

4DT903 Project Proposal

Automated Test Case Generation from User Stories

Samuel Berg (sb224sc)

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1 Objective

1.1 Domain and Problem

This project addresses the challenge of bridging requirements engineering and software testing by automating the generation of test cases from natural language user stories [1].

In agile software development, user stories serve as the primary format for capturing functional requirements [2]. However, translating these stories into comprehensive test cases remains a manual, time consuming, complex and error prone process. Teams often struggle with:

- Inconsistent test coverage across different user stories.
- Manual effort required to maintain traceability between requirements and tests.
- Delayed test creation that pushes testing to later development phases.
- Difficulty ensuring all acceptance criteria are properly tested.

The project will use Model-Driven Engineering (MDE) to automatically transform structured user stories into executable test case specifications [1, 3] that can be exported to popular testing frameworks (such as JUnit for Java, pytest for Python or testing for Go), thereby improving consistency, traceability, and development velocity.

2 Models

2.1 Metamodels and Domains

The project involves three distinct domains, each requiring its own metamodel:

1. User Story Metamodel (Source Domain):

This metamodel captures the structure of user stories following the standard format [2, 4]:

- UserStory: Container element with ID, title, priority, and status.
- Actor: The role performing the action (“As a [role]”).
- Goal: The desired functionality (“I want to [action]”).
- Benefit: The business value (“So that [outcome]”).
- AcceptanceCriteria: Testable conditions using “Given When Then” format:
 - Precondition (Given): Initial state.
 - Action (When): Trigger event.
 - ExpectedResult (Then): Expected outcome.

2. Test Specification Metamodel (Intermediate Domain):

This platform-independent metamodel represents test cases abstractly [1, 3]:

- TestSuite: Groups related test cases.
- TestCase: Individual test with name, description, and priority.
- TestStep: Atomic test actions (Setup, Execute, Assert, Teardown).
- TestData: Input values and expected outputs.
- Assertion: Verification statements with comparison operators.
- Traceability: Links back to source user story elements.

3. Testing Framework Metamodel (Target Domain):

This metamodel represents the structure of popular testing frameworks:

- TestClass: Container for test methods.
- TestMethod: Individual test function with annotations/decorators.
- SetupMethod / TeardownMethod: Fixture management.
- AssertStatement: Framework-specific assertion syntax.
- TestAnnotation: Metadata (e.g. @Test, @DisplayName, @Tag).

2.2 Metamodel Relations

The metamodels are connected through the transformation pipeline [5]:

- User Story → Test Specification: M2M transformation mapping acceptance criteria to abstract test cases.
- Test Specification → Testing Framework: M2M transformation adapting abstract tests to framework-specific structure.
- Testing Framework → Code: M2T transformation generating executable test code.

2.3 Tool Integration

Model Creation:

- User stories will be created using a custom Eclipse-based editor built with EMF, providing a structured form interface for entering user story components [5].
- Models will be stored in XMI format for compatibility with EMF-based tools.

Model Consumption:

- Generated test code files (.java, .py, .go) will be consumed by JUnit 5 (for Java), pytest (for Python) or testing (for Go).
- Test frameworks will execute the generated tests within standard development environments (Eclipse, IntelliJ IDEA, VS Code).

Model Updates:

- When user stories are modified, the transformation pipeline can be re-executed to regenerate affected test cases.
- A traceability model will track which test cases are derived from which user stories, enabling selective regeneration [1].

3 Transformations

3.1 Transformation Pipeline

1. M2M Transformation: User Story to Test Specification (QVTo) [6, 7]

This transformation will:

- Create one TestSuite per UserStory (or group related stories).
- Generate one TestCase per AcceptanceCriteria.
- Map “Given When Then” structure to TestStep sequences:
 - Given → Setup steps.
 - When → Execute steps.
 - Then → Assert steps.
- Extract test data from acceptance criteria descriptions using pattern matching [4].
- Establish traceability links between test elements and story elements.
- Assign test priorities based on user story priority.

2. M2M Transformation: Test Specification to Testing Framework (QVTo) [6, 7]

This transformation adapts the platform-independent test model to a specific framework:

- Map TestSuite to TestClass with appropriate naming conventions.
- Transform TestCase to TestMethod with framework annotations.
- Convert generic Assertions to framework-specific assertion methods (e.g., assertEquals, assertThat).
- Generate Setup/Teardown methods for shared test fixtures.
- Add framework-specific metadata (tags, display names, test order).
- Handle multiple target frameworks using transformation parameters.

3. M2T Transformation: Testing Framework to Code (Acceleo) [8]

This transformation generates executable code:

- Produce Java files with JUnit 5, Python files with pytest or Go files with testing syntax.
- Generate properly formatted, readable code with comments linking to source user stories.
- Include necessary imports and class/module structure.
- Apply coding conventions (naming, indentation, documentation)

3.2 Combining Transformations

The transformations will be orchestrated using an Eclipse workflow script [5] that:

1. Loads the user story model (XMI file).
2. Executes the first M2M transformation (Story → Test Spec)
3. Saves the intermediate test specification model
4. Executes the second M2M transformation (Test Spec → Framework)
5. Executes the M2T transformation to generate code files
6. Outputs test files to a designated directory

Parameterization: The workflow will accept parameters for:

- Target testing framework (JUnit/pytest/testing).
- Output directory.
- Naming conventions.
- Test organization preferences.

Batch Processing: Multiple user story models can be processed in sequence, with all generated tests consolidated into a single test suite structure.

Validation: Each transformation will include validation steps to ensure model compliance with metamodels and report any inconsistencies in the source user stories (e.g. missing acceptance criteria, ambiguous conditions) [6].

This MDE approach ensures consistency, maintainability, and traceability while significantly reducing the manual effort required to create comprehensive test suites from requirements [1,3]. Here is an overview of the flow of metamodels, models and transformations (see Figure 1).

References

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- [7] Eclipse Foundation, “Qvt operational (qvto) documentation,” 2024.
- [8] Eclipse Foundation, “Acceleo user guide,” 2024.

A Figures

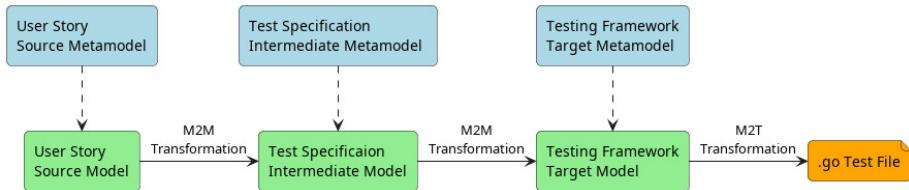


Figure 1: Overview of the Transformations to be implemented in this project