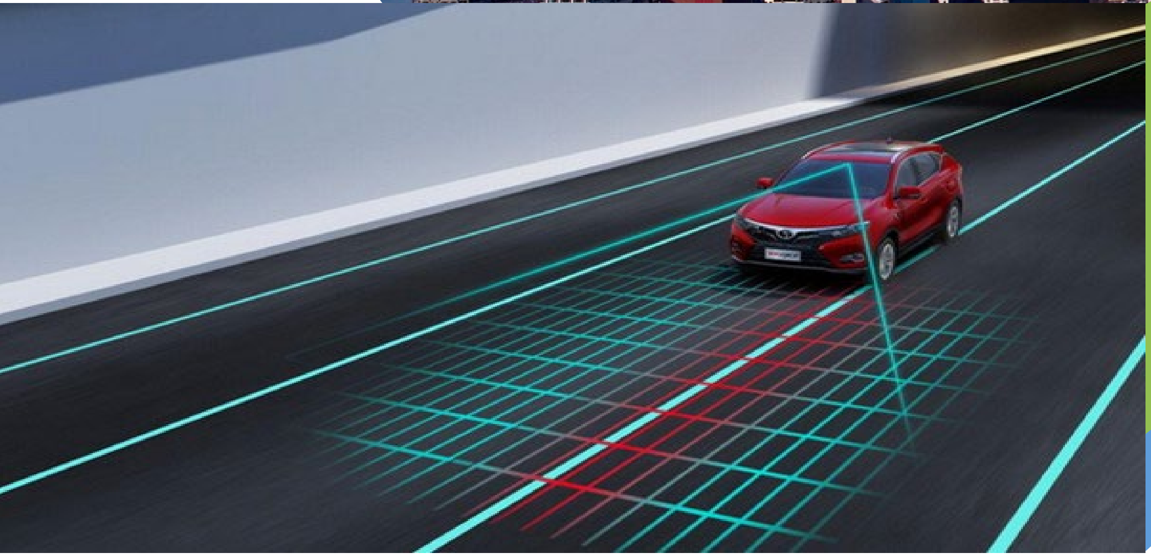

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Research Report on Intelligent Vehicle E/E Architectures(EEA) and Their Impact on Supply Chain in 2024

Sept. 2024

E/E Architecture (EEA) research: Advanced EEAs have become a cost-reducing tool and brought about deep reconstruction of the supply chain

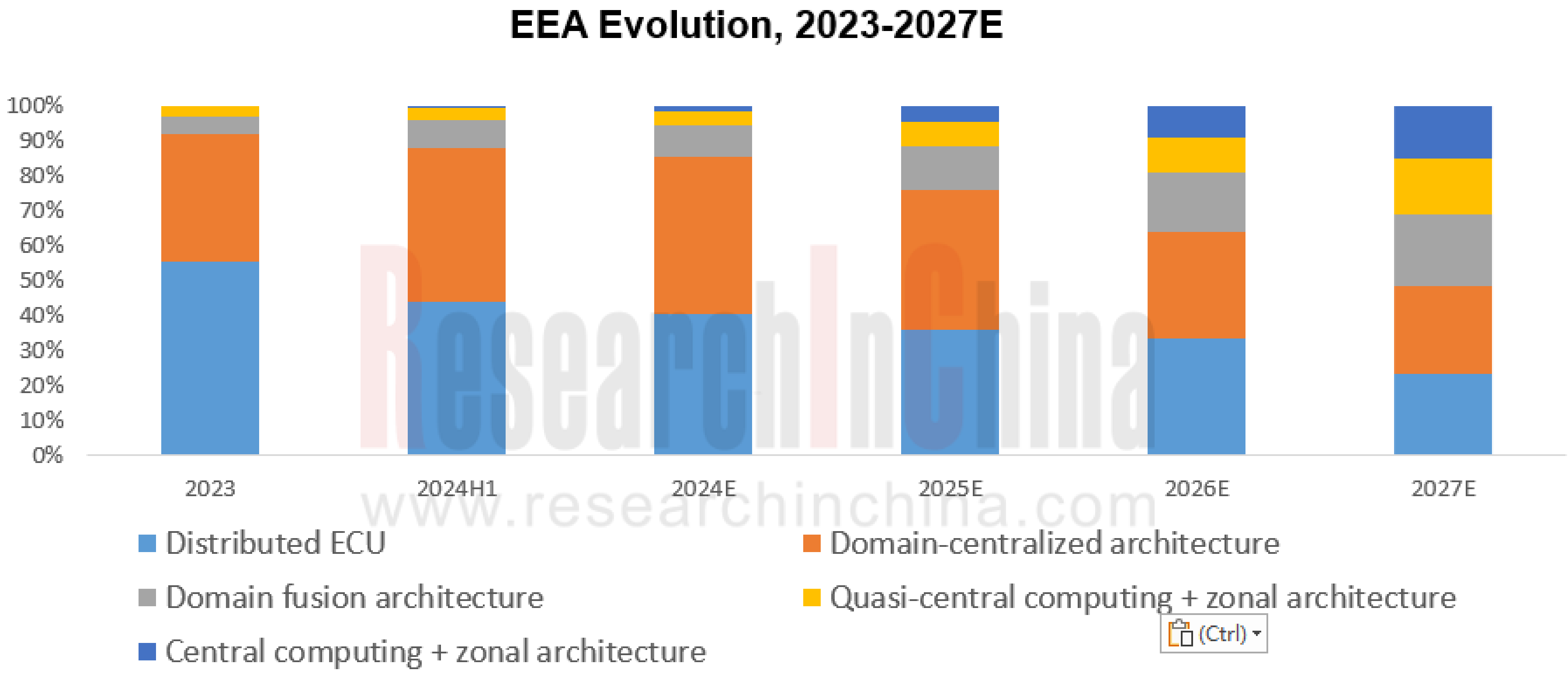
In this report, ResearchInChina divides the EEAs of OEMs into five types:

- ◆ Distributed ECU
- ◆ Domain centralized architecture: The multi-domain architecture spreads to fuel vehicles, A-class and below battery-electric passenger cars;
- ◆ Domain fusion architecture: Usually equipped with the vehicle central domain controller, it can support cross-domain communication, such as cockpit-driving integration, integration of intelligent driving and chassis, cockpit-body-gateway integration, camera sharing, etc.
- ◆ Quasi-central computing + zonal architecture: With ZCUs (intelligent power distribution, zonal servitization), there are still multiple computing centers with multiple boxes and chips;
- ◆ Central computing + zonal architecture: With vehicle-level OS and ZCUs (intelligent power distribution, zonal servitization), it can support a computing center with multiple chips or a single chip in a single box to realize the integration of cockpit domain, intelligent driving domain, vehicle control domain, etc..

The central/quasi-central + zonal architecture has become a way for OEMs to reduce costs

According to statistics from ResearchInChina, 779,000 passenger cars with domain fusion architectures were sold in 2024H1, accounting for 7.9%, followed by 336,000 passenger cars with quasi-central + zonal architectures with a share of 3.4% and 67,000 passenger cars with central + zonal architectures with a share of 0.7%.

Due to the obvious cost advantages incurred by zonal architectures and the superior vehicle space design, the penetration rate of "quasi-central + zonal" architectures and “central + zonal” architectures will reach 16.3% and 14.3% by 2027 respectively.



Source: ResearchInChina

Geely EEA Deployment (Some Models Listed)

For example, Geely secured an electrification rate of 34.2% and a domain fusion architecture penetration rate of 25.4% in 2024H1.

Geely's EEA Deployment (Some Models Listed)

OEM	EEA	Architecture type	Vehicle platform architecture	Brand	Model	Quotation (RMB10,000)	Level	Fuel type	Launch time	2023 Sales volume	Sales volume in 2024H1
Geely	GEEA2.0	Domain centralized architecture	SEA	ZEEKR	ZEEKR 001	26.90-32.90	CAR-C	EV	April 2021	76246	54568
Geely	GEEA2.0	Domain centralized architecture	SEA	ZEEKR	ZEEKR 007	20.99-29.99	CAR-B	EV	December 2023	857	27164
Geely	GEEA2.0	Domain centralized architecture	SEA	ZEEKR	ZEEKR 7X	Pre-sale: RMB239,900+	SUV-B	EV	A new model (2024)		
Geely	GEEA2.0	Domain centralized architecture	e-CMA	Galaxy	Galaxy L6	9.98-15.98	CAR-A	PHEV	September 2023	17250	29822
Geely	GEEA2.0	Domain centralized architecture	e-CMA	Galaxy	Galaxy L7	12.57-18.57	SUV-A	PHEV	May 2023	66247	36182
Geely	GEEA2.0	Domain centralized architecture	CMA2.0 Platform	Lynk & Co	Lynk & Co 08	19.58-28.80	SUV-B	PHEV	September 2023	32129	35643
Geely	GEEA2.0	Domain centralized architecture	SEA	Lynk & Co	Lynk & Co Z10	Pre-sale: RMB215,800+	CAR-C	EV	A new model (2024)		
Geely	GEEA3.0	Quasi-central + zonal architecture	GEA Platform	Galaxy	Galaxy E5	11.28-14.88	SUV-A	EV	A new model (2024)		
Geely Group				Sales volume of electrified models (EV&PHEV&REEV)						558,975	339,574
Geely Group				Sales volume of fuel vehicles						1,196,211	652,439
Geely Group				Total sales volume of all models (electrified + fuel)						1,755,186	992,013
Geely Group				Sales proportion of electrified models (EV&PHEV&REEV)						31.8%	34.2%
Geely Group				Total sales volume of models with domain centralized architectures (GEEA2.0)						349,607	252,158
Geely Group				Sales proportion of models with domain centralized architectures (GEEA2.0)						19.9%	25.4%

Source: ResearchInChina

Geely Galaxy E5 debuted with GEEA 3.0

In August 2024, Geely Galaxy E5 debuted with GEEA 3.0:

- In the body domain, there are a driver-side ZCU (ZCUDM) and a front-passenger-side ZCU (ZCUP)
- Flyme Auto is deeply customized based on Android
- The single-chip "cockpit-parking integration solution is based on "Longying No.1" of SiEngine Technology
- The electric drive system realizes "eleven-in-one": VCU, MCU, HBMS, LBMS, OBC, DCDC, PDU, Motor, Reducer, GWRC and TMS

- As the quasi-central + zonal control architecture brings advantages like better vehicle wiring harness layout, weight reduction, and cost reduction, the usable area in the Galaxy E5 car accounts for 67.2% of the total cockpit space, which is outstanding among battery-electric A-class SUVs of the same level. It is priced at RMB109,800-145,800 after being subsidized and discounted. It is expected to have a huge impact on the A-class battery-electric SUV market.

Geely will promote GEEA 3.0 among more models, and further install vehicle-level OS in vehicles to form a true central computing + zonal architecture platform.

In addition, Leapmotor's vehicles equipped with central + zonal architectures have experienced a surge in sales volume. Leapmotor's main models currently on sale, namely C16, C10, C11 and C01, carry the latest LEAP 3.0 ("Four-leaf Clover" central + zonal architecture). In August 2024, Leapmotor sold 30,305 vehicles, a year-on-year spike of more than 113%.

Based on LEAP 3.0, four domains are integrated into one, and the number of ECUs is slashed. Compared with LEAP 2.0 (domain centralized architecture), LEAP 3.0 makes the number of automotive controllers in the vehicle fall from 42 to 28, the vehicle wiring harness to less than 1.5 km, and the weight to 23 kg. While reducing costs and increasing space, it improves functional configuration and lower the price.

The central/quasi-central + zonal architecture has become a way for OEMs to reduce costs, such as Leapmotor C series, Geely Galaxy E5, IM L6, and the soon-to-be-delivered Voyah Courage.

EEA innovation: In addition to SoCs, ECU integrated design and central cross-domain SoCs (MCUs) will be introduced to accelerate supply chain integration and reduce costs.

A vehicle equipped with a traditional distributed architecture has more than 100 ECUs. The functional domain architecture has achieved partial ECU integration. Under the final central computing + zonal architecture, ZCUs and HPCs will integrate most of the ECUs in the vehicle.

The hardware design concept of ZCUs is to standardize controllers by board-level integration, and integrate all control modules with similar properties in a zone. The MCU integrates ECUs into a super large controller, so that one PCBA controls the functions of different zones. Therefore, under the zonal architecture, the number of ECUs is slashed, and the reduced ECUs are incorporated into ZCUs. Alternatively, they can be uploaded to the HPC, and transformed into smart sensors or actuators.

ZCUs can reduce the number of ECUs and communication interfaces, wiring harness costs and weight while saving space and achieving higher computing power utilization. Currently, most OEMs have planned to use 2 to 4 ZCUs in their next-generation multi-domain computing architectures each to integrate most ECU functions and cut down the number of ECUs.

ECU Integration Design Concept of Some OEMs

ECU Integration Design Concept of Some OEMs

OEM	EEA	OEM ECU integration design	Supplier system	Main chip
Tesla	✓ Quasi Central Architecture	✓ Tesla introduced three ZCUs (BCM-F/L/R) to supply power to each actuator of the vehicle, and conduct the unified management of different zonal nodes and their components through the CCM, and then form interaction via CAN communication, which simplifies the internal topology of the vehicle.	✓ ZCU: independent R&D + OEM	✓ Renesas RH850
Leapmotor	✓ "Four-Leaf Clover" architecture	✓ Based on the "Four-Leaf Clover" architecture, the number of ECUs is slashed, the number of automotive controllers in the vehicle falls from 42 to 28, the vehicle wiring harness is shortened to less than 1.5 km, and the weight drops to 23 kg.	✓ Central computer (C-DCU): Dahua Hirige ✓ ZCU: Jingwei Hirain Technologies	✓ Qualcomm SA8155P/SA8295P ✓ NXP S32G
GAC	✓ X-Soul	✓ The body domain controller (central computing unit) has been introduced, and the main control chip is NXP S32G399. Many original ECUs have been integrated into ZCUs, and the number of separate ECUs (traditional safety and chassis) may not exceed 10.	✓ Body domain controller (central computing unit): Continental	✓ NXP S32G399
IM	✓ Full stack 3.0	✓ The "central computing + zonal control" strategy will halve the number of domain controllers, increase the data bandwidth by 5 times, shorten the wire harness length by 30%, and speed up OTA by 70%	✓ ZXD1: Jiangsu Tianbao, a subsidiary of Yanfeng Visteon	✓ Qualcomm SA8295P ✓ Nvidia Orin-X*1 ✓ NXP S32G3
	✓ Full stack 1.0	✓ The intelligent computing center (ICC), power, chassis, body control. The body controller is connected to the chassis, cockpit and passive safety system through the intelligent computing domain controller	✓ Intelligent computing center (ICC): Jiangsu Tianbao, a subsidiary of Yanfeng Visteon	✓ Renesas R8A77971 ✓ Infineon MCU-TC397
BYD	✓ e3.0 Platform	✓ BYD's integrated body controller is an ECU that integrates multiple vehicle control modules including BCM, gateway controller, cluster controller, I-KEY controller, Bluetooth information station, reversing radar, tire pressure monitoring module, high frequency receiver module, air conditioning controller, thermal management controller, engine sound simulator, etc.. The extended version supports up to 32 traditional distributed ECUs. ✓ The number of power modules is reduced from N to 1, MCUs from N to 1-2, and housings from N to 1. The assembly process is shorter by (N-1), and wiring harnesses by 50.	✓ Integrated [illegible] controller: FinDreams Technology	✓ /

Source: ResearchInChina

High-performance MCUs (SoCs) Have been Widely Used

As most of ECU functions are integrated into the HPC and ZCUs, MCUs (SoCs) have been upgraded, and high-performance MCUs (SoCs) have been widely used.

In addition to the widely used NXP S32G2/G3 series, Renesas R-CarS3/S4 series, TI DRA series, SemiDrive G9H and other chips, NXP's powerful 5nm MCUs (SoCs), SemiDrive E3650, etc. also attract much attention.

NXP's first 5nm automotive MCU (SoC)

At the end of March 2024, NXP officially launched the world's first 5-nanometer automotive MCU. However, NXP did not call it an MCU, but dubbed it the S32N55 processor, the first device in the new S32N family of vehicle super-integration processors. It is actually a SoC with the following features:

- It has highly efficient computing cores that emphasize real-time performance;
- The cores can operate in split or lockstep mode to support different functional safety levels up to ISO 26262 ASIL D;
- It has a variety of network interfaces, including CAN, LIN, FlexRay, automotive Ethernet, CAN-FD, CAN-XL and PCIe, with at least 15 CAN network interfaces;
- Multiple ECU functions are integrated, including vehicle dynamic control, body, comfort, and central gateway. For example, S32N55 boasts the Automotive Math and Motor Control Library (AMMCLib) which supports AUTOSAR and small real-time operating systems (such as Zephyr), Real-Time Drivers (RTD), Type1 hypervisors, Inter-Platform Communication Framework (IPCF), Safety Software Framework (SAF) and Structural Core Self-Test (SCST).

SemiDrive E3650

This product uses the latest ARM Cortex R52+ high-performance lock-step multi-core cluster, supports virtualization, has a non-volatile memory (NVM) up to 16MB, large-capacity SRAM and rich available peripheral resources to enable EEAs with higher integration and wider configurations.

EEA innovation: from decentralized operating system to vehicle-level OS which is the key to central computing

The vehicle OS is oriented towards the central computing platform and is based on SOA. It can integrate the functions of different domains in the vehicle (cockpit, intelligent driving, vehicle control, etc.) into one platform system, thereby providing a vehicle-level platform with the same set of programming interfaces. It is a development and operation platform for all vehicle domain software and services.

- Leapmotor vehicle OS: software and hardware decoupling, SOA, and multi-system software integration.
- Leapmotor OS IVI system: QNX (cluster) + Android (IVI system) based on QNX Hypervisor;
- Gateway, etc.: Linux;
- ADAS, vehicle control, CAN bus system: based on RTOS;
- Communication middleware: DDS distributed communication middleware + Mailbox communication bus;
- SOA: “Four-Leaf Clover” SOA software design architecture. 200+ interfaces are open for custom scenario applications, 500+ interfaces are reserved, scenario codes can be shared. Super senseless OTA: cockpit upgrade completed within 8 seconds (detection environment in 7 seconds, system switching in one second).

NIO's full-stack self-developed vehicle OS - SkyOS

NIO's full-stack self-developed vehicle OS – SkyOS

- **SkyOS-L:** The first real-time operating system that realizes localization of AutoSAR and large-scale commercialization. Compared with AUTOSAR, SkyOS-L has a 30-40% higher real-time periodic signal delivery rate;

- **SkyOS-M:** The microkernel architecture runs in the central brain and mainly controls the body, chassis, suspension, etc. The kernel is more stable than traditional Linux with better service isolation. On the basis of safety isolation, there is a four-layer monitoring and three-layer recovery security mechanism;

- **SkyOS-C:** The deeply customized operating system based on Android carries the functions of the smart cockpit, with the self-developed TOX protocol stack, more stable data transmission, and AI smart experience including NOMI;

- **SkyOS-R:** It improves the load capacity of the system;

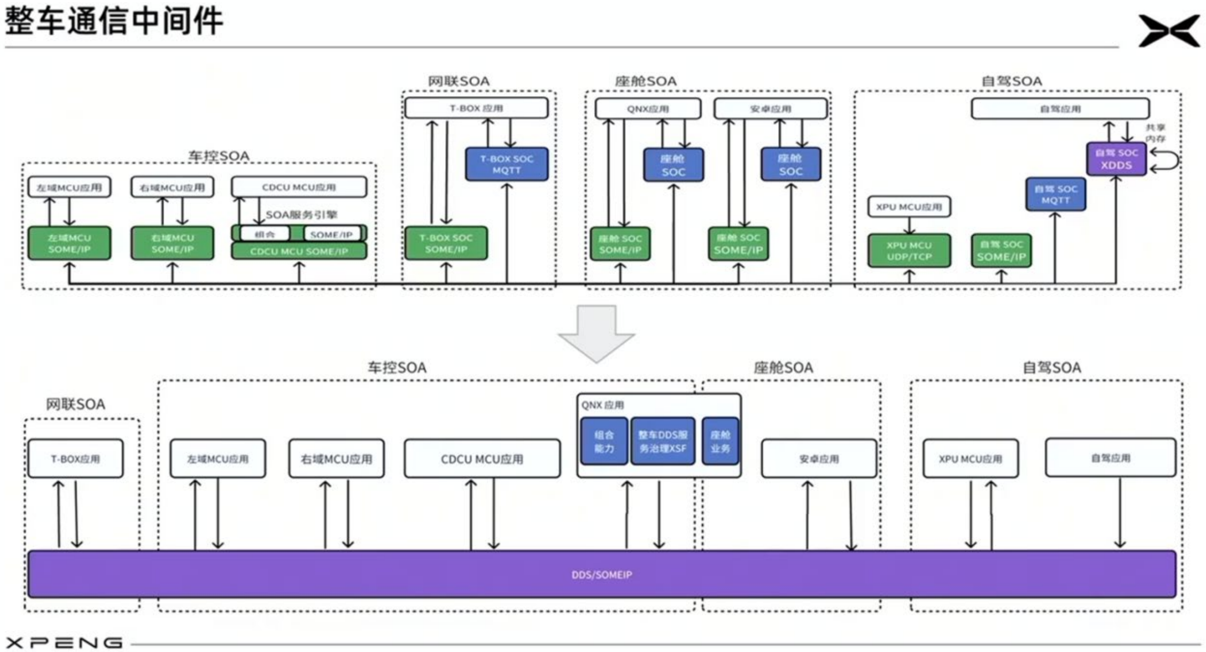
- **SOA framework:** NIO defines a high-performance cross-domain communication protocol named TOX, which means Talks Over X. It can be applied to all network types and all communication terminals;

- **The cross-domain communication protocol TOX** can provide high-bandwidth, high-capacity, low-latency, and high-reliability communication. It can be 30-50 times faster than the traditional CAN bus. Compared with the traditional automotive communication protocol SOME/IP, the end-to-end delay is reduced by 40%, and the zero packet loss threshold is increased by 109%. The reliability of TOX transmission is higher than SOME/IP.

Xpeng's unified cross-domain middleware (UCM) for vehicles

Vehicle communication middleware includes system security middleware, data security middleware, functional safety, vehicle OTA, vehicle SOA, etc. Cockpit applications and autonomous driving applications are immune to differences or changes in hardware platforms, thus greatly improving research and development efficiency and speed.

To optimally allocate hardware resources, Xpeng adopts the "building blocks" approach to arrange and combine resources according to actual needs, so as to make products with optimal utilization, best performance and best experience.

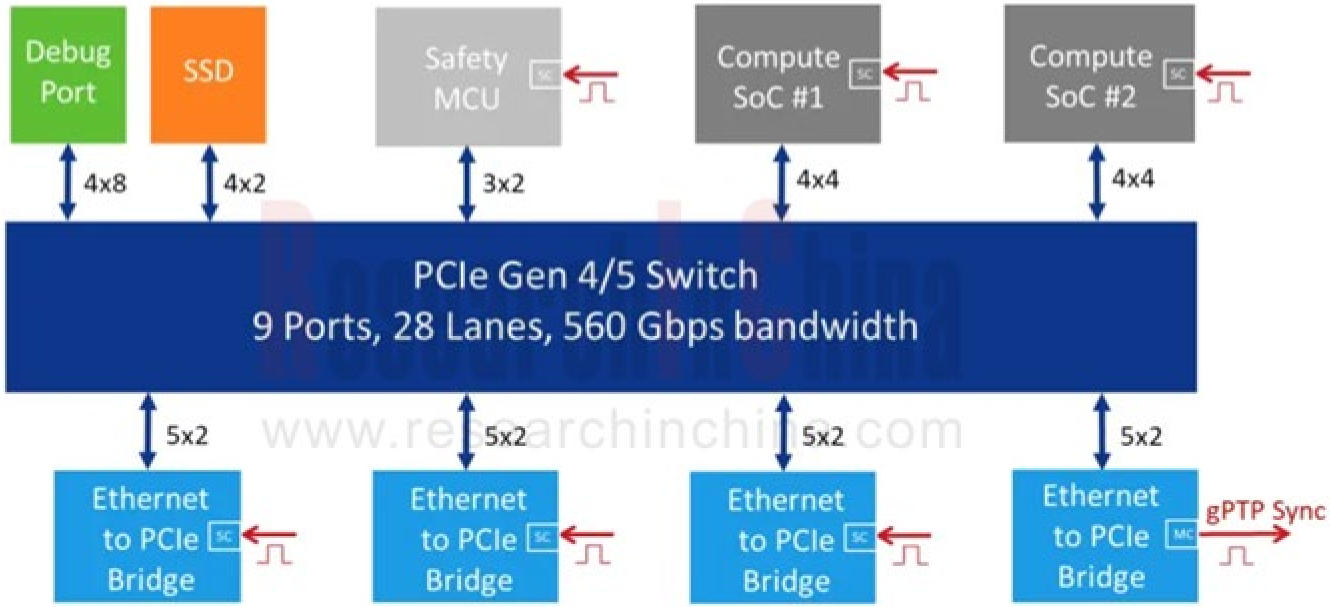


EEA innovation: Cockpit-driving integration and integration of cockpit + driving + vehicle control are gradually becoming the mainstream, and the PCIe communication framework will be built

Under the quasi-central/central architecture, all systems that require computing resources, such as intelligent driving, cockpit, parking, power, chassis, body, and seating systems, may be concentrated in a central computing unit. Therefore, a severe challenge for automotive networks is the high-performance computing interconnection of the central computing platform itself.

According to the degree of concentration of the "central computing platform", there are "Multi-Box", "One-Box", "One-Board" and "One-SoC". In addition to breakthroughs in integrated design technology at the chip hardware level, this centralized process also relies on advances in communication technologies such as inter-board interconnection, inter-chip interconnection, and on-chip interconnection.

As shown in the figure below, 4 Ethernets are connected to the PCIe bridge. The bandwidth of these 4 ECUs is about 50Gbps, so a bridge chip or switch should be used to convert Ethernet to PCIe.

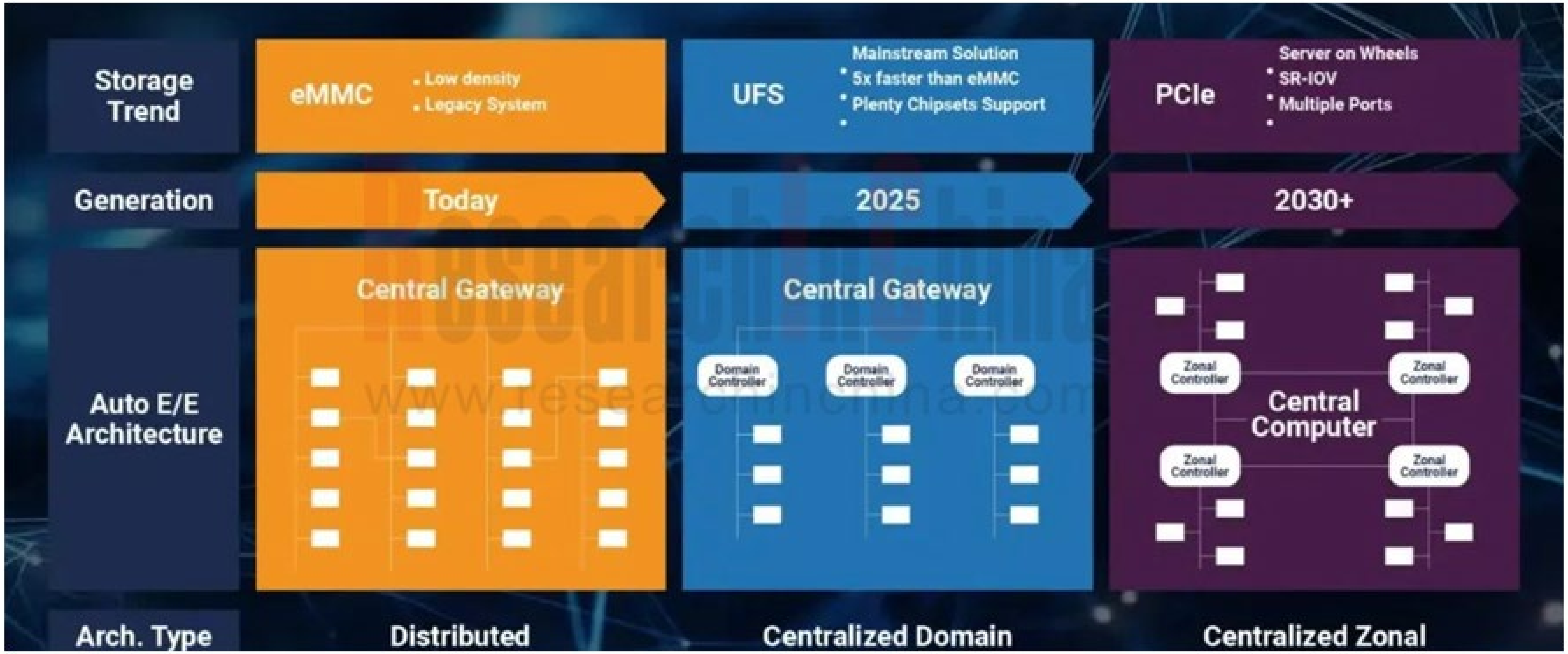


Source: Microchip

Architecture Centralization has Promoted the Development of Data Storage Technology

Architecture centralization has promoted the development of data storage technology from traditional eMMC and UFS to more powerful PCIe 3.0 and PCIe 4.0 SSD. Large-capacity SSDs with PCIe bus will be the main form of automotive storage under zonal architectures in the future.

Evolution of Automotive EEA from eMMC→UFS→PCIe SSD in Storage Demand



Source: Phison Electronics

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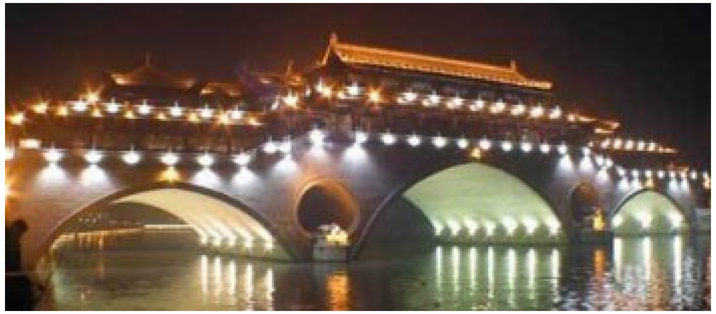

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