CAL - An actor language

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CAL people

- Chris Chang
- Johan Eker (now Ericsson Mobile Platforms, Research)
- Ernesto Wandeler (ETH Zurich)
- Lars Wernli (then ETH Zurich)
- Ed Willink (Thales Research)
- Yang Zhao

Why another language?

- Writing simple actors should be simple.
  - Ptolemy II API very rich
  - actor writing requires considerable skill
  - **BUT: Actors have a lot of common structure.**
- Models should allow efficient code generation.
  - actor descriptions contain a lot of "admin" code
- local precedent:
  - ptlang in Ptolemy Classic (J. Buck)

Why another language?

We should **generate** actors from a more abstract description.

- reduces amount of code to be written
- makes writing actors more accessible
- reduces error probability
- makes code more versatile
  - retargeting (other platforms, new versions of the Ptolemy API)
  - analysis & composition

Simple actors

```
actor ID () In ==> Out :

    action [a] ==> [a] end
end
```

```
actor A (k) Input1, Input2 ==> Output:

    action [a], [b] ==> [k*(a + b)] end
end
```

```
actor Merge ()
    Input1, Input2 ==> Output:

    action Input1: [x] ==> [x] end
    action Input2: [x] ==> [x] end
end
```

actor firing ≡ execution of *one* *enabled* action

An actor with state

```
actor Sum () Input ==> Output:

    sum := 0;

    action [a] ==> [sum]
    do
        sum := sum + a;
    end
end
```

Action guards

```
actor FairMerge ()
    Input1, Input2 ==> Output:

    s := 0;

    action Input1: [x] ==> [x]
    guard s = 0
    do
        s := 1;
    end

    action Input2: [x] ==> [x]
    guard s = 1
    do
        s := 0;
    end
end
```

action

- **input patterns**
  declaring variables
- **guard**
  specifying enabling conditions
- **output expressions**
  computing output tokens
- **body**
  modifying the actor state

Action schedules

```
actor FairMerge ()
    Input1, Input2 ==> Output:

    s := 0;

    action Input1: [x] ==> [x]
    guard s = 0
    do
        s := 1;
    end

    action Input2: [x] ==> [x]
    guard s = 1
    do
        s := 0;
    end
end
```

```
actor FairMerge ()
    Input1, Input2 ==> Output:

 A: action Input1: [x] ==> [x] end
 B: action Input2: [x] ==> [x] end

    schedule fsm State0:
        State0 (A) --> State1;
        State1 (B) --> State0;
    end
end
```

```
actor FairMerge ()
    Input1, Input2 ==> Output:

 A: action Input1: [x] ==> [x] end
 B: action Input2: [x] ==> [x] end

    schedule regexp
        (A B)*
    end
end
```

First-class functions

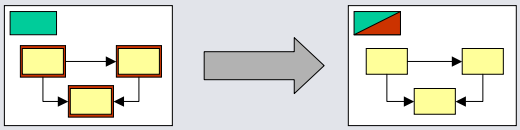
```
actor Sieve (predicate) Input ==> Output:

    filter := lambda (a) : false end;

    action [a] ==> []
    guard filter(a) end

    action [a] ==> [a]
    guard not filter(a)
    var f = filter
    do
        filter := lambda(b) :
                      f(b) or predicate(b,a)
                  end;
    end
end
```


Programming language features

- optionally typed
  - generic polymorphic type system
- full functional sub-language
- everything first-class citizen (well, almost)
  - functions
  - procedures
  - NOT actors or actions (yet)
- lexically scoped
- no aliasing of stateful structures
  - useful for handling concurrency

Executing CAL: Interpreter

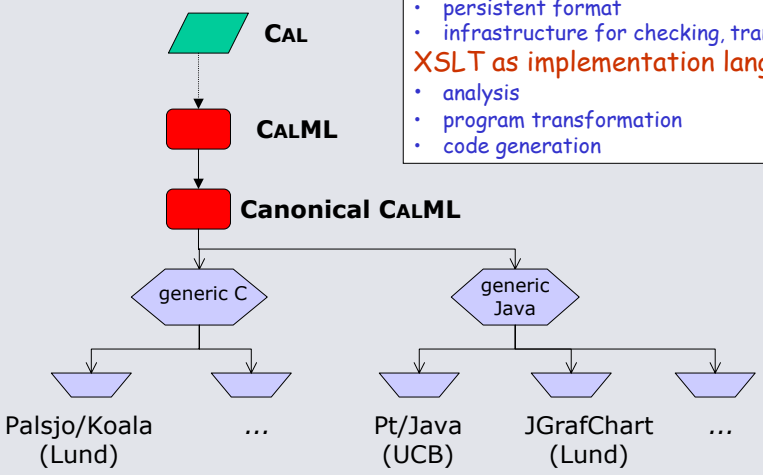
- Ptolemy actor
  - configured by CAL script
  - smooth embedding into Ptolemy II
  - first version in current release
- domain-dependent interpretation
  (Chris Chang)
  - interpreter adapts to domain
  - making actors more domain-polymorphic
  - What's a model of computation?



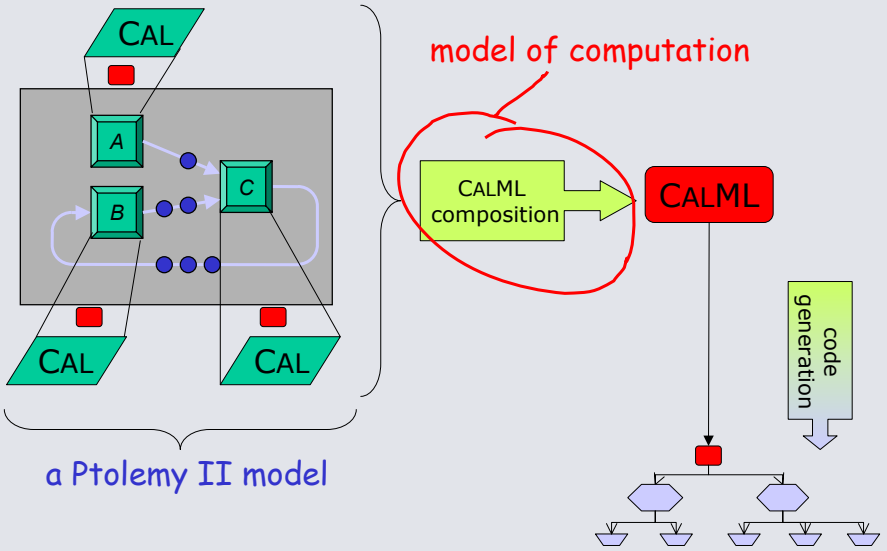
Executing CAL: Translators

XML for representing actors (CALML)
- persistent format
- infrastructure for checking, transformation

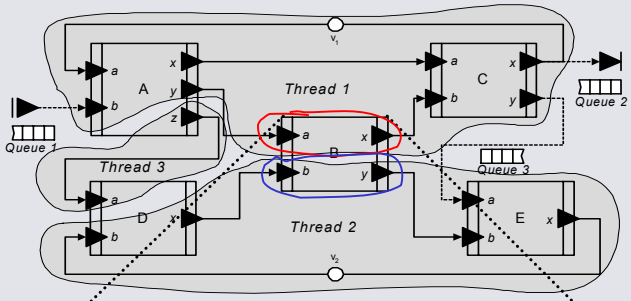
XSLT as implementation language
- analysis
- program transformation
- code generation



Executing CAL: Composer/Translator



Executing CAL: Discovering concurrency




```
actor B () a, b ==> x, y:

    s := <something>;

    action a: [v] ==> x: [f(v, s)] end

    action b: [v] ==> y: [g(v)]
    do
        s := h(v, s);
    end
end
```

Conclusion

- CAL is a Ptolemy scripting language
  - simple, portable description of actors
  - can be analyzed, interpreted, compiled, composed
- new research directions
  - composers as models of computation
    - composer languages?
  - infrastructure for executing actors
    - component models, execution environments
  - transformations/analyses of actor networks
    - distribution
    - efficient translation

Thank you.

resources: www.gigascale.org/caltrop
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