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Comprehensive Modelling for Advanced Systems of Systems

CML Interpreter Design Document

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0.2	06-03-2014	Anders Kaels Malmos	Added introduction and domain description

Abstract

This document describes the overall design of the CML simulator/animator and provides an overview of the code structure targeting developers.

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1 Introduction

This document is targeted at developers and describes the overall design of the CML simulator, it is not a detailed description of each component. This kind of documentation is done in Javadoc and can be generated automatically from the code. It is assumed that common design patterns are known like **??**.

1.1 Problem Domain

The goal of the interpreter is to enable simulation/animation of a given CML **??** model and be able to visualize this in the Eclipse IDE Debugger. CML has a formal semantics defined in **??** which strictly dictates how the interpretation progresses describes in the semantic framework UTP. The overall goal of the CML interpreter is therefore to adhere to semantic rules defined in those documents and somehow visualize this in Eclipse.

In order to understand how CML is interpreted without understanding all the details of the semantics, a small example is given below. In figure

```
channels
start
input : int
output : int

process Writer =
begin
 @ start -> input.1 -> Skip
end

process Reader =
begin
 @ start -> input? x -> output!x -> Skip
end

process System = Writer [|{start, input}|] Reader
```

Listing 1: Coordinating a reader and writer process

Write about the example in the same manner as D32.2 description

1.2 Definitions

CML Compass Modelling Language

UTP Unified Theory of Programming

Simulation Simulation is when the interpreter runs without any form of user interaction other than starting and stoppping.

Animation Animation is when the user are involved in taking the decisions when interpreting the CML model

2 Software Layers

This section describes the layers of the CML interpreter. As depicted in figure 1 two highlevel layers exists.

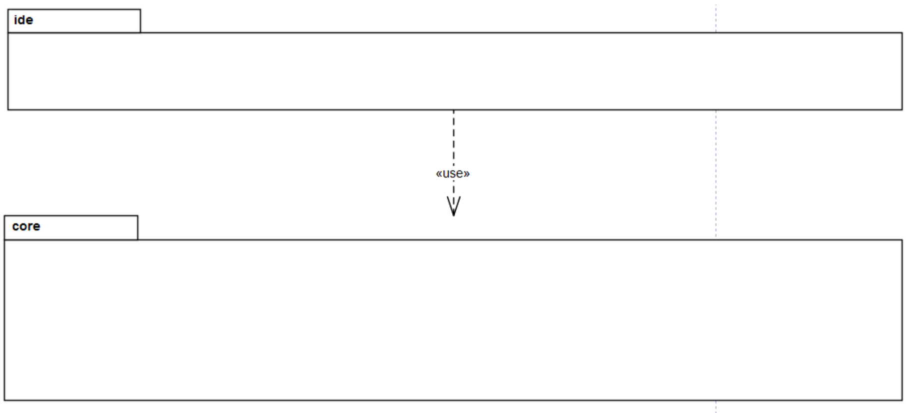

Figure 1: The layers of the CML Interpreter

Core layer Has the responsibility of interpreting a CML model as described in the operational semantics that are defined in [**?**] and is located in the java package named *eu.compassresearch.core.interpreter*

IDE layer Has the responsibility of visualizing the outputs of a running interpretation a CML model in the Eclipse Debugger. It is located in the *eu.compassresearch.ide.cml.interpreter_plugin* package.

Each of these components will be described in further detail in the following sections.

2.1 The Core Layer

The design philosophy of the top-level structure is to encapsulate all the classes and interfaces that makes up the implementation of the core functionality and only expose those that are needed to utilize the interpreter. This provides a clean separation between the implementation and interface and makes it clear for both the users, which not necessarily wants to know about the implementation details, and developers which parts they need to work with.

The following packages defines the top level structure of the core:

eu.compassresearch.core.interpreter.api This package and sub-packages contains all the public classes and interfaces that defines the API of the interpreter. This package includes the main interpreter interface **CmlInterpreter** along with additional interfaces. The api sub-packages groups the rest of the API classes and interfaces according to the responsibility they have.

eu.compassresearch.core.interpreter.api.behaviour This package contains all the components that define any CML behavior. A CML behaviour is either an observable event like a channel synchronization or a internal event like a change of state. The main interface is **CmlBehaviour**.

eu.compassresearch.core.interpreter.api.events This package contains all the public components that enable users of the interpreter to subscribe to multiple on events (this it not CML channel events) from both **CmlIntepreter** and **CmlBehaviour** instances.

eu.compassresearch.core.interpreter.api.transitions This package contains all the possible types of transitions that a **CmlBehaviour** instance can make. This will be explained in more detail in section 3.1.2.

eu.compassresearch.core.interpreter.api.values This package contains all the values used in the CML interpreter. Values are used to represent the the result of an expression or the current state of a variable.

eu.compassresearch.core.interpreter.debug TBD

eu.compassresearch.core.interpreter.utility The utility packages contains components that generally reusable classes and interfaces.

eu.compassresearch.core.interpreter.utility.events This package contains components helps to implement the Observer pattern.

eu.compassresearch.core.interpreter.utility.messaging This package contains general components to pass message along a stream.

eu.compassresearch.core.interpreter This package contains all the internal classes and interfaces that defines the core functionality of the interpreter. There is one important public class in the package, namely the **VanillaInterpreteFactory** faactory class, that any user of the interpreter must invoke to use the interpreter. This can creates **CmlInterpreter** instances.

The **eu.compassresearch.core.interpreter** package are split into several folders, each representing a different logical component. The following folders are present

behavior This folder contains all the internal classes and interfaces that implements the CmlBehaviors. The Cml behaviors will be described in more detail in in section 3.1.1, but they are bassically implemented by CML AST visitor classes.

factories This folder contains all the factories in the package, both the public **VanillaInterpreteFactory** that creates the interpreter and package internal ones.

utility

...

2.2 The IDE Layer

The IDE part is integrating the interpreter into Eclipse, enabling CML models to be debugged/simulated/animated through the Eclipse interface. In Figure 2 a deployment diagram of the debugging structure is shown.

An Eclipse debugging session involves two JVMs, the one that the Eclipse platform is executing in and one where only the Core executes in. All communication between them is done via a TCP connection.

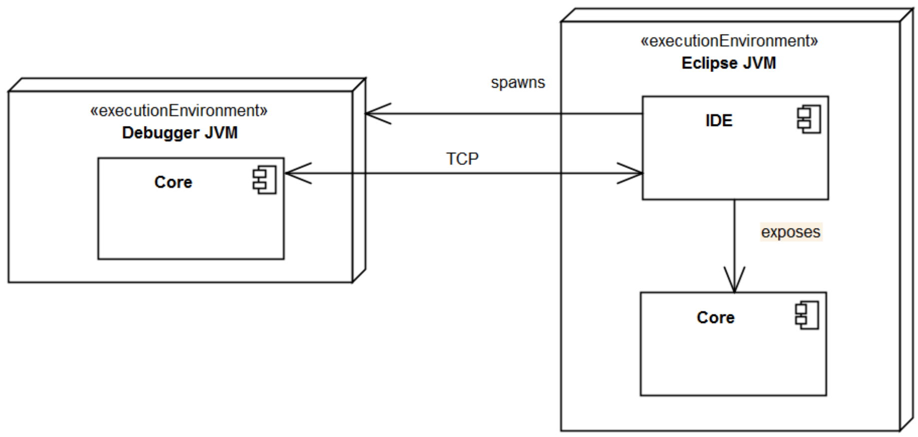

Figure 2: Deployment diagram of the debugger

Before explaining the steps involved in a debugging session, there are two important classes worth mentioning:

- **CmlInterpreterController**: This is responsible for controlling the CmlInterpreter execution in the debugger JVM. All communications to and from the interpreter handled in this class.
- **CmlDebugTarget**: This class is part of the Eclipse debugging model. It has the responsiblity of representing a running interpreter on the Eclipse JVM side. All communications to and from the Eclipse debugger are handled in this class.

A debugging session has the following steps:

1. The user launches a debug session
2. On the Eclipse JVM a **CmlDebugTarget** instance is created, which listens for an incomming TCP connection.
3. A Debugger JVM is spawned and a **CmlInterpreterController** instance is created.
4. The **CmlInterpreterController** tries to connect to the created connection.
5. When the connection is established, the **CmlInterpreterController** instance will send a STARTING status message along with additional details
6. The **CmlDebugTarget** updates the GUI accordingly.
7. When the interpreter is running, status messages will be sent from **CmlInterpreterController** and commands and request messages are sent from **CmlDebugTarget**
8. This continues until **CmlInterpreterController** sends the STOPPED message

TBD...

3 Layer design and Implementation

This section describes the static and dynamic structure of the components involved in simulating/animating a CML model.

3.1 Core Layer

3.1.1 Static Model

The top level interface of the interpreter is depicted in figure 3, followed by a short description of each the depicted components.

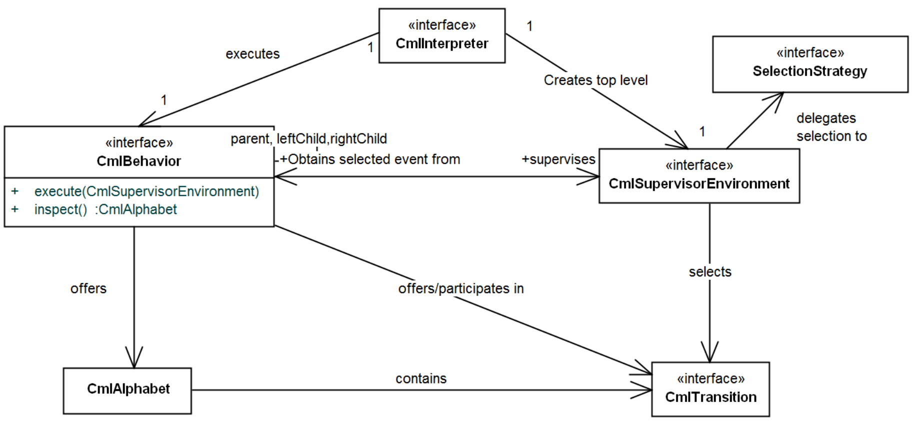

Figure 3: The high level classes and interfaces of the interpreter core component

CmlInterpreter The main interface exposed by the interpreter component. This interface has the overall responsibility of interpreting. It exposes methods to execute, listen on interpreter events and get the current state of the interpreter. It is implemented by the **VanillaCmlInterpreter** class.

CmlBehaviour Interface that represents a behaviour specified by either a CML process or action. It exposes two methods: *inspect* which calculates the immediate set of possible transitions that the current behaviour allows and *execute* which takes one of the possible transitions determined by the supervisor. A specific behaviour can for instance be the prefix action “a -¿ P”, where the only possible transition is to interact in the a event. in any

CmlSupervisorEnvironment Interface with the responsibility of acting as the supervisor environment for CML processes and actions. A supervisor environment selects and exposes the next transition/event that should occur to its pupils (All the CmlBehaviors under its supervision). It also resolves possible backtracking issues which may occur in the internal choice operator.

SelectionStrategy This interface has the responsibility of choosing an event from a given CmlAlphabet. This responsibility is delegated by the CmlSupervisorEnvironment interface.

CmlTransition Interface that represents any kind of transition that a CmlBehavior can make. This structure will be described in more detail in section **??**.

CmlAlphabet This class is a set of CmlTransitions. It exposes convenient methods for manipulating the set.

To gain a better understanding of figure 3 a few things needs mentioning. First of all any CML model (at least for now) has a top level Process. Because of this, the interpreter need only to interact with the top level CmlBehaviour instance. This explains the one-to-one correspondence between the CmlInterpreter and the CMLBehaviour. However, the behavior of top level CmlBehaviour is determined by the binary tree of CmlBehaviour instances that itself and it's child behaviours defines. So in effect, the CmlInterpreter controls every transition that any CmlBehaviour makes through the top level behaviour.

3.1.2 Transition Model

As described in the previous section a CML model is represented by a binary tree of CmlBehaviour instances and each of these has a set of possible transitions that they can make. A class diagram of all the classes and interfaces that makes up transitions are shown in figure 4, followed by a description of each of the elements.

A transition taken by a CmlBehavior is represented by a CMLTransition. This represent a possible next step in the model which can be either observable or silent (also called a tau transition).

An observable transition represents either that time passes or that a communication/synchronization event takes place on a given channel. All of these transitions are captured in the ObservableTransition interface. A silent transitions is captured by the TauTransition and HiddenTransition class and can respectively marks the occurrence of a an internal transition of a behavior or a hidden channel transition.

CmlTransition Represents any possible transition.

CmlTransitionSet Represents a set of CmlTransition objects.

ObservableTransition This represents any observable transition.

LabelledTransition This represents any transition that results in a observable channel event

TimedTransition This represents a tock event marking the passage of a time unit.

ObservableLabelledTransition This represents the occurrence of a observable channel event which can be either a communication event or a synchronization event.

TauTransition This represents any non-observable transitions that can be taken in a behavior.

HiddenEvent This represents the occurrence of a hidden channel event in the form of a tau transition.

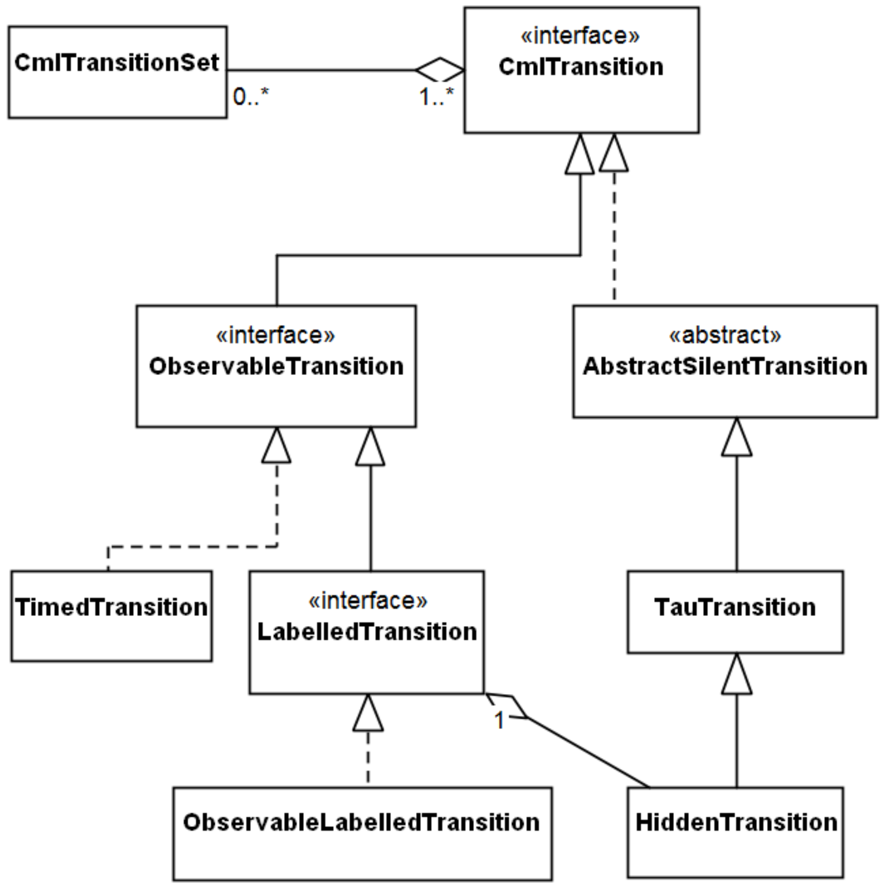

Figure 4: The classes and interfaces that defines transitions/events

3.1.3 Action/Process Structure

Actions and processes are both represented by the CmlBehaviour interface. A class diagram of the important classes that implements this interface is shown in figure 5

As shown the **ConcreteCmlBehavior** is the implementing class of the CmlBehavior interface. However, it delegates a large part of its responsibility to other classes. The actual behavior of a ConcreteCmlBehavior instance is decided by its current instance of the INode interface, so when a ConcreteCmlBehavior instance is created a INode instance must be given. The INode interface is implemented by all the CML AST nodes and can therefore be any CML process or action. The actual implementation of the behavior of any process/action is delegated to three different kinds of visitors all extending a generated abstract visitor that have the infrastructure to visit any CML AST node.

The following three visitors are used:

AbstractSetupVisitor This has the responsibility of performing any required setup

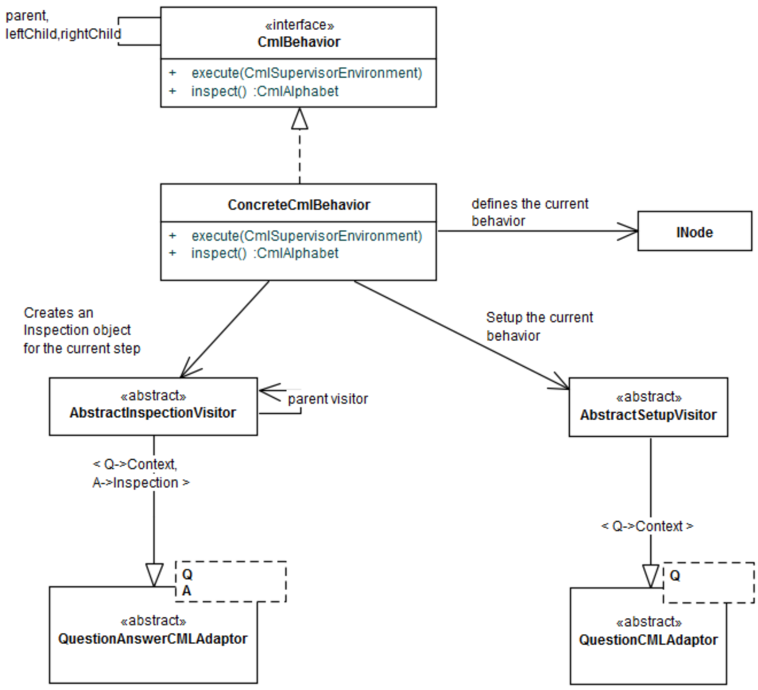

Figure 5: The implementing classes of the CmlBehavior interface

for every behavior. This visitor is invoked whenever a new INode instance is loaded.

AbstractEvaluationVisitor This has the responsibility of performing the actual behavior and is invoked inside the **execute** method. This involves taking one of the possible transitions.

AbstractAlphabetVisitor This has the responsibility of calculating the alphabet of the current behavior and is invoked in the **inspect** method.

In figure 6 a more detailed look at the evaluation visitor structure is given.

As depicted the visitors are split into several visitors that handle different parts of the languages. The sole reason for doing this is to avoid having one large visitor that handles all the cases. At run-time the visitors are setup in a tree structure where the top most visitor is a **CmlEvaluationVisitor** instance which then delegates to either a **ActionEvaluationVisitor** and **ProcessEvaluationVisitor** etc.

3.1.4 Dynamic Model

The previous section described the high-level static structure, this section will describe the high-level dynamic structure.

First of all, the entire CML interpreter runs in a single thread. This is mainly due to the inherent complexity of concurrent programming. You could argue that since

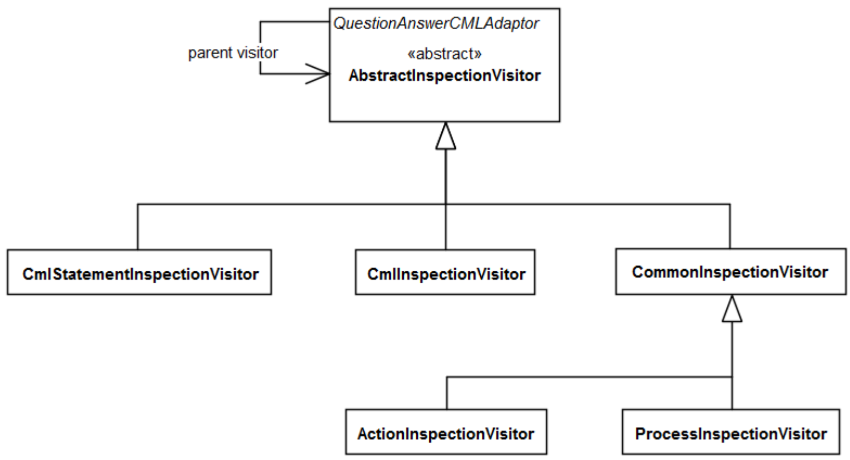

Figure 6: Visitor structure

a large part of COMPASS is about modelling complex concurrent systems, we also need a concurrent interpretation of the models. However, the semantics is perfectly implementable in a single thread which makes a multi-threaded interpreter optional. There are of course benefits to a multi-threaded interpreter such as performance, but for matters such as the testing and deterministic behaviour a single threaded interpreter is much easier to handle and comprehend.

To start a simulation/animation of a CML model, you first of all need an instance of the **CmlInterpreter** interface. This is created through the **VanillaInterpreterFactory** by invoking the **newInterpreter** method with a typechecked AST of the CML model. The currently returned implementation is the **VanillaCmlInterpreter** class. Once a **CmlInterpreter** is instantiated the interpretation of the CML model is started by invoking the **execute** method given a **CmlSupervisorEnvironment**.

In figure 7 a high level sequence diagram of the **execute** method on the **VanillaCmlInterpreter** class is depicted.

As seen in the figure the model is executed until the top level process is either successfully terminated or deadlocked. For each

3.1.5 CmlBehaviors

As explained in section **??** the CmlBehavior instances forms a binary tree at runtime.

3.2 The IDE Layer

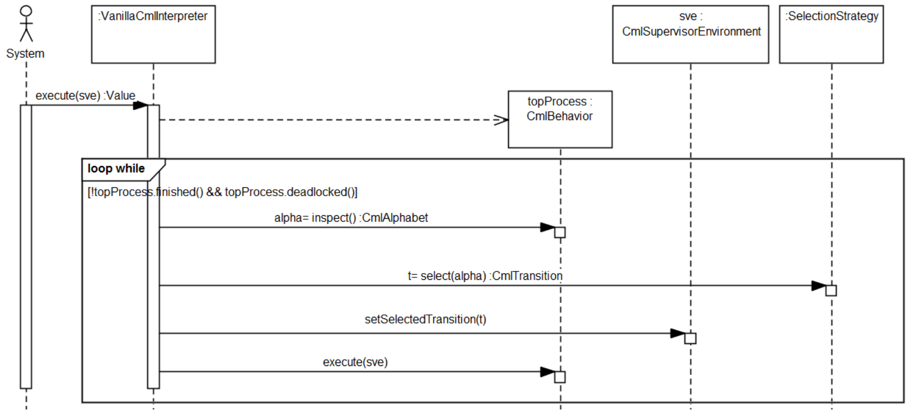

Figure 7: The top level dynamics