

## CSE 341: Programming Languages

Spring 2006

Lecture 10 — “Objects” in ML; Mutual Recursion

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### Provide an ADT

A record of functions is much like an object.

Free variables are private variables.

See the “set” example below & in code.

```
datatype set = S of {add:int -> set, member:int -> bool}  
val empty_set = fn : unit -> set
```

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### Key idioms with closures

- Create similar functions
- Pass functions with private data to iterators (map, fold, ...)
- Combine functions
- Provide an ADT
- As a *callback* without the “wrong side” specifying the environment.
- Partially apply functions (“currying”)

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### Callbacks

A common idiom: Library takes a function to apply later, when an *event* occurs. Examples:

- When a key is pressed, a mouse moved, etc.
- When a packet arrives from the network

The function may be a filter (“I want the packet”) or return a result (“draw a line”), etc.

Library may accept multiple callbacks. Different callbacks may need different private state with different types.

Fortunately, the type of a function does not depend on the type of free variables.

Note: This is why Java added anonymous inner classes (for “event listeners”).

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## Mutual Recursion

We haven't yet seen how multiple functions can recursively call each other? (Why can't we do this with what we have?)

ML uses the keyword `and` to provide different *scope* rules. Example:

```
fun even i = if i=0 then true  else odd  (i-1)
and odd  i = if i=0 then false else even (i-1)
```

Roughly extends the binding form for functions from `fun f1 x1 = e1 to fun f1 x1 = e1 and f2 x2 = e2 and ... and fn xn = en.`

Actually, you can have `val` bindings too, but bindings being defined are in scope only inside function bodies. (Why?)

Syntax gotcha: Easy to forget that you write `and fi xi = ei`, not `and fun fi xi = ei`.

## Mutual Recursion Idioms

1. Encode a state machine (see `product_sign` example)
  - Sometimes easier to understand than explicit state values.
2. Process mutually recursive types, example:

```
datatype webtext = Empty
                | Link of webpage * string * webtext
                | Word of string * webtext
and webpage = Found of string * webtext
            | Unfound of string
```

A function "crawl for word" is inherently mutually recursive. (You could make a datatype for "webtext or webpage", but that's ugly.)

Problem: the Web has *cycles*, which (sigh) is a common need for mutation in ML.

Unproblem: When crawling, we don't want cycles (use Unfound if we have seen the page before).