Recreation

An integer is divided by 9 when a certain one of its digits is deleted, and the resulting number is again divisible by 9.

a. Prove that actually dividing the resulting number by 9 results in deleting another digit.

b. Find all integers satisfying the conditions of this problem.

CS61B Lecture #11: Examples: Comparable & Reader + Some Features Supporting Abstraction

Comparable

- Java library provides an interface to describe Objects that have a *natural order* on them, such as `String`, `Integer`, `BigInteger` and `BigDecimal`:

```
public interface Comparable { // For now, the Java 1.4 version
  /** Returns value <0, == 0, or > 0 depending on whether THIS is
   *  <, ==, or > OBJ.  Exception if OBJ not of compatible type. */
  int compareTo(Object obj);
}
```

- Might use in a general-purpose max function:

```
/** The largest value in array A, or null if A empty. */
public static Comparable max(Comparable[] A) {
  if (A.length == 0) return null;
  Comparable result; result = A[0];
  for (int i = 1; i < A.length; i += 1)
    if (result.compareTo(A[i]) < 0) result = A[i];
  return result;
}
```

- Now `max(S)` will return maximum value in `S` if `S` is an array of Strings, or any other kind of Object that implements `Comparable`.

Examples: Implementing Comparable

```
/** A class representing a sequence of ints. */
class IntSequence implements Comparable {
    private int[] _myValues;
    private int _myCount;
    ...
    public int get(int k) { return _myValues[k]; }

    @Override
    public int compareTo(Object obj) {
       IntSequence x = (IntSequence) obj; // Blows up if obj not an IntSequence
       for (int i = 0; i < _myCount && i < x._myCount; i += 1) {
           if (_myValues[i] < x._myValues[i]) {
              return -1;
           } else if (_myValues[i] > x._myValues[i]) {
              return 1;
       }
       return _myCount - x._myCount;  // <0 iff _myCount < x._myCount
    }
}
```

Implementing Comparable II

- Also possible to add an interface retroactively.
- If `IntSequence` did not implement `Comparable`, but did implement `compareTo` (without `@Override`), we could write

```
class ComparableIntSequence extends IntSequence implements Comparable {

}
```

- Java would then "match up" the `compareTo` in `IntSequence` with that in `Comparable`.

Java Generics (I)

- We've shown you the old Java 1.4 `Comparable`. The current version uses a newer feature: Java generic types:

```
public interface Comparable<T> {
    int compareTo(T x);
}
```

- Here, `T` is like a formal parameter in a method, except that its "value" is a *type*.
- Revised `IntSequence` (no casting needed):

```
class IntSequence implements Comparable<IntSequence> {
    ...
    @Override
    public int compareTo(IntSequence x) {
       for (int i = 0; i < _myCount && i < x._myCount; i += 1) {
           if (_myValues[i] < x._myValues[i]) ...

       return _myCount - x._myCount;
    }
}
```

Example: Readers

- Java class `java.io.Reader` abstracts *sources of characters*.
- Here, we present a revisionist version (not the real thing):

```
public interface Reader {  // Real java.io.Reader is abstract class
  /** Release this stream: further reads are illegal */
  void close();

  /** Read as many characters as possible, up to LEN,
   *  into BUF[OFF], BUF[OFF+1],..., and return the
   *  number read, or -1 if at end-of-stream. */
  int read(char[] buf, int off, int len);

  /** Short for read(BUF, 0, BUF.length). */
  int read(char[] buf);

  /** Read and return single character, or -1 at end-of-stream. */
  int read();
}
```

- Can't write `new Reader()`; it's abstract. So what good is it?

Generic Partial Implementation

- According to their specifications, some of Reader's methods are related.
- Can express this with a *partial implementation,* which leaves key methods unimplemented and provides default bodies for others.
- Result still abstract: can't use **new** on it.

```
/** A partial implementation of Reader. Concrete
 *  implementations MUST override close and read(,,).
 *  They MAY override the other read methods for speed. */
public abstract class AbstractReader implements Reader {
  // Next two lines are redundant.
  public abstract void close();
  public abstract int read(char[] buf, int off, int len);

  public int read(char[] buf) { return read(buf,0,buf.length); }

  public int read() { return (read(_buf1) == -1) ? -1 : _buf1[0]; }

  private char[] _buf1 = new char[1];
}
```

Implementation of Reader: StringReader

The class StringReader reads characters from a String:

```
public class StringReader extends AbstractReader {
  private String _str;
  private int _k;
  /** A Reader that delivers the characters in S. */
  public StringReader(String s) {
      _str = s; _k = 0;
  }

  public void close() { _str = null; }

  public int read(char[] buf, int off, int len) {
      if (_k == _str.length())
          return -1;
      len = Math.min(len, _str.length() - _k);
      _str.getChars(_k, _k + len, buf, off);
      _k += len;
      return len;
  }
}
```

Using Reader

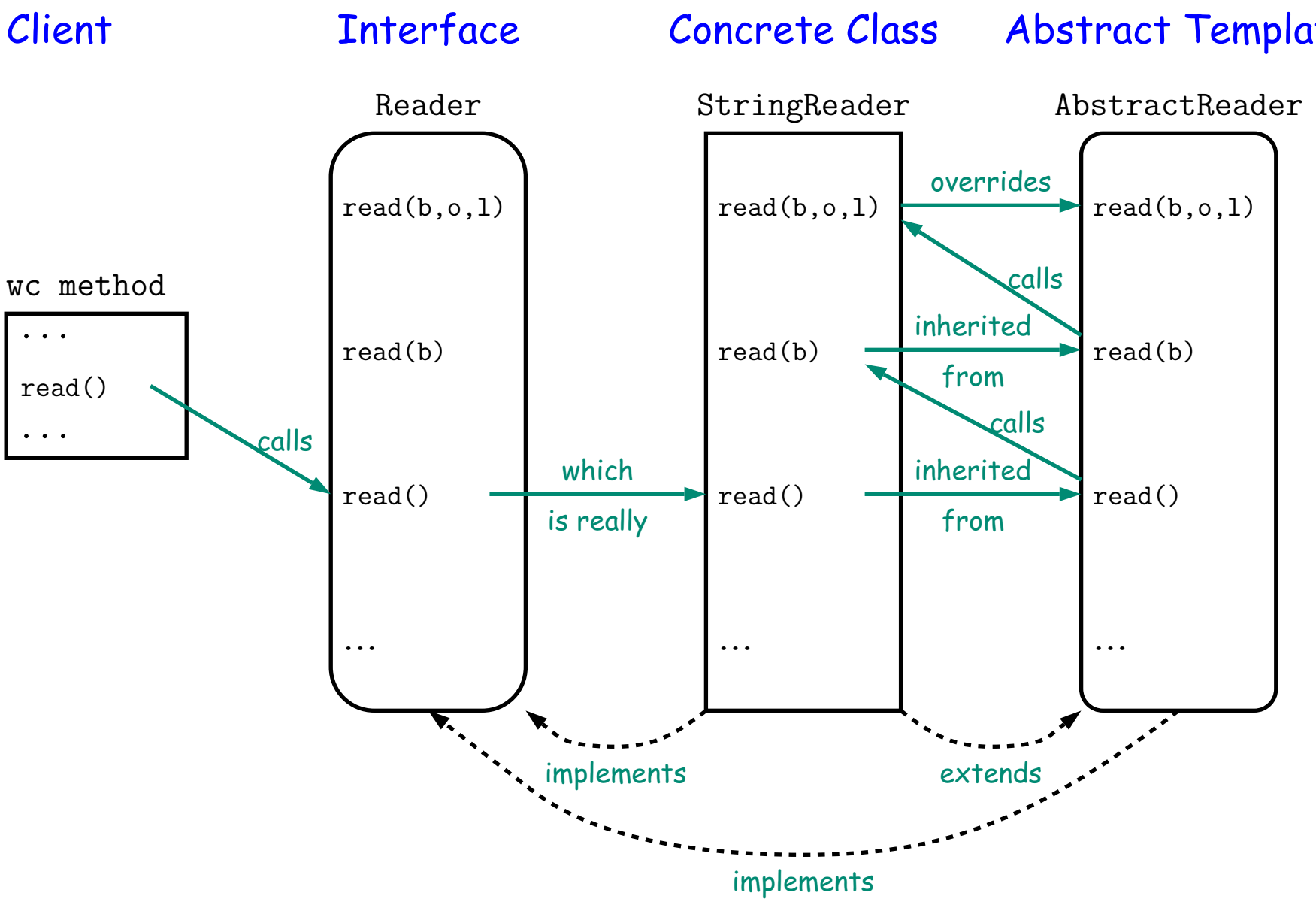
Consider this method, which counts words:

```
/** The total number of words in R, where a "word" is
 *  a maximal sequence of non-whitespace characters. */
int wc(Reader r) {
  int c0, count;
  c0 = ' '; count = 0;
  while (true) {
      int c = r.read();
      if (c == -1) return count;
      if (Character.isWhitespace((char) c0)
          && !Character.isWhitespace((char) c))
          count += 1;
      c0 = c;
  }
}
```

This method works for *any* `Reader`:

```
wc(new StringReader(someText))          // # words in someText
wc(new InputStreamReader(System.in))    // # words in standard input
wc(new FileReader("foo.txt"))           // # words in file foo.txt.
```

How It Fits Together



Lessons

- The `Reader` interface class served as a *specification* for a whole set of readers.
- Ideally, most client methods that deal with `Readers`, like `wc`, will specify type `Reader` for the formal parameters, not a specific kind of `Reader`, thus assuming as little as possible.
- And only when a client creates a new `Reader` will it get specific about what subtype of `Reader` it needs.
- That way, client's methods are as *widely applicable* as possible.
- Finally, `AbstractReader` is a tool for implementors of non-abstract `Reader` classes, and not used by clients.
- Alas, Java library is not pure. E.g., `AbstractReader` is really just called `Reader` and there is no interface. In this example, we saw what they *should* have done!
- The `Comparable` interface allows definition of functions that depend only on a limited subset of the properties (methods) of their arguments (such as "must have a `compareTo` method").

More OOP Features Supporting Abstraction

Parent Constructors

- In lecture notes #7, talked about how Java allows implementer of a class to control all manipulation of objects of that class.
- In particular, this means that Java gives the constructor of a class the first shot at each new object.
- When one class extends another, there are two constructors—one for the parent type and one for the new (child) type.
- In this case, Java guarantees that *one of the parent's constructors is called first.* In effect, there is a call to a parent constructor at the beginning of every one of the child's constructors.
- You can call the parent's constructor yourself explicitly.

```
class Figure {
  public Figure(int sides) {
     ...
  }...
}
```

```
class Rectangle extends Figure {
   public Rectangle() {
      super(4);
   }...
}
```

Default Constructors

- By default, Java calls the "default" (parameterless) constructor if there is no explicit constructor called.

```
  /* This... */
class Thingy extends Rectangle {
    public Thingy() {
       setThingsUp();
    }
}
```

```
  /* Is equivalent to... */
class Thingy extends Rectangle {
    public Thingy() {
        super();
        setThingsUp();
    }
}
```

- And it creates a default constructor for a class if no other constructor is defined for the class.

```
  /* This... */
class Crate {
}
```

```
  /* Is equivalent to... */
class Crate {
    public Crate() {
    }
}
```

```
  /* And thus to... */
class Crate {
    public Crate() {
        super();
    }
}
```

What Happens Here?

```
class Figure {
  public Figure(int sides) {
      ...
  }
}
```

```
class Rectangle extends Figure {
}
```

What Happens Here?

```
class Figure {
  public Figure(int sides) {
      ...
  }
}
```

```
class Rectangle extends Figure {
}
```

Answer: Compiler error. `Rectangle` has an implicit constructor that tries to call the default construvtor in `Figure`, but there isn't one.

Using an Overridden Method

- Suppose that you wish to *add* to the action defined by a superclass's method, rather than to completely override it.
- The overriding method can refer to overridden methods by using the special prefix super.
- For example, you have a class with expensive functions, and you'd like a memoizing version of the class.

```
class ComputeHard {
  int cogitate(String x, int y) { ... }
}

class ComputeLazily extends ComputeHard {
  int cogitate(String x, int y) {
    if (don't already have answer for this x and y) {
       int result = super.cogitate(x, y);  // <<< Calls overridden function
       memoize (save) result;
       return result;
    }
     return memoized result;
  }
}
```