

Kotlin - Generics and Sequences

Jacky Xu

RBC One Kotlin Study Group

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Generics

- ▶ Allows a class or function to operate on objects of various types.
- ▶ Provides compile-time type safety.
- ▶ Not much different from generics in Java.
- ▶ Kotlin compiler can usually infer the parameterized type from the values provided.

```
val list1 = listOf(1, 2, 3)
val list2 = listOf("1", "2", "3")
```

Generics

► Generic class:

```
class Box<T>(val contents: List<T>)
```

► Generic function:

```
fun <T> take(box: Box<T>) { ... }
```

► Generic interface:

```
interface Formatter<T> { ... }
```

Upper Bounds

- ▶ We can specify upper bounds on type parameters

```
// In Java:  
class Box<T extends Fruit> { ... }  
  
// In Kotlin:  
class Box<T: Fruit>(val contents: List<T>)
```

Upper Bounds

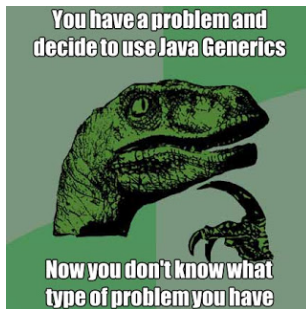
- ▶ If there are multiple upper bounds, we must specify them by the `where` keyword:

```
class Box<T>(val contents: List<T>)  
    where T: Fruit, T: Round
```

- ▶ A type parameter with no upper bound specified will have the upper bound of `Any?`
- ▶ Unlike in Java, there are no lower bounds in Kotlin

Type Erasure

- ▶ In Java, type information is lost at runtime to maintain backwards compatibility with previous versions of JVM.
- ▶ Since Kotlin runs on the JVM, its types are also erased.



Type Erasure

- ▶ Kotlin compiler will try to infer type parameter at compile time:

```
val strings = listOf("1", "2", "3")  
println(strings is List<String>) // true
```

- ▶ If type parameter cannot be inferred at compile time, will throw compile time error:

```
val anys = listOf("1", 2, 3.0)  
println(anys is List<String>) // error
```

Type Erasure

- ▶ We can use **star projection** if we don't care about the type parameter:

```
val anys = listOf("1", 2, 3.0)
println(anys is List<*>) // true
```


Reified Types

- ▶ Kotlin has a way of retaining type information at runtime, called **reification**
- ▶ Reification only works:
 - ▶ On an **inline function**
 - ▶ If the generic type is preceded by the `reified` keyword

```
inline fun <reified T> hasType(box: Box<*>) =  
    box.contents.any { it is T }
```

Reified Types

- ▶ How we **can** use reified type parameters:
 - ▶ In type checks and casts (is, !is, as, as?)
 - ▶ To use the Kotlin reflection APIs (::class)
 - ▶ To get the corresponding java.lang.Class (::class.java)
 - ▶ As a type argument to call other functions

```
inline fun <reified T> List<T>.printType() {  
    println("This list contains elements " +  
        "of type ${T::class}")  
}
```

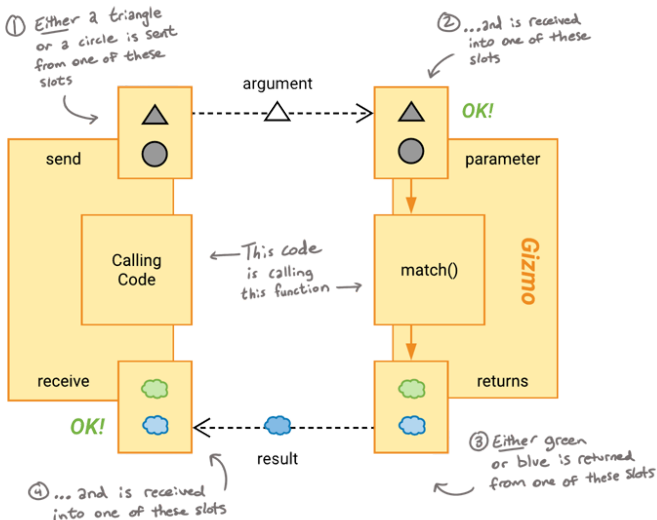
Reified Types

- ▶ How we **can't** use reified type parameters:
 - ▶ Create new instances of the class specified as a type parameter
 - ▶ Call methods on the companion object of the type parameter class
 - ▶ Use a non-reified type parameter as a type argument when calling a function with a reified type parameter
 - ▶ Mark type parameters of classes, properties, or non-inline functions as reified

Variance

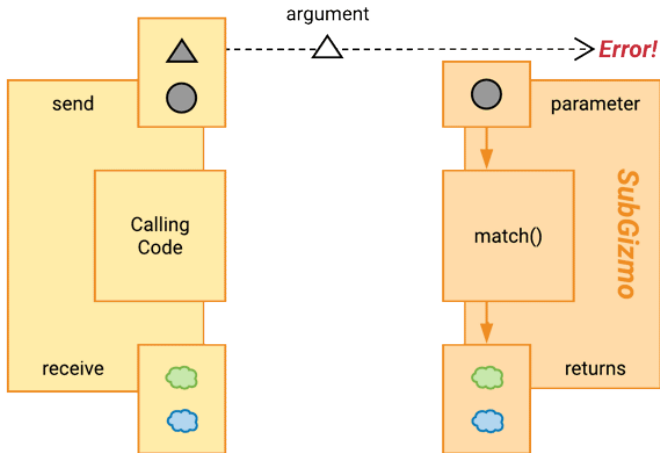
- ▶ Liskov Substitution Principle (LSP): A subtype can be substituted for its supertype without altering expected behavior.

Variance

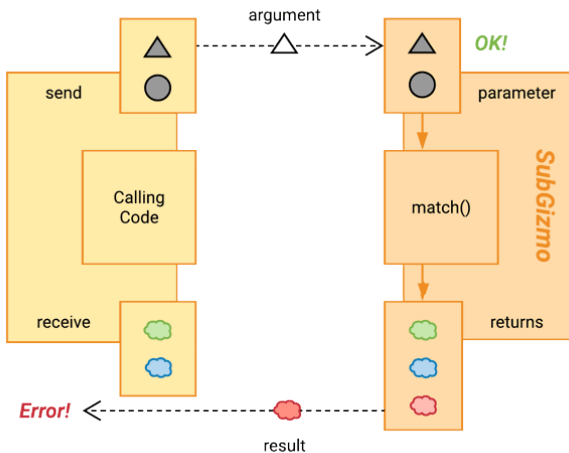


Source: <https://typealias.com/guides/illustrated-guide-covariance-contravariance>

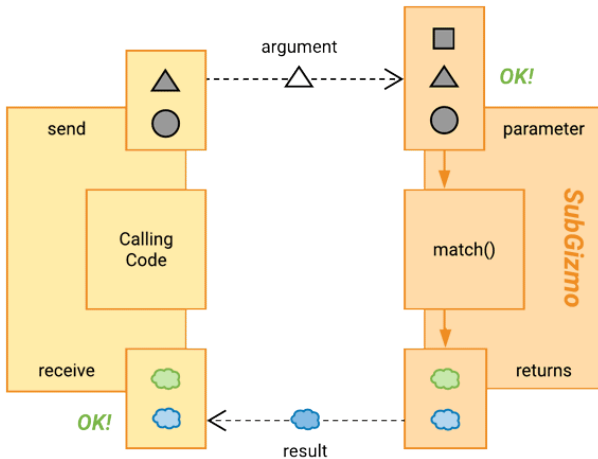
Variance



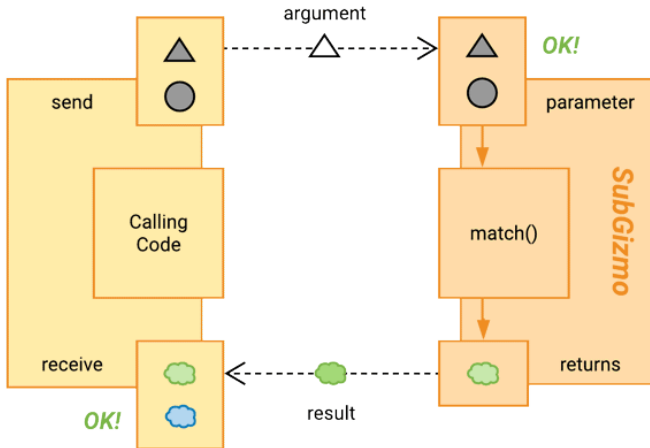
Variance



Variance



Variance

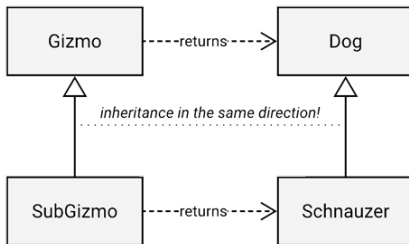


Rules of Variance

- 1 A subtype must **accept at least** the same range of types as its supertype declares.
- 2 A subtype must **return at most** the same range of types as its supertype declares.

Covariance

- ▶ A subtype must **return at most** the same range of types as its supertype declares.
- ▶ This relationship is called **covariance**



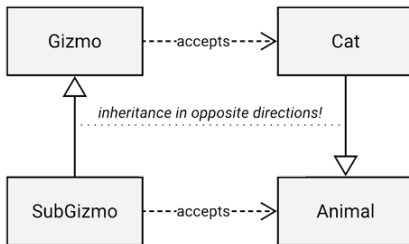
Covariance

- ▶ We specify a type parameter of a class or interface to be **covariant** by prepending the `out` keyword.
- ▶ A contravariant type can only be used as a function return type; it can never be used as a function argument type (why?)
- ▶ A covariant type is said to be in the **out** position.

```
data class Pair<out A, out B>(  
    val first: A, val second: B)  
fun <T> Pair<T, T>.toList(): List<T>  
    = listOf(first, second)
```

Contravariance

- ▶ A subtype must **accept at least** the same range of types as its supertype declares.
- ▶ This relationship is called **contravariance**



Contravariance

- ▶ We specify a type parameter of a class or interface to be **contravariant** by prepending the `in` keyword.
- ▶ A contravariant type can only be used as function argument types; it can never be used as a function return type. (why?)
- ▶ A contravariant type is said to be in the **in** position.

```
interface Comparable<in T> {  
    operator fun compareTo(other: T): Int  
}
```

Invariance

- ▶ By default a type parameters are in neither the in nor the out position.
- ▶ An invariant type can be used in both function arguments and function return types.
- ▶ A covariant type cannot be the type of a var property in a primary constructor of a class.
- ▶ A contravariant type cannot be the type of any property in a primary constructor of a class.

Type Projection

- ▶ All of the variance described above with the 'in' and 'out' keywords is called **declaration-site variance**
- ▶ In Kotlin we can also use **use-site variance**, also called **type projection**
- ▶ When the `in` or `out` keyword is specified in a function declaration, then the type passed in is treated as if it were contravariant or covariant, respectively.

<code>? super T</code>	<code><==></code>	<code>in T</code>
<code>? extends T</code>	<code><==></code>	<code>out T</code>

Sequences

- ▶ A **sequence** in Kotlin is pretty much the same as a stream in Java 8.
- ▶ Kotlin re-implemented this because Java streams aren't available in every platform.
 - ▶ On Android in the past, Java 8 is not fully supported.
- ▶ Sequences have a greater range of supported operations than Java streams and are less verbose.
 - ▶ Eg. `filterIsInstance()`, `zip()`, and `associate()`
- ▶ We can perform all stream operations on any collection without converting them to a stream first.

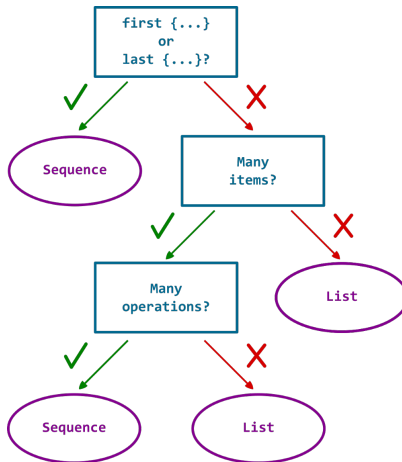
Using Sequences

- ▶ As with streams, sequences are evaluated **lazily**, whereas collections are evaluated **eagerly**.
- ▶ Two types of operations:
 - ▶ **Intermediate operation**: returns another sequence, which is produced lazily.
 - ▶ **Terminal operation**: returns a concrete collection or value, and evaluates all operations previously defined in an optimized manner.
- ▶ Unlike in Java, sequences can be iterated multiple times (unless specified in the docs).
 - ▶ We can constrain a sequence to be only iterable once with `constrainOnce()`.

Using Sequences

- ▶ When we **should** use sequences:
 - ▶ When dealing with large collections with many operations.
 - ▶ When the number of items is infinite or unknown.
 - ▶ When processing a large number of items with some filtering operation. (eg. `first{}` or `last{}`)
- ▶ When we **should not** use sequences:
 - ▶ When dealing with small collections.
 - ▶ When passing/returning the intermediate results to functions.
 - ▶ When you need to access only the `nth` item.

Using Sequences



Source: <https://proandroiddev.com/sequences-a-pragmatic-approach-9d4296086a9d>

Creating Sequences

- ▶ Any iterable can be converted to a sequence using the `asSequence()` method.
- ▶ The `generateSequence()` function and its variants which are helpers for creating sequences.
- ▶ The `buildSequence()` function can be used to yield values in the sequence, similar to how Typescript's generators are implemented.
 - ▶ This feature is experimental.

```
val naturalNumbers: Sequence<Int>  
    = generateSequence(0) {it + 1}
```

Resources

- ▶ Assignment: Udemy's Kotlin challenges (Round Five).
- ▶ Six additional problems in the git repository (Solutions in the `solutions` branch).
- ▶ Kotlin docs:
<https://kotlinlang.org/docs/reference/generics.html>
- ▶ Illustrated guide on variance:
<https://typealias.com/guides/illustrated-guide-covariance-contravariance>
- ▶ Code examples: <https://github.com/gbaldeck/learning-kotlin/blob/master/src/main/kotlin/org/learning/Generics.kt>

Conclusion

Thank you

