Functional data structures 1

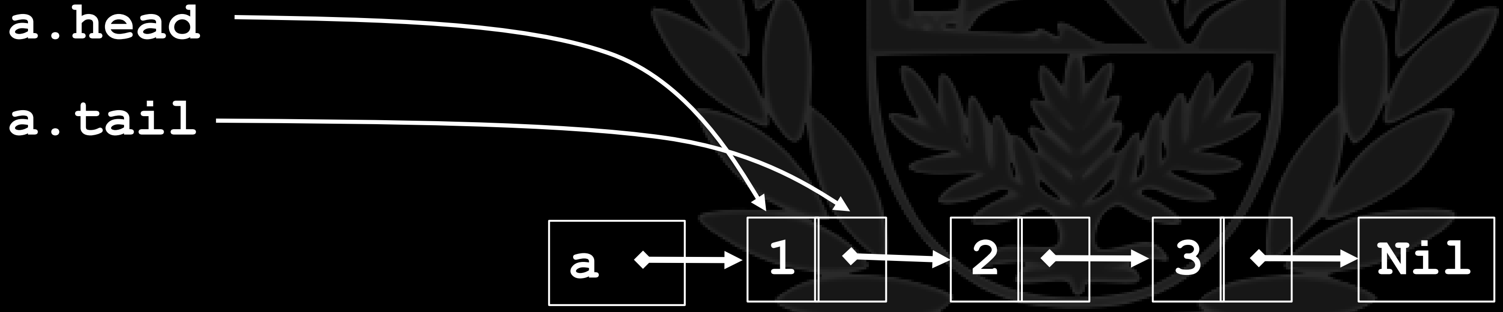
Functional data structures

A combination of functional programming with OOP.

This means we create data structures (e.g. collections) which are immutable.

MyList

```
val a = List(1, 2, 3)
a.head
a.tail
```



MyList

```
class MyList (val head: Int, val tail: ???)
```

MyList

```
abstract class MyList
class NonEmpty (val head: Int, val tail: MyList) extends MyList



val a = new NonEmpty(1, ???)
```

MyList

```scala
abstract class MyList
class NonEmpty (val head: Int, val tail: MyList) extends MyList
object Empty extends MyList


val a = new NonEmpty(1, Empty)
```

MyList

```
abstract class MyList
class NonEmpty (val head: Int, val tail: MyList) extends MyList
object Empty extends MyList

val a = new NonEmpty(1, Empty)
val b = new NonEmpty(1, new NonEmpty(2, Empty))
b.tail.head        // = ???
```

MyList

```
abstract class MyList { def head: Int, def tail: MyList }
class NonEmpty (val head: Int, val tail: MyList) extends MyList
object Empty extends MyList {
  def head = ???
  def tail = ???
}
```

MyList

```
abstract class MyList { def head: Int, def tail: MyList }
class NonEmpty (val head: Int, val tail: MyList) extends MyList
object Empty extends MyList {
  def head = throw new Exception("Empty has no head")
  def tail = throw new Exception("Empty has no tail")
}
```

MyList

```
abstract class MyList {
  def head: Int
  def tail: MyList
  def :: (a: Int): MyList
}
```

MyList

```
class NonEmpty (val head: Int, val tail: MyList) extends MyList {
  def :: (a: Int): MyList = ???
}
object Empty extends MyList {
  def head = throw new Exception("Empty has no head")
  def tail = throw new Exception("Empty has no tail")
  def :: (a: Int): MyList = ???
}
```

MyList

```
class NonEmpty (val head: Int, val tail: MyList) extends MyList {
  def :: (a: Int): MyList = new NonEmpty(a, this)
}
object Empty extends MyList {
  def head = throw new Exception("Empty list")
  def tail = throw new Exception("Empty list")
  def :: (a: Int): MyList = new NonEmpty(a, Empty)
}
```

Option pattern

```
abstract class MyList { ...
  def find (f: Int => Boolean): Int
}
class NonEmpty (val head: Int, val tail: MyList) extends MyList { ...
  def find (f: Int => Boolean): Int = ???
}
```

Option pattern

```
abstract class MyList { ...
  def find (f: Int => Boolean): Maybe
}
class NonEmpty (val head: Int, val tail: MyList) extends MyList { ...
  def find (f: Int => Boolean): Maybe = ???
}
object Empty extends MyList { ...
  def find (f: Int => Boolean): Maybe = ???
}
```

Option pattern

```
trait Maybe

class Yes (val value: Int) extends Maybe

object No extends Maybe
```

Option pattern

```
trait Maybe
class Yes (val value: Int) extends Maybe
object No extends Maybe

val res = l.find(_ % 2 == 0) match {
  case obj: Yes => s"Even number ${obj.value} found"
  case No => "No even numbers found"
}
```

Option pattern

```
class NonEmpty (...) {
  def find (f: Int => Boolean): Maybe = {
    if (f(head)) new Yes(head)
    else tail.find(f)
  }
}
```

Option pattern

```
object Empty {
  def find (f: Int => Boolean): Maybe = No
}
```

Either pattern

```
def pascal(r: Int, c: Int): Int =
  if (r == c || c == 1) 1
  else pascal(r - 1, c - 1) + pascal(r - 1, c)
```

```
pascal(5, 4)      // = 4
```

	1	2	3	4	5	6
1	1					
2	1	1				
3	1	2	1			
4	1	3	3	1		
5	1	4	6	$\boxed{4}$	1	
6	1	5	10	10	5	1

Either pattern

```
def pascal(r: Int, c: Int): Int =
  if (r == c || c == 1) 1
  else pascal(r - 1, c - 1) + pascal(r - 1, c)



pascal(4, 5)      // = ???
```

	1	2	3	4	5	6
1	1					
2	1	1				
3	1	2	1			
4	1	3	3	1	□	
5	1	4	6	4	1	
6	1	5	10	10	5	1

Either pattern

```
def pascal(r: Int, c: Int): ??? =
  if (c > r) ???
  else if (r == c || c == 1) 1
  else pascal(r - 1, c - 1) + pascal(r - 1, c)


pascal(4, 5)        // = ???
```

	1	2	3	4	5	6
1	1					
2	1	1				
3	1	2	1			
4	1	3	3	1		
5	1	4	6	4	1	
6	1	5	10	10	5	1

Either pattern

```
trait ThisOrThat
class This(val value: Int) extends ThisOrThat
class That(val value: String) extends ThisOrThat

val res = pascal(5, 4) match {
  case obj: This => s"Value is ${obj.value}"
  case obj: That => obj.value
}
```

Either pattern

```
def pascal(r: Int, c: Int): ThisOrThat =
  if (c > r) new That(s"No value at row $r, col $c")
  else if (r == c || c == 1) new This(1)
  else (pascal(r - 1, c - 1), pascal(r - 1, c)) match {
    case (a: This, b: This) => new This(a.value + b.value)
    case _ => new That("Something went wrong")
  }
```

Case classes

```
case class Person(name: String)


val jenny =     Person("Jenny")

jenny.name  // = Jenny
```

Case classes

```scala
case class Person(name: String)


val jenny = Person("Jenny")
val otherJenny = Person("Jenny")


jenny == otherJenny     // = true
```

Case classes

```
case class Address(street: String, postnr: Int)
case class Person(name: String, addr: Address)


val jenny = Person("Jenny", Address("Hogskolevagen", 54128))
val otherJenny = Person("Jenny", Address("Hogskolevagen", 54128))


jenny == otherJenny     // = true
```

Case classes

```
case class Address(street: String, postnr: Int)
case class Person(name: String, addr: Address)


val jenny = Person("Jenny", Address("Hogskolevagen", 54128))
val otherJenny = Person("Jenny", Address("Hogskolevagen", 54123))


jenny == otherJenny     // = false
```

Case classes

```
case class Address(street: String, postnr: Int)
case class Person(name: String, addr: Address)


val jenny = Person("Jenny", Address("Hogskolevagen", 54128))
val street = jenny match {
  case Person(_, Address(s, _)) => s
}
```

Algebraic data types (ADT)

An ADT "is the sum or union of its data constructors

and each data constructor is the product of its arguments,

hence the name algebraic data type"*

*Chiusano, P., & Bjarnason, R. (2014). Functional programming in Scala. Manning Publications Co..

Algebraic data types (ADT)

A type composed of other types

e.g.

```
suit = spade | dimond | heart | club
```

Option pattern is an ADT

```
trait Maybe

class Yes (val value: Int) extends Maybe

object No extends Maybe
```

Option pattern is an ADT

```
sealed trait Maybe

class Yes (val value: Int) extends Maybe

object No extends Maybe
```

Option pattern is an ADT

```
sealed trait Maybe
class Yes (val value: Int) extends Maybe
object No extends Maybe

val res = l.find(_ % 2 == 0) match {
  case obj: Yes => s"Even number ${obj.value} found"
  case No => "No even numbers found"
}
```

Option pattern is an ADT

```scala
sealed trait Maybe
case class Yes (value: Int) extends Maybe
object No extends Maybe

val res = l.find(_ % 2 == 0) match {
  case Yes(v) => s"Even number $v found"
  case No => "No even numbers found"
}
```

MyList is an ADT

```
abstract class MyList { def head: Int; def tail: MyList; ... }
class NonEmpty (val head: Int, val tail: MyList) extends MyList {
  def :: (a: Int): MyList = new NonEmpty(a, this)
}
object Empty extends MyList {
  def head = throw new Exception("Empty list")
  def tail = throw new Exception("Empty list")
  def :: (a: Int): MyList = new NonEmpty(a, Empty)
}
```

MyList is an ADT

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sealed abstract class MyList { def head: Int; def tail: MyList; ... }
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  def :: (a: Int): MyList = new NonEmpty(a, Empty)
}
```

MyList is an ADT

```scala
sealed abstract class MyList { def head: Int; def tail: MyList; ... }
case class NonEmpty (val head: Int, val tail: MyList) extends MyList {
  def :: (a: Int): MyList = new NonEmpty(a, this)
}
object Empty extends MyList {
  def head = throw new Exception("Empty list")
  def tail = throw new Exception("Empty list")
  def :: (a: Int): MyList = new NonEmpty(a, Empty)
}
```

MyList is an ADT

```
val ns = 1 :: 2 :: 3 :: Empty


def sum(l: MyList): Int = l match {
  case _: Empty => 0
  case a: NonEmpty => a.head + sum(a.tail)
}
```

MyList is an ADT

```scala
val ns = 1 :: 2 :: 3 :: Empty


def sum(l: MyList): Int = l match {
  case Empty => 0
  case NonEmpty(h, t) => h + sum(t)
}
```