Lập trình hướng đối tượng

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Chapter 8: Generic Programming

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8.1 Why Generic Programming?

- Generic programming: writing code that can be reused for objects of many different types.
- The ArrayList class now has a type parameter that indicates the element type:

```
ArrayList<String> files = new ArrayList<String>();
ArrayList<String> files = new ArrayList<>();
```

8.2 Defining a Simple Generic Class

A generic class is a class with one or more type variables.

The type variables are used throughout the class definition to specify:

- method return types
- the types of fields and local variables.

- Instantiate the generic type by substituting types for the type variables

```
public class Pair<T>
{
   private T first;
   private T second;

   public Pair() { first = null; second = null; }
   public Pair(T first, T second) { this.first = first;
this.second = second; }

   public T getFirst() { return first; }
   public T getSecond() { return second; }

   public void setFirst(T newValue) { first =
newValue; }
   public void setSecond(T newValue) { second =
newValue; }
}

Pair<String> mm;
```

8.3 Generic Methods

```
class ArrayAlg {
	public static <T> T getMiddle(T... a) {
		return a[a.length / 2];
	}
}

String middle = ArrayAlg.getMiddle("John", "Q.", "Public");
```

8.4 Bounds for Type Variables

```
public static <T> T min(T[] a)
{
    if (a == null || a.length == 0)
        return null;
    T smallest = a[0];
    for (int i = 1; i < a.length; i++)
        if (smallest.compareTo(a[i]) > 0)
            smallest = a[i];
    return smallest;
}
```

8.4 Bounds for Type Variables

```
public static <T extends Comparable> T min(T[] a) // almost correct
{
    if (a == null || a.length == 0)
        return null;
    T smallest = a[0];
    for (int i = 1; i < a.length; i++)
        if (smallest.compareTo(a[i]) > 0)
            smallest = a[i];
    return smallest;
}
```

8.5 Generic Code and the Virtual Machine

8.5.1 Type Erasure

- Whenever you define a generic type, a corresponding raw type is automatically provided.
- The raw type: the first bounding type (or **Object** for variables without bounds)

```
public class Pair {
      private Object first;
      private Object second;

      public Pair(Object first, Object second)
      {
            this.first = first;
            this.second = second;
      }
      public Object getFirst() {
            return first;
      }

      public Object getSecond() {
            return second;
      }

      public void setFirst(Object newValue) {
            first = newValue;
      }

      public void setSecond(Object newValue) {
            second = newValue;
      }
}
```

8.5.1 Type Erasure

```
public class Interval<T extends Comparable &
Serializable> implements Serializable {
     private T lower;
     private T upper;
     ...
     public Interval(T first, T second) {
          if (first.compareTo(second) <= 0) {
               lower = first;
               upper = second;
          }
          else {
               lower = second;
               upper = first;
          }
     }
}
```

```
public class Interval implements
Serializable {
     private Comparable lower;
     private Comparable upper;
     ...
     public Interval(Comparable first,
     Comparable second) {
     . . .
     }
}
```

8.5.2 Translating Generic Expressions

- When you call to a generic method, the compiler inserts casts when the return type has been erased.

```
Pair<Employee> buddies = . . .;
Employee buddy = buddies.getFirst();
```

  - A call to the raw method Pair.getFirst
  - A cast of the returned Object to the type Employee

8.5.3 Translating Generic Methods

Before erasure:

```
public static <T extends Comparable> T
min(T[] a)

class DateInterval extends Pair<LocalDate> {
     public void setSecond(LocalDate second){
       if (second.compareTo(getFirst()) >= 0)
          super.setSecond(second);
     }
...
}
```

After erasure:

```
public static Comparable min(Comparable[] a)

class DateInterval extends Pair{
     public void setSecond(LocalDate
second){ . . . }
... }

public class Pair {
     public void setSecond(Object newValue){
          second = newValue;
     }
}
```

8.5.3 Translating Generic Methods

```
DateInterval interval = new DateInterval(. . .);
Pair<LocalDate> pair = interval; // OK--assignment to superclass
pair.setSecond(aDate);  // which setSecond()?
```

How:

The compiler generates a bridge method in the DateInterval class:

```
    public void setSecond(Object second) { setSecond((LocalDate) second);
}
```

8.6 Restrictions and Limitations

8.6.1 Type Parameters Cannot Be Instantiated with Primitive Types

- there is no Pair<double>, only Pair<Double>

8.6.2 Runtime Type Inquiry Only Works with Raw Types

```
if (a instanceof Pair<String>) // Error
if (a instanceof Pair<T>) // Error
if (a instanceof Pair<?>) // OK

Pair<String> stringPair = . . .;
Pair<Employee> employeePair = . . .;
if (stringPair.getClass() == employeePair.getClass())
// they are equal since getClass() return Pair.class
```

8.6 Restrictions and Limitations

8.6.3 You Cannot Create Arrays of Parameterized Types

```
Pair<String>[] table = new Pair<String>[10]; // Error

ArrayList<Pair<String>> list= new ArrayList<>();
```

8.6.5 You Cannot Instantiate Type Variables

```
public Pair() { first = new T(); second = new T(); } // Error

// define makePair()
public static <T> Pair<T> makePair(Supplier<T> constr) {
        return new Pair<>(constr.get(), constr.get());
}

// call makePair()
Pair<String> p = Pair.makePair(String::new);
```

8.6 Restrictions and Limitations

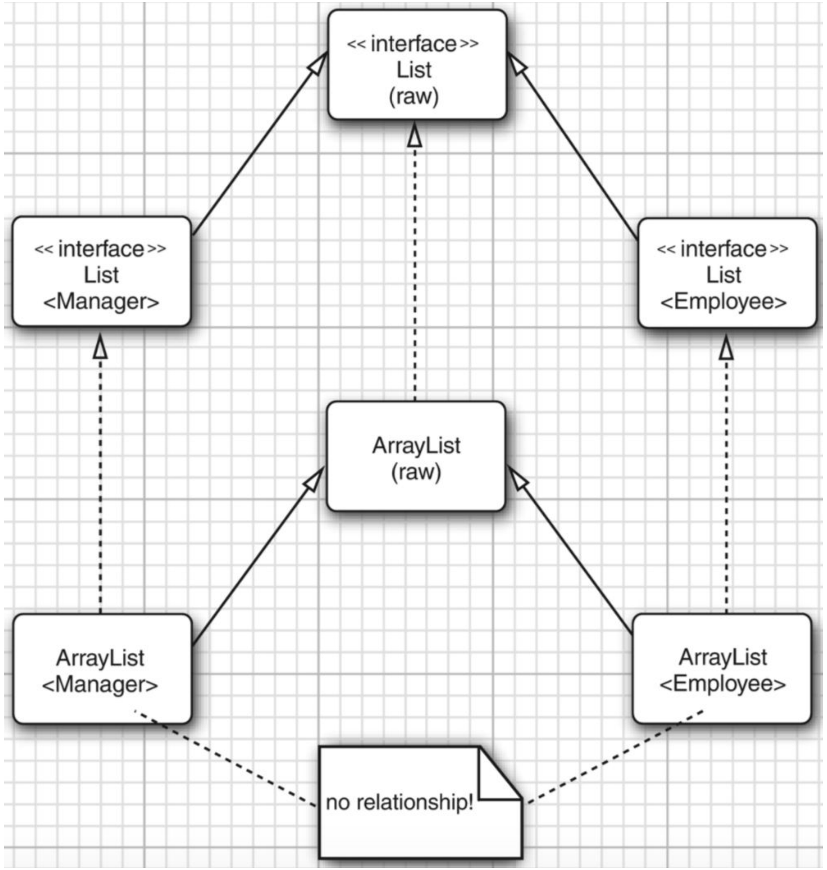
8.6.7 Type Variables Are Not Valid in Static Contexts of Generic Classes

```
public class Singleton<T> {
        private static T singleInstance; // Error
        public static T getSingleInstance() // Error { …
        }
}
```

8.6.8 You Cannot Throw or Catch Instances of a Generic Class

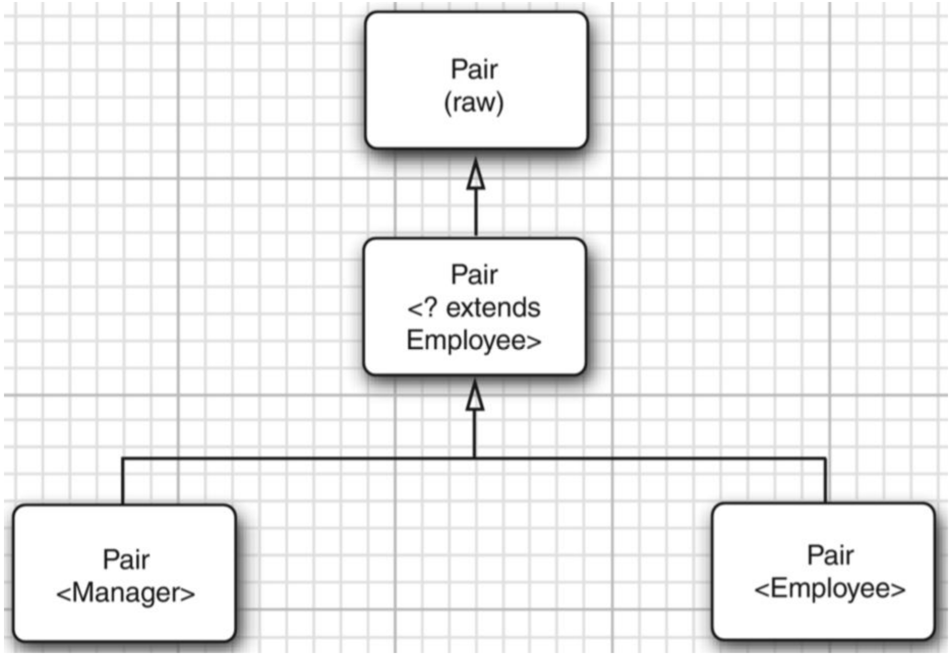
8.7 Inheritance Rules for Generic Types

- no relationship between Pair<S> and Pair<T>, no matter how S and T are related.
- convert a parameterized type to a raw type.
  - Pair<Employee> is a subtype of the raw type Pair.
- generic classes can extend or implement other generic classes.
  - ArrayList<T> implements the interface List<T>



8.8 Wildcard Types

- Pair<? extends Employee>: any generic Pair type whose type parameter is a subclass of Employee, e.g., Pair<Manager>
- Pair<Manager> is a subtype of Pair<? extends Employee>

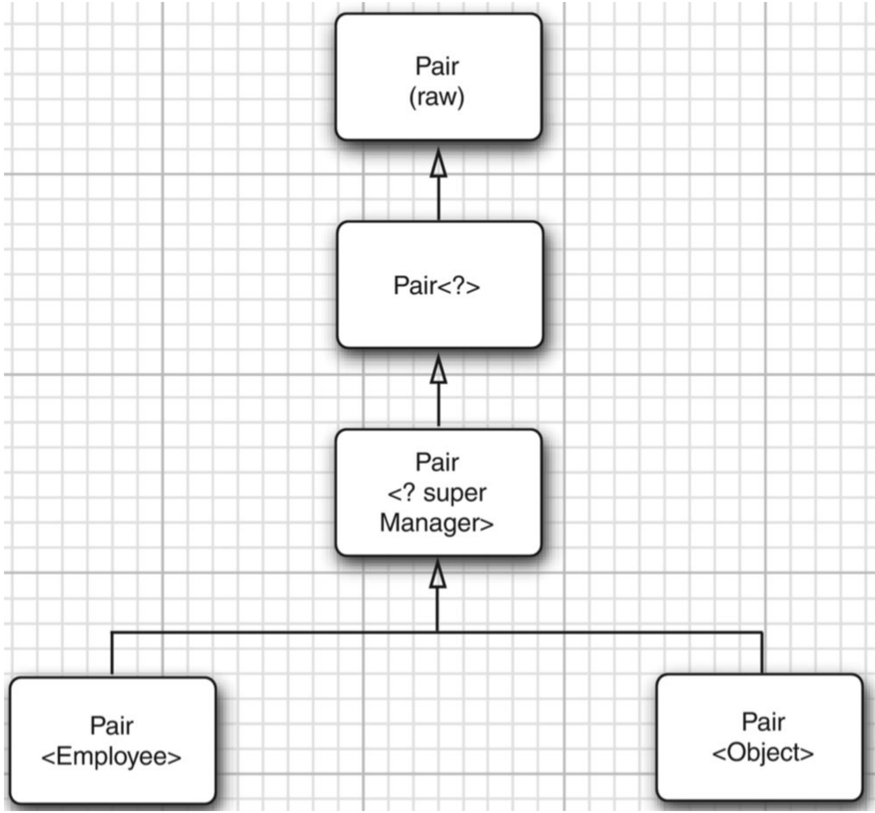


8.8 Wildcard Types

```
public static void printBuddies(Pair<? extends Employee> p) {
    Employee first = p.getFirst();
    Employee second = p.getSecond();
    System.out.println(first.getName() + " and " + second.getName() + " 
are buddies.");
}
Pair<Manager> managerBuddies = new Pair<>(new Manager("CEO", 1500, 1999, 
1, 1), new Manager("CFO", 1500, 2000, 1, 1));
printBuddies(managerBuddies);
```

8.8 Wildcard Types

```
public static void minmaxBonus(Manager[] a,
                    Pair<? super Manager> result) {
      if (a.length == 0)
            return;
      Manager min = a[0];
      Manager max = a[0];
      for (int i = 1; i < a.length; i++) {
            if (min.getBonus() > a[i].getBonus())
                  min = a[i];
            if (max.getBonus() < a[i].getBonus())
                  max = a[i];
      }
      result.setFirst(min);
      result.setSecond(max);
}
```



8.8 Wildcard Types

```
public static boolean hasNulls(Pair<?> p) {
        return p.getFirst() == null || p.getSecond() == null;
}

public static <T> boolean hasNulls(Pair<T> p){
        return p.getFirst() == null || p.getSecond() == null;
}
```