# Lecture 19: Static Analysis Tools

Where static analysis tools fit

Example tools

Limitations of static analysis






# Static Analysis

## Analyzes the program without running it

- Doesn't need any test cases
- Doesn't know what the program is supposed to do
- Looks for violations of good programming practice
- Looks for particular types of programming error

## Where it fits as a verification technique:

1) Avoid dumb mistakes
   - Pair Programming
   - Code Inspection
   - Developer unit testing ("test case first" strategy)
2) Find the dumb mistakes you failed to avoid
   - Style Checkers
   - → Static Analysis
3) Make sure the software does what it is supposed to
   - Black box and system testing
   - Independent testing

(Note: Also need validation techniques!)

# How Static Analysis Works

```
void print_to_file(string filename)
{
    if (path_exists(filename)) {
        // FILENAME exists; ask user to confirm overwrite
        bool confirmed = confirm_loss(filename);
        if (!confirmed)
            return;
    }
    // Proceed printing to FILENAME...
}
```

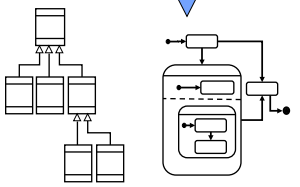
"…should have…"

Manual Inspection?
(impractical or impossible)

Correctness Property P

Automatically construct models for analysis

Implies (automatic test of logical Inference)



Class structure and inheritance

State Machine Model

Dataflow graph

Automatic check of derived model

Model Property P'






# Example tools

## FindBugs

- Originally a research project at U Maryland
- Has large number of bug patterns
- http://findbugs.sourceforge.net/

## JLint

- Developed by Konstantin Knizhnik, updated by Cyrille Artho
- http://jlint.sourceforge.net/

## PMD ("Programming Mistake Detector"??)

- written by Tom Copeland
- focuses on inefficient code, e.g. over-complex expressions
- http://pmd.sourceforge.net/

## ESC/Java (Extended Static Checker for Java)

- Originally developed at Compaq Research
- ESC/Java2 is open source, managed at U College Dublin
- http://kind.ucd.ie/products/opensource/ESCJava2/

# Different tools find different bugs

```
import java.io.*;
public class foo{
  private byte[] b;
  private int length;
  Foo(){ length = 40;
    b = new byte[length]; }
  public void bar(){
    int y;
    try {
      FileInputStream x =
        new FileInputStream("Z");
      x.read(b,0,length);
      c.close();}
    catch(Exception e){
      System.out.println("Oopsie");}
    for(int i = 1; i <= length; i++){
      if (Integer.toString(50) ==
            Byte.toString(b[i]))
        System.out.print(b[i] + " ");
    }
  }
}
```

variable never used (detect by PMD)

Method result is ignored (detected by FindBugs)

Don't use '==' to compare strings (detected by FindBugs and JLint)

May fail to close stream on exception (detected by FindBugs)

Array index possibly too large (detected by ESC/Java)

Possible null dereference (detected by ESC/Java)






# Different tools find different bugs

| Bug Category | Example | ESC/Java | FindBugs | JLint | PMD |
|---|---|---|---|---|---|
| General | Null dereference | ✓ | ✓ | ✓ | ✓ |
| Concurrency | Possible deadlock | ✓ | ✓ | ✓ | ✓ |
| Exceptions | Possible unexpected exception | ✓ | | | |
| Array | Length may be less than zero | ✓ | | ✓ | |
| Mathematics | Division by zero | ✓ | | ✓ | |
| Conditional, loop | Unreachable code due to constant guard | | ✓ | | ✓ |
| String | Checking equality with == or != | | ✓ | ✓ | ✓ |
| Object overriding | Equal objects must have equal hashcodes | | ✓ | ✓ | ✓ |
| I/O stream | Stream not closed on all paths | | ✓ | | |
| Unused or duplicate statement | Unused local variable | | ✓ | | ✓ |
| Design | Should be a static inner class | | ✓ | | |
| Unnecessary statement | Unnecessary return statement | | | | ✓ |

# Limitations of Static Analysis

## Large numbers of false positives

- Tool reports large number of things that aren't bugs
- Programmer must manually review the list and decide
- Sometime too many warnings to sort - E.g. Rutar et. al. (approx 2500 classes)

| | ESC/Java | FindBugs | JLint | PMD |
|---|---|---|---|---|
| Concurrency Warnings | 126 | 122 | 8883 | 0 |
| Null dereferencing | 9120 | 18 | 449 | 0 |
| Null assignment | 0 | 0 | 0 | 594 |
| Index out of bounds | 1810 | 0 | 264 | 0 |

## False negatives

- Types of bugs the tool won't report
  - (increased risk if we filter results to remove false positives?)

## Harmless bugs

- Many of the bugs will be low priority problems
- Cost/benefit analysis: Is it worth fixing these?






# Which bug is worse?

```
int x = 2, y = 3;
if (x == y)
   if (y == 3)
      x = 3;
else
   x = 4;
```

Detected by:
PMD (if using certain rulesets)

Not detected in testing

```
String s = new ("hello");
s = null;
System.out.println(s.length());
```

Detected by:
JLint,
FindBugs,
ESC/Java

Also detected in testing