

A Combination Approach for Enhancing Automated Traceability

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Motivation

- Traceability systems extract links between documentation and source code e.g. to aid understanding and maintenance
- Key metrics:
 - Precision = correct links recovered / total recovered
 - Recall = correct retrieved / total # correct
- How to extract links with both high precision and recall??

Our approach

- Limitations of typically used Vector Space Model (VSM):
 - Low precision at low cut points
 - Low recall at high cut points
 - Miss some links
- Our approach: to combining three supporting techniques with VSM: Regular Expressions, Key Phrases, Clustering

Regular Expression

- Regular Expression (RE)
 - Find all of the occurrences of class names in documents
 - Use two regular expressions, e.g. "Control.java":
 - `(.*)(^a-zA-Zo-g|-)<C-?o-?n-?t-?r-?o-?l>(^a-zA-Zo-g|-)(.*)`
 - `(.*)(^a-zA-Zo-g|-)<each part of package name>(^a-zA-Zo-g|-)(.*)`
- Expands the retrieved link sets at high cut points

Key Phrases

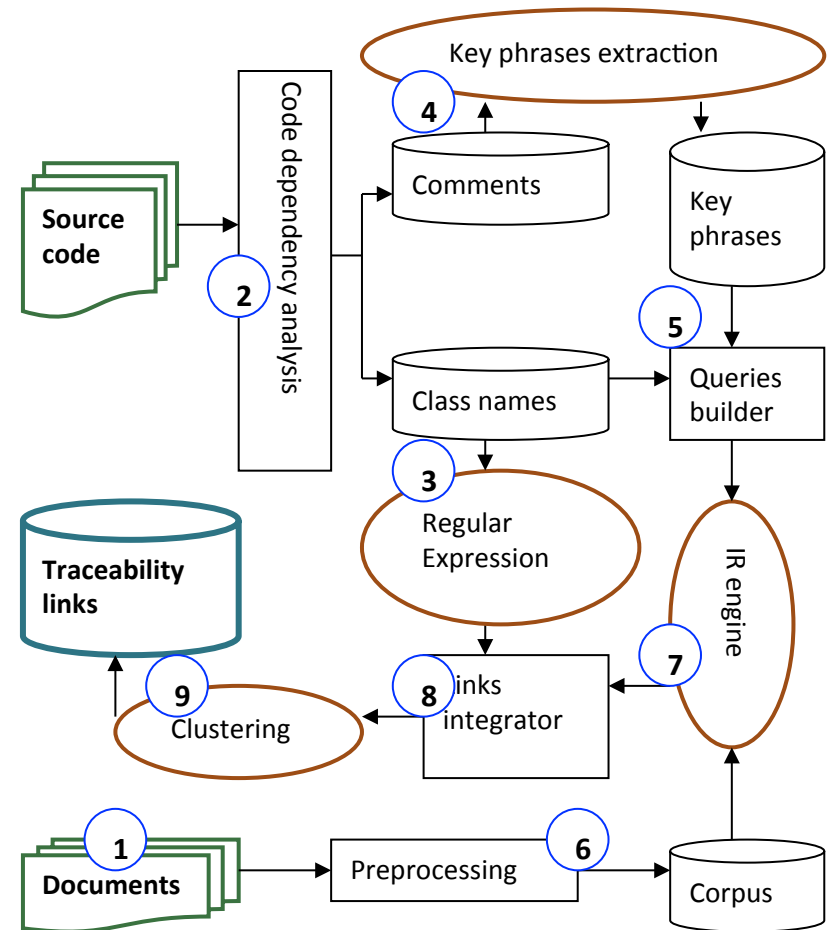
- Key Phrases (KP)
 - Extract key phrases from comments of code
 - Find alternative words to the class name or words indicating what tasks the class fulfills e.g. class "RefAddr" - query is "RefAddr OR ref addr OR ref OR addr"
 - Add these key phrases to VSM queries
- Extracts links missed by VSM

Clustering

- Clustering
 - Utilize the inherent hierarchical structure in documents to cluster extracted traceability links
 - Use modified K-mean algorithm
 - Three main steps: initialization, assignment, and removal
- Eliminates many fault links at low cut points (though does eliminate a few true links)

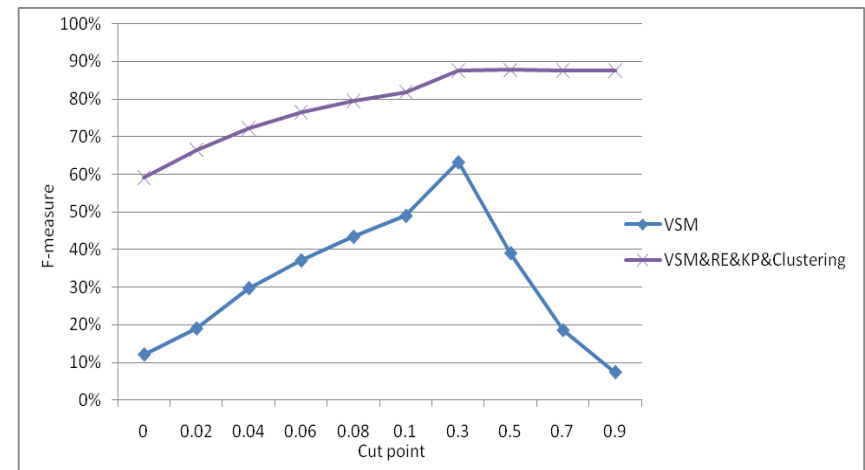
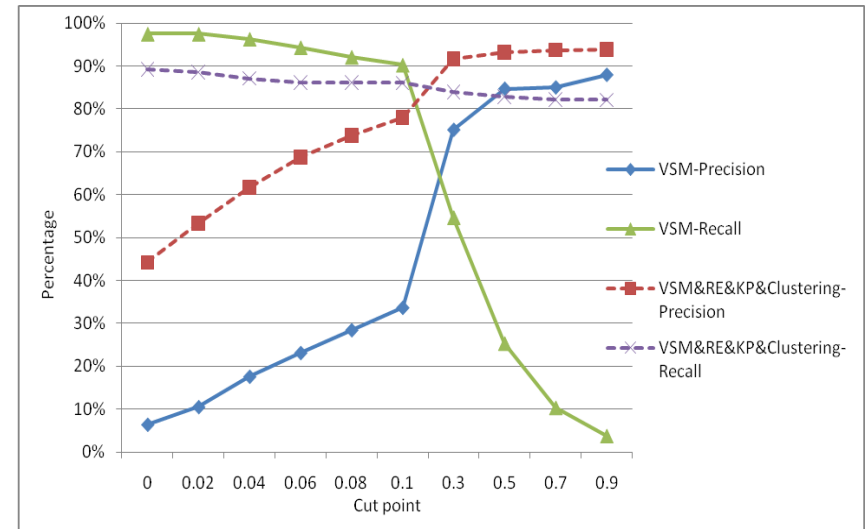
Implementation (see paper!)

1. Divide documents into small subdocuments
2. Extract class names and comments in code
3. Find documents that directly mention class names by RE
4. Extract key phrases from comments by KP
5. Combine extracted key phrases with class names to form VSM queries
6. Preprocessing documents
7. Retrieve links by VSM (IR engine)
8. Merge links
9. Refine extracted links by Clustering



Preliminary Experimental Results

- Case study: JDK1.5
- Top figure:
 - Precision is significantly improved
 - Recall is much higher than for VSM
- Bottom figure:
 - Our approach is more effective than VSM if precision and recall are equally important



Future Work

- Further case studies – now done for JDK1.5, ArgoUML, Freenet & JMeter
- Allow users to configure thresholds, select some or all techniques to apply to extract links
- Allow users to create or edit links
- Visualization tool to visualize extracted traceability links

Example from prototype #1

The screenshot displays the Eclipse IDE in the Traceability Perspective. The top window shows the source code of `PrintJob.java` in the `java.awt` package. The code includes a package declaration, a comment, and a description of the class as an abstract class for initiating and executing print jobs.

```
package java.awt;

/**
 * An abstract class which initiates and executes a print job.
 * It provides access to a print graphics object which renders
 * to an appropriate print device.
 */
```

The bottom window, titled "Documents Code Traceability", provides a visual representation of the code's dependencies. It features a search bar, a Navigator, and a main graph area. The Navigator shows the project structure, including the `PrintJob.java` file. The graph area displays a network of nodes representing source code files and documents. The `PrintJob.java` node is highlighted in yellow, and several document nodes are also highlighted, including "Introduction", "History of Printing on the Java Platform", "What the Java Print Service API Offers", "Java Print Service Architecture", "The javax.print Package", "Discover Print Services", "Specify the Print Data Format", "Create Print Jobs", "The javax.print.event Package", "How Applications Use the Java Print Service", "A Basic Example", "Attributes", "Attribute Categories and Values", and "Attribute Roles".

References

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- 2) Chen, X., Hosking, J.G. and Grundy, J.C. Visualizing Traceability Links between Source Code and Documentation, 2012 IEEE International Symposium on Visual Languages and Human-Centric Computing, Innsbruck, Austria, Sept 30-Oct 4 2012, IEEE CS Press.
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