Code Defenders

Teaching Software Testing Concepts using a Mutation Testing Game

Benjamin Clegg, **José Miguel Rojas**, Gordon Fraser

Class Under Test

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

Attack!

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

Defend!

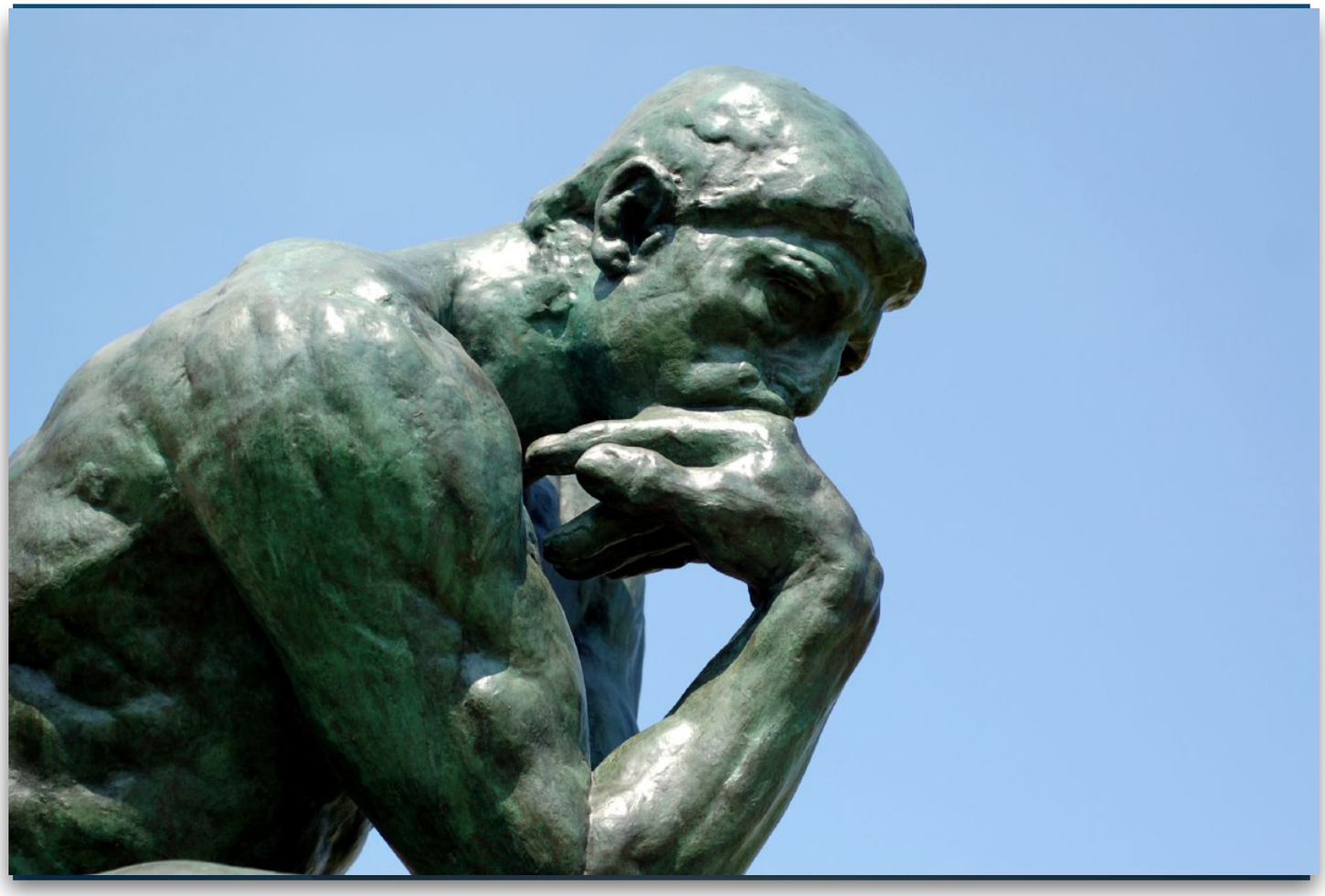
```
public class TestArithmetics {
   @Test
   public void testAbs() {
      Arithmetics a;
      a = new Arithmetics();
      assertEquals(1, a.abs(-1));
   }
}
```

The University Of Sheffield.

Software Testing

Fundamental for Software Quality

Software Testing



by Brian Hillegas (Flickr)

Fundamental for Software Quality

…but *very* demanding

Software Testing Education

Code Defenders

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Software Testing Gamification

Mutation Testing

Mutation Testing

Helps shifting testing effort from coverage to fault detection

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Helps shifting testing effort from coverage to fault detection

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Helps shifting testing effort from coverage to fault detection

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Mutation Testing

Helps shifting testing effort from coverage to fault detection

```
@Test
void testAbs() {
    int res = abs(42);
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}
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Mutation Testing

Helps shifting testing effort from coverage to fault detection

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Too many mutants, often trivial, redundant or equivalent

Code Defenders

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Attackers

Defenders

Code Defenders

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Attackers

Defenders

Code Defenders

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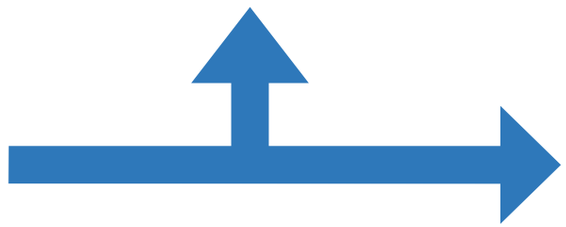

Attackers

Defenders

Code Defenders

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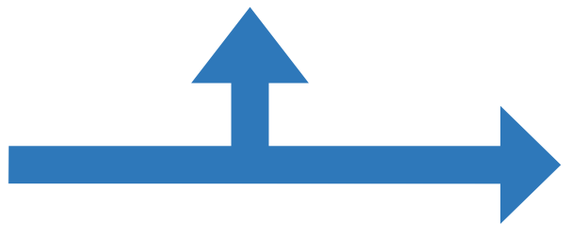

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Attackers

Defenders

Code Defenders

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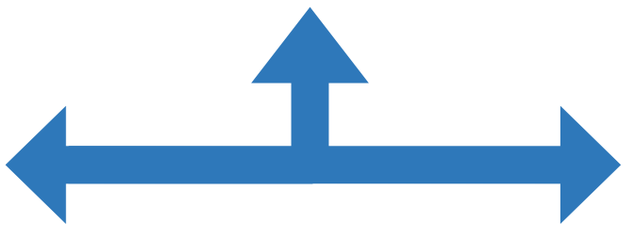

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Attackers

Defenders

Code Defenders

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Score points for surviving mutants

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Attackers

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Defenders

Code Defenders

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Attackers

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Defenders

Code Defenders

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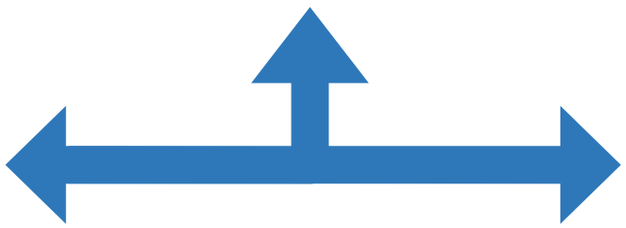
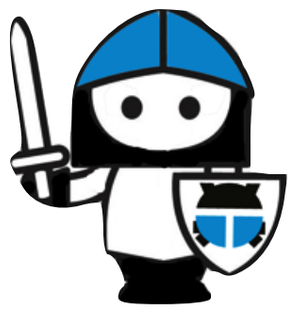


Attackers

Equivalent Mutant Duels

Defenders



Code Defenders

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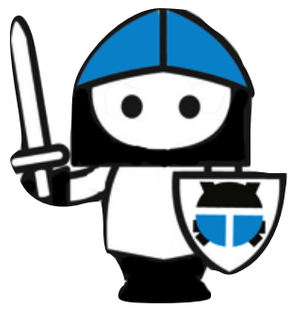
equivalent!

Attackers

Defenders



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Code Defenders

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no way! here is a killing test!

equivalent!

Attackers

Defenders

Equivalent Mutant Duels

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oh no! :(

equivalent!

Attackers

Defenders

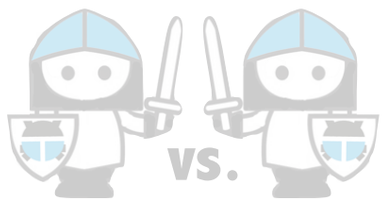
Equivalent Mutant Duels

Code Defenders

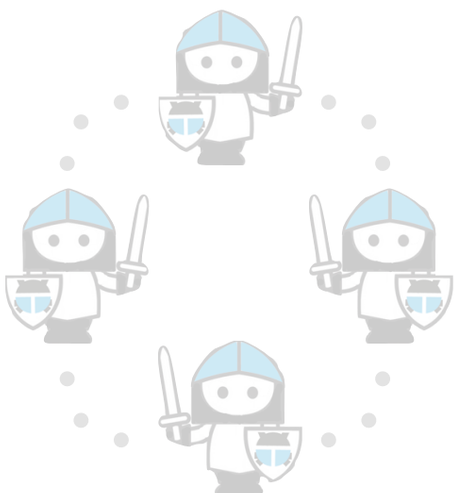
Single-player

vs.

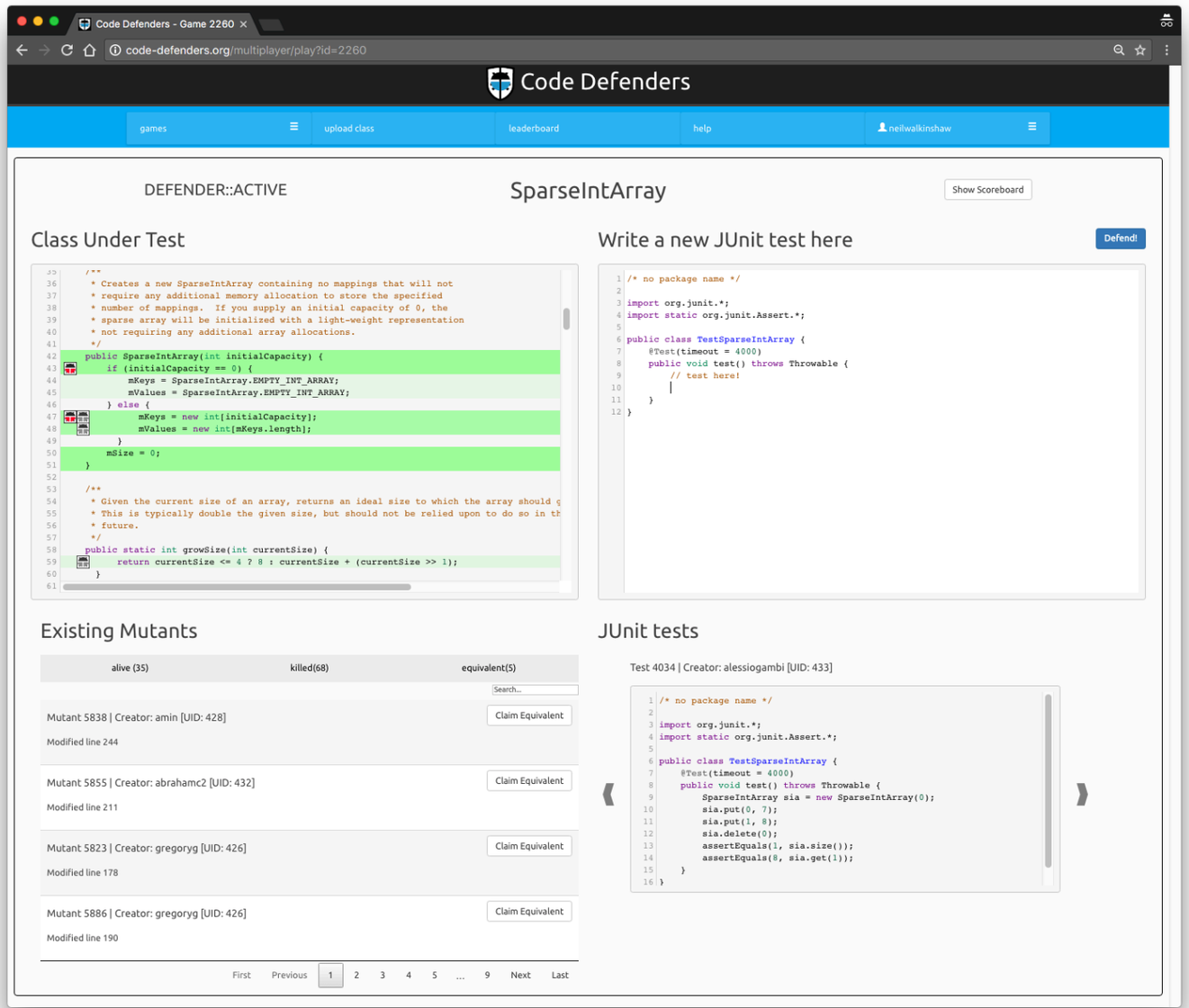
EVOSUITE / MAJOR



Duels



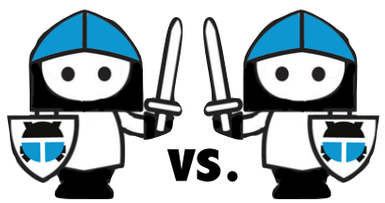
Multi-player



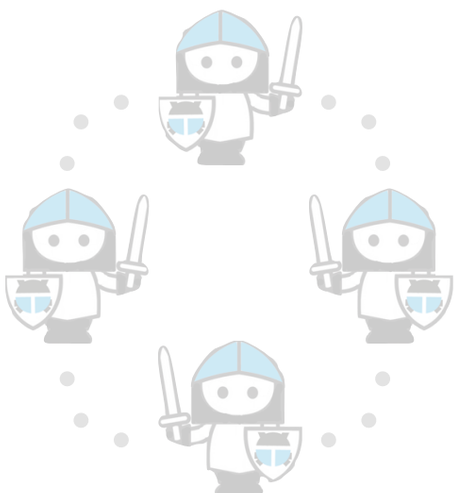
Code Defenders

vs.

EVOSUITE / MAJOR



Duels



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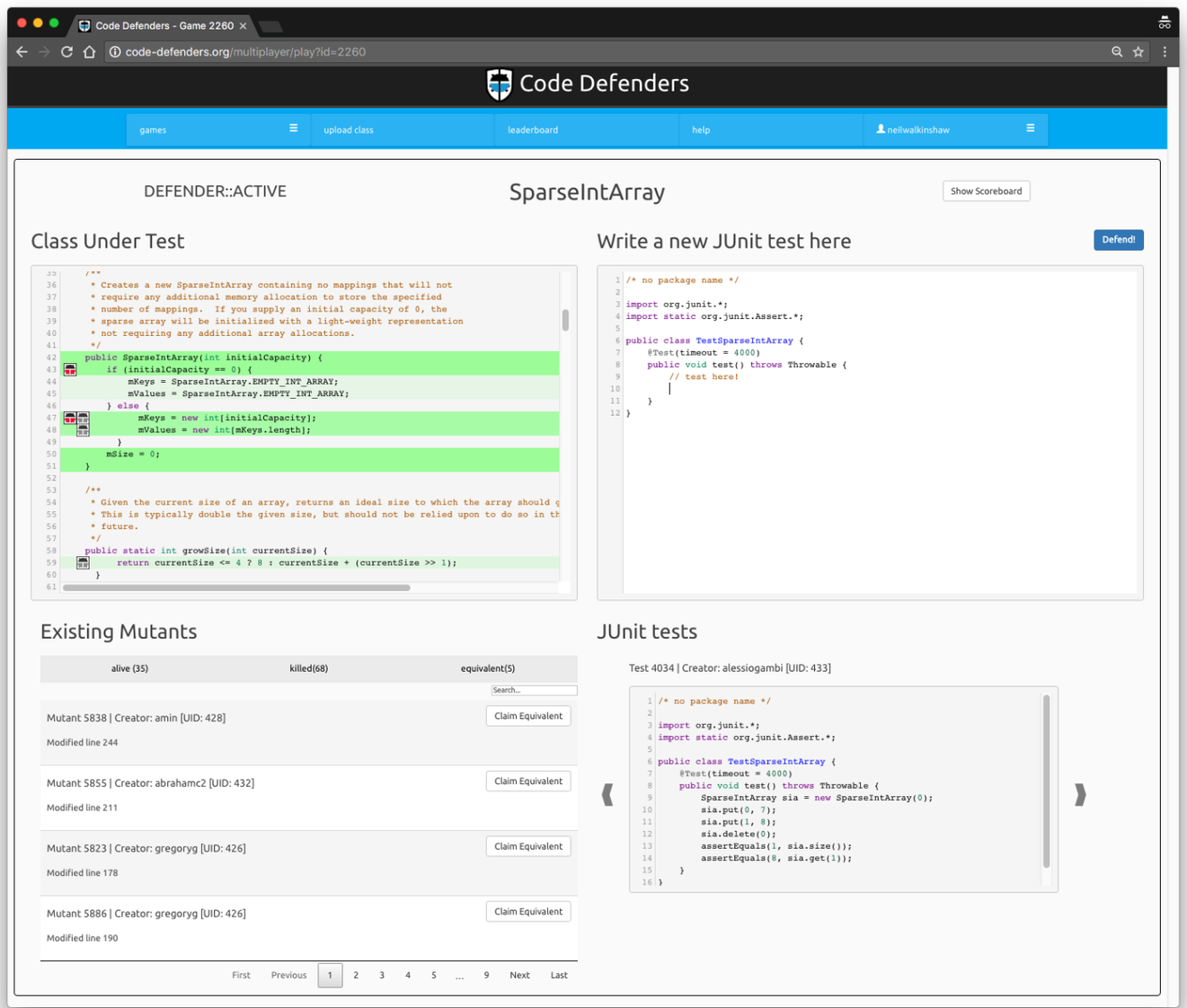
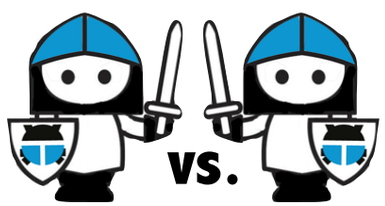


Code Defenders

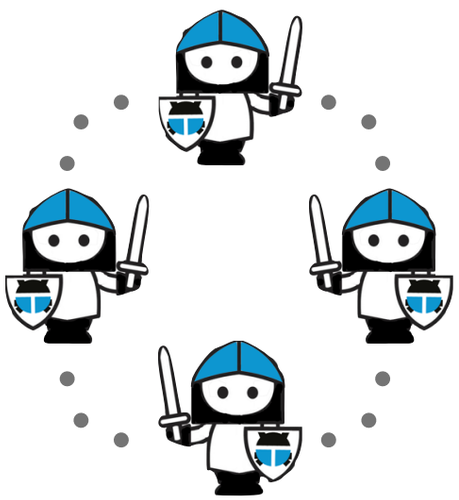
vs.

EVOSUITE / MAJOR

Single-player



Duels



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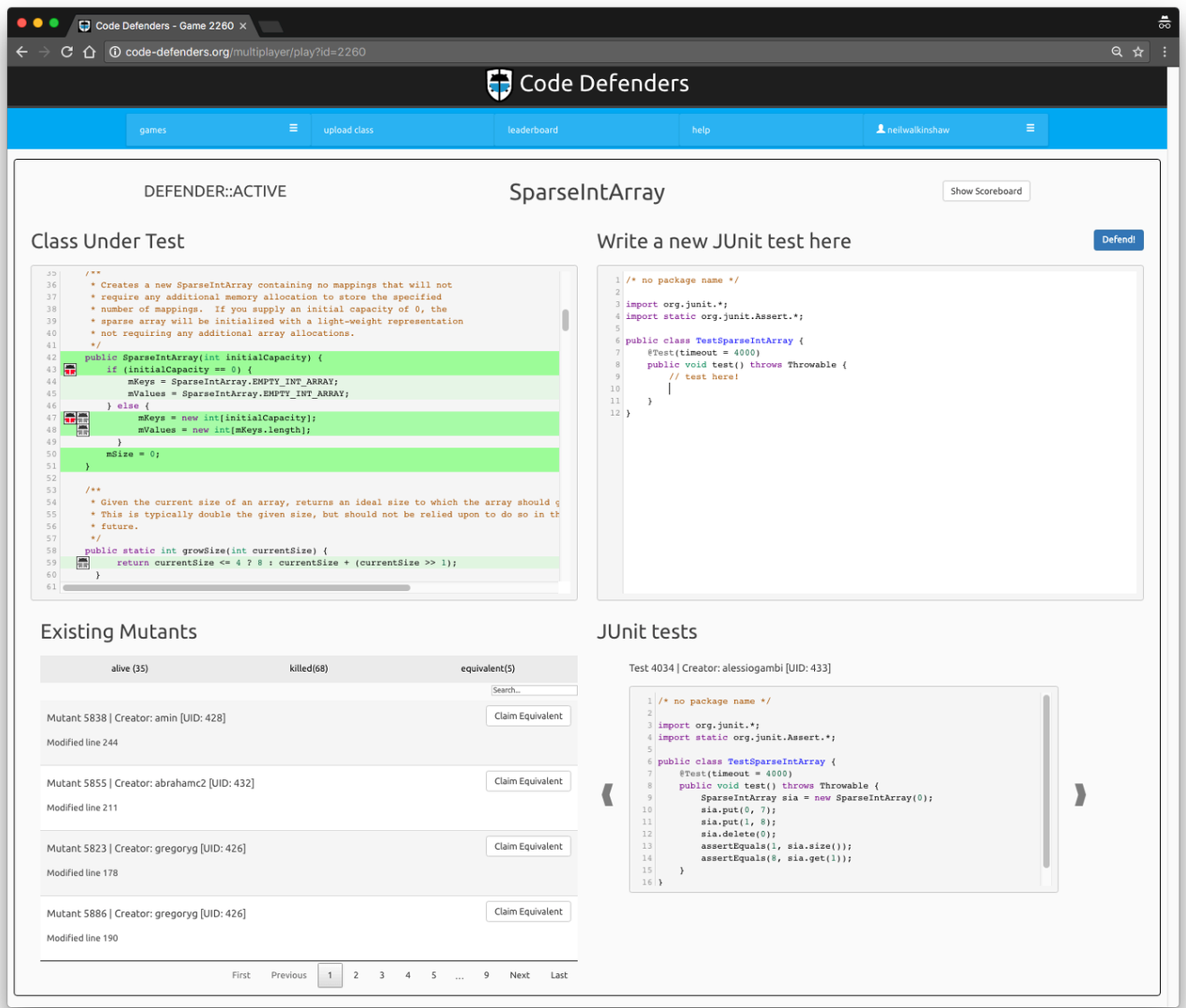

Code Defenders

Single-player

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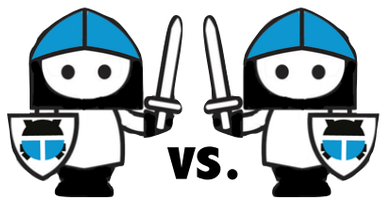

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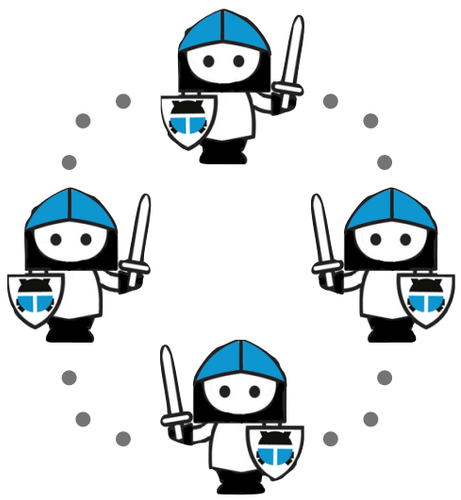

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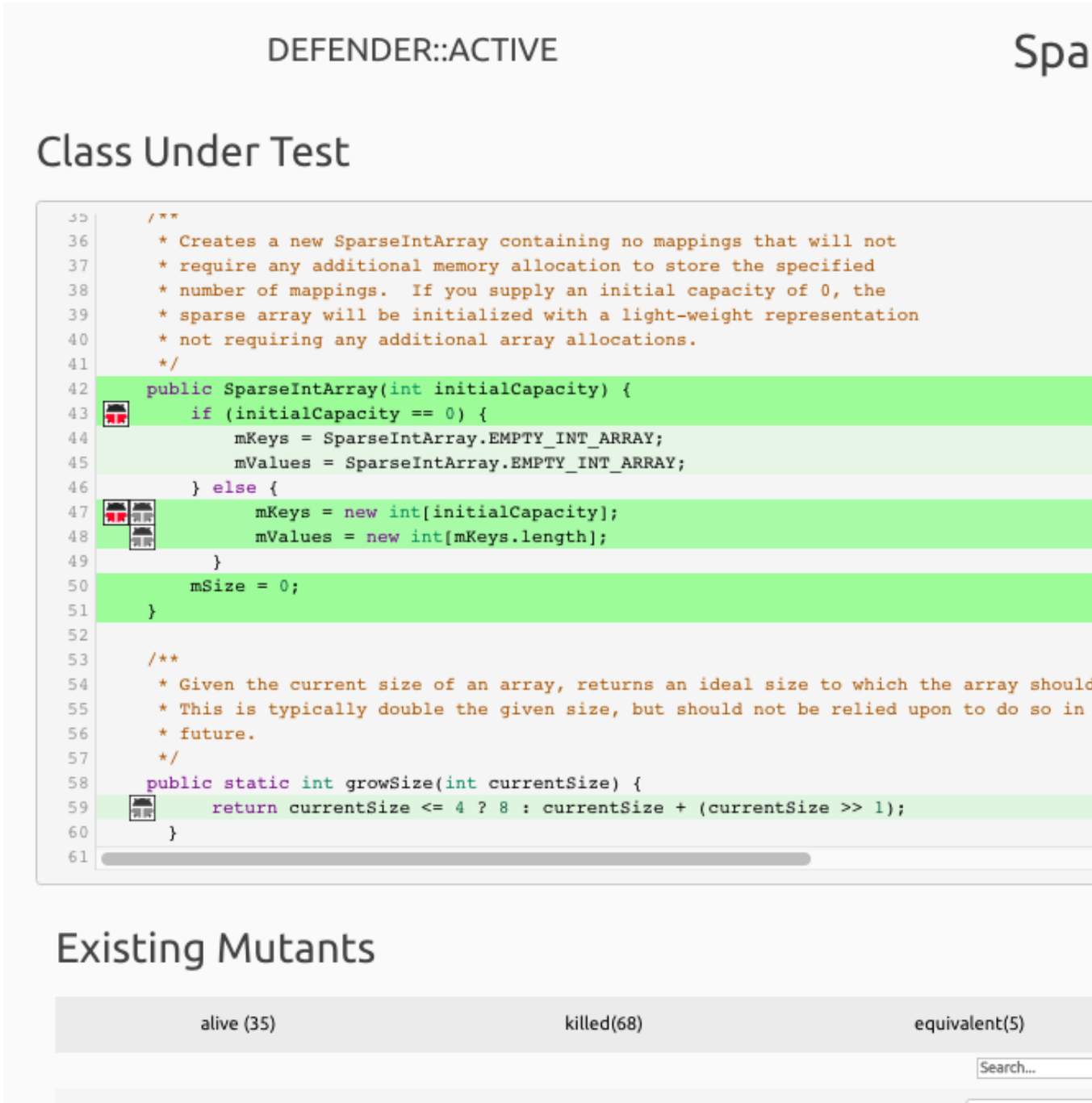

Early Adopters

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Paul Amman

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Jeff Offutt

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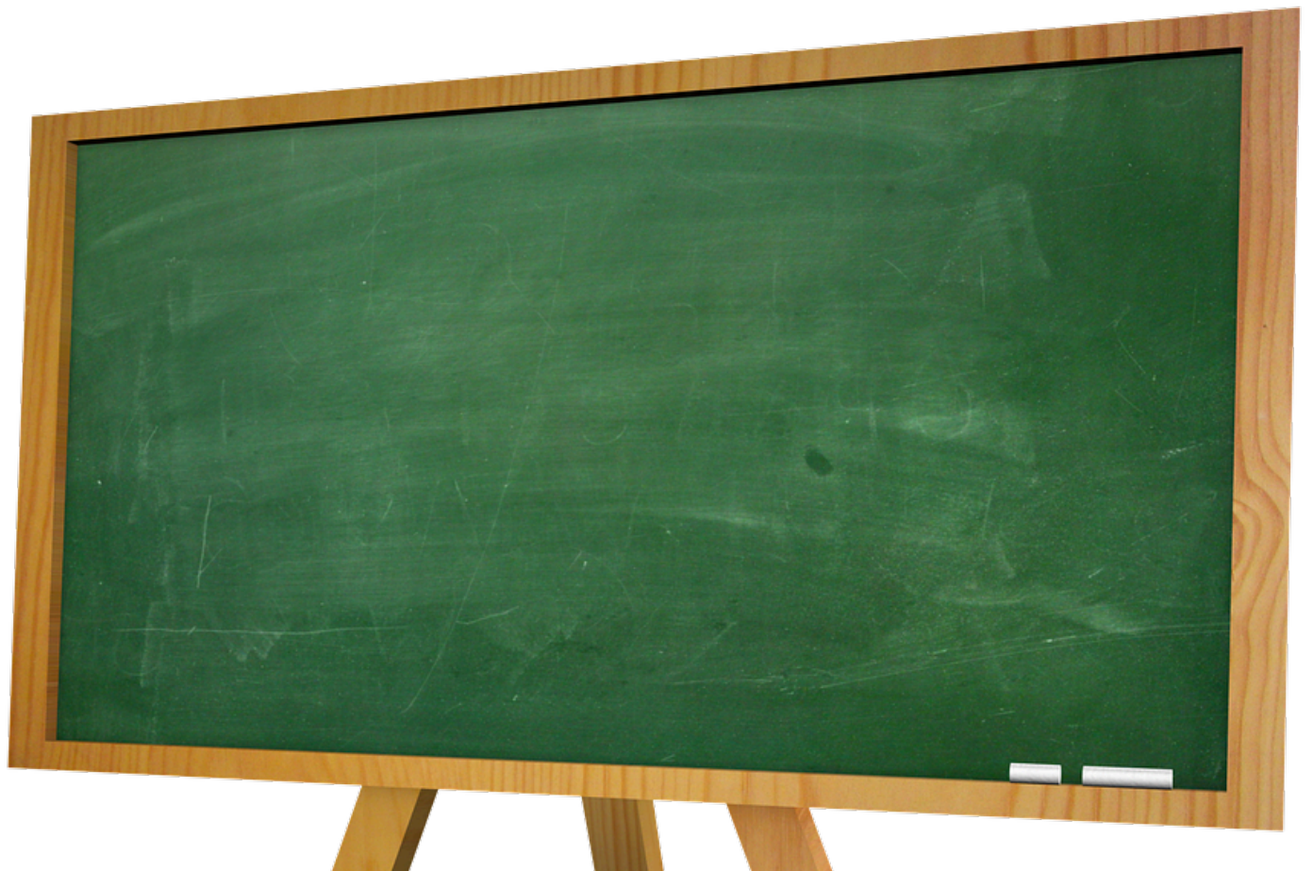
Jeff Offutt

Paul Amman

René Just (UMass)

Teaching Software Testing Concepts with Code Defenders



Encode Software Testing Concepts as Puzzles

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Encode Software Testing Concepts as Puzzles

Statement Coverage

Defending puzzle

Statement Coverage

Defending puzzle

Statement Coverage

Defending puzzle

Given this **code under test**

```
int m(int x) {
   if (int x == 5)
      return 3;
   return (x*8);
}
```

Statement Coverage

Defending puzzle

Given this **code under test**

```
int m(int x) {
  if (int x == 5)
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  return (x*8);
}
```

Statement Coverage

Defending puzzle

…and this **surviving mutant**

```
int m(int x) {
  if (int x == 5)
    return 3;
  return (x*3+7);
}
```

Given this **code under**

```
int m(int x) {
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Statement Coverage

Defending puzzle

Given this **code under test**

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Statement Coverage

Defending puzzle

Given this **code ur**

```
int m(int x)
  if (int x =
    return 3;
  return (x*8
}
```

and this **test suite**

```
@Test
void test() {
  int x = 5;
  assertEquals(3,m(x));
}
@Test
void test() {


}
```

Statement Coverage

Defending puzzle

Given this **code under test**

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Statement Coverage

Defending puzzle

create a **new test** that **detects** the mutant

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  return (x*3+7);
}
```

and this **test suite**

```
@Test
void test() {
  int x = 5;
  assertEquals(3,m(x));
}
@Test
void test() {
  int x = 3;
  assertEquals(24,m(x));
}
```

Branch Coverage

Attacking puzzle

Branch Coverage

Attacking puzzle

Branch Coverage

Attacking puzzle

Given this **code under test**

```
int m(int x) {
   int y = 1;
   if (x == 5) {
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   return (y * 8);
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Branch Coverage

Attacking puzzle

Given this **code under test**

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Branch Coverage

Attacking puzzle

…and this **passing test**

```
@Test
public void test() {
   int x = 5;
   assertEquals(24, m(x));
}
```

Given this **code**

```
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   int y =
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Branch Coverage

Attacking puzzle

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…and this **passing test**

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@Test
public void test() {
  int x = 5;
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Branch Coverage

Attacking puzzle

…**create a surviving mutant.**

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Branch Coverage

Attacking puzzle

Given this **code under test**

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int m(int x) {
  int y = 1;
  if (x == 5) {
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  }
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```

…and this **passing test**

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@Test
public void test() {
  int x = 5;
  assertEquals(24, m(x));
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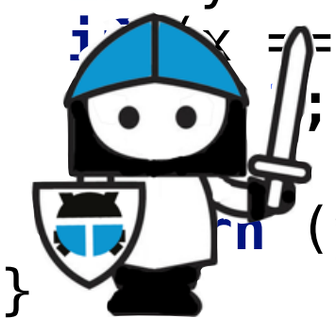

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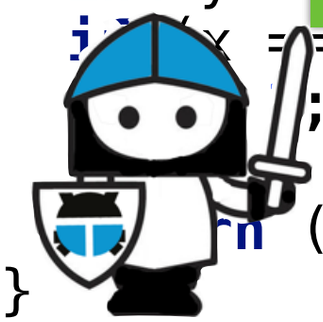

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Other Testing Concepts

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Testing loops

Other Testing Concepts

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Data-flow testing

Other Testing Concepts

Testing loops

Data-flow testing

Boundary value analysis

Other Testing Concepts

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Model-based testing

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Combinatorial testing

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Mutation testing

Related Work

Related Work

When Thursday 14:00-15:30

Session Testing II

Room Libertador C

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When Thursday 14:00-15:30

Session Testing II

Room Libertador C

Code Defenders is Fun

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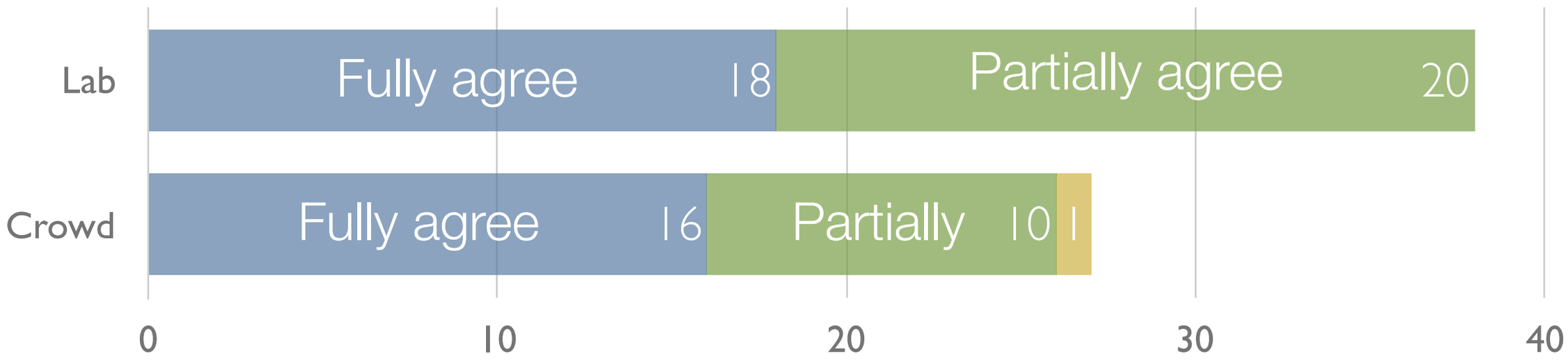
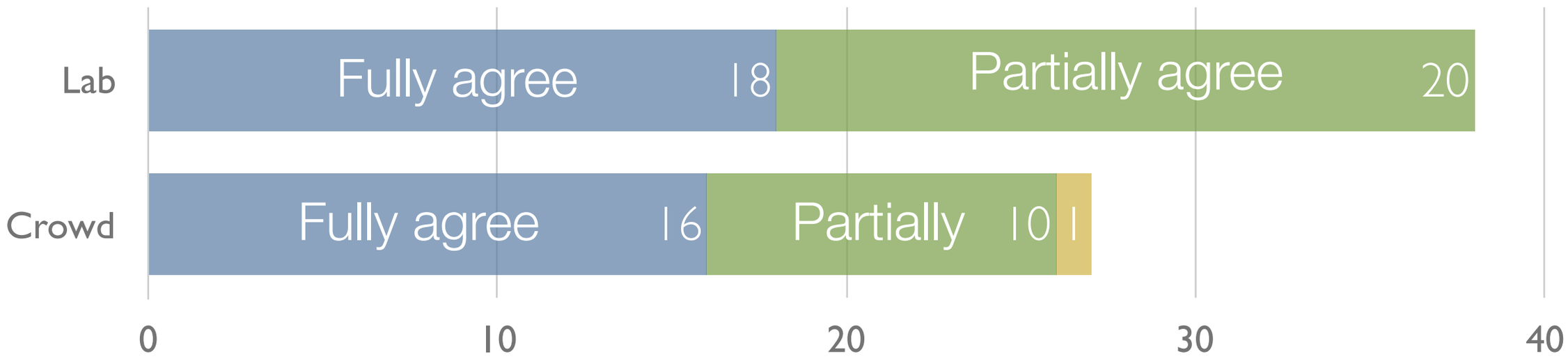
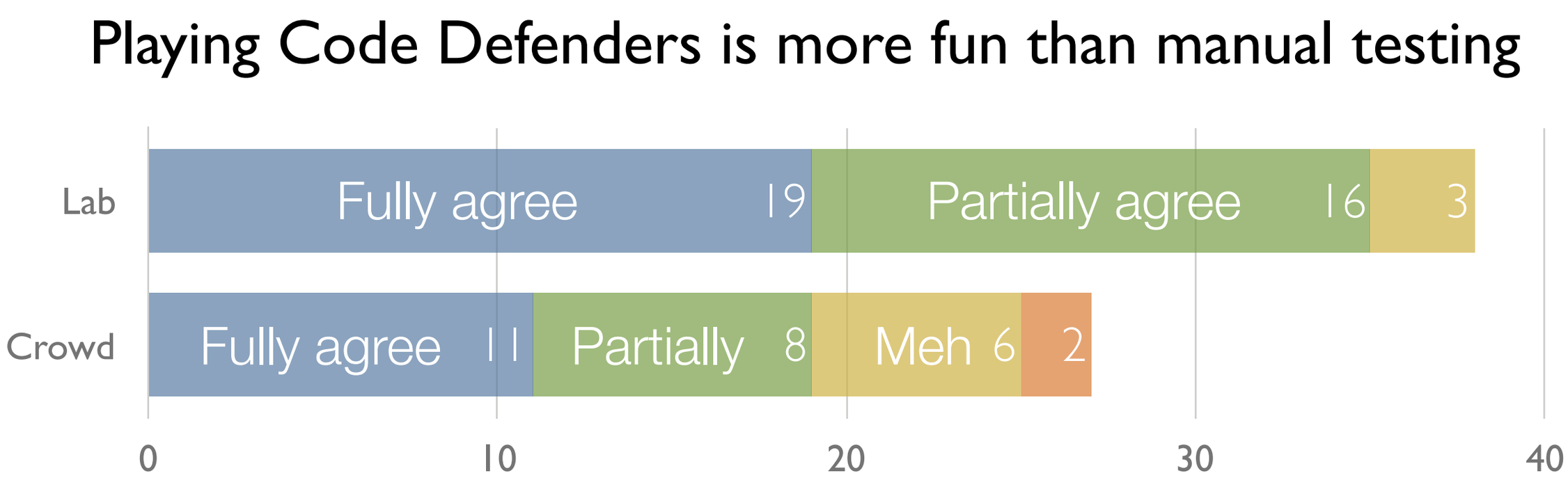
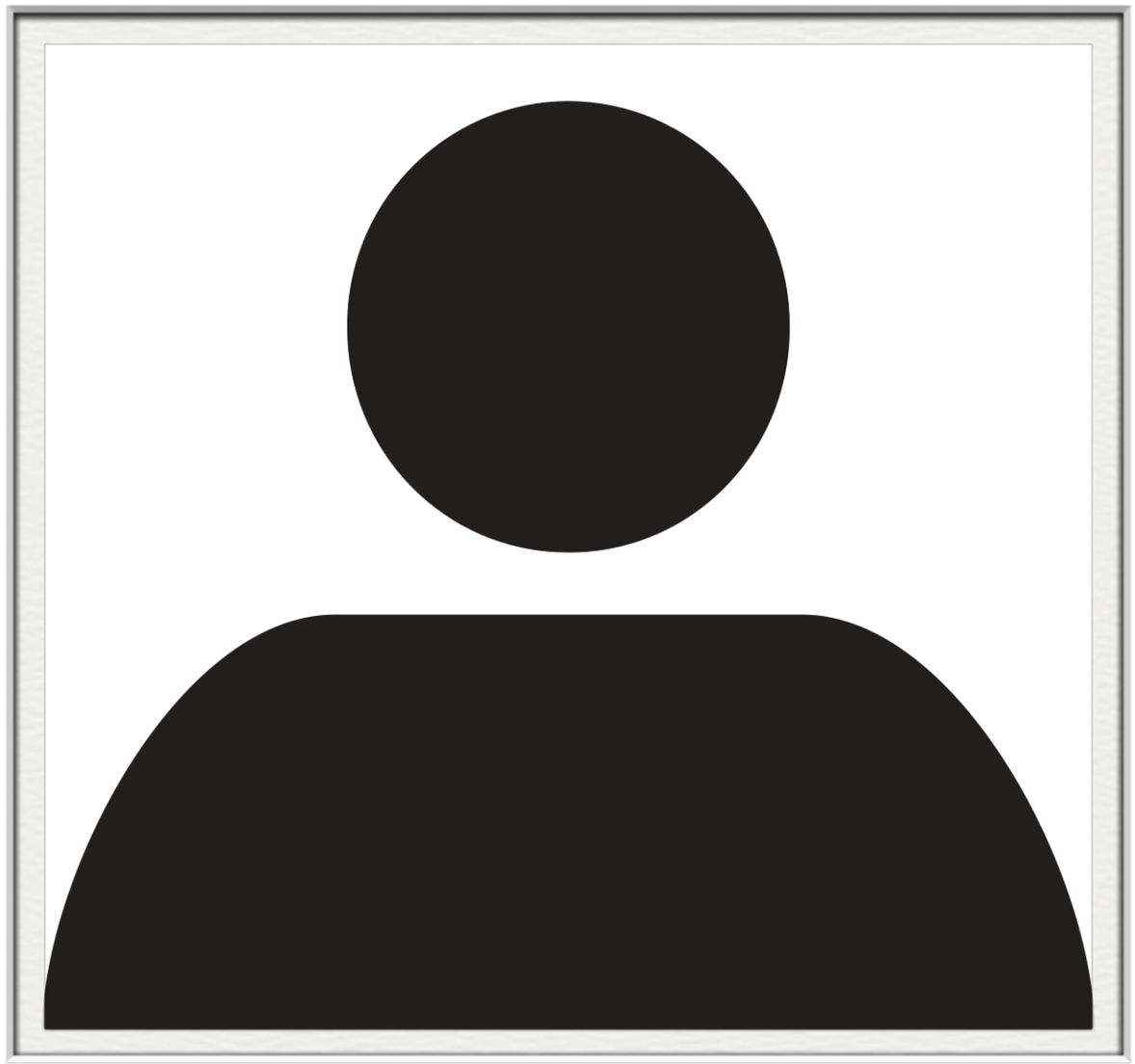


Code Defenders is Fun

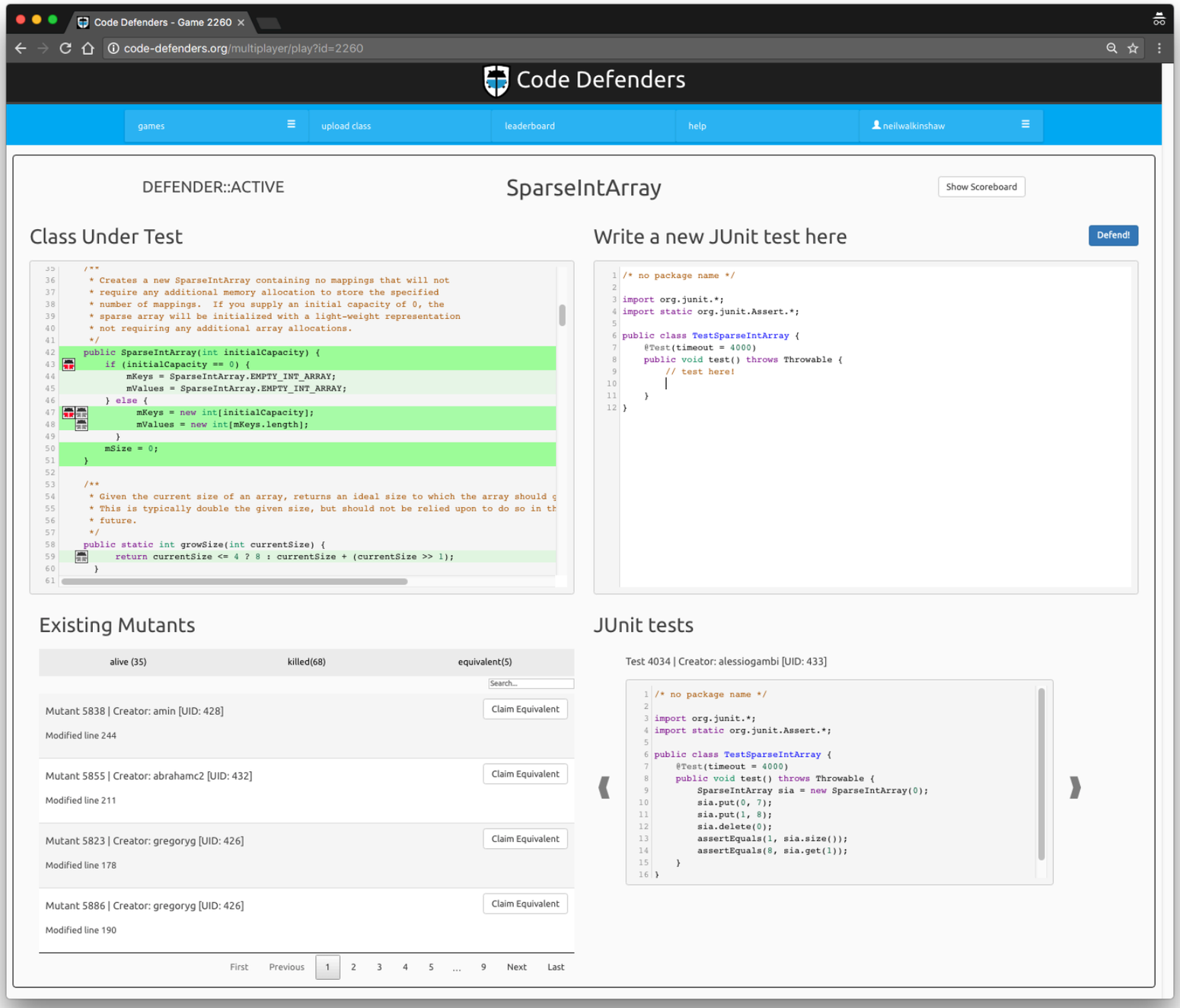




Early Adopters



You?



code-defenders.org