Java Streams

CMSC132

Java Streams: What are they (not)?

- Not related to Java IO Streams!
  - (FileInputStream, InputStreamReader, etc. -- none of those guys)

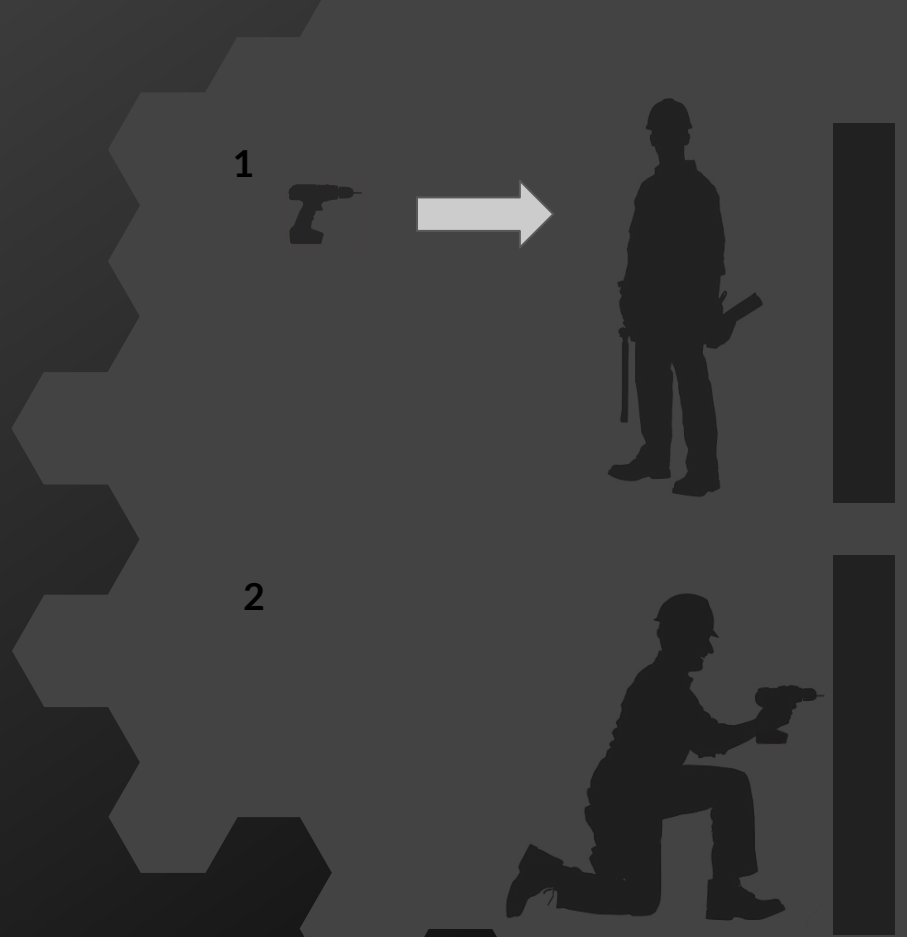
- A basic way to do *functional* programming in Java

What is this... “functional” programming?

- Basic idea: issue **methods** as arguments to other methods,
  - there, execute them with local data as arguments

A Functional Programming Parable

1. You pass a drill to a worker
2. He uses it to drill a hole in the wall next to him



But what is a “Stream”?

- Think “Streaming Collection of Elements”
- Can have different sources
  - Java Collections
  - Arrays
  - A sequence of individual objects
- A sequence of operations can be applied
- Results not available until “terminal” operation

How to make streams?

- Import Stream-related things from java.util.stream
  - `import java.util.stream.*` imports everything related
- Method 1: build from a static array or individual objects using Stream.of
  - ```
    String[] menuItemNames = {"Grits", "Pancakes", "Burrito"};
    Stream.of(menuItemNames); // returns a stream, so needs "=" before it
    ```
  - `Stream.of("Hedgehog", "Kitten", "Fox"); // arbitrary argument count`
- Method 2: call the `stream()` method of any `Collection`
  - `List<String> menuItemNameList = Arrays.asList(menuItemNames);`
  - `menuItemNameList.stream();`
- Method 3: use the StreamBuilder class and it's "accept" method.
    ```

forEach

- ***Intuition*** → iterate over elements in the stream
- Lambda has one argument, return value is ignored
- Terminal operation: does not return another stream!
- ```
  Stream.of(users).forEach(e -> e.logOut());
  ```
  - Logs out all users in system
  ```

forEach

- Loops over stream elements, calling provided function on each element
  - `Stream.of("hello", "world").forEach(word -> System.out.println(word));`
  - A lambda argument is passed

- Can also pass “method references”
  - `Stream.of("hello", "world").forEach(System.out::println);`
  - Syntax: `class::method`

Some More Common Stream Operations

map

Applies a function to each element

filter

Removes elements that don't satisfy a custom rule

sorted

Sorts elements

limit

Return the first N elements

distinct

Removes duplicates

collect

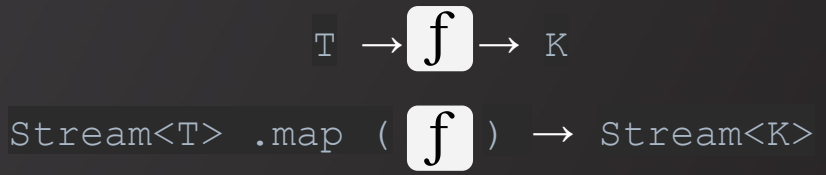
Gets elements out of the stream once we're done (terminal operation)

collect (Basics)

- Also a terminal method.
- Let's say we start with
  - `Stream<Integer> stream = Arrays.asList(3,2,1,5,4,7).stream();`
- Some basic examples: just output all elements as a collection.
  - `List<Integer> list = stream.collect(Collectors.toList());`
  - `Set<Integer> list = stream.collect(Collectors.toSet());`
- Lots more useful goodies,
  - like `Collectors.groupingBy(`  `)` and `Collectors.reducing(`  `);`

map

- ***Intuition*** → modifies the elements of the stream
- The function takes an element of type T and returns an element of type K.



- Example:

```
List<Integer> numbersTripled =
    numbers.stream().map(x -> x*3).collect(toList());
```

map

```
List<Integer> numbersTripled =
    numbers.stream().map(x -> x*3).collect(toList());
```

[1 2 3 4 5 6]

map

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List<Integer> numbersTripled =
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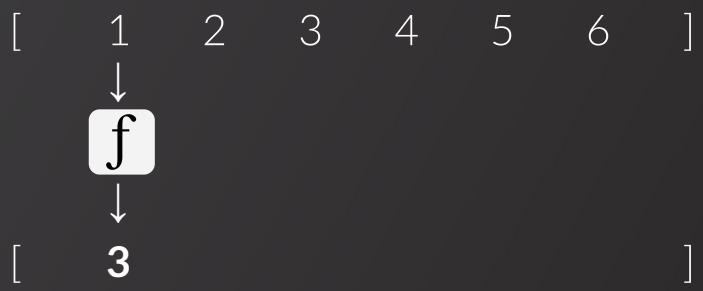

map

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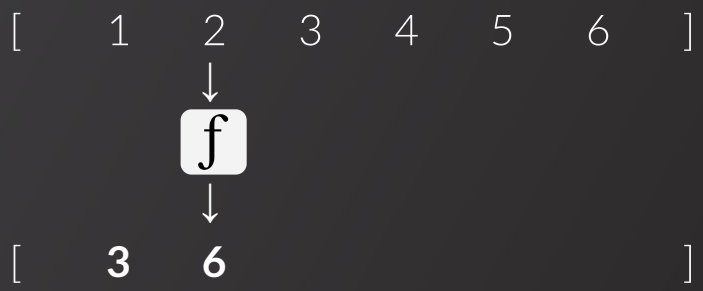

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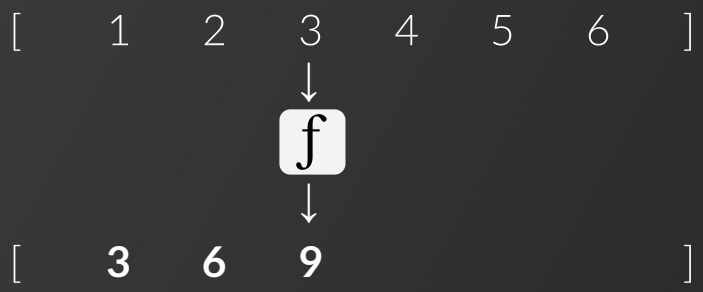

map

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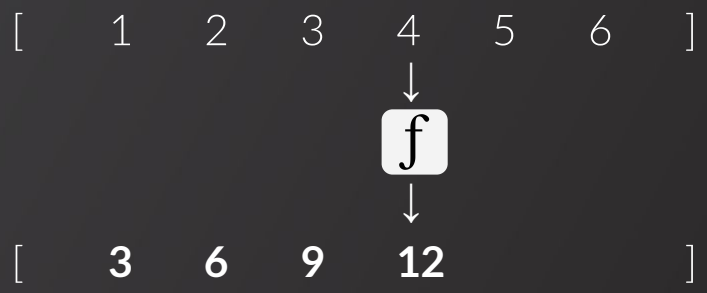

map

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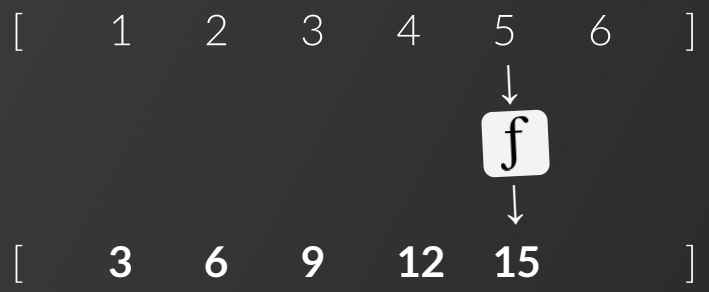

map

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List<Integer> numbersTripled =
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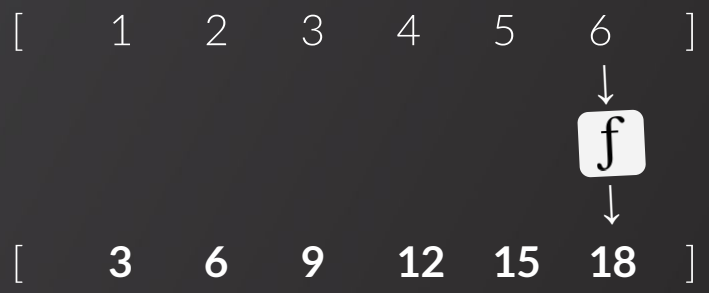


map

The function  can be a...

- One-liner lambda expression

```
.map(x -> x/2)
```

- More complex lambda expression

```
.map(x -> {
    … some code …
    return something;
})
```

- Just any function

```
.map(String::toUpperCase)
```

filter

- ***Intuition*** → keeps elements satisfying some condition
- Lambda has one argument and produces a boolean
- Value of boolean determines whether item should be kept

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[2000 2005 2010 2015 2020 2025]

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[2000 2005 2010 2015 2020 2025]

For each element `y`, what does `y != 2020` evaluate to?

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[**2000** 2005 2010 2015 2020 2025]
  ^

`y != 2020` evaluates to true

For each element `y`, what does `y != 2020` evaluate to?

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[**2000** 2005 2010 2015 2020 2025]
^

`y != 2020` evaluates to true

[2000

For each element `y`, what does `y != 2020` evaluate to?

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[2000 **2005** 2010 2015 2020 2025]

^

`y != 2020` evaluates to true

[2000 2005

For each element `y`, what does `y != 2020` evaluate to?

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[2000 2005 **2010** 2015 2020 2025]

^

`y != 2020` evaluates to true

[2000 2005 2010

For each element `y`, what does `y != 2020` evaluate to?

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[2000 2005 2010 **2015** 2020 2025]
^

`y != 2020` evaluates to true

[2000 2005 2010 2015

For each element `y`, what does `y != 2020` evaluate to?

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[2000 2005 2010 2015 **2020** 2025]
^

`y != 2020` evaluates to false

[2000 2005 2010 2015

For each element `y`, what does `y != 2020` evaluate to?

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[2000 2005 2010 2015 2020 **2025**]
^

`y != 2020` evaluates to true

[2000 2005 2010 2015 2025

For each element `y`, what does `y != 2020` evaluate to?

filter

```
List<Integer> goodYears = years
        .stream().filter(y -> y != 2020).collect(toList());
```

[2000 2005 2010 2015 2020 2025]

Result: new stream only containing values satisfying `y != 2020`

[2000 2005 2010 2015 2025]

filter

- No requirement to have simple or one-liner condition
  - ```
    List<Integer> leapYears =
            years.stream().filter(y -> {
                if (y % 400 == 0) return true;
                if (y % 100 == 0) return false;
                if (y %   4 == 0) return true;
                return false;
            }).collect(toList());
    ```
- Reminder: lambda is anonymous class implementing functional interface
- Implements `Predicate<T>` which has `boolean test(T t)`
    ```

sorted

```
var numbers = Arrays.asList(3, 2, 1, 5, 4, 7);
numbers.stream().sorted().forEach(System.out::println);
```

[3 2 1 5 4 7]

Result: new stream only containing values

[1 2 3 4 5 7]

distinct

```
var numbers = Arrays.asList(3,3,1,1,4,7,8);
numbers.stream().distinct().forEach(System.out::println);
```

[3 3 1 1 4 7 8]

Result: new stream only containing values

[3 1 4 7 8]

limit

```
var numbers = Arrays.asList(3,2,2,3,7,3,5);
numbers.stream().limit(4).forEach(System.out::println);
```

[3 2 2 3 7 3 5]

Result: new stream only containing values

[3 2 2 3]

collect (Reductions)

- `Stream.collect()` allows us to “reduce” a stream to a single output
- This process is called a “reduction”

Some scenarios:

- A list of vote counts in many districts of a state for two candidates can be ***reduced*** to an **aggregate vote count** for each candidate.
- A list of heights for athletes in a basketball team can be ***reduced*** to an **average height** for the whole team.
- A list of ages of students in a class can be ***reduced*** to the **maximum (oldest) age** in the class.

collect (Reductions)

- Create a list of heights (in inches) of team members on a Basketball team

```
List<Integer> teamHeights = List.of(73, 68, 75, 77, 74);
```

- Collect using a “reducer” created with `Collectors.reducing`
- Collectors.reducing() accepts initial accumulator value and a function with two parameters: current value of accumulator and current stream element value

```
int totalHeight = teamHeights.stream().collect(
    Collectors.reducing(0, (accumulator, curr) -> (accumulator + curr))
);
```

- `System.out.println(totalHeight);`
  - Prints: `367`

collect (Reductions)

```
Collectors.reducing(0, (accumulator, curr) -> (accumulator + curr))
```

```
[ 73, 68, 75, 77, 74 ]
  ^
```

```
Accumulator value:        0

Current stream element:   73

New accumulator value:    73
```

collect (Reductions)

```
Collectors.reducing(0, (accumulator, curr) -> (accumulator + curr))
```

```
[ 73, 68, 75, 77, 74 ]
      ^
```

```
Accumulator value:        73

Current stream element:   68

New accumulator value:    141
```

collect (Reductions)

```
Collectors.reducing(0, (accumulator, curr) -> (accumulator + curr))
```

[73, 68, **75**, 77, 74]

^

Accumulator value: 141

Current stream element: 75

New accumulator value: 216

collect (Reductions)

```
Collectors.reducing(0, (accumulator, curr) -> (accumulator + curr))
```

[73, 68, 75, **77**, 74]

^

Accumulator value: 216

Current stream element: 77

New accumulator value: 293

collect (Reductions)

```
Collectors.reducing(0, (accumulator, curr) -> (accumulator + curr))
```

[73, 68, 75, 77, **74**]

^

Accumulator value: 293

Current stream element: 74

New accumulator value: **367** **(Final result)**

Some More Common Stream Operations

count

Counts all elements in a stream (terminal)

skip

Gets rid of the first N elements

findFirst

Gets the first stream element wrapped in Optional (terminal)

toArray

Return elements as an array (terminal)

flatMap

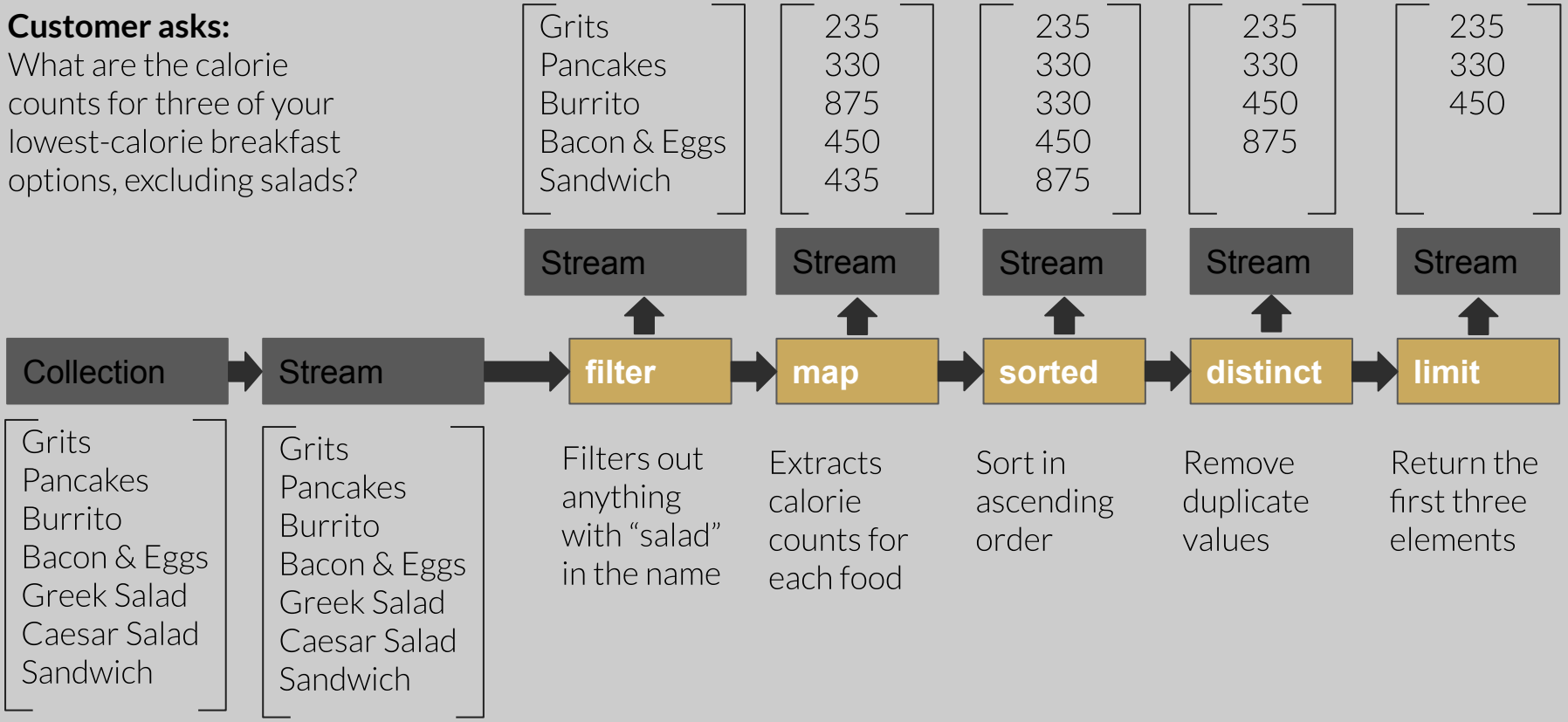
Flatten the data structure (e.g. on stream consisting of Lists)

peek

Do something with each item (like forEach, but not terminal)

Restaurant Example

Customer asks:
What are the calorie counts for three of your lowest-calorie breakfast options, excluding salads?



Streams in code...

- Allude to code example in Eclipse.
- End of presentation. Questions?