CS 635 Advanced Object-Oriented Design & Programming
Spring Semester, 2013
Doc 8 Interpreter, Observer, State
Feb 21, 2013

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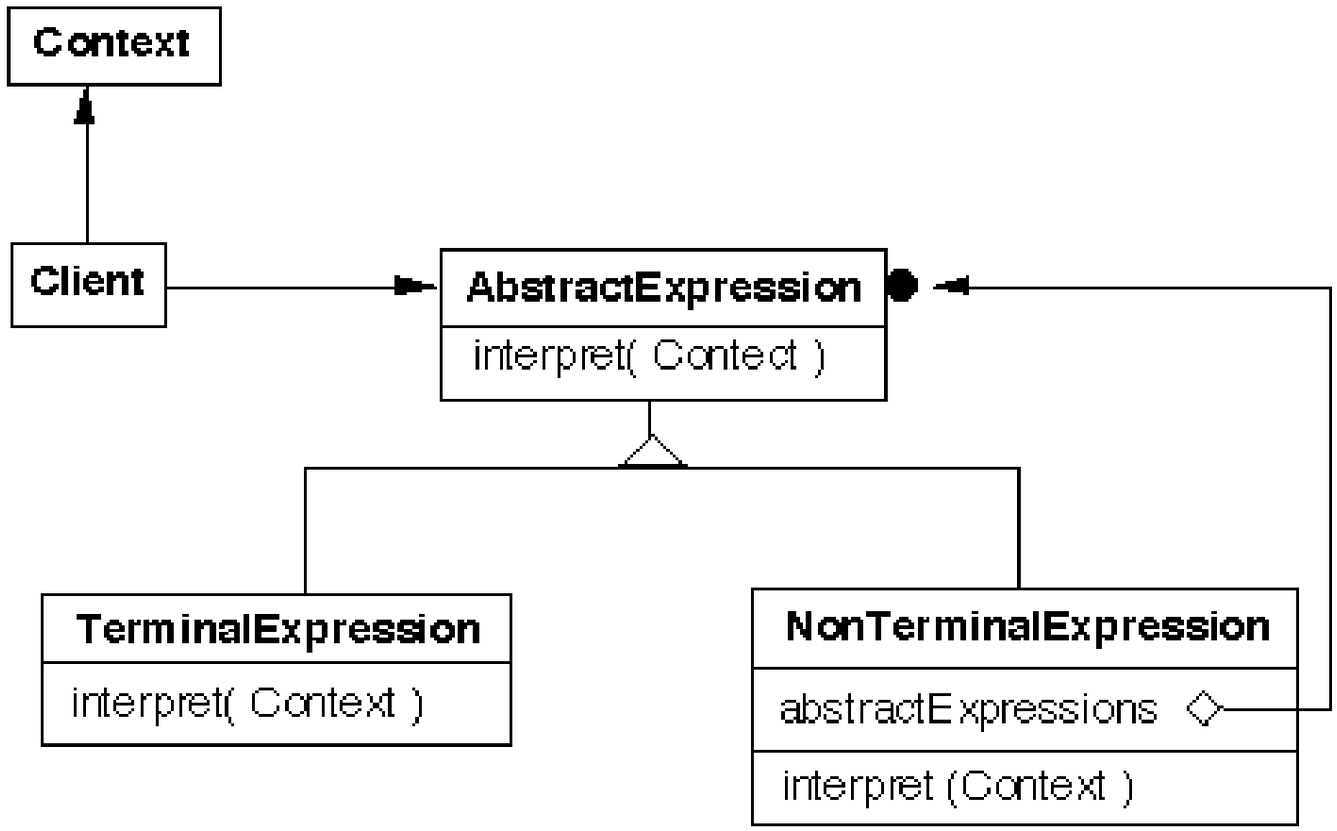
Interpreter

Given a language, define a representation for its grammar along with an interpreter that uses the representation to interpret sentences in the language



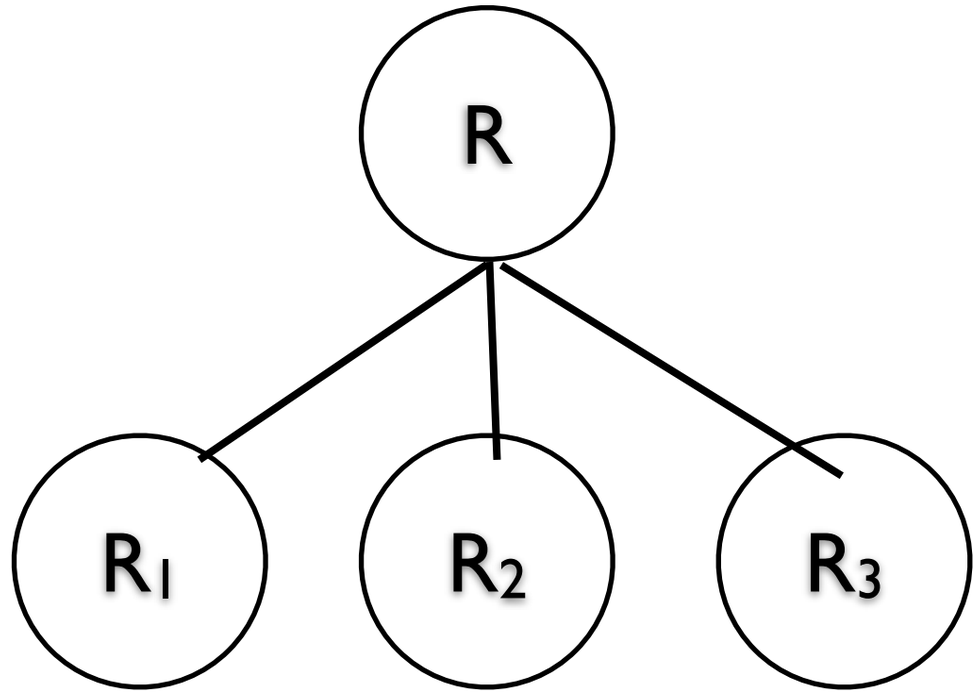
Grammar & Classes

Given a language defined by a grammar like:

$R ::= R_1\ R_2\ R_3$

you create a class for each rule

The classes can be used to construct a tree that represents elements of the language



Example - Boolean Expressions

BooleanExpression ::=

Variable	|
Constant	|
Or	|
And	|
Not	|
BooleanExpression	

And ::= '(' BooleanExpression ‘and’ BooleanExpression ')'

Or ::= '(' BooleanExpression ‘or’ BooleanExpression ')'

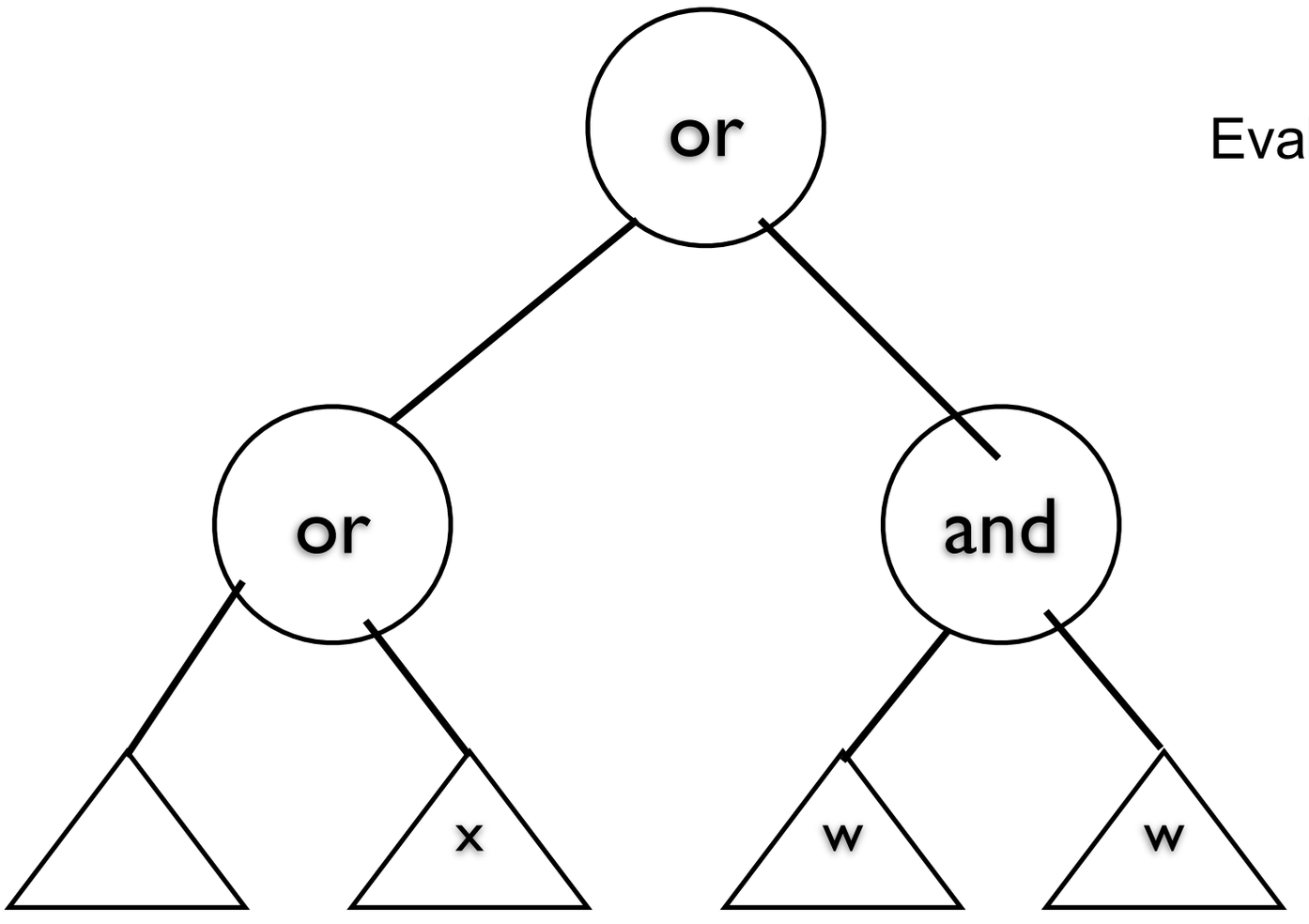
Not ::= ‘not’ BooleanExpression

Constant ::= ‘true’ | ‘false’

Variable ::= String

Sample Expression

((true or x) or (w and x))



Evaluate with

x = true

w = false

Sample Classes

```
public interface BooleanExpression{
        public boolean evaluate( Context values );
        public String toString();
}
```

And

```
public class And implements BooleanExpression {
        private BooleanExpression leftOperand;
        private BooleanExpression rightOperand;

        public And( BooleanExpression leftOperand, BooleanExpression rightOperand) {
                this.leftOperand = leftOperand;
                this.rightOperand = rightOperand;
        }

        public boolean evaluate( Context values ) {
                return leftOperand.evaluate( values ) &&  rightOperand.evaluate( values );
        }

        public String toString(){
                return "(" + leftOperand.toString() + " and " + rightOperand.toString() + ")";
        }
}
```

Constant

```
public class Constant implements BooleanExpression {
        private boolean value;
        private static Constant True = new Constant( true );
        private static Constant False = new Constant( false );

        public static Constant getTrue() {      return True; }

        public static Constant getFalse(){      return False; }

        private Constant( boolean value) { this.value = value; }

        public boolean evaluate( Context values ) { return  value;  }

        public String toString() {
                return String.valueOf( value );
        }
}
```

Variable

```
public class Variable implements BooleanExpression {

        private String name;

        private Variable( String name ) {
                this.name = name;
        }

        public boolean evaluate( Context values ) {
                return values.getValue( name );
        }

        public String toString() { return name; }
}
```

Context

```
public class Context {
    Hashtable<String,Boolean> values = new Hashtable<String,Boolean>();

    public boolean getValue( String variableName ) {
        return values.get( variableName );
    }

    public void setValue( String variableName, boolean value ) {
        values.put( variableName,  value ) );
    }
}
```

((true or x) or (w and x))

```
public class Test {
	public static void main( String args[] ) throws Exception  {
		BooleanExpression left =
			new Or(  Constant.getTrue(), new Variable( "x" ) );
		BooleanExpression right =
			new And(  new Variable( "w" ), new Variable( "x" ) );

		BooleanExpression all = new Or(  left, right );

		System.out.println( all );
		Context values = new Context();
		values.setValue( "x", true );
		values.setValue( "w", false );

		System.out.println( all.evaluate( values ) );
		}
}
```

Consequences

It's easy to change and extend the grammar

Implementing the grammar is easy

Complex grammars are hard to maintain

- Use JavaCC or SmaCC instead

Adding new ways to interpret expressions

- The visitor pattern is useful here

Complicates design when a language is simple

Supports combinations of elements better than implicit language

Implementation

The pattern does not talk about parsing!

Flyweight

If terminal symbols are repeated many times using the Flyweight pattern can reduce space usage

Composite

Abstract syntax tree is an instance of the composite

Iterator

Can be used to traverse the structure

Visitor

Can be used to place behavior in one class

Observer

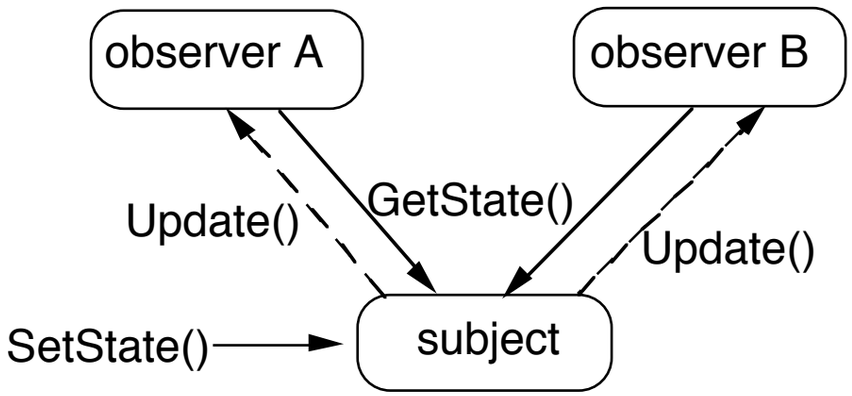
Observer

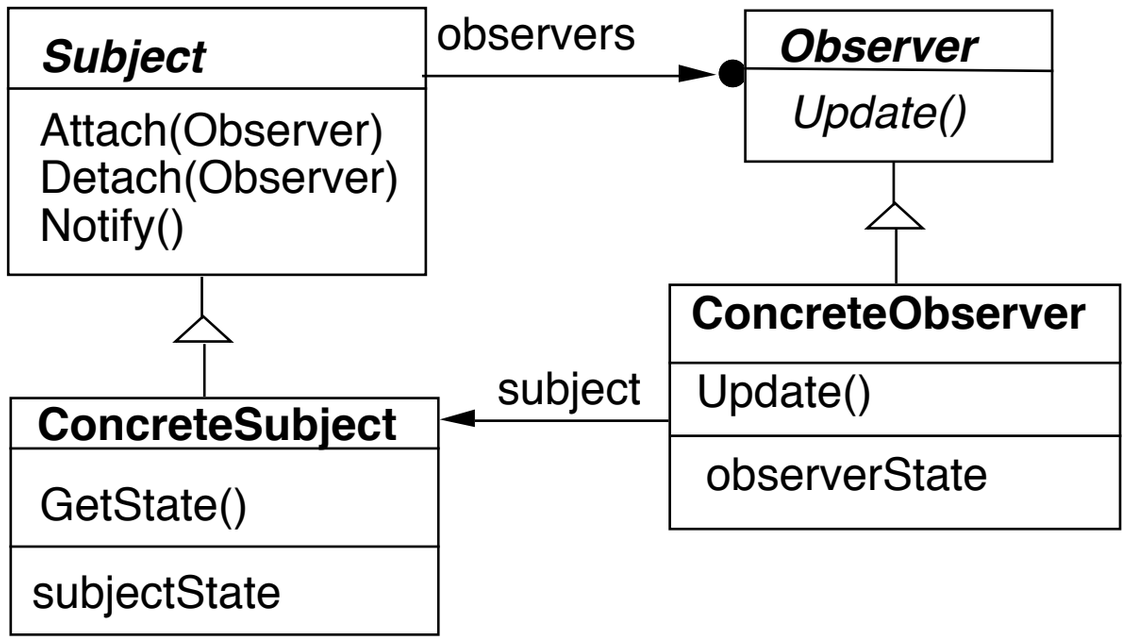
One-to-many dependency between objects

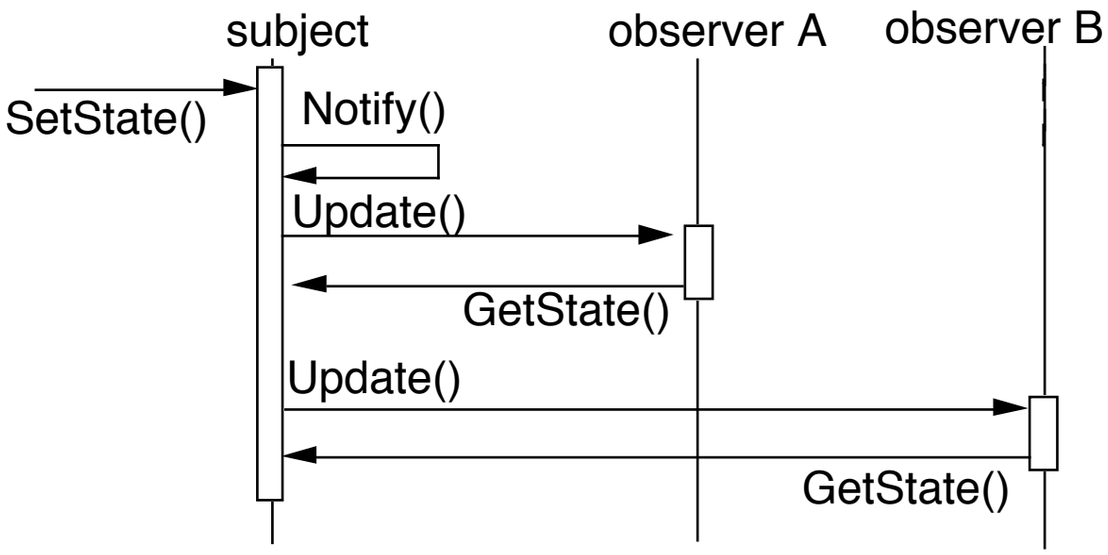
When one object changes state,

all its dependents are notified and updated automatically

Structure


observer A
observer B
Update()
GetState()
Update()
SetState()
subject


Subject
Attach(Observer)
Detach(Observer)
Notify()
observers
Observer
Update()
ConcreteObserver
Update()
observerState
subject
ConcreteSubject
GetState()
subjectState


subject
observer A
observer B
SetState()
Notify()
Update()
GetState()
Update()
GetState()

Pseudo Java Example

```
public class Subject {
   Window display;
   public void someMethod() {
      this.modifyMyStateSomeHow();
      display.addText( this.text() );
   }
}
```

Abstract coupling - Subject & Observer

Broadcast communication

Updates can take too long

```
public class Subject {
   ArrayList observers = new ArrayList();

   public void someMethod() {
      this.modifyMyStateSomeHow();
      changed();
   }

   private void changed() {
      Iterator needsUpdate = observers.iterator();
      while (needsUpdate.hasNext() )
         needsUpdate.next().update( this );
   }
}

public class SampleWindow {
   public void update(Object subject) {
      text = ((Subject) subject).getText();
      Thread.sleep(10000).
   }
}
```

Some Language Support

Smalltalk	Java	Ruby	Observer Pattern
Object	Observer		Abstract Observer class
Object & Model	Observable	Observable	Subject class

Smalltalk Implementation

Object implements methods for both Observer and Subject.

Actual Subjects should subclass Model

Java's Observer

Class java.util.Observable

void addObserver(Observer o)
void clearChanged()
int countObservers()
void deleteObserver(Observer o)
void deleteObservers()
boolean hasChanged()
void notifyObservers()
void notifyObservers(Object arg)
void setChanged()

Java	Observer Pattern
Interface Observer	Abstract Observer class
Observable class	Subject class

Observable object may have any number of Observers

Whenever the Observable instance changes,
it notifies all of its observers

Notification is done by calling the update() method on all observers.

Interface java.util.Observer

Allows all classes to be observable by instances of class Observer

Java Example

```
class Counter extends Observable  {
        public static final String INCREASE = "increase";
        public static final String DECREASE = "decrease";
        private int count = 0;
        private String label;

        public Counter( String label )    {       this.label = label; }

        public String label()                 {  return label; }
        public int value()                    {  return count; }
        public String toString()              {  return String.valueOf( count );}

        public void increase() {
                count++;
                setChanged();
                notifyObservers( INCREASE );
        }

        public void decrease()  {
                count--;
                setChanged();
                notifyObservers( DECREASE );
                }
        }
```

Java Observer

```
class IncreaseDetector implements Observer {
        public void update( java.util.Observable whatChanged,
                                                java.lang.Object message) {
                if ( message.equals( Counter.INCREASE) )  {
                        Counter increased = (Counter) whatChanged;
                        System.out.println( increased.label() + " changed to " +
                                                                increased.value());
                }
        }

        public static void main(String[] args) {
                Counter test = new Counter();
                IncreaseDetector adding = new IncreaseDetector();
                test.addObserver(adding);
                test.increase();
        }
```

Ruby Example

```
require'observer'

class Counter
    include Observable

    attr_reader :count

    def initialize
        @count = 0
    end
    def increase
        @count += 1
        changed
        notify_observers(:INCREASE)
    end

    def decrease
        @count -= 1
        changed
        notify_observers(:DECREASE)
    end
end
```

```
class IncreaseDetector

    def update(type)
        if type == :INCREASE
            puts('Increase')
        end
    end
end

count = Counter.new()
puts count.count
count.add_observer(IncreaseDetector.new)
count.increase
count.increase
puts count.count
```

Implementation Issues

Mapping subjects(Observables) to observers

Use list in subject

Use hash table

```
public class Observable {
    private boolean changed = false;
    private Vector obs;

public Observable() {
        obs = new Vector();
    }

public synchronized void addObserver(Observer o) {
        if (!obs.contains(o)) {
            obs.addElement(o);
        }
    }
```

Observing more than one subject

If an observer has more than one subject how does it know which one changed?

Pass information in the update method

Deleting Subjects

In C++ the subject may no longer exist

Java/Smalltalk observer may prevent subject from garbage collection

Who Triggers the update?

Have methods that change the state trigger update

```
class Counter extends Observable  {              // some code removed
        public void increase()  {
                count++;
                setChanged();
                notifyObservers( INCREASE );
        }
}
```

Have clients call Notify at the right time

```
class Counter extends Observable  {       // some code removed
                public void increase()  {    count++;  }
}

Counter pageHits = new Counter();
pageHits.increase();
pageHits.increase();
pageHits.increase();
pageHits.notifyObservers();
```

Subject is self-consistent before Notification

```
class ComplexObservable extends Observable {
        Widget frontPart = new Widget();
        Gadget internalPart = new Gadget();

        public void trickyChange() {
                frontPart.widgetChange();
                internalpart.anotherChange();
                setChanged();
                notifyObservers( );
        }
}

class MySubclass extends ComplexObservable {
        Gear backEnd = new Gear();

        public void trickyChange() {
                super.trickyChange();
                backEnd.yetAnotherChange();
                setChanged();
                notifyObservers( );
        }
}
```

Adding information about the change

push models - add parameters in the update method

```
class IncreaseDetector extends Counter implements Observer { // stuff not shown

        public void update( Observable whatChanged, Object message) {
            if ( message.equals( INCREASE) )
                increase();
        }
}

class Counter extends Observable {          // some code removed
        public void increase()  {
            count++;
            setChanged();
            notifyObservers( INCREASE );
        }
}
```

Adding information about the change

pull model - observer asks Subject what happened

```
class IncreaseDetector extends Counter implements Observer {
        public void update( Observable whatChanged ) {
                if ( whatChanged.didYouIncrease() )
                        increase();
        }
}

class Counter extends Observable {          // some code removed
        public void increase() {
                count++;
                setChanged();
                notifyObservers( );
        }
}
```

Scaling the Pattern

Java Event Model

AWT/Swing components broadcast events to Listeners

JDK1.0 AWT components broadcast an event to all its listeners

A listener normally not interested all events

Broadcasting to all listeners was too slow with many listeners

Java 1.1+ Event Model

Each component supports different types of events:

Component supports

ComponentEvent	FocusEvent
KeyEvent	MouseEvent

Each event type supports one or more listener types:

MouseEvent

MouseListener	MouseMotionListener

Each listener interface replaces update with multiple methods

MouseListener

mouseClicked()	mouseEntered()
mousePressed()	mouseReleased()

Listeners

- Only register for events of interest
- Don't need case statements to determine what happened

Small Models

Often an object has a number of fields(aspects) of interest to observers

Rather than make the object a subject make the individual fields subjects

- Simplifies the main object
- Observers can register for only the data they are interested in

VisualWorks ValueHolder

Subject for one value

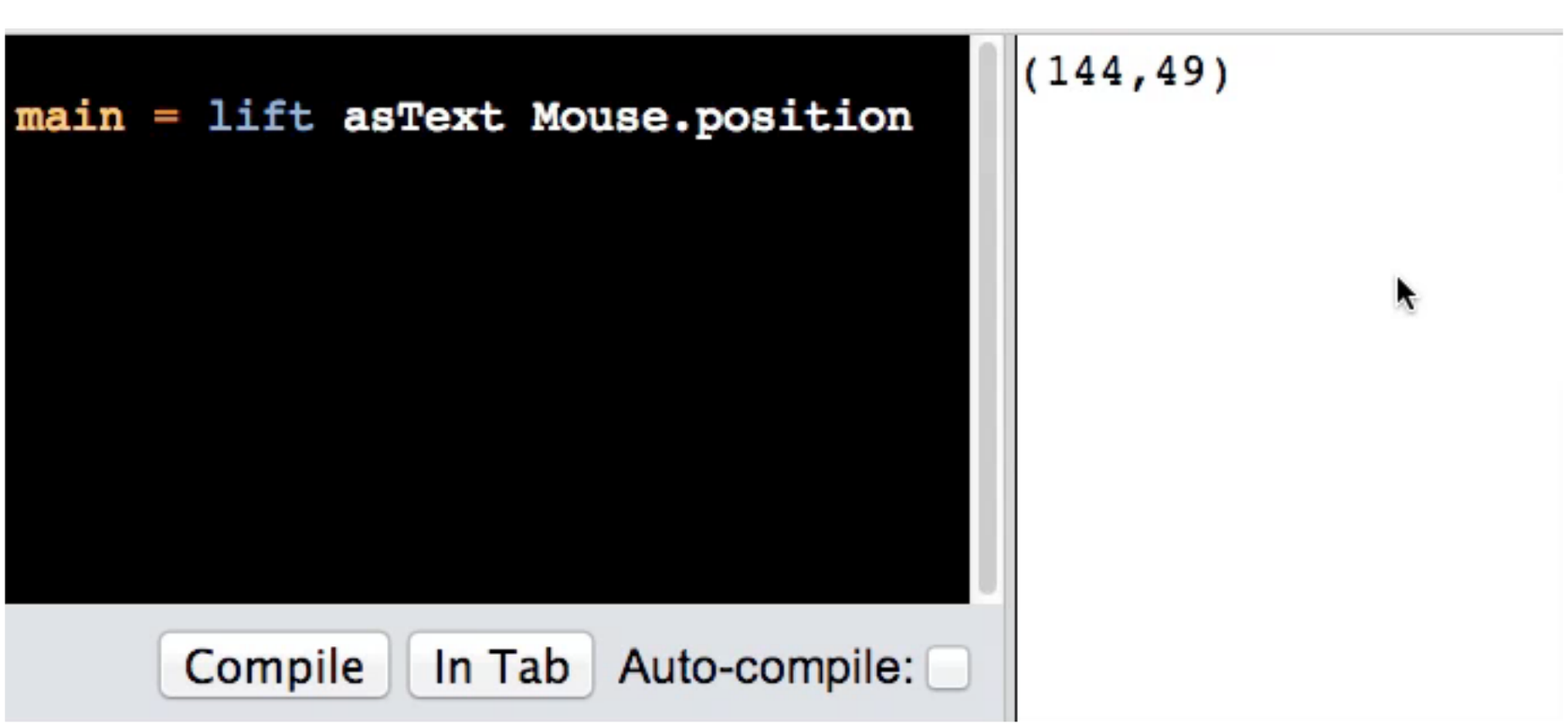
ValueHolder allows you to:

- Set/get the value
  - Setting the value notifies the observers of the change
- Add/Remove dependents

Reactive Programming

datatypes that represent a value 'over time'

Spreadsheets
Elm
Meteor.js



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http://stackoverflow.com/questions/1028250/what-is-functional-reactive-programming
http://elm-lang.org/
http://en.wikipedia.org/wiki/Reactive_programming

State

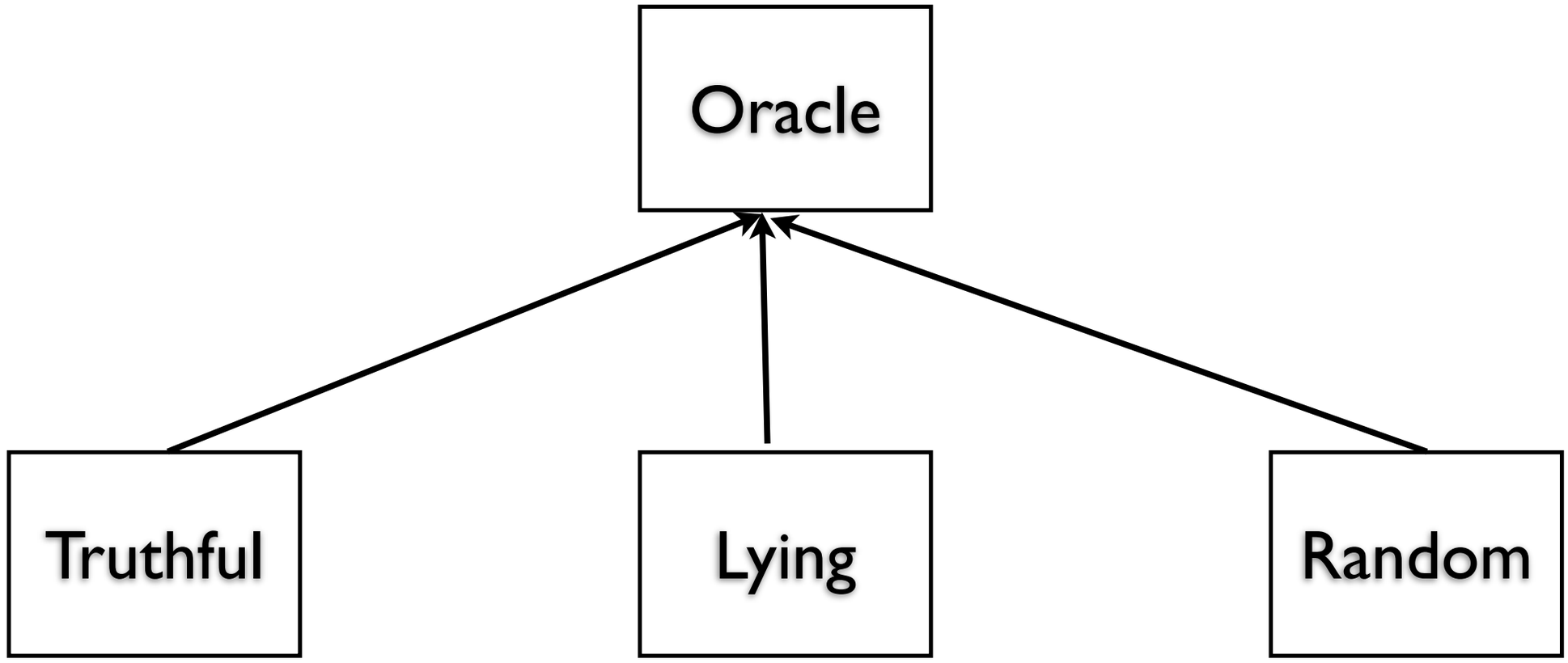
State Pattern

Allow an object to alter its behavior when its internal state changes

The object will appear to change it class

Structure

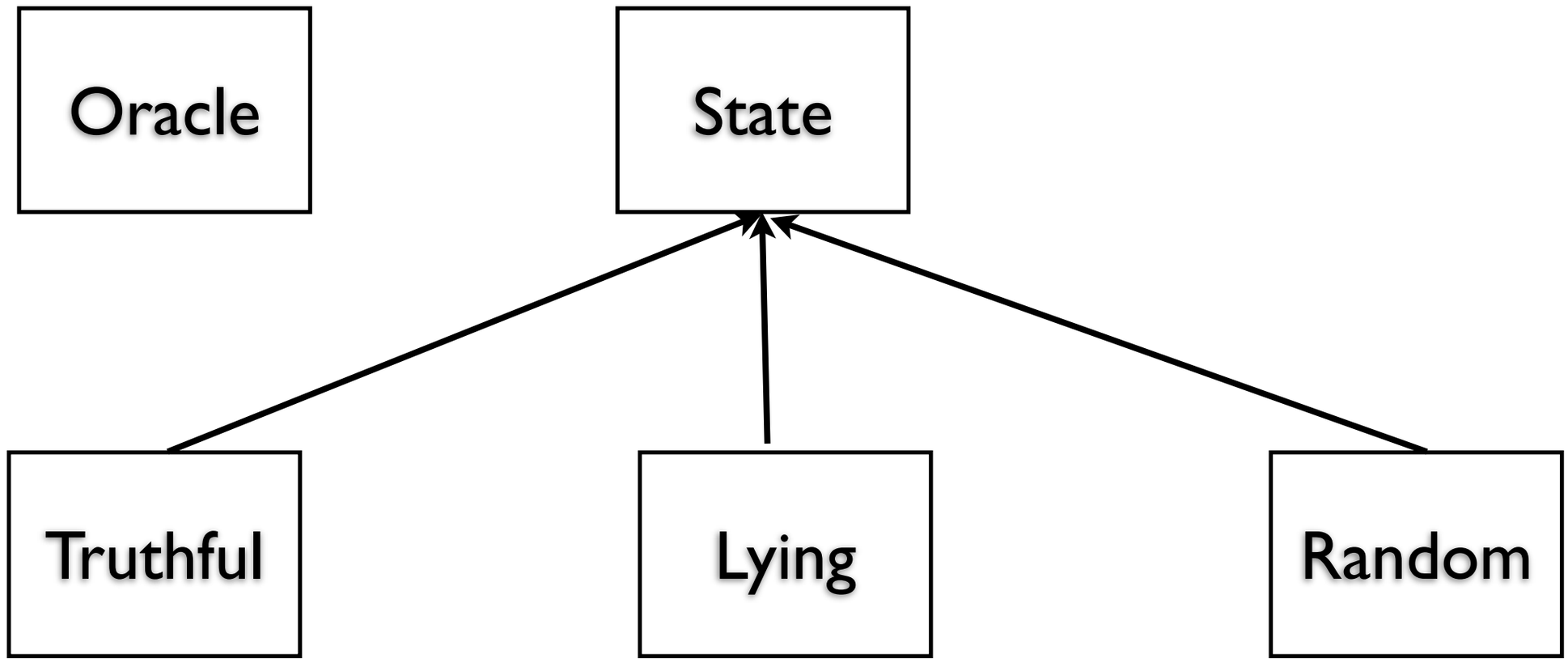
Context
state
request()
State
handle()
state->handle()
ConcreteStateA
handle()
ConcreteStateB
handle()




```
Oracle seer = new Truthful();
seer.willThereBeAFeeIncreaseNextYear();
seer = new Lying();
seer.willThereBeAFeeIncreaseNextYear();
```

Oracle

```
public class Oracle {
    private final TRUTH = "truth";
    private final LIE = "lie";
    private final RANDOM = "random";

    String state = TRUTH;

    public boolean willThereBeAFeeIncreaseNextYear() {
        if (state == TRUTH)
            blah
        else if (state == LIE)
            more blah
        else if (state == RANDOM)
            random blah
    }
```



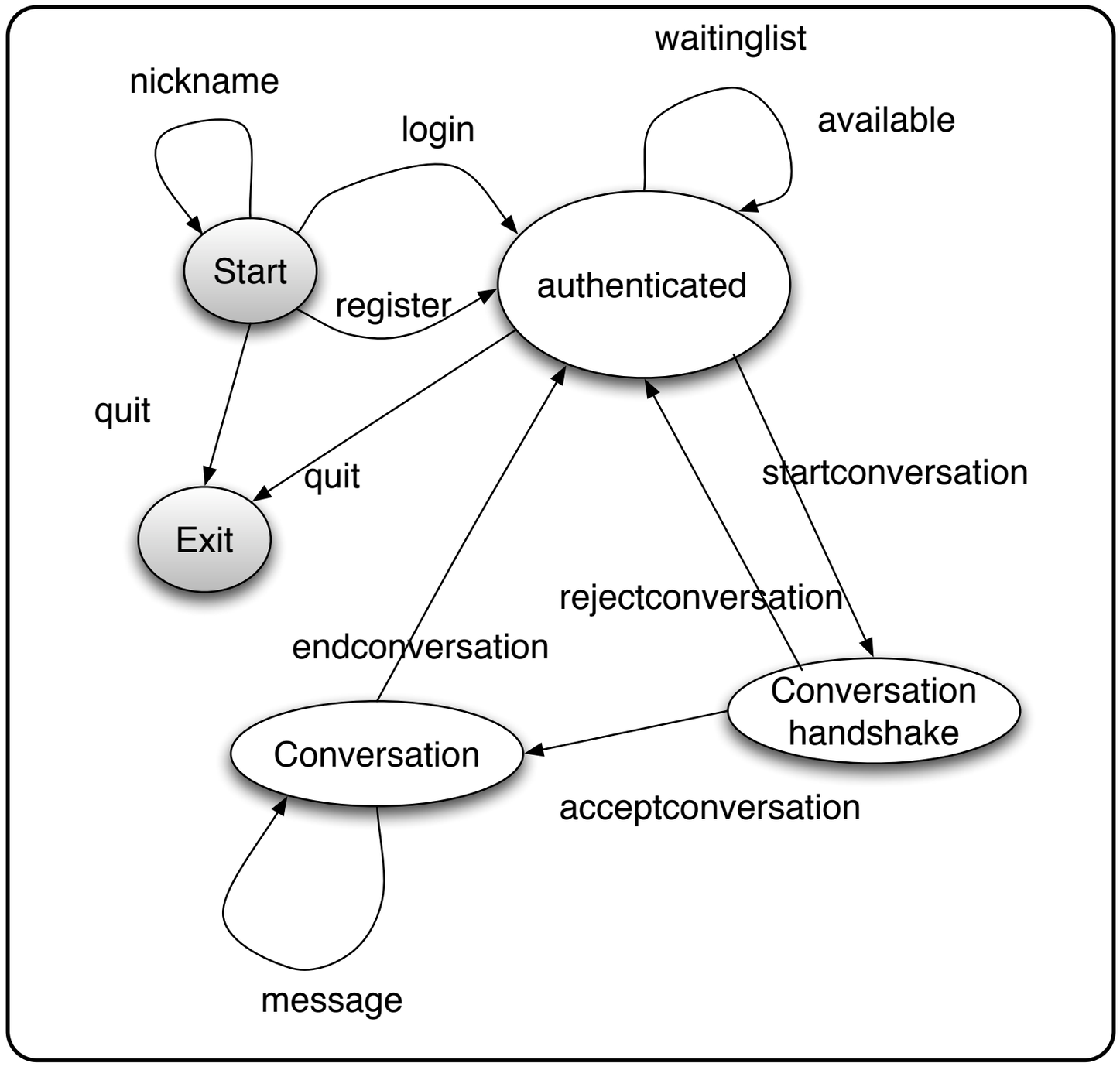

```
class Oracle {
        private State mode = set mode;

        public boolean willThereBeAFeeIncreaseNextYear() {
                return mode. willThereBeAFeeIncreaseNextYear():
        }
}
```

Example: SDChat Server

Commands

"available"
"login"
"register"
"nickname"
"startconversation"
"quit"
"waitinglist"
"acceptconversation"
"message"
"rejectconnection"
"endconversation"

Server States



Without States

```
public class SDChatServer {

    String handleNickname(String data) {
        if (state != START)
            return someErrorMessage();
        handle the main case
    }

    String handleLogin(String data) {
        if (state != START)
            return someErrorMessage();
        handle main case
    }

    String handleWaitinglist(String data) {
        if (state != AUTHENTICATED)
            return someErrorMessage();
        handle main case
    }
```

Who defines state Transitions - Context

```
class Context {
        private AbstractState state = new StartState();

        public Bar foo(int x) {
                int result = state.foo(x);
                if (someConditionHolds() )
                        state = nextState();
        return result;
        }
```

Who defines state Transitions - States

```
class Context {
        private AbstractState state = new StartState();

        public void foo(int x) {
                state = state.foo(x);
                }
```

What if foo returns a value?

Who defines state Transitions - States

```
class Context {
        private AbstractState state = new StartState();

        public int foo(int x) {
                return state.foo(x, this);
                }

        protected void setState(AbstractState newState) {
                state = newState;
        }
```

Sharing State Objects

Stateless state

- State objects without fields
- Can be shared by multiple contexts

Can store date in context and pass as arguments

Large number of state transitions can be expensive

Only create state once & reuse same object

Changing Class - No Need for Context

Language Dependent Feature

Smalltalk & Lisp

```
class Truthful extends Oracle {

    public boolean foo(int x) {
        int result = state.foo(x);
        this.changeClassTo(Random);
        return result;
    }
```

State Verses Strategy

Rate of Change

Strategy

Context usually contains just one strategy object

State

Context often changes state objects

State Verses Strategy

Exposure of Change

Strategy

Strategies all do the same thing

Client do not see change in behavior of Context

State

States act differently

Client see the change in behavior