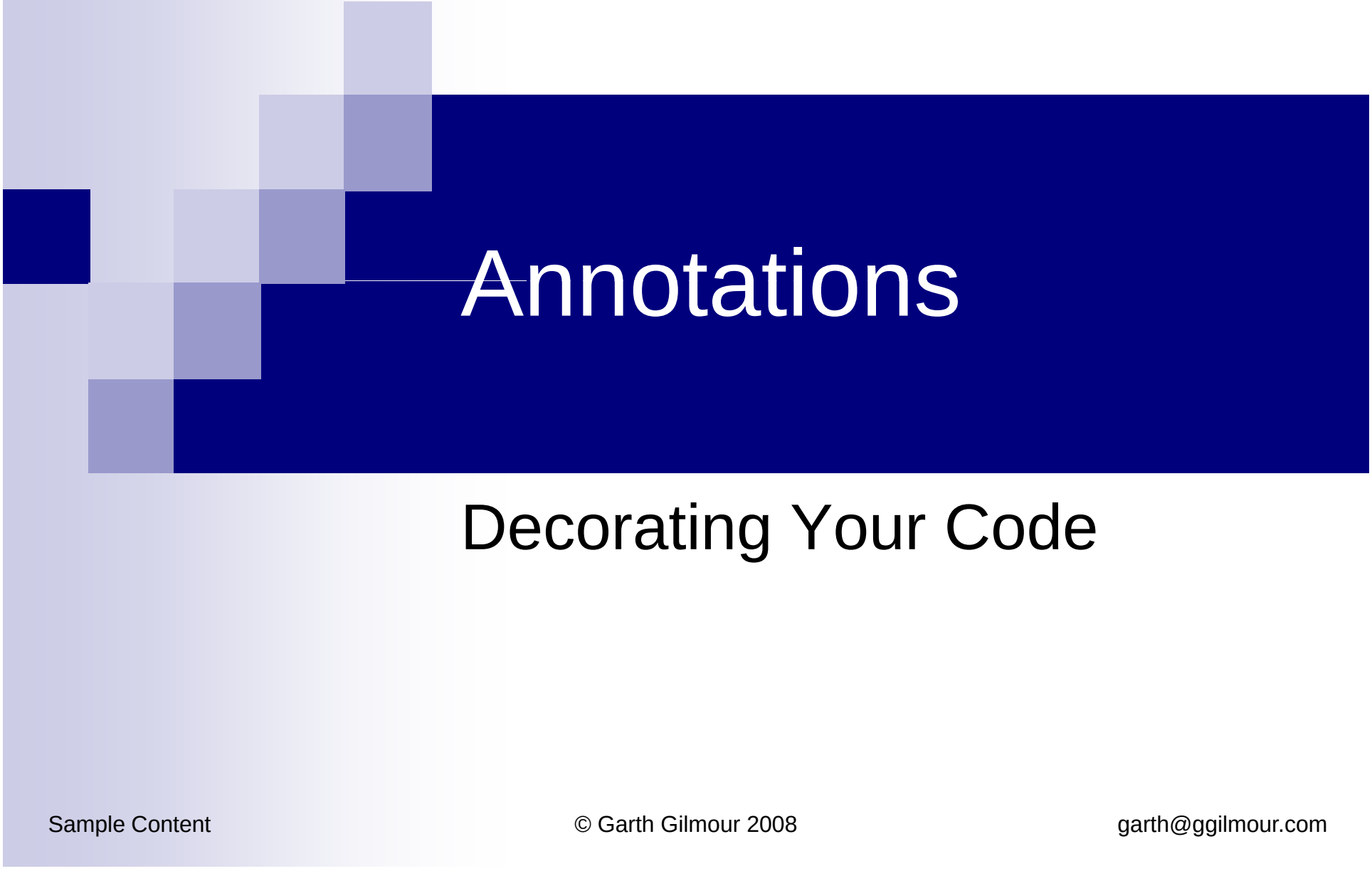

Decorating Your Code

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Annotations

- Annotations are used to store meta-information
  - Data for the compiler, VM or container about what code is intended for and how it can or should be used
  - For example a method is used for testing, requires a transaction or can be used as the basis for a Web Service
- Typically meta-info has been supplied in XML files
  - More properly described as deployment descriptors
  - This has fragmented the way in which components are developed, sacrificing simplicity for reuse potential
  - Not all the information in the XML needs to be there
- Ad-hoc solutions do place meta-info beside the code
  - XDoclet generates code based on JavaDoc style comments

The Syntax of Annotations

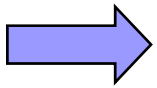
- Annotations are denoted by the '@' symbol
  - For example '@Test',@ThreadSafe and '@WebService'
- Information can be included with the annotation
  - For example '@Test(order = 1)' or '@WebService("SOAP")'
  - These are referred to as 'Annotation Elements'
- We say that code is 'decorated' with annotations
  - Packages, classes, members and variables can all be decorated
- The language defines a small number of annotations
  - Typically they will be defined by the JCP, other standards bodies and creators of open source and proprietary frameworks

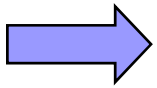
Creating Annotations

- Annotations are declared using ‘@interface’
  - They contain ‘elements’ which resemble method declarations
- All annotations implicitly extend the ‘Annotation’ interface
  - Declared in the package ‘java.lang.annotation’
- An annotations use is specified via ‘meta-annotations’
  - Annotations which are only used to decorate other annotations
  - ‘@Target’ defines where the annotation can be used
    - This is one of the values of the ‘ElementType’ enumeration
  - ‘@Retention’ defines when the annotation can be accessed
    - This is one of the values of the ‘RetentionPolicy’ enumeration

```
@Target(ElementType.TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface TestCase {
	String value() default "Anonymous";
}
```

```
@Target(ElementType.METHOD)
@Retention(RetentionPolicy.RUNTIME)
public @interface Test {
	int order() default 0;
	boolean ignore() default false;
}
```





```
@TestCase
public class MyTestOne {
	public void op1() {
		System.out.println("op1 called");
	}
	@Test
	public void op2() {
		System.out.println("op2 called");
	}
	@Test(order = 2)
	public void op3() {
		System.out.println("op3 called");
	}
	@Test(order = 1, ignore = true)
	public void op4() {
		System.out.println("op4 called");
	}
}
```

Annotations and Reflection

- There are three retention policies
  - With ‘SOURCE’ annotations only exist in the source code
    - The annotation information is discarded by the compiler
  - With ‘CLASS’ annotations are compiled into the class file
    - But may not be accessible via reflection
  - With ‘RUNTIME’ annotations are in the class file and can be investigated via reflection
- Reflection has been expanded in 1.5
  - ‘Field’, ‘Method’ etc… now implement ‘AnnotatedElement’
  - This contains methods for querying and obtaining annotations

```
// Version one of TestRunner – minus error handling and test ordering
public class TestRunner {
	public TestRunner(Class<?> klass) {
		if(klass.isAnnotationPresent(TestCase.class)) {
			this.klass = klass;
		}
	}
	public void runTests() {
		Object instance = klass.newInstance();
		for(Method m: findTestMethods()) {
			m.invoke(instance,new Object[]{});
		}
	}
	private List<Method> findTestMethods() {
		List<Method> testMethods = new ArrayList<Method>();
		for(Method m: klass.getMethods()) {
			Annotation note = m.getAnnotation(Test.class);
			if(note != null) {
				testMethods.add(m);
			}
		}
		return testMethods;
	}
	private Class klass;
}
```

Annotation Elements

- Annotation elements are made up of:
  - The type of the element
    - This must be a primitive type, String, Class or enum
    - Arrays of the above are also allowed
  - The name of the element
  - An empty set of brackets
    - Elements cannot take parameters
  - An optional default value
- Elements are set using ‘name=value’ syntax
  - If a value is specified without a name it is assumed to initialize an element called ‘value’, otherwise a compiler error occurs

Using Annotation Elements

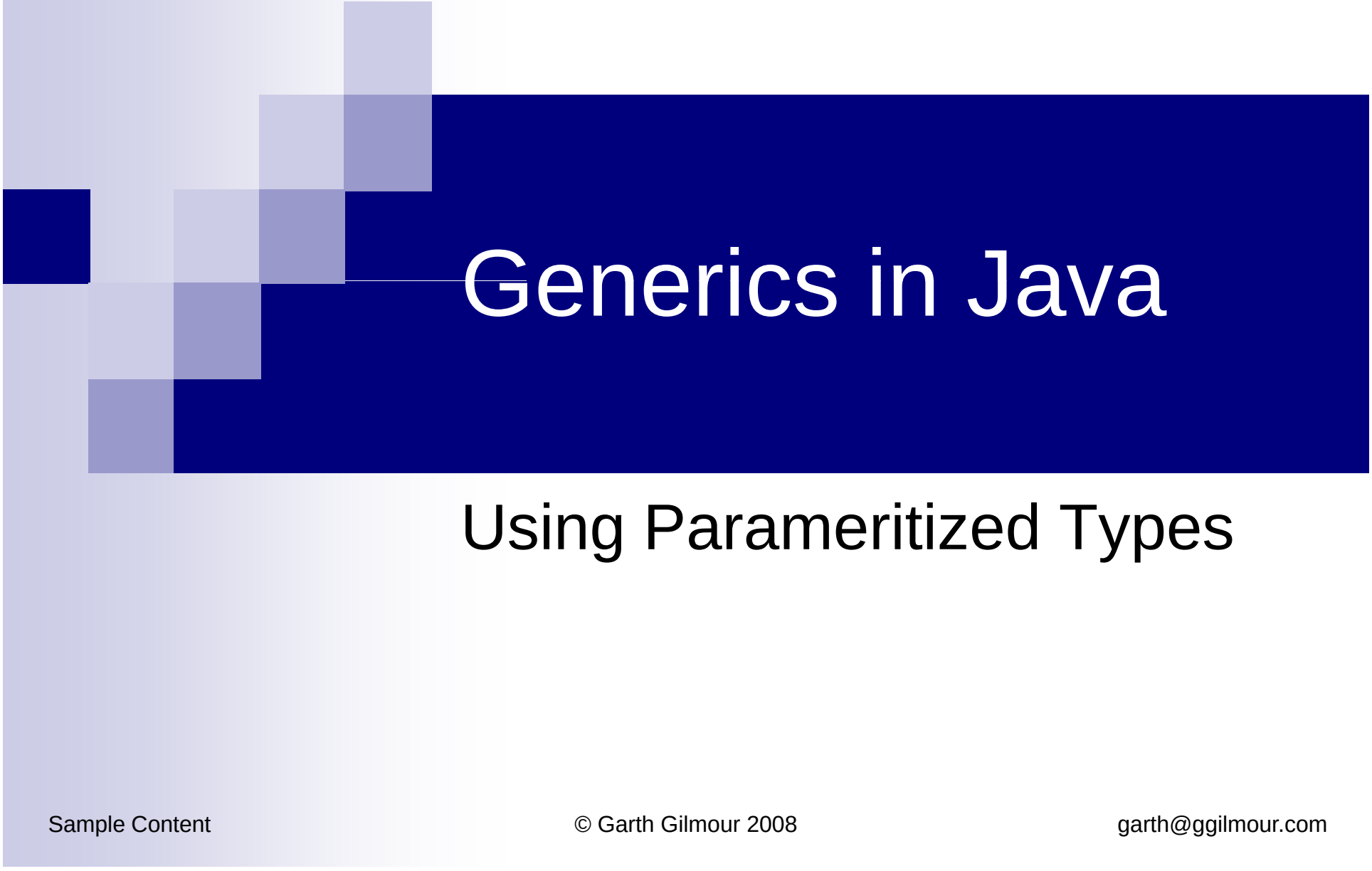
```
public void printTestDetails(PrintStream out) {
	String name = ((TestCase)klass.getAnnotation(TestCase.class)).value();
	out.println("Test methods in [" + name + "] are:");
	for(Method m: findTestMethods()) {
		printTestMethod(out, m);
	}
}
private void printTestMethod(PrintStream out, Method m) {
	Test t = m.getAnnotation(Test.class);
	out.print("\t[");
	out.print(m.getName());
	out.print("] with order ");
	out.print(t.order());
	if(t.ignore()) {
		out.println(" to be ignored");
	} else {
		out.println(" to be executed");
	}
}
```

Built In Annotations

- Java 1.5 defines four meta-annotations
  - The '@Target' and '@Retention' attributes
  - '@Documented' marks an annotation as needing documentation
  - '@Inherited' marks an annotation as applying to subclasses
- It also defines three standard annotations
  - '@Deprecated' marks a feature as deprecated
  - '@Override' indicates a method should override a method of a base class, otherwise there is a compiler error
  - '@SuppressWarnings' causes a compiler not to issue warnings
    - The ID's of the warnings are passed as a parameter
    - Unfortunately the ID's are compiler specific

Validating Annotations in JSE 5/6

- Validating annotations is problematic
  - You can decorate your code with incompatible annotations
  - This is not discovered till the annotation reading tool examines your compiled class (and possibly not even then)
- Annotation validation should be supported by ‘javac’
  - This can only be done by library writers supplying plug-in classes that enforce the appropriate rules
- Processing is available in both JSE5 and JSE6
  - JSE5 ships with the ‘apt’ command line utility
  - JSE6 provides an API for writing annotation processors
    - E.g. javac –processor demos.MyProcessor *.java



Using Parameritized Types

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Introducing Generics

- Generic code represents algorithms which stay the same regardless of the data they are used on
  - For example the store, retrieve and sort methods of a List work the same way regardless of what is placed in it
- Java already lets you write generic code
  - By using references of type ‘java.lang.Object’
  - However this requires casts to keep the compiler happy
- Java 1.5 introduces full support for generic code
  - Classes and methods can be declared with type parameters
    - For example ‘List<Date> list = new LinkedList<Date>()’
  - This removes the need for casts are increases type safety

An Example Generic Type

```
public class Pair<T,U> {
	public Pair(T first, U second) {
		super();
		this.first = first;
		this.second = second;
	}
	public T getFirst() {
		return first;
	}
	public U getSecond() {
		return second;
	}
	private T first;
	private U second;
}
```

```
Pair<Integer,Double> tst1 = new Pair<Integer,Double>(1,2.3);
Pair<Integer,Double> tst2 = new Pair<Integer,Double>(4,5.6);
Pair<Integer,String> tst3 = new Pair<Integer,String>(4,"abc");
Pair<String, Double> tst4 = new Pair<String,Double>("def",5.6);

boolean r1 = haveSameFirst(tst1,tst3);
boolean r2 = haveSameFirst(tst2,tst3);
boolean r3 = haveSameSecond(tst2,tst4);
boolean r4 = haveSameSecond(tst1,tst4);

System.out.printf(“Results are %b, %b, %b, %b\n",r1,r2,r3,r4);
```

```
<T> boolean haveSameFirst(Pair<T,?> p1, Pair<T,?> p2) {
	return p1.getFirst().equals(p2.getFirst());
}
<T> boolean haveSameSecond(Pair<?,T> p1, Pair<?,T> p2) {
	return p1.getSecond().equals(p2.getSecond());
}
```

Generics Compared to C# and C++

- The implementation of Generics in Java is very different from that found in other languages
  - Generics in Java is entirely implemented by the compiler
  - The extra type info is erased and never given to the VM
- In C# and C++ new versions of the code are created
  - Every time ‘LinkedList<T>’ is used with a new value of ‘T’ a separate copy of the code is created and then used
- In Java the same implementation is always used
  - So the ‘java.lang.Object’ version of ‘LinkedList’ is the only one that ever exists and is run inside the Virtual Machine

Generics and Collections

- Generics is the major change to collections in Java 1.5
  - V1.5 collections are easy once you understand type parameters

```
private static void demoGenericList() {
	List<String> strList = new LinkedList<String>();
	strList.add("abc");
	strList.add("def");
	strList.add("ghi");
	strList.add("jkl");
	strList.add("mno");
	strList.add("pqr");
	strList.add("stu");

	System.out.println("LinkedList<String> contents are: ");
	for(String str : strList) {
		System.out.println(str);
	}
}
```

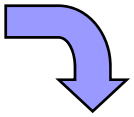
Generic Maps and Sets

```
private static void demoGenericMap() {
	Map<String,Employee> staff = new HashMap<String,Employee>();

	staff.put("ABC123",new Employee("ABC123","Joe Bloggs",20000));
	staff.put("DEF456",new Employee("DEF456","Fred Bloggs",30000));
	staff.put("GHI789",new Employee("GHI789","Dave Bloggs",40000));
	staff.put("JKL012",new Employee("JKL012","Peter Bloggs",50000));

	System.out.println("Map<String,Employee> contents are: ");

	Set<Map.Entry<String,Employee>> contents = staff.entrySet();
	for(Map.Entry<String,Employee> entry : contents) {
		System.out.println(entry.getKey() + " indexes " + entry.getValue());
	}
}
```

Creating Generic Types

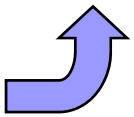
- Using generics in your own code is straightforward
  - Simply introduce type parameters where required
- Some aspects of generics are non-intuitive
  - For example consider ‘void func(ArrayList<Employee> param)’
    - The call ‘func(new ArrayList<Manager>())’ will fail
  - Wildcards were introduced to cope with these situations:
    - ‘void func(ArrayList<?> param);’
      - Any type of ArrayList can be passed in ‘param’
    - ‘void func(ArrayList<? extends Employee> param);’
      - An ArrayList of any subtype of Employee can be passed
    - ‘void func(ArrayList<? super Manager> param);’
      - An ArrayList of any supertype of Manager can be passed

```
//Generic interface for lists
public interface List<T> {
        int size();
        void clear();
        void add(T value);
        void addAll(T ...values);
        T get(int index);
}
```



```
//Generic implementation of the list interface
public class LinkedList<T> implements List<T> {
    public void add(T value) {
        size++;
        if(listIsEmpty()) {
            first = new Node<T>(value,null);
        } else {
            Node<T> current = first;
            while(current.getNext() != null) {
                current = current.getNext();
            }
            current.setNext(new Node<T>(value,current));
        }
    }
    private Node<T> first;
    private int size;
}
```

```
//Generic node class with sample methods
class Node<T> {
        public Node<T> getNext() {
                return next;
        }
        public void setNext(Node<T> other) {
                next = other;
                other.previous = this;
        }
        public T getPayload() {
                return payload;
        }
        private Node<T> next;
        private Node<T> previous;
        private T payload;
}
```



```
public static void main(String[] args) {
        ArrayList<Employee> list1 = new ArrayList<Employee>();
        ArrayList<Manager> list2 = new ArrayList<Manager>();
        ArrayList<Director> list3 = new ArrayList<Director>();

        func1(list1);
        //func1(list2);  //Will not compile
        //func1(list3);  //Will not compile

        func2(list1);
        func2(list2);
        func2(list3);

        //func3(list1);  //Will not compile
        func3(list2);
        func3(list3);

        func4(list1);
        func4(list2);
        //func4(list3);  //Will not compile
}
```

```
class Employee {
}
class Manager extends Employee {
}
class Director extends Manager {
}
```

```
public static void func1(ArrayList<Employee> param) {
        System.out.println(param.size());
}
public static void func2(ArrayList<?> param) {
        System.out.println(param.size());
}
public static void func3(ArrayList<? extends Manager> param) {
        System.out.println(param.size());
}
public static void func4(ArrayList<? super Manager> param) {
        System.out.println(param.size());
}
```