Code Generation Update

Andy Edmunds
University of Southampton
ae2@ecs.soton.ac.uk

Since the last RUDW

- Concluded industrial collaboration,
  - Improvements to translator.
  - Java interface for the Environment.
- Templates and code-injection.
- Event-B to C translation,
  - for use in co-simulation.
- Theory + Java Code for Implementable Sets and Functions.

Improvements to Translators

Generally,

- Automatic flattening of invariants, and events.
- Automatic inference of typing annotations and parameter directions.
- … means fewer steps to generate code from an appropriately constructed model.

For Java integration with Event-B projects,

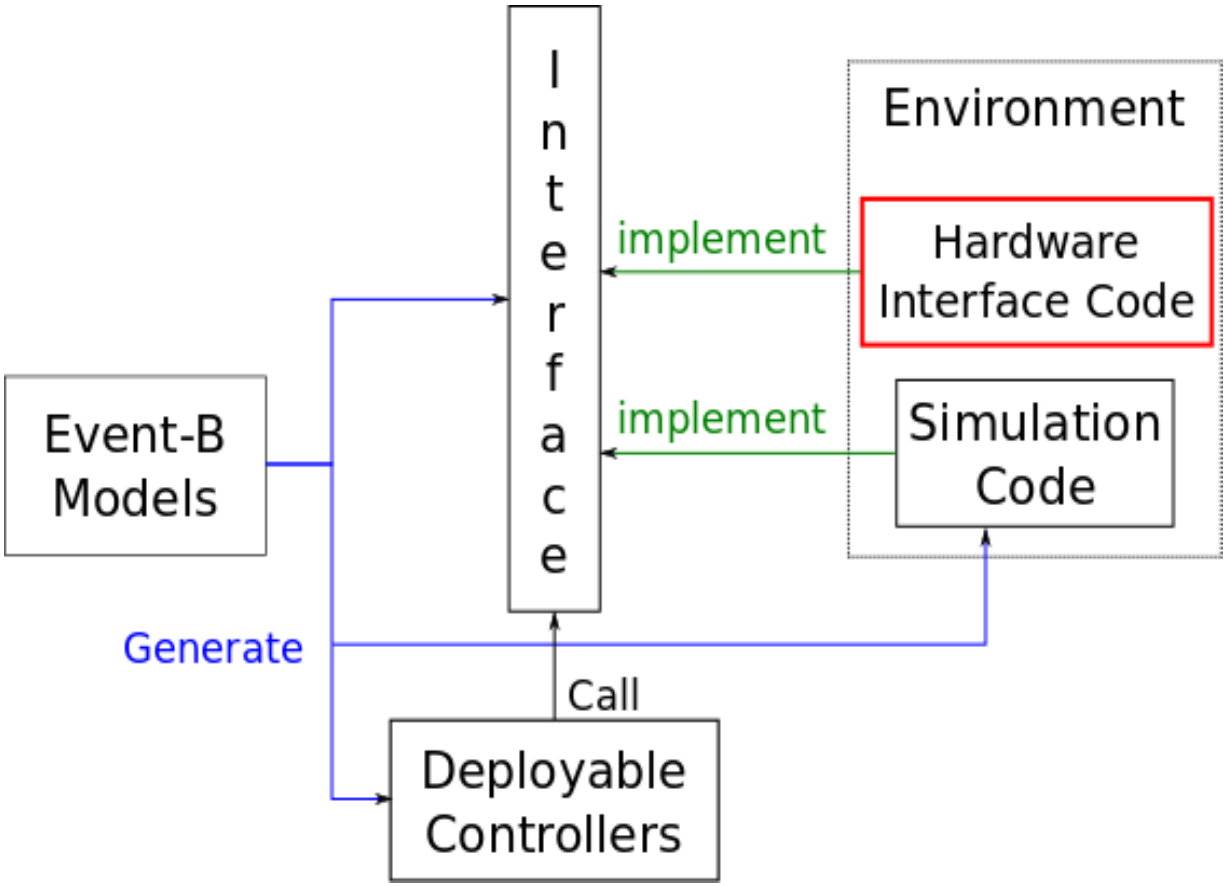
- To use Java Nature and Java Builder (JDT).

Some Items on the To-do List

But, we are still short of the goal, in terms of usability, and features.

- Validation and feedback.
- Translation of nested state-machines.
- Synchronization between events of a state-machine (Other than the current *between-cycles* approach).

New: A Java Interface for the Environment

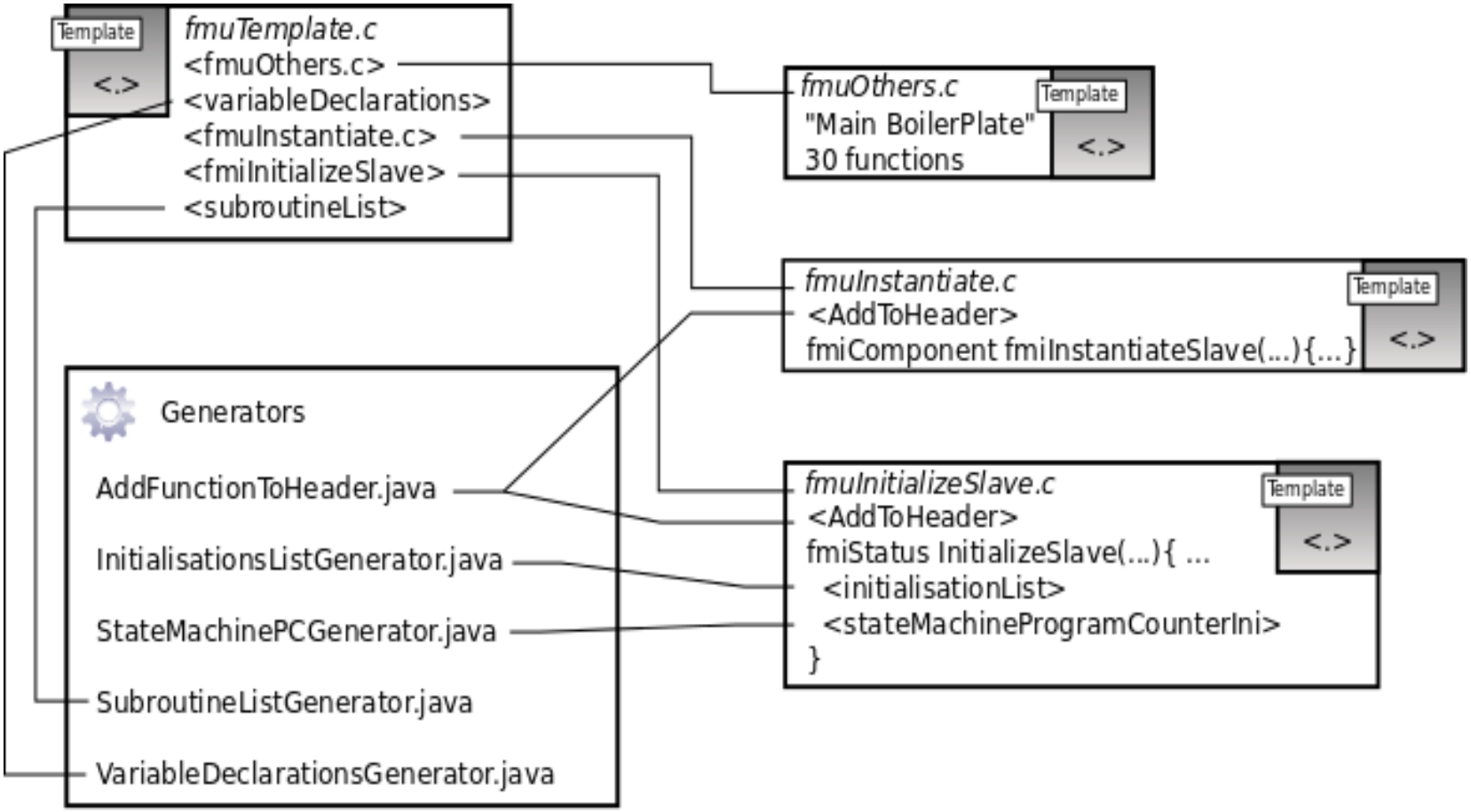


Hardware Interface – most likely manually coded.
Simulation Code – can be auto-generated.

New: Templates and Code Injection

- Short paper in ABZ2014.
- Arose out of Thales' request to think about customisation for deploying on different targets.
- Boilerplate code with injection points.
- Injected code is generated from an Event-B model,
  - using a 'generator' extension point.

Templates (for the FMI Translator)



New: Event-B to C, for Co-simulation

- For Advance EU FP7, uses FMI.
- The objective is to test the generated code in a simulation of its environment.
- Master and Slaves communicate through API.
- Slaves are FMUs.

Event-B to C, for Co-simulation

- The master is cyclic; slaves are initialized,

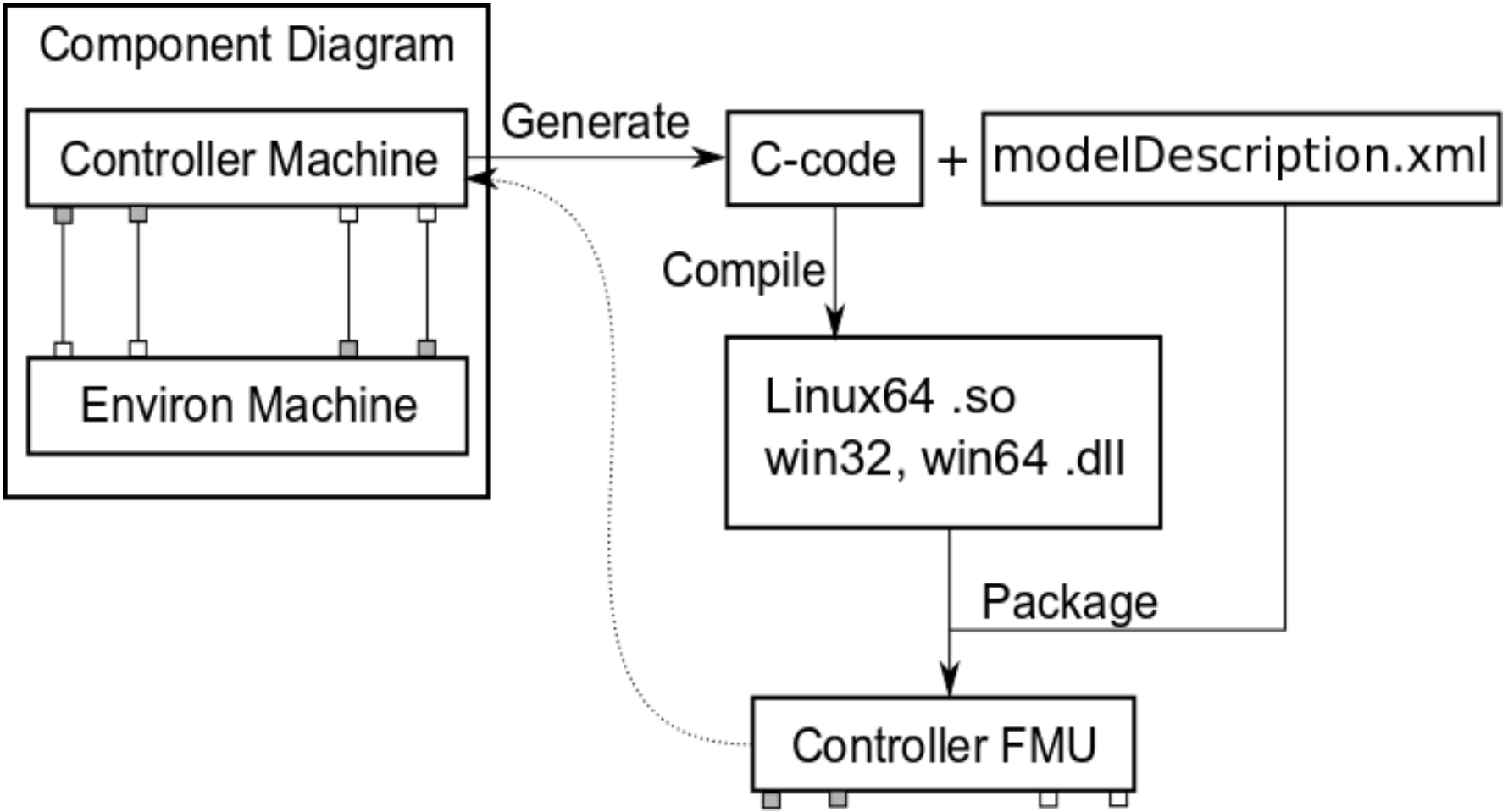
  … then master does simulate-update cycle.

- We can generate an FMU from an Event-B machine and component diagram.

- We can replace the machine, with the FMU, in the component diagram, and simulate/test with that.

- We can also import FMUs into other simulators.

FMUs from Machines



Current Status

- Event-B to C code generator – Working.
- FMU packager – Working.
- Examples pass FMU checkers/simulators
  - Win32
  - Linux64
- Component simulation – not yet working.
- Dymola Simulator import – not yet working.

NEW: Implementable Sets and Functions

- Translate Sets and Functions to code.
  - Uses the Theory plug-in.
- Depends on target language API,
  - Java HashSet and HashMap.
  - Function - domain elements map to keys,
  - Range elements map to values.
- Still *experimental*.
- Used in PRIME project.

Implementable Sets

```
THEORY
  SetImpl
TYPE PARAMETERS
  T
OPERATORS
  •setImpl  :  setImpl(t : T)   EXPRESSION  PREFIX
  direct definition
   setImpl(t : T) ≙ ℙ(T)

  •newSet  :  newSet(t : ℙ(T))   EXPRESSION  PREFIX

  direct definition
   newSet(t : ℙ(T)) ≙ ø⦂ℙ(T)

  •newEnum  :  newEnum(t : T)   EXPRESSION  PREFIX

  direct definition
   newEnum(t : T) ≙ ℙ(T)
  •singleton  :  singleton(a : T)   EXPRESSION  PREFIX
  direct definition
   singleton(a : T) ≙ {a}
  •setUnion  :  setUnion(a : ℙ(T), b : ℙ(T))
  direct definition
   setUnion(a : ℙ(T), b : ℙ(T)) ≙ a ∪ b
```

Translation Rules

TRANSLATOR

Java

Metavariables

- a ∈ ℙ(T)
- b ∈ ℙ(T)
- t ∈ ℙ(T)
- s ∈ T

Translator Rules

IntegerType : Z ⟼ Integer

unionRule : setUnion(a,b) ⟼ a.union(b)

intersectRule : setIntersection(a,b) ⟼ a.intersect(b)

subtractRule : setSubtract(a,b) ⟼ a.subtract(b)

newSetRule : newSet(ø⦂ℙ(t)) ⟼ new SetImpl<t>()

setReduceRule : setReduce(a) ⟼ a.getFirst()

singletonRule : singleton(s) ∪ a ⟼ a.setUnion(s)

newInstanceRule1 : newInst(T) ⟼ new T()

newInstanceRule2 : newInst2(t,s) ⟼ new t(s)

Type Rules

typeTrns2 : Z ⟼ Integer

typeTrns1 : setImpl(T) ⟼ SetImpl<T>

typeTrns3 : newType(T) ⟼ T

Java Set Implementation

```
package setImpls_java;

import java.util.HashSet;

public class SetImpl<E> extends HashSet<E> {

    /**
    private static final long serialVersionUID = 26389

    public SetImpl<E> union(SetImpl<E> otherSet) {
        addAll(otherSet);
        return this;
    }

    public SetImpl<E> intersect(SetImpl<E> otherSet) {
        retainAll(otherSet);
        return this;
    }

    public SetImpl<E> subtract(SetImpl<E> otherSet) {
        removeAll(otherSet);
        return this;
    }

    public E getFirst() {
        Iterator<E> iter = iterator();
        if(iter.hasNext()) return iter.next();
        else return null;
    }

    public SetImpl<E> setUnion(E element) {
        add(element);
        return this;
    }

}
```

Questions:

How to improve plug-in development when much of it is *engineering*, not research?

- Academia v Industry: bridging the gap?
- Providing a platform to 'sell' Event-B?

Day-to-day,

- Keeping up with (communicating) changes?
- Compatibility issues?
- ...