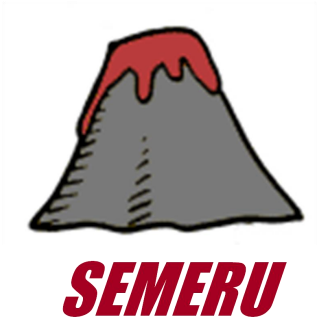
FLAT^3: Feature Location & Textual Tracing Tool

Trevor Savage, Meghan Revelle, Denys Poshyvanyk

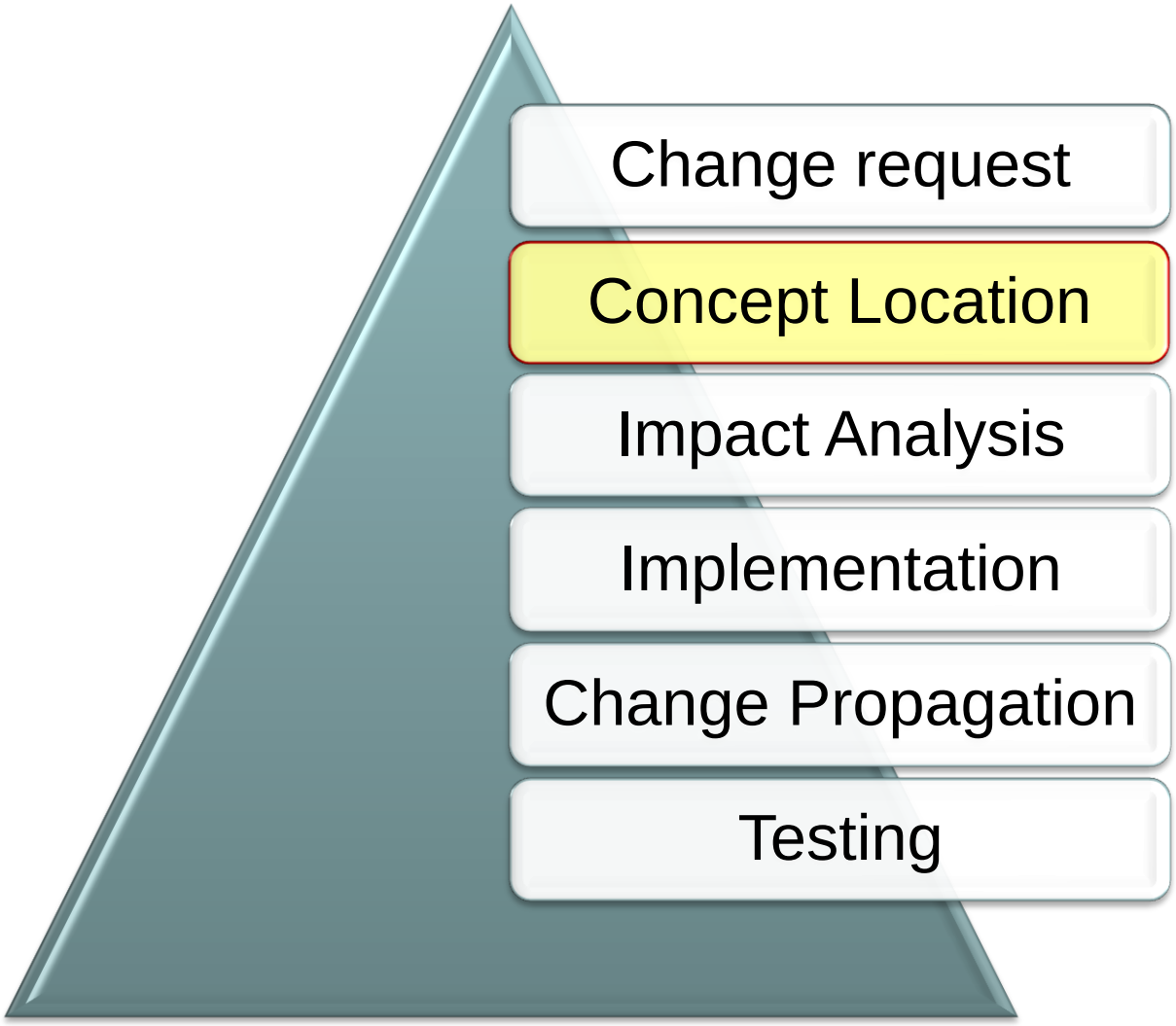
SEMERU Group @ William and Mary



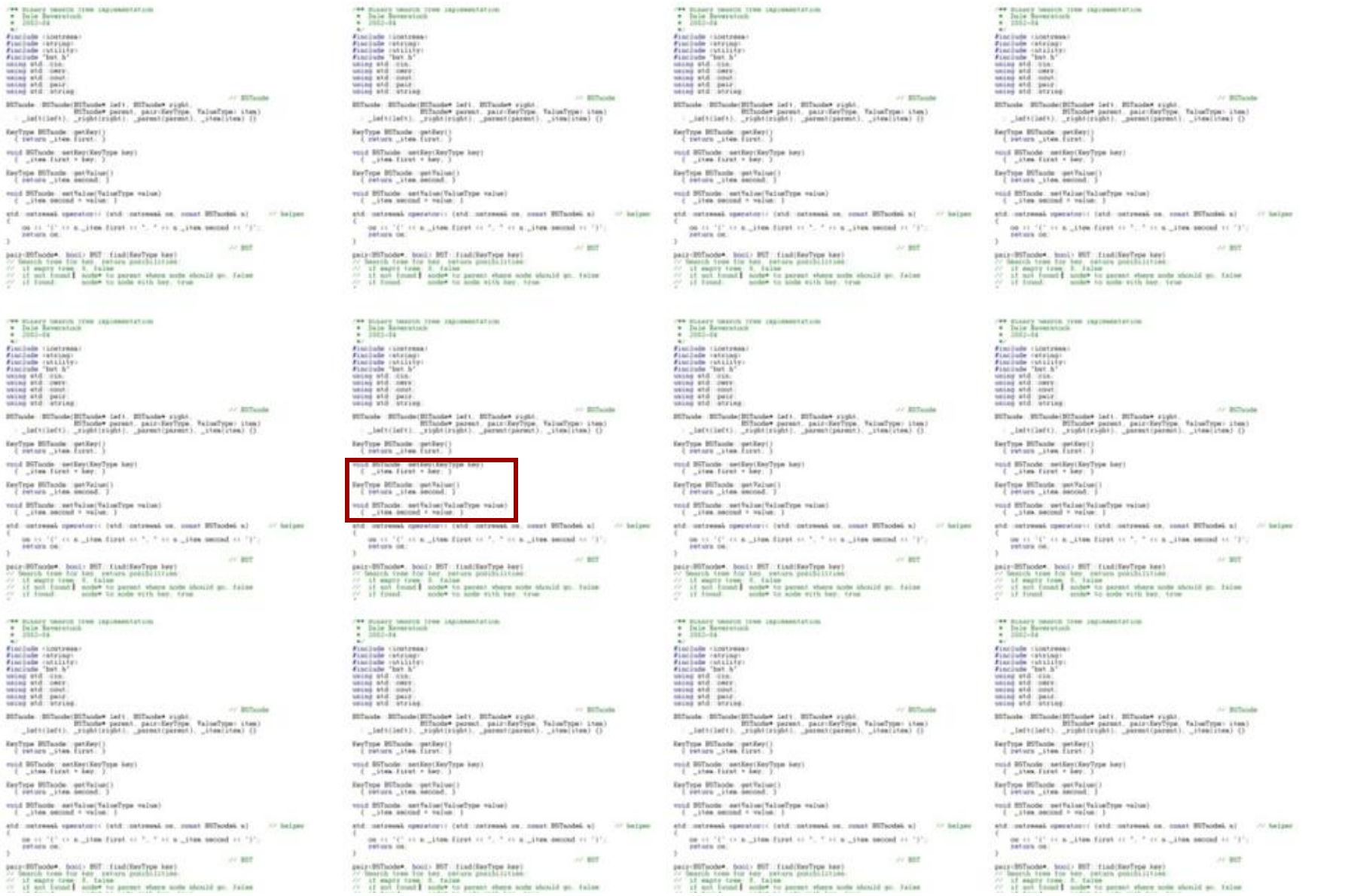
Addressed Problem

- The software developer has to maintain large software systems with:
  - Little or no domain knowledge
  - Absence of the original developer
  - Badly organized, missing, or out of date documentation

Concept Location in Source Code

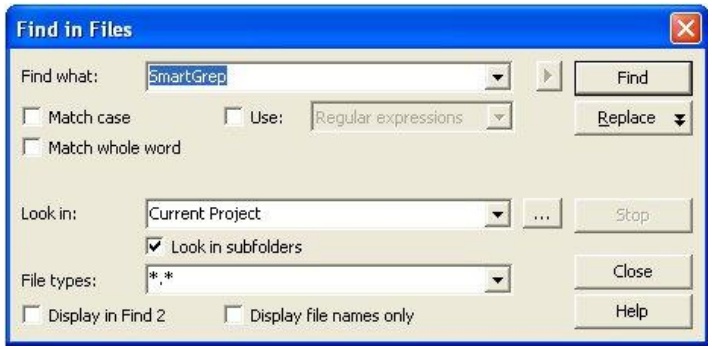


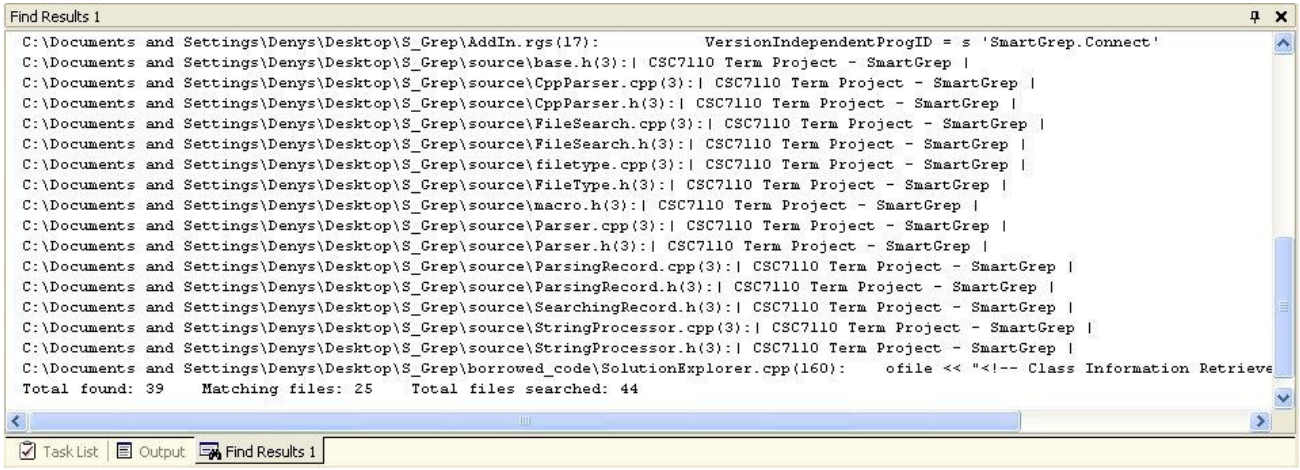
“Finding a Needle in a Haystack”



Concept Location with Regular Expressions

```
BSTnode& BST::insert(KeyType key, ValueType value)
// lookup key, create key/value if not present
// return pointer to node with key
{
    BSTnode& n = getNode(key);
    n._item.second = value;
    return n;
}

BSTnode& BST::getNode(KeyType key)
// lookup key, create key/value if not present
// return pointer to node with key
{
    pair<KeyType, ValueType> item(key, 0); // create item to be inserted

    if ( _root == 0 )
    {                                       // empty tree insert as root
        BSTnode* new_node = new BSTnode(0, 0, 0, item);
        _root = new_node;
        return *_root;
    }

    pair<BSTnode*, bool> result = find(key);    // search for key
                                                // location found
    if ( result.second )
    {                                           // true, node exists
        return *(result.first);
    }
    else
    {                                           // false, create node
        BSTnode* parent = result.first;
        BSTnode* new_node = new BSTnode(0, 0, parent, item);
        if ( key < parent->getKey() )
            parent->_left  = new_node;
        else
            parent->_right = new_node;
        return *new node;
```





Shortcomings of Static Concept Location

- Highly dependent on naming conventions and the developer's experience to write good queries
- Ignores other existing relationships between software components (such as, dependencies)
- May miss important parts of the source code

Feature Location with Software Reconnaissance - Dynamic Analysis

[Wilde'92][Antoniol'06]

Scenario NOT exercising the feature (trace 1)

readAndDispatch -- org.eclipse.swt.widgets.Display
checkDevice -- org.eclipse.swt.widgets.Display
isDisposed -- org.eclipse.swt.graphics.Device
drawMenuBars -- org.eclipse.swt.widgets.Display
runPopups -- org.eclipse.swt.widgets.Display
filterMessage -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control
WM_TIMER -- org.eclipse.swt.widgets.Control
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control
WM_TIMER -- org.eclipse.swt.widgets.Control
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control

Scenario exercising the feature (trace 2)

checkDevice -- org.eclipse.swt.widgets.Display
isDisposed -- org.eclipse.swt.graphics.Device
drawMenuBars -- org.eclipse.swt.widgets.Display
runPopups -- org.eclipse.swt.widgets.Display
filterMessage -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control
readAndDispatch -- org.eclipse.swt.widgets.Display
checkDevice -- org.eclipse.swt.widgets.Display
isDisposed -- org.eclipse.swt.graphics.Device
drawMenuBars -- org.eclipse.swt.widgets.Display
runPopups -- org.eclipse.swt.widgets.Display
runAsyncMessages -- org.eclipse.swt.widgets.Display
removeFirst -- org.eclipse.swt.widgets.Synchronizer

Shortcomings of Dynamic Concept Location

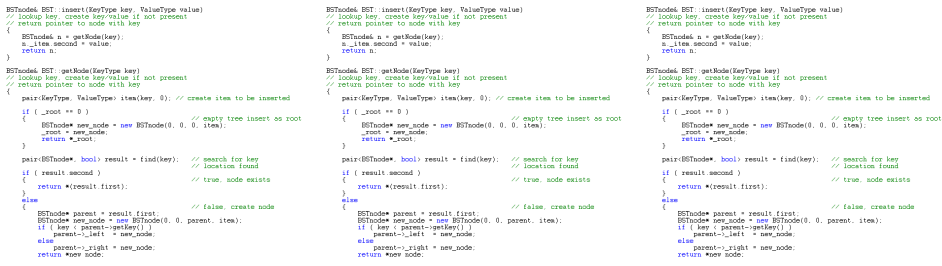
- Execution traces are large even for small systems
- Selecting (ir)relevant scenarios may be difficult
- Filtering the traces is equally problematic – best filtering methods still return hundreds of methods

SIngle Trace Information Retrieval (SITIR) [ASE'07]

Single Execution Trace

readAndDispatch -- org.eclipse.swt.widgets.Display
checkDevice -- org.eclipse.swt.widgets.Display
isDisposed -- org.eclipse.swt.graphics.Device
drawMenuBars -- org.eclipse.swt.widgets.Display
runPopups -- org.eclipse.swt.widgets.Display
filterMessage -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control
WM_TIMER -- org.eclipse.swt.widgets.Control
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control
WM_TIMER -- org.eclipse.swt.widgets.Control
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control
readAndDispatch -- org.eclipse.swt.widgets.Display
checkDevice -- org.eclipse.swt.widgets.Display
isDisposed -- org.eclipse.swt.graphics.Device
drawMenuBars -- org.eclipse.swt.widgets.Display
runPopups -- org.eclipse.swt.widgets.Display
filterMessage -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control
WM_TIMER -- org.eclipse.swt.widgets.Control
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control
WM_TIMER -- org.eclipse.swt.widgets.Control
windowProc -- org.eclipse.swt.widgets.Display
windowProc -- org.eclipse.swt.widgets.Control

Source Code

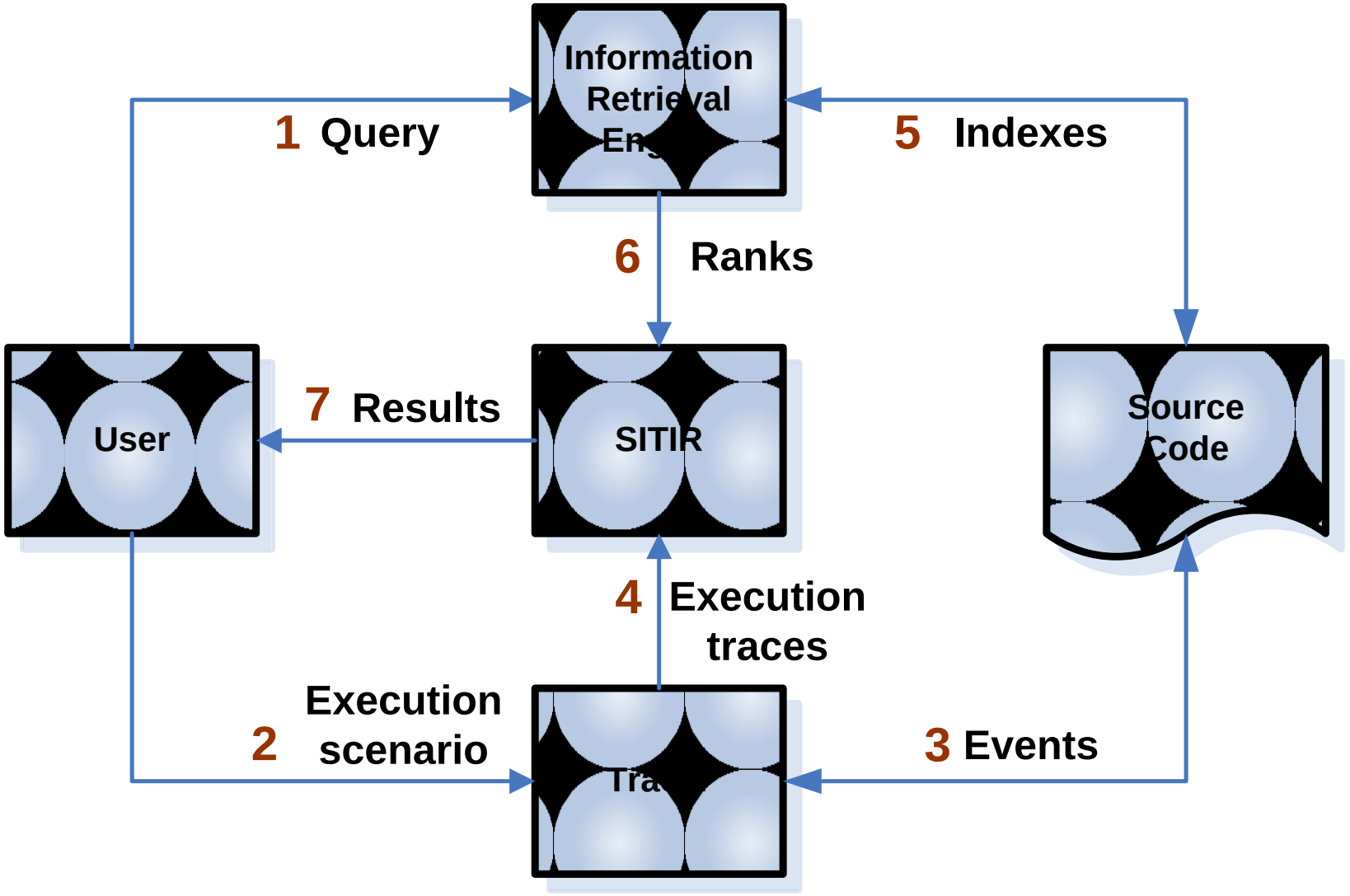


Information Retrieval Engine

Problems | Javadoc | IRiSS View

Class	Method	Similarity
Camera	setScreenParams	0.813055
ScaleObjectTool	mouseDragged	0.807305
Camera	setScreenParamsParalle	0.80328
Camera	setSize	0.788526
ViewerCanvas	setScale	0.723998
GLCanvasDrawer	prepareView3D	0.705305
ViewerCanvas	scaleChanged	0.700639
JitterModule	setZScale	0.690434
JitterModule	setXScale	0.690117
ImageModule	setXScale	0.690104

Feature Location with SITIR/FLAT^3



Collecting Execution Traces in SITIR

- Java Platform Debugger Architecture (JPDA)[1]
  - Infrastructure to build end-user debugging applications for Java platform
- JPDA highlights:
  - Debugger works on a separate virtual machine
  - Minimal interference of a tracing tool with a subject program
  - Separate thread-based traces
  - Marked traces (start/stop recording)

---

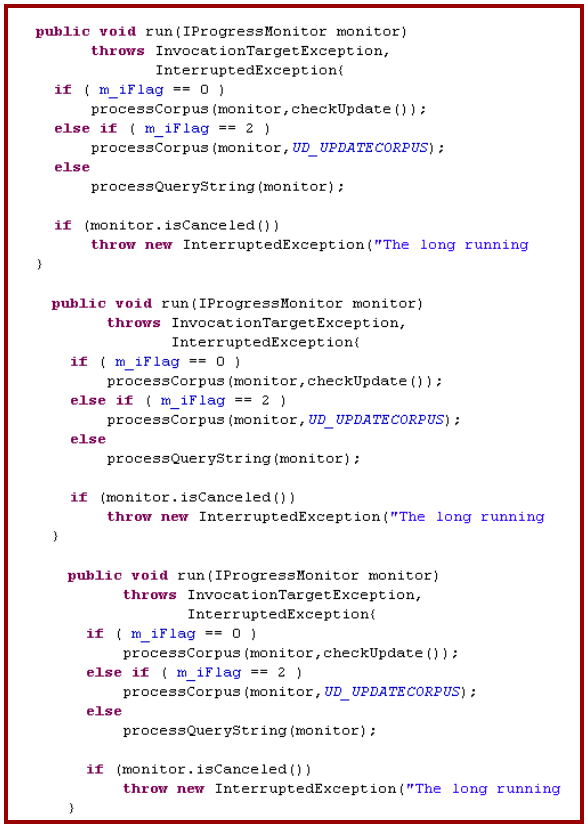
[1] http://java.sun.com/javase/technologies/core/toolsapis/jpda/

Indexing Software with Apache Lucene

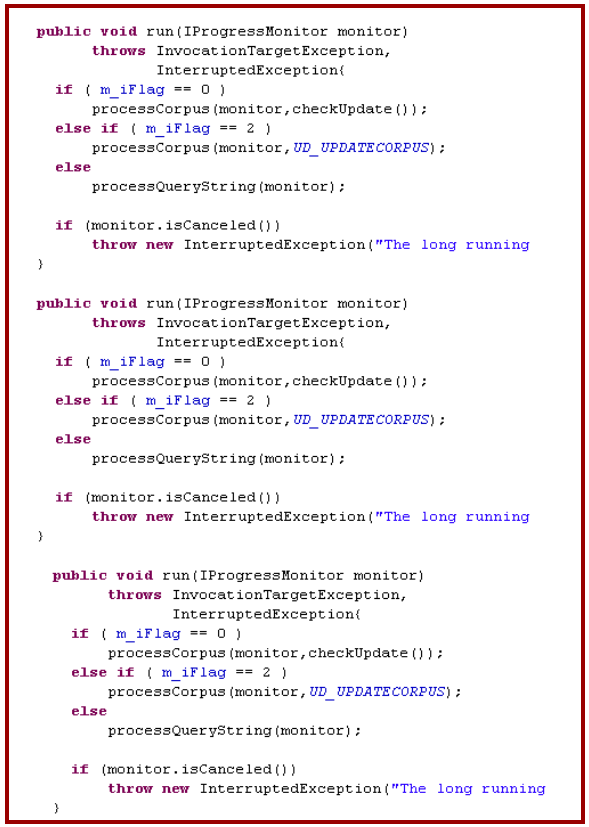
- Parsing source code and extracting documents
  - corpus is a collection of documents (e.g., methods)
- Removing non-literals and stop words
  - common words in English, programming language keywords
- Preprocessing: split_identifiers and SplitIdentifiers
- Indexing and retrieving semantic information with Lucene

Parsing Source Code and Extracting Documents

- Corpus is a collection of documents (e.g., methods, classes, files)



```
public void run(IProgressMonitor monitor)
      throws InvocationTargetException,
             InterruptedException{
  if ( m_iFlag == 0 )
      processCorpus(monitor,checkUpdate());
  else if ( m_iFlag == 2 )
      processCorpus(monitor,UD_UPDATECORPUS);
  else
      processQueryString(monitor);

  if (monitor.isCanceled())
      throw new InterruptedException("The long running
}

  public void run(IProgressMonitor monitor)
        throws InvocationTargetException,
               InterruptedException{
    if ( m_iFlag == 0 )
        processCorpus(monitor,checkUpdate());
    else if ( m_iFlag == 2 )
        processCorpus(monitor,UD_UPDATECORPUS);
    else
        processQueryString(monitor);

    if (monitor.isCanceled())
        throw new InterruptedException("The long running
  }

    public void run(IProgressMonitor monitor)
          throws InvocationTargetException,
                 InterruptedException{
      if ( m_iFlag == 0 )
          processCorpus(monitor,checkUpdate());
      else if ( m_iFlag == 2 )
          processCorpus(monitor,UD_UPDATECORPUS);
      else
          processQueryString(monitor);

      if (monitor.isCanceled())
          throw new InterruptedException("The long running
    }
```



```
public void run(IProgressMonitor monitor)
      throws InvocationTargetException,
             InterruptedException{
  if ( m_iFlag == 0 )
      processCorpus(monitor,checkUpdate());
  else if ( m_iFlag == 2 )
      processCorpus(monitor,UD_UPDATECORPUS);
  else
      processQueryString(monitor);

  if (monitor.isCanceled())
      throw new InterruptedException("The long running
}

public void run(IProgressMonitor monitor)
      throws InvocationTargetException,
             InterruptedException{
  if ( m_iFlag == 0 )
      processCorpus(monitor,checkUpdate());
  else if ( m_iFlag == 2 )
      processCorpus(monitor,UD_UPDATECORPUS);
  else
      processQueryString(monitor);

  if (monitor.isCanceled())
      throw new InterruptedException("The long running
}

  public void run(IProgressMonitor monitor)
        throws InvocationTargetException,
               InterruptedException{
    if ( m_iFlag == 0 )
        processCorpus(monitor,checkUpdate());
    else if ( m_iFlag == 2 )
        processCorpus(monitor,UD_UPDATECORPUS);
    else
        processQueryString(monitor);

    if (monitor.isCanceled())
        throw new InterruptedException("The long running
  }
```

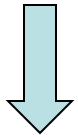
```
public void run(IProgressMonitor monitor)
      throws InvocationTargetException,
             InterruptedException{
 if ( m_iFlag == 0 )
     processCorpus(monitor,checkUpdate());
 else if ( m_iFlag == 2 )
     processCorpus(monitor,UD_UPDATECORPUS);
 else
     processQueryString(monitor);

 if (monitor.isCanceled())
     throw new InterruptedException("The long running
}


 public void run(IProgressMonitor monitor)
       throws InvocationTargetException,
              InterruptedException{
   if ( m_iFlag == 0 )
       processCorpus(monitor,checkUpdate());
   else if ( m_iFlag == 2 )
       processCorpus(monitor,UD_UPDATECORPUS);
   else
       processQueryString(monitor);

   if (monitor.isCanceled())
       throw new InterruptedException("The long running
 }
   public void run(IProgressMonitor monitor)
         throws InvocationTargetException,
                InterruptedException{
     if ( m_iFlag == 0 )
         processCorpus(monitor,checkUpdate());
     else if ( m_iFlag == 2 )
         processCorpus(monitor,UD_UPDATECORPUS);
     else
         processQueryString(monitor);

     if (monitor.isCanceled())
         throw new InterruptedException("The long running
   }
```

Parsing Source Code and Extracting Documents

- Corpus is a collection of documents (e.g., methods, classes, files)

Source Code is Text Too

```
public void run(IProgressMonitor monitor)
      throws InvocationTargetException,
             InterruptedException{
  if ( m_iFlag == 0 )
      processCorpus(monitor,checkUpdate());
  else if ( m_iFlag == 2 )
      processCorpus(monitor,UD_UPDATECORPUS);
  else
      processQueryString(monitor);

  if (monitor.isCanceled())
      throw new InterruptedException("The long running
}
```



public void run IProgressMonitor monitor throws InvocationTargetException InterruptedException if m_iFlag processCorpus monitor checkUpdate else if m_iFlag processCorpus monitor UD_UPDATECORPUS else processQueryString monitor if monitor isCancelled throw new InterruptedException the long running

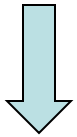
Removing Stop Words

- Common words in English, programming language keywords

public void run IProgressMonitor monitor **throws** InvocationTargetException InterruptedException **if** m_iFlag **the** processCorpus monitor checkUpdate **else if** m_iFlag processCorpus monitor UD_UPDATECORPUS **else a** processQueryString monitor **if** monitor isCancelled **throw new** InterruptedException **the** long running

Splitting Identifiers

public void run IProgressMonitor monitor **throws** InvocationTargetException InterruptedException **if** m_iFlag **the** processCorpus monitor checkUpdate **else if** m_iFlag processCorpus monitor UD_UPDATECORPUS **else a** processQueryString monitor **if** monitor isCancelled **throw new** InterruptedException **the** long running



- IProgressMonitor = i progress monitor
- InvocationTargetException = invocation target exception
- m_IFlag = m i flag
- UD_UPDATECORPUS = ud updatecorpus

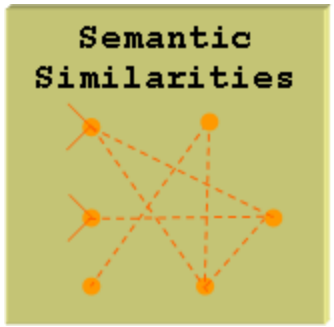
Indexing Source Code with Lucene

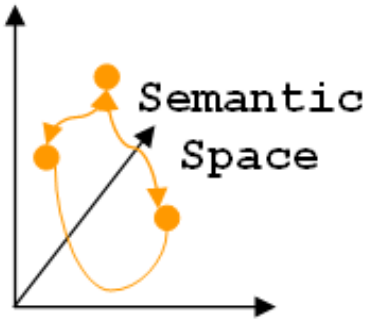
```
public void run(IProgressMonitor monitor)
      throws InvocationTargetException,
             InterruptedException{
  if ( m_iFlag == 0 )
      processCorpus(monitor,checkUpdate());
  else if ( m_iFlag == 2 )
      processCorpus(monitor,UD_UPDATECORPUS);
  else
      processQueryString(monitor);

  if (monitor.isCanceled())
      throw new InterruptedException("The long running
}
```

	process	flag	monitor
run	3	2	6
method1	x	x	x
method2	x	x	x
…	x	x	x

TF-IDF weighting

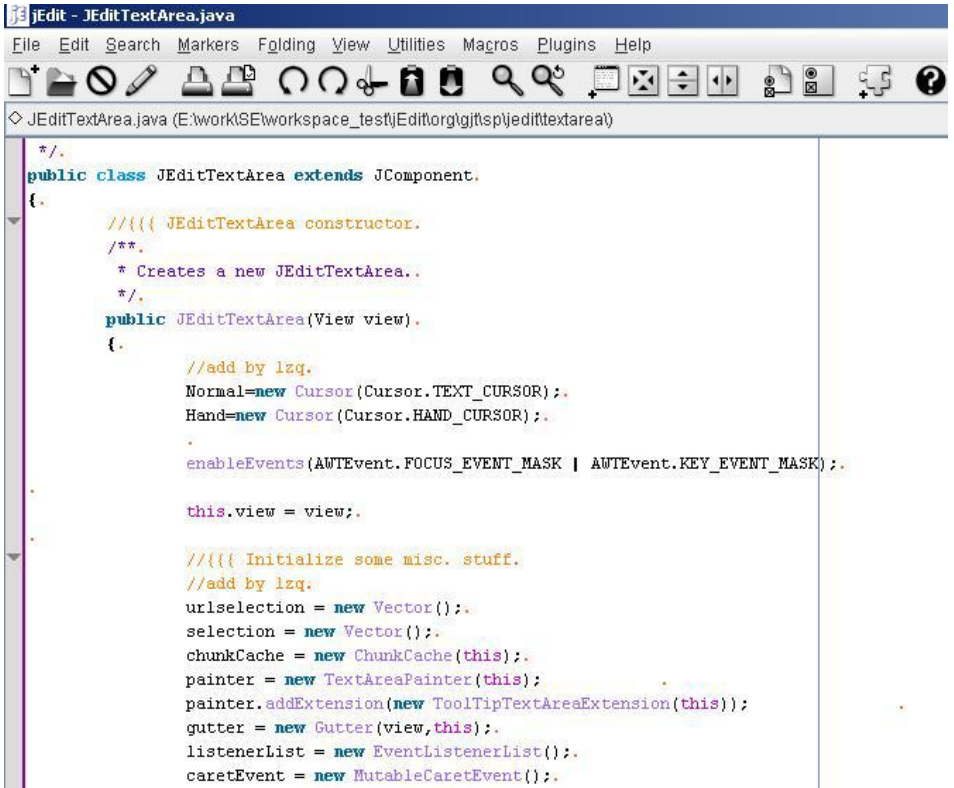
Similarity Measure:
Cosine of the contained angle between the vectors



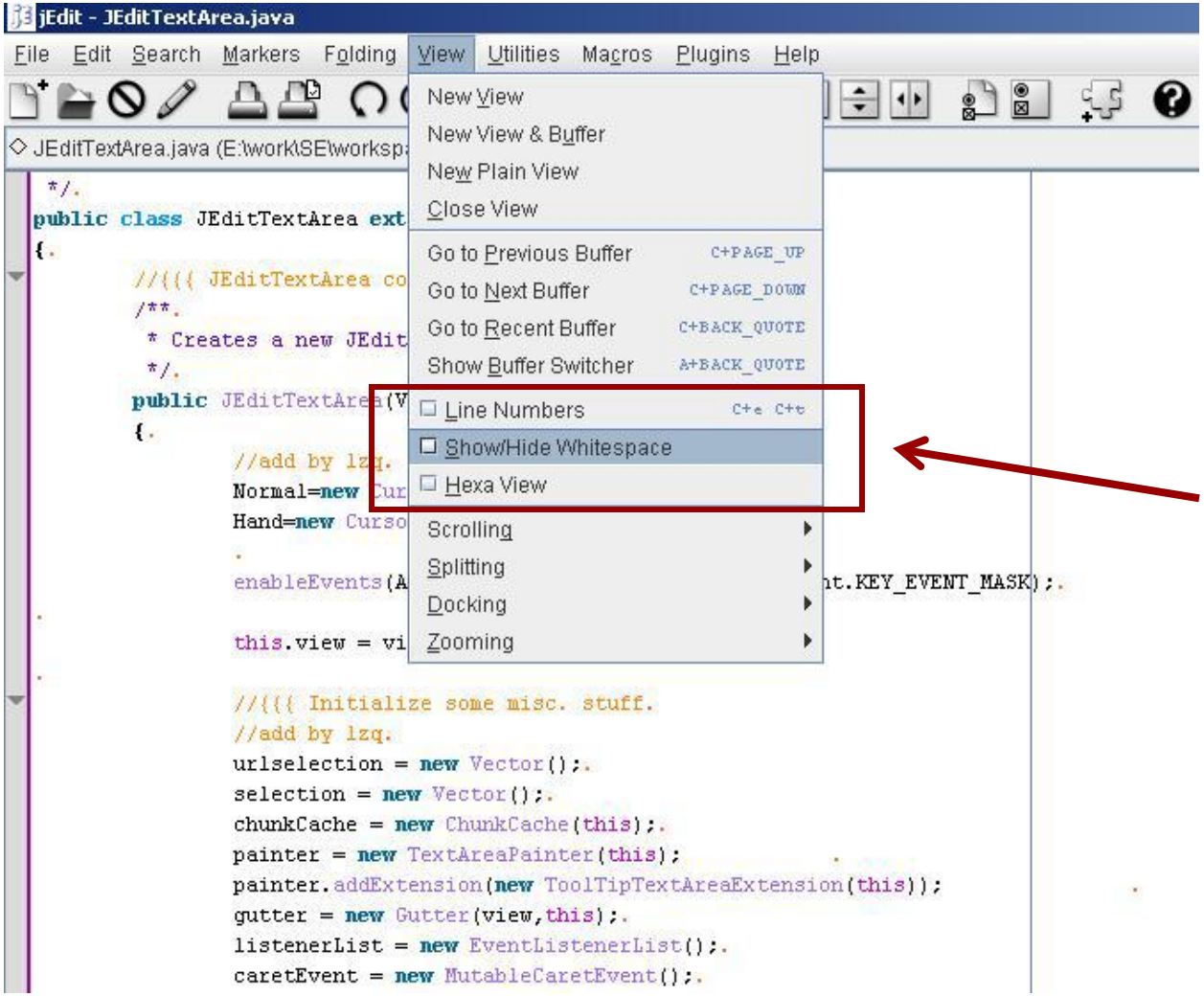


Example of using SITIR

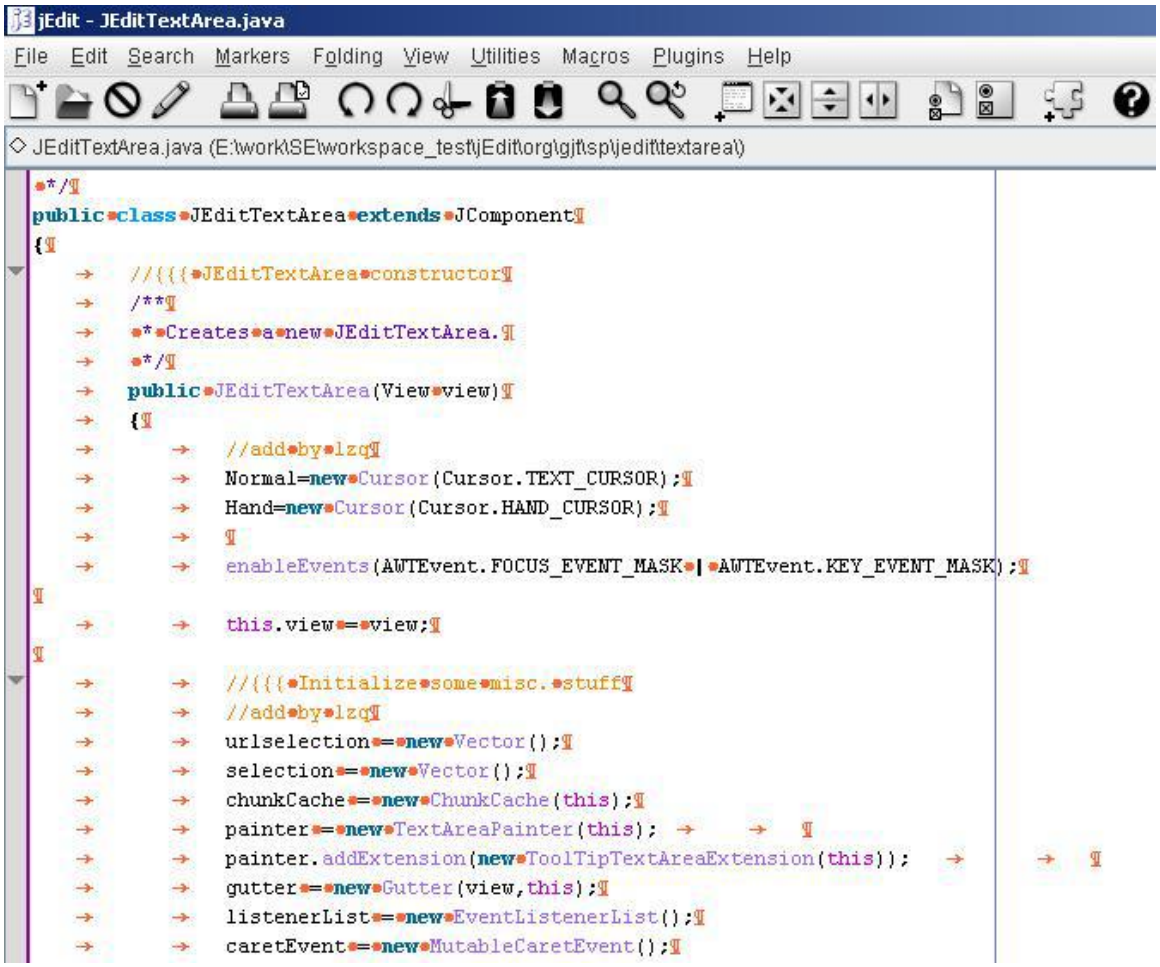
- Locating a feature in JEdit
- Feature: “showing **white-space** as a **visible** symbol in the **text area**”
- Steps:
  - Run a scenario
  - Run query
  - Explore results



Scenario Exercising the Feature

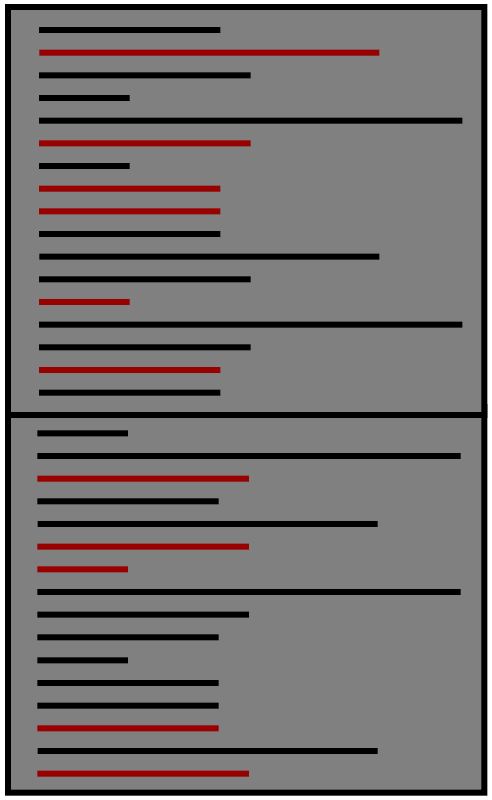


Scenario Exercising the Feature

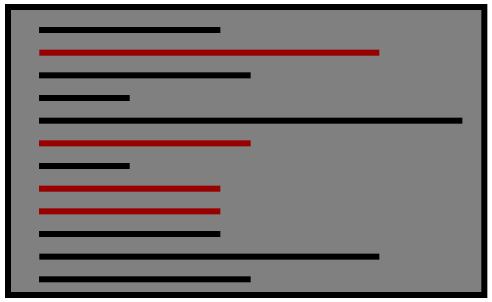


Stop Tracing

Example of using SITIR/FLAT^3 – Results



Executed methods



IR-based rankings

SITIR

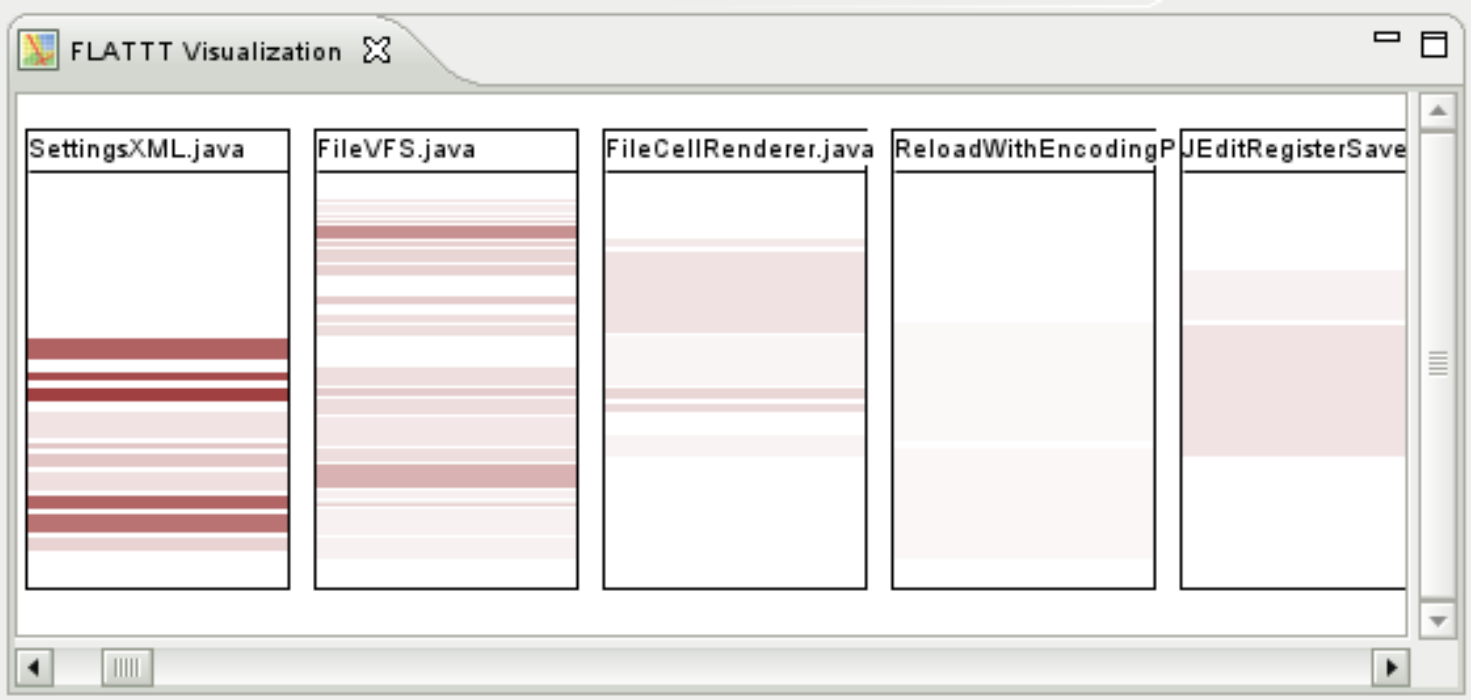
- Number of methods identified in the trace – **284**
- The position of the first relevant method according to IR ranking – **56**
- Position of the first relevant method according to SITIR - **7**

DEMO: Locating Features in JEdit using FLAT^3

- JEdit
  - 105KLOC
  - 910 classes
  - 5,530 methods
- Feature: “Word Count”
- Feature: “Save as”

Other features

- Annotating features
- Visualizing results
- Saving/loading complex traces



Acknowledgements

- ConcernMapper
- ConcernTagger
- MuTT
- AspectBrowser

FLAT^3

- Download the tool and complete source code at SEMERU web-site:

- http://www.cs.wm.edu/semeru/flat3

SEMERU