Polymorphism

References & Inheritance

- A reference can refer to any object of that type.
- eg. `Shape s;`
  - Now, `s` can refer to any shape
- …but classes that inherit `Shape` are also shapes.
  - Remember the "is-a" restriction on the design.
  - So, `s` could also refer to a `Circle` or `Rectangle`.
  - A big part of why we insist on the "is-a" relationship

References & Inheritance

- Perfectly legal:

```
Shape s1;
Rectangle r1 = new Rectangle(…);
s1 = r1;  // all rectangles are shapes
Shape s2 = new Rectangle(…);
Object o = new Circle(…);
```

- Not okay:

```
Shape s = new Circle(…);
Rectangle r = s; // not all shapes are
                 // rectangles.
```

Compile-Time Checking

- Validity of assignments is checked when the program **compiles**, not while it's running.
  - Lets programs run faster; strong typing lets the compiler catch problems immediately.
- Causes non-obvious restriction:

```
Shape s = new Rectangle(…);
…
Rectangle r = s; // not all shapes are
                 // rectangles.
```

Is s still a Rectangle?

Casting

- If you really need to assert a more specific type, the reference can be cast to the proper type:

```
Shape s = new Rectangle(…);
Rectangle r = (Rectangle) s;
```

- Casts should be avoided if possible.
  - unavoidable before Java 5.0 since all collections contained only `Object` references
  - `myArrayList.get(0)` would **always** return an Object and need to be cast to its real type.

Which Method?

- Consider…

```
Shape s = new Rectangle(…);
String myOutput = s.toString();
```

- If `toString()` was defined in `Shape` and overridden in `Rectangle`, which definition is used?
  - `s` is a `Shape` reference: use the one from `Shape`.
  - `s` actually refers to a `Rectangle` instance: use the one from `Rectangle`.

Which Method?

- Look at it this way:

- The reference is followed to the actual instance.
  - The reference is just pointing the to thing we use.
- It's the instance's method that gets used.
  - So in the example, we use the `toString` from `Rectangle`.

Why?

- Lets you used a more generic reference when needed, but still get the right method.

```
public void draw(Collection<Shape> shapes) {
    for(Shape s: shapes) {
        s.draw();
    }
}
```

- Different shapes will have different draw methods (they look different after all)
  - … but this will use the right one in each case.

Interfaces, again

- Implementing an interface is very similar to inheriting a class.

```
class MyClass implements AnInterface { … }
```

  - … this takes everything from `AnInterface` and puts it into `MyClass`, just like inheriting.
  - Except, **all** of the methods must be implemented here.
  - No previous implementations to fall back on.

Interfaces vs. Abstract Classes

- Similarities:
  - Neither can be instantiated.
  - Both can be used as a starting-point for a class.
- Differences:
  - A class can contain implementations of methods.
  - A class can implement many interfaces, but can only inherit one class.
    - … in Java. Other languages allow multiple inheritance and have no interfaces.

Example with Interfaces

- Also works with interfaces:

```
public boolean startsWith(List<int> list,
        int val) {
    return list.get(0)==val;
}
```

- Whether the argument is an `ArrayList`, `Vector`, or `LinkedList`, this function works.
  - uses the `.get()` method appropriate to the underlying implementation.

Comparison

more implementation, less abstract ↓

Interface

- A class **can implement multiple** interfaces.
- **No code** implementing methods allowed.
- Can't be instantiated on its own.

Abstract Class

- **Can't be instantiated**.
- Must be inherited into a non-abstract class to be instantiated.
- Can contain implementations.

Non-Abstract Class

- or "concrete class"
- Can be instantiated.
- Can also be inherited.

Similarities

Interface

Abstract Class

Non-Abstract Class

- You can **declare a reference** to any of these.
- Any **object that implements/ inherits** the reference type can be used for that reference.
- Any method that is defined by the **reference type** can be used.
- The **implementation in the actual instance** will be used when its called.

Example: Coffee

The Problem

- Ordering at a coffee bar.
  - Espresso, mochas, low-fat milk, …
  - Lots of structure, many specific subtypes to make use of inheritance.
- Suppose we are creating a point-of-sale system and have to represent the orders taken by the cashier.
  - They will be passed on to those making the drinks.

How hard is this?

1. Cup.
2. Shots and size.
3. Syrup.
4. Milk and other modifiers.
5. The drink itself.

I'D LIKE TO HAVE AN

ICED, (CUP) DECAF, TRIPLE, GRANDE, (SHOTS AND SIZE) CINNAMON, (SYRUP)

NONFAT, NO-WHIP (MILK AND OTHER MODIFIERS) MOCHA (THE DRINK ITSELF)

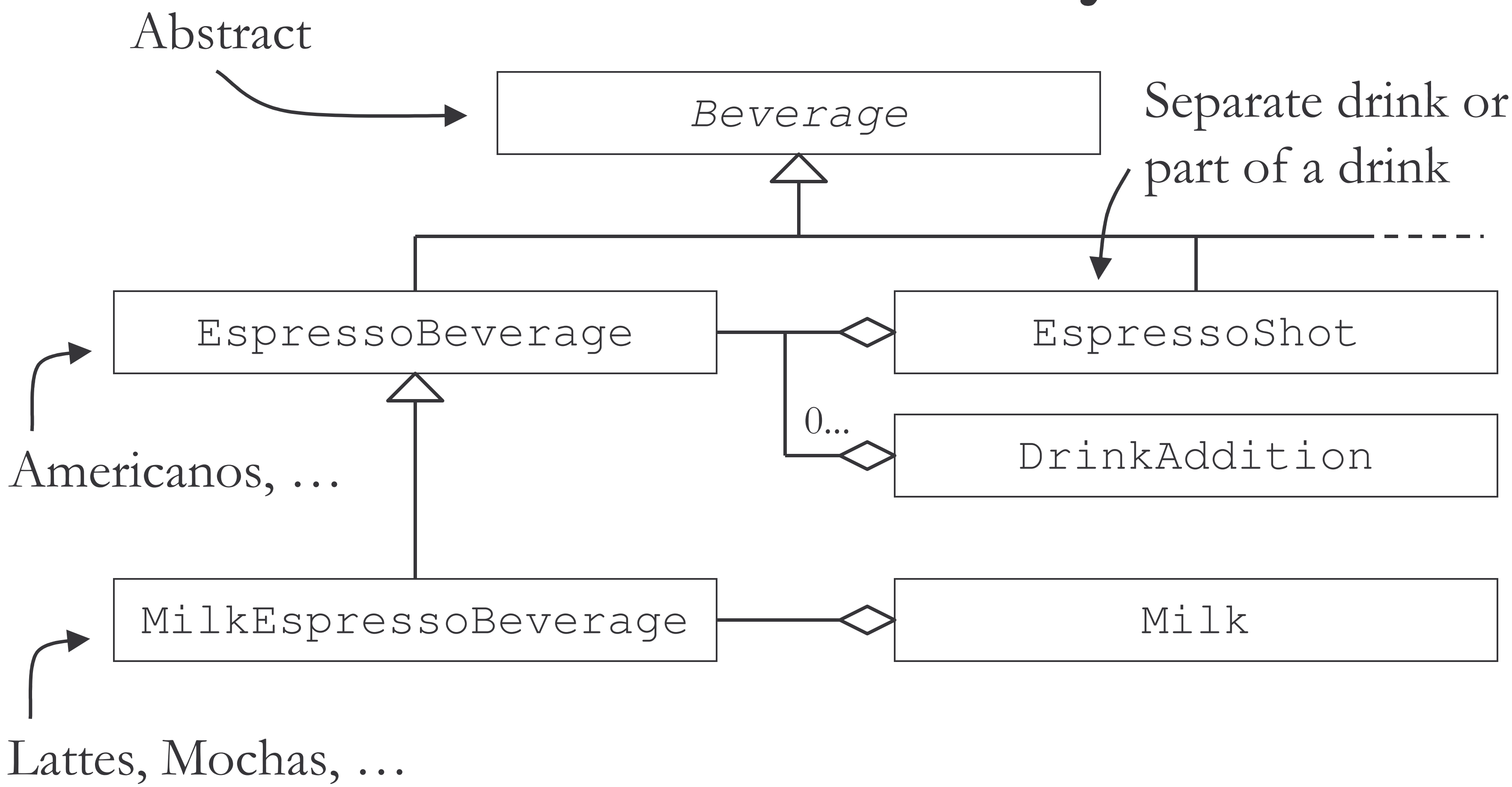
Stuff to Represent

- Cup (to-go, for-here, iced, personal cup)
- Size (small, medium, large)
- Shots (1 or more espresso shots, caf/decaf)
  - default determined by size, but can be changed
- Syrups (0 or more flavour shots)
- Milk, if applicable (whole, 2%, skim, soy)
- Toppings (whipped cream, caramel, …)
- Drink (espresso shot, Americano, mocha, …)

Other Stuff

- There's also a lot of other stuff that doesn't fall into these categories.
  - blended drinks, juice, teas, …
- We should make it possible to represent these too.
  - … but won't implement.

Class Hierarchy



Implementation…