Introduction to Intelligent Vehicles
[1. System Architecture]

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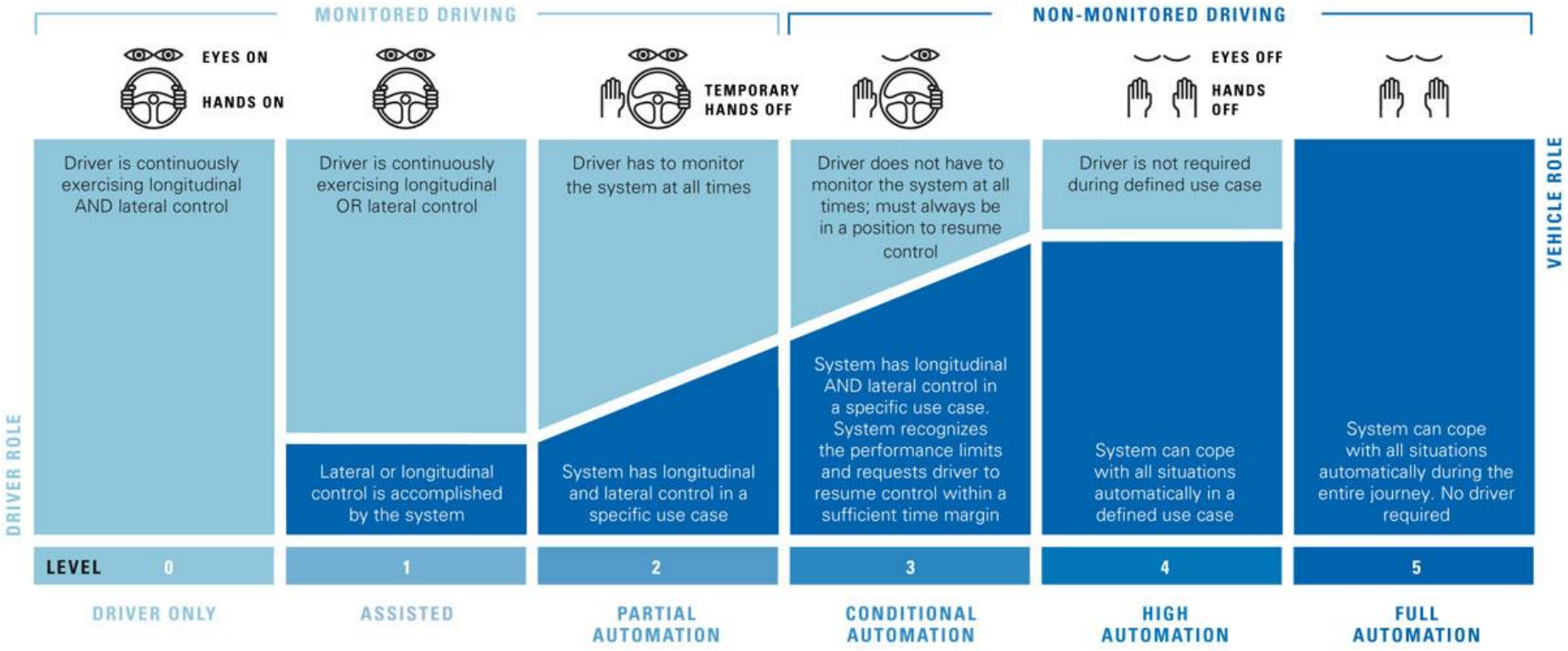
Levels of Autonomy

- Levels of driving automation [SAE J3016 / Wikipedia]
  - Level 1 (Drive Assistance): Adaptive Cruise Control (ACC), Parking Assistance, etc.
  - Level 2 (Partial Automation)
    - The vehicle takes full control of accelerating, braking, and steering
    - The driver must monitor the driving
  - Level 3 (Conditional Automation)
    - The driver can safely turn his/her attention away from the driving tasks
    - The driver must be prepared to intervene, when called upon by the vehicle
  - Level 4 (High Automation)
    - No driver attention is ever required for safety
    - Self driving is supported only in limited spatial areas or under special circumstances
  - Level 5 (Full Automation)

Levels of Autonomy



https://www.birmingham.ac.uk/news/thebirminghambrief/items/2016/11/driving-the-revolution.aspx

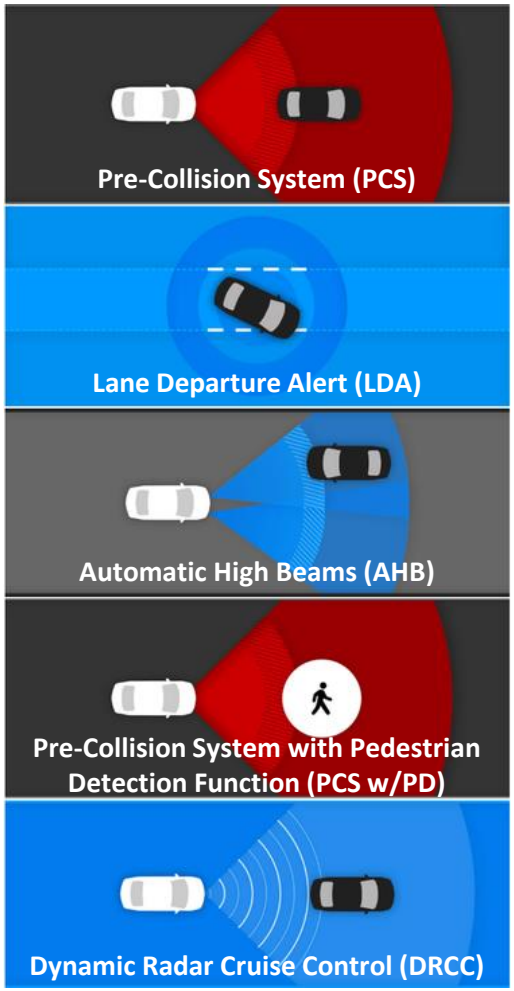
Mike Lemanski

Status of Connectivity

- Communication standards
  - Dedicated Short-Range Communications (DSRC)
  - C-V2X (Cellular Vehicle-to-Everything)

Software Design

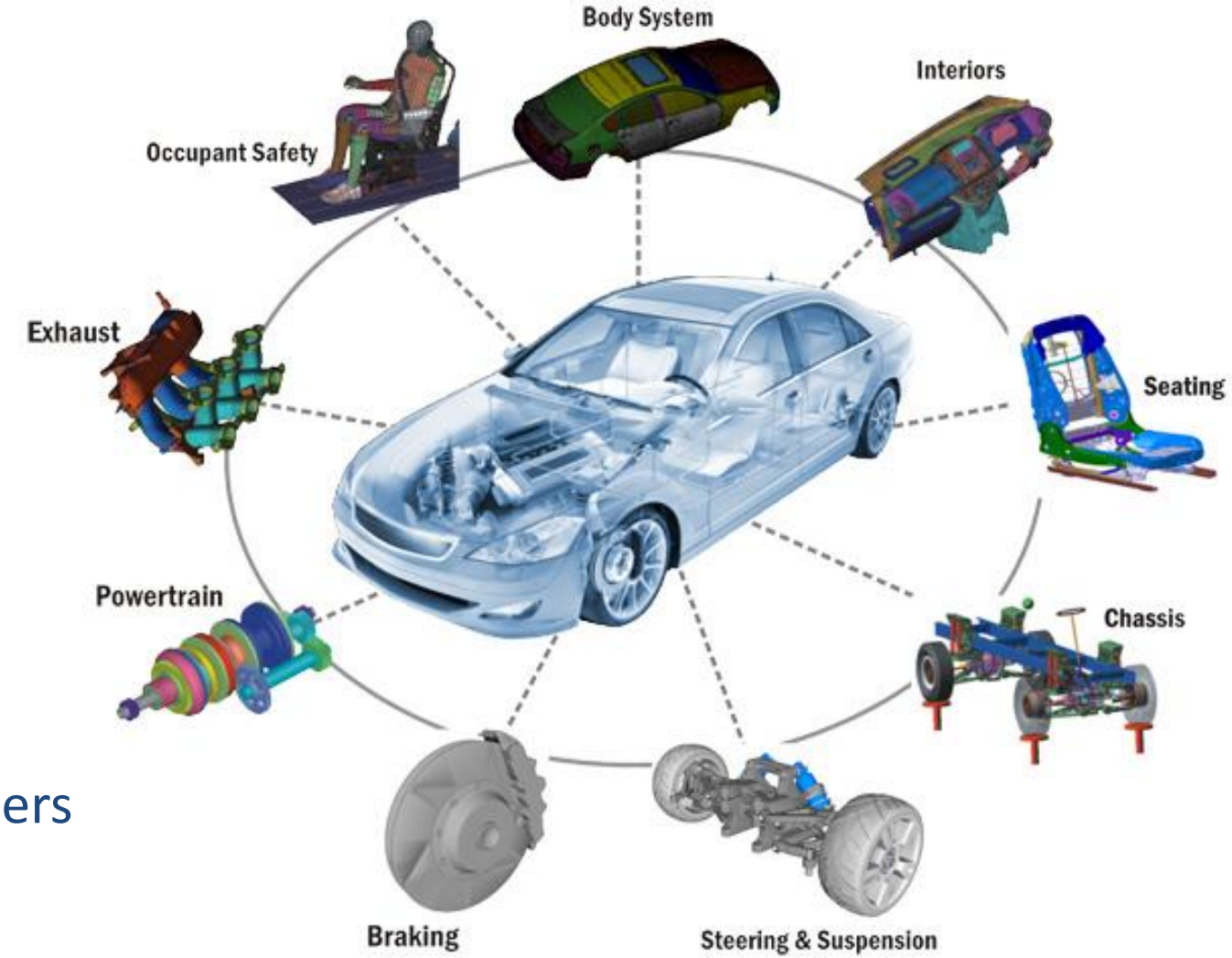
- Various applications including Advanced Driver Assistance Systems (ADAS) and autonomous functions
- Various software programs for sensing, signal processing, control, decision making, etc.
  - Values to vehicle's total value
    - Embedded software: 2% → 13% from 2000 to 2010
    - Electronics system: expected to be 50% in 2030
  - Number of lines of code
    - 1 → 10+ → 100 million from 2000 → 2010 → 2020
- Due to the safety-critical nature, correctness and quality of software are extremely important



http://www.toyota.com/safety-sense/

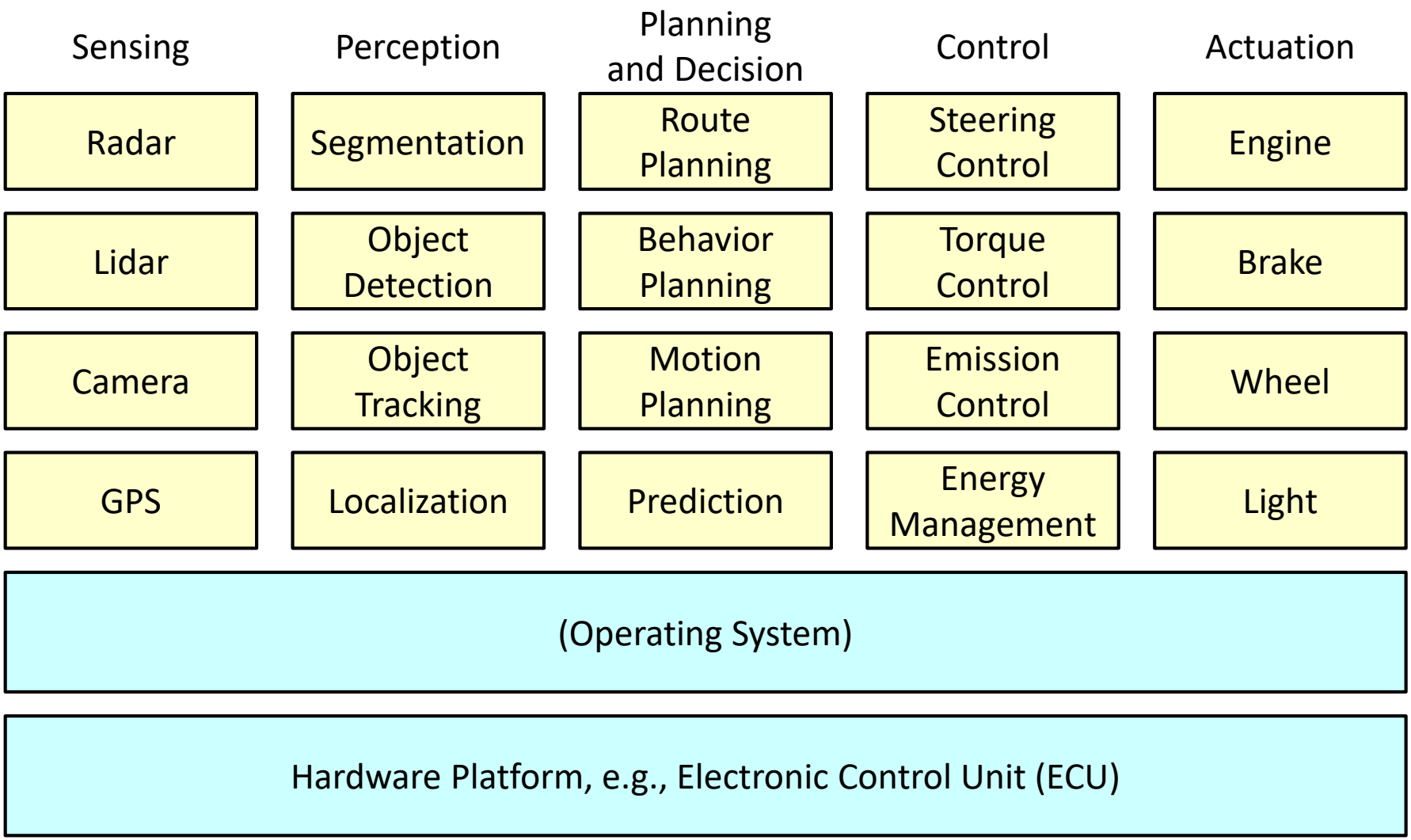
Subsystems

- Body
- Chassis
- Suspension
- **Control**
- Engine
- Transmission
- Braking
- Wiring
- **Electronics**
- And many others



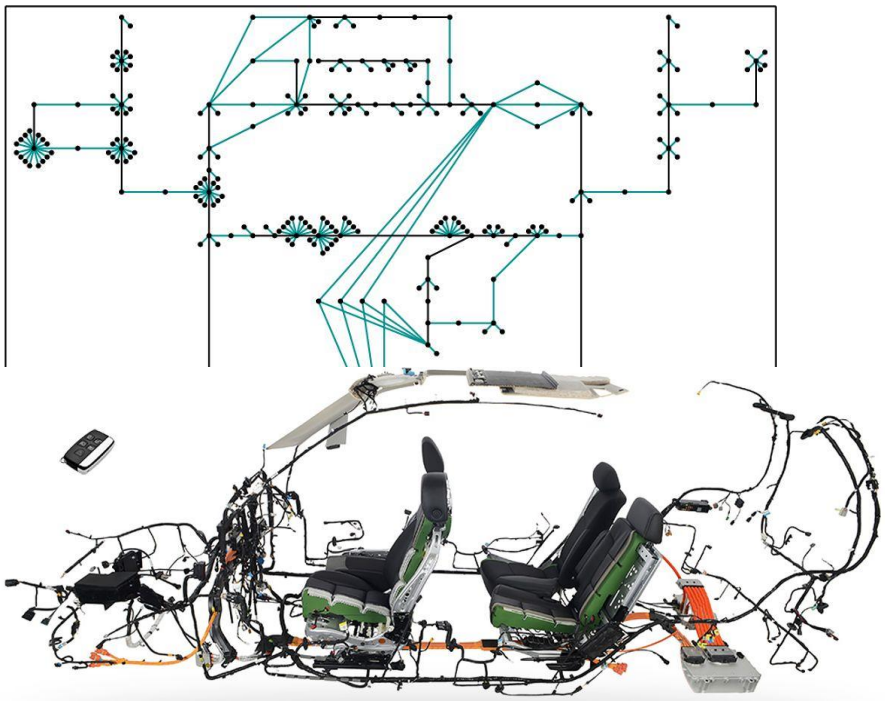
http://www.axiscades.com/automotive.html

Layered View of Autonomous Vehicles



Electronic Control Unit (ECU)

- Is an ECU like a Central Processing Unit (CPU)?
  - Yes? It does some computation
  - No? It is not centralized
- How many ECUs are there?
  - 20 → 50+ in the past decade



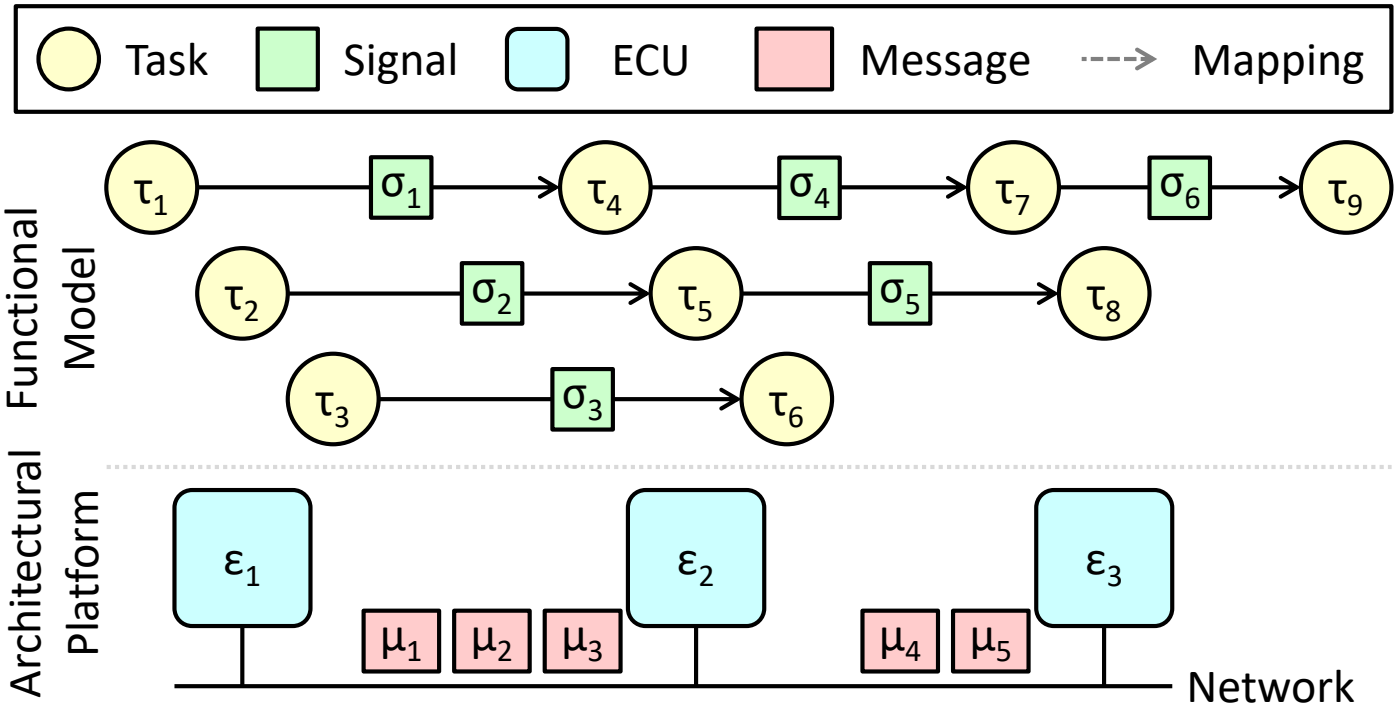
http://www.lear.com/Site/Products/

http://www.denso.co.id/Electro_ecu.html

https://www.indiamart.com/proddetail/denso-engine-electronic-control-unit-18672409991.html

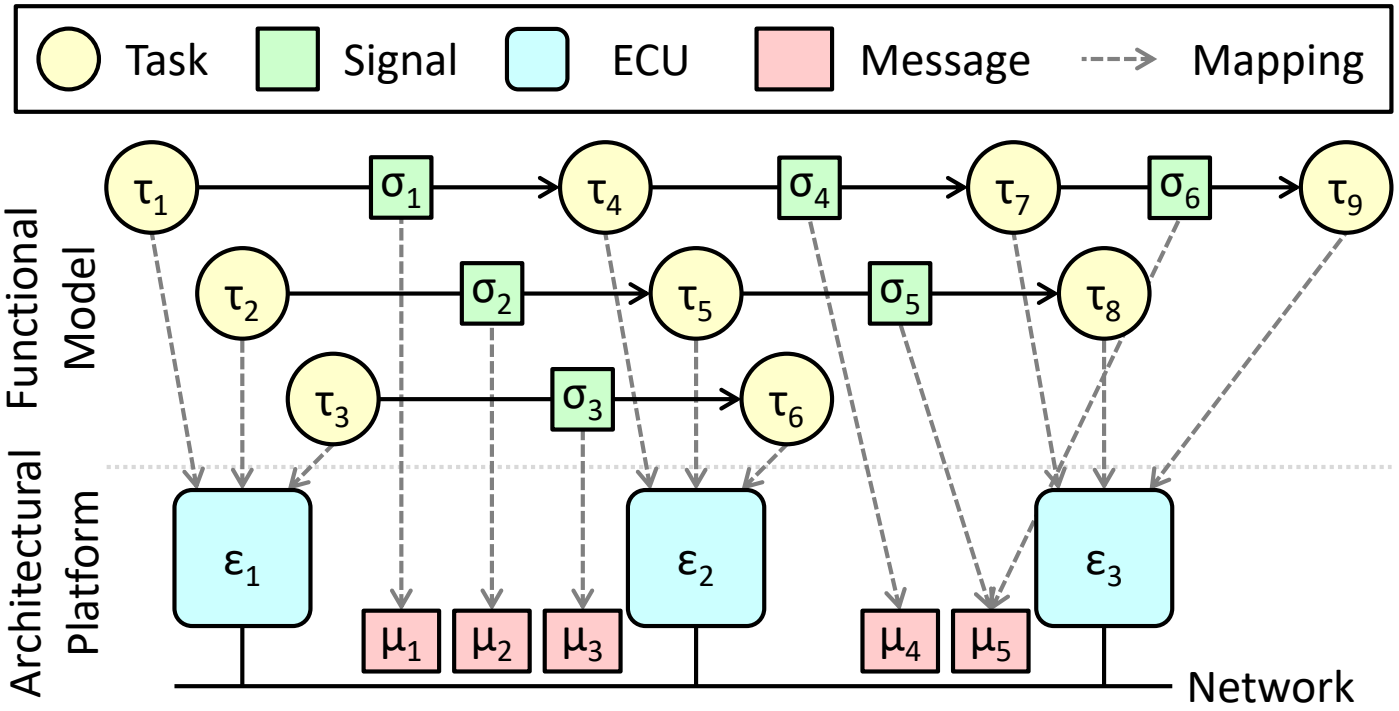
Mapping from Software to Hardware

- Software (functional model): task graph
- Hardware (architectural platform): distributed Electronic Control Units (ECUs) connected by a network



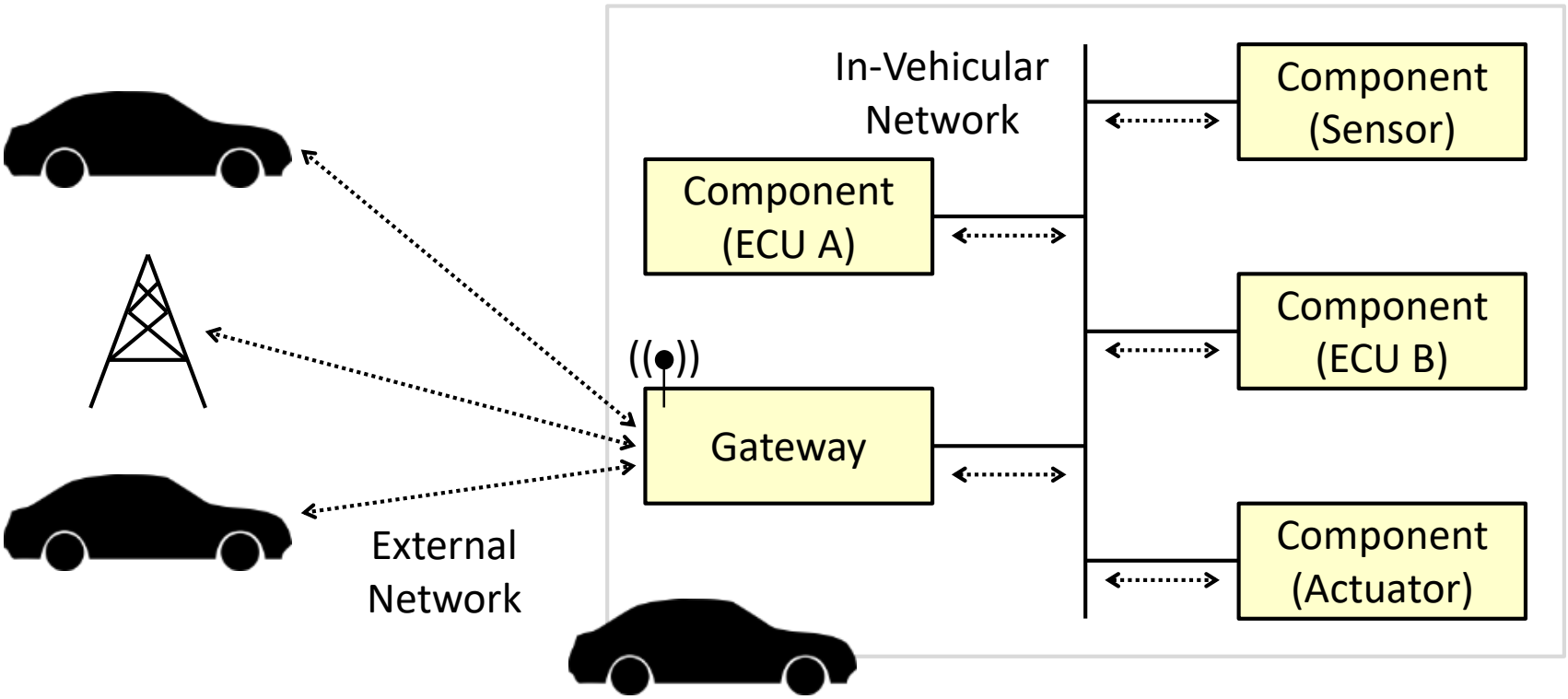
One Example Solution

- Decide task allocation and assign priorities to tasks on ECUs and messages on the network
- Satisfy timing constraints for tasks, signals, and paths



Layered View of Connected Vehicles

- From multiple vehicles to components in a single vehicle



Design-Time vs. Runtime

- Runtime software is executed during vehicle operation
  - It is usually designed during design-time
  - Examples of runtime software / functions
    - Localization algorithm
    - Object detection algorithm
    - Vehicle control algorithm
- Design-time software is executed during the design stage
  - It is more and more difficult to manually design a vehicle
  - Examples of design-time software / tools
    - Modeling
    - Design including optimization
    - Analysis including simulation, verification, and testing

Q&A