Java Specialists in Action

Dr Heinz M. Kabutz

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java training

Voyage of Discovery

- **A voyage of discovery through some of the more advanced topics in Java: dynamic proxies, references, generics and enums**

Short Introduction to Speaker

- **Heinz Kabutz**
  - Born in Cape Town, South Africa, now live in Chania (Crete)
  - PhD Computer Science from the University of Cape Town
    - Famous for world's first successful heart transplant
- **Inventor of The Java Specialists' Newsletter**
  - 165 newsletters, read by ± 50.000 readers in 118 countries
- **Java Programmer & Trainer**
  - Banks, insurance companies, telecoms, etc.
  - Intro to Java, Java 5 Delta, Java Patterns, Extreme Java
- **Java Champion**

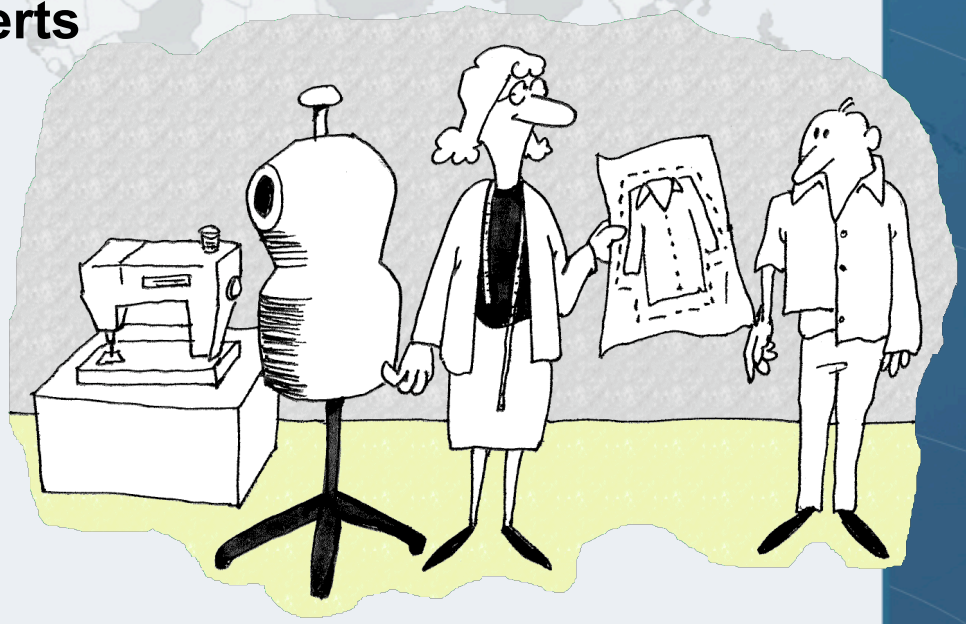
Introduction to Topic

- In this talk, we will look at:
  - Design Patterns
  - Dynamic Proxies in Java
  - Soft, Weak and Strong references
  - Some Java 5 features
- For additional free topics:
  - The Java™ Specialists' Newsletter
    - http://www.javaspecialists.eu
  - And find out how you can make

```
"hi there".equals("cheers!") == true
```

Design Patterns

- **Mainstream of OO landscape, offering us:**
  - **View into brains of OO experts**
  - **Quicker understanding of existing designs**
    - **e.g. Visitor pattern used by Annotation Processing Tool**
  - **Improved communication between developers**
  - **Readjust "thinking mistakes"**



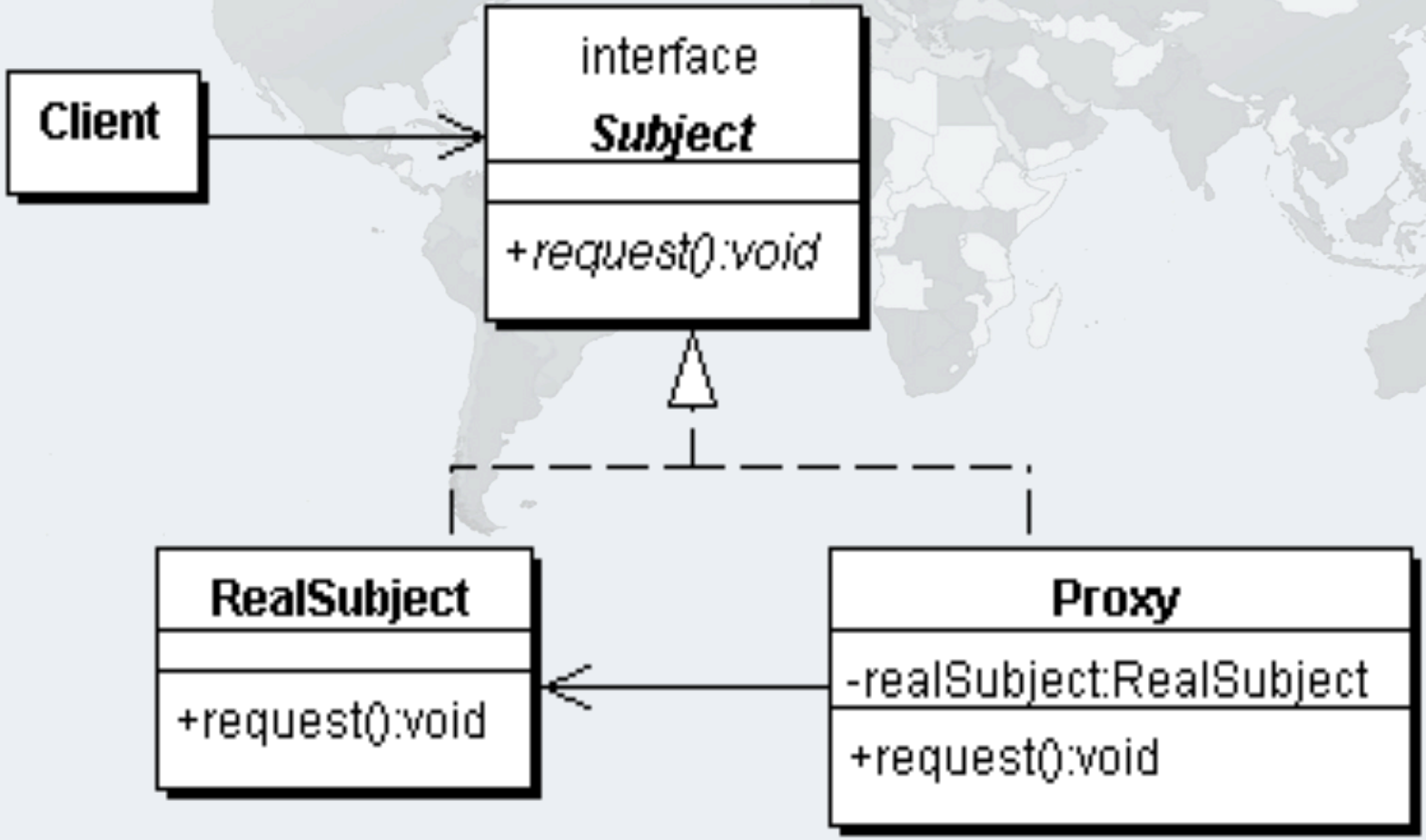
Good Real Ale

- **Software Design is like vintage wine**
  - **To an amateur, all wines are the same**
  - **With experience, you discern difference**
  - **As you become a connoisseur you experience the various attributes you didn't notice before**
    - **Grown on north or south slope**
- **Warning: Once you are hooked, you will no longer be satisfied with inferior designs**

Proxy Pattern

- **Intent [GoF95]**
  - **Provide a surrogate or placeholder for another object to control access to it.**

Proxy Structure



Types of Proxies in GoF

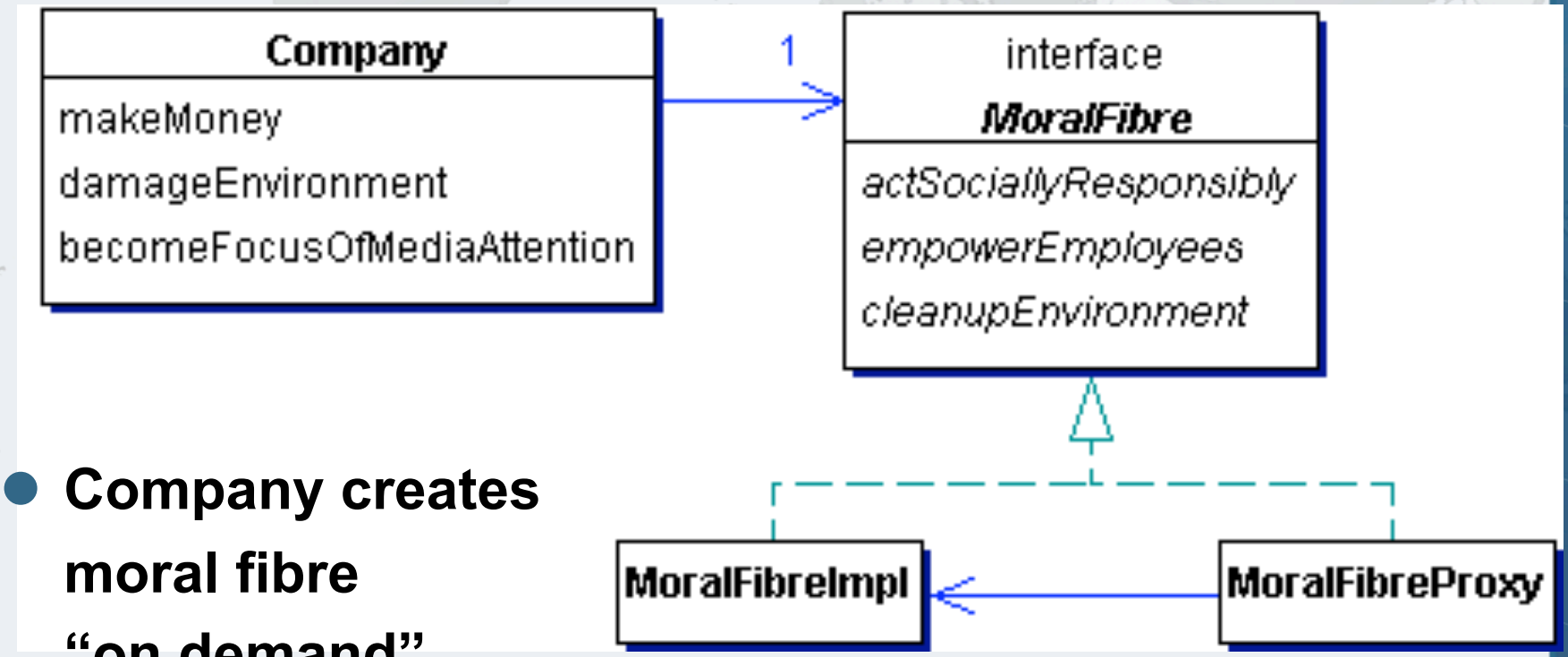
We will focus on this type

- **Virtual Proxy**
  - creates expensive objects on demand
- **Remote Proxy**
  - provides a local representation for an object in a different address space
- **Protection Proxy**
  - controls access to original object

Approaches to writing proxies

- **Handcoded**
  - **Only for the very brave … or foolish**
- **Autogenerated code**
  - **RMI stubs and skeletons created by rmic**
- **Dynamic proxies**
  - **Available since JDK 1.3**
  - **Dynamically creates a new class at runtime**
  - **Flexible and easy to use**

Model for example



- **Company creates moral fibre "on demand"**

```
public class Company {
  // set in constructor ...
  private final MoralFibre moralFibre;

  public void becomeFocusOfMediaAttention() {
    System.out.println("Look how good we are...");
    cash -= moralFibre.actSociallyResponsibly();
    cash -= moralFibre.cleanupEnvironment();
    cash -= moralFibre.empowerEmployees();
  }

  @Override
  public String toString() {
    return String.format("%s has $ %.2f", name, cash);
  }
}
```

Quiz: Where is Autoboxing happening?

```
public interface MoralFibre {

  double actSociallyResponsibly();

  double empowerEmployees();

  double cleanupEnvironment();
}
```

```
public class MoralFibreImpl implements MoralFibre {
  // very expensive to create moral fibre!
  private byte[] costOfMoralFibre =
    new byte[900*1000];

  { System.out.println("Moral Fibre Created!"); }
  // AIDS orphans
  public double actSociallyResponsibly() {
    return costOfMoralFibre.length / 3;
  }
  // shares to employees
  public double empowerEmployees() {
    return costOfMoralFibre.length / 3;
  }
  // oiled sea birds
  public double cleanupEnvironment() {
    return costOfMoralFibre.length / 3;
  }
}
```

Handcoded Proxy

- Usually results in a lot of effort
- Shown just for illustration
- Good programmers have to be lazy
  - DRY principle
    - Don't repeat yourself

```
public class MoralFibreProxy implements MoralFibre {
  private MoralFibreImpl realSubject;
  private MoralFibreImpl realSubject() {
    if (realSubject == null) { // need synchronization
      realSubject = new MoralFibreImpl();
    }
    return realSubject;
  }
  public double actSociallyResponsibly() {
    return realSubject().actSociallyResponsibly();
  }

  public double empowerEmployees() {
    return realSubject().empowerEmployees();
  }

  public double cleanupEnvironment() {
    return realSubject().cleanupEnvironment();
  }
}
```

```
import static java.util.concurrent.TimeUnit.SECONDS;

public class WorldMarket0 {
  public static void main(String[] args)
      throws Exception {
    Company maxsol = new Company("Maximum Solutions",
        1000 * 1000, new MoralFibreProxy());
    SECONDS.sleep(2); // better than Thread.sleep();
    maxsol.makeMoney();
    System.out.println(maxsol);
    SECONDS.sleep(2);
    maxsol.damageEnvironment();
    System.out.println(maxsol);
    SECONDS.sleep(2);
    maxsol.becomeFocusOfMediaAttention();
    System.out.println(maxsol);
  }
}
```

```
Oh goodie!
Maximum Solutions has $ 2000000.00
Oops, sorry about that oilspill...
Maximum Solutions has $ 8000000.00
Look how good we are...
Moral Fibre Created!
Maximum Solutions has $ 7100000.00
```

Dynamic Proxies

- **Handcoded proxy flawed**
  - **Previous approach broken – what if toString() is called?**
  - **Bugs would need to be fixed everywhere**
- **Dynamic Proxies**
  - **Allows you to write a method call handler**
    - **Invoked every time a method is called on interface**
  - **Easy to use**

Defining a Dynamic Proxy

- **We make a new instance of an interface class using java.lang.reflect.Proxy:**

```
Object o = Proxy.newProxyInstance(
  Thread.currentThread().getContextClassLoader(),
  new Class[]{ interface to implement },
    implementation of InvocationHandler
);
```

- **The result is an instance of interface to implement**
  - **You could also implement several interfaces**

```
import java.lang.reflect.*;

public class VirtualProxy<T> implements InvocationHandler {
  private T realSubject;
  private final Object[] constrParams;
  private final Constructor<? extends T> subjectConstr;

  public VirtualProxy(Class<? extends T> realSubjectClass,
                      Class[] constrParamTypes,
                      Object[] constrParams) {
    try {
      subjectConstr = realSubjectClass.
          getConstructor(constrParamTypes);
    } catch (NoSuchMethodException e) {
      throw new IllegalArgumentException(e);
    }
    this.constrParams = constrParams;
  }
```

Finds constructor that matches given parameter types

Why could we not use varargs (...) for constrParamTypes and constrParams?

```
  private T realSubject() throws Throwable {
    synchronized (this) {
      if (realSubject == null) {
        realSubject = subjectConstr.newInstance(
          constrParams);
      }
    }
    return realSubject;
  }

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

A word about synchronization

- We need to synchronize whenever we check the value of the pointer
  - Otherwise several realSubject objects could be created
- We can synchronize on "this"
  - No one else will have a pointer to the object
- Double-checked locking broken pre-Java 5
  - It now works if you make the field volatile
  - Easier to get synchronized correct than volatile

AtomicReference

- **We can also use atomic references to set the realSubject handle**

```
public class VirtualProxy<T> implements InvocationHandler {
  private final AtomicReference<T> realSubject =
    new AtomicReference<T>();
  // ...
  private T realSubject() throws Throwable {
    T result = realSubject.get();
    if (result == null) {
      result = subjectConstr.newInstance(constrParams);
      if (!realSubject.compareAndSet(null, result)) {
        result = realSubject.get();
      }
    }
    return result;
  }
}
```

Casting without Unchecked Warnings

- **Cast to a specific class:**
  - **subjIntf.cast(some_object)**
  - **Allows you to do stupid things, like:**

```
String name = String.class.cast(3);
```

Casting without Unchecked Warnings

- **Cast a class to a typed class**
  - **With "forNamed" classes**

```
Class<?> c = Class.forName( "some_class_name" );
Class<? extends SomeClass> c2 =
  c.asSubclass(SomeClass.class);
```

  - **Allows you to do stupid things, like:**

```
Class<?> c = Class.forName("java.lang.String");
Class<? extends Runnable> runner =
  c.asSubclass(Runnable.class);
Runnable r = runner.newInstance();
r.run();
```

Proxy Factory

- **To simplify our client code, we define a Proxy Factory:**
  - **We want a return type of class subjIntf**

```
import java.lang.reflect.*;

public class ProxyFactory {
  public static <T> T virtualProxy(Class<T> subjIntf,
            Class<? extends T> realSubjClass,
            Class[] constrParamTypes,
            Object[] constrParams) {
    return subjIntf.cast(Proxy.newProxyInstance(
      Thread.currentThread().getContextClassLoader(),
        new Class[] { subjIntf },
        new VirtualProxy<T>(realSubjClass,
            constrParamTypes, constrParams)));
  }
```

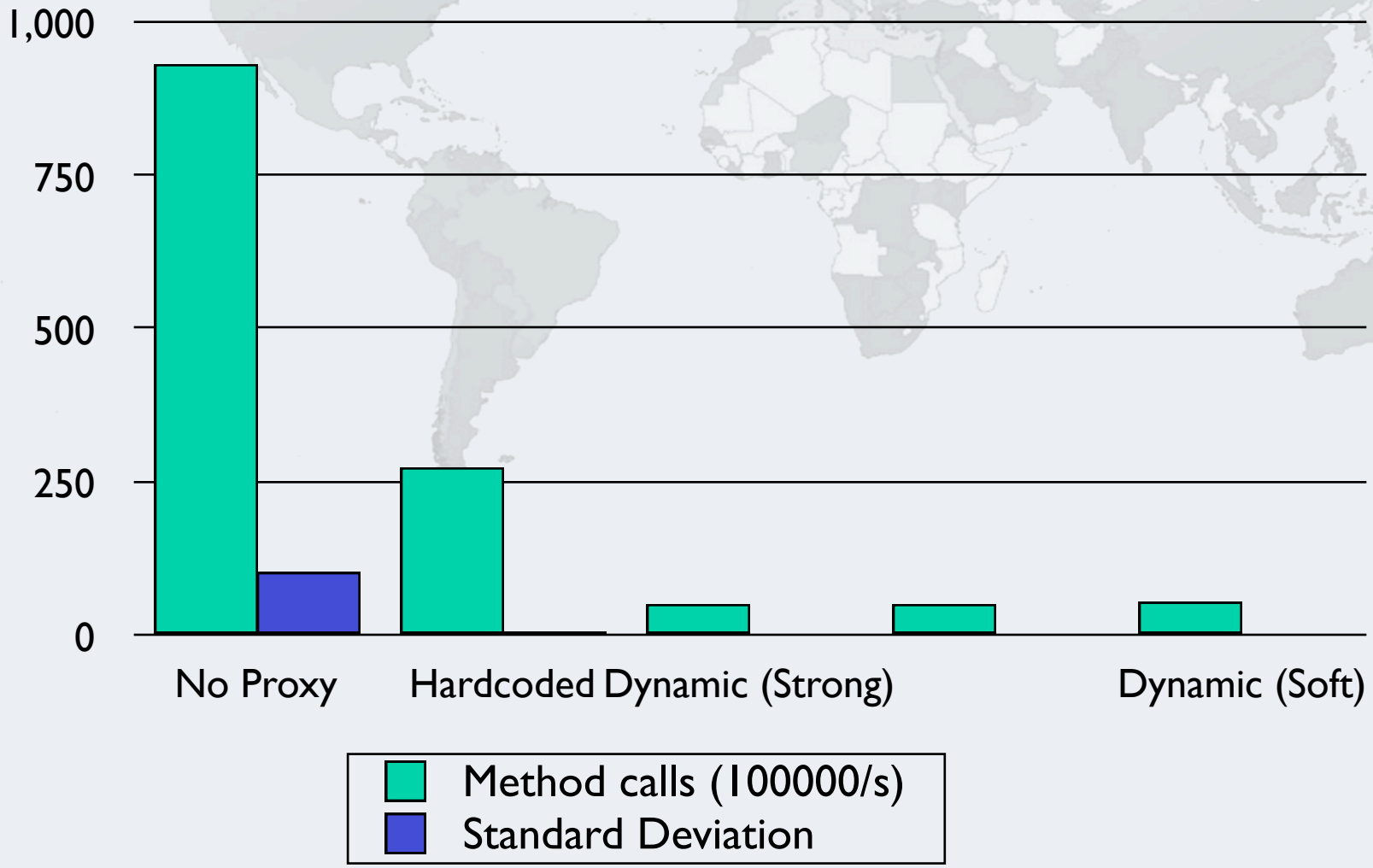
Proxy Factory

```
  public static <T> T virtualProxy(
      Class<T> subjIntf, Class<? extends T> realSubjClass) {
    return virtualProxy(subjIntf, realSubjClass, null, null);
  }

  public static <T> T virtualProxy(Class<T> subjIntf) {
    try {
      Class<?> c = Class.forName(subjIntf.getName() + "Impl");
      Class<? extends T> realSubjClass =
        c.asSubclass(subjIntf);
      return virtualProxy(subjIntf, realSubjClass);
    } catch (ClassNotFoundException e) {
      throw new IllegalArgumentException(e);
    }
  }
}
```

```
import static java.util.concurrent.TimeUnit.SECONDS;
import static proxies.ProxyFactory.virtualProxy;

public class WorldMarket1 {
  public static void main(String[] args)
      throws Exception {
    Company maxsol = new Company("Maximum Solutions",
        1000 * 1000, virtualProxy(MoralFibre.class));
    SECONDS.sleep(2);
    maxsol.makeMoney();
    System.out.println(maxsol);
    SECONDS.sleep(2);
    maxsol.damageEnvironment();
    System.out.println(maxsol);
    SECONDS.sleep(2);
    maxsol.becomeFocusOfMediaAttention();
    System.out.println(maxsol);
  }
}
```

```
Oh goodie!
Maximum Solutions has $ 2000000.00
Oops, sorry about that oilspill...
Maximum Solutions has $ 8000000.00
Look how good we are...
Moral Fibre Created!
Maximum Solutions has $ 7100000.00
```

Performance of Dynamic Proxies

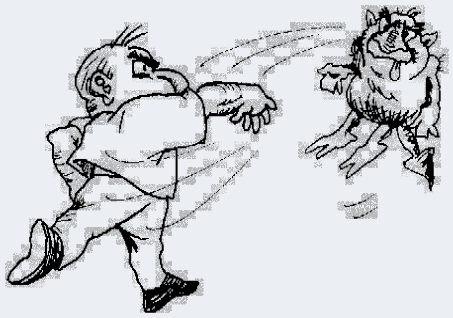


Analysis of Performance Results

- **Consider performance in real-life context**
  - **How often is a method called per second?**
  - **What contention are you trying to solve – CPU, IO or memory?**
    - **Probably the wrong solution for CPU bound contention**
- **Big deviation for "No Proxy" – probably due to HotSpot compiler inlining method call**

Virtual Proxy Gotchas

- **Be careful how you implement equals()**
  - **Should always be symmetric (from JavaDocs):**
    - **For any non-null reference values x and y, x.equals(y) should return true if and only if y.equals(x) returns true**
- **Exceptions**
  - **General problem with proxies**
    - **Local interfaces vs. remote interfaces in EJB**
  - **Were checked exceptions invented on April 1st ?**



Checkpoint

- We've looked at the concept of a Virtual Proxy based on the GoF pattern
- We have seen how to implement this with dynamic proxies (since JDK 1.3)
- Lastly, we were unsurprised that dynamic proxy performs worse than handcoded proxy
- Next we will look at Soft and Weak References

References (Strong, Soft, Weak)

- **We want to release references when possible**
  - **Saves on memory**
  - **Soft, Weak and Strong references offer different benefits**
  - **Works in conjunction with our dynamic proxy**
  - **However, references are not transparent**

Strong, Soft and Weak References

- Java 1.2 introduced concept of soft and weak references
- Strong reference is never released
- Weak reference is released when no strong reference is pointing to the object
- Soft reference can be released, but will typically only be released when memory is low
  - Works correctly since JDK 1.4

Object Adapter Pattern – Pointers

- References are not transparent
- We make them more transparent by defining a Pointer interface
  - Can then be Strong, Weak or Soft

```
public interface Pointer<T> {
  void set(T t);
  T get();
}
```

Strong Pointer

- **Simply contains a strong reference to object**
  - **Will never be garbage collected**

```
public class StrongPointer<T>
    implements Pointer<T> {
  private T t;
  public void set(T t) { this.t = t; }
  public T get()       { return t; }
}
```

Reference Pointer

- **Abstract superclass for soft and weak reference**

```
import java.lang.ref.Reference;

public abstract class RefPointer<T>
    implements Pointer<T> {
  private Reference<T> ref;
  protected void set(Reference<T> ref) {
    this.ref = ref;
  }
  public T get() {
    return ref == null ? null : ref.get();
  }
}
```

Soft and Weak Reference Pointers

- **Contains either soft or weak reference to object**
- **Will be garbage collected later**

```
public class SoftPointer<T> extends RefPointer<T> {
  public void set(T t) {
    set(new SoftReference<T>(t));
  }
}

public class WeakPointer<T> extends RefPointer<T> {
  public void set(T t) {
    set(new WeakReference<T>(t));
  }
}
```

Using Turbocharged enums

- We want to define enum for these pointers
- But, we don't want to use switch
  - Switch and multi-conditional if-else are anti-OO
  - Rather use inheritance, strategy or state patterns
- Enums allow us to define abstract methods
  - We implement these in the enum values themselves

```
public enum PointerType {
  STRONG { // these are anonymous inner classes
    public <T> Pointer<T> make() { // note generics
      return new StrongPointer<T>();
    }
  },
  WEAK {
    public <T> Pointer<T> make() {
      return new WeakPointer<T>();
    }
  },
  SOFT {
    public <T> Pointer<T> make() {
      return new SoftPointer<T>();
    }
  };

  public abstract <T> Pointer<T> make();
}
```

```
public void test(PointerType type) {
  System.out.println("Testing " + type + "Pointer");
  String obj = new String(type.toString());
  Pointer<String> pointer = type.make();
  pointer.set(obj);
  System.out.println(pointer.get());
  obj = null;
  forceGC();
  System.out.println(pointer.get());
  forceOOME();
  System.out.println(pointer.get());
  System.out.println();
}
```

```
Testing STRONG Pointer
STRONG
STRONG
STRONG

Testing WEAK Pointer
WEAK
null
null

Testing SOFT Pointer
SOFT
SOFT
null
```

Danger – References

- References put additional strain on GC
- Only use with large objects
- Memory space preserving measure
  - But can impact on performance
  - Additional step in GC that runs in separate thread

Combining Pointers and Proxies

- **With dynamic proxies, we can create objects on demand**
  - **How can we use our Pointers to clear them again?**

```
import java.lang.reflect.*;

public class VirtualProxy<T> implements InvocationHandler {
  private final Pointer<T> realSubjectPointer;
  private final Object[] constrParams;
  private final Constructor<? extends T> subjectConstr;

  public VirtualProxy(Class<? extends T> realSubjectClass,
                      Class[] constrParamTypes,
                      Object[] constrParams,
                      PointerType pointerType) {
    try {
      subjectConstr = realSubjectClass.
        getConstructor(constrParamTypes);
      realSubjectPointer = pointerType.make();
    } catch (NoSuchMethodException e) {
      throw new IllegalArgumentException(e);
    }
    this.constrParams = constrParams;
  }
```

```
  private T realSubject() throws Throwable {
    synchronized(this) {
      T realSubject = realSubjectPointer.get();
      if (realSubject == null) {
        realSubject = subjectConstr.newInstance(
          constrParams);
        realSubjectPointer.set(realSubject);
      }
      return realSubject;
    }
  }
  public Object invoke(Object proxy, Method method,
                       Object[] args) throws Throwable {
    return method.invoke(realSubject(), args);
  }
}
```

- We now use the PointerType to create either strong, soft or weak references

- **Weak Pointer is cleared when we don't have a strong ref**

```
Company maxsol = new Company(
  "Maximum Solutions", 1000000,
  virtualProxy(MoralFibre.class, WEAK));
SECONDS.sleep(2);
maxsol.damageEnvironment();
maxsol.becomeFocusOfMediaAttention();
```

Oops, sorry about that oilspill...
Look how good we are...
Moral Fibre Created!
Oops, sorry about that oilspill...
Look how good we are...
Moral Fibre Created!

```
// short term memory...
System.gc();
SECONDS.sleep(2);
maxsol.damageEnvironment();
maxsol.becomeFocusOfMediaAttention();
```

- **Soft Pointer more appropriate**

```
Company maxsol = new Company(
  "Maximum Solutions", 1000000,
  virtualProxy(MoralFibre.class, SOFT));
SECONDS.sleep(2);
maxsol.damageEnvironment();
maxsol.becomeFocusOfMediaAttention();
System.gc(); // ignores soft pointer
SECONDS.sleep(2);
maxsol.damageEnvironment();
maxsol.becomeFocusOfMediaAttention();

forceOOME(); // clears soft pointer
SECONDS.sleep(2);
maxsol.damageEnvironment();
maxsol.becomeFocusOfMediaAttention();

private static void forceOOME() {
  try {byte[] b = new byte[1000 * 1000 * 1000];}
  catch (OutOfMemoryError error)
  { System.err.println(error); }
}
```

Oops, sorry about that oilspill...
Look how good we are...
Moral Fibre Created!
Oops, sorry about that oilspill...
Look how good we are...
java.lang.OutOfMemoryError:
Java heap space
Oops, sorry about that oilspill...
Look how good we are...
Moral Fibre Created!

Combining Soft and Atomic References?

- **It should be possible to combine our SoftPointer concept with AtomicReferences**
  - **Perhaps the next Java Specialists' Newsletter?**
  - **http://www.javaspecialists.eu**

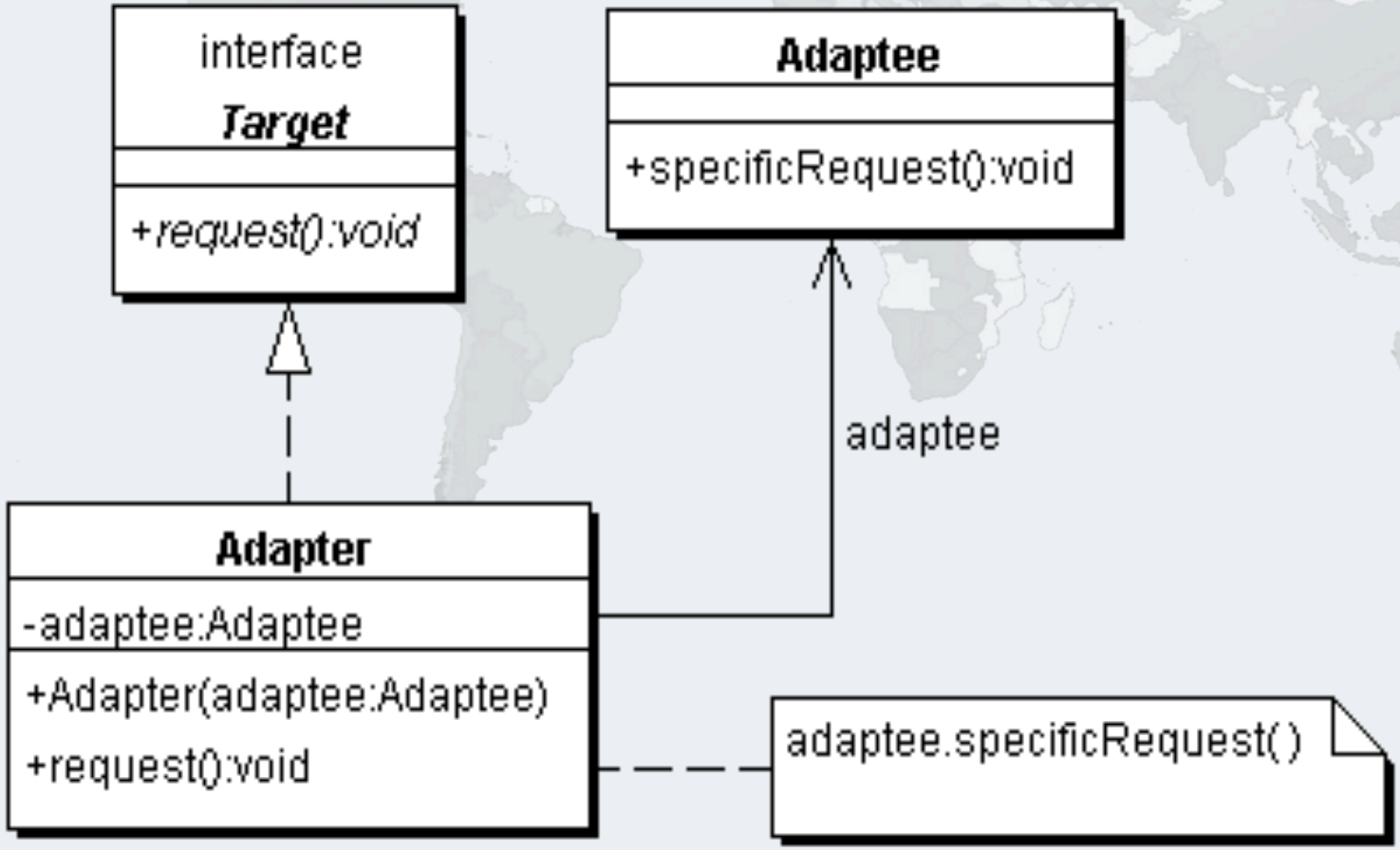
Further uses of Dynamic Proxy

- **Protection Proxy**
  - **Only route call when caller has correct security context**
    - **Similar to the "Personal Assistant" pattern**
- **Dynamic Decorator or Filter**
  - **We can add functions dynamically to an object**
  - **See newsletter # 34**
    - **http://www.javaspecialists.eu/archive/Issue034.html**
  - **Disclaimer: a bit difficult to understand**

Dynamic Object Adapter

- Based on Adapter pattern by GoF
- Plain Object Adapter has some drawbacks:
  - Sometimes you want to adapt an interface, but only want to override some methods
  - E.g. java.sql.Connection
- Structurally, the patterns Adapter, Proxy, Decorator and Composite are almost identical

Object Adapter Structure (GoF)



- We delegate the call if the adapter has a method with this signature
- Objects adaptee and adapter can be of any type

```
public Object invoke(Object proxy, Method method,
                     Object[] args) throws Throwable {
  try {
    // find out if the adapter has this method
    Method other = adaptedMethods.get(
      new MethodIdentifier(method));
    if (other != null) { // yes it has
      return other.invoke(adapter, args);
    } else { // no it does not
      return method.invoke(adaptee, args);
    }
  } catch (InvocationTargetException e) {
    throw e.getTargetException();
  }
}
```

- **The ProxyFactory now gets a new method:**

```
public class ProxyFactory {
   public static <T> T adapt(Object adaptee,
                             Class<T> target,
                             Object adapter) {
     return target.cast(
       Proxy.newProxyInstance(
         Thread.currentThread().getContextClassLoader(),
         new Class[] {target},
         new DynamicObjectAdapter(
           adapter, adaptee)));
   }
}
```

- **Client can now adapt interfaces very easily**

```
import static proxies.ProxyFactory.*;
// ...
Connection con = DriverManager.getConnection("...");
Connection con2 = adapt(con, Connection.class,
  new Object() {
    public void close() {
      System.out.println("No, don't close connection");
    }
  });
```

- **For additional examples of this technique, see The Java Specialists' Newsletter # 108**

Benefits of Dynamic Proxies

- Write once, use everywhere
- Single point of change
- Elegant coding on the client
  - Esp. combined with static imports & generics
- Slight performance overhead
  - But view that in context of application

Dynamic Proxies in Scripting

```
import javax.script.*;

public class ScriptTest {
  public static void main(String[] args)
      throws ScriptException {
    ScriptEngineManager manager =
        new ScriptEngineManager();
    ScriptEngine eng =
        manager.getEngineByExtension("js");
    eng.eval("function run() {" +
        "print('run called\\n'); }");
    Invocable inv = Invocable.class.cast(eng);
    Runnable r = inv.getInterface(Runnable.class);
    r.run();
    System.out.println(r.getClass());
  }
}
```

run called
class $Proxy0

Conclusion

- Dynamic proxies can make coding more consistent
  - Reduce WET
    - Write Everything Twice
- Easy to use, once syntax is understood
- Παν Μετρον Αριστον
  - Everything in moderation!

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