Sharif University of Technology
Department of Computer Science and Engineering

Lec. 1:

Introduction to Embedded Systems Design

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According to Peter Marwedel's Lectures

Embedded Systems

- Information processing systems embedded into a larger product.
- Main reason for buying is not information processing.
- Application Areas
  - ✓ Automotive electronics
  - ✓ Aircraft electronics
  - ✓ Trains
  - ✓ Telecommunication
  - ✓ Robotics
  - ✓ Military applications
  - ✓ Authentication
  - ✓ Fabrication equipment

Consumer Applications

- MP3 player
- DVD player
- Toys
- Television
- Mobile phone
- Sewing machine

Importance of ES

- 79% of all high-end processors are used in embedded systems.
- They are part of almost everything that runs on electricity.
- Crucial application in key industries
  - Automotive industry: 7% of EU's GNP

Characteristics of ES

- Dependability
  - Reliability, Maintainability, Availability, Safety, Security
- Energy efficiency
- Performance
- Real-time constraints
  - For real-time systems, right answers arriving too late are wrong.

Characteristics of ES (Cont.)

- Weight efficient, Cost efficient, Code-size efficient.
- Dedicated towards a certain application.
  - Minimize resources, Maximize robustness
- Dedicated user interface
  - no mouse, keyboard and screen

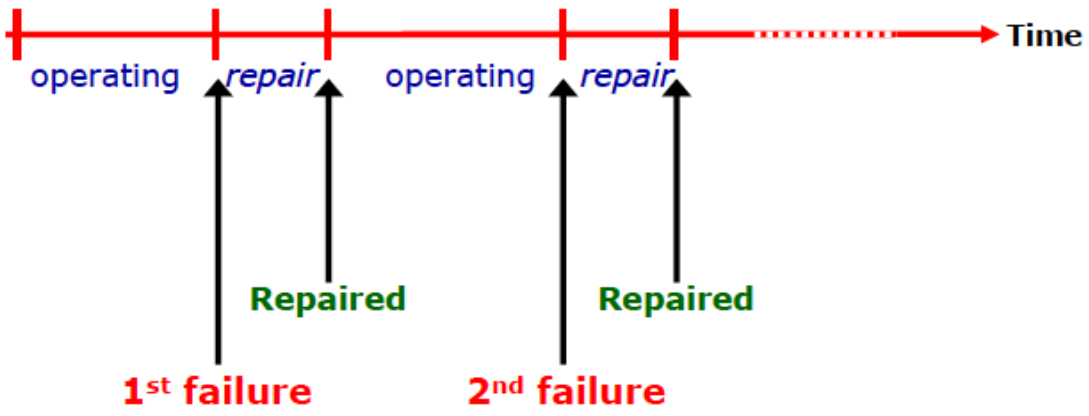
Dependability of ES: (1) Reliability

1) Reliability: The reliability, *R(t)*, of a system is a function of time, defined as the conditional probability that the system will perform correctly throughout the interval $[t_0, t_1]$, given that the system was performing correctly at the time t_0.

- In applications in which repair is impassible, T can be extremely long (≈ 10 years).
- In other applications, i.e., aircraft flight control, T can be several hours. Here, R(t) ≥0.9999999.

Dependability of ES: (2) Availability

2) Availability: The availability, *A(t)*, is a function of time, defined as the probability that system is operating correctly and is available to perform its function at the instant of time *t*.



- The availability depends not only on how frequent the system becomes inoperable, but also on how quickly it can be repaired.

Dependability of ES: (3) Maintainability

3) Maintainability: Maintainability, *M(t)*, is the probability that a failed system will be restored to an operational state within a specified period of time, *t*.

- The restoration process includes:
  - Locating the problem
  - Physically repairing the system
  - Bringing the system back to its operational condition

Dependability of ES: (4) Safety

4) Safety: Safety, *S(t)*, is the probability that a system will **either** perform its functions correctly, **or** will discontinue its function in a manner that does not disrupt the operation of other systems or compromise the safety of any people associated with the system.

- Safety is a measure of the fail-safe techniques of a system

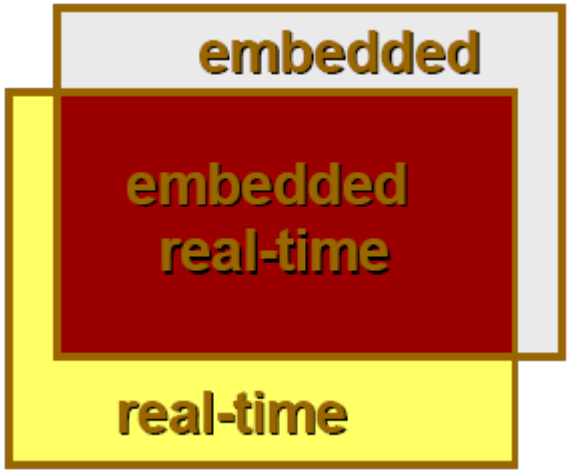
Dependability of ES: (5) Security

5) Security is:

- the prevention of
  - unauthorized access of information and/or
  - unauthorized handling of information and/or
- supporting the authorized access of information.

Embedded and Real-Time Synonymous?

- Most embedded systems are real-time
- Most real-time systems are embedded



A Common Misconception

Misconception:

- The study of embedded systems is simply a combination of some of the well-known areas such as:
  - Dependability
  - Real-time systems
  - Low power design
  - etc.

Challenges for Embedded Systems

- Although the study of embedded systems is an interdisciplinary area of study, it has its own challenges:
  - Interplay of different design objectives
  - Challenges in system specification, design, and verification
  - Special features of embedded systems
    - weight efficient, Cost efficient, Code-size efficient, Diskless systems

Interplay of Design Objectives

- Design objectives:
  - Fault tolerance (Dependability)
  - Energy efficiency
  - Real-time
  - Cost efficient
- The design objectives are at odds:
  - Example: Fault tolerance requires some types of redundancy and redundancy leads to energy consumption.

Reactive Systems

- Typically ES are reactive systems.

"A reactive system is in continual interaction with its environment and executes at a pace determined by that environment."

Reactive Systems (Cont.)

- Reactive Systems = Event-based Systems
- The traditional paradigms of programming (i.e. model of computable functions) are inappropriate.
  - Model of computable functions
    - Von Neumann paradigm
    - Sequential computing
- Suitable model for reactive systems:
  - Automata-based programming paradigm

Automata-Based Programming

- Automata-Based Programming is a programming paradigm whose defining characteristic is the use of finite state machines to describe program behavior.
- The transition graphs of a state machines are used in all stages of software development
  - Specification
  - Implementation
  - debugging
  - documentation

Summary

- Importance of ES
- Characteristics of ES
- Reactive Systems
- Automata-Based Programming