CS 213 – Software Methodology

Spring 2016

Lecture 28: Apr 28

Collecting Data With Streams (Java 8)

Example: Movie Stats

```
public class Movie {

    public static enum Genre {
       ACTION, ADVENTURE, DRAMA, MYSTERY, ROMANCE, SCIFI, THRILLER
    }

    private String name;
    private int year;
    private int rating;
    private Genre category;

    public Movie(String name, int year, int rating, Genre genre) {
       this.name=name; this.year=year; this.rating=rating; category=genre;
    }

    public String getName() { return name; }

    public int getYear() { return year; }

    public int getRating() { return rating; }

    public Genre getCategory() { return category; }

}
```

Example: Movie Stats

```
public static List<Movie> movies = Arrays.asList(
    new Movie("Max Max: Fury Road”,2015,
              5,Genre.ACTION),
    new Movie("Straight Outta Compton”, 2015,
              5,Genre.DRAMA),
    new Movie("Fifty Shades of Grey”, 2015,
              1,Genre.DRAMA),
    new Movie("American Sniper, 2014,
              4,Genre.ACTION),
    new Movie("Transcendence”, 2014,
              1,Genre.THRILLER),
    new Movie("Conan The Barbarian”, 2011,
              2,Genre.ADVENTURE),
    new Movie("The Last Airbender”, 2010,
              2,Genre.ADVENTURE),
    new Movie("Harry Potter and the Deathly Hallows: Part 1”, 2010,
              4,Genre.ADVENTURE),
    new Movie("Sicario”, 2015,
              4,Genre.MYSTERY),
    new Movie("The Gift”, 2000,
              3,Genre.MYSTERY)
    );
```

Movies: Ratings < 3

Want to get list of movies with ratings < 3

Collecting data from a stream:

```
List<String> badMovies =
    movies.stream()
          .filter(m -> m.getRating() < 3)
          .map(Movie::getName)
          .collect(toList());
System.out.println(badMovies);
```

collect the stream into a list

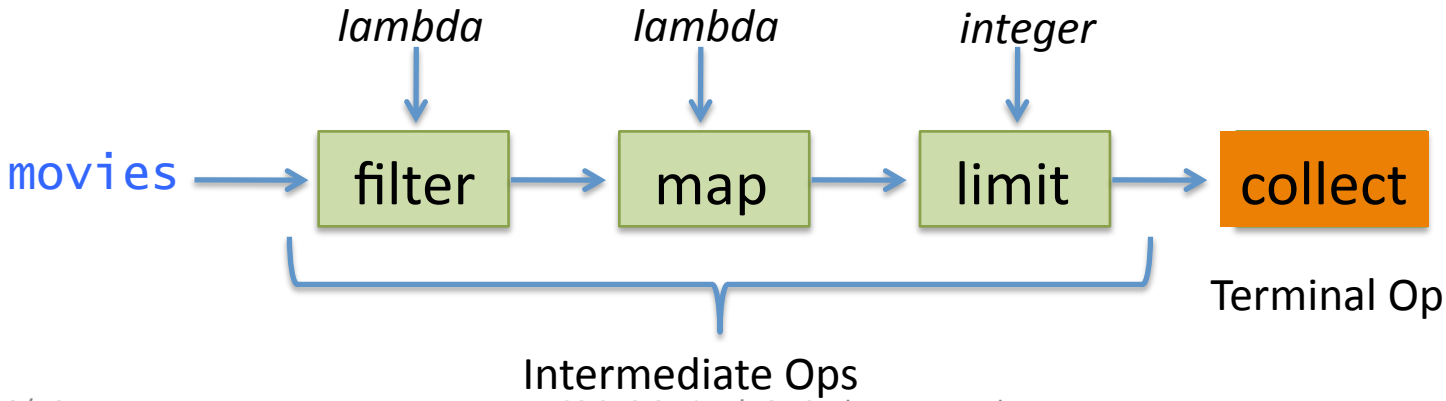
```
[Fifty Shades of Grey, Transcendence, Conan The Barbarian, The Last Airbender]
```

The `Stream collect` operation

`collect` is a terminal operation

A terminal operation produces a non-stream result

```
List<String> badMovies =
    movies.stream()
          .filter(m -> m.getRating() < 3)
          .map(Movie::getName)
          .limit(2)
          .collect(toList());
```



The `Collectors` class

`toList` is actually a static method in the `java.util.stream.Collectors` class

```
import static java.util.stream.Collectors.toList;

List<String> badMovies =
    movies.stream()
          .filter(m -> m.getRating() < 3)
          .map(Movie::getName)
          .limit(2)
          .collect(toList());
```

`toList` returns a `Collector` instance that can gather items in a stream into a `List` instance

This `Collector` is passed as a parameter to the `collect` method of a `Stream` instance

The `Collectors` class

The `Collectors` class provides static methods that return pre-defined `Collector` instances for the following:

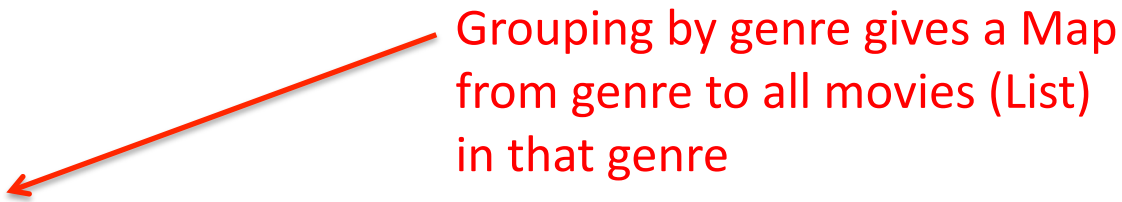
- Reducing and Summarizing
- Grouping
- Partitioning

`Collector` for Grouping

For all examples that follow assume we have coded this to import the required `Collectors` static methods as needed:

```
import static java.util.stream.Collectors.*;
```

Example: Grouping movies by genre:




```
Map<Movie.Genre, List<Movie>> moviesByGenre =
movies.stream()
  .collect(groupingBy(Movie::getCategory));

System.out.println(moviesByGenre);
```

`Collector` for Grouping

Here's the resulting Map for the previous code segment:

```
{
 ADVENTURE=[Conan The Barbarian, The Last Airbender, Harry Potter and the Deathly Hallows: Part 1],
 ACTION=[Max Max: Fury Road, American Sniper],
MYSTERY=[Sicario, The Gift], THRILLER=[Transcendence],
DRAMA=[Straight Outta Compton, Fifty Shades of Grey]
}
```

Each of the `Movie` instances in the map list of values is printed with a call to its `toString` method (which returns the name)

`Collector` for Partitioning

Partitioning is a special kind of grouping based on a predicate, so that there are two groups (partitions), one for when the predicate is false, and the other for when it is true

Example: Partition movies into before 2014, and the rest

```
Map<Boolean, List<Movie>> partitionedMovies =
    movies.stream()
   .collect(partitioningBy(m -> m.getYear() < 2014));

System.out.println(partitionedMovies);
```

```
{
   false=[Max Max: Fury Road, ...],
   true=[Conan The Barbarian, ...]
}
```

`Collector` for Reduction

Example: Count – find number of movies in list

```
long numMovies = movies.stream().collect(counting());
```

which is equivalent to:

```
long numMovies = movies.stream().count();
```

Example: Max – find any highest rated movie

```
Optional<Movie> maxRatedMovie =
movies.stream()
  .collect(maxBy(Comparator.comparingInt(Movie::getRating)));
maxRatedMovie.ifPresent(System.out::println);
```

which is equivalent to:

```
movies.stream().max(Comparator.comparingInt(Movie::getRating)
```

`Collector` for Summarizing

Example: Average – find average rating of movies in list

```
double avgRating =
movies.stream()
  .collect(averagingInt(Movie::getRating));
System.out.println(avgRating);
```

Returns 0 if no elements are present

which can be achieved without collect:

```
movies.stream()
      .mapToInt(Movie::getRating)
      .average()
      .ifPresent(System.out::println);
```

Can also do `summingInt` and summing/averaging for double and long types

`Collector` for Summary Stats

Example: Get summary rating stats for movies in list

In `java.util`

```
IntSummaryStatistics ratingStats =
movies.stream()
  .collect(summarizingInt(Movie::getRating));

System.out.println(ratingStats);
```

```
IntSummaryStatistics{count=10, sum=31, min=1, average=3.100000, max=5}
```

Can also do `DoubleSummaryStatistics` and `LongSummaryStatistics`

Collector for Grouping

Example: Group movies as good, ok, or bad –
good if rating > 3, ok if rating = 3, bad if rating < 3

Use: `public static enum MovieQuality { GOOD, OK, BAD};`

```
Map<MovieQuality, List<Movie>> moviesByQuality =
    movies.stream()
    .collect(groupingBy(
        movie -> {
            if (movie.getRating() > 3) return MovieQuality.GOOD;
            else if (movie.getRating() < 3) return MovieQuality.BAD;
            else return MovieQuality.OK;
        }));
System.out.println(moviesByQuality);
```

```
{
 BAD=[Fifty Shades of Grey, Transcendence, Conan The Barbarian, The Last Airbender],
 OK=[The Gift],
 GOOD=[Max Max: Fury Road, Straight Outta Compton, American Sniper, Harry …, Sicario]
}
```

Two-level Grouping

Example: Group movies by genre, then year

```
Map<Movie.Genre, Map<Integer, List<Movie>>>
moviesByGenreYear =
  movies.stream()
    .collect(groupingBy(Movie::getCategory,
                groupingBy(Movie::getYear)));
System.out.println(moviesByGenreYear);
```

```
{
 ADVENTURE={
   2010=[The Last Airbender, Harry Potter and the Deathly Hallows: Part 1],
   2011=[Conan The Barbarian]},
 ACTION={
   2014=[American Sniper],
   2015=[Max Max: Fury Road]},
 MYSTERY={
   2000=[The Gift], 2015=[Sicario]},
 THRILLER={
   2014=[Transcendence]},
  DRAMA={
   2015=[Straight Outta Compton, Fifty Shades of Grey]}
}
```

Two-level Collection

The second argument for `groupingBy` does not have to be a `groupingBy`, it could be other `Collector` functions.

Example: Count movies by genre

```
Map<Movie.Genre, Long>
numMoviesByGenre =
  movies.stream()
    .collect(groupingBy(Movie::getCategory,
                        counting()));
System.out.println(numMoviesByGenre);
```

```
{ADVENTURE=3, ACTION=2, MYSTERY=2, THRILLER=1, DRAMA=2}
```

The single-argument `groupingBy` is actually short for a 2-arg version with the second argument being `toList()`, which is why the resulting `Map` has a `List` for its value.

Two-level Collection

Example: Get (a) top-rated movie by genre

```
Map<Movie.Genre, Optional<Movie>>
topMoviesByGenre =
  movies.stream()
    .collect(groupingBy(Movie::getCategory,
                  maxBy(comparingInt(Movie::getRating))));
System.out.println(topMoviesByGenre);
```

```
{ADVENTURE=Optional[Harry Potter and the Deathly Hallows: Part 1],
 ACTION=Optional[Max Max: Fury Road], MYSTERY=Optional[Sicario],
 THRILLER=Optional[Transcendence], DRAMA=Optional[Straight Outta Compton]
}
```

`Optional` is of no relevance in this example, because if there is no movie in a genre, there will not be a key for it in the map.

Collecting and Transforming

Since `Optional` is of no use in the previous example, we want to replace the `Optional` value in the mapping with the name of the movie that it holds

To make this happen, we use a different `Collector`, generated by the method `collectingAndThen`

```
Map<Movie.Genre, Movie>
topMovieByGenre = movies.stream()
    .collect(
       groupingBy(Movie::getCategory,
         collectingAndThen(maxBy(comparingInt(Movie::getRating),
                                 Optional::get)));
System.out.println(topMovieByGenre);
```

```
{
  ADVENTURE=Harry Potter and the Deathly Hallows: Part 1,
  ACTION=Max Max: Fury Road, MYSTERY=Sicario,
  THRILLER=Transcendence, DRAMA=Straight Outta Compton
}
```

Two-level Collection

Suppose we want to list, for each genre, all the years for which movies are available in that genre: we want a mapping from genre to years

```
System.out.println("\nYears of movies by genre");

    Map<Movie.Genre, Map<Integer, List<Movie>>> yearMoviesByGenre =
    movies.stream()
          .collect(groupingBy(Movie::getCategory,
                              groupingBy(Movie::getYear)));
System.out.println(yearMoviesByGenre);
```

We can't apply a `groupingBy` on year at the second level because it gives another mapping, not a list of years.

```
{
  ADVENTURE={2010=[The Last Airbender, Harry Potter ...],
             2011=[Conan The Barbarian]},
  ACTION=...
}
```

Two-level Collection

To just get a list of years at the second level, we can use the static method `Collectors.mapping` that returns a `Collector` that can map unique values of a particular attribute (year in this case) to a set

```
System.out.println("\nYears of movies by genre");
   Map<Movie.Genre, Set<Integer>>> yearMoviesByGenre =
      movies.stream()
            .collect(groupingBy(Movie::getCategory,
                        mapping(Movie::getYear, toSet())));
System.out.println(yearMoviesByGenre);
```

```
{
  ADVENTURE=[2010, 2011], ACTION=[2014, 2015], MYSTERY=[2000, 2015],
  THRILLER=[2014],  DRAMA=[2015]
}
```

Three-level Collection

Example: Get movies by genre, then year, then rating

```
Map<Movie.Genre, Map<Integer, Map<Integer, List<Movie>>>>
movies3way =
   movies.stream()
         .collect(groupingBy(Movie::getCategory,
                  groupingBy(Movie::getYear,
                      groupingBy(Movie::getRating))));
```

```
{
 ADVENTURE= {
   2010={2=[The Last Airbender], 4=[Harry Potter and the Deathly Hallows: Part 1]},
   2011={2=[Conan The Barbarian]}},
 ACTION={
   2014={4=[American Sniper]}, 2015={5=[Max Max: Fury Road]}},
 MYSTERY={
   2000={3=[The Gift]}, 2015={4=[Sicario]}},
 THRILLER={2014={1=[Transcendence]}},
  DRAMA={2015={1=[Fifty Shades of Grey], 5=[Straight Outta Compton]}}}
}
```

Collecting on Primitive Stream

If you set up a primitive stream (such as `IntStream)` you will need to convert it into a stream of Integer objects before you can `collect`

```
IntStream.rangeClosed(2,n)
         .boxed()
         .collect(partitioningBy(i -> i % 2 == 0))
```

Useful `Collectors` static factory methods

Factory method	Return Type	Used to
toList	List<T>	Gather into a list
toSet	Set<T>	Gather into a set
counting	Long	Count items
map	Stream<R>	Function<T,R>
summingInt/averagingInt	Integer/Double	Function<T, Stream<R>>
summarizingInt	IntSummaryStatistics	Max, min, total, average
maxBy/minBy	Optional<T>	
reducing	Type of reduction	
collectingAndThen	Type of transformation	Collect+transform
groupingBy	Map<K,List<T>>	Group by K
partitioningBy	Map<Boolean,List<T>	Group by false/true

Both `groupingBy` and `partitioningBy` can take a `Collector` as the second argument, which will change the value type of the returned `Map`