A Small Extension to Java for Class Refinement

Muga Nishizawa and Shigeru Chiba
(Tokyo Institute of Technology, Japan)

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Class Refinement for Software Evolution

- Extend an existing class without modifying its source code

```
class Point  {
    int x, y;
    void setX(int nx) {
        x = nx;
    }
    void setY(int ny) {
        y  = ny;
    }
}
```

```
refine Point  {
    void setX(int x) {
        System.out.println("x :" + x);
        super.setX(x);
    }
    void print() {
        System.out.println(x + ", " + y);
    }
}
```

Dynamic Class Refinement

- Turn refinement on and off during runtime

```
class WebApp {
    static Session context;
    String price(int itemNo) { .. }
            :
}
                    refine  WebApp when context.lang == “jp” {
                        String price(int itemNo) {
                            return toYen(super.price(itemNo)) + “ yen”;
                        }
                    }
```

The GluonJ Language

- Static/dynamic class refinement for Java
- Design goals
  - A normal Java syntax + Java annotations
    - No new language syntax
    - Programming with a normal Java IDE + compiler
  - Manageable runtime type errors
    - Runtime type errors should occur at only limited places
    - Compile-time type checking to a certain degree

Manageable Runtime Type Errors

- Without this, dynamic-refinement causes runtime type errors at too many places

```
class Point {
    int x, y;
    int setX(int nx) { x = nx; }
}

Point p = … ;
p.add(new Observer());
p.setX(0);
p.print();
```

This causes a type error
If Main.debug is false.

appended.

```
refine  Point when Main.debug {
    void print() { … }
    List observer;
    void add(Observer o) { .. }
    void notify() { .. }
    void setX(int ny) { notify(); … }
}
```

Syntax of GluonJ

- It is described as a subclass of the original class.

```
@Glue class Logging {
    @Refine static class BookLogger extends Book {
        @Override int getPrice() {
            System.out.println(price);
            return super.getPrice();
        }
    }
}
```

The @Refine class refines a Book class.

An @Glue class groups @Refine classes related to each other

Indicates the Book class

Calling an Appended Method

- To call a newly appended method, an instance of its target class must be cast

```
Book b = …;
((BookPrinter)b).print();
```

From the type of an original class to the type of an @Refine class

```
@Glue class Printing {
    @Refine static class BookPrinter extends Book {
        void print() {
            System.out.println(“book[“ + title + “,” + price + “]”);
        }
    }
}
```

Bytecode Instrumentation

- A class refinement is directly applied to the bytecode of the original class definition.

```
class Book {
    int getPrice() {
        System.out.println(price);
        return orig_getPrice();
    }
    int orig_getPrice() {
        return price;
    }
}
```

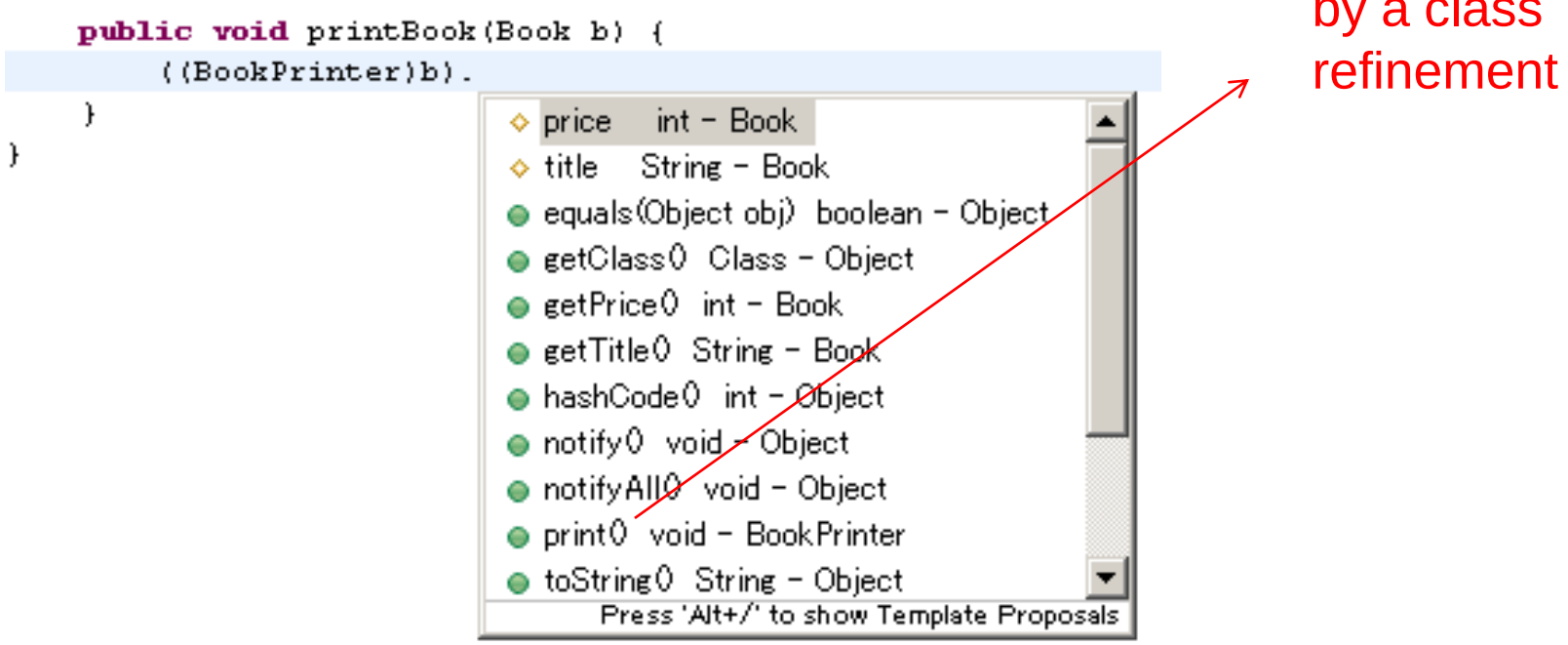
Overridden by @Refine

super.getPrice() is replaced

The original getPrice() is renamed.

Programming with a Java IDE

- An @Refine class is a standard subclass
- Enjoy a code assist by a Java IDE
  - A Java IDE recognizes methods/fields appended by @Refine classes



Dynamic-Refinement

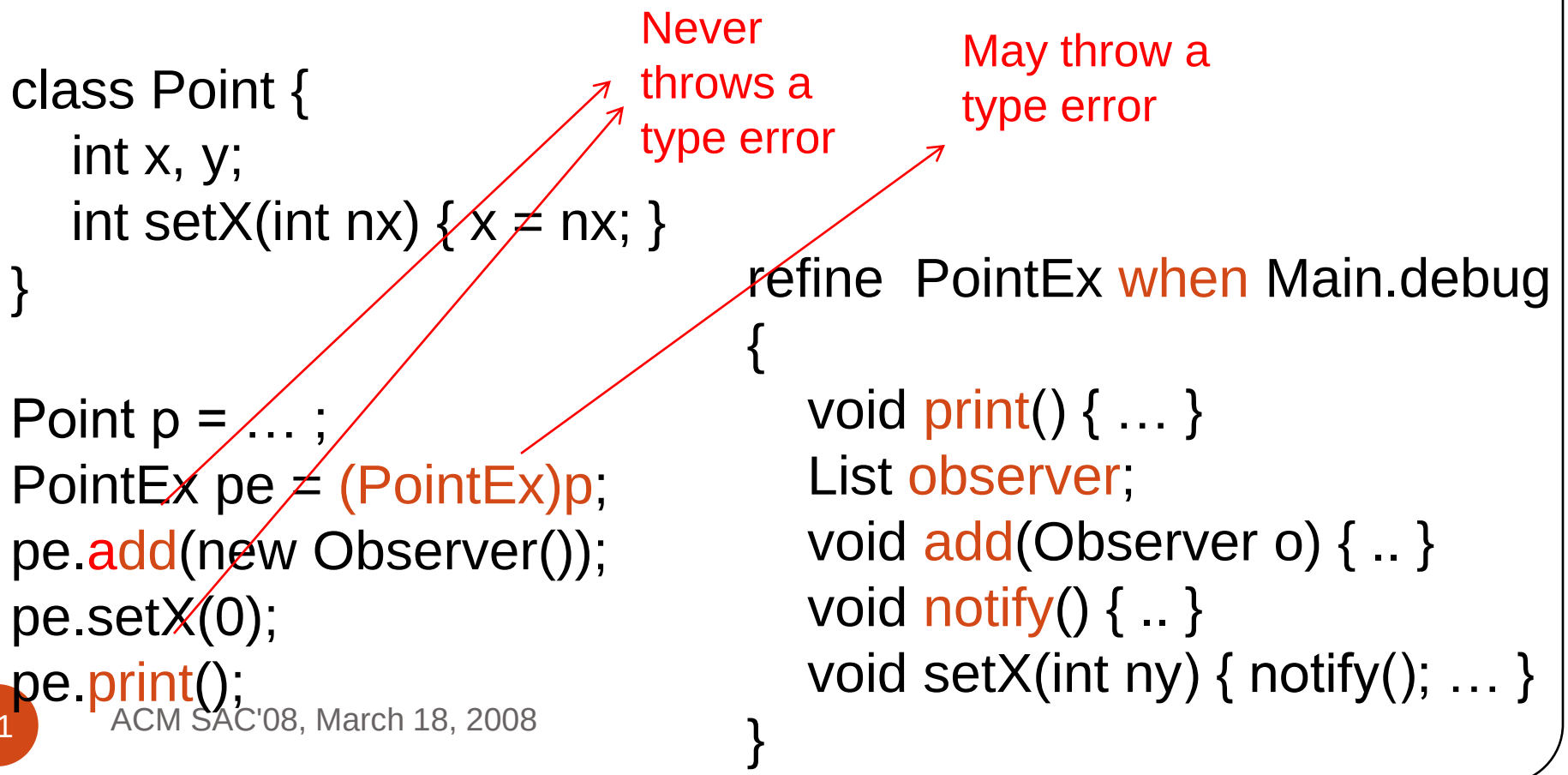
- Effective while the specified method is running.
  - Methods/fields are appended to all instances of the target class during that time.

Print() is appended only
while getBookPrice() is running.

```
@Cflow("void BookStore.getBookPrice(Book)")
@Glue class CflowPrinting {
   @Refine static class BookPrinter extends Book {
      void print() {
         System.out.println("book[" + title + "," + price + "]");
      }
   }
}
```

No `NoSuchMethodError` thrown

- For manageable type errors
  - Only explicit type casts may throw a type error.



Bytecode instrumentation (again)

- All methods/fields in an @Refine class are appended.
- Cast opeartor
  - Before type cast, insert a code for checking whether or not the @Refine class is effective.
  - replace all occurrences of the type name of refinement classes with their target class names.
- Methods
  - Throw NoSuchMethodError if the @Cflow condition is not satisfied.

Coding constraints

- For manageable type errors
  - Once an explicit type cast succeeds, a type error never happens
    - because the @Refine class is effective during the lifetime of the value.
  - The value never escapes from the dynamic scope where the @Refine class is effective.
  - Constraints
    - The value after the type cast cannot be saved in a non-local storage such as a field.
    - This is statically checked.

Coding Constraints (cont.)

Let *G* is an @Glue class associated with @Cflow and let *G* include a @Refine class *R*

- 1. A field of the type *R* appears only within *G*.
- 2. The type *R* is not the return type or one of the parameter types of the method specified as the argument to @Cflow.
- 3. *R* is not an exception type (i.e. a subclass of Throwable). It is not the parameter to a catch clause.
- 4. The refinement class *R* does not override a static method in its original class.

Related Work

- Class Refinement
  - E.g. eJava [Warth'06], AspectJ [Kiczales'01]
  - ContextJ [Costanza'06], CaesarJ [Aracic'06]

- Extended Java languages
  - AspectJ5, JBoss AOP, AspectWerkz
  - Ad-hoc design with Java annotations
    - Thus such extensions are not understood by a normal Java IDE

Conclusion

- GluonJ
  - Static/dynamic class refinement for Java
    - Class refinement is useful for software evolution
- The Design goals of GluonJ
  - A normal Java syntax + Java annotations
    - No new language syntax
    - Programming with a normal Java IDE + compiler
  - Manageable runtime type errors
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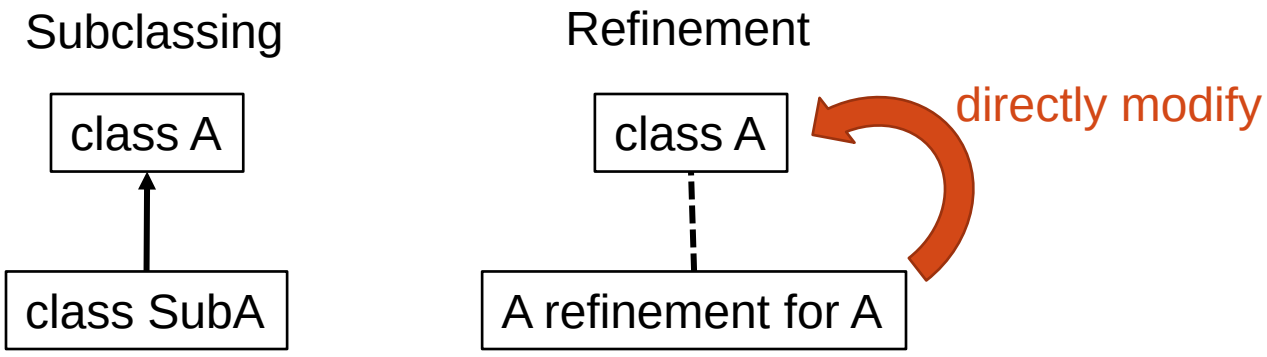
Thank you

Class Refinement

- An effective technology for software evolution
- Its concept is similar to subclassing, mixins
  - It allows separating an extension to a class as a module
- E.g.
  - Changing an existing method in its class
  - Adding new methods, fields, interfaces to an existing class

The Benefit of Refinement

- Unlike subclassing and mixins,
  it directly modifies the definition of a class



- Editing an original source code is NOT necessary
  - A client does not need to explicitly create an instance of the extended version of that class

Various Refinements

- Static-refinement
  - It allows statically changing the structure of a class
  - E.g. eJava [Warth'06], AspectJ [Kiczales'01]
  - E.g. ContextJ [Costanza'06], CaesarJ [Aracic'06]
- Dynamic-refinement
  - It allows switching refinements to a class according to dynamic contexts
- These features are useful for modularly extending and customizing a program