CS 326
Design Patterns, Part 2

Stephen Freund

Design Patterns

- A standard solutions to common programming problems
- Creational patterns
  - constructing objects
- Structural patterns
  - combining objects, controlling heap layout
- Behavioral patterns
  - communicating among objects, affecting object semantics

Structural Patterns: Wrappers

- Wrappers are a thin veneer over an encapsulated class
  - Modify the interface
  - Extend behavior
  - Restrict access

Pattern	Functionality	Interface
Adapter	same	different
Decorator	different	same
Proxy	same	same

- The encapsulated class does most of the work

Adapter

Pattern	Functionality	Interface
Adapter	same	different
Decorator	different	same
Proxy	same	same

- **Problem:** interface to class doesn't match what we want to use.
- Examples:
  - angles passed in radians vs. degrees
  - use "old" method names for legacy code
- **Solution:** Alter the interface without changing functionality
  - Rename a method
  - Convert units
  - Implement a method in terms of another

Adapter: Scaling Rectangles

- We have this Rectangle protocol

```
protocol Rectangle {
  func scale(by: Double)
  ...
  var width : Double { get }
  var area : Double { get }
}
```

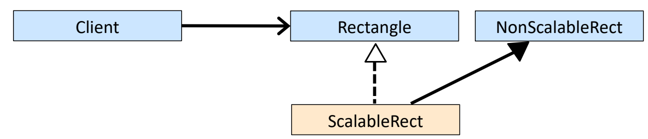
- We have this class, but want one that conforms to Rectangle protocol:

```
class NonScalableRectangle { // not a Rectangle
  var width : Double
  var area : Double
}
```

public mutable vars? Ugh, but trying to keep it simple...

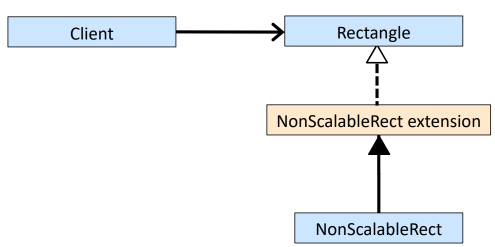
Adapter with Subclassing

```
class ScalableRectable : NonScalableRectangle,
                         Rectangle {
  func scale(by amount : Double) {
    width *= amount
    height *= amount
}
```



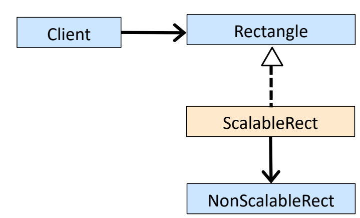
Adapter with Protocol Extension

```
extension NonScalableRectangle : Rectangle {
  func scale(by amount : Double) {
    width *= amount
    height *= amount
  }
}
```



Adapter with Delegation

```
class ScaleableRectable : Rectangle {
  let delegate : NonScaleableRectangle

  init() { delegate = NonScaleableRectangle() }

  var width : Double {
    get { return delegate.width }
    set { delegate.width = newValue }
  }

  func scale(by amount : Double) {
    width *= amount
    height *= amount
  }

  func circumference() -> Double {
    return delegate.circumference()
  }
}
```



Subclass

```
class ScalableRectable:
        NonScalableRectangle,
        Rectangle {
  func scale(by amount : Double) {
    width *= amount
    height *= amount
}
```

Extension

```
extension NonScalableRectangle:
            Rectangle {
  func scale(by amount : Double) {
    width *= amount
    height *= amount
  }
}
```

Delegation

```
class ScaleableRectable : Rectangle {
  let delegate : NonScaleableRectangle

  init() {
    delegate = NonScaleableRectangle()
  }

  var width : Double {
    get { return delegate.width }
    set { delegate.width = newValue }
  }

  func scale(by amount : Double) {
    width *= amount
    height *= amount
  }

  func circumference() -> Double {
    return delegate.circumference()
  }
}
```

Subclass vs Delegation vs Extension

- Subclassing
  - automatically gives access to all methods of superclass
  - built in to the language (syntax, efficiency)
- Delegation
  - permits removal of methods (compile-time checking)
- Extension
  - lightweight, but limited
  - leads to poor code organization
  - no new properties
  - messy if other classes conform to Rectangle protocol

Decorator

Pattern	Functionality	Interface
Adapter	same	different
Decorator	different	same
Proxy	same	same

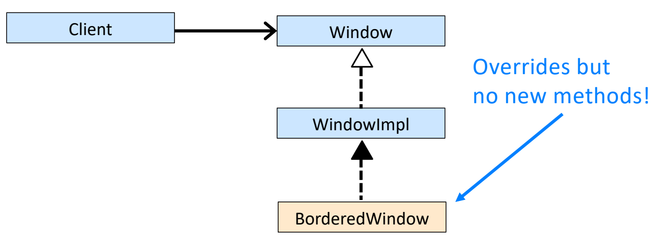
- **Problem:** Want to add functionality to a class without changing the interface
- **Solution:** Extend existing methods to do something more than they currently do
  - (while still preserving the previous specification)
- Not all subclassing is decoration
  - can add new methods too!

Example: Bordered Windows

```
protocol Window {
  // rectangle bounding the window
  var bounds : CGRect { get }

  // draw this on the specified screen
  func draw()
  ...
}

class WindowImpl : Window {
  ...
}
```

Bordered Window via Subclass

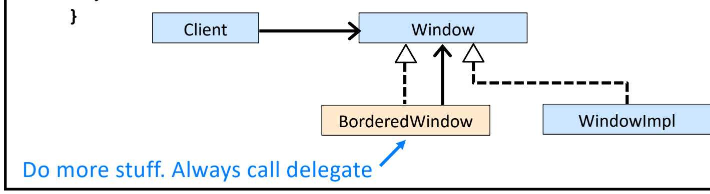
```
class BorderedWindow : WindowImpl {
  func draw() {
    super.draw()
    bounds.draw()
  }
}
```



Bordered Window via Delegation

```
class BorderedWindow : Window {
  let innerWindow : Window

  init(innerWindow : Window) {
    self.innerWindow = innerWindow
  }

  func draw() {
    innerWindow.draw()
    innerWindow.bounds.draw()
  }
}
```

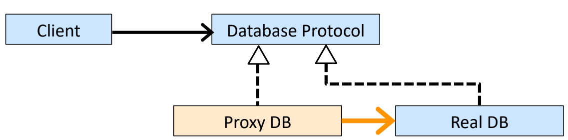
- A window can have multiple borders
- A window can have both bordered and shaded decorations
- Wrappers can be added/removed at run time



Proxy

Pattern	Functionality	Interface
Adapter	same	different
Decorator	different	same
Proxy	same	same

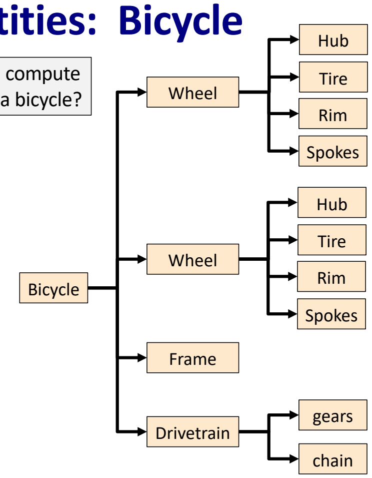
- Same interface and functionality as the wrapped class. So, uh, why wrap it?...
- Control access to wrapped object
  - Communication: manage network details when using a remote object
  - Locking: serialize access by multiple clients
  - Security: permit access only if proper credentials



Composite Entities: Bicycle

How do we compute the cost of a bicycle?

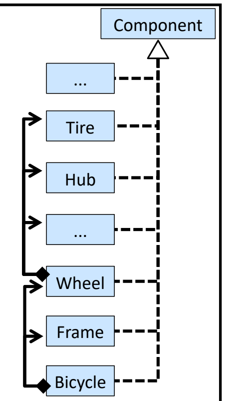
- Bicycle
  - Wheel
    - Hub
    - Spokes
    - Rim
    - Tire
  - Frame
  - Drivetrain
    - gears
    - chain
  - ...



Composite Pattern

- **Problem:** Want to manipulate a single unit and a collection of units in the same way.
- **Solution:** Make all units in a composite structure support the same interface.
  - So no need to "always know" if an object is a collection of smaller objects or not
  - Good for dealing with "part-whole" relationships
- An extended example…

Methods on Components




```
protocol Component {
 func weight() -> Double
 func cost() -> Double
}

class Tire: Component {
 let price: Double
 func cost() -> Double {
  return price
 }
}

class Wheel: Component {
 let assemblyCost: Double
 let hub: Hub
 ...
 let tire: Tire

 func cost() -> Double {
   return assemblyCost
          + hub.cost()
          + ...
          + tire.cost()
 }
}

class Bicycle: Component {
 let assemblyCost: Double
 let frontWheel: Wheel
 let frame: Frame
 ...

 func cost() -> Double {
   return assemblyCost
          + frontWheel.cost()
          + frame.cost()
          + ...
 }
}
```

Three Kinds Of Patterns

- Creational patterns
  - constructing objects
- Structural patterns
  - combining objects, controlling heap layout
- Behavioral patterns
  - communicating among objects, affecting object semantics
  - **Observer Pattern**

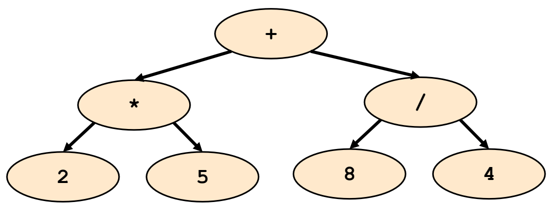
Traversing Composites

- **Goal:** perform operations on all parts of a composite
- **Idea:** generalize the notion of an iterator
  - process the components of a composite in an order appropriate for the application
- Example: arithmetic expressions
  - How do we represent: `2*5 + 8/4`
  - How do we traverse/process these expressions?

Representing Expressions

`2*5 + 8/4`

Operations
- evaluate: 12
- description: "((2*5)+(8/4))"

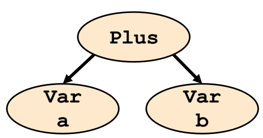


Abstract Syntax Tree (AST)

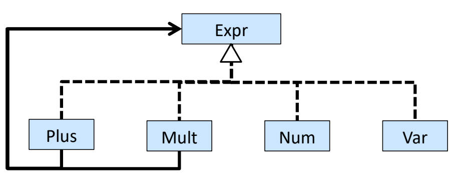
```
protocol Expression { ... }

class Num extends Expression {    // 1,2,3,...
  let val : Int
}

class Plus extends Expression {      // a + b
  let lhs : Expression
  let rhs : Expression
}

class Mult extends Expression {      // a * b
  let lhs : Expression
  let rhs : Expression
}

class Var extends Expression {  // variables
  let name : String
}
```

Object Model vs. Type Hierarchy

- AST for `a + b`:



- Class hierarchy for `Expression`:



Operations on ASTs

- Need to write code for each entry in this table

		Type of Object		
		Number	Plus	Mult
Operation	eval			
	description			

- **Questions:**
  – Should we group together the code for a particular operation or the code for a particular expression?
  – Given an operation and an expression, how do we "find" the proper piece of code?

Operations on ASTs

- Need to write code for each entry in this table

Type of Object

Operation	Number	Plus	Mult
eval			
description			

- **Questions:**
  - Should we group together the code for a particular operation or the code for a particular expression?
  - Given an operation and an expression, how do we "find" the proper piece of code?

Interpreter Pattern

```
protocol Expression : CustomStringConvertible {
  var description : String { get }
  func eval() -> Int
}

class Num : Expression {
  let val : Int
  var description : String { return "\(val)" }
  func eval() -> Int { return val }
}

class Plus : Expression {
  let lhs : Expression
  let rhs : Expression
  var description : String { return "(\(lhs)+\(rhs))" }
  func eval() -> Int { return lhs.eval() + rhs.eval() }
}

class Mult : Expression {
  let lhs : Expression
  let rhs : Expression
  var description : String { return "(\(lhs)*\(rhs))" }
  func eval() -> Int { return lhs.eval() * rhs.eval() }
}
```

Type of Object

Operation	Number	Plus	Mult
eval			
desc.			

Dynamic dispatch chooses the right implementation, for a call like `e.eval()`

Procedural Pattern

```
func eval(_ expr : Expression) -> Int {
  switch expr {
  case let e as Num:
    return e.val
  case let e as Plus:
    return eval(e.lhs) + eval(e.rhs)
  case let e as Mult:
    return eval(e.lhs) * eval(e.rhs)
  default:
    assertionFailure()
    return 0
  }
}

func description(_ expr : Expression) -> String {
  switch expr {
  case let e as Num:
    return "\(e.val)"
  case let e as Plus:
    return "(\(description(e.lhs)) + \(description(e.rhs)))"
  case let e as Mult:
    return "(\(description(e.lhs)) * \(description(e.rhs)))"
  default:
    assertionFailure(); return ""
  }
}
```

Type of Object

	Number	Plus	Mult
eval			
desc.			

Not Considered Poor Design: We must write code to "dispatch" to correct implementation. Can miss cases. Can run slowly...

Interpreter vs Procedural Pattern

- **Interpreter**: Collects code for similar objects, spreads apart code for similar operations
  - Easy to add types of objects
  - Hard to add operations
- **Procedural**: Collects code for similar operations, spreads apart code for similar objects
  - Easy to add operations
  - Hard to add types of objects
  - (Visitor Pattern: form of procedural... we won't cover...)

Alternative Representation

- Represent AST types as cases in an enum.

```
indirect enum Expression {
  case num(val: Int)
  case plus(lhs: Expression, rhs: Expression)
  case mult(lhs: Expression, rhs: Expression)
}
```

  - `indirect` necessary when enum is *recursive*
- Not an OO design, but facilitates procedural pattern.
  - Easy to add new operations
  - Harder to add new cases
- Similar to datatypes in many functional languages.

Alternative Representation

```
indirect enum Expression {
  case num(val: Int)
  case plus(lhs: Expression, rhs: Expression)
  case mult(lhs: Expression, rhs: Expression)
}

func eval(_ expr : Expression) -> Int {
  switch expr {
  case .num(let val): return val
  case .plus(let lhs, let rhs): return eval(lhs) + eval(rhs)
  case .mult(let lhs, let rhs): return eval(lhs) * eval(rhs)
  }
}

func description(_ expr : Expression) -> String {
  switch expr {
  case .num(let val): return "\(val)"
  case .plus(let lhs, let rhs):
    return "(\(description(lhs)) + \(description(rhs)))"
  case .mult(let lhs, let rhs):
    return "(\(description(lhs)) * \(description(rhs)))"
  }
}
```