Exercise 9

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1 Task 1

1.1 Why do we assign priorities to tasks?

We assign priorities to establish a hierarchy of importance. Processes that pertain to the OS, kernel, etc should have a higher priority than user-generated processes.

1.2 What features must a scheduler have for it to be usable for real-time systems?

For a scheduler to be useful in analysis of the system it needs to be predictable.

2 Task 2

2.1 Without priority inheritance

Task	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
a					E							Q	V	E	
b			E	V		V	E	E	E						
c		E	Q							Q	Q				E

2.2 With priority inheritance

Task	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
a					E			Q		V	E				
b			E	V					V			E	E	E	
c		E	Q			Q	Q								E

3 Task 3

3.1 Priority inversion

3.1.1 What is priority inversion?

If a high-priority task and a low-priority task shares the same resource, the high-priority task can end up waiting for the low-priority task, this is called priority inversion.

3.1.2 What is unbounded priority inversion?

Unbounded priority inversion is when another task is preventing the low-priority task from releasing the resource, and the high-priority task ends up waiting forever.

3.2 Does priority inheritance avoid deadlocks?

Priority inheritance does not prevent deadlocks.

4 Task 4

4.1 The simple task model

Assumptions:

- Tasks that are periodic, and with known times.
- A fixed set of tasks
- No overhead
- Independent tasks

Most of these fairly realistic, but some require some workaround.

4.2 Utilization test

For the task set to be schedulable $U \leq n(2^{\frac{1}{n}} - 1)$ needs to be true. Utilization test:

$$U = \sum_{i=1}^{n} \frac{C_i}{T_i} = \frac{5}{20} + \frac{10}{30} + \frac{15}{50} = \frac{53}{60} \approx 0.8833$$

$$n(2^{\frac{1}{n}} - 1) = 3(2^{\frac{1}{3}} - 1) \approx 0.7798$$

$$0.8833 \not\leq 0.7798$$

The test fails, so we do not know if the task set is schedulable.

4.3 Response-time analysis

4.3.1 Task c

$$w_0 = 5$$

$$R_c = 5 \leq 20 \tag{1}$$

4.3.2 Task b

$$w_0 = 10$$

$$w_1 = 10 + \left\lceil \frac{10}{20} \cdot 5 \right\rceil = 15$$

$$w_2 = 10 + \left\lceil \frac{15}{20} \cdot 5 \right\rceil = 15$$

$$R_b = 15 \leq 30 \tag{2}$$

4.3.3 Task a

$$w_0 = 15$$

$$w_1 = 15 + \left\lceil \frac{15}{30} \cdot 10 \right\rceil + \left\lceil \frac{15}{20} \cdot 5 \right\rceil = 30$$

$$w_2 = 15 + \left\lceil \frac{30}{30} \cdot 10 \right\rceil + \left\lceil \frac{30}{20} \cdot 5 \right\rceil = 35$$

$$w_3 = 15 + \left\lceil \frac{35}{30} \cdot 10 \right\rceil + \left\lceil \frac{35}{20} \cdot 5 \right\rceil = 45$$

$$w_4 = 15 + \left\lceil \frac{45}{30} \cdot 10 \right\rceil + \left\lceil \frac{45}{20} \cdot 5 \right\rceil = 50$$

$$w_5 = 15 + \left\lceil \frac{50}{30} \cdot 10 \right\rceil + \left\lceil \frac{50}{20} \cdot 5 \right\rceil = 50$$

$$R_a = 50 \leq 50 \tag{3}$$

From (1), (2) and (3) we can conclude that the task set is schedulable. The reason that the results from task 2 and this one are in disagreement is because the utilization test is only sufficient, not necessary. However, the response-time analysis is both sufficient and necessary.