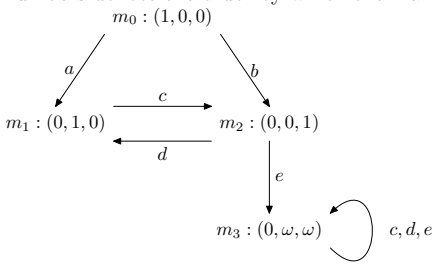
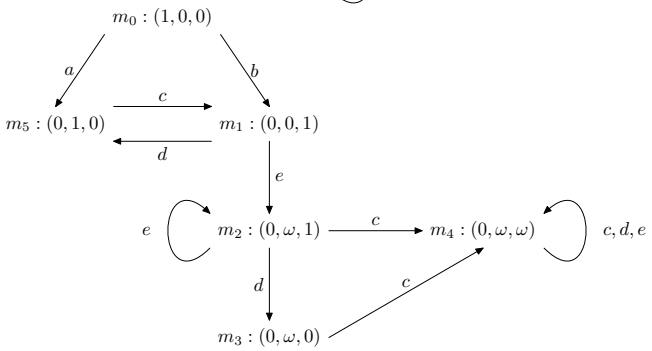
5.1 a) The minimal capacities are: $\text{ready}_w, \text{processing}_w = 2$, writing $= 1$, $\text{ac}, \text{reading} = 3$ and $\text{processing}_r, \text{ready}_r = 4$. These values can be arrived at by constructing a coverability graph and looking at a maximum value that a place can get. In this case, all places are bounded.

b) The rows of the matrix represent the places and the columns transitions. The order of rows is processing_w, ready_w, writing, ac, processing_r, ready_r and reading. The order of columns is w_1,w_2,w_3,r_1,r_2 and r_3.

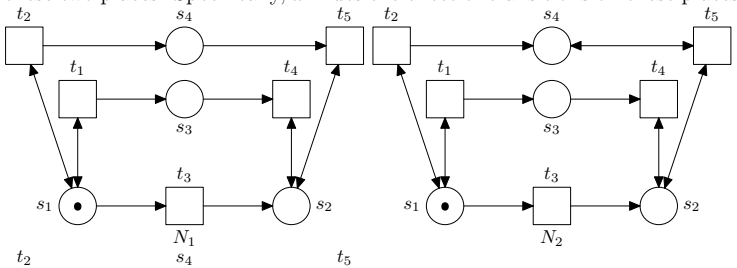
$$\begin{pmatrix} -1 & 0 & 1 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 1 & -1 & 0 & 0 & 0 \\ 0 & -3 & 3 & 0 & -1 & 1 \\ 0 & 0 & 0 & -1 & 0 & 1 \\ 0 & 0 & 0 & 1 & -1 & 0 \\ 0 & 0 & 0 & 0 & 1 & -1 \end{pmatrix}$$

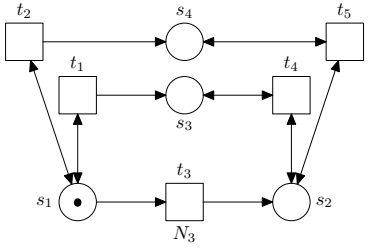
5.2 As the covering is defined in terms of already generated markings, the coverability graphs can be different depending on the order of the firing of transitions. The difference arises when the generation of a marking that is covered by some other marking can be delayed so that the covering marking is generated earlier. Below are two coverability graphs that differ. The subscript numbers denote the order by which the markings were generated.



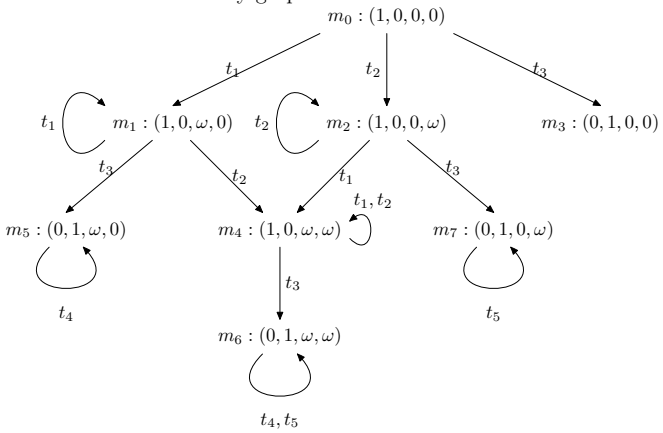


5.4 The principle in the construction was to get a covering marking, and thus ω into the places s_2, s_3. Then the transitions t_2, t_5 can be different regarding these two places. Specifically, ω hides the effect of transitions on these places.





The common coverability graph:



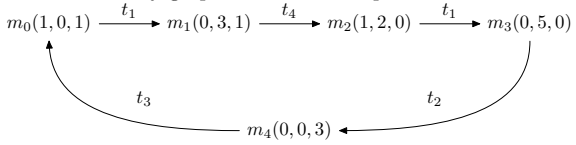
5.5 a) There exists a marking $(0, \omega, \omega)$, which covers the marking $(0, 5, 10)$.

b) There exists no marking covering $(1, 2, 3)$ in the coverability graph.

c) The marking $(0, \omega, \omega)$ means that $\{s_2, s_3\}$ is simultaneously unbounded.

d) All transitions appear in the coverability graph. Therefore, no transition is M_N-dead.

5.6 a) The coverability graph shows that no places are unbounded.



b) The net is live. It is clearly cyclic, and every transition present in the graph is thus live. Furthermore, all transitions are present in the graph.

5.7 The net is not live. For the net to be live, all its transitions must be live. For a transition to be live, a marking where the transition is enabled must be reachable from every marking. Transitions a and b are not live.