

# Introduction to Intelligent Vehicles

## [ 1. System Architecture ]

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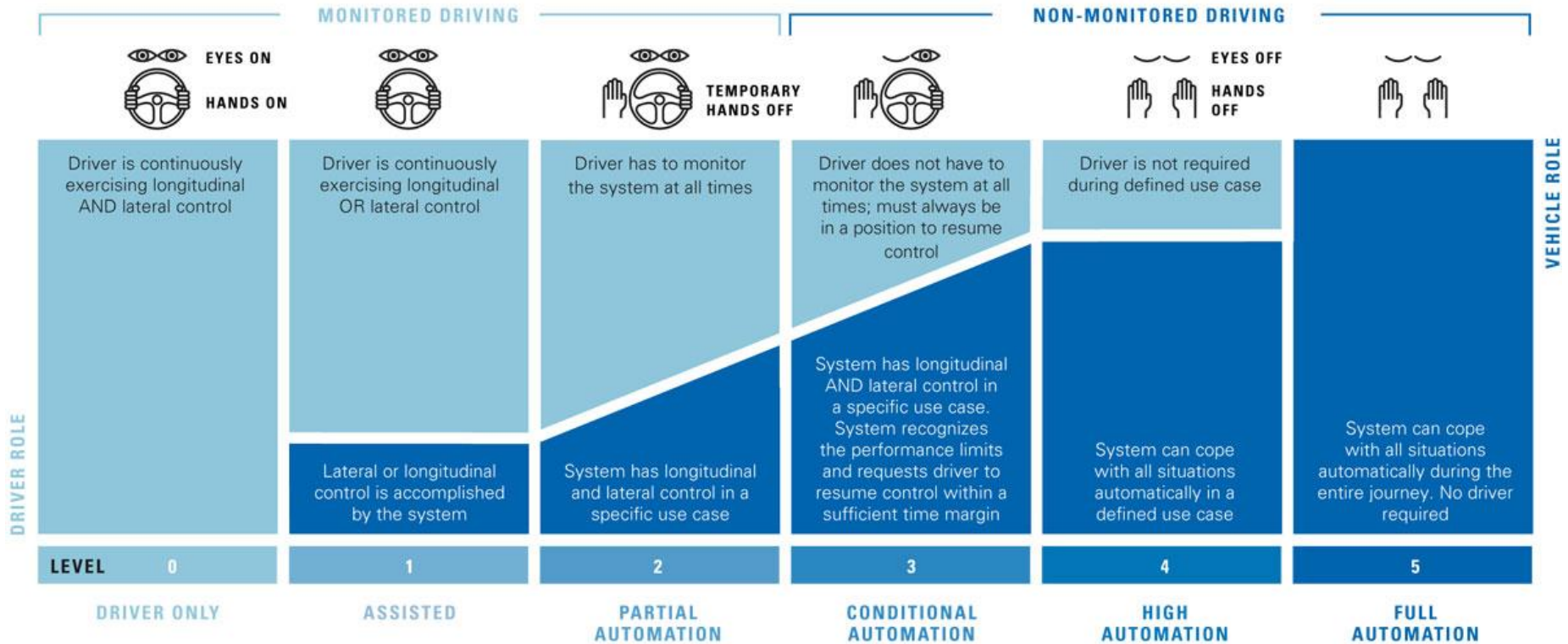
National Taiwan University

# 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

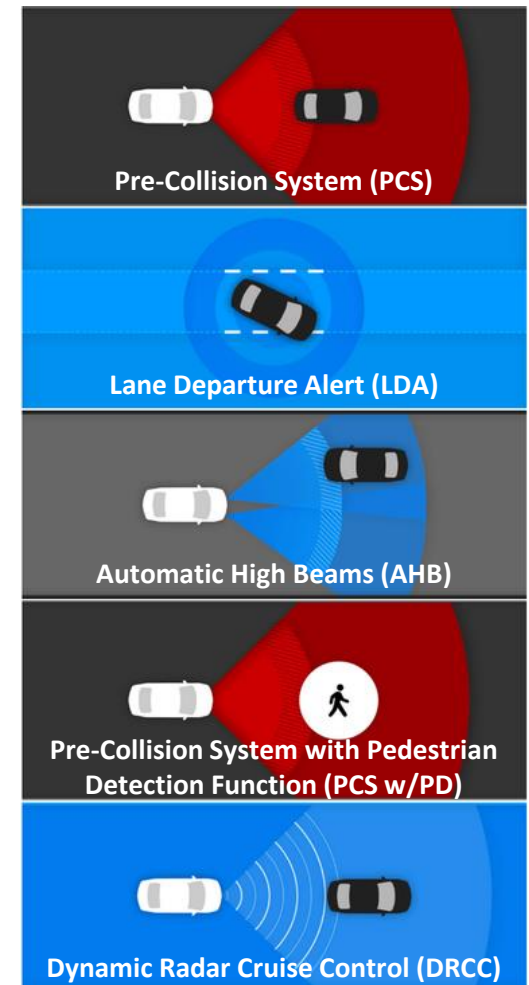
# Status of Connectivity

## ❑ Communication standards

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

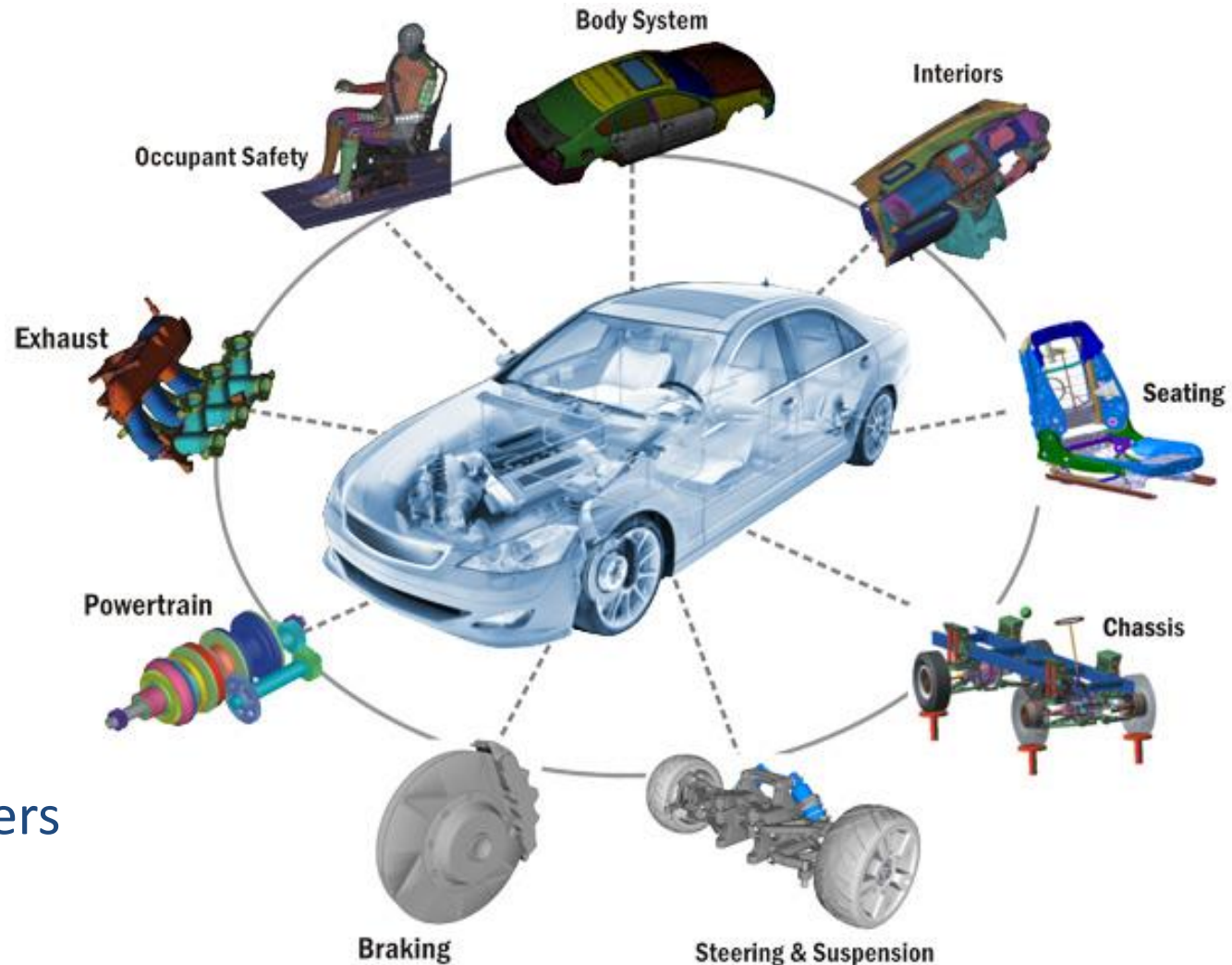
# Software Design

- ❑ 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

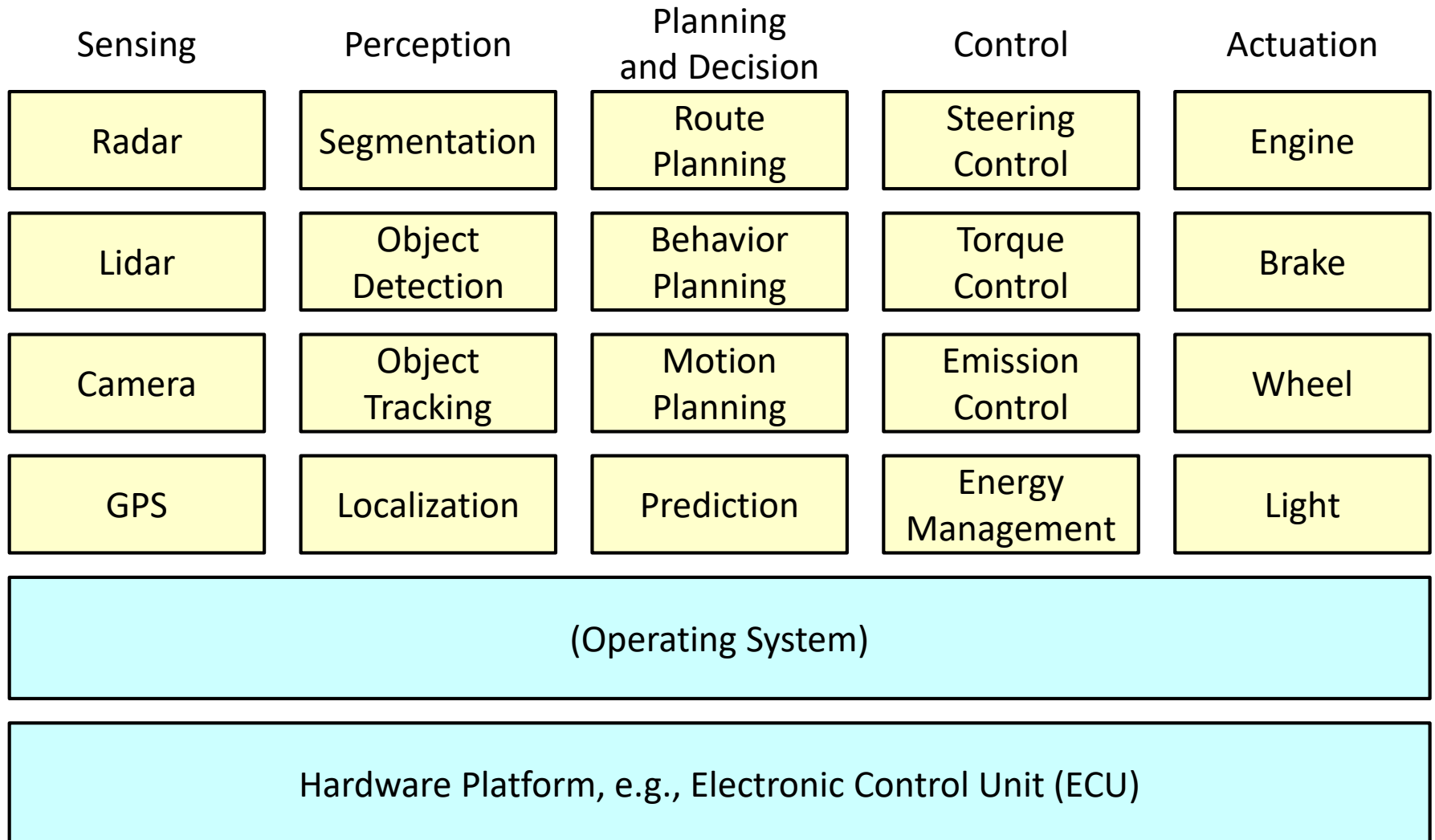


# Subsystems

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



# Layered View of Autonomous Vehicles



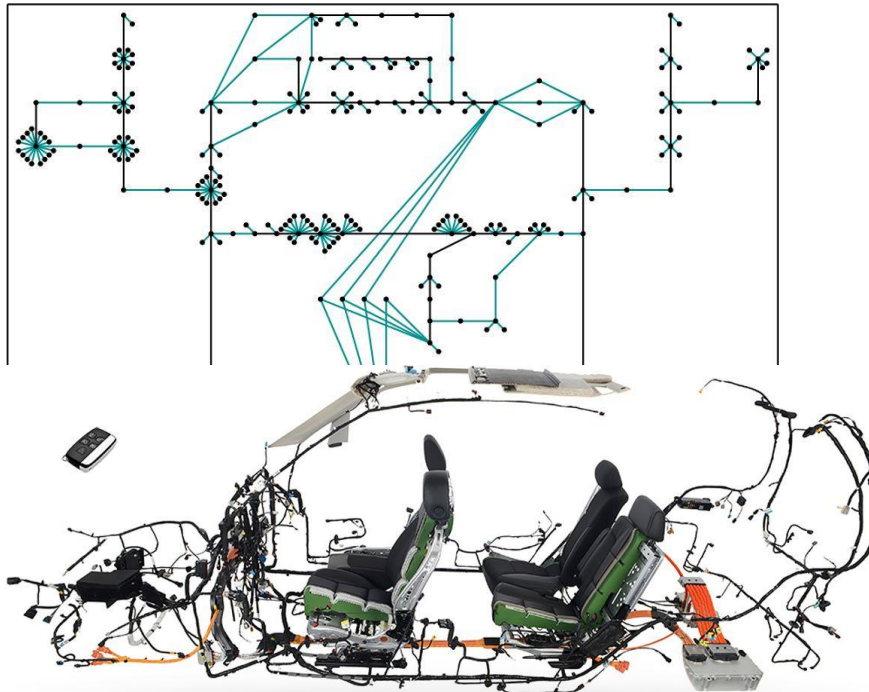
# Electronic Control Unit (ECU)

## ❑ 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](http://www.denso.co.id/Electro_ecu.html)

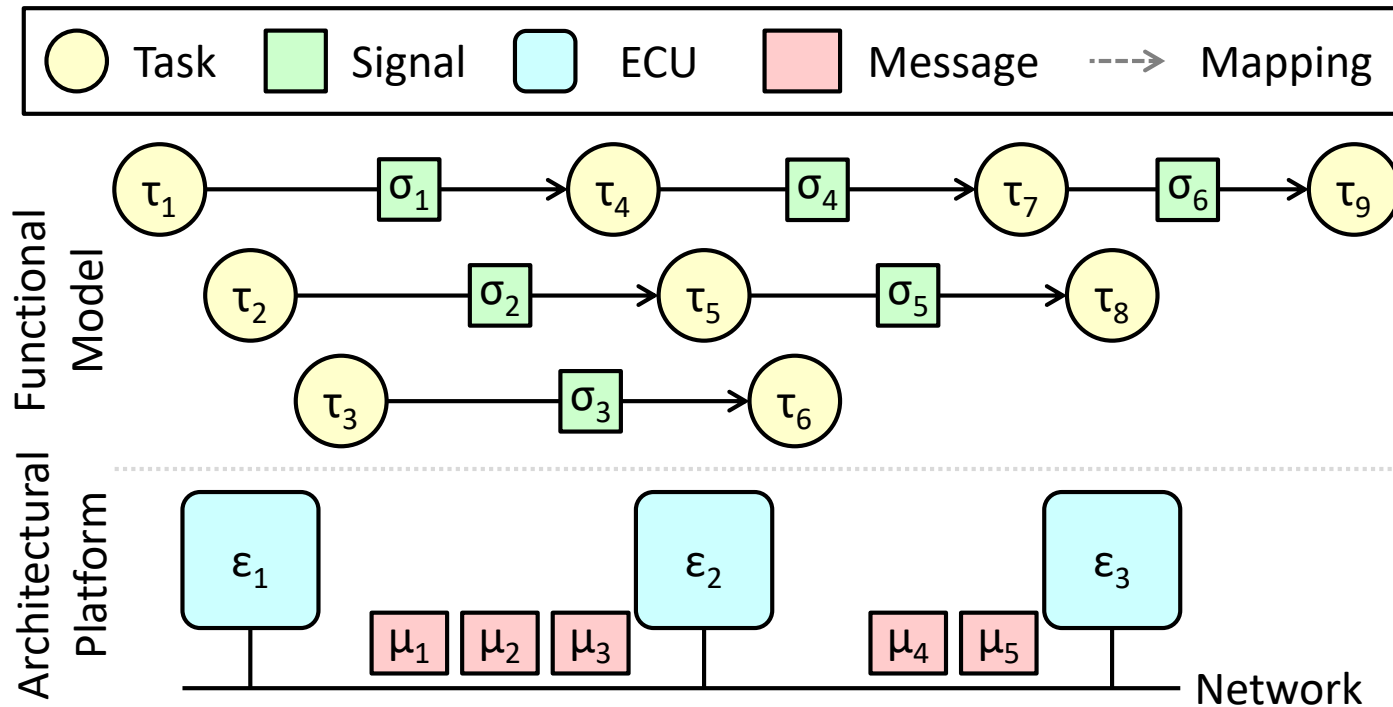


<https://www.indiamart.com/proddetail/denso-engine-electronic-control-unit-18672409991.html>



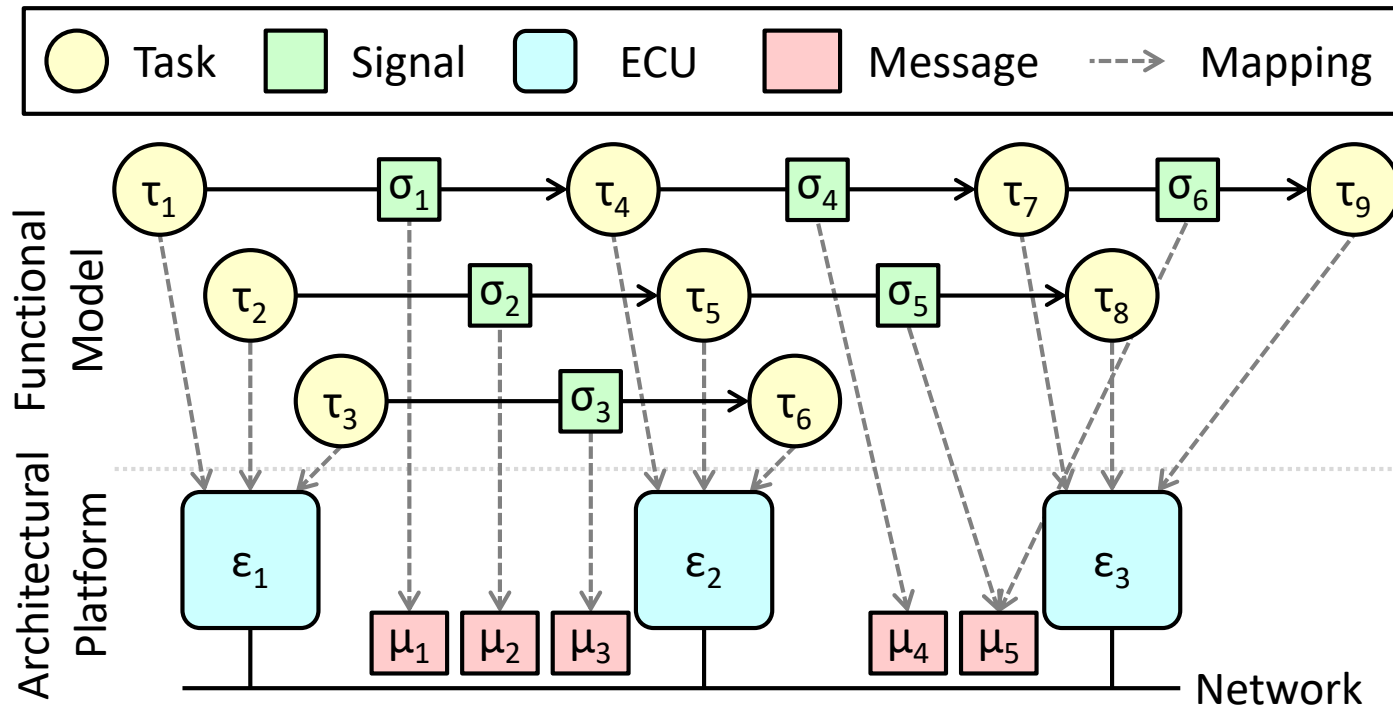
# Mapping from Software to Hardware

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



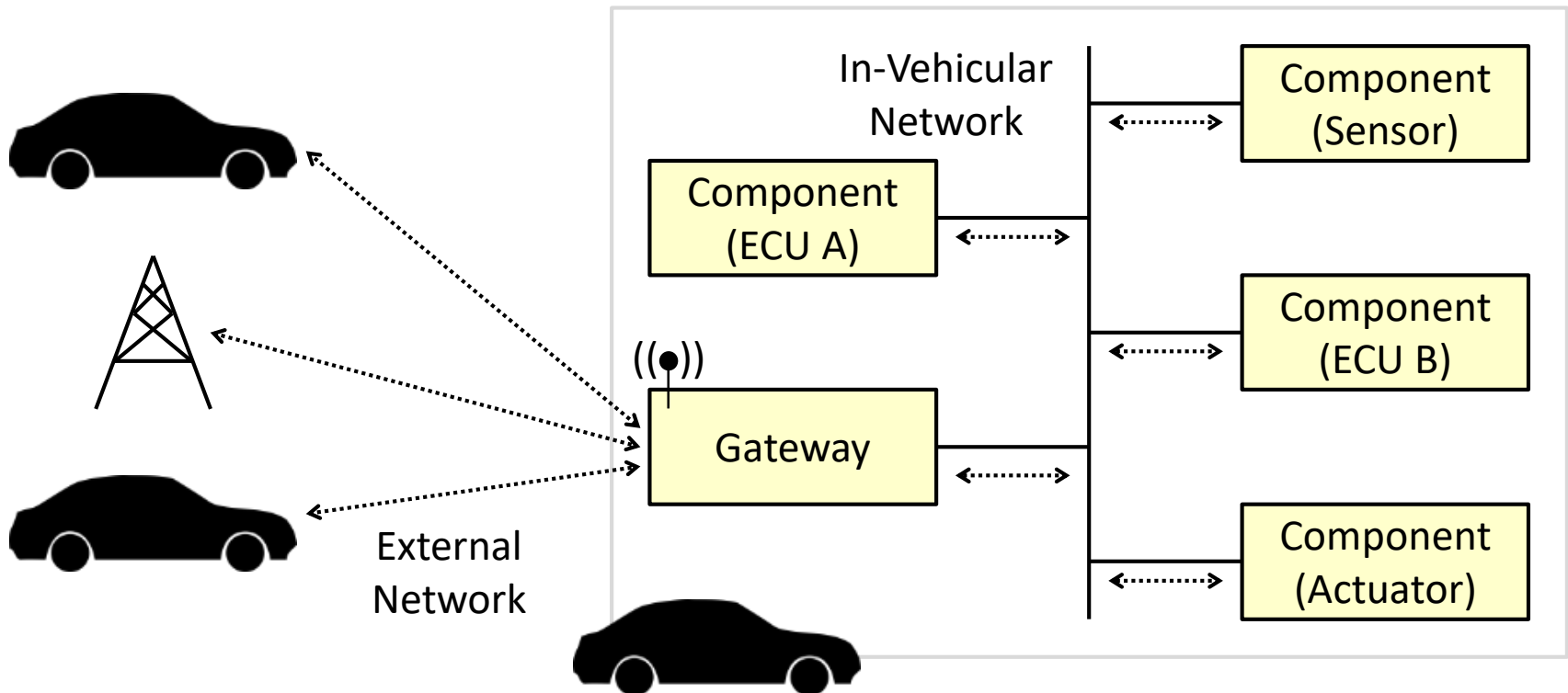
# One Example Solution

- ❑ 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