Embedded Systems Introduction

What is an Embedded System?

- Definition of an embedded computer system:
  - is a digital system.
  - uses a microprocessor (usually).
  - runs software for some or all of its functions.
  - frequently used as a controller.

What an embedded system is NOT.

- Not a computer system that is used primarily for processing.
- Not a software system on a PC or Unix box.
- Not a traditional business or scientific application.

Examples of Embedded Systems

Medical instrument's controls:
CAT scanners, implanted heart monitors, etc.

Automotive systems: electronic dashboards, ABS brakes, transmission controls.

Controls for digital equipment: CD players, TV remote, programmable sprinklers, household appliances, etc.

Why 'embedded'?

- Because the processor is 'inside' some other system.
- A microprocessor is 'embedded' into your TV, car, or appliance.
- The consumer does not think about performing processing,
- Considers running a machine or `making something work'.
- Considered "part of" the thing rather than ***the*** thing

Special Characteristics

hardware and software (in one system)

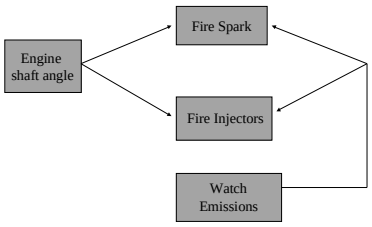
concurrency (several processes working at same time)

timing (often real time)

synchronization (this process must complete before this process begins)

sensors and actuators (for inputs and outputs)

Timing and Concurrency



How are embedded systems different than traditional software?

- Responding to sensors (Was this button pushed?)
- Turning on actuators (Turn on power to the boiler.)
- Real-time (Respond to temperature change within 3 seconds.)

Differences between ES and traditional software development

- Not dealing with only sequential code.
- Routine can stop at completion or in response to an external event.
- Many parts of system might be running concurrently.
- Safety-critical component of many systems.

Small and Many!

- Most embedded systems use 4-, 8-, or 16-bit processors. 32-bit used for intensive applications like printer controls.
- 8-bit processors have about 64K of memory, that limits amount of code.
- "By 1990 a total of about 45 million recognizable computers (i.e., PCs, Macintosh, even CP/M systems) were in place. Yet over 1 billion microprocessors and microcontrollers were shipped in that year alone!"

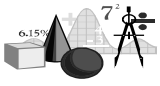
Ganssle, J. The Art of Programming Embedded Systems Academic Press, 1992, San Diego, Cal.

hardware or software ?

- Where to place functionality?
  - ex: A Sort algorithm
    - Faster in hardware, but more expensive.
    - More flexible in software but slower.
    - Other examples?
- Must be able to explore these various trade-offs:
  - Cost.
  - Speed.
  - Reliability.
  - Form (size, weight, and power constraints.)

hardware/software Codesign or 'Codesign'

- Model the hardware **and** the software system in a unified approach.
- Use similar design models.
- Need for 'model continuity' spanning levels of the design process.



Traditional Embedded System Development Approach

- Decide on the hardware
- Give the chip to the software people.
- Software programmer must make software 'fit' on the chip and only use that hardware's capabilities.

Increased Complexity

- Systems are becoming more and more complex.
- Harder to think about total design.
- Harder to fix 'bugs.'
- Harder to maintain systems over time.
- Therefore, the traditional development process has to change,

Less Time to Develop

- In embedded electronics, the total design cycle must decrease.
- Historically, design for automotive electronic systems takes 3-5 years to develop.
- Must become a 1-3 year development cycle.
- Must still be reliable and safe.

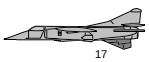
B. Wilkie, R. Frank and J. Suchyta - Motorola Semiconductor Products Sectors, 'Silicon or Software: The Foundation of Automotive Electronics', IEEE Vehicular Tech., August 95.

Solutions to Complexity:

- Need to keep design process abstract for a longer period of time.
- Decomposable hierarchy (object-oriented).
- Reuse previous designs:
  - When a design changes, reuse similar sections.
  - Don't throw away last year's design and start from scratch!
- Automated verification systems.

Example: Fly-by-Wire Airplane

- How would you start to think about developing this complex/large system?
- What are potential problems with deciding on the hardware right away?
- What are possible concurrent systems needs?
- What type of timing constraints might be needed?



Fly-by-Wire Airplane Continued

- What would be the sensors and actuators of this system?
- How concerned should developers be about the safety of the system?
- Would testing be enough?