CSE 403

Software Engineering

Winter 2023

Testing and CI

Today

- Software testing 101
- Continuous Integration
- Live demo and Q & A

Software testing: unit testing example

```
double avg(double[] nums) {
  int n = nums.length;
  double sum = 0;

  int i = 0;
  while (i<n) {
    sum = sum + nums[i];
    i = i + 1;
  }

  double avg = sum * n;
  return avg;
}
```

Testing: is there a bug?

```
@Test
public void testAvg() {
  double nums =
      new double[]{1.0, 2.0, 3.0});
  double actual = Math.avg(nums);
  double expected = 2.0;
  assertEquals(expected,actual,EPS);
}
```

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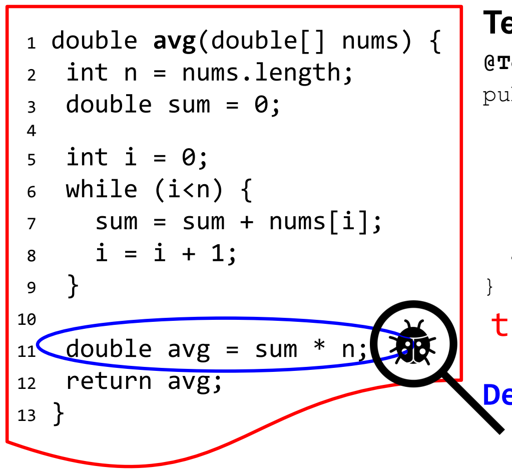
FAIL

```
testAvg failed: 2.0 != 18.0
```

Software testing vs. software debugging



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FAIL

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Debugging: where is the bug?
how to fix the bug?

Unit testing, integration testing, system testing

Unit testing

- Does each unit work as specified?

Integration testing

- Do the units work when put together?

System testing

- Does the system work as a whole?

Unit testing, integration testing, system testing

Unit testing

- Does each unit work as specified?

Integration testing

- Do the units work when put together?

System testing

- Does the system work as a whole?

Key focus in 403: unit testing

Unit testing

- A **unit** is the **smallest testable part** of the software system (e.g., a method in a Java class).
- **Goal**: Verify that each software unit performs as specified.
- **Focus**:
  - Individual units (not the interactions between units).
  - Usually input/output relationships.

Testing best practices: motivating example

Average of the absolute values of an array of doubles

```
public double avgAbs(double ... numbers) {

  // We expect the array to be non-null and non-empty
  if (numbers == null || numbers.length == 0) {
    throw new IllegalArgumentException("Array numbers must not be null or empty!");
  }

  double sum = 0;
  for (int i=0; i<numbers.length; ++i) {
    double d = numbers[i];
    if (d < 0) {
      sum -= d;
    } else {
      sum += d;
    }
  }

  return sum/numbers.length;
}
```

What tests should we write for this method?

Testing best practices: motivating example

Compare two values

```
public class Comp implements Comparable<Comp> {
  private int number;
  public Comp(int number) {this.number = number;}

  @Override
  public int compareTo(Comp other) {
    if (other.number == this.number) return 0;
    return this.number < other.number ? -1 : 1;
  }
}

public class CompTest {
  @Test
  public void testSmaller() {
    Comp c1 = new Comp(10);
    Comp c2 = new Comp(20);
    assertEquals(c1.compareTo(c2), -1);
  }
}
```

What's wrong with this test?

Live example: test automation

Testing best practices

- Table-based testing
- Parameterized unit tests

Continuous Integration

CI/CD: What's the difference?

Continuous Integration (CI)

- Integrates code into a shared repository.
- Builds/tests each change automatically.
- Complements local developer workflows (subset of tests vs. all tests).

Continuous Deployment (CD)

- Builds on top of CI.
- Software can be deployed at any time.
- Automatically pushes changes to production.

403 focuses on establishing good CI practices.

Live example: CI in action

CI examples

- Travis CI
- GitHub Actions

Q & A