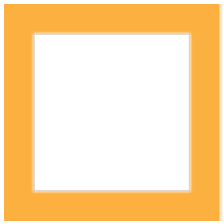
Lisp
Functional Programming

Jens Egholm Pedersen and Anders Kalhauge



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Spring 2018

Outline

Application as data

A computer is a thing that follows an algorithm = computation.

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What can be computed?

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If we can treat functions as memory, they simply become data

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$f(5) = y \mapsto y^2 + 25$

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$f(5) = y \mapsto y^2 + 25 \quad = \lambda y.y^2 + 25$

Known as **currying**

- evaluating a function with multiple arguments in a sequence

Higher order function 1/2

A function that either:

- Takes a function as an argument
- Returns a function as its result

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First part: Returning a function

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$$x \mapsto (y \mapsto x + y)$$

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A function that either:

- Takes a function as an argument
- Returns a function as its result

First part: Returning a function

$$x \mapsto (y \mapsto x + y)$$

$$25 \mapsto (y \mapsto 25 + y)$$

Imperative programming

- Series of instructions

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- Variables in memory

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- Variables in memory = global state

Imperative programming

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  3. Output: setting memory

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- This is how a CPU works
- 1. Input: setting memory
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- **Statements** that changes a program's **state**

Side effects

State = The values in your memory

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Mutability = Changing state

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Mutability + Concurrency =

Side effects

State = The values in your memory

Mutability = Changing state

Side effects = Behaviour outside scope

Mutability + Concurrency = Disaster

Mathematical functions does not have

- State

Functional programming

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Data is changed using $\mapsto$ - immutably

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Immutability + concurrency $=$

Functional programming

Mathematical functions does not have

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Data is changed using $\mapsto$ - immutably

Immutability + concurrency = World domination

Higher order functions 2/2

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Part two: Taking functions as input

Higher order functions 2/2

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Part two: Taking functions as input

Where could this be useful?

Higher-order functions in Java 1/2

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```
interface DoSomething {
  void something(int i);
}
```

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interface DoSomething {
  void something(int i);
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```

```
interface List<T> {
  void foreach(DoSomething function);
}
```

Higher-order functions in Java 1/2

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```
interface DoSomething {
  void something(int i);
}
```

```
interface List<T> {
  void foreach(DoSomething function);
}
```

```
  myList.foreach(
    new DoSomething() {
      void something(int i) { return i * 2; }
    }
  );
```

Higher-order functions in Java 2/2

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How many functions can we choose from in `DoSomething`?

Higher-order functions in Java 2/2

How many functions can we choose from in `DoSomething`?

```
@FunctionalInterface
interface DoSomething {
  void something(int i);
}
```

Higher-order functions in Java 2/2

How many functions can we choose from in `DoSomething`?

```
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interface DoSomething {
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Higher-order functions in Java 2/2

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How many functions can we choose from in `DoSomething`?

```
@FunctionalInterface
interface DoSomething {
  void something(int i);
}
```

```
interface List<T> {
  void foreach(DoSomething function);
}
```

```
  myList.foreach(item -> item + 2);
```

Lisp syntax

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Boolean	`T` and `nil`	
Conditional	`(if expr then else)`	`(if (= 0 0) x y)`
Lists	`(list elements)` or	
	`(cons tail)`	`(list 1 2)` or
		`(cons 1 (cons 2 nil))`
Let binding	`(let ((variables))`	
	`(body))`	`(let ((a 10)) a)`
Functions	`(defun name`	
	`(arguments) body)`	`(defun sum (a b) (+ a b)`
Lambda	`(lambda (arguments))`	
	`body`	
		`(lambda (a b) (+ a b))`

Lisp exercise

Clone the `lisp-exercises` from `cphbus-functional-programming`

`https://github.com/cphbus-functional-programming/lisp-exercises`

Work on the `function.lisp` file

Map and flat map

What was common about the exercises?

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What was the input?

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What was the input?

What was the output?

Map and flat map

What was common about the exercises?

What was the input?

What was the output?

This is called **mapping**: $x \mapsto y$

Mapping

Mapping from one side to the other.

$$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \mapsto \begin{bmatrix} 2 \\ 3 \\ 4 \end{bmatrix} \tag{1}$$

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$$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \mapsto \begin{bmatrix} 2 \\ 3 \\ 4 \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \mapsto \begin{bmatrix} 5 \\ 6 \\ 7 \end{bmatrix} \tag{2}$$

Flattening

Flattens a two dimensional list into one dimension

Flat map

Flattens a two dimensional list into one dimension, and uses `map` on the output

Hand-in

Clone the `lisp-exercises` from `cphbus-functional-programming`

`https://github.com/cphbus-functional-programming/lisp-exercises`

Work on the hand-in in the `flatmap.lisp` file.

- Implement a `map` function
- Implement a `flatten` function
- Implement a `flatmap` function