

Speculative Analysis

Course updates

- Project plan assignment due April 11
- Midterm next week, April 13
- We'll start review today, finish next Tuesday
- Homework 4 extended until April 20, 9 AM EDT

Today's plan

- Brief description of midterm + topics covered
- Lecture on speculative analysis
(last lecture covered by midterm)

What's the midterm like?

- Some true/false questions
- Some multiple choice questions
- Some reasoning questions

On Tuesday

- we'll do some sample questions
- I'll let you ask questions about midterm topics
- if (more questions)
 answer questions
- else
 talk about software architecture

Topics to be covered

- Dynamic analysis
 - Daikon and Purify
- Software development lifecycle
 - ad hoc, code and fix, waterfall, spiral, staged, scrum
- Testing and automated test generation
 - revealing domains, Korat, Chronicle and BugRedux (field failures), SPLat, mobile testing and recovery, mutation testing, delta debugging

Topics to be covered

- Software privacy and reliability
 - sTile and smart redundancy
- Automated Bug Fixing
 - redundant methods, GenProg, Par, staged repair, SemFix, DirectFix, Angelix, ClearView, app method substitutions, program boosting (crowd) quality of repair
- Speculative Analysis
 - Quick fix scout, Crystal, CodeHint, CodebaseReplication
- Refactoring

DECISION MAKING

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



current program

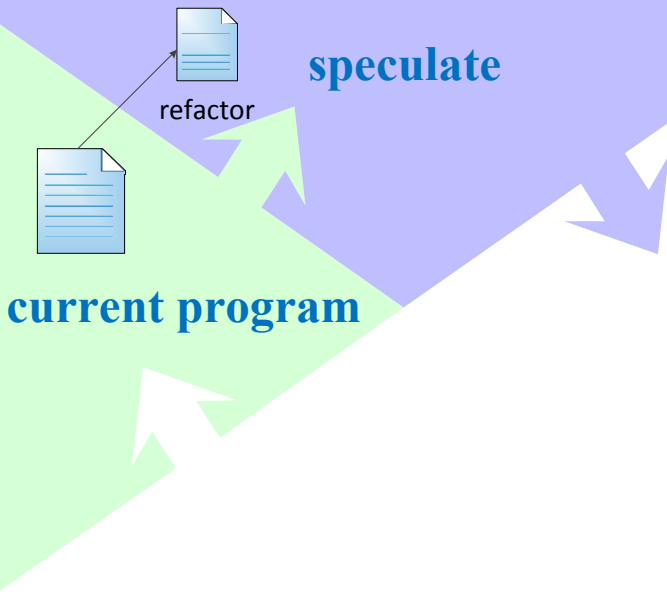
Speculative analysis: predict the future and analyze it



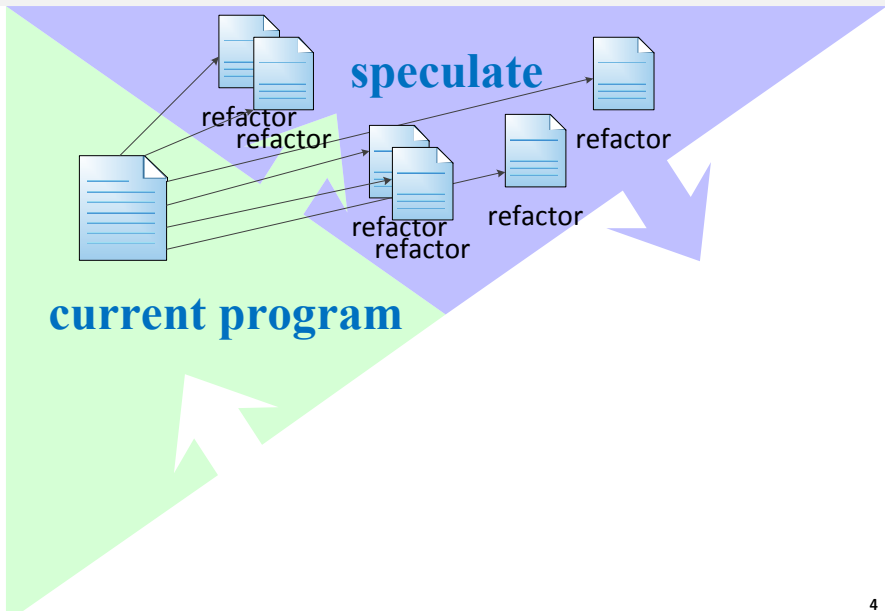
current program

speculate

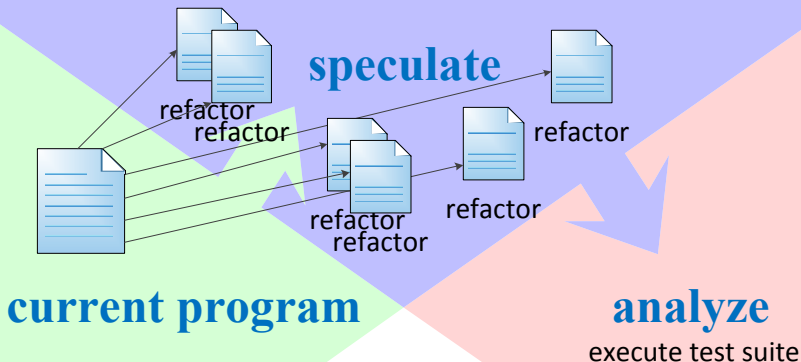
Speculative analysis: predict the future and analyze it



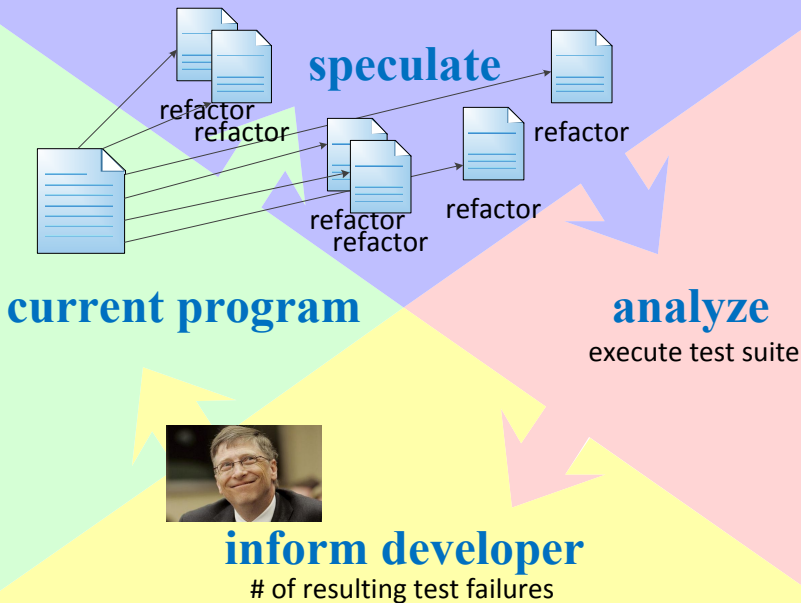
Speculative analysis: predict the future and analyze it



Speculative analysis: predict the future and analyze it

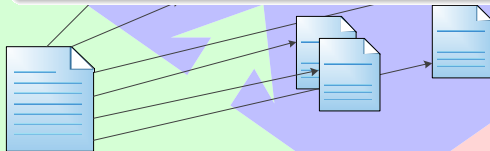


Speculative analysis: predict the future and analyze it



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: Kivanç Muşlu, Reid Holmes, Michael D. Ernst, and David Notkin

The image shows a portion of the Eclipse IDE interface. On the left is a vertical toolbar with icons for various actions. The main area displays a Java code file. The code defines a class named 'UnresolvableType' with a private field 'name' and a 'setName' method. The 'name' field and the 'name' parameter in the method are underlined with red wavy lines, indicating they are unresolved. The 'setName' method takes a 'String' argument and assigns it to 'name'.

```
public class UnresolvableType {  
  
    private string name;  
  
    public void setName(String arg) {  
        name = arg;  
    }  
}
```

Eclipse provides Quick Fixes to resolve compilation errors.

```
public class UnresolvableType {
```













```
    private string name;
```

```
    public void setName(  
        name = arg
```

```
    ) {
```

```
    }
```

```
}
```

-  Create class 'string'
-  Create interface 'string'
-  Change to 'String' (javax.swing)
-  Change to 'String' (java.lang)
-  Change to 'STRING' (javax.print.DocFlavor)
-  Change to 'StringBuffer' (java.lang)
-  Change to 'StringHolder' (org.omg.CORBA)
-  Change to 'StringReader' (java.io)
-  Change to 'StringWriter' (java.io)
-  Create enum 'string'
-  Add type parameter 'string' to 'UnresolvableType'
-  Fix project setup...

Press 'Ctrl+1' to go to original position

But Eclipse can't tell which fix is best.


```
public class UnresolvableType {
```

```
    private string name;
```

```
    public void set
```

```
        name = arg
```

```
    }
```

```
}
```

- ➦ (0) Change to 'String' (java.lang)
- ➦ (1) Change to 'StringBuffer' (java.lang)
- ➦ (1) Change to 'StringHolder' (org.omg.CORBA)
- ➦ (1) Change to 'STRING' (javax.print.DocFlavor)
- ➦ (1) Change to 'StringWriter' (java.io)
- ➦ (1) Change to 'Spring' (javax.swing)
- ➦ (1) Change to 'StringReader' (java.io)
- ➦ (1) Create class 'string'
- ➦ (1) Create interface 'string'
- ➦ (1) Create enum 'string'
- (1) Add type parameter 'string' to 'UnresolvableType'
- ➦ (2) Fix project setup...

Press 'Ctrl+1' to go to original position

We can speculatively apply each fix to find out how many errors remain.

```
public class UnresolvableType {  
  
    private string name;  
  
    public void setName(String arg) {  
        name = arg;  
    }  
}
```

- ⓐ Create class 'name'
- ⓑ Create interface 'name'
 - Change to 'NA' (javax.print.attribute.standard.MediaSize)
 - Change to 'Name' (java.util.jar.Attributes)
 - Change to 'Name' (javax.lang.model.element)
 - Change to 'Name' (javax.naming)
 - Change to 'Name' (javax.xml.soap)
 - Change to 'NameList' (org.w3c.dom)
 - Change to 'Naming' (java.rmi)
 - Change to 'Node' (javax.xml.soap)
 - Change to 'Node' (org.w3c.dom)
- ⓒ Create enum 'name'
 - Add type parameter 'name' to 'UnresolvableType'
 - Add type parameter 'name' to 'setName(String)'
 - Fix project setup...

Press 'Ctrl+1' to go to original position

Sometimes, local fixes cannot resolve an error.

```
public class UnresolvableType {
```

```
    private string name;
```

```
    public void setName(String arg) {
```

```
        name = arg;
```

```
    }
```

```
}
```

➡ (0) UnresolvableType.java:4:18: Change 'string' to 'String' (java.lang)

➡ (2) Change to 'Node' (org.w3c.dom)

➡ (2) Change to 'Name' (javax.naming)

➡ (2) Change to 'Naming' (java.rmi)

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➡ (2) Change to 'Name' (javax.lang.model.element)

○ (2) Add type parameter 'name' to 'setName(String)'

○ (2) Add type parameter 'name' to 'UnresolvableType'

➡ (2) Fix project setup...

ⓐ (2) Create class 'name'

ⓐ (2) Create interface 'name'

ⓐ (2) Create enum 'name'

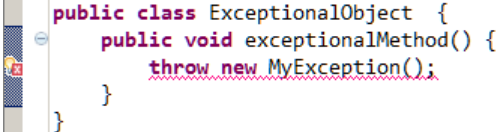
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Press 'Ctrl+1' to go to original position

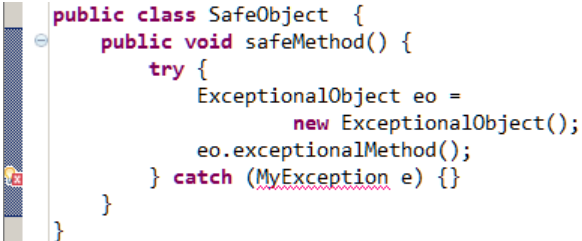
Speculation can discover remote fixes that resolve errors.

Complex error dependencies



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

...



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

<http://quick-fix-scout.googlecode.com>

Complex error dependencies

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        } catch (MyException e) {}  
    }  
}
```

Remove catch clause
Replace catch clause with throws
Press 'Ctrl+1' to go to original position

<http://quick-fix-scout.googlecode.com>

Complex error dependencies

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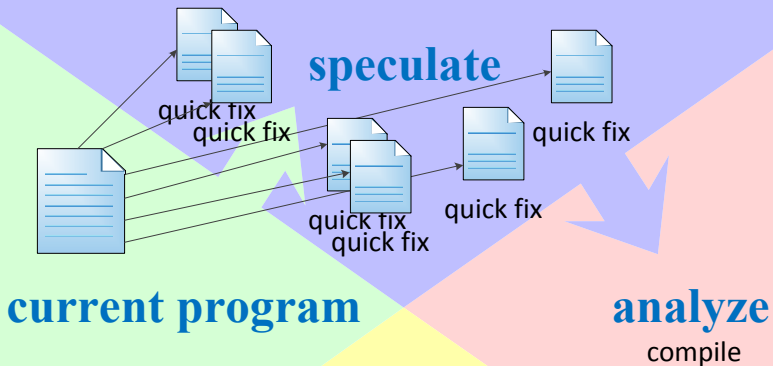
```
public class SafeObject {  
    public void safeMethod() {  
        try {  
            ExceptionalObject eo =  
                new ExceptionalObject();  
            eo.exceptionalMethod();  
        } catch (MyException e) {}  
    }  
}
```

- 0 (0) ExceptionalObject.java:6:12: Add throws declaration to 'exceptionalMethod'
- 0 (1) Replace catch clause with throws
- 0 (1) Remove catch clause

Press 'Ctrl+1' to go to c

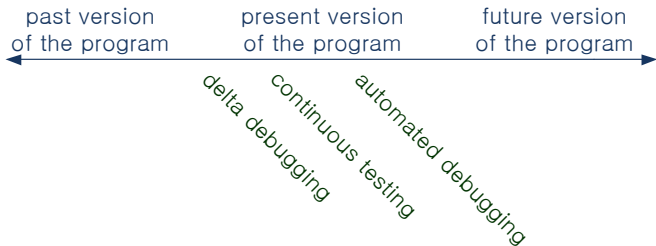
<http://quick-fix-scout.googlecode.com>

Speculative analysis for Quick Fix

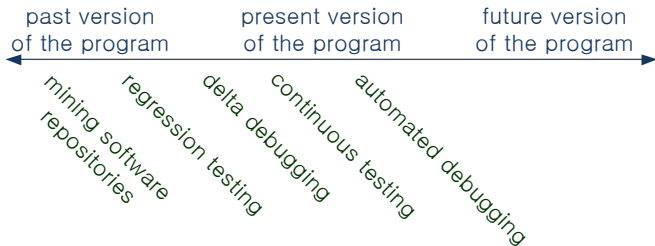


inform developer
of resulting compilation errors

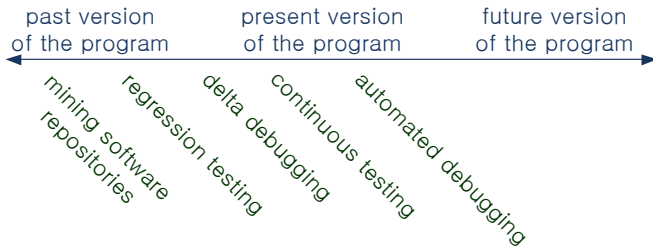
Exploring the future



Exploring the future



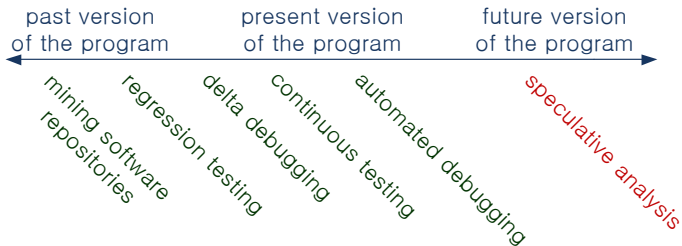
Exploring the future



Continuous development

- compilation [Childers et al. 2003; Eclipse 2011]
- execution [Henderson and Weiser 1985; Karinthe and Weiser 1987]
- testing [Saff and Ernst 2003, 2004]
- version control integration [Guimarães and Rito-Silva 2010]

Exploring the future



Continuous development

- compilation [Childers et al. 2003; Eclipse 2011]
- execution [Henderson and Weiser 1985; Karinthe and Weiser 1987]
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Speculative analysis is **predictive**.

Proactive detection of collaboration conflicts

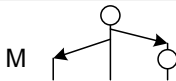
Collaborators: Reid Holmes, Michael D. Ernst, and David Notkin

Version-control terminology

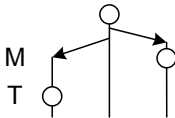
Proactive conflict detection applies to both centralized and distributed version control.

	distributed (hg, git)	centralized (cvs, svn)
local commit:	commit	save
incorporate:	pull and push	update and commit

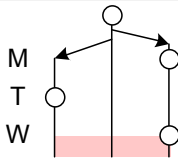
The Gates conflict



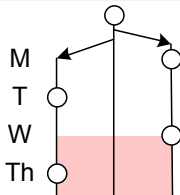
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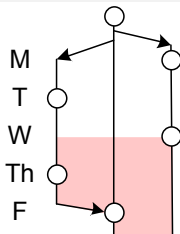
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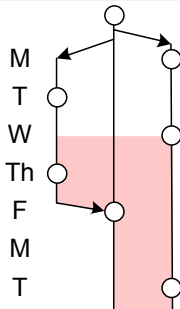
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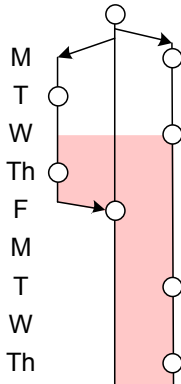
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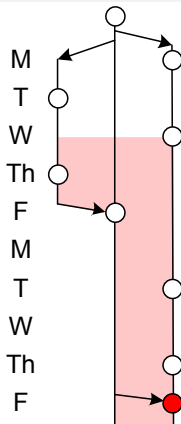
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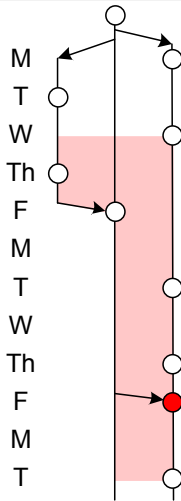
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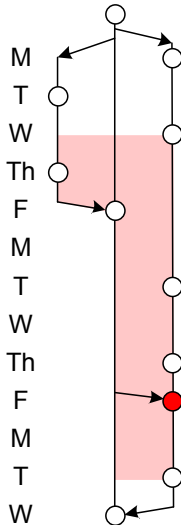
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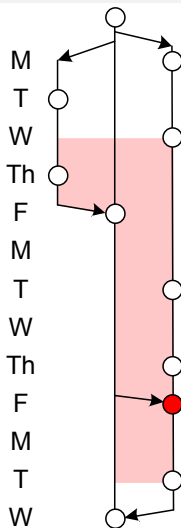
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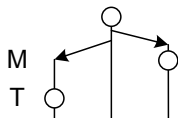


The Gates conflict



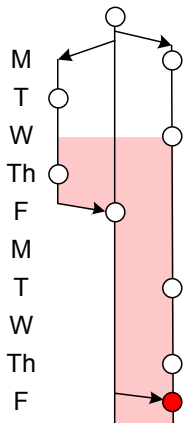
The information was all there, but the developers didn't know it.

What could well-informed developers do?



- avoid conflicts

What could well-informed developers do?



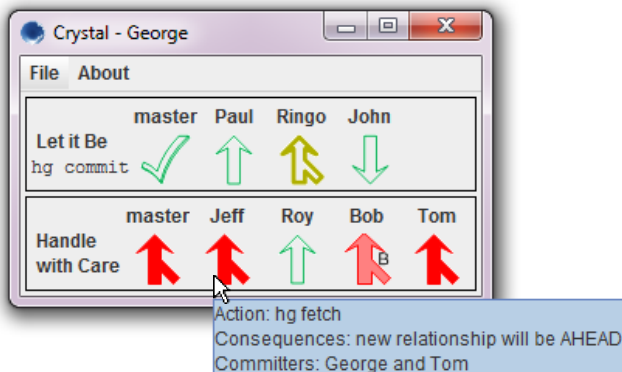
- avoid conflicts
- become aware of conflicts earlier

Introducing Crystal: a proactive conflict detector

DEMO

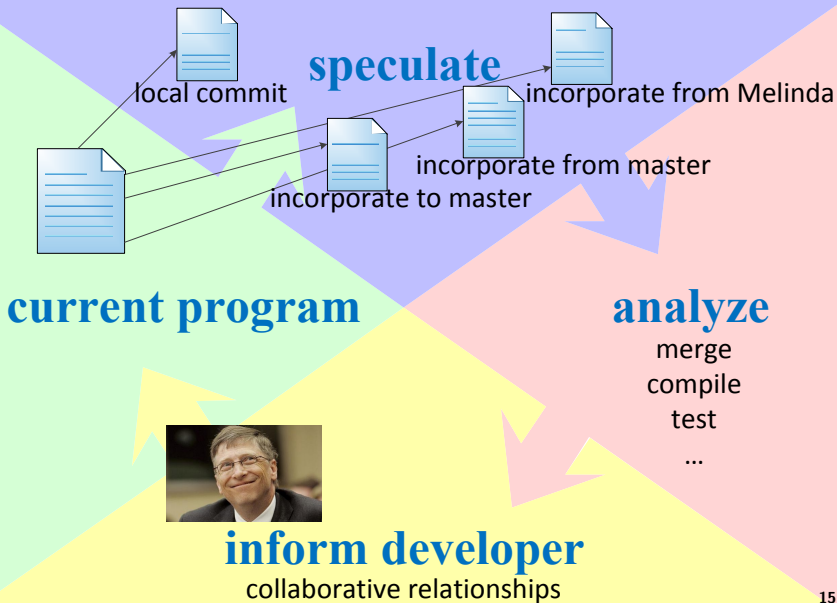
Introducing Crystal: a proactive conflict detector

DEMO



<http://crystalvc.googlecode.com>

Speculative analysis in collaborative development



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

Collaborative awareness

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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?

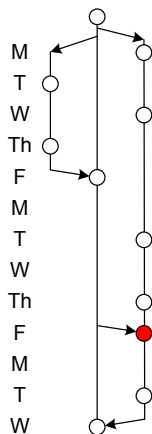
Are textual collaborative conflicts a real problem?

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?

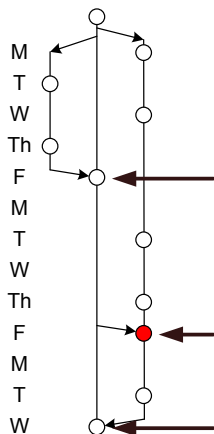


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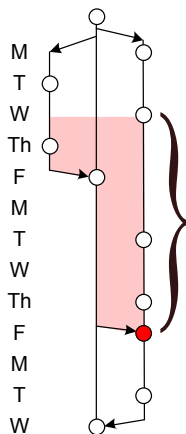
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Are textual collaborative conflicts a real problem?



How frequent are textual conflicts?

Are textual collaborative conflicts a real problem?

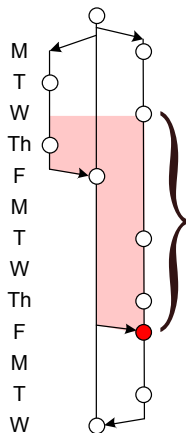


How frequent are textual conflicts?

16% of the merges have textual conflicts.

How long do textual conflicts persist?

Are textual collaborative conflicts a real problem?



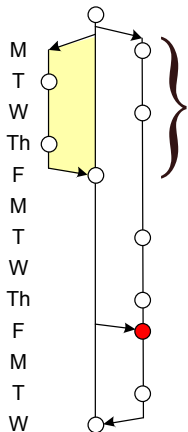
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Conflicts live a mean of 9.8 and median of 1.6 days.
The worst case was over a year.

Are textual collaborative conflicts a real problem?



How frequent are textual conflicts?

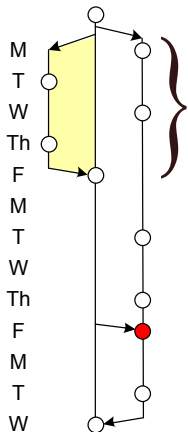
16% of the merges have textual conflicts.

How long do textual conflicts persist?

Conflicts live a mean of 9.8 and median of 1.6 days.
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How long do textually-safe merges persist?

Are textual collaborative conflicts a real problem?



How frequent are textual conflicts?

16% of the merges have textual conflicts.

How long do textual conflicts persist?

Conflicts live a mean of 9.8 and median of 1.6 days.
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How long do textually-safe merges persist?

Textually-safe merges live a mean of 11.0 and
median of 1.9 days.

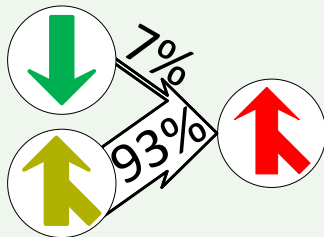
Can textual conflicts be prevented?

Where do textual conflicts come from?

Can textual conflicts be prevented?

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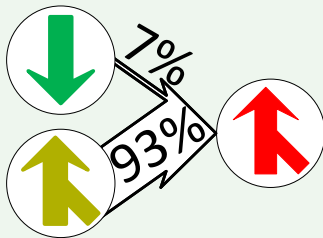
93% of textual conflicts developed from safe merges.



Can textual conflicts be prevented?

Where do textual conflicts come from?

93% of textual conflicts developed from safe merges.



The information Crystal computes can help prevent conflicts.

Do build and test collaborative conflicts exist?

program	conflicts			safe merges
	textual	build	test	
Git	17%	<1%	4%	79%
Perl5	8%	4%	28%	61%
Voldemort	17%	10%	3%	69%

Does merged code fail to build or fail tests?

One in three conflicts are build or test conflicts.

Microsoft Beacon

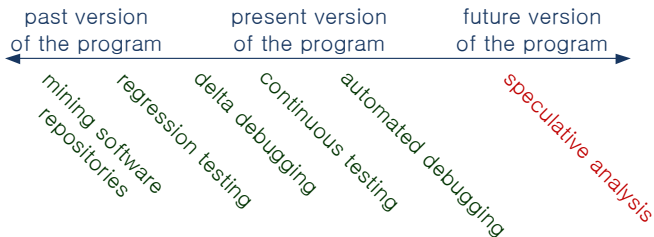
- A centralized version control-based tool.
- Microsoft product groups are using Beacon to help identify conflicts earlier in the development process.

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: Kivanç Muşlu, Christian Bird, Thomas Zimmermann

Contributions of 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

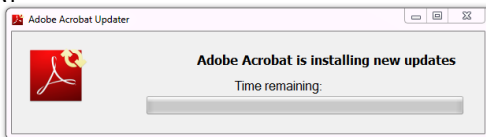
Next speculations:

- automated fault removal
- code parallelization
- test generation and augmentation

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Identify a domain with:

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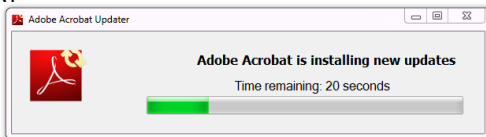
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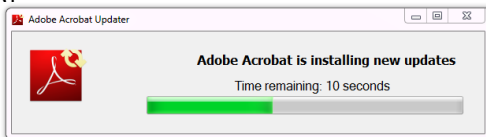
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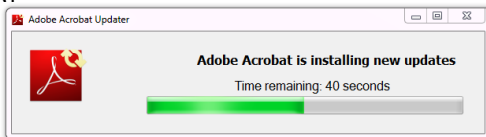
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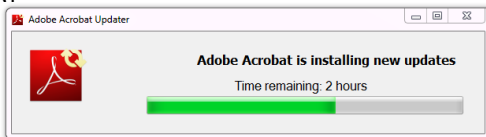
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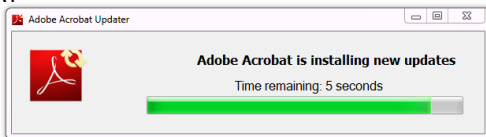
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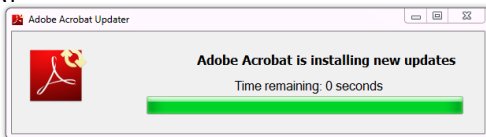
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- informative, efficient analyses
- inferable developer intent⁺



Next speculations:

- automated fault removal
- code parallelization
- test generation and augmentation

Expanding the space of speculative analysis

Identify a domain with:

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

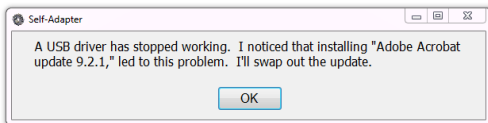
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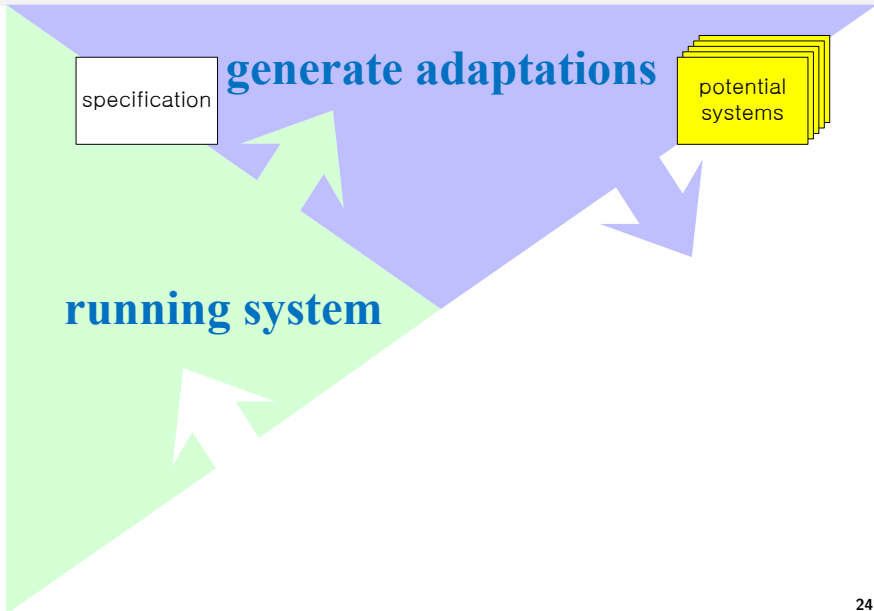
- automated fault removal
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Automating decision making: self-adaptation

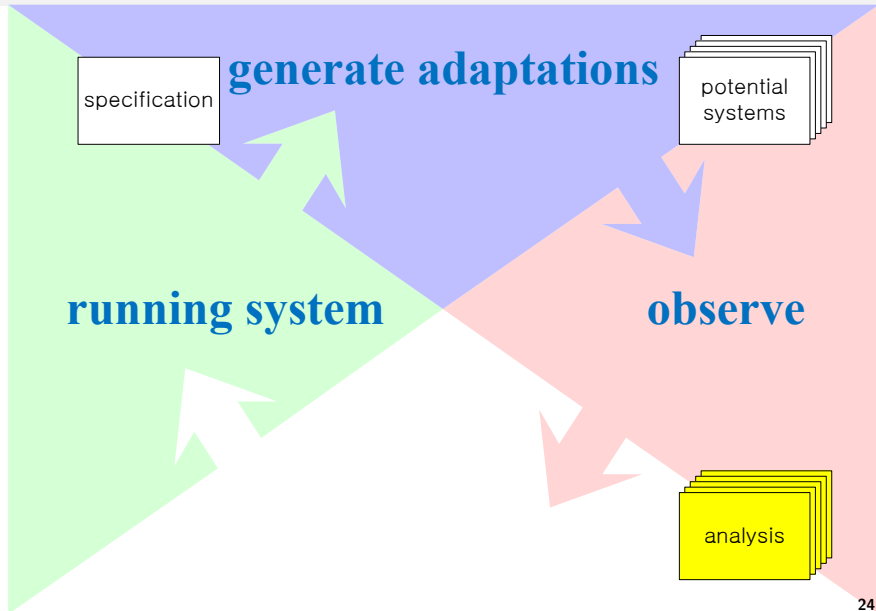
specification

running system

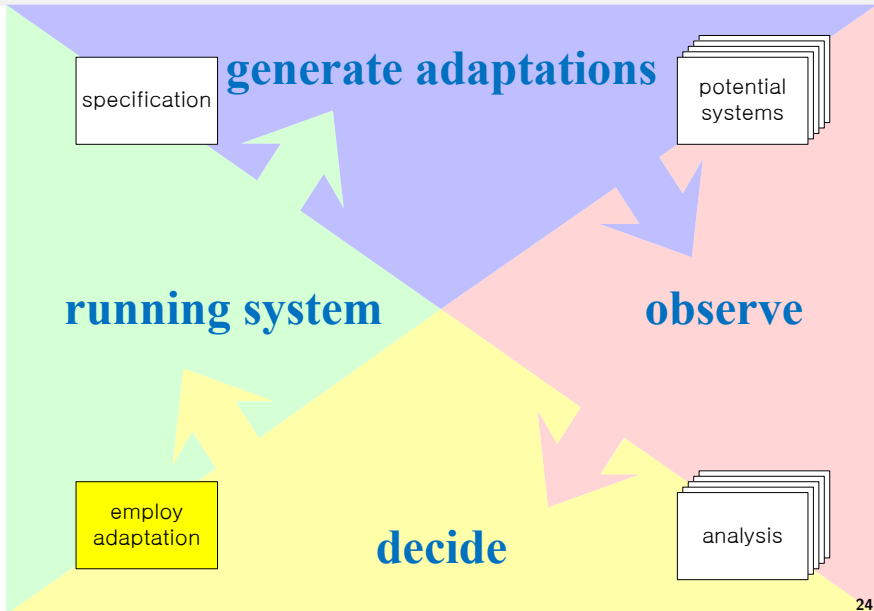
Automating decision making: self-adaptation



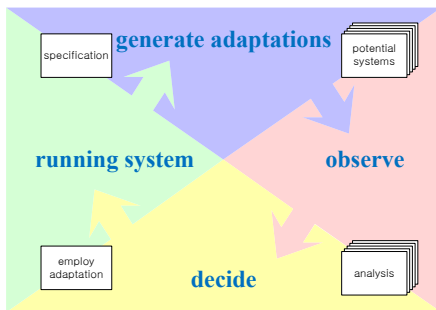
Automating decision making: self-adaptation



Automating decision making: self-adaptation



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

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