Lecture 7

Functional Programming

Passing code with behavior parameterization

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Outline

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Coping with changing requirements

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Requirement 1: Filter green apples

```
public static List<Apple> filterGreenApples(List<Apple> inventory) {
  List<Apple> result = new ArrayList<>();
  for(Apple apple: inventory){
    if( "green".equals(apple.getColor() ) {
      result.add(apple);
    }
  }
  return result;
}
```

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Requirement 2: Filter by arbitrary color

```
public static List<Apple> filterApplesByColor(List<Apple> inventory,
                                              String color) {
    List<Apple> result = new ArrayList<>();
    for (Apple apple: inventory){
      if ( apple.getColor().equals(color) ) {
        result.add(apple);
      }
    }
    return result;
}
```

Calling

```
List<Apple> greenApples = filterApplesByColor(inventory, "green");
List<Apple> redApples = filterApplesByColor(inventory, "red");
...
```

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Requirement 3: Filter by weight

```
public static List<Apple> filterApplesByWeight(List<Apple> inventory,
                                               int weight) {
  List<Apple> result = new ArrayList<>();
  for (Apple apple: inventory){
    if ( apple.getWeight() > weight ){
      result.add(apple);
    }
  }
  return result;
}
```

Coping with changing requirements

Requirement 4: Filter by weight *or* color

```
public static List<Apple> filterApples(List<Apple> inventory,
                                       String color,
                                       int weight,
                                       boolean flag) {
  List<Apple> result = new ArrayList<>();
  for (Apple apple: inventory){
    if ( (flag && apple.getColor().equals(color)) ||
         (!flag && apple.getWeight() > weight) ){
      result.add(apple);
    }
  }
  return result;
}
```

Calling

```
List<Apple> greenApples = filterApples(inventory, "green", 0, true);
List<Apple> heavyApples = filterApples(inventory, "", 150, false);
...
```

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Outline

Behavior parameterization

```
public interface ApplePredicate{
    boolean test (Apple apple);
}
```

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Apple selection strategies

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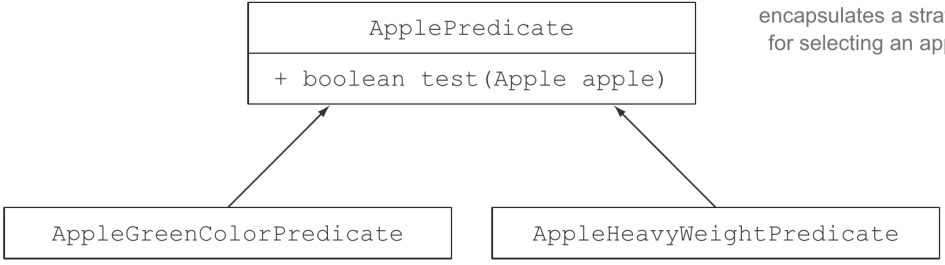

ApplePredicate encapsulates a strategy for selecting an apple.

`ApplePredicate` Implementations

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```
public class AppleHeavyWeightPredicate implements ApplePredicate {
  public boolean test(Apple apple){
    return apple.getWeight() > 150;
  }
}

public class AppleGreenColorPredicate implements ApplePredicate {
  public boolean test(Apple apple){
    return "green".equals(apple.getColor());
  }
}
```

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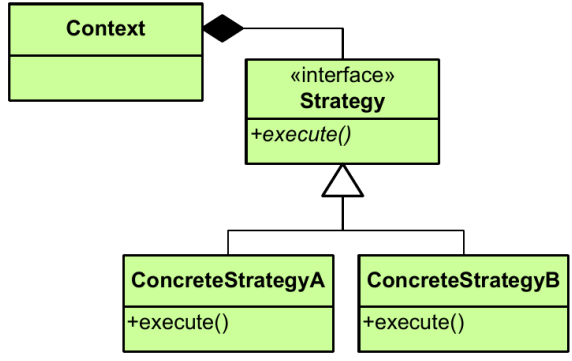
Strategy

Type: Behavioral

What it is:
Define a family of algorithms, encapsulate each one, and make them interchangeable. Lets the algorithm vary independently from clients that use it.



Filtering by Predicate

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```
public static List<Apple> filterApples(List<Apple> inventory,
                                       ApplePredicate p){
  List<Apple> result = new ArrayList<>();
  for(Apple apple: inventory){
    if(p.test(apple)){
      result.add(apple);
    }
  }
  return result;
}
```

Passing Code/Behavior

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Find red apples heavier than 150g?

```
public class AppleRedAndHeavyPredicate implements ApplePredicate{
  public boolean test(Apple apple){
    return "red".equals(apple.getColor()) && apple.getWeight() > 150;
  }
}
```

Calling

```
List<Apple> redAndHeavyApples =
    filterApples(inventory, new AppleRedAndHeavyPredicate());
```

Behavior Parameterization

`ApplePredicate` object

```
public class AppleRedAndHeavyPredicate implements ApplePredicate {
   public boolean test(Apple apple){
      return "red".equals(apple.getColor())
             && apple.getWeight() > 150;
   }
}
```

Pass as argument

```
filterApples(inventory,          );
```

Pass a strategy to the filter method: filter the apples by using the boolean expression encapsulated within the ApplePredicate object. To encapsulate this piece of code, it is wrapped with a lot of boilerplate code (in bold).

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Multiple behaviors, one parameter

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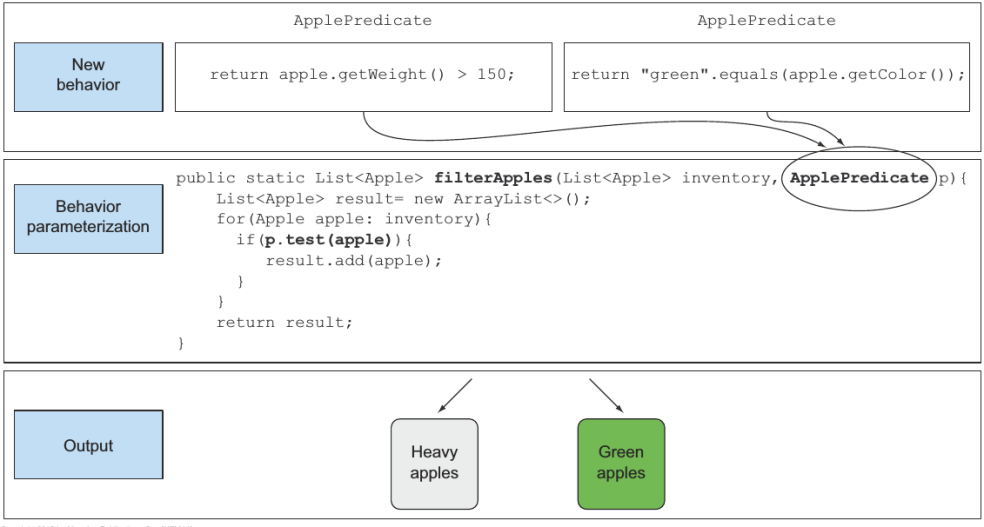

Outline

Tackling verbosity

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```
public interface ApplePredicate{
  boolean test (Apple apple);
}

public class AppleHeavyWeightPredicate implements ApplePredicate{
  public boolean test(Apple apple){
    return apple.getWeight() > 150;
  }
}

public class AppleGreenColorPredicate implements ApplePredicate{
  public boolean test(Apple apple){
    return "green".equals(apple.getColor());
  }
}
```

Tackling verbosity (II)

```
public class FilteringApples{
  public static void main(String...args){
    List<Apple> inventory = Arrays.asList(new Apple(80,"green"),
                                          new Apple(155, "green"),
                                          new Apple(120, "red"));
    List<Apple> heavyApples =
        filterApples(inventory, new AppleHeavyWeightPredicate());
    List<Apple> greenApples =
        filterApples(inventory, new AppleGreenColorPredicate());
  }

  public static List<Apple> filterApples(List<Apple> inventory,
                                         ApplePredicate p) {
    List<Apple> result = new ArrayList<>();
    for (Apple apple : inventory){
      if (p.test(apple)){
        result.add(apple);
      }
    }
    return result;
  }
}
```

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Anonymous classes

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```
List<Apple> redApples = filterApples(inventory, new ApplePredicate() {
  public boolean test(Apple apple){
    return "red".equals(apple.getColor());
  }
});
```

Using a lambda expression

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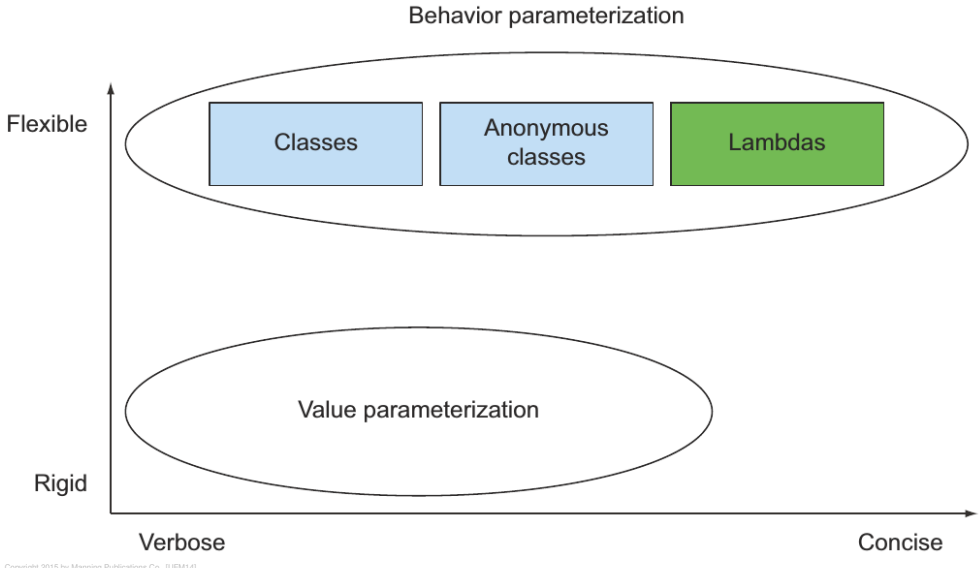
```
List<Apple> result =
filterApples(inventory, (Apple apple)->"red".equals(apple.getColor()));
```

Behavior parameterization vs. value parameterization



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Abstracting over List type

Filter anything, not just `Apple`?

```
public interface Predicate<T>{
  boolean test(T t);
}

public static <T> List<T> filter(List<T> list, Predicate<T> p){
  List<T> result = new ArrayList<>();
  for(T e: list){
    if(p.test(e)){
      result.add(e);
    }
  }
  return result;
}
```

Calling

```
List<Apple> redApples =
  filter(inventory, (Apple apple) -> "red".equals(apple.getColor()));

List<Integer> evenNumbers = filter(numbers, (Integer i) -> i % 2 == 0);
```

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Sorting with a Comparator

`List.sort` in Java 8

```
// java.util.Comparator
public interface Comparator<T> {
  public int compare(T o1, T o2);
}
```

Implementing a `Comparator` using an anonymous class

```
inventory.sort(new Comparator<Apple>() {
  public int compare(Apple a1, Apple a2){
    return a1.getWeight().compareTo(a2.getWeight());
  }
});
```

With a lambda expression

```
inventory.sort(
    (Apple a1, Apple a2) -> a1.getWeight().compareTo(a2.getWeight()));
```

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Executing a block of code with Runnable

Threads

```
// java.lang.Runnable
public interface Runnable{
  public void run();
}
```

Creating a `Thread` using an anonymous class

```
Thread t = new Thread(new Runnable() {
 public void run(){
   System.out.println("Hello world");
 }
});
```

With a lambda expression

```
Thread t = new Thread(() -> System.out.println("Hello world"));
```

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GUI event handling

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JavaFX `EventHandler` using an anonymous class

```
Button button = new Button("Send");
button.setOnAction(new EventHandler<ActionEvent>() {
  public void handle(ActionEvent event) {
    label.setText("Sent!!");
  }
});
```

With a lambda expression

```
button.setOnAction((ActionEvent event) -> label.setText("Sent!!"));
```

Outline

Summary

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Behavior parameterization

- Ability for a method to take multiple different behaviors as parameters and use them internally to accomplish different behaviors
- Lets you make your code more adaptive to changing requirements and saves on engineering efforts in the future

Implementation

- Passing code is a way to give new behaviors as arguments to a method
- Very verbose prior to Java 8
- Anonymous classes were used to get rid of the verbosity associated with declaring multiple concrete classes for an interface that are needed only once
- The Java API contains many methods that can be parameterized with different behaviors, which include sorting, threads, and GUI handling
- Much more concise, readable, and flexible with Java 8 lambdas

Outline

Reading Material

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Required

- [UFM14, Chapter 2] (Passing Code with behavior parameterization)

Supplemental

- [GHJV95] (Strategy Design Pattern)

References

[GHJV95] E. Gamma, R. Helm, R. Johnson, and J. Vlissides.
Design Patterns: Elements of Reusable Object-Oriented Software.
Addison-Wesley, 1995.

[UFM14] Raoul-Gabriel Urma, Mario Fusco, and Alan Mycroft.
Java 8 in Action: Lambdas, streams, and functional-style programming.
Manning Publications, 2014.
https://www.manning.com/books/java-8-in-action.