



Automating Systematic Edits with Cha-Q search-and-replace

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FOD Financiën pilot study

- Calcul IPP project: Simulation personal taxes

The screenshot shows the homepage of the Tax-Calc website. At the top, there are language selection buttons for NL, FR, and CE. The main header features the text 'Al 3 miljoen gebruikers... En jij?' and the 'TAX-Calc' logo. Below this, a navigation bar includes icons for 'M&L', 'M&C', and 'M&J'. A search bar is visible on the left side. The central content area is titled 'Welkom bij Tax-Calc, de berekeningsmodule van de Personenbelasting' and features a laptop icon. A prominent red banner reads 'AANSLAGJAAR 2016 (inkomsten van het jaar 2015)'. Below this, a paragraph explains that users can view an anonymous estimate of their taxes. A 'Ga in Tax-Calc' button is positioned below the text. On the right side, a sidebar titled 'MEER OVER DIT DROGWERK?' contains three links: 'Wat is Tax-Calc?', 'Wie kan Tax-Calc gebruiken?', and 'Hoe Tax-Calc gebruiken?'. At the bottom, there is a footer with the 'be' logo and the text 'FOD FINANCIËN'.

FOD Financiën pilot study

- Calcul IPP project: Simulation personal taxes



- 2987 Java source files; 274883 LOC
- Examined development activity of Sep. 2014 - May 2016 (751 commits)



Introducing fields + usages

```
public class ReportCalcSummary implements Serializable {
    ...
    + private Long impotReferRegulPosVla;
    + public Long getImpotReferRegulPosVla() {
    +     return impotReferRegulPosVla;}
    + public void setImpotReferRegulPosVla(Long impotReferRegulPosVla) {
    +     this.impotReferRegulPosVla = impotReferRegulPosVla;}
    ...
    +     .append("impotReferRegulPosVla = ").append(this.impotReferRegulPosVla).append(TAB)
    ...
    +     dto.setImpotReferRegulPosVla(new Long(0));
    ...
    +     if (g8653 > 0) {dto.setImpotReferRegulPosVla(a(dto.getImpotReferRegulPosVla(), g8653));}
    ...
    +     vo.setImpotReferRegulPosVla(dto.getImpotReferRegulPosVla());
    ...
}
```

Introducing fields + usages

A new field

```
public class ReportCalcSummary implements Serializable {
    ...
    + private Long impotReferRegulPosVla;
    + public Long getImpotReferRegulPosVla() {
    +     return impotReferRegulPosVla;}
    + public void setImpotReferRegulPosVla(Long impotReferRegulPosVla) {
    +     this.impotReferRegulPosVla = impotReferRegulPosVla;}
    ...
    +     .append("impotReferRegulPosVla = ").append(this.impotReferRegulPosVla).append(TAB)
    ...
    +     dto.setImpotReferRegulPosVla(new Long(0));
    ...
    +     if (g8653 > 0) {dto.setImpotReferRegulPosVla(a(dto.getImpotReferRegulPosVla(), g8653));}
    ...
    +     vo.setImpotReferRegulPosVla(dto.getImpotReferRegulPosVla());
    ...
}
```

Introducing fields + usages

```
public class ReportCalcSummary implements Serializable {  
    ...  
+ private Long impotReferRegulPosVla;  
+ public Long getImpotReferRegulPosVla() {  
+     return impotReferRegulPosVla;}  
+ public void setImpotReferRegulPosVla(Long impotReferRegulPosVla) {  
+     this.impotReferRegulPosVla = impotReferRegulPosVla;}  
    ...  
+     .append("impotReferRegulPosVla = ").append(this.impotReferRegulPosVla).append(TAB)  
    ...  
+     dto.setImpotReferRegulPosVla(new Long(0));  
    ...  
+     if (g8653 > 0) {dto.setImpotReferRegulPosVla(a(dto.getImpotReferRegulPosVla(), g8653));}  
    ...  
+     vo.setImpotReferRegulPosVla(dto.getImpotReferRegulPosVla());  
    ...  
}
```

A new field

Its getter

Introducing fields + usages

```
public class ReportCalcSummary implements Serializable {
```

A new field

```
...
```

```
+ private Long impotReferRegulPosVla;
```

```
+ public Long getImpotReferRegulPosVla() {  
+   return impotReferRegulPosVla;}  
}
```

Its getter

```
+ public void setImpotReferRegulPosVla(Long impotReferRegulPosVla) {  
+   this.impotReferRegulPosVla = impotReferRegulPosVla;}  
}
```

Its setter

```
...
```

```
+   .append("impotReferRegulPosVla = ").append(this.impotReferRegulPosVla).append(TAB)
```

```
...
```

```
+   dto.setImpotReferRegulPosVla(new Long(0));
```

```
...
```

```
+   if (g8653 > 0) {dto.setImpotReferRegulPosVla(a(dto.getImpotReferRegulPosVla(), g8653));}
```

```
...
```

```
+   vo.setImpotReferRegulPosVla(dto.getImpotReferRegulPosVla());
```

```
...
```

Introducing fields + usages

```
public class ReportCalcSummary implements Serializable {
```

A new field

```
...
```

```
+ private Long impotReferRegulPosVla;
```

```
+ public Long getImpotReferRegulPosVla() {  
+   return impotReferRegulPosVla;}  
}
```

Its getter

```
+ public void setImpotReferRegulPosVla(Long impotReferRegulPosVla) {  
+   this.impotReferRegulPosVla = impotReferRegulPosVla;}  
}
```

Different usages of the field

Its setter

```
+   .append("impotReferRegulPosVla = ").append(this.impotReferRegulPosVla).append(TAB)  
...  
+   dto.setImpotReferRegulPosVla(new Long(0));  
...  
+   if (g8653 > 0) {dto.setImpotReferRegulPosVla(a(dto.getImpotReferRegulPosVla(), g8653));}  
...  
+   vo.setImpotReferRegulPosVla(dto.getImpotReferRegulPosVla());  
...  
}
```


Systematic edits overview

<i>Type</i>	<i># sys. edits</i>	<i>avg. instances</i>
<i>Adding similar call statements</i>	38	53
<i>Adding/removing similar fields</i>	33	96.26
<i>Adding similar if cases</i>	13	21.92
<i>Adding similar test cases</i>	12	51.67
<i>Generating similar classes</i>	5	8.2
<i>Formatting changes</i>	5	63.6
<i>Miscellaneous</i>	14	33.5
Total	120	

Systematic edits overview

Type	# sys. edits	avg. instances
<i>Adding similar call statements</i>	28	52

- ~16% of commits containing systematic edits
- ~7% of commits are systematic edits related to tax law changes → Likely to reoccur

<i>Formatting changes</i>	5	63.6
<i>Miscellaneous</i>	14	33.5
Total	120	

Cha-Q search-and-replace

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- Systematic edits are unavoidable

Cha-Q search-and-replace

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- Repetitive and error-prone if done manually

Cha-Q search-and-replace

- Systematic edits are unavoidable
- Repetitive and error-prone if done manually
- **Automate** it!
 - Only describe the similar change once
 - Tool can apply it to all locations

Example systematic edit

```
public class BreakStatement extends Statement {
    @EntityProperty(value = SimpleName.class)
    private EntityIdentifier label;

    public EntityIdentifier getLabel() {
        return label;
    }

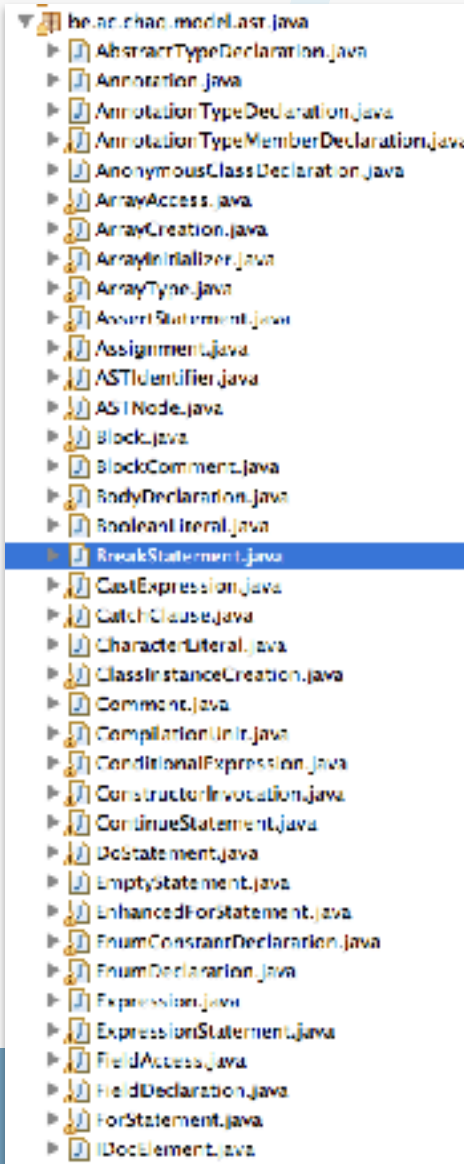
    public void setLabel(EntityIdentifier label) {
        this.label = label;
    }
}
```

Example systematic edit

```
public class BreakStatement extends Statement {
    @EntityProperty(value = SimpleName.class)
    private EntityIdentifier label;

    public EntityIdentifier getLabel() {
        return label;
    }

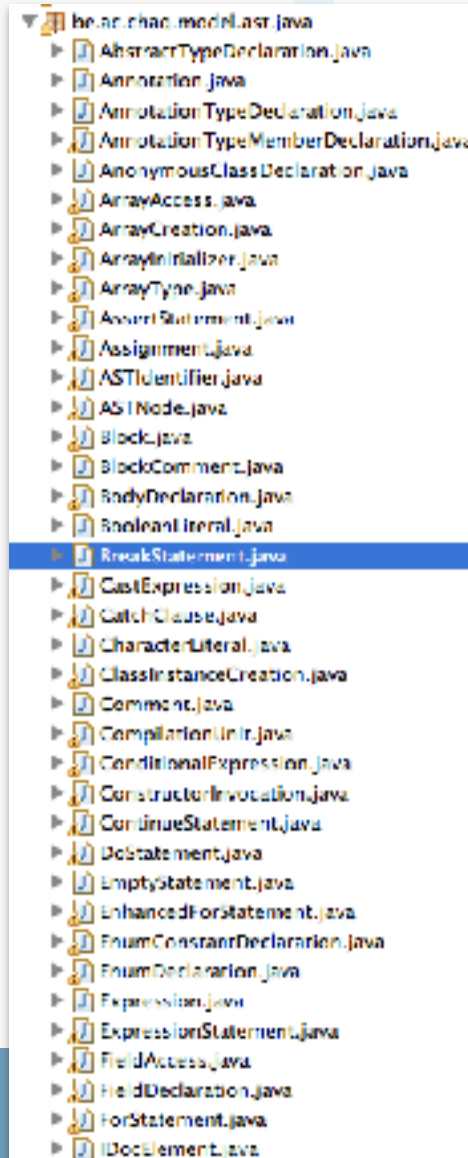
    public void setLabel(EntityIdentifier label) {
        this.label = label;
    }
}
```



Example systematic edit

A field of type EntityIdentifier

```
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier label;  
  
    public EntityIdentifier getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier label) {  
        this.label = label;  
    }  
}
```

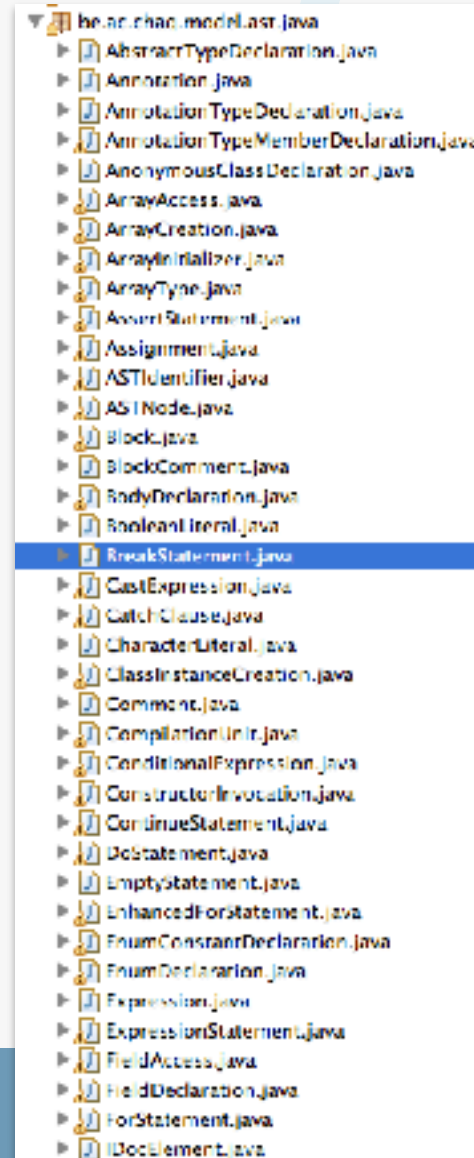


Example

An identifier of an entity .. but what kind of entity?

A field of type EntityIdentifier

```
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier label;  
  
    public EntityIdentifier getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier label) {  
        this.label = label;  
    }  
}
```



Example

An identifier of an entity .. but what kind of entity?

A field of type EntityIdentifier

```
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier label;  
  
    public EntityIdentifier getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier label) {  
        this.label = label;  
    }  
}
```

- ▶ be.an.chao.model.ast.java
- ▶ AbstractTypeDeclaration.java
- ▶ Annotation.java
- ▶ AnnotationTypeDeclaration.java
- ▶ AnnotationTypeMemberDeclaration.java
- ▶ AnonymousClassDeclaration.java
- ▶ ArrayAccess.java
- ▶ ArrayCreation.java
- ▶ ArrayInitializer.java
- ▶ ArrayType.java
- ▶ AssertStatement.java
- ▶ Assignment.java
- ▶ ASTIdentifier.java
- ▶ ASTNode.java
- ▶ Block.java
- ▶ BlockComment.java
- ▶ BodyDeclaration.java
- ▶ BooleanLiteral.java
- ▶ BreakStatement.java
- ▶ CastExpression.java
- ▶ CatchClause.java
- ▶ CharacterLiteral.java
- ▶ ClassInstanceCreation.java
- ▶ Comment.java
- ▶ CompilationUnit.java
- ▶ ConditionalExpression.java
- ▶ ConstructorInvocation.java
- ▶ ContinueStatement.java
- ▶ DoStatement.java
- ▶ EmptyStatement.java
- ▶ EnhancedForStatement.java
- ▶ EnumConstantDeclaration.java
- ▶ EnumDeclaration.java
- ▶ Expression.java
- ▶ ExpressionStatement.java
- ▶ FieldAccess.java
- ▶ FieldDeclaration.java
- ▶ ForStatement.java
- ▶ IDocument.java

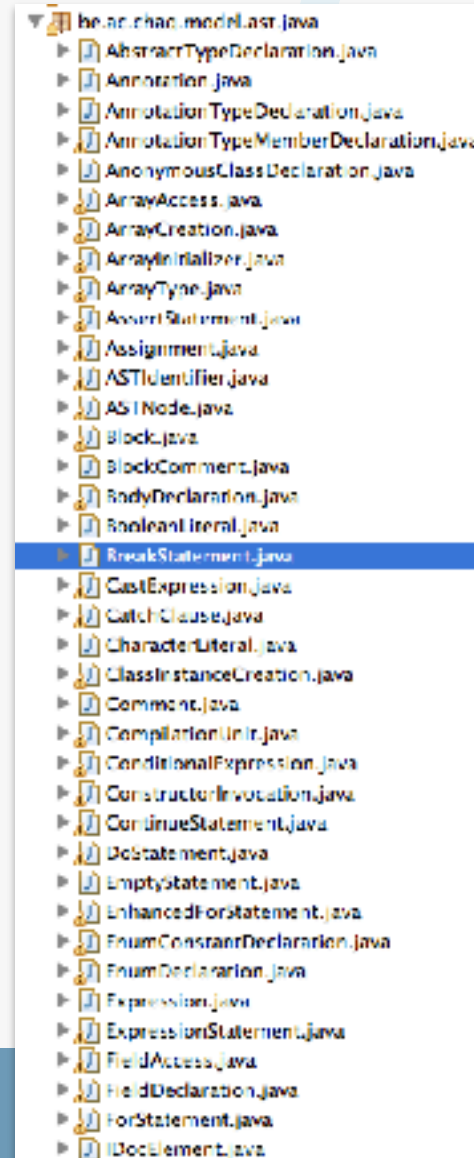
Example

An identifier of an entity .. but what kind of entity?

A field of type EntityIdentifier

```
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier label;  
  
    public EntityIdentifier getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier label) {  
        this.label = label;  
    }  
}
```

```
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier<SimpleName> label;  
  
    public EntityIdentifier<SimpleName> getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier<SimpleName> label) {  
        this.label = label;  
    }  
}
```



Example

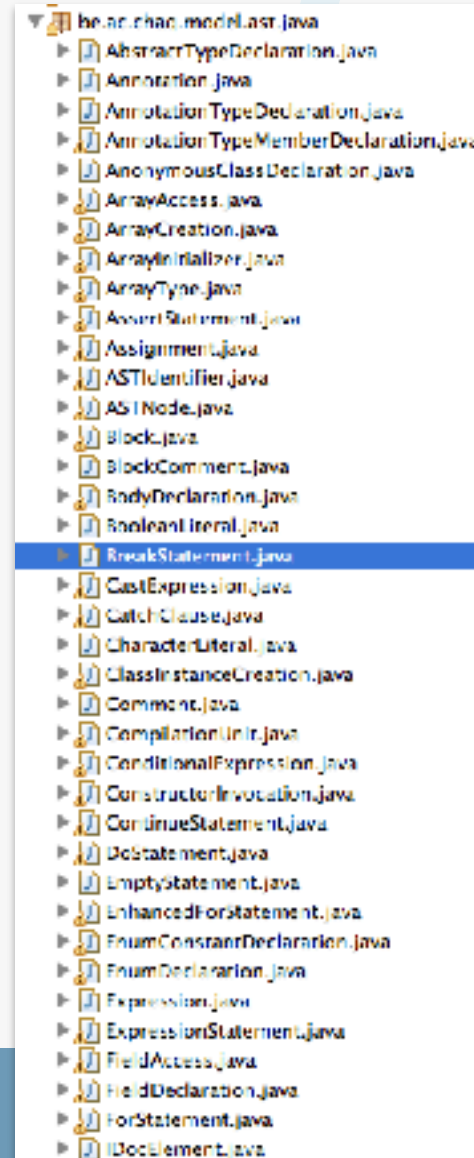
An identifier of an entity .. but what kind of entity?

A field of type EntityIdentifier

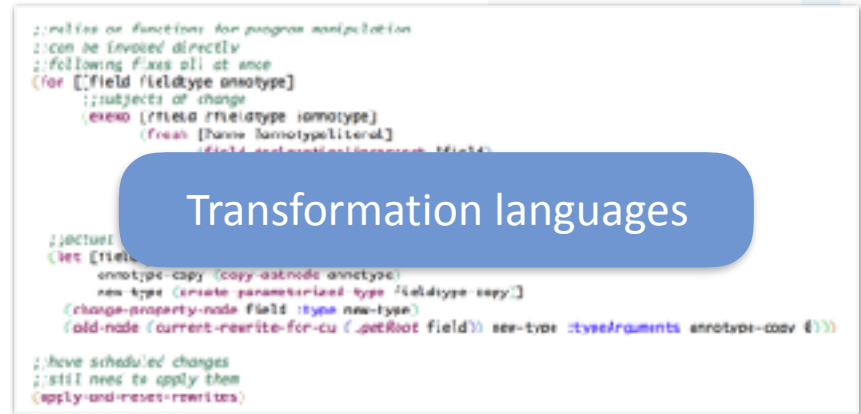
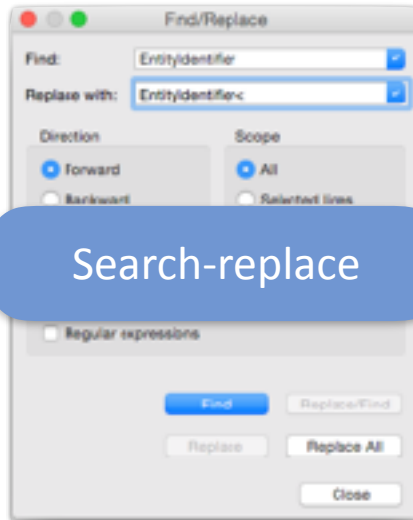
```
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier label;  
  
    public EntityIdentifier getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier label) {  
        this.label = label;  
    }  
}
```

Used as type parameter

```
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier<SimpleName> label;  
  
    public EntityIdentifier<SimpleName> getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier<SimpleName> label) {  
        this.label = label;  
    }  
}
```



State of the art: 2 extremes



Cha-Q search-and-replace



Java - /Users/soft/Documents/Github/damp.ekeko.snippets/damp.ekeko.snippets.plugin.test/resources/EkekoX-Specifi...

chac-demo1.ekx

```
private @EntityProperty(value=Expression.class) EntityIdentifier array;  
-> {  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

Overview Search Templates Replacement Templates

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekeko Console
Adding a new project to the Ekeko model: P/TestCase-TypeParameters
Populating JavcProjectModel for: TestCase-TypeParameters
Gathered information from JDT compilation units in 36ms

Cha-Q search-and-replace



The screenshot shows an IDE window with the following elements:

- File Name:** `chac-demo1.ekk`
- Code Editor:** Contains two lines of Java code:

```
private @EntityProperty(value=Expression.class) EntityIdentifier array;  
  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

The first line is highlighted with a pink box, and an orange arrow labeled "Search template" points to it.
- Search Bar:** Located below the code editor, with tabs for "Overview", "Search Templates", and "Replacement Templates".
- Bottom Panel:** Includes tabs for "Problems", "Javadoc", "Declaration", "Console", "Progress", and "Call Hierarchy".
- Console Output:** Shows the following text:

```
Ekeko Console  
Adding a new project to the Ekeko model: P/TestCase-TypeParameters  
Populating JavcProjectModel for: TestCase-TypeParameters  
Gathered information from JDT compilation units in 36ms
```


Cha-Q search-and-replace



The screenshot shows an IDE window with a Java file named 'chac-demo1.ekx'. The code is as follows:

```
private @EntityProperty(value=Expression.class) EntityIdentifier array;  
  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

Annotations highlight the search and replacement patterns:

- Search template:** `private @EntityProperty(value=Expression.class) EntityIdentifier array;`
- Replacement template:** `private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;`

The IDE interface includes a toolbar with 'Quick Access', 'Resource', and 'Java' buttons. Below the code editor are tabs for 'Overview', 'Search Templates', and 'Replacement Templates'. At the bottom, the 'Ekeko Console' shows the following output:

```
Ekeko Console  
Adding a new project to the Ekeko model: P/TestCase-TypeParameters  
Populating JavcProjectModel for: TestCase-TypeParameters  
Gathered information from JDT compilation units in 36ms
```

Cha-Q search-and-replace



The screenshot shows an IDE window titled "chac-demo1.ekx". The main editor area contains the following Java code:

```
private @EntityProperty(value=Expression.class) EntityIdentifier array;  
-> {  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

Below the code editor, there are tabs for "Overview", "Search Templates", and "Replacement Templates".

The bottom panel shows the "Ekeko Console" with the following output:

```
Ekeko Console  
Adding a new project to the Ekeko model: P/TestCase-TypeParameters  
Populating JavcProjectModel for: TestCase-TypeParameters  
Gathered information from JDT compilation units in 36ms
```



chaq-demo2.ekx

```
@EntityProperty(value=?annoType.class) private EntityIdentifier ...;  
=>  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

Overview Search Templates Replacement Templates

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekoko Console

```
Adding a new project to the Ekoko model: P/TestCase-TypeParameters  
Populating JavaProjectModel for: TestCase-TypeParameters  
Gathered information from JDT compilation units in 36ms
```

Placeholder variable



Demo 2

```
@EntityProperty(value=?annoType.class) private EntityIdentifier ...;  
=>  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

Overview Search Templates Replacement Templates

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekoko Console

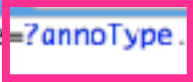
```
Adding a new project to the Ekoko model: P/TestCase-TypeParameters  
Populating JavaProjectModel for: TestCase-TypeParameters  
Gathered information from JDT compilation units in 36ms
```

Placeholder variable



Demo 2

```
@EntityProperty(value=?annoType.class) private EntityIdentifier ...;
```



Wildcard

```
private @EntityProperty(value=Expression.class) EntityIdentifier
```

Overview Search Templates Replacement Templates

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekeko Console

```
Adding a new project to the Ekeko model: P/TestCase-TypeParameters  
Populating JavaProjectModel for: TestCase-TypeParameters  
Gathered information from JDT compilation units in 36ms
```



chaq-demo2.ekx

```
@EntityProperty(value=?annoType.class) private EntityIdentifier ...;  
=>  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

Overview Search Templates Replacement Templates

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekeko Console

```
Adding a new project to the Ekeko model: P/TestCase-TypeParameters  
Populating JavaProjectModel for: TestCase-TypeParameters  
Gathered information from JDT compilation units in 36ms
```



Demo 2

```
@EntityProperty(value=?annoType.class) private EntityIdentifier ...;  
=>  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

ArrayAccess.java

```
package be.ac.chaq.model.ast.java;  
import ... EntityIdentifier; ...  
public class ArrayAccess extends Expression {  
    private @EntityProperty(value = Expression.class)  
    EntityIdentifier array;
```

This field was not found!

private @EntityProperty(value = Expression.class)
EntityIdentifier array;



chaq-demo3.ekx

```
[@EntityProperty(value=?annoType.class) private]@[match|set] EntityIdentifier ...;  
->                                     }  
  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

Overview Search Templates Replacement Templates

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekeko Console
Adding a new project to the Ekeko model: P/TestCase-TypeParameters
Populating JavaProjectModel for: TestCase-TypeParameters
Gathered information from JDT compilation units in 36ms

Demo 3

```
[@EntityProperty(value=?annoType.class) private]e[match|set] EntityIdentifier ...;
```

Directive, to add more control to searches

```
private @EntityProperty(value=Expression.class) Ent
```

Ekoko Console
Adding a new project to the Ekoko model: P/TestCase-TypeParameters
Populating JavaProjectModel for: TestCase-TypeParameters
Gathered information from JDT compilation units in 36ms

Demo 3

```
@EntityProperty(value=?annoType.class) private e[match|set] EntityIdentifier ...;
```

Attached to this piece of code

Directive, to add more control to searches

Overview Search Templates Replacement Templates

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekoko Console
Adding a new project to the Ekoko model: P/TestCase-TypeParameters
Populating JavaProjectModel for: TestCase-TypeParameters
Gathered information from JDT compilation units in 36ms



chaq-demo3.ekx

```
[@EntityProperty(value=?annoType.class) private]@[match|set] EntityIdentifier ...;  
->                                     }  
  
private @EntityProperty(value=Expression.class) EntityIdentifier<Expression> array;
```

Overview Search Templates Replacement Templates

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekeko Console
Adding a new project to the Ekeko model: P/TestCase-TypeParameters
Populating JavaProjectModel for: TestCase-TypeParameters
Gathered information from JDT compilation units in 36ms



chaq-demo4.ecc

```
[@EntityProperty(value=?annoType.class) private]@[matchset] [EntityIdentifier]@[equals ?fieldType] ...;
```

```
[EntityIdentifier<?annoType>]@[replace ?fieldType]
```

Overview Search Templates Replacement Templates

BreakStatement.java

```
import be.ac.chaq.model.entity.EntityIdentifier;

public class BreakStatement extends Statement {
    @EntityProperty(value = SimpleName.class)
    private EntityIdentifier label;

    public EntityIdentifier getLabel() {
        return label;
    }

    public void setLabel(EntityIdentifier label) {
        this.label = label;
    }
}
```

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekeko Console

This piece of code needs to change



Demo 4

chaq-demo4.eex

```
[@EntityProperty(value=?annoType.class) private]@[matchset] EntityIdentifier@[equals ?fieldType] ...;  
=>  
[EntityIdentifier<?annoType>]@[replace ?fieldType]
```

Overview Search Templates Replacement Templates

BreakStatement.java

```
import be.ac.chaq.model.entity.EntityIdentifier;  
  
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier label;  
  
    public EntityIdentifier getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier label) {  
        this.label = label;  
    }  
}
```

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekaka Console

This piece of code needs to change



Demo 4

```
[@EntityProperty(value=?annoType.class) private]@?[matchiset] EntityIdentifier @?(equals ?fieldType) ...;  
=>  
[EntityIdentifier<?annoType>]@?[(replace ?fieldType)]
```

?fieldType now refers to it

Overview Search Templates Replacement Templates

```
BreakStatement.java  
  
import be.ac.chaq.model.entity.EntityIdentifier;  
  
public class BreakStatement extends Statement {  
    @EntityProperty(value = SimpleName.class)  
    private EntityIdentifier label;  
  
    public EntityIdentifier getLabel() {  
        return label;  
    }  
  
    public void setLabel(EntityIdentifier label) {  
        this.label = label;  
    }  
}
```

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekaka Console



chaq-demo4.ecc

```
[@EntityProperty(value=?annoType.class) private]@[matchset] [EntityIdentifier]@[equals ?fieldType] ...;
```

```
[EntityIdentifier<?annoType>]@[replace ?fieldType]
```

Overview Search Templates Replacement Templates

BreakStatement.java

```
import be.ac.chaq.model.entity.EntityIdentifier;

public class BreakStatement extends Statement {
    @EntityProperty(value = SimpleName.class)
    private EntityIdentifier label;

    public EntityIdentifier getLabel() {
        return label;
    }

    public void setLabel(EntityIdentifier label) {
        this.label = label;
    }
}
```

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekeko Console

chaq-demo4.ecc

```
[@EntityProperty(value=?annoType.class) private]@([matchset] [EntityIdentifier]@([equals ?fieldType]) ...;
```

```
[EntityIdentifier<?annoType>]@(replace ?fieldType)]
```

Rewriting directive: replace the value of ?fieldType ..

BreakStatement.java

```
import be.ac.chaq.model.entity.EntityIdentifier;

public class BreakStatement extends Statement {
    @EntityProperty(value = SimpleName.class)
    private EntityIdentifier label;

    public EntityIdentifier getLabel() {
        return label;
    }

    public void setLabel(EntityIdentifier label) {
        this.label = label;
    }
}
```

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekaka Console

chaq-demo4.eex

```
@EntityProperty(value=?annoType.class) private]@[matchset] [EntityIdentifier]@[equals ?fieldType] ...;
```

```
[EntityIdentifier<?annoType>]@[replace ?fieldType]
```

.. with this new piece of code.

Rewriting directive: replace the value of ?fieldType ..

```
import be.ac.chaq.model.entity.EntityIdentifier;

public class BreakStatement extends Statement {
    @EntityProperty(value = SimpleName.class)
    private EntityIdentifier label;

    public EntityIdentifier getLabel() {
        return label;
    }

    public void setLabel(EntityIdentifier label) {
        this.label = label;
    }
}
```

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekaka Console



Demo 4

chaq-demo4.ecc

```
[@EntityProperty(value=?annoType.class) private]@[matchset] [EntityIdentifier]@[equals ?fieldType] ...;
```

```
[EntityIdentifier<?annoType>]@[replace ?fieldType]
```

Overview Search Templates Replacement Templates

BreakStatement.java

```
import be.ac.chaq.model.entity.EntityIdentifier;

public class BreakStatement extends Statement {
    @EntityProperty(value = SimpleName.class)
    private EntityIdentifier label;

    public EntityIdentifier getLabel() {
        return label;
    }

    public void setLabel(EntityIdentifier label) {
        this.label = label;
    }
}
```

Problems Javadoc Declaration Console Progress Call Hierarchy

Ekeko Console

Replace field declaration, getter and setter



- testCase-JDI-CompositeVisitor
- TestCase-TypeParameters Ekeko
- src
 - be.ac.chaq.change
 - be.ac.chaq.model.ast.java
 - AbstractTypeDeclaration.java
 - Annotation.java
 - AnnotationTypeDeclaration
 - AnnotationTypeMemberDe
 - AnonymousClassDeclarati
 - ArrayAccess.java
 - ArrayCreation.java
 - ArrayInitializer.java
 - ArrayType.java
 - AssertStatement.java
 - Assignment.java
 - ASTIdentifier.java
 - ASTNodes.java
 - Block.java
 - BlockComment.java
 - BodyDeclaration.java
 - BooleanLiteral.java
 - BreakStatement.java
 - CastExpression.java
 - CatchClause.java
 - CharacterLiteral.java
 - ClassInstanceCreation.java
 - Comment.java
 - CompilationUnit.java
 - ConditionalExpression.java
 - ConstructorInvocation.java
 - ContinueStatement.java
 - DoStatement.java
 - EmptyStatement.java

```
?modList class ?className {
  [ @... (value=?annoType.class) priv
  public [EntityIdentifier]@[child*
    return [?returned]@[refers-to
  }
  public void ?setterName( [Entity]
    [?assignee]@[refers-to ?field]
  }
  ]@[match|set]}
=>
[EntityIdentifier<?annoType>]@[refl
[EntityIdentifier<?annoType>]@[refl
[EntityIdentifier<?annoType>]@[refl
```

```
package be.ac.chaq.model.ast.java;

import java.util.List;

import be.ac.chaq.model.entity.EntityIdentifier;
import be.ac.chaq.model.entity.EntityListProperty;
import be.ac.chaq.model.entity.EntityProperty;

public class ArrayCreation extends Expression {
  @EntityProperty(value = ArrayType.class)
  private EntityIdentifier type;

  @EntityListProperty(value = Expression.class)
  private List<EntityIdentifier> dimensions;

  @EntityProperty(value = ArrayInitializer.class)
  private EntityIdentifier initializer;

  public EntityIdentifier getType() {
    return type;
  }
}
```

Executes search-and-replace.

ArrayCreation.java

Overview Search Templates "1"

Console Ekeko Query Results

Replace field declaration, getter and setter



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```
?modList class ?className {  
  [ @... (value=?annoType.class) priv  
  public [EntityIdentifier]@[child*  
    return [?returned]@[refers-to  
  }  
  public void ?setterName( [Entity]  
    [?assignee]@[refers-to ?field]  
  }  
  ]@[match|set]}  
=>  
[EntityIdentifier<?annoType>]@[refl  
[EntityIdentifier<?annoType>]@[refl  
[EntityIdentifier<?annoType>]@[refl
```

```
package be.ac.chaq.model.ast.java;  
  
import java.util.List;  
  
import be.ac.chaq.model.entity.EntityIdentifier;  
import be.ac.chaq.model.entity.EntityListProperty;  
import be.ac.chaq.model.entity.EntityProperty;  
  
public class ArrayCreation extends Expression {  
  @EntityProperty(value = ArrayType.class)  
  private EntityIdentifier type;  
  
  @EntityListProperty(value = Expression.class)  
  private List<EntityIdentifier> dimensions;  
  
  @EntityProperty(value = ArrayInitializer.class)  
  private EntityIdentifier initializer;  
  
  public EntityIdentifier getType() {  
    return type;  
  }  
}
```

Console Ekeko Query Results

Executes search-and-replace.

Cha-Q search-and-replace

Cha-Q search-and-replace

- FOD Financiën pilot study:
 - ~62% of systematic edits can be fully automated
 - Remainder can be partially automated

Cha-Q search-and-replace

- FOD Financiën pilot study:
 - ~62% of systematic edits can be fully automated
 - Remainder can be partially automated
- What can Cha-Q search-and-replace do for *you*?



find and fix all occurrences of the same bug



upgrade existing clients to a newer API version



create custom refactorings



co-maintain multiple system variants



evolve existing code to newer versions of Java



automate repeating maintenance tasks

Cha-Q search-and-replace

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