ParTeG - A Model-Based Testing Tool

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Abstract

Model-based testing is the comparison of a system under test to reference specifications in form of models. Tool support for model-based testing is of utter importance. In this paper, we present the model-based testing tool ParTeG, compare it with other model-based testing tools in the same area, and show future extensions.

1 Overview

ParTeG [6] is a model-based testing tool that was initially developed to implement new algorithms into a prototype as a proof of concept. By now, ParTeG is available as a free Eclipse plug-in, hosted by Sourceforge. ParTeG is based on the Eclipse UML 2.0 plug-ins. It automatically generates test cases from UML state machines and class diagrams that are annotated with OCL expressions. ParTeG supports test suite generation for JUnit 3.8, JUnit 4.3, Java Mutation Analysis, and CppUnit 1.12.

The tool has been presented before – we want to use the TAV workshop for further discussions about the tool's approach. A detailed introduction to ParTeG's features are presented in the following sections.

1.1 Interpret OCL Constraints

ParTeG supports a subset of the Object Constraint Language (OCL), excluding some of the expressions for collections. In contrast to other testing tools, like Smartesting Test Designer, ParTeG avoids assumptions if an OCL expression semantics is unclear. For example, the expression `x = y` as postcondition of an operation `f()` may be interpreted as:

1. After the execution of `f()`, the value of `y` has been assigned to `x`.

2. After the execution of `f()`, the value of `x` has been assigned to `y`.

3. After the execution of `f()`, both values `x` and `y` have changed but now they are equal.

ParTeG supports all three kinds, thus it can handle situations where the concrete value of a variable is unknown. To force the first interpretation, the expression should be transformed into the unambiguous form `x = y@pre`.

All variables are classified as *fixed* or *changeable* in the current expression: Input values, parameters, constants, and attributes with `@pre` are fixed (they cannot be changed) – variables marked without `@pre` are changeable in postconditions. This general interpretation of variables and the correspondingly general expression transformation rules allow to deal with inequations in postconditions.

1.2 Combine Coverage Criteria

Coverage criteria are a widely accepted means of test suite quality measurement. They can be compared using subsumption relations. The most important feature of ParTeG is the ability to satisfy *combined coverage criteria*: For instance, control-flow-based coverage criteria (e.g. MC/DC) can be combined with boundary-based coverage criteria (e.g. Multi-Dimensional). From each category (control-flow-based or boundary-based), one coverage criterion can be chosen for the combination. At the moment, the following coverage criteria are supported: All-States, All-Transitions, Decision Coverage, masking MC/DC, and Multiple Condition Coverage as well as random input value selection and different variants of Multi-Dimensional: MD(0) with partition boundary values, and MD(1) with values at absolute range boundaries and with random values from input partitions.

Test cases are generated starting with a control-flow-based respectively transition-based coverage criterion. This coverage criterion is converted into a set of model-specific test goals. For instance, All-States is converted into test goals, each of which is referencing one state of the state machine. The test goals are used to generate transition sequences from the initial state to the referenced state. For each transition sequence, all influencing guard conditions and operations' pre-/postconditions are logged – they are transformed and used for concrete input parameter selection corresponding to the selected boundary-based coverage criterion. The transition sequences and the corresponding concrete input parameters are used to create test cases.

During automatic test generation, a test case for a test goal can cover other test goals. ParTeG supports monitoring of test goals, i.e. all already covered test goals are excluded from further test case generations.
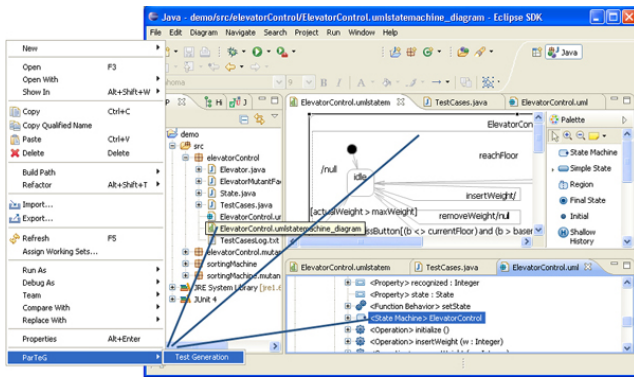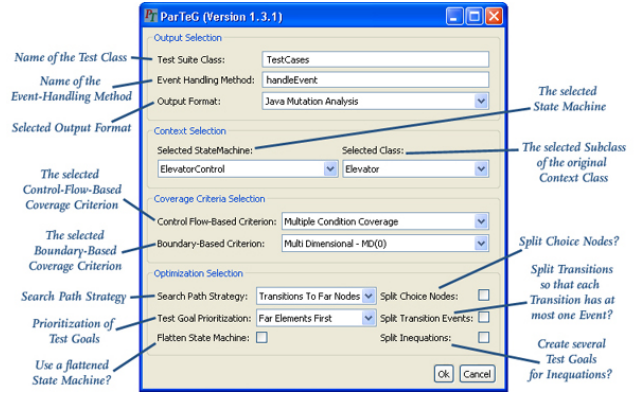
(a) Modeling   (b) Preferences

Figure 1: ParTeG User Interface

1.3 Mutation Analysis

Mutation analysis is a wide-spread approach to measure the fault detection capability of a test suite. This approach is based on fault injection in a correct implementation. All faulty implementations are called mutants. Mutants that are semantically different from the original implementation can be detected (*killed*) by a test suite. The assumption is that the more mutants are detected by a test suite, the better is this test suite's general fault detection capability [1].

ParTeG supports mutation analysis in two ways. First, it can use a mutation factory provided by the tester that delivers a new mutant for each test execution. These mutants can be fed into the factory manually, automatically, or by any other arbitrary means. Second, ParTeG can generate JUnit 3.8 code, which can be used by the mutation tool Jumble [5].

2 Comparison with Commercial Tools

Tool	Test Cases	Detected Mutants
Rhapsody ATG	4	10/24
LTD	4	10/24
ParTeG	5	24/24

Table 1: Comparison with Commercial Tools

In previous case studies, we compared ParTeG to Rhapsody ATG [2] and Leirios (now: Smartesting) Test Designer (LTD) [4]. As quality criterion for test suites, we used mutation analysis. For one of our examples, a freight elevator, we generated 24 mutants. Table 1 shows the results for this relative simple example where only ParTeG is able to detect all mutants. We found that the support of combined coverage criteria has a wide influence on the quality of the generated test suite. For instance, LTD supports only the satisfaction of All-Transitions where ParTeG is able to satisfy a set of combined coverage criteria. The comparison with other tools is based on past versions of these tools. To validate the former results, a new comparison with current versions is necessary.

For this purpose, we collected additional case studies for test generation with ParTeG, among others two industrial case studies.

3 Conclusion and Outlook

ParTeG offers a complete test cycle from the creation of test models (using the UML plugins or the editor TopCased [3]) to test suite generation for combined coverage criteria and subsequent test execution. At the current state, ParTeG supports automatic creation of input partitions even for multiple interacting input parameters, several different search strategies, test goal prioritization, test model adaptations, and derivation of state machines along inheritance relations between classes.

We plan to extend the implemented approach of ParTeG in the future. For example test generation can be supported for other models like a combination of the already integrated models (class diagrams, state machines) with interaction diagrams. A short comparison of ParTeG to commercial tools showed that ParTeG is able to detect more mutants than the others for our examples. We created a set of further test models from academia and industry and plan further comparisons to commercial tools.

References

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