Chianti: A Tool for Change Impact Analysis of Java Programs [1]

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Overview

- Motivation
- Problem
- Approach
- Experiments

Non-locality of change impact in OO programs

- Small source code changes can have major and *non-local* effects in object-oriented systems
  - Due to subtyping and dynamic dispatch

```
class A {
 public void foo(){ }
class B extends A {
 public void foo(){B.bar();}
 public static void bar(){y=17;}
 public static int y;
}
```

```
A x = new B();
…
x.foo();
```


Change Impact Analysis

- A collection of techniques for determining the effects of source code modifications
- It can improve programmer productivity by
  - determining tests whose behaviors may be affected
  - identifying portions of an edit that may affect such tests
  - potentially allowing developers to experiment with different portions of an edit

Chianti Approach Overview

- Given P, P', and regression test suites T
  - Derive atomic changes A = {c1, c2, …cn}
  - For each t∈T, construct dynamic call graph *CG* and *CG'*.
    - If *CG*≠*CG'* or *CG* has overlap with some changed entities, put t into T_a—a set of tests that are potentially affected by changes
  - For each t ∈ T_a, determine the subset of changes affecting the test

An Example

```
class A {
 public void foo(){ }
}
class B extends A {
 public void foo(){ }
}
class C extends A{
}
```

```
public static void test1{
  A a = new A();
  a.foo();//A's foo
}
 public static void test2(){
  A a = new B();
  a.foo(); //B's foo
}
public static void test3(){
 A a = new C();
 a.foo();//A's foo
}
```

An Example

```
class A {
 public void foo() { }
 public int x;
}
class B extends A {
 public void foo(){B.bar();}
 public static void bar() {
       y = 17;}
 public static int y;
}
class C extends A{
 public void foo() {
     x = 18; }
 public void baz() {
     z = 19;}
 public int z;
}
```

Questions:
(1) Which test is affected?
(2) For each affected test, what is the affecting change?

Derive Atomic Changes

- Categories of atomic changes: The granularity is roughly at the method level

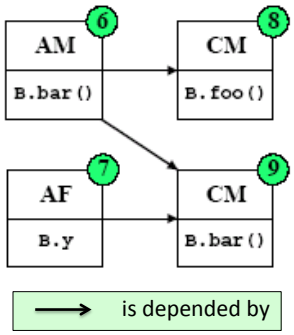
AC Add an empty class
DC Delete an empty class
AM Add an empty method
DM Delete an empty method
CM Change body of a method
LC Change virtual method lookup
AF Add a field
DF Delete a field

CFI Change defn instance field initializer
CSFI Change defn static field initializer
AI Add an empty instance initializer
DI Delete an empty instance initializer
CI Change defn instance initializer
ASI Add empty static initializer
DSI Delete empty static initializer
CSI Change definition of static initializer

Atomic changes and their dependencies

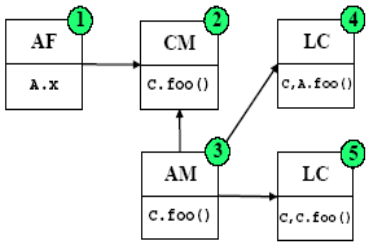
- c2 depends on c1
  - c1 is prerequisite for c2 to guarantee syntactic correctness

```
class A {
 public void foo() { }
 public int x;
}
class B extends A {
 public void foo(){B.bar();}
 public static void bar() {
       y = 17;}
 public static int y;
}
…
```



Atomic changes and their dependencies

```
class A {
 public void foo() { }
 public int x;
}
…
class C extends A{
 public void foo() {
     x = 18; }
 …
}
```

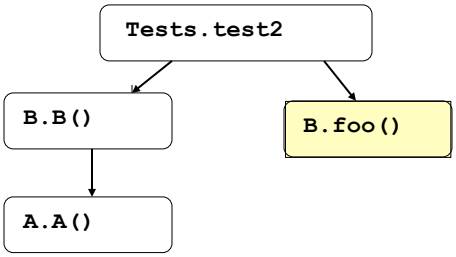


- LC change: (Y, X.m())
  - A call to method X.m() on an object whose runtime type is Y, is dispatched differently.

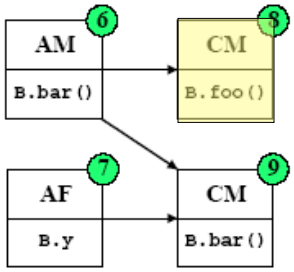
Affected Tests

```
public static void test2(){
  A a = new B();
  a.foo(); //B's foo
}
```

Call Graph of test2
on **original** program



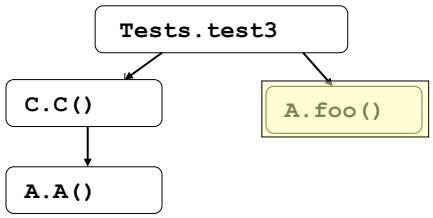

```
class B extends A {
 public void foo()
   {B.bar();}
 public static void
   bar() {
       y = 17;}
 public static int y;
}
```

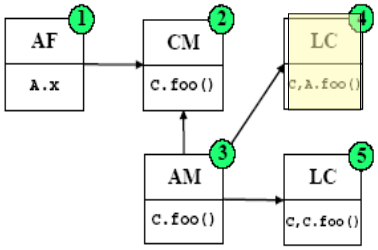


Affected Tests

```
public static void test3(){
 A a = new C();
 a.foo();//C's foo
}
```

Call Graph of test3
on **original** program



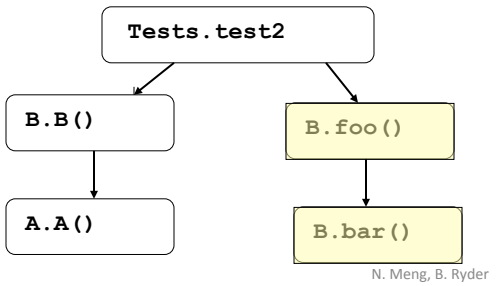


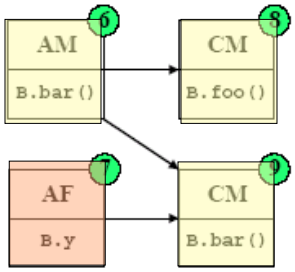
Affecting Changes

```
public static void test2(){
  A a = new B();
  a.foo(); //B's foo
}
```

```
class B extends A {
 public void foo()
   {B.bar();}
 public static void
   bar() {
        y = 17;}
 public static int y;
}
```

Call Graph of test2
on **edited** program





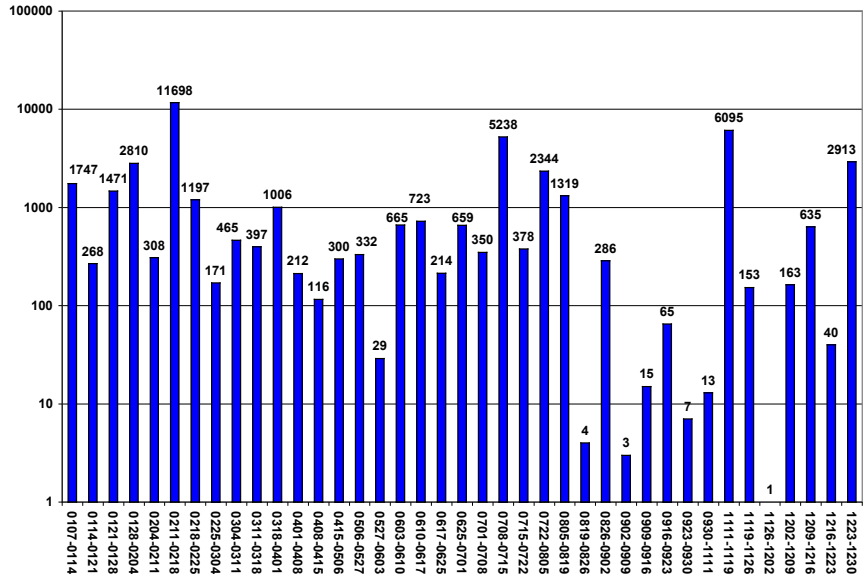
Experiments

- Data: Daikon project (cf M.Ernst, MIT)
  - Obtained CVS repository from 2002 with version history - an active debugging period
  - Grouped code updates within same week to form edit intervals
  - Obtained 39 intervals with code changes
- Measurements: numbers of affected tests and their affecting changes per edit interval
- Platform: Pentium 4 PC at 2.8Ghz with 1Gb RAM.

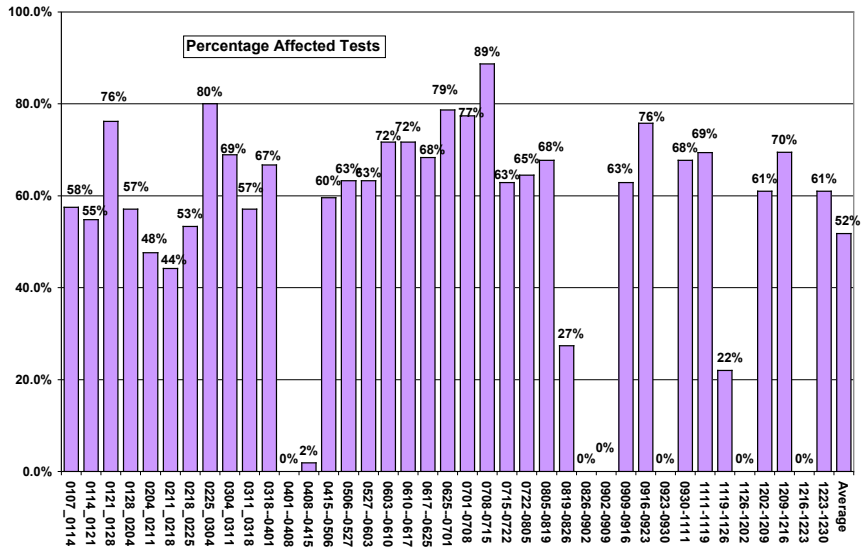
Daikon

- Code base growth in 2002
  - From 48K to 121K lines of code; 357 to 765 classes; 2409 to 6284 methods; 937 to 2885 fields
- Unit test suite used
  - 40-62 unit tests per version
  - Collected dynamic call graphs of tests
  - Achieved on average of 21% coverage of methods, but higher coverage of the *mde* library (47%)

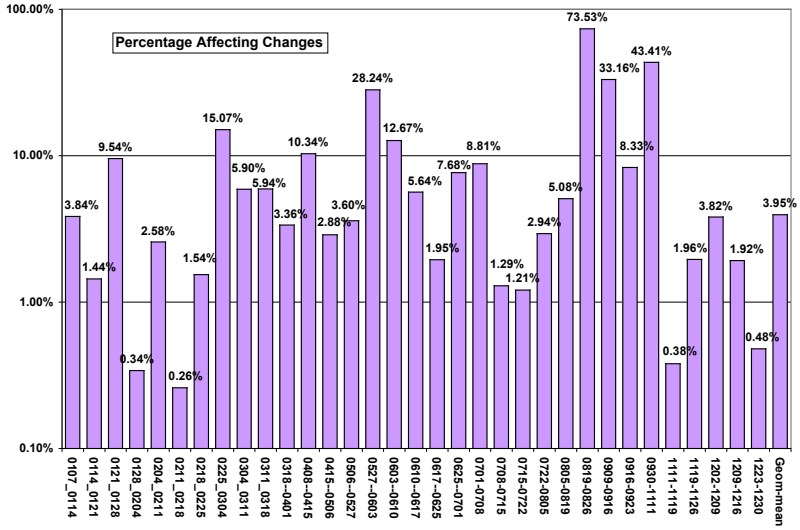
Number of atomic changes



Affected Tests



Affecting Changes



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Performance of Chianti

- Deriving atomic changes from 2 successive versions takes on average 87 secs
  - Median 70 secs, max 343 secs
- Calculating the set of affected tests takes on average 5 secs
  - Median of 2.5 secs, max of 35 secs

Performance of Chianti

- Calculating affecting changes for an affected test takes on average 1.2 secs
  - Median of .5 secs, max of 9 secs
- Results show promise of the change impact framework
  - Practical
  - Ease of use within Eclipse (giving programmer a familiar GUI)

Reference

[1] Xiaoxia Ren, Fenil Shah, Frank Tip, Barbara G. Ryder, and Ophelia Chesley, Chianti: A Tool for Change Impact Analysis of Java Programs, OOPSLA '04