# Software Testing – Unit Testing

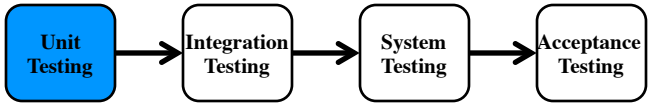
# When should you write a test?

- Traditionally after the source code is written

- In XP before the source code written
  - Test-Driven Development Cycle
    - Add a test
    - Run the automated tests

      => see the new one fail
    - Write some code
    - Run the automated tests

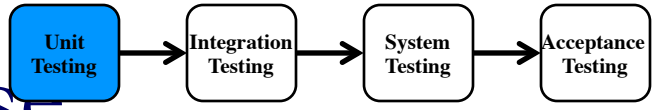
      => see them succeed
    - Refactor code




# Unit Testing

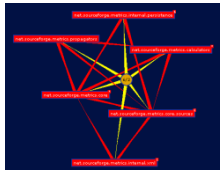
- Static Testing (at compile time)
  - Static Analysis
  - Review
    - Walk-through (informal)
    - Code inspection (formal)
  - Automated tools
    - check for syntax and semantic errors
    - departure from coding standards
- Dynamic Testing (at run time)
  - Black-box testing
  - White-box testing

# Static Analysis with Eclipse



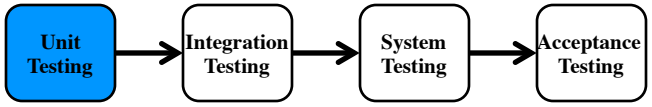

- Compiler Warnings and Errors
  - *Possibly uninitialized Variable*
  - *Undocumented empty block*
  - *Assignment has no effect*
- Checkstyle
  - Check for code guideline violations
  - http://checkstyle.sourceforge.net
- FindBugs
  - Check for code anomalies
  - http://findbugs.sourceforge.net
- Metrics
  - Check for structural anomalies
  - http://metrics.sourceforge.net



# Black-box Testing

- Black-box testing methodology looks at
  - what are the available inputs for an application
  - what the expected outputs are that should result from each input
- Black-box testing is NOT concerned with
  - the inner workings of the application
  - the process that the application undertakes to achieve a particular output
  - any other internal aspect of the application that may be involved in the transformation of an input into an output




# Black-box testing

- Focus: I/O behavior
  - If for any given input, we can predict the output, then the component passes the test
  - Requires test oracle (strategy to determine if a test passes or fails)
- Goal: Reduce number of test cases by equivalence partitioning:
  - Divide input conditions into equivalence classes
  - Choose test cases for each equivalence class.

# Black-box testing: Test case selection

a) Input is valid across range of values

- Developer selects test cases from 3 equivalence classes:
  - Below the range
  - Within the range
  - Above the range

b) Input is only valid, if it is a member of a discrete set

- Developer selects test cases from 2 equivalence classes:
  - Valid discrete values
  - Invalid discrete values

- No rules, only guidelines

# Black box testing: An example

```
public class MyCalendar {

  public int getNumDaysInMonth(int month, int year)
      throws InvalidMonthException
  { … }
}
```

Representation for `month`:
1: January, 2: February, …., 12: December

Representation for `year`:
1904, … 1999, 2000,…, 2006, …

How many test cases do we need for the black box testing of `getNumDaysInMonth()`?

# Black box testing: An example contd.

How many test cases do we need for the black box testing of getNumDaysInMonth()?

Depends on calendar: gregorian calendar

- Month parameter equivalence classes
  - 30 days
  - 31 days
  - February
  - No month 0, 13, -1

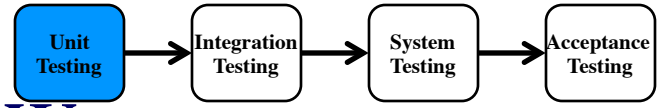
- year: parameter equivalence classes
  - Normal year
  - Leap year:
    - /4
    - /100
    - /400
  - Before christ/ After Christ year -200
  - Before at and after 2000

**=> 12 test cases**

# White-box Testing

- White-box testing methodology looks under the covers and into the subsystem of an application
- It enables you to see what is happening inside the application
- It provides more than just having access to the user interface
- It allows tester to refer to and interact with the objects that comprise an application

# White-box testing overview




- Code coverage (Tool: EclEmma)
  - Statement Coverage
  - Branch coverage
  - Condition coverage
  - Path coverage

# White-box testing

```
public int returnInput (int input, boolean condition1, boolean condition2,
                                   boolean condition3)
{
  int x = input;
  int y = 0;
  if (condition1)
    x++;
  if (condition2)
    x--;
  if (condition3)
    y=x;
  return y;
}
```

# Statement Coverage

TestCase:

*shouldReturnInput(x, true, true, true)*

100% statements covered

# Branch Coverage

TestCase:

*shouldReturnInput(x, true, true, true)*

100% statements covered

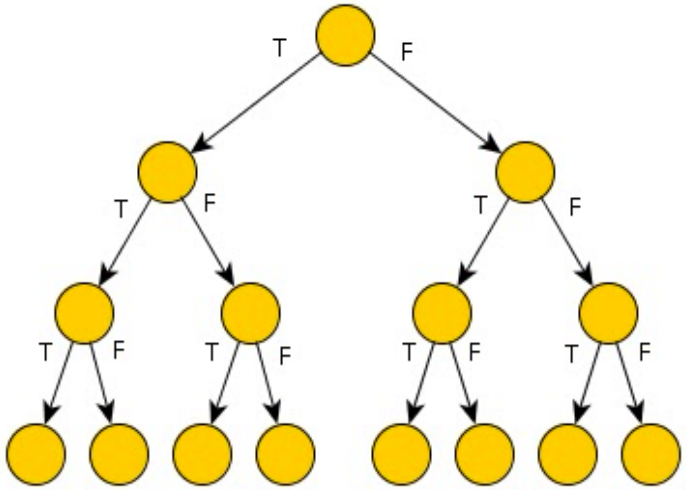
Only half of branches are covered

- Every "if-statement" as two branches (true-branch and false-branch).
- Above test case follows only "true-branches" of every "if-statement". Only 50% of branches are covered.

How can you achieve 100% branch coverage?

- In order to cover 100% of branches we would need to add following testcase: *shouldReturnInput(x, false, false, false)*

# Path Coverage




There are 8 separate paths:
t -t -t - covered with test case 1
t -t -f
t -f -t
t -f -f
f -t -t
f -t -f
f -f -t
f -f -f - covered with test case 2

# Unit Testing Heuristics

1. Create unit tests when object design is completed

   - Black-box test: Test the functional model

   - White-box test: Test the dynamic model

2. Develop the test cases

   - Goal: Find effective number of test cases

3. Cross-check the test cases to eliminate duplicates

   - Don't waste your time!

4. Desk check your source code

   - Sometimes reduces testing time

5. Create a test harness

   - Test drivers and test stubs are needed for integration testing

6. Describe the test oracle

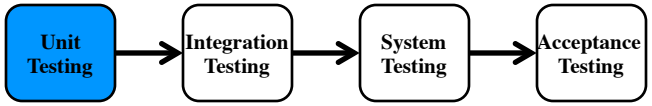
   - Often the result of the first successfully executed test

7. Execute the test cases

   - Re-execute test whenever a change is made ("regression testing")

8. Compare the results of the test with the test oracle

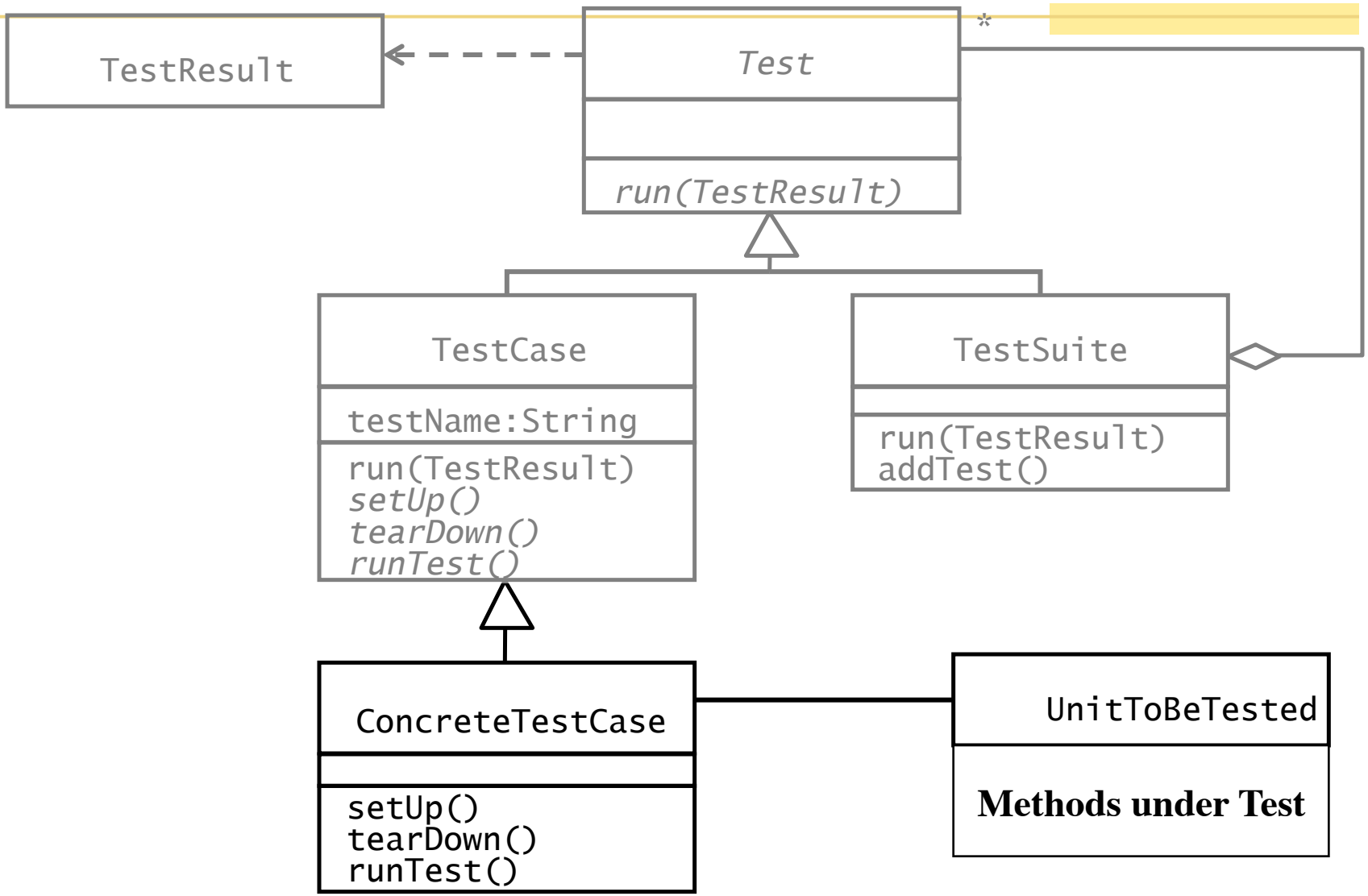
   - Automate this if possible.




# JUnit: Overview

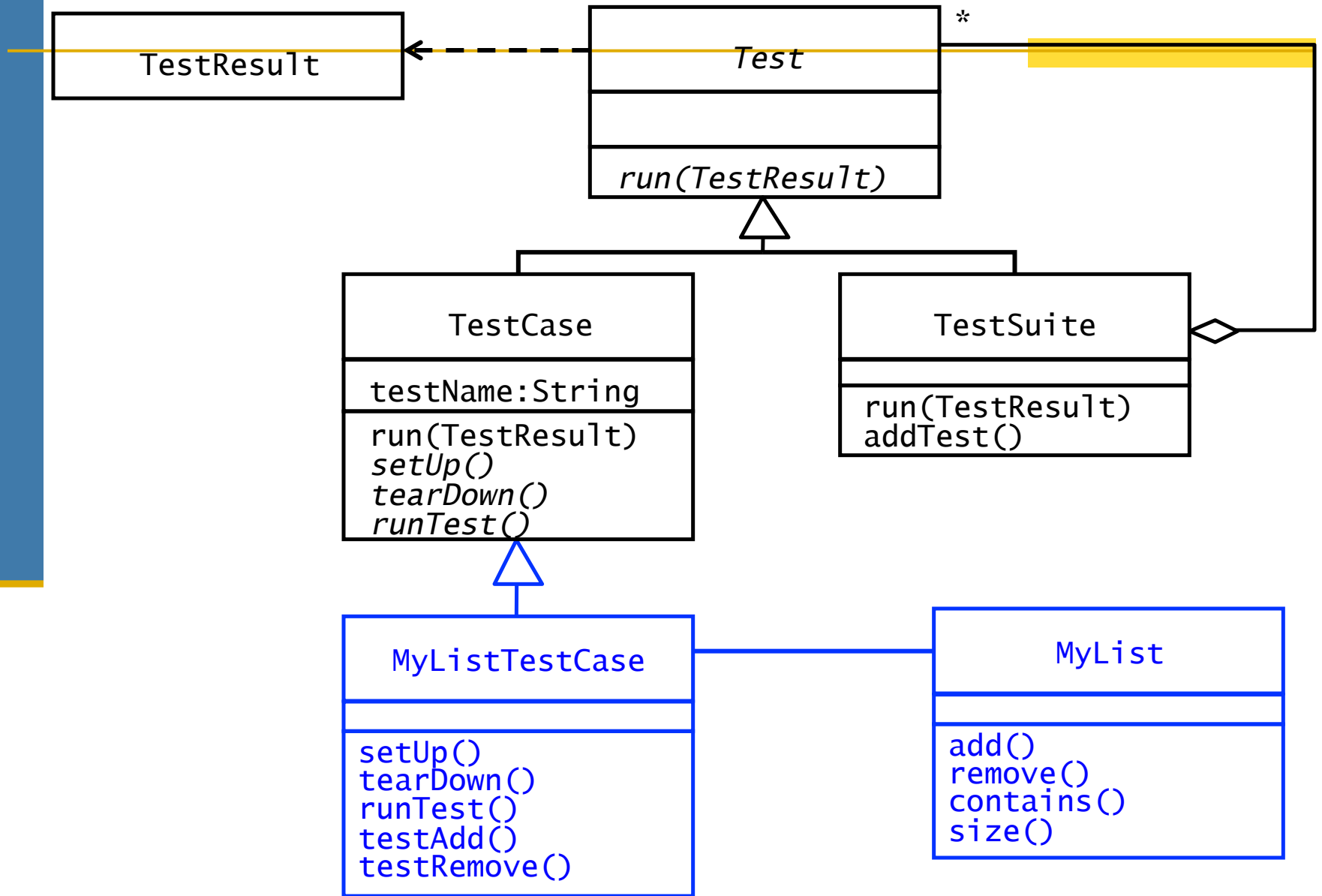
- A Java framework for writing and running unit tests
  - Test cases and fixtures
  - Test suites
  - Test runner
- Written by Kent Beck and Erich Gamma
- Written with “test first” and pattern-based development in mind
  - Tests written before code
  - Allows for regression testing
  - Facilitates refactoring
- JUnit is Open Source
  - www.junit.org

# JUnit Classes



# An example: Testing MyList

- Unit to be tested
  - MyList
- Methods under test
  - add()
  - remove()
  - contains()
  - size()
- Concrete Test case
  - MyListTestCase


TestResult
Test
*
run(TestResult)
TestCase
testName:String
run(TestResult)
setUp()
tearDown()
runTest()
TestSuite
run(TestResult)
addTest()
MyListTestCase
setUp()
tearDown()
runTest()
testAdd()
testRemove()
MyList
add()
remove()
contains()
size()

# Other JUnit features

- Textual and GUI interface
  - Displays status of tests
  - Displays stack trace when tests fail
- Integrated with Maven and Continuous Integration
  - http://maven.apache.org
    - Build and Release Management Tool
  - http://Maven.apache.org/continuum
    - Continous integration server for Java programs
  - All tests are run before release (regression tests)
  - Test results are advertised as a project report
- Many specialized variants
  - Unit testing of web applications
  - J2EE applications