مدينة زويل للعلوم والتكنولوجيا
Zewail City of Science and Technology
COMMUNICATION AND INFORMATION ENGINEERING

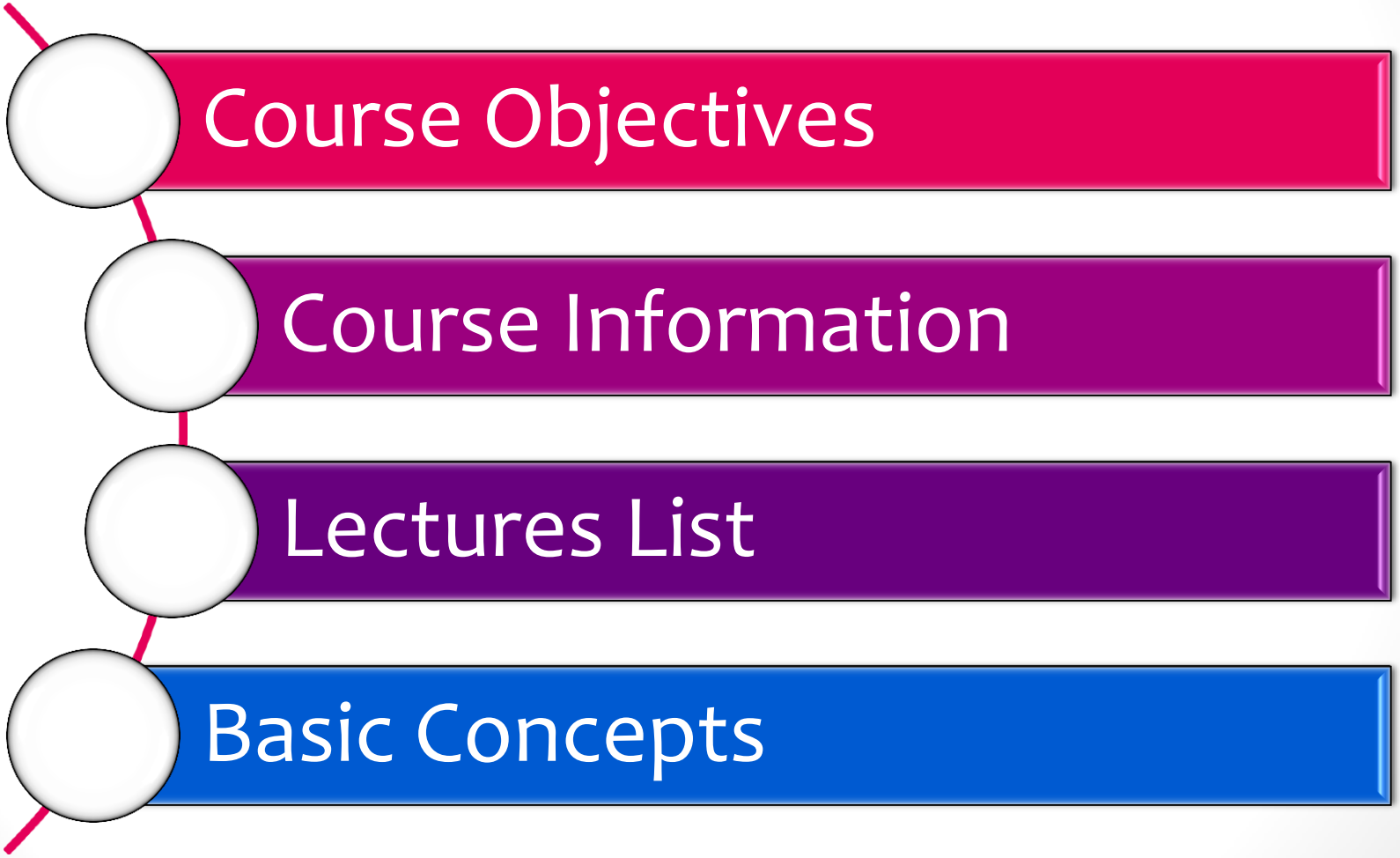
CIE 314
Embedded Systems Fundamentals

Lecture #1
Introduction and Basic Concepts

Instructor:
Dr. Ahmad El-Banna

SPRING 2017

Agenda



About the Instructor

Dr. Ahmad EL-Banna

- B.Sc. in Telecommunications and Electronics, Fac. of Eng. at Shoubra, Benha Univ. 2005.
- 9-month Diploma in Embedded Systems, ITI, 2008.
- M.Sc. in Telecommunications and Electronics, Fac. of Eng. at Shoubra, Benha Univ. 2011.
- PhD. in Telecommunications and Electronics, E-JUST Univ., 2014.
- Visiting Researcher , Wireless Communications Lab, Osaka University, 2013-2014.
- Find more at
  - www.bu.edu.eg/staff/ahmad.elbanna

Course Objectives

The course aims to:

- Gain knowledge about the basics of embedded systems e.g. evolution, structure and classifications.
- Explore the difference between embedded design and traditional electronic device design.
- Be familiar with the design constraints and the special demands on embedded systems including real-time programming, portability, low power usage, and miniaturization.
- Learn the architecture and organization of embedded systems e.g. buses, CPU, memories and Interrupts.

Course Objectives..

- Introduce models and architectures that cover above topics such as specification, system partitioning, design quality, and developing synthesizable models.
- Learn the embedded software design and development including:
  - Time Requirement Analysis for Real-Time Systems.
  - Multi-Tasking Design Methodology.
  - Software Design Issues.
- Cover the basics of the RTOS (Real Time Operating System) e.g.
  - Task scheduling
  - RTOS events.
- Present a simple RTOS.

Learning Outcomes (ILOS)

After finishing the course, the students should be able to:

1. **Describe and/or define** the basics of embedded systems.
2. **Differentiate** between embedded design and traditional electronic device design.
3. **Evaluate** the design constraints and the special demands on embedded systems.
4. **Analyze** the architecture and organization of embedded systems.
5. **Apply** the embedded software design and development including:
   - Time Requirement Analysis for Real-Time Systems.
   - Multi-Tasking Design Methodology.
   - Software Design Issues.
6. **Demonstrate** the basics of the RTOS (Real Time Operating System).

Course Information

Instructor:	Dr. Ahmad El-Banna http://bu.edu.eg/staff/ahmad.elbanna Office: ZC 370 Email: ahmad.elbanna@feng.bu.edu.eg ahmad.elbanna@ejust.edu.eg
Lectures:	Wednesday: 11:50 - 14:00 Location: ZC 101 Prerequisite: CSCI 101: Introduction to Computer Science
Office Hours:	Wednesday: 14:00 - 16:00
T.A.:	Eng. Ahmed El-Naggar
Texts/Notes:	• Lectures slides, available by each lecture, and found online at http://www.bu.edu.eg/staff/ahmad.elbanna-courses/14130 • **Introduction to Embedded Systems,** Springer 2014 by Manuel Jiménez , Rogelio Palomera and Isidoro Couvertier. • **Embedded Software Development with C,** Springer 2009 by Kai Qian, David den Haring and Li Cao.

Course Requirements

Lecture attendance	
Optional	Note: University absence policy & Quiz during the 8th lecture.
Tutorial attendance	
Mandatory	**2%**
Labs attendance	
Mandatory	**3%**

Requirements	Percentage if applicable
4 assignments (Best 4 out of 5)	**12%**
Quiz	**3%**
Project follow up report	**5%**
Project delivery Presentation & Work	**15%**

Sequence of Learning Activities

Week	Syllabi topic
1	Embedded systems evolution, structure and classification
2	Design Constraints
3	Basic microcomputer structure (µc vs. µp, CPU and buses)
4	Memory and IO subsystem organization
5	Mid-term 1
6	CPU Instruction Set
7	Interrupts and Program Design

Sequence of Learning Activities..

Week	Syllabi topic
8	Embedded Software Modeling Analysis and Design
9	Multi-Tasking Design Methodology
10	Mid-term 2
11	RTOS Overview
12	Task Scheduling
13	RTOS Events
14	Sample of RTOS

Assessment Calendar

Assessment (assignements, reports, quinze, … et)	Deadline to be submitted by students	Deadline to submit feedback to students	Covered ILOS
Assignment # 1	Within week#02	Within week#03	1
Assignment # 2	Within week#04	Within week#05	2
Project follow up report	Within week#07	Within week#08	3,4,5
Quiz	Within week#08	Within week#09	1,2
Assignment # 3	Within week#09	Within week#10	4
Assignment # 4	Within week#11	Within week#12	6
Assignment # 5	Within week#12	Within week#13	6
Project delivery Presentation	Within week#13	Within week#14	3,4,5

Assessments Weight

Assessment Type	Percentage
Attendance & Participation	5%
Assignments & Quiz	15%
Midterms	30% (2 midterms) [2x(best one x 0.7 + other x 0.3)] i.e. best one 21%, other 9%
Project	20% (Incl. 5% follow up report)
Final Exam	30%
Total	**100%**

Exam Calendar

Exam	Date	Covered ILOS
First midterm	Week 5 (8th March 2017)	1,2
Second midterm	Week 10 (12th April 2017)	3,4,5
Final	21st May to 1st June 2017 (To be exactly announce)	1,2,3,4,5,6

→ **Find the course outline document at:**
http://www.bu.edu.eg/staff/ahmad.elbanna-courses/14130
Then click on [Download Description]

- Embedded systems evolution,
- structure and
- classification

MEANING AND BASIC CONCEPTS

1.1 EMBEDDED SYSTEMS: HISTORY & OVERVIEW

- Early Forms of Embedded Systems
- Birth and Evolution of Modern Embedded Systems
- Contemporary Embedded Systems

What is an Embedded Systems?

WHAT IS AN EMBEDDED SYSTEM?

- Definition
  - An electronic systems containing tightly coupled hardware and software components
- Characteristics
  - Perform a single function
  - Form part of a larger system
  - Not intended to be independently programmable by the user
  - Are expected to work with minimal or no human interaction
  - Reactive, real-time operation
  - Tightly constrained

EARLY EMBEDDED SYSTEMS

- Early Computers
  - Similar to an ESYS
    - Single functioned
    - Not user programmable
  - Unlike today's ESYS
    - Large and power thirsty
    - Not integrated

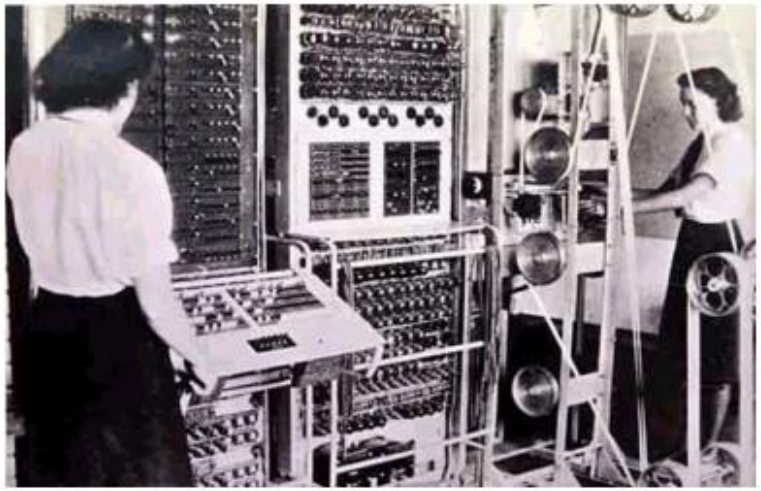


Fig. 1.1: Control panel and paper tape transport view of a Colossus Mark II computer *(Public image by the British Public Record Office, London)*

- First Embedded System
  - The Apollo Guidance Computer (AGC)
    - Guidance & Navigation
    - CPU + MEM + I/O
    - Low-power mode
    - AGC Assembly Programmed

Fig. 1.2: AGC user interface module *(Public photo EC96-43408-1 by NASA)*

MODERN EMBEDDED SYSTEMS

- Born with the Microprocessor
  - TMS1000: The first microcontroller
  - Intel 4004: The first commercial microprocessor
  - US Navy CADC: High-performance embedded system

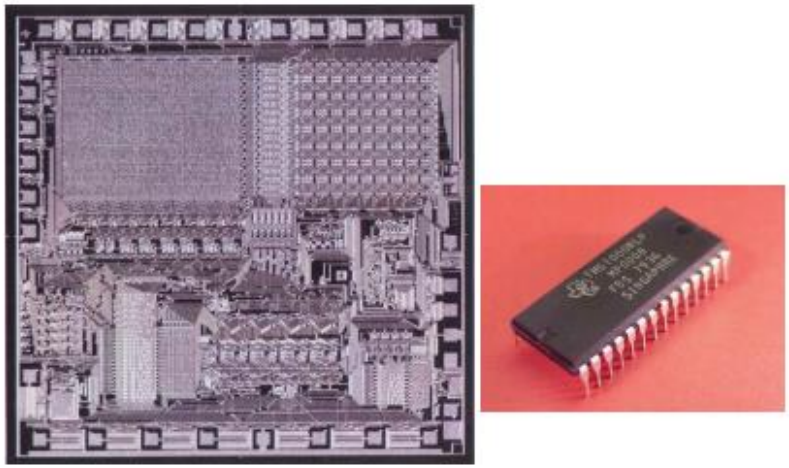


Fig. 1.3: Die microphotograph (left) packaged part for the TMS1000 *(Courtesy of Texas Instruments, Inc.)*

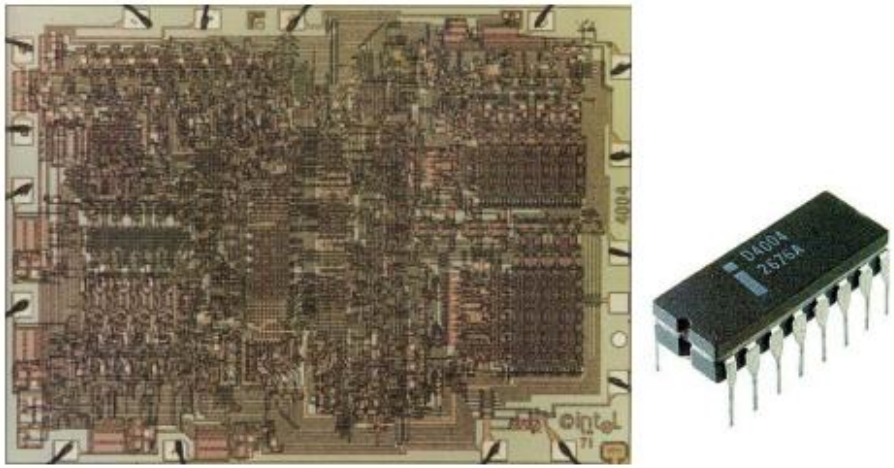


Fig. 1.4: Die microphotograph (left) and packaged part for the Intel 4004 *(Courtesy of Intel Corporation)*

TODAY'S MCU MARKET

- Plenty of Vendors
  - TI (MSP430)
  - Microchip (PIC)
  - Intel (8051, 80x86)
  - Freescale (HC11, HC08)
  - ARM Limited (ARM7)
  - Atmel (ATmega)
- Plenty of Sizes
  - 4-, 8-, 16-, 32-, and 64-bit
  - CISC Vs. RISC
  - Harvard Vs. vonNeumann
- Wide Market
  - Over 6 Billion chips per year
  - Over $50 billion sales

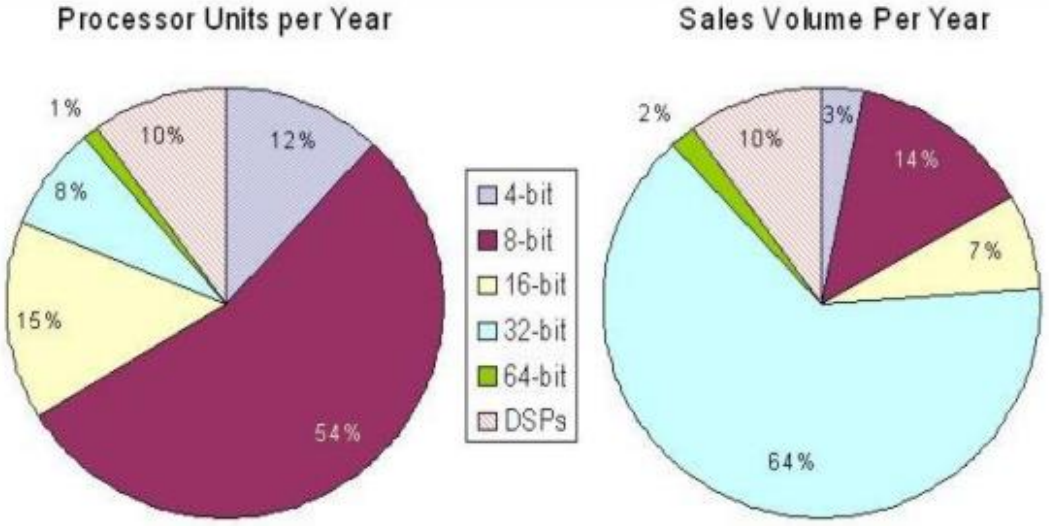


Fig. 1.5: Estimates of processor market distribution *(Source: Embedded Systems Design — www.embedded.com)*

CONTEMPORARY EMBEDDED SYSTEMS

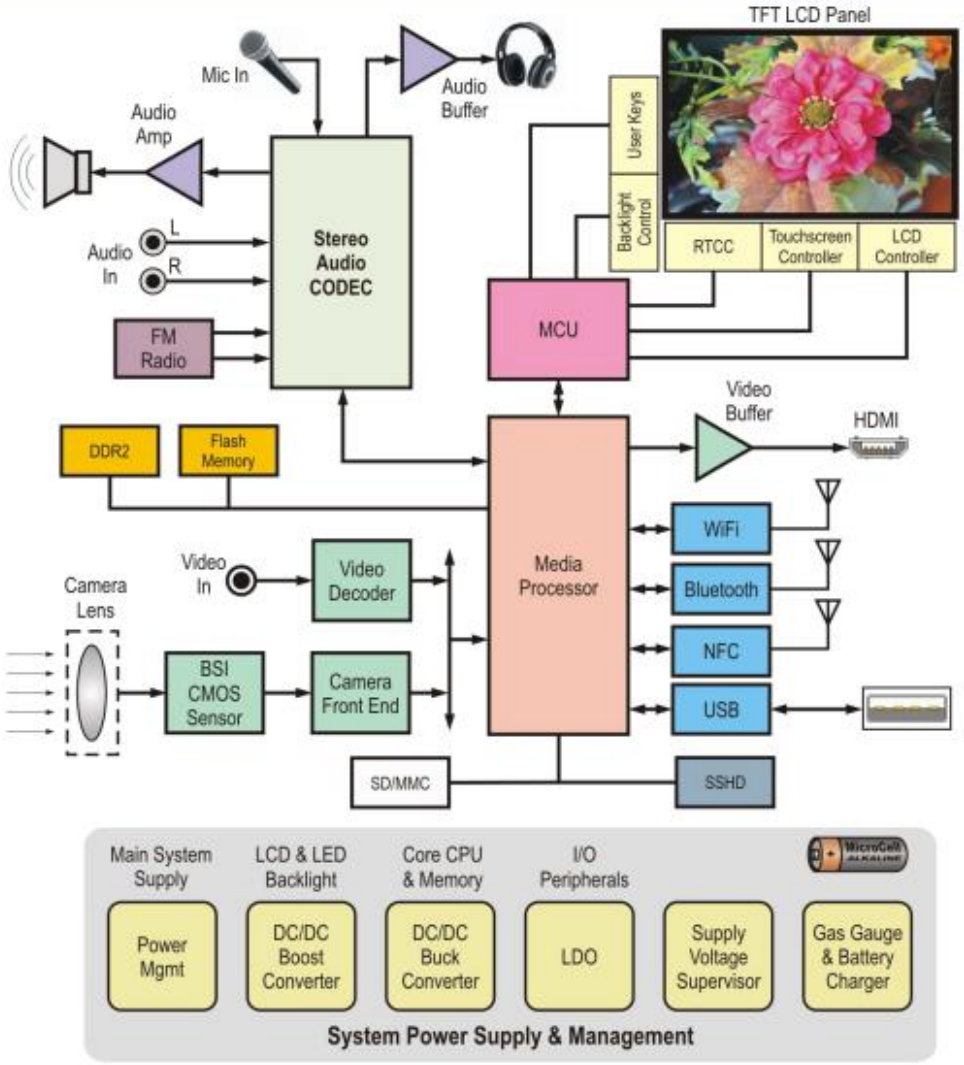


Fig. 1.6 Generic multi-function media player.

- System Components
  - Power management
  - Video processing
  - Audio processing
  - Communications
  - User interfaces
  - Dedicated ASICs
  - Memory management
  - Storage
- Multi-embedding
  - Most components are embedded system by themselves
  - System integration

Applications that depend on embedded systems

1.2 STRUCTURE OF AN EMBEDDED SYSTEM

- Hardware Components
- Software Components

EMBEDDED SYSTEM STRUCTURE

- Hardware Components: Electronics Infrastructure
  - CPU
  - Memory
  - I/O Subsystem
- Software Components: System Functionality
  - Firmware
  - Operating System
  - Application Programs

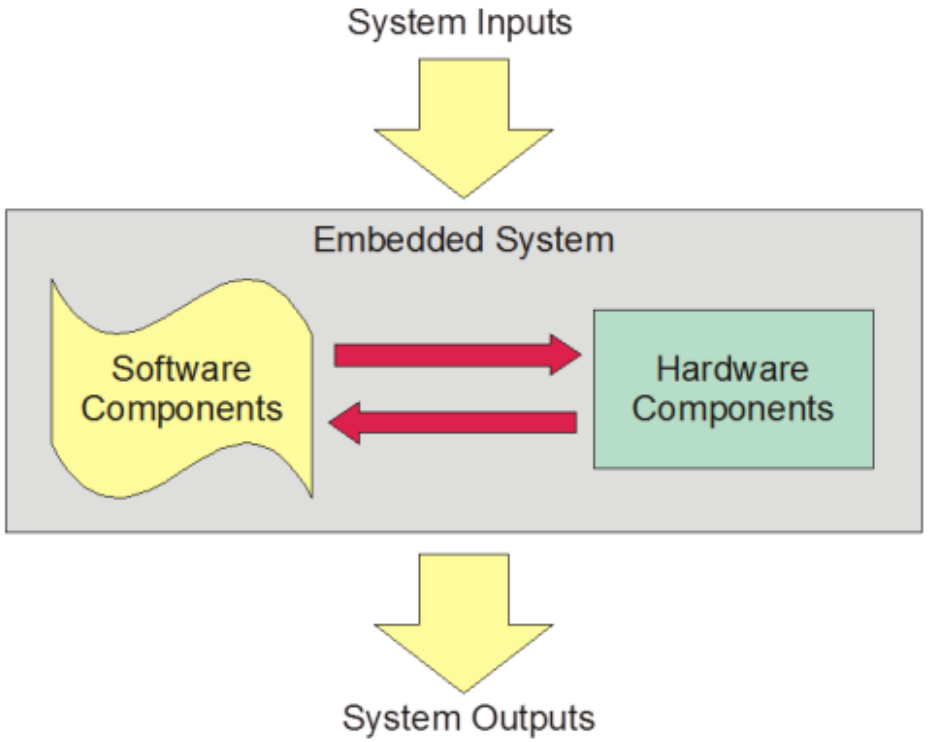


Fig. 1.7: General view of an embedded system

HARDWARE COMPONENTS

- Central Processing Unit
  - Registers, ALU, CU
- Memory
  - Program Memory
  - Data Memory
- I/O Devices
  - Communication ports
  - User Interfaces
  - Sensors & actuators
  - Diagnostics support
  - System controllers
  - Power management
  - Specialized ASICs

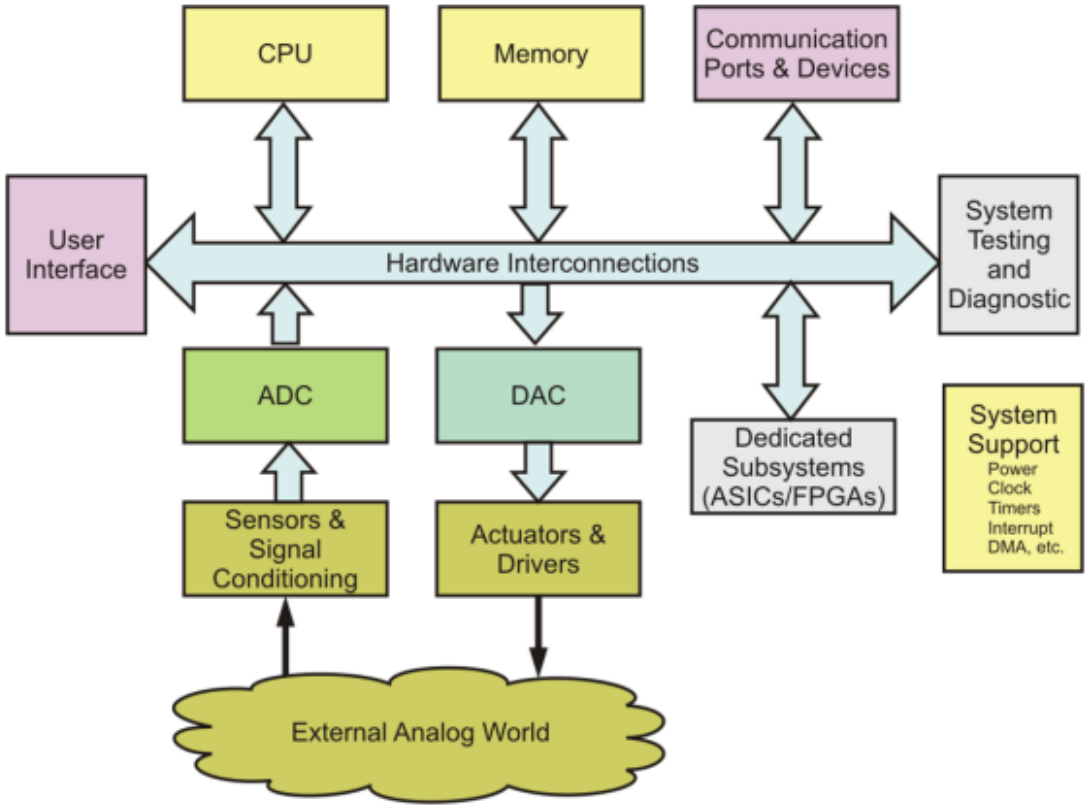


Fig. 1.8: Hardware elements in an embedded system

SOFTWARE COMPONENTS

- System Tasks
  - Actions making use of system resources
- System Kernel
  - Manages system resources
  - Coordinates task services
- Services
  - Routines performing specific tasks

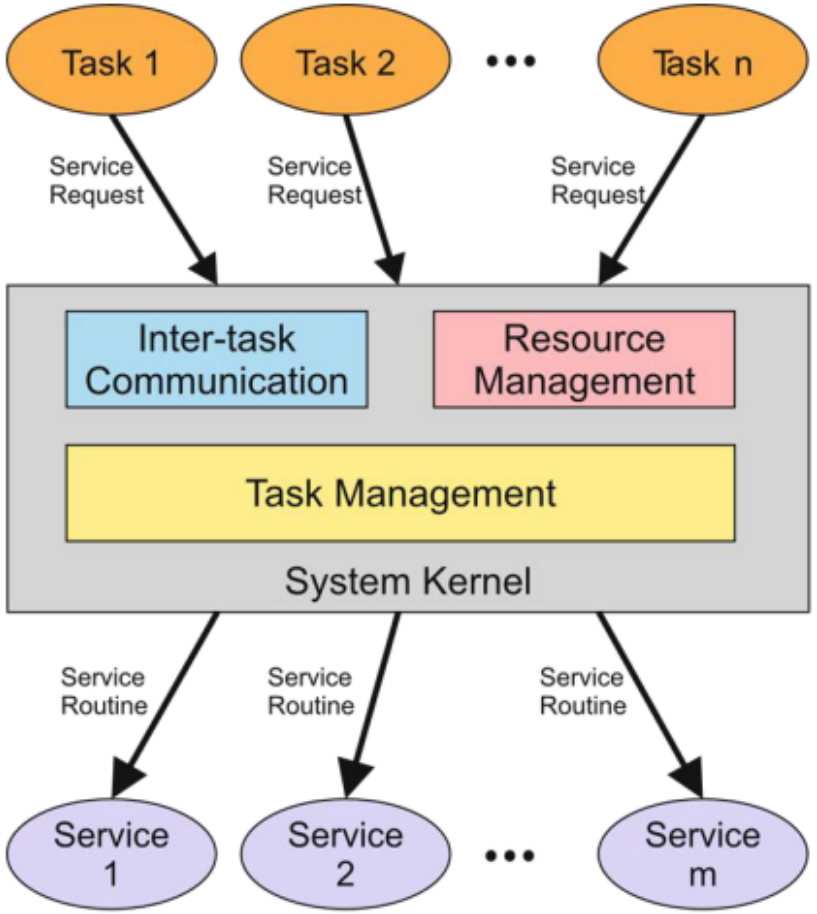


Fig. 1.9: Software structure in an embedded system

1.3 A CLASSIFICATION OF EMBEDDED SYSTEMS

- Small
- Distributed
- High-performance

A CLASSIFICATION OF EMBEDDED

- **Small**
  - MCU-based, low component count
  - Large volume
  - Single tasked
  - Low-cost, maintenance free
- **Distributed**
  - Multi-chip, board-level
  - Multi-tasked
  - Medium volume & cost
  - Maintainable, upgradeable
- **High-performance**
  - Dedicated board-level hardware
  - Task intensive, RTOS-based
  - Low-volume, high cost
  - High maintenance

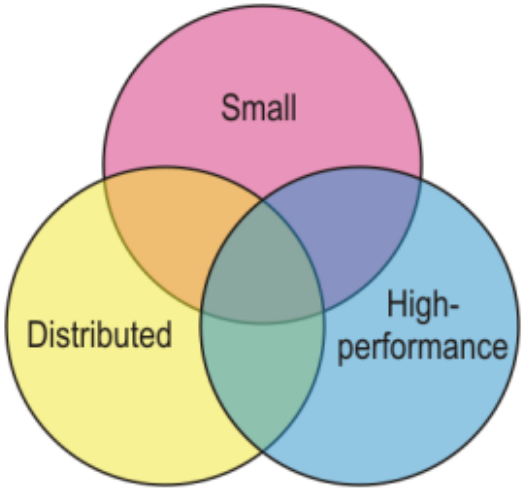


Fig. 1.10 A classification of embedded systems

Summary

- ES are electronic systems that have specific function and are part of a larger system.
- Modern ES were born with the adventure of the microprocessor.
  - TMS 1000 microcontroller
  - I4004 microprocessor
  - MP944 CADC
- ES are composed of:
  - Hardware components (CPU-Memory-I/O)
  - software components (Firmware- OS- Applications)
- ES are classified as:
  - small,
  - distributed and
  - high performance.

- For more details, refer to:
  - Text books for CSCI 101
  - Chapter 1 at **Introduction to Embedded Systems,** Springer 2014 by Manuel Jiménez et al.
- The lecture is available online at:
  - *http://www.bu.edu.eg/staff/ahmad.elbanna-courses/14130/files*
- For inquires, send to:
  - ahmad.elbanna@feng.bu.edu.eg