Digital System & Embedded System

• **Digital System**: may provide service
  - as a self-contained unit (e.g., desktop PC)
  - as part of a larger system (e.g., digital control system for manufacturing plant)

• **Embedded System**:
  - part of a larger unit
  - provides dedicated service to that unit

Examples of Embedded Systems

- PC having dedicated software programs and appropriate interfaces to a manufacturing assembly line
- Microprocessor dedicated to a control function in a computer, e.g., keyboard/mouse input control
Parts of an Embedded System

- USER
- I/O
- MEMORY
- PROCESSOR
- HARDWIRED UNIT
  - Application-specific logic
  - Timers
  - A/D and D/A conversion
- SENSORS
- ACTUATORS
- ENVIRONMENT
Parts

- Actuators - mechanical components (e.g., valve)
- Sensors - input data (e.g., accelerometer for airbag control)
- Data conversion, storage, processing
- Decision-making

- Range of implementation options
- Single-chip implementation: system on a chip
Features of Embedded Systems

1. Application Domains
   - Local
   - Distributed

2. Degree of Programmability
   A) Instruction Set Architecture programming
      (e.g., machine code, assemble, higher level language)
      - microprocessors
      - microcontrollers
      - programmable digital signal processors (DSPs)
   
   B) Hardware Level programming
      - FPGA: field-programmable gate array
        (gate-level interconnects are configured after IC fabricated)
      - ASIC: application-specific integrated circuit
        (programming set at time of manufacture)
        (Gives higher performance and lower power requirements)
Some Application Domains

- **CONSUMER PRODUCTS**
  - Appliances, Games, A/V, Intelligent home devices

- **TRANSPORTATION**
  - Autos, Trains, Ships, Aircrafts

- **PLANT CONTROL**
  - Manufacturing, Chemical, Power Generation

- **NETWORKS**
  - Telecommunication, Defense

- **Local**
  - e.g., appliance

- **Locally distributed**
  - e.g., aircraft control over a LAN

- **Geographically distributed**
  - e.g., telephone network
3. Hardware/Software Partitioning

How is the system functionality partitioned between application-specific hardware and software executed on one or more processors.

Example: Hand-held RS232 terminal (next page).

100% Hardware

100% Software
Figure 1-2. Block diagram for a discrete logic hand-held RS232 Terminal. Parts for device cost approximately $20.14.

Figure 1-3. The same RS232 Terminal as in Figure 1-2, but utilizing a microcontroller. Total cost is around $11.59.