University of British Columbia
CPSC 111, Intro to Computation
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Inheritance II

Lecture 23, Thu Mar 30 2006

based on slides by Kurt Eiselt

http://www.cs.ubc.ca/~tmm/courses/cpsc111-06-spr

News

- Check your lab 7 grade
  - we haven't yet handed out midterm solution, but the window will close soon!
  - **5/70 midterm points** is 1% of your course grade!
- Yet a few more (but not all) Assignment 2s to hand back after class
- Assignment 3 due Friday Apr 7, 5pm
  - start now now now!
- Final exam: Mon Apr 24, 3:30pm, HEBB TH

- Evaluations today (beginning of class)

Recap: Comparable

- sort method that works on array of objects of any type that implements **`Comparable`**
  - type guaranteed to have **`compareTo`** method
- sorted
  - **`int`**
  - **`String`**
  - **`Bunny`**
- revisit **`Bunny.compareTo:`** checking dynamic type of object

Recap: Multiple Interfaces

- Classes can implement more than one interface at once
  - contract to implement all abstract methods defined in every interface it implements

```
public class MyClass implements Interface1, Interface2,
   Interface3
{
}
```

Recap: Inheritance

- Inheritance: process by which new class is derived from existing one
  - fundamental principle of object-oriented programming
- Create new child class (subclass) that **`extends`** existing parent one (superclass)
  - inherits all methods and variables
    - except constructor
  - can just add new variables and methods

Recap: Inheritance and Constructors

```
public class CokeMachine2000 extends CokeMachine2
{
  public CokeMachine2000() {
    super();
  }
  public CokeMachine2000(int n) {
    super(n);
  }
 public void loadCoke(int n)
  {
    numberOfCans = numberOfCans + n;
    System.out.println("Adding " + n + " cans to this machine");
  }
}
```

- Subclass (child class) inherits all methods **except** constructor methods from superclass (parent class)
- Using reserved word **`super`** in subclass constructor tells Java to call appropriate constructor method of superclass

Recap: Inheritance and Scope

- Subclasses inherits but cannot directly access private fields or variables of superclass
- Protected variables can be directly accessed from declaring class and any classes derived from it

Recap: Method Overriding

- If child class defines method with same name and signature as method in parent class
  - say child's version overrides parent's version in favor of its own

Recap: Object Behind the Scenes

- All classes that aren't explicitly extended from a named class are by default extended from `Object` class
  - `Object` class includes a `toString()` method
- so... class header

```
public class myClass
```

- is actually same as

```
public class myClass extends Object
```

Recap: Overriding Variables

- You can, but you shouldn't
- Possible for child class to declare variable with same name as variable inherited from parent class
  - one in child class is called shadow variable
  - confuses everyone!
- Child class already can gain access to inherited variable with same name
  - there's no good reason to declare new variable with the same name

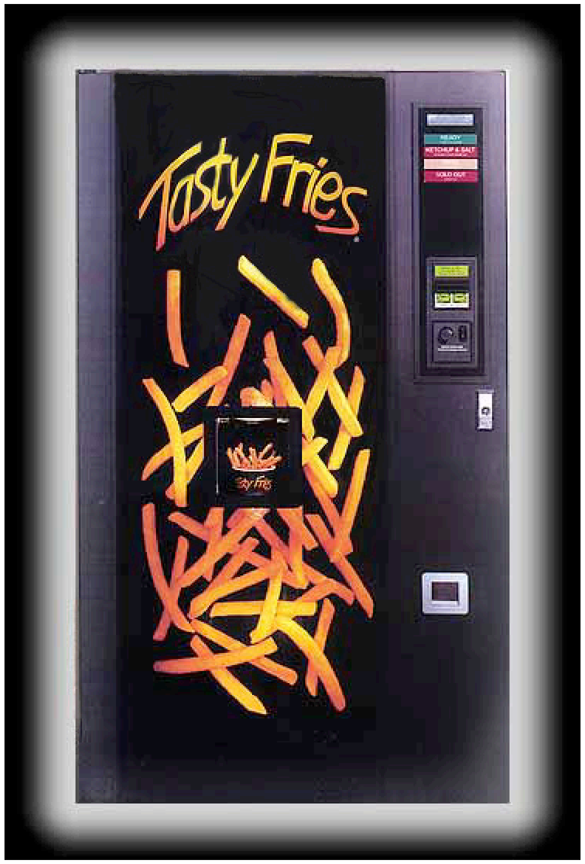
Recap: Method Overloading and Overriding

- Method overloading: "easy" polymorphism
  - in any class can use same name for several different (but hopefully related) methods
  - methods must have different signatures so that compiler can tell which one is intended
- Method overriding: "complicated“ polymorphism
  - subclass has method with same signature as a method in the superclass
  - method in derived class overrides method in superclass
  - resolved at execution time, not compilation time
    - some call it true polymorphism

Objectives

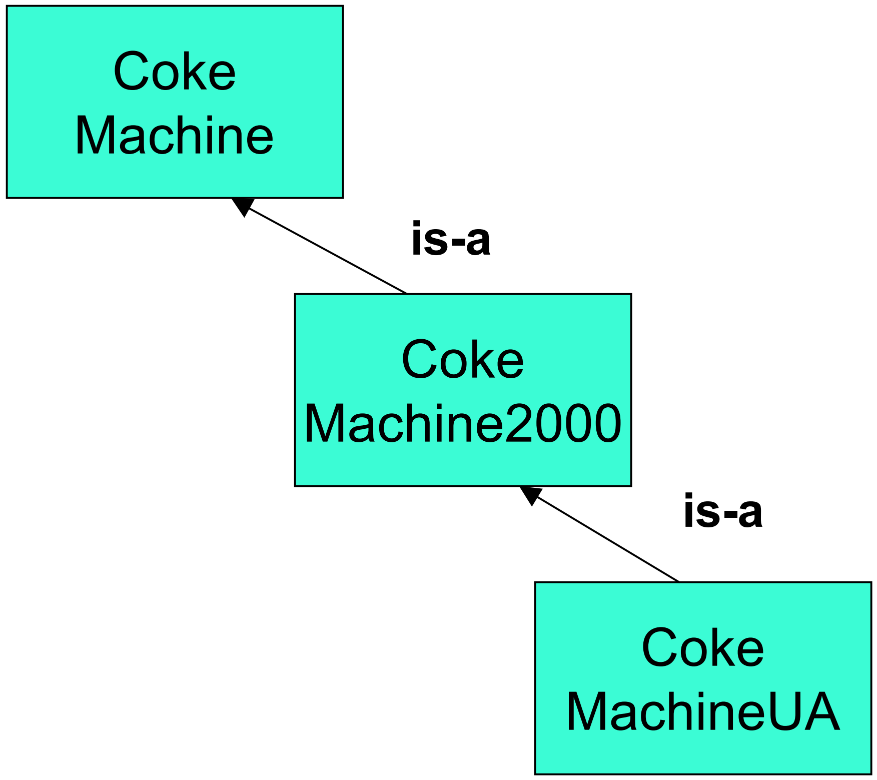
- Understanding when and how to use abstract classes
- Understanding tradeoffs between interfaces and inheritance

A New Wrinkle

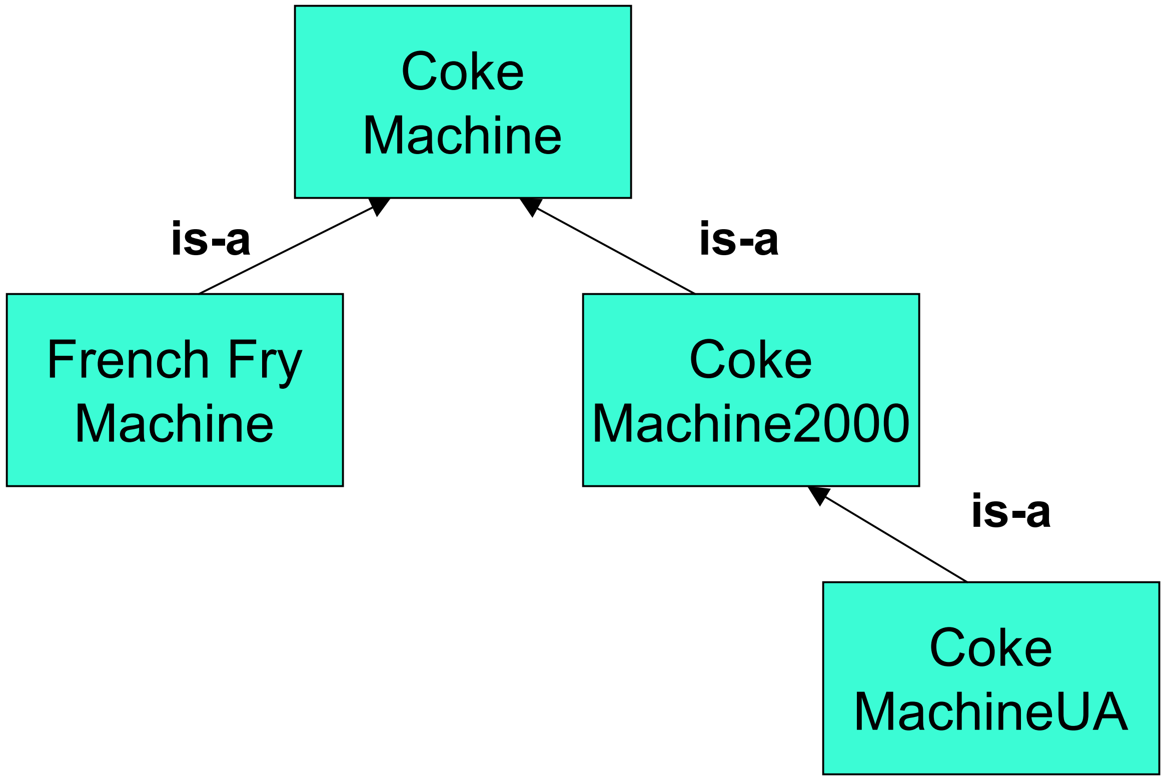


- Expand vending machine empire to include French fry machines
  - is a French fry machine a subclass of Coke Machine?

If We Have This Class Hierarchy...



...Does This Make Sense?



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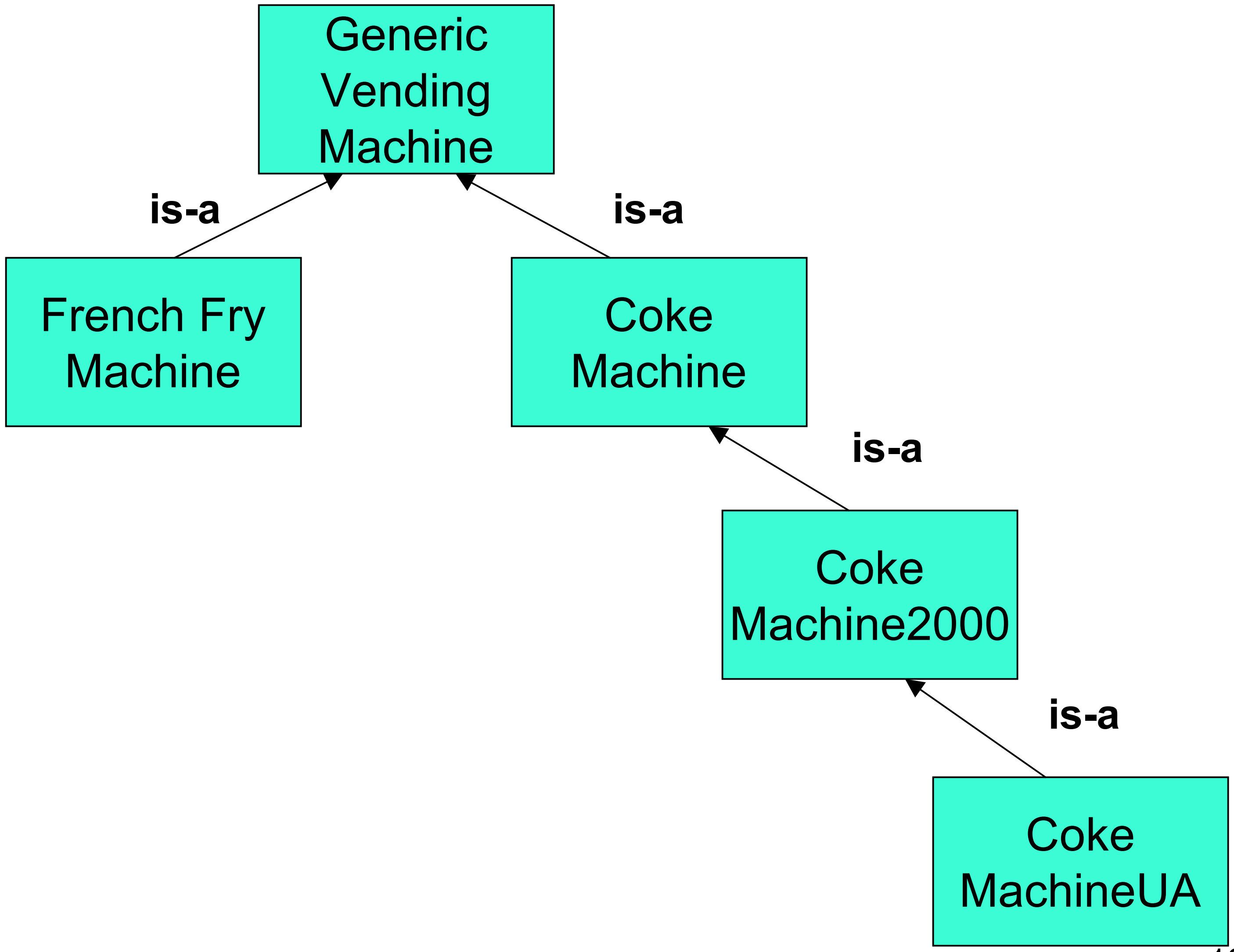

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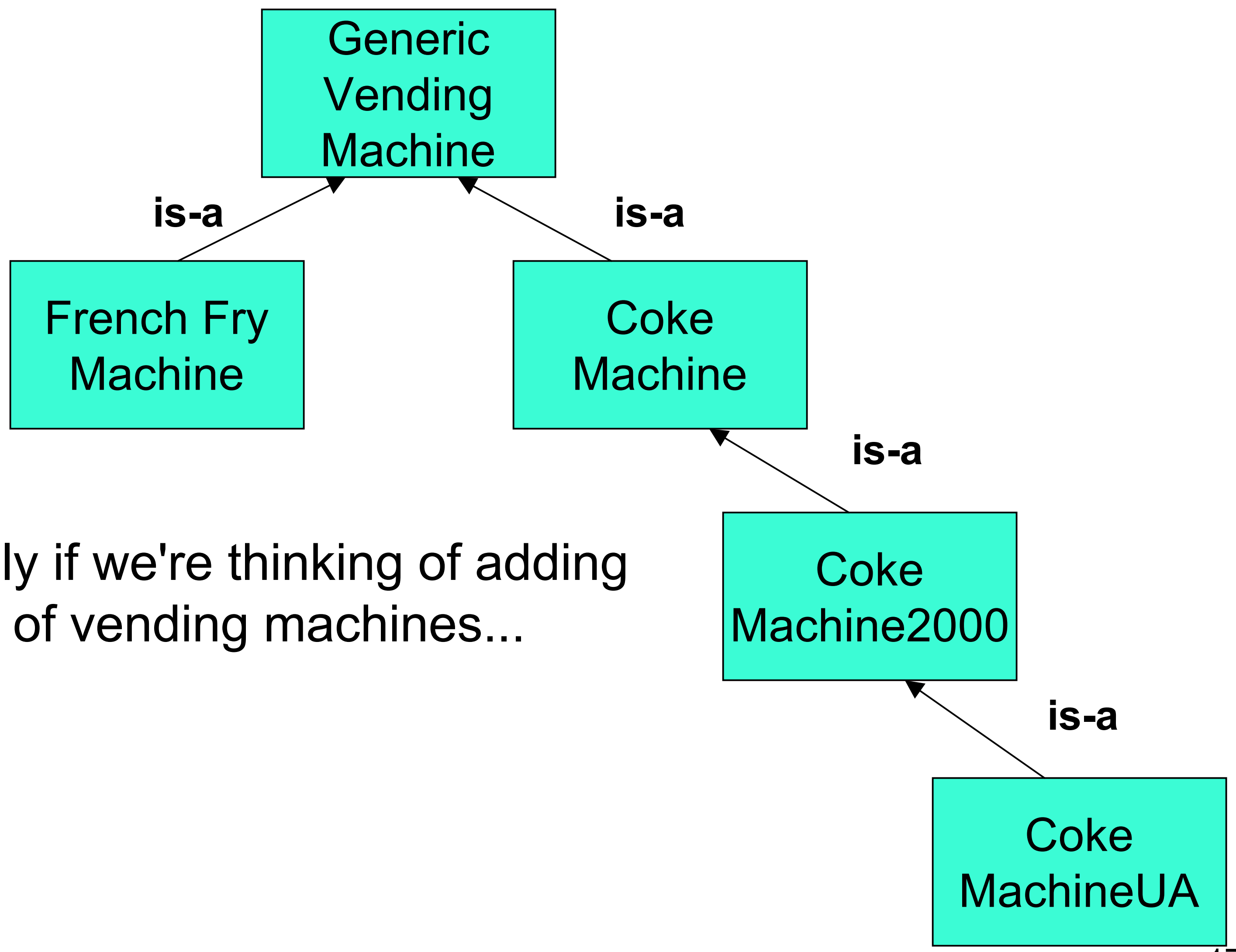
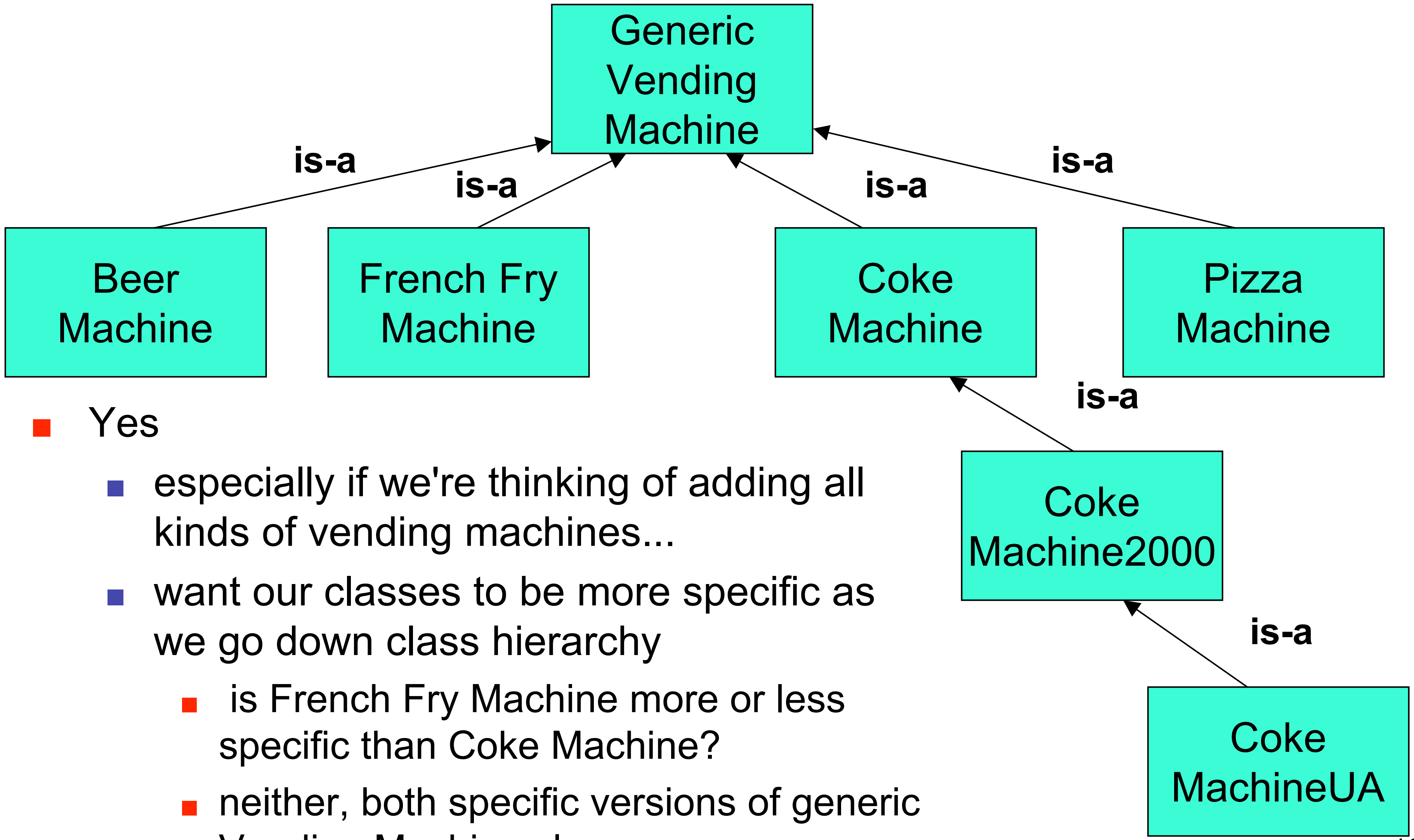


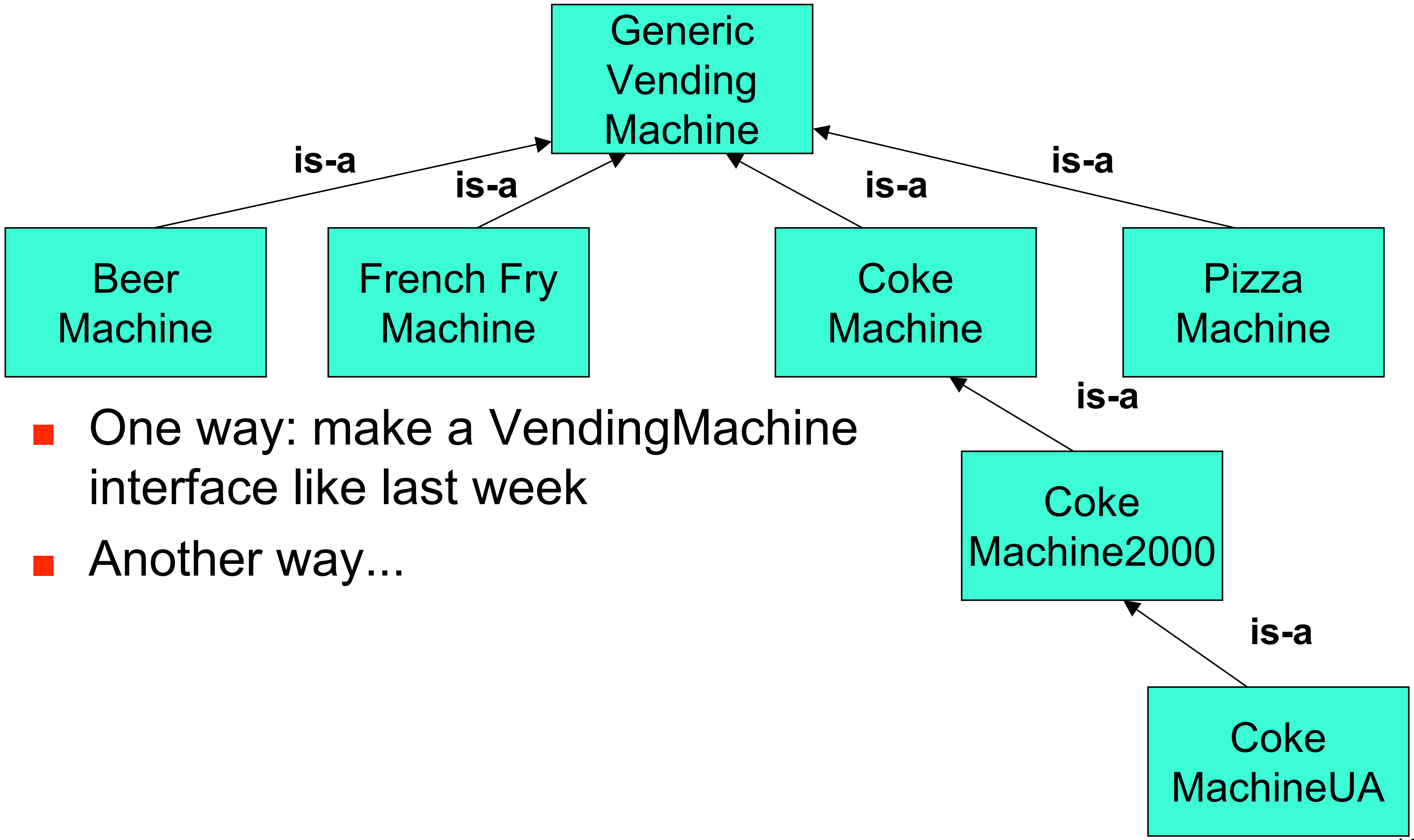
- Yes
  - especially if we're thinking of adding all kinds of vending machines...

Does This Make More Sense?



- Yes
  - especially if we're thinking of adding all kinds of vending machines...
  - want our classes to be more specific as we go down class hierarchy
    - is French Fry Machine more or less specific than Coke Machine?
    - neither, both specific versions of generic Vending Machine class

Does This Make More Sense?



- One way: make a VendingMachine interface like last week
- Another way...

Inheritance Solution

```
public class GenericVendingMachine
{
  private int numberOfItems;
  private double cashIn;

  public GenericVendingMachine()
  {
    numberOfItems = 0;
  }

  public boolean vendItem()
  {
    boolean result;
    if (numberOfItems > 0)
    {
      numberOfItems--;
      result = true;
    }
    else
    {
      result = false;
    }
    return result;
  }
```

Inheritance Solution

```
  public void loadItems(int n)
  {
    numberOfItems = n;
  }

  public int getNumberOfItems()
  {
    return numberOfItems;
  }

}
```

Inheritance Solution

```
public class CokeMachine3 extends GenericVendingMachine
{
  public CokeMachine3()
  {
    super();
  }

  public CokeMachine3(int n)
  {
    super();
    this.loadItems(n);
  }

  public void buyCoke()
  {
    if (this.vendItem())
    {
      System.out.println("Have a nice frosty Coca-Cola!");
      System.out.println(this.getNumberOfItems() + " cans of Coke remaining");
    }
    else
    {
      System.out.println("Sorry, sold out");
    }
  }
```

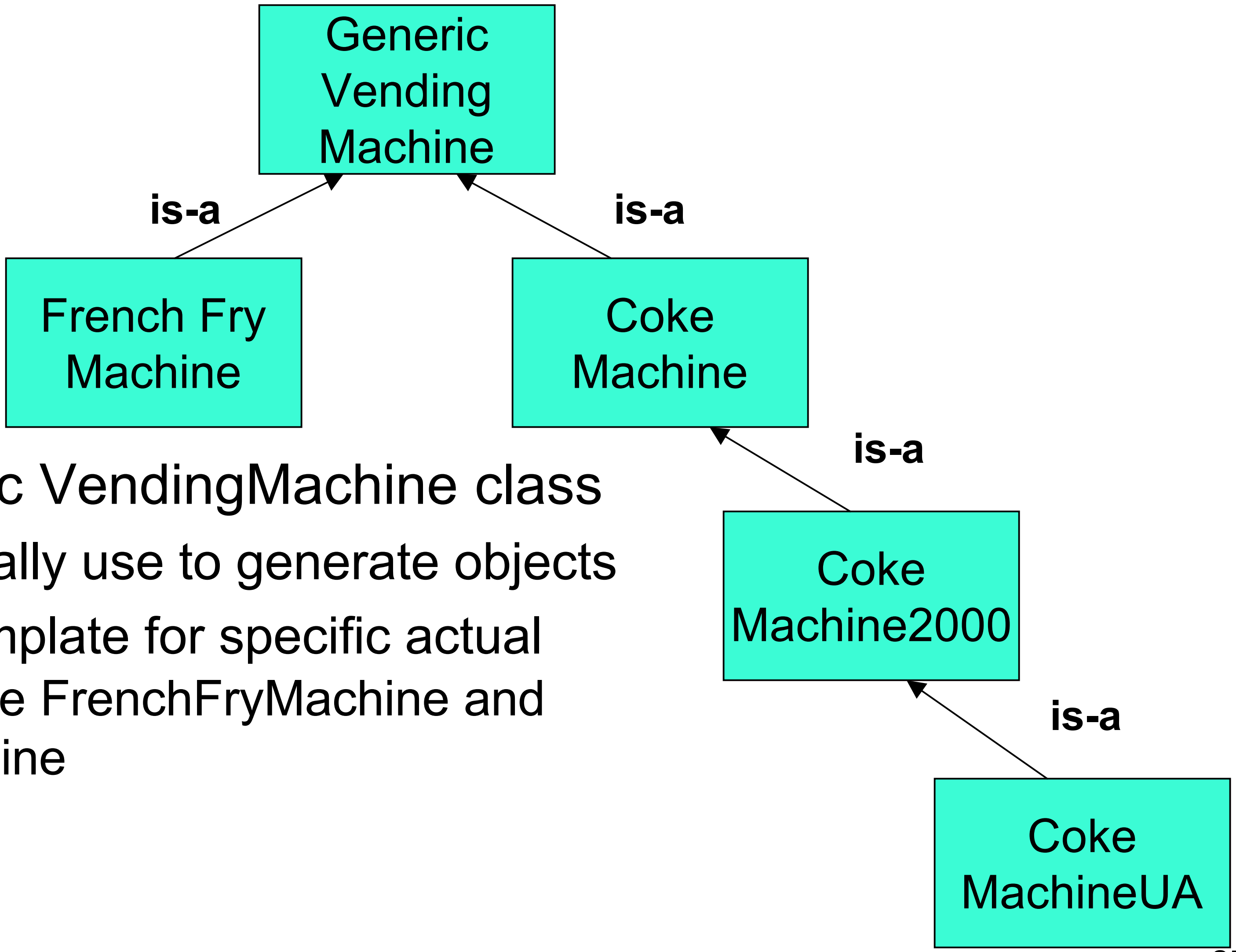
Inheritance Solution

```
  public void loadCoke(int n)
  {
    this.loadItems(this.getNumberOfItems() + n);
    System.out.println("Adding " + n +
                       " ice cold cans of Coke to this machine");
  }
}
```

Inheritance Solution

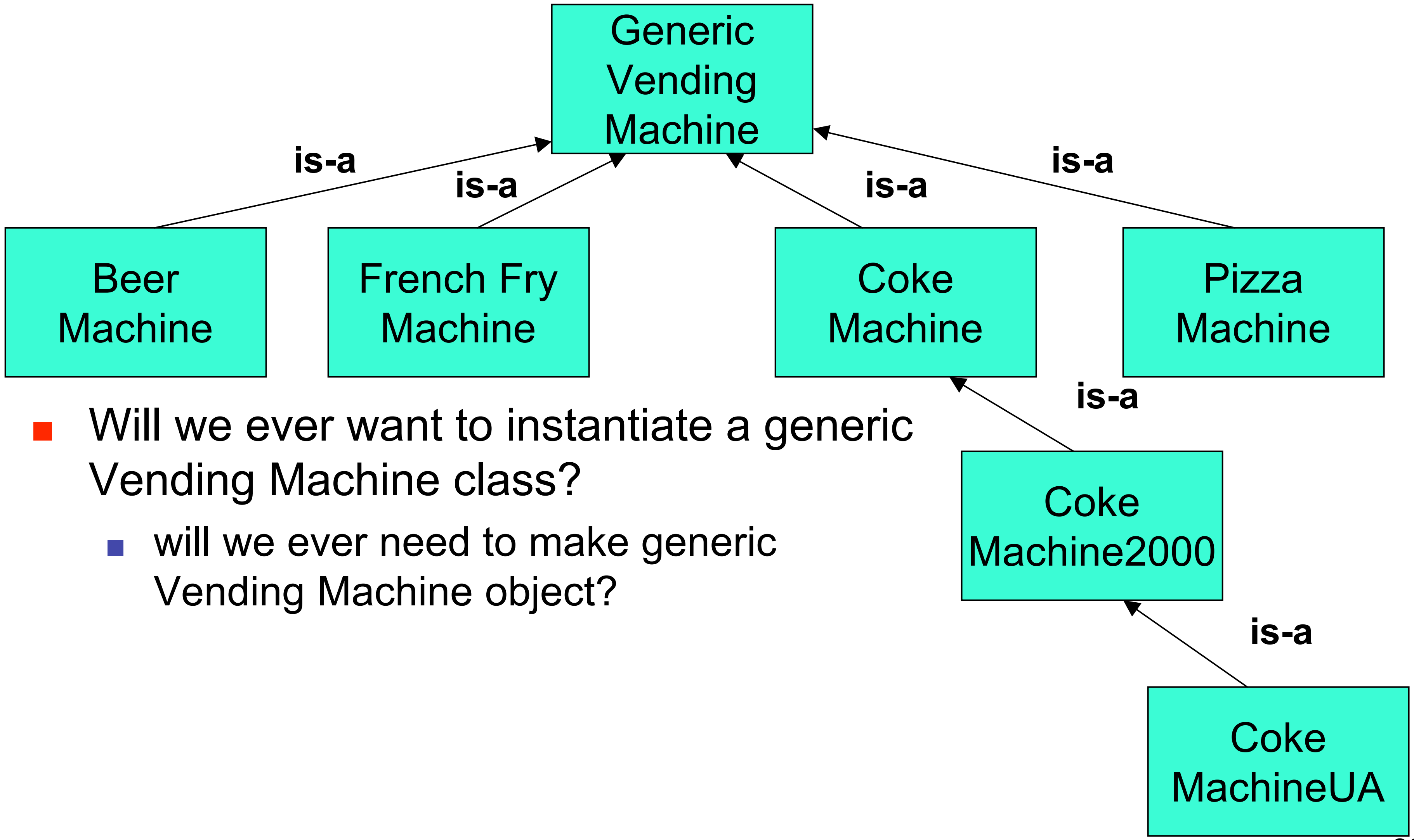
```
public class CokeMachine2000 extends CokeMachine3
{
  public CokeMachine2000()
  {
    super();
  }

  public CokeMachine2000(int n)
  {
    super();
    this.loadItems(n);
  }

  public void loadCoke(int n)
  {
    super.loadCoke(n);
    System.out.println("Loading in the new millennium!");
  }
}
```

Inheritance From Generic Objects



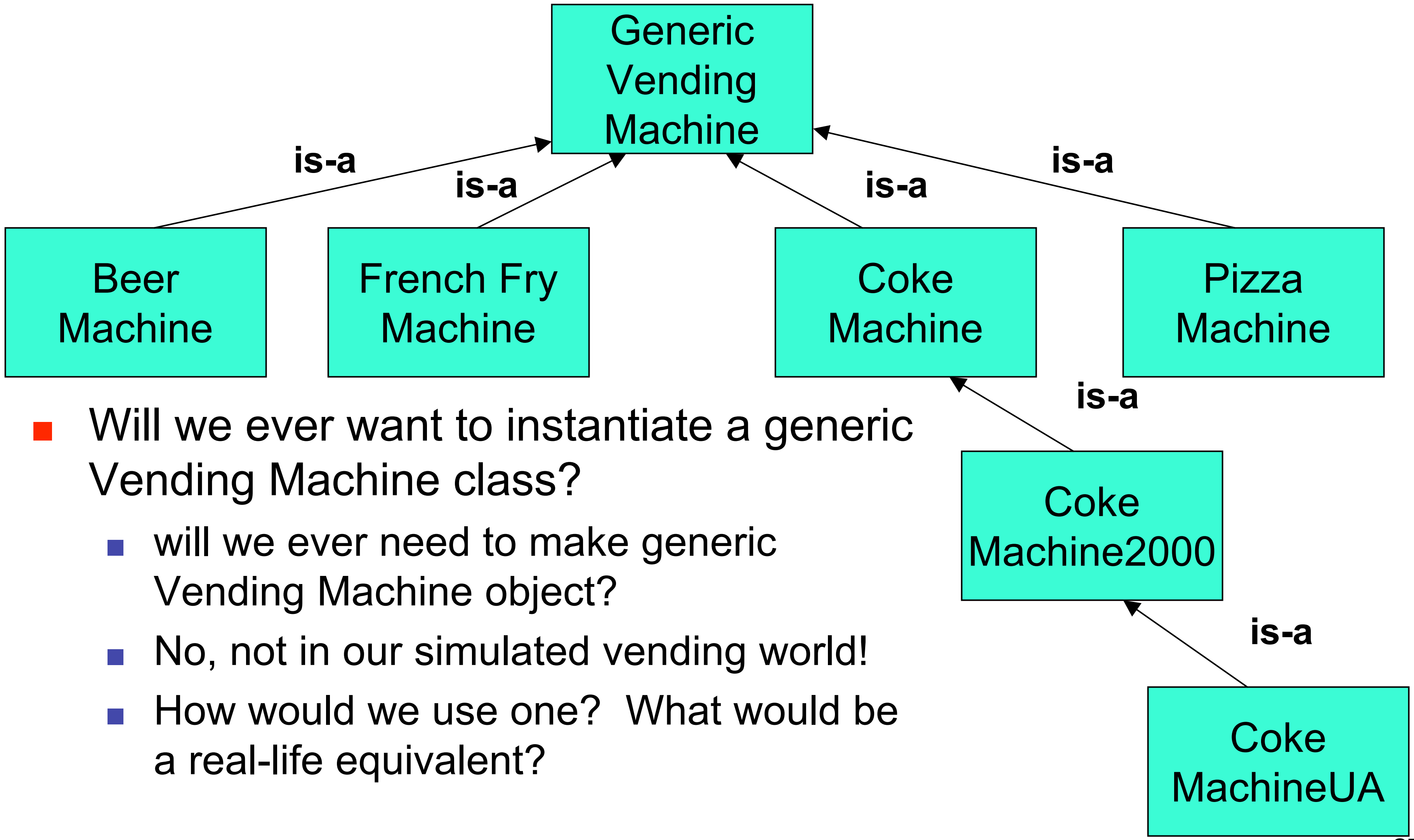
- Want generic VendingMachine class
  - don’t actually use to generate objects
  - use as template for specific actual classes like FrenchFryMachine and CokeMachine

Inheritance From Generic Objects



- Will we ever want to instantiate a generic Vending Machine class?
  - will we ever need to make generic Vending Machine object?

Inheritance From Generic Objects



- Will we ever want to instantiate a generic Vending Machine class?
  - will we ever need to make generic Vending Machine object?
  - No, not in our simulated vending world!
  - How would we use one? What would be a real-life equivalent?

Inheritance From Generic Objects

- Introduced CokeMachineUA to combat vandalism and theft
- Could just add vandalize() methods to CM, CM2000, CMUA
    - but we want to ensure that all Vending Machines have vandalize() methods
    - want all of them to be different
        - if put into base class at top, easy to have them identical
        - no way to force method overriding

Abstract Classes

- Abstract class: not completely implemented
- Usually contains one or more abstract methods
  - has no definition: specifies method that should be implemented by subclasses
  - just has header, does not provide actual implementation for that method
- Abstract class uses abstract methods to specify what interface to descendant classes must look like
  - without providing implementation details for methods that make up interface
- Example: require that all subclasses of VendingMachine class implement **`vandalize()`** method
  - method might differ greatly between one subclass and another
  - use an abstract method

Abstract Classes

- Abstract classes serve as place holders in class hierarchy
- Abstract class typically used as partial description inherited by all its descendants
- Description insufficient to be useful by itself
  - cannot instantiated if defined properly
- Descendent classes supply additional information so that instantiation is meaningful
  - abstract class is generic concept in class hierarchy
  - class becomes abstract by including the **`abstract`** modifier in class header

Abstract Classes

- Use abstract class for generic template
  - can use abstract methods

- Making abstract method
  - Use restricted word **`abstract`** in method header
  - do not provide a method body
  - just end method header with semicolon

Vending Machine Class Revisited

```
public abstract class VendingMachine
{
  private int numberOfItems;

  public VendingMachine()
  {
    numberOfItems = 0;
  }

  public boolean vend()
  {
    boolean result;
    if (numberOfItems > 0)
    {
      numberOfItems--;
      result = true;
    }
    else
    {
      result = false;
    }
    return result;
  }

  public abstract void vandalize();

}
```

Abstract Methods and Abstract Classes

- What happens when we try to compile it all now?
  - Java tells us that there's an abstract class we have to implement

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  - Could put this CokeMachine class:

```
public void vandalize()
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   System.out.println("Take all my money, and have a Coke too");
 }
```

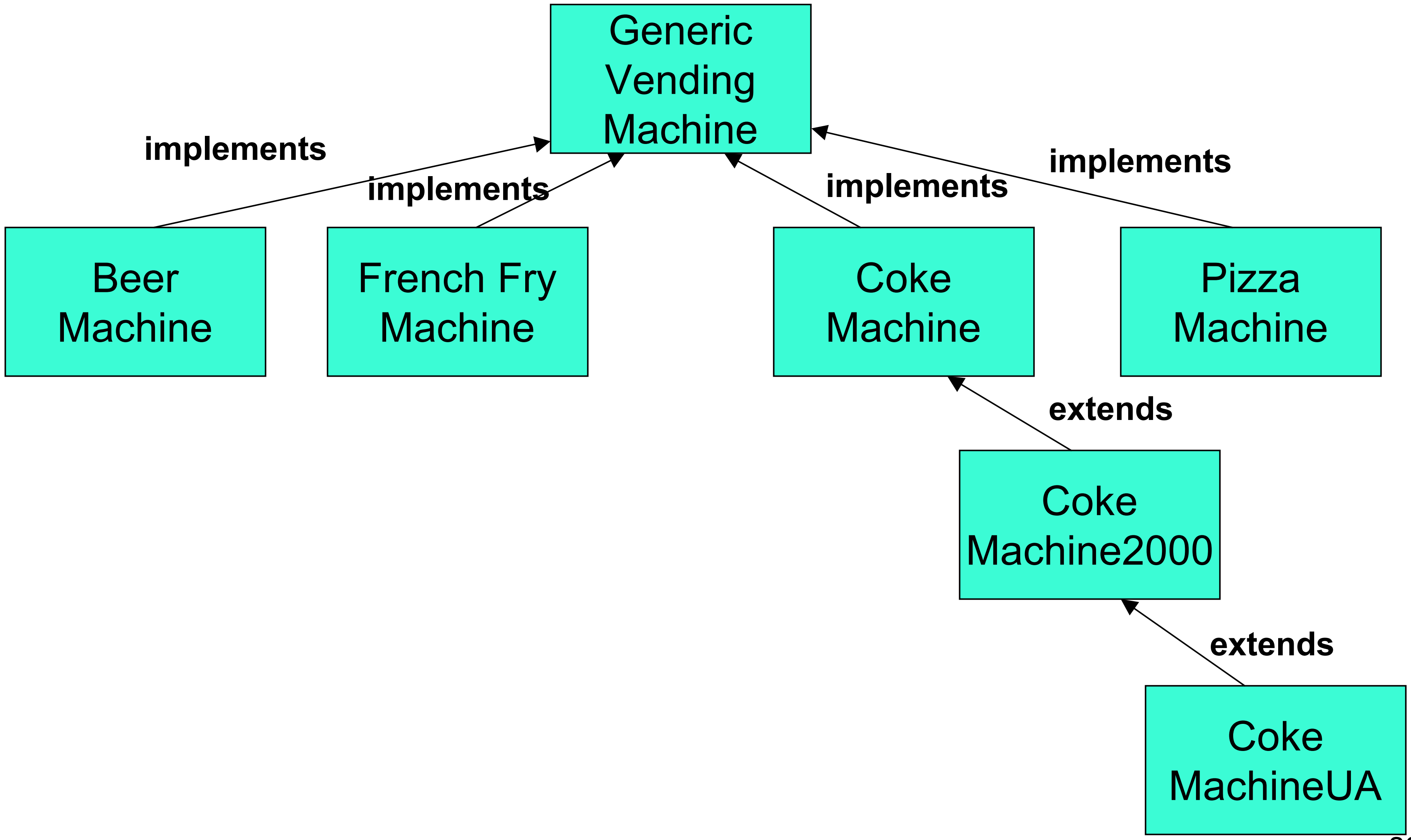
Abstract Methods and Abstract Classes

- What happens when we try to compile it all now?
  - Java tells us that there's an abstract class we have to implement
  - Could put this CokeMachine class:

```
public void vandalize()
 {
   System.out.println("Take all my money, and have a Coke too");
 }
```

- Do we have to implement method in CokeMachine2000 and CokeMachineUA classes too?
  - Yes, if we want them to behave differently when they're vandalized
    - original intent

Which Organization?



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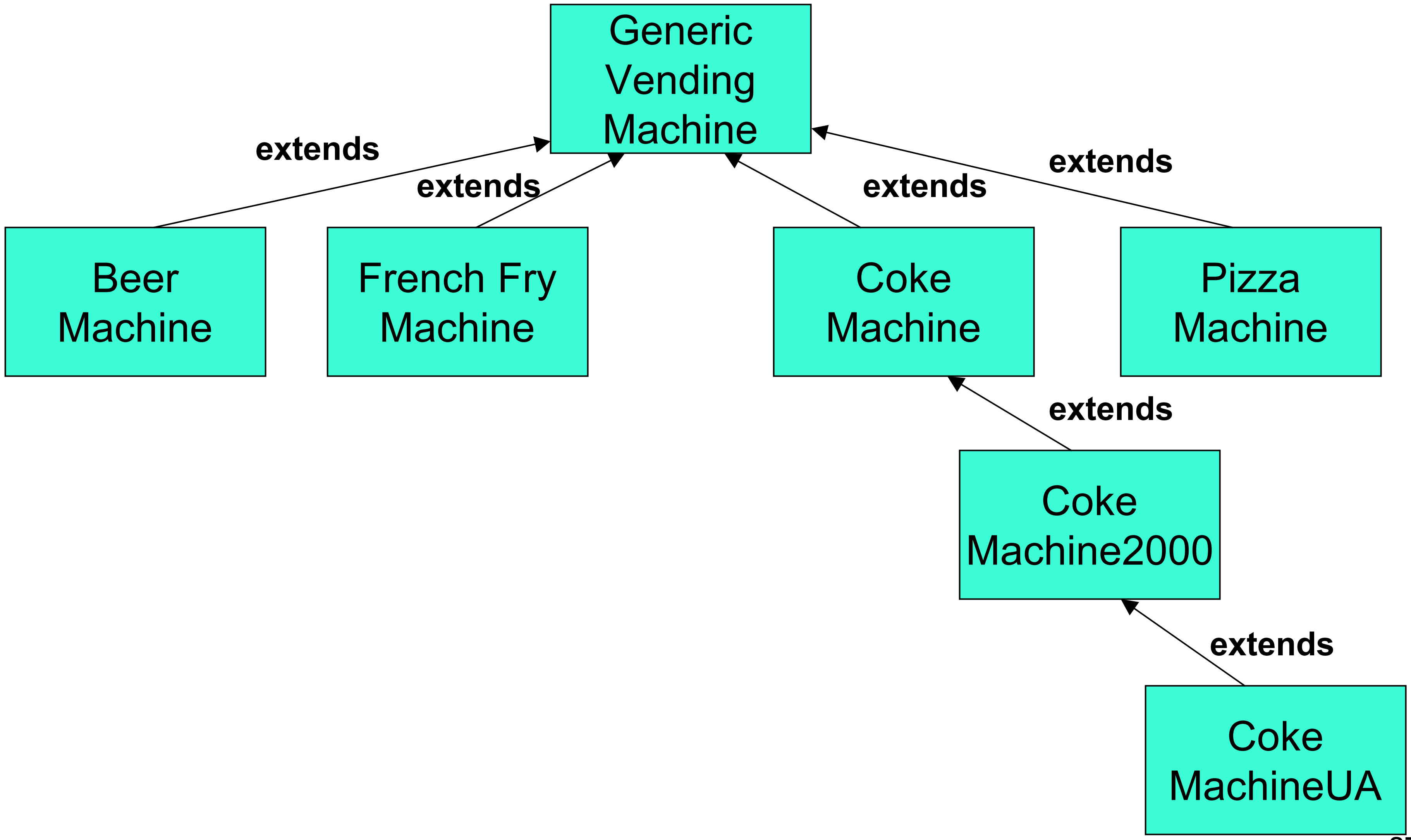

Interfaces vs. Abstract Classes

- If we can have abstract class that contains only abstract methods, why do we need interfaces?

Interfaces vs. Abstract Classes

- If we can have abstract class that contains only abstract methods, why do we need interfaces?
  - Java does not support multiple inheritance: child classes inheriting attributes from multiple parent classes
    - other object-oriented languages do
  - multiple inheritance can be good, but causes problems
    - what if child class inherits two different methods with same signature from two different parents?
      - which one should be used?

Interfaces vs. Abstract Classes

- Java's formal interface provides some of the utility of multiple inheritance without the problems
  - class can implement more than one interface
  - can do this at same time it extends class
- Interface allows us to create classes that "inherit" features from multiple places

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- Interface allows us to create classes that "inherit" features from multiple places
- Why is problem from previous slide solved?
  - might have multiple method headers with same signature

Interfaces vs. Abstract Classes

- Java's formal interface provides some of the utility of multiple inheritance without the problems
  - class can implement more than one interface
  - can do this at same time it extends class
- Interface allows us to create classes that "inherit" features from multiple places
- Why is problem from previous slide solved?
  - might have multiple method headers with same signature
  - but only one will have an actual definition
    - no ambiguity on which will be used
    - but still could be problem with different return types

Interfaces vs. Abstract Classes

- Another useful feature provided by interfaces:
  - inheritance happens between classes that are related
  - But classes can implement completely unrelated interfaces
    - and that can be useful

Interfaces vs. Abstract Classes

- Another useful feature provided by interfaces:
  - inheritance happens between classes that are related
  - But classes can implement completely unrelated interfaces
    - and that can be useful
- Example: implement interfaces for
  - computer, printer, cell phone, vending machine
  - create class for new interactive vending machines that:
    - vend Cokes, show annoying music videos, phone their owner when they're running low on product, and spit out coupons for free prizes

How Interfaces Differ From Abstract Classes

- Abstract class is incomplete class that requires further specialization
  - interface is just specification or prescription for behavior

from Just Java 2 by Peter van der Linden

How Interfaces Differ From Abstract Classes

- Abstract class is incomplete class that requires further specialization
  - interface is just specification or prescription for behavior
- Inheritance implies specialization, interface does not
  - interface just implies "We need something that does 'foo' and here are ways that users should be able to call it.“

from Just Java 2 by Peter van der Linden

How Interfaces Differ From Abstract Classes

- Abstract class is incomplete class that requires further specialization
  - interface is just specification or prescription for behavior
- Inheritance implies specialization, interface does not
  - interface just implies "We need something that does 'foo' and here are ways that users should be able to call it.“
- Class can implement several interfaces at once
  - but class can extend only one parent class

from Just Java 2 by Peter van der Linden

Interfaces vs. Abstract Classes: Bottom Line

- Use abstract class to initiate a hierarchy of more specialized classes
- Use interface to say, "I need to be able to call methods with these signatures in your class."
- Use an interface for some semblance of multiple inheritance

from Just Java 2 by Peter van der Linden

Interfaces vs. Abstract Classes

- Interface can only extend another interface
  - cannot extend abstract class or "concrete" class
- Class can legally implement only some methods of interface if it's abstract class
  - then must be further extended through inheritance before can be instantiated

from Just Java 2 by Peter van der Linden

Who Can Do What?

- Interface can be implemented only by class or abstract class
- Interface can be extended only by another interface
- Class can be extended only by class or abstract class
- Abstract class can be extended only by class or abstract class
- Only classes can be instantiated as objects
  - Interfaces are not classes and cannot be instantiated
  - Abstract classes may have undefined methods and cannot be instantiated