Scheduling Algorithm and Analysis

Interrupts and non-RM Tasks
(Module 31)

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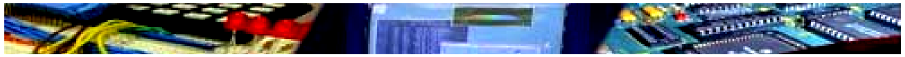
Schedulability with Interrupts

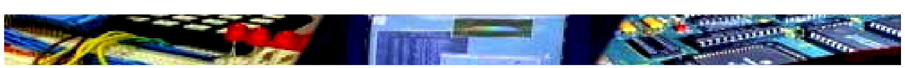
- **Interrupt processing can be inconsistent with rate monotonic priority assignment.**
  - interrupt handler executes with high priority despite its period
  - interrupt processing may delay execution of tasks with shorter periods
- **Effects of interrupt processing must be taken into account in schedulability model.**
- **Question is: how to do that?**



Determining Schedulability with Interrupts

Task(i)	Period(T)	Execution Time(C)	Priority(P)	Deadline (D)
τ_3	200	60	HW	200
τ_1	100	20	High	100
τ_2	150	40	Medium	150
τ_4	350	40	Low	350

τ_3 is an interrupt handler



UB Test with Any Fixed Priority

- **Test is applied to each task.**
- **Determine effective utilization (f_i) of each task i using when $d_i = p_i$**

$$f_i = \sum_{j \in H_n} \frac{e_j}{p_j} + \frac{e_i}{p_i} + \frac{1}{p_i} \sum_{k \in H_1} e_k$$

Preemption form the tasks that can hit more than once (with period less that p_i)

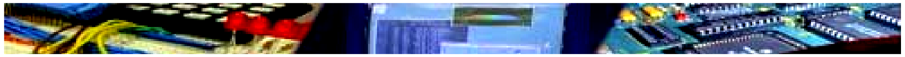
Execution of a task under test

Preemption from tasks That can hit only once (with period greater than p_i)

- **Compare effective utilization against bound, *U(n)*.**

$n = num(H_n) + 1$

$num(H_n)$ = the number of tasks in the set H_n



UB Test with Any Fixed Priority

- **Test is applied to each task.**
- **Determine effective utilization (f_i) of each task *i* using** **when $d_i < p_i$ (e_i must be done within d_i, not pi)**

$$f_i = \sum_{j \in H_n} \frac{e_j}{p_j} + \frac{e_i}{d_i} + \frac{1}{d_i} \sum_{k \in H_1} e_k$$

Preemption form the tasks that can hit more than once (with period less that d_i)

Execution of a task under test

Preemption from tasks That can hit only once (with period greater than d_i)

- **Compare effective utilization against bound, *U(n)*.**

  $n = num(H_n) + 1$

  $num(H_n)$ = the number of tasks in the set H_n

UB Test with Interrupt Priority: τ_3

- For τ_3, no tasks have a higher priority:
  ***H* = *H*$_n$ =*H*$_1$ = { }.**

$$f_3 = \quad 0 + \frac{C_3}{T_3} + 0 \leq U(1)$$

- **Note that utilization bound is *U(1):* num(*H*$_n$) = 0.**

  Plugging in numbers:

$$f_3 = \frac{C_3}{T_3} = \frac{60}{200} = 0.3 < 1.0$$

UB Test with Interrupt Priority: τ_1

- **For τ_1, τ_3 has a higher priority:** $H = \{\tau_3\}$; $H_n = \{\}$; $H_1 = \{\tau_3\}$.

$$f_1 = 0 + \frac{C_1}{T_1} + \frac{1}{T_1}\sum_{k=3} C_k \le U(1)$$

- **Note that utilization bound is** *U(1):* **num(*Hn*) = 0. Plugging in the numbers:**

$$f_1 = \frac{C_1}{T_1} + \frac{C_3}{T_1} = \frac{20}{100} + \frac{60}{100} = 0.800 < 1.0$$

UB Test with Interrupt Priority: τ_2

- For τ_2 : $H=\{\tau_1, \tau_3\}$; $H_n=\{\tau_1\}$; $H_1=\{\tau_3\}$;

$$f_2 = \sum_{j=1} \frac{C_j}{T_j} + \frac{C_2}{T_2} + \frac{1}{T_2} \sum_{k=3} C_k \leq U(2)$$

- Note that utilization bound is $U(2)$: num(H_n) = 1. Plugging in the numbers:

$$f_2 = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} = \frac{20}{100} + \frac{40}{150} + \frac{60}{150} = 0.867 > 0.828$$

UB Test with Interrupt Priority:

- **For** τ_4 **:** $H=\{\tau_1, \tau_2, \tau_3\}$; $H_n=\{\tau_1, \tau_2, \tau_3\}$; $H_1=\{\}$;

$$f_4 = \sum_{j=1,2,3} \frac{C_j}{T_j} + \frac{C_4}{T_4} + 0 \le U(4)$$

- **Note that utilization bound is *U(4):* num(*H*) = 3. Plugging in the numbers:**

$$f_4 = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \frac{C_4}{T_4}$$

$$= \frac{20}{100} + \frac{40}{150} + \frac{60}{200} + \frac{60}{350} = 0.882 > 0.756$$

Supplementary Slides