Week 1

Call by value first resolves the “values” before calling the function, while call by name first calls the function, gets the results and then resolves them.

Week 2

Take a function as a parameter:

```
def sum(f: Int => Int, a: Int, b: Int): Int =
  if a > b then 0
  else f(a) + sum(f, a + 1, b)
```

We can also generate functions using functions:

```
def sum(f: Int => Int): (Int, Int) => Int =
  def sumF(a: Int, b: Int): Int =
    if a > b then 0
    else f(a) + sumF(a + 1, b)
  sumF
```

```
def sumInts = sum(x => x)
def sumCubes = sum(x => x * x * x)
def sumFactorials = sum(fact)
```

```
sumCubes(1, 10) + sumFactorials(10, 20)
```

Generalization:

It’s the same as creating a function that takes the `n-1` arguments, and one takes the last one:

```
def f(ps1)...(psn-1) = (psn ⇒ E)
```

Types

```
Type = SimpleType | FunctionType
FunctionType = SimpleType '=>' Type
| '( ' [ Types ] ') ' '= > ' Type
SimpleType = Ident
Types = Type { ' , ' Type }
```

Several ways of writing functions that return functions

```
def isGreaterThanBasic(x: Int, y: Int): Boolean =
  x > y
val isGreaterThanAnon: (Int, Int) => Boolean =
  (x, y) => x > y
val isGreaterThanCurried: Int => Int => Boolean =
  x => y => x > y // Same as `x => (y => x > y)`
def isGreaterThanCurriedDef(x: Int)(y: Int): Boolean =
  x > y
```

▹ Curried signifie que la fonction prend ses arguments un par un ! (en fait elle renvoie une nouvelle fonction à chaque fois) C’est utile si on veut appliquer des transformations partielles (fixer le premier argument et retarder l’application du second).

Week 3

Classes and Substitutions

Now suppose that we have a class definition,

$$\texttt{class C}(x_1, \ldots, x_m)\{ \ \ldots \ \texttt{def f}(y_1, \ldots, y_n) = b \ \ldots \ \}$$

where

- The formal parameters of the class are $x_1, \ldots, x_m$.
- The class defines a method `f` with formal parameters $y_1, \ldots, y_n$.

(The list of function parameters can be absent. For simplicity, we have omitted the parameter types.)

Question: How is the following expression evaluated?

$$\texttt{C}(v_1, \ldots, v_m).\texttt{f}(w_1, \ldots, w_n)$$

Classes and Substitutions (2)

Answer: The expression $\texttt{C}(v_1, \ldots, v_m).\texttt{f}(w_1, \ldots, w_n)$ is rewritten to:

$$[w_1/y_1, \ldots, w_n/y_n][v_1/x_1, \ldots, v_m/x_m][\texttt{C}(v_1, \ldots, v_m)/\texttt{this}]\, b$$

There are three substitutions at work here:

- the substitution of the formal parameters $y_1, \ldots, y_n$ of the function `f` by the arguments $w_1, \ldots, w_n$,
- the substitution of the formal parameters $x_1, \ldots, x_m$ of the class `C` by the class arguments $v_1, \ldots, v_m$,
- the substitution of the self reference *this* by the value of the object $\texttt{C}(v_1, \ldots, v_n)$.

```
extension (r: Rational)
  def min(s: Rational): Rational = if s.less(r) then s else r
  def abs: Rational = Rational(r.numer.abs, r.denom)
```

Using Extension Methods

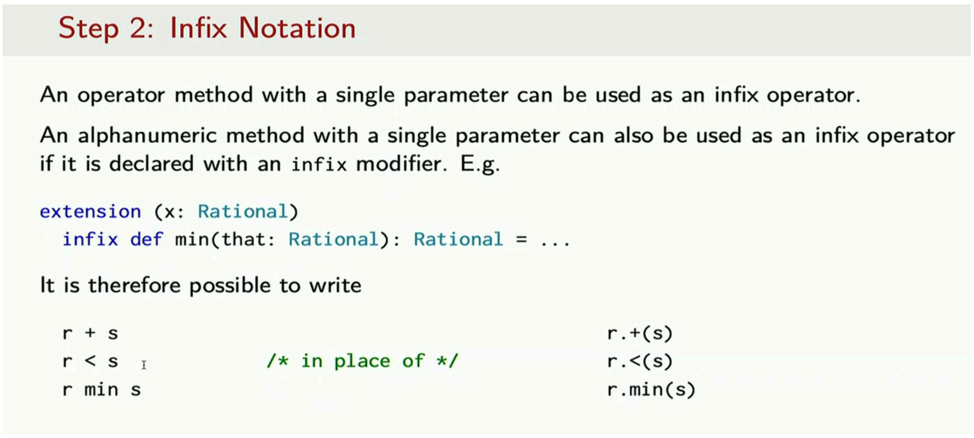
Extensions of a class are visible if they are listed in the companion object of a class (as in the code above) or if they defined or imported in the current scope.

Members of a visible extensions of class `C` can be called as if they were members of `C`. E.g.

```
Rational(1/2).min(Rational(2/3))
```

Caveats:

- Extensions can only add new members, not override existing ones.
- Extensions cannot refer to other class members via `this`



Step 2: Infix Notation

An operator method with a single parameter can be used as an infix operator.

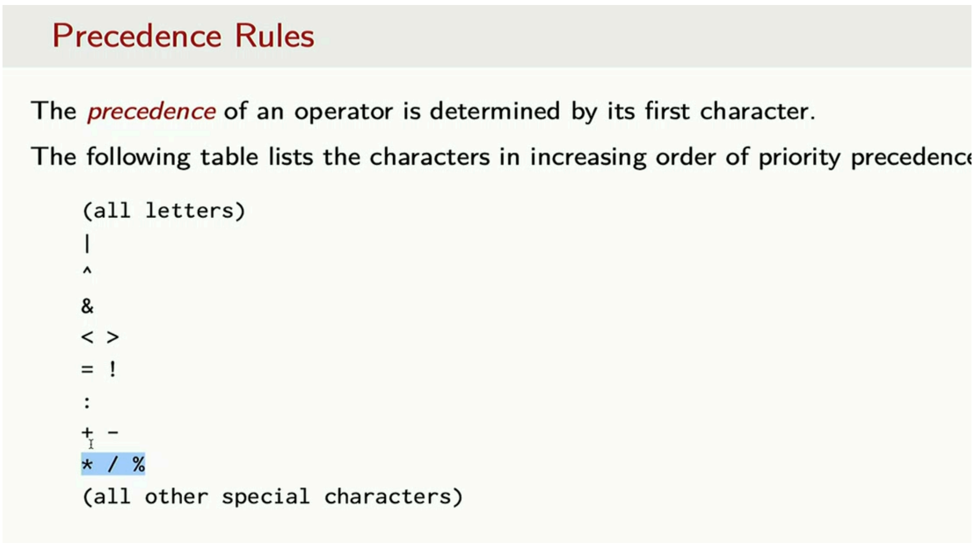
An alphanumeric method with a single parameter can also be used as an infix operator if it is declared with an `infix` modifier. E.g.

```
extension (x: Rational)
  infix def min(that: Rational): Rational = ...
```

It is therefore possible to write

```
  r + s                                     r.+(s)
  r < s          /* in place of */          r.<(s)
  r min s                                   r.min(s)
```

Déterminée en fonction du caractère qui démarre l'opérateur:

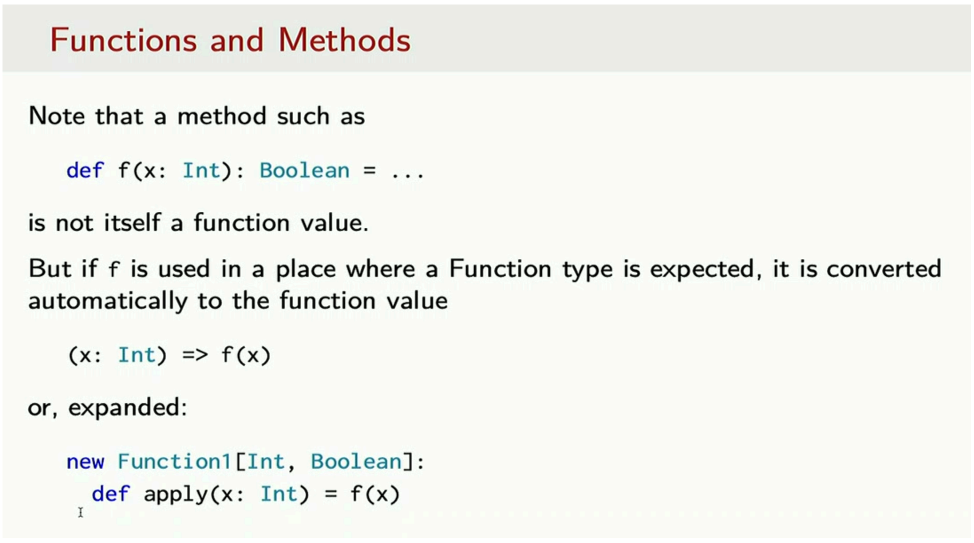


Precedence Rules

The *precedence* of an operator is determined by its first character.

The following table lists the characters in increasing order of priority precedenc

```
(all letters)
|
^
&
< >
= !
:
+ -
* / %
(all other special characters)
```



Functions and Methods

Note that a method such as

```
def f(x: Int): Boolean = ...
```

is not itself a function value.

But if `f` is used in a place where a Function type is expected, it is converted automatically to the function value

```
(x: Int) => f(x)
```

or, expanded:

```
new Function1[Int, Boolean]:
  def apply(x: Int) = f(x)
```

Types

Contravariance : quand un type plus général est utilisé pour un autre type Covariance : quand un type plus précis est utilisé pour un autre type

```
trait Printer[-A] {
  def print(value: A): Unit
}

val animalPrinter: Printer[Animal] = (animal: Animal) => println(s"Printing an
animal: $animal")
val dogPrinter: Printer[Dog] = animalPrinter // ok, Printer[Animal] is a supertype of
Printer[Dog]
```

Mutations

invariants : propriétés qui doivent être vraies à chaque étape de l'exécution du programme (p. ex. dans une fonction qui calcule le maximum, un invariant pourrait être que le maximum doit être plus grand que tous les éléments déjà traités dans la liste ET présent dans la liste déjà traitée).