Reflection Applied: Proxies

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Jonathan Hudson, Ph.D
Assistant Professor (Teaching)
Department of Computer Science
University of Calgary

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Intercession via proxy

Dynamic Proxies

- A ***proxy*** is “a person authorized to act on behalf of another”

- In OO programming, a ***proxy*** is an object that substitutes for another object called the ***target***

  - To work, the proxy must implement the target’s entire interface
    - i.e. support all the target’s methods

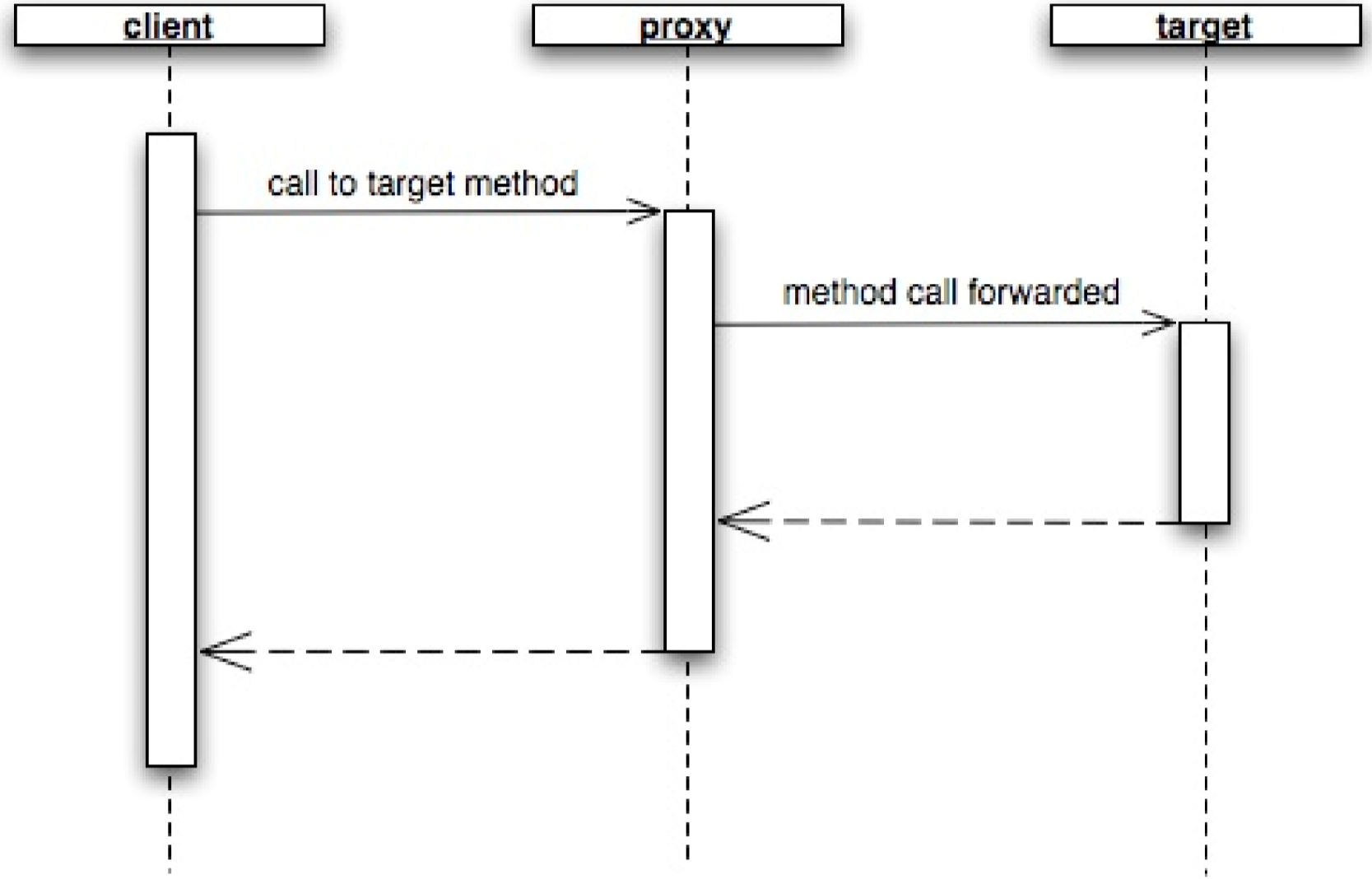
Dynamic Proxies

- The proxy may

1. Implement its own versions of ***all*** the methods
   - Acts as a ***substitute*** for the target

2. Or delegate some or all calls it receives to the target
   - Acts as an ***intermediary*** between the caller and the target

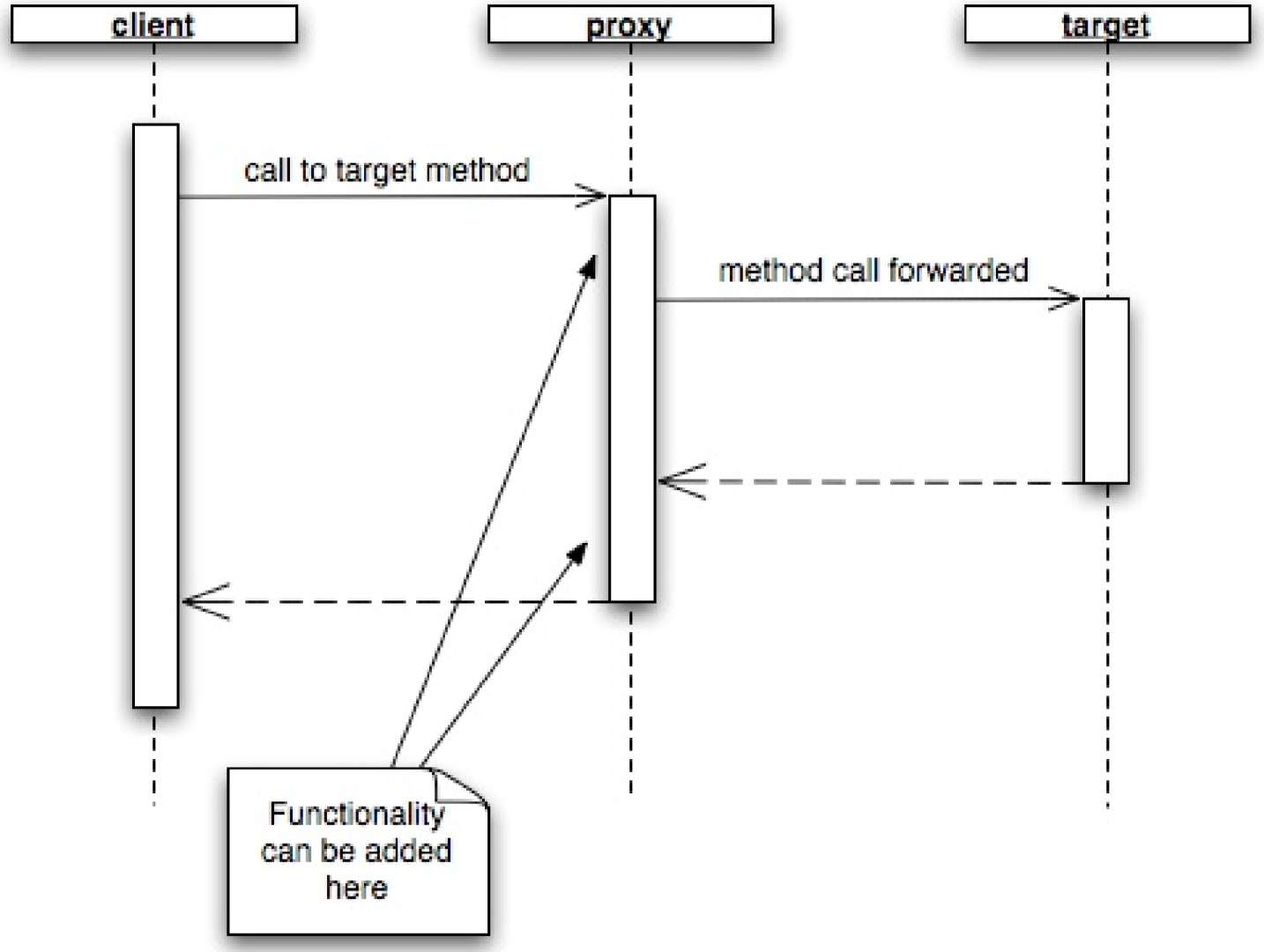
Dynamic Proxies



Dynamic Proxies

- If an intermediary, a proxy may add functionality before and after forwarding the method to the target
    - Allows you to add behavior to objects

Dynamic Proxies



Dynamic Proxies

- Method invocation **intercession** is the ability to intercept method calls reflectively
  - Not supported by Java directly
    - (Java Aspects one way of doing intercession)
  - But is approximated using **dynamic proxies**
    - Proxies can be created at runtime as needed

Dynamic Proxies

- Proxies are useful when you need to add similar behavior to many different classes
  - E.g. Adding tracing code to all method calls

- Without proxies, you could create non-tracing and tracing classes
  - Or subclasses of a common superclass
  - You arrange to instantiate the needed class at runtime

Dynamic Proxies

- Without proxies, you could create non-tracing and tracing classes
  - **Drawbacks:**
    - **Tedious: must be done for all methods of all classes**
    - **Error prone: may overlook a method**
    - **Fragile: if a method is added or changed, then the traced class must also be added/changed**
  - Dynamic proxies allows the added behavior to be implemented in a single class

Intercession via Java proxy

Dynamic Proxies

- java.lang.reflect.Proxy
  - Can create a proxy class (a class object) that implements a set of proxied interfaces with:

    static Class getProxyClass(ClassLoader loader, Class[] interfaces)

Dynamic Proxies

- Proxy classes have a constructor that takes an InvocationHandler parameter
- You create a proxy instance with the constructor and newInstance()
- E.g.

```
Proxy cl = Proxy.getProxyClass(MyInterface.getClassLoader(),
                               Class[] {MyInterface.class});
Constructor c = cl.getConstructor(new Class[]{InvocationHandler.class});
Object proxy = c.newInstance(new Object[]{new MyIH(target)});
```

Dynamic Proxies

- Or with a single call:

```
Object proxy = Proxy.newProxyInstance(MyInterface.getClassLoader(),
                                      new Class[]{MyInterface.class},
                                      new MyIH(target));
```

- Use **isProxyClass()** to see if a class object represents a proxy class
  - E.g.

if (Proxy.isProxyClass(obj.getClass())

. . .

Dynamic Proxies

- The proxy instance delegates handling of methods to its invocation handler
  - Is an object that implements the **InvocationHandler** interface
    - Must implement the **invoke()** method
    - Must also keep a reference to the target object
    - E.g.

Dynamic Proxies

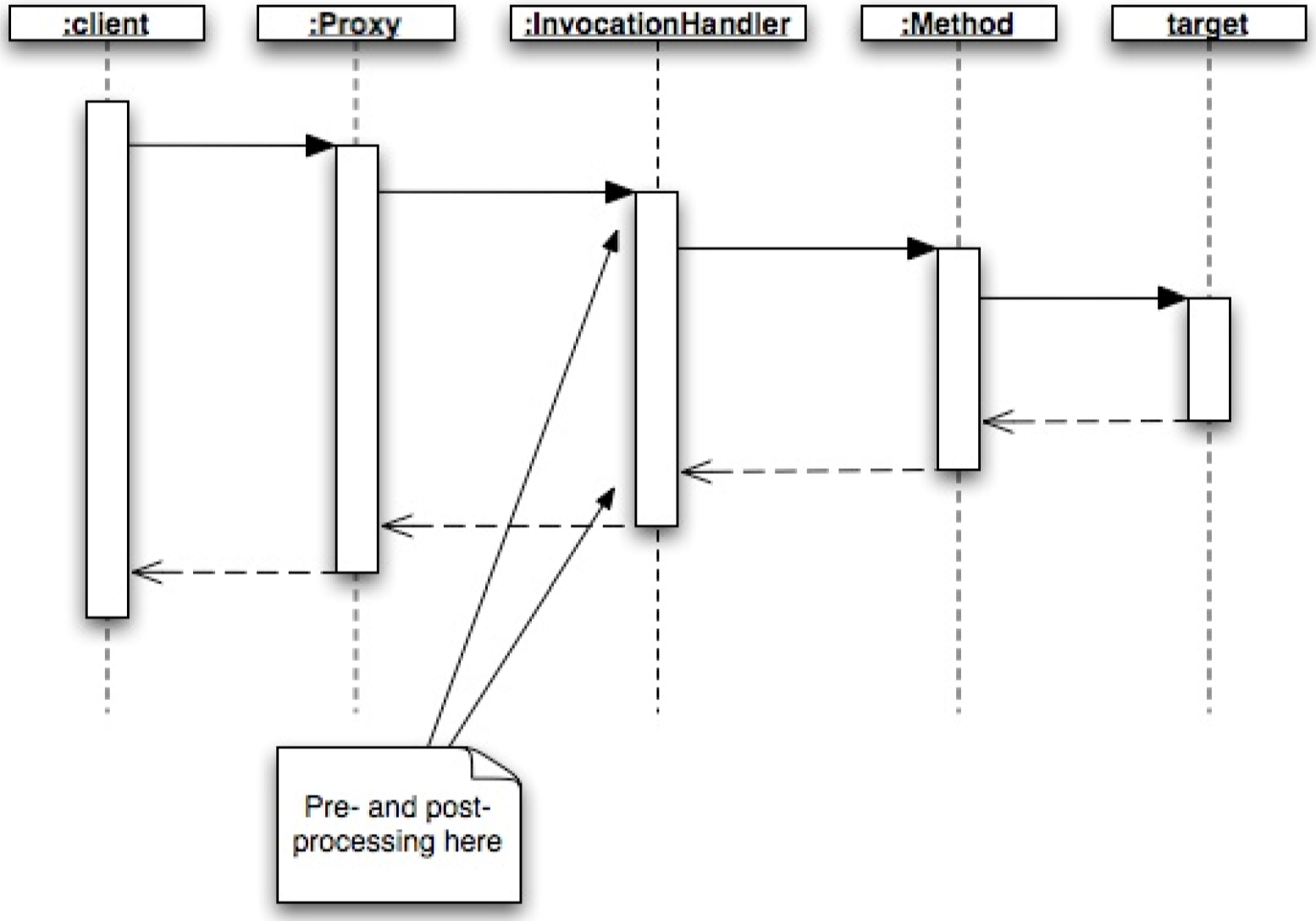
```
public class MyIH implements InvocationHandler {

    private Object target;

    public MyIH(Object obj) {
        target = obj;
    }

    public Object invoke(Object proxy, Method method, Object[] args) throws Throwable {
        return method.invoke(target, args);
    }
}
```

Dynamic Proxies

- The above **invoke()** method merely forwards the message to the target
  - Could add pre- and post-processing
  - E.g.

```
public Object invoke(Object proxy, Method method, Object[] args) throws Throwable {
    Object result = null;
    // preprocessing here
    result = method.invoke(target, args);
    // postprocessing here
    return result;
}
```

Dynamic Proxies



Example

Example – MyInterface.java

- Example: tracing proxy
  - Target interface

```
public interface MyInterface {

   public void print();

   public void display();
}
```

Example – MyClass.java

- Target class

```
public class MyClass implements MyInterface {

    public void print() {
        System.out.println("Hello, world!");
    }

    public void display() {
        System.out.println("Goodbye, cruel world!");
    }
}
```

Example – TracingIH.java

- Invocation handler

```
public class TracingIH implements InvocationHandler {

   public static Object createProxy(Object obj) {
      return Proxy.newProxyInstance(obj.getClass().getClassLoader(), obj.getClass().getInterfaces(), new TracingIH(obj));
   }
   private Object target;

   private TracingIH(Object obj) {
      target = obj;
   }

   public Object invoke(Object proxy, Method method, Object[] args) throws Throwable {
      …
   }
}
```

Example – TracingIH.java (cont'd)

```
public Object invoke(Object proxy, Method method, Object[] args) throws Throwable {
   Object result = null;
   System.out.println(method.getName() + "() begins");
   try {
      result = method.invoke(target, args);
   } catch (InvocationTargetException e) {
      System.out.println(method.getName() + " throws " + e.getCause());
      throw e.getCause();
   }
   System.out.println(method.getName() + "() returns\n");
   return result;
}
```

Example – Test.java

- Client code

```
public static void main(String[] args) {

   args = new String[]{"trace"};

   MyInterface obj = new MyClass();

   if (args.length > 0 && args[0].equals("trace")) {
      MyInterface proxy_obj = (MyInterface) TracingIH.createProxy(obj);
      obj = proxy_obj;
   }

   obj.print();
   obj.display();

}
```

Example – no proxy

- Sample run: java Test

```
C:\Users\jonat\.jdks\openjdk-17.0.2\bin\java.exe ...
Hello, world!
Goodbye, cruel world!

Process finished with exit code 0
```

Example – proxy enabled

- Sample run: java Test trace

```
C:\Users\jonat\.jdks\openjdk-17.0.2\bin\java.exe ...
print() begins
Hello, world!
print() returns

display() begins
Goodbye, cruel world!
display() returns


Process finished with exit code 0
```

Onward to … mocking.

Jonathan Hudson
jwhudson@ucalgary.ca
https://pages.cpsc.ucalgary.ca/~jwhudson/

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