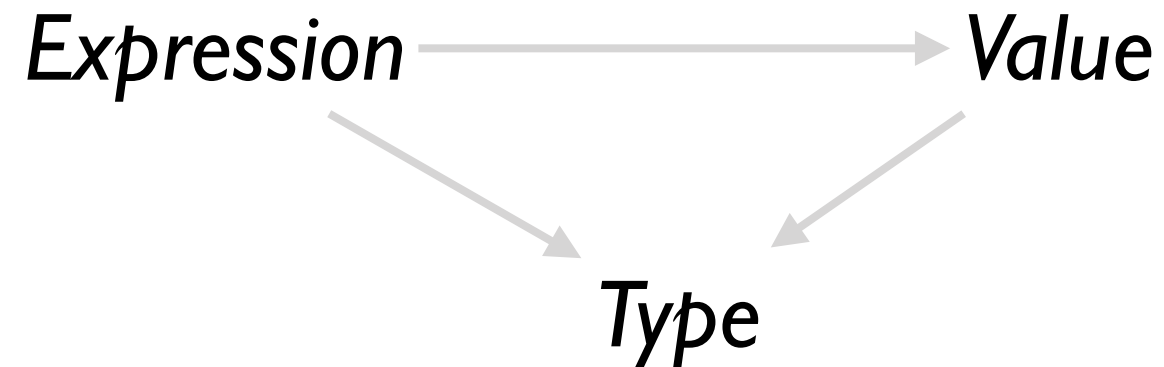


CS 162 Programming languages

Lecture 5: Datatypes

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ML's holy grail



- 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;
```

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  
| 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!

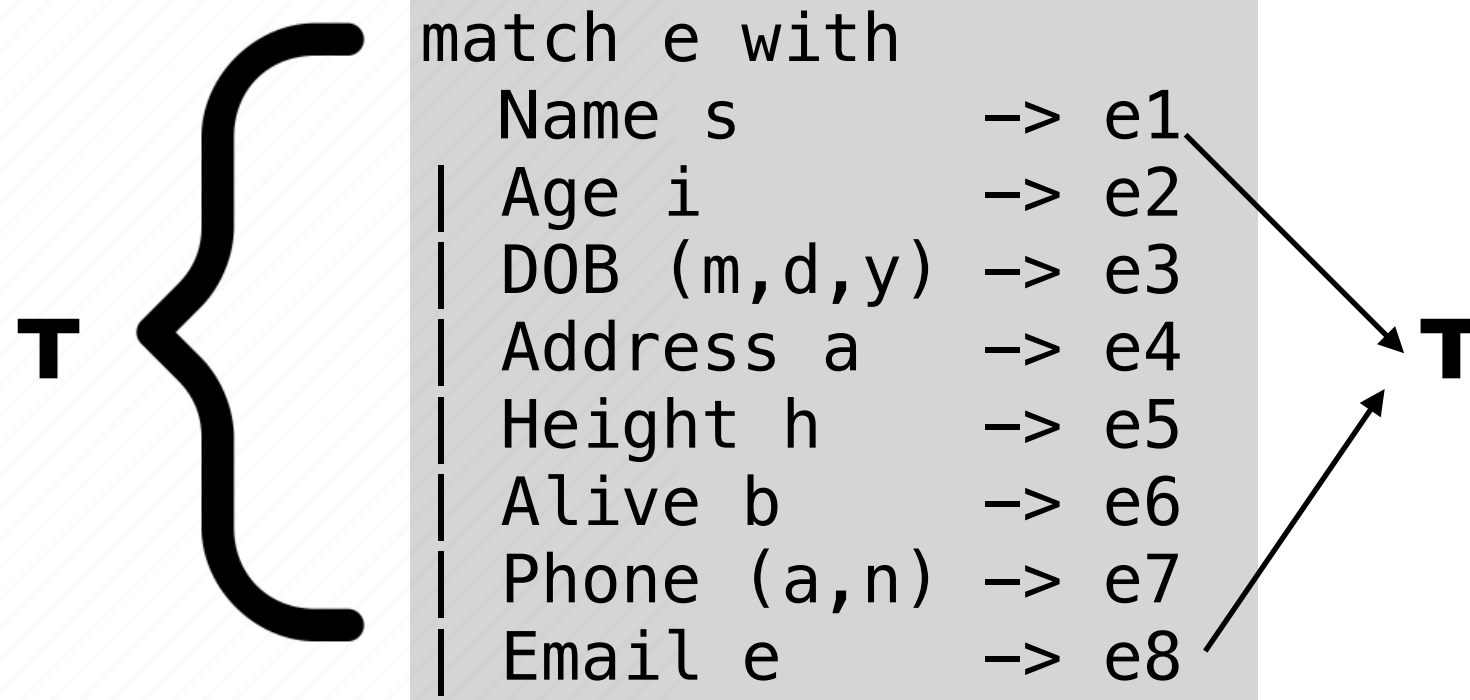
match-with is an Expression

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

Type Rule

- e_1, e_2, \dots, e_n must have same type T
- Type of whole expression is T

match-with is an Expression



Type Rule

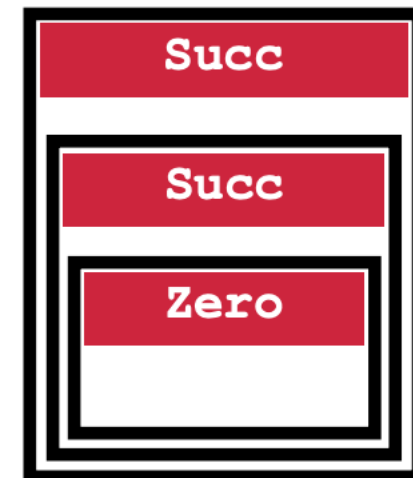
- e_1, e_2, \dots, e_n must have same type **T**
- Type of whole expression is **T**

Recursive types

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

What are values of nat ?
One nat contains another!

nat = recursive type



plus: nat*nat -> nat

Base pattern
Inductive pattern

```
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 expression

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  
    Base pattern | Nil -> 0 Base expression  
    Inductive pattern | Cons(h,t) -> 1 + (len t)  
                                Inductive expression
```

List function: list_max

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

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

TODOs by next lecture

- Hw1 will be due next week
- Hw2 is out
- Come to the discussion session if you have questions