<? extends Generics>

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About Me...

Testing in Scala
(Book)

Beginning Scala Programming
(O'Reilly Video)

Scala Beyond the Basics
(O'Reilly Class)

TDD in Java
(O'Reilly Class)

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Code & Slides Available @

https://github.com/dhinojosa/generics-study

Generics

- Add stability to your code by exposing bugs at compile time
- Provides a way for you to re-use the same code with different inputs allowing for less code
- Eliminates casting
- Eliminates the need for explicit boxing
- One of the harder concepts since JDK 5

Effective Java Item 26

Item 26: Favor generic types

It is generally not too difficult to parameterize your collection declarations and make use of the generic types and methods provided by the JDK. Writing your own generic types is a bit more difficult, but it's worth the effort to learn how.

Generic Terms

Term	Example
Parameterized Type	`List<String>`
Actual Type Parameter	`String`
Generic Type	`List<E>`
Formal Type Parameter	`E`
Unbounded wildcard type	`List<?>`
Raw Type	`List`
Bounded Type Parameter	`<E extends Number>`
Recursive Type Bound	`<T extends Comparable<T>>`
Bounded Wildcard Type	`List<? extends Number>`
Generic Method	`static <E> List<E> asList(E[] a)`
Type Token	`Integer.class`

Source: Effective Java 2nd Edition

Demo: Casting & Boxing

GenericsBasicsTest #1- #7

Effective Java Item 23

Item 23: Don't use raw types in new code

First, a few terms. A class or interface whose declaration has one or more *type parameters* is a *generic* class or interface [JLS, 8.1.2, 9.1.2]. For example, as of release 1.5, the `List` interface has a single type parameter, `E`, representing the element type of the list. Technically the name of the interface is now `List<E>` (read "list of E"), but people often call it `List` for short. Generic classes and interfaces are collectively known as *generic types*.

Erasure

Erasure

- Parameterized Types are *erased* at runtime, this is called *type erasure*
- This can trip up the novice and professional alike
- `List<String>` at runtime is purely `List`
- Generic types are non-reifiable, meaning they are not fully available at runtime

Demo: Erasure

Generic Classes/Generic Instance and Static Methods

Assignment of Generic Types

Assignment of Generic Types

- As default, `List<Integer>` can only be assigned to a `List<Integer>`
- Special Consideration for assignments where `List<Integer>` gets assigned a `List<Object>`
- ...or the other way around: `List<Object>` gets assigned a `List<Integer>`

polymorphism

Number ← <<assignment>> **Integer**

invariant

List<Integer> ← <<assignment>> **List<Integer>**

covariant

List<Number> ← <<assignment>> **List<Integer>**

contravariant

List<Integer> ← <<assignment>> **List<Number>**

polymorphism

Number ← <<assignment>> **Integer**

invariant

List<Integer> ← <<assignment>> **List<Integer>**

covariant

List<? extends Number> ← <<assignment>> **List<Integer>**

contravariant

List<? super Integer> ← <<assignment>> **List<Number>**

What you can take out...

What you can put in...

```
public A foo(A a){...}
```

PECS

Producer-`extends`

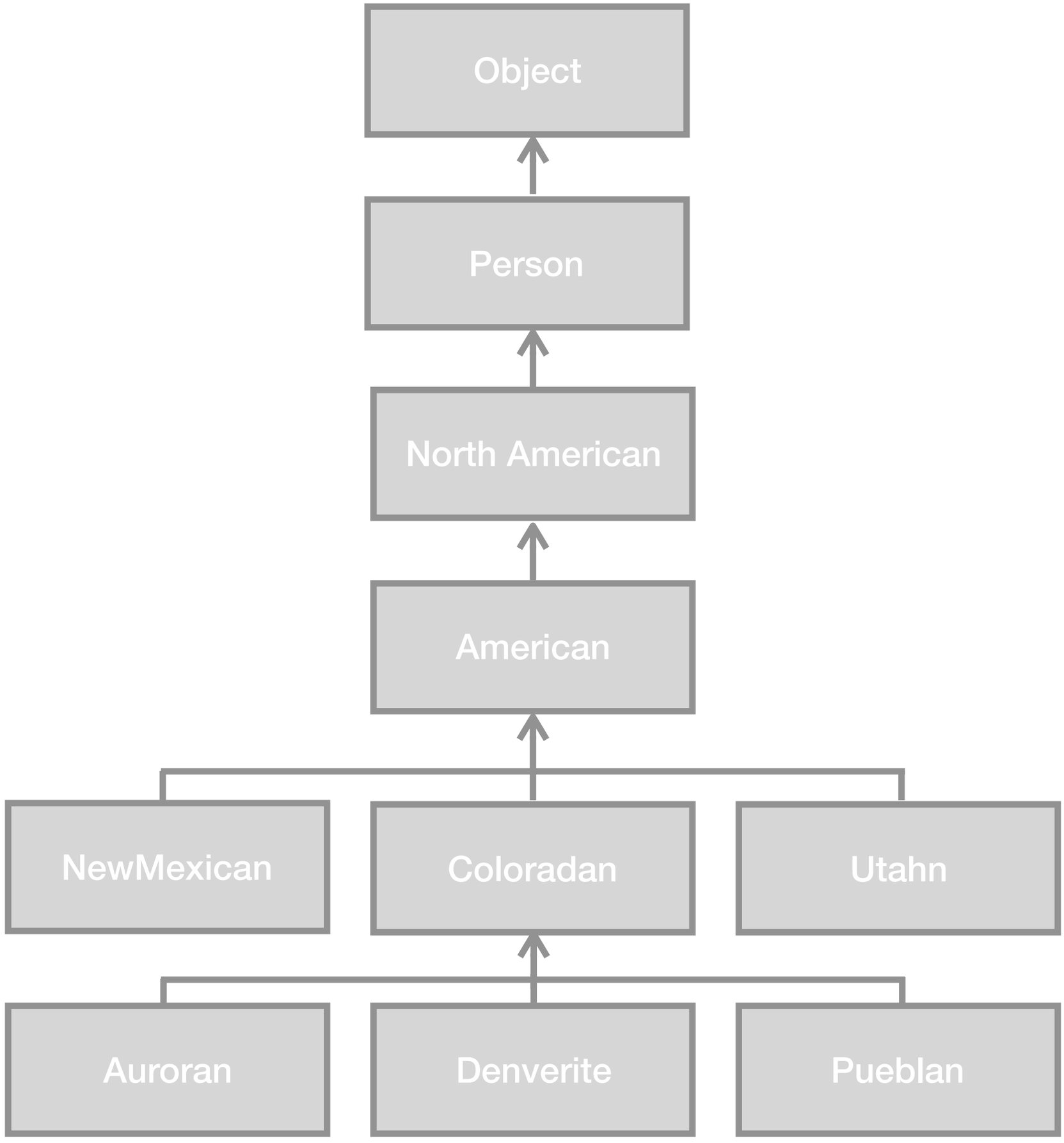
Consumer-`super`

producer consumer

```
public A foo(A a){...}
```


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

Naftalin and Wadler call it the *Get and Put Principle*


Object
Person
North American
American
NewMexican
Coloradan
Utahn
Auroran
Denverite
Pueblan

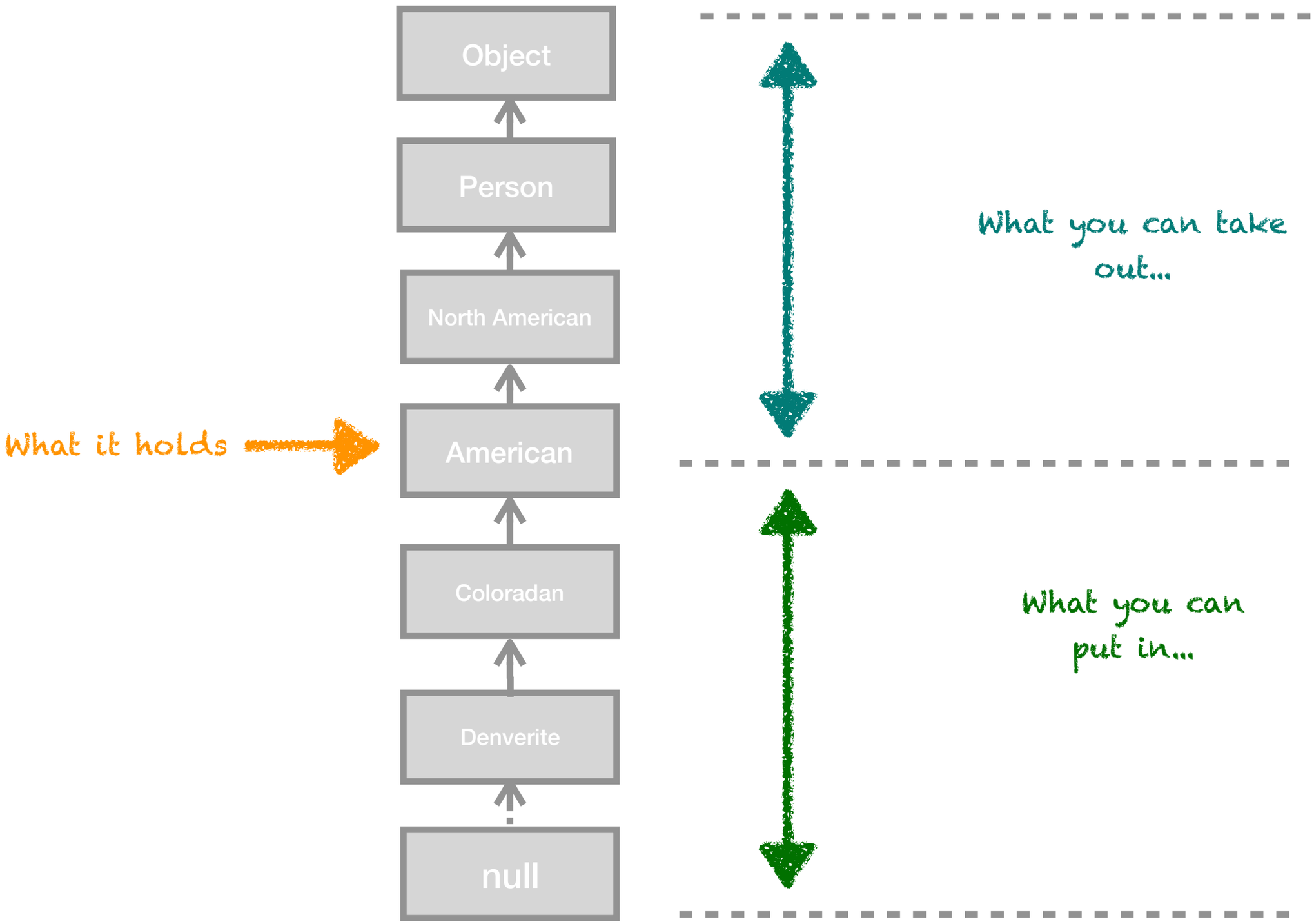
Invariant

invariant

List<Integer> ← **List<Integer>**

<<assignment>>

```
Container<American> c = new Container<American>
```



Demo: Invariant

InvariantTest.java #9-#10

Covariant

covariant

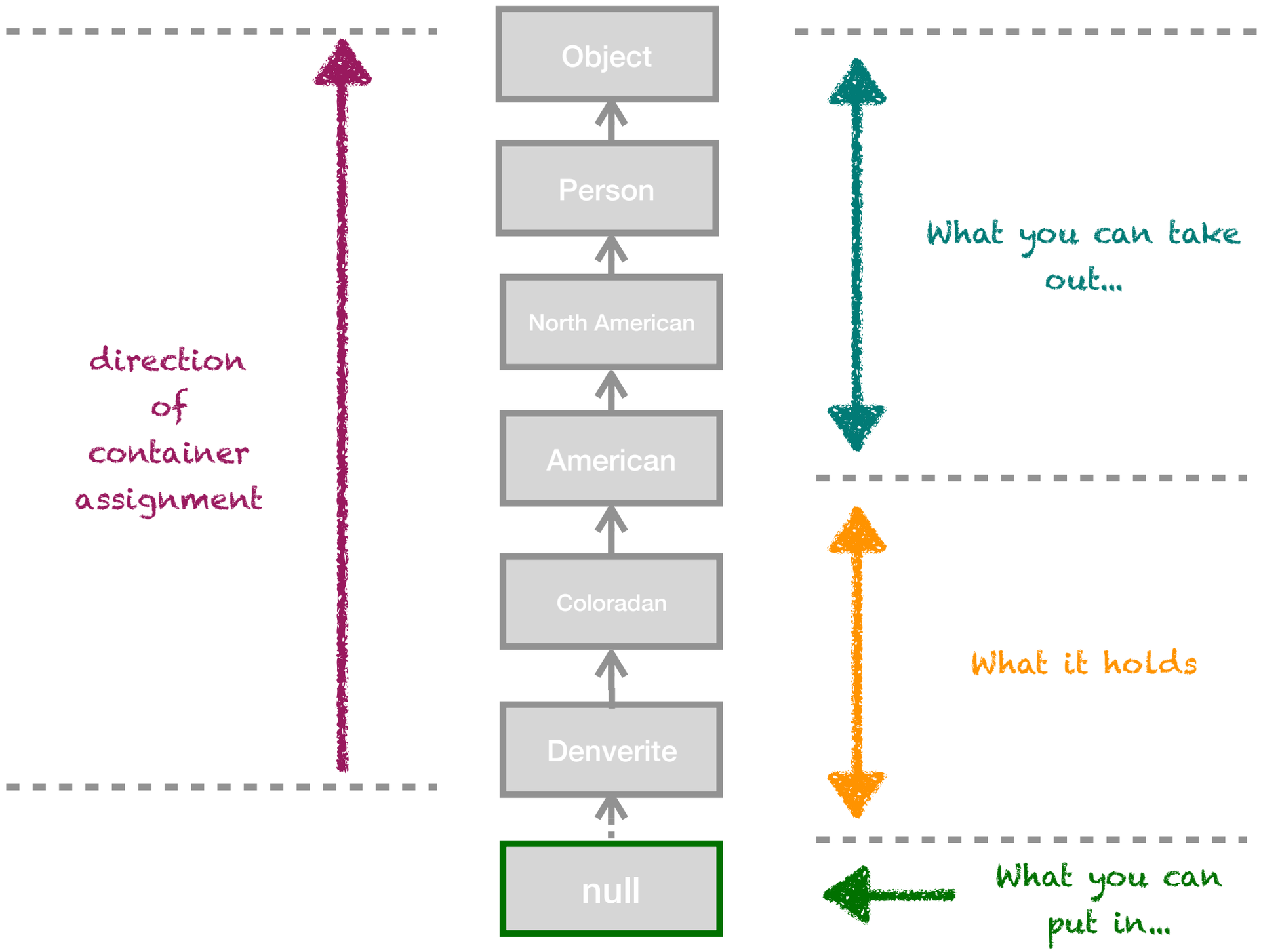
List<? extends Number> ← **List<Integer>**

<<assignment>>

Denverite

? extends American

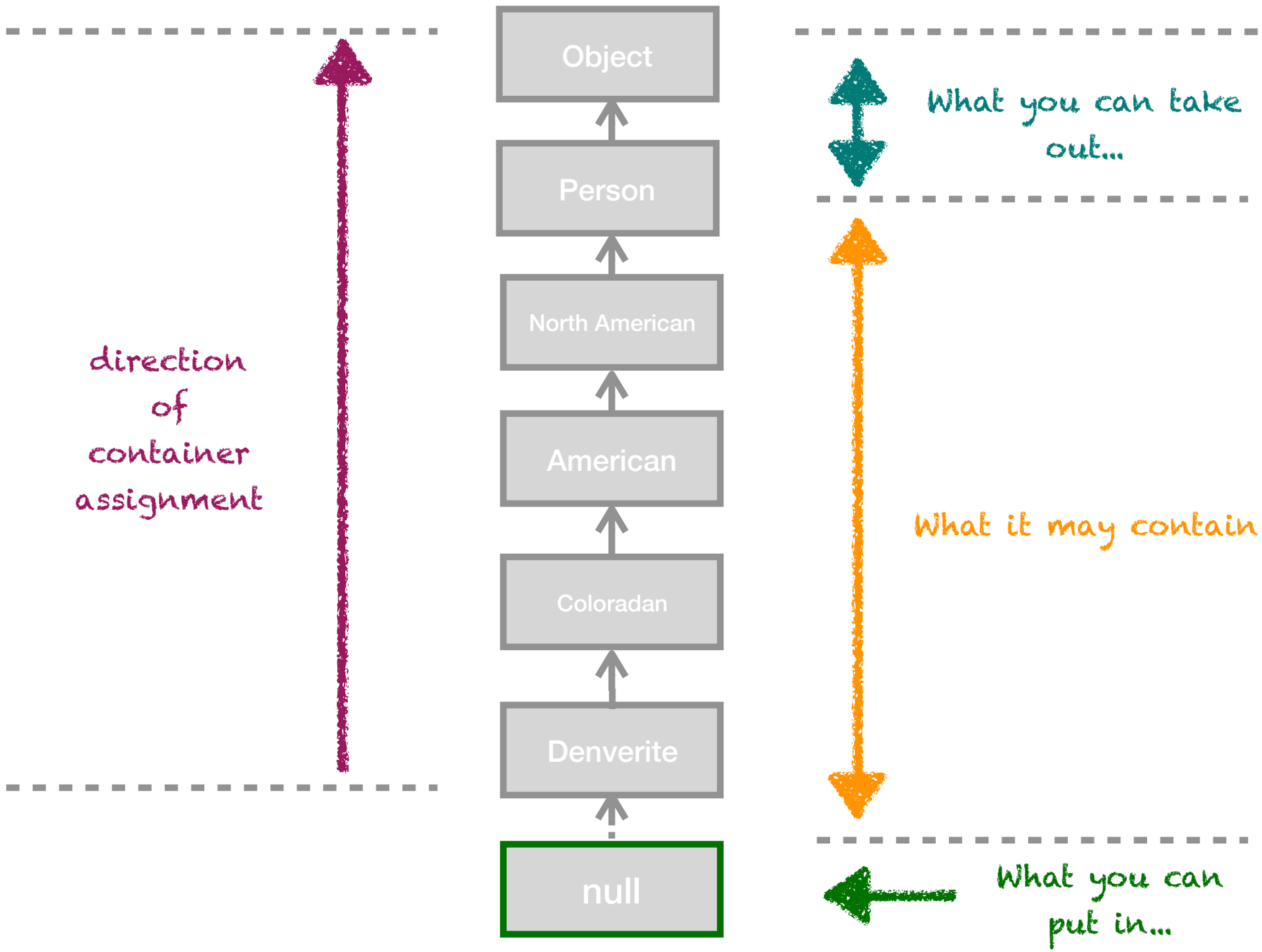
```
Container<? extends American> c = new Container<Denverite>
```



Coloradan

? extends Person

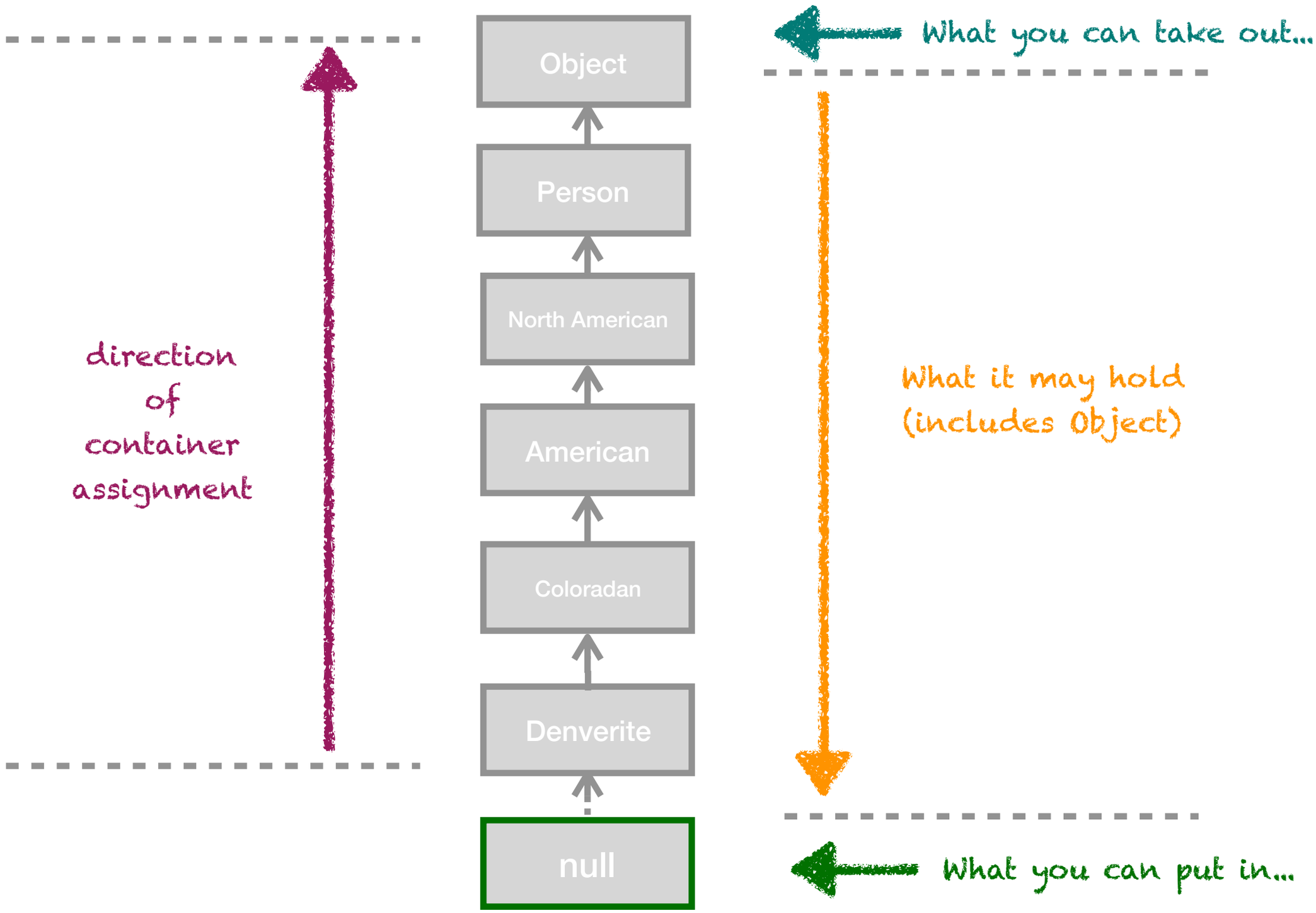
```
Container<? extends Person> c = new Container<Coloradan>();
```



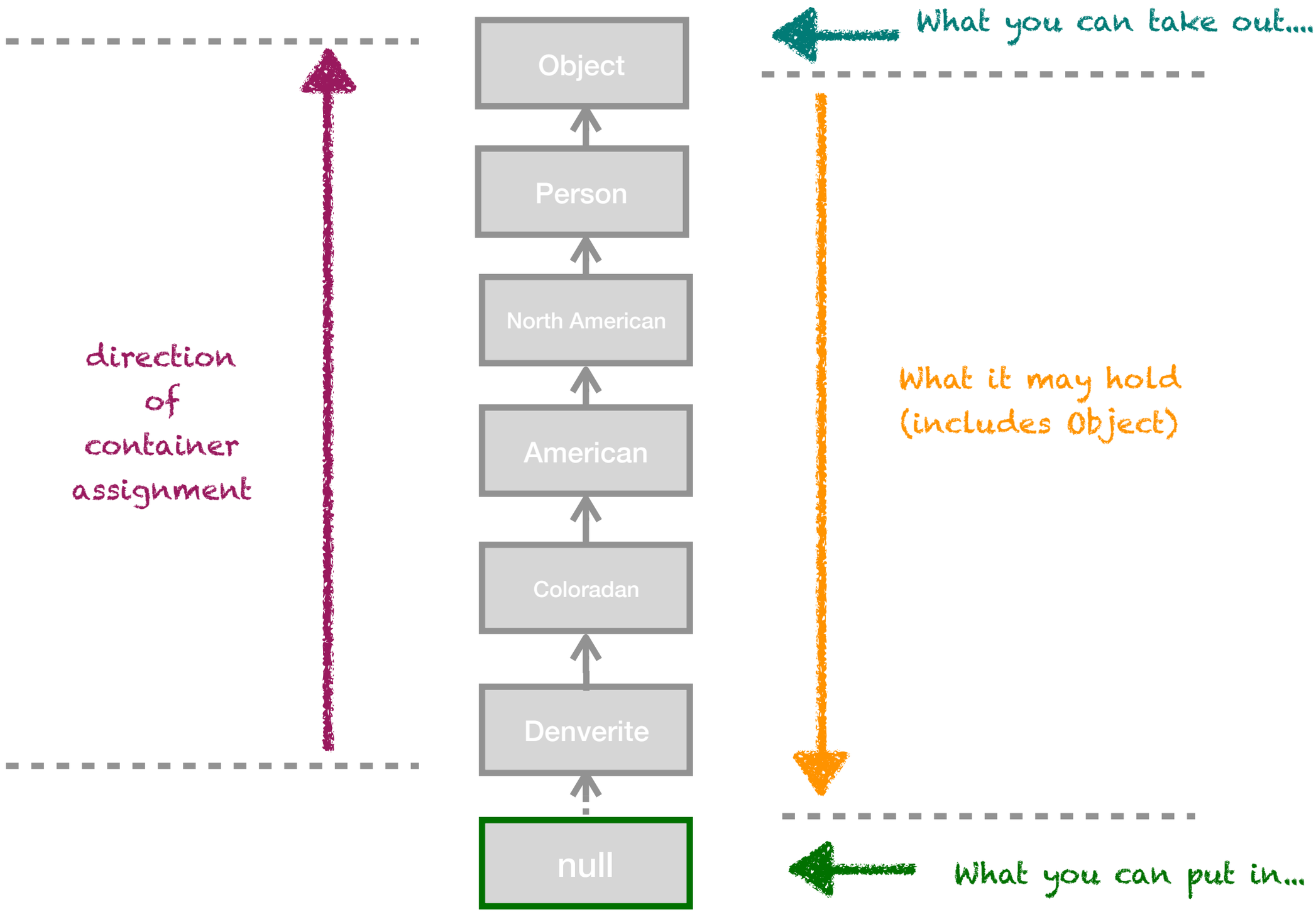
Coloradan

? extends Object

```
Container<? extends Object> c = new Container<Coloradan>();
```



```
Container<?> c = new Container<Coloradan>();
```



Demo: Covariant

CovariantTest.java #11-#15

Contravariance

contravariant

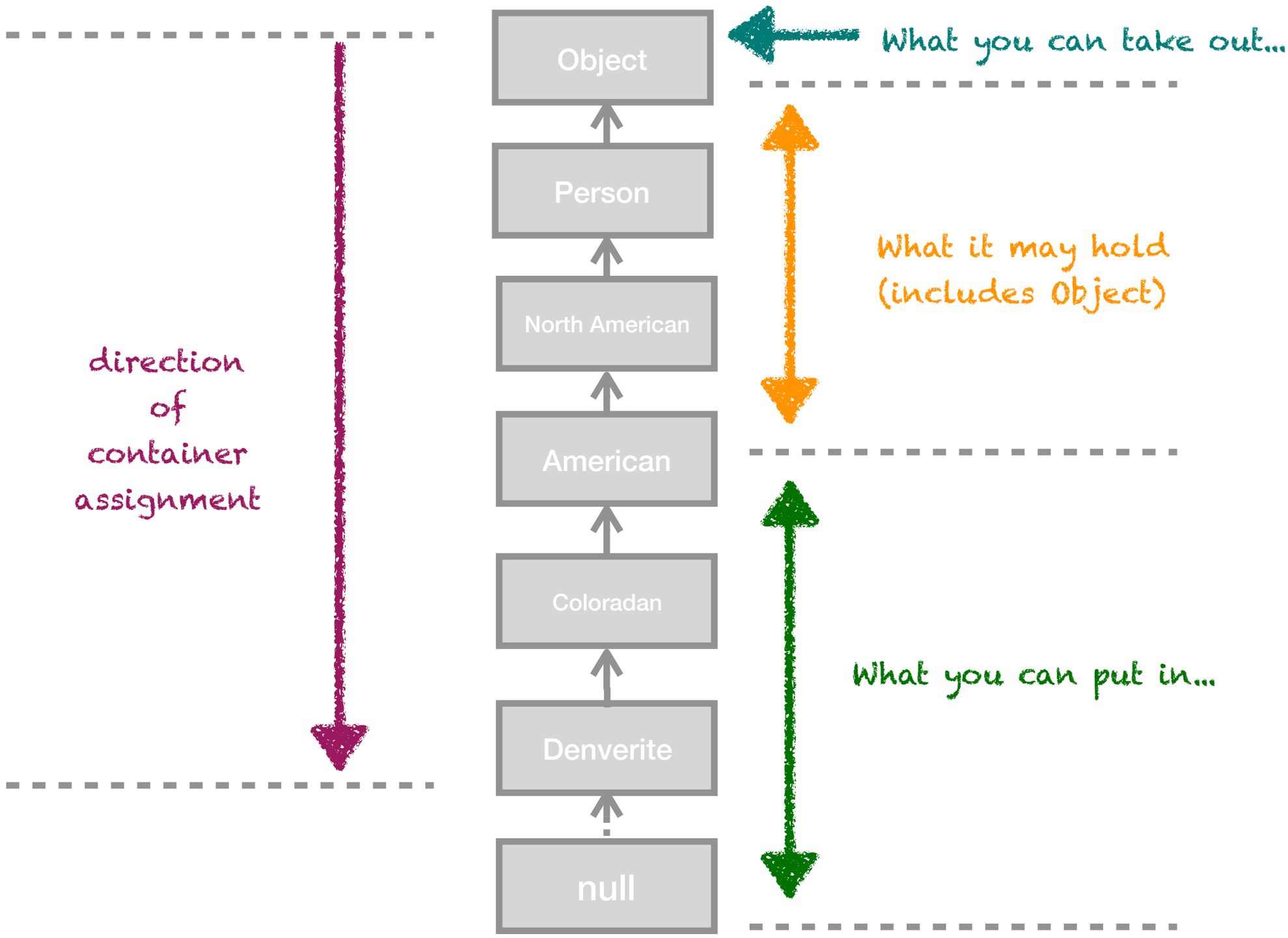
List<? super Integer> ← **List<Number>**

<<assignment>>

Person

? super American

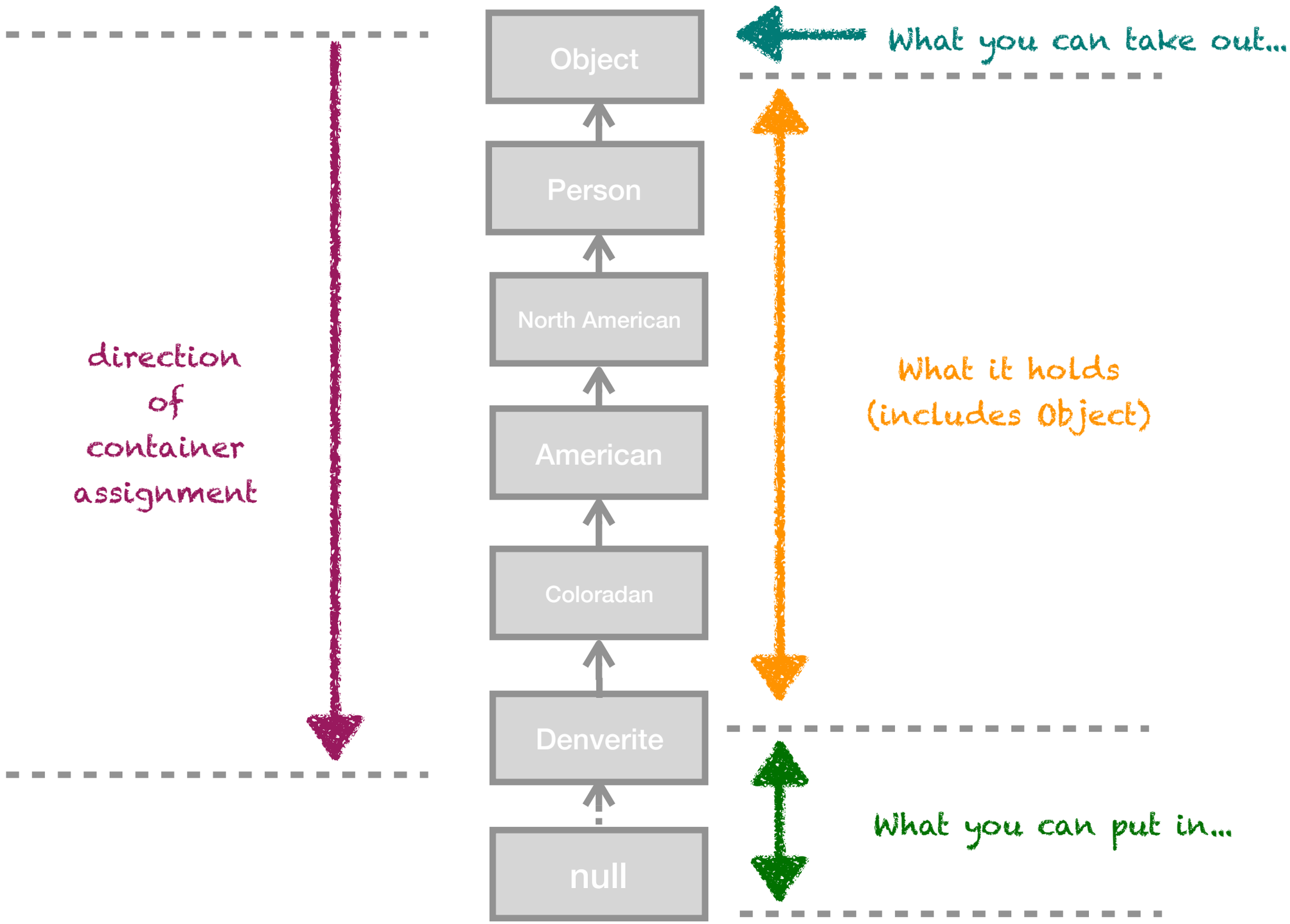
```
Container<? super American> c = new Container<Person>();
```



Person

? super Denverite

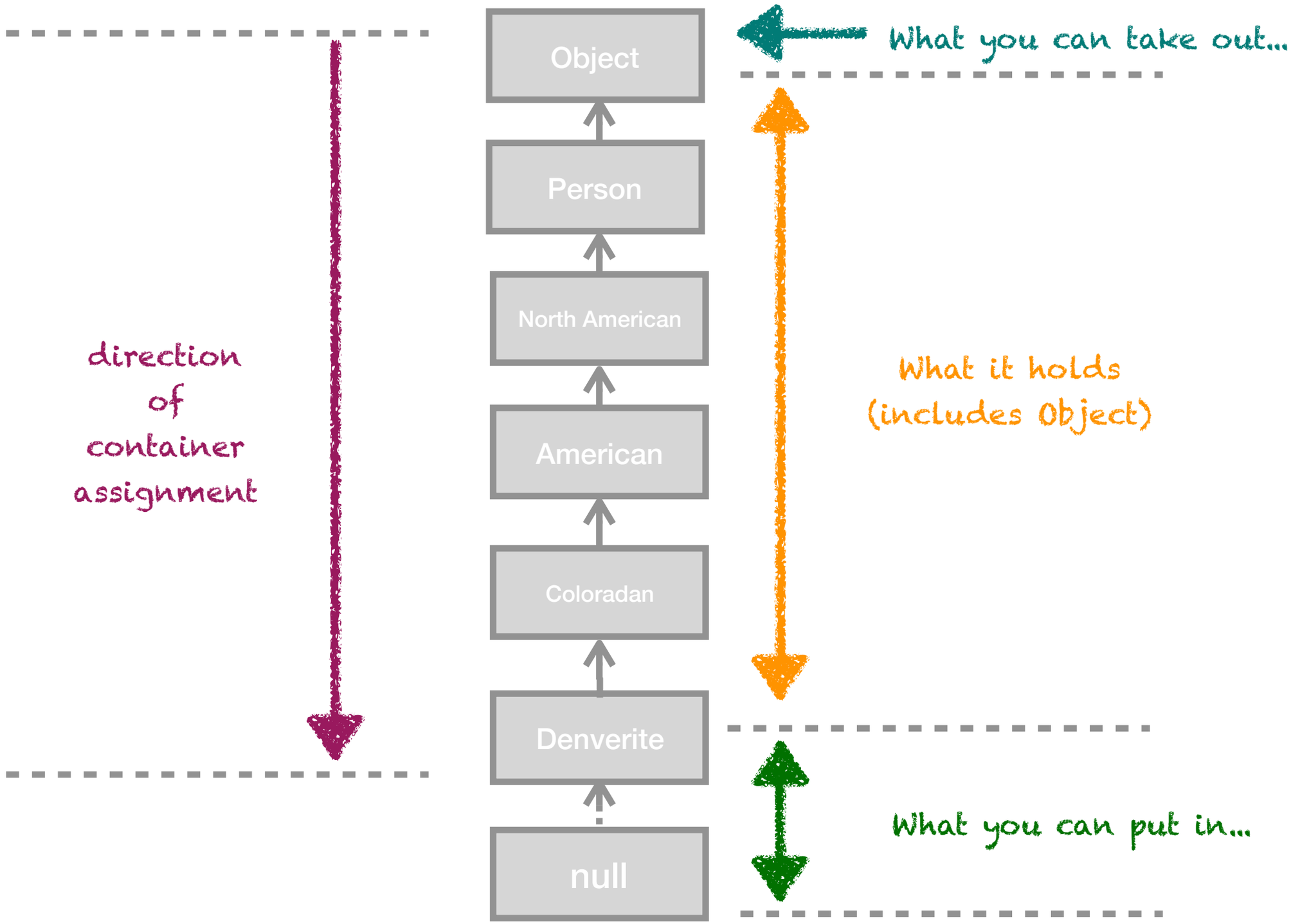
```
Container<? super Denverite> c = new Container<Person>();
```



American

? super Denverite

```
Container<? super Denverite> c = new Container<American>();
```



Demo:
Contravariance

ContravariantTest.java #16-#17

Array Covariance

Array Covariance

- Arrays are covariant
- `Array<Integer>` can be assigned to `Array<Number>` reference.
- Any attempt to do put in something wrong will be met with an `ArrayStoreException`
- An array of `List<String>` at runtime is purely an array of `List`

Demo: Array Covariance

ArraysTest.java #18-#20

SafeVargs & HeapPollution

Heap Pollution

- A situation where a variable of a parameterized type refers to an object that is not of that parameterized type.
- This leads likely to a `ClassCastException`
- Occurs by
  - Mixing Raw Types and Parameterized Types
  - Performing Unchecked Casts
  - Separate Compilation of Transaction Units

Demo: Heap Pollution

HeapPollutionTest.java #21

SafeVargs

- Annotation that marks that the developer is not performing an unsafe operation using varargs
- Particularly committing heap pollution
- Reminder! Arrays are covariant

Demo: SafeVarArgs

SafeVarArgsTest.java #22

Subclassing Generics & The Bridge Method

Subclassing Generics

- A class that is generic `MyClass<T>` can be extended
- The Generic Type can either be
  - Fulfilled by the subclass
  - Kept Generic

Demo: Subclassing

SubclassTest.java #23

Bridge Method

- At times, the compiler may create a synthetic bridge method to add support for the super classes method type.
- This is used to avoid unsafe method calls and `ClassCastException`s

Demo: The Bridge Method

BridgeTest.java #24

Multiple Bounds

Multiple Bounds

- A type parameter can have multiple bounds:
  `<T extends B1 & B2 & B3>`

- If one of the bounds is a class, then it should be first:

```
class A {...}
interface B {...}
interface C {...}

class D <T extends A & B & C> {...}
```

Demo: Multiple Bounds

MultipleBoundsTest.java #25

Recursive Type Bound

Recursive Type Bound

- Bound by an expression involving the type parameter itself
- Usually involves `Comparable<T>` or `Class<T>`
- For example: `String extends Comparable<String>`

Demo: Recursive Type Bound

RecursiveTypeBoundTest.java #26 #27

- Declaration Site Variance using − and +
- Reification of types using `TypeTag` universe
- Use of type classes to change behavior
- No raw type collections

Demo: Scala Parameterized Types

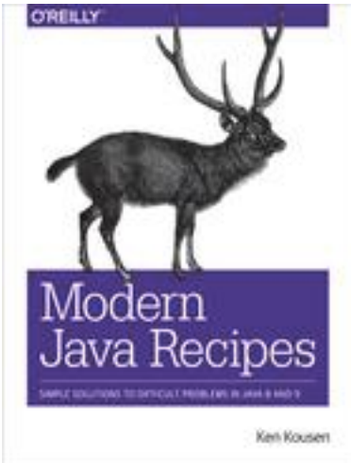
Kotlin

- Declaration Site Variance using `in` and `out`
- Reification of types using `inline` and `reified`
- Type projections to limit behavior
- No raw type collections

Demo: Kotlin Parameterized Types

References/Credit

Java Generics and Collections
by Maurice Naftalin; Philip Wadler
Published by O'Reilly Media, Inc., 2006



Modern Java Recipes
by Ken Kousen
Published by O'Reilly Media, Inc., 2017

Angelika Langer
Java Generics FAQs - Frequently Asked Questions
http://www.angelikalanger.com/GenericsFAQ/JavaGenericsFAQ.html

References/Credit

Java Generics and Collections
by Maurice Naftalin; Philip Wadler
Published by O'Reilly Media, Inc., 2006

Programming Kotlin
by Stephen Samuel; Stefan Bocutiu
Published by Packt Publishing, 2017

Java Generics Tutorial
https://docs.oracle.com/javase/tutorial/java/generics/

Thanks