Introduction to Functional Programming in *OCaml*

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Week 3 - Sequence 1: Recursive types









Deep data structures

- ► Some standard data structures like lists and trees have an **unbounded depth**.
- ▶ We cannot define a type for lists because we have only seen "flat" data types.
- ► Informally, a list of integers is **either**:
 - an empty list, or
 - ▶ an integer and the *rest of the list*.
- ▶ We already know how to define a type by cases using sum types.
- ▶ Now, just realize that the "rest of the list" is also a list.

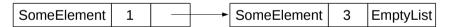
The type for list of integers I

```
type int_list =
    | EmptyList
    | SomeElement of int * int_list;;
# type int_list = EmptyList | SomeElement of int * int_list
```

In the machine

```
► The following value:
SomeElement (1, SomeElement (3, EmptyList));;
```

 \dots implements a **linked list** data structure:



Recursive types

- ► A sum type can refer to itself in its own definition.
- ► Such a sum type is therefore **recursive**.
- ▶ Functions over a recursive type are often defined by case analysis and recursion.

Computing the length of a list I

```
let rec length = function
    | EmptyList -> 0
    | SomeElement (x, 1) -> 1 + length 1;;
# val length : int_list -> int = <fun>
```

A predefined type for lists

▶ The type for lists of elements of type t is predefined in *OCaml* and written:

t list

► The empty list is written:

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- ▶ [] is a special tag corresponding to EmptyList in the previous example.
- \blacktriangleright An integer i followed by the rest of the list r is written:

```
i :: r
```

- ▶ :: is a special tag corresponding to SomeElement.
- ► A list can be defined by enumeration:

```
[ some_expression; ...; some_expression ]
```

Computing the length of a *OCaml* list I

```
let rec length = function
    | [] -> 0
    | x :: xs -> 1 + length xs;;
# val length : 'a list -> int = <fun>
let three = length [1; 2; 3];;
# val three : int = 3
```

Reversing a list in quadratic time I

Reversing a list in linear time I

```
let rec rev_aux accu = function
    | [] -> accu
    | x :: xs -> rev_aux (x :: accu) xs;;

# val rev_aux : 'a list -> 'a list -> 'a list = <fun>
let rev l = rev_aux [] l;;

# val rev : 'a list -> 'a list = <fun>
let l = rev [1; 2; 3];;

# val l : int list = [3; 2; 1]
```

Remove repeated elements I

```
let rec uniq = function
  | [] -> []
  | [x] -> [x]
  | x :: x' :: xs ->
    if x = x, then
    uniq (x' :: xs)
    else
      x :: uniq (x' :: xs);;
# val uniq : 'a list -> 'a list = <fun>
let 11 = uniq [1;2;2;3;4;3];;
# val 11 : int list = [1; 2; 3; 4; 3]
```