CSE 341:
Programming Languages

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Lecture 22—Multiple Inheritance, Interfaces, Mixins
Today

Have seen OO’s essence: inheritance, overriding, dynamic-dispatch.

What if we want these things from more than “exactly 1 superclass”? 

- **Multiple inheritance**: allow $> 1$ superclasses
  - Useful but has some problems (see C++)

- **Java-style interfaces**: allow $> 1$ types
  - “Irrelevant” in a dynamically typed language, but fewer problems

- **Mixins**: allow $> 1$ “sources of methods”
  - Close to multiple inheritance; almost as useful with fewer (?) problems
  - In Ruby
Multiple Inheritance

If code reuse via inheritance is so useful, why not allow multiple superclasses?

- Because it causes some semantic awkwardness and implementation awkwardness (we’ll discuss only the former)
- (With static typing, there are some more issues)

Is it useful? Sure: A simple example is “3DColorPoint” assuming we already have “3DPoint” and “ColorPoint”.

Naive view: Subclass has all fields and methods of all superclasses
Trees, dags, and diamonds

The “class hierarchy” is a (conceptual) graph with edges from subclasses to superclasses.

Ambiguous phrase: subclass, let’s use immediate-subclass or transitive-subclass when we need to be clear.

- With single inheritance, the class hierarchy is a tree.
- With multiple inheritance, the class hierarchy is a dag.
  - Semantic problems arise from diamonds: Multiple ways to show that class A is a transitive-subclass of some class B.
  - If all classes are transitive-subclasses of something like Object, then multiple inheritance always leads to diamonds.
Multiple Inheritance Semantic Problems

What if multiple superclasses define the same message \( m \) or field \( f \)?

- Classic example: Artists, Cowboys, and ArtistCowboys

Options for \( m \):

- Reject subclass—too restrictive (especially due to diamonds)
- “Left-most superclass wins” (leads to silent weirdness and really want per-method flexiblity)
- Require subclass to override \( m \) (can use directed resends)

Options for \( f \): one copy or two copies?

C++ provides two forms of inheritance:

- One always makes two copies
- One makes one copy if fields were declared by same class
  - Would not work well in Ruby?
Java-style interfaces

(Recall?) in Java, we can define interfaces and classes can implement them.

- Interface describes methods and their types

```java
interface Example {
    void m1(int x, int y);
    Foo m2(Example e, String s);
}
```

- Example is a type (can be used for a field, method argument, local variable, etc.)

- If class C implements interface I, then instances of C can have type I but C must define everything in I (directly or via inheritance).

- Given an expression of type I, it type-checks to send it any message I promises.
Interfaces are a typing thing

In Java, you have 1 immediate-superclass and any number of interfaces you implement.

Because interfaces provide no methods or fields (only types of methods), no duplication problems result!

- No problem if \( I_1 \) and \( I_2 \) both “promise” some method \( m \) and \( C \) implements \( I_1 \) and \( I_2 \).

But interfaces do not give us the power we want for making colored 3D points or artist-cowboys.

They’re *totally irrelevant* in a dynamically typed language like Ruby:

- We are already allowed to send any message to any object
- It is up to us to get it right (‘‘interfaces’’ more in comments or reflection, e.g., the methods method of Object)
If you had multiple inheritance, you could replace interfaces with abstract classes containing only abstract methods.

- Called pure virtual methods in C++
- But the whole point is multiple inheritance is more powerful because it doesn’t require \( n - 1 \) superclasses to have only abstract methods.
Mixins

A mixin is a collection of methods

- no fields, constructors, instances, etc.

Languages with mixins (e.g., Ruby) typically allow a class to have 1 superclass but any number of mixins.

Bad news: Less powerful than multiple inheritance; have to decide “upfront” what is a class and what is a mixin.

Good news: Clear semantics on methods/fields and works great for certain idioms.
Ruby mixin basics

A module’s instance methods are mixed into a class by including the module in the class definition.

Method-lookup rules: First class’s methods, then its mixins’ methods (later includes shadow), then immediate-superclass, then immediate-superclass’s mixins, ...

Field rules: It is all one object.
What mixins are good for

We could make Color a mixin and then use it for coloring 2D and 3D points.

- Works fine but often bad style to have mixin methods define fields (could conflict with other fields)

For artist-cowboys, what should the mixin be?

But mixins are extremely elegant for letting classes “get a bunch of methods while defining only a few”.

- All thanks to late-binding!
- Cool examples in Ruby library: Comparable and Enumerable