CS 635 Advanced Object-Oriented Design & Programming
Spring Semester, 2016
Doc 10 Memento, Command, Singleton, Proxy
Mar 3, 2016

Undo

Undo

Some examples

Counter

```
counter.increase();          //increase counter by 1
counter.decrease();          //decrease counter by 1
```

Undo

Some examples

Text editing

Replace "Should" with "Could" at start of 3rd sentence in 5 paragraph

Undo - Some Issues

Redo

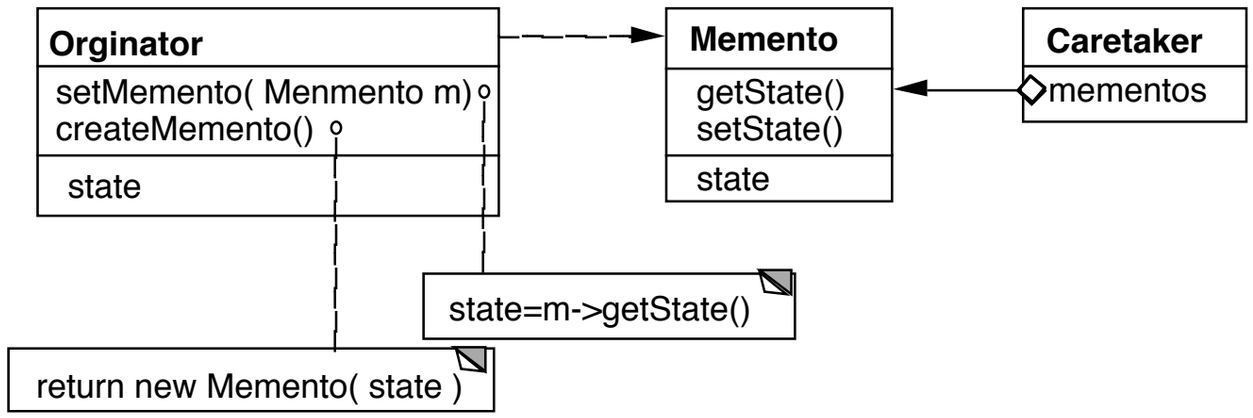
Multiple undo

Memento

Memento

Store an object's internal state, so the object can be restored to this state later without violating encapsulation

undo, rollbacks



Only originator:

Can access Memento’s get/set state methods

Create Memento

Example

```
package Examples;
class Memento{
        private Hashtable savedState = new Hashtable();

        protected Memento() {}; //Give some protection

        protected void setState( String stateName, Object stateValue ) {
                savedState.put( stateName, stateValue );
        }

        protected Object getState( String stateName) {
                return savedState.get( stateName);
        }

        protected Object getState(String stateName, Object defaultValue ) {
                if ( savedState.containsKey( stateName ) )
                        return savedState.get( stateName);
                else
                        return defaultValue;
        }
}
```

Sample Originator

```
package Examples;
class ComplexObject {
        private String name;
        private int someData;
        private Vector objectAsState = new Vector();

        public Memento createMemento() {
                Memento currentState = new Memento();
                currentState.setState( "name", name );
                currentState.setState( "someData", new Integer(someData) );
                currentState.setState( "objectAsState", objectAsState.clone() );
                return currentState;
        }

        public void restoreState( Memento oldState) {
                name = (String) oldState.getState( "name", name );
                objectAsState = (Vector) oldState.getState( "objectAsState" );
                Integer data = (Integer) oldState.getState( "someData");
                someData = data.intValue();
        }
```

Why not let the Originator save its old state?

```
class ComplexObject {
        private String name;
        private int someData;
        private Vector objectAsState = new Vector();
        private Stack history;

        public createMemento() {
                Memento currentState = new Memento();
                currentState.setState( "name", name );
                currentState.setState( "someData", new Integer(someData) );
                currentState.setState( "objectAsState", objectAsState.clone() );
                history.push(currentState);
        }

        public void restoreState() {
                Memento oldState = history.pop();
                name = (String) oldState.getState( "name", name );
                objectAsState = (Vector) oldState.getState( "objectAsState" );
                Integer data = (Integer) oldState.getState( "someData");
                someData = data.intValue();
        }
```

Some Consequences

Expensive

Space

Narrow & Wide interfaces - Keep data hidden

```
Class Memento {
    public:
        virtual ~Memento();
    private:
        friend class Originator;
        Memento();
        void setState(State*);
        State* GetState();
```

```
class Originator {
        private String state;

 private class Memento {
        private String state;
        public Memento(String stateToSave)
                { state = stateToSave; }
public String getState() { return state; }
        }

        public Object memento()
                { return new Memento(state);}
```

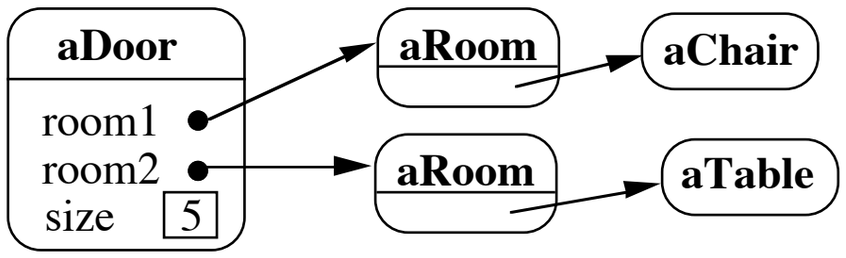
Using Clone to Save State

```
interface Memento extends Cloneable { }

class ComplexObject implements Memento {
        private String name;
        private int someData;

        public Memento createMemento() {
                Memento myState = null;
                try {
                        myState =  (Memento) this.clone();
                }
                catch (CloneNotSupportedException notReachable) {
                }
                return myState;
        }

        public void  restoreState( Memento savedState) {
                ComplexObject myNewState = (ComplexObject)savedState;
                name = myNewState.name;
                someData = myNewState.someData;
        }
}
```

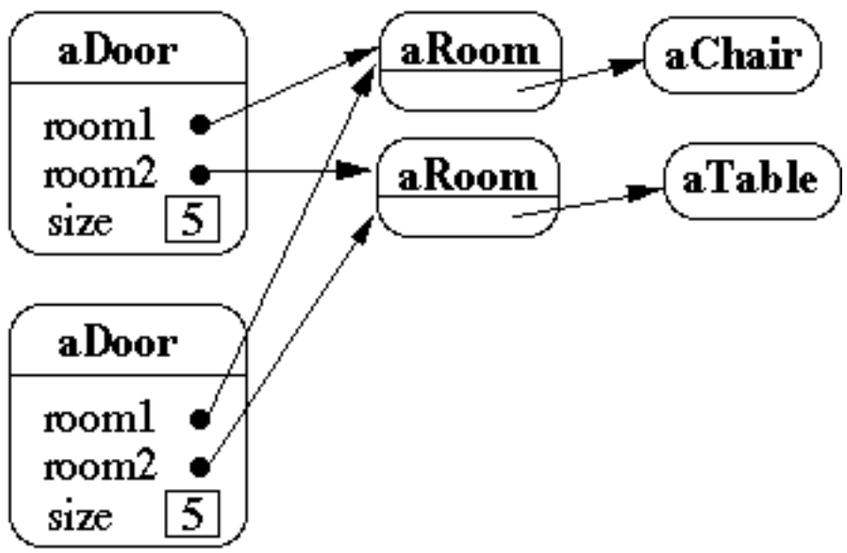
Copying Issues

Shallow Copy Verse Deep Copy

Original Objects

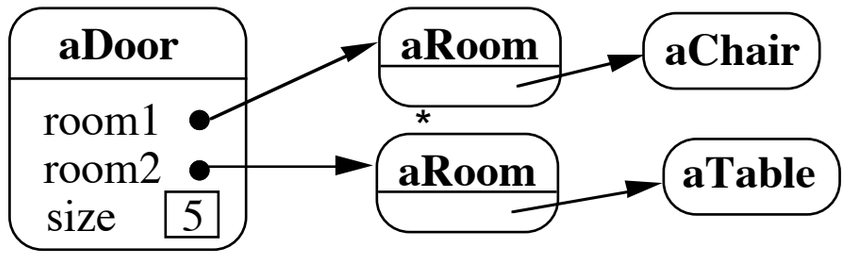


Shallow Copy

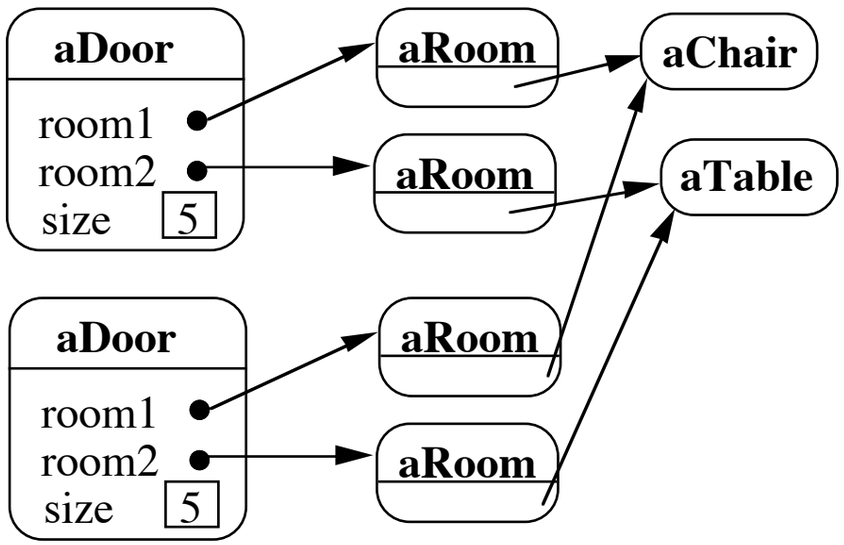


Shallow Copy Verse Deep Copy

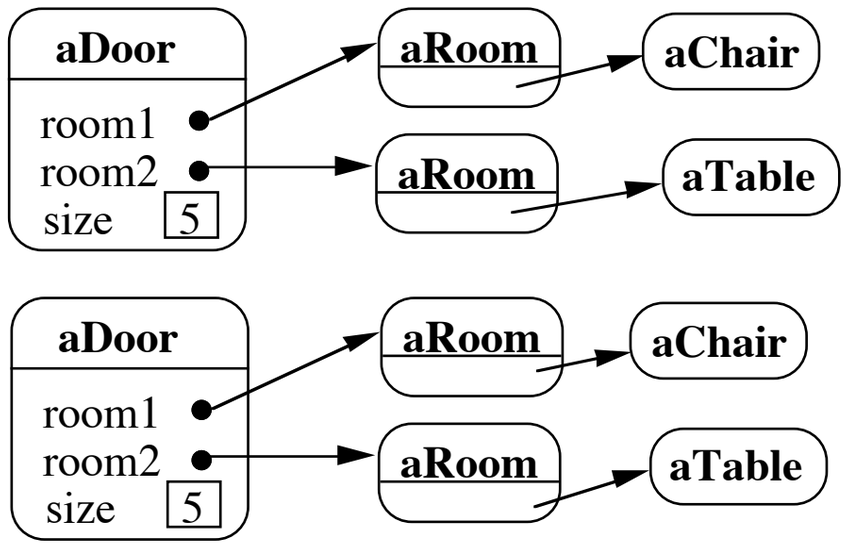
Original Objects



Deep Copy



Deeper Copy



Cloning Issues - C++ Copy Constructors

```
class Door {
        public:
                Door();
                Door( const Door&);
                virtual Door* clone() const;

                virtual void Initialize( Room*, Room* );
                // stuff not shown
        private:
                Room* room1;
                Room* room2;
        }

Door::Door ( const Door& other ) //Copy constructor {
        room1 = other.room1;
        room2 = other.room2;
        }

Door* Door::clone()  const {
        return new Door( *this );
        }
```

Cloning Issues - Java Clone

Shallow Copy

```
class Door implements Cloneable {
        private Room room1;
        private Room room2;

        public Object clone() throws  CloneNotSupportedException {
                return super.clone();
        }
}
```

Deep Copy

```
public class Door implements Cloneable {
        private Room room1;
        private Room room2;

        public Object clone() throws CloneNotSupportedException {
                Door thisCloned =(Door) super.clone();
                thisCloned.room1 = (Room)room1.clone();
                thisCloned.room2 = (Room)room2.clone();
                return thisCloned;
        }
}
```

What if Protocol

When there are complex validations or
performing operations that make it difficult to restore later

Make a copy of the Originator

Perform operations on the copy

Check if operations invalidate the internal state of copy

If so discard the copy & raise an exception

Else perform the operations on the Originator

Memento & Functional Programming

Immutable data

- Data that can not change
- Functional languages have primarily immutable data

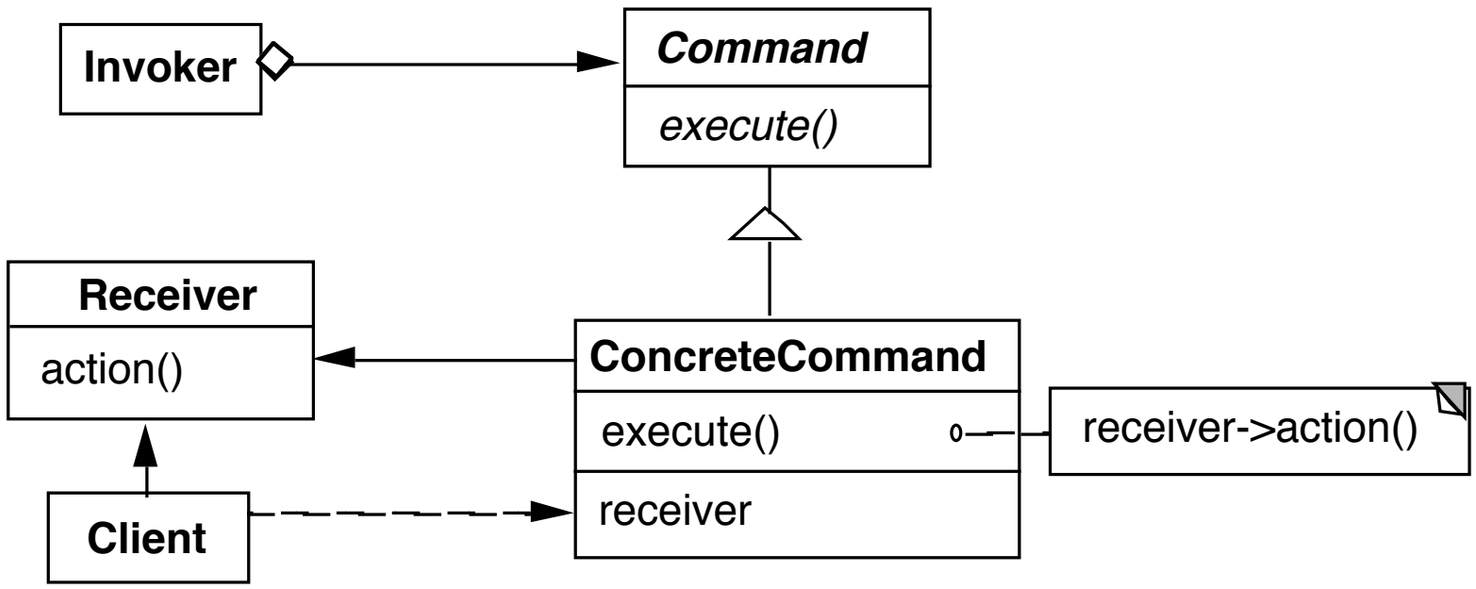
If data can not change

- Don’t need memento pattern

Command

Command

Encapsulates a request as an object



Example

Invoker be a menu

Client be a word processing program

Receiver a document

Action be save

Sample Command

```
public abstract class Command {
    public abstract void execute();
    public abstract void undo();
}

public class IncreaseCommand extends Command {
    private Counter subject;

    public IncreaseCommand(Counter toIncrease) {
        subject = toIncrease;

    public abstract void execute() { subject.increase() };

    public abstract void undo() { subject.decrease() };
}
```

Sample Command - Text Editing

Requires more details

- Text that is being edited
- Location in text to changed
- Replacement text

Undo requires

- Text that is being edited
- Location in text that was changed
- Text that was replaced

When to Use the Command Pattern

Need action as a parameter (replaces callback functions)

Lambda's replace this use

Specify, queue, and execute requests at different times

Undo

Logging changes

High-level operations built on primitive operations

A transaction encapsulates a set of changes to data

Systems that use transaction often can use the command pattern

Macro language

Consequences

Command decouples the object that invokes the operation from the one that knows how to perform it

It is easy to add new commands, because you do not have to change existing classes

You can assemble commands into a composite object

Pluggable Commands

Can create one general Command using reflection

Don’t hard code the method called in the command

Pass the method to call an argument

Java Example of Pluggable Command

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

public class Command
        {
        private Object receiver;
        private Method command;
        private Object[] arguments;

        public Command(Object receiver, Method command,
                                                Object[] arguments )
        {
        this.receiver = receiver;
        this.command = command;
        this.arguments = arguments;
        }

    public void execute() throws InvocationTargetException,
                                                IllegalAccessException
        {
        command.invoke( receiver, arguments );
        }
}
```

Using the Pluggable Command

```
public class Test {
        public static void main(String[] args) throws Exception
                {
                Vector sample = new Vector();
                Class[] argumentTypes = { Object.class };
                Method add =
                        Vector.class.getMethod( "addElement", argumentTypes);
                Object[] arguments = { "cat" };

                Command test = new Command(sample, add, arguments );
                test.execute();
                System.out.println( sample.elementAt( 0));
                }
}
```

Output

```
cat
```

Pluggable Commands using Lambdas

```
public interface Command {
    void execute();
}

public class PluggableCommand {
    Command do;
    Command undo;

    public PluggableCommand(Command do, Command undo) {
        this.do = do;
        this.undo = undo;
    }

    public void execute() { do.execute(); }

    public void undo() { undo.execute(); }
```

Pluggable Commands using Lambdas

```
final Counter example = new Counter();
PluggableCommand increase;

increase = new PluggableCommand(
    () -> example.increase(),
    () -> example.decrease());

increase.execute();
```

Note

Java's lambdas put restrictions on the variable example

Command Pattern & Lambda

Lambda's can replace command objects for

- Callbacks
- Batch processing
- Logging
- Macro language

Functional Programming & Command

Simple cases - can just use function

But what if function needs

- State
- Receiver

Closures

```
function counter()
  n = 0
  return () -> n += 1
end
```

```
counter_a = counter()
counter_b = counter()
counter_a()                    # 1
counter_a()                    # 2
counter_a()                    # 3
counter_b()                    # 1
```

So functions can maintain state

With Multiple Functions

```
function counter(start = 0)
  n = start
  return () -> n += 1, () -> n = start
end
```

```
(plus_a, reset_a) = counter(10)
(plus_b, reset_b) = counter()

plus_a()                    # 11
plus_a()                    # 12
reset_a()                   # 10
plus_b()                    # 1
```

General Command

```
type Command
  execute::Function
  undo::Function
end

function execute(command::Command)
  command.execute()
end

function undo(command::Command)
  command.undo()
end
```

```
function counter(start)
  n = start
  return Command(()-> n += 1, ()-> n -= 1)
end


  count = counter(5)
  execute(count)          # 6
  undo(count)             # 5
```

Command Processor Pattern

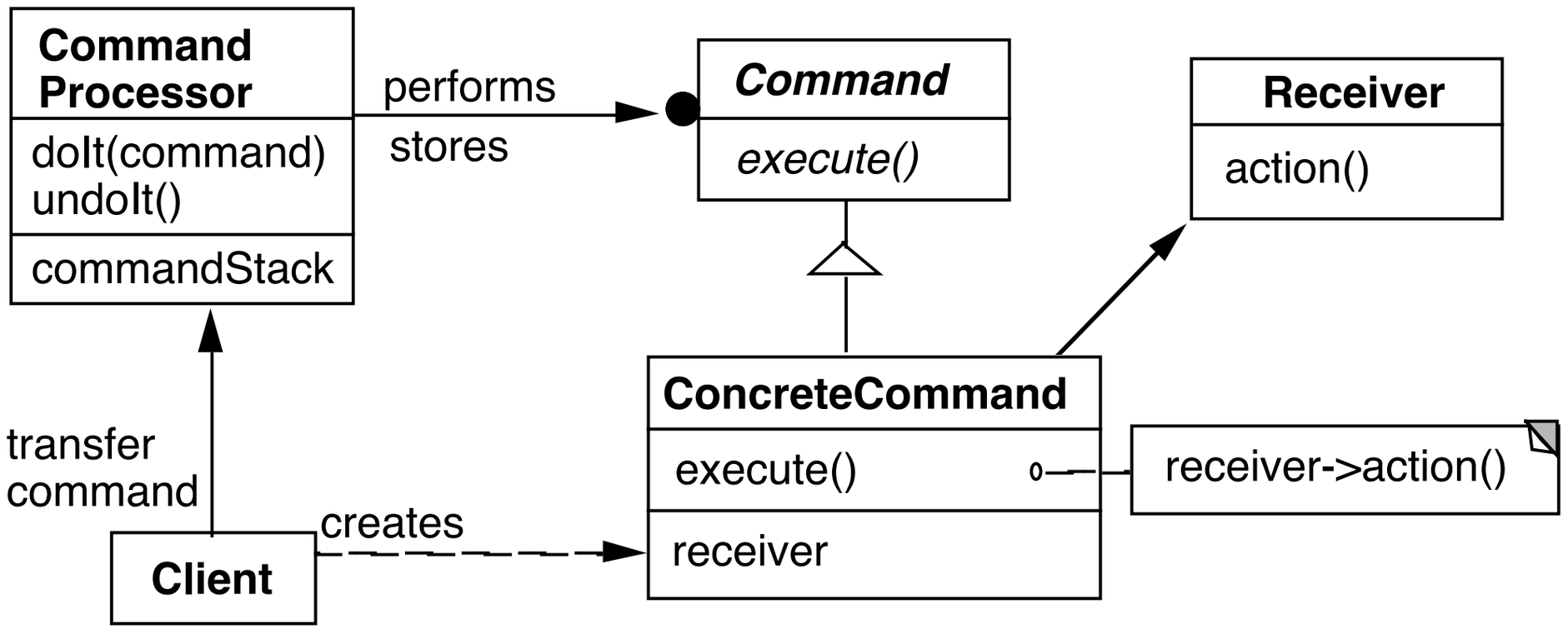
Command Processor Pattern

Command Processor manages the command objects

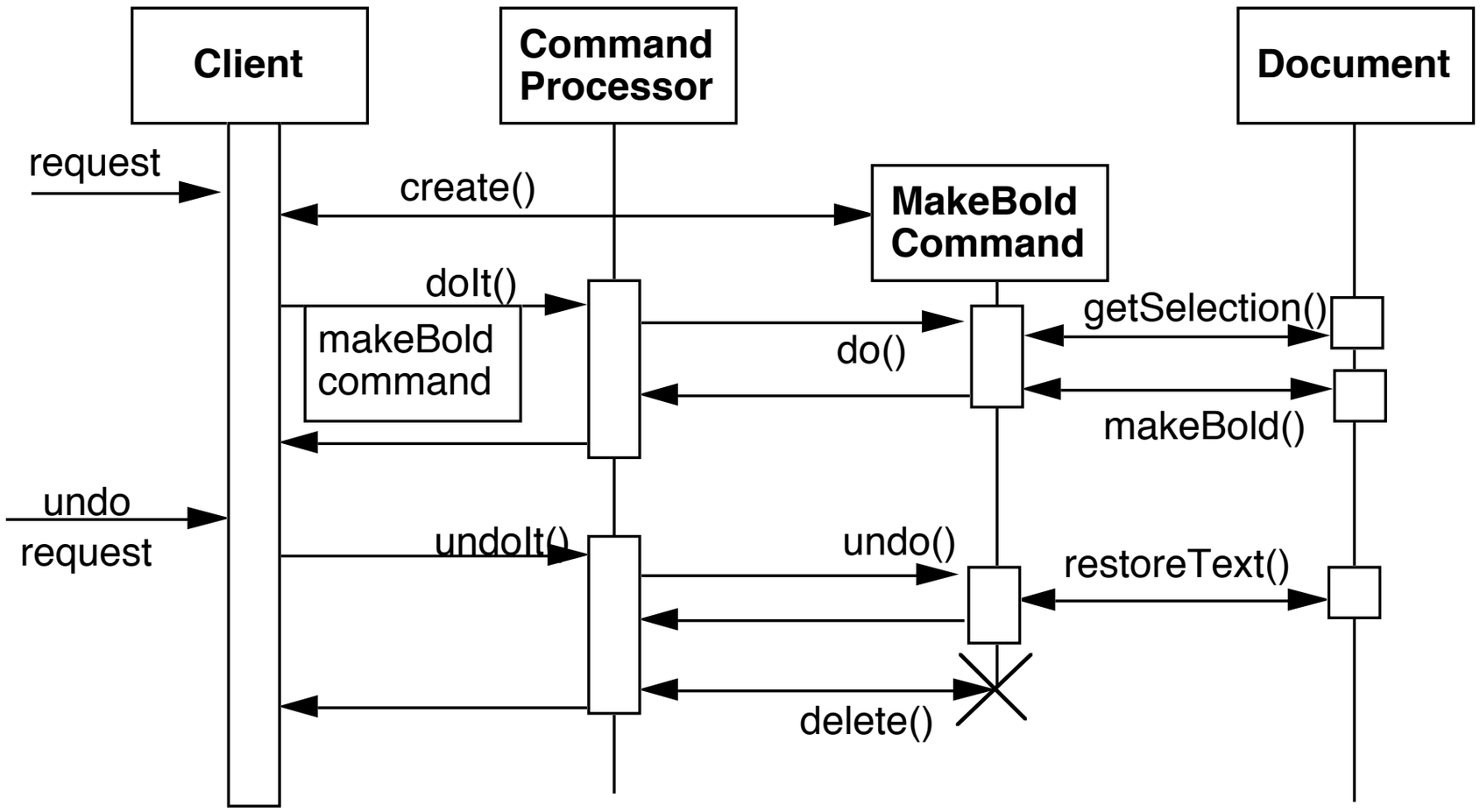
The command processor:

- Contains all command objects
- Schedules the execution of commands
- May store the commands for later unto
- May log the sequence of commands for testing purposes
- Uses singleton to insure only one instance

Structure


Command Processor
doIt(command)
undoIt()
commandStack
performs
stores
Command
execute()
Receiver
action()
ConcreteCommand
execute()
receiver
receiver->action()
transfer command
creates
Client

Dynamics


Client
Command Processor
Document
request
create()
MakeBold Command
doIt()
makeBold command
do()
getSelection()
makeBold()
undo request
undoIt()
undo()
restoreText()
delete()

Benefits

Flexibility in the way requests are activated

- Different user interface elements can generate the same kind of command object
- Allows the user to configure commands performed by a user interface element

Flexibility in the number and functionality of requests

- Adding new commands and providing for a macro language comes easy

Programming execution-related services

- Commands can be stored for later replay
- Commands can be logged
- Commands can be rolled back

Testability at application level

Concurrency

- Allows for the execution of commands in separate threads

Liabilities

Efficiency loss

Potential for an excessive number of command classes

Try reducing the number of command classes by:

Grouping commands around abstractions

Unifying simple commands classes by passing the receiver object as a parameter

Complexity

How do commands get additional parameters they need?

Singleton

Warning

Simplest pattern

- But has subtle issues particularly in Java

Most controversial pattern

Intent

Ensure a class only has one instance

Provide global point of access to single instance

Singleton

```
public class Counter {
      private int count = 0;
      private static Counter instance;
      private Counter() { }

      public static Counter instance() {
            if (instance == null)
                  instance = new Counter();
            return instance;
      }

      public int increase()  {return ++count;}
}
```

One instance

Global access

This version does not work correctly all the time. See later slides

Some Uses

Java Security Manager

Logging a Server

Null Object

Globals are Evil

Why Singletons Are Controversial(Evil)

Singletons provide global access point for some service

Hidden dependencies

Is there a different design that does not need singletons

- Pass a reference

Why Singletons Are Controversial(Evil)

Singletons allow you to limit creation of objects of a class

Should that be the responsibility of the class?

Class should do one thing

Use factory or builder to limit the creation

Why Singletons Are Controversial(Evil)

Singletons tightly couple you to the exact type of the singleton object

No polymorphism

Hard to subclass

Why Singletons Are Controversial(Evil)

Singletons carry state with them that last as long as the program lasts

Persistent state makes testing hard and error prone

Why Singletons Are Controversial(Evil)

A Singleton today is a multiple tomorrow

Singleton pattern makes it hard to change to allow multiple objects

Why Singletons Are Controversial(Evil)

In Java Singletons are a lie

More on this later

Singleton Implementation

Why Not Use This?

```
public class Counter {
        private static int count = 0;

        public static int increase()  {return ++count;}
}
```

Why Not Use This?

```
public class Counter {
        private int count = 0;
        private Counter() { }

        public static Counter instance = new Counter();

        public int increase()  {return ++count;}
}
```


Very subtle the error here

Two Useful Features

Lazy

- Only created when needed

Thread safe

Recommended Implementation

```
public class Counter {
      private int count = 0;
      private Counter() { }

      private static class SingletonHolder {
        private final static Counter INSTANCE = new Counter();
    }

      public static Counter instance() {
                return SingletonHolder.INSTANCE;
      }

      public int increase()  {return ++count;}
}
```


Implementation due to Bill Pugh, found in Wikipedia, http://en.wikipedia.org/wiki/Singleton_pattern. It is thread-safe, lazy and works with all know versions of Java

Correct but not Lazy

```
public class Counter {
        private int count = 0;
        protected Counter() { }

        private final static Counter INSTANCE = new
Counter();

        public static Counter instance() {
                return INSTANCE;
        }

        public int increase()  {return ++count;}
}
```

Lazy, Thread safe with Overhead

```
public class Counter {
        private int count = 0;
        private static Counter instance;
        private Counter() { }

        public static synchronized Counter instance() {
                if (instance == null)
                        instance = new Counter();
                return instance();
        }

        public int increase()  {return ++count;}
}
```

Java Templates & Singleton

Does not compile

```
public class TemplateSingleton<Type> {
    Type foo;

    public static TemplateSingleton<Type> instance =
        new TemplateSingleton<Type>();
}
```

When is a Single Single?

When Java Garbage Collects Classes

Singleton class can be garbage collected
Singleton loses any value it had

Solution

Turn off garbage collection of classes (-Xnoclassgc)

Make sure there is always a reference to the class/instance

When Multiple Java Class Loaders are Used

When loaded by two different class loaders there will be two versions of the class

Some servlet engines use different class loader for each servlet

Using custom class loaders can cause this

Purposely Reloading a Java Class

Servlet engines can force a class to be reloaded

Serialize and Deserialize Singleton Object

Serialize the singleton
Deserialize the singleton
You now have two copies

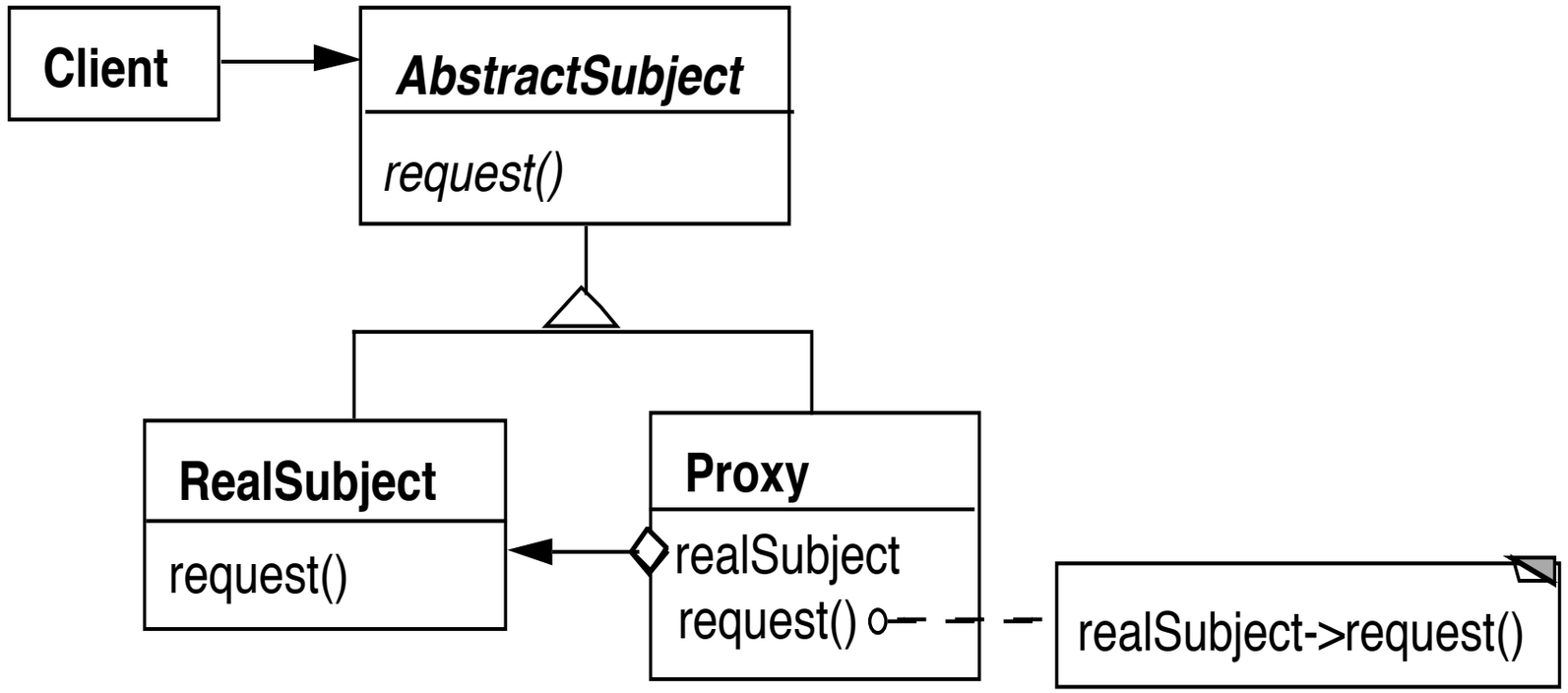
One way to serialize a Java object is using ObjectOutputStream

Ruby Marshal.dump() will not marshal a singleton

Proxy

Proxy (Surrogate)

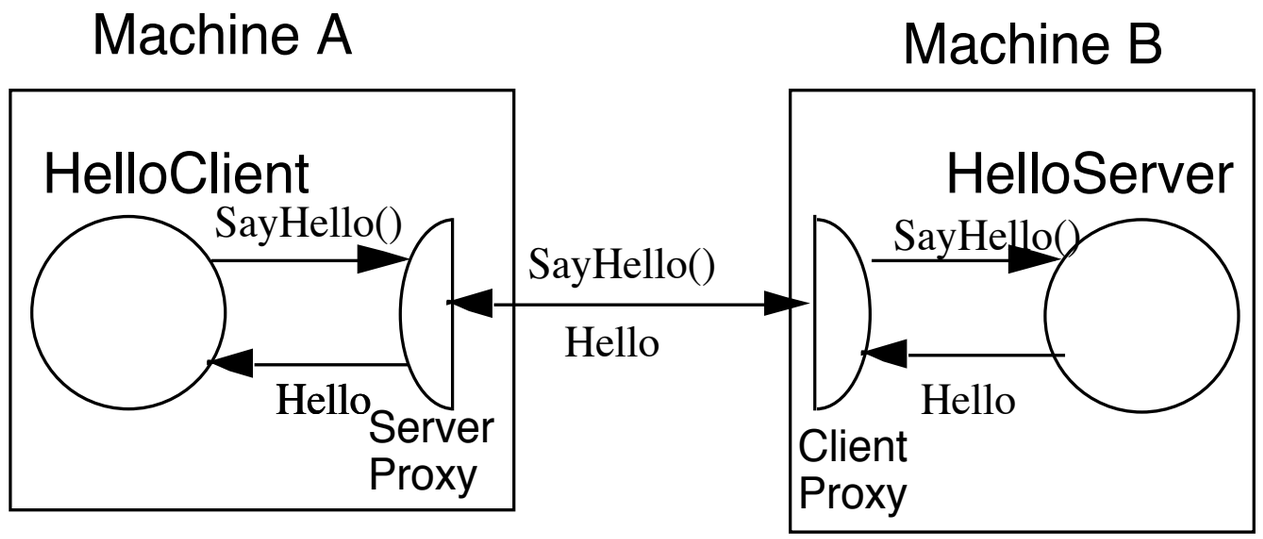
a person authorized to act on behalf of another




```
class Proxy {
        AbstractSubject realSubject;

        public Foo service(Bar x ) {
                return realSubject(x);
        }
```

Why do it?

Remote Proxy




```
String server = getHelloHostAddress( args);
Hello proxy = (Hello) Naming.lookup( server );
String message = proxy.sayHello();
System.out.println( message );
```

More General Proxy

```
class Proxy {
        AbstractSubject realSubject;

        public Foo service(Bar x ) {
                some preprocessing
                result = realSubject(x);
                some postprocessing
        }
```

Virtual Proxy

Creates/accesses expensive objects on demand

O-R Mapping Layers

Java's Synchronized List

```
ArrayList notSafe = new ArrayList();
List threadSafe = Collections.synchronizedList(notSafe);


static class SynchronizedList {
        List list;
        public Object get(int index) {
            synchronized(mutex) {return list.get(index);}
        }
}
```

Java's Unmodifiable List

```
ArrayList notSafe = new ArrayList();
List noChange = Collections.unmodifiableList(notSafe);
```

```
static class UnmodifiableList {
      List list;
      public Object get(int index) { return list.get(index);}

      public Object set(int index, Object element) {
         throw new UnsupportedOperationException();
       }
```

Proxy or Decorator?

```
ArrayList notSafe = new ArrayList();
List noChange = Collections.unmodifiableList(notSafe);
List threadSafe = Collections.synchronizedList(noChange);
```

Proxy verses Decorator

"Decorators can have similar implementations as proxies"

Proxy controls access to an object

Decorator adds one or more responsibilities to an object