



# SENG3320/6320: Software Verification and Validation

School of Electrical Engineering and Computing

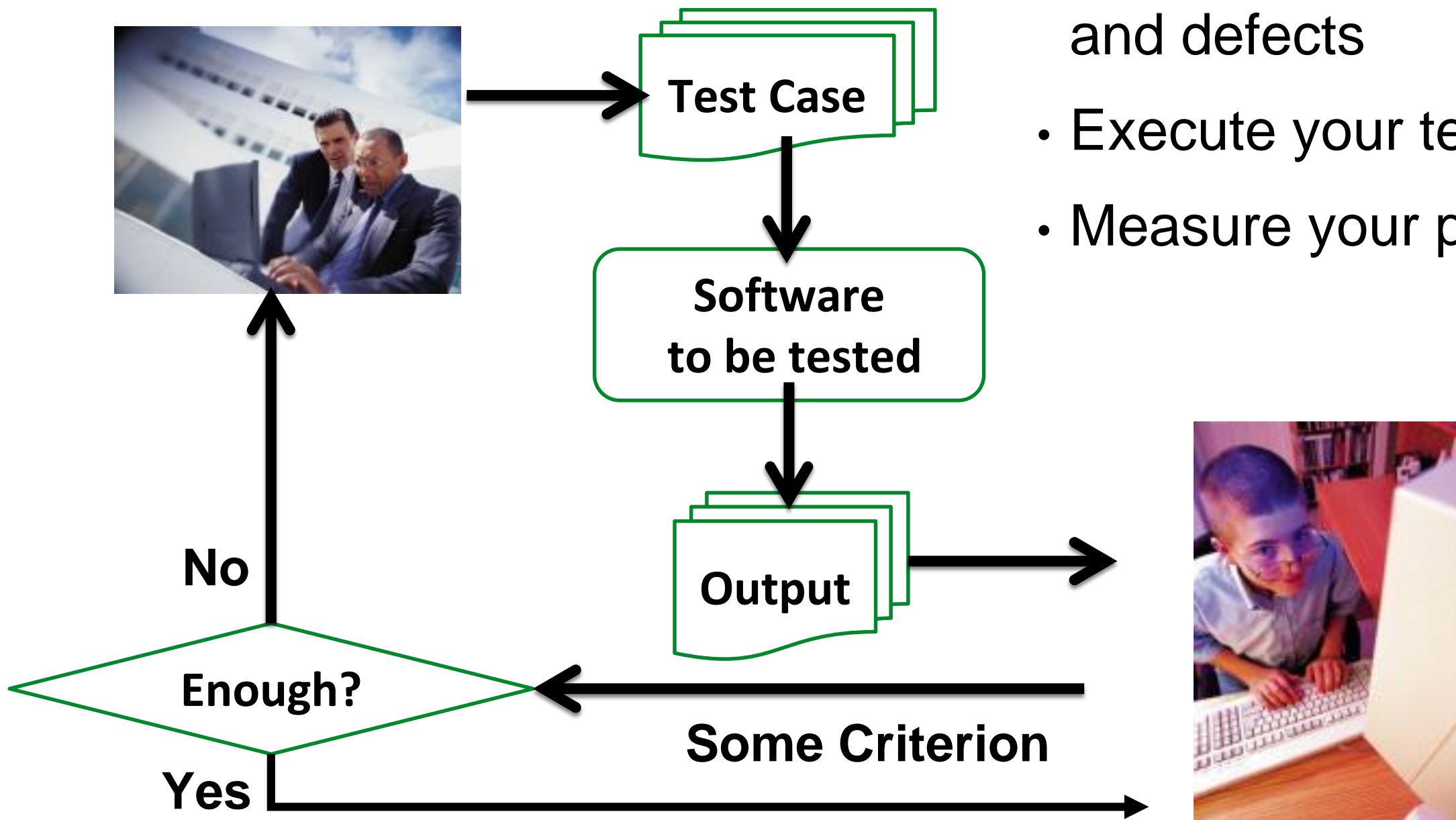
Semester I, 2020

# Test Management

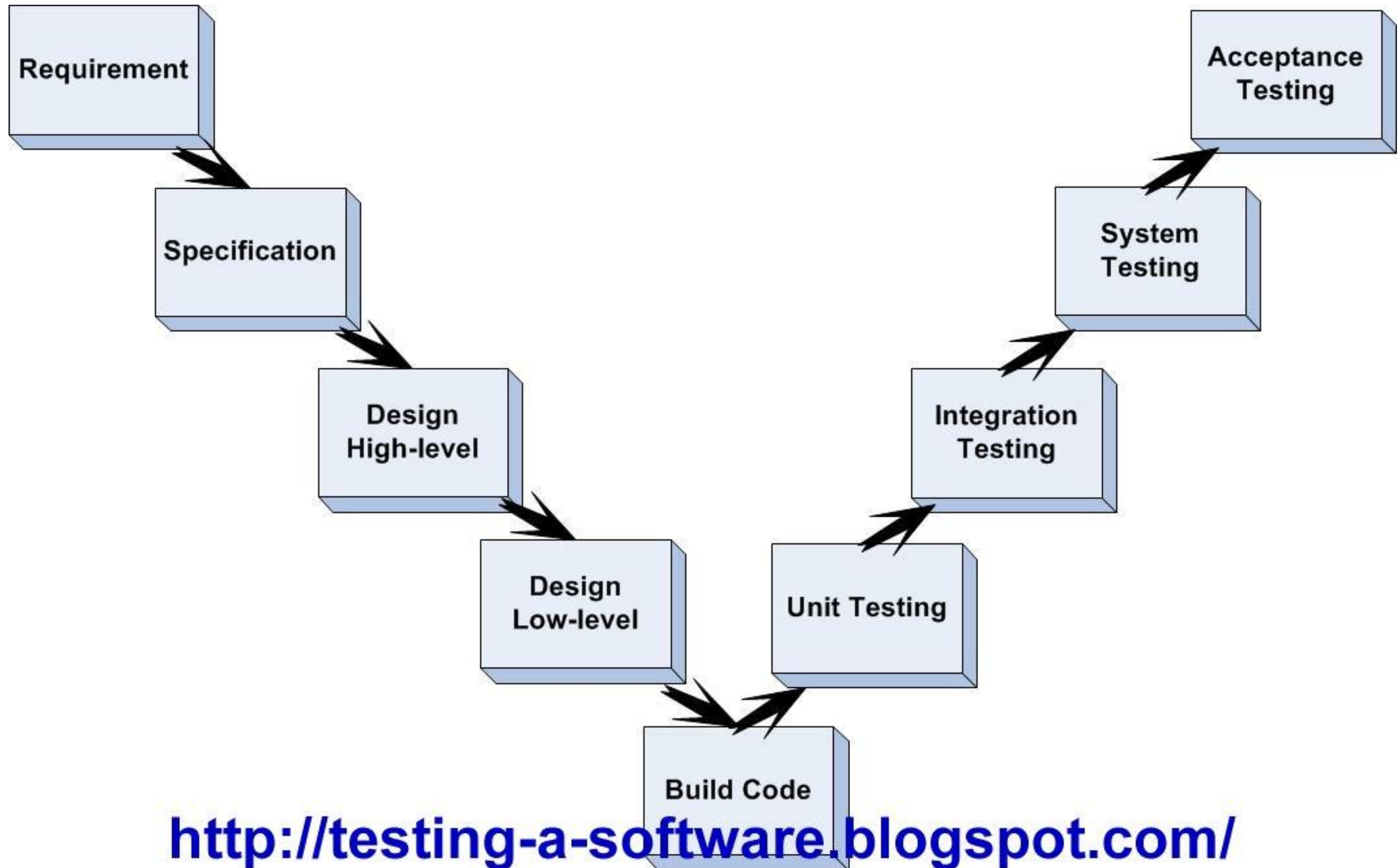
# Test management

- Manage your test plans and cases
- Track your requirements and defects
- Execute your tests
- Measure your progress

## Test case generation



# The V-model of development



# Contents of a software test report

- Test objective
  - Identifying the objectives of testing.
  - Testing should be planned so that all requirements are individually tested.
  - State the exit criteria.
- Testing environment
  - A description of test tools, required packages, hardware and software environment.
- Modules (features) under test and test cases
  - The software modules to be tested and the corresponding test cases.
  - Expected and actual test results
- Testing schedule
  - An overall testing schedule and resource allocation.
- Test summary
  - Summary and analysis of testing results, test coverage report.

# 1 Test Objective

*The Test Report should detail the scope of the testing, the program under testing, the test techniques and overall approach to be adopted, the test deliverables, the test exit criteria, as well as a list of features/requirements to be tested and not-tested.*

# 2 Test Environment

*A description of test tools, required packages, database, hardware and software environment of the testing project.*

# 3 Test Schedule

*An overall testing timeline/schedule and resource allocation.  
The roles and responsibilities of each team member.*

# 4 Examples of Test Cases

## 4.1 Module A

*For each of the test cases:*

- Describe the purpose of the test;*
- Describe the test data which will be used in the testing*
- Describe the actual and expected output;*
- Describe if the test case passes or fails.*

Test Case Description	Test Data	Expected Output	Actual Output	Pass/Fail

## 4.2 Module B

....

# 5 Test Results

*For each module, show the number of test cases, and the number of passing and failing test cases.*

*For each module, show the test coverage.*

# 6 Test Summary

*Summarize the testing project, describe your experience and lessons learned.*

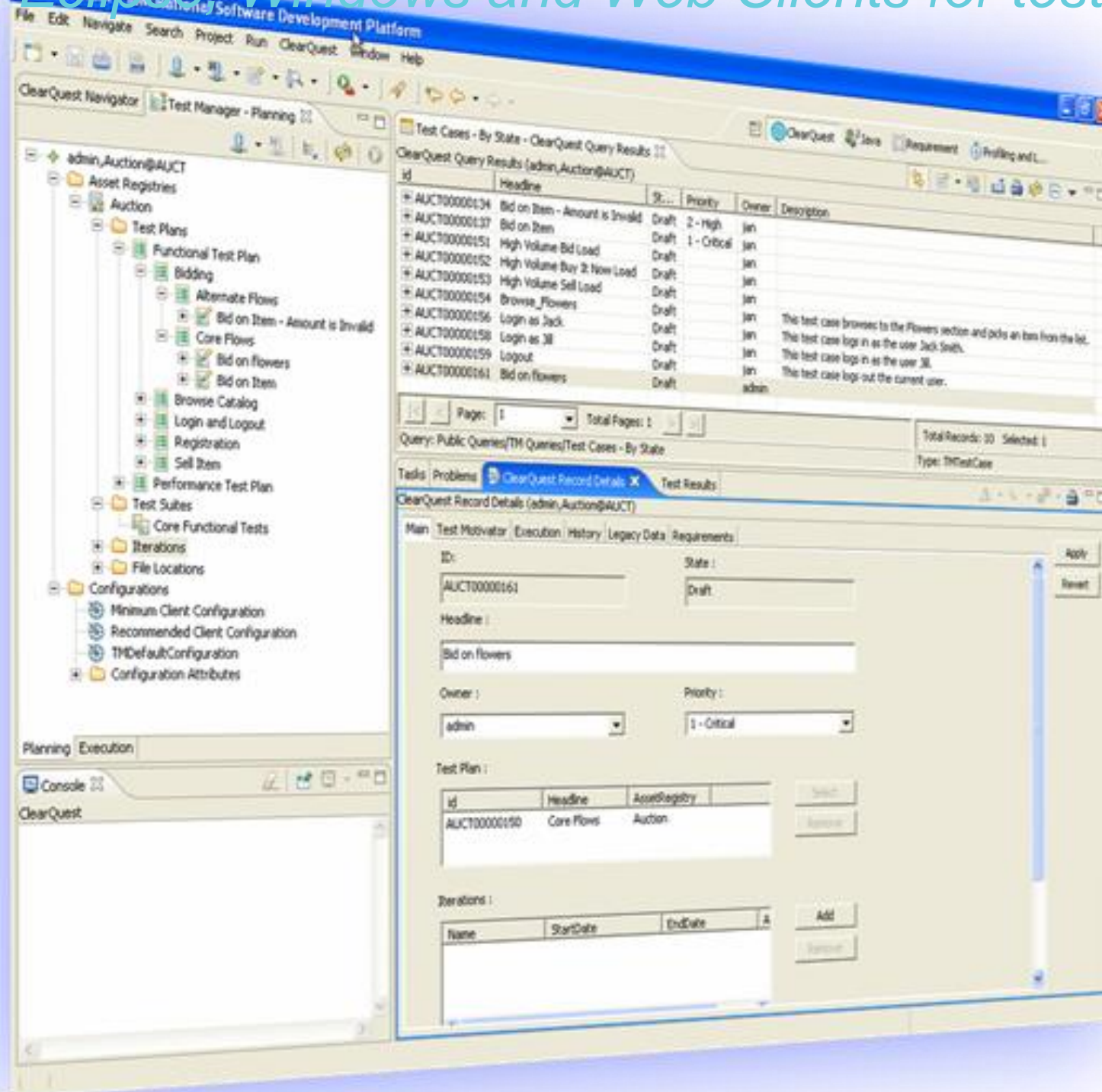
*Discuss how complete is the test, show test coverage.*

An example of  
software test report



# Test Management with ClearQuest

*Eclipse, Windows and Web Clients for test project tracking*



## ■ Eclipse Based Test Management

- ▶ Joins Functional and Performance Tester to complete transition of testing tools to eclipse platform
- ▶ Native and web clients also available

## ■ Key Functional Areas

### ▶ Test Planning

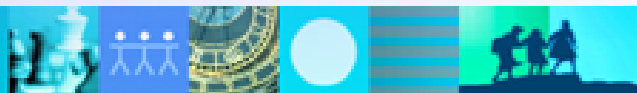
- Create test plans, test cases and configured test cases

### ▶ Test Execution

- Create suites or run individual test cases

### ▶ Test Reporting

- Extensive query and reporting facilities to measure test progress



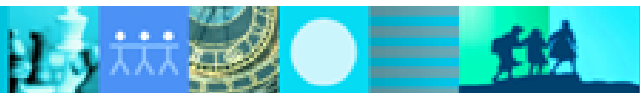
# Lifecycle Traceability

*Query one source for all aspects of project progress*

**Requirements Tests Defects**

Requirements, Verdicts and Defects - ClearQuest Query Results							
ClearQuest Query Results (jan,Auction@AUCTION)							
Tag	Requirement	Configured TC	Verdict	Defect Id	Defect Heading	Defect Priority	Defect State
+ FEAT12	The Buyer should be able to cancel his/her own bid before the bid is accepted.	AUCT00000180	fail	AUCT00000191	Cancel bid function does not actually cancel build	1-Resolve Immediately	Submitted
+ FEAT2	The Seller should be able to create an auction by describing an item or service	AUCT00000184	fail	AUCT00000200	Auction not accepting reserve bids	2-Give High Attention	Closed
+ UC4.2	Register Basic Flow	AUCT00000168	fail	AUCT00000199	System lets you register multiple accounts with same login	1-Resolve Immediately	Submitted

- Query to find
  - Test results associated to requirements
  - Defects associated to test results
  - Defects associated to tests associated to requirements
- Traceability from requirements to tests and defects closes the loop on the software development cycle

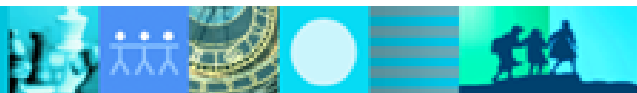
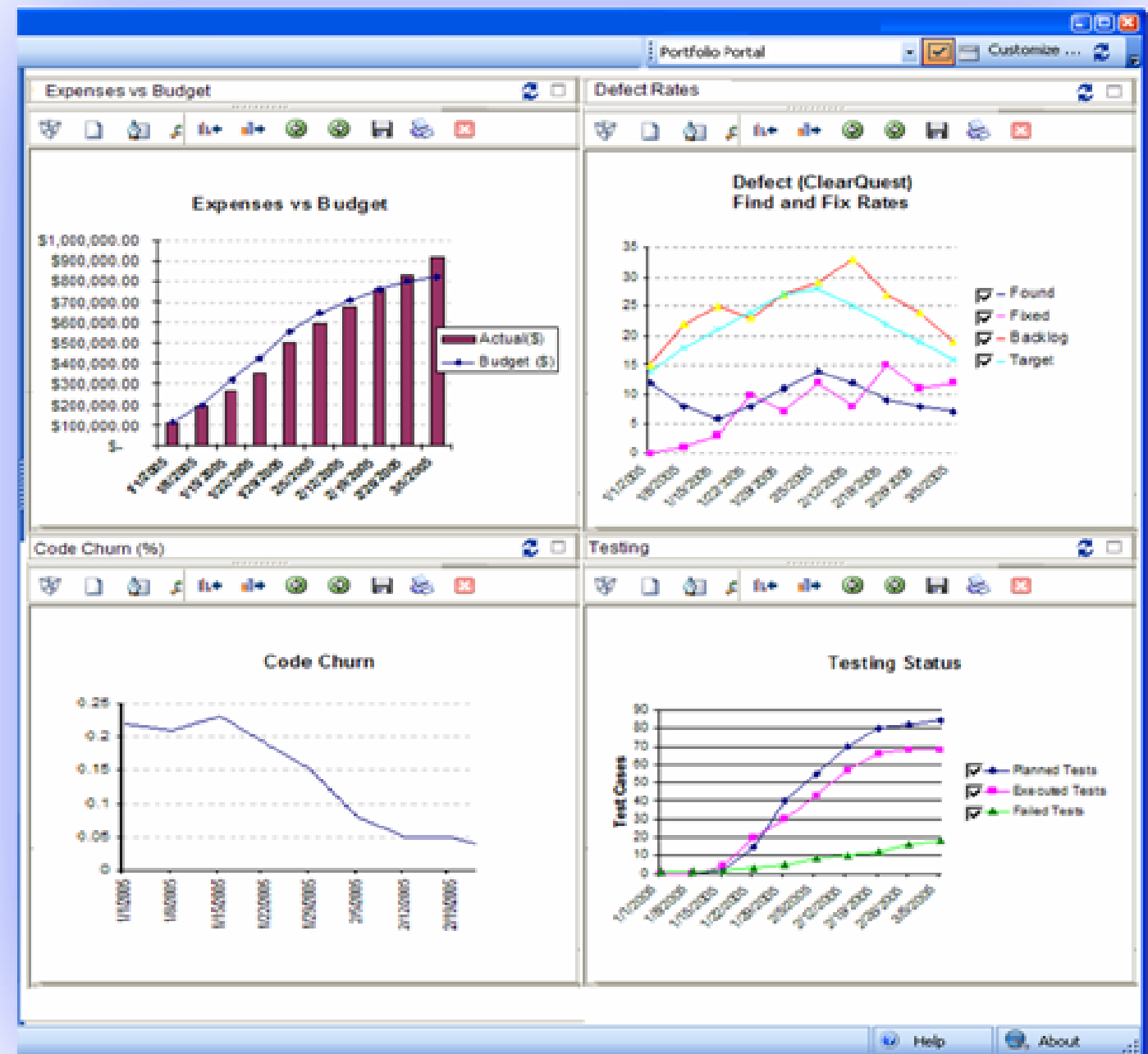




# Beyond Test Metrics

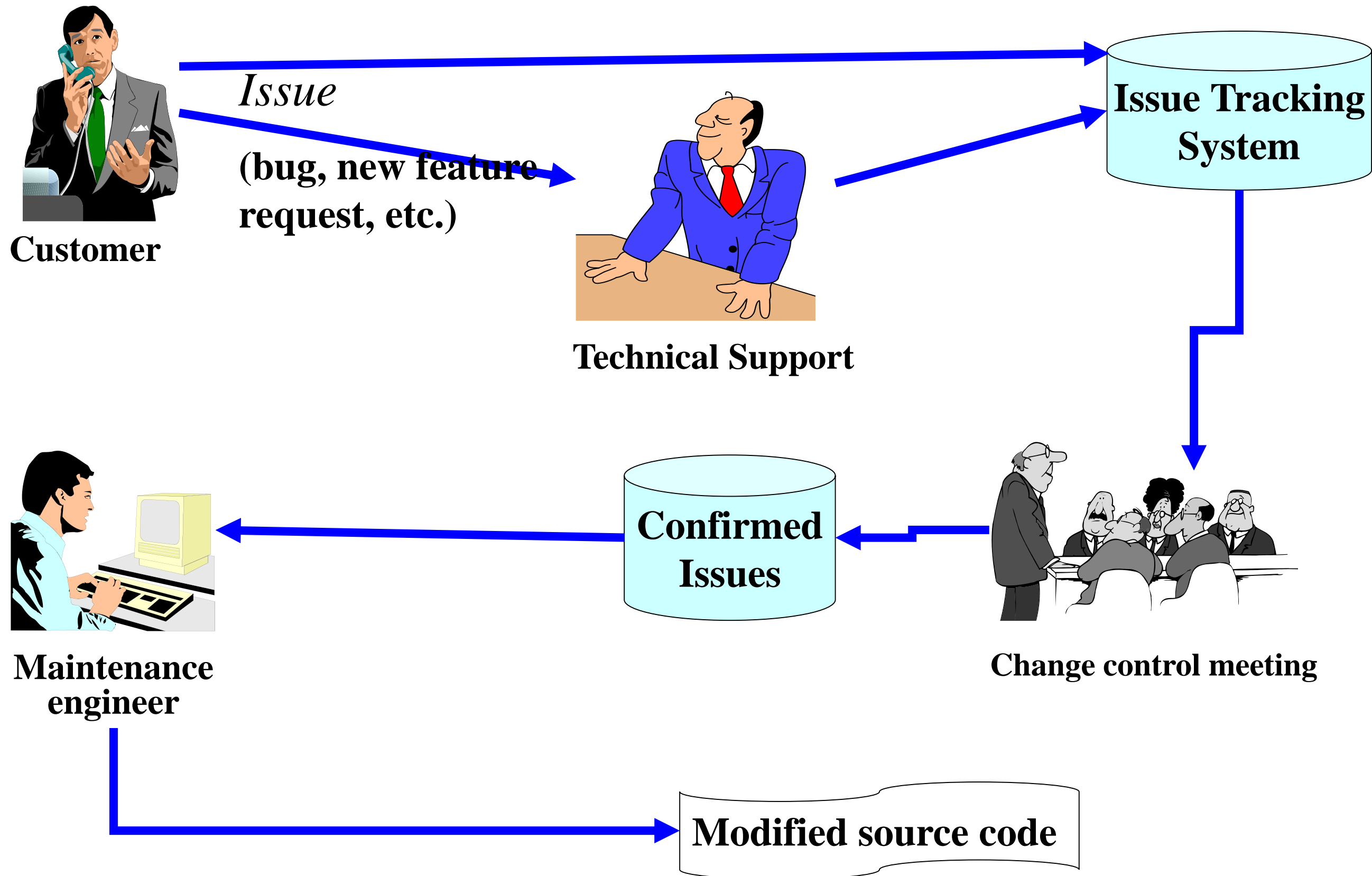
## *ClearQuest data integrated into Project Console and Portfolio Manager*

- Comprehensive project reporting
  - ▶ ClearQuest defect and test project data can be accessed from Rational Project Console and Rational Portfolio Manager
  - ▶ Provides a consolidated dashboard of all project metrics
  - ▶ Provides the information you need for all project decisions



# Issue Tracking System

# A Typical Maintenance Flow



# Issue Tracking System

- An issue tracking system is a software tool that is designed to help developers keep track of reported software issues (including bugs and new feature requests) .
- Extremely valuable in software development, and is used extensively by companies developing software products:
  - Track issues/bugs
  - Communicate with teammates
  - Submit and review patches
  - Manage quality assurance (QA)

# Issue Tracking System Example

## ■ Bugzilla (<http://www.bugzilla.org/>)

- an open source project originally written by Terry Weissman in 1998
- Many applications:
  - Mozilla: <http://bugzilla.mozilla.org/>
  - Gnome: <http://bugzilla.gnome.org/>
  - Eclipse: <http://bugs.eclipse.org/bugs/>



## ■ Similar products:

- Jira (<http://www.atlassian.com/en/software/jira>)
  - Customers: Audi, NASA, eBay, CISCO...
- Android Issue Tracker
- Microsoft Windows Error Reporting
- Apple Bug Reporter

# Bug Data

## ■ Description

- Summary
- Product/Module it belongs to
- Detailed descriptions

## ■ Role

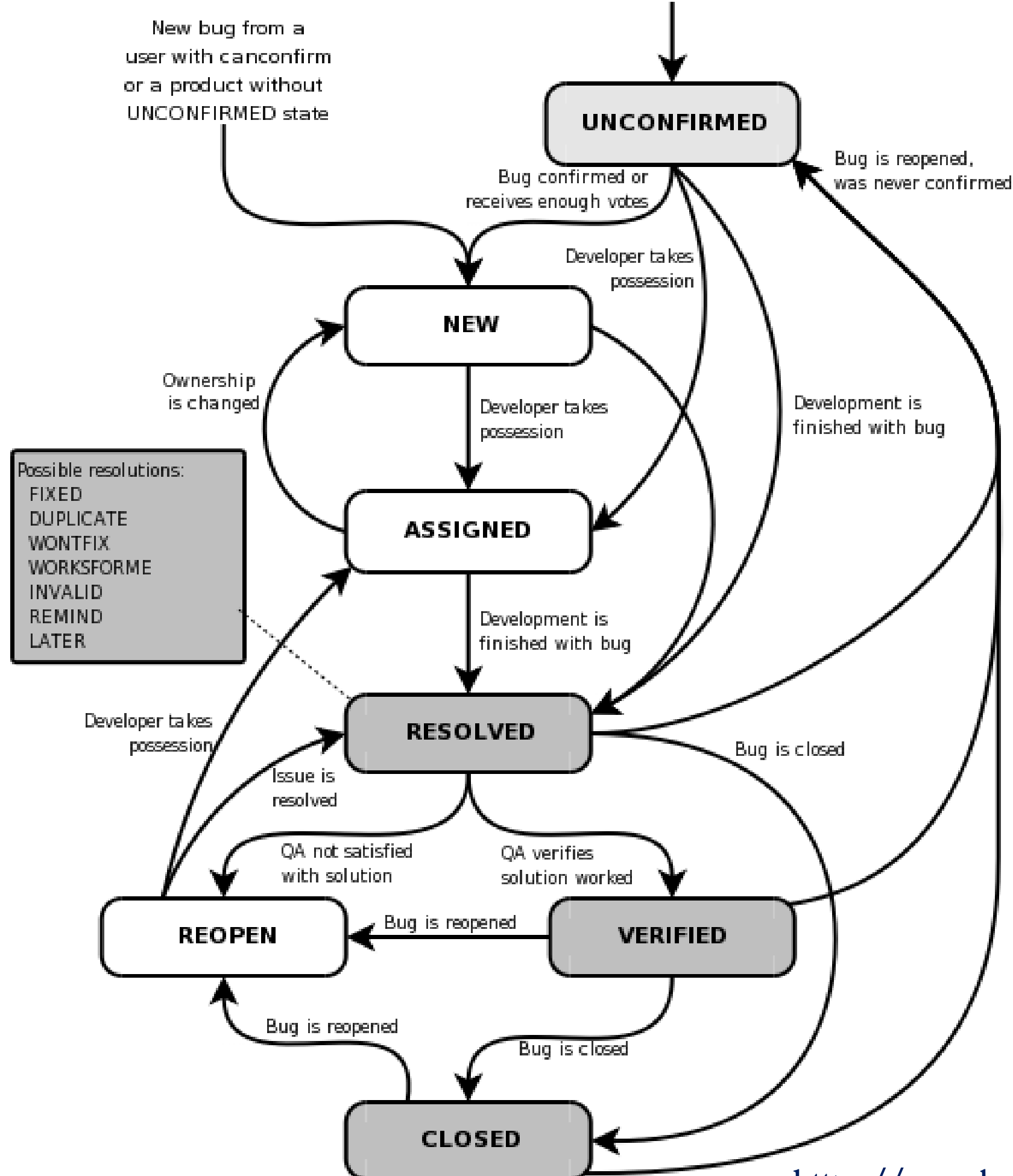
- Reporter/Submitter
- Assignee
- QA Contact

## ■ Status

- Current status
- Resolution
- Priority
- Severity

## ■ Time

- Open date
- Changed date
- Close date
- ..



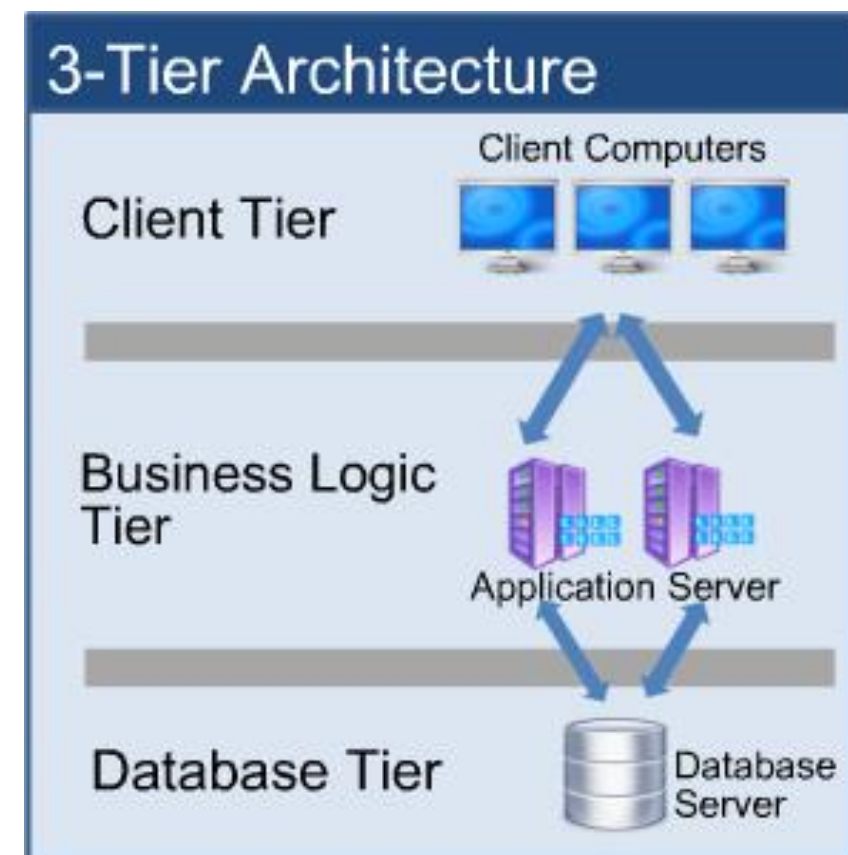
## ■ The Life of a Bug





# The Design of Issue Tracking System

- A typical three-tier software architecture:
  - Database: the main storage for all bug related data.
  - Business Logic: manage the data and implement functions.
  - Client: the user interface/webpage from which the users can access the system.
- Basic functions:
  - Report an issue
  - Search an issue
  - Change the details of an issue
  - ...



Before reporting a bug, please read the [bug writing guidelines](#), please look at the list of [most frequently reported bugs](#), and please [search](#) for the bug.

[Show Advanced Fields](#)

**Product:** WorldControl

**Reporter:** xiaowuhu159@sina.com

**Component:**   
PoliticalBackStabbing  
WeatherControl

Component Description

Control the economic well being of any country using this module. Alan Greenspan is nothing compared to this.

**Version:**

**Severity:**

**Hardware:**

**OS:**

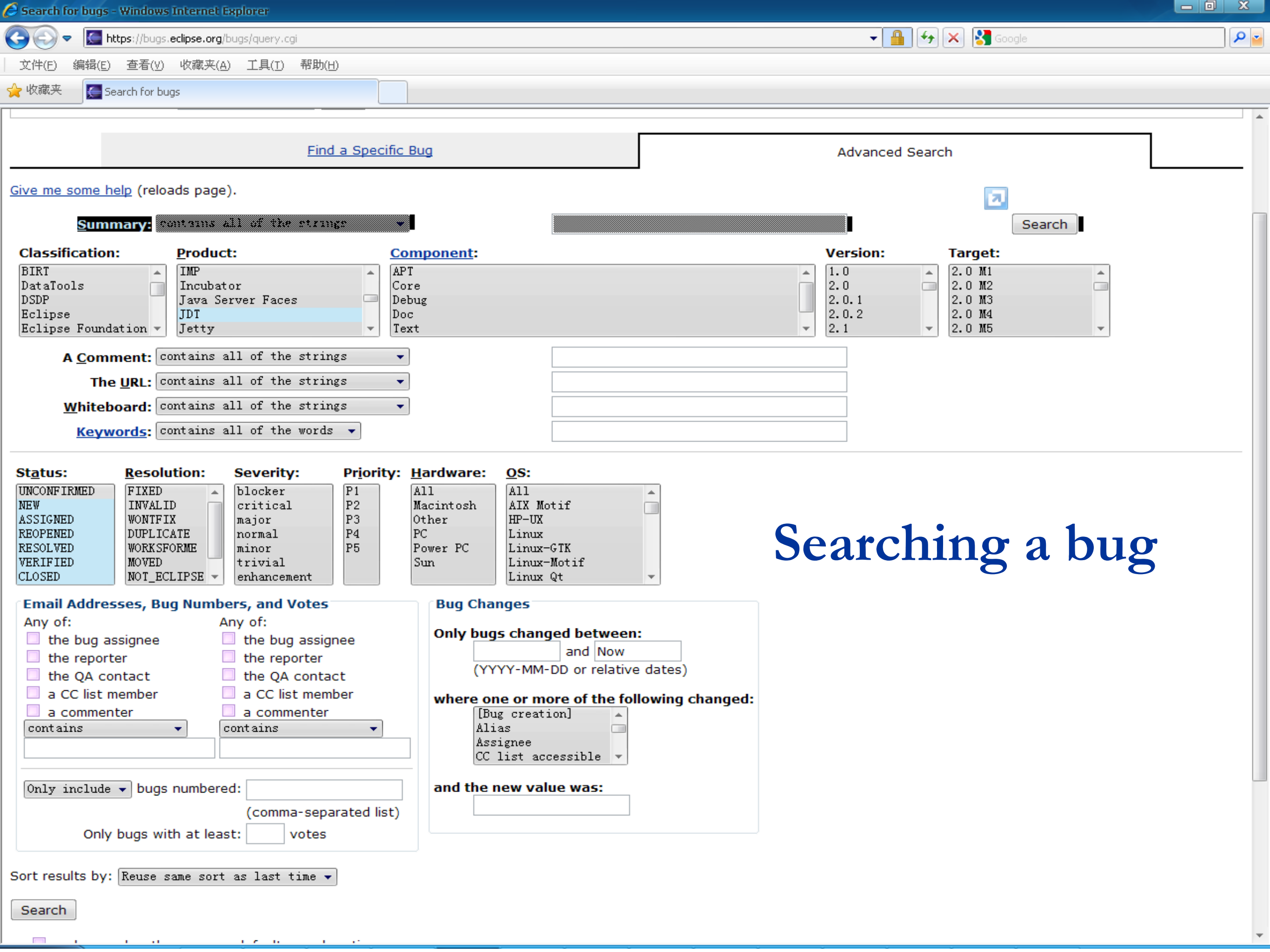
We've made a guess at your operating system and platform. Please check them and make any corrections if necessary.

**Summary:**

**Description:**

**Attachment:**

# Reporting a bug



Bugzilla – Bug List

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Wed Oct 30 2013 02:06:05 EDT

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**Classification:** Eclipse   
**Component:** Core   
**Product:** JDT

# Eclipse Bugs

This result was limited to 500 bugs. [See all search results for this query.](#)

<a href="#">ID</a>	<a href="#">Product</a>	<a href="#">Comp</a>	<a href="#">Status</a>	<a href="#">Resolution</a>	<a href="#">Summary</a>	<a href="#">Opened</a>	<a href="#">Reporter</a>
<a href="#">1834</a>	JDT	Core	VERI	WORK	<a href="#">Cancel build with 10000+ problems takes forever to update (1G2Q9YZ)</a>	2001-10-10	jerome_lanneluc
<a href="#">2857</a>	JDT	Core	VERI	FIXE	<a href="#">Renaming .java class with errors to .txt leaves errors in Task list (1GK06R3)</a>	2001-10-10	Karice_McIntyre
<a href="#">3037</a>	JDT	Core	RESO	DUPL	<a href="#">Core error compiling a java class (1GEJK8Q)</a>	2001-10-10	veronika_irvine
<a href="#">3059</a>	JDT	Core	RESO	FIXE	<a href="#">JRE_LIB not appended to buildPath (1GF7TAZ)</a>	2001-10-10	jeffmcaffer
<a href="#">3123</a>	JDT	Core	RESO	WORK	<a href="#">Refresh local problem? (1GJUBJR)</a>	2001-10-10	dj_houghton
<a href="#">3173</a>	JDT	Core	VERI	FIXE	<a href="#">Constant field code generation (1FEWXZW)</a>	2001-10-10	philippe_mulet
<a href="#">3174</a>	JDT	Core	RESO	WORK	<a href="#">Open-on-selection doesn't work on MouseAdapter (1GF69TH)</a>	2001-10-10	nick_edgar
<a href="#">3175</a>	JDT	Core	RESO	FIXE	<a href="#">JCK1.3a - ICLS - Comparing current instance against enclosing instance inside of anonymous class. (1GLDSBS)</a>	2001-10-10	jerome_lanneluc
<a href="#">3176</a>	JDT	Core	RESO	DUPL	<a href="#">JCK1.3a - STMT - Single declaration in try block (1GLDSH9)</a>	2001-10-10	jerome_lanneluc
<a href="#">3177</a>	JDT	Core	RESO	WONT	<a href="#">64kb method should be a configurable problem (1FJHGVE)</a>	2001-10-10	philippe_mulet
<a href="#">3178</a>	JDT	Core	RESO	WONT	<a href="#">JCK exclude list: unicode character inside package names (1FM7BCT)</a>	2001-10-10	Olivier_Thomann
<a href="#">3179</a>	JDT	Core	RESO	FIXE	<a href="#">Compiler - LF cannot run classes that miss implementations of an interface (1FNFVY8)</a>	2001-10-10	erich_gamma
<a href="#">3180</a>	JDT	Core	RESO	WONT	<a href="#">Better constant expression propagation (1FPE479)</a>	2001-10-10	philippe_mulet
<a href="#">3181</a>	JDT	Core	VERI	FIXE	<a href="#">Does not format nicely anonymous type (1FRLTO1)</a>	2001-10-10	philippe_mulet



# Android Bugs

 Search project

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ID ▼	Type ▼	Status ▼	Owner ▼	Summary + Labels ▼	Opened ▼	Reporter ▼	Priority ▼
<a href="#">61601</a>	Defect	New	sm...@android.com	Problem With Code Snippet	20 minutes ago	challapr...@gmail.com	Medium
<a href="#">61600</a>	Defect	New	sm...@android.com	Support Multiple Screensizes Documentation References Deprecated fill_parent	2 hours ago	dcwil...@gmail.com	Medium
<a href="#">61599</a>	Defect	New	----	Mobile Data turns on automatically	2 hours ago	rodas.ma...@gmail.com	Small
<a href="#">61598</a>	Enhancement	New	to...@android.com	Android Studio - option to select file for editing using single click	2 hours ago	i...@jsilvapiano.com	Medium
<a href="#">61597</a>	Defect	New	e...@google.com	[platform_dalvik] Some more memory leaks and some other misc ones.	4 hours ago	mathew1...@gmail.com	Medium
<a href="#">61596</a>	Defect	New	to...@android.com	ADT Eclipse virtual machine not taking VM heap parameter	4 hours ago	jasonmpr...@gmail.com	Medium
<a href="#">61595</a>	----	New	to...@android.com	Add preview support for OverlayActionBarMode	5 hours ago	bill.and...@gmail.com	----
<a href="#">61594</a>	Defect	New	----	Dial pad gestures from side to side is in the opposite direction	6 hours ago	almogthe...@gmail.com	Small
<a href="#">61593</a>	Defect	New	to...@android.com	ADT plugin close linux session	7 hours ago	syd.s...@gmail.com	Small
<a href="#">61592</a>	----	New	to...@android.com	Android Studio Gradle Project Sharing Issue	10 hours ago	adamhorn...@gmail.com	----
<a href="#">61591</a>	----	New	to...@android.com	Rearrange entries issue	11 hours ago	TomR...@gmail.com	----
<a href="#">61589</a>	----	New	to...@android.com	Keyboard shortcuts not functional in properties pane of a view in layout.	11 hours ago	ondrej.d...@gmail.com	----
<a href="#">61587</a>	Defect	New	ad...@android.com	TextClock and DigitalClock are not updated on the start of a second	12 hours ago	rensoloh...@gmail.com	Medium
<a href="#">61585</a>	Defect	NeedsInfo	to...@android.com	Cannot start Android Studio: error initializing indexing.FileBasedIndex	13 hours ago	um.anus...@gmail.com	Small
<a href="#">61584</a>	----	New	alr...@google.com	hint incorrect when local.properties has incorrect sdk path	13 hours ago	vs...@google.com	----
<a href="#">61583</a>	Defect	New	----	A2DP tuh tuh tuday junior.	13 hours ago	sqsess...@gmail.com	Small
<a href="#">61582</a>	Defect	New	to...@android.com	After updating project properties to add RenderScript support library, Android/RenderScript support library not imported.	14 hours ago	beaworld...@gmail.com	Medium

# Useful Bug Reports

- Useful bug reports are the ones that get bugs fixed.
- A useful bug report should be:
  - **Reproducible:** If an engineer can't see it or conclusively prove that it exists, the engineer will probably stamp it "WORKSFORME" or "INVALID", and move on to the next bug.
  - **Specific:** The quicker the engineer can trace down the issue to a specific problem, the more likely it'll be fixed expediently.

# A Poor Bug Report

**Title:** Error message

**Description:**

When running Eclipse I get an "Internal Error" that says "See the .log file for more details".

It happens when "Object o = null". Doesn't happen when changed to "Object o".



# A Good Bug Report

**Title:** Stepping over "Object o = null" causes Eclipse "Internal Error"

**Description:**

While using Eclipse 3.3.1.1 with m37a of android and the following code:

```
public class TestObjectNull extends Activity {  
    ...    Object o = null; ...  
}
```

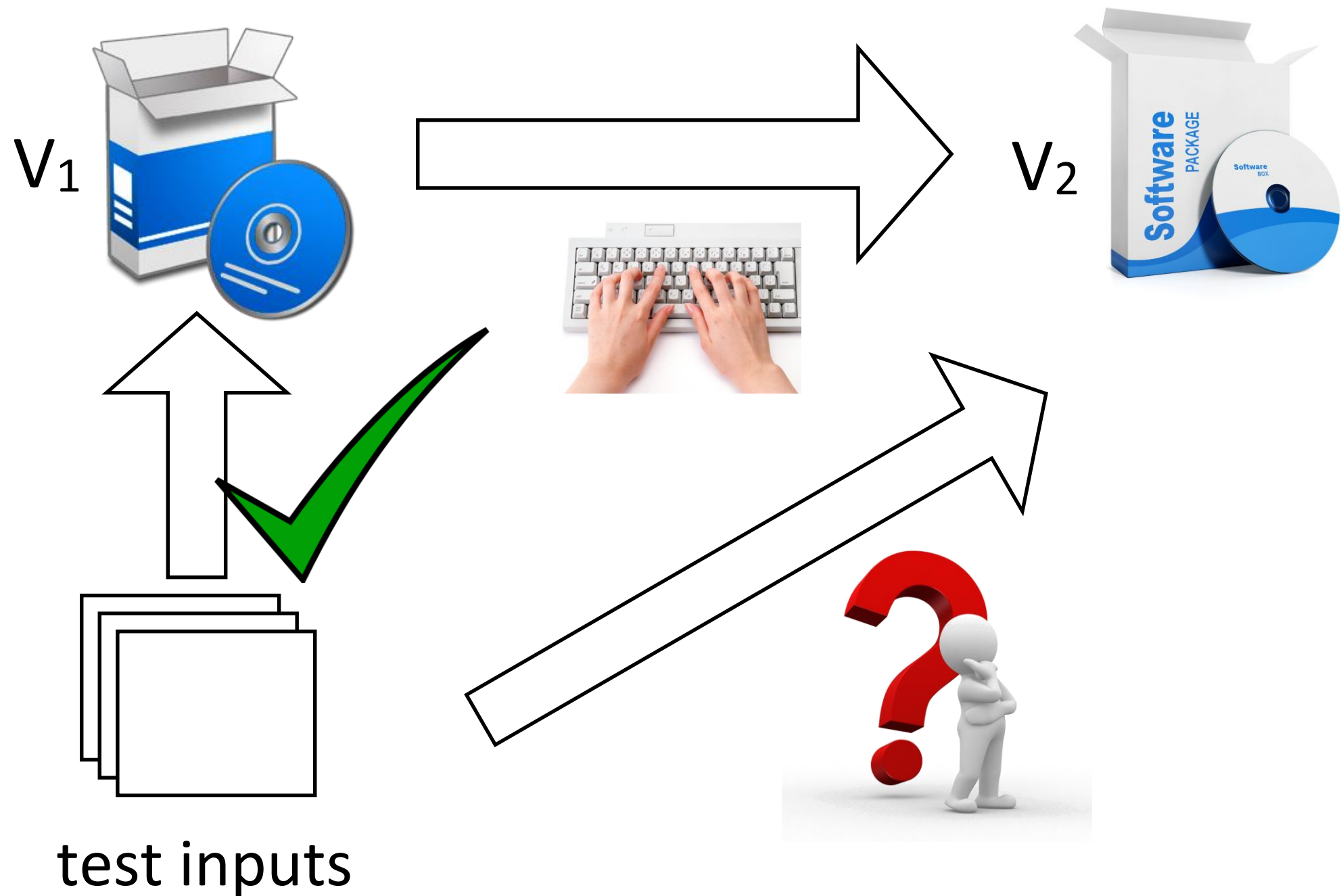
Eclipse indicates an "Internal Error" with "See the .log file for more details" and then asks if I want to exit the workbench. This occurs when I place a break point on "setContentView(R.layout.main);" and then single step over "Object o = null;“...

The last lines of the .log file are:

```
java.lang.InternalError: Invalid signature: "<null>"      at  
org.eclipse.jdi.internal.TypeImpl.signatureToTag(TypeImpl.java:307)  
at org.eclipse.core.internal.jobs.Worker.run(Worker.java:55)  
...
```

# Regression Testing

# Test the evolving software system



# Regression Testing

- When we try to enhance the software
  - We may also bring in bugs
  - The software works yesterday, but not today, it is called "regression"
- Numbers
  - Empirical study on eclipse 2005
    - 11% of commits are bug-inducing
    - 24% of fixing commits are bug-inducing
- Regression Testing
  - Run old test cases on the new version of software

# Regression Testing

“Establishing a policy for regular regression testing is key to achieving successful, reliable, and predictable software development projects.”



**Adam Kolawa,  
co-founder and CEO of Parasoft.**

# Regression Testing

- JUnit is a framework that supports the regression testing process
- Features:
  - Store test cases
  - Execute test cases
  - Compare the actual output with the expected output
  - Report software failure

# Directly rerun the entire test suite?



Salesforce already accumulated over 50K regression tests in 2013

The entire test suite execution for one product of Huawei takes over one month



Engineers at Google have observed a quadratic increase in their total test-running times



# Improving Efficiency of Regression Testing

- It will cost a lot if we run the whole suite each time
- Try to save time and cost for new rounds of testing
  - Test Prioritization
    - Try only the most important test cases
  - Test Selection
    - Try the most relevant test cases

# Regression Test Selection (RTS)

- RTS aims to speed up regression testing by only re-running the tests affected by code changes
- An RTS technique is safe if it selects all tests whose behavior may be affected by code changes
  - Not running any of those tests may miss regressions



# Intra-procedural CFG

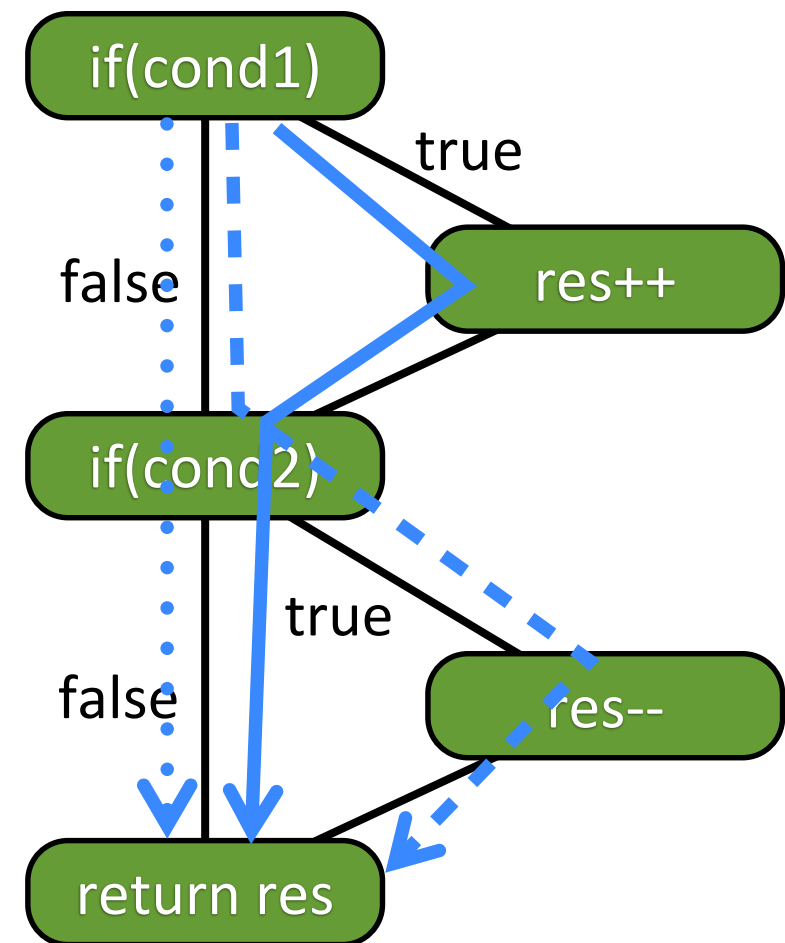
```

public class IntraCFG {
    public int testme(bool cond1, bool cond2) {
        int res=10;
        if (cond1)
            res++;
        if (cond2)
            res--;
        return res;
    }
}

```

$t_1 = (\text{true}, \text{false})$   
 $t_2 = (\text{false}, \text{true})$   
 $t_3 = (\text{false}, \text{false})$

Test suite



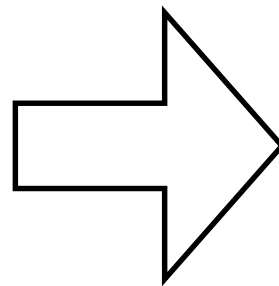
# Program change

```
public class IntraCFG {
    public int testme(bool cond1, bool cond2)
    {
        int res=10;
        if (cond1)
            res++;
        if (cond2)
            res--;
        return res;
    }
}
```

V<sub>1</sub>

t<sub>1</sub>=(true, false)  
t<sub>2</sub>=(false, true)  
t<sub>3</sub>=(false, false)

T<sub>1</sub>



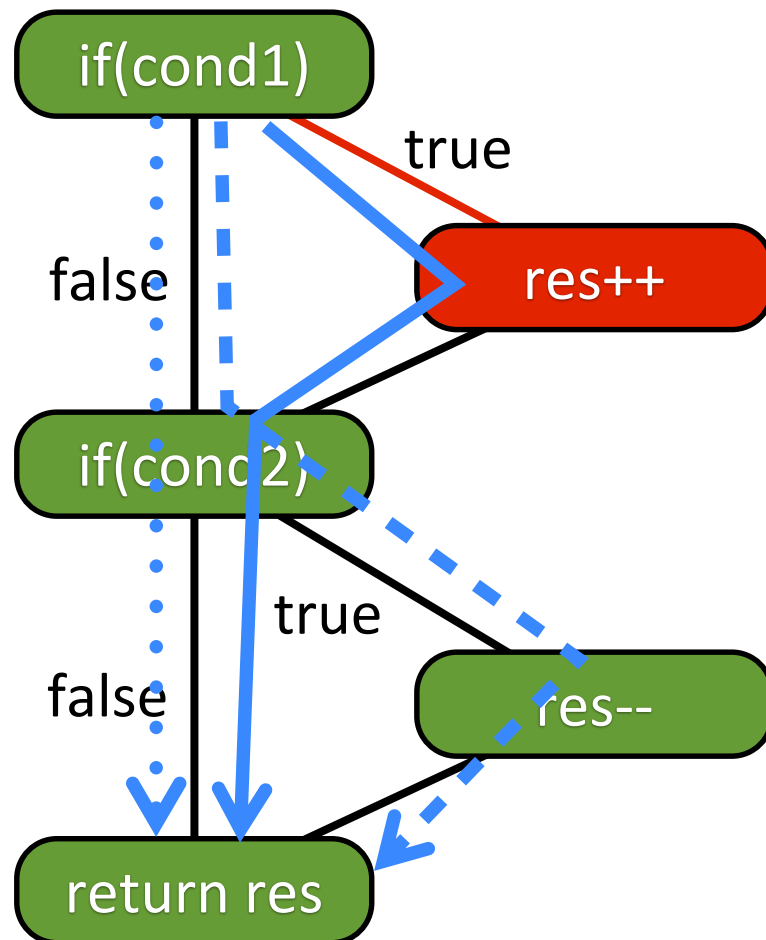
```
public class IntraCFG {
    public int testme(bool cond1, bool cond2)
    {
        int res=10;
        if (cond1)
            res+=2;
        if (cond2)
            res--;
        return res;
    }
}
```

V<sub>2</sub>



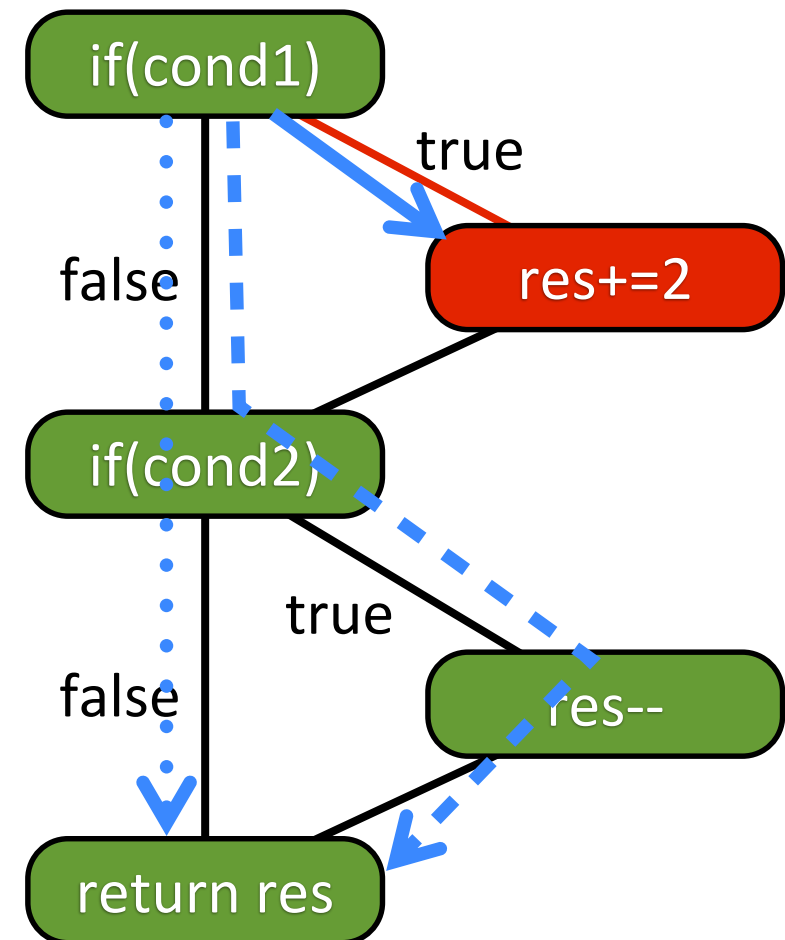
T<sub>2</sub>

With proper technique, we  
can save 66.7% testing  
effort for the new version



$t_1 = (\text{true}, \text{false})$   
 $t_2 = (\text{false}, \text{true})$   
 $t_3 = (\text{false}, \text{false})$

$T_1$



$t_1 = (\text{true}, \text{false})$   
 ~~$t_2 = (\text{false}, \text{true})$~~   
 ~~$t_3 = (\text{false}, \text{false})$~~

$T_2$

# Test prioritization

- Rank all the test cases
  - Run test cases according to the ranked sequence
  - Stop when resources are used up
- 
- How to rank test cases
    - To discover bugs sooner
    - Or approximation: to achieve higher coverage sooner

# Reference

- Lingming Zhang, Dan Hao, Lu Zhang, Gregg Rothermel, Hong Mei: Bridging the gap between the total and additional test-case prioritization strategies. ICSE 2013: 192-201
- IBM Rational ClearQuest: <https://www.ibm.com/us-en/marketplace/rational-clearquest>



# Thanks!

