Streams

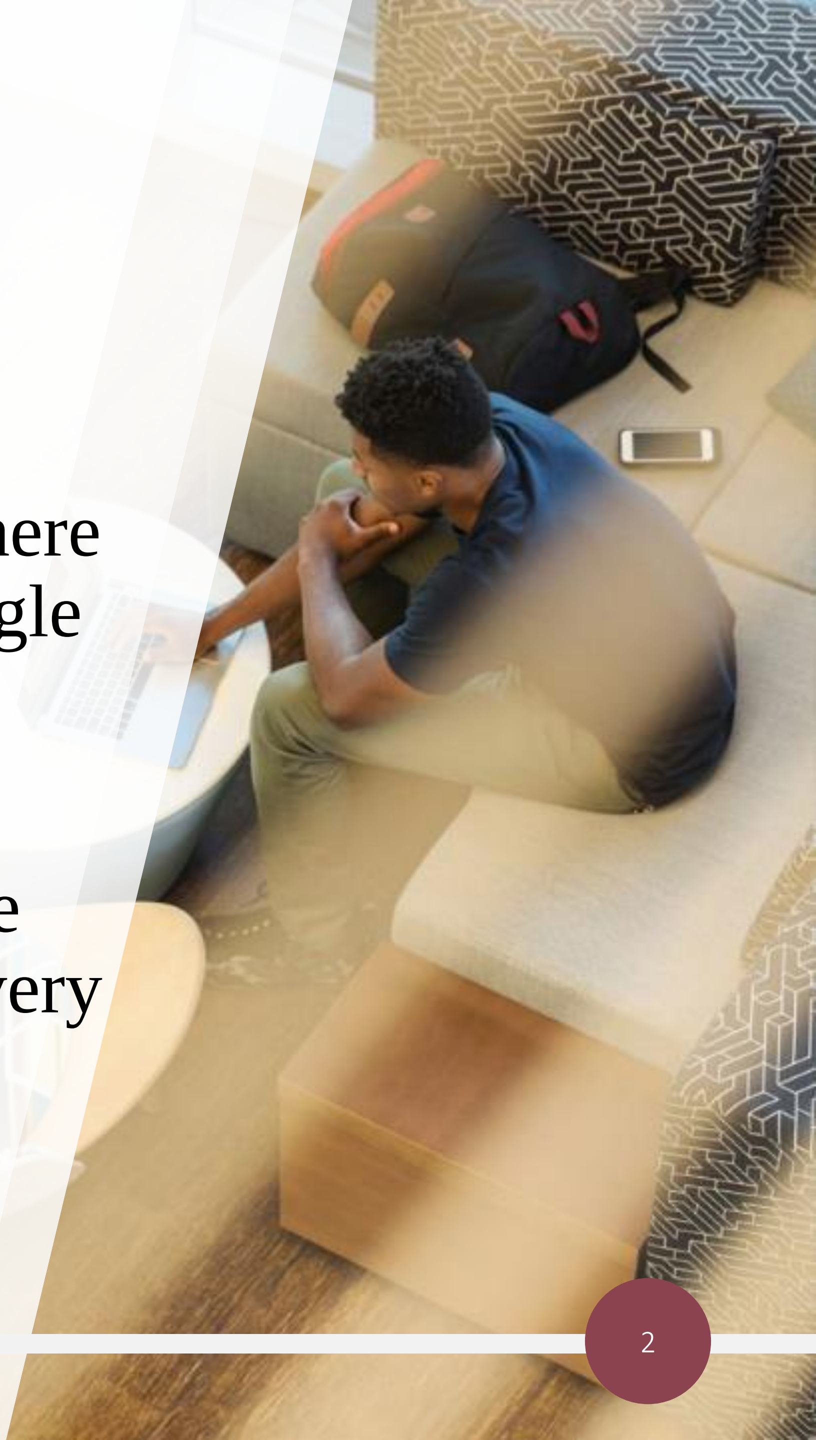
Terminal Operations

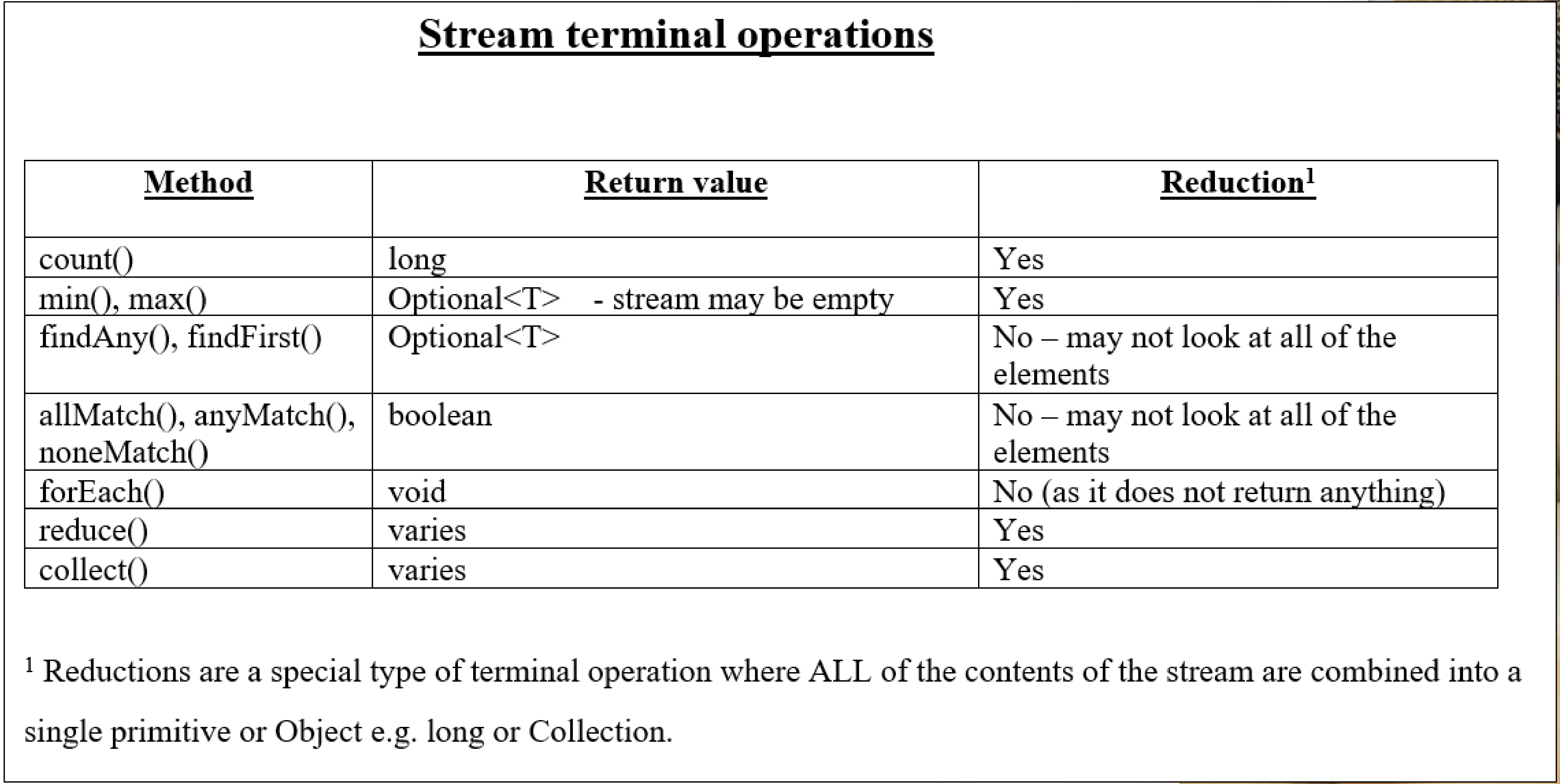
Terminal Operations

- Terminal operations can be performed without any intermediate operations but not the other way around.

- *Reductions* are a special type of terminal operation where all of the contents of the stream are combined into a single primitive or Object (Collection).

- We will have a look at the most common ones over the coming slides. Note that the comments in the code are very important.





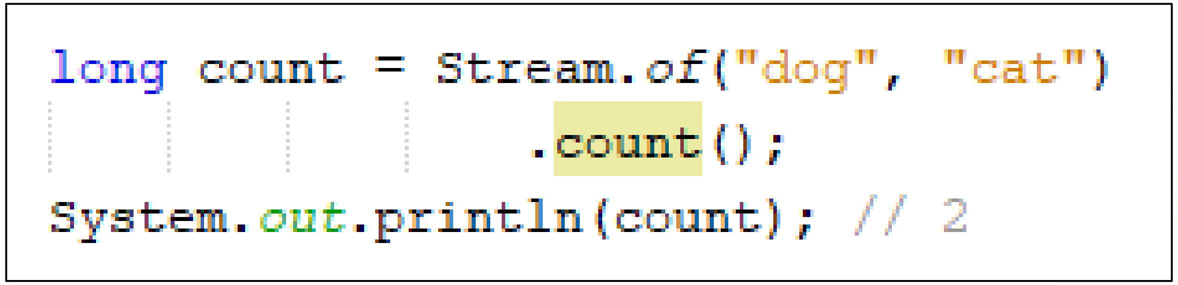
Stream terminal operations

Method	**Return value**	**Reduction**[1]
count()	long	Yes
min(), max()	Optional<T> - stream may be empty	Yes
findAny(), findFirst()	Optional<T>	No – may not look at all of the elements
allMatch(), anyMatch(), noneMatch()	boolean	No – may not look at all of the elements
forEach()	void	No (as it does not return anything)
reduce()	varies	Yes
collect()	varies	Yes

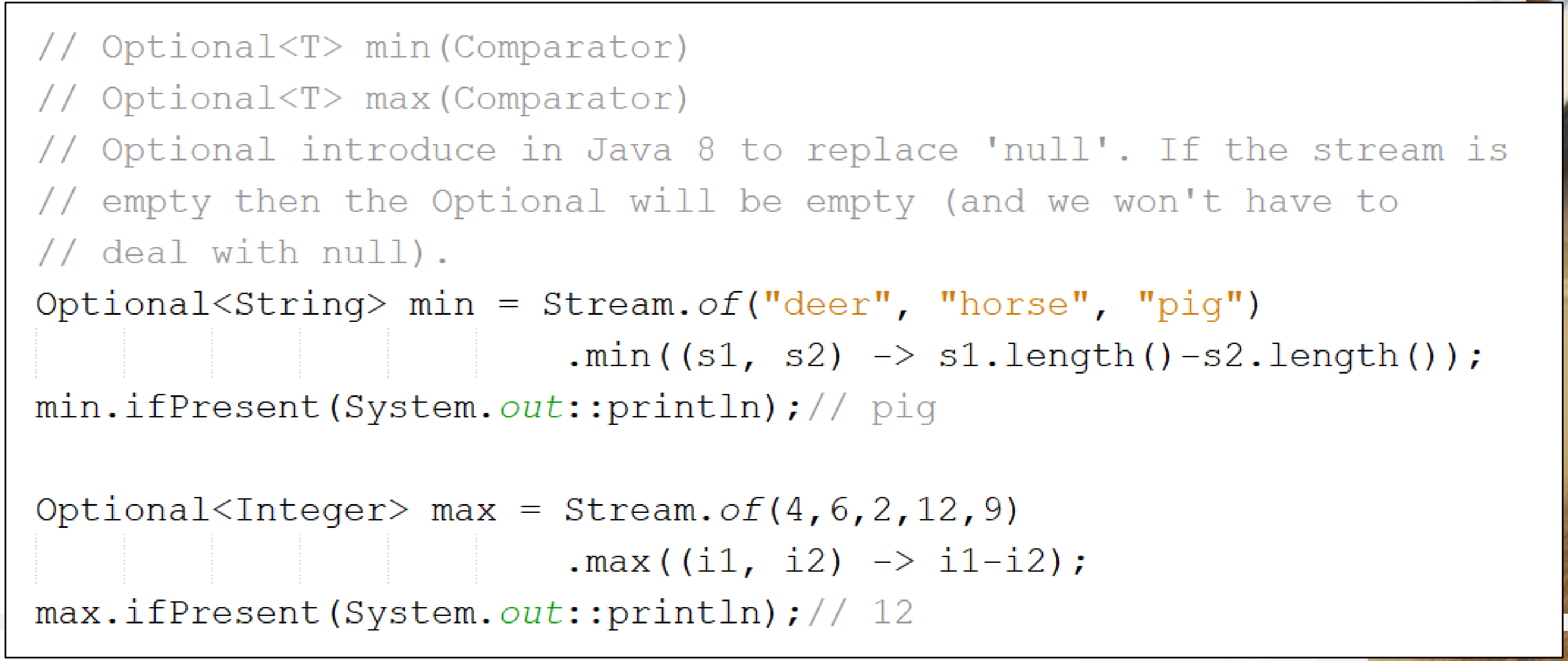
[1] Reductions are a special type of terminal operation where ALL of the contents of the stream are combined into a single primitive or Object e.g. long or Collection.

Terminal Operations

count(), min(), max()

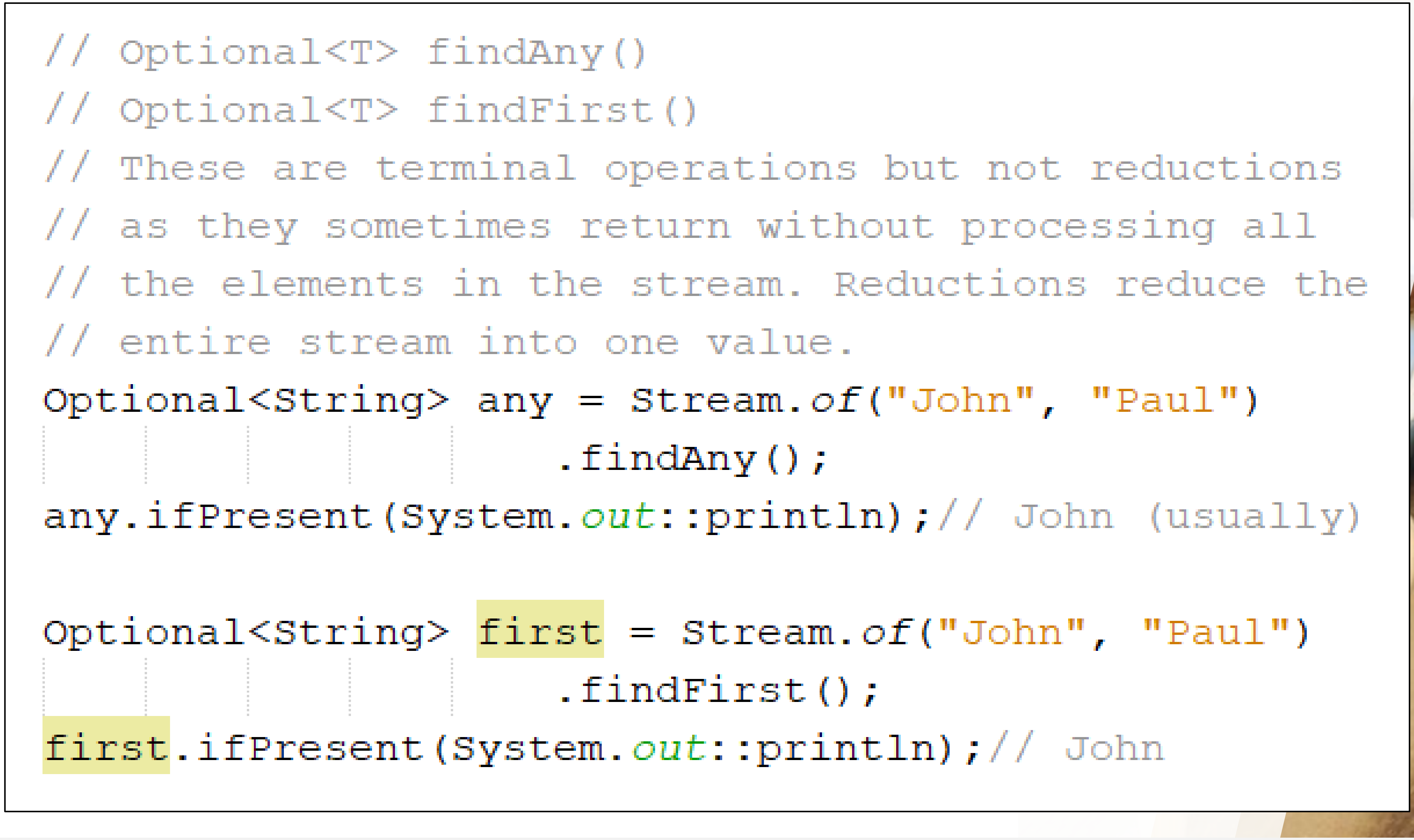


```java
long count = Stream.of("dog", "cat")
                .count();
System.out.println(count); // 2
```



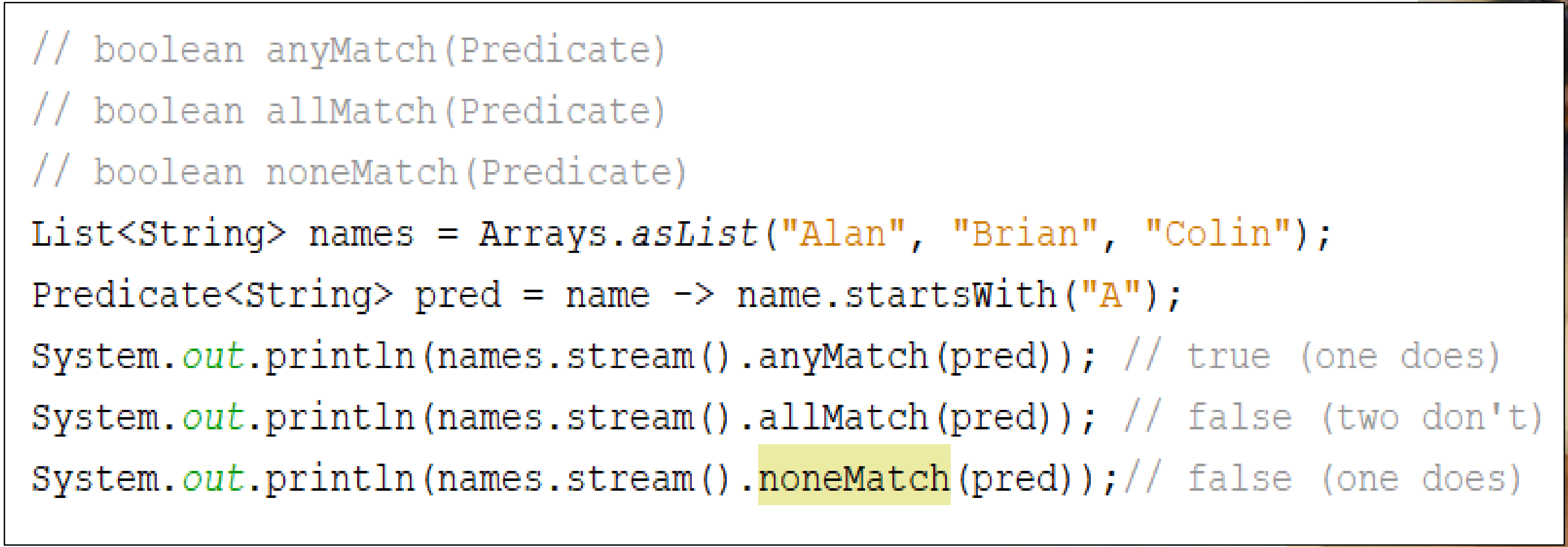
```java
// Optional<T> min(Comparator)
// Optional<T> max(Comparator)
// Optional introduce in Java 8 to replace 'null'. If the stream is
// empty then the Optional will be empty (and we won't have to
// deal with null).
Optional<String> min = Stream.of("deer", "horse", "pig")
                        .min((s1, s2) -> s1.length()-s2.length());
min.ifPresent(System.out::println);// pig

Optional<Integer> max = Stream.of(4,6,2,12,9)
                        .max((i1, i2) -> i1-i2);
max.ifPresent(System.out::println);// 12
```

Terminal Operations
findAny(), findFirst()



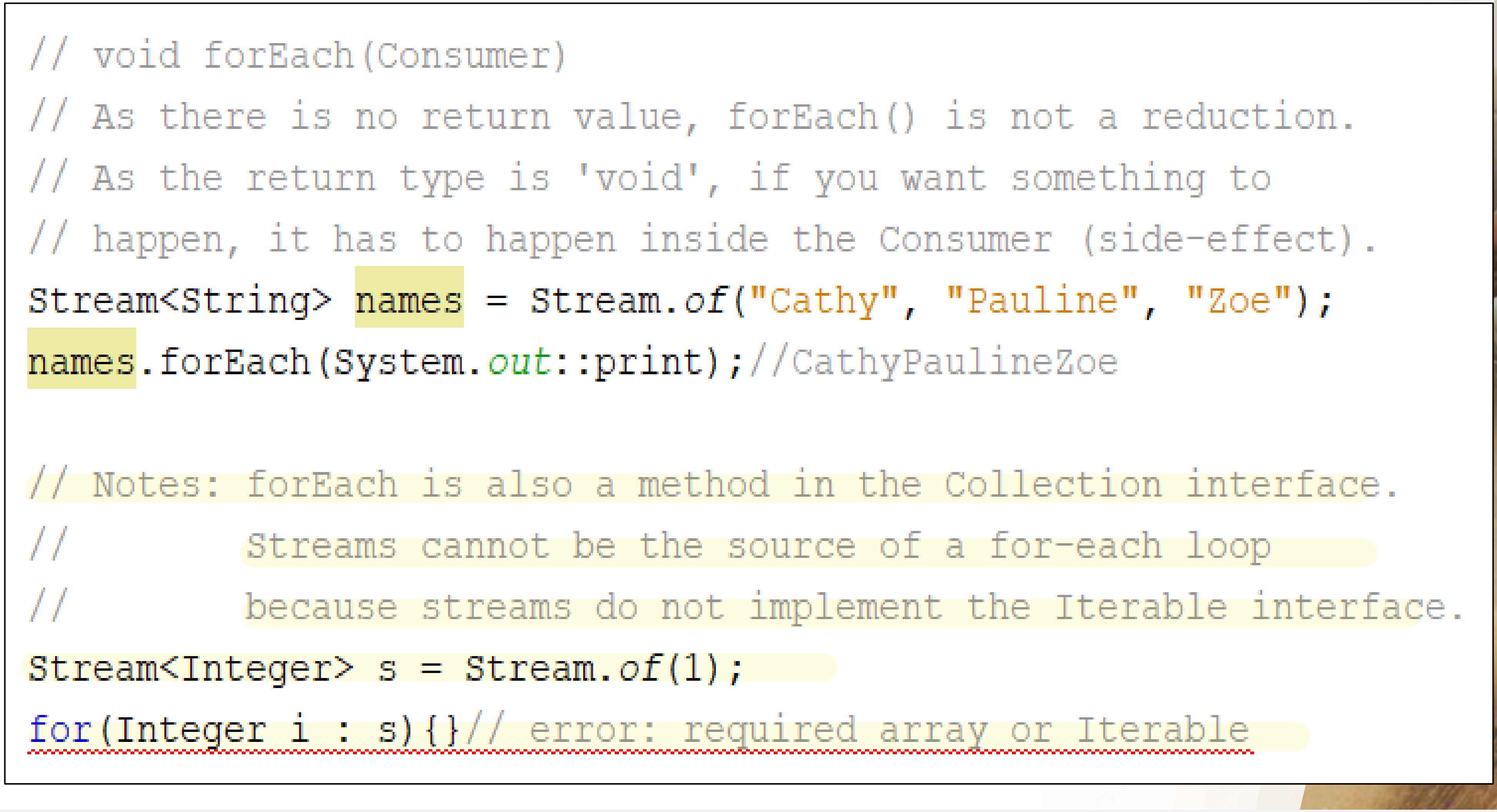
```java
// Optional<T> findAny()
// Optional<T> findFirst()
// These are terminal operations but not reductions
// as they sometimes return without processing all
// the elements in the stream. Reductions reduce the
// entire stream into one value.
Optional<String> any = Stream.of("John", "Paul")
                    .findAny();
any.ifPresent(System.out::println);// John (usually)

Optional<String> first = Stream.of("John", "Paul")
                    .findFirst();
first.ifPresent(System.out::println);// John
```

Terminal Operations
anyMatch(), allMatch(), noneMatch()

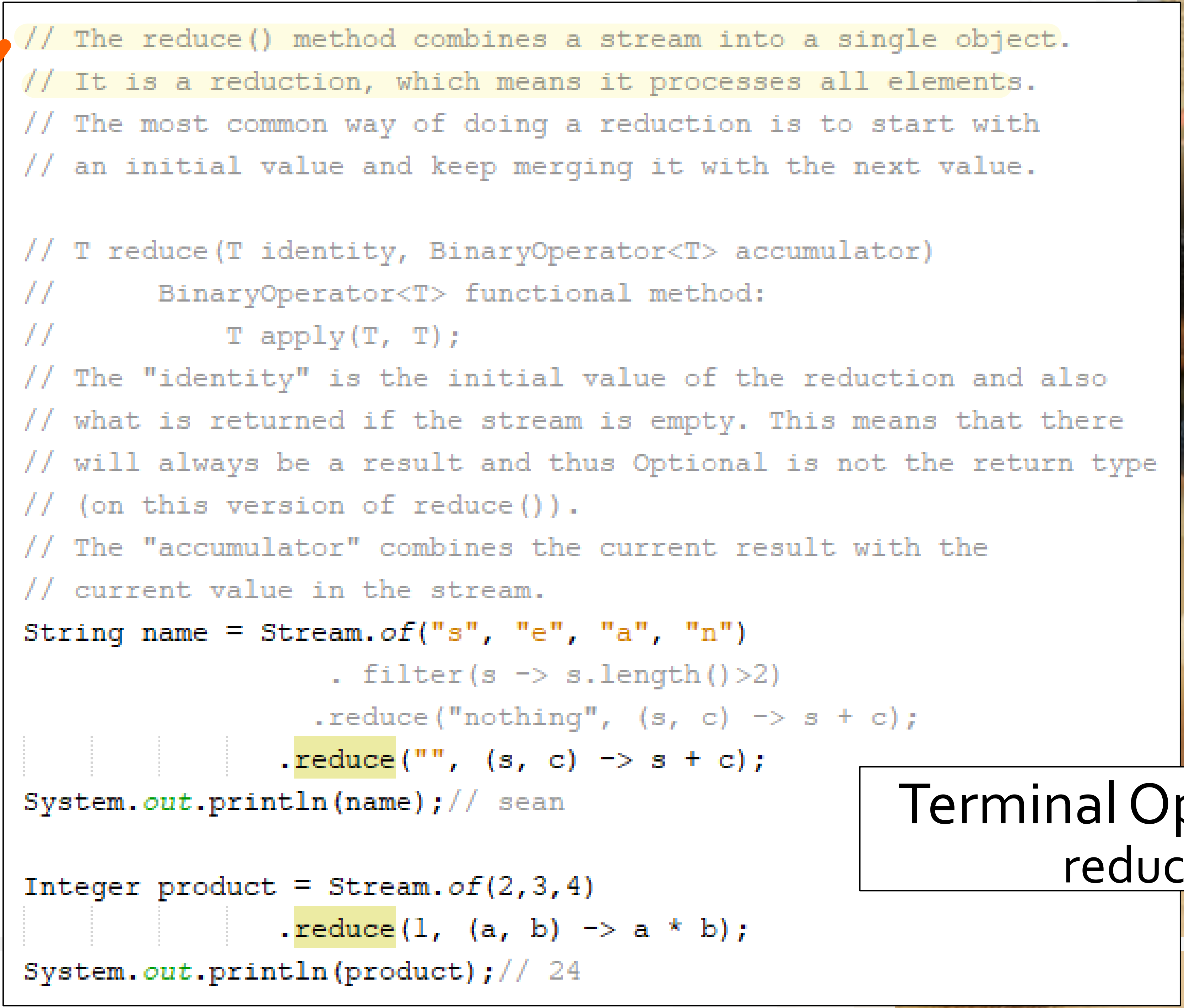


```java
// boolean anyMatch(Predicate)
// boolean allMatch(Predicate)
// boolean noneMatch(Predicate)
List<String> names = Arrays.asList("Alan", "Brian", "Colin");
Predicate<String> pred = name -> name.startsWith("A");
System.out.println(names.stream().anyMatch(pred)); // true (one does)
System.out.println(names.stream().allMatch(pred)); // false (two don't)
System.out.println(names.stream().noneMatch(pred));// false (one does)
```

Terminal Operations
forEach()



```
// void forEach(Consumer)
// As there is no return value, forEach() is not a reduction.
// As the return type is 'void', if you want something to
// happen, it has to happen inside the Consumer (side-effect).
Stream<String> names = Stream.of("Cathy", "Pauline", "Zoe");
names.forEach(System.out::print);//CathyPaulineZoe

// Notes: forEach is also a method in the Collection interface.
//        Streams cannot be the source of a for-each loop
//        because streams do not implement the Iterable interface.
Stream<Integer> s = Stream.of(1);
for(Integer i : s){}// error: required array or Iterable
```

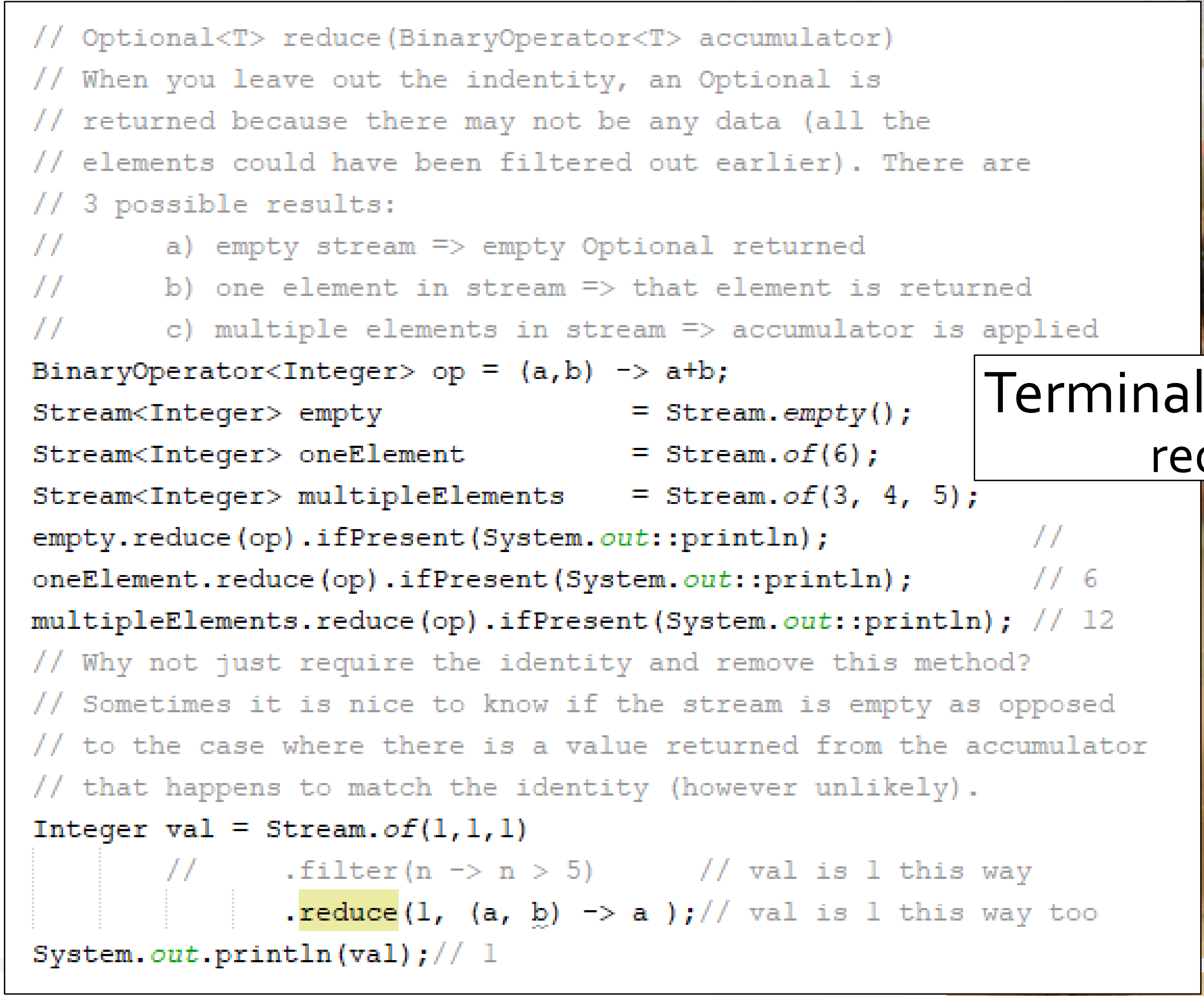


✓

```
// The reduce() method combines a stream into a single object.
// It is a reduction, which means it processes all elements.
// The most common way of doing a reduction is to start with
// an initial value and keep merging it with the next value.

// T reduce(T identity, BinaryOperator<T> accumulator)
//      BinaryOperator<T> functional method:
//          T apply(T, T);
// The "identity" is the initial value of the reduction and also
// what is returned if the stream is empty. This means that there
// will always be a result and thus Optional is not the return type
// (on this version of reduce()).
// The "accumulator" combines the current result with the
// current value in the stream.
String name = Stream.of("s", "e", "a", "n")
                  . filter(s -> s.length()>2)
                 .reduce("nothing", (s, c) -> s + c);
               .reduce("", (s, c) -> s + c);
System.out.println(name);// sean

Integer product = Stream.of(2,3,4)
               .reduce(1, (a, b) -> a * b);
System.out.println(product);// 24
```

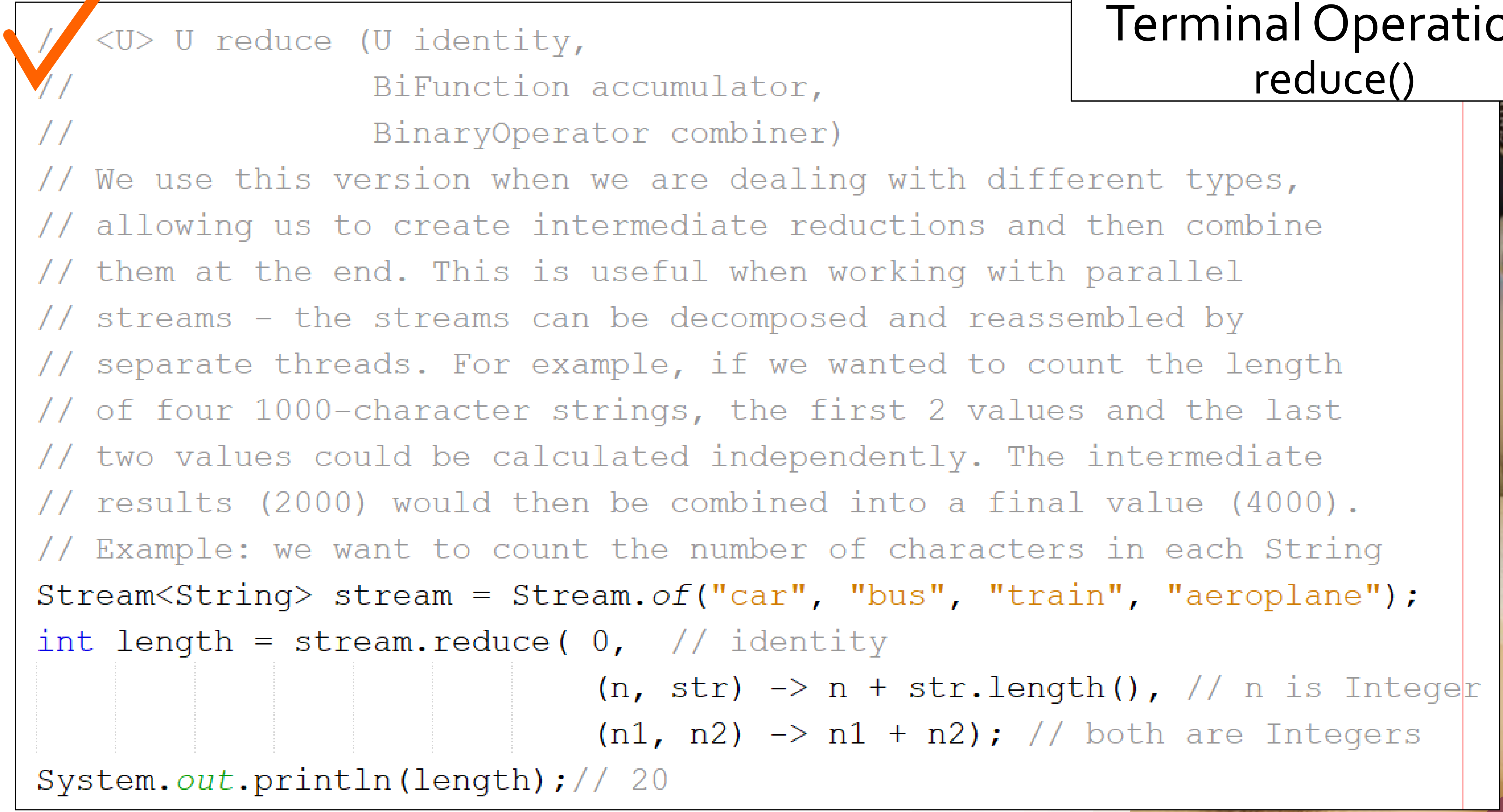
Terminal Operations
reduce()

Terminal Operations
reduce()



```java
// Optional<T> reduce(BinaryOperator<T> accumulator)
// When you leave out the indentity, an Optional is
// returned because there may not be any data (all the
// elements could have been filtered out earlier). There are
// 3 possible results:
//      a) empty stream => empty Optional returned
//      b) one element in stream => that element is returned
//      c) multiple elements in stream => accumulator is applied
BinaryOperator<Integer> op = (a,b) -> a+b;
Stream<Integer> empty               = Stream.empty();
Stream<Integer> oneElement          = Stream.of(6);
Stream<Integer> multipleElements    = Stream.of(3, 4, 5);
empty.reduce(op).ifPresent(System.out::println);            //
oneElement.reduce(op).ifPresent(System.out::println);       // 6
multipleElements.reduce(op).ifPresent(System.out::println); // 12
// Why not just require the identity and remove this method?
// Sometimes it is nice to know if the stream is empty as opposed
// to the case where there is a value returned from the accumulator
// that happens to match the identity (however unlikely).
Integer val = Stream.of(1,1,1)
        //     .filter(n -> n > 5)          // val is 1 this way
               .reduce(1, (a, b) -> a );// val is 1 this way too
System.out.println(val);// 1
```

Terminal Operations
reduce()

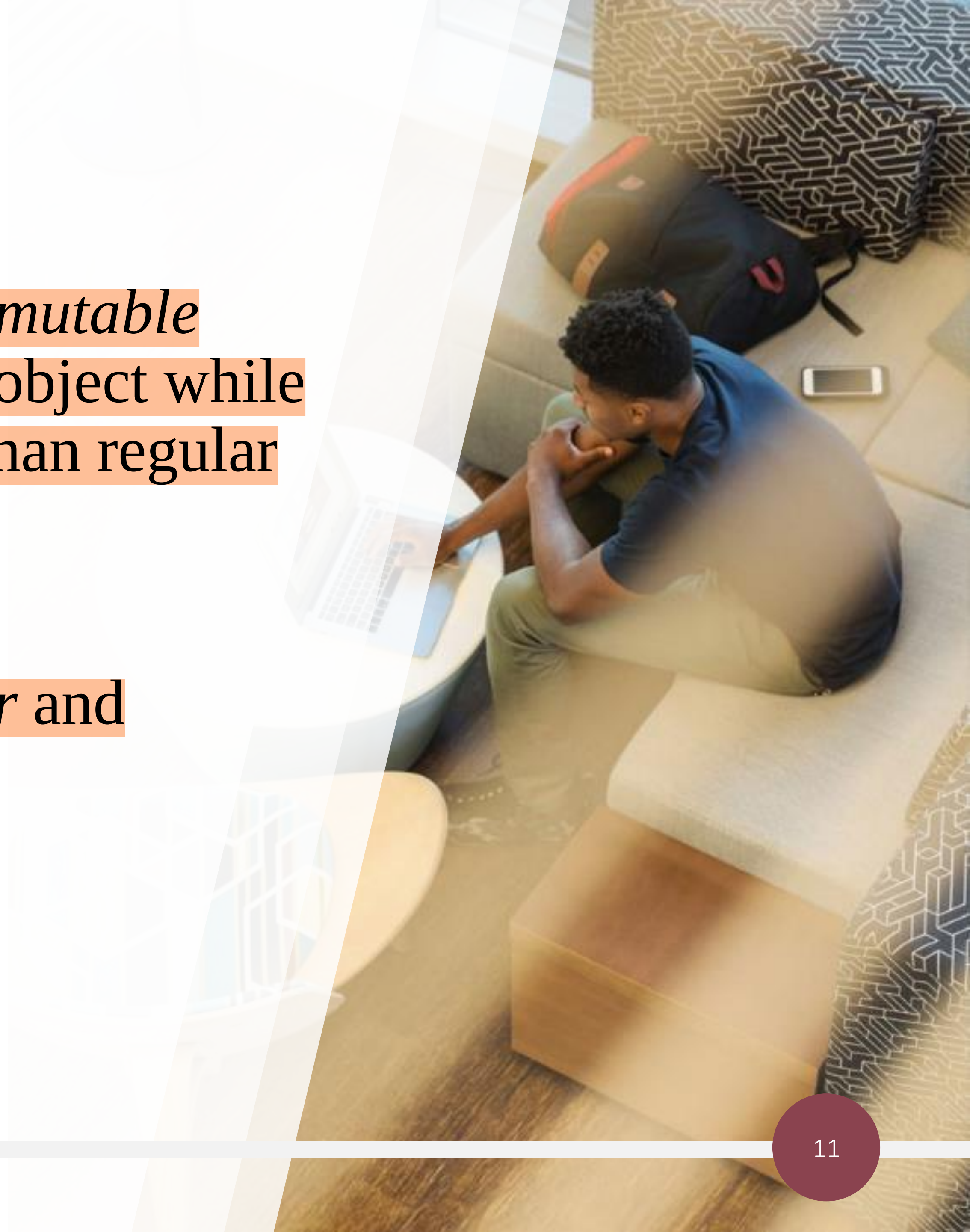


```
// <U> U reduce (U identity,
//                BiFunction accumulator,
//                BinaryOperator combiner)
// We use this version when we are dealing with different types,
// allowing us to create intermediate reductions and then combine
// them at the end. This is useful when working with parallel
// streams - the streams can be decomposed and reassembled by
// separate threads. For example, if we wanted to count the length
// of four 1000-character strings, the first 2 values and the last
// two values could be calculated independently. The intermediate
// results (2000) would then be combined into a final value (4000).
// Example: we want to count the number of characters in each String
Stream<String> stream = Stream.of("car", "bus", "train", "aeroplane");
int length = stream.reduce( 0,  // identity
                            (n, str) -> n + str.length(), // n is Integer
                            (n1, n2) -> n1 + n2); // both are Integers
System.out.println(length);// 20
```

Terminal Operations
collect()

- This is a special type of reduction called a *mutable reduction* because we use the same mutable object while accumulating. This makes it more efficient than regular reductions.

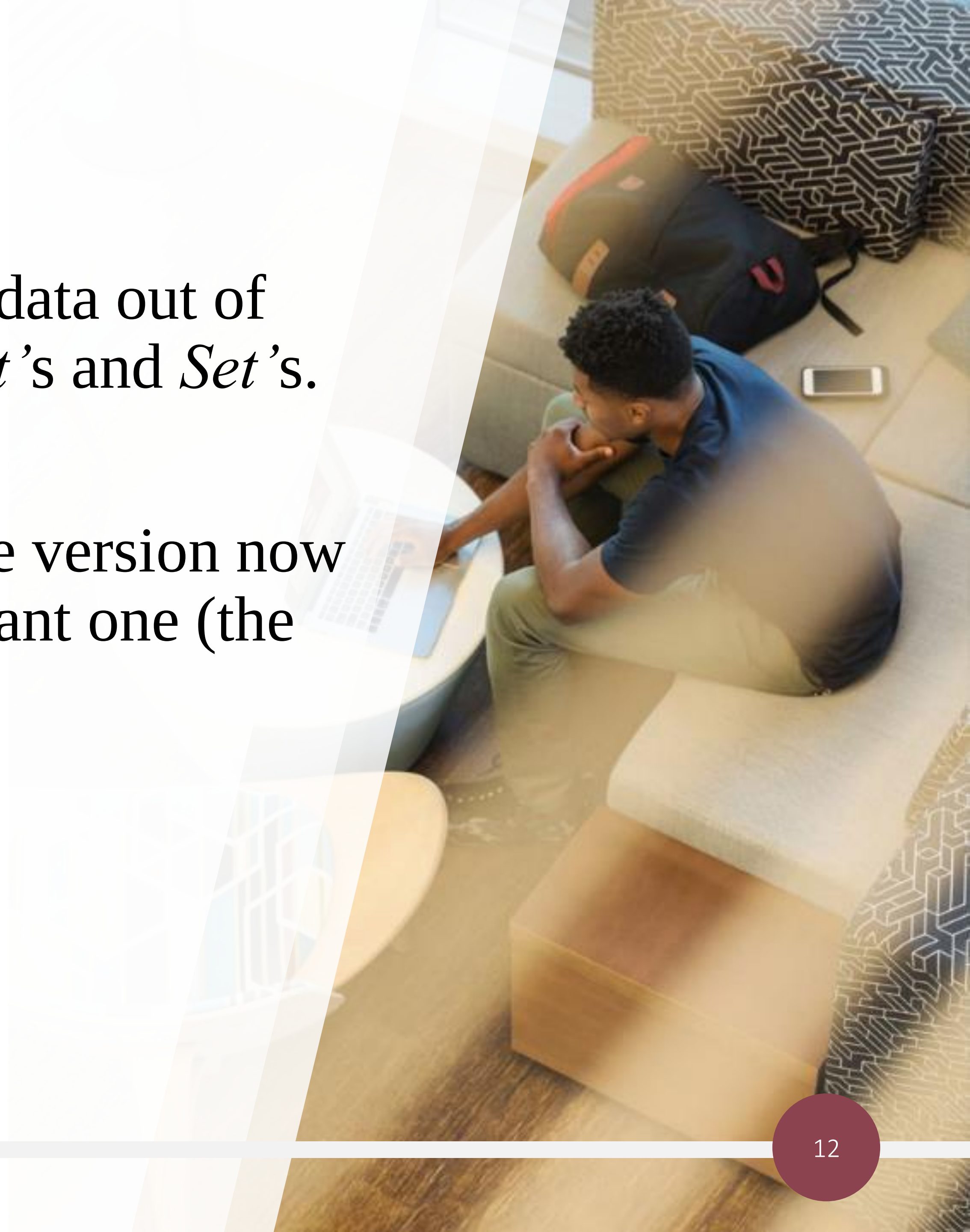
- Common mutable objects are *StringBuilder* and *ArrayList*.



Terminal Operations
collect()

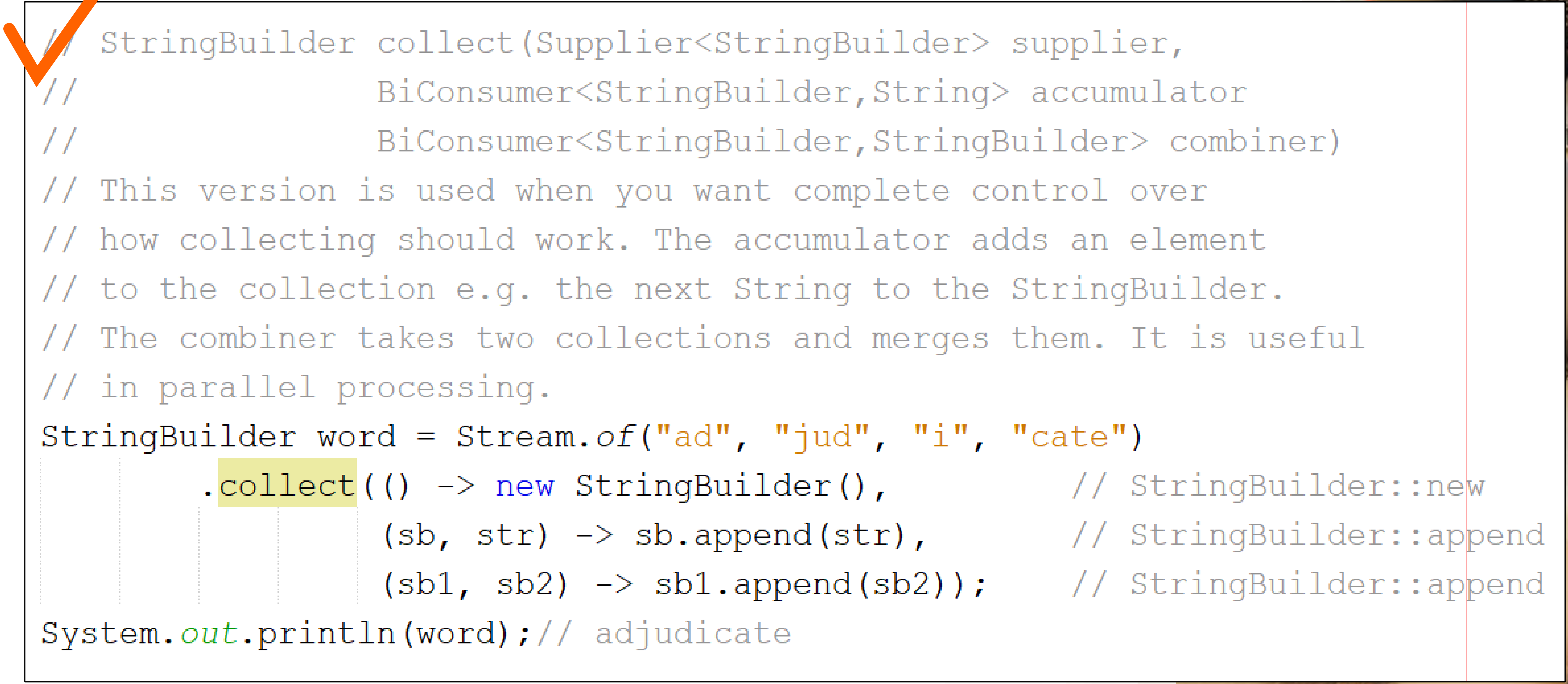
- It is a really useful method as it lets us get data out of streams and into other forms e.g. *Map'*s, *List'*s and *Set'*s.

- There are two versions. We will look at one version now but later on, we will look at the more important one (the one that works with pre-defined collectors).



Terminal Operations

collect()



```java
// StringBuilder collect(Supplier<StringBuilder> supplier,
//                BiConsumer<StringBuilder,String> accumulator
//                BiConsumer<StringBuilder,StringBuilder> combiner)
// This version is used when you want complete control over
// how collecting should work. The accumulator adds an element
// to the collection e.g. the next String to the StringBuilder.
// The combiner takes two collections and merges them. It is useful
// in parallel processing.
StringBuilder word = Stream.of("ad", "jud", "i", "cate")
        .collect(() -> new StringBuilder(),          // StringBuilder::new
                 (sb, str) -> sb.append(str),          // StringBuilder::append
                 (sb1, sb2) -> sb1.append(sb2));       // StringBuilder::append
System.out.println(word);// adjudicate
```