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# Optional

The Mother of all Bikesheds

Stuart Marks  
Core Libraries  
Java Platform Group, Oracle

Java  
Your  
Next  
(Cloud)



## Optional – The Mother of all Bikesheds

- Why do we need Optional?
- How to use Optional
- Use, Abstruse Use, and Abuse
- Bikeshedding
- Summary

# Why Do We Need Optional?



## What Happens Without Optional?

```
// Consider searching List<Customer> for a Customer with a particular ID.  
// Early draft API: Stream.search(Predicate)
```

```
Customer customerByID(List<Customer> custList, int custID) {  
    return custList.stream()  
        .search(c -> c.getID() == custID);  
}
```

```
// What if there is no element in the stream matches the predicate?  
// Presumably search() returns null.  
// customerByID() would then return null.
```

## What Happens Without Optional?

```
// Consider searching List<Customer> for a Customer with a particular ID,  
// and return the Customer name.
```

```
String customerNameByID(List<Customer> custList, int custID) {  
    return custList.stream()  
        .search(c -> c.getID() == custID)  
        .getName();  
}
```

*Throws NullPointerException  
if no Customer is found!*

```
// Instead, need to do...
```

```
String customerNameByID(List<Customer> custList, int custID) {  
    Customer cust = custList.stream()  
        .search(c -> c.getID() == custID);  
    return cust != null ? cust.getName() : "UNKNOWN";  
}
```

## Introducing Optional

- Optional<T> added in Java 8
- Can be in one of two states:
  - contains a non-null reference to a T *also called “present”*
  - is empty *also called “absent” (don’t say “null”)*
- Primitive specializations
  - OptionalInt, OptionalLong, OptionalDouble
- Optional itself is a reference type, and can be null – DON'T

***Rule #1: Never, ever, use null for an Optional variable or return value.***

## Rationale for Optional

Optional is intended to provide a *limited* mechanism for library method *return types* where there is a clear need to represent “no result,” and where using null for that is *overwhelmingly likely to cause errors*.



## Revisiting Example, Using Optional

```
// Actual Streams API has findFirst() and findAny(), returning non-null Optional<T>.  
// Predicate should be passed through a filter() upstream.
```

```
String customerNameByID(List<Customer> custList, int custID) {  
    return custList.stream()  
        .filter(c -> c.getID() == custID)  
        .findFirst()  
        .getName();  
}
```

*Error: findFirst() returns an Optional<Customer>, but getName() needs a Customer.*

## Revisiting Example, Using Optional

```
String customerNameByID(List<Customer> custList, int custID) {  
    Optional<Customer> opt = custList.stream()  
        .filter(c -> c.getID() == custID)  
        .findFirst();  
  
    return opt ??? getName();  
}
```

*How do we get the Customer out of the Optional<Customer> to call getName() on it?*

## Revisiting Example, Using Optional

```
String customerNameByID(List<Customer> custList, int custID) {  
    Optional<Customer> opt = custList.stream()  
        .filter(c -> c.getID() == custID)  
        .findFirst();  
  
    return opt.get().getName();  
}
```



*To get the value from  
an Optional, call get()*

*But get() throws NoSuchElementException  
if the Optional is empty.  
Hardly an improvement!*

# How To Use Optional



## Safely Getting a Value from an Optional

```
// A couple methods on Optional<T>: isPresent() and get()

String customerNameByID(List<Customer> custList, int custID) {
    Optional<Customer> opt = custList.stream()
        .filter(c -> c.getID() == custID)
        .findFirst();
    return opt.isPresent() ? opt.get().getName() : "UNKNOWN";
}
```

*This is safe, but hardly any  
better than checking for null!*

## Safely Getting a Value from an Optional

```
// A couple methods on Optional<T>: isPresent() and get()

String customerNameByID(List<Customer> custList, int custID) {
    Optional<Customer> opt = custList.stream()
        .filter(c -> c.getID() == custID)
        .findFirst();
    return opt.isPresent() ? opt.get().getName() : "UNKNOWN";
}
```

***Rule #2: Never use Optional.get() unless you can prove that the Optional is present.***

*Unfortunately, this just leads people into testing isPresent() before get()...*

## Safely Getting a Value from an Optional

```
// A couple methods on Optional<T>: isPresent() and get()

String customerNameByID(List<Customer> custList, int custID) {
    Optional<Customer> opt = custList.stream()
        .filter(c -> c.getID() == custID)
        .findFirst();
    return opt.isPresent() ? opt.get().getName() : "UNKNOWN";
}
```

***Rule #2: Never use `Optional.get()` unless you can prove that the `Optional` is present.***

***Rule #3: Prefer alternatives to `Optional.isPresent()` and `Optional.get()`***

## The orElse() Method Family

```
// orElse(default)
Optional<Data> opt = ...
Data data = opt.orElse(DEFAULT_DATA);
```

*Returns the value if present,  
**or else** a default value*

```
// orElseGet(supplier)
Optional<Data> opt = ...
Data data = opt.orElseGet(Data::new);
```

*Returns the value if present,  
**or else gets** a default value by  
calling a supplier*

```
// orElseThrow(exsupplier)
Optional<Data> opt = ...
Data data = opt.orElseThrow(IllegalStateException::new);
```

*Returns the value if present,  
**or else throws** an exception  
obtained from a supplier*



## The map() Method

```
String customerNameByID(List<Customer> custList, int custID) {  
    Optional<Customer> opt = custList.stream()  
        .filter(c -> c.getID() == custID)  
        .findFirst();  
  
    return opt.isPresent() ? opt.get().getName() : "UNKNOWN";  
}
```

## Example: Using map() and orElse()

```
String customerNameByID(List<Customer> custList, int custID) {  
    Optional<Customer> opt = custList.stream()  
        .filter(c -> c.getID() == custID)  
        .findFirst();  
  
    // return opt.isPresent() ? opt.get().getName() : "UNKNOWN";  
  
    return opt.map(Customer::getName).orElse("UNKNOWN");  
}
```

*map() – If present, transforms or maps the value into another and returns the result in an Optional; otherwise returns an empty Optional.*

## Example: Using map() and orElse()

```
String customerNameByID(List<Customer> custList, int custID) {  
    Optional<Customer> opt = custList.stream()  
        .filter(c -> c.getID() == custID)  
        .findFirst();  
  
    // return opt.isPresent() ? opt.get().getName() : "UNKNOWN";  
  
    return opt.map(Customer::getName).orElse("UNKNOWN");  
}
```

*orElse() can be chained directly off the result of the map() call to extract the value if present, or the default*

## Example: Using map() and orElse()

```
String customerNameByID(List<Customer> custList, int custID) {  
    return custList.stream()  
        .filter(c -> c.getID() == custID)  
        .findFirst()  
        .map(Customer::getName)  
        .orElse("UNKNOWN");  
}
```

*The map() and orElse() calls on Optional can be chained directly off the end of a stream pipeline.*

## The filter() Method

```
// (adapted with some liberties from OpenJDK Layer.java, since superseded)
// Given a Configuration object, establish an invariant
// between its parent Configuration and this Layer's Configuration.
```

```
Optional<Configuration> oparent = config.parent();
if (!oparent.isPresent() || oparent.get() != this.config()) {
    throw new IllegalArgumentException()
}
```

## The filter() Method

```
// (adapted with some liberties from OpenJDK Layer.java, since superseded)
// Given a Configuration object, establish an invariant
// between its parent Configuration and this Layer's Configuration.
```

```
Optional<Configuration> oparent = config.parent();
if (!oparent.isPresent() || oparent.get() != this.config()) {
    throw new IllegalArgumentException()
}
```

```
config.parent()
    .filter(c -> c == this.config())
    .orElseThrow(IllegalArgumentException::new);
```

*filter() – if absent, returns empty; if present, applies a predicate to the value, returning present if true or empty if false.*

## The ifPresent() Method

```
// Not to be confused with isPresent()!
```

```
// Another example from the JDK:
```

```
Optional<Task> oTask = getTask(...);  
if (oTask.isPresent()) {  
    executor.runTask(oTask.get());  
}
```

*Note isPresent() and get() calls*

## The ifPresent() Method

```
// Not to be confused with isPresent()!
```

```
// Another example from the JDK:
```

```
Optional<Task> oTask = getTask(...);  
if (oTask.isPresent()) {  
    executor.runTask(oTask.get());  
}
```

```
// better:
```

```
getTask(...).ifPresent(task -> executor.runTask(task));
```

*ifPresent() – if present, executes lambda (a Consumer) on the value, otherwise does nothing.*



## The ifPresent() Method

```
// Not to be confused with isPresent()!
```

```
// Another example from the JDK:
```

```
Optional<Task> oTask = getTask(...);  
if (oTask.isPresent()) {  
    executor.runTask(oTask.get());  
}
```

```
// better:
```

```
getTask(...).ifPresent(task -> executor.runTask(task));
```

```
// best:
```

```
getTask(...).ifPresent(executor::runTask);
```

*Method references for the win!!*

## Additional Methods

- Static factory methods
  - `Optional.empty()` – returns an empty `Optional`
  - `Optional.of(T)` – returns a present `Optional` containing `T`
    - `T` must be non-null
- `Optional.equals()` and `hashCode()` – mostly as one would expect
- Technique: unit testing a method that returns `Optional`

```
assertEquals(Optional.of("expected value"), optionalReturningMethod());  
assertEquals(Optional.empty(), optionalReturningMethod());
```

## New Optional Methods in Java 9

- `Stream<T> Optional.stream()`
  - returns a Stream of zero or one value depending on whether the Optional is absent or present
- `void Optional.ifPresentOrElse(Consumer<T>, Runnable)`
  - calls the consumer on the present value, or calls the runnable if the value is absent
- `Optional<T> Optional.or(Supplier<Optional<T>>)`
  - if 'this' optional is present, returns it
  - otherwise calls the supplier and returns the Optional it produces

## Example: Stream of Optional

```
// Convert List<CustomerID> to List<Customer>, ignoring unknowns
```

```
// Java 8
```

```
List<Customer> list = custIDlist.stream()  
    .map(Customer::findByID)  
    .filter(Optional::isPresent)  
    .map(Optional::get)  
    .collect(Collectors.toList());
```

*Assume findById() returns  
Optional<Customer>*

*Let only present Optionals through*

*Extract values from them*

```
// Java 9 adds Optional.stream(), allowing filter/map to be fused into a flatMap:
```

```
List<Customer> list = custIDlist.stream()  
    .map(Customer::findByID)  
    .flatMap(Optional::stream)  
    .collect(Collectors.toList());
```

*Optional.stream() allows filter() &  
map() to be fused into flatMap()*

## Example: Adapting Between Null and Optional

- Sometimes you need to adapt Optional-using code to code that wants null, or vice-versa
- If you have a nullable reference and you need an Optional  
`Optional<T> opt = Optional.ofNullable(ref)`
- If you have an Optional and you need a nullable reference  
`opt.orElse(null)`
  - Otherwise, generally avoid `orElse(null)`

# Use, Abstruse Use, and Abuse

## Method Chaining is Cool, But...

```
// BAD

String process(String s) {
    return Optional.ofNullable(s).orElseGet(this::getDefault);
}
```

```
// GOOD

String process(String s) {
    return (s != null) ? s : getDefault();
}
```

***Rule #4: It's generally a bad idea to create an Optional for the specific purpose of chaining methods from it to get a value.***

## Avoiding If-Statements is Cool, But...

```
Optional<BigDecimal> first = getFirstValue();
Optional<BigDecimal> second = getSecondValue();

// Add first and second, treating empty as zero, returning an Optional of the sum,
// unless BOTH are empty, in which case return an empty Optional.

Optional<BigDecimal> result = ...
```

<http://stackoverflow.com/q/39498338/1441122>



## Avoiding If-Statements is Cool, But...

```
Optional<BigDecimal> first = getFirstValue();  
Optional<BigDecimal> second = getSecondValue();
```

```
// Add first and second, treating empty as zero, returning an Optional of the sum,  
// unless BOTH are empty, in which case return an empty Optional.
```

```
Optional<BigDecimal> result =  
    Stream.of(first, second)  
        .filter(Optional::isPresent)  
        .map(Optional::get)  
        .reduce(BigDecimal::add);
```

*// OK, BUT COULD BE BETTER*

*Clever, and allows any number  
of Optionals to be combined.*

## Avoiding If-Statements is Cool, But...

```
Optional<BigDecimal> first = getFirstValue();
Optional<BigDecimal> second = getSecondValue();

// Add first and second, treating empty as zero, returning an Optional of the sum,
// unless BOTH are empty, in which case return an empty Optional.

Optional<BigDecimal> result =
    first.map(b -> second.map(b::add).orElse(b)) // NOT RECOMMENDED
        .map(Optional::of)
        .orElse(second);
```

*Even more clever!*

*Exercise: verify this is correct.*

## Avoiding If-Statements is Cool, But...

```
Optional<BigDecimal> first = getFirstValue();
Optional<BigDecimal> second = getSecondValue();

// Add first and second, treating empty as zero, returning an Optional of the sum,
// unless BOTH are empty, in which case return an empty Optional.
```

```
Optional<BigDecimal> result;

if (!first.isPresent() && !second.isPresent()) {
    result = Optional.empty();
} else {
    result = Optional.of(first.orElse(ZERO).add(second.orElse(ZERO)));
}
}
```

*Not the shortest,  
or cleverest, but is  
it the clearest?*

***Rule #5: If an Optional chain is nested or has an intermediate result of Optional<Optional<T>>, it's probably too complex.***

## The Problem With Optional.get()

Brian Goetz' biggest Java 8 regret:

There is a `get()` method on `Optional`; we should have never called it `get()`. We should have called it `getOrThrowSomethingHorribleIfTheThingIsEmpty()` because everybody calls it thinking, "I am just supposed to call `Optional.get()`" and they don't realize that that it completely undermines the purpose of using `Optional`, because it is going to throw [an exception] if the `Optional` is empty.

On Stack Overflow, every second post that uses `Optional` misuses `Optional.get()`, and it's totally my fault, because I should have named it something much more horrible. In your IDE, the `get()` method pops up, and you say, "oh yeah, that's what I want" and if something with a scarier name popped up, it might make you think, "Which of these `get` methods do I want? Do I want the one that throws, or do I want the one that returns an alternative?"

JAX 2015 *Fragen und Antworten zu Java 8* with Angelika Langer, at 16:00.  
<https://jaxenter.de/fragen-und-antworten-zu-java-8-qa-33108>

## The Problem With Optional.get()

- The get() method is an “attractive nuisance”
  - it’s much less useful than its short name would indicate
  - easy to forget to guard it
  - easy to be misled into poor isPresent() / get() coding style
  - get() is misused in a significant fraction of cases => therefore it’s a bad API
- Plan
  - introduce replacement for get()
  - deprecate get()
    - not for removal
  - deprecation on hold because of warnings it introduces

***Rule #2: Never use Optional.get() unless you can prove that the Optional is present.***

***Rule #3: Prefer alternatives APIs over Optional.isPresent() and Optional.get().***

## Places Not to Use Optional

- Avoid using Optional in fields
  - fill in replacement value at init time; use “null object” pattern; use actual null
- Avoid using Optional in method parameters
  - it doesn’t really work for making parameters optional
  - forces call sites to create Optionals for everything:

```
myMethod(Optional.of("some value")); // DON'T DO THIS!  
myMethod(Optional.empty());
```
- Avoid using Optional in collections
  - usually indicates a design smell of sorts
  - often better ways of representing things

***Rule #6: Avoid using Optional in fields, method parameters, and collections.***

## Places Not to Use Optional

- Remember, Optional is a box!
  - is a separate object, consumes 4x memory of a bare reference
  - potentially adds GC pressure
  - always requires a dependent load, leading to cache misses
  - could turn into a performance/space problem if used frequently
- Don't replace every null with an Optional
  - null can be safe, if it's well controlled
  - null in a private field can be easily checked
  - nullable parameters are ok (if déclassé)
    - library code should take responsibility for checking args

# Bikeshedding





# Bikeshedding

*Flatmap() should allow nulls!*

*Optional should allow 'present' with a value of null!*

*Optional.ifPresent() should return 'this' instead of void, to enable chaining!*

*Optional doesn't prevent all NPEs, therefore it's useless!*

*Optional shouldn't be final!*

*Optional doesn't prevent all NPEs, therefore it's useless!*

*Optional violates the Monad Law!*

*Null Optionals are allowed and are redundant with empty Optionals!*

*Optional should have Present and Empty subclasses!*

*Java should have added @Nullable / @NonNull instead of Optional!*

*Optional should be serializable!*

*Optional should be fully supported in the language, not just be a library construct!*

*Optional should implement Iterable so it can be used in a for-loop!*

*Java should have added null-safe dereference (Elvis) operator instead of Optional!*



## Why Isn't Optional Serializable?

- Background: Value types – Project Valhalla
  - a value is like an object, but it has no notion of identity
  - “codes like a class, works like an int”
  - we eventually want to convert Optional into a value type
- Disclaimer from Optional's javadoc:

*This is a value-based class; use of identity-sensitive operations (including reference equality (==), identity hash code, or synchronization) on instances of Optional may have unpredictable results and should be avoided.*

***Rule #7: Avoid using identity-sensitive operations on Optionals.***

## Serialization Impact on Future Evolution

- JDK rule: *forward and backward* serialization compatibility across releases
- If Optional were serializable today, it would be serialized as an Object
  - it'll always be serialized as an Object, even if it eventually becomes a value type
- Serialization inherently depends on object identity
- Consequences of Optional being Serializable
  - it might prevent it from being converted into a value type in the future
  - deserializing an Optional might result in a “boxed” value type

## Why Not Use Optional in Fields?

- More a style issue than a correctness issue
  - usually there's a better way to model absence of a value
  - distinguish usage in API vs internal representation
  - use of Optional in fields often arises from slavish desire to eliminate nullable fields
  - remember, eliminating nulls isn't a goal of Optional
- Using Optional in fields...
  - creates another object for every field – 4x memory overhead vs bare reference
  - introduces a dependent load from memory on every field read
  - clutters up your code
  - to what benefit? ability to chain methods?

## Why Not Use Optional in Fields?

- Colebourne: *Optional, A Pragmatic Approach*
  - <http://blog.joda.org/2015/08/java-se-8-optional-pragmatic-approach.html>
  - use nullable fields, getters should return Optional
- Ernst: *Nothing is Better Than the Optional Type*
  - <https://homes.cs.washington.edu/~mernst/advice/nothing-is-better-than-optional.html>
  - use Nullness Checker
  - glass is one-quarter full

# Summary & Conclusion



## Summary & Conclusion

Optional is intended to provide a *limited* mechanism for library method *return types* where there is a clear need to represent “no result,” and where using null for that is *overwhelmingly likely to cause errors*.

## Summary & Conclusion

- ***Rule #1: Never, ever, use null for an Optional variable or return value.***
- ***Rule #2: Never use Optional.get() unless you can prove that the Optional is present.***
- ***Rule #3: Prefer alternatives to Optional.isPresent() and Optional.get().***
- ***Rule #4: It's generally a bad idea to create an Optional for the specific purpose of chaining methods from it to get a value.***
- ***Rule #5: If an Optional chain has a nested Optional chain, or has an intermediate result of Optional<Optional<T>>, it's probably too complex.***
- ***Rule #6: Avoid using Optional in fields, method parameters, and collections.***
- ***Rule #7: Avoid using identity-sensitive operations on Optionals.***



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