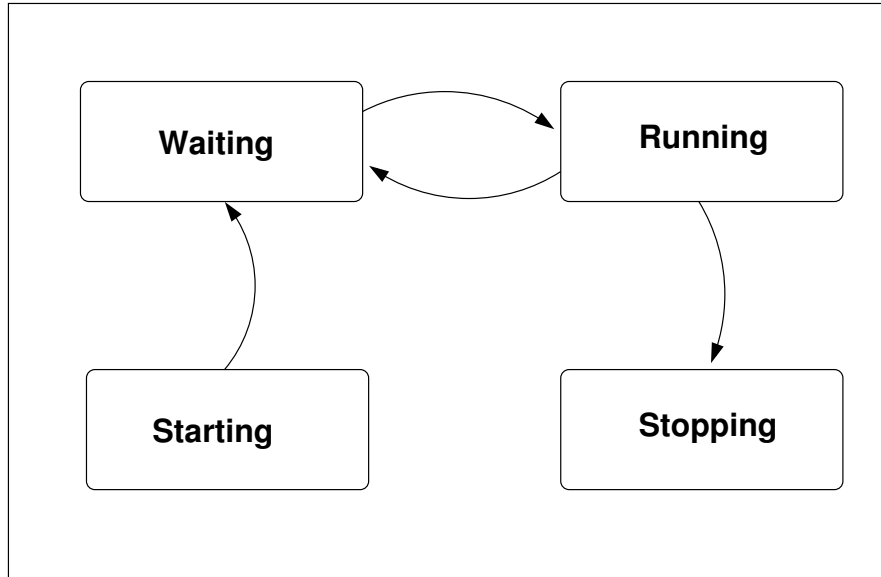


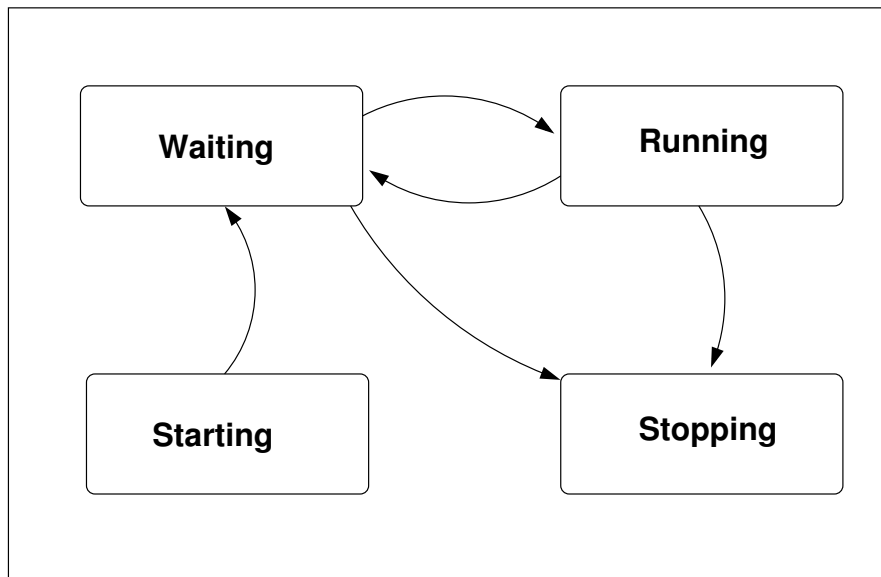
Exercice 1 *ex1-tut1.zip*

Express the following states machine using an Event B machines and check properties on the resulting models.



Exercice 2 *ex2-tut1.zip*

Express the following states machine using an Event B machines and check properties on the resulting models.



Exercice 3 *(ex3-simple-tut.zip)*

Soient trois ensembles A , B et C qui sont des parties de U .

- Ecrire un modèle Event-B qui utilise deux variables v et w deux sous-ensembles de A et B

- Ajouter une fonction partielle de A dans B .
- Définir un événement $\ominus 1$ qui enlève un élément de A qui est élément de C .
- Définir un événement $\ominus 2$ qui enlève un élément de AB qui est élément de C .
- Définir un événement $\ominus 3$ qui crée un lien entre un élément de v et un élément de w à condition que v et w ne contiennent plus d'éléments de C .

Exercice 4 *ex4-tut1.zip*

We consider a finite sequence of integers v_1, \dots, v_n where n is the length of the sequence and is supposed to be fixed. Write an Event B specification modelling the computation of the value of the summation of the sequence v . You should define carefully v , n and the summation of a finite sequence of integers.

Exercice 5 *ex51-tut1.zip* and *ex52-tut1.zip*

Express the following property in Event B :

- (*ex51-tut1.zip*) We assume to have p resources which may be shared by n processes. If a process uses a given resource, the resource can not be used by another process. A process can use several resources.
- (*ex52-tut1.zip*) We assume to have p resources which may be shared by n processes. If a process uses a given resource, the resource can not be used by another process. A process can use possibly more than one resource.

Exercice 6 *ex6-tut1.zip*

A Petri net is a tuple $R=(S,T,F,K,M,W)$

- S is a finite set of places.
- T is a finite set of transitions.
- $S \cap T = \emptyset$
- F is the flow relation : $F \subseteq S \times T \cup T \times S$
- K is expressing the capacity of each place :
 $K \in S \rightarrow \text{Nat} \cup \{\omega\}$
- M is representing the initial marking of each place :
 $M \in S \rightarrow \text{Nat} \cup \{\omega\}$ and satisfies the following condition $\forall s \in S : M(s) \leq K(s)$.
- W is the weight of each edge :
 $W \in F \rightarrow \text{Nat} \cup \{\omega\}$

The state of a Petri net R is defined by a set of markings :

- a marking M for R is a function from S to $\text{Nat} \cup \{\omega\}$:
 $M \in S \rightarrow \text{Nat} \cup \{\omega\}$ and it satisfies the condition $\forall s \in S : M(s) \leq K(s)$.
- a transition t of T is ready to fire for a marking M of R , if

$$1. \forall s \in \{s' \in S \mid (s', t) \in F\} :$$

$$M(s) \geq W(s, t).$$

$$2. \forall s \in \{s' \in S \mid (t, s') \in F\} :$$

$$M(s) \leq K(s) - W(s, t).$$

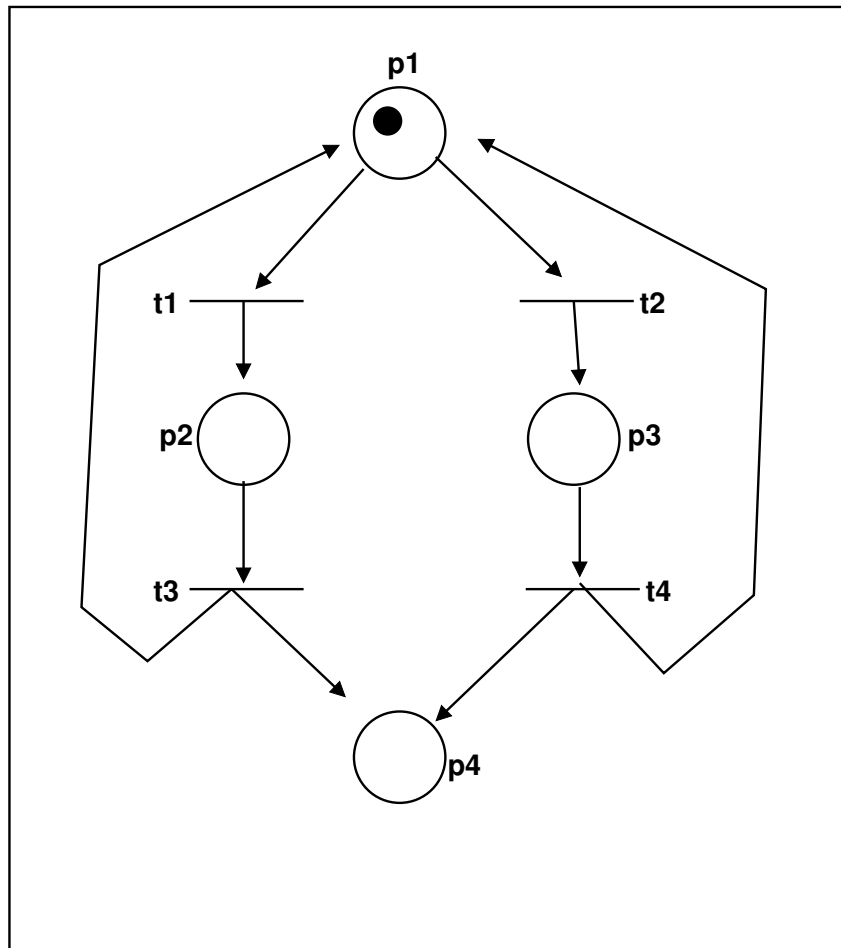
- $t \in T : \text{Pre}(t) = \{s' \in S : (s', t) \in F\}$ and $\text{Post}(t) = \{s' \in S : (t, s') \in F\}$

The simulation of a Petri net is defined by a relation linking three elements : a marking M , a marking M' and a transition t as follows :

- the new marking M' is defined as follows from M :

$$M'(s) = \begin{cases} M(s) - W(s, t), & \text{SI } s \in \text{PRE}(t) - \text{POST}(t) \\ M(s) + W(t, s), & \text{SI } s \in \text{POST}(t) - \text{PRE}(t) \\ M(s) - W(s, t) + W(t, s), & \text{SI } s \in \text{PRE}(t) \cap \text{POST}(t) \\ M(s), & \text{SINON} \end{cases}$$

We consider the following Petri net :



Question 6.1 *Translate this Petri net in Event B.*

Question 6.2 *Express safety properties that you can discover from the diagram.*

Exercice 7 (*ex7-tut1.zip*)

Nous considérons le modèle suivant.

```

MACHINEM1
VARIABLES
   $x$ 
INVARIANTS
  ...
EVENTS
EVENT INITIALISATION
  BEGIN
     $act1 : x := -10$ 
  END
EVENT evt1
  WHEN
     $grd1 : x \geq -1$ 
  THEN
     $act1 : x := x+1$ 
  END
EVENT evt2
  WHEN
     $grd1 : x \leq -1$ 
     $grd2 : x \geq -44$ 
  THEN
     $act1 : x := x-1$ 
  END
END

```

On considère plusieurs cas pour l'invariant.

Question 7.1 (M1)

$$inv1 : x \in \mathbb{Z}$$

$$inv3 : x \leq -1$$

Est-ce que toutes les conditions de vérification sont prouvées par le prouveur de l'application Rodin ? Expliquez clairement pourquoi elles sont prouvées ou non.

Question 7.2 (M2)

$$inv1 : x \in \mathbb{Z}$$

$$inv3 : x \leq -3$$

Est-ce que toutes les conditions de vérification sont prouvées par le prouveur de l'application Rodin ? Expliquez clairement pourquoi elles sont prouvées ou non.

Question 7.3 (M3)

$$inv1 : x \in \mathbb{Z}$$

$$inv4 : -45 \leq x \wedge x \leq -10$$

Est-ce que toutes les conditions de vérification sont prouvées par le prouveur de l'application Rodin ? Expliquez clairement pourquoi elles sont prouvées ou non.

Question 7.4 (M4)

$$inv1 : x \in \mathbb{Z}$$

$$inv3 : x \leq -3$$

$$inv4 : -45 \leq x \wedge x \leq -10$$

$$inv2 : x \leq -1$$

Est-ce que toutes les conditions de vérification sont prouvées par le prouveur de l'application Rodin ? Expliquez clairement pourquoi elles sont prouvées ou non.

Exercise 8 *ex8-tut1.zip*

A semaphore s is a shared variable accessible by two operations : $P(s)$ and $V(s)$. Informally, we can describe the effect of these two operations as follows :

- $P(s)$ is testing if the value of s is greater than 0 and is not equal to 0. If the value of s is 0, the process which is executing $P(s)$ is inserted in a queue.
- $V(s)$ is increasing the value of s by one, if the queue is non empty. If the queue is non empty, the first waiting process of the queue is awoken and becomes a lively process.

Using the Event B modelling features, describe a system using the primitives.

Exercise 9 *ex9-tut1.zip*

We assume that two $n \times n$ matrices of boolean values are given : A and B .

Write an Event B specification modelling the multiplication of the two matrices.

Exercise 10 (*ex10-1-tut1.zip* and *ex10-2-tut1.zip*)

A system is used to sum two numbers $x0$ and $y0$ by adding one unit to a variable z . It includes an $incx2z$ event which decreases the value of x by one and increases the value of z by one, and an $incy2z$ event which decreases y by one and increases z by one. The overall process stops when the two variables x and y are zero.

Write a model in Event-B for the system.

Exercise 11 (*ex11-tut1*)

A system allows the sum of two numbers $x0$ and $y0$ to be calculated by adding one unit to a variable z . It comprises an event $incx2z$ that decreases the value of x by one unit and increases the value of z by one unit, and an event $incy2z$ that decreases y by one unit and increases z by one unit. The overall process stops when both variables x and y are zero.

Write an Event-B model that models this system.