

# ADVANCED TEST DRIVEN DEVELOPMENT

ROBERT C. MARTIN  
(UNCLE BOB)



# WHY TDD?





Civilization depends upon us.

in ways it doesn't yet understand.

In ways *we* don't yet understand.



WE  
RULE  
THE  
WORLD

**WE ARE HEADED TOWARDS A  
DISASTER**



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## JAMES CORDEN

My joy at being part of the funniest play of the year

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Old folk need to get web-wise

Your Money page 30

# The Daily Telegraph

Tuesday, November 8, 2011

telegraph.co.uk

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# VW CHEATS EPA, EMITS NOXIOUS FUMES

By James Minty  
Deputy Political Editor

THERE IS now being fresh questions about her judgment last night after it emerged that she extracted a secret selection of Britain's border controls without having obtained information about the security implications of the move.

A leading lawmaker claimed that in July the Home Secretary authorized UK Border Agency staff not to carry out full checks on the passports of thousands of thousands of people arriving at British airports and ports from six countries.

In September, Mrs May disclosed the decision – which was never made public – to end her six-month despite having only “very limited information” about the consequences of the change.

The stated reason of suggested officials

had been a desire to defer to other passport control officials seeking ministerial approval. Last night the Home Office insisted this was a long-standing practice to allow staff to deal with emergency situations.

In the House of Commons yesterday, Mrs May came under intense pressure as she was accused by Labour of giving the “green light” to a secret border controls and fighting Conservative questioned her judgment.

She insisted she should have known but admitted that she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the selected checking system she put in place.

The lawmaker claimed her actions had reflected that she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the selected checking system she put in place.

The Daily Telegraph reported yesterday that in July Mrs May ordered the UKBA's Border Force to make the checks applied to people entering Britain with European

passports. As that “green scheme” could not be applied until then, she issued the checks applying to non-Europeans instead.

Mrs May named Bobbie Clark, the senior-most head of the Border Force, as ordering that secret situation without her permission.

The paper revealed all this without doubtfully that the situation of checks that remained was not mentioned by me,” she told MPs, adding that Mr Clark could have coincidentally been to his actions.

“As a result of this, I would have had no idea what happened or will never know how many people entered the country who should have been prevented from doing so,” Mrs May said.

The Home Secretary insisted MPs that under her rules foreigners had still been checked against a Watchdog Index of suspicious individuals and criminals.

The second selection of passport-holders

began of six unknown point during Mrs May’s authorized pilot. She said she only learnt of it two weeks before she was informed by senior officials.

Before the pilot ran due to conclude in mid-September, Mrs May decided to allow another six-week selection of passport-holders.

A Home Office official said Mrs May took that decision based on “very limited information” about the pilot in September.

“It was a very limited exercise, so she decided to extend more information,” the official said. “There was not enough data on the extended trial.”

Mrs May’s pilot allowed border officials to check off electronic chips in members’ passports, which contains photographs and other “biometric” data about holders.

Unlike simple photographs, that information is almost impossible to forge. Mrs

May’s decision to allow the chips to go unchecked was criticized by Philip Hollobone, a Conservative MP. “I and my constituents would want every biometric chip to be checked,” he told her.

Trotter Cooper, the Labour shadow home secretary, condemned Mrs May’s handling of Britain’s borders to Ring. MPs said the July decision to ban passport control had left the second selection.

Mrs Cooper said: “The truth is that instead of allowing the checks process to run as all previous ministers had recommended to do, this Home Secretary decided to water them down as official government policy, even though she never told this House.”

She added: “She has blamed officials for failing the checks. Another thing she intended. But she gave the green light. Continued on Page 7



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## BUG: KNIGHT CAPITAL LOSES

# \$450M IN 45 MINUTES!

By James Minty  
Deputy Political Editor

THERE IS now being fresh questions about her judgment last night after it emerged that she extracted a secret selection of Britain's border controls without having obtained information about the security implications of the move.

A leading lawmaker claimed that in July the Home Secretary authorized UK Border Agency staff not to carry out full checks on the passports of thousands of thousands of people arriving at British airports and ports from six countries.

In September, Mrs May disclosed the decision - which was never made public - to end her six-month despite having only "very limited information" about the consequences of the change.

The stated reason of suggested officials

had been a desire to reduce the number of controls without risking ministerial approval. Last night the Home Office admitted this was a long-standing practice to allow staff to deal with emergency.

In the House of Commons yesterday, Mrs May came under intense pressure as she was accused by Labour of giving the "green light" to a secret border controls and fighting Conservative questioned her judgment.

She insisted she should have known but admitted that she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the selected checking system she put in place.

The Daily Telegraph reported yesterday that in July Mrs May ordered the UKBA's Border Force to make the checks applied to people entering Britain with European

passports. As that "green scheme" could not be carried out without the checks applied to non-EU passport holders.

Mrs May named Bobbie Clark, the senior-most head of the Border Force, as the person in charge of the secret selection without her knowledge.

"The government will show without doubt that the situation of checks that remained was not monitored by me," she told MPs, adding that Mr Clark could face criminal charges for his actions.

"As a result of this stand border officials we will never know how many people crossed the country who should have been prevented from doing so," Mrs May said.

The Home Secretary insisted MPs that under her rules foreigners had still been checked against a Watchdog Index of suspected criminals and terrorists.

The second selection of passport-holders

began at an unknown point during Mrs May's authorized pilot. She said she only found out last week when she was informed by senior officials.

Before the pilot was due to conclude in mid-September, Mrs May decided to allow another six-week selection of passport-holders.

A Home Office official said Mrs May took that decision based on "very limited information" about the pilot in September.

"It was a very limited exercise, so she decided to extend more information," the official said. "There was not enough data as she evaluated the pilot."

Mrs May's pilot allowed border officials to check off electronic chips in mobile phones which contain photographs and other "biometric" data about holders.

Unlike simple photographs, that information is almost impossible to forge. Mrs

May's decision to allow the chips to go unchecked was criticized by Philip Hollobone, a Conservative MP. "I and my constituents would want every biometric chip to be checked," he told her.

Tony Cooper, the former shadow home secretary, condemned Mrs May's handling of Britain's borders to Ring. MPs said the July decision to ban passport controls had left the second selection.

Mrs Cooper said: "The truth is that instead of allowing the checks process to run as all previous ministers had intended to do, this Home Secretary decided to water them down as official government policy, even though she never told this House."

She added: "She has blamed officials for failing to check off another three who intended. But she gave the green light. Continued on Page 5



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## HEALTHCARE.GOV

By James Minty  
Deputy Political Editor

THERE'S MAY was facing fresh questions about her judgment last night after it emerged that she extricated a secret selection of Britain's border controls without having obtained detailed information about the security implications of the move.

A House of Commons official claimed that in July the Home Secretary authorised UK Border Agency staff not to carry out full checks on the passports of hundreds of thousands of people arriving at British airports and ports from six countries.

In September, Mrs May disclosed the scheme – which was never made public – to members of the public despite having only “very limited information” about the consequences of the change.

The scaled-down suggested officials

had been given discretion rather than a formalised contract without seeking ministerial approval. Last night the Home Office insisted this was a long-standing practice to allow staff to deal with emergency situations.

In the House of Commons yesterday, Mrs May came under intense pressure as she was accused by Labour of giving the “green light” to scaled-down border controls and frightening Conservative questioned her judgment.

The Conservative claimed she had not been told she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the scaled-down checking system she put in place.

She insisted she should have known but admitted she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the scaled-down checking system she put in place.

The Daily Telegraph reported yesterday that in July Mrs May ordered the UKBA's Border Force to水准 the checks applied to people entering Britain with European

passports. As that “green light” coding was issued, border staff then relaxed the checks applied to non-Europeans.

Mrs May named Bobbi Clark, the operational head of the Border Force, as ordering that scaled-down checks without her permission.

The paper revealed all this without甃ing that the relaxation of checks that occurred was not sanctioned by her, she told MPs, adding that Mr Clark could face criminal charges for his actions.

“As a senior official would know full well we will never know how many people entered the country who should have been prevented from doing so,” Mrs May said.

The Home Secretary insisted MPs had understood her when they asked that all been checked against a Watchdog Index of suspicious individuals and criminals.

The second relaxation of passport rules

began at an unknown point during Mrs May’s authorised pilot. She said she only learnt of it last week when she was informed by senior officials.

Before the pilot was due to conclude in mid-September, Mrs May decided to allow another six-week relaxation of passport rules.

A Home Office official said Mrs May took that decision based on “very limited information” about the pilot in September.

“It was a very limited exercise, so she decided to extend some information,” the official said. “There was not enough data so she extended the pilot.”

Mrs May’s pilot allowed border officials not to check the electronic chips in members’ passports, which contains photographs and other “biometric” data about holders.

Unlike simple photographs, that information is almost impossible to forge. Mrs

May’s decision to allow the chips to go unchecked was criticised by Philip Hollobone, a Conservative MP. “I and my constituents would want every biometric chip to be checked,” he told her.

Trotter Cooper, the Labour shadow home secretary, condemned Mrs May’s scaling of Britain’s borders to Ring. MPs said the July decision to limit passport controls had fulfilled the second condition.

Mrs Cooper said: “The truth is that instead of scaling back the checks process year on year, ministers had remained fail to do this. Home Secretary decided to water them down as official government policy, even though she never told this House.”

She added: “The last biometric officials to scaling the checks further than she intended. But she gave the green light

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# TENS OF THOUSANDS DIE IN SOFTWARE CATASTROPHE

By James Minty  
Deputy Political Editor

THERE IS now being fresh questions about her judgment last night after it emerged that she extricated a secret selection of Britain's border controls without having obtained detailed information about the security implications of the move.

A leading lawmaker claimed that in July the Home Secretary authorized UK Border Agency staff not to carry out full checks on the passports of thousands of thousands of people arriving at British airports and ports from six countries.

In September, Mrs May disclosed the decision – which was never made public – to end her six-month despite having only “very limited information” about the consequences of the change.

The scaled-down suggested officials

had been given discretion rather than a formalized contract without ministerial approval. Last night the Home Office admitted this was a long-standing practice to allow staff to deal with emergency situations.

In the House of Commons yesterday, Mrs May came under intense pressure as she was accused by Labour of giving the “green light” to a scaled-down controls and fighting Conservative questioned her judgment.

She insisted she had no knowledge but admitted that she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the scaled-down checking system she put in place.

She insisted she should have known but admitted that she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the scaled-down checking system she put in place.

The Daily Telegraph reported yesterday that in July Mrs May ordered the UKBA's Border Force to make the checks applied to people entering Britain with European

passports. As that “green scheme” could not be applied until then, she altered the checks applied to non-Europeans instead.

Mrs May named Bobbie Clark, the operational head of the Border Force, as ordering that second selection without her permission.

The paper revealed all this without doubtfully that the situation of checks that remained was not monitored by me,” she told MPs, adding that Mr Clark could face criminal charges for his actions.

“As a result of this, I would have had no idea what happened. We will never know how many people entered the country who should have been prevented from doing so,” Mrs May said.

The Home Secretary insisted Mrs May had never been informed that all three checks against a Nato-style index of suspected criminals and criminals.

The second selection of passport-holders



began at an unknown point during Mrs May’s authorized pilot. She said she only found out that week when she was informed by senior officials.

Before the pilot was due to conclude in mid-September, Mrs May decided to allow another six-week selection of passport-holders.

A Home Office official said Mrs May took that decision based on “very limited information” about the pilot in September.

“It was a very limited exercise, so she decided she needed more information,” the official said. “There was not enough data on the outcome of the pilot.”

Mrs May’s pilot allowed border officials not to check the electronic chips in members’ passports, which contains photographs and other “biometric” data about holders.

Unlike simple photographs, that information is almost impossible to forge. Mrs

May’s decision to allow the chips to go unchecked was criticized by Philip Hollobone, a Conservative MP. “I and my constituents would want every biometric chip to be checked,” he told her.

Tony Cooper, the Labour shadow home secretary, condemned Mrs May’s handling of Britain’s borders to Ring. MPs said the July decision to limit passport controls had left the second selection.

Mrs Cooper said: “The truth is that instead of making the checks process easier, all previous ministers had recommended to do this. Home Secretary decided to water them down as official government policy, even though she never told this House.”

She added: “She has blamed officials for failing the checks. Another thing she intended. But she gave the green light. Continued on Page 7

HOW  
COULD  
YOU...



...HAVE  
LET  
THIS  
HAPPEN?

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# CONGRESS PASSES SWEEPING SOFTWARE REGULATIONS

By James Minty  
Deputy Political Editor

THEIR IS ONE being fresh questions about her judgment last night after it emerged that she extracted a secret selection of Britain's border controls without having obtained information about the security implications of the move.

A leading lawmaker claimed that in July the Home Secretary authorized UK Border Agency staff not to carry out full checks on the passports of thousands of thousands of people arriving at British airports and ports from six countries.

In September, Mrs May disclosed the decision - which was never made public - to end her six-month despite having only "very limited information" about the consequences of the change.

The stated reason of suggested officials

had been a desire to allow the agency to make quick checks without ministerial approval. Last night the Home Office admitted this was a long-standing practice to allow staff to deal with emergency.

In the House of Commons yesterday, Mrs May came under intense pressure as she was accused by Labour of giving the "green light" to violate border controls and frightening Conservative questioned her judgment.

She insisted she had no knowledge but admitted that she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the relaxed checking system she put in place.

The lawmaker claimed he and others had calculated that she did not know how many suspected terrorists, criminals and illegal immigrants had been able to enter the country under the relaxed checking system she put in place.

The Daily Telegraph reported yesterday that in July Mrs May ordered the UKBA's Border Force to waive the checks applied to people entering Britain with European

passports. As that "green scheme" could not be applied until the checks were applied to non-EU passport holders.

Mrs May named Bobbie Clark, the senior-most head of the Border Force, as the person in charge of the relaxation without her permission.

"The government will show with pride that the situation of checks that remained was not sanctioned by me," she told MPs, adding that Mr Clark could face criminal charges for his actions.

"As a result of this stand border officials we will never know how many people crossed the country who should have been prevented from doing so," Mrs May said.

The Home Secretary insisted MPs that under her rules foreigners had still been checked against a Watchlist index of suspected criminals and terrorists.

The second relaxation of passport rules

began at an unknown point during Mrs May's ministerial pilot. She said she only learnt of it last week when she was informed by senior officials.

Before the pilot was due to conclude in mid-September, Mrs May decided to allow another six-week relaxation of passport rules.

A Home Office official said Mrs May took that decision based on "very limited information" about the pilot in September.

"It was a very limited exercise, so she decided to extend more information," the official said. "There was not enough data as she extended the pilot."

Mrs May's pilot allowed border officials not to check the electronic chips in members' passports, which contains photographs and other "biometric" data about holders.

Unlike simple photographs, that information is almost impossible to forge. Mrs

May's decision to allow the chips to go unchecked was criticized by Philip Hollobone, a Conservative MP. "I and my constituents would want every biometric chip to be checked," he told her.

Tony Cooper, the Labour shadow home secretary, condemned Mrs May's handling of Britain's borders to Ring. MPs said the July decision to ban passport controls had left the second松懈。

Mrs Cooper said: "The truth is that instead of stopping the checks, Mrs May has given the green light to the second松懈. She May's pilot allowed border officials not to check the electronic chips in members' passports, which contains photographs and other "biometric" data about holders.

The added: "She has allowed officials to waive the checks. Another three she intended. But she gave the green light

Continued on Page 7



# THE THREE LAWS OF TEST DRIVEN DEVELOPMENT.



# ARBITRARY DISCIPLINE

---

- Like a surgeon scrubbing for surgery.
- Like a pilot following a checklist.

# THE WORD “UNIT”

---

- There is no good definition of unit in unit-test.
- Some people call them micro-tests or programmer-tests.
- They are tests written by programmers for programmers.

# THE FIRST LAW

---

- You are not allowed to write any production code until you have written a unit test that fails due to its absence.

## THE SECOND LAW

---

- You are not allowed to write more of a unit test than is sufficient to fail. Failing to compile is failing.

## THE THIRD LAW

---

- You are not allowed to write more production code than is sufficient to cause the currently failing test to pass.

## THE IMPOSSIBLY TINY LOOP

---

- This just sounds dumb.
- Boring, tedious, slow, awful.
- Interrupts true thought.
- Always in the way.

## BUT, IMAGINE...

---

- A team of people working this way.
  - Pick one at random.
  - Everything worked a minute ago!

# HOW MUCH DEBUGGING WOULD YOU DO?

---

- Are you good at the debugger?
  - This is not a skill to be desired!
  - The three laws reduce debugging time.

# THE CODE EXAMPLES

---

- Have you integrated a third party package.
  - You read the code examples, not the manual.
- Unit tests are the code examples for the whole system

# DOCUMENTS!

---

- Written in a language you understand.
- Utterly unambiguous.
- So formal they execute.
- They cannot get out of sync with the application.
- Easy to understand. Not a system.

## TEST AFTER THE FACT?

---

- Boring.
  - You've already tested manually.
- The function that's hard to test...
  - Leave a hole in the test suite.
  - And if you do it...
- Do you shrug when your tests pass?

# TEST FIRST

---

- Fun. You *make* it work!
- You can't write the function that's hard to test.
- System is testable.
- System is decoupled.
- You trust the tests!

# SO THE THREE LAWS GIVE YOU:

---

- Reduced debug time.
- A stream of “perfect” documentation.
- Fun.
- Decoupled design.

# TRUSTED TESTS MEAN REDUCED FEAR!

---

- That's the real reason we do TDD.
- The three laws give us a test suite we trust.
- We don't fear changing the code.
- We can clean it.

# OBJECTIONS HEARD (BUT NOT BELIEVED)

- “I know how to just write the class, but I don’t know how to test it.”
- “We have to write twice as much code and provide two people to do it.”
- “I have to debug twice as much code.”
- “We have a testing department.”
- “I can test my code after I write it.”

# DISCUSSION

---

- Fears, concerns, confounds and blockages.
  - Organizational Resistance
  - Crushing Deadlines
  - Testing Taliban
  - Test After
  - Sole TDDer

# PROFESSIONALISM RANT.

---

- Laborers take orders.
- Professionals “Profess”
  - Hired for knowledge and expertise
- Managers will push, and want push-back.
  - Professionals push back.

# WHO ELSE HAS OUR PROBLEM.

---

- We produce complex documents full of arcane symbols.
- Must be correct or terrible things happen.

# ACCOUNTANTS!

---

- The right digit, in the right place, at the right time...
- Brings the company down and sends the executives to jail.

# HOW DO ACCOUNTANTS PREVENT THIS?

---

- They have a discipline.
- 500 years old.
- Double Entry Bookkeeping.

# DOUBLE ENTRY BOOKKEEPING.

- Every transaction is entered twice.
- Once under Assets. Once under Liabilities and Equities.
- The two sides are summed.
- The sums are subtracted on the balance sheet.
- The result must be zero.

# THE PROCEDURE

---

- Accountants are taught to enter transactions one at a time.
- For obvious reasons.

# TDD IS DOUBLE ENTRY BOOKKEEPING.

---

- The practices are the same.
- They are done for the same reason.
- Every behavior is entered twice.
  - Once as a test, again as production code.
- The two entries must agree.

# IF ACCOUNTANTS CAN DO IT...

---

- Accountants have schedules and deadlines just like us.
- Our documents are not less important than the accountant's.
- If they can do it...

# CLEAN TESTS



# WHAT DOES THIS TEST DO?

```
@Test
public void tableWithSymbolSubstitution() throws Exception {
    getResultsForPageContents(
        "!|DT:fitnesse.slim.test.TestSlim|\n" +
        "|string|getStringArg?|\n" +
        "|Bob|$V=|\n" +
        "|$V|$V|\n" +
        "|Bill|$V|\n" +
        "|John|$Q|\n"
    );
    TableScanner ts = getScannedResults();
    Table dt = ts.getTable(0);
    assertEquals("$V<-[Bob]", unescape(dt.getCellContents(1, 2)));
    assertEquals("$V->[Bob]", unescape(dt.getCellContents(0, 3)));
    assertEquals("<span class=\"pass\">$V->[Bob]</span>", unescape(dt.getCellContents(1, 3)));
    assertEquals("[Bill] <span class=\"fail\">expected [$V->[Bob]]</span>", unescape(dt.getCellContents(1, 4)));
    assertEquals("[John] <span class=\"fail\">expected [$Q]</span>", unescape(dt.getCellContents(1, 5)));
}
```

# PROBLEMS WITH THIS TEST.

- More than one logical assert.

```
@Test
public void tableWithSymbolSubstitution() throws Exception {
    getResultsForPageContents(
        "!|DT:fitnesse.slim.test.TestSlim|\n" +
        "|string|getStringArg?|\n" +
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    assertEquals("[John] <span class=\"fail\">expected [$Q]</span>", unescape(dt.getCellContents(1, 5)));
}
```

# PROBLEMS WITH THIS TEST.

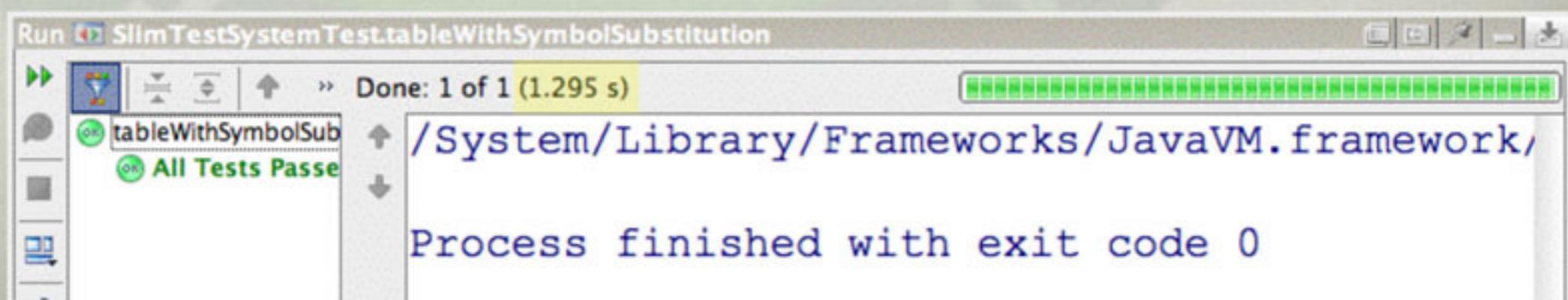
```
@Test
public void tableWithSymbolSubstitution() throws Exception {
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}
```

- More than one logical assert
- Accidental Complexity

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    assertEquals("[John] <span class=\"fail\">expected [$Q]</span>", unescape(dt.getCellContents(1, 5)));
}
```

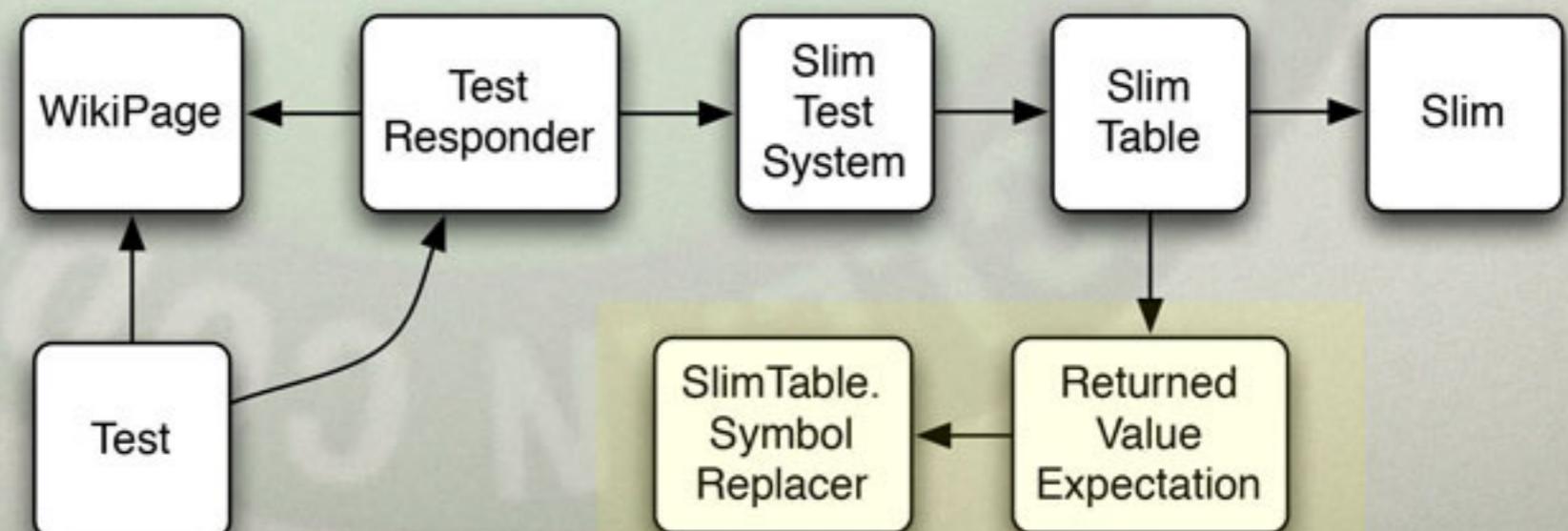
- More than one logical assert.
- Accidental Complexity
- Too Slow



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    assertEquals("[John] <span class=\"fail\">expected [$Q]</span>", unescape(dt.getCellContents(1, 5)));
}
```

- Accidental Complexity
- Too Slow
- Wide Scope



# PROBLEMS WITH THIS TEST.

```
@Test
public void tableWithSymbolSubstitution() throws Exception {
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        "!|DT:fitnesse.slim.test.TestSlim|\n" +
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        "|Bob|$V=|\n" +
        "|$V|$V|\n" +
        "|Bill|$V|\n" +
        "|John|$Q|\n"
    );
    TableScanner ts = getScannedResults();
    Table dt = ts.getTable(0);
    assertEquals("$V<-[Bob]", unescape(dt.getCellContents(1, 2)));
    assertEquals("$V->[Bob]", unescape(dt.getCellContents(0, 3)));
    assertEquals("<span class=\"pass\">$V->[Bob]</span>", unescape(dt.getCellContents(1, 3)));
    assertEquals("[Bill] <span class=\"fail\">expected [$V->[Bob]]</span>", unescape(dt.getCellContents(1, 4)));
    assertEquals("[John] <span class=\"fail\">expected [$Q]</span>", unescape(dt.getCellContents(1, 5)));
}
```

- Accidental Complexity
- Too Slow
- Wide Scope
- Colloquialisms

# BETTER TESTS

The screenshot shows an IDE interface with a code editor and a test results window.

**Code Editor Content:**

```
1 @Test
2 public void matchedSymbolIsReplaced() throws Exception {
3     testContext.setSymbol("S", "Value");
4     assertExpectationMessage("$S", "Value", "pass($S->[Value])");
5 }
6
7 @Test
8 public void mismatchedSymbolIsReplaced() throws Exception {
9     testContext.setSymbol("S", "Value");
10    assertExpectationMessage("$S", "WrongValue", "[WrongValue] fail(expected [$S->[Value]])");
11 }
```

**Test Results Window:**

- Test Name: ReturnedValueExpectationTest.mismatchedUnboundSymbolsNotReplaced
- Status: Done: 1 of 1 (0.268 s)
- Output: /System/Library/Frameworks/JavaVM.framework/Versions/1.6.0/Home/bin/java -Dfi
- Details:
  - All Tests Passed

- One Logical Assert
- No Accidental Complexity
- Fast
- Narrow Scope
- Meaningful Values

# COMPOSED ASSERTION

```
private void assertExpectationMessage(String expected, String value, String message) throws Exception {  
    TableScanner ts = new HtmlTableScanner("<table><tr><td>x</td></tr></table>");  
    Table t = ts.getTable(0);  
    SlimTable slimTable = new DecisionTable(t, "id", testContext);  
    SlimTable.Expectation expectation = slimTable.makeReturnedValueExpectation("instructionId", 1, 2);  
    assertEquals(message, HtmlTable.colorize(expectation.evaluationMessage(value, expected)));  
    assertEquals(message, expectation.getEvaluationMessage());  
    assertEquals(2, expectation.getRow());  
    assertEquals(1, expectation.getCol());  
    assertEquals("instructionId", expectation.getInstructionTag());  
}
```

- Changes many asserts into one.
- Hides accidental complexity.

# COMPOSED TEST RESULT

```
@Test  
public void turnOnHeaterAndBlowerIfTooCold() throws Exception {  
    tooCold();  
    assertEquals("HBchl");  
}
```

```
public String getState() {  
    String state = "";  
    state += heater ? "H" : "h";  
    state += blower ? "B" : "b";  
    state += cooler ? "C" : "c";  
    state += hiTempAlarm ? "H" : "h";  
    state += loTempAlarm ? "L" : "l";  
    return state;  
}
```

- A test result that merges many variables into one.
  - e.g. Booleans into an integer or a string.
- Human interpretation should be simple.
- Changes many asserts into one.

# **STUBBING VS MOCKING**

# **TESTING BEHAVIOR VS**

# **STATE**

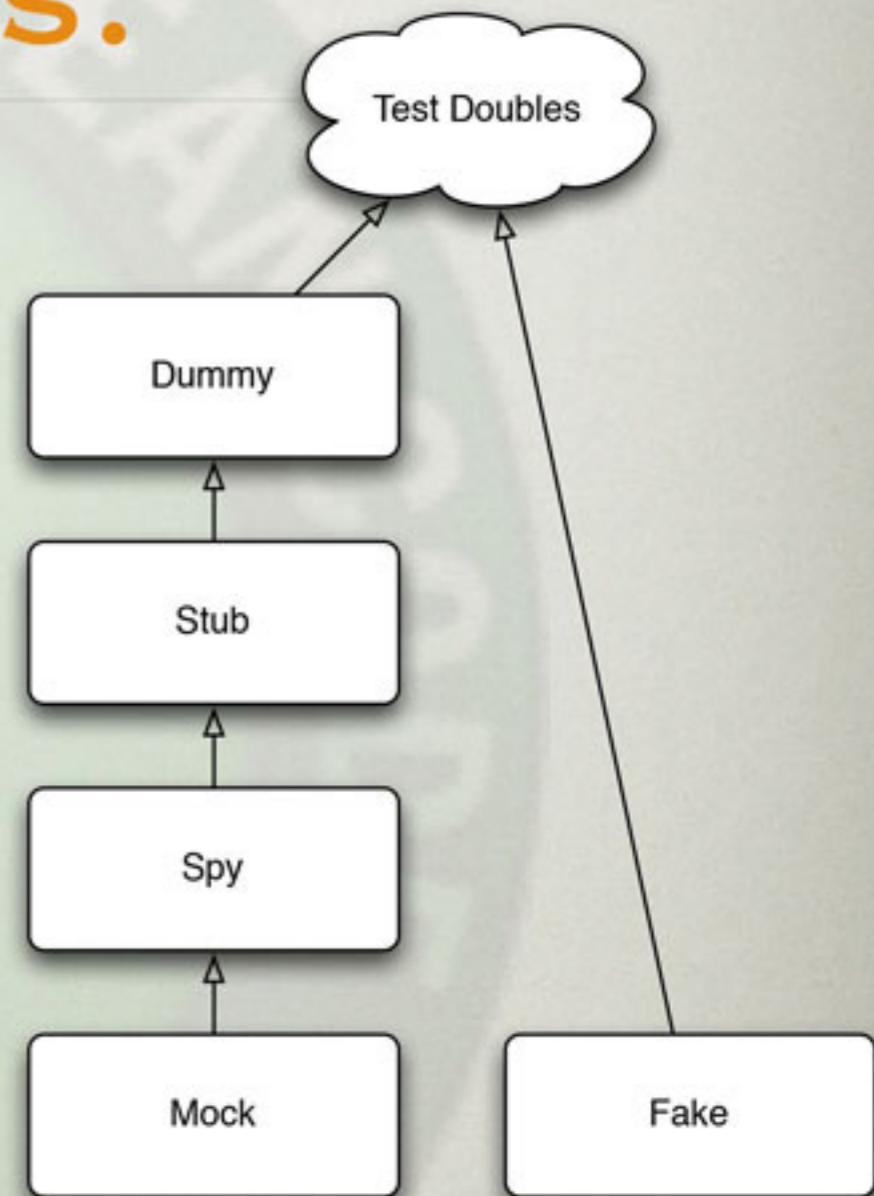


# MOCKS, SPIES, STUBS, AND TEST DOUBLES.

- Dummy
  - Do nothing. Return degenerate values.

```
public interface Authenticator {  
    Boolean authenticate(String username,  
                        String password);  
}
```

```
public class AuthenticatorDummy implements Authenticator {  
    public Boolean authenticate(String username, String password) {  
        return null;  
    }  
}
```

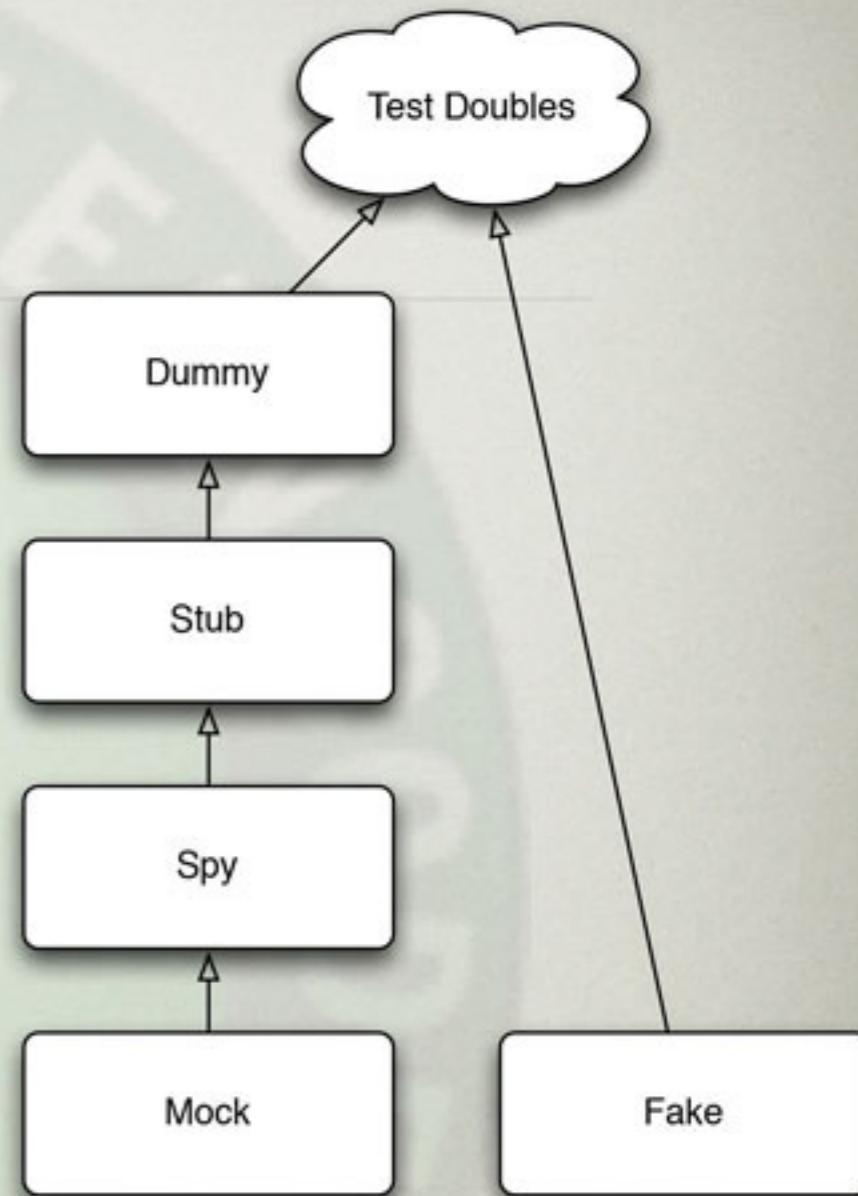


# USING A DUMMY

```
public class LoginPageTest {  
    @Test  
    public void canCancelLoginPage() throws Exception {  
        LoginPage page = new LoginPage(new AuthenticatorDummy());  
        page.show();  
        boolean success = page.sendEvent(CLOSE);  
        assertTrue(success);  
    }  
}
```

# STUBS

- A Dummy that returns Test Specific Values.



```
public class RejectingAuthenticatorStub implements Authenticator {  
    public Boolean authenticate(String username, String password) {  
        return false;  
    }  
}  
  
public class PromiscuousAuthenticatorStub implements Authenticator{  
    public Boolean authenticate(String username, String password) {  
        return true;  
    }  
}
```

# USING STUBS

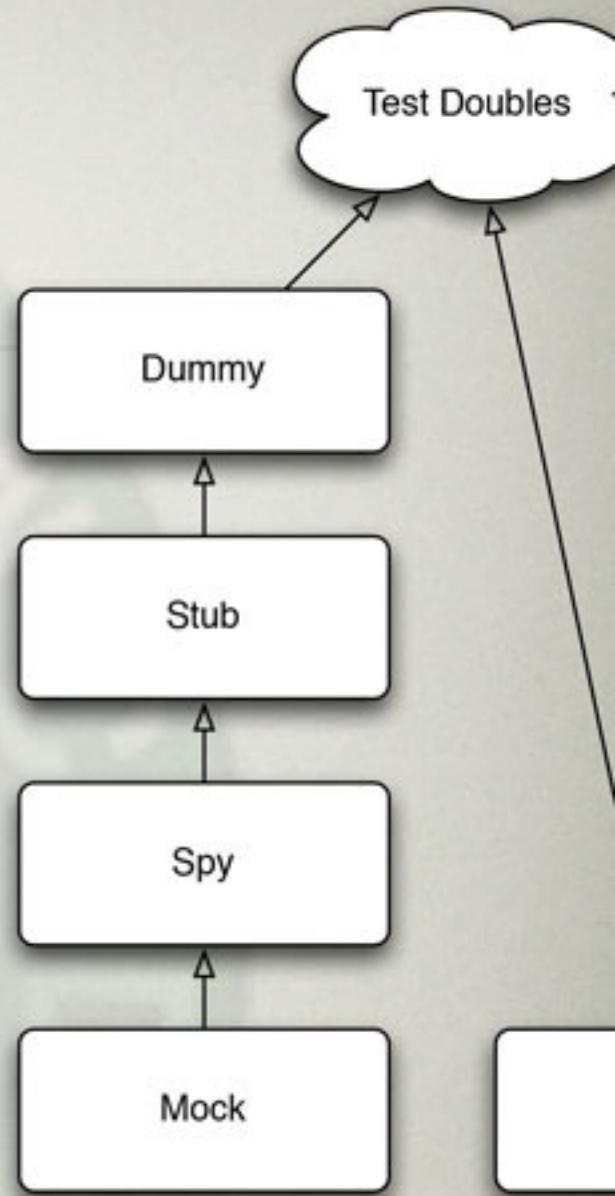
```
@Test  
public void canLogin() throws Exception {  
    LoginPage page = new LoginPage(new PromiscuousAuthenticatorStub());  
    page.show();  
    boolean success = page.submit("some user name", "some password");  
    assertTrue(success);  
}
```

```
@Test  
public void failsLogin() throws Exception {  
    LoginPage page = new LoginPage(new RejectingAuthenticatorStub());  
    page.show();  
    boolean success = page.submit("some user name", "some password");  
    assertFalse(success);  
}
```

# SPIES

- Stub that remembers facts about the method calls.

```
public class AuthenticatorSpy implements Authenticator {  
    private Boolean result = null;  
    private int count = 0;  
    private String lastUsername;  
    private String lastPassword;  
  
    public String getLastUsername() { return lastUsername; }  
  
    public String getLastPassword() { return lastPassword; }  
  
    public int getCount() { return count; }  
  
    public void setResult(Boolean result) { this.result = result; }  
  
    public Boolean authenticate(String username, String password) {  
        count++;  
        lastUsername = username;  
        lastPassword = password;  
        return result;  
    }  
}
```



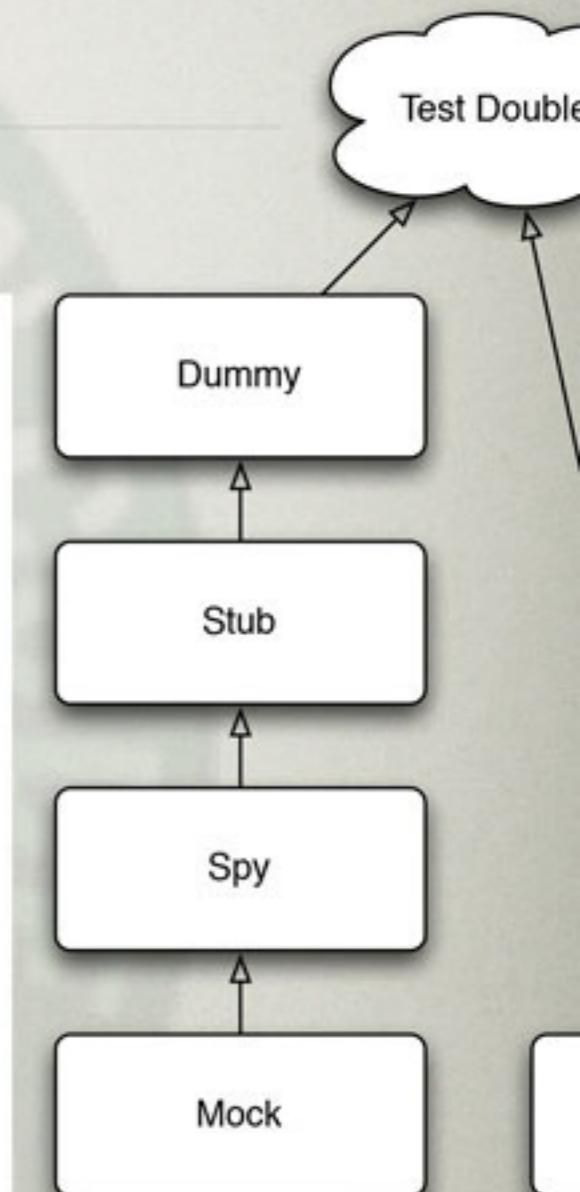
# USING SPIES

```
@Test  
public void authenticatorCalledCorrectly() throws Exception {  
    AuthenticatorSpy spy = new AuthenticatorSpy();  
    LoginPage page = new LoginPage(spy);  
    spy.setResult(true);  
    page.show();  
    boolean success = page.submit("user", "pw");  
    assertTrue(success);  
    assertEquals(1, spy.getCount());  
    assertEquals("user", spy.getLastUsername());  
    assertEquals("pw", spy.getLastPassword());  
}
```

# MOCK

- Spy that knows how methods *should* be called.

```
public class AuthenticatorMock extends AuthenticatorSpy {  
    private String expectedUsername;  
    private String expectedPassword;  
    private int expectedCount;  
  
    public AuthenticatorMock(String expectedUsername,  
                            String expectedPassword,  
                            int expectedCount) {  
        this.expectedUsername = expectedUsername;  
        this.expectedPassword = expectedPassword;  
        this.expectedCount = expectedCount;  
    }  
  
    public boolean validate() {  
        return getCount() == expectedCount &&  
               getLastPassword().equals(expectedPassword) &&  
               getLastUsername().equals(expectedUsername);  
    }  
}
```

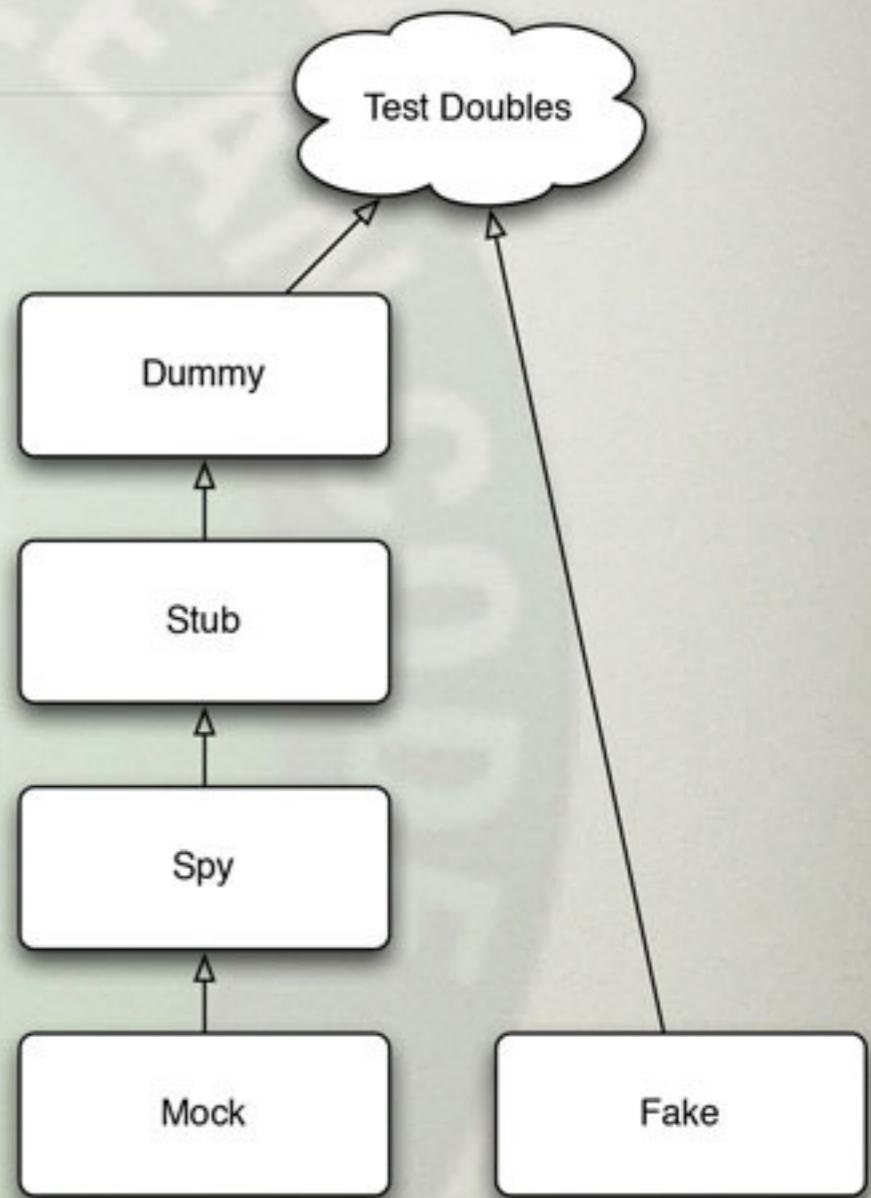


# USING A MOCK

```
@Test  
public void authenticatorCallValidated() throws Exception {  
    AuthenticatorMock mock = new AuthenticatorMock("Bob", "xyzzy", 1);  
    LoginPage page = new LoginPage(mock);  
    mock.setResult(true);  
    page.show();  
    boolean success = page.submit("Bob", "xyzzy");  
    assertTrue(success);  
    assertTrue(mock.validate());  
}
```

# FAKE

- A Simple Simulator.



```
public class AuthenticatorFake implements Authenticator{  
    public Boolean authenticate(String username, String password) {  
        return (username.equals("unclebobmartin") &&  
            password.equals("xyzzy"));  
    }  
}
```

# TESTING STATE (CLASSICAL TESTING)

- Very traditional
  - Arrange, Act, Assert.
  - What you assert is the state of the outcome.
  - You have no idea HOW the outcome was achieved.

```
public void testChangingMethod() throws Exception {  
    builder.setMethod("POST");  
    String text = builder.getText();  
    assertHasRegexp("POST / HTTP/1.1\r\n", text);  
}
```

# TESTING BEHAVIOR (MOCKISM)

- Typically using a Mock or a Spy
  - Or business objects that spy on themselves.
- Tests the algorithmic steps were taken
  - By checking whether certain methods were called in certain ways

```
@Test
public void credentialsShouldBeNullIfNoServiceName() throws Exception {
    NegotiateAuthenticator authenticator = new NegotiateAuthenticator(manager, properties);
    assertNull(authenticator.getServerCredentials());
    verify(manager, never()).createName(anyString(), (Oid) anyObject(), (Oid) anyObject());
}
```

# THE TDD UNCERTAINTY PRINCIPLE

---

- Testing State leaves you uncertain that all answers will be correct.
- Mocking provides certainty but leads to Fragile Tests.
- Fragility increases with certainty.

# WISDOM

---

- Avoid Test Doubles except when crossing architectural boundaries.
- Avoid Mocking tools unless you need superpowers.

# F.I.R.S.T



# F.I.R.S.T.

## F.I.R.S.T Principles ②

**F**ast: test runs < 1 second.

**I**solated: fault is clearly isolated

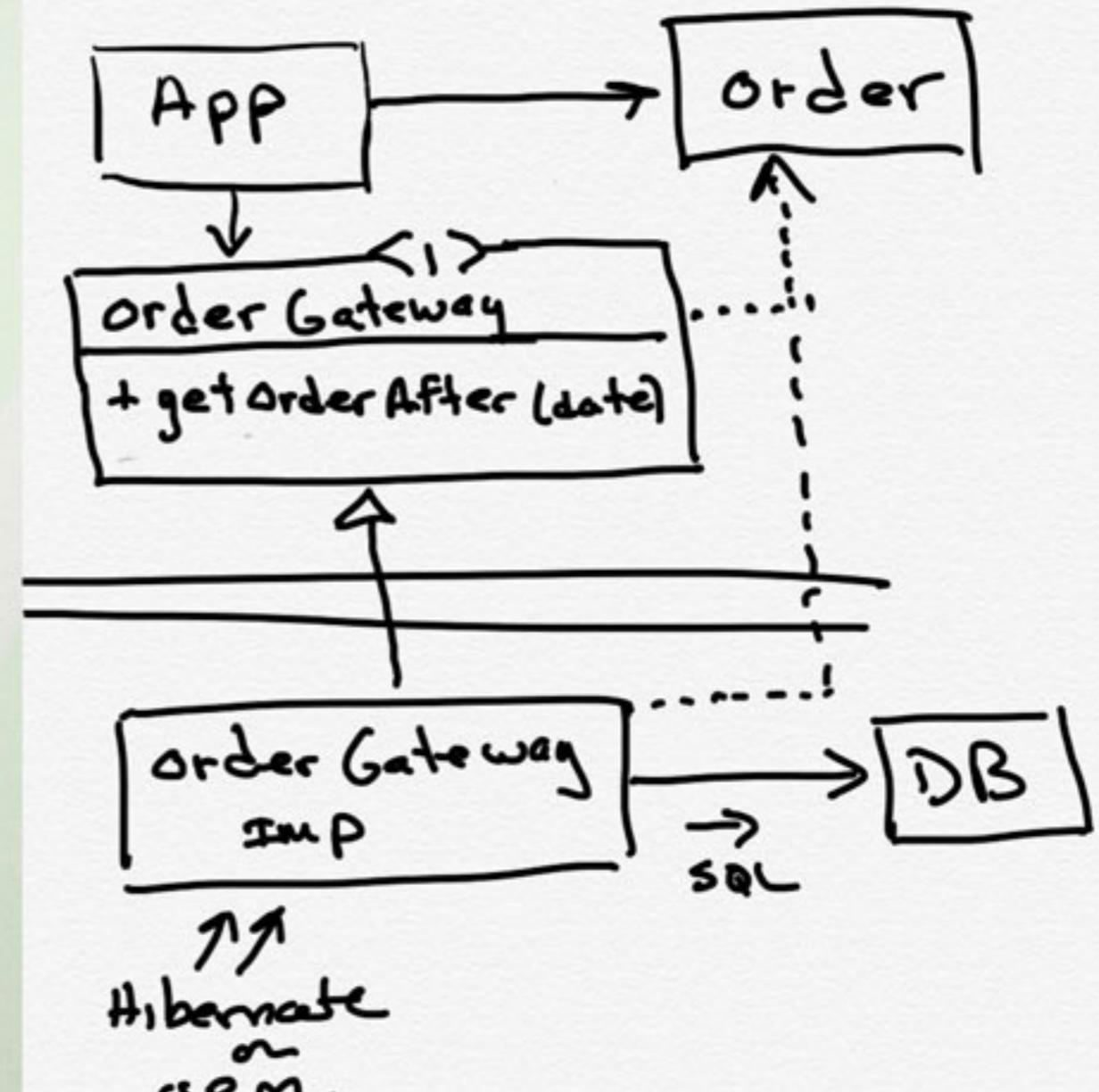
**R**epeatable: constant behavior

**S**elf-verifying: pass OR fail

**T**imely: 1 code change = 1 test

# FAST

- Database isolation
  - Hypersonic
  - Stored Procedures
  - Query Gateways.
- Web Container Isolation



## ISOLATED & INDEPENDENT

---

- Tests do not depend upon each other.  
Each tests can stand alone.
- Tests can be run in any order.
- Junit does not guarantee order.
- Be careful of static variables.

## REPEATABLE

---

- Tests should not be dependent upon environmental issues.
- Should run the same in the lab, and at 30,000 feet over the Atlantic.
- Never subject to network timing, memory usage, other processes, etc.
- There should never be an excuse for a failure.

## **SELF VERIFYING**

---

- The test has a binary result. Pass/Fail.
- No interpretation is required.

## TIMELY

---

- Tests are written first, before the code that passes them. (most of the time).

# THE REAL MEANING OF “FIRST”

---

- The Tests Come First.
  - They are written first.
  - They are refactored first.
  - They are higher priority than the application code.
- Because without the tests
  - The code must rot.

# TEST DESIGN



# DECOPUPLE TESTS FROM APPLICATION CODE.

---

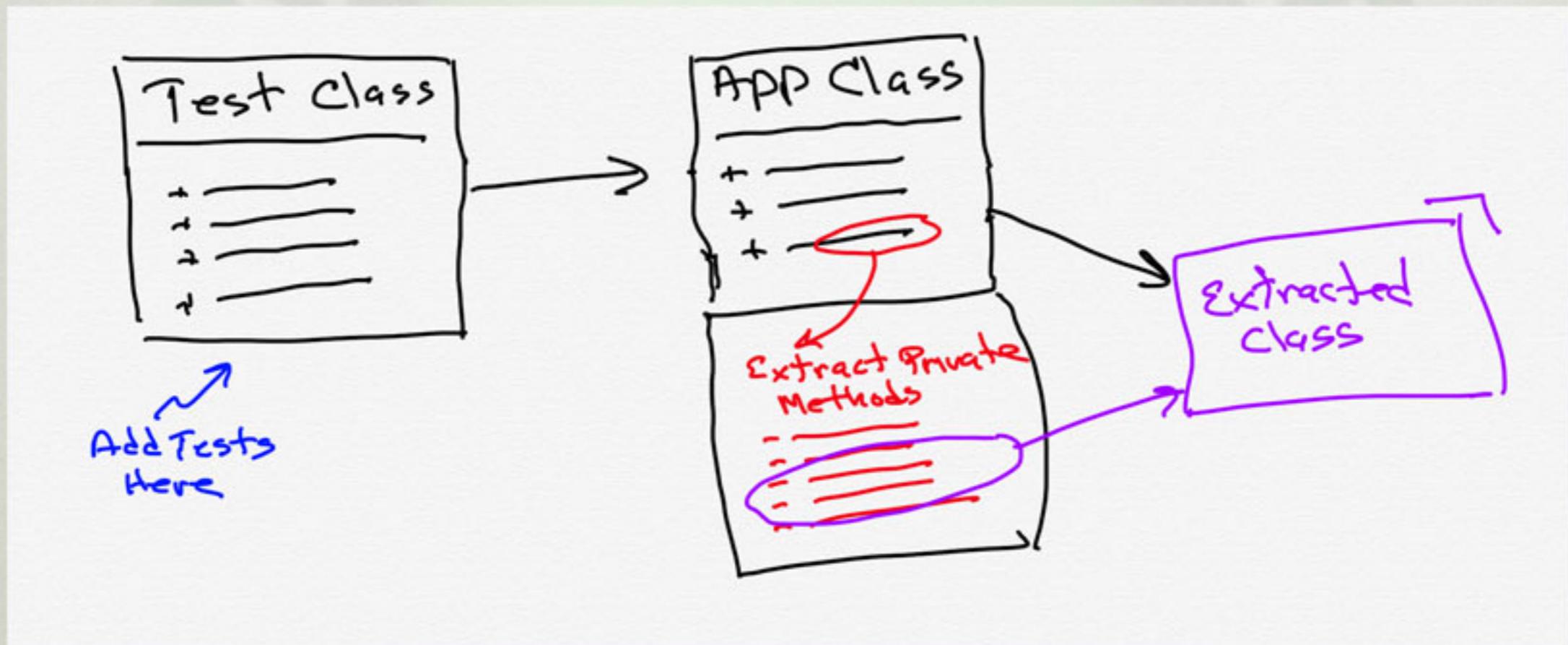
- Otherwise the tests become fragile.
- All the same principles apply.
- Use a testing API to isolate the tests from the code.
- Do not allow the tests to be too intimate with the code.

## DECOPLE THE STRUCTURE

---

- Do not create a test class for each production class!
- This couples the structure and creates fragility.

# ADD TESTS, BUT EXTRACT FUNCTIONS AND CLASSES.

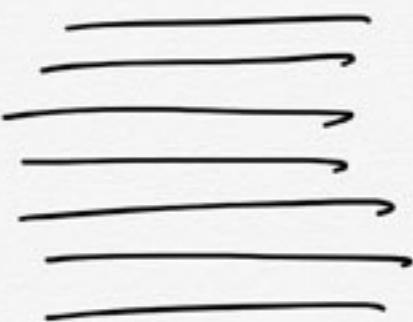




**AS THE TESTS GET MORE  
SPECIFIC...**

**THE CODE GETS MORE  
GENERIC.**

Tests

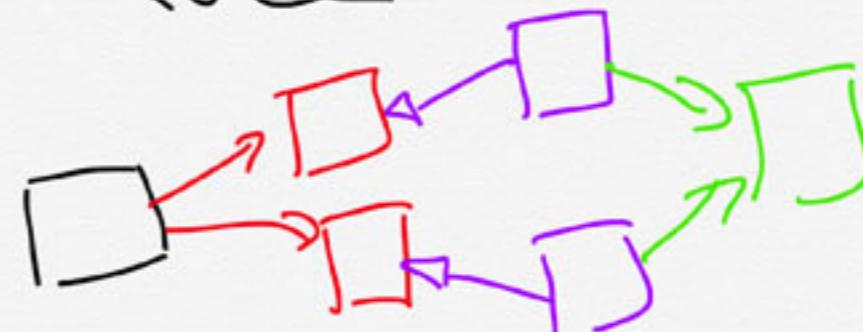


Each new Test  
Makes the Test  
Suite More Specific



The Two Designs DIVERGE

Code



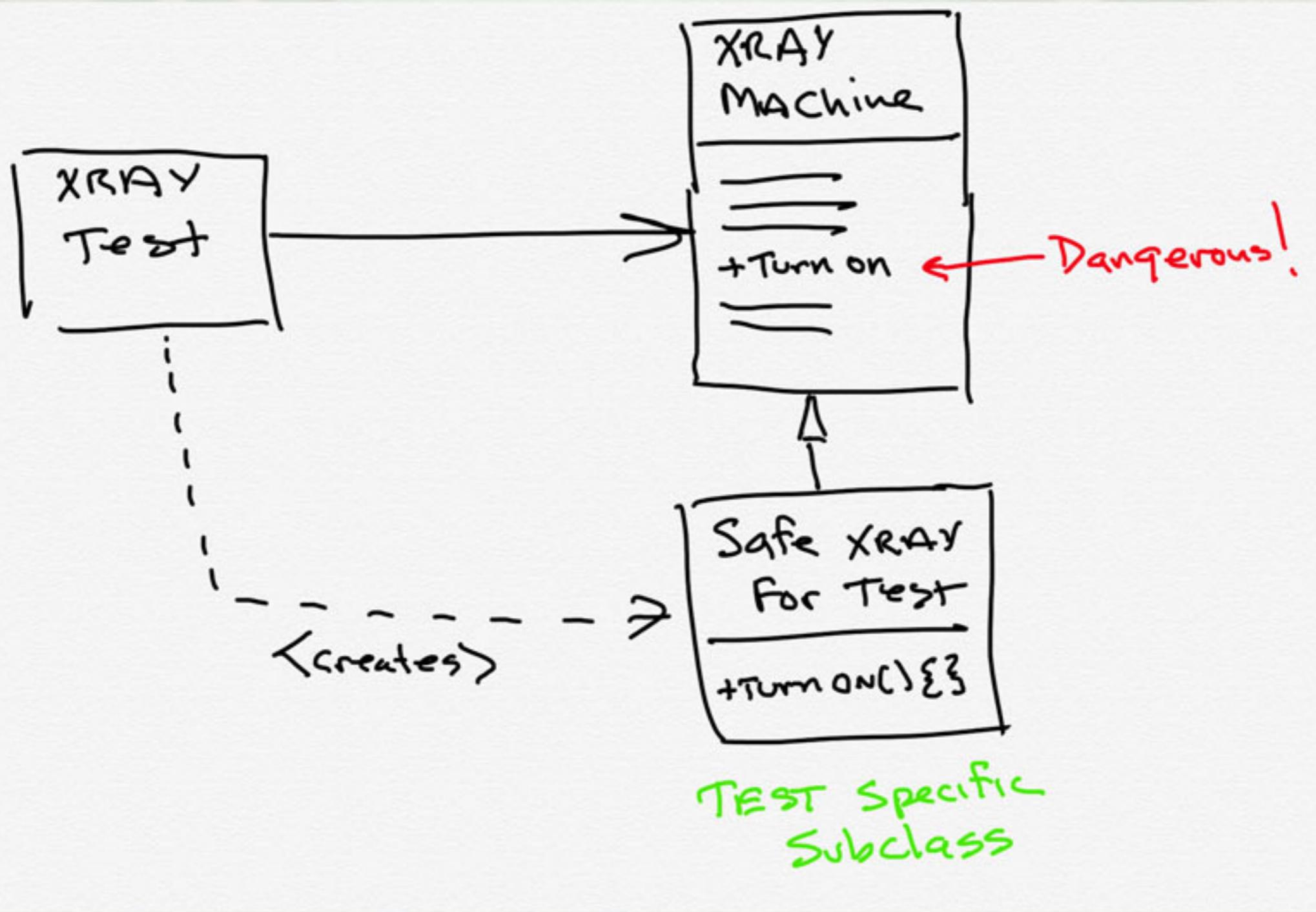
Every Refactoring  
makes the code  
More generic



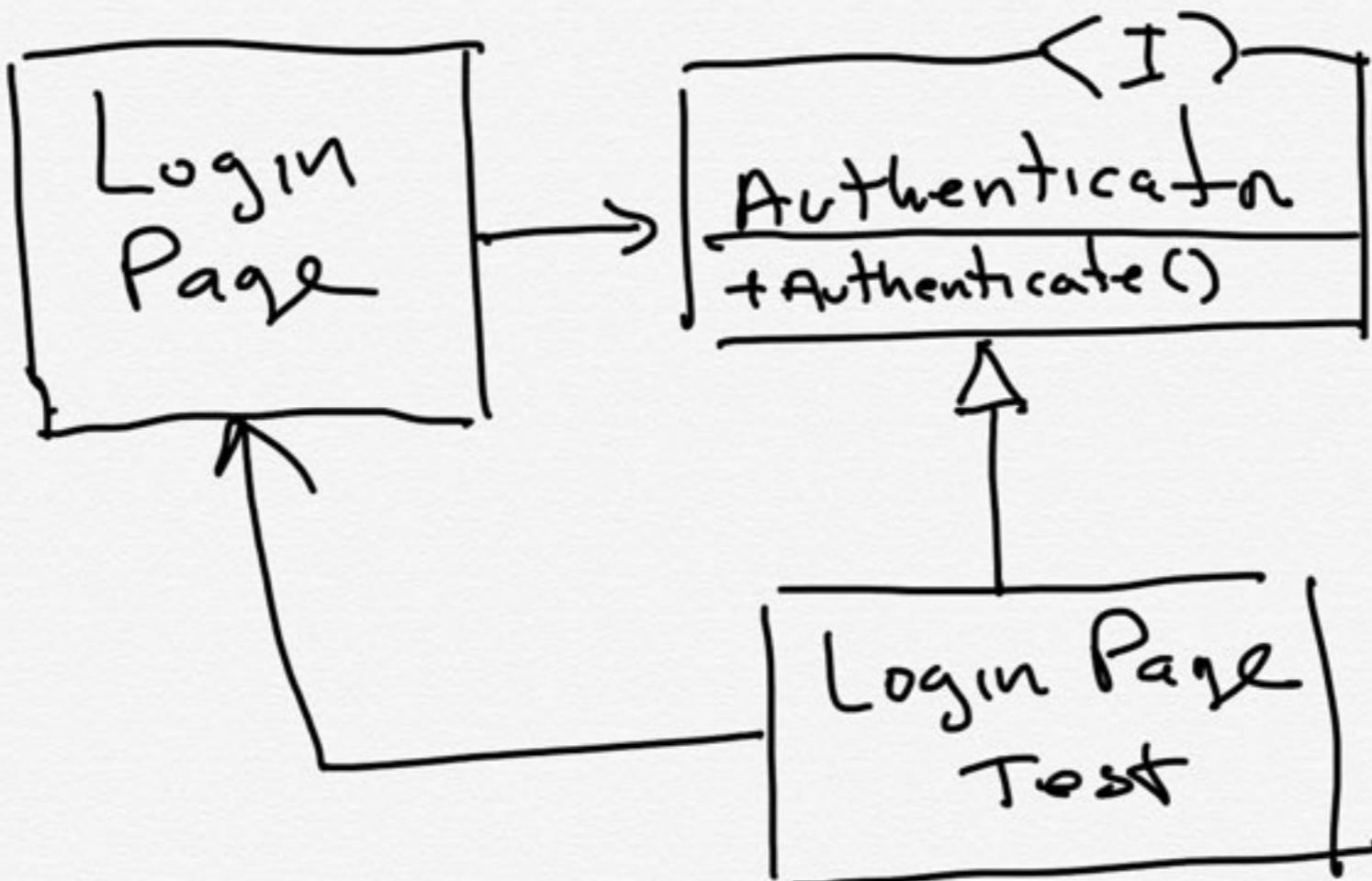
# TEST PATTERNS



# TEST SPECIFIC SUBCLASS

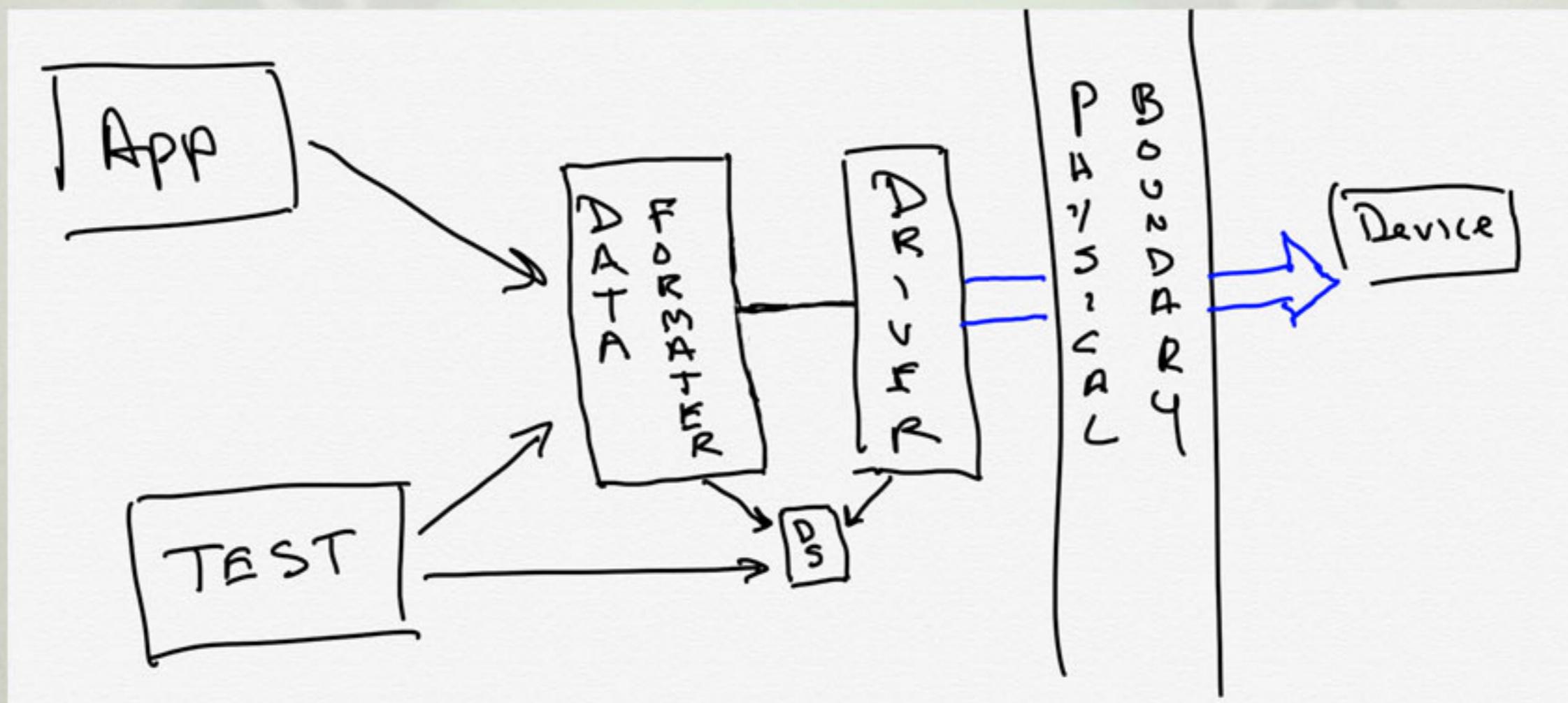


# SELF-SHUNT



Self Shunt.

# HUMBLE OBJECT



# TEST CONVENTIONS



# TEST NAMES

---

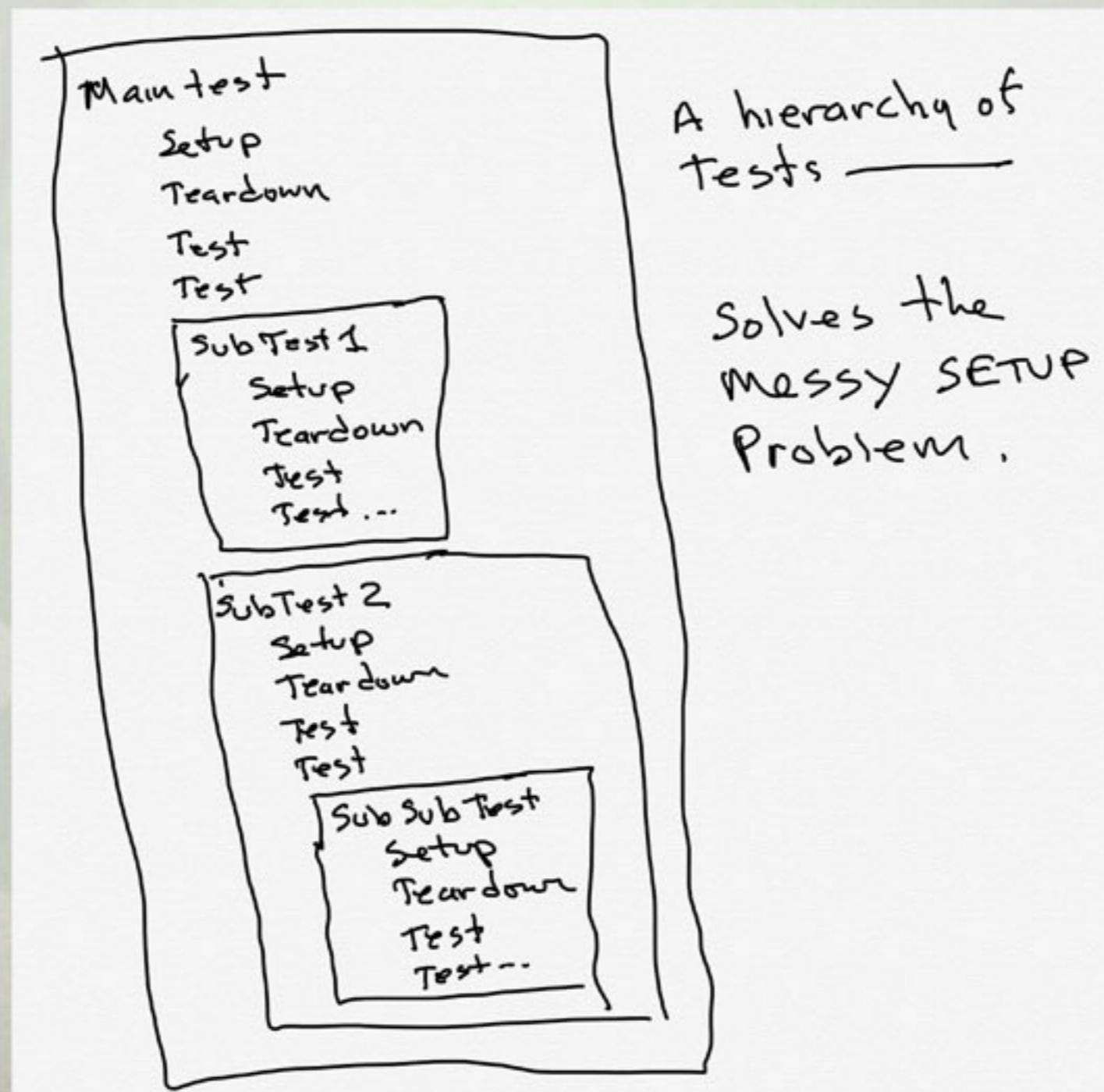
- The WHEN\_THEN convention
  - `unboundSymbol_notReplaced`
  - `boundSymbol_replaced`
  - `nullBuffer_noAction`
  - `nullSymbol_noAction`
- <http://weblogs.asp.net/rosherove/archive/2005/04/03/TestNamingStandards.aspx>

# TESTING PRIVATE OR PROTECTED METHODS.

- **Principle #1: Don't Test Private or Protected Methods.**
  - Test public and extract private and protected methods.
  - Extracted methods are already tested.
- **Principle #2: Testing Trumps Privacy**
  - If you have a private method that needs testing, make it protected and put the test in the same package.
  - Or, better yet, extract the private method into it's own class where it can be public.
- **Principle #3: Testing privates implies a design error.**
  - You can't test through public interface.
  - Therefore private method does more than public can ask

# HIERARCHICAL TESTS

- Junit: HierarchicalContextRunner



# COVERAGE AND METRICS



# COVERAGE

---

- **Goal is 100%**
  - Asymptotic
  - FitNesse is at 90% (Probably more)
- **Coverage should be measured, plotted, and visible**
  - Everyone should see the current test coverage numbers
- **Coverage should not be mandated**
  - Leads to false positives, e.g. “no asserts”
- **Tests should be regularly reviewed**
  - To make sure they assert what is covered

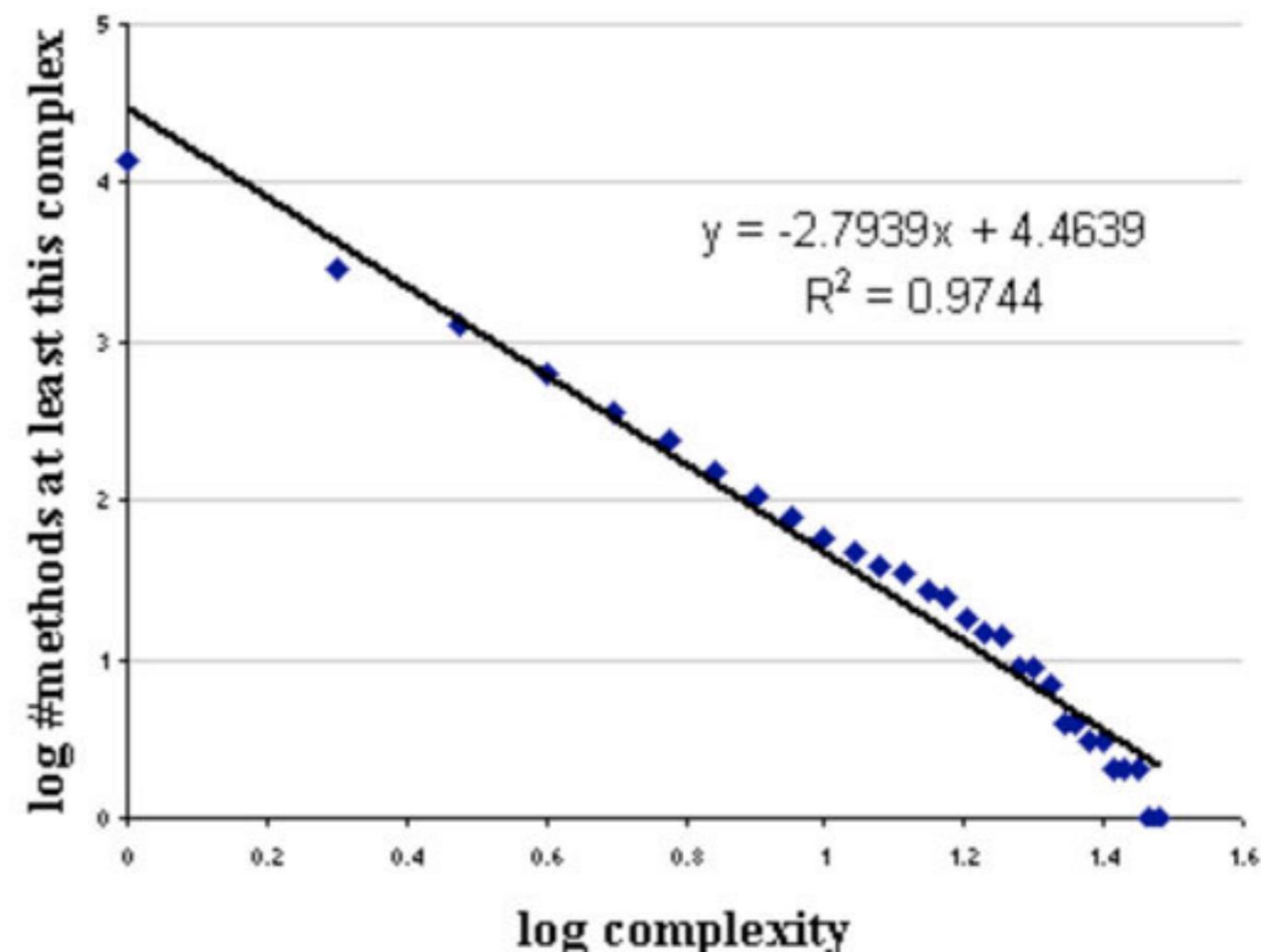
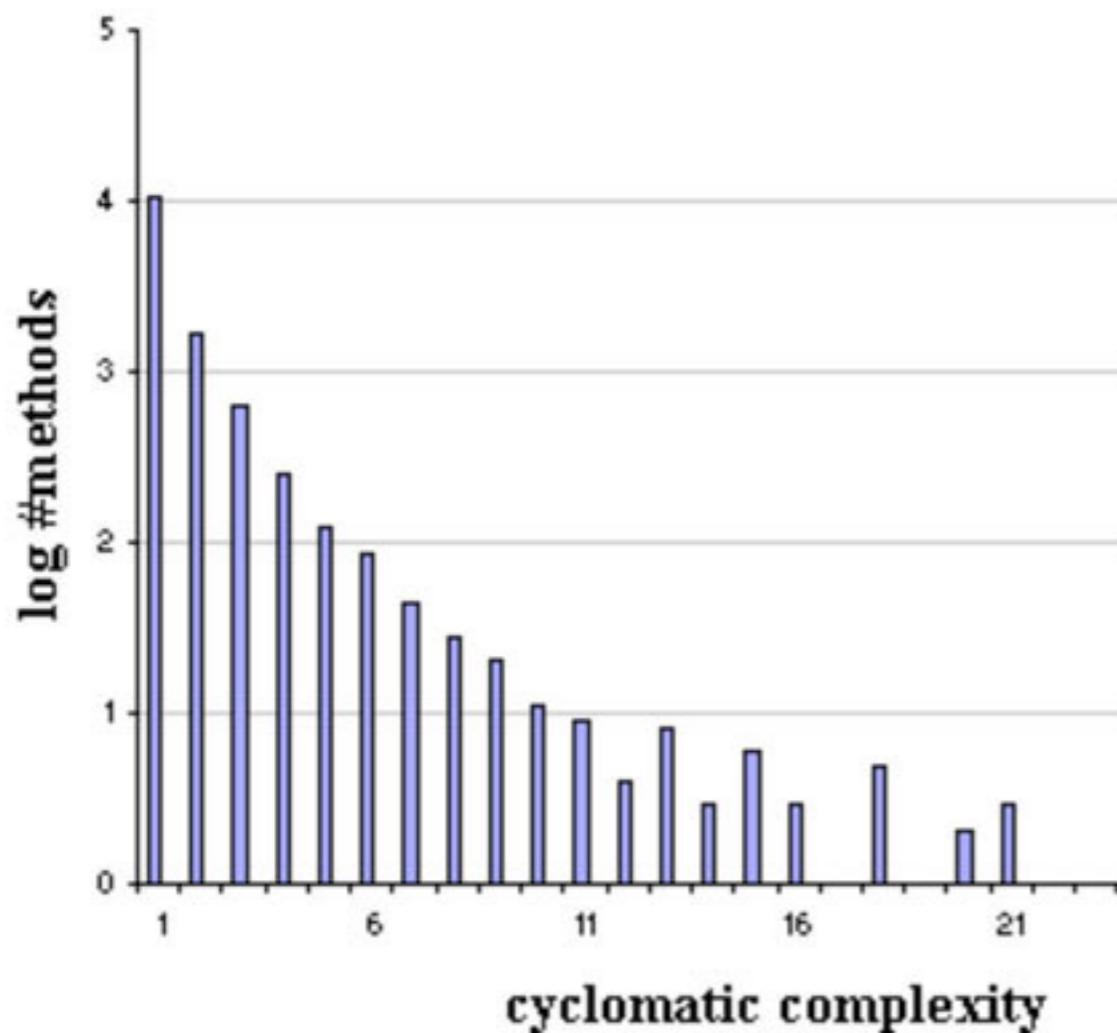
# MUTATION TESTING

---

- pitest.org.
- Tool runs coverage. Sees tests pass.
- Tool makes one semantic mutation (byte code)
  - Re-runs tests and coverage.
  - Marks mutation as “living” if tests pass.
  - Repeat for all possible semantic mutations.
- Finds all unasserted code.

# BRAITHWAITE'S CORRELATION

- <http://peripateticaxiom.blogspot.com/2006/05/complexity-and-test-first-0.html>
- Slope of the linear regression of the Pareto distribution of Cyclomatic Complexity over Methods. <grin>
  - TDD > 2.0?
  - non TDD < 2.0?
  - Low slope means few large complicated methods.
  - High slow means many large complicated methods.



# BEHAVIOR DRIVEN DEVELOPMENT



# THE DIFFERENCE BETWEEN TDD AND BDD

---

- {} -- The empty set. BDD == TDD
- OK, there is a difference in Phraseology
  - Given/When/Then
  - The State Machine Analogy
  - Arrange, Act, Assert
- BDD is TDD with an emphasis on *Readability*

# CUCUMBER SYNTAX

- Feature: Search courses

In order to ensure better utilization of courses

Potential students should be able to search for courses

Scenario: Search by topic

Given there are 240 courses which do not have the topic "biology"

And there are 2 courses A001, B205 that each have "biology" as one of the topics.

When I search for "biology"

Then I should see the following courses:

Course code	
A001	
B205	

# GUI TESTING

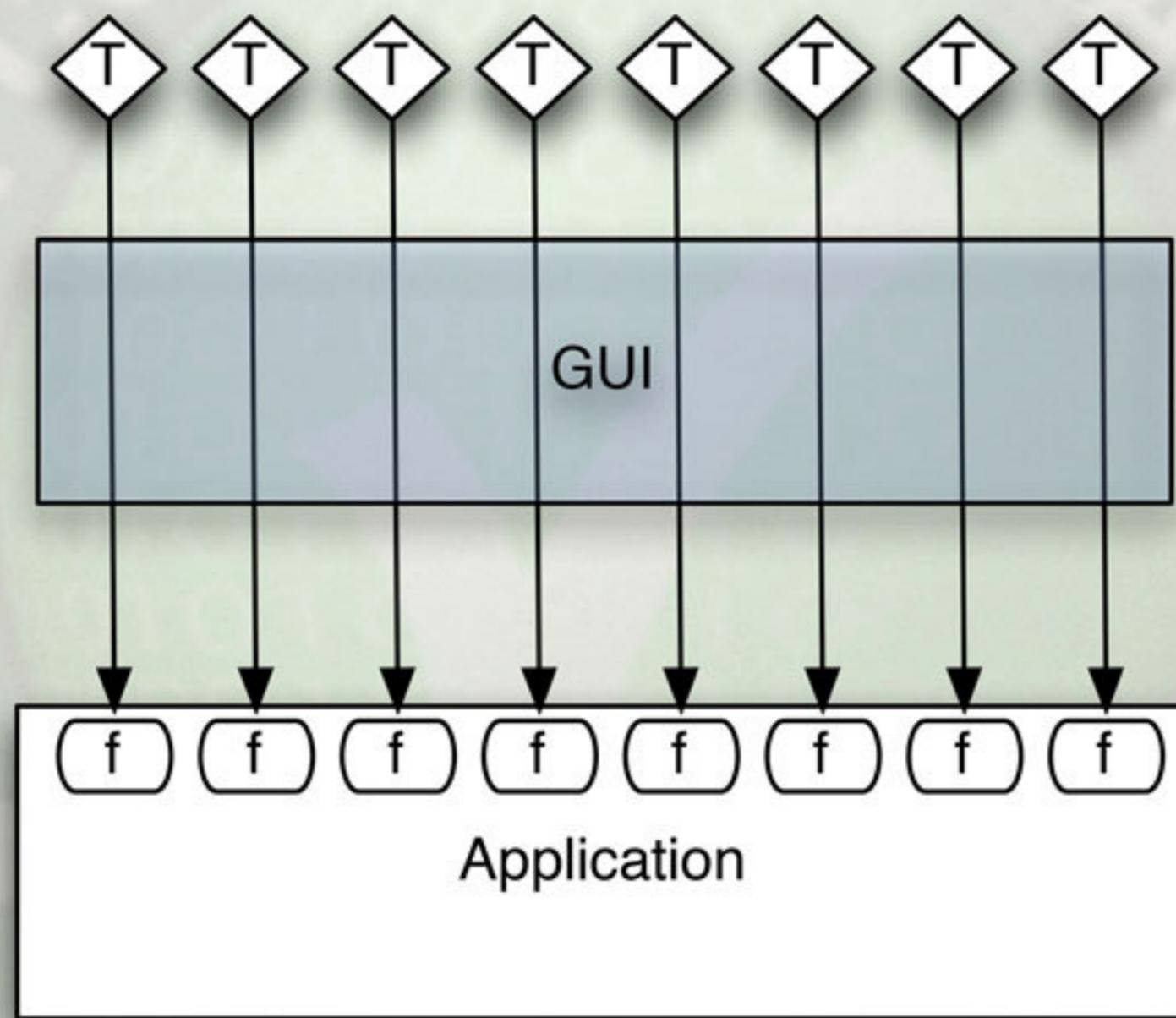


# HARD

---

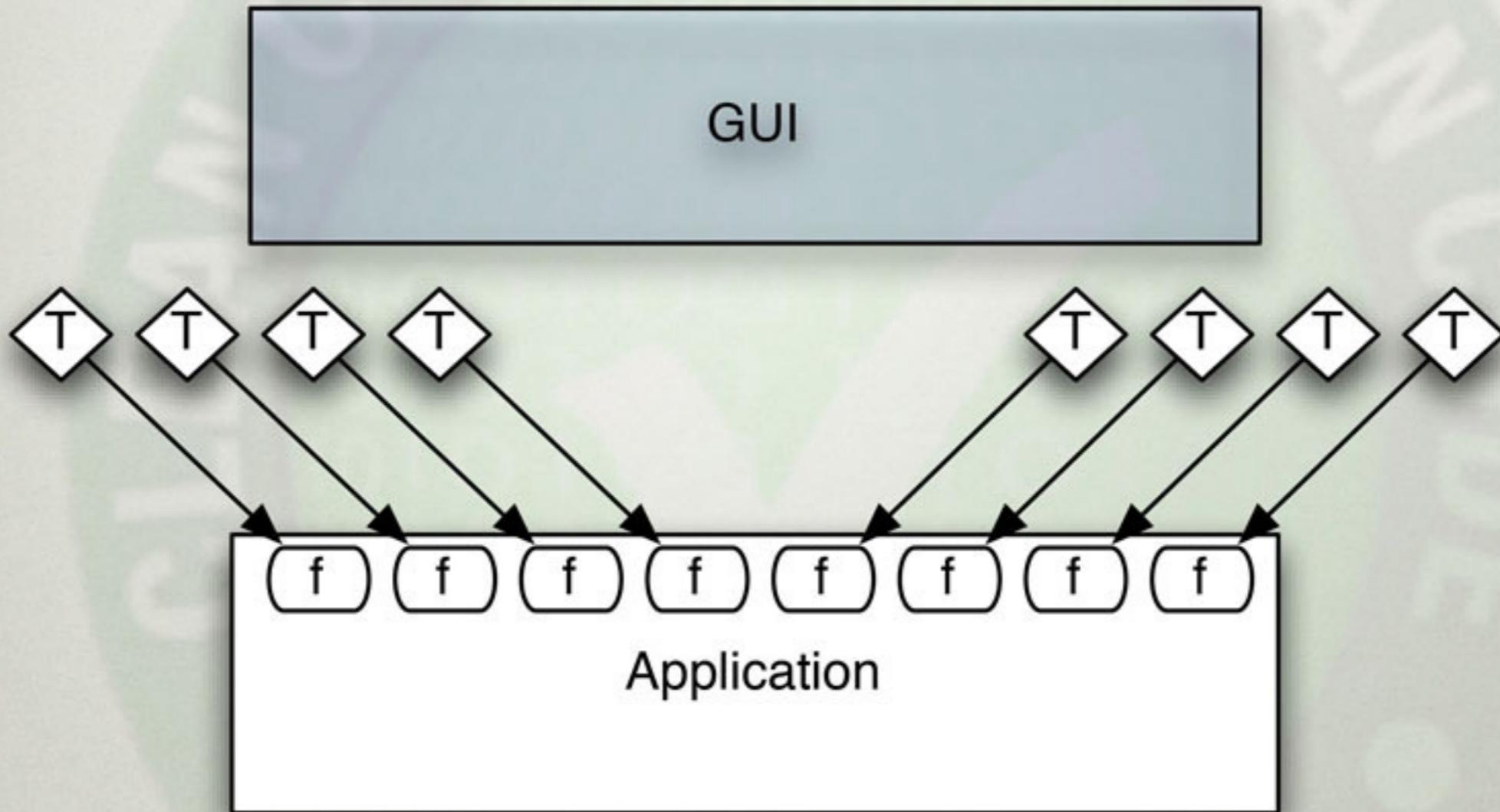
- I usually don't test GUI code.
- I use Humble Objects instead. (coming)
- I verify GUI by eye.
- But sometimes GUI testing is necessary.

# TESTING THROUGH THE GUI.



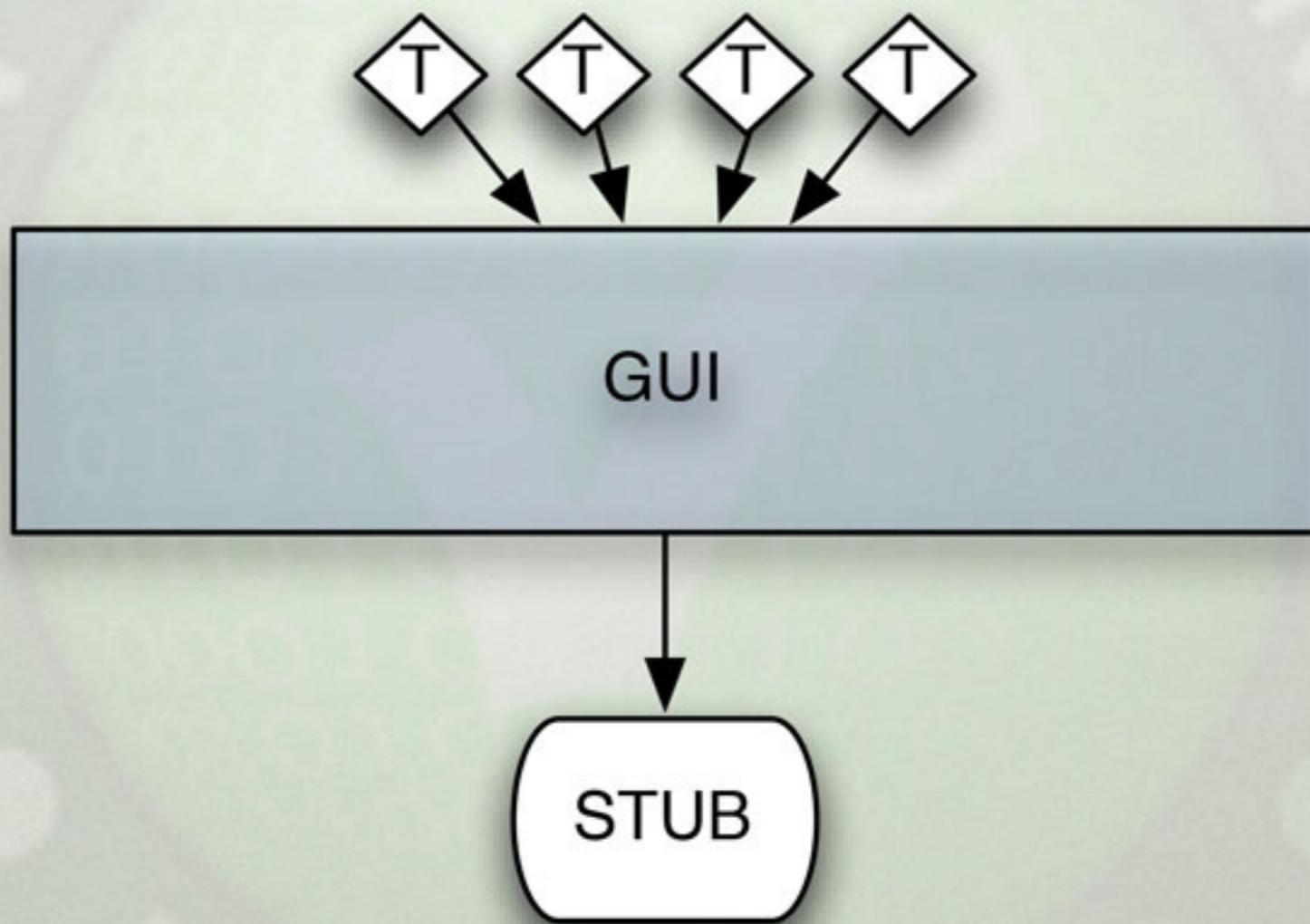
- Couples the tests to the GUI.

# TEST BUSINESS RULES THROUGH THE API



- Decouple the tests from the GUI.

# GUI TESTS TEST ONLY GUI

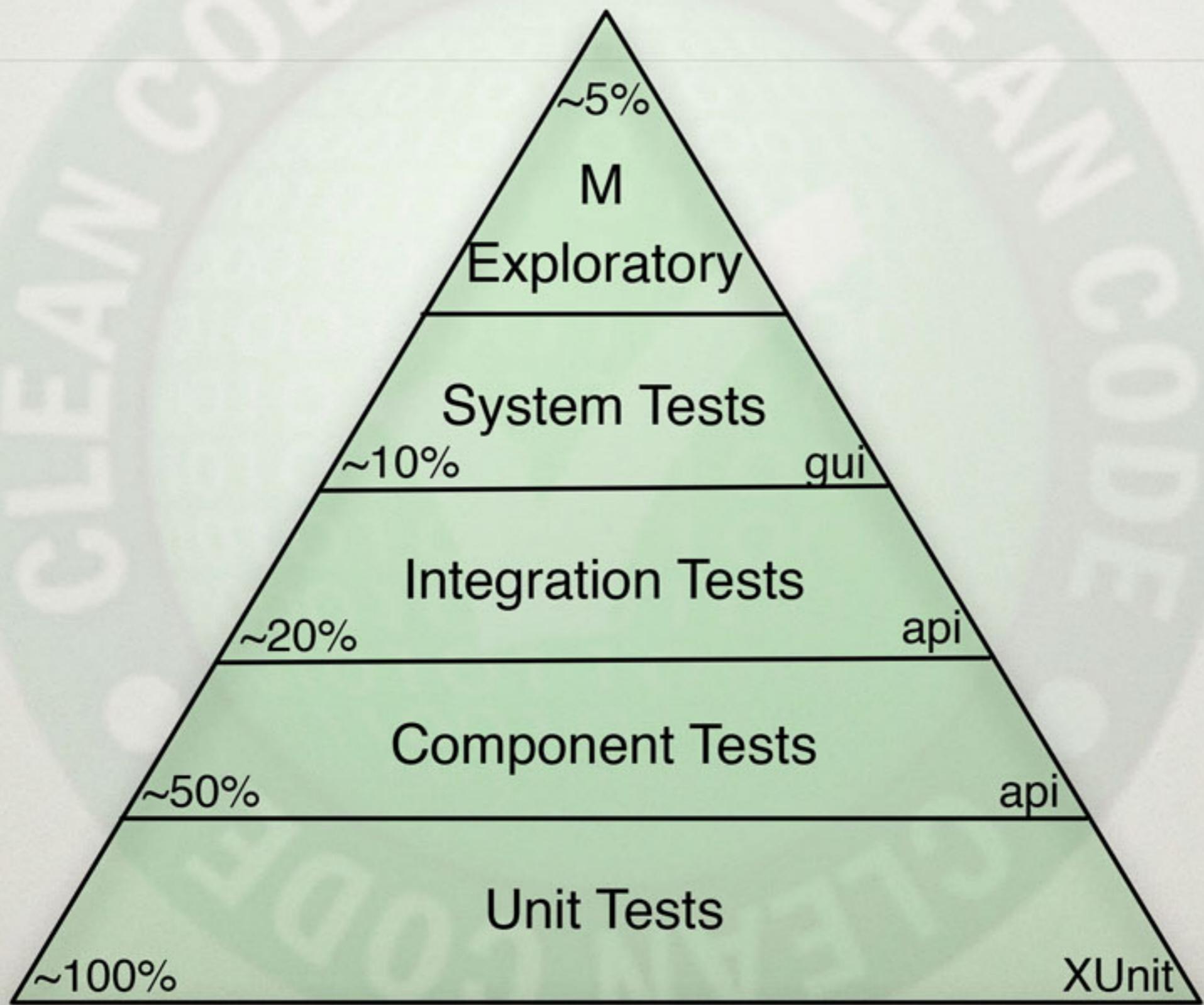


- Stub out the application to prevent testing business rules.

# TESTING LEVELS

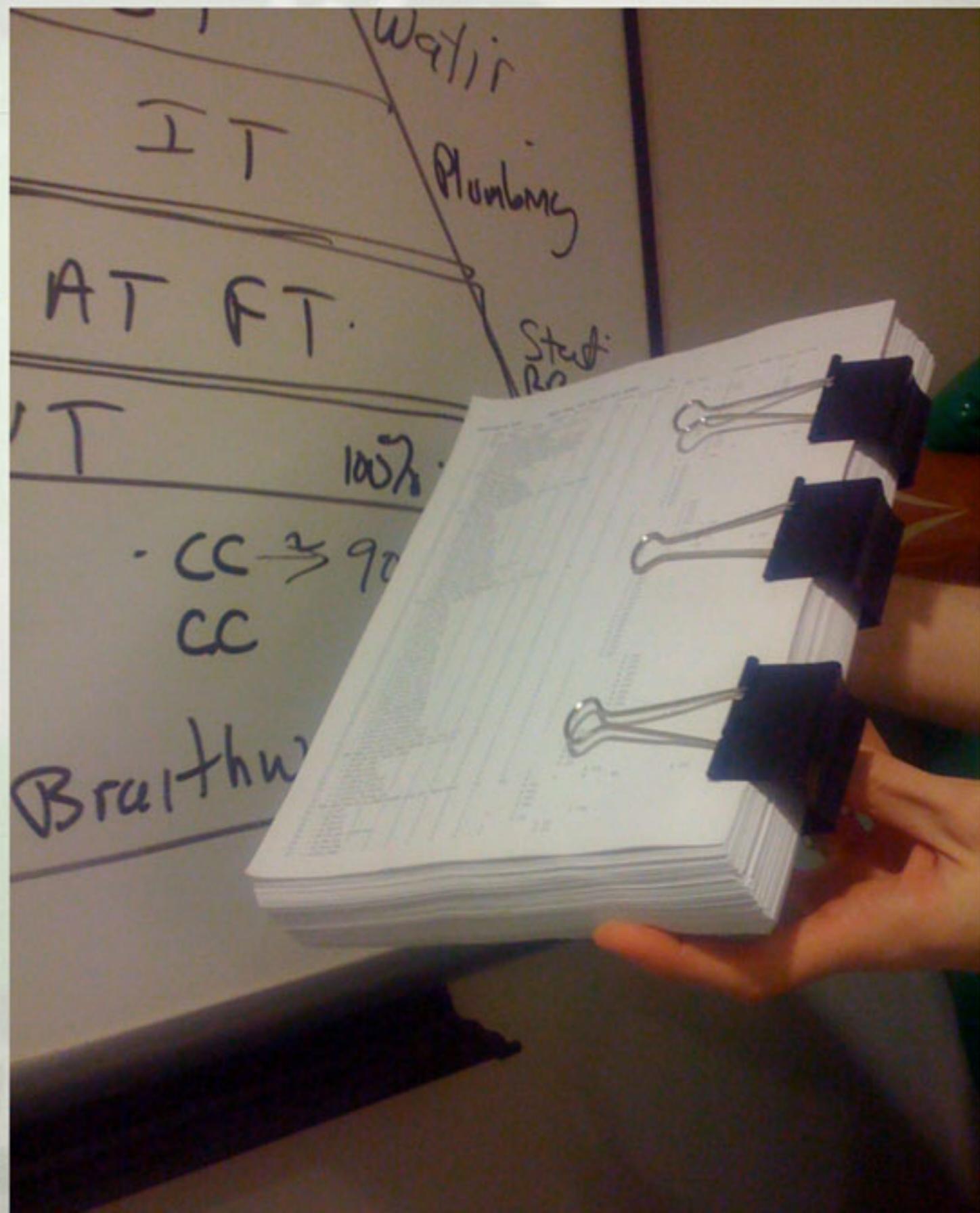


# LEVELS OF TESTING.



# THE MANUAL DILEMMA

- Contents of Test Plan.
  - 80,000 Manual Tests.
  - \$1,000,000 every 6 months.
  - 50% budget cut

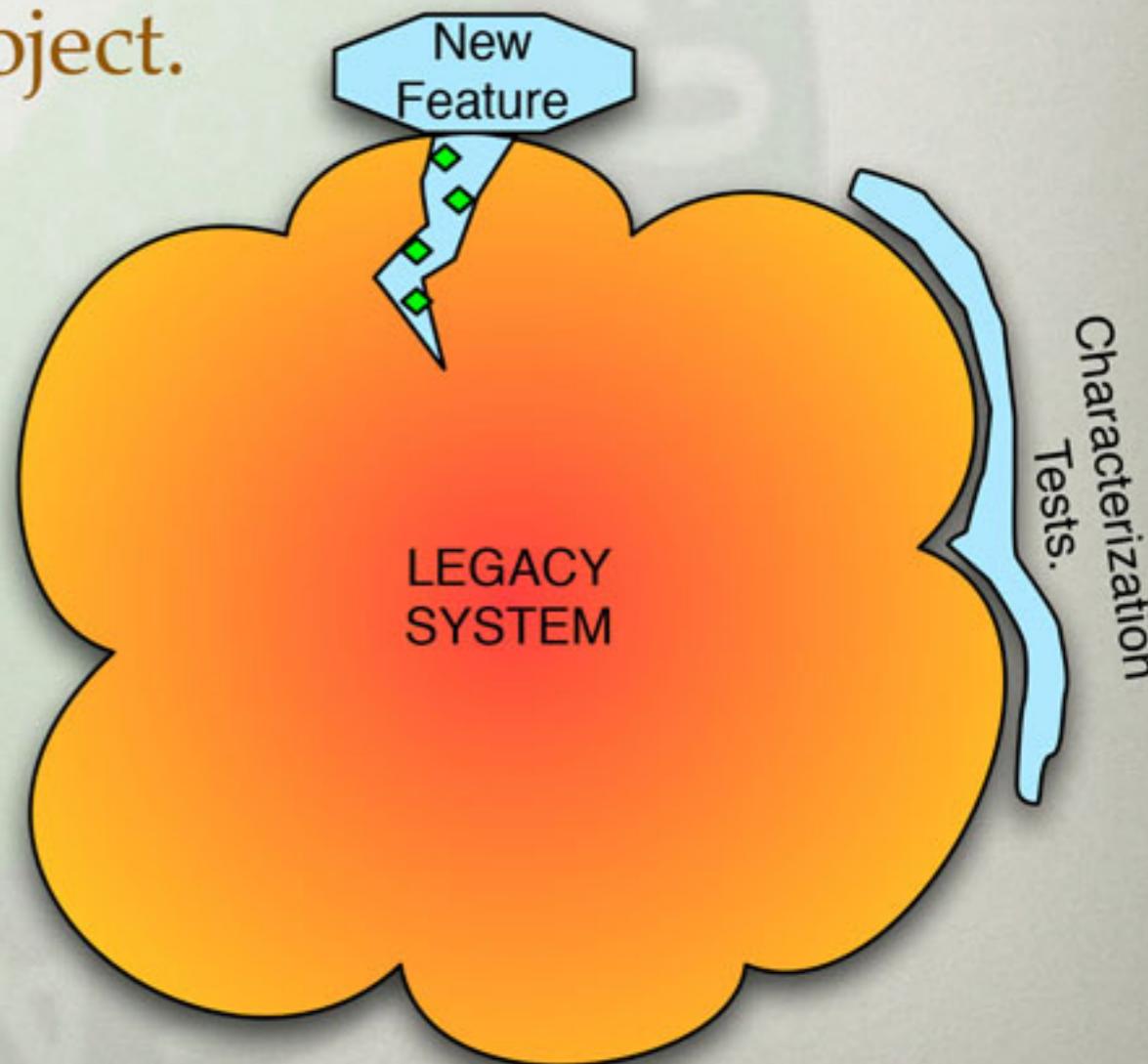
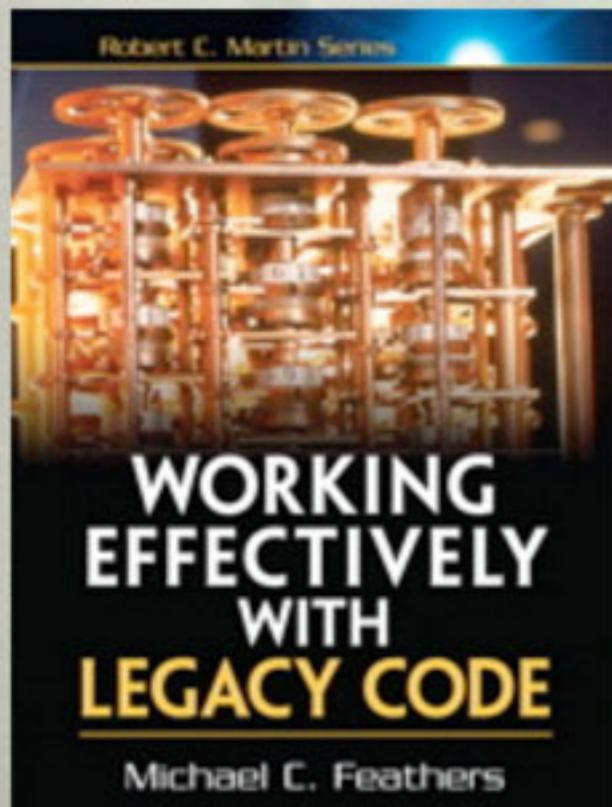


# LEGACY CODE



# GETTING LEGACY CODE UNDER TEST.

- No Magic Bullet.
- Took years to make the mess.
  - Will take a long time to undo it.
- Don't tackle as a single huge project.
  - Use the 'Boy Scout Rule'



# CONVINCING



## HOW DO I CONVINCE....

---

- You can't force people to believe.
- You can be a role model.
- You can exhort and encourage.
- You can give demos.
- You will convince some.
  - But not others.
- Divorce.

# FIN

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- [cleancoders.com](http://cleancoders.com)

