Object-Oriented Programming in Scala

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Scala OOP Overview

Mostly like Java with important differences:

- overridden methods must have `override` modifier, which is part of the language, not an annotation
- instead of interfaces Scala has *traits*, which are much richer
  - traits can have everything a class can have except constructors
  - a class can "mix-in" any number of traits (kinda like multiple inheritance, but without the "diamond inheritance problem")

Note: these slides based on examples in Cay Horstmann's excellent Scala for the Impatient, 2ed

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Extending Classes

```
1  class Person(val name: String, val age: Int) {
2    override def toString = s"${getClass.getName}[name=$name]"
3  }
4  class Employee(name: String, age: Int) extends Person(name, age) {
5    var salary: Int = 0.0
6  }
```

- `Person` implicitly extends `AnyRef` (`java.lang.Object`)
- `name` and `age` are *parametric fields* – constructor parameters that define instance variables
- `Employee`'s constructor takes two parameters that are passed to `Person` constructor (equivalent to a `super()` call in a Java constructor)

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Run-time Type Identification

- `obj.isInstanceOf[Cl]` like `obj instanceof Cl` in Java
- `obj.asInstanceOf[Cl]` like `(Cl) obj` in Java
- `classOf[Cl]` like `Cl.class` in Java

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Overriding Fields

```
1  abstract class Person(val name: String) {
2    def id: Int
3    override def toString = s"${getClass.getName}[name=$name]"
4  }
5  class SecretAgent(val id: Int, codename: String)
6      extends Person(codename) {
7    override val name = "secret" // 'Dont want to reveal name . . .
8    override val toString = "secret" // . . . or class name
9  }
```

- `id` is abstract in `Person` because it is not defined (so `Person` must be declared `abstract`, just like in Java)
- `SecretAgent` overrides `id` with a `val` field (could add `override` modifier, but not required when overriding abstract member)

Rules

- A `def` can only override another `def`
- A `val` can only override another `val` or a parameterless def
- A `var` can only override an abstract `var`

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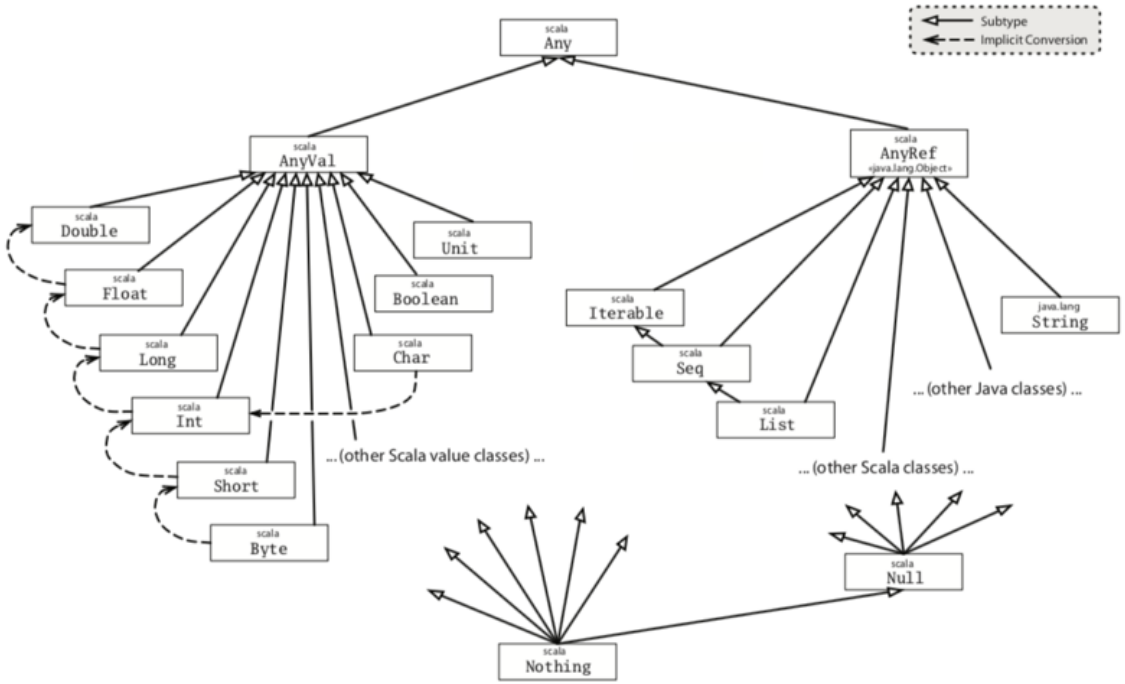
Scala's Class Hierarchy



Scala has two "bottom types"

- `Null` has a single value, `null`, which is an instance of any class
- `Nothing` has no instances and is useful in a couple of places:
  - Empty list `Nil` has type `List[Nothing]`, which is a subtype of `List[T]` for any `T`
  - `AnyRef` defines a `???` method with return type `Nothing` that simply throws a `NotImplementedError` when invoked

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Equality

Use `eq` for identity equality (alias test – like `==` in Java). Similar to Java, `AnyRef`'s `equals` method invokes `eq`. Override `equals` like this:

```
1  class Item(val description: String, val price: Double) {
2    final override def equals(other: Any) = other match {
3      case that: Item => description == that.description && price ==
           that.price
4      case _ => false
5    }
6    final override def hashCode = (description, price).##
7  }
```

- Recipe similar to Java's, but much more convenient
- Remember parameter type is `Any`
- Marked `final` to prevent symmetry problems in subclasses
- `##` is a convenience method on tuples which makes defining `hashCode` trivial

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Companion Objects

Scala doesn't have "static" members but use cases for static members can be done with a *companion object*, which:

- has the same name as its companion class
- must be defined in the same source file as its companion class
- has access to its companion class's private members (and vice-versa)

Companion objects are most often used for factory methods:

```
1  class Item(val description: String, val price: Double)
2
3  object Item {
4    def apply(description: String, price: Double): Item =
5      new Item(description, price)
6  }
7
8  val item = Item("Key Lime", 3.14) // Calls Item.apply
```

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Traits as Interfaces

```
1  trait Logger {
2    def log(msg: String)
3  }
4  class ConsoleLogger extends Logger {
5    def log(msg: String) = { println(msg) }
6  }
```

- Pretty much like a Java interface
- `extends`, not `implements`

Traits with Concrete Implementations

Traits can have concrete implementations (like default methods in Java interfaces), so our `ConsoleLogger` could be a trait:

```
1  trait ConsoleLogger extends Logger {
2    def log(msg: String) { println(msg) }
3  }
```

Then we can "mix-in" the trait without having to override any methods:

```
1  abstract class SavingsAccount(var balance: Int) extends ConsoleLogger {
2    def withdraw(amount: Int) {
3      if (amount > balance) log("Insufficient funds")
4      else balance -= amount
5     }
6  }
```

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Objects with Traits

We can have `SavingsAccount` extend the abstract `Logger` instead of the concrete `ConsoleLogger`.

```
1  abstract class SavingsAccount(var balance: Int) extends Logger {
2    def withdraw(amount: Int) {
3      if (amount > balance) log("Insufficient funds")
4      else balance -= amount
5    }
6  }
```

You can mix in a trait with a concrete implementation of `log` at construction:

```
1  val acct = new SavingsAccount(1) with ConsoleLogger
```

This works because `SavingsAccount` is a subtype of `Logger` and so is `ConsoleLogger`.

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Stackable Modifications

Traits can invoke methods in other traits that have a common supertype declaring the method. The supertype can be abstract, and the result is that a chain of operations takes place when the method is called.

```
1  trait Timestamping extends ConsoleLogger {
2    override def log(msg: String) =
         super.log(s"${java.time.Instant.now()} $msg")
3  }
4  trait Shortening extends ConsoleLogger {
5    override def log(msg: String) =
6      super.log( if (msg.length <= 15) msg else s"${msg.substring(0,
           12)}...")
7  }
```

Here, `super` doesn't mean "supertype", it means "trait that was mixed-in to my left."

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Resolution of `super` in Stacked Traits (1/2)

For simple mixin sequences you may think of method resolution as "back to"front". (Note the `with` syntax when extending multiple traits.)

```
1 val acct1 = new SavingsAccount(1) with Timestamping with Shortening
2 acct1.withdraw(2)
```

In the code above, `Shortening` is furthest to the right, so its `log` method is called with "Insufficient funds", which, being 18 characters, is passed to the `log` method in `Timestamping` so we get something like

```
1 2019-02-17T23:28:15.747452Z Insufficient funds
```

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Resolution of `super` in Stacked Traits (2/2)

Here we mix-in `Timestamping` last, so its `log` method is called with "Insufficient funds", `Timestamping.log` prepends a timestamp, then passes the result to `Shortening.log` because its to the left of `Timestamping` in the mix-in order. So

```
1 val acct2 = new SavingsAccount(1) with Shortening with Timestamping
2 acct2.withdraw(2)
```

gives us something like

```
1 2019-02-17
```

Abstract Overrides

Because `super` calls are dynamically bound, you can invoke an abstract method as long as you mark your method as `abstract override`. See the `Shouting` we've added below.

```
1  trait Timestamping extends ConsoleLogger {
2    override def log(msg: String) =
         super.log(s"${java.time.Instant.now()} $msg")
3  }
4  trait Shortening extends ConsoleLogger {
5    override def log(msg: String) =
6      super.log( if (msg.length <= 18) msg else s"${msg.substring(0,
           10)}")
7  }
8  trait Shouting extends Logger {
9    abstract override def log(msg: String) =
10     super.log(msg.toUpperCase)
11 }
```

This is saying "we assume a concrete `log` method exists." The compiler ensures that you can only mix `Shouting` into a class that somehow provides a concrete `log` method.

Compiling Traits with Abstract Overrides

The compiler ensures that the super call will succeed. So this will compile because `Shortening` provides a concrete `log` method (from `ConsoleLogger`) for the `super` call in `Shouting`

```
1 val acct3 = new SavingsAccount(1) with Shortening with Shouting
2 acct3.withdraw(2) // => INSUFFICIENT FUNDS
```

But this will not compile because `Shortening`'s `super` call is refferring to `Shouting`'s `log` method, which has no concrete `log` method for its `super` call.

```
1 // Won't compile
2 val acct4 = new SavingsAccount(1) with Shouting with Shortening
3 acct4.withdraw(2)
```

The resolution of `super` is called *linearization* and it is the (somewhat complicated) way Scala solves the diamond inheritance problem.

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Packages

Like Java, Scala code that's not in a named package is in the global *unnamed* package. Put code into packages in two ways:

- Putting a package declaration at top of source code file, like in Java:

```
1 package edu.gatech.cs2340.zoo
2
3 class Animal
4 trait Mammal extends Animal
5 class Dog extends Animal with Mammal
```

and . . .

Namespace Packaging Syntax

- Explicit packaging syntax (like the namespace feature of other languages):

```
1 package edu.gatech.cs2340 {
2   package zoo {
3     class Animal
4     trait Mammal extends Animal
5     class Dog extends Animal with Mammal
6   }
7 }
```

The second approach is flexible but not used much in practice.

Note: although Scala allows you to organize your code any way you want, be a good person and follow Java's package naming (reverse domain name) and source code organization conventions (source directory tree mirrors package structure).

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Imports

Scala imports are more flexible than Java's

- `import edu.gatech.cs2340.zoo.Animal` – import `Animal` into namespace as simple name (name without package).
- `import edu.gatech.cs2340.zoo.{Animal, Mammal}` – import `Animal`, `Mammal` but not `Dog` into namespace as simple names.
- `import edu.gatech.cs2340.zoo._` – import all top-level names in `zoo` into namespace as simple names.
- `import edu.gatech.cs2340.zoo.Animal._` – import all members of `Animal` into namespace as simple names.
- `import edu.gatech.cs2340.zoo.{Mammal => FurryCreature}` – import `Mammal` into namespace but rename to `FurryCreature`.
- `import edu.gatech.cs2340.zoo.{Mammal => _, _}` – import everything from `zoo` except `Mammal`.

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Conclusion

- OOP in Scala is more consistent, more expressive, more flexible, and less verbose than in Java
- With great power comes great resonsibility
  - Don't get too crazy with trait mix-ins, whose linearizations can be difficult to understand
- Stick to Java's conventions for packages and source file organization

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