Around Weaving in abc

Objectives

- Avoid heap allocations
- Inlining not as the general strategy
  - to avoid code duplication
- Keep code in original classes
  - to avoid visibility problems

The starting point

- Around advice ⇒ advice method
  - same return type
  - arguments matching the advice formals
    - plus arguments for thisJoinpoint etc.
- `proceed` statement ⇒ call to dummy method
- Dynamic residue AST
  - includes all the bindings
  - (can fail)

Review: Closure strategy

- closure interface:

```
public interface AroundClosure$1 {
  public [ret-type] proceed([arg-type] arg1, ...);
}
```

- advice method:

```
[ret-type] adviceMethod$1(AroundClosure$1 closure,
                          [arg-type] arg1, ...) {
  ...
  [ret-type] result=closure.proceed(arg1', ...);
  ...
  return result;
}
```

Review: Closure strategy (2)

- Closure instantiation

```
public class ShadowClass {
    public void shadowMethod() {
          AroundClosure$1 closure=new
                  AroundClosure$1$Implementation$1();
          ...store additional information...
          Aspect.aspectOf().adviceMethod$1(closure, arg1, ...);
    }
    ...
}
```

- Closure implementation

```
public class AroundClosure$1$Implementation$1 implements AroundClosure$1 {
    public [ret-type] proceed([arg-type] arg1, ...) {
          ... do what the shadow did...
    }
}
```

Avoiding the closure (1)

- Using the object itself
  - simply add an interface to the class of the shadow

```
public class ShadowClass implements AroundClosure$1
{
   public [ret-type] proceed([arg-type] arg1, ...) {
       ...do what the shadow did...
   }
   public void shadowMethod()  {
       Aspect.aspectOf().adviceMethod$1(this,
             arg1, ...);
   }
}
```

Avoiding the closure (2)

- Problem: The same advice can apply multiple times within the same class
- Solution: the shadow ID

Shadow ID

```
public class ShadowClass implements AroundClosure$1 {
   public [ret-type] proceed(int shadowID, [arg-type] arg1, ...) {
        switch(shadowID) {
        case 0:
                ... do what the first shadow did...
        case 1:
                ... do what the second shadow did...
        }
   }
   public void shadowMethod() {
        Aspect.aspectOf().adviceMethod$1(this, 0, arg1, ...);
   }
   public void anotherShadowMethod() {
        Aspect.aspectOf().adviceMethod$1(this, 1, arg1, ...);
   }
}
```

Shadow ID (2)

- Problem: inheritance
  - subclasses may need to implement the same interface, but this overrides the original implementation of the superclass
- Solution: unique shadow ID, super() call

Shadow ID (3)

```
public class ShadowClassExt extends ShadowClass
                                implements AroundClosure$1 {
   public [ret-type] proceed(int shadowID, [arg-type] arg1, ...) {
        switch(shadowID) {
        case 2:
                ... do what the shadow did...
                break;
        default:
                super(shadowID, arg1, ...);
        }
   }
   public void anotherShadowMethod() {
        Aspect.aspectOf().adviceMethod$1(this, 2, arg1, ...);
   }
}
```

Static methods

- Problem: shadows in static methods.
  - which object instance do we pass as the closure?
  - ideas:
    - create a temporary instance
    - use a singleton instance

Static Class ID

- Solution: the static class ID.
  - assign a unique integer ID to each class
  - implement a static proceed method where necessary.
  - pass this ID to the advice method
  - transform each proceed call into a switch statement

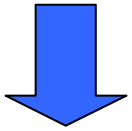
Static Class ID (2)

- static proceed method, unique id

```
public class ShadowClass implements AroundClosure$1 {
   public static[ret-type] proceed_s(int shadowID,
                            [arg-type] arg1, ...) {
       switch(shadowID) ... as before ...
   }
   public static shadowMethod() {
       Aspect.aspectOf().adviceMethod$1(null, 0,
             1, arg1, ...);
   }
}
```

Static Class ID (3)

```
[ret-type] adviceMethod$1(AroundClosure$1 closure, int shadowID,
   [arg-type] arg1, ...) {
   ...
   closure.proceed(shadowID, arg1, ...);
   ...
}
```



```
[ret-type] adviceMethod$1(AroundClosure$1 closure, int shadowID,
   int staticClassID, [arg-type] arg1, ...) {
   ...
   switch (staticClassID) {
   case  0: closure.proceed(shadowID, arg1, ...); break;
   case  1: ShadowClass.proceed_s(shadowID, arg1, ...); break;
   ...
   }
   ...
}
```

Static Class ID (4)

- This method for the static cases can also be used for the non-static cases
- Tests indicate that this method is slightly faster

Transferring joinpoint context

- abc adds arguments to the advice method and the proceed method to carry the context
  - no heap allocations
- Problem: advice can apply to different joinpoints with different context
- Solution: add enough arguments to handle all the cases

Transferring joinpoint context (2)

- Mapping types
  - all reference types: Object
  - simple types are mapped to themselves
    - int-like types (short, byte, boolean and char) are mapped to int
  - (possibility of using exact reference types to avoid casts)
- This approach does not need boxing/unboxing for simple types

Transferring joinpoint context (3)

```
public class Foo {
    public static void main(String args[]) {
        new Foo().bar1("test");
        new Foo().bar2(1.0d);
    }
    public void bar1(String s) {}
    public void bar2(double d) {}
}
aspect Aspect {
    void around(): call(void *.bar*(..)) {
        proceed();
    }
}
```

Transferring joinpoint context (4)

```
public class Foo {
    public static void proceed$1(int shadowID,
       java.lang.Object contextArg1,
       double           contextArg2,
       java.lang.Object contextArg3)  {

       switch (shadowID) {
            case 0: ((Foo)contextArg1).test2(contextArg2);
                return;
            case 1: ((Foo)contextArg1).test1(contextArg3);
                return;
        default: throw new RuntimeException();
        }
   }
   public static void main(java.lang.String[] r0) {
        Foo target1 = new Foo();
        Aspect.aspectOf().adviceMethod$1(1, 1, target1, 0.0, "test");
        Foo target2 = new Foo();
        Aspect.aspectOf().adviceMethod$1(0, 1, target2, 1.0, null);
        return;
   }
   ...
}
```

Transferring joinpoint context (5)

```
class Aspect {
   final void adviceMethod$1(int shadowID,
        java.lang.Object contextArg1,
        double           contextArg2,
        java.lang.Object contextArg3)
   {
        ...
        Foo.proceed$1(shadowID,
               contextArg1,
               contextArg2,
               contextArg3);
        ...
        return;
   }
   ...
}
```

Binding context

- When skipping the advice, the advice formals must be ignored
- The Skip Flag indicates this to the proceed method

Skip Flag

- Example program

```
public class Foo
{
   public static void main(String args[])
   {
       new Foo().bar(0);
   }
   public void bar(int i) {}
}
aspect Aspect
{
    void around(int intArg):
        call(void *.bar*(..)) &&
        args(intArg) &&
        target(Foo)
    {
        proceed(intArg);
    }
}
```

Skip Flag (2)

```
public class Foo {
   public static void proceed$0(
        int intArg, // advice formal
        int shadowID, boolean skipFlag,
        java.lang.Object contextArg1, int contextArg2 ) {

        int arg;
        switch(shadowID) {
             case 0:
                 if (skipFlag)
                      arg=contextArg2; // unbound case
                  else
                      arg=intArg;      // bound case

                  Foo callTarget=(Foo)contextArg1; // never bound
                  callTarget.bar(arg);
                  break;
             default:  throw new RuntimeException();
         }
   }
   ...
```

Skip Flag (3)

```
public class Foo {
   ...
   public static void main(String args[])    {
        Foo foo=new Foo();
        int i=0;
        if (foo instanceof Foo) {
                // residue passed
                Aspect.aspectOf().adviceMethod$0(…);
        } else {
                // residue failed
                proceed$0(
                      …,
                       true,  // skip flag
                      …);
        }
   }
   public void bar(int i) {}
}
```

Alternative bindings

```
aspect Aspect {
    void around(String s): call(void *.foo*(..)) &&
        (args(s,..) ||  args(.., s))
    {
        proceed("new");
    }
}
public class Foo {
   public static void main(String args[]) {
       new Foo().foo("string", new Integer(0));
       new Foo().foo(new Integer(0), "string");
   }
   public void foo(Object ob1, Object ob2) {
       System.out.println(ob1 + ", " + ob2);
   }
}
```

Output:

```
new, 0
0, new
```

Alternative bindings (2)

```
public class Foo {
    public static void main(String args[]){
       Foo foo=new Foo();
       Object arg1="string";
       Object arg2=null;
       String adviceFormal;
       int bindMask=0; // initialization
       label_0: {
           if (arg1 instanceof String) {
               adviceFormal=arg1;
               bindMask|=0; // removed by optimizer
           } else {
               if (arg2 instanceof String) {
                   adviceFormal=arg2;
                   bindMask|=2; // set bit 1
               } else  { // skipped case
                   bindMask=1; // set skip flag
                   adviceFormal=null;
                   proceed_s$0(adviceFormal, 0, bindMask, foo, arg1, arg2);
                   break label_0;
               }
           }
           Aspect.aspectOf().adviceMethod$0(
               adviceFormal, null, 0, 1, bindMask, foo, arg1, arg2);
       }
    …
}
```

Alternative bindings (3)

```
public class Foo {
   public static void proceed_s$0(String s, int shadowID, int bindMask,
       Object contextArg1, Object  contextArg2, Object contextArg3) {
       …
       Object arg1;
       Object arg2;
       if (bindMask==1) { // skip case
          arg1=contextArg2;
          arg2=contextArg3;
       } else {
          arg1=contextArg2; // first assign the default context
          arg2=contextArg3;
          switch ((bindMask & 2) >> 1) { // then overwrite the bound value
       case 0: arg1 = s; break;
            case 1: arg2 = s; break;
            default: throw new RuntimeException();
          }
       }
       Foo foo(Foo)contextArg1; // never bound
       foo.foo(arg1, arg2);
       …
   }
```

Local and anonymous classes

- Problem: `proceed` in local/anonymous classes
  - can occur at an arbitrarily deep nesting level
- Solution: All relevant parameters of the advice method are stored as dedicated fields in each class at the outermost nesting level
- Classes at a deeper nesting level refer to the enclosing outermost class

Advice execution

- Around-advice applying to the execution of around-advice
- Weaving is done as described
- Problem: once an advice method has been woven into, it itself cannot be woven anymore
- Solution: topological sort of graph of applications

Circular advice execution

- Detected by topological sort
- Once an advice method has been woven into, use closure approach
  - closure simply implements interface of that advice method
- Closures or similar construct necessary

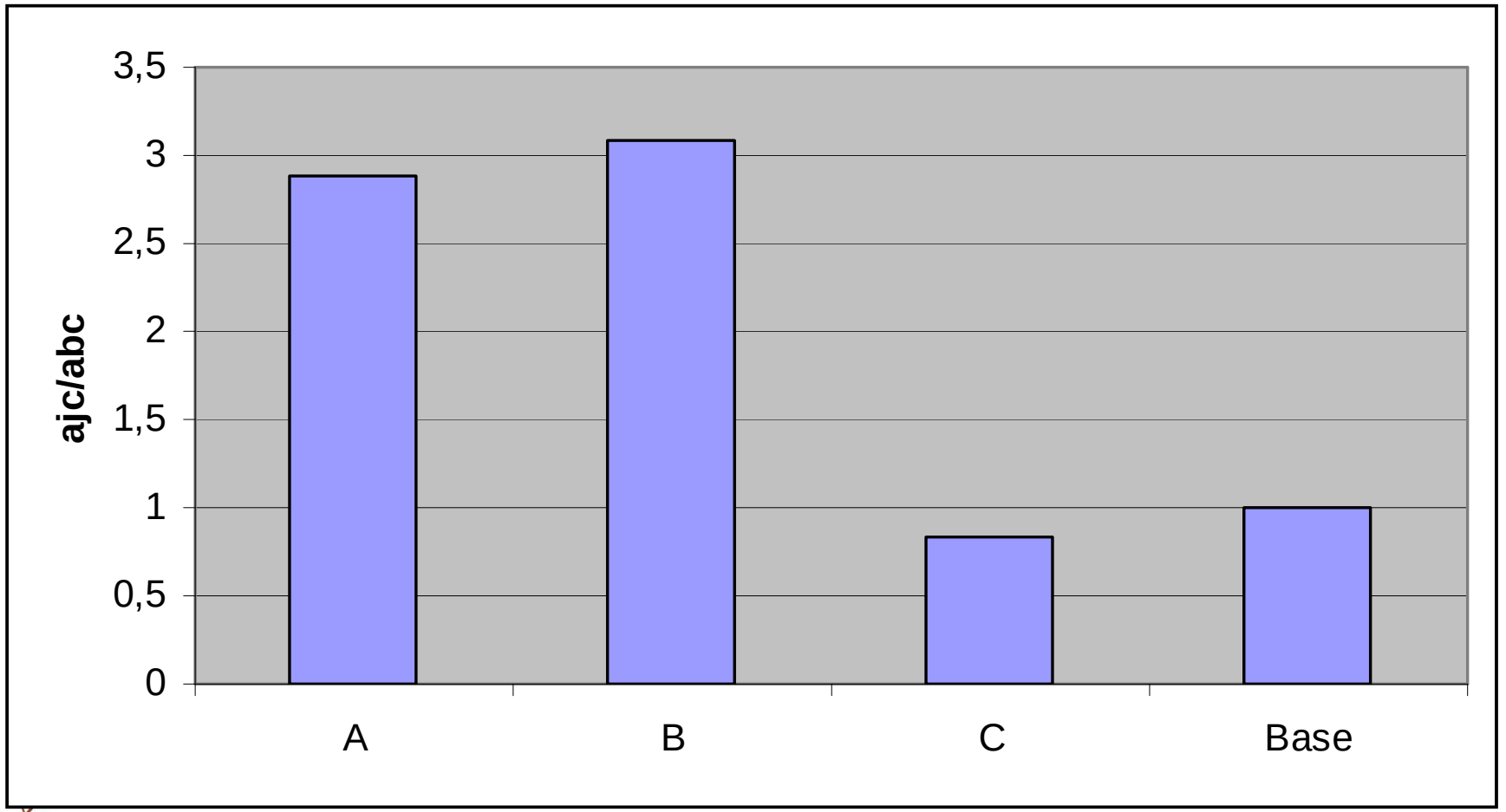
Closures

- Dedicated fields for all values
  - no Object array
- Actual shadow is moved to static method inside of original class
- No closure creation if residue fails

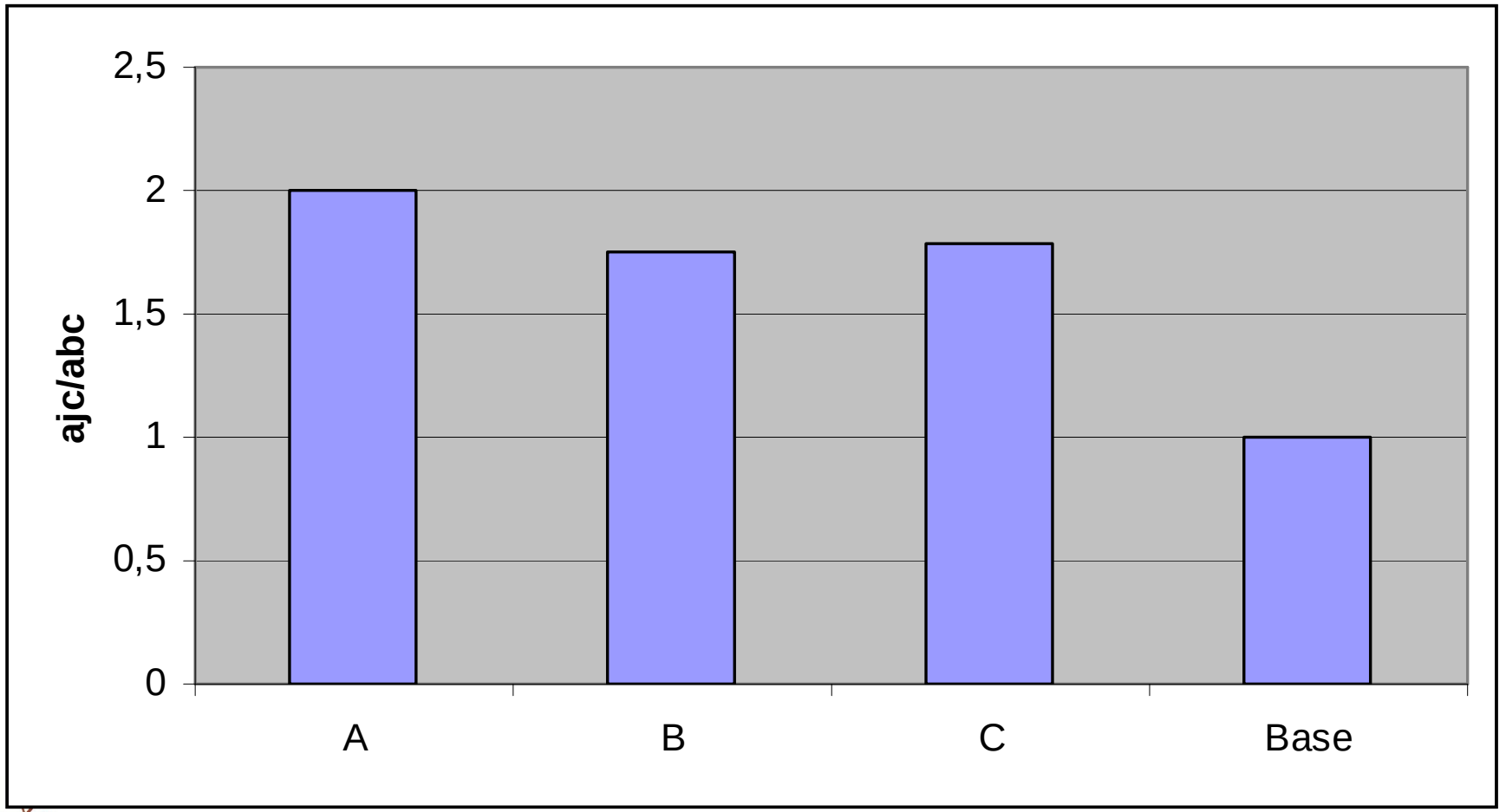
Benchmarks – Nullptr

```
aspect Nullptr {
    pointcut methodsThatReturnObjects():
        ...
    Object around():
        methodsThatReturnObjects(){
        Object lRetVal = proceed();
        if(lRetVal == null)
            System.err.println(
                        "Null return value: " + thisJoinPoint);
        return lRetVal;
    }
}
A: pointcut methodsThatReturnObjects():
        call(* *.*(..)) && !call(void *.*(..));
B: pointcut methodsThatReturnObjects():
        call(Object+ *.*(..));
C: pointcut methodsThatReturnObjects():
        call(Object+ *.*(..)) && !within(lib.aspects..*);
```

Benchmarks – Nullptr (2)



Benchmarks (2) - Closures



Future work

- Obvious optimizations
  - unused arguments, conditionals, table-switch etc.
- Adaptive inlining
  - post processing step
- Optimization of advice execution cycles
  - reduce likelihood of closure creation