Embedded Systems

Assignment 9

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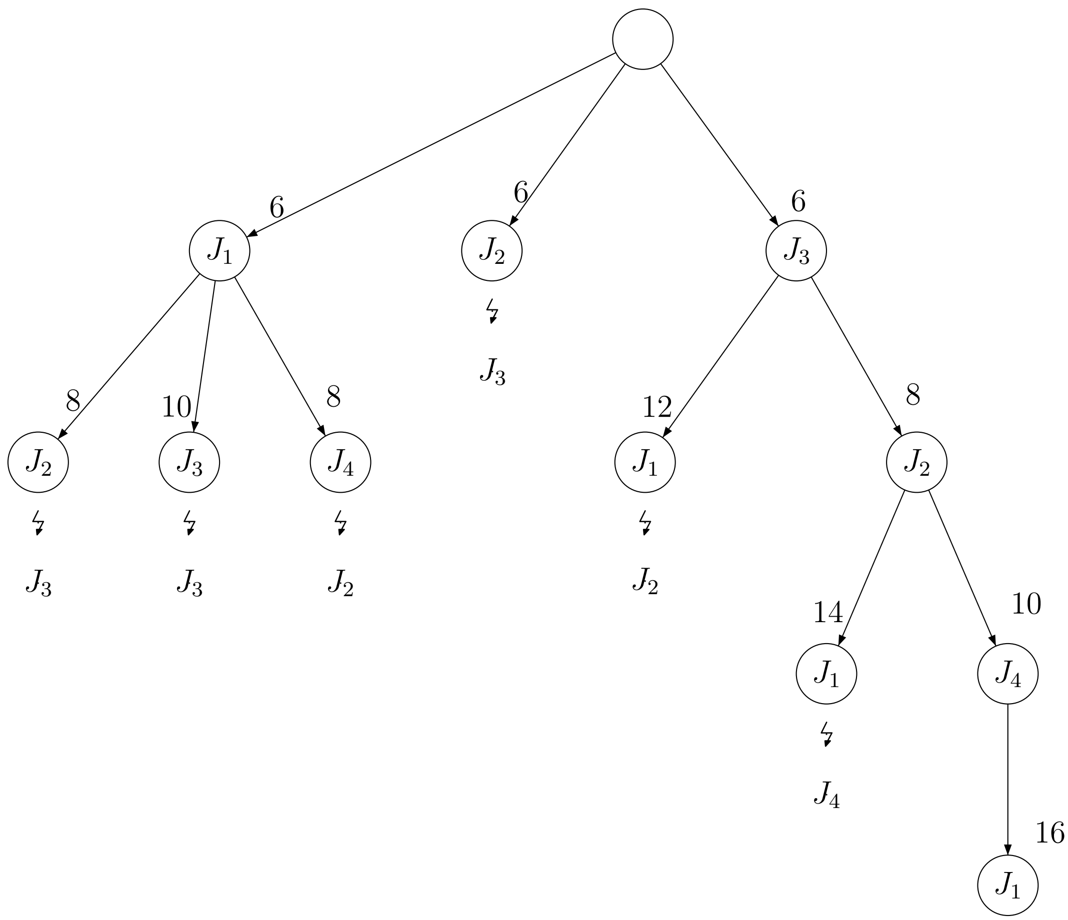
9.1 Scheduling

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.
-

$$\begin{aligned} a_B^* &= max(\{a_H^* + C_H | H \rightarrow B\} \cup a_B) \\ &= max(\{a_A^* + C_A\} \cup \{a_B\}) \\ &= max(\{2, 0\}) \\ a_B^* &= 2 \end{aligned}$$

- selecting task C.
-

$$\begin{aligned} a_C^* &= max(\{a_H^* + C_H | H \rightarrow C\} \cup \{a_C\}) \\ &= max(\{2, 5, 0\}) \\ a_C^* &= 5 \end{aligned}$$

- selecting task D.
-

$$\begin{aligned} a_D^* &= max(\{a_H^* + C_H | H \rightarrow D\} \cup \{a_D\}) \\ &= max(\{2, 5, 8, 0\}) \\ a_D^* &= 8 \end{aligned}$$

- selecting task E.
-

$$\begin{aligned} a_E^* &= max(\{a_H^* + C_H | H \rightarrow E\} \cup \{a_E\}) \\ &= max(\{2, 5, 8, 13, 0\}) \\ a_E^* &= 13 \end{aligned}$$

- selecting task F.
-

$$\begin{aligned} a_F^* &= max(\{a_H^* + C_H | H \rightarrow F\} \cup \{a_F\}) \\ &= max(\{2, 5, 8, 13, 14, 0\}) \\ a_F^* &= 14 \end{aligned}$$

- selecting task G.
- $$\begin{aligned} a^*_G &= max(\{a^*_H + C_H | H \rightarrow G\} \cup \{a_G\}) \\ &= max(\{2, 5, 8, 13, 14, 19, 0\}) \\ a^*_G &= 19 \end{aligned}$$

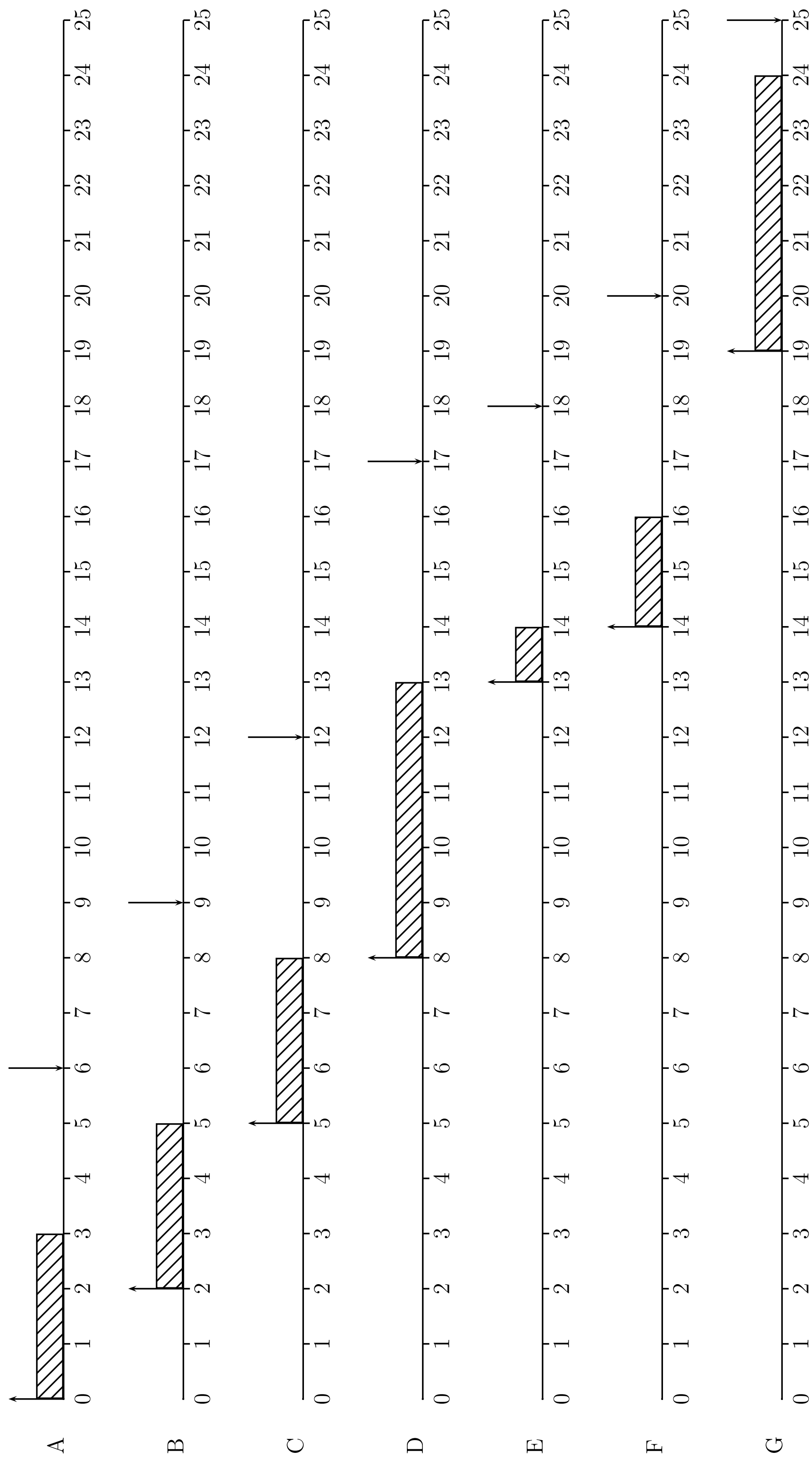
2. In the second step, we have to *modify the deadlines*. Using the algorithm, we get the following:
   - $d^*_G = d_G = 25$
     $d_G = 25$ since $d_G = a_G + D_G = 0 + 25 = 25$.
   - selecting task F.
   - $$\begin{aligned} d^*_F &= min(\{d^*_H - C_H | F \rightarrow H\} \cup \{d_F\}) \\ &= min(\{d^*_G - C_G\} \cup \{d_F\}) \\ &= min(\{20, 25\}) \\ d^*_F &= 20 \end{aligned}$$
   - selecting task E.
   - $$\begin{aligned} d^*_E &= min(\{d^*_H - C_H | E \rightarrow H\} \cup \{d_E\}) \\ &= min(\{18, 20, 25\}) \\ d^*_E &= 18 \end{aligned}$$
   - selecting task D.
   - $$\begin{aligned} d^*_D &= min(\{d^*_H - C_H | D \rightarrow H\} \cup \{d_D\}) \\ &= min(\{17, 18, 20, 25\}) \\ d^*_D &= 17 \end{aligned}$$
   - selecting task C.
   - $$\begin{aligned} d^*_C &= min(\{d^*_H - C_H | C \rightarrow H\} \cup \{d_C\}) \\ &= min(\{12, 17, 18, 20, 25\}) \\ d^*_C &= 12 \end{aligned}$$

- 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 $(1 - 0.01) = 0.99 = 99\%$