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# Real-Time Computing and Its Applications

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## What is Real-Time Computing ?

### ☐ Misconceptions

- Real-time computing is equivalent to fast computing
- The objective of real-time computing is to minimize the response time of a given set of tasks

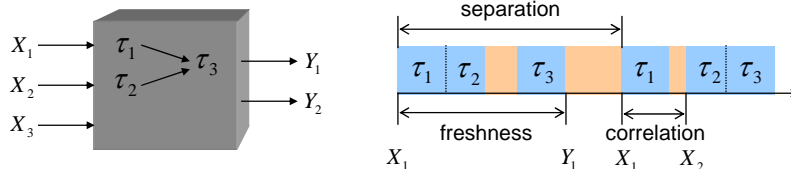
### ☐ Theoretical definition

- The correctness of computing depends not only on the correctness of its logical result but also on the result delivery time
- In addition, real-time computing must be predictable

# Classification of Timing Requirements

## □ Three types of timing requirements

- **Freshness -> deadline**
  - The time delay for data to flow through the system
- **Separation -> period**
  - The time interval between two consecutive activations (completions)
- **Correlation -> synchronization**
  - The time skew between several inputs to produce an output



# Typical Real-Time Systems

## □ Automatic control systems

### □ Such systems monitor and control their environment

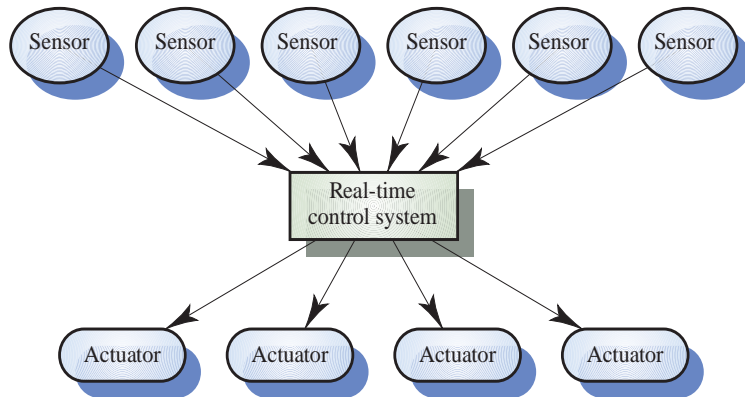
### □ Inevitably associated with hardware devices

- **Sensors:** Collect data from the system environment
- **Actuators:** Change (in some way) the system's environment

### □ Time is critical

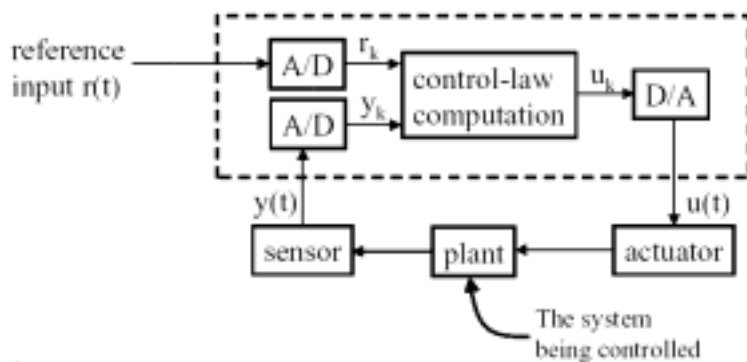
- **Real-time systems MUST respond within specified times**

# Real-Time Control System Structure



## A Simple RT Control System Model

### □ SISO (Single Input Single Output) control loop



# Control Loop Implementation

## ❑ Pseudo code for the SISO control system

```
set timer to interrupt periodically with period  $T$ ;  
at each timer interrupt do  
    do analog-to-digital conversion to get  $y$ ;  
    compute control output  $u$ ;  
    output  $u$  and do digital-to-analog conversion;  
od
```

- $T$  (sampling period)
  - Design choice between a lower bound and an upper bound

## ❑ Timing requirements

- Control systems have periodicity requirements, and therefore deadline requirements to complete periodic jobs

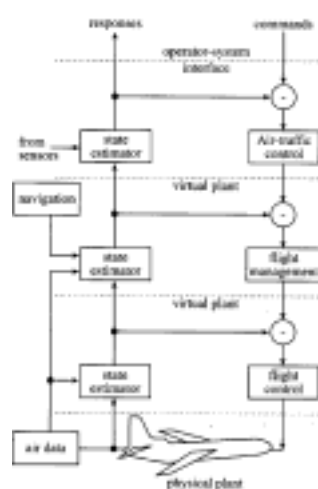
# Real-Time Control Applications

## ❑ Air traffic and flight control

- Hierarchy model

## ❑ Other applications include

- Radar surveillance system
- Robot control system
- Cruise control system



# Hard and Soft Real-Time Systems

## ☐ Hard deadline

- A deadline miss results in a catastrophe
- Probabilistic perspective: deadline miss probability is zero

## ☐ Soft deadline

- Deadline misses are allowed, but degrades system performance
- Probabilistic perspective: deadline miss probability is small

## ☐ Firm deadline

- Completing a task after its deadline is not useful and may even be harmful

# Hard and Soft Real-Time Systems

## ☐ Guaranteed service

- The user wants guarantees on services
- Hard real-time or soft real-time guarantees
- Hard real-time applications
  - Control systems
  - Database systems
- Soft real-time applications
  - Multimedia and network applications with service guarantees

## ☐ Best-effort service

- The system attempts to provide best services with no guarantees