UTA

Today's Agenda

- Real-Time Systems Overview

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Real-Time Systems Overview

- Introduction
- Examples of Real-Time Systems
- Characteristics of Real-Time Systems
- Summary

What is it?

- Any system in which the time at which output is produced is significant
  - From Oxford Dictionary of Computing
- Any system that is required to react to externally generated input stimuli within a finite and specified period

The correctness of a real-time system depends on the logical results PLUS the time of delivery.

Timing Requirements

- Often expressed as deadlines, i.e., time when execution must be completed.
  - Can be specified as a point in time or a delta-time interval
- Hard deadline: Late delivery may result in serious consequences
- Firm deadline: Late delivery is no good, but does not put you in trouble
- Soft deadline: Late delivery is undesirable, but may be good results (within some upper limit)

Concurrency

- Most of real-time systems are concurrent
  - Multiple threads are often created to handle external events from different sources
  - Many events need to be processed in parallel
- Communication and synchronization are the two cores issues in a concurrent system
  - Communication is concerned with how different threads exchange information with each other
  - Synchronization is concerned with how to enforce a certain order among concurrent events

Misconceptions

- Real-time systems are concurrent systems
  - Concurrent systems do not have explicit time
- Real-time systems are real fast systems
  - A real-fast system may not always satisfy its timing requirements
- Hardware over-capacity is enough
  - Without appropriate resource management, there is no appropriate resource distribution

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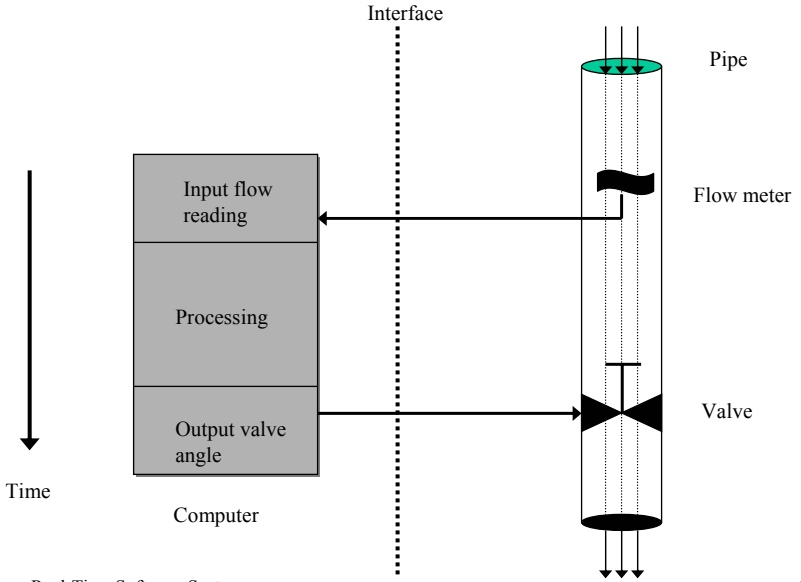
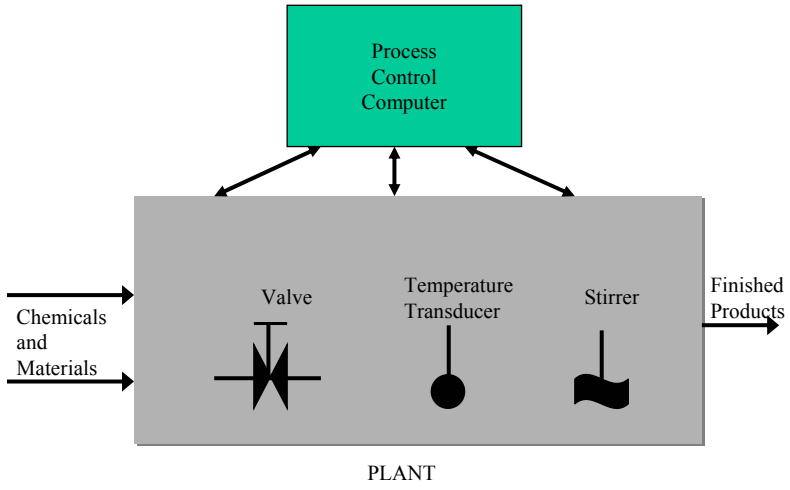
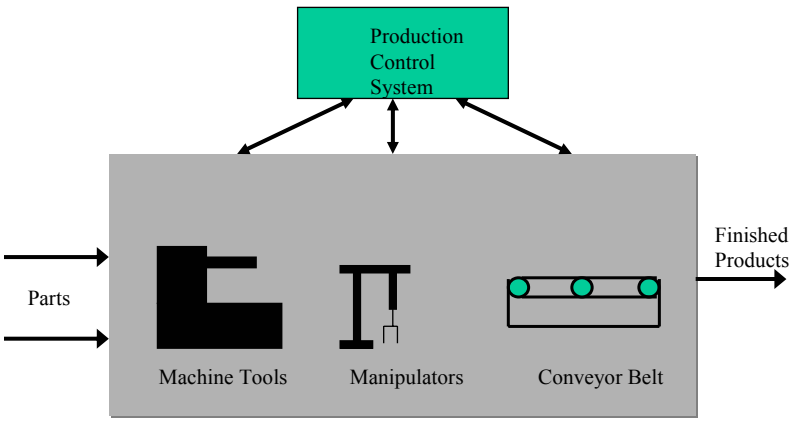
A Fluid Control System



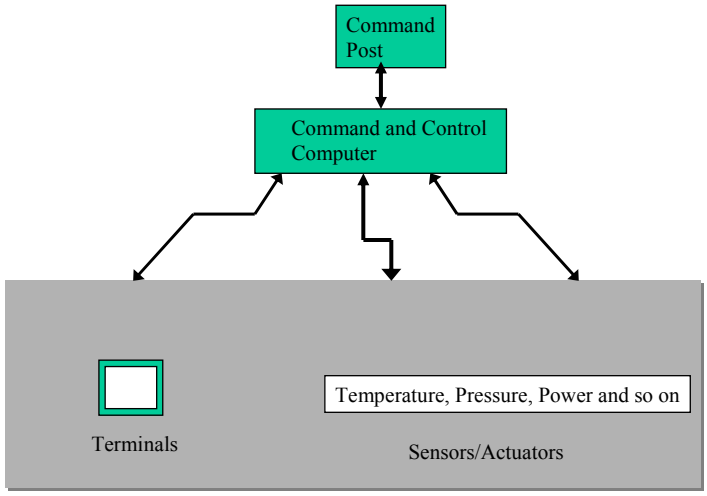
A Process Control System



A Production Control System



A Command And Control System



More Examples

- Cars: engine control, ABS, drive-by-wire
- Planes: stability, jet engine, fly-by-wire
- Military: weapons, command and control
- Domestic: microwave, thermostat, dishwasher,
- Medical: pacemaker, medical monitoring
- Protection: intruder alarm, gas/smoke detection

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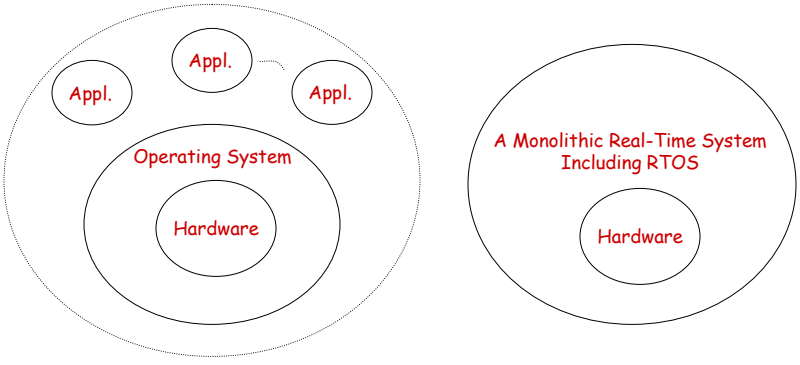
Common Characteristics (1)

- Embedded system: a component of a larger engineering system.
  - Many people consider embedded systems is synomous real-time systems.
- Concurrent system: the system simultaneously controls and/or reacts to different aspects of the environment, many events that need to be processed in parallel.
- Safety critical system: not only reliable but also safe, if it fails then without causing injury or loss of life. The development of safe system involves architectural redundancy.
- Reactive system: there is a continuous interaction with the environment, event-driven and must respond to external stimuli, system response is typically state dependent.

Common Characteristics (2)

- Operate under more severe constraints than "normal" software systems.
  - e.g., Must operate with a minimum memory footprint and with minimum of support hardware.
- Control and monitor physical processes in a timely fashion
  - Often need to directly interact with various physical devices
- Perform without direct human intervention, i.e., not interactive
  - Do not provide conventional computer display or keyboard.
- Perform reliably for long periods
  - Are not supposed to terminate

RTOS vs. GPOS



Predictability

- Real-time systems must be predictable under certain assumptions about workload and sufficient resource availability.
- Static predictability can be achieved if complete knowledge about workload and resource availability is known at design time.
- The underlying OS must have predictable behavior; otherwise, it is impossible to achieve predictability at the application level

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- Real-time systems must produce the right results at the right time.
- Two main challenges in designing and developing real-time systems
  - How to ensure the satisfaction of timing requirements
  - How to deal with concurrency, i.e., thread/process synchronization and communication
- Real-time systems are typically closed
  - No admission of applications whose timing characteristics are not known