Diplomarbeit

**CPC**

„an Eclipse framework for automated clone life cycle tracking and update anomaly detection“

Valentin Weckerle

weckerle@inf

- Introduction
- Requirements
- Problems
- CPC
- Current Status
- Discussion
• **Introduction**
  - Clone Definition
  - Related Work

• **Requirements**
  - A perfect world...
  - ... back in 2007
  - Goals
  - Not covered

• **Problems**
  - A closer look
  - Eclipse

• **CPC**
  - Architecture
  - User Interface
  - Heuristics

• **Current Status**

• **Discussion**
Clone Definition

- No universal definition
  - often “defined” as the class of similarities detected by a specific Clone Detection Tool

- Different Types
  - Simple Clones
    - parametrised / gapped / reordered
  - Structural Clones

- For Us
  - whatever you copy&paste :o)

- Similarity Metric
  - edit distance, parametric differences, metrics
Related Work (1/5)

“A Language Independent Approach for Detecting Duplicated Code”
S. Ducasse, M. Rieger, S. Demeyer, Univ. of Berne
ICSM 1999

- GCC (460 kLOC, C)
  - 8.7% clones
- DBS (245 kLOC, Smalltalk)
  - 36.4% clones
- Payroll System (40 kLOC, Cobol)
  - 59.3% clones
- Message Board System (6.5 kLOC, Python)
  - 29.4% clones
- (Metrics based)
Related Work (2/5)


Z. Li, S. Lu, S. Myagmar, Y. Zhou

University of Illinois
Symposium on OS Design & Implementation 2004

- Linux 2.6.6 (4,365 kLOC)
  - 22.3% clones
- FreeBSD 5.2.1 (3,299 kLOC)
  - 20.4% clones
- PostgreSQL 7.4.2 (458 kLOC)
  - 22.2% clones
- Apache 2.0.49 (223 kLOC)
  - 17.7% clones
“An Investigation of Cloning in Web Applications”

D.C. Rajapakse, S. Jarzabek
National University of Singapore
ICWE 2005

- 17 Web applications
- Open & closed source
- 33 – 1719 source files
- all major programming languages
- **16 – 63% clones**
- **average 41% clones**
- stddev 15%
- *(CCFinder, 20 tokens)*
Related Work (4/5)

“An Ethnographic Study of Copy and Paste Programming Practices in OOPL”

M. Kim, L. Bergman, T. Lau, D. Notkin
University of Washington
Symposium on Empirical Software Engineering 2004

- observe 9 experienced programmers for 60 hours
- 16 C&P actions per hour (median 12)
  - 74% <line, 17% block, 8% method, 1% class
  - 25% non-trivial => 4 per hour
- C&P is software “reuse”
- C&P actions may capture important design decisions
  - crosscutting concerns
Related Work (5/5)

And many more...

- Programmers do use Copy&Paste
  - and rightly so
- Cloning is inevitable
  - Programming language limitations
  - Conflicting design goals
  - Cloning may be intentional
    - performance, reliability
- Automated Clone Detection is problematic
  - “accidental” clones / false positives
- Refactoring of clones may not be beneficial
  - many clones are short lived
  - long lived clones are hard to refactor
TOC

- Introduction
  - Clone Definition
  - Related Work

- Requirements
  - A perfect world...
  - ... back in 2007
  - Goals
  - Not covered

- Problems
  - A closer look
  - Eclipse

- CPC
  - Architecture
  - User Interface
  - Heuristics

- Current Status

- Discussion
In a perfect world...

- **we know** about all clones
  - even “legacy” clones *(import)*
- **we know** which clones are important
- **we know** which changes to propagate
- **we know** when to drop a clone
- **we know** when to yell *(and how)*

- in short
  - **we know** the users current intention
    - even if he/she doesn't?
    - **we know** how to be of use

- but this world isn't perfect...
  - so **we guess? we gamble?**
… back in 2007

- We *know* very little
  - But we want to learn...
    - Collecting C&P clone data
    - Collecting user feedback
  - ... about the real world
    - Lab/student experiments won't do

- Tool Support - A solution (?)
  - free, open source
  - integrated into IDE
  - long term, iterative improvement
  - basis for other tools / framework
  - real world data for future research
  - as many users as possible
Goals for this thesis

- Eclipse IDE plugin
  - for Java programs
- Framework approach
  - flexible and powerful API which allows extension and modification
  - basis for future work
- Suitable for a production environment
  - multiple developers, multiple workstations
  - best effort tracking of clones with graceful fallback
- Export of collected clone data
- Only very basic, simple heuristics
- Simple user interface
Not covered by this thesis

- Advanced heuristics
  - i.e. AI based
- Empirical analysis of clone data / user behaviour
  - no data
- Thorough evaluation / validation
  - no time
- Advanced GUI features
  - i.e. linked editing/change propagation, adv. visualisation
- Advanced conflict resolution
  - on external edit or merge
- Advanced import of legacy clone data
  - multiple static clone detectors, filtering, evaluation, ...
• Introduction
  ▪ Clone Definition
  ▪ Related Work

• Requirements
  ▪ A perfect world...
  ▪ ... back in 2007
  ▪ Goals
  ▪ Not covered

• Problems
  ▪ A closer look
  ▪ Eclipse

• CPC
  ▪ Architecture
  ▪ User Interface
  ▪ Heuristics

• Current Status

• Discussion
A closer look (1/3)

- A Framework...
  - most potential future uses of CPC are unknown
    - API requirements are unknown
    - different levels of reuse
      - add a new view
      - just reuse clone tracking
      - reuse everything, “just” with another definition of clone
    - i.e. BP Tool, LCM, Refactoring, Templates
  - flexibility is key
  - leads to complexity

- being all things to all people
  - over engineering at its best
  - hard choices
A closer look (2/3)

- Clone Tracking
  - loose one character, loose everything
    - clone positions and source need to be kept in sync, at all times
    - System/Eclipse crash...
  - automated document modifications
    - refactorings, source reformats, code completion/generation, ...
    - save actions / paste actions
  - external modifications
    - anything other than Eclipse
  - revert/undo/redo
    - ...
  - performance
    - updating 100 clones, 100 times, on one key press?
    - ECG Sensor ...
  - ...

A closer look (3/3)

• **Synchronisation**
  - development teams
    • multiple developers, multiple workstations
    • concurrent modification
    • intermittent network connectivity
  - CVS / 2*SVN / ...
    • many team providers out there
  - merges / merge conflicts
  - revert / checkout of specific revision or branch
  - no central server besides the repository?
    • ease of use
    • open source projects
  - API...
    • what API?
Eclipse – Love it, Hate it (1/3)

• Going where no one has gone before...
  ▪ Lots of documentation and discussions
    • for the common problems

• non-JavaDoc Documentation
  ▪ does only cover part of the API
  ▪ many things are only mentioned in the JavaDoc

• “creative” API usage
  ▪ Naming schemes, Indexes, Headlines, ...
    • geared towards the main purpose of an API part
    • but often much more can be done...

• Nice API, but...
  ▪ ... does every-(any?)one implement it?

• Legacy API

• Lots of exploratory Eclipse source code reading
Eclipse – Love it, Hate it (2/3)

- **Conservative development**
  - If it is a simple bug with an indisputable fix
    - ~3-6 months
  - If there are multiple ways of fixing it
    - ~6-12 months
  - If it can't be reliably reproduced
    - open end
    - 150934: text editor synchronisation (2006-07-18)
      - gives me multiple text editor crashes a day
      - trying to get it fixed since 2007-09-04
  - If it affects the API
    - open end
    - 36418: make IMarkerImageProvider API (2003-04-11)
Eclipse – Love it, Hate it (3/3)

• One day during development...
  ▪ you work on some new features
  ▪ you make some changes to the core

• The next day...
  ▪ Eclipse starts crashing with out of memory errors

• You waste 3 days trying to find “your” bug...

• Then you find the culprit...
  ▪ an Eclipse auto-update introduced a new Eclipse bug
  ▪ easy workaround exists
  ▪ ... once you know about it
Introduction
  • Clone Definition
  • Related Work

Requirements
  • A perfect world...
  • ... back in 2007
  • Goals
  • Not covered

Problems
  • A closer look
  • Eclipse

CPC
  • Architecture
  • User Interface
  • Heuristics

Current Status

Discussion
CPC Component “Overview”

Core Components

15 Event Types, 11 Provider
Basic Components

- CPC Sensor
- Event Hub
- Store Pr.
- CPC Track
- Classification Pr.
- Clone Factory Pr.
Modularisation Approach
Clone Objects (1/2)

Clone

*public*

*private (module A)*

*private (module B)*

... 

Extension I

Extension II

Extension III

Predefined

3rd Party
**User Interface (1/3)**

```java
public class Test {
    public void someFunc()
    {
        //some comment
        System.out.println("Hello World!");
    }
}
```

```java
public class Test {
    public void someFunc()
    {
        //some comment
        System.out.println("Hello World!");
    }
}
```

```java
public void someFunc2()
{
    //some comment
    System.out.println("Hello World!");
}
```

The clone will be marked as ignored. Its position will still be tracked and it will still be displayed in the user interface. It will not receive any CPC notifications for modifications made this clone. An ignored clone can be "unignored" at any time.
User Interface (2/3)

<table>
<thead>
<tr>
<th>S</th>
<th>Pos</th>
<th>Len</th>
<th>Creator</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36</td>
<td>85</td>
<td>exp</td>
<td>2007-12-05</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>86</td>
<td>exp</td>
<td>2007-12-05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S</th>
<th>Project</th>
<th>File</th>
<th>Pos</th>
<th>Len</th>
<th>Creator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>e11bbc12-408</td>
<td>Test.java</td>
<td>126</td>
<td>86</td>
<td>exp</td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td>Test.java</td>
<td>36</td>
<td>85</td>
<td>exp</td>
</tr>
</tbody>
</table>

2 errors, 1 warning, 1 info

<table>
<thead>
<tr>
<th>Description</th>
<th>Resource</th>
<th>Path</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPC: possible update anomaly</td>
<td>Test.java</td>
<td>Test/src/test</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
public void someFunc2()
{
    //some comment
    System.out.println("Hello World!");
    //some additional comment
    someFunc();
    SomeFunc();
}
Heuristics (1/3)

- Classification
  - each clone instance is classified on creation
    - clones can be rejected by a classifier
  - classifications are arbitrary strings
  - multiple classifications are possible
  - reclassification is possible
  - rationale: performance

- Currently implemented
  - rejection: minimum token length

- Ideas
  - Class, Method, Control structure, Condition
  - Complex, Template
Heuristics (2/3)

• Similarity
   given two clones, how similar are they?
   result: 0 – 100 %
   “preprocessing” and “compare” steps

• Currently implemented
   preprocessing: generic whitespace normalisation
   preprocessing: Java code tokeniser/normaliser
   compare: Levenshtein Distance

• Ideas
   preprocessing: Java parser, Identifier normalisation
    • problem: clones are not always complete code blocks
   compare: ?
Heuristics (3/3)

- Notification
  - should a clone modification result in a notification?
  - right now or later?

- Currently implemented
  - ignore: clones with classification “Template”
  - ignore: whitespace only changes
  - ignore: “equivalent” to old state
  - ignore: “equivalent” to their origin/group members
  - delay all notifications by X seconds/minutes

- Ideas
  - ignore same class? ignore young clones?
• Introduction
  ▪ Clone Definition
  ▪ Related Work

• Requirements
  ▪ A perfect world...
  ▪ ... back in 2007
  ▪ Goals
  ▪ Not covered

• Problems
  ▪ A closer look
  ▪ Eclipse

• CPC
  ▪ Architecture
  ▪ User Interface
  ▪ Heuristics

• Current Status

• Discussion
Complexity

- 22 Plugins - 75 Interfaces - 308 Classes - 58,656 LOC
Pending Problems

- Remote Synchronisation
  - every repository provider does his own thing
    - even global APIs are often not implemented
  - no suitable APIs
    - No update/commit listener!
  - extremely time consuming

- Undo
  - performance issues
  - there maybe no good solution

- Heuristics
  - many possibilities
  - but which of them are good?
• Introduction
  - Clone Definition
  - Related Work

• Requirements
  - A perfect world...
  - ... back in 2007
  - Goals
  - Not covered

• Problems
  - A closer look
  - Eclipse

• CPC
  - Architecture
  - User Interface
  - Heuristics

• Current Status

• Discussion
Discussion
Starters... :o)

- Who is programming mostly in Java?
- Who is using the Eclipse IDE?
- “What” do you copy & paste?
- Heuristics, Heuristics, Heuristics...
- What's next?
- 2015: Could C&P tracking save your day?