Testing and Integration

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Signs a module is test-deficient

- Changes to a module take twice as long to debug and deploy as other modules
- Changes to a module broke the app more than twice
- A module's code is never deleted or modified, only added to.
- "We don't touch that module. It's too important to risk breaking."

Types and purposes of testing

- Acceptance tests
  - just-in-time requirements for each user story
- Unit tests
  - executable documentation of the intended behavior of every unit of code
  - regression tests
    - a regression test catches changes that break previously working code
- Integration tests
  - confirmation that tested modules work together correctly

Acceptance tests

A user can add an item to the shopping cart

Given I am logged in
When I add an item to my shopping cart
Then my shopping cart page contains the item

Given I am not logged in
When I add an item to my shopping cart
Then my shopping cart page contains the item

Given my shopping cart page contains items
and I am not logged in
When I log in
Then my shopping cart page has the same items as before

Acceptance tests

- Client and developers define acceptance tests for each user story
  - current iteration stories only!
- Typically a new product will end up with dozens to a hundreds
- Many tools exist to make these more readable by clients
  - Cucumber: http://cukes.info/
  - Fitnesse: http://fitnesse.org/

Unit tests

```
public void TestPhoneValidator()
{
      string goodPhone = "(123) 555-1212";
      string badPhone = "555 12"

      PhoneValidator validator = new PhoneValidator();

      Assert.IsTrue(validator.IsValid(goodPhone));
      Assert.IsFalse(validator.IsValid(badPhone));
}
```

http://stackoverflow.com/questions/4910138/unit-test-examples

Unit tests

- Written by developers
- Test units (functions, methods, classes)
- Need to be numerous, fast, automated
  - if not fast and automated, they won't be run
- Frameworks for writing and running unit tests exist for all modern programming languages
  - Don't write your own framework!

Test-driven Development (TDD)

- When writing a new unit of code
  - write test code for it first
  - run all the unit tests
  - make sure only the right new ones fail
- Write just enough code to make all tests pass
- Repeat

Integration tests

This tests the business logic for an order page

```
public class OrderStateTester extends TestCase {
  private static String TALISKER = "Talisker";
  private Warehouse warehouse = new WarehouseImpl();

  protected void setUp() throws Exception {
    warehouse.add(TALISKER, 50);
  }

  public void testOrderIsFilledIfEnoughInWarehouse() {
    Order order = new Order(TALISKER, 50);
    order.fill(warehouse);
    assertTrue(order.isFilled());
    assertEquals(0, warehouse.getInventory(TALISKER));
  }

  public void testOrderNotFilledIfNotEnoughInWarehouse() {
    Order order = new Order(TALISKER, 51);
    order.fill(warehouse);
    assertFalse(order.isFilled());
    assertEquals(50, warehouse.getInventory(TALISKER));
  }
}
```

making calls to a warehouse database object

order objects and warehouse data must update consistently

Integration tests

- Written by developers
- Test collections of communicating modules
  - should include all major communication paths
- Are typically fewer and slower than unit tests
- Failure should lead to new unit tests, e.g., if module B fails when called by A
  - if A sent bad data, add unit tests on A to catch that
  - if B failed to handle good data, add unit tests on B to catch that

Testing: the fine points

Test names should be sentences

My first “Aha!” moment occurred as I was being shown a deceptively simple utility called agiledox, written by my colleague, Chris Stevenson. It takes a JUnit test class and prints out the method names as plain sentences, so a test case that looks like this:

```
public class CustomerLookupTest extends TestCase {
    testFindsCustomerById() {
        ...
    }
    testFailsForDuplicateCustomers() {
        ...
    }
    ...
}
```

becomes

```
CustomerLookup
- finds customer by id
- fails for duplicate customers
- ...
```

[Developers] found that when they wrote the method name in the language of the business domain,the generated documents made sense to business users, analysts, and testers.

http://dannorth.net/introducing-bdd/

Test naming

`test`[Event][CorrectResult]`()`

- ~~testAccounts~~
- ~~testDeposit~~
- ~~testDepositZero~~
- testDepositZeroIsError
- testDepositZeroLeavesBalanceUnchanged

- Greater clarity to all readers
- Easy review to see what's been tested
- Encourages one test to a test

Only test functions worth testing

- Only test public functions
  - Private functions can and should be able to change freely
  - Private function bugs only matter when they affect public behavior
- Only test logically non-trivial functions
  - Don't write tests for accessors, e.g., getRadius(), setName(), ... unless there's more code than getting/setting an internal variable

Document bugs in tests

- When a bug happens, don't fix it.
- First, write a unit test that reliably reproduces the bug.
  - Until you can, you don't understand the bug
- Now write code to pass the test and fix the bug.

A Unit Test Challenge

- Unit tests
  - should be numerous, fast, automated
  - should test the unit, not other classes
  - should not cross module boundaries
- How can you unit test code without making integration tests?
  - calling code in other modules
  - very slow, e.g., database connections
  - calling code that may not exist yet

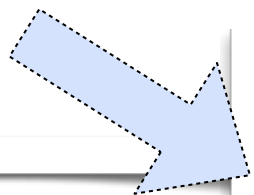
Solution: Mock objects

- A mock object imitates an object from another class
- A mock object provides two key features:
  - it can be used like an object needed by the unit under test
  - it can record and verify that the mock object was correctly used by the unit under test
- Implementing mock objects by hand can be tedious for classes with many methods
- Mock libraries provide tools for making mocks in just a few steps

Preparing for mock objects

- In languages like Java that distinguish classes (code) from interfaces (APIs), replace classes to be mocked with interfaces. (Good practice in general)

```
public class Warehouse {
  public int getInventory(int unitId) {
    ...db query...
  }
  ...
}
```



```
public interface Warehouse {
  public int getInventory(int unitId)
  ...
}
```

```
public class WarehouseImpl implements Warehouse {
  public int getInventory(int unitId) {
    ...db query...
  }
  ...
}
```

jMock 1: using Mock class

```
public class OrderTester extends TestCase {
  private Warehouse warehouse = new WarehouseImpl();
  ...
  public void testOrderIsFilledIfEnoughInWarehouse() {
    Order order = new Order(TALISKER, 50);
    order.fill(warehouse);
    assertTrue(order.isFilled());
    assertEquals(0, warehouse.getInventory(TALISKER));
  }
```

```
public class OrderTester extends MockObjectTestCase {
  ...
  public void testOrderIsFilledIfEnoughInWarehouse()
{
    Order order = new Order(TALISKER, 50);
    Mock warehouseMock = new Mock(Warehouse.class);
    ...
    order.fill((Warehouse) warehouseMock.proxy());
    assertTrue(order.isFilled());
    warehouseMock.verify();
  }
```

create a mock Warehouse

pass the mock to Order

verify the mock's expectations

http://martinfowler.com/articles/mocksArentStubs.html

jMock 1: using mock() method

```
public class OrderTester extends TestCase {
  private Warehouse warehouse = new WarehouseImpl();
  ...
  public void testOrderNotFilledIfNotEnoughInWarehouse() {
    Order order = new Order(TALISKER, 51);
    order.fill(warehouse);
    assertFalse(order.isFilled());
    assertEquals(50, warehouse.getInventory(TALISKER));
  }
```

defines mock() method

```
public class OrderTester extends MockObjectTestCase {
  ...
 public void testOrderNotFilledIfNotEnoughInWarehouse
    Order order = new Order(TALISKER, 51);
    Mock warehouse = mock(Warehouse.class);
    ...
    order.fill((Warehouse) warehouse.proxy());
    assertFalse(order.isFilled());
  }
```

call mock() to make mocked object

mocked() objects are verified automatically when test finishes

http://martinfowler.com/articles/mocksArentStubs.html

jMock 1: setting expectations

```
public void testOrderIsFilledIfEnoughInWarehouse() {
  Order order = new Order(TALISKER, 50);
  Mock warehouseMock = new Mock(Warehouse.class);

  warehouseMock.expects(once()).method("hasInventory")
    .with(eq(TALISKER),eq(50))
    .will(returnValue(true));
  warehouseMock.expects(once()).method("remove")
    .with(eq(TALISKER), eq(50))
    .after("hasInventory");

  order.fill((Warehouse) warehouseMock.proxy());
  warehouseMock.verify();
  assertTrue(order.isFilled());
}
```

expectations define the expected usage of mock object in a specific test

hasInventory (TALISKER, 50) should be called once, and will return

remove(TALISKER, 50) should be called once, after hasInventory() call

http://martinfowler.com/articles/mocksArentStubs.html

EasyMock 1: setting expectations

```
public class OrderEasyTester extends TestCase {
  ...
  private MockControl warehouseControl;
  private Warehouse warehouseMock;

  public void setUp() {
    warehouseControl = MockControl.createControl(Warehouse.class);
    warehouseMock = (Warehouse) warehouseControl.getMock();
  }

  public void testOrderIsFilledIfEnoughInWarehouse() {
    Order order = new Order(TALISKER, 50);

    warehouseMock.hasInventory(TALISKER, 50);
    warehouseControl.setReturnValue(true);
    warehouseMock.remove(TALISKER, 50);
    warehouseControl.replay();

    order.fill(warehouseMock);
    warehouseControl.verify();
    assertTrue(order.isFilled());
  }
```

normal JUnit TestCase

record and replay approach to setting expectations

compiled method calls

http://martinfowler.com/articles/mocksArentStubs.html

jMock 2: generic API

```
public class OrderTester extends MockObjectTestCase {
  ...
  public void testOrderIsFilledIfEnoughInWarehouse() {
    final Order order = new Order(TALISKER, 50);
    final Warehouse warehouseMock = mock(Warehouse.class);

    checking(new Expectations() {{
      final Sequence ordering = sequence("ordering");
      oneOf (warehouseMock).hasInventory(TALISKER, 50);
      inSequence(ordering);
      oneOf (wareHouseMock).remove(TALISKER, 50);
      inSequence(ordering);
    }}

    order.fill(warehouseMock);
    assertTrue(order.isFilled());
  }
```

with Java generics, no Mock class, no typecasting

Java Double-Brace initializer block

expectations stored in separate Expectations object

sequences are optional and separate objects

EasyMock 3.0 also has a generic API

Mock libraries

- Javascript
  - http://testdrivenwebsites.com/2010/05/06/java-script-mock-frameworks-comparison/
- Ruby
  - http://www.ruby-toolbox.com/categories/mocking.html
- PHP
  - SimpleTest includes a mocking API:
    - http://www.lastcraft.com/mock_objects_documentation.php
  - Mockery, usable with PHPUnit
    - http://blog.astrumfutura.com/2010/05/mockery-from-mock-objects-to-test-spies/
- Python
  - Mocker -- uses record/replay approach
    - http://labix.org/mocker
  - Fudge - modeled on jMock
    - http://farmdev.com/projects/fudge/

Testing web pages

Browser compatibility testing, Part 1

- Use the right DOCTYPE
  - http://hsivonen.iki.fi/doctype/#choosing
  - Avoid quirks mode at all costs!
    - http://www.cs.tut.fi/~jkorpela/quirks-mode.html
- Validate your HTML and CSS
  - Keep your browser Console open. Make sure your pages generate no errors or warnings.
  - Run a validator for HTML and CSS before checkin.
    - http://validator.w3.org/
    - http://jigsaw.w3.org/css-validator/

Browser compatibility testing, Part 2

- install multiple browsers
  - at least IE, Firefox, Safari, Chrome
    - there are ways to run multiple versions of IE, e.g.,
      - http://utilu.com/IECollection/
  - visually inspect your pages at least once a week in every browser

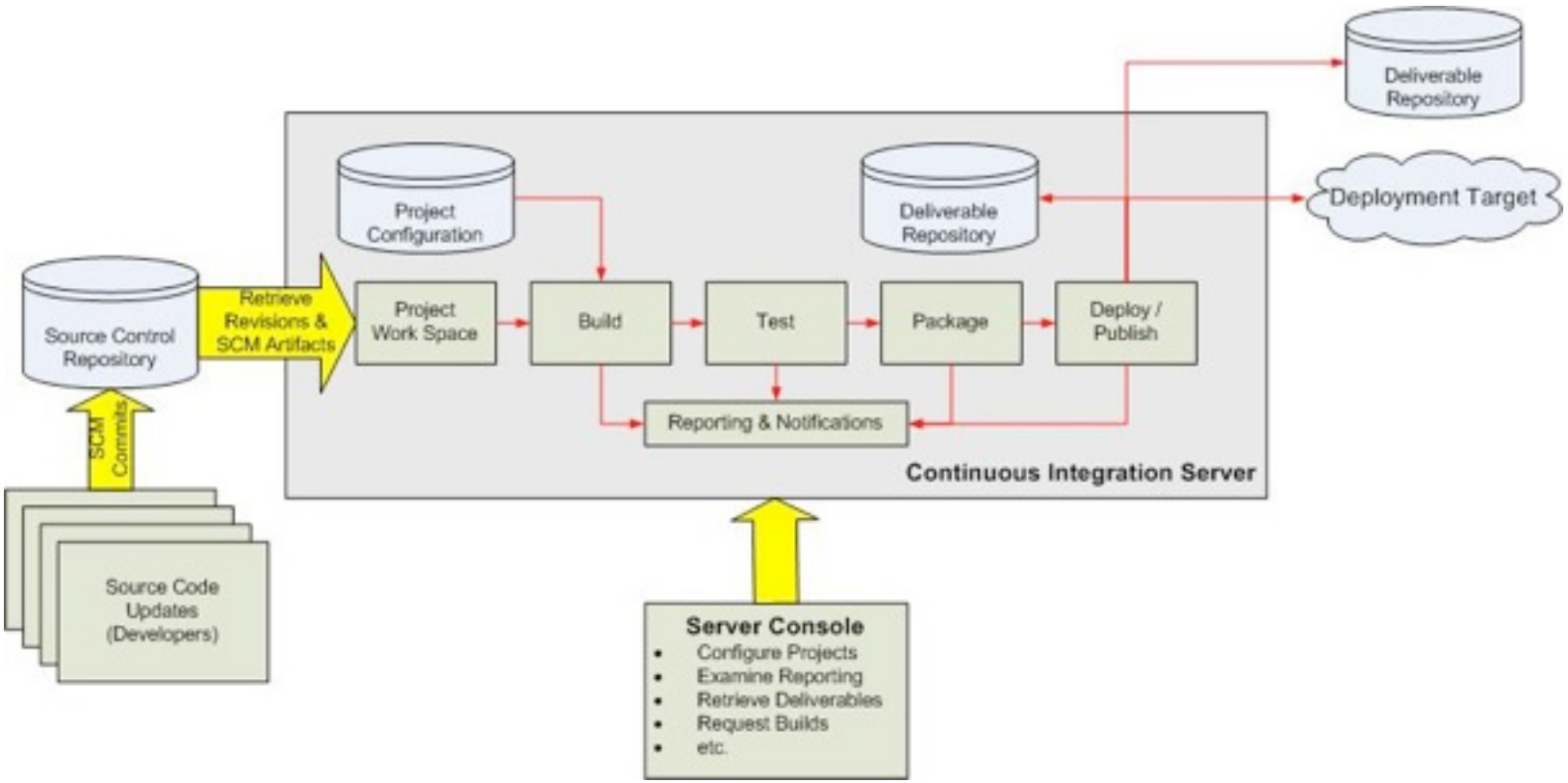
Browser compatibility testing, Part 3

- Use a web unit testing tool
  - Does not need to be written in the same language as your server!
  - E.g.,
    - http://seleniumhq.org/
    - http://jwebunit.sourceforge.net/
    - http://www.softwareqatest.com/qatweb1.html#FUNC

"On the Internet, nobody knows you're a dog."

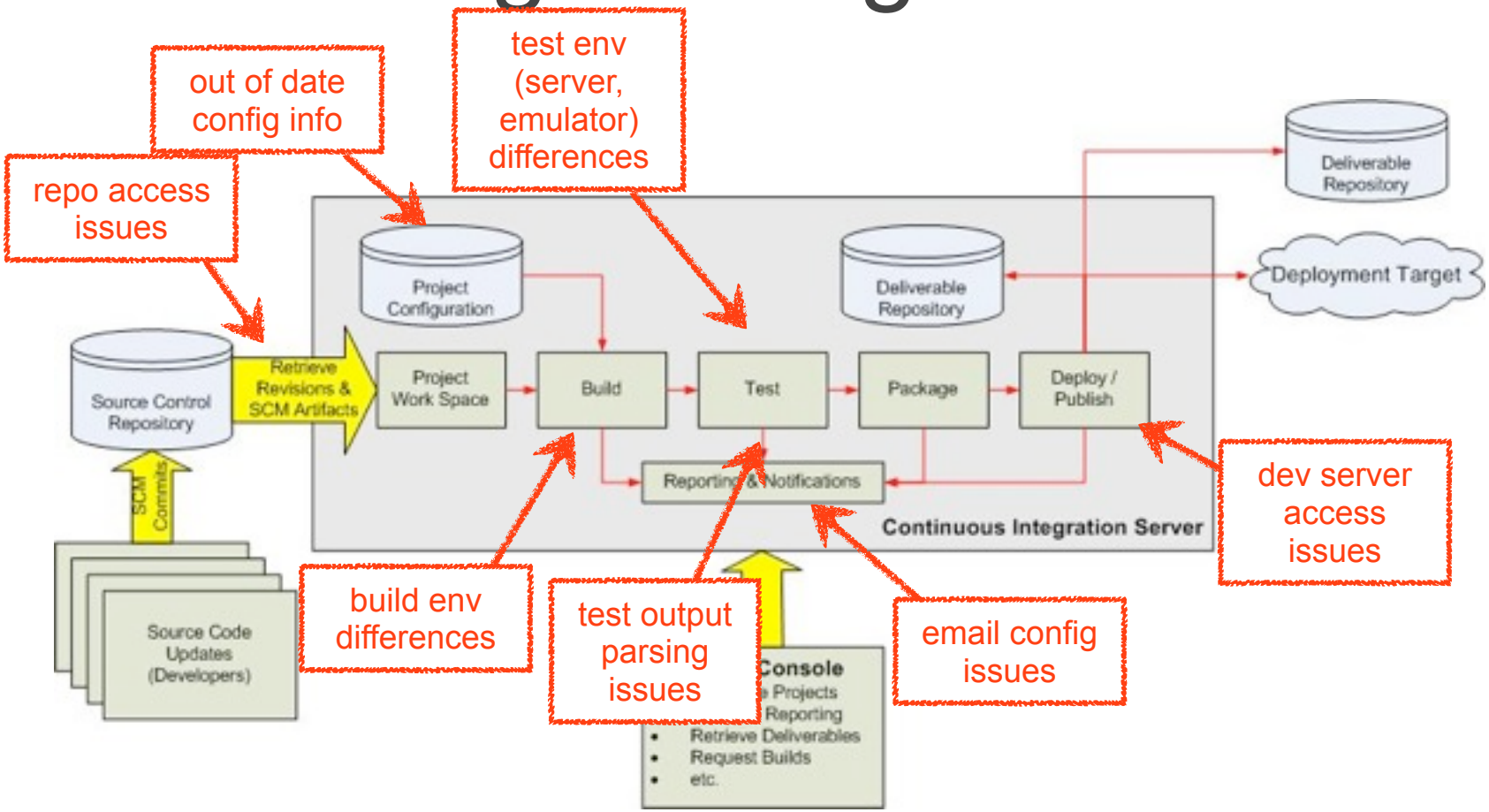
Continuous Integration

Continuous Integration Server



http://www.javaworld.com/javaworld/jw-12-2008/jw-12-hudson-ci.html

What can go worng?



http://www.javaworld.com/javaworld/jw-12-2008/jw-12-hudson-ci.html

Continuous Integration

- Setup complicated but worth it.
- Once in place, it supports and encourages many
  - test-driven development
  - continuous deployment
  - transparent development status
  - shared code ownership
- The point of CI server is to automate these practices.
- First you need to do them!

Continuous Integration Practices

- One source repository
- Automated self-testing builds
- Daily commits, fast builds
- Commits build application
- Tests run in production environment
- Easy access to executable, build status
- Automated deployment

http://martinfowler.com/articles/continuousIntegration.html

One source repository

- Minimize branches
- Include everything needed to build:
  - test scripts
  - properties files
  - database schema
  - install scripts
  - third party libraries

"I've known projects that check their compilers into the repository."

"You should be able to walk up to the project with a virgin machine, do a checkout, and be able to fully build the system."

Automated self-testing builds

- A separate stand-alone build script
- Not your IDE "build project"
- Build script
  - compiles new code and builds application
  - runs all tests
  - test failure is stops build
- Many tools:
  - Make, Ant, Rake, MSBuild, Gradle, ...
  - http://en.wikipedia.org/wiki/List_of_build_automation_software

Daily commits, fast builds

- Everyone commits once a day, or more!
  - Do local (private) build before commit
  - Update working copy before local build
  - Slice tasks into small committable bits
- Fast build
  - 10 minutes or less
  - If build gets too long, use staged builds
    - commit build runs unit tests, with mock objects
    - secondary build runs acceptance and integration tests when commit build succeeds

Commits build application

- Every commit rebuilds the mainline on a dedicated integration machine
- Many Continuous Integration servers available now
  - Hudson / Jenkins (it's a long story)
  - CruiseControl (Java and Ruby versions)
  - Go (formerly Cruise)
  - http://en.wikipedia.org/wiki/Comparison_of_Continuous_Integration_Software

Tests run in the production environment

- Don't assume all Windows / Linux / MacOS machines are the same
- Virtualization to the rescue
  - e.g., VirtualBox http://www.virtualbox.org/
- CI server creates a clone of the deployment environment
  - http://drnicwilliams.com/2010/11/09/making-ci-easier-to-do-than-not-to-with-hudson-ci-and-vagrant/

Easy access to executable and status

- CI deploys to publicized location
- CI displays results publicly

BUILD FAILED
file:C:/work/dms/builds/
checkout/dms/build.xml:77:
Tests failed! Check test reports.

http://www.pragmaticautomation.com/cgi-bin/pragauto.cgi/Monitor/Devices/BubbleBubbleBuildsInTrouble.rdoc

Automated deployment

- One step deploy to client machines
  - http://toni.org/2010/05/19/in-praise-of-continuous-deployment-the-wordpress-com-story/
  - http://radar.oreilly.com/2009/03/continuous-deployment-5-eas.html
  - http://www.limitedwipsociety.ch/en/case-study.html
    - great look at Facebook history and dev processes
  - http://www.infoq.com/presentations/Continuous-Deployment-50-Times-a-Day

> "Everyone in our company has access to a deploy button that releases the latest checked in code to about 400 production servers in our web tier in less than 30 seconds."
> Toni Schneider, WordPress

Sources

- The definition and reasons for Continuous Integration are given in Chapter 15 of The Agile Samurai book.
- The section on CI is based on http://martinfowler.com/articles/continuousIntegration.html
  - This is a revision of one of the first articles on Continuous Integration (CI) by Matthew Foemmel and Martin Fowler
  - Note: Martin Fowler is also the father of refactoring

CI Server Setup Help

- Many tutorials out there, for setting up CI servers with Ruby on Rails, Django, PHP, Javascript, ... E.g.,
  - http://solitarygeek.com/java/hudson-ci-server-a-step-by-step-guide-part-i
  - http://cjohansen.no/en/javascript/javascript_continuous_integration_with_hudson_and_jstestdriver
  - (Jenkins and Hudson are basically the same)
- Spring EECS 394 student-written guides:
  - http://www.cs.northwestern.edu/academics/courses/394/ci-server/