

Object-Oriented Programming

Lecture 16

CS 565

4/10/08

Object-Based Programming

- View basic features found in object-based systems:
 - objects
 - dynamic dispatch
 - encapsulation of state
 - inheritance
 - self-reference (self/this)
 - late binding
- As derived forms in a lower-level language:
 - records
 - references
 - recursion
 - subtyping

Characterization

- Dynamic dispatch:
 - when an operation is invoked on an object, the resulting actions depend upon the object itself.
 - different objects which respond to the same set of operations (interface/signatures) may have different implementations
 - determining the actions to be performed may not be possible at compile-time
 - contrast with functions and their application

Characterization

- Encapsulation
 - Objects consist of both internal and external state
 - Not all "oo"-languages provide this kind of encapsulation (e.g., Dylan, Cecil, or CLOS)
 - Originally used as a form of information hiding (CLU or Simula 67)
 - hidden representation type t
 - a collection of operations for manipulating t
 - only one hidden representation and only one implementation
 - commonly referred to as abstract data types

Subtyping

- The type of an object is the set of operations that can be performed on it
- An interface listing more operations is "better" than one listing fewer operations
- Types do not expose internal representation
- Object interfaces fit naturally into a subtype model.

Inheritance

- Objects that share parts of their interfaces can sometimes share parts of their behavior.
 - Avoid code duplication
 - Code reuse expressed via a class structure and form of subclassing that allows new classes to be derived from old ones by adding implementation features

Late Binding

- Allows a method within a class to call another method via the pseudo-variable (`self` or `this`). If the second method is overridden by some subclass so is the first.

Objects

Example: A simple counter

```
c = let x = ref 1
    in { get = λ _:Unit. !x,
        inc = λ _:Unit. x := succ(!x)
```

→ c : Counter

```
where Counter = {get : Unit → int,
                 inc : Unit → Unit}
```

Objects and Object Generators

$\text{inc3} = \lambda c:\text{Counter}. (c.\text{inc unit}, c.\text{inc unit}, c.\text{inc unit}) \rightarrow$
 $\text{inc3} : \text{Counter} \rightarrow \text{unit}$

$(\text{inc3 } c; c.\text{get unit}) \rightarrow 4$

$\text{newCounter} =$
 $\lambda ;\text{Unit}. \text{let } x = \text{ref } 1$
 $\quad \text{in } \{ \text{get} = \lambda _:\text{Unit}. !x,$
 $\quad \quad \text{inc} = \lambda _:\text{Unit}. x := \text{succ}(!x) \}$
 $\rightarrow \text{newCounter} : \text{Unit} \rightarrow \text{Counter}$

Subtyping

```
ResetCounter = { get : Unit → Nat,  
                 inc : Unit → Unit,  
                 reset : Unit → Unit }
```

```
newResetCounter =  
  λ _ : Unit. let x = ref 1  
              in { get = λ _ : Unit. !x,  
                  inc = λ _ : Unit. x := succ(!x),  
                  reset = λ _ : Unit. x := 1 }
```

→ newResetCounter : Unit → ResetCounter

```
rc = newResetCounter unit;  
(inc3 rc; rc.reset unit; inc3 rc; rc.get unit) → 4
```

Classes

- Both `newCounter` and `newResetCounter` provide identical implementations except for the `reset` method.
- Violates basic software engineering principles:
 - each piece of behavior should be implemented in just one place in the program.

Reuse

```
resetCounterFromCounter =  
  λ c:Counter. let x = ref 1  
                in { get = c.get,  
                    inc = c.inc,  
                    reset = λ_:Unit. x := 1 }
```

What's wrong with this approach?

Classes

Need to separate definition of methods from state manipulated by these methods:

$\text{counterClass} = \lambda r:\text{CounterRep}.$

$\quad \{\text{get} = \lambda _:\text{Unit}. !(r.x),$

$\quad \text{inc} = \lambda _:\text{Unit}. r.x := \text{succ}(!(r.x))\}$

$\rightarrow \text{counterClass} : \text{CounterRep} \rightarrow \text{Counter}$

$\text{CounterRep} : \{ x : \text{Nat ref} \}$

Subclass

resetCounterClass =

λ r: CounterRep.

let super = counterClass r

in { get = super.get,

inc = super.inc,

reset = λ ;Unit. r.x := 1}

→ resetCounterClass : CounterRep → ResetCounter

newResetCounter =

λ _: Unit. let r = {x=ref 1} in resetCounterClass r

→ newResetCounter : Unit → ResetCounter

Extending Representations

- May wish to add new instance variables (fields) to a representation

BackupCounter = {get: Unit → Nat,
inc: Unit → Unit,
reset: Unit → Unit,
backup: Unit → Unit}

BackupCounterRep = {x: Nat ref, b: Nat ref}

Instance Variables

```
backupCounterClass =  
  λ r: BackupCounterRep.  
    let super = resetCounterClass r  
    in {get = super.get,  
        inc = super.inc,  
        reset = λ _: Unit. r.x := !(r.b),  
        backup = λ _:Unit. r.b := !(r.x)}  
→ backupCounterClass :  
   BackupCounterRep → BackupCounter
```

Two interesting features:

1. overrides method reset defined in resetCounterClass
2. uses subtyping in definition of super:
resetCounterClass expects an argument of type CounterRep, but we are providing an argument of type BackupCounterRep which has more fields.

Invoking Super

Suppose every call to `inc` must first backup the current state. Avoid copying the code for backup by making `inc` use the backup and `inc` methods from `super`:

```
funnyBackupCounterClass =  
  λ r: BackupCounterRep.  
    let super = BackupCounterClass r  
    in {get = super.get,  
        inc = λ _: Unit. (super.backup unit; super.inc unit),  
        reset = super.reset,  
        backup = super.backup}  
funnyBackupCounterClass:  
  BackupCounterRep → BackupCounter
```