End-to-end Testing Framework

JavaTea

User Guide

Revision History

Version	Date	Author	Description
0.0.1	5/1/2019	Masayuki Otoshi	Document Created

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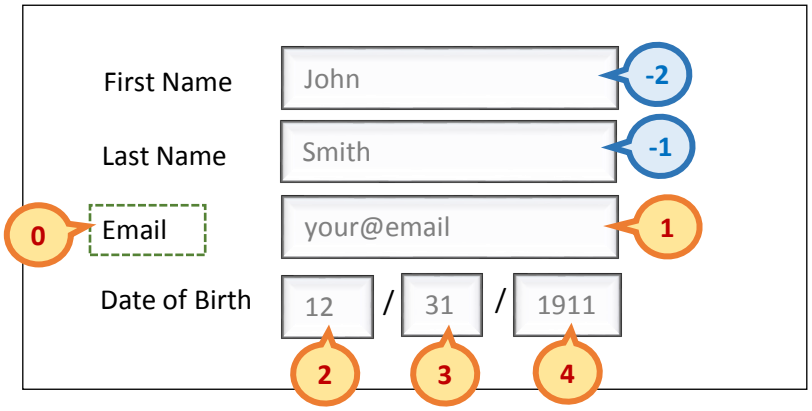
1. Introduction

Selenium is a tool widely used to code tests in test automation. It is very efficient to make sure all functions work as we expected. However, in order to make our tests reusable and maintainable, for example, applying Page Object Model (POM), some amount of programming is required. With this approach, you need to create page classes and define properties that represent elements to be displayed on target web page. This concept works fine while your web application works stable. But, in real word, we need to continuously change the code to enhance features and fix issues. The changes break existing tests and you need to spend time to fix. Because of this, developers spends a lot of time to manage tests as well as application code.

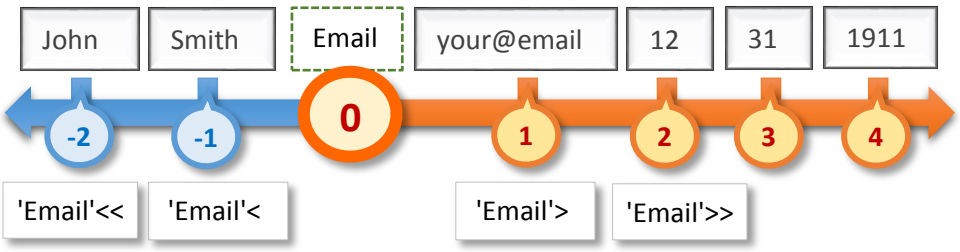
To reduce the cost of test automation, testing tool must be highly flexible and describable. JavaTea is designed to capture web elements based on text strings shown on the web page to provide an intuitive and easy way to point the target element.



Suppose we have the above web page and want to populate values in each input element. Now you can get an element of the 'Email' label with the expression below:

```
'Email'
```

Tea script finds a text element from the page by using the text 'Email'. Also it allows you to access other input elements around the text element by using the index number from the text. Since we are on the Email label, the index number is now numbered as shown below:



To move the index, '**>**' and '**<**'operators can be used. The > moves the index to the right and < operator moves to the left. Likewise, '**>>**' and '**<<**' operators move by two input elements to the right and left, respectively.
If you want to enter an email address in the Email input box, you can describe the script using the > operator:

```
#'Email'> = 'your@email';
```

If you want to enter your date of birth (for example, December 31st, 1911), describe this:

```
#'Email'>> = 12  31  1911;
```

This expression tries to access the second input element on the right direction from the Email label, which is the input box next to 'Date of Birth' label on the right. After the first value '12' is entered, the index is automatically counted up and the index becomes 3, which is now points to the second input box for the Date of Birth. So, the number '31' is populated into the second input box, and the index is also counted up again. The last number '1911' is populated into the third input box.
Next example is using < operator. If you want to enter first and last names (first name: John, last name: Smith), use this expression:

```
#'Email'< = 'Smith' 'John';
```

The '<' operator sets index to -1 from the current position, thus, the first value 'Smith' is set to Last name input box. This time, the index is decreased and the value becomes '-2', which points to the First name input box. Thus, the next value 'John' is populated into the First name input box.
In order to show example to use < operator, I accessed starting from the Email label, however, in real world, we usually gets the first label on the page and simply enter the values from the top to bottom.

```
#
   'First name'> = 'John' 'Smith'
   'your@email' // Email
   12  31  1911 // Date of birth
;
```

Or you can also specify label text for each element in order to make your script robustness for future changes:

```
#
   'First name'> = 'John' 'Smith'
   'Email'> = 'your@email'
   'Date of Birth'> = 12  31  1911
;
```

The tea script is described in Java code, and it is compiled as a Java class. Thus, you can easily integrate existing other Java libraries. Also you can debug the Java code compiled from Tea script using your favorite IDE.
JavaTea also supports pairwise testing with using 2 and 3-wise algorithm to reduce the number of combinations. A test script created for a single test scenario can be easily extended to the script for pairwise testing by adding possible values to each element.
For more details, please see chapter Pairwise Testing.

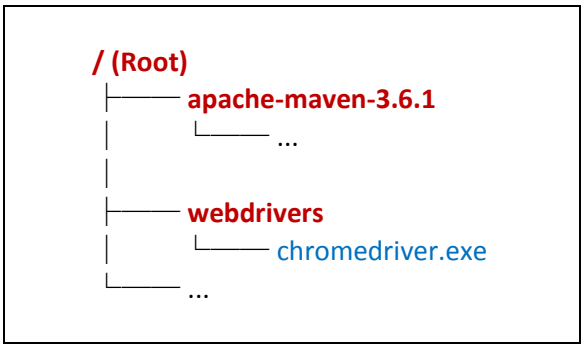
2. Installation

Dependencies

JavaTea requires the following software:

- **Java SE Version 8** or above
  https://www.oracle.com/technetwork/java/javase/
- **Maven Version 3.1.6** or above
  https://maven.apache.org/
- **Chrome browser**
  https://www.google.com/chrome/
- **ChromeDriver (WebDriver for Chrome)**
  http://chromedriver.chromium.org/

In this document, we assume that Maven and ChromeDriver are installed in the following folder structure:



The apache-maven and webdrivers directories should be placed on your system **PATH**.

```
SET PATH=%PATH%;/apache-maven-3.6.1;/webdrivers
```

3. Getting Started

Download, Compile and Run

JavaTea samples are available to get from the site:
https://github.com/teafarm/javatea/tree/master/examples/

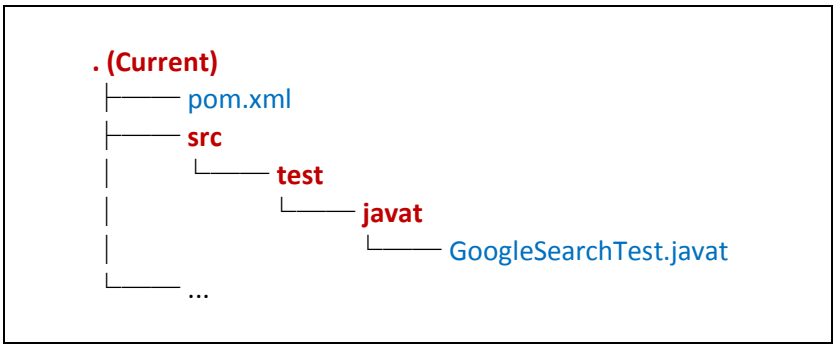
We here show one of easiest samples, how to run GoogleSearch test.

Step 1. Download the following files:

- pom.xml
  https://github.com/teafarm/javatea/tree/master/examples/GoogleSearch/pom.xml

- GoogleSearchTest.javat
  https://github.com/teafarm/javatea/tree/master/examples/GoogleSearch/src/test/GoogleSearchTest.javat

Store the files in the following folder structure:



Step 2. Compile and Run tests

```
C:> SET PATH=/apache-maven-3.6.1/bin;/webdrivers;C:/Windows/System32
C:> mvn exec:java
C:> mvn test
```

A chrome browser will be opened and show a Google site. And a keyword search will be executed automatically.

Basic Syntax

To understand basic syntax on JavaTea and Tea script, go back to previous chapter and see the sample code.

```
import org.junit.jupiter.api.Test;

public class GoogleSearchTest extends tea.TeaBase {
  @Test
  public void test() {
    createDriver('chrome');
    driver.get('http://www.google.com');
    #
      'name:q' = 'Test Tool'
         true
    ;
  }
}
```

There are the following JavaTea specific rules:

Rule 1: A test class must inherit from tea.TeaBase class:

```
public class GoogleSearchTest extends tea.TeaBase {
```

Rule 2: createDriver() must be called with a browser name before starting to access target web pages. Once you call this, a WebDriver object is created internally and available to use through a property 'driver'.

```
createDriver('chrome');
```

Rule 3: driver.get() must be called to display the target web page.

```
driver.get('http://www.google.com');
```

Rule 4: Tea script must be described between **#** and **;** or **#** and **#**.

```
#'name:q' = 'Test Tool';
```

As for **#** and **#** syntax, the second **#** can be omitted if the script ends with ',' or ')'.

```
assertEquals(#'NAME'@>, 'John', 'Name entered');
```

The above code can be described as show below with the second **#**:

```
assertEquals(#'NAME'@>#, 'John', 'Name entered');
```

4. Examples

This chapter shows some useful examples to understand how to compile and run JavaTea tests and how to describe Tea scripts in it.

Locations Example

The first example is Locators. This example accesses the web page shown below and shows various ways to find element objects:

Text locator (text:)

Text locator is the most-used locator in JavaTea. It finds a web element by a text displayed on the page. The text must exact match with the body text of a tag. For example, if you want to find 'Name', it has to be defined as Name. If it may contains extra spaces such as Name , use partial text locator instead.

To use a text locator, add 'text:' prefix on the target text string. For example, if you want to find a text element of label 'Name', describe as shown below:

```
'text:Name'
```

Or you can also simply specify the label text only ('text:' is optional)

```
'Name'
```

If you access the text element in a function parameter, use # # syntax.

```
assertEquals(#'Name', 'Name', 'text locator');
```

Partial Text locator (partial:)
Partial text locator finds an element by using a part of text string.
With specifying the partial: prefix, you can find Name text element by using a partial string, for example, ‘ame’.

```
'partial:ame'
```

The ‘partial:ame’ matches all displayed text elements which contains a text ‘ame’, e.g. ‘Name’, ‘frame’, ‘america’

XPath locator (xpath:)
XPath locator finds an element by using a XPath expression. The expression below returns an input element whose id attribute is ‘name’:

```
'xpath://input[@id="name"]'
```

ID locator (id:)
ID locator finds an element by using an id attribute value. The expression below returns a tag whose id attribute is ‘name’:

```
'id:name'
```

Name locator (name:)
Name locator finds an element by using a name attribute value. The expression below returns a tag whose name attribute is ‘option-value’:

```
'name:option-value'
```

Link Text locator (linkText:)
Link Text locator finds an element by using a text string of a hyper link. The expression below returns an anchor link tag whose body text exacts match with the given text ‘Visit JavaTea site’:

```
'linkText:Visit JavaTea site'
```

Partial Link Text locator (partialLinkText:)
Partial Link Text locator finds an element by using a text string of a hyper link with using partial match condition. The expression below returns an anchor link tag whose body text contains the given text ‘JavaTea site’:

```
'partialLinkText:JavaTea site'
```

Class Name locator (className:)
Class Name locator finds an element by using a class attribute value. The expression below returns a tag whose class is ‘label’, class=”label”:

```
'className:label'
```

Tag Name locator (tagName:)

Tag Name locator finds an element by using a tag name. The expression below returns a tag whose tag name is h2:

```
'tagName:h2'
```

CSS Selector locator (cssSelector:)

CSS Selector locator finds an element by using a CSS Selector expression. The expression below returns a tag whose id attribute is ‘name’:

```
'cssSelector:#name'
```

This Locators example contains a sample code to obtain a TeaElement object by using # # syntax.

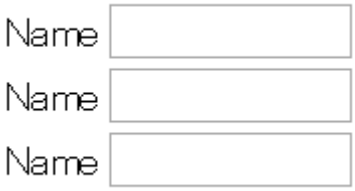
```
TeaElement name = #'id:name'#;
```

The TeaElement implements WebElement interface, so you can get the element information through the APIs.

```
name.getTagName();
name.getAttribute('id');
name.getText();
name.getCssValue('font-family');
name.getLocation();
name.getSize();
```

ArraySuffix (and Shift) Example

Locator returns the first element if it found more than one element with the given condition. If you want to access another element, for example the second element, use array suffix to specify the index. The index number starts with zero.




```
'Name'[0]    // returns the first Name text element
'Name'[1]    // returns the second Name text element
'Name'[2]    // returns the third Name text element
```

Once you obtained an element object, you can move to another form element (input, button, select, etc) by using shift operator '>'.


```
'Name'>     // returns the first input element displayed right next to the Name element
'Name'>>    // returns the second input element
'Name'2>    // returns the second input element
'Name'>>>   // returns the third input element
'Name'3>    // returns the third input element
```

Elements Example

This sample shows ways to set a value into various type of elements.

Input element

Enter a value ‘John Smith’ into an input element displayed right next to ‘Name’ text element.

1) Clear and enter the given value.

```
'Name'> = 'John Smith'
```

2) Enter the given value
   Keep the original value and append the given value (Use += assignment)

```
'Name'> += ' suffix'
```

Select element - single selection

There are some ways to select an option.

1) Select an option by the displayed text ‘Tokyo’. (Use an equal assignment)

```
'Place'> = 'New York'
```

2) Select an option by the option value ‘ny’. (Use @= assignment)

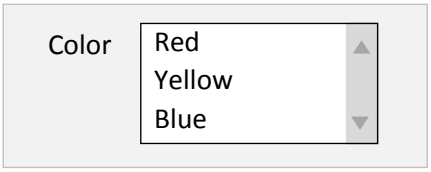
```
'Place'> @= 'ny'
```

3) Select an option by the display text with using a regular expression. (Use /…/ leteral)
   (Select an option text starting with ‘New’)

```
'Place'> = /New.*/
```

Select element - multiple selection

Select options by the displayed texts. (Use an array).




```
'Color'> = ['Red', 'Blue']
```

Radio button

Click on a radio button (Use true literal).

1) Click on Auto radio button.

```
'Type'> = true
```

2) Click on Truck (Skip Auto radio button).

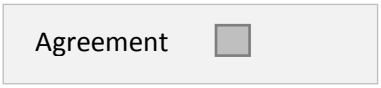
```
'Type'> = false true
```

or

```
'Truck'< = true
```

Check box

Click on a check box (Use true literal).




```
'Agreement'> = true
```

Button element

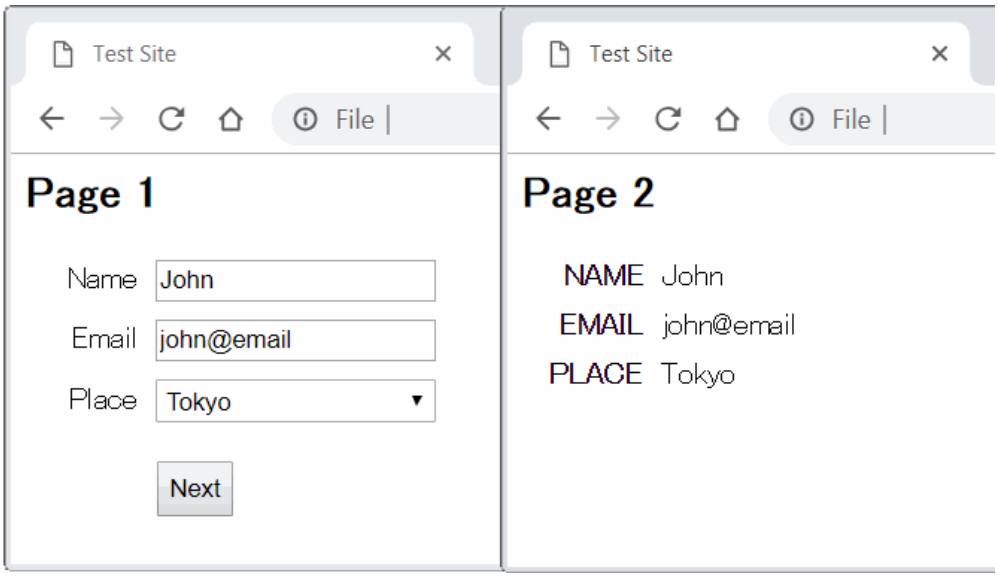
Click on a button (Use true literal).


```
'Next' = true
```

Note that '>' is not needed to specify. In this case, we want to click the 'Next' button itself.

Wizard Example

This is a realistic example compared to previous ones. We here test HTML pages with wizard style. There are two pages titled Page 1 and Page 2. This sample enters a name, an email address and select a place on the first page. Then the second page shows the values entered.



Here is the JavaTea file to test the pages above.

WizardTest.javat

```
import static tea.TeaAssert.assertEquals;
import org.junit.jupiter.api.Test;

public class WizardTest extends tea.TeaBase {
 @Test
 public void test() {
  createDriver('chrome');
  driver.get(new java.io.File('Page1.html').toURI().toString());

  #
   'Name'> = 'John'
          'john@email'
          'Tokyo'
          true
  ;

  assertEquals(#'NAME'@>, 'John', 'Name entered');
  assertEquals(#'EMAIL'@>, 'john@email', 'Email entered');
  assertEquals(#'PLACE'@>, 'Tokyo', 'Place selected');
```

```
    driver.quit();
  }
}
```

The main Tea script code in this sample is this:

```
    'Name'> = 'John'
            'john@email'
            'Tokyo'
            true
```

The assignment statement in the first line represents sending a value to Name input field. The 'Name' is a text locator which returns a text element object of the Name label. But > operator is attached on the right, so it actually returns a Name input element object displayed right next to the Name label. Thus, the test string 'John' is set in the Name field after execution of this line.
The assignment statement also counts up element index pointing to current element. Thus current element index is now pointed to Email input field.
After the first line, there is a value defined in each line. This is because the first line element index has already set. Since JavaTea moves among elements automatically when a value is set, you don't have to specify where you set the value.
The second text string 'john@email' is set into the Email field, and element index is increased and points to the next input element. Likewise, the third line selects 'Tokyo' from the selection box. And the fourth line clicks on the Next button.

After submitted the form on the Page 1, the sample code validates the values entered with the code below:

```
    assertEquals(#'NAME'@>, 'John', 'Name entered');
    assertEquals(#'EMAIL'@>, 'john@email', 'Email entered');
    assertEquals(#'PLACE'@>, 'Tokyo', 'Place selected');
```

The assertEquals() takes three parameters:

```
 void assertEquals( TesElement actual, String expected, String message );
```

To set an actual value displayed on the Page 2, we want to use a Tea script. So the first parameter starts with a **#** sign, and specify the label text of the target value. Next we need to make a shift and get a target text string of Name. Although we used > operator to shift and find an input element, this time we need to use @> operator instead. It is because the target operator is read-only text element, not editable one. 'Name'@> finds a text string displayed right next to the 'Name' label. In this sample, it is expected to be 'John'. If the application works fine as expected, the first parameter in the assertion returns 'John' and it matches with the second parameter which is an expected value.

In the sample folder, run the following commands to compile and run the test.

```
C:> SET PATH=/apache-maven-3.6.1/bin;/webdrivers;C:/Windows/System32
C:> mvn exec:java
C:> mvn test
```

5. Tea Script Language Specifications

This chapter describes language specifications of Tea script. Tea script can be described between **#** and **;** or **#** and **#** in Java code.

Expression	Description
# <script> **;**	Sets a value into a specified element or current element object. Multiple statements can be described in a script section. For example, **#**'Name'> = 'John Smith'**;** **#**'Date of Birth'> = 1911 2 3**;** The above two statements can be rewritten as shown below: **#** 'Name'> = 'John Smith' 'Date of Birth'> = 1911 2 3 **;**
# <script> **#**	Returns a value without setting into an element object. You can omit the closing number-sign character if it ends with a comma ',' or closing parenthesis. For example, assertEquals(**#**'Name'@>**#**, **#**'UserName'@>**#** **)**; the above line can be rewritten as shown below: assertEquals(**#**'Name'@>, **#**'UserName'@> **)**;

Between those notations, the following tokens are available to describe.

Comments

- /* comment */
  Multiple-line comment can be described between /* and */.
- // comment
  Single-line comment can be described after //.

Keywords

The following word is reserved for use as Tea script keywords and cannot be used as identifiers.

- optional

The 'optional' keyword makes element optional. By default, JavaTea waits until it finds the element or timed out (default: 20 seconds). If you specify the optional keyword, JavaTea checks the existence of the element once. If the element does not exist, JavaTea skips the statement and execute the next line.

Keyword	Description
optional	Do not wait for appearance of the target element. (JavaTea waits until the target element appears on the page by default)

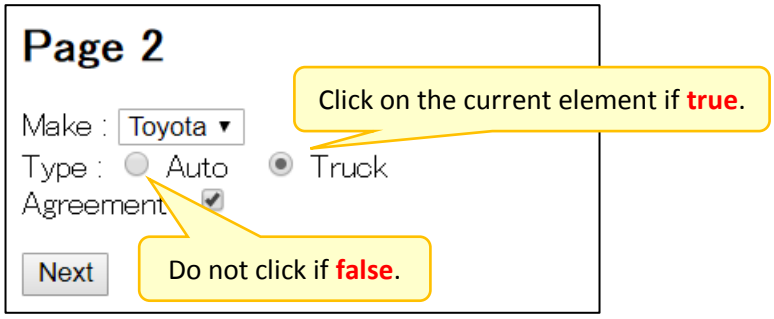
Boolean Literals

A boolean type has two values below:

- true
- false

A true value represents a mouse click, and false does nothing to do. For example, the following code makes a mouse click on Truck (second option) but Auto.

```
'Track'> = false true
```



String Literals

A string literal consist of zero or more characters enclosed in single or double quotes.
One character must be enclosed in double quotes.

- "text"
- 'text'

Regular Expression Literals

A regular expression literal consist of a regular expression enclosed with slashes. Flags can be added.

- /regular expression/
- /regular expression/flags

Below are the flags available to specify:

Flag	Description	Value in Java

e	Enables canonical equivalence.	Pattern.CANON_EQ
i	Enables case-insensitive matching.	Pattern.CASE_INSENSITIVE
x	Permits whitespace and comments in pattern.	Pattern.COMMENTS
s	Enables dotall mode.	Pattern.DOTALL
l	Enables literal parsing of the pattern.	Pattern.LITERAL
m	Enables multiline mode.	Pattern.MULTILINE
u	Enables Unicode-aware case folding.	Pattern.UNICODE_CASE
c	Enables the Unicode version of Predefined character classes and POSIX character classes.	Pattern.UNICODE_CHARACTER_CLASS
d	Enables Unix lines mode.	Pattern.UNIX_LINES

Character Literals

A character literal consist of one character enclosed in single quotes. For example,

- 'a'

Number Literals

A number literal consist of one or more digits. It may starts with a minus sign.
For example,

- 123
- -123

Java Code Section

By default, javat file is in Java mode. Hence, you can start writing Java code without any special notations. Use the following expressions, when you need to change back to Java mode from Script mode.

- { Java code }

```
String s = #'Name'>{.toString()};
```

Note that the number of start and close curly braces must be matched in the code. If it does not match, use {%, %}.

- {% Java code %}

```
#
  {% for (int index=0; index<10; index++) { %}
    'Name'index> = ''
  {% } %}
;
```

Java and script modes can be nested.

```
#
   'Name'> = () -> {
      return 'Test' + getUserID(#'User'@>);
   }
;
```

Lambda Java Functions

A lambda function executes the Java code and set the return value to the current element object if it is not null.

- Thin arrow
  (parameters) -> {
  Java code
  }
- Fat arrow
  (parameters) => {
  Java code
  }

Curly braces are optional if there is only a single function call in the body section.

- () -> func()

The above expression is equivalent to the following code:

- () -> { func(); }

Java Methods

A Java method executes the method, but the return value is ignored. It isn't set to the current element object.

- method(parameters)

The above expression is equivalent to the following code:

- { method(parameters); }

Element

An element represents a web element on the target web page.

Locators

The element can be found by Selenium locators (xpath, cssName, tagName, etc) as well as text string displayed on the page.

By default, JavaTea uses text locator. The text locator searches web elements that the body text matches with the given text. Suppose you described 'Name' in your script, the text locator could return an element object, for example, <SPAN>Name</SPAN>.

Other locator names are the same as the ones defined in Selenium Java API.

Locator name	Description
text	Finds element based on the text displayed on the page. (**default**)
partial	Finds element based on the partial text displayed on the page.
partialText	Same as 'partial'
className	Finds element based on the value of the "class" attribute.
cssSelector	Finds element via the driver's underlying W3 Selector engine.
id	Finds element based on the value of the "id" attribute.
linkText	Finds element based on the body text of the "a" tag.
name	Finds element based on the value of the "name" attribute.
partialLinkText	Finds element based on the partial body text of the "a" tag.
tagName	Finds element based on the tag name.
xpath	Finds element based on the given xpath.

The locator names can be described at the beginning of element text string. The locator name and element text must be separated by ':'. If you do not specify a locator name, text locator is used by default.

```
#
   'Name' // text locator
   'text:Name'
   'partial:Name'
   'xpath://button'  // xpath locator
   'id:ID-name'
   'name:Name'
   'className:Element Class'
   'tagName:TABLE'
   'linkText:Click here'
   'partialLinkText:Partial Link Text'
   'cssSelector:tag.class[attribute=value]'
```

OPTIONAL

In addition to locators, element accepts the keyword below:

- optional JavaTea does not wait for the element appearance.

```
#optional 'Name';
```

The above statement searches a text element which body test is 'Name'. And it tries to search once (optional). If the element does not exist, JavaTea moves to the next statement to execute.

ARRAY SUFFIX

An array suffix represents an index number of elements found. When multiple elements found with the given text, you need to specify the index number to pick one element from the elements. The index number starts with zero.

- 'label'[0] The first element in the found elements.

SHIFT INDEX

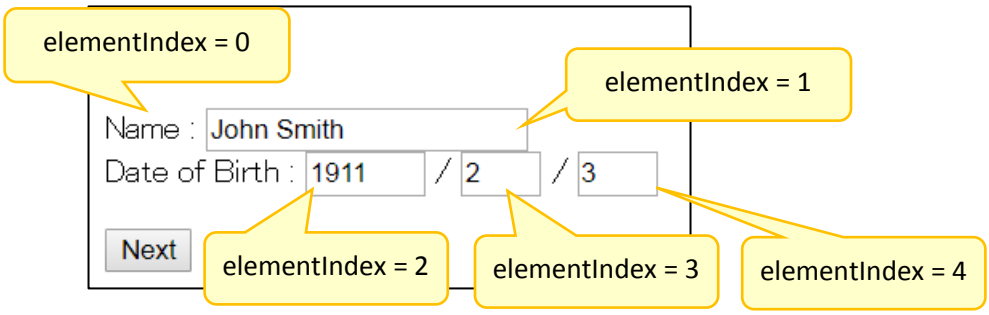
TeaElement internally has an index number pointing to the current index. With using a shift expression, you can increase or decrease the index number.

Notation	Description
<>	Stays at the current position.
>	Moves 1 unit forward from the current position. (Same as '1 >')
>>	Moves 2 units forward from the current position. (Same as '2 >')
>>>	Moves 3 units forward from the current position. (Same as '3 >')
<	Moves 1 unit backward from the current position. (Same as '1 <')
<<	Moves 2 units backward from the current position. (Same as '2 <')
<<<	Moves 3 units backward from the current position. (Same as '3 <')
number >	Moves ***number*** units forward from the current position.
number <	Moves ***number*** units backward from the current position.

Example

'Name' points to the text element whose tag body is 'Name', and the element index is set to zero. Now, we want to get a web element next to the Name text. By using a shift operator **>** , we can move the position to the right.

'Name'> represents the element for the Name input box. Likewise, 'Name'>> or 'Name'2> returns the element of year input box. And 'Name'>>> or 'Name'3> returns the element of month input box.



Assignment

An assignment statement sets a value to the given element object.

If you use '+=' against an input or textarea element, the given value is appended at the end of existing value.
If you use '@=' against a select element, the option in the select box is chosen by the given value. (It is not selected by the visible value)

- <element> = <value>
- <input or textarea> += <value>
- <select> @= <value>

For examples,

- 'label'[1]> = 'Test value'
- 'label'[1]> += 'Test value' // append mode
- 'typeSelect'> @= 'value1' // select by value
- 'label' = () -> func()

Most of elements treats the value as a String value. For example, even if you specify a number, the number is converted into a String object and sent to the target element.

```
#'Name'> = '123';
#'Name'> = 123;
```

If the 'Name'> represents an input box, the above two statements behaves exact same. A String "123" is set to the input.
However, if the target element is a select element, the behavior is different depending on the type of value.

```
#'Make'> = '0';
```

If you specify a String value, it searches an option which visible text is '0'. Instead of the String, if you specify a number, it selects by an index. In this example below, the first option is selected. (The index is zero-origin)

```
#'Make'> = 0;
```

Array

An array values pass multiple values to an element object.

- <element> = [$value_1$, $value_2$, …, $value_n$]

  This expression is only available when the element is select tag with 'multiple' attribute. The values in the array are selected.

- <element$_1$> | <element$_2$> | … | <element$_n$> = [value$_1$, value$_2$, …, value$_n$]
- <element$_1$> | <element$_2$> | … | <element$_n$> = value

Multiple elements can be described on the left hand side to switch processes based on order of element appearance on the page. JavaTea watches all the elements and executes only the value for the first element appeared.
If there is only one value (not an array) on the right hand side, no matter what element is chosen, the value is set to the element found.

6. Preprocessor

JavaTea reads the source code before parsing Tea script for the following preprocessing.

Command	Description
include <path>	Includes the file contents. The file must be in your CLASSPATH.

Example: Include contents of **Common.javatt**.

```
include 'Common,javatt'
```

7. TeaBase defined variables and methods

TeaBase declares some variables and methods for your development.

Variables:

Name	Description
driver	A WebDriver object. You must call createDriver(browser) method in your Test to populate a driver object into this variable.

Methods:

Name	Description
createDriver(String)	Initializes a WebDriver object based on the given browser type. The generated driver object is set into the driver variable.
options.setVerbose(boolean)	Displays detail messages on console if true is given. No messages are displayed if it is false. (default: true)
setPropertiesFile(String)	Set a properties file that defines message keys and values. {key} expression in your text is replaced with the value for the key defined in the properties file. (default: no properties)
$(String)	Expand properties expressions in the given text.
pushContext() popContext()	If you want to execute your method in different context (use another element index), call pushContext() when entered into your method. And call popContext() before leaving from your method.
element(String)	Finds an element object by using the given text, and returns the element object when you call build() method.
elements()	Returns a list of elements in current context stack.
currentElement()	Returns a current element object.
elementIndex()	Returns an index number of the current element.
buildOr(elementBuilder…)	Chooses one element from the given element builders.

shift(int)	Returns a xpath string to find an element shifted by the given number.
shiftAt(int)	Same as shift(int) except finding an text element.
print(String)	Prints the given text on console. When verbose is false, it does not display any messages.
takeScreenshot(String)	Takes a screenshot and generates a PNG file.
setAttribute(element, key, value)	Sets an attribute value to the even element.
removeAttribute(element, key)	Removes an attribute from even element.

Also TeaBase provides the following methods to wait under various conditions.

Methods:

Name	**Description**
waitForText(String)	Waits until the given text is displayed on the page.
waitForNotText(String)	Waits until the given text disappears from the page.
waitForPartialText(String)	Waits until a text containing the given partial text is displayed.
waitForNotPartialText(String)	Waits until texts containing the given text disappear from the page.
waitUntil(BooleanSupplier)	Wait until the supplier function returns true.
waitUntilSuccess(Runnable)	Wait until the runner function is executed with no errors.

8. Custom Shift Methods

Override

Shift methods are the methods to define how to move an element by using <, > operators. By default, Tea script provide you two shift methods, shift and shiftAt. Each method is called when you use the following operators:

Method	Operators
shift(int **n**)	>, >>, >>>, **n**>, <, <<, <<<, **n**<
shiftAt (int **n**)	@>, @>>, @>>>, @**n**>, @<, @<<, @<<<, @**n**<

For example, > operator is converted into shift(1), << operator is shift(-2). Likewise, @> is converted to shiftAt(1), @<< is shiftAt(-2).
Let's see the source code of the shift():

```
protected String shift(int n) {
   return "./" + (n < 0 ? "preceding" : "following") +
            "::*[self::input or self::select or self::textarea or self::a or self::button]";
}
```

The methods returns a XPath string that defines HTML tags to find. By default, it only captures input, select, textarea, a and button tags.
How about shiftAt()?

```
protected String shiftAt(int n) {
   return "./" + (n < 0 ? "preceding" : "following") +
            "::*[text() and (self::div or self::span or self::p)]";
}
```

As you can see the source code above, shiftAt() finds text node only and also it limits to get div, span and p tags only.
Since it is a protected, you can override with another implementation in your test class. For example, if you want to move on input tag only, override the shift() with the implementation below:
Let's see the source code of the shift():

```
protected String shift(int n) {
   return "./" + (n < 0 ? "preceding" : "following") + "::input";
}
```

Custom Shift

If you want to use additional implementation with keeping the default implementations, you can define a custom shift method.

Define a shift method in your test class with the name starting “shift”. For example, if you need a shift method moving on input tag only, you can define the following method with the name “shiftinput”.

```
protected String shiftinput(int n) {
   return "./" + (n < 0 ? "preceding" : "following") + "::input";
}
```

To call the method from your script, specify the name ‘input’ between the text string and @> operator.

```
# 'Name'input@> = 'Your Name';
```

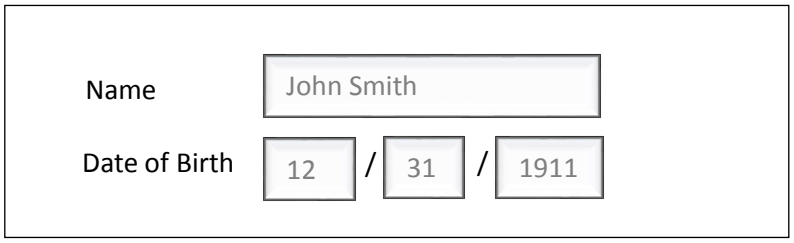
To move the element by 5 to the right, describe the number between @ and > operator.

```
# 'Name'input@5> = 'Your Name';
```

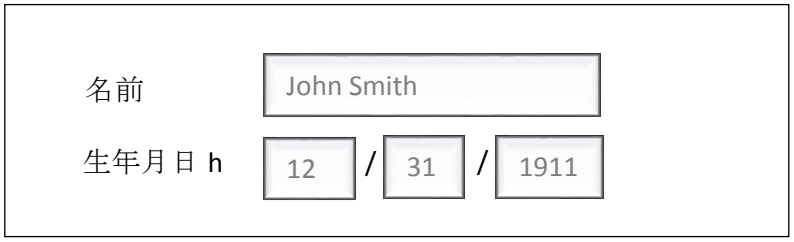
9. Properties File – Multiple Languages

This chapter shows how to handle to test web site that supports multiple languages. To do so, you need to create properties file and define messages in it for each language. Here is an example of web site that supports English and Japanese.

English



Japanese



First, you need to create properties files for English and Japanese, and define the keys and values of each language.

message.properties

```
Name = Name
DOB = Date of Birth
TestName = John Smith
```

message_ja_JP.properties

```
Name = 名前
DOB = 生年月日
TestName = ジョン　スミス
```

In your script, you need to set properties file by calling setPropertiesFile() method, and then use {key} expression instead of the actual message.

```
setPropertiesFile('message.properties');
#
   '{Name}' = '{TestName}'
   '{DOB}' = 12  31  1911
```

```
;
```

The {Name} is replaced with the Name value, ‘Name’, in message.properties file. Likewise, the {TestName} and {DOB} are replaced with ‘John Smith’ and ‘Date of Birth’, respectively.
When you test Japanese messages, set message_ja_JP.properties.

```
setPropertiesFile('message_ja_JP.properties');
#
   '{Name}' = '{TestName}'
   '{DOB}' = 12  31  1911
;
```

String values for element and value are automatically expanded into actual values defined in properties file. However, you may need to access actual value to specify in other places, such as JavaScript parameters. In that case, you can use $() method to expand {key} expression.

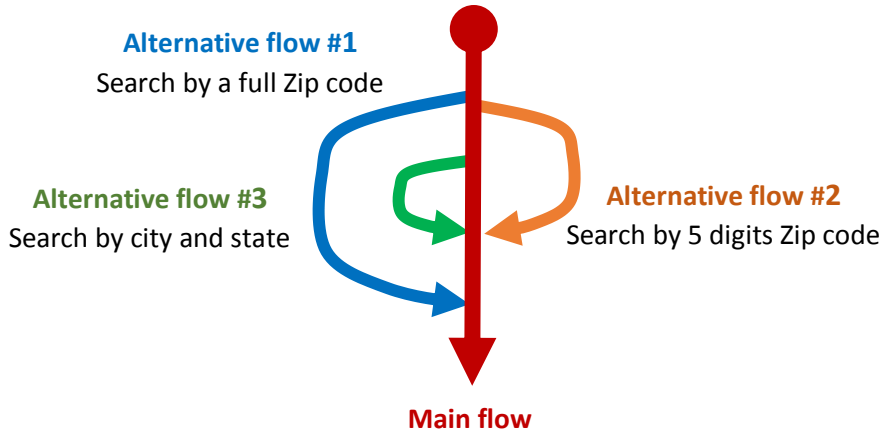
```
assertEquals(#'Name'@>, $('{TestName}') );
```

The 'Name' is handled as element text, hence, you don’t have to convert using $(). But the second parameter is neither element text nor element value, so you have to expand the {TextName} by yourself using the $() method.

10. Template Transformation

In practice, you may often have created many different versions of test script based on a main scenario. It is because there are many alternative flows in web site. Suppose you are entering your address on an address form.

- You normally need to enter Street address, city, state and zip code (Main flow).
- If you know 9 digits of a full zip code, the web site may be able to populate the rest of all information (Alternative flow #1).
- Even if you know only 5 digits zip code, the site could detect your city and state (Alternative flow #2).
- Instead of entering zip code, if user enters city and state, the site could populate the zip code automatically.



To test all the scenarios (main and alternative flows), you need to create four test scripts. But they are representing operations executed on the same page, thus, the scripts tend to have duplicate codes. To avoid the duplicates, JavaTea provides a template transformation feature that transforms specific parts of a template file by using advice and joinpoint. The following advice types are available.

Advice	Description
before	Inserts code before a joint point.
after	Inserts code after a joint point.
around	Replace a joint point or codes between joint points with the given code. Around advice can use a 'proceed' keyword to keep the original code.

The advice can be described in the following format:

advice joinpoint { *code* }

Addition to that, around advice can be also described in the format below:

around start-joinpoint end-joinpoint { code }

Joinpoint is a point where the code is inserted or replaced with. The following joinpoint types are available to specify:

Joinpoint	Description
String literal	A quoted string, e.g. 'My Class', "assertEquals".
Label	JavaTea label ending with an exclamation mark, e.g. Label!
Regular expression literal	A regular expression enclosed between slashes and flags, e.g. /public.*\(\)/g , /testcase/i

The string literal and label joinpoints can add Array Suffix, Shift Suffix and AddSub Suffix.

Array Suffix

Array Suffix	Description
[n]	The n^{th} joinpoint in joinpoints found.
[s .. e]	Joinpoints between s^{th} and e^{th}. The s and e are optional. **1..3** represents 1^{st}, 2^{nd} and 3^{rd} joinpoints **..2** represents 0^{th}, 1^{st} and 2^{nd} joinpoints **1..** represents 1^{st}, 2^{nd}, …, and the last endpoint. **..** represents all joinpoints

Array Suffix also accepts multiple values split by a comma. Below are the examples:

[1, 3, 5] // 1^{st}, 3^{rd} and 5^{th} joinpoints [..2, 5, 7..9, 11, 15..] // 0, 1, 2, 5, 7, 8, 9, 11, 15 and the rest of joinpoints

Shift Suffix

Array Suffix	Description
n>, >>, >>>	Move jointpoint to the n^{th} newline code to the right from the given joinpoint.
n<, <<, <<<	Move jointpoint to the n^{th} newline code to the left from the given joinpoint.

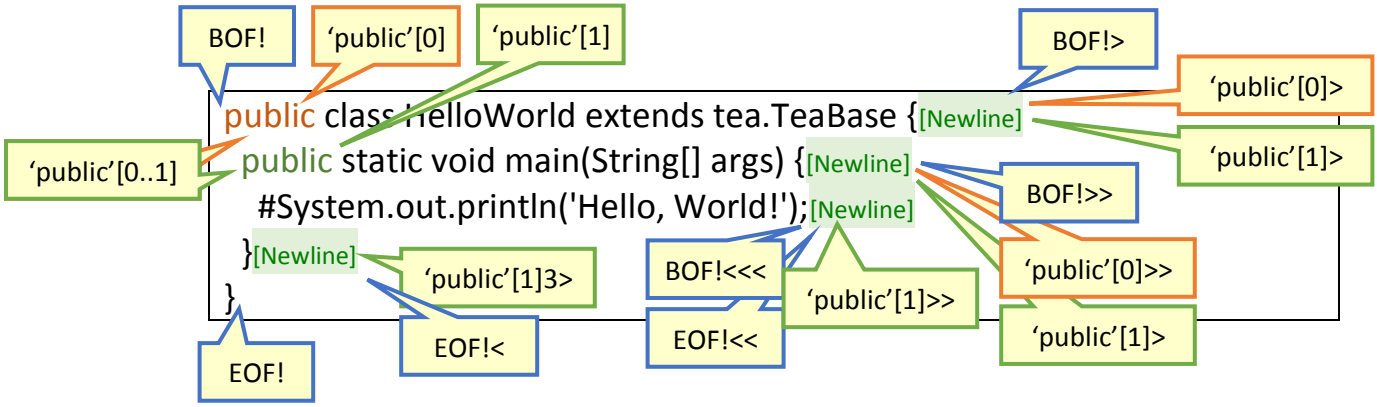
AddSub Suffix (Only available for before/after advice)

Array Suffix	Description
+ n	Move jointpoint by n characters to the right from the given joinpoint.
- n	Move jointpoint by n characters to the left from the given joinpoint.

Also following two labels are predefined. You can use the labels without defining in your template file.

Predefined Label	Description
BOF!	Beginning of file. It points to the top of the file.
EOF!	End of file. It points to the end of the file.

Below shows some examples of joinpoints:



Before starting to operate file contents, you need to load the file into memory. The commands below operate files to load and save.

Command	Description
load 'path'	Load the file contents into memory.
save 'path'	Save the updated contents in memory into a file. This command is used for debugging purpose.

Alternative Flow

Let's create an alternative flow based on WizardTest using template feature. Here is the javat code, WizardTest, explained in Getting Started chapter.

WizardTest.javat

```
import static tea.TeaAssert.*;
import static tea.Assert.*;

public class WizardTest extends tea.TeaBase {
  public static void main(String[] args) {
    new WizardTest().start();
  }

  private void next() {
```

```
    print('next');
    #'xpath://button'[0] = true;
  }

  private void start() {
    createDriver('chrome');
    driver.get(new java.io.File('Page1.html').toURI().toString());

    #
      // Page 1
      'Name'> = 'John Smith'
      'Date of Birth'> = 1911 2 3
      next()

      // Page 2
      'Make'> = 'Toyota'
      'Type'> = false true
      'Agreement'> = true
      next()
    ;

    // Page 3
    assertEquals(#'Name'@>, 'John Smith', 'Name on Page 3');
    assertEquals(#'Make'@>, 'Toyota', 'Make on Page 3');

    driver.close();
  }
}
```

To implement another Test class for an alternative flow, create a javatt file below:

Alternative1.javatt

```
// Load template code into this working memory.
load 'WizardTest.javat'

// Replace class names.
around 'WizardTest' {Alternative1}

// Insert a new statement
before "'Type'" {
  'Area'> = ['Tokyo', 'Other']
}

// Insert a new assertion
```

```
after 'assertEquals'[1]> {
  assertEquals(#'Area'@>, 'Tokyo,Other', 'Area on Page 3');
}
```

First, you need to load the base javat file.

```
load 'WizardTest.javat'
```

Next, replace the class name with the new name, Alternative1, by using around advice.

```
around 'WizardTest' {Alternative1}
```

The around advice searches the keyword, 'WizardTest', in the loaded code. It will find two places, at line 4 and 6. By default, it replaces both with the code in { and }, 'Alternative1'.

The next advice is 'before' that inserts a new statement for setting Area selection values.

```
before "'Type'" {
  'Area'> = ['Tokyo', 'Other']
}
```

The before advice searches the keyword "'Type'" and insert the code described in { and } before the keyword. Thus, the new statement will be added between Make and Type statements.

The last advice is 'after' that inserts a new statement for Area assertion.

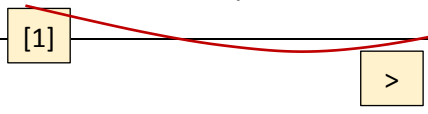
```
after 'assertEquals'[1]> {
  assertEquals(#'Area'@>, 'Tokyo,Other', 'Area on Page 3');
}
```

The after advice searches the given keyword 'assertEquals', however, array and shift suffixes are attached.

```
'assertEquals'[1]>
```

The array suffix [1] represents to pick the specific keyword from the keywords founds by the index number. The index starts with zero, so it returns the second keyword.
Also it has a shift suffix '>' that means the position where found the keyword will be moved to the place where a newline code appears to the right.
As you can see, there are two 'assertEquals', and the 'assertEquals'[1] points to the second one. And then it searches a newline code to the right from the second 'assertEquals'.

```
   // Page 3[newline]
   assertEquals(#'Name'@>, 'John Smith', 'Name on Page 3');[newline]
   assertEquals(#'Make'@>, 'Toyota', 'Make on Page 3');[newline]
[newline]
```



Thus, the after advice inserts the code after the newline code at the end of the second assertEquals method.
Run the command below to generate javat file from the javatt.

```
C:> java tea.JavaTea Alternative1.javatt
```

It will generate Alternative1.javat below:

Alternative1.javat

```
import static tea.TeaAssert.*;
import static tea.Assert.*;

public class Alternative1 extends tea.TeaBase {
  public static void main(String[] args) {
    new Alternative1().start();
  }

  private void next() {
    print('next');
    #'xpath://button'[0] = true;
  }

  private void start() {
    createDriver('chrome');
    driver.get(new java.io.File('../Wizard/Page1.html').toURI().toString());

    #
      // Page 1
      'Name'> = 'John Smith'
      'Date of Birth'> = 1911 2 3
      next()

      // Page 2
      'Make'> = 'Toyota'

  'Area'> = ['Tokyo', 'Other']
'Type'> = false true
      'Agreement'> = true
      next()
    ;

    // Page 3
    assertEquals(#'Name'@>, 'John Smith', 'Name on Page 3');
    assertEquals(#'Make'@>, 'Toyota', 'Make on Page 3');
```

```
  assertEquals(#'Area'@>, 'Tokyo,Other', 'Area on Page 3');

    driver.close();
  }
}
```

To compile and execute the generated javat, run the following commands.

```
C:> java tea.JavaTea Alternative1.javat
C:> javac Alternative1.java
C:> java Alternative1
```

TestNG Template

This section shows another example using a template. When you created a test for TestNG, you may notice that some codes are reusable in most of your tests. We here define the common code as a template, and define test specific code in javatt.
First, we create a common template for TestNG:

TestTemplate.javat

```
import static tea.TeaAssert.*;
import static org.testng.Assert.*;
import org.testng.annotations.Parameters;
import org.testng.annotations.Optional;
import org.testng.annotations.Test;
import!

public class className! extends tea.TeaBase {

 @Parameters({ "browser", "verbose" })
 @Test
 public void test(String browser, @Optional String verbose) {
  try {
   createDriver(browser);
   options.setVerbose(verbose);
   scenario();
  } catch (Throwable t) {
   takeScreenshot("error{***ID***}.png");
  } finally {
   driver.close();
  }
 }

 private void scenario() {
  driver.get(url!);
  testcode!
 }

 javacode!
}
```

The above code was created based on WizardTest.javat for TestNG, but we deleted test scenario code and Java methods called from the scenario. Also we added some Tea labels to make us easily point the place to insert or replace with new code from javatt.
Now we can create a test based the template.

WizardTest.javatt

```
load 'TestTemplate.javat'

around className! {WizardTest}

around url! {new java.io.File('../Wizard/Page1.html').toURI().toString()}

before import! {
  import tea.TeaElement;
}

before javacode! {
  private void next() {
    print('next');
    #'xpath://button'[0] = true;
  }

  private String error() {
    TeaElement el = #"xpath://*[contains(@class, 'error')]"[0]#;
    return el != null ? el.toString().trim() : null;
  }

  private Object checkElement(TeaElement element) {
    assertEquals(element.getAttribute("id"), "area");
    return null;
  }
}

before testcode! {
  // Page 1 (error)
  #'Name'> = '';
  next();

  if (error() == null) fail('Should show a validation error message for an empty name.');

  #
    // Page 1 (success)
    'Name'> = {*'John Smith','George Washington'*}
    'Date of Birth'> = {*1911 2 3, '2001' '02' '03'*}
    assertEquals(#'Name'>,
        {***0***},
        'Failed to fill in name element.')
    next()

    // Page 2
```

```
    'Make'> = 'Toyota'
    'Area'> = checkElement(#.#) [{*'Tokyo', 'Osaka'*}, 'Other'] // (multiple selection)
    'Type'> = false true
    'Agreement'> = () -> {
      return 'Toyota'.equals(#'Make'>#.toString());
    }
    next()
  ;

  // Page 3
  assertEquals(#'Name'@>, {***0***}, 'Name on Page 3');
  assertEquals(#'Area'@>, {***2***}+',Other', 'Area on Page 3');
  assertEquals(#'Make'@>, 'Toyota', 'Make on Page 3');
  assertEquals(#'Type'@>, 'Truck', 'Type on Page 3');
  assertTrue(#'Agreement'@>, 'Agreement on Page 3');
}
```

At first, load the template into the memory and replace className! with the actual class name 'WizardTest' by using around advice. Likewise, replace url! Label with an accrual URL.
Next, insert an import statement before the import! label.
Likewise, insert Java methods before javacode! And insert test scenario code before testcode!.
To generate javat from the javatt, execute the following command.

```
C:> java tea.JavaTea WizardTest.javatt
```

It generates WizardTest.javat, so run these to generate java files and compile.

```
C:> java tea.JavaTea -X -t 2 WizardTest.javat
C:> javac *.java
```

The –X option generates a testing.xml, so you can run it using TestNG with the following command.

```
C:> java org.testng.TestNG testng.xml
```

11. Debugging Tips

This chapter introduces some tips to debug javat and javatt files.

Screenshot

If you want to see element states on screen while running your script, you can take a screenshot and check the image. JavaTea provides you the following method to take a screenshot:

```
void takeScreenshot ( String path );
```

The method take a screenshot of the current screen and save it in your local disk with the given path.
If you have already narrowed down where could go wrong, you can manually add the method call in your script. But if you have no idea where is wrong and you need to check all screens to see what is wrong, you can create a custom EventListener class and implement events where you want to take screenshots. For example, most of updates on screen happens by mouse-click. So, it is a good idea to capture beforeClickOn and afterClickOn events and implement code to take a screenshot in each event.
For the details, see chapter Event Listener.

Element location

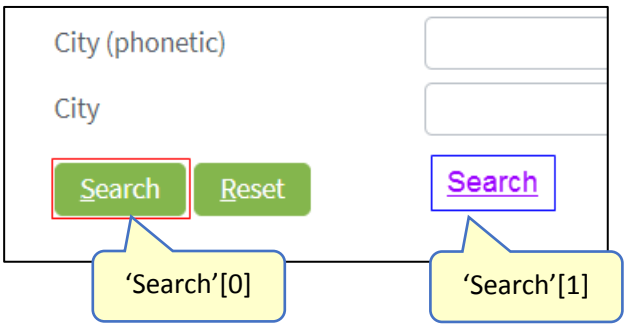
JavaTea provides setAttibute() method below:

```
void setAttribute ( TeaElement gwElement, String attrName, String attrValue );
```

The method populates a given value to the specified attribute in the element object. With using this, you can draw a box surrounding the target element to ensure that your script code properly finds the element you intended.
Suppose there are multiple Search buttons on a page, and you wanted to click one of the Search buttons but search was not performed. You somehow need to identify what element was actually selected with the expression of the locator.
For that purpose, you can call setAttribute method with the locator expression:

```
setAttribute(#'Search'[0], 'style', 'border: 1px solid red');
setAttribute(#'Search'[1], 'style', 'border: 1px solid blue');
```

The setAttribute sets a value into an attribute of the element found. The above example searches elements which the body text is ‘Search’, and populates a style attribute with a value that draws a border box surround its element in RED and BLUE, respectively.



If you want to click the Search button, describe the statement below:

```
#'Search'[0] = true;
```

If you want to click on the Search link, describe below:

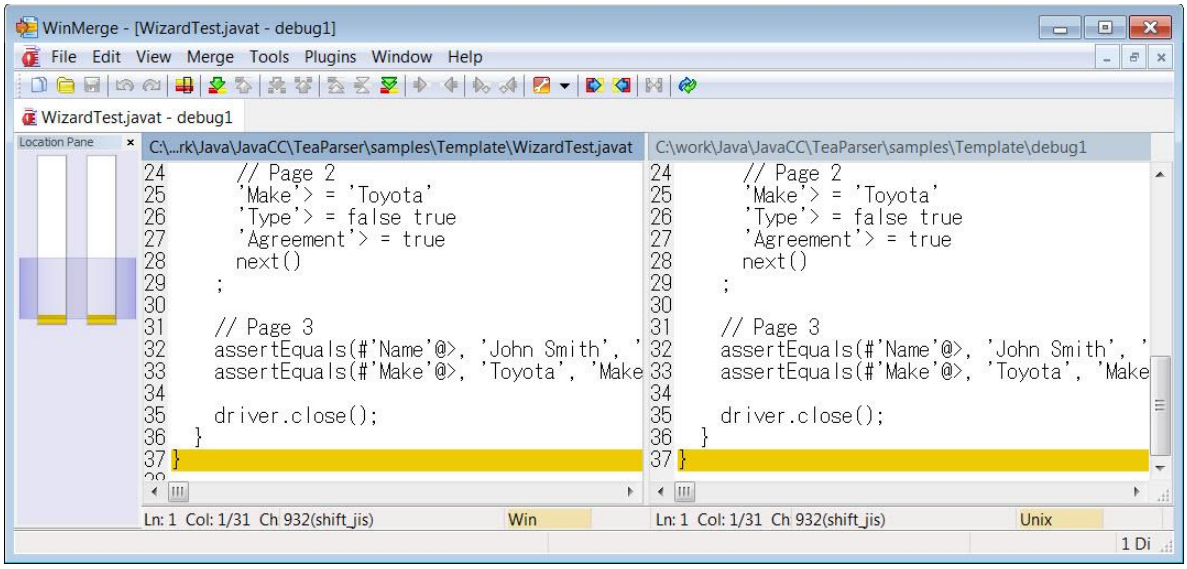
```
#'Search'[1] = true;
```

Debug javatt

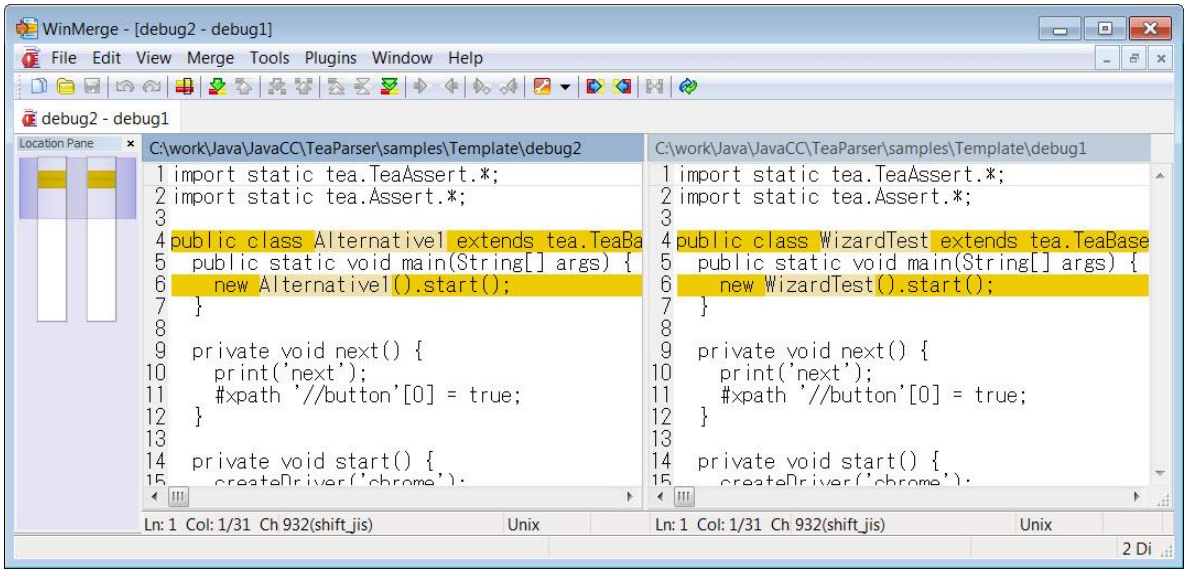
In javatt file, if you describes many advices and updated contents a lot, it may be hard to understand what keywords are there to define joinpoints in later steps. To see the updated contents and what parts are updated in each step, JavaTea provides save command.

```
load 'WizardTest.javat'
save 'debug1'
around 'WizardTest' {Alternative1}
save 'debug2'
before "'Type'" {
  'Area'> = ['Tokyo', 'Other']
}
save 'debug3'
after 'assertEquals'[1]> {
  assertEquals(#'Area'@>, 'Tokyo,Other', 'Area on Page 3');
}
save 'debug4'
```

As you can see in the above, if you add save command between steps, you can check to see what are updated in each step. After you run the javatt, debug1 to 4 files will be generated as well as javat file. And then you can compare the files using diff command or tool.
For example, if you compare 'WizardTest.javat' with 'debug1', you will see a difference at the bottom of the file. If you use Mac



This is because load command removes spaces at the beginning and end of the file so that you can easily count lines from BOF! And EOF!.
Likewise, compare 'debug1' with 'debug2'. You will see changes updated by the statement, “around 'WizardTest' {Alternative1}”.



The above shows that replacement of WizardTest with Alternative1 was applied in two places at line 4 and 6.

12. Event Listener

Selenium has a capability to listen events and fire actions defined in custom EventListener class. It enables us to create effective logging, taking screenshot and reporting in Selenium. You can use the capability from JavaTea also. This chapter shows how to capture screenshot before and after mouse click is fired as an example.

First, you need to create your custom EventListener class:

CustomEventListener.java

```
import java.io.*;
import org.openqa.selenium.*;
import org.openqa.selenium.io.FileHandler;
import org.openqa.selenium.support.events.AbstractWebDriverEventListener;

public class CustomEventListener extends AbstractWebDriverEventListener {
   private int index = 0;

   @Override
   public void beforeClickOn(WebElement element, WebDriver driver) {
      takeScreenshot(driver, "screenshot"+(++index)+".png");
   }

   @Override
   public void afterClickOn(WebElement element, WebDriver driver) {
      takeScreenshot(driver, "screenshot"+(++index)+".png");
   }

   protected void takeScreenshot(WebDriver driver, String path) {
      try {
         File out = ((TakesScreenshot) driver).getScreenshotAs(OutputType.FILE);
         FileHandler.copy(out, new File(path));
      } catch (IOException ioe) {
         throw new RuntimeException("Failed to take a screenshot. path: "+path);
      }
   }
}
```

Your EventListener class must be extended from AbstractWebDriverEventListener, and override interface that you want to change default behavior. We here want to capture mouse events and insert our custom logic to take screenshot before and after mouse click, so we override the following two interface:

- void beforeClickOn(WebElement element, WebDriver driver)

- void afterClickOn(WebElement element, WebDriver driver)

The beforeClickOn method is fired before mouse click, hence we can capture a screen image before the mouse click and save into a PNG image file. Likewise, the afterClickOn method is fired after mouse click, and save a screen image after the mouse click.

Next, you need to register the CustomEventListener class into WebDriver. Since WebDriver is generated in createDriver() method, you need to override the method and create a EventFiringWebDriver in your test class.

```
import org.openqa.selenium.chrome.ChromeDriver;
import org.openqa.selenium.support.events.EventFiringWebDriver;

public class WizardTest extends tea.TeaBase {

 @Override
 protected void createDriver(String browser) {
  ChromeDriver webDriver = new ChromeDriver();
  driver = new EventFiringWebDriver(webDriver);
  ((EventFiringWebDriver) driver).register(new CustomEventListener());
 }
 …
```

The above is a sample code of createDriver() method that replaces with your own implementation that creates an EventFiringWebDriver object and registers your custom EventListener into it. Now the WebDriver calls beforeClickOn and afterClickOn methods implemented in your CustomEventListener class whenever mouse click is executed.

13. Command Usage

JavaTea

JavaTea command converts Tea scripts into Java code, and generates a Java file.

```
java  tes.JavaTea [ -t <n> ] [ -i <input-dir> ] [ -o <output-dir> ] [ -X ] [ -x <path> ]  javat-file…
```

JavaTea accepts the following options:

Option	Description
-t	t-wise number (a degree of thoroughness) **0** : All combinations **1** : Single **2** : Pairwise (**default**) **3** : 3-wise
-i <input-dir>	A directory path where javat / javatt source files are stored. (default: current directory)
-o <output-dir>	A directory path where java / javat output files are generated. (default: current directory)
-X	Generates a testing.xml file to execute the tests with using TestNG tool.
-x <path>	Generates a testing XML file with the given path name.

After that, it accepts javat or javatt file names. If you specify javat file, JavaTea generates a java file. If you specify javatt file, javat file is generated.

Examples:

Generate a java files that covers with the test cases created based on pairwise (2-wise) algorithm. Also it generates a Test NG XML file with the name, ‘wizard.xml’.

```
java  tea.JavaTea –t 2 –x wizard.xml  WizardTest.javat
```

14. Troubleshooting

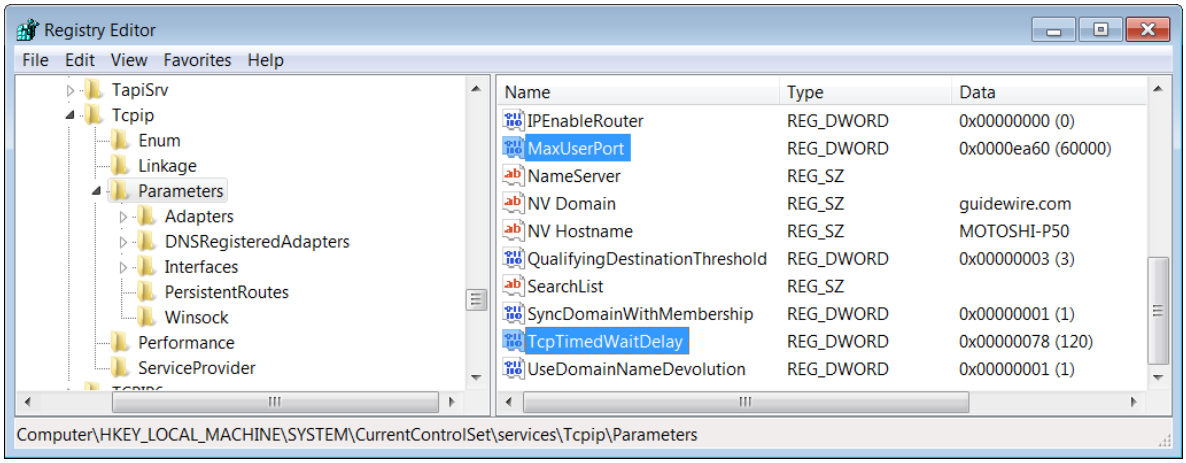
Bind error (socket) on Windows

If you run tests with parallel executions on Windows machine, you need to edit the following two Windows Registry values.
Modern browsers make HTTP connections with keep-alive. Even though the communication was done, the connection is still alive. It makes the number of using connections increase and uses up all available ports and you will see socket bind errors in your console. To avoid the error, you need to increase the number of available ports and change to shorter timeout to release used connections timely.

Location:

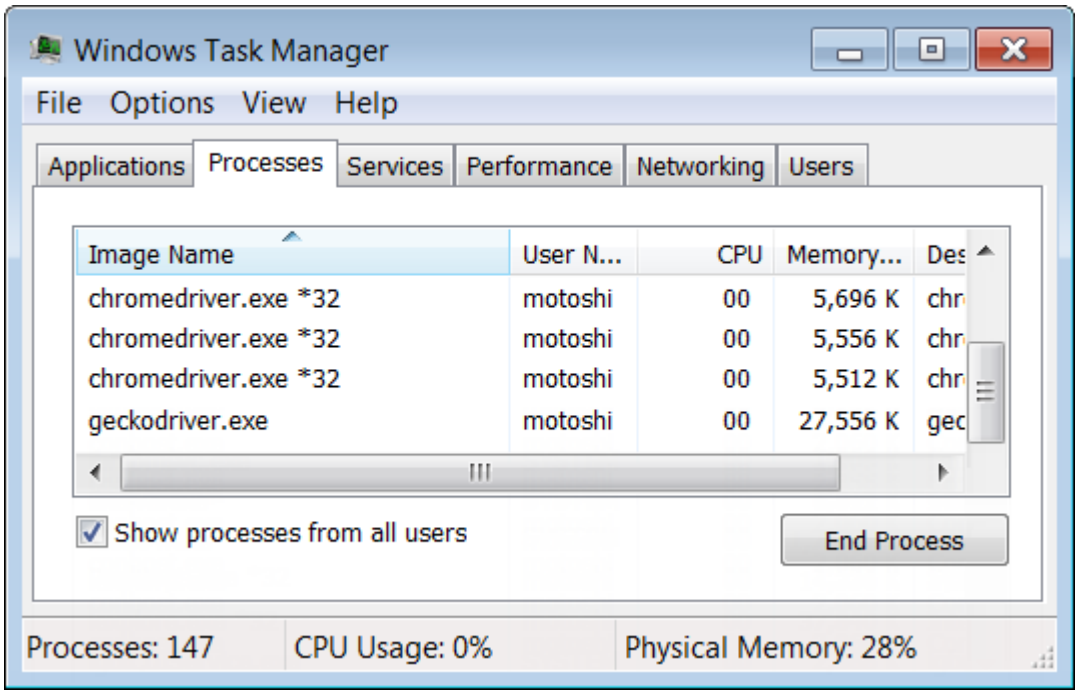
HKEY_LOCAL_MACHINE¥SYSTEM¥CurrentControlSet¥Services¥Tcpip¥Parameters

Parameter Name	Data Type	Description	Recommended Value
MaxUserPort	REG_DWORD	Determines the highest port number TCP can assign when an application requests an available user port from the system.	65534
TcpTimedWaitDelay	REG_DWORD	Determines the time that must elapse before TCP can release a closed connection and reuse its resources. This interval between closure and release is known as the TIME_WAIT state or 2MSL state.	60 to 120



Kill driver process

Even though you closed the browser by using close function, the driver process (e.g. chromedriver.exe for Chrome, geckodriver.exe for FireFox, IEDriverServer.exe for IE) still exists.



To kill the process, you need to run command below from command line:

```
C:> taskkill /im chromedriver.exe /im geckodriver.exe /im IEDriverServer.exe /f
```

Out of disk space

Selenium drivers create temporary folders and some of folders are not removed after WebDriver finishes the process. Thus, disk space on your machine will be consumed and you will encounter out of disk space error.
Where and what folders are created depends on selenium driver version and your machine. Here is an example of chromedriver.exe on Windows 7.

Location:

```
C:\Users\<username>\AppData\Local\Temp
```

or

```
%AppData%\..\Local\Temp
```

Folders and files created by Selenium:

```
scoped_dir1234_56789
seleniumSslSupport12345678901234567890.selenium.doesnotexist
screenshot12345678901234567890.png
```

We strongly recommend you watching in your temporary directory and clean up regularly if you found such folders.

15. Pairwise Testing

For those who never heard about Pairwise Testing, this chapter explains the basic idea of the testing. Pairwise Testing is a method of software testing to create test cases that covers all combinations for all possible parameter values. There are many terms to express Pairwise Testing, for example, All Pairs, 2-wise, t-wise, etc. The letter 't' represents the number of parameters that cover all combinations, so it expresses the degree of thoroughness and bigger number generates more test cases. The 2-wise is one of instances of t-wise, in this case, 2-wise represents t-wise testing with 2 degree of toughness.
It will come up a question which degree is enough to detect errors. Below shows cumulative percent of faults triggered by t-wise testing:

t	RAX conver-gence	RAX correct-ness	RAX interf	RAX engine	POSIX modules	Medical Devices	Browser	Server	NASA GSFC
1	61	72	48	39	82	66	29	42	68
2	97	82	54	47	*	97	76	70	93
3	*	*	*	*	*	99	95	89	98
4	*	*	*	*	*	100	97	96	100
5	*	*	*	*	*		99	96	
6	*	*	*	*	*		100	100	

*= not reported

Source: IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, VOL. 30, NO. 6, JUNE 2004
Software Fault Interactions and Implications for Software Testing
https://pdfs.semanticscholar.org/1ad8/adab7815cf9299b752e00ea860bc28c4c090.pdf

According to the case study, if your target application is a mission critical system that requires extremely high quality, you may need to test with t=3 to 6. But it requires more test cases to test, and it is unrealistic to apply such a big number to all tests. Hence, in general, we apply t=2 (pairwise) on general test scenarios and apply t=3 (3-wise) on some critical scenarios.

To understand how pairwise covers test patterns, let's see test cases created for all combinations and test cases created by using pairwise. Consider pairs of three input boxes on a page, and each element could have two values.
For example,

- 'John' and <empty> for First Name,
- 'Smith' and <empty> for Last Name,
- 'your@email' and 'invalid' for Email.

To simplify this explanation, we here call the elements, Parameter A, B and C instead of First Name, Last Name and Email. And each parameter could have two values: 0 or 1, instead of actual values.

- A = 0 or 1
- B = 0 or 1
- C = 0 or 1

If we test all the combinations of the three parameters, the total number of combinations will be eight (2 x 2 x 2 = 8), and the test patterns are below:

Test Case ID	A	B	C
1	0	0	0
2	0	0	1
3	0	1	0
4	0	1	1
5	1	0	0
6	1	0	1
7	1	1	0
8	1	1	1

Now, let's focus on all combinations of each two parameters: AB, BA and AC.

A	B
0	0
0	1
1	0
1	1

B	C
0	0
0	1
1	0
1	1

A	C
0	0
0	1
1	0
1	1

Next, create a test case with zero values for all parameters.

Test Case ID	A	B	C
1	0	0	0

This test case covers three parameter combinations (AB=00, BC=00, AC=00) to test.

A	B
0	0
0	1
1	0
1	1

B	C
0	0
0	1
1	0
1	1

A	C
0	0
0	1
1	0
1	1

Create another test case with zero values for all parameters.

Test Case ID	A	B	C
1	0	0	0
2	0	1	1

The test case covers another three parameter combinations (AB=01, BC-11, AC=01).

A	B
0	0
0	1
1	0
1	1

B	C
0	0
0	1
1	0
1	1

A	C
0	0
0	1
1	0
1	1

Likewise, create two more test cases below:

Test Case ID	A	B	C
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	0

And the additional test cases covers the rest of combinations as shown below:

A	B
0	0
0	1
1	0
1	1

B	C
0	0
0	1
1	0
1	1

A	C
0	0
0	1
1	0
1	1

By focusing on combinations of two parameters, we can reduce the number of test cases to 4 from 8. This is a basic idea of pairwise algorithm that only covers all patterns for between two parameters.

We could reduce the number of test cases with pairwise, but you may feel that it is not a big difference. However, in real world, we could have more elements and possible values that make the number of test cases dramatically increase. If we have, for example, 6 elements and 3 possible values each, the total number combinations are 729 (3 x 3 x 3 x 3 x 3 = 729). If we apply pairwise (2-wise) on it, it can be decreased to about 15 to 30 test cases (the number is vary depending on implementation of pairwise algorithm). That is a reasonable number of tests that we can execute.
For more information about Pairwise Testing, see the site below:
https://inductive.no/pairwiser/knowledge-base/introduction-to-pairwise-testing/