

# COMP 306 (Embedded System)

# What is an Embedded System?

- An embedded is an electronic/electro-mechanical system designed to perform a specific function and is a combination of both hardware and firmware (software).
- Every embedded system is unique, and the hardware as well as the firmware is highly specialized to the application domain.
- IOT ??

- Each of the appliances will have a processor and special hardware to meet the specific requirement of the application along with the embedded software that is executed by the processor for meeting that specific requirement.
- Appliances such as the air-conditioner, VCD player, DVD player, printer, fax machine, mobile phone etc, are examples of Embedded systems.

# History of Embedded System

<https://www.youtube.com/watch?v=1hX4urTFXr0>

- In the 1980's the availability of computer networks brings Computer and Telecommunication together.
- from the 90s Internet and World Wide Web become available, allowing widespread access to digital technologies.
- Finally, towards the beginning of the 2000s, a second parallel revolution occurs for Embedded Systems though it has been developed for many decades with less visibility. Now it can be pretended as over 95% of all electronic chips produced today are for embedded systems

- With the advent of the networked information appliances, even tiny embedded systems can be network-enabled.
- Another innovation in the embedded system arena is in the software development.
- High-level languages such as C, C++, and Java
- Android Programming, Iphone

# Economic Challenges

- Embedded technologies are of strategic importance for current economics.
- Embedded system developer company are responsible for booming the Countries economic  
For example, Apple, Samsung, Huawei, Xaomi
- Embedded Software plays an increasingly significant role with respect to hardware: software functionalities allow differentiation between products that are based on the same hardware.

# Class Activities

- Moodle



# Major application areas of Embedded Systems

- **Consumer electronics** : cameras
- **Household appliances**: Television, DVD players, washing machine, fridge, microwave oven etc
- **Home automation and security systems**: Air conditioners, sprinklers, intruder detection alarms,
- Closed circuit television cameras, fire alarms etc
- **Automotive industry**: Anti-lock breaking systems (ABS), engine control, ignition systems, automatic navigation systems, etc

- **Telecom:** Cellular telephones, telephone switches, handset multimedia applications, etc
- **Computer networking systems:** Network routers, switches, hubs, firewalls, etc
- **Healthcare:** Different kinds of scanners, EEG, ECG machines etc
- **Measurement & Instrumentation:** Digital multi meters, digital CROs, logic analyzers PLC systems etc
- **Banking & Retail:** Automatic teller machines (ATM) and currency counters, point of sales (POS)
- **Card Readers:** Barcode, smart card readers, hand held devices etc.

- Let's take an example of automobile car. In the high end cars, there are over 80 distinct processors for handling these various emerging functionalities- that allow manufacturers to increase improves security, performance, attractiveness, and in the end, their market share.
- *Give example of automated cars that are build up , like for servicing data, how much the Kilo meter it moves and many more*

# Purpose of Embedded System

- **Data Collection/Storage/Representation**
- **Data Communication**
- **Data (signal) processing**
- **Monitoring**
- **Control**
- **Application specific user interfaces**

# Purpose of Embedded System (Cont..)

- **Data Collection/Storage/Representation**

- Several system are designed for the data collection, that could in text, voice, image, video, electrical signals and many other measurable quantities.
- The collected data may be stored in the system or may be transmitted to some other source.
- A digital camera is a typical example of an embedded system with data collection/storage/representation of data.

# Purpose of Embedded System (Cont..)

- **Data Communication**

- Embedded data communication systems are deployed in applications ranging from complex satellite communication system to simple home networking systems.
- The data collected by an embedded terminal may require transferring of the same to some other system located remotely. The transmission is achieved either by a wire-line medium or by a wire-less medium.
- For example: Bluetooth, wireless router

# Purpose of Embedded System (Cont..)

- **Data (signal) processing**

- The data (voice, image, video, electrical signals and other measurable quantities) collected by embedded systems may be used for various kinds of data processing. Embedded systems with signal processing functionalities are employed in applications demanding signal processing like speech coding, synthesis, audio video codec, transmission applications etc.
- A digital hearing aid is a typical example of an embedded system employing data processing. Digital hearing aid improves the hearing capacity of hearing impaired persons, Musical Gadgets

# Purpose of Embedded System (Cont..)

- **Monitoring**

- Embedded system falling under this categories are specifically designed for monitoring purpose.
- They are used for determining the state of some variables using input sensors.
- Most of the Embedded system categories for monitoring lies in medical purpose.
  - Example: electro cardiogram (ECG) machine for monitoring the heartbeat of a patient.



# Purpose of Embedded System (Cont..)

- **Control**

- Embedded systems with control functionalities impose control over some variables according to the changes in input variables. A system with control functionality contains both sensors and actuators.
- Sensors are connected to the input port for capturing the changes in environmental variable or measuring variable. The actuators connected to the output port are controlled according to the changes in input variable to put an impact on the controlling variable to bring the controlled variable.
- Eg. An Airconditioner for controlling room temperature. Embedded system with Control functionality.

# Purpose of Embedded System (Cont..)

- **Application specific user interface**

- There are embedded systems with application-specific user interfaces like buttons, switches, keypad, lights, bells, display units, etc. Mobile phone is an example for this.

# Categories of Embedded System

- Based on functionalities and performance requirements, embedded systems can be categorized as.
  - Stand-alone embedded systems
  - Real-time systems
  - Networked Information Appliances
  - Mobile Devices

# Categories of Embedded System (Cont..)

- **Stand-alone Embedded System**

- This system works in stand-alone position.
- Some of the examples are digital camera, microwave oven, CD player, Air Conditioner and TV
- They take inputs, process them and produce the desired output.
- The input can be electrical signals to drive another system, and LED display or LCD display for displaying of information to the users.
- In a process control system, the inputs are from sensors that convert a physical entity such as temperature or pressure into its equivalent electrical signal. These electrical signals are processed by the system and the appropriate electrical signals are produced using which an action is taken such as opening a valve.

# Categories of Embedded System (Cont..)

- **Real-Time Systems**

- System that needs to be done specific time period are called Real-Time System.
- For example, Pacemaker, if the heart doesn't start to beat, after certain millisecond, the Pacemaker needs to start. If this Pacemaker does not start than there would cause big disaster. Such systems with strict deadlines are called hard-real systems.
- In some embedded systems there are system which needs to work after certain time frame, but if they couldn't fulfill within the time it will not hamper that much. These embedded systems are called soft real-time systems.
- Hard real time systems & Soft real time system(Remote Control in TV)

Real-time systems are categorized as hard real-time systems and soft real-time systems. In hard real-time systems, missing a deadline may lead to a catastrophe. In soft real-time systems, meeting the deadline is important but missing the deadline will not lead to a catastrophe.

Hard real time systems(Pace Maker) & Soft real time system(Remote Control in TV)

# Categories of Embedded System (Cont..)

- **Networked Information Appliances**

- System that are called networked information appliances. Such embedded systems are connected to a network, typically a network running TCP/IP (Transmission Control Protocol/ Internet Protocol)
- *Lets take an example, camera doing job of guard(supervision); the camera is taking video and sending data to the system, if the web camera network doesn't work at the time when thief came than; thief will do his duty. 😊*
- *Door-lock of your home can be small embedded system with TCP/IP and HTTP server.*
- *Early Warning System(to Distant Places)*

# Categories of Embedded System (Cont..)

- **Mobile Devices**

- Mobile phone, Personal Digital Assistants (PDAs), smart phones etc.
- PDA is a general-purpose tasks, they need to be designed just like the conventional embedded systems.



# Specialties of Embedded Systems

- As compared to desktop computers, workstations or mainframes, embedded systems have many specialties. Developer need to keep these specialties in mind while designing embedded Systems.
  - Reliability
  - Performance
  - Power Consumption
  - Cost
  - Size
  - Limited user Interface
  - Software Up gradation Capability

# Specialties of Embedded Systems (Cont..)

- **Reliability**

- The system should be highly reliability and it's a paramount importance.
- Example is like of Pacemaker before. It needs to run continuously, as it stop for certain than it may cause the disaster.
- There are special software/hardware needs to be built into the system to take care of it. This special module is called **watchdog timer**.
- There are several Embedded system that needs to be work in extreme environmental conditions. Such system able to work reliably in extreme environmental condition is known as **ruggedness**.

# Specialties of Embedded Systems (Cont..)

- **Performance**

- The performance of Embedded system is very important.
- For example if the temperature exceeds 50 degree of the engine car, than there must be the system that needs to give alarm to the owner, or needs to open the valves of any engine part. If the system doesn't perform as required than there could be big disaster.

# Specialties of Embedded Systems (Cont..)

- **Power Consumption**

- Most of the embedded systems operate through a battery. To reduce the battery drain and avoid frequent recharging of the battery, the power consumption of the embedded system has to be very low.
- Its better to develop a system that automate off power ingredient component of the Embedded System. For example if the system is not being used disable wifi system of the Mobile,
- Develop a system that could use less power.
- To reduce component count, the hardware designers have the option of using Programmable Logic Devices (PLDs) and Field Programmable Gate Arrays (FPGAs).

# Specialties of Embedded Systems (Cont..)

- **Cost**

- This is very important in context to the economical value of the Embedded System.
- If the system is being used directly to the consumer prospective, the system must be cheaper where as if the embedded system is being used in the nuclear plant, than in this circumstance, money matter may not be count.

# Specialties of Embedded Systems (Cont..)

- **Size**

- Size is certainly a factor for an embedded system.
- Its very important in context to aircraft, missiles etc.
- Hardware designer needs to reduce the size of the board and other components that hold to reduce the size of Embedded system.



# Specialties of Embedded Systems (Cont..)

- **Limited User Interface**

- User Interface in Embedded System is not given that much important, as its working performance and its reliability is being believed as most important.
- In some Embedded System there is no any input command from the user prospective as it gets input as electrical signal, in another side, output is displayed in a sets of LEDs or small LCD.
- Mobile phone has displayed as it has, but current scenario for the mobile technologies has given priority for the User Interface as well.

# Specialties of Embedded Systems (Cont..)

- **Software Upgrade Capability**

- In some case, there is need to upgrade the software to make the system more smooth, secure and reliable.
  - There are several example like upgrading firmware in the routers so that there compatibility increase.
  - Nowadays, software upgrade is done by downloading the software onto the embedded system through the Internet.