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Software Testing & Debugging

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Plan for Today

- ▶ Unit Testing Randomness
- ▶ Unit Testing methods that do I/O
- ▶ RESTful API Testing

Test Randomness

► We need to distinguish:

- ❖ How to test a (pseudo)random generator?
- ❖ How to test a program that makes use of a (pseudo)random generator

How to test a (pseudo)random generator?

- ▶ How to test a (pseudo)random generator?
 - ❖ In some applications, such as cryptography, it's not enough that the random number generator works to produce an apparently random sequence, it has to be really random
 - ❖ A truly random sequence 1) must be *unpredictable* and 2) *cannot be reliably reproduced*.
 - ❖ Need statistical tests e.g., chi-square test to verify this
 - Outside the scope of our discussion

How to test a program that makes use of a pseudo-random generator

- ▶ 1. Control for the “seed” value in pseudo-random generators
 - ❖ Repeatability
- ▶ 2. Probe the range
 - ❖ Call the pseudo-random generator (a number of times) and verify the actual outputs are within the expected range
- ▶ 3. Probe the distribution
 - ❖ e.g., uniform distribution: all digits should occur with (roughly) equal frequency over a sufficiently long period of time
- ▶ 4. Use a deterministic pseudo-random generator

Set the seed value

- ▶ The algorithm of pseudo-random generator use a recursive routine starting from a base value that is determined by a value named the **"seed"**.
- ▶ Seed value “locks” the pseudo-random generator so that it produces the same exact sequence of values on every separate run.
- ▶ Thus, setting the seed value allows for replicability of runs

Example

```
public class Die {  
    private final int DEFAULT_SEED = 0;  
    Random rnd;  
    public Die(Random rnd) {  
        this.rnd = rnd;  
    }  
    public Die() {  
        this.rnd = new Random(DEFAULT_SEED);  
    }  
    public Die(int seed) {  
        this.rnd = new Random(seed);  
    }  
    public int throwDie(int bound) {  
        return rnd.nextInt(bound) + 1;  
    }  
}
```

Set the seed value

- ▶ Using a fixed seed value, a fixed sequence is generated every single time

@Test

```
public void testDie() {  
    Dice die = new Die(2);  
    assertEquals(5, dice.throwDie(6));  
    assertEquals(1, dice.throwDie(6));  
    assertEquals(3, dice.throwDie(6));  
    assertEquals(2, dice.throwDie(6));  
    // ...  
}
```

Seed value



Probe the range

```
@RepeatedTest(100)
@Test
public void testDieRange() {
    Die die = new Die(2);
    int dieVal = die.throwDie(6);
    assertTrue(dieVal <= 6 && dieVal >= 1);
}
```

Using a deterministic (Pseudo)Random

```
public class DeterministicRandom extends Random {  
    int sequentialNum = 0;  
  
    public DeterministicRandom() {  
        super();  
    }  
  
    public int nextInt() {  
        return sequentialNum++;  
    }  
}
```

// Sample usage:

```
Dice die = new Die(new DeterministicRandom());
```

Using a deterministic (Pseudo)Random

@Test

```
public void testDieDeterministicRandom() {  
    Die die = new Die(new DeterministicRandom());  
    assertTrue(die.throwDie(6) == 1);  
    assertTrue(die.throwDie(6) == 2);  
    assertTrue(die.throwDie(6) == 3);  
    // so on so forth ...  
}
```

A Method that works with an Input Stream

Reads in
its input
from an
input
stream

```
// defined in a class named MyIOUnit
public List<String> read(InputStream input) throws IOException {
    List<String> tokens = new ArrayList<>();
    StringBuilder builder = new StringBuilder();

    int data = input.read(); // read one byte of data
    while (data != -1) { // as long as there are bytes to read
        if (((char)data) != ',') { // has not reached end of token
            builder.append((char) data);
        } else {
            tokens.add(builder.toString().trim()); // add token to list
            builder.delete(0, builder.length());
        }
        data = input.read(); // read next byte of data
    }
    return tokens;
}
```

Unit Testing it!

@Test

```
public void testRead() throws IOException {  
    MyIOUnit unit = new MyIOUnit();  
    // set up the input  
    byte[] data = "123,456,789,123,456,789".getBytes();  
    InputStream input = new ByteArrayInputStream(data);  
  
    // call the method that does inputting  
    List<String> tokens = unit.read(input);  
  
    // verify results  
    assertEquals("123", tokens.get(0));  
    assertEquals("456", tokens.get(1));  
    assertEquals("789", tokens.get(2));  
    assertEquals("123", tokens.get(3));  
    assertEquals("456", tokens.get(4));  
    assertEquals("789", tokens.get(5));  
}
```

A Method that works with Output Stream

The method does not return anything!

// defined in a class named MyIOUnit

```
public void write(OutputStream output, List<String> tokens) throws IOException {  
    for(int i = 0; i < tokens.size(); i++){  
        if(i > 0) {  
            output.write(',');  
        }  
        output.write(tokens.get(i).getBytes());  
    }  
}
```

Writes its output into
an output stream!

Unit Testing it!

```
@Test
public void testWrite() throws IOException {
    MyIOUnit unit = new MyIOUnit();
    ByteArrayOutputStream output = new ByteArrayOutputStream();

    List<String> tokens = new ArrayList<>();
    tokens.add("one");
    tokens.add("two");
    tokens.add("three");

    unit.write(output, tokens);

    String string = new String(output.toByteArray());
    assertEquals("one,two,three", string);
}
```

How to test methods that perform standard I/O

- ▶ **Redirect** standard input and output using **system calls**
 - ❖ *A system call is when a program requests a service from the operating system*
 - ❖ `System.setIn(...)` and `System.setOut(...)` in Java
 - ❖ Similar constructs in other languages

A method that works with Standard I/O

```
// defined in a class named MyIOUnit
public void standardIO() {
    Scanner scnr = new Scanner(System.in);
    String st = scnr.next();
    if (st.length() > 2) {
        System.out.print("long string");
    } else {
        System.out.print("short string");
    }
}
```

Unit Testing it!

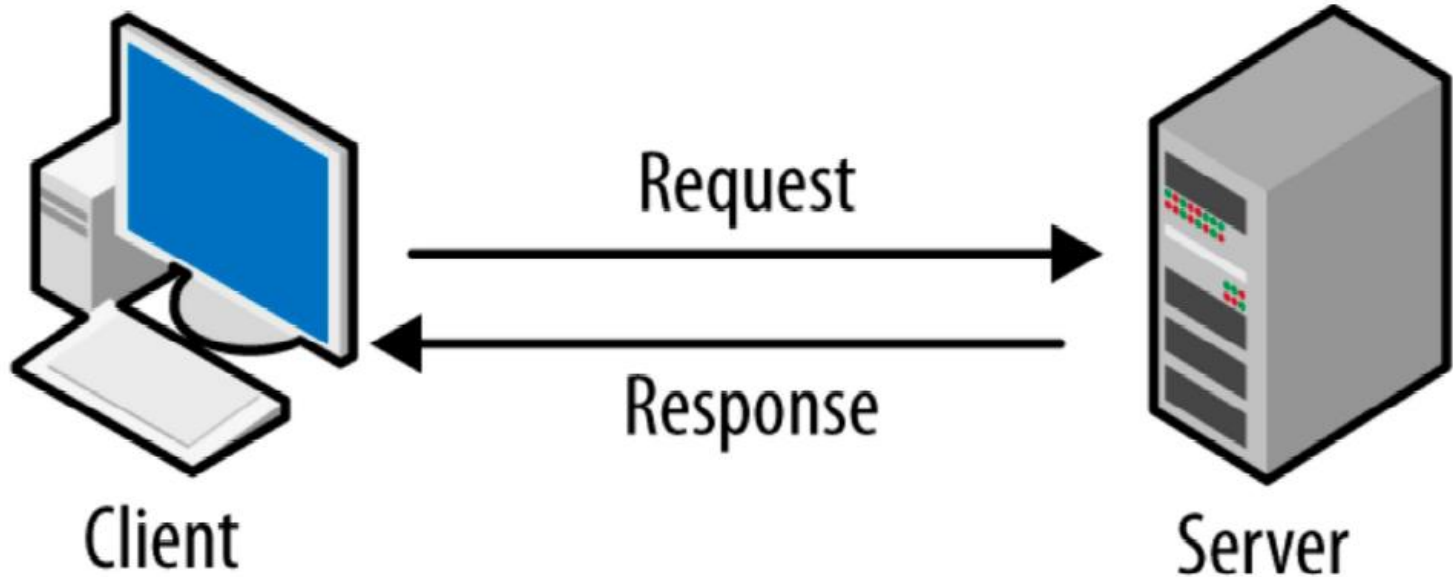
@Test

```
public void testStandardIO() {  
    MyIOUnit unit = new MyIOUnit();  
    // set up testable input and output channels  
    byte[] data = "software testing".getBytes(StandardCharsets.UTF_8);  
    BufferedInputStream in = new BufferedInputStream(new ByteArrayInputStream(data));  
    ByteArrayOutputStream output = new ByteArrayOutputStream();  
    PrintStream out = new PrintStream(output);  
    // redirect the standard channels  
    System.setIn(in);  
    System.setOut(out);  
    // call method that does standard I/O & verify results  
    unit.standardIO();  
    String string = out.toString();  
    assertEquals("long string", string);  
    // redirect the standard channels back!  
    System.setIn(System.in);  
    System.setOut(System.out);  
}
```

System calls requesting the operating system to
redirect standard I and O

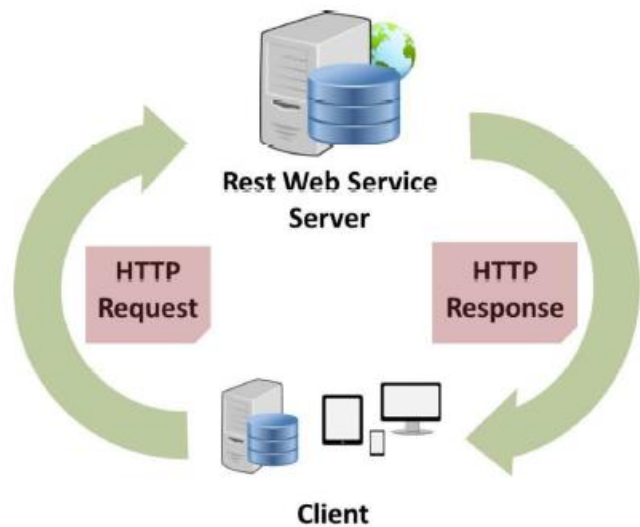
Redirecting back to originals!

Rest API Testing



Rest API Testing

- ▶ We already discussed tools like Selenium that are used for front-end (client-side) testing!
- ▶ The back-end (server-side) often-times comprised of API end-points.
 - ❖ An API endpoint is a URL that acts as the point of contact between an API client and an API server.
 - ❖ API clients send requests to API endpoints to access the API's functionality and data.
 - ❖ A typical REST API has many endpoints.



Rest API Testing

- ▶ Test each and every API end-point by
 - ❖ 1. sending an http request
 - ❖ 2. receive the response and verify it
- ▶ Kinds of http requests:
 - ❖ GET: fetch (read) a resource
 - ❖ POST: save (create) a resource
 - ❖ DELETE: remove a resource
 - ❖ PUT: update a resource

Rest API Testing

- ▶ Tool to facilitate implementing your API endpoint tests as unit tests:
 - ❖ Java: OkHttp, Unirest, Rest Assured etc.
 - ❖ Python: pyresttest
 - ❖ JS: chakram, SuperTest etc..
- ▶ Stand-alone dedicated REST API testing framework:
 - ❖ Postman
 - ❖ Eggplant
 - ❖ Etc.