Object-Oriented Programming in Scala

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Outline

Object-Oriented Programming Goals

- Programs as collections of collaborating objects
- Object has public interface, hidden implementation
- Objects are classfied according to their behavior
- Objects may represent real-world entities or entities that produce services for a program
- Objects may be reusable across programs

Introduction To OOP Languages

There are many object-oriented programming (OOP) languages

- Some are pure OOP language (e.g., Smalltalk).
- Newer languages do not support other paradigms but use their imperative structures (e.g., Java and C♯).
- Some support procedural and data-oriented programming (e.g., Ada and C++).
- Some support functional program (e.g., Scala)

Some Important Features of OOP

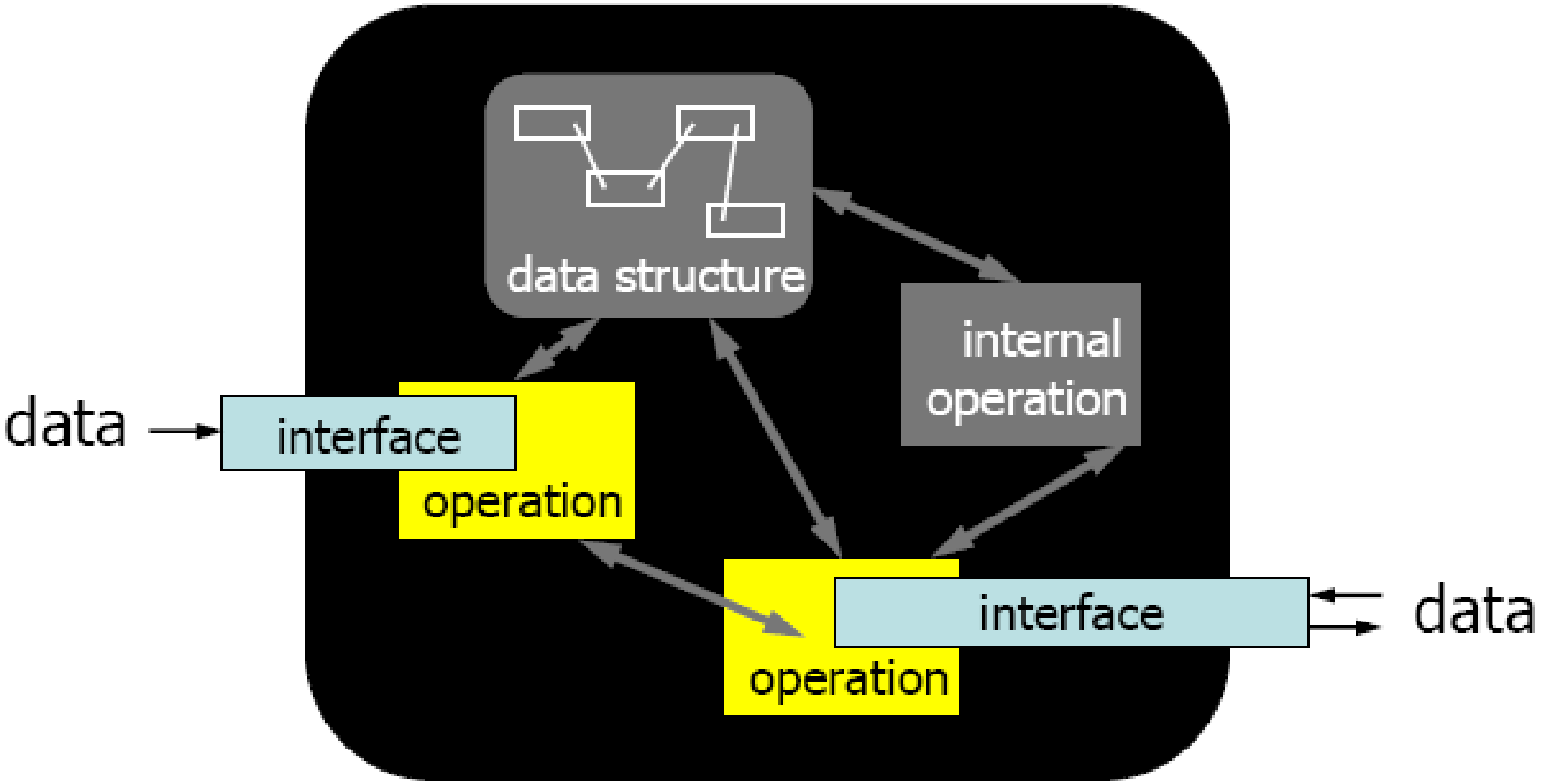
- Abstract data types
  - Encapsulation
  - Information Hiding
- Class Hierarchy
- Inheritance
- Polymorphism - Dynamic Binding

Data Abstraction

An abstract data type is data type that satisfies the following two conditions:

- **Encapsulation:**
  - Attributes and operations are combined in a single syntactic unit
  - compiled separately
- **Information Hiding:**
  - The access to members are controlled
  - Reliability increased

Information Hiding



ADT Example

Operations on a stack:

- create(stack)
- destroy(stack)
- empty(stack)
- push(stack,element)
- pop(stack)
- top(stack)

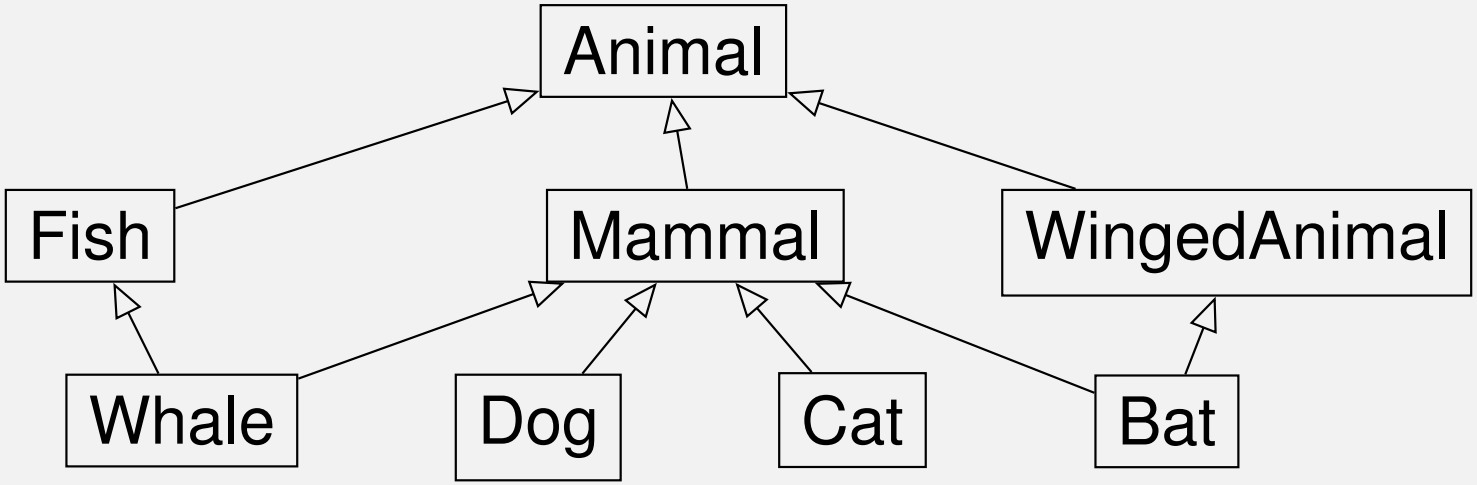
Client code:

```
...
create(stk1);
push(stk1, color1);
push(stk1, color2);
if (! empty(stk1))
    temp = top(stk1);
...
```

Implementation can be adjacent or linked list. Client: don't care!

Class Hierarchy

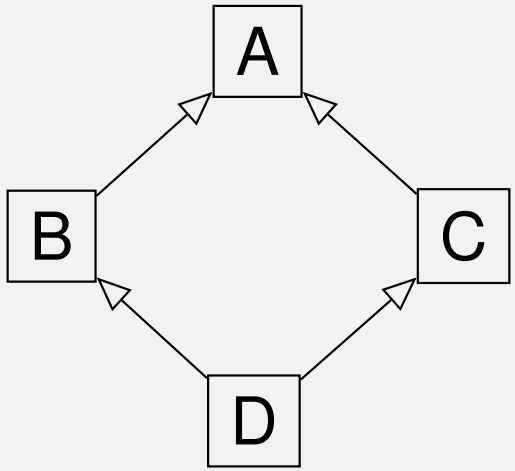
- A class may have some Subclasses
- A class may have one/many Superclass(es)



Inheritance

- A subclass is able to inherit **non-private** members of its superclasses
- A subclass can add its own members and **override** its inherited members
- Single vs. multiple inheritance
- Inheritance increases the reusability in OOP

Diamond Problem in Multiple Inheritance



- if D inherits from B and C different versions of the same behaviour, which version will be effective in D?
- this problem, called diamond problem, is solved differently in different OO language
- is there the diamond problem in Java?

Class vs. Object

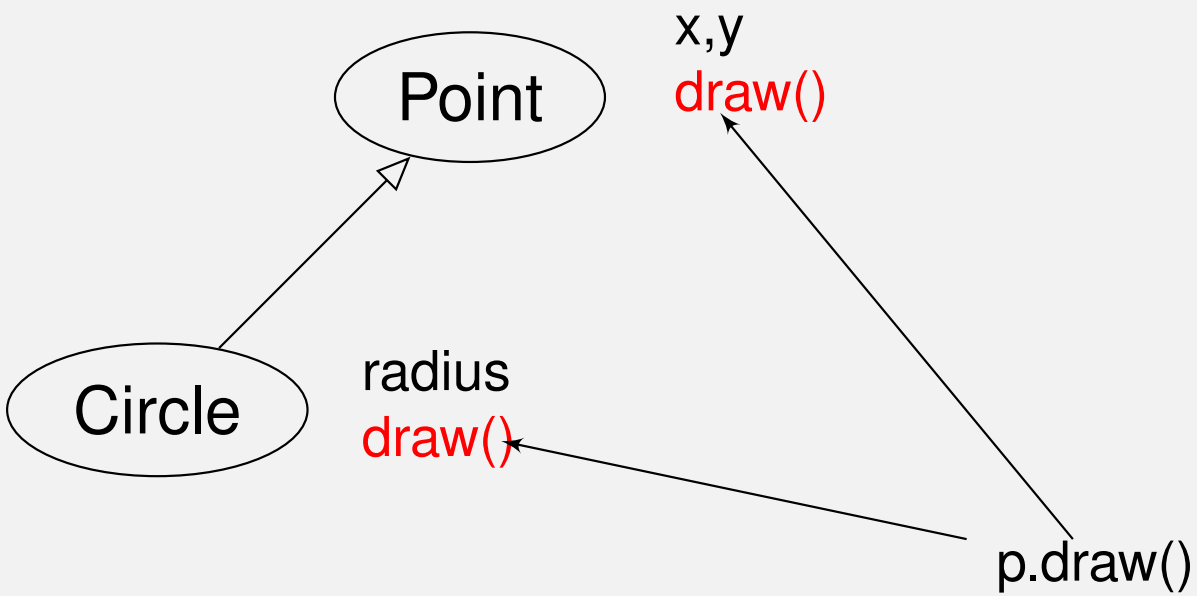
- A class defines the abstract characteristics of a thing
  - its attributes or properties and
  - its behaviors or methods or features.
    A Dog has *fur* and is able *to bark*
- An object is a particular instance of a class.
  Lassie is a dog

Method vs. Message

- A method describes a behavior of an object.
  A dog can bark
- A message is a process at which a method of an object is invoked.
  Lassie barks

Polymorphism

- Polymorphism: different objects can respond to the same message in different ways.



- Dynamic binding

Other Concepts

- There are two kinds of variables in a class:
  - Class variables
  - Instance variables
- There are two kinds of methods in a class:
  - Class methods – accept messages to the class
  - Instance methods – accept messages to objects

Scala

- Invented by Martin Ordesky at EPFL, Lausanne, Switzerland.
- Similar to Java
- Work smoothly with Java
- Run on Java Virtual Machine
- OOP + FP
- Include lexer and parser generator

Classes and Objects in Scala

Class

- class [1]
- abstract class [5]
- trait [2]
- case class [3]

Object

- new <class name>
- <case class name>
- object

Example [7]

```
class Rational(n:Int, d:Int){
    require(d != 0)

    private val g = gcd(n.abs, d.abs)
    private def gcd(a: Int, b: Int): Int =
                    if (b == 0) a else gcd(b, a % b)
    val numer = n / g
    val denom = d / g

    def this(n: Int) = this(n, 1)

    def + (that: Rational): Rational =
        new Rational(
              numer * that.denom + that.numer * denom,
              denom * that.denom
        )

    override def toString = numer +"/"+ denom
}
```

Example on Abstract class [4]

```
abstract class Element {
    def contents: Array[String] //no body: abstract
    val height = contents.length
    val width =
      if (height == 0) 0 else contents(0).length
}
class ArrayElement(conts: Array[String])
                        extends Element {
      def contents: Array[String] = conts
}
class LineElement(s: String)
                        extends ArrayElement(Array(s)) {
    override def width = s.length
    override def height = 1
}
```

Example on Object [1]

```
object Element {

    def elem(contents: Array[String]): Element =
        new ArrayElement(contents)

    def elem(line: String): Element =
        new LineElement(line)
}

val space = Element.elem(" ")
val hello = Element.elem(Array("hello","world"))
```

Which kind of Element will be assigned to *space* and *hello*?

Example on Case Class [3]

```
abstract class Expr

case class Var(name: String) extends Expr
case class Number(num: Double) extends Expr
case class UnOp(operator: String, arg: Expr)
                                        extends Expr
case class BinOp(operator: String,
        left: Expr, right: Expr) extends Expr

val v = Var("x")
val op = BinOp("+", Number(1), v)
v.name
op.left
```

Example 1 on Traits [9]

Reusability:



```
abstract class Bird

trait Flying {
    def flyMess: String
    def fly() = println(flyMess)
}
trait Swimming {
    def swim() = println("I'm swimming")
}

class Penguin extends Bird with Swimming

class Hawk extends Bird with Swimming with Flying {
    val flyMess = "I'm a good flyer"
}
class Frigatebird extends Bird with Flying {
    val flyMess = "I'm an excellent flyer"
}
```

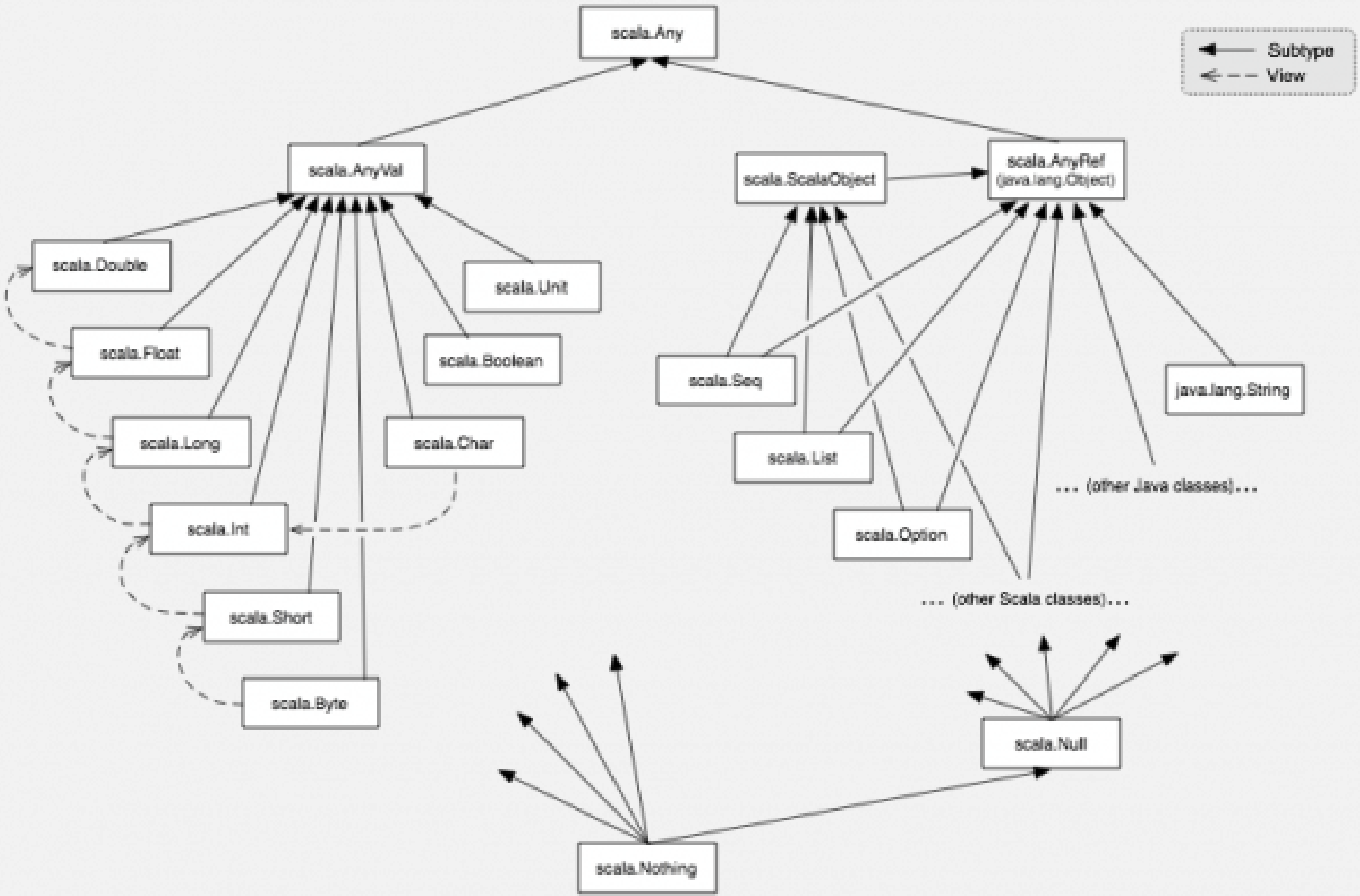
Example 2 on Traits [2]

Stackable Modifications:

```
abstract class IntQueue {
    def get(): Int
    def put(x: Int)}
class BasicIntQueue extends IntQueue {
    private val buf = new ArrayBuffer[Int]
    def get() = buf.remove(0)
    def put(x: Int) { buf += x }}
trait Doubling extends IntQueue {
    abstract override def put(x:Int) {super.put(2*x)}}
trait Incrementing extends IntQueue {
    abstract override def put(x:Int) {super.put(x+1)}}

val queue =
    new BasicIntQueue with Incrementing with Doubling
queue.put(10)
queue.get() //???
```

Scala Hierarchy [8]



Access Modifiers [6] in Scala

- public
- protected
- private
- protected[<name>]
- private[<name>]

Example,

```
package Assignment
...
protected[Assignment] val field1 = 100
private[this] val field2 = 2;
```

Summary

What are still in your mind?

References I

[1] Classes and Objects, http://www.artima.com/pins1ed/classes-and-objects.html, 19 06 2014.

[2] Traits, http://www.artima.com/pins1ed/traits.html, 19 06 2014.

[3] Case Class and Pattern Matching, http://www.artima.com/pins1ed/case-classes-and-pattern-matching.html, 19 06 2014.

[4] Abstract Members, http://www.artima.com/pins1ed/abstract-members.html, 19 06 2014.

[5] Compositions and Inheritance, http://www.artima.com/pins1ed/composition-and-inheritance.html, 19 06 2014.

[6] Packages and Imports, http://www.artima.com/pins1ed/packages-and-imports.html, 19 06 2014.

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[7] Functional Objects, http://www.artima.com/pins1ed/functional-objects.html, 19 06 2014.

[8] Scala Hierarchy, http://www.artima.com/pins1ed/scalas-hierarchy.html, 19 06 2014.

[9] Learning Scala part seven -Traits, http://joelabrahamsson.com/learning-scala-part-seven-traits/, 19 06 2014.