A (hopefully brief) Intro to Unit Testing

Nick Sumner
with material from the GoogleTest documentation
Many different levels of testing can be considered:

- Unit Tests
- Integration Tests
- System Tests
- Acceptance Tests
- ...
Levels of Testing

• Many different levels of testing can be considered:
  – Unit Tests
  – Integration Tests
  – System Tests
  – Acceptance Tests
  – ...

• The simplest of these is *Unit Testing*
  – Testing the smallest possible fragments of a program
Unit Testing

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    - Wheels work. Steering wheel works....
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  - **System Test** a car:
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- **Not testing how well things are glued together.**
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**Why? How is this beneficial?**
Unit Tests

- A dual view:
  - They specify the expected behavior of individual components
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  - An executable specification
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• Can even be built first & used to guide development
  – Usually called Test Driven Development
Unit Tests

- Some guiding principles:
  - *Focus* on one component *in isolation*
  - Be *simple* to set up & run
  - Be easy to *understand*
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  - Focus on one component *in isolation*
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- Usually managed by some automating framework ....
GoogleTest

- Increasingly used framework for C++
  - Not dissimilar from JUnit
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- Test cases are written as functions:

```cpp
TEST(TriangleTest, isEquilateral) {
  Triangle tri{2,2,2};
  EXPECT_TRUE(tri.isEquilateral());
}
```
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The **TEST** macro defines individual test cases.
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The first argument names related tests.
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The second argument names individual test cases.
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```cpp
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  EXPECT_TRUE(tri.isEquilateral());
}
```

`EXPECT` and `ASSERT` macros provide correctness oracles.
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```

**ASSERT** oracles terminate the program when they fail.

**EXPECT** oracles allow the program to continue running.
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**TEST()** cases are automatically registered with GoogleTest and are executed by the test driver.
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- Test cases are written as functions.
- **TEST()** cases are automatically registered with GoogleTest and are executed by the test driver.
- Some tests require common **setUp & tearDown**
  - Group them into **test fixtures**
  - A fresh fixture is created for each test
class StackTest : public ::testing::Test {
  protected:
    void SetUp() override {
      s1.push(1);
      s2.push(2);
      s2.push(3);
    }

    void TearDown() override {
    }

    Stack<int> s1;
    Stack<int> s2;
};

Derive from the fixture base class
class StackTest : public ::testing::Test {
protected:

void SetUp() override {
    s1.push(1);
    s2.push(2);
    s2.push(3);
}

void TearDown() override { }

Stack<int> s1;
Stack<int> s2;

SetUp() will be called before all tests using the fixture.
class StackTest : public ::testing::Test {
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    void SetUp() override {
        s1.push(1);
        s2.push(2);
        s2.push(3);
    }

    void TearDown() override {
    }

    Stack<int> s1;
};
Use the fixture in test cases defined with `TEST_F`:

```cpp
TEST_F(StackTest, popOfOneIsEmtpy) {
  s1.pop();
  EXPECT_EQ(0, s1.size());
}
```
Use the fixture in test cases defined with `TEST_F`:

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Use the fixture in test cases defined with `TEST_F`:

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TEST_F(StackTest, popOfOneIsEmpty) {
  s1.pop();
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}
```

Behaves like

```cpp
{
  StackTest t;
  t.SetUp();
  t.popOfOneIsEmpty();
  t.TearDown();
}
```
Use the fixture in test cases defined with **TEST_F**: 

```cpp
test_f(StackTest, popOfOneIsEmpty) {
    s1.pop();
    
    EXPECT_EQ(0, s1.size());
}
```

A different expectation than before!
Use the fixture in test cases defined with `TEST_F`:

```cpp
TEST_F(StackTest, popOfOneIsEmpty) {
    s1.pop();
    EXPECT_EQ(0, s1.size());
}
```
Use the fixture in test cases defined with \texttt{TEST\_F}:

\begin{verbatim}
TEST_F(StackTest, popOfOneIsEmpty) {
    s1.pop();
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}
\end{verbatim}
GoogleTest

- Many different assertions and expectations available

```cpp
ASSERT_TRUE(condition);
ASSERT_FALSE(condition);
ASSERT_EQ(expected, actual);
ASSERT_NE(val1, val2);
ASSERT_LT(val1, val2);
ASSERT_LE(val1, val2);
ASSERT_GT(val1, val2);
ASSERT_GE(val1, val2);

EXPECT_TRUE(condition);
EXPECT_FALSE(condition);
EXPECT_EQ(expected, actual);
EXPECT_NE(val1, val2);
EXPECT_LT(val1, val2);
EXPECT_LE(val1, val2);
EXPECT_GT(val1, val2);
EXPECT_GE(val1, val2);
```
GoogleTest

- Many different assertions and expectations available
- More information available online
  - github.com/google/googletest/blob/master/googletest/docs/Primer.md
  - github.com/google/googletest/blob/master/googletest/docs/AdvancedGuide.md
Common Patterns (Ammonn & Offutt)

- Checking State
  - Final State
    - Prepare initial state
    - Run test
    - Check final state
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    • Check initial state as well as final state
  - Relative effects
    • Check final state relative to some initial state
  - Round trips
    • Check behavior on transform/inverse transform pairs
Common Patterns (Ammonn & Offutt)

- Checking Interactions/Behavior
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```c
void walkAroundSquare(Person& person) {
    person.step();
    person.turnRight();
    person.step();
    person.turnRight();
    person.step();
    person.step();
    // Skipped: person.turnRight();
    person.step();
}
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```

How can we test `walkAroundSquare()`?

Intended

Actual...
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- Checking Interactions/Behavior
  - Use *mocks*
Common Patterns (Ammonn & Offutt)

• Checking Interactions/Behavior
  – Use *mocks*
    • Testing 'fakes' that verify expected interactions
      e.g. a fake *Person* that looks for correct steps & turns
Common Patterns (Ammonn & Offutt)

- Checking Interactions/Behavior
  - Use mocks
    - Testing 'fakes' that verify expected interactions
      e.g. a fake `Person` that looks for correct steps & turns

```cpp
class MockPerson : public Person {
  // Override methods to check for
  // expected behavior.
};
```
Common Patterns (Ammonn & Offutt)

- Checking Interactions/Behavior
  - Use *mocks*
    - Testing 'fakes' that verify expected interactions
      - e.g. a fake `Person` that looks for correct steps & turns
    - [http://martinfowler.com/articles/mocksArentStubs.html](http://martinfowler.com/articles/mocksArentStubs.html)
    - [http://googletesting.blogspot.ca/2013/03/testing-on-toilet-testing-state-vs.html](http://googletesting.blogspot.ca/2013/03/testing-on-toilet-testing-state-vs.html)
Mocking Framework Example

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- Frameworks exist that can automate the boilerplate behind:
  - Mocking
    - e.g. GoogleMock, Mockito, etc.
  - Dependency Injection
    e.g. Google Guice, Pico Container, etc.
Using GoogleMock

• Steps:
  1) Derive a mock class from the class you wish to fake

```cpp
class MockThing : public Thing {
    ...
};
```
Using GoogleMock

Steps:
1) Derive a mock class from the class you wish to fake
2) Replace virtual calls with uses of MOCK_METHODn() or MOCK_CONST_METHODn().

```cpp
class MockThing : public Thing {
    public:
        ...
        MOCK_METHOD1(foo, int(int));
        MOCK_METHOD1(bar, void(int));
};
```
Using GoogleMock

- **Steps:**
  1) Derive a mock class from the class you wish to fake
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  3) Use the mock class in your tests.
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4) Specify expectations before use via `EXPECT_CALL()`.

```cpp
InSequence dummy;
EXPECT_CALL(mockThing, foo(Ge(20)))
  .Times(2)
  .WillOnce(Return(100))
  .WillOnce(Return(200));
EXPECT_CALL(mockThing, bar(Lt(5)));```

What arguments? How many times? In what order?

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  3) Use the mock class in your tests.
  4) Specify expectations before use via `EXPECT_CALL()`.
     • What arguments? How many times? In what order?
  5) Expectations are automatically checked in the destructor of the mock.
Using GoogleMock

- Precisely specifying mock behavior

```cpp
InSequence dummy;
EXPECT_CALL(mockThing, foo(Ge(20)))
  .Times(2) // Can be omitted here
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Complex behaviors can be checked using these basic pieces.
```
Common Guidelines

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  - `Foo.cpp` → `test/FooTest.cpp`
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• Keep each test case focused

• Try to test all conditions & lines
  – Much more on this in CMPT 473
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- Tests can verify *state* or *behaviors*.

And this only scratches the surface.