Metropolis

GSRC

Metropolis Project Team

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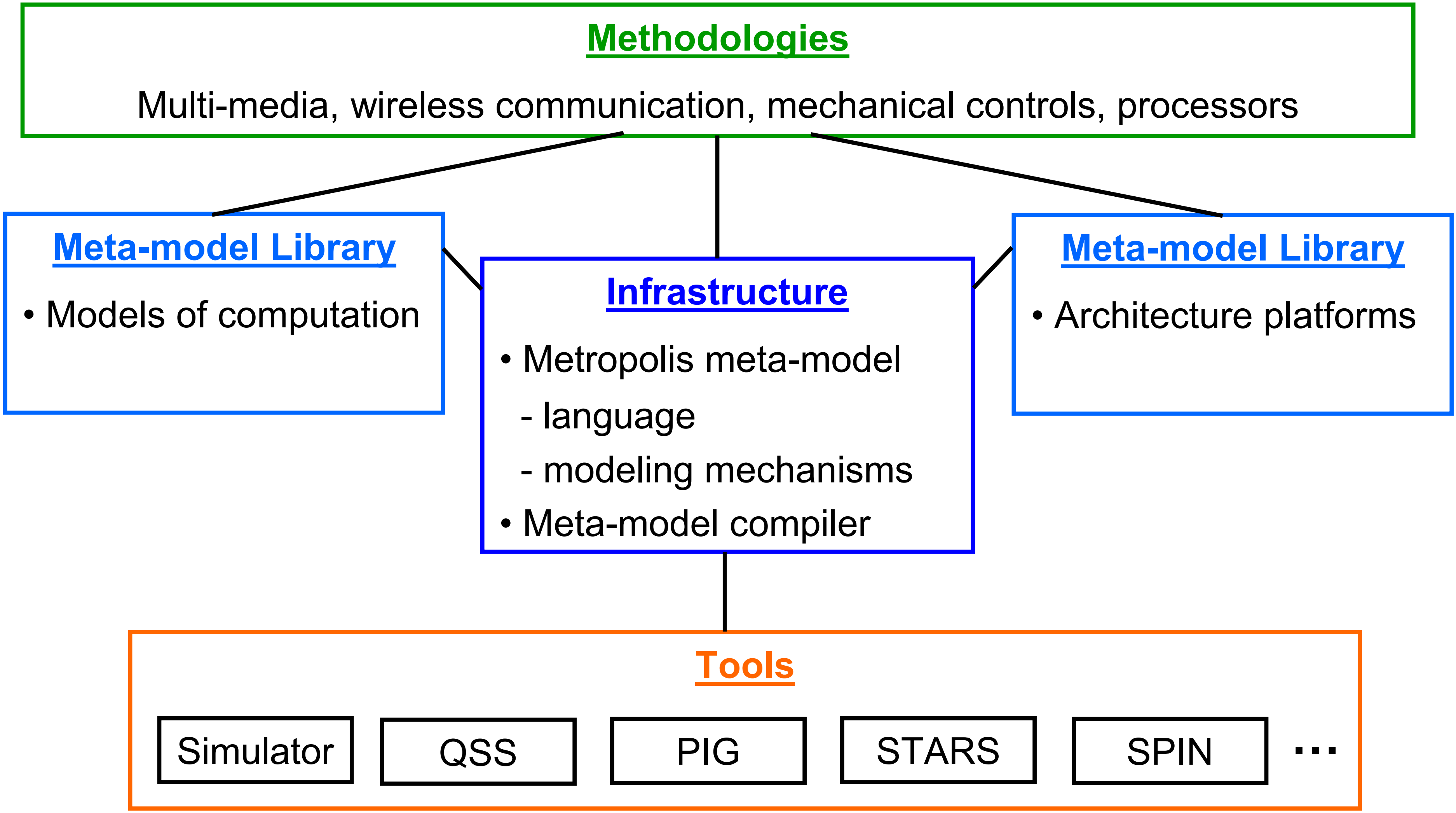
Metropolis Framework



Methodologies

Multi-media, wireless communication, mechanical controls, processors

Meta-model Library

- Models of computation

Infrastructure

- Metropolis meta-model
  - language
  - modeling mechanisms
- Meta-model compiler

Meta-model Library

- Architecture platforms

Tools

Simulator

QSS

PIG

STARS

SPIN

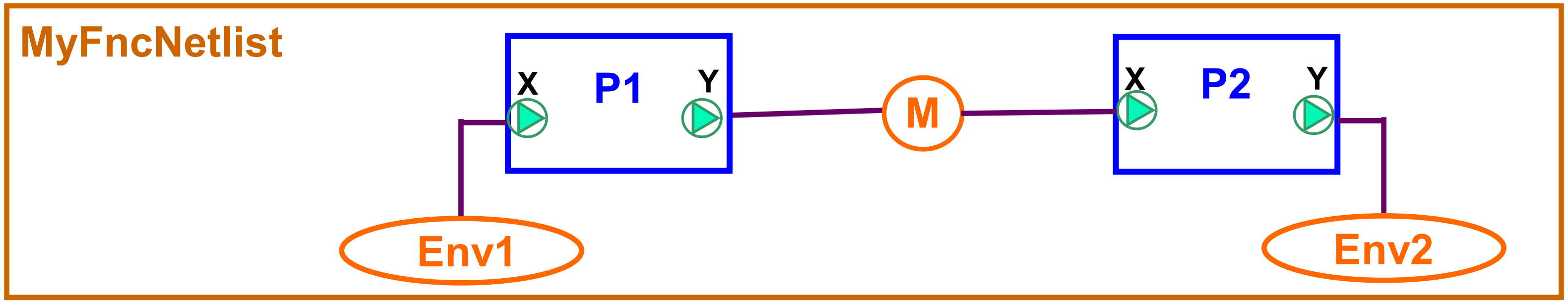
…

Metropolis meta-model

Concurrent specification with a formal execution semantics:

- **Computation** : $f : X \rightarrow Z$
  - **process** : generates a sequence of *events*
- **Communication** : state enumeration and manipulation
  - **medium** : defines *states* and *methods*
- **Coordination** : constraints over concurrent actions
  - **quantity** : annotated with events
  - **logic** : relates events wrt quantities, defines axioms on quantities
  - **q-manager** : algorithms to realize annotation subject to relations

Meta-model : function netlist



```
process P{
  port reader X;
  port writer Y;
  thread(){
   while(true){
    ...
    z = f(X.read());
    Y.write(z);
   }}}
```

```
interface reader extends Port{
    update int read();
    eval int n();
}
```

```
interface writer extends Port{
    update void write(int i);
    eval int space();
}
```

```
medium M implements reader, writer{
   int storage;
   int n, space;
   void write(int z){
       await(space>0; this.writer ; this.writer)
           n=1; space=0; storage=z;
    }
    word read(){ ... }
}
```

Meta-model: execution semantics

- Processes take *actions*.
  - statements and some expressions, e.g.

    y = z+port.f();, z+port.f(), port.f(), i < 10, …

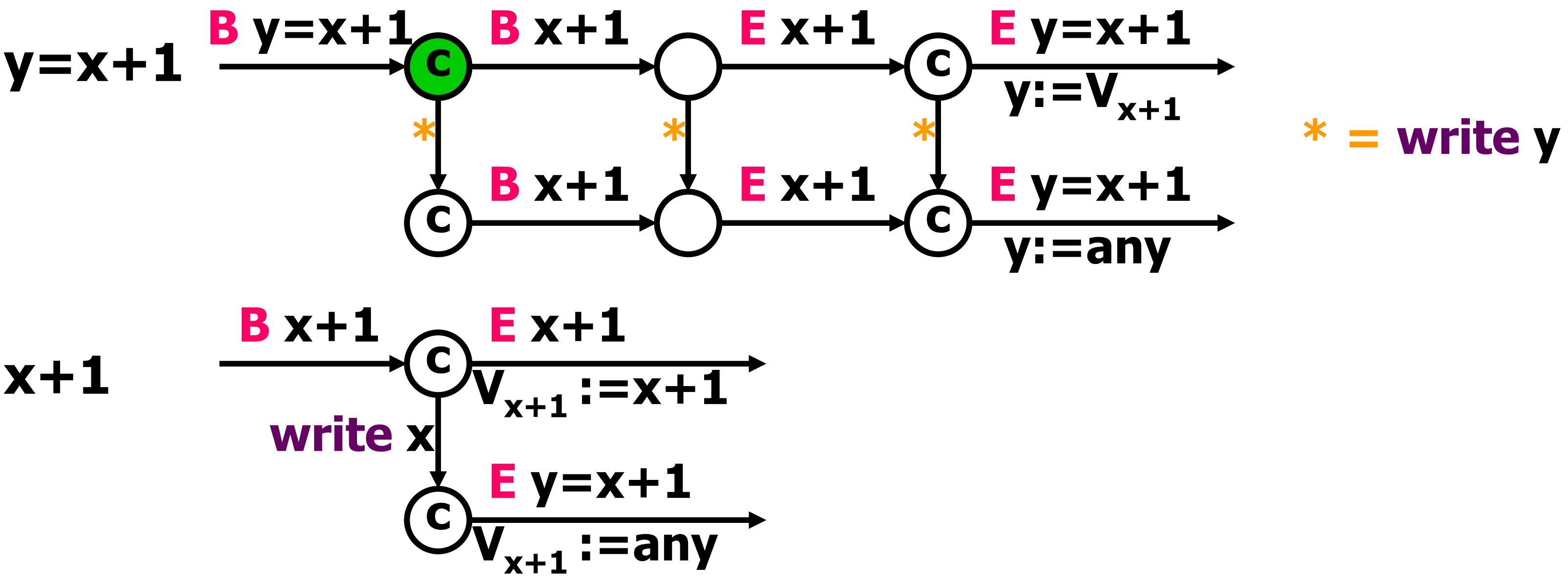
- An *execution* of a given netlist is a sequence of vectors of *events*.
  - *event* : the beginning of an action, e.g. B(port.f()),

    the end of an action, e.g. E(port.f()), or null N
  - the *i*-th component of a vector is an event of the *i*-th process

- An execution is *feasible* if
  - it satisfies all coordination constraints, and
  - it is accepted by all action automata.

Meta-model: action automata

- y=x+1;



V_{x+1}	0
y	0
x	0

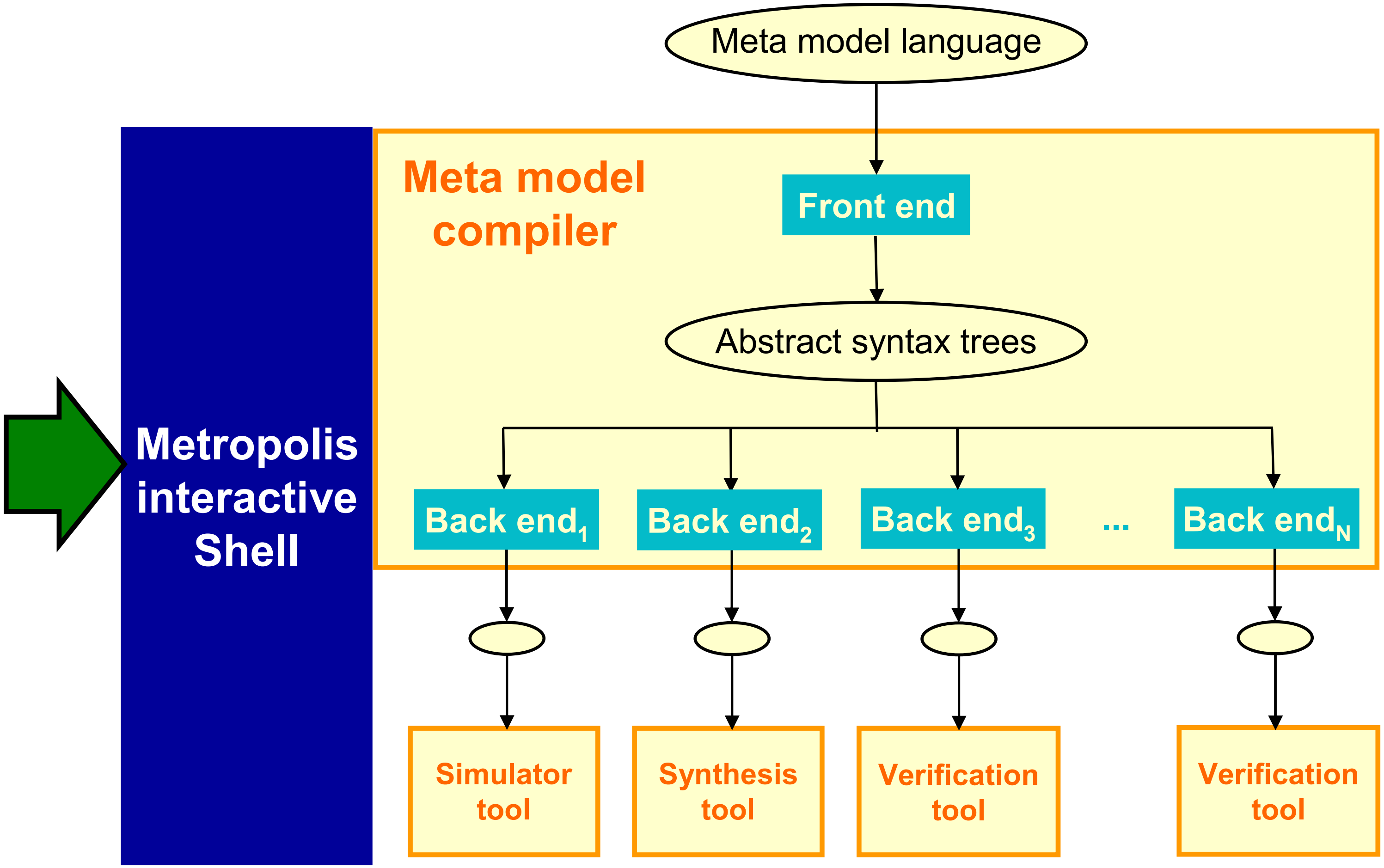
B y=x+1 N

Meta-model: execution semantics

- Processes run sequential code concurrently, each at its own arbitrary pace
- Read-Write and Write-Write hazards may cause unpredictable results
  - atomicity has to be explicitly specified
- Progress may block at synchronization points
  - await's
  - function calls and labels to which await-s or LTL constraints refer

Metropolis design environment

- Load designs
- Browse designs
- Relate designs
  refine, map etc
- Invoke tools
- Analyze results



Meta model language

Metropolis interactive Shell

Meta model compiler

Front end

Abstract syntax trees

Back end$_1$

Back end$_2$

Back end$_3$

…

Back end$_N$

Simulator tool

Synthesis tool

Verification tool

Verification tool

Formal models from the meta-model

Example: Petri nets

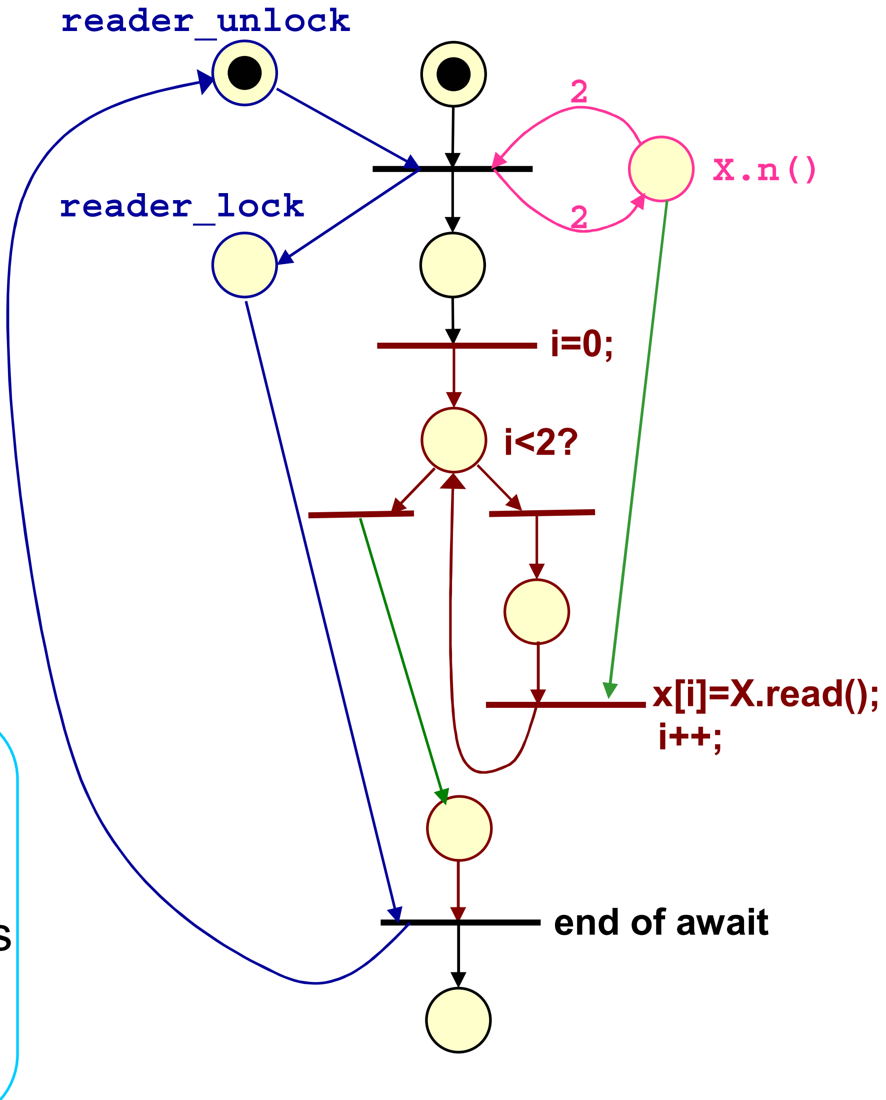
```
await(X.n()>=2; X.reader; X.reader)
  for(i=0; i<2; i++) x[i]=X.read();
```

Restriction:

condition inside await is conjunctive.

Formal methods on Petri nets:

- analyze the schedulability
- analyze upper bounds of storage sizes
- synthesize schedules


reader_unlock
2
X.n()
reader_lock
2
i=0;
i<2?
x[i]=X.read();
i++;
end of await