

# Introduction to the module

## KF6010 – Distributed Real Time Systems

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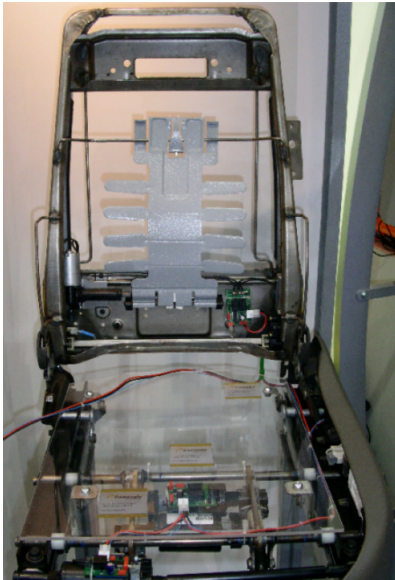
### Lecture 1

# Part I

## Some definitions

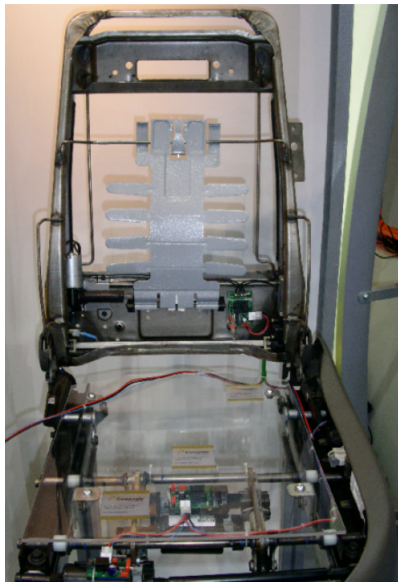
# Embedded systems are everywhere

How many CPUs in a car seat?



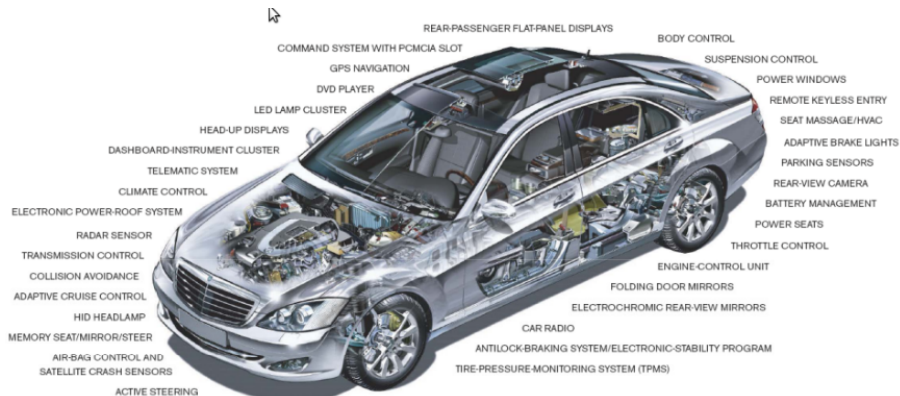
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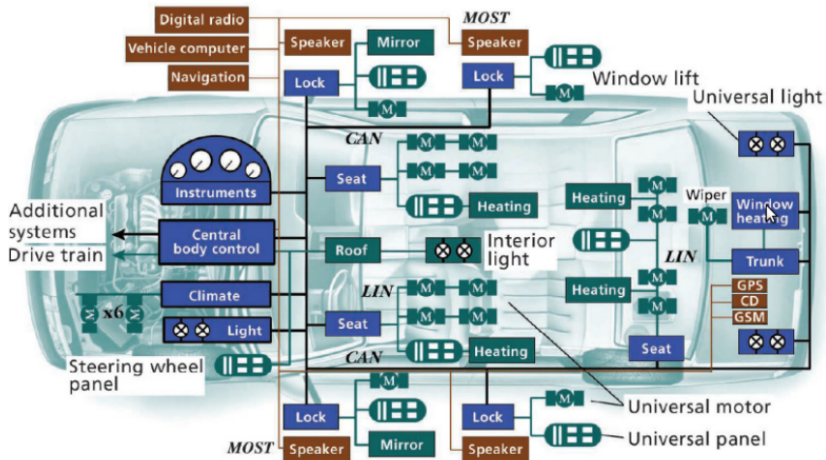


- Low speed LIN network to connect seat motion control nodes
- This is a distributed embedded system
- CPUs
  - ▶ Front-back motion
  - ▶ Seat tilt motion
  - ▶ Lumbar support
  - ▶ Control button interface

# How many CPUs in a car?



# How many CPUs in a car?



CAN Controller area network  
 GPS Global Positioning System  
 GSM Global System for Mobile Communications  
 LIN Local interconnect network  
 MOST Media-oriented systems transport

# What is an embedded system?

## A working definition

**Embedded system** a computer built-into other systems

**Embedded systems** monitor and control their environment

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## Applications

- Aerospace
  - ▶ Avionics – flight control systems
  - ▶ Engine management
- Buildings
  - ▶ Lift control
  - ▶ HVAC (Heating Ventilation Air-Conditioning)
  - ▶ Lighting
- Transport (see above)
- Consumer devices
  - ▶ remote controls
  - ▶ fridges



## Part II

# Some Engineering Detail

*The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behaviour under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property.*

— The American Engineers' Council for Professional Development

*For a successful technology, reality must take precedence over public relations, for nature cannot be fooled.*

— Richard Feynman

# Embedded Systems Characteristics

**Concurrent** – composed of multi-tasking and/or distributed processes

**Communicating** – specialised processes communicate in order to achieve some overall system function

**Real-Time** – timing requirements are established by the environment

**Resource-constrained** – limited resources: processing, memory, peripherals, power, . . .

# Concurrency

- Arises when multiple processes (tasks) share a single processor
- allocation of the processor to a different task can be:
  - event-triggered** A response to **any** of many possible **interrupts**:  
periodic-timer overflow, arrival of message on CAN bus,  
the pressing of a switch, the completion of an A/D  
conversion, . . .
  - time-triggered** Response to **one** source of **interrupt** only: usually a  
periodic timer
- Managing and reasoning about concurrency is a major challenge for  
the Embedded Systems Engineer

- Computing nodes that communicate with each other, form a **distributed system**
- Economic and safe allocation of resources in a distributed system requires a **predictable** communication network
- Predictable communications networks include
  - ▶ CAN, TTCAN
  - ▶ TTEthernet

# Real-Time

- A **real-time system** is a system where the total correctness of an operation depends not just on the **logical correctness** of the result, but also its **temporal correctness**. *i.e.* the time at which it is produced.
- A **deadline** specifies the time by which an operation must complete and deliver its result.
- A **hard real-time system** is a system that is considered useless if an operation misses a single deadline
- A **soft real-time system** tries to meet its deadlines, but can tolerate an occasional missed deadline, perhaps giving reduced service quality

Application of scientific principles to:

- the design of embedded systems
- the construction of embedded systems with *full cognisance* of their design
- the forecasting of the behaviour of embedded systems under specific operating conditions

*with respect to intended function, economics of operation, and safety to life and property*



## Part III

# Module content

# Module content

## summary of key parts

- Uni-processor systems
  - ▶ Event-triggered
  - ▶ Time-triggered
- Distributed solutions
  - ▶ Networks for embedded systems
    - ▶ CAN bus
    - ▶ MQTT
  - ▶ Analysing networked embedded systems
    - ▶ Distributed Response Time Analysis
- Other topics
  - ▶ C programming for embedded systems
  - ▶ Methods, tools
  - ▶ Standards