Adaptable compute platforms in autonomous driving

Xilinx Adapt Automotive | January 2021

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Pony.ai at a glance

Leading AD technology

L4 technology: Full-stack software and hardware system, vehicle-agnostic

Diverse ODD coverage: Dense urban, suburban to highway

Strong partnership ecosystem

Partnerships with OEMs, T1s and suppliers

Backing from leading strategic and financial investors

Impactful target markets

Urban, personalized Mobility-as-a-Service, and long-haul logistics

Robotaxi and logistics operations in US and China

System engineering plays key role in autonomous driving

AD sensor inputs

- LIDAR
- Radar
- Camera
- (Ultra)-sound
- GNSS
- IMU

AD SW stack - executed on AD compute platform

- Perception
- Localization
- Prediction
- Planning
- Motion Control

Vehicle actuators

- Steering
- Braking
- Throttle

- Varying sensor strategies, use-case / ODD dependent
- Frequent iterations, L4 still in active development phase

- Core modules of L4 AD software stack
- AD compute HW typically heterogeneous design combining various high-performance semiconductor components

- Strict safety goals for L4 (ASIL-D, double/triple redundancy)

AD compute platforms need to meet high requirements

Computational challenges in L4 AD

Strict computation latency requirements – **99% latency**

High performance while maintaining **power efficiency**

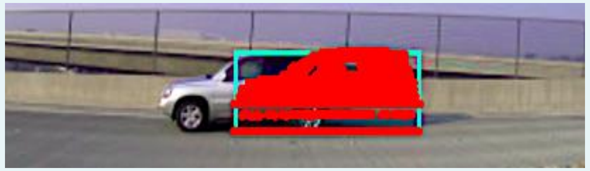
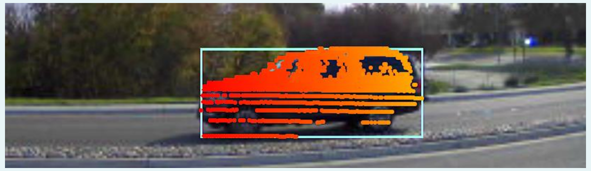
Deterministic run-time behavior needed

Customizable platform adaptable to different computational tasks

High standards for **functional safety** and validation

Cost-efficient and **scalable** design across AD market use-cases

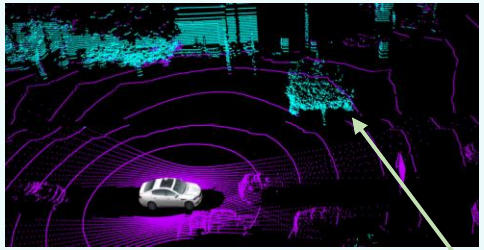
Case study 1: Lidar and camera sensor fusion

	CPU & GPU implementation	FPGA implementation
Latency improvement	• Baseline	• 12x improvement
Power consumption	• 250 W	• 30 W
Real-time accuracy	• Not real-time • Non-deterministic latency	• Cycle accurate pipeline • Deterministic fixed latency
Compute adaptability	• Cache hit rate ~60% • Computing core utilization rate <10%	• Cache hit rate ~100% (custom memory architecture) • Computing core utilization rate ~100%
Sensor fusion performance[1]	 • Sensor fusion discrepancy ~1/3 car length	 • No sensor fusion discrepancy

1. Test scenario: Lidar / camera fusion, relative speed of target vehicle to ego vehicle ~30 m/s

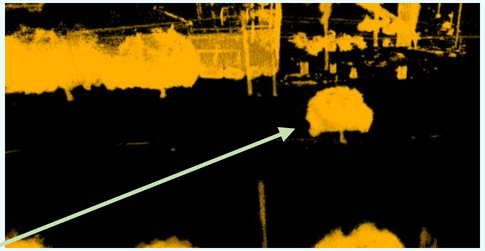
Case study 2: Scan Match localization

Scan Match method for accurate L4 AD localization..



LIDAR scan (real-time)

Landmark



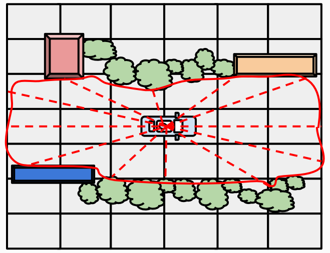
HD map

- **Scan Match:** Compares real-time LIDAR scans with pre-built HD map to achieve accurate localization necessary for L4
- **Requirements:** Low, deterministic latency times, power-efficient

… on FPGA compute platform for optimal performance

Ideal use-case for FPGAs

- Scan Match memory-intensive algorithm
- FPGAs ideal platform for designing high-performance data pipelines with tailored memory architectures



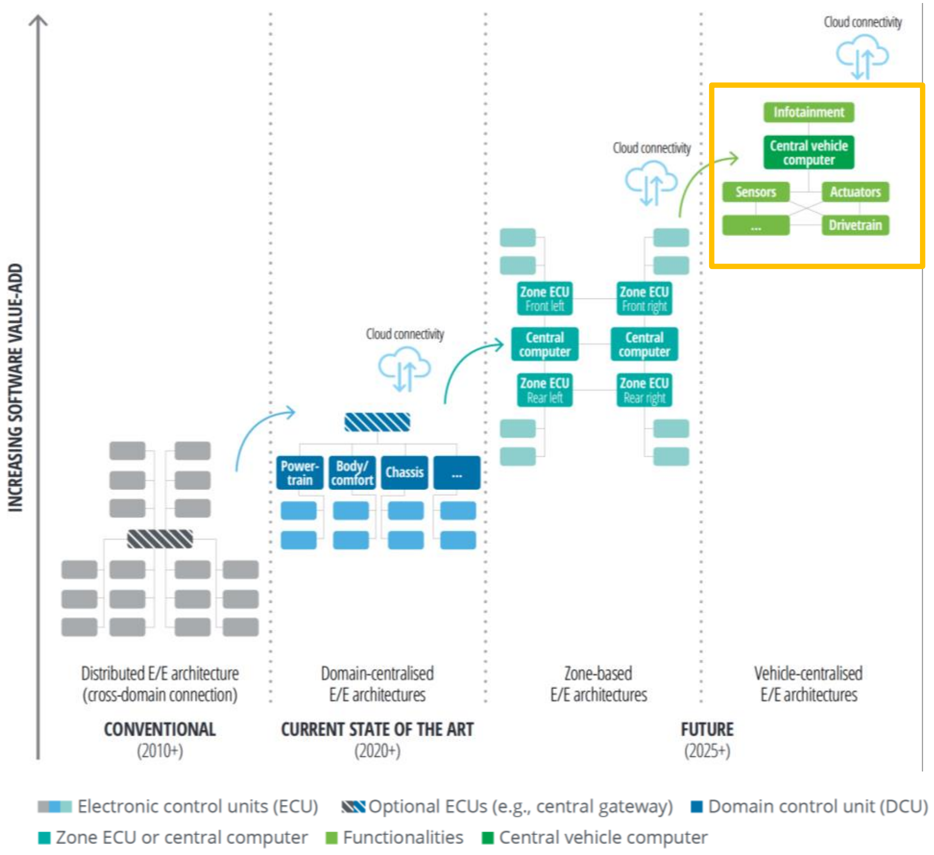
Model illustration

FPGA-based compute solution highlights

- Real-time localization with deterministic latency
- Significant power-efficiency improvement vs GPU solution

Adaptable compute platforms key enabler towards scalable autonomous and connected mobility

Trend towards centralized E/E architectures…



…increases need for adaptable compute platforms

Increasing requirements on compute hardware…

- High-end onboard processing power
- Data processing from ADAS / AD systems, personalized mobility (IVI), ubiquitous connectivity (cloud)
- Consolidation of function-specific ECUs to fewer, more versatile domain-specific DCUs

and software…

- Software content and complexity growing rapidly
- Software-based features increasingly drive product differentiation

highlights need for adaptable compute platforms

- Future-proof expensive compute HW through vehicle life cycle
- De-couple SW application development from vehicle SOP and physical life cycle
- Faster market scalability and standardization potential, e.g., less vertically integrated OEMs which do not 'own silicon'

Source: Deloitte, Bosch Automotive Electronics

Summary

Development of L4 autonomous technology complex system engineering challenge

AD compute platforms need to meet high-performance requirements across diverse tasks

Adaptable compute platforms key enabler towards scalable autonomous and connected mobility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