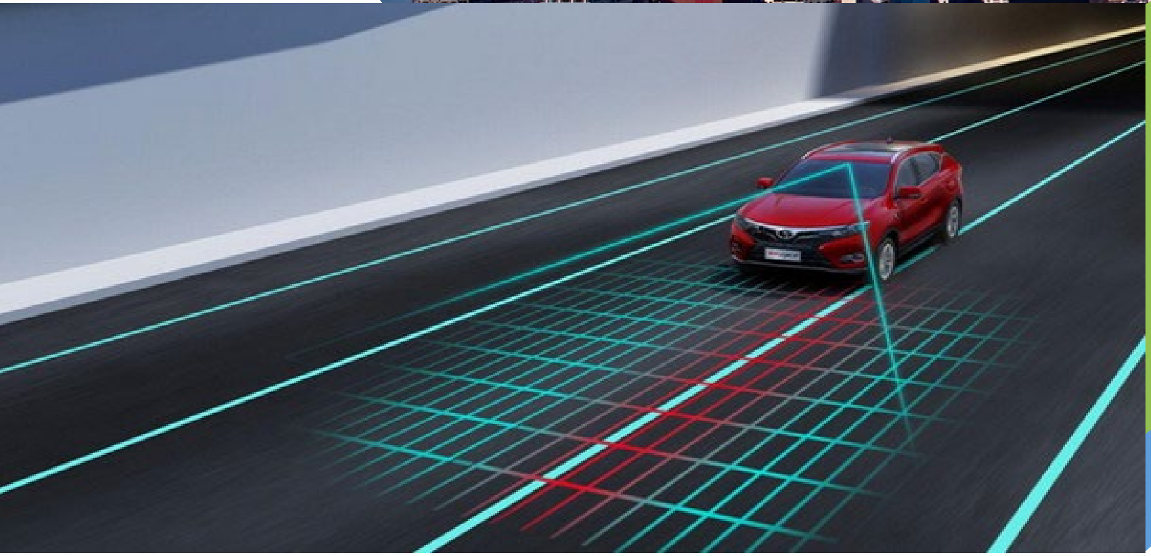

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# Intelligent Vehicle E/E Architecture and Computing Platform Industry Research Report, 2021

# Abstract

**E/E Architecture and Computing Platform Industry Research: Three Evolution Stages of Automakers' E/E Architectures**

Domain centralized architectures will gradually evolve to quasi-central and central computing architectures

The evolution of the brand-new automotive E/E architecture, which may take ten years, can be divided into three stages:

**(1) Domain centralized architecture stage**

At present, automakers mainly stay at the domain centralized architecture stage. For example, Volkswagen's E3 architecture, Great Wall's GEEP3.0 architecture, BYD's E platform 3.0 architecture, Geely's SEA architecture, Xpeng's EE 2.0 architecture, etc. are all typical domain centralized architectures.

Automotive E/E architectures will inevitably develop towards centralized E/E architectures. From the perspective of mass-produced models, centralized E/E architectures prevail now, with domain control over power, chassis, body, intelligent driving and cockpit. However, it is difficult to fully realize standard domain architectures and central architectures due to technical thresholds, diversified configuration gradients, consumption habits and other factors, so the domain hybrid architecture of "distributed ECUs + domain controllers" will be common in the short term.

At present, Volkswagen, BMW, Geely ZEEKR, Huawei, Visteon, etc. adopt three-domain E/E architecture solutions which mainly include intelligent driving domain, intelligent cockpit domain, and vehicle controller domain.

**Volkswagen** has upgraded the MQB distributed E/E architecture to the MEB (E3) domain centralized E/E architecture which includes 3 domain controllers: vehicle control (ICAS1), intelligent driving (ICAS2), and intelligent cockpit (ICAS3). Modules such as chassis and airbags that do not have integration capabilities belong to ICAS1. At present, ICAS1 and ICAS3 have been developed and installed on ID.3, ID.4 and other models, while ICAS2 has not been developed yet.

In terms of the software architecture, E3 adopts a service-oriented architecture, using CP and AP service middleware to enable SOA communication; as for the communication architecture, E3's backbone network is Ethernet.

On the CC architecture, **Huawei** has launched three domain control platforms of intelligent cockpit (CDC), vehicle control (VDC), and intelligent driving (MDC) respectively, and released related open platforms and operating systems, such as the autonomous driving operating system AOS, the intelligent cockpit operating system HarmonyOS and the vehicle control operating system VOS.
In terms of communication architecture, the CC architecture has set up 3-5 VIUs (vehicle interface units). All actuators and sensors are connected to distributed gateways so as to form loops. Once a single loop fails to work, the other three loops maintain operation, hereby effectively improving safety.

# Abstract

**(2) Quasi-central computing architecture stage**

In the next step, automakers will work hard in the quasi-central architecture of "the central computing platform + regional controllers". Through SOA, it shares the computing power of different domain controllers like a central computing platform. The GEEP 4.0 architecture to be launched by Great Wall in 2022 and the FEEA3.0 architecture (to be mass-produced in 2023) released by FAW Hongqi in 2021 are quasi-central architectures.

Tesla's EEA architecture is the most advanced, at least 5 years ahead of that of traditional automakers. The E/E architecture of Model 3 has marked Tesla's entry into the quasi-central architecture stage consisting of central computing module (CCM), Body Control Module Left (BCMLH) and Body Control Module Right (BCMRH), basically materializing the prototype of a centralized architecture with the self-developed Linux, FOTA of the whole vehicle and communication via the Ethernet backbone network.

Tesla's quasi-central E/E architecture has sparked a harness revolution. The wiring harness of Model S/Model X is as long as 3 kilometers, while Model 3 reduces the wiring harness length to 1.5 kilometers, and Model Y further shortens it to around 1 kilometer. Tesla's plans to make the length as short as 100 meters.

**(3) Central computing architecture stage**

From the perspective of development trends, the automotive E/E architecture will eventually evolve to the central computing architecture, concentrating the functional logic to a central controller. The OEM Great Wall plans to launch the central computing architecture GEEP 5.0 in 2024, and Changan also intends to complete the development of its central domain architecture in 2025.

In the next 3-5 years, OEMs will focus on R&D and layout of quasi-central architectures.

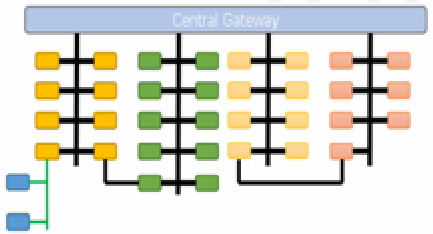
As per the E/E architecture solutions of traditional automakers, most OEMs at home and abroad have transferred from distributed architectures to domain centralized architectures, and they have taken quasi-central architectures as the focus of R&D and layout in the next 3-5 years. Quasi-central and centralized architectures can effectively reduce the number of controllers and wiring harnesses, promote the further decoupling of automotive hardware and software, and drag down the cost further. In order to keep up with the upgrades of automotive technology, OEMs speed up the deployment of quasi-central architectures, introduce SOA architectures and make layout in central computing platforms, etc..

# Evolution of Automotive E/E Architecture

| Before 2020 | 2020-2025 | 2025-2030 | After 2030 |
|---|---|---|---|

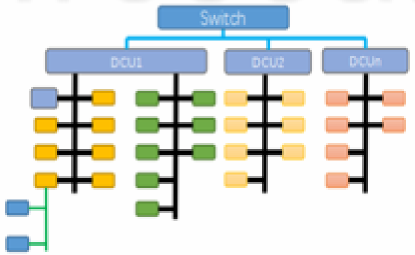
### Distributed Architecture

- In the traditional gateway distributed architecture, CAN acts as the backbone network
- Functions are realized by stacked controllers
- Software and hardware are tightly coupled; there are many couplings between controllers; the application and updates of new technologies and new functions are restricted by the E/E architecture



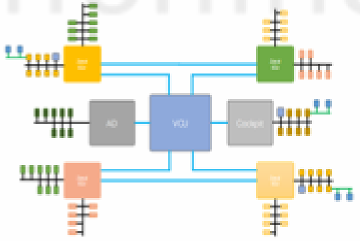

### Domain Control Architecture

- Domain controller centralized architecture; some functions in the domain are implemented by domain controllers
- Ethernet is used as the backbone network for communication, and the domain control handles routing in the domain
- Support L3+ intelligent driving, big data FOTA and cross-domain function integration
- Software SOA in local domains



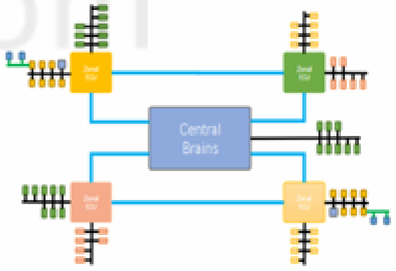

### Quasi-Central Domain Architecture

- Multiple central computing platforms + Zona domain architecture
- Most functions of the vehicle are realized by HPC, and the Zona controller is responsible for the realization of the software logic in the zone
- TSN Ethernet becomes the backbone network, supporting L4-L5 intelligent driving
- The whole vehicle features software SOA, software and hardware decoupling, hardware IO standardization, independent dynamic loading of hardware, and dynamic configuration of functions
- Zonal architecture shows its advantages in scalability, reusability, costs, and wire harness lightweight



### Central Architecture

- Cloud control
- Ethernet & high-speed wireless network
- Vehicle functions on the cloud
- An automotive central computer covers the body domain, power domain, chassis domain, and security domain; computing chips tend to be integrated



# Features of Next-generation E/E Architectures of Some OEMs

| OEMs | EEA | Features of hardware architecture | Features of software architecture | Features of communication architecture | Production models and time |
|---|---|---|---|---|---|
| **Toyota** | TNGA architecture (quasi-central architecture) | • Central computing + domain controllers (according to physical space, the vehicle is symmetrically divided into multiple domains); typical Zonal-EEA; ECU integration cuts down hardware costs | • The SOA architecture based on Adaptive AUTOSAR and Classic AUTOSAR enables convenient software iteration and functional scalability | • Minimize the length of the wire harness, simplify the design of the wire harness, reduce weight and costs, and improve the automation of the production line | -- |
| **Tesla** | Model 3 architecture (similar to quasi-central architecture) | • Three domain controllers are formed according to the physical space, which reduces the wiring harness, costs and weight further<br>• FSD can be upgraded in hardware, with high hardware redundancy | • Independent development of operating system, middleware and application software | • Ethernet + CAN | Model 3 (2017) |
| **Great Wall** | GEEP 4.0 (quasi-central architecture) | • Central computing, smart cockpit, optional advanced autonomous driving platform | • Hybrid automotive software platform; integration based on MCU and HPC; the computing platform and dedicated controllers include different levels of ECUs; different levels of software are included | • Some hardware communication methods have been transformed into Ethernet atomic services; abstracted decoupling changes the distribution structure;<br>• Independent gateways | WEY MOCHA |
| **Xpeng** | EE 2.0 (domain architecture) | • Most body functions can be migrated to the so-called domain controllers<br>• The hardware foundation of SOA can basically be realized | • The SOA architecture (transition phase) is a three-tier interactive automotive software architecture which includes body function layer, application layer, and interaction layer | • The backbone network covers the data of "Ethernet + CANFD"; the CPU and several other domain controllers are basically based on Ethernet interaction, with the additional CANFD | P5 (2021) |
| **Hongqi** | FEEA3.0 architecture (quasi-central architecture) | • "Central computing + domain control" simplifies the topology, reducing the number of controllers by 50% | • The SOA concept has been introduced to design and develop the automotive layered software architecture | • The length of the wire harness has been shortened by more than 50% | Hongqi EV-Concept (2023) |

# Evolution of Great Wall’ s E/E Architecture

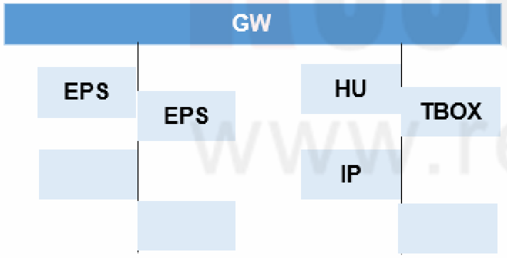
**Great Wall** has independently developed the GEEP E/E architecture which has evolved to the third-generation GEEP 3.0 so far. As the domain control architecture, it boasts 4 domain controllers. With integrated software and hardware and self-developed application software, it has been successfully applied to all models. At present, Great Wall is actively developing the fourth- and fifth-generation E/E architectures.

As “the central computing platform + regional controllers” architecture, the fourth-generation E/E architecture of Great Wall comprises three large computing platforms for central computing, intelligent cockpit, and optional advanced autonomous driving respectively. The central computing platform integrates body, gateways, air conditioning, EV, power chassis and ADAS, featuring cross-domain integration. It is scheduled to be launched in 2022. The fifth-generation E/E architecture is to highly concentrate the entire automotive software in a central brain to achieve 100% SOA, and it will be available in 2024.

## 2021

**The third-generation EEA**

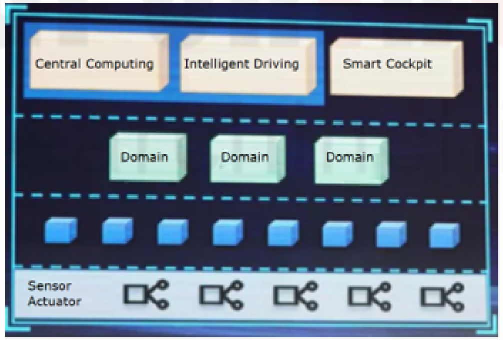
- 4 domain controllers; self-developed application software; mass-produced and applied to all models




## 2022

**The fourth-generation EEA**

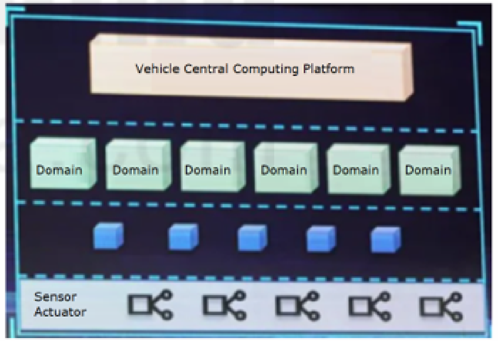
- Service-oriented, standardized, flexible and partner-oriented technical advantages; it has entered the product development stage; it will be available on brand-new electric and hybrid platforms, and will gradually spread to all models
- Central computing + domain architecture: a computing platform covering central computing, smart cockpits and high-level autonomous driving is formed
- Independent gateways




## 2024

**The fifth-generation EEA**

- The vehicle software is highly concentrated in a central brain to complete the construction of a standardized software platform for vehicles
- One Brain architecture, central brain, intelligent area control



# Trends under new E/E architectures

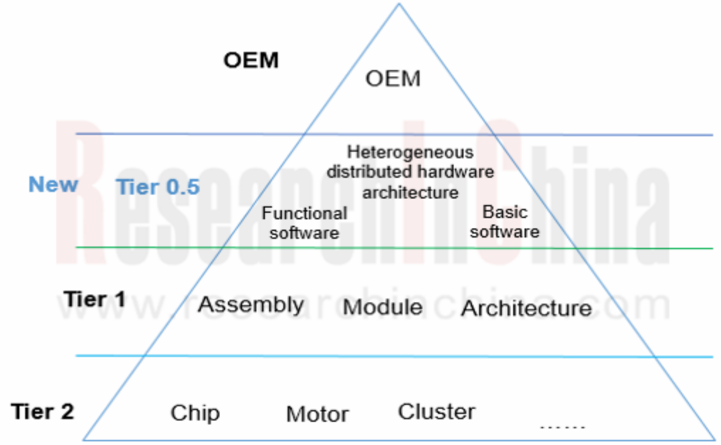
As automotive E/E architectures gradually develop toward central architectures, the centralization of computing power, software services, and peripheralization of sensors and actuators tend to be more obvious; the industrial chain structure has been reshaped, and the business model has undergone significant changes.

**(1) The supply chain system is reshaped**

Under the traditional distributed E/E architecture, the hardware and algorithms of controllers are provided by Tier 1 suppliers and OEMs coordinate different suppliers, so that the collaboration is extremely inefficient.

Under the new E/E architecture, OEMs enjoy the dominance. Based on their own software and hardware platforms, they directly convey their demand to suppliers, among which Tier 1 suppliers are no longer dominant while Tier 0.5 suppliers emerge to provide algorithms and software for autonomous driving.

**E/E Architecture Revolution – Reshaping of the Supply Chain System**




Source: ResearchInChina

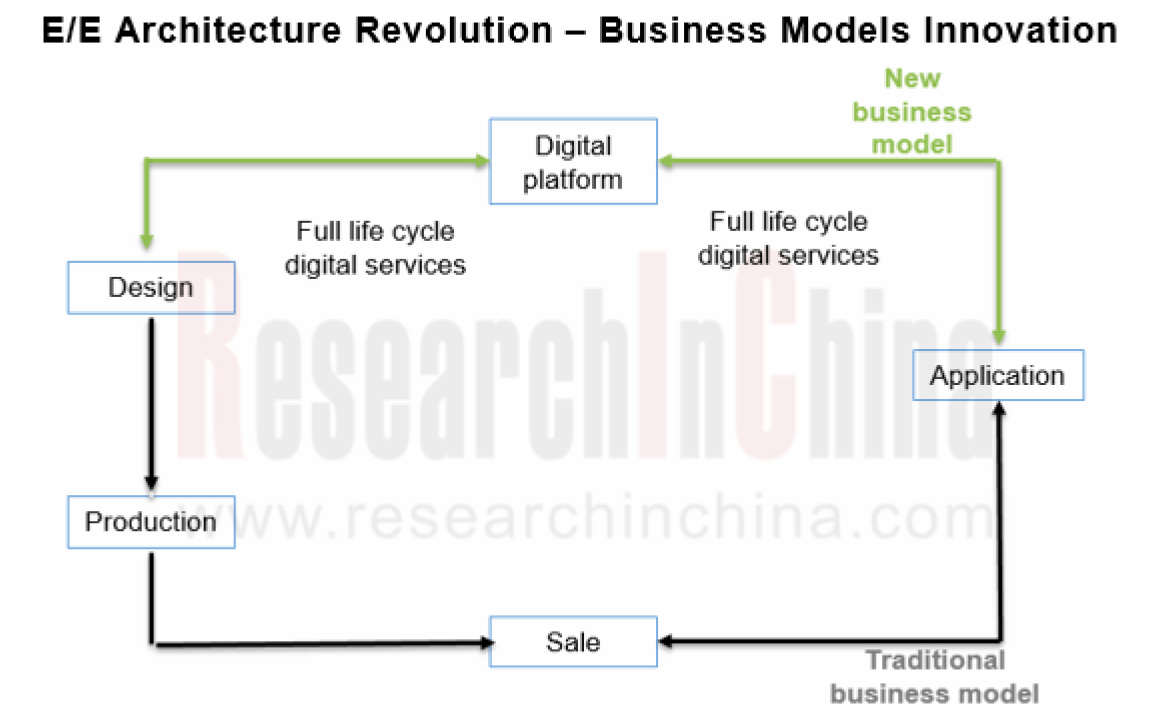
**(2) The traditional "turnkey" model transfers to the "full stack" development model**

OEMs manipulate the development of software platforms (covering functions integrated, suppliers, etc.) to accomplish deeper development. With the development of autonomous driving technology, OEMs are more inclined to carry out "full-stack" development: they gradually master E/E architectures, operating systems, core algorithms, cloud big data, chips and other capabilities, then provide sustainable and iterative product experience and services with a focus on smart scenarios and consumer experience.

**(3) Business models are innovated, and the vehicle OTA sees the completed closed loop of business models**

In addition, with the evolution of E/E architectures and the rapid development of vehicle OTA, the sales models of automobiles have altered accordingly. Automakers have turned from one-time product providers to “products + full life cycle services” providers. Around smart scenarios and consumer experience, they provide sustainable and iterative product experience and services. Emerging automakers represented by Tesla update software to iterate and upgrade vehicles. In addition to vehicle sales, OEMs may charge software updates via OTA in the future. For example, the leader Tesla has earned more than USD1.2 billion from software updates.

# E/E architectures Revolution—Business Models Innovation




Source: ResearchInChina

Intelligent Vehicle E/E Architecture and Computing Platform Industry Research Report 2021 by ResearchInChina mainly studies the following:

- Overview, technology evolution trends, reform trends, market size, etc. of automotive E/E architectures;
- Status quo, evolution trends, etc. of E/E architectures of major OEMs (emerging brands, independent brands, foreign brands);
- Status quo, planning, etc. of E/E architectures of major Tier 1 enterprises;
- Status quo of main E/E architectures (including computing architecture, software architecture, communication architecture, power management architecture, etc.);
- Solutions of major manufacturers; evolution of new E/E architectures.

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