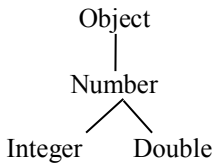
Bounded wildcards made simple

The topic of bounded wildcards is often cloaked in mystery. We attempt to introduce the topic in a way that uncloaks the mystery, making the topic as simple as possible. We will present two methods to help explain bounded wildcards. You will understand this topic more easily if you copy-and-paste the methods into a Java program and play with them as we suggest, so that you see for yourself what happens.



We will be using classes Integer and Double, which are both subclasses of type Number.

To the right is method m1. The type of parameter p contains an *upper-bounded wildcard*:

? extends Number

```
public static void m1(ArrayList<? extends Number> p) {
    Number x= p.get(5);
    // p.add(new Integer(5));
}
```

This means that the corresponding argument of a call on m1 can be an ArrayList whose elements are of class Number or of any class that extends class Number, including Integer and Double.

Within the body of m1, when an element of ArrayList p is retrieved, it is viewed as a Number.

Copy method m1 into a Java class and note that it compiles. Now, uncomment the call p.add(…). This call is syntactically incorrect; it does not compile; it violates the typing rules. This is good! Method m1 should not be allowed to *change* p. For example, if the argument of a call is of type ArrayList<Double>, adding an Integer to p would be a mistake.

SUMMARY. Use an upper-bounded wild card only when values are to be retrieved and processed and the data structure (ArrayList) won't be changed.

To the right is method m2. The type of parameter p contains a *lower-bounded wildcard*:

? super Integer

```
public static void m2(ArrayList<? super Integer> p) {
    p.add(5);
    // Integer x= p.get(5);
}
```

This means that the corresponding argument of a call on m2 can be an ArrayList whose elements are of any class that is Integer or a superclass of Integer, including Number and Object. But an element of the ArrayList is viewed as an Integer.

Within the body of m2, it's OK to add Integer's to ArrayList p because the possible types of the ArrayList elements are Integer and any superclass of Integer. For example, an Integer is a Number and also an Object.

Copy method m2 into a Java class and note that it compiles. Now uncomment the assignment to x. This assignment is syntactically incorrect; it does not compile; it violates the typing rules. This is good! Method m2 should not be allowed to retrieve values from the ArrayList because it views them all as of type Integer and they need not be Integers. For example, if the argument of a call has type ArrayList<Number>, an element might be a Double, which can't be stored in an Integer variable.

SUMMARY. Use a lower-bounded wild card only when the data structure, in this case the ArrayList, is to be changed, but not to process its elements.

Notes

1. In the upper-bounded wildcard of the form ? extends C , C can be a class *or* an interface. In this context, the word *extends* is used for both classes and interfaces.
2. In the lower-bounded wildcard of the form ? super C , C can be a class *or* an interface. In this context, the word *super* is used for both classes and interfaces.
3. You may hear the terminology *in parameter* for a parameter that provides data to be processed. An upper-bounded wildcard can be used for this parameter. On the other hand, the terminology *out parameter* means a parameter that accepts data. A lower-bounded wildcard can be used for this parameter.
4. Don't use wildcards in return types because that forces a user who is writing calls on the method to deal with them.