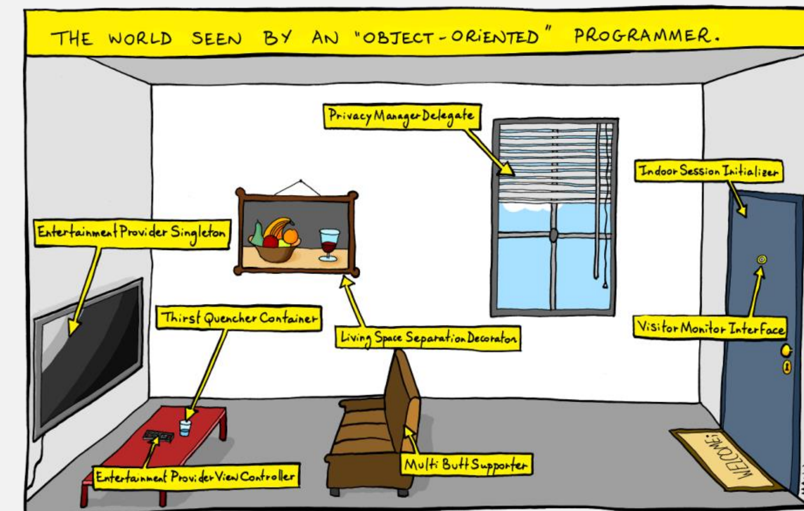
UMass Boston Computer Science

CS450 High Level Languages (section 2)

How To Design … OO Programs?

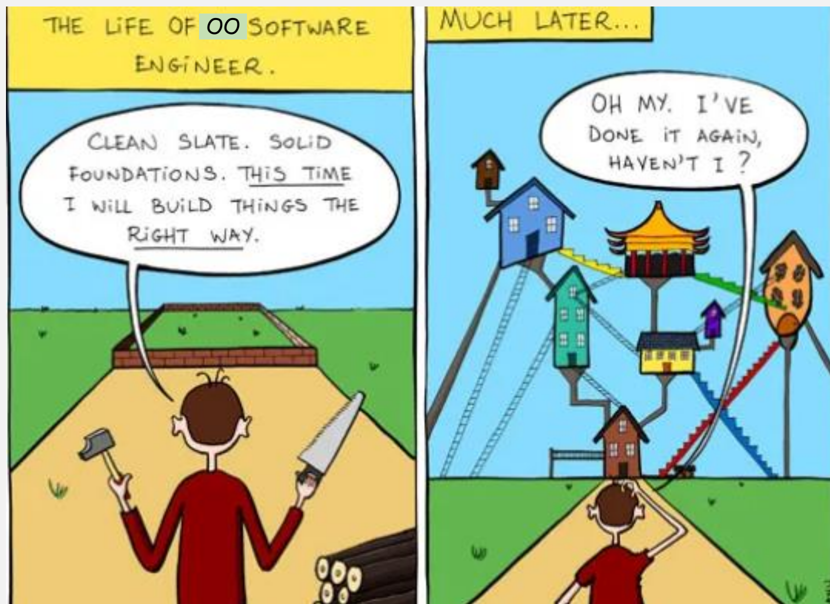
Monday, December 9, 2024

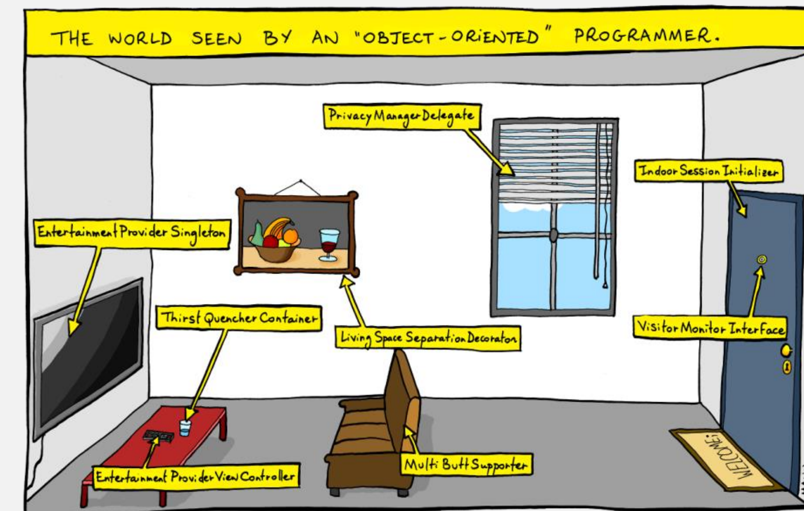


Logistics

- **HW 13 out**
  - <u>due</u>: **Wed 12/11 12pm (noon) EST**

- **HW 14 maybe?** (Shapes!)
  - <u>Out?</u>: **Wed 12/18 12pm (noon) EST**





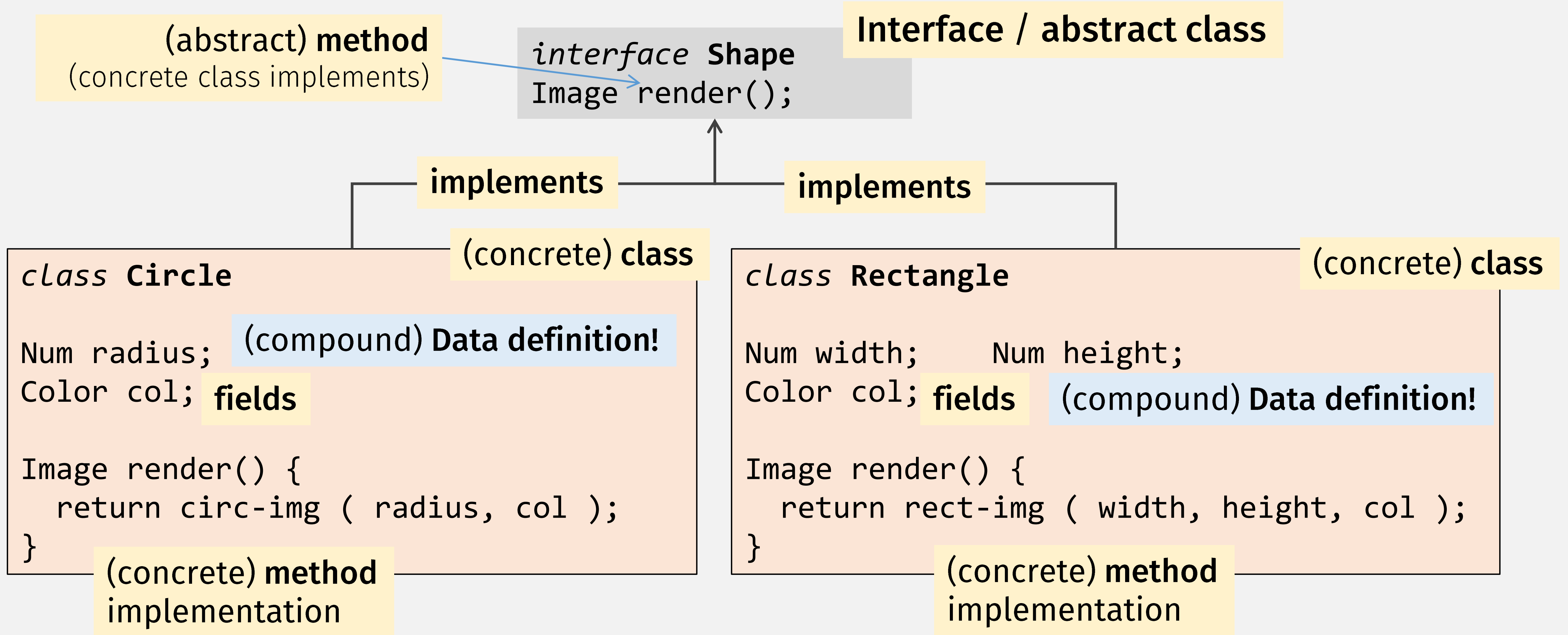
A Simple OO Example: Shapes

```
interface Shape
Image render();
```

```
class Circle

Num radius;
Color col;

Image render() {
  return circ-img ( radius, col );
}
```

```
class Rectangle

Num width;    Num height;
Color col;

Image render() {
  return rect-img ( width, height, col );
}
```

A Simple OO Example: Terminology



CS450 vs OO Comparison

CS 450 Design Recipe

- **Compound data** (`struct`) have fields, <u>separate</u> <u>fns</u> process data

OO Programming

- **Compound data** (`class`) <u>group</u> fields and <u>methods</u> <u>together</u>!

A Simple OO Example: Compare to CS450

(itemization) **Data definition**

```
interface Shape
Image render();
```

(itemization) **Data definition** item

```
class Circle

Num radius;
Color col;

Image render() {
  return circ-img ( radius, col );
}
```

(compound) **Data definition**

function implementation (one **cond** clause) **for Shape data** (split up)

(itemization) **Data definition** item

```
class Rectangle

Num width;    Num height;
Color col;

Image render() {
  return rect-img ( width, height, col );
}
```

(compound) **Data definition**

function implementation (one **cond** clause) **for Shape data** (split up)

CS450 vs OO Comparison

CS 450 Design Recipe

- **Compound data** (`struct`) have fields, separate fns process data
- **Itemization** Data Defs explicitly defined

OO Programming

- **Compound data** (`class`) group fields and methods together!
- **Itemization** Data Defs implied by interface / class definitions

CS450 vs OO Comparison

CS 450 Design Recipe	**OO Programming**
• **Compound data** (`struct`) have fields, separate fns process data	• **Compound data** (`class`) group fields and methods together!
• **Itemization** Data Defs explicitly defined	• **Itemization** Data Defs implied by interface / class definitions
• **Functions** organized by the kind of data they process!	• **Methods** organized by the kind of data they process!

1 function,
1 task, … processes
1 data definition!

A Simple OO Example: Compare to CS450

```
interface Shape
Image render();
```

```
;; A Shape is one of:
;; - (rect Num Num Color)
;; interp: fields are width, height, color
;; - (circ Num Color)
;; interp: fields are radius and color
;; Represents a shape to be drawn on a canvas
```

```
class Circle

Num radius;
Color col;

Image render() {
  return circ-img
}
```

```
(struct circ [r col])
```

```
class Rectangle

Num width;    Num height;
Color col;

Image render() {
                  g ( width, height, col );
```

```
(struct rect [w h col])
```

```
;; render: Shape -> Image
(define (render sh)
  (cond
    [(rect? sh) (render-rect sh)]
    [(circ? sh) (render-circ sh)]))
```

method "**dispatch**"

"abstract" implementation

"concrete" implementations

CS450 vs OO Comparison

CS 450 Design Recipe

- **Compound data** (`struct`) have fields, separate fns process data
- **Itemization** Data Defs explicitly defined
- **Functions** organized by the kind of data they process!
- Explicit itemization **dispatch** (cond)

```
;; (explicit) render: Shape -> Image
(define (render sh)
 (cond
  [(rect? sh) (render-rect sh)]
  [(circ? sh) (render-circ sh)]))
```

OO Programming

- **Compound data** (`class`) group fields and methods together!
- **Itemization** Data Defs implied by interface / class definitions
- **Methods** organized by the kind of data they process!
- Implicit itemization **dispatch**

```
;; (implicit) render: Shape -> Image
Image render (Shape sh)
  if (sh instanceof Rectangle){ render-rect(sh); }
  else if (sh instanceof Circle){ render-circ(sh); }
```

A Simple OO Example: Constructors

```
interface Shape
Image render();
```

```
Circle c = Circle( 10, blue );
Image img = c.render();
```

```
class Circle

Num radius;    Color col;
// …
Circle( r, c) {
  radius = r;
  col = c;
}
```

```
class Rectangle

Num width;    Num height;    Color col;
// …
Rectangle( w, h, c) {
  width = w;    height = h;
  col = c
}
```

Q: Where are method implementations for an obj instance “stored”?

A: It’s another (hidden) **field** (see “**method table**”)!

CS450 vs OO Comparison

CS 450 Design Recipe

- **Compound data** (`struct`) have fields, separate fns process data
- **Itemization** Data Defs explicitly defined
- **Functions** organized by the kind of data they process!
- Explicit itemization **dispatch** (cond)
- Struct **Constructor** explicitly includes method defs ???

OO Programming

- **Compound data** (`class`) group fields and methods together!
- **Itemization** Data Defs implied by interface / class definitions
- **Methods** organized by the kind of data they process!
- Implicit itemization **dispatch**
- Object **Constructor** implicitly includes method defs

OO-style Constructors … with structs!

Shape "dispatch" function

```
;; render : Shape -> Image
(define (render sh)
 (cond
  [(rect? sh) (render-rect sh)]
  [(circ? sh) (render-circ sh)]))
```

Shape "interface" definition

Method implementation (as a field)

```
(struct Shape [render-method])
```

```
(struct circ Shape [r col])
```

superstruct

circ constructor must be given 3 args

Shape constructors

```
(define (mk-circ r col
             [circ-render-fn render-circ])
  (circ circ-render-fn r col))
```

default

(make method an optional argument, with default)

Q: Where are method implementations for an obj instance "stored"?

A: It's another (hidden) **field!**

Then create same definitions for **rect** …

CS450 vs OO Comparison

CS 450 Design Recipe	OO Programming
• **Compound data** (`struct`) has (possibly function) fields!	• **Compound data** (`class`) group fields and methods together!
• **Itemization** Data Defs explicitly defined	• **Itemization** Data Defs implied by interface / class definitions
• **Functions** organized by the kind of data they process!	• **Methods** organized by the kind of data they process!
• Explicit itemization **dispatch** (`cond`)	• Implicit itemization **dispatch**
• Struct **Constructor** explicitly includes method defs	• Object **Constructor** implicitly includes method defs

OO-Style Dispatch … with structs!

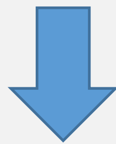
450-style "dispatch" function

```
;; render : Shape -> Image
(define (render sh)
 (cond
  [(rect? sh) (render-rect sh)]
  [(circ? sh) (render-circ sh)]))
```

Shape OO-style "interface and "class" definitions

```
(struct Shape [render-method])
```

```
(struct circ Shape [r col])
(struct rect Shape [w h col])
```



OO-Style "dispatch"

```
;; render : Shape -> Image
(define (render sh)
 ((Shape-render-method sh) sh))
```

```
(define c (mk-circ 10 "blue"))
(define img (render c))
```

equivalent

Q: But object itself must be argument to methods?

A: In OO langs, this is also true!
… but it's a hidden argument (see "**this**")!

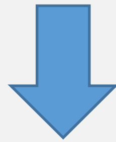
```
Circle c = Circle( 10, blue );
Image img = c.render(); // equiv to render(c) !
```

OO-Style Dispatch … with structs!

450-style "dispatch" function

```
;; render : Shape -> Image
(define (render sh)
 (cond
  [(rect? sh) (render-rect sh)]
  [(circ? sh) (render-circ sh)]))
```

```
;; render-circ : Circle -> Image
(define (render-circ this)
  (match-define (circ r col) this)
  (circle r "solid" col)) ; 2htdp/image fn
```



OO-Style "dispatch"

```
;; render : Shape -> Image
(define (render sh)
 ((Shape-render-method sh) sh))
```

```
;; render-rect : Rectangle -> Image
(define (render-rect this)
  (match-define (rect w h col) this)
  (rectangle w h "solid" col)) ; 2htdp/image fn
```

CS450 vs OO Comparison

CS 450 Design Recipe

- **Compound data** (`struct`) has (possibly function) fields!
- **Itemization** Data Defs explicitly defined
- **Functions** organized by the kind of data they process!
- Explicit itemization **dispatch** (`cond`)
- **Constructor** explicitly includes method defs
- Data to process is explicit arg

OO Programming

- **Compound data** (`class`) group fields and methods together!
- **Itemization** Data Defs implied by interface / class definitions
- **Methods** organized by the kind of data they process!
- Implicit itemization **dispatch**
- **Constructor** implicitly includes method defs
- Data to process (“`this`”) is implicit arg

How to Design … OO-Style Programs

- For **Itemization Data Definition**
  1. List Item Data Defs (and other prev data def parts)
  2. Specify required methods
  3. Define "abstract" struct (with # fields = # of methods)
  4. Define explicit dispatch function(s) (one per method)

```
;; A Shape is one of:
;; - Rectangle
;; - Circle
;; interp: Represents shape to draw on a canvas
;; Required methods:
;; - render : Shape -> Image
```

```
(struct Shape [render-meth])
```

```
;; render : Shape -> Image
(define (render sh)
 ((Shape-render-meth sh) sh))
```

How to Design … OO-Style Programs

- For **Itemization Data Definition**
  1. List Item Data Defs (and other prev data def parts)
  2. Specify required methods
  3. Define "abstract" struct (with # fields = # of methods)
  4. Define explicit dispatch function(s) (one per method)
- For **each item**:
  1. Define separate Data def
  2. Define a struct, as substruct of "abstract" struct
  3. Define required methods
  4. Define constructor that includes method implementations

How to Design … OO-Style Programs

```
;; A Rectangle is a:
;; (rect width  : Num
;;       height : Num
;;       color  : Color)
```

```
;; A Circle is a:
;; (circ radius : Num
;;       color  : Color)
```

```
;; render-circ : Circle -> Image
(define (render-circ this)
  (match-define (circ r col) this)
  (circle r “solid” col)) ; 2htdp/image fn
```

```
;; render-rect : Rectangle -> Image
(define (render-rect this)
  (match-define (rect w h col) this)
  (rectangle w h “solid” col)) ; 2htdp/image fn
```

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Defs (and other

ed methods

ct” struct (w

dispatch fu

- For each item:
  1. Define separate Data def
  2. Define a struct, as substruct of “ab
  3. Define required methods
  4. Define constructor that includes m

```
;; constructors create shape “objects”
(define (mk-rect w h col
          [render-meth render-rect])
  (rect render-meth w h col))
(define (mk-circ r col)
          [render-meth render-circ])
  (circ render-meth r col))
```

```
(struct rect Shape [w h col])
(struct circ Shape [r col])
```

Course Evals!

(see piazza for url)