# CS 213 – Software Methodology

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Lambda Expressions – Part 1

# Example: List Filtering

Given a list, want to extract a subset of items based on some filtering condition

# Example: List Filtering

Pick even numbers out of a list

```
List<Integer> result =
      new ArrayList<Integer>();
for (Integer i: list) {
    if (i % 2 == 0) {
       result.add(i);
    }
}
return result;
```

Pick numbers > 10 out of a list

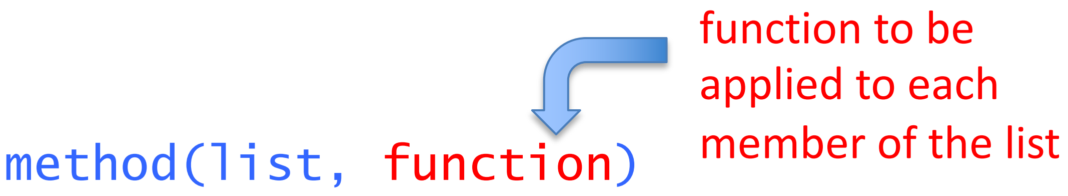
```
List<Integer> result =
      new ArrayList<Integer>();
for (Integer i: list) {
    if (i > 10) {
       result.add(i);
    }
}
return result;
```

There may be other conditions for filtering numbers out of a list that an application may need to use elsewhere
(e.g. pick multiples of 5, pick primes, etc.)

How to redo this so that we can maintain a single scaffolding (loop through list and apply condition), and change ONLY the actual condition as needed?

# Passing Behavior to Method

Setup: Write a method with two parameters:
the list, *and a filtering function*



```
method(list, function)
```

function to be
applied to each
member of the list

Technically, there's no way to pass a function (method) as a parameter

But, as of Java 8, there is a way to pass a method through a very light object, with simple syntax that *makes it appear as if we are just passing a function instead of an object*

# Define Behavior in Functional Interface

Start by defining an interface that has only ONE abstract method.
(There may be other methods, so long as they are not abstract.)
This makes it a *functional interface*

```
public interface IntPicker {
   boolean pick(int i);
}
```

Next, implement the filter method with an instance of the functional interface as the second parameter

*can have an interface type for parameter*

```
public List<Integer>
filter( List<Integer> list, IntPicker picker) {
   List<Integer> result = new ArrayList<Integer>();
   for (Integer i: list) {
       if (picker.pick(i)) {
          result.add(i);
       }
   }
   return result;
}
```

# Passing function argument : v1

## Named interface implementation

For each type of filter, make a named class that implements the interface:

```
public class EvenPicker
implements IntPicker {
   public boolean pick(int i) {
      return i % 2 == 0;
   }
}
```

```
public class GreaterThan10Picker
implements IntPicker {
   public boolean pick(int i) {
      return i > 10;
   }
}
```

Set up a list:

```
List<Integer> list = Arrays.asList(2,3,16,8,-10,15,5,13);
```

(`List` and `Arrays` are in `java.util`)

Call the filter method:

```
List<Integer> evens = filter(list, new EvenPicker());

List<Integer> greaterThan10s = filter(list, new GreaterThan10Picker());
```

# Passing function argument: v2

## Anonymous interface implementation

Write anonymous interface on the fly when calling the filter method:

```
List<Integer> list = Arrays.asList(2,3,16,8,-10,15,5,13);

List<Integer> evens = filter(list,
                             new IntPicker() {
                                 public boolean pick(int i) {
                                    return i % 2 == 0;
                                 }
                             });

List<Integer> greaterThan10s = filter(list,
                             new IntPicker() {
                                 public boolean pick(int i) {
                                    return i > 0;
                                 }
                             });
```

# Passing function argument: v3

## Named Lambda Expression

A lambda expression is essentially a simplified syntax to define the method of a functional interface:

```
IntPicker evenPicker = (int i) -> i % 2 == 0;
```

Since the method `pick` is defined to accept an `int` and return a `boolean`, the LHS of the expression is the `int` input, and the RHS is the `boolean` return

```
IntPicker greaterThan10Picker = (int i) -> i > 10;
```

Call the filter method:

```
List<Integer> list = Arrays.asList(2,3,16,8,-10,15,5,13);

List<Integer> evens = filter(list, evenPicker);

List<Integer> greaterThan10s = filter(list, greaterThan10Picker);
```

# Passing function argument: v4

## On-the-fly Unnamed Lambda Expression

Call the filter method:

```
List<Integer> list = Arrays.asList(2,3,16,8,-10,15,5,13);

List<Integer> evens = filter(list, (int i) -> i % 2 == 0);

List<Integer> greaterThan10s = filter(list, (int i) -> i > 10);
```

Type of LHS var can be dropped since it can be unambiguously resolved:

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

List<Integer> greaterThan10s =
       filter(list, i -> i > 10);
```

```
public interface IntPicker {
   boolean pick(int i);
}
```

*In both calls to filter,* `i` *is required to be an* `int` *to match with parameter to* `pick`

# Lambda Expressions (or just lambdas)

A lambda expression gets compiled into an object that implements a *functional interface,* with parameter and return types resolved according to context

IntPicker

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

Because filter takes an instance of `IntPicker` as 2nd parameter, the matching lambda expression argument gets compiled to an instance of `IntPicker`

Because the method (name irrelevant) in the `IntPicker` functional interface takes a single `int` parameter and returns a `boolean`, the LHS of the lambda is taken to be an `int` type var, and the RHS expression is verified to be applicable to an `int`, with a `boolean` return

Multiple statements in RHS must be in a braces-block:

```
x -> { x++; System.out.println(x); }
```

# Some Pre-Defined Functional Interfaces in

# `java.util.function`

# Generalizing filter method to work on some boolean test on ANY type

Want to make boolean filter method work on ANY data type, not just `int`

Want to generalize

```
public List<Integer>
filter( List<Integer> list, IntPicker picker) {
   List<Integer> result = new ArrayList<Integer>();
   for (Integer i: list) {
       if (picker.pick(i)) {
          result.add(i);
       }
   }
   return result;
}
```

# Generalizing filter method to work on some boolean test on ANY type

Java has a pre-defined functional interface for this very purpose, in the package `java.util.function`:

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

← functional method (the single abstract method of the interface)

There are other methods in this interface, which are either `static` or `default`, that are not abstract (fully implemented). So this is a functional interface because a single method, `test`, is abstract.

# Using java.util.function.Predicate

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

Calls made for Integer list:

```
List<Integer> list =
   Arrays.asList(2,3,16,8,-10,15,5,13);
List<Integer> evens =
   filter(list, i -> i % 2 == 0);
List<Integer> greaterThan10s =
   filter(list, i -> i > 10);
```

Calls made for String list:

```
List<String> colors =
   Arrays.asList(
   “red”,”green”,”orange”,”violet”,
   ”blue”,”white”,”yellow”,”indigo”);
List<String> shortColors =
   filter(colors, s -> s.length() < 4);
List<String> longColors =
   filter(colors, s -> s.length() > 5);
```

# Beyond Predicates: Applying Non-Boolean Functions

`java.util.function.Function` interface helps with this:

```
interface Function<T,R> {
    R apply(T t); ...
}
```

```
public static <T,R> List<R>
map(List<T> list, Function<T,R> f) {
   List<R> result = new ArrayList<R>();
   for (T t: list) {
       result.add(f.apply(t));
   }
   return result;
}
```

```
// square all numbers in list
List<Integer> squares = map(list, i -> i * i);
```

```
// map color names to their lengths
List<Integer> lengths = map(colors, s -> s.length())
```

# Consumer Interface

The `java.util.function.Consumer` interface “consumes” its single argument, returning nothing

```
interface Consumer<T> {
    void accept(T t);
    ...
}
```

```
public static <T> void
consume(List<T> list,
            Consumer<T> cons) {
    for (T t: list) {
        cons.accept(t);
    }
}
```

```
// print colors, capitalized
consume(colors, s ->
                System.out.println(
                      Character.toUpperCase(s.charAt(0)) +
                      s.substring(1));
```