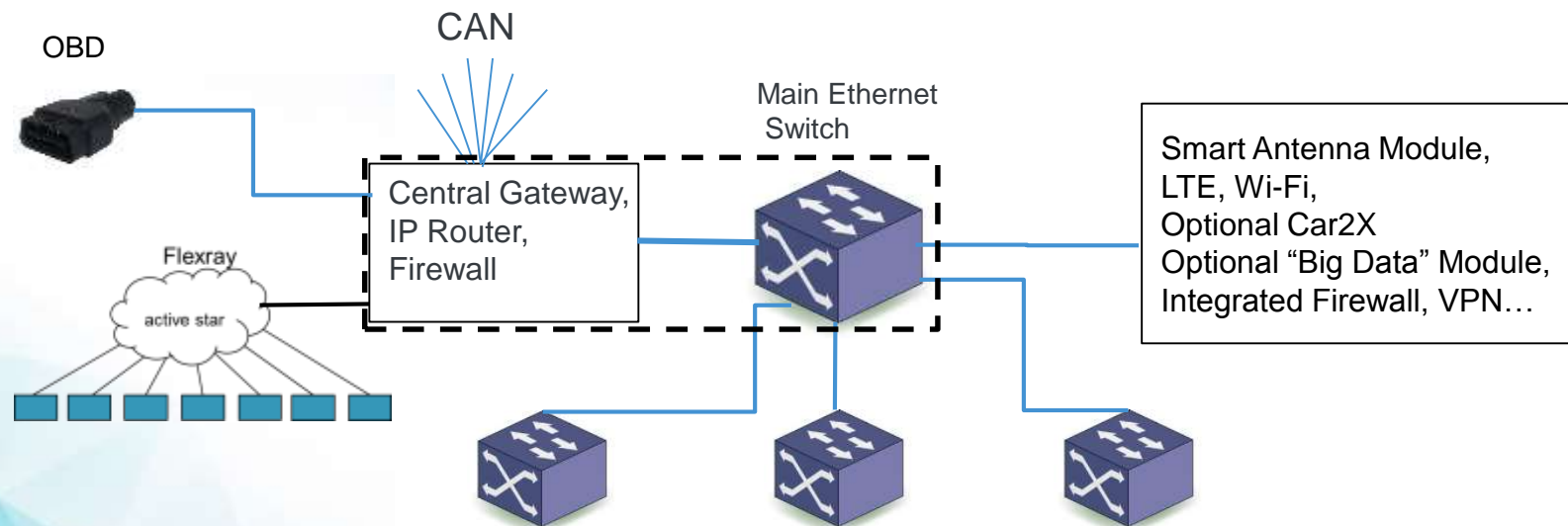
# Central Gateway / Router / Firewall

- Domains are separated in VLANs
- Intra-Domain Traffic can be switched by Layer 2 Ethernet Switch
- Cross-Domain Traffic must be routed at higher layers (IP, Gateway, ...) and inspected (Firewall, Stateful inspection)
- Due to different nature of signal-based and service-based communications, an overlay network of legacy automotive protocols (i.e. CAN, FlexRay) might be a better solution.



# Alternative Legacy Automotive Overlay Network

- To simplify migration from existing vehicle network architecture an overlay network of the existing automotive interfaces (CAN, FlexRay, LIN) in the central Gateway could be a potential solution
- This reduces the complexity of network migration to only the Gateway
  - Legacy nodes talk e.g. CAN, FlexRay
  - New nodes talk IP, Service-based communication
- An additional benefit of this approach is, that for specific needs, ultra-low latency routing of legacy messages could be achieved
- This also provides a redundant communication path to avoid single point of failures

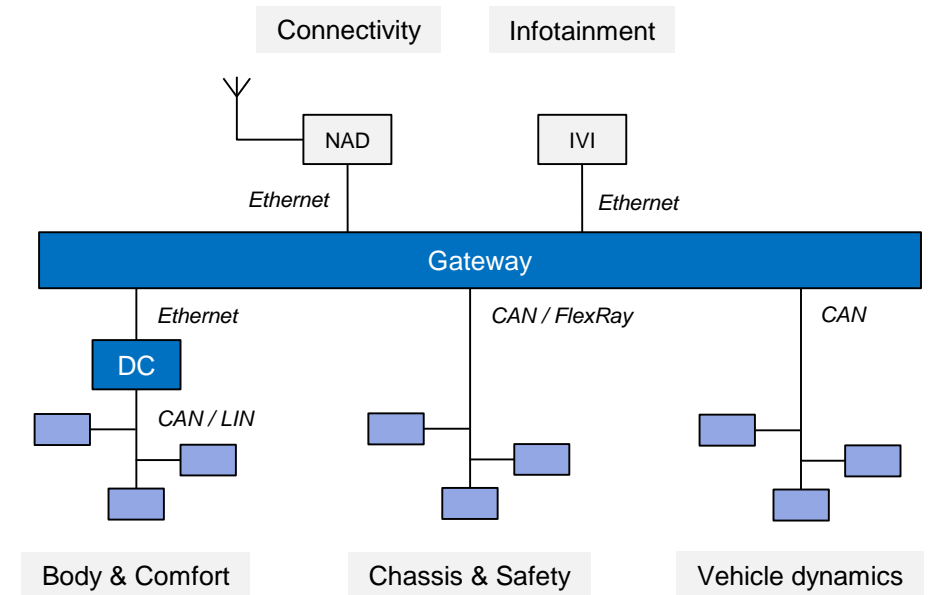


# Gateway Evolution – Market Trends



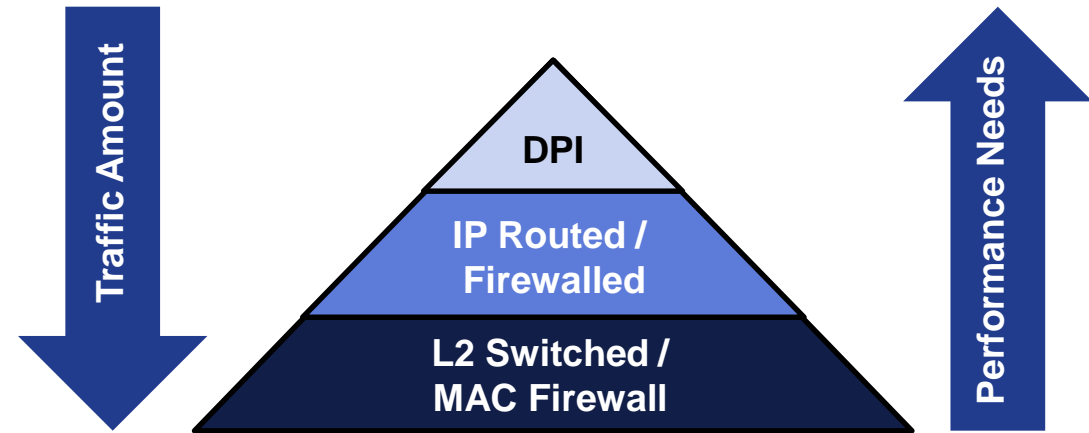
# Market Trends: Networking

- Move to a predominately **Ethernet backbone**
  - Bandwidth needs – Autonomous Driving Platforms
  - Domain controller approach – 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 + 8+ CAN**
- # of CAN channels increasing
  - Isolation of increasing number of ECUs
  - Up to ~175 ECUs in some high-end vehicles!



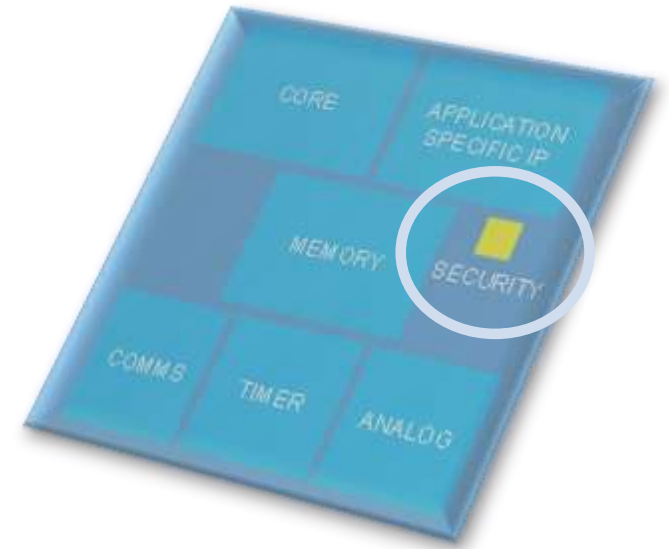
# Market Trends: Network Security

- Gateway is considered as a **central location for security**.
  - Policing vehicle information, monitoring traffic between networks
- **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

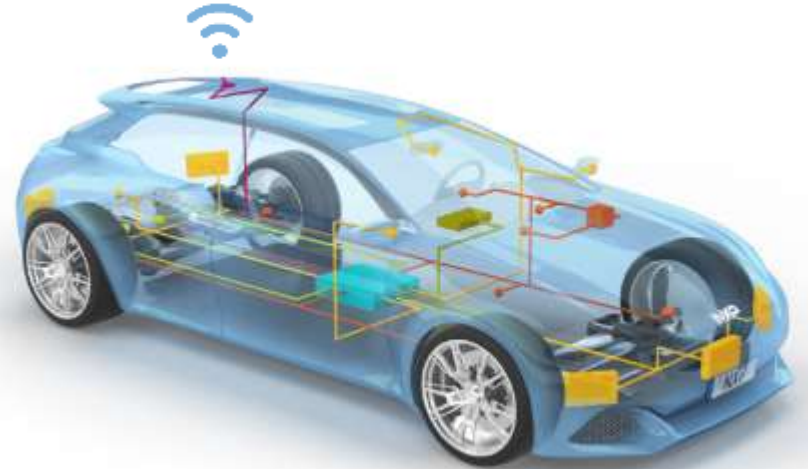
- Industry woke up to security following public hacks of 2015
- Need to **secure MCU/MPU from malicious attacks**
  - Taking control of the ECU
  - Stealing Intellectual Property
- **Connected services driving additional layers of security in the gateway**
  - Public Key handling acceleration, connecting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





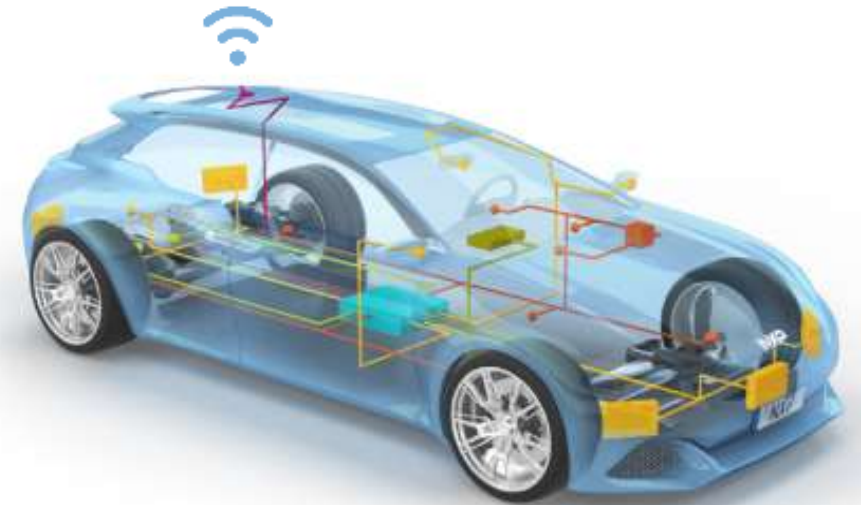
# Market Trends: Over-The-Air (OTA)

- **Over-the-Air firmware/software updates** (to main ECUs) 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)
- See 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 gateway capabilities and new applications
- **ECU consolidation:** Feature deployment by SW package rather than new ECU
- **Big Data Analytics:** Descriptive / Diagnostics / Predictive
  - Looking at security, safety & integrity of the vehicle & network

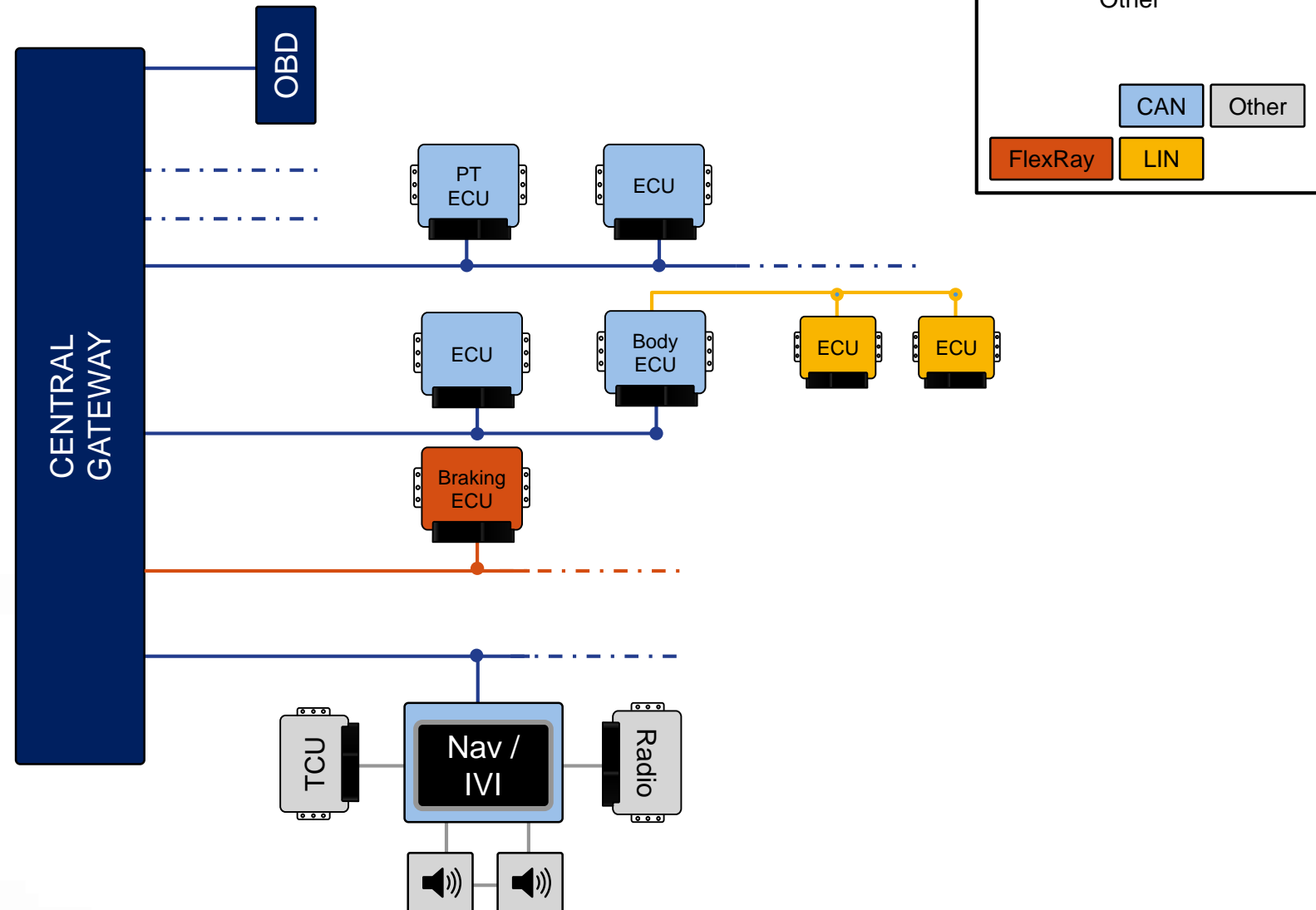


# Gateway Evolution - Architectures



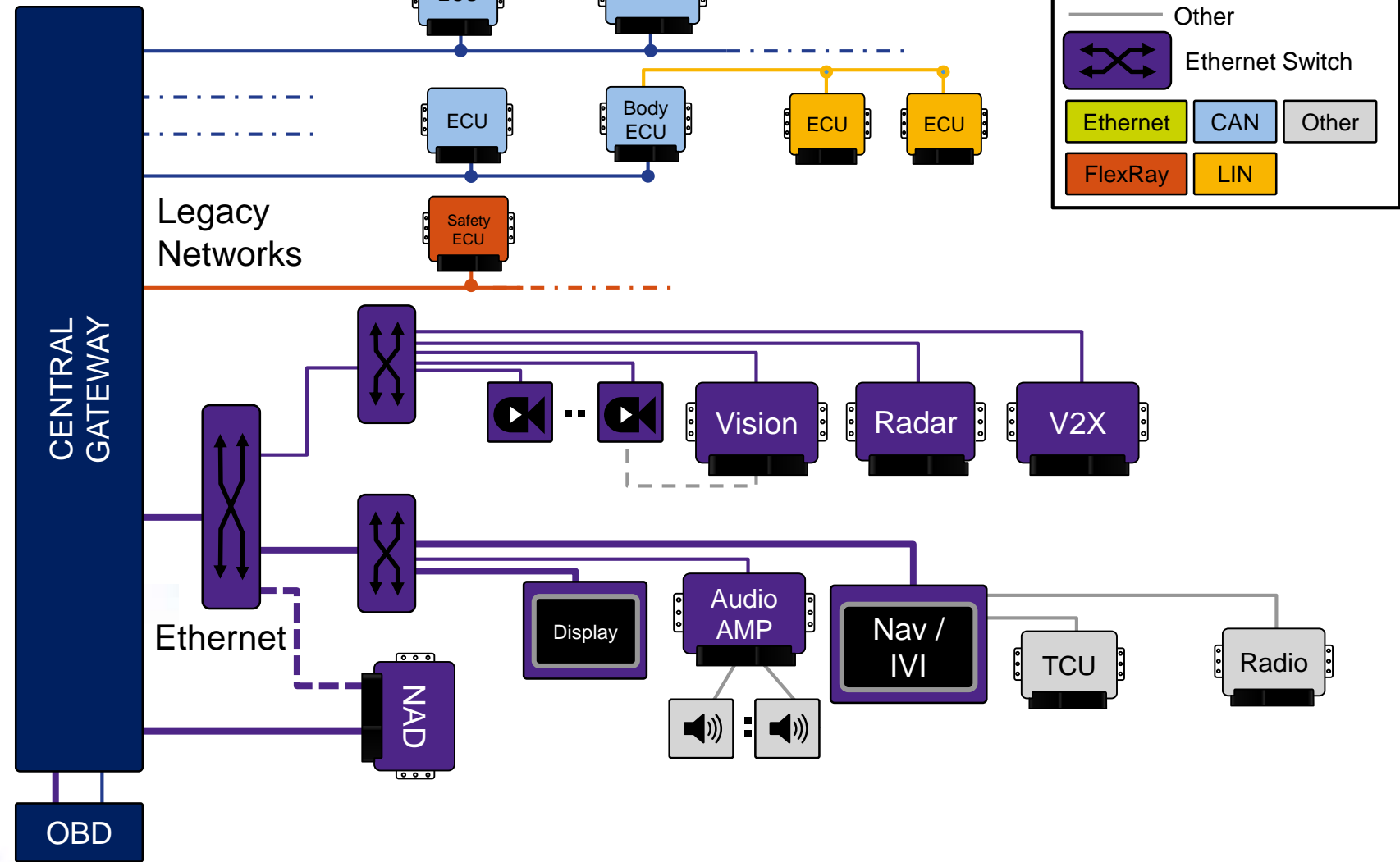
# CAN Central Gateway Architecture

- 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 (e.g. MOST)
- Physical Isolation
  - Functional domains
  - Safety / Non-safety
- Gateway role
  - Firewall internal traffic
  - Protocol translation



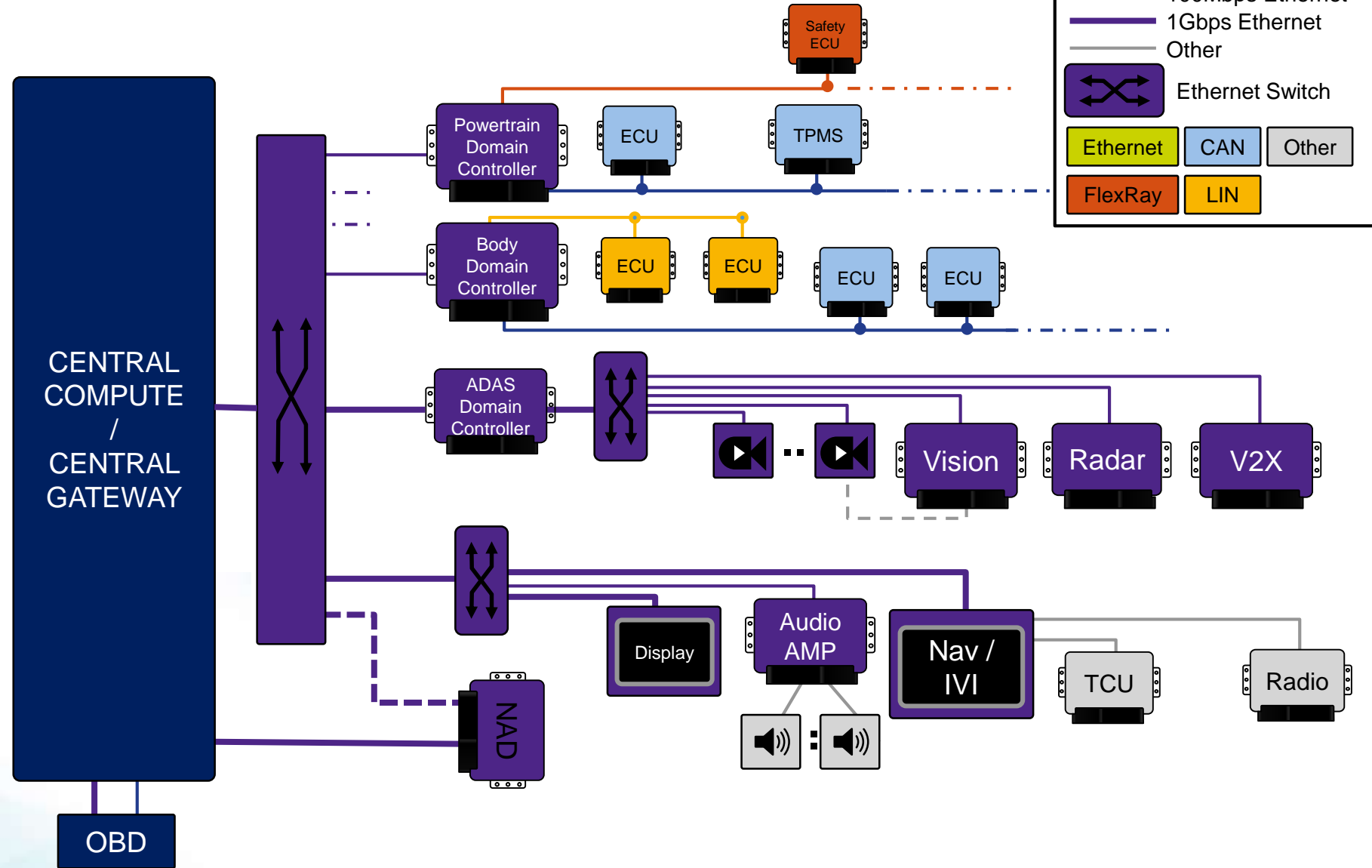
# Hybrid Ethernet Architecture

- 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



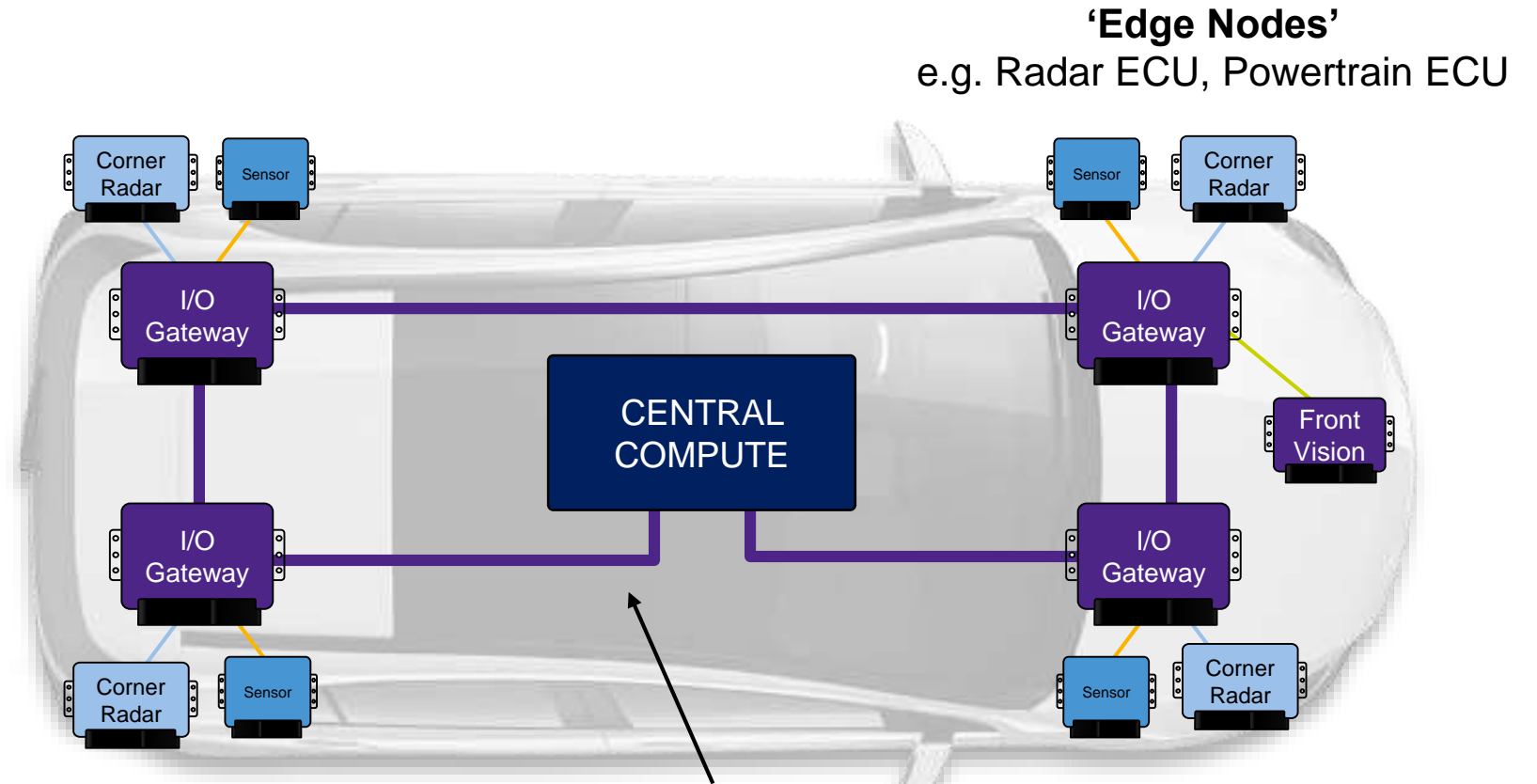
# Ethernet Backbone with Domain Controllers

- **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)



**High Speed Ethernet Network  
(Mesh/Ring)**  
Optimised to vehicle topology for  
Reduced Wiring

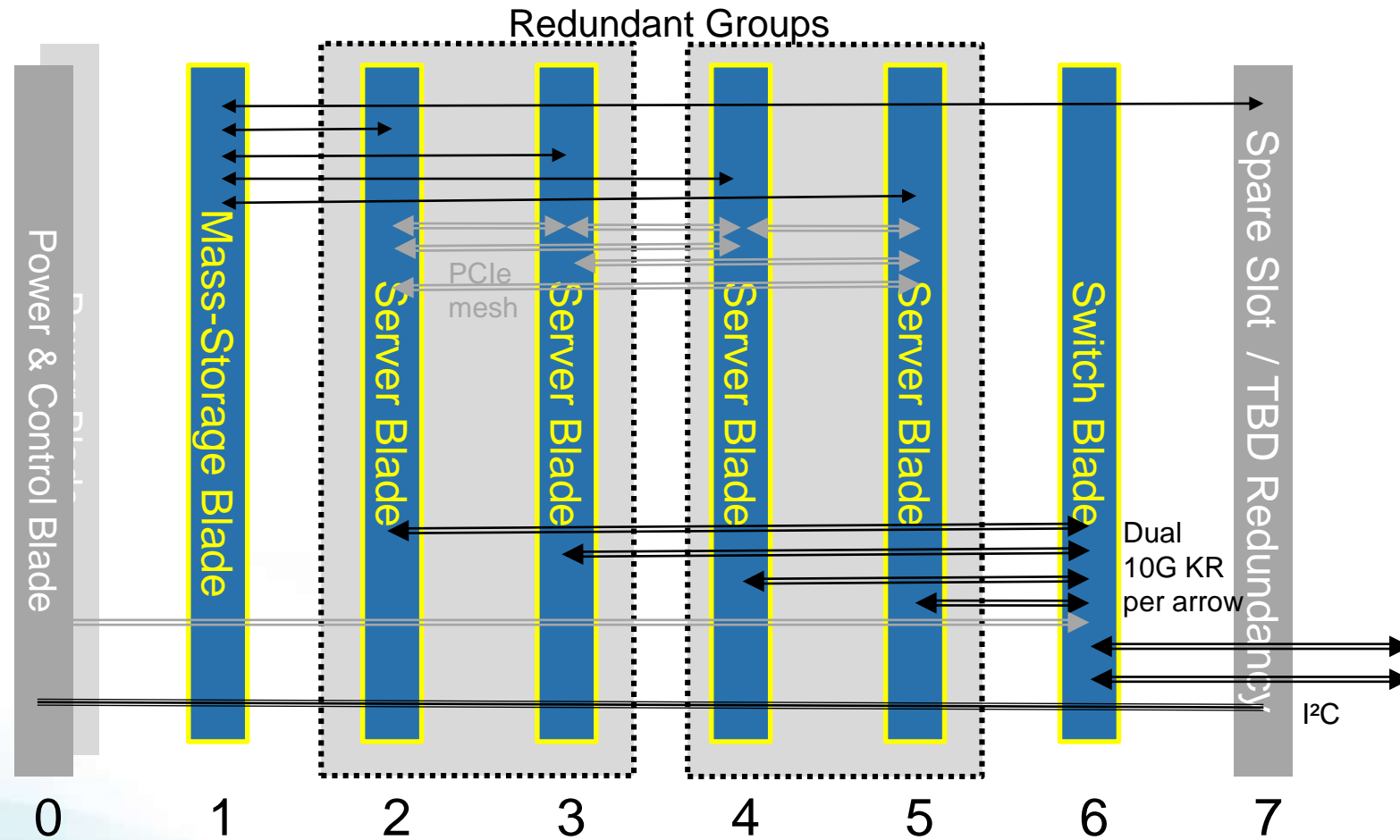


# Moving Towards a “Server in the Car”

- 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



# Conceptual Vehicle Server Communications Links



# NXP Gateway Reference Solutions



# NXP Secure Gateway Reference Design

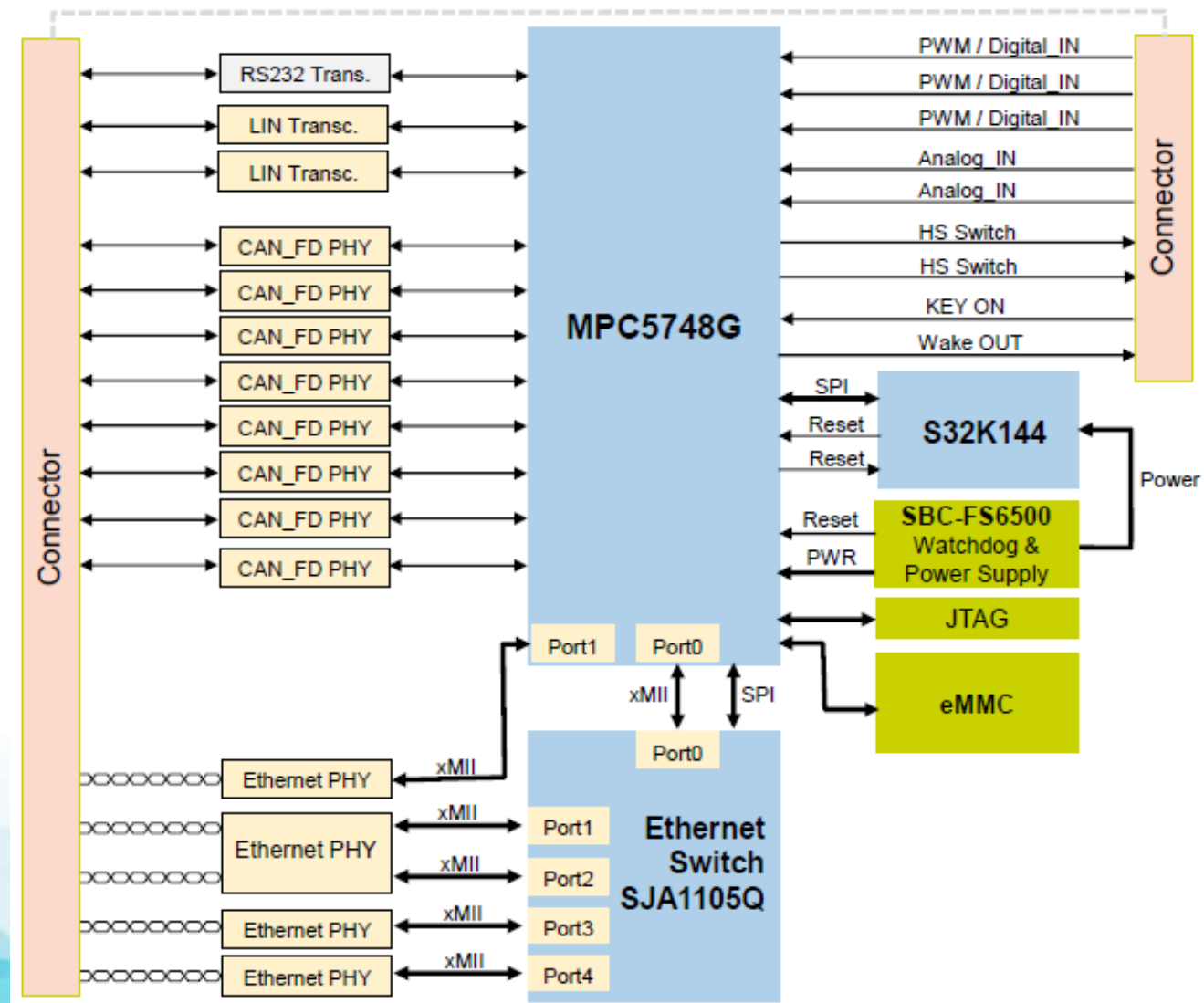
## Hardware Features

- 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

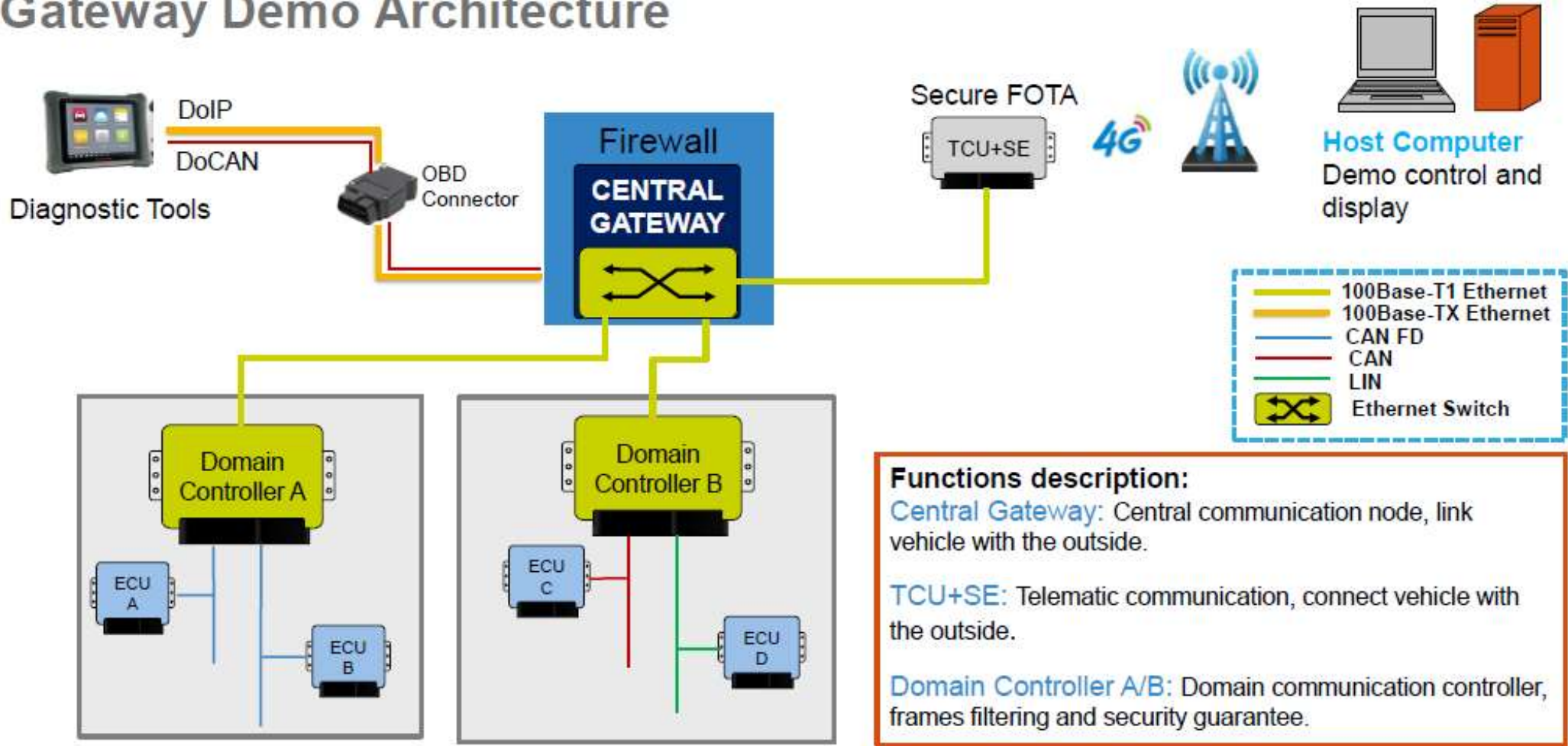


Based on NXP MPC5748G Gateway Microcontroller

# NXP Secure Gateway Block Diagram



# Gateway Demo Architecture



# Dual Chip Gateway Solution

- **Enables Next-Gen CAN-Ethernet Gateways**

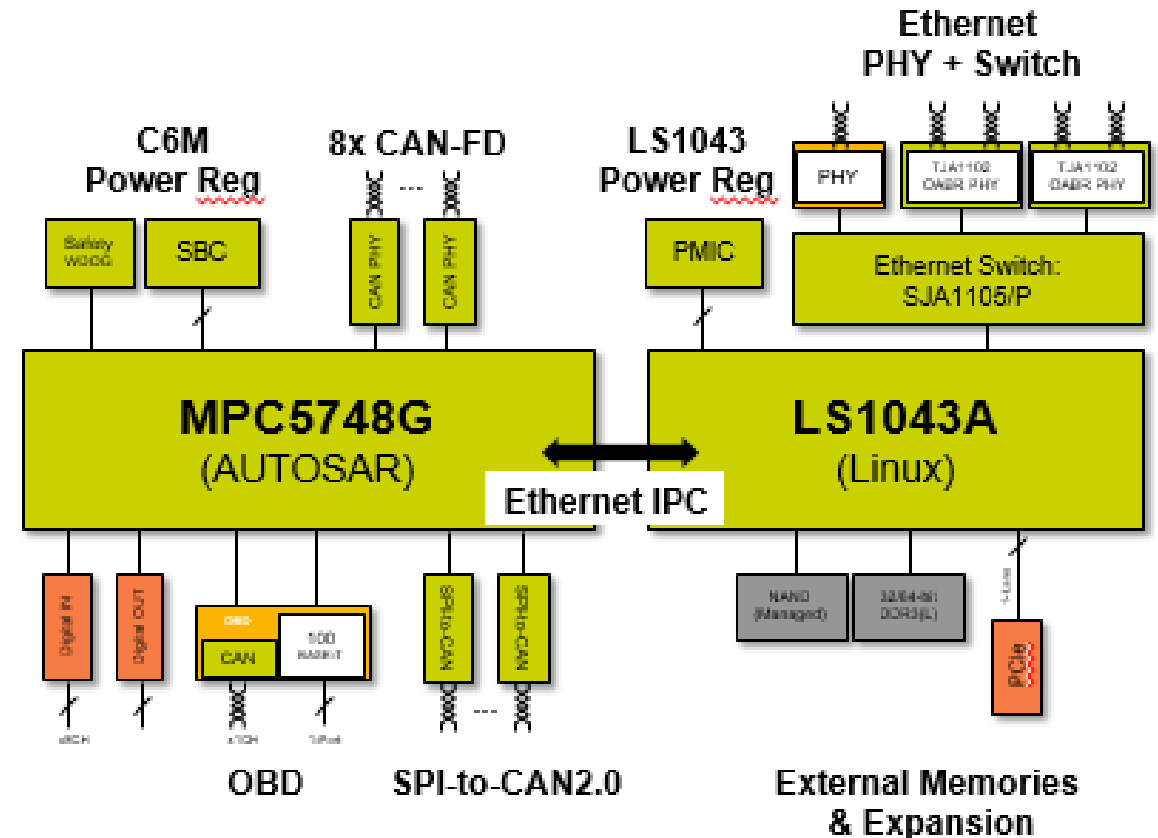
- Automotive Gateway + Network Processing (Gigabit Ethernet Packet Routing) + Applications
- High-performance processing + IP acceleration
- MPC5748G + LS1043A (MCU + MPU)
- Available today

- **Feature Set**

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

- **OS Support**

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



# 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 Central Gateway Site](#)

[NXP Secure Gateway & In-Vehicle Networking](#)





SECURE CONNECTIONS  
FOR A SMARTER WORLD

[www.nxp.com](http://www.nxp.com)