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Objects

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Objectives

You should be able to ...

In this lecture, we extend the idea of local state from last time to create a simple implementation of objects and discuss its limitations. We will also show the message dispatch model of objects, which allows for inheritance and virtual functions. Your objectives:

- ▶ Be able to explain what an object is.
- ▶ Implement an object using records and HOFs.
- ► Implement an object using a message dispatcher.





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Preliminaries

▶ We will use the following functions during our discussion:

Point

Here is an example of a point using local state.

- ▶ This defines a tuple of functions that share a common state.
- ▶ It is cumbersome to use.

```
let (lref,getx,gety,show,move) = mktPoint (2,4);;
```





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Improvement: Use Records

```
type point = {
  loc : (int * int) ref; getx : unit -> int;
   gety : unit -> int; draw : unit -> unit;
  move : int * int -> unit;
5}
6 let mkrPoint newloc =
    let myloc = ref newloc in
    { loc = myloc;
      getx = (fun () -> pi1 !myloc);
     gety = (fun () -> pi2 !myloc);
      draw = (fun () -> report !myloc);
      move = (fun dl -> myloc := movept !myloc dl)}
```

Adding Self

By the way, this lecture is really about recursion.

```
let mkPoint newloc =
2 let rec this =
 { loc = ref newloc;
    getx = (fun () -> pi1 !(this.loc));
    gety = (fun () -> pi2 !(this.loc));
    draw = (fun () -> report !(this.loc));
    move = (fun dl ->
             this.loc := movept !(this.loc) dl)}
9 in this;;
```

We can store "this" explicitly in the record if we want.



Local State Dispatching

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Real Life

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Message Dispatching

Last time we said that an object is a kind of data that can receive messages from the program or other objects.

- ► Q: How do we normally represent messages?
- ► A: With strings!

Let a point object be a function that takes a string and returns an appropriate function matching that string.

Question: Suppose p is our point object. What will be its type?

mkPoint

```
let mkPoint x y =
  let x = ref x in
  let y = ref y in
  fun st ->
     match st with
    | "getx" -> (fun _ -> !x)
     | "gety" -> (fun -> !y)
     | "movx" \rightarrow (fun nx \rightarrow x := !x + nx; nx)|
     | "movy" -> (fun ny -> y := !y + ny; ny)
     -> raise (Failure "Unknown message.")
```

All methods now have to have type int -> int.





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Subclassing

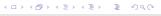
- ► Warmup exercise: How would we add a report method?
- ► Another one: How would we add this support?

Let's say we want a fastpoint, which moves twice as fast as the original point. What does it mean for fastpoint to be a *subclass* of point?

- fastpoint should respond to the same messages.
 - It may override some of them.
 - lt may add its own.
 - lt may **not** remove any methods.
- ▶ The fastpoint object will need access to some of the data in point.

Implementing

- ► Two entities involved: the superclass (point) and the subclass (fastpoint)
- ▶ fastpoint needs to create an instance of point.
- point construction needs to return the "public" data to fastpoint.
- ► fastpoint returns a dispatcher:
 - ▶ If the fastpoint dispatcher can handle a message, it does.
 - ▶ Otherwise, it sends the message to point.





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Code: point

Code: fastpoint

```
1 let mkFastpoint x y =
2  let ((x,y),super) = mkSuperPoint x y in
3  fun st ->
4  match st with
5  | "movx" -> (fun nx -> x := !x + 2 * nx; nx)
6  | "movy" -> (fun ny -> y := !y + 2 * ny; ny)
7  | _ -> super st;;
```

- ► This technique is flexible; we can add methods very easily.
- ▶ But it's also slow. Imagine if we had a chain of 20 classes!

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C++

- Methods and variables are kept in a table: a fixed location.
- "this" is an implicit argument, allowing only one copy of the function to be needed.
- ▶ Virtual methods are kept in a *vtable*, which counts as local data.

Vtable for point:

| movx | pointer to point.movx | movy | pointer to point.movy |
| (fastpoint vtable is similar.) getx, etc. is static.

Discussion

- ▶ Other languages (i.e., smalltalk) use a technique very similar to this one.
- ▶ Java uses the "every object is of type Object" technique.
- ► A strong type system makes it somewhat cumbersome to simulate objects. You either have to:
 - b define a new type to encompass all objects, or
 - ▶ force all methods to have the same type.
- ► Important concept: *polymorphism* when functions can operate on multiple types. (This is different than *overloading* when multiple functions exist with the same name, but different inputs.)



