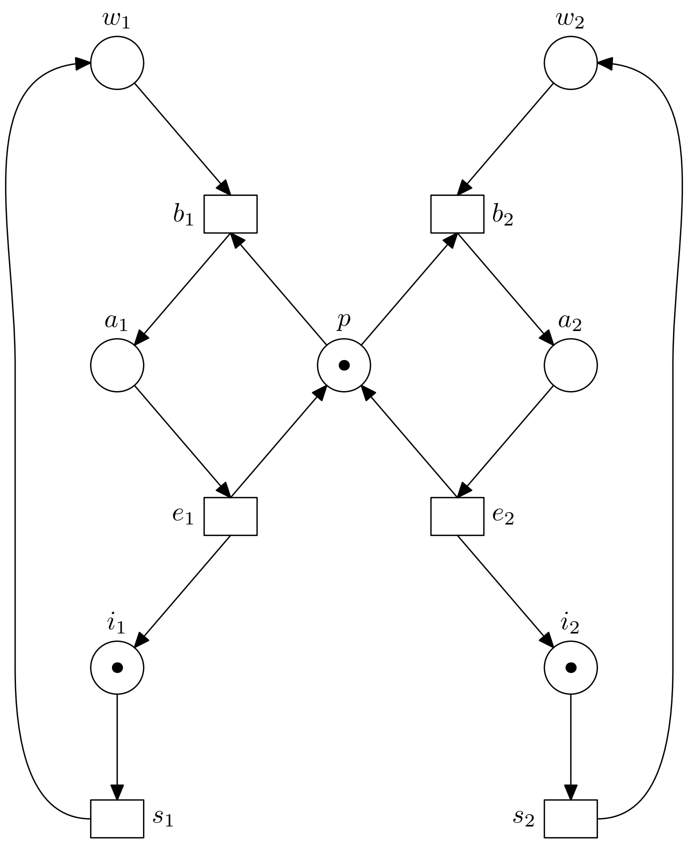
1. Below is shown a place/transition system. There are two processes, 1 and 2, which access a shared resource. The access to the resource is controlled by place p. The system could, for example, model a situation where two processes need access to same file. The places a_i model the situation where a process has access to the file. The places w_i model the situation where the processes are doing computation where the file is not needed. Places w_i model the situation where the processes are waiting for access to the file.

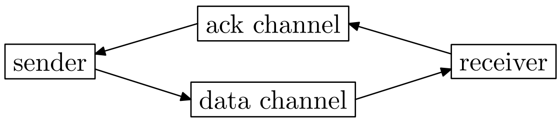


Let us give the following firing rates for transitions:
$\lambda_{b_1} = 20$, $\lambda_{b_2} = 15$, $\lambda_{e_1} = 30$, $\lambda_{e_2} = 15$, $\lambda_{s_1} = 5$ and $\lambda_{s_2} = 2$.

Compute the steady state distribution and the average marking of the places w_1 and w_2. Use for example GNU Octave for the computations.

Let us change the firing rates of transitions s_1 and s_2: $\lambda_{s_1} = 10$ and $\lambda_{s_2} = 9$. How does this change the steady state distribution and the average marking of the places?

2. Let us examine a communication protocol. The protocol consists of a sender, a receiver, a data channel and a acknowledgement channel.



The sender sends two kinds of messages, 0 and 1. The sender resends each message until it receives an acknowledgement for the message. The sender expects an acknowledgement k0 for a message 0 and k1 for a message 1. The data channel may lose messages, but the acknowledgement channel is reliable. The sender has a timer controlling the resending of messages.

Create a CCS description of the protocol. Model the sender and receiver and channels separately and connect them with the parallel composition defined below:

Parallel composition: Let Q, R be agents and $\alpha, \beta_1 \ldots \beta_n$ actions. Let us write $R \overset{\beta_1 \ldots \beta_n}{\not\longrightarrow} R'$, if R can not perform the actions $\beta_1 \ldots \beta_n$. $(Q \mid R)$ is an agent.

1. If $Q \xrightarrow{\alpha} Q'$ and $R \overset{\beta_1 \ldots \beta_n \overline{\alpha}}{\not\longrightarrow} R'$ then $(Q \mid R) \xrightarrow{\alpha} (Q' \mid R)$.
2. If $R \xrightarrow{\alpha} R'$ and $Q \overset{\beta_1 \ldots \beta_n \overline{\alpha}}{\not\longrightarrow} Q'$ then $(Q \mid R) \xrightarrow{\alpha} (Q \mid R')$.
3. If $Q \xrightarrow{\alpha} Q'$ and $R \xrightarrow{\overline{\alpha}} R'$ then $(Q \mid R) \xrightarrow{\tau} (Q' \mid R')$.

Compute the parallel composition by transforming the description into a low level Petri net and generating a reachability graph.