Interfaces In Java

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Before We Begin…

- Couple more slides on checkers, then a challenge
- There is also an “AIntelligence” class
  - — This encapsulates the idea of a checker-playing intelligence
  - — Human or otherwise!

```
abstract class Intelligence {
  private Checker myColor;

  protected boolean isMyColor (Checker pieceToCheck) {}

  protected Intelligence (Checker youAreThisColor) {}

  abstract Board computeNextMove (Board startWithMe)
    throws IOException;
}
```

Then the Main Program Is…

```
public static void main (String [] args) throws IOException {

  // create a new checker board
  Board myBoard = new Board ();
  myBoard.init ();
  myBoard.print ();

  // get two players
  Intelligence playerOne = new Human (new RedChecker (0, 0));
  Intelligence playerTwo =
    new BruteForceSearch (new BlackChecker (0, 0), 5);

  // keep processing moves until someone wins
  while (true) {

    // player one moves
    myBoard = playerOne.computeNextMove (myBoard);
    myBoard.print ();
    if (myBoard.isDone ())
      break;
```

The Main Program (cont'd)

```
    // player two moves
    myBoard = playerTwo.computeNextMove (myBoard);
    myBoard.print ();
    if (myBoard.isDone ())
      break;
  }
}
```

The Simple AI That I Implemented

- Assigns a score to each board
  - — Score is summed over all checkers
  - — King is 5 points, regular piece worth 2 points
  - — Piece on left or right edge is an extra point
  - — Score is flipped for opponent
- Then it recursively runs all possible scenarios
  - — Assumes opponent always does the smartest thing
  - — Then always chooses the move with the best, worst outcome (“minimax”)
- Pretty darn good early on in the game
  - — But quite poor at the endgame
  - — Needs more strategy; brute-force minimax does not cut it

The Challenge…

- I challenge you to build an AI!
  - — Start from scratch or modify mine
  - — When you get one that can beat mine, send it to me
  - — I'll wait a week and then have them play in a tournament
  - — Will post the submitted codes (with permission), and announce the winner
  - — <Insert joke here about winner getting no prize, but undying admiration of peers>
- Ground rules
  - — Can't download a code from the Internet
  - — Must average 10 seconds or less per turn over an entire game, or automatic loss
  - — Must use existing checkers framework, can't modify code to make it faster
  - — But can add methods and such to code to make your AI work

Now On To Interfaces in Java

- Java gives the ability to declare an “interface”
- Like a class, except:
  - — Can’t declare any member variables (well, you can, but don’t do it)
  - — All functions are implicitly abstract, public
  - — So no implementations for anything!
- Example: “Iterator” in Java standard class library:

```
interface Iterator <E> { // note: this is a generic interface
  boolean hasNext ();    // parameterized on type E
  E next ();
  void remove ();
}
```

- So why does Java have these?

Interfaces vs. Abstract Classes

- Like an abstract class
- Very similar, but are a few key differences
- A class “implements” an interface, vs. “extends” another class.
- Ex:

```
class IntArrayIter implements Iterator <Integer> { }
```

- Or, if “Iterator” hadn’t been generic:

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class IntArrayIter implements Iterator { }
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- Another key difference: multiple inheritance is allowed:

```
class IntArrayIter implements Iterator <.>, IResettable { }
// “IResettable” might look like:
interface IResettable {
  void startOver ();
}
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Is this a good idea here?

```
// “IResettable” might look like:
interface IResettable {
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```

Don’t Abuse Multiple Inheritance!

- In this example, would have been much better to extend “Iterator”:

```
interface IResettable <T> extends Iterator <T> {
  void startOver ();
}

class IntArrayIter implements IResettable <Integer> { }
```

- Why is this better?

Don’t Abuse Multiple Inheritance!

- In this example, would have been much better to extend “Iterator”:

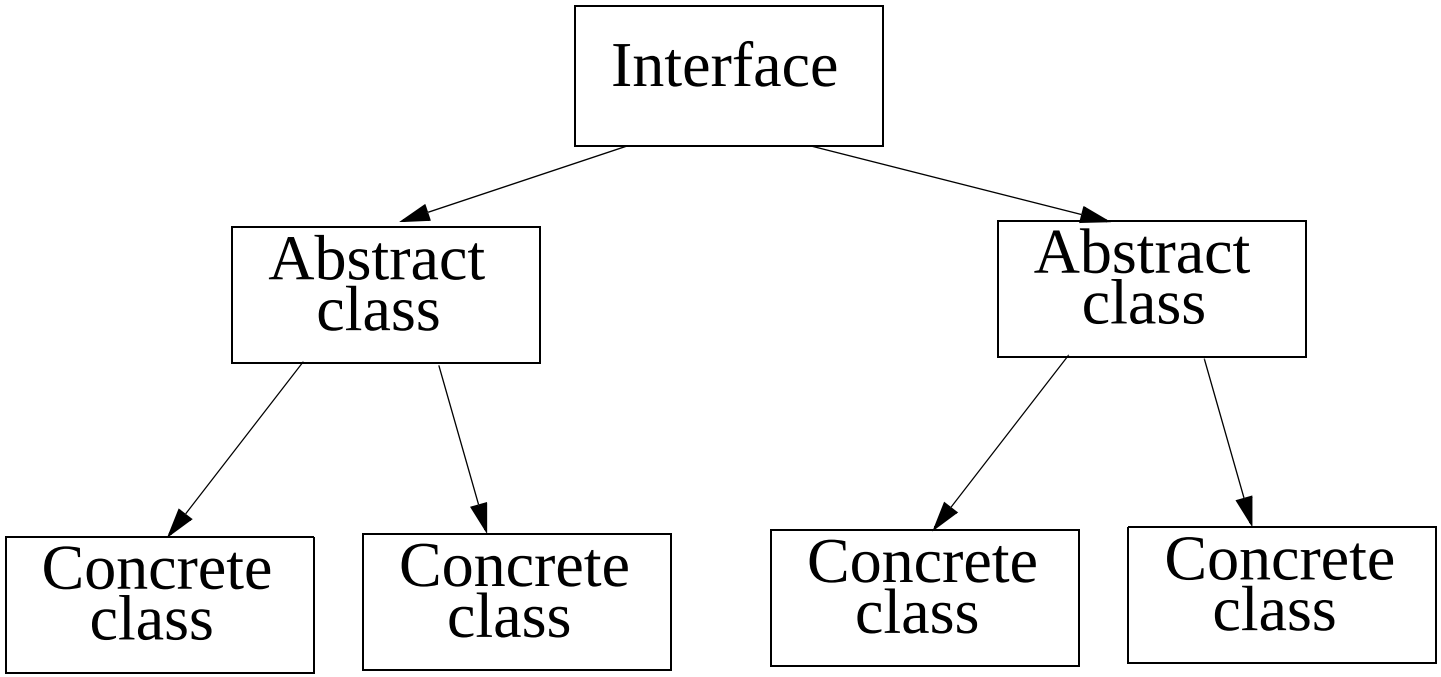
```
interface IResettable <T> extends Iterator <T> {
  void startOver ();
}

class IntArrayIter implements IResettable <Integer> { }
```

- Why is this better?
  - — We really are adding to the interface... “IResettable” does not make much sense outside the context of “Iterator”
  - — Use multiple inheritance only if a class really provides many, totally separate types of functionality

Question: When Should You Use Abstract Classes, Interfaces, "Regular Classes"

- Typically, you will use all three:



What Do You Put In An Interface?

- All of the functionality that is so abstract...
- That it has nothing to do with an implementation
  - — Examples:
  - — A stack has “push” and “pop”
  - — A queue has “enqueue” and “dequeue”
  - — A map has “add” and “lookup” (well, a Java map doesn’t...)

What Do You Put In An Abstract Class?

- Here you'll put functionality that many/all imps will share
- Mostly, it will be interface functions that can be written in terms of other interface functions
- Out of the following methods:

```
void push (int);
Integer pop ();
boolean isEmpty ();
void reverse ();
```

  - — Which one would go in the an abstract class?
  - — What does the pseudo-code look like?

What Do You Put In An Abstract Class?

- In this example, might put “reverse” in there:

```
abstract class AIntStack implements IInstStack {

  public void reverse () {
    ????
  }

  private void addAtBottom (int me) {
    ????
  }
}
```

What Do You Put In An Abstract Class?

- In this example, might put “reverse” in there:

```
abstract class AIntStack implements IInstStack {

  public void reverse () {
    if (!isEmpty ()) {
      int i = pop ();
      reverse ();
      addAtBottom (i);
    }
  }

  private void addAtBottom (int me) {
    if (isEmpty ()) {
      push ();
    } else {
      int temp = pop ();
      addAtBottom (me);
      push (temp);
    }
  }

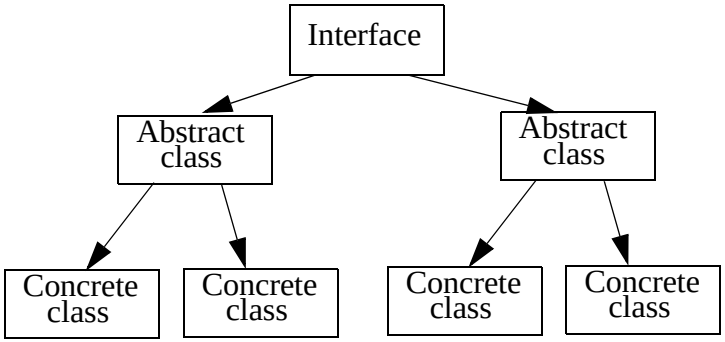
}
```

What Do You Put In The Concrete Class?

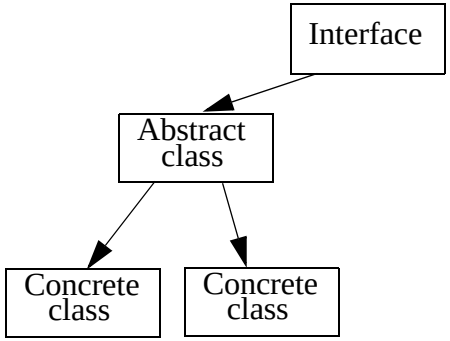
- The actual implementation!
- Ex: can implement “AIntStack” using “ArrayList <Integer>”:
  - “push (i)” uses “list.add (i)” (adds integer at end of list)
  - “pop ()” uses “list.remove (list.length () - 1)”
  - “isEmpty ()” uses “list.length () == 0”
  - Note: can over-ride addAtBottom for better performance!

Now Time for Some Navel Gazing

- Will you actually ever have this?



Or is it always this:



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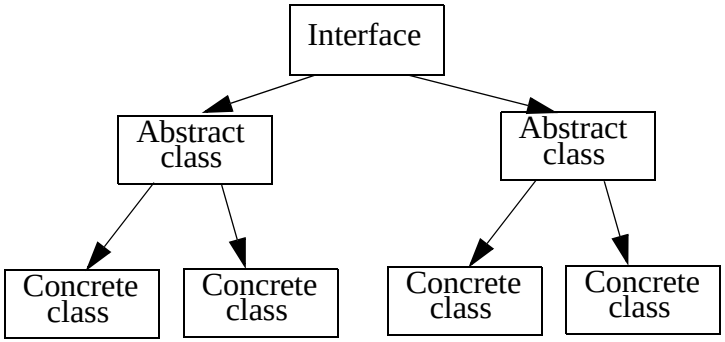

This one should be pretty rare!

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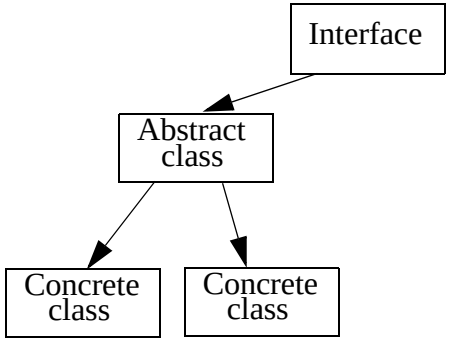

Why Avoid Multiple Abstract Imps?

- Often this is the knee-jerk reaction to multiple implementations of interface ops that can be written in terms of other interface ops
- But this can be problematic
  - — Imagine multiple stack implementations
  - — Along with multiple implementations of “Reverse”
  - — Where all are interchangeable
  - — What happens if use “multiple abstract class” solution, put each in diff abstract?

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  - — What should we have done?

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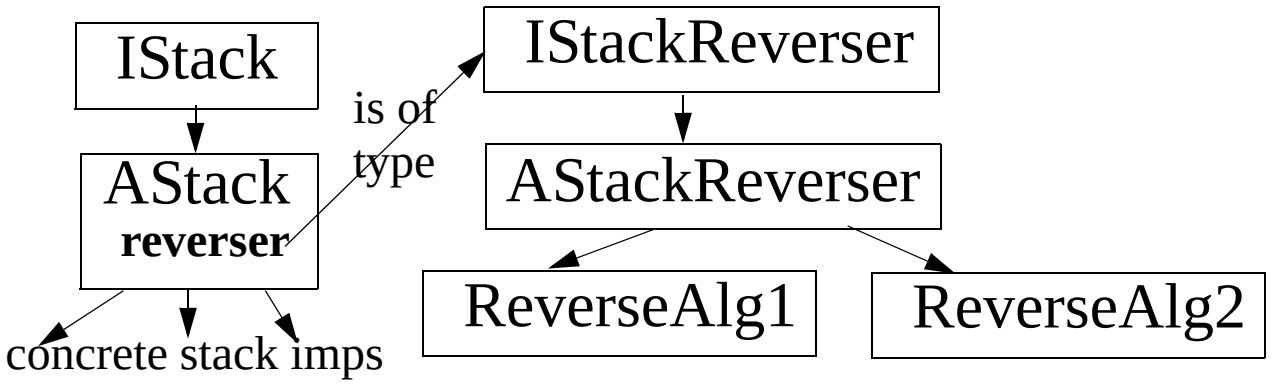
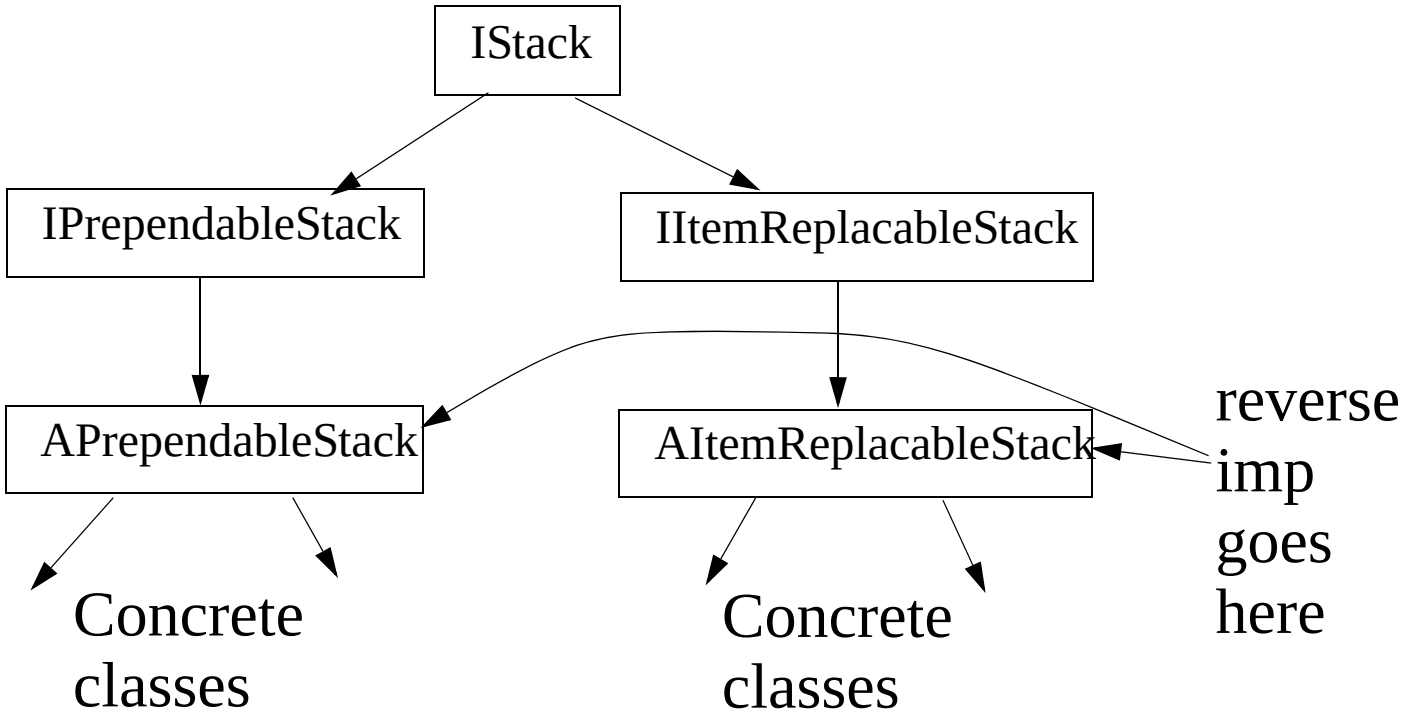


Do We Ever Actually Need Mult Abstracts?

- What if diff implementations of reverse depend on different ops...
  - — And those ops are not gonna be common to all imps?
  - — Imagine multiple stack implementations
  - — Easy to implement “addAtBottom” for some imps
  - — Easy to implement “replaceValAtPosI (val, pos)” for other imps
  - — (An aside: what does “reverse” look like using “replaceValAtPosI”?)
- It’s clear we can’t use prior design strategy here
- In this case, should you have multiple abstract classes?
  - — Not clear...
  - — What might we have done instead?

A Better Design?



Sooo... is this better? I'd say: it depends

Last Bit of Navel Gazing

- Should you **always** have at least a three-level hierarchy?
  - — Interface, abstract base, (multiple?) concrete
- Some will argue emphatically "**YES!**"
  - — Perhaps even in later classes you'll be told this?
- I'll be a little more permissive
  - — Either have one level (only a single concrete base)
  - — Or three or more (that is, never start with an abstract base)
- Why?

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- Why?
  - — Sometimes you'll have a class where you **know** you'll never need mult. imps
  - — Just make sure to switch over at first sign of trouble!
  - — But if you've got an abstract base, just define the interface

This Sort of Does It For the Formal Intro To OODesign

- Talked about how one uses inheritance, polymorphism, and the proper role of interfaces
  - — You'll get this much more rigorously in COMP 310
  - — Will distill many of the ideas we've discussed here into "design patterns"
- Closing throughts
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  - — I know many of you are skpetical. But keep in mind:
  - — I'll grant you that the best programmers can write 50K SLOC in a year...
  - — ...and never think explicitly about design...
  - — ...and the code just works perfectly
  - — HOWEVER, most people (inluding, probably, you!) just are not that good
  - — And even if you are, heaven forbid you ever move on...

We Finish Up With Some Notes on A2

- Goal is to implement the “IDoubleVector” interface
  - — Having a vector of doubles is a key abstraction to implementing our ML algorithm
- We’ll need two actual implementations
  - — A dense one (built on top of array of doubles)
  - — A sparse one (built on top of ISparseArray generic, which you’ll imp next)
  - — What’s the diff between a dense array and a sparse array?

Need to Have a Notion of a “Backing Value”

- What’s that?
  - — It’s the default value for entry in an IDoubleVector
  - — Every non-empty slot is actually a “delta” or diff from the backing value
  - — Allows you to add same number to every entry in constant time
  - — Vital for sparse vector, might as well use for dense one, too

Most Ops Are Self-Explanatory

- In case you haven't seen it, the "L1" norm of a vector...
  - — Is the sum of the absolute values of the entries in the vector
- Noramlization...
  - — Means you scale all of the entries to the L1 norm is one
  - — Keeping all ratios constant

A Super-Quick Note on Java Exceptions

- An “exception” tells caller that there was a problem in a method
  - — Caller is forced to handle this using the “try-catch” framework
  - — Look at test code to see this
- Many of the IDoubleVector ops throw “OutOfBoundsException”
  - — This means that whenever someone does something out of range...
  - — You should execute the line:

```
throw new OutOfBoundsException ();
```

- Much more on exceptions next lecture...