## Liu & Layland Test :

'if CPU utilization > max CPU utilization then tasks are not schedulable.

$$\text{Max CPU utilization} = n * (2^{1/n} - 1)$$

where n – no. of task

- for multiple task (n) – max CPU utilization = 69.3%

## Liu & Lehockzy test :—

if According Liu & Layland test, tasks are not schedulable then try scheduling of tasks for at least one hyper period. If tasks are schedulable in first hyper period then your task are schedulable

# RMA

| CPU | Burst | Deadline | Period |
|---|---|---|---|
| P1 | 20 | 100 | 100 |
| P2 | 30 | 150 | 150 |
| P3 | 90 | 200 | 200 |

Hyper period = LCM(100, 150, 200)

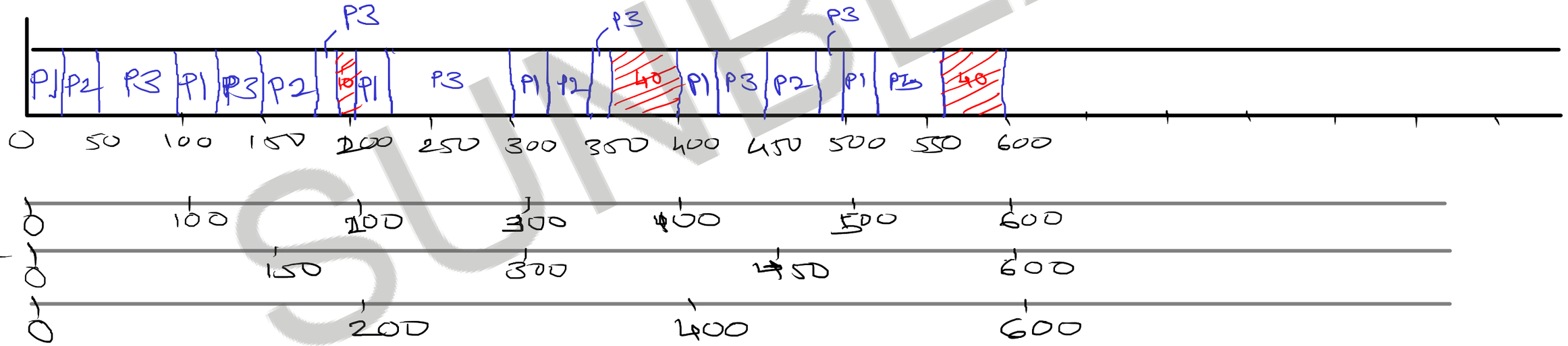
= 600

$$\text{Priority} \propto \frac{1}{\text{Period}}$$

P1 > P2 > P3

(H) (L)

Release point (phase) = 0




CPU utilization = $\frac{510}{600} = 0.85 = 85\%$

# DMA

| | CPU Burst | Deadline | Period |
|---|---|---|---|
| P1 | 3 | 7 | 20 |
| P2 | 2 | 4 | 5 |
| P3 | 2 | 9 | 10 |

if deadline is not given, then it will behave like RMA

$$\text{CPU Utilization} = \frac{3}{20} + \frac{2}{5} + \frac{2}{10} = 0.75$$

$$\text{Max CPU Utilization} = 3*(2^{1/3} - 1) = 0.78$$

Hyper period = LCM(20, 5, 10) = 20

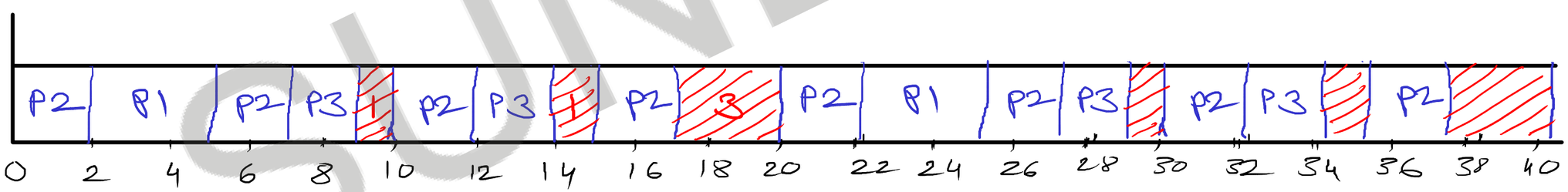
$$\text{priority} \propto \frac{1}{\text{deadline}}$$

P2 > P1 > P3

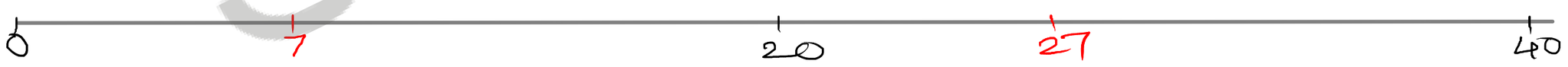
(H) (L)

Fixed / static

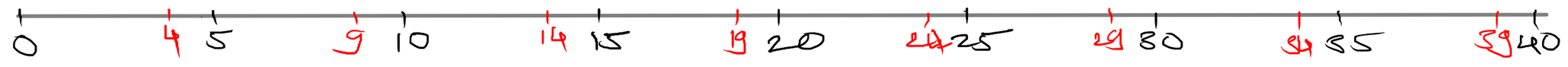
Release point = 0



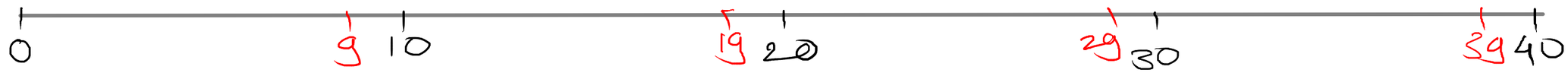

(3) P1




(2) P2




(2) P3




$$\text{CPU Utilization} = \frac{15}{20} = 0.75 = 75\%$$

# EDF

| | CPU Burst | Deadline | Period |
|---|---|---|---|
| **P1** | 20 | 50 | 50 |
| **P2** | 35 | 80 | 80 |

$$\text{CPU Utilization} = \frac{20}{50} + \frac{35}{80} = 0.84$$

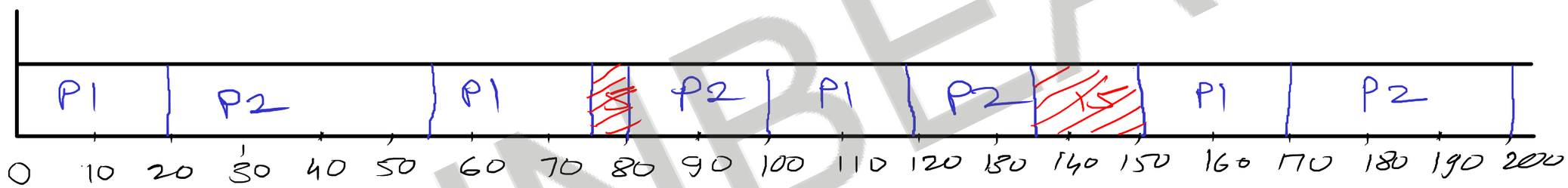
Max CPU Utilization = 0.82

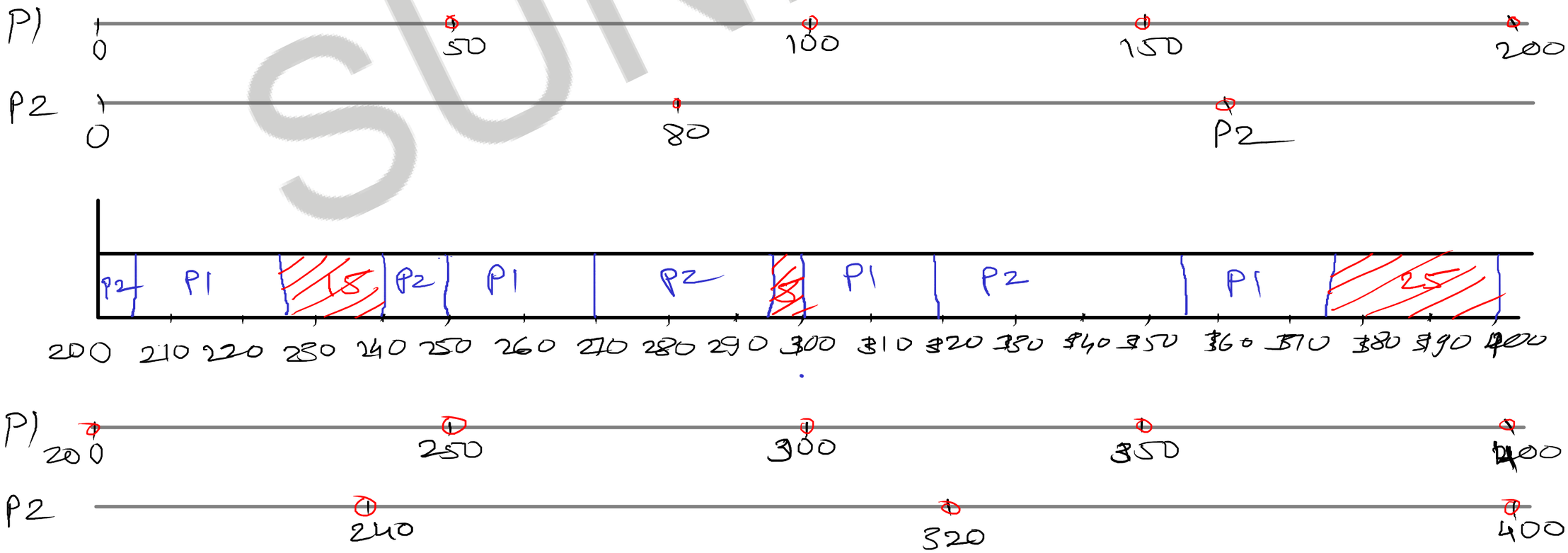
Hyper Period = LCM (50, 80)
= 400

Release Point = 0

Priority – earliest deadline first
Dynamic

$\frac{335}{400}$



# LSTF

Least Slack Time (Laxity) First

**slack time = Deadline - real time wrt cycle - remain time**

| | CPU Burst | Deadline | Period |
|---|---|---|---|
| **P1** | 3 | 7 | 20 |
| **P2** | 2 | 4 | 5 |
| **P3** | 2 | 8 | 10 |

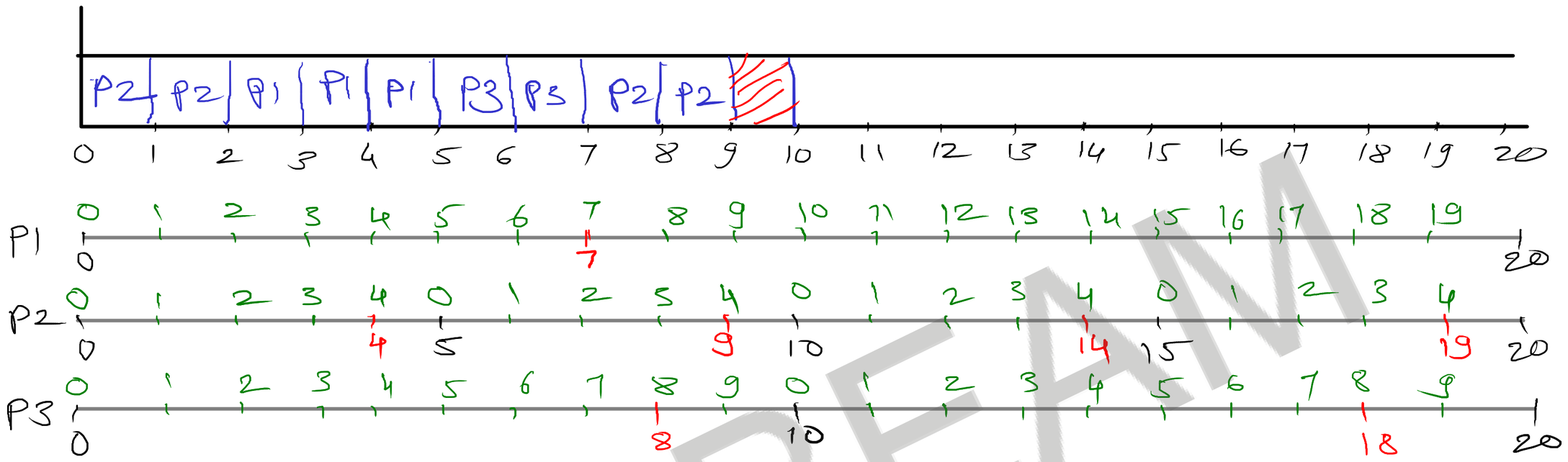
$$\text{CPU Utilization} = \frac{3}{20} + \frac{2}{5} + \frac{2}{10} = 0.75$$

$$\text{Max CPU Utilization} = 3*(2^{1/3} - 1) = 0.78$$

Hyper period = LCM(20, 5, 10) = 20

Release Point = 0

- slack time will be calculated at every 1 unit time
- slack time is going to vary, so priorities will also vary
  dynamic
- the process whose slack time is less will highest priority




Slack time = deadline − real time − remaining time

time 0: P1 = 7 − 0 − 3 = 4
P2 = 4 − 0 − 2 = 2 (1)
P3 = 8 − 0 − 2 = 6

time 1: P1 = 7 − 1 − 3 = 3
P2 = 4 − 1 − 1 = 2 (0)
P3 = 8 − 1 − 2 = 5

time 2: P1 = 7 − 2 − 3 = 2 (2)
P3 = 8 − 2 − 2 = 4

time 3: P1 = 7 − 3 − 2 = 2 (1)
P3 = 8 − 3 − 2 = 3

time 4: P1 = 7 − 4 − 1 = 2 (0)
P3 = 8 − 4 − 2 = 2

time 5: P2 = 4 − 0 − 2 = 2
P3 = 8 − 5 − 2 = 1 (1)

time 6: P2 = 4 − 1 − 2 = 1
P3 = 8 − 6 − 1 = 1 (0)

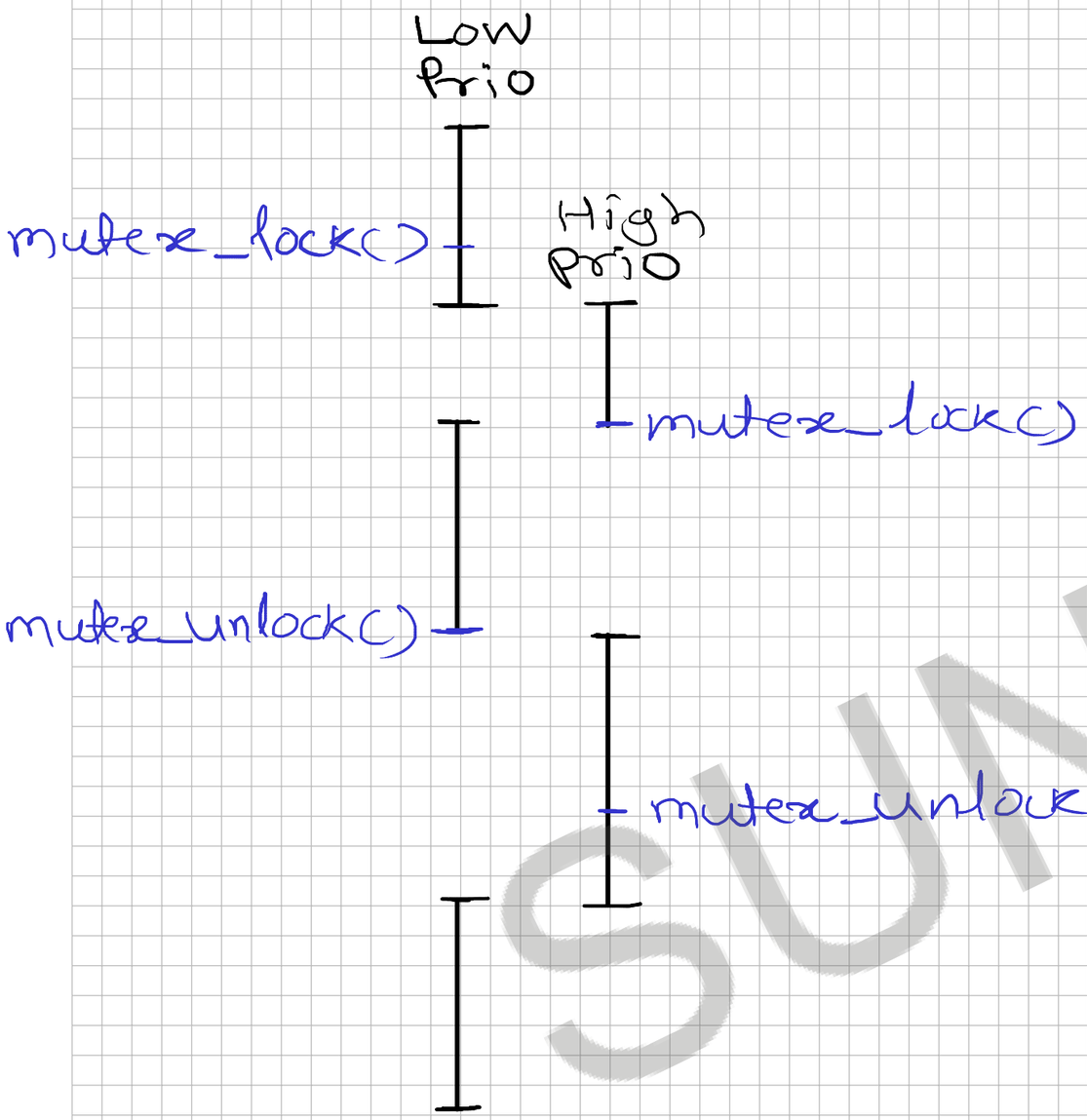
time 7: P2 = 4 − 2 − 2 = 0 (1)

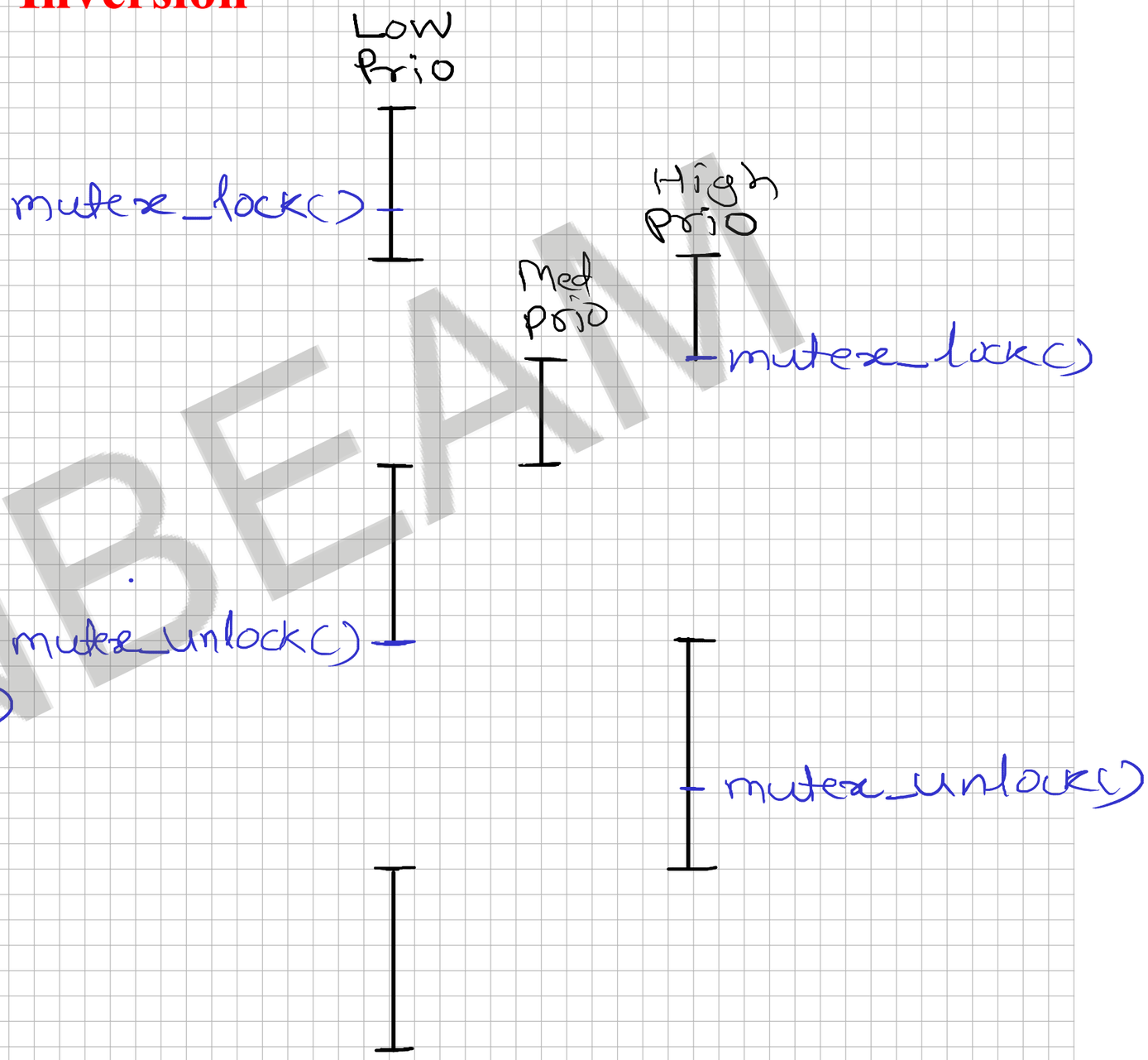
time 8: P2 = 4 − 3 − 1 = 0 (0)

time 9:

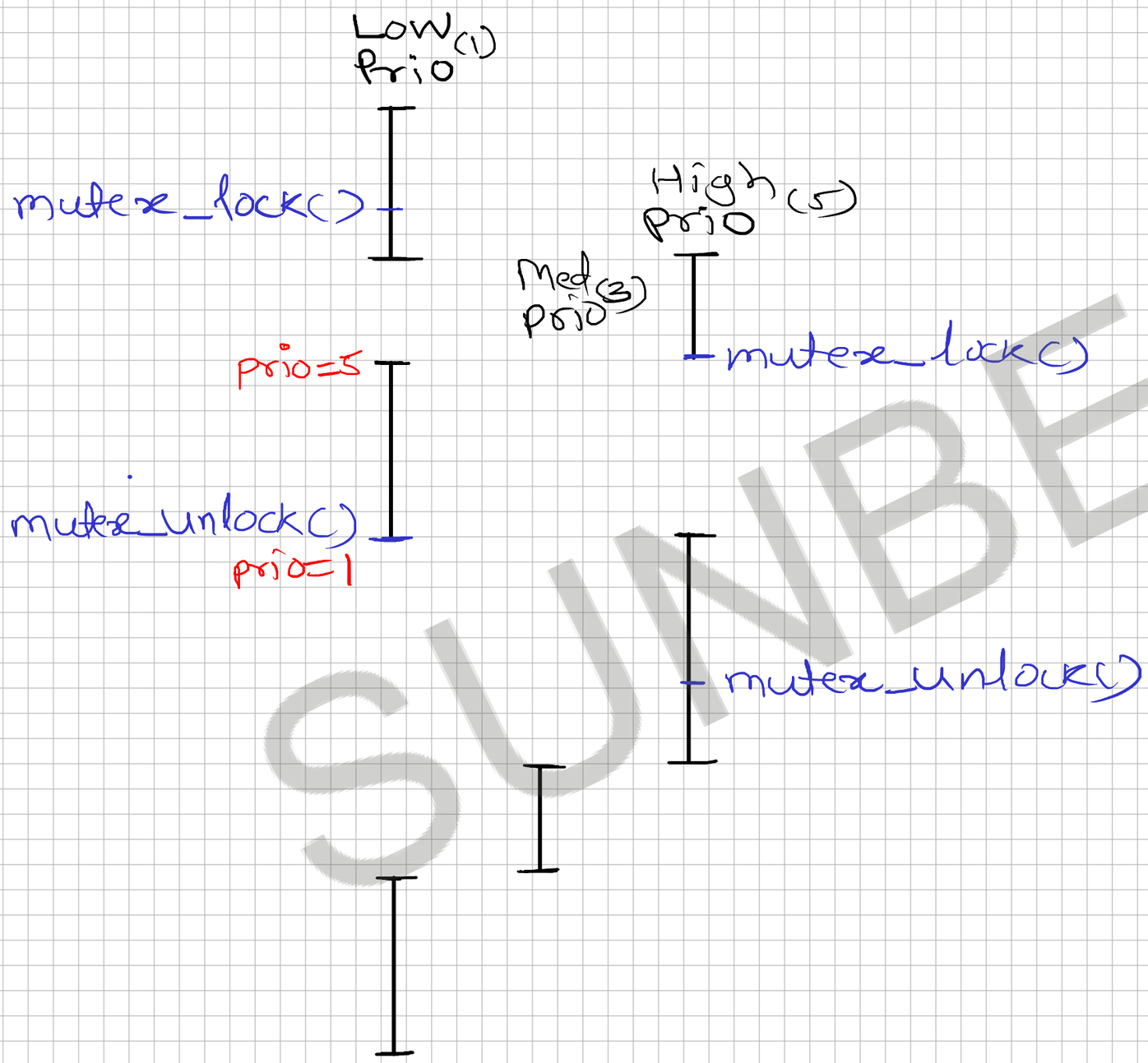
time 10: P2 =
P3 =

# Priority Inversion

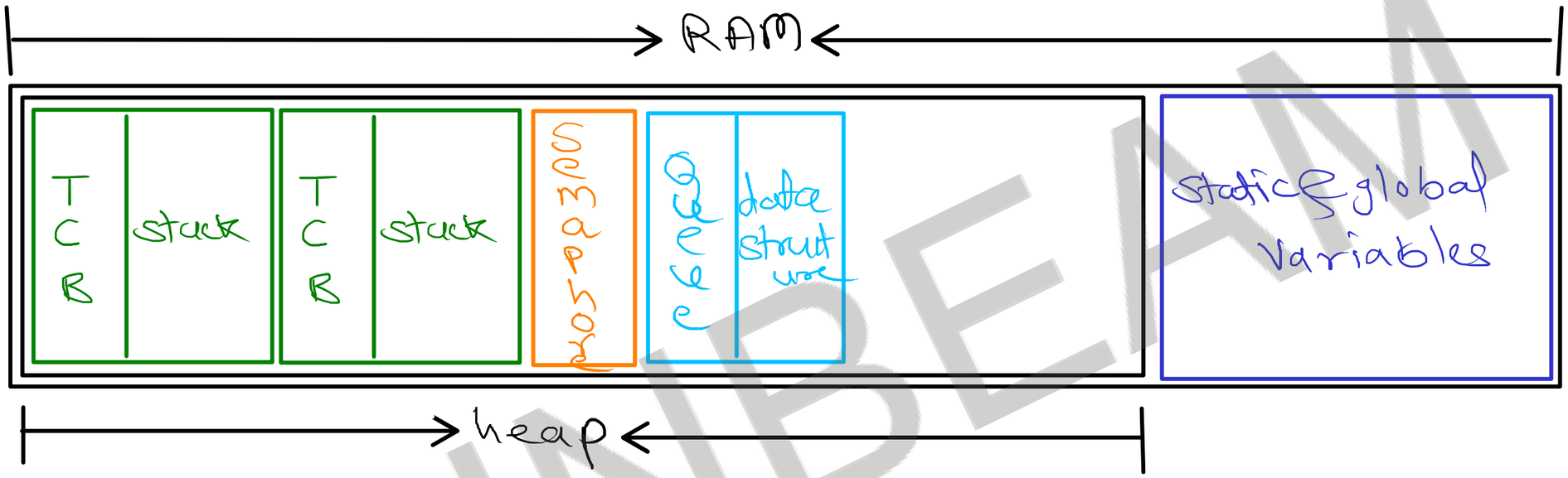


# Priority Inheritance / Priority Ceiling



# Memory Management

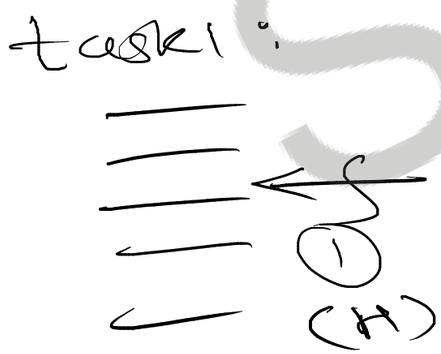


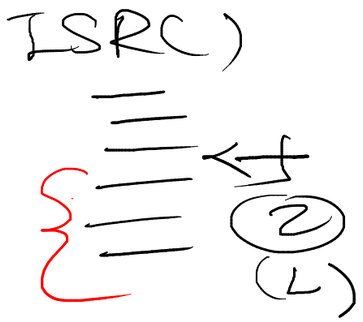
Ratio : $\frac{\text{task execution + intr handling}}{\text{task execution time}}$ — intrupt latencies (o)

close to 1

$$\text{CPU load} = \sum \frac{\text{task load}}{} + \sum \text{Kernel} + \sum \frac{\text{intr latencies}}{\text{ISR}}$$

$$\frac{\text{Worst case execution time}}{\text{min/avg case execution time}}$$




intr jitter