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

```java
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:

```java
/** 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 = A[0];
    for (int i = 1; i < A.length; i++)
        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.

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

```java
class ComparableIntSequence extends IntSequence implements Comparable {
    // Blows up if incomparable
    for (int i = 0; i < myCount && i < x.myCount; i++)
        if (myValues[i] < x.myValues[i])
            return -1;
        else if (myValues[i] > x.myValues[i])
            return 1;
    return myCount - x.myCount; // Umm. A bit tricky
}
```

Example: Readers

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

```java
public interface Reader {
    /** Release this stream: further reads are illegal */
    void close();
    /** Read as many characters as possible, up to LEN, * into BUF[0..[LEN], 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.

```java
/** A partial implementation of Reader. Complete implementations MUST override close and read(,,). They MAY override the other read methods for speed. */
public abstract class AbstractReader implements Reader {
    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:

```java
public class StringReader extends AbstractReader {
    private String str;
    private int k;
    /** A Reader delivering the characters in STR. */
    public StringReader(String str) {
        this.str = str; 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:

```java
/** 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 = ' '; cnt = 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:

```java
// Number of words in the String someText:
wc(new StringReader(someText))
// Number of words in standard input.
wc(new InputStreamReader(System.in))
// Number of words in file named fileName:
wc(new FileReader(fileName))
```

**How It Fits Together**

\[
\text{Client} \quad \text{Interface} \quad \text{Concrete Class} \quad \text{Abstract Template}
\begin{align*}
\text{Reader} & \quad \text{read(b,o,l)} \quad \text{read(b,o,l)} \quad \text{read(b,o,l)} \\
\text{StringReader} & \quad \text{read(b,o,l)} \quad \text{read(b,o,l)} \quad \text{read(b,o,l)} \\
\text{AbstractReader} & \quad \text{read(b,o,l)} \quad \text{read(b,o,l)} \quad \text{read(b,o,l)}
\end{align*}
\]
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").