

Ocaml

KOSMOS

앞으로 2주 동안 쓸 언어

$$\begin{array}{l} F \rightarrow E \\ E \rightarrow n \\ \quad | \ x \\ \quad | \ true \\ \quad | \ false \\ \quad | \ E + E \\ \quad | \ E - E \\ \quad | \ E * E \\ \quad | \ E / E \\ \quad | \ iszero\ E \\ \quad | \ if\ E\ then\ E\ else\ E \\ \quad | \ let\ [rec]\ x = E\ in\ E \\ \quad | \ fun\ x \rightarrow E \\ \quad | \ E\ E \\ \quad | \ read \end{array}$$

앞으로 2주 동안 쓸 언어

$$\frac{\rho \vdash E_1 \Rightarrow v' \quad [x \mapsto v']\rho \vdash E_2 \Rightarrow v}{\rho \vdash \text{let } x = E_1 \text{ in } E_2 \Rightarrow v}$$

$$\frac{\rho \vdash E_1 \Rightarrow (x', E', \rho') \quad [x \mapsto (x, x', E', \rho')]\rho \vdash E_2 \Rightarrow v}{\rho \vdash \text{let rec } x = E_1 \text{ in } E_2 \Rightarrow v}$$

$$\frac{\rho \vdash E_1 \Rightarrow v' \quad [x \mapsto v']\rho \vdash E_2 \Rightarrow v}{\rho \vdash \text{let rec } x = E_1 \text{ in } E_2 \Rightarrow v}$$

이 프로그램의 문제점이 무엇일까요?

```
let a = read in  
let f = fun x -> if iszero x then false else x - 1 in  
1 + f a
```

```
> 1
```

```
1
```

이 프로그램의 문제점이 무엇일까요?

```
let a = read in  
let f = fun x -> if iszero x then false else x - 1 in  
1 + f a
```

> 0

Fatal error: exception Eval.UndefinedSemantics

Dynamic Property

프로그램이 실행되는 과정에서 결정되는 성질

Static Property

프로그램이 실행되기 전에 결정되는 성질

Dynamic Property: Type

```
let a = read in  
let f = fun x -> if iszero x then false else x - 1 in  
1 + f a
```

f a 의 타입?

- int
- bool

Static Property: Type

```
let a = read in  
let f = fun x -> if iszero x then false else x - 1 in  
1 + f a
```

f a 의 타입?

- type error

타입

$$\begin{array}{l} T \rightarrow int \\ | \quad bool \\ | \quad T \rightarrow T \end{array}$$

$$\Gamma : Var \rightarrow T$$

$$\Gamma \vdash e : t$$

Typing Rule

$$\overline{\Gamma \vdash n : \text{int}} \quad \overline{\Gamma \vdash x : \Gamma(x)} \quad \overline{\Gamma \vdash \text{true} : \text{bool}} \quad \overline{\Gamma \vdash \text{false} : \text{bool}} \quad \overline{\Gamma \vdash \text{read} : \text{int}}$$

$$\frac{\Gamma \vdash E_1 : \text{int} \quad \Gamma \vdash E_2 : \text{int}}{\Gamma \vdash E_1 + E_2 : \text{int}} \quad \frac{\Gamma \vdash E_1 : \text{int} \quad \Gamma \vdash E_2 : \text{int}}{\Gamma \vdash E_1 - E_2 : \text{int}} \quad \frac{\Gamma \vdash E_1 : \text{int} \quad \Gamma \vdash E_2 : \text{int}}{\Gamma \vdash E_1 * E_2 : \text{int}} \quad \frac{\Gamma \vdash E_1 : \text{int} \quad \Gamma \vdash E_2 : \text{int}}{\Gamma \vdash E_1 / E_2 : \text{int}}$$

$$\frac{\Gamma \vdash E : \text{int}}{\Gamma \vdash \text{iszero } E : \text{bool}} \quad \frac{\Gamma \vdash E_1 : \text{bool} \quad \Gamma \vdash E_2 : t \quad \Gamma \vdash E_3 : t}{\Gamma \vdash \text{if } E_1 \text{ then } E_2 \text{ else } E_3 : t}$$

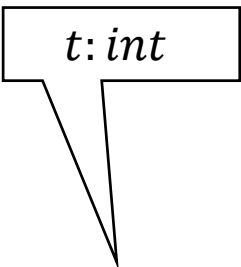
$$\frac{\Gamma \vdash E_1 : t_1 \quad [x \mapsto t_1] \Gamma \vdash E_2 : t_2}{\Gamma \vdash \text{let } x = E_1 \text{ in } E_2 : t_2} \quad \frac{[x \mapsto t_1] \Gamma \vdash E_1 : t_1 \quad [x \mapsto t_1] \Gamma \vdash E_2 : t_2}{\Gamma \vdash \text{let rec } x = E_1 \text{ in } E_2 : t_2}$$

$$\frac{[x \mapsto t_1] \Gamma \vdash E : t_2}{\Gamma \vdash \text{fun } x \rightarrow E : t_1 \rightarrow t_2} \quad \frac{\Gamma \vdash E_1 : t_1 \rightarrow t_2 \quad \Gamma \vdash E_2 : t_1}{\Gamma \vdash E_1 E_2 : t_2}$$

이 프로그램의 타입은

$$\begin{array}{c}
 \boxed{t: \text{int}} \qquad \boxed{\text{bool} \neq \text{int}} \\
 \begin{array}{c}
 \hline \Gamma \vdash x: \text{int} \\
 \hline \Gamma \vdash \text{iszero } x: \text{bool} \quad \Gamma \vdash \text{false}: \text{bool} \quad \frac{\Gamma \vdash x: \text{int} \quad \Gamma \vdash 1: \text{int}}{\Gamma \vdash x - 1: \text{int}} \\
 \hline [x \mapsto t] \Gamma \vdash \text{if iszero } x \text{ then false else } x - 1: \\
 \hline \Gamma \vdash \text{fun } x \rightarrow \text{if iszero } x \text{ then false else } x - 1: \\
 \hline \vdots \\
 \hline \Gamma \vdash \text{read}: \text{int} \quad \text{let } f = \\
 [a \mapsto \text{int}] \Gamma \vdash \text{fun } x \rightarrow \text{if iszero } x \text{ then false else } x - 1 \text{ in } 1 + f \ a : \\
 \hline \text{let } a = \text{read in} \\
 [] \vdash \text{let } f = \text{fun } x \rightarrow \text{if iszero } x \text{ then false else } x - 1 \text{ in } 1 + f \ a
 \end{array}
 \end{array}$$

이 프로그램의 타입은


$$\frac{\frac{\frac{\Gamma \vdash x: int}{[x \mapsto t]\Gamma \vdash x + 1: int} \quad \Gamma \vdash 1: int}{\Gamma \vdash fun\ x \rightarrow x + 1: int \rightarrow int} \quad \Gamma \vdash 1: int}{[] \vdash (fun\ x \rightarrow x + 1)(1): int}$$