Tutorial-4

CAN Scheduling

A processing unit (PU) has 5 tasks implemented in it. After completetion, they transmit messages through the CAN bus as described in the table. The Adaptive Cruise Control (ACC) feature is to be added to the PU. The ACC has two modes of operation: Cruise mode and Safe-distance mode. In cruise mode, the vehicle will run at pre-determined cruise speed when there is no obstacle within safe distance. It switches to safe-distance mode if there are obstacles (traffic) within safe distance and maintains speed less than or equal to cruise speed depending upon relative velocity of the front vehicle. Assume all the messages arrive with zero offset. The message from ACC task has transmission time as follows: Cruise Mode: 4 ms and Safe-distance mode: 6 ms. The ACC task runs at periodicity of 20 ms with static priority of 3. *After incorporating ACC feature, is the system schedulable in CAN? If not, which task(s) will miss the deadline?*

Messages	Transmission Time (ms)	Periodicity	Priority
M1	1	20	1
M2	4	20	2
M3	3	30	4
M4	2	30	5
M5	3	60	6

Since transmission time of ACC in safe mode (6 ms) is more than that of in cruise mode (4 ms), we consider only the safe mode in schedulability analysis

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M1	1	20	1
M2	4	20	2
M3	3	30	4
M4	2	30	5
M5	3	60	6
ACC	4 (cruise) 6 (safe)	20	3

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Step 1: Blocking time computation

$$B_{mi} = \max_{k \in lp(mi)} (c_i)$$

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Step 1: Blocking time computation

$$B_{mi} = \max_{k \in lp(mi)} (c_i)$$

$$B_{M1} = \max\{4,3,2,3,6\} = 6$$
$$B_{M2} = \max\{3,2,3,6\} = 6$$

$$B_{M3} = \max\{2,3\} = 3$$
$$B_{M4} = 3$$
$$B_{M5} = 0$$
$$B_{ACC} = \max\{3,2,3\} = 3$$

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M2	4	20	2
M3	3	30	4
M4	2	30	5
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ACC	4 (cruise) 6 (safe)	20	3

Step 2: Busy period computation

$$t_{mi}^{k+1} = B_{mi} + \sum_{\forall m \in hp(m_i) \cup m_i} \left\lceil \frac{t_{mi}^{k}}{p_m} \right\rceil c_{m}$$

Initialization: $t_{mi}^{0} = c_{mi}$

Termination condition: $t_{mi}^{k+1} = t_{mi}^{k}$

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Initialization: $t_{mi}^{0} = c_{mi}$

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Let's calculate the busy period for M1 :

$$t_1^0 = 1$$
$$t_1^1 = 6 + \left\lceil \frac{1}{20} \right\rceil \times 1 = 7$$
$$t_1^2 = 6 + \left\lceil \frac{6}{20} \right\rceil \times 1 = 7$$
$$\boldsymbol{t_1 = 7}$$

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Step 2: Busy period computation

$$t_{mi}^{k+1} = B_{mi} + \sum_{\forall m \in hp(m_i) \cup m_i} \left\lceil \frac{t_{mi}^k}{p_m} \right\rceil c_m$$

Initialization: $t_{mi}^0 = c_{mi}$

Termination condition: $t_{mi}^{k+1} = t_{mi}^k$

Let's calculate the busy period for M2 :

$$t_2^0 = 4$$

$$t_2^1 = 6 + \left\lceil \frac{4}{20} \right\rceil \times 4 + \left\lceil \frac{4}{20} \right\rceil \times 1 = 11$$

$$t_2^2 = 6 + \left\lceil \frac{11}{20} \right\rceil \times 4 + \left\lceil \frac{11}{20} \right\rceil \times 1 = 11$$

$$t_2^3 = 6 + \left\lceil \frac{11}{20} \right\rceil \times 4 + \left\lceil \frac{11}{20} \right\rceil \times 1 = 11$$

$$\boldsymbol{t_2 = 11}$$

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M1	1	20	1
M2	4	20	2
M3	3	30	4
M4	2	30	5
M5	3	60	6
ACC	4 (cruise) 6 (safe)	20	3

Step 2: Busy period computation

$$t_{mi}^{k+1} = B_{mi} + \sum_{\forall m \in hp(m_i) \cup m_i} \left\lceil \frac{t_{mi}^{k}}{p_m} \right\rceil c_{m}$$

Initialization: $t_{mi}^{0} = c_{mi}$

Termination condition: $t_{mi}^{k+1} = t_{mi}^{k}$

Similarly, $t_3 = 17, t_4 = 19, t_5 = 19, t_{ACC} = 14$

Since busy period is less than the period of each task, response time of each task is its busy period and the task set is schedulable.