Annotations in Java & Unit Testing with JUnit

Advanced Programming Course – Spring 2019

CEIT-AUT

Annotations

- An annotation is a form of syntactic metadata that can be added to Java source code.
  - Annotations are meta-meta-objects which can be used to describe other meta-objects. Meta-objects are classes, fields and methods.
  - Annotations provide data about a program that is not part of the program itself.

- Annotations can be interpreted at development-time by the IDE or the compiler, or at run-time by a framework.

Annotations - cont.

- Annotations start with ‘@’.
- Annotations do not change action of a compiled program.
- Annotations help to associate metadata (information) to the program elements i.e. instance variables, constructors, methods, classes, etc.
- Annotations are not pure comments as they can change the way a program is treated by compiler.

Annotations - cont.

- Some annotations applied to Java code:
  - **@Override** - Checks that the method is an override. Causes a compile error if the method is not found in one of the parent classes or implemented interfaces.
  - **@Deprecated** - Marks the method as obsolete. Causes a compile warning if the method is used.
  - **@SuppressWarnings** - Instructs the compiler to suppress the compile time warnings specified in the annotation parameters.

Annotations - cont.

- Usage of annotations:
    - Documentation, e.g. XDoclet
    - Compilation
    - IDE
    - Testing framework, e.g. JUnit
    - and many more...

Unit Testing

- Test of individual parts of an application
  - Opposed to *application testing*
- e.g. a single class, a single method
- Any single method, once written and compiled, can and should be tested.
- Manual testing: time consuming and boring! ☹
- Recall "Regression Testing"
  - We need Automated Testing
  - For Java: JUnit, TestNG, Mockito, Spock, Arquillian, …

A Quote

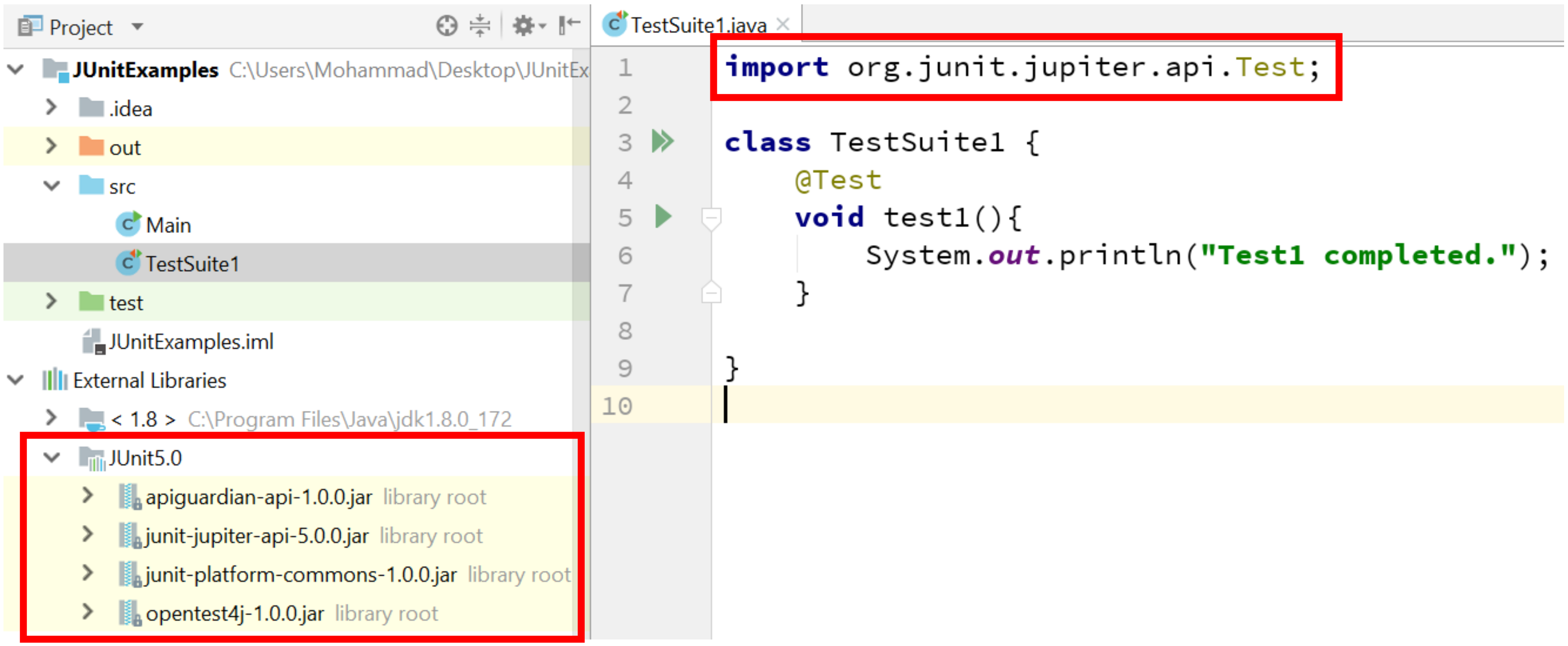
Edsger Dijkstra

Program testing can be used to show the presence of bugs, but never to show their absence!

JUnit

- A unit testing framework for Java
- Important in Test-Driven Development (TDD)
- Stable release: 5.4.1 / March 2019
- JUnit is linked as a JAR at compile-time
  - under package *org.junit* for JUnit 4 and later

How to Use JUnit in IntelliJ (The Simplest Way) – cont.



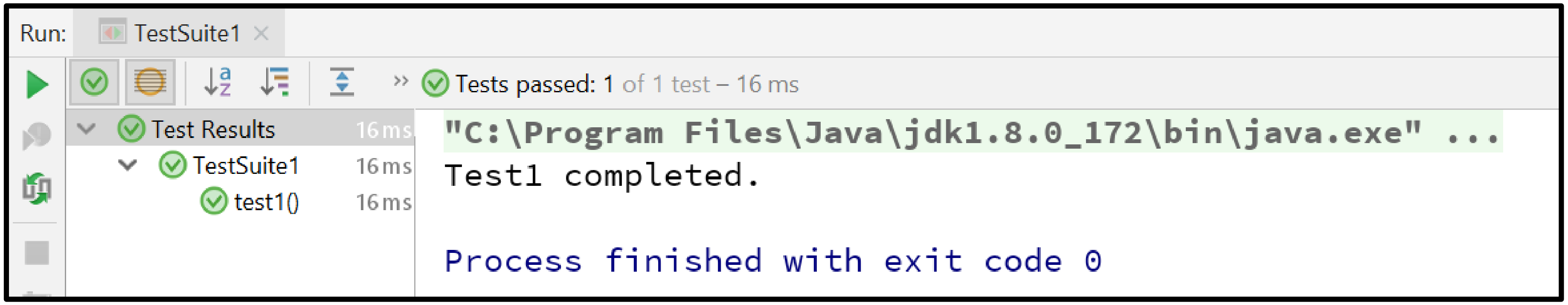
Project
JUnitExamples C:\Users\Mohammad\Desktop\JUnitEx
.idea
out
src
Main
TestSuite1
test
JUnitExamples.iml
External Libraries
< 1.8 > C:\Program Files\Java\jdk1.8.0_172
JUnit5.0
apiguardian-api-1.0.0.jar library root
junit-jupiter-api-5.0.0.jar library root
junit-platform-commons-1.0.0.jar library root
opentest4j-1.0.0.jar library root
TestSuite1.java

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

class TestSuite1 {
    @Test
    void test1(){
        System.out.println("Test1 completed.");
    }

}
```

Example 1

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

import static org.junit.jupiter.api.Assertions.assertEquals;

class TestSuite1 {

    @Test
    void test1() {
        assertEquals(“hello", “hel"+“lo");
        System.out.println("Test1 completed.");

    }
}
```

Example 1



```
"C:\Program Files\Java\jdk1.8.0_172\bin\java.exe" ...
Test1 completed.

Process finished with exit code 0
```

```
class TestSuite1 {

    @Test
    void test1() {
        assertEquals(“hello", “hel"+“lo");
        System.out.println("Test1 completed.");

    }
}
```

Static Import

- Allows access to static members of a class directly without class name or any object
- Without import static:

```
class Calculations {
    public static void main(String[] args)
    {
        System.out.println(Math.sqrt(16));
        System.out.println(Math.pow(4, 3));
    }
}
```

static method

Static Import– cont.

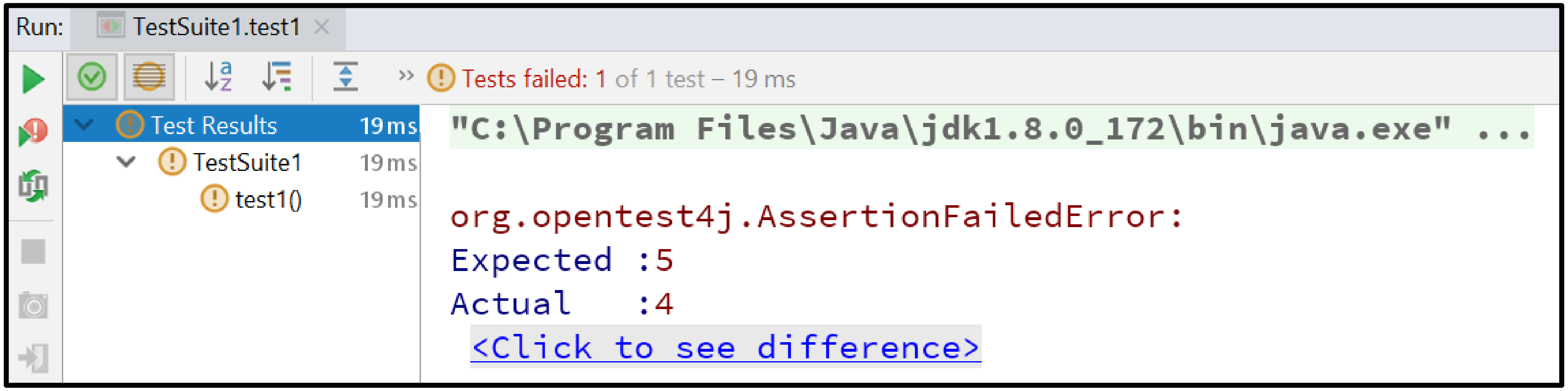
- With import static:

```
import static java.lang.Math.*;
class Calculations {
   public static void main(String[] args)
   {
      System.out.println(sqrt(16));
      System.out.println(pow(4, 3));
   }
}
```

Example 2

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

import static org.junit.jupiter.api.Assertions.assertEquals;

class TestSuite2 {

    @Test
    void test1() {
        assertEquals(5, 2*2);
        System.out.println("Test1 completed.");

    }
}
```

Example 2



```
"C:\Program Files\Java\jdk1.8.0_172\bin\java.exe" ...

org.opentest4j.AssertionFailedError:
Expected :5
Actual   :4
 <Click to see difference>
```

```
    @Test
    void test1() {
        assertEquals(5, 2*2);
        System.out.println("Test1 completed.");

    }
}
```

Annotations

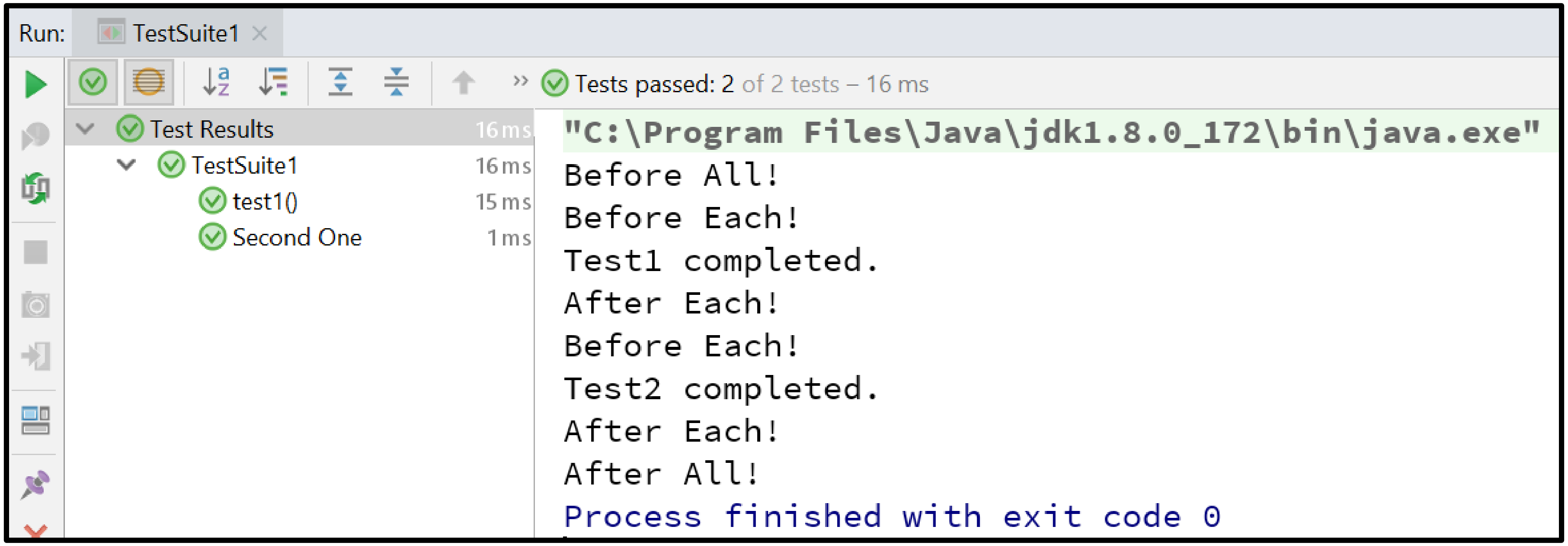
Annotation	Description
@Test	Denotes that a method is a test method.
@RepeatedTest(<Number>)	Denotes that a method is a test template for a repeated test.
@BeforeEach	Denotes that the annotated method should be executed *before* **each** @Test and @RepeatedTest methods in the current class;
@AfterEach	Denotes that the annotated method should be executed *after* **each** @Test and @RepeatedTest methods in the current class;
@BeforeAll	Denotes that the annotated method should be executed *before* **all** @Test and @RepeatedTest methods in the current class;
@AfterAll	Denotes that the annotated method should be executed *after* **all** @Test and @RepeatedTest methods in the current class;
@Nested	Denotes that the annotated class is a nested, non-static test class.
@Disabled	Used to *disable* a test class or test method; (JUnit 4: @Ignore)
@DisplayName(“<Name>")	<Name> that will be displayed by the test runner. In contrast to method names the DisplayName can contain spaces.

Example 3

```
class TestSuite1 {
    @Test
    void test1(){
        assertEquals(2, 1+1);
        System.out.println("Test1
completed.");
    }

    @Test
    @DisplayName(“Second One")
    void test2(){
        System.out.println("Test2
completed.");
    }

    @BeforeEach
    void testBeforeEach(){
        System.out.println("Before
Each!");
    }
```

```
 @AfterEach
    void testAfterEach(){
        System.out.println("After
Each!");
    }
    @BeforeAll
    static void testBeforeAll(){
        System.out.println("Before
All!");
    }

    @AfterAll
    static void testAfterAll(){
        System.out.println("After
All!");
    }
}
```

Example 3 - Output



```
"C:\Program Files\Java\jdk1.8.0_172\bin\java.exe"
Before All!
Before Each!
Test1 completed.
After Each!
Before Each!
Test2 completed.
After Each!
After All!
Process finished with exit code 0
```

Assertions

Assertion	Description
assertTrue [assertFalse]	to verify that a boolean value is true [false]
assertNull [assertNotNull]	to verify that an object is [not] null
assertEquals [assertNotEquals]	to verify that the expected value (or object) is [not] equal to the actual value (or object)
assertSame [assertNotSame]	to ensure that two objects [do not] refer to the same object
assertArrayEquals	to verify that two arrays are equal
assertThrows	to write assertions for the exceptions thrown by the system under test
assertTimeout/assertTimeoutPreemptively	to ensure that the execution of the system under test is completed before a specified timeout is exceeded
assertAll()	to write an assertion for a state that requires multiple assertions

Example 4

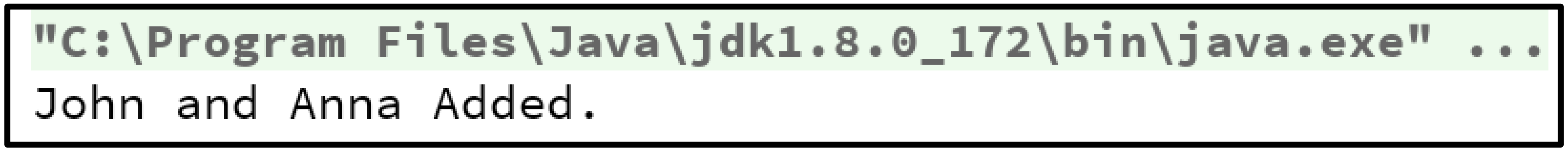
```
class UserTest {

    private static ArrayList<User> userList = new ArrayList<>();

    private static User findOne(ArrayList<User> array, String email) {
        Iterator<User> it = array.iterator();
        while (it.hasNext()) {
            User temp = it.next();
            if (temp.getEmail().equals(email)) {
                return temp;
            }
        }
        return null;
    }
```

Example 4 – cont.

```
@BeforeAll
static void addData() {
    User user1 = new User("john@gmail.com", "John");
    User user2 = new User("ana@gmail.com", "Ana");
    userList.add(user1);
    userList.add(user2);
    System.out.println("John and Anna Added.");
}
```

Example 4 – cont.

```java
@BeforeAll
static void addData() {
    User user1 = new User("john@gmail.com", "John");
    User user2 = new User("ana@gmail.com", "Ana");
    userList.add(user1);
    userList.add(user2);
    System.out.println("John and Anna Added.");
}
```



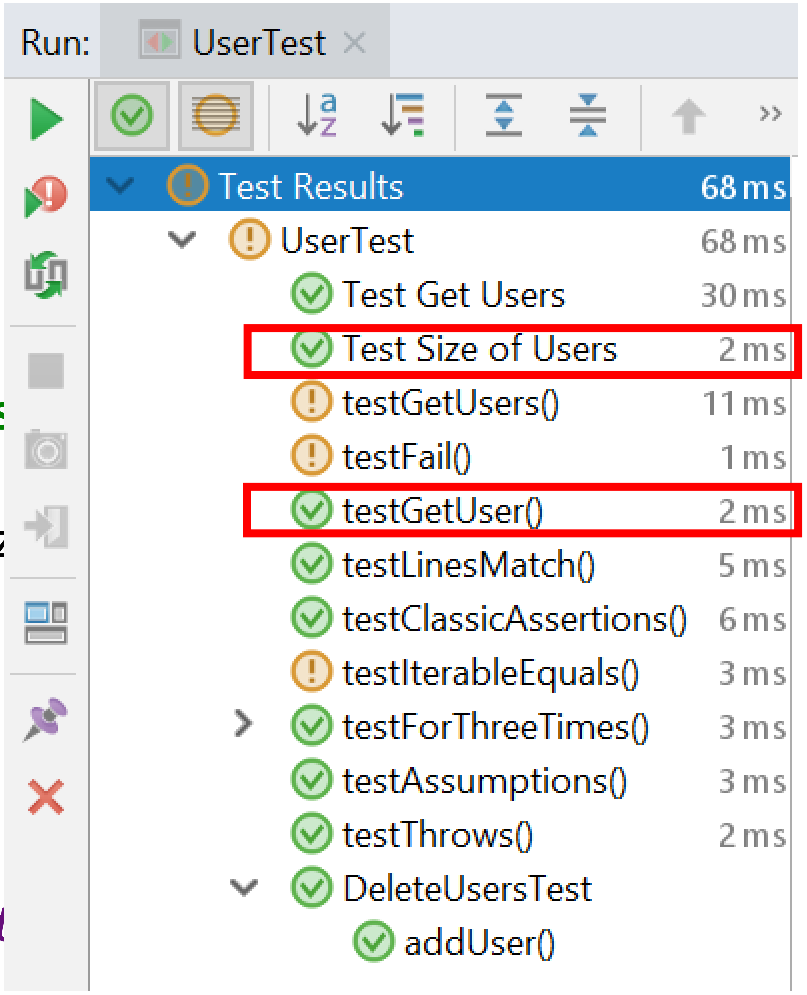
```
"C:\Program Files\Java\jdk1.8.0_172\bin\java.exe" ...
John and Anna Added.
```

Example 4 – cont.

```
@Test
@DisplayName("Test Size of Users")
void testSizeOfUsers() {
    assertEquals(2, userList.size());
}


@Test
void testGetUser() {
    User user = findOne(userList, "john@gmail.com");

    assertNotNull(user);
    assertEquals("John", user.getName(),
            "User name:" + user.getName() + " incorrect");
}
```

Example 4 – cont.

```
@Test
@DisplayName("Test Size of Users
void testSizeOfUsers() {
    assertEquals(2, userList.siz
}


@Test
void testGetUser() {
    User user = findOne(userList

    assertNotNull(user);
    assertEquals("John", user.getName(),
            "User name:" + user.getName() + " incorrect");
}
```



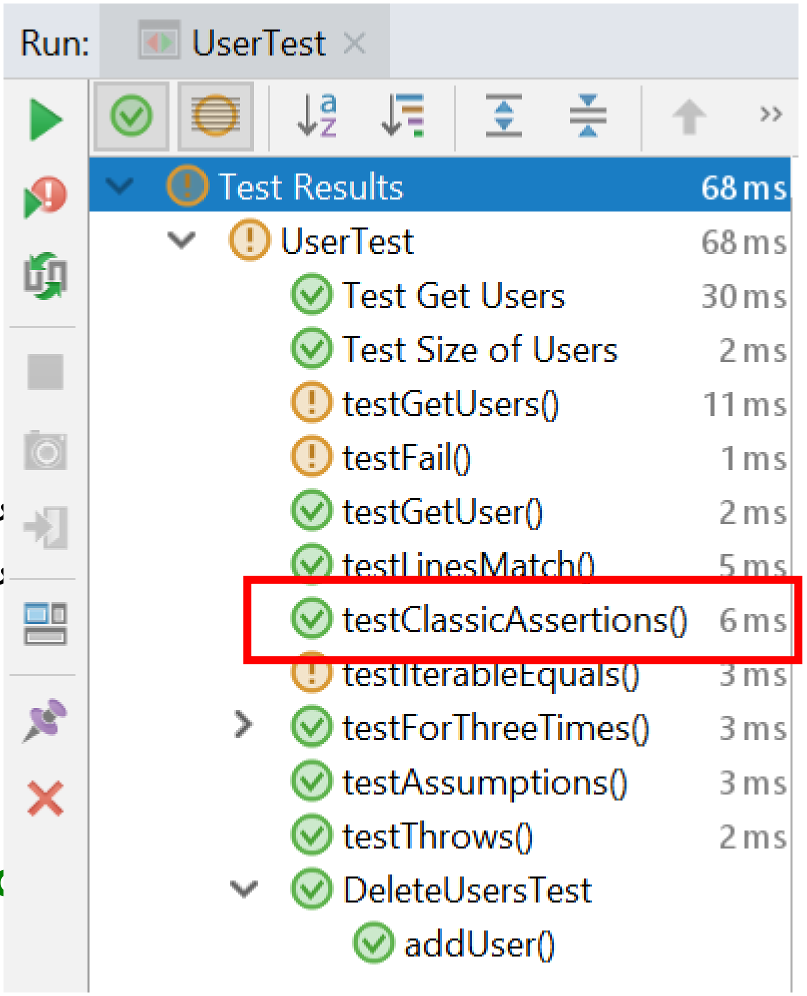
```
Test Results              68 ms
  UserTest                68 ms
    Test Get Users        30 ms
    Test Size of Users     2 ms
    testGetUsers()        11 ms
    testFail()             1 ms
    testGetUser()          2 ms
    testLinesMatch()       5 ms
    testClassicAssertions() 6 ms
    testIterableEquals()   3 ms
    testForThreeTimes()    3 ms
    testAssumptions()      3 ms
    testThrows()           2 ms
    DeleteUsersTest
      addUser()
```

Example 4 – cont.

```
@Test
void testClassicAssertions() {
    User user1 = findOne(userList, "john@gmail.com");
    User user2 = findOne(userList, "john@yahoo.com");

    assertNotNull(user1);
    assertNull(user2);

    user2 = new User("john@yahoo.com", "John");
    assertEquals(user1.getName(), user2.getName(), "Names
are not equal");
    assertFalse(user1.getEmail().equals(user2.getEmail()),
"Emails are equal");
    assertNotSame(user1, user2);
}
```

Example 4 – cont.

```
@Test
void testClassicAssertions() {
    User user1 = findOne(userList,
    User user2 = findOne(userList,

    assertNotNull(user1);
    assertNull(user2);

    user2 = new User("john@yahoo.c
    assertEquals(user1.getName(),
are not equal");
    assertFalse(user1.getEmail().equals(user2.getEmail()),
"Emails are equal");
    assertNotSame(user1, user2);
}
```



```
Run:   UserTest
Test Results                    68 ms
    UserTest                    68 ms
        Test Get Users          30 ms
        Test Size of Users       2 ms
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        testFail()               1 ms
        testGetUser()            2 ms
        testLinesMatch()         5 ms
        testClassicAssertions()  6 ms
        testIterableEquals()     3 ms
      > testForThreeTimes()      3 ms
        testAssumptions()        3 ms
        testThrows()             2 ms
      DeleteUsersTest
          addUser()
```

Example 4 – cont.

```java
@Test
void testGetUsers() {
    User user = findOne(userList, "john@gmail.com");

    assertAll("user",
            () -> assertEquals("Johnson", user.getName()),
            () -> assertEquals("johnson@gmail.com", user.getEmail()));
}

@Test
void testIterableEquals() {
    User user1 = new User("john@gmail.com", "John");
    User user2 = new User("ana@gmail.com", "Ana");

    List<User> users = new ArrayList<>();
    users.add(user1);
    users.add(user2);
    assertIterableEquals(users, userList);
}
```

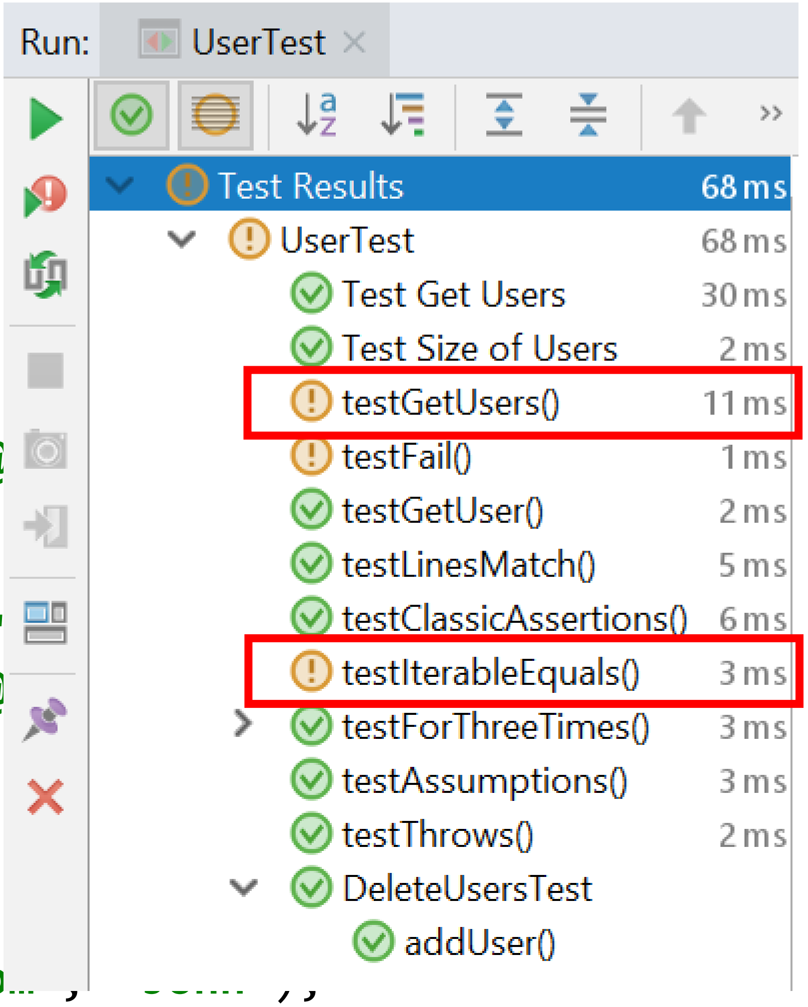
Example 4 – cont.

```java
@Test
void testGetUsers() {
    User user = findOne(userList, "john@

    assertAll("user",
            () -> assertEquals("Johnson"
            () -> assertEquals("johnson@
}

@Test
void testIterableEquals() {
    User user1 = new User("john@gmail.com", "John");
    User user2 = new User("ana@gmail.com", "Ana");

    List<User> users = new ArrayList<>();
    users.add(user1);
    users.add(user2);
    assertIterableEquals(users, userList);
}
```



```
Test Results               68 ms
  UserTest                 68 ms
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    testGetUsers()         11 ms
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    testGetUser()           2 ms
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    testClassicAssertions() 6 ms
    testIterableEquals()    3 ms
    testForThreeTimes()     3 ms
    testAssumptions()       3 ms
    testThrows()            2 ms
    DeleteUsersTest
      addUser()
```
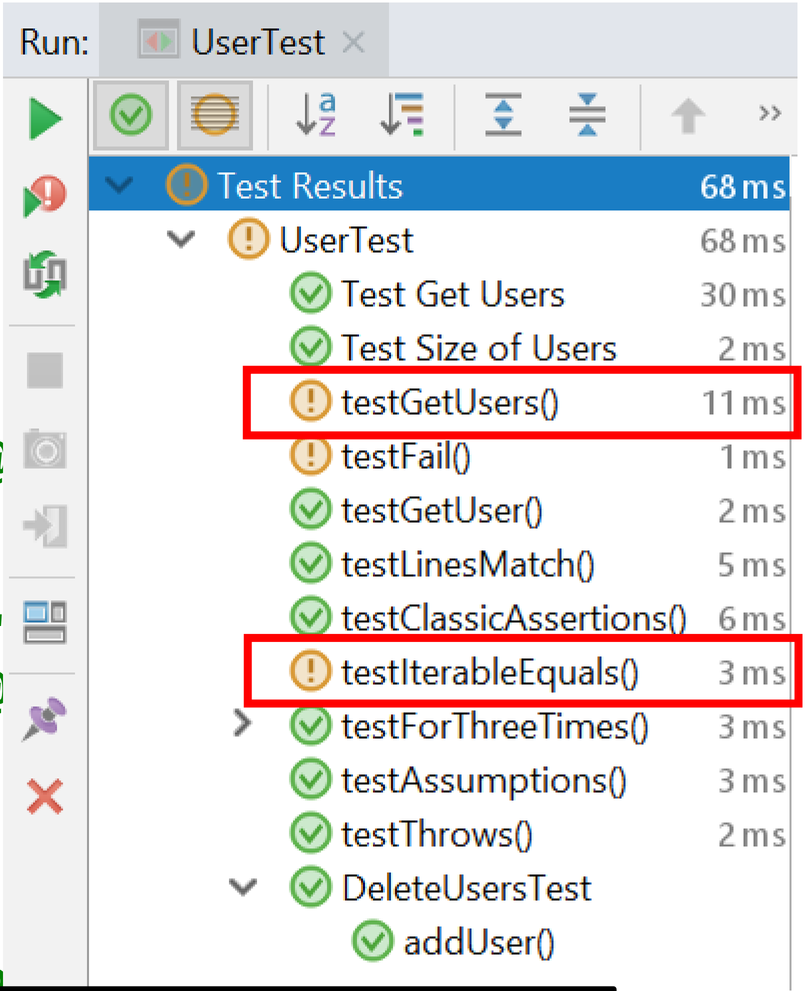
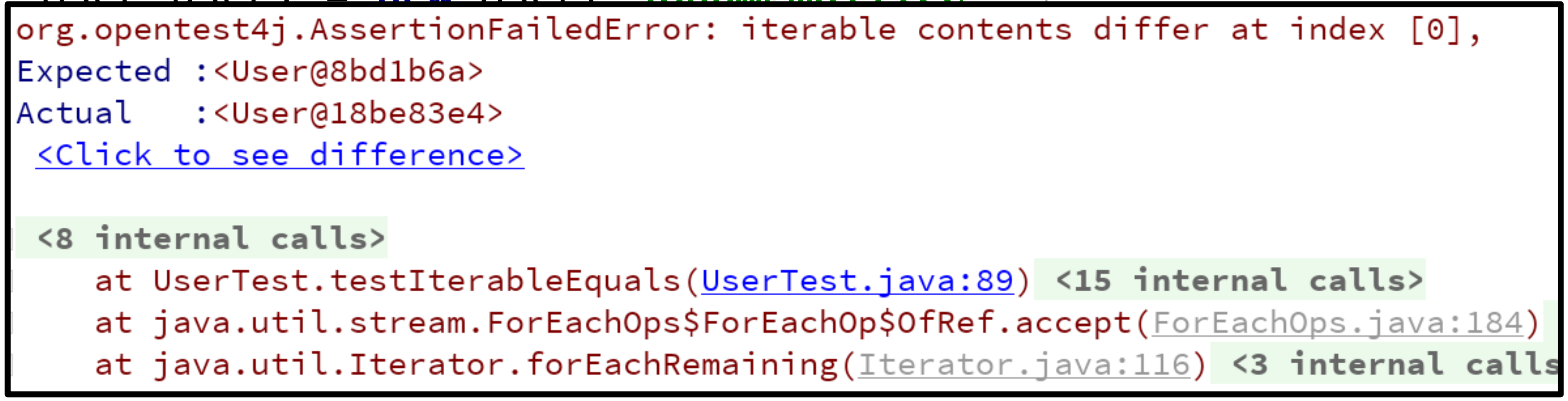

Example 4 – cont.

```
@Test
void testGetUsers() {
    User user = findOne(userList, "john@

    assertAll("user",
            () -> assertEquals("Johnson"
            () -> assertEquals("johnson@
}

@Test
void testIterableEquals() {
    User user1 = new User("john@gmail.co
```


Run: UserTest

Test Results	68 ms
UserTest	68 ms
Test Get Users	30 ms
Test Size of Users	2 ms
testGetUsers()	11 ms
testFail()	1 ms
testGetUser()	2 ms
testLinesMatch()	5 ms
testClassicAssertions()	6 ms
testIterableEquals()	3 ms
testForThreeTimes()	3 ms
testAssumptions()	3 ms
testThrows()	2 ms
DeleteUsersTest	
addUser()	


```
org.opentest4j.AssertionFailedError: iterable contents differ at index [0],
Expected :<User@8bd1b6a>
Actual   :<User@18be83e4>
 <Click to see difference>

 <8 internal calls>
    at UserTest.testIterableEquals(UserTest.java:89) <15 internal calls>
    at java.util.stream.ForEachOps$ForEachOp$OfRef.accept(ForEachOps.java:184)
    at java.util.Iterator.forEachRemaining(Iterator.java:116) <3 internal calls
```

```
}
```

Example 4 – cont.

```
@Test
void testLinesMatch() {
    List<String> expectedLines =
Collections.singletonList("(.*)@(.*)");
    List<String> emails = Arrays.asList("john@gmail.com");
    assertLinesMatch(expectedLines, emails);
}

@Test
void testThrows() {
    User user = null;
    Exception exception =
assertThrows(NullPointerException.class, () ->
user.getName());
    System.out.println(exception.getMessage());
}
```

Example 4 – cont.

```
@Test
void testLinesMatch() {
    List<String> expectedLines =
Collections.singletonList("(.*)@(.*
    List<String> emails = Arrays.as
    assertLinesMatch(expectedLines,
}

@Test
void testThrows() {
    User user = null;
    Exception exception =
assertThrows(NullPointerException.class, () ->
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    System.out.println(exception.getMessage());
}
```

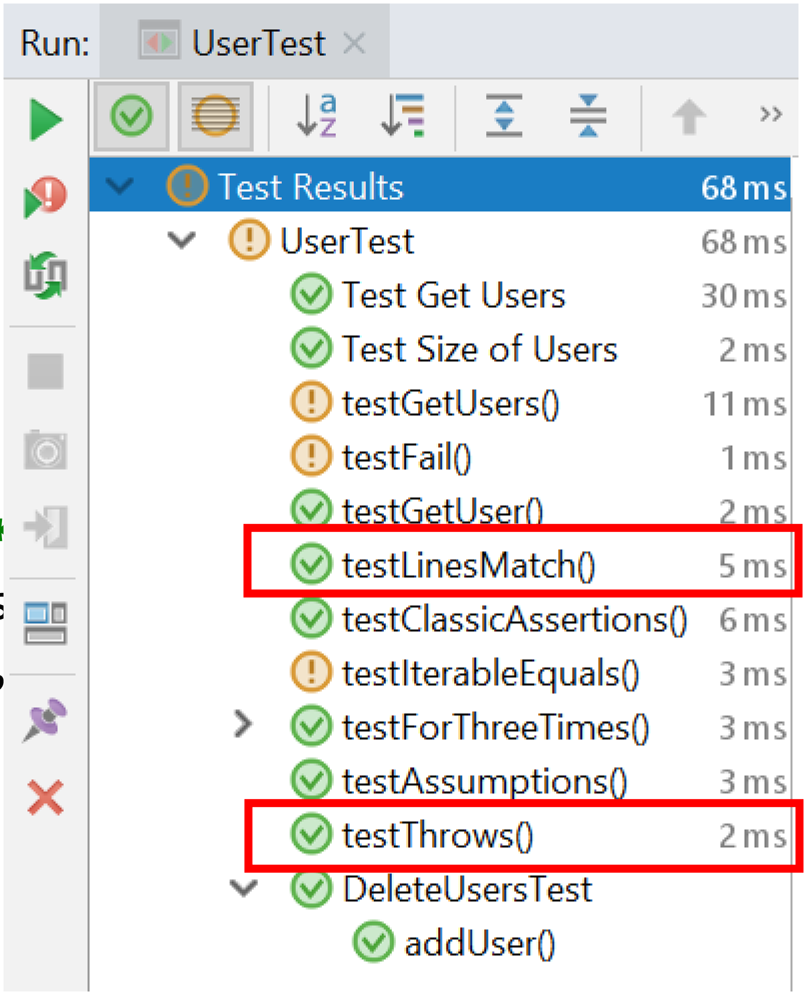

Run: UserTest

Test Results	68 ms
UserTest	68 ms
Test Get Users	30 ms
Test Size of Users	2 ms
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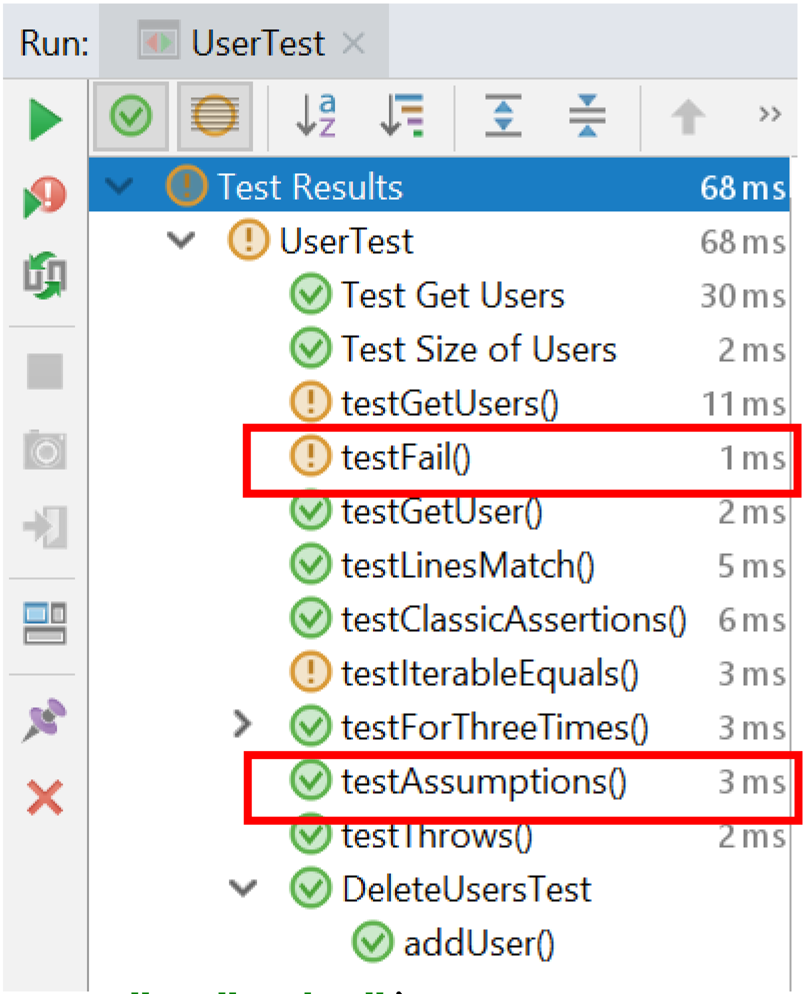
testGetUser()	2 ms
testLinesMatch()	5 ms
testClassicAssertions()	6 ms
testIterableEquals()	3 ms
testForThreeTimes()	3 ms
testAssumptions()	3 ms
testThrows()	2 ms
DeleteUsersTest	
addUser()	

Example 4 – cont.

```
@Test
void testFail() {
    fail("this test fails");
}

@Test
void testAssumptions() {
    List<User> users = userList;
    assumeFalse(users == null);
    assumeTrue(users.size() > 0);

    User user1 = new User("john@gmail.com", "John");
    assumingThat(users.contains(user1), () ->
assertTrue(users.size() > 1));
}
```

Example 4 – cont.

```
@Test
void testFail() {
    fail("this test fails");
}

@Test
void testAssumptions() {
    List<User> users = userList;
    assumeFalse(users == null);
    assumeTrue(users.size() > 0);

    User user1 = new User("john@gmail.com", "John");
a
}
```



```
Run:   UserTest
Test Results                 68 ms
  UserTest                   68 ms
    Test Get Users           30 ms
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    testAssumptions()         3 ms
    testThrows()              2 ms
  DeleteUsersTest
    addUser()
```
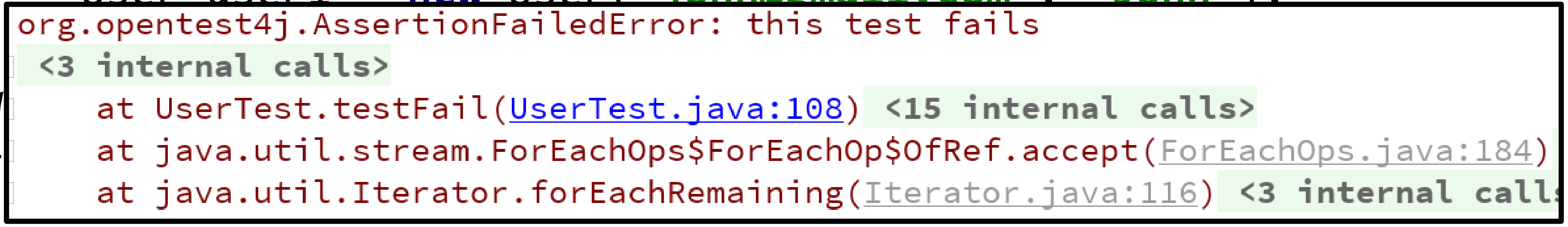



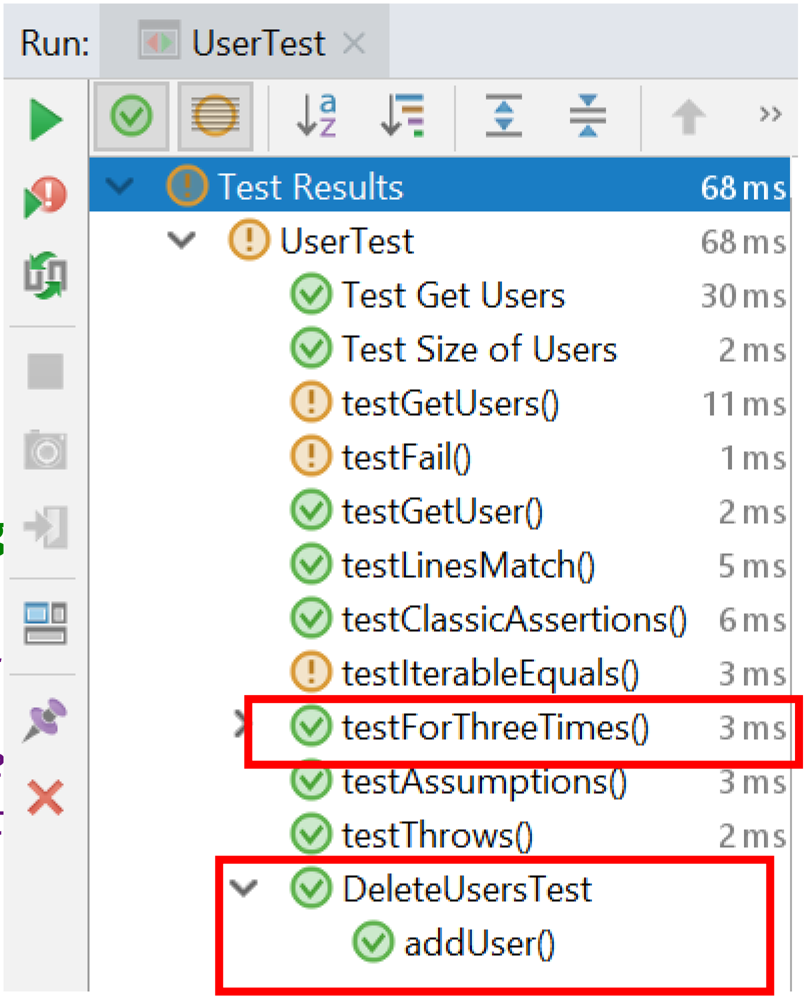
```
org.opentest4j.AssertionFailedError: this test fails
 <3 internal calls>
    at UserTest.testFail(UserTest.java:108) <15 internal calls>
    at java.util.stream.ForEachOps$ForEachOp$OfRef.accept(ForEachOps.java:184)
    at java.util.Iterator.forEachRemaining(Iterator.java:116) <3 internal call
```

Example 4 – cont.

```java
@Nested
class DeleteUsersTest {
    @Test
    void addUser() {
        User user = new User("bob@gmail.com", "Bob");
        userList.add(user);
        assertNotNull(findOne(userList, "bob@gmail.com"));

        userList.remove(findOne(userList,"bob@gmail.com"));
        assertNull(findOne(userList,"bob@gmail.com"));
    }
}

@RepeatedTest(3)
void testForThreeTimes() {
    assertTrue(1 == 1);
    System.out.println("Repeated Test");
}
```

Example 4 – cont.

```
@Nested
class DeleteUsersTest {
    @Test
    void addUser() {
        User user = new User("bob@g
        userList.add(user);
        assertNotNull(findOne(userL

        userList.remove(findOne(use
        assertNull(findOne(userList
    }
}

@RepeatedTest(3)
void testForThreeTimes() {
    assertTrue(1 == 1);
    System.out.println("Repeated Te
}
```



```
Run: UserTest
Test Results                68 ms
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    testAssumptions()        3 ms
    testThrows()             2 ms
    DeleteUsersTest
      addUser()
```

```
Repeated Test
Repeated Test
Repeated Test
```

Example 4 – cont.

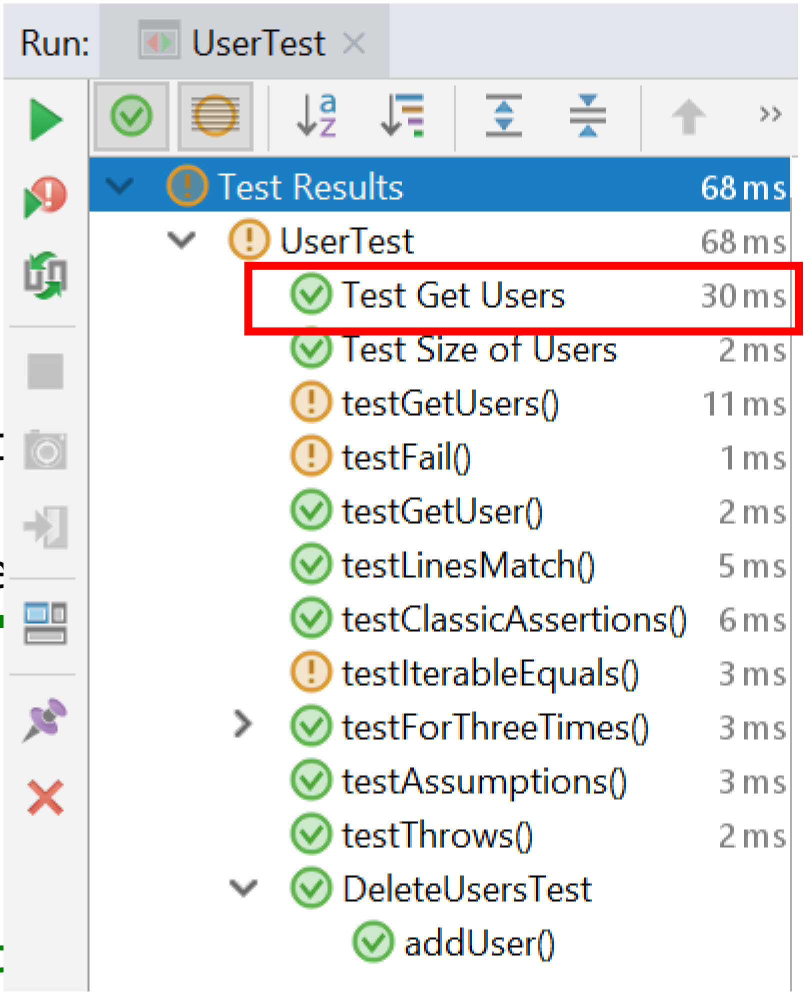
```
@Test
@DisplayName("Test Get Users")
public void testGetUsersNumberWithInfo(TestInfo testInfo)
{
    assertEquals(2, userList.size());
    assertEquals("Test Get Users",
testInfo.getDisplayName());
    assertEquals(UserTest.class,
testInfo.getTestClass().get());

    System.out.println("Running test method:" +
testInfo.getTestMethod().get().getName());
}
```

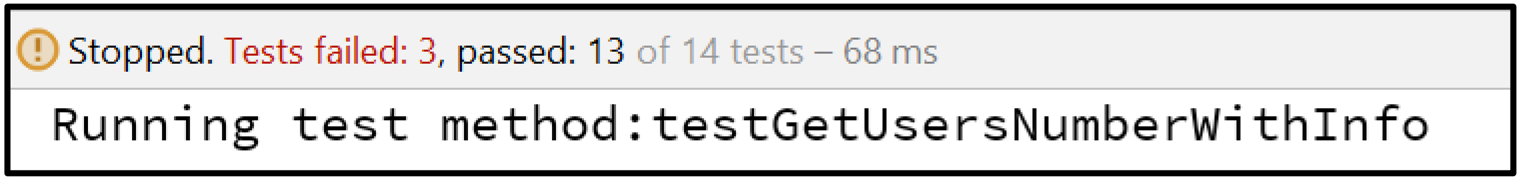
Example 4 – cont.

```
@Test
@DisplayName("Test Get Users")
public void testGetUsersNumberWit
{
    assertEquals(2, userList.size
    assertEquals("Test Get Users"
testInfo.getDisplayName());
    assertEquals(UserTest.class,
testInfo.getTestClass().get());

    System.out.println("Running t
testInfo.getTestMethod().get().getName());
}
```



```
Test Results              68 ms
  UserTest                68 ms
    Test Get Users        30 ms
    Test Size of Users     2 ms
    testGetUsers()        11 ms
    testFail()             1 ms
    testGetUser()          2 ms
    testLinesMatch()       5 ms
    testClassicAssertions() 6 ms
    testIterableEquals()   3 ms
    testForThreeTimes()    3 ms
    testAssumptions()      3 ms
    testThrows()           2 ms
    DeleteUsersTest
      addUser()
```



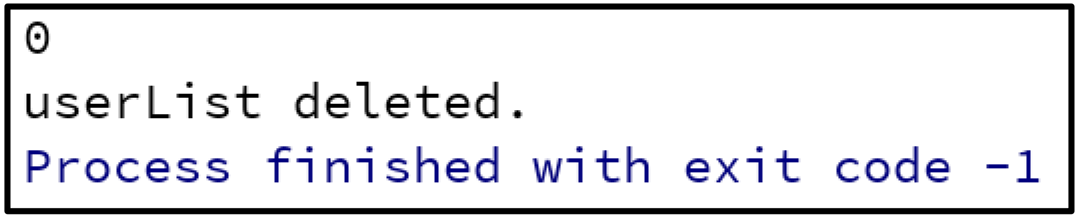
```
Stopped. Tests failed: 3, passed: 13 of 14 tests – 68 ms
Running test method:testGetUsersNumberWithInfo
```

Example 4 – cont.

```
@AfterAll
static void removeData() {
    userList.removeAll(userList);
    System.out.println(userList.size());
    System.out.println("userList deleted.");
}
```

Example 4 – cont.

```
@AfterAll
static void removeData() {
    userList.removeAll(userList);
    System.out.println(userList.size());
    System.out.println("userList deleted.");
}
```



```
0
userList deleted.
Process finished with exit code -1
```