

# OOP with Java

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# OOP with Java

- 通知
  - Project 7 :6 月 27 日晚 9 点
  - 6 月 14 日复习
  - 6 月 21 日考试
  - 答疑
    - 6 月 20 日 13 : 00 – 15 : 00
    - 理科楼 B911



**KEEP  
CALM  
ITS  
QUIZ  
TIME**

```
abstract class demo
{
    public int a;
    demo() {
        a = 10;
    }
    abstract public void set();
    abstract final public void get();
}
class Test extends demo
{
    public void set(int a) {
        this.a = a;
    }
    final public void get() {
        System.out.println("a = " + a);
    }
    public static void main(String[] args) {
        Test obj = new Test();
        obj.set(20);
        obj.get();
    }
}
```

```
class Test {
public static void main (String[] args) {
    try {
        int a = 0;
        System.out.println ("a = " + a + "\n");
        int b = 20 / a;
        System.out.println ("b = " + b);
    }
    catch(ArithmeticException e) {
        System.out.println ("Divide by zero error");
    }
    finally {
        System.out.println ("inside the finally block");
    }
}
}
```

```
public class Test {
    private int x = 1;
    private int y = 2;
    private static int z = 3;
    public static void main(String[] args) {
        int x = 4;
        int y = 5;
        int z = 6;
        new Test().new Inner().init();
    }
    class Inner{
        void init(){
            System.out.println(x + " " + y + " " +z);
        }
    }
}
```

```
interface Foo{
    int x = 10;
}

public class Test {

    public static void main(String[] args) {
        Foo.x = 20;
        System.out.println(Foo.x);
    }
}
```

1. 定义一个 `LinkedList`, 其中包含 `String` 对象 .
2. 编写方法遍历该 `LinkedList`.

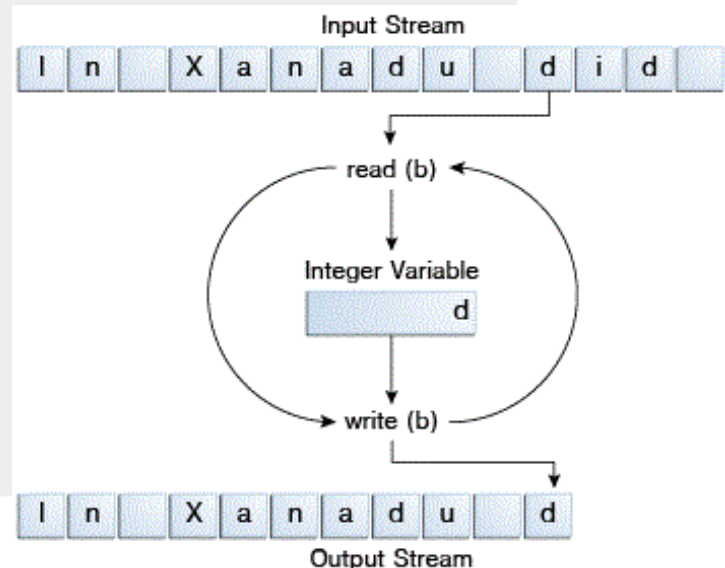


- 复习
- I/O 流
  - InputStream/Reader
    - read()
  - OutputStream/Writer
    - write()
  - 抽象：数据的来源 / 数据的目的地
    - ByteArrayInputStream, FileStream StringStream ObjectStream

```

import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;
public class CopyBytes {
    public static void main(String[] args) throws IOException {
        FileInputStream in = null;
        FileOutputStream out = null;
        try {
            in = new FileInputStream("xanadu.txt");
            out = new FileOutputStream("outagain.txt");
            int c;
            while ((c = in.read()) != -1)
                out.write(c);
        } finally {
            if (in != null)
                in.close();
            if (out != null)
                out.close();
        }
    }
}

```



- 装饰器

- FilterInputStream/FilterOutputStream

- BufferedInputStream
    - DataInputStream

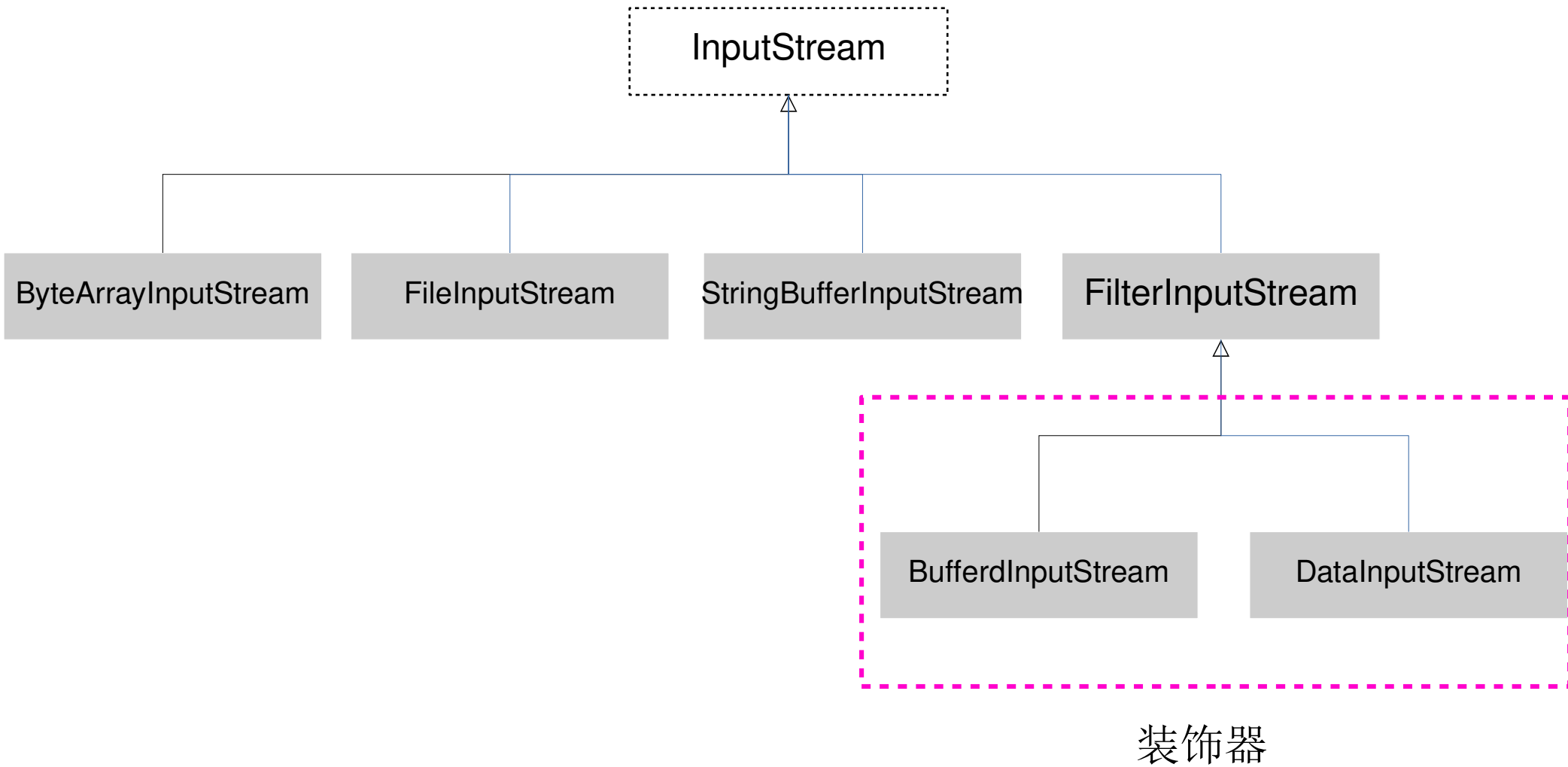
```
FileInputStream fin = new FileInputStream("xanadu.txt");  
BufferedInputStream bf = new BufferedInputStream(fin);  
DataInputStream din = new DataInputStream(bf);
```

```
din.read(); din.readInt(); din.readDouble();
```

```
FileOutputStream fout = new FileOutputStream("xanadu.txt");  
BufferedOutputStream bf = new BufferedOutputStream(fout);  
DataOutputStream dout = new DataOutputStream(bf);
```

```
dout.write(1); dout.writeInt(10); dout.writeDouble(3.14);
```

- 复习



# OOP with Java

- 运行时类型信息
- 泛型

# RTTI

- 运行时类型信息
  - RunTime Type Information (RTTI)
  - Class 类
    - 每一个类都包含一个 Class 类的对象
    - 该对象包含该类的信息
      - 类名字
      - 类的有哪些方法
      - 类的有哪些成员

# RTTI

- 每个类的静态成员
  - 所有对象共享一个 `Class` 对象
- 每个对象调用 `getClass()` 获得 `Class` 类的对象
  - `String s = "hello"; Class c = s.getClass();`
- 每个类通过 `.class` 获得 `Class` 类的对象
  - `Class c = String.class`

# RTTI

- **Class** 类的方法
  - getName()
  - getInterfaces()
  - getSuperclass()
  - newInstance()



```
interface A { }
interface B { }
interface C { }
```

```
class Toy {
    Toy() {}
    Toy(int i) {}
}
```

```
class FancyToy extends Toy
    implements A, B, C
{
    FancyToy() { super(1); }
}
```

```
public class ToyTest {

    static void printInfo(Class c) {
        System.out.println("Class name: " + c.getName() );
        System.out.println("Is interface?" + c.isInterface());
        System.out.println("Simple name: " + c.getSimpleName());
        System.out.println("Canonical name : " + c.getCanonicalName());
    }

    public static void main(String[] args) {
        Class c = null;
        try {
            c = Class.forName("FancyToy");
        } catch(ClassNotFoundException e) {
            System.out.println("Can't find FancyToy");System.exit(1);
        }
        printInfo(c);

        for(Class face : c.getInterfaces())
            printInfo(face);

        Class up = c.getSuperclass();
        Object obj = null;
        try {
            // Requires default constructor:
            obj = up.newInstance();
        } catch(InstantiationException e) {
            System.out.println("Cannot instantiate"); System.exit(1);
        } catch(IllegalAccessException e) {
            System.out.println("Cannot access"); System.exit(1);
        }

        printInfo(obj.getClass());
    }
}
```

# RTTI

- RTTI 的用途

- 给定 Object 引用，判断它的类型 (Downcasting)

```
String s = new String("hello");  
Object o = s;  
String type = o.getClass().getName();  
String t = (String)o;
```

# 泛型

- 容器

- new ArrayList();

```
class Apple {  
    private static long counter;  
    private final long id = counter++;  
    public long id() { return id; }  
}  
class Orange { }
```

```
public class ApplesAndOrangesWithoutGenerics {  
    public static void main(String[] args) {  
        ArrayList apples = new ArrayList();  
        for(int i = 0; i < 3; i++)  
            apples.add(new Apple());  
  
        // Not prevented from adding an Orange to apples:  
        apples.add(new Orange());  
        for(int i = 0; i < apples.size(); i++)  
            ((Apple)apples.get(i)).id();  
        // Orange is detected only at run time  
    }  
}
```

# 泛型

- 类型安全的容器
  - `new ArrayList<Apple>();`

```
public class ApplesAndOrangesWithGenerics {
    public static void main(String[] args) {
        ArrayList<Apple> apples = new ArrayList<Apple>();
        for(int i = 0; i < 3; i++)
            apples.add(new Apple());

        // Compile error!
        // apples.add(new Orange());
        for(int i = 0; i < apples.size(); i++)
            apples.get(i).id();
    }
    for(Apple c: apples)
        System.out.println(c.id());
}
```

# 泛型

- 不同类型间的相互替代？
  - Upcasting 与 多态

```
Class A {}
```

```
void f (A arg) {  
    // ...  
}
```

```
f(new A());
```

```
Class A {}  
Class B {}
```

```
void f (A arg) {  
    // ...  
}
```

```
f(new B());
```

```
Class A {}  
Class B {}  
Class C extends A {}
```

```
void f (A arg) {  
    // ...  
}
```

```
f(new C());
```

# 泛型

- 不同类型间的相互替代？
  - 泛型：更灵活的方式

# 基本概念

- 泛型 (generics)

- 在定义类的成员和方法时，类型为可变参数

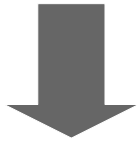
```
class MyType {  
    ? member = null;  
}
```

```
void f (? arg) {  
    // ...  
}
```

# 基本概念

- 语法

```
class MyType {  
    ? member = null;  
}
```



```
class MyType<T> {  
    T member = null;  
}
```

```
void f (? arg) {  
    // ...  
}
```



```
<T> void f (T arg) {  
    // ...  
}
```



# Example: A simple Holder class

```
class Apple { }

public class Holder {
    private Apple a;
    public Holder(Apple a) { this.a = a; }
    public void set(Apple a) { this.a = a; }
    public Apple get() { return a; }

    public static void main(String[] args) {
        Holder h = new Holder(new Apple());
        Apple a = h.get();
        // h.set("Not an Apple"); // Error
        // h.set(1); // Error
    }
}
```

# Example: A simple Holder class

```
class Apple { }

public class Holder<T> {
    private T a;
    public Holder(T a) { this.a = a; }
    public void set(T a) { this.a = a; }
    public T get() { return a; }

    public static void main(String[] args) {
        Holder<String> hs = new Holder<String>(new String("hello"));
        String s = hs.get();

        Holder<Integer> hi = new Holder<Integer>(1);
        int l = hi.get();

        Holder<Apple> h = new Holder<Apple>(new Apple());
        Apple a = h.get();
        // h.set("Not an Apple"); // Error
        // h.set(1); // Error
    }
}
```

# Example: A simple Holder class

```
class Apple { }

public class Holder<T> {
    private T a;
    public Holder(T a) { this.a = a; }
    public void set(T a) { this.a = a; }
    public T get() { return a; }

    public static void main(String[] args) {
        Holder<Apple> h = new Holder<Apple>(
            new Apple());
        Apple a = h.get();
    }
}
```

```
class Apple { }

public class Holder {
    private Object a;
    public Holder(Object a) { this.a = a; }
    public void set(Object a) { this.a = a; }
    public Object get() { return a; }

    public static void main(String[] args) {
        Holder h = new Holder(new Apple());
        Apple a = (Apple)h.get();
    }
}
```

# 基本概念

- 方法
  - 形参
  - 实参
  - 类型参数

# Example: A tuple library

- Tuple
  - 不可变数组（数组元素不可变）
  - 用途：
    - 函数返回多个值
    - Data transfer object

# Example: A tuple library

```
public class TwoTuple<A,B> {  
    public final A first;  
    public final B second;  
    public TwoTuple(A a, B b) { first = a; second = b; }  
    public String toString() {  
        return "(" + first + ", " + second + ")";  
    }  
}
```

# Example: A tuple library

```
public class ThreeTuple<A,B,C> extends TwoTuple<A,B> {
    public final C third;
    public ThreeTuple(A a, B b, C c) {
        super(a, b);
        third = c;
    }
    public String toString() {
        return "(" + first + ", " + second + ", " + third + ")";
    }
}
```

```
public class FourTuple<A,B,C,D> extends ThreeTuple<A,B,C> {
    public final D four;
    public ThreeTuple(A a, B b, C c, D d) {
        super(a, b, c);
        third = d;
    }
    public String toString() {
        return "(" + first + ", " + second + ", " + third + ", " + four + ")";
    }
}
```

# Example: A tuple library

```
class Apple { }
class Orange { }

public class TupleTest {

    static TwoTuple<String,Integer> f() {
        return new TwoTuple<String,Integer>("hi", 47); // Autoboxing
    }

    static ThreeTuple<Apple,String,Integer> g() {
        return new ThreeTuple<Apple, String, Integer>(new Apple(), "hi", 47);
    }

    static FourTuple<Orange,Apple,String,Integer> h() {
        return new FourTuple<Orange,Apple,String,Integer>(new Orange(), new Apple(), "hi", 47);
    }

    public static void main(String[] args) {
        TwoTuple<String,Integer> ttsi = f();
        System.out.println(ttsi);
        // ttsi.first = "there"; // Compile error: final
        System.out.println(g());
        System.out.println(h());
    }
}
```



# 泛型接口

- 带有类型参数的接口

```
public interface Generator<T> { T next(); }
```

```
public class Coffee {  
    private static long counter = 0;  
    private final long id = counter++;  
    public String toString() {  
        return getClass().getSimpleName() + " " + id;  
    }  
}
```

```
public class Latte extends Coffee {}  
public class Mocha extends Coffee {}  
public class Cappuccino extends Coffee {}  
public class Americano extends Coffee {}  
public class Breve extends Coffee {}
```

```

import java.util.*;
public class CoffeeGenerator implements Generator<Coffee> {

    private Class[] types = { Latte.class, Mocha.class,
        Cappuccino.class, Americano.class, Breve.class, };

    private static Random rand = new Random(47);
    private int size = 0;
    public CoffeeGenerator() {}
    public CoffeeGenerator(int sz) { size = sz; }

    public Coffee next() {
        try {
            return (Coffee) types[rand.nextInt(types.length)].newInstance();
            // Report programmer errors at run time:
        } catch (Exception e) {
            throw new RuntimeException(e);
        }
    }

    public static void main(String[] args) {
        CoffeeGenerator gen = new CoffeeGenerator();
        for(int i = 0; i < 5; i++)
            System.out.println(gen.next());
    }
}

```

```
// public class CoffeeGenerator implements Generator<Coffee>

public class Fibonacci implements Generator<Integer> {
    private int count = 0;
    public Integer next() { return fib(count++); }
    private int fib(int n) {
        if(n < 2) return 1;
        return fib(n-2) + fib(n-1);
    }
    public static void main(String[] args) {
        Fibonacci gen = new Fibonacci();
        for(int i = 0; i < 18; i++)
            System.out.print(gen.next() + " ");
    }
}
```

# 泛型方法

- 方法的参数，返回值带有类型参数
- 语法

```
public <T> void f(T x) { //... }
```

<T> 说明该方法带有类型参数 T  
需要放在返回值说明之前

# 泛型方法

```
public class GenericMethods {  
    public <T> void f(T x) {  
        System.out.println(x.getClass().getName());  
    }  
    public static void main(String[] args) {  
        GenericMethods gm = new GenericMethods();  
        gm.f(""); gm.f(1); gm.f(1.0); gm.f(1.0F); gm.f('c'); gm.f(gm);  
    }  
}
```

方法的类型参数可以与类的类型参数无关

```
public class GenericMethods<E> {  
    E member;  
    public <T> void f(T x) {  
        System.out.println(x.getClass().getName());  
    }  
}
```

# 类型推理

- 编译器推理出类型变量的值

```
import java.util.*;
public class New {
    public static <K, V> Map<K, V> build() {
        return new HashMap<K, V>();
    }
    public static void main(String []args){
        Map<String, List<String>> s = New.build();
    }
}
```

1. 由 `Map<String, List<String>> s = New.build();` 推断出 `build()` 方法中的 `K=String, V=List<String>`

2. 可以通过语法明确泛型方法调用时的类型参数  
`Map<String, List<String>> s = New.<String, List<String>>Map();`

```
// Diamond
```

```
ArrayList<String> s = new ArrayList<>();
HashMap<String, Integer> h = new HashMap<>();
```

# 小结

- 泛型类

```
public class TwoTuple<A, B> { //... }
```

- 泛型接口

```
public interface Generator<T> { T next(); }
```

- 泛型方法

```
public <T> void f(T x) { //... }
```

```
public class Generators {
    public static <T> Collection<T> fill(Collection<T> coll, Generator<T> gen, int n) {
        for(int i = 0; i < n; i++)
            coll.add(gen.next());
        return coll;
    }
    public static void main(String[] args) {
        Collection<Coffee> coffee = fill(new ArrayList<Coffee>(), new CoffeeGenerator(), 4);
        for(Coffee c : coffee)
            System.out.println(c);

        Collection<Integer> fnumbers = fill(new ArrayList<Integer>(), new Fibonacci(), 12);
        for(int i : fnumbers)
            System.out.print(i + ", ");
    }
}
```



# Type Erasure

- 当给定不同的类型参数时，泛型的类型是否相同？

```
class A { }
class B extends A{ }

public class Test {
    public static void main(String []args){
        ArrayList<String> strlist = new ArrayList<>();
        ArrayList<Integer> intl = strlist;

        ArrayList<B> blist = new ArrayList<>();
        ArrayList<A> alist = blist;
    }
}
```

编译错误！

ArrayList<String>, ArrayList<Integer>, ArrayList<B>, ArrayList<A>  
是不同类型！

# Type Erasure

- 当给定不同的类型参数时，泛型的类型是否相同？
  - Class Object

```
import java.util.*;

public class ErasedTypeEquivalence {

    public static void main(String[] args) {
        Class c1 = new ArrayList<String>().getClass();
        Class c2 = new ArrayList<Integer>().getClass();
        System.out.println(c1 == c2);
    }
}
```

输出：**true**！

# Type Erasure

```
import java.util.*;
class Frob {}
class Fnorkle {}
class Quark<Q> {}
class Particle<POSITION,MOMENTUM> {}
```

```
public class LostInformation {
    public static void main(String[] args) {
        List<Frob> list = new ArrayList<Frob>();
        Map<Frob,Fnorkle> map = new HashMap<Frob,Fnorkle>();
        Quark<Fnorkle> quark = new Quark<Fnorkle>();
        Particle<Long,Double> p = new Particle<Long,Double>();

        System.out.println(Arrays.toString(list.getClass().getTypeParameters()));
        System.out.println(Arrays.toString(map.getClass().getTypeParameters()));
        System.out.println(Arrays.toString(quark.getClass().getTypeParameters()));
        System.out.println(Arrays.toString(p.getClass().getTypeParameters()));
    }
}
```

输出：

```
[E]
[K, V]
[Q]
[POSITION, MOMENTUM]
```

# Type Erasure

- 泛型是如何实现的？
- `ArrayList<String>` 与 `ArrayList <Integer>` 的区别在哪里？

# Type Erasure

- 类型擦除 (Type Erasure),
  - T 仅作为占位符，不包含任何具体类型的信息
  - 所有 T 类型的对象引用最终实现为 Object 对象引用

# Type Erasure

```
class HasF {
    public void f() { System.out.println("HasF.f()"); }
}

class Manipulator<T> {
    private T obj;
    public Manipulator(T x) { obj = x; }
    // Error: cannot find symbol: method f():
    public void manipulate() { obj.f(); }
}

public class Manipulation {
    public static void main(String[] args) {
        HasF hf = new HasF();
        Manipulator<HasF> manipulator = new Manipulator<HasF>(hf);
        manipulator.manipulate();
    }
}
```

# Type Erasure

```
public class Erased<T> {  
    private final int SIZE = 100;  
    public void f(Object arg) {  
  
        if(arg instanceof T) { }    // compile error  
  
        T var = new T();            // compile error  
  
        T[] array = new T[SIZE]; // compile error  
    }  
}
```

# Type Erasure

- Type Erasure 实现原理 1:
  - 所有引用最后都变为 Object 引用
  - 编译器自动添加 Downcasting 代码

```
class Apple { }

public class Holder<T> {
    private T a;
    public Holder(T a) { this.a = a; }
    public void set(T a) { this.a = a; }
    public T get() { return a; }

    public static void main(String[] args) {
        Holder<Apple> h = new Holder<Apple>(
            new Apple());
        Apple a = h.get();
    }
}
```

```
class Apple { }

public class Holder {
    private Object a;
    public Holder(Object a) { this.a = a; }
    public void set(Object a) { this.a = a; }
    public Object get() { return a; }

    public static void main(String[] args) {
        Holder h = new Holder(new Apple());
        Apple a = (Apple)h.get();
    }
}
```

生成相同的机器代码  
编译器在 get() 返回处自动添加了类型转换代码



# Type Erasure

- Type Erasure 的实现原理 2:
  - 编译器只做静态检查

```
class A { }
class B extends A { }

public class Test {
    public static void main(String []args){
        ArrayList<String> strlist = new ArrayList<>();
        ArrayList<Integer> intl = strlist;

        ArrayList<B> blist = new ArrayList<>();
        ArrayList<A> alist = blist;
    }
}
```

1. 编译器通过静态检查报错 (ArrayList<String> 与 ArrayList<Integer> 类型不同)
2. 但实际存储中, 无论 <String> 还是 <Integer> 都存储的是 Object 类型的引用

# Type Erasure

- Type Erasure
  - 类型变量仅仅对编译器的静态检查有用
  - 当通过静态检查，所有类型参数被擦除

# Type Erasure

- 如何解决 Type Erasure 带来的问题？
  - Class 对象

```
public class Erased<T> {  
    private final int SIZE = 100;  
    public static void f() {  
        T var = new T(); // compile error  
    }  
}
```

```
public class TypeCapture<T> {  
    Class<T> kind;  
    public TypeCapture(Class<T> kind){ this.kind = kind; }  
    public T f() {  
        T r = null;  
        try{ r = kind.newInstance(); }  
        catch (Exception e){  
            System.out.println("fail");  
        }  
        return r;  
    }  
    public static void main(String []args) {  
        TypeCapture<String> c = new TypeCapture<>(String.class);  
        System.out.println(c.f());  
    }  
}
```

# Type Erasure

- 如何解决 Type Erasure 带来的问题？

```
public class HasF {  
    public void f() { System.out.println("HasF.f()"); }  
}
```

```
class Manipulator<T> {  
    private T obj;  
    public Manipulator(T x) { obj = x; }  
    // Error: cannot find symbol: method f():  
    public void manipulate() { obj.f(); }  
}
```

```
class Manipulator<T extends HasF> {  
    private T obj;  
    public Manipulator(T x) { obj = x; }  
  
    public void manipulate() { obj.f(); }  
}
```

```
public class Manipulation {  
    public static void main(String[] args) {  
        HasF hf = new HasF();  
        Manipulator<HasF> manipulator = new Manipulator<HasF>(hf);  
        manipulator.manipulate();  
    }  
}
```

# 被限定的类型参数

- 限定类型参数的范围

- 语法：

```
class A <T extends B> { //... }
```

- 表示类型参数 **T** 只能是 **B** 类型或者 **B** 的子类型
    - 作用：静态检查时，可以合法引用 **T** 的方法（但最终仍然是 **Object**）
    - 多个限定类型

```
class A <T extends B & C> { //... }
```

- 如果有类和接口，类应该出现在第一个位置

# 被限定的类型参数

```
interface HasColor { java.awt.Color getColor(); }
class Colored<T extends HasColor> {
    T item;
    Colored(T item) { this.item = item; }
    T getItem() { return item; }
    // The bound allows you to call a method:
    java.awt.Color color() { return item.getColor(); }
}

class Dimension { public int x, y, z; }
// Multiple bounds:
class ColoredDimension<T extends Dimension & HasColor> {
    T item;
    ColoredDimension(T item) { this.item = item; }
    T getItem() { return item; }
    java.awt.Color color() { return item.getColor(); }
    int getX() { return item.x; }
    int getY() { return item.y; }
    int getZ() { return item.z; }
}
```

# 通配符

```
class Fruit { }
class Apple extends Fruit{ }
class Orange extends Fruit{ }

public class Test {
    public static void main(String []args){
        List<Apple> alist = new ArrayList<Apple>();
        // compile error
        // List<Fruit> flist = new ArrayList<Apple>();
    }
}
```

如何表达 `ArrayList` 中的元素是 `Fruit` 的某个子类？

# 通配符

```
class Fruit { }
class Apple extends Fruit{ }
class Orange extends Fruit{ }

public class Test {
    public static void main(String []args){
        List<Apple> alist = new ArrayList<Apple>();
        // compile error
        // List<Fruit> flist = new ArrayList<Apple>();
        List<? extends Fruit> flist = new ArrayList<Apple>();
        // Compile Error: can't add any type of object:
        // flist.add(new Apple());
        // flist.add(new Fruit());
        // flist.add(new Object());
        flist.add(null); // Legal but uninteresting
        // We know that it returns at least Fruit:
        Fruit f = flist.get(0);
    }
}
```



# 通配符

`<? extends B>`

- 类型参数为某个 **B** 的子类型
- 具体是哪一个无法确定
- `List<? extends Fruit>`
  - 无法 `add` 任何对象
    - `List` 中存储的对象类型无法确定
  - 可以 `get` 对象
    - `Fruit` 类型

# 通配符

`<? super B>`

- 类型参数为某个 **B** 的父类型
- 具体是哪一个无法确定
- **List<? super Apple>**
  - 无法 **get** 任何对象
    - 无法确定是哪个父类
  - 可以 **add Apple** 的子类对象

```
import java.util.*;
public class SuperTypeWildcards {
    static void writeTo(List<? super Apple> apples) {
        apples.add(new Apple());
        apples.add(new Jonathan());
        // apples.add(new Fruit()); // Error
    }
}
```

# 总结

- Type Erasure

- 类型变量仅仅对编译器的静态检查有用
- 当通过静态检查，所有类型参数被擦除

- 被限制的类型参数

```
class A <T extends B & C> { //... }
```

- 通配符

```
<? extends B>
```

```
<? super B>
```