Tutorial Modelling Software-based Systems
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Tutorial 1 : Specifying a problem using the Eevent-B modelling language
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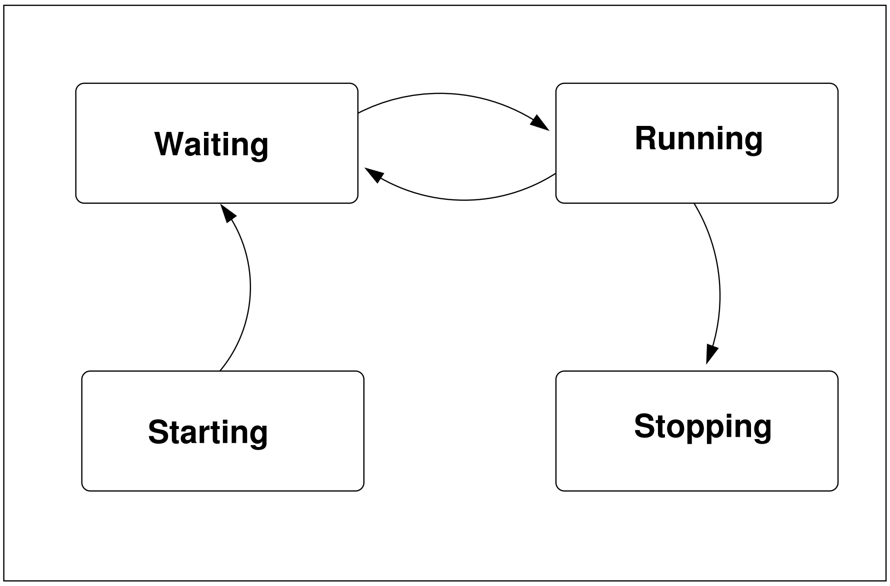
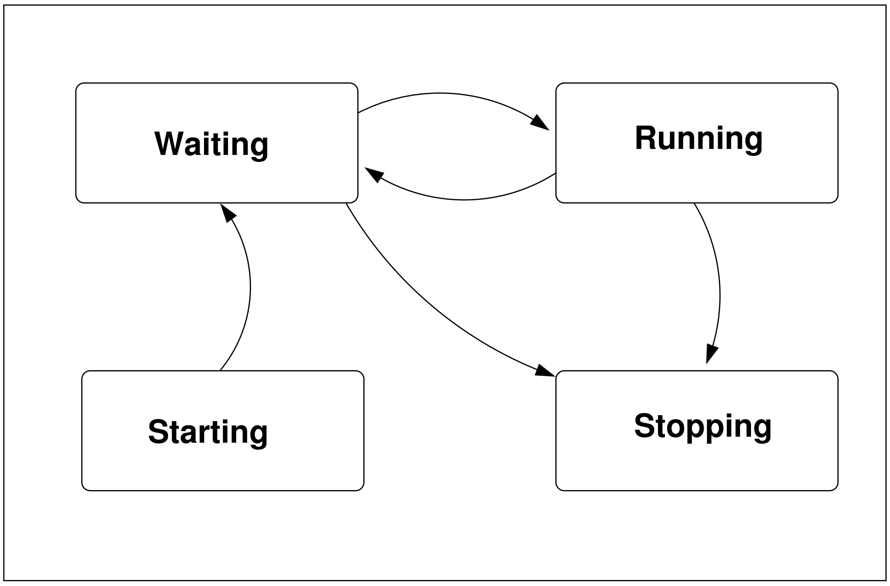
Exercice 1 *ex1-tut1.zip*
Express the following states machine using an Event B machines and check properties on the resulting models.



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 e1 qui enlève un élément de A qui est élément de C.*
— *Définir un événement e2 qui enlève un élément de AB qui est élément de C.*
— *Définir un événement e3 qui crée un lien entre un élément de v et un élément de w à condition que v et w ne contiennet plus d'éléments de C.*

Exercice 4 *ex4-tut1.zip*
We consider a finite sequence of integers $v_1, \ldots, v_n$ 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 cerafully v, n and the summation of a finite sequence of integers.

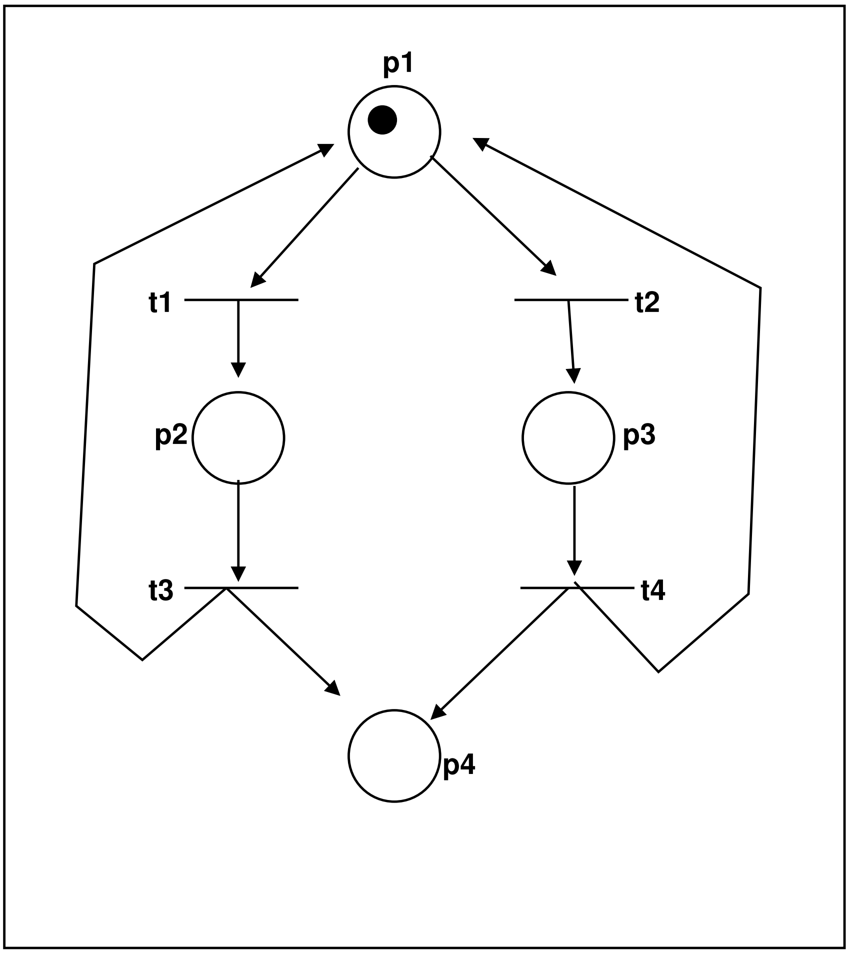
Exercice 5 *ex51-tut1.zip and ex52-tut1.zip*
Express the following property in Event B :
— *(ex51-tut1.zip) We assume to have p resources which may be shared by n processes. If a process uses a given resource, the resource can not be used by another process. A process can use severall resources.*
— *(ex52-tut1.zip) We assume to have p resources which may be shared by $nmcs$ 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 ressoyrce. .*

Exercice 6 *ex6-tut1.zip*
A Petri net is a uple R=(S,T,F,K,M,W)
— *S is a finite set of places.*
— *T is a finite set of transitions.*
— $S \cap T = \varnothing$
— *F is the flow relation :* $F \subseteq S \times T \cup T \times S$
— *K is expressing the capacity of each place :*
$K \in S \rightarrow Nat \cup \{\omega\}$
— *M is reprenting the initial marking of each place :*
$M \in S \rightarrow Nat \cup \{\omega\}$ *and satisfies the following condition* $\forall\, s \in S : M(s) \leq K(s)$.
— *W is the weight of each edge :*
$W \in F \rightarrow Nat \cup \{\omega\}$
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 Nat* $\cup \{\omega\}$:
$M \in S \rightarrow Nat \cup \{\omega\}$ *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. $\forall\, s \in \{ s' \in S \mid (t,s') \in F \}$:
$M(s) \leq K(s) - W(s,t)$.

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

$$M'(s) = \begin{cases} M(s) - W(s,t), \text{ si } s \in Pre(t) - Post(t) \\ M(s) + W(t,s), \text{ si } s \in Post(t) - Pre(t) \\ M(s) - W(s,t) + W(t,s), \text{ si } s \in Pre(t) \cap Post(t) \\ M(s), \text{ sinon} \end{cases}$$

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.

MACHINE $M1$
VARIABLES
x
INVARIANTS
$\ldots$
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)*

$inv1 : x \in \mathbb{Z}$
$inv4 : -45 \leq x \land x \leq -10$

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)*

$inv1 : x \in \mathbb{Z}$
$inv3 : x \leq -3$
$inv4 : -45 \leq x \land x \leq -10$
$inv2 : x \leq -1$

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.

Exercice 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. Il 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 awaken and becomes a lively process.*

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

Exercice 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 matrcices.

Exercice 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 syste.

Exercice 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.