M8(b)- Inversion of Control

Jin L.C. Guo

Image source: https://www.goodfreephotos.com/albums/animals/mammals/red-squirrel-climbing-up-a-tree.jpg

Objective

- Be able to Use Callback to achieve decoupling
- Be able to use the Observer design pattern effectively;
- Event Handling in GUI applications
- Understand the concept of an application framework;
- Understand the Model-View-Controller Decomposition;
- Be able to use the Visitor Design Pattern effectively;
- Be able to determine when to used different design patterns effectively.

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Event

- A notification that something interesting has happened.
- Examples in Graphic Interface?

Move a mouse

User click a button

Press a key

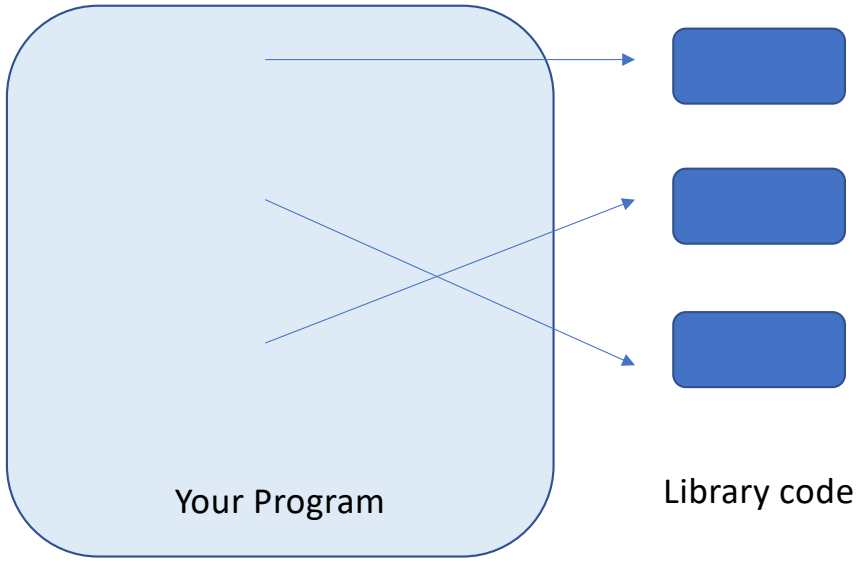
Mouse press and drag

Menu item is selected

Window is closed

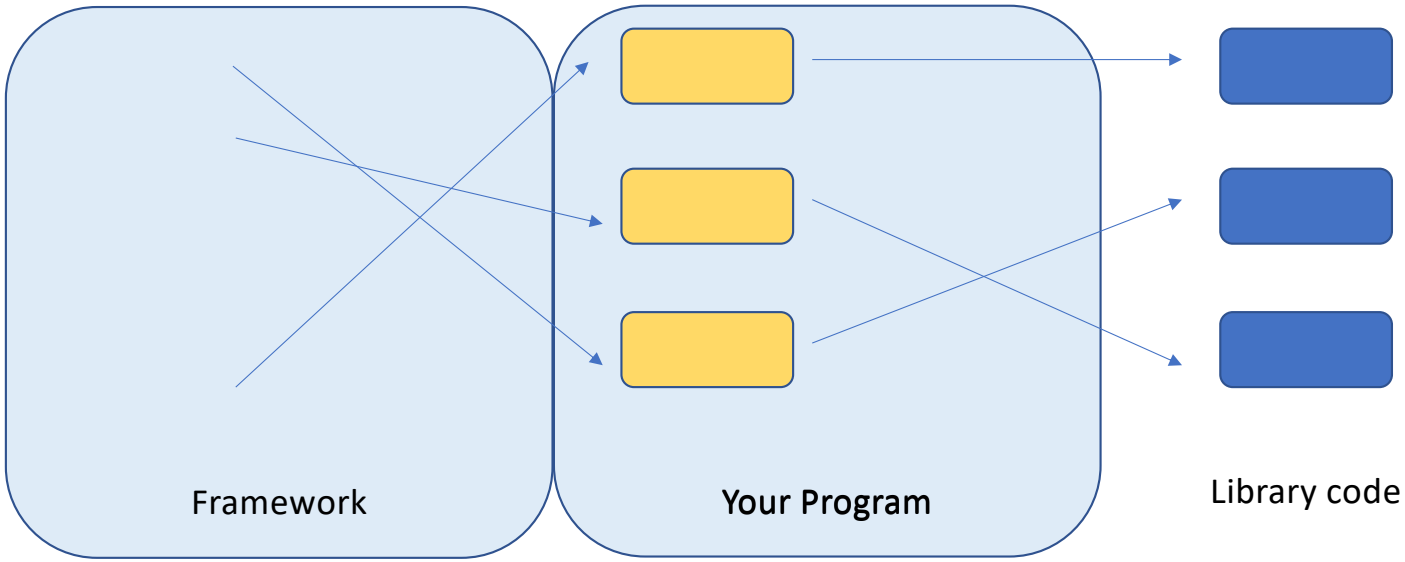
Popup window is hidden

Library vs Framework




```
public static void main(String[] arg)
```

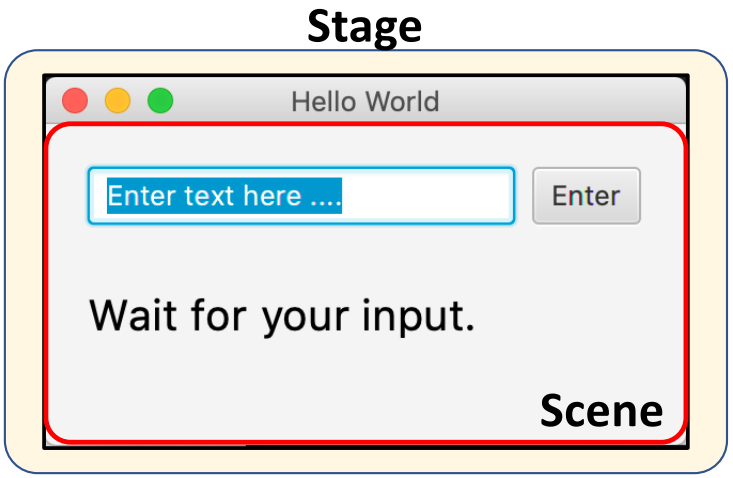
Library vs Framework

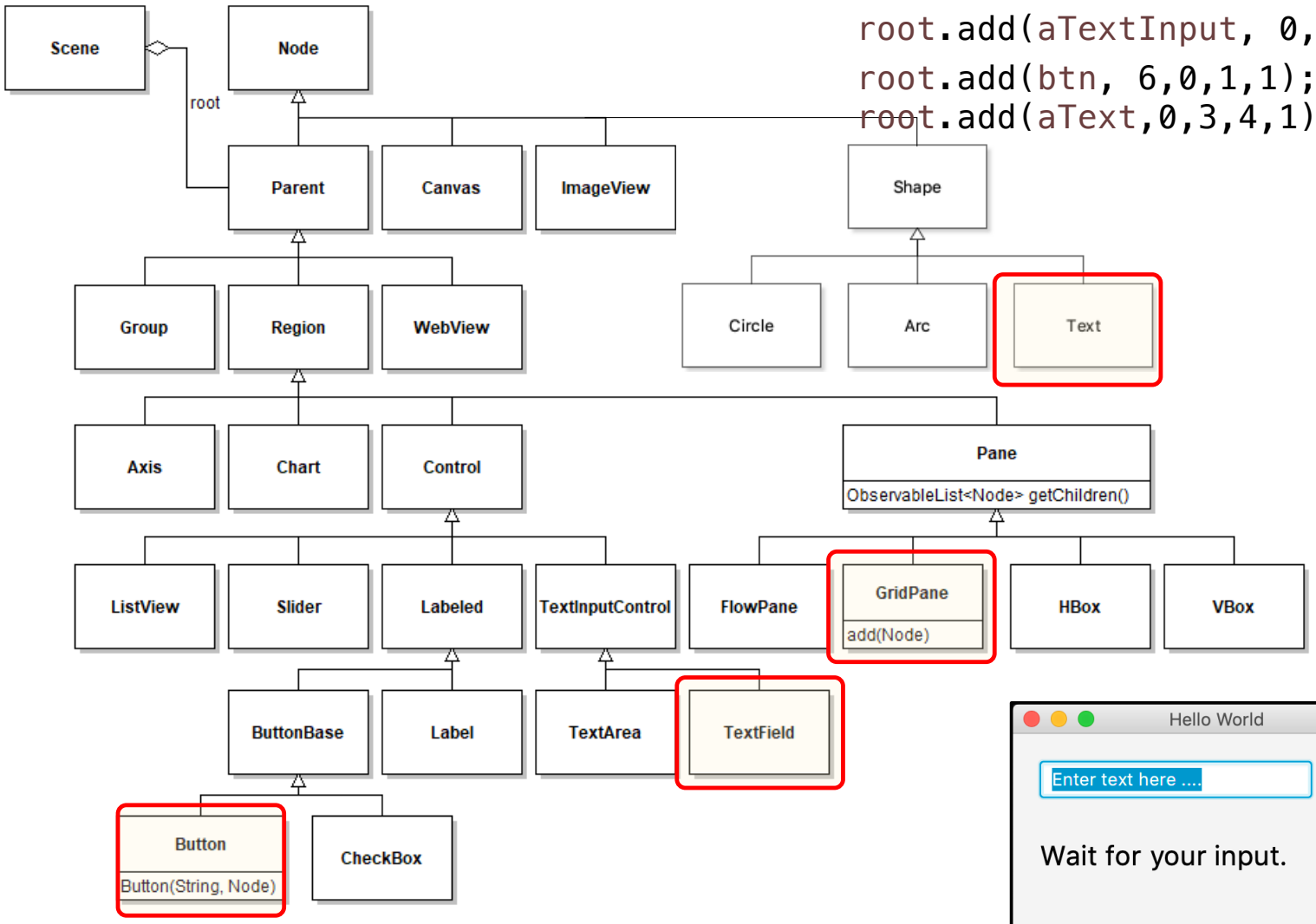


Launch JavaFX framework

```
public class MyApplication extends Application
{
    /**
    * Launches the application.
    * @param pArgs This program takes no argument.
    */
    public static void main(String[] pArgs)
    {
        launch(pArgs);
    }

    @Override
     public void start(Stage pPrimaryStage)
     {
         //Setup the stage
         pPrimaryStage.show();
     }
}
```

```
@Override
 public void start(Stage pPrimaryStage)
 {
      … //Other setup steps

      GridPane root = new GridPane();
      root.add(aTextInput, 0,0,6,1);
      root.add(btn, 6,0,1,1);
      root.add(aText,0,3,4,1);

       Scene scene = new Scene(root, Width, Height);
       … //Other setup steps

       primaryStage.setScene(scene);


       pPrimaryStage.show();
 }
```

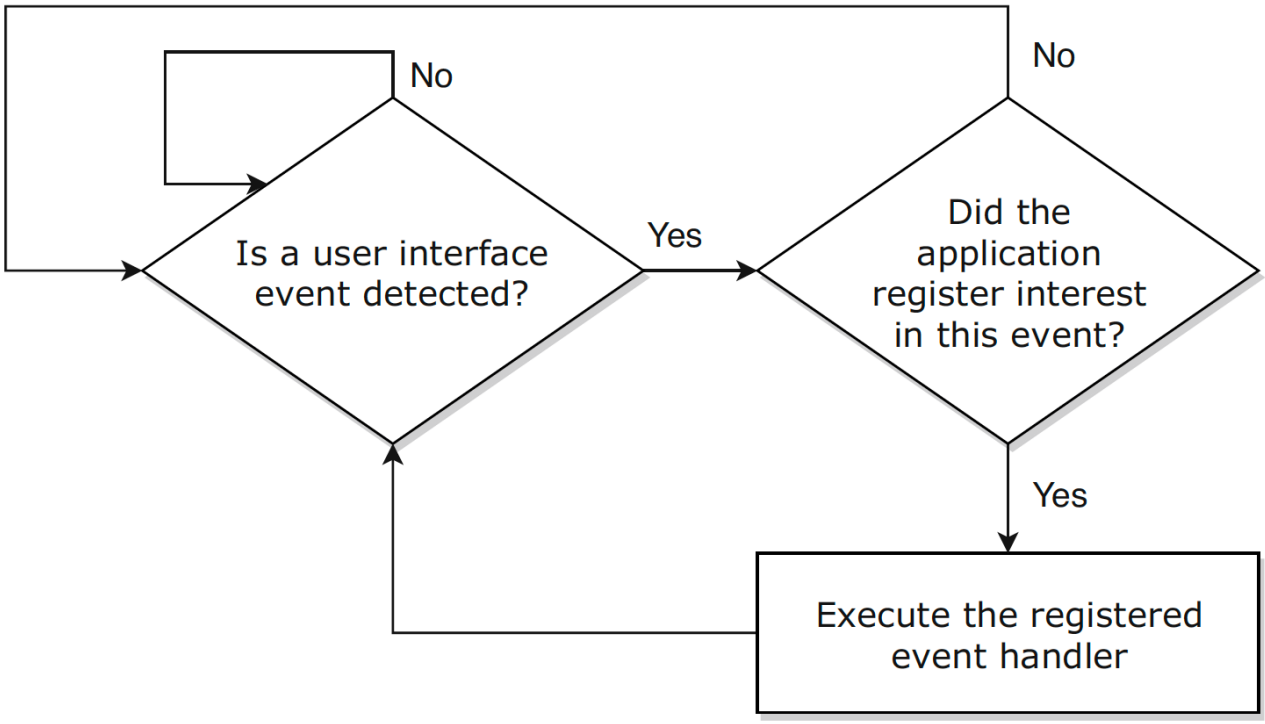





```
root.add(aTextInput, 0,0,2,1);
root.add(btn, 6,0,1,1);
root.add(aText,0,3,4,1);
```

```
Scene scene = new Scene(root, Width, Height);
```

When does event handling happen?



Text Display Example


```
Text aText = new Text();

TextField aTextInput = new TextField();

aTextInput.setOnAction((actionEvent) -> aText.setText(aTextInput.getText()));

Button btn = new Button();
btn.setOnAction((actionEvent) -> aText.setText(aTextInput.getText()));
```

Recap: Objective

- Be able to Use Callback to achieve decoupling
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- Event Handling in GUI applications
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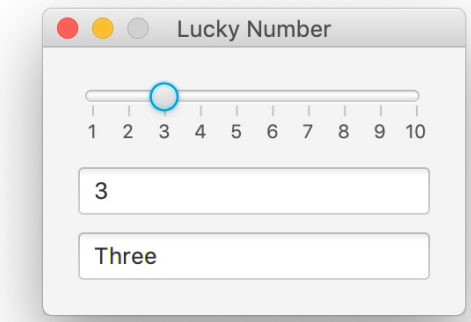
- Be able to determine when to used different design patterns effectively.

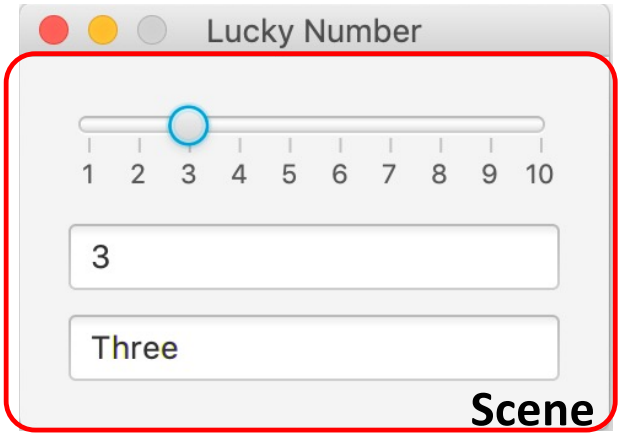
Lucky Number Example

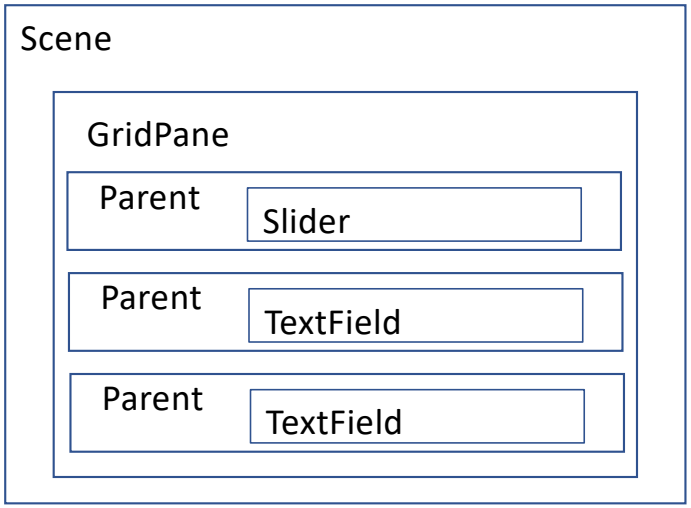


The user should be able to select a number between 1 and 10 inclusively.

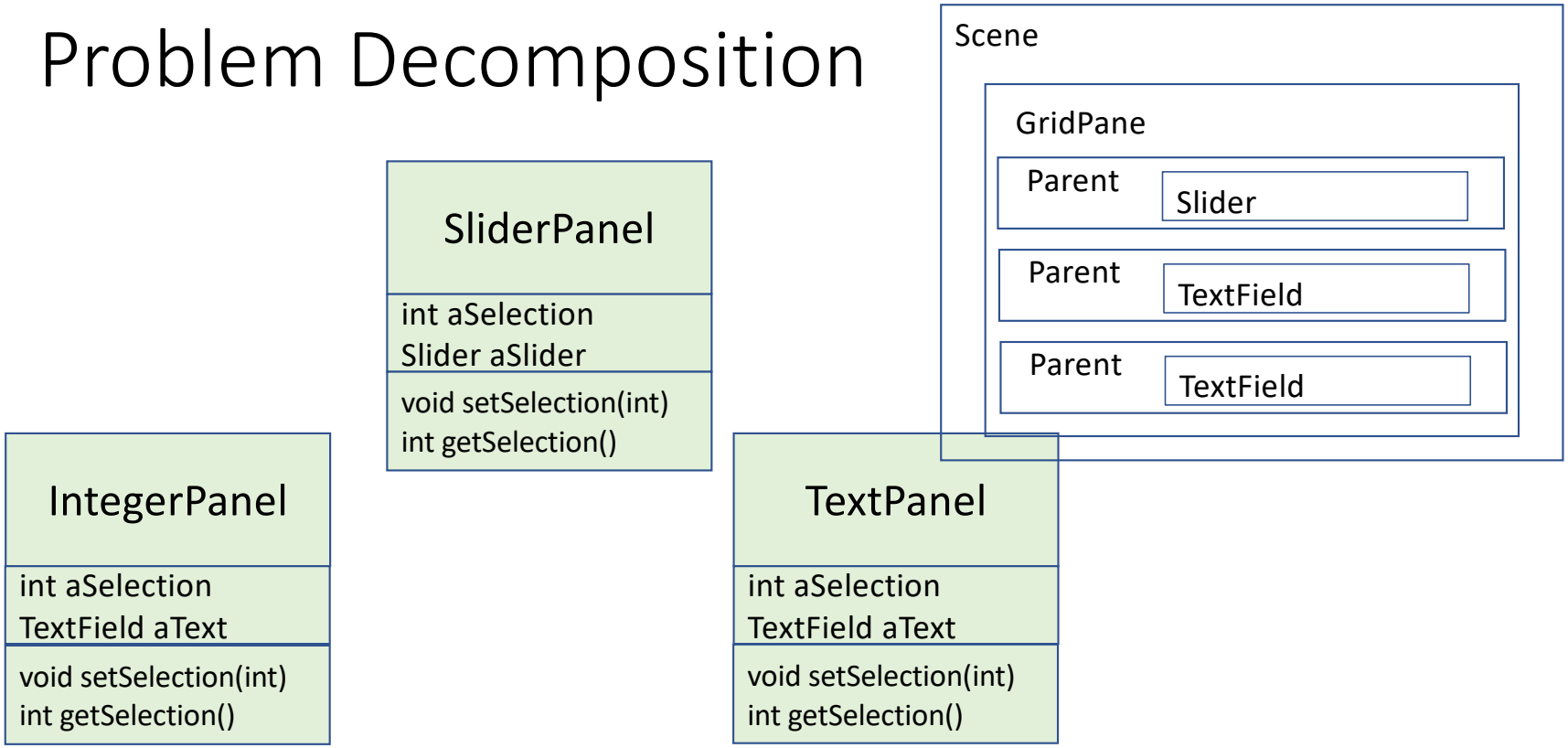
The selection should be performed through either typing it, writing it out in the corresponding fields, or selecting it from a slider.

The current selection should also be able to viewed in the integer and text fields and the slider.

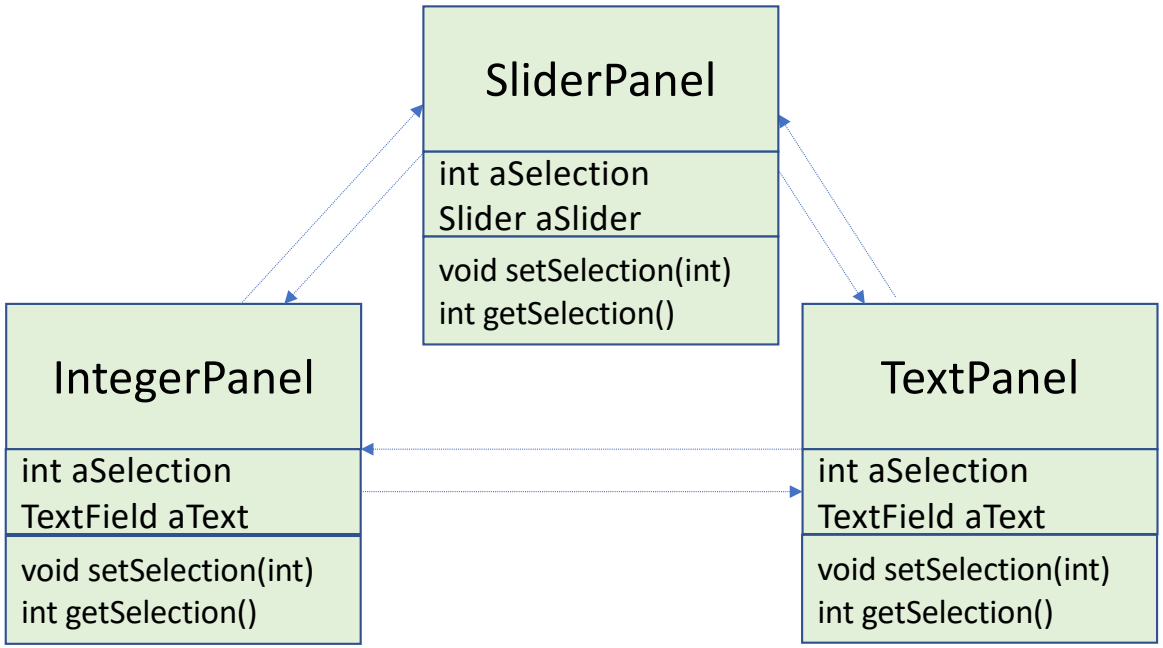

Lucky Number
1 2 3 4 5 6 7 8 9 10
3
Three
Scene


Scene
GridPane
Parent
Slider
Parent
TextField
Parent
TextField

Problem Decomposition



Problem Decomposition



High Coupling

Components are inter-dependent

Low Extensibility

hard to add/remove selection mechanism

MVC Decomposition

Model – View – Controller

Design pattern

Architectural pattern

Guideline to separate concerns

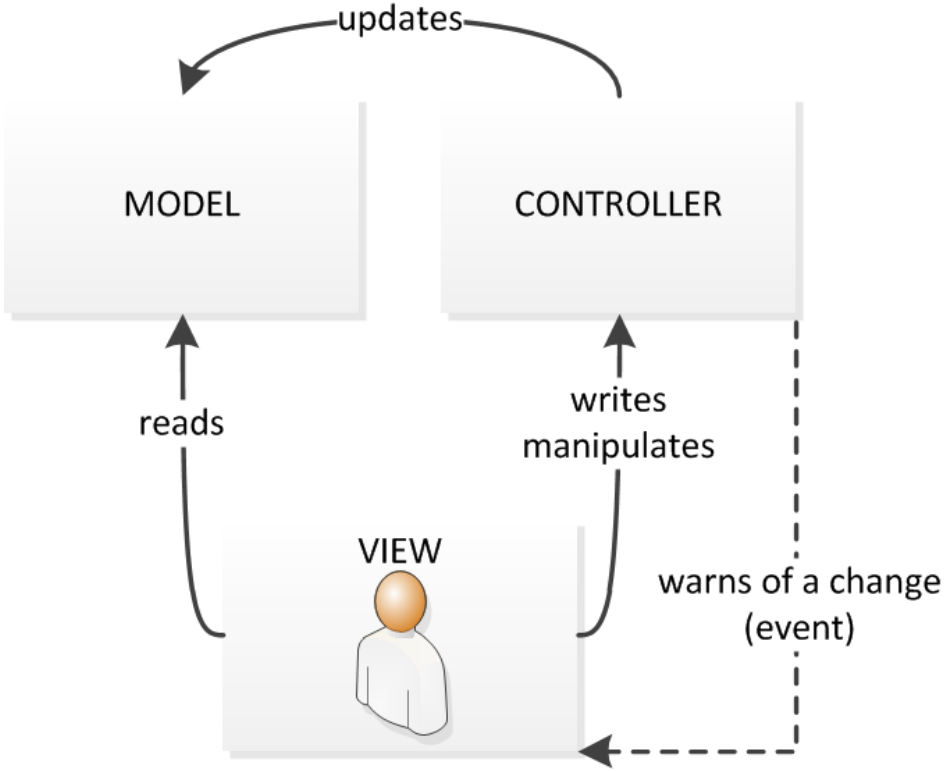
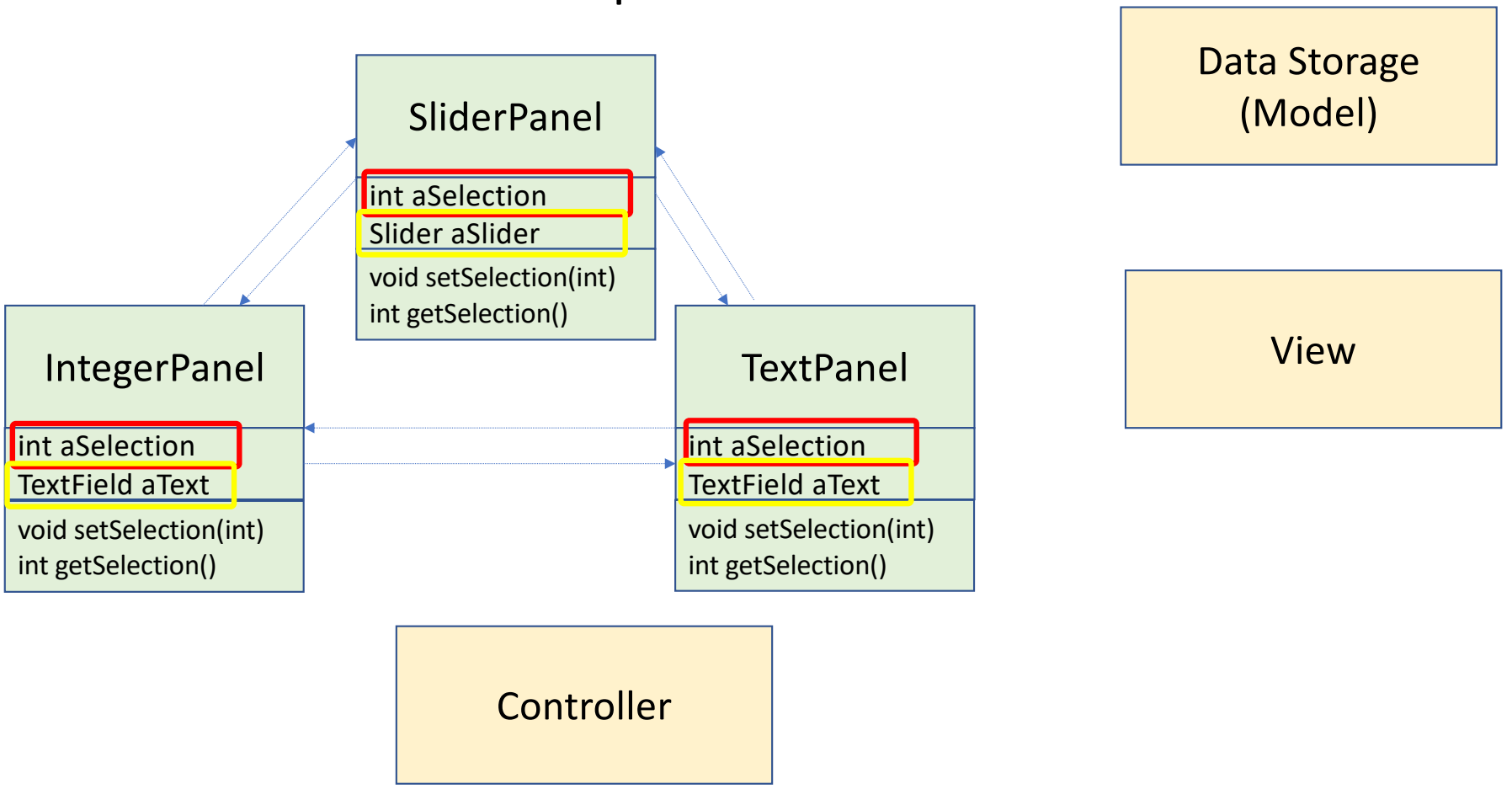
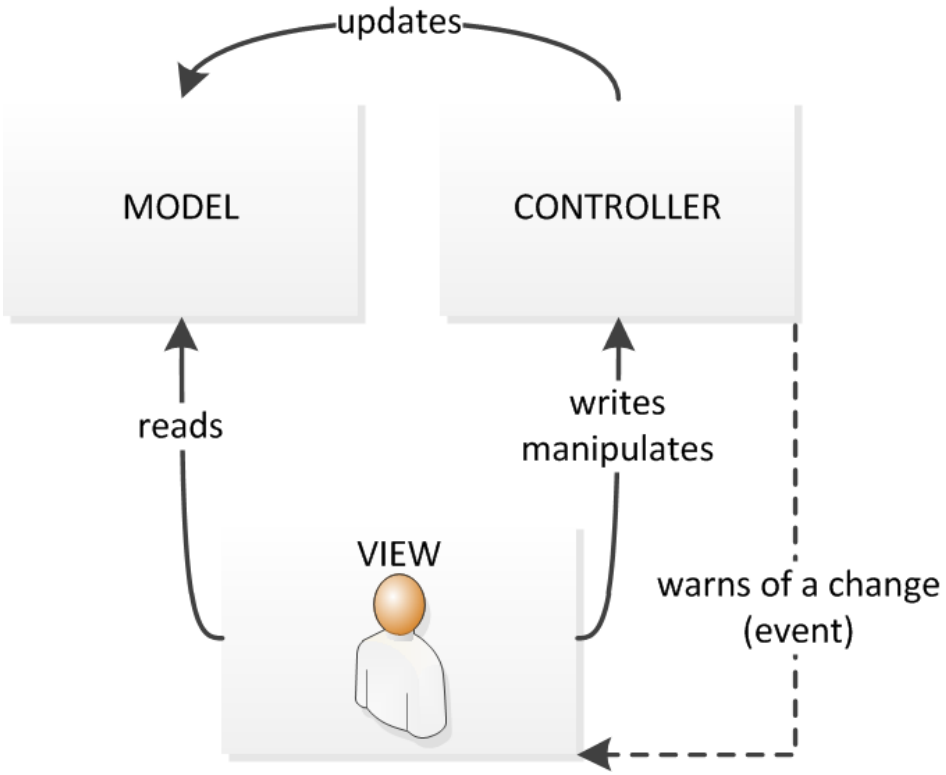


Image Source: https://upload.wikimedia.org/wikipedia/commons/6/63/ModeleMVC.png

Problem Decomposition



Problem Decomposition



Data Storage
(Model)

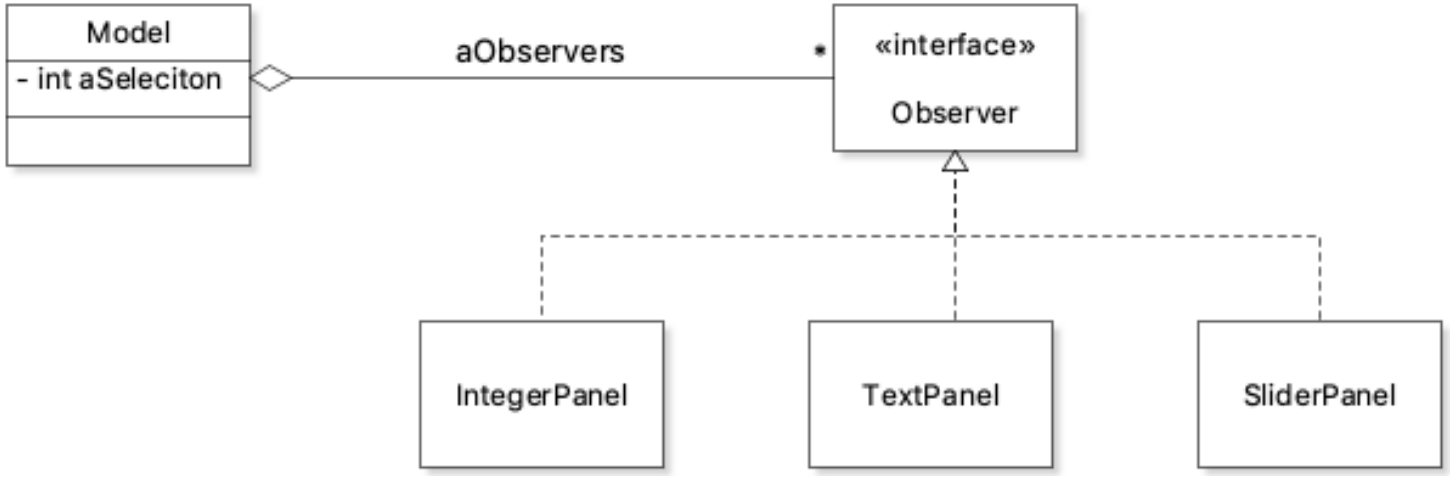
View/Controller

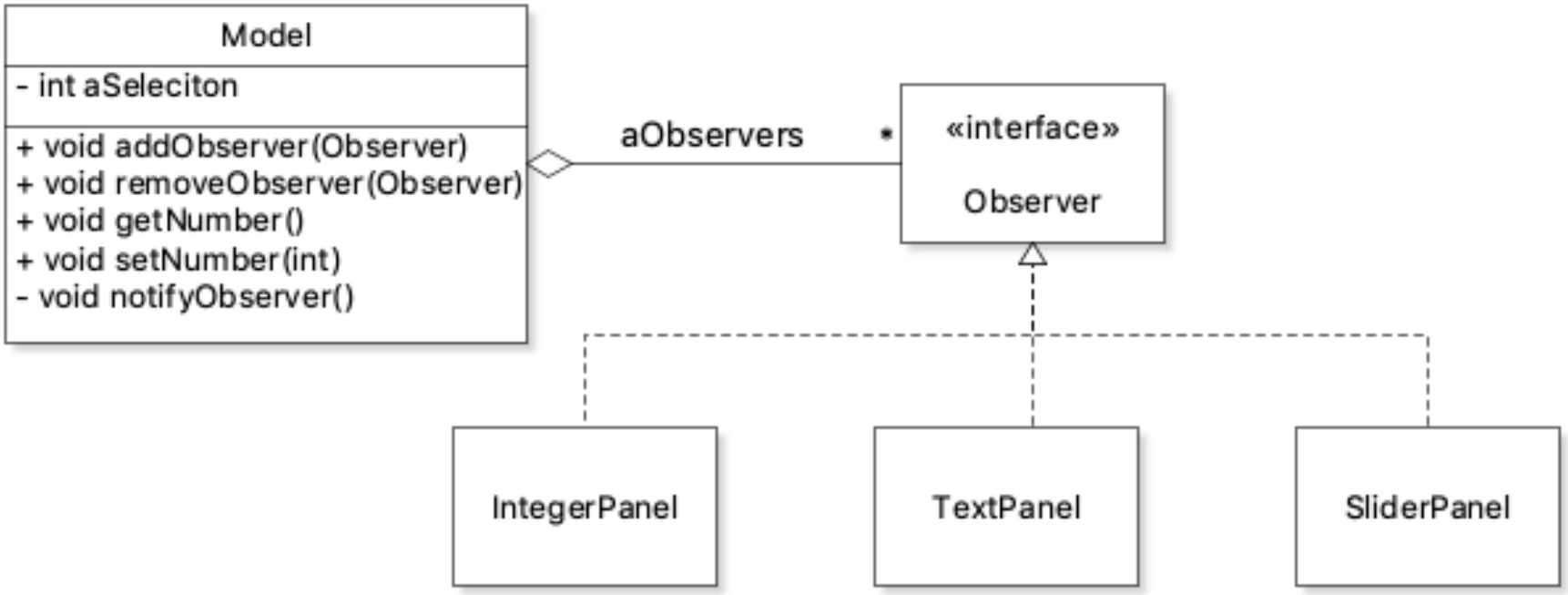
Activity

- Improve the design using Observer Pattern and MVC decomposition.

Activity: Applying Observer in MVC

- What methods should be included in Model?



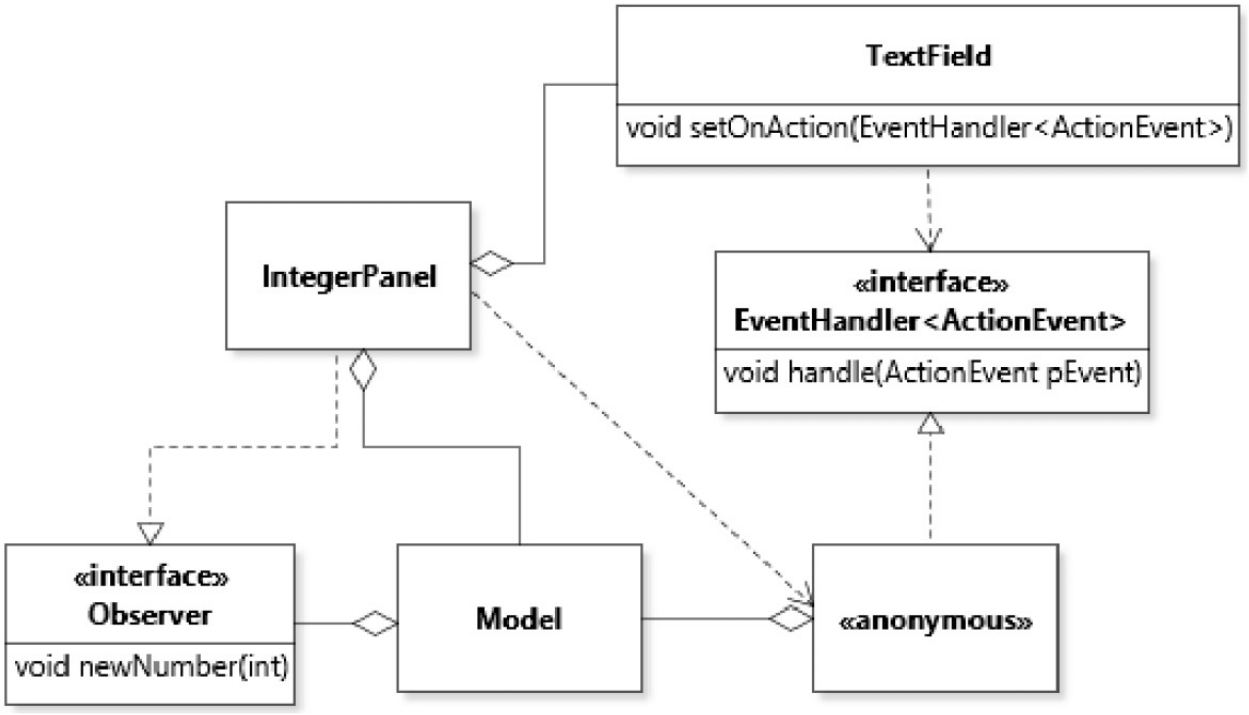

Model
- int aSeleciton
+ void addObserver(Observer)
+ void removeObserver(Observer)
+ void getNumber()
+ void setNumber(int)
- void notifyObserver()
aObservers
*
«interface»
Observer
IntegerPanel
TextPanel
SliderPanel

```
/**
 * Abstract observer role for the model.
 */
interface Observer
{
   void newNumber(int pNumber);
}
```

```
class IntegerPanel extends Parent implements Observer
{
   private TextField aText = new TextField();
   private Model aModel;
                                Call aModel.setNumber(lInteger);
   … …
   @Override
   public void newNumber(int pNumber)
   {
      aText.setText(new Integer(pNumber).toString());
   }
}
```

```
/**
 * Constructor.
 */
IntegerPanel(Model pModel)
{
   aModel = pModel;
   aModel.addObserver(this);
   aText.setMinWidth(LuckyNumber.WIDTH);
   aText.setText(new Integer(aModel.getNumber()).toString());
   getChildren().add(aText);

   aText.setOnAction(new EventHandler<ActionEvent>(){
      @Override
      public void handle(ActionEvent pEvent){
         int lInteger = 1;
         try{
            lInteger = Integer.parseInt(aText.getText());
         } catch(NumberFormatException pException ){
            //Code to handle exception
         }
         aModel.setNumber(lInteger);
      }
   });
}
```


TextField
void setOnAction(EventHandler<ActionEvent>)
IntegerPanel
«interface»
EventHandler<ActionEvent>
void handle(ActionEvent pEvent)
«interface»
Observer
void newNumber(int)
Model
«anonymous»

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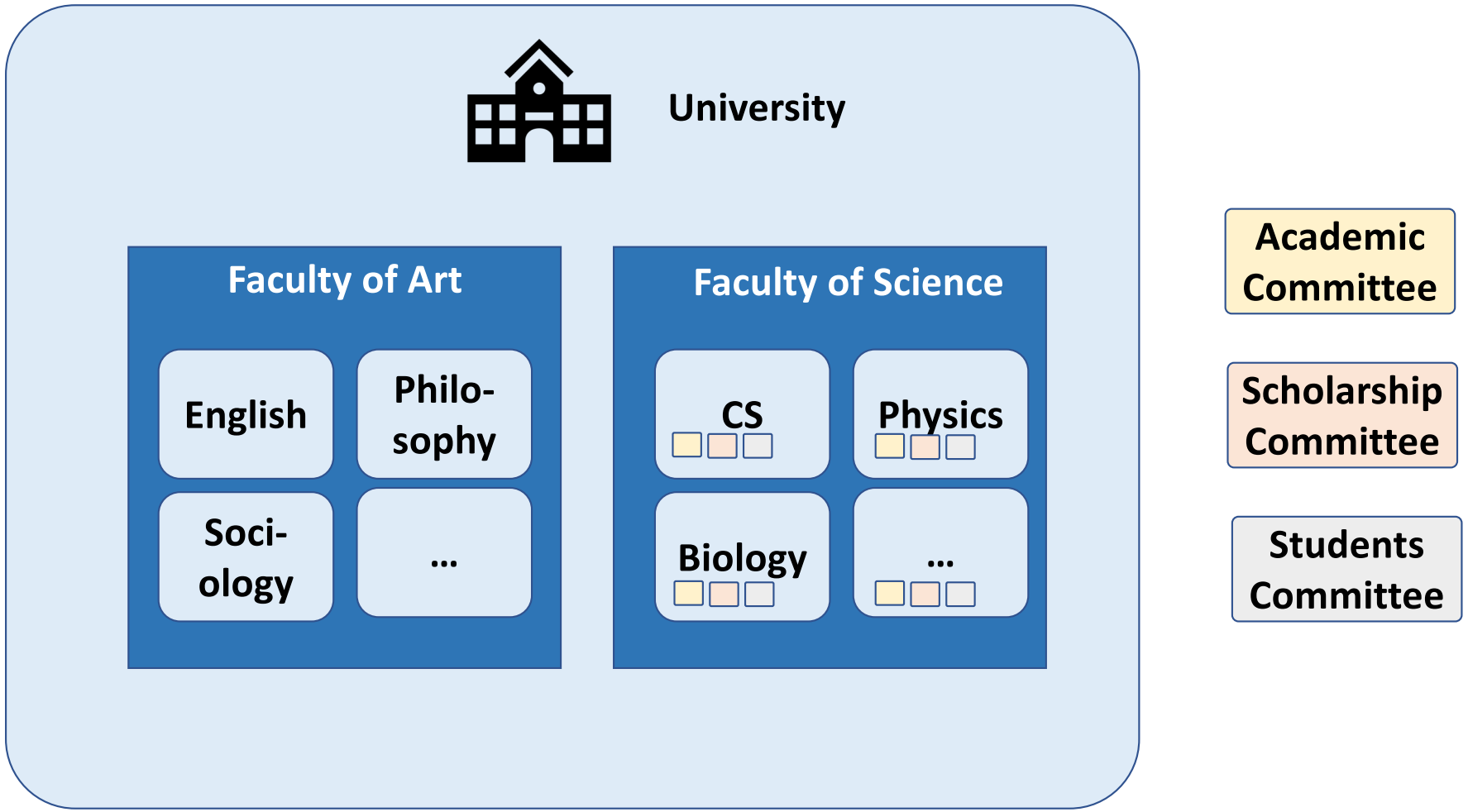
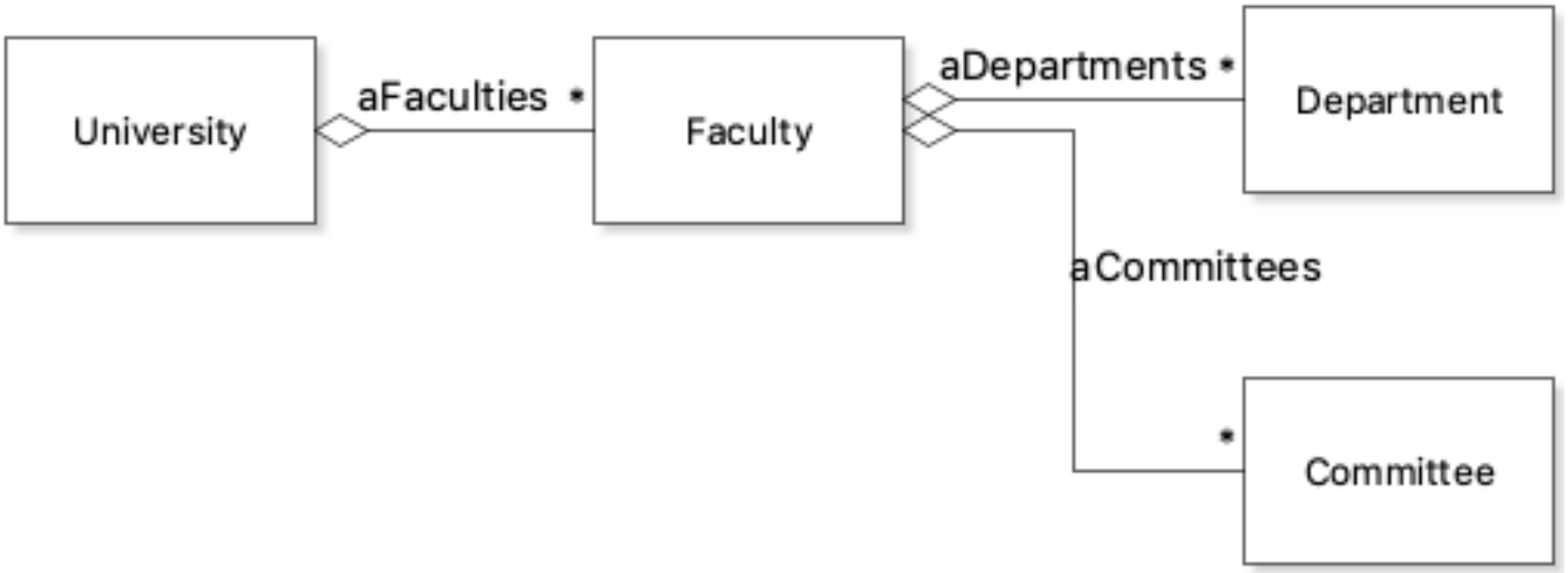

University
Faculty of Art
English
Philo-
sophy
Soci-
ology
...
Faculty of Science
CS
Physics
Biology
...
Academic
Committee
Scholarship
Committee
Students
Committee


University
aFaculties
*
Faculty
aDepartments
*
Department
aCommittees
*
Committee

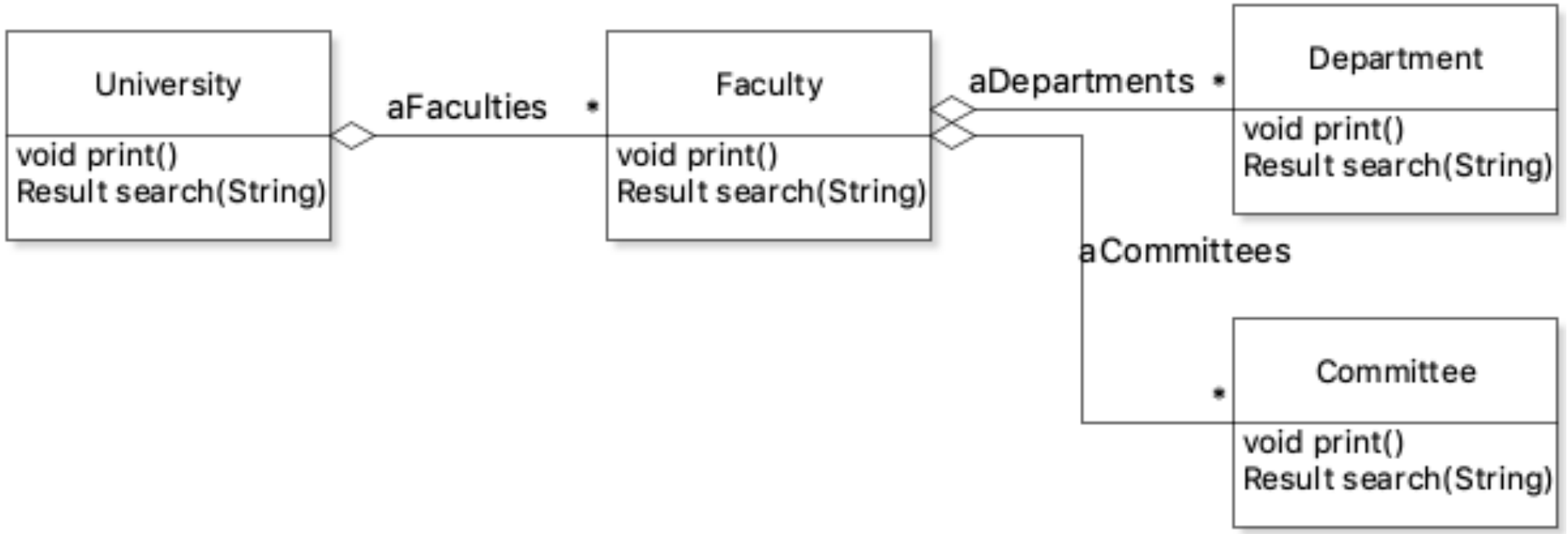
Add functionalities to aggregate

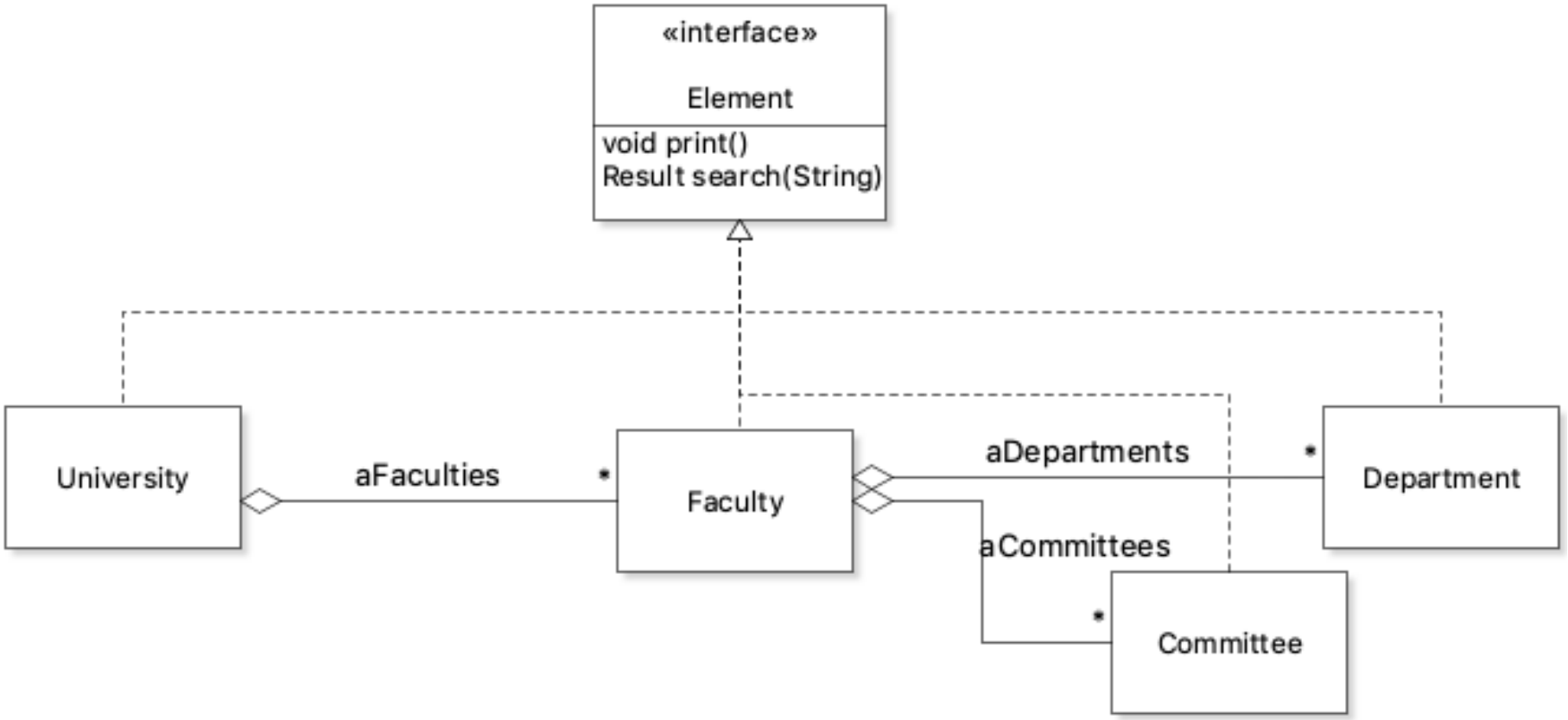
Print annual report for every organizations in university

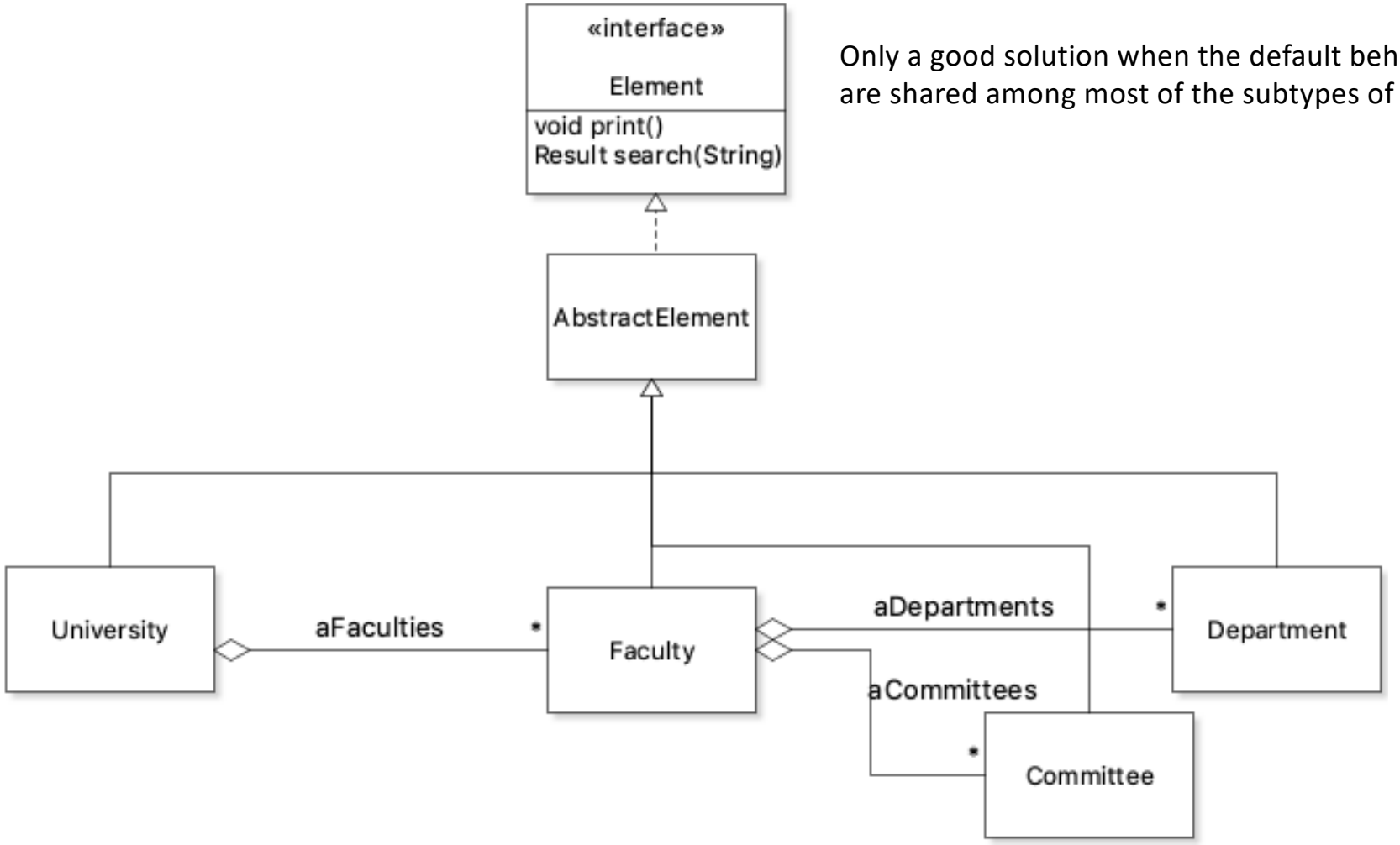
Search if one person belongs to any organization in university

… …

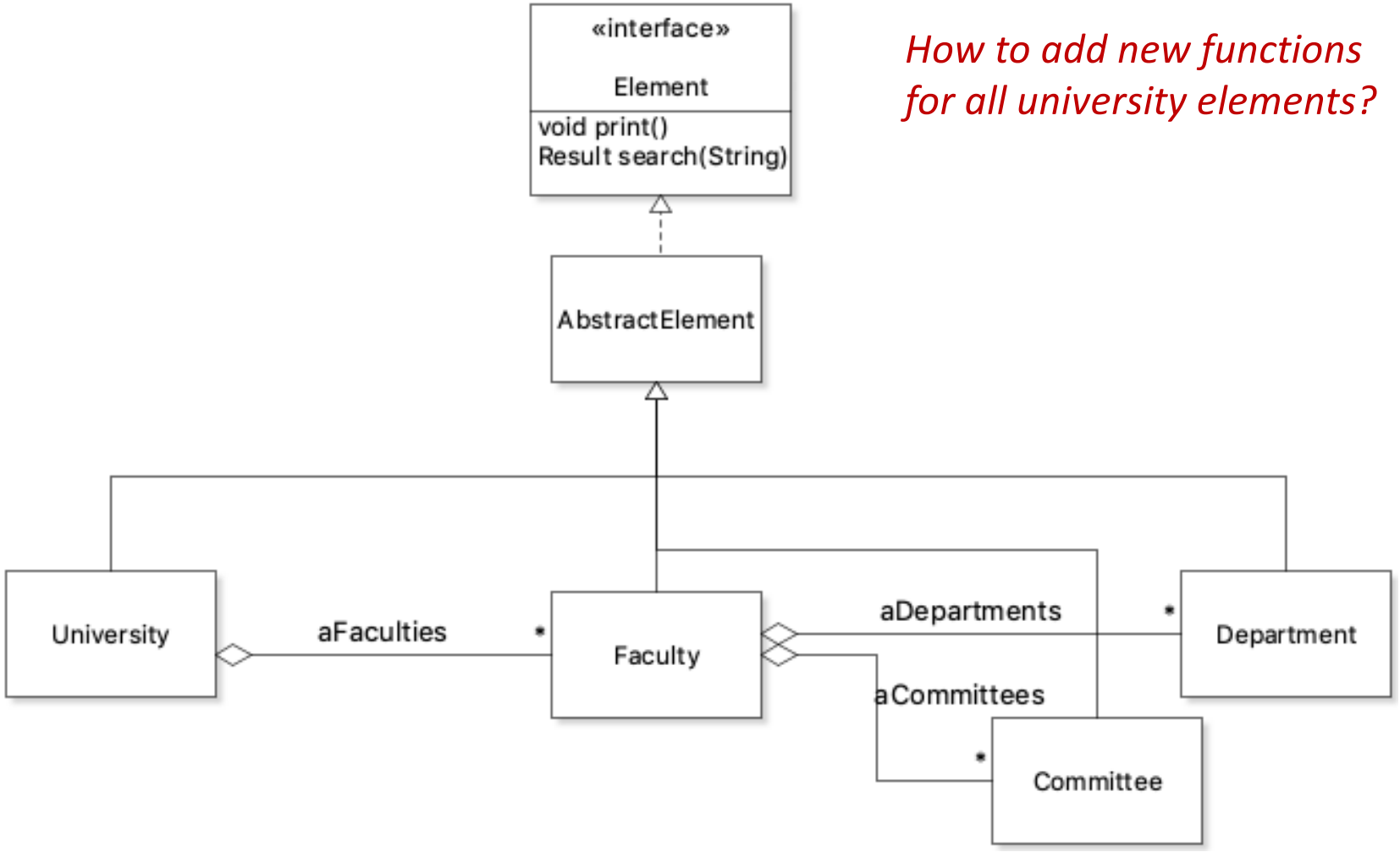
All requires traverse all the elements in University,
and process them (potentially differently)


University
void print()
Result search(String)
aFaculties
*
Faculty
void print()
Result search(String)
aDepartments
*
Department
void print()
Result search(String)
aCommittees
*
Committee
void print()
Result search(String)

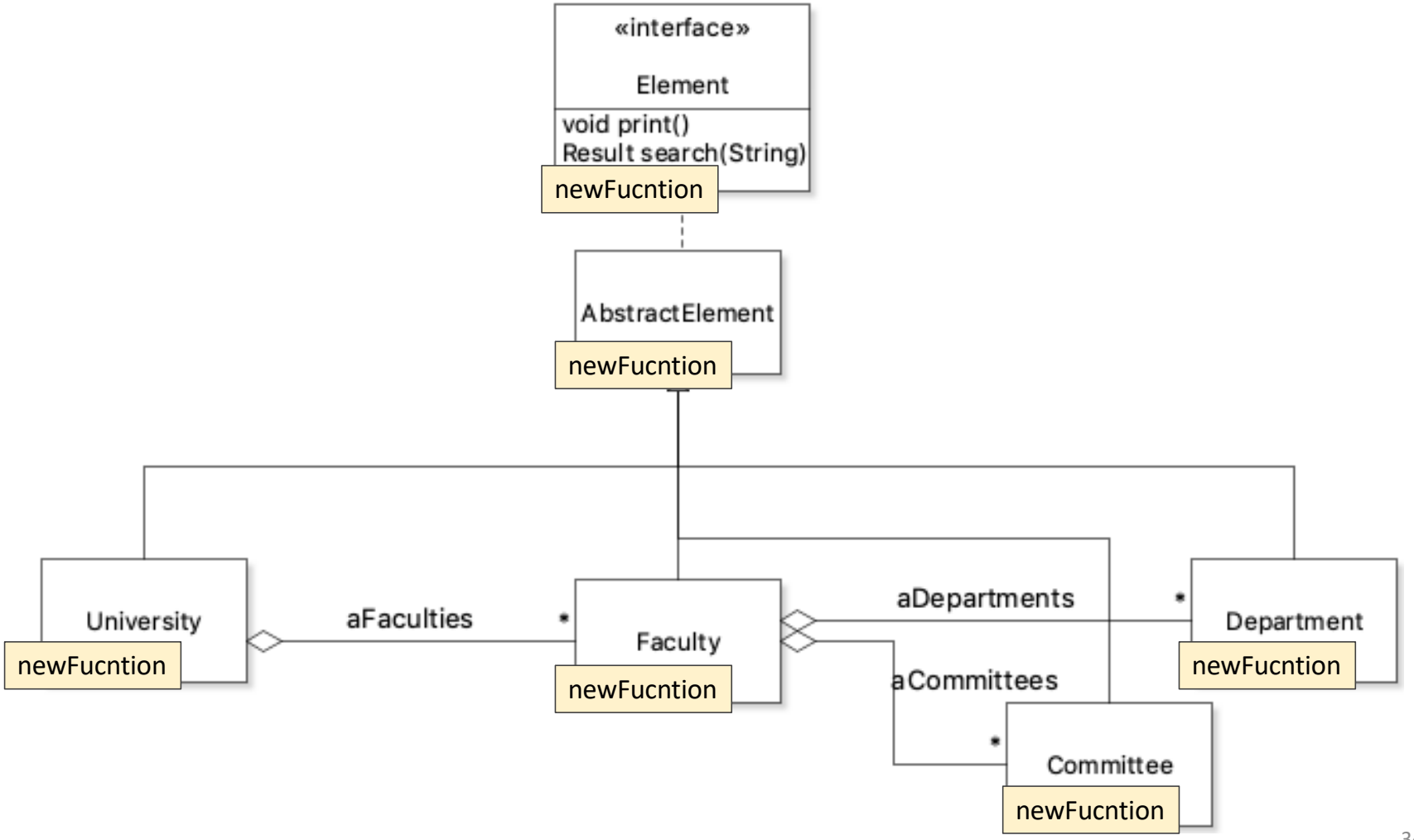

«interface»
Element
void print()
Result search(String)
University
aFaculties
*
Faculty
aDepartments
*
Department
aCommittees
*
Committee



Only a good solution when the default behaviors are shared among most of the subtypes of element.



How to add new functions for all university elements?

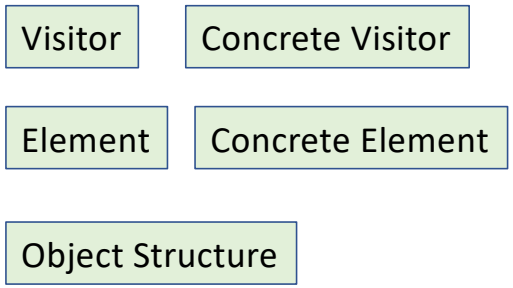

«interface»
Element
void print()
Result search(String)
newFucntion
AbstractElement
newFucntion
University
newFucntion
aFaculties
*
Faculty
newFucntion
aDepartments
*
Department
newFucntion
aCommittees
*
Committee
newFucntion

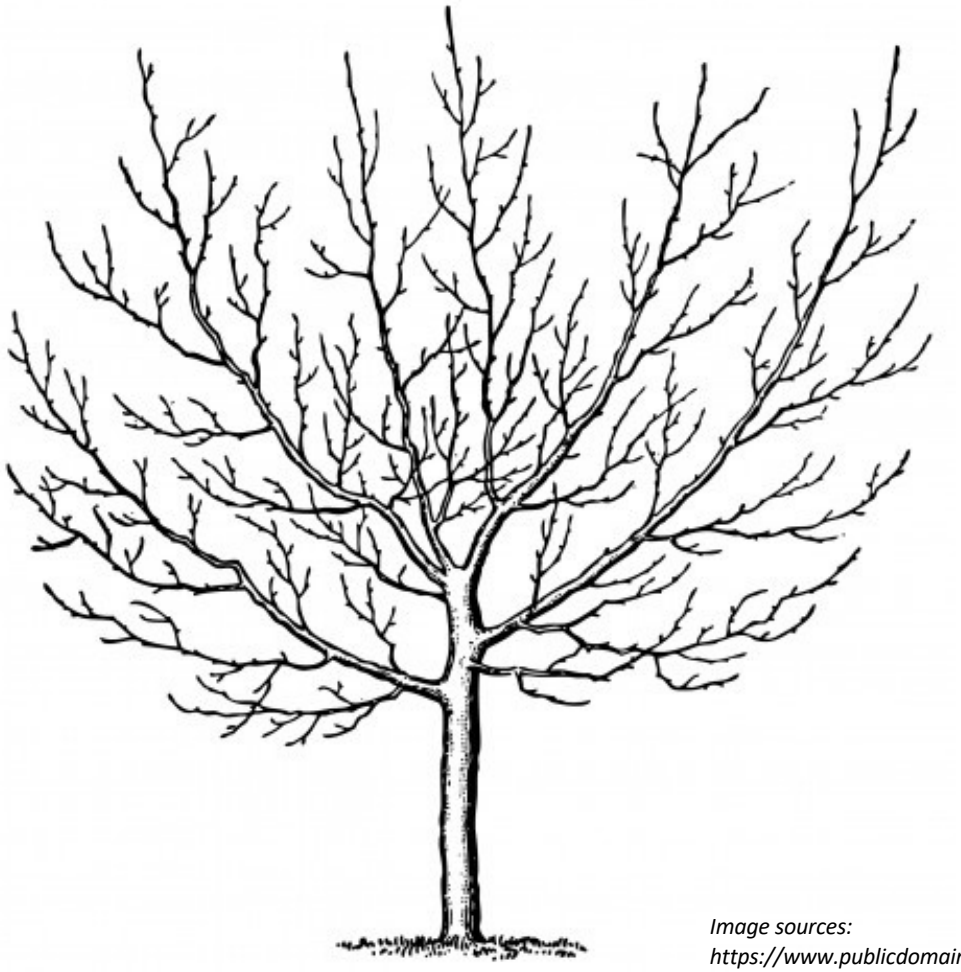
Visitor

- Intent:

Represent an operation to be performed on the elements of an object structure. Visitor lets you define a new operation without changing the classes of the elements on which it operates.

- Participants:





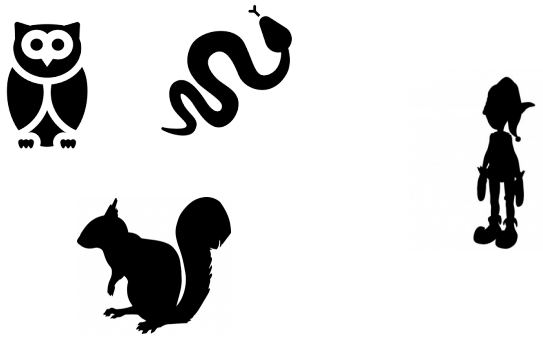
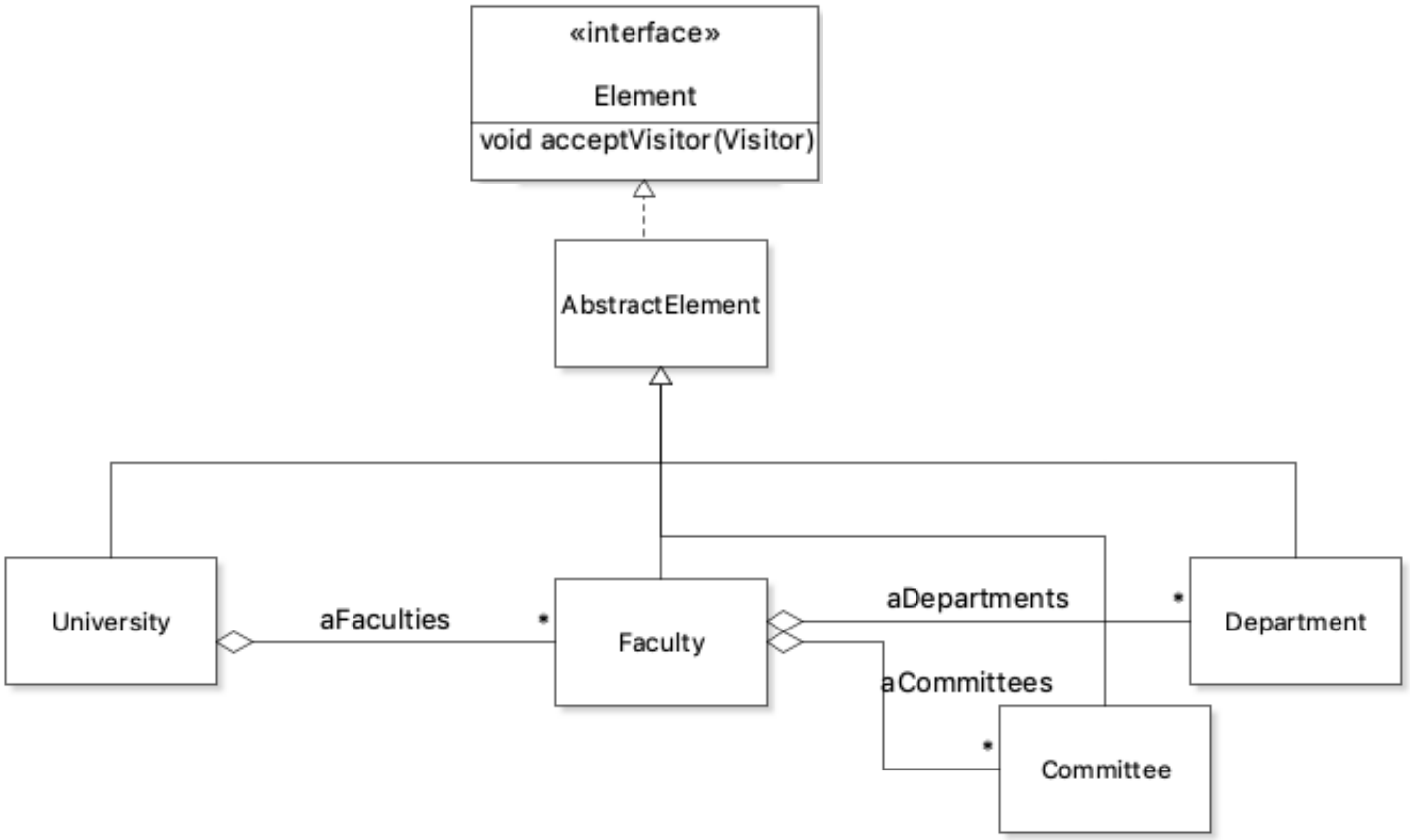


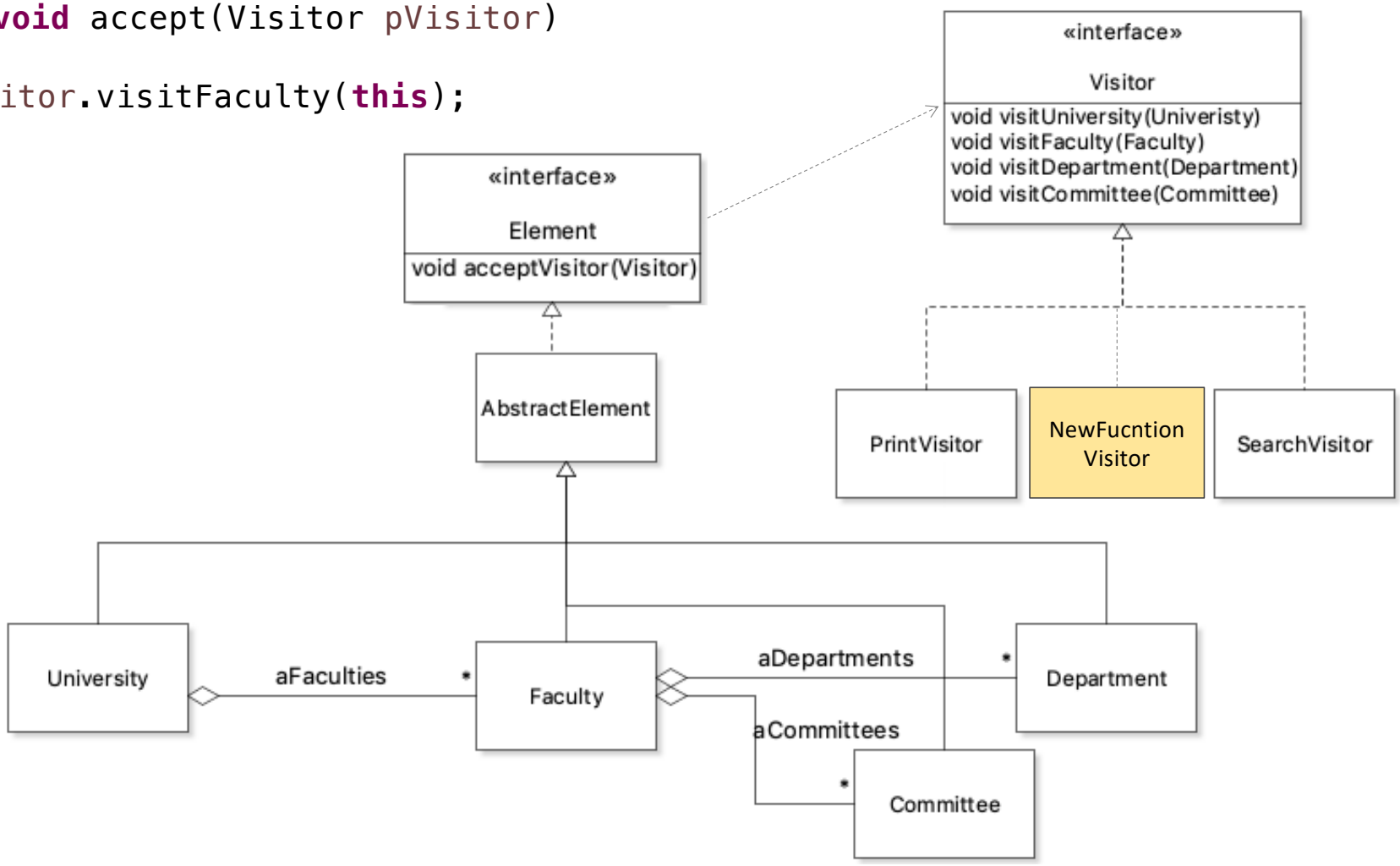
Image sources:
https://www.publicdomainpictures.net/pictures/100000/nahled/tree-1409250600Al7.jpg
https://www.publicdomainpictures.net/pictures/140000/nahled/black-elf.jpg
https://www.publicdomainpictures.net/pictures/190000/nahled/squirrel-silhouette-1469799208bea.jpg

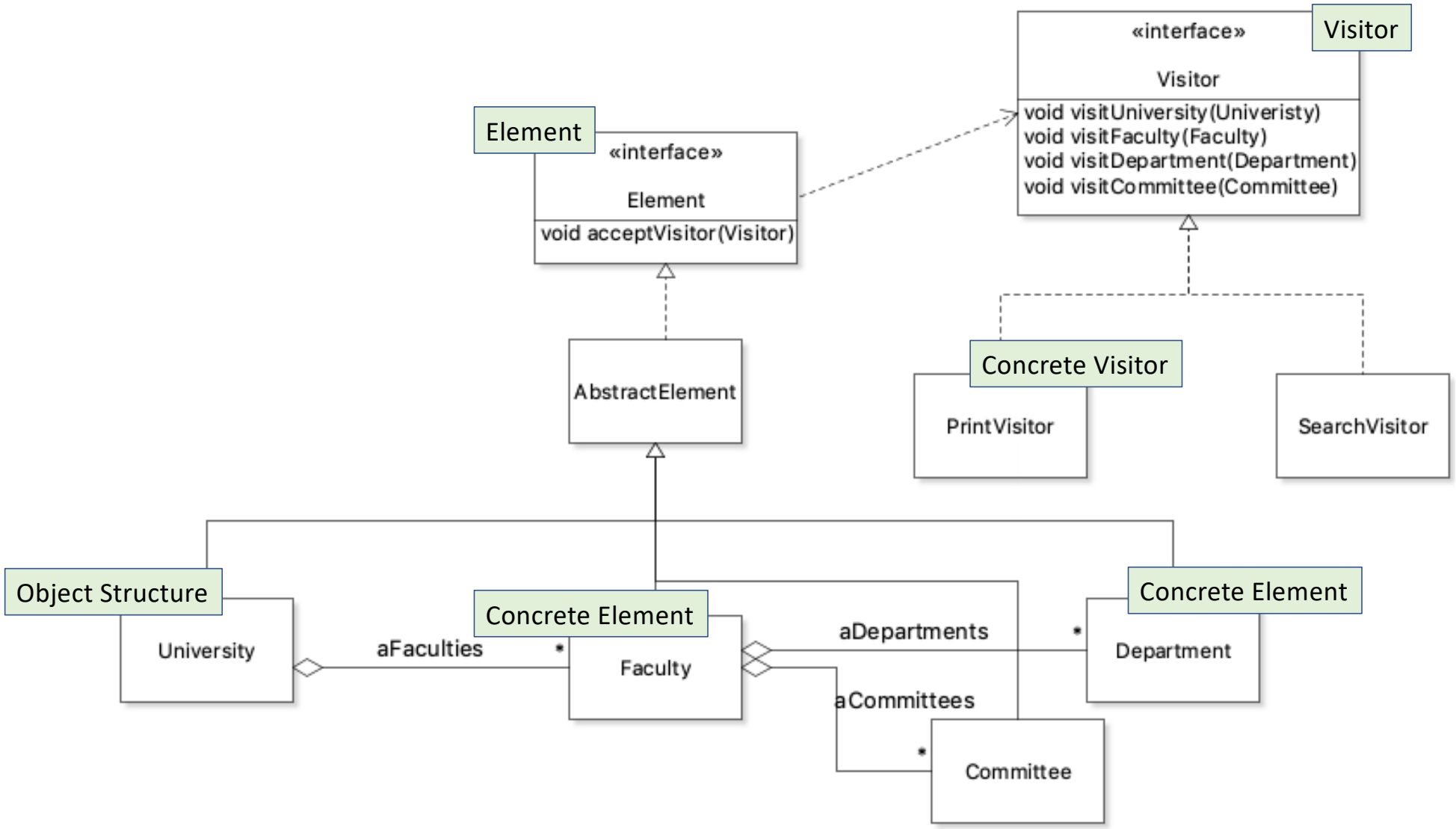
```java
@Override
public void accept(Visitor pVisitor)
{
    // Use callback functions from pVisitor
}
```

How to pass around functions?



```java
@Override
public void accept(Visitor pVisitor)
{
    pVisitor.visitFaculty(this);
}
```

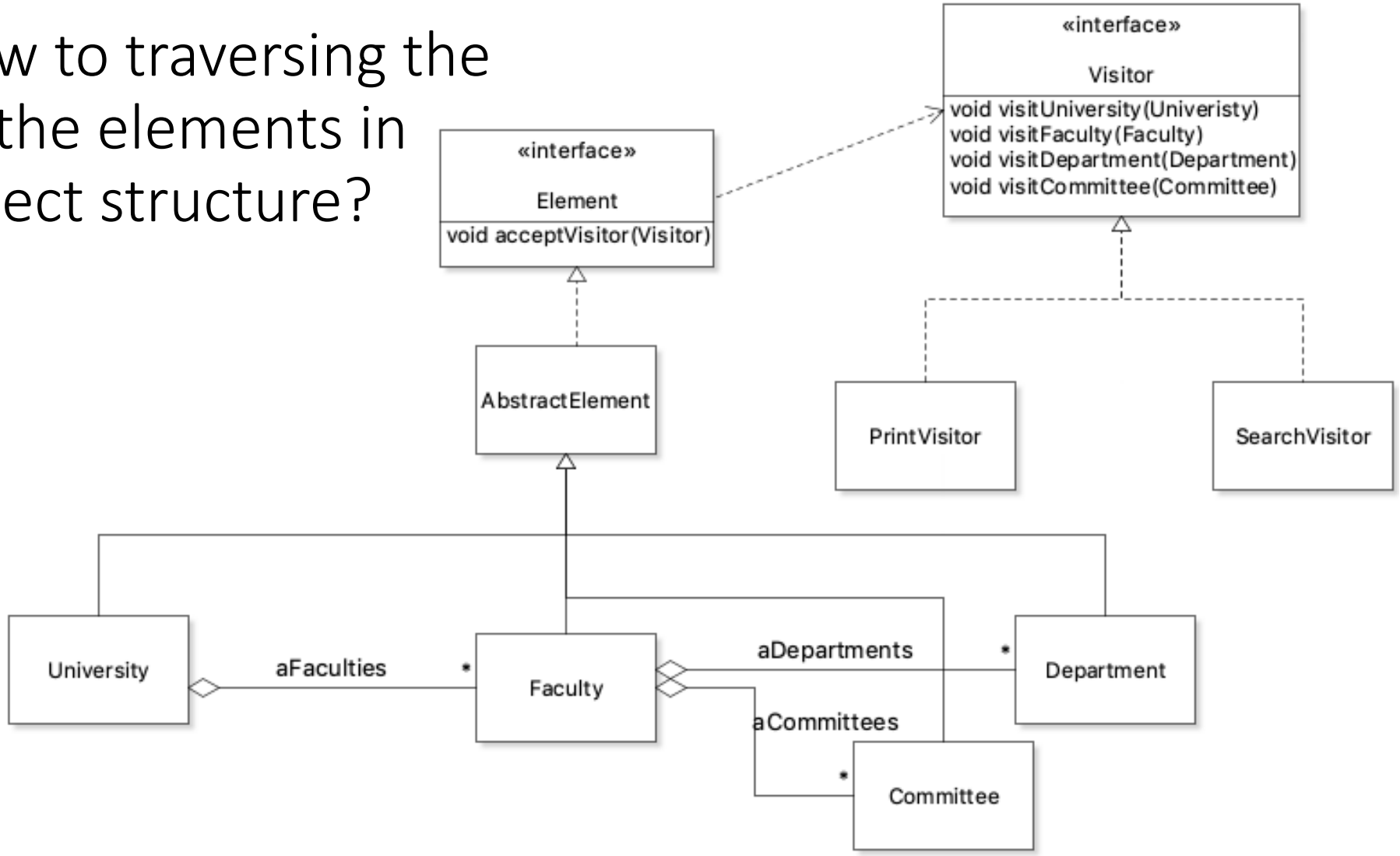



Visitor
«interface»
Visitor
void visitUniversity(Univeristy)
void visitFaculty(Faculty)
void visitDepartment(Department)
void visitCommittee(Committee)
Element
«interface»
Element
void acceptVisitor(Visitor)
AbstractElement
Concrete Visitor
PrintVisitor
SearchVisitor
Object Structure
University
aFaculties
*
Concrete Element
Faculty
aDepartments
*
Department
aCommittees
*
Committee
Concrete Element

Please think and discuss the consequences when applying Visitor pattern.

Activity 1:

How to traversing the all the elements in object structure?



Method1:

```
class University extends AbstractElement
{
    private final List<Faculty> aFaculties = new ArrayList<Faculty>();
    public University(String pName) { super(pName); }
    public void addFaculty(Faculty pFaculty) { aFaculties.add(pFaculty); }


    @Override
    public void accept(Visitor pVisitor)
    {
        pVisitor.visitUniversity(this);

        for( Faculty f : aFaculties )
        {
            f.accept(pVisitor);
        }
    }
}
```

← Traverse in the aggregate object structure.

Method1:

```
public class PrintVisitor implements Visitor
{
   @Override
   public void visitUniversity(University pUniversity)
   {

      // Printing operation for University

   }

   @Override
   public void visitFaculty(Faculty pFaculty)
   {

      // Printing operation for Faculty

   }

}
```

Method2:

```
class University extends AbstractElement
{
    private final List<Faculty> aFaculties = new ArrayList<Faculty>();
    public University(String pName) { super(pName); }
    public void addFaculty(Faculty pFaculty) { aFaculties.add(pFaculty); }
    public Iterator<Faculty> getFaculties() { return aFaculties.iterator(); }

    @Override
    public void accept(Visitor pVisitor)
    {
        pVisitor.visitUniversity(this);
    }
}
```

↑ But provide a traversal mechanism to its elements

← Not in the object structure.

Method2:

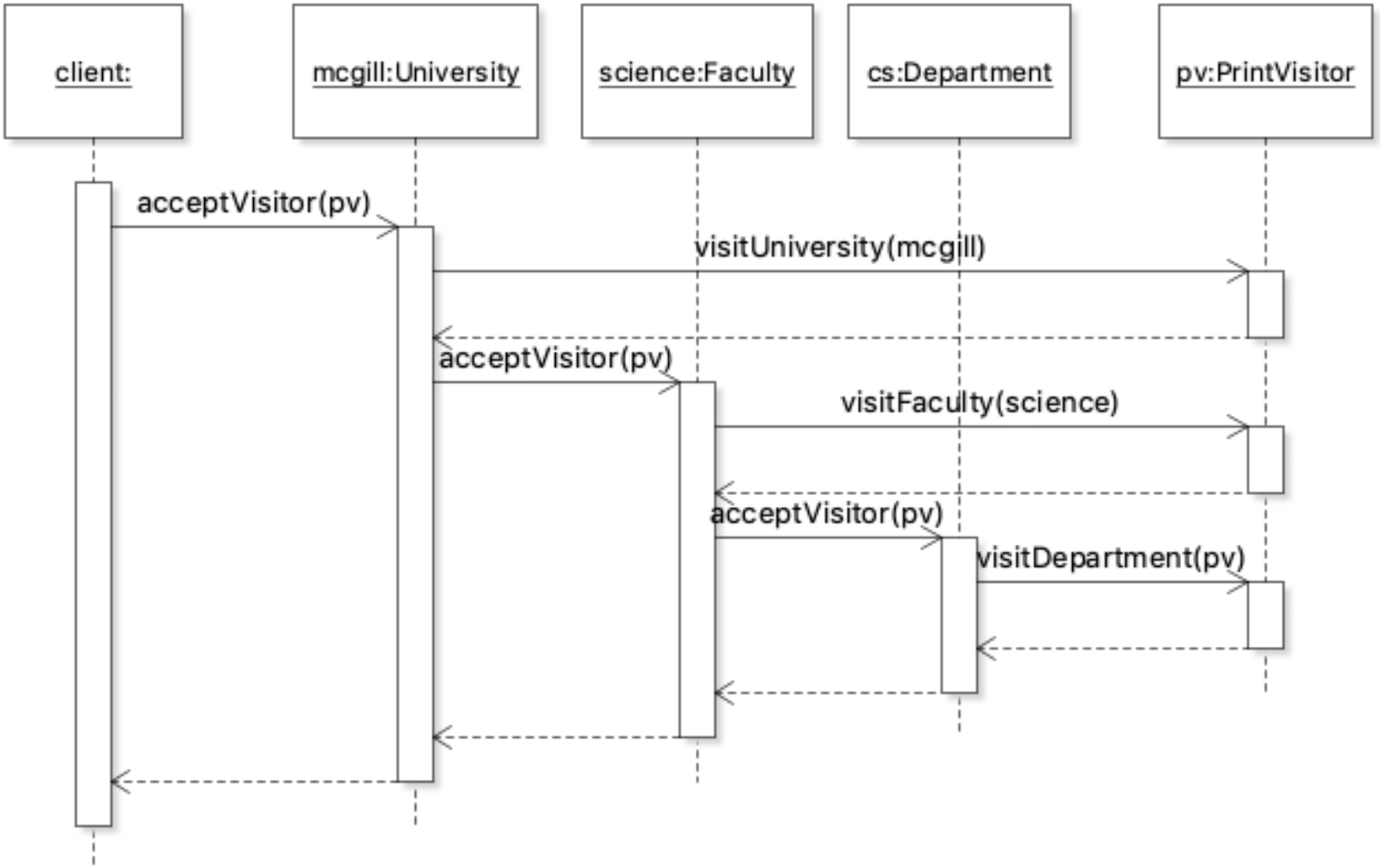
```
public class PrintVisitor implements Visitor
{


   @Override
   public void visitUniversity(University pUniversity)
   {
      // Printing operation for University
      for( Iterator<Faculty> i = pUniversity.getFaculties();
         i.hasNext(); )
         {
            i.next().accept(this);
         }
   }
}
```

Traverse in the visitor→

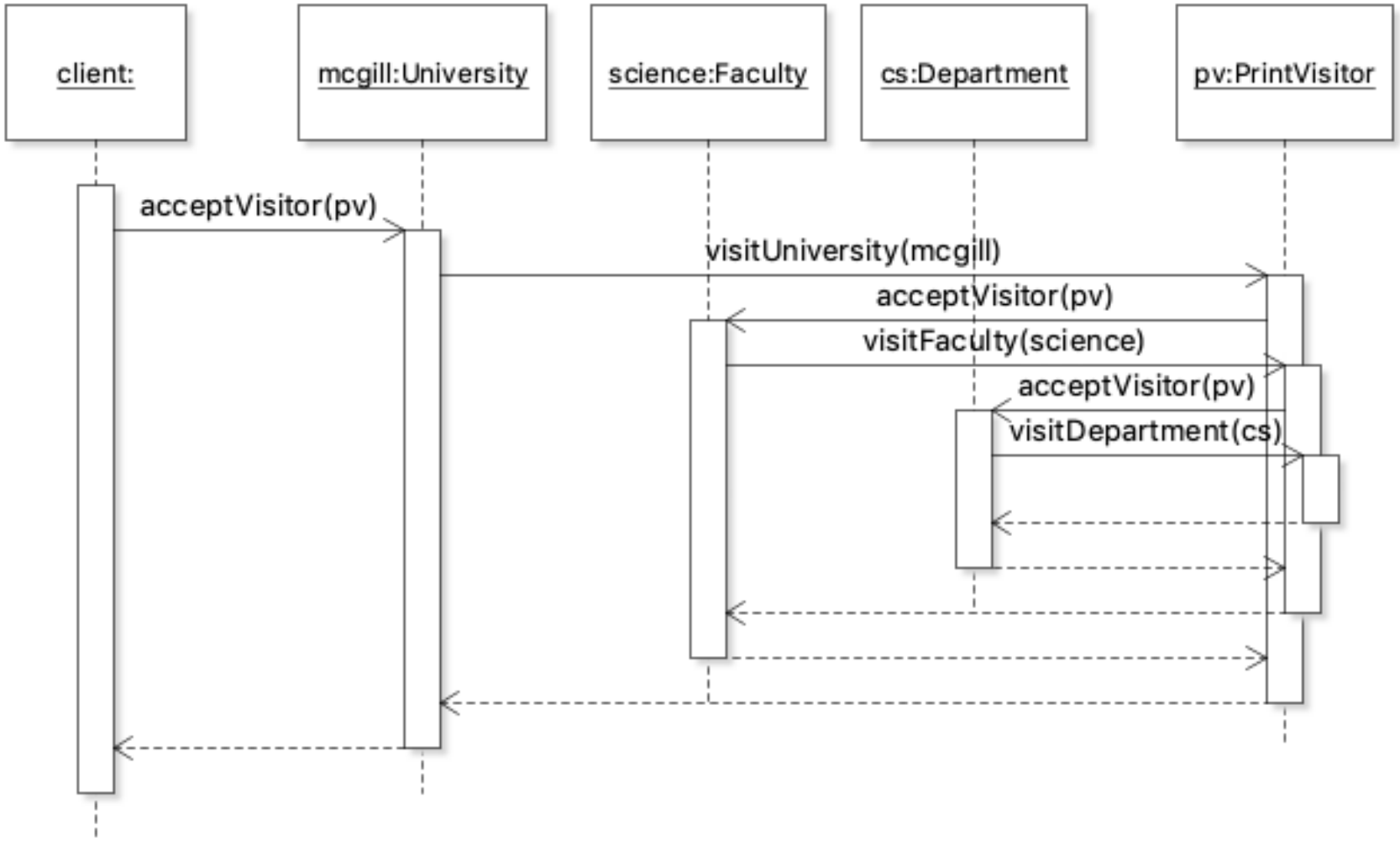
Activity2: Sequence Diagram for Visitor pattern

```
University mcGill = new University("McGill");
Faculty science = new Faculty("Science");
Department cs = new Department("Computer Science");

mcGill.addFaculty(science);
science.addDepartment(cs);

Visitor pv = new PrintVisitor();
mcGill.acceptVisitor(pv);
```

Traverse in the object structure



Sequence diagram for traversal in Visitor?


client:
mcgill:University
science:Faculty
cs:Department
pv:PrintVisitor
acceptVisitor(pv)
visitUniversity(mcgill)
acceptVisitor(pv)
visitFaculty(science)
acceptVisitor(pv)
visitDepartment(cs)

Demo on McGill Visitor

What is design pattern again?

- A standard solution to a common programming problem
- A technique for making code more flexible
- Shorthand for describing program design
- Vocabulary for communication & documentation

	Creational	Structural	Behavioral
Class	Factory Method	Adapter (class)	Integreter
			Template Method ✓
Object	Abstract Factory	Adapter (class)	Chain of Responsibility
	Builder	Bridge	Command ✓
	Prototype ✓	Composite ✓	Iterator ✓
	Singleton ✓	Decorator ✓	Mediator
		Flyweight ✓	Momento
		Façade	Observer ✓
		Proxy	State
			Strategy ✓
			Visitor ✓

Creational Patterns

- Creational Patterns control object creation
  - encapsulate knowledge about which concrete classes the system uses
  - hide how instances of concrete classes are created and combined.

Why not using the constructors?
Cannot return a subtype
Always create a new object

	Creational	Structural	Behavioral
Class	Factory Method	Adapter (class)	Interpreter
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			Strategy ✓
			Visitor ✓

Structural Patterns

- Concerned with how classes and objects are composed to form larger structures.
- Patterns are similar on structure:
  - single and multiple inheritance for class-based patterns
  - object composition for object patterns.
- Patterns have distinct intention

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Behavioral Patterns

- Concerned with algorithms and the assignment of responsibilities between objects.
- Describe not just patterns of objects or classes but also the patterns of communication between them.

Encapsulating Variation

- When an aspect of a program changes frequently, the behavioral patterns define an object that encapsulate that aspect:
  - A Strategy object encapsulates _____;
  - An iterator object encapsulates _____;
  - A command object encapsulates _____;
  - A visitor object encapsulates_____;

Passing around object

- Object is returned to the client and will be used at later time.
  - An iterator
  - A command
- Object is passed into the system as argument
  - A strategy
  - A visitor

Review Objectives of “Inversion of control”

- Be able to Use Callback to achieve decoupling
- Be able to use the Observer design pattern effectively;
- Event Handling in GUI applications
- Understand the concept of an application framework;
- Understand the Model-View-Controller Decomposition;
- Be able to use the Visitor Design Pattern effectively;
- Be able to determine when to used different design patterns effectively.