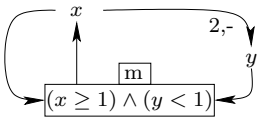
SVS-BBC **Formal methods for discrete modelling** 1 Oct. 2022

Tutorial n^o 2 : Hoare Logic

The aim of this tutorial is to learn how to use Hoare's logic to formalize the dynamic properties of a biological system.

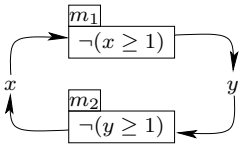
Exercice 1 : (**Reminders**)

A) Let us consider the regulatory network shown on the right.



1. Calculate the table of resources that links the resources of each variable.
2. Can the 2 loops be simultaneously fonctionnal ?

B) Let us now consider the regulatory network shown on the right.



1. Calculate the table of resources that links the resources of each variable.
2. Calculate the characteristic states of the circuit.
3. Assuming that the circuit is functional, what is the CTL formula expressing that there are two distinct attraction bassins ?

Exercice 2 : (**A first example**)

Let us consider a regulatory network consisting of 2 genes (x and y), which are regulated as follows : $x \xrightarrow{1+} y$, $y \xrightarrow{1-} x$ and $x \xrightarrow{2+} x$.

1. Consider the Hoare triplet : $\{y = 0\}x+, x+, y + \{x = 2, y = 1\}$. Assuming that this triplet is satisfied, deduce the maximum parameter.
2. We add another Hoare triplet : $\{\}x+, y+, x-, y - \{\}$. What can we deduce ?
3. We add Snoussi's conditions. What parameters can we deduce ?
4. Construct the transition graph(s).
5. Repeat the same procedure, swapping the thresholds on the arcs coming out of x.

Exercice 3 : (**A second example**)

Let us consider a regulatory network consisting of 2 genes (x and y), which are regulated as follows : $x \xrightarrow{2+} y$, $y \xrightarrow{2-} x$, $x \xrightarrow{1+} x$ and $y \xrightarrow{1+} y$.

1. Consider the Hoare triplet : $\{\}x+, x+, y+, y+, x-, x-, y-, y - \{\}$. Assuming that this triplet is satisfied, deduce the maximum parameter.
2. We add Snoussi's conditions. What parameters can we deduce ?
3. Construct the transition graph(s).
4. Which regulations are not visible in the state graph ?
5. Repeat the same procedure on the graph containing only the 2 regulations : $x \xrightarrow{2+} y$ and $y \xrightarrow{2-} x$.