Lecture 25

Clone Detection
CCFinder

EE 382V Spring 2009 Software Evolution - Instructor Miryung Kim

Today's Agenda (1)

- Recap of Polymetric Views
- Class Presentation
  - Suchitra (advocate)
  - Reza (skeptic)

Today’s Agenda (2)

- CCFinder, Kamiya et al. TSE 2002

Recap of Polymetric Views

- Polymetric view is a customizable software visualization tool enriched software metrics.
- This tool targets initial understanding of a legacy system.
- This tool can help programmers develop a high-level mental model.
- It is simple, powerful, scalable, and customizable; however, it requires some training to parse these generated views.

Class Presentation

- Suchitra (advocate)
- Reza (skeptic)

CCFinder

- CCFinder: A multilinguistic token-based code clone detection system for large scale source code, Kamiya et al. TSE 2002

Definition of Code Clones

- There is no precise or consistent definition on what clones are.
  - “a code portion in source files that is identical or similar to another code”
  - Clone are often operationally defined by a definition of a clone detector.

When and Why do programmers create clones?

When and Why do programmers create clones?

- What we have is slight different what we want.
- When reusing code as a mental macro template
- Due to programming language limitations
- Legacy code is well-tested and often reliable.
- Management reasons
  - A team does not want to create a dependency on another team's code.
  - A team does not support other teams' usage scenarios and customization
- Automatic code generation

Why is code cloning a problem during software evolution?

Why is code cloning a problem during software evolution?

- When a fault is found in one system, it may have to be propagated to other counterpart systems.
- When cloned systems require similar changes, all systems need to be modified consistently.
  - If you miss to update these clones consistently, missed updates could lead to a potential bug.
- Redundant development efforts
- Code plagiarism

Research problem addressed by CCFinder

- How can we find clones written in ***popular programming languages*** in a ***fast*** & ***scalable*** way?
    - industrial strength
    - million-line size system within affordable computation time and memory
    - can use heuristics for finding helpful clones
    - robust to renaming & small edits
    - limited uses of language-dependent clone detection

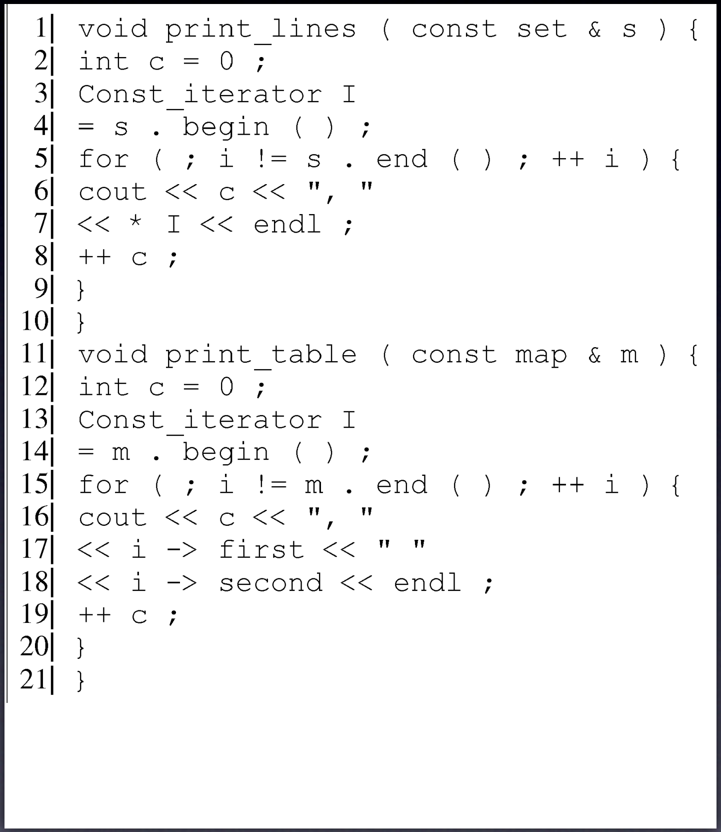
Approach

- Language-***dependent*** parts
  - Lexical analysis
  - Rule-based source transformation
- Language-***independent*** parts:
  - Suffix-tree matching algorithm for matching token sequences

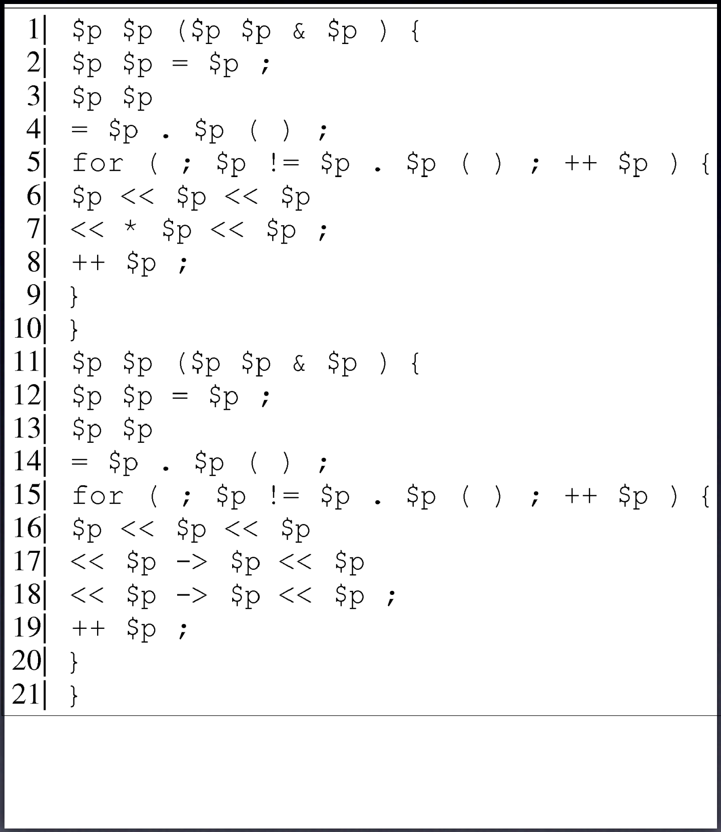
Rule-based Transformations

- Remove package names
- Supplement callees
- Remove initialization lists
- Separate class definitions
- Remove accessibility keywords
- Convert to compound block

Parameter Replacement



```
void print_lines ( const set & s ) {
int c = 0 ;
Const_iterator I
= s . begin ( ) ;
for ( ; i != s . end ( ) ; ++ i ) {
cout << c << ", "
<< * I << endl ;
++ c ;
}
}
void print_table ( const map & m ) {
int c = 0 ;
Const_iterator I
= m . begin ( ) ;
for ( ; i != m . end ( ) ; ++ i ) {
cout << c << ", "
<< i -> first << " "
<< i -> second << endl ;
++ c ;
}
}
```



```
$p $p ($p $p & $p ) {
$p $p = $p ;
$p $p
= $p . $p ( ) ;
for ( ; $p != $p . $p ( ) ; ++ $p ) {
$p << $p << $p
<< * $p << $p ;
++ $p ;
}
}
$p $p ($p $p & $p ) {
$p $p = $p ;
$p $p
= $p . $p ( ) ;
for ( ; $p != $p . $p ( ) ; ++ $p ) {
$p << $p << $p
<< $p -> $p << $p
<< $p -> $p << $p ;
++ $p ;
}
}
```

Other minor contributions

- Similar to duploc's scatter-plot visualization
- Suggestions of metrics for clones

Evaluation (1)

- Research questions
- RQ1: Is CCFinder scalable and can be applied to industry size programs?
    - e.g. Two versions of OpenOffice. 10 million lines in total. 68 minutes
    - e.g. FreeBSD, NetBSD, and OpenBSD
- RQ2: What is the impact of each transformation rule?

Evaluation (2)

- RQ3: Can CCFinder be used for investigating where and how similar code fragments are used among similar software systems such as FreeBSD, NetBSD, and Linux?
  - A hypothesis: FreeBSD and NetBSD are more similar to each other than Linux.
  - Results: about 40% of source files in FreeBSD have clones with NetBSD; whereas less than 5% of source fules in FreeBSD or NetBSD have clones with Linux.

Other Existing Clone Detection Techniques (1)

- String
  - Baker's Dup: a lexer and a line-based string matching tool: it removes white spaces and comments; replaces identifiers; concatenates all files; hashes each line for comparison; and extracts a set of pairs of longest matches using a suffix tree algorithm
- Token
  - CCFinder transforms tokens using a language specific rules and performs a token-by-token comparison

Other Existing Clone Detection Techniques (2)

- AST
  - Baxter et al.'s CloneDr parses source code to build an abstract syntax tree, compares its subtrees by characterization metrics.
  - Jiang et al. and Koschke et al.
- PDG
  - Komondoor and Horwitz clone detector finds isomorphic PDG subgraphs using program slicing
  - Krinke uses a k-length patch matching to find similar PDG subgraphs.
  - PDG-based clone detectors are robst to reordered statements, code insertion and deletion, intertwined code, non-contiguous code.

Other Existing Clone Detection Techniques (3)

- Metric-based
  - Metric-based clone detectors compare various metrics called fingerprinting functions. They find clones at a particular syntactic granularity such as a class, a function, or a method because these fingerprints are often defined for a particular syntactic unit.

My general thoughts on CCFinder

- CCFinder is a robust and scalable clone detector.
- As there is no consistent definition of code clones, finding X% of clones in one system does not mean very much; however,
  - Its case studies show that CCFinder can be applied to industrial size programs.
  - Its case studies show that CCFinder can be used for checking hypotheses about the origin of a system.

Revisiting this course’s goal (1)

- I hope you had a fun learning about state-of-the-art methods and tools in software evolution research.
  - You have learned how to break down challenges in constructing and evolving software.
  - You have learned how to cope with software engineering problems **systematically**.
  - Now you probably know that building and evolving large scale software systems is challenging, yet there are systematic solutions (tool support and techniques) out there.

Revisiting this course's goal (2)

- I hope you gained confidence in doing research. Why? I believe that research skills are important for both practitioners and researchers.
  - I hope you gained perspectives in **identifying and formulating research questions.**
  - I hope you now have learned how to **identify open problems** through a literature survey.
  - I hope you are more comfortable about **reading research papers critically** and evaluating research works.
  - I hope you learned the **importance of evaluation component** and how to evaluate research solutions.

Preview for Next Lecture

- We will continue with code duplication research.
  - Empirical studies of code clone genealogies, Kim et al. FSE 2005

Announcement

- The peer review form is available on the blackboard.
- Please take your graded homework -- practical uses of software evolution research, part 1.
- Your grade review period ends on Apr 27th 11:50 PM.