SCALA 101 - INTRODUCTION TRAINING

SESSION 1

WELCOME

- Experience and expectations
- Objectives
  - Scala syntax
  - Object-oriented concepts in Scala
  - Basics of functional programming
  - Using Scala's Collections
  - Working with SBT and ScalaTest

FORMAT OF THE TRAINING

```
repeat {
  I.explain(Some("Scala features"))
  you.do(exercises)
  we.interact()
}
```

SESSION 1

- Cleaner Java
- Object-oriented programming
- Tools
  - SBT
  - ScalaTest
- Scala Collections

WHAT IS SCALA

> *Scala combines object-oriented and functional programming in one concise, high-level language. Scala's static types help avoid bugs in complex applications, and its JVM and JavaScript runtimes let you build high-performance systems with easy access to huge ecosystems of libraries.*

Source: https://www.scala-lang.org/

WHAT IS SCALA

- Functional *and* Object-Oriented
- Fully compatible with Java
  - But more concise
- Strongly Typed
  - With type inference
- Proven in production

SCALA'S STRONG POINTS

- Concurrency
- Programs correct by definition
- Good support for Domain Specific Languages (DSLs)
- All the things that Java is good at

SCALA'S CHALLENGES

- Complexity
  - Syntax
  - Type system
  - Operator overloading
- Paradigm shift
  - Object-Oriented vs Functional
- Concurrency
  - Mutability is still possible

SCALA 101 - MODULE 1

A CLEANER JAVA

LOOK MAMA, NO SEMICOLONS

```
println("Hello World!")
```

TYPE INFERENCE

Types are given *after* the identifier (as opposed to Java where they are placed in front of the identifier)

```
val str: String = "Hello World!"
```

is equivalent to

```
val str = "Hello World!"
```

The compiler infers the type of `str` from the type of the assignment expression

STRING INTERPOLATION

Given

```
val hello = "Hello"
val world = "world"
```

This assignment

```
val greeting = hello + ", " + world + "!"
```

is equivalent to

```
val greeting = s"$hello, $world!"
```

The string interpolation is compiled as a sequence of operations on a `StringBuffer`

STRING ESCAPING

Triple quotes allow you to use quote literals in your string expressions without escaping them:

```
val str = "Hello, \"world\"!"
```

is equivalent to

```
val str = """Hello, "world"!"""
```

The triple-quote strings also support string interpolation (`s"""Hello $name"""`)

You can use the `.stripMargin` operator to create a long string with embedded newlines (`\n`):

```
val longString = """
    |This is a pretty
    |long string that spans multiple
    |lines""".stripMargin
```

is equivalent to

```
val longString = "This is a pretty\nlong string that spans multiple\nlines"
```

JAVA INTEROPERABILITY

What differences do you spot compared to Java?

```
import java.util.ArrayList

val dates = new ArrayList[LocalDate]

dates.add( new LocalDate(2022, 10, 25))
dates.add( new LocalDate(1999, 12, 31))

println(dates.size)
```

A NOTE ABOUT STYLE

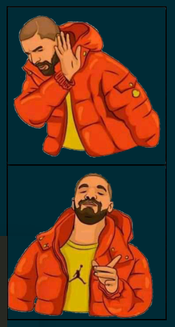
- Parentheses (`()`) can often be omitted
- Convention is to
  - keep them if the call has side effects
    - `dates.clear()`
    - `control.fireTheMissiles()`
  - omit them if the call has *NO* side effects
    - `room.getTemperature`

INFIX NOTATION

- Functions that take exactly 1 parameter can be called in different ways
- Depending on the context this can greatly improve readability

```
val str = "hello"

str.contains("e")   // normal function call
str contains "e"      // infix notation of same call
```

A NOTE ABOUT STYLE



- Never use infix notation for side-effecting calls

```
dates add new LocalDate(2002, 9, 11) // DON'T DO THIS

dates.add(new LocalDate(2022, 10, 25)) // Correct
```

INFIX NOTATION

```
// method call on Integer
1.to(3)

// can be written as
1 to 3
```

SYMBOLIC METHODS

Symbols can be powerful conveyors of meaning when used appropriately.

```
val s = "Hello"
val t = "world"

// Do not use this Java style
val same = s.equals(t)
val hash = s.hashCode

// Use this Scala style
val same = s == t
val hash = s.##
```

SYMBOLIC METHODS

Scala allows you to (re)define methods with symbols in their name

```
// + is just a function name
1.+(3)

// can be written as
1 + 3
```

SYMBOLIC METHODS

Some more examples:

```
// operators on Types
bigDecimal1 + bigDecimal2

// send a message to an actor
actor ! "message"

val todo = ???
```

???

- The `???` can be used to tell the scala compiler that this part is not yet written
- Compiler will treat this as valid in any context where it is used
- Throws a `scala.NotImplementedError` exception when code is reached at runtime
- From the scala source code:

```
/** `???` can be used for marking methods that remain to be implemented.
 *  @throws NotImplementedError when `???` is invoked.
 *  @group utilities
 */
def ??? : Nothing = throw new NotImplementedError
```

A NOTE ABOUT STYLE

- Do not go overboard with inventing symbolic operators. It poses a strain on developers that need to learn the meaning
- `x :⊣ y`

Periodic Table of Dispatch Operators

All operators of Scala's marvelous Dispatch library on a single page

Start building a Request from scratch

/\	<<? (values)	POST	>> ((in, charset) => result)	as_source
:/ (host, port)	/ (path)	PUT	>> ((in) => result)	as_str
:/ (host)	<<< (text)	DELETE	>~ ((source) => result)	>>> (out)
/ (path)	<<< (file, content_type)	HEAD	>- ((text) => result)	>:> ((map) => result)
url (url)	<<< (values)	secure	>>~ ((reader) => result)	>+ (block)
	<< (text)	<& (request)	<> ((elem) => result)	~> ((conversion) => result)
	<< (values)	>\ (charset)	</> ((nodeseq) => result)	>+> (block)
	<< (text, content_type)	to_uri	>\# ((json) => result)	>! (listener)
	<< (bytes)		>|	
	<:< (map)			
	as (user, passwd)			
	as_! (user, passwd)			
	gzip			

EXCERCISE 1: THE BASICS

- Open a new Scala worksheet
  - File->New->Scala Worksheet
- Experiment!
- Press the green arrow to "run" the worksheet
- Observe the results

EXTRA

- Open https://scala-lang.org/api/current
- Find `Int.to`
- What parameters does it accept?
- What does it return?
- What about `Int.until`?

SCALA 101 - MODULE 2

OBJECT-ORIENTED PROGRAMMING

CLASSES

Initialiser values are private by default

```
class Shape(area: Double) {
  // area is private
}

val shape = new Shape(1.0)
```

CLASSES

Public members can be added

```
class Shape(a: Double) {
  // a is private, area is public
  val area = a
}

val shape = new Shape(1.0)
println(shape.area)
```

The `val` can also be used in the class definition:

```
class Shape(val area: Double) {
  // area is public
}
```

SUB CLASSES

Scala has support for inheritance, allows you to create specialisations of a class

```scala
class Shape(val area: Double) {
  // area is public
}

class Circle(val r: Double) extends Shape(Math.PI * r * r) {
  // ...
}

val circle = new Circle(1.0)
println(circle.area)
```

SUB CLASSES

Body of the class definition is the constructor

```
class Circle(val r: Double) extends Shape(Math.PI * r * r) {
  require(r > 0)
}
val circle = new Circle(-1.0) // throws!
```

METHODS

You can use imperative style and functional style

```
class Circle(val r: Double) {
  // imperative style
  def circumference: Double = {
    return 2 * Math.PI * r
  }

  // is equivalent to functional style
  def circumference: Double = 2 * Math.PI * r
}
```

METHODS

```
class Circle(val r: Double) {

  def draw(c: Canvas): Unit = {
    val box = determineBoundingBox // draw using box

    private def determineBoundingBox = new Rectangle(2 * r, 2 * r)
  }
```

A NOTE ABOUT STYLE

- Avoid using explicit return statements
- Always provide a return type for public `def`s

NAMED PARAMETERS

- When calling methods or creating objects, you can explicitly assign to the parameters
- By using the name of the parameter, you are no longer restricted in the order of the arguments
- Very useful for methods with a lot of parameters (that have default values)

```
def createQueue( durable: Boolean, exclusive: Boolean, autoAcknowledge: Boolean) = ???

val queue = createQueue(true, false, false) // what do these mean

val queue2 = createQueue( autoAcknowledge = false, exclusive = false, durable = true) // now it is clear
```

IDE's will help you these days (with parameter hints), but we should not rely on those features too much

DEFAULT PARAMETERS

```
def createQueue( durable: Boolean, exclusive: Boolean, autoAcknowledge: Boolean = true) = ???

val queue = createQueue(true, false) // uses default value for autoAcknowledge
```

CASE CLASSES

JAVA

```java
public class Point {
    private final int x;
    private final int y;

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }

    public int getX() {
        return x;
    }

    public int getY() {
        return y;
    }

    @Override
    public String toString() {
        return "Point[x=" + x + ", y=" + y + "]";
    }
```

```java
    @Override
    public int hashCode() {
        final int prime = 31;
        int result = 1;
        result = prime * result + x;
        result = prime * resuls + y;
        return result;
    }

    @Override
    public boolean equals( Object obj) {
        if (this == obj)
            return true;
        if (obj == null)
            return false;
        if (getClass() != objk.getClass())
            return false;
        Point other = (Point) obj;
        if (x != other.x)
            return false;
        if (y != other.y)
            return false;
        return true;
    }
```

CASE CLASSES

SCALA

```scala
case class Point(x: Int, y: Int)
```

CASE CLASSES

Advantages of case classes

- Constructor, `equals`, `hashCode` (also `.##` alias in Scala)
- Immutable
- `copy` method
- Easy serialisation with the `apply` and `unapply` methods
- Put your whole domain in a single short file

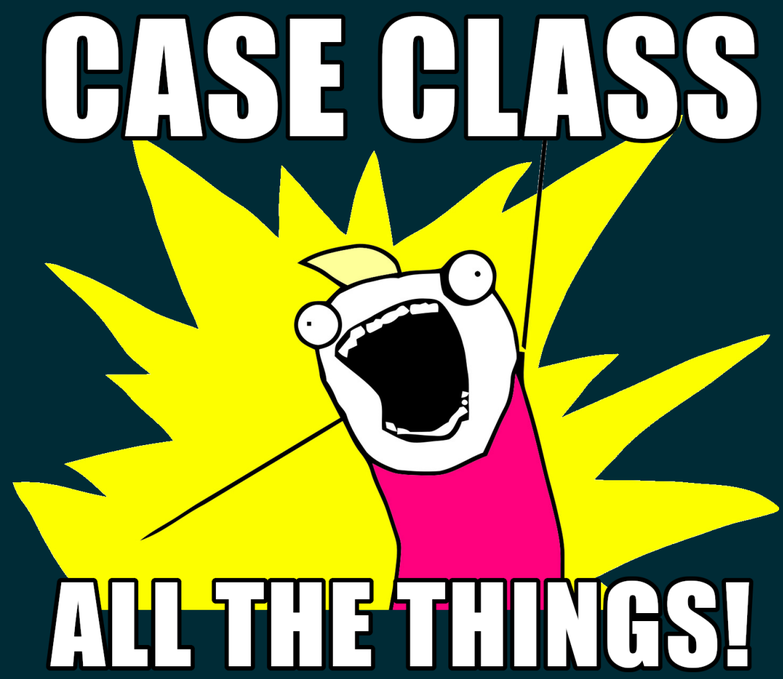
CASE CLASSES

Improve safety of your application by reducing the need for Stringly typed code

```
// Stringly typed
def execute(sql: String): Result
```

Using (case) classes makes the intent more visible and prevents mixups:

```
case class Sql(s: String)
def execute(sql: Sql): Result
```



SINGLETON OBJECT

- Similar to Java static methods

```
object Main {
  def main(args: Array[String]): Unit = {
    println("Hello world!")
  }
}
```

SINGLETON OBJECT

- You could write Java-like code in Scala:

```
class Circle(val r: Double)

object CircleFactory {
  def create(r: Double): Circle = new Circle(r)
}

val c = CircleFactory.create(1.0)
```

COMPANION OBJECT

- In Scala we do not like factory classes
- Companion objects offer easy ways to create instances of a specific class
- Companion objects *must* be in the same file as their class

```
1 class Circle(val r: Double)
2
3 object Circle { // notice that object uses the same name as the class
4   def create(r: Double): Circle = new Circle(r)
5 }
6
7 val c = Circle.create(1.0)
```

APPLY METHOD

- An even more Scala-esque way is to use the `apply` method for object creation

```scala
class Circle(val r: Double)

object Circle {
  def apply(r: Double): Circle = new Circle(r)
}

val c = Circle(1.0)
```

This `apply` method is automatically generated for case classes

A NOTE ABOUT STYLE

- Do not overuse the `apply` method
- Use it for factory methods in companion objects
  - Provides a nice way to convert objects into other types
- Use it when creating Domain Specific Languages

TRAITS

```
trait Ordered[T] {
  def compareTo(other: T): Int
}

case class Player(skill: Int) extends Ordered[Player] {
  override def compareTo(other: Player): Int =
    skill.compareTo(other.skill)
}

player1.compareTo(player2) < 0
```

Traits are like Java's interfaces

TRAITS

```
trait Ordered[T] {
  def compareTo(other: T): Int

  def <(other: T): Boolean = this.compareTo(other) < 0
  def >(other: T): Boolean = this.compareTo(other) > 0
}

case class Player(skill: Int) extends Ordered[Player] {
  override def compareTo(other: Player): Int =
    skill.compareTo(other.skill)
}

player1 < player2
```

- Traits allow you to add implementations
- Traits can be combined `... extends Trait1 with Trait2 with ...`

ENUM

```
sealed trait Color

object Color {
  case object Red extends Color
  case object Green extends Color
  case object Blue extends Color
}

val color = Color.Blue
```

- Typed enums (no risk of mixing up different enums)
- Pattern matching

OPTION

- Scala tries to avoid using `null` explicitly
- `Option` is a class that models the presence or absence of a value explicitly

```
def findUser(id: Int): Option[Person] = {
  val result = doQuery(id)

  if (result == null)
    None
  else
    Some(result)

  // shorthand for this if statement:
  // Option(result)
}
```

OPTION

```
val user: Option[Person] = findUser(42)

if (user.isDefined) {
  val u = user.get
  // do something
} else {
  // do something else
}
```

OPTION

```
val user: Option[Person] = findUser(42)

val u = user.getOrElse(defaultUser)
val a: Option[Address] = user.map(_.address)

Option(null) == None
```

IMPLICIT CLASSES

```
implicit class RichInt(val i: Int) extends AnyVal {
  def twice = i * 2
}

println(2.twice)
```

- Allows you to add functionality to existing classes
  - very powerful, so keep in mind: W.G.P.C.G.R :)

A NOTE ABOUT STYLE

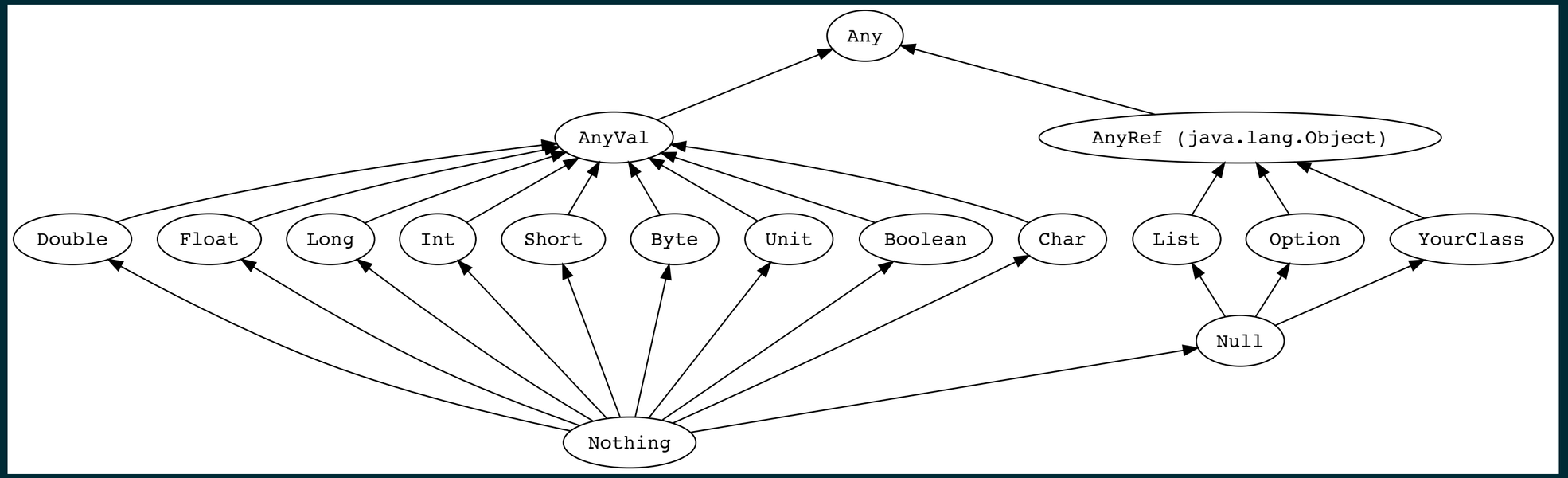
- Implicits are a controversial Scala feature
- Implicits are an advanced Scala feature
  - API / DSL designers
  - You must be aware that they exist
- Often, implicits make code harder to understand
  - `implicit def` is even more magical, and almost always a bad idea

RICH WRAPPERS

Standard Java types are enhanced by Scala's standard library:

```
1.to(3)                                 // val res0: scala.collection.immutable.Range.Inclusive = Range 1 to 3
42.toHexString                          // val res1: String = 2a
"42".toInt                              // val res2: Int = 42
"2" * 3                                 // val res3: String = 222
"[x=%d, y=%d]".format(2, 3)             // val res4: String = [x=2, y=3]
val regex1 = ".*@.*\\.com".r            // val regex1: scala.util.matching.Regex = .*@.*\.com
val regex2 = """.*@.*\.com""".r         // val regex2: scala.util.matching.Regex = .*@.*\.com
```

TYPE HIERARCHY



EXERCISE 2 - ONE POSSIBLE SOLUTION

```scala
case class Author(firstName: String, lastName: String) extends PrettyPrintable {
  override def prettyPrint: String = s"$firstName $lastName"
}

case class Book(title: String, author: Author, year: Int) extends PrettyPrintable {
  override def prettyPrint: String = s"$title, by ${author.prettyPrint}, as published in $year"
}

def toScreen(p: PrettyPrintable): Unit = println(p.prettyPrint)
```

SCALA 101 - MODULE 3

TOOLS

SBT

- https://www.scala-sbt.org/
- Scala Build Tool
- Simple Build Tool
- Interactive Build Tool

SBT

- You can also use ant, gradle, make, maven, ...

- Most Scala projects use SBT
  - It's faster for Scala code
  - It has an interactive mode
  - It has good support for cross-compiling

BUILD.SBT

```
name := "My Cool Project"
version := "1.0"
scalaVersion := "2.13.10"

libraryDependencies ++= Seq(
  "com.typesafe.akka" %% "akka-actor" % "2.5.6",
  "org.scalatest" %% "scalatest" % "3.2.14" % Test
)
```

- `% Test` is the scope in which you want this dependency to appear

BUILD.SBT

- Some dependencies are available for different scala versions
  - org.scalatest:scalatest_2.12:3.2.14
  - org.scalatest:scalatest_2.13:3.2.14
- Dependency in build.sbt
  - Use `%%` to make SBT choose the appropriate minor version based on `scalaVersion`
  - "org.scalatest" % "scalatest_2.13" % "3.2.14" % Test
  - "org.scalatest" %% "scalatest" % "3.2.14" % Test

PROJECT/BUILD.PROPERTIES

- It must contain the version of SBT you want to use in this project

```
sbt.version=1.7.2
```

- This *must* be present, or weird errors may happen
- It helps keeping your build stable across different installations

RUNNING SBT

- sbt clean
- sbt compile
- sbt test
- sbt
  - starts the interactive prompt

RUNNING SBT INTERACTIVELY

```
$ sbt
[info] welcome to sbt 1.7.2 (Oracle Corporation Java 11.0.2)
[info] loading global plugins from /Users/jml/.sbt/1.0/plugins
[info] loading project definition from /Users/jml/work/ordina/training/scala101-full-course/project
[info] loading settings for project root from build.sbt ...
[info] set current project to Scala 101 Full Course (in build file:/Users/jml/work/ordina/training/scala101-full-course/)
[info] sbt server started at local:///Users/jml/.sbt/1.0/server/1222e06f84b0a561587e/sock
[info] started sbt server
sbt:Scala 101 Full Course> _
```

RUNNING SBT INTERACTIVELY

```
sbt:Scala 101 Full Course> compile
[info] compiling 4 Scala sources to /Users/jml/work/ordina/training/scala101-full-course/exercises/target/scala-2.13/classes ..
[error] /Users/jml/work/ordina/training/scala101-full-course/exercises/src/main/scala/exercise2/Hamlet.scala:13:21: not found: v
[error]   val shakespeare = Author("William", "Shakespeare")
[error]                     ^
[error] /Users/jml/work/ordina/training/scala101-full-course/exercises/src/main/scala/exercise2/Hamlet.scala:14:16: not found: v
[error]   val hamlet = Book("Hamlet", shakespeare, 1603)
[error]                ^
[error] two errors found
[error] (exercises / Compile / compileIncremental) Compilation failed
[error] Total time: 2 s, completed 29 Oct 2022, 11:56:56
sbt:Scala 101 Full Course> _
```

RUNNING SBT INTERACTIVELY

```
sbt:Scala 101 Full Course> ~compile
[info] compiling 4 Scala sources to /Users/jml/work/ordina/training/scala101-full-course/exercises/target/scala-2.13/classes ..
[error] /Users/jml/work/ordina/training/scala101-full-course/exercises/src/main/scala/exercise2/Hamlet.scala:13:21: not found: v
[error]   val shakespeare = Author("William", "Shakespeare")
[error]                     ^
[error] /Users/jml/work/ordina/training/scala101-full-course/exercises/src/main/scala/exercise2/Hamlet.scala:14:16: not found: v
[error]   val hamlet = Book("Hamlet", shakespeare, 1603)
[error]                ^
[error] two errors found
[error] (exercises / Compile / compileIncremental) Compilation failed
[error] Total time: 0 s, completed 29 Oct 2022, 11:58:59
[info] 1. Monitoring source files for root/compile...
[info]    Press <enter> to interrupt or '?' for more options.
```

SBT WITH INTELLIJ

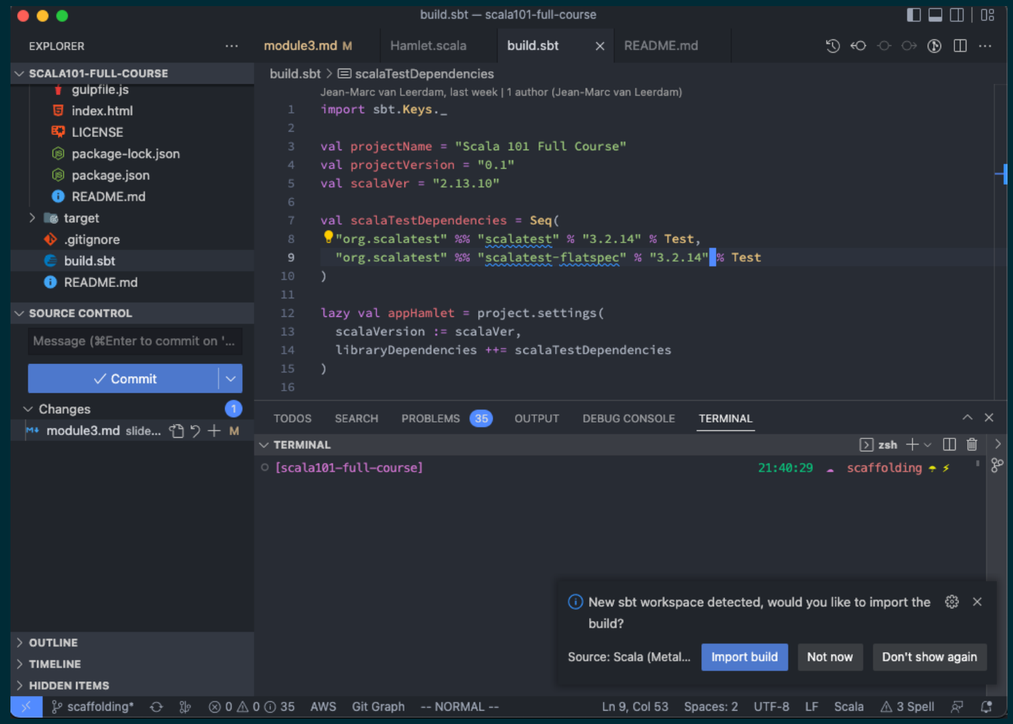
- IntellIJ has support for scala and sbt through the Scala plugin
  - provided by JetBrains
- Open project by opening the `build.sbt`

SBT WITH VSCODE

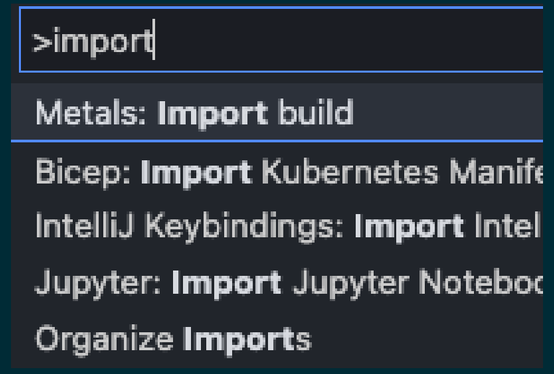
- VSCode supports scala via an extension from Scalameta, called scalameta language server, or Metals
  - Rich IDE features (completions, GOTO, import build, etc.)
  - No sbt built-in
    - sbt commands are run from Terminal instead

IMPORT A BUILD

- The first time you open Metals in a new workspace, it prompts you to import the build.
  - This is "vanilla" indexing like IntelliJ
  - Click "Import build" to start the installation step.

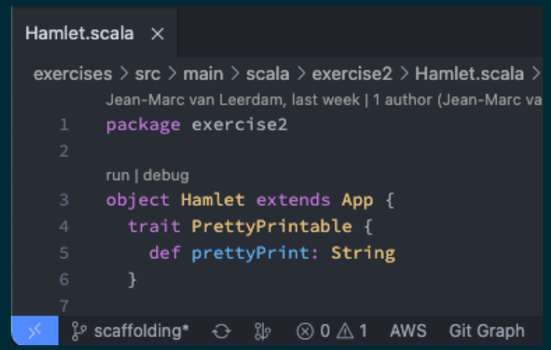


- You can manually import a build from Command Palette (`Cmd + Shift + P`)


>import
Metals: Import build
Bicep: Import Kubernetes Manife
IntelliJ Keybindings: Import Intel
Jupyter: Import Jupyter Noteboo
Organize Imports

RUN CODE

- Once import successful, you can run the application via the UI.
- A launching point of the application must be either
  - an object that extends the `App` trait
  - an object with a properly defined `main` method



- Otherwise, launch an sbt instance from Terminal and run commands from there

SCALATEST

- Most used testing framework for Scala
- Beautifully designed DSLs

SCALATEST

The problem with JUnit: everything has to be a method

```
@Test public void twoIntsAddedWithPlusShouldBeTheSumOfTwoInts(){ ... }

@Test public void plus() { ... }
```

Test names typically are long and hard to read, or short and unclear

SCALATEST

The solution in ScalaTest:

```
// when using FunSuite
class exampleSpec extends AnyFunSuite with Matchers {
  test("2 ints added with + should be the sum of 2 ints") {
    2 + 2 shouldBe 4
  }
}

// or, when using AnyFlatSpec:
class exampleSpec extends AnyFlatSpec with Matchers {
  "2 ints added with + " should "be the sum of 2 ints" in {
    2 + 2 shouldBe 4
  }
}
```

This also works well with test tooling showing the results:

```
sbt:Scala 101 Full Course> test
...
[info] exampleSpec:
[info] 2 ints added with +
[info] - should be the sum of 2 ints
```

SCALATEST

- Assertions

```
class exampleSpec extends AnyFlatSpec with Matchers {
  "2 ints added with + " should "be the sum of 2 ints" in {
    2 + 2 should be (4)
    2 + 2 shouldBe 4
  }

  "my HashMap" should "contain 1 as a key" in {
    val map = HashMap((1 -> "a"), (2 -> "b"))

    map should contain key 1
  }
}
```

SCALATEST

- Testing Exceptions

```
class exampleSpec extends AnyFlatSpec with Matchers {

  "division by 0" should "throw an exception" in {
    intercept[ArithmeticException] {
      1 / 0
    }
  }
}
```

SCALATEST

- There are many styles in which you can write tests
- ScalaTest lets you choose your favourite style
  - by mixing in Traits

TRAIT MIXINS

- Traits can be combined
- Similar to multiple inheritance

```
trait A {
  def doA(): Unit = println("a")
}

trait B {
  def doB(): Unit = println("b")
}

class X extends A with B

val x = new X
x.doA()
x.doB()
```

CONFIGURE SCALATEST WITH TRAITS

- `org.scalatest.funsuite.AnyFunSuite` gives you the `test` method
- `org.scalatest.flatspec.AnyFlatSpec` gives you
  - `"something" should "behave like x" in`
- `org.scalatest.matchers.should.Matchers` gives you
  - `[expr] should be ([expectation])`
  - `[expr] shouldBe expectation`
- and many more, see https://www.scalatest.org/user_guide/selecting_a_style

FLATSPEC DETAILS

- Good fit to describe behavior of classes

```
class IntegerTest extends AnyFlatSpec with Matchers {
  behavior of "Integer"

  it should "add 2 ints with +" in {
    1 + 1 shouldBe 2
  }
}
```

CONFIGURE SCALATEST WITH TRAITS

- ScalaTest also has `must` matchers that allow you to use `must` instead of `should`
- `OneInstancePerTest` - to create a new instance of the class for each test case (like JUnit)
- `BeforeAndAfter` - gives you methods to setup and tear down before each test
- `BeforeAndAfterAll` - gives you methods to setup and tear down before the test suite
- `MockitoSugar` - gives you syntactic sugar for calling Mockito

SCALA 101 - MODULE 4

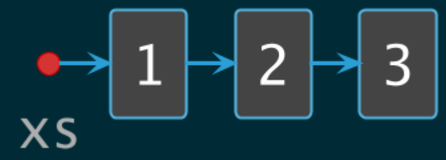
COLLECTIONS

COLLECTIONS

- Immutable by default
- Mutable if you need it

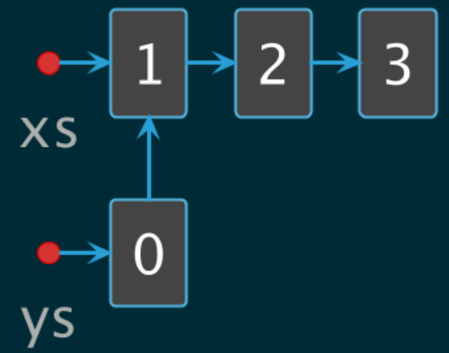
IMMUTABLE COLLECTIONS

```
val xs = List(1, 2, 3)
```



IMMUTABLE COLLECTIONS

```
val xs = List(1, 2, 3)
val ys = 0 :: xs
```



- Immutable collections can be implemented efficiently by re-using parts of existing collections
- In a linked list, pre-pending simply re-uses the existing list, and the old pointer remains valid

IMMUTABLE COLLECTIONS

This technique is called *persistent collections*

- Has nothing to do with databases

- Demonstrated addition to a linked list
- Other collections are similarly implemented
- Other operations (like remove) are also similarly implemented
- Results in very performant operations
  - But you must understand the characteristics

LISTS

```
val xs = List(1, 2, 3)
val ys = 4 :: 5 :: 6 :: Nil
val zs = xs ++ ys

zs.head
zs.tail

zs(2)
zs take 3
zs drop 2

zs.size
zs.isEmpty
```

```
val xs: List[Int] = List(1, 2, 3)
val ys: List[Int] = List(4, 5, 6)
val zs: List[Int] = List(1, 2, 3, 4, 5, 6)

val res5: Int = 1
val res6: List[Int] = List(2, 3, 4, 5, 6)

val res7: Int = 3
val res8: List[Int] = List(1, 2, 3)
val res9: List[Int] = List(3, 4, 5, 6)

val res10: Int = 6
val res11: Boolean = false
```

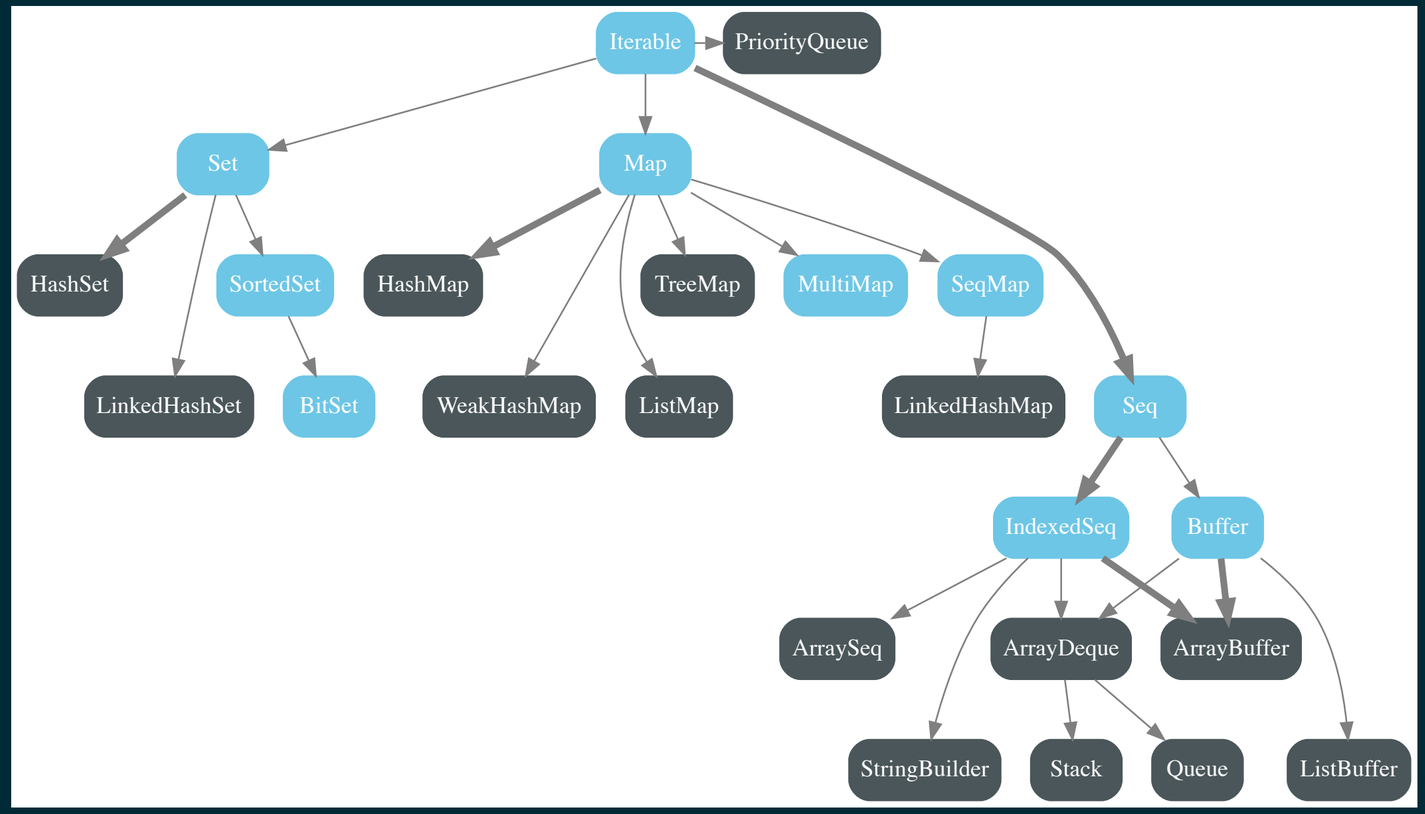
LISTS

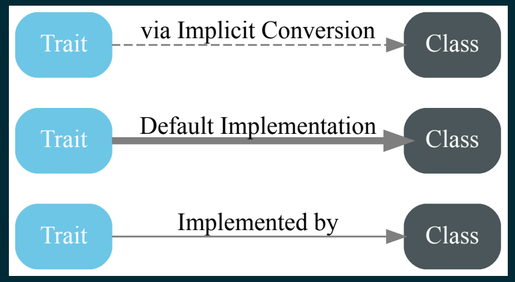
```
zs mkString ","
zs.reverse

zs.min
zs.max
zs.sum

xs zip ys

val rs = List(2, 4, 1, 3)
rs.zipWithIndex
rs.sorted
```

```
val res12: String = 1,2,3,4,5,6
val res13: List[Int] = List(6, 5, 4, 3, 2, 1)

val res14: Int = 1
val res15: Int = 6
val res16: Int = 21

val res17: List[(Int, Int)] = List((1,4), (2,5), (3,6))

val rs: List[Int] = List(2, 4, 1, 3)
val res18: List[(Int, Int)] = List((2,0), (4,1), (1,2), (3,3))
val res19: List[Int] = List(1, 2, 3, 4)
```

COLLECTIONS

- `List` is not the only collection





COLLECTIONS

Scala defines several collection classes:

- Base Traits
  - `Iterable` (collections you can iterate on)
  - `Seq` (ordered sequences)
  - `Set` (unordered without duplicates)
  - `Map` (lookup data structure)
- Immutable Collections
  - `List` (linked list, provides fast sequential access)
  - `Stream` (same as List, except that the tail is evaluated only on demand)
  - `Vector` (array-like type, implemented as tree of blocks, provides fast random access)
  - `Range` (ordered sequence of integers with equal spacing)
  - `String` (Java type, implicitly converted to a character sequence, so you can treat every string like a `Seq[Char]`)
  - `Map` (collection that maps keys to values)
  - `Set` (collection without duplicate elements)

COLLECTIONS

Scala defines several collection classes:

- Mutable Collections
  - `Array` (Scala arrays are native JVM arrays at runtime, therefore they are very performant)
  - Scala also has mutable maps and sets

Be aware: the *contents* of a Scala Array is mutable, even if you declare a `val ar: Array[Int] = ???`

A NOTE ABOUT STYLE

- Consider `List`
  - for pattern matching
  - for recursion
- Consider `Vector`
  - If you need to index elements
  - It is like Java's `ArrayList` (*NOT* like Java's `Vector`)

COLLECTION PERFORMANCE CHARACTERISTICS

- https://docs.scala-lang.org/overviews/collections-2.13/performance-characteristics.html

lookup	Testing whether an element is contained in set, or selecting a value associated with a key.
add	Adding a new element to a set or key/value pair to a map.
remove	Removing an element from a set or a key from a map.
min	The smallest element of the set, or the smallest key of a map.

C	The operation takes (fast) constant time.
eC	The operation takes effectively constant time, but this might depend on some assumptions such as maximum length of a vector or distribution of hash keys.
aC	The operation takes amortized constant time. Some invocations of the operation might take longer, but if many operations are performed on average only constant time per operation is taken.
Log	The operation takes time proportional to the logarithm of the collection size.
L	The operation is linear, that is it takes time proportional to the collection size.
-	The operation is not supported.

SETS

- An unordered collection of items, without duplicates

```
import scala.collection.immutable.SortedSet

val s = Set(3, 1, 2, 1)
val t = SortedSet(3, 5, 4)

t + 42
t - 3

t.size
t.isEmpty
t contains 5

t intersect s
t union s
t diff s
```

```
import scala.collection.immutable.SortedSet

val s: Set[Int] = Set(3, 1, 2)
val t: SortedSet[Int] = TreeSet(3, 4, 5)

val res0: SortedSet[Int] = TreeSet(3, 4, 5, 42)
val res1: SortedSet[Int] = TreeSet(4, 5)

val res2: Int = 3
val res3: Boolean = false
val res4: Boolean = true

val res5: SortedSet[Int] = TreeSet(3)
val res6: SortedSet[Int] = TreeSet(1, 2, 3, 4, 5)
val res7: SortedSet[Int] = TreeSet(4, 5)
```

MAPS

- Collection to store Key-Value pairs

```
val m = Map(1 -> "a", 2 -> "b", 3 -> "c")

m + (4 -> "d")
m - 1
m.updated(3, "newValue")

m(2)
m(5)
m.get(2)
m.get(5)
m.getOrElse(5, "WTF")

m.isEmpty
m contains 5

m.keys
m.unzip
```

```
val m: Map[Int,String] = Map(1 -> a, 2 -> b, 3 -> c)

val res8: Map[Int,String] = Map(1 -> a, 2 -> b, 3 -> c, 4 -> d)
val res9: Map[Int,String] = Map(2 -> b, 3 -> c)
val res10: Map[Int,String] = Map(1 -> a, 2 -> b, 3 -> newValue)

val res11: String = b
java.util.NoSuchElementException: key not found: 5
val res13: Option[String] = Some(b)
val res14: Option[String] = None
val res15: String = WTF

val res16: Boolean = false
val res17: Boolean = false

val res18: Iterable[Int] = Set(1, 2, 3)
val res19: (Iterable[Int], Iterable[String])
 = (List(1, 2, 3),List(a, b, c))
```

EXCERCISE 3: SHAKESPEARE

Write code that takes the following input and produces the output listed below.

```
val phrase = "brevity is the soul of wit"
```

Target:

```
(brevity,0)
(is,1)
(of,4)
(soul,3)
(the,2)
(wit,5)
```

The words are sorted alphabetically, and show their position in the original string

Open `exercises/src/main/scala/exercise3/Brevity.scala` and add/update the code to make the program work as expected.

Exercises available at https://github.com/code-star/scala101-full-course.git

One possible solution:

```
phrase.split(" ").zipWithIndex.sorted.mkString("\n")
```