Updated: 2021-01-23

2.5
More Detail on Scala Syntax

With emphasis on the functional way of doing things

© 2019 Robin Hillyard

Objects

- All code is in either an *Object* or a *Class*. But we will start with Objects because you always need at least one *Object* to run a Scala program:
  - An object takes no parameters and doesn't need a companion class;
  - An object which extends *App* invokes its initialization code within the (invisible) *main* method.
  - The *main* method does not yield a value (technically, it yields *Unit*) so, unlike everywhere else in Scala, it must contain side-effects, otherwise it would do nothing..

```
object Newton extends App {
  val newton = Newton("cos(x)-x", x => math.cos(x) - x, x => -math.sin(x) - 1)
  newton.solve(10, 1E-10, 1) match {
    case Success(x) => println(s"""The solution to "$newton=0" is $x""")
    case Failure(t) => System.err.println(s"""$newton unsuccessful: ${t.getLocalizedMessage}”””)
  }
}
```

Classes

- Classes
  - Like objects, classes can have initialization code (what would be in a Java constructor or within {}). But generally, all the useful code of a class is in one of its methods.
  - All fields and methods of a class are *instance* fields/methods. If you want “class” fields/methods then you need to declare a companion object (one with the same name and in the same module).
  - A class generally takes both value parameters and type parameters; Unless it is a “case” class, you will need to invoke the constructor using the *new* keyword.

```
case class Newton(w: String, f: Double => Double, dfbydx: Double => Double) {
  override def toString: String = w
  private def step(xy: Try[Double], yy: Try[Double]) = for (x <- xy; y <- yy) yield x - y / dfbydx(x)
  def solve(tries: Int, threshold: Double, initial: Double): Try[Double] = {
    @tailrec def inner(ry: Try[Double], n: Int): Try[Double] = {
      val yy = for (r <- ry) yield f(r)
      (for (y <- yy) yield math.abs(y) < threshold) match {
        case Success(true) => ry
        case _ =>
       if (n == 0) Failure(new Exception(s"failed to converge in $tries tries, " +
         s"starting from x=$initial and where threshold=$threshold”))
          else inner(step(ry, yy), n - 1)
      }
    }
    inner(Success(initial), tries)
  }
}
```

Modules

- The code in one file (module) is treated like being in its own package.
  - Privacy rules can apply at the module level.
  - A module may contain any number of traits, classes and objects.

```
sealed trait Foo {
  def a: String
  def create(a: String): Foo
}

case class Bar(a: String,b: Option[Int]) extends Foo{
  def create(a: String) = Bar(a,None)
}

case class Buzz(a: String, b: Boolean) extends Foo {
  def create(a: String) = Buzz(a,false)
}
```

Abstract methods simply lack an expression

Traits

- A trait defines some behavior (something like an interface in Java):
  - Traits have type parameters (typically) but cannot have value parameters.
  - Methods and fields of traits can have concrete values.
  - A trait (usually) cannot be instantiated (but if all properties are concrete, you could write **val** *s* = **new** Silly {} or something like that).
  - A trait which may only be extended *in-module* is marked as “sealed”.

```
sealed trait TraitExample[T] extends Comparable[TraitExample[T]] {
  def name: String
  def property: T
  def compareTo(o: TraitExample[T]): Int = name.compareTo(o.name)
  def >(o: TraitExample[T]): Boolean = compareTo(o)>0
  def <(o: TraitExample[T]): Boolean = compareTo(o)<0
  def >=(o: TraitExample[T]): Boolean = compareTo(o)>=0
  def <=(o: TraitExample[T]): Boolean = compareTo(o)<=0
  def ==(o: TraitExample[T]): Boolean = compareTo(o)==0
}
case class Telephone(name: String, number: String) extends TraitExample[String] {
  def property: String = number
}
case class Age(name: String, age: Int) extends TraitExample[Int] {
  def property: Int = age
}
```

Expressions

- So, now we know where we can write code, what sort of code can we write?
- Basically, we will write expressions:
  - An expression yields a result (of any type, including “Unit”, a non-result);
  - An expression can be preceded by definitions of “memoizing” variables;
  - An expression can be preceded or followed by definitions of methods;
  - An expression can be preceded by *import* statement(s) which allow us essentially to create aliases of types;
  - An expression is a series of identifiers/literals/method invocations interspersed with operators;
  - When a method invocation takes parameters, the values of those parameters will also be expressions.

Variable definitions

- The following are examples of variable definitions:
  - `val x = Math.PI` *or*
  - `val x: Double = Math.PI`
  - `val x = Math.PI/2 + 1`
  - `var x = 0`
  - `lazy val x = connection.get("date")`

Variable definitions with patterns

- When we wrote:
  - `val x: Double = Math.PI`
- We used a very simple pattern as the identifier (*x*) and that pattern is now in scope for the remainder of the current context, but:
  - We can do more generalized pattern-matching as in, for example:
    - `val h :: t = List(1,2,3)`
    - `println h`
- You should see “1” printed on the console because *h* matches 1 and *t* matches *List(2, 3)*
- What if the expression on the right isn’t a list at all?
  - The compiler will warn you.
  - What if it’s an empty list (but that’s not known until run-time)?
  - Then it will throw a *MatchError* at run-time. basically, you should be quite sure that these patterns in “val” definitions are really what they are expected to be.

Variable definitions with patterns (2)

- We can use very general complex patterns of the form:
  - **`val` *`pattern = expression`***
  - For example (the first one is a very common situation):
    - **`val (odd, even) = xs.partition*(_ % 2 == 1)`**
    - **`println(s”odd: $odd, even: $even”)`**
    - **`val Some(x) = methodWithOptionalResult()`**
    - **`println x`**
- In the second example, what if the result of calling the method is *None*?
  - In that case, you will get a *MatchError* at run-time.
  - But, if the compiler knows that the pattern won’t match, it will let you know at compile time. Again, it’s best to be sure when you use these patterns. This one is probably a bad idea.

** Partition puts all elements evaluating to true in the first sequence and the rest in the second sequence.*

Method definitions

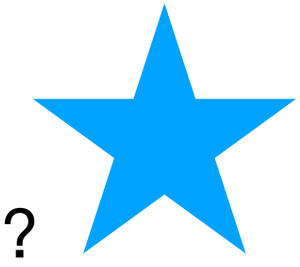
- The following are examples of method definitions:
  - `def x = Math.PI` *or*
  - `def x: Double = Math.PI/2 + 1`
  - `def x(s: String) = connection.get(s)`
  - `def x(s: String) = {`

```
    val connection = makeConnection(“myServer”)
    val r = connection.get(s)
    connection.close()
    r
  }
```

- The following can also be used when there are no parameters and no side-effects:
  - `lazy val x = Math.PI`

Control flow*?

- OK, that's great but what about control flow?
- Well, in a functional programming language, we define expressions, we don't put together a series of statements interspersed with control flows.
- But what about a simple *if*?
  - `if (x>=0) x else -x`
- And what about some kind of switch?
  - ```
    def length(xs: Seq[X]): Int = xs match {
        case Nil => 0
        case _ :: t => length(t) + 1
      }
    ```
- And what about some kind of loop?
  - `for (x <- xs) yield x * 2`
  - `for (x <- xs) println(x)`
  - `xs foreach println`



An "if" clause should always have an "else"

This is is called pattern-matching and is *much* more powerful than a switch statement in Java

A "for comprehension" with "yield" always returns a result of the same "shape" as its generator (*xs*)

* Refresher: we covered this earlier in 2.0
    ```