Manipulating Java Programs

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A guided tour through code manipulation services

- Java Model
- Search Engine
- Abstract Syntax Tree & AST Rewriting
- Refactoring

Each part is associated with examples

- **Encapsulate field**: create getter/setter methods for a field and use only those to access the field

  ```java
class Example {
    public String name;

    public void main(String[] args) {
      System.out.println(example.name);
    }
}
```

  ```java
class Example {
  private String name;

  public String getName() { return name; }
  public void setName(String name) { ... }

  public void main(String[] args) {
    System.out.println(example.getName());
  }
}
```

- **Rename method**: rename the method’s declaration and update all references to it

  ```java
class Example {

  public void main(String[] args) {
    System.out.println(example.name);
  }
}
```
The Java Model – `org.eclipse.jdt.core`

- Render entire workspace from Java angle
  - using .classpath
    - classpath entry is package fragment root
    - can even denote JAR outside workspace
  - granularity down to individual fields or methods

- Pure source model
  - accurate independently of build actions
  - fault-tolerant
  - no resolved information

- Handle/Info design
  - scalability: model non exhaustive
  - info lazily populated, LRU cache
  - stable handle
The Java Model Offering

- Navigation
- Type hierarchies
- Self-updating with change notification
- Basic modifying operations
- Many more…
  - code completion, selection
  - formatting, sorting
  - resolving, evaluating
Using the Java Model

- Check status of Java element to be manipulated
  - is the element declared in a class file, is it final, …
  - is the code syntactically correct

- Type hierarchies – rename method
  - ripple effect computation

```java
interface I1 {
    void foo();
}

interface I2 {
    void foo();
}

Class C1 extends I1, I2 {
    public void foo(){};
}

Class C2 extends I2 {
    public void foo(){};
}
```

- check if renamed method overrides existing method or is overridden in subclass
The Search Engine – `org.eclipse.jdt.core.search`

- Pattern-based
  - construct: package, type, field, method, constructor
  - occurrence: declaration, reference, read/write-access, extends/implements
  - wildcards: find all references to any method foo (any arguments)
  - pattern can also be based on Java element

- Scoped search
  - scope = set of Java elements
  - predefined workspace and hierarchy scopes

- Match contains details
  - range information, accuracy, enclosed element

- Indexing
  - pure source, updated automatically in background
  - built-in support to perform concurrent queries
  - looking up in indexes to find possible document matches

- Locating
  - document matches are processed to issue actual search matches
Using the Search Engine

- Find references to affected code
- Anticipate semantic changes – rename method

```java
public class Example {
    public void set(Object o) { ... };
    public void set(String s) { ... };
    void client() {
        set(new String());
    }
}
```

- Rename setString to set

- Compute set of conflicting elements: {Example#set(Object)}
  - name of the conflicting element is equal to new name
  - conflicting element is overloaded, shadowed or hidden by the refactored element

- Determine references to conflicting elements: set1= {Example#client()}
- Perform the refactoring in memory
- Determine references to conflicting elements: set2= { }
- A semantic change occurred if set1 != set2
Abstract Syntax Tree – org.eclipse.jdt.core.dom

- Zooming in a compilation unit
  - a node for every construct in the language
  - source range
  - editable, with some simple validation

- Pure source model
  - instant life-cycle, fully populated
  - can resolve all references to bindings
  - bindings are fully connected

- Analysis using visitor

- Limitations in 2.1
  - cannot persist edits
  - cannot reify all comments
  - cannot create AST on arbitrary sources
Using the Abstract Syntax Tree

- Perform advanced precondition checks – encapsulate field
  
  **Original Code**
  
  ```java
  foo(field++);
  public void visit(PostfixExpression node) {
    checkIfNodeRepresentsField();
    ASTNode parent = node.getParent();
    if (!(parent instanceof ExpressionStatement))
      warnUser();
    ...
  }
  ```

  **Refactored Code**
  
  ```java
  int temp = getField();
  setField(temp + 1);
  foo(temp);
  ```

  **Gather additional information to manipulate code – encapsulate field**

  ```java
  foo(++field);
  public void visit(PrefixExpression node) {
    checkIfNodeRepresentsField();
    ASTNode parent = node.getParent();
    if (!(parent instanceof ExpressionStatement))
      fSetterMustReturnValue = true;
    ...
  }
  ```

  ```java
  foo(setField(getField() + 1));
  ```
AST Rewriting – org.eclipse.jdt.core.dom

- Instead of manipulating the source code change the AST and write changes back to source

- Descriptive approach
  - describe changes without actually modifying the AST
  - allow reuse of the AST over several operations
  - support generation of a preview

- Modifying approach
  - directly manipulates the AST
  - API is more intuitive
  - implemented using the descriptive rewriter

- Rewriter characteristics
  - preserve user formatting and markers
  - generate an edit script
Using AST Rewriting

Original Code

```java
public class Example {
    String field;
    public void foo() {
        field= "EclipseCon" + /*…*/ "2004";
    }
}
```

Refactored Code

```java
public class Example {
    String field;
    public void foo() {
        setField("EclipseCon" + /*…*/ "2004");
    }
}
```

Code snippet demonstrating the rewriter

```java
final ASTRewrite rewrite= new ASTRewrite(root);
root.accept(new ASTVisitor() {
    public boolean visit(Assignment assignment) {
        // check if affected
        AST ast= assignment.getAST();
        MethodInvocation setter= ast.newMethodInvocation();
        setter.setName(ast.newSimpleName(setterName));
        setter.arguments().add(rewrite.createMoveTarget(assignment.getRightHandSide()));
        rewrite.replace(assignment, setter);
    }
});

TextEdit edit= rewrite.rewriteAST(document);
```
Code Manipulation Toolkits

- Refactoring – org.eclipse.refactoring
  - refactorings - org.eclipse.refactoring.core.Refactoring
    - responsible for precondition checking
    - create code changes
  - code changes - org.eclipse.refactoring.core.Change
    - provide Undo/Redo support
    - support non-textual changes (e.g. renaming a file)
    - support textual changes based on text edit support
  - user interface is dialog based

- Quick fix & Quick Assist – org.eclipse.jdt.ui.text.java
  - AST based
  - processors - org.eclipse.jdt.ui.text.java.IQuickFixProcessor
    - check availability based on problem identifier
    - generate a list of fixes
  - user interface is provided by editor
Open-up Search – `org.eclipse.jdt.core.search`

- Evolve search into a framework for searching in Java-like languages:
  - JSP, SQLJ, ...

- Framework provides:
  - pluggable search participant, e.g. `JavaParticipant`
  - built-in index infrastructure
  - scheduling queries and background indexing activity
  - extensible patterns
  - combining multiple participants in one search

- Each participant describes specifics for a language
  - indexing: parsing a document for indexing
  - locating: resolve and find matches in one document

- Participants can cooperate and delegate to each other
  - e.g., translate JSP to Java equivalent, and delegate to Java participant
Open-up Refactoring – org.eclipse.refactoring.core

- Provide language independent refactoring API
- Enable other plug-in to participate in certain refactorings
  - generic refactorings for rename, move, delete, …
    - update JSPs when renaming types, methods, …
    - update `<a href="…”>` tags when moving HTML file
  - language specific refactorings
    - update JSPs and SQLJ when changing method signature

- Refactoring is split into
  - one processor
    - comparable to a single “closed” refactoring
    - define user interface
  - 0..n participants
    - each participant provides domain specific precondition checking and code changes
    - cannot contribute to the user interface
Summary

- JDT delivers powerful program manipulation services
  - Java Model, Search engine and DOM AST
  - provided through Eclipse Java IDE
  - but also in headless mode (can be used programmatically)
    - Visual Editor, EMF, metric tools, ...

- New in 3.0
  - AST rewriting API
  - Refactoring & Quick Fix becomes API
  - ability to participate in Search & Refactoring

- Community feedback is essential
  - bug reports:  http://bugs.eclipse.org/bugs
  - mailing lists: http://www.eclipse.org/mail/index.html
  - newsgroups: news://news.eclipse.org/eclipse.tools.jdt
Questions

Martin Aeschlimann  Jérôme Lanneluc  Kai-Uwe Mätzel
André Weinand  Tom Eicher
Kent Johnson  Jim des Rivières  Philippe Mulet
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