Last time: Type-directed coding

Common idea in functional programming: “lifting”

```ml
val lift : forall 'a . ('a -> bool) -> ('a list -> bool)
fun lift p [] = false
  | lift p (z::zs) = p z orelse lift p zs
```
Types and their C constructs

<table>
<thead>
<tr>
<th>Type</th>
<th>Produce</th>
<th>Consume</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>struct</code></td>
<td>&quot;initializer&quot;</td>
<td>dot notation</td>
</tr>
<tr>
<td></td>
<td>{ . . . , . . . }</td>
<td><code>e.next, e-&gt;next</code></td>
</tr>
<tr>
<td><code>pointer</code></td>
<td>&amp;</td>
<td>*</td>
</tr>
<tr>
<td><code>function</code></td>
<td>(definition form)</td>
<td>application</td>
</tr>
</tbody>
</table>
Types and their ML constructs

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<th>Type</th>
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<tr>
<td>arrow</td>
<td>Lambda (fn)</td>
<td>Application</td>
</tr>
<tr>
<td>constructed (algebraic)</td>
<td>Apply constructor</td>
<td>Pattern match</td>
</tr>
<tr>
<td>constructed (tuple)</td>
<td>(e₁, ..., eₙ)</td>
<td>Pattern match!</td>
</tr>
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</table>
Type this: Language of expressions

Numbers and Booleans:

datatype exp = ARITH of arithop * exp * exp
    | CMP of relop * exp * exp
    | LIT of int
    | IF of exp * exp * exp

and arithop = PLUS | MINUS | TIMES | ...
and relop = EQ | NE | LT | LE | GT | GE

datatype ty = INTTY | BOOLTY

Problem to solve: integer register or flags register?
Type checking in ML (no variables!)

val typeof : exp -> ty
exception IllTyped
fun typeof (ARITH (_, e1, e2)) =
  (case (typeof e1, typeof e2)
   of (INTTY, INTTY) => INTTY
   | _ => raise IllTyped)
| typeof (CMP (_, e1, e2)) =
  (case (typeof e1, typeof e2)
   of (INTTY, INTTY) => BOOLTY
   | _ => raise IllTyped)
| typeof (LIT _) = INTTY
| typeof (IF (e,e1,e2)) =
  (case (typeof e, typeof e1, typeof e2)
   of (BOOLTY, tau1, tau2) =>
     if eqType (tau1, tau2)
     then tau1 else raise IllTyped
   | _ => raise IllTyped)