The Real-Time CORBA tutorial

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The Real-Time CORBA tutorial Part-1

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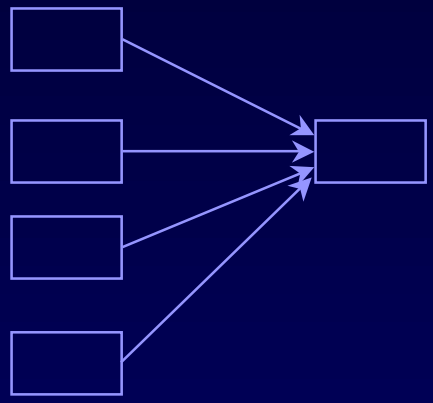
Introduction to Real-Time Principles

What is Real-Time All About?

Real-Time is Not About

- **Speed**
- **Efficiency**



Real-Time **is** About Time Constraints

- Objects contend for system resources (e.g., CPU, LAN,I/O)
- Rules for contention resolution follow different strategies
  - These strategies are **NOT** equivalent in terms of resource utilization or engineering viability
  - There is a wide range of approaches (e.g., frames, round-robin, priority)

Introduction to Real-Time

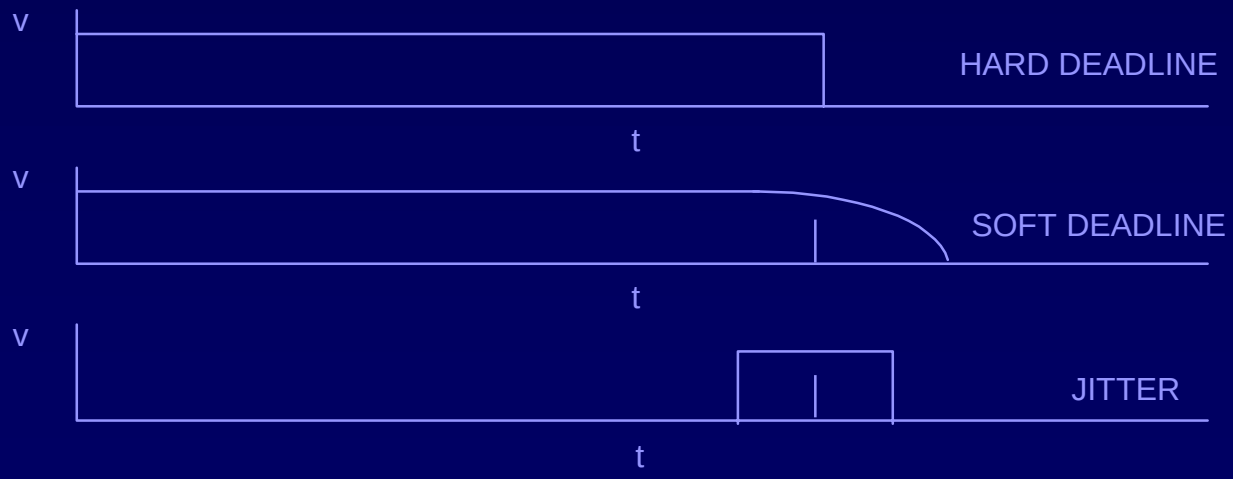
Definition of a Real-Time System

A real-time system is one in which correctness depends on meeting time constraints.

- **Correctness arguments must reason about response time requirements as well as functional requirements**

A real-time system produces a value to the user which is a function of time

Sample real-time program values



Hard Real-Time, Soft Real-Time

Hard Real-Time

- Resources must be managed to guarantee all hard real-time constraints are met, all the time
- No unbounded priority inversions are permitted
- Missing a time constraint is considered a failure to meet requirements

Soft Real-Time

- At least three kinds, possibly in combination:
  - Time constraints may be missed by only small amounts (usually expressed as a percentage of the time constraint)
  - Time constraints may be missed infrequently (usually expressed as a percentage of instances)
  - Occasional events or periodic instances may be skipped (usually expressed as a probability)
- Resources must be managed to meet the stated requirements
  - Same mechanisms as for hard real-time, but guarantees harder to define
  - Soft real-time is not the same as non-real-time, or meeting an average response time.

Hard Real-Time is hard, but Soft Real-Time is harder!

Timing Requirement Sources

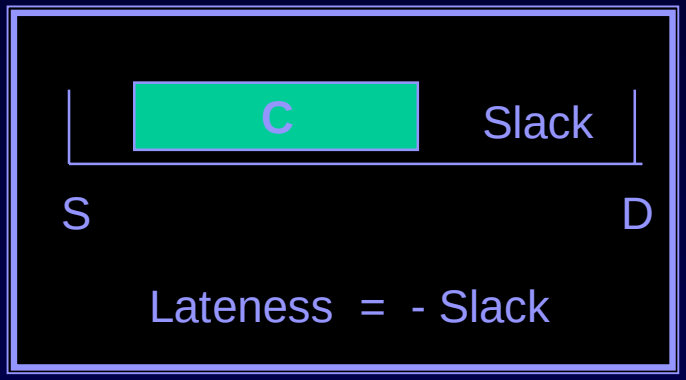
- Time Constraint Requirements Have Only Two Sources:
  - Explicit Top Level Requirements, e.g.,
    - Display a video frame within 33 milliseconds.
    - This is not the most common source of Timing Requirements.
  - Derived Requirements, e.g.,
    - Accuracy – "Maintain aircraft position to within 1 meter => Periodicity"
    - Fault Tolerance – "Recover from message loss within 500 ms."
    - Human Computer Interface Requirements –
      - Process switch depressions within 250 ms.
      - Refresh display within 68 ms.

Real-Time Scheduling

System Resource Scheduling: The Principal Difference Between a Real-Time and Non-Real-Time System.

- Definition of Real-Time Scheduling:
  - Real-Time scheduling is the process of sequencing shared resource allocations to meet user's time constraints.
- The Principal Three Goals:
  1. Meet all application time constraints, if feasible.
  2. Meet all important time constraints if meeting all time constraints is not feasible.
  3. Be able to accurately predict how well goals 1 and 2 are met for any given process load.
- Real-Time ≡ Real-Fast

Real-Time Scheduling Algorithms



Shortest Processing Time First (SPT)
- Minimizes mean lateness
- Optimal for Goals 1 and 3, stochastically

Earliest Deadline First (EDD, or Deadline)
- Minimizes maximum lateness
- Optimal for Goals 1 and 3 (fails disastrously on overload)

Smallest Slack Time First (Minimum Slack or Minimum Laxity)
- Maximizes minimum lateness
- Optimal for Goals 1 and 3 (fails disastrously on overload)

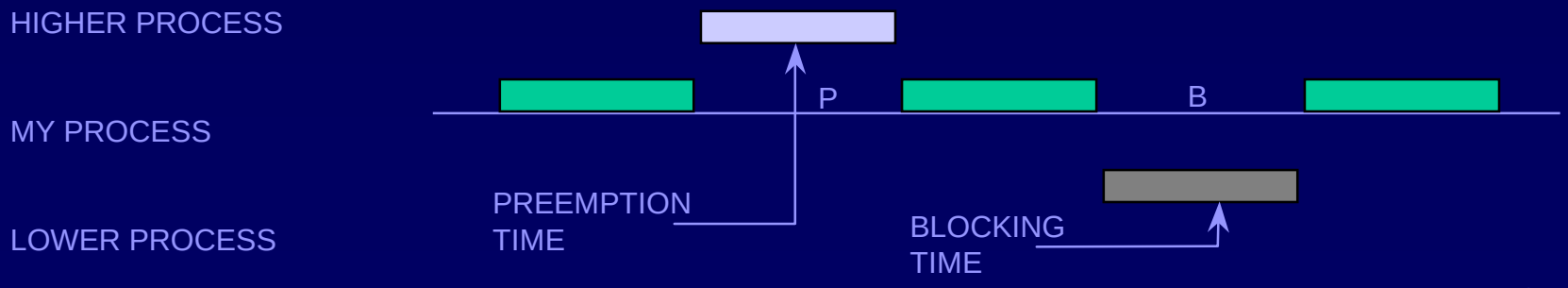
Rate Monotonic Scheduling (RMS)
- Approximates EDD with reduced utilization bound
- Non-optimal, but fulfills all real-time goals for mostly periodic processing domains
- Optimal for fixed priority scheduling

Scheduling in Real-Time CORBA 1.0

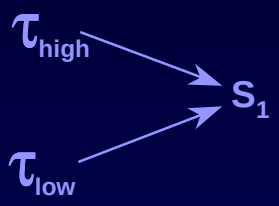
- Fixed Priority (Static) Scheduling
  - Provides a basis for resource allocation
  - Threads have priority based on time constraints
  - Underlying Theoretical Basis
    - Rate Monotonic Scheduling
    - Deadline Monotonic Scheduling
  - Fixed Priority means priorities change only
    - To prevent priority inversion
    - When required by application

Shared Resource Concepts

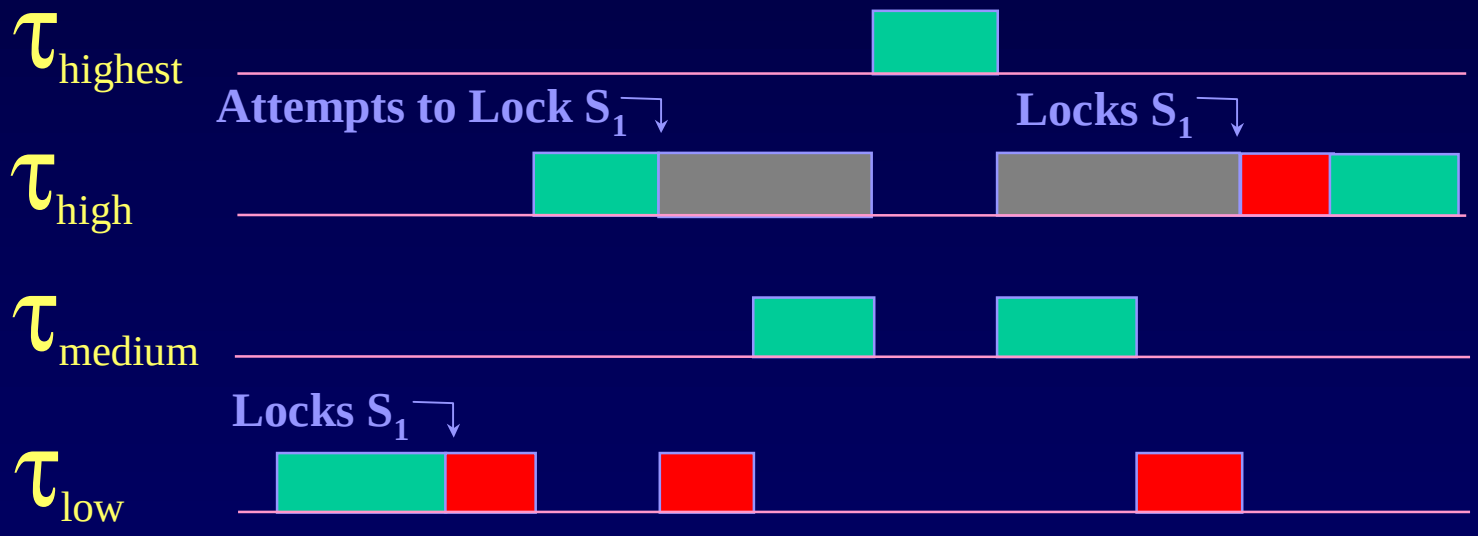
- Preemption.
  - Execution delayed by higher priority tasks
- Blocking (Priority inversion)
  - Execution delayed by lower priority tasks
- Mutual Exclusion (Mutex)
  - Sequenced access to a shared resource, typically implemented by locking and waiting for locks.
- Critical Section
  - Execution while holding a lock.



Shared Resources and Priority Inversion



High and low priority tasks share a critical section- Can lead to **UNBOUNDED** Blocking

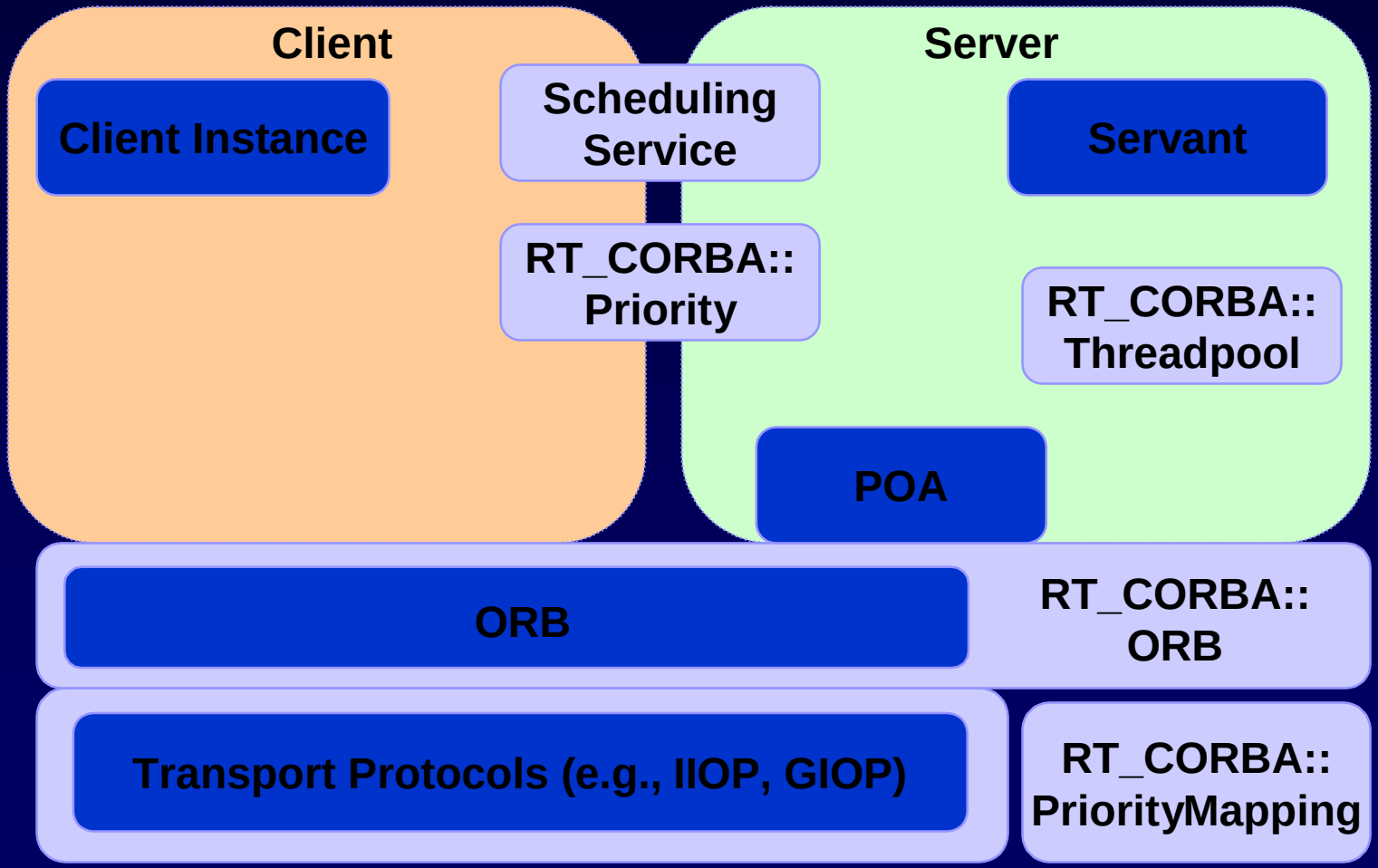


Normal execution

Execution in Critical Section

Unbounded Priority Inversion

RT-CORBA Components



Concurrency & CORBA

- Concurrency is fundamental to real-time systems
  - CORBA extends the concurrency model
  - Requires resource controls
- Concepts supported by RT CORBA
  - Threadpools
    - Multiple, Static or Dynamic, Default priorities
  - Scheduling policies
    - Client to Server Propagation or Server Defined
- Choices among concepts strongly impact performance

Transport Protocols

Communication from client to server

- A major contributor and consideration in RTCORBA systems design – a science in itself

Communication from client to server

- Represents yet another resource to be scheduled
- Source of potentially unbounded delays
- RT CORBA permits choosing among available protocols

Real-Time Principles Summary

- Real-Time $\neq$ Real-Fast
- Scheduling concepts are frequently counter-intuitive
- Resource management is the fundamental requirement to deal with response time issues, whether hard real-time or soft real-time

Next –
The Real-Time CORBA 1.0 Specification details