CMPT 373
Software Development Methods

A (hopefully brief) Intro to Unit Testing

Nick Sumner
with material from the GoogleTest documentation

Levels of Testing

- Many different levels of testing can be considered:
  - Unit Tests
  - Integration Tests
  - System Tests
  - Acceptance Tests
  - …

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- 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

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Why? How is this beneficial?

Unit Tests

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- A dual view:
  - They specify the expected behavior of individual components
  - An executable specification
- 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*

Unit Tests

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

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- Increasingly used framework for C++
  - Not dissimilar from JUnit

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TEST(TriangleTest, isEquilateral) {
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}
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The **`TEST`** macro defines individual test cases.

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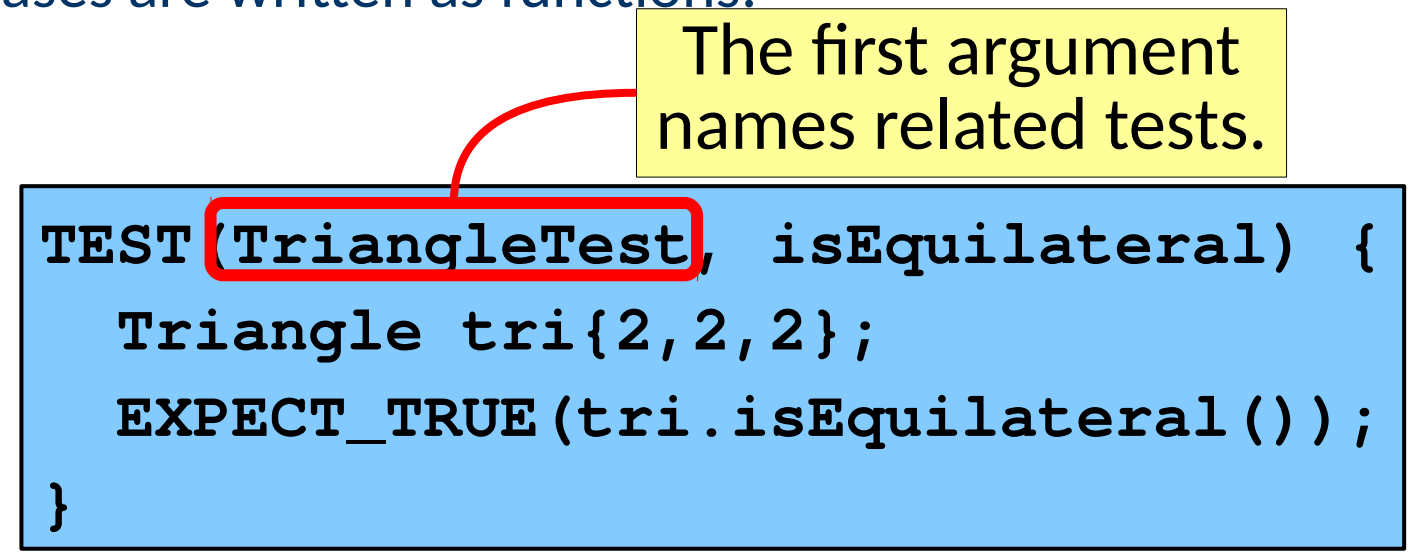

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The second argument names individual test cases.

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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 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

GoogleTest - Fixtures

```
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

GoogleTest - Fixtures

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class StackTest : public ::testing::Test {
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`TearDown()` will be called ***after*** all tests using the fixture

GoogleTest - Fixtures

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

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

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TEST_F(StackTest, popOfOneIsEmpty) {
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```

Behaves like

```
{
  StackTest t;
  t.SetUp();
  t.popOfOneIsEmpty();
  t.TearDown();
}
```

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

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A different expectation than before!

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expected value

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GoogleTest

- Many different assertions and expectations available

```
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);
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...

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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  - Relative effects
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  - Round trips
    - Check behavior on transform/inverse transform pairs

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```
void walkAroundSquare(Person& person) {
  person.step();
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  person.step();
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Intended

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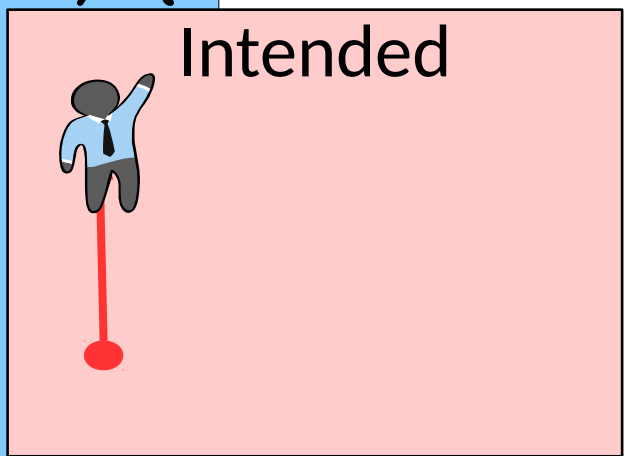

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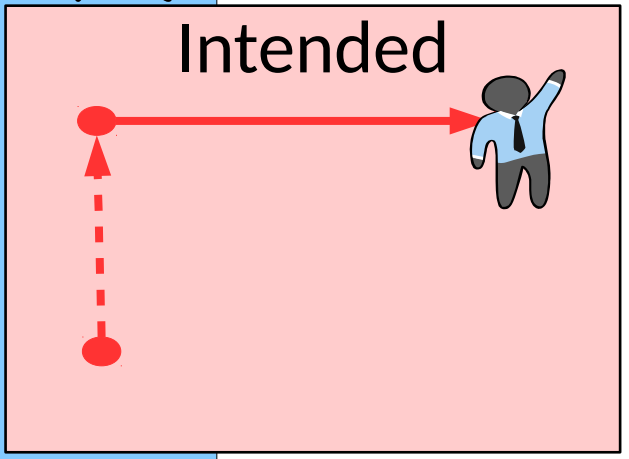

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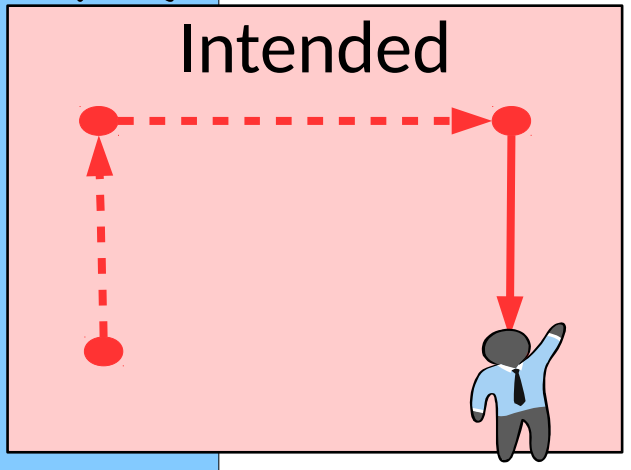

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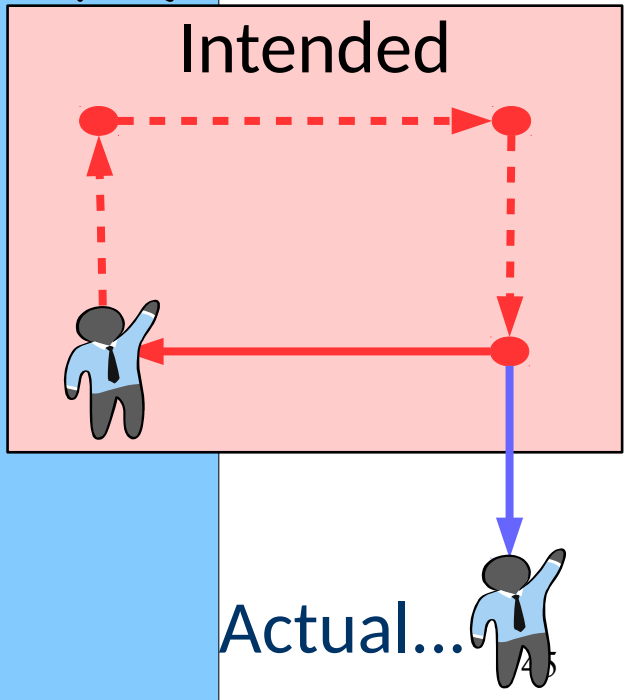

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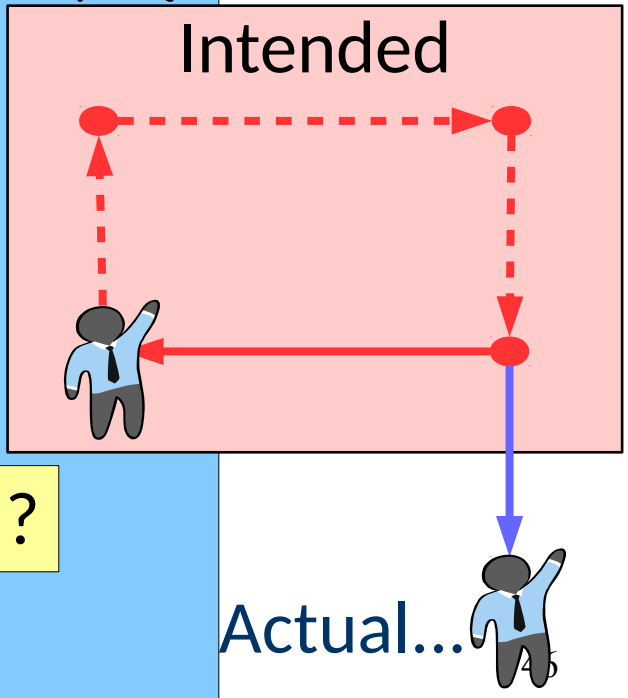
How can we test `walkAroundSquare()`?



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      e.g. a fake **`Person`** that looks for correct steps & turns

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      e.g. a fake **`Person`** that looks for correct steps & turns

```
class MockPerson : public Person {
  // Override methods to check for
  // expected behavior.
};
```

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- 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://googletesting.blogspot.ca/2013/03/testing-on-toilet-testing-state-vs.html

Mocking Framework Example

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    - 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

```
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()`**.

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

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  4) Specify expectations before use via **`EXPECT_CALL()`**.

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

```
InSequence dummy;
EXPECT_CALL(mockThing, foo(Ge(20))
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Complex behaviors can be checked using these basic pieces.

Using GoogleMock

```
TEST(walkingTests, testWalkAroundSquare) {

}
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Using GoogleMock

```
TEST(walkingTests, testWalkAroundSquare) {
   MockPerson mockPerson;









   walkAroundSquare(mockPerson);
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Using GoogleMock

```
TEST(walkingTests, testWalkAroundSquare) {
  MockPerson mockPerson;
  InSequence dummy;
  EXPECT_CALL(mockPerson, step());
  EXPECT_CALL(mockPerson, turnRight());
  …
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Note: Mocking couples implementation to tests. In practice it should be used carefully.

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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.