Session 10
Generics

(http://docs.oracle.com/javase/tutorial/java/generics/index.html)

Generic: same type

What is Generics?

- A technique allows programmers creating general processes on data whose data types are not determined (generic is not used) or they can be determined (generic is used) when they are used.
- A way allows programmer implementing general algorithms which can be used to process multi-type input → Polymorphism.

Objectives

- How we can create a list of arbitrary elements?
- Generics in Java API (java.util pakage)
- Advantages of Generics
- How to create a generic class/ method/ interface
- How is a generic class treated by compiler?
- How to give bounded type parameters?
- Restrictions on Generics

A list of arbitrary elements

- Reference type conformity: fatherRef=sonRef
- The Object class is the ultimate class of all Java class

➔We can create a list of elements which can belong to different classes

➔ **A demonstration:**

```
class Point {
    int x, y;
    Point(int x, int y) { this.x=x; this.y=y;}
    public String toString() {...}
}
public class NonGenericDemo {
    Object[] ar = new Object[100];
    int n=0;
    void add(Object obj){ ar[n++]=obj;}
    void print(){
        for (int i=0; i<n;i++) System.out.println(ar[i]);
    }
    public static void main(String[] args){
        NonGenericDemo obj= new NonGenericDemo();
        obj.add(new String("Hello"));
        obj.add(5);
        obj.add(new Point(9,3));
        obj.print();
    }
}
```

```
run:
Hello
5
[9,3]
```

Generic Classes in java.util

- Almost of interfaces and classes related to lists in the Java API declared as generic.
- Type Parameter Naming Conventions
  - By convention, type parameter names are single, uppercase letters.
  - The most commonly used type parameter names are:
    - E : Element/ K: Key
    - N – Number/ T - Type
    - V - Value
    - S,U,V etc. - 2nd, 3rd, 4th types

- java.lang.**Object**
  - java.util.**AbstractCollection**<E>
    - java.util.**AbstractList**<E>
      - java.util.**AbstractSequentialList**<E>
        - java.util.**LinkedList**<E>
      - java.util.**ArrayList**<E>
      - java.util.**Vector**<E>
        - java.util.**Stack**<E>
    - java.util.**AbstractQueue**<E>
      - java.util.**PriorityQueue**<E>
    - java.util.**AbstractSet**<E>
      - java.util.**EnumSet**<E>
      - java.util.**HashSet**<E>
        - java.util.**LinkedHashSet**<E>
      - java.util.**TreeSet**<E>
  - java.util.**AbstractMap**<K,V>
    - java.util.**EnumMap**<K,V>
    - java.util.**HashMap**<K,V>
      - java.util.**LinkedHashMap**<K,V>
    - java.util.**IdentityHashMap**<K,V>
    - java.util.**TreeMap**<K,V>
    - java.util.**WeakHashMap**<K,V>

Generics on a List

- Sometimes, we want to create a list with restrictions as elements must belong to some types → Generic
- Generic is a technique which allows a list of arbitrary objects and supports advantages if elements of a list belong to the same data type.

Advantages of Generics

- Generics add stability to your code by making more of your bugs detectable at compile time.
- Generics enable *types* (classes and interfaces) to be parameters when defining classes, interfaces and methods and limits on parametric types may be declared.
- Code that uses generics has many benefits over non-generic code.
  - Stronger type checks at compile time
  - Elimination of casts.
  - Enabling programmers to implement generic algorithms.

Generics are not used

- The package java.util supports general-purpose implementations which allows lists containing arbitrary elements
- The cost of this flexibility is we may have to use a casting operator when accessing an element.

Generic1.java *

```
1  import java.util.Vector;
2  class Person {
3      String name; int age;
4      Person(String n, int a)
5          { name=n; age=a; }
6      void print ()
7        { System.out.println( name + ", " + age);}
8  }
9  public class Generic1 {
10   public static void main(String[] args) {
11       Vector v = new Vector();
12       v.add (new Person("Hoa", 23));
13       v.add (new Person("Tuấn", 27));
14       for (int i= v.size()-1; i>=0; i--)
15           ((Person)(v.get(i))).print();
16   }
17 }
```

Output - Chapter08 (run)

```
run:
Tuấn, 27
Hoa, 23
BUILD SUCCESSFUL (total time: 0 seconds)
```

The class **Object** does not have the **print()** method

Generics are used

- If all elements of the collection are homogeneous(identical), the generic technique should be used.
- Generics add stability to your code by making more of your bugs detectable at compile time. Casting can not be used.

Generic1.java | Generic2.java

```
1  import java.util.Vector;
2  class Person2 {
3      String name; int age;
4      Person2(String n, int a)
5          { name=n; age=a; }
6      void print ()
7        { System.out.println( name + ", " + age); }
8  }
9  public class Generic2 {
10   public static void main(String[] args) {
11       Vector<Person2> v = new Vector<Person2> ();
12       v.add (new Person2("Hoa", 23));
13       v.add (new Person2("Tuấn", 27));
14       for (int i= v.size()-1; i>=0; i--)
15           v.get(i).print();
16   }
17 }
18
```

The casting operators are missed.

Output - Chapter08 (run)

```
run:
Tuấn, 27
Hoa, 23
BUILD SUCCESSFUL (total time: 1 second)
```

Using Generics- Syntax

- **Invoking and Instantiating a Generic Type**
  - *Box<Integer> integerBox = new Box<Integer>();*
- **The Diamond**
  - *Box<Integer> integerBox = new Box<>();*
- **Multiple Type Parameters**
  - *Pair<String, Integer> p1 = new OrderedPair<String, Integer>("Even", 8);*
- **Parameterized Types**
  - *OrderedPair<String, **Box<Integer>**> p = new OrderedPair<>("primes", new Box<Integer>(...));*

Implementing a Generic class

- Syntax:

class name<T1, T2, ..., Tn> {

code

}

```
public class Box<T> {
 // T stands for "Type"
private T t;
public void set(T t) { this.t = t; }
public T get() { return t; }
}
```

Implementing Generic Methods

```
/* Generic class for processing arrays */
import java.util.Arrays;
public class GenericArray <T> {
    public static <T> T get( int i, T[] ar){
        return ar[i];
    }
    public static <T> void output(T[] ar){
        for (T x: ar) System.out.print(x + ", ");
        System.out.println();
    }
    public static <T> void sort(T[] ar){
        Arrays.sort(ar);
    }
}
```

Implementing Generic Methods…

```
class GenericArrayUse {
    public static void main(String[] args){
        Integer a[]={1,2,3,4,5};
        GenericArray obj1= new GenericArray();
        obj1.output(a);
        System.out.println(GenericArray.get(3,a));
        Double b[]={1.1, 2.2, 3.3, 4.4};
        GenericArray<Double> obj2= new GenericArray<Double>();
        obj2.output(b);
        String list[]= {"you", "love", "I"};
        GenericArray<String> obj3= new GenericArray<String>();
        obj3.output(list);
        obj3.sort(list);
        obj3.output(list);
    }
}
```

Generic is not used

Generic is used

```
run:
1, 2, 3, 4, 5,
4
1.1, 2.2, 3.3, 4.4,
you, love, I,
I, love, you,
```

How generic class is treated?

- Compiler will save generic information in this class to class files (file.class)
- When this class is used (an object of this class is created)
  - If an argument types are declared: Compiler updates type information.
  - If no argument type is declared, type information in parameters are erased or changed to Object

Implementing a Generic Methods

- *Generic methods* are methods that introduce their own type parameters.
- The type parameter's scope is limited to the method where it is declared.
- The syntax for a generic method includes a type parameter, inside angle brackets, and appears before the method's return type.

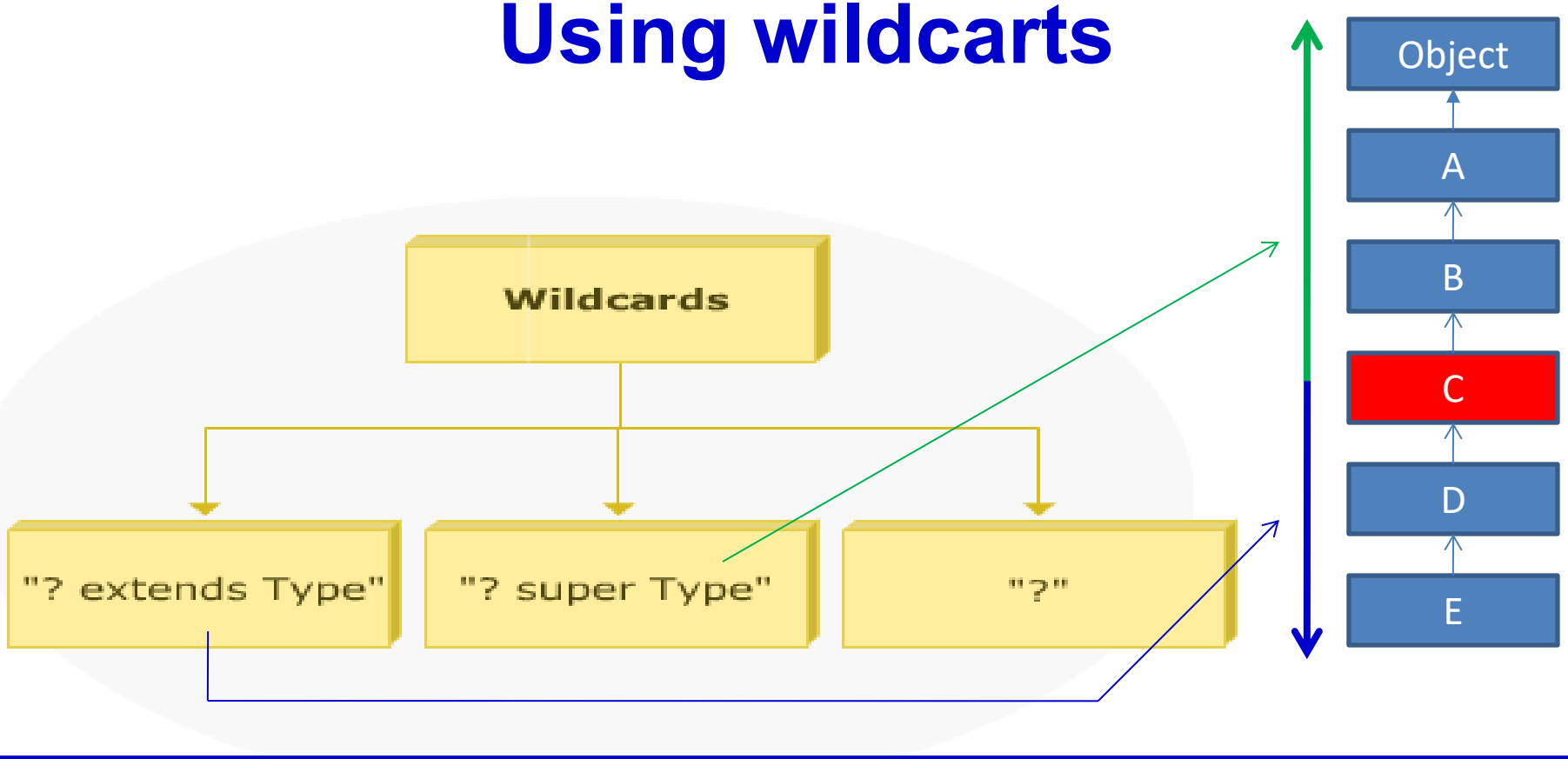
```
public static <K, V> boolean equals(Pair<K, V> p1, Pair<K, V>
p2) {
        return p1.getKey().equals(p2.getKey()) &&
                p1.getValue().equals(p2.getValue());
}
```

Bounded Type Parameters

- Restriction on types of arguments when a method is called.

```
public class GenericExtendDemo <T> {
   private T t;
    public void set(T t) { this.t = t; }
    public T get() { return t;}
    public <U extends Number> void inspect(U u){
     System.out.println("T: " + t.getClass().getName());
     System.out.println("U: " + u.getClass().getName());
    }
    public static void main(String[] args) {
     GenericExtendDemo<Integer> integerBox = new GenericExtendDemo<Integer>();
     integerBox.set(new Integer(10));
     integerBox.inspect("some text"); //error:cannot be applied to given type
    }
}
```

Bounded Type Parameters: Using wildcarts



The ? stands for an unknown type
? **extends** Type : a *bounded wildcard*. Type is upper bound
? super Type : a *bounded wildcard*. Type is lower bound

Wildcards

- The question mark (?), called the *wildcard*, represents an unknown type.
- The wildcard can be used in a variety of situations: as the type of a parameter, field, or local variable.
- The wildcard is never used as a type argument for a generic method invocation, a generic class instance creation, or a super type.

Wildcards Demo.

```
/* WildCard_Demo.java */
import java.util.*;
class A
{  int a=3;
   public String toString() { return "" + a; }
}
class B extends A
{  int b=5;
   public String toString() { return "" + (a+b); }
}
class C
{ int c= 10;
  public String toString() { return "" + c; }
}
```

```
public class WildCard_Demo {
    /** Creates a new instance of WildCard_Demo */
    public WildCard_Demo() {
    }
    static public void print1 (Collection<?> col)
    {  for (Object o:col) System.out.print(o + " ,");
    }
    static public void print2 (Collection<? extends A> col)
    {  for (Object o:col) System.out.print(o+ " ,");
    }
    static public void print3 (Collection<? super B> col)
    {  for (Object o:col) System.out.print(o+ " ,");
    }
    public static void main(String args[])
    { Vector VA= new Vector();
      VA.add(new A());VA.add(new A());VA.add(new A());
      Vector VB= new Vector();
      VB.add(new B());VB.add(new B());VB.add(new B());
      Vector VC= new Vector();
      VC.add(new C());VC.add(new C());VC.add(new C());
      WildCard_Demo.print1(VC); System.out.println();
      WildCard_Demo.print2(VB);System.out.println();
      WildCard_Demo.print3(VA);System.out.println();
      WildCard_Demo.print2(VC);
    }
}
```

```
C:\WINDOWS\system32\cmd.exe

E:\GiangDay\Aptech-Materials\ACCP-2007-Sem2\Java-Adva
\classes>java WildCard_Demo
10 ,10 ,10 ,
8 ,8 ,8 ,
3 ,3 ,3 ,
Exception in thread "main" java.lang.ClassCastException: C cannot be cast to A
        at WildCard_Demo.print2(WildCard_Demo.java:23)
        at WildCard_Demo.main(WildCard_Demo.java:38)

E:\GiangDay\Aptech-Materials\ACCP-2007-Sem2\Java-Advanced\Assignments\Ass6\build
\classes>pause
Press any key to continue . . .
```

Raw Types

- When a generic type like collection is used without a type parameter, it is called a raw type. Compiler will execute **erasure process** to remove all generic type information. All the type information between angle brackets are thrown out.

```
public class Box<T> {
        public void set(T t) { /* ... */ }
    // ...
}
//…
Box<String> stringBox = new Box<>();
Box rawBox = stringBox;
Box rawBox = new Box();        // rawBox is a raw type of Box<T>
Box<Integer> intBox = rawBox;  // warning: unchecked conversion
```

Type Erasure

- Type erasure will
  - Replace all bounded type parameters in generic types with their bounds

    public <U extends A> void inspect (U obj)

    → public void inspect (A obj)
  - Change unbounded type parameter to Object

    public void f (**T** obj)

    → public void f (**Object** obj)
  - Insert type casts if necessary to preserve type safety.
  - Generate bridge methods to preserve polymorphism in extended generic types.

→ The produced bytecode, therefore, contains only ordinary classes, interfaces, and methods.

Type Erasure – Demo.

- Erasure of Generic Method

Type information is erased.

```
public static <T> int count(T[] anArray, T elem) {
    int cnt = 0;
    for (T e : anArray)
        if (e.equals(elem))
            ++cnt;
        return cnt;
}
//T is unbounded, the Java compiler replaces it with Object
public static int count(Object[] anArray, Object elem) {
    int cnt = 0;
    for (Object e : anArray)
        if (e.equals(elem))
            ++cnt;
        return cnt;
}
```

Restrictions on Generics

- Cannot Instantiate Generic Types with Primitive Types.
- Cannot Create Instances of Type Parameters.
- Cannot Declare Static Fields Whose Types are Type Parameters.
- Cannot Use Casts or instanceof With Parameterized Types.
- Cannot Create Arrays of Parameterized Types.
- Cannot Create, Catch, or Throw Objects of Parameterized Types.
- Cannot Overload a Method Where the Formal Parameter Types of Each Overload Erase to the Same Raw Type.

Summary

- Generics on methods, classes and collections
- Bounded Type Parameters
- Working with Wildcards
- Working with type erasure
- Generic restrictions