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Kotlin fundamentals

Kotlin is fundamentally an object-oriented language. This, along with the constraints imposed by the JVM, means that classes and data will be structured in much the same way as in Java, C++, or any other object-oriented language.

Kotlin's primary advantage to developers is that it manages to be extremely expressive while remaining fairly short; for example, Kotlin code is completely semicolon-free!

Files

Unlike many other languages, the Kotlin compiler has the additional concept of a "file". Whereas all symbols in Java or C# must either be or be contained in *classes*, Kotlin allows properties and functions to be declared at the *top level*:

```
class Test {}

val foo = "This is a top-level property"
fun thisIsATopLevelFunction() {}
```

Top-level symbols are placed in the current package's scope, unless they are `private` — private top-level symbols are only visible within the same file. They can be imported with `[package-name].[symbol-name]`, similarly to classes:

```
// File A
package a

val foo = "This is a top-level property"

// File B
package b
import a.foo

fun main() = println(foo) // "This is a top-level property"
```

Kotlin files typically have the extension `.kt`.

The Kotlin compiler, `kotlinc`, supports dynamic execution of *Kotlin scripts*. Kotlin scripts have the extension `.kts` and do not require a `main` function; all statements found at the top level are executed sequentially.

> If you *do* use a `main` function in a Kotlin script, nothing will happen when it is executed. This is because you are essentially defining a function that is never called, since `main` no longer has any special meaning.

Getting started

You can download `kotlinc`'s binaries here. If you prefer package managers, you can also install it with `pacman` (Arch Linux), Homebrew (macOS/Linux), Snappy (primarily Ubuntu), or Chocolatey (Windows).

`kotlinc` isn't necessary to compile or run Kotlin code, though. JetBrains' IntelliJ IDEA, unsurprisingly, has first-class Kotlin support built in to the IDE. An easy way to play around with Kotlin is to create a `.kts` *scratch file* (*`Ctrl+Alt+Shift+Insert`*). If you want to create a full Kotlin project, you can easily do so by using JetBrains' Kotlin Maven archetype or by selecting "Kotlin/JVM" in the Gradle project creation dialog. This will generate a full, working Maven project for you with a sample Kotlin entry point and test class.

While there exists an equivalent plugin for Eclipse, it unfortunately tends to be updated quite infrequently, is prone to bugs, and is usually out of date.

`new`

Kotlin does not have a `new` operator. Constructors are called using standard function-call syntax:

```
val person = Person("Test", "Testerson")
```

This is a nice time-saver, and is consistent with C++ syntax, where the keyword originates.

In C++, `new` is used to allocate dynamic memory, call a constructor, and return a pointer, or to otherwise create the object on the stack and return an rvalue (more specifically, a prvalue), which is essentially a value that may be appear on the **r**ight-hand side of an expression. As there is no real functional distinction between heap- and stack-allocated values on the JVM, since one generally does not have to deal with pointers, there is no reason to keep the keyword.

`?`

`?` is an integral part of Kotlin's type system; `?` designates a type as *nullable*:

```
val foo1: String = "bar"  // ok
val foo2: String? = "bar" // ok
val foo1: String = null   // ERROR
val foo2: String? = null  // ok
```

Non-nullable types cannot have the value `null` assigned to them! This is one of Kotlin's advantages — it is extremely difficult to write proper Kotlin code that throws a `NullPointerException`.

Unlike reference/value wrapper types (*cf.* Java's `Optional` and C#'s `Nullable`), Kotlin's nullable values are a real part of the type system and play well with other language features such as generics. This means that using nullable values has no overhead; `T?` and `T` both get compiled to a simple nullable `T` in bytecode.

Under the hood, **non-nullability** is ensured by inserting null-check assertions into methods, constructors, and properties. The compiler will even add the appropriate `@Nullable`/`@NotNull` annotations. This means that no calling code can ever violate these preconditions, which allows a Kotlin library to be safely consumed from other Java/JavaScript/native modules.

Nullable types come with their own useful utilities.

`?.`, the *safe call* operator, can be used to perform operations on nullable values. If the value is `null`, it performs the operation; otherwise, it too returns `null`. This is useful for chaining methods on values that may be null:

```
val input: String? = readLine()
val enteredInt =
    input            // String?
    ?.trim()         // String? -> String?
    ?.toIntOrNull() // String? -> Int?

if (enteredInt == null) println("You did not enter an integer")
```

The Elvis operator (`?:`, try turning it 90° clockwise) is frequently used as the last element in a `?.` chain to return a fallback value. The result of an `?:` expression returns the left operand if it is not `null`; otherwise, it returns the right operand.

This is equivalent to the `??` operator in C#.

```
val envvar: String? = System.getProperty("FOO")
val displayValue: String = envvar ?: "No value found" // Not nullable!

if (enteredInt == null) println("The value of FOO is: $displayValue")
```

If you *really* need to force the compiler to dereference a nullable value, the `!!` operator can be used for this purpose:

```
val maybeFoo: Foo? = retrieveMaybeFoo()
val foo = maybeFoo!!
```

Note that this will throw an exception if the value is indeed `null`. Unless you are dealing with complex scenarios (e.g. reflection) where you can be *absolutely sure* that a value will not be null, **never** use this operator. There is always a better way to solve nullability issues, such as using the aforementioned safe call and Elvis operators, combined with `return` or `throw` expressions.

`Unit`

Kotlin, like many functional languages, does not have the concept of "no return type"; every function must return a value. So how do we deal with `void` methods?

Kotlin represents the unit type as Unit. This is equivalent to `()` in Rust or Haskell, and `Unit` in Swift. `Unit` is a singleton value that holds no information, making it a perfect choice for methods that return nothing. It is automatically returned from blocks of code that do not contain a `return` expression:

```
val value = run {}
println(value) // kotlin.Unit
```

It also plays extremely well with generics! Previously, to create a `void` Callable in Java, one would have to specify the type parameter as `void`'s peculiar wrapper type, Void, and then manually return `null` from the implementation of the `call` method:

```
new Callable<Void>() {
    Void call() {
        foo();
        return null;
    }
}
```

This is redundant! Since there exist no valid instances of `Void`, there is no use in returning any sort of value. Furthermore, the client of this API would need to know to discard the returned value.

Fortunately, since `Unit` is implicitly returned, all we need to do in Kotlin is:

```
Callable<Unit> { foo() }
```

This also enables function chains returning `Unit` to compose nicely.

> This particular example makes use of SAM conversions.

`Nothing`

While Nothing as a type is fundamentally similar to `Void`, they are extremely different in terms of usage.

A function returning `Nothing` will never return. This is primarily used for functions that will always throw exceptions (i.e. exception helpers), or that will loop forever. All statements following an expression that returns `Nothing` will never execute:

```
fun throwDataException(error: String): Nothing {
    throw DataException("SQL error: $error")
}

try {
    doDatabaseStuff()
} catch(e: SQLException) {
    throwDataException(e.message)
    foo() // Warning: unreachable code
}
```

This is used quite effectively in the standard library by the utility function TODO, often used during development to mark sections of code that are not implemented and should throw an error.

```
if (foo()) {
    handleFoo()
} else {
    // Not done with this yet
    TODO("handleNotFoo()")
    //^ NotImplementedError: "An operation is not implemented:
handleNotFoo()"
}
```

> Since `Nothing` cannot hold a value, and `T?` is a union between `T` and `null`, the type `Nothing?` can be used to hold a value that is always null.

`Any`

`Any` is Kotlin's equivalent to Object — it is the implicit base class for all types. It is functionally equivalent to `Object`, except that most of its methods have been removed:

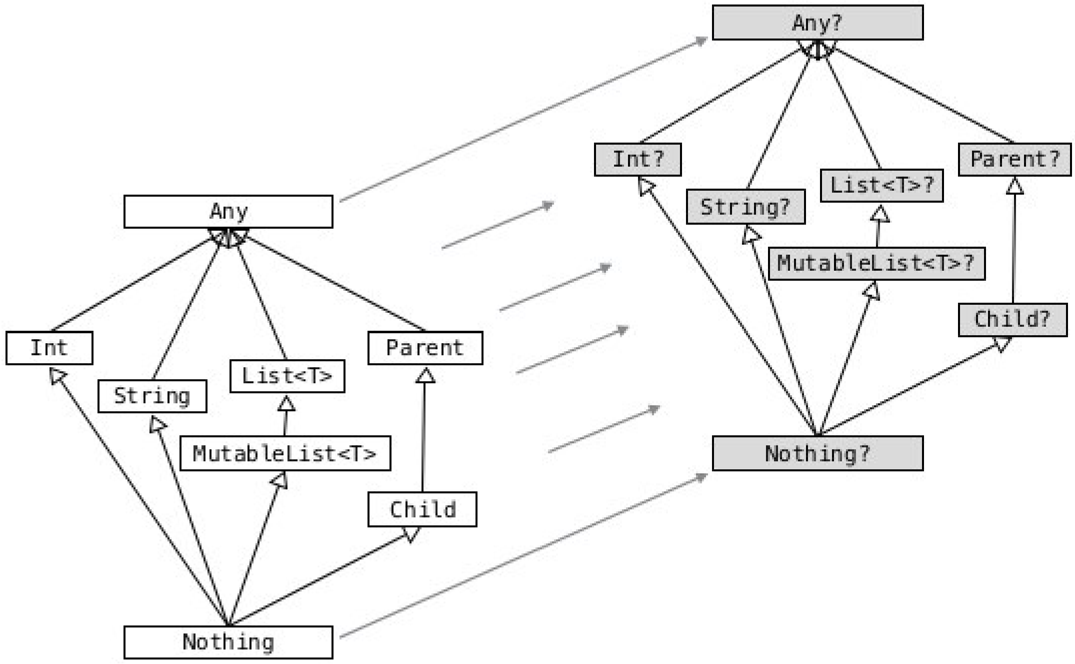
- `clone`
  - Implement `Cloneable` instead, if you *really* need `clone`.

- `finalize`
- `wait`, `notify`, `notifyAll`
    - Use of these methods has been discouraged for years — Kotlin has simplified things by removing them outright.
- `getClass`
    - This method has been replaced by the `::class` operator.

If you need to use any of `Object`'s methods, you can force the compiler to make them visible by casting an object to `Object`:

```
val foo = ...
(foo as java.lang.Object).notify()
```

Kotlin’s type hierarchy



The base type for all other types in Kotlin is `Any`. All nullable types are subtypes of their respective non-nullable types. This is important since it allows nullable types to hold a regular, non-null value.

`Nothing`, the type discussed earlier, is at the bottom of the type hierarchy; it is considered a subtype of every other type, meaning that a variable of type `Nothing` cannot be implicitly assigned to.

The only expressions in Kotlin that return `Nothing` are:

- `return`
- `throw`
- `continue`
- `break`

Yes, `return` returns a value! This allows us to extremely easily handle precondition failures, and is a very common Kotlin idiom:

```
fun login(user: User): Boolean {
    val username = user.name ?: return false // User has no name, don't try to log in
    val token = doLogin(user) ?: throw LoginException("Could not log in")
    return true // Success
}
```

In this case, `?:` will either return the preceding value or execute the right-hand expression, forcing the function to return prematurely without too much boilerplate code. This can also be used with `continue` or `return` to prematurely end the loop body.

Of course, this allows us to write meaningless code:

```
return return throw return throw throw return return throw return
```

While the compiler will warn that each of the expressions (except the last) is unreachable, this is valid code.

It should hopefully be clear that code like this should never be written.

Statements and expressions

Generally, *expressions* are snippets of code that have a *value*. Statements, on the other hand, do not necessarily have any sort of resulting value.

Apart from declarations and assignments, everything in Kotlin is an expression:

```
val password = readLine()
val output = when (password) {
    "hunter2" -> "Authenticated!"
    else -> "Hacker detected!"
}
```

Even an `if` statement returns a value:

```
println(
    if (room.isSmoking) "This is a smoking room"
    else "This is a no-smoking room"
)
```

This is incredibly versatile, since it is possible to place multiple statements within the `if` statement's block — every *block* in Kotlin also returns a value!

Because `if` is an expression, Kotlin does not have the `? :` ternary operator.

The result of the last statement in a block implicitly becomes the result of the block itself. If the last statement is not an expression, it returns `Unit` instead:

```
val value = run {
    val foo = 40
    foo + 2
}
print(value) // 42
```

Unlike in most other C-like languages, assignments are not expressions. This means many classic sources of programmer error can be eliminated:

```
_Bool ok = doSomething(...);
if (ok = true) { // = instead of ==, this will always get executed!
    printf("Success\n");
} else {
    // This will never get executed!
    printf("An error occured\n");
    abort();
}
```

Visibility modifiers

Kotlin has the following visibility modifiers:

- `public`
- `internal`
- `protected`
- `private`

`public`, `protected` and `private` members work as they do in Java and C++. `private` *top-level symbols* are visible everywhere in the same file.

> Top-level symbols cannot be `protected`, as this would not make any sense — they do not have anything to do with inheritance.

Unlike Java, Kotlin does not have package-private (default) access. It replaces this with `internal` access, which makes a symbol visible to all other classes *in the same module*. Files outside a project (i.e. in other modules) will not be able to access an `internal` symbol.

> The **default access modifier** for a symbol, when one is not specified, is `public`! This means specifying `public` explicitly is almost always redundant.

Hello, world!

As with any other programming language, to write an executable program we need an entry point. A Kotlin program's entry point is a top-level function called `main`. As many programs do not make use of command-line arguments, the `args` parameter is optional. This means a "hello world" program could look something like:

```
fun main(args: Array<String>) {
    println("Hello, world!")
}
```

or

```kotlin
fun main() {
    println("Hello, world!")
}
```

Our golfing opportunities don’t end here, though. In the interest of enabling terse, functional programming, there exists a shorter syntax for functions that consist of and return a single expression:

```kotlin
fun main() = println("Hello, world!")
```