Kotlin - Generics and Sequences

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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

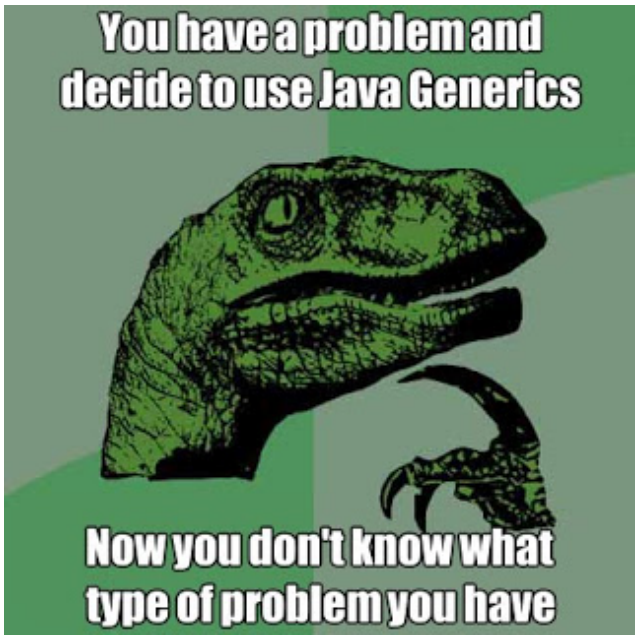
- If there are multiple upper bounds, we must specify them by the `where` keyword:

```
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:
  - In an **inlined 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}")
}
```

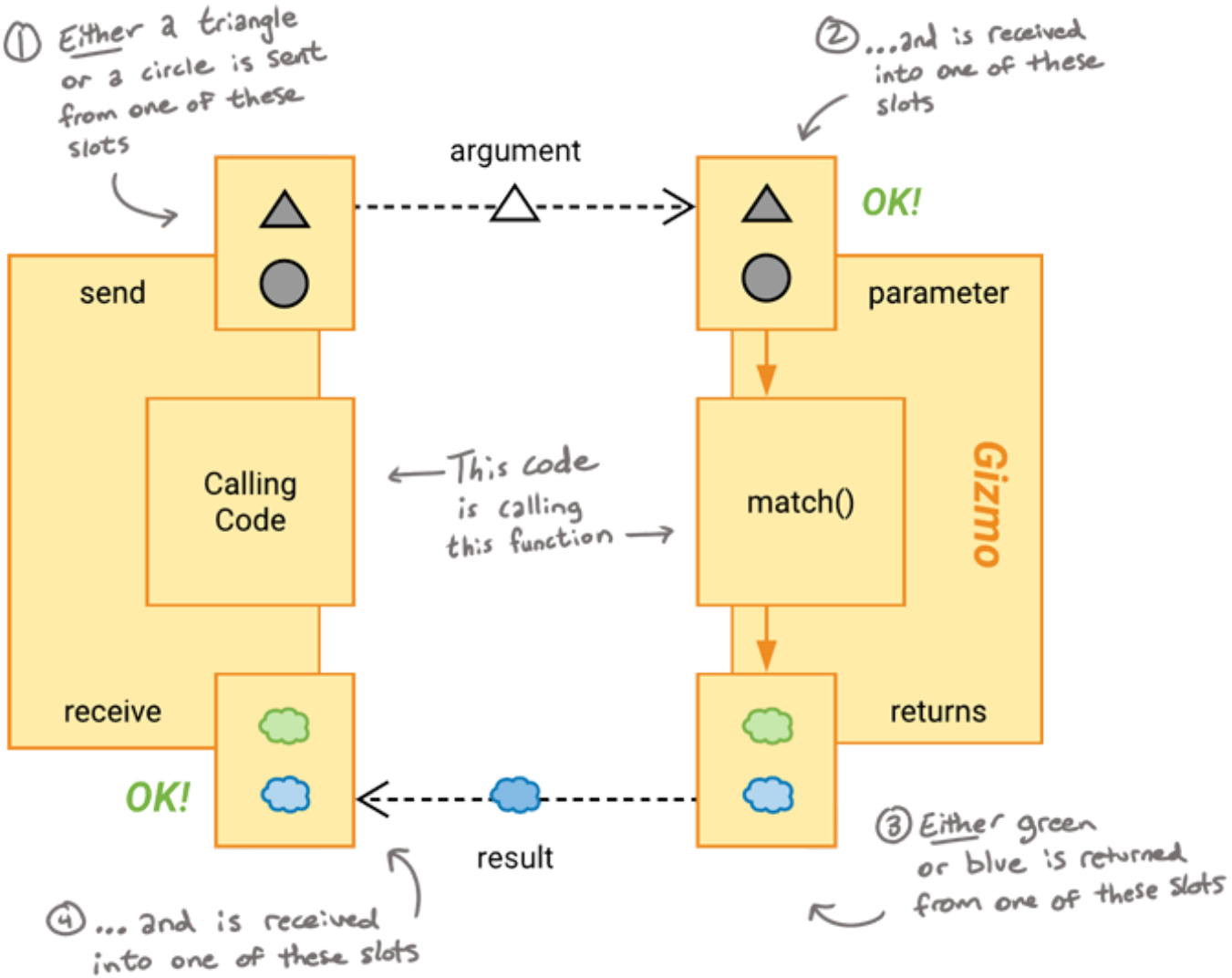
Reified Types

- 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

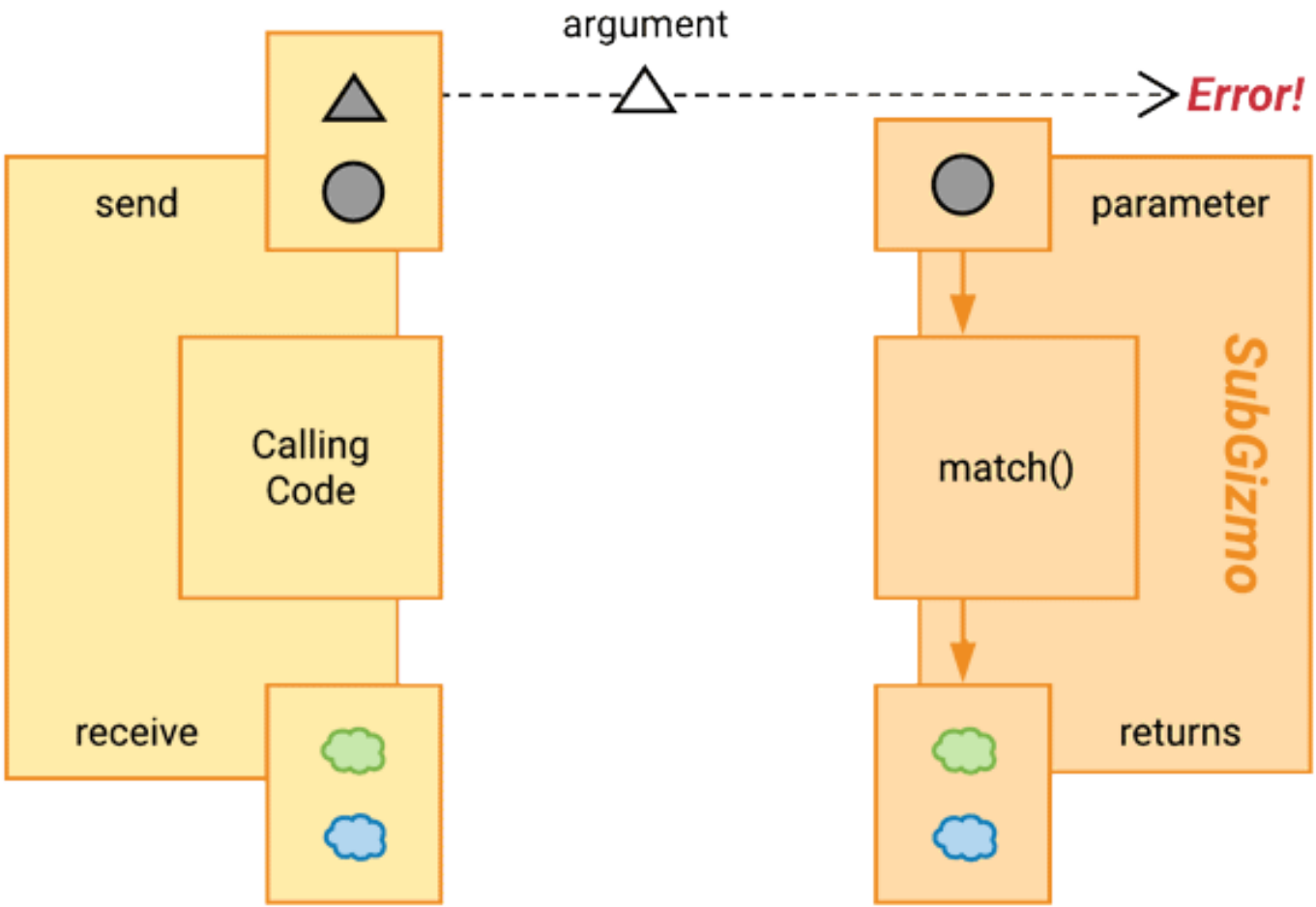
- Liskov Substitution Principle (LSP): A subtype can be substituted for its supertype without altering expected behavior.

Variance

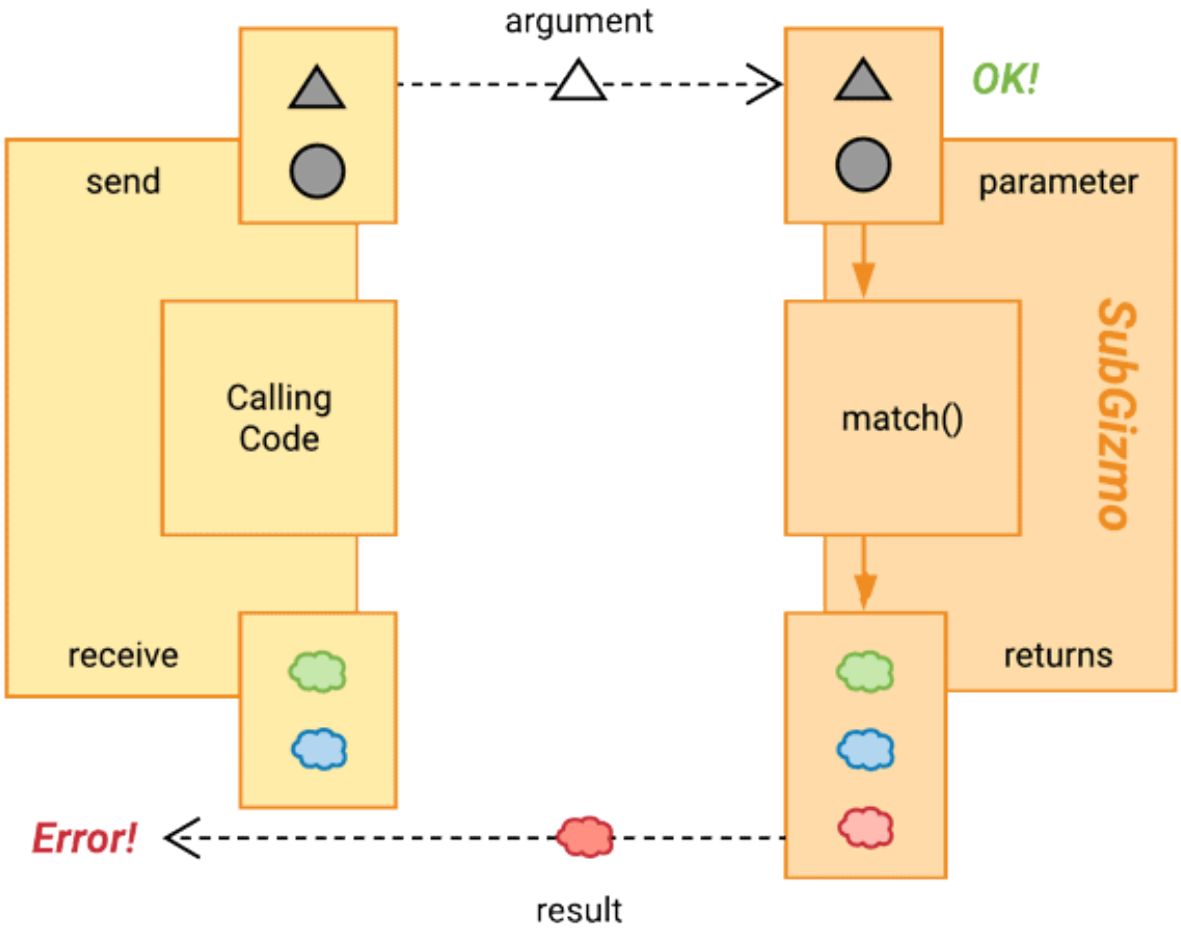


Source: https://typealias.com/guides/illustrated-guide-covariance-contravariance

Variance


argument
Error!
send
parameter
Calling
Code
match()
SubGizmo
receive
returns

Variance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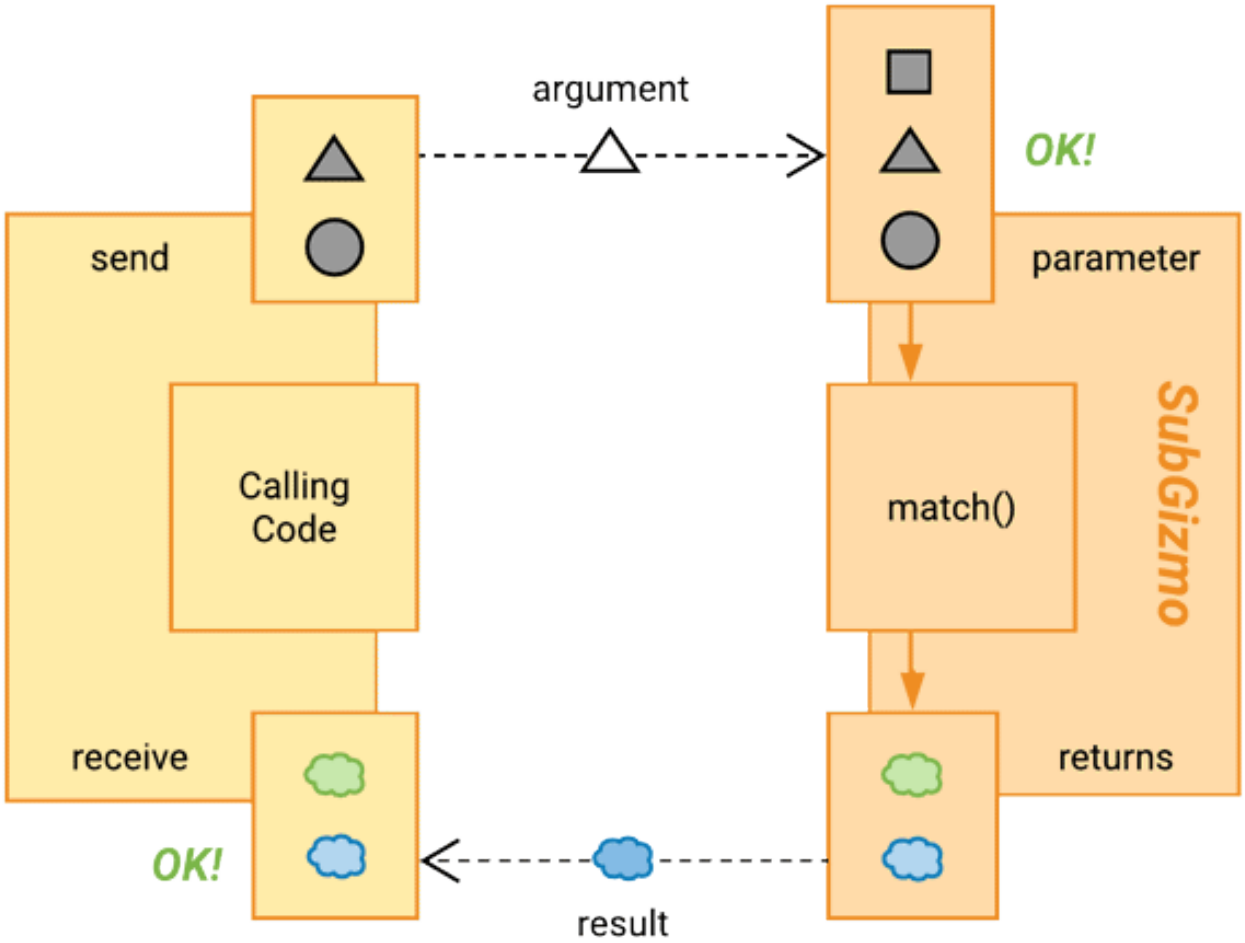
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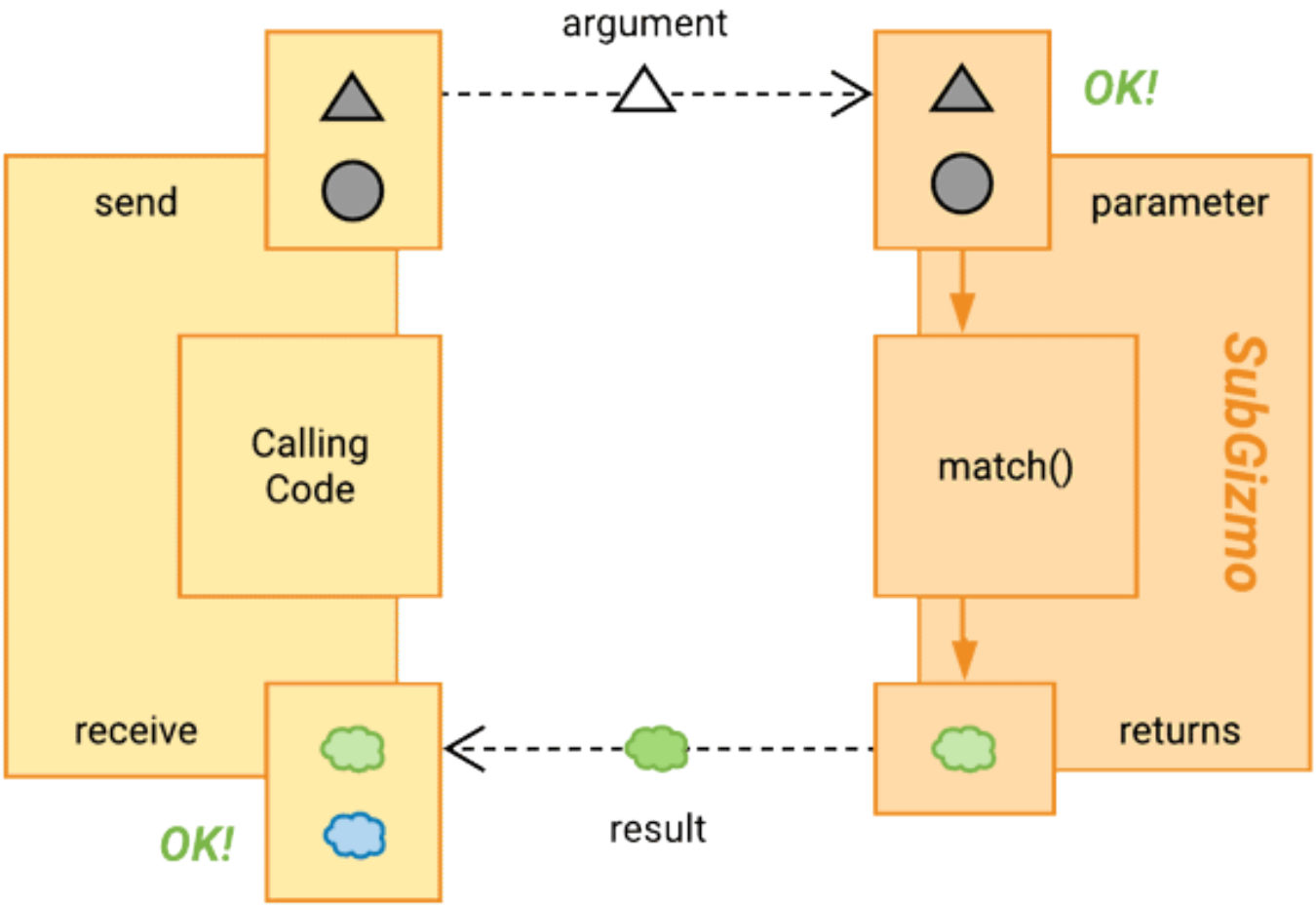
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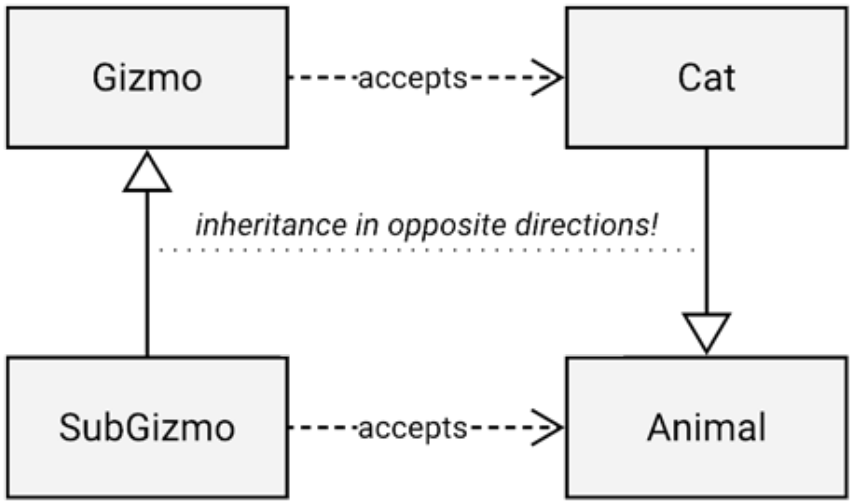
Rules of Variance

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.

Contravariance

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



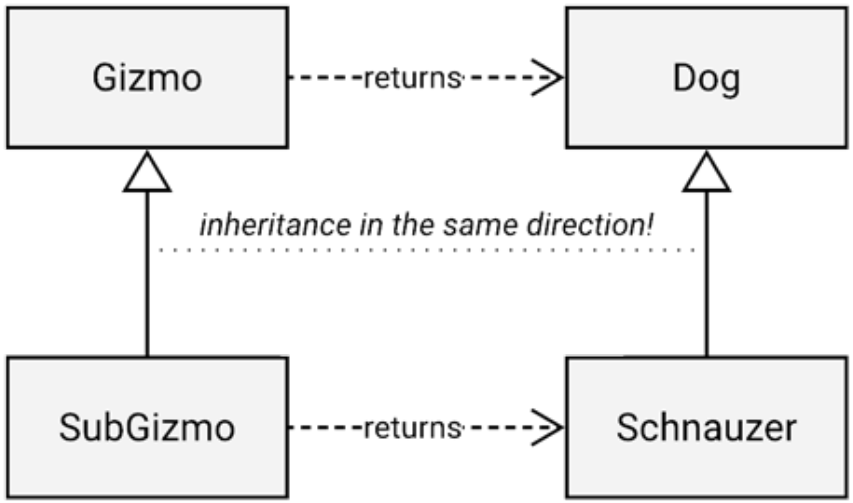
Contravariance

- 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
}
```

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)
```

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.

`? super T <==> in T`
`? extends T <==> out T`

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.

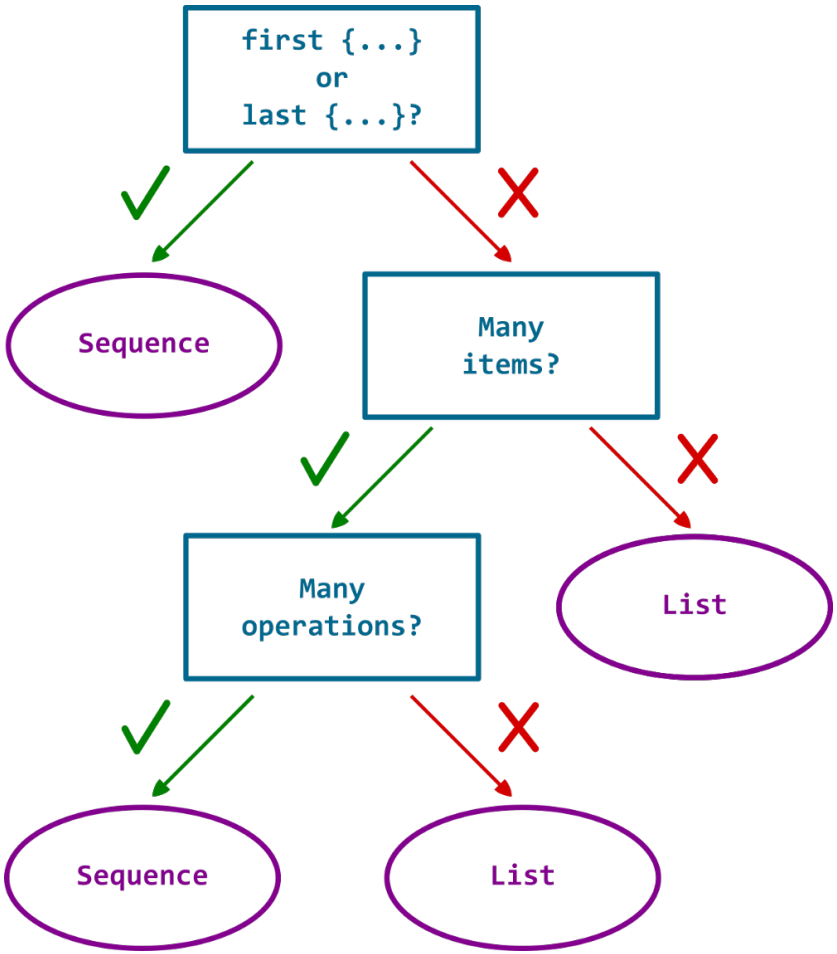
Using Sequences

- 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)
- Additional problems are in the git repository of this session, under the `com.rbc.rbcone.studygroup.kotlin` package.
  - Six problems total.
  - Solutions are in the `solutions` branch.
- Slides and code examples are in the git repository.

Conclusion

Thank you