Scheduling

Johan Montelius

KTH

2021

process scheduling

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- What metrics are important?
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- Are there optimal solutions?

The unrealistic assumption ...

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This is unrealistic - we will relax these requirements.

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Performance metrics

$$T_{\text{turnaround}} = T_{\text{completion}} - T_{\text{arrival}}$$

How long time does it take to complete the job?

First Come First Serve (FCFS)

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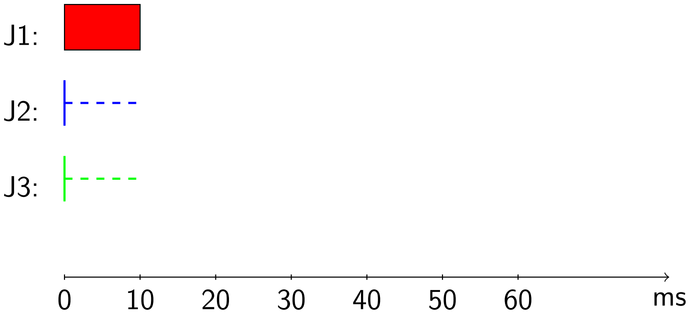

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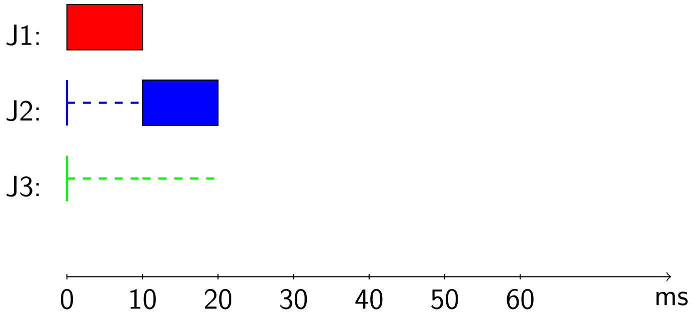

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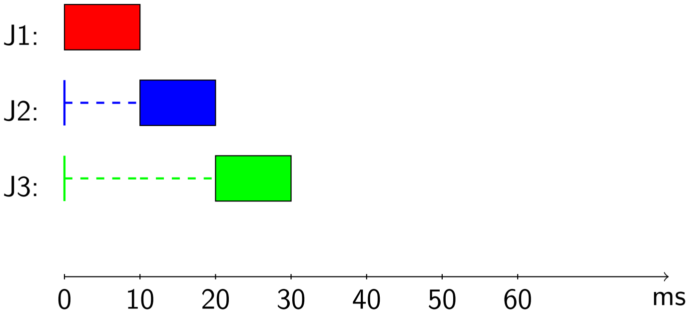

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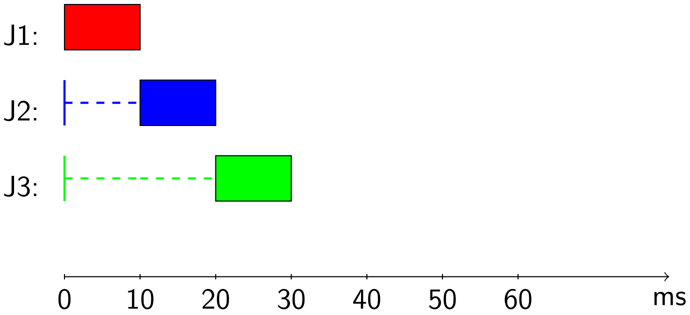

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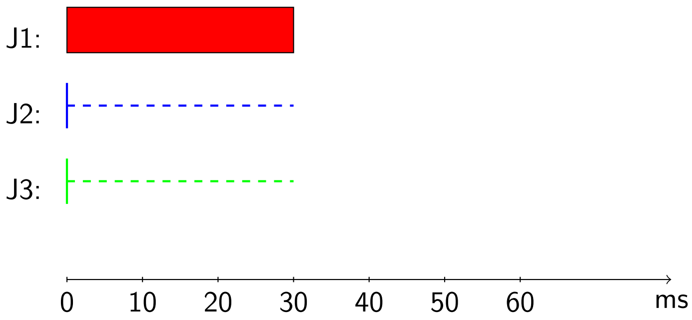

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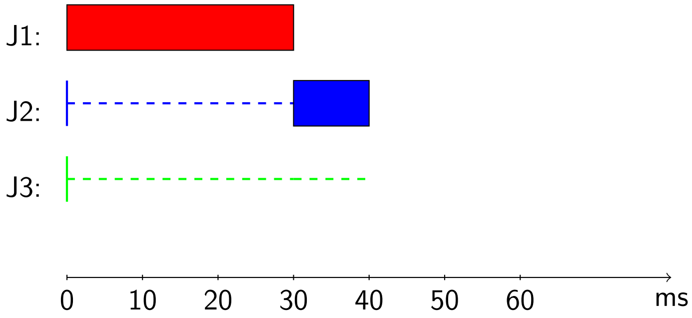

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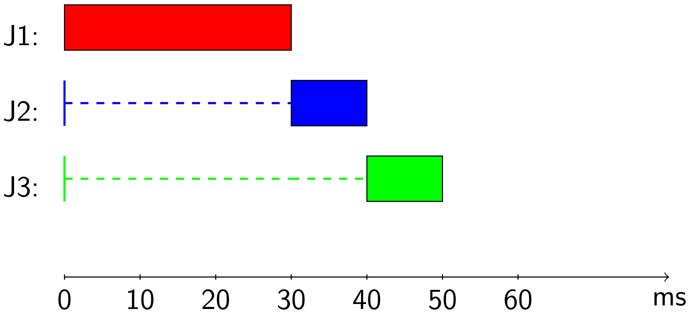

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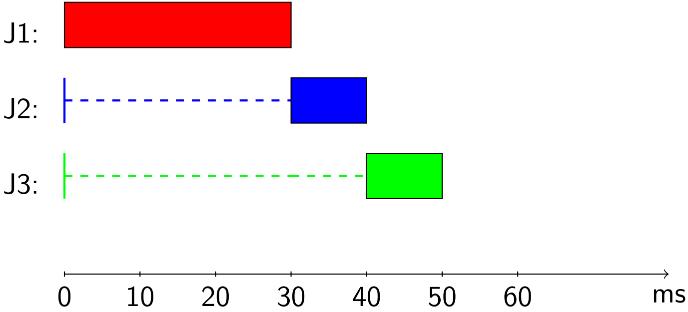

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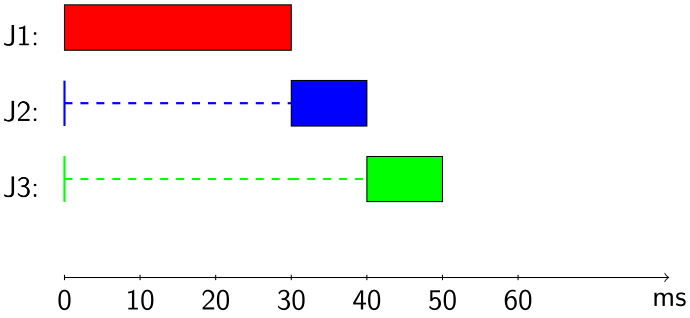

What is the average $T_{\text{turnaround}}$? Can we do better?

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Always schedule the shortest job.

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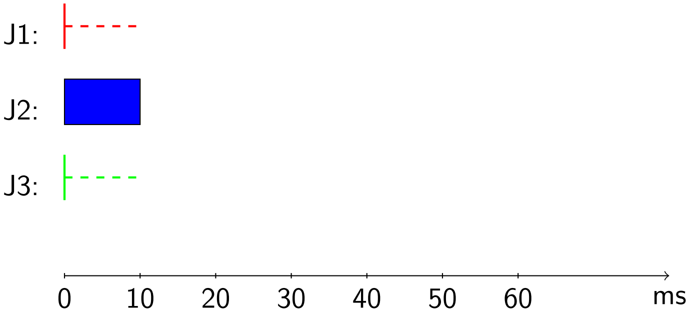

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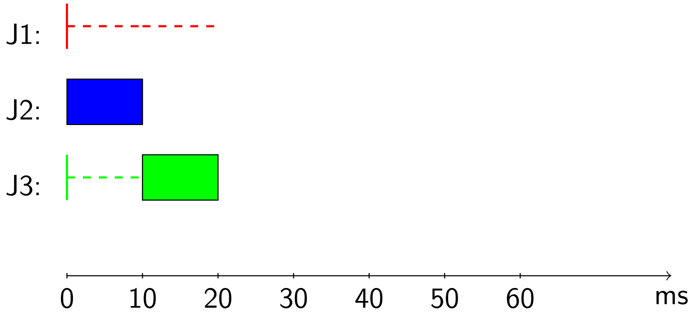

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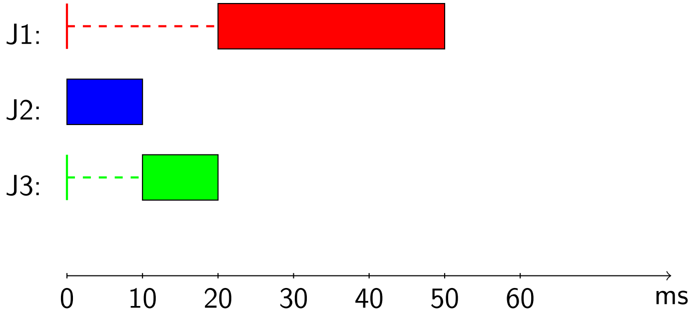

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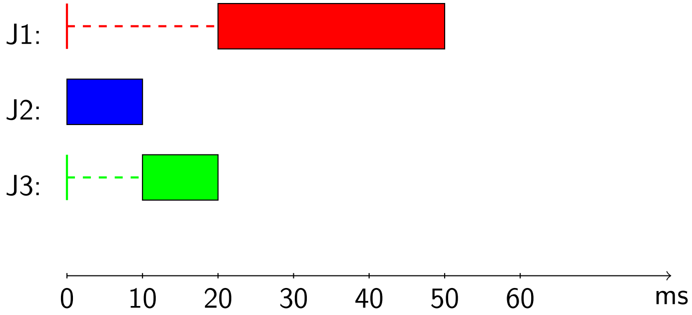

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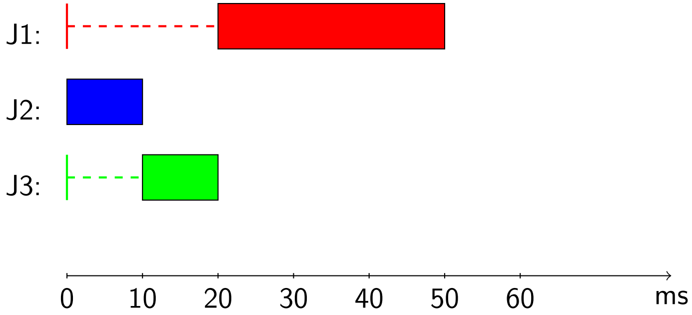

What is the average $T_{\text{turnaround}}$? Problem solved!

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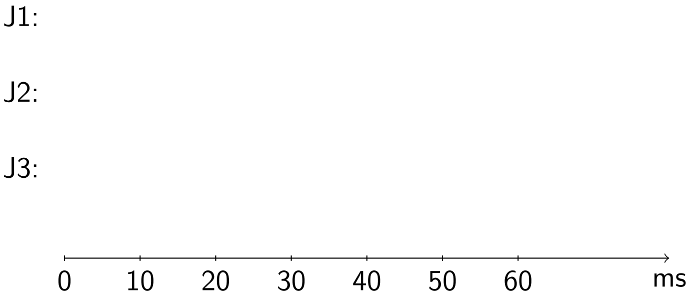

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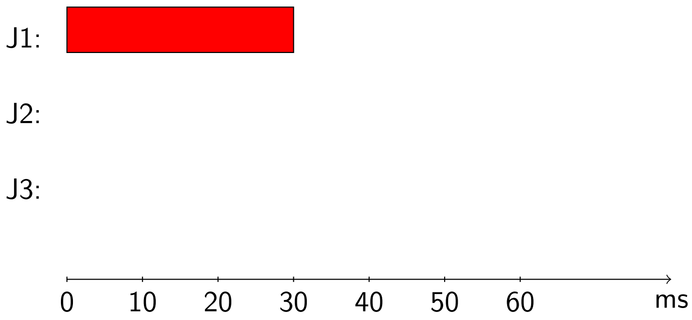

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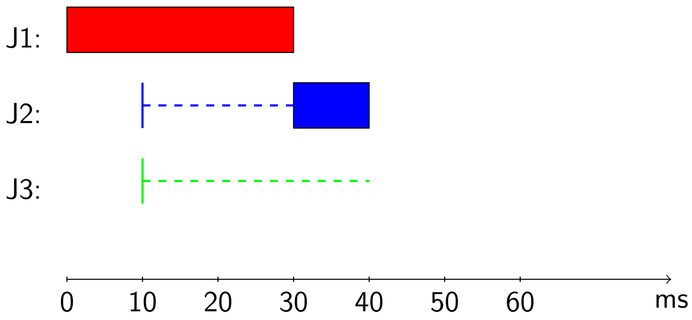

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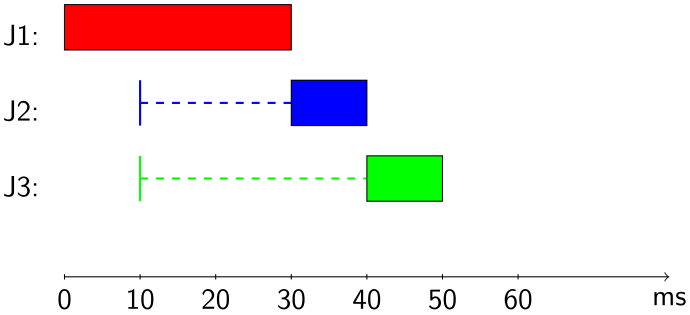

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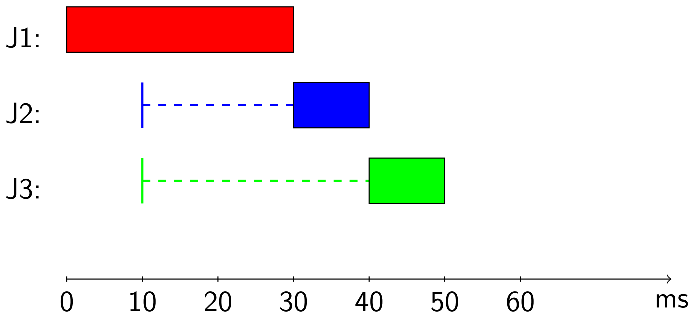
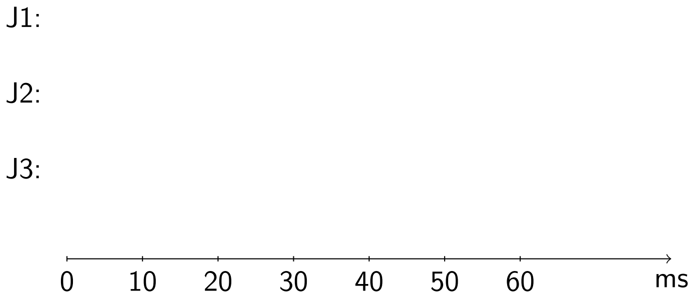


We need to preempt the execution of a job.

Shortest Time-to-Completion First (STCF)

Let's always schedule the task that has the shortest time left to completion.



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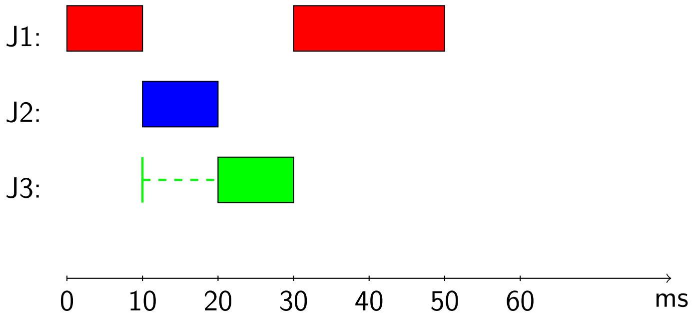

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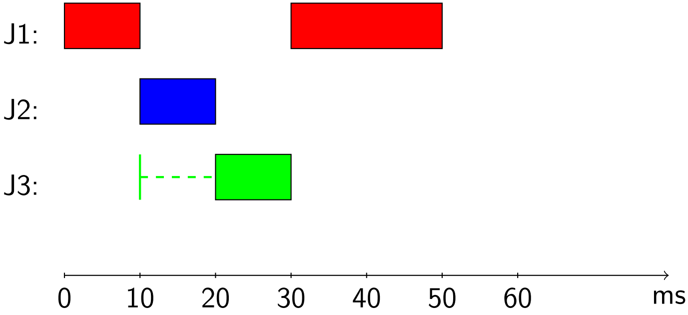

The policy is also known as Preemptive Shortest Job First (PSJF)

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If we actually know the total execution time of each job as they arrive, then ....

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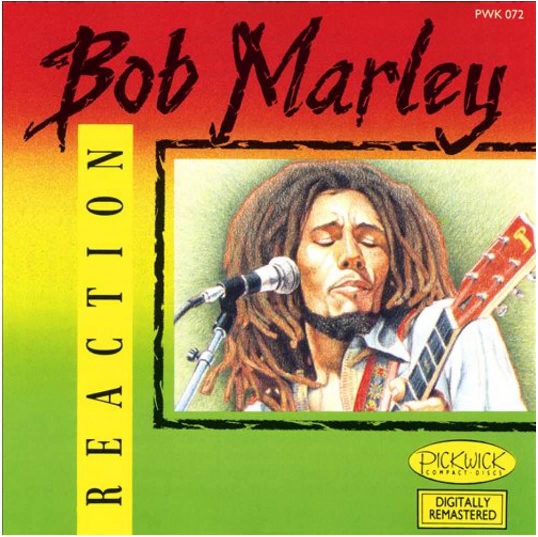
There might be more important metrics than turnaround time.

Talk about ...


PWK 072
Bob Marley
REACTION
PICKWICK
COMPACT DISCS
DIGITALLY REMASTERED

Response time

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The response might not be completed unless the job completes but it's an ok metrics.

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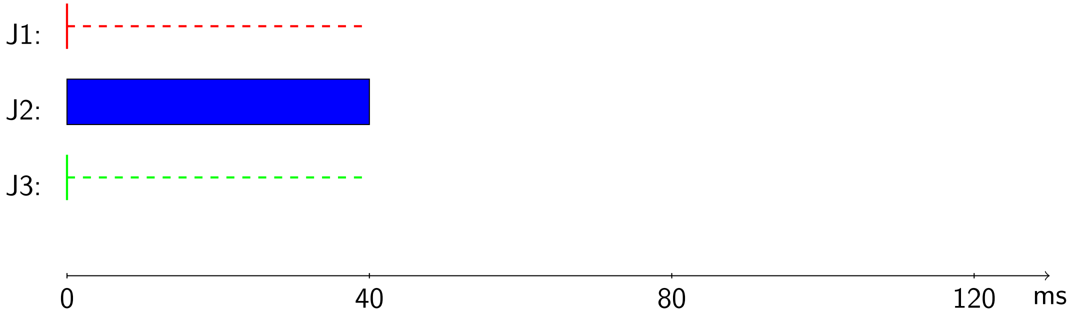

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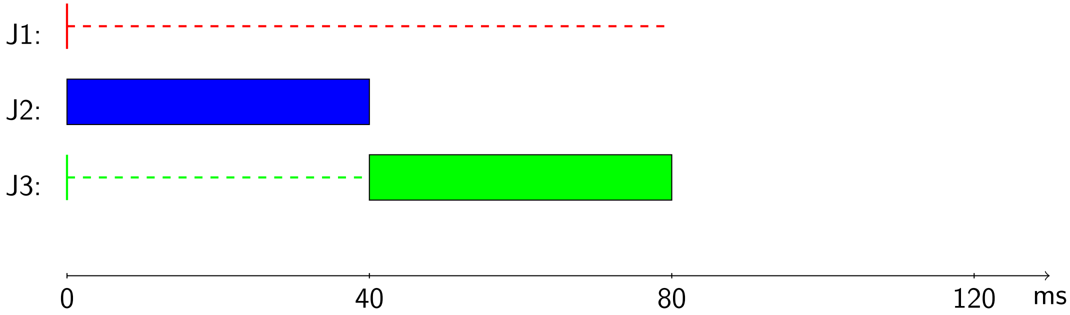

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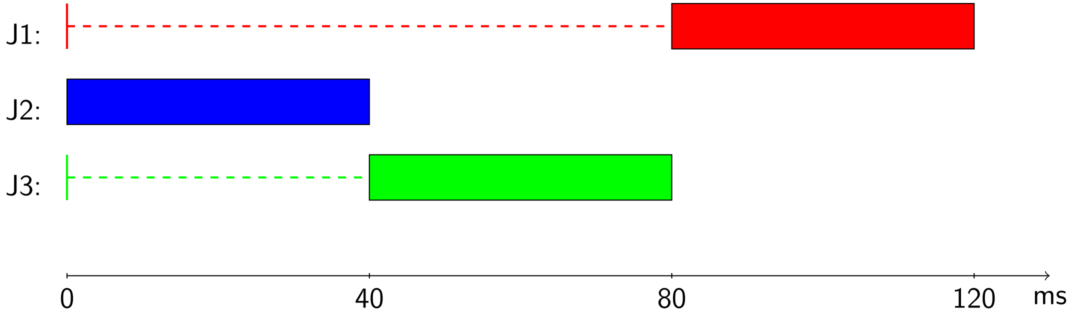

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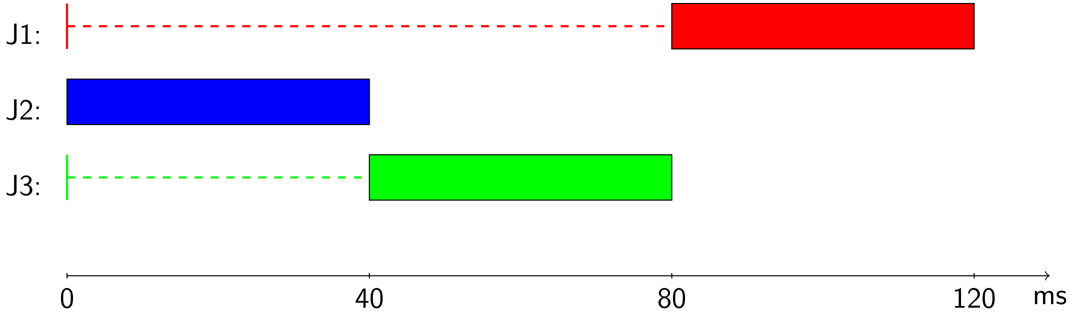

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Preempt a job in order to improve response time, give each job a time-slice of 10 ms.

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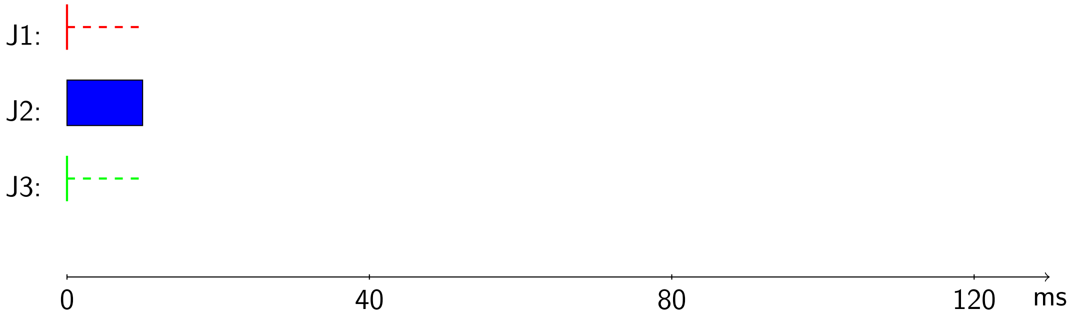

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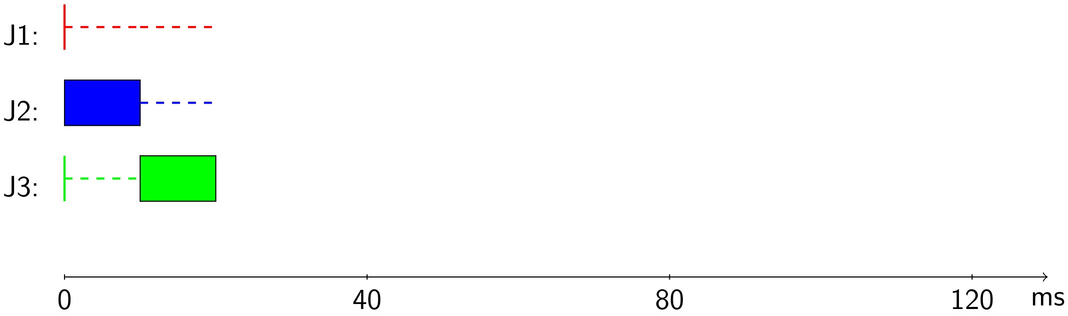

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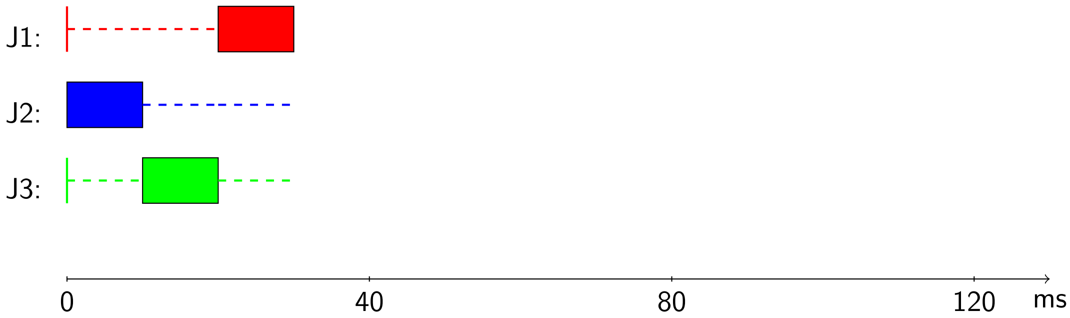

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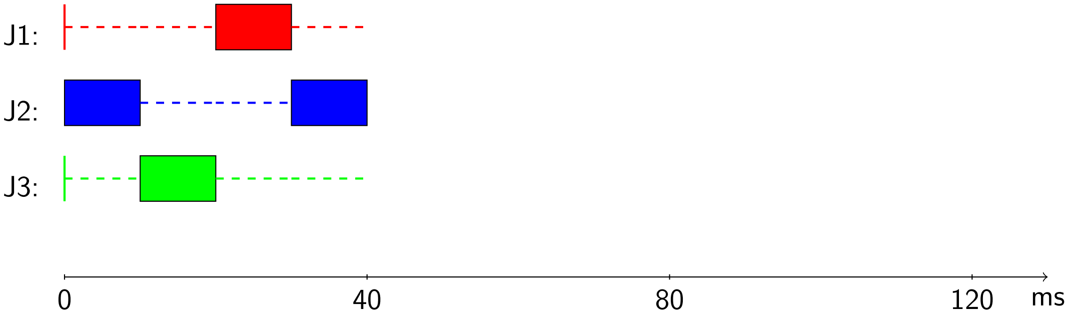

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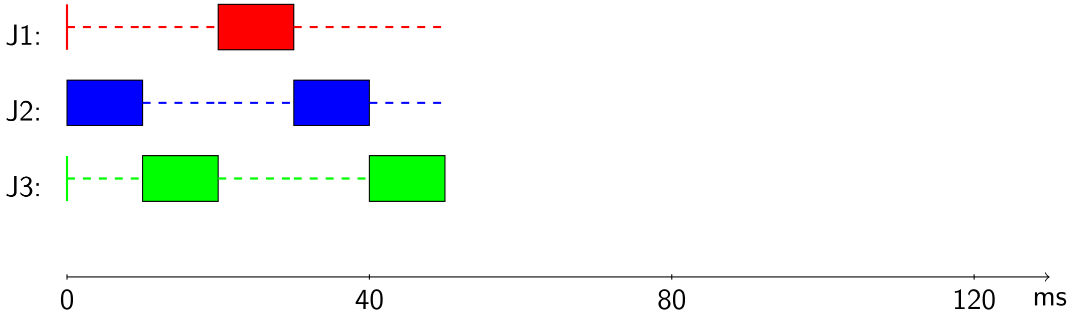

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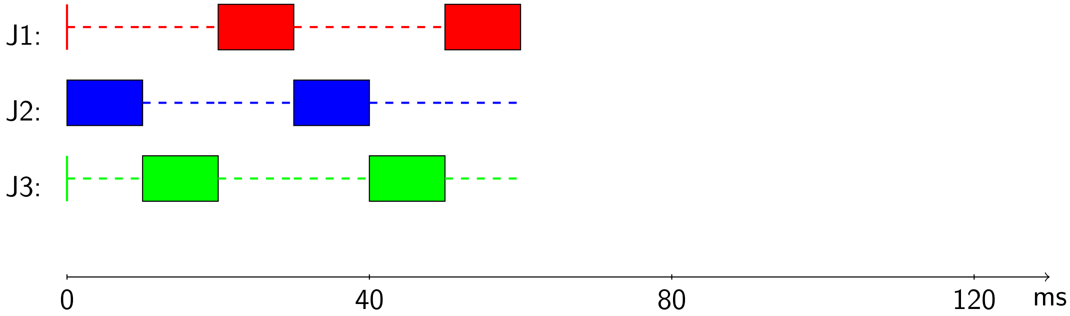

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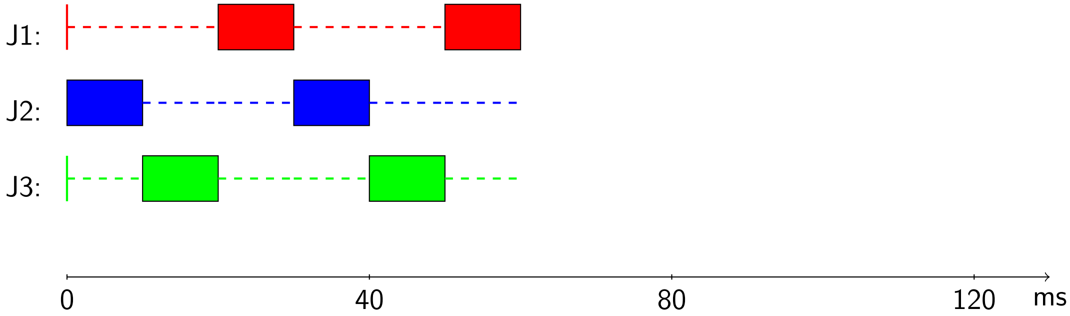

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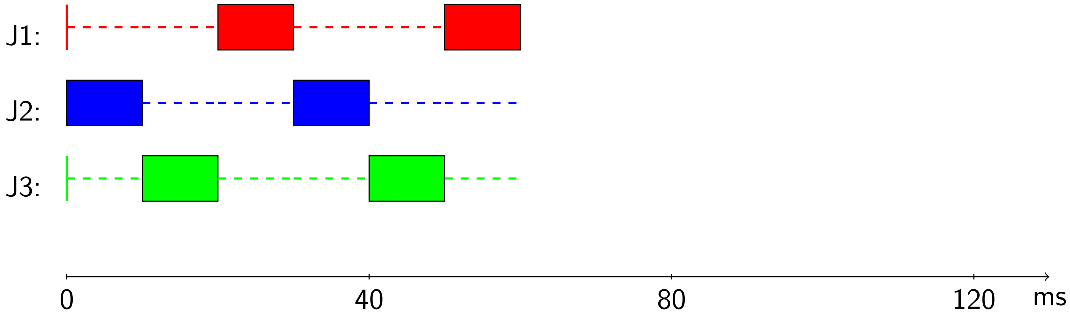

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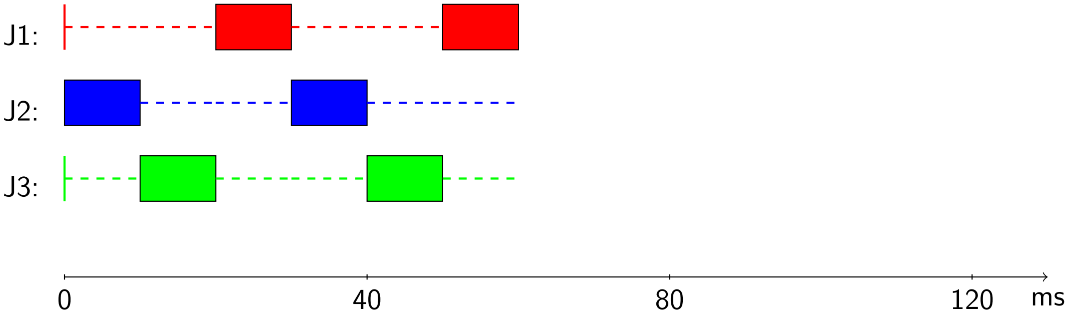

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How to choose the time-slice?

You can’t ....


6103 062
sad day
DECCA
the rolling stones
you can't always get
what you want

processes do I/O

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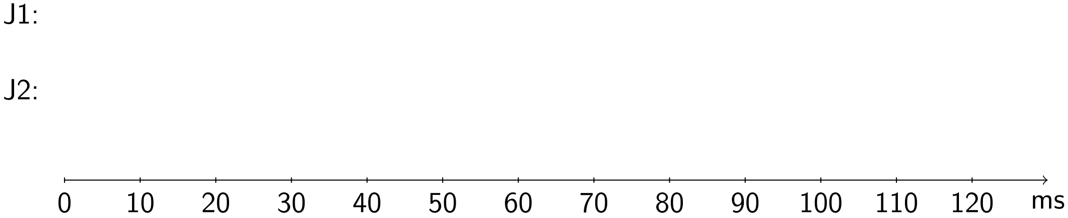

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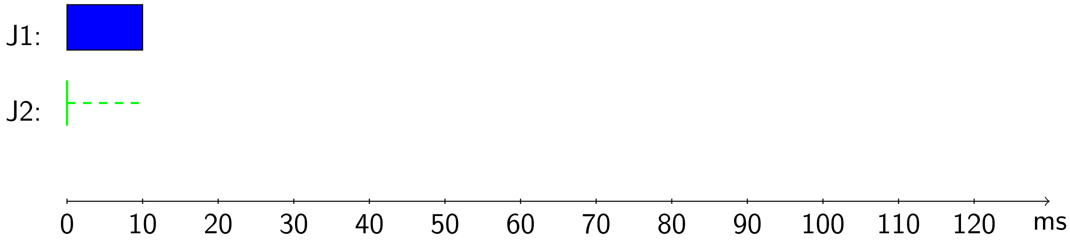

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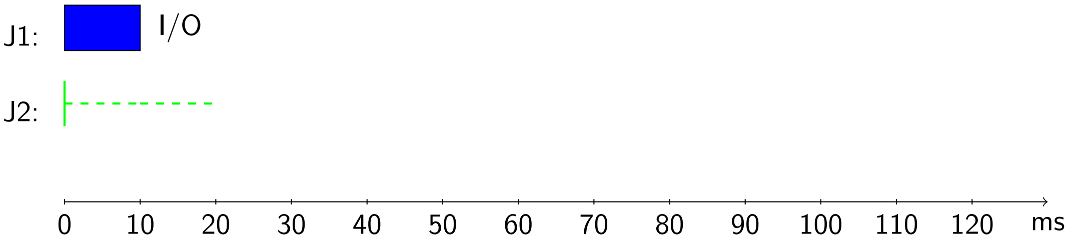

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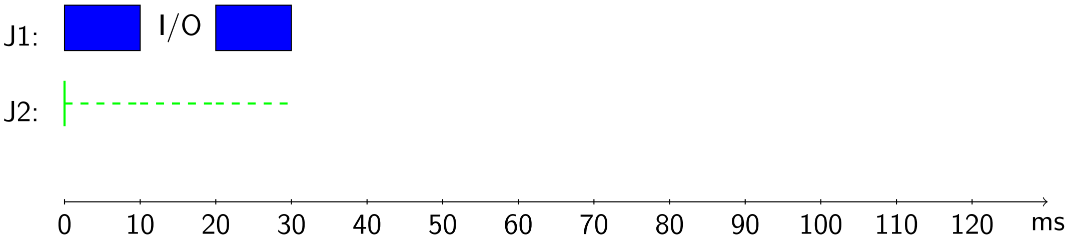

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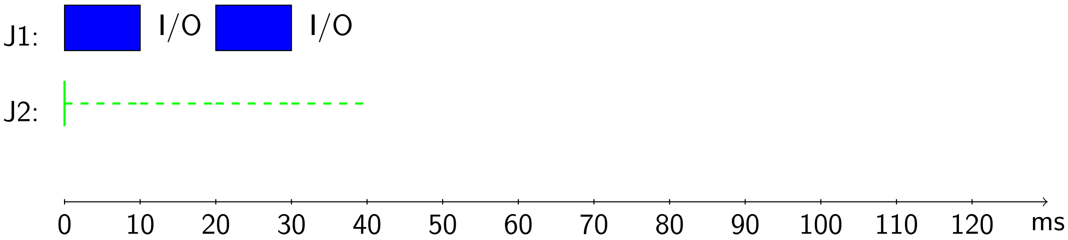

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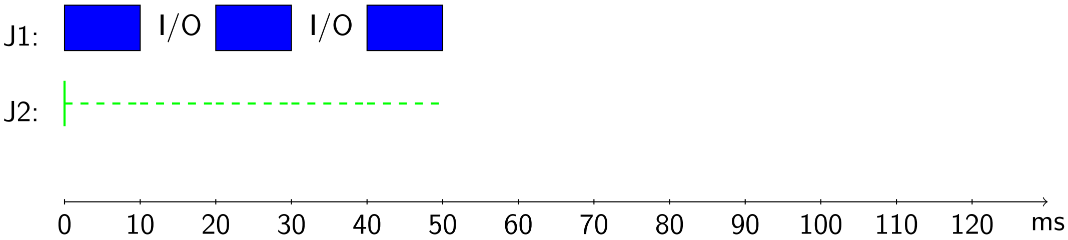

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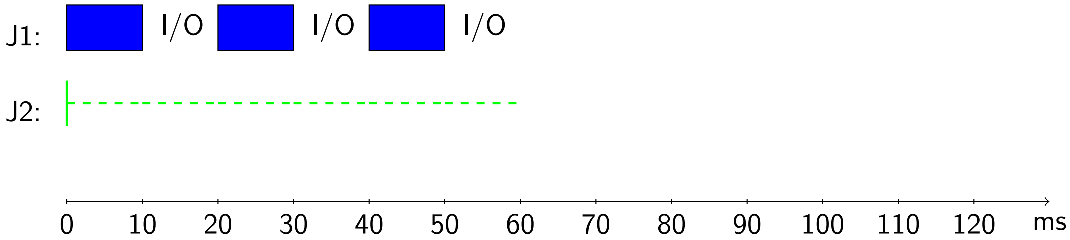

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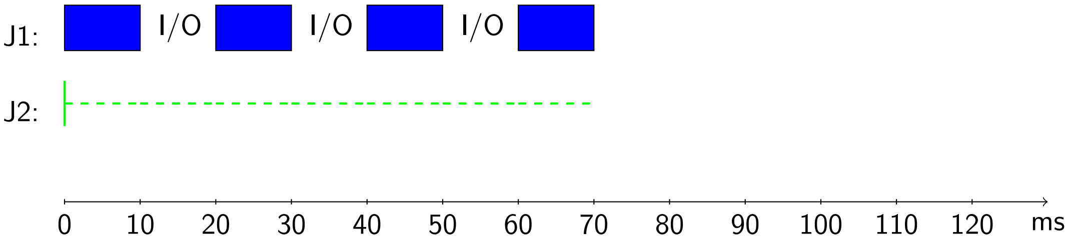

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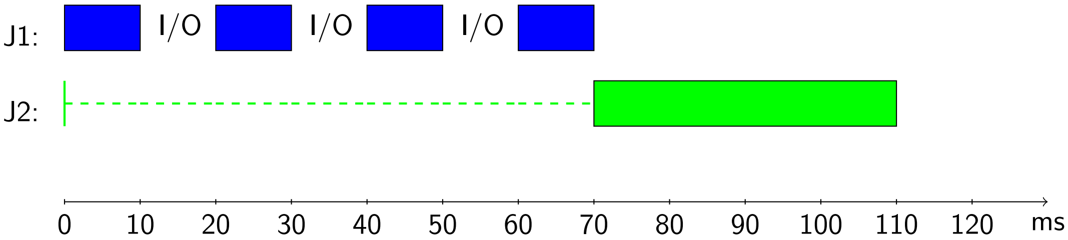

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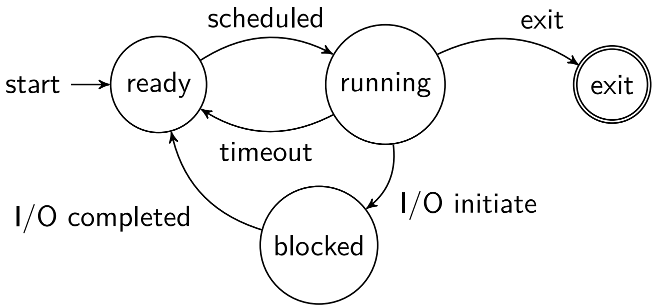

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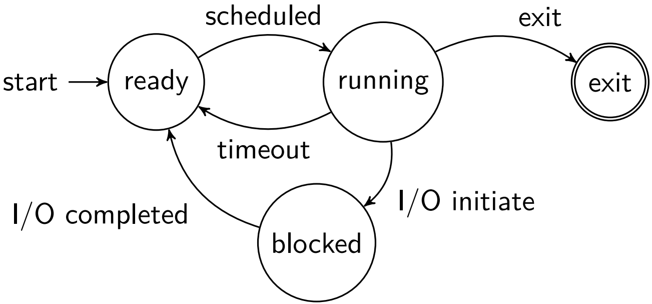
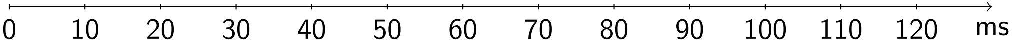


A process is descheduled if it is preempted or if it initiates a I/O-operation.

much better

J1:

J2:



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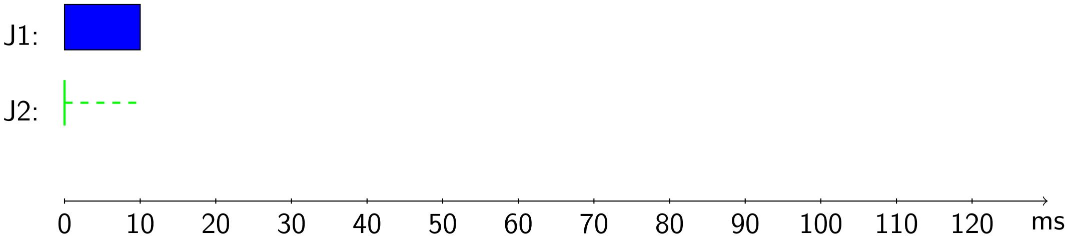

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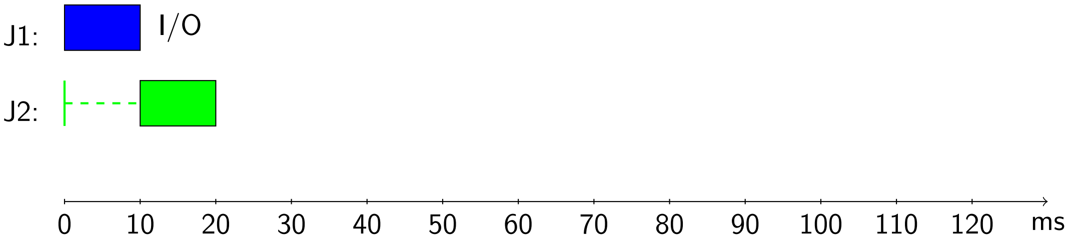

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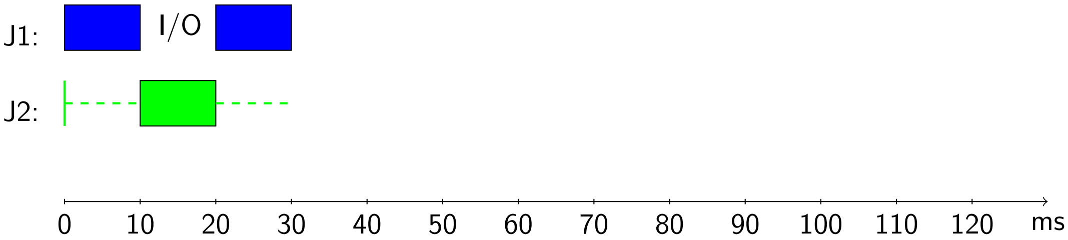

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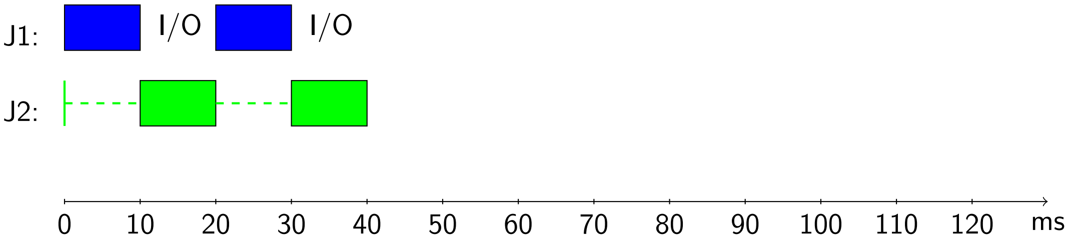

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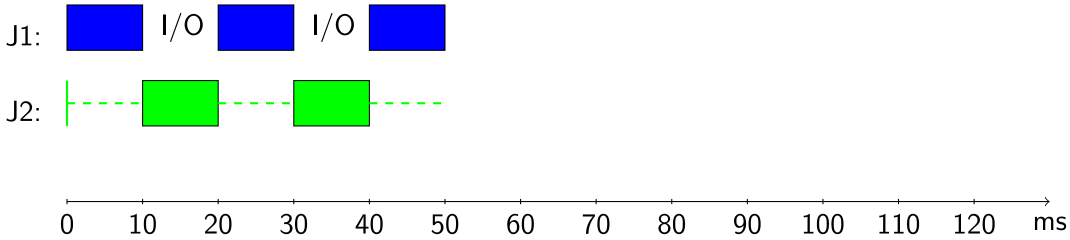

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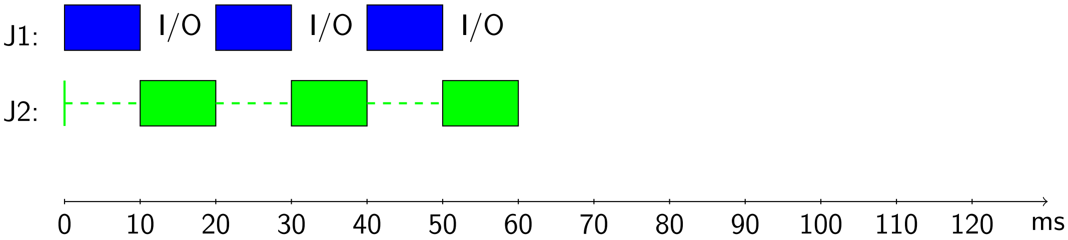

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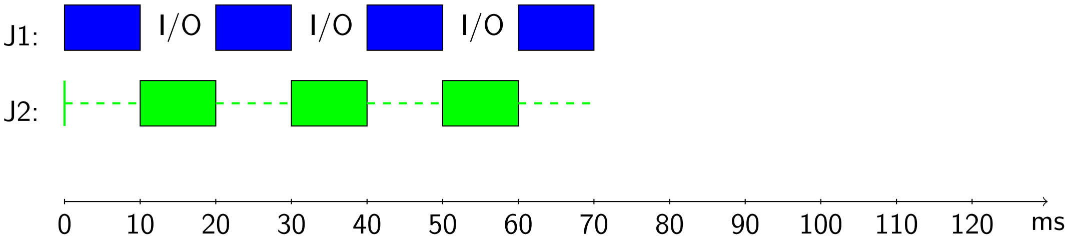

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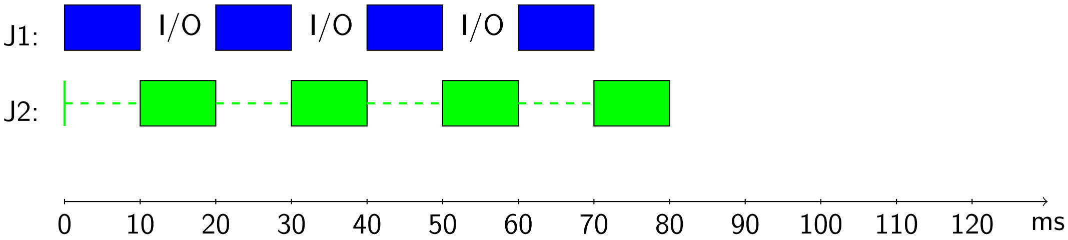

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Can we design scheduling policies that give us good turn-around time and short response time?

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How do we identify interactive processes and how do we make sure that they have high priority?

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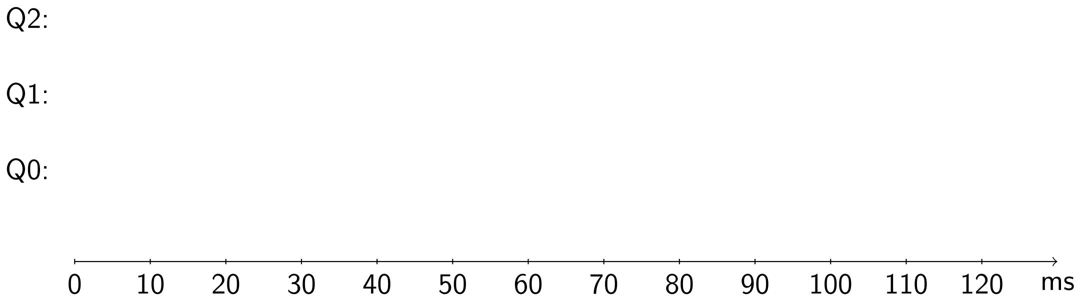
- Rule 4b: a job that initiates a I/O-operation (or yields) remains on the same level.

fine, no problem ...



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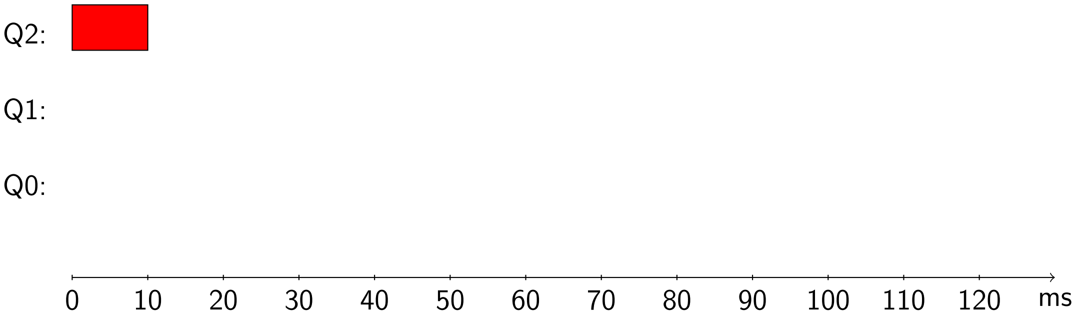

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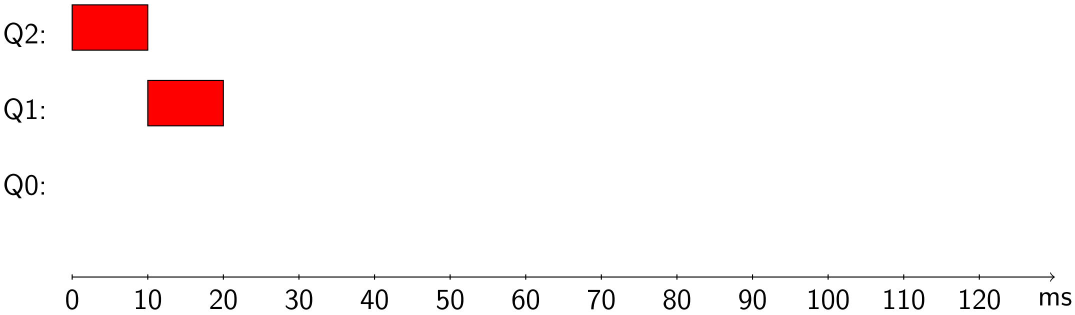

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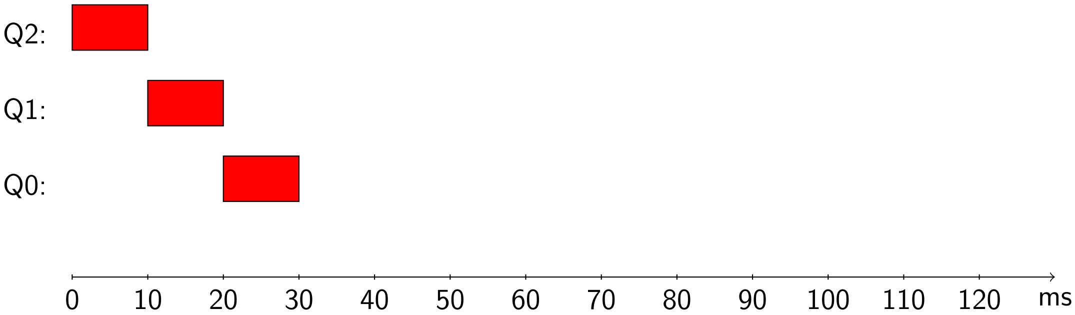

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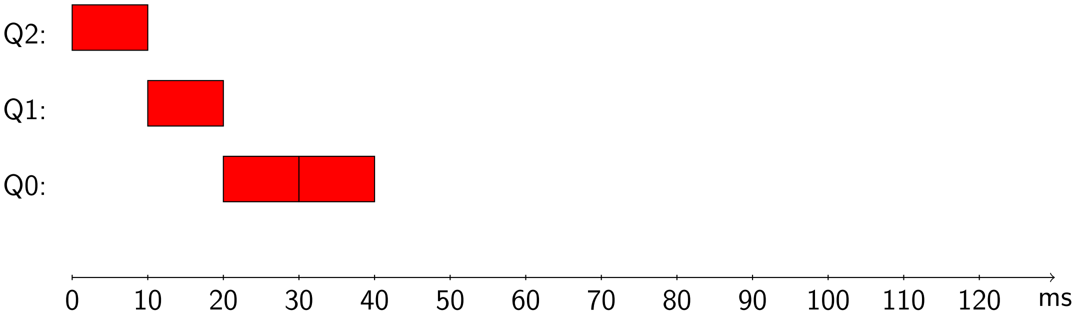

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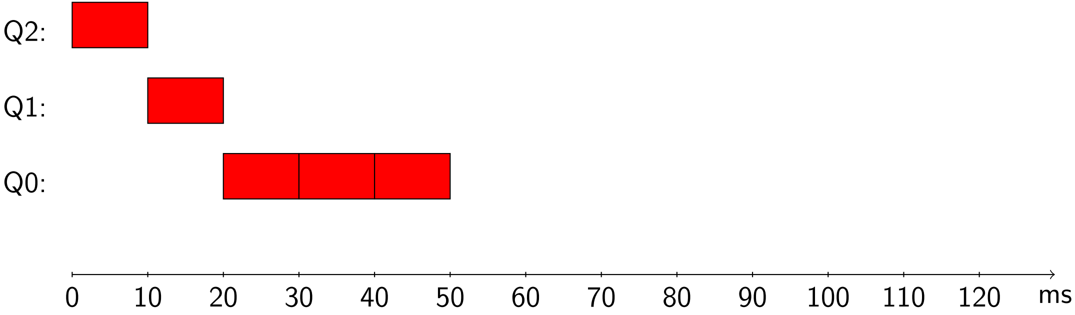

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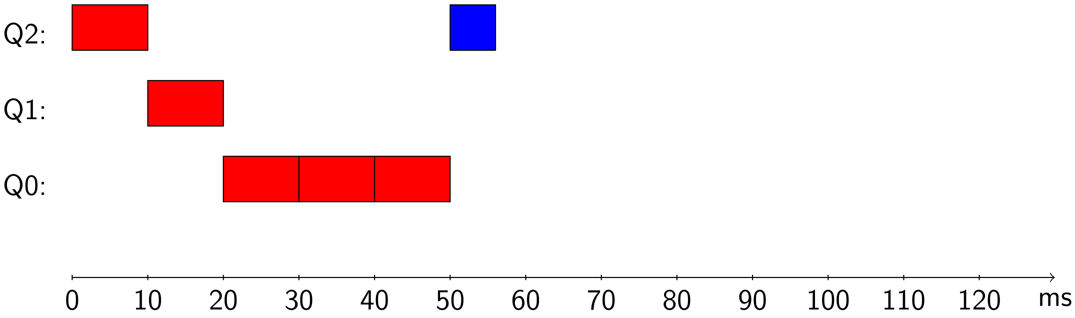

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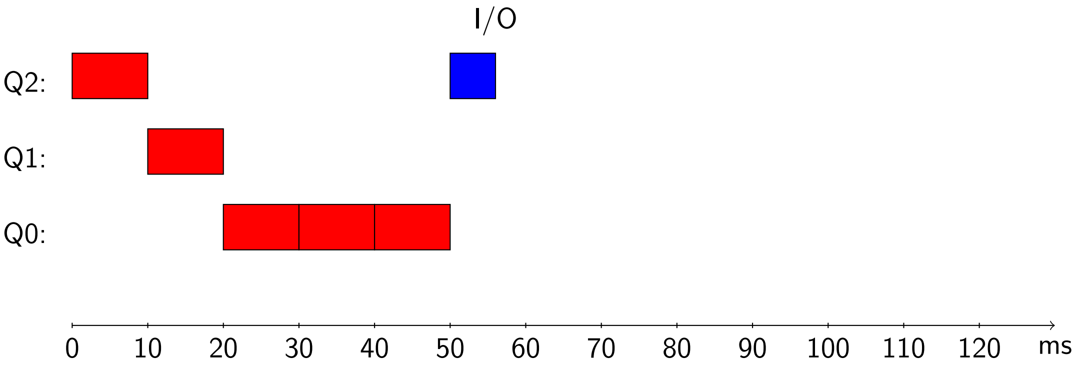

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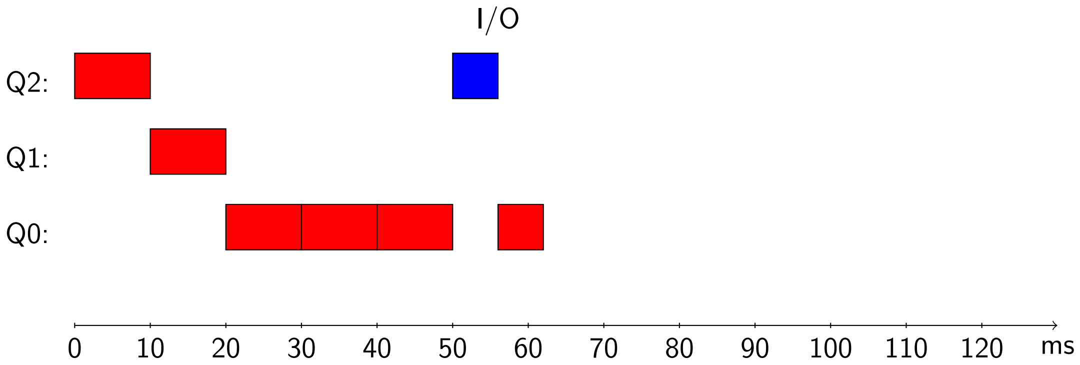

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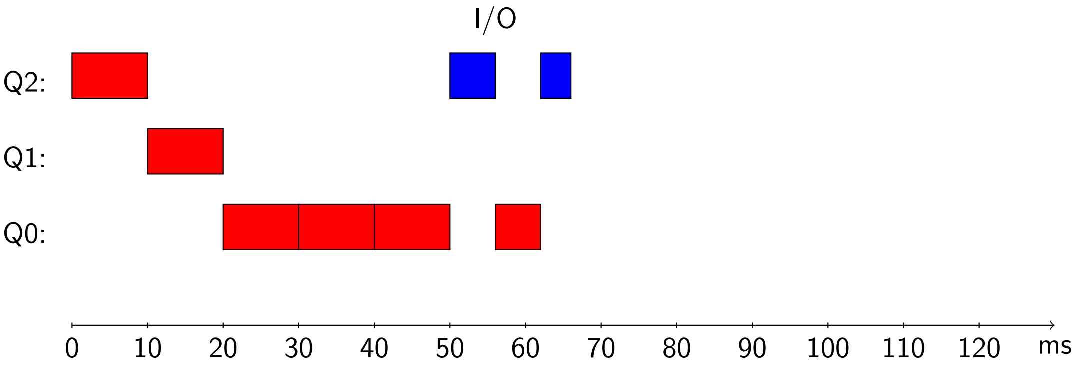

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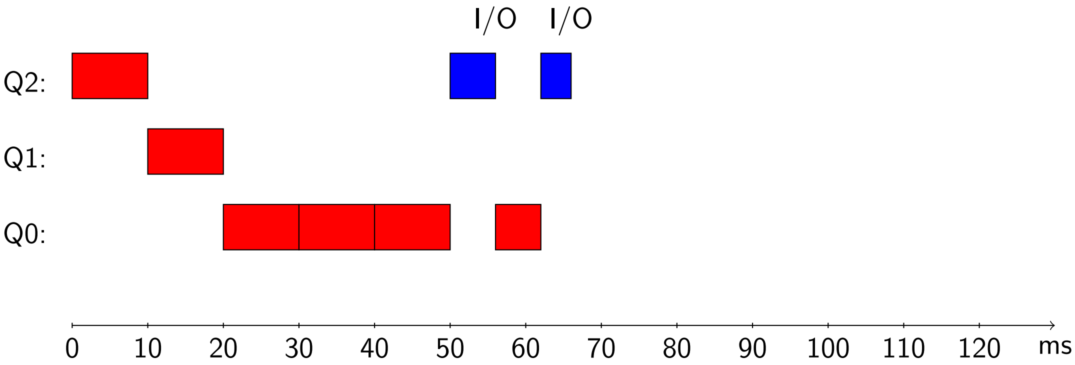

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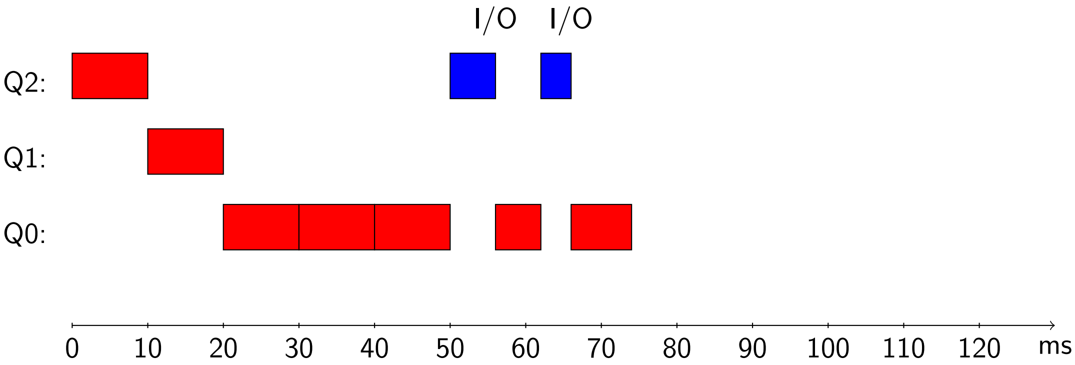

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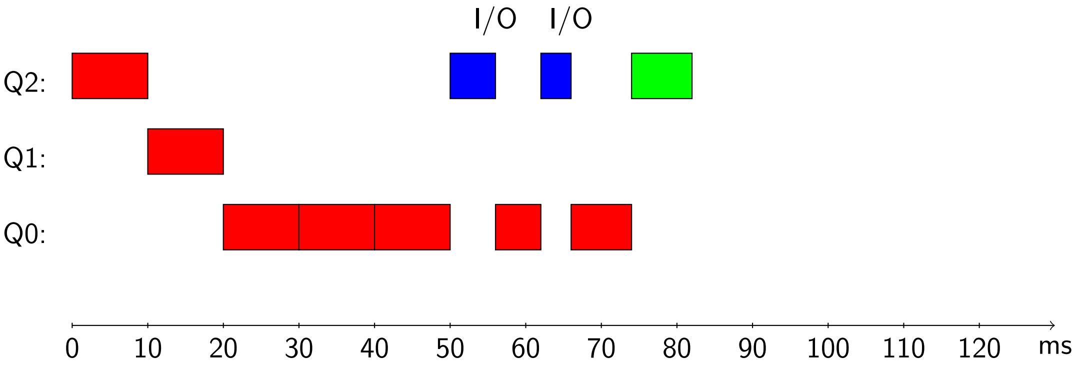

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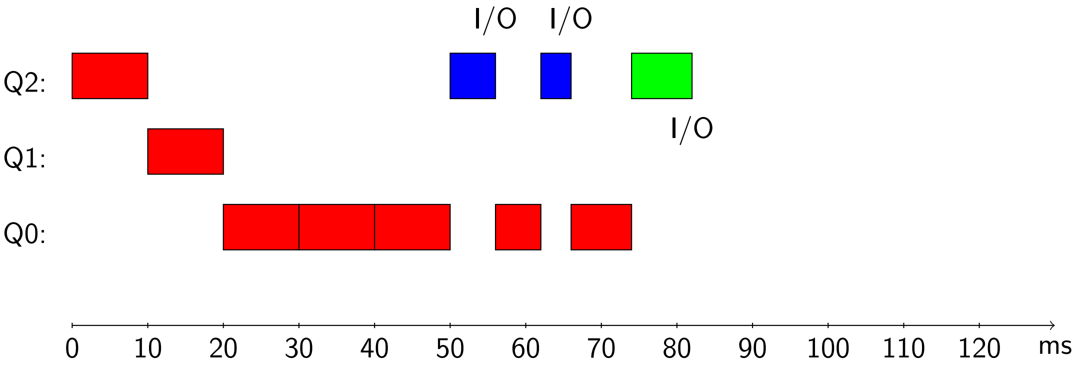

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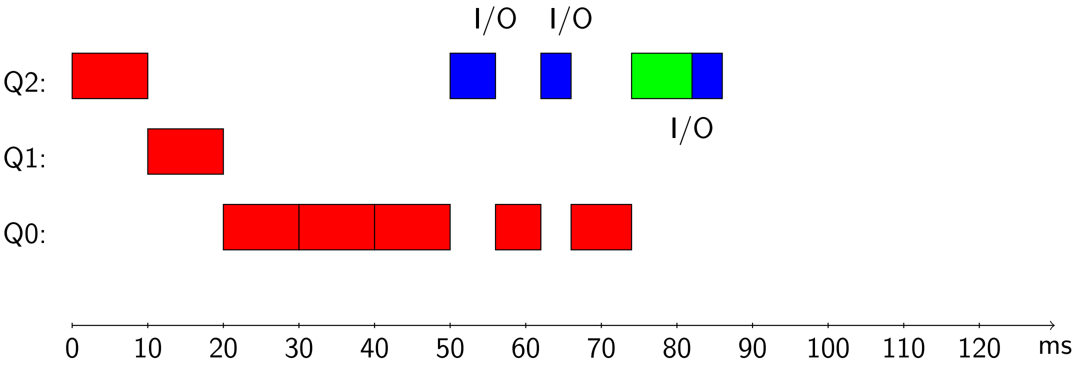

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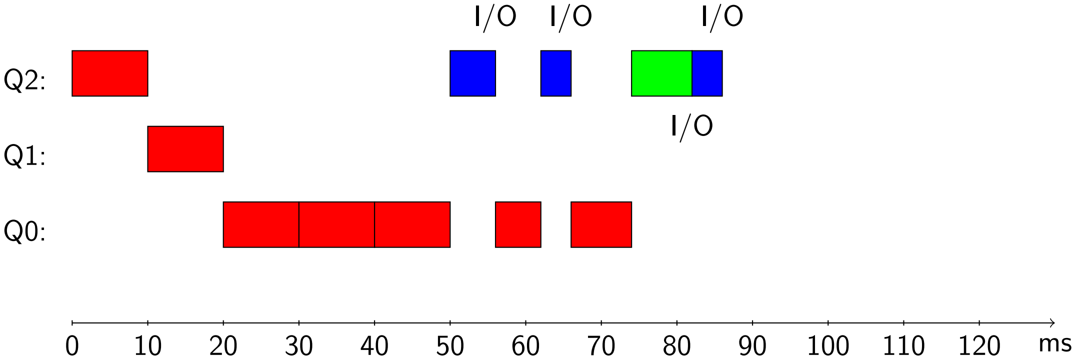

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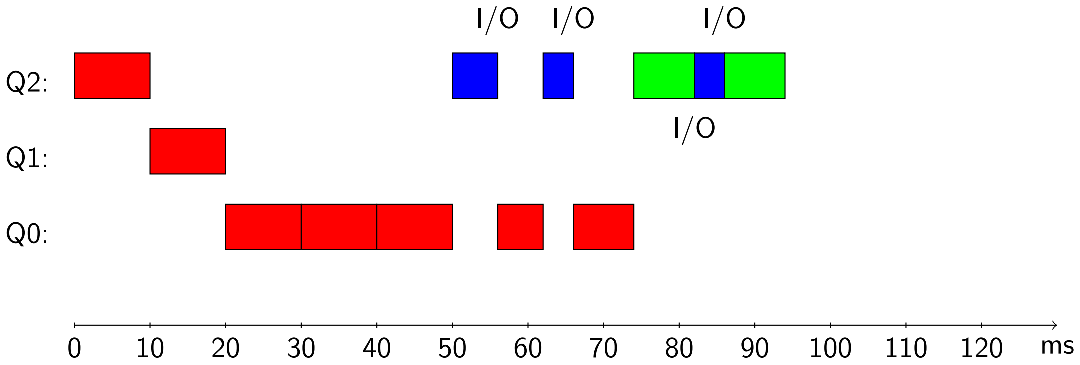

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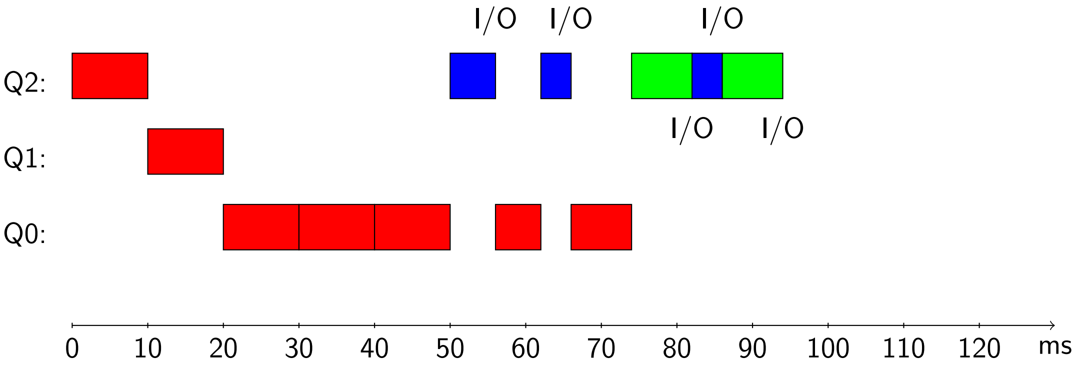

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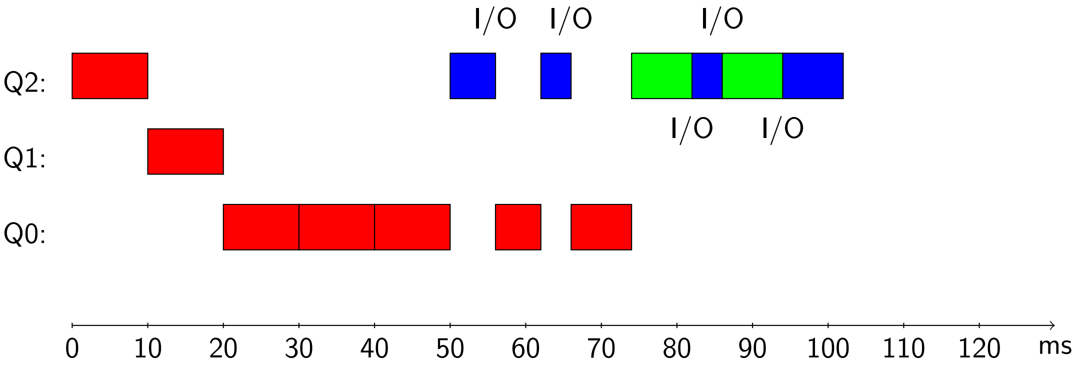

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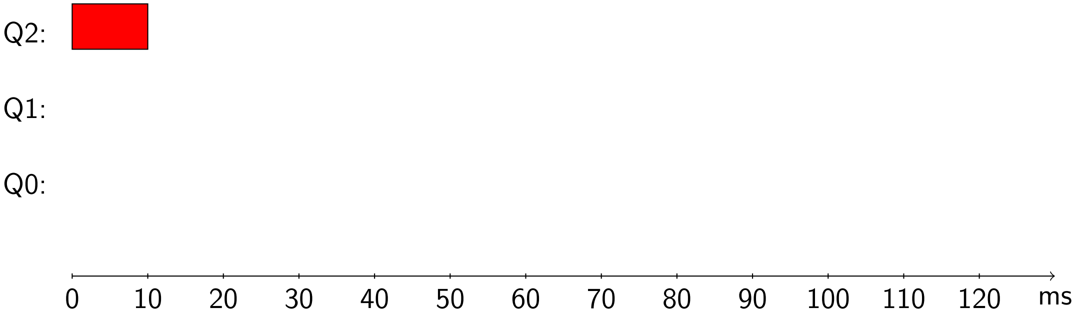

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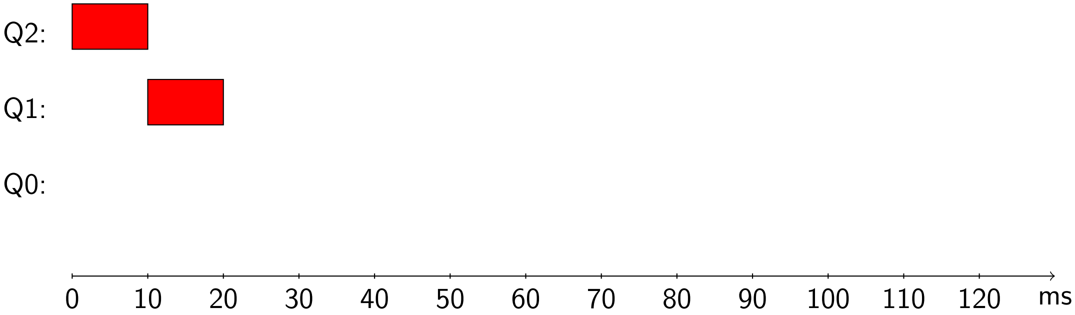

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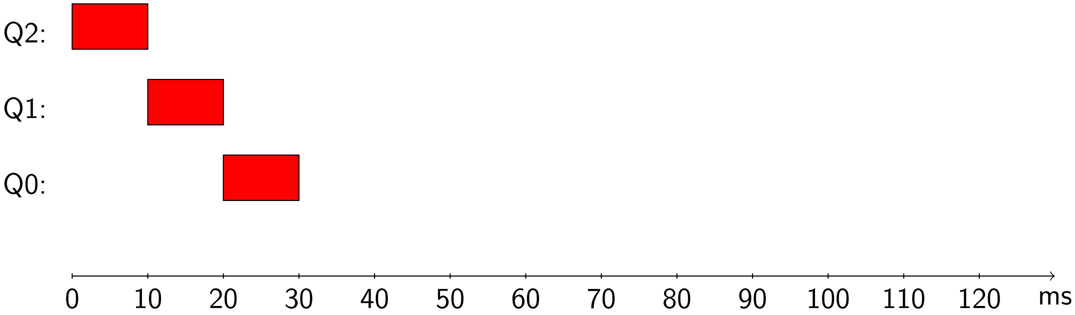

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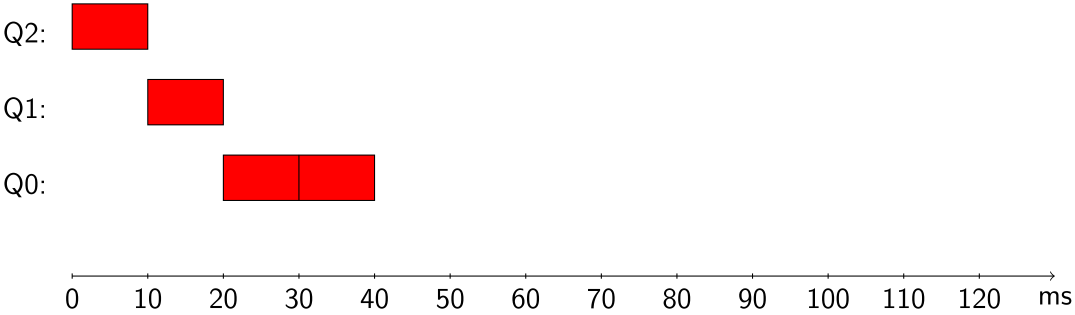

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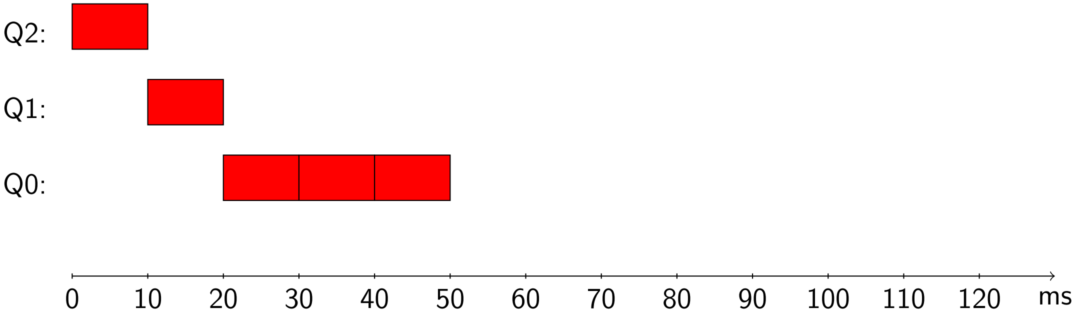

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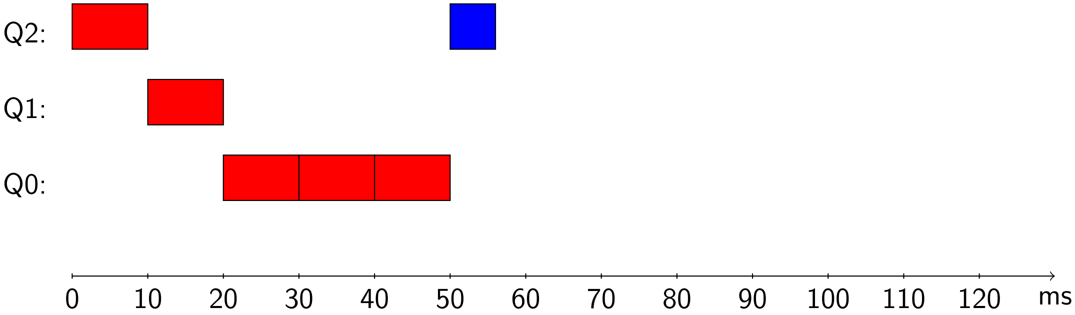

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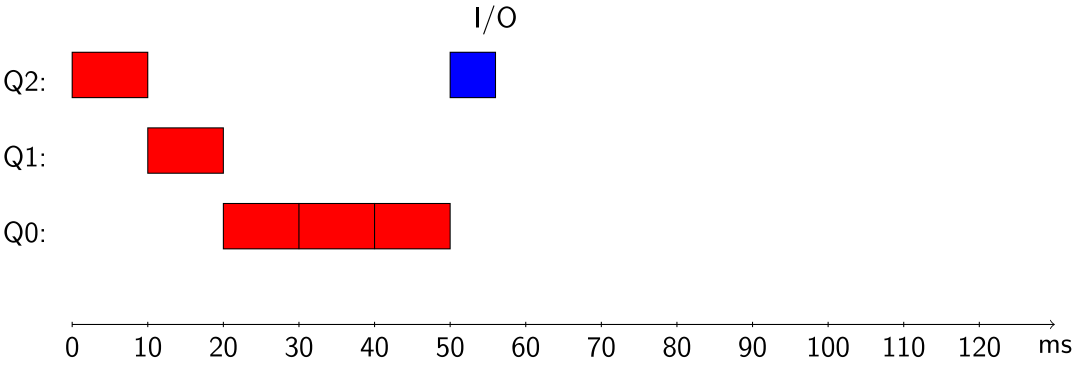

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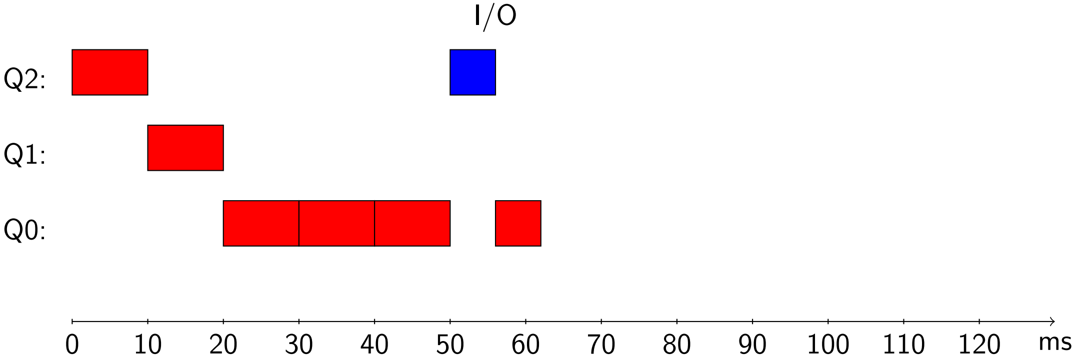

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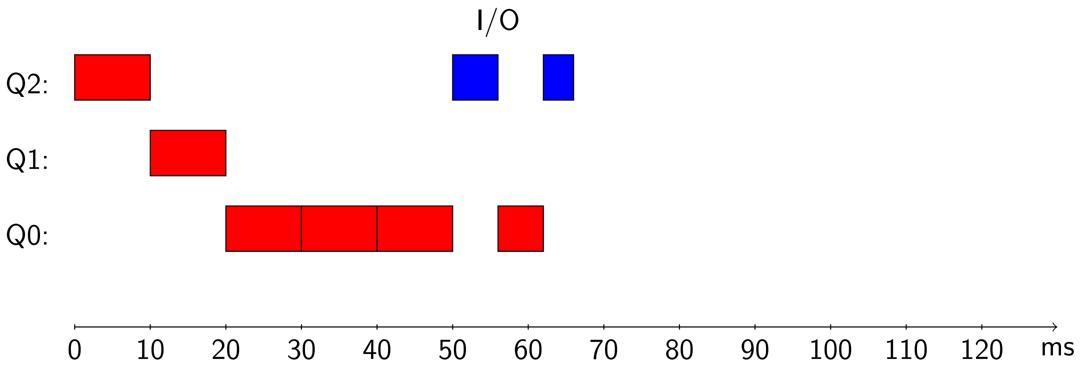

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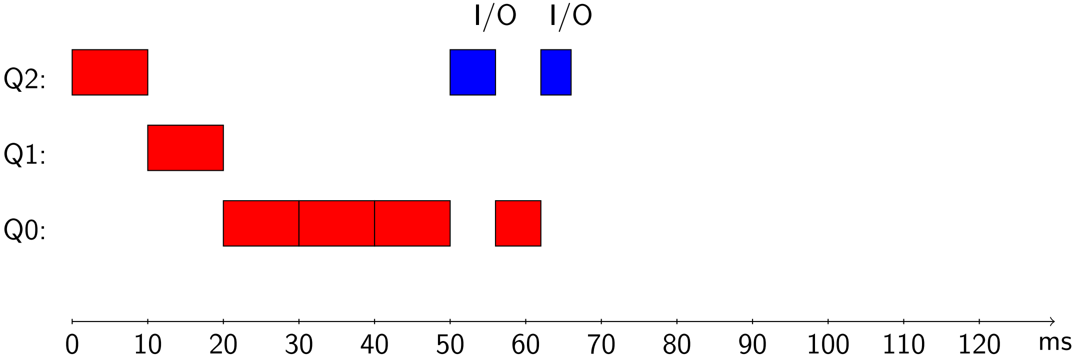

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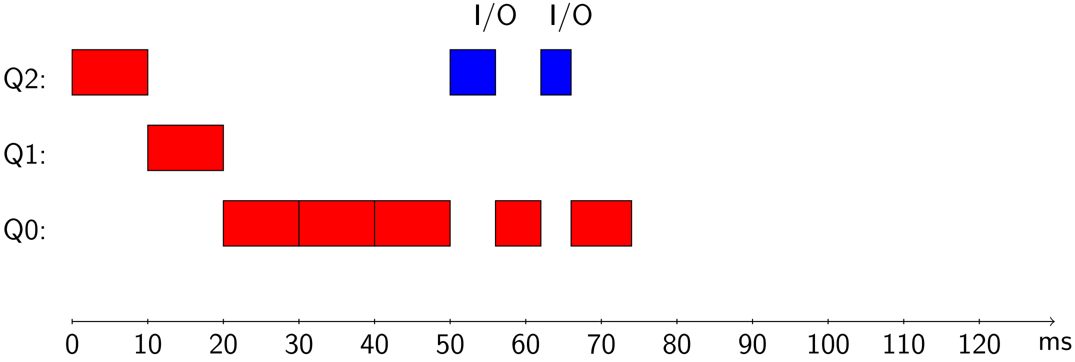

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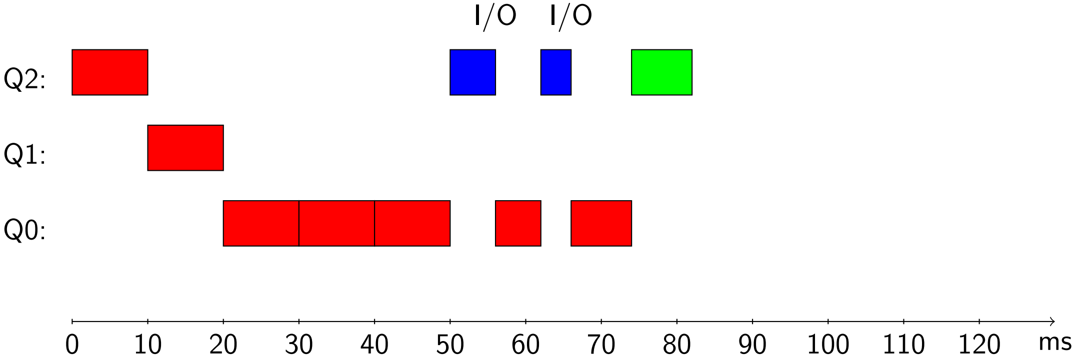

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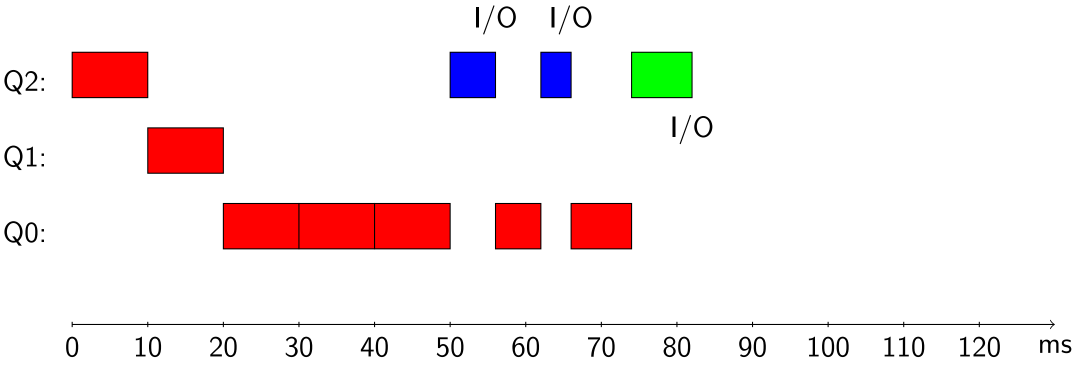

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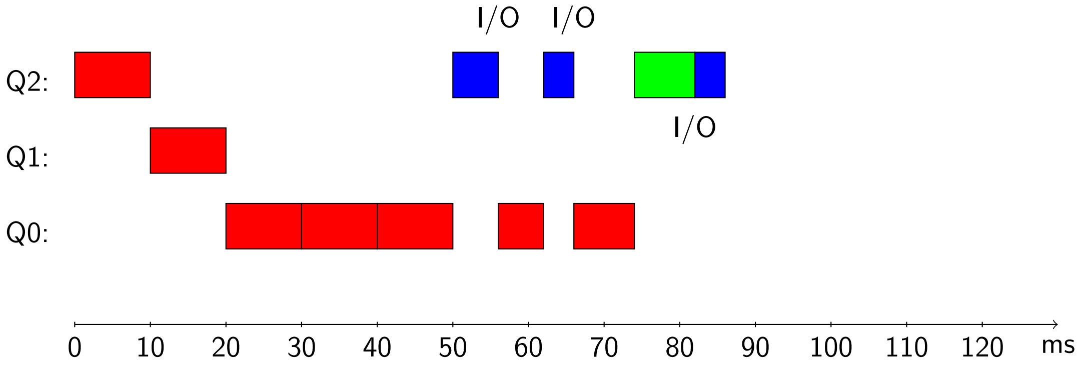

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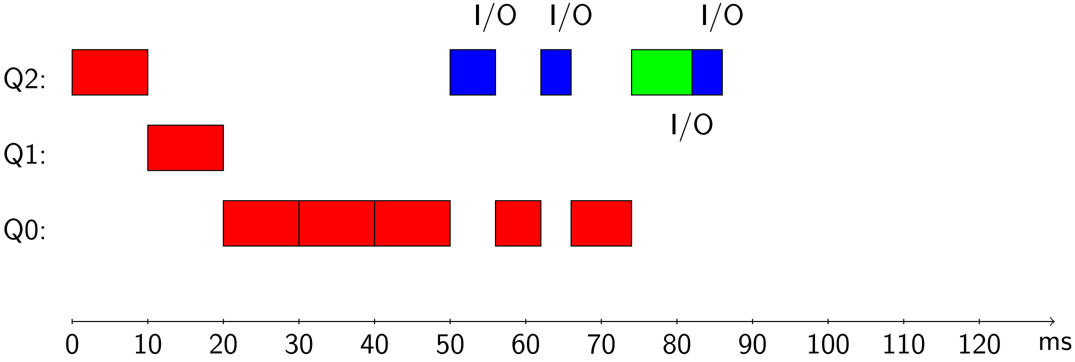

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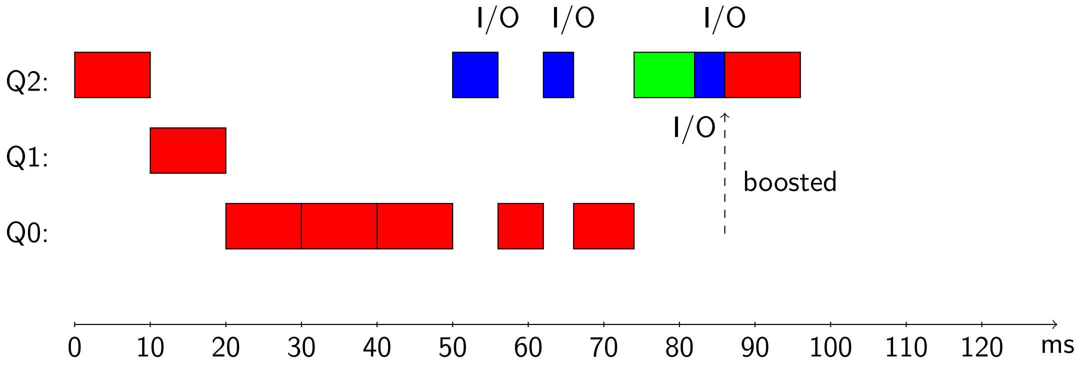

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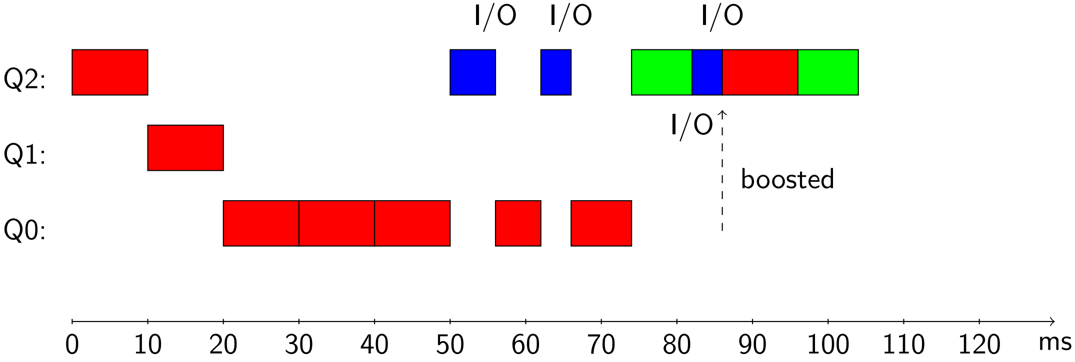

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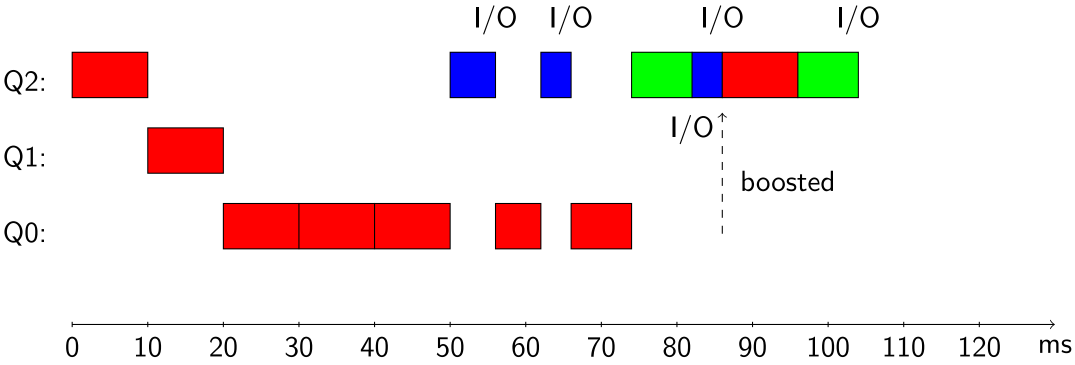

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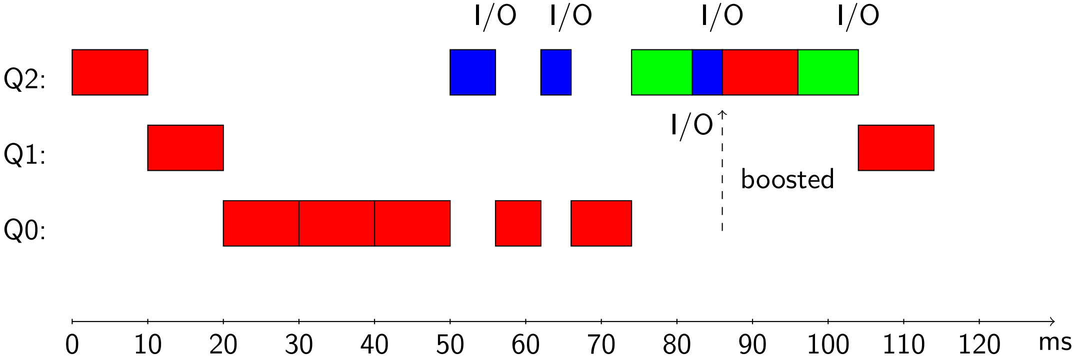

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- Rule 4a: a job that has to be preempted (time-slice consumed) is moved to a lower priority.
- Rule 4b: a job that initiates a I/O-operation (or yields) remains on the same level.
- Rule 5: after some time, move a job to the highest priority.

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let's try this

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tune the scheduler

Setting the parameters:

tune the scheduler

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- How long is a time slice?
- How many queues should there be?
- How long time should a allotted time be in a specified queue?
- How often should a job be boosted to the highest priority?

Change the perspective

What if:

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Give each job fair share.


METALLICA
...AND JUSTICE FOR ALL

Proportional share

Let's have a lottery:

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We divide the tickets among the jobs: A - 35 tickets, B - 15 tickets and C - 50 tickets.

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- We can give a *user* a set of tickets and allow the user to distribute them among its jobs.
- Each user can have its local tickets and then have a local lottery.
- We could allow each user to create new tickets, i.e. inflation, if we trust each other.

How to implement?

Stand in line

- Each job is given a number that represents the number of tickets it owns.
- All jobs are lined up i a row.
- Pick a random number from zero to the total number of tickets.
- Walk down the line and select the winner.

How does this work?

Why random?

A deterministic approach: stride scheduling

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A low stride value will make it more likely to be scheduled soon again.

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We often have real-time requirements that are simply met since we happen to have the available resources.

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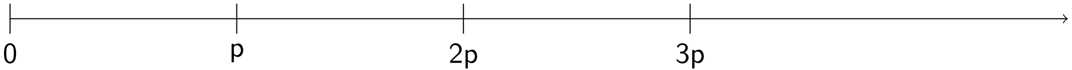

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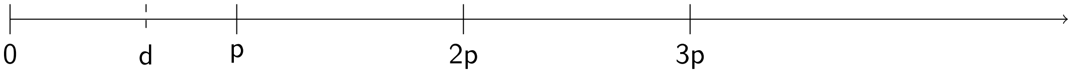

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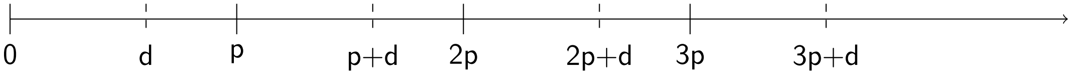

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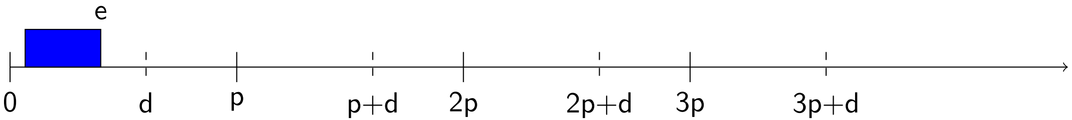

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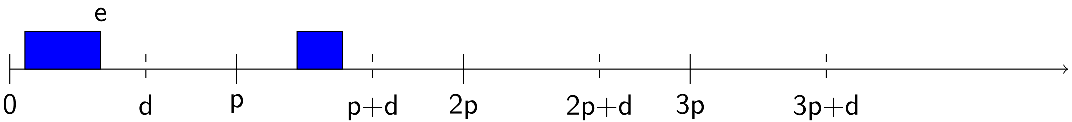

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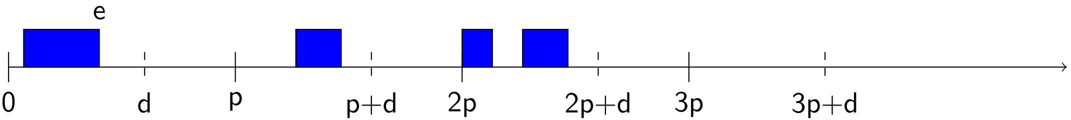

$d < p$: *constrained*, $d = p$ *default*, $d > p$ *several out-standing*

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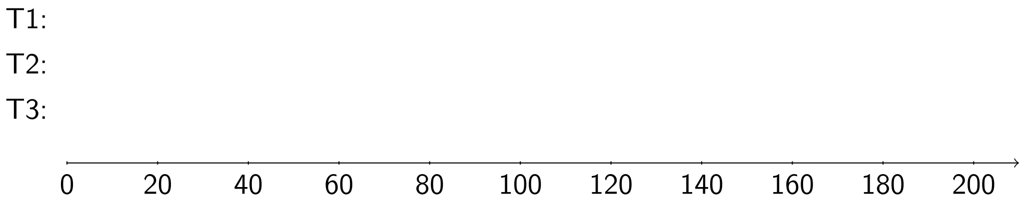

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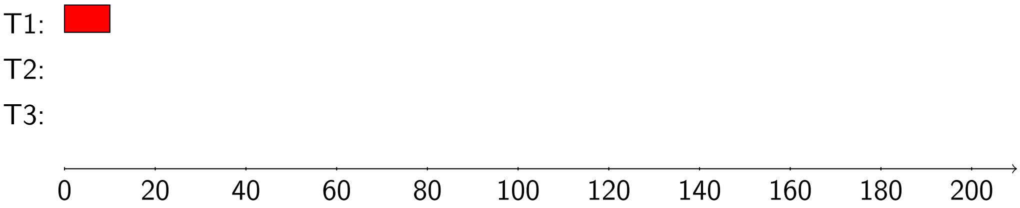

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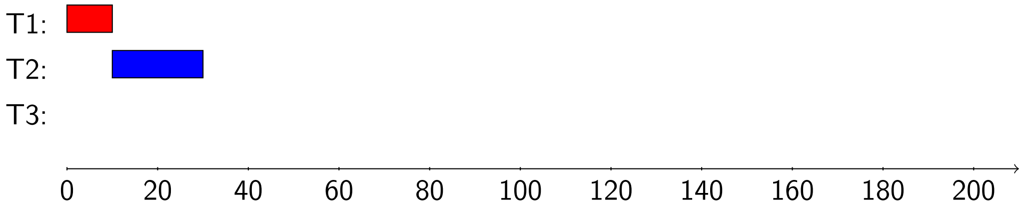

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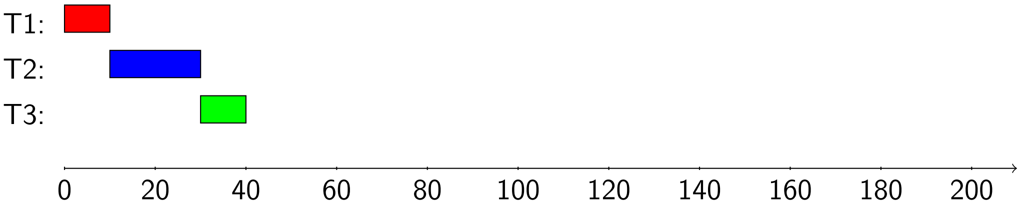

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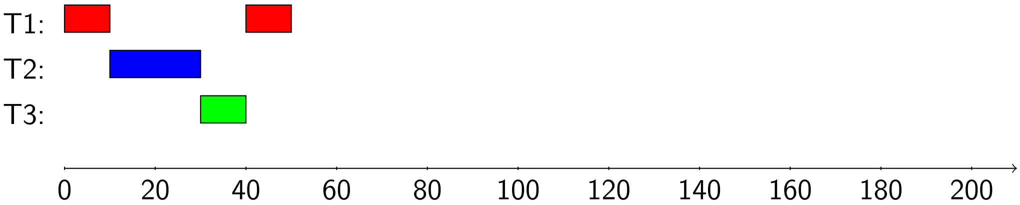

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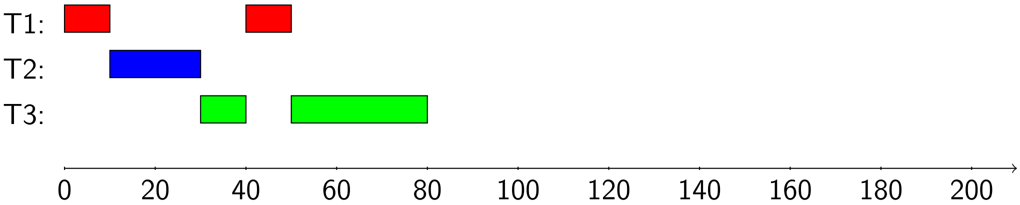

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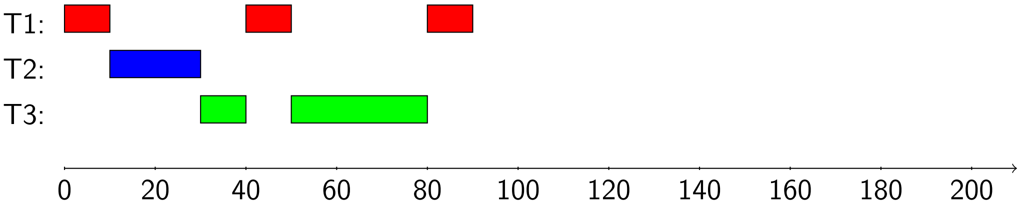

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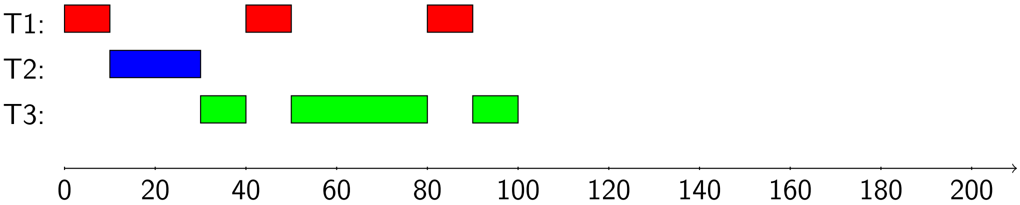

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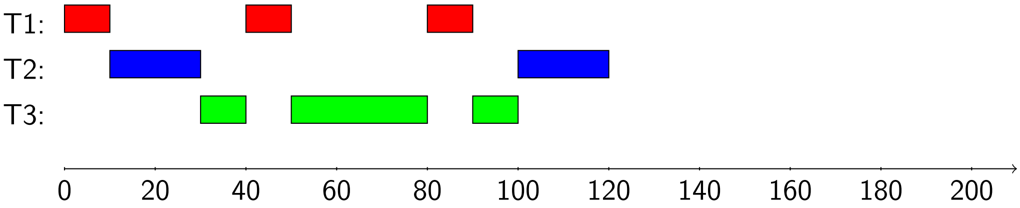

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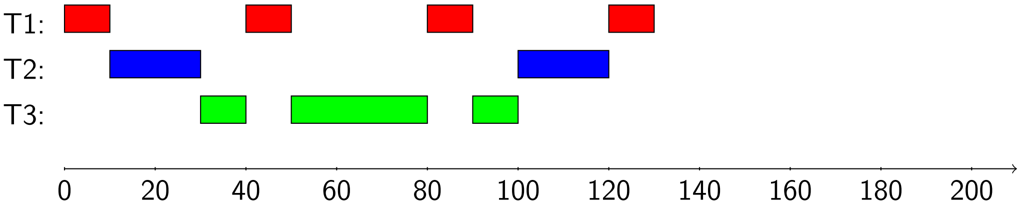

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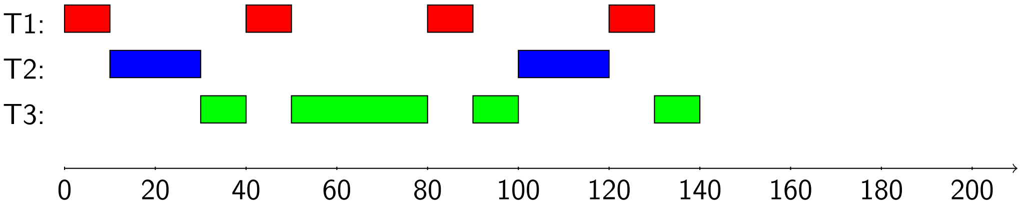

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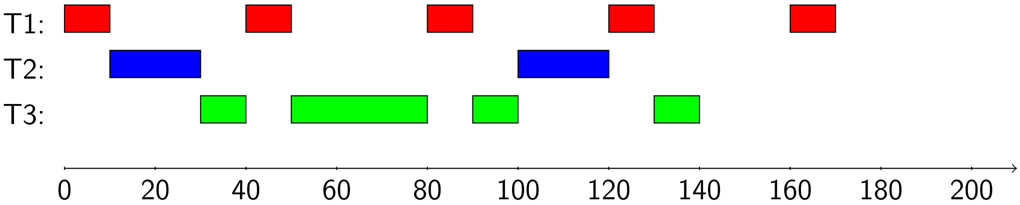

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Given that $p = d$ i.e. a task must be completed within its period.

- Rate Monotonic Scheduling (RMS):
  - Schedule the avilable task with the shortest period
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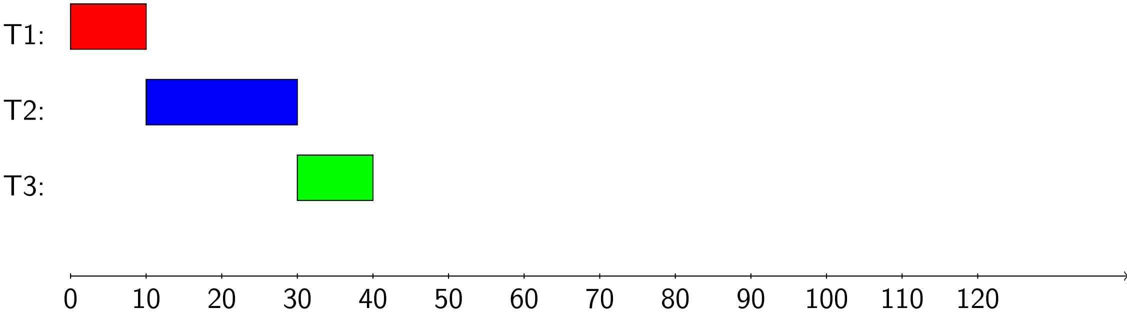

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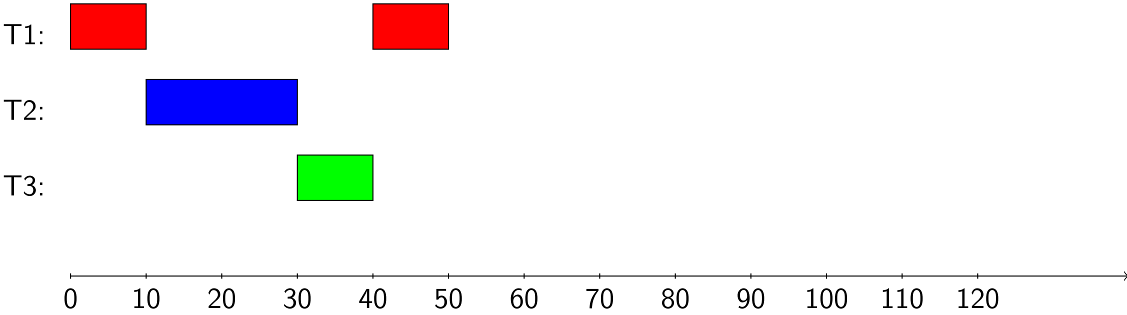

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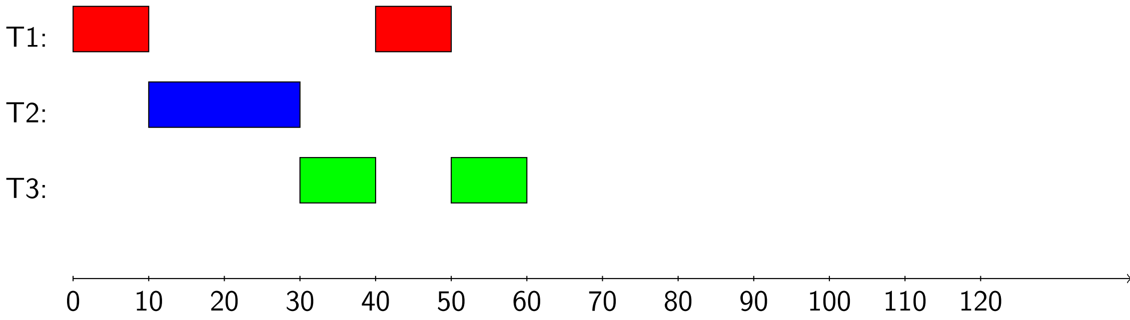

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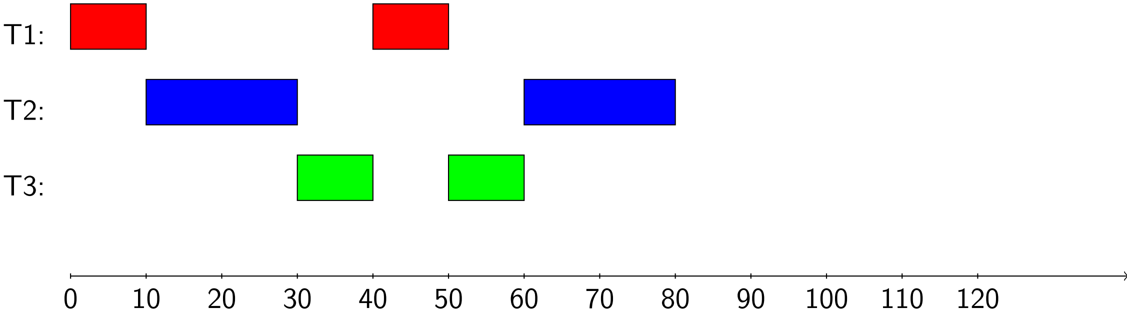

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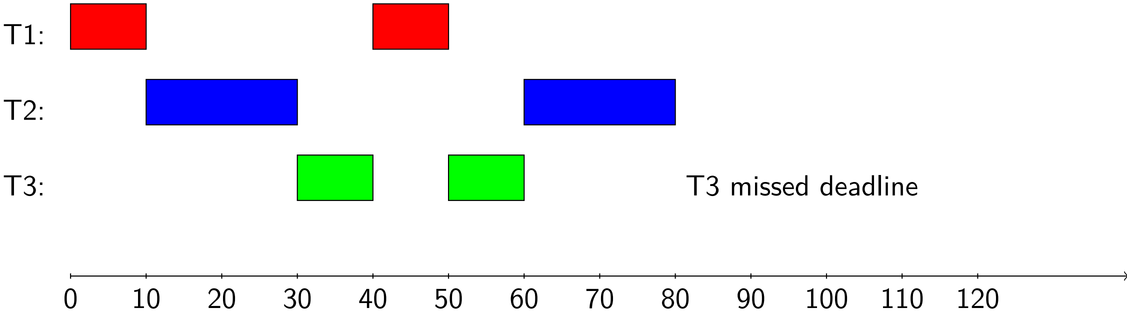

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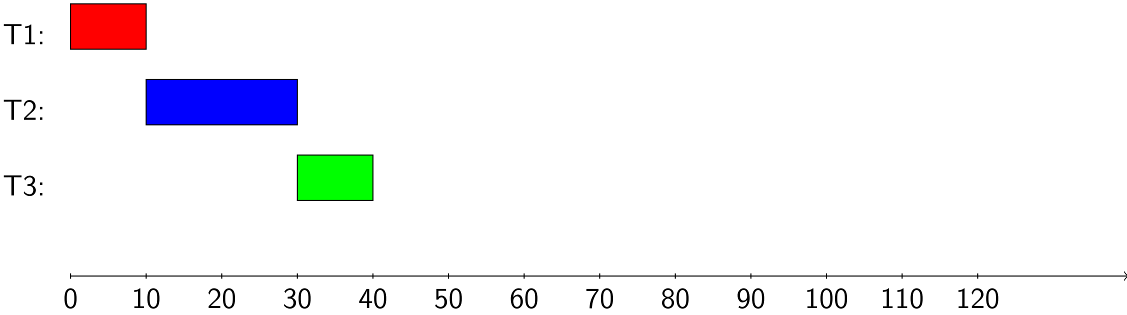

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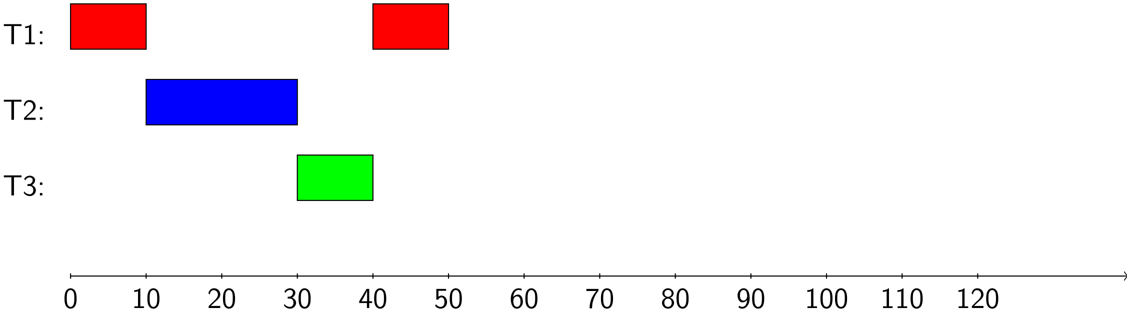

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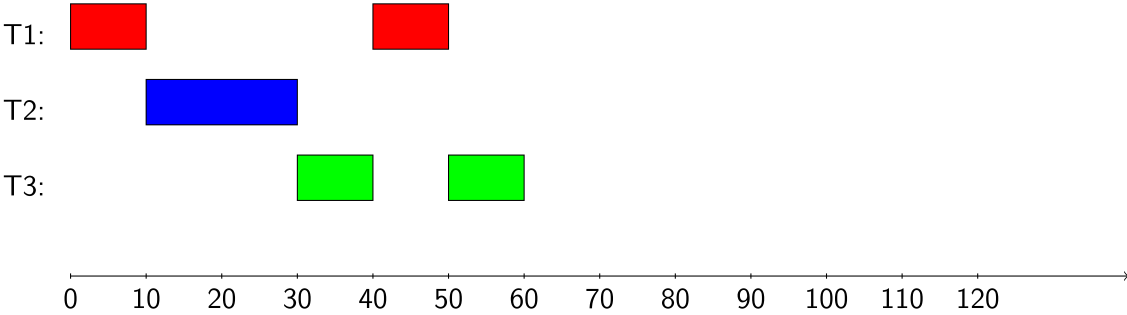

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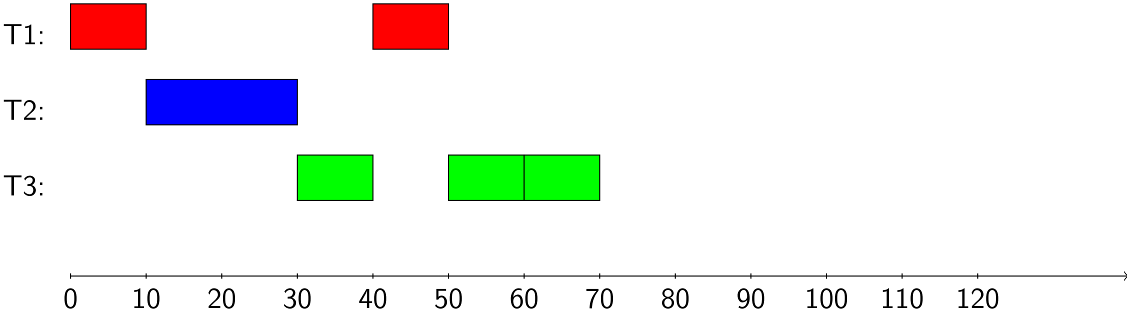

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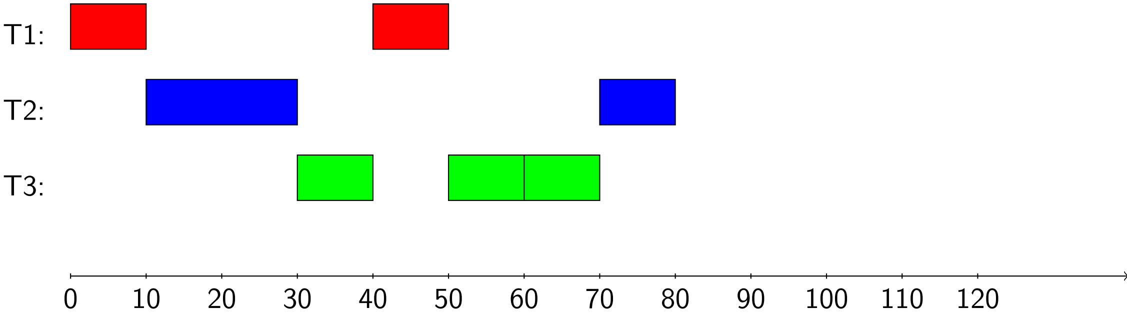

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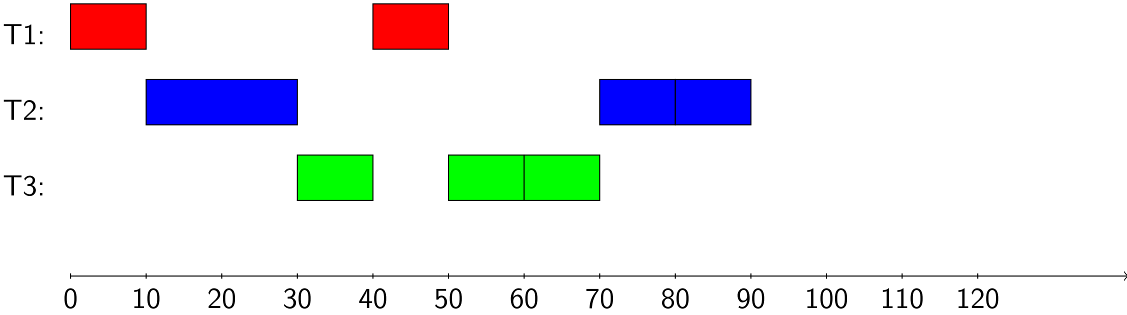

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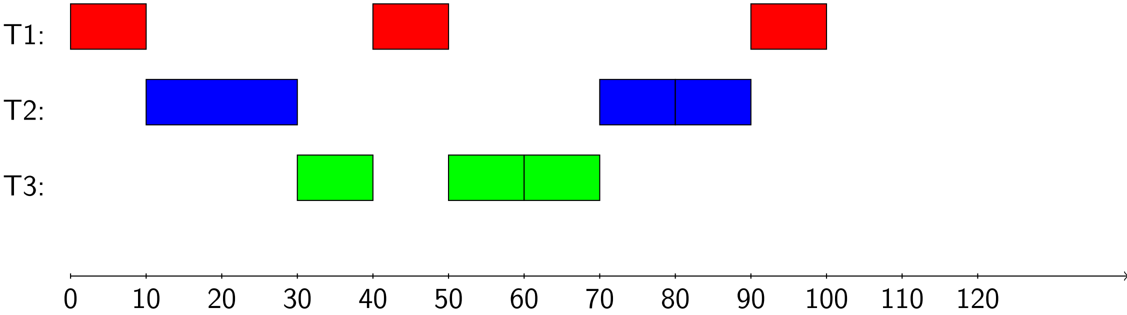

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What happens when we have critical resources that are protected by locks?

Multi-core architectures

Scheduling for a multi-core architecture more problematic (or rather more problematic to achieve high utilization).

Why?

Scheduling in Linux

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- BF scheduler: no I will not tell you what it stands for.

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- Linux: Completely Fair Scheduler, schedules in $O(lg(n))$ time, similar to stride scheduling.