Kotlin - aimed to make developers happier

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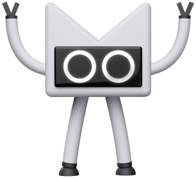

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Introduction

Say "Hello World" and go home

HelloWorld.kt

```
fun main() = println("Hello, Kotlin World")
```

Short history background

- unveiled in 2011 (being designed from 2010) by JetBrains

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- named for the island Kotlin near Saint Petersburg
- announced as official Android language in 2017
- becomes multiplatform programming language

Main design goals

- concise, object-oriented language

Kotlin

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- enable systems migration step-by-step
- provide great tooling and easy learning curve

Use cases

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Kotlin

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- frontend development
- being introduced to data science
- even tried in competitive programming

Language

"Simplify" our greeting

HelloWorldKt.kt

```
object HelloWorldKt {
  @JvmStatic
  fun main(args: Array<String>): Unit {
      val name: String? = readLine()
      if (name == null) return
      System.out.println("Hello " + name)
  }
}
```

Imperative approach

HelloWorld.kt

```
fun main() {
  val name = readLine() ?: return
  println("Hello $name")
}
```

Kotlin

Declarative approach

HelloWorld.kt

```
fun main() = readLine()
  ?.let { println("Hello $it") }
  ?: Unit
```

Basic language assumptions

- items are   by default

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- items are `public` by default

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- classes and methods are by default

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- items are `public` by default
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- no primitive types but quite a lot of optimizations including effective usage of them
- `final` variables used by default with the keyword `val`
- high usage of type inference in different contexts (`val`s and `var`s used as fields and variables definitions)

Program structure

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  - `Array<T>` and specialized versions for primitives `IntArray`, `DoubleArray`, ...

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- statically typed variables with:
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  - `String`, `Char` and `Boolean` types
  - `Array<T>` and specialized versions for primitives `IntArray`, `DoubleArray`, ...
  - ends on `Any` and includes also `nullable` types

Kotlin

Null safety - elvis operator

ElvisOperator.kt

```kotlin
val beOrNotToBe: String? = "be"
```

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val beOrNotToBe: String? = "be"

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val beOrNotToBe: String? = "be"
val answerSize: Int? = beOrNot?.length
val decided: String = beOrNot ?: "not"
```

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```
val beOrNotToBe: String? = "be"

val answerSize: Int? = beOrNot?.length

val decided: String = beOrNot ?: "not"

val sureAnswerSize: Int = beOrNot!!.length
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val beOrNotToBe: String? = "be"
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val decided: String = beOrNot ?: "not"
val sureAnswerSize: Int = beOrNot!!.length
```

also supported in safe casting with `as?` operator

Lambdas definitions

Kotlin introduces new syntax for lamdas i.e. { }

Lambdas.kt

```
val hasSense: (Int) -> Boolean = { it == 42 }
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val hasSense: (Int) -> Boolean = { it == 42 }

val beep = { println("beep") }
```

Lambdas definitions

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Lambdas.kt

```
val hasSense: (Int) -> Boolean = { it == 42 }

val beep = { println("beep") }

val printWarn = { msg: Any ->
  println("WARN: $msg")
}
```

Lambdas definitions

Kotlin introduces new syntax for lamdas i.e. { }

Lambdas.kt

```
val hasSense: (Int) -> Boolean = { it == 42 }

val beep = { println("beep") }

val printWarn = { msg: Any ->
  println("WARN: $msg")
}

beep(); printWarn(hasSense(42))
```

Expression controlled flow

FlowFeatures.kt

```
val state = if (readLine() == "42") "alive"
            else "dead"
```

Expression controlled flow

FlowFeatures.kt

```
val state = if (readLine() == "42") "alive"
            else "dead"

val mood =
  when (val grade = (2..6).random()) {
    in 3..4 -> "uff... I passed with $grade"
    5, 6 -> "happy getting $grade"
    else -> "sad because of $grade"
  }
```

Named loops and scopes

FlowFeatures.kt

```
val friends = listOf("Alice", "Bob", "Carol")

for (friend in friends)
  println("Hello $friend")

friends@ for (friend in friends) {
  for (i in 0..3) {
    println("Hello $friend")
    if (friend.last() == 'a') break@friends
  }
}
```

Fast return from flow

FlowFeatures.kt

```
while (true) {
  readLine()
    ?.let(::println)
    ?: break
}
```

Fast return from flow

FlowFeatures.kt

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while (true) readLine()?.let(::println) ?: break
```

Fast return from flow

FlowFeatures.kt

```
while (true) {
  readLine()
    ?.let(::println)
    ?: break
}

val name = readLine() ?: return
val surname = readLine() ?: return
println("Your full name is $name $surname")
```

Kotlin

Functions in Kotlin

BasicFunctions.kt

```kotlin
fun add(a: Int, b: Int): Int {
  return a + b
}

fun sub(a: Int, b: Int) = a - b
```

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  return a + b
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fun sub(a: Int, b: Int) = a - b

val op = ::add
```

Kotlin also supports functions references that belong to one of the `KFunction<out R>` subtypes

Default arguments

SyntaxFeaturesArgs.kt

```
fun fib(
  idx: UInt,
  curr: Long = 1,
  last: Long = 0,
): Long =
  if (idx == 0U) curr
  else fib(idx - 1U, curr + last, curr)

fib(idx = 42U, curr = 42, last = 1)
fib(42U)
```

Kotlin

Extension functions

ExtensionFunctions.kt

```
// this can be omitted
fun Any.printHash() =
  println(hashCode())

// also for final classes
fun String.twice() = this + this

"42".twice().printHash()
```

Defined as `static` functions with first hidden parameter desugared from `this`

Infix functions

InfixFunctions.kt

```
infix fun Int.times(i: Int) = this * i
val life = 6 times 7
```

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val life = 6 times 7
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StdLibInfixFunctions.kt

```
val numberName = mapOf(
  1 to "one",
  2 to "two",
)
```

Kotlin

Operators

Predefined set of operators in language like `+a`, `!a`, `a++`, `a..b`, `a + b`, `a in b` (and much more) that can be manually defined for every type

OperatorFunctions.kt

```
operator fun String.not() = this.map {
  if (it.isUpperCase()) it.lowercaseChar()
  else it.uppercaseChar()
}.joinToString("")
```

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Predefined set of operators in language like `+a`, `!a`, `a++`, `a..b`, `a + b`, `a in b` (and much more) that can be manually defined for every type

OperatorFunctions.kt

```
operator fun String.not() = this.map {
  if (it.isUpperCase()) it.lowercaseChar()
  else it.uppercaseChar()
}.joinToString("")

println(!"wOw")
```

and used as standard operators.

High order functions

HighOrderFunctions.kt

```
fun <T, U> Iterable<T>.foldLeft(
  initAcc: U, f: (U, T) -> U
): U {
  var acc = initAcc
  for (element in this) acc = f(acc, element)
  return acc
}
```

Idiomatic Kotlin code uses convention of having function parameters as last ones.

High order functions

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fun <T, U> Iterable<T>.foldLeft(
  initAcc: U, f: (U, T) -> U
): U {
   var acc = initAcc
   for (element in this) acc = f(acc, element)
   return acc
}

numbers.foldLeft(0) { acc, e -> acc + e }
numbers.foldLeft(1, Int::times)
```

Idiomatic Kotlin code uses convention of having function parameters as last ones.

Generic functions

GenericFunctions.kt

```
fun <T : Comparable<T>>
    List<T>.maxOr(default: () -> T): T =
  maxOrNull() ?: default()
```

while compiler is smart enough to usually guess all needed types

Generic functions

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while compiler is smart enough to usually guess all needed types

GenericFunctions.kt

```
listOf(3, 1, 4, 1, 5).maxOr { 92 }
```

Inline functions

InlineFunctions.kt

```
inline fun <reified T, V>
    Any?.letOrNull(f: (T) -> V) =
  if (this is T) f(this) else null
```

where the function parameter can have also `crossinline` or `noinline` modifiers

Kotlin

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InlineFunctions.kt

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inline fun <reified T, V>
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"Kotlin".letOrNull<String, Int> { it.length }
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"Kotlin".letOrNull<String, Int> { it.length }

"Kotlin".letOrNull { str: String -> str.length }
```

where the function parameter can have also `crossinline` or `noinline` modifiers

Perform transformations on it

ItMappers.kt

```
inline fun <T> T.also(f: (T) -> Unit): T {
  f(this)
  return this
}

inline fun <T, R> T.let(f: (T) -> R): R {
  return f(this)
}
```

Perform transformations on it - examples

ItMappers.kt

```
val maxVal = listOf(3, 1, 4)
  .maxOrNull()
  .also(::println)

val doubled = maxVal?.let { it * 2 }
```

Perform transformations on this

ThisMappers.kt

```
inline fun <T> T.apply(f: T.() -> Unit): T {
  this.f()
  return this
}
```

Perform transformations on `this`

ThisMappers.kt

```
inline fun <T> T.apply(f: T.() -> Unit): T {
  this.f()
  return this
}

val server = JettyServer().apply {
  install(ForceHttps)
  install(Cors)
  start()
}
```

Tail recursion

TailRecursiveFunctions.kt

```
tailrec fun factorial(c: UInt, r: UInt): UInt =
  if (c > 1U) factorial(c - 1U, r * c) else r
```

Optimized by compiler to standard `while` loop pattern.

Tail recursion

TailRecursiveFunctions.kt

```
fun factorial(n: UInt): UInt {
  tailrec fun go(c: UInt, r: UInt): UInt =
    if (c > 1U) go(c - 1U, r * c) else r
  return go(n, 1U)
}
```

Optimized by compiler to standard `while` loop pattern.

Classes in Kotlin

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- `objects` being singleton classes
- `typealiases` resolved at compile-time
- inline classes as `value classes`
- `inner classes` as well as nested `classes`

Base classes

BasicClasses.kt

```
abstract class Animal constructor(
  val color: Color, val owner: Person
) : Comparable<Animal> {
  enum class Color { RED, GREEN, BLUE }

  override fun compareTo(other: Animal) =
    color.compareTo(other.color)
}
```

Kotlin

Data classes

DataClasses.kt

```
data class Person(val name: String, val age: Int)

val alice = Person("Alice", 42)
val equal = alice == Person("Bob", 22)
val olderAlice = alice.copy(age = 66)
```

Data classes

DataClasses.kt

```
data class Person(val name: String, val age: Int)

val alice = Person("Alice", 42)
val equal = alice == Person("Bob", 22)
val olderAlice = alice.copy(age = 66)

val (name, age) = alice
println("Hello, I'm $name and I'm $age")
```

Data classes

DataClasses.kt

```
data class Person(val name: String, val age: Int)

val alice = Person("Alice", 42)
val equal = alice == Person("Bob", 22)
val olderAlice = alice.copy(age = 66)

with(alice) {
  println("Hello, I'm $name and I'm $age")
}
```

Example: Interpreter classes structure

InterpreterClasses.kt

```
typealias Ident = String
typealias Env = MutableMap<Ident, Int?>
typealias IntOp = (Int, Int) -> Int
interface Exp { fun eval(env: Env): Int? }

sealed class BinOp(val op: IntOp)
abstract class AddOp(op: IntOp) : BinOp(op)
abstract class MulOp(op: IntOp) : BinOp(op)
```

Kotlin

Example: Interpreter classes structure

InterpreterClasses.kt

```
object Plus : AddOp(Int::plus)
object Minus : AddOp(Int::minus)
object Times : MulOp(Int::times)
object Divide : MulOp(Int::div)
```

Example: Interpreter classes structure

InterpreterClasses.kt

```
data class BinExp(
  val l: Exp, val op: BinOp, val r: Exp
): Exp {
  override fun eval(env: Env): Int? {
    val lValue = l.eval(env) ?: return null
    val rValue = r.eval(env) ?: return null
    return op.op(lValue, rValue)
  }
}
```

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Example: Interpreter classes structure

InterpreterClasses.kt

```
@JvmInline
value class NumExp(val value: Int): Exp {
  override fun eval(env: Env): Int = value
}

data class IdentExp(val i: Ident): Exp {
  override fun eval(env: Env): Int? = env[i]
}
```

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Example: Interpreter classes structure

InterpreterClasses.kt

```
sealed class Stmt
class ExpStmt(val exp: Exp) : Stmt()
class AssStmt(val i: Ident, val e: Exp) :
  Stmt()
```

Example: Interpreter classes structure

InterpreterClasses.kt

```kotlin
fun step(env: Env, stmt: Stmt) = when(stmt) {
  is ExpStmt -> env.also {
    println(stmt.exp.eval(it))
  }
  is AssStmt -> env.apply {
    put(stmt.i, stmt.e.eval(env))
  }
}
```

Kotlin

Example: Interpreter classes structure

InterpreterClasses.kt

```
data class Program(
  private val stmts: MutableList<Stmt>
  = mutableListOf()
) {
  fun interpret(env: Env = mutableMapOf()) =
    stmts.fold(env, ::step)

  // we could stop there but...
```

Example: Interpreter classes structure

InterpreterClasses.kt

```
  // let's revisit functions knowledge
  infix fun Ident.eq(e: Exp) {
    stmts.add(AssStmt(this, e))
  }
  operator fun Exp.not() {
    stmts.add(ExpStmt(this))
  }
}
```

Example: Interpreter classes structure

InterpreterClasses.kt

```
operator fun Exp.plus(e: Exp) =
  BinExp(this, Plus, e)
operator fun Exp.times(e: Exp) =
  BinExp(this, Times, e)

inline fun def(i: Ident) = IdentExp(i)
inline fun num(i: Int) = NumExp(i)
```

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Interpreter DSL usage example

InterpreterClasses.kt

```
val program = Program().apply {
  "x" eq num(42)
  "y" eq num(24)
  "z" eq def("x") + def("y")
  !def("z")
  !(def("z") * def("u"))
}
program.interpret()
println(program)
```

Kotlin

Interpreter DSL usage example

InterpreterClasses.kt

```
val program = Program().apply {
  "x" eq num(42)
  "y" eq num(24)
  "z" eq def("x") + def("y")
  !def("z")
  !(def("z") * def("u"))
}
program.interpret()
println(program)
```

It was less than 100 short lines of code

Kotlin

Interpreter DSL usage example

InterpreterClasses.kt

```
val program = Program().apply {
  "x" eq num(42)
  "y" eq num(24)
  "z" eq def("x") + def("y")
  !def("z")
  !(def("z") * def("u"))
}
program.interpret()
println(program)
```

It was less than 100 short lines of code but the effect is amazing.

Destructuring declarations

PairDestructuring.kt

```
val keyValue = "key" to Unit
val (k, v) = keyValue
```

Destructuring declarations

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// which corresponds to
val desugaredK = keyValue.component1()
val desugaredV = keyValue.component2()
```

where these fuctions can be defined as operators and are also predefined e.g. for lists and `data classes`.

Destructuring in lambdas

LambdaDestructuring.kt

```
{ a -> ... } // one parameter
{ a, b -> ... } // two parameters
{ (a, b) -> ... } // a destructured pair
{ (a, b), c -> ... } // pair and parameter
```

Delegated properties

Classes having defined `operator` functions `getValue` and `setValue`

Observables.kt

```
import kotlin.properties.Delegates.observable

class User {
  var name: String by observable("noname") {
    _, old, new -> println("$old -> $new")
  }
}
```

Delegated properties

The most commonly used is probably `lazy` initializer

LazyProperties.kt

```
class Book {
  val description: String by lazy {
    "value downloaded from database"
  }
}
```

which in other languages usually have to be defiend manually.

Ranges

There is only single range operator in language

Ranges.kt

```
val include = 1..42
val notInclude = 1 until 42
val down = 42 downTo 1
val collection = listOf(1, 2, 3)
for (i in collection.indices)
        println("At $i got ${collection[i]}")
```

Kotlin

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val down = 42 downTo 1
val collection = listOf(1, 2, 3)
for (i in collection.indices)
        println("At $i got ${collection[i]}")

for ((i, v) in collection.withIndex())
        println("At $i got $v")
```

Kotlin

"Not implemented" marker

TODO.kt

```
fun `does P = NP`(): Boolean =
  TODO("Waiting for proof")
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"Not implemented" marker

TODO.kt

```
fun `does P = NP`(): Boolean =
  TODO("Waiting for proof")

inline fun TODO(reason: String): Nothing =
  throw NotImplementedError(
    "An operation is not implemented: $reason")
```

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Kotlin

Tricky lambda scope

Swap.kt

```
var a = 42
var b = 24
```

Tricky lambda scope

Swap.kt

```kotlin
var a = 42
var b = 24

val temp = a
a = b
b = temp
```

Tricky lambda scope

Swap.kt

```kotlin
var a = 42
var b = 24

a = b.also { b = a }
// now a = 24 and b = 42
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as in Kotlin variables captured in the closure can be modified in the lambda. It is not used commonly as `vars` aren't used.

Infrastructure

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- Kotlin offers not only REPL for easy testing code but also provides mechanism of scripts
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- can be run with `kotlinc` compiler but also custom solution like `kscript` exists
- defines the structure of `Gradle` project

Shell script

SimpleScript.kts

```
#!/usr/bin/env kscript
import java.io.File

val dir = args.singleOrNull() ?: "."
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#!/usr/bin/env kscript
import java.io.File

val dir = args.singleOrNull() ?: "."

File(dir)
  .walkTopDown()
  .filter(File::isFile)
  .sorted()
  .forEach(::println)
```

Kotlin DSL in Gradle

build.gradle.kts

```
plugins {
  kotlin("jvm") version "1.5.31"
}

// ...

tasks.withType<KotlinCompile> {
  kotlinOptions.jvmTarget = "1.8"
}
```

Kotlin Multiplatform

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- features code sharing between all or some platforms used in project
- uses mechanism of `expect` and `actual` declarations
- reuse the multiplatform logic in common and platform-specific code (it's even simpler when there are more and more multiplatform libraries)

expect and actual in action

Common.kts

```
// common
expect fun randomUUID(): String
```

expect and actual in action

Common.kts

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// Android
actual fun randomUUID() =
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expect and actual in action

Common.kts

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expect fun randomUUID(): String

// Android
actual fun randomUUID() =
  java.util.UUID.randomUUID().toString()

// iOS
actual fun randomUUID(): String =
  platform.Foundation.NSUUID().UUIDString()
```

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Let's try CLion or AppCode to test these great features if you're interested.

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  - `macosX64Main:desktopMain` code specific for MacOS x64 platforms

Kotlin new compiler - K2

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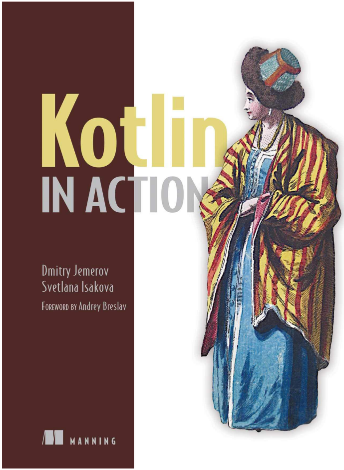
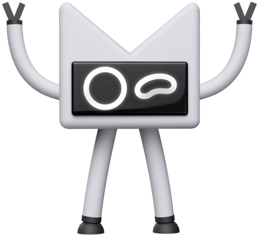
- introduce new type inference algorithm
- provide new JVM and JS IR backend
- introducing FIR (frontend intermediate representation)
- goal: performance improvements, provide an API for compiler extensions

Kotlin in Action - highly recommend





Thank you for your attention