Implementation and Evaluation of Multiprocessor Resource Synchronization Protocol (MrsP) on LITMUS^{RT}

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Outline

- Background and motivations
- Implementation of MrsP [1]
- Evaluation
- Conclusions

Background and motivation

- Resource synchronization protocols are needed
  - Semaphores are used to protect shared resources
  - Priority inversion [2] may destroy the predictability
- Many synchronization protocols are available
  - MPCP [3] DPCP [7] and DNPP (suspension-based)
  - MrsP [1] (spin-based)
- Include runtime overheads into schedulability analysis

Platform

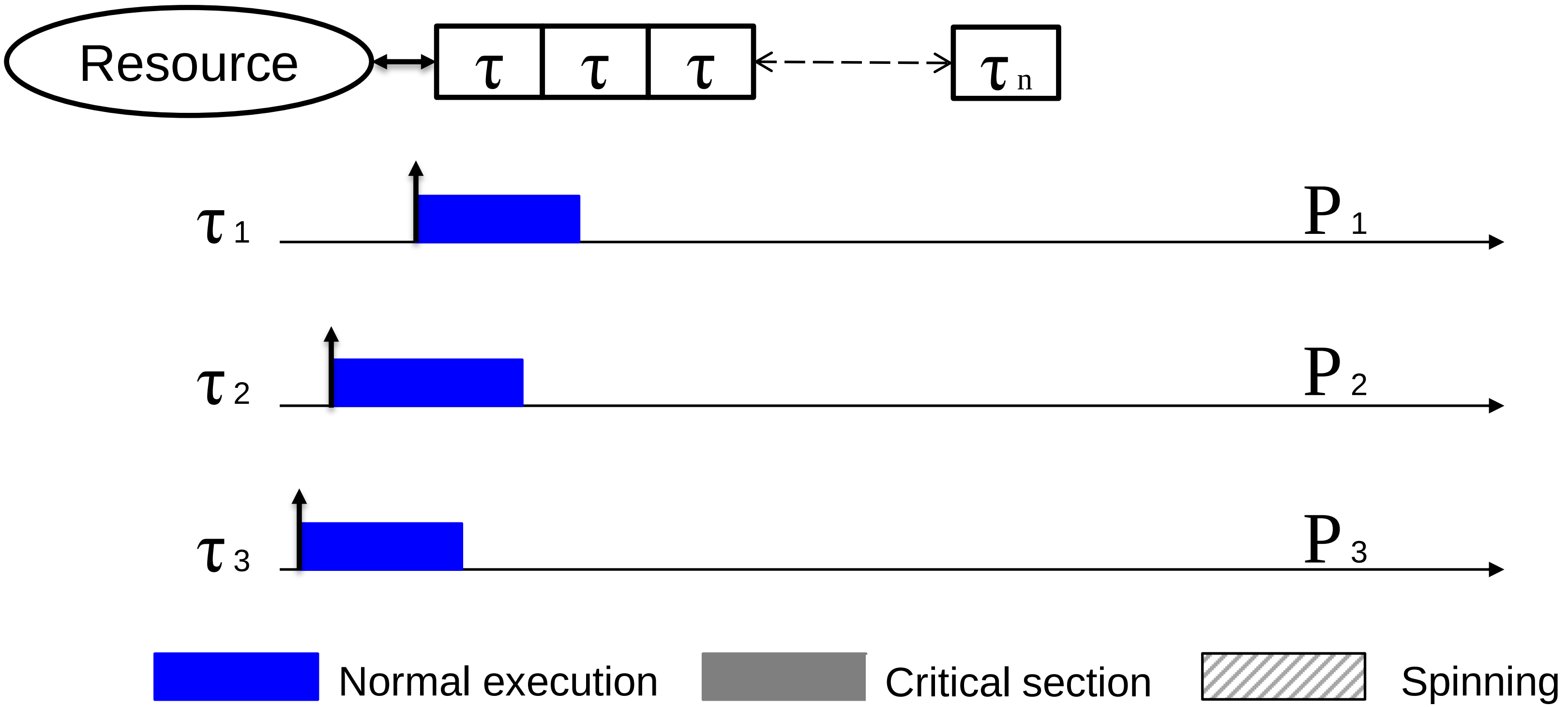
Why LITMUS^{RT} [8] ?

- Open source code
- Well established evaluation platform
- Well distributed, plug-in architecture
- Useful tools provided (overheads and schedule tracing)
- Several protocols have been implemented (MPCP/DPCP)

Linux Testbed for Multiprocessor Scheduling in Real-Time Systems

MrsP

- Requests in FIFO queue



MrsP

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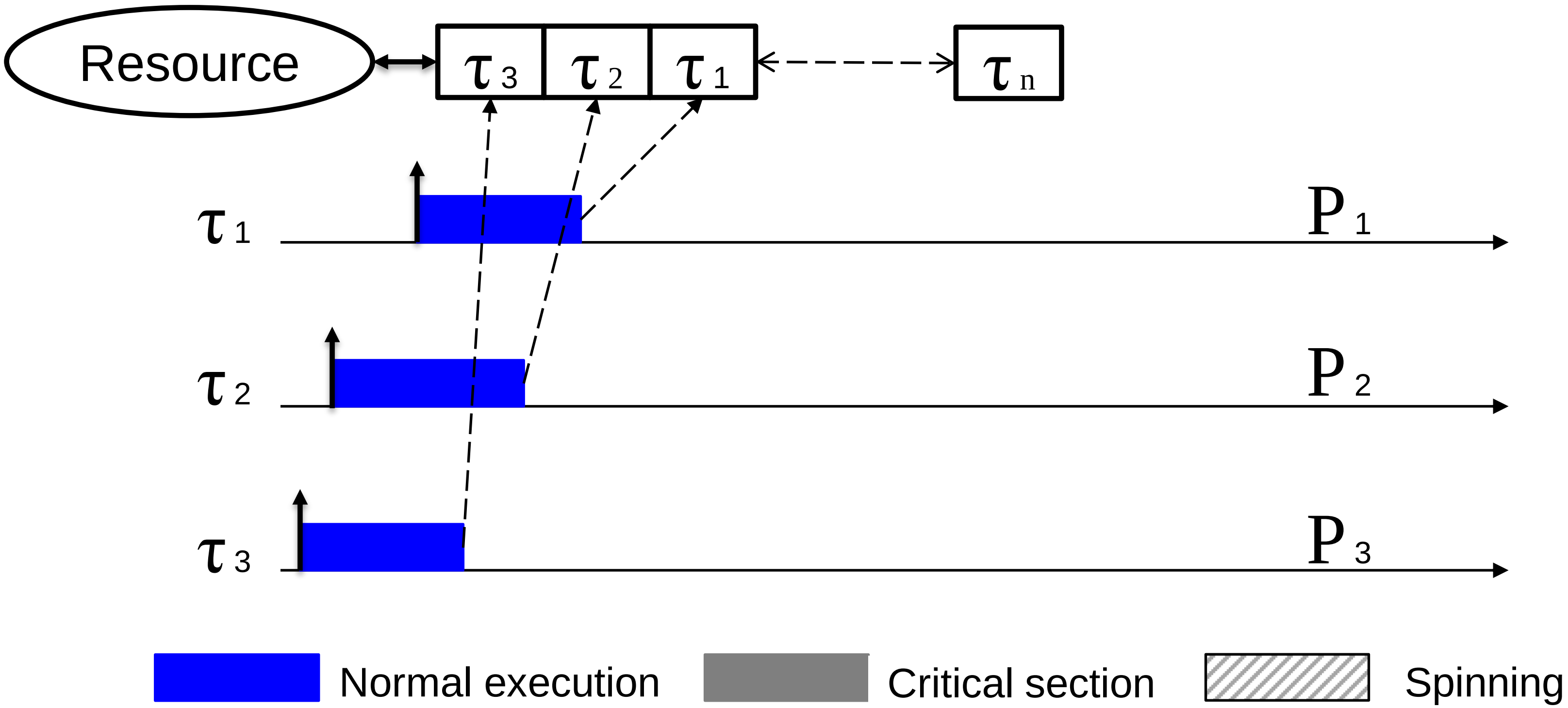

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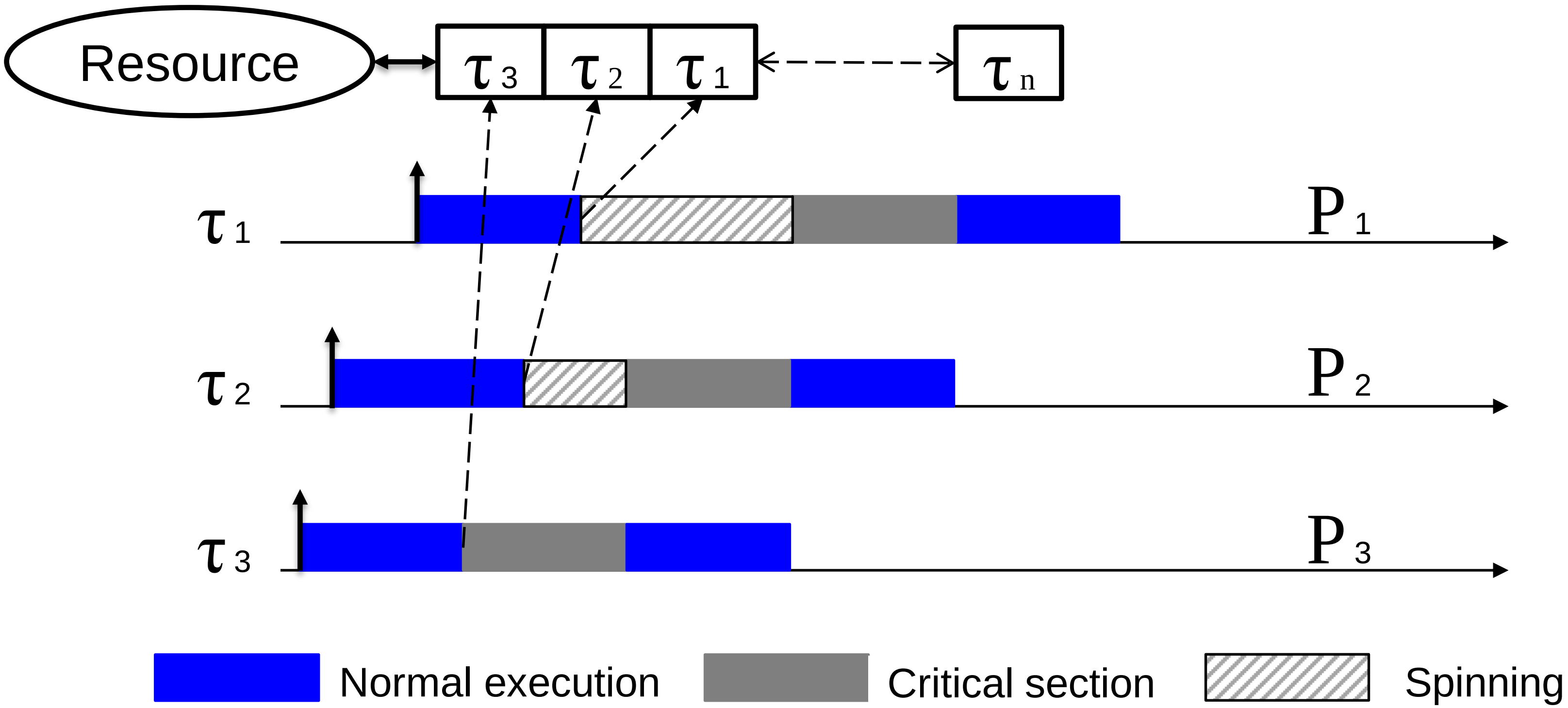
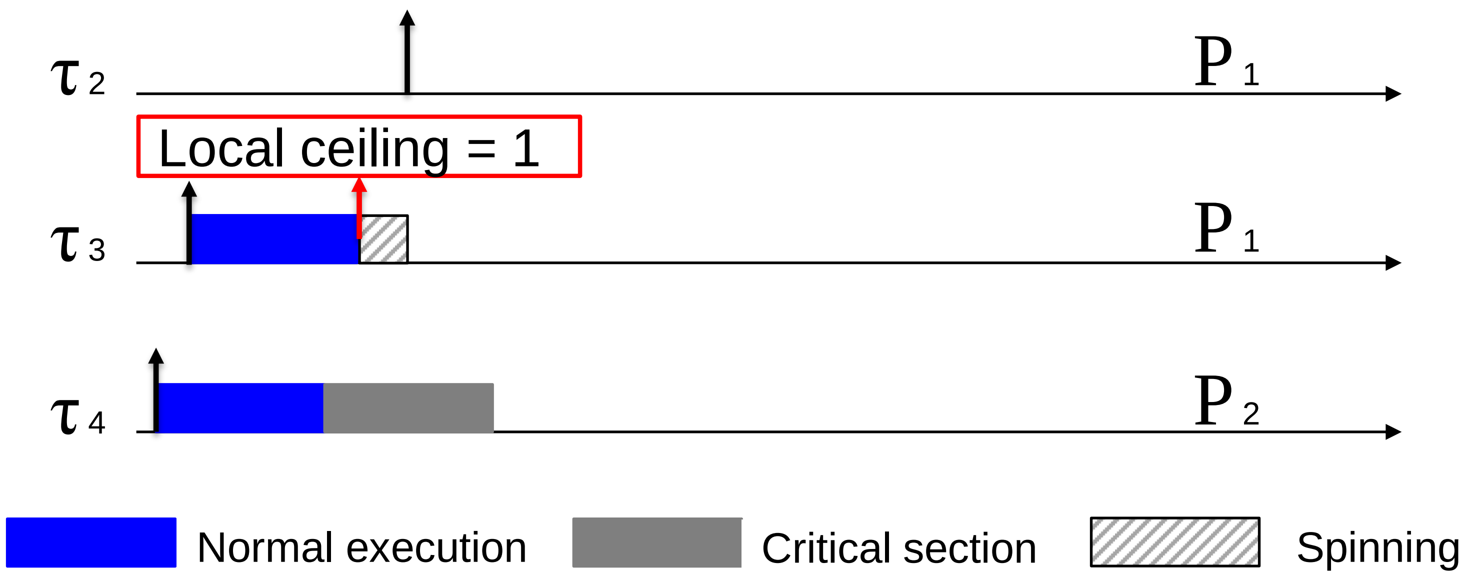


MrsP

- Local ceilings are needed while spin waiting and executing



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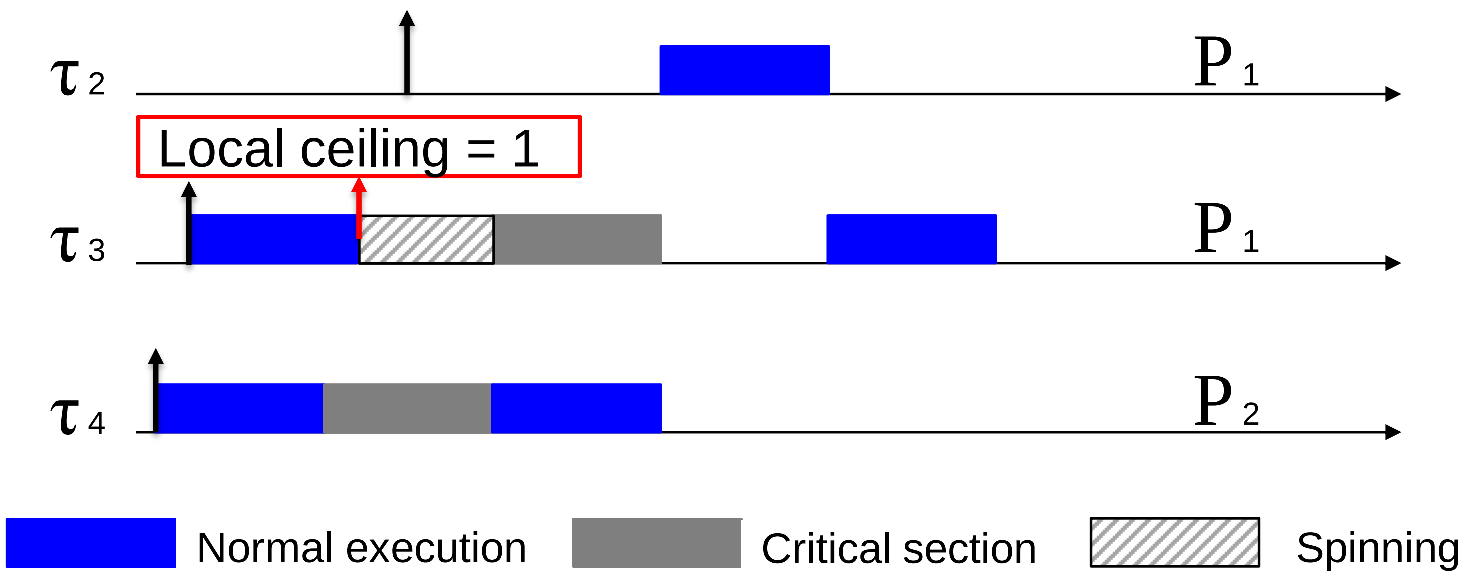
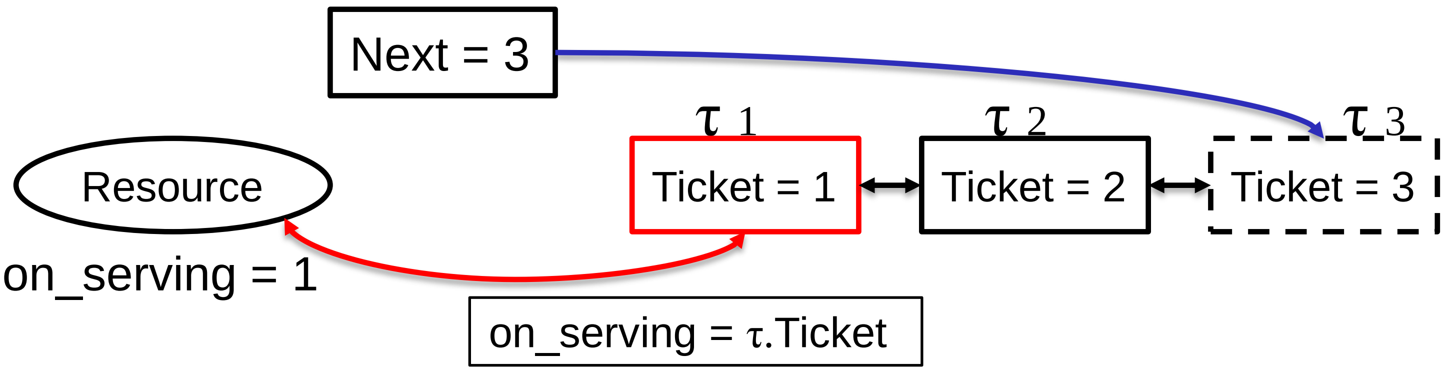


Implementation of MrsP

- Requests in FIFO queue
  - Ticket based spin lock [9]



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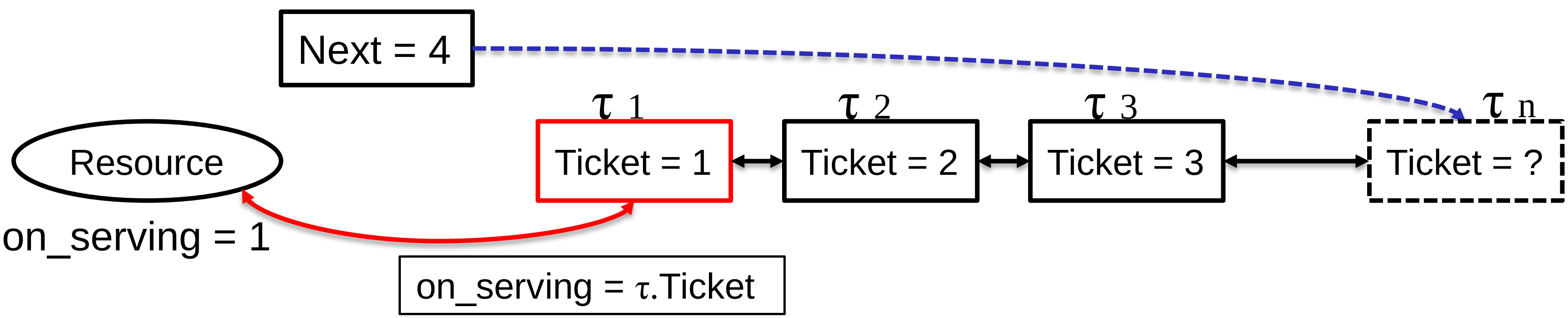

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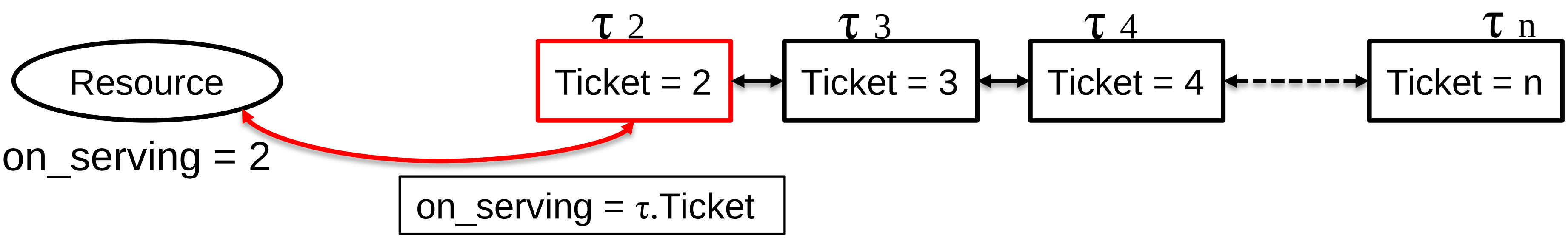
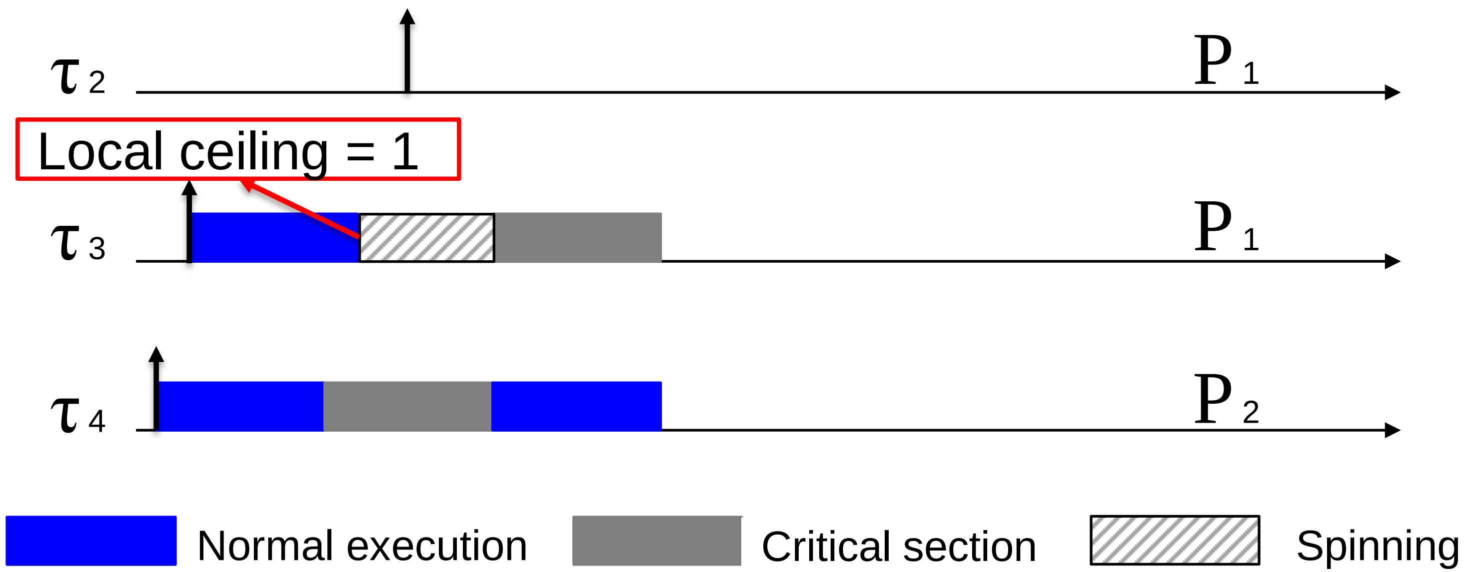


Implementation of MrsP

- Local ceilings are needed while spin waiting and executing
  - Local ceilings are given by users
  - Save the original priority before raising to the ceiling
  - Lower the priority after finishing the critical section



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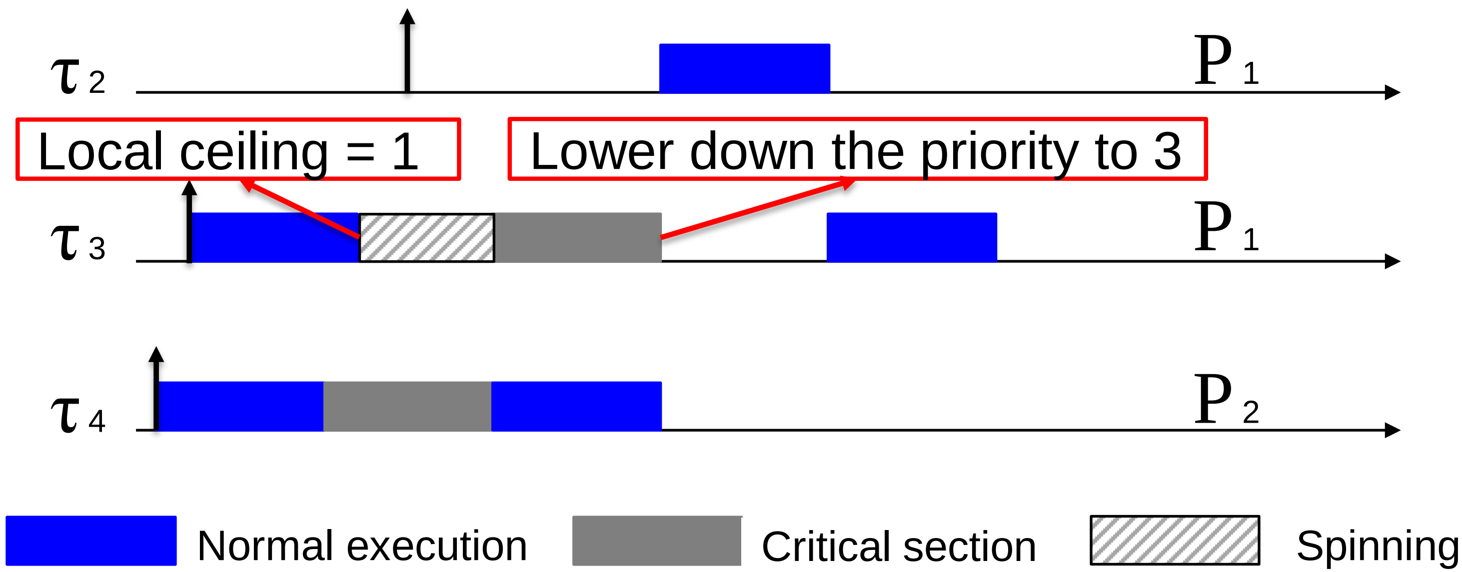

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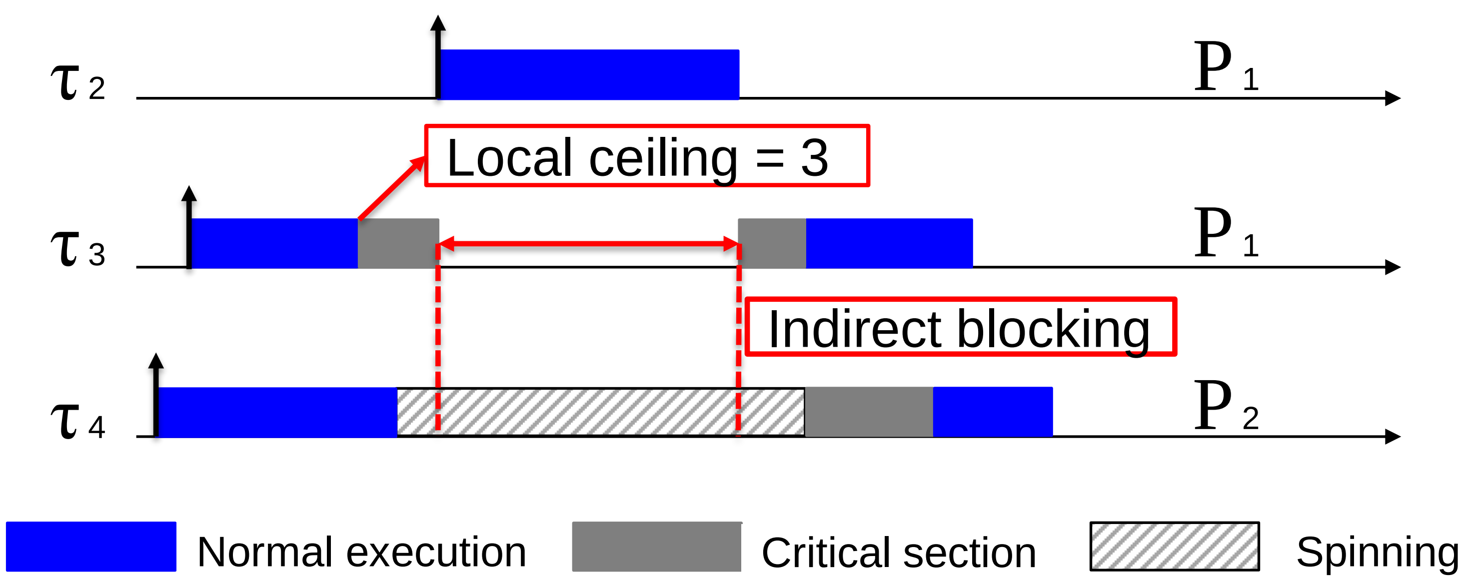
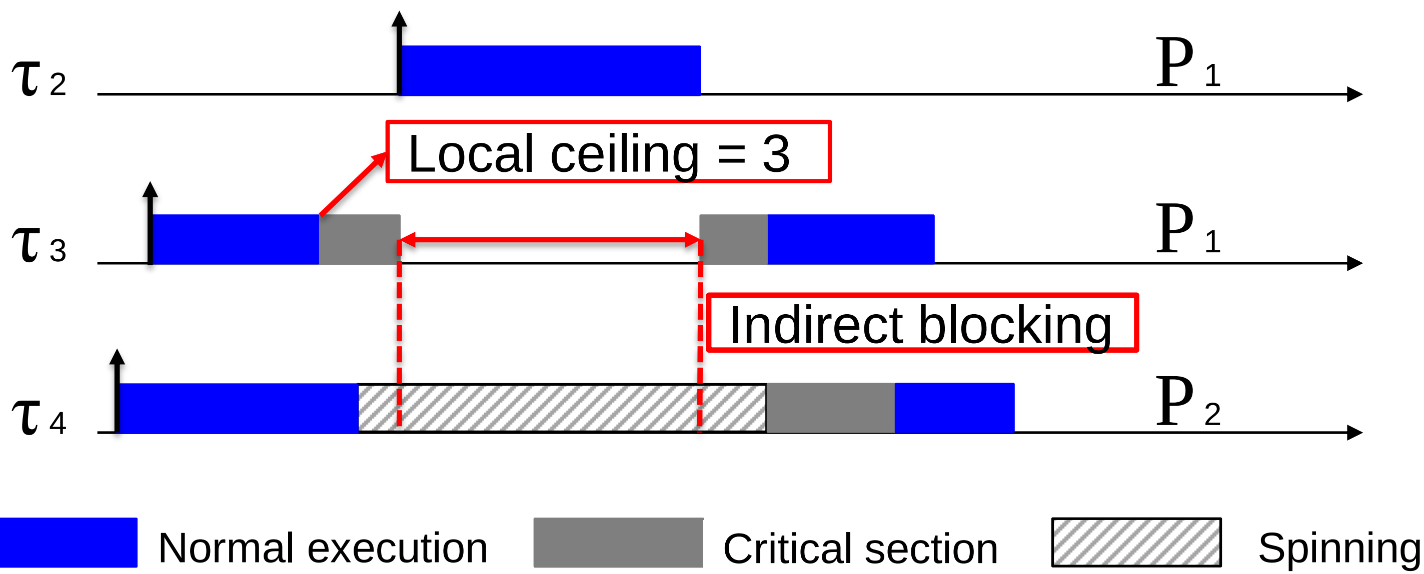


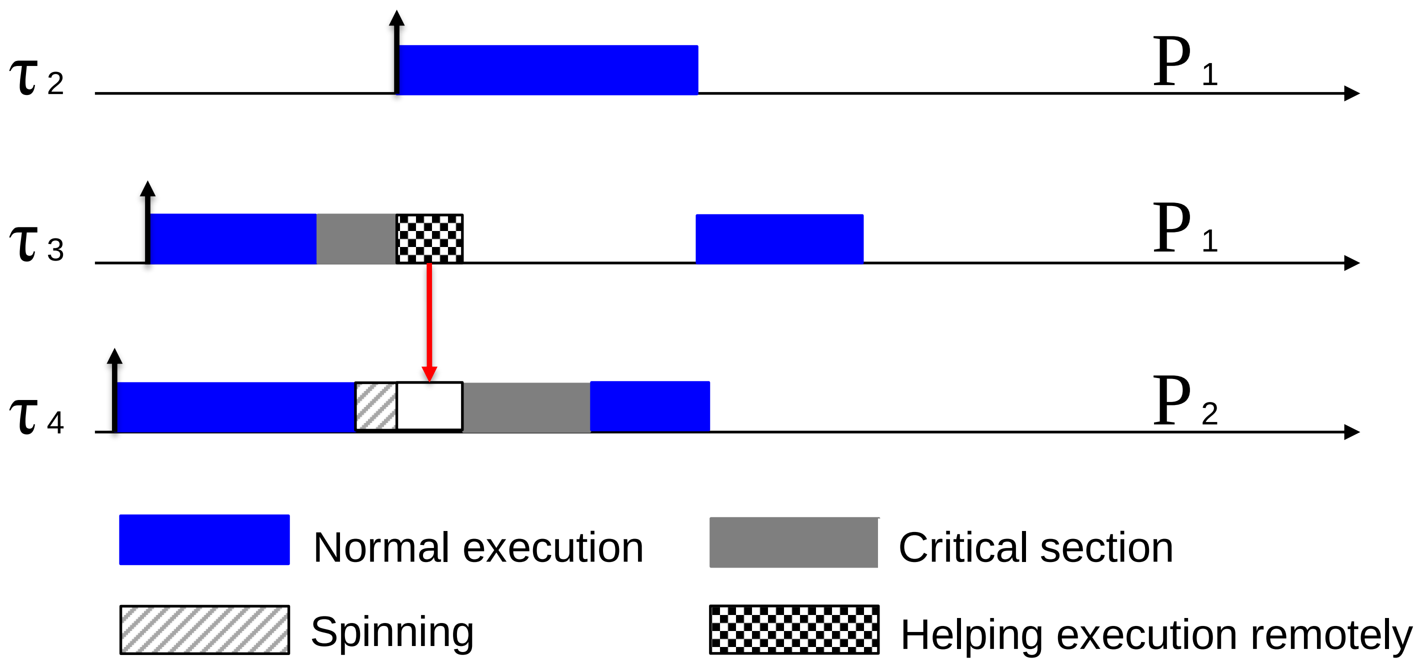
Implementation of MrsP

- Requests in FIFO queue
- Local ceilings are needed while spin waiting and executing
- Help mechanism
  - Spinning tasks help preempted semaphore owners



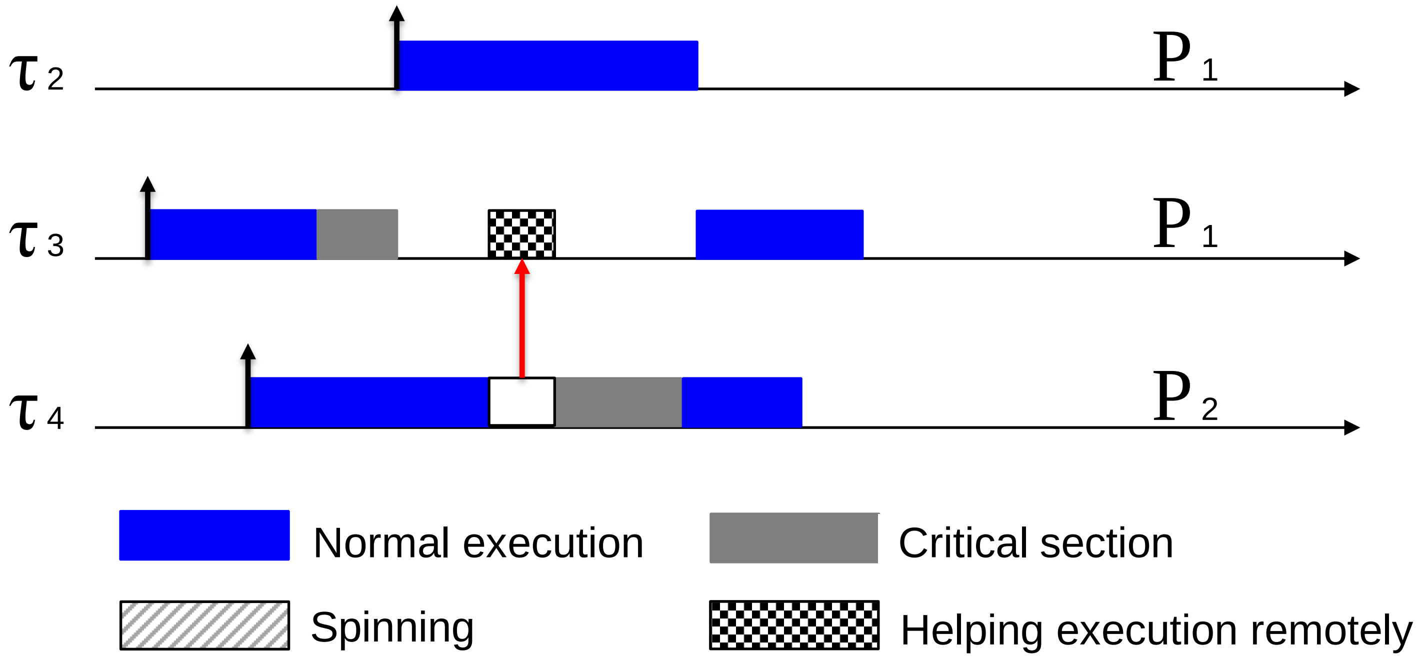
PUSH

- Semaphore owner can migrate to the helper's processor by itself after being preempted



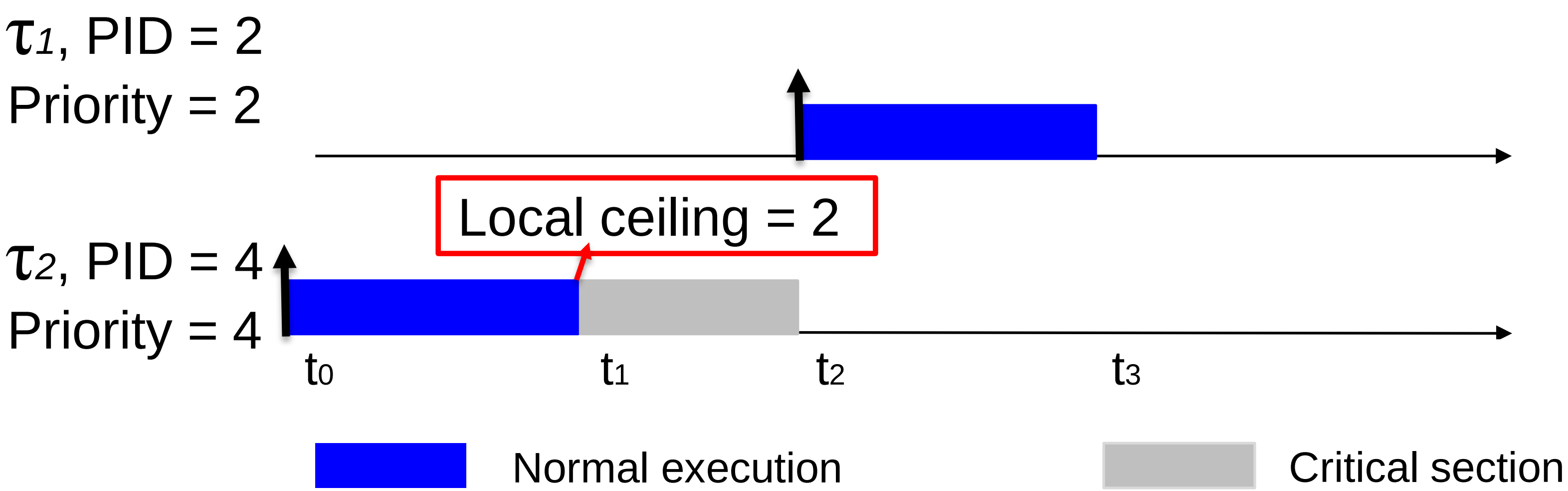
PULL

- Semaphore owner is on the ready queue, helper pulls it to the current processor



Potential implementation Deadlock

- Which task can be executed when there are two tasks have the same priority?
  - According to the PID number (first created first execute)



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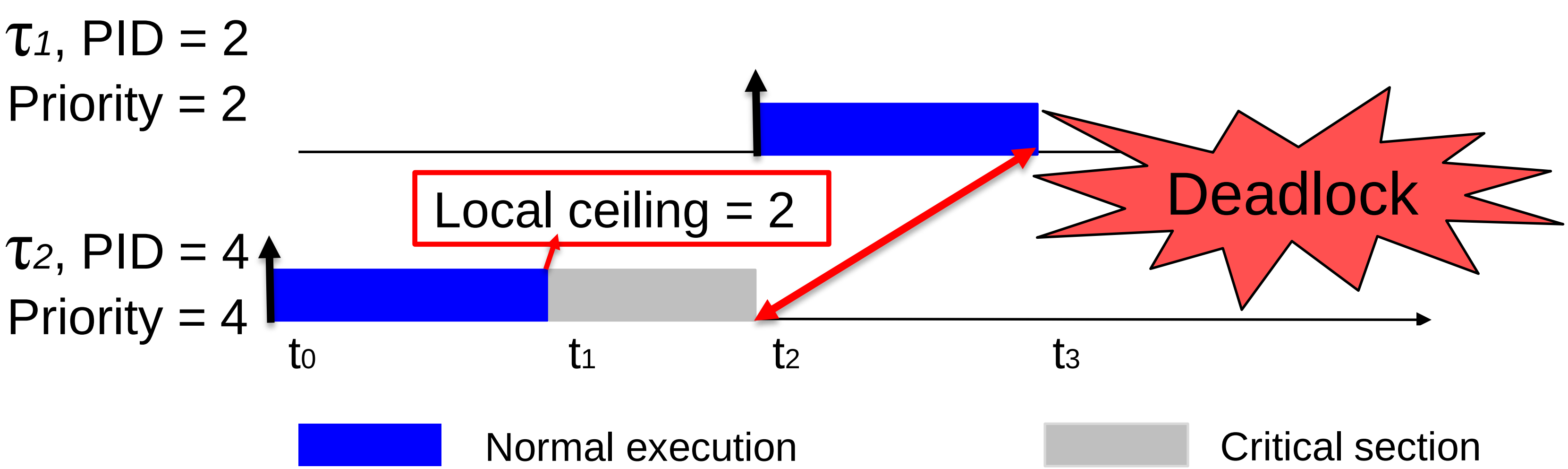
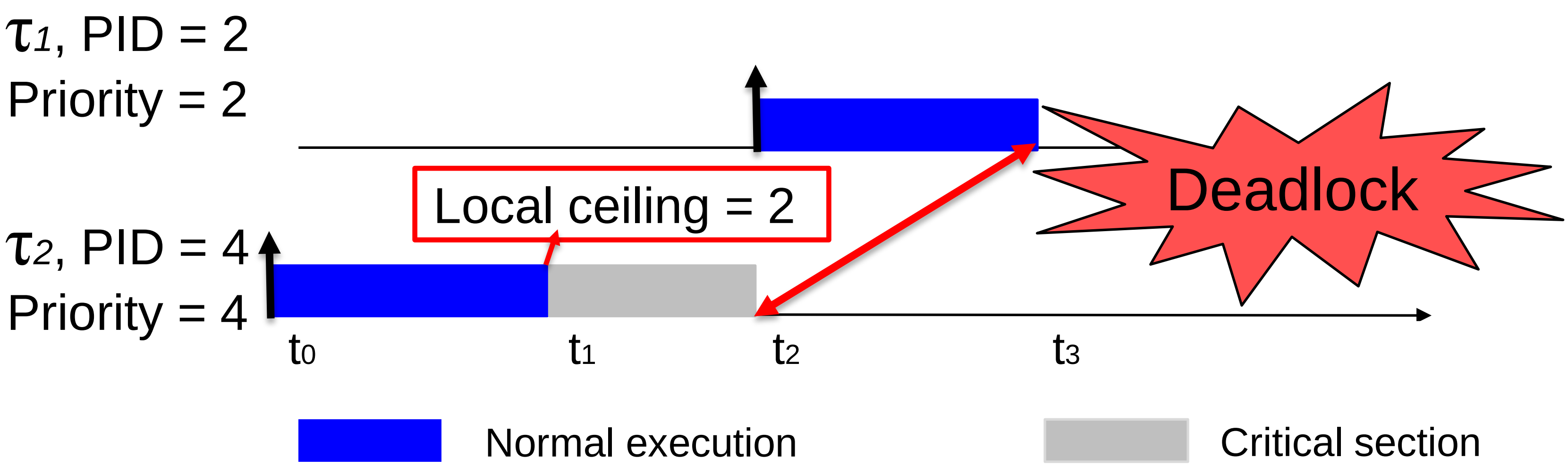


Potential implementation Deadlock

- Which task can be executed when there are two tasks have the same priority?
  - According to ~~the PID number (first created~~ first execute)
  - First executing task can continue its execution



Task set construction

- The number of tasks with different periods (40 tasks)

Period (ms)	5	10	20	50	100	200	1000
Num of tasks	2	5	8	10	8	5	2

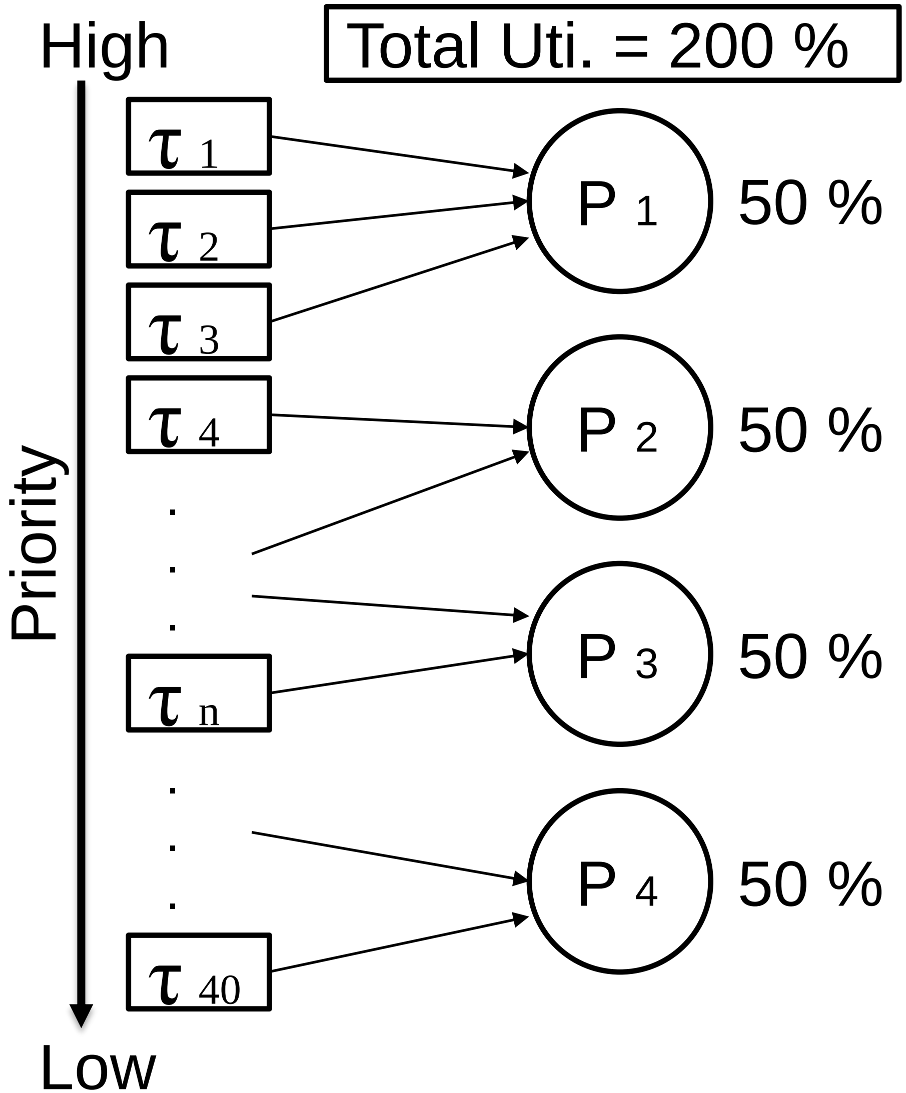
- Utilization for each task: 0.1 % - 10 %
- Total utilization (120 % - 280 %, step 40 %)
- Arithmetic progression is used
- Priorities are assigned under Rate-Monotonic
- BCET = 50 % * WCET, ACET = 90 % * WCET
- Normal distribution to generate real execution time

Shared resources

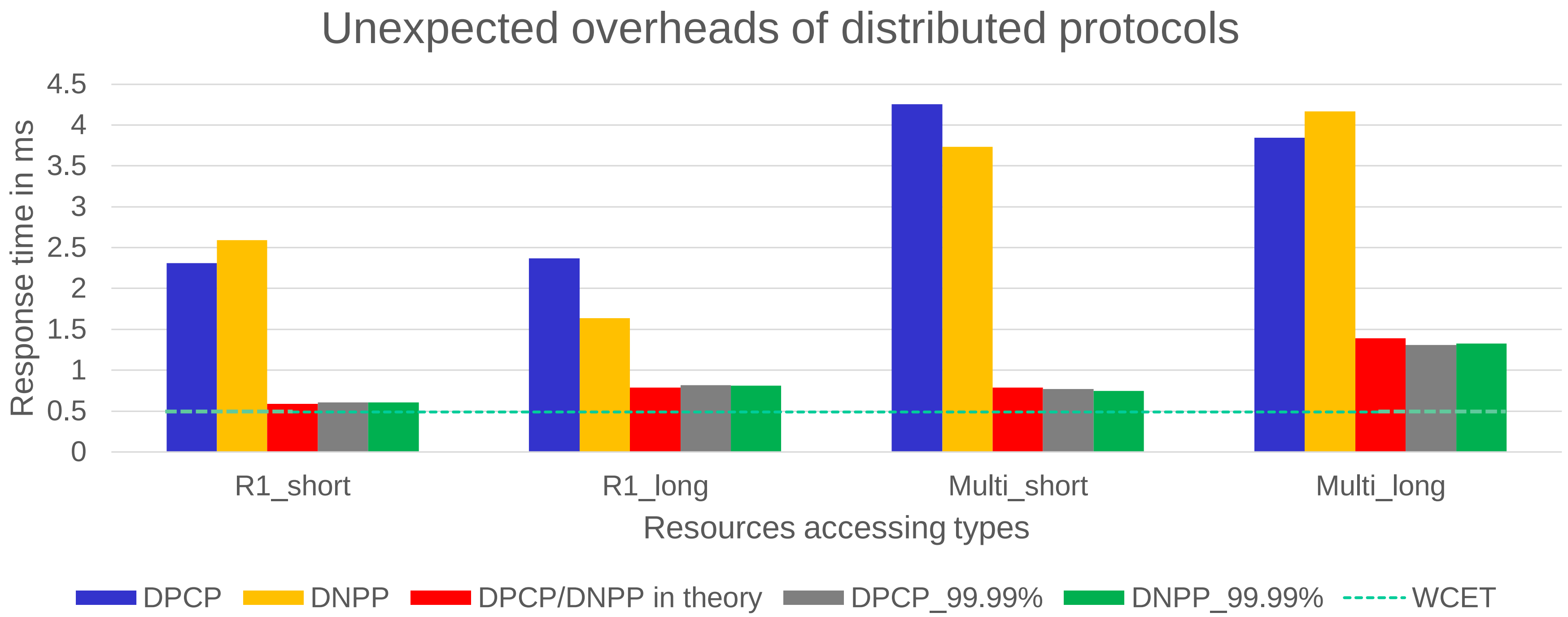
- Length of these shared resources
  - 0 us < R_{short} <= 100 us and 200 us < R_{long} <= 300 us
    - R_{short} = 20 % * execution time
    - Single: R_{long} = 80 % * execution time
    - Multi: R_{long} = 30 % * execution time
- Shared resources allocation
  - Request one short / long resource once
  - Request 3 short / long resources from 6 resources

Partition algorithm

- Sort tasks
- Calculate utilizations
- Allocate tasks



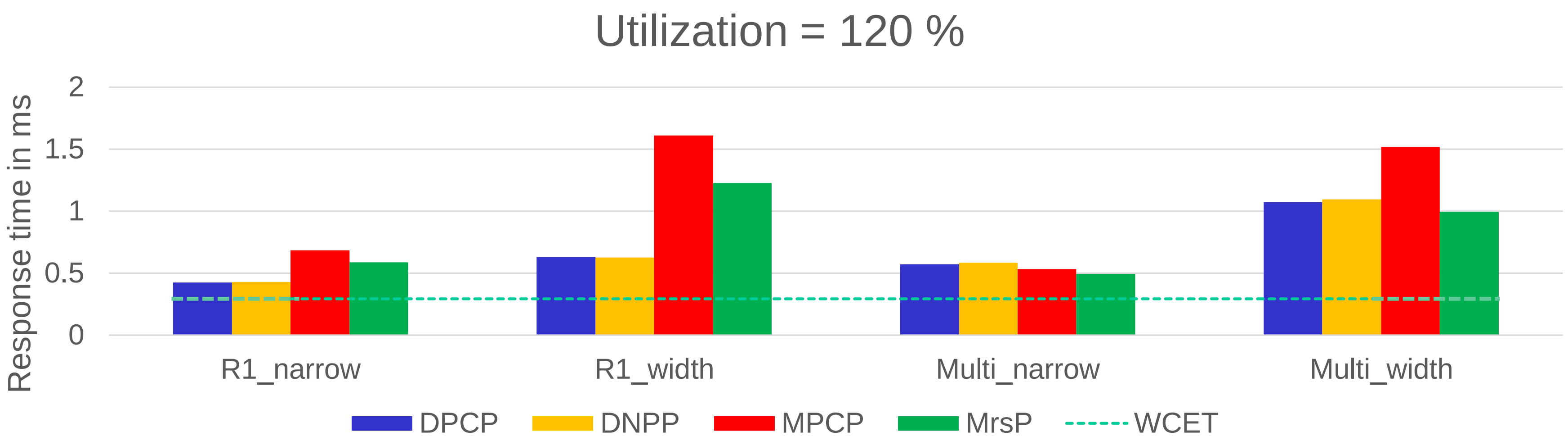
Overheads

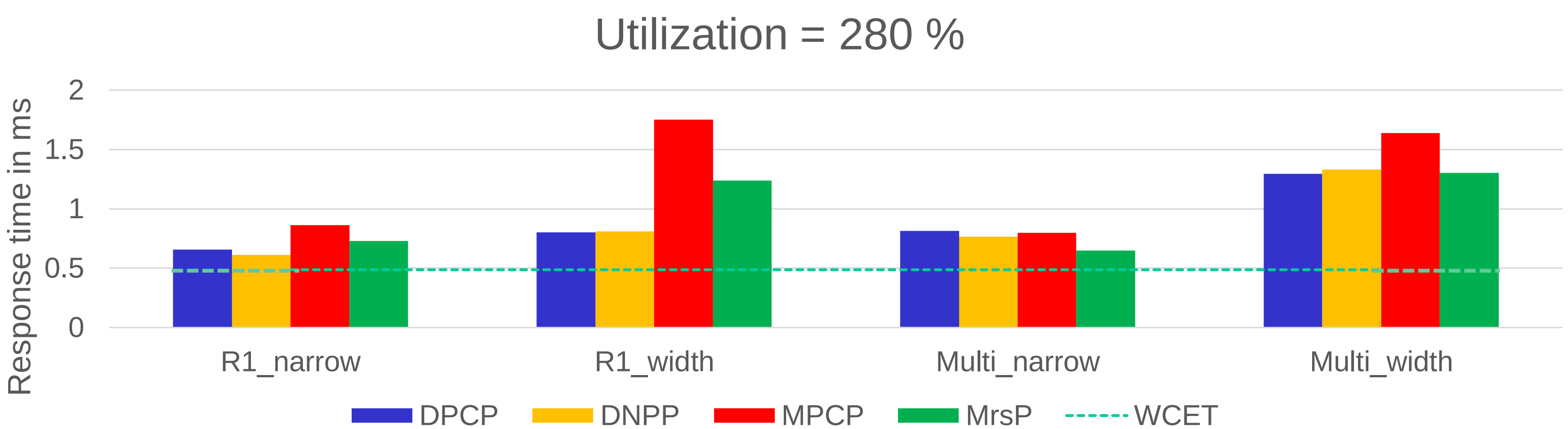


The results of the overheads measurement

	Migration	SCHED (MrsP)	Context switch
Average case	5.6 us	< 1 us	1.5 us

Experiment results





Conclusions and future work

- Conclusions
  - The first publicly available implementation of the MrsP
  - On $LITMUS^{RT}$, frequent migration may cause unexpected overhead
- Future work
  - Eliminate unexpected overhead of the DPCP/DNPP
  - When doing schedulability test, include the overheads and adopt proper partition algorithm.

Reference

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