White-Box Testing

White Box Testing - Review

- You know the code
  - Given knowledge of the internal workings, you thoroughly test what is happening on the inside
  - Close examination of procedural level of detail
  - Logical paths through code are tested
    - » Conditionals
    - » Loops
    - » Branches
  - Status is examined in terms of expected values
  - Impossible to thoroughly exercise all paths
    - » Exhaustive testing grows without bound
  - Can be practical if a limited number of “important” paths are evaluated
  - Can be practical to examine and test important data structures

Build scaffolding for incomplete code

Stubs and drivers are code that are (temporarily) written in order to unit test a program

- **Driver is a *software module used to invoke a module under test and often, provide test inputs, controls, and monitor execution and report test results***

```
main () {
    movePlayer(Player, diceRoll);
}
```

- **Stub is a module that simulates components that aren't written yet, formally defined as a *computer program statement substituting for the body of a software module that is or will be defined elsewhere***

```
public void movePlayer(Player player, int diceValue) {
    player.setPosition(1);
}
```

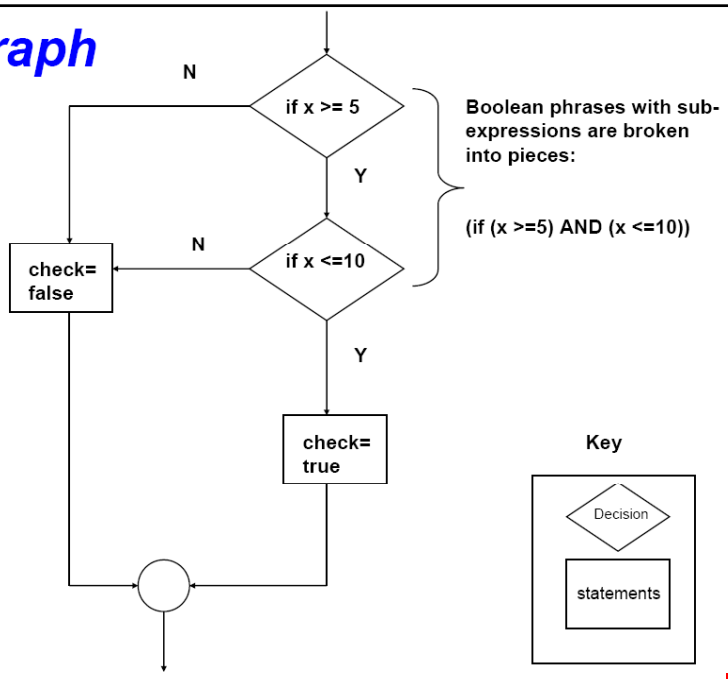

Devising a prudent set of test cases

- **Equivalence Class/Boundary Value Analysis**
  - **Still applies!**
- **Basis (Path) Set**
- **A metric for assessing how good your test suite is**
  - **Method Coverage**
  - **Statement Coverage**
  - **Decision/Branch Coverage**
  - **Condition Coverage**
- **Think diabolically**

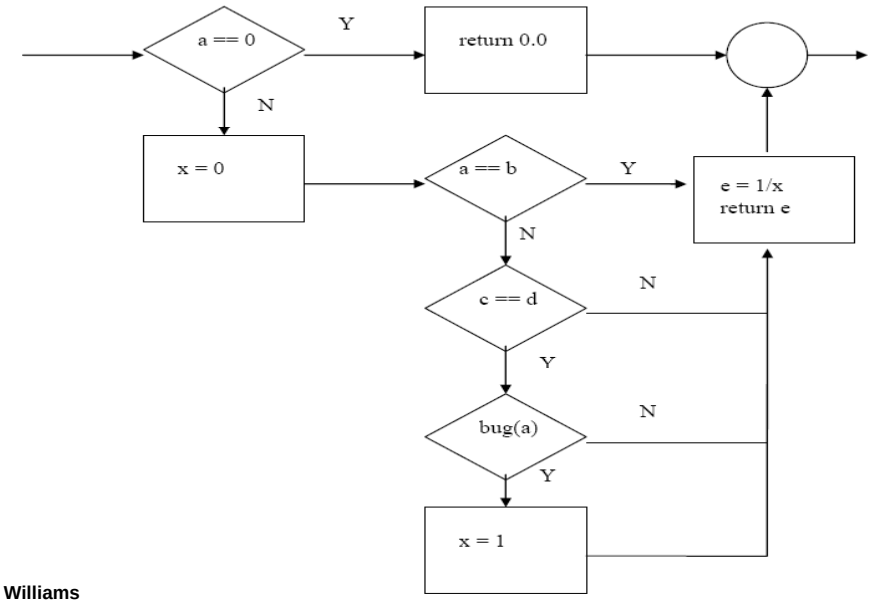
Basis Set

- Compute Cyclomatic number - V(G)
  - This gives us an estimate of how many tests must be designed and executed to guarantee coverage
  - The number of independent paths that must be tested to ensure that all statements have been executed at least once and every condition will have been executed on its true and false side!!
- Edges – Nodes + 2

Flow Graph



Compound Predicate



100% Method Coverage

- All methods in all classes have been called
- Test case 1: Foo(0, 0, 0, 0, 0) = 0.0
- float foo (int a, b, c, d, e) {

```
    if (a == 0) {
       return 0.0;
    }
    int x = 0;
    if ((a==b) OR ((c==d) AND bug(a) )) {
       x =1;
    }
    e = 1/x;
    return e;
}
```

100% Statement Coverage

- All lines in a method have been executed
- Test case 2: Foo(1, 1, 1, 1, 1) = 1.0
- float foo (int a, b, c, d, e) {

```
    if (a == 0) {
       return 0.0;
    }
    int x = 0;
    if ((a==b) OR ((c==d) AND bug(a) )) {
       x =1;
    }
    e = 1/x;
    return e;
}
```


100% Branch/Decision Coverage

- All predicates have been true and false
- Test case 3: Foo(1, 2, 1, 2, 1) ← division by zero!
- float foo (int a, b, c, d, e) {

```
    if (a == 0) {
       return 0.0;
    }
    int x = 0;
    if ((a==b) OR ((c==d) AND bug(a) )) {
       x =1;
    }
    e = 1/x;
    return e;
}
```

Line #	Predicate	True	False
3	(a == 0)	Test Case 1 foo(0, 0, 0, 0, 0) return 0	Test Case 2 foo(1, 1, 1, 1, 1) return 1
7	((a==b) OR ((c == d) AND bug(a)))	Test Case 2 foo(1, 1, 1, 1, 1) return 1	

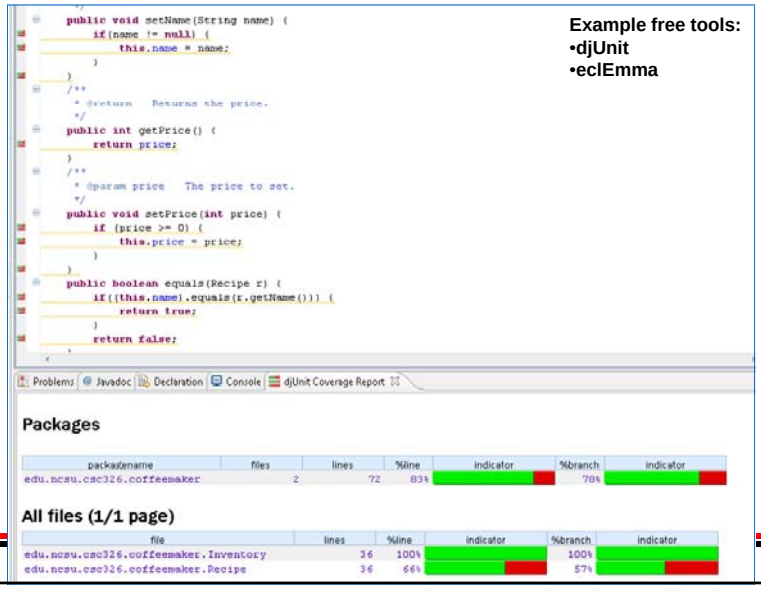
100% Condition Coverage

- All sub-expression predicates have been true and false
- Test case 4: Foo(1, 2, 1, 1, 1) ← a bug!
- float foo (int a, b, c, d, e) {

```
    if (a == 0) {
       return 0.0;
    }
    int x = 0;
    if ((a==b) OR ((c==d) AND bug(a) )) {
        x =1;
    }
    e = 1/x;
    return e;
}
```

Predicate	True	False
(a==b)	Test Case 2 **foo(1, 1, x, x, 1)** **return value 0**	Test Case 3 **foo(1, 2, 1, 2, 1)** **division by zero!**
(c==d)		Test Case 3 **foo(1, 2, 1, 2, 1)** **division by zero!**
bug(a)		

Coverage

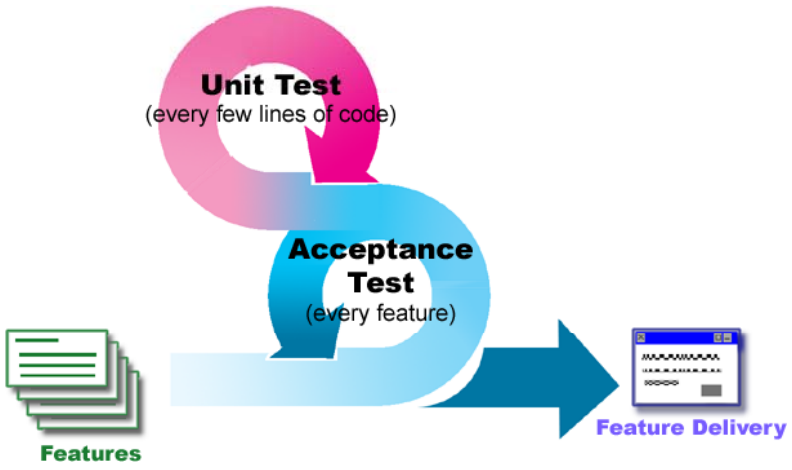


Example free tools:
- djUnit
- eclEmma

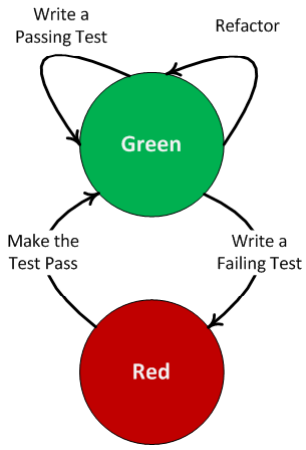
Loops

- **Write a test case such that you:**
  - Don't go through the loop at all
  - Go through the loop once
  - Go through the loop twice
  - Go through loop max times
  - Try to go through look max+1 times

Test-driven Development



Mantra: Red-Green-Refactor



http://www.agileprogrammer.com/uploads/bradwils/red_2Dgreen_2Drefactor.png

IBM and Microsoft TDD

Metric Description	IBM: Drivers	Microsoft: Windows	Microsoft: MSN	Microsoft: VS
Defects/KLOC of comparable team in organization but not using TDD	W	X	Y	Z
Actual defects/KLOC (using TDD)	0.61W	0.38X	0.16Y	0.09Z
Increase in time taken to code the feature because of TDD (%) [Management estimates]	15-20%	25-35%	15%	25-20%

TDD vs. Test-last Unit Test Automation

Metric Description	IBM: Drivers TDD	Microsoft: Windows TDD	Microsoft: MSN TDD	Microsoft: VS TDD	Microsoft: App Test-Last
Defects/KLOC of comparable team in organization but not using TDD	W	X	Y	Z	A
Actual defects/KLOC (using TDD)	0.61W	0.38X	0.16Y	0.09Z	.80A
Increase in time taken to code the feature because of TDD (%) [Management estimates]	15-20%	25-35%	15%	25-20%	30%

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  - **Still applies!**
- **Basis Set**
- **A metric for assessing how good your test suite is.**
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