



Code Defenders Game

How to for Teachers

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Teaching Software Testing





Mutation Testing

1970's — DeMillo (Georgia Tech), Lipton (Princeton), Sayward (Yale)

```
@Test  
void testAbs() {  
    int res = abs(42);  
    assertEquals(42, res);  
}
```



```
int abs(int x) {  
    if (x >= 0)  
        return x;  
    else  
        return -x;  
}
```



Mutation Testing

1970's — DeMillo (Georgia Tech), Lipton (Princeton), Sayward (Yale)

```
@Test  
void testAbs() {  
    int res = abs(42);  
    assertEquals(42, res);  
}
```



```
int abs(int x) {  
    if (x >= 0)  
        return x;
```

```
int abs(int x) {  
    if (x <= 0)  
        return x;  
    else  
        return -x;  
}
```





Mutation Testing

1970's — DeMillo (Georgia Tech), Lipton (Princeton), Sayward (Yale)

```
@Test
void testAbs() {
    int res = abs(42);
    assertEquals(42, res);
}
```



```
int abs(int x) {
    if (x >= 0)
        return x;
```

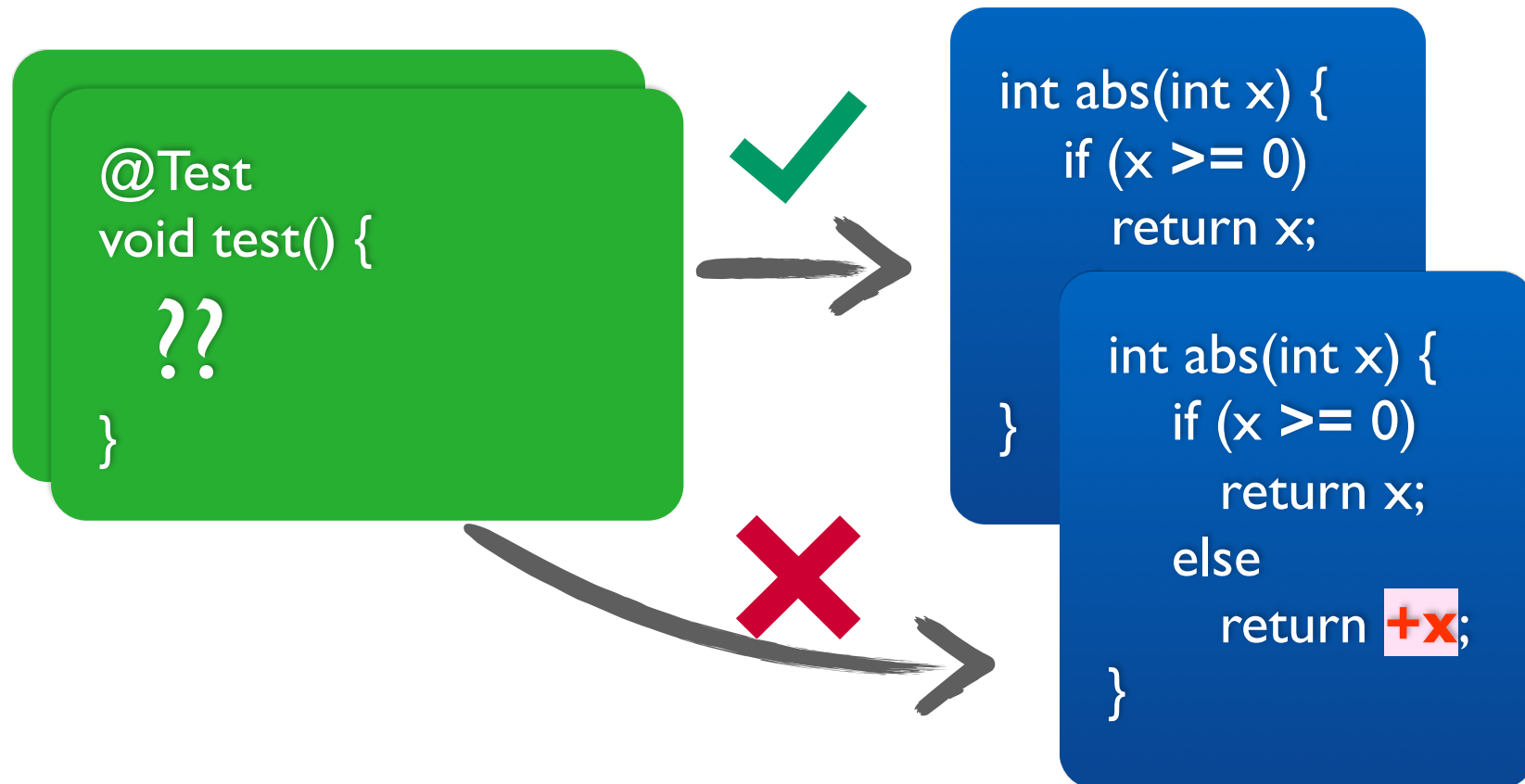
```
int abs(int x) {
    if (x >= 0)
        return x;
    else
        return +x;
}
```





Mutation Testing

1970's — DeMillo (Georgia Tech), Lipton (Princeton), Sayward (Yale)





Code Defenders

Class Under Test

Score points for surviving mutants

Score points for effective tests

```
public class Arithmetics {  
    public int abs(int x) {  
        if (x < 0)  
            return x;  
        else  
            return -x;  
    }  
}
```

```
public class Arithmetics {  
    public int abs(int x) {  
        if (x >= 0)  
            return x;  
        else  
            return -x;  
    }  
}
```

```
public class TestArithmetics {  
    @Test  
    public void testAbs() {  
        Arithmetics a;  
        a = new Arithmetics();  
        assertEquals(1, a.abs(-1));  
    }  
}
```

no way! here is
a killing test!

oh no! :(

equivalent!



Attackers



Defenders

Equivalent Mutant Duels



Code Defenders

Code Defenders - Game 2260

code-defenders.org/multiplayer/play?id=2260

Code Defenders

games upload class leaderboard help neilwalkinshaw

DEFENDER::ACTIVE SparseIntArray Show Scoreboard

Class Under Test

```
39 /**
36  * Creates a new SparseIntArray containing no mappings that will not
37  * require any additional memory allocation to store the specified
38  * number of mappings. If you supply an initial capacity of 0, the
39  * sparse array will be initialized with a light-weight representation
40  * not requiring any additional array allocations.
41  */
42 public SparseIntArray(int initialCapacity) {
43     if (initialCapacity == 0) {
44         mKeys = SparseIntArray.EMPTY_INT_ARRAY;
45         mValues = SparseIntArray.EMPTY_INT_ARRAY;
46     } else {
47         mKeys = new int[initialCapacity];
48         mValues = new int[mKeys.length];
49     }
50     mSize = 0;
51 }
52
53 /**
54  * Given the current size of an array, returns an ideal size to which the array should grow.
55  * This is typically double the given size, but should not be relied upon to do so in the
56  * future.
57  */
58 public static int growSize(int currentSize) {
59     return currentSize <= 4 ? 8 : currentSize * (currentSize >> 1);
60 }
61
```

Write a new JUnit test here

```
1 /* no package name */
2
3 import org.junit.*;
4 import static org.junit.Assert.*;
5
6 public class TestSparseIntArray {
7     @Test(timeout = 4000)
8     public void test() throws Throwable {
9         // test here!
10     }
11 }
12
```

Existing Mutants

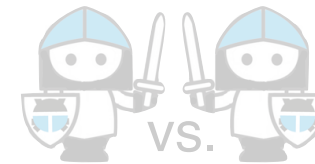
| alive (35) | killed (68) | equivalent (5) |
|---|-------------|------------------|
| Search... | | |
| Mutant 5838 Creator: amin [UID: 428] | | Claim Equivalent |
| Modified line 244 | | |
| Mutant 5855 Creator: abrahamc2 [UID: 432] | | Claim Equivalent |
| Modified line 211 | | |
| Mutant 5823 Creator: gregory [UID: 426] | | Claim Equivalent |
| Modified line 178 | | |
| Mutant 5886 Creator: gregory [UID: 426] | | Claim Equivalent |
| Modified line 190 | | |

JUnit tests

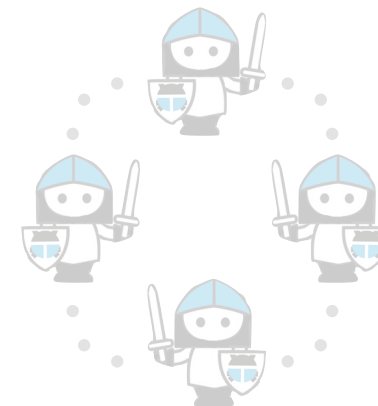
Test 4034 | Creator: alessiogambi [UID: 433]

```
1 /* no package name */
2
3 import org.junit.*;
4 import static org.junit.Assert.*;
5
6 public class TestSparseIntArray {
7     @Test(timeout = 4000)
8     public void test() throws Throwable {
9         SparseIntArray sia = new SparseIntArray(0);
10         sia.put(0, 1);
11         sia.put(1, 0);
12         sia.delete(0);
13         assertEquals(1, sia.size());
14         assertEquals(0, sia.get(1));
15     }
16 }

```



Two-player



Multi-player



Code Defenders

Demo



Software Testing 2017 @ Uni Passau

Structure:

- 2h Lectures
- 1h Exercise
- **2h Lab session**

Target audience:

- MSc+BSc students
- 180 registered
- 120 accepted

Lab Sessions:

- 1 game per week
- Teams of 3-5 students
- Students alternate attacker/defender roles weekly
- Increasing difficulty
- Practicals count towards grade



Classroom Management

Problem:

- Students arrive late
- Students skip sessions
- Students (temporarily) switch to other sessions
- 3 vs 3 games only for students present in lab

Solution:

- First take attendance
- Admin interface to create games
- Assign late-comers to “stale” games



Game Management

Problem:

- Balanced teams are important
- If students are not challenged, they disengage
- If opponents are too strong, students get frustrated

Solution:

- Rank students by defender score
- Create teams based on similar rank



Game Management

Problem:

- Students try to “cheat” (maximise their score)
 - ...by creating equivalent / silly / tricky mutants
 - ...by using reflection etc.
 - ...by using dubious strategies

Solution:

- Refined, configurable restrictions
- Leave some opportunities for very good students
- Feedback mechanism



Course Management

Problem:

- Each session needs a new class under test
- Difficulty should increase to keep students engaged
- Interface makes handling dependencies complicated

Solution:

- Pairs of classes, so students play attacker and defender on same type of class (in successive sessions)
- Open source classes, some isolation (anonymisation)
- Largely datastructure-like classes



Software Testing 2018 @ Uni Passau

Problem last year:

- Game gets boring for students

Solution:

- Only three Code Defenders sessions
- Other topics for other sessions




Open Challenges

- Communication mechanism to foster collaboration
- Bootstrapping games with mutants/tests
- Many opportunities to spice up gameplay
- Integrating more technologies (GUI, concurrency, etc.)
- Analysis for grading and intervention
- ...



How to use Code Defenders?

 Code Defenders

[login](#) [research](#) [help](#)

Code Defenders

A Mutation Testing Game

Enter

Attack!

```
public class Arithmetics {  
    public int abs(int x) {  
        if (x >= 0) {  
            return x;  
        }  
        else {  
            return -x;  
        }  
    }  
}
```

Class Under Test

```
public class Arithmetics {  
    public int abs(int x) {  
        if (x >= 0) {  
            return x;  
        }  
        else {  
            return -x;  
        }  
    }  
}
```




Defend!

```
public class TestArithmetics {  
    @Test  
    public void testAbs() {  
        Arithmetics a;  
        a = new Arithmetics();  
        assertEquals(1, a.abs(-1));  
    }  
}
```

Important note: Internet Explorer is not currently supported.



How to use Code Defenders?

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Gamification of Mutation Testing

[1,539 commits](#) [3 branches](#) [9 releases](#) [Fetching contributors](#)

[Branch: master](#) [New pull request](#) [Create new file](#) [Upload files](#) [Find file](#) [Clone or download](#)



| | | |
|--|--|--------------|
| docker | Turning off access log to reduce clutter and verbosity of nginx | Jun 27, 2018 |
| installation | Included HOST and PORT configurations inside SQL commands | May 4, 2018 |
| scripts | Merge branch 'master' into '116-set-users-to-inactive' | May 9, 2018 |
| src | Fix wrong expectations in MutantTest. getLines gives us the lines mod... | Jun 27, 2018 |
| .gitattributes |  Added .gitattributes | Jul 8, 2015 |
| .gitignore | Add generated docker files to .gitignore | May 23, 2018 |
| IDEAS.md | idea | May 9, 2016 |
| LICENSE.txt | license | Oct 26, 2016 |
| README.md | Enable scalability and persistence using load balancing and data volumes | Jun 25, 2018 |
| code-format.xml | Include Default IntelliJ code format with Tabs | Dec 5, 2017 |
| config.properties | Enable block.attacker as global property, store that into the user se... | Dec 15, 2017 |
| config.properties@docker | Implement system tests using docker containers for deploying code-def... | May 10, 2018 |
| makefile | Tentative makefile. Does not fail the build if properties are missing | Nov 17, 2017 |
| pom.xml | Update version in pom.xml | Jun 3, 2018 |



How to use Code Defenders?



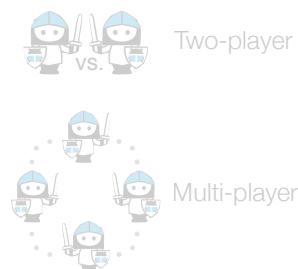
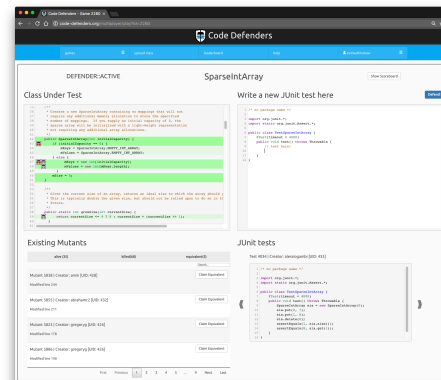
- Use Docker Container shipped with sources
- Sets up everything on the fly
- Fully automated
- Easy load balancing for more users



Teaching Software Testing



Code Defenders



How to use Code Defenders?



code-defenders.org

