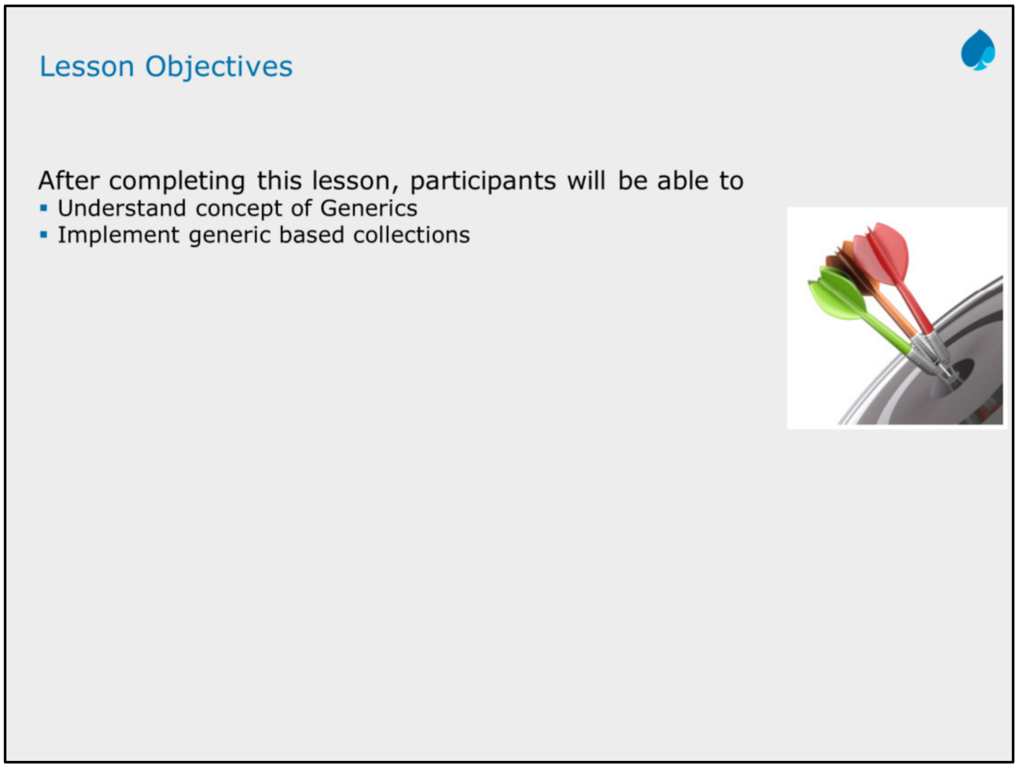
Core Java 8

Lesson 15 : Generics

Capgemini



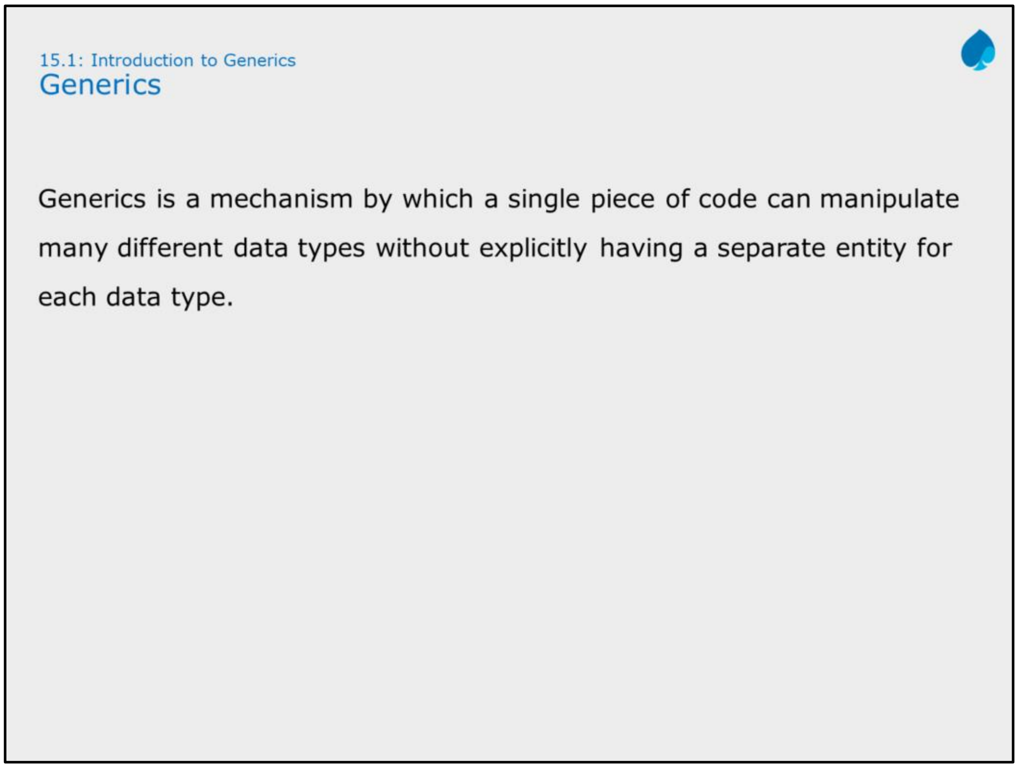
Lesson Objectives

After completing this lesson, participants will be able to
- Understand concept of Generics
- Implement generic based collections

This lesson discusses about generics feature in Java.

Lesson outline:

15.1: Generics
15.2: Writing Generic Classes
15.3: Using Generics with Collections
15.4: Best Practices



15.1: Introduction to Generics

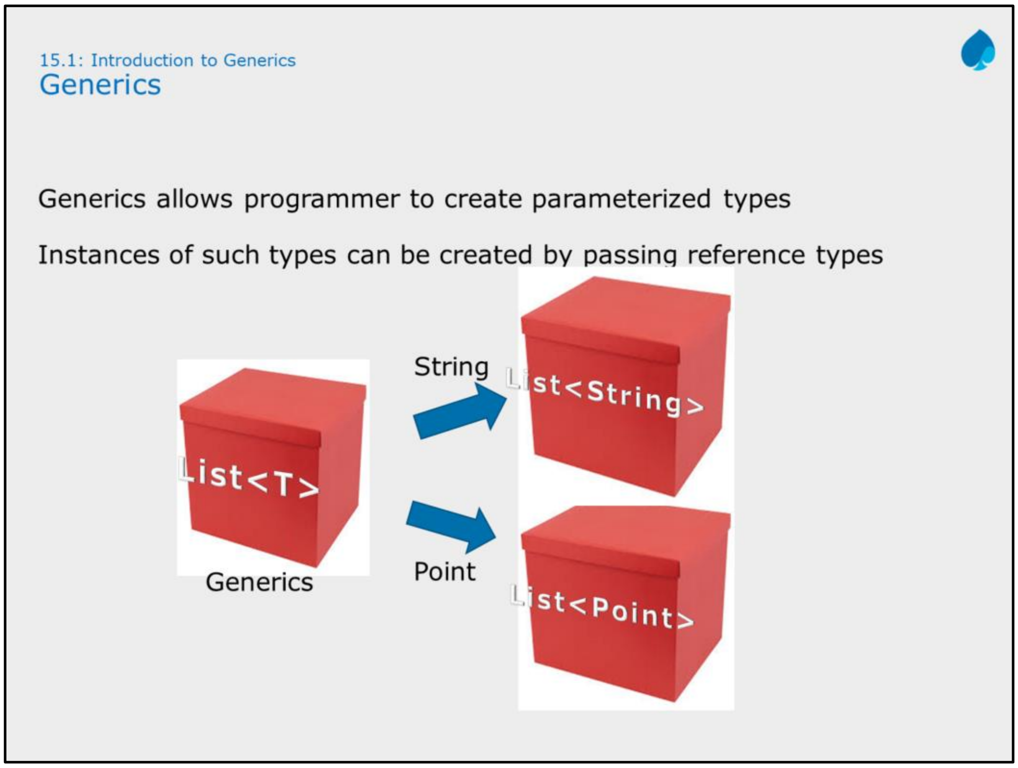
Generics

Generics is a mechanism by which a single piece of code can manipulate many different data types without explicitly having a separate entity for each data type.

What and Why of Generics:
JDK 1.5 introduces several extensions to the Java programming language. One of these is generics. Generics allow you to abstract over types. The most common examples are container types, such as those in the Collection hierarchy.
Here is a typical usage of that sort:

```
List myIntegerList = new LinkedList(); // 1
myIntegerList.add(new Integer(0)); // 2
Integer intObj = (Integer) myIntegerList.iterator().next(); // 3
```

The cast on line 3 is slightly annoying. Typically, the programmer knows what kind of data has been placed into a particular list. However, the cast is essential. The compiler can only guarantee that an Object will be returned by the iterator. To ensure the assignment to a variable of type Integer is type safe, the cast is required. Of course, the cast not only introduces clutter, it also introduces the possibility of a run time error, since the programmer might be mistaken. What if programmers could actually express their intent, and mark a list as being restricted to contain a particular data type? This is the core idea behind generics.

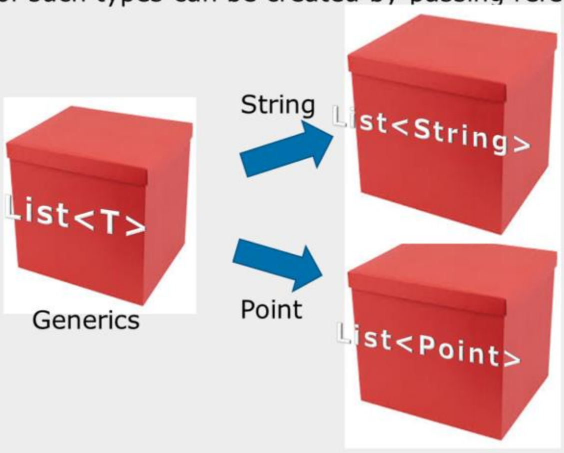


15.1: Introduction to Generics

Generics

Generics allows programmer to create parameterized types

Instances of such types can be created by passing reference types



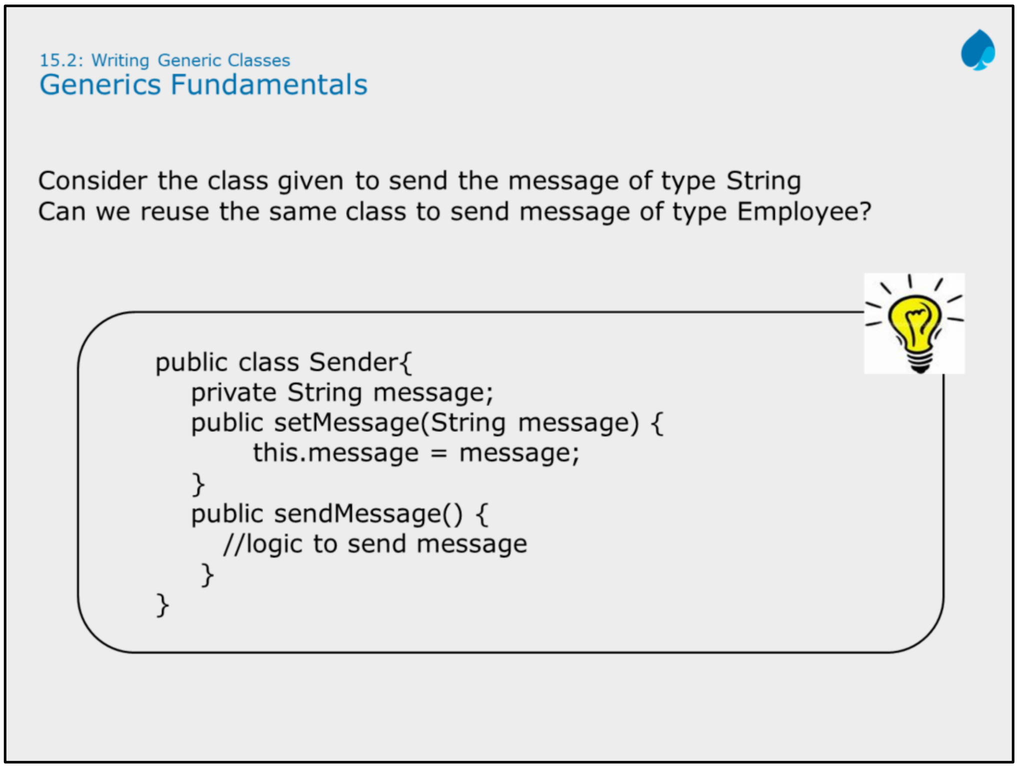
What is Generics?:

Generics allows to write Parameterized type like List<T> and allows us to pass references to create instance of that type. Like when we pass the reference of String to List<T> as a reference type it creates List of strings.

Why generics?

Use of generics enables stricter compiler check. It means when List is created of type string, compiler only allows to add string elements to the list.

No need to perform casting. In case of generics enabled collections, no need to perform explicit casting.



15.2: Writing Generic Classes

Generics Fundamentals

Consider the class given to send the message of type String
Can we reuse the same class to send message of type Employee?

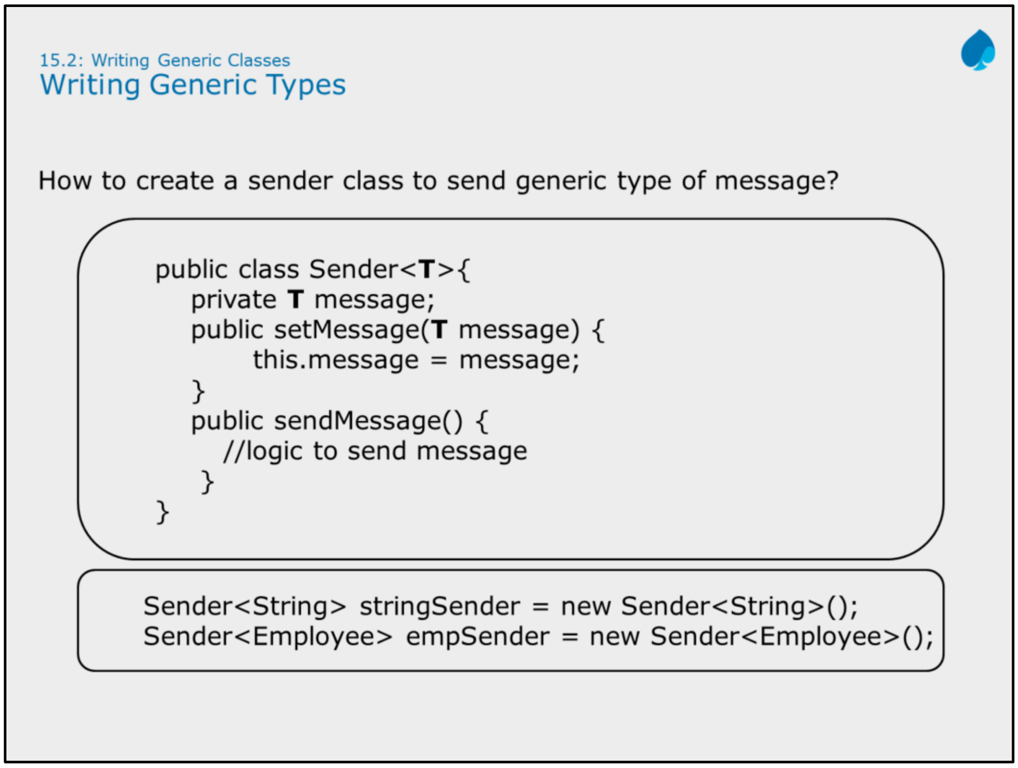
```
public class Sender{
   private String message;
   public setMessage(String message) {
        this.message = message;
   }
   public sendMessage() {
      //logic to send message
    }
}
```

Generics Fundamentals:

Consider the example given in the slide, if you want to reuse the same class to send employee object as a message, then we need to create one more additional class as shown below:

```
public class Sender{
   private Employee message;
   public setMessage(Employee message) {
        this.message = message;
   }
   public sendMessage() {
            //logic to send message
    }
}
```

Is it possible to create a class with generic type of message? Yes. Generics enables us to create a parameterized class and later we can instantiate it as per our required reference type.



15.2: Writing Generic Classes

Writing Generic Types

How to create a sender class to send generic type of message?

```
public class Sender<T>{
   private T message;
   public setMessage(T message) {
        this.message = message;
   }
   public sendMessage() {
      //logic to send message
    }
}
```

```
Sender<String> stringSender = new Sender<String>();
Sender<Employee> empSender = new Sender<Employee>();
```

Generics Fundamentals:

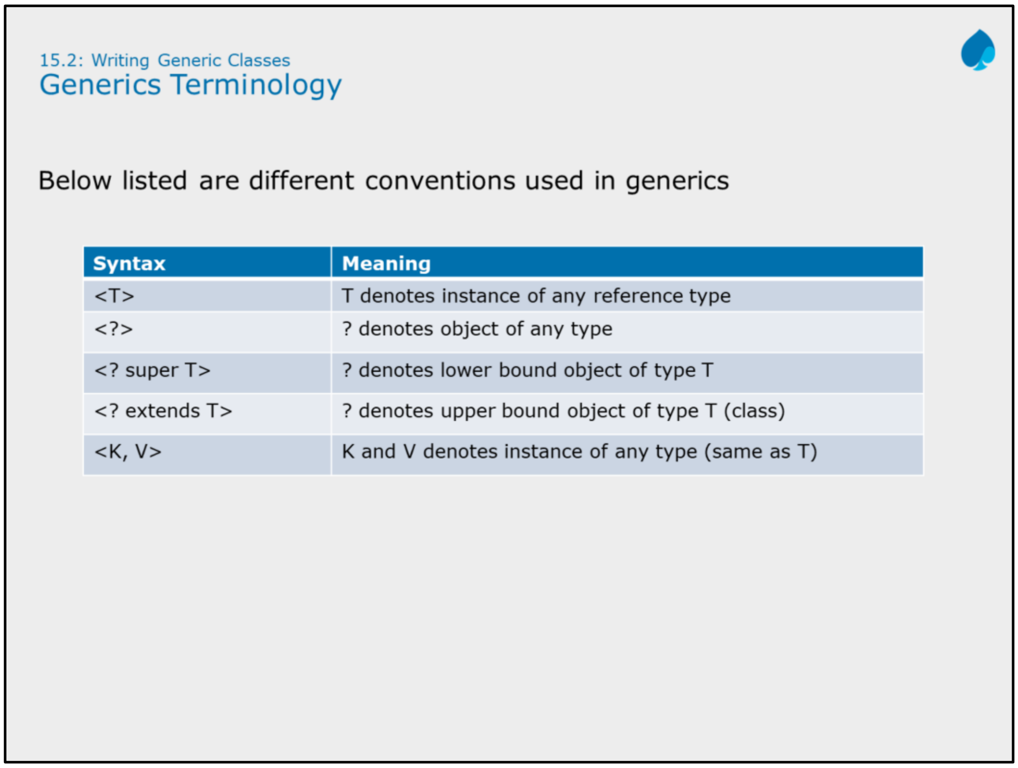
As shown in the slide example, The sender class is declared as parameterized generic type of one parameter as “T”. The “T” in diamond operator refers as generic type of message.

In case of String message sender, the class instance would be initialized as:

```
Sender<String> stringSender = new Sender<String>() ;
```

In the above instance creation, the type T is replaced by String reference type. The same generic sender can be used to send message of type employee as shown below:

```
Sender<Employee> stringSender = new Sender<Employee>() ;
```



15.2: Writing Generic Classes

Generics Terminology

Below listed are different conventions used in generics

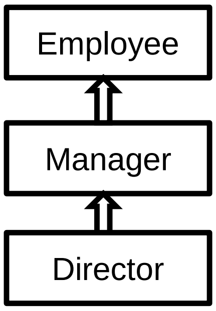
Syntax	Meaning
<T>	T denotes instance of any reference type
<?>	? denotes object of any type
<? super T>	? denotes lower bound object of type T
<? extends T>	? denotes upper bound object of type T (class)
<K, V>	K and V denotes instance of any type (same as T)

Generics Terminology:

In generics, different conventions are used to indicate the applicable reference type. For example, class Sender<T> indicates, the allowed reference type to create instance of Sender are:
Any reference type T
Subclass of T

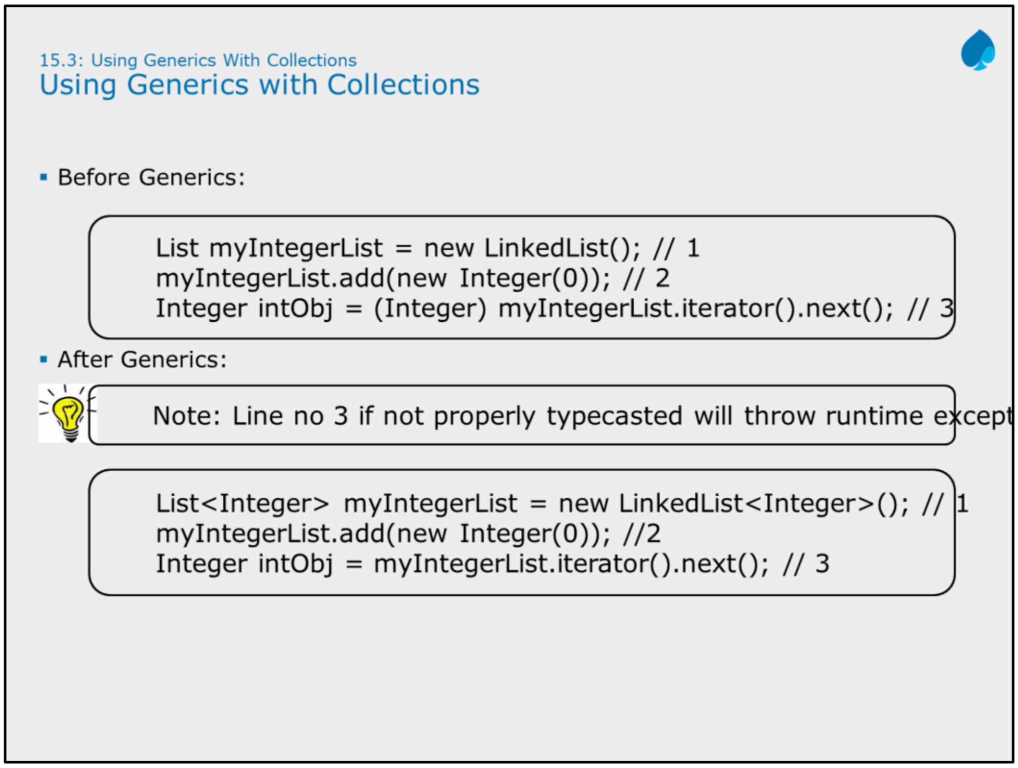
The wildcard ? is used to indicate any type. There are two variations in using wildcard.
? super T: indicates lower bound meaning, any reference types which are superclass of T are allowed.
? extends T: indicated upper bound meaning, any reference types which are subclass of T are allowed.

Consider the given example for inheritance relationship.



List<? super Manager> means, list can be created of Manager, Employee etc. That is all superclass's of Manager.

List<? extends Manager> means, list can be created of Manager, Director etc. That is all subclasses of Manager.



15.3: Using Generics With Collections

Using Generics with Collections

- Before Generics:

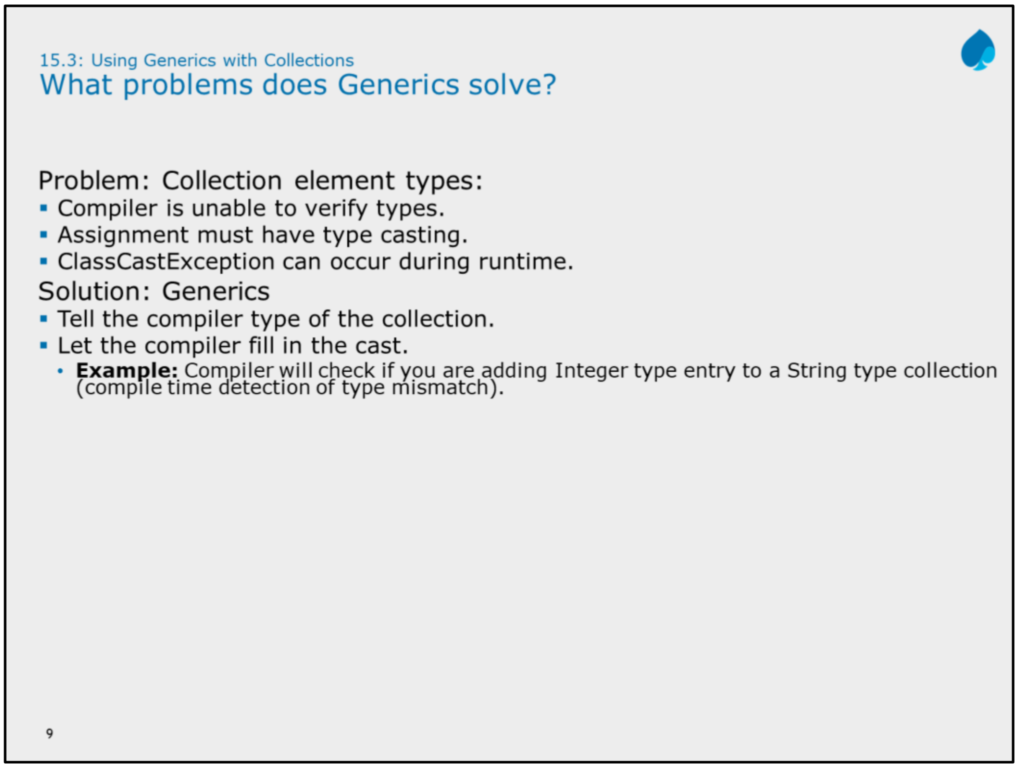
```
List myIntegerList = new LinkedList(); // 1
myIntegerList.add(new Integer(0)); // 2
Integer intObj = (Integer) myIntegerList.iterator().next(); // 3
```

- After Generics:

Note: Line no 3 if not properly typecasted will throw runtime except

```
List<Integer> myIntegerList = new LinkedList<Integer>(); // 1
myIntegerList.add(new Integer(0)); //2
Integer intObj = myIntegerList.iterator().next(); // 3
```

What and Why of Generics:
Observe the program fragment given above (in box #2) using generics:
Notice the type declaration for the variable myIntegerList. It specifies that this is not just an arbitrary List, but a List of Integer, written as List<Integer>. We say that List is a generic interface that takes a type parameter - in this case, Integer. We also specify a type parameter while creating the list object. Notice that the cast is gone from line 3. It may seem that all that's accomplished is just moving the clutter around. Instead of a cast to Integer on line 3, we have Integer as a type parameter on line 1.
However, there is a very big difference here. The compiler can now check the type correctness of the program at compile-time. When we say that myIntegerList is declared with type List<Integer>, this tells us something about the variable myIntegerList, which holds true wherever and whenever it is used, and the compiler will guarantee it. In contrast, the cast tells us something the programmer thinks is true at a single point in the code. The net effect, especially in large programs, is improved readability and robustness.



15.3: Using Generics with Collections

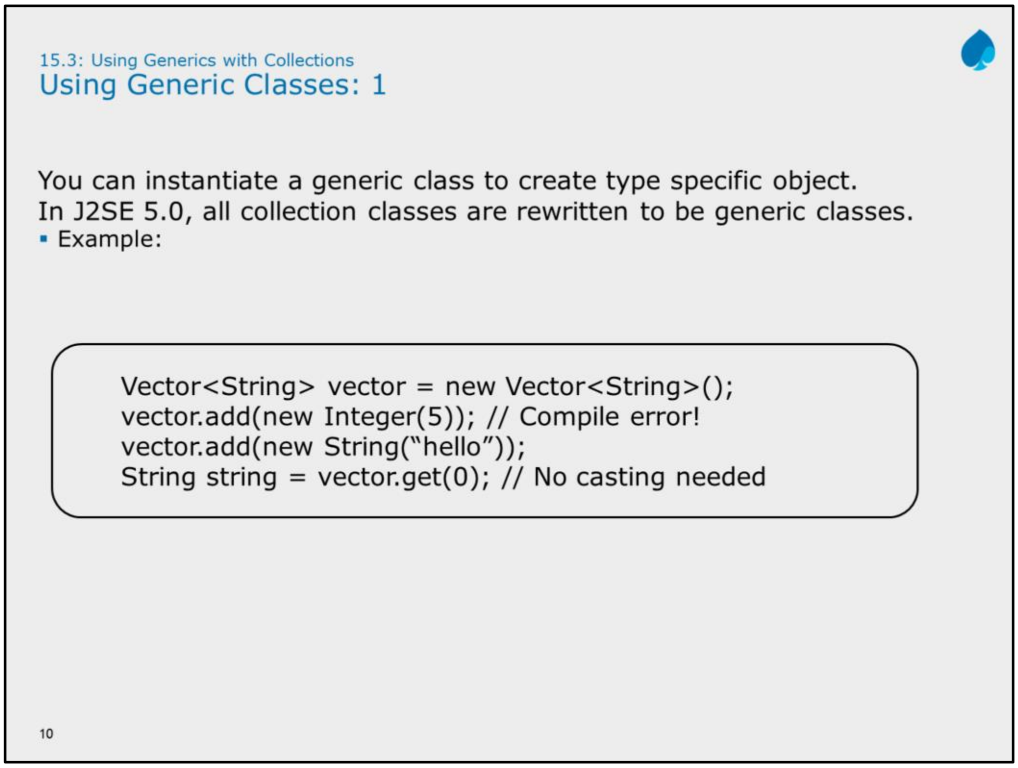
What problems does Generics solve?

Problem: Collection element types:
- Compiler is unable to verify types.
- Assignment must have type casting.
- ClassCastException can occur during runtime.

Solution: Generics
- Tell the compiler type of the collection.
- Let the compiler fill in the cast.
  - **Example:** Compiler will check if you are adding Integer type entry to a String type collection (compile time detection of type mismatch).

9

What and Why of Generics:
What problems does Generics solve?
Type cast not being checked at compile-time leads to a major problem occurring at application’s runtime.
Biggest achievement of the Generics is to avoid the runtime exceptions.



15.3: Using Generics with Collections

Using Generic Classes: 1

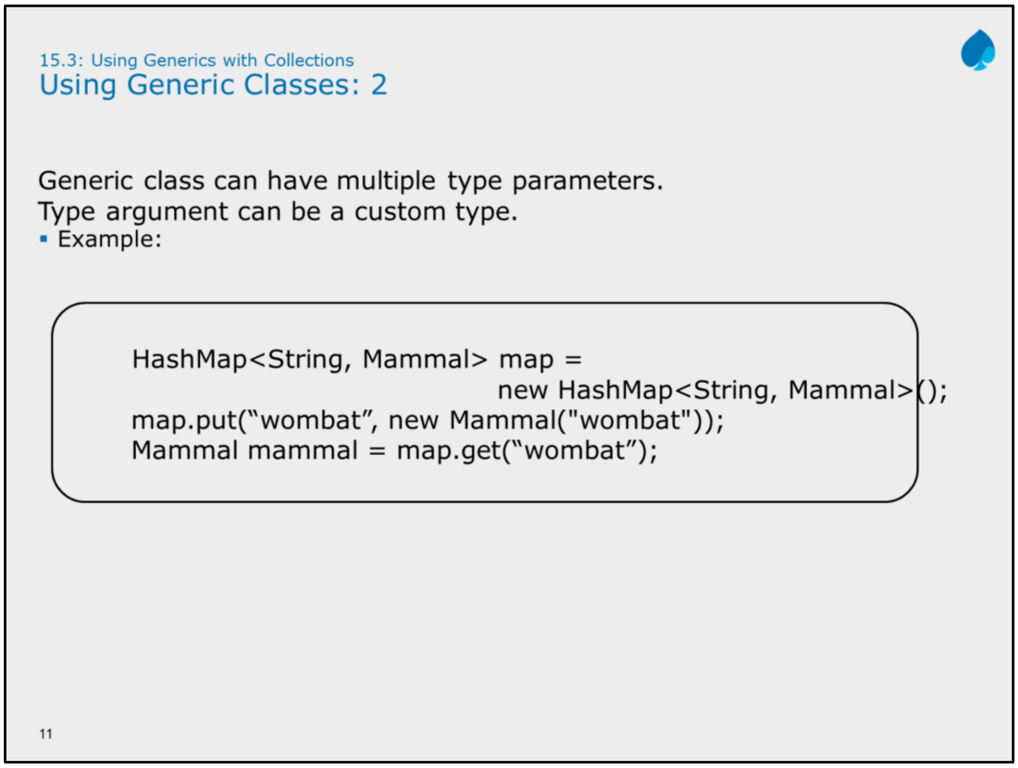
You can instantiate a generic class to create type specific object.
In J2SE 5.0, all collection classes are rewritten to be generic classes.

- Example:

```
Vector<String> vector = new Vector<String>();
vector.add(new Integer(5)); // Compile error!
vector.add(new String("hello"));
String string = vector.get(0); // No casting needed
```

10

Usage of Generics:
Usage of Generic classes is pertaining to the type that is required.
Once the Generic class is used for specific type, compile-time and runtime errors can be avoided.



15.3: Using Generics with Collections

Using Generic Classes: 2

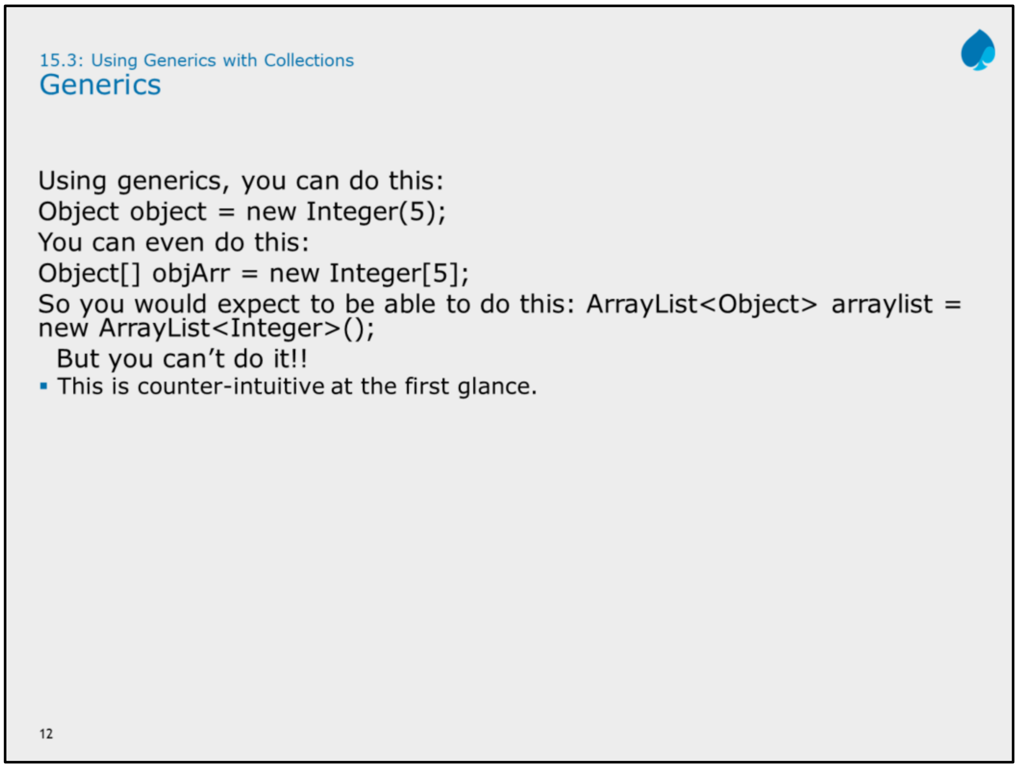
Generic class can have multiple type parameters.
Type argument can be a custom type.

- Example:

```
HashMap<String, Mammal> map =
                              new HashMap<String, Mammal>();
map.put("wombat", new Mammal("wombat"));
Mammal mammal = map.get("wombat");
```

11

Usage of Generics:
Generic classes in use can have multiple arguments. Arguments can be standard as well as custom types.



15.3: Using Generics with Collections

Generics

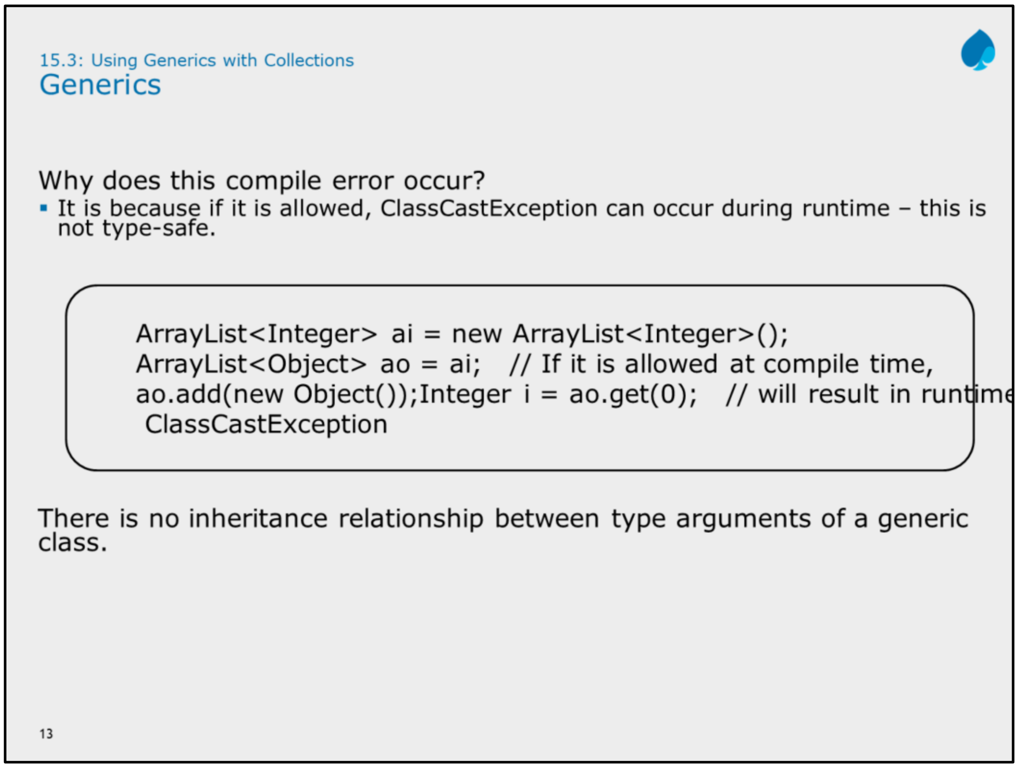
Using generics, you can do this:
Object object = new Integer(5);
You can even do this:
Object[] objArr = new Integer[5];
So you would expect to be able to do this: ArrayList<Object> arraylist = new ArrayList<Integer>();

But you can't do it!!

- This is counter-intuitive at the first glance.

12

Note: Generic classes cannot be assigned according to the super or subclass hierarchy of them.



15.3: Using Generics with Collections

Generics

Why does this compile error occur?

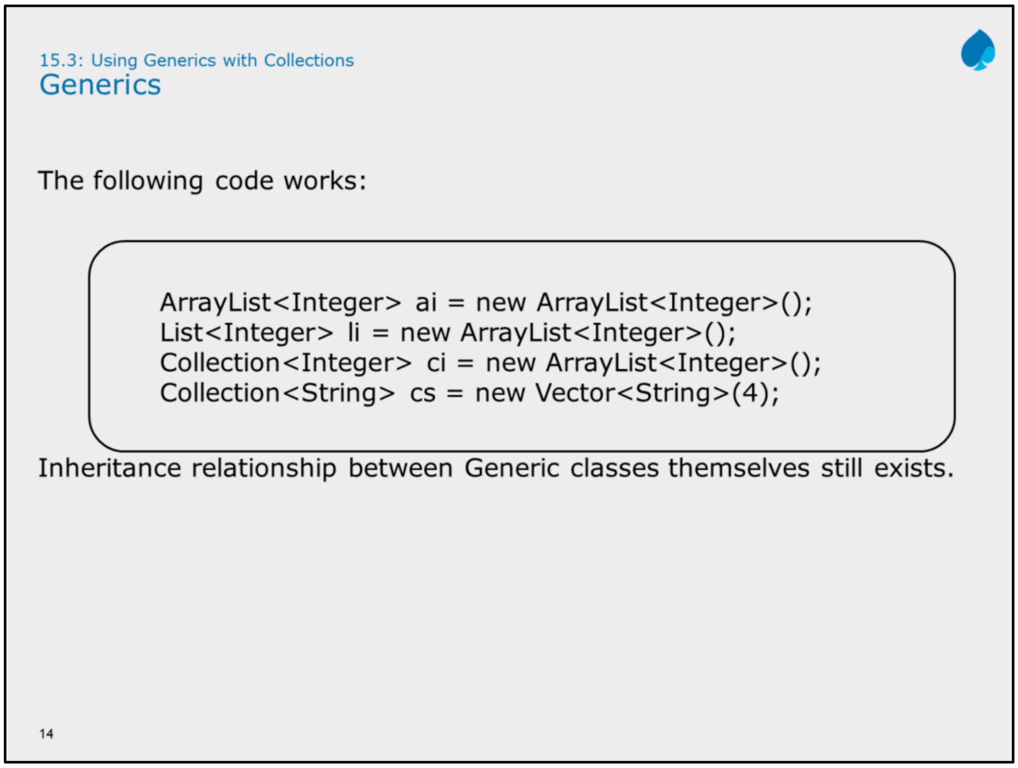
- It is because if it is allowed, ClassCastException can occur during runtime – this is not type-safe.

```
ArrayList<Integer> ai = new ArrayList<Integer>();
ArrayList<Object> ao = ai;   // If it is allowed at compile time,
ao.add(new Object());Integer i = ao.get(0);   // will result in runtime
 ClassCastException
```

There is no inheritance relationship between type arguments of a generic class.

13

Note: Generic classes do not support inheritance relationship between type arguments.



15.3: Using Generics with Collections

Generics

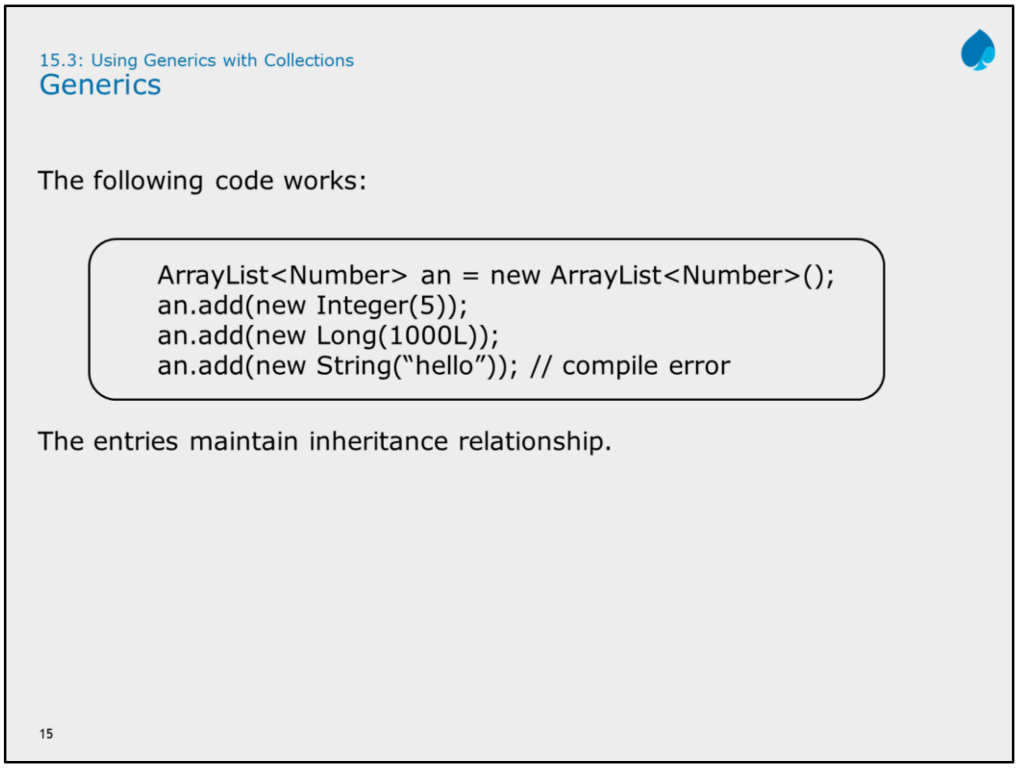
The following code works:

```
ArrayList<Integer> ai = new ArrayList<Integer>();
List<Integer> li = new ArrayList<Integer>();
Collection<Integer> ci = new ArrayList<Integer>();
Collection<String> cs = new Vector<String>(4);
```

Inheritance relationship between Generic classes themselves still exists.

14

Note: Although the inheritance relationship between the type arguments of the generic classes does not exist, Inheritance relationship between Generic classes themselves still exist.



15.3: Using Generics with Collections

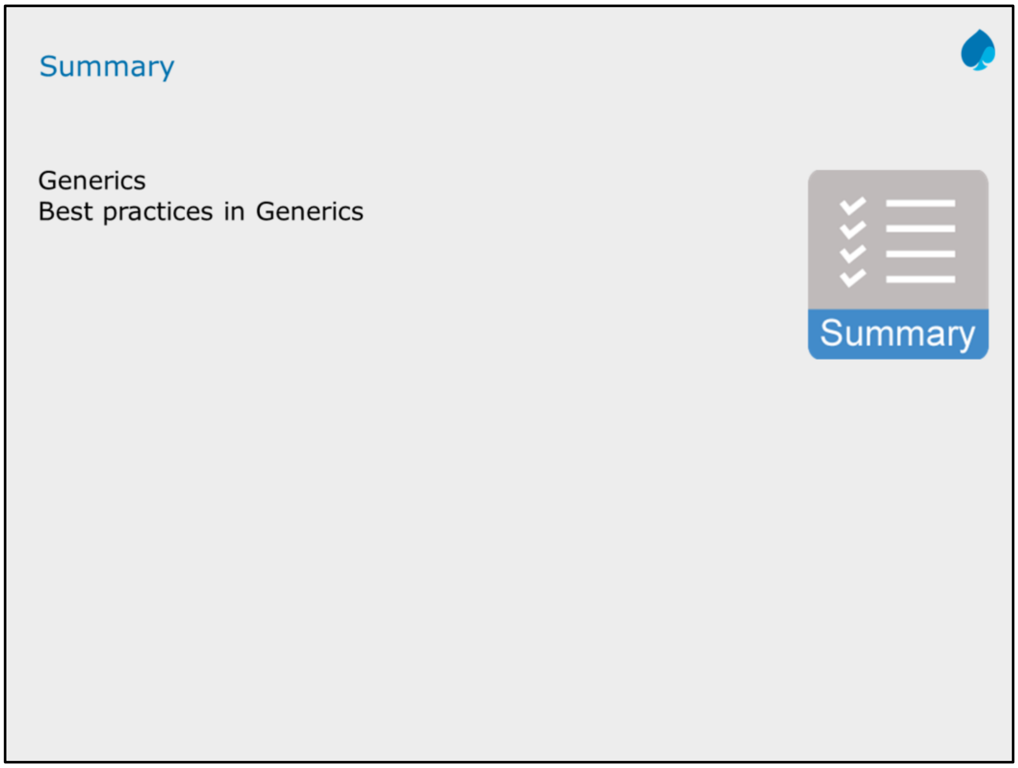
Generics

The following code works:

```
ArrayList<Number> an = new ArrayList<Number>();
an.add(new Integer(5));
an.add(new Long(1000L));
an.add(new String(“hello”)); // compile error
```

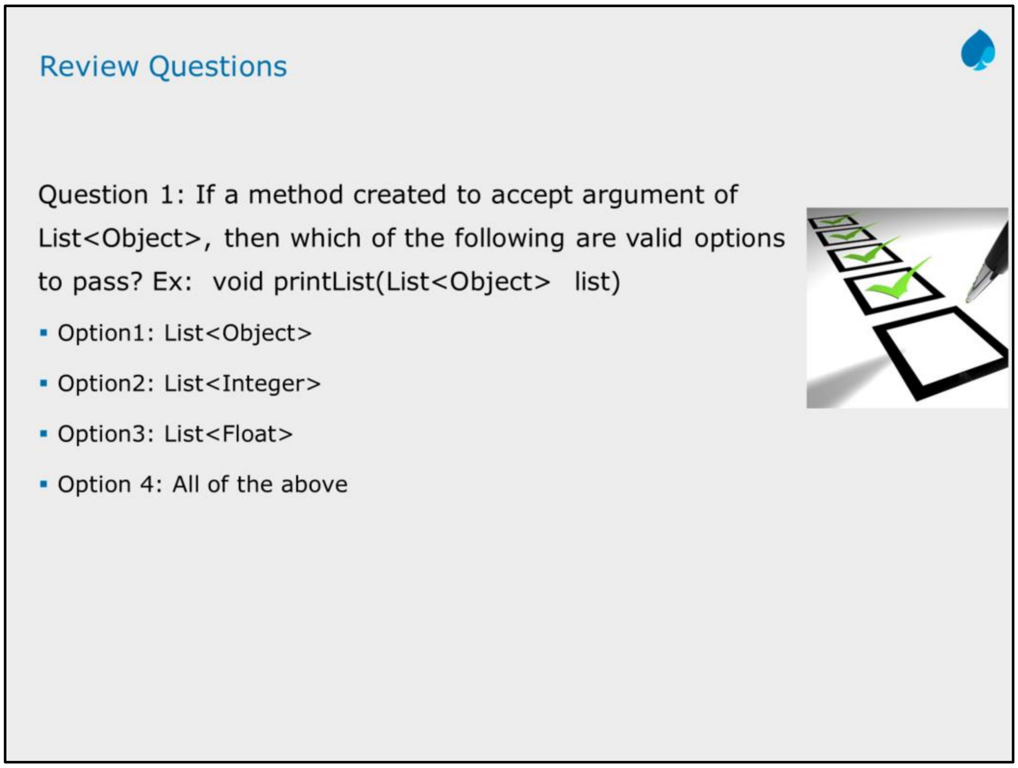
The entries maintain inheritance relationship.

15



Summary

Generics
Best practices in Generics



Review Questions

Question 1: If a method created to accept argument of List<Object>, then which of the following are valid options to pass? Ex: void printList(List<Object> list)

- Option1: List<Object>
- Option2: List<Integer>
- Option3: List<Float>
- Option 4: All of the above