13

# Using Interfaces


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# Objectives

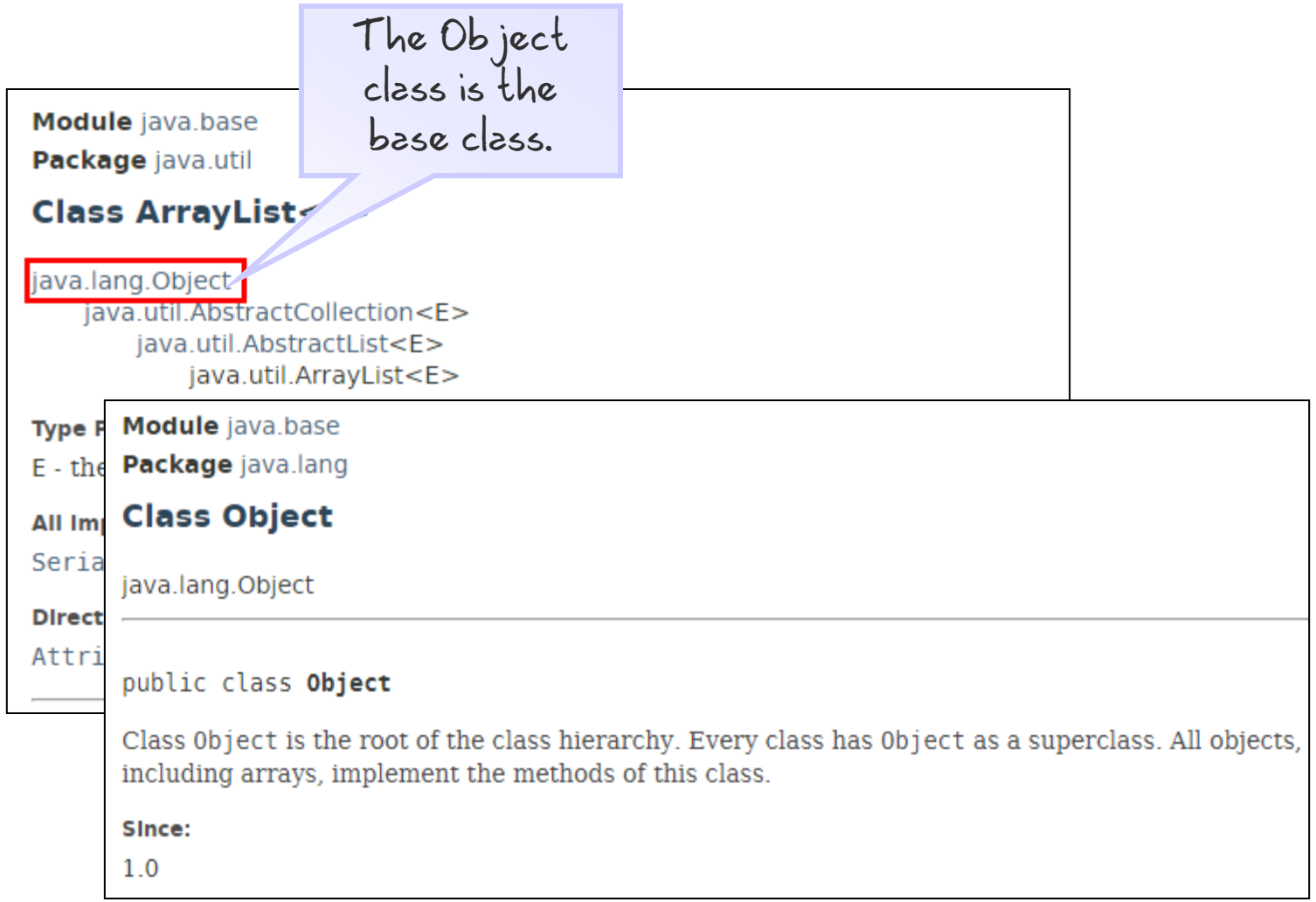
After completing this lesson, you should be able to:

- Override the `toString` method of the `Object` class
- Implement an interface in a class
- Cast to an interface reference to allow access to an object method
- Use the local variable type inference feature to declare local variables using `var`
- Write a simple lambda expression that consumes a `Predicate`

# Topics

- Polymorphism in the JDK foundation classes
- Using Interfaces
- Using local variable type inference
- Using the `List` interface
- Introducing lambda expressions

# The `Object` Class



# Calling the `toString` Method

Object's `toString` method is used.

StringBuilder overrides Object's `toString` method.

First inherits Object's `toString` method.

Second overrides Object's `toString` method.

```
1  public class Main {
2      public static void main(String[] args) {
3
4          // Output an Object to the console
5          System.out.println(new Object());
6
7          // Output this StringBuilder object to the console
8          System.out.println(new StringBuilder("Some text for StringBuilder"));
9
10         //Output a class that does not override the toString() method
11         System.out.println(new First());
12
13         //Output a class that *does* override the toString() method
14         System.out.println(new Second());
15     }
16 }
```

```
Output - TestCode (run)
run:
java.lang.Object@3e25a5
Some text for StringBuilder
First@19821f
This class named Second has overridden the toS
BUILD SUCCESSFUL (total time: 1 second)
```

The output for the calls to the `toString` method of each object

# Overriding `toString` in Your Classes

Shirt class example

```
1  public String toString(){
2    return "This shirt is a " + desc + ";"
3        + " price: " + getPrice() + ","
4        + " color: " + getColor(getColorCode());
5  }
```

Output of `System.out.println(shirt);`

- Without overriding `toString`

  `examples.Shirt@73d16e93`

- After overriding `toString` as shown above

  `This shirt is a T Shirt; price: 29.99, color: Green`

# Topics

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- Introducing lambda expressions

# The Multiple Inheritance Dilemma

Can I inherit from *two* different classes? I want to use methods from both classes.

```
public class Red{
    public void print(){
        System.out.print("I am Red");
    }
}
```

```
public class Blue{
    public void print(){
        System.out.print("I am Blue");
    }
}
```

```
public class Purple extends Red, Blue{
      public void printStuff() {
         print();
      }
}
```

Which implementation of `print()` will occur?

# The Java Interface

- An interface is similar to an abstract class, except that:
  - Methods are implicitly abstract (except default, static, and private methods)
  - A class does not *extend* it, but *implements* it
  - A class may implement more than one interface
- All abstract methods from the interface must be implemented by the class.

```
1 public interface Printable {
2     public void print();
3 }
```

Implicitly abstract

```
1 public class Shirt implements Printable {
2         ...
3         public void print(){
4                 System.out.println("Shirt description");
5         }
6 }
```

Implements the print() method.

# No Multiple Inheritance of State

- Multiple Inheritance of methods is not a problem
- Multiple Inheritance of state is a big problem
  - Abstract classes may have instance and static fields.
  - Interface fields must be static final.

Key difference between abstract classes and interfaces

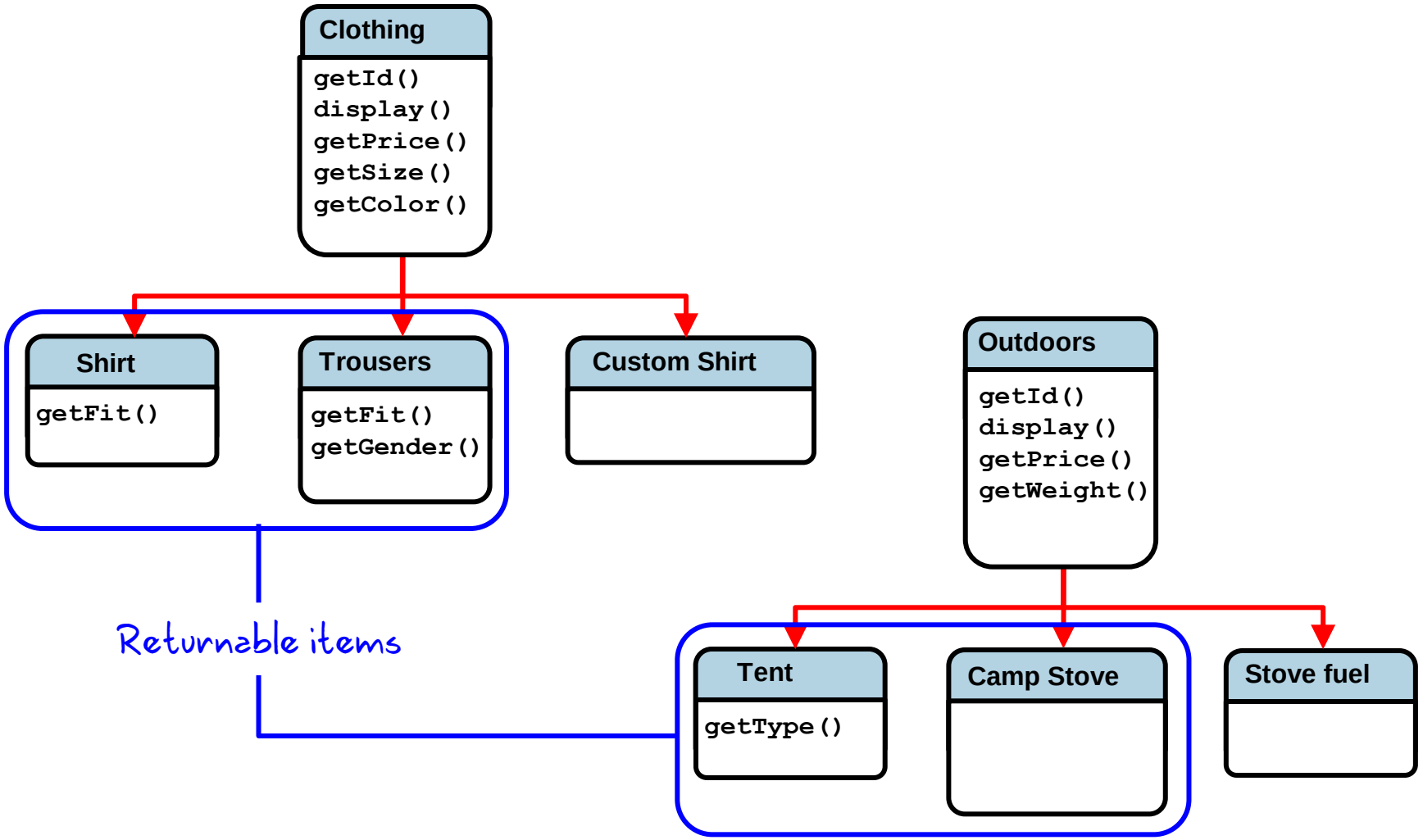
```
public abstract class Red{
    public String color = "Red";
}
```

```
public abstract class Blue{
    public String color = "Blue";
}
```

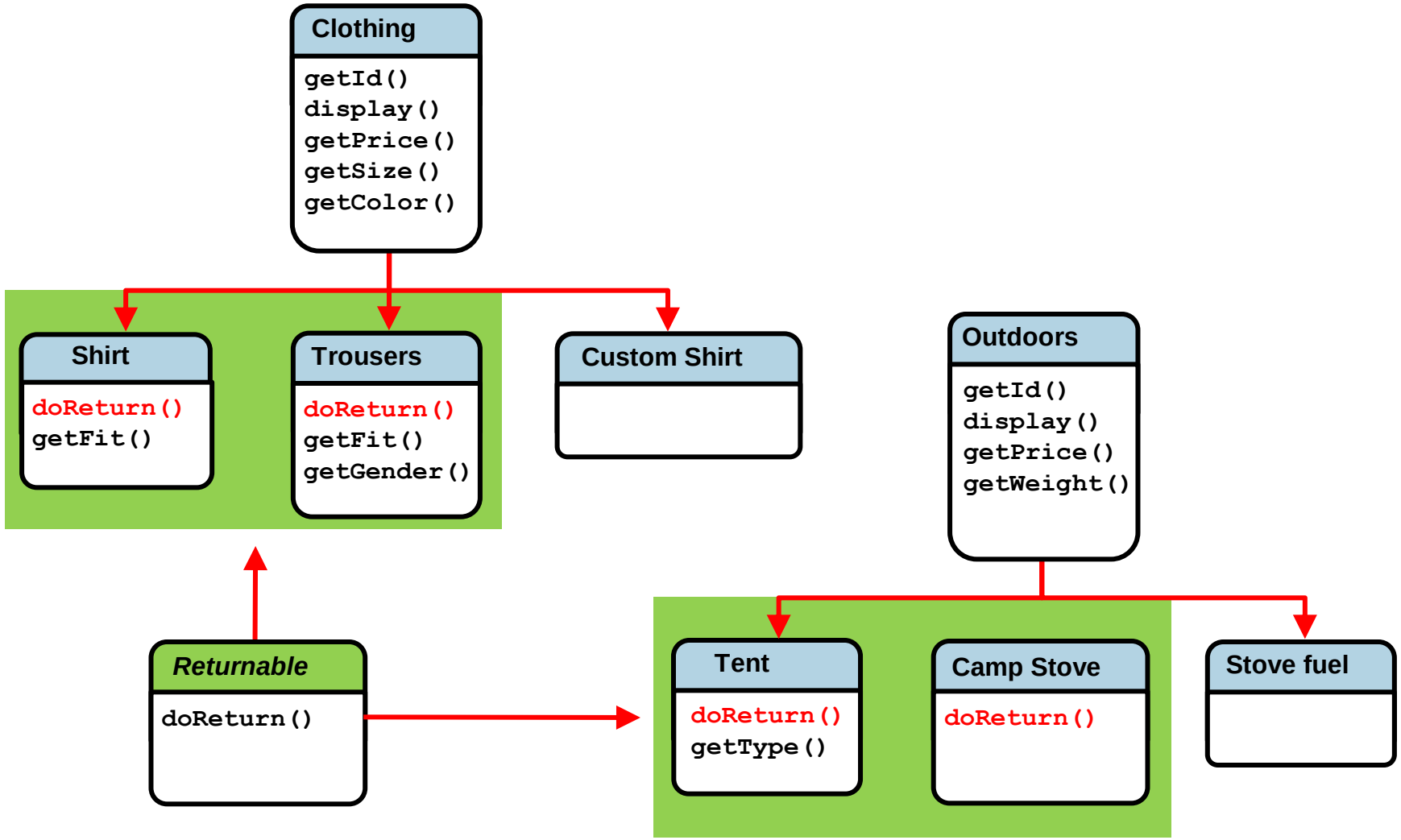
```
public class Purple extends Red, Blue{
      public void printStuff() {
         System.out.println(color);
      }
}
```

Which value of `color` will print?

# Multiple Hierarchies with Overlapping Requirements



# Using Interfaces in Your Application



# Implementing the `Returnable` Interface

## `Returnable` interface

```
01  public interface Returnable {
02   public String doReturn();
03 }
```

Implicitly abstract method

## `Shirt` class

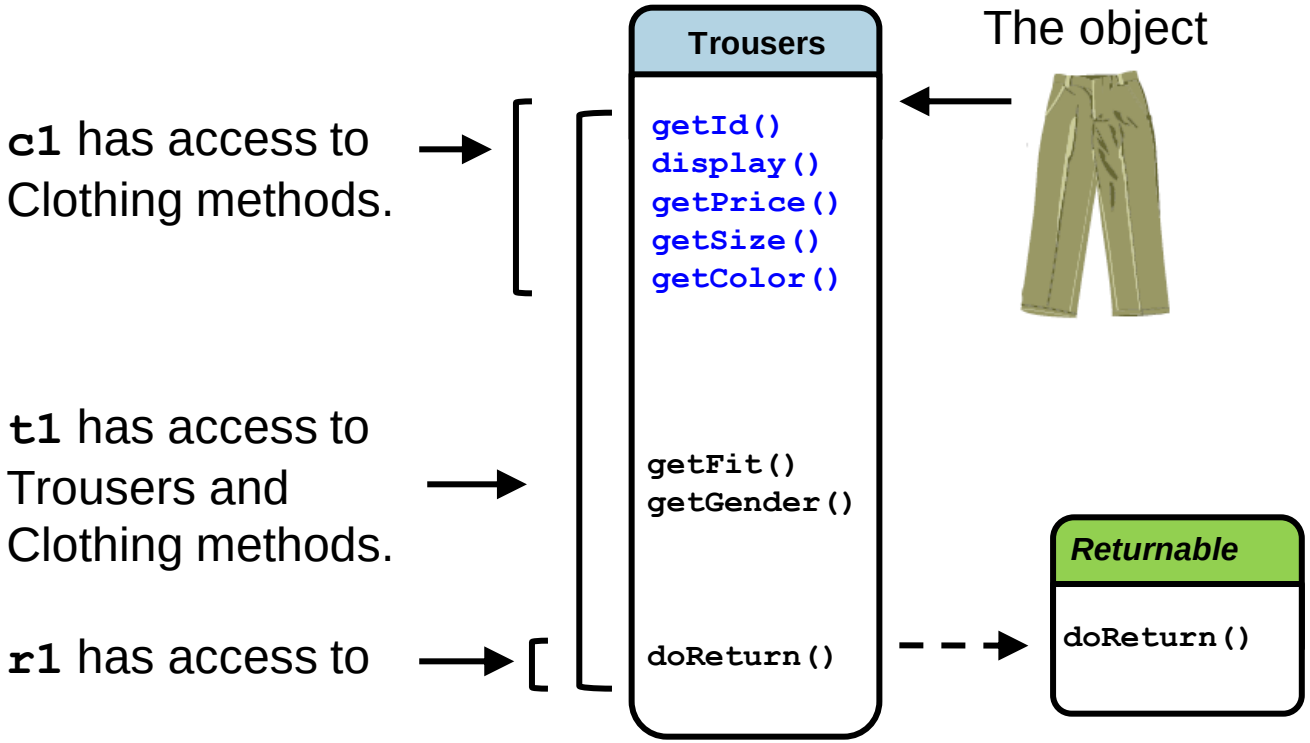
Now, Shirt 'is a' Returnable.

```
01  public class Shirt extends Clothing implements Returnable {
02   public Shirt(int itemID, String description, char colorCode,
03                double price, char fit) {
04      super(itemID, description, colorCode, price);
05      this.fit = fit;
06   }
07  public String doReturn() {
08    // See notes below
09     return "Suit returns must be within 3 days";
10  }
11  ...< other methods not shown > ...        } // end of class
```

Shirt implements the method declared in Returnable.

# Access to Object Methods from Interface

```
Clothing c1 = new Trousers();
Trousers t1 = new Trousers();
Returnable r1 = new Trousers();
```



# Casting an Interface Reference

```
Clothing c1 = new Trousers();
Trousers t1 = new Trousers();
Returnable r1 = new Trousers();
```

- The `Returnable` interface does not know about `Trousers` methods:

```
r1.getFit()                    //Not allowed
```

- Use **casting** to access methods defined outside the interface.

```
((Trousers)r1).getFit();
```

- Use `instanceof` to avoid inappropriate casts.

```
if(r1 instanceof Trousers) {
        ((Trousers)r1).getFit();
}
```

# Quiz

Which methods of an object can be accessed via an interface that it implements?

a. All the methods implemented in the object's class
b. All the methods implemented in the object's superclass
c. The methods declared in the interface

# Quiz

How can you change the reference type of an object?

a. By calling `getReference`
b. By casting
c. By declaring a new reference and assigning the object

# Topics

- Polymorphism in the JDK foundation classes
- Using Interfaces
- Using local variable type inference
- Using the `List` interface
- Introducing lambda expressions

# What is This Feature?

- Local variable type inference is a new language feature in Java 10.
- Use `var` to declare local variables.
- The compiler infers the datatype from the variable initializer.

Before Java 10

```
ArrayList list = new ArrayList<String>();
```

Datatype declared twice

Now

```
var list = new ArrayList<String>();
```

Datatype declared once

# Benefits

- There's less boilerplate typing.
- Code is easier to read with variable names aligned.

```
String desc = "shirt";
ArrayList<String> list = new
ArrayList<String>();
int price = 20;
double tax = 0.05;
```

```
var desc = "shirt";
var list = new ArrayList<String>();
var price = 20;
var tax = 0.05;
```

- It won't break old code.
  - Keywords cannot be variables names.
  - `var` is not a keyword.
  - `var` is a reserved type name.
  - It's only used when the compiler expects a variable type.
  - Otherwise, you can use `var` as a variable name. But it's a bad name...

# Where Can it be Used?

## Yes

- Local variables

```
var x = shirt1.toString();
```

- `for` loop

```
for(var i=0; i<10; i++)
```

- `for-each` loop

```
for(var x : shirtArray)
```

## No

- Declaration without an initial value

```
var price;
```

- Declaration and initialization with a null value

```
var price = null;
```

- Fields

```
public var price;
```

- Parameters

```
public void setPrice(var price){}
```

- Method return types

```
public var getPrice(){
    return price;
}
```

# Why is The Scope So Narrow?

- Larger scopes increase the potential for issues or uncertainty in inferences.
- To prevent issues, Java restricts the usage of `var`.

```
public var getSomething(var something){
      return something;
}
```

How should this compile?
`something` could be anything!

# Exercise 13-1: Local Variable Type Inference

1. Open the project **`Exercise_13-1`** in NetBeans.
2. Edit `TestClass.java`.
3. Replace the variable declarations with the `var` variable type inference feature in the following cases. Note which cases produce an error.
   - As a local variables
   - As a reference to Collection
   - In the enhanced for loop
   - As the index counter in the traditional for loop
   - Saving the returned value from a method
   - As a method return type

# Topics

- Polymorphism in the JDK foundation classes
- Using Interfaces
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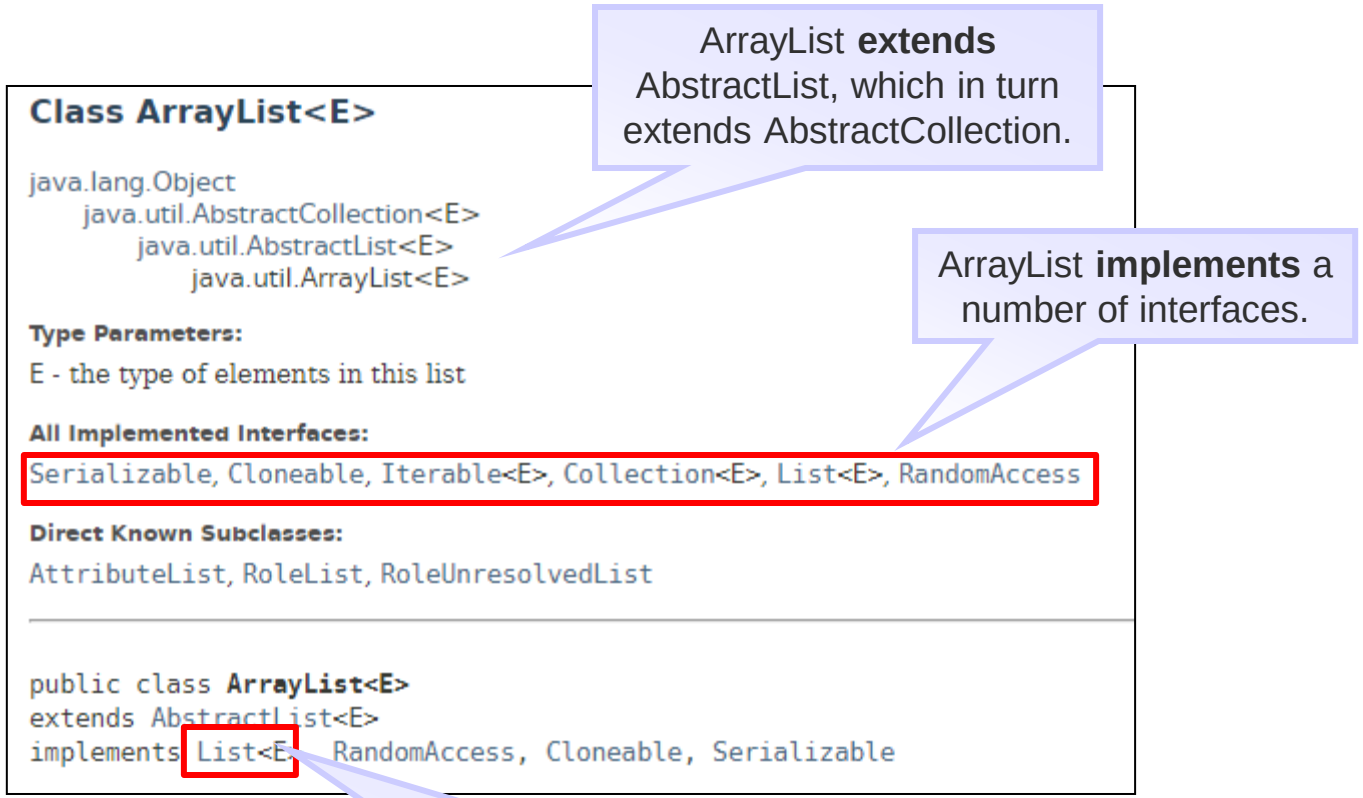
- Using the List interface
- Introducing lambda expressions

# The Collections Framework

The collections framework is located in the `java.util` package. The framework is helpful when working with lists or collections of objects. It contains:

- Interfaces
- Abstract classes
- Concrete classes (Example: `ArrayList`)

# `ArrayList` Example



# `List` Interface

**Module** java.base
**Package** java.util

**Interface List<E>**

**Type Parameters:**
E - the type of elements in this list

**All Superinterfaces:**
`Collection<E>, Iterable<E>`

**All Known Subinterfaces:**
`ObservableList<E>, ObservableListValue<E>, WritableListValue<E>`

**All Known Implementing Classes:**
`AbstractList, AbstractSequentialList, ArrayList, AttributeList, CopyOnWriteArrayList, FilteredList, LinkedList, ListBinding, ListExpression, ListProperty, ListPropertyBase, ModifiableObservableListBase, ObservableListBase, ReadOnlyListProperty, ReadOnlyListPropertyBase, ReadOnlyListWrapper, RoleList, RoleUnresolvedList, SimpleListProperty, SortedList, Stack, TransformationList, Vector`

Many classes implement the `List` interface.

All of these object types can be assigned to a `List` variable:

```
1    ArrayList words = new ArrayList<String>();
2    List mylist = words;
```

```
1      var words = new ArrayList();
2      var mylist = words;
```

Using local variable type inference

# Example: `Arrays.asList`

The `java.util.Arrays` class has many static utility methods that are helpful in working with arrays.

- Converting an array to a `List`:

```
1    String[] nums = {"one","two","three"};
2    List<String> myList = Arrays.asList(nums);
```

List objects can be of many different types. What if you need to invoke a method belonging to `ArrayList`?

```
mylist.replaceAll()
```

This works! `replaceAll` comes from List.

```
mylist.removeIf()
```

Error! `removeIf` comes from Collection (superclass of ArrayList).

# Example: `Arrays.asList`

Converting an array to an `ArrayList`:

```
1 String[] nums = {"one","two","three"};
2 List<String> myList = Arrays.asList(nums);
3 ArrayList<String> myArrayList = new ArrayList(myList);
                    or
  var myArrayList = new ArrayList(myList);
```

Shortcut:

```
1 String[] nums = {"one","two","three"};
2 ArrayList<String> myArrayList = new ArrayList( Arrays.asList(nums));
                    or
   var myArrayList = new ArrayList(Arrays.asList(nums));
```

# Exercise 13-2: Converting an Array to an ArrayList, Part 1

1. Open the project **`Exercise_13-2`** in NetBeans or create your own Java Main Class named `TestClass`
2. Convert the days array to an `ArrayList`.
   - Use Arrays.asList to return a List.
   - Use that List to initialize a new ArrayList.
   - Preferably do this all on one line.
3. Iterate through the ArrayList, testing to see if an element is "sunday".
   - If it is a "sunday" element, print it out, converting it to upper case.

     Use String class methods:
     - public boolean equals (Object o);
     - public void toUpperCase();
   - Else, print the day anyway, but not in upper case.

# Exercise 13-2: Converting an Array to an ArrayList, Part 2

4. After the `for` loop print out the `ArrayList`.
   - While within the loop, was `"sunday"` printed in upper case?
   - Was the `"sunday"` array element converted to upper case?
   - Your instructor will explain what's going on in the next topic.

# Topics

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- Using Interfaces
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# Example: Modifying a List of Names

Suppose you want to modify a `List` of names, changing them all to uppercase. Does this code change the elements of the `List`?

```
1  String[] names = {"Ned","Fred","Jessie","Alice","Rick"};
2  List<String> mylist = new ArrayList(Arrays.asList(names));
3
4  // Display all names in upper case
5  for( var s: mylist){
6     System.out.print(s.toUpperCase()+", ");
7  }
8  System.out.println("After for loop: " + mylist);
```

Returns a new String to print

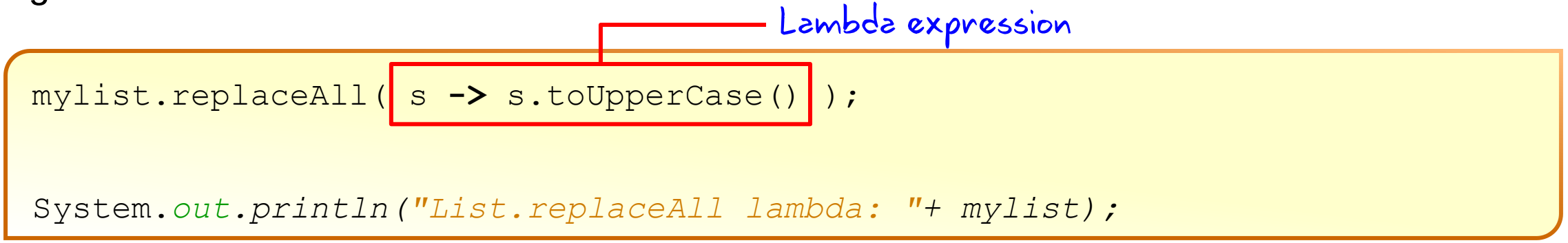
Output:

```
NED, FRED, JESSIE, ALICE, RICK,
After for loop: [Ned, Fred, Jessie, Alice, Rick]
```

The list elements are unchanged.

# Using a Lambda Expression with `replaceAll`

`replaceAll` is a default method of the `List` interface. It takes a lambda expression as an argument.




Output:

```
List.replaceAll lambda: [NED, FRED, JESSIE, ALICE, RICK]
```

# Lambda Expressions

Lambda expressions are like methods used as the argument for another method. They have:

- Input parameters
- A method body
- A return value

Long version:

```
mylist.replaceAll((String s) -> {return s.toUpperCase();} );
```

Declare input parameter

Arrow token

Method body

Short version:

```
  mylist.replaceAll( s  ->   s.toUpperCase() );
```

# The Enhanced APIs That Use Lambda

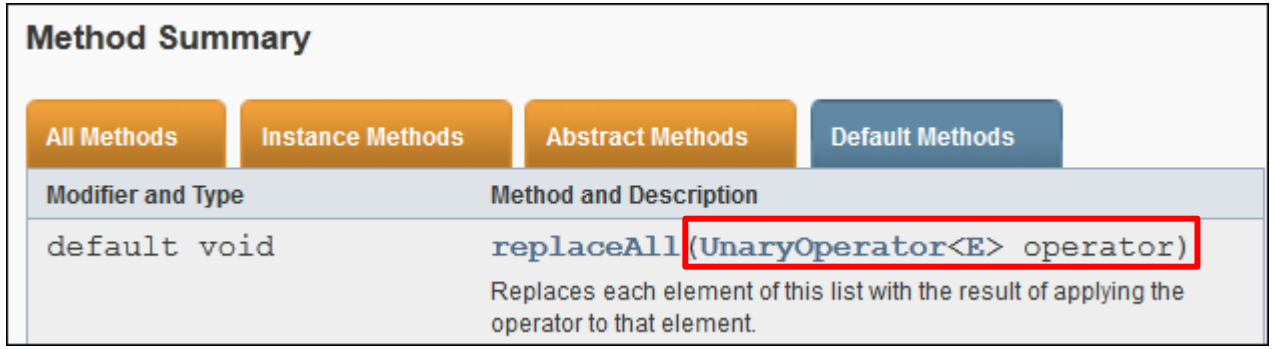
There are three enhanced APIs that take advantage of lambda expressions:

- `java.util.functions`
  - Provides target types for lambda expressions
- `java.util.stream`
  - Provides classes that support operations on streams of values
- `java.util`
  - Interfaces and classes that make up the collections framework
    - Enhanced to use lambda expressions
    - Includes List and ArrayList

# Lambda Types

A lambda *type* specifies the type of expression a method is expecting.

- `replaceAll` takes a `UnaryOperator` type expression.

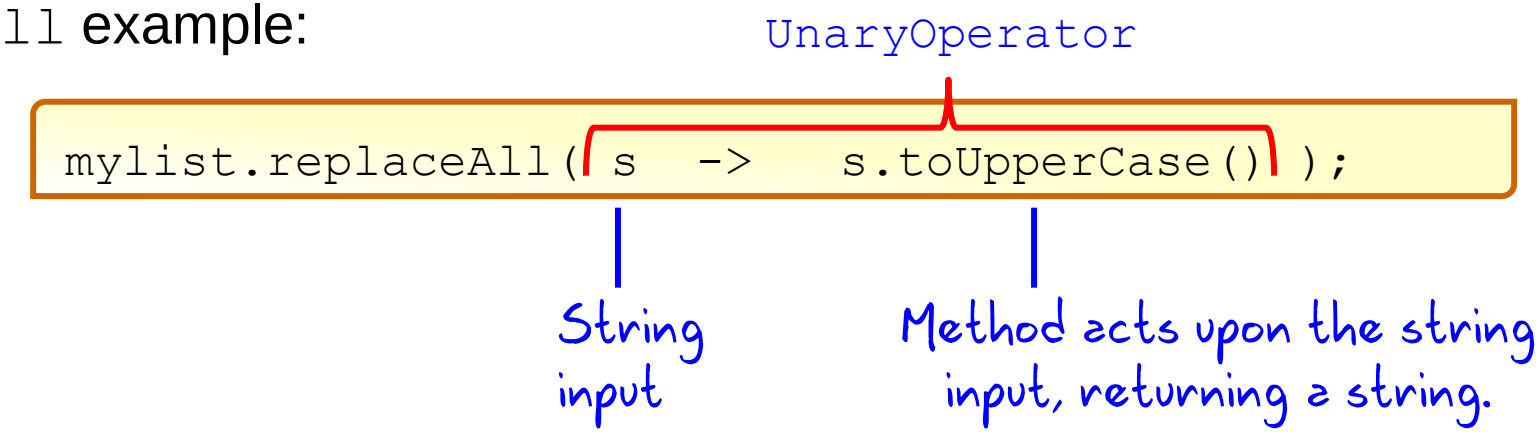



- All of the types do similar things, but have different inputs, statements, and outputs.

# The `UnaryOperator` Lambda Type

A `UnaryOperator` has a single input and returns a value of the same type as the input.

- Example: `String` *in* – `String` *out*
- The method body acts upon the input in some way, returning a value of the same type as the input value.
- `replaceAll` example:



# The `Predicate` Lambda Type

A `Predicate` type takes a single input argument and returns a boolean.

- Example: `String` *in* – `boolean` *out*
- `removeIf` takes a `Predicate` type expression.
  - Removes all elements of the `ArrayList` that satisfy the `Predicate` expression

| removeIf |
| --- |
| `public boolean removeIf(Predicate<? super E> filter)` |

- Examples:

```
mylist.removeIf (s -> s.equals("Rick"));
mylist.removeIf (s -> s.length() < 5);
```

# Exercise 13-3: Using a `Predicate` Lambda Expression

1. Open the project **`Exercise_13-3`**.

In the `ShoppingCart` class:

2. Examine the code. As you can see, the items list has been initialized with 2 shirts and 2 pairs of trousers.
3. In the `removeItemFromCart` method, use the `removeIf` method (which takes a `Predicate` lambda type) to remove all items whose description matches the `desc` argument.
4. Print the items list. Hint: the `toString` method in the `Item` class has been overloaded to return the item description.
5. Call the `removeItemFromCart` method from the main method.

   Try different description values, including ones that return `false`.
6. Test your code.

# Summary

In this lesson, you should have learned the following:

- Override the `toString` method of the `Object` class
- Implement an interface in a class
- Cast to an interface reference to allow access to an object method
- Use local variable type inference feature to declare local variables using `var`
- Write a simple lambda expression that consumes a `Predicate`

# Practice Overview

- 13-1: Overriding the `toString` Method
- 13-2: Implementing an Interface
- 13-3: Using a Lambda Expression for Sorting