

CSC 347 - Concepts of Programming Languages

Option Type

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Reporting Missing Data

```
1 def find[X](xs: List[X],
2               p: X=>Boolean) : X =
3   xs match {
4     case Nil => ???
5     case x :: rest =>
6       if p(x) then x
7       else find(rest, p)
8   } ensuring {
9     case result => ???
10 }
```

```
1 def reduce[X](xs: List[X],
2                f: (X,X)=>X) : X =
3   xs match {
4     case Nil => ???
5     case x :: Nil => x
6     case x :: rest =>
7       f(x, reduce(rest))
8   } ensuring {
9     case result => ???
10 }
```

- ⚠ `case Nil => null` : contract and clients have to distinguish between `null` and a result
- ⚠ `case Nil => throw IllegalArgumentException(...)` : exceptions for expected behavior bad, how to write exception contract?



Learning Objectives

❓ How to represent missing results?

- Identify uses of option types



Option Type

- Principled approach to missing data
- `Option[T]` resembles `List[T]` with length ≤ 1
 - `None` represents absence of data
 - `Some` represents presence
- Example expressions of type `Option[Int]` : `None` , `Some(5)`



Absence of Data

Programming with `null`

```
1 def find[X](xs: List[X],  
2             p: X => Boolean): X =  
3   xs match  
4     case Nil => null.asInstanceOf[X]  
5     case x :: _ if p(x) => x  
6     case _ :: rest => find(rest, p)  
7 end find
```

Programming with optionals

```
1 def find[X](xs: List[X],  
2             p: X => Boolean): Option[X] =  
3   xs match  
4     case Nil => None  
5     case x :: _ if p(x) => Some(x)  
6     case _ :: rest. => find(rest, p)  
7 end find
```



Absence of Data: Clients

> Find `x > 5`, if found return `"found x"`, else find `x > 3`, if found return `"found x"`, else print `"not found"`

```
1 val xs = List(1, 2, 3, 4, 5)
```

Client handling null

```
1 find(xs, _ > 5) match
2   case null => find(xs, _ > 3) match
3     case null => "not found"
4     case n    => s"found $n"
5   end match
6   case n      => s"found $n"
7 end match
```

Client handling option

```
1 find(xs, _ > 5) orElse find(xs, _ > 3) match
2   case None    => "not found"
3   case Some(n) => s"found $n"
4 end match
```

- `null`: no compiler support for null-checking, cannot have methods
- Map, fold, filter all work on `Option`



Nested Options

Safe division returns on zero: `None` (division undefined)

```
1 def safeDivide (n:Int,m:Int) : Option[Int] =  
2   if m == 0 then None  
3   else Some (n/m)
```

```
1 def safeDivide (n:Int,m:Int) : Option[Int] =  
2   Option.when(m!=0)(n/m) // Option.unless(m==0)(n/m)
```

- Divide an optional int safely

```
1 val i: Option[Int] = Some(4)  
2 i.map(safeDivide(_,2)) // val res: Option[Option[Int]] = Some(Some(2))  
3 i.map(safeDivide(_,0)) // val res: Option[Option[Int]] = Some(None)
```

- Avoid nested options

```
1 val i: Option[Int] = Some(4)  
2 i.flatMap(safeDivide(_,2)) // val res: Option[Int] = Some(2)
```



Types of Emptiness

Scala

```
1 def sum (xs : List[Int]) : Int = xs match
2   case Nil => 0
3   case y::ys => y + sum(ys)
```

- `Nil` : empty list
- `null` : empty reference
- `None` : empty option
- `Unit` : always has `()`

Java

```
1 int sum (Node<Integer> xs)
2   if (xs == null) return 0;
3   else return xs.item + sum(xs.next);
```

- `null` : used to represent emptiness
- `null` : empty reference
- `Optional.empty()` : empty option
- `void` : no return value



Nullable Types

- In Scala, we often pretend `null` does not exist
- Recent languages identify `None` and `null` : e.g. [Swift](#), [Kotlin](#)
- These languages distinguish *nullable* and *non-nullable* types



Nullable Types

Kotlin nullable versus non-nullable types

- `T?` in Kotlin resembles `Option[T]` in Scala
- `null` is used for `None`
- Types without `?` do not allow `null`

```
1 var a: String = "abc"
2 a = null /* compilation error */
3 a.length /* always safe */
4
5 var b: String? = "abc"
6 b = null /* ok */
7 b.length /* compiler error */
8
9 b!!.length /* may raise exception */
10
11 /* Safe call */
12 b?.length
13 /* Explicitly expanded safe call */
14 if (b != null) b.length else null
15
16 /* Safe call with default */
17 b?.length ?: -1
18 /* Explicitly expanded */
19 val t = b?.length; if (t != null) t else -1
```



Summary

- `Option` type represents presence/absence of data
- `Either` type represents alternative results
- Support higher-order functions `map` , etc.
- Enable expressing alternative computation attempts concisely (`orElse` , `getOrElse`)