
Test Driven

Lasse Koskela

Chapter 2: Beginning TDD

Paul Ammann

&

Jeff Offutt

2018

Overview

- From requirements to tests
- Choosing the first test
- Breadth-first, depth-first
- Let's not forget to refactor
- Adding a bit of error handling
- Loose ends on the test list

Experience is a hard teacher because she gives the test first, the lesson afterward

General Problem Statement

Build a subsystem for an email application

Allow users to use **email templates** to create personalized responses to people in the company

From Requirements To Tests:

Template System Example

Template System as Tasks

- Write a regular expression to identify variables from the template
- Implement a template parser that uses the regex
- Implement a template engine that provides a public application programmer interface (API)
- ...

Template System as Tests

- Template without any variables renders as is
- Template with one variable is rendered with variables replaces by value
- Template with multiple variables is rendered with each variable replace by an appropriate value
- ...

Which approach do you find more natural?

What Are Good Tests Made Of?

- A good test is atomic
 - Does one and only one thing
 - Keeps things focused
- A good test is isolated
 - Does not depend on other tests
 - Does not affect other tests

This is not a complete list, but a start

Programming By Intention

- Given an initial set of tests
 - Pick one
 - Goal: **Most progress** with least effort
- Next, write test code
 - Wait! Code won't compile!
 - Imagine code exists
 - Use most natural expression for call (design the API)
- Benefit of **programming by intention**
 - Focus on what we COULD have
 - Not what we DO Have

Evolutionary API design from client perspective

Choosing The First Test

- Some detailed requirements:
 - System replaces variable placeholders like `${firstname}` in template with values provided at runtime
 - Sending template with undefined variables raises error
 - System ignores variables that aren't in the template
- Some corresponding tests:
 - Evaluating template “Hello, `${name}`” with value `name = Reader` results in “Hello, Reader”
 - Evaluating “`${greeting}, ${name}`” with “Hi” and “Reader” results in “Hi, Reader”
 - Evaluating “Hello, `${name}`” with “name” undefined raises `MissingValueError`

Writing the First Failing Test

- Evaluating template “Hello, \${name}” with value Reader results in “Hello, Reader”
- Listings 2.1, 2.2, 2.3

```
public class TestTemplate
```

```
{
```

```
    @Test
```

```
    public void oneVariable() throws Exception {
```

```
        Template template = new Template (“Hello, ${name}”);
```

```
        template.set (“name”, “Reader”);
```

```
        assertEquals (“Hello, Reader”, template.evaluate());
```

```
    }
```

```
}
```

We just made the following decisions about the implementation

DO try this at home

Code To Make Compiler Happy

```
public class Template
{
    public Template (String templateText) {
    }
    public void set (String variable, String value) {
    }
    public String evaluate() {
        return null;
    }
}
```

- This allows the test to **compile**
- The test **fails**, of course (listing 2.4)
- Running it should result in a RED bar
- We're at the RED part of RED-GREEN-REFACTOR

Making The First Test Pass

```
public class Template
{
    public Template (String templateText) {
    }
    public void set (String variable, String value) {
    }
    public String evaluate() {
        return "Hello, Reader";    // Couldn't get simpler than this!
    }
}
```

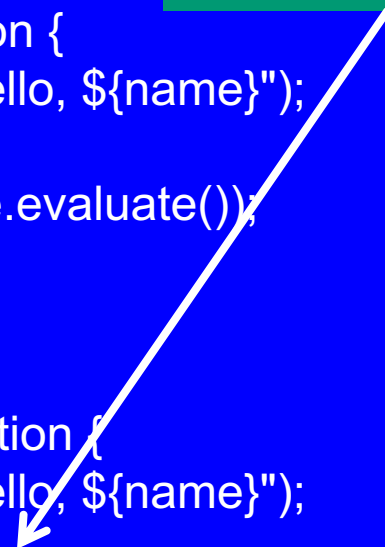
- We're looking for the **green bar** – listing 2.6
- We know this code **will change later** – That's fine
- Three dimensions to push out code : variable, value, template

Another Test

- Purpose of 2nd test (listing 2.7) is to “drive out” hard coding of variable’s value
- Koskela calls this **triangulation**

```
public class TestTemplate {  
    @Test  
    public void oneVariable() throws Exception {  
        Template template = new Template ("Hello, ${name}");  
        template.set ("name", "Reader");  
        assertEquals ("Hello, Reader", template.evaluate());  
    }  
  
    @Test  
    public void differentValue() throws Exception {  
        Template template = new Template ("Hello, ${name}");  
        template.set ("name", "someone else");  
        assertEquals ("Hello, someone else", template.evaluate());  
    }  
}
```

Triangulate
with a different
value



Another Test

- Revised code (listing 2.8) on page 57

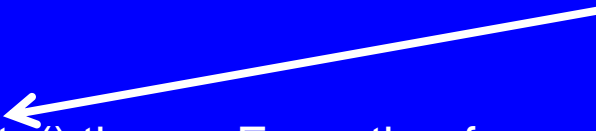
```
public class Template
{
    private String variableValue;
    public Template (String templateText) {
    }
    public void set (String variable, String value) {
        this.variableValue = value;
    }
    public String evaluate() {
        return "Hello, " + variableValue;
    }
}
```

Another Test


- Note revisions to JUnit in listing 2.9

```
public class TestTemplate {  
    @Test  
    public void oneVariable() throws Exception {  
        Template template = new Template ("Hello, ${name}");  
        template.set ("name", "Reader");  
        assertEquals ("Hello, Reader", template.evaluate());  
    }  
  
    @Test  
    public void differentTemplate() throws Exception {  
        Template template = new Template ("Hi, ${name}");  
        template.set ("name", "someone else");  
        assertEquals ("Hi, someone else", template.evaluate());  
    }  
}
```

Rename test to
match what
we're doing



Squeeze out
more hard
coded values



Breadth-First, Depth-First

- What to do with a “hard” red bar?
- Issue is **what to fake** vs. **what to build**
- “Faking” is an accepted part of TDD that means “**deferring a design decision**”
- **Depth first** means supplying detailed functionality
- **Breadth first** means covering end-to-end functionality (even if some is faked)

Handling Variables as Variables:

Listing 2.10

```
public class Template {  
    private String variableValue;  
    private String templateText;  
  
    public Template (String templateText) {  
        this.templateText = templateText;  
    }  
  
    public void set (String variable, String value) {  
        this.variableValue = value;  
    }  
  
    public String evaluate() {  
        return templateText.replaceAll ("\\$\\{name\\}", variableValue);  
    }  
}
```

Multiple Variables

- Test (page 60)

```
@Test
public void multipleVariables() throws Exception {
    Template template = new Template ("${one}, ${two}, ${three}");
    template.set ("one", "1");
    template.set ("two", "2");
    template.set ("three", "3");
    assertEquals ("1, 2, 3", template.evaluate());
}
```


Multiple Variables: Listing 2.11

```
public class Template {  
    private Map<String, String> variables;  
    private String templateText;  
  
    public Template (String templateText) {  
        this.variables = new HashMap<String, String>();  
        this.templateText = templateText;  
    }  
  
    public void set (string name, String value) {  
        this.variables.put (name, value);  
    }  
  
    public String evaluate() {  
        String result = templateText;  
        for (Entry<String, String> entry : variables.entrySet()) {  
            String regex = "\\$\\{" + entry.getKey() + "\\}";  
            result = result.replaceAll (regex, entry.getValue());  
        }  
        return result;  
    }  
}
```

Store variable values in HashMap

Loop through variables

Replace each variable with its value

Special Test Case

- Special case test page 62
- This test passes for free!

```
@Test
public void unknownVariablesAreIgnored() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    template.set ("doesnotexist", "Hi");
    assertEquals ("Hello, Reader", template.evaluate());
}
```

Let's Not Forget To Refactor

- Refactoring applies to both the **functional code** and to the **test code**
- Compare listing 2.12 (pg 63) with refactored listing 2.13 (pg 64)
- Note use of **fixtures**

Listing 2.12: Problems

```
@Test public void oneVariable() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    assertEquals ("Hello, Reader", template.evaluate());
}

@Test public void differentTemplate() throws Exception {
    Template template = new Template ("Hi, ${name}");
    template.set ("name", "someone else");
    assertEquals ("Hi, someone else", template.evaluate());
}

@Test public void multipleVariables() throws Exception {
    Template template = new Template ("${one}, ${two}, ${three}");
    template.set ("one", "1");
    template.set ("two", "2");
    template.set ("three", "3");
    assertEquals ("1, 2, 3", template.evaluate());
}

@Test public void unknownVariablesAreIgnored() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    template.set ("doesnotexist", "Hi");
    assertEquals ("Hello, Reader", template.evaluate());
}
```

Listing 2.12: Problems

```
@Test public void oneVariable() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    assertEquals ("Hello, Reader", template.evaluate());
}

@Test public void differentTemplate() throws Exception {
    Template template = new Template ("Hi, ${name}");
    template.set ("name", "someone else");
    assertEquals ("Hi, someone else", template.evaluate());
}

@Test public void multipleVariables() throws Exception {
    Template template = new Template ("${one}, ${two}, ${three}");
    template.set ("one", "1");
    template.set ("two", "2");
    template.set ("three", "3");
    assertEquals ("1, 2, 3", template.evaluate());
}

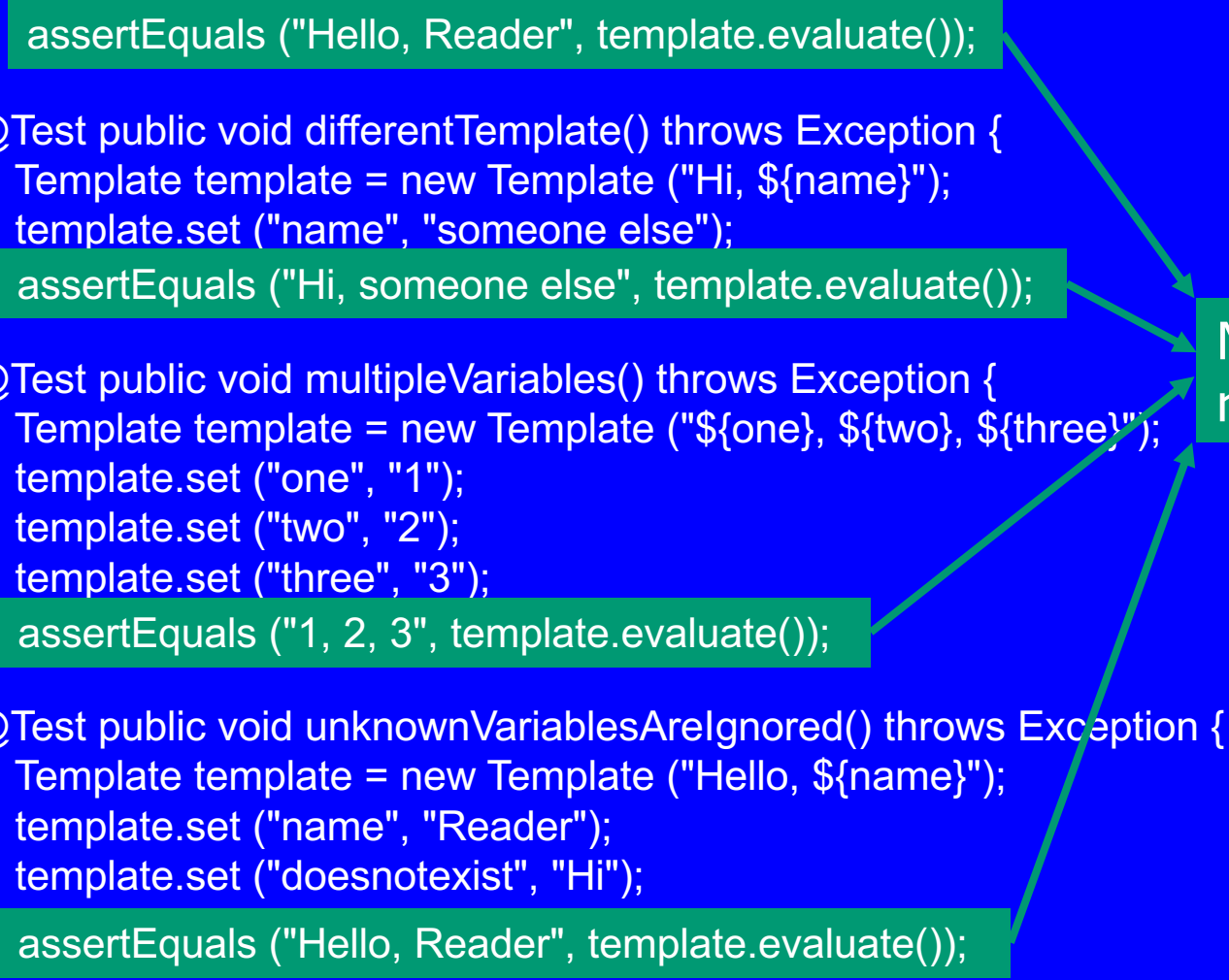
@Test public void unknownVariablesAreIgnored() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    template.set ("doesnotexist", "Hi");
    assertEquals ("Hello, Reader", template.evaluate());
}
```

Redundancy
creates risk



Listing 2.12: Problems

```
@Test public void oneVariable() throws Exception {  
    Template template = new Template ("Hello, ${name}");  
    template.set ("name", "Reader");  
    assertEquals ("Hello, Reader", template.evaluate());  
}  
  
@Test public void differentTemplate() throws Exception {  
    Template template = new Template ("Hi, ${name}");  
    template.set ("name", "someone else");  
    assertEquals ("Hi, someone else", template.evaluate());  
}  
  
@Test public void multipleVariables() throws Exception {  
    Template template = new Template ("${one}, ${two}, ${three}");  
    template.set ("one", "1");  
    template.set ("two", "2");  
    template.set ("three", "3");  
    assertEquals ("1, 2, 3", template.evaluate());  
}  
  
@Test public void unknownVariablesAreIgnored() throws Exception {  
    Template template = new Template ("Hello, ${name}");  
    template.set ("name", "Reader");  
    template.set ("doesnotexist", "Hi");  
    assertEquals ("Hello, Reader", template.evaluate());  
}
```



More redundancy

Listing 2.12: Problems

```
@Test public void oneVariable() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    assertEquals ("Hello, Reader", template.evaluate());
}

@Test public void differentTemplate() throws Exception {
    Template template = new Template ("Hi, ${name}");
    template.set ("name", "someone else");
    assertEquals ("Hi, someone else", template.evaluate());
}

@Test public void multipleVariables() throws Exception {
    Template template = new Template ("${one}, ${two}, ${three}");
    template.set ("one", "1");
    template.set ("two", "2");
    template.set ("three", "3");
    assertEquals ("1, 2, 3", template.evaluate());
}

@Test public void unknownVariablesAreIgnored() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    template.set ("doesnotexist", "Hi");
    assertEquals ("Hello, Reader", template.evaluate());
}
```



Same test
twice

Listing 2.12: Problems

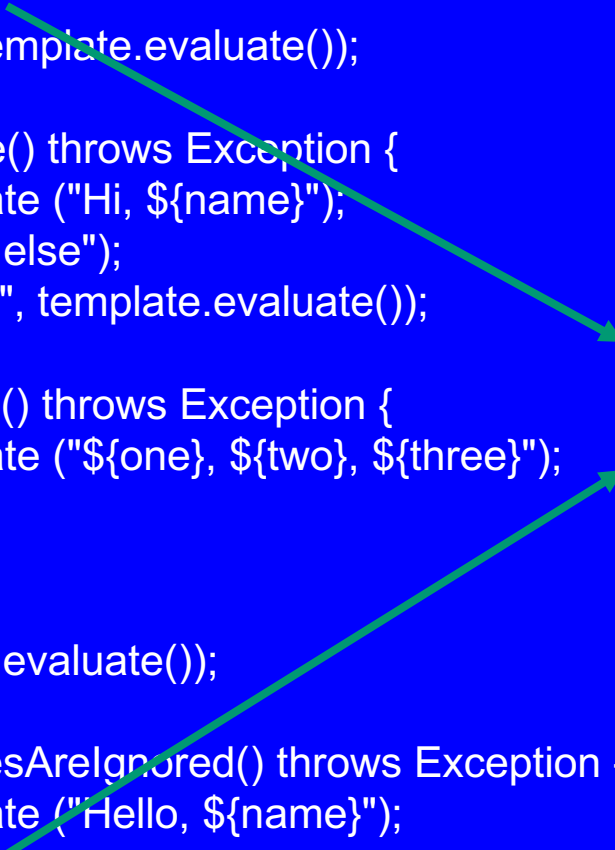
```
@Test public void oneVariable() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    assertEquals ("Hello, Reader", template.evaluate());
}

@Test public void differentTemplate() throws Exception {
    Template template = new Template ("Hi, ${name}");
    template.set ("name", "someone else");
    assertEquals ("Hi, someone else", template.evaluate());
}

@Test public void multipleVariables() throws Exception {
    Template template = new Template ("${one}, ${two}, ${three}");
    template.set ("one", "1");
    template.set ("two", "2");
    template.set ("three", "3");
    assertEquals ("1, 2, 3", template.evaluate());
}

@Test public void unknownVariablesAreIgnored() throws Exception {
    Template template = new Template ("Hello, ${name}");
    template.set ("name", "Reader");
    template.set ("doesnotexist", "Hi");
    assertEquals ("Hello, Reader", template.evaluate());
}
```

Same test
values
twice



Listing 2.13: Refactor Test Code

```
public class TestTemplate {  
    private Template template;  
    @Before  
    public void setUp() throws Exception {  
        template = new Template ("${one}, ${two}, ${three}");  
        template.set ("one", "1");  
        template.set ("two", "2");  
        template.set ("three", "3");  
    }  
  
    @Test  
    public void multipleVariables() throws Exception {  
        assertTemplateEvaluatesTo ("1, 2, 3");  
    }  
  
    @Test  
    public void unknownVariablesAreIgnored() throws Exception {  
        template.set ("doesnotexist", "whatever");  
        assertTemplateEvaluatesTo ("1, 2, 3");  
    }  
  
    private void assertTemplateEvaluatesTo (String expected) {  
        assertEquals (expected, template.evaluate());  
    }  
}
```

Common
fixtures for all
tests

Simple,
focused tests

Shared method

Adding A Bit Of Error Handling

- A variable does not have a value
- Adding exception test listing 2.14
 - Note different approaches to testing exceptions
 - try-catch block with fail() vs. @Test (expected= ...)

```
@Test
public void missingValueRaisesException() throws Exception {
    try {
        new Template ("${foo}").evaluate();
        fail ("evaluate() should throw an exception if "
            + "a variable does not have a value!");
    } catch (MissingValueException expected) {
    }
}
```

Listings 2.15, 2.16

```
public String evaluate() {
    String result = templateText;
    for (Entry<String, String> entry : variables.entrySet()) {
        String regex = "\\$\\{" + entry.getKey() + "\\}";
        result = result.replaceAll (regex, entry.getValue());
    }
    if (result.matches (".*\\$\\{.+\\}.*")) {
        throw new MissingValueException();
    }
    return result;
}
```

Does **result** still have a variable with no value?

Refactor to move an if-block out of **evaluate()**

```
public String evaluate() {
    String result = templateText;
    for (Entry<String, String> entry : variables.entrySet()) {
        String regex = "\\$\\{" + entry.getKey() + "\\}";
        result = result.replaceAll (regex, entry.getValue());
    }
    checkForMissingValues (result);
    return result;
}

private void checkForMissingValues (String result) {
    if (result.matches (".*\\$\\{.+\\}.*")) {
        throw new MissingValueException();
    }
}
```

Extract Method Refactoring

```
public String evaluate() {  
    String result = templateText;  
    for (Entry<String, String> entry : variables.entrySet()) {  
        String regex = "\\$\\{" + entry.getKey() + "\\}";  
        result = result.replaceAll (regex, entry.getValue() );  
    }  
    checkForMissingValues (result);  
    return result;  
}
```

- `evaluate()` does two things:
 1. Replacing variables with values
 2. Checking for missing values
- These are different, and should be separate
 - This is called “*extract method*” refactoring

More Refactoring: Listing 2.17

```
public String evaluate() {  
    String result = replaceVariables();  
    checkForMissingValues (result);  
    return result;  
}
```

evaluate()
method's internals
better balanced

```
private String replaceVariables() {  
    String result = templateText;  
    for (Entry<String, String> entry : variables.entrySet()) {  
        String regex = "\\$\\{" + entry.getKey() + "\\}";  
        result = result.replaceAll (regex, entry.getValue());  
    }  
    return result;  
}
```

New method is simple
and has a single,
clear purpose

```
private void checkForMissingValues (String result) {  
    if (result.matches (".*\\$\\{.+\\}.*")) {  
        throw new MissingValueException();  
    }  
}
```

Must re-run all the tests
to ensure nothing broke

A Truly Difficult Special Case

- What happens in the special case that a value has a special character such as ``$'`, ``{'`, or ``}'`?
 - These are the kinds of non-happy path tests TDD often skips
- Implementing this test breaks the current implementation:

@Test

```
public void variablesGetProcessedJustOnce() throws Exception {  
    template.set ("one", "${one}");  
    template.set ("two", "${three}");  
    template.set ("three", "${two}");  
    assertTemplateEvaluatesTo ("${one}, ${three}, ${two}");  
}
```

Values have the special characters ``$'`, ``{'`, and ``}'`

- `regex` throws an `IllegalArgumentException`
 - Requiring a major design change

Chapter 3 addresses major rewrites