CPEN 432: Homework Assignment 3

Deadline: 11:59 PM, 7 March, 2022

1 Fixed-Priority Scheduling [20 points]

A single on-board computer controls several features on a new car. The on-board computer plays music from a local hard-disk, and this task (τ_1) requires 20ms of time every 100ms. The GPS system (τ_2) that provides directions requires 30ms of execution time every 250ms. The one other task that runs on this computer manages the temperature and humidity in the car; this task (τ_3) is performed every 400ms and requires 100ms of execution each period. Tasks are scheduled using *rate monotonic* scheduling.

1. You are a new engineer on this project and you have been assigned the task of integrating an additional feature on this on-board computer. This feature, a traffic monitor, scans a special communications channel and identifies routes that are congested or under repair. The traffic monitor (τ_4), as it is currently implemented, runs for 100ms every 280ms. You need to determine if this task can be introduced without causing any deadline violations. If not, you need to instruct the feature engineers to redesign the traffic monitor and reduce its execution time (you cannot alter the frequency because it has been determined to provide drivers with sufficient time to change routes). What would your recommendation be?

2. Assume that only the original three tasks (τ_1, τ_2, τ_3) are running on the on-board computer. In a redesign stage, it is determined that these tasks need to update a display by sending some information over a data bus. This communication takes time but the display needs to be updated within the task's period. As a result, the relative deadlines for the three tasks need to be shortened and the tasks scheduled using *deadline monotonic* scheduling instead. For simplicity, all tasks will have their deadlines reduced by a factor f. In other words, the relative deadline D_i for task τ_i will become $D_i = f \cdot T_i$ where T_i is the period of the task. What is the smallest value of f such that the tasks will continue to meet their deadlines.

2 Resource Sharing [30 points]

Consider a periodic task set $\tau = \{\tau_1, \tau_2, \tau_3, \tau_4\}$ consisting of four tasks with three shared resources $\{R_1, R_2, R_3\}$, as summarized in the table below. The duration for which each

Task	C_i	T_i	Resources used
τ_1	4	10	R_1, R_2
τ_2	5	20	R_2, R_3
τ_3	10	35	R_3
τ_4	2	40	R_1

resource is used by the tasks is specified in another table below. Assume that a task

Resource	Duration
R_1	2
R_2	1
R_3	2

locks only one resource at a time, *i.e.*, there are no nested critical sections. Assume *implicit* deadlines. Can task set τ be scheduled to meet deadlines using

1. RM with NPP?
2. RM with PIP?
3. RM with PCP?
4. EDF with NPP?
5. EDF with PIP?
6. EDF with PCP?

In each case, explain your answer (*i.e.*, show the analysis steps) and, if your answer is no, specify which tasks may miss their deadlines.

Note: For resource sharing protocols where the blocking time is bounded by the length of a single critical section, when computing the blocking time, one time unit is subtracted from the length of the critical section. For example, in Equations 7.4 and 7.16 in the textbook, $\delta_{j,k} - 1$ is used instead of just $\delta_{j,k}$.