Winter Semester 16/17

Software Engineering Design & Construction

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Programming Languages and Design Principles

Making Code Look Like Design

“Designing” with Pseudo-Assembler

What does the following program do?

```
i = 1
TEST: if i < 4
   then goto BODY
   else goto END
BODY: print i
   i = i + 1
   goto TEST
END:
```

“Designing” with Pseudo-Assembler

What does the following program do?

```
    i = 1
LOOP: print i
    i = i + 1
    if i < 4 goto LOOP
END:
```

Style can only be recommended, not enforced!

Designing with Structured Programming Languages

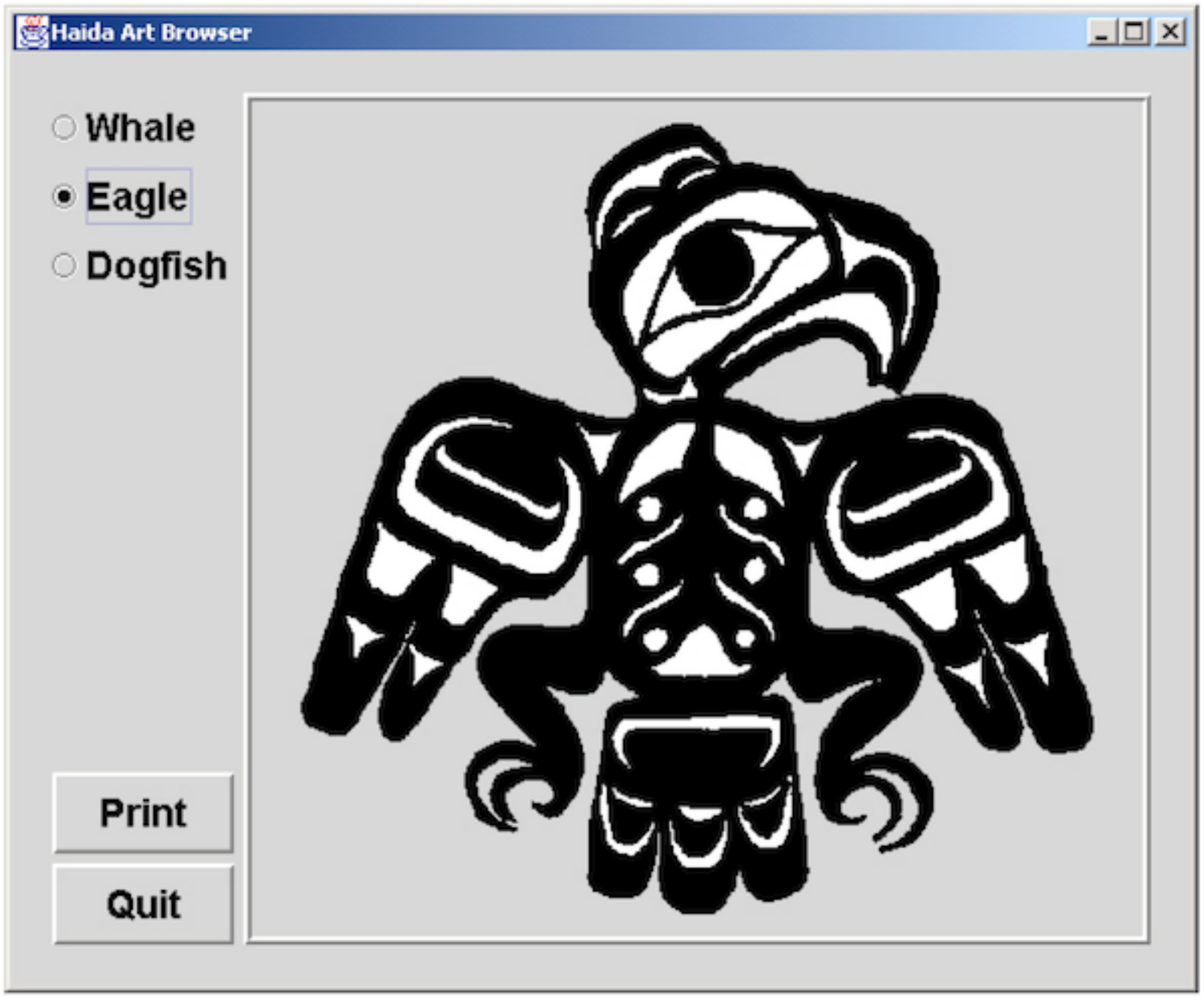
What does the following program do?

```
i = 1
while ( i < 4 ) {
   print(i)
   i = i + 1
}
```

Style gets enforced!

Better languages, More challenging tasks…

A simple image browser with structured programming



Code for Image Browser Structured into Procedures

Try to identify which method calls which method!

```
main () {
draw_label(“Art Browser”)
   m = radio_menu(
      {“Whale”, “Eagle”,
       “Dogfish”})
   q = button_menu({“Quit”})
   while ( !check_buttons(q) ) {
      n = check_buttons(m)
      draw_image(n)
   }
}

set_x (x) {
   current_x = x
}

draw_circle (x, y, r) {
   %%primitive_oval(x, y, 1, r)
}

set_y (y) {
   current_y = y
}
```

```
radio_menu(labels) {
   i = 0
   while (i < labels.size) {
      radio_button(i)
      draw_label(labels[i])
      set_y(get_y()
         + RADIO_BUTTON_H)
      i++
   }
}

radio_button (n) {
   draw_circle(get_x(),
      get_y(), 3)
}

get_x () {
   return current_x
}

get_y () {
   return current_y
}
```

```
draw_image (img) {
   w = img.width
   h = img.height
   do (r = 0; r < h; r++)
      do (c = 0; c < w; c++)
         WINDOW[r][c] = img[r][c]
}

button_menu(labels) {
   i = 0
   while (i < labels.size) {
      draw_label(labels[i])
      set_y(get_y()
         + BUTTON_H)
      i++
   }
}

draw_label (string) {
   w = calculate_width(string)
   print(string, WINDOW_PORT)
   set_x(get_x() + w)
}
```

Structured Programming with Style

```
main()
```

```
gui_radio_button(n)

gui_button_menu(labels)

gui_radio_menu(labels)
```

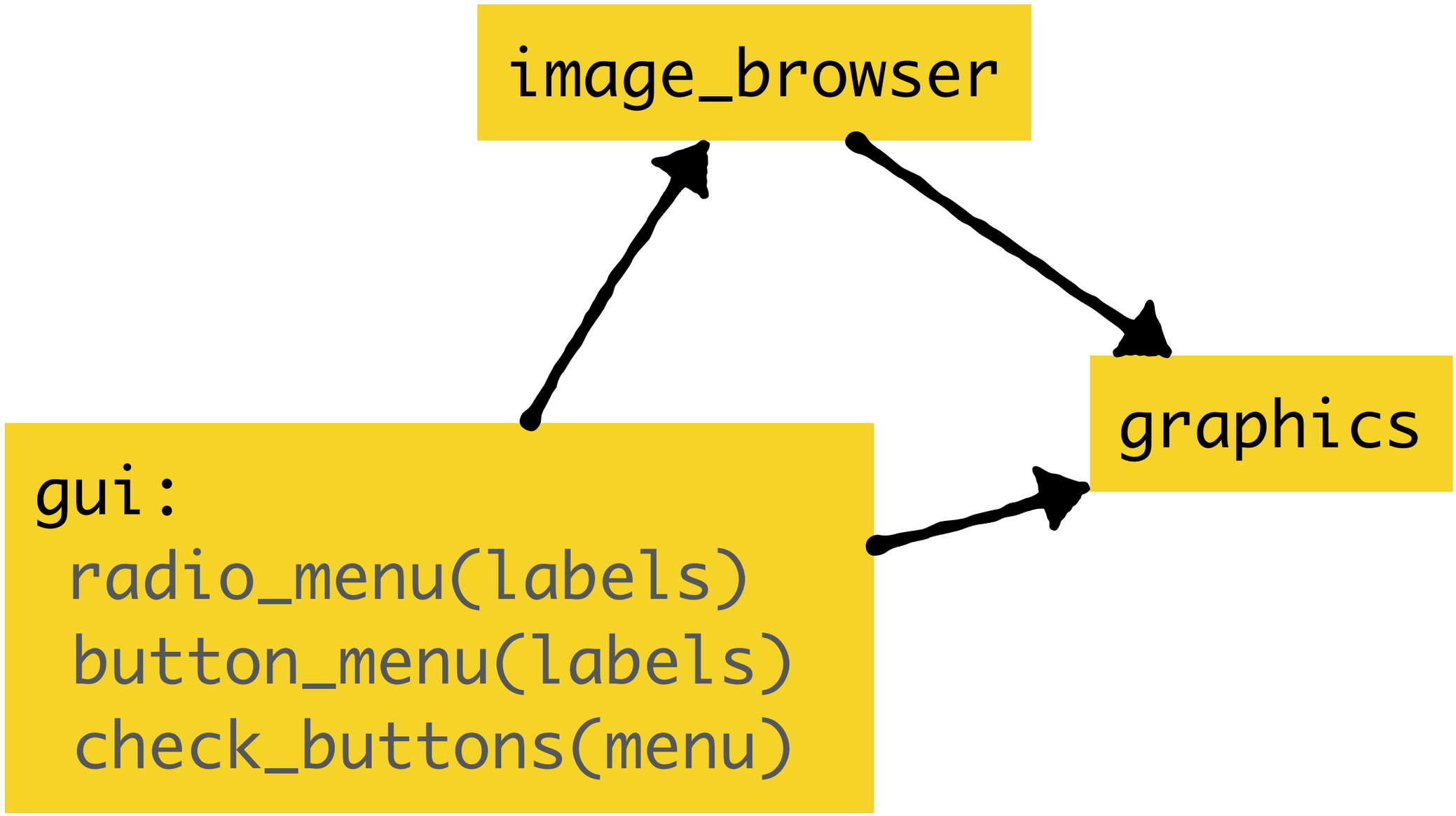
```
graphic_draw_image (img)

graphic_draw_circle (x, y, r)

graphic_draw_label (string)
```

```
state_set_y (y)

state_get_y ()

state_set_x (x)

state_get_x ()
```

Designing with Modular Programming Languages

```
module gui {
        exports:
            radio_menu(labels)
            button_menu(labels)
            check_buttons(menu)
}
```

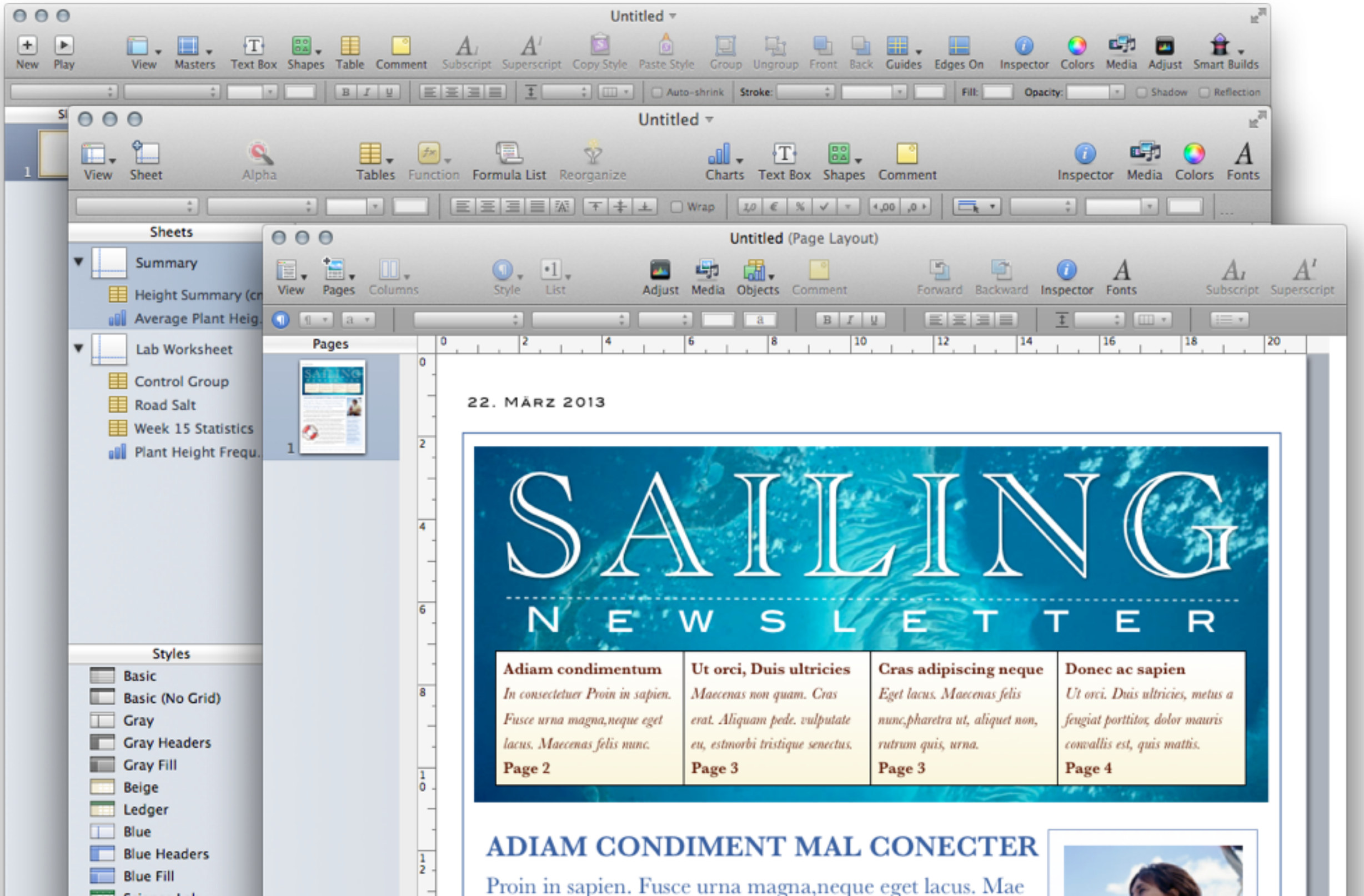
Module-based Abstraction



Abstraction mechanisms enable us to code and design simultaneously!

"Write what you mean."

Let’s “develop” application families with sophisticated GUIs with uniform look and feel with modular programming…

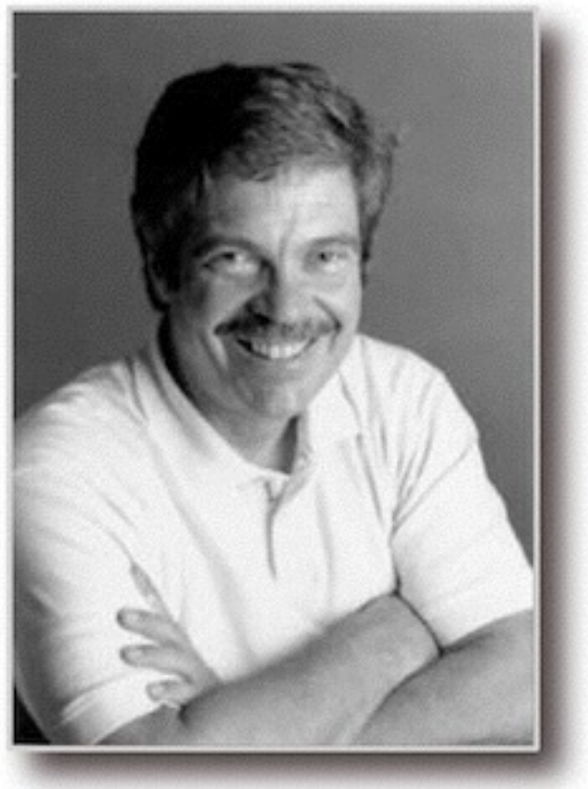


Designing with Object-Oriented Programming Languages

Object-oriented programming languages introduce new abstraction mechanisms:

- classes
- inheritance
- subtype polymorphism
- virtual methods

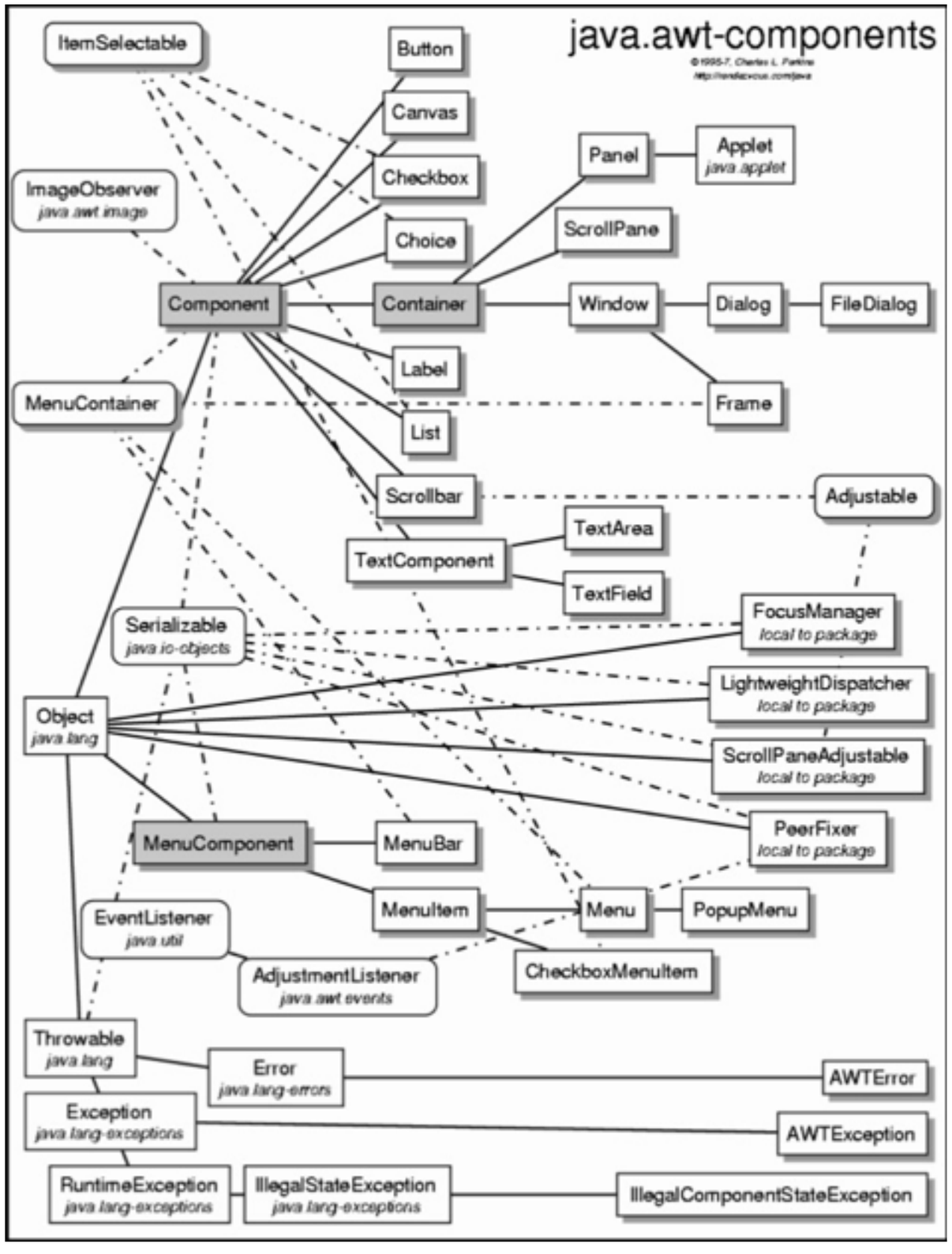
The roots of object-oriented programming languages are in the sixties.



Allan Kay,
Smalltalk 70 - 80

Dahl and Nygaard,
Simula 64, 68

Programming Languages are not a Panacea



"The significant problems we face cannot be solved at the same level of thinking we were at when we created them."

–Einstein

[…] improvements in programming techniques and programming languages in particular are overwhelmingly more important than anything else in the software business […]

[…] programmers are interested in design […] when more expressive programming languages become available, software developers will adopt them.

–Jack Reeves, To Code is to Design, C++ Report 1992

Implementing `trait Col[X]{map[T](f:(X)=>T){…}}`

This is only a first approximation of the mehtod's signature.

Try to **implement** the classical **`map`** function, which performs a mapping of the values of a collection using a given function, **only once for all collection classes**.

The function should be defined by the "top-level" class (e.g., **`Collection`**).

The type of the collection with the mapped values should correspond to runtime type of the source collection. If this is not possible, a *reasonable* other collection should be created. (The function should not fail!)

Implementing `Col[X]{map[T](f:(X)=>T){…}}`

Initial Draft

```
trait Col[X] { def map[T](f : (X) => T) : Col[T] = {…} }
class List[X] extends Col[X] { /*does not override map!*/ …}
class BitSet extends Col[Int] {/*does not override map!*/ …}
```

```
val l = List(1,2,3)
l.map(i => i +1) // should result in List[Int](2,3,4)
val b = BitSet(1,2,3)
b.map(i => i +1) // should result in BitSet[Int](2,3,4)
b.map(i => “I:"+i) // should result in ???("I:1","I:2","I:3")
```

Designing with Functional, Object-Oriented Programming Languages

Fill an array with n Person objects where each Person has a unique id.

Code:

```
class Person(id : Int)

var ids = 0
def nextId() : Int = { val id = ids ; ids+= 1; id }

Array.fill(15){ new Person(nextId()) }
```

Result:

```
=> Array[Person] = Array(Person(0), …, Person(14))
```

Designing with Functional, Object-Oriented Programming Languages **with a Flexible Syntax**

Creating an abstraction to express that we want to repeat something n times.

```
def repeat[T: scala.reflect.ClassTag](times: Int)(f: ⇒ T): Array[T] = {
  val array = new Array[T](times)
  var i = 0
  while (i < times) { array(i) = f; i += 1 }
  array
}
```

Now, we can express that we want to create an Array of 15 unique person objects using our new control-abstraction.

```
repeat(15){ new Person(nextId()) }
```

Designing with Functional, Object-Oriented Programming Languages with a Flexible Syntax vs. Explicit Language Features

Java's native try-with-resources statement

```
File tempFile = File.createTempFile("demo", "tmp");
try (FileOutputStream fout = new FileOutputStream(tempFile)) {
  fout.write(42);
}
```

Using Scala's language features enables us to define a new control structure that resembles Java's try-with-resources statement.

```
def process[C <: Closeable, T](closable: C)(r: C ⇒ T): T = {
    try { r(closable) }
    finally { if (closable != null) closable.close() }
}

val tempFile = File.createTempFile("demo", "tmp");
process(new java.io.FileOutputStream(tempFile)) { fout ⇒
  fout.write(42);
}
```

Programming Languages with notable Features:

- RUST avoids buffer errors statically (based on ownership)
  Graydon Hoare, 2009

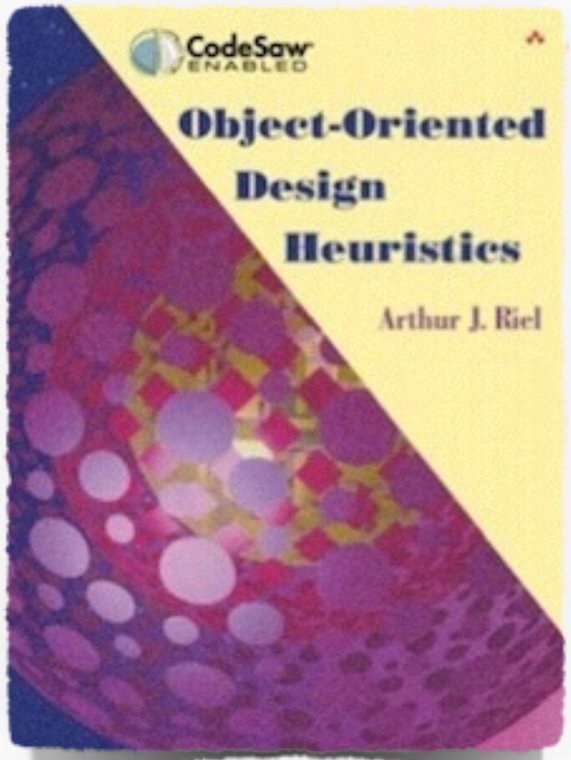
- Checked C avoids buffer errors statically and dynamically (introduces new checked pointer types)
  David TardiF, June 2016 (v 0.5)

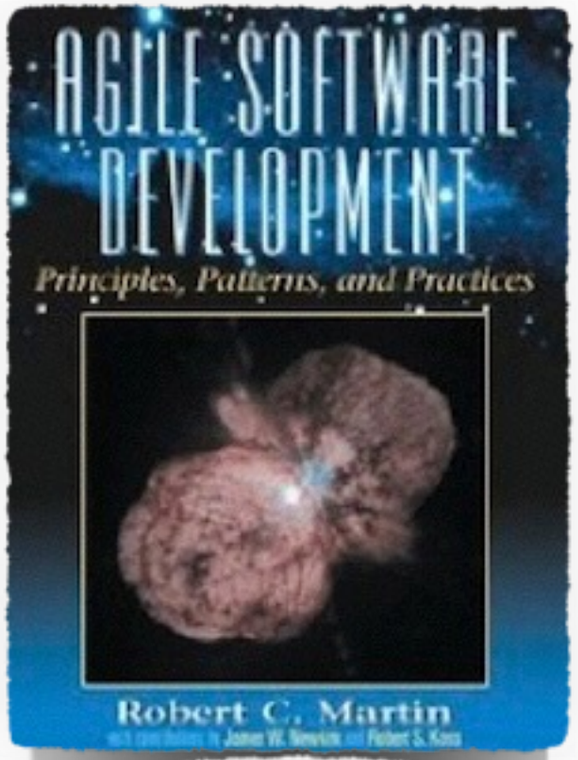
- Perl (3) implements a taint mode to avoid injections dynamically
  Larry Wall, 1987

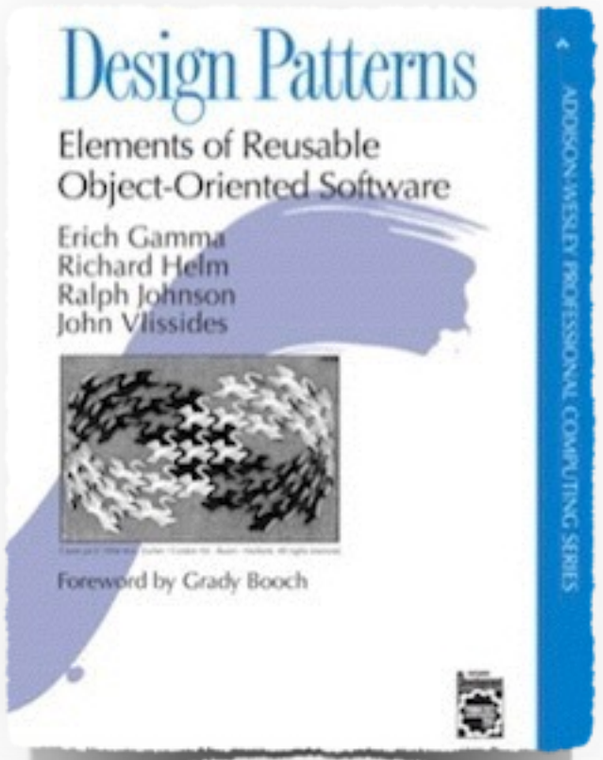
- Java made first steps to avoid cryptographic issues with the “Cryptography Architecture”

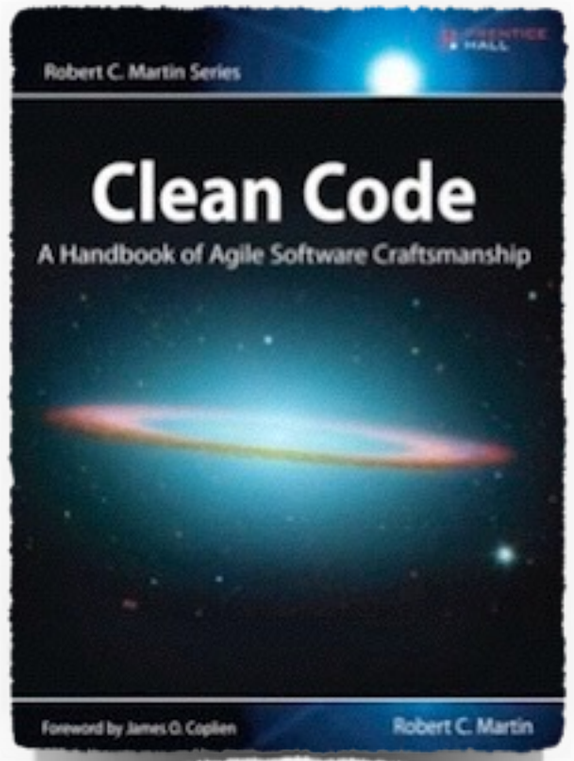
- GO, Erlang,… have advanced support for concurrency

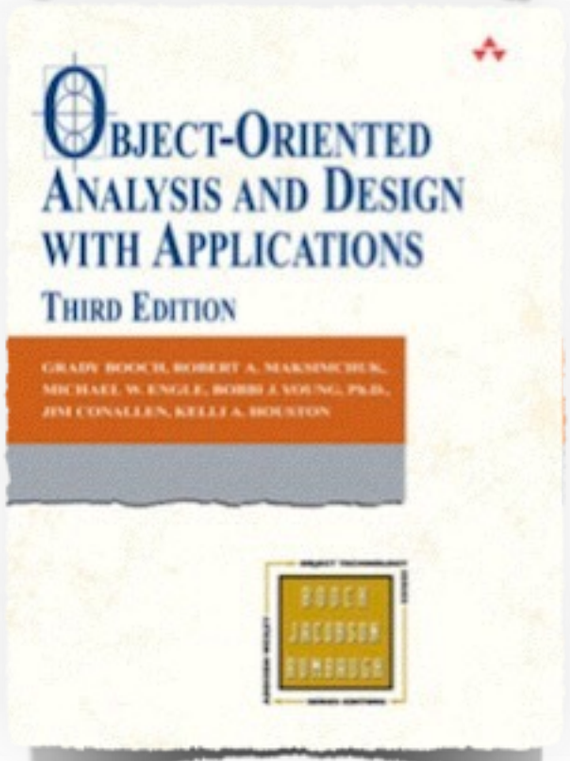
We need good style to cope with complexity!

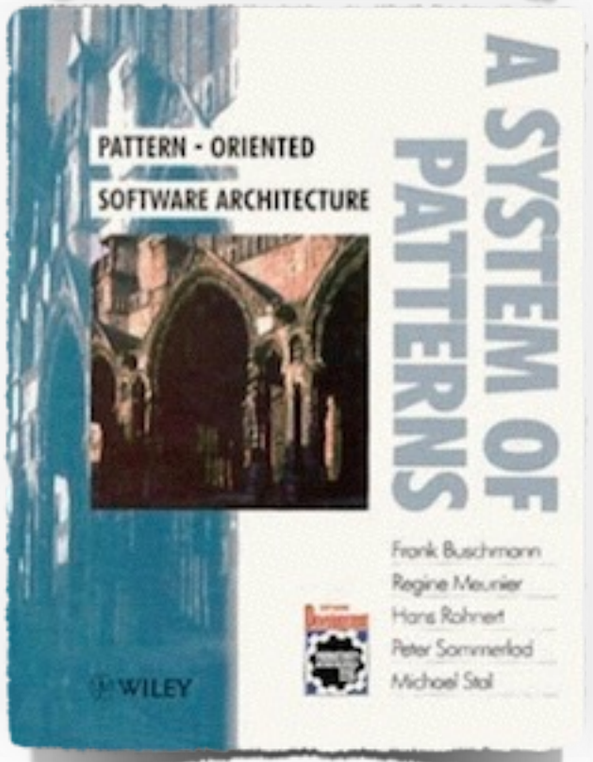


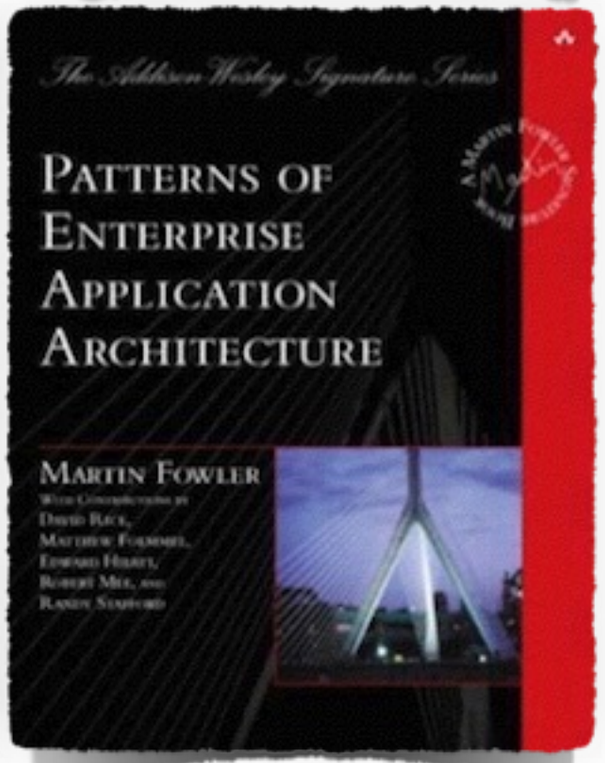












General Design Principles

The following principles apply at various abstraction levels!

- Keep it short and simple
- Don't repeat yourself (also just called "DRY-Principle")
- High Cohesion
- Low Coupling
- No cyclic dependencies
- Make it testable
- Open-closed Design Principle
- Make it explicit/use Code
- Keep related things together
- Keep simple things simple
- Common-reuse/Common-closure/Reuse-release principles

Object-Oriented Design Principles

- Liskov Substitution Principle
- Responsibility Driven Design
- ...

Design Constraints

- **Conway's Law**
  A system's design is constrained by the organization's communication structure.