CSE341: Programming Languages

Lecture 22
Multiple Inheritance, Interfaces, Mixins

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What next?

Have used classes for OOP's essence: inheritance, overriding, dynamic dispatch

Now, what if we want to have more than *just 1 superclass*

- *Multiple inheritance*: allow > 1 superclasses
  - Useful but has some problems (see C++)
- Java-style *interfaces*: allow > 1 types
  - Mostly irrelevant in a dynamically typed language, but fewer problems
- Ruby-style *mixins*: 1 superclass; > 1 method providers
  - Often a fine substitute for multiple inheritance and has fewer problems

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Multiple Inheritance

- If inheritance and overriding are so useful, why limit ourselves to one superclass?
  - Because the semantics is often awkward (next couple slides)
  - Because it makes static type-checking harder (not discussed)
  - Because it makes efficient implementation harder (not discussed)
- Is it useful? Sure!
  - Example: Make a **`ColorPt3D`** by inheriting from **`Pt3D`** and **`ColorPt`** (or maybe just from **`Color`**)
  - Example: Make a **`StudentAthlete`** by inheriting from **`Student`** and **`Athlete`**
  - With single inheritance, end up copying code or using non-OOP-style helper methods

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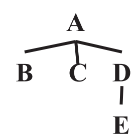
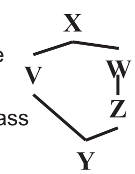
Trees, dags, and diamonds

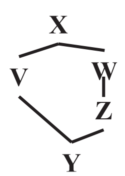
- Note: The phrases *subclass*, *superclass* can be ambiguous
  - There are *immediate* subclasses, superclasses
  - And there are *transitive* subclasses, superclasses
- Single inheritance: the *class hierarchy* is a tree
  - Nodes are classes
  - Parent is immediate superclass
  - Any number of children allowed



- Multiple inheritance: the class hierarchy no longer a tree
  - Cycles still disallowed (a directed-acyclic graph)
  - If multiple paths show that *X* is a (transitive) superclass of *Y*, then we have *diamonds*



What could go wrong?



- If *V* and *Z* both define a method **`m`**, what does *Y* inherit? What does **`super`** mean?
  - *Directed resends* useful (e.g., **`Z::super`**)
- What if *X* defines a method **`m`** that *Z* but not *V* overrides?
  - Can handle like previous case, but sometimes undesirable (e.g., **`ColorPt3D`** wants **`Pt3D`**'s overrides to "win")
- If *X* defines fields, should *Y* have one copy of them (**`f`**) or two (**`V::f`** and **`Z::f`**)?
  - Turns out each behavior is sometimes desirable (next slides)
  - So C++ has (at least) two forms of inheritance

3DColorPoints

If Ruby had multiple inheritance, we would want **`ColorPt3D`** to inherit methods that share one **`@x`** and one **`@y`**

```
class Pt
  attr_accessor :x, :y
  …
end
class ColorPt < Pt
 attr_accessor :color
 …
end
class Pt3D < Pt
 attr_accessor :z
 … # override methods like distance?
end
class ColorPt3D < Pt3D, ColorPt # not Ruby!
end
```

ArtistCowboys

This code has **Person** define a pocket for subclasses to use, but an **ArtistCowboy** wants *two* pockets, one for each **draw** method

```
class Person
  attr_accessor :pocket
  …
end
class Artist < Person # pocket for brush objects
 def draw # access pocket
 …
end
class Cowboy < Person # pocket for gun objects
 def draw # access pocket
 …
end
class ArtistCowboy < Artist, Cowboy # not Ruby!
end
```


Java interfaces

Recall (?), Java lets us define *interfaces* that classes explicitly *implement*

```
interface Example {
  void   m1(int x, int y);
  Object m2(Example x, String y);
}

class A implements Example {
  public void m1(int x, int y) {…}
  public Object m2(Example e, String s) {…}
}
class B implements Example {
  public void m1(int pizza, int beer) {…}
  public Object m2(Example e, String s) {…}
}
```


What is an interface?

```
interface Example {
  void   m1(int x, int y);
  Object m2(Example x, String y);
}
```

- An interface is a type!
  - Any implementer (including subclasses) is a *subtype* of it
  - Can use an interface name wherever a type appears
  - (In Java, classes are also types in addition to being classes)
- An implementer type-checks if it defines the methods as required
  - Parameter names irrelevant to type-checking; it's a bit strange that Java requires them in interface definitions
- A user of type **Example** can objects with that type have the methods promised
  - I.e., sending messages with appropriate arguments type-checks

Multiple interfaces

- Java classes can implement any number of interfaces
- Because interfaces provide no methods or fields, no questions of method/field duplication arise
  - No problem if two interfaces both require of implementers and promise to clients the same method
- Such interfaces aren't much use in a dynamically typed language
  - We don't type-check implementers
  - We already allow clients to send any message
  - Presumably these types would change the meaning of **is_a?**, but we can just use **instance_methods** to find out what methods an object has

Why no interfaces in C++?

If you have multiple inheritance and abstract methods (called pure virtual methods in C++), there is no need for interfaces

- *Abstract method*: A method declared but not defined in a class. All instances of the (sub)class must have a definition
- *Abstract class*: Has one or more abstract methods; so disallow creating instances of this exact class
  - Have to subclass and implement all the abstract methods to create instances
- Little point to abstract methods in a dynamically typed language
- In C++, instead of an interface, make a class with all abstract methods and inherit from it – same effect on type-checking

Mixins

- A *mixin* is (just) a collection of methods
  - Less than a class: no fields, constructors, instances, etc.
  - More than an interface: methods have bodies
- Languages with mixins (e.g., Ruby modules) typically allow a class to have one superclass but any number of mixins
- Semantics: *Including a mixin makes its methods part of the class*
  - Extending or overriding in the order mixins are included in the class definition
  - More powerful than helper methods because mixin methods can access methods (and instance variables) on **self** not defined in the mixin

Example

```
module Doubler
  def double
    self + self # assume included in classes w/ +
  end
end
class String
  include Doubler
end
class AnotherPt
  attr_accessor :x, :y
  include Doubler
  def + other
    ans = AnotherPt.new
    ans.x = self.x + other.x
    ans.y = self.y + other.y
    ans
end
```


Lookup rules

Mixins change our lookup rules slightly:

- When looking for receiver `obj0`'s method `m`, look in `obj0`'s class, then mixins that class includes (later includes shadow), then `obj0`'s superlcass, then the superclass' mixins, etc.
- As for instance variables, the mixin methods are included in the same object
  - So usually bad style for mixin methods to use instance variables since a name clash would be like our `CowboyArtist` pocket problem (but sometimes unavoidable?)

The two big ones

The two most popular/useful mixins in Ruby:

- Comparable: Defines <, >, ==, !=, >=, <= in terms of <=>
- Enumerable: Defines many iterators (e.g., map, find) in terms of each

Great examples of using mixins:
  - Classes including them get a bunch of methods for just a little work
  - Classes do not "waste" their "one superclass" for this
  - Do not need the complexity of multiple inheritance

- See `lec22.rb` for some example uses

Replacement for multiple inheritance?

- A mixin probably works well for `ColorPt3D`:
  - Color a reasonable mixin except for using an instance variable

```
module Color
 attr_accessor :color
end
```

- A mixin works awkwardly-at-best for `ArtistCowboy`:
  - Natural for `Artist` and `Cowboy` to be `Person` subclasses
  - Could move methods of one to a mixin, but it is odd style and still doesn't get you two pockets

```
module ArtistM …
class Artist < Person
  include ArtistM
class ArtistCowboy < Cowboy
  include ArtistM
```