CSE 413
Programming Languages & Implementation

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Multiple Inheritance, Interfaces, Mixins

Overview

- Essence of object-oriented programming: inheritance, overriding, dynamic-dispatch
- Classic inheritance includes specification (types) and implementation (code)
- What about multiple inheritance (>1 superclass)?
  - When does it make sense?
  - What are the issues?

Inheritance Models

- Single Inheritance: at most 1 superclass
  - Subclass inherits methods and state from superclass; can override methods, add more methods and instance variables

- Multiple Inheritance: >1 superclass
  - Why? Factor different traits/behavior into small classes, then extend several of them
  - But hard to use well (e.g., C++)
    - Typical problem: big, brittle inheritance graph, methods migrate to bloated superclasses over time; becomes (very) hard to make changes

Inheritance Models

- Java-style interfaces: >1 type
  - Doesn’t apply to dynamically-typed languages
  - Class “inherits” (has) multiple types, but…
  - …only inherits code from one parent class
  - Fewer problems than multiple inheritance

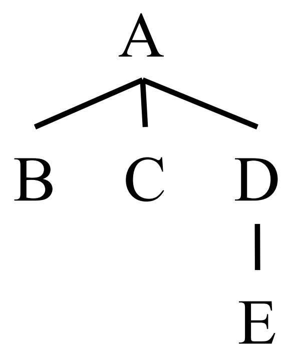
- Mixins: >1 “source of methods”
  - Similarities to multiple inheritance – many of the goodies with fewer(?) problems

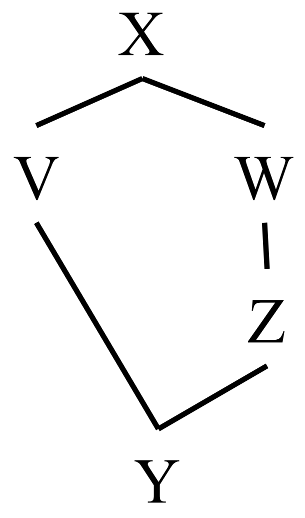
Multiple Inheritance

- If single inheritance is so useful, why not allow multiple superclasses?
  - Semantics are often awkward (next few slides)
  - Static type checking is harder (not discussed)
  - Efficient implementation is harder (hints next time)
- Is it useful? Sure:
  - **`Color3DPoint extends 3DPoint, ColorPoint`**
  - **`StudentAthlete extends Student, Athlete`**
- Naïve view: subclass has all fields and methods of all superclasses; avoids copying code

Trees, DAGs, and Diamonds

- Class hierarchy forms a graph
  - Nodes are classes
  - Edges from subclasses to superclasses
  - Single inheritance: a tree
  - Multiple inheritance: a DAG (but no cycles allowed)
- Diamonds
  - With multiple inheritance, may be multiple ways to show that Y is a (transitive) subclass of X
  - If all classes are transitive subclasses of e.g. Object, multiple inheritance always leads to diamonds



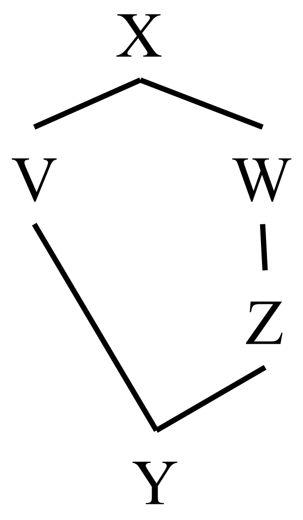


Multiple Inheritance: Semantic Issues

- What if multiple superclasses define the same message **`m`** or field **`f`**?
  - Classic example: **`Artists, Cowboys, ArtistCowboys`**
    - All have a **`draw`** method
    - The **`draw`** methods access a (the?) **`pocket`** instance variable

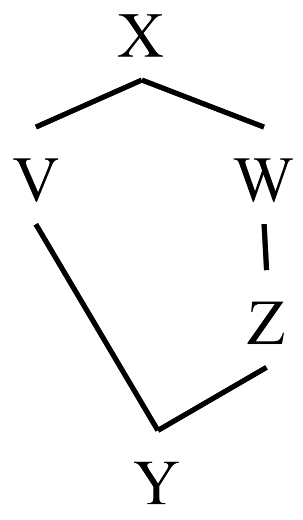
Multiple Inheritance: Methods

- If V and Z both define method **`m`**, which one does Y inherit? What does super mean?
  - Can use *directed resends*: Z::m
- What if X defines **`m`** that Z overrides but V does not?
  - Can do the same thing, but often we want Z to “win” (e.g., **`ColorPt3D`** wants **`Pt3D`**’s overrides)



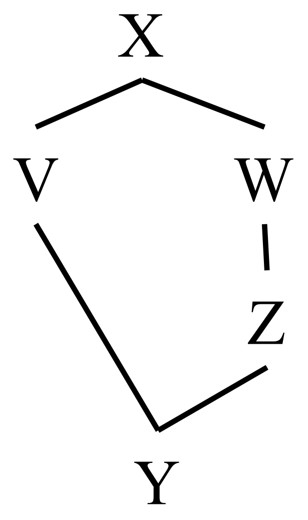
Multiple Inheritance: Methods

- Some options for method **`m`**:
  - Reject subclass as ambiguous – but this is too restrictive (esp. w/ diamonds)
  - “Left-most superclass wins” – too restrictive (want per-method flexibility) + silent weirdness
  - Require subclass to override **`m`** (can use explicitly qualified calls to inherited methods)



Multiple Inheritance: Fields

- Options for field **`f`**: One copy of **`f`** or multiple copies?
  - Multiple copies: what you want if **`Artist::draw`** and **`Cowboy::draw`** use inherited fields differently (e.g., both use a **`pocket`** variable)
  - Single copy: what you want for **`Color3dPoint x`** and **`y`** coordinates
- C++ provides both kinds of inheritance
  - Either two copies always, or one copy if field declared in same (parent) class



Java-Style Interfaces

- In Java we can define *interfaces* and classes can *implement* them
  - Interface describes methods and types
  - Interface *is* a type – program can create variables, parameters, etc. with that type
  - If class C implements interface I, then instances of C have type I but must define everything in I (directly or via inheritance)

Interfaces are all about Types

- A Java class can have implement any number of interfaces (and also has one superclass – Object if nothing else declared)
- Interfaces provide no methods or fields – no duplication problems
  - If I1 and I2 both include some method **`m`**, implementing class must provide it somehow
- But this doesn't allow what we want for **`Color3DPoints`** or **`ArtistCowboys`**
  - No code inheritance/reuse possible

Java Interfaces and Ruby

- Concept is totally irrelevant for Ruby
  - We can already send any message to any object (dynamic typing)
  - We need to get it right (can always ask an object what messages it responds to)
  - We don’t type-check implementers

Why no interfaces in C++?

- C++ allows methods and classes to be *abstract*
  - Specified in class declaration but with no implementation (same as Java)
  - Called pure virtual methods in C++
- Abstract classes can be extended but not instantiated
- So a class can extend multiple abstract classes
  - Same as implementing interfaces
- But if that's all you need, you don't need multiple inheritance
  - Multiple inheritance is not just typing

Mixins

- A mixin is a (just) collection of methods
  - Less than a class: no fields, constructors, instances, etc.
  - More than an interface: methods have implementations
- Languages with mixins typically allow one superclass and any number of mixins (e.g., Ruby)

Mixin Semantics

- Including a mixin makes its methods part of the class
  - Mixins extend or override in the order they are included in the class definition
  - More powerful than helper methods because mixin methods can access methods and instance variables not defined in the mixin using self

- Not quite as powerful as multiple inheritance, but…
- Clear semantics, great for certain idioms (**`Enumerate`** and **`Comparable`** using **`each`**, **`<=>`**)

Next time

- Implementing inheritance, dynamic dispatch
- Then on Friday: wrapup, review, the end.