INTEGRATED TECHNICAL EDUCATION CLUSTER
AT ALAMEERIA

E-626-A
Real-time Embedded Systems (RTES)

Lecture #1
Introduction to Embedded Systems

Instructor:
Dr. Ahmad El-Banna

SPRING 2015

Agenda

- Course Objectives
- Course Information
- Introduction to Embedded System

Course Objectives

- ***Determine and analyze the concepts and principles of real-time systems and definition of embedded systems.***
- ***Build/construct an embedded system around a PIC microcontroller with evaluating embedded system performance, correctness, and speed.***
- ***Perform continuation of system performance evaluation.***
- ***Conduct evaluation performance analysis.***

Course Information

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Lectures:	Sunday, 12:30 -14:15
Office Hours:	Sunday (14:15~15:30)
T.A.:	Eng.
Texts/Notes:	• John Catsoulis, **Designing Embedded Hardware**, 2005. • Qing Li and Carolyn Yao, **Real-Time Concepts for Embedded Systems**, 2003. • Michael Barr, **Programming Embedded Systems in C and C++**, 1999.
Assignments	• Assignment #1 (P1:P4), 7th week. • Assignment #2 (P5:P8), 14th week.

Lectures List

- **Weeks 1:3**
  - *Determine and analyze the concepts and principles of real-time systems and definition of embedded systems.*
- **Weeks 4:7**
  - *Build/construct an embedded system around a PIC microcontroller with evaluating embedded system performance, correctness, and speed.*
- **Weeks 8:10**
  - *Perform continuation of system performance evaluation.*
- **Weeks 11:14**
  - *Conduct evaluation performance analysis.*
- **Week 15**
  - *Course close and feedback*

INTRODUCTION TO EMBEDDED SYSTEMS

Examples of Embedded Systems

What's an Embedded System?

- An ***embedded system*** **(ES)** is a combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a ***specific function***.
- A good example is the microwave oven. Almost every household has one, and tens of millions of them are used every day.
- Frequently, an embedded system is a component within some larger system.
- For example, modern cars and trucks contain many embedded systems.
- If an embedded system is designed well, the existence of the processor and software could be completely unnoticed by a user of the device. Such is the case for a microwave oven, VCR, or alarm clock.

Embedded vs. Standalone Systems

- Embedded Systems is in direct contrast to the personal computer in the family room. It too is comprised of computer hardware and software and mechanical components (disk drives, for example).
- However, a personal computer is *not* designed to perform a *specific function*. Rather, it is able to do many different things.
- Many people use the term ***general-purpose computer*** to make this distinction clear.
- At the possible risk of confusing you, it is important to point out that a general-purpose computer is itself made up of numerous embedded systems.
- For example, the computer consists of a keyboard, mouse, video card, modem, hard drive, floppy drive, and sound card- each of which is an embedded system.

Real-Time Systems

- One subclass of embedded systems is worthy of an introduction at this point.
- As commonly defined, a*real-time system* is a computer system that has timing constraints.
- In other words, a real-time system is partly specified in terms of its ability to make certain calculations or decisions in a timely manner.
- These important calculations are said to have deadlines for completion.
- And, for all practical purposes, a missed deadline is just as bad as a wrong answer.

Hard and Soft Real-Time Systems

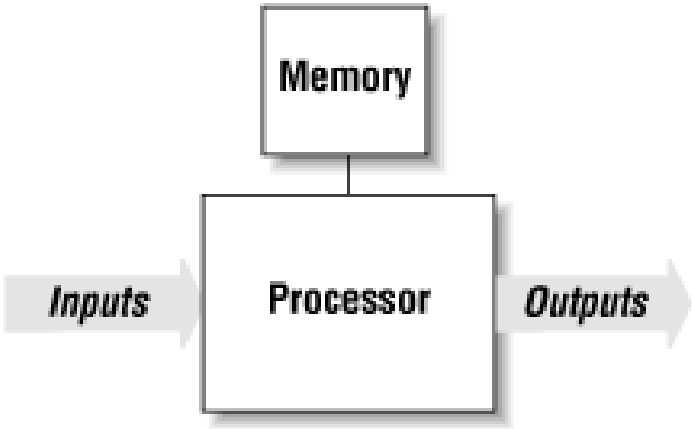
- The issue of what happens if a deadline is missed is a crucial one.
- For example, if the real-time system is part of an airplane's flight control system, it is possible for the lives of the passengers and crew to be endangered by a single missed deadline.
- However, if instead the system is involved in satellite communication, the damage could be limited to a single corrupt data packet.
- The more severe the consequences, the more likely it will be said that the deadline is "**hard**" and, thus, the system a *hard real-time system*.
- Real-time systems at the other end of this continuum are said to have "**soft**" deadlines.

Variations on the theme

- Unlike software designed for general-purpose computers, embedded software cannot usually be run on other embedded systems without significant modification.
- This is mainly because of the incredible variety in the underlying hardware.
- The hardware in each embedded system is tailored specifically to the application, in order to keep system costs low.
- As a result, unnecessary circuitry is eliminated and hardware resources are shared wherever possible.

A Generic Embedded Systems

- By definition all embedded systems contain a processor and software, but what other features do they have in common?
- Certainly, in order to have software, there must be a place to store the executable code and temporary storage for runtime data manipulation. These take the form of ROM and RAM, respectively.
- All embedded systems also contain some type of inputs and outputs. (u wave oven)



Design Requirements of ES

- Production cost
- *Processing power*
- *Memory*
- *Development cost*
- *Number of units*
- *Expected lifetime*
- *Reliability*

Criterion	Low	Medium	High
Processor	4- or 8-bit	16-bit	32- or 64-bit
Memory	< 16 KB	64 KB to 1 MB	> 1 MB
Development cost	< $100,000	$100,000 to $1,000,000	> $1,000,000
Production cost	< $10	$10 to $1,000	> $1,000
Number of units	< 100	100-10,000	> 10,000
Expected lifetime	days, weeks, or months	years	decades
Reliability	may occasionally fail	must work reliably	must be fail-proof

The range of possible values for each of the previous design requirements.

- For more details, refer to:
  - Chapter 1, Michael Barr, **Programming Embedded Systems in C and C++**, 1999.
- The lecture is available online at:
  - http://bu.edu.eg/staff/ahmad.elbanna-courses
- For inquires, send to:
  - ahmad.elbanna@feng.bu.edu.eg