Programming Languages and Techniques (CIS120)

Lecture 3

January 19th 2016

Lists and Recursion

Announcements

- Recitations start today!
- Homework 1: OCaml Finger Exercises
  - Due: Tuesday 1/26 at midnight
- Clickers: attendance grades start Friday
  - Quizzes: TP160116
- Reading: Please read Chapter 3 of the course notes, available from the course web pages
  - And chapters 1 and 2, if you haven’t yet!
- Questions?
  - Post to Piazza (privately if you need to include code!)
  - Look at HW1 FAQ
- TA office hours: on course Calendar webpage

Have you successfully installed OCaml on your laptop?

1) Yes

2) No

Have you started working on HW 01?

1) Yes
2) No

What is an OCaml module?

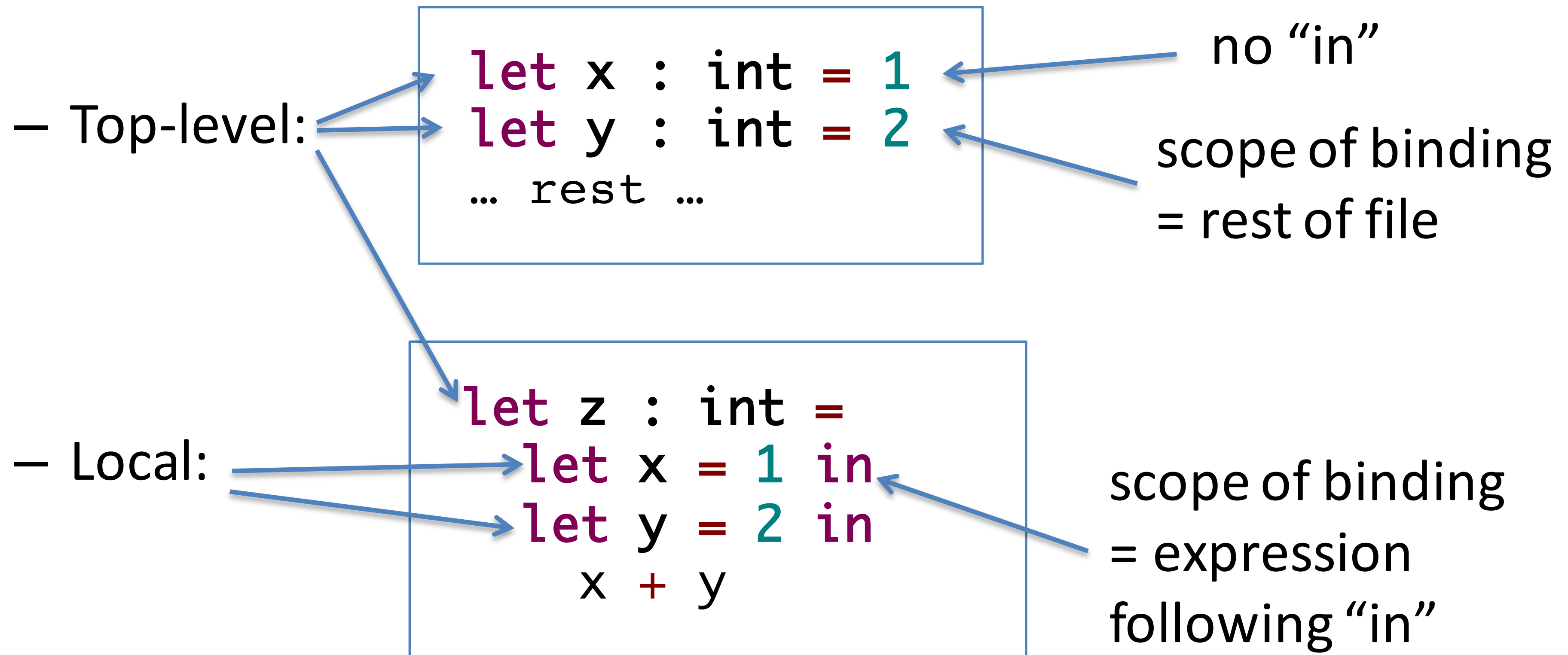
```
;; open Assert

let attendees (price:int) :int =
  (-15 * price) / 10 + 870

let test () : bool =
   attendees 500 = 120

;; run_test "attendees at 5.00" test

let x : int = attendees 500

;; print_int x
;; print_endline "end of demo"
```

Toplevel items:

- Declarations (start with let)
  - Identifiers
  - Functions
- Commands (start with ;;)
  - module imports
  - run_test
  - printing

Summary of 'let' Syntax

- OCaml offers two forms of 'let' declarations:



What is the value computed for ‘answer’ in the following program? (0 .. 9)

```
let answer : int =
  let x = 1 in
  let y = x + x in
  x + y
```

```
let answer : int =
  let y = 1 + 1 in
  1 + y
```

```
let answer : int =
  let y = 2 in
  1 + y
```

```
let answer : int =
  1 + 2
```

```
let answer : int =
  3
```

What is the value computed for 'answer' in the following program? (0 .. 9)

```
let answer : int =
  let x = 1 in
  let y = x + x in
  let x = 2 in
  x + y
```

```
let answer : int =
  let y = 1 + 1 in
  let x = 2 in
```

```
let answer : int =
  let y = 2 in
  let x = 2 in
```

```
let answer : int =
  let x = 2 in
```

```
let answer : int =
  2 + 3
```

(Top-level) Function Declarations

function name parameter names parameter types

```
let total_secs (hours:int)
               (minutes:int)
               (seconds:int)
             : int =
  (hours * 60 + minutes) * 60 + seconds
```

result type

function body (an expression)

Function Calls

Once a function has been declared, it can be invoked by writing the function name followed by a list of arguments. This is a *function application* expression.

```
total_secs 5 30 22
```

(Note that the list of arguments is *not* parenthesized.)

Calculating With Functions

- To calculate the value of a function application, first calculate values for its arguments and then *substitute* them for the parameters in the body of the functions.

```
  total_secs (2 + 3) 12 17
⟼ total_secs 5 12 17
⟼ (5 * 60 + 12) * 60 + 17      subst. the args in the body
⟼ (300 + 12) * 60 + 17
⟼ 312 * 60 + 17
⟼ 18720 + 17
⟼ 18737
```

```
let total_secs (hours:int)
               (minutes:int)
               (seconds:int)
             : int =
(hours * 60 + minutes) * 60 + seconds
```

Working with lists

A Design Problem / Situation

Suppose we are asked by Penn to design a new email system for notifying instructors and students of emergencies or unusual events.

What should we be able to do with this system?
Subscribe students to the list, query the size of the list, check if a particular email is enrolled, compose messages for all the list, filter the list to just students, etc.

Slatest YOUR NEWS COMPANION JAN. 19 2016 12:43 PM

This "Blizzard for the Ages" Headed for the East Coast Is Very Much the Real Deal

By Eric Holthaus

Snow certain; how much is question

1 to 2 feet of snow possible this weekend

Milk, bread, eggs stocked ahead of snowstorm

Design Pattern

1. Understand the problem

   What are the relevant concepts and how do they relate?

2. Formalize the interface

   How should the program interact with its environment?

3. Write test cases

   How does the program behave on typical inputs? On unusual ones? On erroneous ones?

4. Implement the behavior

   Often by decomposing the problem into simpler ones and applying the same recipe to each

1. Understand the problem

How do we store and query information about email addresses?

Important concepts are:

1. An email list (collection of email addresses)
2. A fixed collection of *instructor_emails*
3. Being able to *subscribe* students & instructors to the list
4. Counting the *number_of_emails* in a list
5. Determining whether a list *contains* a particular address
6. Given a message to send, *compose* messages for all the email addresses in the list
7. *remove_instructors*, leaving an email list just containing the list of enrolled students

2. Formalize the interface

- Represent an email by a *string* (the email address itself)
- Represent an email list using an *immutable list of strings*
- Represent the collection of instructor emails using a *toplevel definition*

```
let instructor_emails : string list = …
```

- Define the interface to the functions:

```
let subscribe (email : string)
              (lst : string list) : string list = …

let length (lst : string list) : int = …

let contains (lst : string list) (email : string) : bool =
…
```

3. Write test cases

```
let l1 : string list = [ “sweirich@cis.upenn.edu”;
                         “mattch@seas.upenn.edu”;
                         “maxmcc@sas.upenn.edu” ]
let l2 : string list = [ “mattch@seas.upenn.edu” ]
let l3 : string list = []

let test () : bool =
  (length l1) = 3
;; run_test “length l1” test

let test () : bool =
  (length l2) = 1
;; run_test “length l2” test

let test () : bool =
  (length l3) = 0
;; run_test “length p3” test
```

Define email lists for testing. Include a variety of lists of different sizes and incl. some instructor and non-instructor emails as well.

Interactive Interlude

email.ml