GENERIC

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Topik

- Å Definisi Generic
- Å Non Generic Class
- Å Cara mendeklarasikan Type Generic
- Å Aturan Penamaan Type Parameter
- Å Subtyping
- Å Class Generic dengan Dua Type Parameter
- Å Generic pada List
- Å Nested generic type
- Å Raw Types
- Å Generic and Collections
- Å Menggunakan Interface Generic Comparable
- Å Type parameter yang dibatasi
- Å Menggunakan ? Wildcard
- Å Menggunakan Bounded Wildcard dalam Method

Generic

Å Generic merupakan cara Java dalam melakukan generalisasi terhadap tipe data tanpa mengurangi kemampuan Java dalam menjaga keamanan penggunaan tipe data.

Penggunaan Generic

Å Generic class declarations

Å Generic interface declarations

Å Generic method declarations

Å Generic constructor declarations.

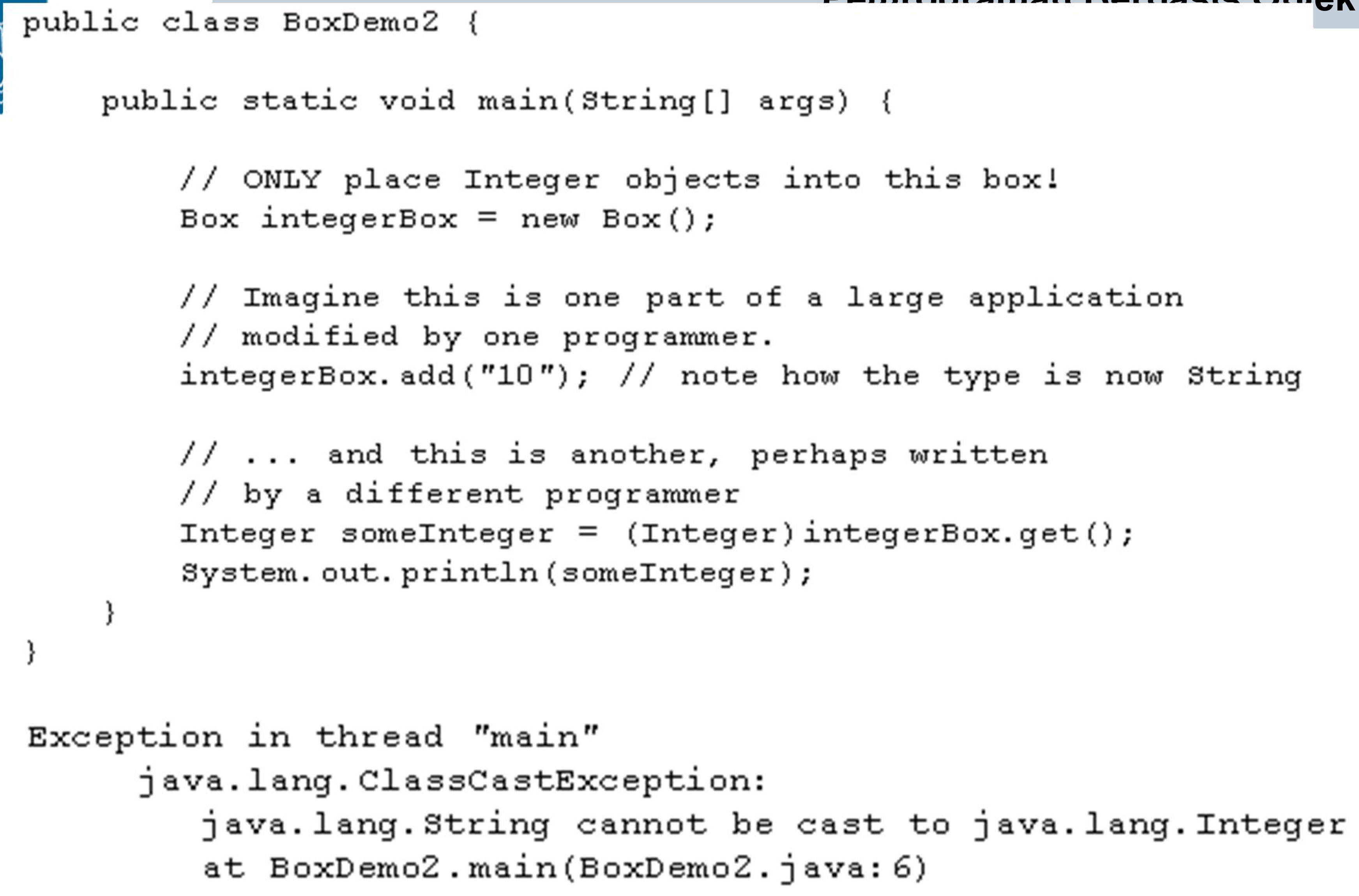
Non Generic Class

```
public class Box {

    private Object object;

    public void add(Object object) {
        this.object = object;
    }

    public Object get() {
        return object;
    }
}
```

Buatlah object Box, kita bisa memasukkan sembarang object karena parameter pada method add adalah Class Object, tapi pada saat mengambil object tersebut harus diubah sesuai dengan tipe dari object tersebut.

Contoh object Box yaitu integerBox diberikan object Integer, pada saat mengambil harus diubah menjadi Integer

```
public class BoxDemo1 {

    public static void main(String[] args) {

        // ONLY place Integer objects into this box!
        Box integerBox = new Box();

        integerBox.add(new Integer(10));
        Integer someInteger = (Integer)integerBox.get();
        System.out.println(someInteger);
    }
}
```



```
public class BoxDemo2 {

    public static void main(String[] args) {

        // ONLY place Integer objects into this box!
        Box integerBox = new Box();

        // Imagine this is one part of a large application
        // modified by one programmer.
        integerBox.add("10"); // note how the type is now String

        // ... and this is another, perhaps written
        // by a different programmer
        Integer someInteger = (Integer)integerBox.get();
        System.out.println(someInteger);
    }
}
```

```
Exception in thread "main"
     java.lang.ClassCastException:
        java.lang.String cannot be cast to java.lang.Integer
        at BoxDemo2.main(BoxDemo2.java:6)
```

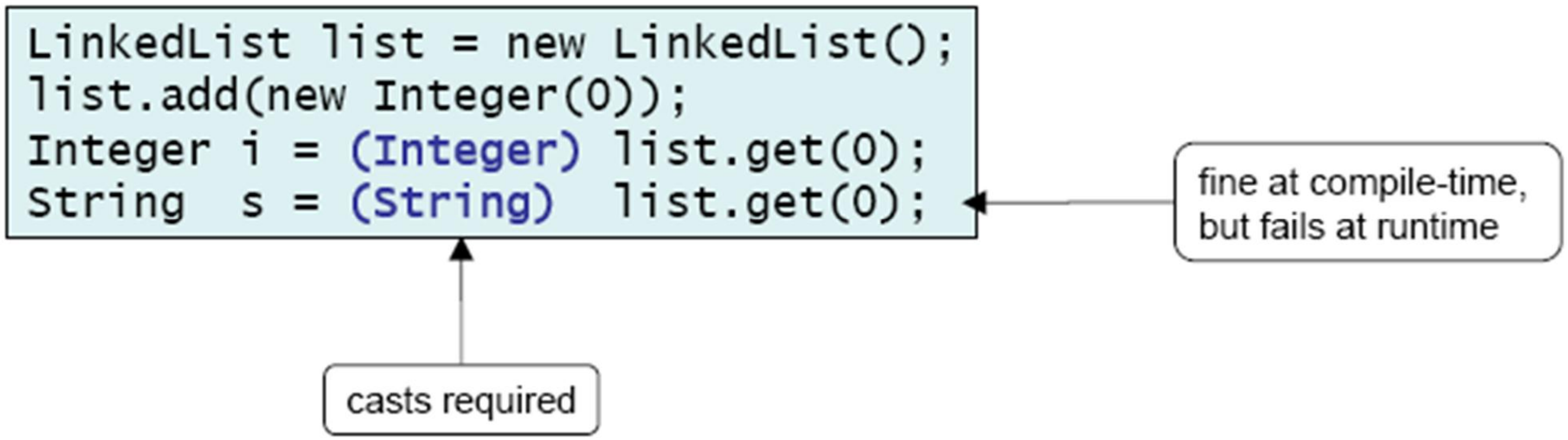
Penjelasan

Å Mengapa Error ?

Pada object IntegerBox dimasukkan object 10 tapi dengan tipe String, tapi pada saat mengambil object, diubah menjadi tipe Integer. Tipe data tidak sesuai sehingga error

Non Generic Class

- Permasalahan ?
- no homogeneous collections
  - memerlukan banyak casting
- Tidak ada pengecekan pada saat kompile, kesalahan baru bisa terdeteksi pada saat runtime.



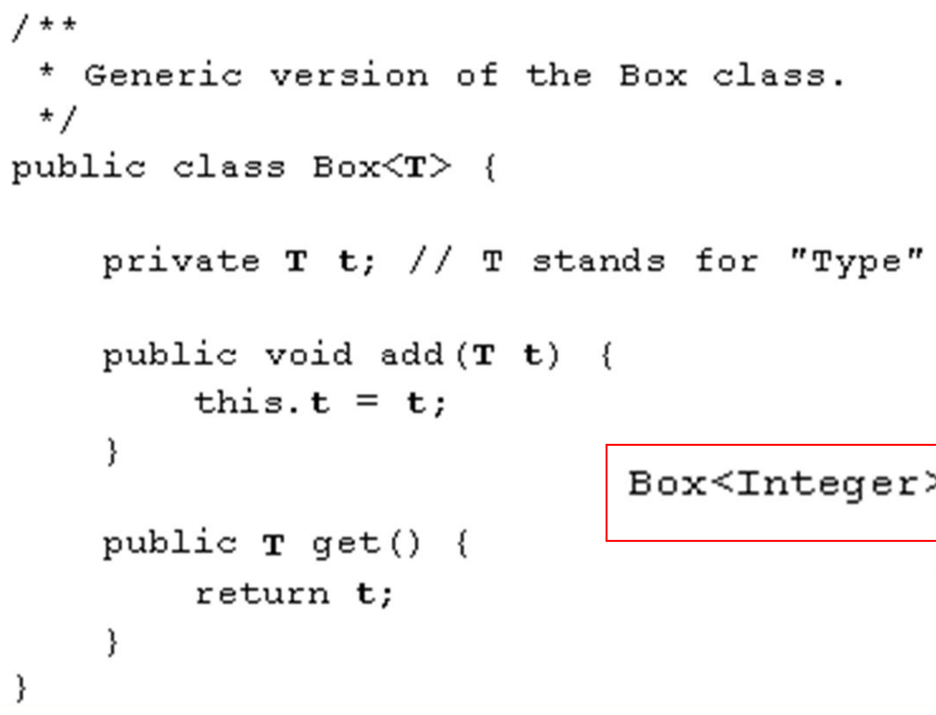
```
LinkedList list = new LinkedList();
list.add(new Integer(0));
Integer i = (Integer) list.get(0);
String  s = (String)  list.get(0);
```

Cara mendeklarasikan Class dg Type Generics

Å Ubah class Box menggunakan generics

Å Pendeklarasian type generics dengan mengubah public class Box → public class Box <T>

- ï T biasanya disebut parameter type formal (formal type parameter)
- ï T adalah type parameter yang akan diganti dengan tipe sebenarnya (Type dari T bisa berupa class, interface atau tipe variabel lainnya).
- ï T adalah nama dari type parameter.



```
/**
 * Generic version of the Box class.
 */
public class Box<T> {

    private T t; // T stands for "Type"

    public void add(T t) {
        this.t = t;
    }

    public T get() {
        return t;
    }
}
```

Membuat Object

```
Box<Integer> integerBox;

integerBox = new Box<Integer>();
```

atau

```
Box<Integer> integerBox = new Box<Integer>();
```

Cara mendeklarasikan Class dg Type Generics

- Tidak perlu proses casting pada saat menggunakan fungsi get().

```
public class BoxDemo3 {

    public static void main(String[] args) {
        Box<Integer> integerBox = new Box<Integer>();
        integerBox.add(new Integer(10));
        Integer someInteger = integerBox.get(); // no cast!
        System.out.println(someInteger);
    }
}
```

- Tapi jika kita menambahkan ke box dengan tipe yang tidak sesuai (misal : String) maka pada saat di kompile akan mengalami error.

```
BoxDemo3.java:5: add(java.lang.Integer) in Box<java.lang.Integer>
cannot be applied to (java.lang.String)
    integerBox.add("10");
                  ^
1 error
```

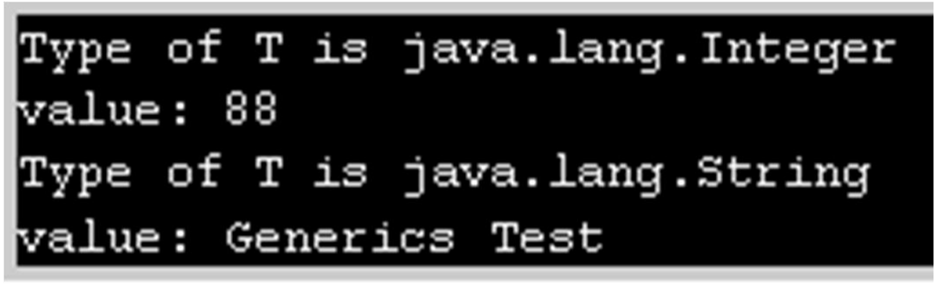
Aturan Penamaan Type Parameter

Å Nama type parameter biasanya satu huruf dan huruf besar.

Å Jenis nama tipe parameter yang sering digunakan :

- ï E - Element (biasanya digunakan untuk Collection Framework)
- ï K ï Key
- ï N ï Number
- ï T - Type
- ï V - Value
- ï S,U,V dll. - 2nd, 3rd, 4th types

```java
class GenericClass<T> {
  T ob;

  GenericClass(T o) {
    ob = o;
  }

  T getob() {
    return ob;
  }

  void showType() {
    System.out.println("Type of T is " + ob.getClass().getName());
  }
}
```

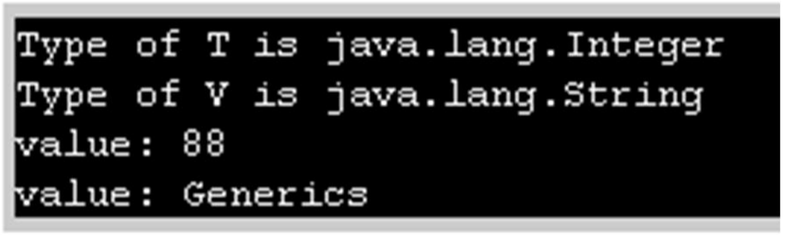


```
Type of T is java.lang.Integer
value: 88
Type of T is java.lang.String
value: Generics Test
```

```java
public class MainClass {
  public static void main(String args[]) {
    // Create a Gen reference for Integers.
    GenericClass<Integer> iOb = new GenericClass<Integer>(88);
    iOb.showType();

    // no cast is needed.
    int v = iOb.getob();
    System.out.println("value: " + v);

    // Create a Gen object for Strings.
    GenericClass<String> strOb = new GenericClass<String>("Generics Test");
    strOb.showType();

    String str = strOb.getob();
    System.out.println("value: " + str);
  }
}
```

Class Generic dengan Dua Type Parameter

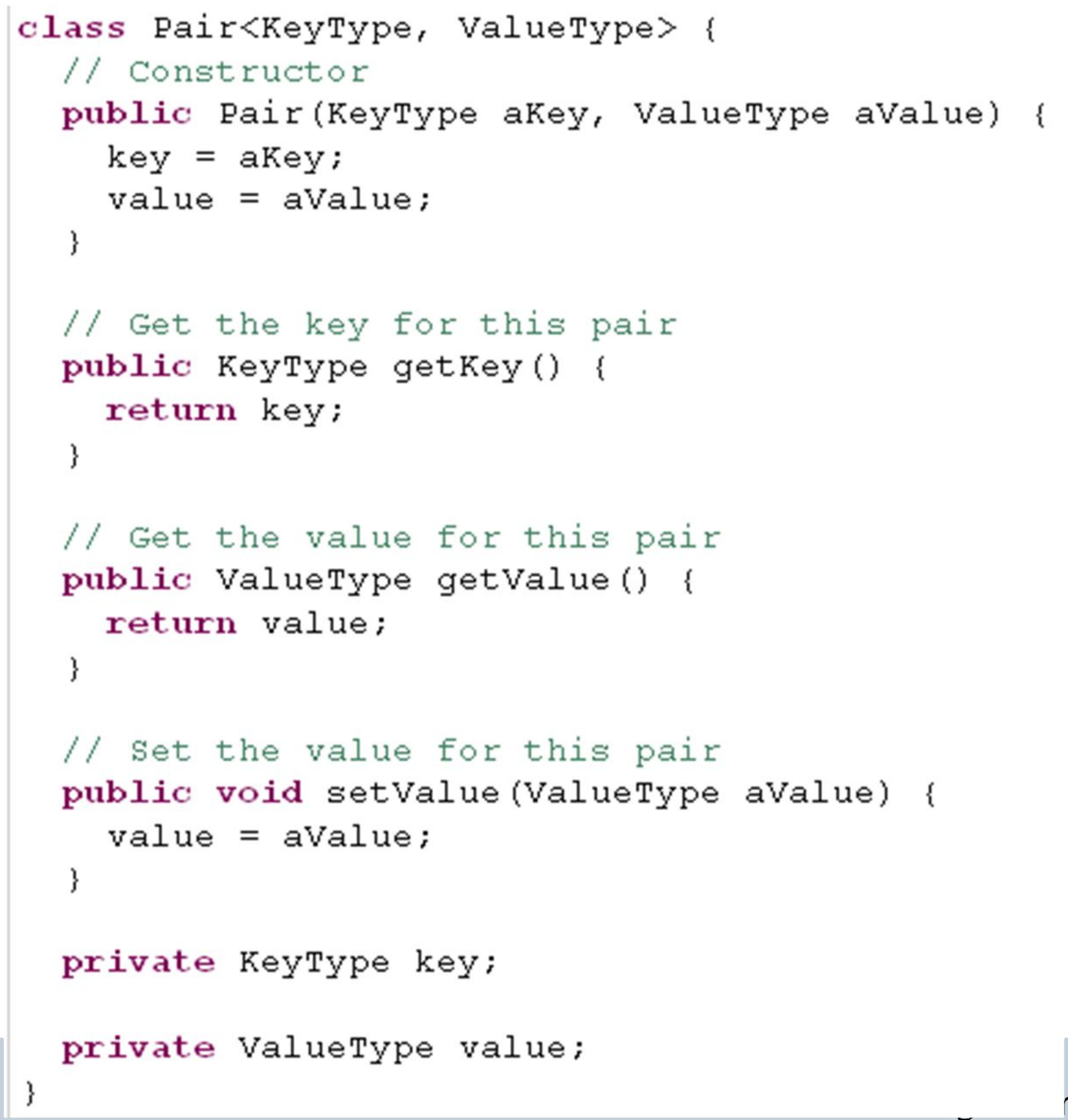
```
class TwoGen<T, V> {
  T ob1;

  V ob2;

  TwoGen(T o1, V o2) {
    ob1 = o1;
    ob2 = o2;
  }

  void showTypes() {
    System.out.println("Type of T is " + ob1.getClass().getName());

    System.out.println("Type of V is " + ob2.getClass().getName());
  }

  T getob1() {
    return ob1;
  }

  V getob2() {
    return ob2;
  }
}
```



```
Type of T is java.lang.Integer
Type of V is java.lang.String
value: 88
value: Generics
```

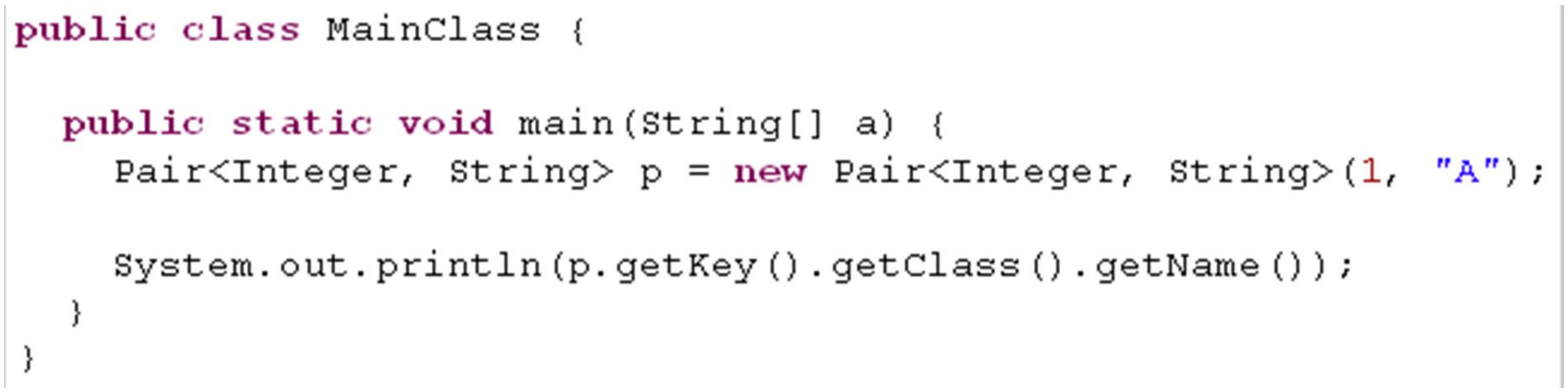
```
public class MainClass {
  public static void main(String args[]) {
    TwoGen<Integer, String> tgObj = new TwoGen<Integer, String>(88, "Generics");
    tgObj.showTypes();

    int v = tgObj.getob1();
    System.out.println("value: " + v);

    String str = tgObj.getob2();
    System.out.println("value: " + str);
  }
}
```

Class Generic dengan Dua Type Parameter

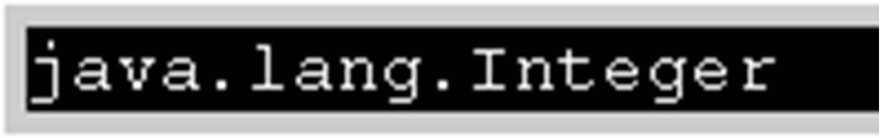


```
class Pair<KeyType, ValueType> {
  // Constructor
  public Pair(KeyType aKey, ValueType aValue) {
    key = aKey;
    value = aValue;
  }

  // Get the key for this pair
  public KeyType getKey() {
    return key;
  }

  // Get the value for this pair
  public ValueType getValue() {
    return value;
  }

  // Set the value for this pair
  public void setValue(ValueType aValue) {
    value = aValue;
  }

  private KeyType key;

  private ValueType value;
}
```

Class Generic dengan Dua Type Parameter



```
public class MainClass {

  public static void main(String[] a) {
    Pair<Integer, String> p = new Pair<Integer, String>(1, "A");

    System.out.println(p.getKey().getClass().getName());
  }
}
```

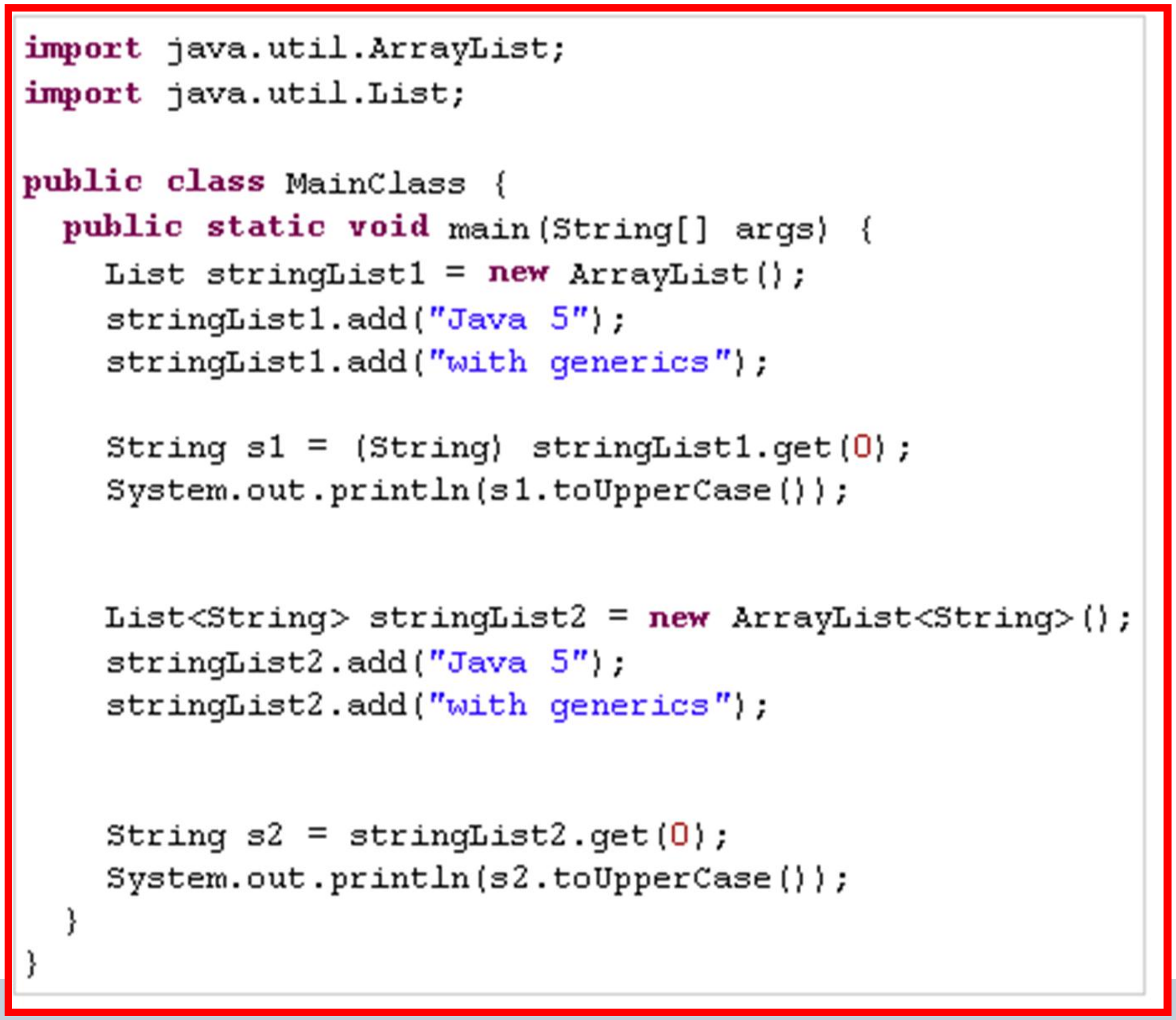


```
java.lang.Integer
```

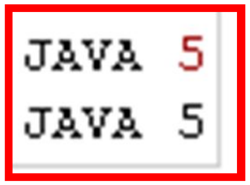
Generics pada List

- List <E> myList ;
- E disebut type variabel, variabel yang diganti dengan type.
- Jika E adalah class, maka kita bisa melewatkan subclass E.
- Jika E adalah interface maka kita bisa melewatkan class yang mengimplementasikan E.

Generics List



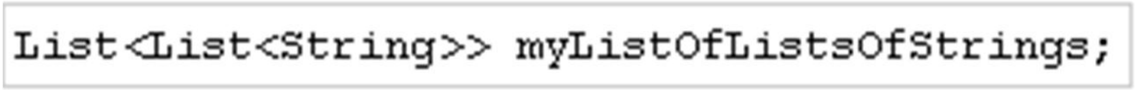
```
import java.util.ArrayList;
import java.util.List;

public class MainClass {
  public static void main(String[] args) {
    List stringList1 = new ArrayList();
    stringList1.add("Java 5");
    stringList1.add("with generics");

    String s1 = (String) stringList1.get(0);
    System.out.println(s1.toUpperCase());


    List<String> stringList2 = new ArrayList<String>();
    stringList2.add("Java 5");
    stringList2.add("with generics");


    String s2 = stringList2.get(0);
    System.out.println(s2.toUpperCase());
  }
}
```



```
JAVA 5
JAVA 5
```

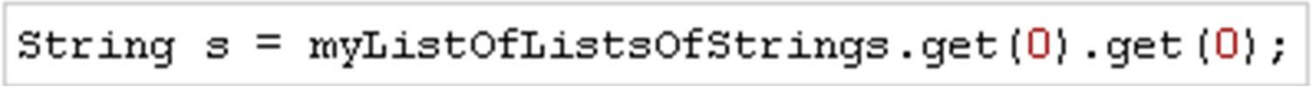
Nested generic type

Å A generic type is itself a type and can be used as a type variable

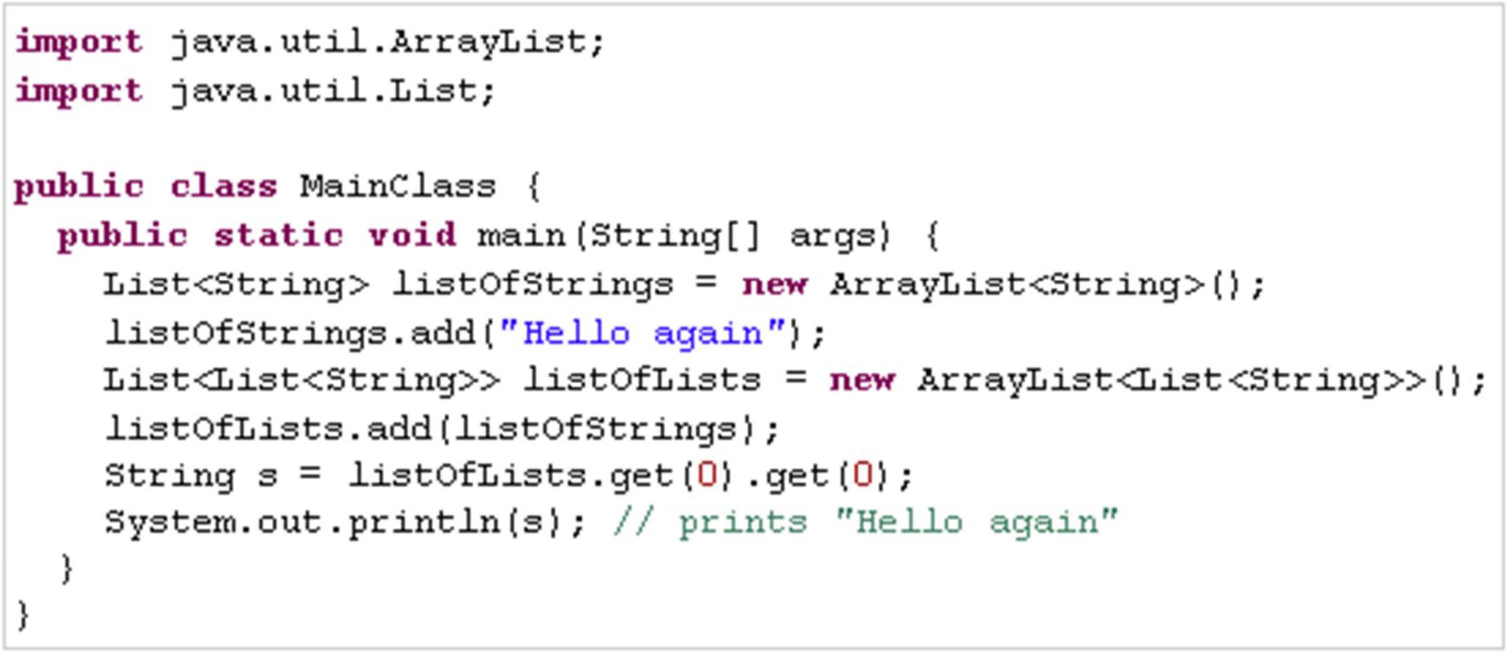


```java
List<List<String>> myListOfListsOfStrings;
```

Å Cara untuk mendapatkan string dari list pertama :



```java
String s = myListOfListsOfStrings.get(0).get(0);
```

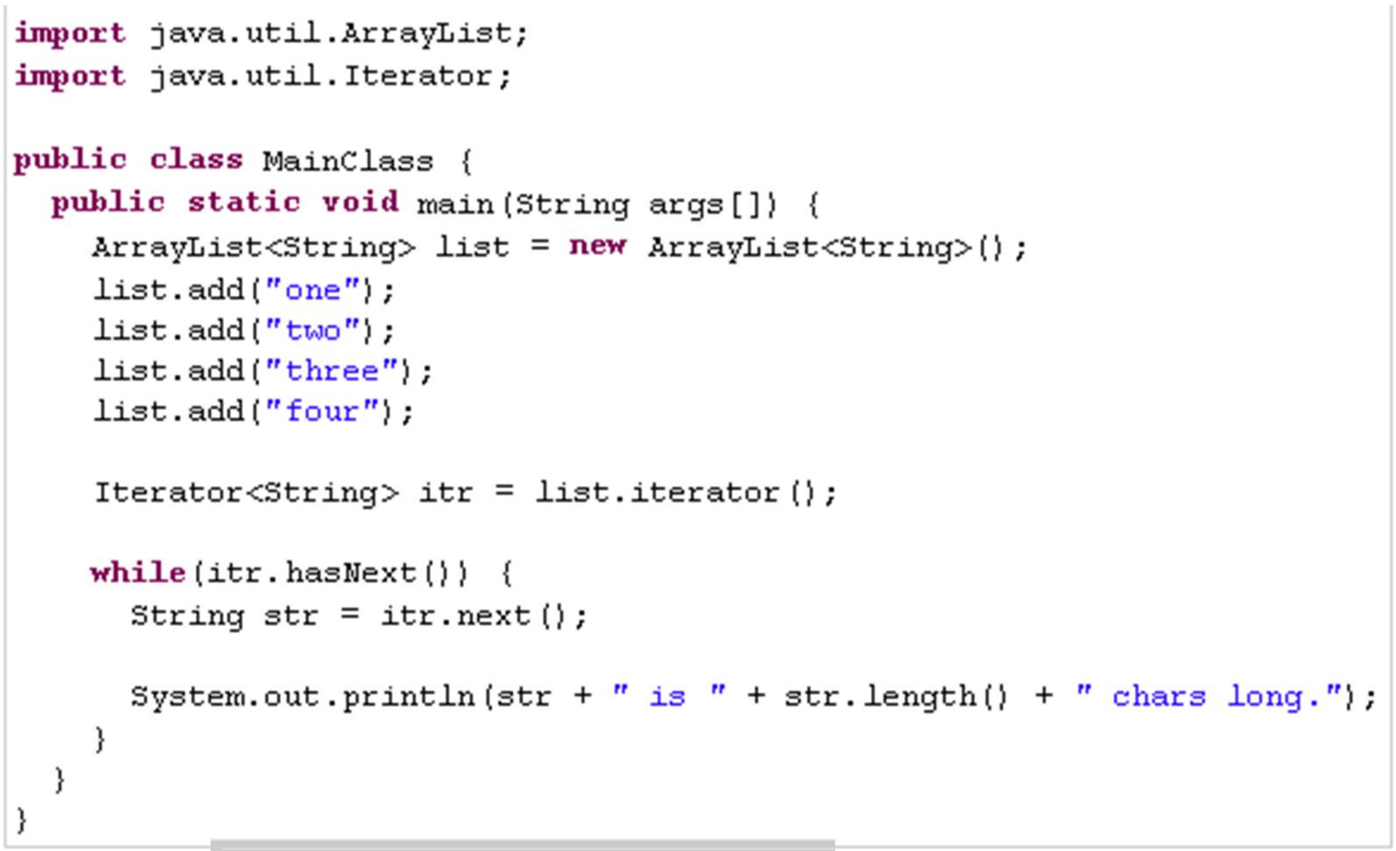


```java
import java.util.ArrayList;
import java.util.List;

public class MainClass {
  public static void main(String[] args) {
    List<String> listOfStrings = new ArrayList<String>();
    listOfStrings.add("Hello again");
    List<List<String>> listOfLists = new ArrayList<List<String>>();
    listOfLists.add(listOfStrings);
    String s = listOfLists.get(0).get(0);
    System.out.println(s); // prints "Hello again"
  }
}
```

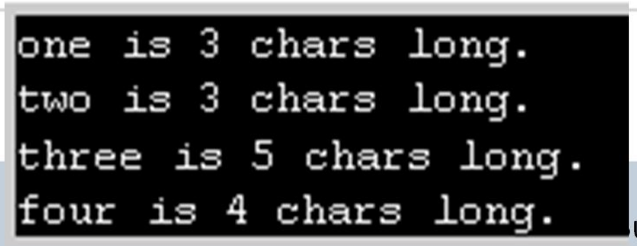
Type Generic dapat menerima lebih dari satu type variabel

```
import java.util.HashMap;
import java.util.Map;

public class MainClass {
    public static void main (String[] args) {
        Map<String, String> map = new HashMap<String, String>();
        map.put ("key1", "value1");
        map.put ("key2", "value2");
        String value1 = map.get("key1");
    }
}
```

Generics and Collections: ArrayList



```
import java.util.ArrayList;
import java.util.Iterator;

public class MainClass {
  public static void main(String args[]) {
    ArrayList<String> list = new ArrayList<String>();
    list.add("one");
    list.add("two");
    list.add("three");
    list.add("four");

    Iterator<String> itr = list.iterator();

    while(itr.hasNext()) {
      String str = itr.next();

      System.out.println(str + " is " + str.length() + " chars long.");
    }
  }
}
```



```
one is 3 chars long.
two is 3 chars long.
three is 5 chars long.
four is 4 chars long.
```

Subtyping

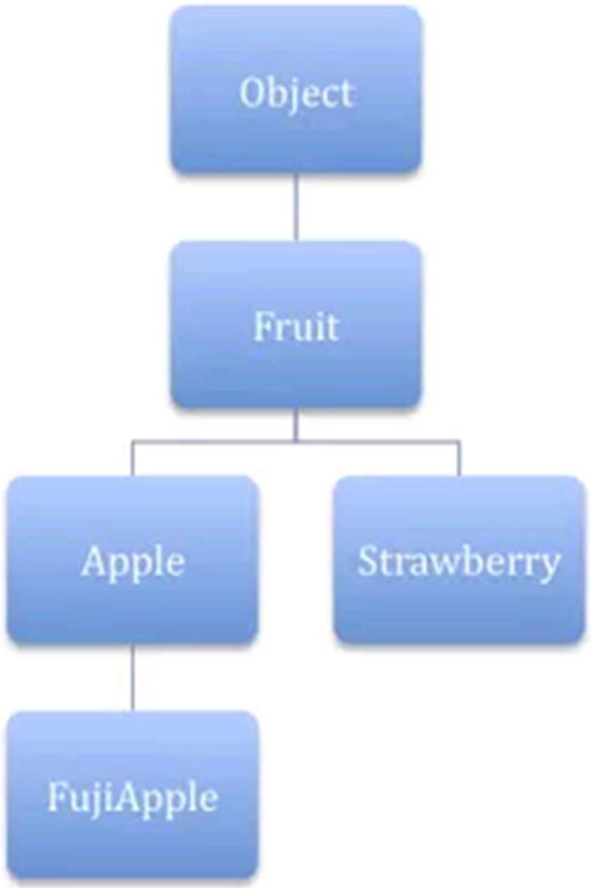
- `Box<String> gS = new Box<String>();`
- `Box<Object> gO = new Box<Object>();`
- `Object O ;`
- `String S ;`
- `O = gO ;`
- `O = gS ;`
- `gO = gS ; //error karena Box<String> bukan subtype dari Box<Object>`

- `G<Object> gA ;`
- `G<String> gB;`
- `gA = gB // error karena G<String> bukan subtype dari G<Object>`

Å Secara umum jika B adalah dari A dan G adalah suatu tipe data generics maka tidak berarti G<B> adalah subtype dari G<A>.

Subtype

Å FujiApple is a subtype of Apple
Å Apple is a subtype of Fruit
Å FujiApple is a subtype of Fruit.



Subtype

Manakah program yang error ?

Å Apple a = new Apple();

Å Fruit f = a;

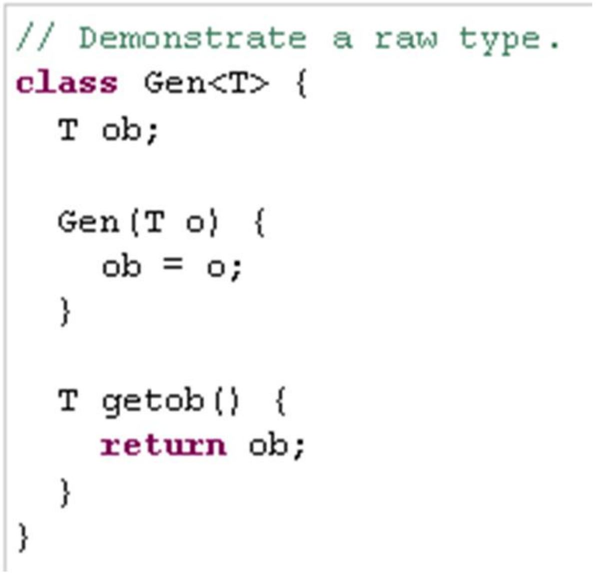
Å List<Apple> apples;

Å List<Fruit> fruits ;

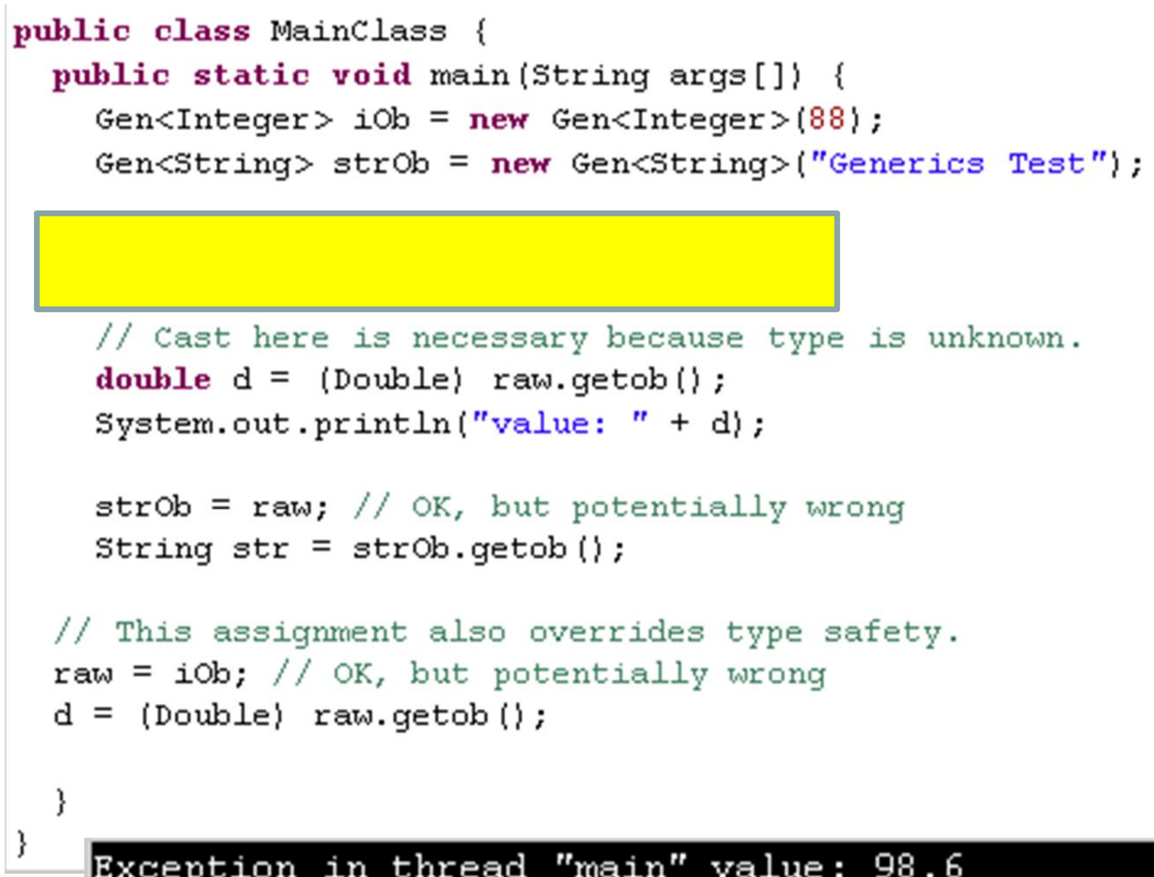
Å apples = fruits;

Raw Types

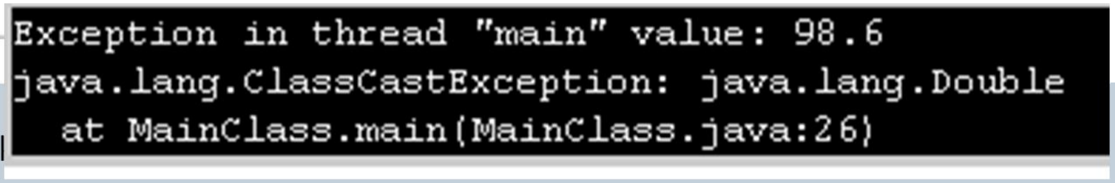
Å Java membolehkan class generic digunakan tanpa type argument.



```
// Demonstrate a raw type.
class Gen<T> {
  T ob;

  Gen(T o) {
    ob = o;
  }

  T getob() {
    return ob;
  }
}
```



```
public class MainClass {
  public static void main(String args[]) {
    Gen<Integer> iOb = new Gen<Integer>(88);
    Gen<String> strOb = new Gen<String>("Generics Test");

 [redacted]
    // Cast here is necessary because type is unknown.
    double d = (Double) raw.getob();
    System.out.println("value: " + d);

    strOb = raw; // OK, but potentially wrong
    String str = strOb.getob();

  // This assignment also overrides type safety.
  raw = iOb; // OK, but potentially wrong
  d = (Double) raw.getob();

  }
}
```

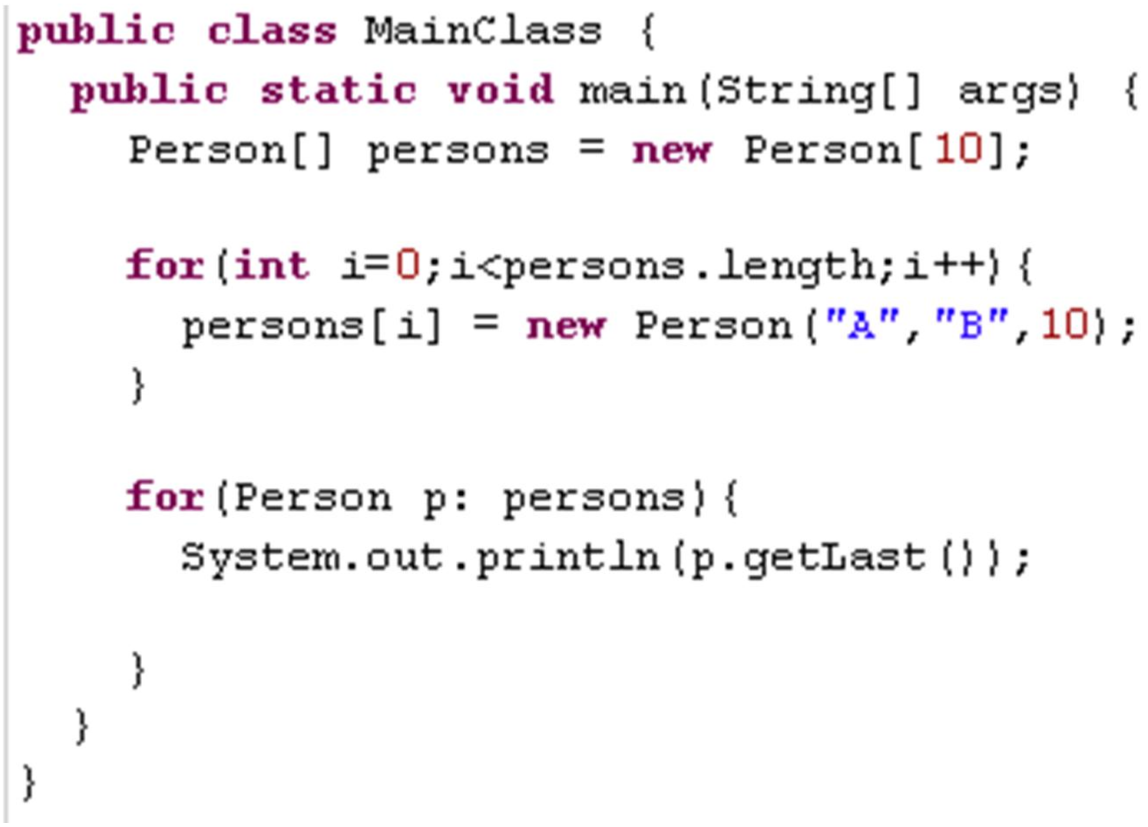


```
Exception in thread "main" value: 98.6
java.lang.ClassCastException: java.lang.Double
  at MainClass.main(MainClass.java:26)
```

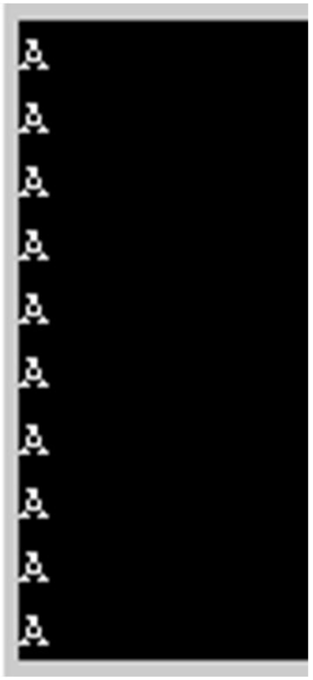
Penggunaan Generic pada Interface Comparable

```java
class Person {
  private String lastName;
  private String firstName;

  private int age;

  public Person(String last, String first, int a) {
    lastName = last;
    firstName = first;
    age = a;
  }

  public String toString() {
    return "Last name: " + lastName + " First name: " + firstName + " Age: " + age;
  }

  public String getLast() {
    return lastName;
  }
}
```

Penggunaan Generic pada Interface Comparable

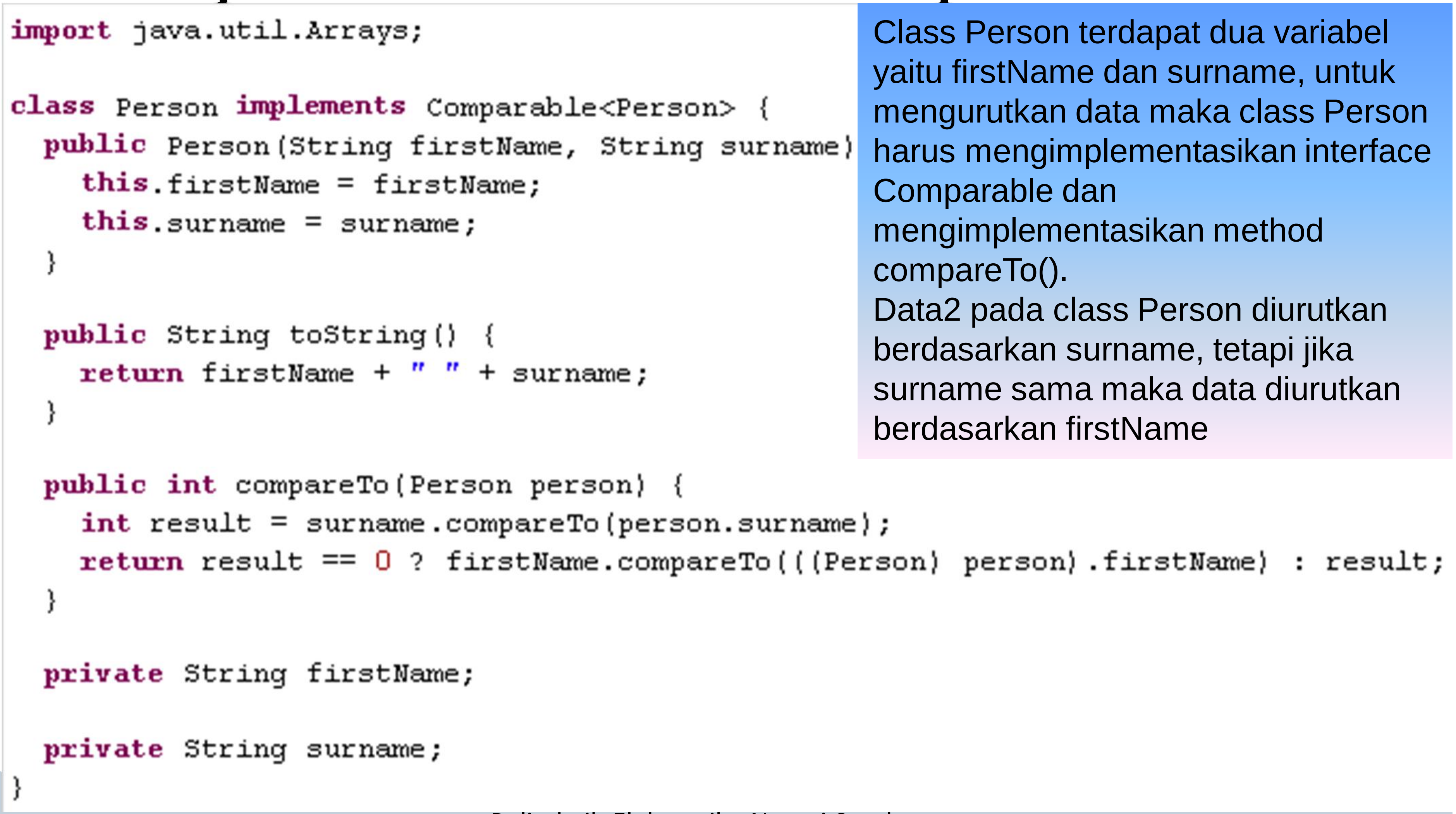


```
public class MainClass {
  public static void main(String[] args) {
    Person[] persons = new Person[10];

    for(int i=0;i<persons.length;i++){
      persons[i] = new Person("A","B",10);
    }

    for(Person p: persons){
      System.out.println(p.getLast());

    }
  }
}
```



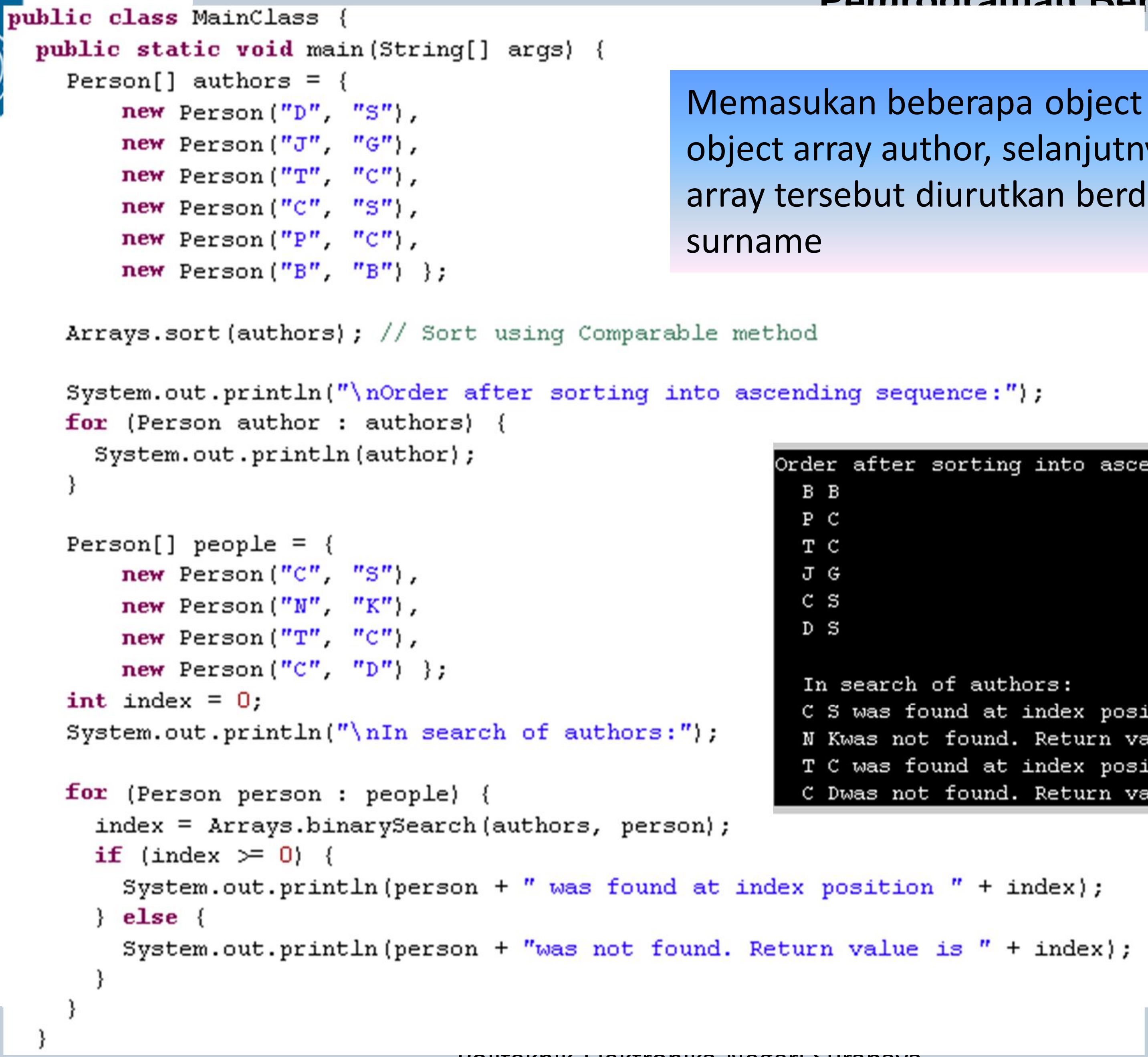
```
A
A
A
A
A
A
A
A
A
A
```

Penggunaan Generic pada Interface Comparable



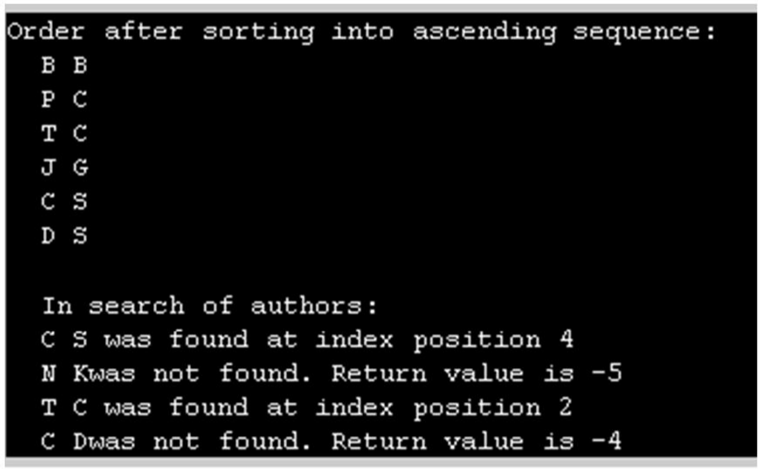
```
import java.util.Arrays;

class Person implements Comparable<Person> {
  public Person(String firstName, String surname)
    this.firstName = firstName;
    this.surname = surname;
  }

  public String toString() {
    return firstName + " " + surname;
  }

  public int compareTo(Person person) {
    int result = surname.compareTo(person.surname);
    return result == 0 ? firstName.compareTo(((Person) person).firstName) : result;
  }

  private String firstName;

  private String surname;
}
```

Class Person terdapat dua variabel yaitu firstName dan surname, untuk mengurutkan data maka class Person harus mengimplementasikan interface Comparable dan mengimplementasikan method compareTo().
Data2 pada class Person diurutkan berdasarkan surname, tetapi jika surname sama maka data diurutkan berdasarkan firstName



```
public class MainClass {
  public static void main(String[] args) {
    Person[] authors = {
        new Person("D", "S"),
        new Person("J", "G"),
        new Person("T", "C"),
        new Person("C", "S"),
        new Person("P", "C"),
        new Person("B", "B") };

    Arrays.sort(authors); // Sort using Comparable method

    System.out.println("\nOrder after sorting into ascending sequence:");
    for (Person author : authors) {
      System.out.println(author);
    }

    Person[] people = {
        new Person("C", "S"),
        new Person("N", "K"),
        new Person("T", "C"),
        new Person("C", "D") };
    int index = 0;
    System.out.println("\nIn search of authors:");

    for (Person person : people) {
      index = Arrays.binarySearch(authors, person);
      if (index >= 0) {
        System.out.println(person + " was found at index position " + index);
      } else {
        System.out.println(person + "was not found. Return value is " + index);
      }
    }
  }
```

Memasukan beberapa object Person pada object array author, selanjutnya data pada array tersebut diurutkan berdasarkan surname



```
Order after sorting into ascending sequence:
  B B
  P C
  T C
  J G
  C S
  D S

  In search of authors:
  C S was found at index position 4
  N Kwas not found. Return value is -5
  T C was found at index position 2
  C Dwas not found. Return value is -4
```

Type parameter yang dibatasi (*bounded type parameter*)

Å Jika kita ingin memberikan batasan type yang diperbolehkan untuk dilewatkan ke type parameter. Contoh method dengan parameter number, hanya menerima object dari class Number dan subclass. Hal ini yang disebut *bounded type parameter*.

Å Cara

```
<U extends Number>
```

Å Jika terdapat interface yang harus diimplementasikan gunakan &

```
<U extends Number & MyInterface>
```

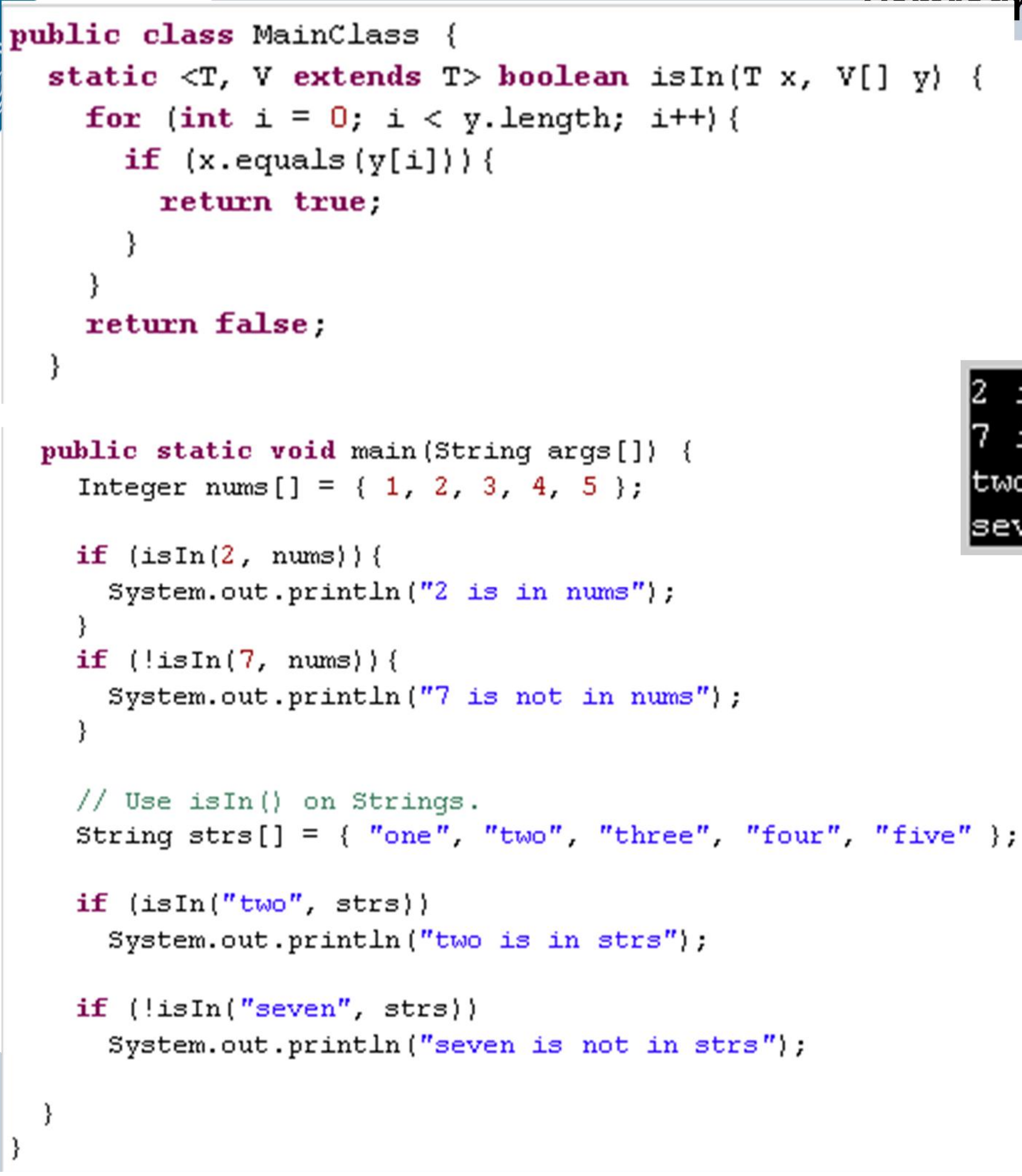
Å Tidak boleh menggunakan ǐsuperò

```
public class Box<T> {

    private T t;

    public void add(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) {
        Box<Integer> integerBox = new Box<Integer>();
        integerBox.add(new Integer(10));
        integerBox.inspect("some text"); // error: this is still String!
    }
}
```

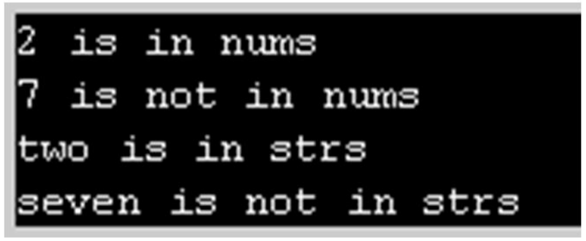
Yang menjadi parameter dari method inspect() adalah semua object yang merupakan anak dari class Number

```
Box.java:21: <U>inspect(U) in Box<java.lang.Integer> cannot
  be applied to (java.lang.String)
                        integerBox.inspect("10");
                                  ^
1 error
```

Generic Method

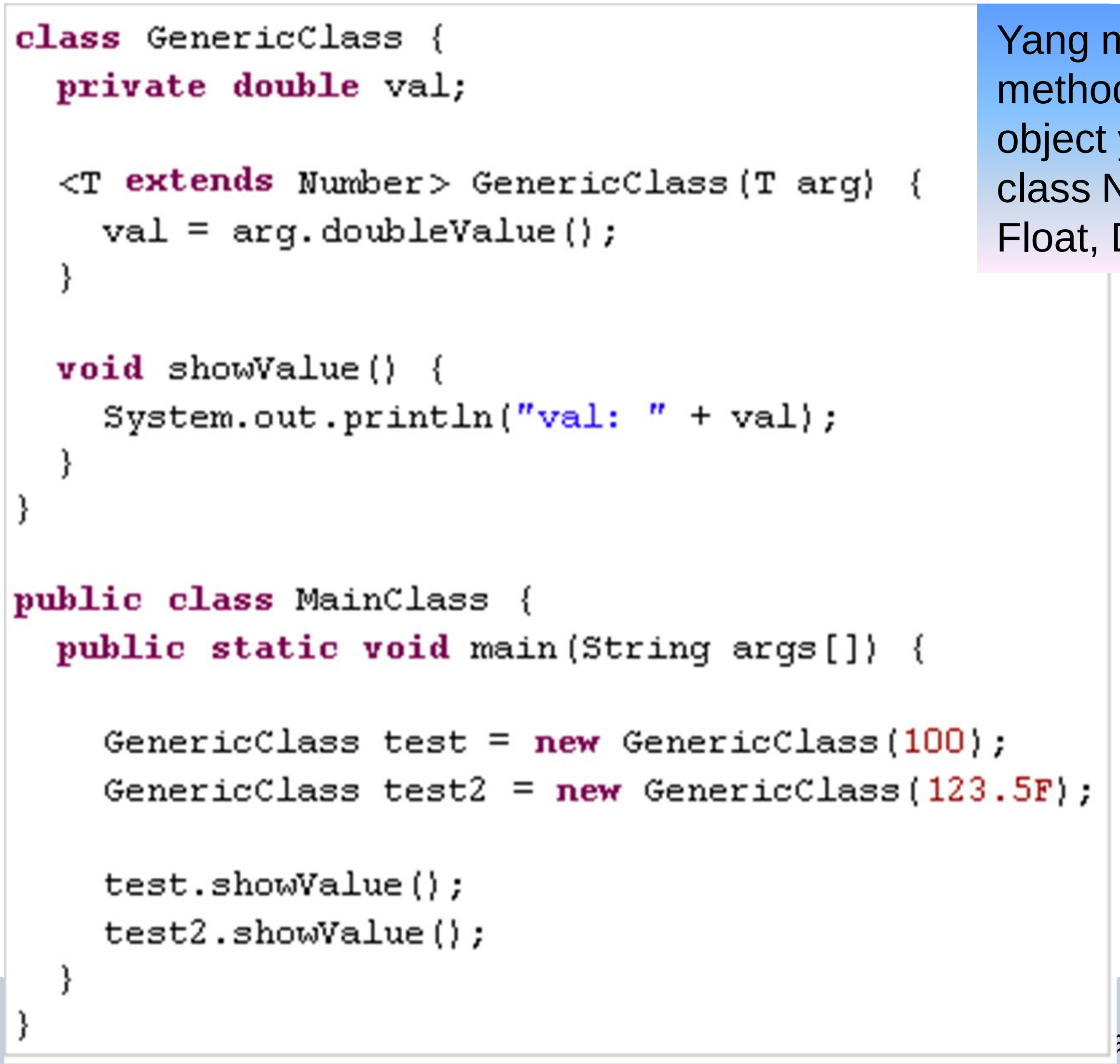


```java
public class MainClass {
  static <T, V extends T> boolean isIn(T x, V[] y) {
    for (int i = 0; i < y.length; i++){
      if (x.equals(y[i])){
        return true;
      }
    }
    return false;
  }

  public static void main(String args[]) {
    Integer nums[] = { 1, 2, 3, 4, 5 };

    if (isIn(2, nums)){
      System.out.println("2 is in nums");
    }
    if (!isIn(7, nums)){
      System.out.println("7 is not in nums");
    }

    // Use isIn() on Strings.
    String strs[] = { "one", "two", "three", "four", "five" };

    if (isIn("two", strs))
      System.out.println("two is in strs");

    if (!isIn("seven", strs))
      System.out.println("seven is not in strs");

  }
}
```



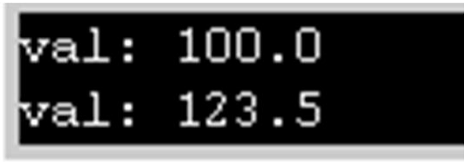
```
2 is in nums
7 is not in nums
two is in strs
seven is not in strs
```

Generic Constructor

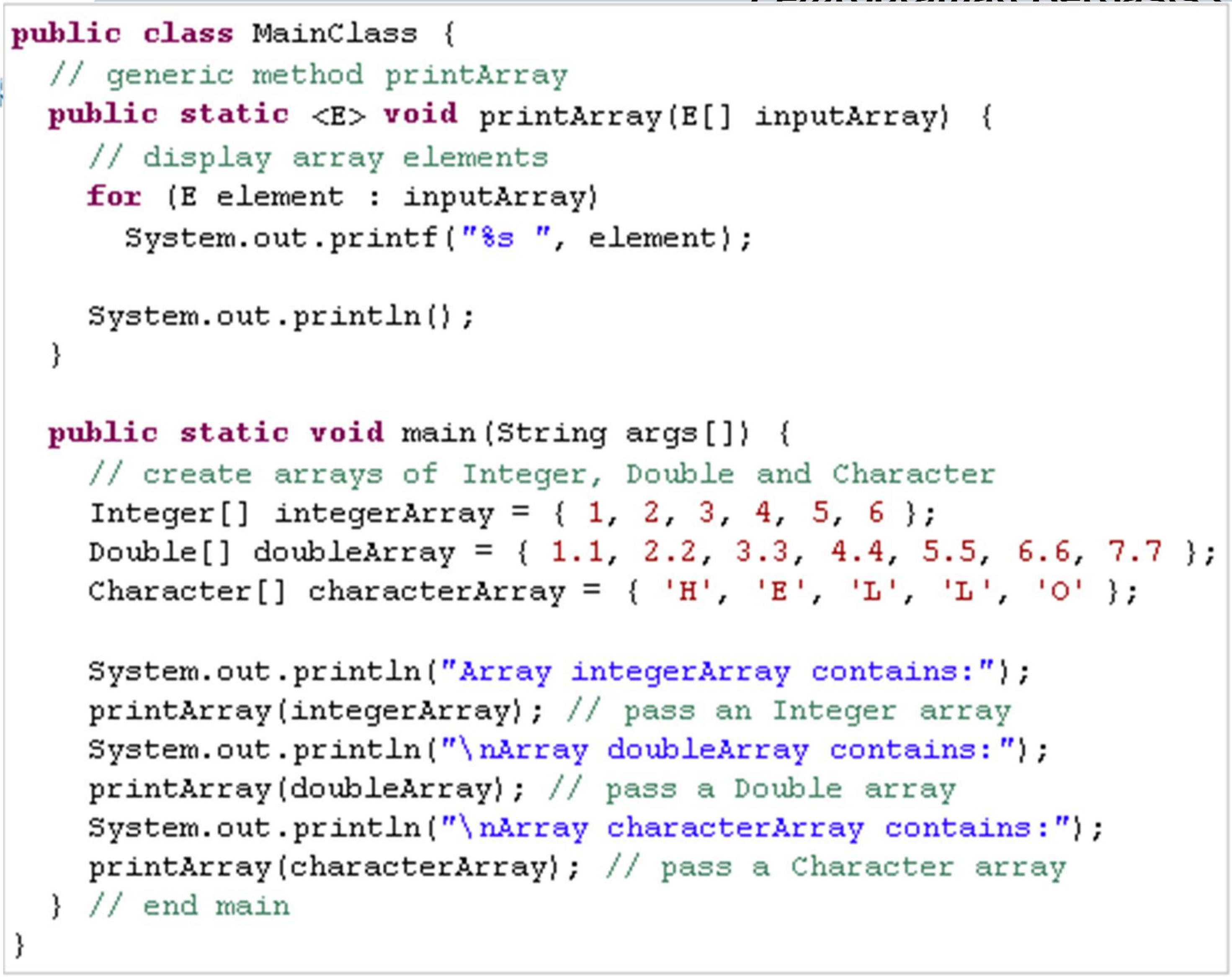


```
class GenericClass {
  private double val;

  <T extends Number> GenericClass(T arg) {
    val = arg.doubleValue();
  }

  void showValue() {
    System.out.println("val: " + val);
  }
}

public class MainClass {
  public static void main(String args[]) {

    GenericClass test = new GenericClass(100);
    GenericClass test2 = new GenericClass(123.5F);

    test.showValue();
    test2.showValue();
  }
}
```

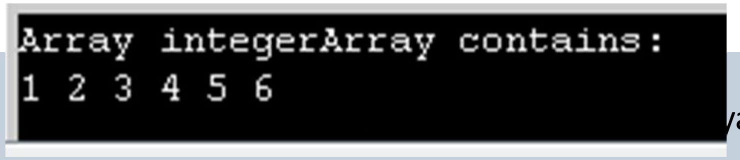
Yang menjadi parameter dari method inspect() adalah semua object yang merupakan anak dari class Number misal object Integer, Float, Double



```
val: 100.0
val: 123.5
```

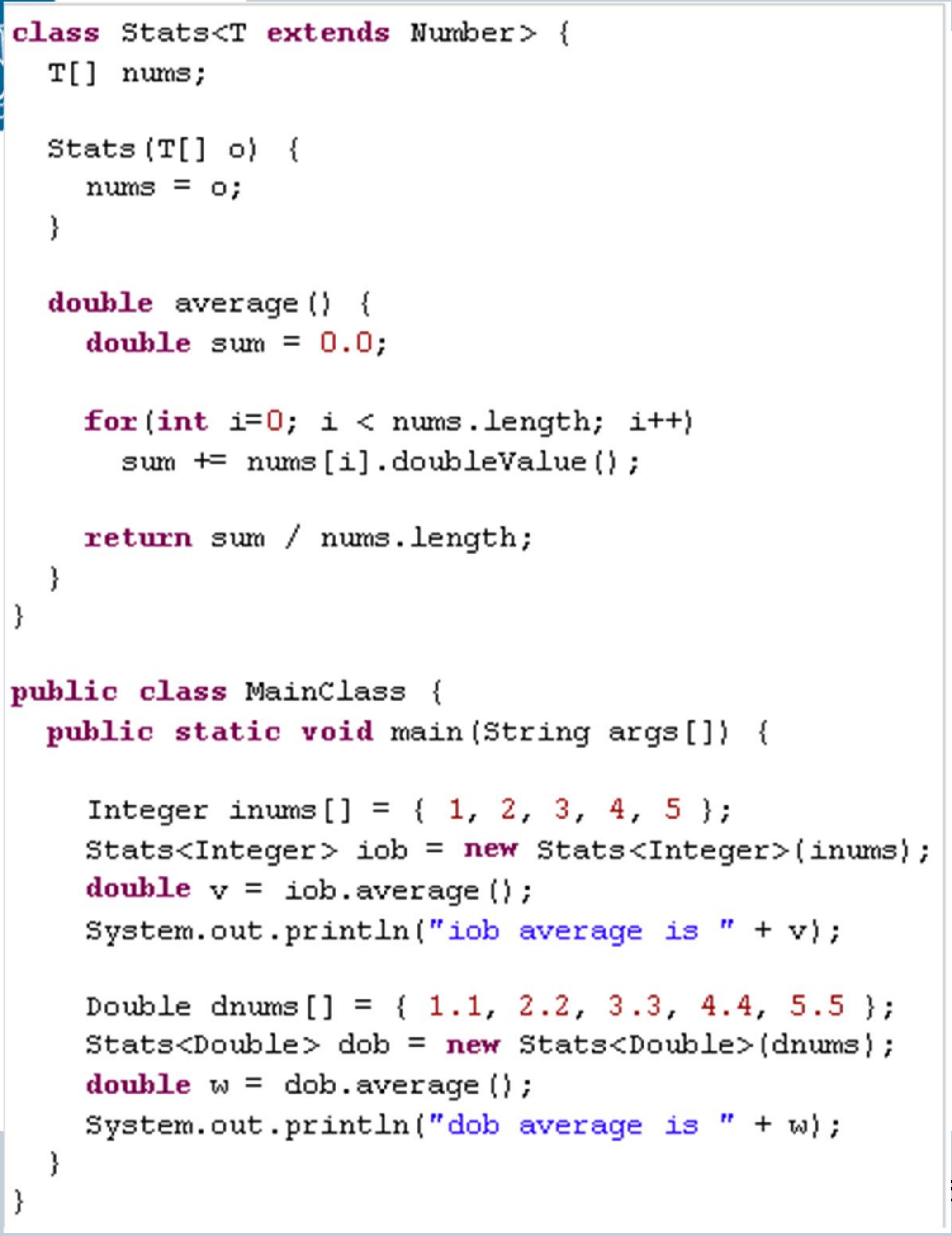


```java
public class MainClass {
  // generic method printArray
  public static <E> void printArray(E[] inputArray) {
    // display array elements
    for (E element : inputArray)
      System.out.printf("%s ", element);

    System.out.println();
  }

  public static void main(String args[]) {
    // create arrays of Integer, Double and Character
    Integer[] integerArray = { 1, 2, 3, 4, 5, 6 };
    Double[] doubleArray = { 1.1, 2.2, 3.3, 4.4, 5.5, 6.6, 7.7 };
    Character[] characterArray = { 'H', 'E', 'L', 'L', 'O' };

    System.out.println("Array integerArray contains:");
    printArray(integerArray); // pass an Integer array
    System.out.println("\nArray doubleArray contains:");
    printArray(doubleArray); // pass a Double array
    System.out.println("\nArray characterArray contains:");
    printArray(characterArray); // pass a Character array
  } // end main
}
```

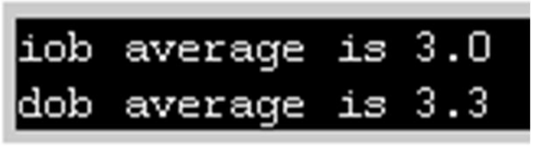


```
Array integerArray contains:
1 2 3 4 5 6
```

Type parameter yang dibatasi



```
class Stats<T extends Number> {
  T[] nums;

  Stats(T[] o) {
    nums = o;
  }

  double average() {
    double sum = 0.0;

    for(int i=0; i < nums.length; i++)
      sum += nums[i].doubleValue();

    return sum / nums.length;
  }
}

public class MainClass {
  public static void main(String args[]) {

    Integer inums[] = { 1, 2, 3, 4, 5 };
    Stats<Integer> iob = new Stats<Integer>(inums);
    double v = iob.average();
    System.out.println("iob average is " + v);

    Double dnums[] = { 1.1, 2.2, 3.3, 4.4, 5.5 };
    Stats<Double> dob = new Stats<Double>(dnums);
    double w = dob.average();
    System.out.println("dob average is " + w);
  }
}
```



```
iob average is 3.0
dob average is 3.3
```

Penggunaan ? Wildcard

Å Simbol ? disebut *wildcard*, menyatakan an unknown type.

Penggunaan ? Wildcard

```
public abstract class Animal
{
   public abstract void playWith(Collection<Animal>
playGroup);
}
public class Dog extends Animal
{
   public void playWith(Collection<Animal> playGroup)
   {   }
}
```

```
Collection<Dog> dogs = new ArrayList<Dog>();

Dog aDog = new Dog();
aDog.playWith(dogs); //ERROR
```

Å The Animal class has a playWith() method that accepts a Collection of Animals. The Dog, which extends Animal, overrides this method. Letô s try to use the Dog class in an example.

Å Here, I create an instance of Dog and send a Collection of Dogs to its playWith() method. We get a compilation error:

```
Error:  line (29) cannot find symbol
method playWith(java.util.Collection<com.agiledeveloper.Dog>)
```

Å This is because a Collection of Dogs canô t be treated as a Collection of Animals which the playWith() method expects. However, it would make sense to be able to send aCollection of Dogs to this method, isnô t it? How can we do that? This is where the *wildcard* or *unknown* type comes in.

Penggunaan ? Wildcard

Å We modify both the playMethod() methods (in Animal and Dog) as follows:

```
public void playWith(Collection<?> playGroup)
```

Å The Collection is not of type Animal. Instead it is of *unknown type* (?). Unknown type is not Object, it is just unknown or unspecified.

Å Now, the code:

```
aDog.playWith(dogs);
```

Å compiles with no error.

Penggunaan ? Wildcard

Å There is a problem however. We can also write:

Å ArrayList<Integer> numbers = new ArrayList<Integer>(); aDog.playWith(numbers);

Å The change I made to allow a Collection of Dogs to be sent to the playWith() method now permits aCollection of Integers to be sent as well. If we allow that, that will become one weird dog. How can we say that the compiler should allow Collections of Animals or Collections of any type that extends Animal, but not anyCollection of other types? This is made possible by the use of upper bounds as shown below:

Å public void playWith(Collection<? extends Animal> playGroup)

Å One restriction of using wildcards is that you are allowed to get elements from a Collection<?>, but you canôt add elements to such a collection ï the compiler has no idea what type it is dealing with.

```
List<Object> list1 = new ArrayList<Object>();
List<String> list2 = new ArrayList<String>();
```

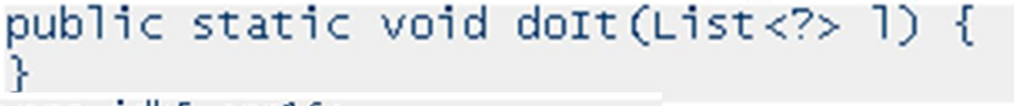
list1 mengacu ke List dengan tipe java.lang.Object dan list2 mengacu ke List String. Meskipun String merupakan subclass dari Object, List<String> tidak ada hubungannya dengan List<Object>, sehingga melewatkan List<String> ke method yang memiliki parameter List<Object> akan menyebabkan error.

```
package com.brainysoftware.jdk5.app16;
import java.util.ArrayList;
import java.util.List;

public class AllowedTypeTest {
  public static void doIt(List<Object> l) {
  }
  public static void main(String[] args) {
    List<String> myList = new ArrayList<String>();
    // this will generate a compile error
    doIt(myList);
  }
}
```

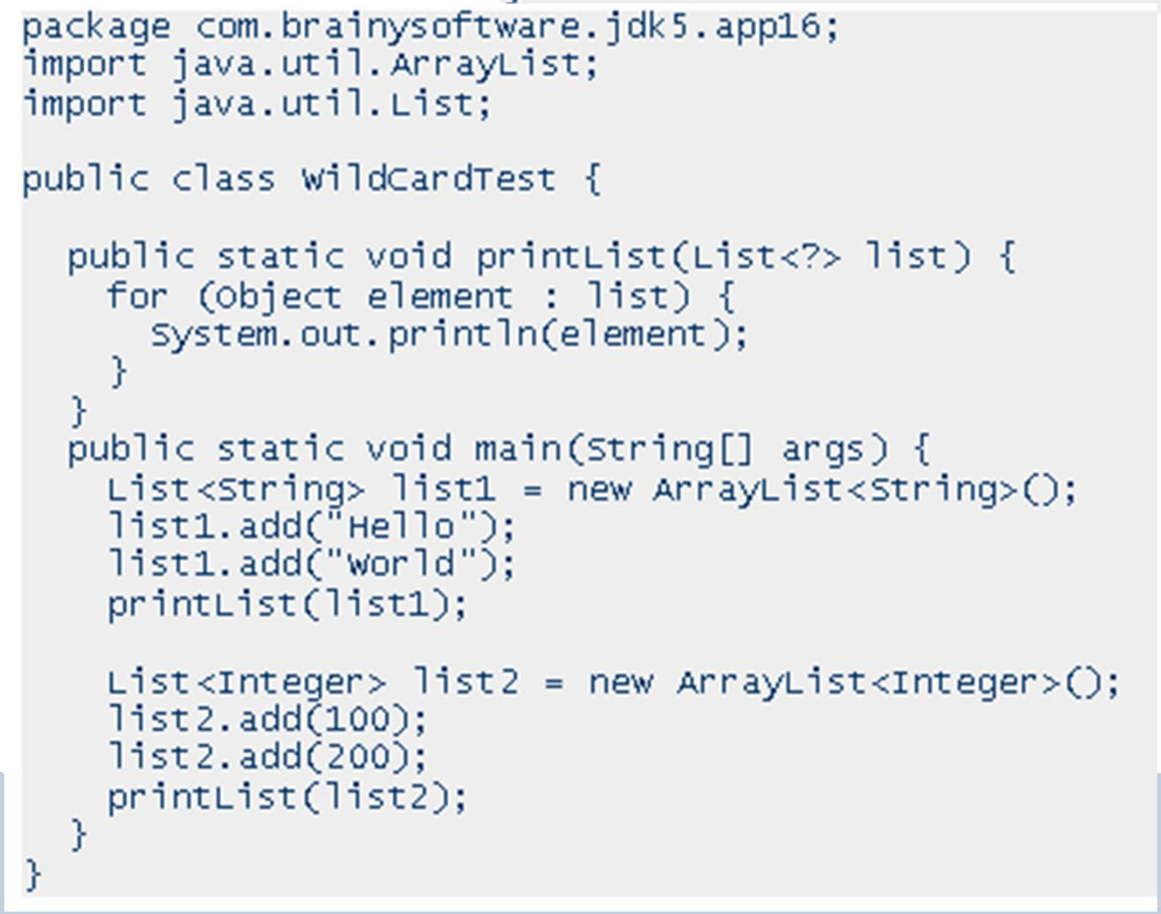
Penggunaan ? Wildcard

Å Bagaimana penyelesaiannya ?

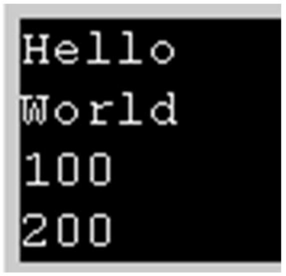
Å Menggunakan ? Wildcard. List<?> berarti list dengan object unknown type



```
public static void doIt(List<?> l) {
}
```



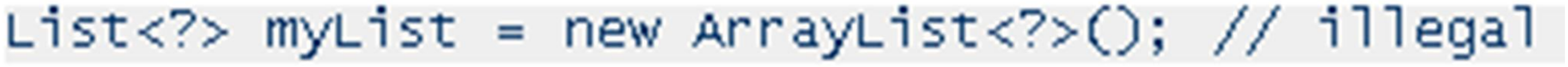
```
package com.brainysoftware.jdk5.app16;
import java.util.ArrayList;
import java.util.List;

public class WildCardTest {

  public static void printList(List<?> list) {
    for (Object element : list) {
      System.out.println(element);
    }
  }
  public static void main(String[] args) {
    List<String> list1 = new ArrayList<String>();
    list1.add("Hello");
    list1.add("World");
    printList(list1);

    List<Integer> list2 = new ArrayList<Integer>();
    list2.add(100);
    list2.add(200);
    printList(list2);
  }
}
```



```
Hello
World
100
200
```

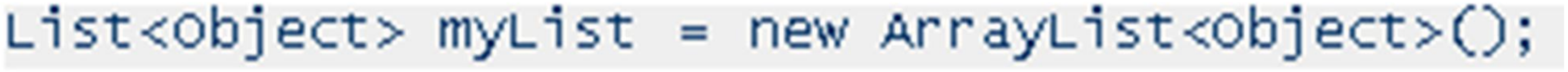
Penggunaan ? Wildcard

Å Illegal menggunakan wildcard pada saat create type generic.



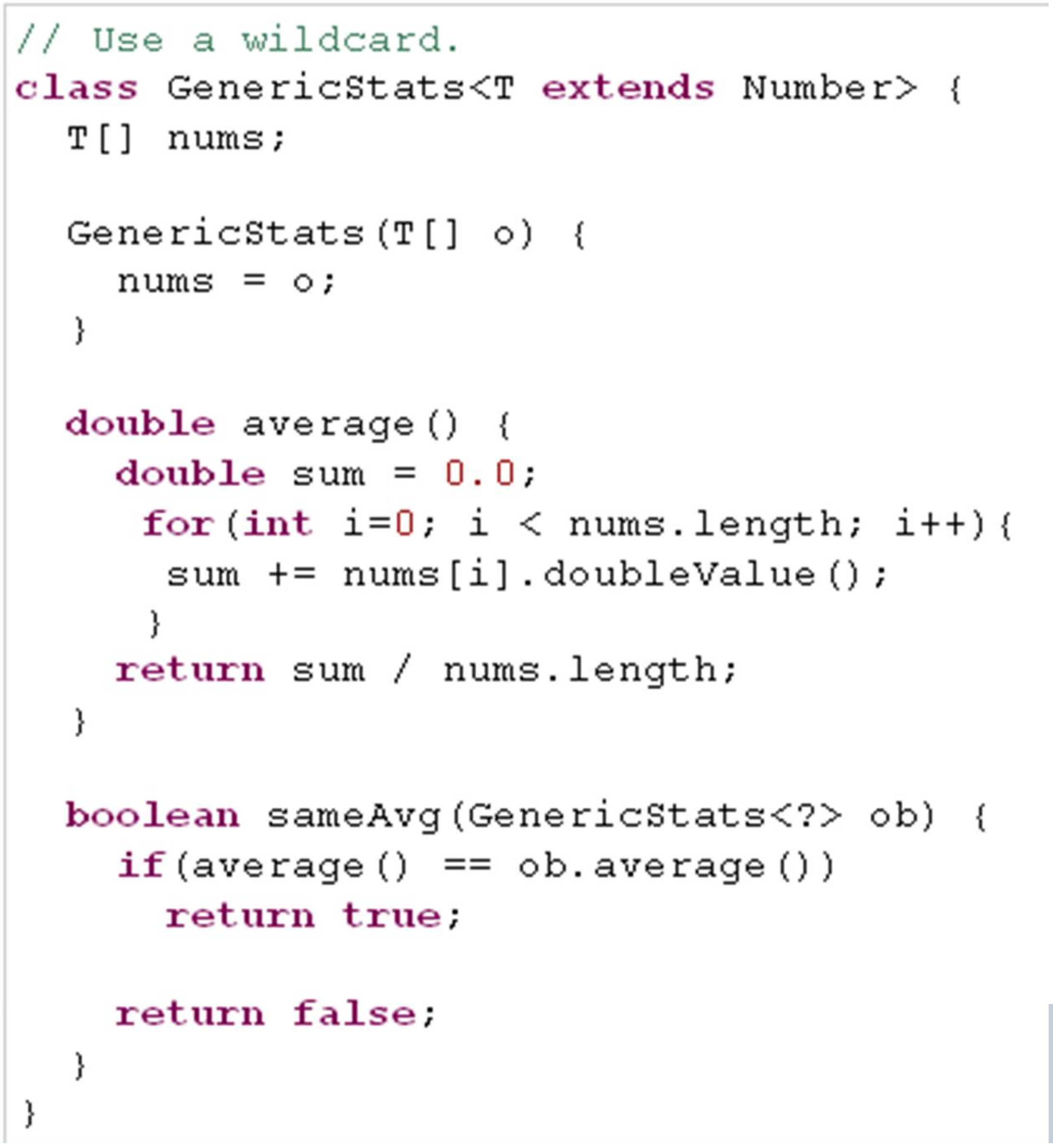
```
List<?> myList = new ArrayList<?>(); // illegal
```

Å Jika list bisa menerima sembarang object, gunakan class Object sebagai type variabel.

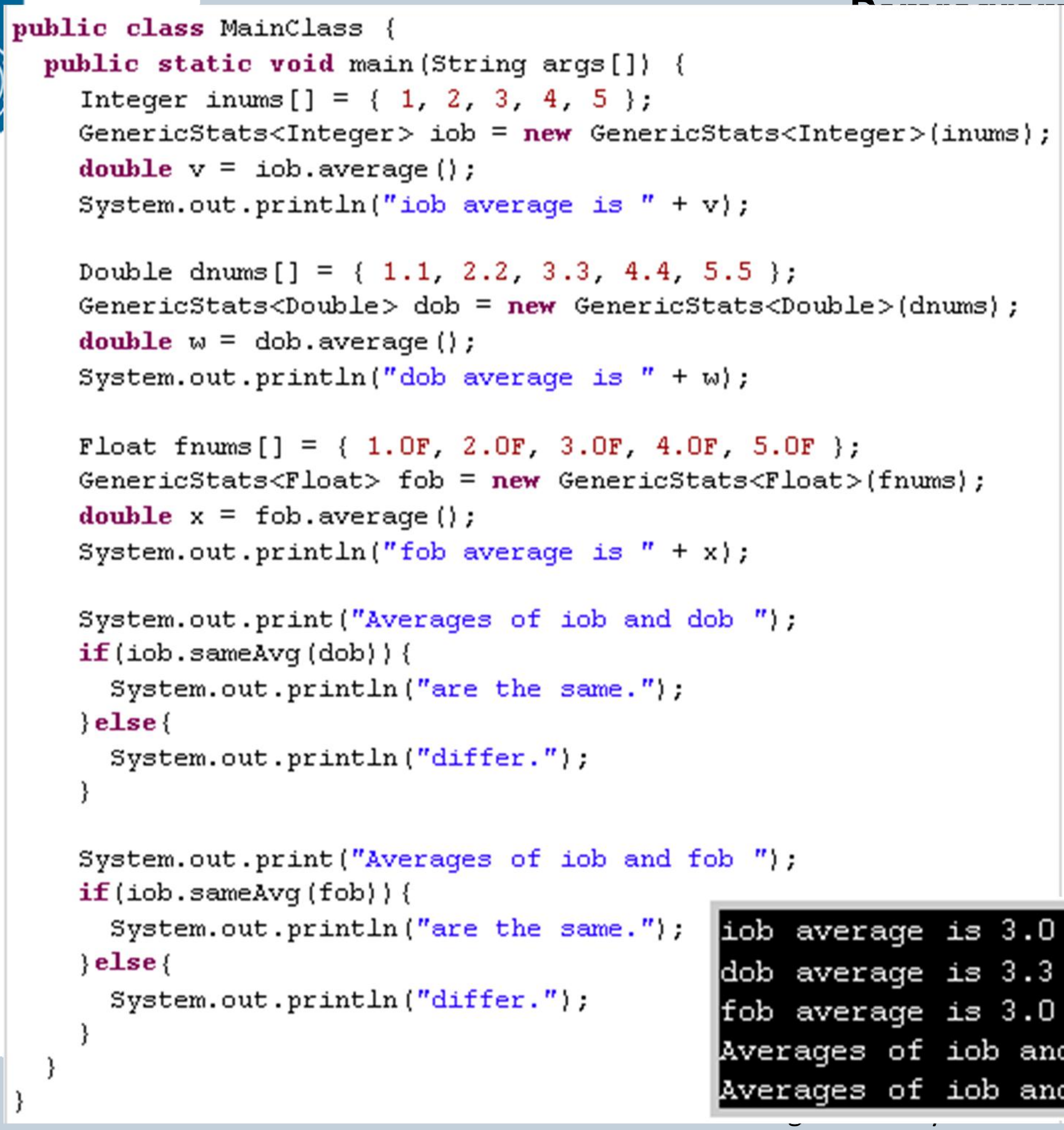


```
List<Object> myList = new ArrayList<Object>();
```

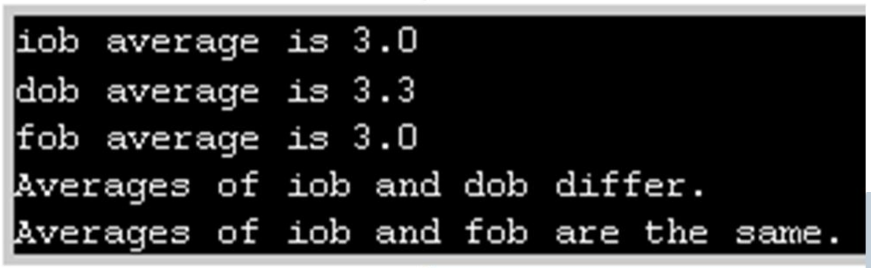
Penggunaan ? Wildcard



```java
// Use a wildcard.
class GenericStats<T extends Number> {
  T[] nums;

  GenericStats(T[] o) {
    nums = o;
  }

  double average() {
    double sum = 0.0;
     for(int i=0; i < nums.length; i++){
      sum += nums[i].doubleValue();
     }
    return sum / nums.length;
  }

  boolean sameAvg(GenericStats<?> ob) {
    if(average() == ob.average())
      return true;

    return false;
  }
}
```



```java
public class MainClass {
  public static void main(String args[]) {
    Integer inums[] = { 1, 2, 3, 4, 5 };
    GenericStats<Integer> iob = new GenericStats<Integer>(inums);
    double v = iob.average();
    System.out.println("iob average is " + v);

    Double dnums[] = { 1.1, 2.2, 3.3, 4.4, 5.5 };
    GenericStats<Double> dob = new GenericStats<Double>(dnums);
    double w = dob.average();
    System.out.println("dob average is " + w);

    Float fnums[] = { 1.0F, 2.0F, 3.0F, 4.0F, 5.0F };
    GenericStats<Float> fob = new GenericStats<Float>(fnums);
    double x = fob.average();
    System.out.println("fob average is " + x);

    System.out.print("Averages of iob and dob ");
    if(iob.sameAvg(dob)){
      System.out.println("are the same.");
    }else{
      System.out.println("differ.");
    }

    System.out.print("Averages of iob and fob ");
    if(iob.sameAvg(fob)){
      System.out.println("are the same.");
    }else{
      System.out.println("differ.");
    }
  }
}
```



```
iob average is 3.0
dob average is 3.3
fob average is 3.0
Averages of iob and dob differ.
Averages of iob and fob are the same.
```

Penggunaan Bounded Wildcard dalam Method

- Sintak upper bound untuk wildcard:

  GenericType <? extends upperBoundType>

- Contoh :

  List <? extends Number>

- Berarti kita bisa melewatkan object dari List<Integer>, List<Double>, List<Float>

- Sintak lower bound untuk wildcard:

  GenericType <? super Integer>

  berarti kita bisa melewatkan List<Integer> atau list yang berisi object yang merupakan superclass dari class Integer.

Lower Bounded Wildcards

Å Assume we want to copy elements from one collection to another. Here is my first attempt for a code to do that:

Å public static <T> void copy(Collection<T> from, Collection<T> to) {é }

Å Letôs try using this method:

Å ArrayList<Dog> dogList1 = new ArrayList<Dog>();

ArrayList<Dog> dogList2 = new ArrayList<Dog>();

//…

copy(dogList1, dogList2);

Å In this code, we are copying Dogs from one Dog ArrayList to another.

Lower Bounded Wildcards

Å Since Dogs are Animals, a Dog may be in both a Dogâs ArrayList and an Animalâs ArrayList, isnât it? So, here is the code to copy from a Dogâs ArrayList to an Animalâs ArrayList.

Å
```
ArrayList<Dog> dogList1 = new ArrayList<Dog>();
ArrayList<Animal> animalList = new ArrayList<Animal>();
copy(dogList1, animalList);
```

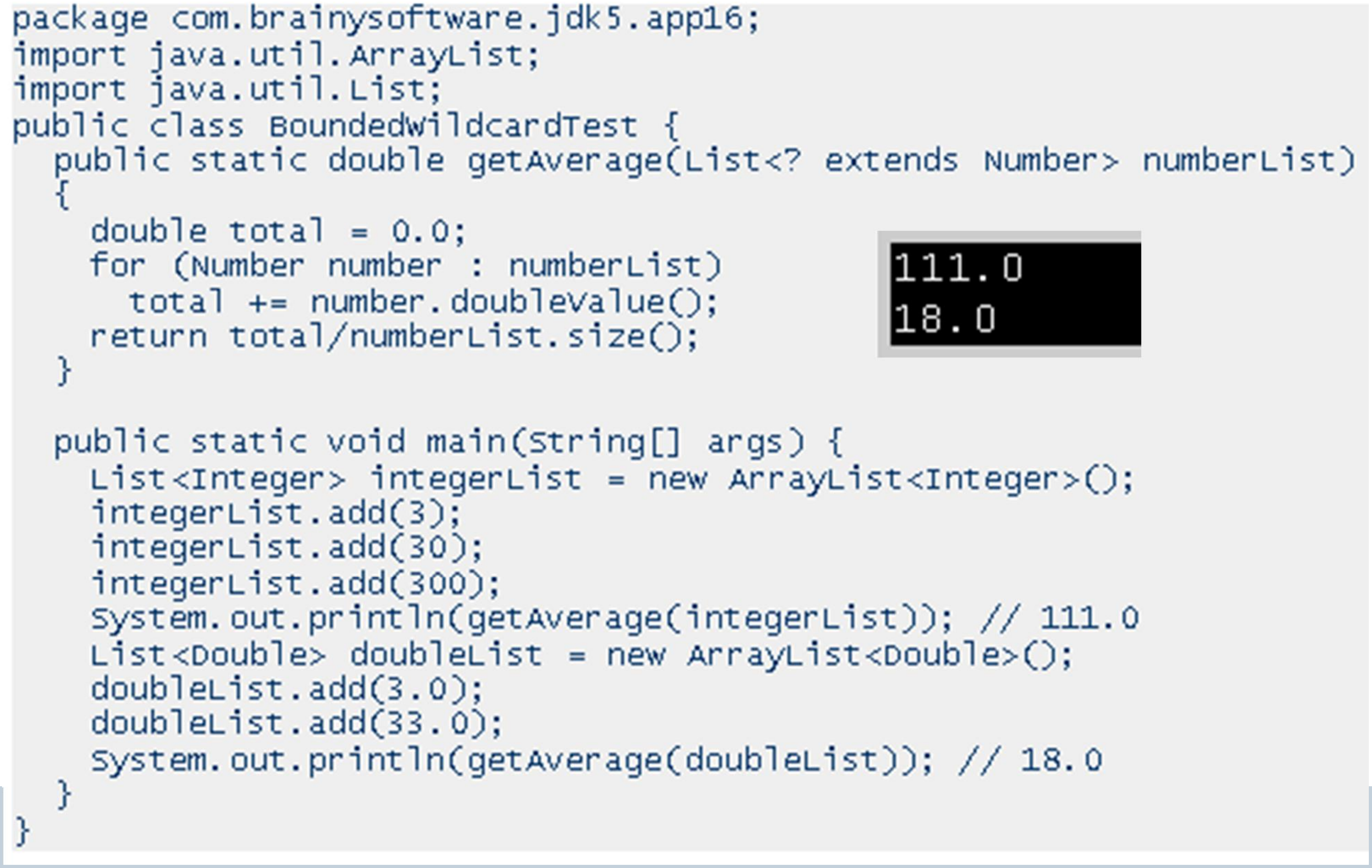
Å This code, however, fails compilation with error:

Å
```
Error: line (36)
<T>copy(java.util.Collection<T>,java.util.Collection<T>) in
com.agiledeveloper.Test cannot be applied to
(java.util.ArrayList<com.agiledeveloper.Dog>,
java.util.ArrayList<com.agiledeveloper.Animal>)
```

Lower Bounded Wildcards

- How can we make this work? This is where the lower bounds come in. Our intent for the second argument of Copy is for it to be of either type T or any type that is a base type of T. Here is the code:
- public static <T> void copy(Collection<T> from, Collection<? **super T**> to)
- Here we are saying that the type accepted by the second collection is the same type as T is, or its super type.

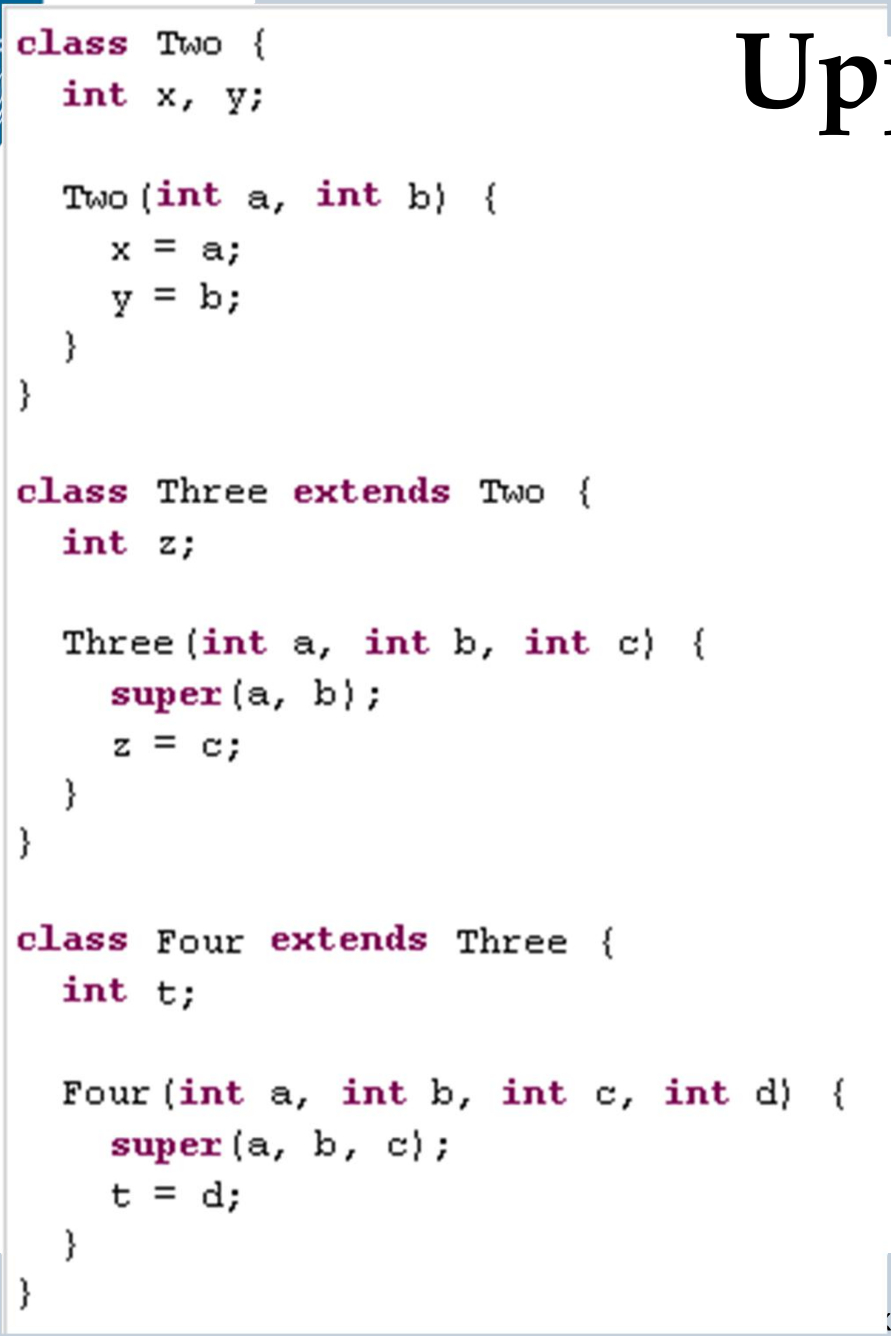
Penggunaan **Upper Bounded Wildcard** dalam Method



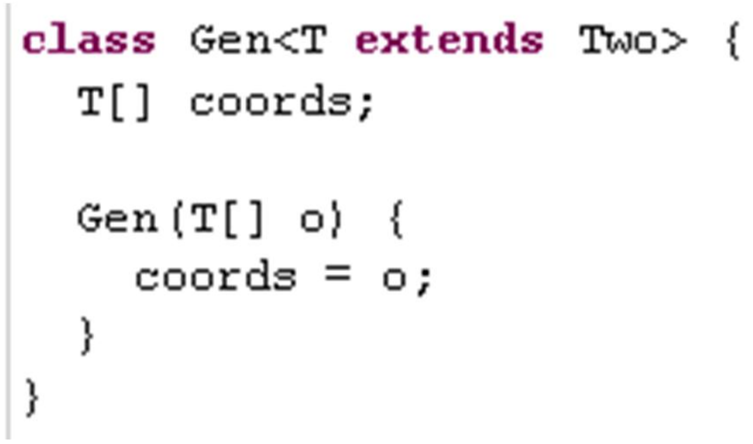
```java
package com.brainysoftware.jdk5.app16;
import java.util.ArrayList;
import java.util.List;
public class BoundedWildcardTest {
  public static double getAverage(List<? extends Number> numberList)
  {
    double total = 0.0;
    for (Number number : numberList)
      total += number.doubleValue();
    return total/numberList.size();
  }

  public static void main(String[] args) {
    List<Integer> integerList = new ArrayList<Integer>();
    integerList.add(3);
    integerList.add(30);
    integerList.add(300);
    System.out.println(getAverage(integerList)); // 111.0
    List<Double> doubleList = new ArrayList<Double>();
    doubleList.add(3.0);
    doubleList.add(33.0);
    System.out.println(getAverage(doubleList)); // 18.0
  }
}
```

```
111.0
18.0
```

Upper Bounded Wildcard

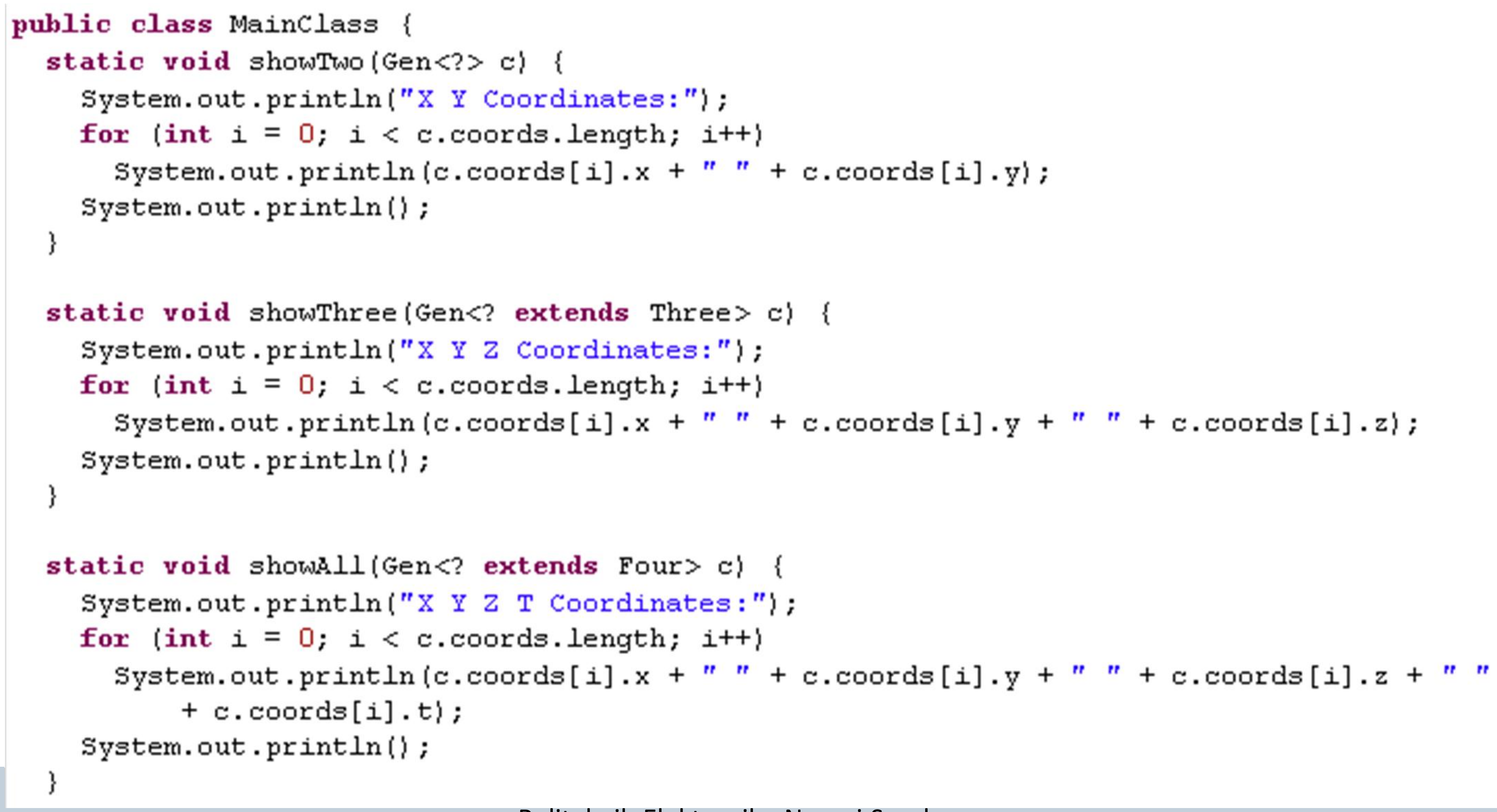


```java
class Two {
  int x, y;

  Two(int a, int b) {
    x = a;
    y = b;
  }
}

class Three extends Two {
  int z;

  Three(int a, int b, int c) {
    super(a, b);
    z = c;
  }
}

class Four extends Three {
  int t;

  Four(int a, int b, int c, int d) {
    super(a, b, c);
    t = d;
  }
}
```



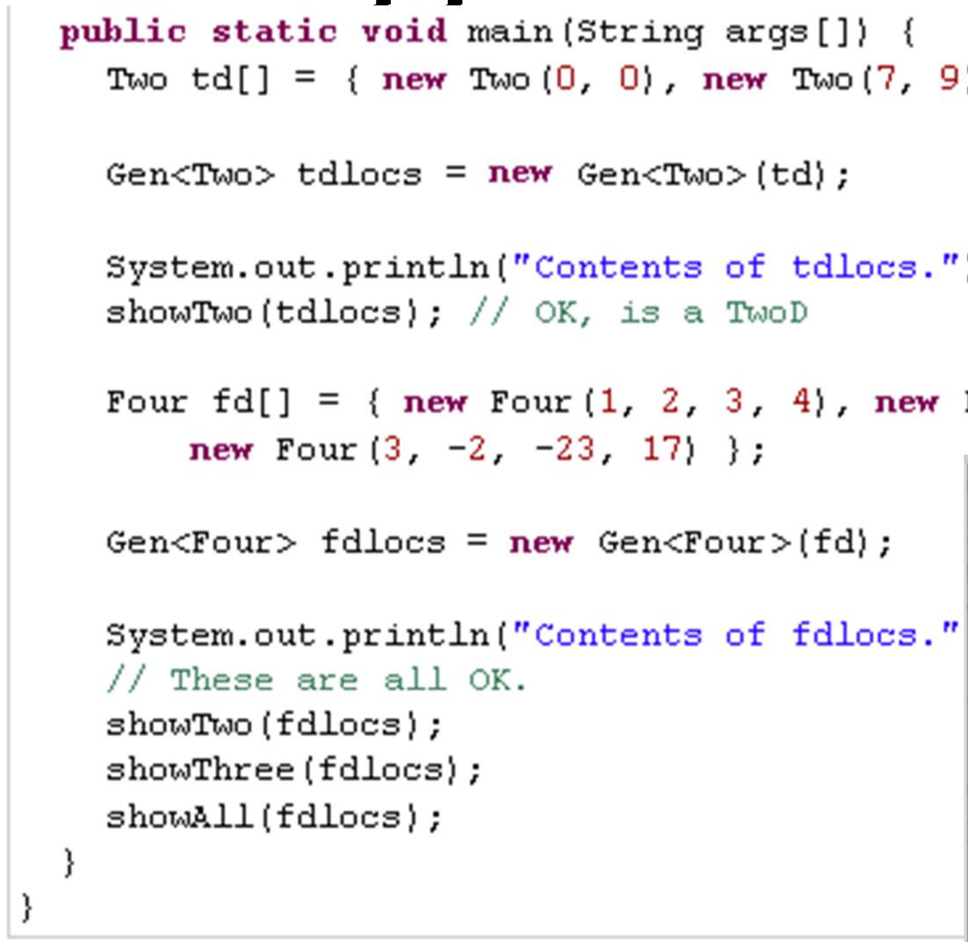
```java
class Gen<T extends Two> {
  T[] coords;

  Gen(T[] o) {
    coords = o;
  }
}
```

Upper Bounded Wildcard

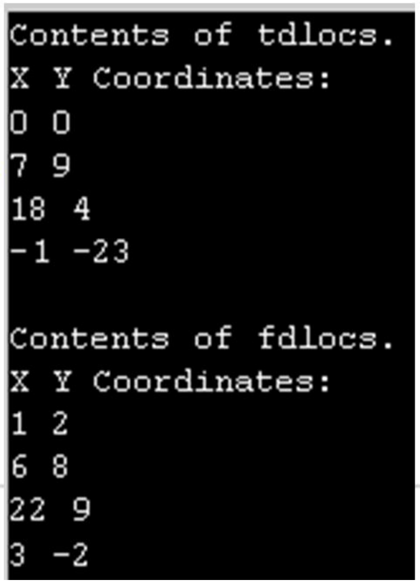


```java
public class MainClass {
  static void showTwo(Gen<?> c) {
    System.out.println("X Y Coordinates:");
    for (int i = 0; i < c.coords.length; i++)
      System.out.println(c.coords[i].x + " " + c.coords[i].y);
    System.out.println();
  }

  static void showThree(Gen<? extends Three> c) {
    System.out.println("X Y Z Coordinates:");
    for (int i = 0; i < c.coords.length; i++)
      System.out.println(c.coords[i].x + " " + c.coords[i].y + " " + c.coords[i].z);
    System.out.println();
  }

  static void showAll(Gen<? extends Four> c) {
    System.out.println("X Y Z T Coordinates:");
    for (int i = 0; i < c.coords.length; i++)
      System.out.println(c.coords[i].x + " " + c.coords[i].y + " " + c.coords[i].z + " "
          + c.coords[i].t);
    System.out.println();
  }
```

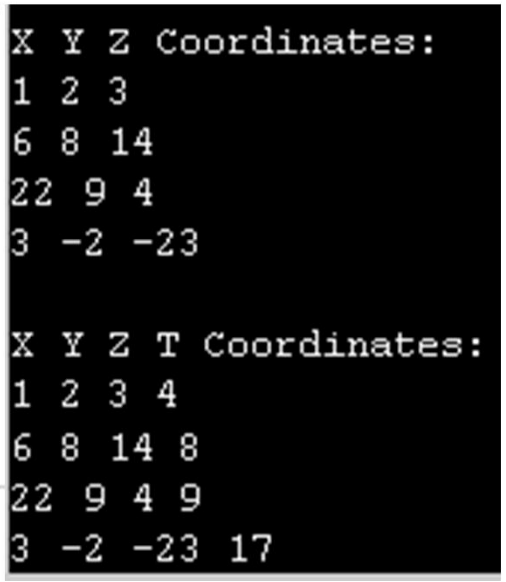
Upper Bounded Wildcard



```
public static void main(String args[]) {
  Two td[] = { new Two(0, 0), new Two(7, 9), new Two(18, 4), new Two(-1, -23) };

  Gen<Two> tdlocs = new Gen<Two>(td);

  System.out.println("Contents of tdlocs.");
  showTwo(tdlocs); // OK, is a TwoD

  Four fd[] = { new Four(1, 2, 3, 4), new Four(6, 8, 14, 8), new Four(22, 9, 4, 9),
      new Four(3, -2, -23, 17) };

  Gen<Four> fdlocs = new Gen<Four>(fd);

  System.out.println("Contents of fdlocs."
  // These are all OK.
  showTwo(fdlocs);
  showThree(fdlocs);
  showAll(fdlocs);
 }
}
```



```
Contents of tdlocs.
X Y Coordinates:
0 0
7 9
18 4
-1 -23

Contents of fdlocs.
X Y Coordinates:
1 2
6 8
22 9
3 -2
```



```
X Y Z Coordinates:
1 2 3
6 8 14
22 9 4
3 -2 -23

X Y Z T Coordinates:
1 2 3 4
6 8 14 8
22 9 4 9
3 -2 -23 17
```