

Aiding the
integration of
automatically
generated
tests into pre-
existing
manually
written test
suites

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The Problem

Test Suite Reduction
through the merging of
redundant tests

Identifying optimal
approach for selection
of automatically
generated tests for
integration with similar
manually written tests

```
import static org.junit.Assert.assertNull;
import static org.junit.Assert.assertTrue;
import static org.junit.Assert.fail;

import org.junit.Test;

@SuppressWarnings("deprecation") // OptionBuilder is marked deprecated
public class OptionBuilderTest
{
    /**
     * 1. Creates a new Option using OptionBuilder and checks its opt, long opt,
     * description, type, arg, if its required and its args.
     */
    @Test
    public void testCompleteOption() {
        Option simple = OptionBuilder.withLongOpt( "simple option")
            .hasArg( )
            .isRequired( )
            .hasArgs( )
            .withType( Float.class )
            .withDescription( "this is a simple option" )
            .create( 's' );

        assertEquals( "s", simple.getOpt( ) );
        assertEquals( "simple option", simple.getLongOpt( ) );
        assertEquals( "this is a simple option", simple.getDescription( ) );
        assertEquals( simple.getType(), Float.class );
        assertTrue( simple.hasArg( ) );
        assertTrue( simple.isRequired( ) );
        assertTrue( simple.hasArgs( ) );
    }

    /**
     * 1. Creates a new Option "simple" using OptionBuilder and checks its
     * opt, long opt, description, type, arg, if it is required and its args.
     * 2. Creates a new Option using OptionBuilder and assigns it to "simple", and
     * checks its opt, long opt, description, type, arg, if it is required and
     * its args.
     */
    @Test
    public void testTwoCompleteOptions() {
        Option simple = OptionBuilder.withLongOpt( "simple option")
            .hasArg( )
            .isRequired( )
            .hasArgs( )
            .withType( Float.class )
            .withDescription( "this is a simple option" )
            .create( 's' );

        assertEquals( "s", simple.getOpt( ) );
        assertEquals( "simple option", simple.getLongOpt( ) );
        assertEquals( "this is a simple option", simple.getDescription( ) );
        assertEquals( simple.getType(), Float.class );
        assertTrue( simple.hasArg( ) );
        assertTrue( simple.isRequired( ) );
        assertTrue( simple.hasArgs( ) );

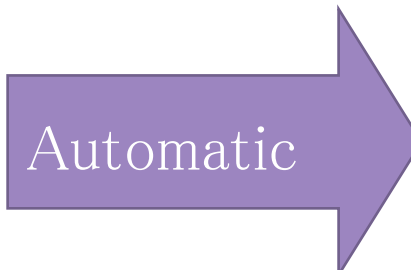
        simple = OptionBuilder.withLongOpt( "dimple option")
            .hasArg( )
            .withDescription( "this is a dimple option" )
            .create( 'd' );

        assertEquals( "d", simple.getOpt( ) );
        assertEquals( "dimple option", simple.getLongOpt( ) );
        assertEquals( "this is a dimple option", simple.getDescription( ) );
        assertEquals( String.class, simple.getType( ) );
        assertTrue( simple.hasArg( ) );
        assertEquals( !simple.isRequired( ) );
        assertTrue( !simple.hasArgs( ) );
    }

    /**
     * 1. Creates a new Option using OptionBuilder and checks its opt, description and if it
     * has arg.
     */
    @Test
    public void testBaseOptionCharOpt() {
        Option base = OptionBuilder.withDescription( "option description")
            .create( 'o' );

        assertEquals( "o", base.getOpt( ) );
        assertEquals( "option description", base.getDescription( ) );
        assertTrue( !base.hasArg( ) );
    }

    /**
     * 1. Creates a new Option using OptionBuilder and checks its opt, description and if it
     * has arg.
     */
    @Test
    public void testBaseOptionStringOpt() {
```



```
1  /*
2  This file was automatically generated by EvoSuite
3  * Mon Sep 11 18:52:57 GMT 2017
4  */
5
6  package org.apache.commons.cli;
7
8  import org.junit.Test;
9  import static org.junit.Assert.*;
10 import static org.evosuite.runtime.EvoAssertions.*;
11 import org.apache.commons.cli.Option;
12 import org.apache.commons.cli.OptionBuilder;
13 import org.evosuite.runtime.EvoRunner;
14 import org.evosuite.runtime.EvoRunnerParameters;
15 import org.junit.runner.RunWith;
16
17 @RunWith(EvoRunner.class) @EvoRunnerParameters(mockJVMNonDeterminism = true, useVFS = true, useVNET =
18 public class OptionBuilder_ESTest extends OptionBuilder_ESTest_scaffolding {
19
20     /**
21      * 1. Creates a new OptionBuilder using method withType of OptionBuilder
22      * and checks if it is not null.
23      */
24     @Test(timeout = 4000)
25     public void test00() throws Throwable {
26         Class<Object> class0 = Object.class;
27         OptionBuilder optionBuilder0 = OptionBuilder.withType((Object) class0);
28         assertNotNull(optionBuilder0);
29     }
30
31     /**
32      * 1. Calls method "isRequired" of OptionBuilder.
33      * 2. Creates a new OptionBuilder and checks if it is
34      * required and if its args are equal to -1.
35      */
36     @Test(timeout = 4000)
37     public void test01() throws Throwable {
38         OptionBuilder.isRequired();
39         Option option0 = OptionBuilder.create("SQT$h");
40         assertTrue(option0.isRequired());
41         assertEquals((-1), option0.getArgs());
42     }
43
44     /**
45      * 1. Calls method withLongOpt of OptionBuilder with argument "org.apache.commons.cli.OptionBuilder"
46      * 2. Creates a new OptionBuilder using method create of OptionBuilder and checks if its args equal
47      */
48     @Test(timeout = 4000)
49     public void test02() throws Throwable {
50         OptionBuilder.withLongOpt("org.apache.commons.cli.OptionBuilder");
51         Option option0 = OptionBuilder.create("");
52         assertEquals((-1), option0.getArgs());
53     }
54
55     /**
56      * 1. Calls method withArgName of OptionBuilder with argument "SQT$h"
57      * 2. Creates a new OptionBuilder using method create of OptionBuilder and checks if its args equal
58      */
59     @Test(timeout = 4000)
60     public void test03() throws Throwable {
61         OptionBuilder.withArgName("SQT$h");
62         Option option0 = OptionBuilder.create("SQT$h");
63         assertEquals((-1), option0.getArgs());
64     }
65
66     /**
67      * 1. Calls method hasOptionalArgs of OptionBuilder with argument 0
68      * 2. Creates a new OptionBuilder using method create of OptionBuilder and checks if it has optional
69      * and if its args equals 0.
70      */
71     @Test(timeout = 4000)
72     public void test04() throws Throwable {
73         OptionBuilder.hasOptionalArgs(0);
74         Option option0 = OptionBuilder.create("");
75         assertTrue(option0.hasOptionalArg());
76         assertEquals(0, option0.getArgs());
77     }
78
79     /**
80      * 1. Calls method hasArgs of OptionBuilder with argument 61
```

Our Approach

- Manual process is arduous and complex, even with test case scenarios and identifier renaming
- The systematic nature of our approach simulates a manual experts process of by-hand clustering:
 - Analyze jUnit manually written tests with Evosuite automatically written tests (in Java)
 - Identify key features of similarity
 - isolate and relate test cases based on the key features
 - Apply NLP-based information retrieval on key features to identify model(s) that best reduce false positive rates from the cluster list

Evaluation and Current Results

- We create an oracle based on results from manual clustering, we then evaluate model performance based on this oracle
- Clustering identifies groups of two or more test cases that are similar, our oracle simplifies these clusters into one-to-one matches
- Current approach narrows down potential one to one matches by over 50%

Identifying information that could help us categorize and find similar test cases...

```
/**
 * 1. Creates a new Option using OptionBuilder and checks its opt, long opt,
 * description, type, arg, if its required and its args.
 */
@Test
public void testCompleteOption( ) {
    Option simple = OptionBuilder.withLongOpt( "simple option")
        .hasArg( )
        .isRequired( )
        .hasArgs( )
        .withType( Float.class )
        .withDescription( "this is a simple option" )
        .create( 's' );

    assertEquals( "s", simple.getOpt() );
    assertEquals( "simple option", simple.getLongOpt() );
    assertEquals( "this is a simple option", simple.getDescription() );
    assertEquals( simple.getType(), Float.class );
    assertTrue( simple.hasArg() );
    assertTrue( simple.isRequired() );
    assertTrue( simple.hasArgs() );
}
```

[1, creates, a, new, option, using, option, builder, and, checks, its, opt, long, opt, description, type, arg, if, its, required, and, its, args]

[public, void, test, complete, option, option, simple, option, builderwith, long, opt, simple, option, has, arg, is, required, has, args, with, type, floatclass, with, description, this, is, a, simple, option, create, s, assert, equals, s, simpleget, opt, assert, equals, simple, option, simpleget, long, opt, assert, equals, this, is, a, simple, option, simpleget, description, assert, equals, simpleget, type, floatclass, assert, true, simplehas, arg, assert, true, simpleis, required, assert, true, simplehas, args]

...Sequencing of words/keywords, similar words and keywords. And...

Digging a little deeper into sequencing by analyzing the Abstract Syntax Tree of the test case...

```
/**
 * 1. Creates a new Option using OptionBuilder and checks its opt, long opt,
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 */
@Test
public void testCompleteOption( ) {
    Option simple = OptionBuilder.withLongOpt( "simple option")
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        .withType( Float.class )
        .withDescription( "this is a simple option" )
        .create( 's' );

    assertEquals( "s", simple.getOpt() );
    assertEquals( "simple option", simple.getLongOpt() );
    assertEquals( "this is a simple option", simple.getDescription() );
    assertEquals( simple.getType(), Float.class );
    assertTrue( simple.hasArg() );
    assertTrue( simple.isRequired() );
    assertTrue( simple.hasArgs() );
}
```

[OptionBuilder, withLongOpt, hasArg, isRequired, hasArgs, withType, withDescription, create]

[assertEquals, literal, typestrings, simple, getOpt, assertEquals, literal, typestrings, simple, getOpt, assertEquals, literal, typestrings, simple, getOpt, assertEquals, literal, typestrings, simple, getOpt, assertEquals, literal, typestrings, simple, getOpt, assertEquals, literal, typestrings, simple, getOpt]

...Sequencing of words/keywords, similar words and keywords, similar methods being called, similar assert statements.

```
<?xml version="1.0" encoding="
<root>
<function>
<annotation>
@
<name>
Test
</name>
</annotation>
<type>
<specifier>
public
</specifier>
<name>
void
</name>
</type>
<name>
testCompleteOption
</name>
<parameter_list>
( )
</parameter_list>
<block>
{
<block_content>
<decl_stmt>
<decl>
<type>
<name>
Option
</name>
</type>
<name>
simple
</name>
<init>
=
<expr>
<call>
<name>
OptionBuilder
</name>
<operator>
.
</operator>
<name>
withLongOpt
</name>
</name>
<argument_list>
(
<argument>
<expr>
<literal type="string">
"simple option"
</literal>
</expr>
</argument>
)
</argument_list>
</call>
```

Our Progress So Far...

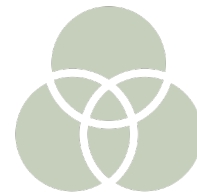
- Identified key features of test case and test case scenario to use as fruitful data inputs for similarity models (scenario words, assert statements, invoked methods)
- Series of models identifying test cases with these similar key features have reduced the potential cluster group to 50% of the possible cluster group, with plenty of room for more growth through further experimentation

Conclusions



Impacts of this Research:

Auto-identified clusters through a light-weight prototype can help programmers to select which test cases to keep, integrate, or discard



Next Steps:

Continue working towards reducing False Positive rates by finding/tuning models to identify key features of similarity (similar wording, similar methods being tested, similar sequences of actions, etc) and continue creating the 'series of experts' prototype

Acknowledgements

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Thank You!!
...Questions?
