CSIE 5452, Fall 2018 — Homework 2

Due November 12 (Monday) at Noon

Points may be deducted for solutions that do not show intermediate work.

1 Timing Analysis of TDMA-Based Protocols (28pts)

Following the assumptions (each time slot has the same length, each time slot serves exactly one frame, and a frame is transmitted only if the whole time slot is available) in the lecture, please compute the worst-case response time of the "asynchronous" message with the frame arrival pattern $(4, 10, 0, 1, 3, 6)$ and the schedule pattern $(2, 5, 0, 1)$ by completing the following steps.

1. (4pts) Please duplicate the schedule pattern (hint: $(4, 10, 0, 1, \ldots)$). No intermediate work is needed here.
2. (4pts) Please duplicate the arriving times of frames in the frame arrival pattern but fix $m = 4$ and $p = 10$. No intermediate work is needed here.
3. (4pts) Please duplicate the starting times of time slots in the schedule pattern but fix $n = 4$ and $q = 10$. No intermediate work is needed here.
4. (8pts) Please complete the following table:

k	$\max_{1\le j\le n}(s_{j+k} - s_j)$	=	$\min_{1\le i\le m}(a_{i+k-1} - a_i)$	=	(Column-3) − (Column-5)
1	$\max_{1\le j\le 4}(s_{j+1} - s_j)$		$\min_{1\le i\le 4}(a_i - a_i)$		
2	$\max_{1\le j\le 4}(s_{j+2} - s_j)$		$\min_{1\le i\le 4}(a_{i+1} - a_i)$		
3	$\max_{1\le j\le 4}(s_{j+3} - s_j)$		$\min_{1\le i\le 4}(a_{i+2} - a_i)$		
4	$\max_{1\le j\le 4}(s_{j+4} - s_j)$		$\min_{1\le i\le 4}(a_{i+3} - a_i)$		

5. (4pts) Please compute the worst-case response time (which is waiting time plus transmission time) of the message.
6. (4pts) Now, you can change the schedule pattern $(2, 5, 0, 1)$ to $(2, 5, 0, s)$ where $s \in \{2, 4\}$. Which one can minimize the worst-case response time of the message. No detailed computation is needed, but short explanation (hint: check the "Discussion" slide) is required.

2 MILP Linearization (24pts)

We will prove or make the following propositions are equivalent so that we can transform constraints to linear forms and thus apply the Mixed Integer Linear Programming (MILP). Note that "$\Longleftrightarrow$" denotes "equivalence" and "$\wedge$" denotes "logical conjunction" (AND).

1. (8pts) Given α, β, γ which are binary variables, prove

$$\alpha + \beta + \gamma \neq 2 \Longleftrightarrow \alpha + \beta - \gamma \leq 1 \wedge \alpha - \beta + \gamma \leq 1 \wedge -\alpha + \beta + \gamma \leq 1$$

by filling "T" (True) or "F" (False) in the following table (if LHS=RHS in all cases, then LHS and RHS are equivalent):

α	β	γ	LHS	$\alpha + \beta - \gamma \leq 1$	$\alpha - \beta + \gamma \leq 1$	$-\alpha + \beta + \gamma \leq 1$	RHS	LHS=RHS?
0	0	0						
0	0	1						
0	1	0						
0	1	1						
1	0	0						
1	0	1						
1	1	0						
1	1	1						

2. (8pts) Given α, β, γ which are binary variables, prove

$$\alpha\beta = \gamma \Longleftrightarrow \alpha + \beta - 1 \leq \gamma \wedge \gamma \leq \alpha \wedge \gamma \leq \beta$$

by filling "T" (True) or "F" (False) in the following table (if LHS=RHS in all cases, then LHS and RHS are equivalent):

α	β	γ	LHS	$\alpha + \beta - 1 \leq \gamma$	$\gamma \leq \alpha$	$\gamma \leq \beta$	RHS	LHS=RHS?
0	0	0						
0	0	1						
0	1	0						
0	1	1						
1	0	0						
1	0	1						
1	1	0						
1	1	1						

3. (8pts) Given β which is a binary variable, x, y which are positive real variables, and a constraint $x \leq 2018$, select a value of M to guarantee

$$\beta x = y \Longleftrightarrow 0 \leq y \leq x \wedge x - M(1-\beta) \leq y \wedge y \leq M\beta,$$

where you can refer to the following table:

β	LHS	$0 \leq y \leq x$	$x - M(1-\beta) \leq y$	$y \leq M\beta$	RHS
0	$0 = y$	$0 \leq y \leq x$	$x - M \leq y$	$y \leq 0$	$x - M \leq y = 0 \leq x$
1	$x = y$	$0 \leq y \leq x$	$x \leq y$	$y \leq M$	$0 \leq y = x \leq M$

3 Simulated Annealing for Priority Assignment (24pts)

Please download the benchmark "input1.dat" from the "Resources" area of Piazza. In the benchmark, the first number is n, the number of messages. The second number is τ. Each of the following lines contains the priority (P_i), the transmission time (C_i), and the period (T_i) of each message. Now, you are asked to use the Simulated Annealing to decide the priority of each message. The requirements are:

- The objective is to minimize the summation of the worst-case response times of all messages.
- The priority of each message must be an integer in the range $[0, n-1]$.
- The priority of each message must be unique.
- The worst-case response time of each message must be smaller than or equal to the period of each message.
- The given priorities are the initial solution in the Simulated Annealing.
- We expect the total runtime less than 15 seconds.

You are required to do three things in your submission:

1. You should print out n numbers (one number per line) representing the priorities of those messages. Note that you need to follow the message ordering in the benchmark, *e.g.*, the first number in the list is the priority of the first message in the benchmark.
2. You should print out 1 number representing your objective value (best one during your run). We do not expect an optimal solution in this problem.
3. You should also print out your source codes. We may ask you to provide your source codes which must be the same as those on your printout. If the worst-case response times above are correct but the source codes are clearly wrong implementation, it is regarded as academic dishonesty.

4 Realization of Level-X Autonomy (24pts)

In your opinion, when will be level-3/level-4/level-5 autonomy become realized? There will be no correct answers to these questions, and you can also answer them from many different perspectives including technology, cost, regulation, law, and human comfort. However, you should justify your answers with some explanation (*e.g.*, few sentences for each level). We will have discussion session after the midterm.

1. (8pts) Level 3.
2. (8pts) Level 4.
3. (8pts) Level 5.