Introduction to Functional Programming in R

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Andrei Serjantov

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Contents

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Functional Languages

- Static Typing
- Functions as first class "citizens"
  - Passing functions as arguments
  - Returning functions as results (partially applying functions)
- (often involves lots of recursion)
- Examples
  - ML (OCAML)
  - Haskell
  - Scheme

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Static Typing (vs Dynamic Typing)

```
> 1+"c"
Error in 1 + "c" : non-numeric argument to binary operator
> if(FALSE) {1+"c"} else {print("c")}
[1] "c“
```

```
b = if False then (1+"c") else 1
perm.hs:82:19:
    No instance for (Num [Char])
      arising from the literal `1' at perm.hs:82:19
    Possible fix: add an instance declaration for (Num [Char])
    In the first argument of `(+)', namely `1'
    In the expression: (1 + "c")
    In the expression: if False then (1 + "c") else 1
```

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Functions as "First Class Objects"

```
add :: (Int,Int) → Int
add (x,y) = x + y

perform_operation :: ((Int,Int) → Int) → Int
perform_ operation f = f(3,4)

perform_operation_with_3 :: ((Int,Int) → Int) → Int → Int
perform_ operation f x = f(3,x)

add_with_3 = perform_operation_with_3 add
add_with_3 5

> 8
```

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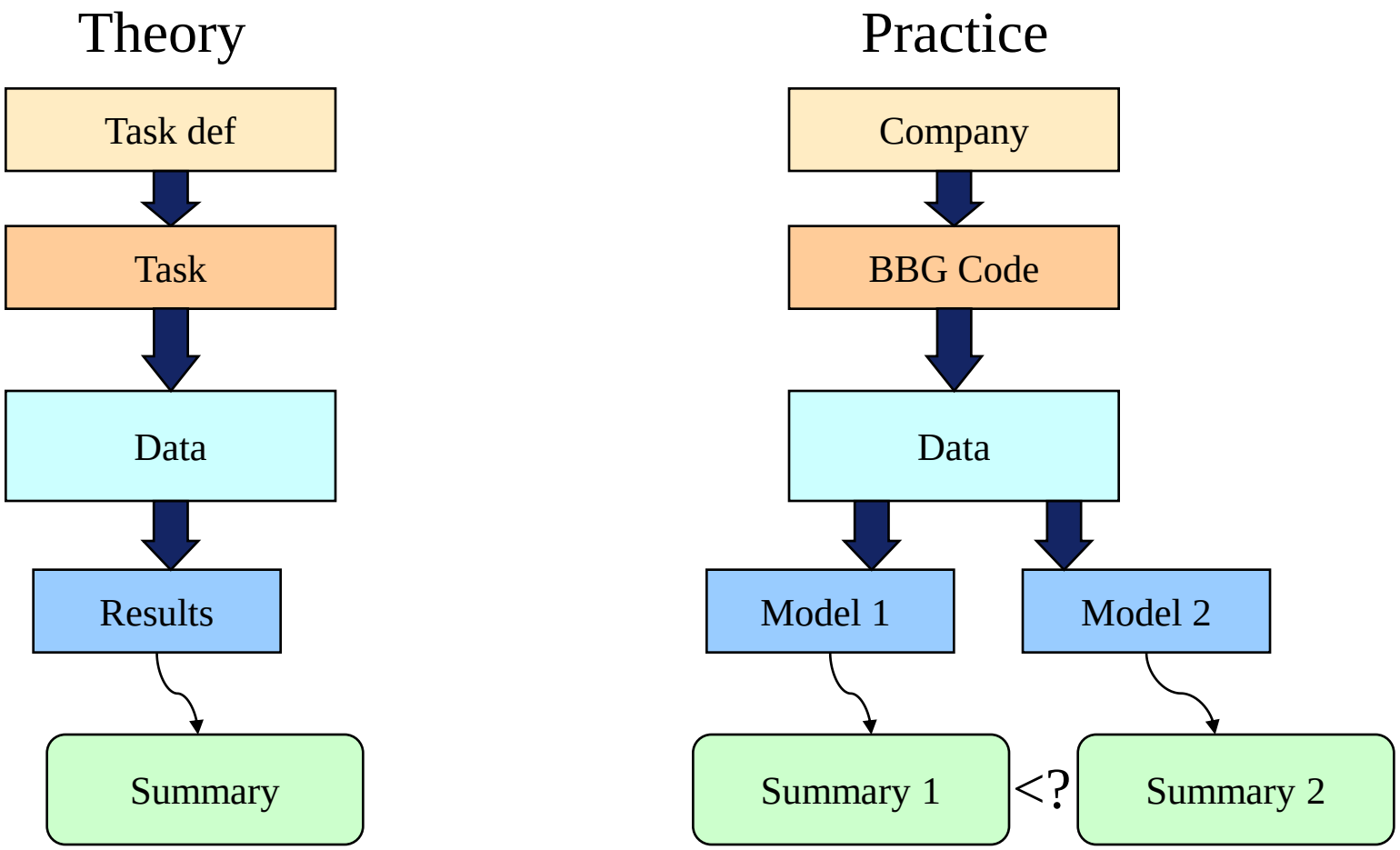
Example



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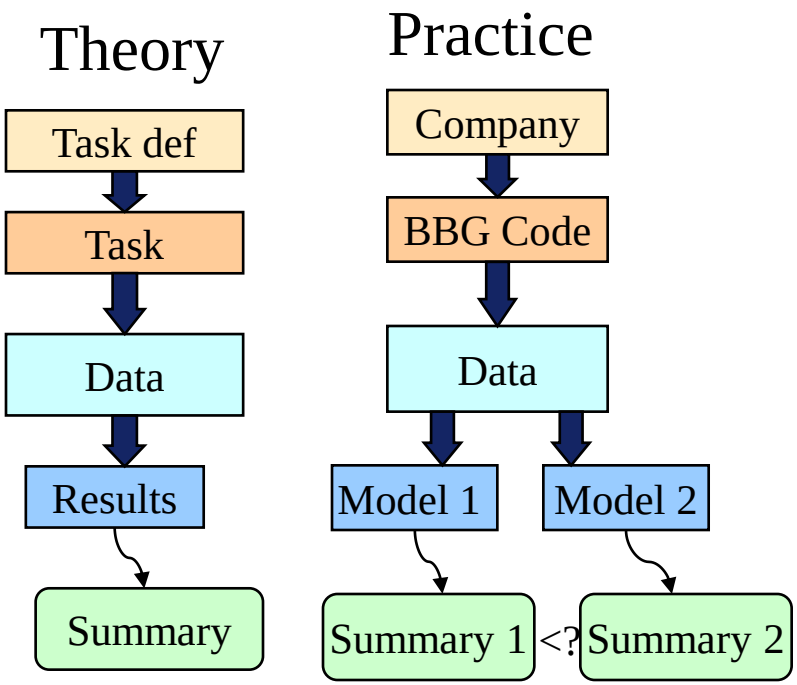
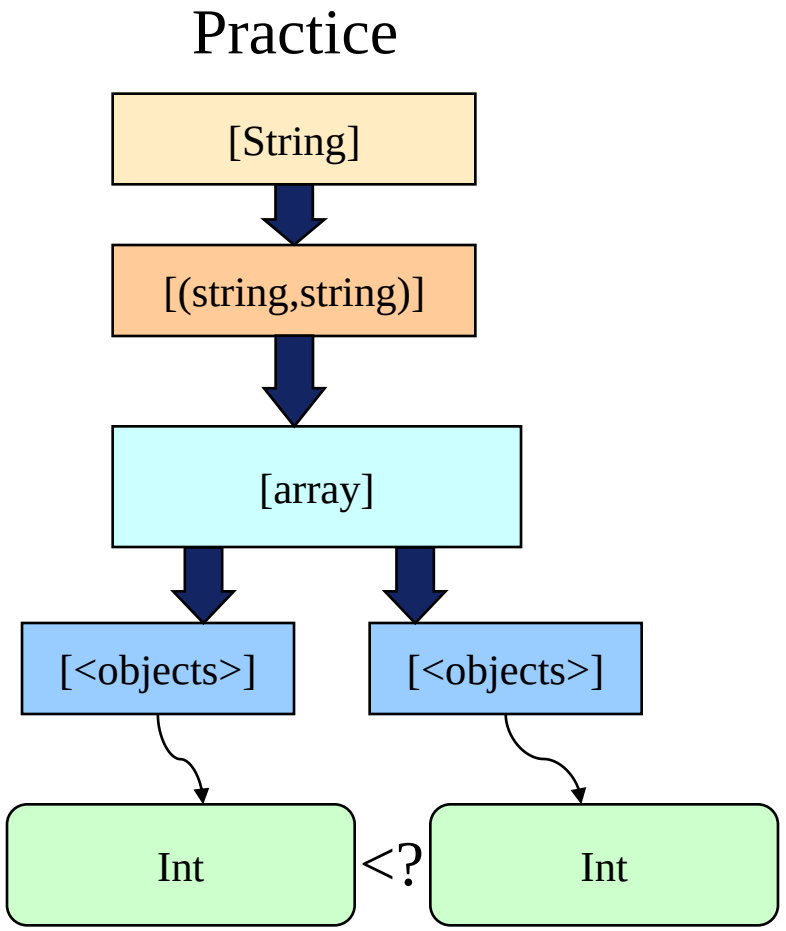
Example



[1,2,3] is a list containing 1,2,3



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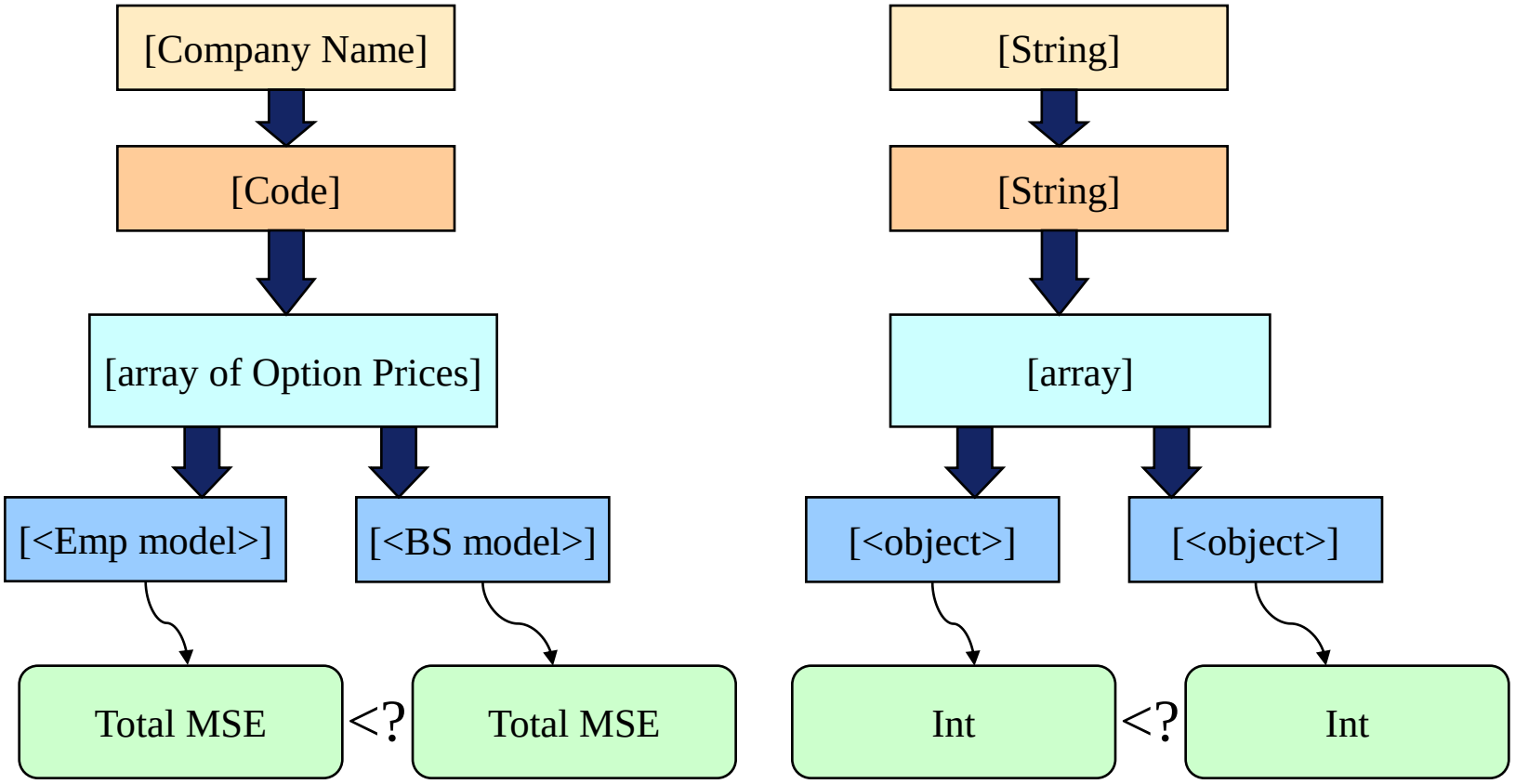

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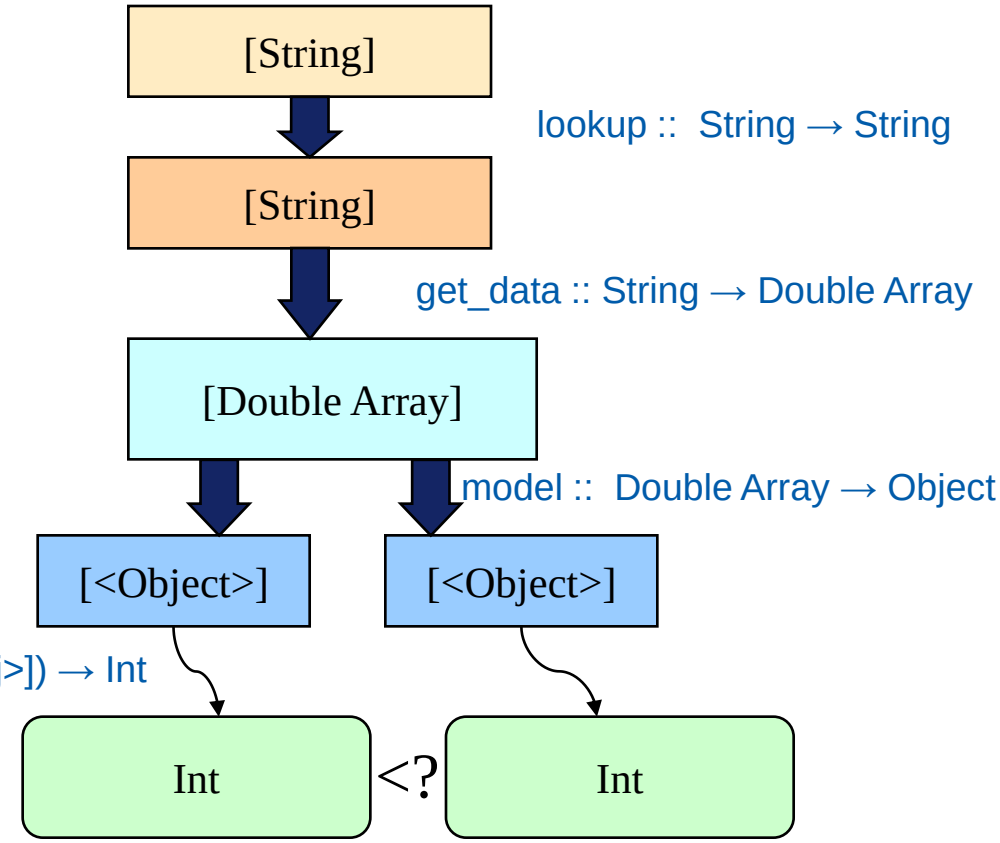
Map and fold

map :: ((a → b),[a]) → [b]

fold :: (((a,b) →a),a,[b]) → a



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Folds I

What does fold do?

Think of a conveyor:

conveyor :: [parts] → partly_built_car

worker :: (part,partly_built_car) → partly_built_car

fold :: $(((\alpha, \beta) \rightarrow \alpha), \alpha, [\beta]) \rightarrow \alpha$

fold :: ((part,partly_built_car) → partly_built_car, partly_built_car, [parts]) → partly_built_car

fold (funct, almost_car, [ ]) = almost_car

fold (worker, almost_car, part:other_parts) = fold(worker, worker(part,almost_car), other_parts)

What's the difference between this and:

fold (worker, almost_car, part:other_parts) = worker(part,fold(worker, almost_car, other_parts))

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Folds II

Summary in the previous slide can be implemented as follows:

```
obj_list = <list of lm objects>        # x:: [Object]
mse_list = map(extract_MSE, X)  # extract_MSE :: Object → Double
summary_stat = sum(mse_list)
```

So, how do we write "sum" functional-style ???

```
sum :: [Double] → Double
sum [ ] = 0
sum (x:xs) = x + sum(xs)
```

OR notice that

```
+ :: (Double, Double) → Double
```

So

```
sum xs = fold(+,0.0,xs)
```

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Functional R

map = lapply

fold = reduce

Also:

Mapply

Vectorize

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In R

```
> A = list(3,4)
> add_3 = function(x,y=3) x+y
> add = function(x,y) x+y
> lapply(A,add_3)
[[1]]
[1] 6

[[2]]
[1] 7

> lapply(A,add)
Error in FUN(X[[1L]], ...) : element 2 is empty;
   the part of the args list of '+' being evaluated was:
   (x, y)
```

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In Haskell

```
-- Compile time error which simply does not occur in dynamically typed languages
new_list = map (add_one) ["a", "b", "c"]
perm.hs:59:26:
    Couldn't match expected type `Int' against inferred type `[Char]'
    In the expression: "a"
    In the second argument of `map', namely `["a", "b", "c"]'
    In the expression: map (add_one) ["a", "b", "c"]

never_error = if (True) then [ ] else  (map (add_one) ["a", "b", "c"])
perm.hs:55:54:
    Couldn't match expected type `Int' against inferred type `[Char]'
    In the expression: "a"
    In the second argument of `map', namely `["a", "b", "c"]'
    In the expression: (map (add_one) ["a", "b", "c"])
```

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Partial Function Application in R

optim(par, fn, gr = NULL, ... , method = c("Nelder-Mead", "BFGS", "CG", "L-BFGS-B", "SANN"))

Arguments

... Further arguments to be passed to fn and gr.

```
f = function(x) log(x)+1
obj_fun = function(x,f)  (x-f(x))^2
solution = optim(1000, obj_fun, NULL, f, method="BFGS")
```

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Partial Function Application in Haskell

```
f :: Double → Double
f x = log(x) + 1
obj_fun :: (Double → Double) → Double → Double
obj_fun f x = (x-(f x))^2
a = optim(1000, (obj_fun f), method = "BFGS")
```

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Some more partial function application

Consider the function mapply (in fact, it's more general than that):

mapply :: ((α, β) →γ,[α],[β]) →[γ])

list_of_stuff = list("a","b","c") ############################## [“a”,”b”,”c”]

some_labels = as.list(seq(10,14,by=2)) ############################## [10,12,14]

mapply(pair_up, list_of_stuff,some_labels, SIMPLIFY=FALSE) ###### [[“a”,10],[”b”,12],[”c”,14]]

There is also a function called Vectorize:

Vectorize :: ((α, β) →γ) →(([α],[β]) →[γ])

new_function = Vectorize(pair_up, SIMPLIFY=FALSE)

new_function(list_of_stuff, some_labels)

in Haskell this happens automatically, mapply :: ((α, β) →γ) →[α] →[β] →[γ]

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```
ins_every_position :: a -> [a] -> [[a]]
ins_every_position elt lst = insert elt [] lst

insert :: a -> [a] -> [a] -> [[a]]
insert elt front [ ]  = [front ++ [elt]]
insert elt front (x:xs)  = (front ++(elt:x:xs)):(insert elt xs (front++[x]))
```