The UPPAAL tool

M1-GLSD

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TOV

L.Kahloul

Outlines of the course

- What and why?
- **Modelling language**: templates, constants & variables, synchronisation, **locations**: committed & urgent, **expressions**: select, guard, synchronisation, update, invariant
- **Verification**: TCTL
- **Simulation**

What and **Why** is Uppaal?

- **Uppaal**= developed jointly by Basic Research in Computer Science at **Aalborg** University in Denmark and the Department of Information Technology at **Uppsala** University in Sweden.

- Tool: Specification+Verification+Simulation

- Implementation: Server (specification)+client (query language for verification)

- Programming: Java, C++, xml

Modelling language of Uppaal "what is in?"

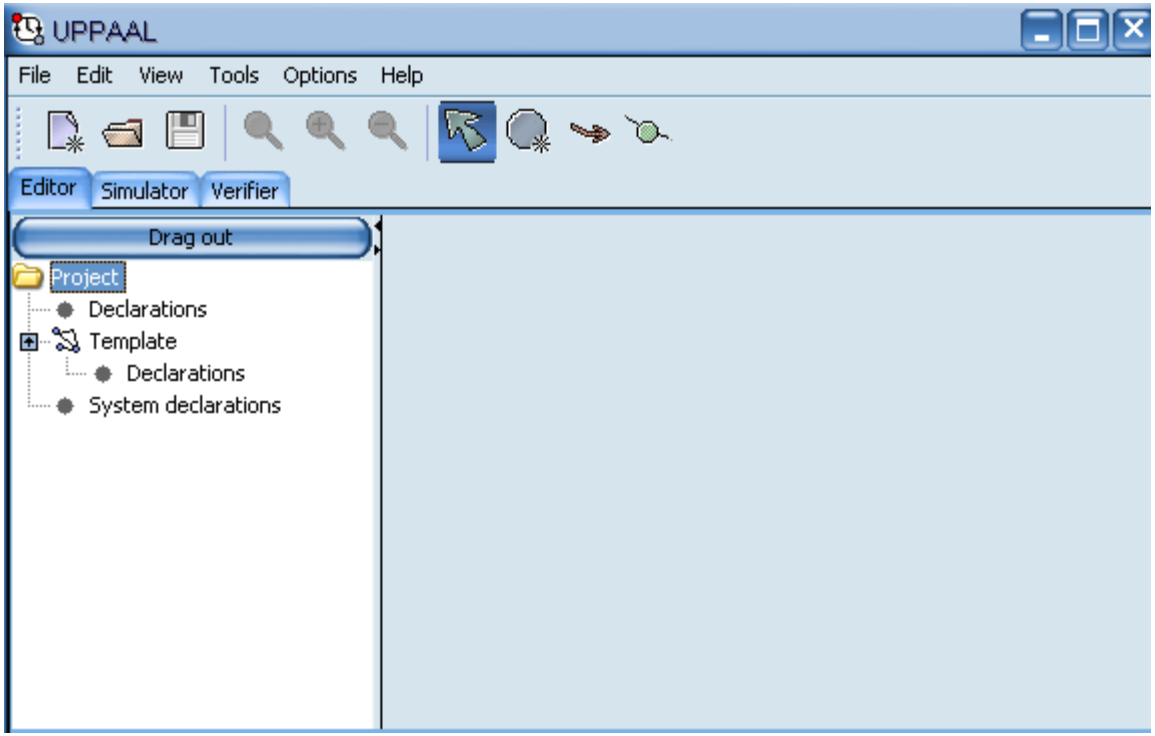
- **Besides** timed-automata, the Uppaal offers a **rich language** that facilitates modelling;

- The language used by uppaal is similar to a programming **language based on C language**;

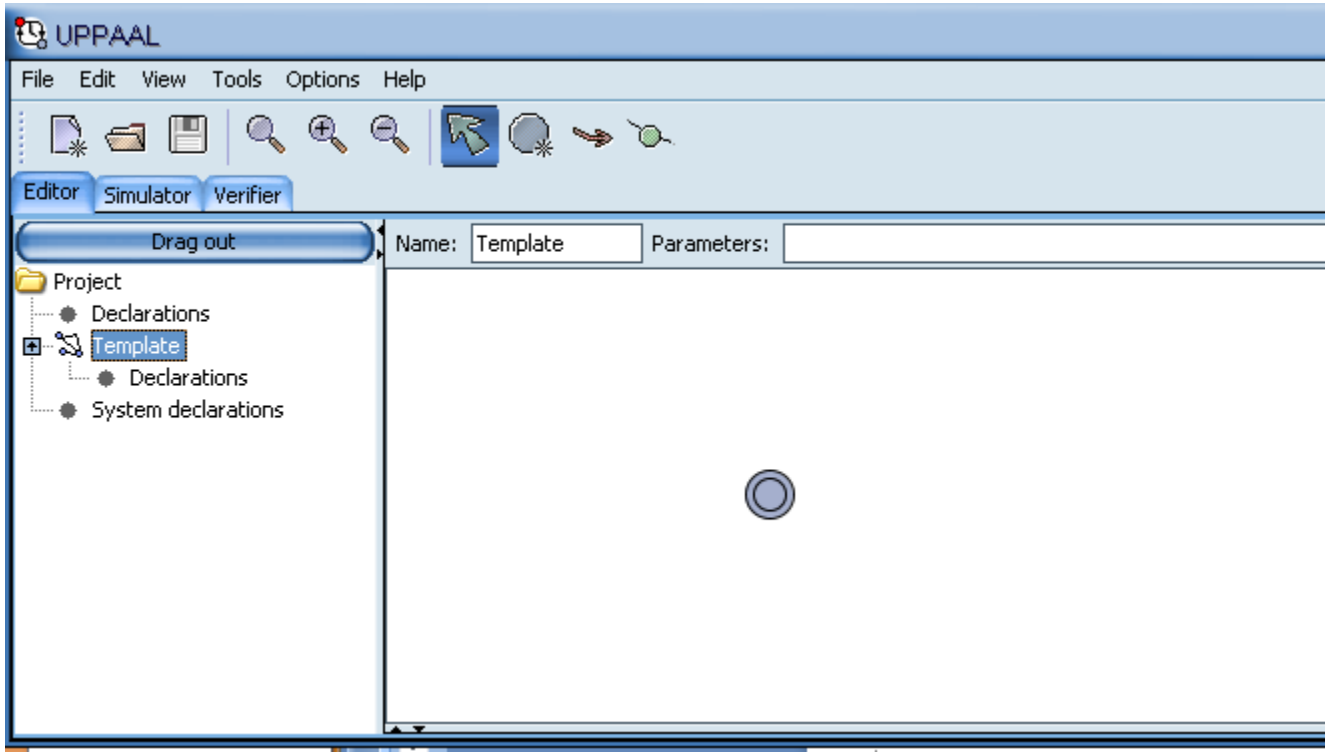
- The language of uppaal introduces the concepts: **Template**, **constant**, **bounded integer variables**, **binary synchronisation**, **broadcast channels**, **urgent synchronisation**, **urgent or committed locations**, **arrays**, **initialiser**, **record types**, **custom types**, **user function**

Modelling language of Uppaal **“templates”**

- **Template**: automaton is considered as a template. It can be instantiated and **parameterised** with some parameters.



Modelling language of Uppaal
“templates”



Modelling language of Uppaal
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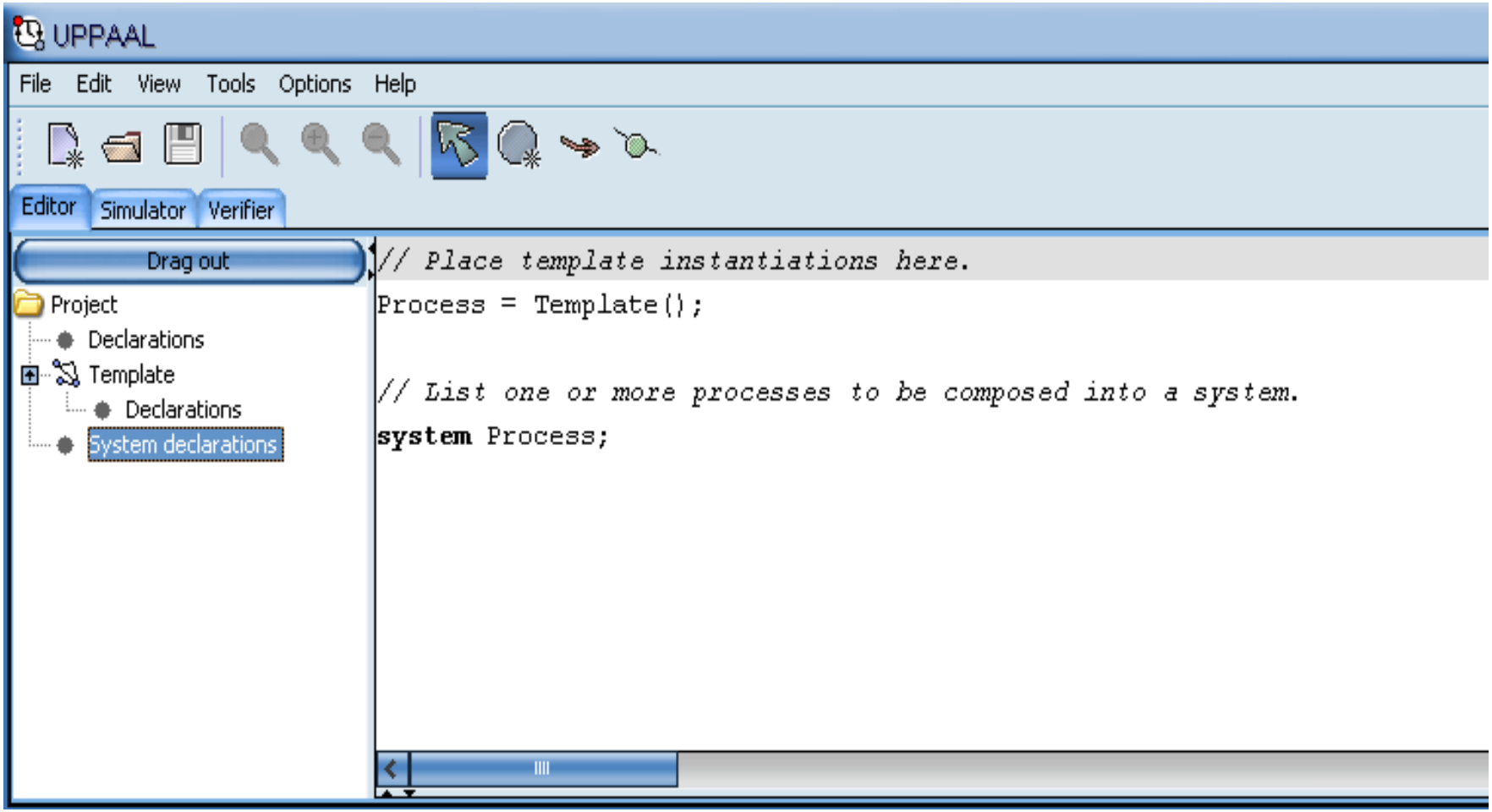
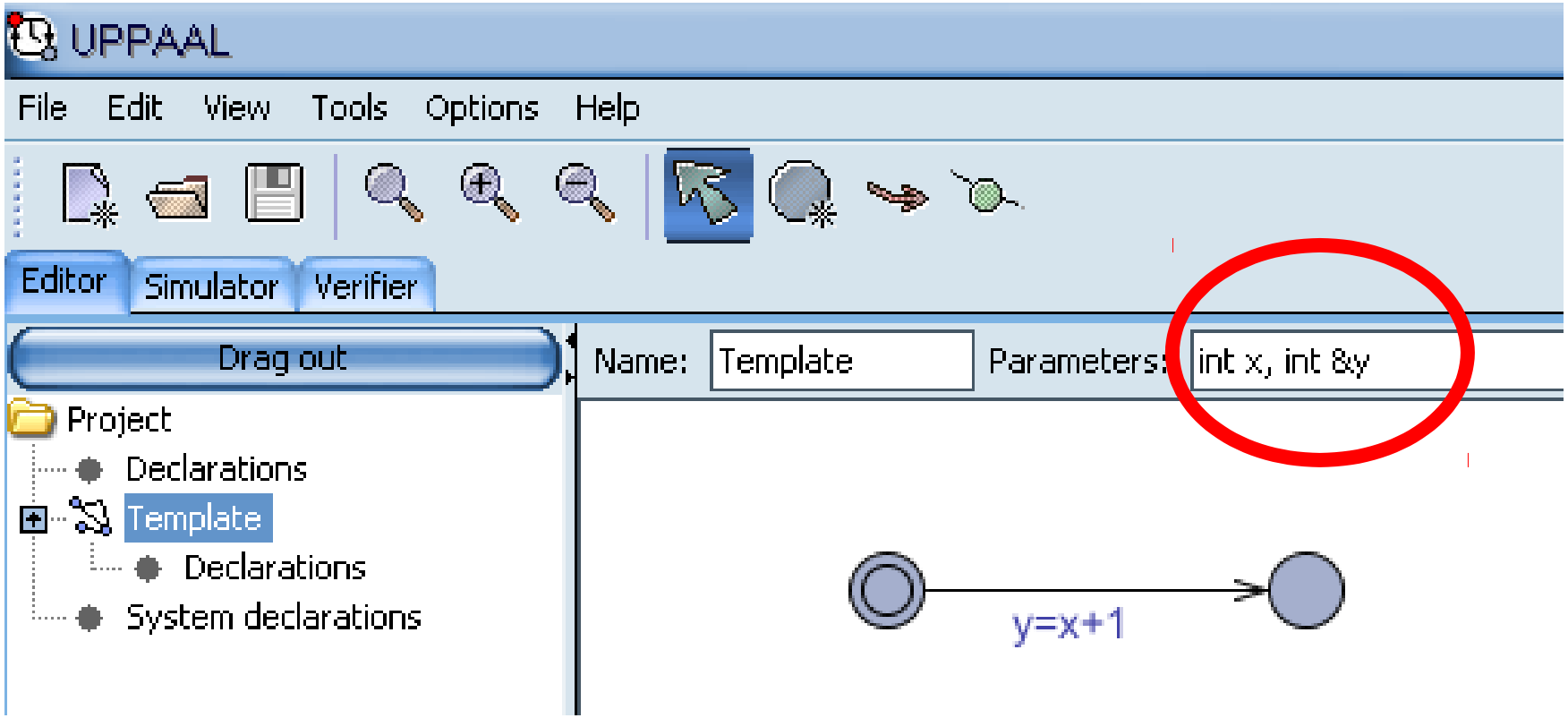


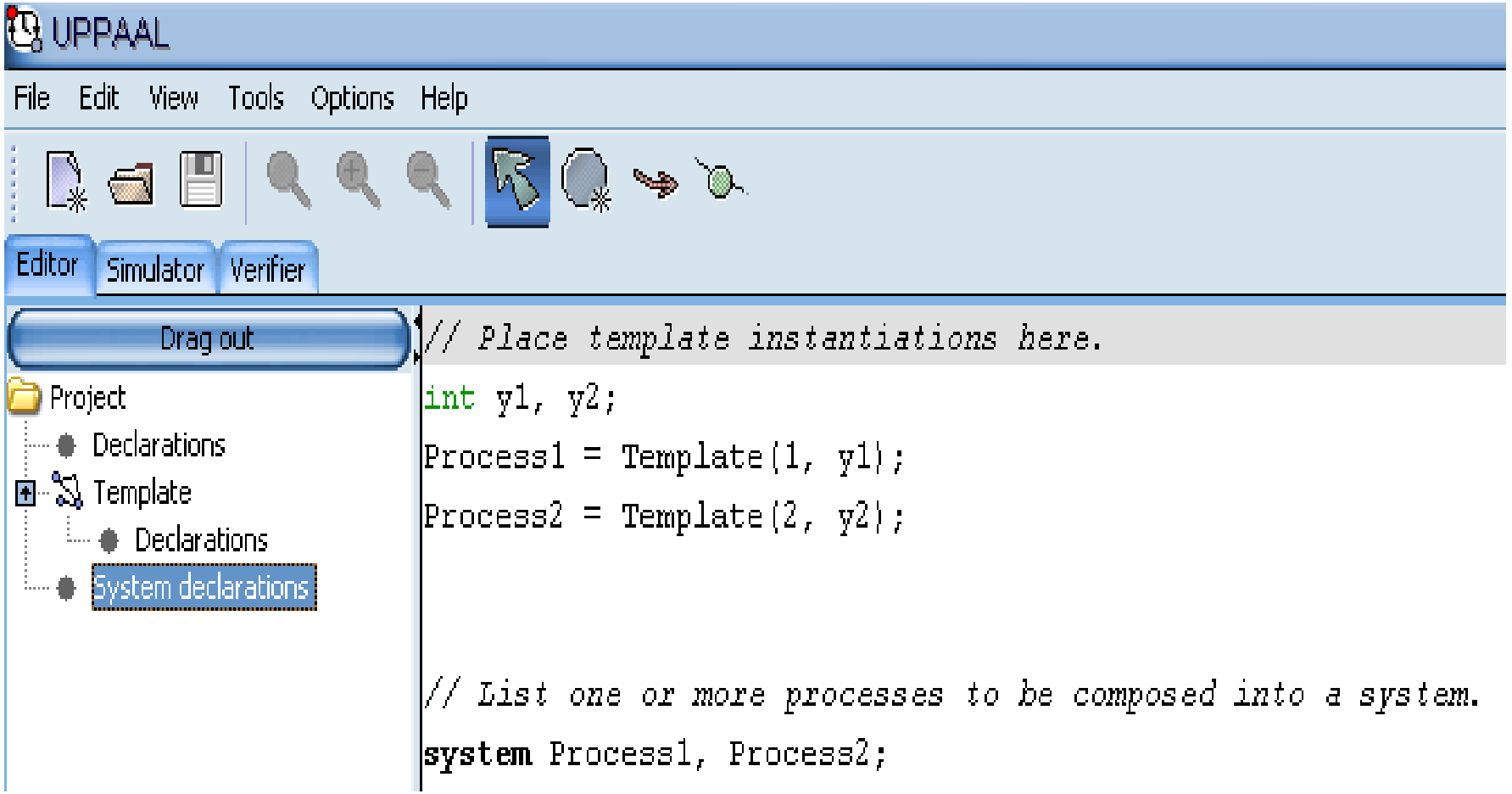
Modelling language of Uppaal

“templates”



Modelling language of Uppaal

“templates”



Modelling language of Uppaal

"constants and variables"

- **constant**: **const name value;**

  const int N=5; **const** int x=2;

- **bounded integer variables**:

  Int[min, max] name;

  -32768 to 32768

  Example: Int [2, 4] x;

Modelling language of Uppaal "synchronisation"

- **binary synchronisation**: this requires the declaration of a **channel** between two templates (or automata).

chan name**;**

Example: **chan** move;

Two edges labelled **move?** (to receive) and **move!** (to send) must exist, respectively, in the two automata

- Send and receive are **blocking actions**

Modelling language of Uppaal
"synchronisation"

- **broadcast channels**: this requires the declaration of a broadcast **channel** between several templates (or automata).

broadcast chan name**;**

Example: boradcast **chan** move;

An edge labelled **move!** (to send) and several **move?** (to receive) must exist, respectively, in the sender and the receivers automata

- send is not a **blocking action**

Modelling language of Uppaal
"synchronisation"

- **urgent synchronisation**: the declaration of the channel is preceded by: **urgent**.

Example: **urgent chan** move;

- Edges using urgent channels for synchronisation cannot have time constraints, i.e., no clock guards.

Modelling language of Uppaal

"locations: urgent, commited"

- **urgent locations:** with a **U** inside the location. **time is not allowed to pass** when the system is in an urgent location.

How can we model this using the usual TA?

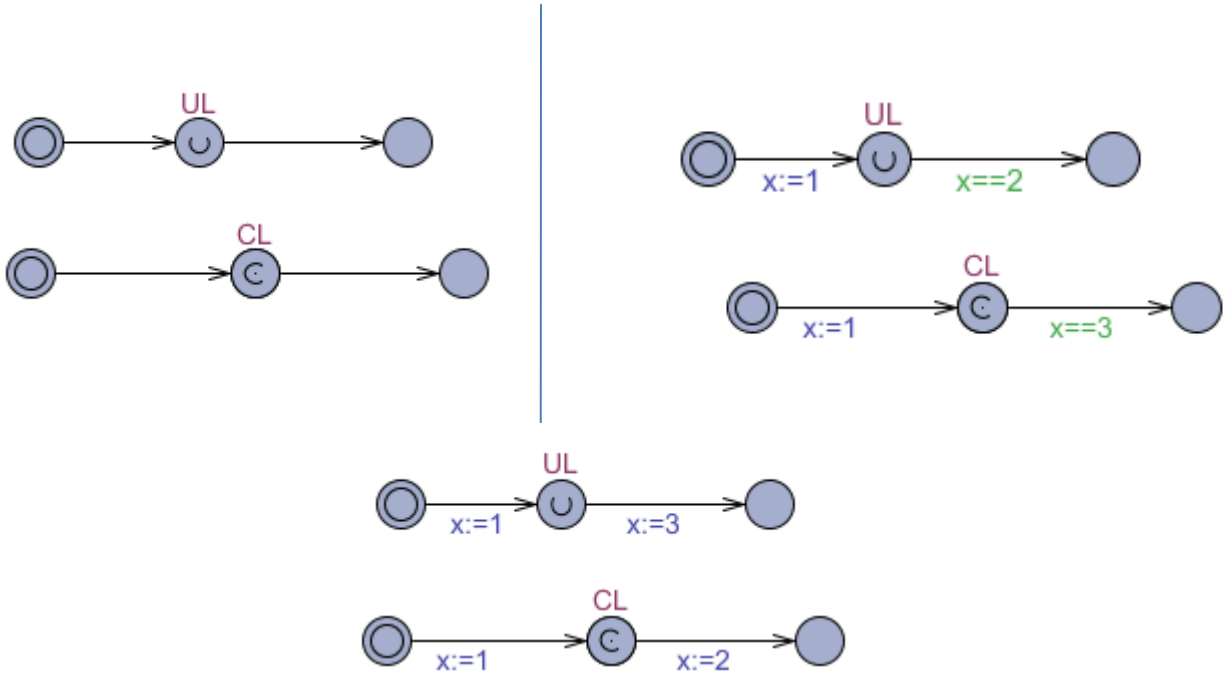
- **committed locations**: with a **C** inside the location. It is an **urgent location** & in a committed state (a state where at least one process is in a committed location) the **system must leave the committed location in the next transition** (i.e. the only possible transition is the one that fires the edge outgoing from a committed location).

why we use these locations ?????????

Modelling language of Uppaal

"locations: urgent, commited": **example**

- How can the following processes work?



- Consider the two cases: x is shared or local.

Modelling language of Uppaal

- **arrays**, : we can have arrays of clocks, channels, constants and integer variables:

  chan c[4];

  clock a[2];

  const int c[2]={0,2};

  int[3,5] u[7];

Modelling language of Uppaal

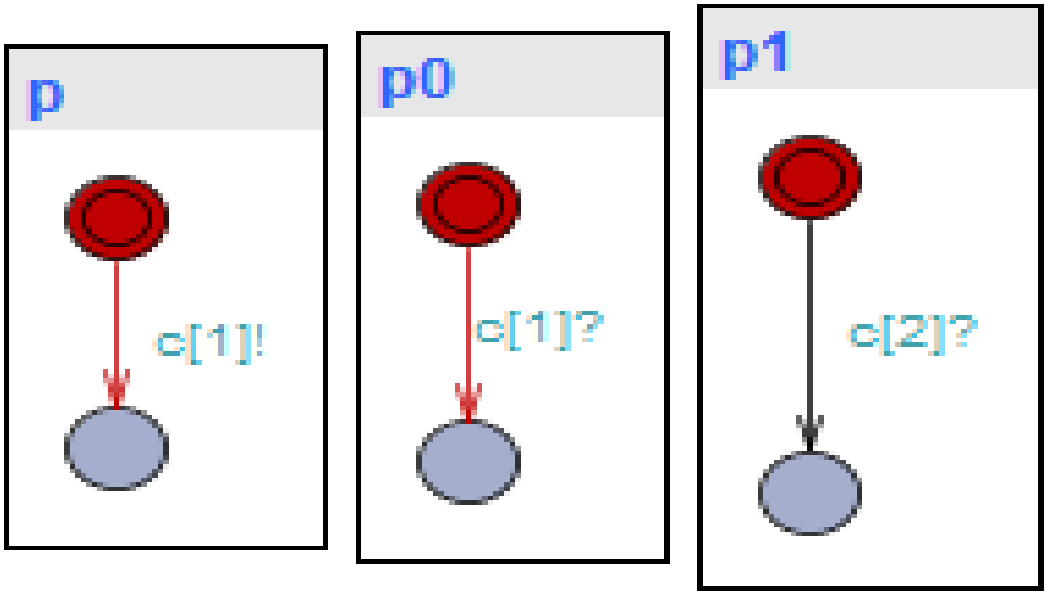
- **arrays of channels:**

chan c[n]:

- The value i is then used both as an array index when deciding what channel to synchronize on,
- and as an argument that can be used after.

Modelling language of Uppaal

- Example: even the three processes p, p0, p1 use the same channel ***c***, but ***c[1]*** synchronises, only, ***p*** with ***p0***



Modelling language of Uppaal

- **initialiser**, are used to initialise integer variables and arrays of integer variables. Example:

```
int i = 2;
int i[3] = {1, 2, 3};
```

- **record types** : are declared with the **struct** construct like in C

```
struct {
int x;
int y;
} str;
```

Modelling language of Uppaal

- **custom types :** are defined with the C-like **typedef** construct.

```
typedef struct {
int x;
int y;
} str_t;
str_t str;
str.x=1;
```

Modelling language of Uppaal

- **User function** : defined either **globally** or **locally** to templates.
- Template parameters are **accessible** from local **functions**. The syntax is similar to C except that there is **no pointer**.

```
int f(){
    str_t str;
    str.x=1;
    return str.x;
}
```

Modelling language of Uppaal
“expressions”

- Expressions range over **clocks** and **integer variables**.
- **Four** kinds of expressions: **select**, **guard**, **synchronisation**, **update**, **invariant**

Modelling language of Uppaal
“expressions”

- **Select**: (on edges)

Syntax: name1: type1, name2:type2, …

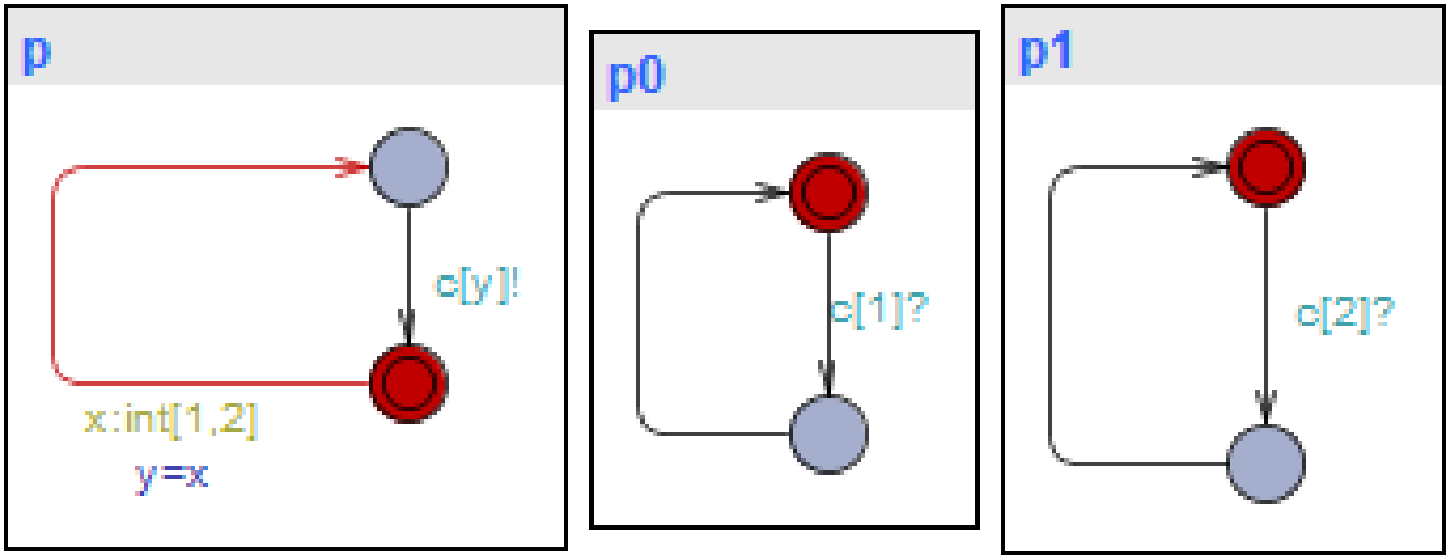
Semantics: assign randomly a value form the type to the name

Example:

- **x:int**; selects an integer random value;
- **x:int[2,3]**; selects an integer random value inside the interval [2,3]

Modelling language of Uppaal
“expressions”

- Deduct the behaviour of this example



Modelling language of Uppaal
“expressions”

- **Guard: (**on edges)

Syntax: expression1 **op** value1 **and** expression2 **op** value2 **and** …

op in {==, <, >, <=, >=}

Example: x==2 and y<=3 and x-y<=0 and …

Modelling language of Uppaal
“expressions”

- **Synchronisation**: (on edges)

Syntax: chan_name!

chan_name?

Semantics: synchronise with another transition in another automaton

- **Update**: (on edges)

Syntax: var_name1:=value1, var_name2:=value2, ...

Example : x:=1, y:=2, z:=4, …

Modelling language of Uppaal
“expressions”

- **Invariant: (on locations)**

Syntax: expression1 **op** value1 **and** expression2 **op** value2 **and** …

op in {==, <, >, <=, >=}

Example: x==2 and y<=3 and and x==y and x-y<=0 and …

Remarks: (1) x, y can be variables or clocks

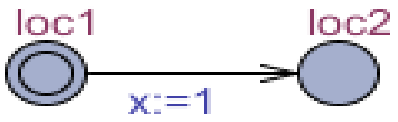
Verification with Uppaal
“TCTL”

- Two kinds of formulae

1) State formulae describe individual states: (**name_proc.name_loc**)
2) Futur (F) is written: <>, and Globaly (G) is writen []
3) Path formulae (quantify over paths or traces of the model):

   - reachability: **E<> φ**
   - safety: something good is invariantly true. **A[] φ**
   - liveness: something will eventually happen **A<> φ**

Verification with Uppaal
"TCTL": example



If proc is the name of this process,

- **A<> proc.loc2** : the location loc2 is reachable eventually **(<>)** in all paths (**A**),
- **A[] proc.loc2** : the location loc2 is reachable gloably (**[]**) in all paths **(A)**
- **A<>proc.x>=1 ???**
- **E<>proc.x>=1 ???**
- **p-->q is equivalent to A[](p=>A<>q)**