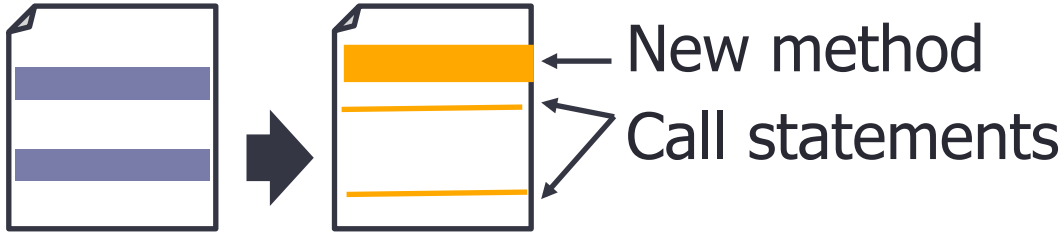
METHOD DIFFERENTIATOR USING SLICE-BASED COHESION METRICS

Akira Goto (Osaka University)
Norihiro Yoshida (Nara Institute of Science and Technology)
Masakazu Ioka (Osaka University)
Eunjong Choi (Osaka University)
Katsuro Inoue (Osaka University)

Source code differentiation

- Developers need to understand differences between a pair of methods in Java source code
  - When developers refactor a method pair into a module



  - When developers modify a method pair simultaneously
    - For enhancement, bug fix

However, manual differentiation is tedious and error prone.

Example of similar methods

It is hard to understand the differences between the method pair

```
public void similarMethodA(){
                    ⋮
 if(finalBuffer.remaining() < 8){
  while(finalBuffer.remaining() > 0){
   finalBuffer.put((byte)0);
  }
  finalBuffer.position(0);
  transform(finalBuffer);
  finalBuffer.position(0);
 }
 finalBuffer.putLong(length << 3);
 finalBuffer.position(0);
 transform(finalBuffer);
                    ⋮
}
```

```
public void similarMethodB(){
                    ⋮
 if(finalBuffer.remaining() < 8){
  while(finalBuffer.remaining() > 0){
   finalBuffer.put((byte)0);
  }
  finalBuffer.position(0);
  transform(finalBuffer.array(),0);
  finalBuffer.position(0);
 }
 finalBuffer.putLong(length << 3);
 finalBuffer.position(0);
 transform(finalBuffer.array(),0);
                    ⋮
}
```

Automatic code differentiation

- Textual Diff
  - e.g., GNU Diff
- Syntactic Diff
  - e.g., Eclipse
- PDG-based Diff [Xue2011]
  - Comprehension support for differences in terms of dependency type
  - For a pair of duplicated code fragments

[Xue2011] Xue, et al., “CloneDifferentiator: Analyzing clones by differentiation", ASE 2011.

Example of similar methods

Syntactic differences are insufficient to support refactoring, enhancement and bug fix.

```
public void similarMethodA(){
                    ⋮
 if(finalBuffer.remaining() < 8){
  while(finalBuffer.remaining() > 0){
   finalBuffer.put((byte)0);
  }
  finalBuffer.position(0);
  transform(finalBuffer);
  finalBuffer.position(0);
 }
 finalBuffer.putLong(length << 3);
 finalBuffer.position(0);
 transform(finalBuffer);
                    ⋮
}
```

```
public void similarMethodB(){
                    ⋮
 if(finalBuffer.remaining() < 8){
  while(finalBuffer.remaining() > 0){
   finalBuffer.put((byte)0);
  }
  finalBuffer.position(0);
  transform(finalBuffer.array(),0);
  finalBuffer.position(0);
 }
 finalBuffer.putLong(length << 3);
 finalBuffer.position(0);
 transform(finalBuffer.array(),0);
                    ⋮
}
```

Example of similar methods

Syntactic differences are insufficient to support refactoring, enhancement and bug fix.

```
public void similarMethodA(){
                    ⋮
 if(finalBuffer.remaining() < 8){
  while(finalBuffer.remaining() > 0){
   finalBuffer.put((byte)0);
  }
  finalBuffer.position(0);
  transform(finalBuffer);
  finalBuffer.position(0);
 }
 finalBuffer.putLong(length << 3);
 finalBuffer.position(0);
 transform(finalBuffer);
                    ⋮
}
```

```
public void similarMethodB(){
                    ⋮
 if(finalBuffer.remaining() < 8){
  while(finalBuffer.remaining() > 0){
   finalBuffer.put((byte)0);
  }
  finalBuffer.position(0);
  transform(finalBuffer.array(),0);
  finalBuffer.position(0);
 }
 finalBuffer.putLong(length << 3);
 finalBuffer.position(0);
 transform(finalBuffer.array(),0);
                    ⋮
```

Which part should be merged into one method?

Example of similar methods

Syntactic differences are insufficient to support refactoring, enhancement and bug fix.

```
public void similarMethodA(){
                    ⋮
 if(finalBuffer.remaining() < 8){
  while(finalBuffer.remaining() > 0){
   finalBuffer.put((byte)0);
  }
  finalBuffer.position(0);
  transform(finalBuffer);
  finalBuffer.position(0);
 }
 finalBuffer.putLong(length << 3);
 finalBuffer.position(0);
 transform(finalBuffer);
                    ⋮
```

```
public void similarMethodB(){
                    ⋮
 if(finalBuffer.remaining() < 8){
  while(finalBuffer.remaining() > 0){
   finalBuffer.put((byte)0);
  }
  finalBuffer.position(0);
  transform(finalBuffer.array(),0);
  finalBuffer.position(0);
 }
 finalBuffer.putLong(length << 3);
 finalBuffer.position(0);
 transform(finalBuffer.array(),0);
                    ⋮
```

Which part should be modified simultaneously for enhancement and bug fix?

Motivation

- Developers often try to understand which part of a source file corresponds to each functionality.
  - During refactoring
    - A code fragment that implements a single functionality is a good candidate for code extraction.
  - During enhancement and bug fix
    - Simultaneous editing should be considered for each code fragment that implements a single functionality.

The existing differentiators do not take into account functionalities implemented in a source file.

Research overview

- We have developed a method differentiator MEDICO.
- The differentiation is based on slice-based cohesion metrics.
  - In order to identify a set of code fragments, each of which implements a single functionality
- Cohesion metric is generally defined as
  - a measure which expresses, in order for each of the constituent parts to realize a specific feature, the extent to which they work together. [Stevens1974]

[4] W. P. Stevens, G. J. Myers, and L. L. Constatine, “Structured design,” IBM Systems Journal, 1974.

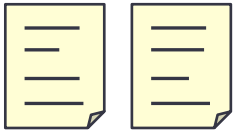
Cohesion metrics for code fragment

- Most of the existing cohesion metrics are aimed at calculating the degree of the cohesion of a class/method.
- However, cohesion metrics for calculating the cohesion of a code fragment are needed.
  - in order to identify a code fragment that includes a set of cohesive statements and implements a single functionality
- We modified slice-based cohesion [Weiser1981] to calculate the cohesion of a code fragment.
  - Calculate slice-based metrics after the code fragment is extracted
  - Tightness, Coverage, Overlap → FTightness, FCoverage, FOverlap

[Weiser1981] Weiser: Program slicing, *Proc. of ICSE1981*

Steps of the differentiation by MEDICO

Input: A pair of Java methods



AST-based Differencing

Enumerating all possible differences

Ranking of differences using cohesion metrics