



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

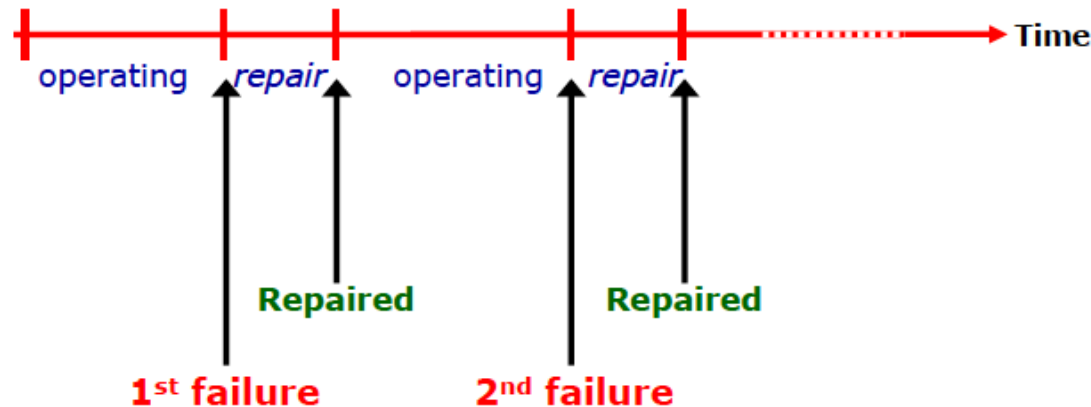
- 1) **Reliability**: The reliability, $R(t)$, of a system is a function of time, defined as **the conditional probability** that the system will perform correctly throughout the interval $[t_0, t_1]$, given that the system was performing correctly at the time t_0 .



- ❖ 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, $R(t) \geq 0.9999999$.

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

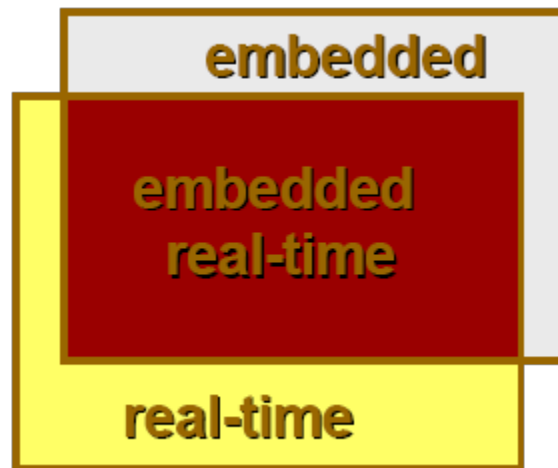
Dependability of ES: (5) Security

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