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♥ Java Generics in no time "? extends" & "? super" explained with a diagram

Posted on June 25, 2015 by Arulkumaran Kumaraswamipillai

Generics in Java can be be a bit tricky to get your head around. Hope the explanation below enhances your understanding of generics. This complements 3 scenarios to get handle on Java generics.

Plain old List, List<Object>, and List<?>

The plain old List: is a heterogeneous mixture or a mixed bag that contains elements of all types, for example Integer, String, Pet, Dog, etc.

The List<Object>: is also a heterogeneous mixture like the plain old List, but not the same and can be more restrictive than a plain old List. It is incorrect to think of this as the super type for a collection of any object types.

The List<?>: is a homogenous collection that represents a family of generic instantiations of List like List<String>, List<Integer>, List<Pet>, List<Dog>, etc.

List<?> is the **super type** for all generic collection as Object[ ] is the super type for all arrays.

What can I assign to? What can I add to the Collection?

When working with Collection & Generics, you need to ask 4 important questions.

1) Can the RHS be assigned to the LHS?
2) What types of objects can I add to the collection?
3) Is it a read only or read & write collection?
4) When to use which wild card ("? extends", "? super") ?

If you do the wrong thing, you will get "compile-time" errors. Also, note that you can't use wildcards on the RHS when assigning and Java 8 supports empty "<>" on the RHS.

Understanding Generics and assign-abilities

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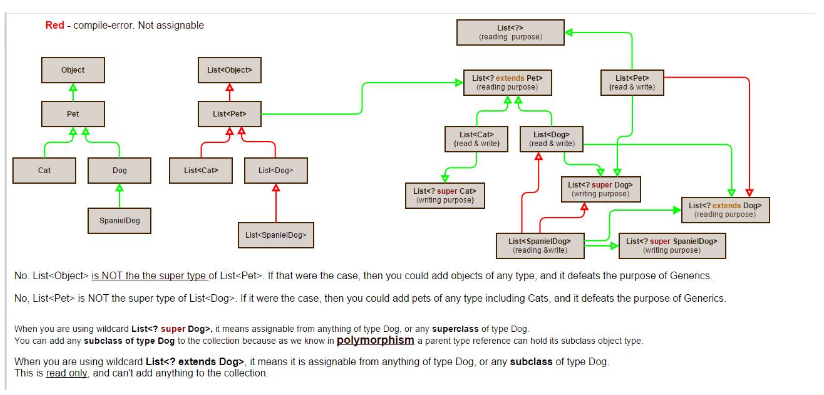

Red - compile-error. Not assignable
Object
Pet
Cat
Dog
SpanielDog
List<Object>
List<Pet>
List<Cat>
List<Dog>
List<SpanielDog>
List<?> (reading purpose)
List<? extends Pet> (reading purpose)
List<Pet> (read & write)
List<Cat> (read & write)
List<Dog> (read & write)
List<? super Cat> (writing purpose)
List<? super Dog> (writing purpose)
List<? extends Dog> (reading purpose)
List<SpanielDog> (reading &write)
List<? super SpanielDog> (writing purpose)

No. List<Object> is NOT the the super type of List<Pet>. If that were the case, then you could add objects of any type, and it defeats the purpose of Generics.

No, List<Pet> is NOT the super type of List<Dog>. If it were the case, then you could add pets of any type including Cats, and it defeats the purpose of Generics.

When you are using wildcard **List<? super Dog>**, it means assignable from anything of type Dog, or any **superclass** of type Dog.
You can add any **subclass of type Dog** to the collection because as we know in **polymorphism** a parent type reference can hold its subclass object type.

When you are using wildcard **List<? extends Dog>**, it means it is assignable from anything of type Dog, or any **subclass** of type Dog.
This is read only, and can't add anything to the collection.

Java Generics Overview for assignability

Note: "**?**" is a wild card meaning anything. "? extends Pet" means "**anything** that extends a Pet".

Now let's see a code example based on the above diagram. Click on the diagram to expand.

```
package com.generics;

import java.util.ArrayList;
import java.util.List;

public class GenericsAssignable {

    public static void main(String[] args) {
        new GenericsAssignable().create();
    }

    public void create() {

        List<Object> objectsBad = new ArrayList<
        List<Pet> petsBad = new ArrayList<Dog>()


        //===== "?" and "? extends" - read only
        List<?> petsOk = new ArrayList<Pet>(); /
        List<? extends Pet> petsOk2 = new ArrayL
        List<? extends Pet> petsOk3 = new ArrayL
        List<? extends Dog> petsOk4 =  new Array
        List<? extends Dog> petsOk5 =  new Array

        List<? extends Dog> petsBad2 =  new Arra

        //====  "? super" - can add objects to c
        List<? super Dog> petsOk6 = new ArrayLis
        List<? super Dog> petsOk7 = new ArrayLis
        List<? super Dog> petsOk8 = new ArrayLis

        //can add Dog or any subclass of Dog
        petsOk6.add(new Dog());
        petsOk6.add(new SpanielDog());//polymorp

        petsOk6.add(new Pet()); //4. COMPILE ERR
```

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```

        List<? super Dog> petsBad3 = new ArrayLi

    }
}
```

5 Compile Errors marked in the above code reasoning

#1. List<Pet> is NOT the super type of List<Dog>. If it were the case, then you could add pets of any type including Cats, and it defeats the purpose of Generics. **List<?>** is the super type of **List<Pet>**. But read only. Can't add any objects.

#2. Same as **#1**. If were not illegal, you could add a Cat to a Dog collection. Defeating the purpose of Generics.

#3. List<? extends Dog> means assignable from any objects that are of type **Dog** or **subclasses** of Dog. Pet is a **superclass** of Dog.

#4. You can only add objects of type **Dog** or **subclasses** of Dog. Subclasses are possible because of **polymorphism** , where a parent type reference can hold its subclass object type. So, you can add objects of type Dog or its subclasses like SpanielDog, but NOT its super classes.

#5. List<? super Dog> means assignable from any objects that are of type **Dog** or **superclasses** of type Dog. Pet, Object, etc are valid superclasses. But SpanielDog is a subclass.

So, how to decide when to use a wild card, and when not to?

1. Use the ? extends wildcard if you need to retrieve object from a data structure. That is **read only**. You can't add elements to the collection.

2. Use the ? super wildcard if you need to add objects to a data structure.

3. If you need to do both things (i.e. read and add objects), don’t use any wildcard.

More code examples to validate your understanding

```java
package com.generics;

import java.util.ArrayList;
import java.util.List;

public class GenericsByExample {

    public static void main(String[] args) {
        new GenericsByExample().create();
    }

    public void create() {

        // dogs only
        List<Dog> dogs = new ArrayList<Dog>();
        dogs.add(new Dog());
        dogs.add(new SpanielDog()); //polymorphi
        dogs.add(new Pet()); // compile error
        dogs.add(new Cat()); // compile error

        // cats only
        List<Cat> cats = new ArrayList<Cat>();
        cats.add(new Cat());
        // cats.add(new Dog()); //No can't add d

        // any pets can be added
        List<Pet> pets = new ArrayList<Pet>();
        pets.add(new Dog()); //polymorphism
        pets.add(new Cat()); //polymorphism
        pets.add(new Pet());

        // so, wrong to say List<Pet> is a super
        // defeats the purpose of having Generic

        // RHS allows Pet, Dog, Cat, SpanielDog,
        List<? extends Pet> petsOnlyForReading =

        // RHS allows Dog and SpanielDog, but r
        List<? extends Dog> dogsOnlyForReadingy

        petsOnlyForReading.add(new Dog()); // co
        dogsOnlyForReadingy.add(new Cat()); // c

        List<Dog> dogsOnly = new ArrayList<Pet>(

        List<? super Dog> dogsOnly1 = new ArrayL
        dogsOnly1.add(new Dog());
        dogsOnly1.add(new SpanielDog()); // poly
        dogsOnly1.add(new Pet()); // compile err

        List<? super Dog> dogsOnly2 = new ArrayL
        dogsOnly2.add(new Dog());
        dogsOnly2.add(new SpanielDog()); // poly
        dogsOnly2.add(new Pet()); // compile err

        List<? super Dog> dogsOnly3 = new ArrayL
        dogsOnly3.add(new Dog());
        dogsOnly3.add(new SpanielDog()); // poly
        dogsOnly3.add(new Pet()); // compile err
        dogsOnly3.add(new Object()); // compile

        List<? super SpanielDog> spanielsOrSubcl
        spanielsOrSubclassesOnly.add(new Dog());
        spanielsOrSubclassesOnly.add(new Spaniel
        spanielsOrSubclassesOnly.add(new Pet());
    }
}
```

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