P2 - Exercise hour

Julius Oeftiger

2020-03-13
Ex. 3 Recap

Unit Testing

(Ex. 4 Precap)
Ex. 3 Recap

**Parser**
- Reads input and creates commands

**Command classes**
- CommandWest, -North, ... implement ICommand
- Knowledge about board not needed!

**Turtle**
- Stores current position
- Executes commands
class Boardmaker {
    ...
    public boolean[][] makeBoardFrom(String program) ... {
        ...
        List<ICommand> commands = CommandParser.parse(program);
        for (ICommand c : commands) {
            turtle.executeCommand(c);
        }
        ...
    }
    ...
}
```java
class Turtle {
    public void moveEast(int steps) {...}
    public void moveTo(int x, int y) {...}
    ...

    public void executeCommand(ICommand cmd) {
        cmd.execute(this);
    }
}
```
class Turtle {
    public void moveEast(int steps) {...}
    public void moveTo(int x, int y) {...}
...

    public void executeCommand(ICommand cmd) {
        cmd.execute(this);
    }
}

Note: The turtle executes any command according to the command supertype...
class CommandEast implements ICommand {
    private final int steps;

    CommandEast(int steps) {
        this.steps = steps;
    }

    @Override
    public void execute(Turtle turtle) {
        turtle.moveEast(steps);
    }
}

... and commands select the correct ”move” method.
class CommandEast implements ICommand {
    private final int steps;

    CommandEast(int steps) {
        this.steps = steps;
    }

    @Override
    public void execute(Turtle turtle) {
        turtle.moveEast(steps);
    }
}

... and commands select the correct ”move” method.

- Elegant way to avoid casting.
- Actual drawing takes place in turtle code.
- See ”Design Patterns” book on course website (visitor pattern)
JUnit 5

@BeforeEach
public void initGame() {
    Player jack = new Player("Jack");
    Player jill = new Player("Jill");
    Game game = new Game(10, new Player[] { jack, jill });

    assertTrue(game.notOver());
    assertTrue(game.firstSquare().isOccupied());
    assertEquals(1, jack.position());
    // ...
}

JUnit 5: Assertions

- import static org.junit.jupiter.api.Assertions.*;
  - Provides methods like `assertTrue`, `assertEquals`,...
- Import static allows you to use all the (static) assert methods without having to use a qualified name like:
  - `Assertions/assertTrue(...) vs assertTrue(...)"
JUnit 5: Assertions

```java
assertTrue(condition);
assertEquals(expected, actual);

assertNull(object);
assertNotNull(object);

assertSame(expected, actual);
assertNotSame(expected, actual);

assertSame(expected, actual);
assertNotSame(expected, actual);
...```
JUnit 5: Assertions

```java
assertTrue(condition);
assertEquals(expected, actual);

assertNull(object);
assertNotNull(object);

assertSame(expected, actual);
assertNotSame(expected, actual);
...
```

Assert condition;
Do not use the Java assertions!
JUnit 5: Assertions

```java
assertTrue(jack.position() == 1);
```
JUnit 5: Assertions

```java
assertTrue(jack.position() == 1);
```

Tests failed: 1 of 1 test – 7 ms

java.lang.AssertionError <3 internal calls>
  at exercise_04.JUnitExamples.testPosition1(JUnitExamples.java:12) <22 internal calls>
JUnit 5: Assertions

```java
assertTrue(jack.position() == 1);
```

Tests failed: 1 of 1 test - 7 ms

```
java.lang.AssertionError  <3 internal calls>
    at exercise_04.JUnitExamples.testPosition1(JUnitExamples.java:12)  <22 internal calls>
```

What went wrong? Need to check the code...
JUnit 5: Assertions

```java
assertEquals(jack.position(), 1);
```
JUnit 5: Assertions

```java
assertEquals(jack.position(), 1);
```

Tests failed: 1 of 1 test – 10 ms

```java
java.lang.AssertionError:
Expected :0
Actual :1
<Click to see difference>
```

<1 internal call>
  at org.junit.Assert.failNotEquals(Assert.java:834) <2 internal calls>
  at exercise 04JUnitExamples.testPosition2JUnitExamples.java:18) <22 internal calls>
JUnit 5: Assertions

```java
assertEquals(jack.position(), 1);
```

**Wrong order: we expect 1, not 0!**
JUnit 5: Assertions

```
assertEquals(1, jack.position());
```
JUnit 5: Assertions

```java
assertEquals(1, jack.position());
```

Tests failed: 1 of 1 test – 9 ms

java.lang.AssertionError:
Expected : 1
Actual : 0
<Click to see difference>
JUnit 5: Assertions

```java
assertEquals(1, jack.position());
```

Tests failed: 1 of 1 test – 9 ms

java.lang.AssertionError:
Expected :1
Actual :0
<br>Click to see difference<br>

<1 internal call>
at org.junit.Assert.failNotEquals(Assert.java:834) <2 internal calls>
at exercise 04JUnitExamples.testPosition3JUnitExamples.java:24 <22 internal calls>

Correct order, but still unclear...
JUnit 5: Assertions

assertEquals(1, jack.position(),
            "Jack is on the first square.");
JUnit 5: Assertions

```java
assertEquals(1, jack.position(),
        "Jack is on the first square.");
```

Tests failed: 1 of 1 test - 15 ms

java.lang.AssertionError: Jack is on the first square.
Expected :1
Actual   :0
<Click to see difference>

<1 internal call>
+ at org.junit.Assert.failNotEquals(Assert.java:834) <1 internal call>
+ at exercise_04.JUnitExamples.testPosition4(JUnitExamples.java:30) <22 internal calls>
JUnit 5: Assertions

```java
assertEquals(1, jack.position(),
            "Jack is on the first square.");
```

Tests failed: 1 of 1 test – 15 ms

java.lang.AssertionError: Jack is on the first square.
Expected : 1
Actual   : 0
<Click to see difference>

<1 internal call>
at org.junit.Assert.failNotEquals(Assert.java:834) <1 internal call>
at exercise_04.JUnitExamples.testPosition4(JUnitExamples.java:30) <22 internal calls>

Provide a message (describing the expected outcome).
JUnit 5: Assertions

assertTrue(game.notOver() &&
    game.firstSquare().isOccupied() &&
    (1 == jack.position()) &&
    (1 == jill.position()));
JUnit 5: Assertions

```java
assertTrue(game.notOver() &&
            game.firstSquare().isOccupied() &&
            (1 == jack.position()) &&
            (1 == jill.position()));
```

Tests failed: 1 of 1 test – 9 ms

`java.lang.AssertionError`<3 internal calls>
at exercise_04.JUnitExamples.testPosition5(JUnitExamples.java:38)<22 internal calls>
Which condition made the assertion fail?
assertTrue(game.notOver(),
        "Game is not over.");
assertTrue(game.firstSquare().isOccupied(),
        "First square is occupied.");
assertEquals(1, jack.position(),
        "Jack is on the first square.");
assertEquals(1, jill.position(),
        "Jill is on the first square.");
JUnit 5: Assertions

```java
assertTrue(game.notOver(),
            "Game is not over.");
assertTrue(game.firstSquare().isOccupied(),
            "First square is occupied.");
assertEquals(1, jack.position(),
            "Jack is on the first square.");
assertEquals(1, jill.position(),
            "Jill is on the first square.");
```

Tests failed: 1 of 1 test – 9 ms

java.lang.AssertionError: First square is occupied.
  at exercise_04.JUnitExamples.testPosition6(JUnitExamples.java:52)
JUnit 5: Assertions

```java
assertTrue(game.notOver(),
           "Game is not over.");
assertTrue(game.firstSquare().isOccupied(),
           "First square is occupied.");
assertEquals(1, jack.position(),
            "Jack is on the first square.");
assertEquals(1, jill.position(),
            "Jill is on the first square.");
```

Tests failed: 1 of 1 test – 9 ms

java.lang.AssertionError: First square is occupied.
<2 internal calls>
at exercise_04.JUnitExamples.testPosition6JUnitExamples.java:52 <22 internal calls>

Use one condition per assertion!
private Game game;
private Player jack, jill;

@BeforeEach
public void initNewGame() {
    jack = new Player("Jack");
    jill = new Player("Jill");
    game = new Game(10, new Player[] { jack, jill });
}
JUnit 5: Initialization

```java
private Game game;
private Player jack, jill;

@BeforeEach
public void initNewGame() {
    jack = new Player("Jack");
    jill = new Player("Jill");
    game = new Game(10, new Player[]{jack, jill});
}
```

Use `@BeforeEach` to initialize a new game before each test method.
JUnit 5: Setup & Teardown

- **@BeforeEach**
  - Initialize before each test
  - Use for creating things common to all tests

- **@AfterEach**
  - Clean up after each test
  - Executed even if @BeforeEach or @Test fails
JUnit 5: Setup & Teardown

- **@BeforeEach**
  - Initialize before each test
  - Use for creating things common to all tests

- **@AfterEach**
  - Clean up after each test
  - Executed even if @BeforeEach or @Test fails

- **@BeforeAll** (must be static)
  - Called once before any @Test method is executed.
  - Use for time intensive tasks (creating database connections, ...)

- **@AfterAll** (must be static)
  - Clean up after all tests were run
JUnit 5: Testing Exceptions

- Make sure an exception is thrown
- Useful for making sure errors (e.g. bad input) are actually detected and handled correctly

```java
@Test
public void negativeMoveIsIllegal() {
    assertThrows(IllegalMoveException.class,
                  () -> turtle.moveEast(-1));
}
```
JUnit 5: Testing Performance

- Testing execution speed using the timeout parameter
- Time in milliseconds (!)

```java
@Test
@TimeOut(1)
// @TimeOut(value=1, TimeUnit.SECONDS) [equivalent]
public void turtleIsFast() {
    turtle.moveEast(10);
}
```
JUnit 5

- **No** control over order of execution (!)
JUnit 5

- **No** control over order of execution (!)
- Tests should not depend on other tests
JUnit 5

- **No** control over order of execution (!)
- Tests should not depend on other tests
- Do not share data between tests (instance variables, ...)

Writing good tests

- Consider different inputs and parameters
  - Common inputs, values raising exceptions
- Boundary values
  - "off-by-one" errors
- Uncommon values
  - `null` (if allowed by the contracts)
  - Empty list, array, ...
- Test outputs
  - Returned values and exceptions
- Test side effects
  - State of the system
Writing good tests

- Test classes should thoroughly test a single class
- Write test **during** development
  - You can write them even before you implemented the functionality. You know you’re done, when all tests pass.
- Write tests for every feature
As with all code: **make it readable**
- Proper, self-explaining naming
- JavaDoc if needed
- Use the appropriate assertions
- Keep tests short (few assertions per method)
Mocking

- Some components may be hard to test
  - Non-deterministic results (e.g. a die)
  - Behaviour that is difficult to reproduce (e.g. network failures)
  - Slow or expensive components
  - Incomplete components
Mocking

Some components may be hard to test
- Non-deterministic results (e.g. a die)
- Behaviour that is difficult to reproduce (e.g. network failures)

Let’s just fake it!
Mocking

- Mock objects: Crash test dummies for programmers
- Fake the real thing by manually specifying the behaviour
- Use in place of real objects
Mocking

// you can mock concrete classes, not only interfaces
ArrayList mockedList = mock(ArrayList.class);

Create a mock object
→ it can be used like any other object of that type

0Code from https://site.mockito.org/#how
Mocking

// you can mock concrete classes, not only interfaces
ArrayList mockedList = mock(ArrayList.class);

// stubbing appears before the actual execution
when(mockedList.get(0)).thenReturn("first");

Tell the mock object how to behave.
Here: when `get(0)` is called, return the String "first".

0Code from https://site.mockito.org/#how
// you can mock concrete classes, not only interfaces
ArrayList mockedList = mock(ArrayList.class);

// stubbing appears before the actual execution
when(mockedList.get(0)).thenReturn("first");

// the following prints "first"
System.out.println(mockedList.get(0));

// the following prints "null",
// because get(999) was not stubbed
System.out.println(mockedList.get(999));

0Code from https://site.mockito.org/#how
// you can mock concrete classes, not only interfaces
ArrayList mockedList = mock(ArrayList.class);

Read the documentation!

// the following prints "null",
// because get(999) was not stubbed
System.out.println(mockedList.get(999));
public ISquare moveAndLand(int moves) {
    assert moves >= 0;
    return game.findSquare(position, moves)
        .landHereOrGoHome();
}

@Test
public void testMoveAndLand() {
    Game game = new Game(10, new Player("Jack"));
    ISquare start = game.getSquare(2);
    ISquare destination = startSquare.moveAndLand(2);
    assertEquals(game.getSquare(4), destination);
}
public ISquare moveAndLand(int moves) {
    assert moves >= 0;
    return game.findSquare(position, moves)
        .landHereOrGoHome();
}

@Test
public void testMoveAndLand() {
    Game game = new Game(10, new Player("Jack"));
    ISquare start = game.getSquare(2);
    ISquare destination = start.moveAndLand(2);
    assertEquals(game.getSquare(4), destination);

    // Also needs Game.getSquare, Game.findSquare and ISquare.LandHereOrGoHome to work properly!
}

@Test
public void testMoveAndLandOnly() {
    Game game = mock(Game.class);

    when(game.isValidPosition(anyInt())).thenReturn(true);

    ISquare testSquare = new Square(game, 1);
    ISquare finding = mock(Square.class);
    ISquare landing = mock(Square.class);

    when(game.findSquare(1, 2)).thenReturn(finding);
    when(finding.landHereOrGoHome()).thenReturn(landing);

    ISquare destination = testSquare.moveAndLand(2);
    assertEquals(landing, destination);
}
@Test
class void testMoveAndLandOnly() {
    Game game = mock(Game.class); // create fake Game
    // tell the game mock what to do if isValidPosition() is called
    when(game.isValidPosition(anyInt())).thenReturn(true);

    ISquare testSquare = new Square(game, 1);
    ISquare finding = mock(Square.class);
    ISquare landing = mock(Square.class);

    when(game.findSquare(1, 2)).thenReturn(finding);
    when(finding.landHereOrGoHome()).thenReturn(landing);

    ISquare destination = testSquare.moveAndLand(2);
    assertEquals(landing, destination);
}
@Test
public void testMoveAndLandOnly() {
    Game game = mock(Game.class); // create fake Game
    // tell the game mock what to do if isValidPosition() is called
    when(game.isValidPosition(anyInt())).thenReturn(true);

    // create target on which we want to test moveAndLand()
    ISquare testSquare = new Square(game, 1);
    ISquare finding = mock(Square.class); // mocks for findSquare()
    ISquare landing = mock(Square.class); // and landHereOrGoHome()

    when(game.findSquare(1, 2)).thenReturn(finding);
    when(finding.landHereOrGoHome()).thenReturn(landing);

    ISquare destination = testSquare.moveAndLand(2);
    assertEquals(landing, destination);
}
@Test
public void testMoveAndLandOnly() {
    Game game = mock(Game.class); // create fake Game
    // tell the game mock what to do if isValidPosition() is called
    when(game.isValidPosition(anyInt())).thenReturn(true);

    // create target on which we want to test moveAndLand()
    ISquare testSquare = new Square(game, 1);
    ISquare finding = mock(Square.class); // mocks for findSquare()
    ISquare landing = mock(Square.class); // and landHereOrGoHome()

    // mock behaviour of game and finding
    when(game.findSquare(1, 2)).thenReturn(finding);
    when(finding.landHereOrGoHome()).thenReturn(landing);

    ISquare destination = testSquare.moveAndLand(2);
    assertEquals(landing, destination); // actual test for testSquare
}
Exercise 4

- Test Snakes & Ladders (our implementation)
- Fix exercise 3 if necessary
- Use JUnit and Mockito
- Write good tests with code coverage and qualitative criteria in mind
- See `exercise_04.md` for more details