Templates for Event-B Code Generation

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Code Generation with Tasking Event-B

- Tasking Event – B is
  - an extension to Event-B.
  - flow control language and annotations.

- Tasking Machines (1) map to task implementations.
- Shared Machines map to protected objects,
  - provide monitor-style protection.
- Environ Machines (2) map to tasks for simulation.

Code Generation with Tasking Event-B

- Tasking/Environ machines have 'Task Bodies'
  - to describe program flow.
  - which map to program statements.
- Program flow such as,
  - IF event1 ELSE event2 END
  - event1 ; event2
- Events 'populate' sequences, branches, loops, update statements, procedures, procedure calls.

Why Templates?

- Configuration of code generation targets.
  - 'Templates' can be used for configuration,
  - and avoids hard-coding in the translators.
  - Templates are re-usable.
  - But, Acceleo / JET etc. – more than we need?

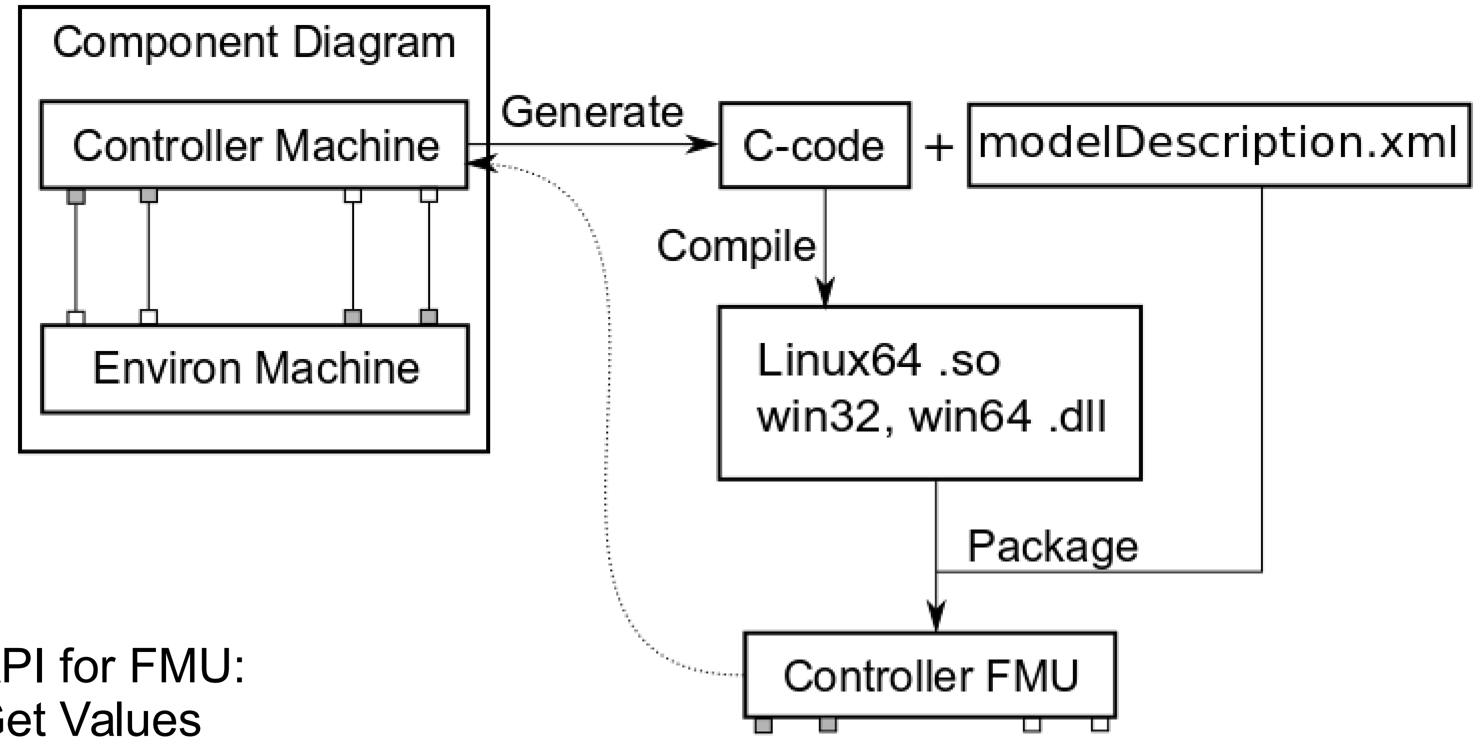
- Reuse of the generated code,
  - The same Event-B model can be used to generate simulation code and deployable code.

- Used in the EU FP7 **Advance** project for FMI-C code generation.

Co-simulation with FMI

- Master and Slaves communicate through API.
  - Enables Discrete/Continuous Simulation.
  - Slaves are FMUs.
  - The master is cyclic; slaves are initialized, then does simulate-update cycle.
- We can generate an FMU from a machine.
  - But, tasking machines map to protected objects,
  - … because of the 'hidden' master.
- Simulation uses a 'component diagram'.
  - We can replace the Event-B Machine in a diagram, with an FMU and simulate/test with executable code.

FMUs from Machines

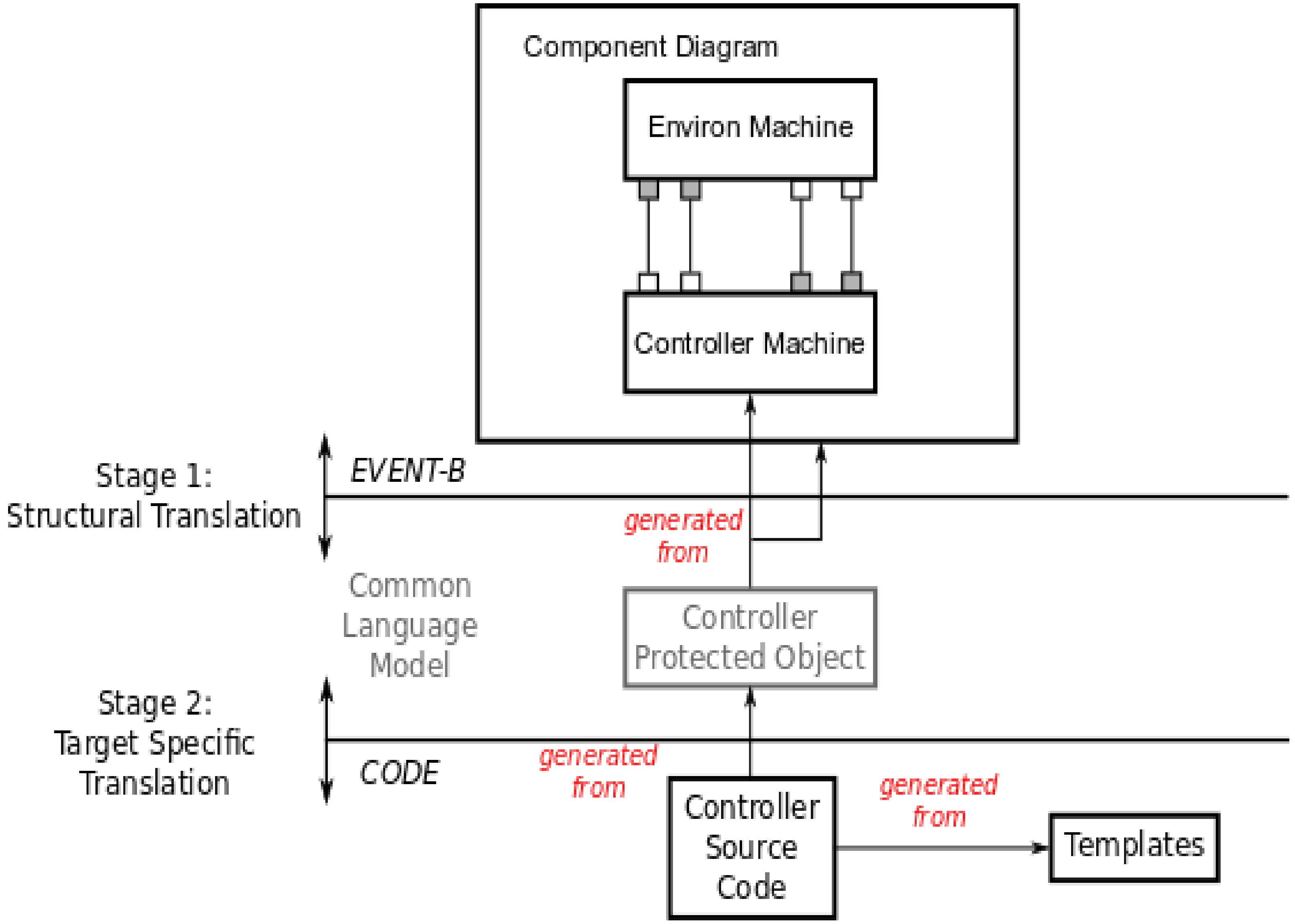


API for FMU:
Get Values
Set Values
Query Status
Instantiation
Initialisation
Simulation Step

Using Templates for FMI-C

- The initial idea: Some code needs configuration, depending on the target;
  - e.g. FMI life-cycle functions.
  - but doesn't need to be modelled formally.
  - and is re-usable.
- The code generated from Event-B models should be the 'critical' code.
  - Can be sent to different targets.
- Some merging of the two is needed.

Translation Stages



Template Tags

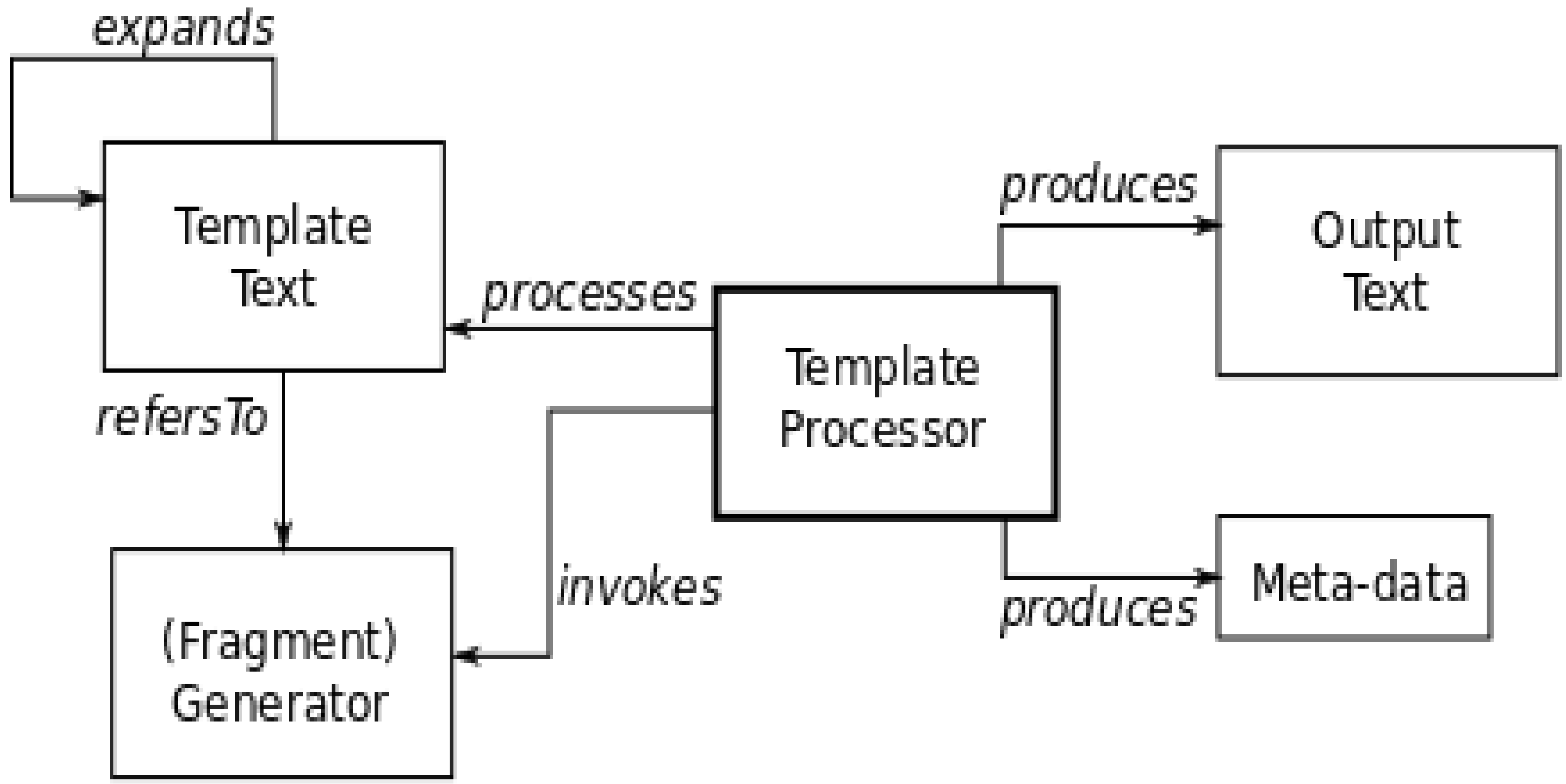
- Tags facilitate:
  - code injection points, and use of generators.
  - further template expansion.
  - production of meta-data, using generator.

- The notation:
  - *//## <name>*

    where *name* identifies a template or generator name.

- Generators are stored internally in a map of name to class.

Template Processor Architecture

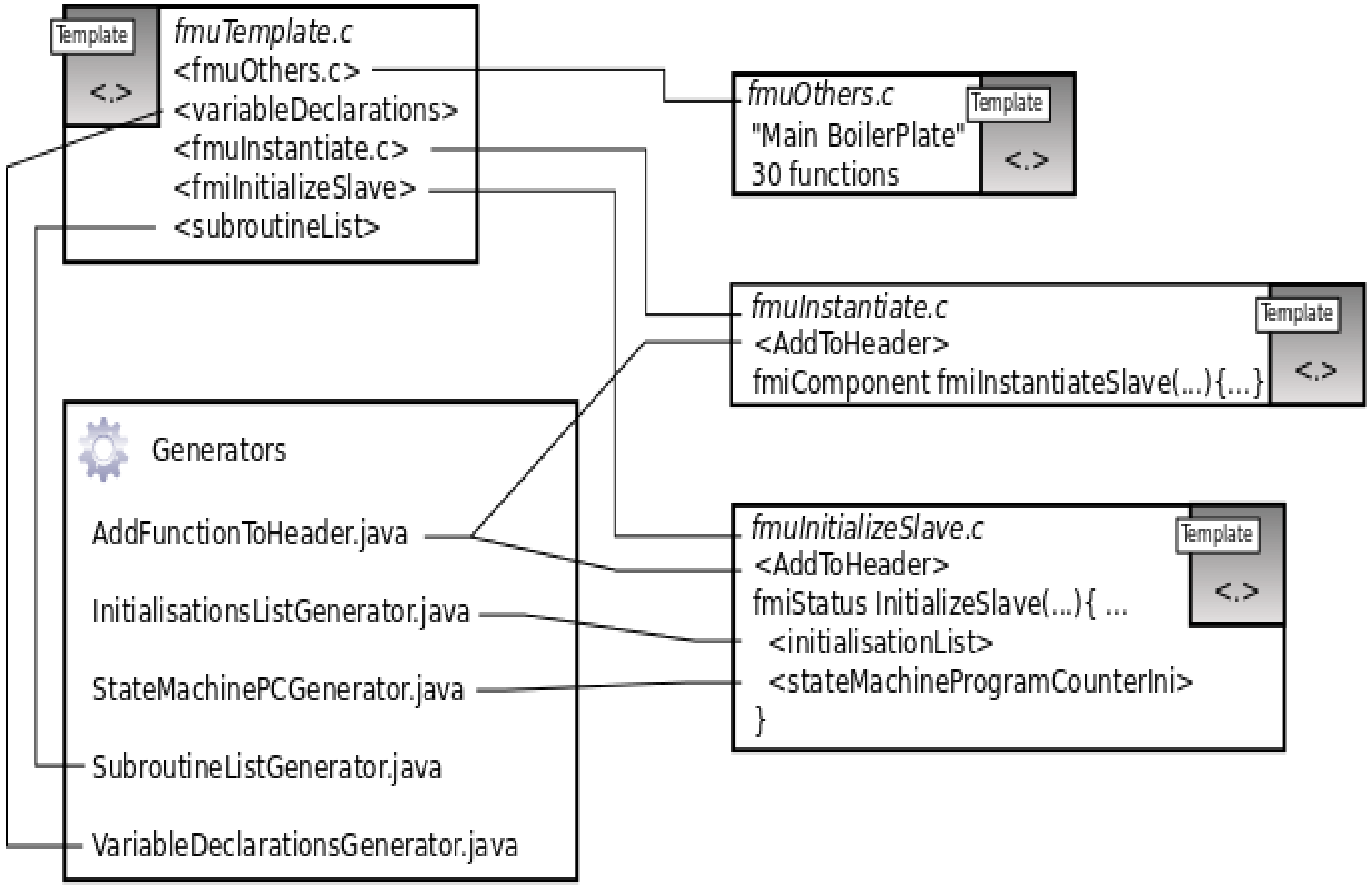


An Example Template

```
//## <addToHeader>
fmiStatus fmiInitializeSlave(fmiComponent c,
        fmiReal tStart, fmiBoolean StopTimeDefined,
        fmiReal tStop) {
    ModelInstance* comp = (ModelInstance*) c;
    //## <initialisationsList>
    //## <stateMachineProgramCounterIni>
    return fmiOK;
}
```

Tags are 'processed'.
Other lines are output verbatim.

Templates and Generators



Extension Points

- Extend IGenerator to provide a new generator,
  - use the extension point
    - *org.eventb.codegen.templates.generator.*
  - then implement the method,
    - public List<String> generate(IGeneratorData data).
    - and supply any necessary data using *IGeneratorData.*

- A *Tag's* characters can be specified; so that it matches the comment characters of a target language.

Translating...

- TemplateHelper.generate(“fmiInitialiseSlave”)
  - finds the generator, and calls it.
  - For fmiInitialiseSlave it does the following,

```
public List<String> generate(IGeneratorData data){
 //(1) Un-pack the generator data.
 //(2) for each protected object...
       translate each variable declaration/initialisation.
 //(3) Return the new code listing.
}
```

Resulting Code

```
fmiStatus fmiInitializeSlave(fmiComponent c,
        FmiReal tStart, fmiBoolean StopTimeDefined,
        fmiReal tStop) {
    ModelInstance* mc = (ModelInstance*) c;
    // Generated By InitialisationsListGenerator
    mc->i[c_level_ControllerImpl_] = 100;
    mc->b[c_pumpOnReq_ControllerImpl_] = fmiFalse;
    …
    return fmiOK;
}
```

Summary

- Templates could be used to replace much of the hard-coding that exits in the current translators.

- A GUI could assist with target configuration, and produce a template.

- The principle may be of use to others working on similar activities.