

CSE 341: Programming Languages

Winter 2005

Lecture 9— ADTs, Callbacks, and Currying

Key idioms with closures

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

Provide an ADT

A record of functions is much like an object.

Free variables are private variables.

Our “set” example is fancy stuff, but you should be able to understand it.

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

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”).

Callback example (with mutable state!)

Library interface:

```
datatype action = ...  
fun register_callback : ((int -> bool),action) -> unit
```

Library implementation (mutation, but hidden from clients)

```
val cbs : (int -> bool) list ref = ref []  
fun register_callback f = cbs := f::(!cbs)  
fun on_event i =  
  let fun f l =  
        case l of  
          [] => []  
        | (f,a)::tl =>  
            if (f i) then a::(f tl) else inner tl  
        in f (!cbs) end
```

Example continued

Clients (kind of pseudocode):

```
register_callback ((fn i => true),    Log ...)  
register_callback ((fn i => i = 80), Http_get ...)  
fun in_lst j =  
  case lst of [] => false | hd::tl => hd=j orelse in_lst tl  
register_callback (in_lst, Other ...)
```

Key point: client functions can use client-defined data, without library knowing anything about that data

Partial application (“currying”)

Recall every function in ML takes exactly one argument.

Previously, we simulated multiple arguments by using one n-tuple argument.

Another way: take one argument and return a function that takes another argument and ...

This is called “currying” after its inventor, Haskell Curry

Example:

```
val inorder3 = fn x => fn y => fn z =>
                z >= y andalso y >= x
((inorder3 4) 5) 6
inorder3 4 5 6
val is_pos = inorder3 0 0
```

More currying idioms

Currying is particularly convenient when creating similar functions with iterators:

```
fun fold_old (f,acc,l) =
  case l of
    []      => acc
  | hd::tl => fold_old (f, f(acc,hd), tl)
fun fold_new f = fn acc => fn l =>
  case l of
    []      => acc
  | hd::tl => fold_new f (f(acc,hd)) tl
fun sum1 l = fold_old ((fn (x,y) => x+y), 0, l)
val sum2 = fold_new (fn (x,y) => x+y) 0
```

There's even convenient syntax: `fun fold_new f acc l = ...`

Currying vs. Pairs

Currying is elegant, but a bit backward: the function writer chooses which *partial application* is most convenient.

Of course, it's easy to write wrapper functions:

```
fun other_curry1 f = fn x => fn y => f y x
```

```
fun other_curry2 f x y = f y x
```

```
fun curry f x y = f (x,y)
```

```
fun uncurry f (x,y) = f x y
```

Digression: There's something really, really intriguing about the types of `curry` and `uncurry` if you pronounce `->` as *implies* and `*` as *and*.

Function-Call Efficiency

First: Function calls take constant ($O(1)$) time, so until you're using the right algorithms and have a critical *bottleneck*, forget about it.

That said, ML's "all functions take one argument" can be inefficient in general:

- Create a new n -tuple
- Create a new function closure

In practice, implementations *optimize* common cases. In some implementations, n -tuples are faster (avoid building the tuple). In others, currying is faster (avoid building intermediate closures).

In the < 1 percent of code where detailed efficiency matters, you program against an implementation. Bad programmers worry about this stuff at the wrong stage and for the wrong code.