Carl Kingsford, 02-201, Fall 2015

Lecture 17: Interfaces

The principle of encapsulation

A fundamental design principle in programming is encapsulation:

> group together related things, and hide as many details as possible from the rest of the world, exposing only a small "interface" to the rest of the program.

Examples we have seen so far:

- **Functions** — to use "fmt.Printf" I only need to know the rules about what parameters it takes and what it returns; how it is implemented is totally hidden from me.
- **Packages** — inside the "fmt" package is a huge amount of code, but we only need to know about the functions.
- **Objects & methods** – I access a stack using only the methods on the Stack type --- it doesn't matter if Stack is implemented as a list or some other technique. `S.Pop()` and `S.Push(x)` hide those details, but still let you share data between invocations of functions.

Interfaces

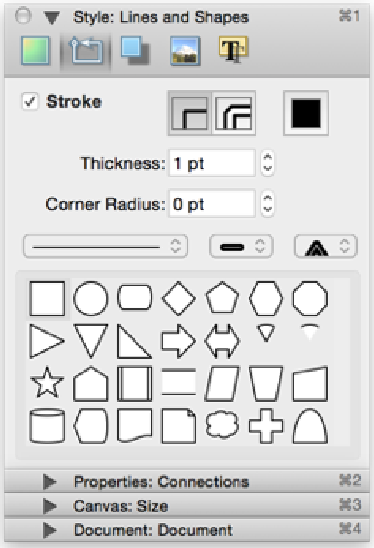
Interfaces let you formally define a set of operations that a type supports. They let you hide completely how the operations are carried out. They let you specify a type that will support a given set of operations without even specifying the details about the type.

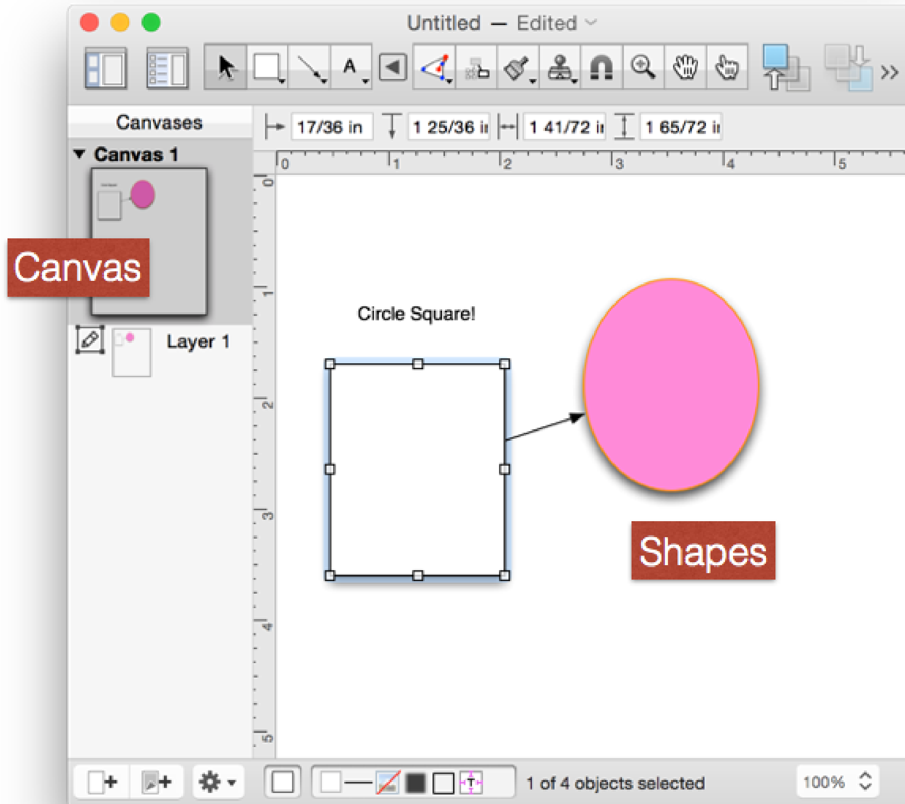
This will be made clearer with an example.

Example: Design for a drawing program

Drawing program objects

A typical drawing program manipulates: shapes, text, lines. It also displays and allows users to manipulate handles on the shapes, colors, shadows, layers, canvases, etc.





It would be natural to create an object for each type of shape: Circle, Oval, Triangle, Star, Square, ...

For example, here's an object for `Square`:

```
type Square struct {
    x0,y0 int
    x1,y1 int
    fillColor color.Color
    strokeColor color.Color
    lineWidth int
}

func (s *Square) MoveTo(x,y int)
func (s *Square) Resize(w,h int)
func (s *Square) Handles() []Handles
func (s *Square) Draw(c *DrawingCanvas)
func (s *Square) SetLineWidth(w int)
func (s *Square) ContainsPoint(x,y int)
```

And here's an object for `Oval`:

```go
type Oval struct {
    x0,y0 int
    radius int
    fillColor color.Color
    strokeColor color.Color
    lineWidth int
}

func (s *Oval) MoveTo(x,y int)
func (s *Oval) Resize(w,h int)
func (s *Oval) Handles() []Handles
func (s *Oval) Draw(c *DrawingCanvas)
func (s *Oval) SetLineWidth(w int)
func (s *Oval) ContainsPoint(x,y int)
```

The methods for `Square` and `Oval` are needed for every shape.

Challenge: a `DrawingCanvas` type

We want to write a type that corresponds to a canvas. A canvas can have lots of different shapes on it:

```go
type DrawingCanvas struct {
    width, height int
    backgroundColor color.Color
    shapes []????    // <- what type should go here!!!?
}
```

Question 1: What type shouhd the *shape* field have?

We assume that `DrawingCanvas` should have a method to draw all the shapes:

```go
func (c *DrawingCanvas) DrawAllShapes()
```

This function should should call the `Draw()` function on each of the shapes that the canvas contains. It should do something like:

```go
func (c *DrawingCanvas) DrawAllShapes() {
    for shape := range shapes {
        shape.Draw(c)
    }
}
```

Question 2: How can the above code know to call `(*Oval) Draw` for ovals and `(*Square) Draw` for squares?

The benefits of the above design are that:

- `DrawAllShapes` is conceptually very simple: it just loops through the shapes and asks each of them to draw themselves
- All the shape-specific knowledge is encapsulated inside each shape type: an Oval knows how to draw itself; a Square knows how to draw itself, etc.
- Adding a new shape is easy: just create a new shape type. You don't need to modify any existing shape types (each shape can store the data it needs, i.e. radius vs. width/length). You don't even need to modify `DrawAllShapes` when you add a shape!

So how do we answer the above 2 questions so we can use this design? The answer to both of these questions is the use of `interface` types.

`interface` types

The main problem above is that the shapes all have different types but we want to put them into a single list.

The thing that is common to "shapes" is what you can do with them: `Draw` , `MoveTo` , `Resize` , etc.

Go lets you define a type that specifies only the operations that can be performed on the type:

```go
type Shape interface {
    MoveTo(x,y int)
    Resize(w,h int)
    Handles() []Handles
    Draw(c *DrawingCanvas)
    SetLineWidth(w int)
}
```

This looks nearly the same as a `struct` but (a) using the word `interface` and (b) listing *functions* instead of data. The way to read this is that a `Shape` is a thing that has these methods.

If I have a `Shape`, I don't need to know what kind of shape, or how its shape functions are implemented.

Modifying the `DrawingCanvas` struct:

Now we can write:

```
type DrawingCanvas struct {
   width, height int
   backgroundColor color.Color
   shapes []Shape
}
```

This makes the `shape` field be a list of `Shapes`. This list can now contain anything that supports all the methods of the `Shape` interface.

```
func (c *DrawingCanvas) DrawAllShapes() {
    for shape := range shapes {
        // we know shape as a Draw() method b/c it is a Shape
       shape.Draw(c)
    }
}
```

Putting it all together

Here are some `Shape` objects:

```go
//================================
// What all shapes must do
//================================

type Shape interface {
   MoveTo(x,y int)
   Draw()
}

//================================
// An Oval Shape
//================================

type Oval struct {
   x0,y0 int
}

func (s *Oval) MoveTo(x,y int) {
    s.x0, s.y0 = x,y
}

func (s *Oval) Draw() {
    fmt.Println("I'm an OVAL!!!! at", s.x0, s.y0)
}

//================================
// A Square Shape
//================================

type Square struct {
   x0,y0 int
}

func (s *Square) MoveTo(x,y int) {
    s.x0, s.y0 = x,y
}

func (s *Square) Draw() {
    fmt.Println("I'm a SQUARE!!!! at ", s.x0, s.y0)
}
```

We can then write the functions:

```go
//================================
// A function to draw all the shapes
//================================

func DrawAllShapes(shapes []Shape) {
    fmt.Println("==================================")
    for _, shape := range shapes {
        shape.Draw()
    }
    fmt.Println("==================================")
}

//================================
// Create some shapes and add them to the list
//================================

func main() {
    shapes := make([]Shape, 0)
    var s1 Shape = &Square{10,10}
    var s2 Shape = &Square{100,100}
    var s3 Shape = &Oval{60,75}
    shapes = append(shapes, s1)
    shapes = append(shapes, s2)
    shapes = append(shapes, s3)

    DrawAllShapes(shapes)

    shapes[1].MoveTo(3333,3333)
    DrawAllShapes(shapes)

}
```

Duck typing

Notice that we never said that `Oval` was a `Shape` or that `Square` was a `Shape`. Go figured that out on its own.

This is called "duck typing" because "If it walks like a duck, swims like a duck, and quacks like a duck, it’s a duck." So "If it Draw()s like a Shape, MoveTo()s like a Shape, and Resize()s like a Shape, it’s a Shape.".

Summary

- Interfaces let you create a type that depends only on the operations you can perform on it.
- Let's you write general code that words for any type that supports that interface.

Glossary

- encapsulation: the principle that programs should be "local": details should be hidden and any dependencies should be confined to small parts of a program.