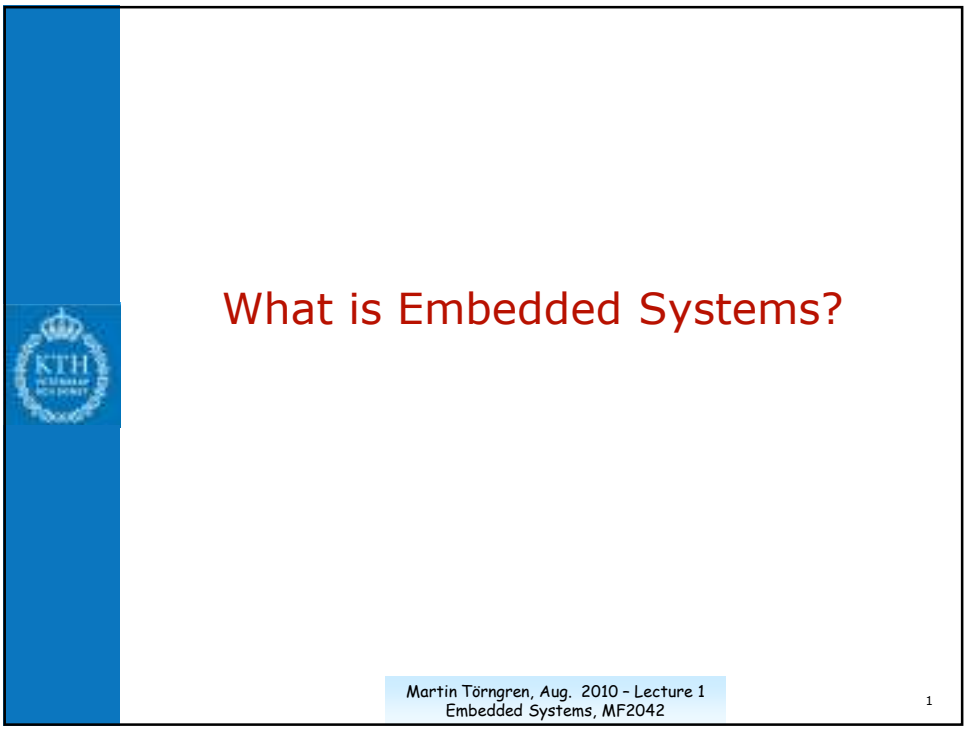
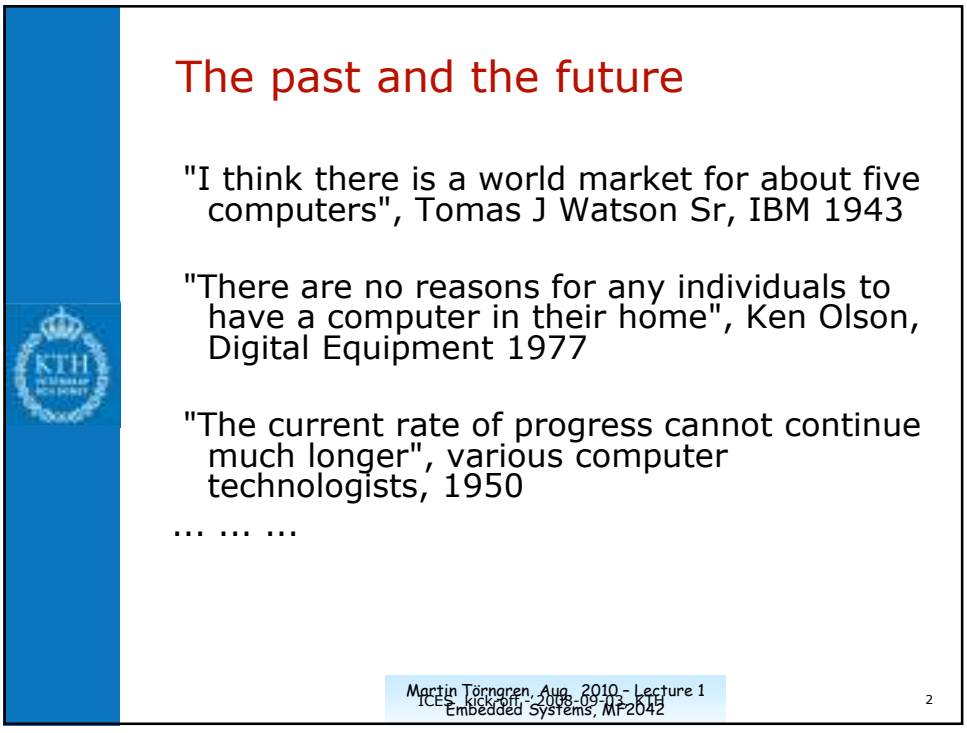


What is Embedded Systems?



The past and the future

"I think there is a world market for about five computers", Tomas J Watson Sr, IBM 1943

"There are no reasons for any individuals to have a computer in their home", Ken Olson, Digital Equipment 1977

"The current rate of progress cannot continue much longer", various computer technologists, 1950

... ...

Evolution of electronics

Technology scaling continues according to Moore's law:
~ 2X increase in functionality every 2 years. Multicore
~ 65nm in 2005, 45 nm in 2007, 32 nm in 2009, ...?

Example
From Intel 4004, 1971: 2300 transistors, 108 kHz
To Pentium 4, 2000: 42 MTransistors, 1.5 GHz

Software and Electronics provide nearly unbounded opportunities:

Ubiquitous computing, Smart-its,
Societal telematics, Cyber-physical systems, …

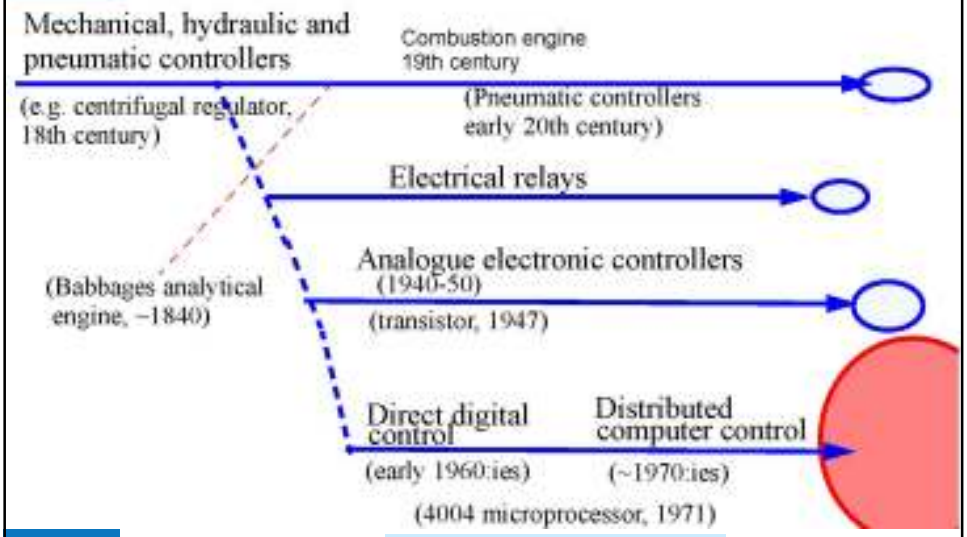
Definition (IEEE)

Embedded computer system:

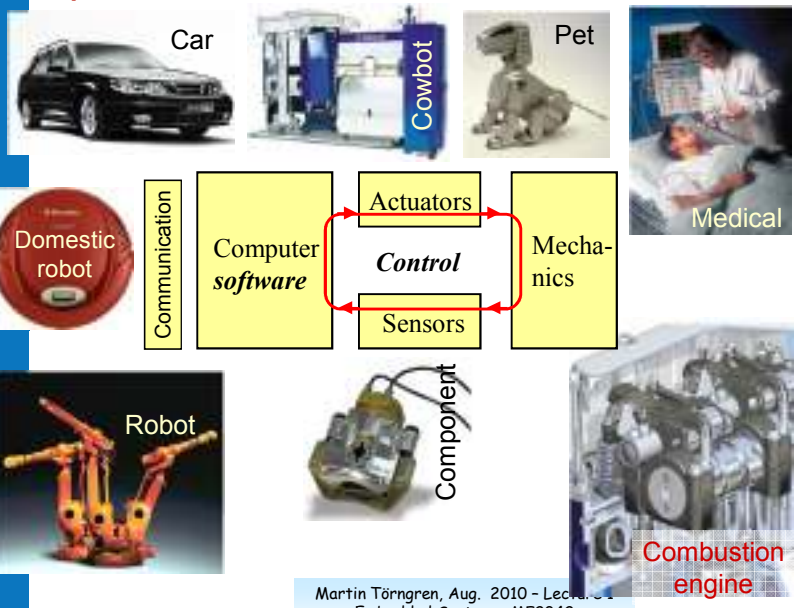
A computer system that is part of a larger system and performs some of the requirements of that system; for example, a computer system used in an aircraft or rapid transit system.

Hidden in products, not thought of as computers.
Designed to perform a few dedicated functions.
Tight integration & interaction with its environment.
Function, Performance, Dependability and Cost

Alternative implementation technologies and evolution



Mechatronical products and embedded systems



Key issues and characteristics

- Basic terms
  - Embedded system, Control system, Mechatronics
- Main characteristics
  - Multiple views
  - Product, tools, Processes and Organizations
- Issues:
  - The step from Control design to implementation
  - Concurrent programming and Distributed systems
    - Real-time operating systems, Controller Area Network
  - Design space, Testing and V&V

Concurrency and scheduling

You are at home and deeply involved in preparing tomorrow's lab for the MF2042 course!

Suddenly the following things happen:

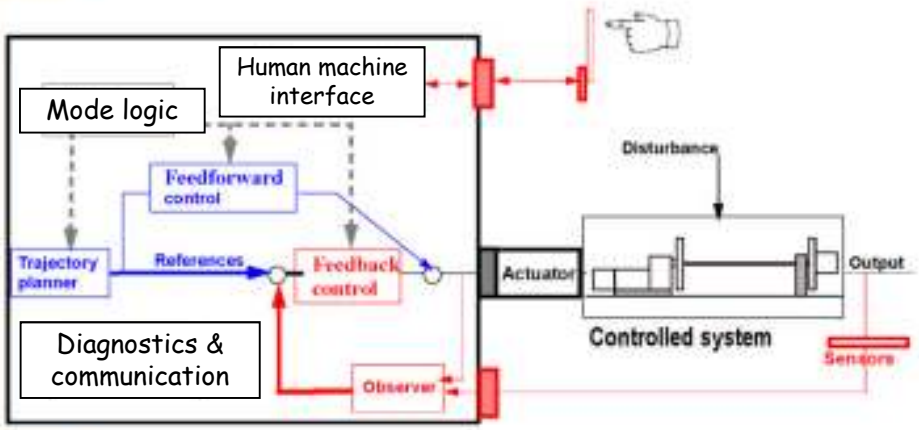
- The telephone is ringing.
- Someone is knocking on the door.
- The alarm is ringing from the kitchen.
- You still have not fixed your troubling computer.

Many activities … and only one Processor. ➔ Scheduling!

Scheduling algorithm: FPS, EDF, FIFO, SJF, …

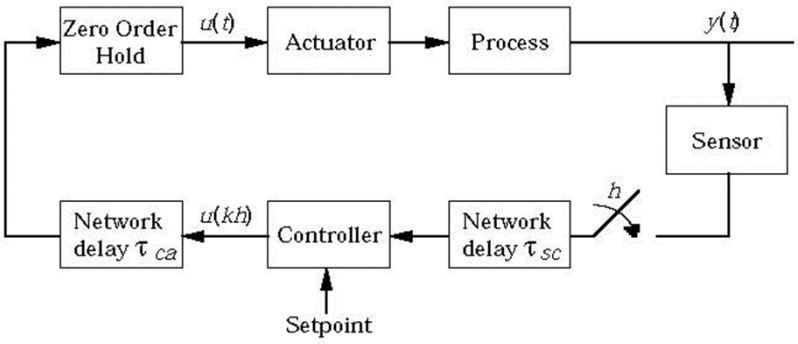
Managing task states, transitions, and meeting system requirements.

Control systems



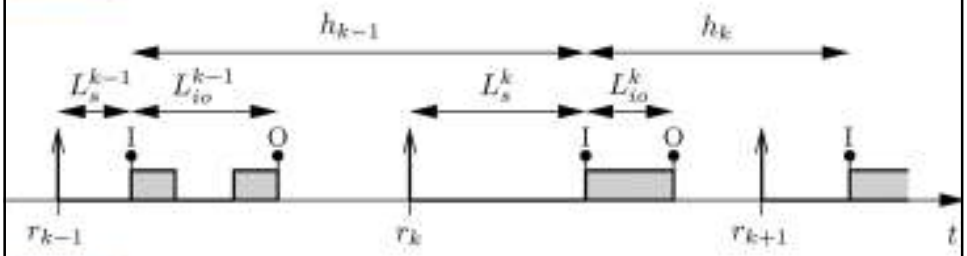
Note: Controller code is usually a small part of the total amount of code

Control systems are real-time systems!



Time variations in embedded control systems

- Time varying period and sampling periods



Source: Course book Figure 1.5

Key issues and characteristics

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Development of advanced multidisciplinary products

Organization
- Competence
- Responsibilities
- Communication

Process
- Analysis
- Modelling/tool use
- Synthesis/decisions

Social Integration

Model Based Integration

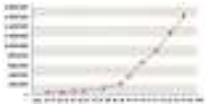
Technology: Products & Tools
- Function
- Implementation

Architecture Integration

The Embedded Systems Revolution

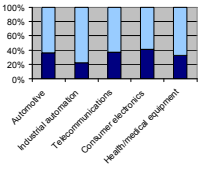
- The vast majority (98%) of processors in the world are hidden as Embedded systems
  - > 4 billion embedded processors sold (~2006)
  - >10% annual growth rate
- Increased innovation
  - 90% of future innovations will stem from advances in Embedded Systems
  - From expensive HW to cheap electronics with embedded SW
  - Product upgrades
  - Life-cycle impact
- Added Value

Lines of code in mobile phone apps. (e.g., address book) **



**Source: Swedsoft*

Share of the value of Embedded Systems in the final product *



Embedded control systems – Opportunities, innovation and challenges!

- Embedded systems are often developed just like they were 20-30 years ago
- From single processor to distributed systems
- Methodology and theory is lagging behind
- Lack of skilled embedded systems engineers
- Human abilities are challenged
- A case for research, cooperation between academia and industry