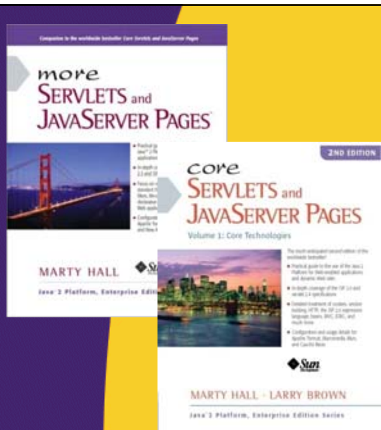
Streams in Java 8: Part 2

Originals of slides and source code for examples: http://www.coreservlets.com/java-8-tutorial/
Also see the general Java programming tutorial – http://courses.coreservlets.com/Course-Materials/java.html
and customized Java training courses (onsite or at public venues) – http://courses.coreservlets.com/java-training.html



Topics in This Section

- **More Stream methods**
  - reduce, sum
  - limit, skip
  - sorted, min, max , distinct
  - noneMatch, allMatch, anyMatch, count
- **Parallel Streams**
- **Infinite Streams**
  - Really unbounded streams with values that are calculated on the fly
- **Grouping stream elements**
  - Fancy uses of collect

reduce: Combining Stream Elements

reduce

- **Big idea**
  - You start with a seed (identity) value, combine this value with the first entry of the Stream, combine the result with the second entry of the Stream, and so forth
    - One version takes starter value and BinaryOperator. Returns result directly.
    - Alternative version takes BinaryOperator, with no starter. It starts by combining first two values with each other. Returns an Optional.
    - reduce is particularly useful when combined with map or filter
    - Works in parallel if operator is associative and has no side effects
- **Quick examples**
  - Maximum of numbers
    - nums.stream().reduce(Double.MIN_VALUE, Double::max)
      - There is also builtin "max" method, so you can do even better than the above
  - Product of numbers
    - nums.stream().reduce(1, (n1, n2) -> n1 * n2)

Concatenating Strings

- **Code**

This is the starter (identity) value. It is combined with the first entry in the Stream.

```
List<String> letters =
  Arrays.asList("a", "b", "c", "d");
String concat = letters.stream()
                       .reduce("", String::concat);
System.out.printf("Concatenation of %s is %s.%n",
                  letters, concat);
```

- **Results**

```
Concatenation of [a, b, c, d] is abcd.
```

This is the BinaryOperator. It is the same as (s1, s2) -> s1 + s2.
It concatenates the seed value with the first Stream entry, concatenates that resultant String with the second Stream entry, and so forth.

Concatenating Strings: Variations

- **Data**
  – List<String> letters = Arrays.asList("a", "b", "c", "d");
- **Various reductions**
  – letters.stream().reduce("", String::concat);
    → "abcd"
    - Remember that String::concat here is the same as if you had written the lambda (s1,s2) -> s1+s2
  – letters.stream().reduce("", (s1,s2) -> s2+s1);
    → "dcba"
    - This just reverses the order of the s1 and s2 in the concatenation
  – letters.stream().reduce("",
        (s1,s2) -> s2.toUpperCase() + s1.toUpperCase());
    → "DCBA"

Finding Biggest

- **Code**

```
List<Double> nums1 = Arrays.asList(1.2, -2.3, 4.5, -5.6);
double maxNum = nums1.stream().reduce(Double.MIN_VALUE,
                                      Double::max);
System.out.printf("Max of %s is %s.%n", nums1, maxNum);
Employee poorest = new Employee("None", "None", -1, -1);
BinaryOperator<Employee> richer = (e1, e2) -> {
  return(e1.getSalary() >= e2.getSalary() ? e1 : e2);
};
Employee richestGoogler = googlers().reduce(poorest, richer);
System.out.printf("Richest Googler is %s.%n",
                  richestGoogler);
```

- **Results**

```
Max of [1.2, -2.3, 4.5, -5.6] is 4.5.
Richest Googler is Larry Page [Employee#1 $9,999,999].
```

reduce uses the BinaryOperator to combine the starter value with the first Stream entry, then combines that result with the second Stream entry, and so forth.

Summing Numbers: Three Alternatives

- **Version 1: same reduce approach as before**

```
List<Integer> nums2 = Arrays.asList(1, 2, 3, 4);
int sum1 = nums2.stream().reduce(0, Integer::sum);
```

- **Version 2: using reduce with no starter**
  - Starts by combining first two Stream entries. Since there might not be enough entries, returns an Optional.

```
int sum2 =
  nums2.stream().reduce(Integer::sum).get();
```

- **Version 3: using sum method of IntStream**
  - Supplying int[] instead of Integer[] to Stream.of results in IntStream. IntStream has builtin sum method.

```
int[] nums3 = { 1, 2, 3, 4 };
int sum3 = Arrays.stream(nums3).sum();
```


Combining map and reduce

- **Code**

```
int sum4 = nums2.stream().map(EmployeeSamples::findGoogler)
                         .map(Employee::getSalary)
                         .reduce(0, Integer::sum);
System.out.printf
    ("Combined salaries of Googlers with IDs %s is $%,d.%n",
     nums2, sum4);
```

- **Results**

```
Combined salaries of Googlers with IDs [1, 2, 3, 4]
is $33,333,330.
```

Operations that Limit the Stream Size: limit, skip

Limiting Stream Size

- **Big ideas**
  - limit(n) returns a Stream of the first n elements.
  - skip(n) returns a Stream starting with element n (i.e., it throws away the first n elements)
    - Note: this was called substream in most Java-8 beta releases, and was renamed to skip quite late. But, skip is better name.
  - Both are short-circuit operations. E.g., if you have a 1000-element stream and then do the following, it applies fn1 exactly 10 times, evaluates pred exactly 10 times, and applies fn2 at most 10 times

```
strm.map(fn1).filter(pred).map(fn2).limit(10)
```

- **Quick examples**
  - First 10 elements
    - someLongStream.limit(10)
  - Last 15 elements
    - twentyElementStream.skip(5)

limit and skip: Example

- **Code**

```
List<String> emps =
  googlers().map(Person::getFirstName)
            .limit(8)
            .skip(2)
            .collect(Collectors.toList());
System.out.printf("Names of 6 Googlers: %s.%n", emps);
```

- **Point**
  – getFirstName is called only 6 times, even if Stream has 10,000 elements
- **Results**

```
Names of 6 Googlers:
  [Eric, Nikesh, David, Patrick, Susan, Peter].
```


Operations that use Comparisons: sorted, min, max, distinct

Comparisons

- **Big ideas**
  – Sorting Streams is more flexible than sorting arrays because you can do filter and mapping operations first
  – min and max are more efficient than sorting in forward or reverse order, then taking first
  – distinct uses equals as its comparison
- **Quick examples**
  – Sorting by salary
```
empStream.map(…).filter(…).limit(…)
  .sorted((e1, e2) -> e1.getSalary() - e2.getSalary())
```
  – Richest Employee
```
empStream.max((e1, e2) -> e1.getSalary() –
                          e2.getSalary())
         .get();
```
  – Words with duplicates removed
```
stringStream.distinct()
```


Sorting

- **Big ideas**
  – The advantage of someStream.sorted(…) over Arrays.sort(…) is that with Streams you can first do operations like map, filter, limit, skip, and distinct
  – Doing limit or skip after sorting does *not* short-circuit in the same manner as in the previous section
    - Because the system does not know which are the first or last elements until after sorting
  – If the Stream elements implement Comparable, you may omit the lambda and just use someStream.sorted(). Rare.
- **Supporting code from Person class**
```
public int firstNameComparer(Person other) {
  System.out.println("Comparing first names");
  return(firstName.compareTo(other.getFirstName()));
}
```

Sorting by Last Name: Example

- **Code**

```
List<Integer> ids = Arrays.asList(9, 11, 10, 8);
List<Employee> emps1 =
  ids.stream().map(EmployeeSamples::findGoogler)
              .sorted((e1, e2) ->
                          e1.getLastName()
                            .compareTo(e2.getLastName()))
              .collect(Collectors.toList());
System.out.printf
    ("Googlers with ids %s sorted by last name: %s.%n",
     ids, emps1);
```

- **Results**

```
Googlers with ids [9, 11, 10, 8] sorted by last name:
  [Gilad Bracha [Employee#11 $600,000],
   Jeffrey Dean [Employee#9 $800,000],
   Sanjay Ghemawat [Employee#10 $700,000],
   Peter Norvig [Employee#8 $900,000]].
```


Sorting by First Name then Limiting: Example

- **Code**

```
List<Employee> emps3 =
  sampleEmployees().sorted(Person::firstNameComparer)
                   .limit(2)
                   .collect(Collectors.toList());
System.out.printf("Employees sorted by first name: %s.%n",
                  emps3);
```

- **Point**
  - The use of limit(2) does *not* reduce the number of times firstNameComparer is called (vs. no limit at all)
- **Results**

```
Employees sorted by first name:
  [Amy Accountant [Employee#25 $85,000],
   Archie Architect [Employee#16 $144,444]].
```

min and max

- **Big ideas**
  - min and max use the same type of lambdas as sorted, letting you flexibly find the first or last elements based on various different criteria
    - min and max could be easily reproduced by using reduce, but this is such a common case that the short-hand reduction methods (min and max) are built in
  - min and max both return an Optional
  - Unlike with sorted, you must provide a lambda, regardless of whether or not the Stream elements implement Comparable
- **Performance implications**
  - Using min and max is faster than sorting in forward or reverse order, then using findFirst
    - min and max are O(n), sorted is O(n log n)

min: Example

- **Code**

```
Employee alphabeticallyFirst =
  ids.stream().map(EmployeeSamples::findGoogler)
              .min((e1, e2) ->
                       e1.getLastName()
                         .compareTo(e2.getLastName()))
              .get();
System.out.printf
    ("Googler from %s with earliest last name: %s.%n",
     ids, alphabeticallyFirst);
```

- **Results**

```
Googler from [9, 11, 10, 8] with earliest last name:
  Gilad Bracha [Employee#11 $600,000].
```

max: Example

- **Code**

```
Employee richest =
  ids.stream().map(EmployeeSamples::findGoogler)
              .max((e1, e2) -> e1.getSalary() -
                               e2.getSalary())
              .get();
System.out.printf("Richest Googler from %s: %s.%n",
                  ids, richest);
```

- **Results**

```
Richest Googler from [9, 11, 10, 8]:
  Peter Norvig [Employee#8 $900,000].
```


distinct: Example

- **Code**

```
List<Integer> ids2 =
  Arrays.asList(9, 10, 9, 10, 9, 10);
List<Employee> emps4 =
  ids2.stream().map(EmployeeSamples::findGoogler)
               .distinct()
               .collect(Collectors.toList());
System.out.printf("Unique Googlers from %s: %s.%n",
                  ids2, emps4);
```

- **Results**

```
Unique Googlers from [9, 10, 9, 10, 9, 10]:
  [Jeffrey Dean [Employee#9 $800,000],
   Sanjay Ghemawat [Employee#10 $700,000]].
```

Operations that Check Matches: allMatch, anyMatch, noneMatch, count

Checking Matches

- **Big ideas**
  - allMatch, anyMatch, and noneMatch take a Predicate and return a boolean. They stop processing once an answer can be determined.
    - E.g., if the first element fails the Predicate, allMatch would immediately return false and skip checking other elements
  - count simply returns the number of elements
    - count is a terminal operation, so you cannot first count the elements, then do a further operation on the same Stream based on the count
- **Quick examples**
  - Is there at least one rich dude?
    - employeeStream.anyMatch(e -> e.getSalary() > 500000)
  - How many employees match the criteria?
    - employeeStream.filter(somePredicate).count()

Matches: Examples

- **Code**

```
boolean isNobodyPoor =
  googlers().noneMatch(e -> e.getSalary() < 200000);
Predicate<Employee> megaRich = e -> e.getSalary() > 7000000;
boolean isSomeoneMegaRich = googlers().anyMatch(megaRich);
boolean isEveryoneMegaRich = googlers().allMatch(megaRich);
long numberMegaRich = googlers().filter(megaRich).count();
System.out.printf("Nobody poor? %s.%n", isNobodyPoor);
System.out.printf("Someone mega rich? %s.%n", isSomeoneMegaRich);
System.out.printf("Everyone mega rich? %s.%n", isEveryoneMegaRich);
System.out.printf("Number mega rich: %s.%n", numberMegaRich);
```

- **Results**

```
Nobody poor? true.
Someone mega rich? true.
Everyone mega rich? false.
Number mega rich: 3.
```


Parallel Streams

Parallel Streams

- **Big idea**
  - By designating that a Stream be parallel, the operations are automatically done in parallel.
  - No explicit multi-threading code is required.
    - This is easiest to see with methods like forEach (assuming the operation is thread-safe!): the performance should scale linearly with the number of cores. But, even operations like map, filter, reduce, and findAny can get big performance gains. Operations in those cases must be stateless and non-interfering (and reduce op must be associative).
- **Quick examples**
  - Do side effects serially
    - someStream.forEach(someThreadSafeOp)
  - Do side effects concurrently
    - someStream.parallel().forEach(someThreadSafeOp)

Helper Methods for Timing

```
private static void timingTest(Stream<Employee> testStream) {
  long startTime = System.nanoTime();
  testStream.forEach(e -> doSlowOp());
  long endTime = System.nanoTime();
  System.out.printf(" %.3f seconds.%n",
                    deltaSeconds(startTime, endTime));
}

private static double deltaSeconds(long startTime,
                                   long endTime) {
  return((endTime - startTime) / 1000000000);
}
```

Helper Method: Operation that Takes One Second

```
// Simulate a time-consuming operation

private static void doSlowOp() {
  try {
    TimeUnit.SECONDS.sleep(1);
  } catch (InterruptedException ie) {
    // Nothing to do here.
  }
}
```


Parallel Example: Code

```
System.out.print("Serial version [11 entries]:");
timingTest(googlers());
int numProcessorsOrCores =
  Runtime.getRuntime().availableProcessors();
System.out.printf("Parallel version on %s-core machine:",
                  numProcessorsOrCores);
timingTest(googlers().parallel());
System.out.print("Serial version [4 entries]:");
timingTest(googlers().limit(4));
System.out.printf("Parallel version on %s-core machine:",
                  numProcessorsOrCores);
timingTest(googlers().parallel().limit(4));
```

Parallel Example: Results

```
Serial version [11 entries]: 11.000 seconds.
Parallel version on 4-core machine: 3.000 seconds.
Serial version [4 entries]: 4.000 seconds.
Parallel version on 4-core machine: 1.000 seconds.
```


Infinite (Unbounded On-the-Fly) Streams

Infinite Streams: Big Ideas

- **Stream.generate(valueGenerator)**
  - Stream.generate lets you specify a Supplier. This Supplier is invoked each time the system needs a Stream element.
    - Powerful when Supplier maintains state, but won't work in parallel
- **Stream.iterate(initialValue, valueTransformer)**
  - Stream.iterate lets you specify a seed and a UnaryOperator f. The seed becomes the first element of the Stream, f(seed) becomes the second element, f(second) becomes third element, etc.
- **Usage**
  - The values are not calculated until they are needed
  - To avoid unterminated processing, you must eventually use a size-limiting operation like limit or findFirst (but not skip alone)
    - The point is not really that this is an "infinite" Stream, but that it is an unbounded "on the fly" Stream – one with no fixed size, where the values are calculated as you need them.

generate

- **Big ideas**
  - You supply a function (Supplier) to Stream.generate. Whenever the system needs stream elements, it invokes the function to get them.
  - You must limit the Stream size.
    - Usually with limit. skip alone is not enough, since the size is still unbounded
  - The function can maintain state so that new values are based on any or all of the previous values
- **Quick example**

```
List<Employee> emps =
  Stream.generate(() -> randomEmployee())
        .limit(…)
        .collect(Collectors.toList());
```

Stateless generate Example: Random Numbers

- **Code**

```
Supplier<Double> random = Math::random;
System.out.println("2 Random numbers:");
Stream.generate(random).limit(2).forEach(System.out::println);
System.out.println("4 Random numbers:");
Stream.generate(random).limit(4).forEach(System.out::println);
```

- **Results**

```
2 Random numbers:
0.00608980775038892
0.2696067924164013
4 Random numbers:
0.7761651889987567
0.818313574113532
0.07824375091607816
0.7154788145391667
```


Stateful generate Example: Supplier Code

```
public class FibonacciMaker implements Supplier<Long> {
  private long previous = 0;
  private long current = 1;

  @Override
  public Long get() {
    long next = current + previous;
    previous = current;
    current = next;
    return(previous);
  }
}
```

Lambdas cannot define instance variables, so we use a regular class instead of a lambda to define the Supplier.

Helper Code: Simple Methods to Get Any Amount of Fibonaccis

```
public static Stream<Long> makeFibStream() {
  return(Stream.generate(new FibonacciMaker()));
}

public static Stream<Long> makeFibStream(int numFibs) {
  return(makeFibStream().limit(numFibs));
}

public static List<Long> makeFibList(int numFibs) {
  return(makeFibStream(numFibs)
               .collect(Collectors.toList()));
}

public static Long[] makeFibArray(int numFibs) {
  return(makeFibStream(numFibs).toArray(Long[]::new));
}
```


Stateful generate Example

- **Main code**

```
System.out.println("5 Fibonacci numbers:");
FibStream.makeFibStream(5)
         .forEach(System.out::println);
System.out.println("25 Fibonacci numbers:");
FibStream.makeFibStream(25)
         .forEach(System.out::println);
```

- **Results**

```
5 Fibonacci numbers:
1
1
2
3
5
25 Fibonacci numbers:
1
1
...
75025
```

iterate

- **Big ideas**
  - You specify a seed value and a UnaryOperator f. The seed becomes the first element of the Stream, f(seed) becomes the second element, f(second) [i.e., f(f(seed))] becomes third element, etc.
  - You must limit the Stream size.
    - Usually with limit. skip alone is not enough, since the size is still unbounded
- **Quick example**

```
List<Integer> powersOfTwo =
  Stream.iterate(1, n -> n * 2)
        .limit(…)
        .collect(Collectors.toList());
```


Simple Example: Twitter Messages

- **Idea**
  - Generate a series of Twitter messages
- **Approach**
  - Start with a very short String as the first message
  - Append exclamation points on the end
  - Continue to 140-character limit
- **Core code**

```
Stream.iterate("Base Msg",
               msg -> msg + "Suffix")
      .limit(someCutoff)
```

Twitter Messages

- **Code**

```
System.out.println("14 Twitter messages:");
Stream.iterate("Big News!!",
               msg -> msg + "!!!!!!!!!!")
      .limit(14)
      .forEach(System.out::println);
```

- **Results**

```
Big News!!
Big News!!!!!!!!!!!!
Big News!!!!!!!!!!!!!!!!!!!!!!
Big News!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
[Etc]
```


More Complex Example: Large Prime Numbers

- **Idea**
  - Generate a series of very large consecutive prime numbers (e.g., 100 or 150 digits or more)
  - Large primes are used extensively in cryptography
- **Approach**
  - Start with a prime BigInteger as the seed
  - Supply a UnaryOperator that finds the first prime number higher than the given one
- **Core code**

```
Stream.iterate(Primes.findPrime(numDigits),
               Primes::nextPrime)
      .limit(someCutoff)
```

Helper Methods: Idea

- **Idea**
  – Generate a random odd BigInteger of the requested size, check if prime, keep adding 2 until you find a match.
- **Why this is feasible**
  – The BigInteger class has a builtin probabilistic algorithm (Miller-Rabin test) for determining if a number is prime without attempting to factor it. It is ultra-fast even for 100-digit or 200-digit numbers.
  – Technically, there is a 2^{100} chance that this falsely identifies a prime, but since 2^{100} is about the number of particles in the universe, that's not a very big risk
    - Algorithm is not fooled by Carmichael numbers

Helper Methods: Code

```
public static BigInteger nextPrime(BigInteger start) {
  if (isEven(start)) {
    start = start.add(ONE);
  } else {
    start = start.add(TWO);
  }
  if (start.isProbablePrime(ERR_VAL)) {
    return(start);
  } else {
    return(nextPrime(start));
  }
}
public static BigInteger findPrime(int numDigits) {
  if (numDigits < 1) {
    numDigits = 1;
  }
  return(nextPrime(randomNum(numDigits)));
}
```

Complete source code can be downloaded from http://www.coreservlets.com/java-8-tutorial/

Making Stream of Primes

```
public static Stream<BigInteger> makePrimeStream(int numDigits) {
  return(Stream.iterate(Primes.findPrime(numDigits),
                        Primes::nextPrime));
}


public static Stream<BigInteger> makePrimeStream(int numDigits,
                                                 int numPrimes) {
  return(makePrimeStream(numDigits).limit(numPrimes));
}

public static List<BigInteger> makePrimeList(int numDigits,
                                             int numPrimes) {
  return(makePrimeStream(numDigits, numPrimes).
              collect(Collectors.toList()));
}

public static BigInteger[] makePrimeArray(int numDigits, int numPrimes) {
  return(makePrimeStream(numDigits, numPrimes).toArray(BigInteger[]::new));
}
```


Primes

- **Code**

```
System.out.println("10 100-digit primes:");
PrimeStream.makePrimeStream(100, 10)
               .forEach(System.out::println);
```

- **Results**

```
10 100-digit primes:
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867976353
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867976647
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867976663
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867976689
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867977233
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867977859
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867977889
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867977989
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867978031
3484894489805924599033259501599559961057903572743870105972345438458556253531271262848463552867978103
```

collect: Fancier Stream Output

Customized Java EE Training: http://courses.coreservlets.com/
Java 7, Java 8, JSF 2.2, PrimeFaces, JSP, Ajax, jQuery, Spring, Hibernate, RESTful Web Services, Hadoop, Android.
Developed and taught by well-known author and developer. At public venues or onsite at *your* location.

collect

- **Big idea**
  - Combined with methods in the Collectors class, you can build many data types out of Streams
- **Quick examples**
  - List (shown in previous section)
    - anyStream.collect(toList())
  - String
    - stringStream.collect(joining(*delimiter*)).toString()
  - Set
    - anyStream.collect(toSet())
  - Other collection
    - anyStream.collect(toCollection(*CollectionType*::new))
  - Map
    - strm.collect(partioningBy(...)), strm.collect(groupingBy(...))

The examples here assume you have done "import static java.util.stream.Collectors.*", so that toList() really means Collectors.toList()

Building Lists

- **Code**

```
List<Integer> ids = Arrays.asList(2, 4, 6, 8);
List<Employee> emps =
  ids.stream().map(EmployeeSamples::findGoogler)
              .collect(Collectors.toList());
System.out.printf("Googlers with ids %s: %s.%n",
                  ids, emps);
```

- **Results**

```
Googlers with ids [2, 4, 6, 8]:
  [Sergey Brin [Employee#2 $8,888,888],
   Nikesh Arora [Employee#4 $6,666,666],
   Patrick Pichette [Employee#6 $4,444,444],
   Peter Norvig [Employee#8 $900,000]].
```

Remember that you can do a static import on java.util.stream.Collectors.* so that you can use toList() instead of Collectors.toList().

Also recall that List has a builtin toString method that prints the entries comma-separated inside square brackets. Here and elsewhere, line breaks and whitespace added to printouts for readability.

Aside: The StringJoiner Class

- **Big idea**
  - Java 8 added new StringJoiner class that builds delimiter-separated Strings, with optional prefix and suffix
  - Java 8 also added static “join” method to the String class; it uses StringJoiner
- **Quick examples (result: "Java, Lisp, Ruby")**
  - Explicit StringJoiner with no prefix or suffix

```
StringJoiner joiner1 = new StringJoiner(", ");
String result1 =
   joiner1.add("Java").add("Lisp").add("Ruby").toString();
```

  - Usually easier: String.join convenience method

```
String result2 = String.join(", ", "Java", "Lisp", "Ruby");
```

Building Strings

- **Code**

```
List<Integer> ids = Arrays.asList(2, 4, 6, 8);
String lastNames =
  ids.stream().map(EmployeeSamples::findGoogler)
              .map(Employee::getLastName)
              .collect(Collectors.joining(", "))
              .toString();
System.out.printf("Last names of Googlers with ids %s: %s.%n",
                  ids, lastNames);
```

- **Results**

```
Last names of Googlers with ids [2, 4, 6, 8]:
Brin, Arora, Pichette, Norvig.
```


Building Sets

- **Code**

```
Set<String> firstNames =
  googlers().map(Employee::getFirstName)
            .collect(Collectors.toSet());
Stream.of("Larry", "Harry", "Peter", "Deiter", "Eric", "Barack")
      .forEach(s -> System.out.printf
                       ("%s is a Googler? %s.%n",
                        s,
                        firstNames.contains(s) ? "Yes" : "No"));
```

- **Results**

```
Larry is a Googler? Yes.
Harry is a Googler? No.
Peter is a Googler? Yes.
Deiter is a Googler? No.
Eric is a Googler? Yes.
Barack is a Googler? No.
```

Building Other Collections

- **Big idea**
  - You provide a Supplier<Collection> to collect. Java takes the resultant Collection and then calls "add" on each element of the Stream.
- **Quick examples**
  - ArrayList
    - someStream.collect(toCollection(ArrayList::new))
  - TreeSet
    - someStream.collect(toCollection(TreeSet::new))
  - Stack
    - someStream.collect(toCollection(Stack::new))
  - Vector
    - someStream.collect(toCollection(Vector::new))

The examples here assume you have done "import static java.util.stream.Collectors.*", so that toCollection(...) really means Collectors.toCollection(...)

Building Other Collections: TreeSet

- **Code**

```
TreeSet<String> firstNames2 =
  googlers().map(Employee::getFirstName)
            .collect(Collectors.toCollection(TreeSet::new));
Stream.of("Larry", "Harry", "Peter", "Deiter", "Eric", "Barack")
      .forEach(s -> System.out.printf
                      ("%s is a Googler? %s.%n",
                       s,
                       firstNames2.contains(s) ? "Yes" : "No"));
```

- **Results**

```
Larry is a Googler? Yes.
Harry is a Googler? No.
Peter is a Googler? Yes.
Deiter is a Googler? No.
Eric is a Googler? Yes.
Barack is a Googler? No.
```

partioningBy: Building Maps

- **Big idea**
  - You provide a Predicate. It builds a Map where true maps to a List of entries that passed the Predicate, and false maps to a List that failed the Predicate.
- **Quick example**

```
Map<Boolean,List<Employee>> oldTimersMap =
  employeeStream().collect
    (partitioningBy(e -> e.getEmployeeId() < 10));
```

  - Now, oldTimersMap.get(true) returns a List<Employee> of employees whose ID's are less than 10, and oldTimersMap.get(false) returns a List<Employee> of everyone else.

partitioningBy: Example

- **Code**

```
Map<Boolean,List<Employee>> richTable =
  googlers().collect
           (partitioningBy(e -> e.getSalary() > 1000000));
System.out.printf("Googlers with salaries over $1M: %s.%n",
                  richTable.get(true));
System.out.printf("Destitute Googlers: %s.%n",
                  richTable.get(false));
```

- **Results**

```
Googlers with salaries over $1M: [Larry Page [Employee#1 $9,999,999],
Sergey Brin [Employee#2 $8,888,888], Eric Schmidt [Employee#3 $7,777,777],
Nikesh Arora [Employee#4 $6,666,666], David Drummond [Employee#5 $5,555,555],
Patrick Pichette [Employee#6 $4,444,444],
Susan Wojcicki [Employee#7 $3,333,333]].

Destitute Googlers: [Peter Norvig [Employee#8 $900,000],
Jeffrey Dean [Employee#9 $800,000], Sanjay Ghemawat [Employee#10 $700,000],
Gilad Bracha [Employee#11 $600,000]].
```

groupingBy:
Another Way of Building Maps

- **Big idea**
  - You provide a Function. It builds a Map where each output value of the Function maps to a List of entries that gave that value.
    - E.g., if you supply Employee::getFirstName, it builds a Map where supplying a first name yields a List of employees that have that first name.
- **Quick example**

```
Map<Department,List<Employee>> deptTable =
  employeeStream()
    .collect(Collectors.groupingBy(Employee::getDepartment));
```

  - Now, deptTable.get(someDepartment) returns a List<Employee> of everyone in that department.

groupingBy: Supporting Code

- **Idea**
  - Make a class called Emp that is a simplified Employee that has a first name, last name, and office/location name, all as Strings.
- **Sample Emps**

```
private static Emp[] sampleEmps = {
  new Emp("Larry", "Page", "Mountain View"),
  new Emp("Sergey", "Brin", "Mountain View"),
  new Emp("Lindsay", "Hall", "New York"),
  new Emp("Hesky", "Fisher", "New York"),
  new Emp("Reto", "Strobl", "Zurich"),
  new Emp("Fork", "Guy", "Zurich"),
};
public static List<Emp> getSampleEmps() {
  return(Arrays.asList(sampleEmps));
}
```

groupingBy: Example

- **Code**

```
Map<String,List<Emp>> officeTable =
  EmpSamples.getSampleEmps().stream()
            .collect(Collectors.groupingBy(Emp::getOffice));
System.out.printf("Emps in Mountain View: %s.%n",
                  officeTable.get("Mountain View"));
System.out.printf("Emps in NY: %s.%n",
                  officeTable.get("New York"));
System.out.printf("Emps in Zurich: %s.%n",
                  officeTable.get("Zurich"));
```

- **Results**

```
Emps in Mountain View:
  [Larry Page [Mountain View], Sergey Brin [Mountain View]].
Emps in NY: [Lindsay Hall [New York], Hesky Fisher [New York]].
Emps in Zurich: [Reto Strobl [Zurich], Fork Guy [Zurich]].
```


Wrap-Up

Summary: More Stream Methods

- **reduce**
  - someStream.reduce(seedValue, someBinaryOperator)
    - Also someStream.reduce(binaryOp), returning an Optional
- **Limiting Stream size**
  - limit, skip
    - Cause short-circuiting
- **Using comparisons**
  - sorted, min, max, distinct
- **Finding matches**
  - allMatch, anyMatch, noneMatch, count
- **Fancy output for "collect"**
  - toList, joining, toSet, toCollection, partioningBy, groupingBy

Summary: Fancy Stream Types

- **Parallel Streams**
  - anyStream.parallel().forEach(someOperation)
    - Useful also for findAny, map, filter, reduce, etc.
- **Infinite (unbounded on-the-fly) Streams**
  - Stream.generate(someStatelessSupplier).limit(…)
  - Stream.generate(someStatefullSupplier).limit(…)
  - Stream.iterate(seedValue, operatorOnSeed).limit(…)
    - The benefit is that there is no predetermined number of entries: values are calculated as you need them

Questions?

More info:
http://courses.coreservlets.com/Course-Materials/java.html – General Java programming tutorial
http://www.coreservlets.com/java-8-tutorial/ – Java 8 tutorial
http://courses.coreservlets.com/java-training.html – Customized Java training courses, at public venues or onsite at *your* organization
http://coreservlets.com/ – JSF 2, PrimeFaces, Java 7 or 8, Ajax, jQuery, Hadoop, RESTful Web Services, Android, HTML5, Spring, Hibernate, Servlets, JSP, GWT, and other Java EE training