The Caltrop Actor Language

Johan Eker
UC Berkeley

MoBIES group, Carnegie Mellon, November 30, 2001

What is an Actor?

- Input & output ports
- States
- Parameters
- Consumes and produces tokens
- An actor is said to be fired

Why Another Language?

- Java is current practice
  - No need to learn another language
  - The functional behavior of the actor is mixed with platform issues
  - Most of the actor code deals with administration
- Caltrop offers a concise, more abstract description
  - Simplifies code generation
  - Allows some analysis
  - Quick to implement actors, “throw away actors”
  - Protects IP - Insulates the actor from the platform

Caltrop Actor Language

- Imperative, but with a functional flavor
- Embedded in a host language
  - All data types are imported
- Operates on token streams

```
actor Add () double A, double B ➔ double C:
  action [a], [b] ➔ [c]:
    c := a + b;
  end
end
```

A:[1,2,3,...], B: [1,2,3,...] ⇒C: [2,4,6,...]

Type Polymorphism

- Type parameters

```
actor Add [T1, T2]() T1 A, T1 B ➔ T2 C:
  where T2 > T1:
  action [a], [b] ➔ [a+b]: end
end
```

- Type lattice not part of the language
- Operators are injected from the environment
- Type checking and/or type inference

Actions and Patterns

- Matches patterns on input ports

```
actor MyActor () double A, double B ➔ double C:
  action [a, b], [c] ➔ [a+b+c]: end
end
```

  - Assume the following sequence on both ports [1,2,3,4,5,....], the output would then be the sequence [1+2+1,3+4+2,...]=[4,9,14,...]
- The pattern `[a, b | c]` binds a and b to the two first tokens, and c to the rest of the input sequence

Actions and Patterns cont'd

- One actor, many actions

```
actor Sum () double A, double B ➔ double C:
  action [a], [b] ➔ [a+b]: end
  action [a], [] ➔ [a]: end
  action [], [b] ➔ [b]: end
end
```

- Conditional actions

```
actor Abs () double A ➔ double B:
  action [a] ➔ [a] where a > 0: end
  action [a] ➔ [-a] where a <=0: end
end
```

Multi ports

- A port may have several channel
  - A multi ports is a map from *ChannelID* to data type
  - Syntax: <pattern> <expression>
- The Switch actor
  - One selector input port
  - One data multi input port

```
actor Switch [T] () int i, multi T input ➔ T out:
  action [i], [a] i ➔ [a]: end
end
```

Multi ports cont'd

```
actor Add [T] () multi T input ➔ T out:
  action [a] any ➔ [sum] with T sum := 0:
    foreach int i in dom a :
      sum := sum + a[i];
    end
  end
  action [a] {1,2,3} ➔ [sum] with T sum := 0:
    foreach int i in dom a :
      sum := sum + a[i];
    end
  end
end
```

Behavior polymorphism

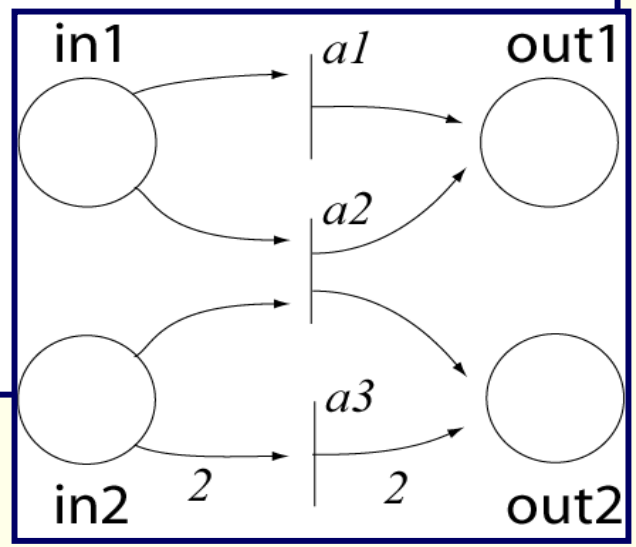
- The semantics for Caltrop is not complete
- Different interpretation for different targets, i.e. the same Caltrop block will have different meaning in Simulink and Ptolemy II/SDF. For example:

```
actor MyActor () int in1, int in2 ➔ int out:
  action [a], [b] ➔ [a+b]:  end
  action [a], []  ➔ [2*a]:  end
  action [], [b]  ➔ [2*b]:  end
end
```

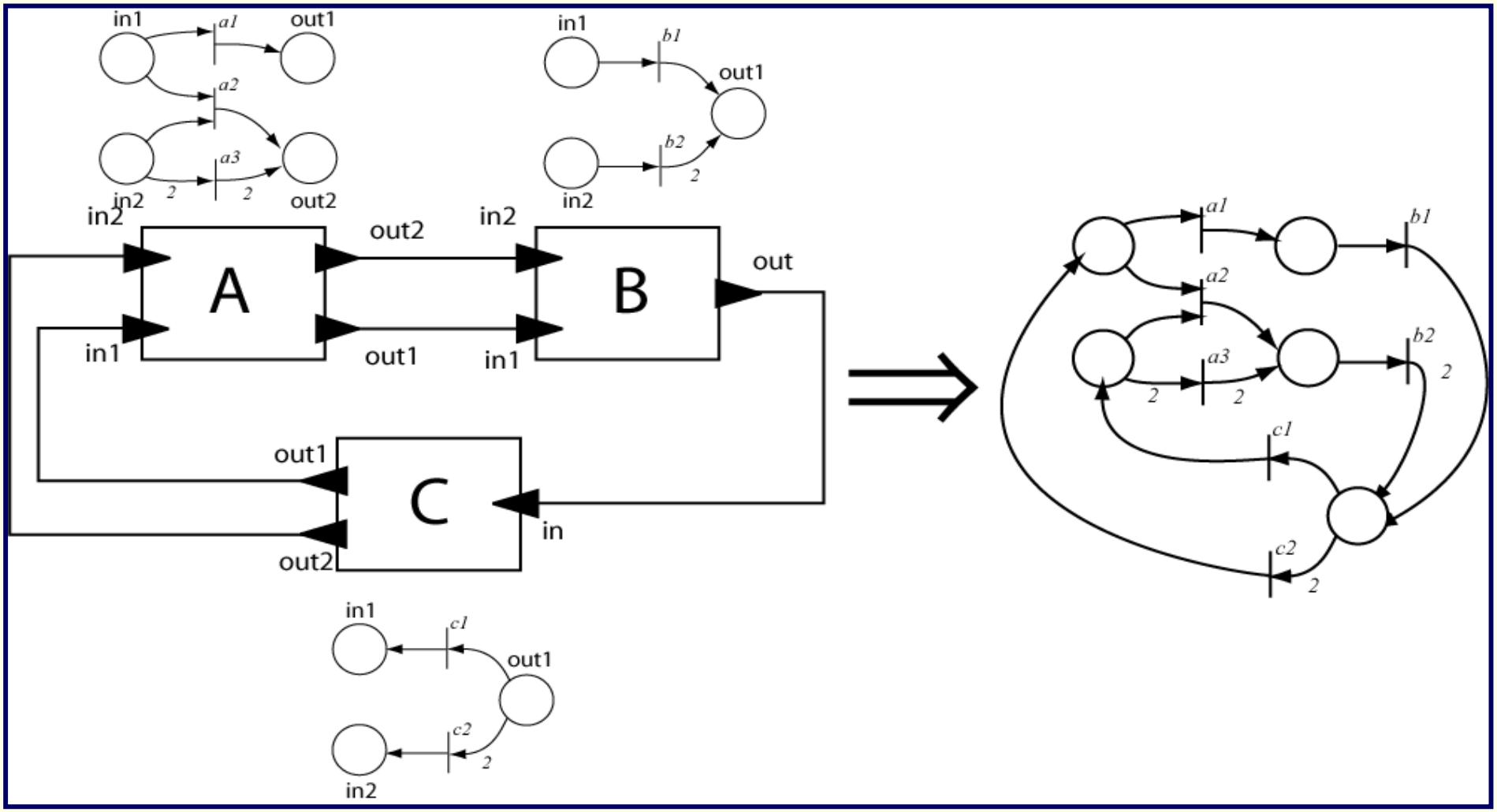
Analysis

- Production and consumption rates may be extracted by inspection of patterns

```
actor MyActor () int in1, int in2 ➔ int out1, int out2:
  a1: action [a], [b] ➔ [a], [b]:
      end
  a2: action [a], [] ➔ [a, a], []:
      end
  a3: action [], [b] ➔ [], [b, b]:
      end
end
```



Composing Caltrop Actors



Behavioral Restrictions

- Restrict the allowed actions
- Regular expressions over actions

```
actor MyActor () int in1, int in2 ➔ int out1, int out2:
  a1: action [a], [b] ➔ [a], [b]: end
  a2: action [a], [] ➔ [a, a], []: end
  a3: action [], [b] ➔ [], [b, b]: end

 selector
    a1 (a2|a3)*
  end
end
```

- The first action must be a1 which then is followed by either a2 or a3 zero or more times

The Rest of Caltrop

- Expressions are side effect free
- Lambda closures
- Statements
  - **foreach**
  - **while**
  - **if-then-else**
- Built-in types: list, map, set

Current Status

- 2 Post-docs + 2 graduate students
- Compiler and interpreter in the works
- http://www.gigascale.org/caltrop