CS 162 Programming Languages

Lecture 3: OCaml Crash Course II

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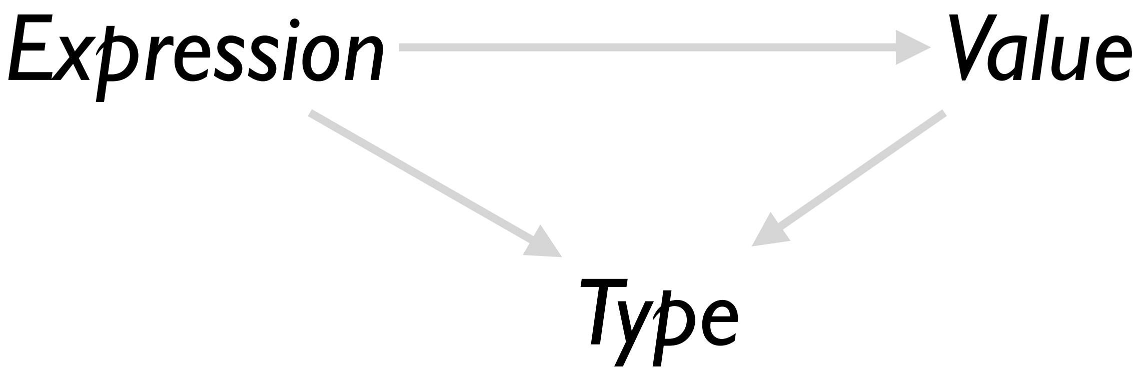
Outline for today

- Data types
- Pattern matching

ML’s holy grail



Expression

Value

Type

- Simple
- Variables
- Functions

Building datatypes

Three key ways to build complex types/values

- "Each-of" types:

  Value of T contains value of T1 and a value of T2

- "One-of" types:

  Value of T contains value of T1 or a value of T2

- "Recursive"

  Value of T contains (sub)-value of same type T

One-of types

We’ve defined a “one-of” type named attrib

Elements are one of:

- string
- `int`
- `int*int*int`
- float
- bool

```
type attrib =
  Name of string
| Age of int
| DOB of int*int*int
| Address of string
| Height of real
| Alive of bool
| Phone of int*int
| Email of string;
```

Each-of types

We've defined a "Each-of" type (i.e., product type) named "DOB" attrib is the composition of three ints:

- `int*int*int`

```
type attrib =
  Name of string
| DOB of int*int*int
```

Test & Take whats in box?

Is it a …
string?
or an int?
or …

Check the TAG!

Whats in the box

```
type attrib =
  Name of string
| Age of int
| DOB of int*int*int
| Address of string
| Height of real
| Alive of bool
| Phone of int*int
| Email of string;
```

```
match e with
| Name s -> printf "%s" s
| Age i -> printf "%d" i
| DOB(d,m,y) -> printf "%d/%d/%d" d m y
| Address s -> printf "%s" s
| Height h -> printf "%f" h
| Alive b -> printf "%b" b s
| Phone(a,r) -> printf "(%d)-%d" a r
```

Pattern-match expression: check if e is of the form …

- On match:
  - value in box bound to pattern variable
  - matching result expression is evaluated
- Simultaneously test and extract contents of box

Beware to handle all tags!

```
# match (Name “Bob”) with
| Age i -> Printf.printf "%d" I
| Email s -> Printf.printf "%s" s ;;

Exception: Match Failure!!
```

None of the cases matched the tag (Name)
Causes nasty Run-Time Error!

Compiler to rescue!

```
# # let printAttrib a = match a with
| Name s -> Printf.printf "%s" s
| Age i -> Printf.printf "%d" I
| DOB (d,m,y) -> Printf.printf "%d / %d / %d" d m y
| Address addr -> Printf.printf "%s" addr
| Height h -> Printf.printf "%f" h
| Alive b -> Printf.printf "%b" b
| Email e -> Printf.printf "%s" e
;;
Warning P: this pattern-matching is not
exhaustive.Here is an example of a value that is
not matched:Phone (_, _)
```

Compile-time checks for:
missed cases: ML warns if you miss a case!

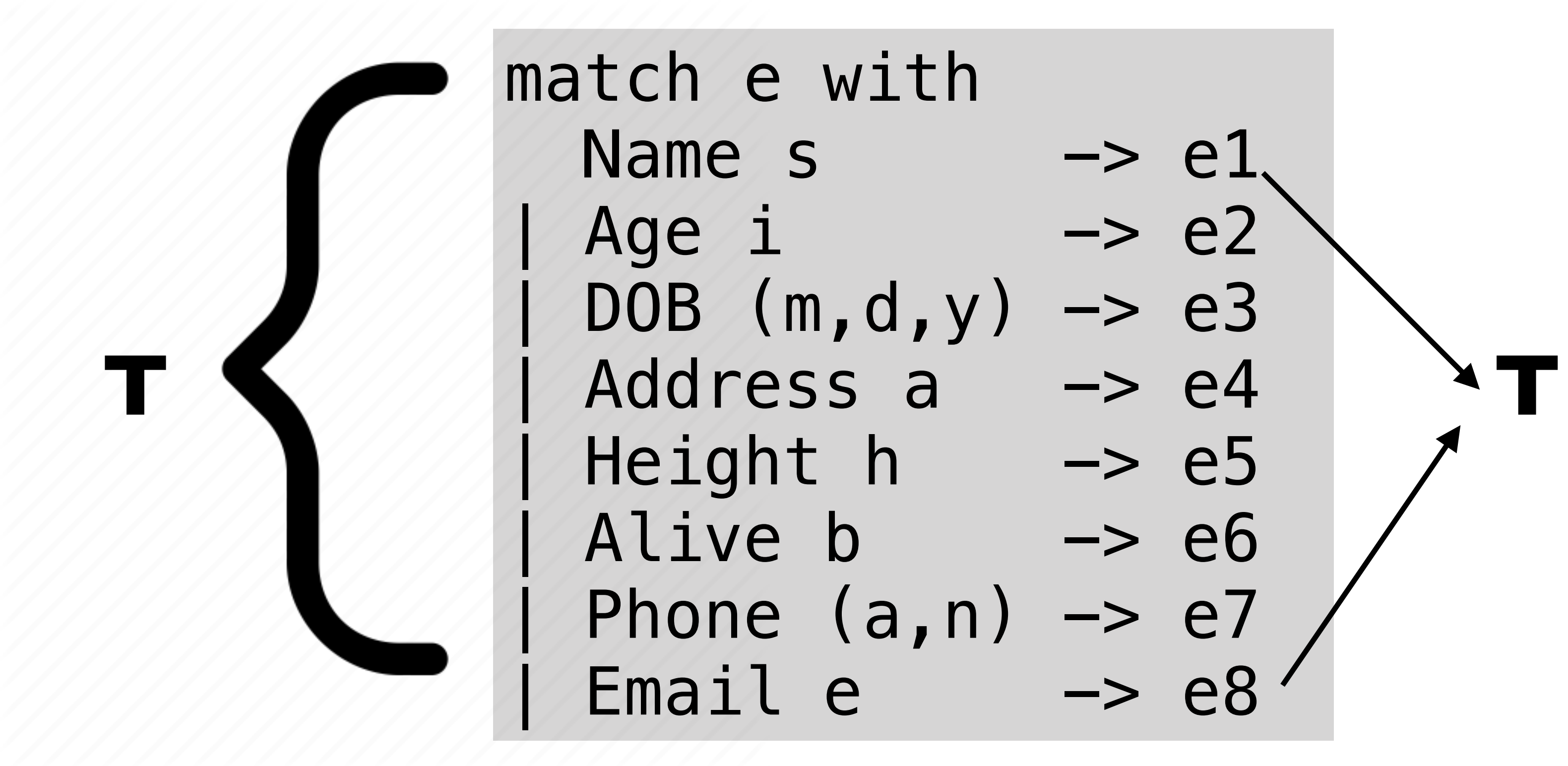
match-with is an Expression

```
match e with
  C1 x1 -> e1
| C2 x2 -> e2
| …
| Cn xn -> en
```

Type Rule

- e1, e2,…,en must have same type T
- Type of whole expression is T

match-with is an Expression



```
match e with
  Name s        -> e1
| Age i         -> e2
| DOB (m,d,y)   -> e3
| Address a     -> e4
| Height h      -> e5
| Alive b       -> e6
| Phone (a,n)   -> e7
| Email e       -> e8
```

Type Rule

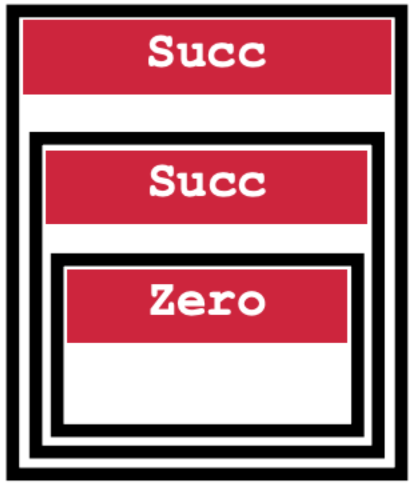
- e1, e2,…,en must have same type T
- Type of whole expression is T

Recursive types

```
type nat = Zero | Succ of nat
```

What are values of nat ?
One nat contains another!

nat = recursive type



plus: nat*nat -> nat

```
type nat =
| Zero
| Succ of nat
```

Base pattern

Inductive pattern

```
let rec plus n m =
match m with
| Zero -> n
| Succ m’ -> Succ (plus n m’)
```

Base pattern

Base expression

Inductive pattern

Inductive expression

List datatype

```
type int_list =
  Nil
| Cons of int * int_list
```

Lists are a derived type: built using elegant core!

1. Each-of
2. One-of
3. Recursive

:: is just a syntactic sugar for “Cons”
[] is a syntactic sugar for “Nil”

List function: length

```
let rec len l =
  match l with
  | Nil -> 0
  | Cons(h,t) -> 1 + (len t)
```

Base pattern

Base expression

Inductive pattern

Inductive expression

List function: list_max

```
let rec list_max l =
    match l with
    | Nil -> 0
    | Cons(h,t) -> max h (list_max t)
```

Base pattern

Base expression

Inductive pattern

Inductive expression

```
let max x y = if x > y then x else y;;
```

Option types

```
type 'a option = Some of 'a | None

type 'a btree = {
  value : 'a;
  left :  'a btree option;
  right : 'a btree option;
}

match tree with
    | None -> []
    | Some node -> …
```

an option type is a built-in data type that represents a value that can either be present or absent. It's a way to safely handle cases where a value might be missing, rather than using something like null (which can lead to runtime errors).

TODOs by next lecture

- Come to the discussion session if you have questions
- Start to work on HW1