# Scheduling Algorithm and Analysis

## RT Synchronization Protocol
## (Module 33)

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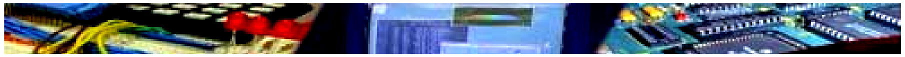
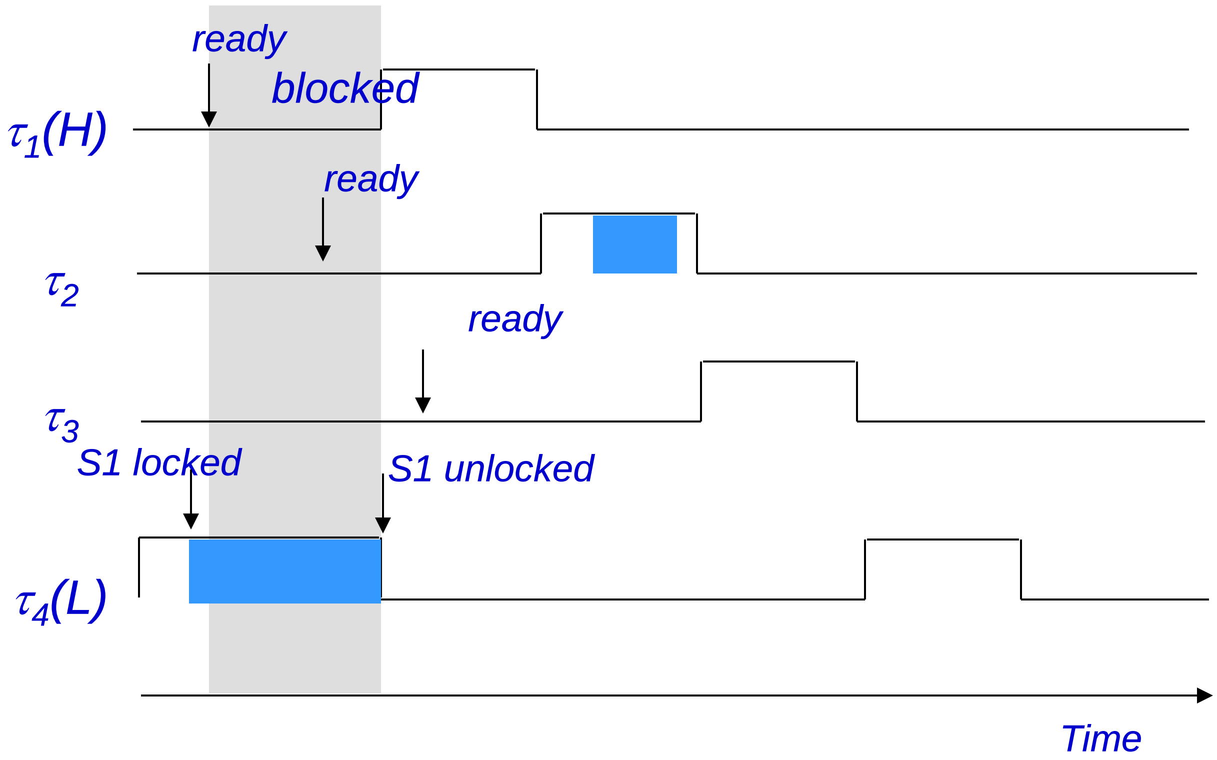
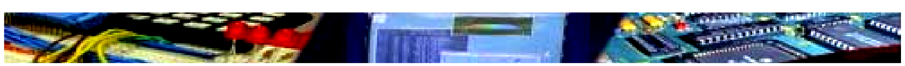


# Nonpreemption Protocol

$\tau_2$:{…P(S1)…V(S1)…}

$\tau_4$:{…P(S1)…V(S1)…}



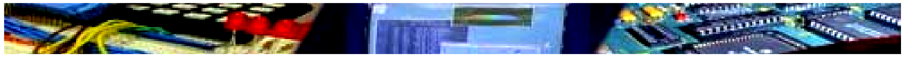
# Advantages and Disadvantages

## ❑ Advantages:

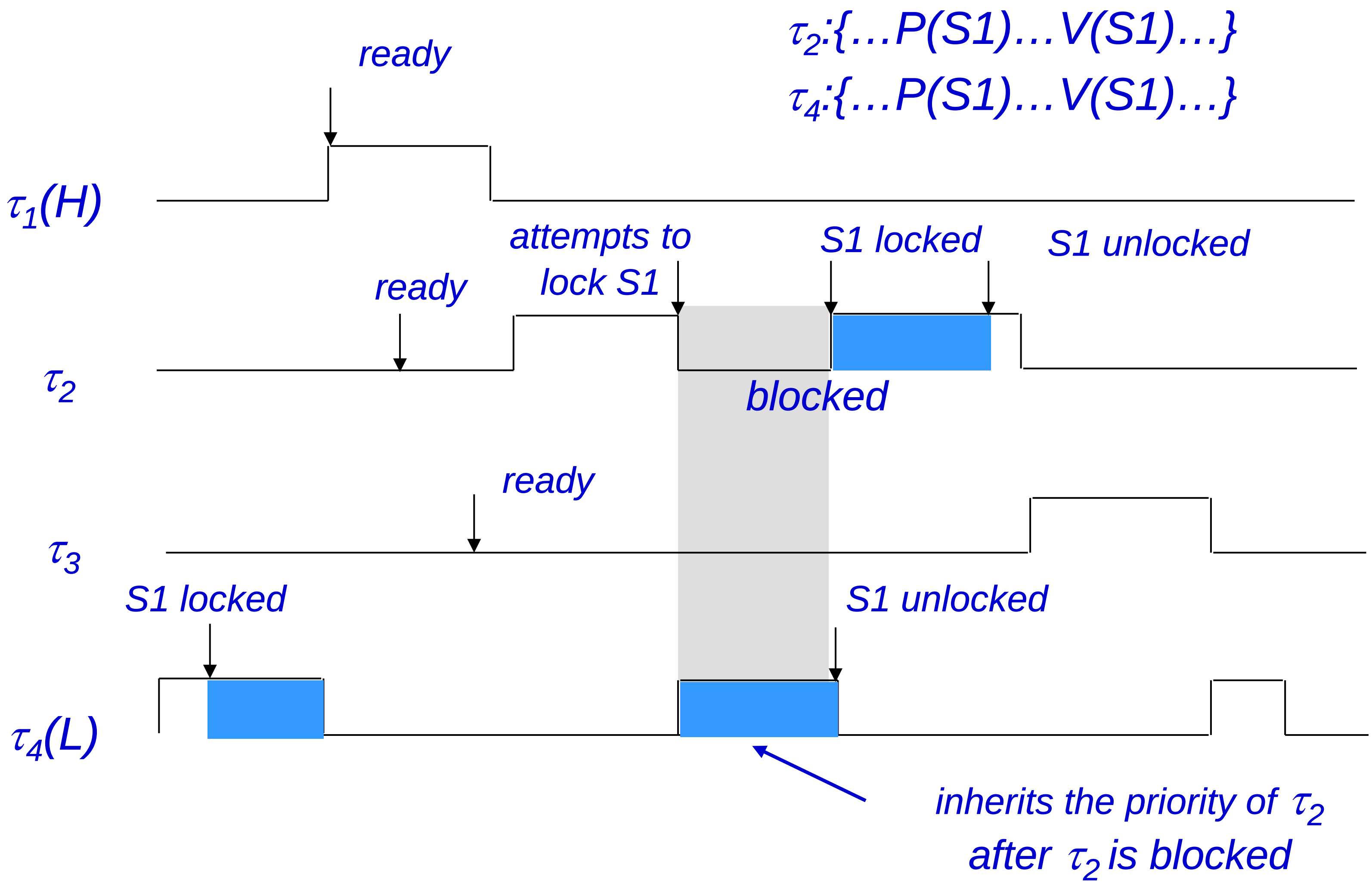
- Simplicity
- Use with fixed-priority and dynamic-priority systems
- No priori knowledge about resource requirement by each task
- Good when all critical sections are short

## ❑ Disadvantages:

- Every task can be blocked by every lower priority task, even when there is no resource sharing between the tasks.
- Blocking time: $max(cs_i)$



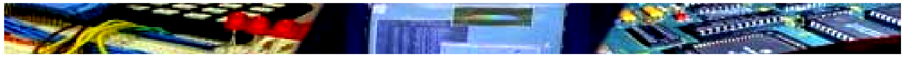
# Basic Inheritance Protocol (BIP)



# Some Notations

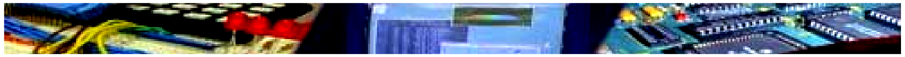
- $J_i$ is the i-th job in Task $T$.
- $\pi_i$ = Assigned priority of Job $J_i$
- $\pi_i(t)$ = current priority of $J_i$
- If the decision to change the priority of Job $J_i$ is made at $t = t_1$ then
  - $\pi_i(t_1^-)$ = priority at and immediately before,
  - $\pi_i(t_1^+)$ = priority immediately after the priority change

- $\Omega$ = nonexistent priority, lower than the lowest priority



# Terminology and Assumptions

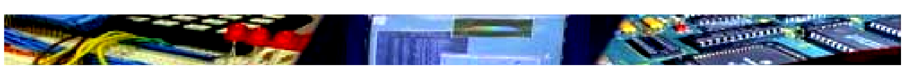
- *At time t1, job $J_i$ requests resource $R_k$.*
- *$R_k \rightarrow J_l$: Resource $R_k$ is held by Job $J_l$*
- *$J_i \rightarrow R_k$: Job $J_i$ is blocked waiting for resource $R_k$ to be released ($J_i \rightarrow R_k \rightarrow J_l$)*
- ***Scheduling Rules*:**
  - Ready Jobs scheduled on processors preemptively in a priority driven manner according to their current priorities, $\pi_i$(t).
  - At job release time the priority is equal to its assigned priority
    - if $J_i$ is release at $t = t'$, then $\pi_i(t') = \pi_i$
- ***Resource allocation*:**
  - If a resource is free then it is allocated when requested
  - if not free then the request is denied and the requesting job is blocked



# Priority Inheritance Rules

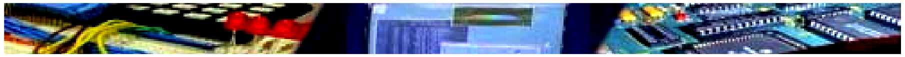
- ***Scheduling Rule:*** **same as the assumptions**
- ***Allocation Rule:*** **same as the assumptions**
- ***Priority-Inheritance Rule:***
  - if $J_i \rightarrow R_k \rightarrow J_l$ and $\pi_l(t_1^-)$ = priority of $J_l$ at $t = t_1$
  - then $\pi_l(t_1^+) = \pi_i(t_1)$
  - until $J_l$ releases $R_k$ at $t_2$ when $\pi_l(t_2^+) = \pi_l(t_1^-)$

- **L. Sha, R. Rajkumar, J. Lehoczky, "Priority Inheritance Protocols: An Approach to Real-Time Synchronization",** ***IEEE Transactions on Computers*****, Vol. 39, No. 9, pp. 1175-1185, 1990**



# Properties of Priority Inheritance

- For each resource (semaphore), a list of blocked tasks must be stored in a priority queue.
- A task (job) $\tau_i$ uses its assigned priority, and uses (inherits) the highest dynamic priority of all the tasks it blocks when it is in its critical section and blocks some higher priority tasks.
- Priority inheritance is *transitive*; that is, if task $\tau_i$ blocks $\tau_j$ and $\tau_j$ blocks $\tau_k$ , then $\tau_i$ can inherit the priority of $\tau_k$.
- When task $\tau_i$ releases a resource, which priority it should use?
- Chained blocking if requesting multiple resources (nested mutex requests)
- Direct blocking and indirect (inheritance) blocking (when the lower priority task inherits the higher priority task's priority).



# Supplementary Slides