

CSC 347 - Concepts of Programming Languages

Methods and Functions: Currying

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Learning Objectives

- ❓ How are methods in object-oriented programming and functions in functional programming related?
- Identify and describe the difference between methods and functions in Scala
 - Identify and describe the difference between tupled and curried definitions
 - Identify and use partial function application



Functional Programming

- We say that functions are *first-class* if they can be
 - declared within any scope,
 - passed as arguments to other functions, and
 - returned as results of functions.
- Functions `foreach`, `map`, `filter` are *higher-order functions*
 - they take a function as argument
 - Also common: return a function as the result



Paired Methods

```
1 def add(x:Int, y:Int) = x+y  
2 add(11, 21)
```

```
1 add: (x: Int, y: Int): Int  
2 res: Int = 32
```

- This is the usual style of methods that take multiple arguments
- `add` is a *method* that
 - Takes a pair of `Int` s
 - Returns an `Int`



Functions

- Scala has first-class support for both functions and methods

Method

```
1 def add(x:Int, y:Int) = x+y  
2 add(1,2)
```

- Part of a class structure
- Can be overridden
- Has access to fields

Function

```
1 val add = (x:Int, y:Int) => x+y  
2 add(1,2)
```

- Can be passed as arguments, returned, assigned to variables



Function Notation

- Using lambda notation

```
1 val add = (x:Int, y:Int) => x+y  
2 add(11,21)
```

- Use underscore when parameters used exactly once

```
1 val add = (_:Int) + (_:Int)  
2 add(11,21)
```

- Types may be inferred in some contexts

```
1 def g(x: Int, y: Int, f: (Int,Int)=>Int) = f(x,y)  
2 g(1, 2, _ + _)
```



Curried Functions

```
1 val add = (x:Int) => (y:Int) => x+y
2 add(11)(21)
```

```
1 add: Int => (Int => Int) = $$Lambda$...
2 res: Int = 32
```

- This is a **curried** definition
- `add` is a *function* that
 - Takes an `Int`
 - Returns a function of type `Int=>Int`



Curried Methods

```
1 def add(x: Int) =  
2   (y: Int) => x+y  
3  
4 add(11)(21)
```

```
1 add: (x: Int): Int => Int  
2  
3  
4 res: Int = 32
```

- You can mix the notations
- `add` is a method that
 - Takes an `Int`
 - Returns a function of type `Int=>Int`



Converting Methods to Functions

```
1 def add(x:Int, y:Int) = x+y  
2 val addf = add
```

```
1 add: (x: Int, y: Int)Int  
2 addf: (Int, Int) => Int = $$Lambda$...
```

- Creates an anonymous function from a method
- Extracts method from its object (more about this in lecture on closures)

Use Case

```
1 def g(x: Int, y: Int, f: (Int, Int)=>Int) = f(x, y)  
2 g(add)
```



Partial Application

```
1 val add = (x:Int) => (y:Int) => x+y
2 val addp = addf(11)
3 val r = addfp(21)
```

```
1 add: Int => (Int => Int) = $$Lambda$
2 addp: Int => Int = $$Lambda$
3 r: Int = 32
```

Use Case

```
1 // add is Int=>Int=>Int, but map expects Int=>Int
2 List(1,2,3).map(add(1))      // provide first argument
3 List(1,2,3).map(add(_)(1))  // provide second argument
```



Functions and Methods

- `def` defines a *method* with explicit parameter types
- `=>` defines a *function* with inferable parameter types
- Functions are objects with method `apply`
 - Function `e:X=>Y` gets compiled to an object

```
1 val e = new Function[X,Y] {  
2   def apply(x:X) : Y = ...  
3 }
```

- Function application `e(args)` is method invocation `e.apply(args)`



Summary

- Tupled definitions: functions with multiple arguments
- Curried definitions: a family of single-argument functions
- In Scala, functions are objects with an `apply` method
- Partial application creates new functions



Partial Application

```
1 def add1(x:Int, y:Int) = x+y
2 def add2(x:Int)(y:Int) = x+y
3 val add3 = (x:Int, y:Int) => x+y
4 val add4 = (x:Int) => (y:Int) => x+y
5 def add5(x:Int) = (y:Int) => x+y
6
7 val add1p = add1(11, _) /* x=>add1(11, x) */
8 val add2p = add2(11)(_) /* x=>add2(11)(x) */
9 val add3p = add3(11, _) /* x=>add3(11, x) */
10 val add4p = add4(11)
11 val add5p = add5(11)
12 for f <- List(add1p, add2p, add3p, add4p, add5p)
13   yield f(21)
```

```
1 fs: List[Int => Int] = List($$Lambda$, $$Lambda$, $$Lambda$, $$Lambda$, $$Lambda$)
2 res1: List[Int] = List(32, 32, 32, 32, 32)
```