Speculative Analysis
Homework 2

• On pair programming
• Due Monday, Oct 7, 9 AM on moodle
• This homework requires creativity
  – Creativity cannot be forced in the last day
  – Start early!
What’s going on with projects?

• 621 students assemble into project groups
  – see project group self-assembly on moodle
  – due Monday Oct 7 as well
• 521 students do not have to do a project
  – but can if they want to

• Everyone who does a project will do 1 paper presentation
• Everyone else will do 2 paper presentations
What do I have to do by Monday?

• Homework 2
• 621 students: self-assemble into groups
  – complete moodle group selection assignment
• 521 students: if you want to do a project, complete moodle group selection assignment
Developers often make decisions based on experience and intuition.
Implement a new feature?

Incorporate another developer’s changes?

Fix a bug?

DECISION MAKING

Upgrade a library?

Refactor for code reuse?

Run tests?
Implement a new feature?

Incorporate another developer’s changes?

Fix a bug?

**DECISION MAKING**

Developers often make decisions based on experience and intuition.

Upgrade a library?

Refactor for code reuse?

Run tests?
Can we predict the future to help make decisions?
Speculative analysis: predict the future and analyze it
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- Are there domains for which speculative analysis is possible?
- Can speculative analysis be made computationally feasible?
- Can speculative analysis help, and not overwhelm, developers?
Speculative analysis: predict the future and analyze it

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Speculative analysis: predict the future and analyze it

- Current program
- Speculate
- Refactor
- Analyze
  - Execute test suite

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Can speculative analysis be made computationally feasible?

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Speculative analysis: predict the future and analyze it

Are there domains for which speculative analysis is possible?

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current program

speculate

analyze

execute test suite

inform developer

# of resulting test failures
Speculative analysis: research questions

Are there domains for which speculative analysis is possible?

current program

Can speculative analysis be made computationally feasible?

Can speculative analysis help, and not overwhelm, developers?
Quick Fix Scout

Collaborators: Kıvanç Muşlu, Reid Holmes, Michael D. Ernst, and David Notkin
Eclipse provides Quick Fixes to resolve compilation errors.
But Eclipse can’t tell which fix is best.
We can speculatively apply each fix to find out how many errors remain.
Sometimes, local fixes cannot resolve an error.
Speculation can discover remote fixes that resolve errors.
Complex error dependencies

```java
public class ExceptionalObject {
    public void exceptionalMethod() {
        throw new MyException();
    }
}
```

... 

```java
public class SafeObject {
    public void safeMethod() {
        try {
            ExceptionalObject eo = 
            new ExceptionalObject();
            eo.exceptionalMethod();
        } catch (MyException e) {
        }
    }
}
```

http://quick-fix-scout.googlecode.com
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Speculative analysis for Quick Fix

- **speculate**
  - quick fix
  - quick fix
  - quick fix

- **current program**

- **analyze**
  - compile

- **inform developer**
  - # of resulting compilation errors
Exploring the future

past version of the program

present version of the program

future version of the program

delta debugging

continuous testing

automated debugging

Continuous development
compilation [Childers et al. 2003; Eclipse 2011]
execution [Henderson and Weiser 1985; Karinthi and Weiser 1987]
testing [Sand and Ernst 2003, 2004]
version control integration [Guimarães and Rito-Silva 2010]
Exploring the future

- past version of the program
  - mining software repositories
  - regression testing
- present version of the program
  - delta debugging
  - continuous testing
- future version of the program
  - automated debugging
Exploring the future

Continuous development

- compilation [Childers et al. 2003; Eclipse 2011]
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Speculative analysis is **predictive**.
Proactive detection of collaboration conflicts

Collaborators: Reid Holmes, Michael D. Ernst, and David Notkin
Version-control terminology

Proactive conflict detection applies to both centralized and distributed version control.

<table>
<thead>
<tr>
<th>local commit:</th>
<th>distributed (hg, git)</th>
<th>centralized (cvs, svn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>commit</td>
<td>pull and push</td>
<td>update and commit</td>
</tr>
</tbody>
</table>
The Gates conflict

M

The information was all there, but the developers didn’t know it.
The Gates conflict

[Diagram with nodes labeled M and T]
The Gates conflict
The Gates conflict
The Gates conflict

The information was all there, but the developers didn’t know it.
The Gates conflict
The Gates conflict
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The Gates conflict
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The information was all there, but the developers didn’t know it.
What could well-informed developers do?

- avoid conflicts
What could well-informed developers do?

- avoid conflicts
- become aware of conflicts earlier
Introducing Crystal: a proactive conflict detector

DEMO
Introducing Crystal: a proactive conflict detector

DEMO

http://crystalvc.googlecode.com
Speculative analysis in collaborative development

- Speculate
  - local commit
  - incorporate from Melinda
  - incorporate from master
  - incorporate to master

- Current program

- Analyze
  - merge
  - compile
  - test
  - ...

- Inform developer
  - Collaborative relationships
Reducing false positives in conflict prediction

Collaborative awareness

- Palantír [Sarma et al. 2003]
- FASTDash [Biehl et al. 2007]
- Syde [Hattori and Lanza 2010]
- CollabVS [Dewan and Hegde 2007]
- Safe-commit [Wloka et al. 2009]
- SourceTree [Streeting 2010]
Reducing false positives in conflict prediction

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Crystal analyzes **concrete artifacts**, eliminating false positives and false negatives.
Utility of conflict detection

- Are textual collaborative conflicts a real problem?
- Can textual conflicts be prevented?
- Do build and test collaborative conflicts exist?
Are textual collaborative conflicts a real problem?

Histories of 9 open-source projects:

- **size:** 26K–1.4MSLoC
- **developers:** 298
- **versions:** 140,000

Perl5, Rails, Git, jQuery, Voldemort, MaNGOS, Gallery3, Samba, Insoshi
Are textual collaborative conflicts a real problem?

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Are textual collaborative conflicts a real problem?

How frequent are textual conflicts?

16% of the merges have textual conflicts.

Conflicts live a mean of 9.8 and median of 1.6 days.
The worst case was over a year.

Textually-safe merges live a mean of 11.0 and median of 1.9 days.
Are textual collaborative conflicts a real problem?

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Textually-safe merges live a mean of 11.0 and median of 1.9 days.
Can textual conflicts be prevented?

Where do textual conflicts come from?
Can textual conflicts be prevented?

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93% of textual conflicts developed from safe merges.
Can textual conflicts be prevented?

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93% of textual conflicts developed from safe merges.

The information Crystal computes can help prevent conflicts.
Do build and test collaborative conflicts exist?

<table>
<thead>
<tr>
<th>program</th>
<th>conflicts</th>
<th>safe merges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>textual</td>
<td>build</td>
</tr>
<tr>
<td>Git</td>
<td>17%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Perl5</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Voldemort</td>
<td>17%</td>
<td>10%</td>
</tr>
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Does merged code fail to build or fail tests?

One in three conflicts are build or test conflicts.
Microsoft Beacon

- A centralized version control-based tool.
- Microsoft product groups are using Beacon to help identify conflicts earlier in the development process.

Next steps:
- Measure Crystal’s effect on conflict frequency and persistence
- Evaluate qualitative effects on user experience
- Identify what helps and what does not

Additional collaborators: Kıvanç Muşlu, Christian Bird, Thomas Zimmermann
Contributions of speculative analysis

- past version of the program
  - mining software repositories
- present version of the program
  - regression testing
  - delta debugging
- future version of the program
  - continuous testing
  - automated debugging
  - speculative analysis

Improving developer awareness when making decisions

- compute precise, accurate information
- convert a pull mechanism to a push one
Expanding the space of speculative analysis

Identify a domain with:

- likely, automatable developer actions
- informative, efficient analyses
- inferable developer intent

Next speculations:

- automated fault removal
- code parallelization
- test generation and augmentation
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Automating decision making: self-adaptation

- specification

running system
Automating decision making: self-adaptation

generate adaptations

running system

specification

potential systems
Automating decision making: self-adaptation

specification → generate adaptations → running system

observe → potential systems → analysis
Automating decision making: self-adaptation

- **specification**
- **running system**
- **potential systems**
- **observe**
- **employ adaptation**
- **decide**
- **generate adaptations**
- **analysis**
Future research: automation

1. Automating decision making: removing the developer
2. Using new automation to enrich speculative analysis
3. Bridging requirement specification and behavioral model inference


