# Embedded Systems

## Assignment 9

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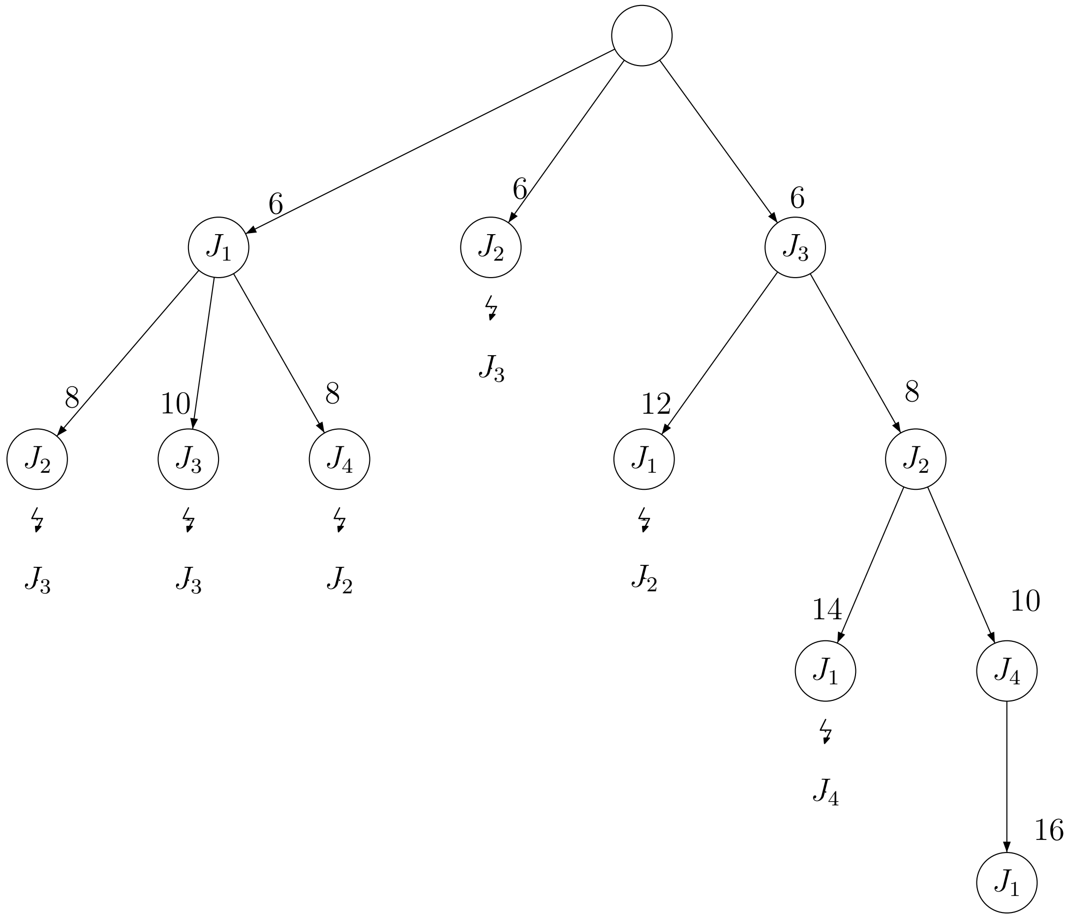
## 9.1 Scheduling

First of all, we give the set of tasks by using $d_i$ instead of $D_i$:

| | $J_1$ | $J_2$ | $J_3$ | $J_4$ |
|---|---|---|---|---|
| $a_i$ | 0 | 4 | 2 | 6 |
| $C_i$ | 6 | 2 | 4 | 2 |
| $d_i$ | 18 | 8 | 9 | 10 |

Now we state the tree by using this set of tasks:



## 9.2 Scheduling

**a**. 1. In the first step, we have to *modify the activation times*. Using the algorithm gives the following:

- $a_A^* = a_A = 0$
- selecting task $B$.
- $$\begin{aligned} a_B^* &= max(\{a_H^* + C_H | H \to B\} \cup a_B) \\ &= max(\{a_A^* + C_A\} \cup \{a_B\}) \\ &= max(\{2, 0\}) \\ a_B^* &= 2 \end{aligned}$$
- selecting task $C$.
- $$\begin{aligned} a_C^* &= max(\{a_H^* + C_H | H \to C\} \cup \{a_C\}) \\ &= max(\{2, 5, 0\}) \\ a_C^* &= 5 \end{aligned}$$
- selecting task $D$.
- $$\begin{aligned} a_D^* &= max(\{a_H^* + C_H | H \to D\} \cup \{a_D\}) \\ &= max(\{2, 5, 8, 0\}) \\ a_D^* &= 8 \end{aligned}$$
- selecting task $E$.
- $$\begin{aligned} a_E^* &= max(\{a_H^* + C_H | H \to E\} \cup \{a_E\}) \\ &= max(\{2, 5, 8, 13, 0\}) \\ a_E^* &= 13 \end{aligned}$$
- selecting task $F$.
- $$\begin{aligned} a_F^* &= max(\{a_H^* + C_H | H \to F\} \cup \{a_F\}) \\ &= max(\{2, 5, 8, 13, 14, 0\}) \\ a_F^* &= 14 \end{aligned}$$

- selecting task $G$.
-

$$\begin{aligned} a_G^* &= max(\{a_H^* + C_H | H \to G\} \cup \{a_G\}) \\ &= max(\{2, 5, 8, 13, 14, 19, 0\}) \\ a_G^* &= 19 \end{aligned}$$

2. In the second step, we have to *modify the deadlines*. Using the algorithm, we get the following:
   - $d_G^* = d_G = 25$
     $d_G = 25$ since $d_G = a_G + D_G = 0 + 25 = 25$.
   - selecting task $F$.
   -

$$\begin{aligned} d_F^* &= min(\{d_H^* - C_H | F \to H\} \cup \{d_F\}) \\ &= min(\{d_G^* - C_G\} \cup \{d_F\}) \\ &= min(\{20, 25\}) \\ d_F^* &= 20 \end{aligned}$$

   - selecting task $E$.
   -

$$\begin{aligned} d_E^* &= min(\{d_H^* - C_H | E \to H\} \cup \{d_E\}) \\ &= min(\{18, 20, 25\}) \\ d_E^* &= 18 \end{aligned}$$

   - selecting task $D$.
   -

$$\begin{aligned} d_D^* &= min(\{d_H^* - C_H | D \to H\} \cup \{d_D\}) \\ &= min(\{17, 18, 20, 25\}) \\ d_D^* &= 17 \end{aligned}$$

   - selecting task $C$.
   -

$$\begin{aligned} d_C^* &= min(\{d_H^* - C_H | C \to H\} \cup \{d_C\}) \\ &= min(\{12, 17, 18, 20, 25\}) \\ d_C^* &= 12 \end{aligned}$$

- selecting task $B$.
- 

$$\begin{aligned} d_B^* &= min(\{d_H^* - C_H | B \rightarrow H\} \cup \{d_B\}) \\ &= min(\{9, 12, 17, 18, 20, 25\}) \\ d_B^* &= 9 \end{aligned}$$

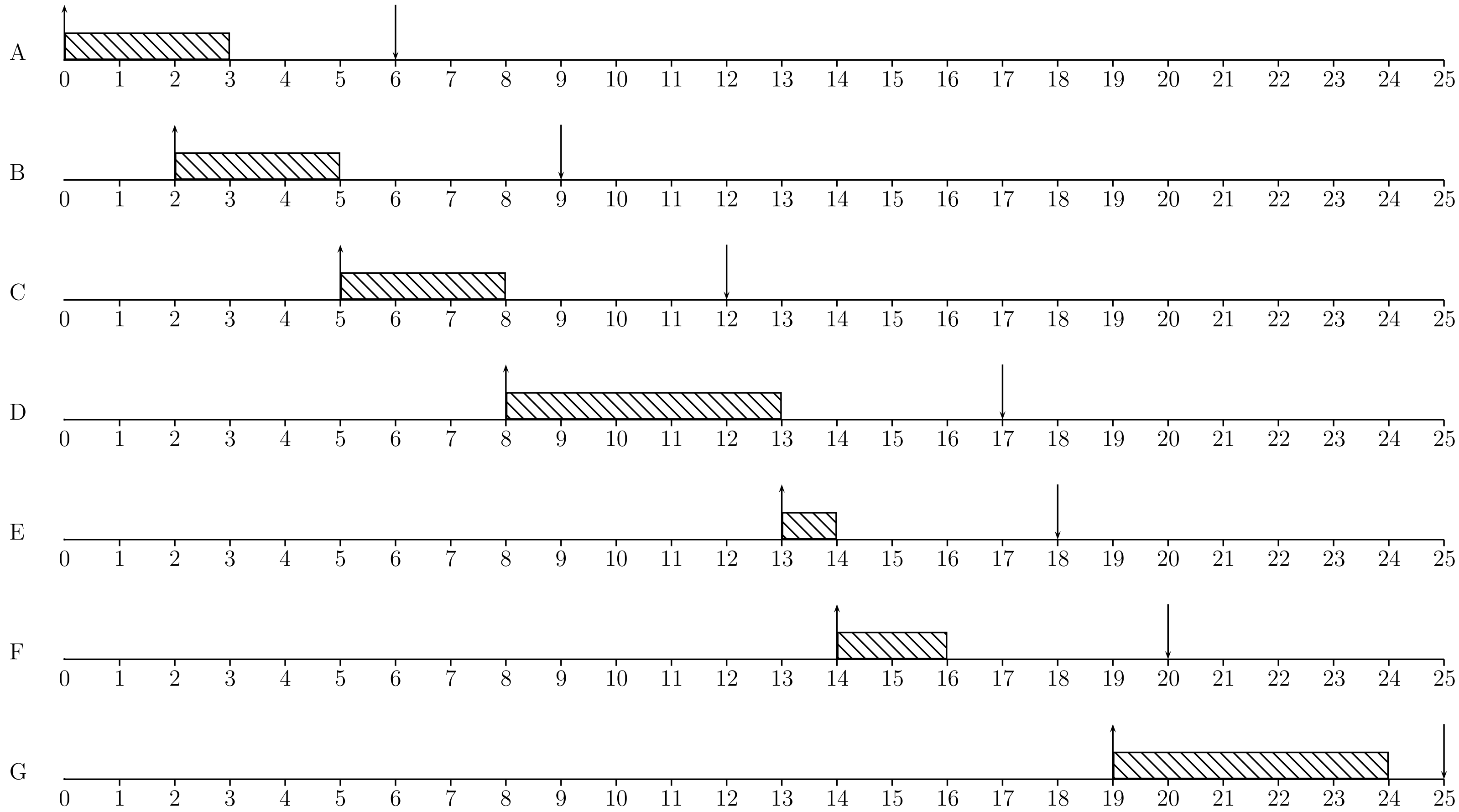
- selecting task $A$.
- 

$$\begin{aligned} d_A^* &= min(\{d_H^* - C_H | A \rightarrow H\} \cup \{d_A\}) \\ &= min(\{6, 9, 12, 17, 18, 20, 25\}) \\ d_A^* &= 6 \end{aligned}$$

We now have a new task set $\mathcal{J}^*$, which looks like this:

| | $A$ | $B$ | $C$ | $D$ | $E$ | $F$ | $G$ |
|---|---|---|---|---|---|---|---|
| $a_i^*$ | 0 | 2 | 5 | 8 | 13 | 14 | 19 |
| $C_i$ | 2 | 3 | 3 | 5 | 1 | 2 | 5 |
| $d_i^*$ | 6 | 9 | 12 | 17 | 18 | 20 | 25 |

**b**. We use the results from the previous exercise to run EDF, obtaining an EDF-schedule for $\mathcal{J}^*$:
(the schedule is depicted on the next page)


A
B
C
D
E
F
G
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

## 9.3 Fault tree analysis

**a.**
- Determine formula of the fault tree:

$$fault = ((C \vee E) \wedge A) \vee (B \wedge (A \vee (D \wedge \neg E)))$$

- Get DNF of fault:

$$\begin{aligned} &((C \vee E) \wedge A) \quad \vee \quad (B \wedge (A \vee (D \wedge \neg E))) \\ = &(C \wedge A) \vee (E \wedge A) \quad \vee \quad (B \wedge A) \vee (B \wedge D \wedge \neg E) \end{aligned}$$

- Minimize:
  The term is already minimal (wrt. the DNF). The prime implicants are:
  - $(C \wedge A)$: "Hauptrechner fails and this is not recognized"
  - $(E \wedge A)$: "Hauptrechner fails and the switch does not trigger the Fehlererkennung"
  - $(B \wedge A)$: "Both Hauptrechner and Reserverechner fail"
  - $(B \wedge D \wedge \neg E)$: "'false positive'. Reserverechner fails, Hauptrechner is said to have failed and the switch triggers Fehlererkennung"

**b.** We can immediately compute the probability of a prime implicant to occur:

$$\begin{aligned} P(C \wedge A) &\overset{ind.}{=} P(C) \cdot P(A) = 0.006 \cdot 0.1 = 0.0006 \\ P(E \wedge A) &\overset{ind.}{=} P(E) \cdot P(A) = 0.05 \cdot 0.1 = 0.005 \\ P(B \wedge A) &\overset{ind.}{=} P(B) \cdot P(A) = 0.1 \cdot 0.1 = 0.01 \\ P(B \wedge D \wedge \neg E) &\overset{ind.}{=} P(B) \cdot P(D) \cdot P(\neg E) \\ &= P(B) \cdot P(D) \cdot (1 - P(E)) \\ &= 0.1 \cdot 0.02 \cdot (1 - 0.05) = 0.002 \cdot 0.95 = 0.0019 \end{aligned}$$

$\Longrightarrow$ The lower bound of reliability if $(1 - 0.01) = 0.99 = 99\%$