VT16 – EL2450 – Assignment II

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1 Part One: Scheduling

Throughout this part, the pendulum with length $l_1 = 0.1$ m will be referred to as P_1, $l_2 = 0.2$ m as P_2 and $l_3 = 0.3$ m as P_3.

2 Part Three: Discrete Event System

2.1 Question 1

The discrete event systems that model a machine M and a buffer B are illustrated in figures 1 and 2 respectively.

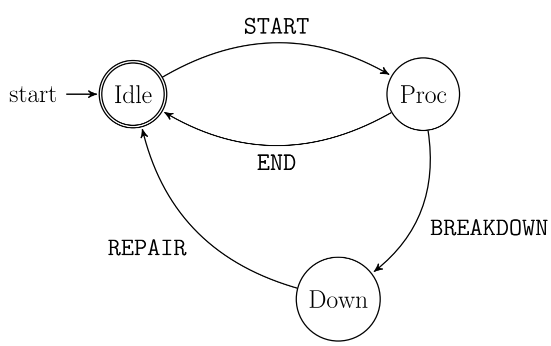

Figure 1: The DES that models machines M_1 and M_2.

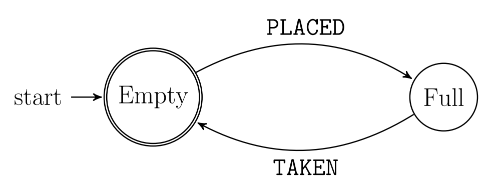

Figure 2: The DES that models buffer B.

3 Question 2

The set of states of the discrete event system that models the complete manufacturing process Q will be a subset of the set of states comprised by the combination of all states of the DES of machines M_1, M_2 and buffer M:

$$Q \subseteq Q_{M_1} \times Q_{M_2} \times Q_B$$

Table 1 features the complete set of states that result from the combination of states of M_1, M_2 and B.

state notation of the complete DES	M1	M2	B
(I,I,E)	Idle	Idle	Empty
(I,I,F)	Idle	Idle	Full
(I,P,E)	Idle	Processing	Empty
(I,P,F)	Idle	Processing	Full
(I,D,E)	Idle	Down	Empty
(I,D,F)	Idle	Down	Full
(P,I,E)	Processing	Idle	Empty
(P,I,F)	Processing	Idle	Full
(P,P,E)	Processing	Processing	Empty
(P,P,F)	Processing	Processing	Full
(P,D,E)	Processing	Down	Empty
(P,D,F)	Processing	Down	Full
(D,I,E)	Down	Idle	Empty
(D,I,F)	Down	Idle	Full
(D,P,E)	Down	Processing	Empty
(D,P,F)	Down	Processing	Full
(D,D,E)	Down	Down	Empty
(D,D,F)	Down	Down	Full

Table 1: The complete set of all state combinations between machines M_1 and M_2 and buffer B.

The set of events of the overall DES is the union of the sets of the three separate DES:

$$
\begin{aligned}
&E = E_{M_1} \cup E_{M_2} \cup E_B = \\
&\quad \{\texttt{START(1), END(1), BREAKDOWN(1), END(1),} \\
&\quad\ \ \texttt{START(2), END(2), BREAKDOWN(2), END(2),} \\
&\quad\ \ \texttt{PLACED, TAKEN}\}
\end{aligned}
$$

where the number X inside parentheses denotes an event pertaining to machine M_X.

The initial state q_0 shall be state $q_0 = (I, I, E)$, that is, both M_1 and M_2 are idle, and buffer B is empty. Furthermore, the marked state shall be the initial state $Q_m \equiv \{q_0\}$.

The transition function $\delta()$ is shown in tables 2 and ??.

$\delta((\text{I,I,E}), \texttt{PLACED}) = (\text{I,I,F})$	$\delta((\text{P,I,E}), \texttt{START(2)}) = (\text{P,P,E})$
$\delta((\text{I,I,E}), \texttt{START(2)}) = (\text{I,P,E})$	$\delta((\text{P,I,E}), \texttt{BREAKDOWN(1)}) = (\text{D,I,E})$
$\delta((\text{I,I,E}), \texttt{START(1)}) = (\text{P,I,E})$	$\delta((\text{P,I,F}), \texttt{END(1)}) = (\text{I,I,F})$
$\delta((\text{I,I,F}), \texttt{TAKEN}) = (\text{I,I,E})$	$\delta((\text{P,I,F}), \texttt{TAKEN}) = (\text{P,I,E})$
$\delta((\text{I,I,F}), \texttt{START(2)}) = (\text{I,P,F})$	$\delta((\text{P,I,F}), \texttt{END(2)}) = (\text{P,P,F})$
$\delta((\text{I,I,F}), \texttt{START(1)}) = (\text{P,I,F})$	$\delta((\text{P,I,F}), \texttt{BREAKDOWN(1)}) = (\text{D,I,F})$
$\delta((\text{I,P,E}), \texttt{END(2)}) = (\text{I,I,E})$	$\delta((\text{P,P,E}), \texttt{END(1)}) = (\text{I,P,E})$
$\delta((\text{I,P,E}), \texttt{PLACED}) = (\text{I,P,F})$	$\delta((\text{P,P,E}), \texttt{END(2)}) = (\text{P,I,E})$
$\delta((\text{I,P,E}), \texttt{BREAKDOWN(2)}) = (\text{I,D,E})$	$\delta((\text{P,P,E}), \texttt{PLACED}) = (\text{P,P,F})$
$\delta((\text{I,P,E}), \texttt{START(1)}) = (\text{P,P,E})$	$\delta((\text{P,P,E}), \texttt{BREAKDOWN(2)}) = (\text{P,D,E})$
$\delta((\text{I,P,F}), \texttt{END(2)}) = (\text{I,I,F})$	$\delta((\text{P,P,E}), \texttt{BREAKDOWN(1)}) = (\text{D,P,E})$
$\delta((\text{I,P,F}), \texttt{TAKEN}) = (\text{I,P,E})$	$\delta((\text{P,P,F}), \texttt{END(1)}) = (\text{I,P,F})$
$\delta((\text{I,P,F}), \texttt{BREAKDOWN(2)}) = (\text{I,D,F})$	$\delta((\text{P,P,F}), \texttt{END(2)}) = (\text{P,I,F})$
$\delta((\text{I,P,F}), \texttt{START(1)}) = (\text{P,P,F})$	$\delta((\text{P,P,F}), \texttt{TAKEN}) = (\text{P,P,E})$
$\delta((\text{I,D,E}), \texttt{REPAIR(1)}) = (\text{I,I,E})$	$\delta((\text{P,P,F}), \texttt{BREAKDOWN(2)}) = (\text{P,D,F})$
$\delta((\text{I,D,E}), \texttt{PLACED}) = (\text{I,D,F})$	$\delta((\text{P,P,F}), \texttt{BREAKDOWN(1)}) = (\text{D,P,F})$
$\delta((\text{I,D,E}), \texttt{START(1)}) = (\text{P,D,E})$	$\delta((\text{P,D,E}), \texttt{END(1)}) = (\text{I,D,E})$
$\delta((\text{I,D,F}), \texttt{REPAIR(2)}) = (\text{I,I,F})$	$\delta((\text{P,D,E}), \texttt{REPAIR(2)}) = (\text{P,I,E})$
$\delta((\text{I,D,F}), \texttt{TAKEN}) = (\text{I,D,E})$	$\delta((\text{P,D,E}), \texttt{PLACED}) = (\text{P,D,F})$
$\delta((\text{I,D,F}), \texttt{START(1)}) = (\text{P,D,F})$	$\delta((\text{P,D,E}), \texttt{BREAKDOWN(1)}) = (\text{D,D,E})$
$\delta((\text{P,I,E}), \texttt{END(1)}) = (\text{I,I,E})$	$\delta((\text{P,D,F}), \texttt{END(1)}) = (\text{I,D,F})$
$\delta((\text{P,I,E}), \texttt{PLACED}) = (\text{P,I,F})$	$\delta((\text{P,D,F}), \texttt{REPAIR(2)}) = (\text{P,I,F})$

Table 2: Allowed transitions between states (part I).

δ((P,D,F), `TAKEN`) = (P,D,E)
δ((P,D,F), `BREAKDOWN(1)`) = (D,D,F)
δ((D,I,E), `REPAIR(1)`) = (I,I,E)
δ((D,I,E), `PLACED`) = (D,I,F)
δ((D,I,E), `START(2)`) = (D,P,E)
δ((D,I,F), `REPAIR(1)`) = (I,I,F)
δ((D,I,F), `TAKEN`) = (D,I,E)
δ((D,I,F), `START(2)`) = (D,P,F)
δ((D,P,E), `REPAIR(1)`) = (I,P,E)
δ((D,P,E), `END(2)`) = (D,I,E)
δ((D,P,E), `PLACED`) = (D,P,F)
δ((D,P,E), `BREAKDOWN(2)`) = (D,D,E)
δ((D,P,F), `REPAIR(1)`) = (I,P,F)
δ((D,P,F), `END(2)`) = (D,I,F)
δ((D,P,F), `TAKEN`) = (D,P,E)
δ((D,P,F), `BREAKDOWN(2)`) = (D,D,F)
δ((D,D,E), `REPAIR(1)`) = (I,D,E)
δ((D,D,E), `REPAIR(2)`) = (D,I,E)
δ((D,D,E), `PLACED`) = (D,D,F)
δ((D,D,F), `REPAIR(1)`) = (I,D,F)
δ((D,D,F), `REPAIR(2)`) = (D,I,F)
δ((D,D,F), `TAKEN`) = (D,D,E)

Table 3: Allowed transitions between states (part II).

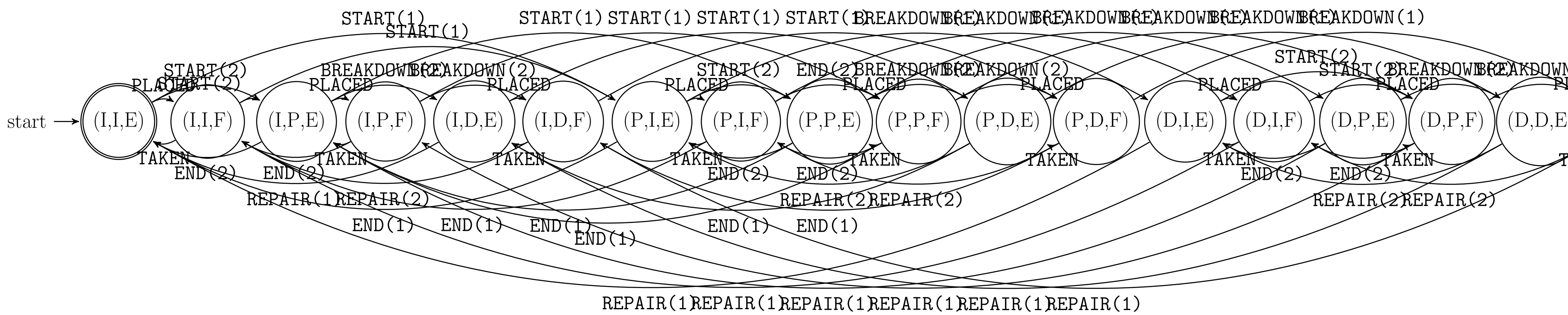
start
(I,I,E)
(I,I,F)
(I,P,E)
(I,P,F)
(I,D,E)
(I,D,F)
(P,I,E)
(P,I,F)
(P,P,E)
(P,P,F)
(P,D,E)
(P,D,F)
(D,I,E)
(D,I,F)
(D,P,E)
(D,P,F)
(D,D,E)
START(1)
START(2)
PLACED
TAKEN
END(1)
END(2)
BREAKDOWN(1)
BREAKDOWN(2)
REPAIR(1)
REPAIR(2)

Figure 3

A Appendix

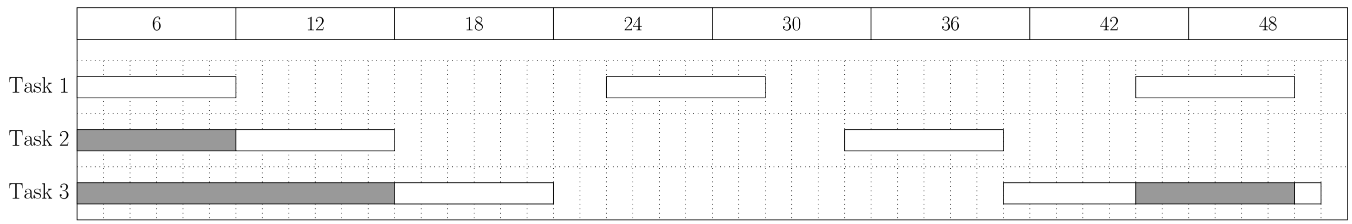

Figure 4: A portion of the RM schedule σ for tasks J_1, J_2, J_3. Shaded areas denote the waiting time.

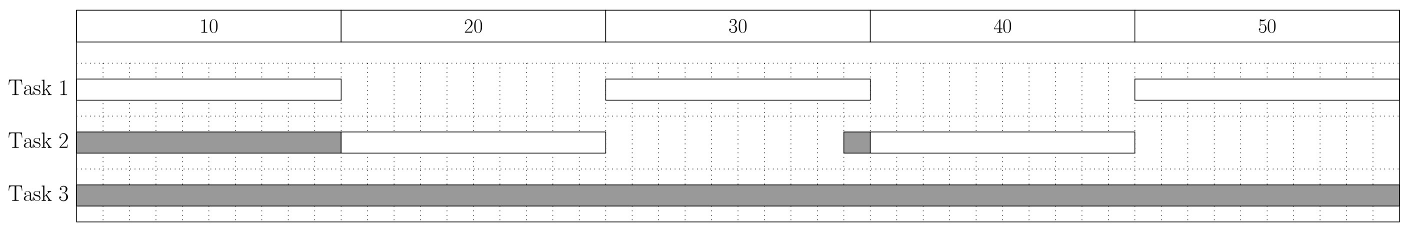

Figure 5: A portion of the RM schedule σ for tasks J_1, J_2, J_3 for $C_i = 10$ ms. Shaded areas denote the waiting time. Notice that J_3 misses its deadlines consecutively, indicative of the inability of schedulability.

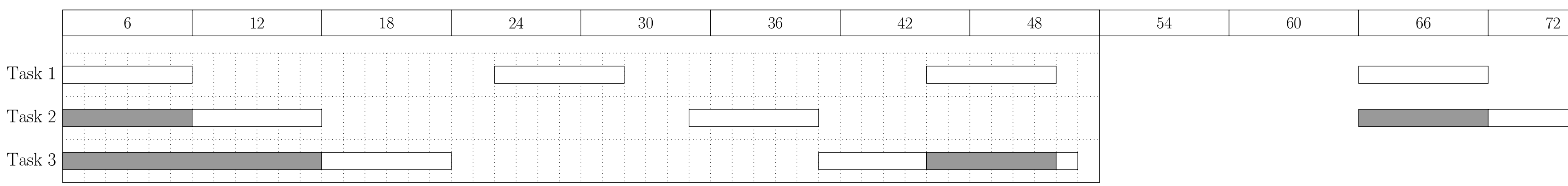

Figure 6: A portion of the EDF schedule σ for tasks J_1, J_2, J_3. Shaded areas denote the waiting time.