Embedded Systems

4th Stage

Lecture Two

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CLASSIFICATION OF EMBEDDED SYSTEM

CHARACTERISTICS OF EMBEDDED SYSTEM

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

CLASSIFICATION OF EMBEDDED SYSTEM

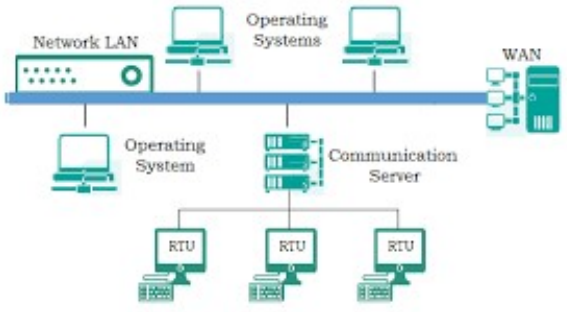
The classification of embedded system is based on following criteria's:

- On Generation
- On Complexity and Performance
- On deterministic behaviour
- On triggering

Classification of Embedded System On Generation

- **First generation(1G):**
  - Built around 8bit microprocessor & microcontroller.
  - Simple in hardware circuit & firmware developed.
    - Examples: Digital telephone keypads.

- **Second generation(2G):**
  - Built around 16-bit µp & 8-bit µc.
  - They are more complex & powerful than 1G µp & µc.
    - Examples: SCADA systems



Classification of Embedded System On Generation

- **Third generation(3G):**
  - Built around 32-bit µp & 16-bit µc.
  - Concepts like Digital Signal Processors(DSPs), Application Specific Integrated Circuits(ASICs) evolved.

    Examples: Robotics, Media, etc.

- **Fourth generation**:
  - Built around 64-bit µp & 32-bit µc.
  - The concept of System on Chips (SoC), Multicore Processors evolved.
  - Highly complex & very powerful.
    - Examples: Smart Phones.

Classification of Embedded System on Complexity & Performance

- **Small-scale:**
  - Simple in application need
  - Performance not time-critical.
  - Built around low performance & low cost 8 or 16 bit µp/µc

    Example: an electronic toy

- **Medium-scale:**
  - Slightly complex in hardware & firmware requirement.
  - Built around medium performance & low cost 16 or 32 bit µp/µc.
  - Usually contain operating system.

    Examples: Industrial machines.

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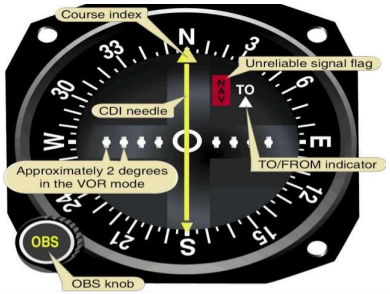
Classification of Embedded System on Complexity & Performance

❑Large-scale:

- Highly complex hardware & firmware.
- Built around 32 or 64 bit RISC µp/µc or PLDs or Multicore Processors.
- Response is time-critical.
  - Examples: Mission critical applications like Navigating system of an aircraft and online banking companies



Classification of Embedded System on Deterministic Behaviour

This classification is applicable for “Real Time” systems. The task execution behaviour for an embedded system may be deterministic or non-deterministic. Based on execution behaviour Real Time embedded systems are divided into Hard and Soft.

Hard Real Time System

A real time system is a data processing system. The time taken by the system to respond to an input and provide the output or display the updated information is known as the response time.

Soft Real Time System

In a soft real time, system, the time requirement is not very crucial. The system should perform the task or give the output within the deadline but there can be a small tolerance occasionally. If the system, did not perform the task within the deadline it is not considered as a failure as long as it provides the required output. But performance is considered to be degraded.

Classification Of Embedded System on Deterministic Behaviour

Hard vs Soft Real Time System	
A hard-real time system is a system in which a failure to meet even a single deadline may lead to complete or catastrophic system failure.	A soft real time system is a system in which one or more failures to meet the deadline is not considered as complete system failure but that performance is considered to be degraded.
Restrictive Nature	
A Hard-real time system is very restrictive.	A Soft real time system is not very restrictive.
Deadline	
A Hard-real time system should not miss the deadline. Missing the deadline cause complete or catastrophic system failure.	A Soft real time system can miss the deadline occasionally. Missing the deadline is not considered as a complete system failure but degrades the performance.
Utility	
A hard-real time system has more utility.	A soft real time system has less utility.
Examples	
Air traffic control systems, missile, and nuclear reactor control systems are some examples of hard real time systems.	Multimedia streaming, advanced scientific projects, and virtual reality are some examples of soft real time systems.

Classification of Embedded System on Triggering

Embedded systems which are “Reactive” in nature can be based on triggering. Reactive systems can be:

Event triggered

Is a software architecture paradigm promoting the production, detection, consumption of, and reaction to events

Time triggered

Is a computer system that executes one or more sets of tasks according to a pre-determined and set task schedule

Example : International safety standards such as IEC 61508 (industrial systems), ISO 26262 (automotive systems), IEC 62304 (medical systems) and IEC 60730 (household goods).

CHARACTERISTICS OF EMBEDDED SYSTEM

Following are some of the characteristics of an embedded system that make it different from a general purpose computer:

Application and Domain specific

- An embedded system is designed for a specific purpose only. It will not do any other task.
- Ex. A washing machine can only wash, it cannot cook
  - Certain embedded systems are specific to a domain: ex. A hearing aid is an application that belongs to the domain of signal processing.

CHARACTERISTICS OF EMBEDDED SYSTEM

- **Reactive and Real time**
  - Certain Embedded systems are designed to react to the events that occur in the nearby environment. These events also occur real-time.

  - Ex. An air conditioner adjusts its mechanical parts as soon as it gets a signal from its sensors to increase or decrease the temperature when the user operates it using a remote control.

  - An embedded system uses Sensors to take inputs and has actuators to bring out the required functionality

CHARACTERISTICS OF EMBEDDED SYSTEM

- **Operation in Harsh Environment**
  - Certain embedded systems are designed to operate in harsh environments like very high temperature of the deserts or very low temperature of the mountains or extreme rains.

  - These embedded systems have to be capable of sustaining the environmental conditions it is designed to operate in.

CHARACTERISTICS OF EMBEDDED SYSTEM

- **Distributed**
  - Certain embedded systems are part of a larger system and thus form components of a distributed system.
  - These components are independent of each other but have to work together for the larger system to function properly.
  - Ex. A car has many embedded systems controlled to its dashboard. Each one is an independent embedded system yet the entire car can be said to function properly only if all the systems work together.

CHARACTERISTICS OF EMBEDDED SYSTEM

- **Small Size and Weight**

- An embedded system that is compact in size and has light weight will be desirable or more popular than one that is bulky and heavy.

- Ex. Currently available cell phones. The cell phones that have the maximum features are popular but also their size and weight is an important characteristic.

- For convenience users prefer mobile phones than tablets. (phone + tablet pc).

CHARACTERISTICS OF EMBEDDED SYSTEM

- **Power Concerns**

- It is desirable that the power utilization and heat dissipation of any embedded system be low.
- If more heat is dissipated then additional units like heat sinks or cooling fans need to be added to the circuit.
- If more power is required then a battery of higher power or more batteries need to be accommodated in the embedded system.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

These are the attributes that together form the deciding factor about the quality of an embedded system.

There are two types of quality attributes are:-

I. **Operational Quality Attributes.**

These are attributes related to operation or functioning of an embedded system. The way an embedded system operates affects its overall quality.

II. **Non-Operational Quality Attributes.**

These are attributes **not** related to operation or functioning of an embedded system. The way an embedded system operates affects its overall quality.

These are the attributes that are associated with the embedded system before it can be put in operation.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

I. Operational Attributes

1. Response

- Response is a measure of quickness of the system.
- It gives you an idea about how fast your system is tracking the input variables.
- Most of the embedded system demand fast response which should be real-time.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

I. Operational Attributes

2. Throughput

Throughput deals with the efficiency of system.

- It can be defined as rate of production or process of a defined process over a stated period of time.
- In case of card reader like the ones used in buses, throughput means how much transaction the reader can perform in a minute or hour or day.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

I. Operational Attributes

3. Reliability

- Reliability is a measure of how much percentage you rely upon the proper functioning of the system .
- Mean Time between failures and Mean Time To Repair are terms used in defining system reliability.
- Mean Time between failures can be defined as the average time the system is functioning before a failure occurs.
- Mean time to repair can be defined as the average time the system has spent in repairs.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

I. Operational Attributes

4. Maintainability

- Maintainability deals with support and maintenance to the end user or a client in case of technical issues and product failures or on the basis of a routine system checkup

- It can be classified into two types :-

  A. Scheduled or Periodic Maintenance. .

  B. Maintenance to unexpected failure

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

A. Scheduled or Periodic Maintenance

This is the maintenance that is required regularly after a periodic time interval.

- Example :
  - Periodic Cleaning of Air Conditioners
  - Refilling of printer cartridges.

B. Maintenance to unexpected failure

This involves the maintenance due to a sudden breakdown in the functioning of the system.

- Example:
  - Air conditioner not powering on
  - Printer not taking paper in spite of a full paper stack

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

I. Operational Attributes

5. Security

- Confidentiality, Integrity and Availability are three corner stones of information security.
- Confidentiality deals with protection data from unauthorized disclosure.
- Integrity gives protection from unauthorized modification.
- Availability gives protection from unauthorized user
- Certain Embedded systems have to make sure they conform to the security measures.

Ex. An Electronic Safety Deposit Locker can be used only with a pin number like a password.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

I. Operational Attributes

6. Safety

- Safety deals with the possible damage that can happen to the operating person and environment due to the breakdown of an embedded system or due to the emission of hazardous materials from the embedded products.

- A safety analysis is a must in product engineering to evaluate the anticipated damage and determine the best course of action to bring down the consequence of damages to an acceptable level.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

II. Non Operational Attributes:

1. Testability and Debug-ability

- It deals with how easily one can test his/her design, application and by which mean he/she can test it.
- In hardware testing the peripherals and total hardware function in designed manner
- Firmware testing is functioning in expected way
- Debug-ability is means of debugging the product as such for figuring out the probable sources that create unexpected behavior in the total system

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

II. Non Operational Attributes:

2. Evaluability

- For embedded system, the qualitative attribute "Evolvability" refer to ease with which the embedded product can be modified to take advantage of new firmware or hardware technology.

3. Portability

- Portability is measured of "system Independence".
- An embedded product can be called portable if it is capable of performing its operation as it is intended to do in various environments irrespective of different processor and or controller and embedded operating systems.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

II. Non Operational Attributes:

4. Time to prototype and market

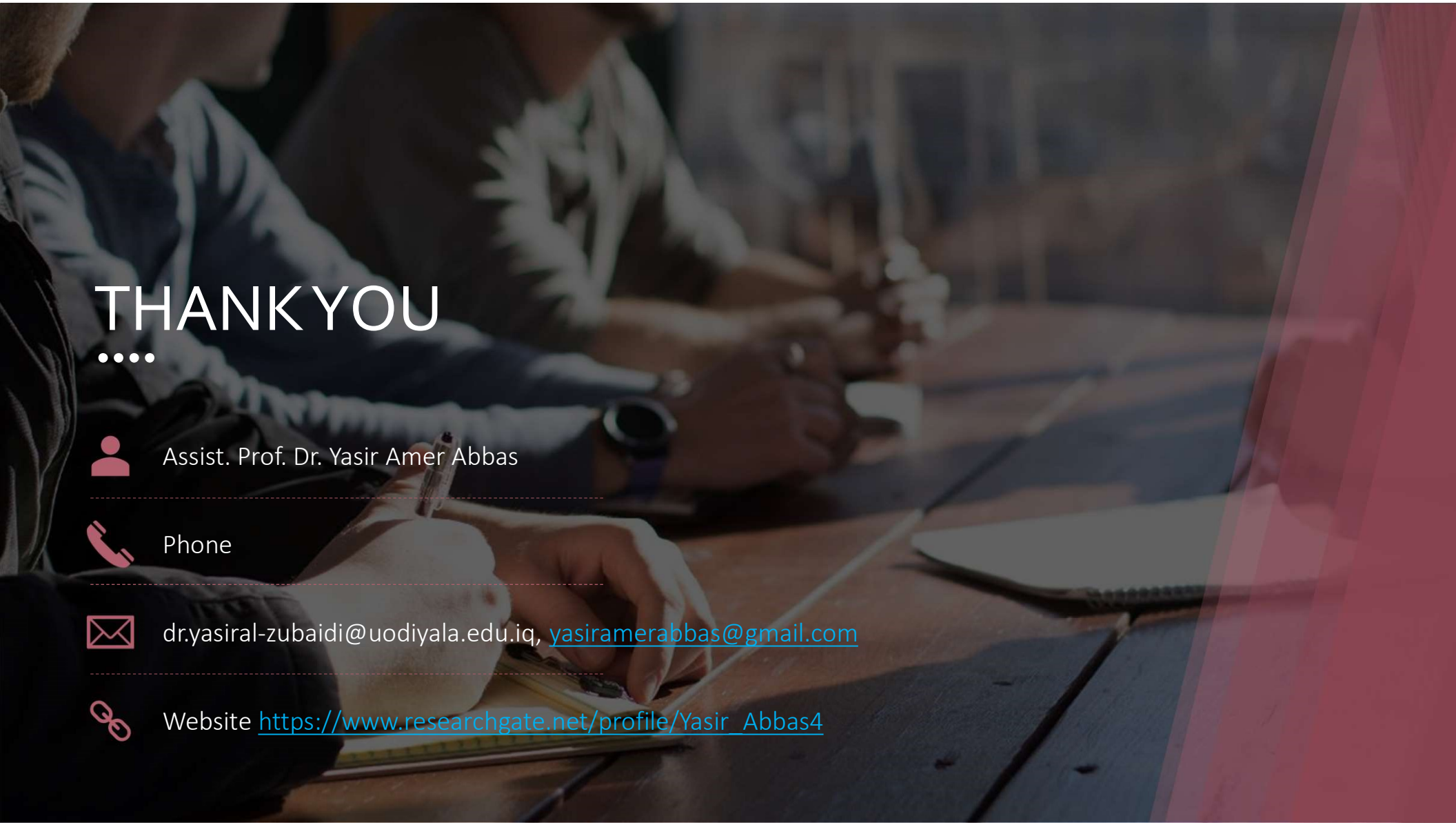
- Time to Market is the time elapsed between the conceptualization of a product and time at which the product is ready for selling or use
- Product prototyping help in reducing time to market.
- Prototyping is an informal kind of rapid product development in which important feature of the under consider are develop.
- In order to shorten the time to prototype, make use of all possible option like use of reuse, off the self component etc.

QUALITY ATTRIBUTES OF EMBEDDED SYSTEM

II. Non Operational Attributes:

5. Per unit and total cost

- Cost is an important factor which needs to be carefully monitored. Proper market study and cost benefit analysis should be carried out before taking decision on the per unit cost of the embedded product.
- When the product is introduced in the market, for the initial period the sales and revenue will be low
- There won't be much competition when the product sales and revenue increase.
- During the maturing phase, the growth will be steady and revenue reaches highest point and at retirement time there will be a drop in sales volume.



THANK YOU

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