Scheduling

Topics

1) How does the OS decide which task to run next?
(Why do we care with RT systems?)

2) What is priority inversion?
(Why do we care?)

Scheduling

Task Priority

- Each task has a priority
  - High priority: should be run sooner (RT tasks)
  - Normal/Low priority: run later, and preemptible
- Linux Priorities (PRI#)
  - In user level we see PRI# 0:139
    - Non Real-time: 100-139
    - Real-time: 0-99
  - "Lower" PRI# means higher priority
  - Often called..
    The nicer you are, the higher your PRI#
- Ex: Run at a higher priority

```
(bbg)$ nice -n -10 ./lightSampler
```

Scheduling

- OS decides which of the ready tasks..

- Linux normally uses: Completely Fair Scheduler (CFS)
  - Aims to maximize CPU usage and minimize delays for interactive programs
  - Next scheduled task:

    ..
  - Max length time = $\frac{\text{The time the process has waited to run}}{\text{Total number of processes}}$
  - Processes which sleep a lot get scheduled often
  - Used for SCHED_NORMAL priority
- Why not great for RT?

Linux “RT” Task Scheduling

- RR: Round Robin
  - Starting with the highest priority level, ..
  - Then, move to the next lower priority.
- FIFO: First In, First Out
  - .. run till completion
  - Great for highest priority, time-critical tasks
- What could be a problem with FIFO?

Linux Scheduling

- Linux Scheduler Sequence
  Each time Linux wants to schedule a task, it does:
  - First do all FIFO tasks
  - Then do all RR tasks
  - Then do all CFS tasks
- Challenge for system designer:
  - ..
    to allow for the correct operation of the device

Earliest Deadline First

- Linux also supports Earliest Deadline First
  - Tasks declare..
- Scheduler tests new task for schedulability:
  - Given current set of tasks and their deadlines, can the OS..
  - Yes?
Accepts it (guaranteeing it will have the CPU budget to meet its deadline)
  - No?
Rejects it
- Tasks are scheduled based on EDF

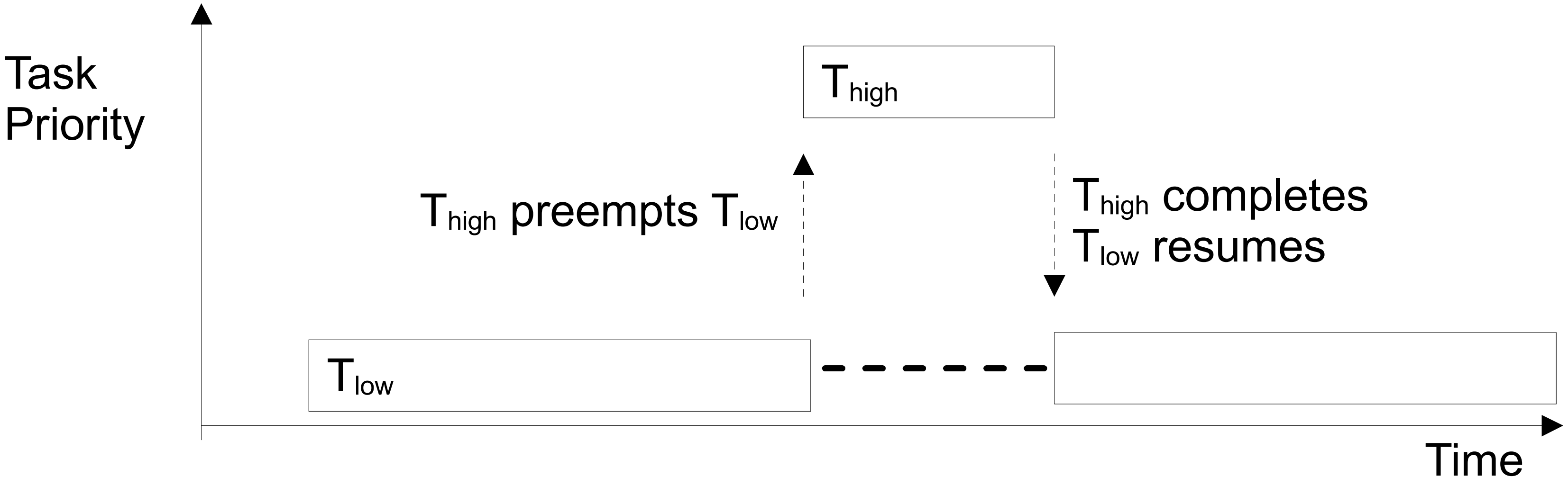
EDF vs FIFO/RR

- RR and FIFO
  - Developer must set a task priority to meet deadlines
  - ..
- EDF
  - ..
    a task which misses its deadline does not take down other tasks

Priority Inversion

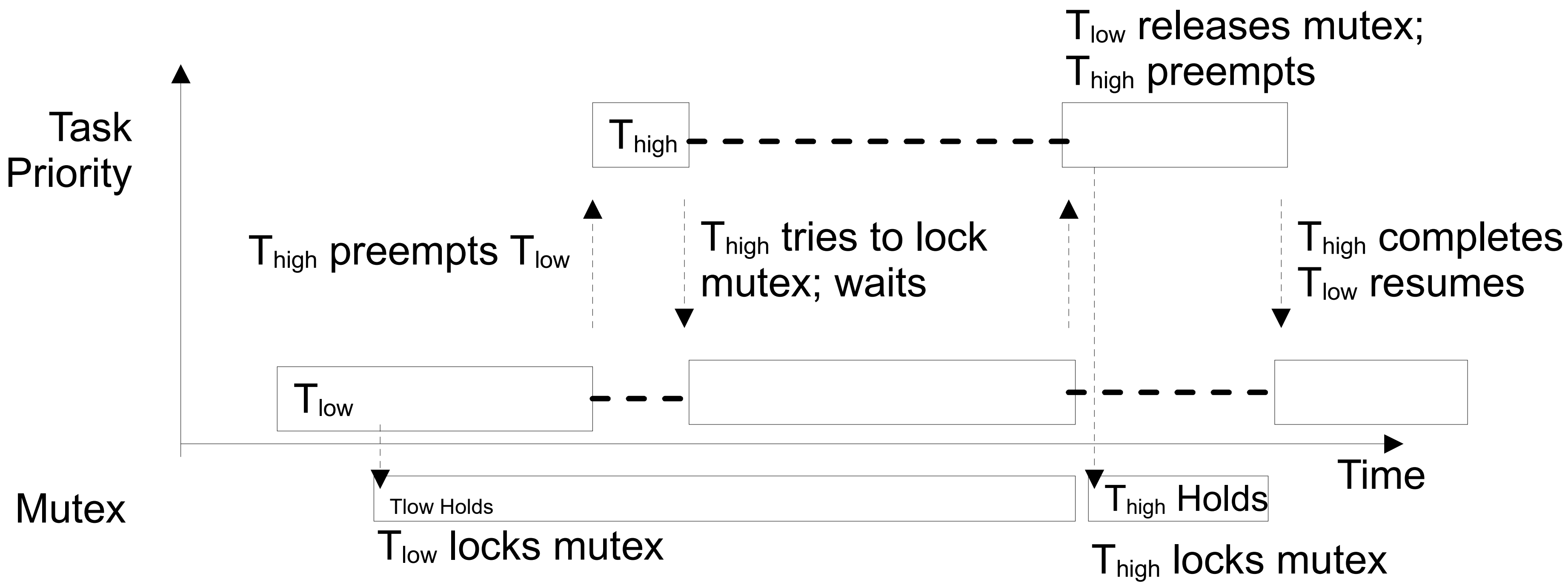
How Priority Works

- The simple case of preemption with priority



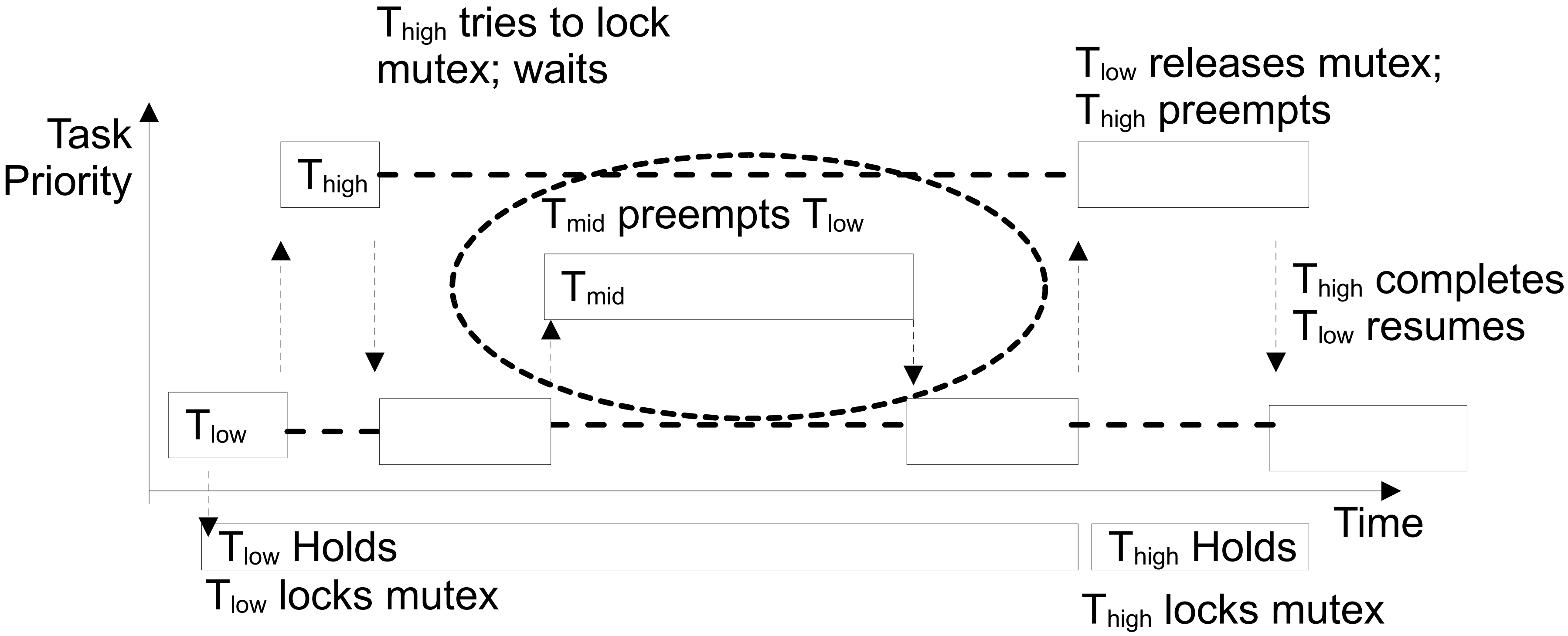
Priority with Mutexes

- What if processes of different priorities share a mutex?



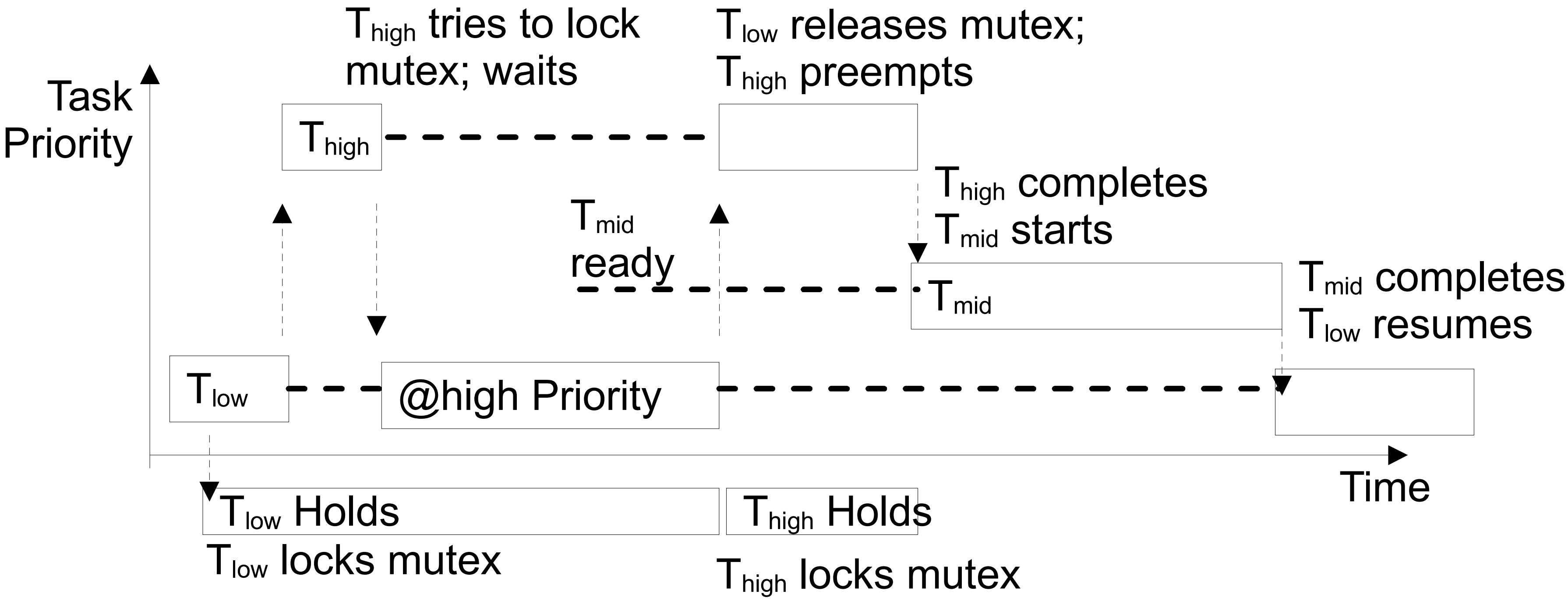
What could go wrong?

- Mutex held between tasks of two priorities with other tasks preempting low priority task..


T_{high} tries to lock mutex; waits
T_{low} releases mutex; T_{high} preempts
Task Priority
T_{high}
T_{mid} preempts T_{low}
T_{mid}
T_{high} completes T_{low} resumes
T_{low}
Time
T_{low} Holds
T_{high} Holds
T_{low} locks mutex
T_{high} locks mutex

Solution: Priority Inheritance

- When a higher priority process blocks on a mutex held by a lower priority process, then..



T_{high} tries to lock mutex; waits

T_{low} releases mutex; T_{high} preempts

Task Priority

T_{high}

T_{high} completes T_{mid} starts

T_{mid} ready

T_{mid}

T_{mid} completes T_{low} resumes

T_{low}

@high Priority

Time

T_{low} Holds

T_{high} Holds

T_{low} locks mutex

T_{high} locks mutex

Summary

- OS Schedules tasks
  - Round Robin
  - First-in First-out
  - Completely Fair Schedule
  - Earliest Deadline First
- Priority Inversion
  - When a high priority task is waiting on an resource held by a low priority task, and that low priority task is preempted by a mid priority task.
- Priority Inheritance
  - When holding a mutex, a task’s priority is promoted to the priority of other tasks waiting on that mutex.