Shared Resources and Blocking in Real-Time Systems

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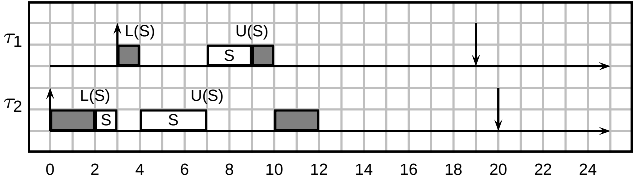
October 10, 2008

Outline

1. Priority inversion
2. Priority Inheritance Protocol
3. Priority Ceiling
4. Stack Resouce Policy

Blocking and priority inversion

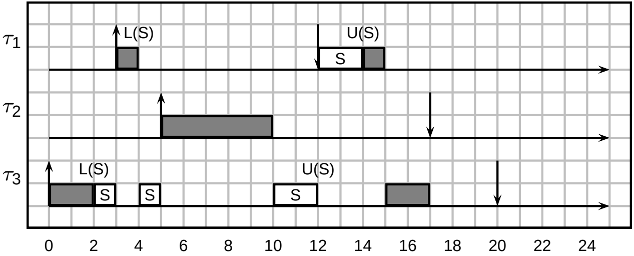
- A blocking condition happens when a high priority tasks wants to access a resource that is held by a lower priority task.
- Consider the following example, where $p_1 > p_2$.



- From time 4 to 7, task τ_1 is blocked by a lower priority taskτ_2; this is a *priority inversion*.
- Priority inversion is not avoidable; in fact, τ_1 must wait for τ_2 to leave the critical section.
- However, in some cases, the priority inversion could be too large.

Example of priority inversion

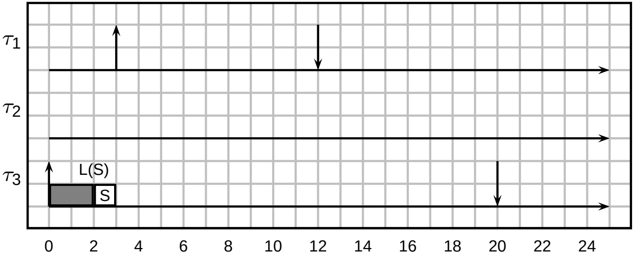
- Consider the following example, with $p_1 > p_2 > p_3$.



- This time the priority inversion is very large: from 4 to 12.
- The problem is that, while τ_1 is blocked, τ_2 arrives and preempt τ_3 before it can leave the critical section.
- If there are other medium priority tasks, they could preempt τ_3 as well.
- Potentially, the priority inversion could be unbounded!

Example

- In the previous example:



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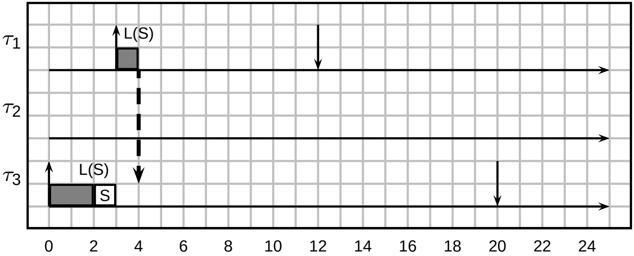

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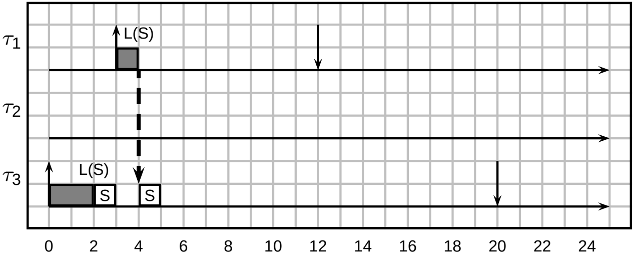

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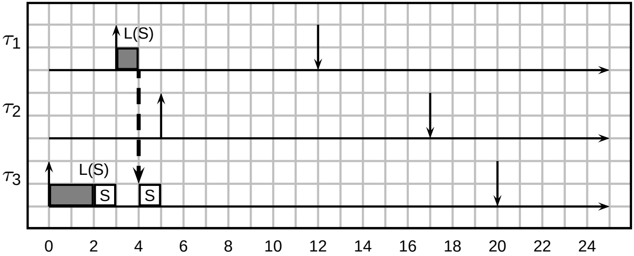

- Task τ_3 inherits the priority of τ_1

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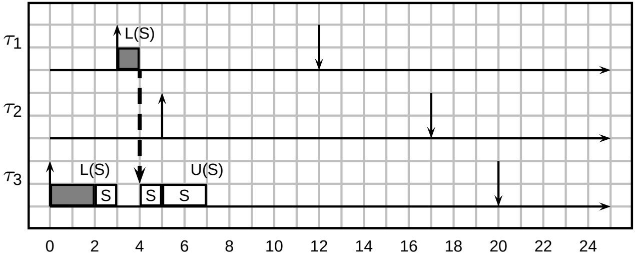

- Task τ_3 inherits the priority of τ_1
- Task τ_2 cannot preempt τ_3 ($p_2 < p_1$)

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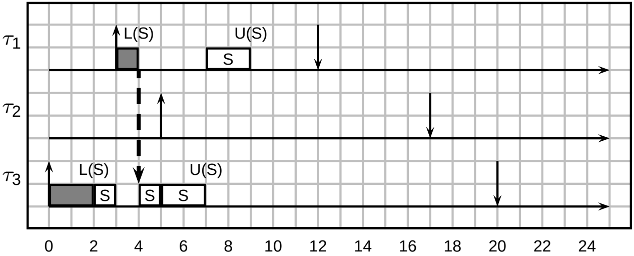

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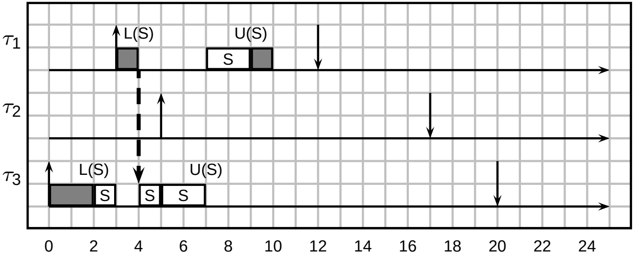

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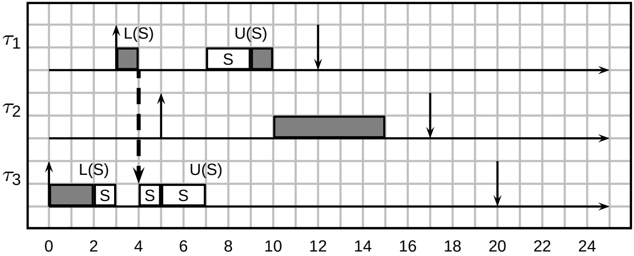

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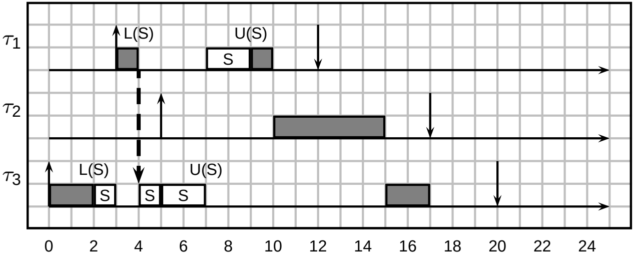

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Multiple inheritance

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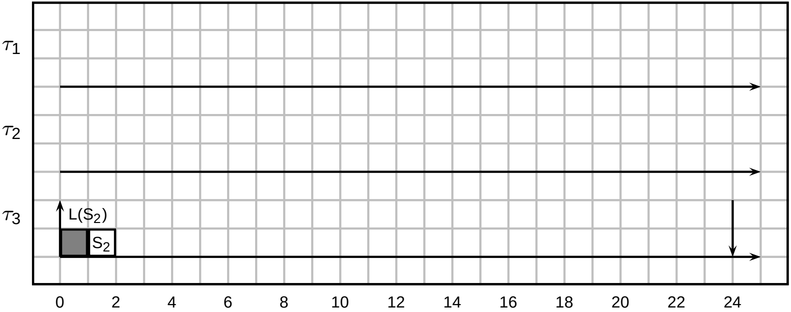

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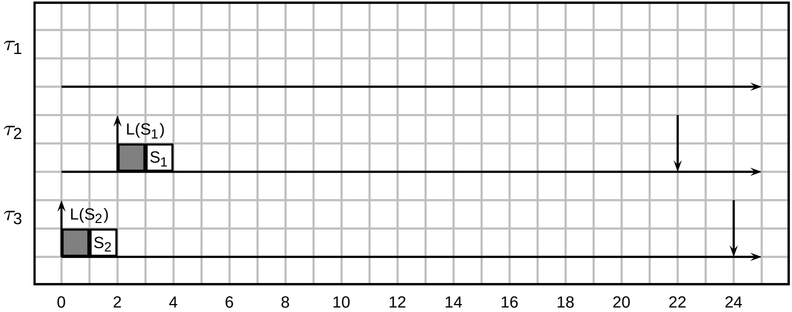

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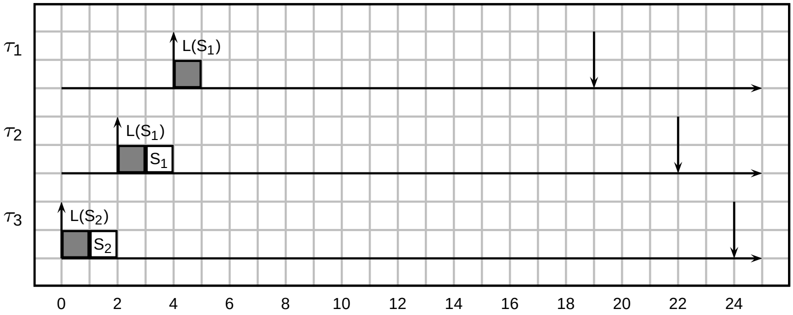

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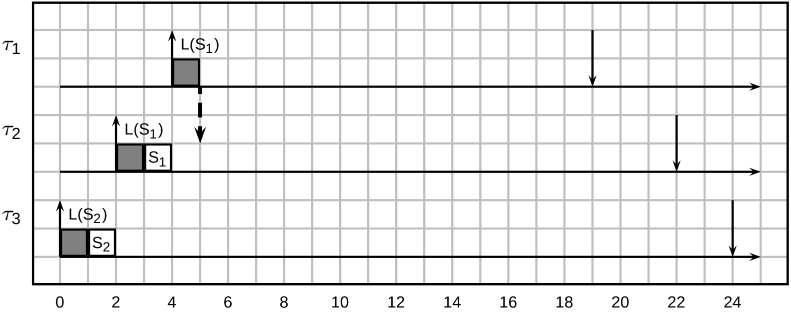

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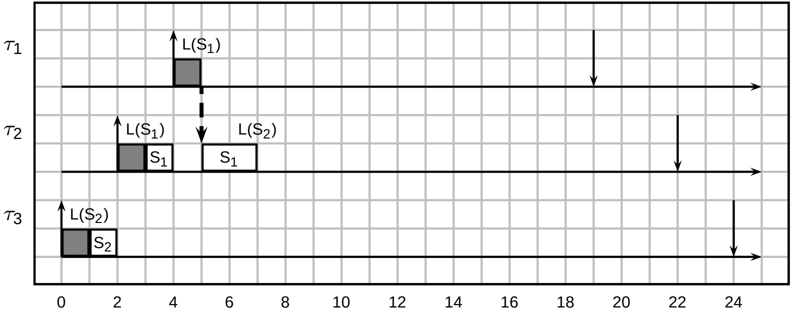

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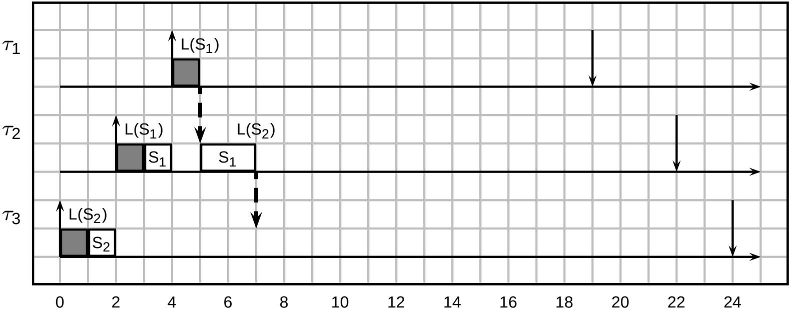

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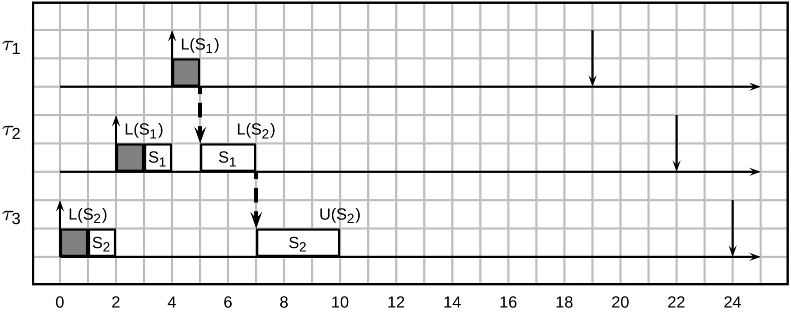

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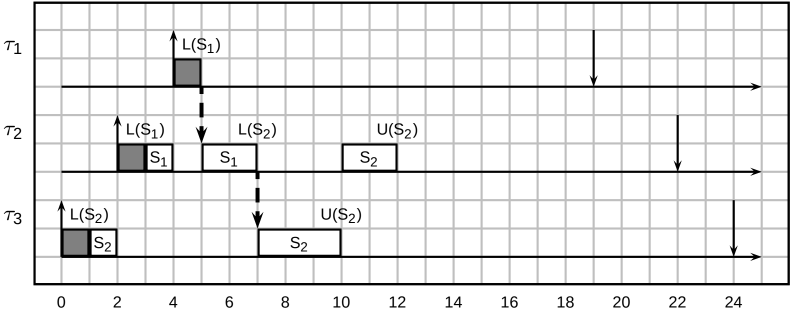

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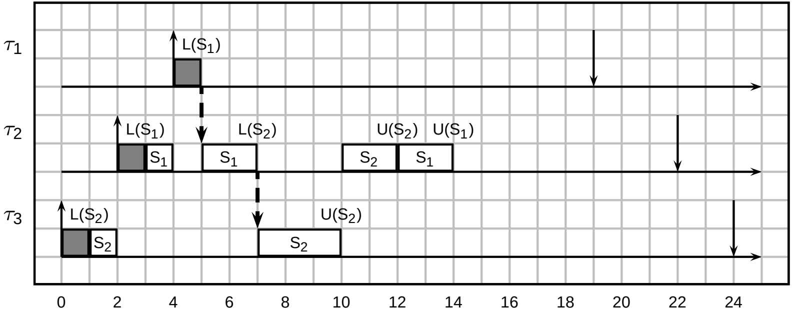

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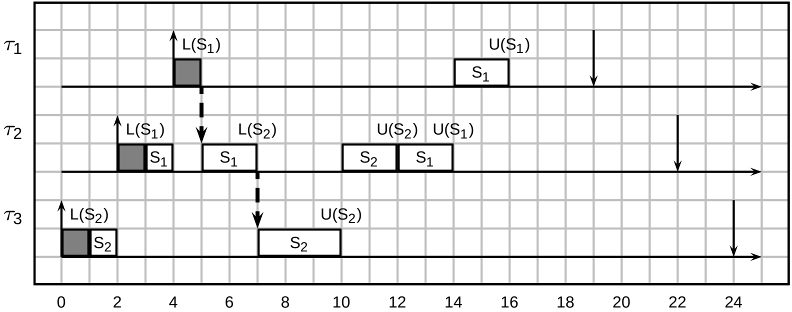

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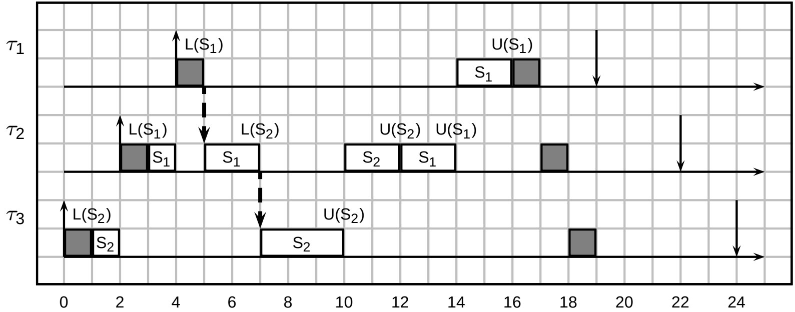

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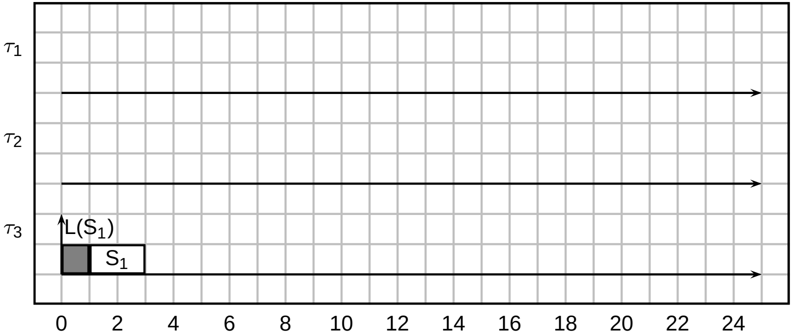

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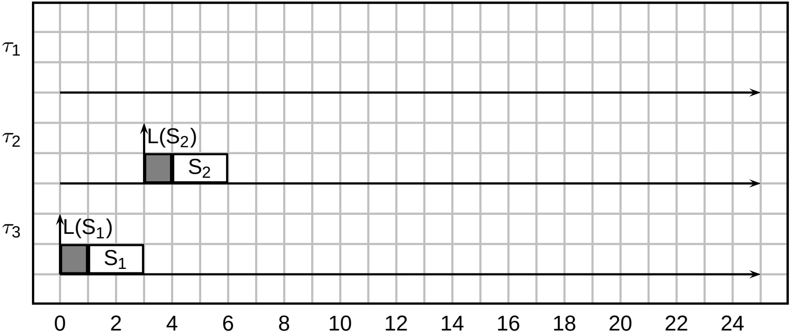

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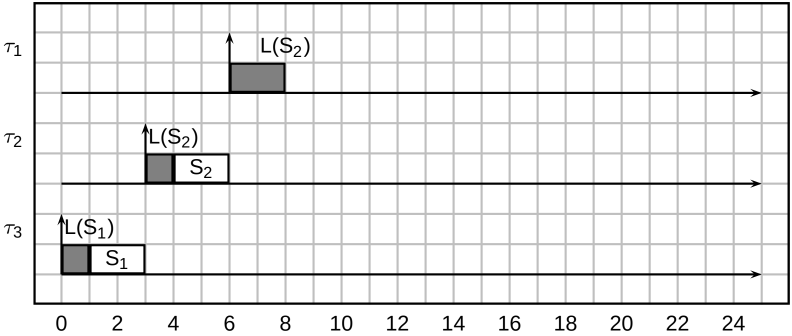

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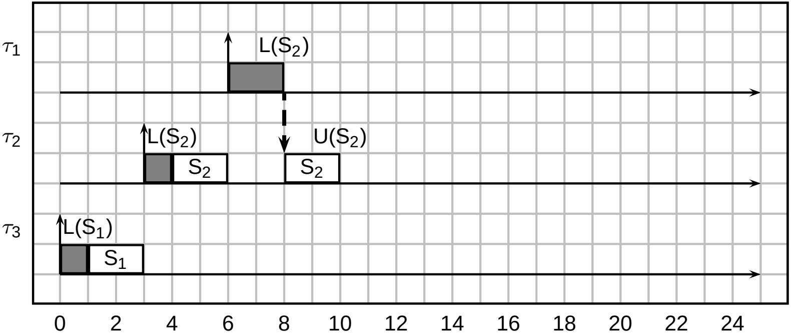

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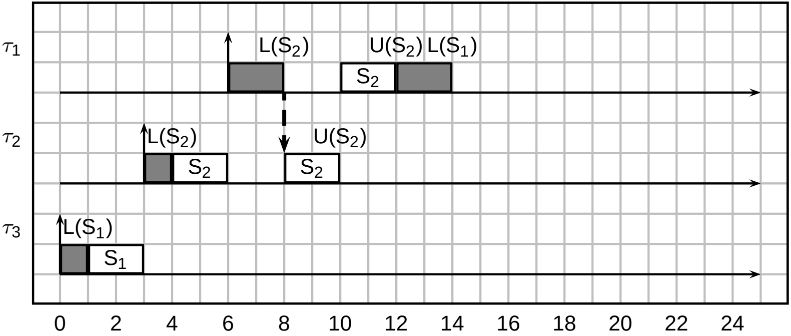

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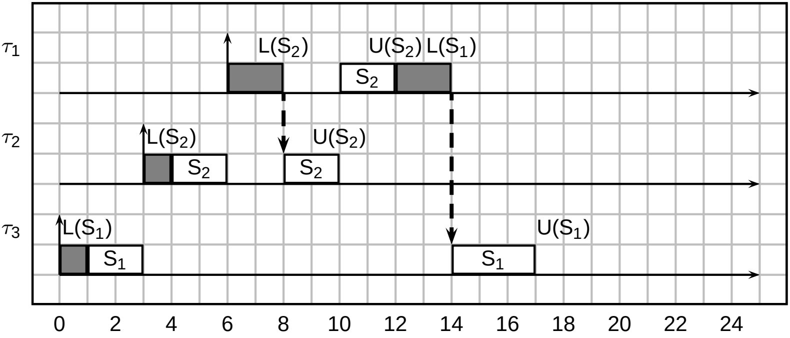

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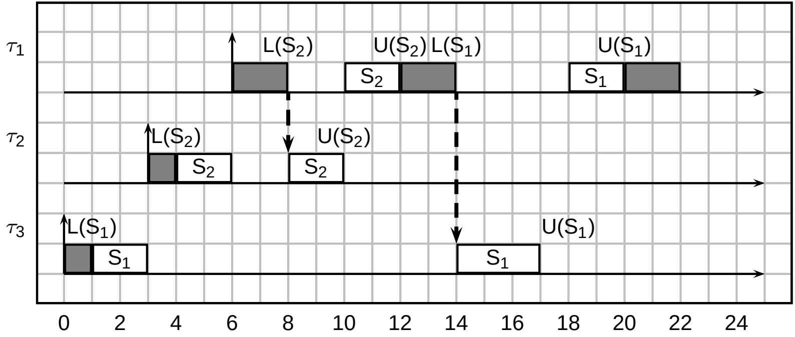

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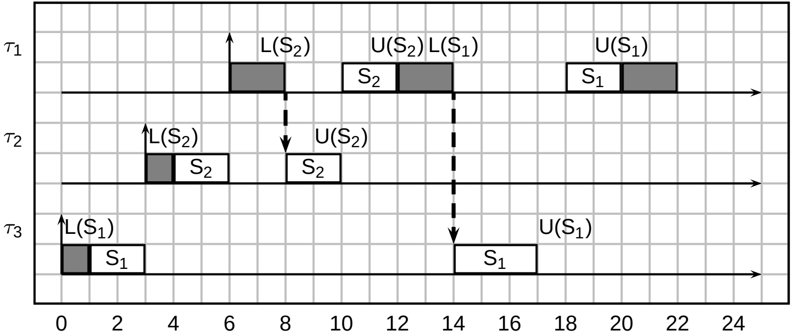

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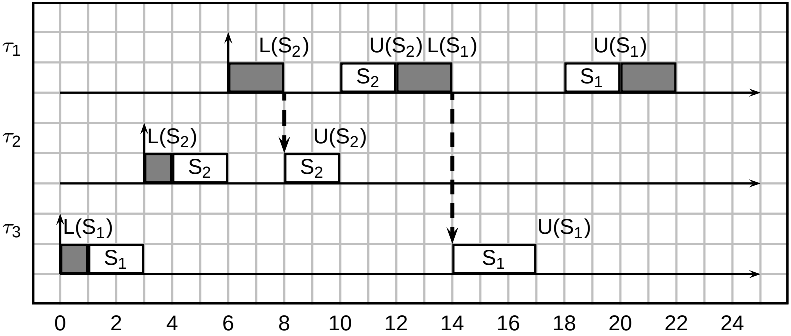
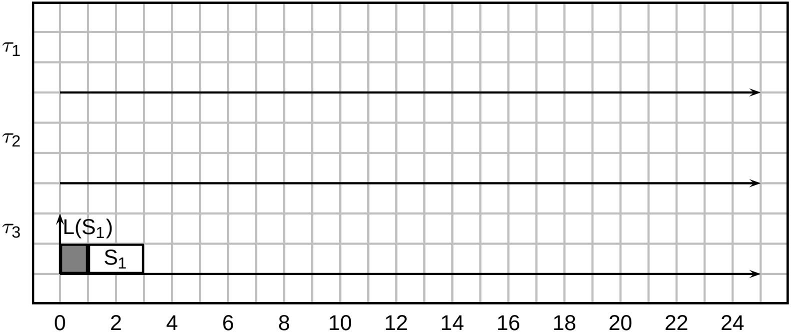


- task τ_1 is blocked twice on two different resources

Example:

ceil$(S_1) = p_1$ and ceil$(S_2) = p_1$



- task τ_3 acquires the lock

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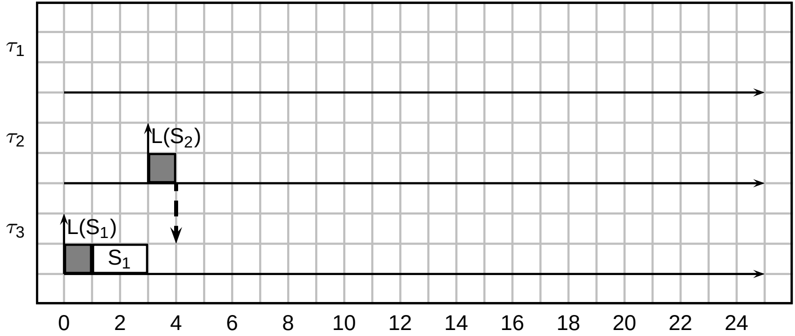

- task τ_3 acquires the lock
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- task τ_3 inherits τ_2's priority

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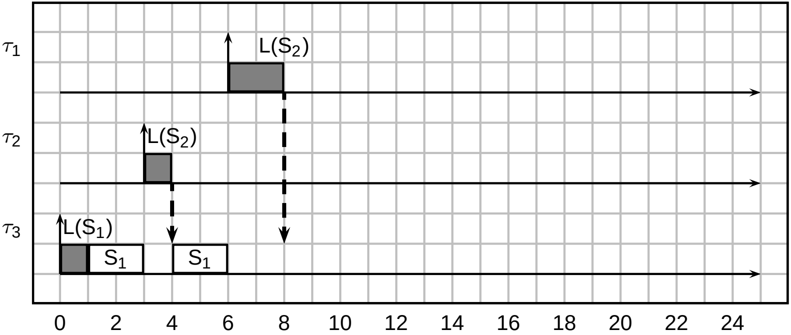

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- task τ_1 is blocked for the same reason
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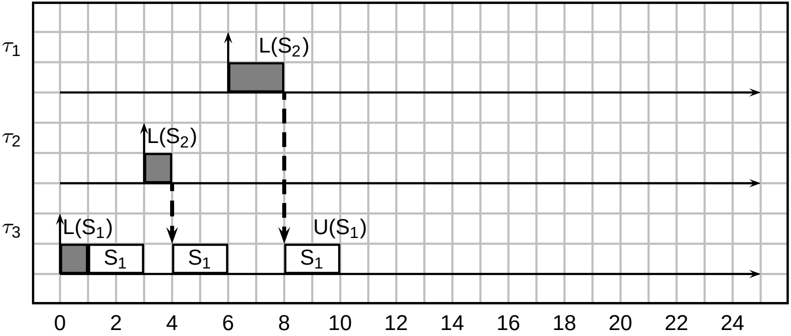

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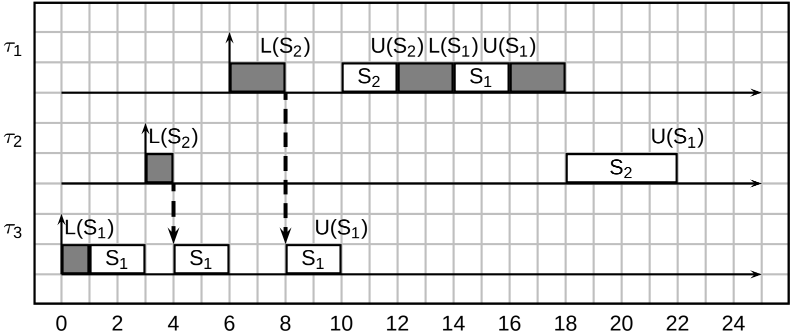

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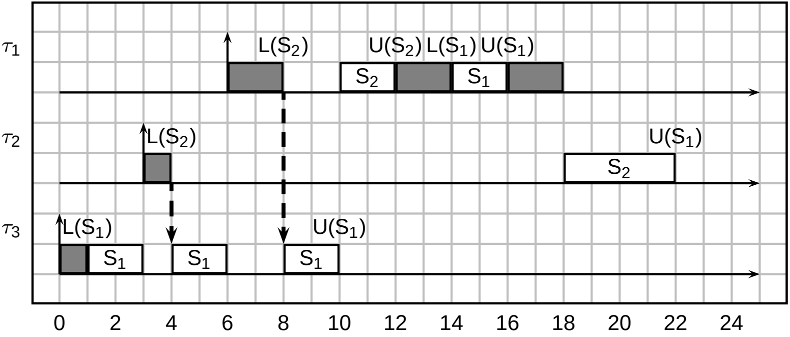

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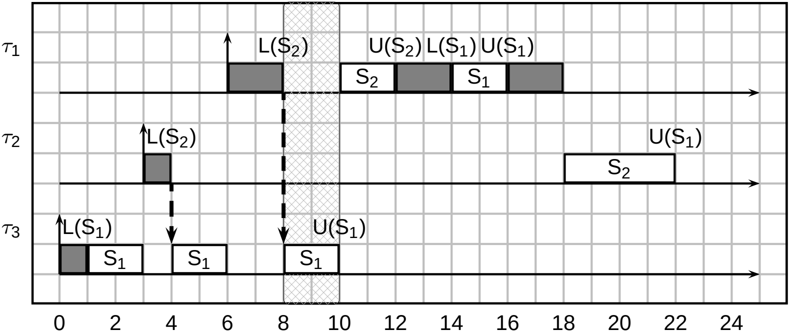

- Blocking time for τ_1: 2

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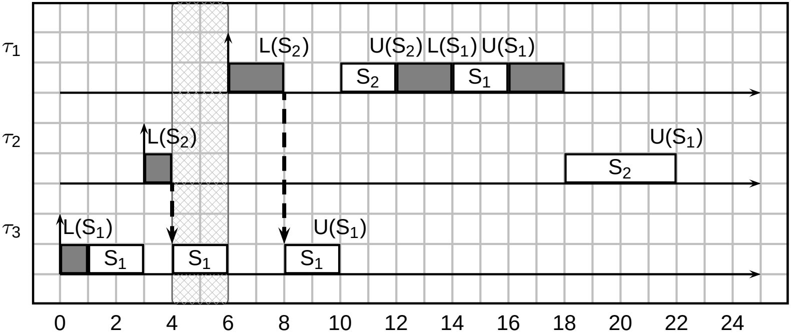

- Blocking time for τ_1: 2
- Blocking time for τ_2: 2

Blocking

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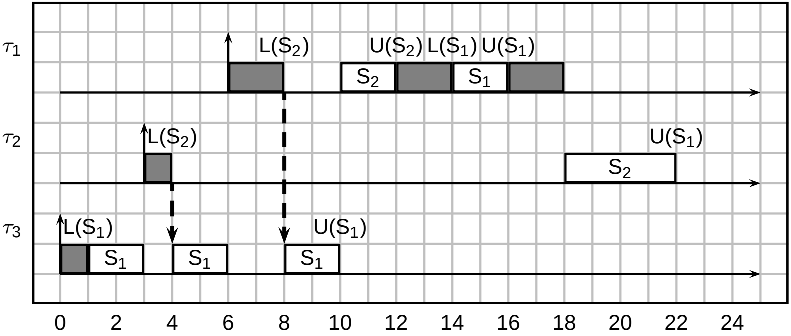

- Blocking time for τ_1: 2
- Blocking time for τ_2: 2
- No multiple blockings!

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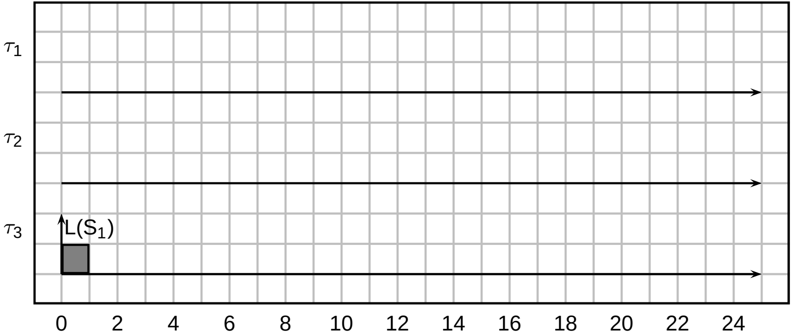

- Task τ_3 raises the sys ceiling to p_1

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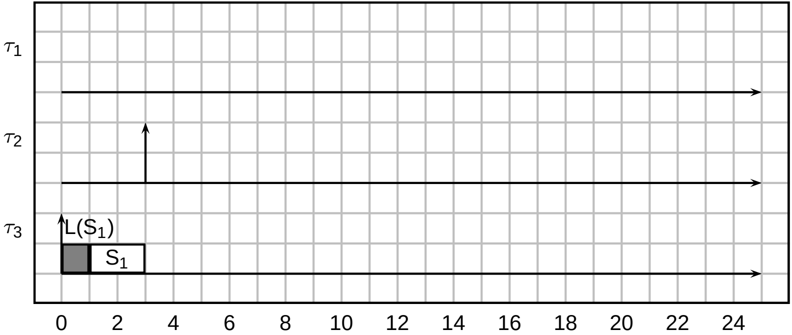

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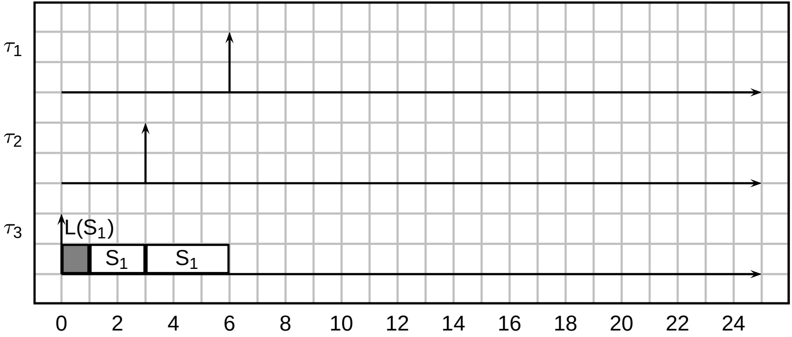

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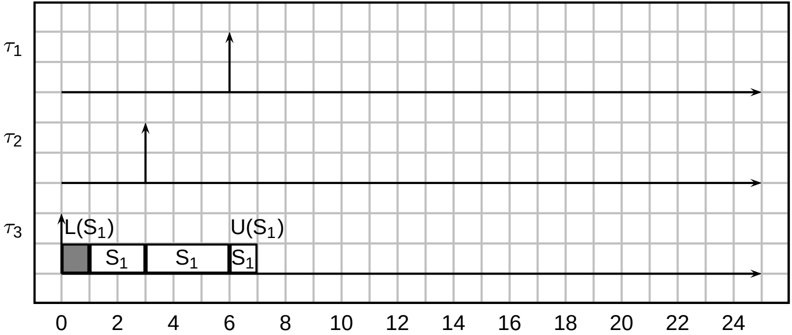

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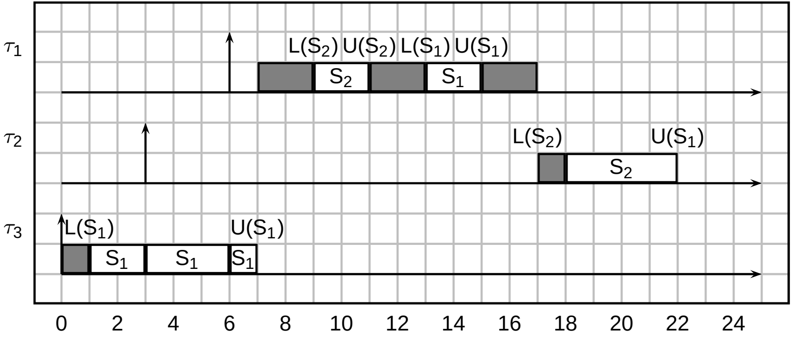

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