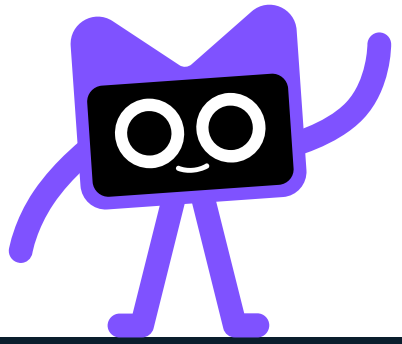
/sit schwarz IT



Web development in Kotlin

Suman Venkat
Sebastian Muskalla

42 / TUM Heilbronn | May 7, 2025

Agenda

01 Introduction
Introduction of SIT, trainers and participants

02 About Kotlin

03 Morning session
Kotlin basics

04 Lunch break + Q & A

05 Afternoon session
Web development

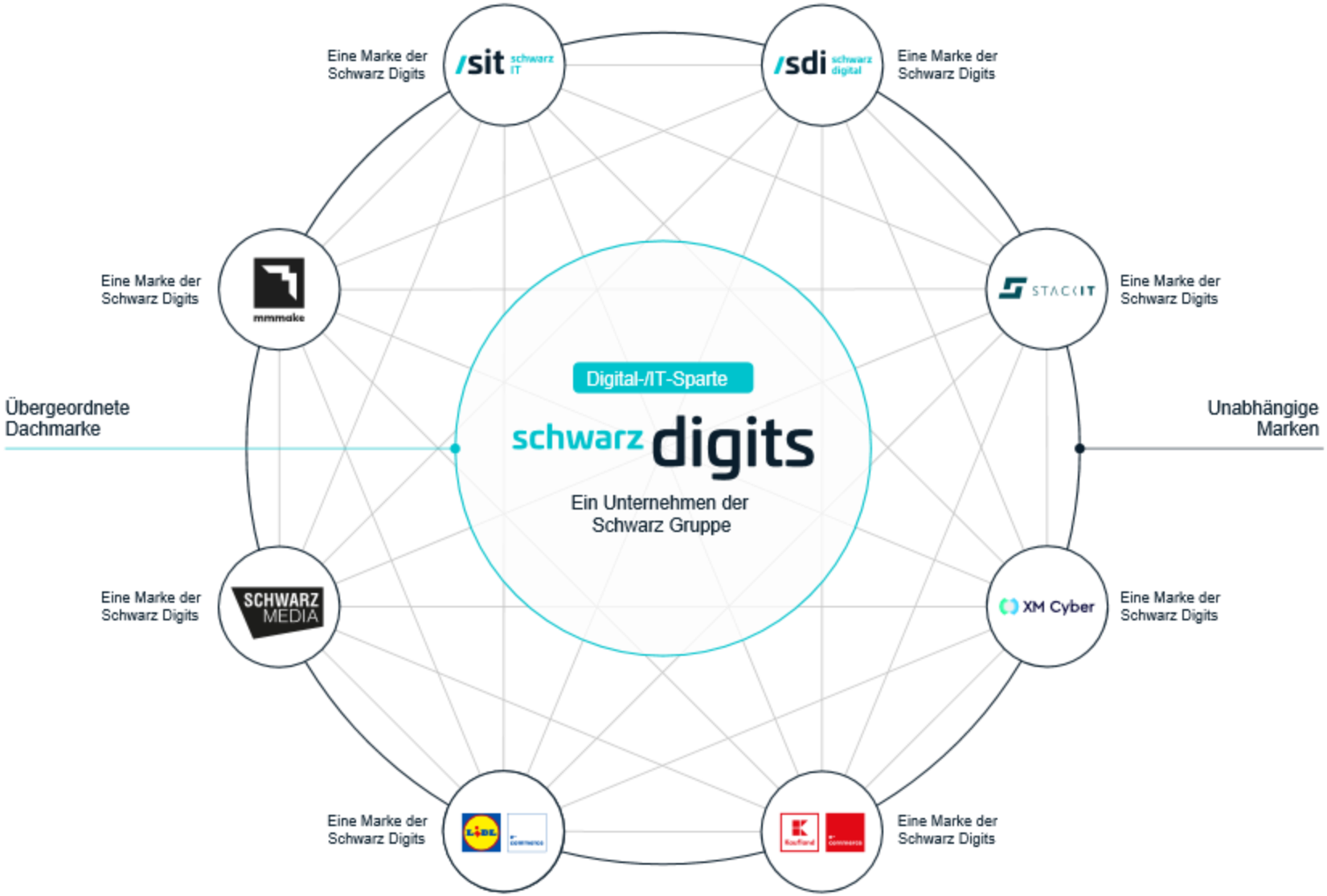
06 Q & A

01

Introduction


SCHWARZ
LIDL
Kaufland
SCHWARZ
Produktion
pre
zero
schwarz
digits

Schwarz Digits



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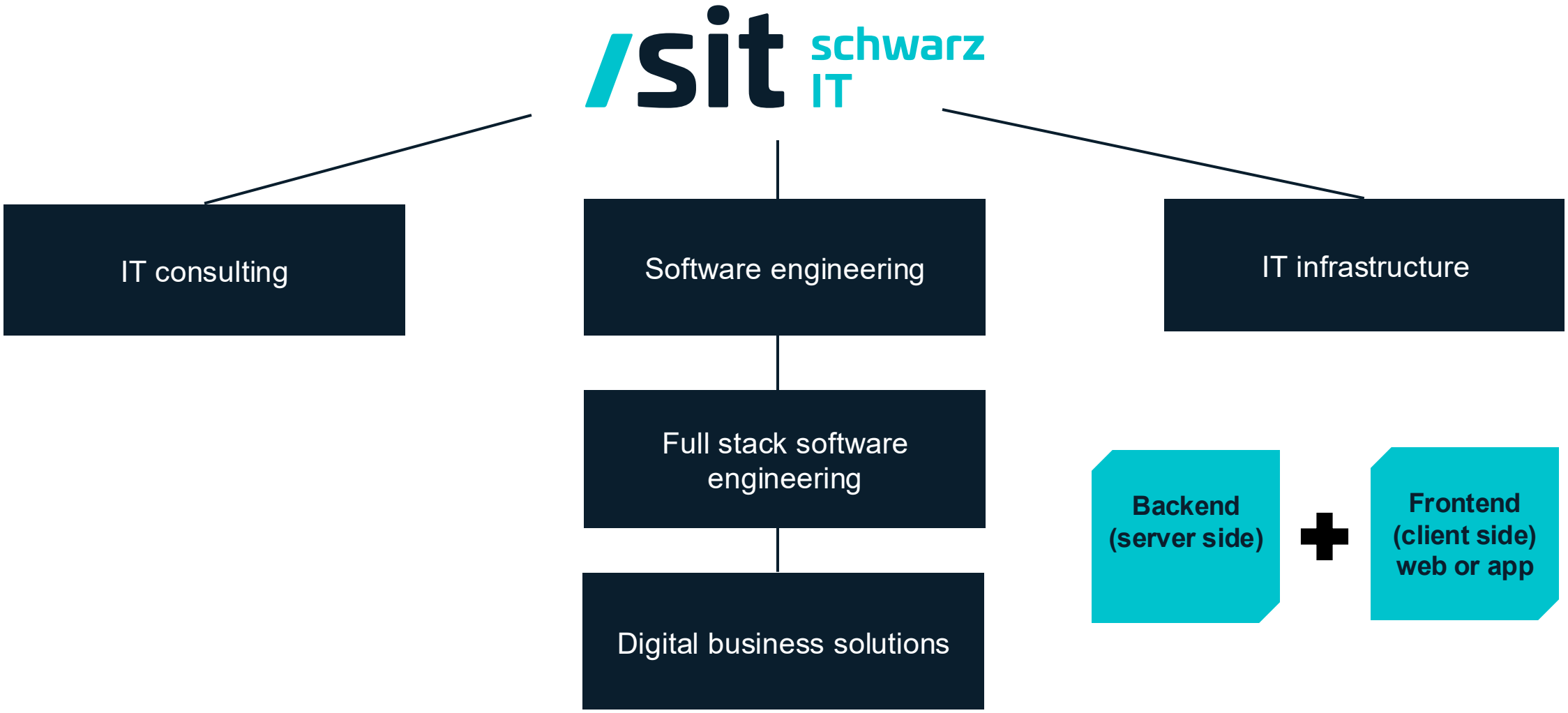
IT consulting
Software engineering
IT infrastructure
Full stack software engineering
Digital business solutions
Backend (server side)
Frontend (client side) web or app

Sebastian Muskalla

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2015 M.Sc. (mathematics)

2022 PhD (theoretical computer science)

2023 Full stack software engineer @ Schwarz IT

Suman Venkat

Suman.Venkat@mail.schwarz

2019 Junior Consultant @ Schwarz IT

2021 Full stack software engineer

Introduction: You!

- Your name
- How long have you been at 42 / TUM Heilbronn?
- With which technologies / programming languages do you have experience?
- What do you hope to learn in this workshop?

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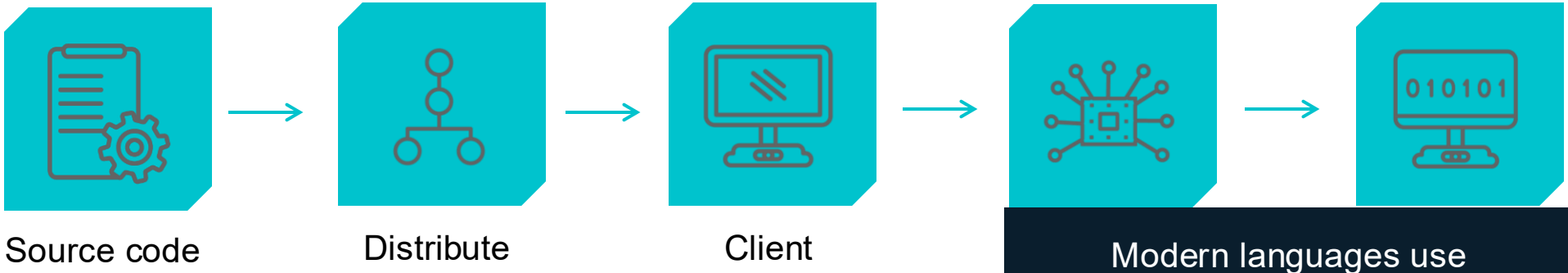
02

About Kotlin

Compiled and interpreted languages

Compiled languages

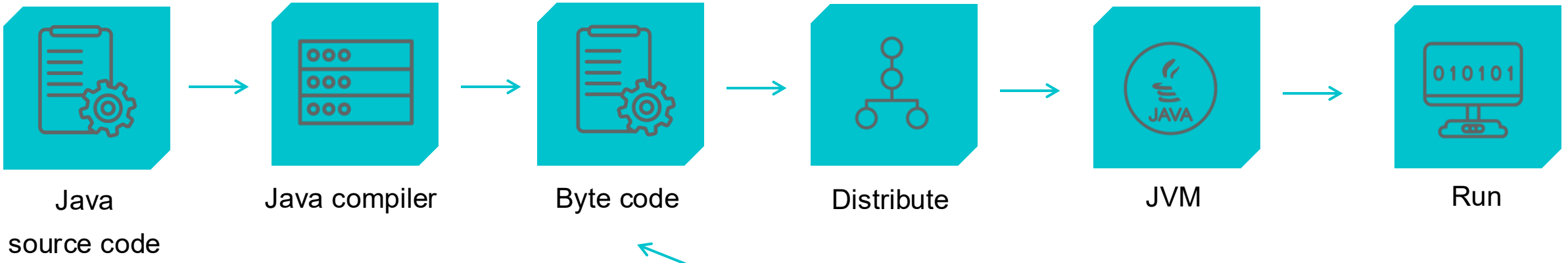
Interpreted languages



Modern languages use

JIT compilation

Java and the Java virtual machine (JVM)



- Originally released in 1996
- The most popular programming language of the last 25 years [1]
  - Business sector
  - Android
- Failed attempts to replace it: Groovy, Scala, …
- Dropping popularity in the last few years:
  - JavaScript/TypeScript, Python
  - **Kotlin**

[1] https://www.tiobe.com/tiobe-index/

HelloWorld.java

```java
public class HelloWorld {
    public static void main(String[] args) {
        System.out.println("Hello, World!");
    }
}
```

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Kotlin

2010: Start of development

2011: Public announcement by JetBrains

2012: Open source‘d (Apache license)

2016: First stable release

2017: Kotlin Multiplatform beta

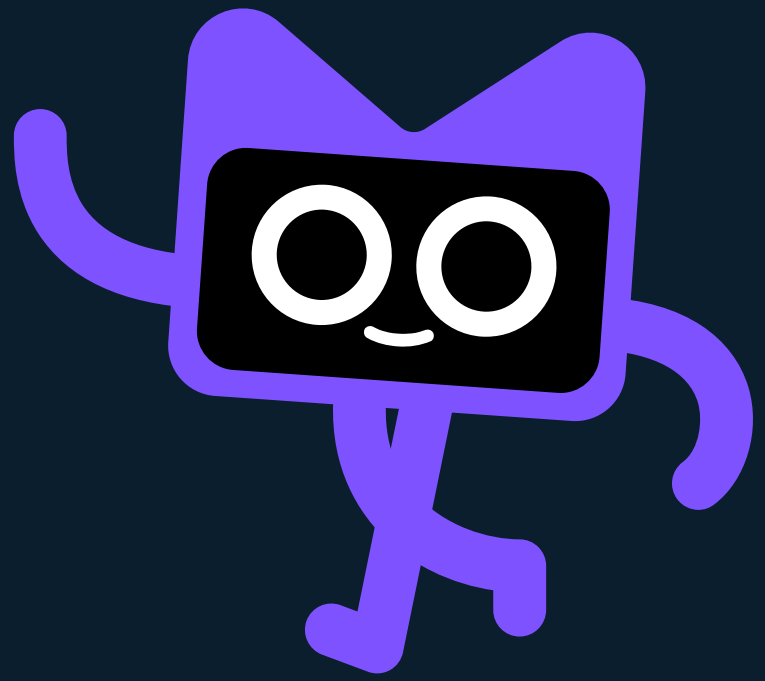
2019: Declared by Google as preferred language for Android apps

2023: Kotlin Multiplatform stable

2024: Kotlin 2.0

Why Kotlin?

- Less verbose
- Full Java interoperability
- Null-safety
- Declarative programming

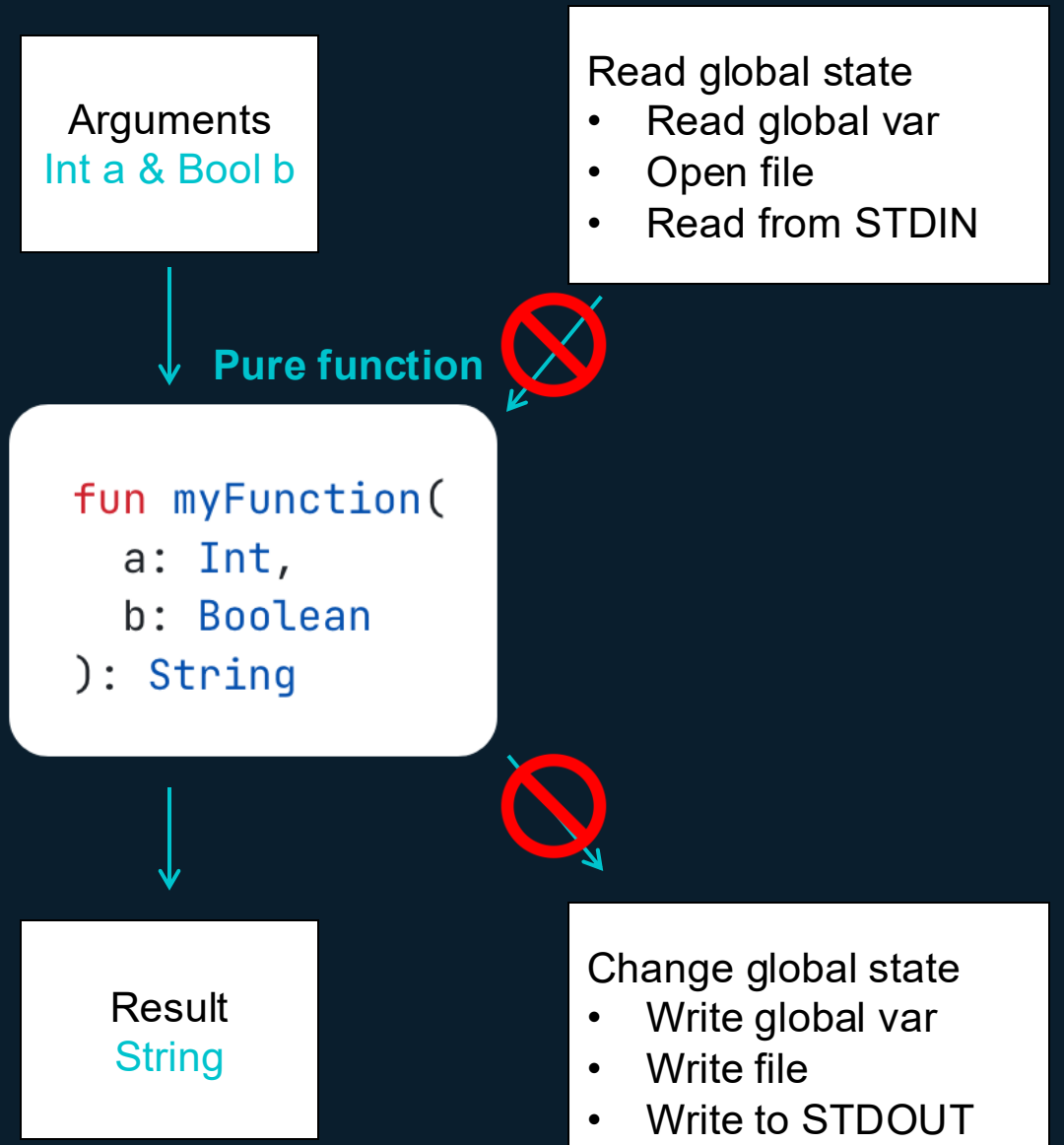


Kodee

Declarative programming

- Telling the computer what to do,
  not how to do it
- Focus on immutability
- Functional programming with pure functions
- Higher-order functions

Makes code easier to read, test, debug, maintain



Kotlin setup check

https://github.com/SIT-Kotlin-Workshop

03

Morning session

Immutable data

Immutable data: State cannot be modified creation

For variables:

- **var:** Mutable variable
- **val:** Immutable value – no reassignment possible

For lists:

- **listOf, List:** Immutable list – no modification possible
- **mutableListOf, MutableList:** Mutable list

Prefer immutable data!

ImmutableVariables.kt

```kotlin

var number = 42
number = 1337 // OK

val number2 = 2 * 668 + 1
number2 = 42 // ERROR

```

ImmutableLists.kt

```kotlin
val list = listOf(42)
list.add(1337) // ERROR

val list2 = mutableListOf(1)
list2.add(2) // OK
list2 = mutableListOf(1, 2, 3) // ERROR

```

Basic syntax overview

- While Loop & Do-While Loop
- For Loop
- If-Then(-Else)
- When
- Functions
  - With body
  - With expression

BasicSyntax.kt (1)

```kotlin
println("Countdown:")
var number = 10

while (number > 0) {
    println("$number...")
    number--
}

println("Go!")
```

BasicSyntax.kt (2)

```kotlin
do {
    println("Enter \"break\" to terminate loop!")
    print("Input: ")
    val input = readln()
} while (input ≠ "break")

println("Exited loop!")
```

BasicSyntax.kt (3)

```kotlin
for (i in 1..5) {
    println(i)
}

for (i in 1..<5) {
    println(i)
}

for (i in 10 downTo 1 step 2) {
    println(i)
}

val mascots = listOf("Rust: Ferris", "Java: Duke", "Kotlin: Kodee")
for (mascot in mascots) {
    println(mascot)
}
```

BasicSyntax.kt (4)

```kotlin
val number = 5
if (number > 2) {
    println("Number is greater than 2!")
}

if (number > 3) {
    println("Number is also greater than 3!")
} else {
    println("Number is less than 3!")
}
```

BasicSyntax.kt (5)

```kotlin
val number = 5

val output =
    if (number > 4) {
        "Number is greater than 4!"
    } else {
        "Number is less than 4!"
    }

println(output)
```

BasicSyntax.kt (6)

```kotlin
val number = 5

when {
    number == 1 -> println("One")
    number == 2 -> println("Two")
}

when (number) {
    1 -> println("One")
    2 -> println("Two")
}
```

BasicSyntax.kt (7)

```kotlin
val number = 5

val output =
    when (number) {
        1 -> "One"
        2 -> "Two"
        else -> "Many"
    }

println(output)
```

FunctionWithBody.kt

```kotlin

fun calculateDiscountedPrice(
    price: Double,
    discountPercent: Double,
): Double {
    val discount = price * (discountPercent / 100)
    return price - discount
}

```

FunctionExpression.kt

```kotlin

fun calculateDiscountedPriceExpression(
    price: Double,
    discountPercent: Double,
) = price - (price * (discountPercent / 100))

```

Return type `: Double` is optional and can be inferred

BasicSyntaxOverview.kt

```kotlin
val number = 5

val output =
    when (number) {
        1 -> "One"
        2 -> "Two"
        else -> "Many"
    }

val output2 =
    if (number > 4) {
        "Number is greater than 4!"
    } else {
        "Number is less than 4!"
    }

for (i in 1..5) {
    println(i)
}

val names = listOf("Suman", "Sebastian")
for (name in names) {
    println(name)
}
```

When

If-Else

For

FunctionsOverview.kt

```kotlin

fun square(x : Int) : Int {
    return x * x
}

fun square(x : Int) = x * x

fun repeatName(
    name : String,
    times : Int,
) = name.repeat(times)

// Calling it
println(repeat("Kotlin!", 42))

println(
    repeat(
        name = "Kotlin!",
        times = 42,
    )
)
```

Function with body

Function expression

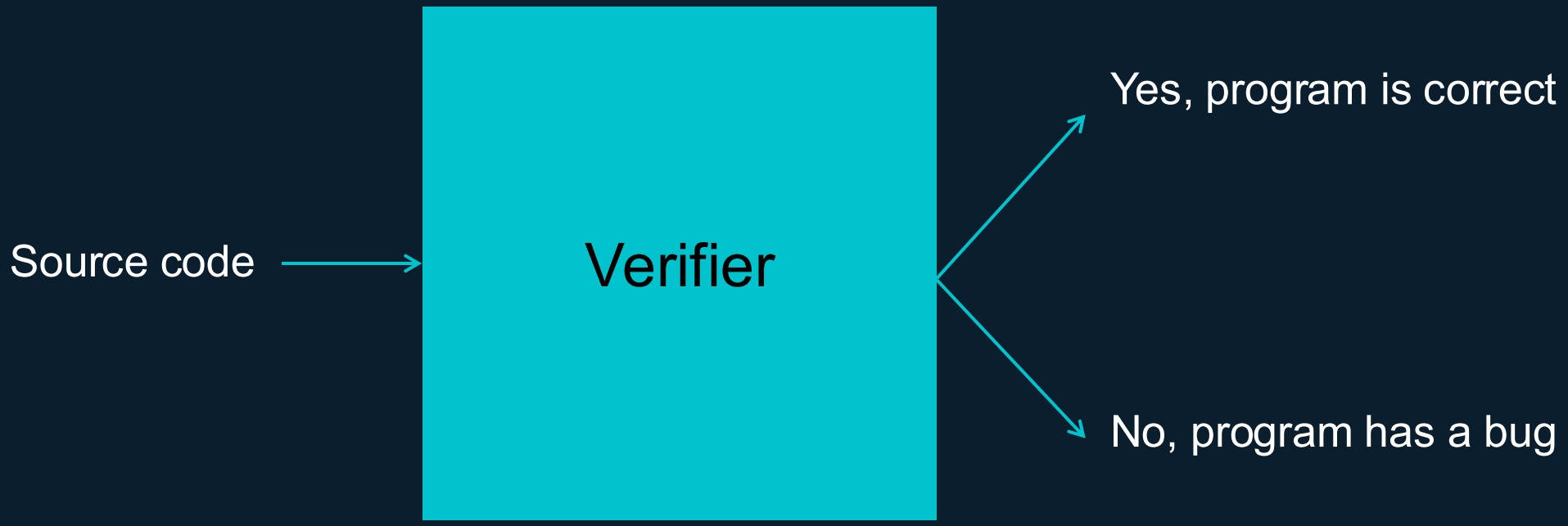
Function call

/sit schwarz IT

Basic syntax

Exercises

Automated testing


Source code
Verifier
Yes, program is correct
No, program has a bug


Source code
Test scenario
Expected outcome
Test framework
Yes, outcome is as expected
No, program has a bug

SimpleTest.kt (1)

```kotlin
// Built-in assertions
// Only enabled with special flag
assert(
    "kotlin".uppercase(Locale.GERMAN) ==
        "kotlin".uppercase(Locale.ENGLISH)
)

// Using assertk
assertThat(
    "kotlin".uppercase(Locale.GERMAN) ==
        "kotlin".uppercase(Locale.ENGLISH)
).isTrue()
```

SimpleTest.kt (2)

```
1  assertThat(
2      "kotlin".uppercase(Locale.of("tr", "TR")) ==
3          "kotlin".uppercase(Locale.ENGLISH)
4  ).isTrue()
```

```kotlin
@Test
fun `simple assert - false`() {
    assertThat( actual: "kotlin".uppercase(Locale.of( language: "tr",  country: "TR")) == "kotlin".uppercase(Locale.ENGLISH))
        .isTrue()
}
```

npleTest.simple assert - false ×

Tests failed: 1 of 1 test – 16 ms

```
expected to be true
org.opentest4j.AssertionFailedError Create breakpoint : expected to be true
    at schwarz.it.kotlin.workshop.basic.testing.SimpleTest.simple assert - false(SimpleTest.kt:28) <1 internal line>
    at java.base/java.util.ArrayList.forEach(ArrayList.java:1596)
    at java.base/java.util.ArrayList.forEach(ArrayList.java:1596)
```

SimpleTest.kt (3)

```
1  assertThat(
2    "kotlin".uppercase(Locale.of("tr", "TR"))
3  ).isEqualTo(
4    "kotlin".uppercase(Locale.ENGLISH)
5  )
```

```kotlin
@Test
fun `better assert - false`() {
    assertThat("kotlin".uppercase(Locale.of( language: "tr",  country: "TR")))
        .isEqualTo("kotlin".uppercase(Locale.ENGLISH))
}
```

npleTest.better assert - false ×

Tests failed: 1 of 1 test – 19 ms

```
Expected :KOTLIN
Actual   :KOTLİN
<Click to see difference>

org.opentest4j.AssertionFailedError Create breakpoint : expected:<"KOTL[I]N"> but was:<"KOTL[İ]N">
    at schwarz.it.kotlin.workshop.basic.testing.SimpleTest.better assert - false(SimpleTest.kt:34) <1 internal line>
    at java.base/java.util.ArrayList.forEach(ArrayList.java:1596)
    at java.base/java.util.ArrayList.forEach(ArrayList.java:1596)
```

Testing

- Use testing framework + assertion library to write expressive tests (Here: JUnit 5 + assertk)
- Detecting regressions
- Code coverage
- Test driven development
- Automatic test execution as part of CI/CD

Several types of tests

- Unit tests: Test component in isolation
- Integration tests: Test interaction between components (requires starting web framework, later)

SimpleTest.kt (4)

```kotlin
import assertk.assertThat
import assertk.assertions.contains
import org.junit.jupiter.api.Test

class SimpleTest() {

@Test
fun `another test`() {

    val mascots = listOf(
        "Duke",
        "Ferris",
        "Kodee",
        "Gopher"
    )

    assertThat(mascots)
        .contains("Kodee")
}

}
```

Testing

Exercises

Immutable classes in Kotlin

- **Data classes:**
  Kotlin‘s data **class** feature simplifies the creation of immutable classes by automatically generating useful methods such as:
  - equals()
  - hashcode()
  - toString()
  - copy()

Immutable class

ImmutableClass.kt

```kotlin
1  data class CartItem(val name: String, val quantity: Int, val price: Double)
2
3  val originalItem = CartItem("T-Shirt", 1, 5.99)
4
5  // compile-time error
6  originalItem.price = 4.99
7
8  // Apply discount by creating a new copy
9  val discountedItem = originalItem.copy(price = 4.99)
10
11 println(originalItem)
12 println(discountedItem)
13
```

All properties are read-only

CartItem(name=T-Shirt, quantity=1, price=5.99)

CartItem(name=T-Shirt, quantity=1, price=3.99)

Nullability

In Java and other languages, the special value null is allowed for (almost) all types.

It can mean

- not initialized
- undefined / not provided (as an argument of a function)
- error (as a return value of a function)
- …

Problems:

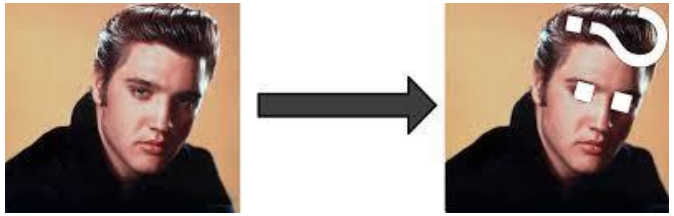
- Don‘t know which of the above
- Don‘t know when objects are null
- Accessing null crashes with NPE (NullPointerException)

Nullability.kt

```kotlin
data class Person(
    val name: String,
    val birthday: LocalDate,
) {
    fun format(): String = "$name ($birthday)"
}

fun main() {

    val person: Person = null

    // Property access would crash with NPE
    println(person.name)

    // Function call would crash with NPE
    println(person.format())
}
```

Null safety

- In Kotlin, null is only allowed as value for nullable types of shape Type?
- Compiler enforces that no NPEs happen at runtime
- Safe navigation ?.
  - only call property / function if object is not null
- Elvis operator ?:
  - Take alternative when object is null
- Smart casting



Null safety.kt

```kotlin

data class Company(
    val companyName: String,
    val numberOfEmployees: Int,
)

data class Worker(
    val name: String,
    val company: Company,
)

private fun main() {
    // val worker : Worker = null

    val worker: Worker? = null

    // println(worker.name)

    println(worker?.name)
    println(worker?.company?.companyName)

    println(worker?.name ?: "Unknown")

    if (worker ≠ null) {
        println(worker.name)
    }
}
```

Immutable Data & Nullability

Exercises

04

Lunch break
+ Q & A / Networking

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05

Afternoon session
Web development

Functional programming with higher-order functions

Functions.kt

```kotlin
val cartPrices = listOf(5.99, 12.39, 19.99, 8.59, 3.45)

// Filter out cheap items
val filteredPrices = cartPrices.filter { it >= 5.0 }

// Add 10% tax to each item
val taxedPrices = filteredPrices.map { it * 1.1 }

// Calculate total
val totalWithTax = taxedPrices.fold(0.0) { acc, price -> acc + price }

```

CombineFunctions.kt

```kotlin
val cartPrices = listOf(5.99, 12.39, 19.99, 8.59, 3.45)

val totalWithTax = cartPrices
            .filter { it >= 5.0 } // Filter out prices less than 5.0
            .map { it * 1.1 }     // Add 10% tax
            .fold(0.0) { acc, value -> acc + value } // Accumulate total

```

ImperativeApproach.kt

```kotlin
fun imperativeEvenDouble(input: List<Int>): List<Int> {
  val result = mutableListOf<Int>()
  for (number in input) {
    if (number % 2 == 0) {
      result.add(number * 2)
    }
  }
  return result
}
```

FunctionalApproach.kt

```kotlin
fun functionalEvenDouble(input: List<Int>): List<Int> {
    return input.filter { it % 2 == 0 }
        .map { it * 2 }
}
```

Functional programming

- **Functions as First-Class citizens**
  - Assigned to variables
  - Passed as arguments to other functions
  - Returned from other functions
- **Higher-order Functions**
  - Functions that take other functions as parameters or return them
  - Common examples: `map`, `filter`,`fold`, `reduce`
- **Lambdas**
  - Anonymous functions that can be used as values
  - Often passed to higher-order funtions for concise, functional-style code

```kotlin
val greet: (String) -> String = { name -> "Hello, $name" }
println(greet("World")) // Output: Hello, World
```

```kotlin
fun <T, R> higherOrderFunction(func: (T) -> R, value: T): R {
  return func(value)
}
```

HigherOrderFunction.kt

```kotlin
fun main() {
  val double: (Int) -> Int = { it * 2 }
  println(higherOrderFunction(double, 5)) // Result: 10
}

fun <T, R> higherOrderFunction(func: (T) -> R, value: T): R {
  return func(value)
}
```

Functional programming with higher-order functions

Exercises

Backend web development using Ktor

StaticRoutes.kt

```kotlin
fun Route.staticRoutes() {
    staticResources("/frontend", "static") {
        default("index.html")
    }
}
```

http://localhost:8080/frontend/index.html

BasicRoutes.kt (1)

```kotlin
fun Route.basicRoutes() {
    route("/basic") {
        get("/static.html") {
            call.respondText(
              contentType = ContentType.Text.Html,
              status = HttpStatusCode.OK
            ) {
                """
                <html>
                <body>
                    <h1>Welcome at Kodee's online shop</h1>
                </body>
                </htmL>
                """.trimIndent()
            }
        }
    }
}
```

http://localhost:8080/basic/static.html

BasicRoutes.kt (2)

```kotlin
get("/dynamic.html") {
    val totalOrders = Random.nextInt(from = 5, until = 20)
    val inDelivery = Random.nextInt(from = 2, until = totalOrders / 2)

    call.respondText(
      contentType = ContentType.Text.Html,
      status = HttpStatusCode.OK
    ) {
        """
        <html>
        <body>
            <h1>Welcome at Kodee's online shop</h1>
            Open orders at ${LocalDateTime.now()}:
                $totalOrders open,
                $inDelivery of which in delivery
        </body>
        </html>
        """.trimIndent()
    }
}
```

http://localhost:8080/basic/dynamic.html

Web technologies

The beginnings:

- Web server delivers static HTML

Later:

- Dynamic content: Web server renders page on request

15-25 years ago: AJAX etc.

- Browser and backend communicate asynchronously via API
- REST
- JSON

ShopStatisticsDTO.kt

```kotlin
@Serializable
data class ShopStatisticsDTO(
    val timestamp: String,
    val totalOrders: Long,
    val ordersInDelivery: Long,
)
```

BasicRoutes.kt (3)

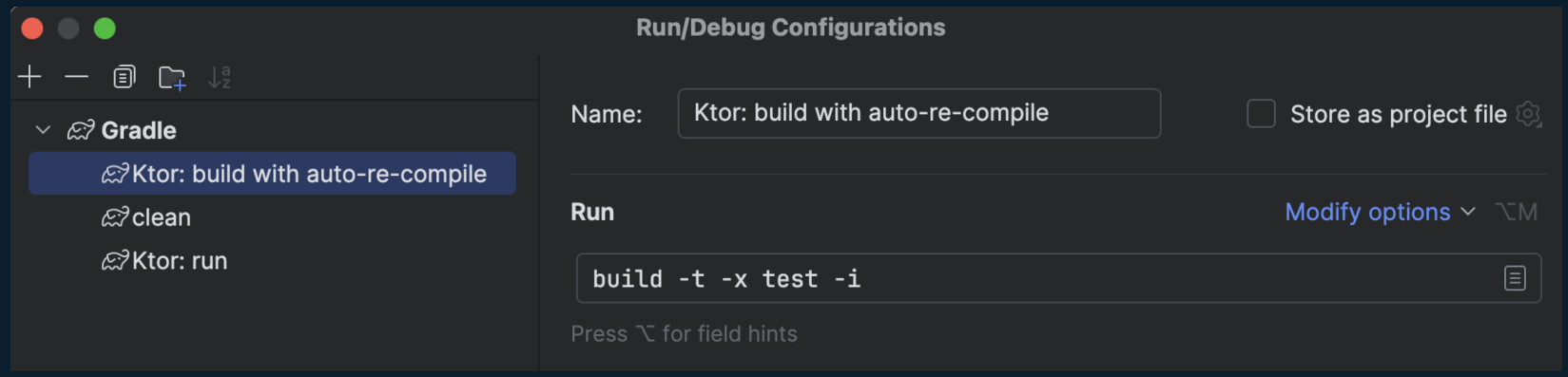
```kotlin
get("/decoupled") {
    val totalOrders = Random.nextLong(from = 5, until = 20)
    val inDelivery = Random.nextLong(from = 2, until = totalOrders / 2)

    val response =
        ShopStatisticsDTO(
            timestamp = LocalDateTime.now().toString(),
            totalOrders = totalOrders,
            ordersInDelivery = inDelivery,
        )

    call.respond(HttpStatusCode.OK, response)
}
```

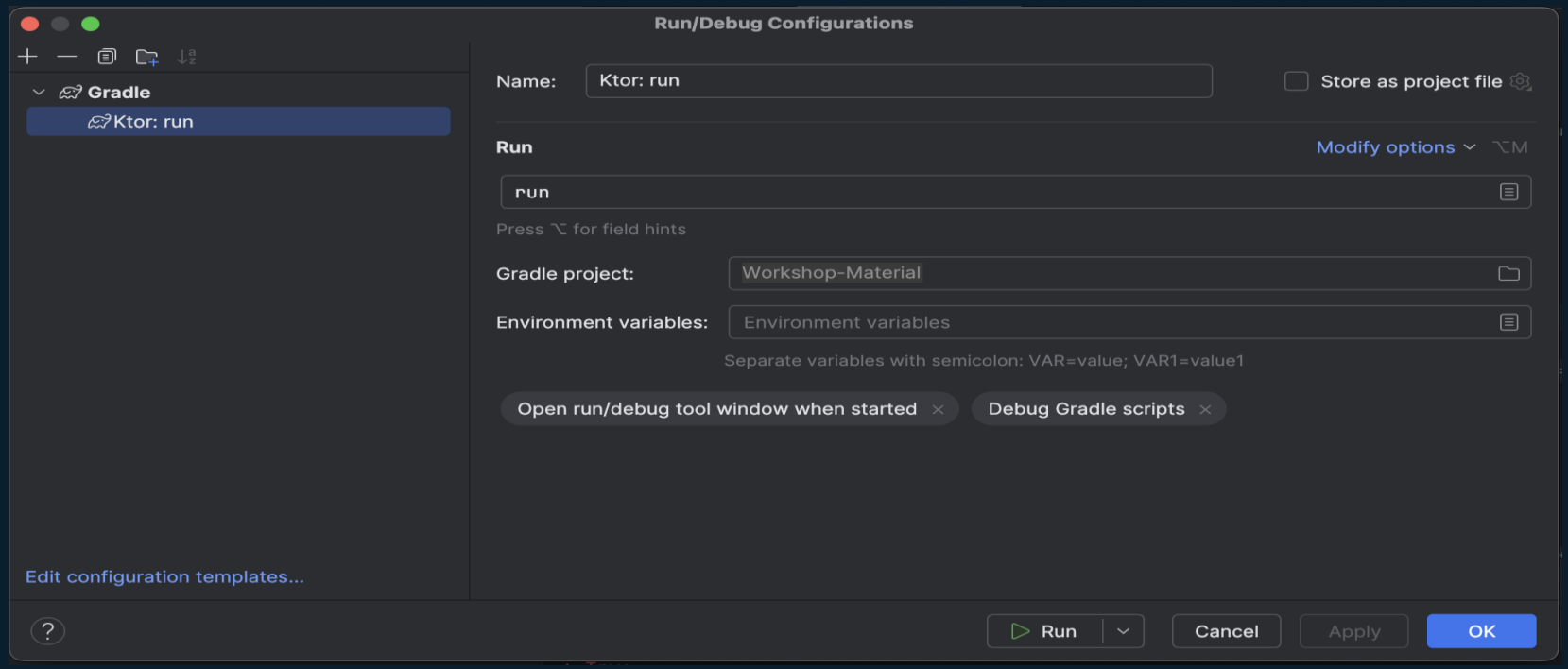
http://localhost:8080/basic/decoupled

http://localhost:8080/frontend/basic.html

index.kt

```kotlin
class BasicRoutesTest {
    @Test
    fun `endpoint decoupled - returns statistics`() =
        integrationTest { client →
            val response = client.get("/basic/decoupled")

            assertThat(response.status).isEqualTo(HttpStatusCode.OK)

            val body = response.body<ShopStatisticsDTO>()

            assertThat(body.totalOrders).isLessThan(20)
            assertThat(body.ordersInDelivery).isLessThan(body.totalOrders)
            assertThat(body.ordersInDelivery).isGreaterThanOrEqualTo(2)
        }
}

```


Run/Debug Configurations
Gradle
Ktor: build with auto-re-compile
clean
Ktor: run
Name:
Ktor: build with auto-re-compile
Store as project file
Run
Modify options
⌥M
build -t -x test -i
Press ⌥ for field hints


Run/Debug Configurations
Gradle
Ktor: run
Name:
Ktor: run
Store as project file
Run
Modify options
⌥M
run
Press ⌥ for field hints
Gradle project:
Workshop-Material
Environment variables:
Environment variables
Separate variables with semicolon: VAR=value; VAR1=value1
Open run/debug tool window when started
Debug Gradle scripts
Edit configuration templates...
Run
Cancel
Apply
OK

Advanced project demo in IDE / browser

http://localhost:8080/frontend/advanced.html

Backend web development using Ktor

Exercises

http://localhost:8080/frontend/exercise.html

http://localhost:8080/frontend/advanced.html

Further reading

- Databases and ORM libraries
  e.g. https://github.com/JetBrains/Exposed
- Dependency injection
- Layered architecture
- OpenAPI specifications
- Frontend technology
  e.g. Vue.js

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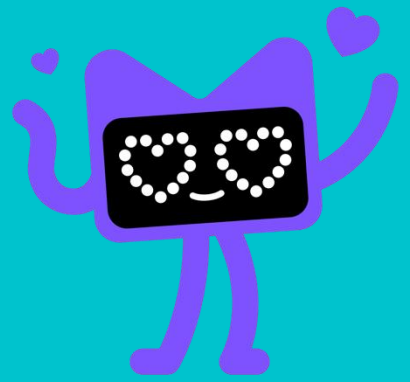
06

Q&A

Thank you for attending!



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