Real-time Architectures

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Real-time Architectures
Car
Car
Car
Climate control
Electrical system
Engine
Suspension
Powertrain
Car
Pre 1970: Mechanical control
Late 1970s: First ECU
Early 1980s: More ECU functions
Early 1980s: Several ECUs
Early 1980s: Point-to-point communication
1990s: More ECUs
1990s: More ECUs
1990s: Shared communication medium
2000s: Electronic explosion
2000s: Electronic explosion
Car control in software

• High complexity and cost
  – ~ 100 million lines of code (2010), $10 / line

• Implementing functions in software allows:
  – Greater accuracy than mechanic solutions, more flexibility than electronic hardware
  – Map several functions onto the same ECU
  – Cost-effective remote diagnostic and repair (near future)
Real-time Architectures
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Real-time requirements

• Example: inflation of an air bag
  – real-time ≠ fast
  – real time: fulfill specific timing requirements
Real-time requirements

• Example: fuel injection
  – real-time ≠ fast
  – real time: fulfill specific timing requirements
Example real-time requirements for engine control

• Requirements
  – Keep the fuel intake valve open for $f(x) \text{ \mu s}$ at $x \text{ rpm}$.

• Relevance:
  – avoid mechanical damage
  – provide quality of control (e.g. fuel efficiency)

• Challenges:
  – latency between sending “close” command to valve and the actual time when the valve closes
    • Communication latency
    • Environmental conditions (e.g. temperature)
Real-time architectures in context

• Real-time control of the Star Range Extender (SREX) for Tesla Model S
  – monitoring battery capacity
  – switching from electric engine to SREX
Goals for the course

• After this course you should be able to:
  – Explain and apply the fundamental concepts and terminology of real-time systems in the automotive domain
  – Explain and address the fundamental problems of real-time systems
  – Analyze real-time systems designs
  – Design a real-time system
  – Implement simple programs on an embedded platform
ECU
Example ECU (Freescale board EVB9512XF)
http://www.win.tue.nl/~mholende/automotive