AN AUTOMATED MODEL-DRIVEN TESTING FRAMEWORK
For Model-Driven Development and Software Product Lines

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Abstract: This work presents an automated testing framework that can be applied to Model-Driven Development and Software Product Line development. The framework uses standards metamodels such as UML, UML Testing Profile and standards transformation languages such as Query/View/Transformation or MOF2Text. Test cases are automatically generated from UML sequence diagrams that represent the functionality to test.

1 INTRODUCTION

Model-based Testing (MBT) provides a technique for the automatic generation of test cases using models extracted from software artifacts (Dalai, Jain et al. 1999).

Model-Driven Engineering (MDE) and Software Product Lines (SPL) are new software development paradigms. In MDE, models are transformed to obtain the product code, while in SPL, several products share the same base structure. In both approaches, automation is one of the main characteristics -- in MDE the code generation is automated from models while in SPL each product is automatically generated from a base structure. In addition, there are many works that merge MDE and SPL(Deelstra, Sinnema et al. 2003; Czarnecki, Antkiewicz et al. 2005; Trujillo, Batory et al. 2007).

The aim is to maximize reuse and minimize time to market, without losing the final product quality. In SPL, the products in the line shared common functionality. If a defect is present in one of the common parts, that defect is translated to each product in the SPL. The final product quality directly depends on the quality of each of the parts.

In this context, the goal is to reduce the test time without affecting the product quality. In the case of MDE, a change in one model involves rebuilding the models and code automatically, and it takes little time to generate the new code. However, from the testing point of view, ensuring that this change does not introduce defects entails retesting everything again. If the tests are manually executed, the cost of testing increases. The same applies to LPS. Testing the common things is not sufficient; the integration of each product must also be tested. For this reason, the automation of tests from models in these two paradigms is essential.

This work presents an automated framework for model-driven testing that can be applied in MDE and SPL development. The main characteristics of the framework are:

- **Standardized:** The framework is based on Object Management Group (OMG) standards, where possible. The standards used are UML, UML Testing Profile as metamodels and Query/View/Transformation (QVT) and MOF2Text as transformation languages.
- **Model-driven Test Case Scenario Generation:** The framework generates the test cases at the functional testing level (which can be extended to other testing levels), the test case scenarios are automatically generated from design models and evolve with the product until test code generation. Design models represent the system behaviour using UML sequence diagrams.
- **Framework Implementation using Existing Tools:** No tools are developed to develop the framework; existing market tools that conform to the standards can be used. The requisite is that

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the modelling tool can be integrated with the tools that produces the transformations.

This paper is organized as follows: Section 2 introduces the main concepts used in the article and outlines the Lottery SPL; this SPL is used as the running example. Section 3 outlines the entire model-driven testing framework. Section 4 describes the activities for the framework in MDE development. Section 5 describes the activities in SPL development. Section 6 summarizes related works. Finally, Section 7 draws some conclusions and presents future lines of work.

2 BACKGROUND

Model-Driven Engineering (MDE) considers models as first-order citizens for software development, maintenance and evolution through model transformation (Mens and Van Corp 2006). In addition to independence between models, **Model-Driven Architecture** (MDA, (OMG 2003)) clearly separates business complexity from implementation details by defining several software models at different abstraction levels. MDA defines three viewpoints of a system: (i) the Computation Independent Model (CIM), which focuses on the context and requirements of the system without considering its structure or processing, (ii) the Platform Independent Model (PIM), which focuses on the operational capabilities of a system outside the context of a specific platform, and (iii) the Platform Specific Model (PSM), which includes details relating to the system for a specific platform.

The **UML 2.0 Testing Profile** (UML-TP) defines a language for designing, visualizing, specifying, analyzing, constructing and documenting the artifacts of test systems. It extends UML 2.0 with test specific concepts for testing, grouping them into test architecture, test data, test behaviour and test time. As a profile, UML-TP seamlessly integrates into UML. It is based on the UML 2.0 specification and is defined using the metamodeling approach of UML(OMG 2005). The test architecture in UML-TP is the set of concepts to specify the structural aspects of a test situation (Baker, Dai et al. 2007). It includes TestContext, which contains the test cases (as operations) and whose composite structure defines the test configuration. The test behaviour specifies the actions and evaluations necessary to evaluate the test objective, which describes what should be tested. The test case behaviour is described using the Behavior concept and can be shown using UML interaction diagrams, state machines and activity diagrams. The TestCase specifies one case to test the system, including what to test it with, the required input, result and initial conditions. It is a complete technical specification of how a set of TestComponents interacts with an SUT to realize a TestObjective and return a Verdict value (OMG 2005). This work focuses on test cases, whose behavior is represented by UML sequence diagrams.

Software Product Lines (SPL) are suitable for development with Model Driven principles: an SPL is a set of software-intensive systems sharing a common, managed set of features which satisfy the specific needs of a particular market segment or mission and which are developed from a common set of core assets in a prescribed way(Clements and Northrop 2001). Therefore, products in a line share a set of characteristics (commonalities) and differ in a number of variation points, which represent the variabilities of the products. Software construction in SPL contexts involves two levels: (1) Domain Engineering, referred to the development of the common features and to the identification of the variation points; (2) Product Engineering, where each concrete product is built, what leads to the inclusion of the commonalities in the products, and the corresponding adaptation of the variation points. Thus, the preservation of traceability among software artifacts is an essential task, both from Domain to Product engineering, as well as among the different abstraction levels of each engineering level.

The way in which variability is managed in SPL is critical in SPL development. In this work, the proposal by Pohl et al. (Pohl, Böckle et al. 2005) is used to manage the variability, defined in their **Orthogonal Variability Model** (OVM). In OVM, variability information is saved in a separate model containing data about variation points and variants (a variation point may involve several variants in, for example, several products). OVM allows the representation of dependencies between variation points and variable elements, as well as associations among variation point and variants with other software development models (i.e., design artifacts, components, etc.). Associations between variants may be *requires_V_V* and *excludes_V_V*, depending on whether they denote that a variation *requires* or *excludes* another variation. In the same way, associations between a variation and a variation point may be *requires_V_VP* or *excludes_V_VP*, also to denote whether a variation requires or excludes the corresponding variation point.

The variants may be related to artifacts of an arbitrary granularity. Since variants may be related to any type of software artifact (and in the proposal the software artifacts are described using a UML metamodel), to obtain the best fit in this integration, OVM was translated into an UML Profile. With this solution, OVM is managed and manipulated as a part (actually, an extension) of UML 2.0 More details about the defined OVM profile can be found in (Pérez Lamancha, Polo Usaola et al. 2009). Figure 1 shows the OVM model for the Lottery SPL used as an example in this paper.

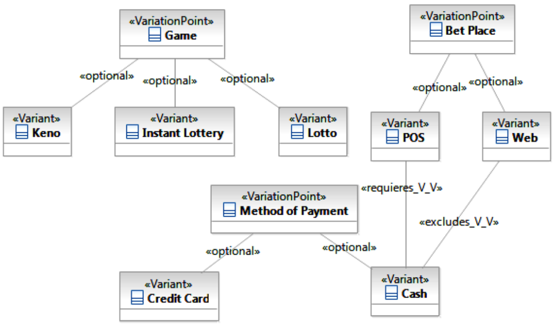


Figure 1: OVM model for Lottery SPL.

Lottery SPL manages the bets and payments for different lottery-type games. The types of games considered are:

- **Instant Lottery:** played using a scratch card, whose participants rub or scratch it to remove a coating that conceals one or more playing game pieces and related cash prize amounts. Generally, instant lottery tickets are printed on heavy paper or cardboard.
- **Lotto:** played by selecting a predetermined quantity of numbers in a range: depending on the right numbers, the prize is greater or lower. For example, one chooses six numbers from 1 to 49.
- **Keno:** basically played in the same manner, although it differs from "Lotto" games in that (i) the population of playing game pieces is even larger, e. g., integers from 1 to 80; (ii) participants can choose the quantity of numbers that they want to match; and (iii) the number of winning game numbers, e. g., twenty, is larger than the number of a participant's playing numbers, e. g. two to ten. One example of the Keno type is Bingo.

This SPL has several variation points, but for purposes of illustration, this paper only analyzes the variation points in Figure 1:

- Game: can be Instant Lottery, Lotto or Keno
- Bet Place: The game can be played at a Point of Sale (POS) or through a web page.
- Method of Payment: Can be cash or credit card.

3 MODEL-DRIVEN TESTING FRAMEWORK

Figure 2 shows a global overview of the framework, which is divided horizontally into Domain Engineering and Application Engineering. In Domain Engineering, the SPL core assets are modelled. In Application Engineering, each product is modelled; it can be derived from the SPL or can be one single product developed following MDE software development.

The framework is also divided vertically into Design models (left) and Testing models (right). In Domain Engineering, a test model is generated for SPL core assets. In Application Engineering, the models follow the MDA levels, and are based on the idea from Dai (Dai 2004).

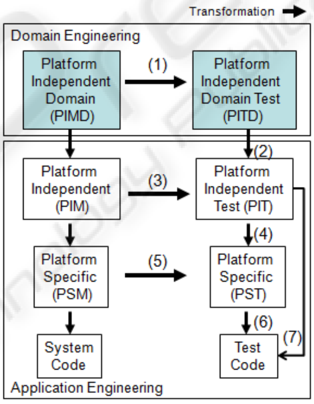


Figure 2: Testing framework overview.

The arrows in Figure 2 represent transformations between models. The objective is to automate the test model from design models that represent the functionalities to test the model using model transformation. To develop the entire framework, the following decisions were taken:

- **Tool to Support the Framework:** This decision is crucial for the development of the framework. We could develop a tool to support the framework or could use tools already available on the market. The aim of our proposal is to automate testing in MDE and SPL. Therefore, a tool built by us must consider modelling elements for both development paradigms. In this case, operators using our approach must use our tool to model the line or product to obtain the test cases. However, these models must also be used for code generation (due to the fact that the development follows an MDE approach), for which specific tools exist. It seems unrealistic to think that developers will do the double job of modelling, with its associated maintenance cost. Therefore, our proposal must be adapted to the way it is modelled and developed in MDE and SPL. Thus, we decided to develop the framework using existing tools on the market, which brought about another problem: the integration of existing tools to achieve the complete implementation of the framework.

- **Design Metamodel:** We can develop our own metamodels or use existing ones. We decided to use existing metamodels and specifically used UML 2.0 (OMG 2007) due to its being the most widely used metamodel to design software products and the fact that there are several tools to support it in the MDE environment.
- **Testing Metamodel:** Again, we could develop our metamodel or use an existing one. We decided to use the UML 2.0 Testing Profile.
- **Standardized Approach:** Since UML 2.0 is used as the design metamodel and the UML Testing Profile as the testing metamodel, both OMG standards and those using commercial tools are more likely to be compatible with standardized approaches. We decided to use standards whenever possible for the construction of the framework.
- **Variability Metamodel:** Unfortunately, there is no defined standard for defining metamodel variability in product line development. Several metamodels to represent variability exist. This work uses the Orthogonal variability model (OVM, (Pohl, Böckle et al. 2005)) (see Section 2).
- **Model to Model Transformation Language:** A model transformation is the process of converting one model to another model in the same system (Miller and Mukerji 2003). The most important elements in a transformation are: (1) source model and target model, (2) source metamodel and target metamodel and (3) the definition of the transformation. A model transformation language is a language that takes a model as input and, according to a set of rules, produces an output model. Using transformations between models, arrows 1,2,3,4 and 5 in Figure 2 can be solved. The OMG standard for model transformation in the MDA context is the Query-View-Transformation language (QVT, (OMG 2007)), which depends on MOF (Meta-Object Facility, (OMG 2002)) and OCL 2.0 (OMG 2006) specifications.
- **Model to Text Transformation Language:** Arrows 6 and 7 in Figure 2 require the transformation from model to test code (for example, this can be the JUnit test code). The OMG standard to translate a model to various text artifacts such as code is the MOF Model to Text standard (MOF2Text, (OMG 2008)).

3.1 Models in Domain Engineering

As discussed above, the framework uses UML as its metamodel. UML has several diagrams to represent the static and dynamic aspects in software development. Figure 3 shows the UML diagrams used in the framework. This can be extended to other UML diagrams, but for the moment, the framework supports the models defined in Figure 3.

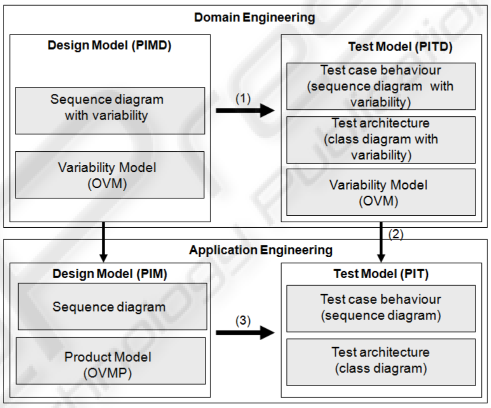


Figure 3: Framework models at PIM level.

In Domain Engineering, product line design models are automatically transformed into test models following UML-TP (arrow 1). The variability is traced from the design to the test models. In the transformation, the following models are used as source models:

- **Sequence Diagrams with Variability:** which describe use case scenarios. As a metamodel, this kind of model uses extended UML interactions with stereotypes to represent variability. The extension represents each variation point as a CombinedFragment stereotyped with a Variation Point. Each variant is an InteractionOperand stereotyped as a Variant (see Section 5).
- **Variability Model:** this model represents the variability in the SPL. The definition of a UML profile to integrate OVM into UML is required.

These models are transformed, using the QVT language, into the following target UML-TP elements (arrow 1 in Figure 3):

- **Test Case Behaviour:** describes the test case behaviour that tests the source sequence diagram. As a metamodel, this model uses the same variability extension for UML interactions as the source sequence diagram (see Section 5).

- **Variability Model:** this is the source variability model, but in the transformation, the variability model is augmented by traces to the test artifacts.
- **Test Architecture:** this model is a class diagram that uses an extension for the UML Testing Profile as its metamodel. This extension applies the stereotypes Variation Point and Variant to the variable elements in the test architecture (see Section 5).

3.2 Models in Application Engineering

Application Engineering takes into account both the MDE and SPL development. In the case of SPL, at this level the variability must be resolved. Thus, this level contains both the test cases refined from the domain engineering for a product (which involves resolving the variability corresponding to arrow 2), as well as the test cases for the functionalities added only for that product. For the new functionalities, the test cases are automatically generated using QVT from sequence diagrams (arrow 3). The transformation generates the test case behaviour as another sequence diagram and a class diagram representing the test architecture. Both models conform to the UML Testing Profile.

3.3 Framework Implementation

The implementation of the framework requires the selection of a modelling tool from those on the market and defining the tools that perform the transformations between the models and from model to code.

The transformations between the models use QVT language, which requires having a tool that implements the standard. *medini QVT* implements OMG's QVT Relations specification in a QVT engine. We used it to develop and execute the QVT transformations.

The integrated developed framework *Eclipse* makes it possible to use modelling tools in an integrated way, using extensions in the form of plug-ins. A *medini QVT* plug-in for *Eclipse* currently exists and is used for the model transformation in our proposal.

Other Eclipse plug-ins are used to perform the modelling tasks:

- Eclipse Modelling Framework (EMF): this is a modelling framework that allows the development of metamodels and models, from a model specification described in XMI, provides tools and runtime support to produce a set of Java classes for the model, along with a set of adapter classes that enable viewing and command-based editing of the model, and a basic editor.
- UML2: this is an EMF-based implementation of the UML 2.0 OMG metamodel for the Eclipse platform.
- UML2 Tools: A Graphical Modelling Framework editor for manipulating UML models.

Using these integrated tools for transformations between models requires that the input models for transformations be XMI (which is the default serialized form of EMF) in eclipse UML2 format. Therefore, the selected tool for the graphical modeling must support the import and export of models in the UML2 format through XMI.

There are many tools available that export UML models to the UML2 format through XMI, but few import the UM2 format.

In our case, since the behavior of the test case is automatically generated as a sequence diagram, it is crucial that the modelling tool be able to import the transformed models and visualize them.

The tool selected is the IBM Rational Software Modeler. This tool graphically represents the sequence diagrams and exports them to UML2 through XMI. This XMI is the input for the QVT transformation, which returns the XMI corresponding to the Test Model. This output XMI is imported to the IBM Rational Software Modeler, which shows the graphical representation for the test cases. The models shown in this paper were obtained using this tool.

4 TESTING FRAMEWORK FOR MDE

The preceding sections have presented the decisions taken in the process of defining the framework, and the metamodels and models defined for it. This section describes the activities necessary to implement the testing framework in MDE development.

Figure shows the process for generating the test model for MDE development. The activities at the PIM level are:

- **P1-Add New Functionality for the Product:** in this activity, the functionality for the product is described. The result is a sequence diagram representing a use case scenario. Figure shows the Interaction diagram for the functionality to

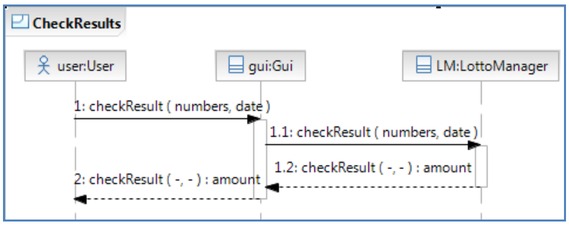


Figure 4: Check results functionality.

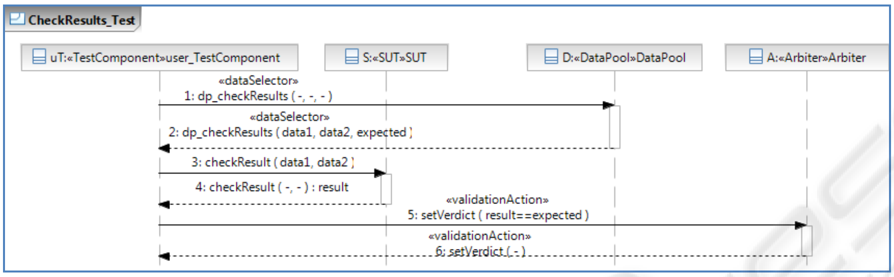
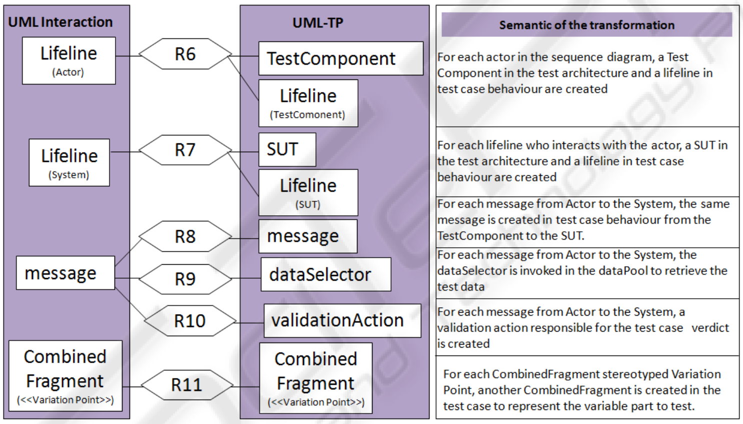


Figure 5: Test case for Check Results.



For each actor in the sequence diagram, a Test Component in the test architecture and a lifeline in test case behaviour are created

For each lifeline who interacts with the actor, a SUT in the test architecture and a lifeline in test case behaviour are created

For each message from Actor to the System, the same message is created in test case behaviour from the TestComponent to the SUT.

For each message from Actor to the System, the dataSelector is invoked in the dataPool to retrieve the test data

For each message from Actor to the System, a validation action responsible for the test case verdict is created

For each CombinedFragment stereotyped Variation Point, another CombinedFragment is created in the test case to represent the variable part to test.

Figure 6: Semantic of QVT transformation for test case generation.

check the results for a bet in the Lotto game.

- **P3-Test Model Generation for the Product:** this activity consists of running the QVT scripts which automatically generate the test models for the product. The inputs for the transformation are the sequence diagram generated in activity P1, which were exported to the XMI format. The outputs are the test architecture and the test case scenario, both of which follow the UML-TP. These models are imported to the modelling tool. Using the UML-TP, actors are represented by TestComponents, whilst the System is represented by the SUT. In our proposal, each message between the actor and the SUT must be tested (functional testing). Figure shows the test case generated for the Check Results functionality in Figure . Figure summarizes the semantics of the QVT transformation to generate the test case scenario, in which the following

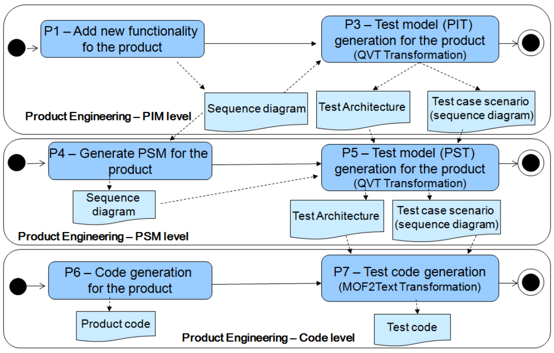


Figure 7: Framework activities in MDE development.

steps are necessary (more details can be found in (Pérez Lamancha, Reales Mateo et al. 2009)):

- **Obtaining the Test Data:** To execute the test case, according to UML-TP, the test data are needed and stored in the DataPool. The TestComponent asks for the test data using the DataSelector operation in the DataPool. Figure shows the *dp_checkResult()* stereotyped as DataSelector which returns the values: data1, data2 and expected. The first two are the values to test the parameters in the operation and the third is the expected result for the test case.
- **Executing the Test Case in the SUT:** The TestComponent simulates the actor and stimulates the system under test (SUT). The TestComponent calls the message to test in the SUT. For the example in Figure , the operation to test is *checkResult*. It is tested with the data returned by the DataPool. The operation is called in the SUT and returns the *result* data.
- **Obtaining the Test Case Verdict:** The TestComponent is responsible for checking whether the value returned for the SUT is correct, and informs the Arbiter of the test result. For the example in Figure , the validation action checks if the *result* (actual value) is equal to the *expected* (expected value) to return a verdict for the test case.

The activities at the PSM level are similar, but in this case the models are refined with platform specific aspects. The activities at code level are:

- **P6 – Code Generation for the Product:** in this activity the product code is generated following specific MDE tools. Once the executable product is obtained, it can be tested.
- **P3 – Test Code Generation for the Product:** this activity consists of running the MOF2Text scripts which automatically generate the test code from the PST model. The inputs for the transformation are the sequence diagram that represents the test cases generated in activities P3 or P5. The output is the test case code following the same development language used at the PSM level. For example, if Java is used, the test cases can be developed using JUnit.

5 TESTING FRAMEWORK FOR SPL

This section describes the activities necessary to implement the testing framework in SPL development. The activities required for SPL are added to those existing for MDE development. Figure shows the activities added to Figure .

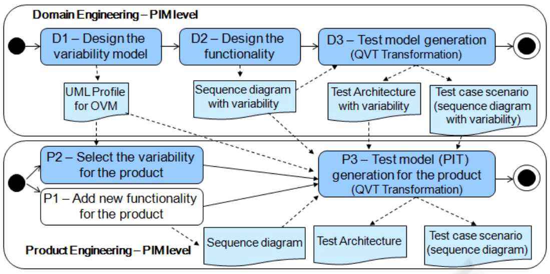


Figure 8: Framework activities in SPL development.

For domain engineering, the activities added are:

- **D1 – Design the Variability Model:** in this activity, the OVM model for the SPL is developed. This model follows the UML Profile defined for OVM.
- **D2 – Design the Functionality:** in this activity, the common functionalities for the SPL are described, including the variabilities. The results are a sequence diagram with the extension defined to deal with variability, where it represents each variation point as a CombinedFragment stereotyped with a Variation Point. Each variant is an InteractionOperand in the CombinedFragment. Figure 9 shows the Bet Payment functionality for the Lottery SPL. In it, the player calculates the amount of the bet and then makes the payment. As can be seen in Figure 1, the method of payment is a Variation Point, and the Combined Fragment is thus stereotyped as <<Variation Point>> in Figure 9. In the Combined Fragment, the behaviour differs if the payment is by credit card or with cash.
- **D3 – Test Model Generation:** this activity consists of running the QVT scripts which automatically generate the test models for the SPL. The inputs for the transformation are the OVM model and the sequence diagram with variability. The outputs are the test architecture and the test case scenario, both of which follow the UML Testing Profile and the extension defined for variability. Figure 10 shows the test case for Bet Payment, the same steps that the P3-Test model generation for the product activity is doing, but in this case, the CombinedFragment is translated to the test case. More about test case generation in the SPL context can be found in (Pérez Lamancha, Polo Usaola et al. 2009).

In the product domain, the variability is resolved and then the test model for each product is generated; the activities added are:

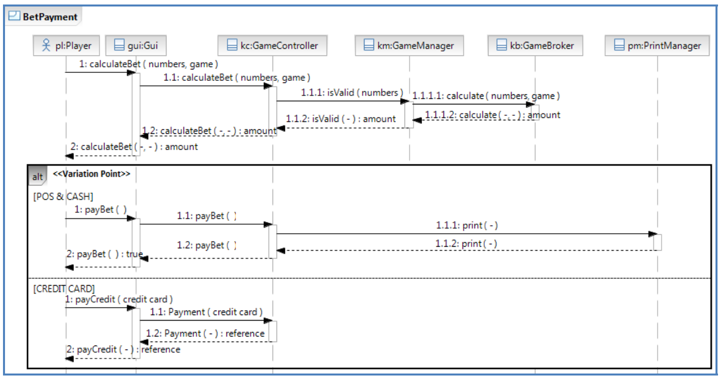


Figure 9: Bet Payment.

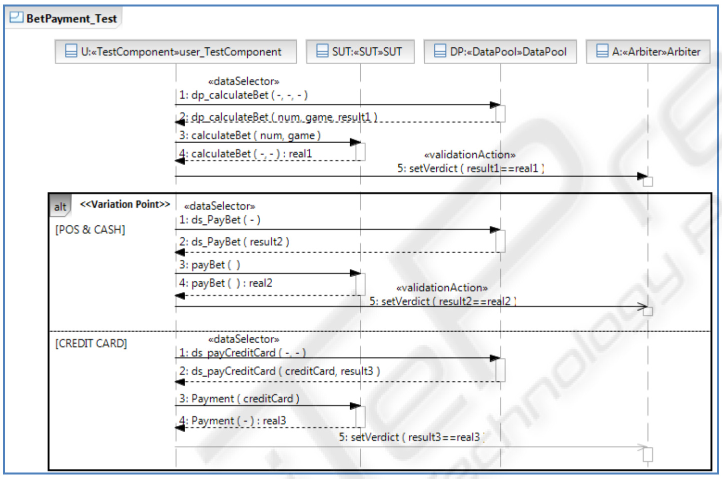


Figure 10: Test case for Bet Payment.

- **P1 – Add New Functionality for the Product:** in this activity, the functionality (which is specific to the product) is described. The result is a sequence diagram representing the functionalities present only in this product. It is the same activity as for MDE development**.**
- **P2 – Select the Variability for the Product:** To determine the test cases corresponding to each product, it is necessary to know which variation points and variants are included in each product. In this activity, the valid variants for the product are selected and this information is stored in the Orthogonal Variability Model of each product (OVMP). Figure 12 shows the variants selected for the Lotto Web product.
- **P3 – Test Model Generation for the Product:** Taking the test case for *Bet Payment* (Figure 10) as an example, to generate the test cases for the product Lotto Web, the variability in the CombinedFragment must be resolved. The inputs are: (1) the variability model for the Lotto Web (Figure 11), and (2) the *Bet Payment*_Test test case (Figure 10). The output is the *Bet Payment_Test* test case for the Lotto Web product (Figure 12). The entire CombinedFragment is deleted in the final test case, i.e. the variability is resolved at the product level.

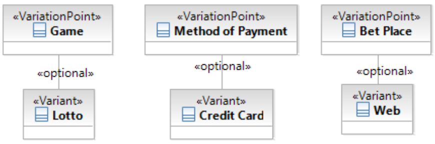


Figure 11: Variability model for Lotto Web product.

The activities described in this section are added in SPL development to what exists for MDE development (see Figure 4). Furthermore, the activities defined for the PSM and code level also apply to SPL development.

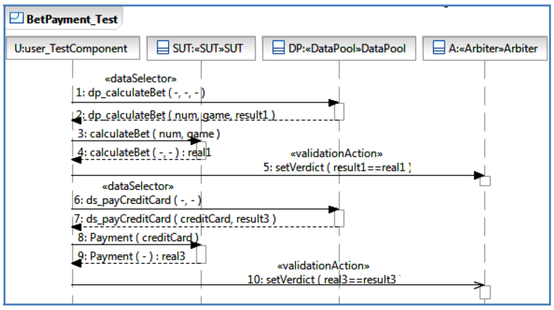


Figure 12: Bet Payment test case for Lotto Web Product.

6 RELATED WORKS

This section reviews the most significant works in this field. Several proposals for test case generation in SPL use UML artifacts as a basis. All of them provide traceability between Domain and Application Engineering in SPL. However, none of them take into account the capabilities of standard test models, such as UML-TP. Moreover, since model-based approaches are quite suitable for SPL, using a standard transformation language for automating the model generation is quite appropriate. A full description of existing works on SPL can be found in a recently published systematic review (Pérez Lamancha, Polo Usaola et al. 2009). Nebut et al. (Nebut, Pickin et al. 2003) propose a strategy in which test cases for each of the different products of an SPL are generated from the same SPL functional requirements. Test cases are obtained from high level sequence diagrams. The test cases for each product are derived from these sequence diagrams. Bertolino et al. (Bertolino, Gnesi et al. 2004) propose an abstract methodology, PLUTO (Product Line Use Case Test Optimization), for planning and managing abstract descriptions of test scenarios, which are described in PLUCs (Product Line Use Cases). A PLUC is a traditional use case where scenarios are described in natural language, but also contain additional elements to describe variability. Each PLUC includes a set of categories (input parameters and environment description) and test data. Then, and according to the variability labels, categories are annotated with restrictions, to finally obtain the test cases. Kang et al. (Kang, Lee et al. 2007) use an extended sequence diagram notation to represent use case scenarios and variability. The sequence diagram is used as the basis for the formal derivation of the test scenario given a test architecture. Reuys et al. (Reuys, Kamsties et al. 2005) present ScenTED (Scenario-based Test case Derivation) where the test model is represented as an activity diagram from which test case scenarios are derived. Test case scenarios are specified in sequence diagrams without providing concrete test data. Test case scenarios can be generated automatically, but test case specifications are developed manually.

Olimpiew and Gomma (Olimpiew and Gomaa 2006) describe a parametric method, PLUS (Product Line UML-based Software engineering). Here, customizable test models are created during software product line engineering in three phases: creation of activity diagrams from the use cases, creation of decision tables from the activity diagrams, and creation of test templates from the decision tables. Test data would then be generated to satisfy the execution conditions of the test template.

Many proposals exist about model-based testing but few of them focus on automated test model generation using model transformation. Dai (Dai 2004) describes a series of ideas and concepts to derive UML-TP models from UML models, which are the basis for a future model-based testing methodology. Test models can be transformed either directly to test code or to a platform specific test design model (PST). After each transformation step, the test design model can be refined and enriched with specific test properties. However, to the best of our knowledge, this interesting proposal has no practical implementation for any tool. These transformations are carried out with Java algorithms, which results in a mixed proposal between the two approaches described in this paper.

Baker et al. (Baker, Dai et al. 2007) define test models using UML-TP. Transformations are done manually instead of with a transformation language. Naslavsky et al. (Naslavsky, Ziv et al. 2007) use model transformation traceability techniques to create relationships among model-based testing artifacts during the test generation process. They adapt a model-based control flow model, which they use to generate test cases from sequence diagrams. They adapt a test hierarchy model and use it to describe a hierarchy of test support creation and persistence of relationships among these models. Although they use a sequence diagram (as does this proposal) to derive the test cases, they do not use it to describe test case behaviour. They have plans to use the traceability metamodel of ATL, but their proposal has not been automated yet.

Javed et al. (Javed, Strooper et al. 2007) generate unit test cases based on sequence diagrams. The sequence diagram is automatically transformed into a unit test case model, using a prototype tool based on the Tefkat transformation tool and MOFScript for model transformation.

7 CONCLUSIONS

A framework for model-driven testing that can be applied in MDE and SPL development was presented. The proposal includes a methodological approach to automate the generation of test models from design models. In the case of SPL, a way to handle the variability in test models is presented, based on OVM. Currently, the proposal is implemented for PIM models in domain and application engineering. Future work includes extending the proposal for PSM and code.

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