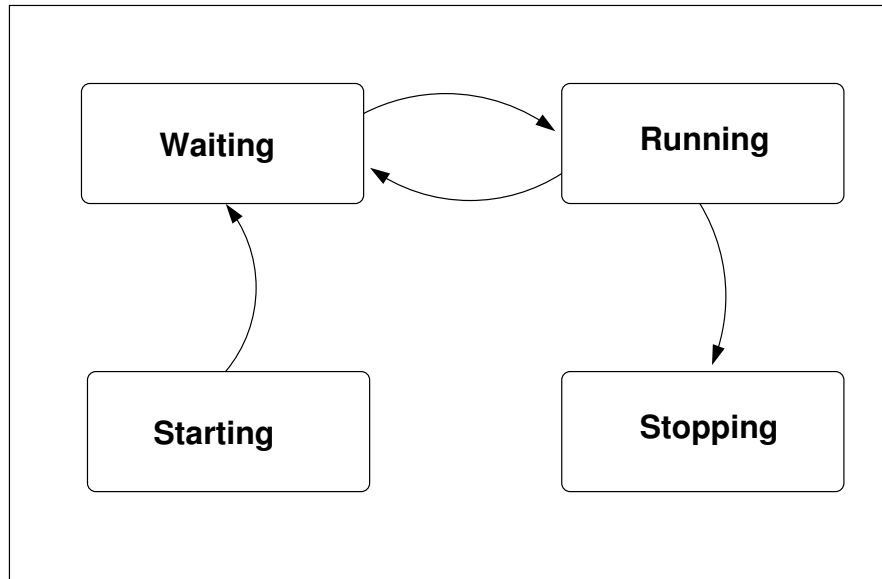


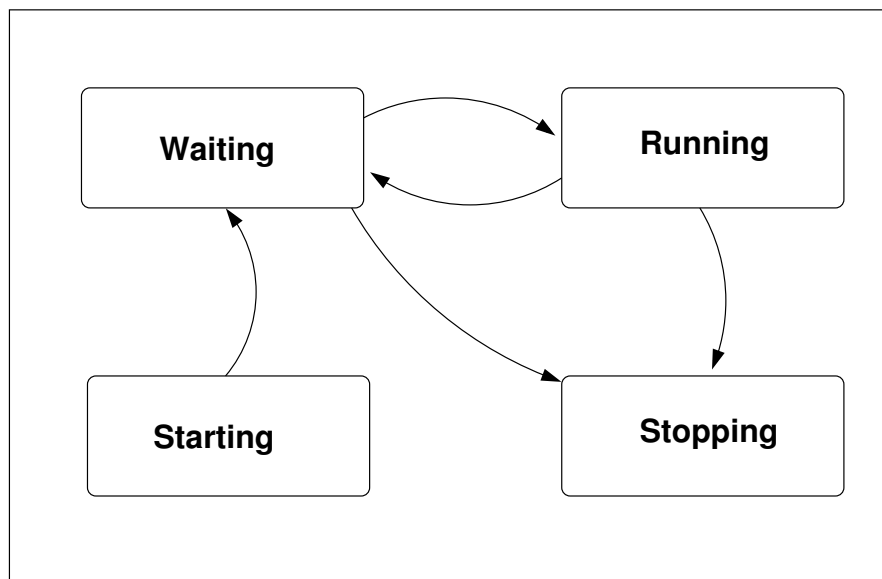
**Exercice 1** *ex1-tut1.zip*

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.