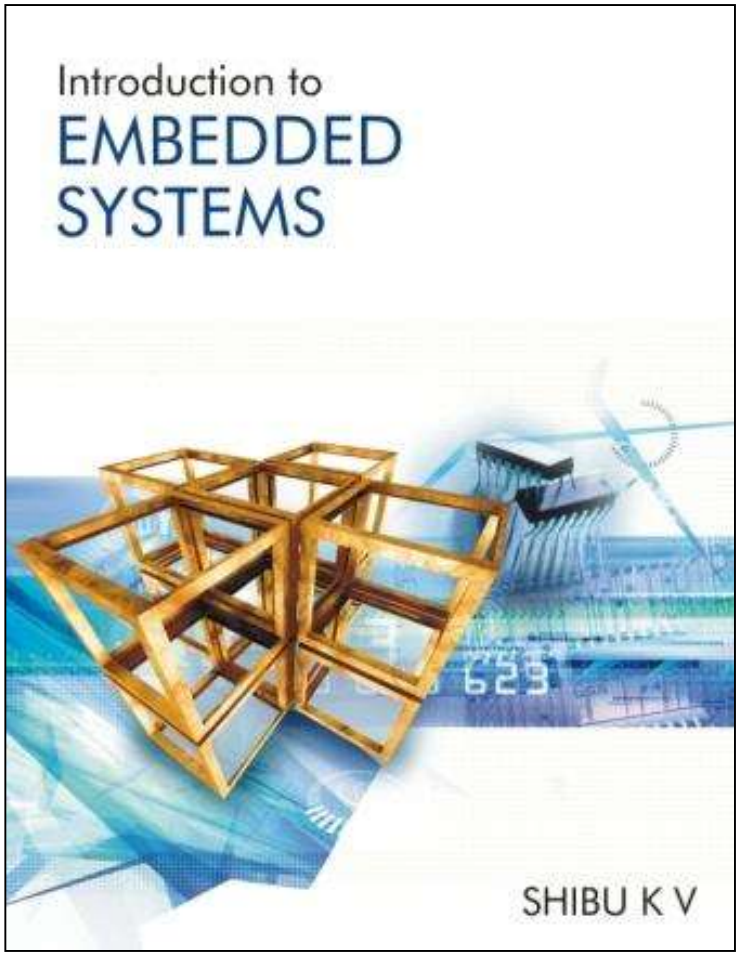
Mc Graw Hill Education



Introduction to Embedded System

What is Embedded System?

An Electronic/Electro mechanical system which is designed to perform a specific function and is a combination of both hardware and firmware (Software)

E.g. Electronic Toys, Mobile Handsets, Washing Machines, Air Conditioners, Automotive Control Units, Set Top Box, DVD Player etc…

Embedded Systems are:

- ❑ Unique in character and behavior
- ❑ With specialized hardware and software

Embedded Systems Vs General Computing Systems

General Purpose System	Embedded System
A system which is a combination of generic hardware and General Purpose Operating System for executing a variety of applications	A system which is a combination of special purpose hardware and embedded OS for executing a specific set of applications
Contain a General Purpose Operating System (GPOS)	May or may not contain an operating system for functioning
Applications are alterable (programmable) by user (It is possible for the end user to re-install the Operating System, and add or remove user applications)	The firmware of the embedded system is pre-programmed and it is non-alterable by end-user (There may be exceptions for systems supporting OS kernel image flashing through special hardware settings)
Performance is the key deciding factor on the selection of the system. Always 'Faster is Better'	Application specific requirements (like performance, power requirements, memory usage etc) are the key deciding factors
Less/not at all tailored towards reduced operating power requirements, options for different levels of power management.	Highly tailored to take advantage of the power saving modes supported by hardware and Operating System
Response requirements are not time critical	For certain category of embedded systems like mission critical systems, the response time requirement is highly critical
Need not be deterministic in execution behavior	Execution behavior is deterministic for certain type of embedded systems like 'Hard Real Time' systems

Introduction to Embedded System

History of Embedded Systems:

First Recognized Modern Embedded System: Apollo Guidance Computer (AGC)

First Mass Produced Embedded System: *Autonetics* ***D-17*** Guidance computer

Classification of Embedded Systems:

- ❑ Based on Generation
- ❑ Based on Complexity & Performance Requirements
- ❑ Based on deterministic behavior
- ❑ Based on Triggering

Introduction to Embedded System

Embedded Systems - Classification based on Generation

First Generation: The early embedded systems built around 8bit microprocessors like 8085 and Z80 and 4bit microcontrollers

Second Generation: Embedded Systems built around 16bit microprocessors and 8 or 16bit microcontrollers, following the first generation embedded systems

Third Generation: Embedded Systems built around high performance 16/32 bit Microprocessors/controllers, Application Specific Instruction set processors like Digital Signal Processors (DSPs), and Application Specific Integrated Circuits (ASICs)

Fourth Generation: Embedded Systems built around System on Chips (SoCs), Re-configurable processors and multicore processors

Introduction to Embedded System

Embedded Systems - Classification based on Complexity & Performance

Small Scale: The early embedded systems built around 8bit microprocessors like 8085 and Z80 and 4bit microcontrollers

Medium Scale: Embedded Systems built around 16bit microprocessors and 8 or 16bit microcontrollers, following the first generation embedded systems

Large Scale/Complex: Embedded Systems built around high performance 16/32 bit Microprocessors/controllers, Application Specific Instruction set processors like Digital Signal Processors (DSPs), and Application Specific Integrated Circuits (ASICs)

Classification based on deterministic behaviour

- It is applicable for Real time systems

- **Soft real time systems**: Missing a deadline may not be critical and can be tolerated to a certain degree.
- **Hard real time systems**: Missing a program/task execution time deadline can have catastrophic consequences(financial, human loss of life etc)

Based on Triggering

- Event Triggered: Activities within the system are dynamic and depend upon the occurrence of different events
- Time triggered: Activities within the system follow statically computed schedule(ie they are allocated time slots during which they can takes place)

Introduction to Embedded System

Major Application Areas of Embedded Systems

- Consumer Electronics: Camcorders, Cameras etc.
- Household Appliances: Television, DVD players, Washing machine, Fridge, Microwave Oven etc.
- Home Automation and Security Systems: Air conditioners, sprinklers, Intruder detection alarms, Closed Circuit Television Cameras, Fire alarms etc.
- Automotive Industry: Anti-lock breaking systems (ABS), Engine Control, Ignition Systems, Automatic Navigation Systems etc.
- Telecom: Cellular Telephones, Telephone switches, Handset Multimedia Applications etc.
- Computer Peripherals: Printers, Scanners, Fax machines etc.
- Computer Networking Systems: Network Routers, Switches, Hubs, Firewalls etc.
- Health Care: Different Kinds of Scanners, EEG, ECG Machines etc.
- Measurement & Instrumentation: Digital multi meters, Digital CROs, Logic Analyzers PLC systems etc.
- Banking & Retail: Automatic Teller Machines (ATM) and Currency counters, Point of Sales (POS)
- Card Readers: Barcode, Smart Card Readers, Hand held Devices etc.

Introduction to Embedded System

Purpose of Embedded Systems

Each Embedded Systems is designed to serve the purpose of any one or a combination of the following tasks.

- Data Collection/Storage/Representation
- Data Communication
- Data (Signal) Processing
- Monitoring
- Control
- Application Specific User Interface

Introduction to Embedded System

Purpose of Embedded Systems – Data Collection/Storage/Representation

- ✓ Performs acquisition of data from the external world.
- ✓ The collected data can be either analog or digital
- ✓ Data collection is usually done for storage, analysis, manipulation and transmission
- ✓ The collected data may be stored directly in the system or may be transmitted to some other systems or it may be processed by the system or it may be deleted instantly after giving a meaningful representation

Digital Camera for Image capturing/storage/display
Photo Courtesy of Casio -Model EXILIM ex-Z850
(www.casio.com)

Introduction to Embedded System

Purpose of Embedded Systems – Data Communication

- ✓ Embedded Data communication systems are deployed in applications ranging from complex satellite communication systems to simple home networking systems
- ✓ Embedded Data communication systems are dedicated for data communication
- ✓ The data communication can happen through a wired interface (like Ethernet, RS-232C/USB/IEEE1394 etc) or wireless interface (like Wi-Fi, GSM,/GPRS, Bluetooth, ZigBee etc)
- ✓ Network hubs, Routers, switches, Modems etc are typical examples for dedicated data transmission embedded systems

Wireless Network Router for Data Communication
Photo Courtesy of Linksys (www.linksys.com).
A division of CISCO system

Introduction to Embedded System

Purpose of Embedded Systems – Data (Signal) Processing

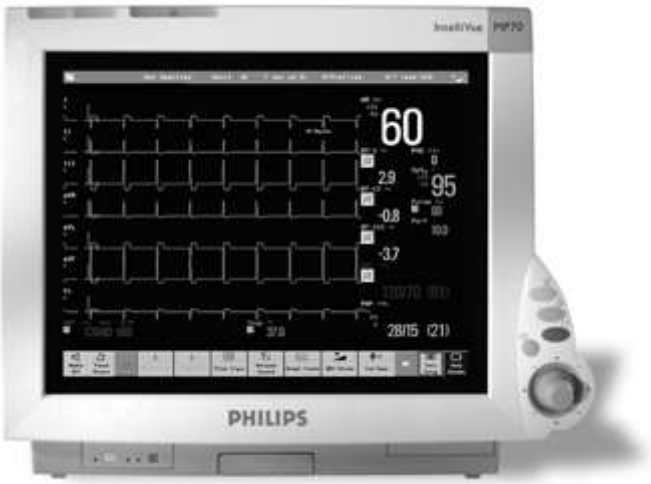
- ✓ Embedded systems with Signal processing functionalities are employed in applications demanding signal processing like Speech coding, synthesis, audio video codec, transmission applications etc
- ✓ Computational intensive systems
- ✓ Employs Digital Signal Processors (DSPs)

Digital hearing Aid employing Signal Processing Technique
Siemens TRIANO 3 Digital hearing aid;
Siemens Audiology Copyright © 2005

Introduction to Embedded System

Purpose of Embedded Systems – Monitoring

- ✓ Embedded systems coming under this category are specifically designed for monitoring purpose
- ✓ They are used for determining the state of some variables using input sensors
- ✓ Electro Cardiogram (ECG) machine for monitoring the heart beat of a patient is a typical example for this
- ✓ The sensors used in ECG are the different Electrodes connected to the patient's body
- ✓ Measuring instruments like Digital CRO, Digital Multi meter, Logic Analyzer etc used in Control & Instrumentation applications are also examples of embedded systems for monitoring purpose



Patient Monitoring system
Photo courtesy of Philips Medical Systems (www.medical.philips.com/)

Introduction to Embedded System

Purpose of Embedded Systems – Control

- ✓ Embedded systems with control functionalities are used for imposing control over some variables according to the changes in input variables
- ✓ Embedded system with control functionality contains both sensors and actuators
- ✓ Sensors are connected to the input port for capturing the changes in environmental variable or measuring variable
- ✓ The actuators connected to the output port are controlled according to the changes in input variable to put an impact on the controlling variable to bring the controlled variable to the specified range
- ✓ Air conditioner for controlling room temperature is a typical example for embedded system with 'Control' functionality
- ✓ Air conditioner contains a room temperature sensing element (sensor) which may be a thermistor and a handheld unit for setting up (feeding) the desired temperature
- ✓ The air compressor unit acts as the actuator. The compressor is controlled according to the current room temperature and the desired temperature set by the end user.

Air Conditioner for controlling room temperature

Photo Courtesy of Electrolux Corporation
(www.electrolux.com/au)

Introduction to Embedded System

Purpose of Embedded Systems – Application Specific User Interface

- ✓ Embedded systems which are designed for a specific application
- ✓ Contains Application Specific User interface (rather than general standard UI) like key board, Display units etc
- ✓ Aimed at a specific target group of users
- ✓ Mobile handsets, Control units in industrial applications etc are examples for this

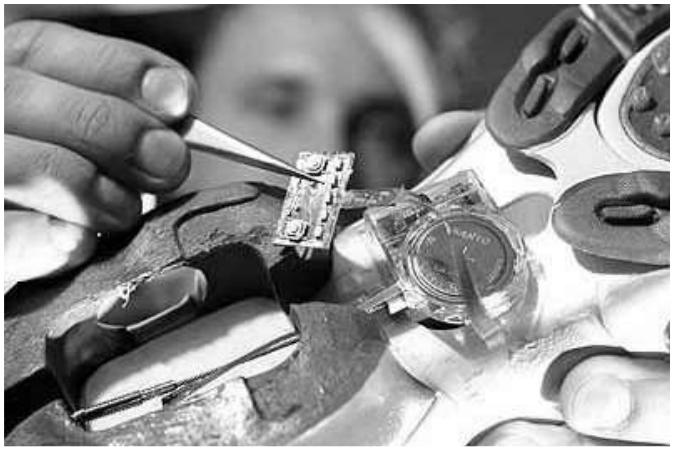
Patient Monitoring system
Photo courtesy of Philips Medical Systems
(www.medical.philips.com/)

Introduction to Embedded System

'Smart' running shoes from Adidas – The Innovative bonding of Life Style with Embedded Technology

- ✓ Shoe developed by Adidas, which constantly adapts its shock-absorbing characteristics to customize its value to the individual runner, depending on running style, pace, body weight, and running surface
- ✓ It contains sensors, actuators and a microprocessor unit which runs the algorithm for adapting the shock-absorbing characteristics of the shoe
- ✓ A 'Hall effect sensor' placed at the top of the "cushioning element" senses the compression and passes it to the Microprocessor
- ✓ A micro motor actuator controls the cushioning as per the commands from the MPU, based on the compression sensed by the 'Hall effect sensor'

What an innovative bonding of Embedded Technology with Real life needs !!!☺



Electronics-enabled "Smart" running shoes from Adidas
Photo Courtesy of Adidas – Salomon AG (www.adidas.com)