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SSW-555: Agile Methods for Software Development

Testing and Continuous Integration
Week 4

Today's Topics

- Overview of testing
  - Definition
  - Testing stages
- Comparing testing in traditional plan driven approach and agile approach
- Test-First (or Test-Driven) Development
- From Test-Driven to Behavior-Driven

Acknowledgements

- https://www.cs.tau.ac.il/~nachumd/horror.html
- https://www.guru99.com/software-testing-introduction-importance.html
- https://www.tutorialspoint.com/junit/
- http://junit.org/junit4/javadoc/4.12/org/junit/package-summary.html
- https://docs.python.org/dev/library/unittest.html
- http://www.softwaretestinggenius.com/all-about-system-testing-an-important-part-of-our-software-testing-effort
- http://softwaretestingfundamentals.com/acceptance-testing/

What is Software Testing?

The process of *dynamically exercising a program*, to determine whether a software system meets specific quality requirements such as conformance to specifications, performance, reliability, or robustness, etc.

- Does the system do what it's supposed to do?

Why is Testing Important?

Software failures can cause monetary and human loss…

https://www.cs.tau.ac.il/~nachumd/horror.html
https://www.guru99.com/software-testing-introduction-importance.html

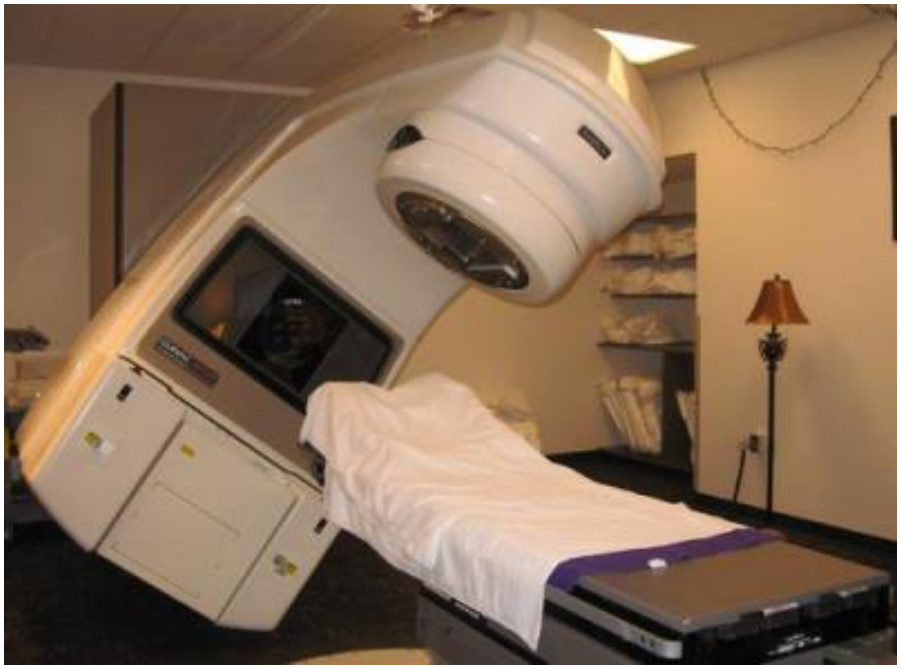
Air Crash

- A China Airlines Airbus A300 crashes on April 26, 1994

264 people killed

Therac-25 Failure

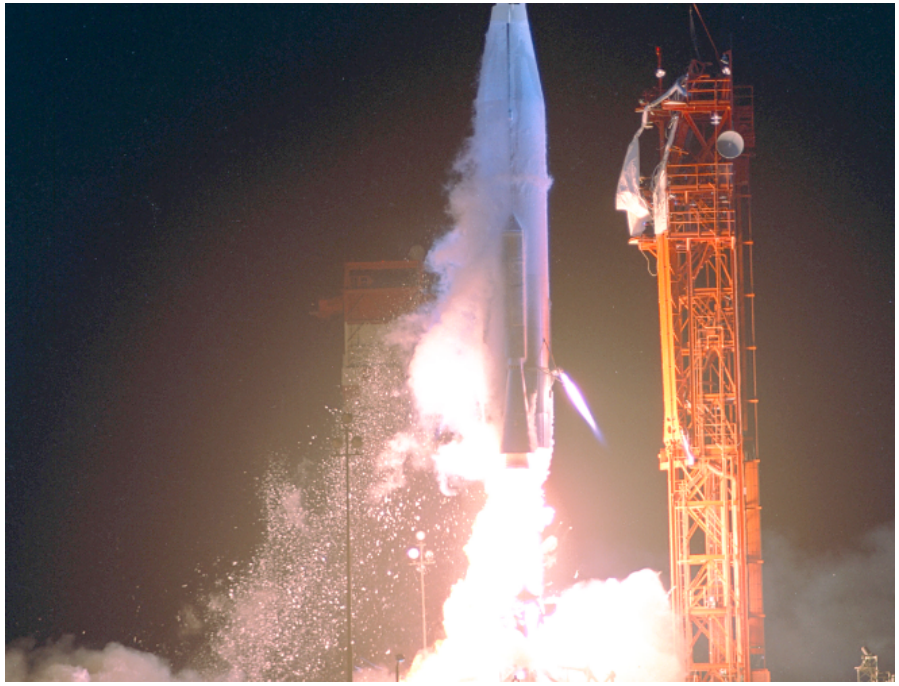
- The Therac-25 radiation overdose due to software bugs



4 patients killed, 2 life-long injured

The Most Expensive Hyphen

- 1962, the Mariner I exploded less than 5 minutes into flight due to a tiny typo in mathematical code.



$ 80 million went to waste

U.S. Bank Accounts

- May 1996, the bank updated its ATM transaction software with new message codes. The message codes were unfortunately not tested on all ATM protocols

823 customers paid $920 million

Software Testing is Important!

Software bugs could be expensive and dangerous!

Software Testing Methods

Black box testing: Examines the *functionality* of an application without peering into its internal structures or workings.

White box testing: tests internal structures or workings of an application, as opposed to its functionality.

Software Testing Phases

1. Unit Test: Test new features
2. Integration Test: Combine and test code of multiple developers
3. Regression Test: Verify that new changes haven't broken previous working code
4. System Test: Test the entire system as a whole
   - Functionality, performance, stress, security
5. User Acceptance Test: Verify that the customers are happy!

Unit Testing (xUnit)

- Framework for unit tests, e.g. jUnit, PyUnit(unittest)
- Tests are written as class methods
  - Developers appreciate that tests are code
- Test code is separate from production code
- There are similar xUnit frameworks and tools for many other programming languages
  - CUnit
  - CppUnit
  - csUnit
  - ...

Architecture of a Test

1. **fixture** – creates objects and context for test
2. **exercise** – invokes methods under test
3. **result** – asserts equality (or something else) about the results of the exercise

    Assert equal, not equal, close, membership, etc.

Example Test Fixture in Java

```java
// Setup resources for test: this is run before every test
@Override
protected void setUp() {

    m12CHF = new Money(12, "CHF");
    m14CHF = new Money(14, "CHF");
}


// Test method for add
public void testAdd() {

    Money expected26 = new Money(26, "CHF"); // Fixture
    assertNotNull(expected26);

    Money result26 = m12CHF.add(m14CHF); // Exercise
    assertNotNull(result26);
    result26 = m14CHF.add(m12CHF);
    assertNotNull(result26);

    assertEquals(expected26, result26); // Result
    assertEquals(expected26, result26);

}
```

Combining Tests in a Suite

Collect all the tests for a class in a test suite:

1. Create a new instance of TestSuite

2. Use the addTest method to include the tests you have written

```
// It allows us to choose which tests to add to your test suite
public static Test suite() {
    TestSuite suite = new TestSuite();
    suite.addTest(new MoneyTest("testEquals"));
    suite.addTest(new MoneyTest("testAdd"));
    return suite;
}

// Test method for Equal
public void testEquals() {
    Money expected = new Money(12, "CHF");
    assertEquals(expected, m12CHF);
    assertEquals(m12CHF, m12CHF);
    assertNotSame(expected, m12CHF);
    assertFalse(m12CHF.equals(m14CHF));
    assertFalse(expected.equals(m14CHF));
}
```

```
// Test method for all
public void testAdd() {

    Money expected26 = new Money(26, "CHF"); // Fixture
    assertNotNull(expected26);

    Money result26 = m12CHF.add(m14CHF); // Exercise
    assertNotNull(result26);
    result26 = m14CHF.add(m12CHF);
    assertNotNull(result26);

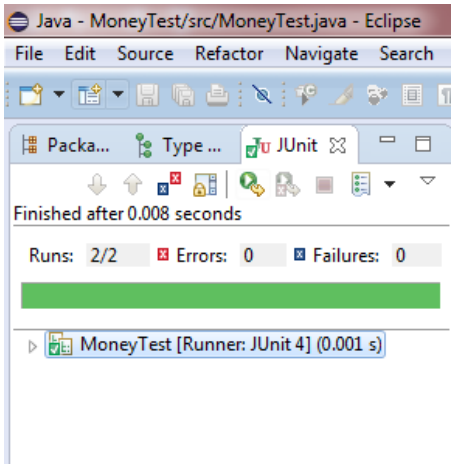
    assertEquals(expected26, result26); // Result
    assertEquals(expected26, result26);

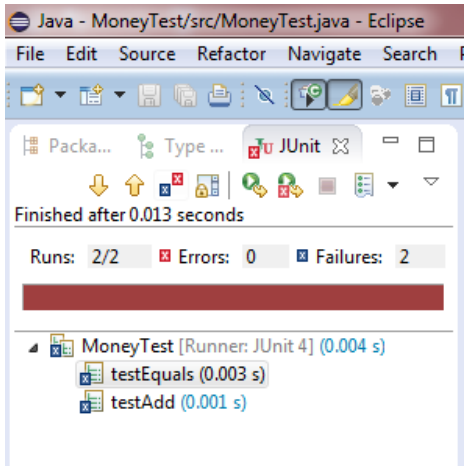
}
```

Testing and Debugging

```
// It allows us to choose which tests to add to your test suite
public static Test suite() {
    TestSuite suite = new TestSuite();
    suite.addTest(new MoneyTest("testEquals"));
    suite.addTest(new MoneyTest("testAdd"));
    return suite;
}
```

- Testing discovers problems
- Debugging fixies problems





Java Assertion

Method	Description
void assertEquals(boolean expected, boolean actual)	Checks that two primitives/objects are equal.
void assertTrue(boolean condition)	Checks that a condition is true.
void assertFalse(boolean condition)	Checks that a condition is false.
void assertNotNull(Object object)	Checks that an object isn't null.
void assertNull(Object object)	Checks that an object is null.
void assertSame(boolean condition)	The assertSame() method tests if two object references point to the same object.
void assertNotSame(boolean condition)	The assertNotSame() method tests if two object references do not point to the same object.
void assertArrayEquals(expectedArray, resultArray)	The assertArrayEquals() method will test whether two arrays are equal to each other.

https://www.tutorialspoint.com/junit/
http://junit.org/junit4/javadoc/4.12/org/junit/package-summary.html

Simple Python Unittest


```
import unittest

class TestStringMethods(unittest.TestCase):

    def test_upper(self):
        self.assertEqual('foo'.upper(), 'FOO')

    def test_isupper(self):
        self.assertTrue('FOO'.isupper())
        self.assertFalse('Foo'.isupper())

    def test_split(self):
        s = 'hello world'
        self.assertEqual(s.split(), ['hello', 'world'])
        # check that s.split fails when the separator is not a string
        with self.assertRaises(TypeError):
            s.split(2)

if __name__ == '__main__':
    unittest.main()
```

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1. Import unittest module that provides classes for supporting tests

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2. Derive a test class from *unittest.TestCase.* The test class name is arbitrary

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            s.split(2)

if __name__ == '__main__':
    unittest.main()
```

3. Define a set of methods for each Test case.

- Each test case contains calls to *unittest.TestCase.assert*()*
- Method name should begin with *'test_'*

Simple Python Unittest


```
import unittest

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            s.split(2)

if __name__ == '__main__':
    unittest.main()
```

4. Call unitttest.main() to automatically invokes all methods in test class

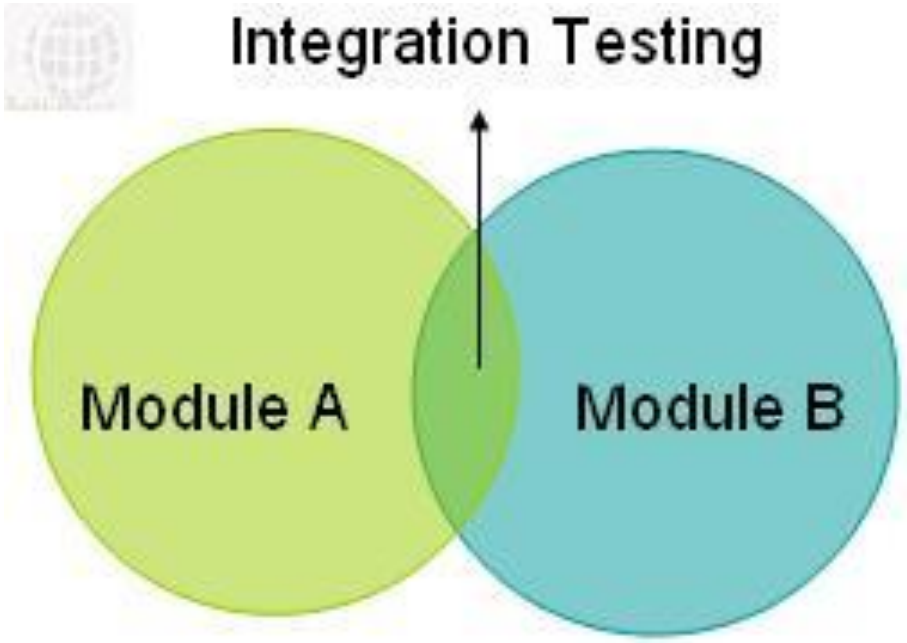
Python unittest Assert Methods

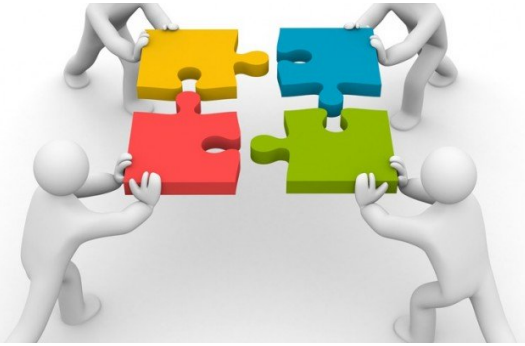
Method	Checks
assertEqual(a, b, msg=None)	a == b
assertNotEqual(a, b, msg=None)	a != b
assertAlmostEqual(a, b, places=7,msg=None)	round(a-b, places) == 0
assertNotAlmostEqual(a, b, places=7,msg=None)	round(a-b, places) != 0
assertTrue(v, msg=None)	bool(v) is True
assertFalse(v, msg=None)	bool(v) is False
assertIs(a, b, msg=None)	a is b
assertIsNot(a, b, msg=None)	a is not b
assertIsNone(v, msg=None)	v is None
assertIsNotNone(v, msg=None)	v is not None
assertIn(a, b, msg=None)	a in b
assertNotIn(a, b, msg=None)	a not in b
assertIsInstance(a, b, msg=None)	isinstance(a, b)
assertNotIsInstance(a, b, msg=None)	not isinstance(a, b)
assertRaises(Exception, function, [function args])	Exception is raised

https://docs.python.org/dev/library/unittest.html

Integration Testing

The purpose of integration testing is to verify the functional, performance, and reliability between the modules that are integrated.



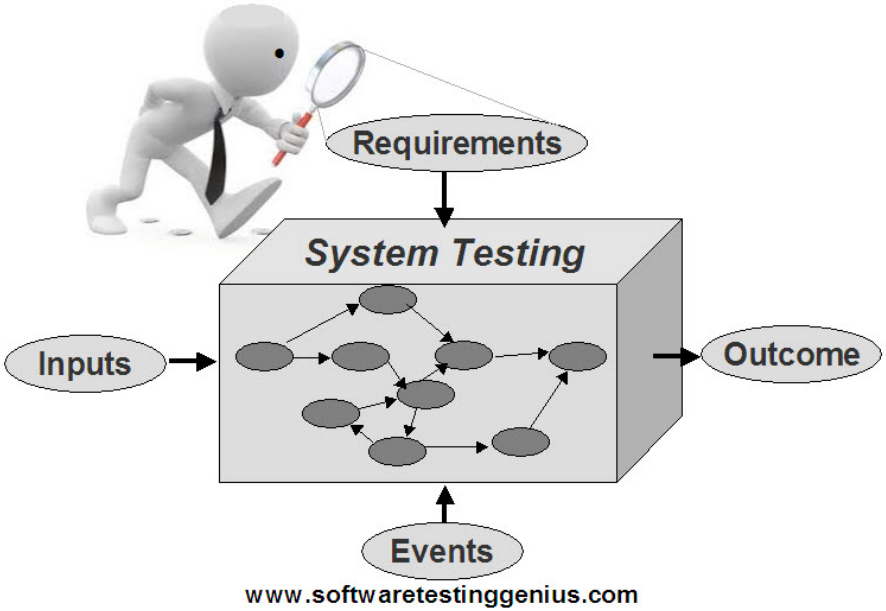


Regression Testing

- Verifies that software, which was previously developed and tested, still performs correctly after it was changed or interfaced with other software.
  - Changes may include software enhancements, patches, configuration changes, bug fixes, etc.
- Techniques:
  - Retest all
  - Test selection
  - Test prioritization

System Testing

- System Testing (ST) is a black box testing technique performed to evaluate the complete system the system's compliance against specified requirements.
- In System testing, the functionalities of the system are tested from an end-to-end perspective.
  - Functionality
  - Performance
  - Scalability
  - Stress
  - Reliability



http://www.softwaretestinggenius.com/all-about-system-testing-an-important-part-of-our-software-testing-effort

Acceptance Testing

Formal testing with respect to user needs, requirements, and business processes conducted to determine whether or not a system satisfies the acceptance criteria and to enable the user, customers or other authorized entity to determine whether or not to accept the system.

http://softwaretestingfundamentals.com/acceptance-testing/

Software Testing Comparison

Traditional Methods

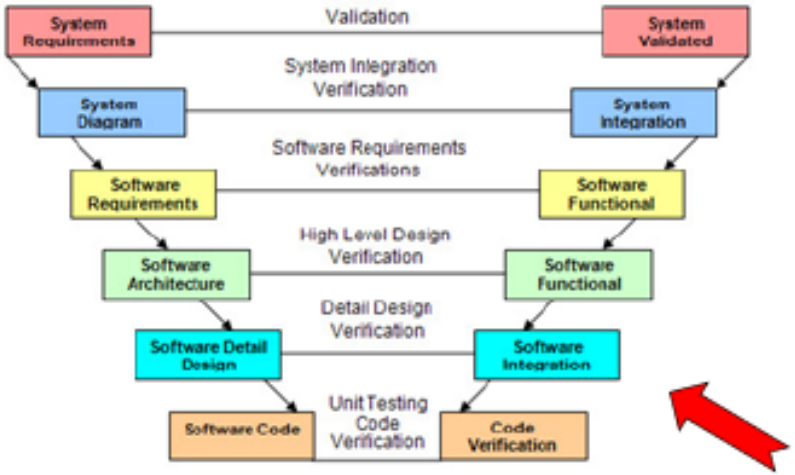
React to quality issues

Agile Methods

Proactively reduce quality issues

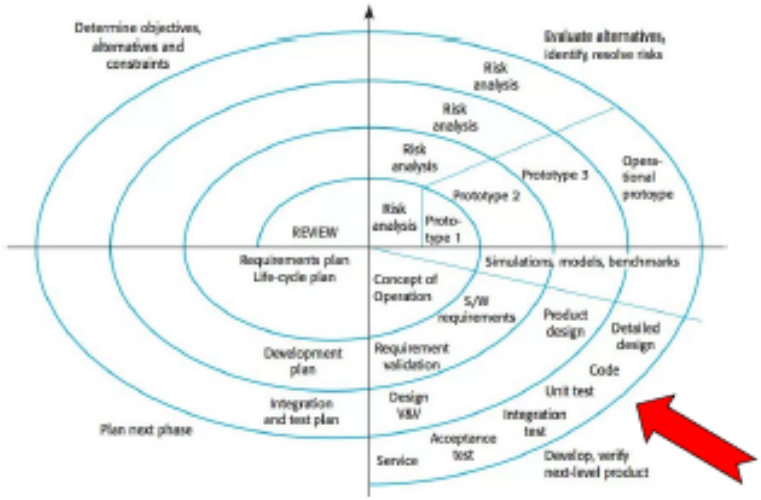
Traditional Software Testing

Waterfall/V Model



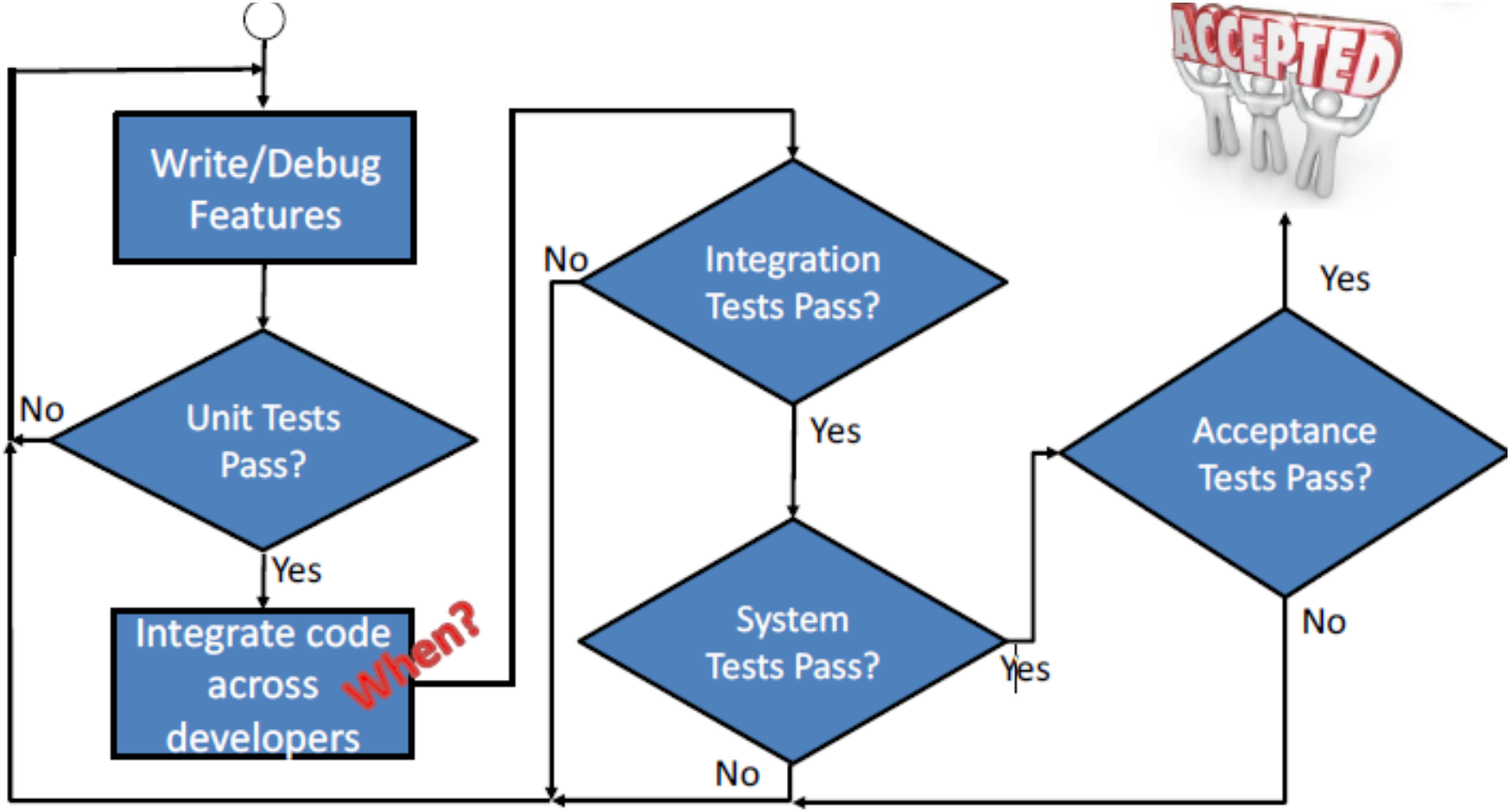
https://sites.google.com/site/advancedsofteng/software-acquisition/software-development-lifecycle-approaches

Spiral Model

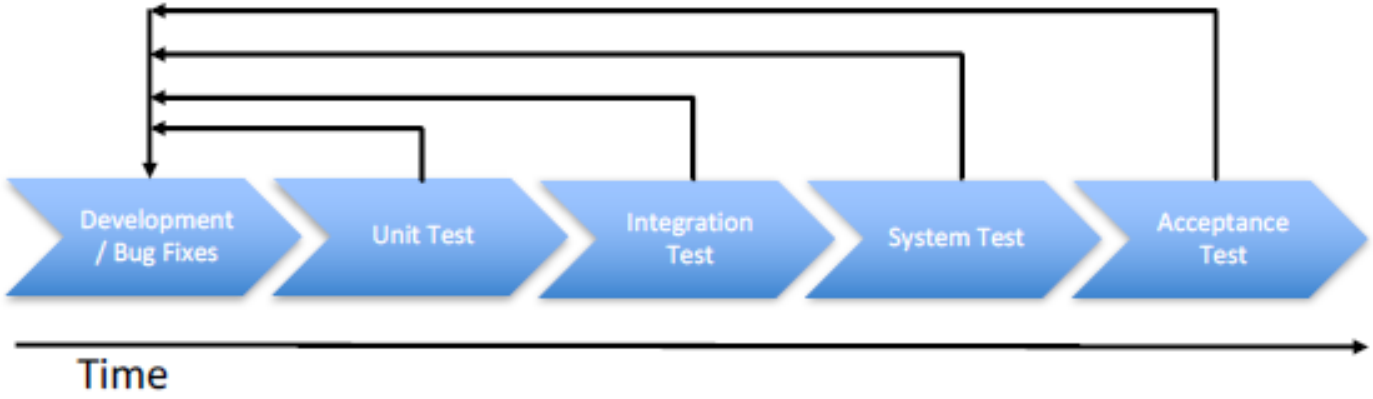


http://iansommerville.com/software-engineering-book/web/spiral-model/

Traditional Testing Flow



Traditional Testing



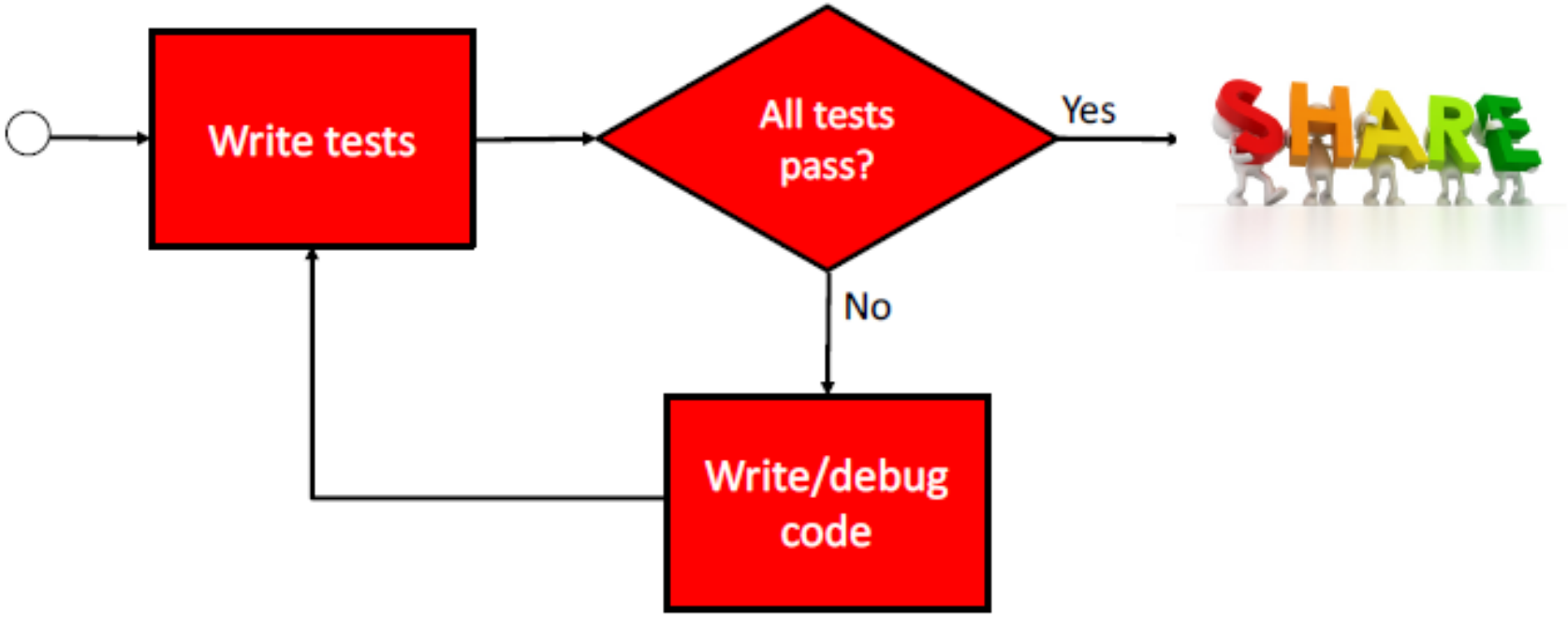
- Testing is blocked until development is “complete”
- Testing is performed by a separate test team
  - Developers might not be trusted to test their own code
- Testing schedule may be compressed if development schedule slips

Agile Testing

- Testing is NOT a separate phase with Agile Methods
  - Instead, testing is integrated into every step
- Focus on ***automated testing*** and ***continuous integration***
  - Find problems as quickly as possible
  - Expect frequent changes, so facilitate them

Agile testing is not just a passing phase…

Agile Testing Flow: Automated and Continuous



Customer Bug Reports?

- Agile Methods' focus on automated testing and continuous integration helps to reduce, but doesn't eliminate bugs found by customers
- Scrum adds new features each sprint
  - How are bugs tracked?
  - When are bugs fixed?
- Add bugs as user stories to the product backlog
  - Product owner prioritizes new features and bug fixes

Unit Testing

	Traditional	**Agile**
Who?	Developers	Developers using automated Testing platforms
What?	New features or bug fixes; Code/branch coverage	New features or bug fixes code/branch coverage
When?	After code complete; Before integration	Tests written before code is written; Run tests while developing code

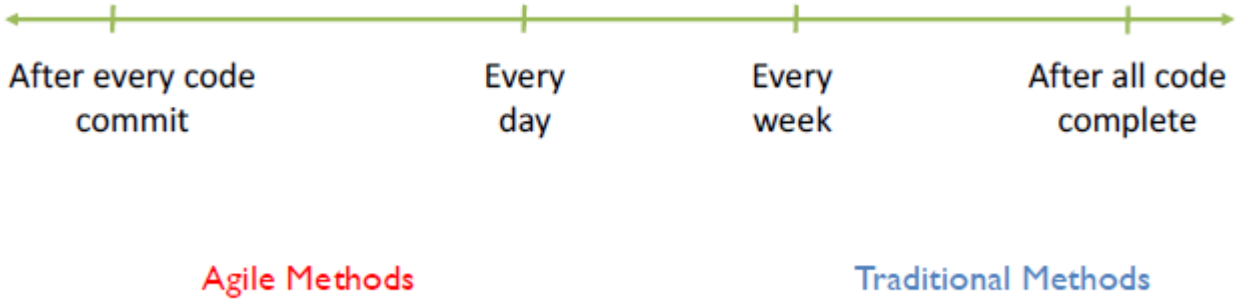
Integration Testing

	Traditional	**Agile**
Who?	Developers and/or testers	Developers using automated testing platforms
What?	Test multiple modules from potentially different developers	Test all modules from all developers
When?	After unit test is complete on relevant modules	Continuously: at least once per day if not on every code check in using existing tests

When to integrate?

Integration combines code from multiple developers

How frequently? Continuously? Periodically?



Regression Testing

	Traditional	Agile
Who?	Testers (Not the developers)	Developers using automated testing platforms
What?	Integrated modules	Entire system or selected components
When?	After changes to code for bug fixes or new features	After changes to code for bug fixes or new features

System Testing

	Traditional	Agile
Who?	System Test Team (not the developers)	Developers using automated testing platforms
What?	Test complete system Performance, security, stress testing	Test complete system Performance, security, stress testing
When?	After all code modules are complete and tested	Optional: may be done before product release cycle after several sprints

Acceptance Testing

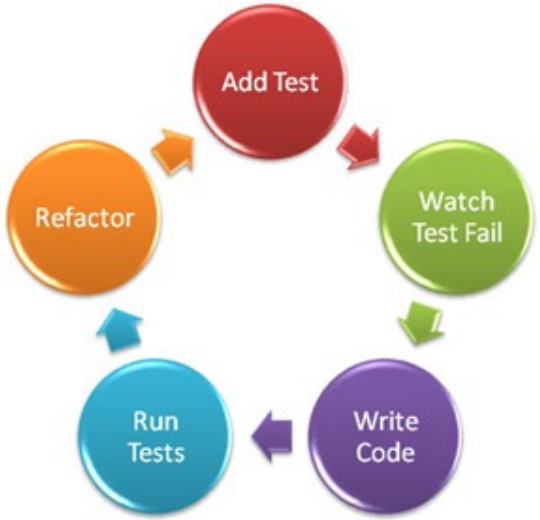
	Traditional	**Agile**
Who?	Customer test engineers	Product Owner, Stakeholders
What?	Complete system based on requirements	Overall system, Including new features from latest sprint
When?	After system test, frequently before final payment	Sprint Review

Test-First or Test-Driven Development (TDD)

- Motivation:
  - Programmers don't write tests because:
    - They don't like to
    - They don't have time
    - They have "more important" things to do
  - Result:
    - Code breaks
    - Debugging reduces productivity and doesn’t improve testing
    - Still no tests

Alternative TDD Scenario

- Write tests first
- Run the tests (they will probably fail)
- Write some code
- Rerun the tests
- Debug until the tests pass
  - Relatively little untested code at any one time so bugs are likely to be in the most recent code



TDD Provides Useful Feedback

- Programmers get feedback when their tests pass
- Programmers get feedback when their tests fail
- Customers get feedback when the tests pass or fail
  - Provides insights on how the developers are doing
- Provides frequent metrics for management

Pace

- Write a few tests
- Write a few lines of code

- Don't write too many tests at once
- Don't write too much code at once because it’s harder to debug until you know it works properly

From TDD to BDD (Behavior-Driven Development)

- Customers and some developers have trouble defining tests:
  - Where to start?
  - What to test?
  - What to call the tests?
- How can we improve the test process to include the customer?
  - Change the syntax and simplify the process!

Simplify Testing

- Replace source code with natural language descriptions
  - Eliminate the word "Test"
- Change from:
  - *public class CustomerLookupTest extends TestCase {*
    - *testFindsCustomerById() { ... }*
    - *testFailsForDuplicateCustomers() { ... }*
    - *...*
  - *}*
- To:

  CustomerLookup

  finds customer by id

  fails for duplicate customers

  ...

Map User Story to Tests

As a [X]

I want [Y]

so that [Z]

As a customer,

I want to withdraw cash from an ATM,

so that I don’t need to wait in line at the bank.

Behavior Templates Aid Testing

Given some initial context (the givens),

When an event occurs,

Then ensure some outcomes.

Given the account is in credit

And the card is valid

And the dispenser contains cash — Pre-conditions

When the customer requests cash — Event

Then ensure the account is debited

And ensure cash is dispensed

And ensure the card is returned — Post-conditions

User Stories to Behavior Stories

- Behavior stories are still easy for customers to write and understand
  - Describe what needs to happen
- BUT…

Behavior Stories are easier to map automatically from user descriptions to executable test cases

BDD Tools

- JBehave: JUnit for customers
- RBehave: JBehave in Ruby
- Behave: Behave for Python
- RSpec: Evolution of RBehave
- Cucumber: UI specs in natural language for Ruby

... similar tools for Python, C, C++, Delphi, PHP, .Net

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