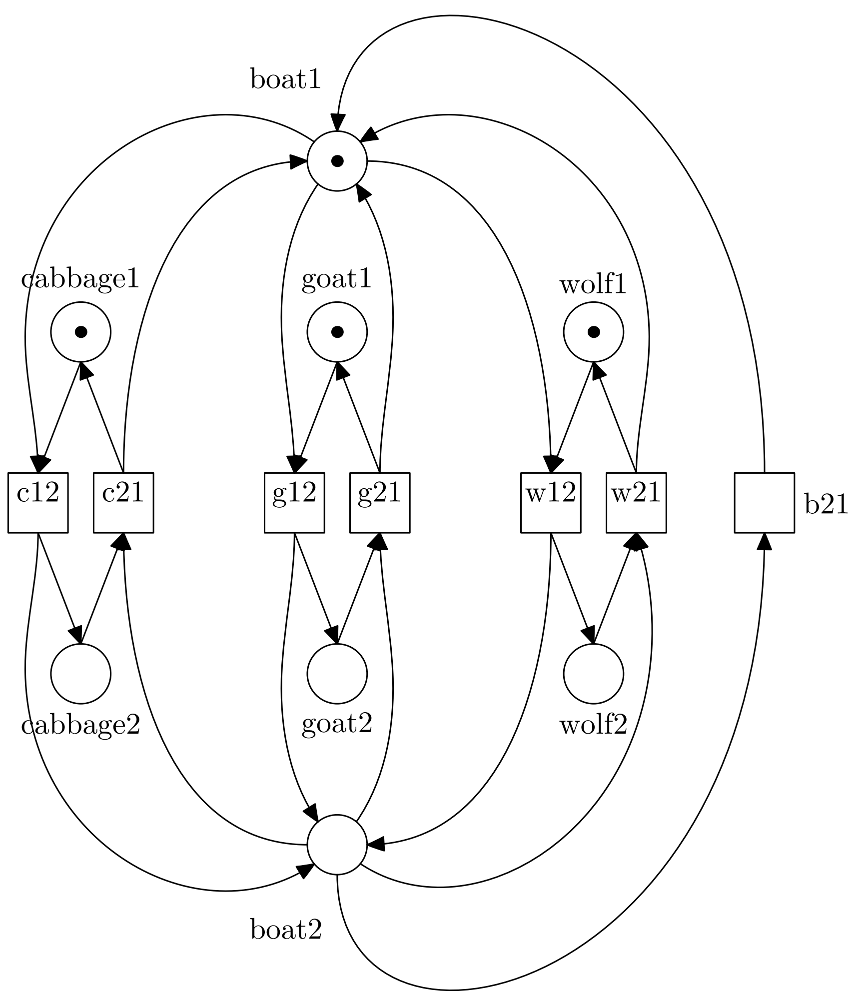
1. Below is presented the place/transition system modelling the problem. The places *cabbage1*, *goat1* and *wolf1* model the situation where the corresponding passengers have not yet crossed the river. The places *cabbage2*, *goat2* and *wolf2* model the situation where the passengers have crossed the river. The places *boat1* and *boat2* represent the location of the boat.




One way to find the unwanted states from the system is to use *fact transitions*. A fact transition is constructed in such a way that it is enabled only if the system is in unwanted state. In this case we need four separate fact transitions, one for each of the unwanted states. The fact transition 1 gets the places *cabbage2*, *goat2* and *boat1* as its preplaces; fact transition 2 gets *goat2*, *wolf2* and *boat1* as its preplaces. Similarly for the fact transitions 3 and 4.

Another possibility would be to use temporal logic to state the properties. In this case the names of places could be used as atomic propositions. The truth values would then be defined so that a proposition P corresponding to place p is true iff there is a token in place p. Now we could define the unwanted properties in the following way:
$\Box\neg((\mathit{cabbage2} \wedge \mathit{goat2} \wedge \mathit{boat1}) \vee (\mathit{goat2} \wedge \mathit{wolf2} \wedge \mathit{boat1}) \vee$
$(\mathit{cabbage1} \wedge \mathit{goat1} \wedge \mathit{boat2}) \vee (\mathit{goat1} \wedge \mathit{wolf1} \wedge \mathit{boat2}))$

The temporal operator $\Box$: $\Box\phi$ is true iff $\phi$ holds in all the markings (states) of the model.

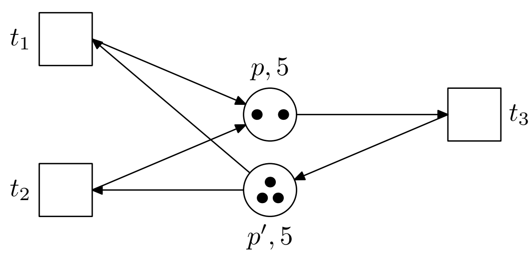
Another possibility is to write the net in Maria's net description language and use the `reject` statement in Maria. The `reject` statement takes a boolean formula which specifies when to reject a state. If, when generating the reachability graph, we encounter a state which causes the formula to evaluate to true, Maria will report the number of the state that is rejected. In this case we could use the formula
$(\mathit{cabbage2} \wedge \mathit{goat2} \wedge \mathit{boat1}) \vee (\mathit{goat2} \wedge \mathit{wolf2} \wedge \mathit{boat1}) \vee$
$(\mathit{cabbage1} \wedge \mathit{goat1} \wedge \mathit{boat2}) \vee (\mathit{goat1} \wedge \mathit{wolf1} \wedge \mathit{boat2})$

In the formula the names of the places are taken as atomic propositions. The interpretation of the atomic propositions is that the proposition is true iff there is a token in the corresponding place.

2. A complement place $p'$ is connected to transitions connected to place $p$ in the following way:

   - If the place $p$ is a preplace of the transition $t$, $p'$ will become a postplace of $t$.
   - If the place $p$ is a postplace of the transition $t$, $p'$ will become a preplace of $t$.

   The initial marking of the complement place $p'$ will be a difference of the capacity of place $p$ and the number of tokens in $p$.



3. The coverability graph is constructed as the reachability graph, except when adding a new marking to the graph. Before adding a new marking to the graph, a check is made whether the new marking *covers* an existing marking (lecture slides p. 2-15).

   The coverability graphs of the nets are identical. The net $N_1$ cannot deadlock after it has fired the transition $t_1$ even once. The net $N_2$, however, can deadlock in the same situation, e.g. with the firing sequence $t_1, t_3, t_2$.

   Our conclusion is that the coverability graph does not maintain all information about the reachability of markings.

   Joint coverability graph: