JAVA 8

Course Objectives

Why Java 8 ?

- Most popular and widely accepted language in the world.

- Java creators wanted to introduce the Functional features such as:
  - Lambdas
  - Streams
  - Optional and etc.,

- Technological advancements with the mobile/laptops/systems.

- New **Java 8** features simplify the concurrency operations.

Functional Programming:

- Embraces creating Immutable objects.
- More concise and readable code.
- Using functions/methods as first class citizens.

Example:

```
Function<String,String> addSomeString =  (name) ->
name.toUpperCase().concat("default");
```

- Write code using **Declarative approach**.

Imperative vs Declarative Programming

Imperative Style of Programming

- Focuses on how to perform the operations.
- Embraces Object mutability.
- This style of programming lists the step by step of instructions on how to achieve an objective.
- We write the code on what needs to be done in each step.
- Imperative style is used with classic Object Oriented Programming.

Declarative Style of Programming

- Focuses on what is the result you want.
- Embraces Object immutability.
- Analogous to **SQL** (Structured Query Languague).
- Use the functions that are already part of the library to achieve an objective.
- Functional Programming uses the concept of declarative programming.

Imperative vs Declarative Programming

Example 1

Sum of 100 numbers from 0 to 100

```
public static void main(String[] args) {
int sum1 = 0;
for (int j = 0; j < 100; j++) {  // method 1
sum1 = sum1 + j;
}
System.out.println(sum1);
//method 2
int sum = IntStream.range(0, 100).sum();
System.out.println(sum);

}
```

Imperative vs Declarative Programming

Example 2

Removing duplicates from a list of integers

```
public static void main(String[] args) {
List<Integer> list1 = new ArrayList(Arrays.asList(3, 4, 4, 5, 7, 3, 3, 4, 5, 6, 7,
8, 98, 9, 9, 9));
List<Integer> collect = list1.stream().distinct().collect(Collectors.toList());
System.out.println(collect);
}
```

Imperative Programming

```
public static void main(String[] args) {
List<Integer> list1 = new ArrayList(Arrays.asList(3, 4, 4, 5, 7, 3, 3, 4, 5, 6, 7, 8,
98, 9, 9, 9));
System.out.println(removeDuplicate(list1));
}

public static List<Integer> removeDuplicate(List<Integer> origianlList) {
ArrayList<Integer> list = new ArrayList();
for (int i = 0; i < origianlList.size(); i++) {
if (!list.contains(origianlList.get(i))) {
list.add(origianlList.get(i));
}
}
return list;
}
```

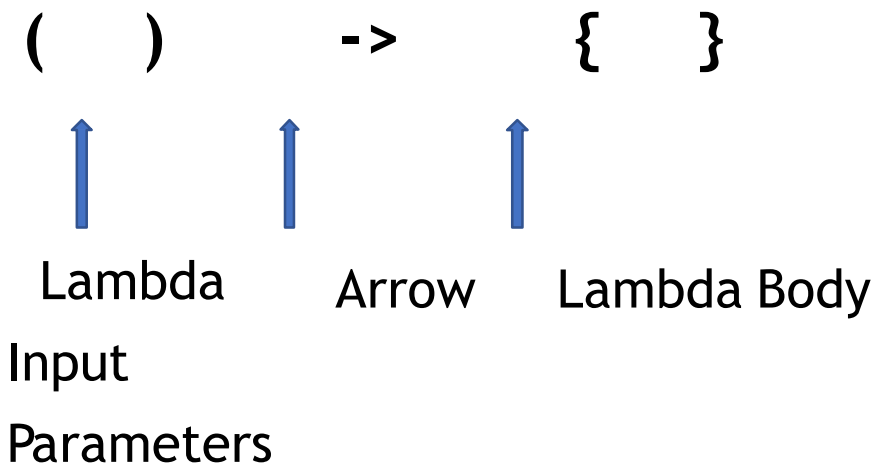
What is Lambda Expression?

- **Lambda** is equivalent to a function (method) without a name.

- Lambda's are also referred as **Anonymous** functions.
  - Method parameters
  - Method Body
  - Return Type
- Lambdas are not tied to any class like a regular method.
- Lambda can also be assigned to variable and passed around.

Syntax of the Lambda Expression

Lambda Expression:



Usages of Lambda

- Lambda is mainly used to implement Functional Interfaces(SAM).

```
@FunctionalInterface
public interface Comparator<T> {
     int compare(T o1, T o2);
}

@FunctionalInterface
public interface Runnable {
    public abstract void run();
}
```

Lets code our first Lambda!

Implement Runnable using Lambda

Lambda in Practice (Things to keep in Mind)

( ) -> Single Statement or Expression; // curly braces are not needed.

( )-> { <Multiple Statements> }; // curly braces are needed for multiple //statements

Lambdas vs Legacy Java(until Java7)

Legacy:

```
Runnable runnable = new Runnable() {
    @Override
    public void run() {
        System.out.println("Inside Runnable 1");
    }
};
```

Java 8:

```
Runnable runnableLambda = () -> {System.out.println("Inside Runnable 2");};
```

Functional Interfaces

- Exists since Java 1.0

Definition:

- A Functional Interface(SAM) is an interface that has exactly one abstract method.

@FunctionalInterface:

- This annotation is introduced as part of the JDK 1.8.

- Optional annotation to signify an interface as Functional Interface.

New Functional Interfaces in Java8

- Consumer
- Predicate
- Function
- Supplier

New Functional Interfaces in Java8

- Consumer – BiConsumer
- Predicate - BiPredicate
- Function – BiFunction, UnaryOperator, BinaryOperator
- Supplier

New Functional Interfaces in Java8

- **Consumer** – IntConsumer, DoubleConsumer, LongConsumer
- **Predicate** – IntPredicate, BiPredicate, LongPredicate
- **Function** – IntFunction, DoubleFunction,
  LongFunction,IntToDoubleFunction,
  IntoLongFunction,DoubletoIntFunction,
  DoubletoLongFunction,LongtoIntFunction,
  LongtoDoubleFunction,ToIntFunction,
  ToDoubleFunction,ToLongFunction
- **Supplier** – IntSupplier, LongSupplier, DoubleSupplier, BooleanSupplier

Method Reference

- Introduced as part of Java 8 and its purpose is to simplify the implementation Functional Interfaces.
- Shortcut for writing the **Lambda Expressions**.
- Refer a method in a class.

Syntax of Method Reference

ClassName::instance-methodName

ClassName::static-methodName

Instance::methodName

Where to use Method Reference?

- Lambda expressions referring to a method directly.

Using Lambda:

Function<String,String> *toUpperCaseLambda* = (s)->s.toUpperCase();

Using Method Reference:

Function<String,String> *toUpperCaseMethodRefernce* =
String::toUpperCase;

Where Method Reference is not Applicable ?

Example:

Predicate<Student> *predicateUsingLambda* = (s) -> s.getGradeLevel()>=3;

Constructor Reference

- Introduced as part of Java 1.8

Syntax:

```
Classname::new
```

Example:

```
Supplier<Student> studentSupplier = Student::new;
```

Invalid:

```
Student student =  Student::new; // compilation issue
```

Lambdas and Local Variables

What is a **Local variable** ?

- Any variable that is declared inside a method is called a local variable.

- Lambdas have some restrictions on using local variables:
  - Not allowed to use the same the local variable name as **lambda parameters** or inside the **lambda body**.
  - Not allowed **re-assign** a value to a local variable.

- No restrictions on **instance** variables.

Local Variables - Not Allowed

Repeated Variable Name:

- Variable **i** is declared in the same scope and used as a parameter in Lambda.
- You cannot use the same variable as a lambda parameter or inside the lambda body.

Same Variable as Input:

```
int i=0;  //Repeated varibale name not allowed
 Consumer<Integer> c1 = (i) -> {
        System.out.println(i+value);
 };
```

Local Variables - Not Allowed

Same Variable as Lambda parameter:

```
int i=0;
Consumer<Integer> c1 = (i) -> {  //Repeated variable name not allowed
    System.out.println(i+value);
};
```

Same Variable in Lambda Body:

```
int i=0;
Consumer<Integer> c1 = (a) -> {
    int i=0; //Repeated variable name not allowed
    System.out.println(i+value);
};
```

Local Variables - Not Allowed

- Not allowed to modify the value inside the lamda

```
int value =4;
Consumer<Integer> c1 = (a) -> {
    //value=6; //reassigning not allowed
    //  System.out.println(i+value);
};
```

Effectively Final

- Lambda's are allowed to use local variables but not allowed to modify it even though they are not declared final. This concept is called **Effectively Final.**

- Not allowed to modify the value inside the lamda

```
int value =4;
Consumer<Integer> c1 = (a) -> {
    //value=6; //reassigning not allowed
    //   System.out.println(i+value);
};
```

- Prior to Java 8 , any variable that's used inside the anonymous class should be declared **final.**

Advantages of Effectively Final:

- Easy to perform concurrency operations.
- Promotes Functional Programming and demotes the Imperative style programming.

Introduction to Streams API:

- Introduced as part of **Java8**
- Main purpose is to perform some **Operation on Collections.**
- **Parallel operations** are easy to perform with Streams API without having to spawn a multiple threads.
- Streams API can be also used with arrays or any kind of I/O .

What is a Stream ?

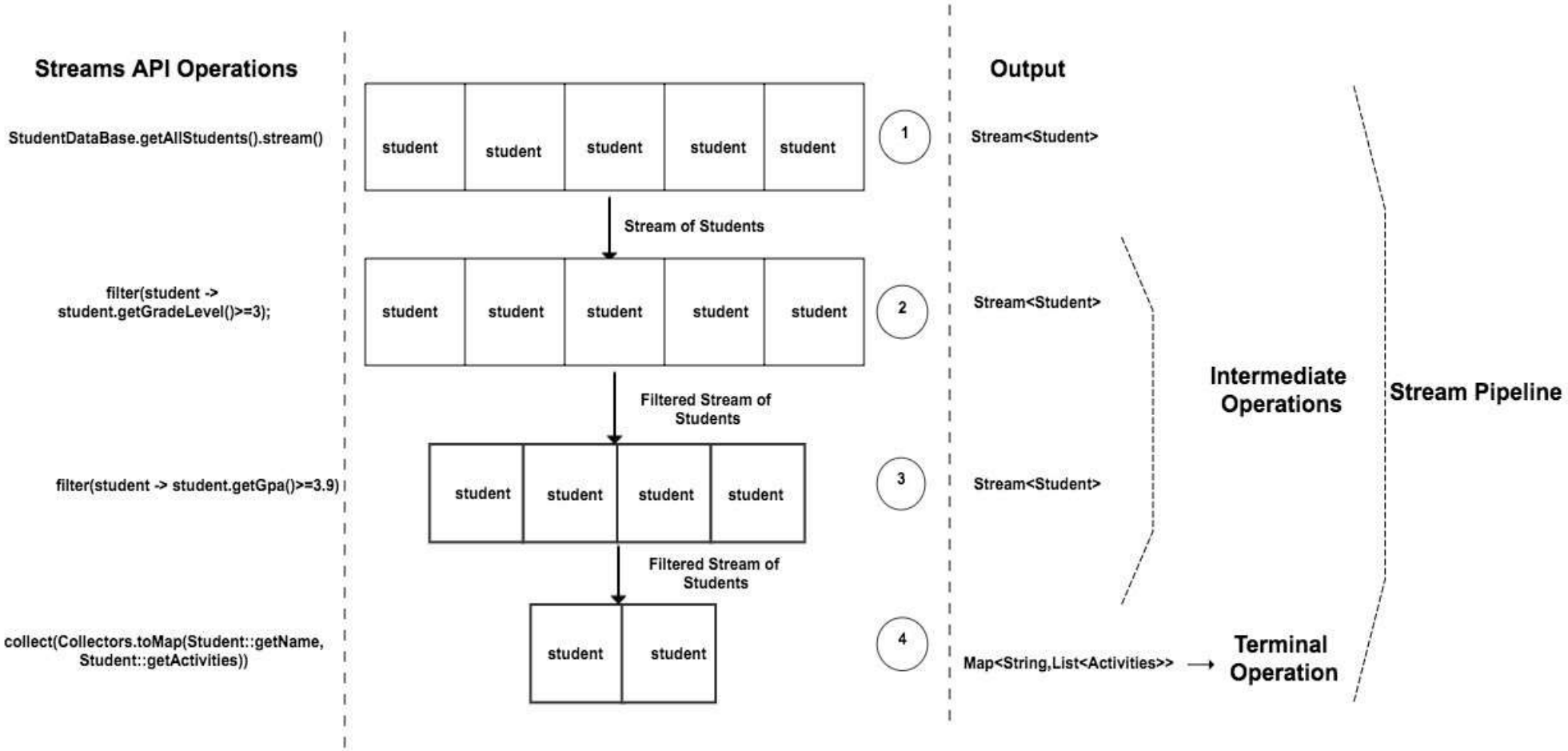
- Stream is a sequence of elements which can be created out of a collections such as **List or Arrays** or any kind of **I/O** resources and etc.,

```
List<String> names = Arrays.asList("adam","dan","jenny");
names.stream();  // creates a stream
```

- Stream operations can be performed either **sequentially** or **parallel**.

```
names.parallelStream(); // creates a parallel stream
```

How Stream API Works ?



Collections and Streams

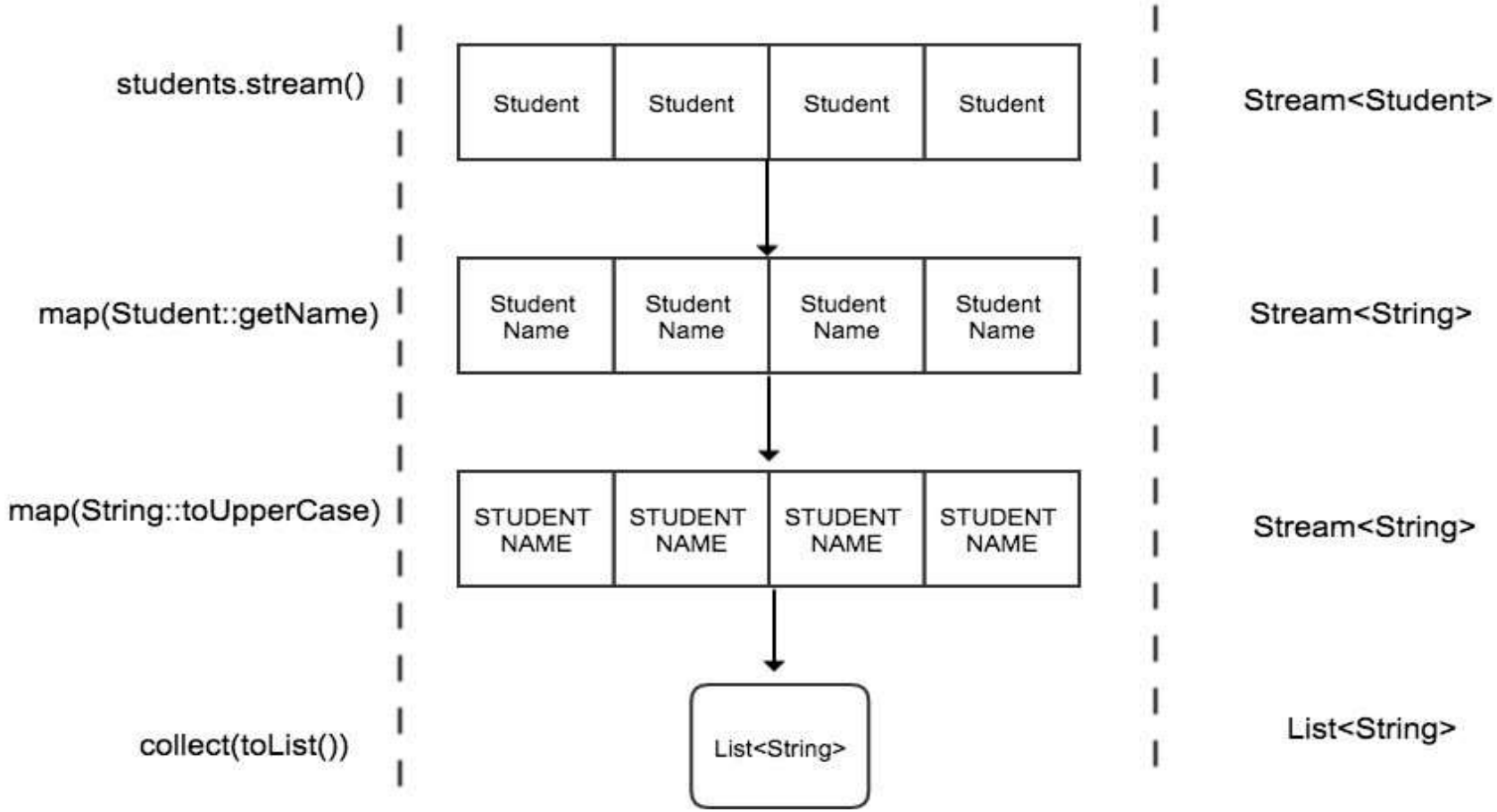
Collections	Streams
Can add or modify elements at any point of time. For Example: **List -> list.add(<element>)**	Cannot add or modify elements in the stream. It is a fixed data set.
Elements in the collection can be accessed in any order. Use appropriate methods based on the collection. For Example: **List -> list.get(4);**	Elements in the Stream can be accessed only in sequence.
Collection is eagerly constructed.	Streams are lazily constructed.

Collections and Streams

Collections	Streams
Collections can be traversed “n” number of times.	Streams can be traversed only once.
Performs **External Iteration** to iterate through the elements.	Performs **Internal Iteration** to iterate through the elements.

Stream API : map()

- **map** : Convert(transform) one type to another.
- Don’t get confused this with **Map** Collection.


students.stream()
Student
Student
Student
Student
Stream<Student>
map(Student::getName)
Student Name
Student Name
Student Name
Student Name
Stream<String>
map(String::toUpperCase)
STUDENT NAME
STUDENT NAME
STUDENT NAME
STUDENT NAME
Stream<String>
collect(toList())
List<String>
List<String>

Stream API : flatMap()

- **flatMap** : Converts(Transforms) one type to another as like map() method
- Used in the context of Stream where each element in the stream represents multiple elements.

Example:

- Each Stream element represents multiple elements.
  - Stream<List>
  - Steam<Arrays>

Stream API – distinct() , count() and sorted()

- **distinct** – Returns a stream with unique elements

- **count** – Returns a long with the total no of elements in the Stream.

- **sorted -** Sort the elements in the stream

Stream API - filter()

- **filter -** filters the elements in the stream.

Input to the filter is a **Predicate** Functional Interface.

Streams API - reduce()

- **reduce** – This is a terminal operation. Used to reduce the contents of a stream to a single value.

- It takes two parameters as an input.
  - **First parameters** – default or initial value
  - **Second Parameter** – BinaryOperator<T>

Stream API : Max/Min using reduce()

- **max** -> Maximum(largest) element in the stream.

- **min** -> Minimum(smallest) element in the stream.

Stream API : limit() and skip()

- These two function helps to create a sub-stream.
- **limit(n)** – limits the **“n”** numbers of elements to be processed in the stream.
- **skip(n) –** skips the **“n”** number of elements from the stream.

Streams API : anyMatch(), allMatch() , noneMatch()

- All these functions takes in a **predicate** as an input and returns a **Boolean** as an output.

- **anyMatch()-** Returns **true** if any one of the element matches the predicate, otherwise false.
- **allMatch() -** Returns **true** if all the element in the stream matches the predicate, otherwise false.
- **noneMatch()** – Just opposite to **allMatch()**. Returns **true** if none of the element in the stream matches the predicate, otherwise false.

Streams API : findFirst() and findAny()

- Used to find an element in the stream.

- Both the functions returns the result of type **Optional**.

- **findFirst()** – Returns first element in the stream.
- **findAny() -** Returns the first encountered element in the stream.

Streams API - Short Circuiting

What is Short Circuiting ?

Examples of Short Circuiting:

Example 1:

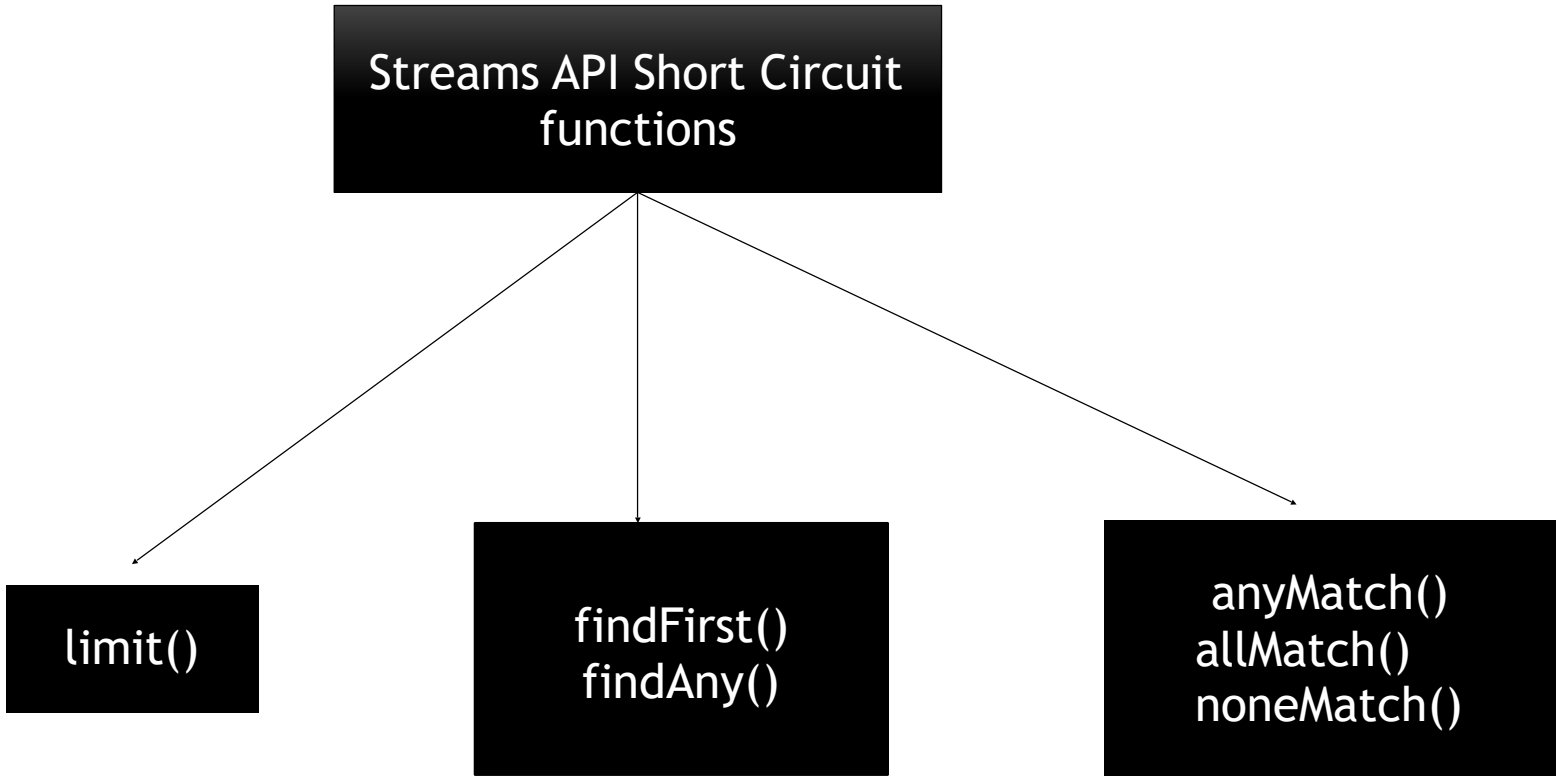
```
if(boolean1 && boolean2){ //AND
        //body
}
```

- If the first expression evaluates to false then the second expression wont even execute.

Example 2:

```
if(boolean1 || boolean2){ //OR
        //body
}
```

- If the first expression evaluates to true then the second expression wont even execute.



- All these functions does not have to iterate the whole stream to evaluate the result.

Streams API : Stateful vs Stateless

- Does Streams have an internal state?
  - **Yes**
- Does all the Stream functions maintain an internal state ?
  - **No**

What is a State in Streams API ?

Converts a List<Student> to List<String>

```
private static List<String> namesUpperCase(List<Student> names){
    List<String> namesUpperCase = names.stream()
            .map(Student::getName)
            .map(String::toUpperCase)
            .collect(toList());

    return namesUpperCase;
}
```

(Stream State) **(Stream Pipeline)**

Intermediate Operations

- Stateful functions
  - distinct()
  - sorted()
  - skip()
  - limit()
- Stateless functions
  - map()
  - filter(), etc.,

Stateful functions:

Convert List<Student> to List<String>

```
public static List<String> printUniqueStudentActivities() {

    List<String> studentActivities = StudentDataBase.getAllStudents()
            .stream()
            .map(Student::getActivities)
            .flatMap(List::stream)
            .distinct() // needs the state of the previously processed elements
            .sorted() // needs the state of the previously processed elements
            .collect(toList());
    return studentActivities;

}
```

Stateless Functions:

Convert List<Student> to List<String>

```
private static List<String> namesUpperCase(List<Student> names){
    List<String> namesUpperCase = names.stream() //Stream<Student>
            .map(Student::getName) //Stream<String> - stateless
            .map(String::toUpperCase) // Stream<String> -> UpperCase - stateless
            .collect(toList()); // returns List  - stateless
return namesUpperCase;
}
```

Streams API – Factory methods

- Of()
- generate()
- iterate()

Streams API – of(), iterate() and generate()

- **Of()** -> Creates a stream of certain values passed to this method.

Example:

Stream<String> stringStream = Stream.of(“adam”,”dan”,”Julie”);

iterate(), generate() -> Used to create infinite Streams.

Example:

Stream.iterate(1, x->x*2)

Example:

Stream.generate(<Supplier>)

Numeric Streams

Represents the **primitive values** in a Stream.

- IntStream
- LongStream
- DoubleStream

Numeric Stream Ranges:

Int Stream:

IntStream.*range*(1,50) -> Returns an IntStream of 49 elements from 1 to 49.

IntStream.rangeClosed(1,50) -> Returns an IntStream of 50 elements from 1 to 50.

Long Stream:

LongStream.*range*(1,50) -> Returns a LongStream of 49 elements from 1 to 49.

LongStream.*rangeClosed*(1,50) -> Returns a LongStream of 50 elements from 1 to 50.

DoubleStream:

- It does not support the range ()and rangeClosed().

Numeric Stream – Aggregate Functions

- sum()
- max()
- min()
- average()

Numeric Streams : Boxing() and UnBoxing()

Boxing():

- Converting a primitive type to Wrapper Class type

Example:

- Converting an int (primitive) to Integer(wrapper).

UnBoxing():

- Converting a Wrapper Class type to primitive type.

Example:

- Converting an Integer(wrapper) to int(primitive).

Numeric Streams - mapToObj(), mapToLong(), mapToDouble()

- **mapToObj** -> Convert a each element numeric stream to some Object.

- **mapToLong** -> Convert a numeric stream to a Long Stream.

- **mapToDouble** -> Convert a numeric stream to a Double Stream.

Stream Terminal Operations

- Terminal Operations collects the data for you.
- Terminal Operations starts the whole stream pipeline.

- Terminal Operations:
  - forEach()
  - min()
  - max()
  - reduce()
  - collect() and etc.

Terminal Operation - collect()

- The **collect()** method takes in an input of type Collector.
- Produces the result as per the input passed to the collect() method.

Terminal Operations - joining()

- **joining()** Collector performs the String concatenation on the elements in the stream.

- **joining()** has three different overloaded versions.

Terminal Operations - counting()

- **counting()** Collector returns the total number of elements as a result.

Terminal Operation - mapping()

- **mapping()** collector applies a transformation function first and then collects the data in a collection(could be any type of collection)

Terminal Operations – maxBy() , minBy()

- **Comparator** as an input parameter and Optional as an output.
- **maxBy()**
  - This collector is used in conjunction with comparator. Returns the max element based on the property passed to the comparator.
- **minBy()**
  - This collector is used in conjunction with comparator. Returns the smallest element based on the property passed to the comparator.

Terminal Operations - summingInt(), averagingInt()

- **summingInt() -** this collector returns the sum as a result.
- **averagingInt() -** this collector returns the average as a result.

Terminal Operations - groupingBy()

- **groupingBy()** collector is equivalent to the groupBy() operation in SQL.
- Used to group the elements based on a property.
- The output of the groupingBy() is going to be a Map<K,V>
- There are three different versions of groupingBy().
  - groupingBy(classifier)
  - groupingBy(classifier,downstream)
  - groupingBy(classifier,supplier,downstream)

Terminal Operations - partitioningBy()

- **partitioningBy()** collector is also a kind of **groupingBy().**

- **paritioningBy()** accepts a predicate as an input.

- Return type of the collector is going to be Map<K,V>
  - The key of the return type is going to be a Boolean.
- There are two different versions of partitioningBy()
  - partitioningBy(predicate)
  - partitioningBy(predicate,downstream) // downstream -> could be of any collector

Introduction to Parallel Streams

What is a Parallel Stream ?

- Splits the source of data in to multiple parts.
- Process them parallelly.
- Combine the result.

How to Create a Parallel Stream ?

Sequential Stream:

```
IntStream.rangeClosed(1,1000)
        .sum();
```

Parallel Stream:

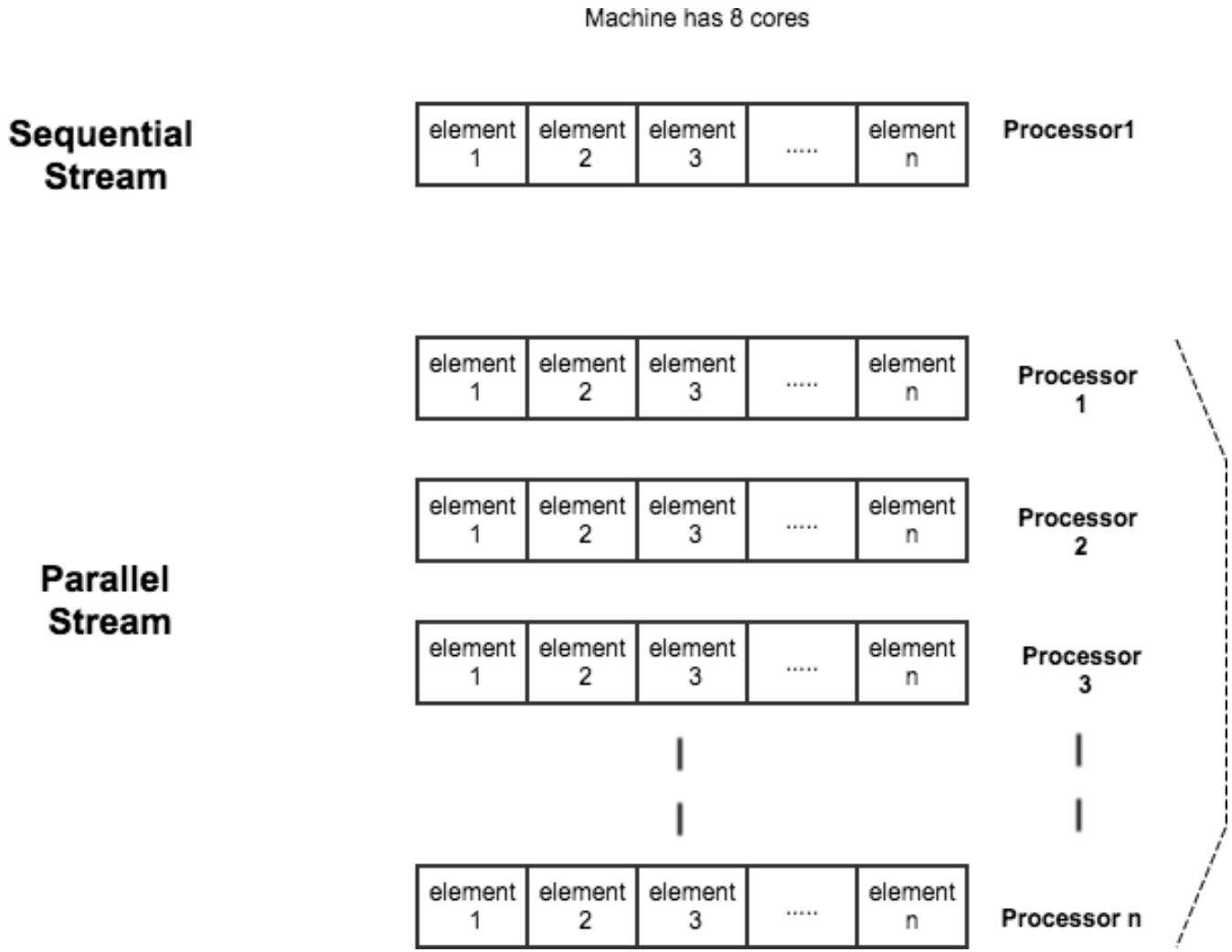
```
IntStream.rangeClosed(1,1000)
      .parallel()
        .sum();
```

How Parallel Stream works ?

- Parallel Stream uses the **Fork/Join framework** that got introduced in Java 7.

How many Threads are created ?

- Number of threads created == number of processors available in the machine.


Machine has 8 cores
Sequential Stream
element 1
element 2
element 3
.....
element n
Processor1
Parallel Stream
element 1
element 2
element 3
.....
element n
Processor 1
Processor 2
Processor 3
Processor n

Introduction to Optional

- Introduced as part of Java 8 to represent a Non-Null value
- Avoids **Null Pointer Exception** and **Unnecessary Null Checks.**
- Inspired from the new languages such as scala , groovy etc.,

Default and Static Methods in Interfaces

Interfaces in Java - Prior Java 8:

- Define the contract.
- Only allowed to declare the method. Not allowed to implement a method in Interface.
- Implementation is only allowed in the Implementation class.
- Not easy for an interface to evolve.

Default Methods – Java 8

- **default** keyword is used to identify a default method in an interface.

Example from List Interface:

```
default void sort(Comparator<? super E> c) {
    Object[] a = this.toArray();
    Arrays.sort(a, (Comparator) c);
    ListIterator<E> i = this.listIterator();
    for (Object e : a) {
        i.next();
        i.set((E) e);
    }
}
```

- Prior to Java 8 we normally use Collections.sort() to perform the similar operation.
- Can be overridden in the Implementation class.
- Used to evolve the Interfaces in Java.

Static Methods – Java 8

- Similar to **default** methods.

- This cannot be overridden by the implementation classes.

Abstract Classes vs Interfaces in Java 8

- Instance variables are not allowed in Interfaces.

- A class can extend only one class but a class can implement multiple interfaces.

Does this enable Multiple Inheritance in Java?

- Yes

- This was never possible before Java 8.

Introduction to New Date/Time Libraries

- LocalDate, LocalTime and LocalDateTime and part of the **java.time** package.
- These new classes are created with the inspiration from the **Joda-Time** library.
- All the new time libraries are **Immutable**.
- Supporting classes like **Instant, Duration,Period** and etc.
- Date, Calendar prior to Java 8.

LocalDate: Used to represent the date.

LocalTime: Used to represent the time.

LocalDateTime: Used to represent the date and time.

Period:

- Period is a date-based representation of time in **Days , Months and Years** and is part of the **java.time** package.

- Compatible with **LocalDate**.

- It represents a **Period of Time** not just a specific date and time.

Example:

```
Period period1 = Period.ofDays(10); // represents a Period of 10 days
Period period2 = Period.ofYears(20); // represents a Period of 20 years
```

Period : Use-Case

- Mainly used calculate the difference between the two dates.

Example:

```
LocalDate  localDate = LocalDate.of(2018,01,01);
LocalDate  localDate1 = LocalDate.of(2018,01,31);

Period period = Period.between(localDate,localDate1); // calculates the difference between the two dates
```

Duration

- A time based representation of time in **hours , minutes, seconds and nanoseconds.**
- Compatible with **LocalTime** and **LocalDateTime**
- It represents a duration of time not just a specific time.

Example:

```
Duration duration1 = Duration.ofHours(3);;   // represents the duration of 3 hours
Duration duration1 = Duration. ofMinutes(3);   // represents the duration of 3 minutes
```

Duration : Use-Case

- It can be used to calculate the difference between the time objects such as **LocalTime** and **LocalDateTime**.

Example:

```
LocalTime localTime = LocalTime.of(7,20);
LocalTime localTime1 = LocalTime.of(8,20);

Duration duration = Duration.between(localTime,localTime1);
```

Instant:

- Represent the time in a machine readable format.

Example:

Instant ins = Instant.now();

- Represents the time in seconds from January 01,1970**(EPOCH)** to current time as a huge number.

Time Zones

- ZonedDateTime, ZoneID, ZoneOffset

- **ZonedDateTime** - Represents the date/time with its time zone.

Example:

2018-07-18T08:04:14.541-05:00[America/Chicago]

ZoneOffset-> -05:00

ZoneId -> America/Chicago

DateTimeFormatter

- Introduced in **Java 8** and part of the **java.time.format** package.

- Used to parse and format the **LocalDate**, **LocalTime** and **LocalDateTime**.

Parse and Format

- **parse -** Converting a String to a LocalDate/LocalTime/ LocalDateTime.

- **format -** Converting a LocalDate/LocalTime/LocalDateTime to a String.