

CS 162 Programming Languages

# Lecture 2: OCaml Crash Course I

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# History of ML

- ML = “Meta Language”
- Designed by Robin Milner @ Edinburgh
- Language to manipulate Theorems/Proofs
- Several dialects:
  - Standard” ML (of New Jersey)
  - French dialect with support for objects
  - State-of-the-art
  - Extensive library, tool, user support



# Who are using OCaml



**Bloomberg**



# OCaml vs. C

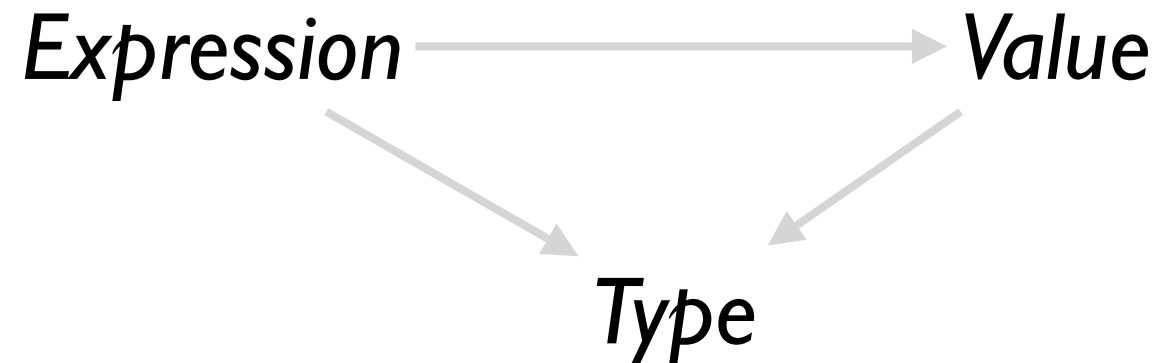
```
void sort(int arr[], int beg, int end){
    if (end > beg + 1){
        int piv = arr[beg];
        int l = beg + 1;
        int r = end;
        while (l != r-1){
            if(arr[l] <= piv)
                l++;
            else
                swap(&arr[l], &arr[r--]);
        }
        if(arr[l]<=piv && arr[r]<=piv)
            l=r+1;
        else if(arr[l]<=piv && arr[r]>piv)
            {l++; r--;}
        else if (arr[l]>piv && arr[r]<=piv)
            swap(&arr[l++], &arr[r--]);
        else
            r=l-1;
        swap(&arr[r--], &arr[beg]);
        sort(arr, beg, r);
        sort(arr, l, end);
    }
}
```

Quicksort in C

```
let rec sort l =
  match l with [] -> []
  | (h::t) ->
    let (l,r) = List.partition ((<=) h) t in
    (sort l)@h::(sort r)
```

Quicksort in Ocaml

# ML's holy grail



- Everything is an expression
- Everything has a value
- Everything has a type

# Interacting with ML

## *“Read-Eval-Print” Loop*

Repeat:

1. System reads expression  $e$
2. System evaluates  $e$  to get value  $v$
3. System prints value  $v$  and type  $t$

*What are these expressions, values and types ?*

# Basic types

# 2;;

2



# 2+3;;

Int

5

---

# "hi";;

"hi"



# "hi,"^"0Caml";;

String

"hi, 0Caml"

---

# true;;

true



# 2>3;;

Bool

false

# Type errors

```
# "Hi," ^ 2;;  
# (2+3) || 9;;
```

Untypable expression is rejected

- No casting or coercing
- Fancy algorithm to catch errors
- ML's single most powerful feature



# Complex types: Lists

List operators:

- Cons (::): “cons” element to a list of same type
- append (@): only append two list of the same type
- Head (List.hd): return the head element of a nonempty list
- Tail (List.tl): return the tail of nonempty list

Syntax:

- Lists = semicolon

Semantics:

- Same type, unbounded number

# Complex types: Tuples

```
# (9-3, "ab"^"cd", (2+2, 7>8));;
```

**(6, "abcd", (4, false))**



**int \* string \* (int \* bool))**

Syntax:

- Lists = comma

Semantics:

- Different type, fixed number

# Variables and bindings

**let**  $x = e$

*“Bind the value of expression  $e$  to the variable  $x$ ”*

```
# let x = 2+2;;  
val x : int = 4
```

# Variables and bindings

Later declared expressions can use x

- Most recent “bound” value used for evaluation

```
# let x = 2+2;;  
val x : int = 4  
# let y = x * x * x;;  
val y : int = 64  
# let z = [x;y;x+y];;  
val z : int list = [4;64;68]
```

# Variables and bindings

Undeclared variables (i.e. without a value binding)  
are not accepted !

```
# let p = a + 1;  
Characters 8-9:  
    let p = a + 1 ;;  
^ Unbound value a
```

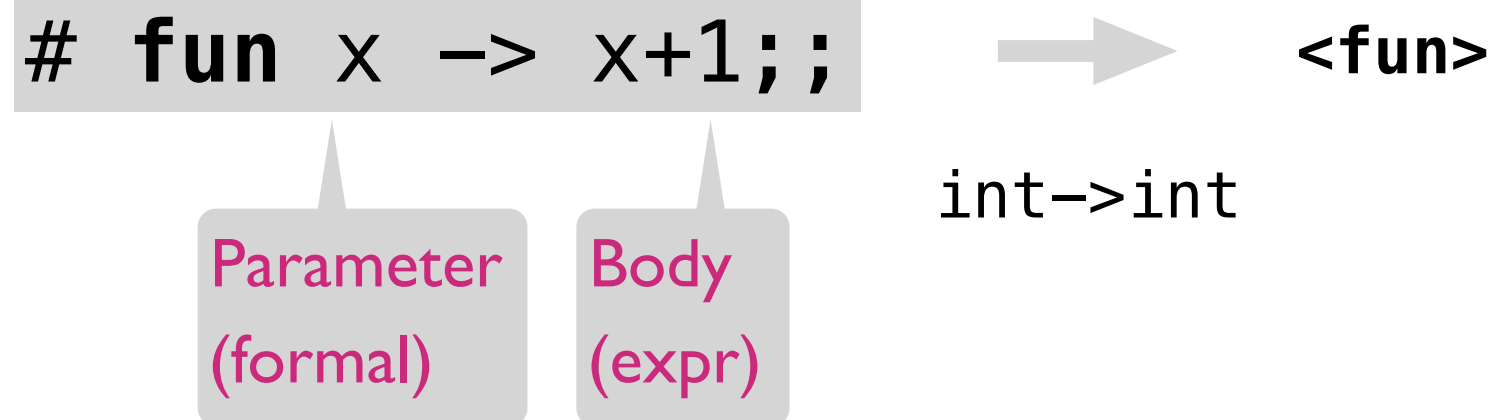
# Local bindings

for expressions using “temporary” variables

```
# let
    tempVar = x + 2 * y
in
    tempVar * tempVar ;;
```

- tempVar is bound only inside expr body from in ... ;;
- Not visible (“in scope”) outside

# Complex types: functions




```
# let inc = fun x -> x+1 ;  
val inc : int -> int = fn  
# inc 0;  
val it : int = 1  
# inc 10;  
val it : int = 11
```

How to evaluate a function app:

- Evaluate the argument
- Bind formal to arg value
- Evaluate the “body expr”

# Complex types: functions

`# fun x -> fun y -> x < y;;`  `<fun>`

`'a -> ('a -> bool)`

Wow! A function can return a function

```
# let lt = fun x -> fun y -> x < y;;  
val lt : 'a -> 'a -> bool = fn  
# let is5Lt = lt 5;  
val is5lt : int -> bool = fn;;  
# is5lt 10;;  
val it : bool = true;  
# is5lt 2;;  
val it : bool = false;
```



# Complex types: functions

**# fun f -> fun x -> not (f x);;**  **<fun>**

**( 'a->bool)->( 'a->bool)**

A function can also take a function argument

```
# let neg = fun f -> fun x -> not (f x);  
val lt : (a -> bool) -> a -> bool = fn  
# let is5gte = neg is5lt;  
val is5gte : int -> bool = fn  
# is5gte 10;  
val it : bool = false;  
# is5gte 2;  
val it : bool = true;
```

# Pattern matching

A pattern matching is somewhat similar to switch statement but offers a lot more expressive power. It really boils down to matching an argument against an exact value, a predicate, or a type constructor.

```
type animal = Dog of string | Cat of string ;;
```

```
let say x =  
    match x with  
    | Dog x -> x ^ " says woof"  
    | Cat x -> x ^ " says meow"  
  
;;  
  
say (Cat "Tom") ;; (* "Tom says meow". *)
```

# Put it together: a “filter” function

If arg matches  
this pattern

then use this  
body expr

```
# let rec filter f l =  
  match l with  
  | [] -> []  
  | (h::t)-> if f h then h::(filter f t)  
              else (filter f t);;  
  
val filter : ('a -> bool) -> 'a list -> 'a list = <fun>  
  
# let list1 = [1;31;12;4;7;2;10];;  
# filter is5lt list1 ;;  
val it : int list = [31;12;7;10]
```

# Put it together: a “quicksort” function

```
# let partition f l = (filter f l, filter (neg f) l);;  
val partition : ('a->bool)->'a list->'a list * 'a list = fn  
# let list1 = [1;31;12;4;7;2;10];  
# partition is5lt list1 ;  
val it : (int list * int list) = ([31;12;7;10],[1;4;2])
```

```
# let rec sort l =  
    match l with  
    [] -> []  
  | (h::t) ->  
    let (l,r) = partition ((<) h) t in  
    (sort l)@(h::(sort r)) ;;
```

# TODOs by next lecture

- Get familiar with OCaml
- Come to the discussion session if you are new to OCaml