CS 635 Advanced Object-Oriented Design & Programming
Fall Semester, 2020
Doc 9 Strategy, State, Command
Sep 22, 2020

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Why Software Projects Go Wrong

More software projects have gone awry for lack of quality, which is part of many destructive dynamics, than for all other causes combined.

Gerald M. Weinberg

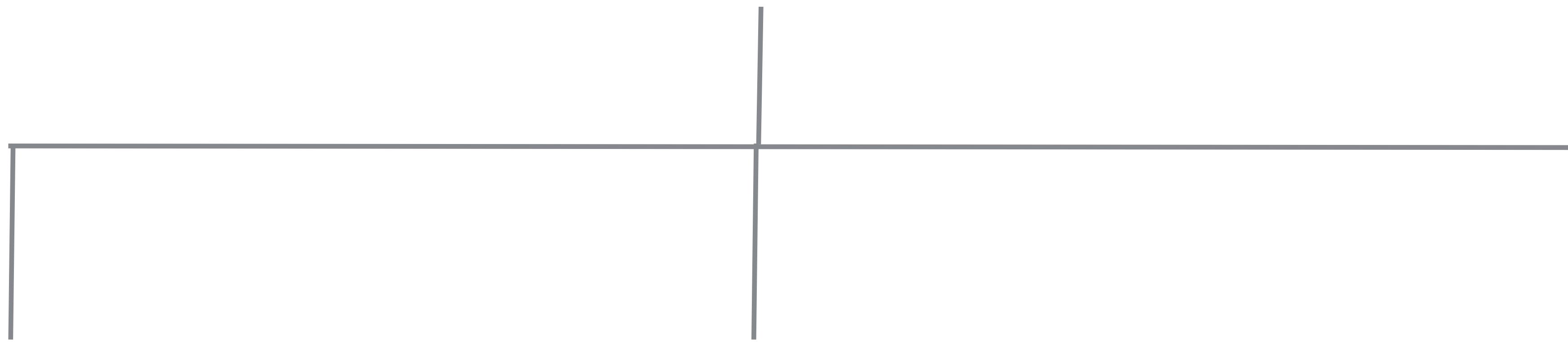
Strategy Pattern

Favor Composition over Inheritance

Orderable List

Sorted
Reverse Sorted
Random

OrderableList



SortedList ReverseList RandomList

One size does not fit all

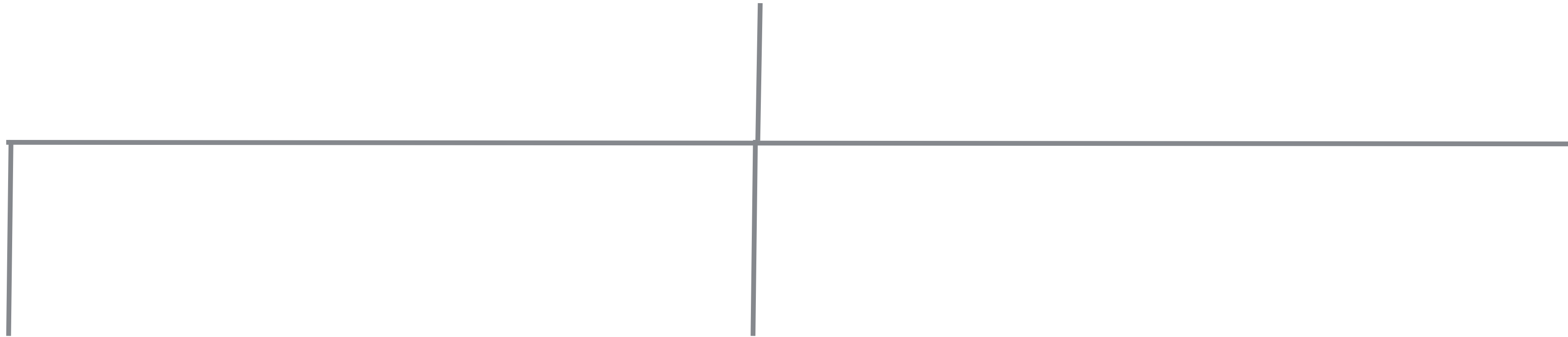
Issue 1 - Orthogonal Features

Order
Sorted
Reverse Sorted
Random

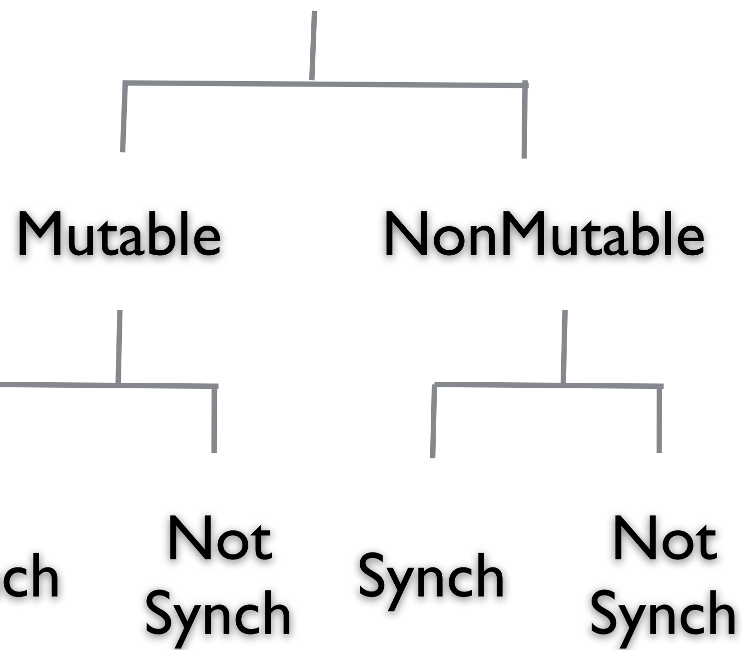
Threads
Synchronized
Unsynchronized

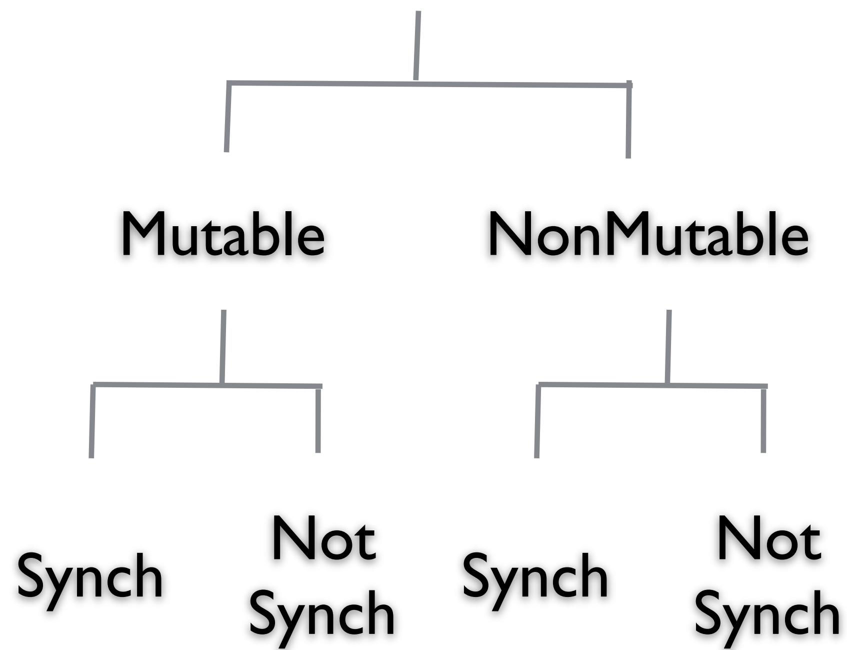
Mutability
Mutable
Non-mutable

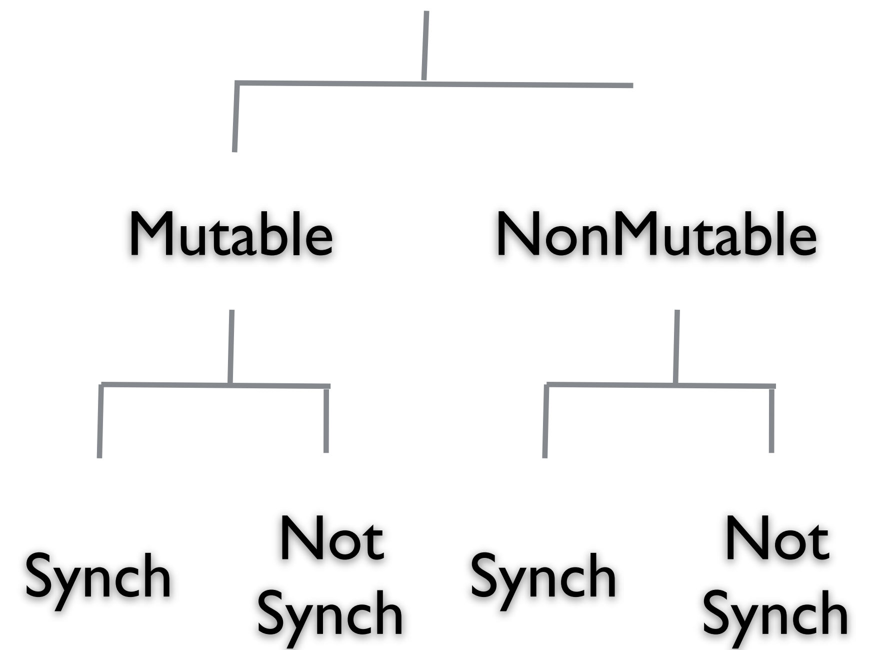
OrderableList



SortedList ReverseList RandomList







Issue 2 - Flexibility

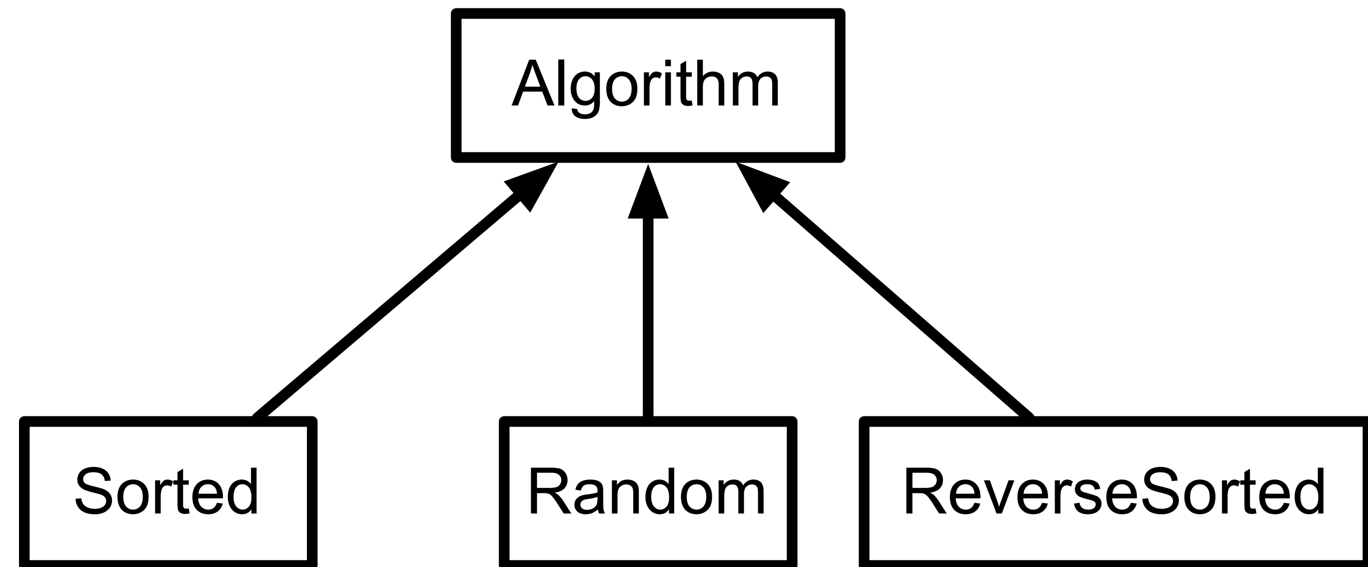
Change behavior at runtime

```
OrderableList x = new OrderableList();
x.makeSorted();
x.add(foo);
x.add(bar):
x.makeRandom();
```

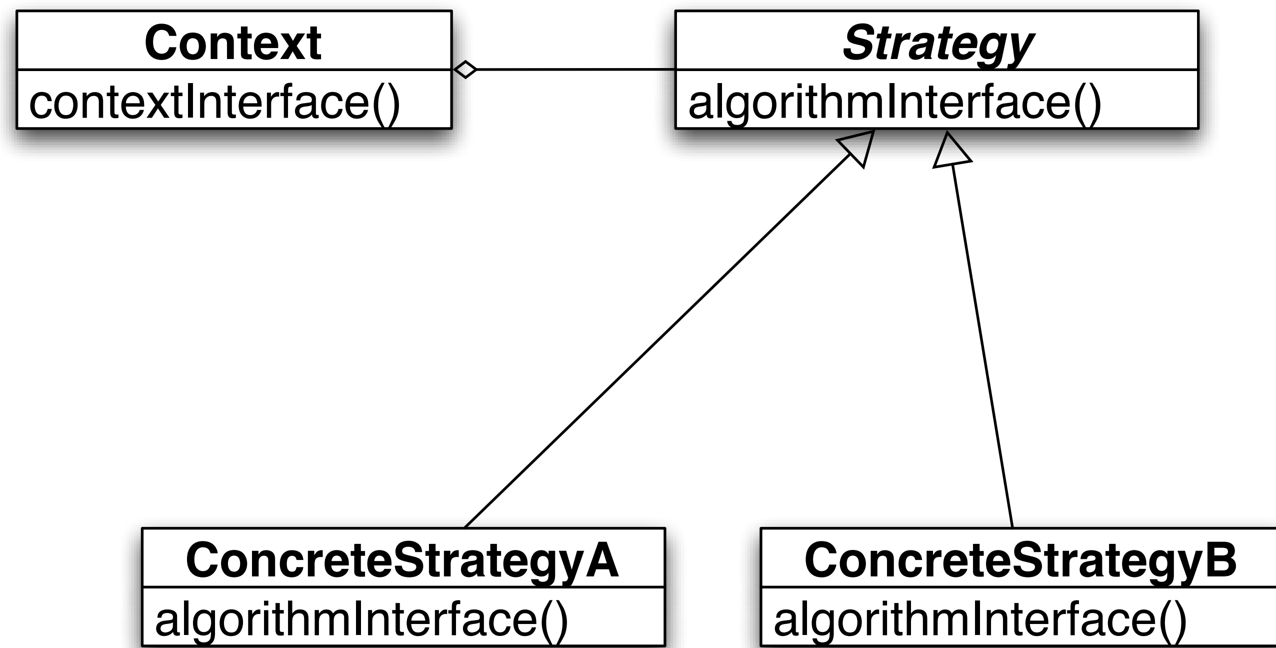
Configure objects behavior at runtime

Strategy Pattern

```
class OrderableList {
   private Object[ ] elements;
   private Algorithm orderer;

   public OrderableList(Algorithm x) {
      orderer = x;
   }

  public void add(Object element) {
     elements = ordered.add(elements,element);
  }
```



Structure



The algorithm is the operation

Context contains the data

How does this work?

Prime Directive

Data + Operations

How does Strategy Get the Data?

Pass needed data as parameters in strategy method

Give strategy object reference to context

Strategy extracts needed data from context

Example - Java Layout Manager

```
import java.awt.*;
class  FlowExample  extends Frame  {

   public FlowExample( int  width, int height ) {
      setTitle( "Flow Example" );
      setSize( width, height );
      setLayout( new FlowLayout( FlowLayout.LEFT) );

      for ( int label = 1; label < 10; label++ )
          add( new Button( String.valueOf( label ) ) );
      show();
   }

   public  static  void  main( String  args[] ) {
      new  FlowExample( 175, 100 );
      new  FlowExample( 175, 100 );
   }
}
```

Example - Smalltalk Sort blocks

```
| list |
list := #( 1 6 2 3 9 5 ) asSortedCollection.
Transcript
    print: list;
    cr.
list sortBlock: [:x :y | x > y].
Transcript
    print: list;
    cr;
    flush.
```

Java Sorting

How to sort a Collection in Java?

~~ArrayList~~ List method - sort(Comparator<? super E> c)

Create a subclass of Comparator

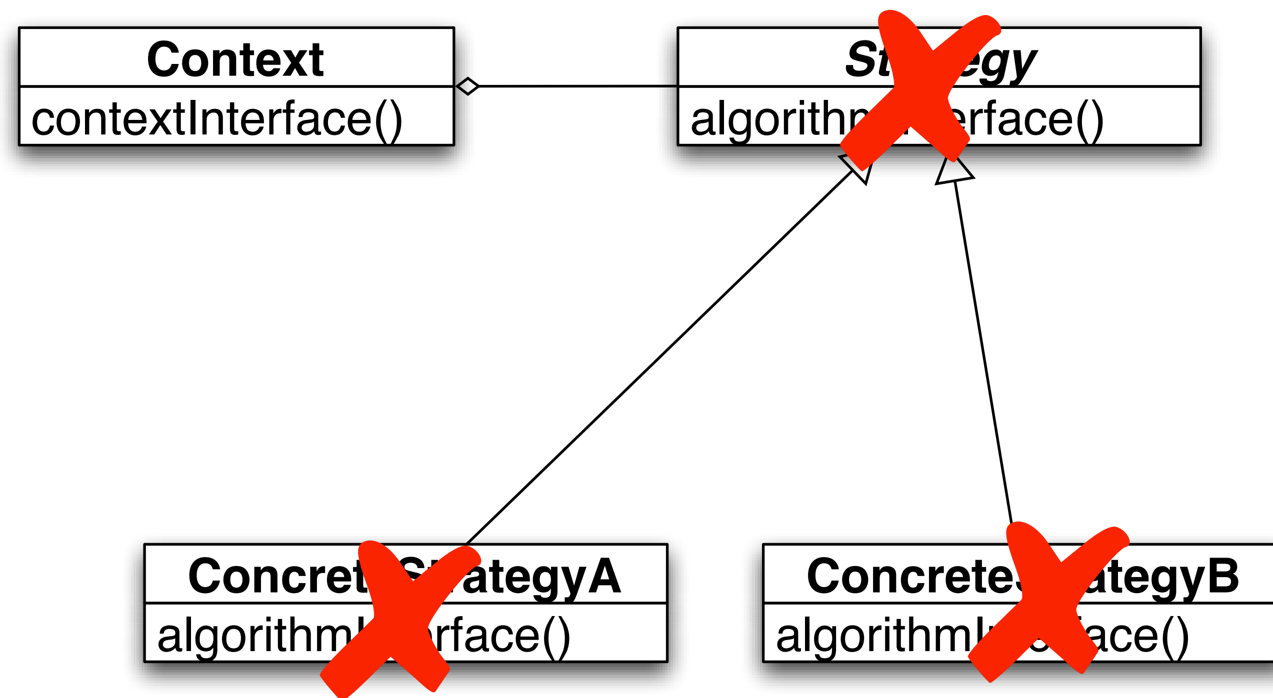
Pass in comparator object to sort method

```
List<Students> students = new ArrayList<>();
add students
students.sort(new SortByGPA());
```

Lambda & Strategy Pattern

If strategy only contains one method

Can replace Strategy classes with a lambda



In Java may need to define lambda type

Java Sorting Using Lambda

```
List<Students> students = new ArrayList<>();

add students

students.sort( (a, b) -> (a.gpa() <= b.gpa()) ? -1 : 1);
```

Costs

Clients must be aware of different Strategies

Communication overhead between Strategy and Context

Increase number of objects

Benefits

Alternative to subclassing of Context

Eliminates conditional statements

Replace in Context code like:

```
switch  ( flag ) {
    case A: doA(); break;
    case B: doB(); break;
    case C: doC(); break;
}
```

With code like:

```
strategy.do();
```

Gives a choice of implementations

Refactoring:

Conditional logic in a method controls which of several variants of a calculation are executed

so

Create a Strategy for each variant and make the method delegate the calculation to a Strategy instance

Replace Conditional Logic with Strategy

```
class Foo {
   public void bar() {
      switch  ( flag ) {
         case A: doA(); break;
         case B: doB(); break;
         case C: doC(); break;
      }
   }
}
```

```
class Foo {
   private strategy;
   public void bar() {
      strategy.do(data);
   }
}
```

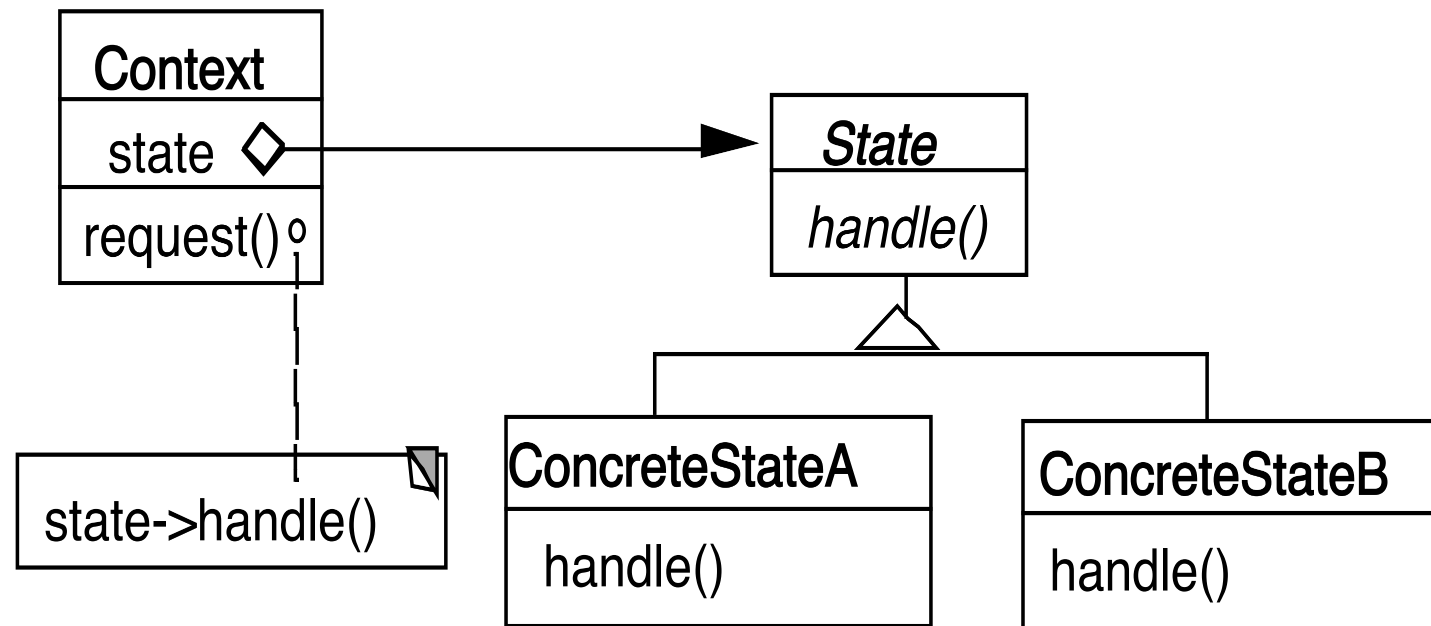
State

State Pattern

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

The object will appear to change it class

Structure



Grade Program

Operations

- View assignment dates
- Log in
- View grades
- Post grades

States

Not logged in

- View dates, Log in

Invalid operations

- View & post grades

Logged in - student

- View dates & grades

Invalid operations

- Post grades, log in

Logged in - instructor

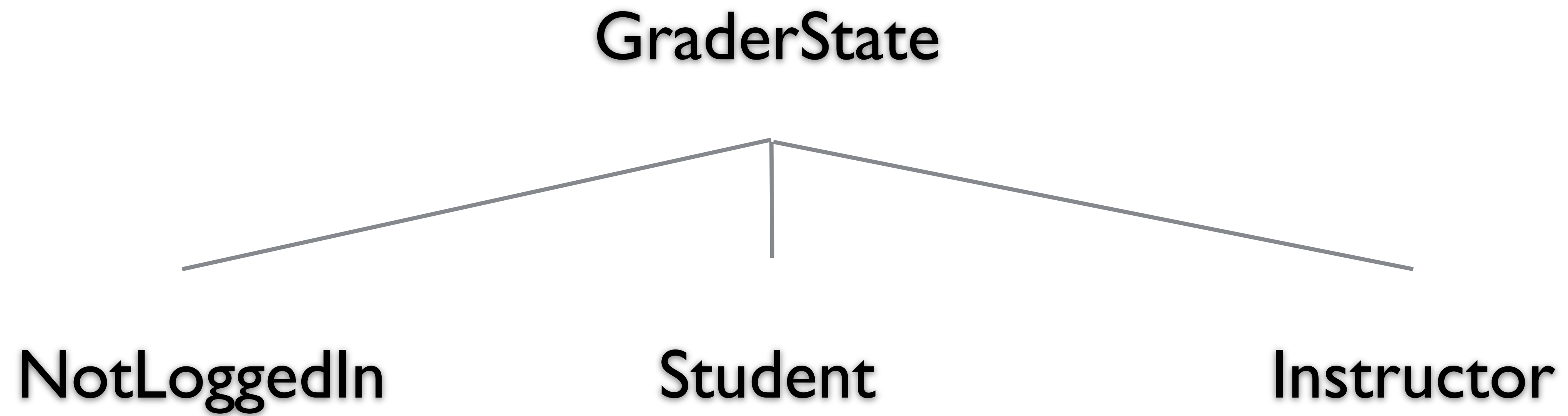
- View dates & grades, post grades

Invalid operations

- log in

```
public class Grader {
  static final int NOT_LOGGED_IN = 0;
  static final int STUDENT = 1;
  static final int INSTRUCTOR = 2;
  int state = NOT_LOGGED_IN;

  public viewGrades() {
    if (state == NOT_LOGGED_IN)
      redirectToLogin();
    if (state == STUDENT)
      showStudentGrade();
    if (state == INSTRUCTOR)
      showAllGrades();
  }
}
```

```
public postGrades() {
  if (state == NOT_LOGGED_IN)
    redirectToLogin();
  if (state == STUDENT)
    showError();
  if (state == INSTRUCTOR)
    getGradeFile();
}
```




```
public class GraderState {
  public GraderState login() {...}
  public GraderState viewGrades() {}
  public GraderState postGrades() {}
}
```

```
public class Grader {
  GraderState state = new NotLoggedIn();

  public void login() {
    state = state.login();
  }

  public viewGrades() {
    state = state.viewGrades();
  }
}
```

```
public class Student : GraderState {
  public GraderState login() {
    displayError(); // already login
    return self;
  }

  public GraderState viewGrades() {
    fetchStudentsGrades();
    display
  }

  public GraderState postGrades() {
    logStudentAttempt();
    displayError();
    return this;
  }
}
```

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

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

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;
    }
```

Java/C++/C# Example - Single Dispatch

```
public class Parent {
}

public class Child extends Parent {
}

public class Bar {

   public foo(Parent x) {
      return “Parent”;
   }

   public foo(Child x) {
      return “Child”;
   }
}
```

```
Bar test = new Bar();

Parent x = new Parent();
test.foo(x);
```

Parent

```
x = new Child();
test.foo(x);
```

Parent

```
Child y = new Child();
test.foo(y);
```

Child

Actual type of foo's argument is not used
Just the declared type

Only runtime selection(dispatch) is on
type actual type of receive of method

Multiple Dispatch - Julia

```
foo(a::Integer,b::Integer) = "Integer,Integer"
foo(a::Integer,b::Number) = "Integer,Number"
foo(a::Number,b::Integer) = "Number,Integer"
foo(a::Number,b::Number) = "Number,Number"
foo(a::Number,b::Complex) = "Number,Complex"
```

foo(1,2)	Integer,Integer
foo(1,2.3)	Integer,Number
foo(2//3,1)	Number,Integer
foo(2.3,2im + 2)	Number,Complex

Why Important

```
function power(n::Number,exponent::Real)
     Some complicated process for float exponent
end

function power(n::Number,exponent::Complex)
    Deal with complex exponent
end

function power(n::Number, exponent::Integer)
  if exponent == 0
    return 1
  result = n
  for k in 1:n-1
    result *= n
  end
  result
end
```

Open & Closed

A module is open if can

- Add/remove fields
- Add/remove methods

A module is closed if

- It can be used by other modules

Open-Close Principle

Module should be open for extension

But closed for modification

Multiple Dispatch & State Pattern - Julia

```
function viewGrades(user::NotLoggedIn)
  goToLogInPage(user)
end

function viewGrades(user::Student)
  getAndDisplayGrades(user)
end
```

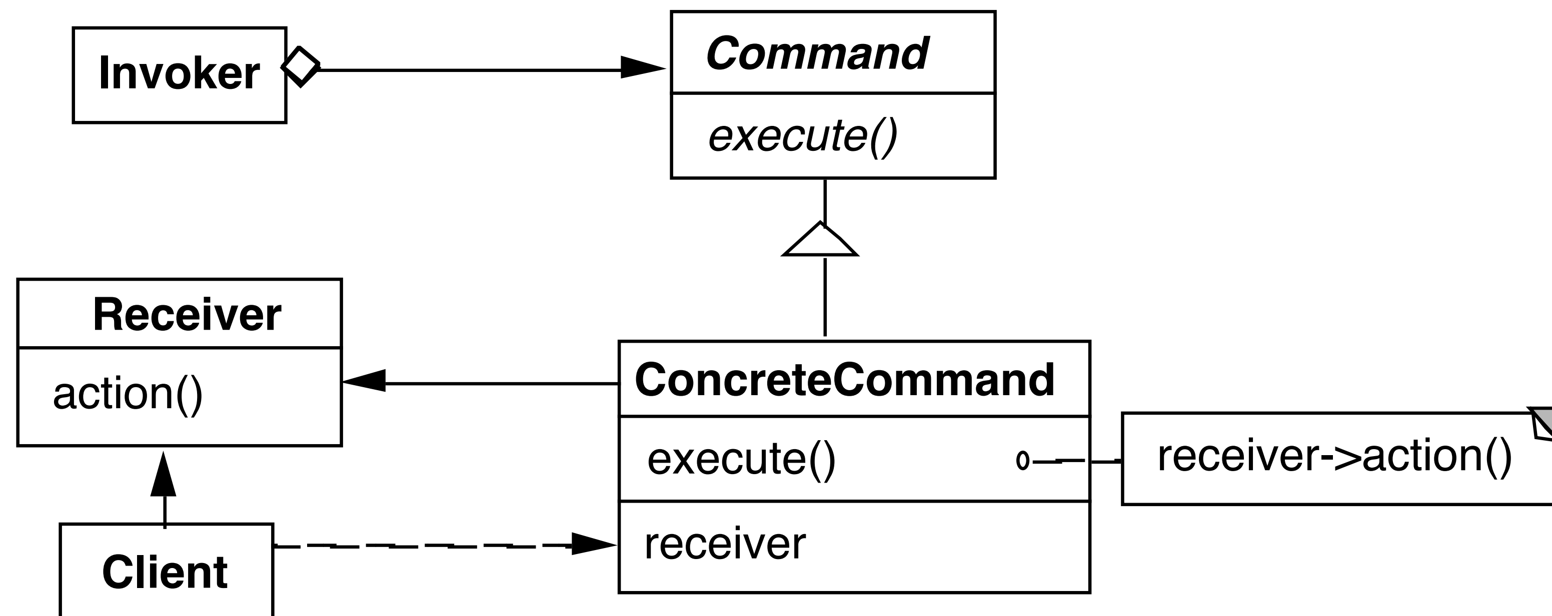
Multiple Dispatch & State Pattern - Clojure

```
(defmulti view-grades (fn [user] (:state user))


(defmethod view-grades :not-logged-in
  [user]
  (go-to-log-in-page user))

(defmethod view-grades :student
  [user]
  (student-grade user))

 (defmethod view-grades :instructor
   [user]
   (all-course-grades user)))
```

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
```