

## ECE 6970: Real-Time Systems Homework 3

Due March 29, 2007

(1) Consider an IRIS task set where all tasks have identical linear reward curves

$$r_i(t) = \begin{cases} 3t & \text{if } t \leq e_i \\ 3e_i & \text{if } t > e_i \end{cases}$$

and zero mandatory portions.  $e_i$  is the execution time of  $T_i$ , and  $u_i = e_i/P_i$  is its utilization. Find the average reward rate for this system, i.e.,

$$\lim_{t \rightarrow \infty} \frac{\text{Total reward gained up to time } t}{t}$$

(2) You have an IRIS task set, whose tasks have identical concave reward functions

$$r_i(t) = \begin{cases} 1 - e^{-at} & \text{if } t \leq 20 \\ 1 - e^{-20a} & \text{if } t > 20 \end{cases}$$

and zero mandatory portions ( $a$  is some constant). The maximum execution time of each task is  $e_i = 20$ . All four *non-periodic* tasks  $T_1, T_2, T_3, T_4$ , in this task set are released at time 0. The absolute deadlines of the tasks are 4, 6, 12, 16, respectively. Draw an optimal schedule, i.e., one which maximizes the total reward up to time 16. (Since the tasks are non-periodic, you only have to consider the iterations that are released at time 0.)

(3) This question deals with voltage scaling to reduce energy consumption. Recall that the energy consumption at  $v$  volts to execute any given task is  $Kv^2$ , where  $K$  is a constant of proportionality. Assume that the clock rate varies linearly with the supply voltage (e.g., doubling the supply voltage would allow you to double the clock frequency and thus halve the execution time for a given task).

You are given the following set of three periodic tasks:  $(e_i, P_i) = (1, 3), (1, 5), (2, 7)$ , where the execution times are those measured when the processor supply voltage is 2

volts. Your processor can be set to run at any voltage in the range  $V = [1.0, 2.0]$  volts; however, this setting must be static, i.e., it must be set at that voltage throughout the execution, and cannot be changed. (For example, it cannot be changed to reclaim time released by a task which has finished before its worst-case execution time.)

You are using the rate monotonic algorithm to schedule these tasks. What voltage level,  $v_\ell$ , would you pick to minimize the total energy consumed and still meet all deadlines? What would be the value of the following:

$$\frac{\text{Energy consumed at } v_\ell \text{ volts}}{\text{Energy consumed at 2 volts}}$$