Computer System Design & Application

计算机系统设计与应用A

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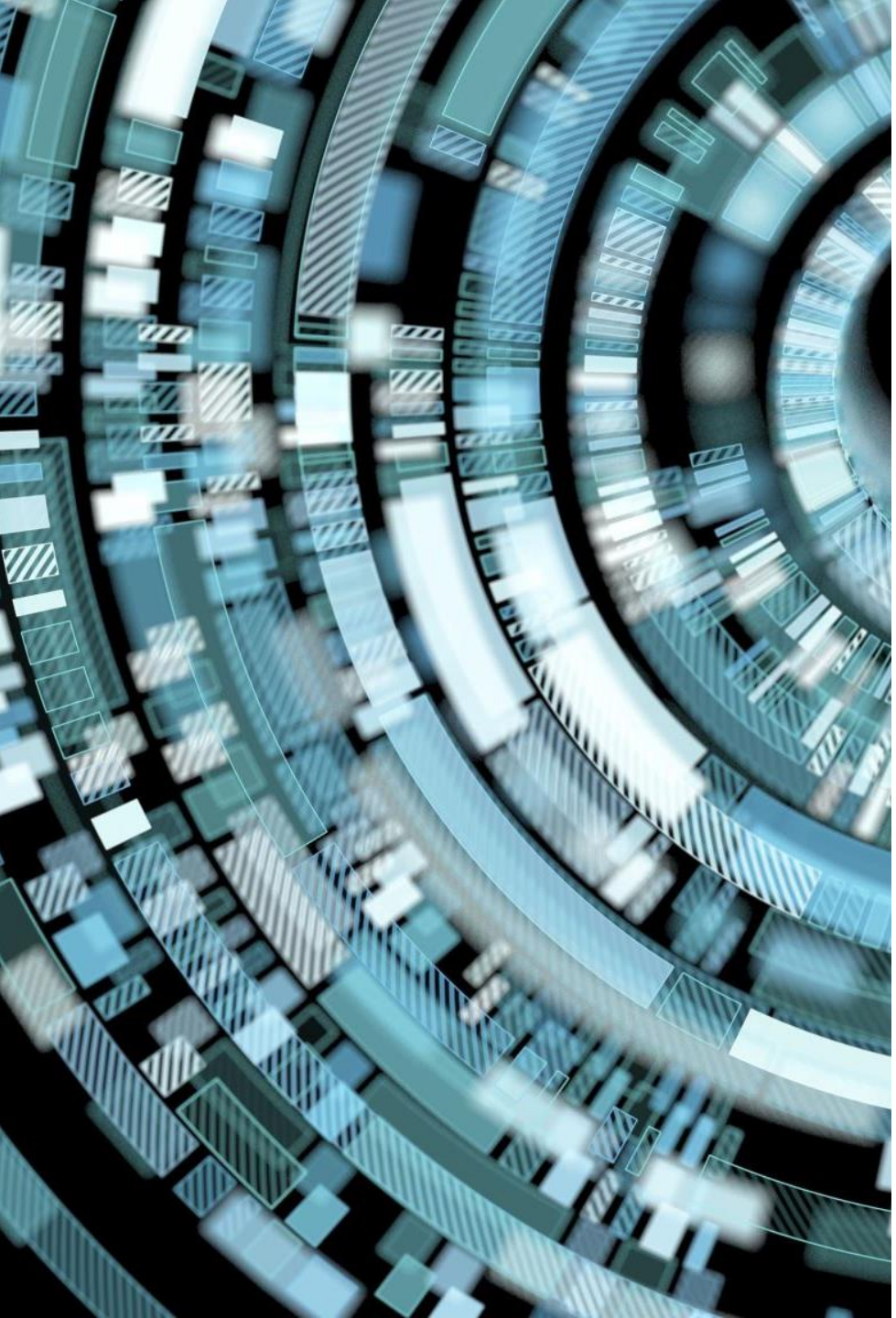


Lecture 4

- Java 8 Stream
- Optional<T>

Java Stream API Overview

```
public interface Stream<T>
```

- The `Stream` API is introduced in Java 8 (`java.util.stream`), don't confuse it with I/O Streams!

- Used to process collections of objects
  - Data stream is obtained from a source
  - Data stream is processed through chained intermediate operations (pipeline)
  - Getting the result from a terminal operation

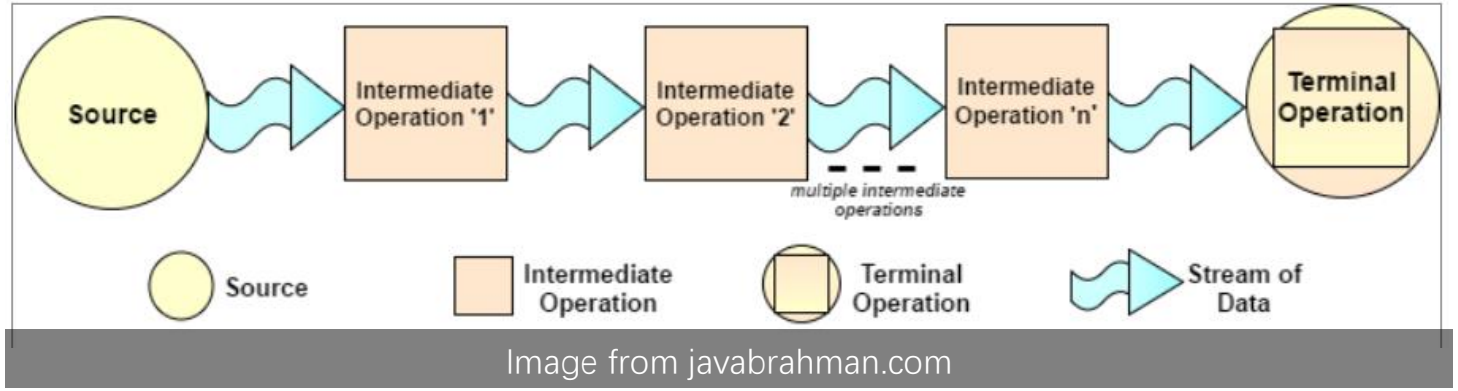


Image from javabrahman.com

Create a Stream

```
default Stream<E> stream()
```

Returns a sequential `Stream` with this collection as its source.

- Approach I: getting a `Stream` from a Java `Collection`, which has the `stream()` method

```
List<String> list = new ArrayList<String>();

list.add(“a”);
list.add(“b”);

Stream<String> stream = list.stream();
```

Create a Stream

```
static <T> Stream<T> generate(Supplier<T> s)
```

- Approach II: using `Stream.generate()`, which needs a `Supplier` as input

```
Stream<String> echos = Stream.generate(() -> "Echo");

Stream<Double> randoms = Stream.generate(Math::random);
```

Could generate “infinite” streams

Create a Stream

```
static <T> Stream<T> generate(Supplier<T> s)
```

- Approach II: using `Stream.generate()`, which needs a `Supplier` as input

Example: generate a stream of natural numbers and print the first 20

```
Stream<Integer> natual = Stream.generate(new NatualSupplier());
natual.limit(20).forEach(System.out::println);


class NatualSupplier implements Supplier<Integer> {
    int n = 0;
    public Integer get() {
        n++;
        return n;
    }
}
```

Example from
https://www.liaoxuefeng.com/wiki/1252599548343744/1322655160467490

Create a Stream

```
static <T> Stream<T> iterate(T seed,
                             UnaryOperator<T> f)
```

- Approach III: using `Stream.iterate()`, which creates a stream of seed, f(seed), f(f(seed)), etc.

```
Stream<Integer> evenNumber = Stream.iterate(2, n -> n + 2);

evenNumber.limit(10).forEach(System.out::println);
```

Create a Stream

```
static <T> Stream<T> of(T... values)
```

- Approach IV: using `Stream.of()`, which has a `varargs` parameter (take any number of arguments)

```
Integer[] array = new Integer[]{1,2,3};
Stream<Integer> istream = Stream.of(array);

Stream<String> sentence = Stream.of("This","is","Java","2");
```

Primitive Type Streams

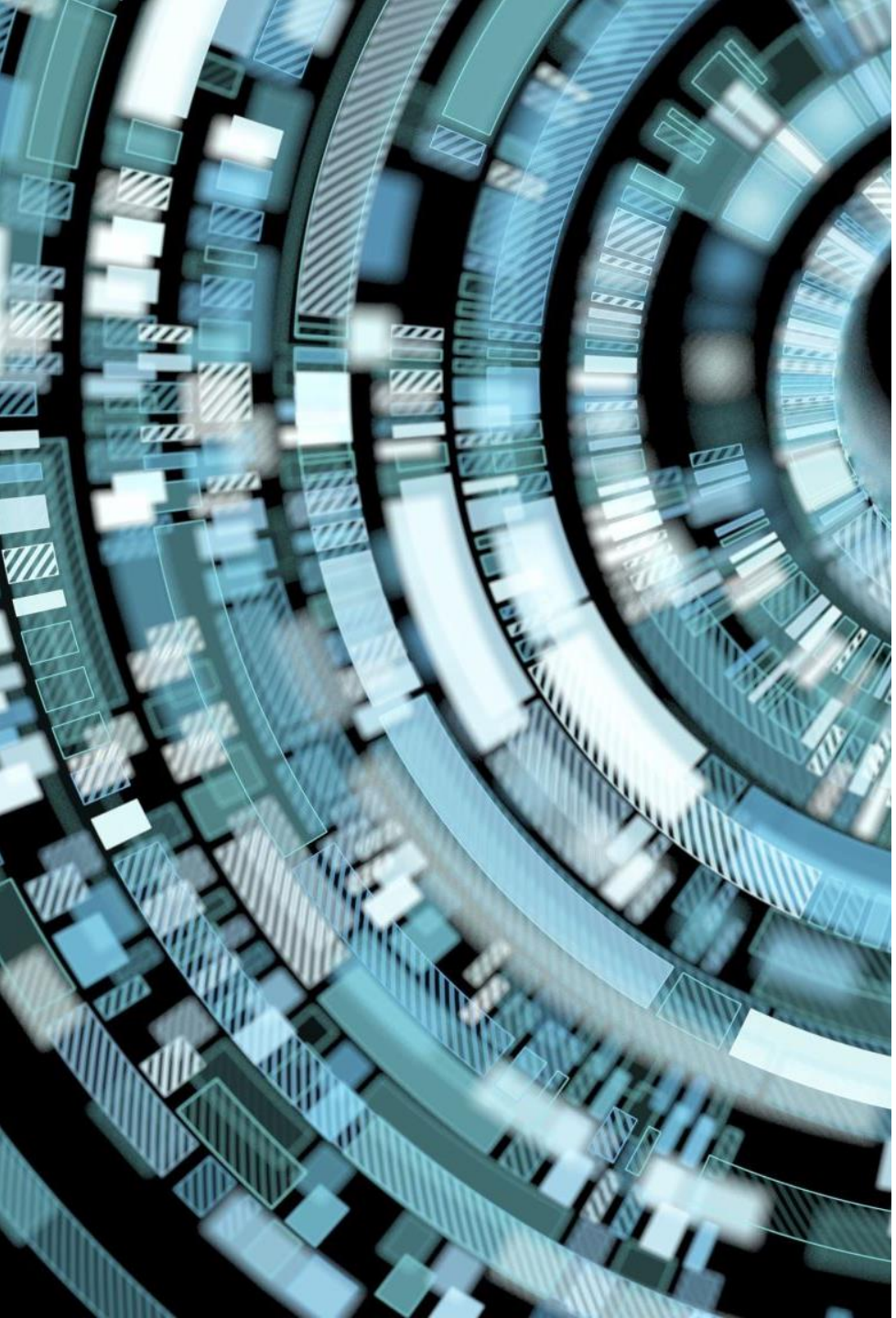
The `Stream` library has specialized types `IntStream`, `LongStream`, and `DoubleStream` that store primitive values directly, without using wrappers (e.g., `Integer`).

```
IntStream stream0 = Arrays.stream(new int[]{1,2,3});

IntStream stream1 = IntStream.of(1,2,3,5,8);

IntStream stream2 = IntStream.range(5,10);

Stream<String> sentences = Stream.of("This","is","Java","2");
IntStream stream3 = sentences.mapToInt(String::length);
```



Lecture 4

- Java 8 Stream
  - Stream Creation
  - Intermediate Operations
  - Terminal Operations
- Optional<T>

Intermediate Operations

- Intermediate (non-terminal) operations transform or filter the elements in the stream
  - `filter()`
  - `map()`
  - `sorted()`
  - `distinct()`
  - `peek(), limit(), skip()`
- We get a new stream back as the result when adding an intermediate operation to a stream
- [Lazy evaluation] All intermediate operations do not get executed until a terminal operation is invoked (discussed later)

filter()

```
Stream<T> filter(Predicate<? super T> predicate)
```

```
Predicate<T>          boolean test(T t)
```

The `Predicate` interface represents functions who take an argument and return a boolean

- Returns a stream consisting of the elements of this stream that match the given predicate.

```
List<Integer> list = Arrays.asList(10,20,33,43,54,68);
list.stream()
    .filter(element -> (element % 2==0))
    .forEach(element -> System.out.print(element+ " "));
```

map()

```
<R> Stream<R> map(Function<? super T,? extends R> mapper)
```

```
Function<T,R>        R apply(T t)
```

The `Function` interface represents functions whose result and argument types could differ

- Returns a stream consisting of the results of applying/mapping the given function to the elements of this stream.

```
List<String> strList = new ArrayList<String>();
strList.add("123");
strList.add("456");

strList.stream()                    Stream<String>
        .map(Integer::parseInt)     Stream<Integer>
        .forEach(System.out::println);
```

sorted()

- `sorted()`: sort the elements by natural order
  `list.stream().sorted().forEach(System.out::println)`
- `sorted(Comparator<? super T> comparator)`: sort the elements according to the given `Comparator`

```
class Point
{
        Integer x, y;
        Point(Integer x, Integer y) {
                this.x = x;
                this.y = y;
        }

} // Point's toString() is omitted here
```

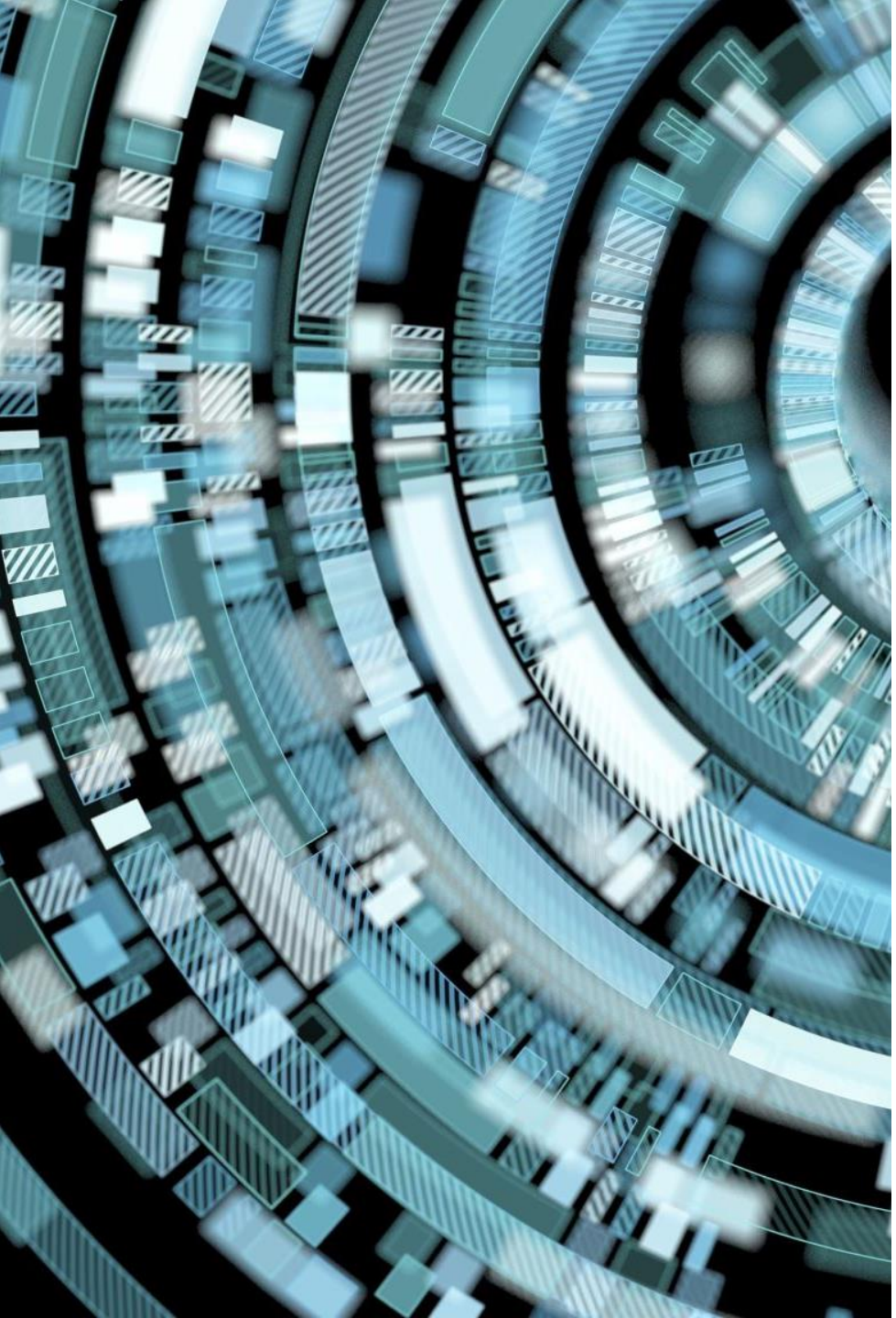
```
pointList.stream()
        .sorted((p1, p2)->p1.x.compareTo(p2.x))
        .forEach(System.out::println);
```

Example: https://www.geeksforgeeks.org/stream-sorted-in-java/

Stream Pipeline Example

- A stream pipeline consists of a stream source, followed by zero or more intermediate operations, and a terminal operation.

```
List<Integer> ilist = Arrays.asList(4,2,3,1,3,5,7,1);
ilist.stream()
        .filter(element -> (element % 2 == 1))
        .map(element -> (element*element))
        .sorted()
        .distinct()
        .limit(3)
        .forEach(System.out::println);
```



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- Optional<T>

Terminal Operation

```
anyMatch()
allMatch()
noneMatch()
collect()
count()
findAny()
findFirst()
forEach()
min()
max()
reduce()
toArray()
```

- A terminal operation marks the end of the stream and is always the last operation in the stream pipeline
- A terminal operation returns a non-stream type of result
  - Return primitive type (`count()`)
  - Return reference type (`collect()`)
  - Return void (`forEach()`)
- [Eager execution] Terminal operations are early executed (discuss later)

Reduction

- A reduction is a terminal operation that aggregates a stream into a type or a primitive
- Reduction operations in Java 8 Stream API
  - `min()`
  - `max()`
  - `average()`
  - `sum()`
  - `reduce(): <- the general one`

reduce()

```
BinaryOperator<T>    T apply(T t1, T t2)
Optional<T> reduce(BinaryOperator<T> accumulator)
```

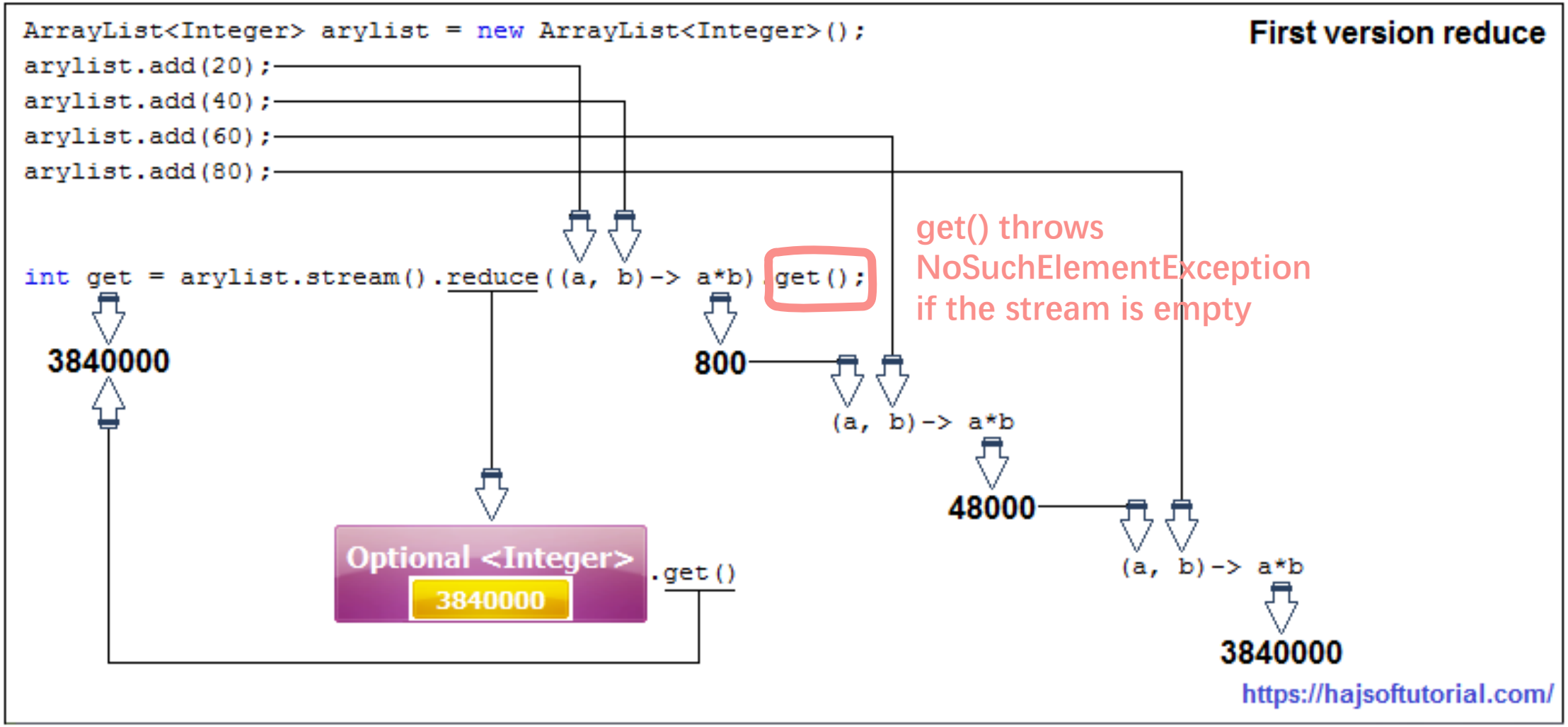
Next element: e.g., the next number in the stream

```
reduce( (a, b) -> a + b )
```

Partial result: e.g., the sum of all processed numbers so far

Accumulator function: e.g., add two numbers

Example of reduce()



Example of `reduce()`

- To avoid the exception potentially thrown by `get()`, you may use:

```
int sum = arrayList.stream().reduce((a,b)->a+b).orElse(0);

int sum = arrayList.stream().reduce(0, (a,b)->a+b);
```

The identity element is both the initial value of the reduction and the default result if there are no elements in the stream

Collecting Results

- When you are done with a stream, you often want to collect the result in a data structure
- `Stream.collect(Collector collector)` performs a reduction operation on the elements of this stream using a `Collector`
- `Collector<T,A,R>` interface
  - **`T`** - the type of input elements to the reduction operation
  - **`R`** - the result type of the reduction operation
  - **`A`** - the mutable accumulation type of the reduction
    - accumulating elements into a Collection
    - concatenating strings
    - computing summary information about elements such as sum, min, max
    - .....

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Collecting Results

- The `Collectors` class provides implementations for various useful reduction operations (i.e., common collectors)

```
List<String> result = stream.collect(Collectors.toList())

Set<String> result = stream.collect(Collectors.toSet())

TreeSet<String> result = stream.collect(Collectors.toCollection(TreeSet::new))
```

Collecting Results

```
Stream<String> stream = Stream.of("a", "bb", "cc", "ddd");
```

```
Map<String, Integer> map =
stream.collect(Collectors.toMap(Function.identity(), String::length));
```

{bb=2, cc=2, a=1, ddd=3}

```
String joined =
stream.collect(Collectors.joining("$"));
```

abbcc$ddd

Grouping & Downstream Collectors

We use `Collectors.groupingBy(Function<T, K> classifier)` returns a collector, which produces `Map<K, List<T>>` that maps elements of type T to some key type K and corresponding elements into a list as the map value

```
Stream<String> stream = Stream.of("a", "bb", "cc", "ddd", "a", "bb", "eee");

Map<Integer, List<String>> group = stream.collect(Collectors.groupingBy(String::length));
```

{1=[a, a], 2=[bb, cc, bb], 3=[ddd, eee]}

Grouping & Downstream Collectors

We could use `Collectors.groupingBy(Function classifier, Collector downstream)` if we want to further perform reduction operations on the list of values

```
Stream<String> stream = Stream.of("a", "bb", "cc", "ddd", "a", "bb", "eee");

Map<Integer, Set<String>> group = stream.collect(Collectors.groupingBy(String::length, Collectors.toSet()));
```

{1=[a], 2=[bb, cc], 3=[eee, ddd]}

Grouping & Downstream Collectors

```
Stream<String> stream = Stream.of("a", "bb", "cc", "ddd", "a", "bb");
Map<String, Long> group =
stream.collect(Collectors.groupingBy(Function.identity(), Collectors.counting()));
```

```
Stream<String> stream = Stream.of("1a", "1bb", "1c", "2a", "2a", "2bb");
Map<Character, Set<String>> group =
                    stream.collect(Collectors.groupingBy(s->s.charAt(0),
                    Collectors.mapping(s->s.substring(1), Collectors.toSet())));
```

Lazy Evaluation

Benefits?

Intermediate operations are lazily executed

- They only remember the operations, but don't do anything right away (lazy)

Terminal operations are eagerly executed

- When terminal operations are initiated, the remembered operations are performed one by one (eager)

Example

How many operations do we have to perform when the code is executed eagerly / lazily?

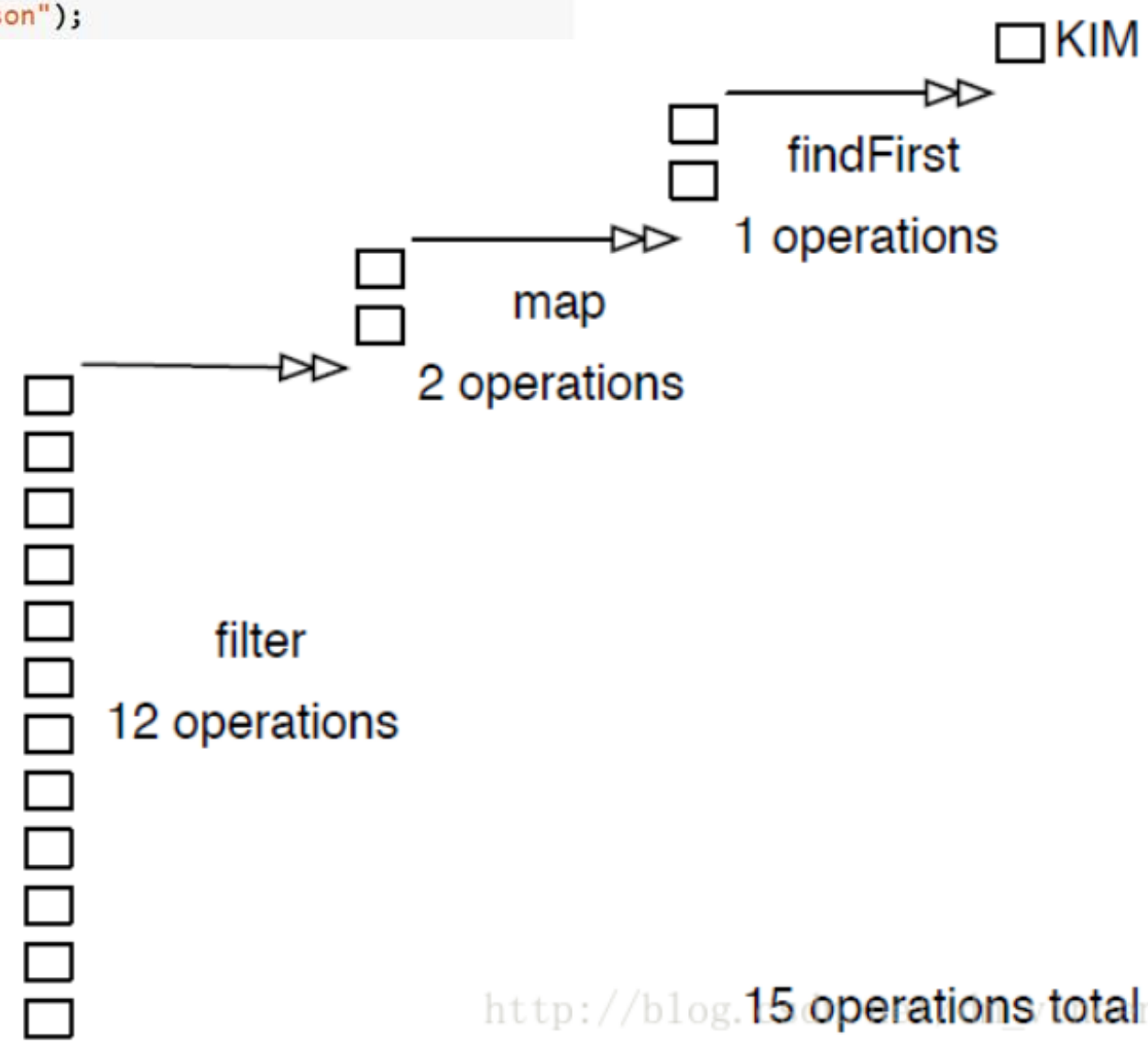
```
        List<String> names = Arrays.asList("Brad", "Kate", "Kim", "Jack", "Joe", "Mike",
"Susan", "George", "Robert", "Julia", "Parker", "Benson");

        final String firstNameWith3Letters = names.stream()
            .filter(name -> length(name) == 3)
            .map(name -> toUpper(name))
            .findFirst()
```

Reference: https://blog.csdn.net/dm_vincent/article/details/40503685

```
List<String> names = Arrays.asList("Brad", "Kate", "Kim", "Jack", "Joe", "Mike",
"Susan", "George", "Robert", "Julia", "Parker", "Benson");
```

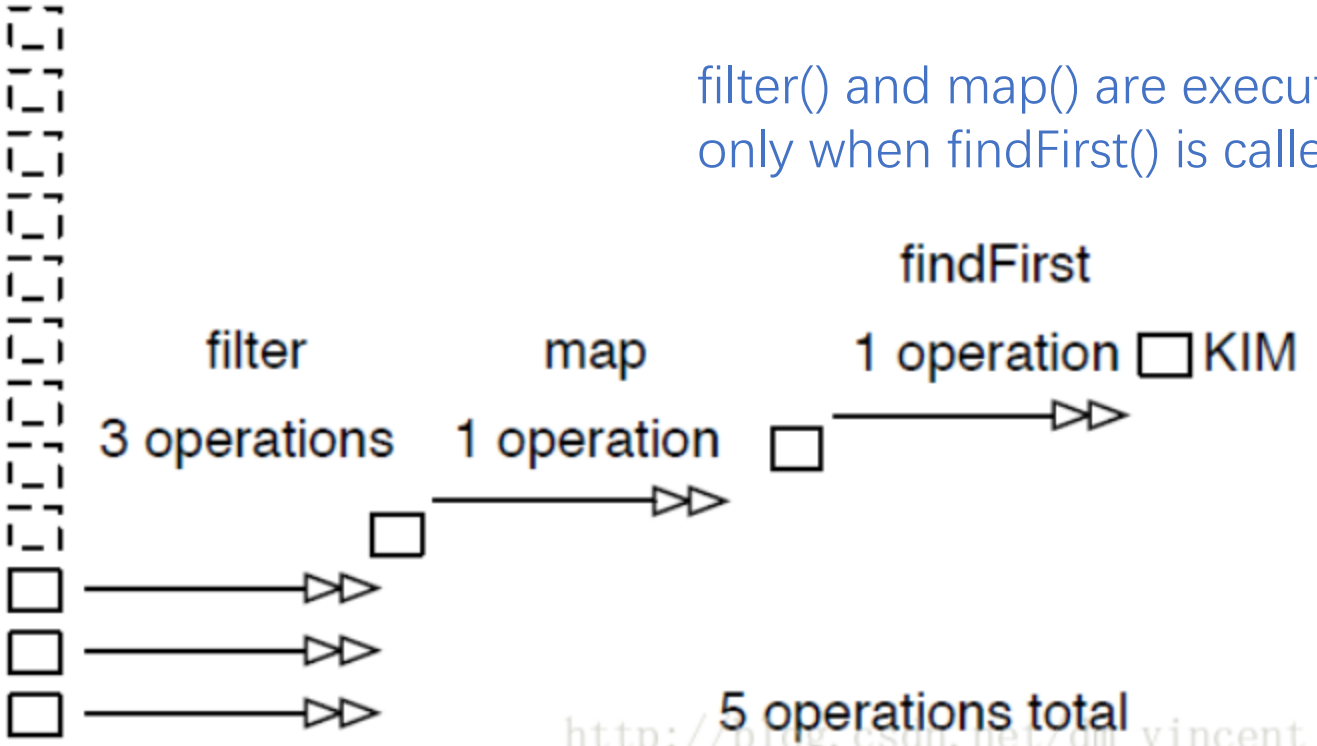
Eager Execution



Reference: https://blog.csdn.net/dm_vincent/article/details/40503685

Lazy Execution

```
List<String> names = Arrays.asList("Brad", "Kate", "Kim", "Jack", "Joe", "Mike",
"Susan", "George", "Robert", "Julia", "Parker", "Benson");
```



filter() and map() are executed only when findFirst() is called

filter() finds the first matching element and pass it to map()

The calculation terminates as long as we get the result.

Reference: https://blog.csdn.net/dm_vincent/article/details/40503685

findFirst()

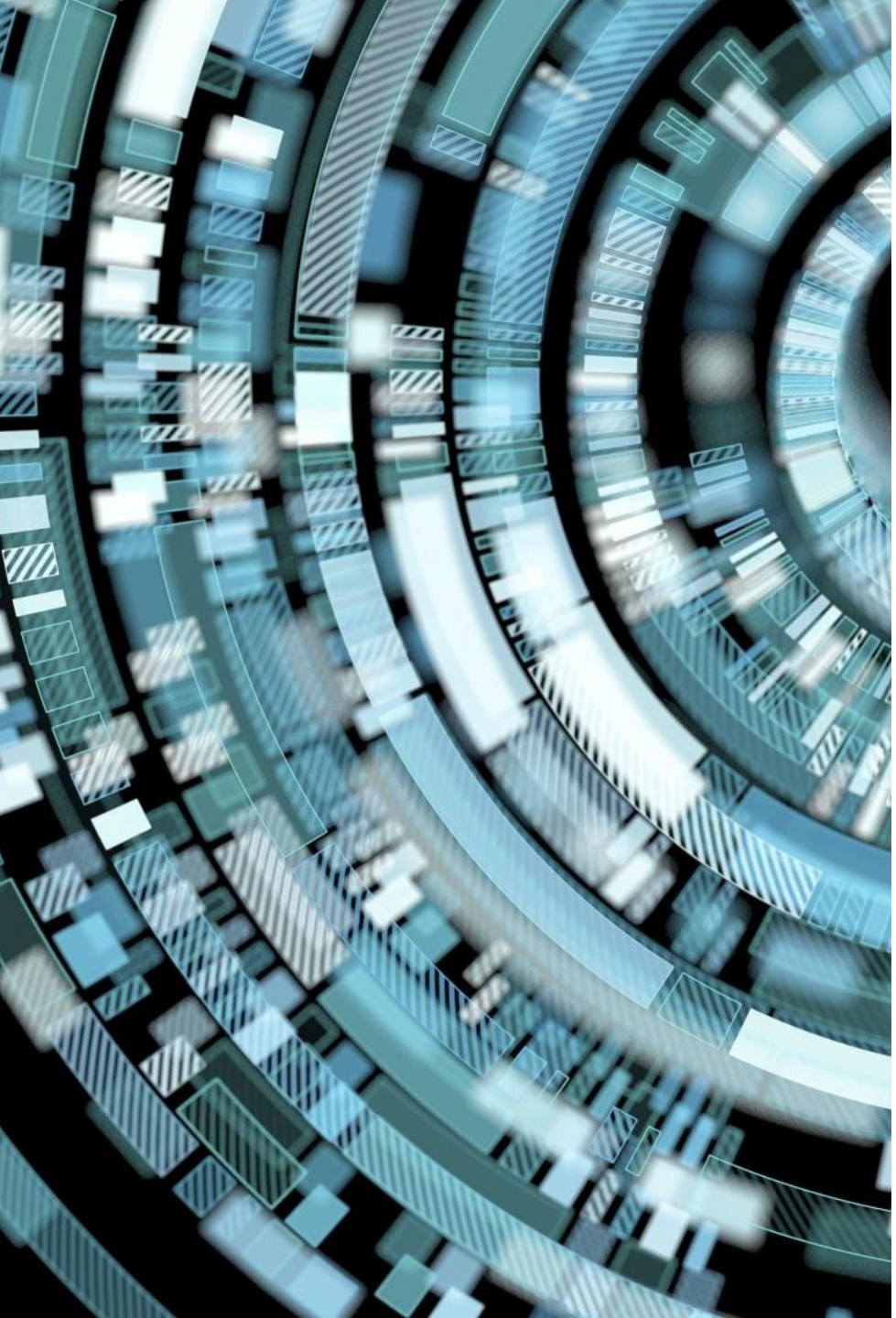
- Returns an `Optional` describing the first element of this stream, or an empty `Optional` if the stream is empty

```
List<String> stringList = new ArrayList<String>();

stringList.add("one");
stringList.add("two");
stringList.add("three");

Stream<String> stream = stringList.stream();
Optional<String> result = stream.findFirst();

System.out.println(result.orElse("unknown"));
```



Lecture 4

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  - Terminal Operations

- Optional<T>

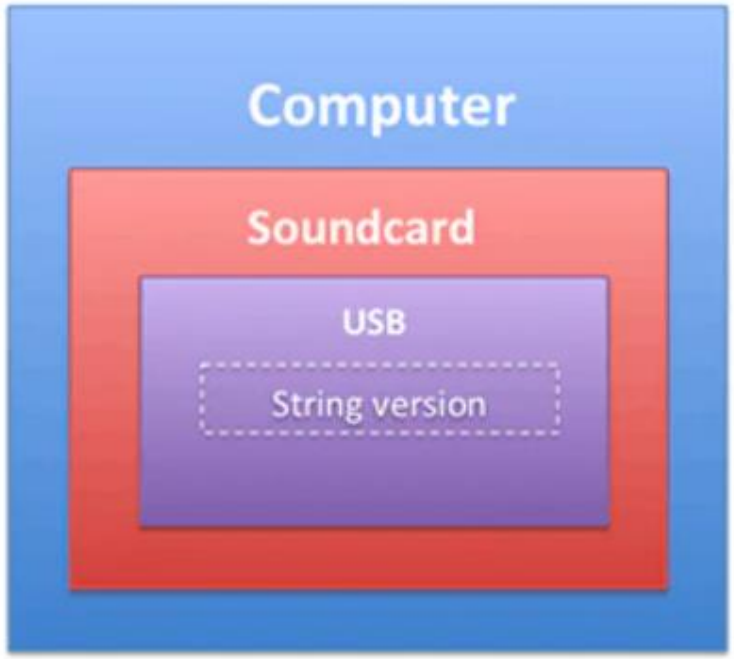
Tired of Null Pointer Exceptions? Consider Using Java SE 8's "Optional"!

by Raoul-Gabriel Urma
Published March 2014

Make your code more readable and protect it against null pointer exceptions.


```
janv. 10, 2018 10:45:29 AM org.apache.catalina.core.StandardWrapperValve invoke
GRAVE: "Servlet.service()" pour la servlet cs a généré une exception
java.lang.NullPointerException
        at dao.ProduitDaoImpl.ProduitsParMC(ProduitDaoImpl.java:49)
        at web.ControleurServlet.doPost(ControleurServlet.java:47)
        at web.ControleurServlet.doGet(ControleurServlet.java:28)
        at javax.servlet.http.HttpServlet.service(HttpServlet.java:622)
        at javax.servlet.http.HttpServlet.service(HttpServlet.java:729)
        at org.apache.catalina.core.ApplicationFilterChain.internalDoFilter(ApplicationFilterChain.java:230)
        at org.apache.catalina.core.ApplicationFilterChain.doFilter(ApplicationFilterChain.java:165)
        at org.apache.tomcat.websocket.server.WsFilter.doFilter(WsFilter.java:52)
        at org.apache.catalina.core.ApplicationFilterChain.internalDoFilter(ApplicationFilterChain.java:192)
        at org.apache.catalina.core.ApplicationFilterChain.doFilter(ApplicationFilterChain.java:165)
        at org.apache.catalina.core.StandardWrapperValve.invoke(StandardWrapperValve.java:198)
        at org.apache.catalina.core.StandardContextValve.invoke(StandardContextValve.java:96)
        at org.apache.catalina.authenticator.AuthenticatorBase.invoke(AuthenticatorBase.java:474)
        at org.apache.catalina.core.StandardHostValve.invoke(StandardHostValve.java:140)
        at org.apache.catalina.valves.ErrorReportValve.invoke(ErrorReportValve.java:79)
        at org.apache.catalina.valves.AbstractAccessLogValve.invoke(AbstractAccessLogValve.java:624)
        at org.apache.catalina.core.StandardEngineValve.invoke(StandardEngineValve.java:87)
        at org.apache.catalina.connector.CoyoteAdapter.service(CoyoteAdapter.java:349)
        at org.apache.coyote.http11.Http11Processor.service(Http11Processor.java:783)
        at org.apache.coyote.AbstractProcessorLight.process(AbstractProcessorLight.java:66)
        at org.apache.coyote.AbstractProtocol$ConnectionHandler.process(AbstractProtocol.java:798)
        at org.apache.tomcat.util.net.NioEndpoint$SocketProcessor.doRun(NioEndpoint.java:1434)
        at org.apache.tomcat.util.net.SocketProcessorBase.run(SocketProcessorBase.java:49)
        at java.util.concurrent.ThreadPoolExecutor.runWorker(Unknown Source)
        at java.util.concurrent.ThreadPoolExecutor$Worker.run(Unknown Source)
        at org.apache.tomcat.util.threads.TaskThread$WrappingRunnable.run(TaskThread.java:61)
        at java.lang.Thread.run(Unknown Source)
```

Prevent Null Pointer Exception (NPE)




```
String version = "UNKNOWN";
if(computer != null){
  Soundcard soundcard = computer.getSoundcard();
  if(soundcard != null){
    USB usb = soundcard.getUSB();
    if(usb != null){
      version = usb.getVersion();
    }
  }
}
```

Works, but hard to read!

```
String version = computer.getSoundcard().getUSB().getVersion();
```

https://www.oracle.com/technical-resources/articles/java/java8-optional.html

The Optional<T> class

- Purpose: a type-level solution for representing optional values instead of `null` references
- A container object which may or may not contain a non-null value (safe alternative for "object or null")
- Help us to specify alternative values to return or alternative actions to take if the value is `null`, without having to use null checkers

```
Optional<String> optionalString = … // the value could be null (e.g., user input)
```

```
String result = optionalString.orElse("");
String result = optionalString.orElseGet(() -> System.getProperty("user.dir"));
String result = optionalString.orElseThrow(IllegalStateException::new);
```

https://horstmann.com/corejava/livelessons2/lesson02/index.html#(23)

```java
class Computer {
    private Optional<Soundcard> soundcard;

    public Optional<Soundcard> getSoundcard() {
        return soundcard;
    }
    public void setSoundcard(Optional<Soundcard> soundcard) {
        this.soundcard = soundcard;
    }

}
```

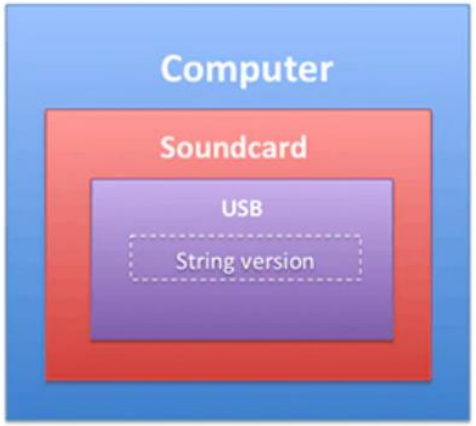
```java
class Soundcard {
    private Optional<USB> usb;

    public void setUsb(Optional<USB> usb) {
        this.usb = usb;
    }
    public Optional<USB> getUsb() {
        return usb;
    }
}

class USB{
    String version;

    public String getVersion() {
        return version;
    }
    public void setVersion(String version) {
        this.version = version;
    }
}
```

Example



```java
public static String getUsbVersion(Computer computer) {
    return computer.getSoundcard() Optional<Soundcard>
            .flatMap(Soundcard::getUsb) Optional<USB>
            .map(USB::getVersion) Optional<String>
            .orElse( other: "UNKNOWN");
}
```

1.0
UNKNOWN
UNKNOWN

```
static <T> Optional<T> empty()
```
Returns an empty Optional instance.

```
static <T> Optional<T> of(T value)
```
Returns an Optional with the specified present non-null value.

```java
public static void main(String[] args) {
    USB usb = new USB();
    usb.setVersion("1.0");

    Soundcard soundcard1 = new Soundcard();
    soundcard1.setUsb(Optional.of(usb));
    Soundcard soundcard2 = new Soundcard();
    soundcard2.setUsb(Optional.empty());

    Computer computer1 = new Computer();
    computer1.setSoundcard(Optional.of(soundcard1));

    Computer computer2 = new Computer();
    computer2.setSoundcard(Optional.of(soundcard2));

    Computer computer3 = new Computer();
    computer3.setSoundcard(Optional.empty());

    System.out.println(getUsbVersion(computer1));
    System.out.println(getUsbVersion(computer2));
    System.out.println(getUsbVersion(computer3));
}
```

Example

Next Lecture

- I/O Streams
- Character Encoding