

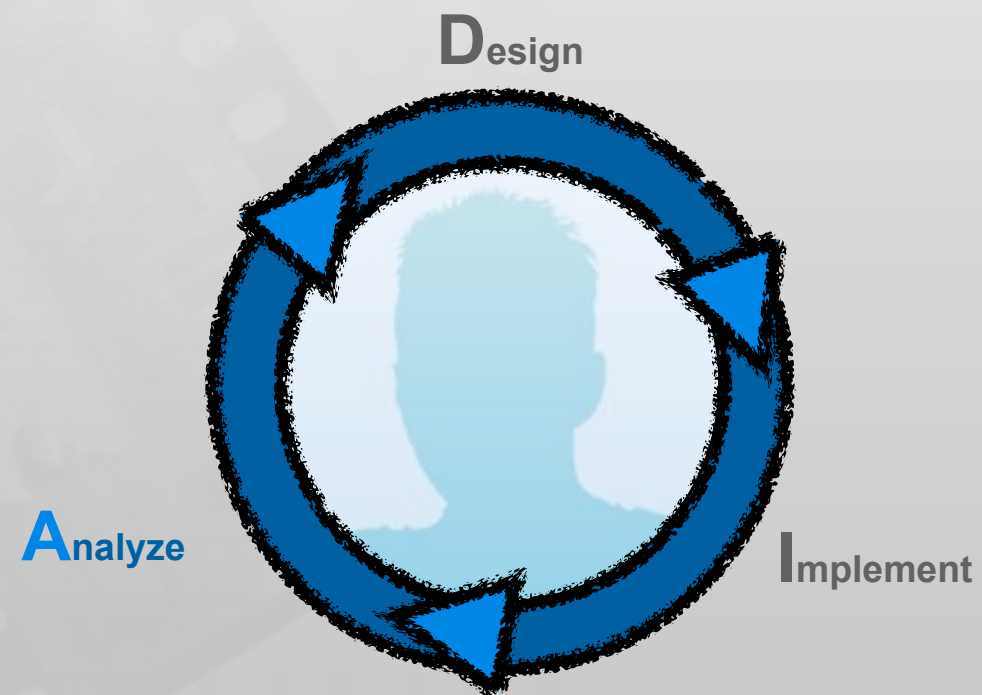
Research in Coding and IDEs

*Jan-Peter Krämer
Media Computing Group
RWTH Aachen University*

<http://hci.rwth-aachen.de/cthci>

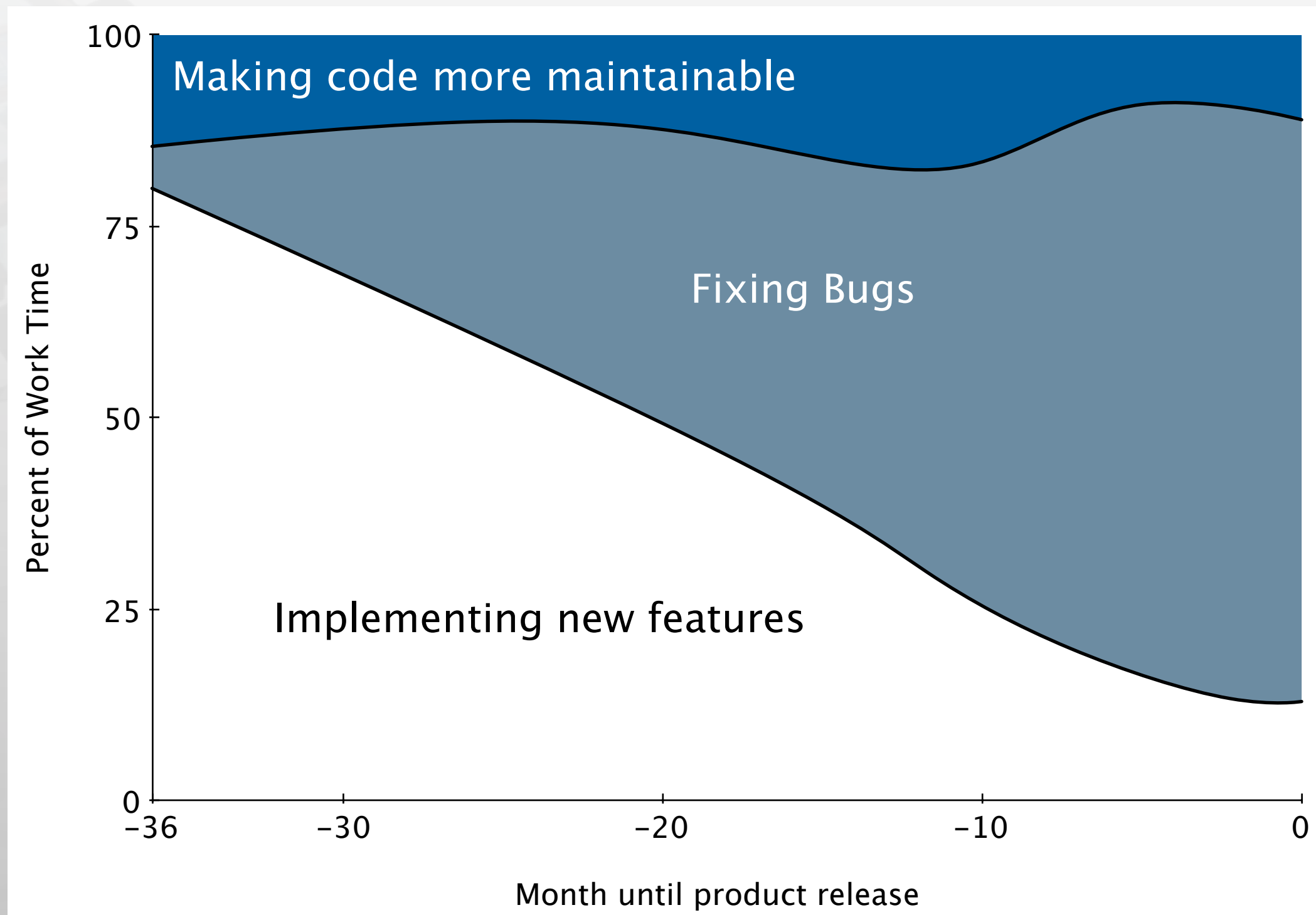


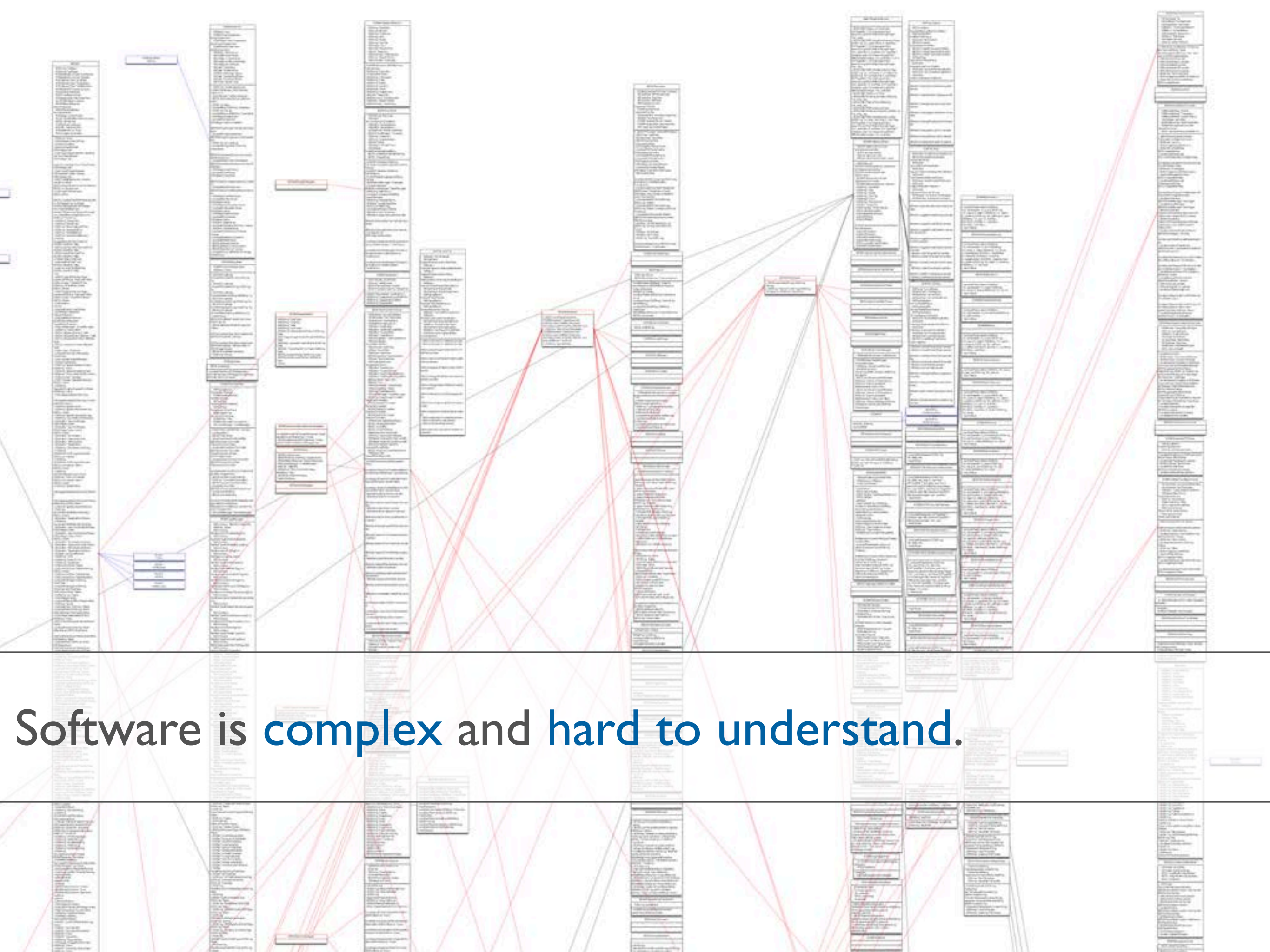
Status Quo



Time in Software Development

[LaToza2006, Maintaining mental models: a study of developer work habits]





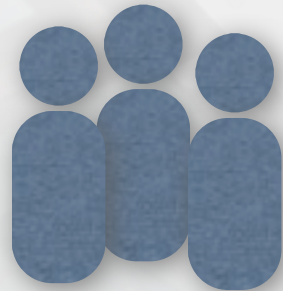
Software is **complex** and hard to understand.

Task context

- What is relevant information?
- What strategies are applied to find information?

Models for Developer Strategies

[Ko2006, An Exploratory Study of How Developers Seek, Relate, and Collect Relevant Information during Software Maintenance Tasks]



31 Professional Java Developers



5 Maintenance tasks
(3 Bugs, 2 Enhancements)

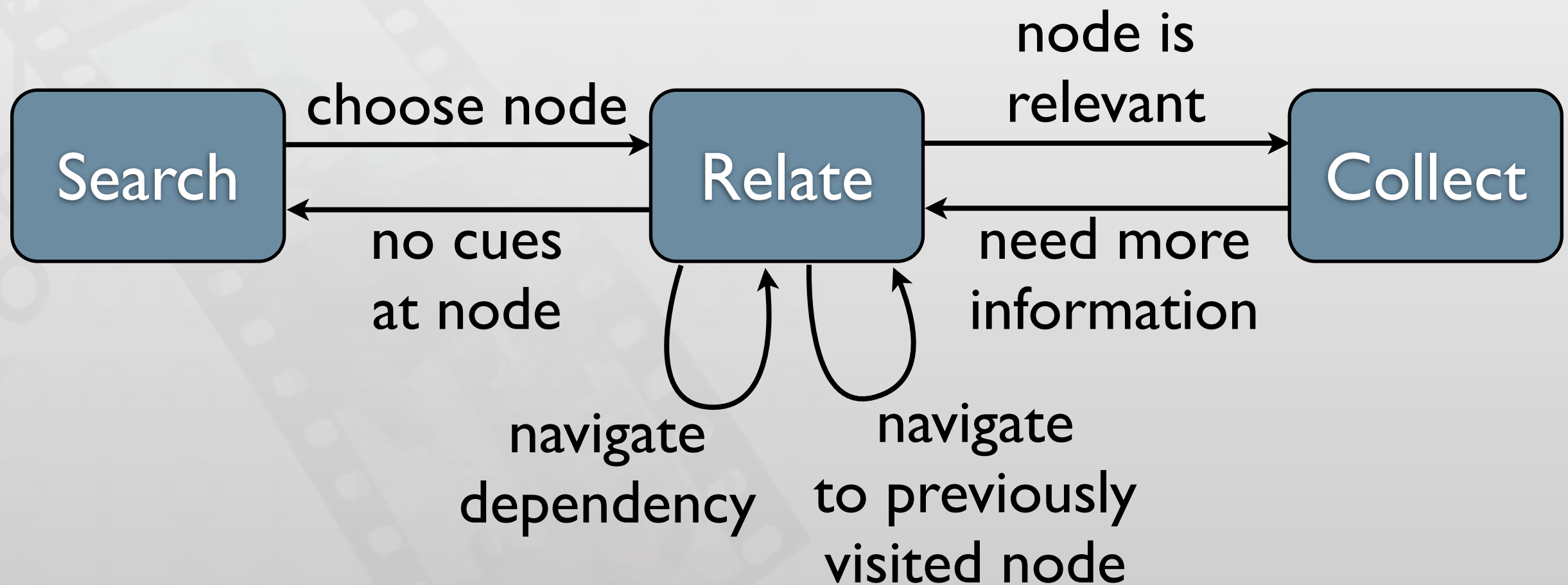


500 SLOC Java Paint
Application



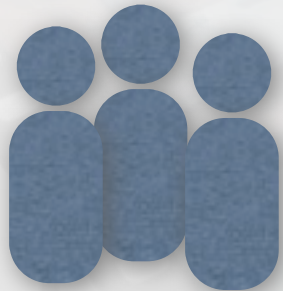
Models for Developer Strategies

[Ko2006, An Exploratory Study of How Developers Seek, Relate, and Collect Relevant Information during Software Maintenance Tasks]

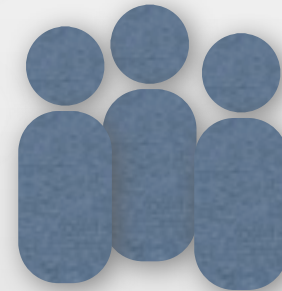


Models for Developer Strategies

[Sillito2008, Asking and Answering Questions during a Programming Change Task]



9 experienced developers (pair programming)



16 developers from industry



1 of 5 maintenance tasks per session



Real world change task



ArgoUML
60k SLOC

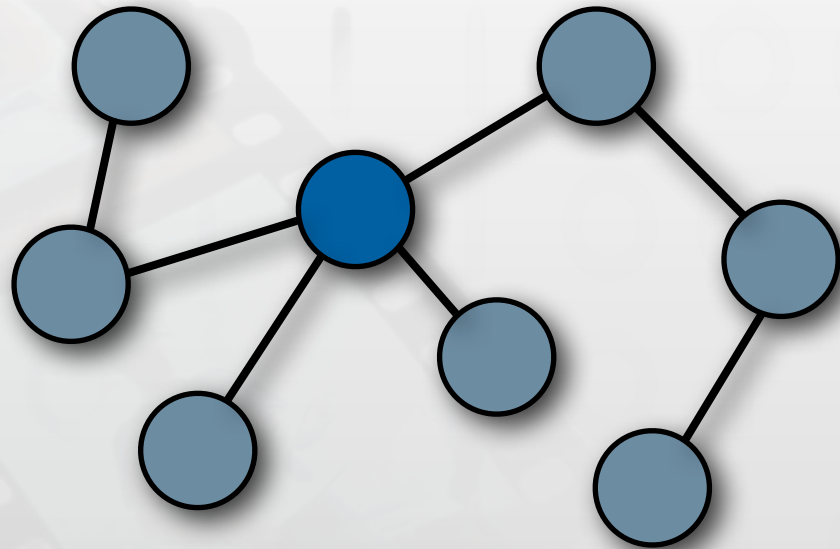


Real world sour code

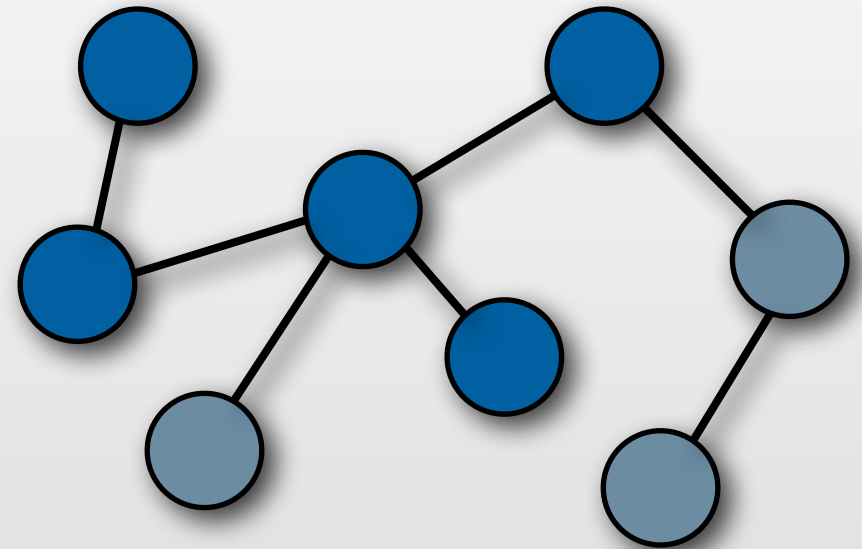


Models for Developer Strategies

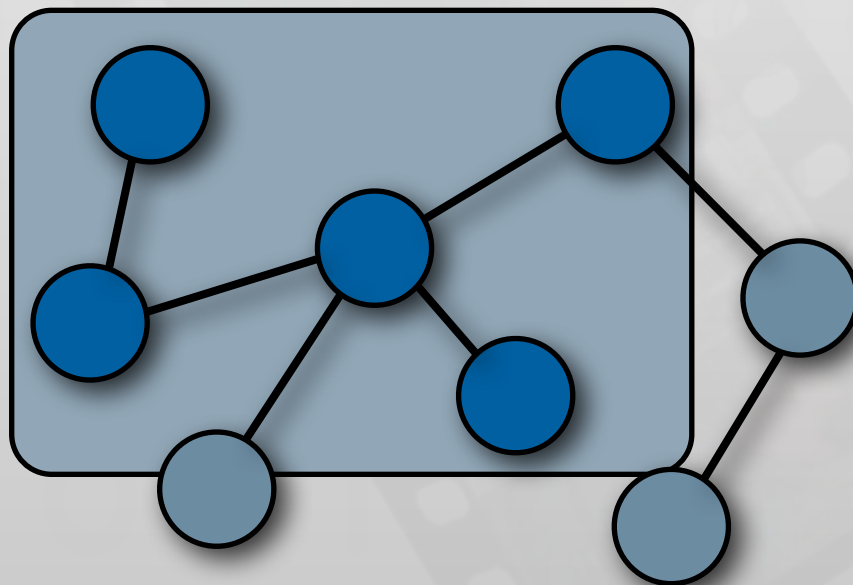
[Sillito2008, Asking and Answering Questions during a Programming Change Task]



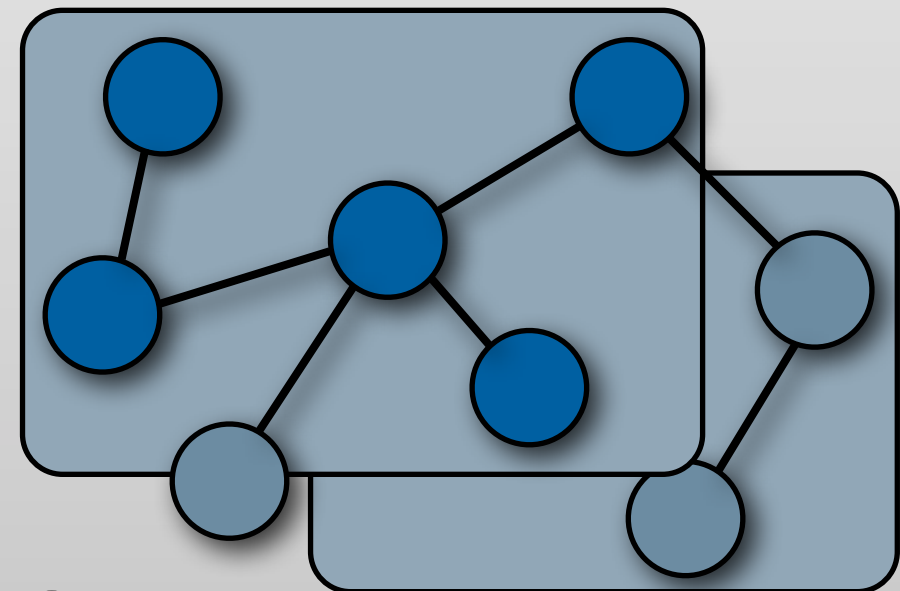
Finding focus points



Expanding focus points



Understanding a subgraph



Questions over groups of subgraphs



Java - jHotDraw/src/org/jhotdraw/contrib/DesktopEvent.java - Eclipse SDK - /Users/jpkraemer/Downloads/jhotdraw60b1

Package Explorer: jHotDraw, src, org.jhotdraw, org.jhotdraw.applet, org.jhotdraw.application, org.jhotdraw.contrib, org.jhotdraw.contrib.dnd, org.jhotdraw.contrib.html, org.jhotdraw.contrib.zoom, org.jhotdraw.figures, org.jhotdraw.framework, org.jhotdraw.images, org.jhotdraw.samples, org.jhotdraw.samples.javadraw, AnimationDecorator.java, Animator.java, BouncingDrawing.java, FollowURLTool.java, JavaDrawApp.java, JavaDrawApplet.java, JavaDrawViewer.java, MySelectionTool.java, PatternPainter.java, URLTool.java, JavaDrawAppletHelp.html, org.jhotdraw.samples.javadraw.sam, org.jhotdraw.samples.minimap, org.jhotdraw.samples.net, org.jhotdraw.samples.nothing, org.jhotdraw.samples.pert, org.jhotdraw.samples.pert.images, org.jhotdraw.standard, org.jhotdraw.test, org.jhotdraw.test.contrib, org.jhotdraw.test.figures, org.jhotdraw.test.framework, org.jhotdraw.test.samples.javadraw, org.jhotdraw.test.samples.minimap, org.jhotdraw.test.samples.net, org.jhotdraw.test.samples.nothing, org.jhotdraw.test.samples.pert, org.jhotdraw.test.standard, org.jhotdraw.test.util, org.jhotdraw.test.util.collections.jdk, org.jhotdraw.test.util.collections.jdk, org.jhotdraw.util, org.jhotdraw.util.collections.jdk11, org.jhotdraw.util.collections.jdk12, JRE System Library [JavaSE-1.6]

Editor: DesktopEvent.java

```
package org.jhotdraw.contrib;

import org.jhotdraw.framework.DrawingView;

/**
 * @author C.L.Gilbert <dnayeb@users.sourceforge.net>
 * @version <CURRENT_VERSION>
 */
public class DesktopEvent extends EventObject {
    private DrawingView myDrawingView;

    /**
     * Some events require the previous DrawingView (e.g. when a new DrawingView
     * is selected).
     */
    private DrawingView myPreviousDrawingView;

    public DesktopEvent(Desktop newSource, DrawingView newDrawingView) {
        this(newSource, newDrawingView, null);
    }

    public DesktopEvent(Desktop newSource, DrawingView newDrawingView, DrawingView newPreviousDV) {
        super(newSource);
        setDrawingView(newDrawingView);
        setPreviousDrawingView(newPreviousDV);
    }

    private void setDrawingView(DrawingView newDrawingView) {
        myDrawingView = newDrawingView;
    }

    public DrawingView getDrawingView() {
        return myDrawingView;
    }

    private void setPreviousDrawingView(DrawingView newPreviousDrawingView) {
        myPreviousDrawingView = newPreviousDrawingView;
    }

    public DrawingView getPreviousDrawingView() {
        return myPreviousDrawingView;
    }
}
```

Outline: org.jhotdraw.contrib, import declarations, DesktopEvent, myDrawingView : DrawingView, myPreviousDrawingView : DrawingView, DesktopEvent(Desktop, DrawingView), DesktopEvent(Desktop, DrawingView, DrawingView), setDrawingView(DrawingView) : void, getDrawingView() : DrawingView, setPreviousDrawingView(DrawingView) : void, getPreviousDrawingView() : DrawingView

Problems: Javadoc, Declaration, Call Hierarchy

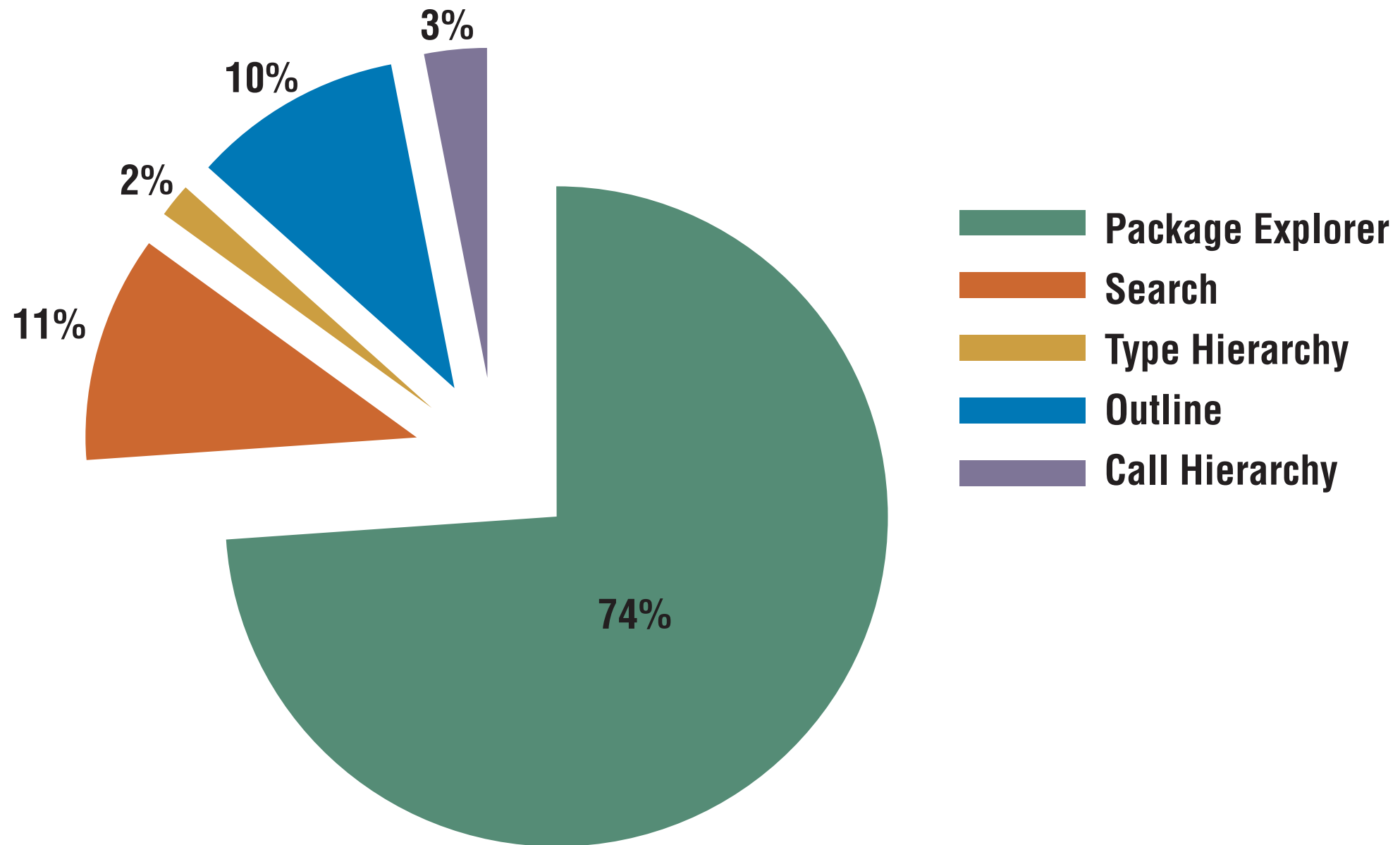
Calls from 'DesktopEvent(Desktop, DrawingView, DrawingView)' - in workspace

- DesktopEvent(Desktop, DrawingView, DrawingView) - org.jhotdraw.contrib.DesktopEvent
 - EventObject(Object) - java.util.EventObject
 - setDrawingView(DrawingView) : void - org.jhotdraw.contrib.DesktopEvent
 - setPreviousDrawingView(DrawingView) : void - org.jhotdraw.contrib.DesktopEvent

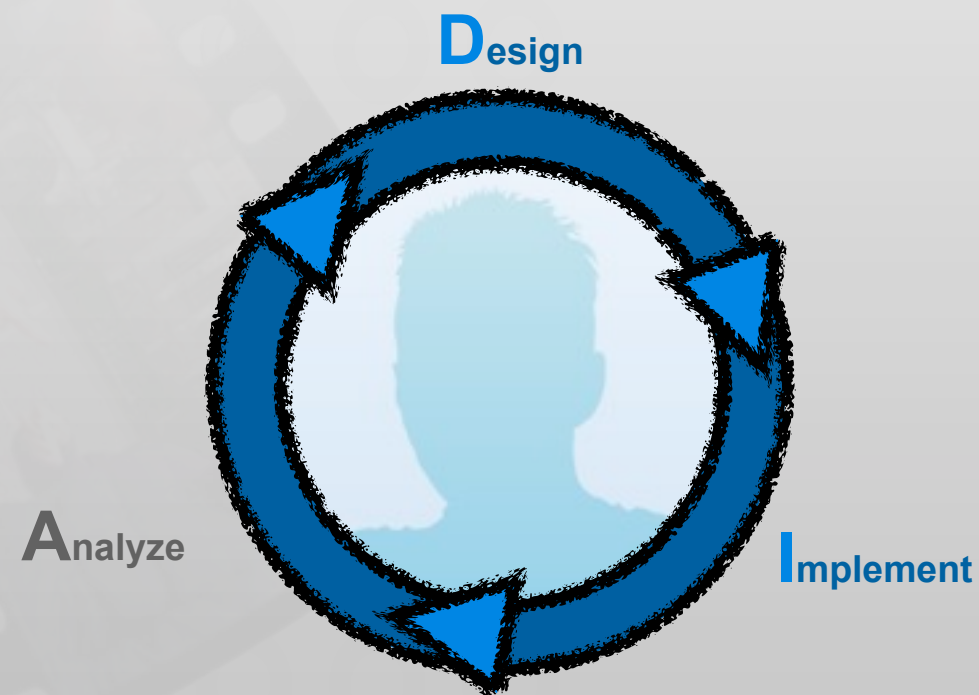
org.jhotdraw.samples.javadraw.Animator.java - jHotDraw/src

Tools Used in Eclipse

[Murphy2006, How Are Java Software Developers Using the Eclipse IDE?]



Easing Access to Task Context



Java - Attach error log entries into new bug reports - Eclipse SDK

File Edit Navigate Search Project Run Window Help

Package Exp Hierarchy

org.eclipse.myllyn.bugzilla.core [dev]

src

org.eclipse.myllyn.internal.bugzilla

BugzillaAttributeMapper.java

BugzillaAttributeMapper

BugzillaClient.java

BugzillaClient

postAttachment(String)

BugzillaClientFactory.java

BugzillaClientFactory

taskRepositoryLocator

org.eclipse.myllyn.bugzilla.ui [dev]

src

org.eclipse.myllyn.internal.bugzilla

BugzillaUpdateAttachment

BugzillaUpdateAttachment

currentSelection

init(IViewPart)

BugzillaAttributeMapper.java

*216640: Attach error log entries into new bug reports

Bug 216640

Eclipse

Attach error log entries into new bug reports

P5 Status: NEW Bug: 216640 Opened: Jan 25, 2008 Modified: Jan 29, 2008 2:32 AM

Attributes

Attachments (0)

Description

Comments (1)

1: Mik Kersten, Jan 29, 2008 1:54 AM

New Comment

Looking into this now, see also related bug 124224.

Actions

Leave as NEW

Accept (change status to ASSIGNED)

Resolve as FIXED

Duplicate of

Reassign to m

Reassign to default

Submit

People

Assigned to: Mylyn Inbox <mylyn-inbox@e

Reporter: Willian Mitsuda <wmitsuda@c

QA Contact:

Add CC:

jacek.pospychala@pl.ibm.com

mik.kersten@tasktop.com

(Select to remove)

Task List

Find:

All Allow to ed...

Mylyn - Mik [Bugzilla]

162335: [context] Allow "Make Landi

267524: create Mylyn 3.2 release plan

Mylyn - Rob [Bugzilla]

124224: Allow to edit priorities in

Project - Steffen [Trac]

83: filter sort results

84: upgrade ws api

5: address web site nits

Target - Rob [Atlassian]

PLE-290: logged in as wrong user wr

PLE-327: Documentation for Eclipse

PLE-172: Create Crucible review with

PLE-238: add an action to a cha

Synchronize

Change Sets for CVS (Workspace)

Allow to edit priorities in the task list

org.eclipse.myllyn.bugzilla.core [dev]

streamline task attachments

Planning Context Bugzilla

[Kersten2006, Using Task Context to Improve Programmer Productivity]

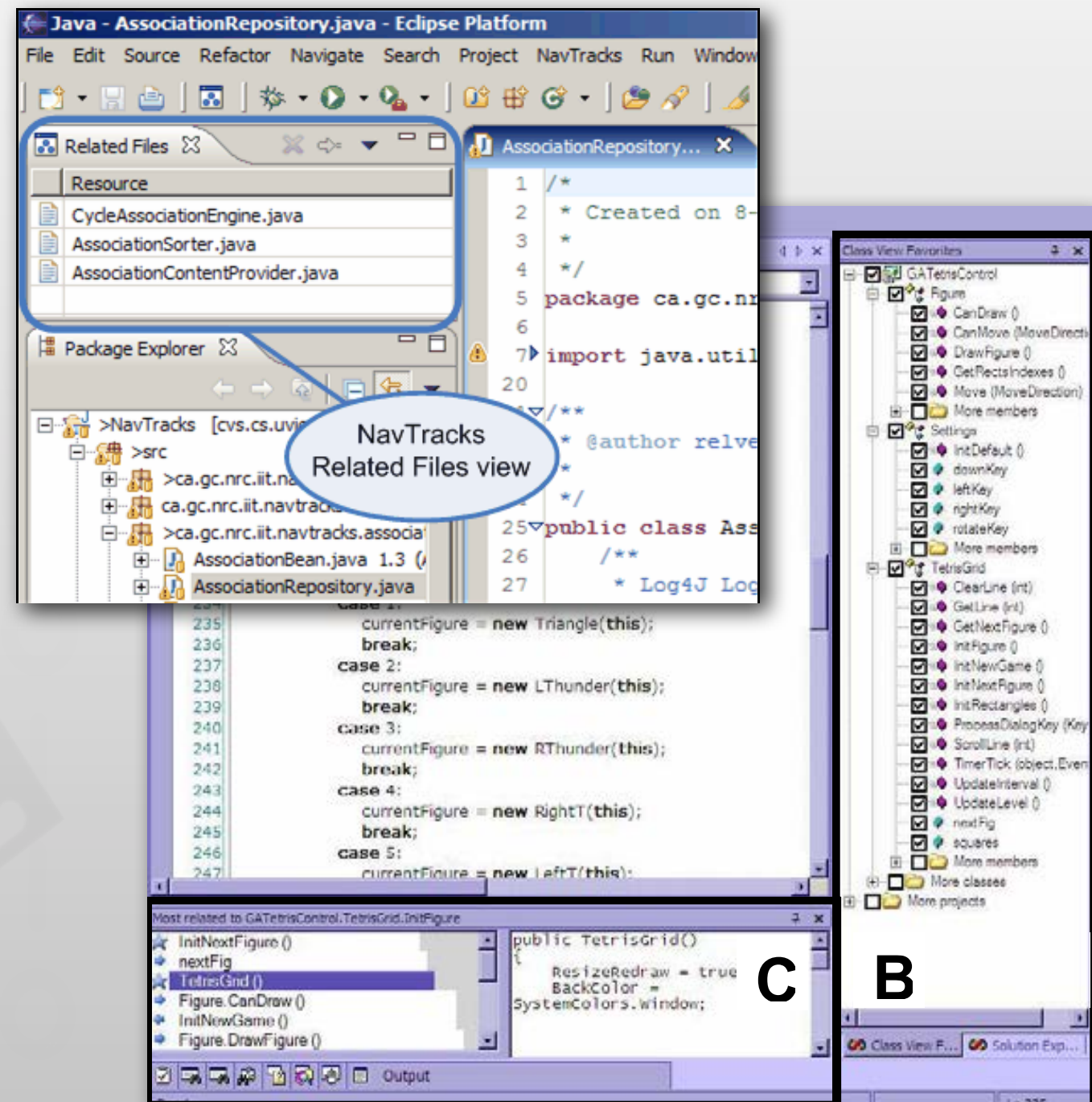
Recommender Tools

[Singer2005, NavTracks: supporting navigation in software maintenance]

[DeLine2005, Easing program comprehension by sharing navigation data]

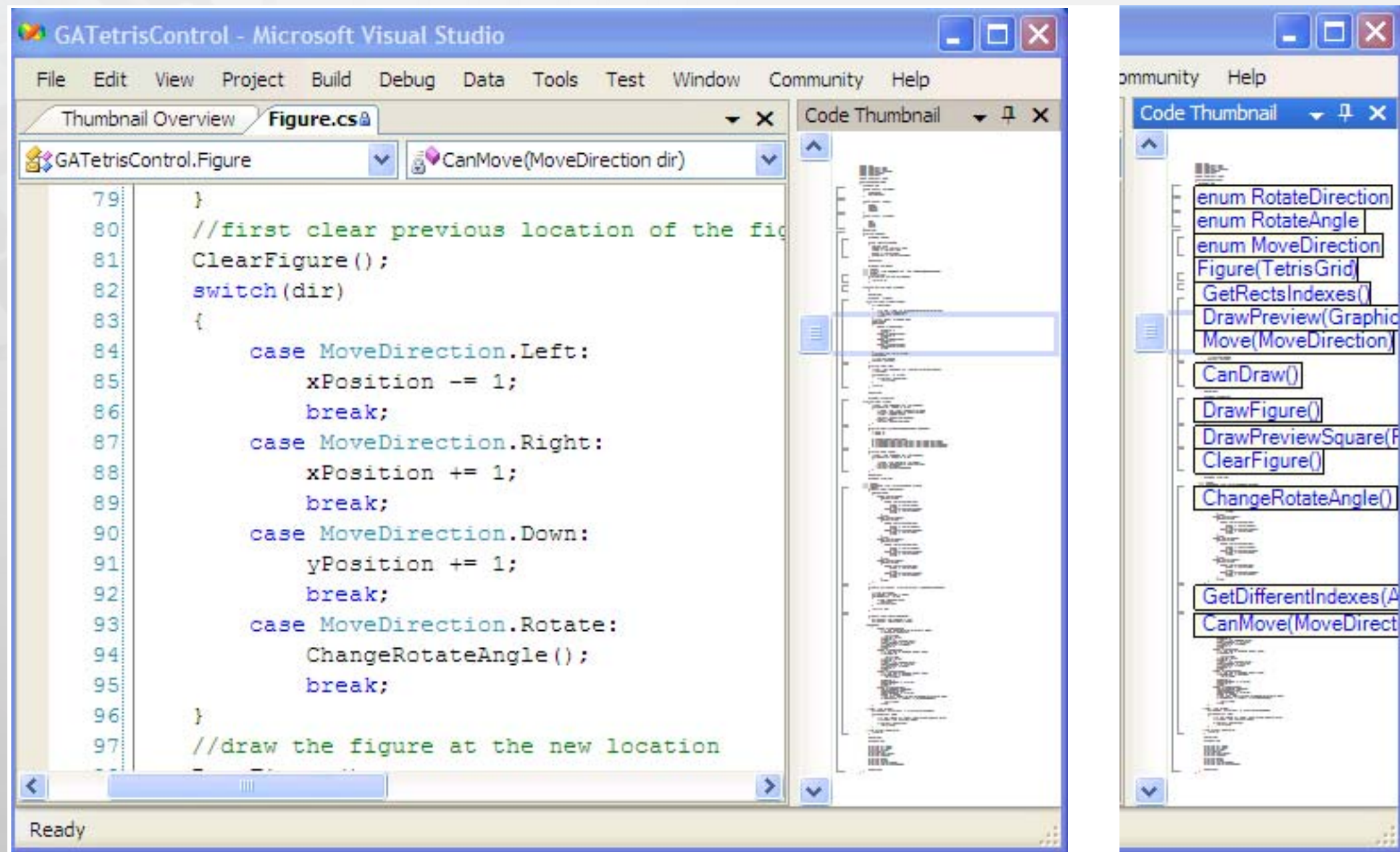
[Čubranić 2005, Hipikat: recommending pertinent software development artifacts]

- Calculate a Degree of Interest for source code elements based on:
 - reading history
 - editing history
 - history of other team members
 - information from version control systems



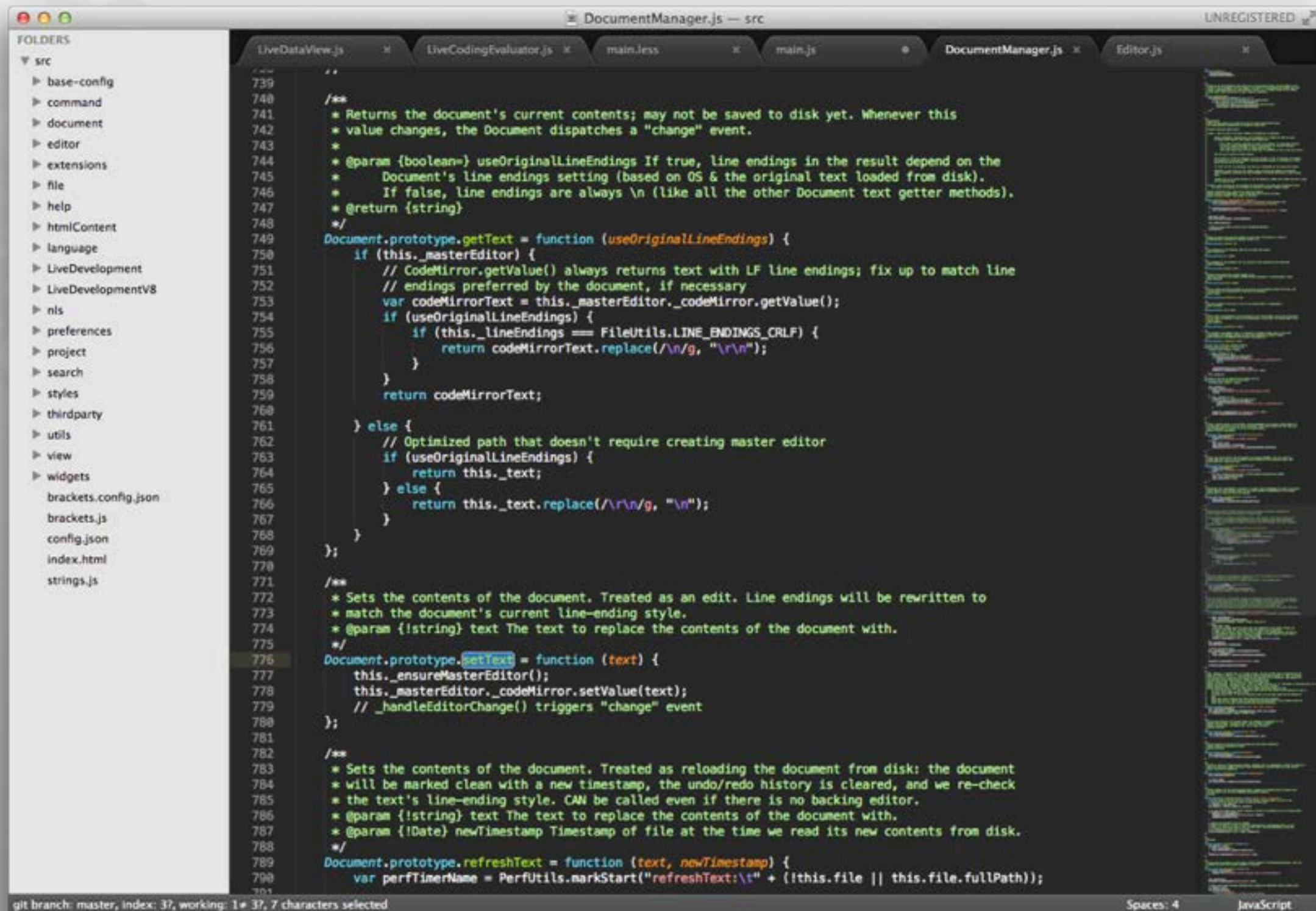
Changing the Presentation

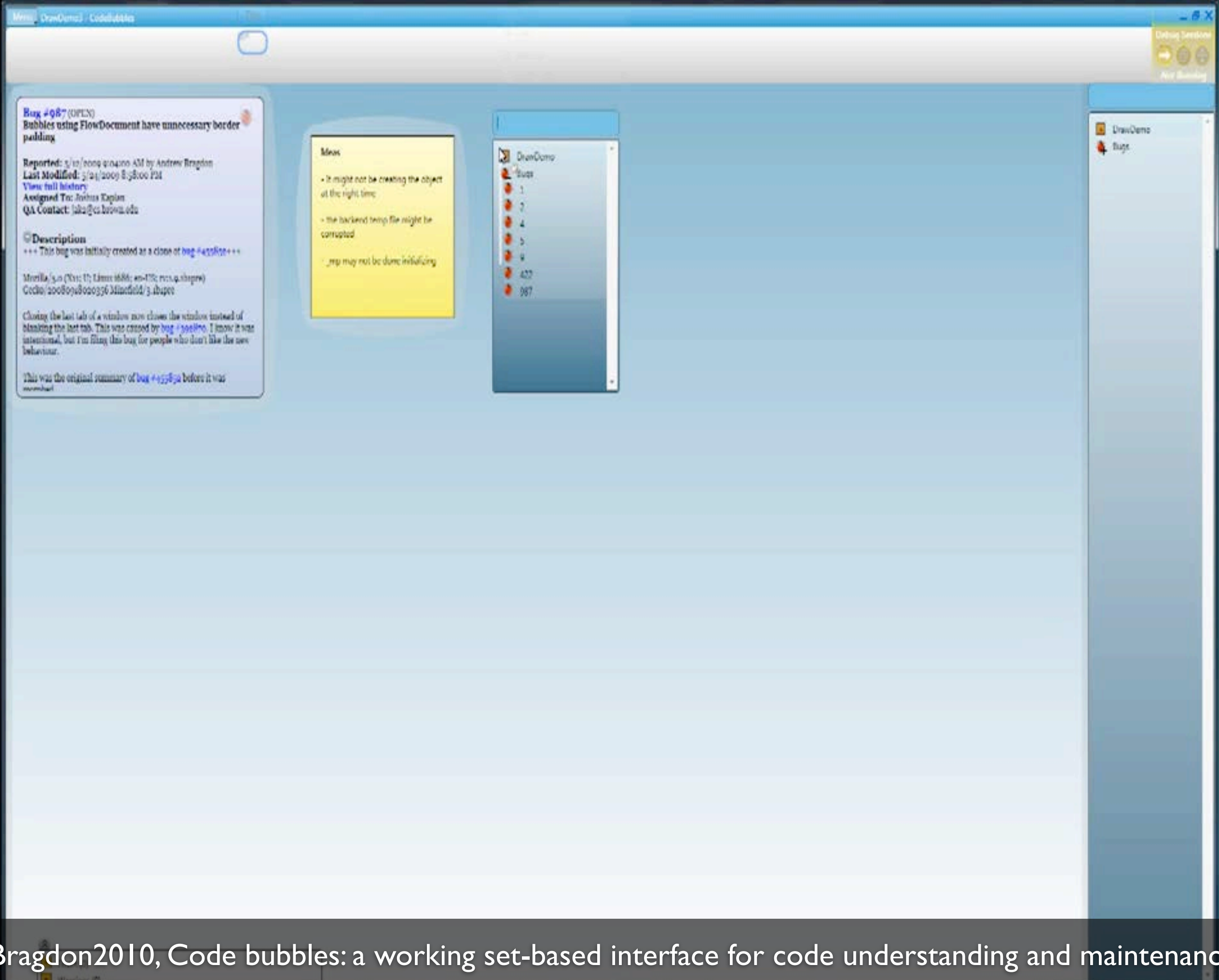
[DeLine2006, Code Thumbnails: Using Spatial Memory to Navigate Source Code]



Changing the Presentation

[Sublime Text 2, <http://www.sublimetext.com/2>]





[Bragdon2010, Code bubbles: a working set-based interface for code understanding and maintenance]

DrawDemo - CodeBubbles

DrawDemo - MainPanel

```
public void generateStatisticsGUI(String[] messages) {
    String msg = "There is currently 3 shape on the screen";
    String[] messages = new String[3];
    messages[0] = msg;
    return messages;
}
```

DrawDemo - MainPanel

```
public void handleOrderOfPanel() {
    panel.setBorder(new javax.swing.border.
        MatteBorder(4,4,4,4));
}

init();

DrawDemo - MainPanel
```

```
public void logMenuOp(String action) {
    _action.add(action);
    windowLog();
}
```

DrawDemo - MainPanel

```
public static void test() {
}
```

DrawDemo - MainPanel

```
public void handleStatisticsGUI(String[]
    messages) {
    _statisticsButton = StatisticsButton.getInstance(
        messages);
}
```

DrawDemo - MainPanel

```
protected void handleClick() {
    String displayText = "";
    displayText += _messages[0];
    _statisticsButton.handleClick(displayText);
}
```

DrawDemo - MainPanel

```
public ShapeButton[] createShapeButtons() {
    ShapeButton[] shp = new ShapeButton[4];
    shp[0] = ShapeButton.getInstance("Line",
        this);
    shp[1] = ShapeButton.getInstance(
        "Round Rectangle", this);
    shp[2] = ShapeButton.getInstance("Ellipse",
        this);
    shp[3] = ShapeButton.getInstance("Pie Shape",
        this);

    _holder = new ButtonHolder(_lines);
    return shp;
}
```

DrawDemo - MainPanel

```
private static final long serialVersionUID =
    1L;
private JButton _line0;
private JButton _shapeButtons;
private JButton _deleteShape;
private ButtonHolder _holders;
public LinkedList<String> _actions = new
    LinkedList<String>();
private DrawingPanel _dp;
private ShapePanel _shapePanel;
```

Toolbar Setup Code

```
DrawDemo - MainPanel
```

```
private static final long serialVersionUID =
    1L;
private JButton _line0;
private JButton _shapeButtons;
private JButton _deleteShape;
private ButtonHolder _holders;
public LinkedList<String> _actions = new
    LinkedList<String>();
private DrawingPanel _dp;
private ShapePanel _shapePanel;
```

DrawDemo

```
ButtonHolder
    _currentSelection private ShapeButton _currentSelection, _nextSelection;
    selfSelected public void setSelected(ShapeButton button);
DrawingPanel
    isSpecifyDimensions returns ShapeButton.inspectifyDimension();
MainPanel
    _line0 private ShapeButton _line0;
    MainPanel ShapeButton[] shapeButtons = this.createShapeButtons();
    createShapeButtons public ShapeButton[] createShapeButtons() {
        ShapeButton[] shp = new ShapeButton[4];
        shp[0] = ShapeButton.getInstance("Line", this);
        shp[1] = ShapeButton.getInstance("Round Rectangle", this);
        shp[2] = ShapeButton.getInstance("Ellipse", this);
        shp[3] = ShapeButton.getInstance("Pie Shape", this);
        _shapeButtonPanel public JPanel makeShapeButtonPanel(ShapeButton[] button) {
            ShapeButton
```

DrawDemo

- Add Class...
- App
- ActionButton
- ButtonHolder
- CanvasOfMainMenuItem
- ClearGridMenuButton
- DeleteButton
- DrawingPanel
- GridMenuButton
- HighlightedMenuButton
- LoadMenuButton
- MainPanel
- Top of file
- Member Variables
- Add Method...
- MainPanel
- createMenu1
- createMenu2
- createMenu3
- createMenu4
- createMenu5
- createMenu6
- createMenu7
- createMenu8
- createMenu9
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- createMenu99

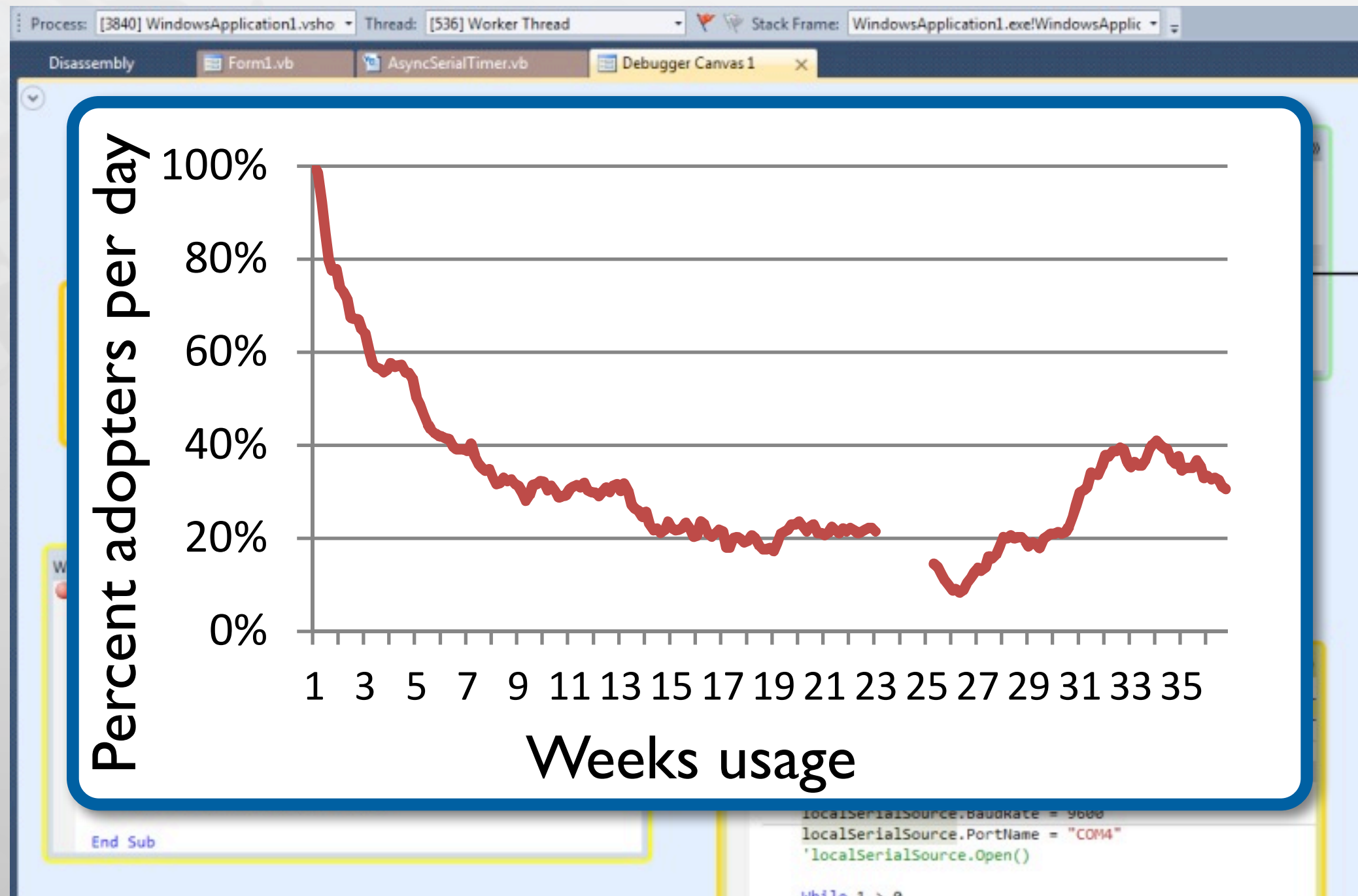
[Bragdon2010, Code bubbles: a working set-based interface for code understanding and maintenance]



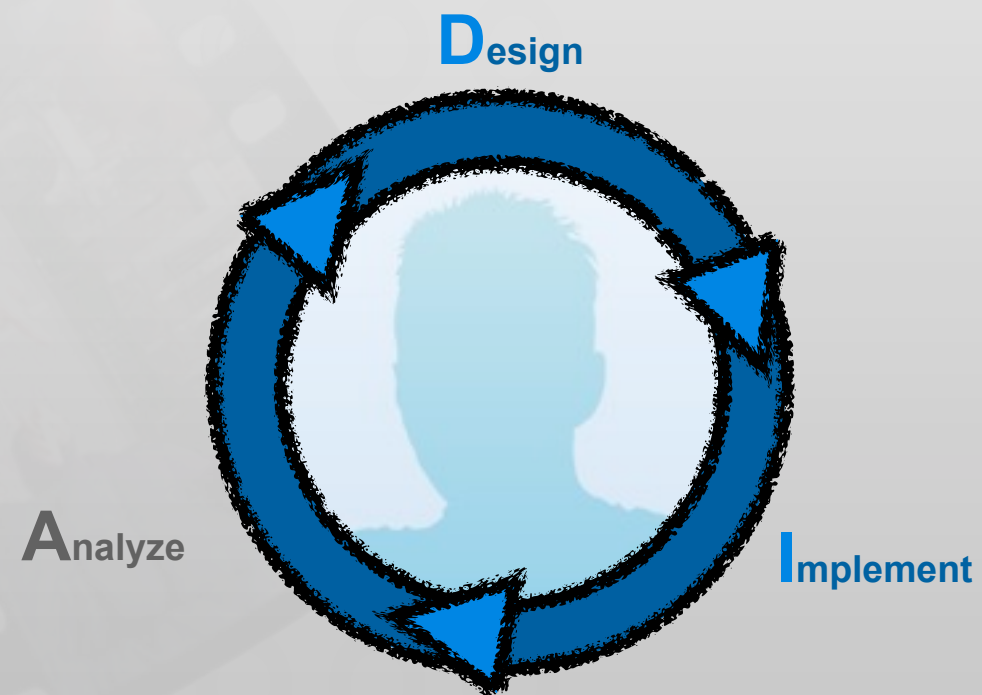


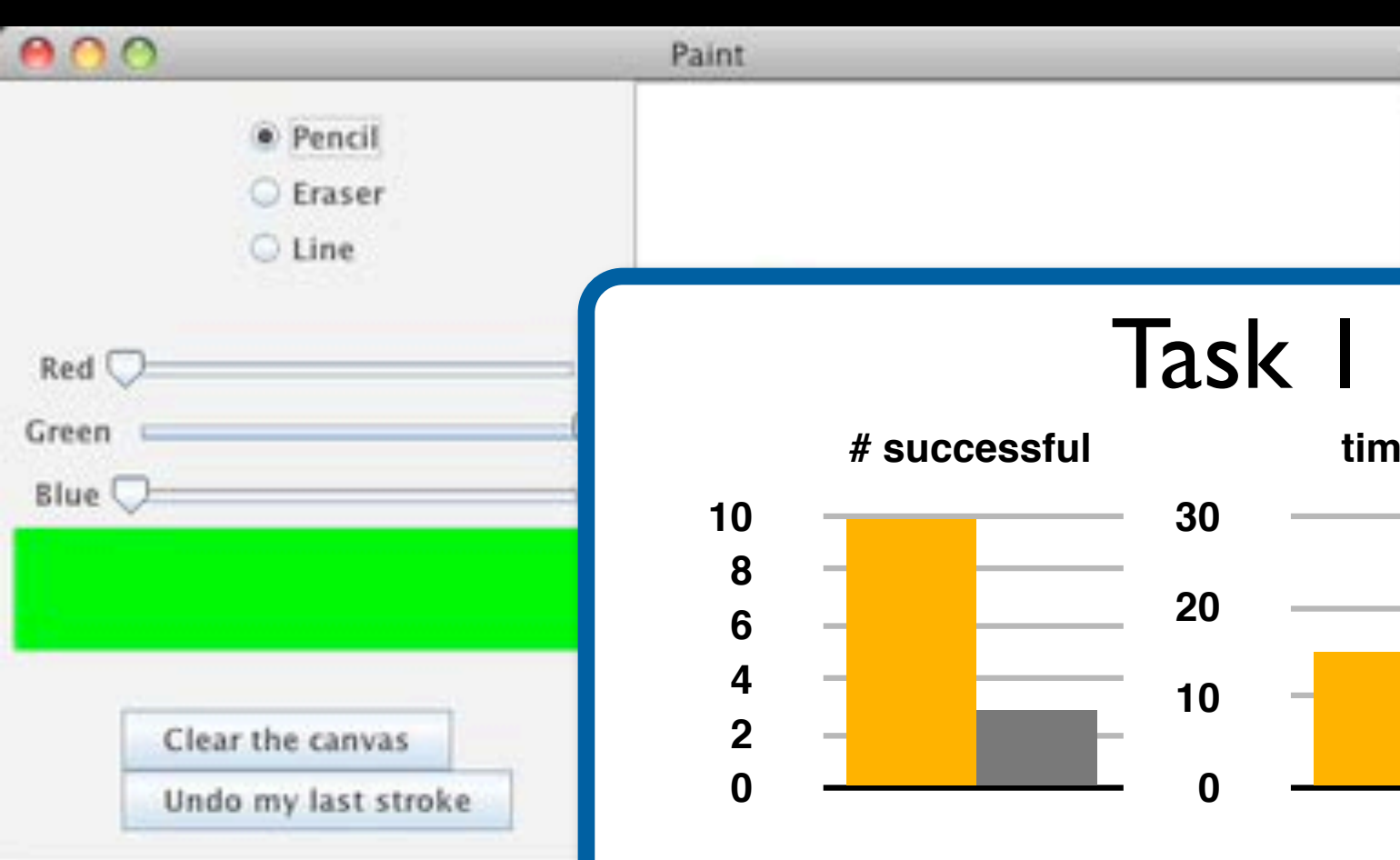
Canvas Interfaces in the Wild

[DeLine2012, Debugger Canvas: Industrial experience with the code bubbles paradigm]

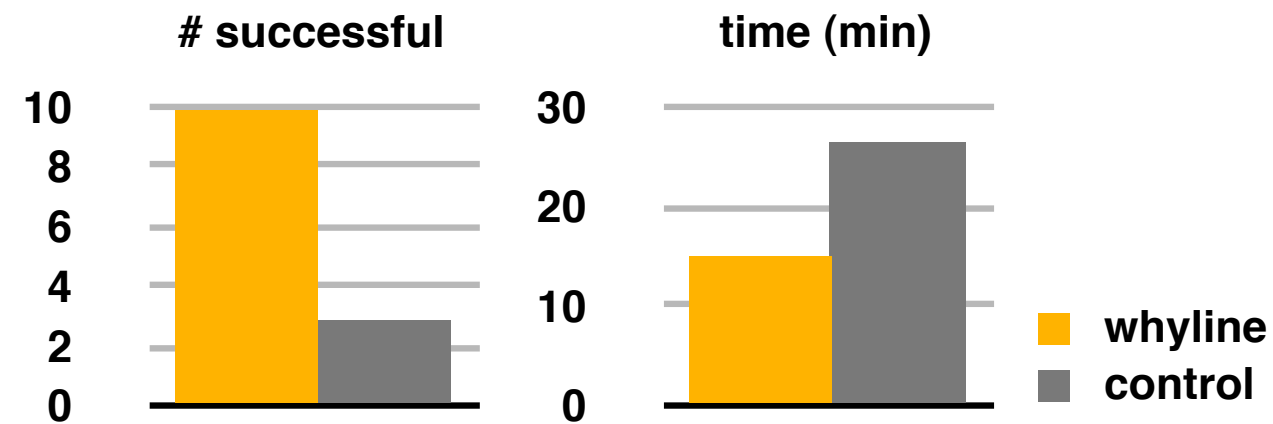


Utilizing the Call Graph

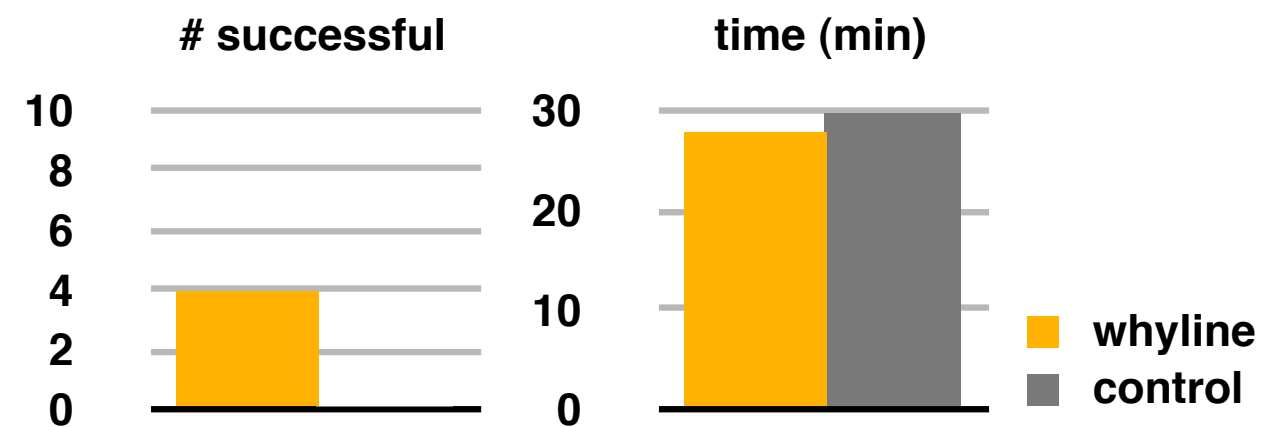




Task 1

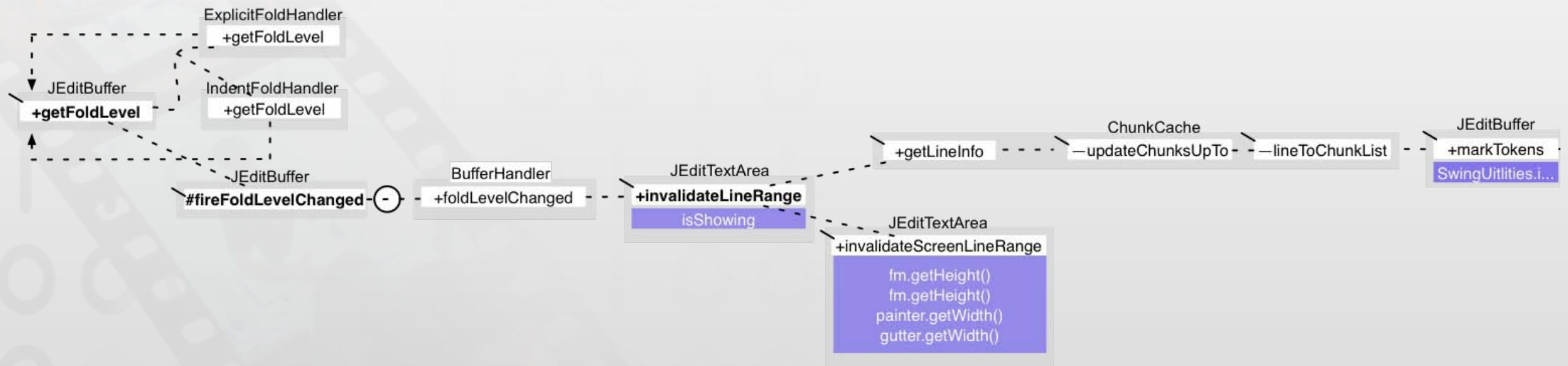


Task 2



Utilizing Call Graph Information

[LaToza2010, Searching Across Paths]



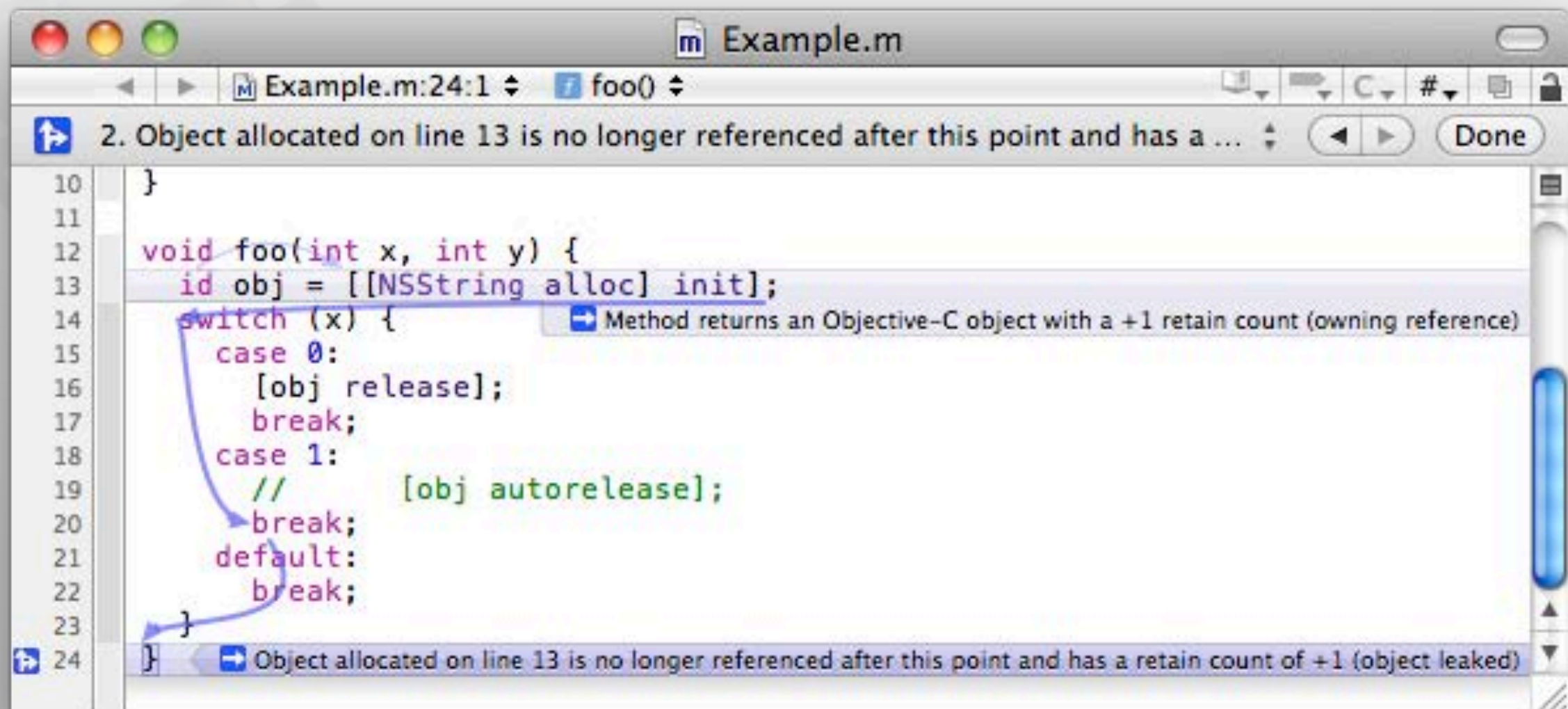
Legend

<code>+methodName</code>	public / protected / private method	————	method call that is always executed		recursive method call
<code>#methodName</code>	method visited by developer	-----	method call that might execute		paths of calls with hidden methods
<code>-methodName</code>	method with callers that are not shown		mutually exclusive method calls		data flow
<code>TypeName</code>	type with type name		method call in a loop		expression that matches search



Static Analysis in the Wild

[Clang Static Analyzer, <http://clang-analyzer.llvm.org/>]



The screenshot shows a code editor window titled "Example.m". The code is as follows:

```
10 }
11
12 void foo(int x, int y) {
13     id obj = [[NSString alloc] init];
14     switch (x) {
15         case 0:
16             [obj release];
17             break;
18         case 1:
19             // [obj autorelease];
20             break;
21         default:
22             break;
23     }
24 }
```

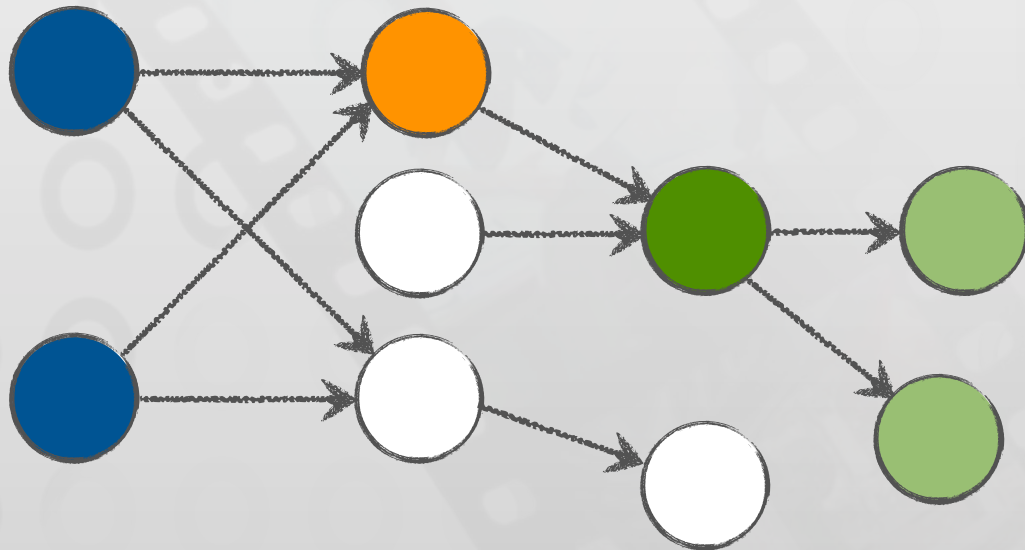
Two warnings from the Clang Static Analyzer are visible:

- Warning 2: "Object allocated on line 13 is no longer referenced after this point and has a ..." (partially visible).
- Warning at line 24: "Object allocated on line 13 is no longer referenced after this point and has a retain count of +1 (object leaked)".

Blue arrows indicate the control flow from the allocation on line 13 through the switch statement to the end of the function, showing that the object is not released in all paths.



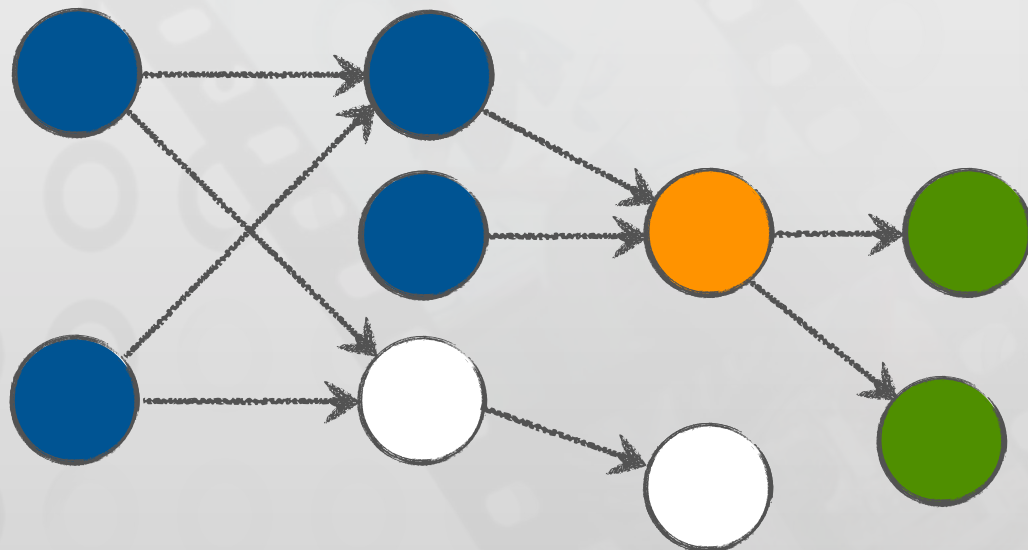
Call Hierarchy



```
29 -(void)convertClicked:(id)sender;
30 {
31     //do something
32     if (self.theConverter == nil) {
33         self.theConverter = [[Converter alloc] init];
34     }
35     [self performConvert];
36 }
37
38
39 -(void)performConvert;
40 {
41     if ([self.input floatValue] != 0) || ([self.input st
42     {
43         [self convert];
44     }
45 }
46
47 -(void)menuCallback:(id)sender;
48 {
49     [self convert];
50 }
51
52 //convert from Celsius
53 //to Fahrenheit
54 -(void)convert;
55 {
56     //get celsius value
57     float c = [self.input floatValue];
58
59     //convert to fahrenheit
60     float f = [self.theConverter c2f:c];
61
62     //update view
63     [self update:f];
64 }
65
66 -(void)update:(float)f;
67 {
68     //do something
69 }
70
71 @end
72
73
74
75
76
77
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88
```

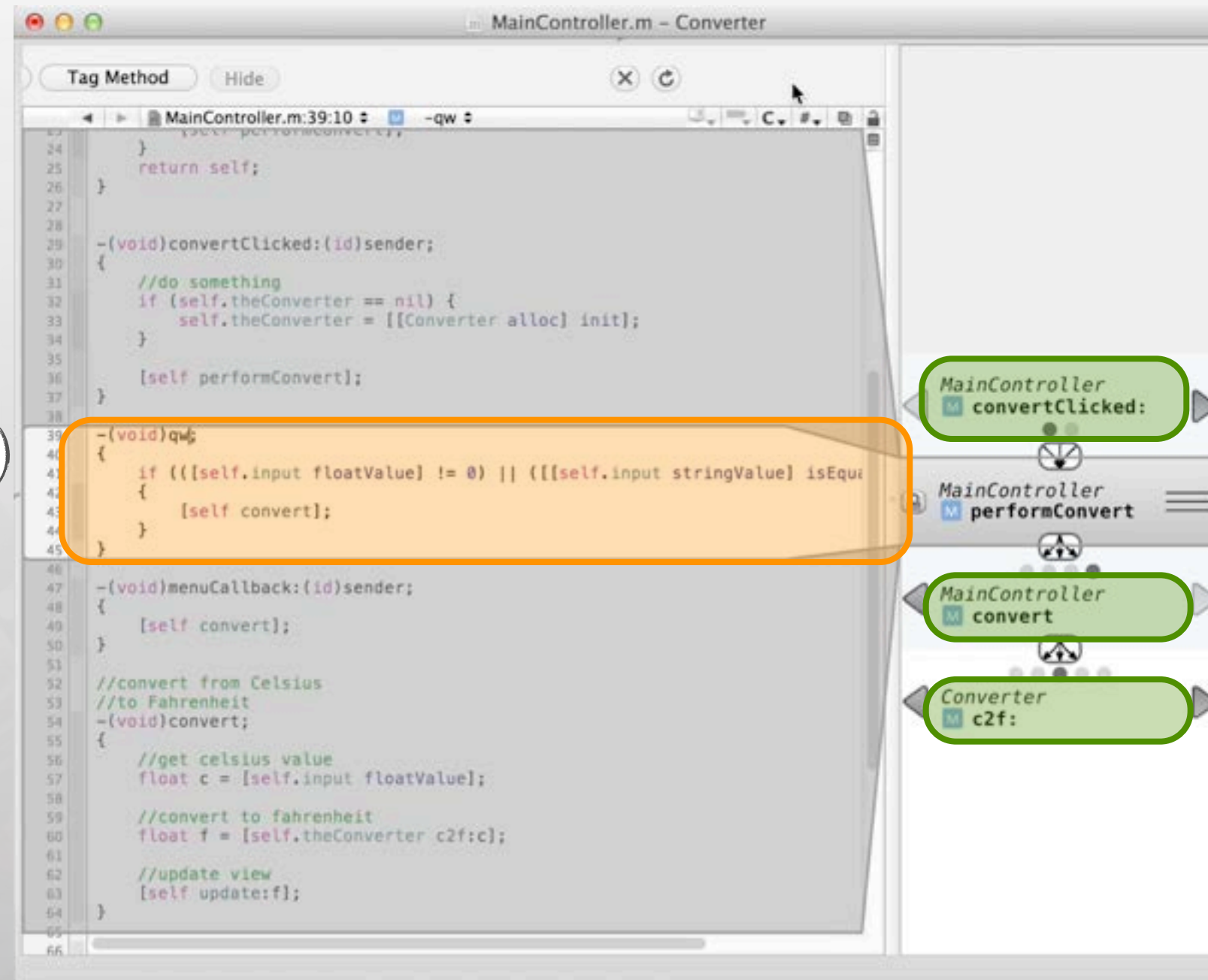
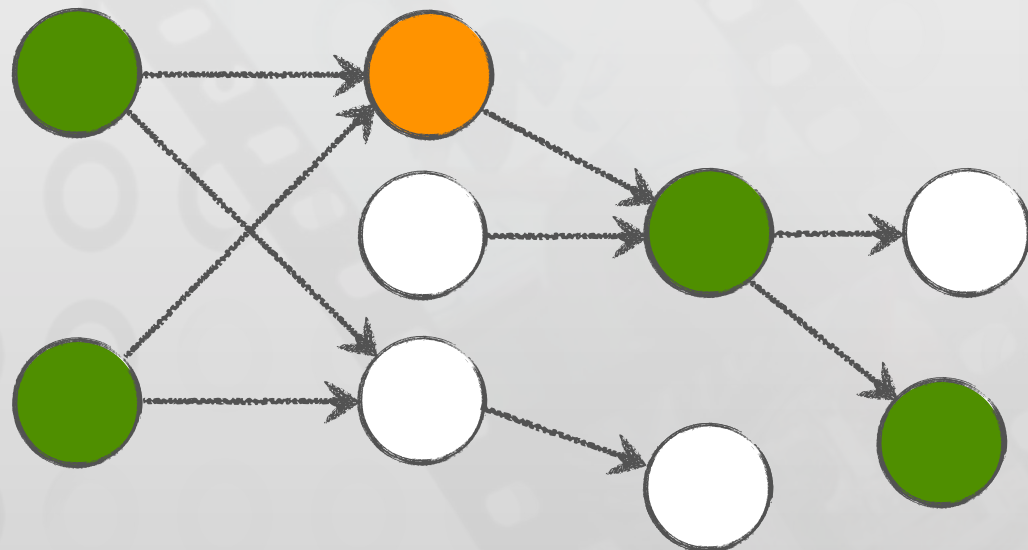
Stacksplorer

[Karrer2011, Stacksplorer: Call Graph Navigation Helps Increasing Code Maintenance Efficiency]

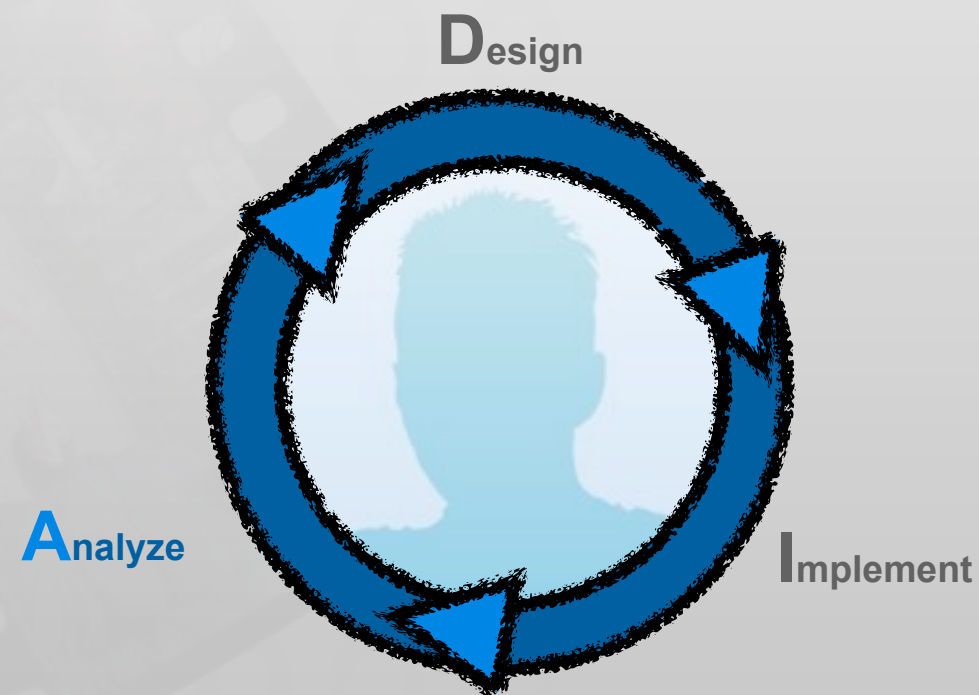


Blaze

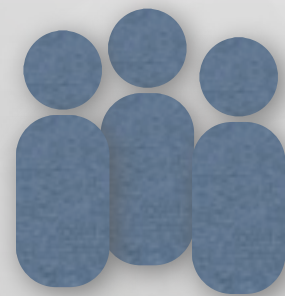
[Krämer2012, Blaze: Supporting Two-phased Call Graph Navigation in Source Code]



Analyzing Navigation Behavior



	Xcode	Call Hierarchy	Stacksplorer	Blaze
Find Change Location	Task Success Task Completion Time			
Side Effects of Change				



33 Developers



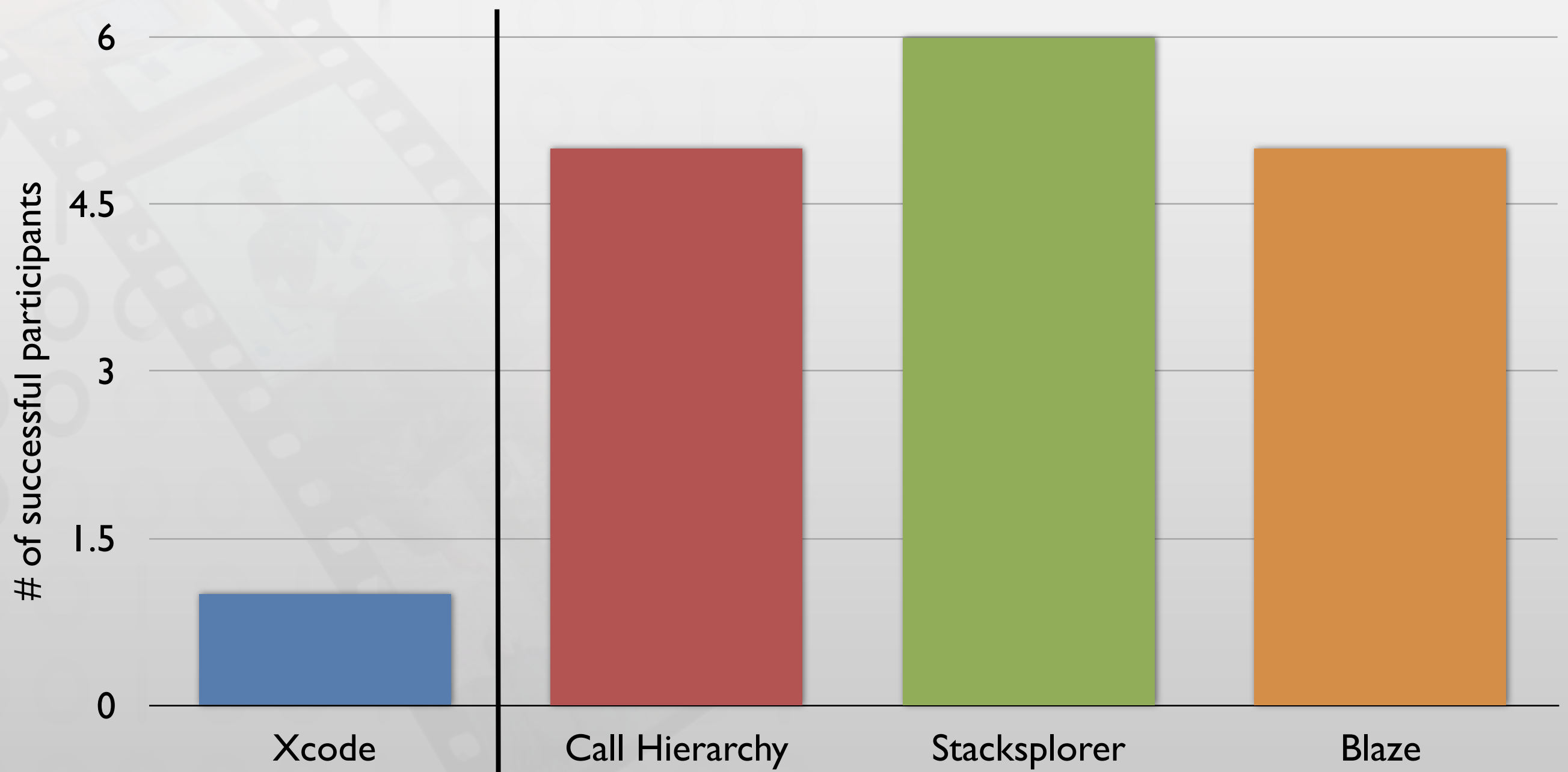
80.000 Lines of Code

[Krämer2013, How Tools in IDEs Shape Developers' Navigation Behavior]

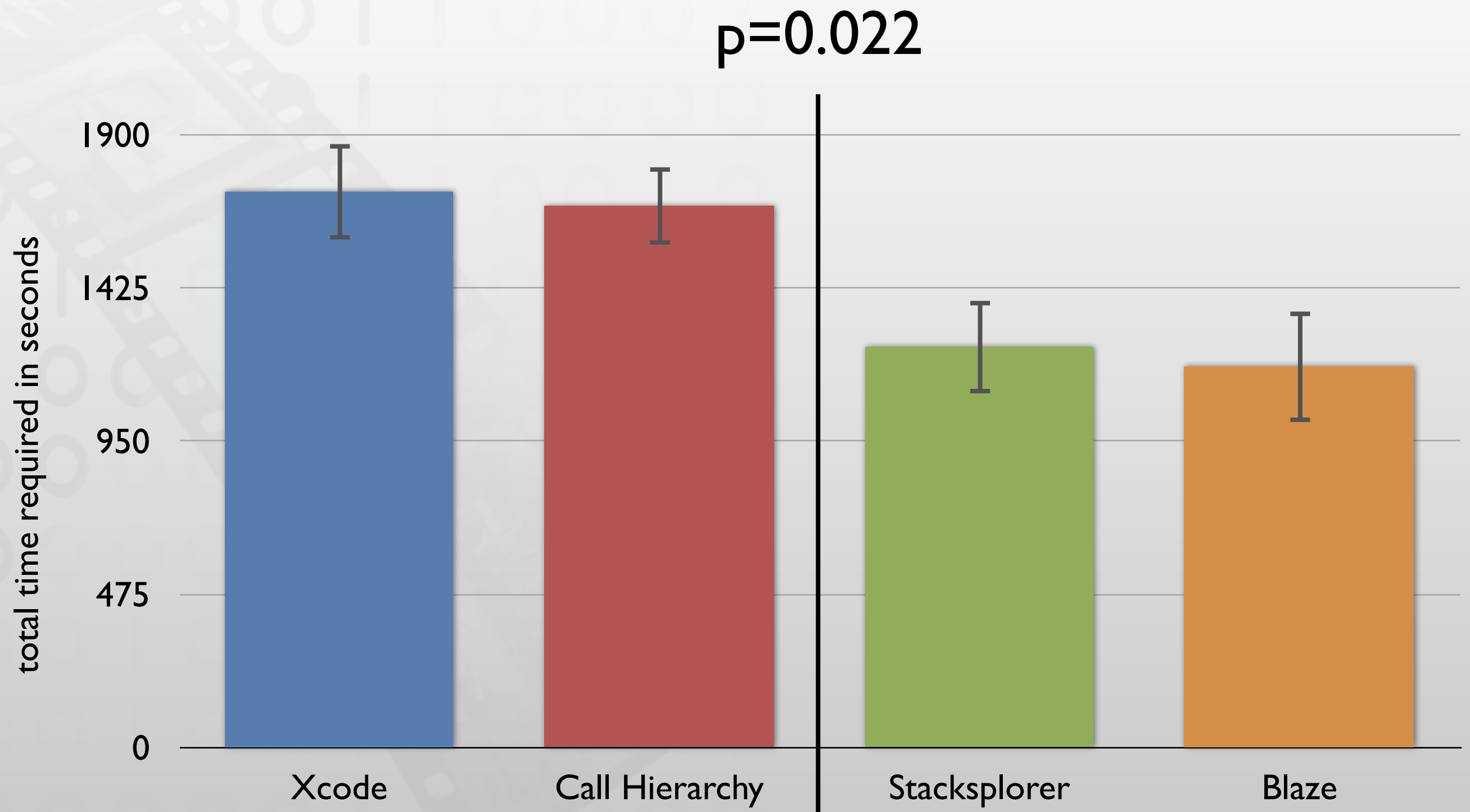


Task Success

$p = 0.015$



Task Completion Time



Effectiveness

Xcode

Call
Hierarchy

Stacksplorer

Blaze

Efficiency

Xcode

Call
Hierarchy

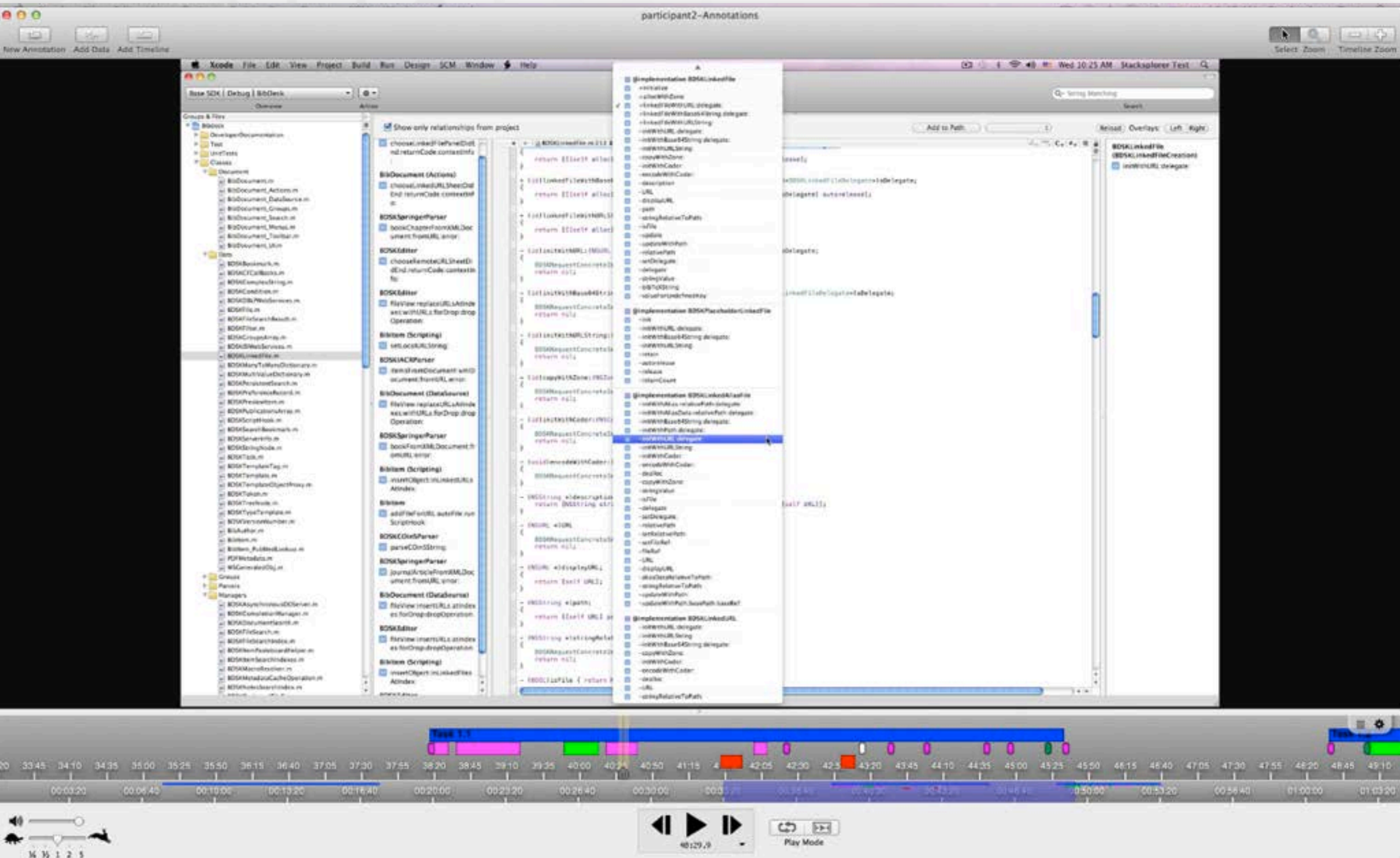
Stacksplorer

Blaze

Why?

UI Differences

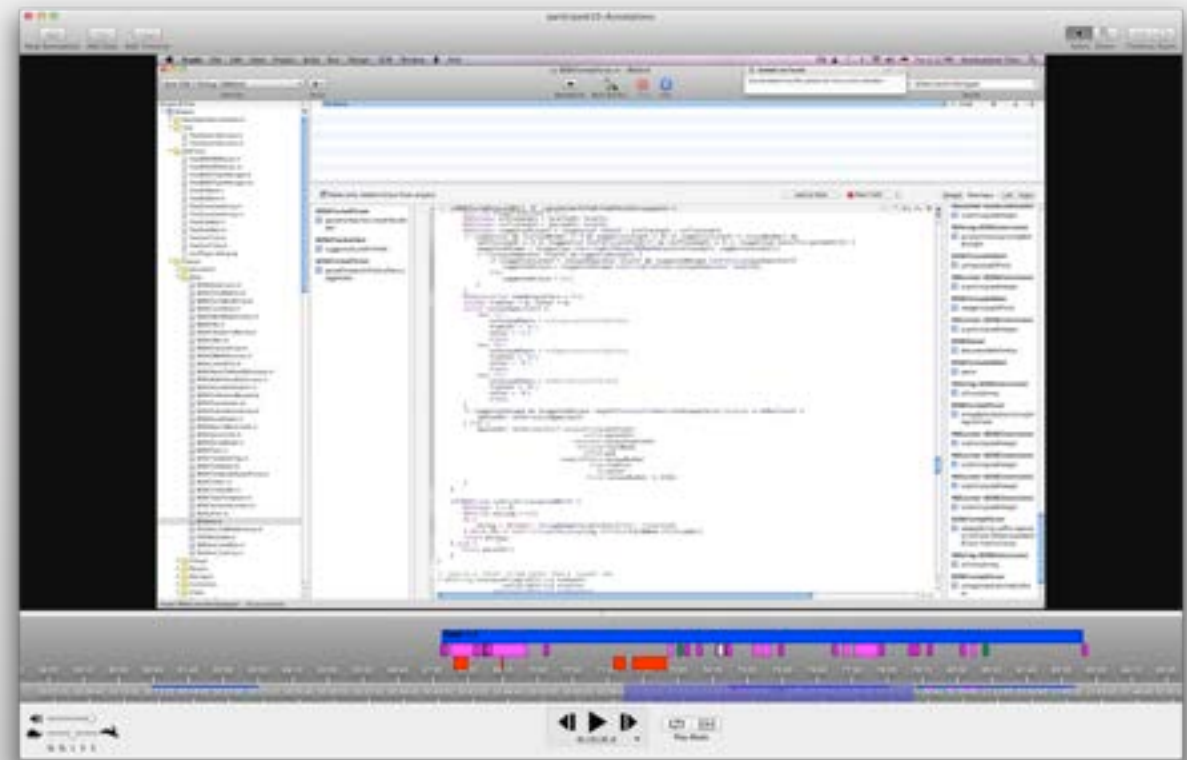
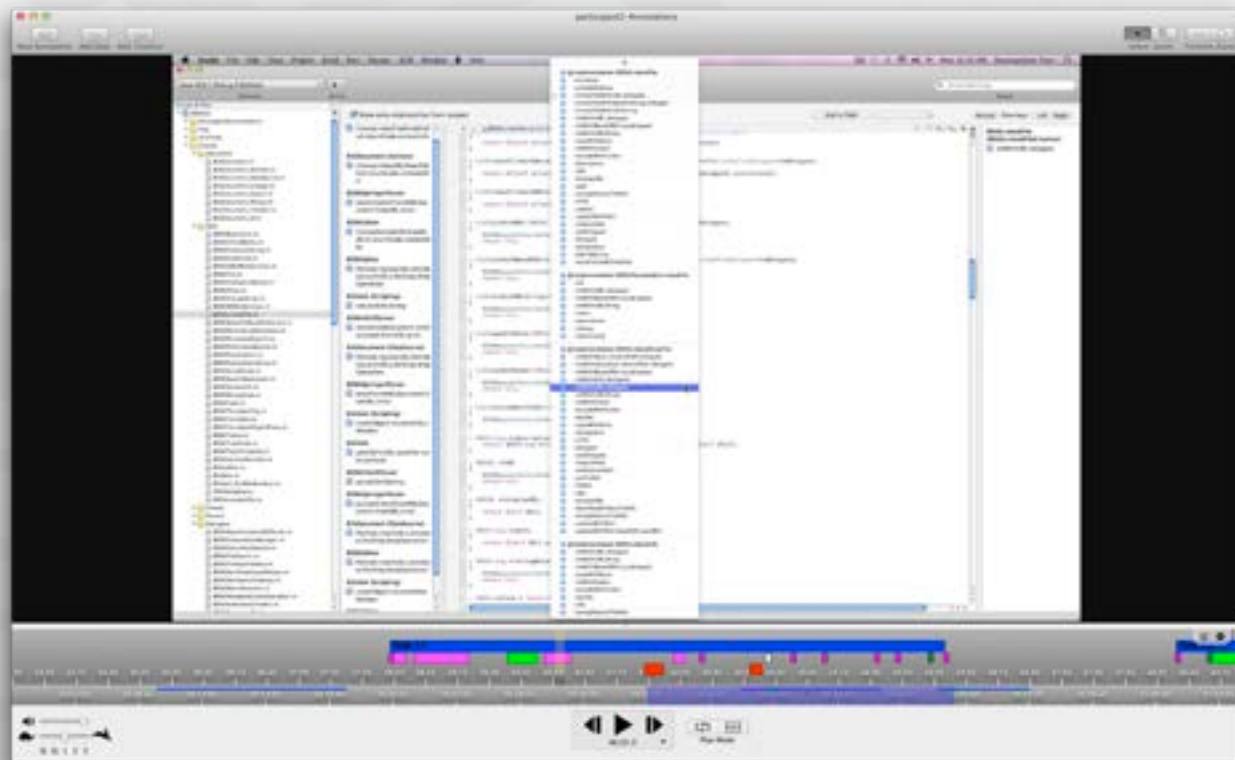
Navigation Behavior



[Fouse2011, ChronoViz: A system for supporting navigation of time-coded data]

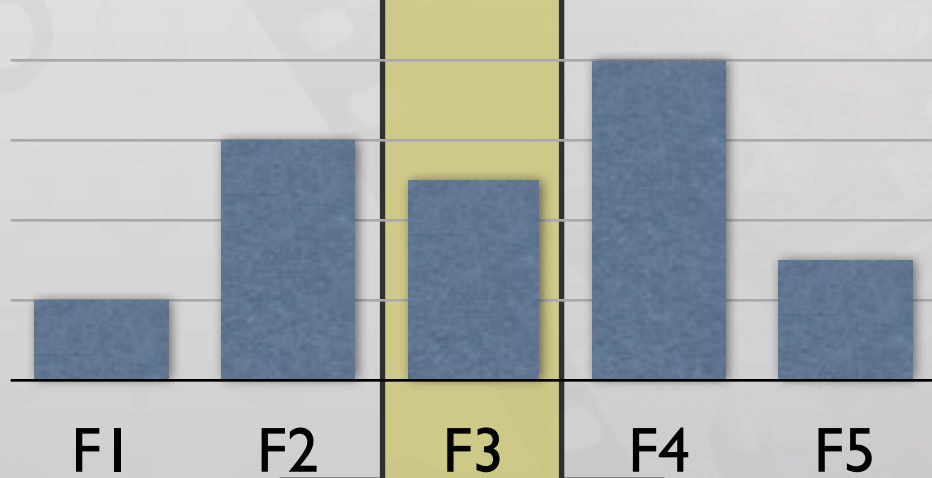


Comparing Navigation Behavior

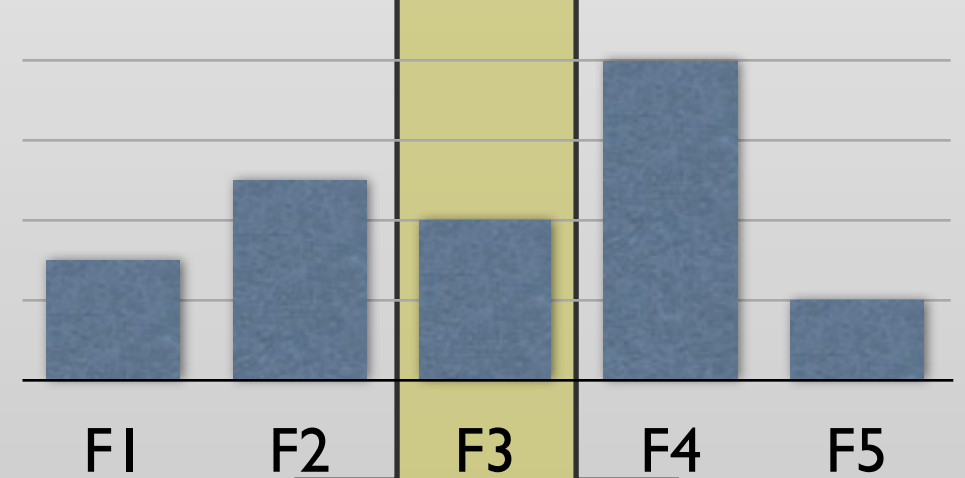




$$I_1 = (p_{1,1}, \dots, p_{640,480})$$



$$I_2 = (p_{1,1}, \dots, p_{1024,768})$$

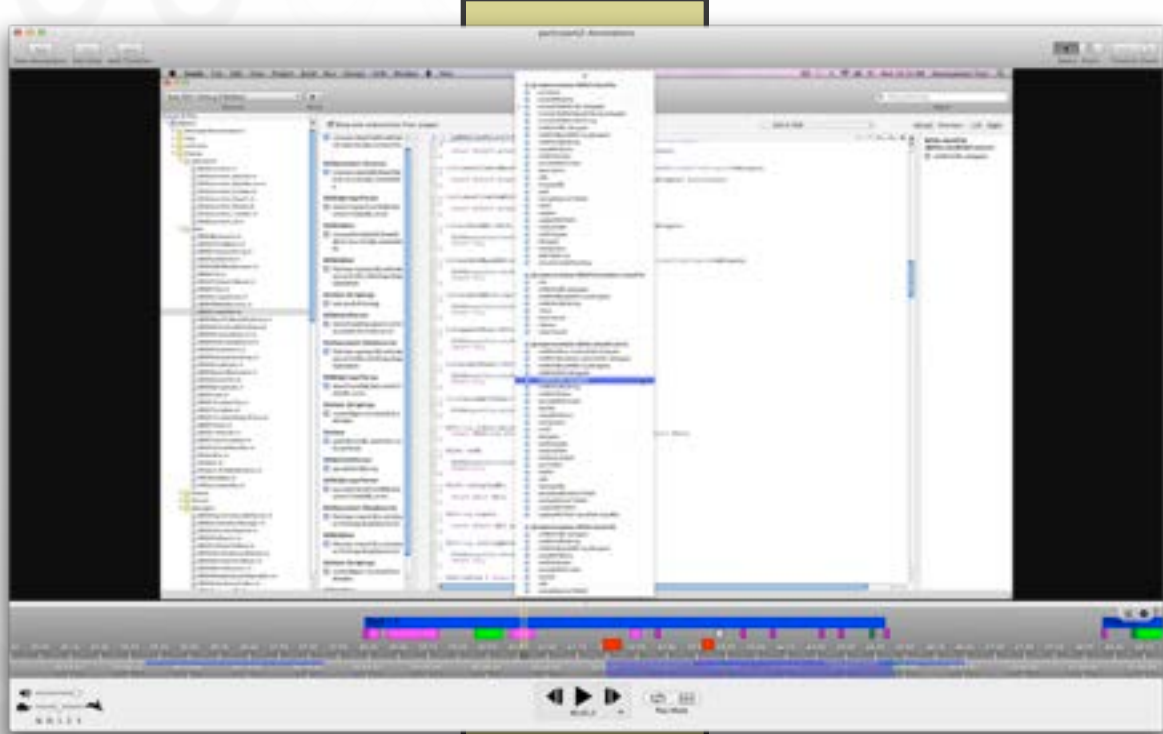


1. Features

2. Transformations

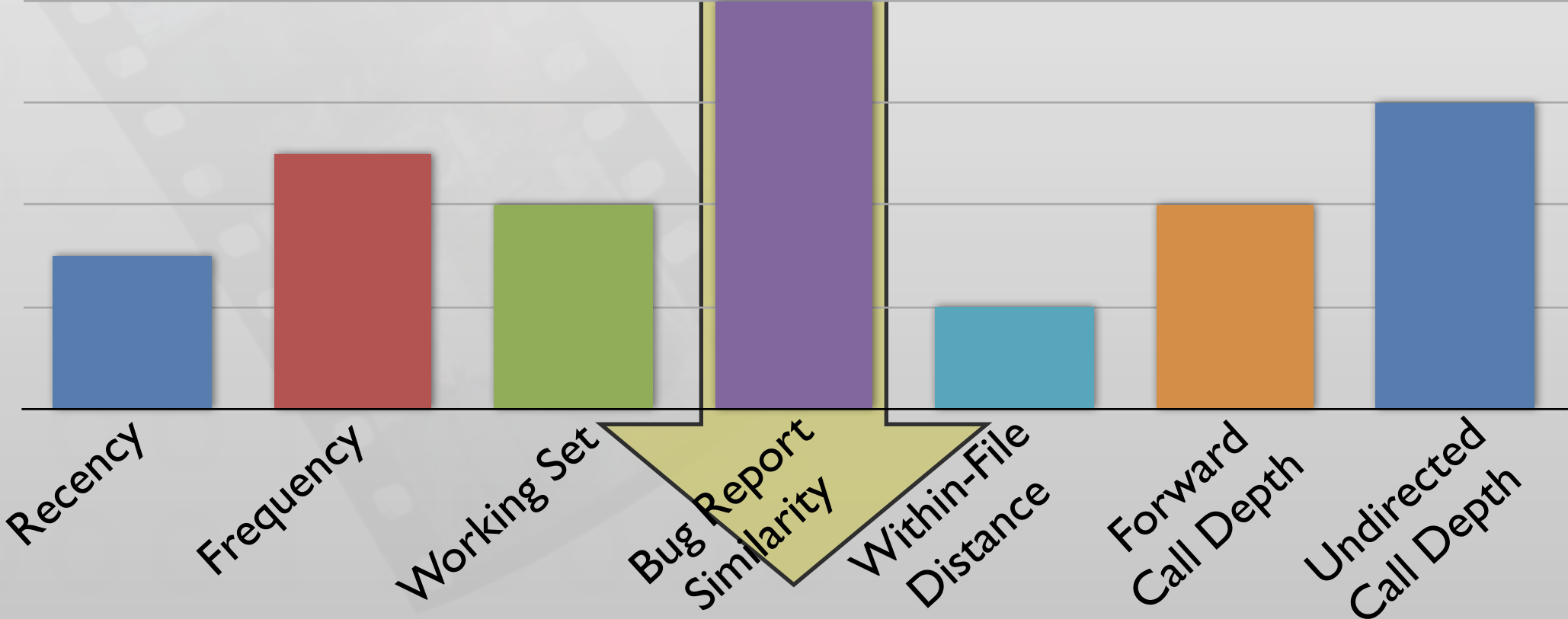


[Piorkowski2011,
Modeling programmer
navigation:A head-to-
head empirical evaluation
of predictive models]



$$H=(m_1, ..., m_i)$$

Prediction Accuracy



A Predictor

[Piorkowski2011, Modeling programmer navigation: A head-to-head empirical evaluation of predictive models]

$$H = (m_1, \dots, m_i)$$

Navigation History

$$H = (a, b, a, d)$$

$$M_i$$

All methods known
to developer at time
 i

$$M_4 = \{a, b, d\}$$

$$A_i: M_i - \{m_i\} \rightarrow \mathbb{R}$$

Activation value for
each method in M_i

$$A_4(a) = 3$$

$$A_4(b) = 2$$

$$R_i: M_i - \{m_i\} \rightarrow \mathbb{N}$$

Rank-transformed
version of A_i

$$R_4(a) = 1$$

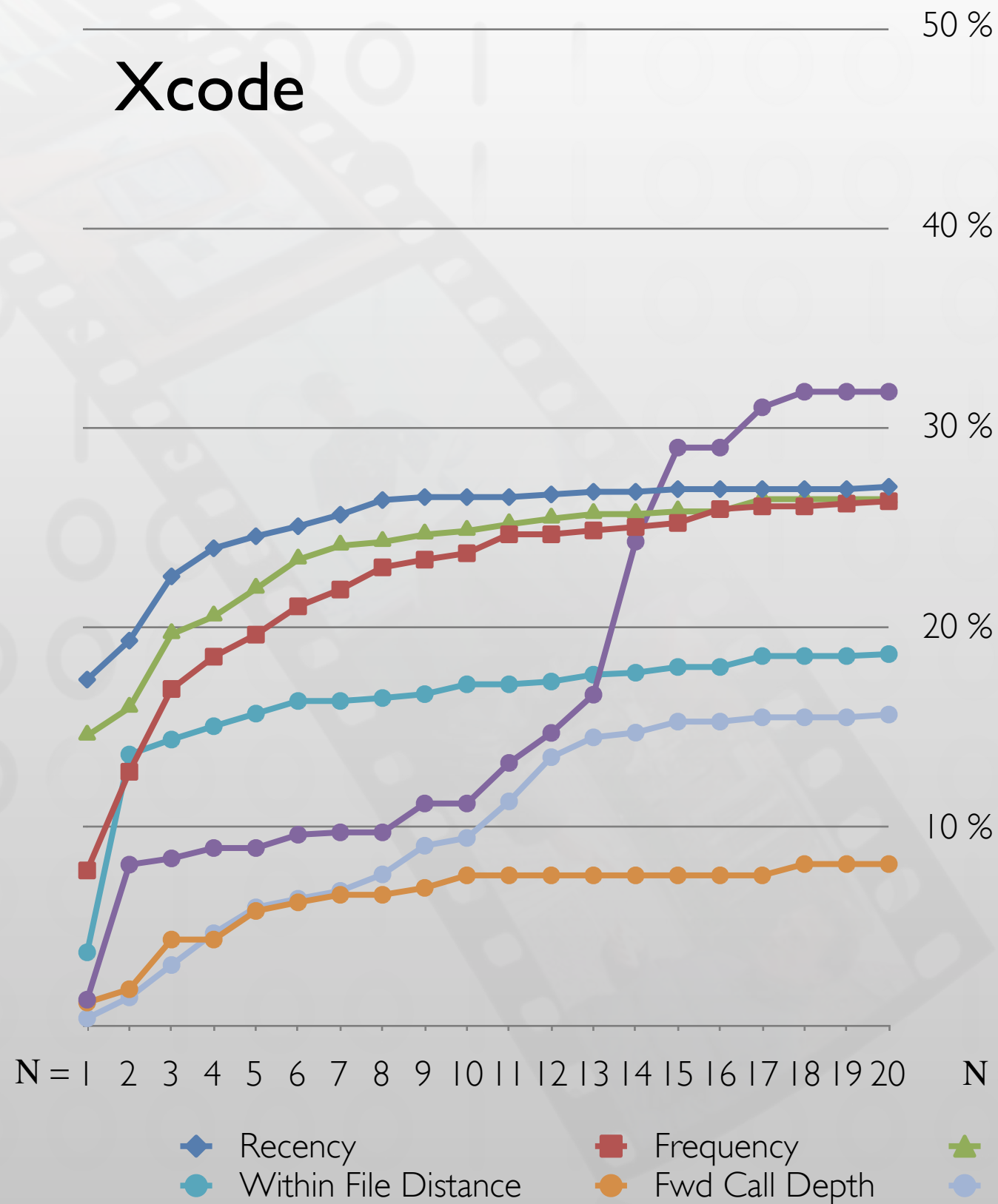
$$R_4(b) = 2$$

Result: N top-ranked methods

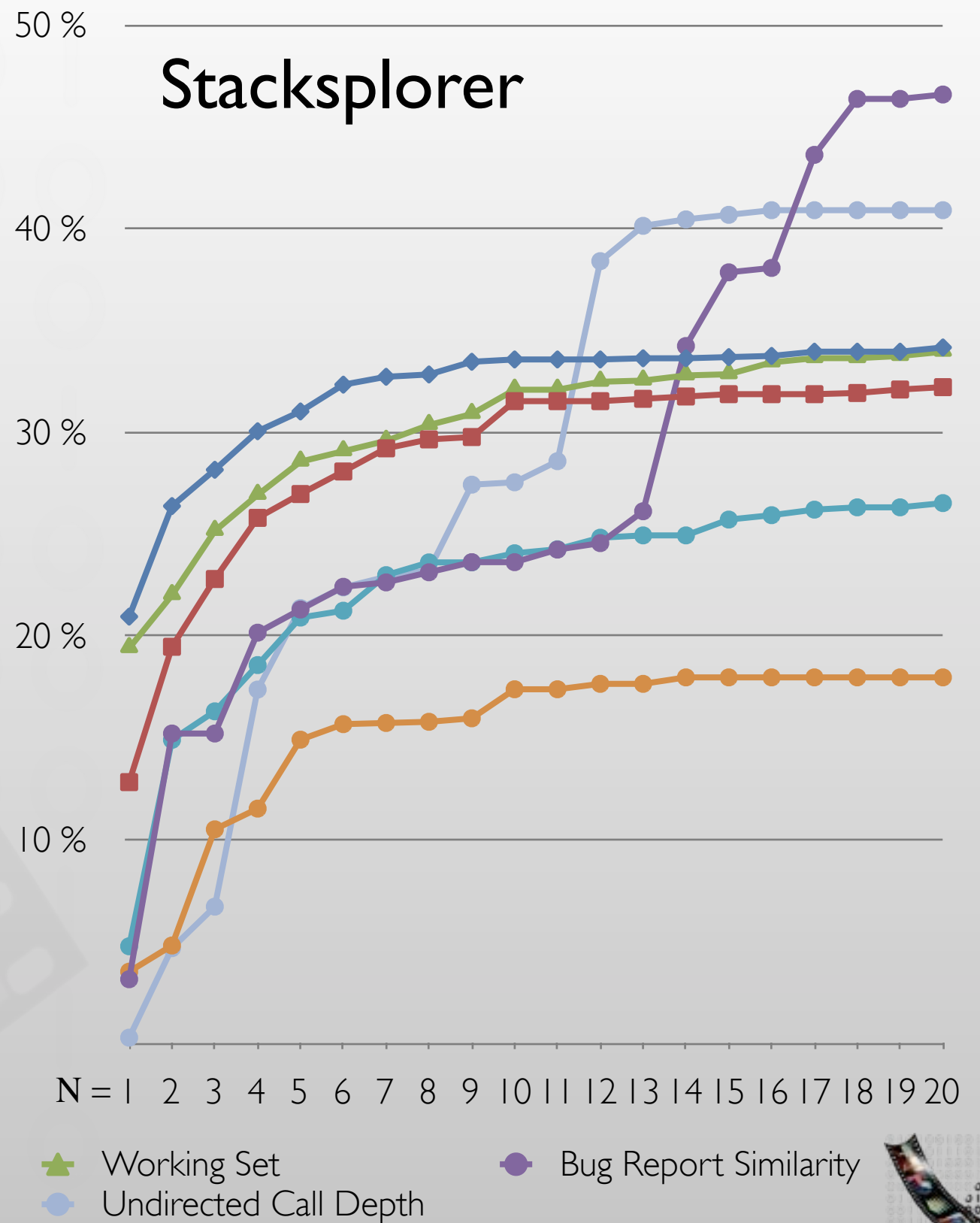


Prediction Accuracy

Xcode

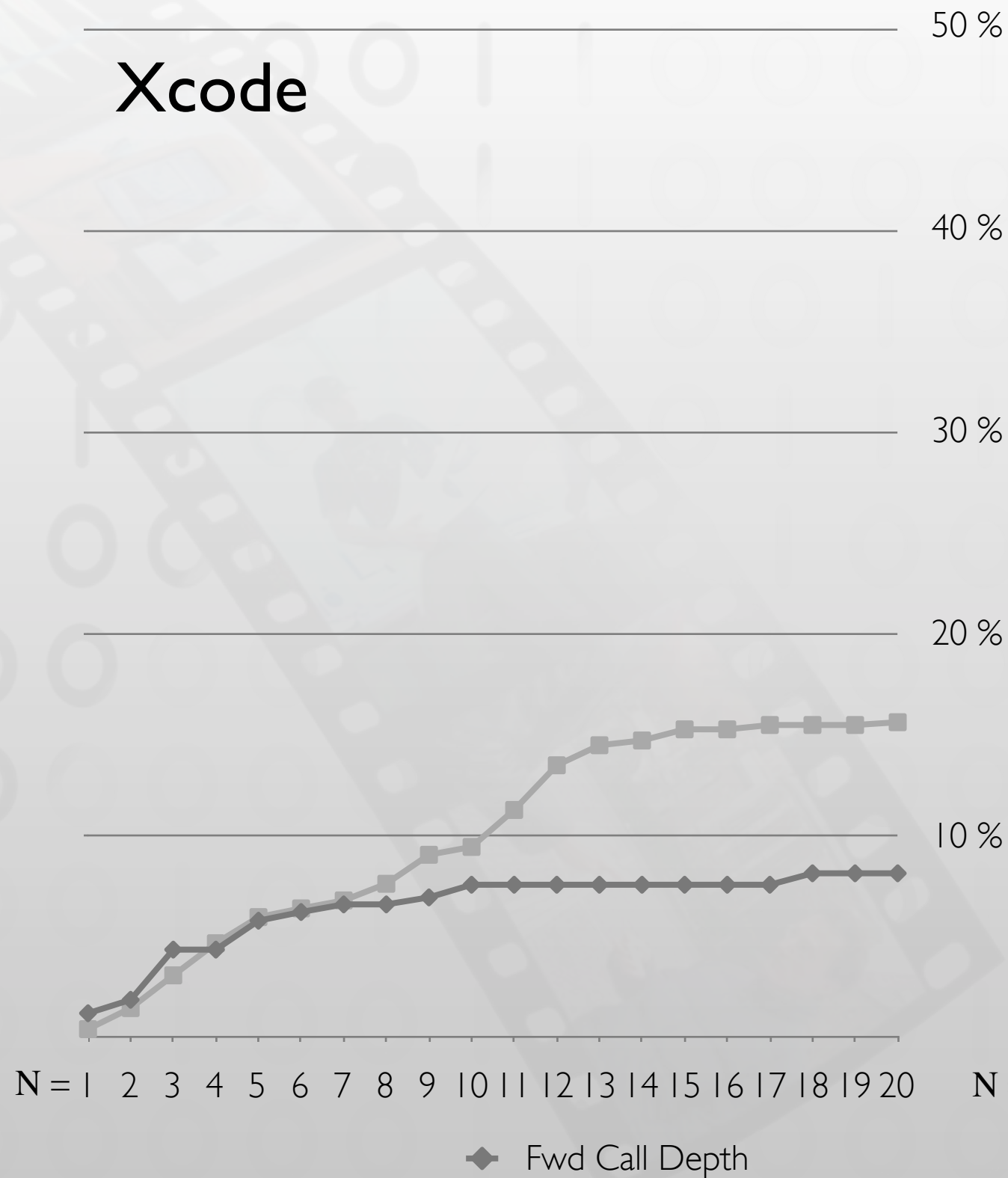


Stacksplorer



Prediction Accuracy

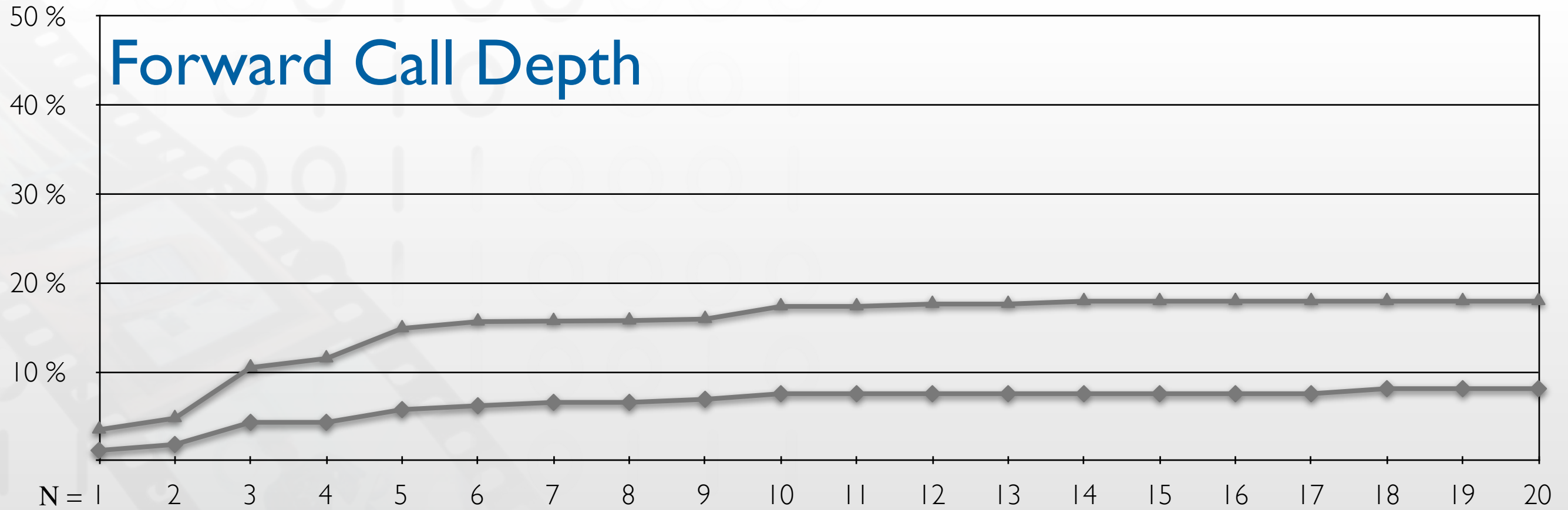
Xcode



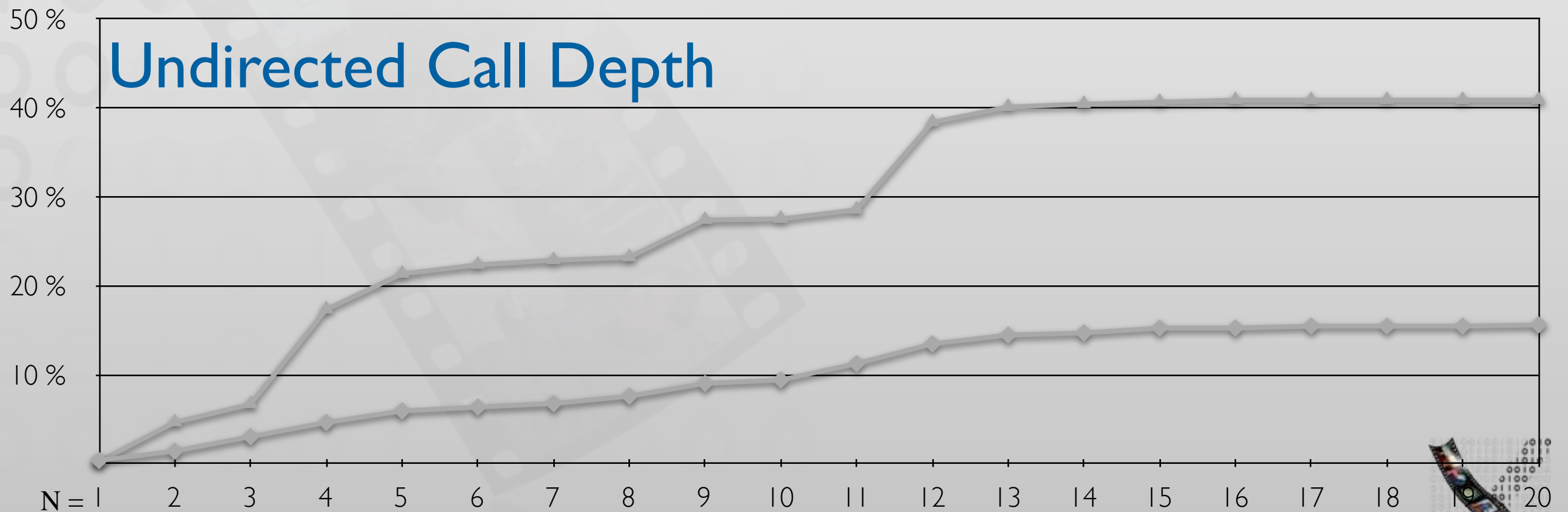
Stacksplorer



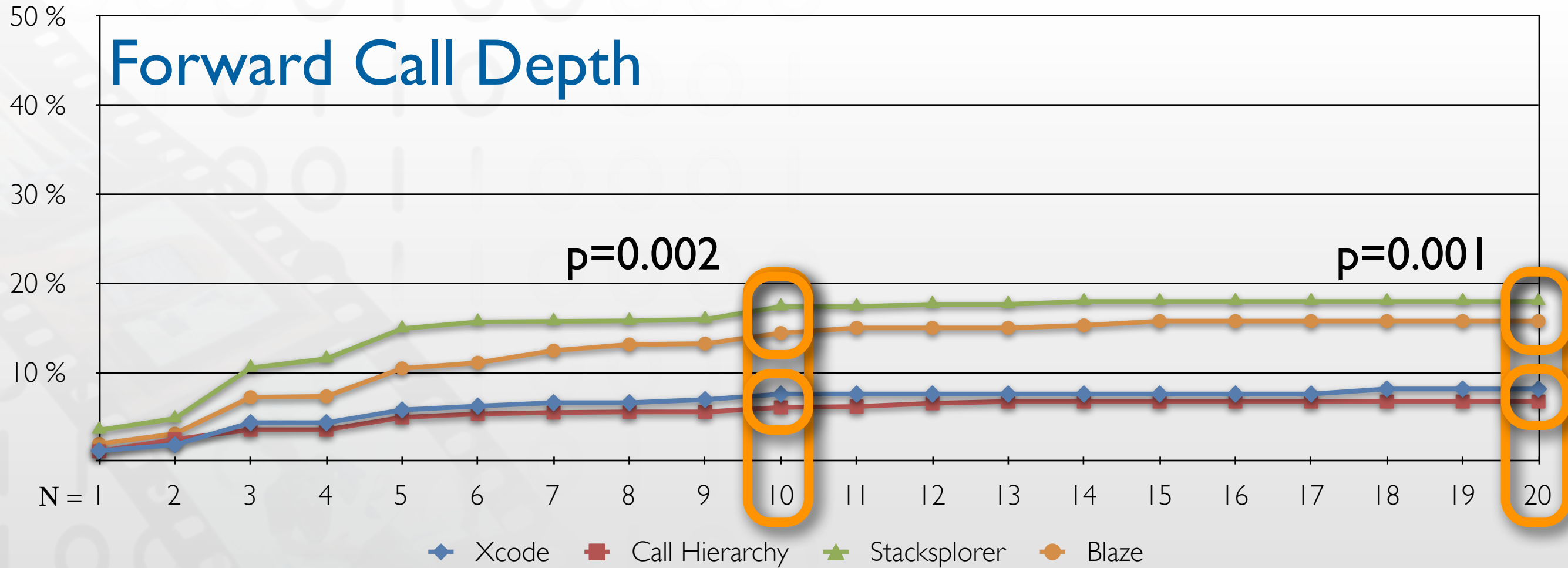
Forward Call Depth



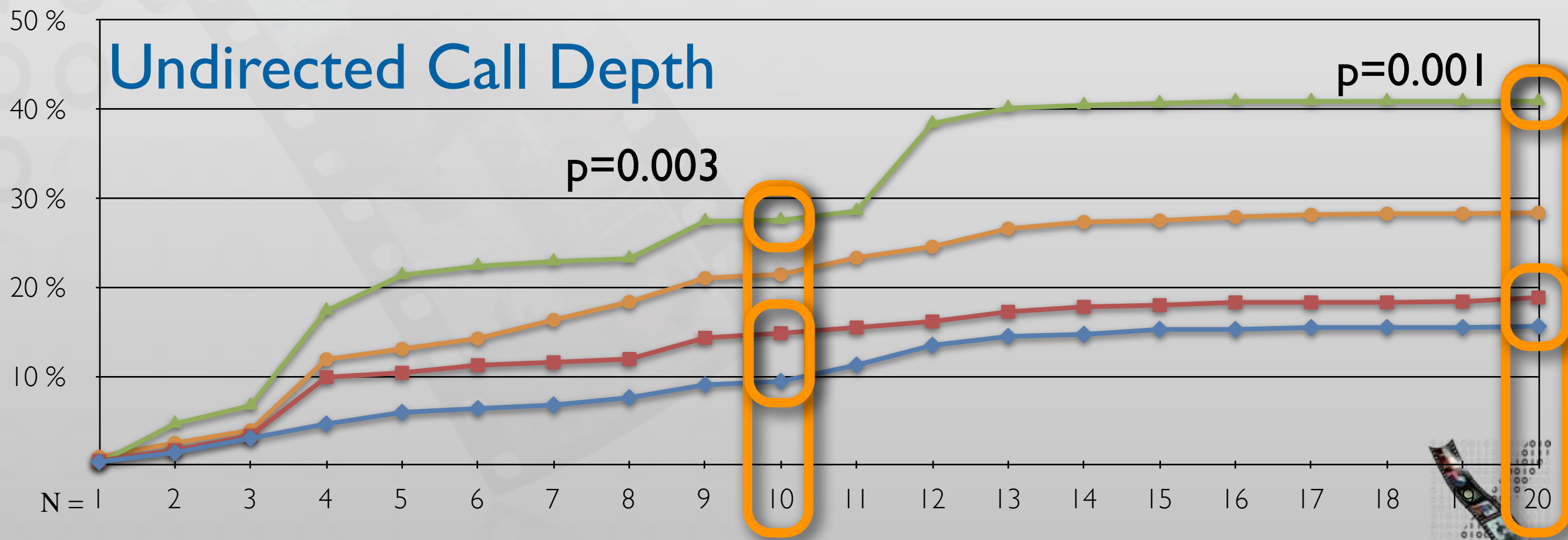
Undirected Call Depth



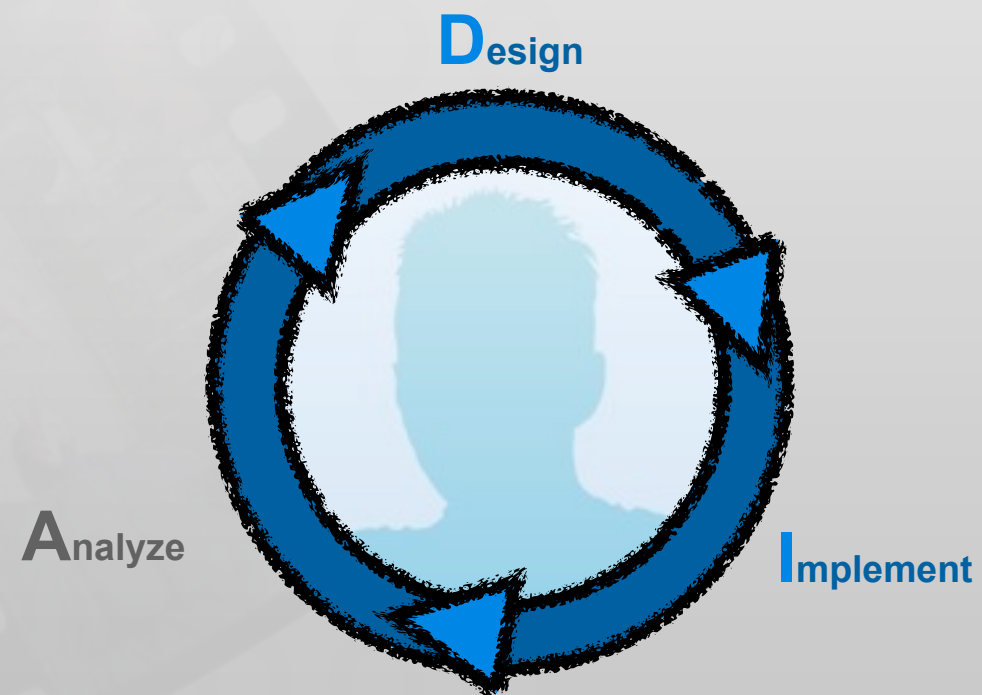
Forward Call Depth

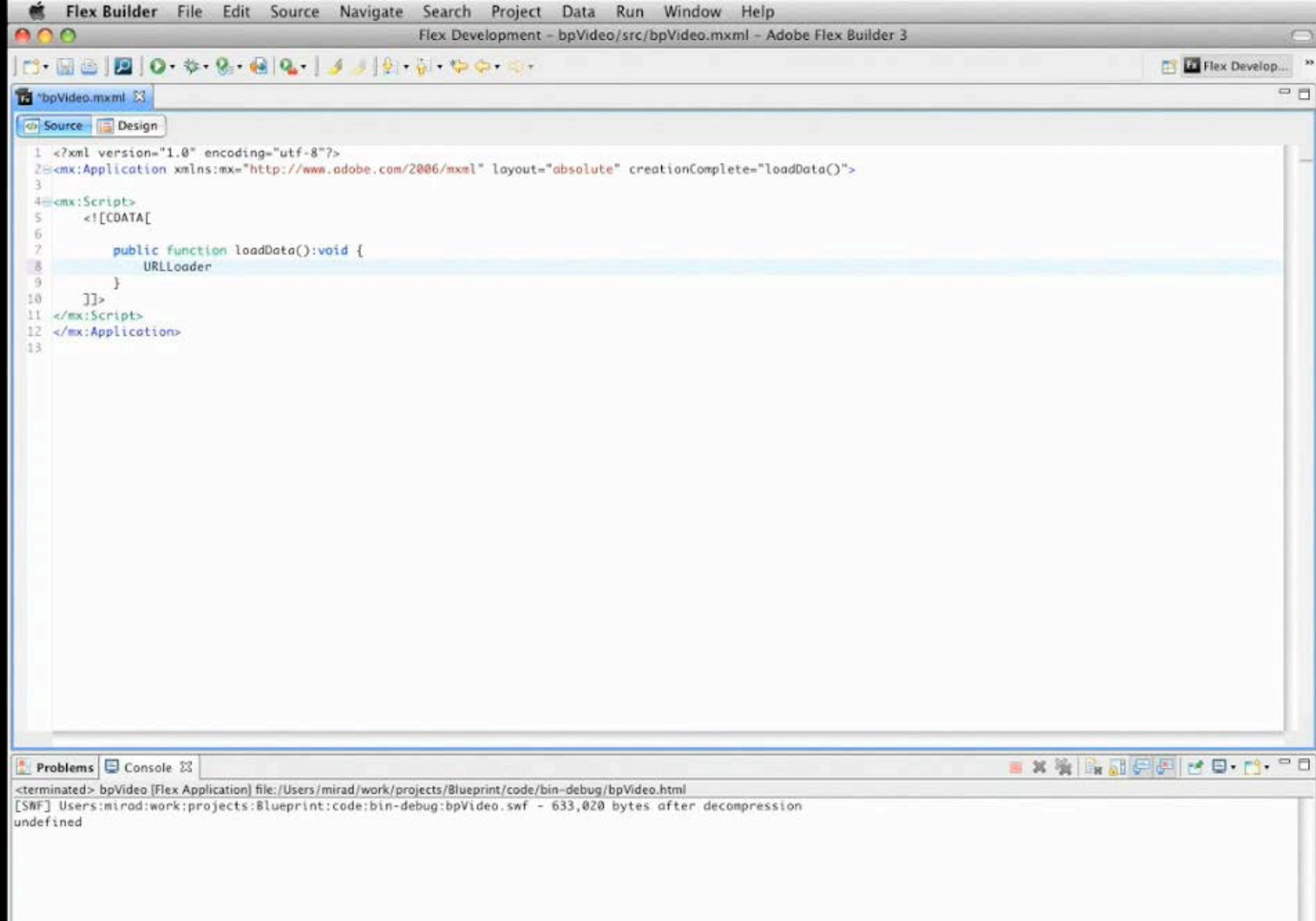


Undirected Call Depth

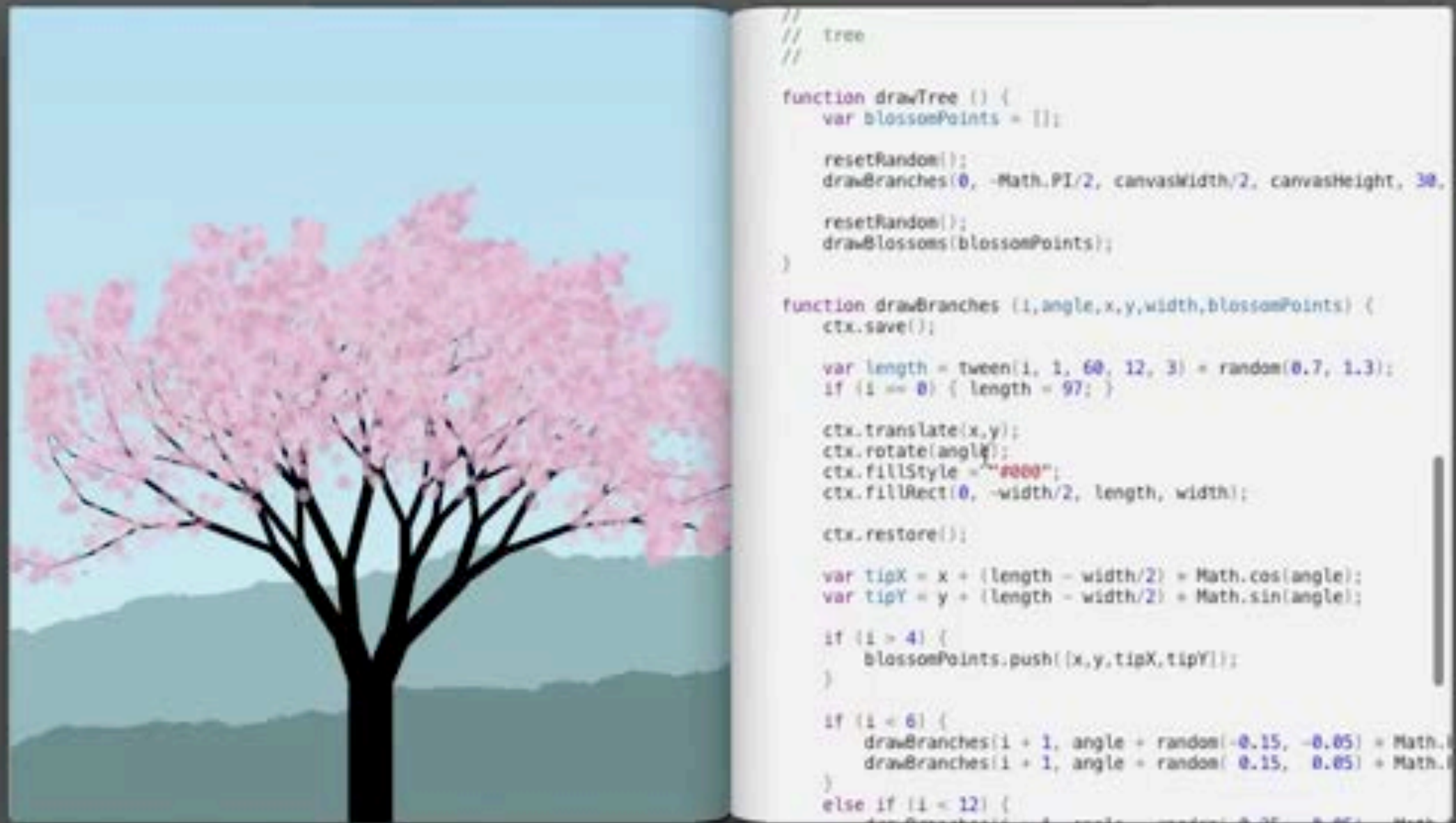


Outlook

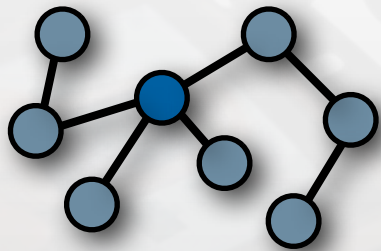




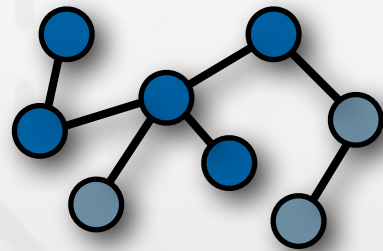
// Introducing Codelets...



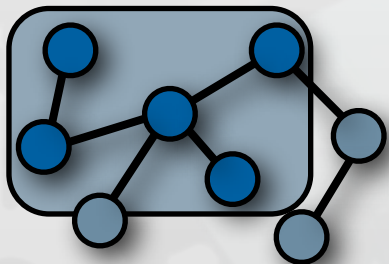
Summary



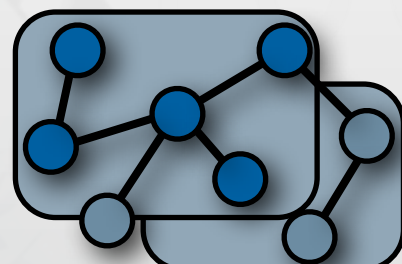
Finding focus points



Expanding focus points



Understanding a subgraph



Questions over groups of subgraphs

