

Introduction to Embedded Systems

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Acknowledgement

- The bulk of the material in this lecture is adapted from:
Embedded System Design– A Unified Hardware/Software Introduction, by Frank Vahid and Tony Givargis, John Wiley & Sons Inc., 2002

What is a Computer?

- Most of us think of “desktop” computers
 - PC’s
 - Laptops
 - Mainframes
 - Servers



- But, there is another kind of computing system that is far more common

Embedded Systems

- Embedded computing systems
 - Computing systems embedded within electronic devices
 - Hard to define. Nearly any computing system other than a desktop computer
 - Billions of units produced yearly, versus millions of desktop units
 - Perhaps 50 per household and per automobile



Embedded Systems are Everywhere



Picture is from the cover of **Embedded Systems Design, A Unified Hardware/Software Approach**, by Frank Valic and Tony Givargis

A "short list" of embedded systems

Test tool probes
 Auto focus cameras
 Automatic teller machines
 Automatic toll systems
 Automatic transmission
 Avionic systems
 Battery chargers
 Camcorders
 Cell phone base stations
 Control planes
 Cruise control
 Carbide chips in systems
 Digital cameras
 Disk drives
 Electronic card readers
 Electronic instruments
 Electronic toys/games
 Factory control
 Fax machines
 Fingerprint identification
 Home security systems
 Life support systems
 Medical imaging systems

Modems
 MPEG decoders
 Network cards
 Network video/telemetry
 On board navigation
 Pagers
 Palmtop/laptop
 Parts of auto systems
 Portable video games
 Processors
 Satellite phones
 Scanners
 Smart TV sets/digital video
 Speech recognition
 Stereo systems
 Tel monitoring systems
 Teletext
 Temperature controllers
 Time-sharing systems
 TV set top boxes
 VCR's, DVD players
 Video game consoles
 Video phones
 Webcams and digcams

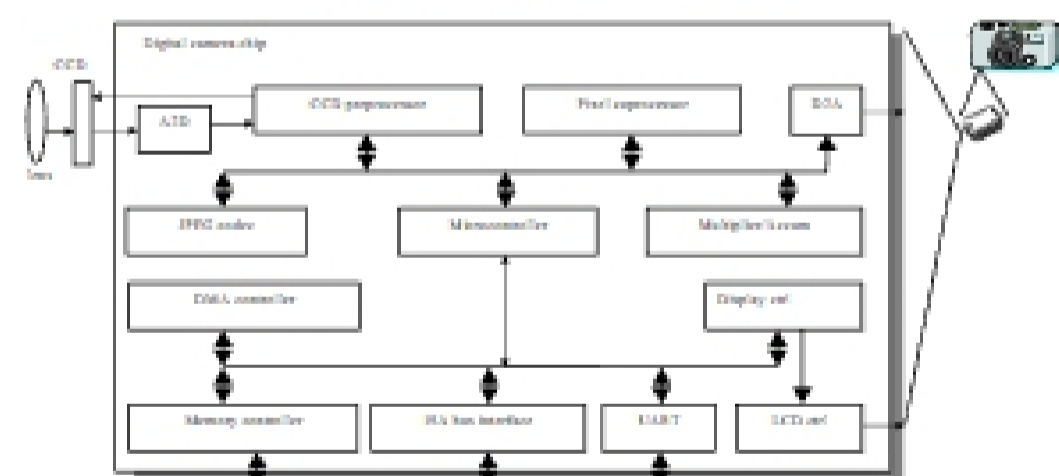


Today, almost all nontrivial electronic systems include one or more embedded processors

Embedded Systems vs. Desktop Computing

- Most Embedded Systems are single-functioned
 - Executes a single program, repeatedly
- Generally, Embedded Systems are tightly-constrained
 - Low cost, low power, small, fast, etc.
- Most Embedded Systems are reactive and real-time
 - Continually react to changes in the system's environment
 - Must compute results in "real-time"

An Embedded System Example: Digital Camera



Embedded Design Challenge: Optimizing Design Metrics

- Obvious design goal:
 - Construct an implementation with desired functionality
- Key design challenge:
 - Simultaneously optimize numerous design metrics
- Design metric
 - A measurable feature of a system's implementation
 - Optimizing design metrics is a key challenge

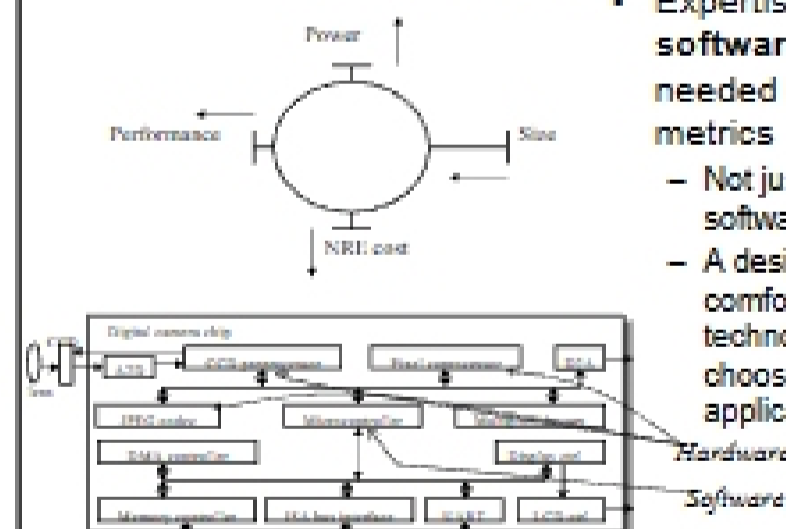
Embedded Systems Design Metrics

- Common metrics:
 - **Unit cost:** the monetary cost of manufacturing each copy of the system, excluding NRE cost
 - **NRE cost (Non-Recurring Engineering cost):** The one-time monetary cost of designing the system
 - **Size:** the physical space required by the system
 - **Performance:** the execution time or response time of the system
 - **Memory:** The amount of memory required to hold the program and data
 - **Power:** the amount of power consumed by the system

Embedded System Design Metrics (Continued)

- Common metrics (continued)
 - **Flexibility:** the ability to change the functionality of the system without incurring heavy NRE cost
 - **Time-to-prototype:** the time needed to build a working version of the system
 - **Time-to-market:** the time required to develop a system to the point that it can be released and sold to customers
 - **Maintainability:** the ability to modify the system after its initial release
 - **Robustness:** System stability and reliability
 - **Safety:** Assurance that the system will not expose people to dangers

Design Metrics May Be At Odds With One Another



- Expertise with both **software and hardware** is needed to optimize design metrics
 - Not just a hardware or software expert, as is common
 - A designer must be comfortable with various technologies in order to choose the best for a given application and constraints