General-purpose systems (*hardware* and *software*) are tangible and intangible components of computer systems where operations are not subject to performance constraints. There may be desirable response characteristics, but there are no hard deadlines and no detrimental consequences other than perhaps poor quality of service if the response times are unusually long.

1. the time at which a response is delivered is as important as the correctness of that response, and
2. the consequences of a late response are just as hazardous as the consequences of an incorrect response.

Embedded systems are information processing systems that are embedded into a larger product and that are normally not directly visible to the user. Examples of embedded systems include information processing systems in telecommunication equipment, in transportation systems, in fabrication equipment and in consumer electronics.

telecommunication equipment, in transportation systems, in fabrication equipment and in consumer electronics.

Basic consept

Watch example.

Embed System : it combine software and hardwar . it design to perform a particular job or task.

The task has to be completed in a given time.

Example:

Washing machine

What is a real - Time OS ?

- An embedded system responds to external inputs:

if response time to an event is too long the system fails

General OS is not design for real time system.

Real time OS

Help tasks and jobs to meet its deedline

Application areas

Automotive electronics: Modern cars can be sold only if they contain a significant amount of electronics. These include air bag control systems, engine control systems, anti-braking systems (ABS), air-conditioning, GPSsystems, safety features, and many more.

Aircraft electronics: A significant amount of the total value of airplanes is due to the information processing equipment, including flight control systems, anti-collision systems, pilot information systems, and others. .

Trains: For trains, the situation is similar to the one discussed for cars and airplanes. Again, safety features contribute significantly to the total value of trains, and dependability is extremely important.

Telecommunication: Mobile phones have been one of the fastest growing markets in the recent years. For mobile phones, radio frequency (RF) design, digital signal processing and low power design are key aspects.

Medical systems: There is a huge potential for improving the medical service by taking advantage of information processing taking place within medical equipment.

Military applications: Information processing has been used in military equipment for many years. In fact, some of the very first computers analyzed military radar signals.

Consumer electronics: Video and audio equipment is a very important sector of the electronics industry. The information processing integrated into such equipment is steadily growing. New services and better quality are implemented using advanced digital signal processing techniques.
Many TV sets, multimedia phones, and game consoles comprise highperformance processors and memory systems. They represent special cases of embedded systems.

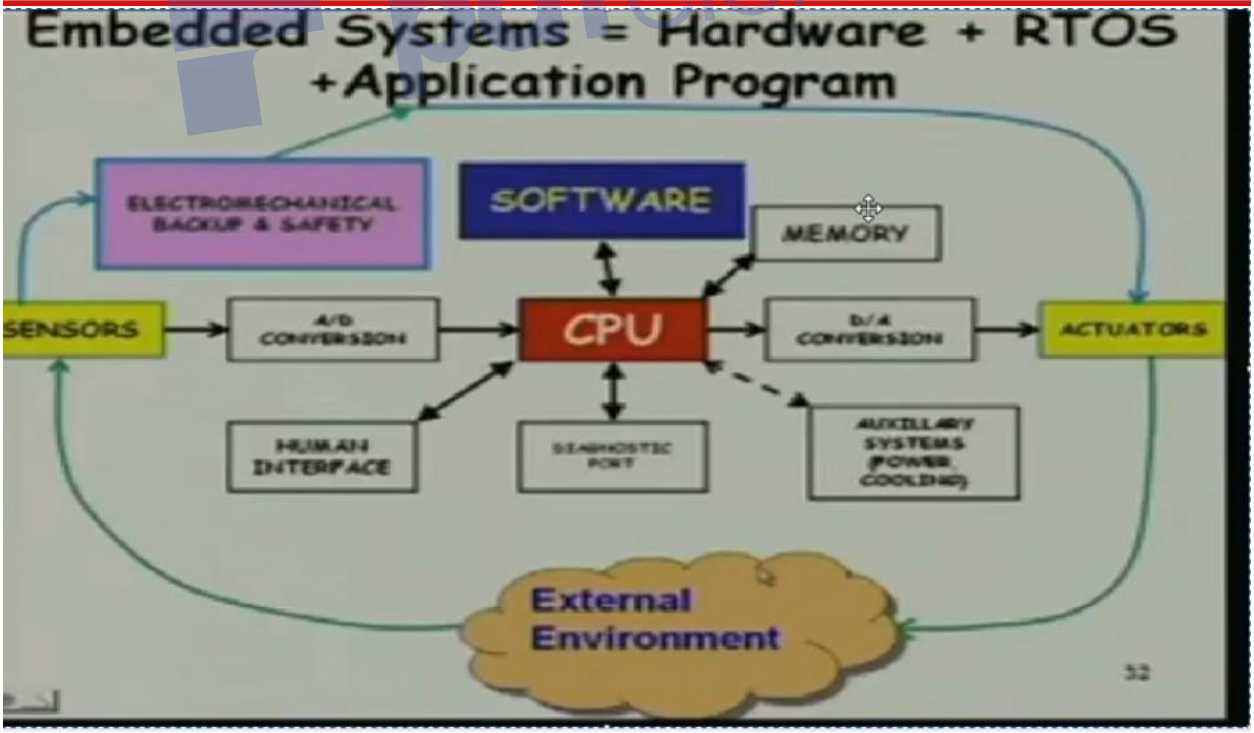
Fabrication equipment: Fabrication equipment is a very traditional area in which embedded systems have been employed for decades. Safety is very important for such systems, the energy consumption is less a problem.

Smart buildings: Information processing can be used to increase the comfort level in buildings, can reduce the energy consumption within buildings, and can improve safety and security. .

Robotics: Robotics is also a traditional area in which embedded systems have been used. Mechanical aspects are very important for robots. Most of the characteristics described above also apply to robotics. Recently, some new kinds of robots, modeled after animals or human beings, have been designed. Fig. 1.4 shows such a robot.

Figure 1.4. Robot "Johnnie" (courtesy H. Ulbrich, F. Pfeiffer, Lehrstuhl f¨ur Angewandte Mechanik, TU Mu¨nchen), c TU Mu¨nchen

This set of examples demonstrates the huge variety of embedded systems. Why does it make sense to consider all these types of



Characteristics of An Embedded System

- Real-time:
  - Every real-time task is associated with some time constraints, e.g. a Deadline.
- Correctness Criterion:
  - Results should be logically correct,
  - And within the stipulated time.

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Characteristics of an Embedded System Cont...

- Safety and Task Criticality:
  - A critical task is one whose failure causes system failure (example: obstacle avoidance).
  - A safe system does not cause damage.
  - A safety-critical real-time system is one where any failure causes severe damage.

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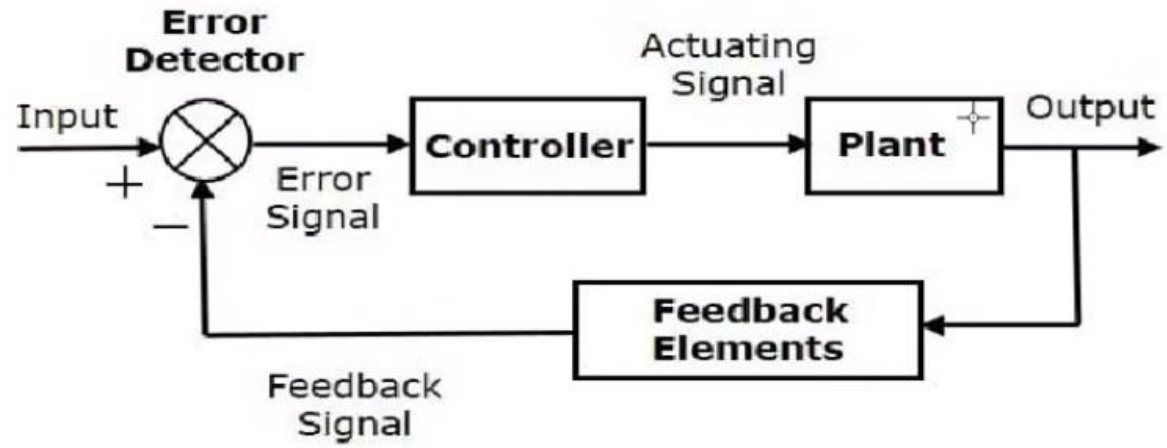
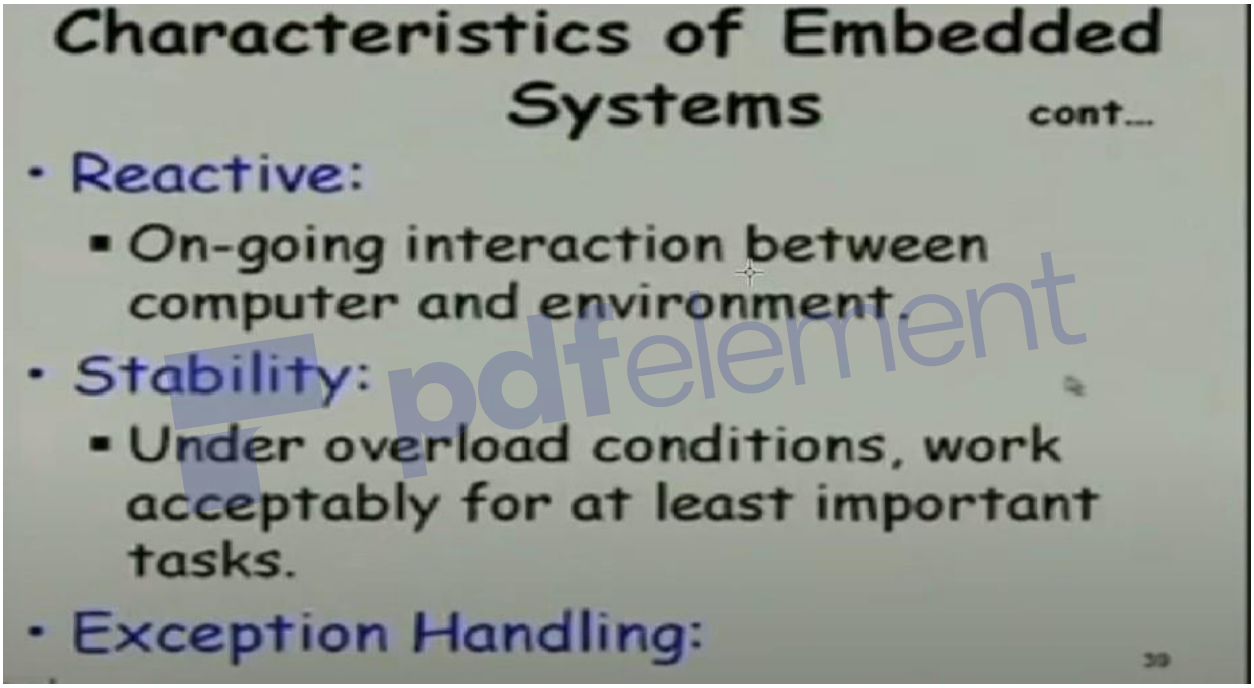
Characteristics of an Embedded System cont...

- Concurrency:
  - A RT system needs to respond to several independent events.
  - Typically separate tasks process each independent event.
  - For the same inputs, the result can be different (Non-determinism).

Characteristics of Embedded Systems cont...

- Distributed and Feedback Structure
- Custom Hardware:
  - An embedded system is often implemented on custom H/W that is specially designed and developed for the purpose.





Safety and Reliability

- Independent concepts in traditional systems.
  - A safe system does not cause damage even when it fails.
  - A reliable system operates for long time without any failure.

Safety and Reliability

- In traditional systems, safety and reliability are independent concerns:
  - A system can be safe and unreliable and vice versa.
  - Give examples of:
    - A safe and unreliable system
    - A reliable and unsafe system

Safety and Reliability

cont...

- Interrelated in safety-critical system.
  - A safety critical system is one for which any failure of the system would result in severe damage.
- Safety can be ensured only through increased reliability.

Safety and Reliability

- An unreliable system can be made safe upon a failure:
  - By reverting to a fail-safe state.
- A fail-safe state: