# Tutorial 2

Scheduling

# Rate Monotonic

**Q. Verify the schedulability and construct the schedule according to the RM policy for the following set of periodic tasks. Here $C_i$ and $T_i$ are the execution time and periods respectively.**

| | $C_i$ | $T_i$ |
|---|---|---|
| $\tau_1$ | 2 | 6 |
| $\tau_2$ | 2 | 8 |
| $\tau_3$ | 2 | 12 |

Ans.

Utilization (U) = 2/6 + 2/8 + 2/12 = 0.75

Processor utilization upper bound $U_{max} = n(2^{1/n} - 1) = 0.78$

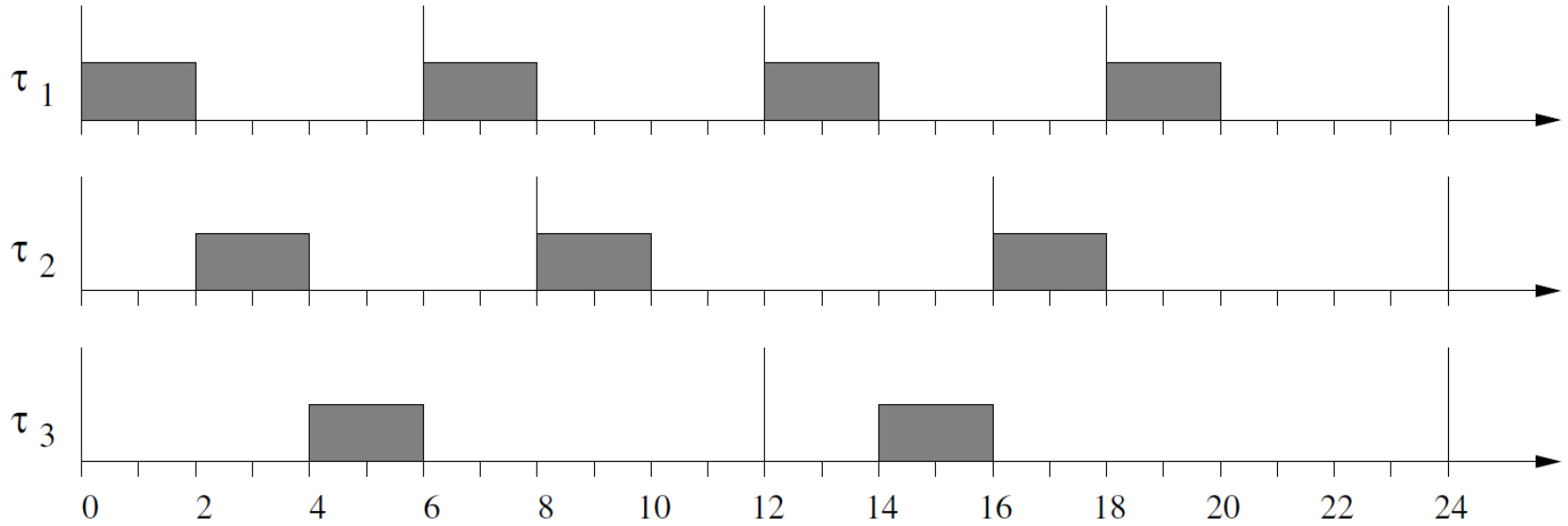
$U < U_{max}$ ➔ The task set is RM schedulable

# Rate Monotonic

**Q. Write down the RM schedule for the given task set.**

Hyper-period = lcm (6,8,12) = 24

| | $C_i$ | $T_i$ |
|---|---|---|
| $\tau_1$ | 2 | 6 |
| $\tau_2$ | 2 | 8 |
| $\tau_3$ | 2 | 12 |




RM Schedule: $T_1^1$ $T_2^1$ $T_3^1$ $T_1^2$ $T_2^2$ $T_1^3$ $T_3^2$ $T_2^3$ $T_1^4$

# Rate Monotonic

Consider the following set of tasks

| Tasks | $C_i$ | $T_i$ |
|---|---|---|
| $\tau_1$ | 2 | 5 |
| $\tau_2$ | 4 | 7 |

Utilization (U) = 2/5 + 4/7 = 0.97

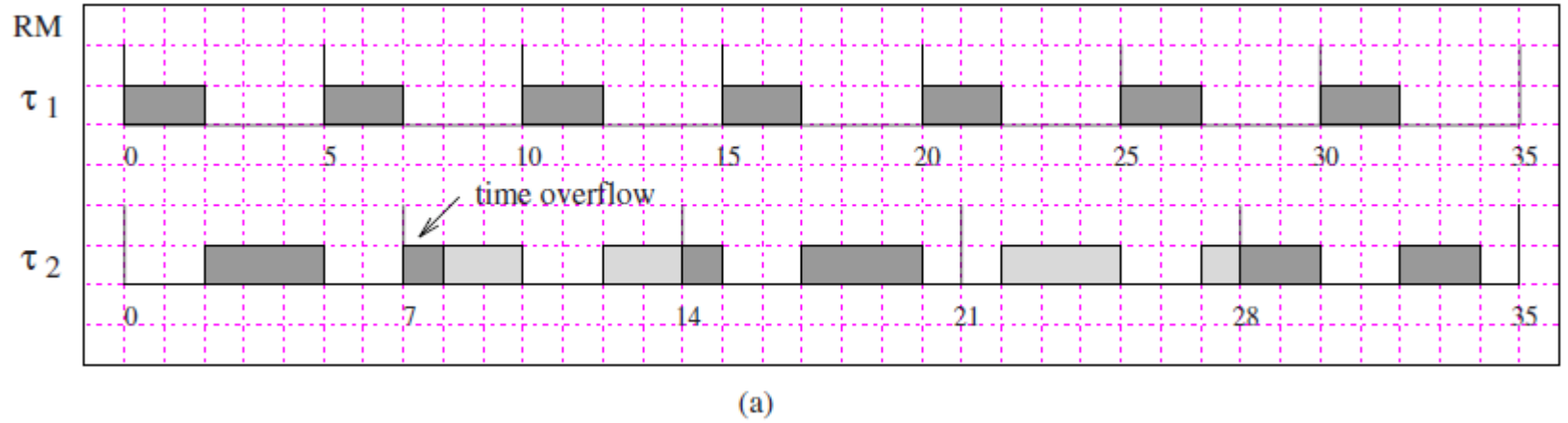
Processor utilization upper bound $U_{max} = n(2^{1/n} - 1) = 0.83$

$U > U_{max}$ ➔ The task set **may not be RM schedulable**

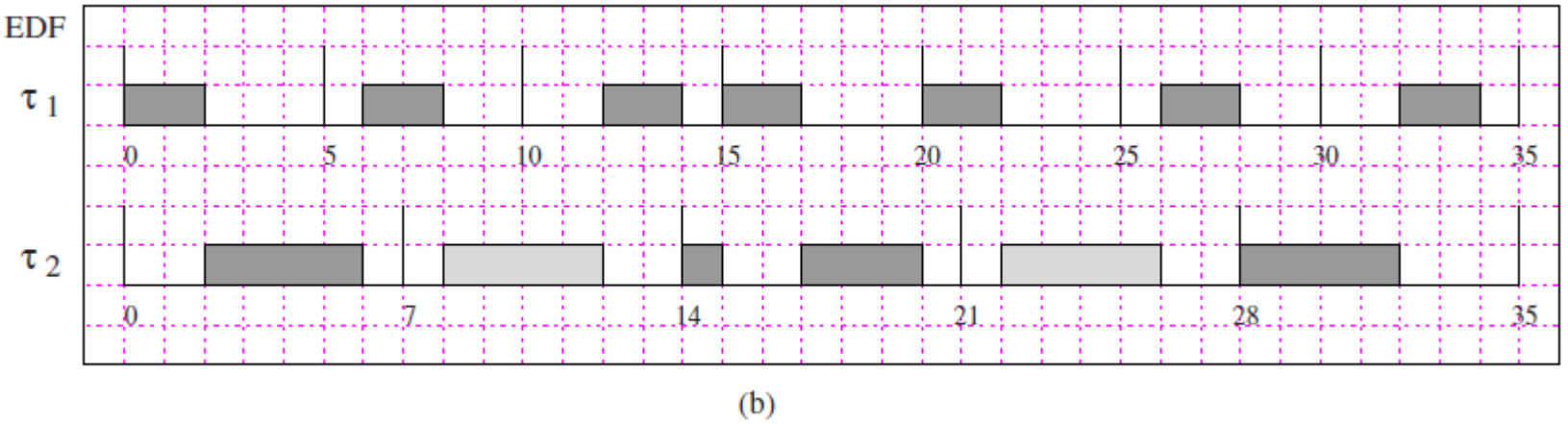
**Lets check !!**

# Earliest Deadline First (EDF)

Hyper-period = lcm (5, 7) = 35




(a)




(b)

| Tasks | $C_i$ | $T_i$ |
|---|---|---|
| $\tau_1$ | 2 | 5 |
| $\tau_2$ | 4 | 7 |

# Rate Monotonic

**Q. Check if the following task set is RM schedulable?**

| Tasks | Execution Time | Period |
|---|---|---|
| T1 | 20 | 100 |
| T2 | 30 | 150 |
| T3 | 90 | 200 |

# Rate Monotonic

**Q. Check if the following task set is RM schedulable?**

| Tasks | Execution Time | Period |
|---|---|---|
| T1 | 20 | 100 |
| T2 | 30 | 150 |
| T3 | 90 | 200 |

Ans.

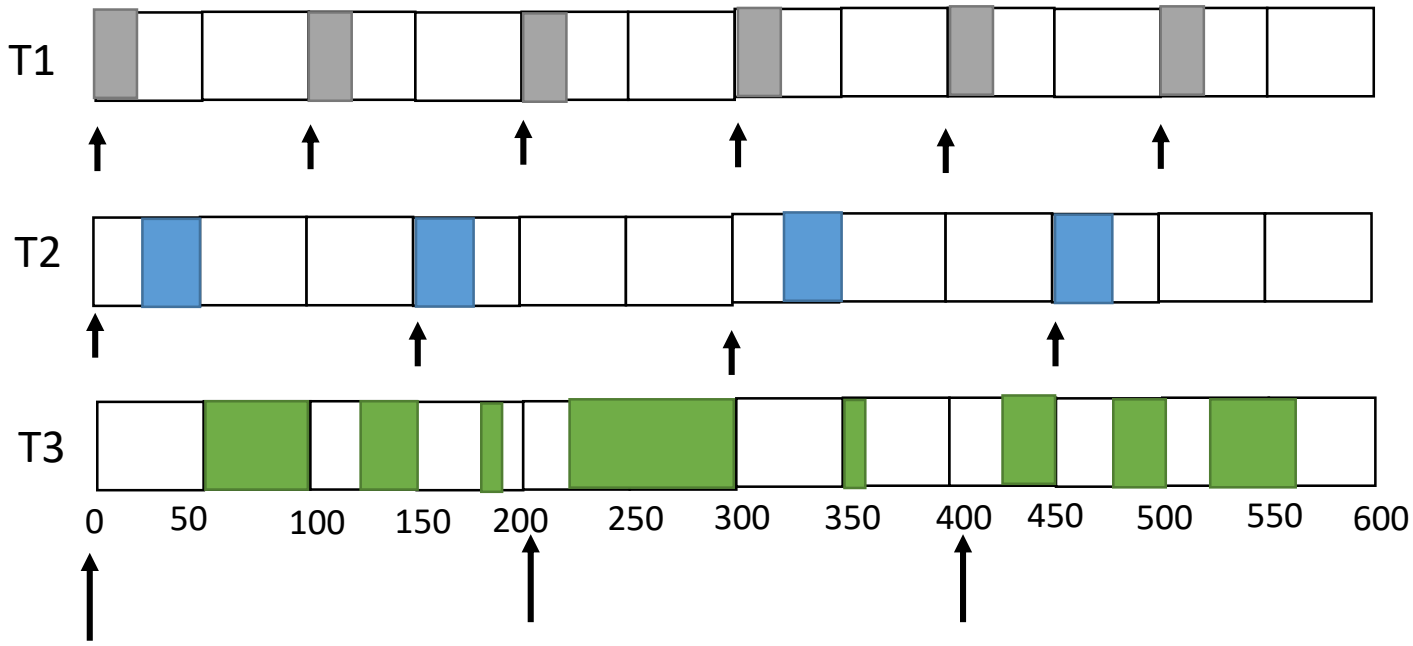
Utilization (U) = 20/100 + 30/150 + 90/200 = 0.85

Processor utilization upper bound $U_{max} = n(2^{1/n} - 1) = 0.78$

$U > U_{max}$ ➔ The task set may not be RM schedulable

# Rate Monotonic

Hyper-period = LCM(100,150,200) = 600



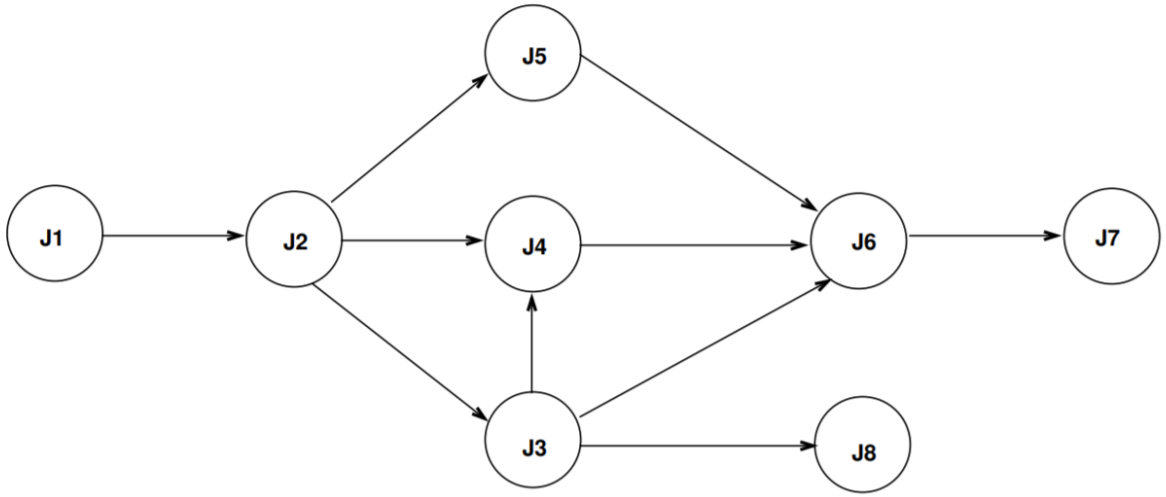

| Tasks | Execution Time | Period |
|---|---|---|
| T1 | 20 | 100 |
| T2 | 30 | 150 |
| T3 | 90 | 200 |

**RM Schedule: $T1^1$ $T2^1$ $T3^1$ $T1^2$ $T3^1$ $T2^2$ $T3^1$ $T1^3$ $T3^2$ $T1^4$ $T2^3$ $T3^2$ $T1^5$ $T3^3$ $T2^4$ $T3^3$ $T1^6$ $T3^3$**

# Latest Deadline First (LDF) Scheduling

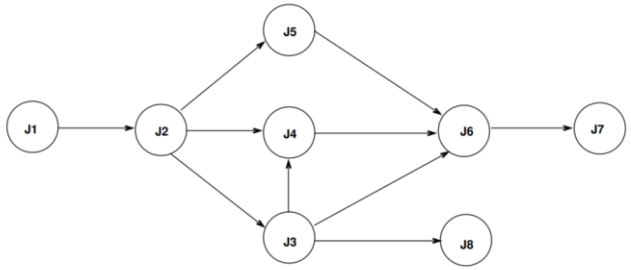
Given the precedence graph in following figure and the following table of task deadlines ($D_i$), determine a Latest Deadline First (LDF) schedule.

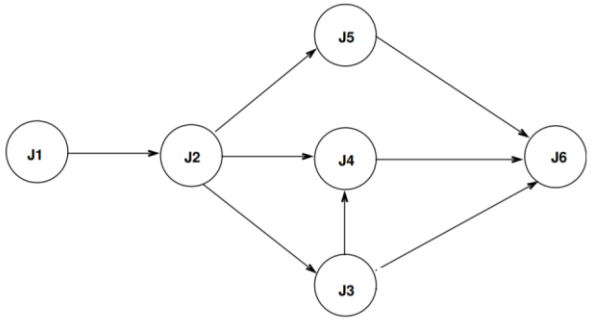
| | $J_1$ | $J_2$ | $J_3$ | $J_4$ | $J_5$ | $J_6$ | $J_7$ | $J_8$ |
|---|---|---|---|---|---|---|---|---|
| $D_i$ | 5 | 8 | 11 | 15 | 12 | 18 | 19 | 20 |

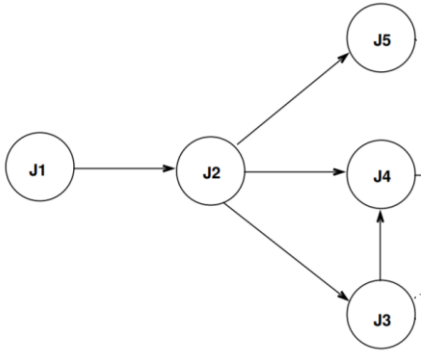


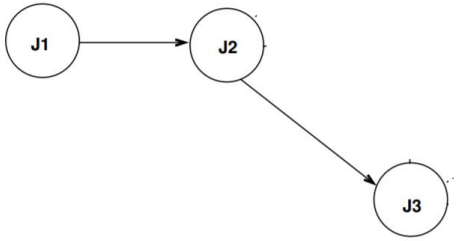
# LDF Scheduling

| | $J_1$ | $J_2$ | $J_3$ | $J_4$ | $J_5$ | $J_6$ | $J_7$ | $J_8$ |
|---|---|---|---|---|---|---|---|---|
| $D_i$ | 5 | 8 | 11 | 15 | 12 | 18 | 19 | 20 |



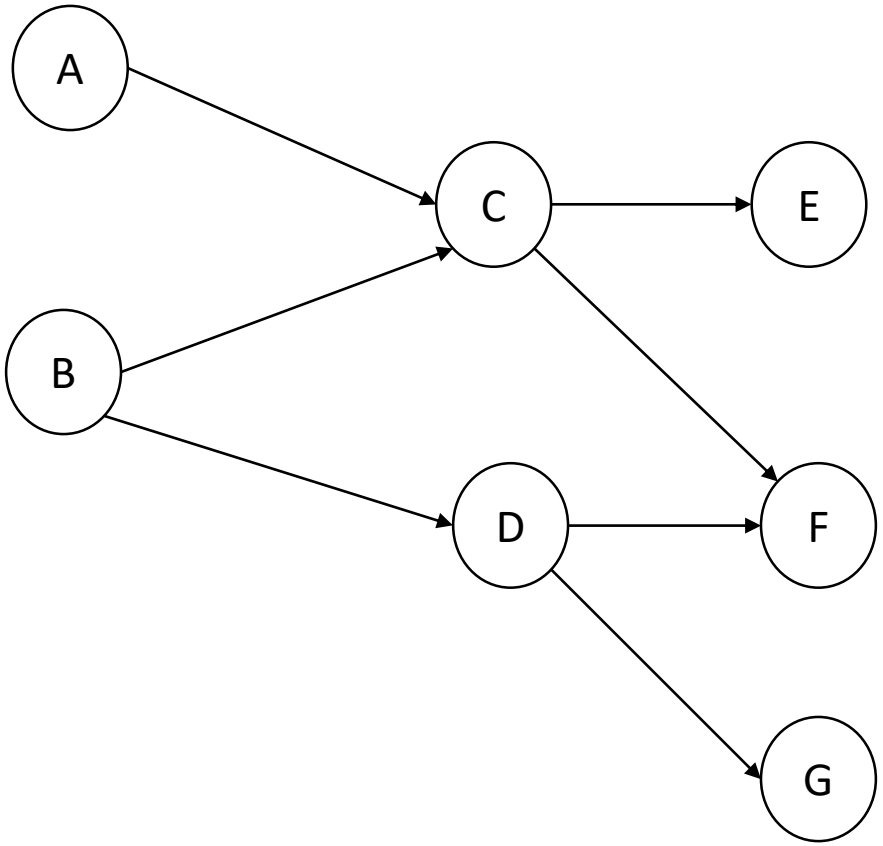




Schedule: $J_1$ $J_2$ $J_3$ $J_5$ $J_4$ $J_6$ $J_7$ $J_8$

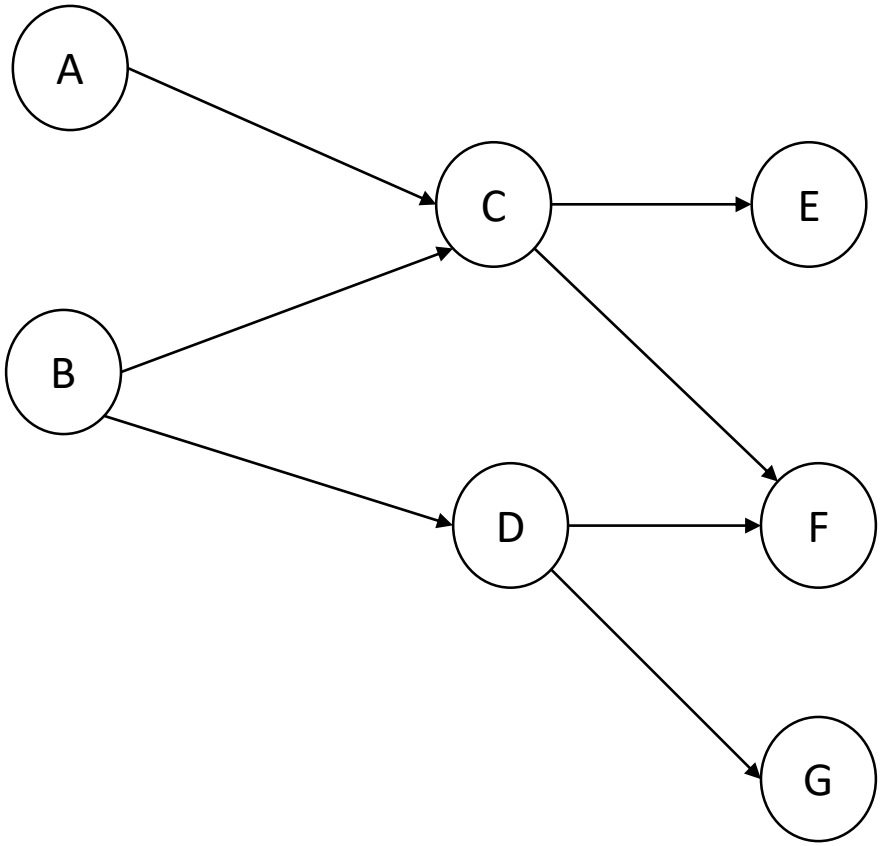
# EDF* Scheduling




All tasks arrive at t=0. They all have deadline d=20. Their execution times are given below. Determine the EDF* schedule.

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| $C_i$ | 3 | 2 | 4 | 3 | 2 | 5 | 1 |

# EDF* Scheduling




| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| $C_i$ | 3 | 2 | 4 | 3 | 2 | 5 | 1 |

$$d'_i = \min(d_i, \min_{j \in D(i)} (d'_j - e_j)) \ .$$

$d'_E = 20$
$d'_F = 20$
$d'_G = 20$
$d'_C =$ min(20, 20-2,20-5) =15
$d'_D =$ min(20, 20-5,20-1) =15
$d'_B =$ min(20, 15-4,15-3) =11
$d'_A =$ min(20, 15-4) =11

EDF* schedule: A,B,C,D,E,F,G