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# *Scheduling Algorithm and Analysis*

*RT analysis  
(Module 30)*

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# Schedulability: RT Test

- **Theorem:** for a set of independent, periodic tasks, if each task meets its first deadline, with worst-case task phasing, the deadline will always be met.
- **Response Time (RT) test:** let  $a_n$  = response time of task  $i$ .
  - ❖  $a_n$  may be computed by the following iterative formula:

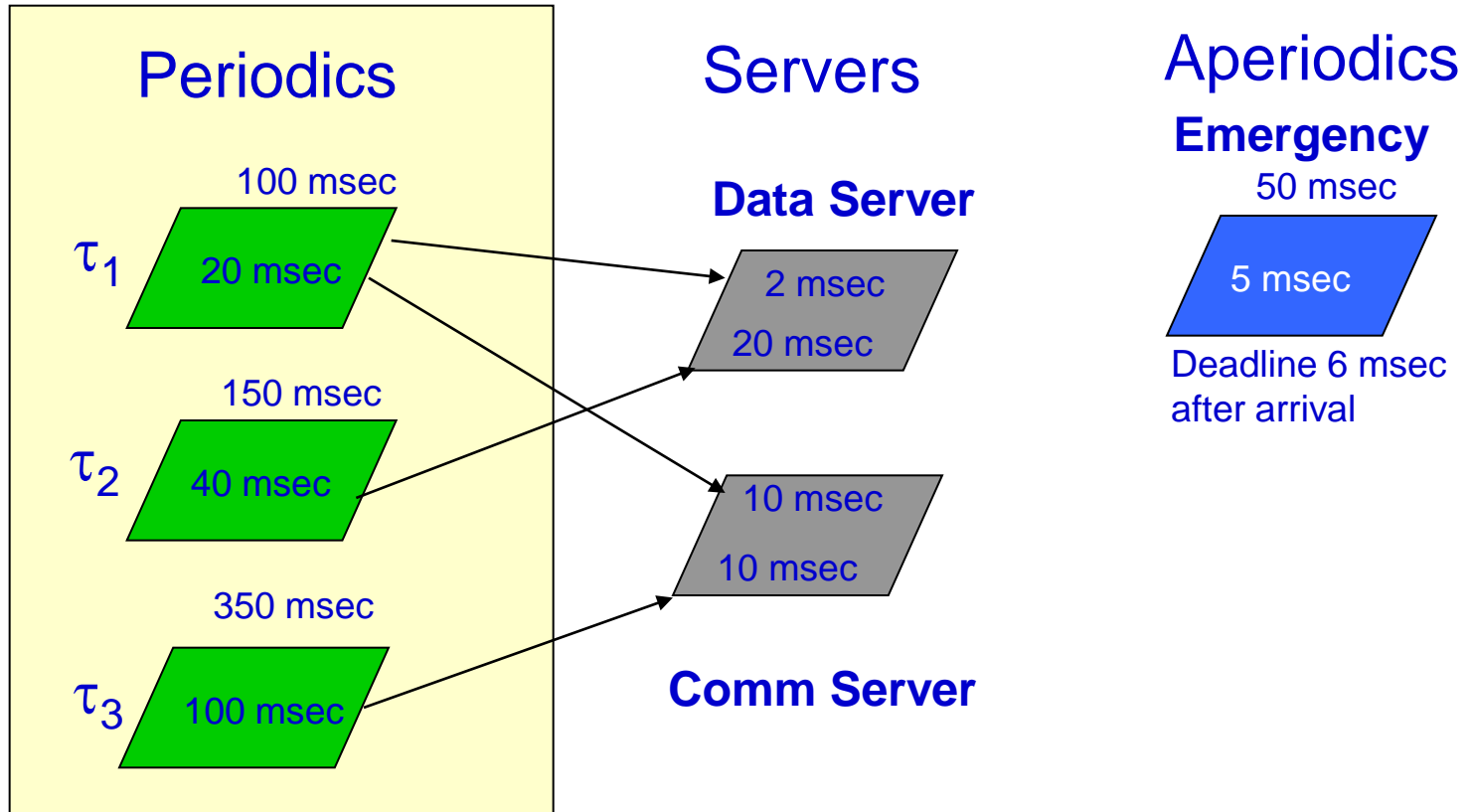
$$a_{n+1} = C_i + \sum_{j=1}^{i-1} \left\lceil \frac{a_n}{T_j} \right\rceil C_j \quad \text{where} \quad a_0 = \sum_{j=1}^i C_j$$

- ❖ Test Terminates when  $a_{n+1} = a_n$
- ❖ Task  $i$  is schedulable if its response time is before its deadline:  $a_n \leq T_i$



# RMA for Periodic Tasks

## □ A Sample Problem - Periodics



# Sample Problem: UB Test

	$C$	$T$	$U$
Task $\tau_1$	40	100	0.400
Task $\tau_2$	40	150	0.267
Task $\tau_3$	100	350	0.286

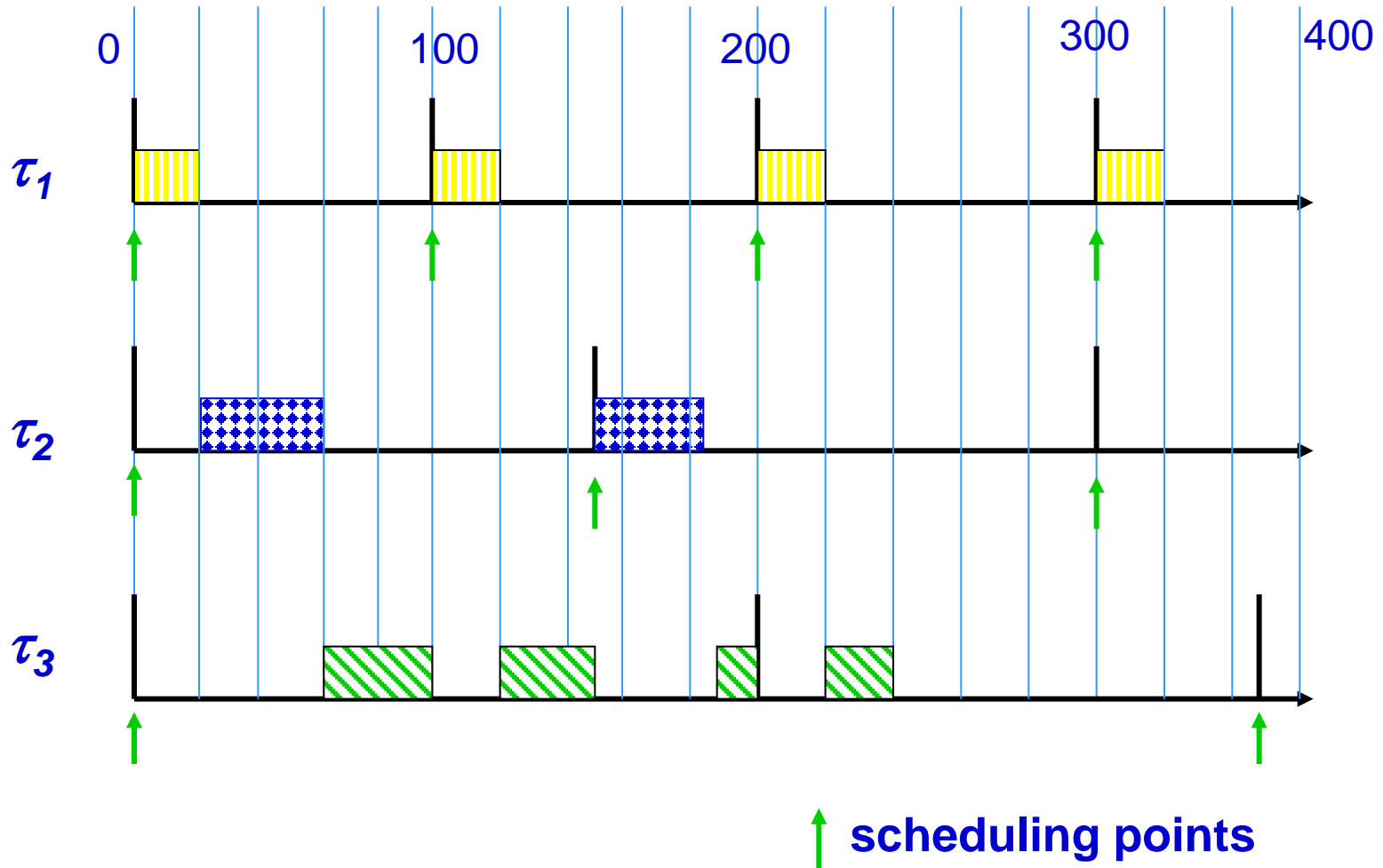
□ Total utilization is

$$.400 + .267 + .286 = .953 > U(3) = .779$$

□ The periodic tasks in the sample problem are schedulable according to the UB test.



# Timeline for The Sample Problem



# Example: Applying RT Test (1)

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- ❑ If we increase the compute time of  $\tau_1$  from 20 to 40; is the task set still schedulable?
- ❑ Utilization for the first task :  $40/100=0.4 < U(1)$
- ❑ Utilization of first two tasks:  $0.667 < U(2) = 0.828$ 
  - ❖ First two tasks are schedulable by UB test
  
- ❑ Utilization of all three tasks:  $0.953 > U(3) = 0.779$ 
  - ❖ UB test is inconclusive
  - ❖ Need to apply RT test



## Example: Applying RT Test (2)

- Use RT test to determine if  $\tau_3$  meets its first deadline:

$$i = 3$$

$$a_0 = \sum_{j=1}^3 e_j = e_1 + e_2 + e_3 = 40 + 40 + 100 = 180$$

$$\begin{aligned} a_1 &= e_i + \sum_{j=1}^{i-1} \left\lceil \frac{a_0}{p_j} \right\rceil e_j = e_3 + \sum_{j=1}^2 \left\lceil \frac{a_0}{p_j} \right\rceil e_j \\ &= 100 + \left\lceil \frac{180}{100} \right\rceil (40) + \left\lceil \frac{180}{150} \right\rceil (40) = 100 + 80 + 80 = 260 \end{aligned}$$



## Example: Applying RT Test (3)

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$$a_2 = e_i + \sum_{j=1}^{i-1} \left\lceil \frac{a_1}{p_j} \right\rceil e_j = 100 + \left\lceil \frac{260}{100} \right\rceil (40) + \left\lceil \frac{260}{150} \right\rceil (40) = 300$$

$$a_3 = e_i + \sum_{j=1}^{i-1} \left\lceil \frac{a_2}{p_j} \right\rceil e_j = 100 + \left\lceil \frac{300}{100} \right\rceil (40) + \left\lceil \frac{300}{150} \right\rceil (40) = 300$$

$$a_3 = a_2 = 300$$

Done!

□ **Task is schedulable using RT test.**

$$\blacklozenge a_3 = 300 < p_3 = 350$$







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# Supplementary Slides

