Midpoint Oral Presentation

Statistical-based Clone Detection

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Invent the Future

Outline

- Problem Definition
- Solution Design
- Implementation Status
- Technical Challenges
- Future Work

Problem Definition

- Code Clone
  - Code fragment identical or similar to another
- Pros
  - Improves efficiency
  - Increases readability
- Cons
  - Low maintainability
  - Increases code size
- Clone Types (Type 1, 2, 3, 4)
- Techniques and Tools (Text, Token, Tree, Graph)

Problem Definition

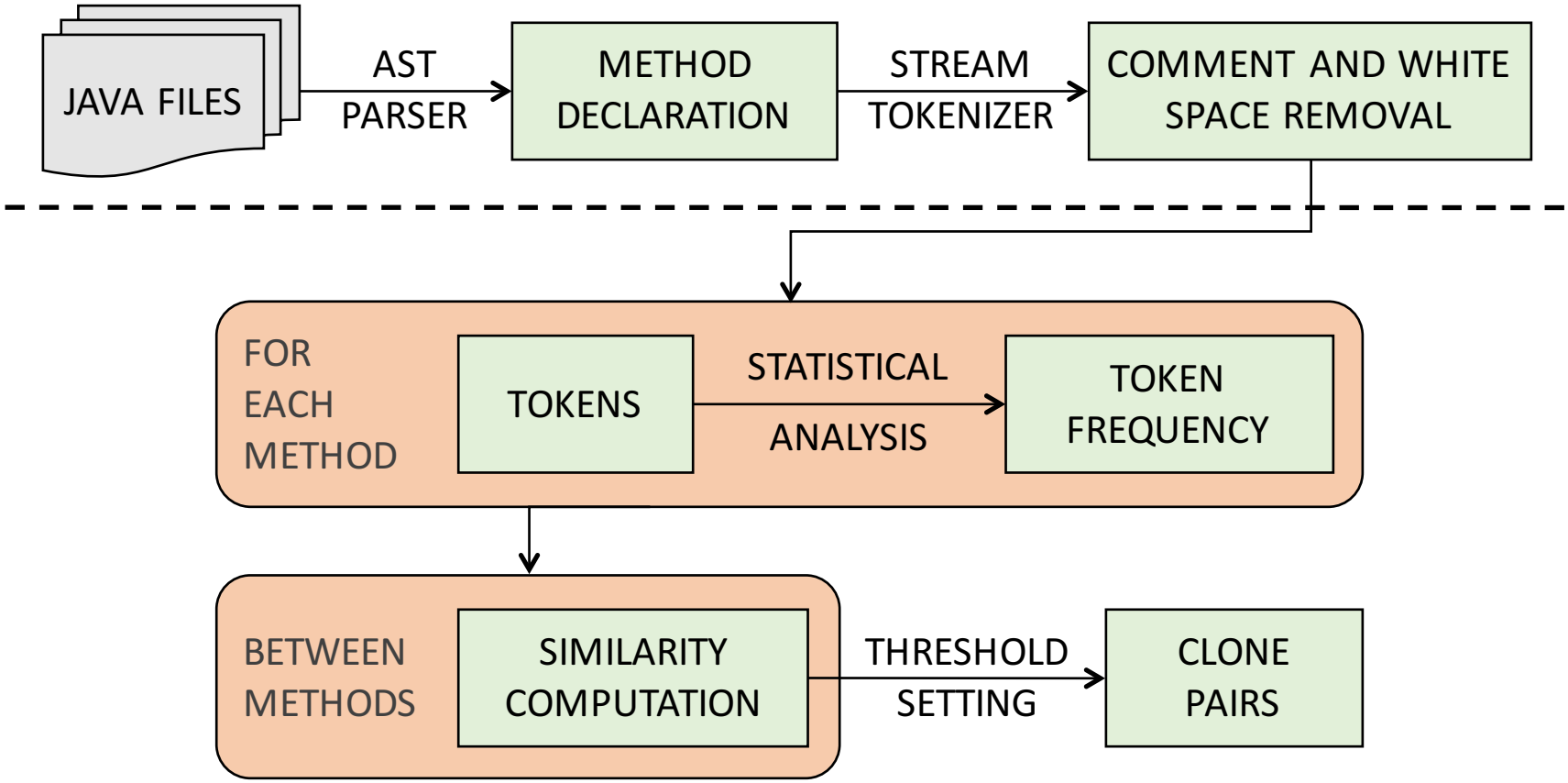
- Prerequisites
  - Token-based detection tool shows the best performance
  - Developers won't make dramatic changes in code clone
- Goal
  - Design and implement STCD (Statistical-based Clone Detection) tool to detect the Type 1, 2, 3 code clones between methods based on tokens
- Validity
  - Ambiguous match

Solution Design

- Fragment A and B
  - Use a parser to catch all the tokens
  - Categorize key tokens into numbers, types, keywords, markers, operators, etc.
  - Accumulate the occurrences of each key token
  - Transform the fragment into a list of key token and frequency
  - Calculate the similarity between two lists
  - Set a threshold to the final output

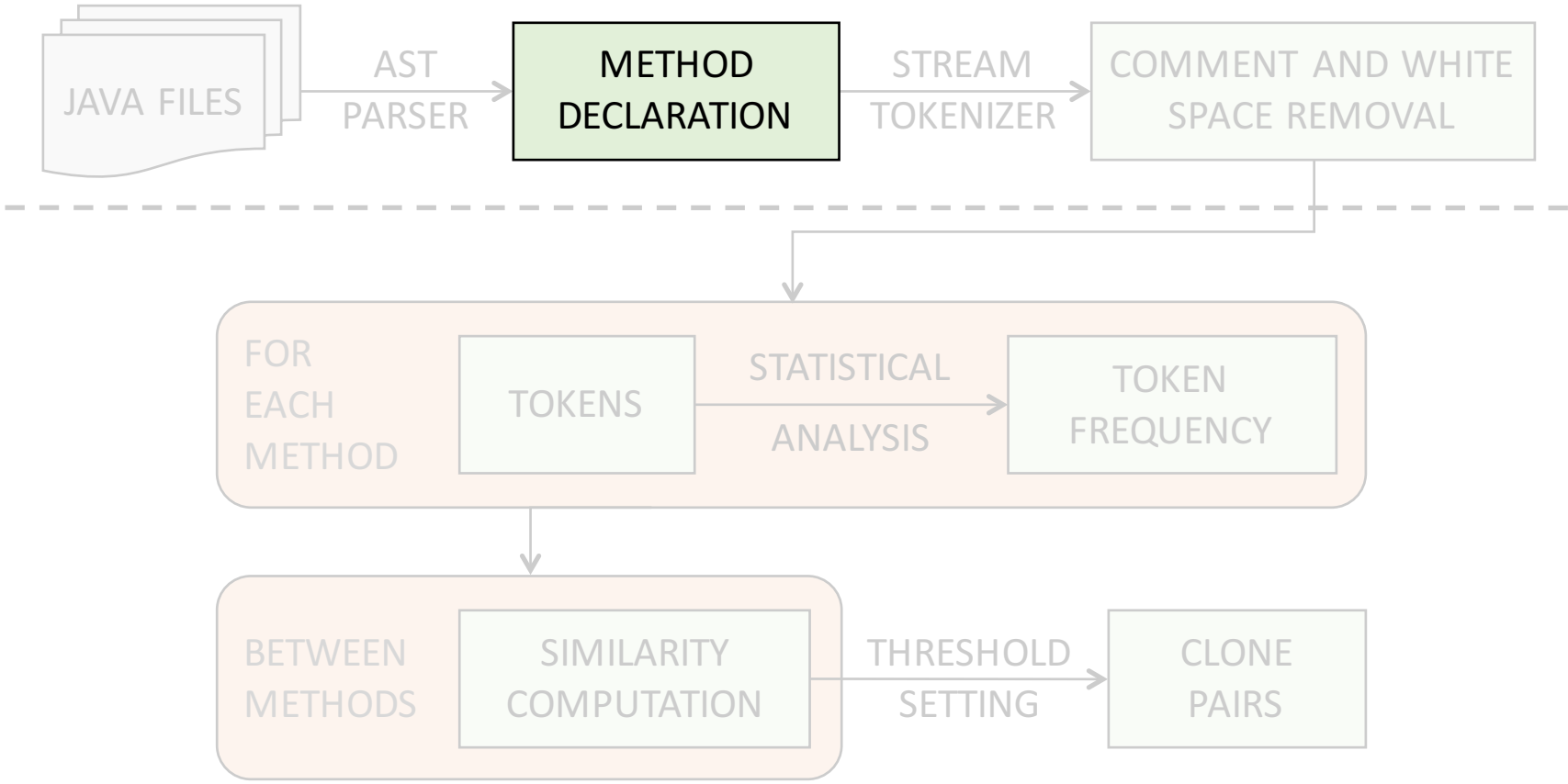
Solution Design

- Overall Current Project Diagram



Solution Design

- Overall Current Project Diagram



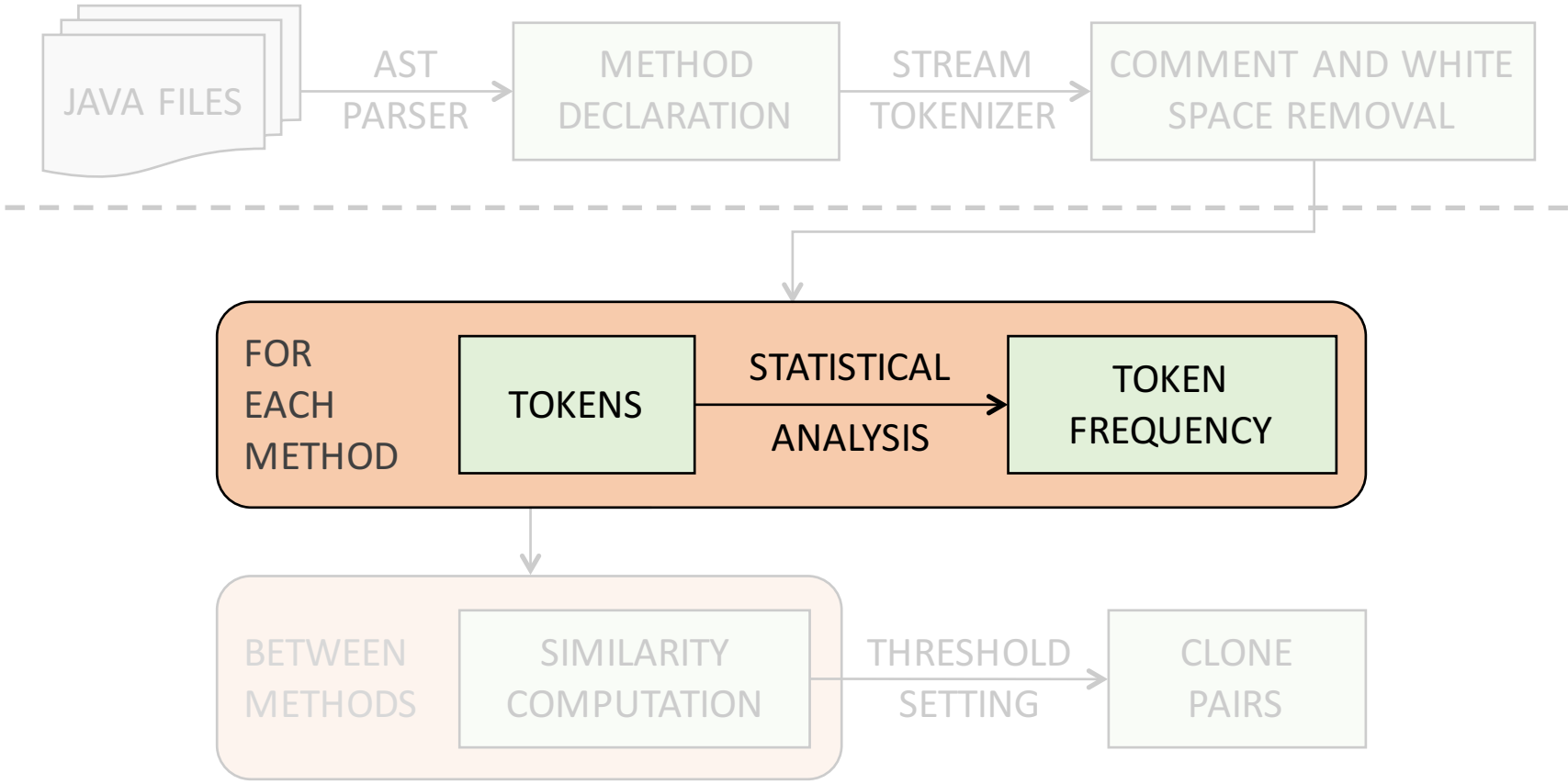
Solution Design

- Method Declaration
  - CompilationUnit result
  - MethodDeclaration method

Method Info.	Function
startLineNumber	result.getLineNumber(…)
endLineNumber	result.getLineNumber(…)
methodName	method.getName()
methodPara	method.parameters()
methodType	method.getReturnType2()
methodBody	method.getBody()

Solution Design

- Overall Current Project Diagram



Solution Design

- Token & Token Frequency
  - StreamTokenizer

Categories	Tokens
Number	123, 24.5, …
Type	int, char, double, boolean, null, true, false, …
Keyword	static, for, if, else, while, return, this, const, …
Marker	{, }, [,], (,)
Operator	+, -, *, /, %, ^, <, >, !, …
Other1	variables, …
Other2	?, #, $, …

Solution Design

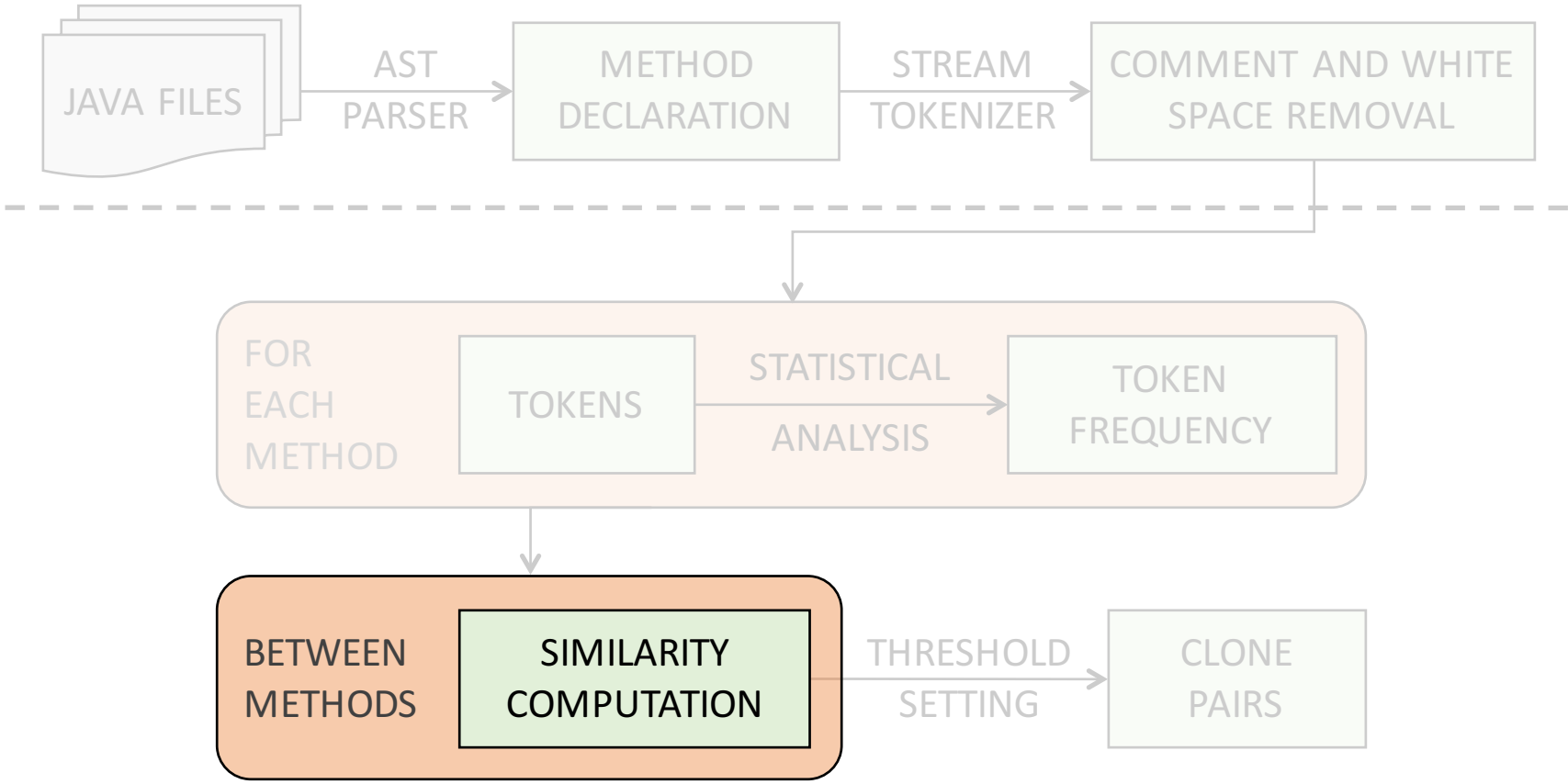
- Token & Token Frequency
  - tokenList: store token frequency
  - For two categories(e.g. Type and Keywords)

Type	Frequency
int	8
char	6
double	3
boolean	0
…	…
true	2
false	2

Keywords	Frequency
for	2
if	1
else	1
return	2
…	…
this	4
static	3

Solution Design

- Overall Current Project Diagram



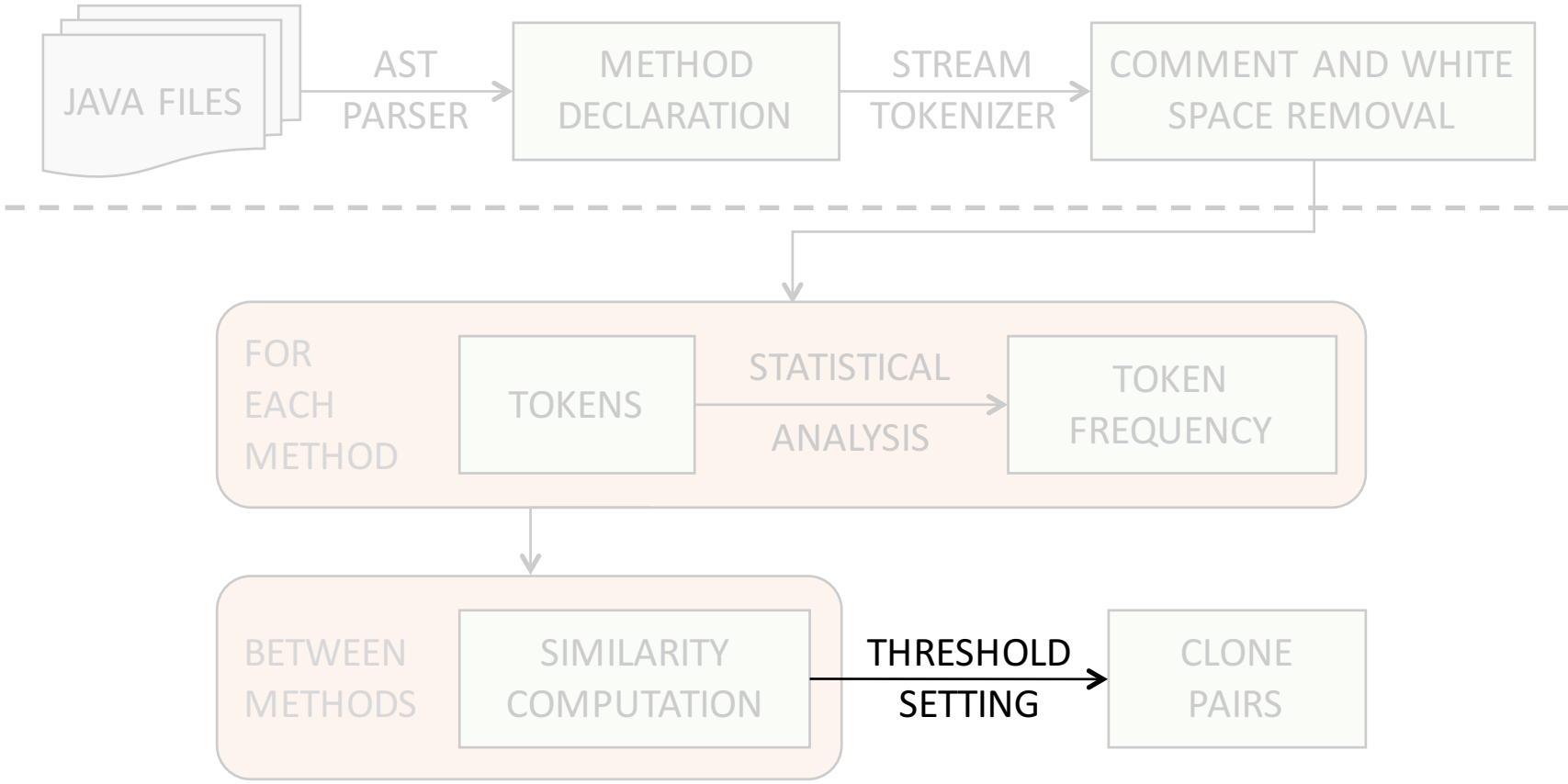
Solution Design

- Similarity Computation
  - Method Similarity
  - 9-Dimentional Vetcor
    - X = <X1, X2, X3, X4, X5, X6, X7, X8, X9>
    - Y = <Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8, Y9>
    - Sim(X1, Y1) = bigram(X1, Y1)
    - Sim(X2, Y2) = 1 / 0
    - Sim(X_{else}, Y_{else}) = 1 / 1 + Distance(X_{else}, Y_{else})
    - Distance (X_{else}, Y_{else}): Euclidean Distance
    - Sim(X, Y) = Sum(wi * Sim(Xi, Yi)) (i = 1, 2, …, 9)

Vector
methodPara
methodType
tokenListNum
tokenListType
tokenListKeyword
tokenListMarker,
tokenListOperator
tokenListOther1
tokenListOther2

Solution Design

- Overall Current Project Diagram



Solution Design

- Threshold Setting 1
  - For Variables: DrawPointLine vs. PointLineDraw
  - tokenThreshold for bigram similarity
  - e.g. tokenThreshold > 0.7
- Threshold Setting 2
  - detectThreshold for method similarity
  - e.g. detectThreshold > 0.5
- Threshold Setting 3
  - lineThreshold for method lines
  - e.g. endLineNum - startLineNum > 7

Implementation Status

- Source: https://github.com/CSCC5704
  - CodeClone.java
    - Detect cloned code in java files
  - MethodSimilarity.java
    - Calculate the similarity of two methods
  - BiGramSimilarity.java
    - Calculate the similarity of two strings by using bi-gram algorithm
  - ASTParserTool.java
    - Use JDT ASTParser to parse the java source code into methods
  - MethodTokenizerTool.java
    - Tokenize method body and get the frequency of tokens
  - MethodList.java, MethodVector.java
  - TokenList.java, TokenVector.java, …

Implementation Status

- TokenList.java

Token	Category	Freq
int	Type	1
for	Keyword	1
i	Other1	8
System	Other1	3
out	Other1	3
println	Other1	3
toBinary	Other1	1
Integer	Other1	1
toBinaryString	Other1	1
(	Marker	6

Token	Category	Freq
)	Marker	6
}	Marker	2
{	Marker	1
+	Operator	6
=	Operator	1
-	Operator	1
<	Operator	1
:	Other2	2
5.0	Num	1
33.0	Num	1

Implementation Status

- Java Source Files from GitHub with LOC 200~3000
- Find out pairs of clone code
  - Output Format

    Clone Group # --> Similarity: #

    Method Name 1 Start Line # End Line #

    Method Name 2 Start Line # End Line #
- Matches well with manual examination

Implementation Status

```
86      public void testUIComputation() throws Exception {
87          // populate text fields with values
88          populate();
89          // trigger computation by using the button
90          WebElement button = driver.findElement(By.className("UIAButton"));
91          button.click();
92          // is sum equal ?
93          WebElement texts = driver.findElement(By.className("UIAStaticText"));
94          assertEquals(String.valueOf(values.get(0) + values.get(1)), texts.getText());
95      }

142     public void testFindElementByClassName() throws Exception {
143         Random random = new Random();
144
145         WebElement text = driver.findElementByClassName("UIATextField");
146         int number = random.nextInt(MAXIMUM - MINIMUM + 1) + MINIMUM;
147         text.sendKeys(String.valueOf(number));
148
149         driver.findElementByClassName("UIAButton").click();
150
151         // is sum equal ?
152         WebElement sumLabel = driver.findElementByClassName("UIAStaticText");
153         assertEquals(String.valueOf(number), sumLabel.getText());
154     }
```

Source: https://github.com/appium/sample-code

Clone Group 3 --> Similarity: 0.5102

Implementation Status

```
142     public void testFindElementByClassName() throws Exception {
143         Random random = new Random();
144
145         WebElement text = driver.findElementByClassName("UIATextField");
146         int number = random.nextInt(MAXIMUM - MINIMUM + 1) + MINIMUM;
147         text.sendKeys(String.valueOf(number));
148
149         driver.findElementByClassName("UIAButton").click();
150
151         // is sum equal ?
152         WebElement sumLabel = driver.findElementByClassName("UIAStaticText");
153         assertEquals(String.valueOf(number), sumLabel.getText());
154     }
```

```
157     public void testFindElementsByClassName() throws Exception {
158       Random random = new Random();
159
160       WebElement text = driver.findElementsByClassName("UIATextField").get(1);
161       int number = random.nextInt(MAXIMUM - MINIMUM + 1) + MINIMUM;
162       text.sendKeys(String.valueOf(number));
163
164       driver.findElementByClassName("UIAButton").click();
165
166       // is sum equal ?
167       WebElement sumLabel = driver.findElementsByClassName("UIAStaticText").get(0);
168       assertEquals(String.valueOf(number), sumLabel.getText());
169     }
```

Source: https://github.com/appium/sample-code

Clone Group 5 --> Similarity: 0.6676

Implementation Status

```
142     public void testFindElementByClassName() throws Exception {
143         Random random = new Random();
144
145         WebElement text = driver.findElementByClassName("UIATextField");
146         int number = random.nextInt(MAXIMUM - MINIMUM + 1) + MINIMUM;
147         text.sendKeys(String.valueOf(number));
148
149         driver.findElementByClassName("UIAButton").click();
150
151         // is sum equal ?
152         WebElement sumLabel = driver.findElementByClassName("UIAStaticText");
153         assertEquals(String.valueOf(number), sumLabel.getText());
154     }
```

```
172     public void testAttribute() throws Exception {
173         Random random = new Random();
174
175         WebElement text = driver.findElement(By.xpath("//UIATextField[1]"));
176
177         int number = random.nextInt(MAXIMUM - MINIMUM + 1) + MINIMUM;
178         text.sendKeys(String.valueOf(number));
179
180         assertEquals("TextField1", text.getAttribute("name"));
181         assertEquals("TextField1", text.getAttribute("label"));
182         assertEquals(String.valueOf(number), text.getAttribute("value"));
183     }
```

Source: https://github.com/appium/sample-code

Clone Group 6 --> Similarity: 0.6190

Implementation Status

- Apache Commons
  - http://commons.apache.org
- Two Files
  - FileUtils.java
    - Total methods: 106
    - Cloned methods: 11 pairs (no clusters)
    - Ratio: 20.8%
  - IOUtils.java
    - Total methods: 105
    - Cloned methods: 4 pairs (no clusters)
    - Ratio: 7.62%

Technical Challenges

- ASTParser
  - Excessive time cost
  - Improve the method parsing process
  - e.g. regular expression

- Manual weights and threshold
  - 9-Dimentional (w1, …, w9)
  - Machine Learning Techniques (Training Data)
  - e.g. Multilayer perceptron (MLP)

Future Work

- Variables Comparison
  - Bigram Algorithm
- Data Collection
  - Training Data for Machine Learning
  - Test Data for results comparison
- Results Comparison
  - Precision & Recall
- UI Development
  - Java WindowBuilder

Thank you !