JOHANNES KEPLER
UNIVERSITÄT LINZ

OpenTelemetry Instrumentation using Kotlin Multiplatform Compiler Plugins

Fabian Schoenberger
Markus Weninger, Institute for System Software

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Viewing Note

- This presentation is designed with animations and is best experienced in PowerPoint. This PDF version is provided for your convenience for printing and sharing.

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Motivation: OpenTelemetry

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OpenTelemetry

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OpenTelemetry	Standard to collect, transport and store telemetry data

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Telemetry

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Telemetry Collection of *measurements or other data* at remote points and their automatic transmission to receiving equipment *for monitoring*

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Traces

Motivation: OpenTelemetry

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Telemetry Collection of *measurements or other data* at remote points and their automatic transmission to receiving equipment *for monitoring*

Traces The path of a request through your application.

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Traces	The path of a request through your application.
Span	

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Logs

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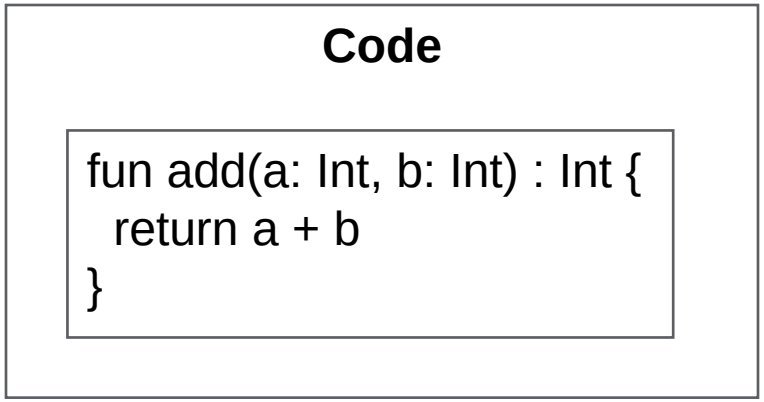
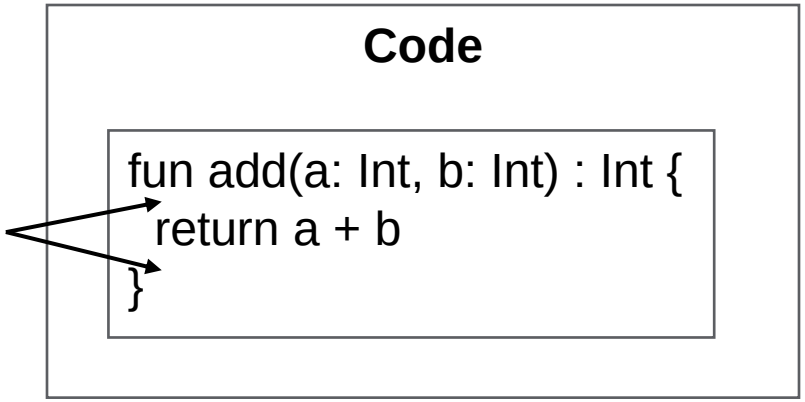


Motivation: OpenTelemetry

Instrumentation: Add measurement code



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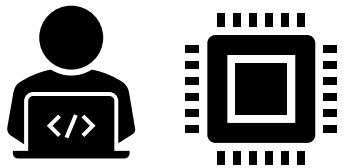

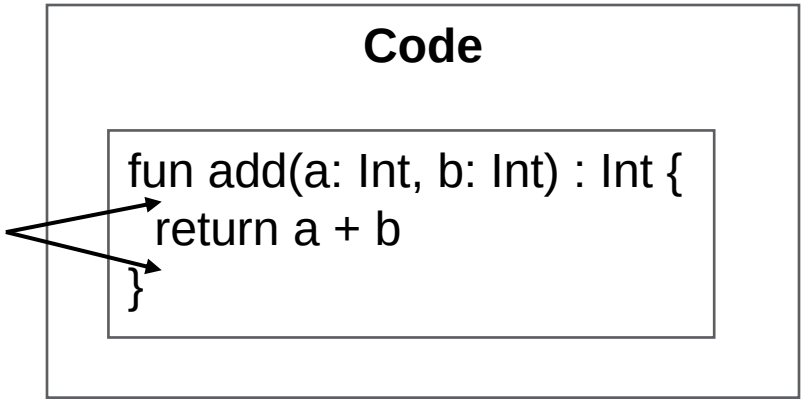

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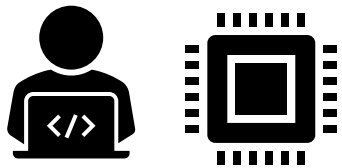

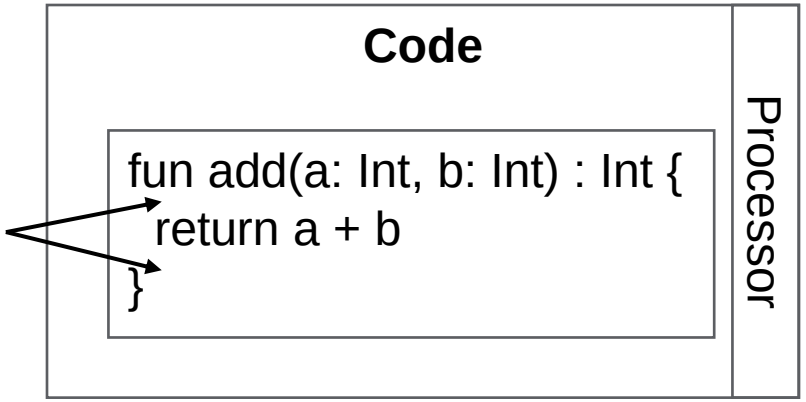

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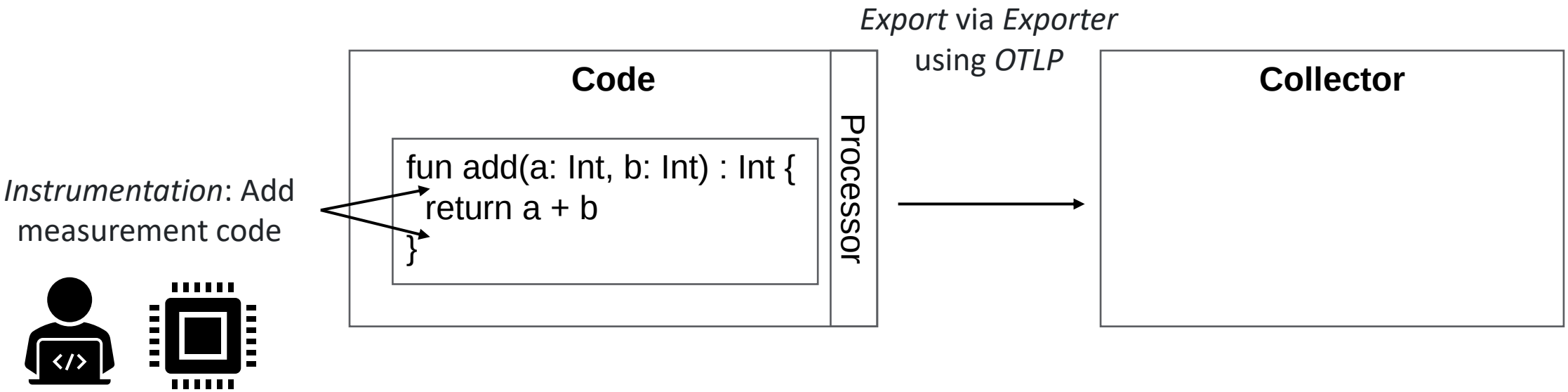

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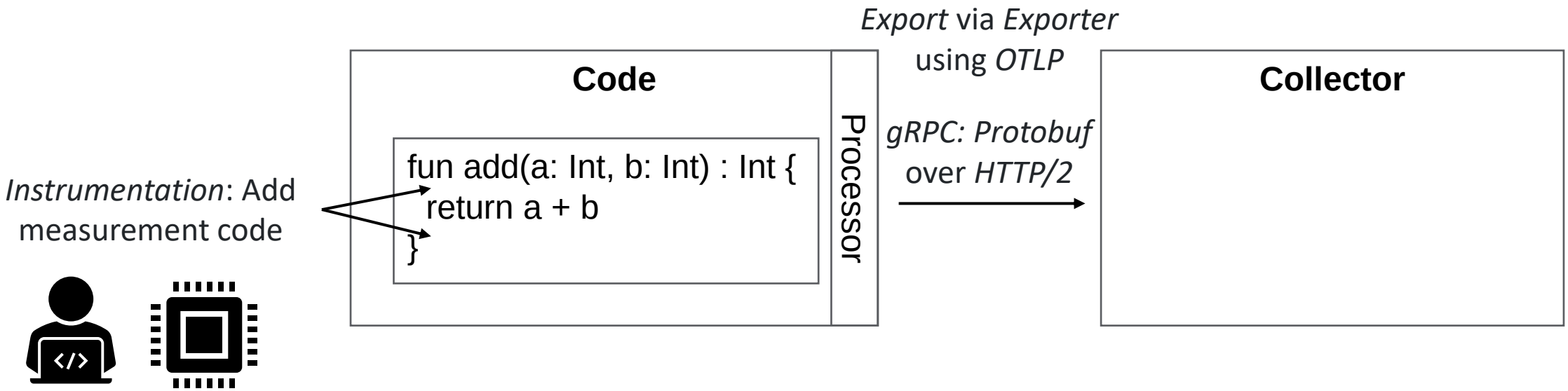

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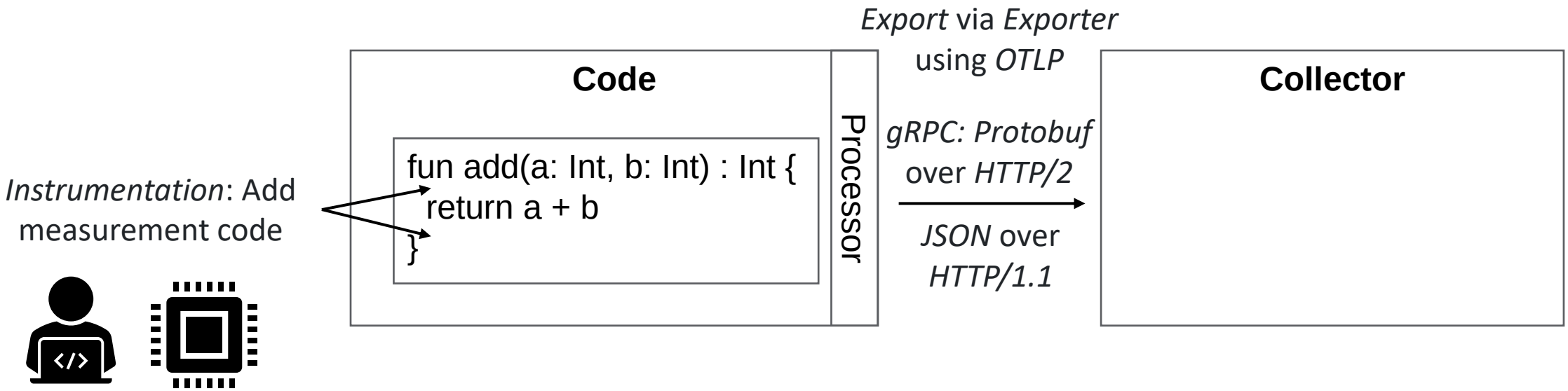

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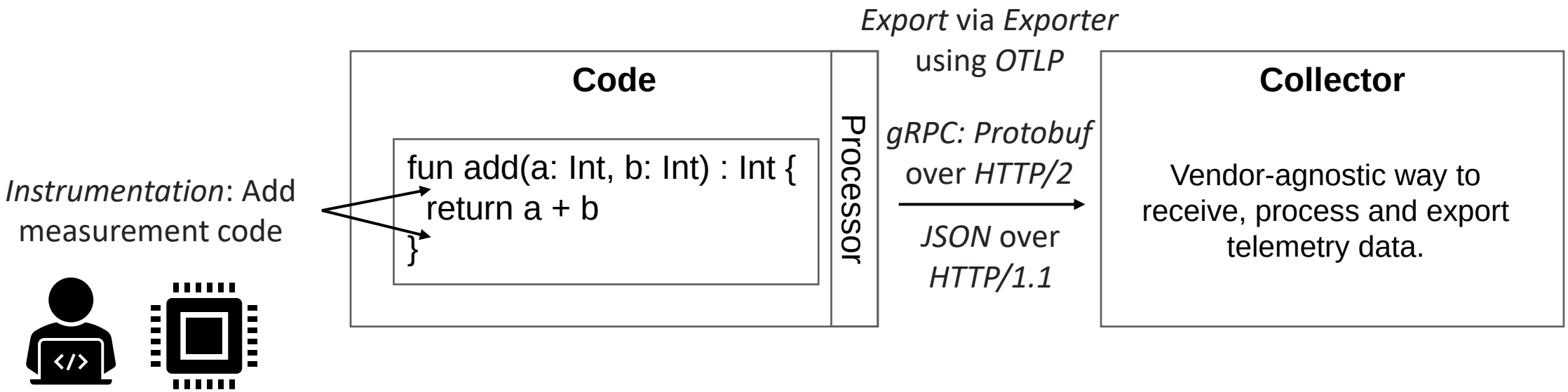

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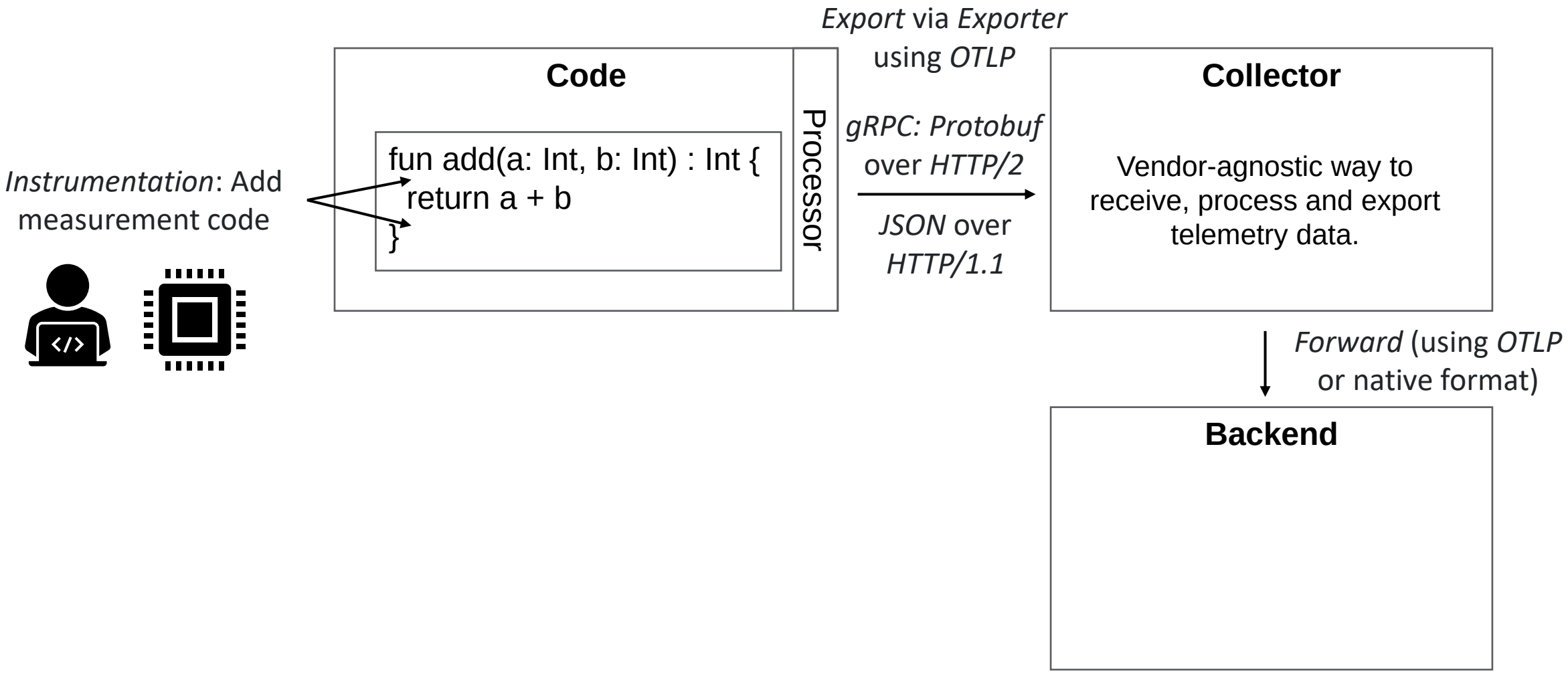

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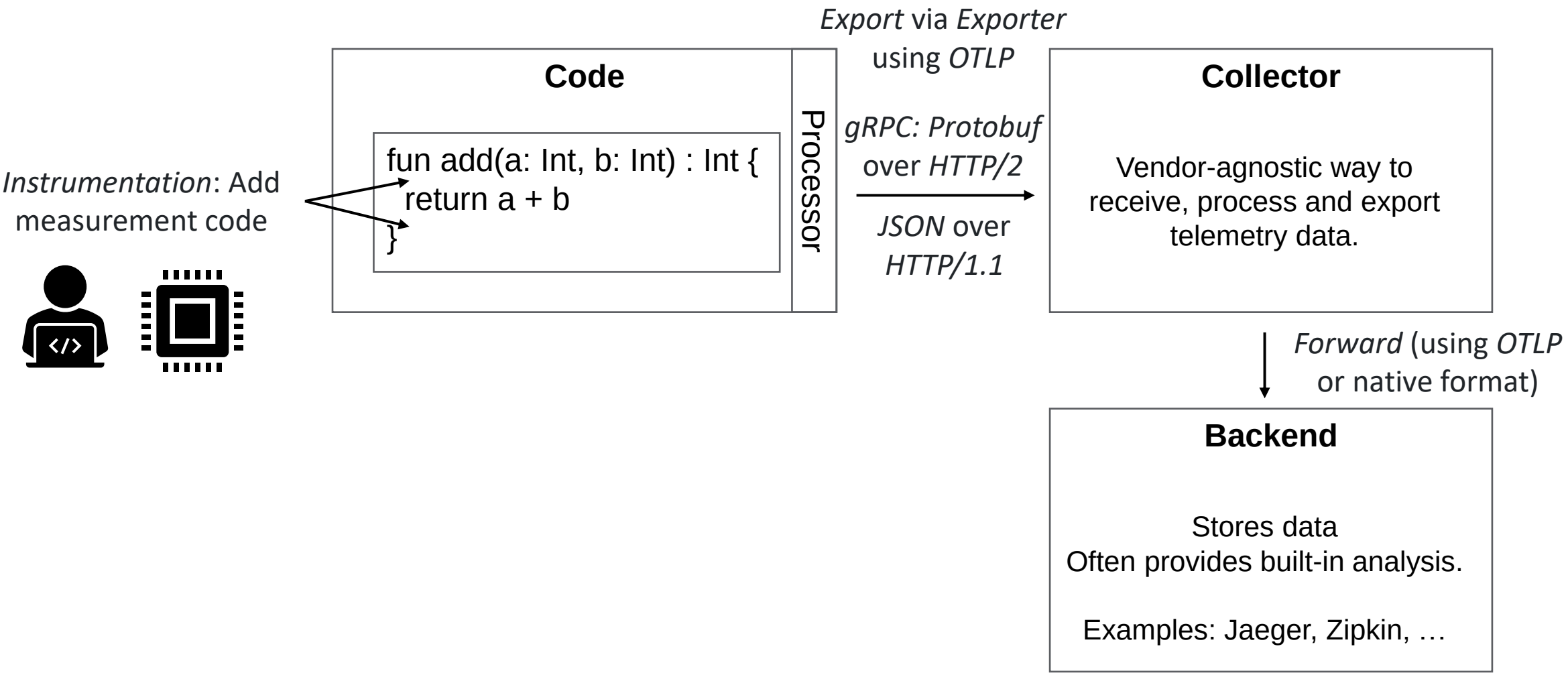

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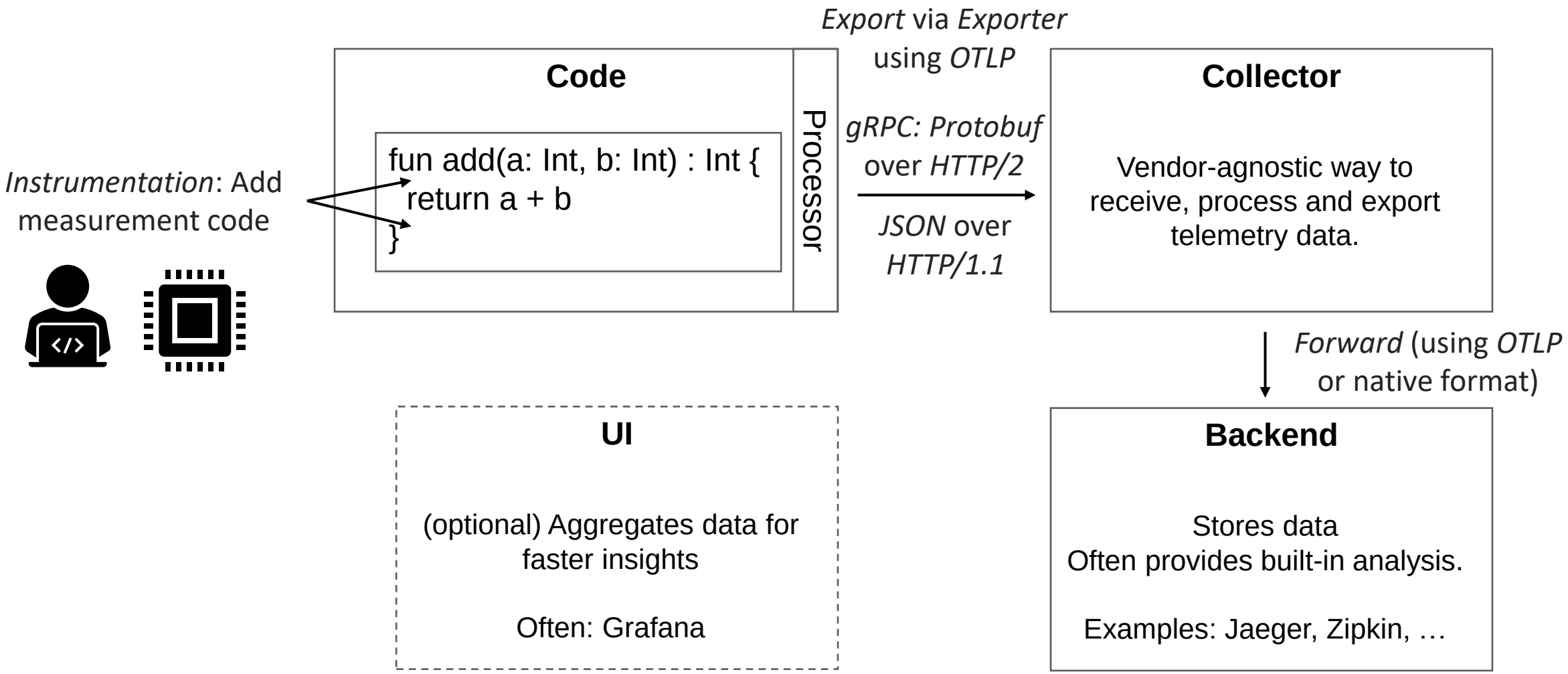

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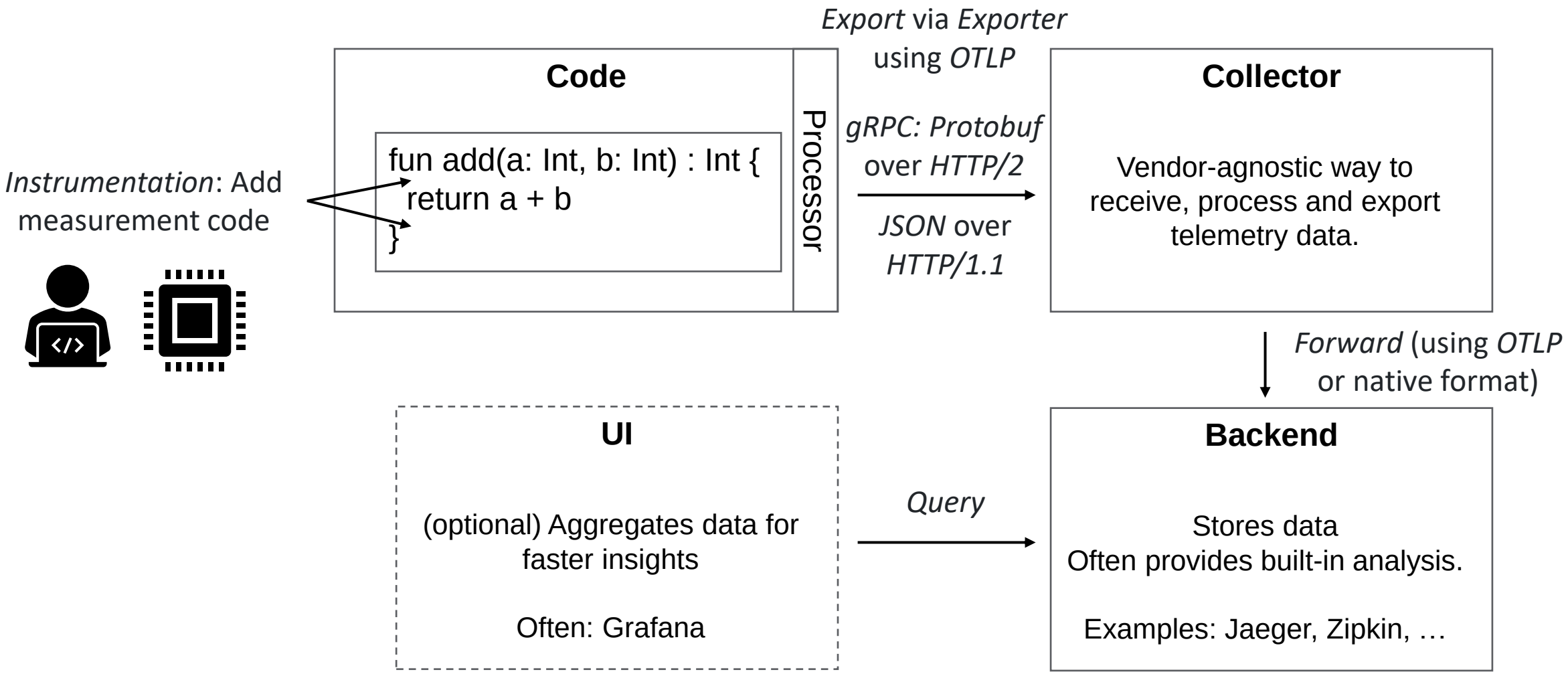

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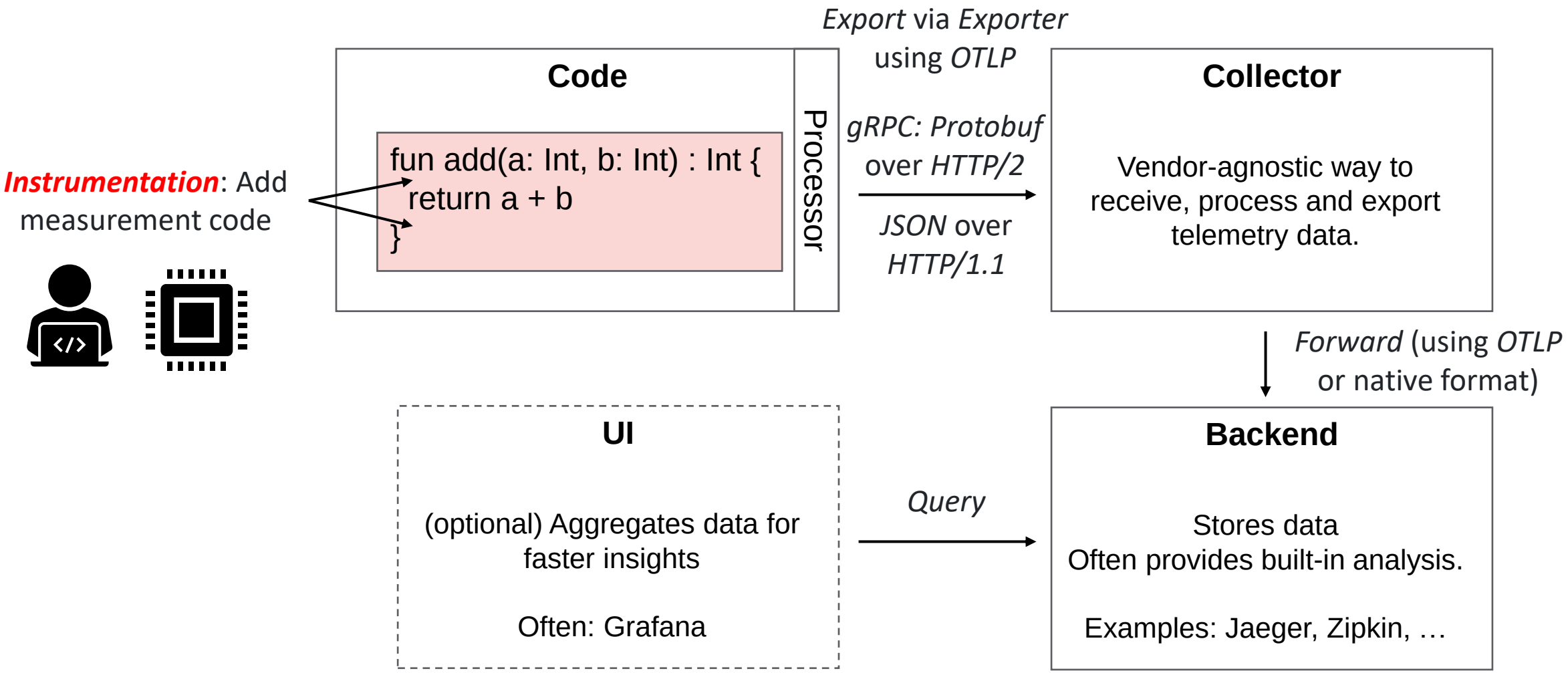

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Motivation: Instrumentation

```
fun myFunction () {
  val x = 1
  val y = 1
  val z = x + y
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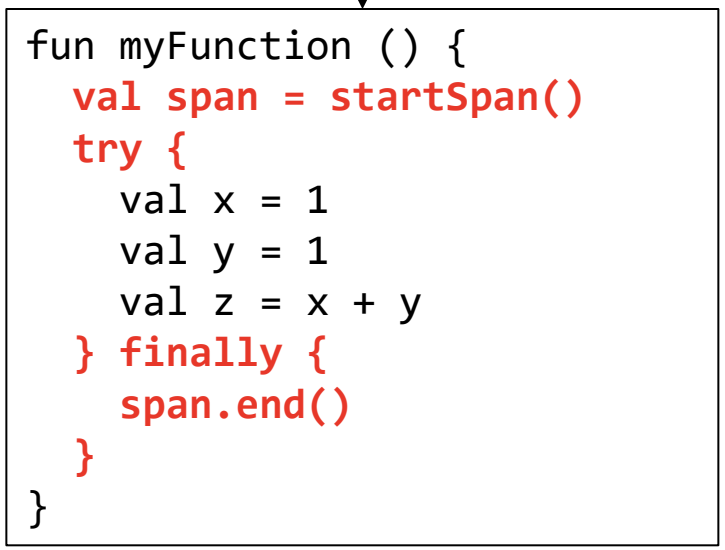

```
fun myFunction () {
  val span = startSpan()
  try {
    val x = 1
    val y = 1
    val z = x + y
  } finally {
    span.end()
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? How to best instrument **Kotlin**?

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Motivation: Kotlin Multiplatform

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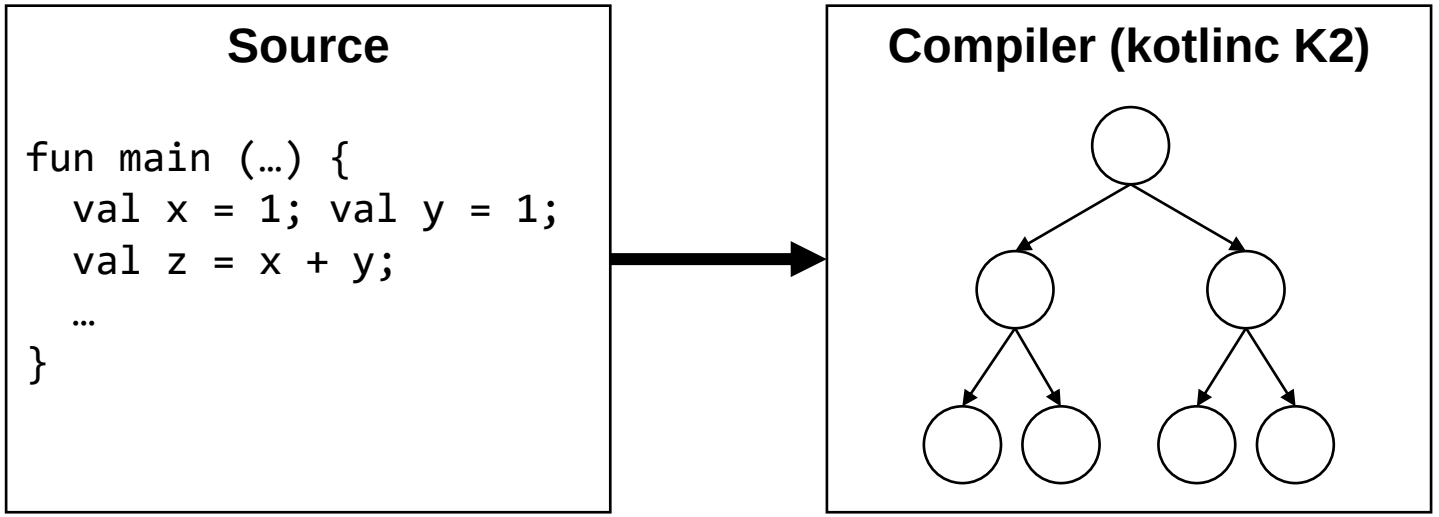
Source

```
fun main (…) {
  val x = 1; val y = 1;
  val z = x + y;
  …
}
```

Motivation: Kotlin Multiplatform



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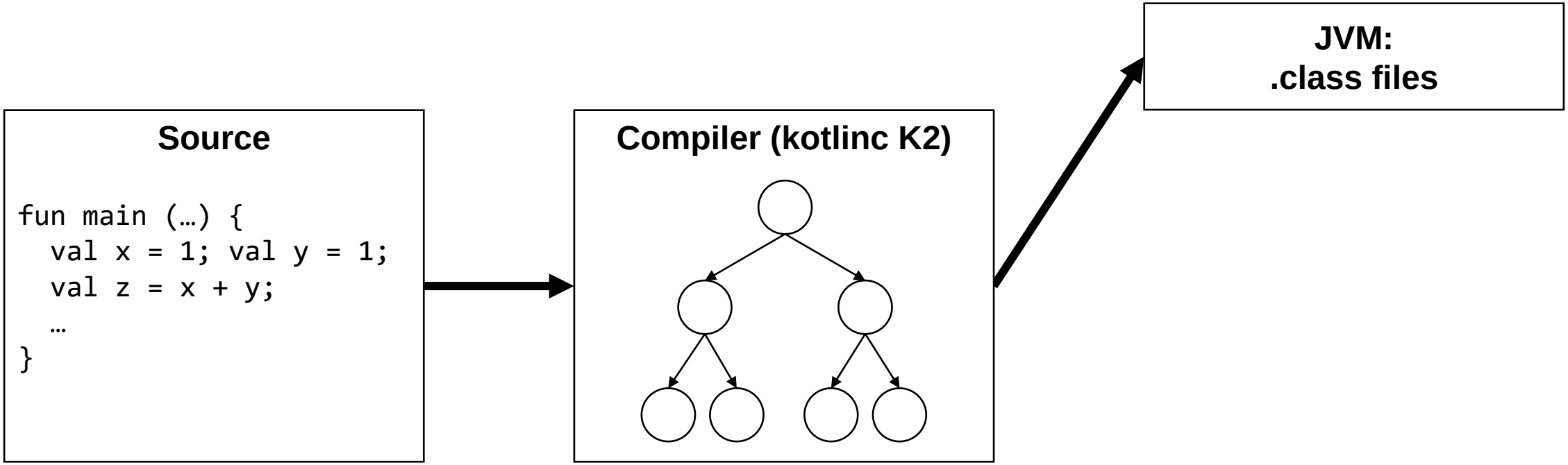

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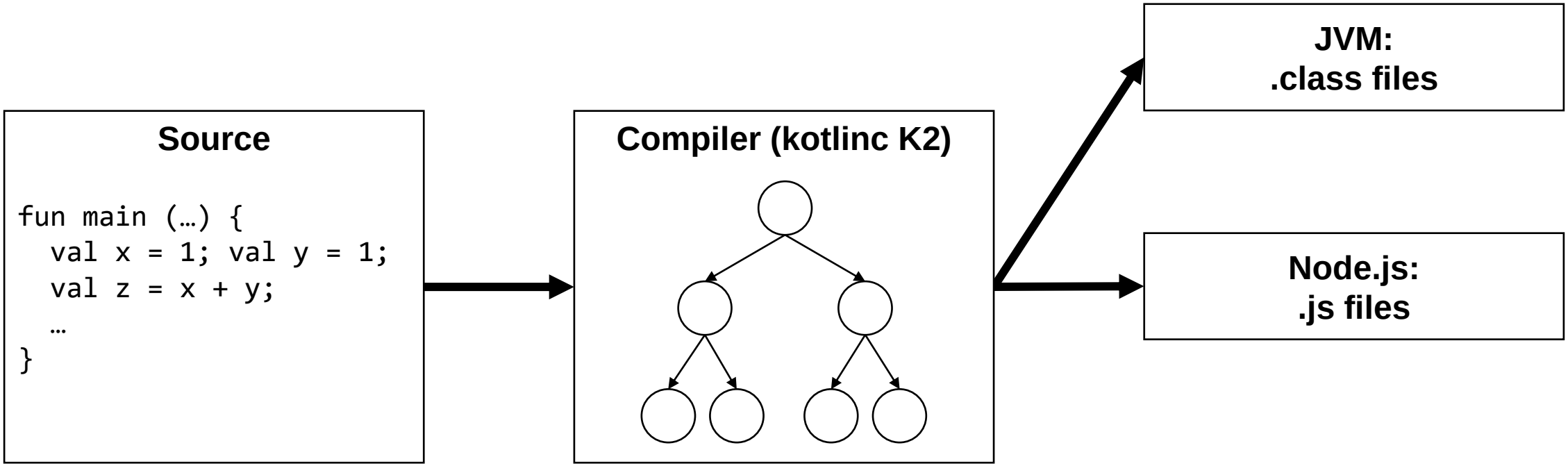

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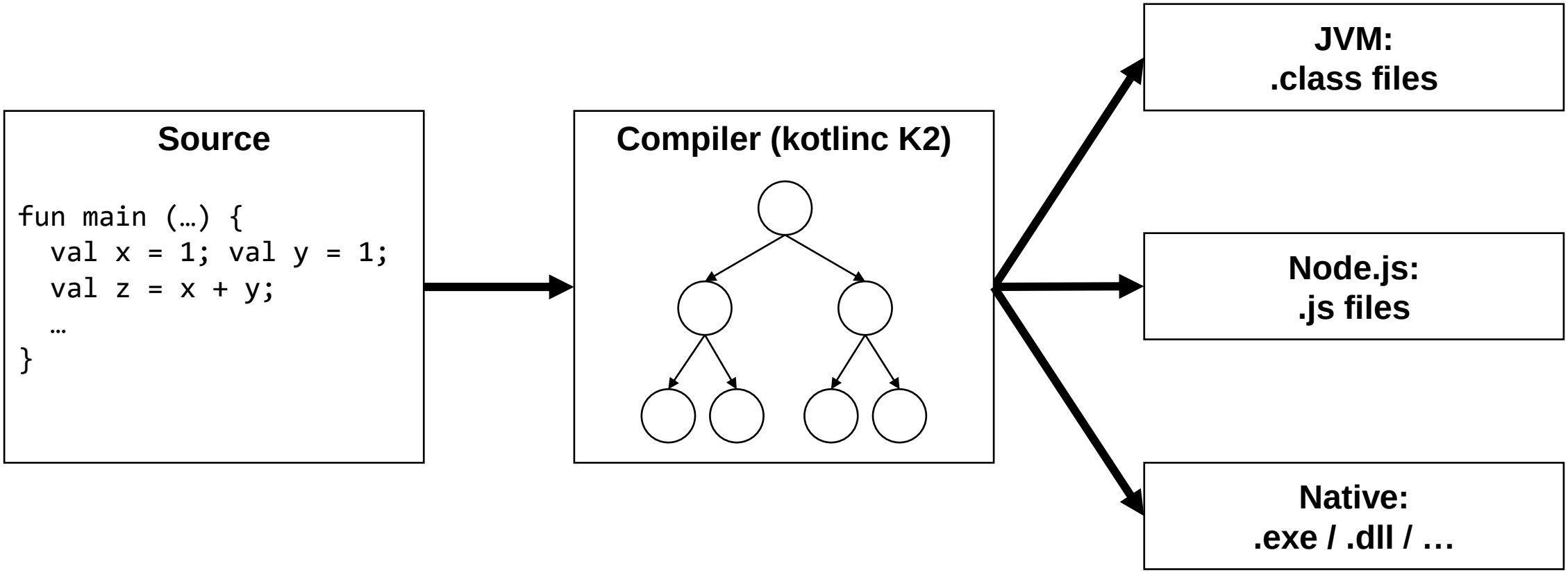

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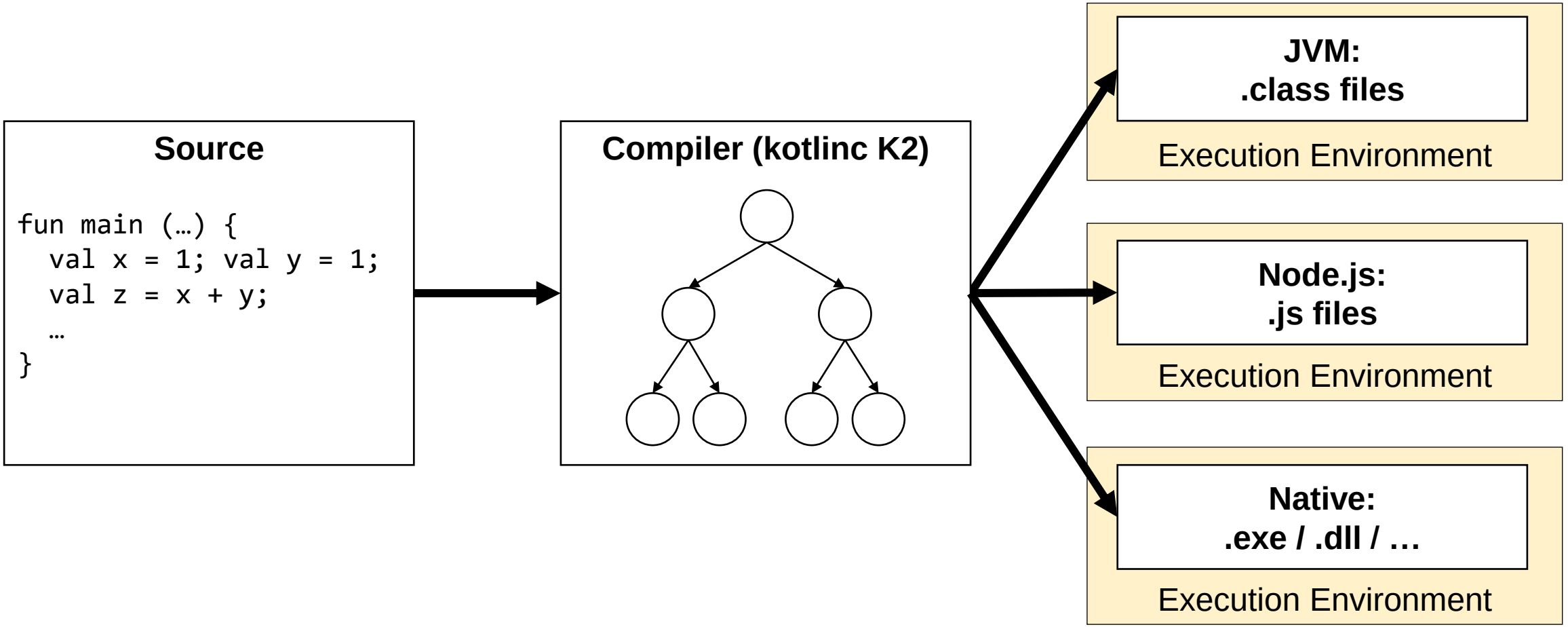
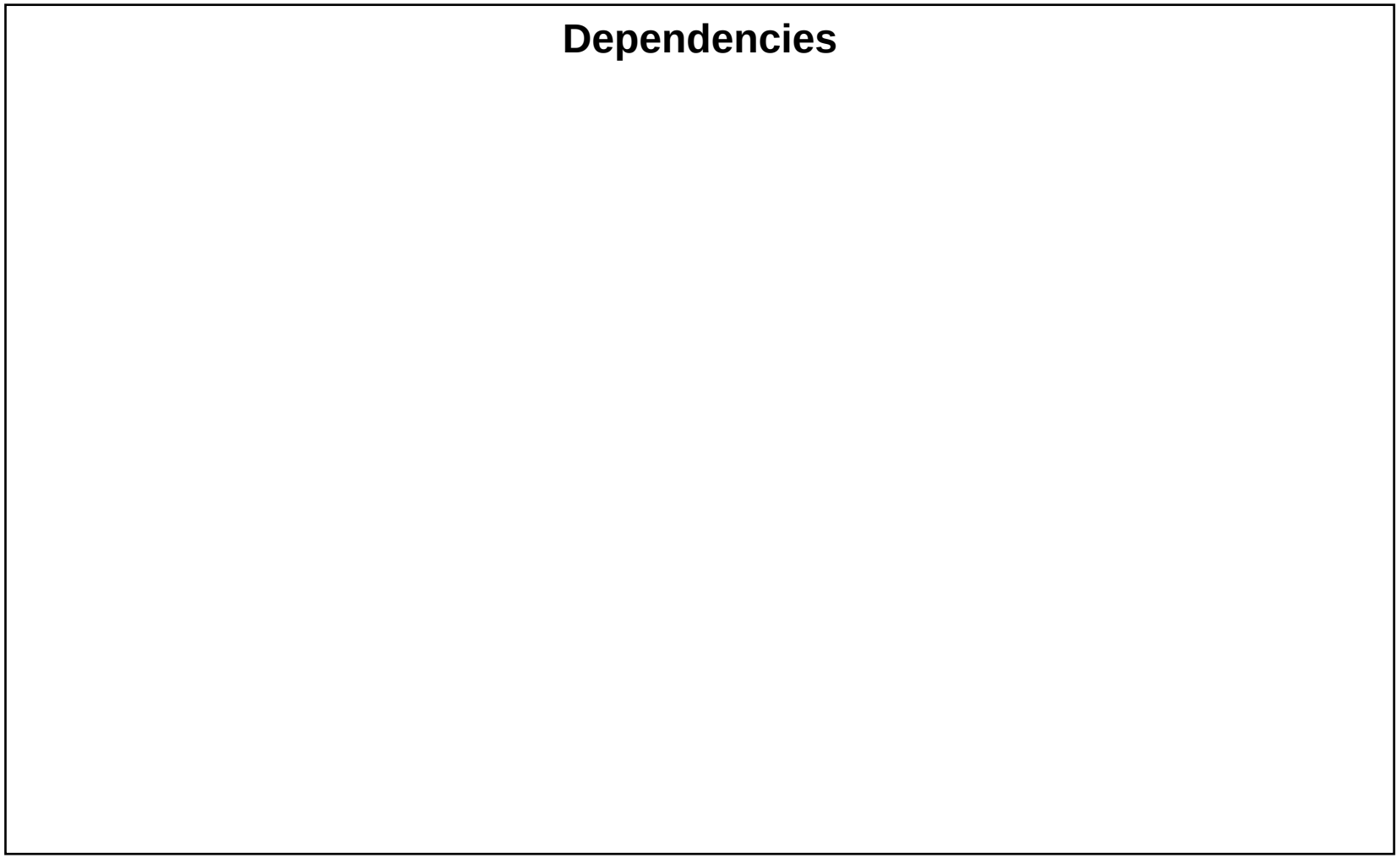


Requirements for Kotlin Multiplatform Projects



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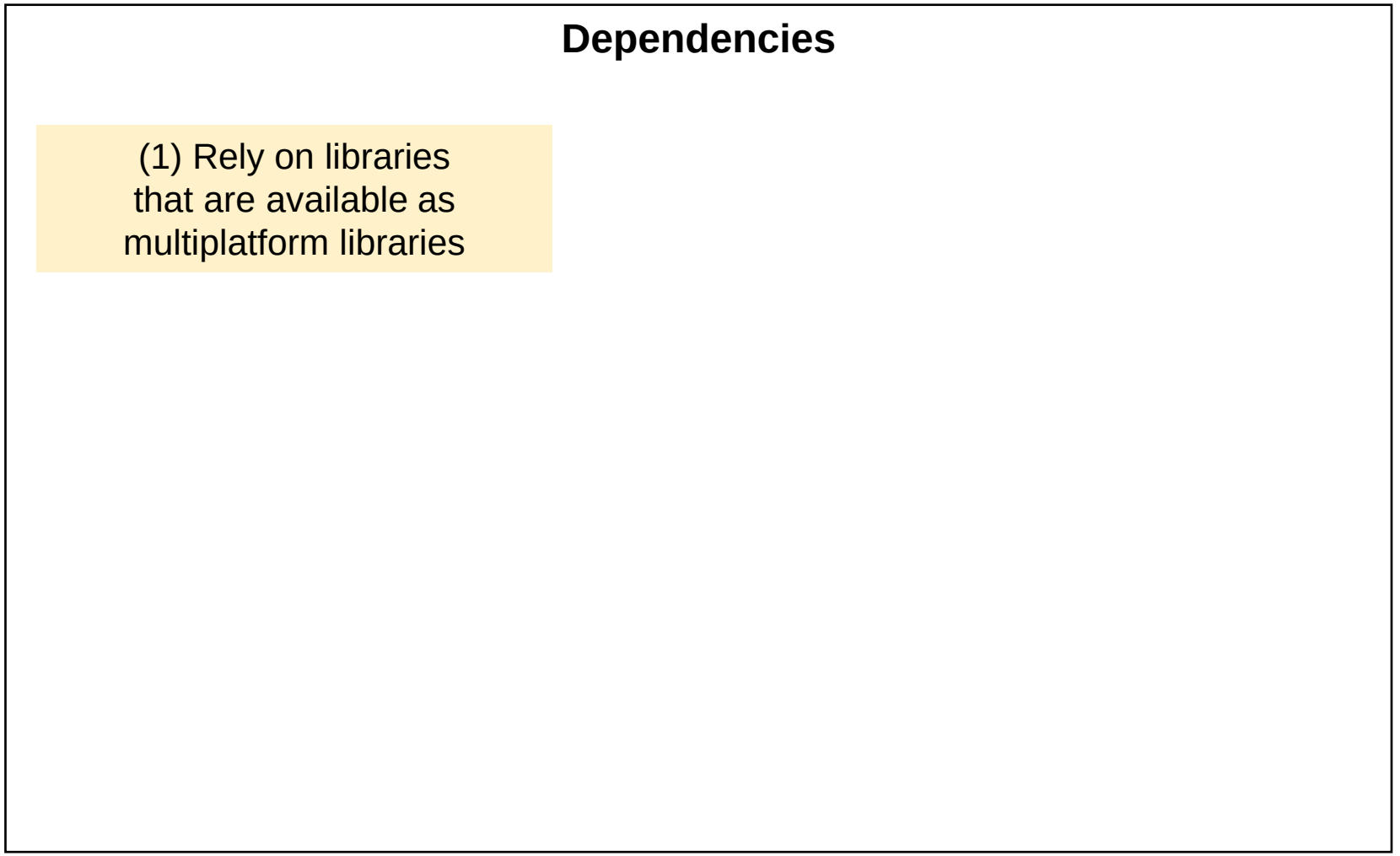

Requirements for Kotlin Multiplatform Projects

Dependencies

(1) Rely on libraries that are available as multiplatform libraries

```
sourceSets {
  commonMain.dependencies {
    implementation 'io.opentelemetry.kotlin.api’
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OpenTelemetry as KMP library?

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OpenTelemetry as KMP library?

(2) Have a separate dependency per target

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 }
}
```

(2) Have a separate dependency per target

```
sourceSets {
 …
 jvmMain.dependencies {
  implementation("io.ktor:ktor-client-java:3.1.0")
 }
 jsMain.dependencies {
  implementation("io.ktor:ktor-client-js:3.1.0")
 }
 linuxMain.dependencies {
  implementation("io.ktor:ktor-client-curl:3.1.0")
 }
}
```

Requirements for Kotlin Multiplatform Projects

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Different HTTP clients on different platforms

OpenTelemetry as Kotlin Multiplatform Projects?

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Official Repo

https://klibs.io/

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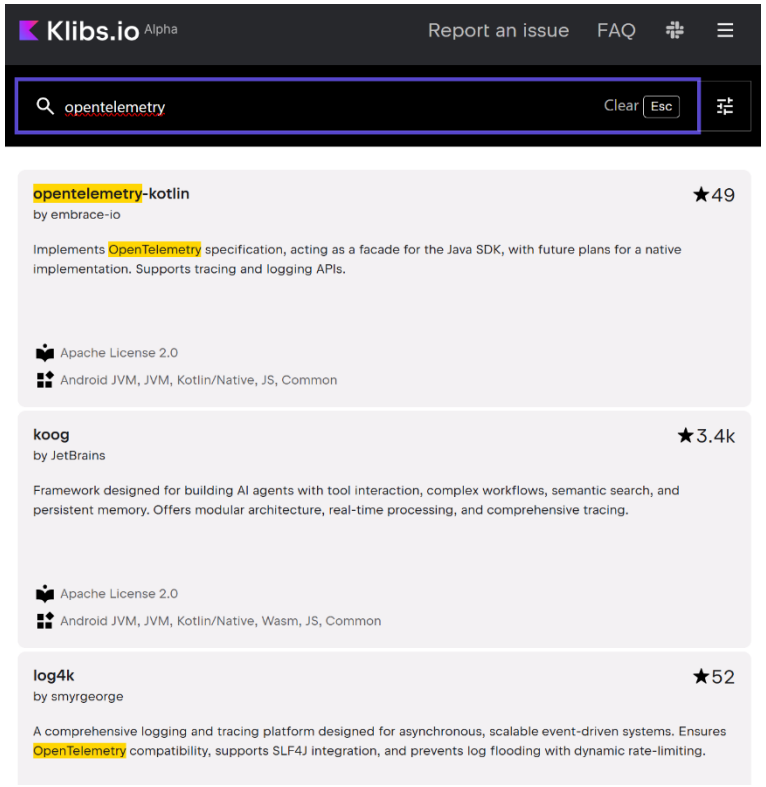

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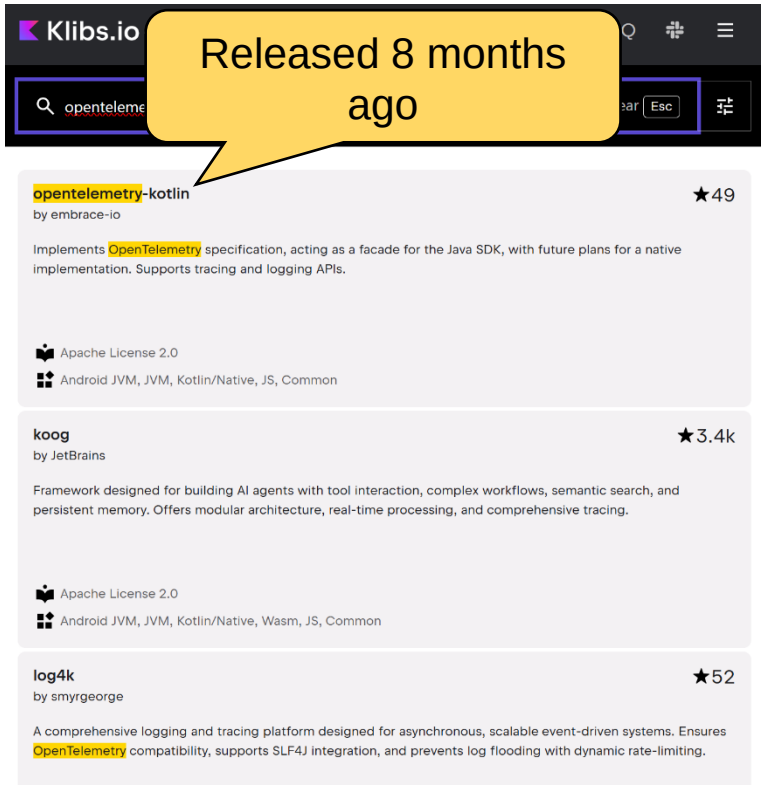

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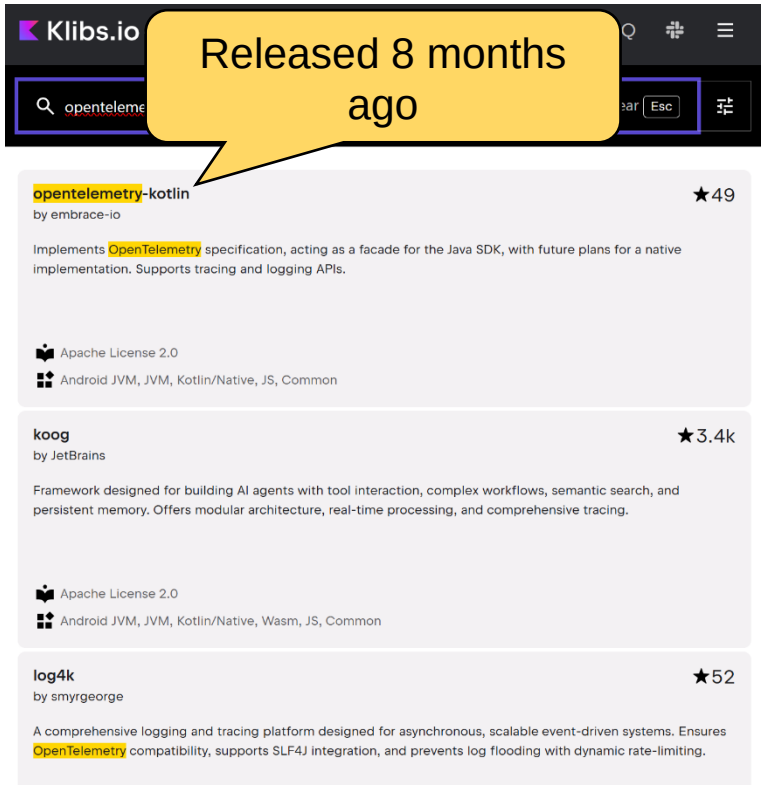

Github

dcxp/opentelemetry-kotlin

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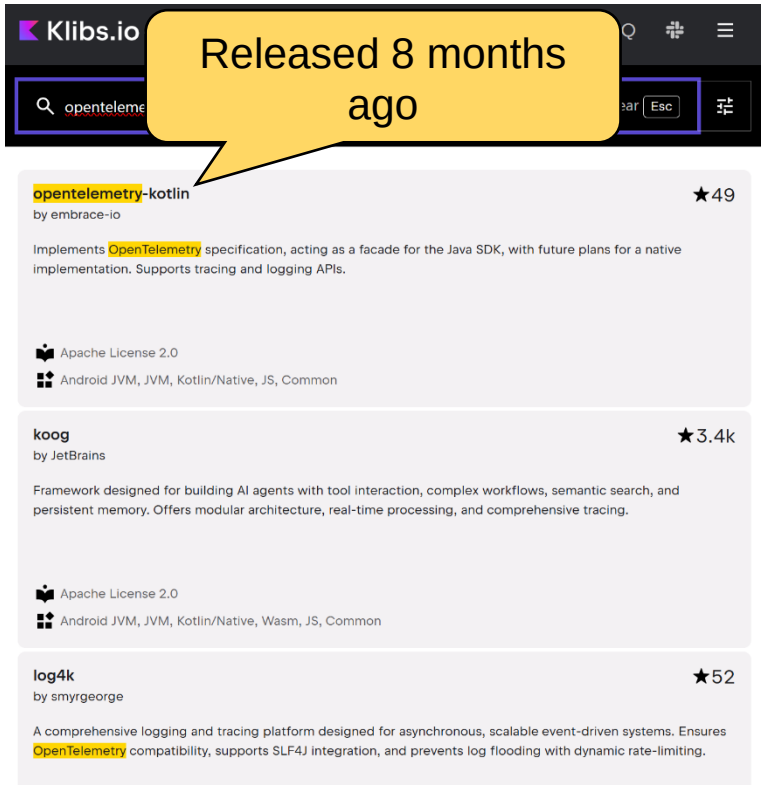

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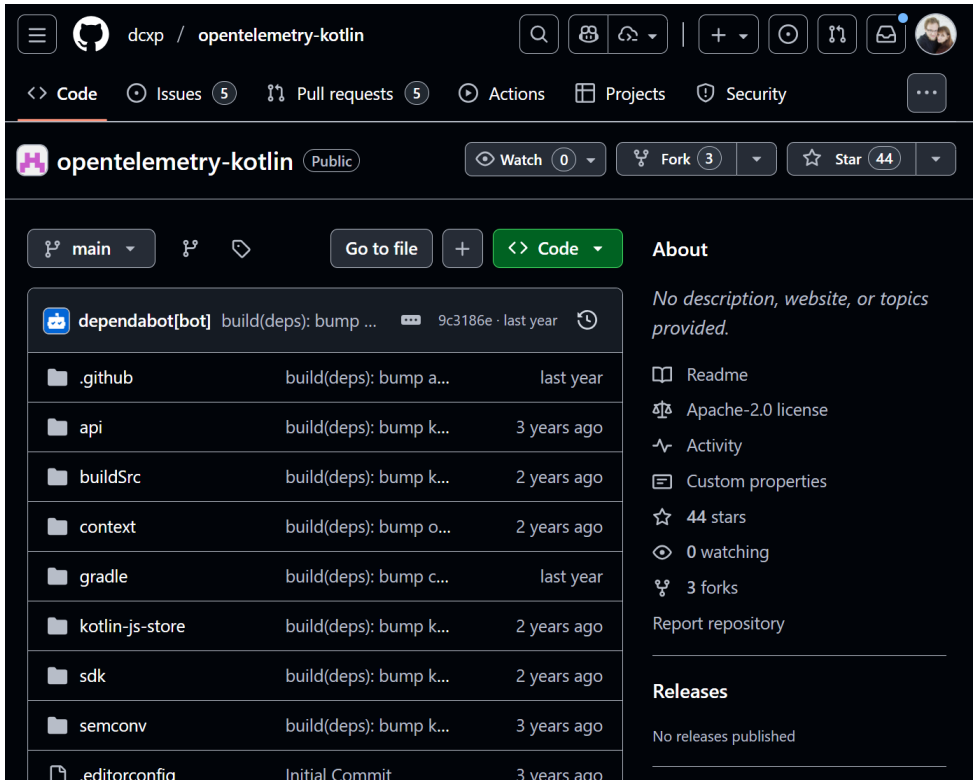

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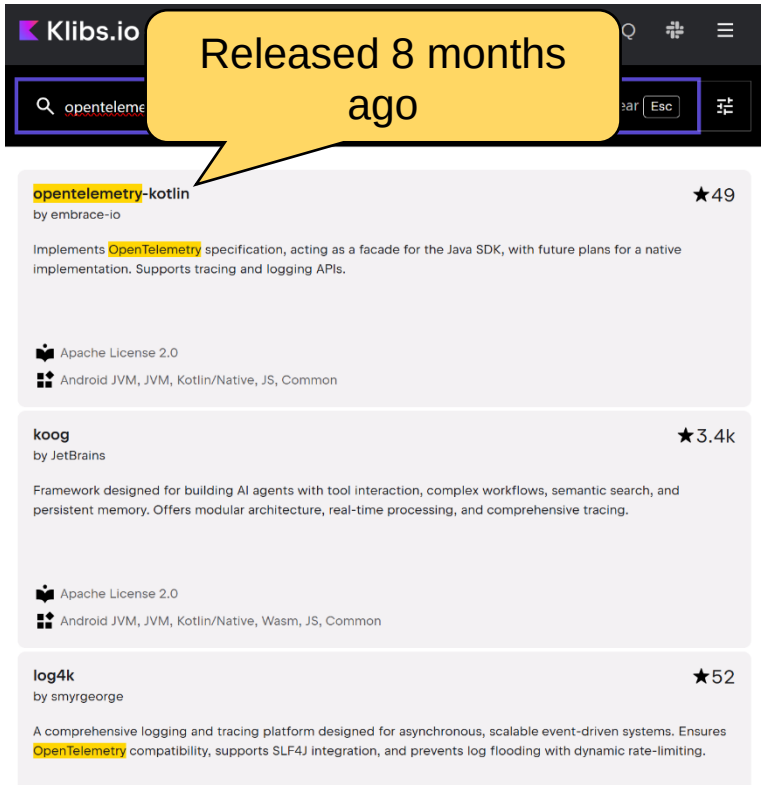

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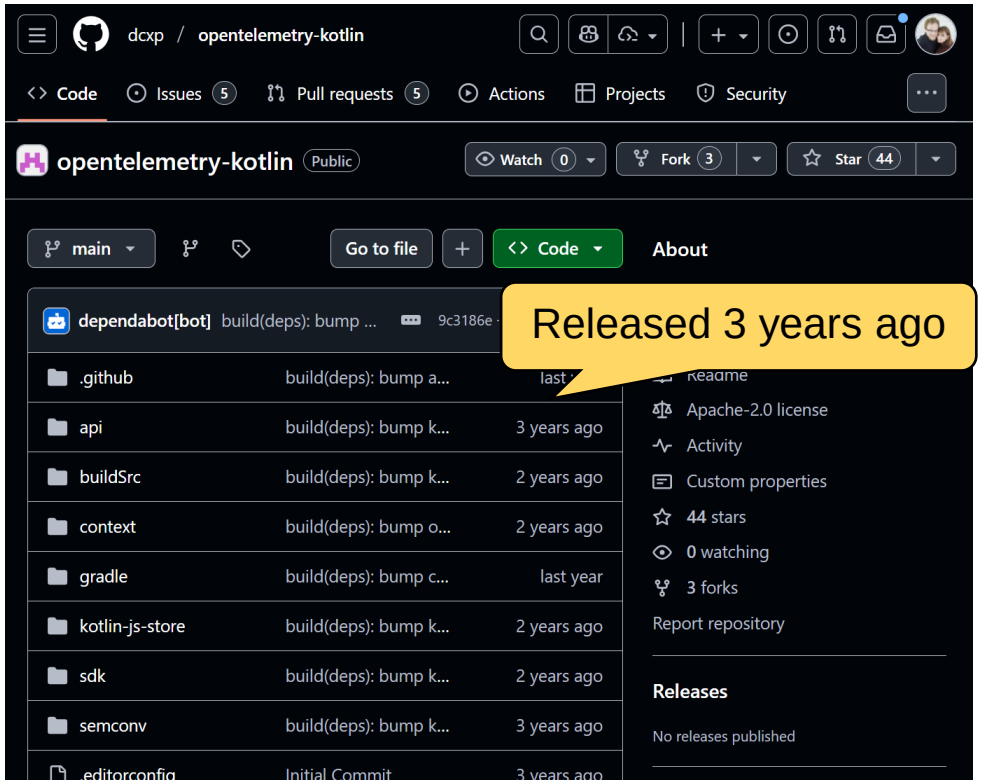

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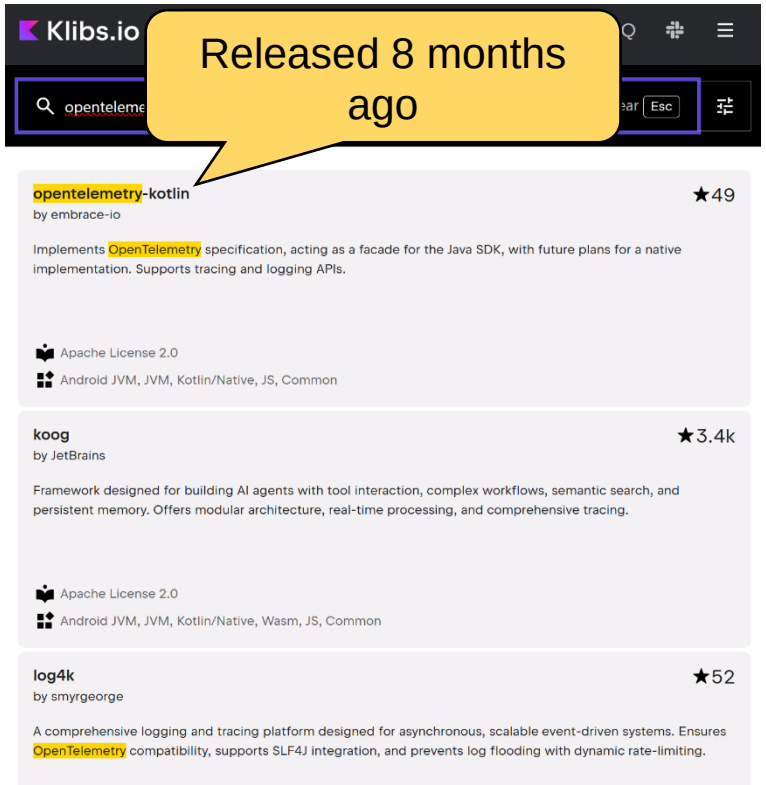

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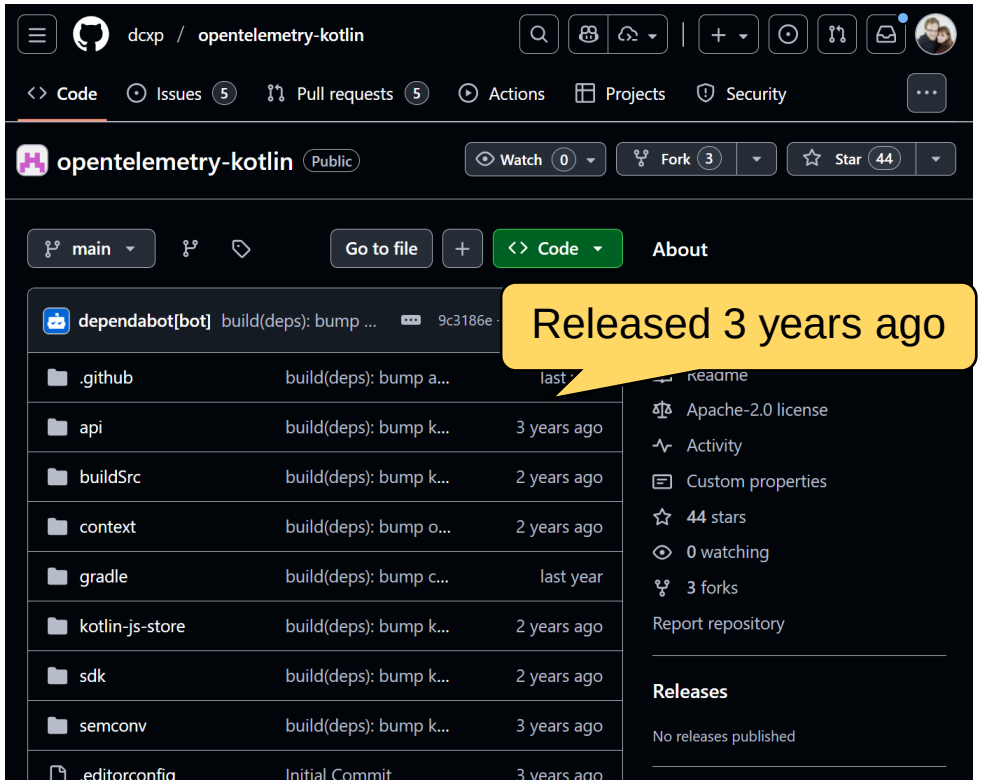

Collections

terrakok/kmp-awesome: An awesome list that curates the best Kotlin Multiplatform libraries, tools and more.

AAkira/Kotlin-Multiplatform-Libraries: Kotlin Multiplatform Libraries.

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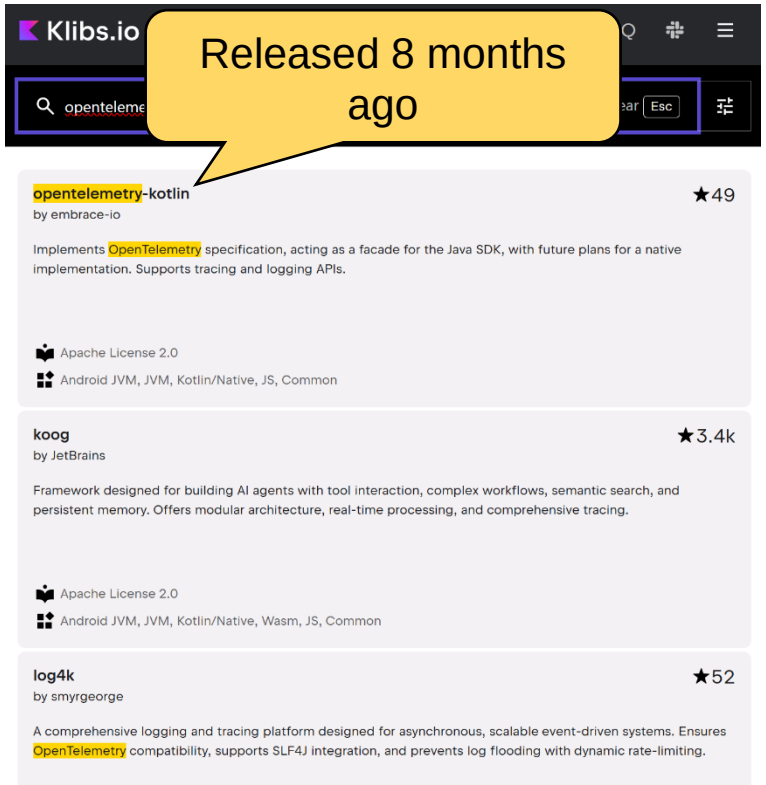

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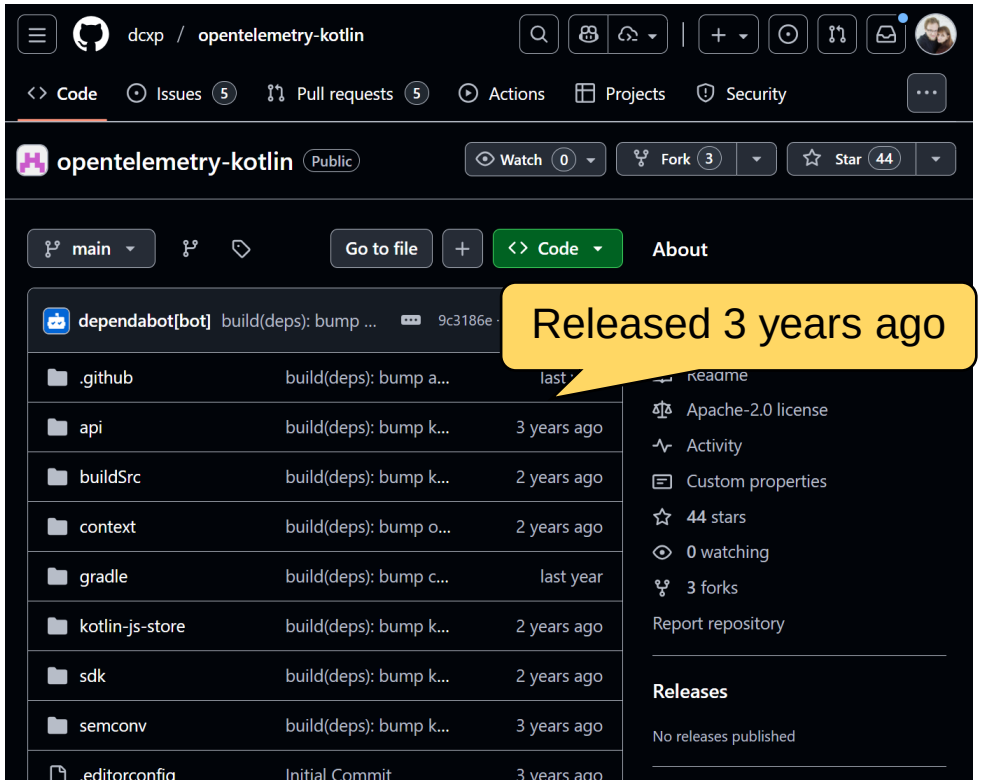


Collections

No OTEL ☹

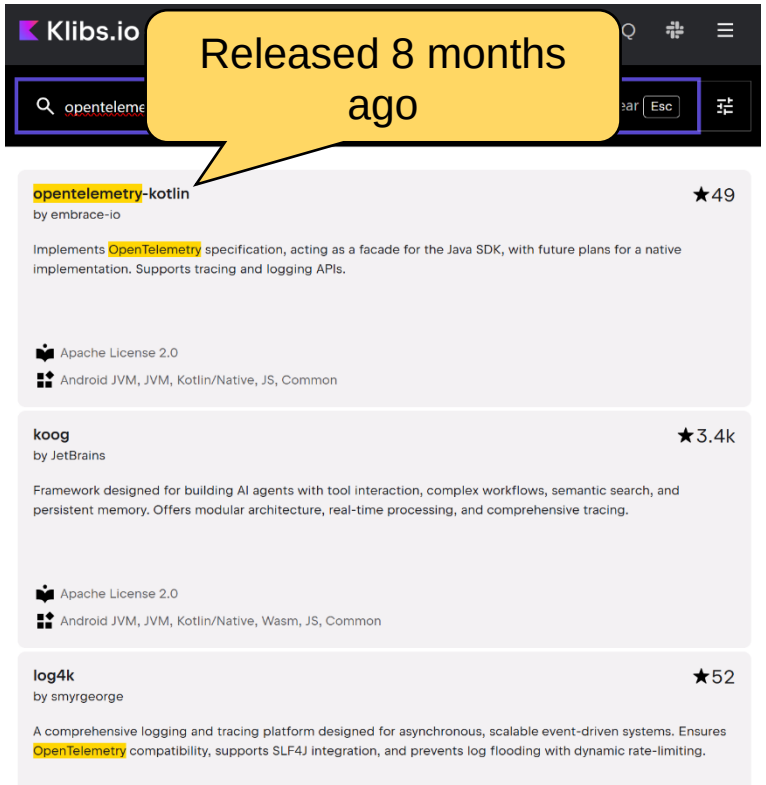
[awesome: An awesome list that curates the best Kotlin Multiplatform libraries, tools and more.]

[AAkira/Kotlin-Multiplatform-Libraries: Kotlin Multiplatform Libraries.]

OpenTelemetry as Kotlin Multiplatform Projects?

Official Repo

https://klibs.io/



Github

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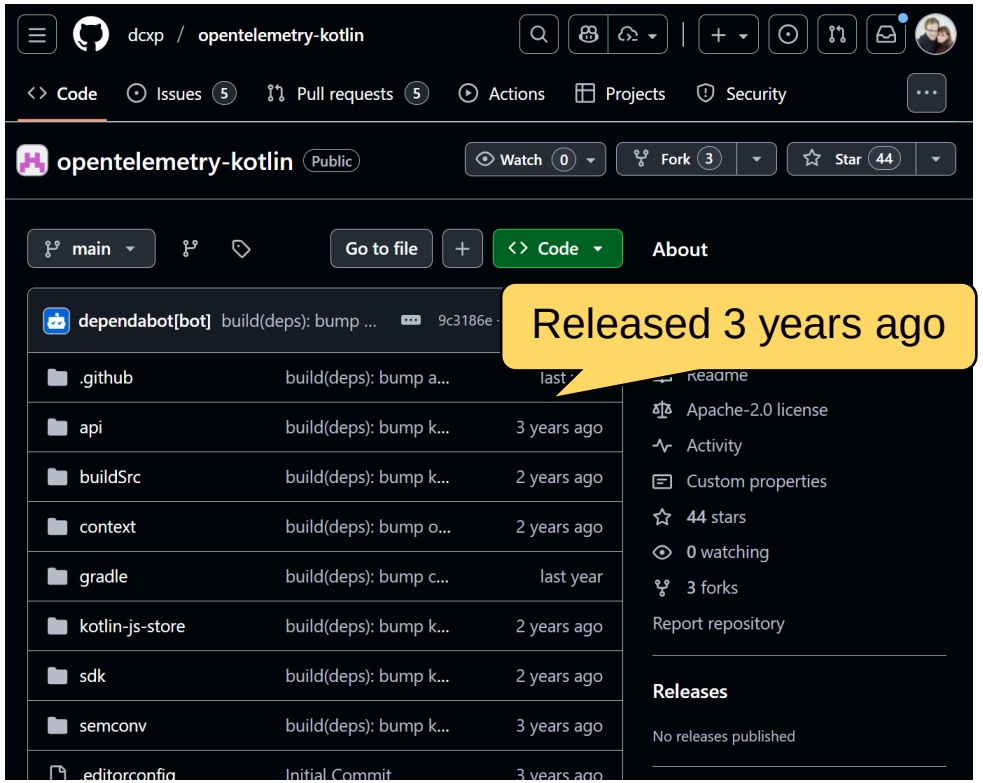

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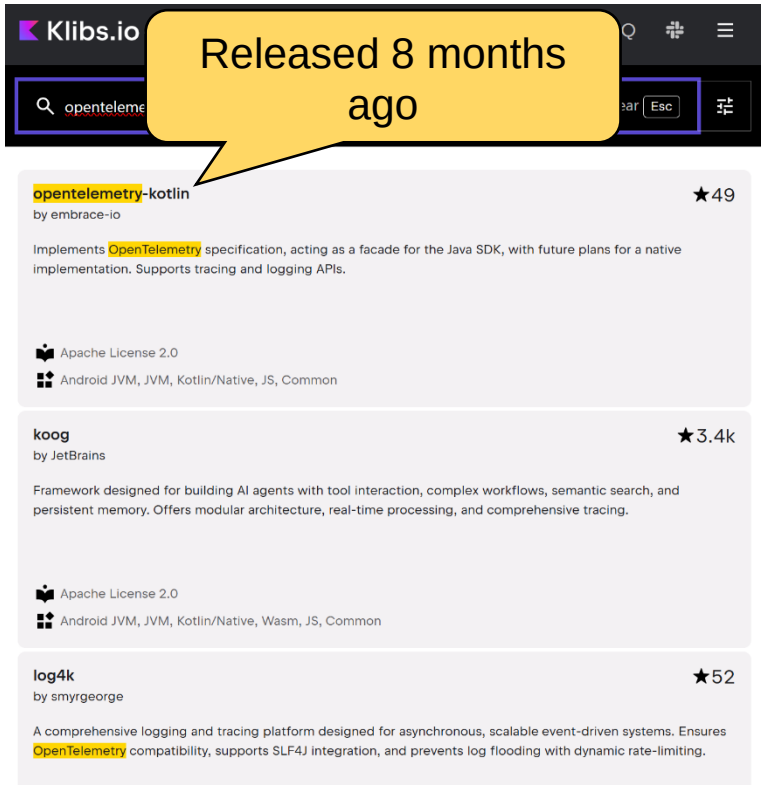

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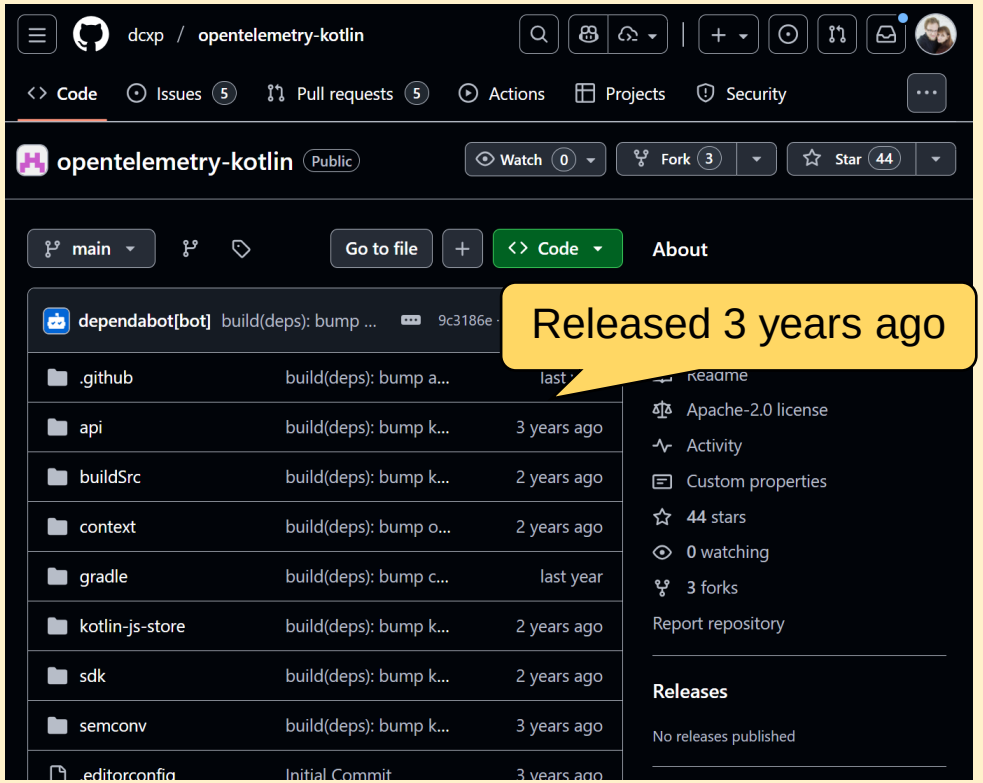

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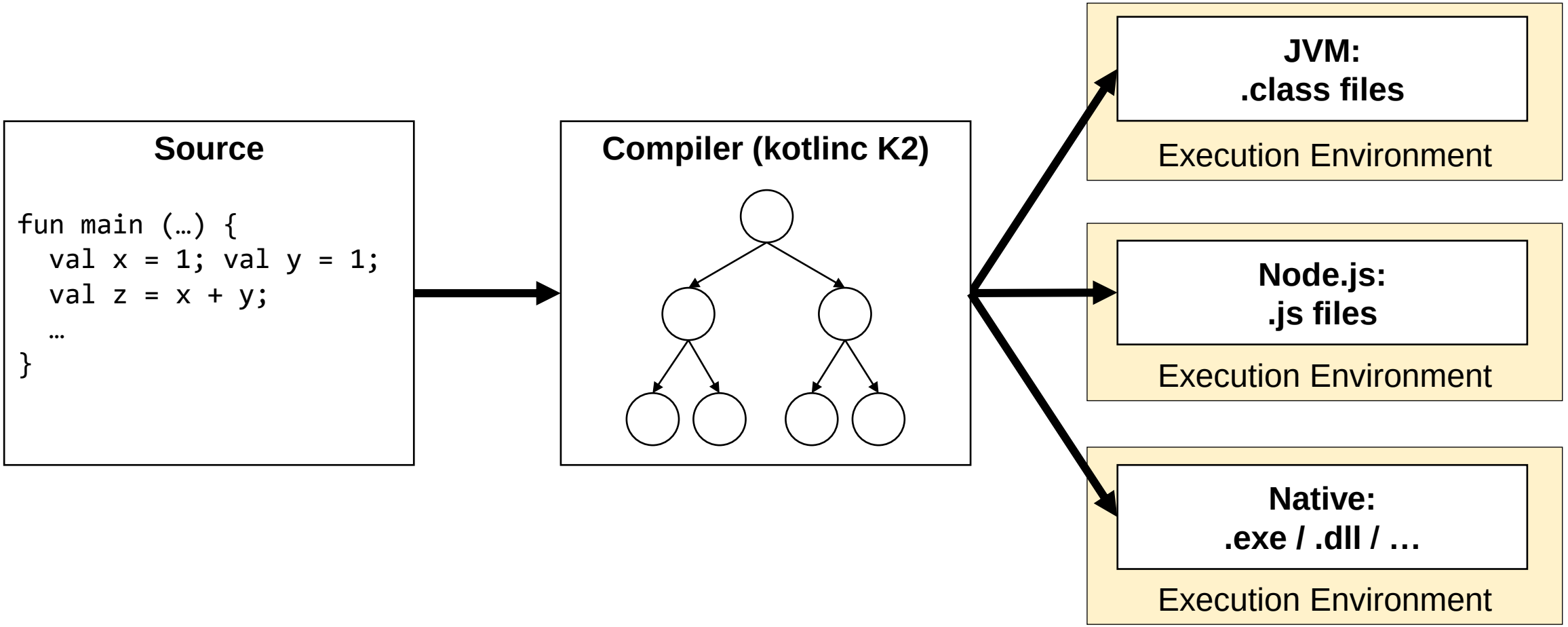
[Kotlin-Multiplatform-Libraries: Kotlin Multiplatform Libraries.]

OpenTelemetry Instrumentation



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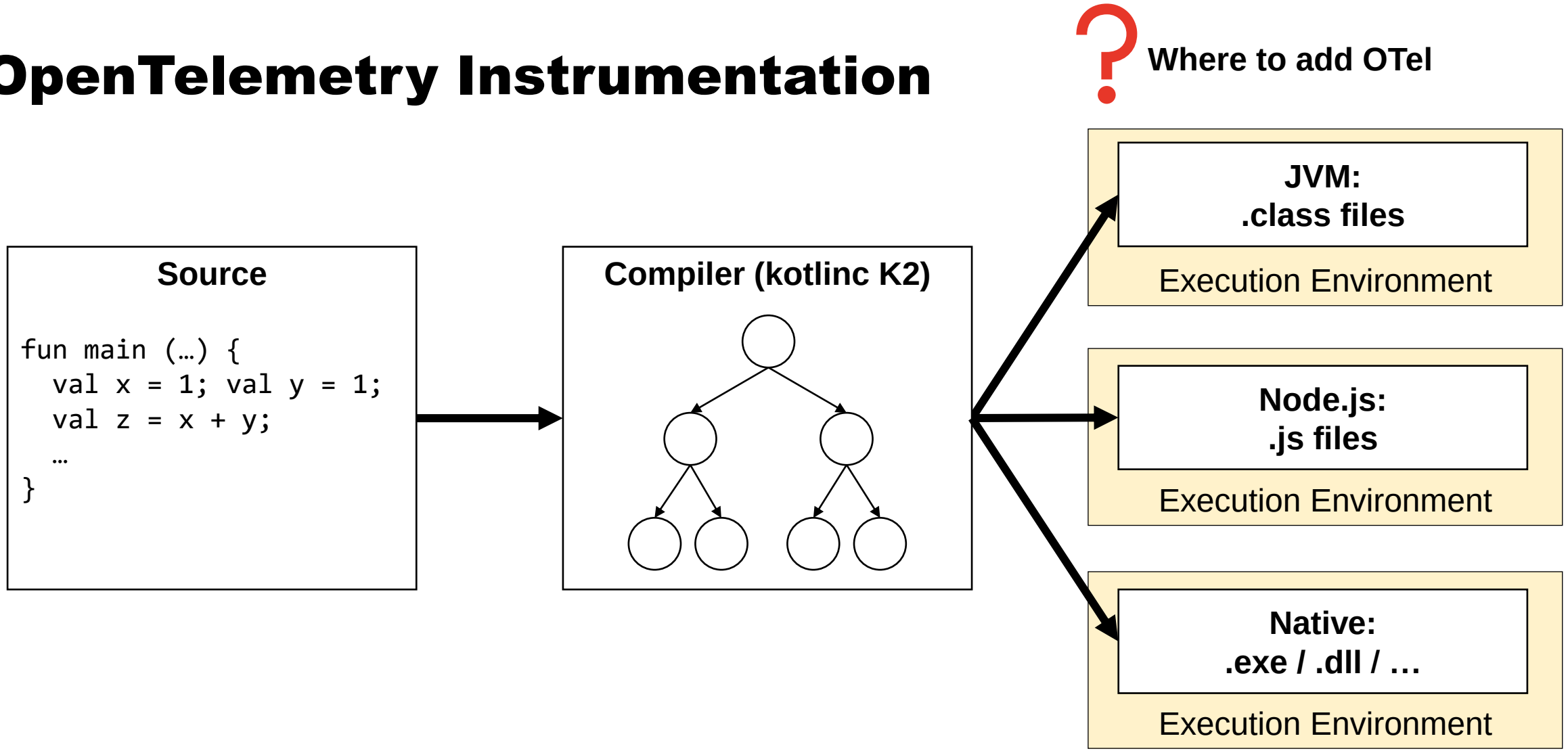

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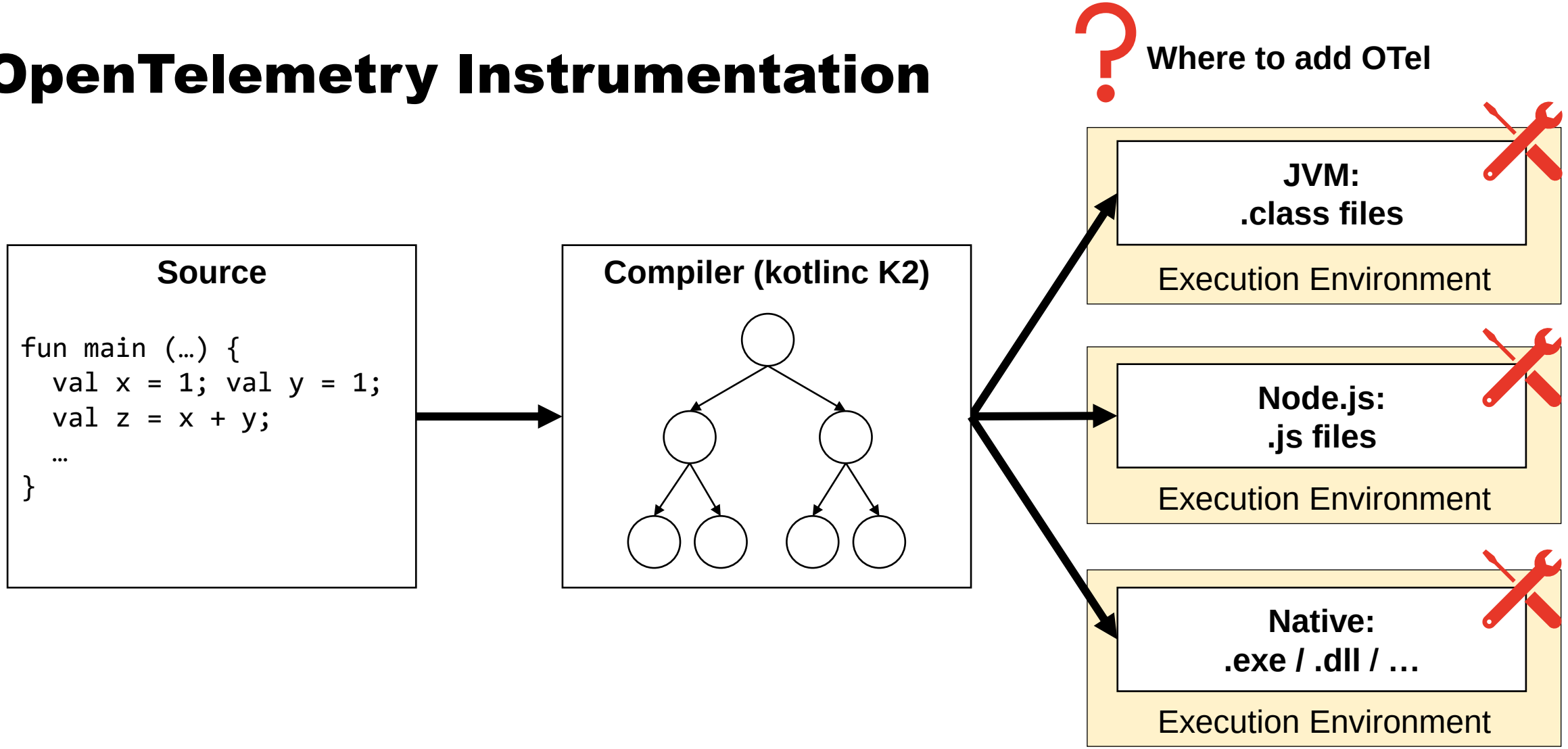

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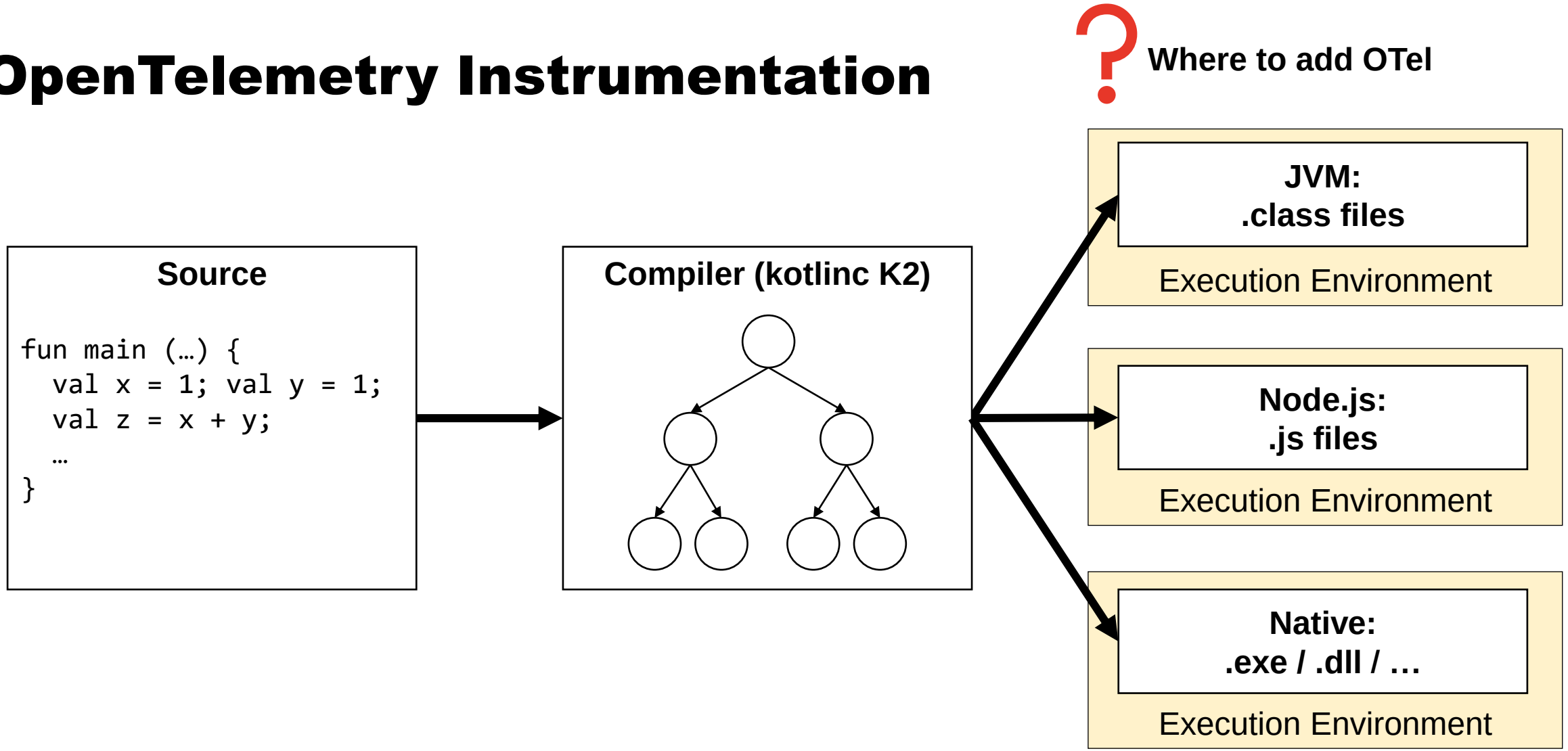

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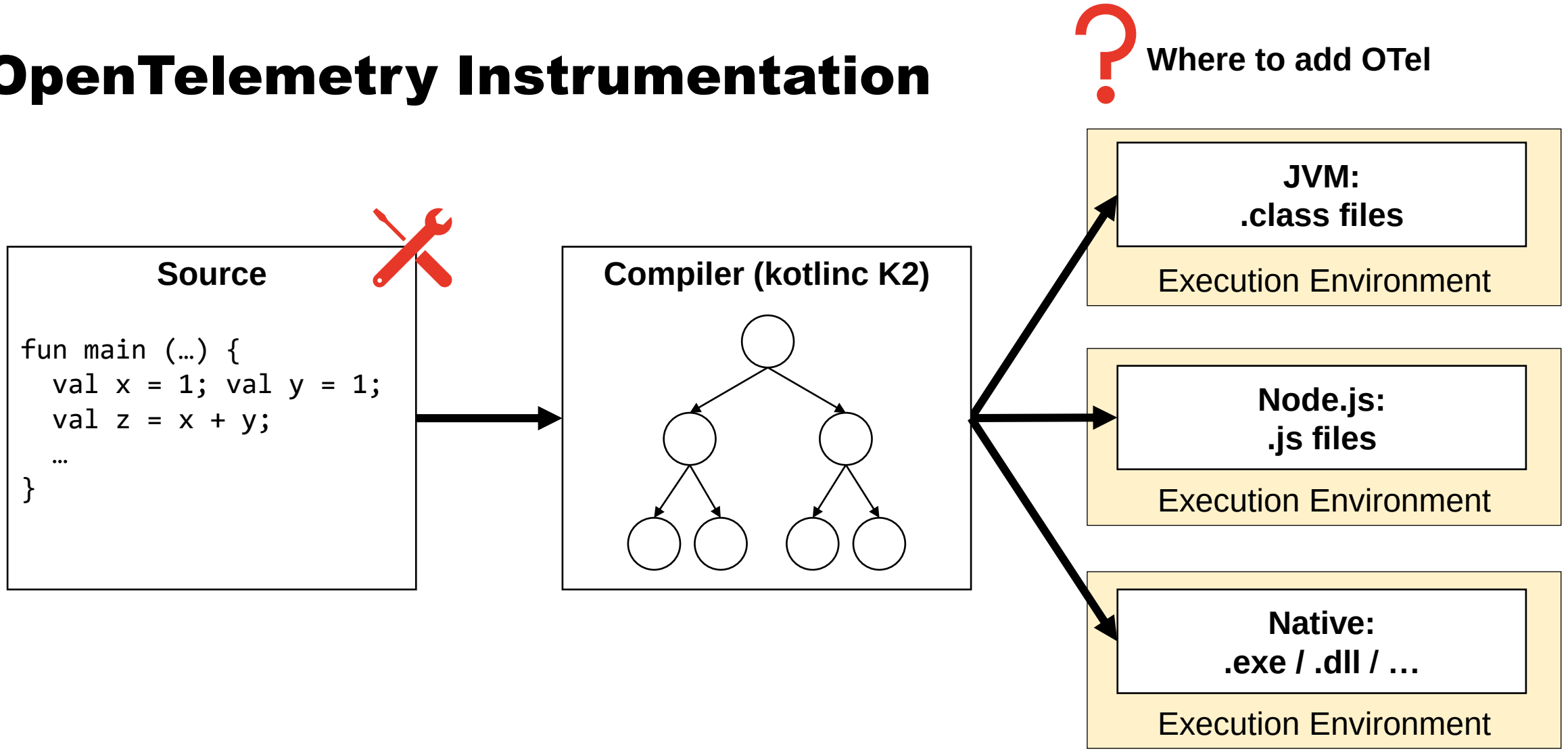

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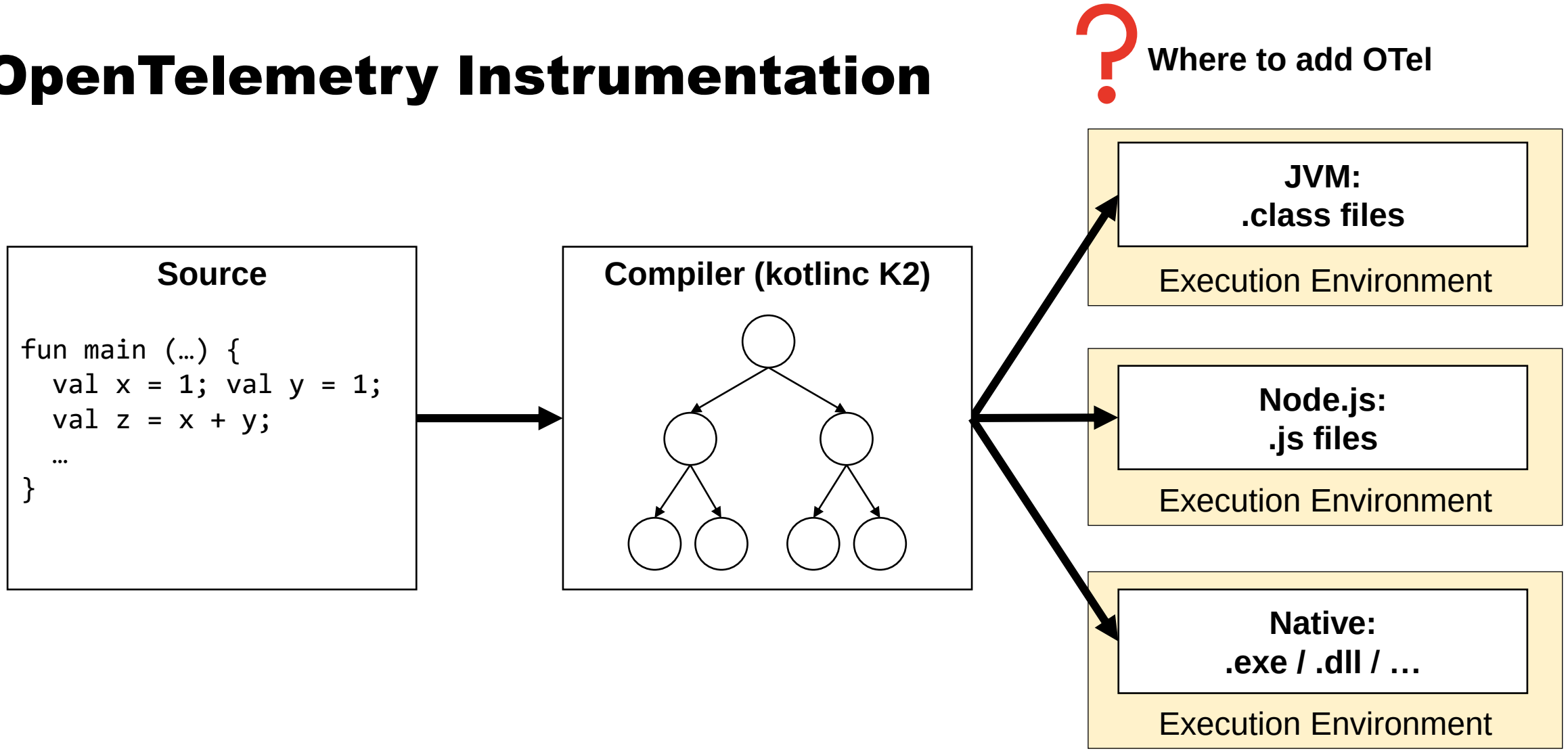

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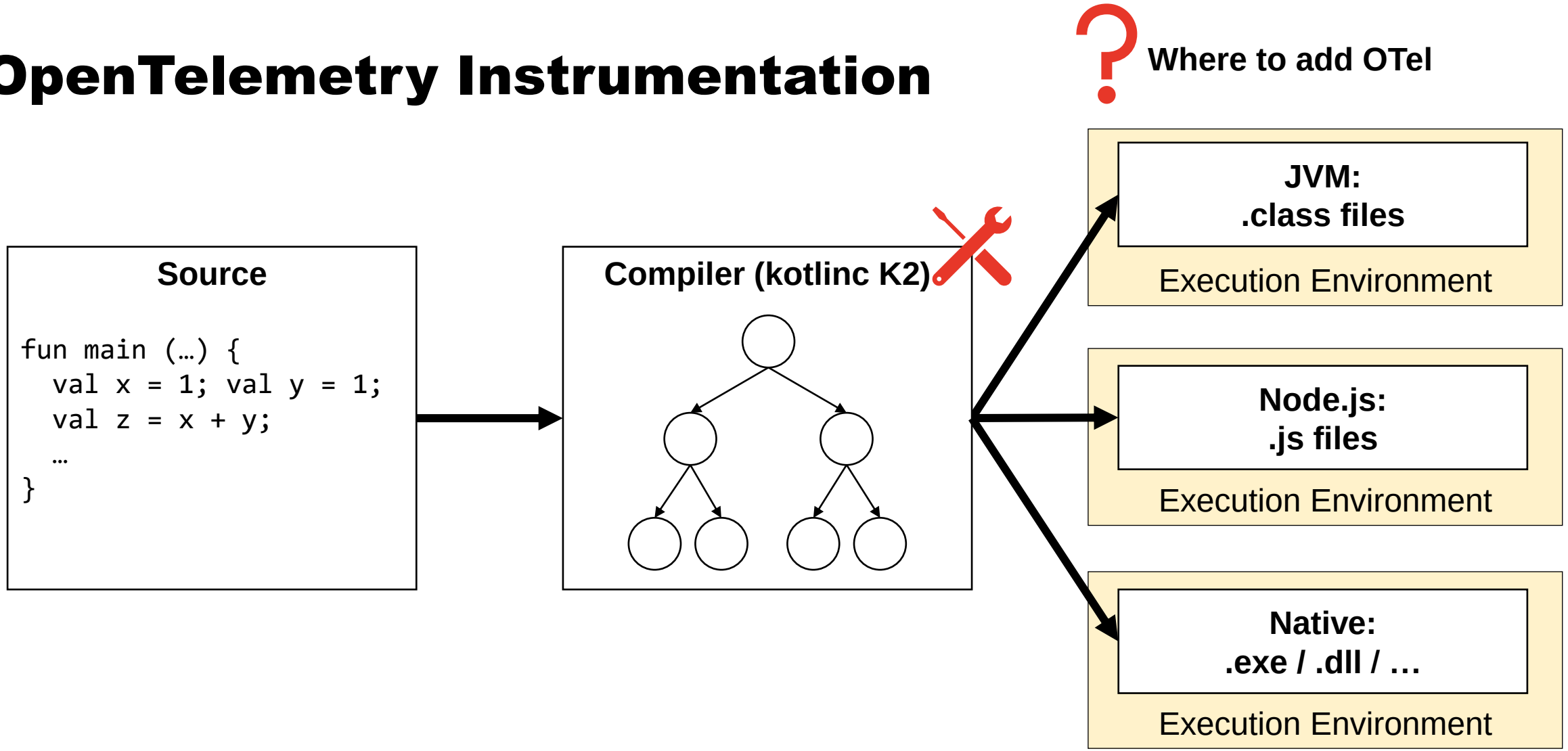

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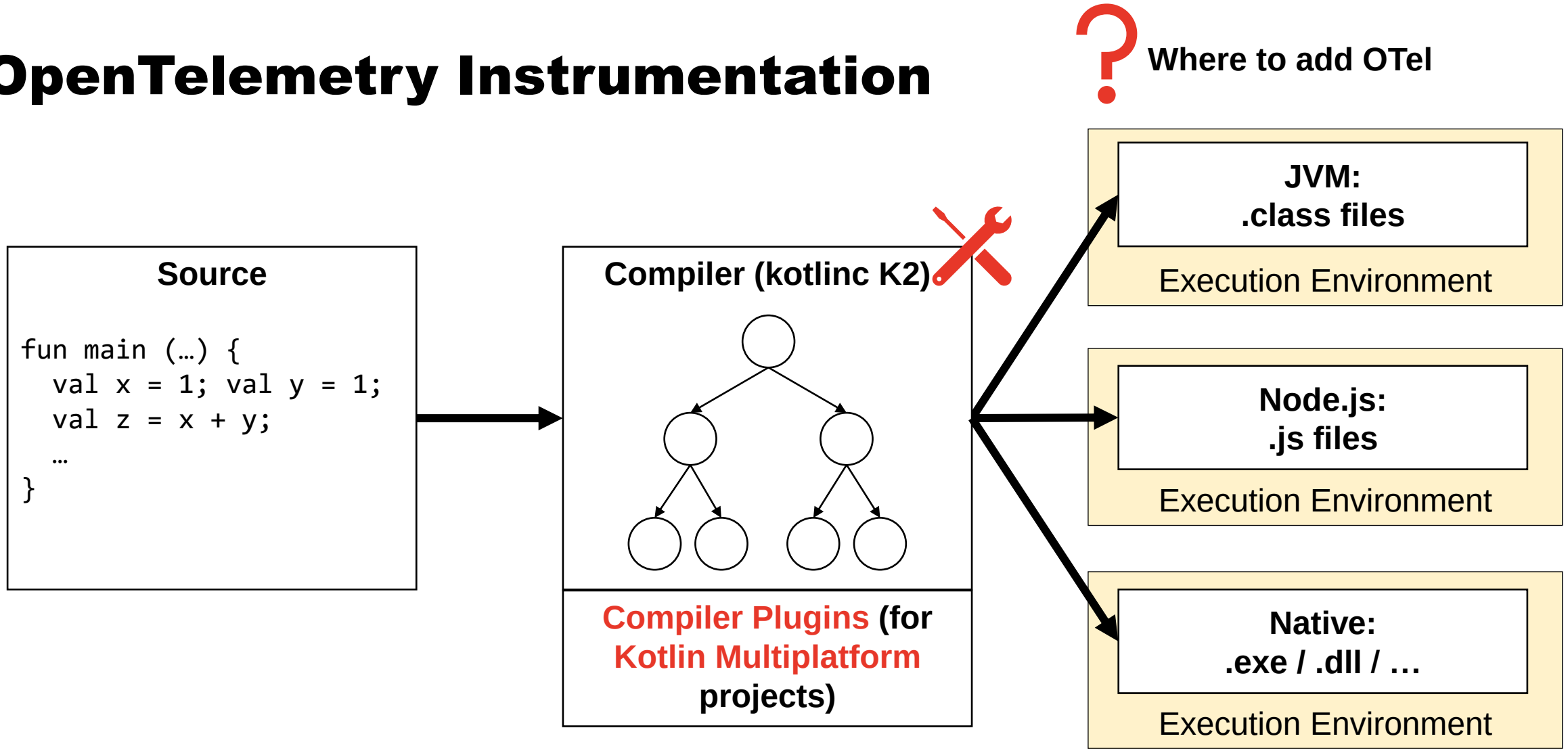

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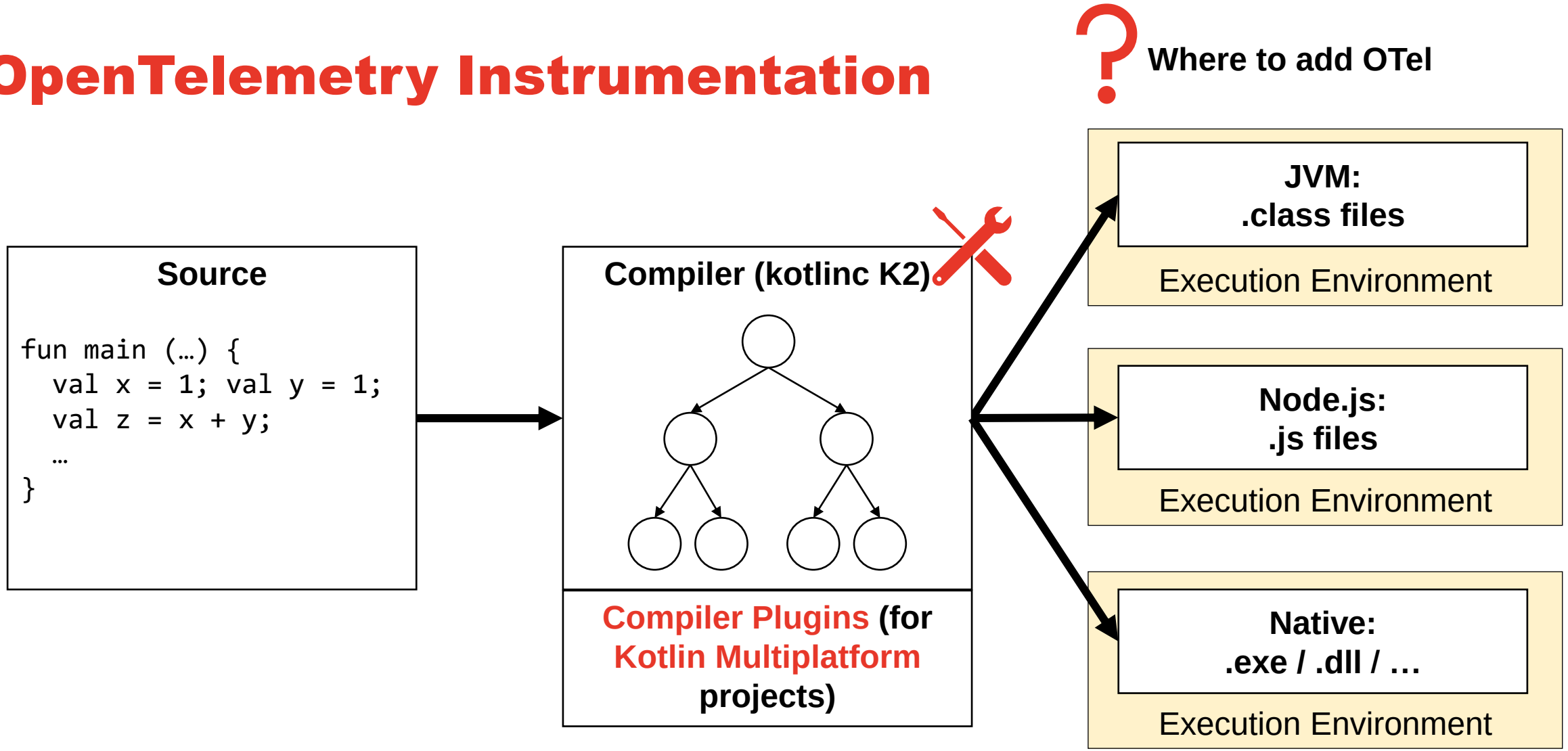


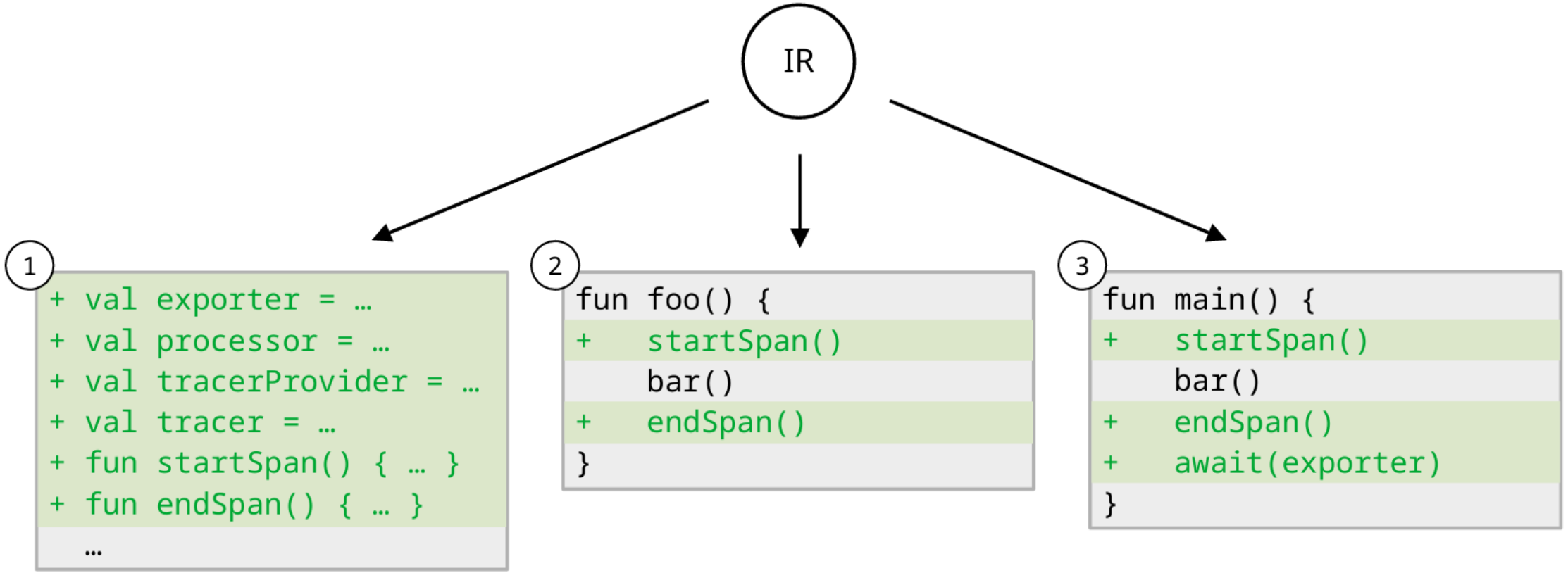
JOHANNES KEPLER
UNIVERSITÄT LINZ

OpenTelemetry Instrumentation using Kotlin Multiplatform Compiler Plugins

Fabian Schoenberger
Markus Weninger, Institute for System Software

JOHANNES KEPLER
UNIVERSITÄT LINZ
Altenberger Straße 69
4040 Linz, Österreich
jku.at

Our IR Instrumentation Plugin



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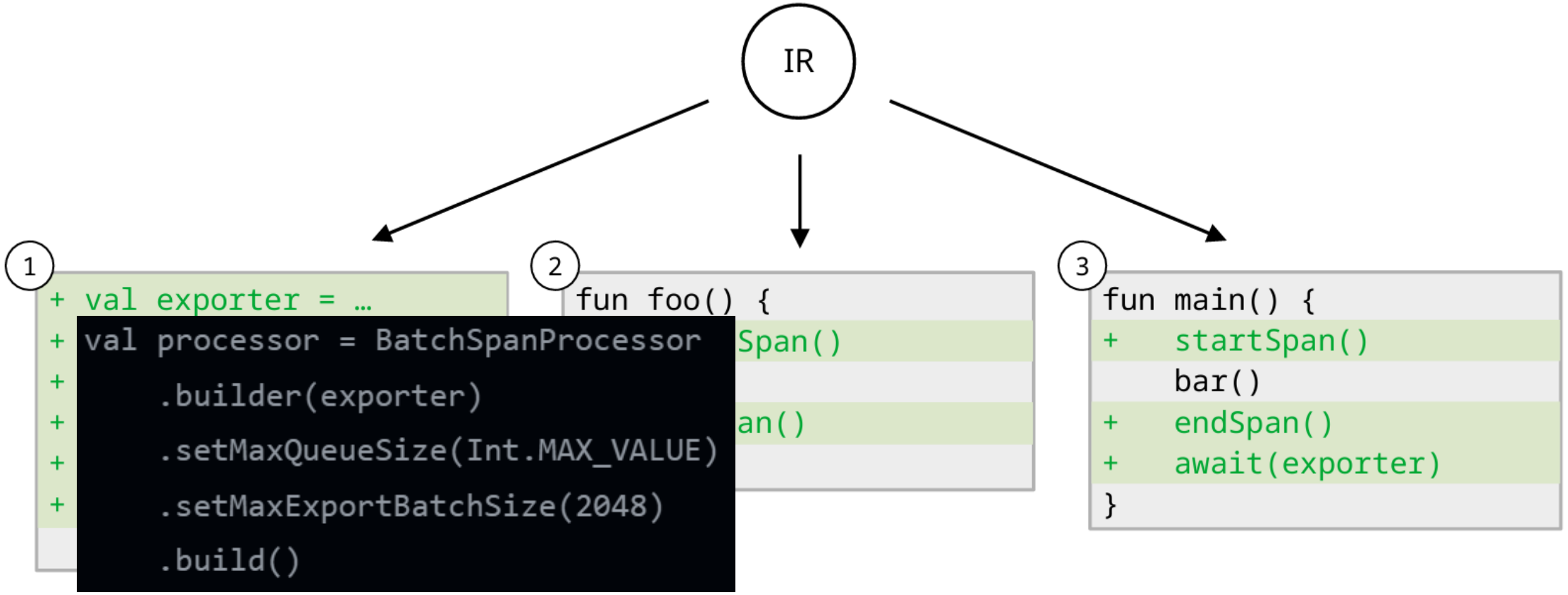

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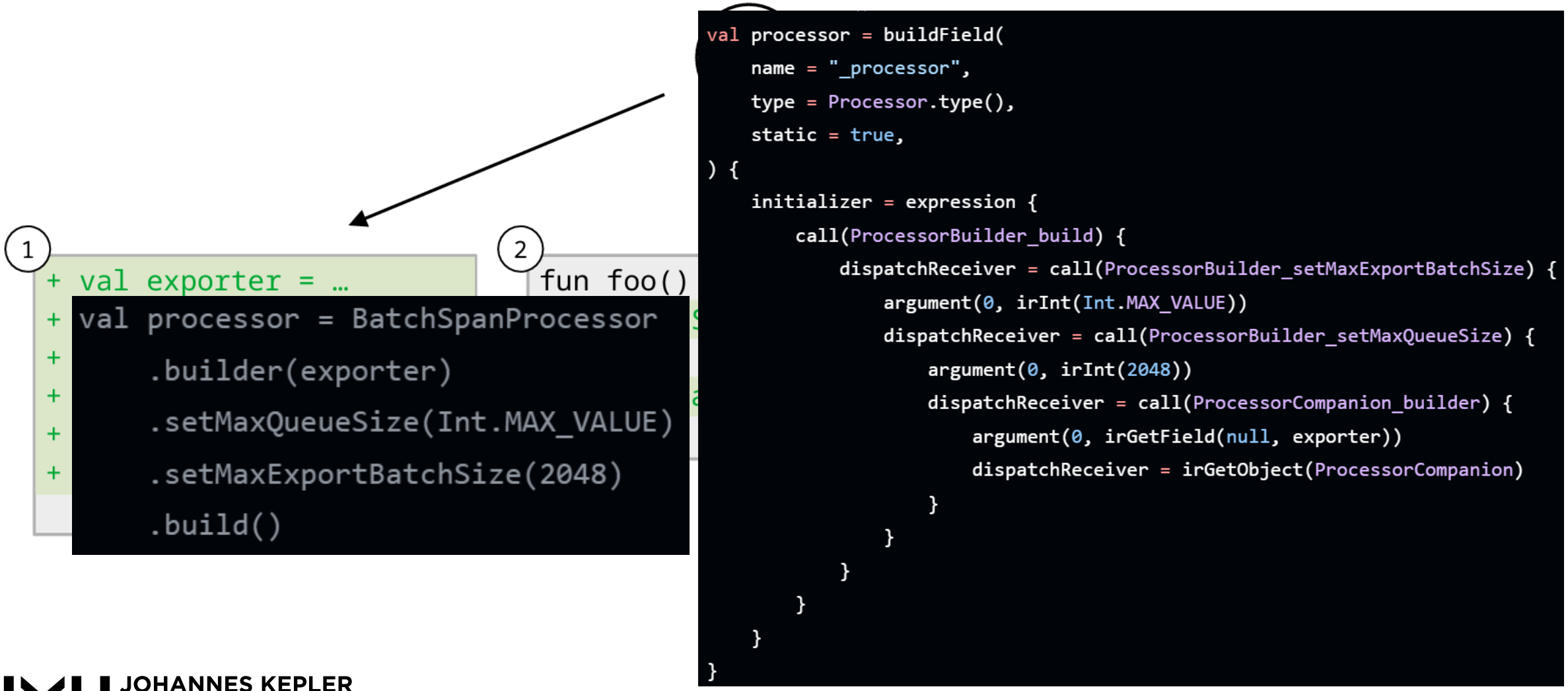

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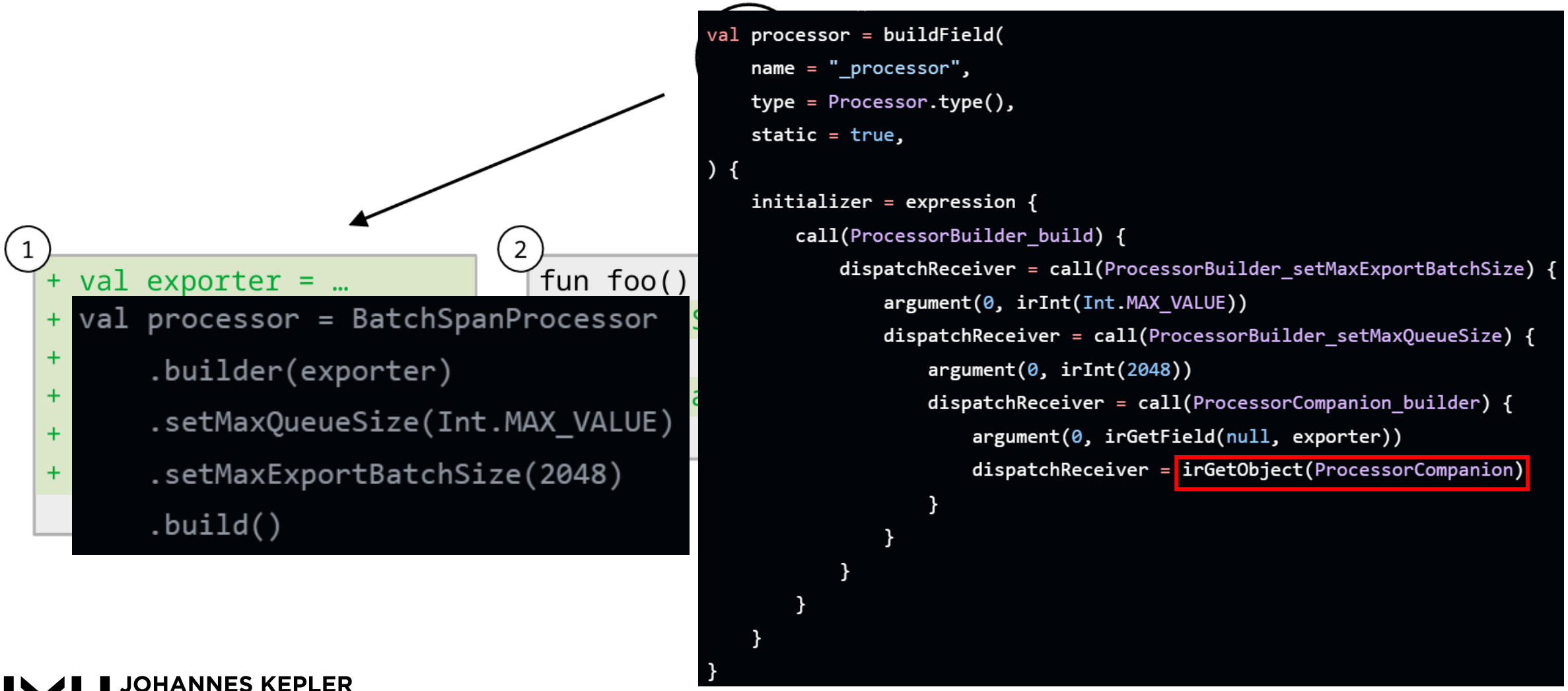

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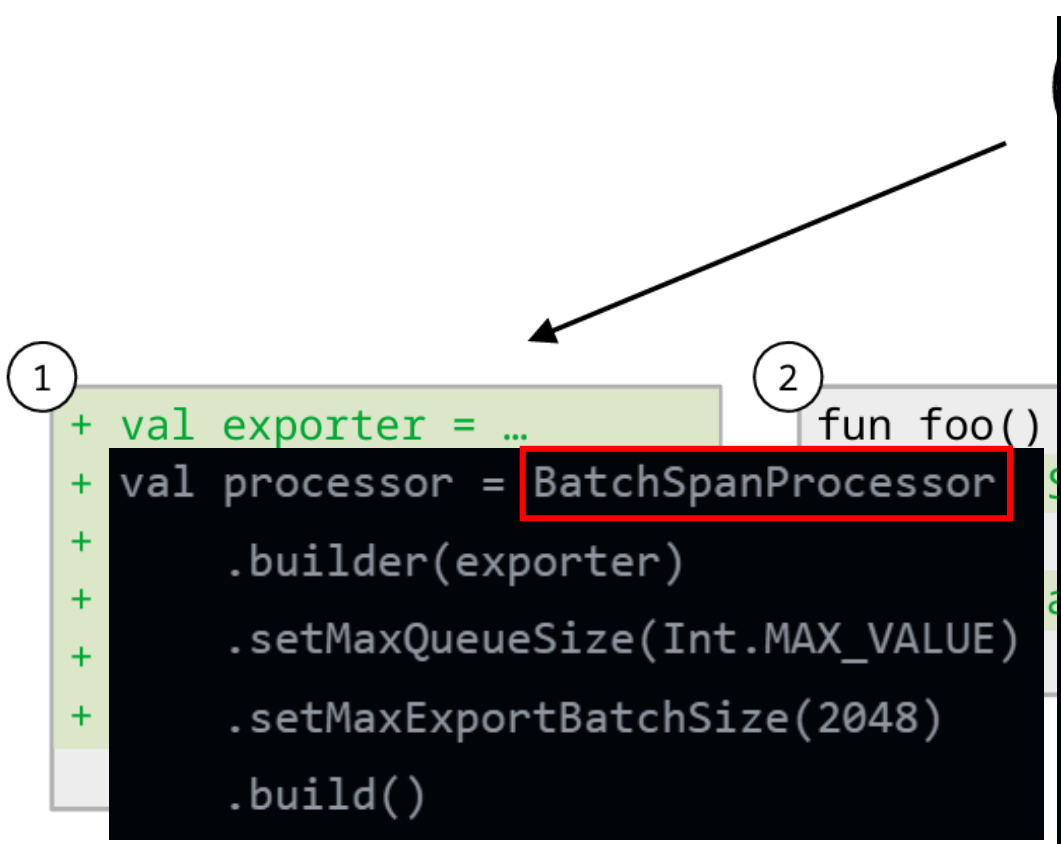


```
val processor = buildField(
    name = "_processor",
    type = Processor.type(),
    static = true,
) {
    initializer = expression {
        call(ProcessorBuilder_build) {
            dispatchReceiver = call(ProcessorBuilder_setMaxExportBatchSize) {
                argument(0, irInt(Int.MAX_VALUE))
                dispatchReceiver = call(ProcessorBuilder_setMaxQueueSize) {
                    argument(0, irInt(2048))
                    dispatchReceiver = call(ProcessorCompanion_builder) {
                        argument(0, irGetField(null, exporter))
                        dispatchReceiver = irGetObject(ProcessorCompanion)
                    }
                }
            }
        }
    }
}
```

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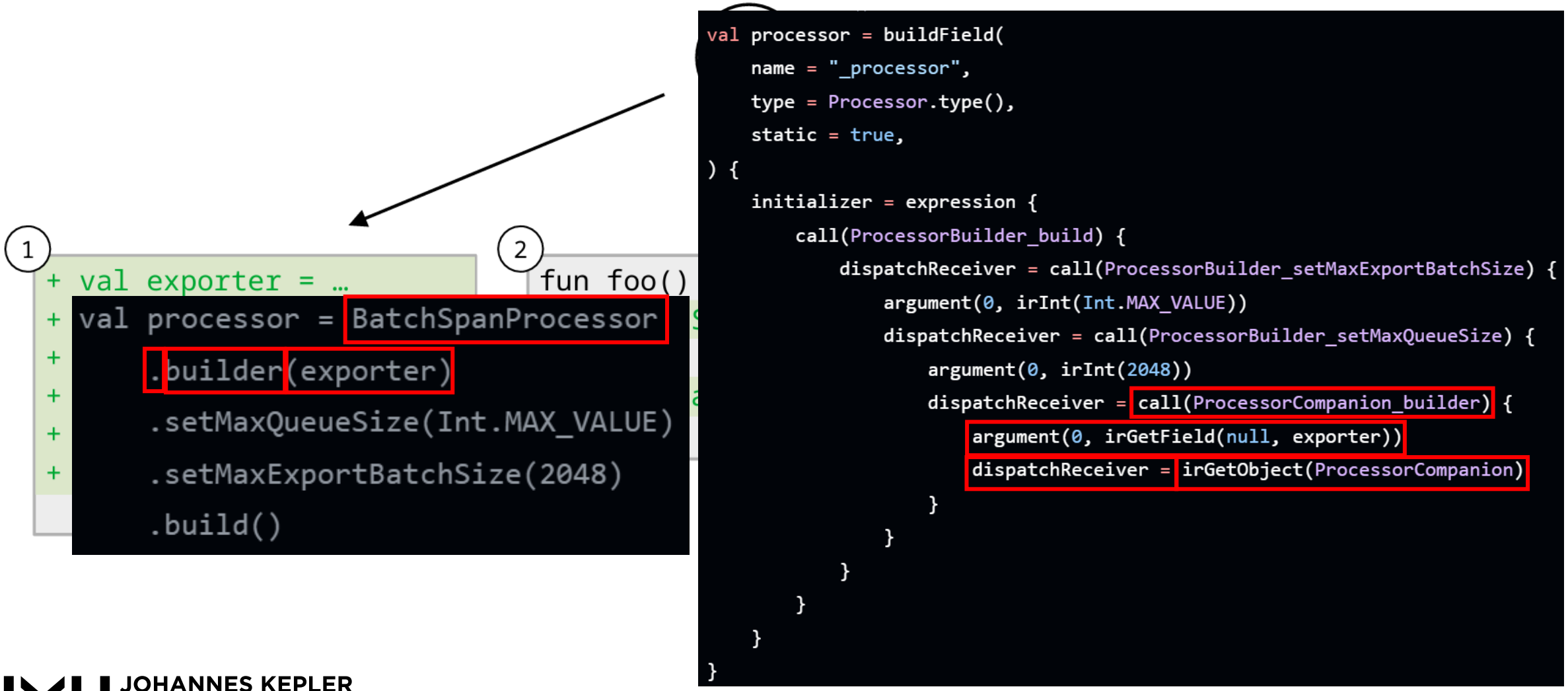

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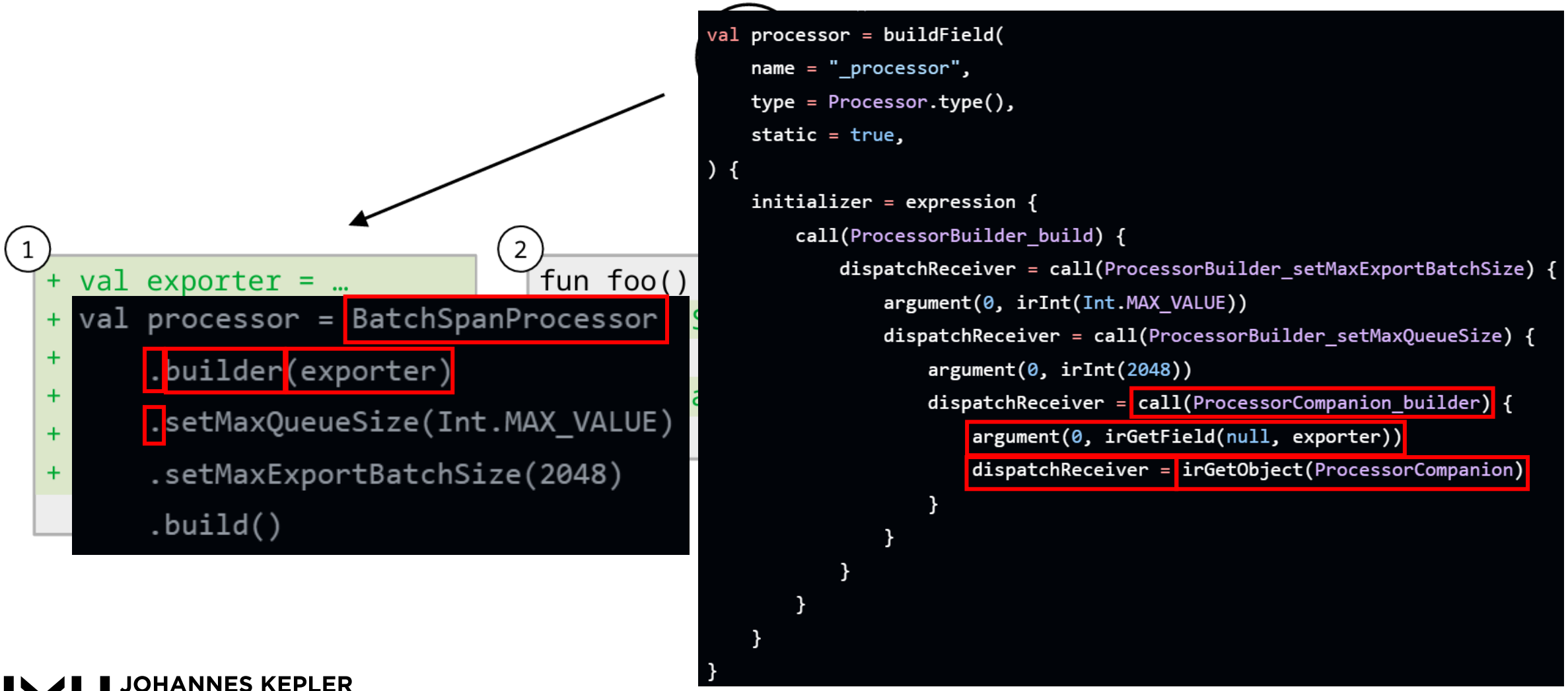

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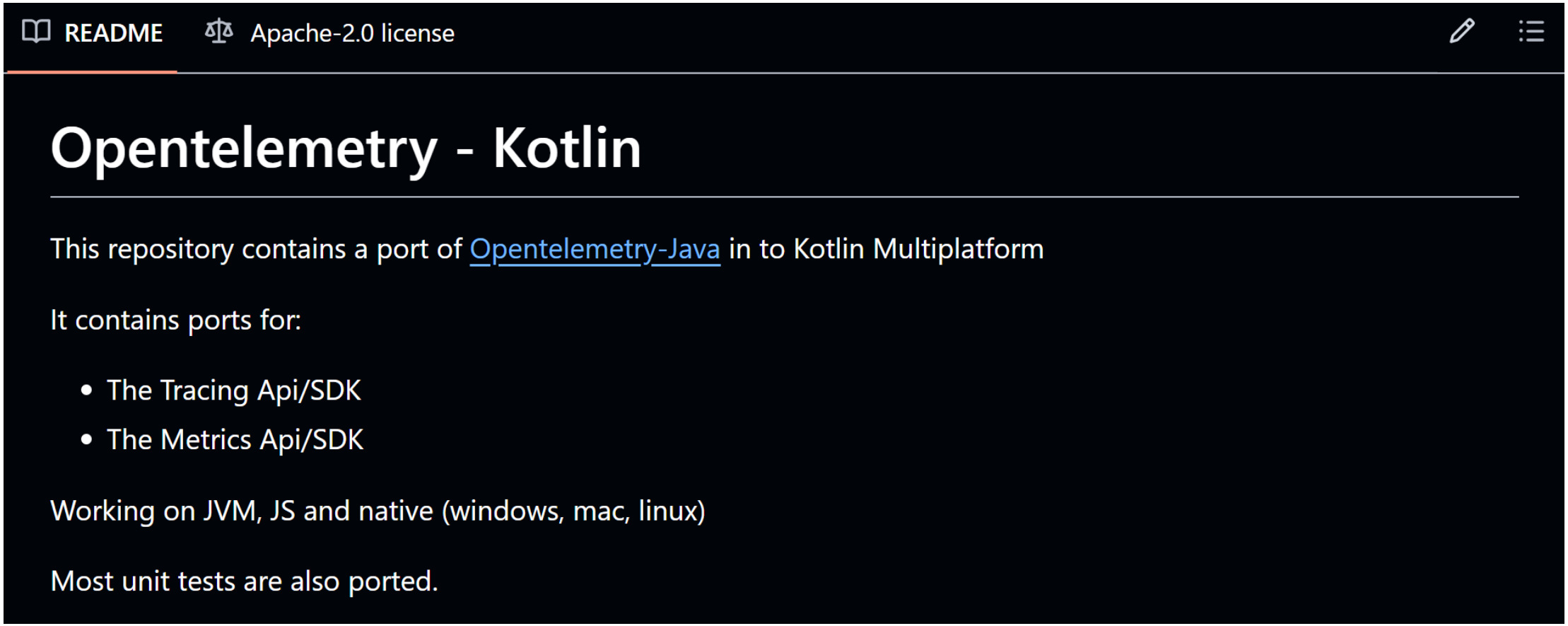
One Major Oversight



One Major Oversight

README Apache-2.0 license

Opentelemetry - Kotlin

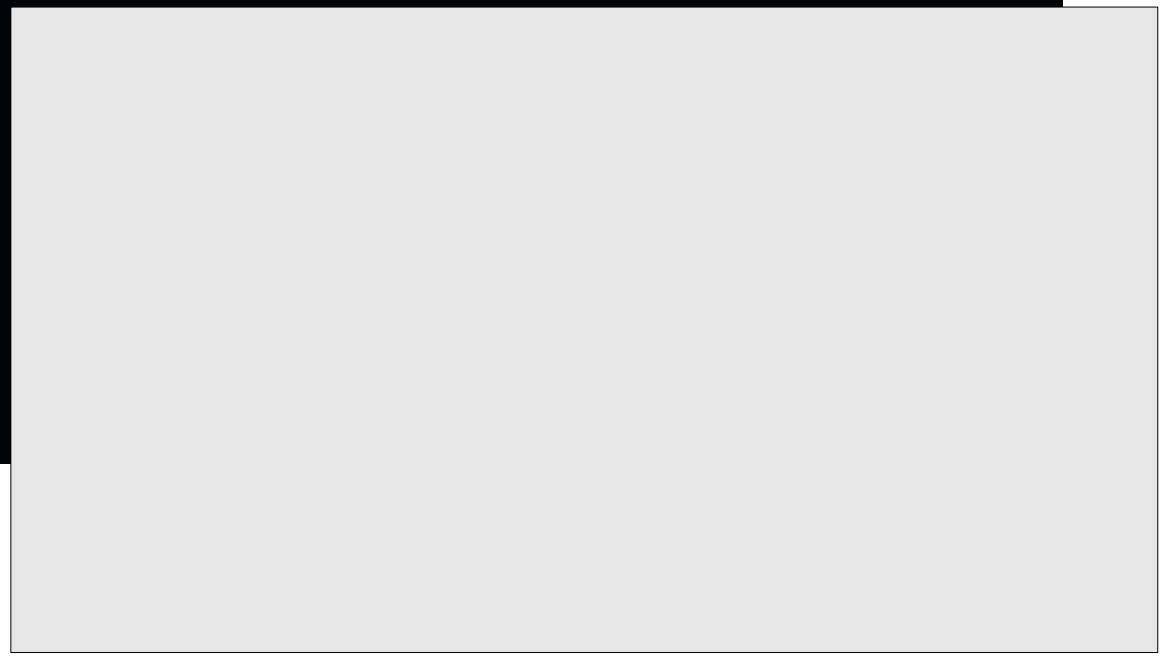
This repository contains a port of Opentelemetry-Java in to Kotlin Multiplatform

It contains ports for:

- The Tracing Api/SDK
- The Metrics Api/SDK

Working on JVM, JS and native (windows, mac, linux)

Most unit tests are also ported.



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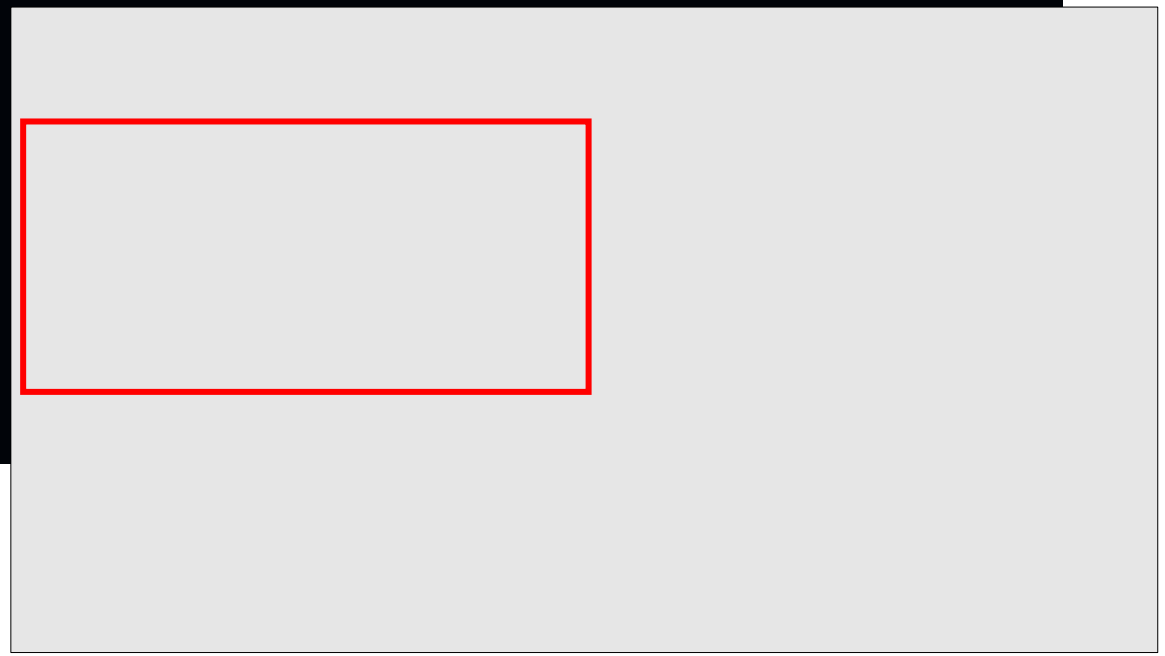

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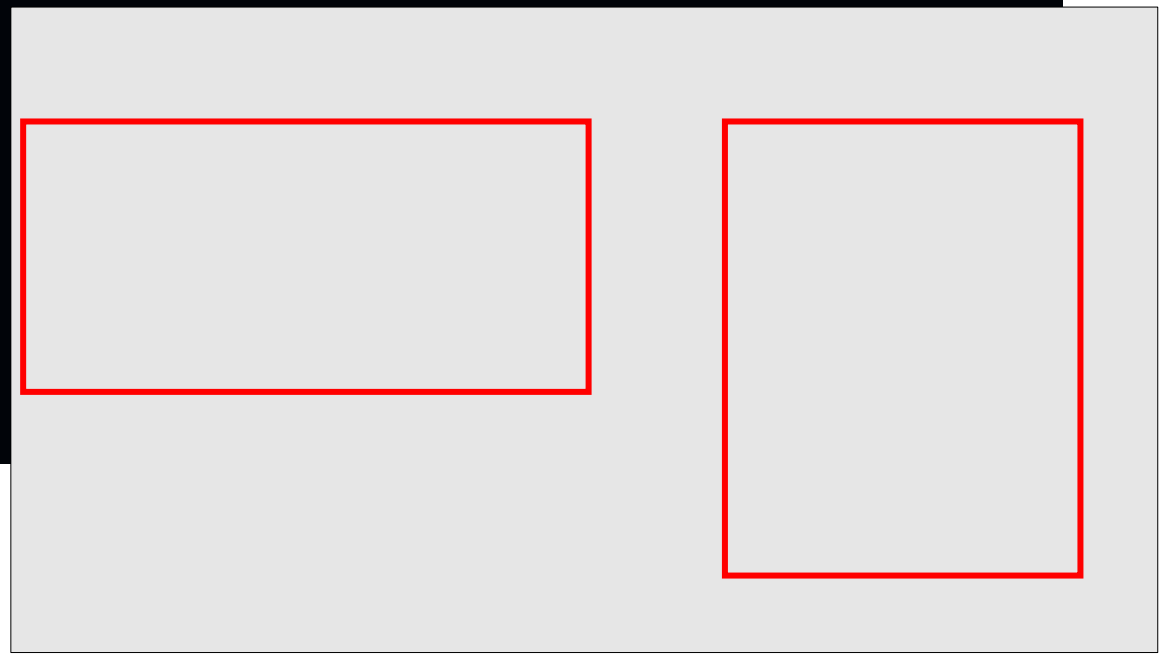

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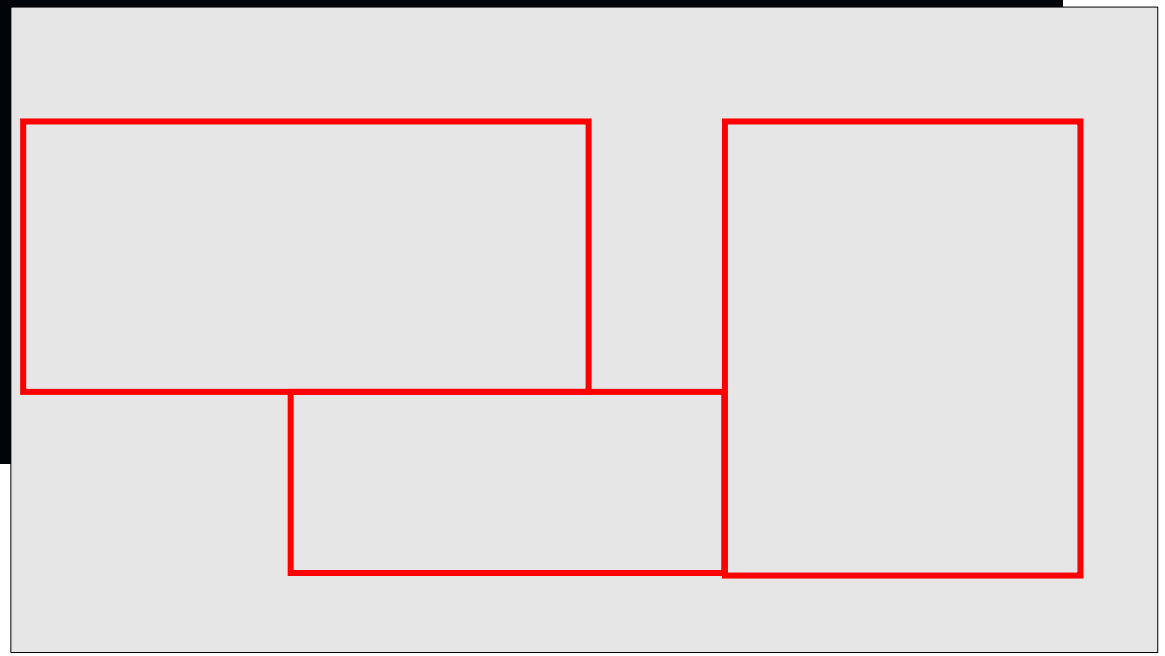

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Exporter NOT part of SDK! ☹

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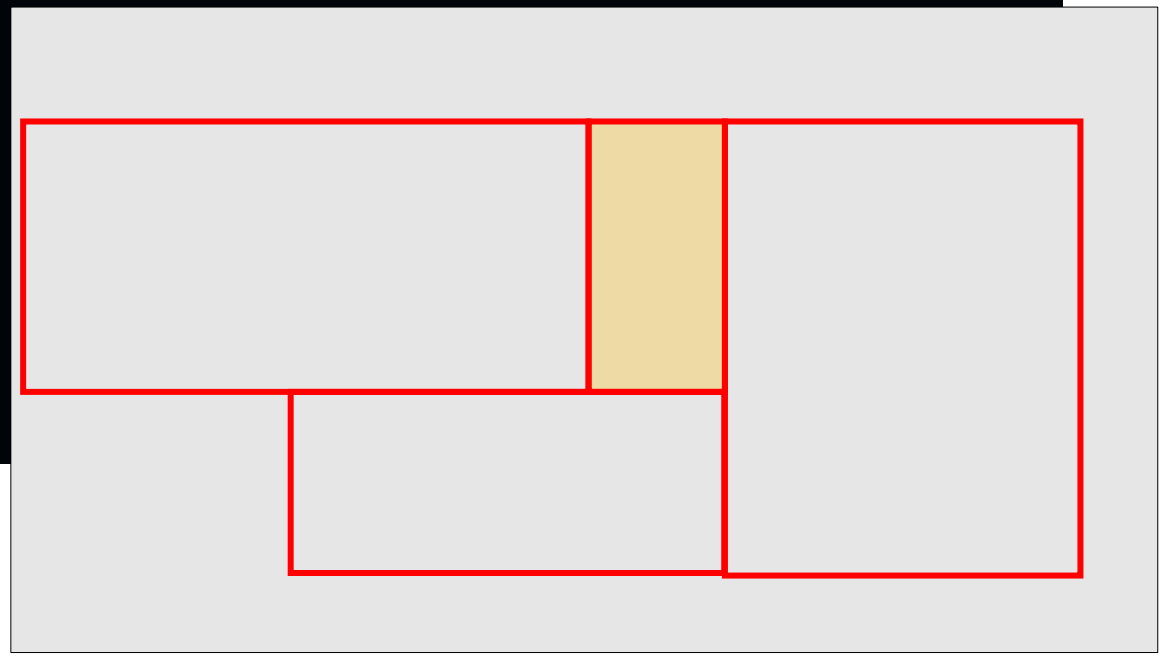

Exporter

```
class OtlpExporter(
    val host: String,
    val service: String
) : SpanExporter {
    private val client = HttpClient()
    private val scope = CoroutineScope(Dispatchers.Default)
    private val jobs: MutableList<Job> = mutableListOf()

    suspend fun await() {
        jobs.joinAll()
    }

    override fun export(
        spans: Collection<SpanData>
    ): CompletableResultCode {
        val job = scope.launch {
            val payload = spans.serialize(service)
            client.post("http://$host/v1/traces") {
                contentType(ContentType.Application.Json)
                setBody(payload)
            }
        }
        jobs.add(job)

        return CompletableResultCode.ofSuccess()
    }

    override fun flush(): CompletableResultCode {
        return CompletableResultCode.ofSuccess()
    }

    override fun shutdown() = flush()
}
```

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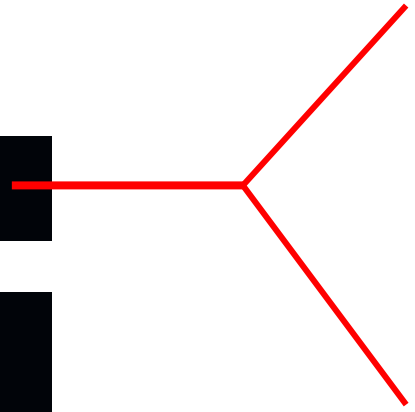

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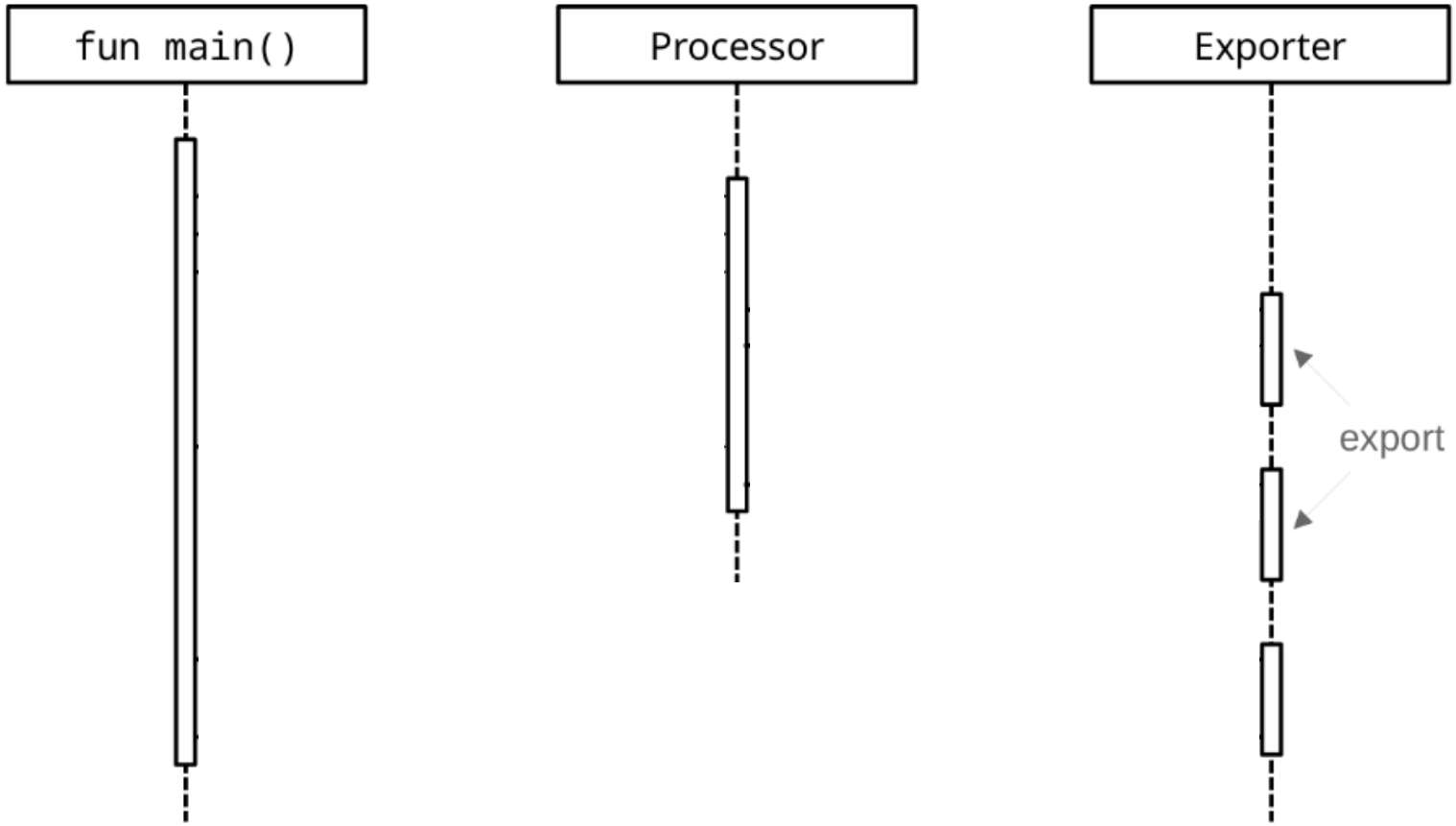
```

```
sourceSets {
 ...
 jvmMain.dependencies {
  implementation("io.ktor:ktor-client-java:3.1.0")
 }
 jsMain.dependencies {
  implementation("io.ktor:ktor-client-js:3.1.0")
 }
 linuxMain.dependencies {
  implementation("io.ktor:ktor-client-curl:3.1.0")
 }
}
```

Waiting for the Exporter



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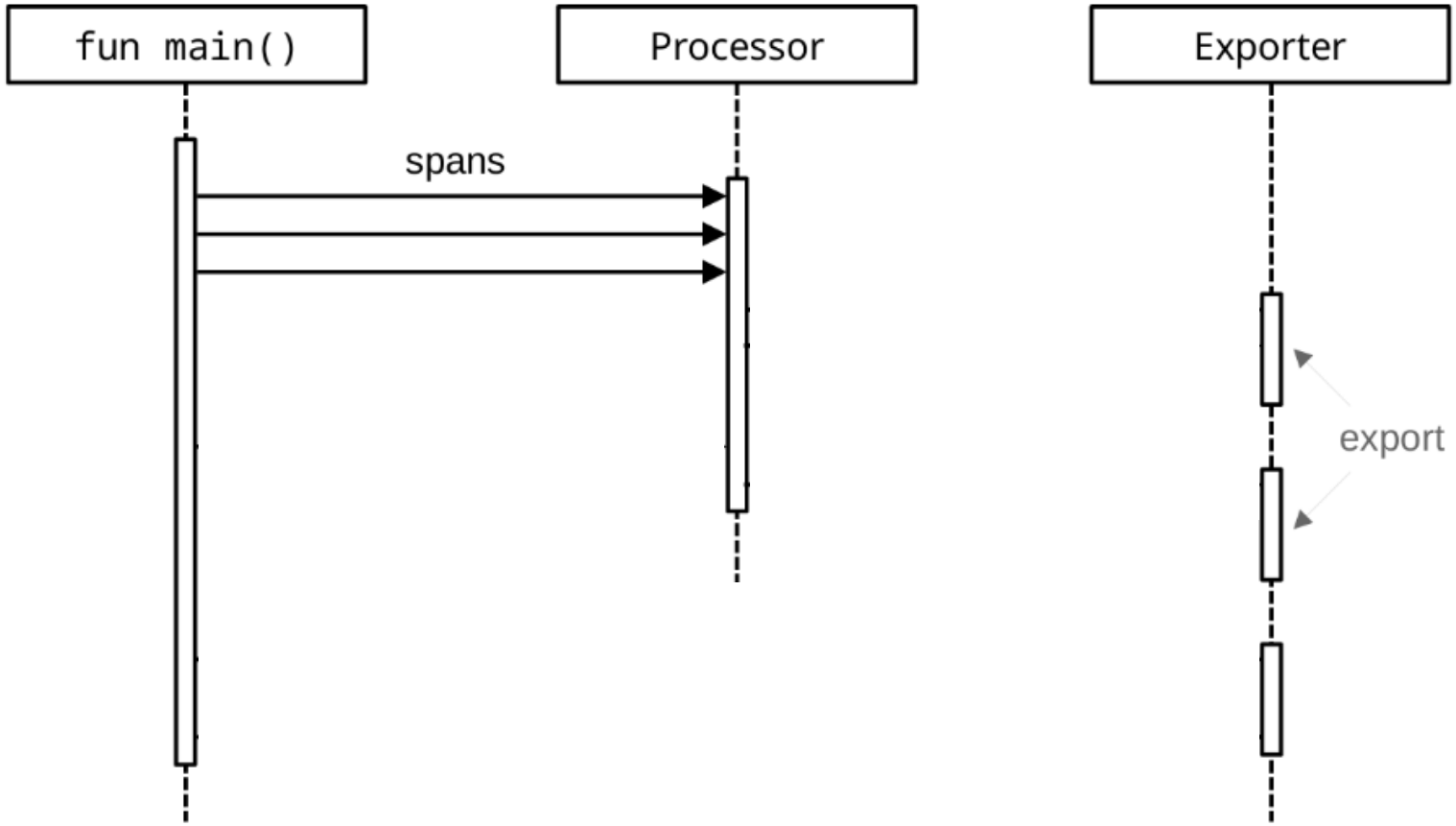

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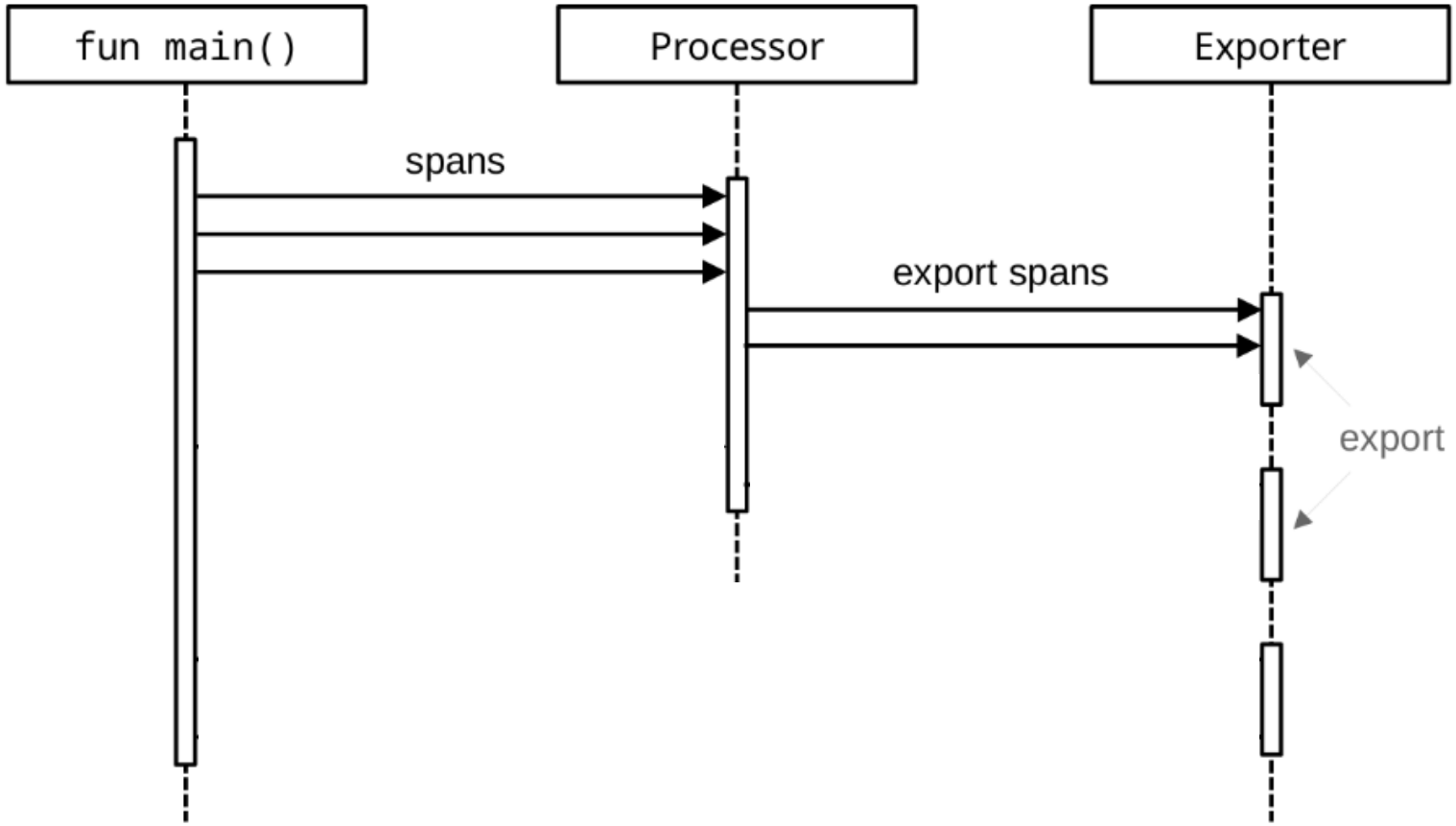

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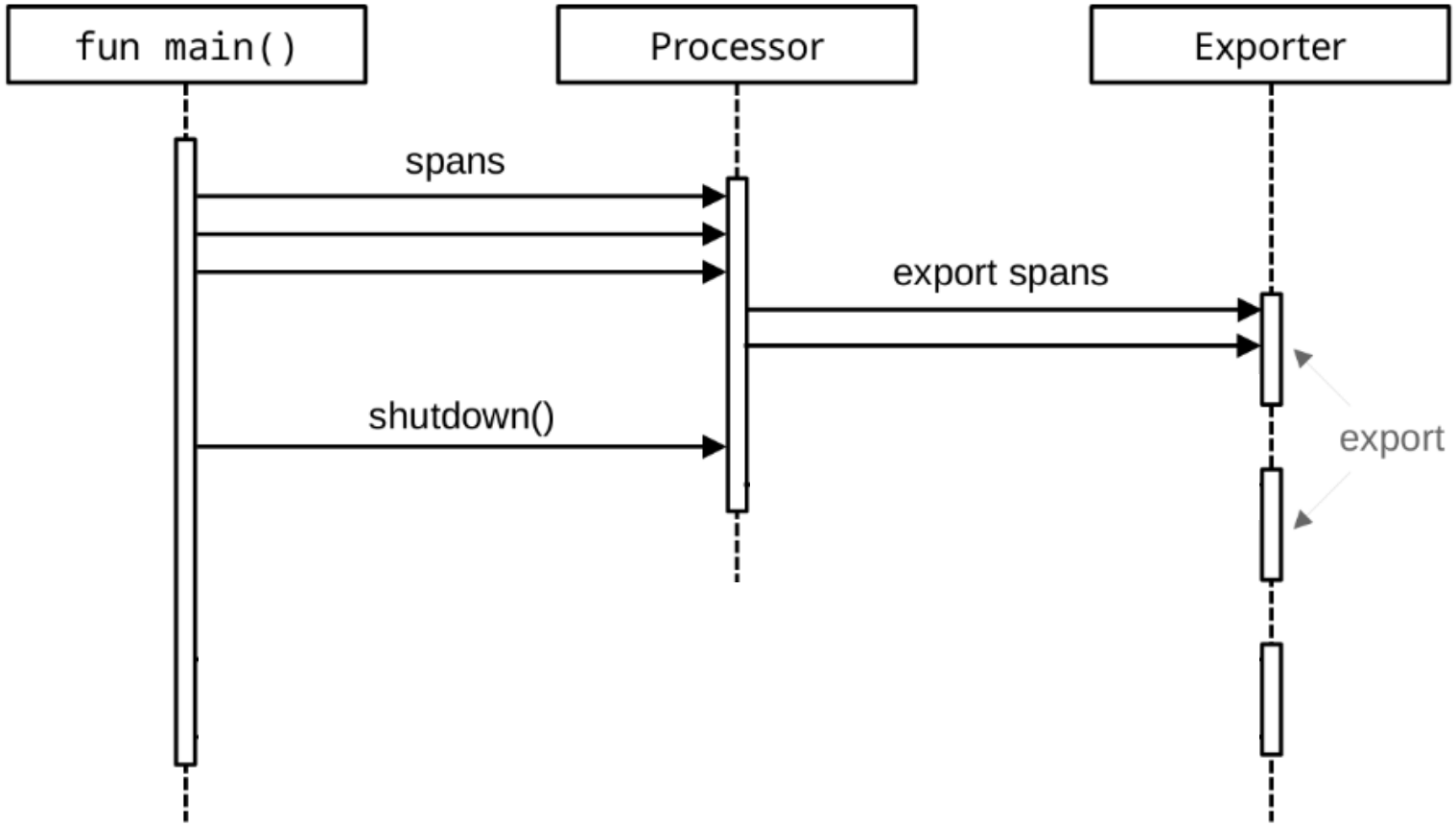

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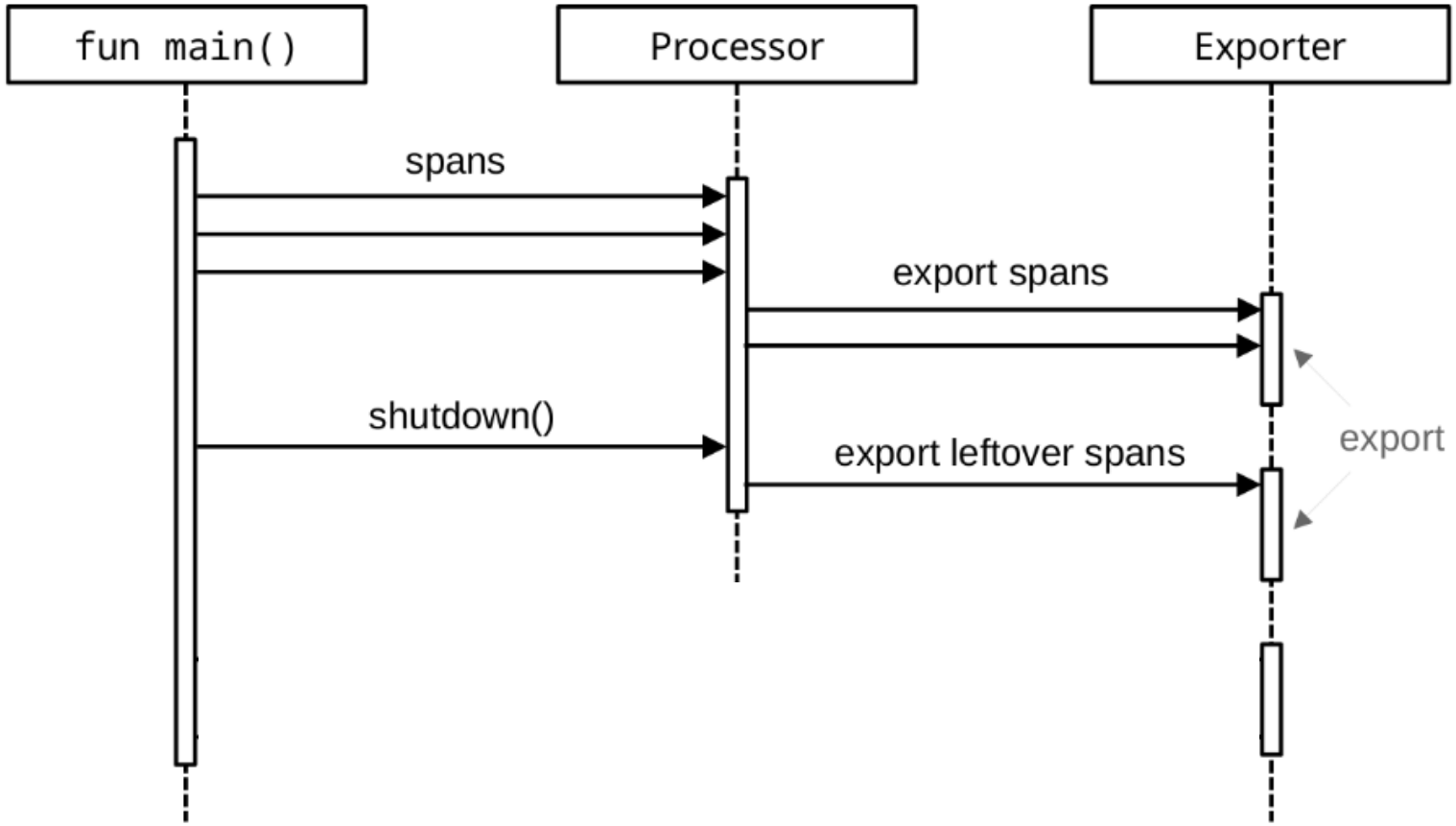

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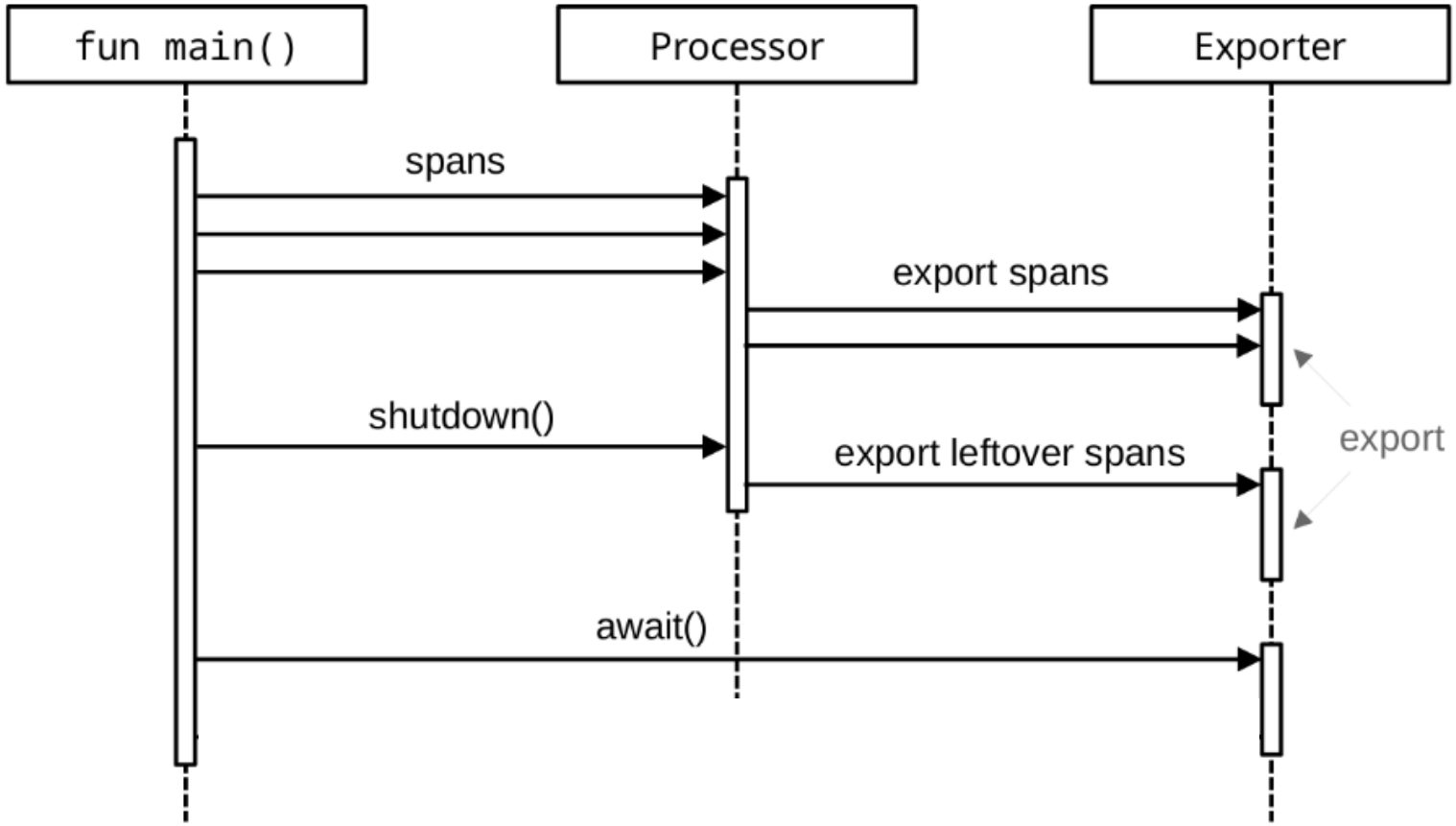

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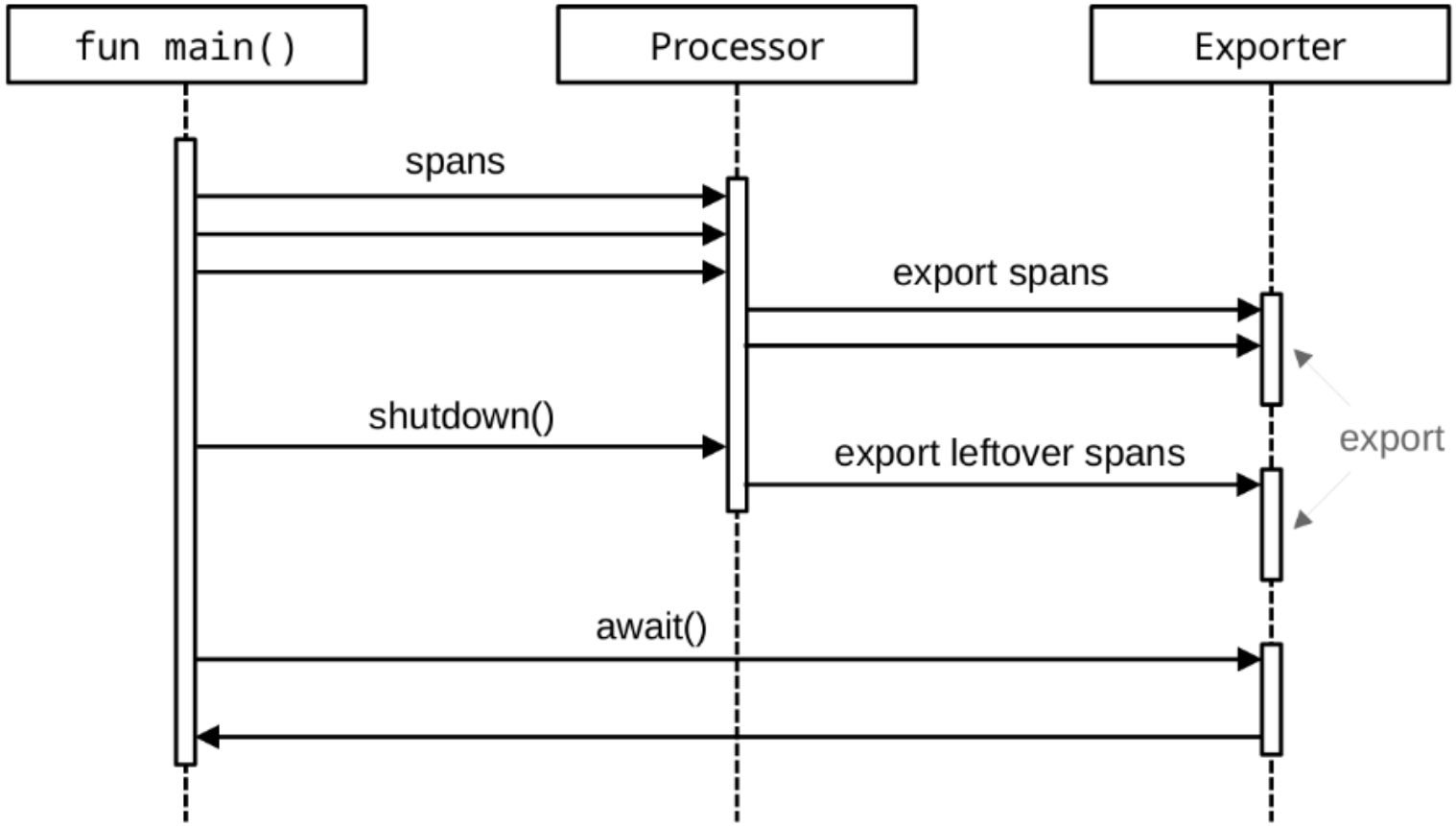

Results from last year (kperf with custom format)

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```
>;1         // main entered
>;2         // sayHello entered
<;230       // sayHello left after 0.23ms
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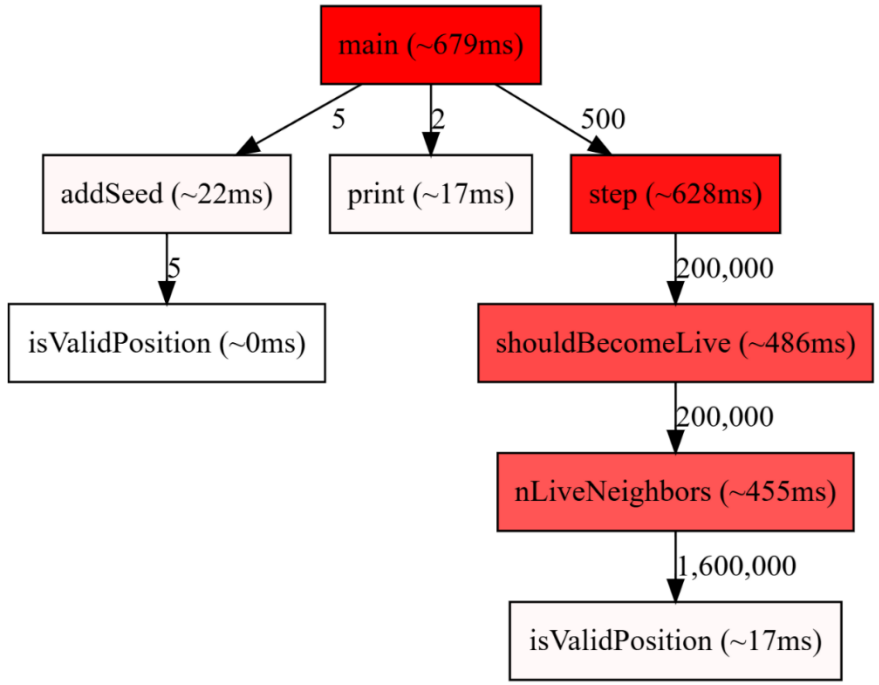

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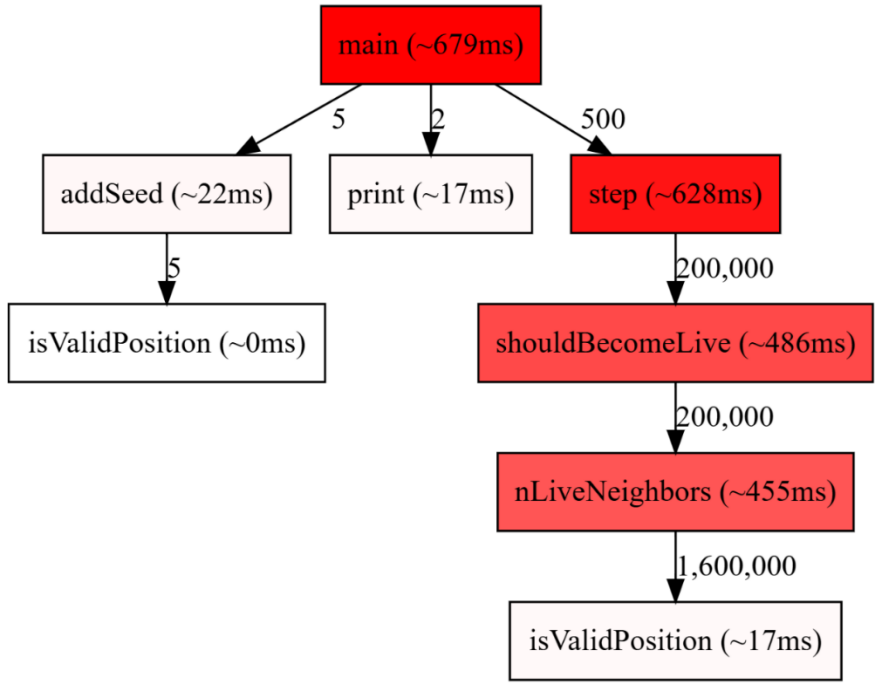

KMP Game of Life	**JVM**	**JS**	**native (.exe)**
Build Size - w/o plugin	1753.2 kB	106.9 kB	741.9 kB
Build Size w/ plugin	1912.5 kB	167.9 kB	851.5 kB
Run Time w/o plugin	83.0 - 85.3 ms	127.5 - 130.8 ms	242.9 - 248.0 ms
Run Time w/ plugin	411.2 - 429.8 ms	9364.8 - 9771.0 ms	5322.4 - 5497.0 ms

Table 1: Build sizes (incl. Kotlin runtime + dependencies) and run times (95% conf. int. of 100 runs).

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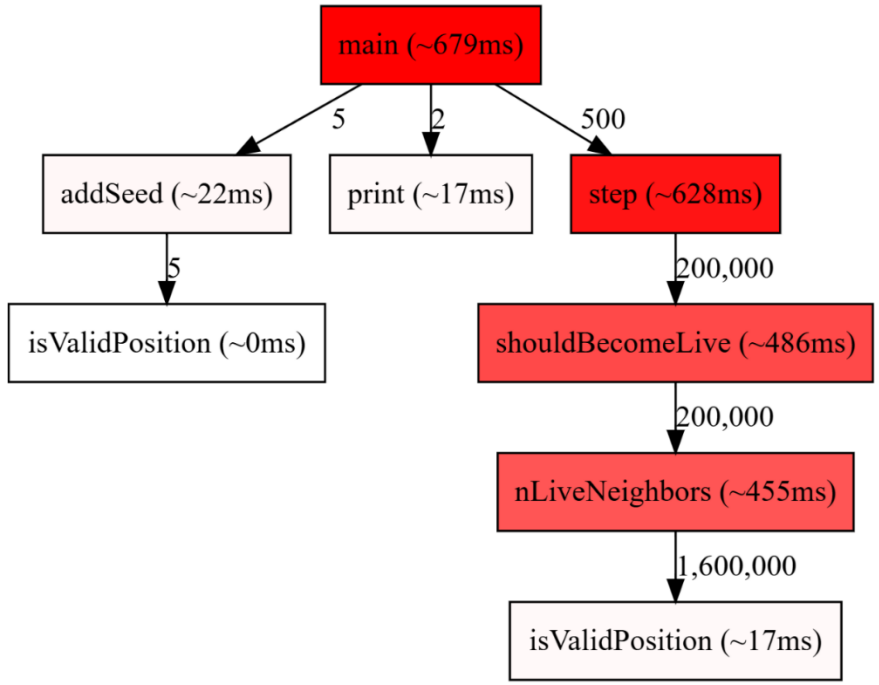

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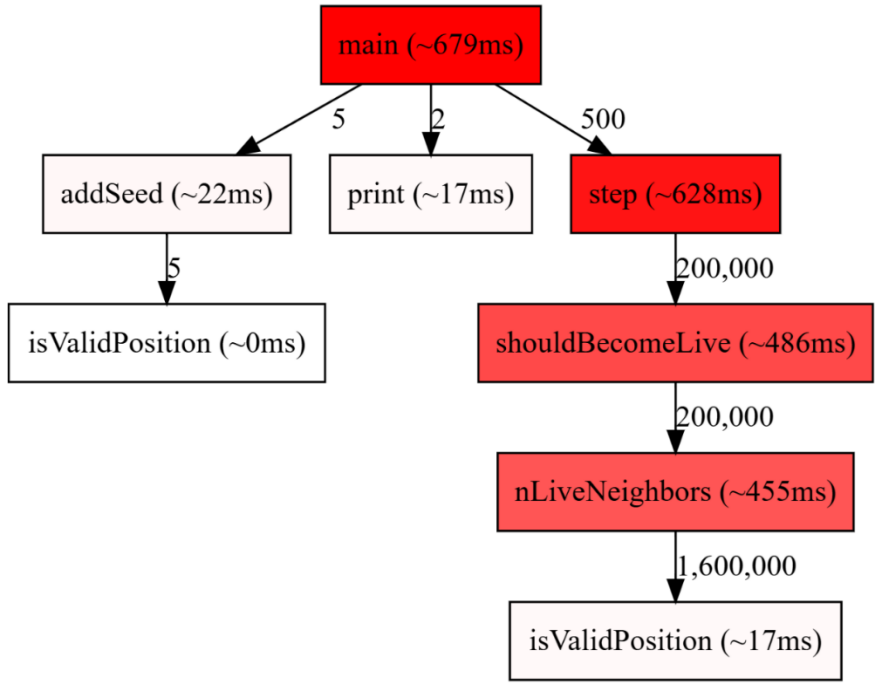


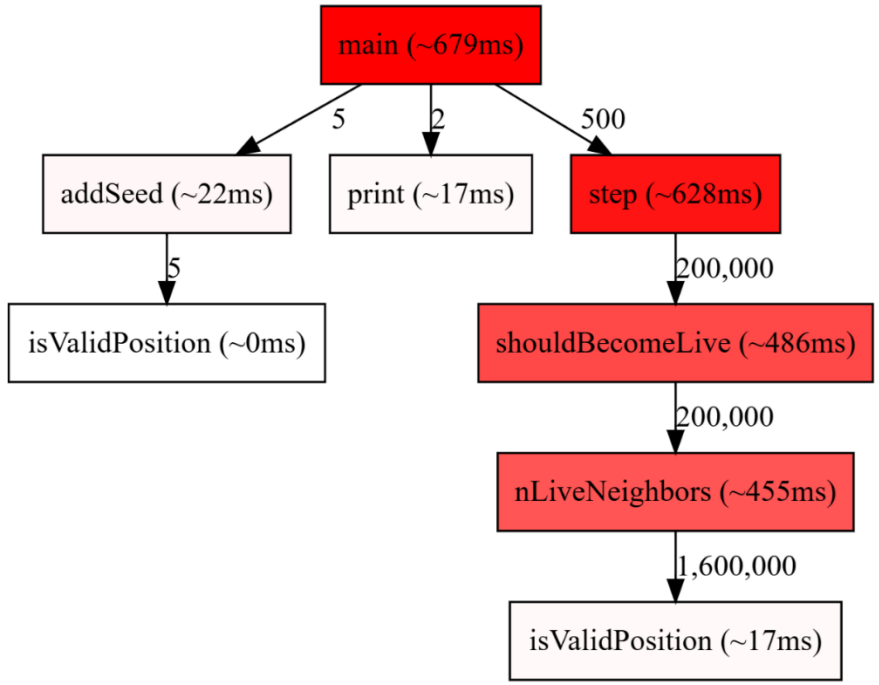
KMP Game of Life	**JVM**	**JS**	**native (.exe)**
Build Size - w/o plugin	1753.2 kB	106.9 kB	741.9 kB
Build Size w/ plugin	1912.5 kB	167.9 kB	851.5 kB
Run Time w/o plugin	83.0 - 85.3 ms	127.5 - 130.8 ms	242.9 - 248.0 ms
Run Time w/ plugin	411.2 - 429.8 ms	9364.8 - 9771.0 ms	5322.4 - 5497.0 ms

x5

Table 1: Build sizes (incl. Kotlin runtime + dependencies) and run times (95% conf. int. of 100 runs).

Results from last year (kperf with custom format)

```
>;1         // main entered
>;2         // sayHello entered
<;230       // sayHello left after 0.23ms
>;2         // sayHello entered
<;250       // sayHello left after 0.25ms
<;7500      // main left after 7.5ms
```



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x5

x74

Table 1: Build sizes (incl. Kotlin runtime + dependencies) and run times (95% conf. int. of 100 runs).

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<;230       // sayHello left after 0.23ms
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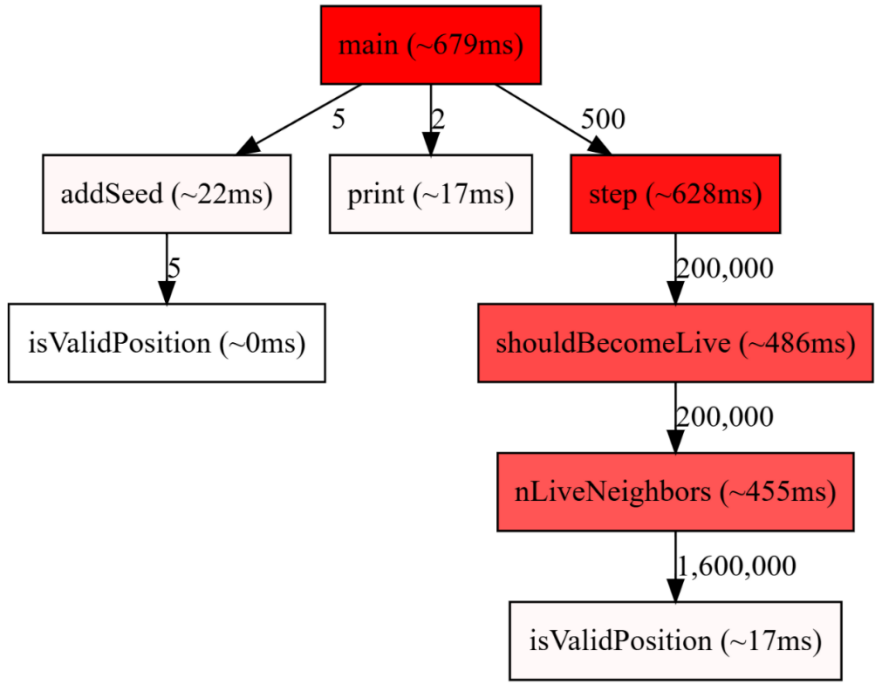

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x5 x74 x22

Table 1: Build sizes (incl. Kotlin runtime + dependencies) and run times (95% conf. int. of 100 runs).

Results from kperf-otel

Results from kperf-otel

		JVM	**JavaScript**	**Native** (Linux)
Reference	execution	$[33.84 \pm 0.59]$	$[20.82 \pm 0.37]$	$[3.68 \pm 0.18]$
Manual	execution	$[9,269.59 \pm 240.36]$	$[19,742.54 \pm 118.23]$	$[72,831.72 \pm 957.3]$
	total	$[9,602.45 \pm 243.77]$	$[110,749.40 \pm 533.53]$	$[73,270.53 \pm 956.53]$
Automatic	execution	$[8,352.11 \pm 126.42]$	$[19,584.33 \pm 124.95]$	$[70,581.19 \pm 700.64]$
	total	$[8,644.29 \pm 142.92]$	$[109,786.73 \pm 420.45]$	$[71,018.52 \pm 697.57]$

Results from kperf-otel

		JVM	**JavaScript**	**Native** (Linux)
Reference	execution	$[33.84 \pm 0.59]$	$[20.82 \pm 0.37]$	$[3.68 \pm 0.18]$
Manual	execution	$[9,269.59 \pm 240.36]$	$[19,742.54 \pm 118.23]$	$[72,831.72 \pm 957.3]$
	total	$[9,602.45 \pm 243.77]$	$[110,749.40 \pm 533.53]$	$[73,270.53 \pm 956.53]$
Automatic	execution	$[8,352.11 \pm 126.42]$	$[19,584.33 \pm 124.95]$	$[70,581.19 \pm 700.64]$
	total	$[8,644.29 \pm 142.92]$	$[109,786.73 \pm 420.45]$	$[71,018.52 \pm 697.57]$

x255

Results from kperf-otel

		JVM	**JavaScript**	**Native** (Linux)
Reference	execution	$[33.84 \pm 0.59]$	$[20.82 \pm 0.37]$	$[3.68 \pm 0.18]$
Manual	execution	$[9,269.59 \pm 240.36]$	$[19,742.54 \pm 118.23]$	$[72,831.72 \pm 957.3]$
	total	$[9,602.45 \pm 243.77]$	$[110,749.40 \pm 533.53]$	$[73,270.53 \pm 956.53]$
Automatic	execution	$[8,352.11 \pm 126.42]$	$[19,584.33 \pm 124.95]$	$[70,581.19 \pm 700.64]$
	total	$[8,644.29 \pm 142.92]$	$[109,786.73 \pm 420.45]$	$[71,018.52 \pm 697.57]$

x255

4.3 ns/func

Results from kperf-otel

		JVM	**JavaScript**	**Native** (Linux)
Reference	execution	$[33.84 \pm 0.59]$	$[20.82 \pm 0.37]$	$[3.68 \pm 0.18]$
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Automatic	execution	$[8,352.11 \pm 126.42]$	$[19,584.33 \pm 124.95]$	$[70,581.19 \pm 700.64]$
	total	$[8,644.29 \pm 142.92]$	$[109,786.73 \pm 420.45]$	$[71,018.52 \pm 697.57]$

x255

4.3 ns/func

x5,273

Results from kperf-otel

		JVM	JavaScript	Native (Linux)
Reference	execution	$[33.84 \pm 0.59]$	$[20.82 \pm 0.37]$	$[3.68 \pm 0.18]$
Manual	execution	$[9,269.59 \pm 240.36]$	$[19,742.54 \pm 118.23]$	$[72,831.72 \pm 957.3]$
	total	$[9,602.45 \pm 243.77]$	$[110,749.40 \pm 533.53]$	$[73,270.53 \pm 956.53]$
Automatic	execution	$[8,352.11 \pm 126.42]$	$[19,584.33 \pm 124.95]$	$[70,581.19 \pm 700.64]$
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x255

4.3 ns/func

x5,273

54.8 ns/func

Results from kperf-otel

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Reference	execution	$[33.84 \pm 0.59]$	$[20.82 \pm 0.37]$	$[3.68 \pm 0.18]$
Manual	execution	$[9,269.59 \pm 240.36]$	$[19,742.54 \pm 118.23]$	$[72,831.72 \pm 957.3]$
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x255

4.3 ns/func

x5,273

54.8 ns/func

x19,300

Results from kperf-otel

		JVM	**JavaScript**	**Native** (Linux)
Reference	execution	$[33.84 \pm 0.59]$	$[20.82 \pm 0.37]$	$[3.68 \pm 0.18]$
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	total	$[8,644.29 \pm 142.92]$	$[109,786.73 \pm 420.45]$	$[71,018.52 \pm 697.57]$

x255

4.3 ns/func

x5,273

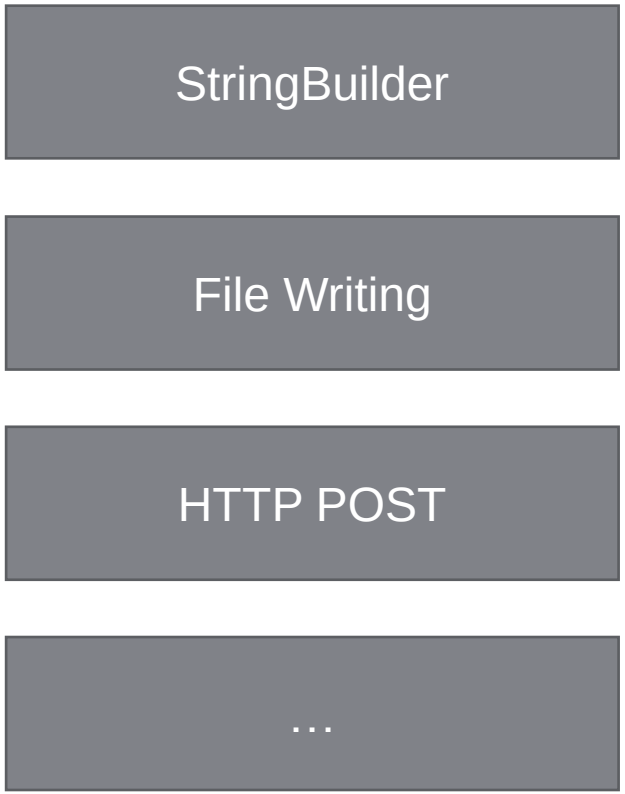
54.8 ns/func

x19,300

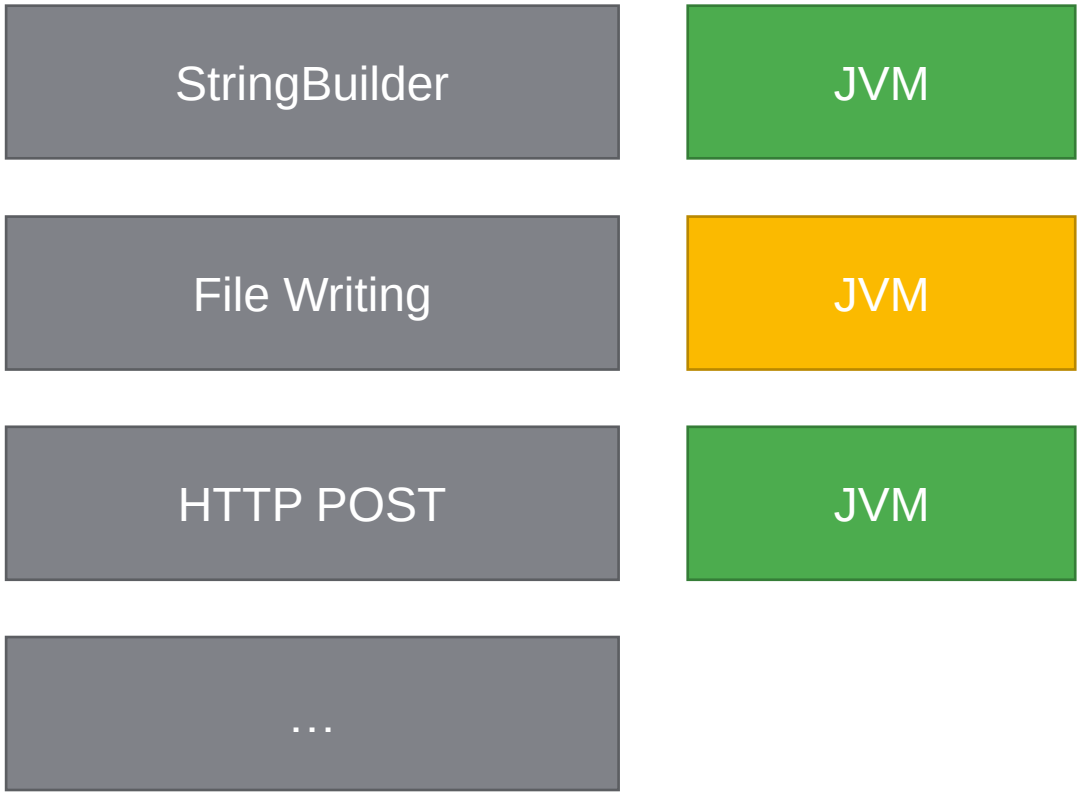
35.5 ns/func

Future Work: Target-specific Performance Impact Analysis of Kotlin IR Instrumentation

Future Work: Target-specific Performance Impact Analysis of Kotlin IR Instrumentation



Future Work: Target-specific Performance Impact Analysis of Kotlin IR Instrumentation



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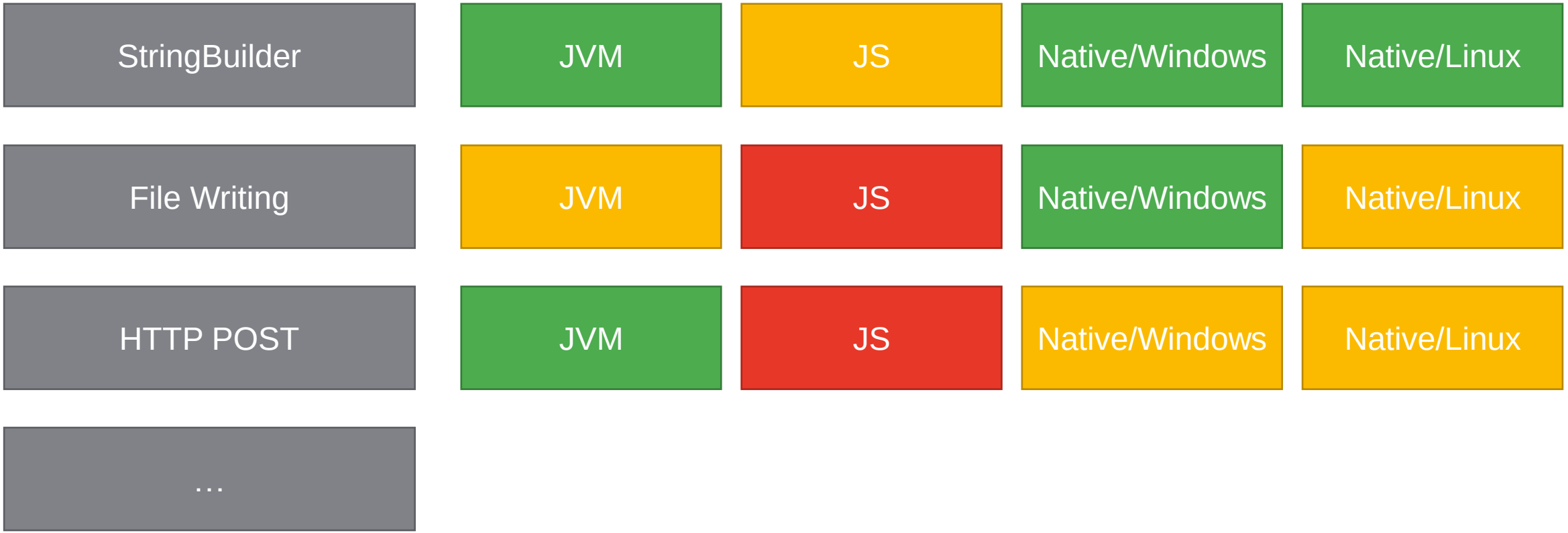

Future Work: Multi-Threading

Listing 11: Instrumented OpenTelemetry functions

```
1  fun _startSpan(name: String, parent: Context): Span {
2      val span = tracer.spanBuilder(name)
3          .setParent(parent)
4          .setStartTimestamp(Clock.System.now())
5          .startSpan()
6      parent.with(span).makeCurrent() // create new span-context
7      return span
8  }
9
10 fun _endSpan(span: Span, parent: Context) {
11     span.end(Clock.System.now())
12     parent.makeCurrent()
13 }
```

Future Work: Multi-Threading

Currently: One Context for all threads

Listing 11: Instrumented Op s

```
1  fun _startSpan(name: String, parent: Context): Span {
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3          .setParent(parent)
4          .setStartTimestamp(Clock.System.now())
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```
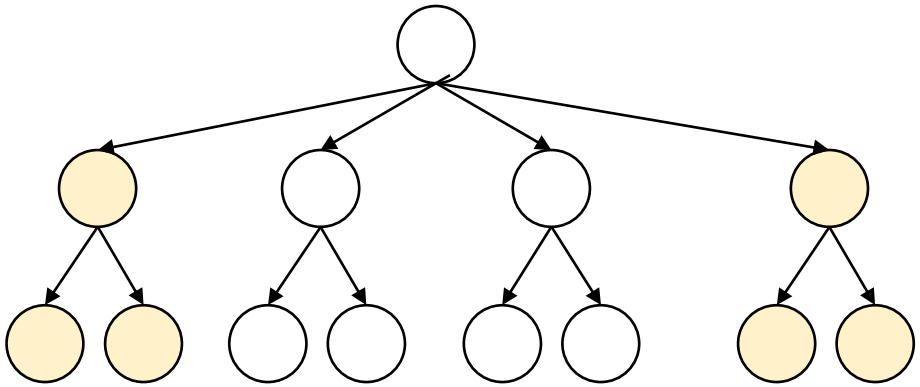
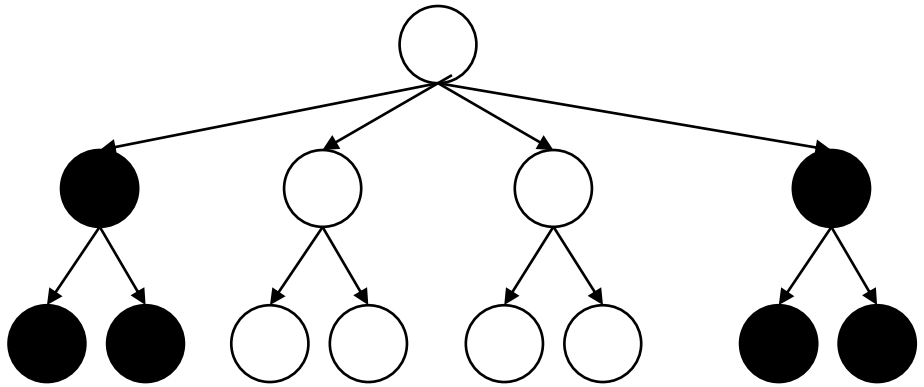

Future Work: Adaptive Tracing



Future Work: Adaptive Tracing



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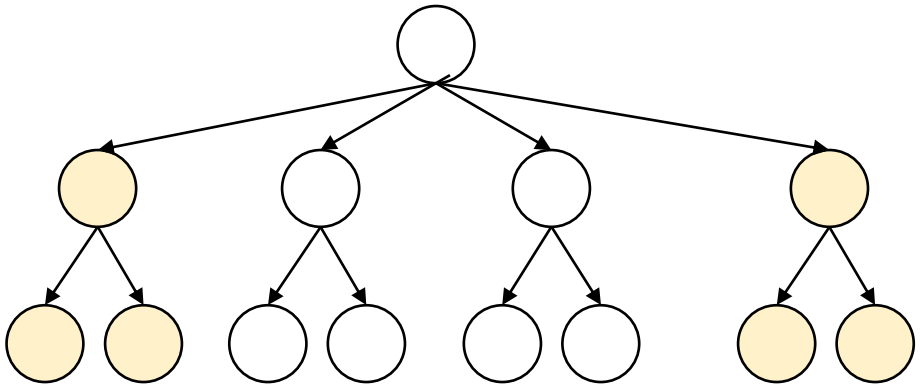

Future Work: Compiler-in-a-Compiler Instrumenation

Compiler Plugin

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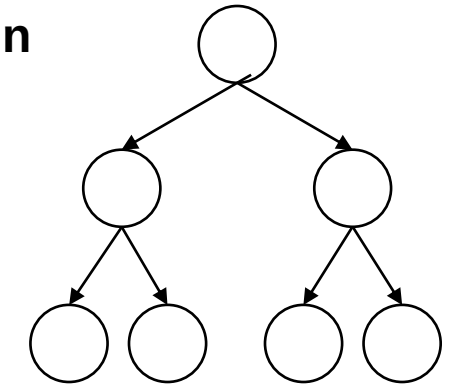
Compiler Plugin



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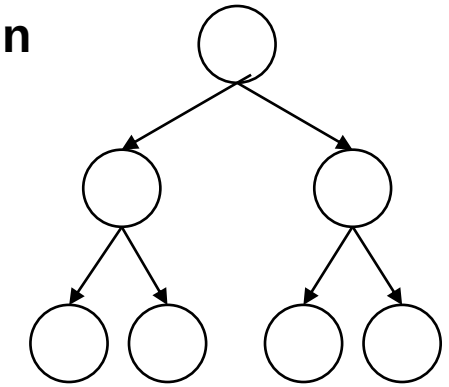
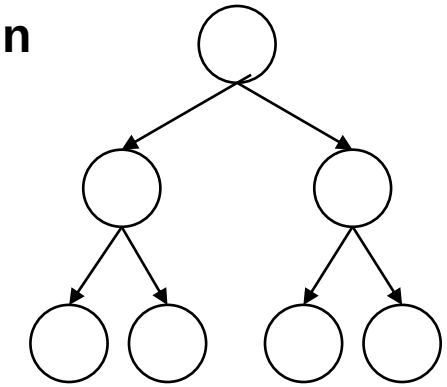


```
myFunc.insertFirst("val span = openSpan()")
```

Future Work: Compiler-in-a-Compiler Instrumenation

Compiler Plugin



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myFunc.insertFirst(myCodeAsString);
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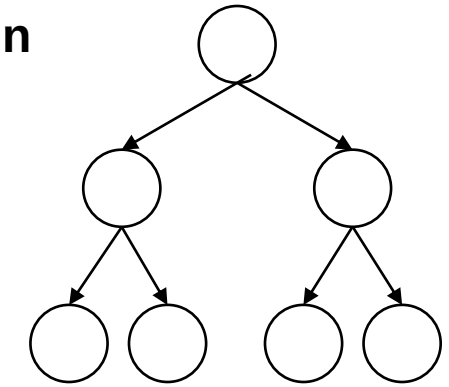
Compiler Plugin



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Embedded Compiler

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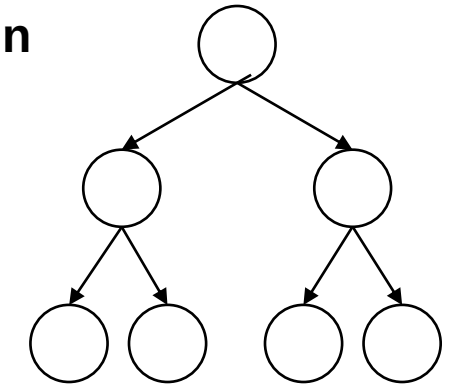

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fun dummy() {
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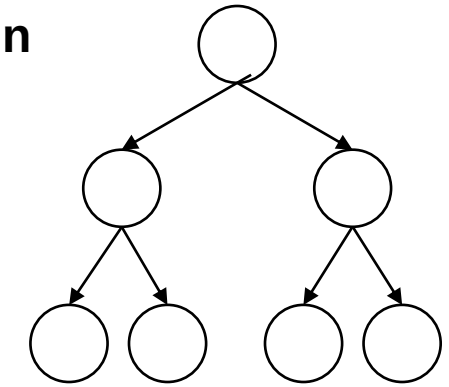
Compiler Plugin



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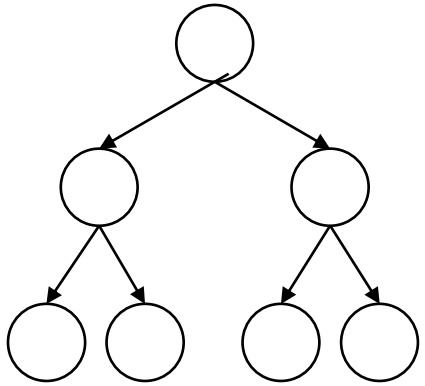

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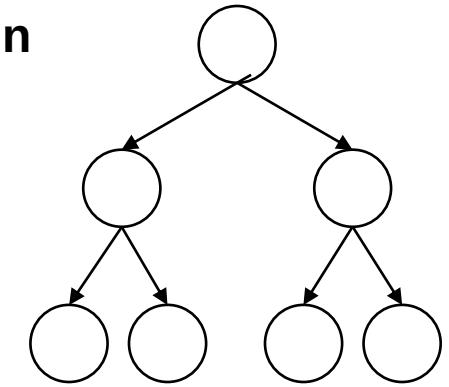

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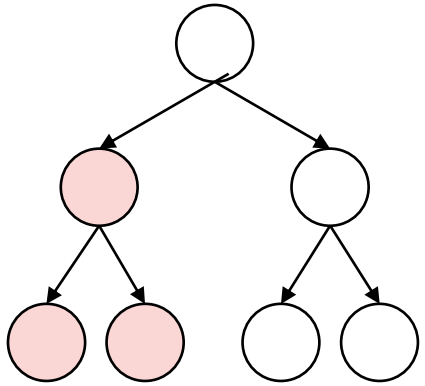

Future Work: Compiler-in-a-Compiler Instrumenation

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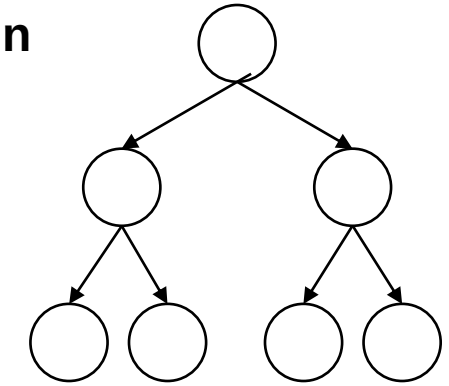

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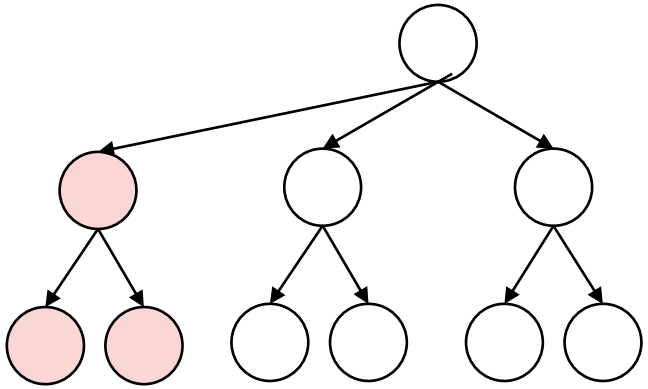

Embedded Compiler

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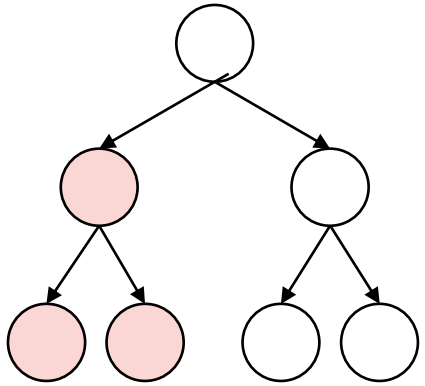


Take Aways

Take Aways

OpenTelemetry

Collect, transport and store:

Traces

Metrics

Logs

Take Aways

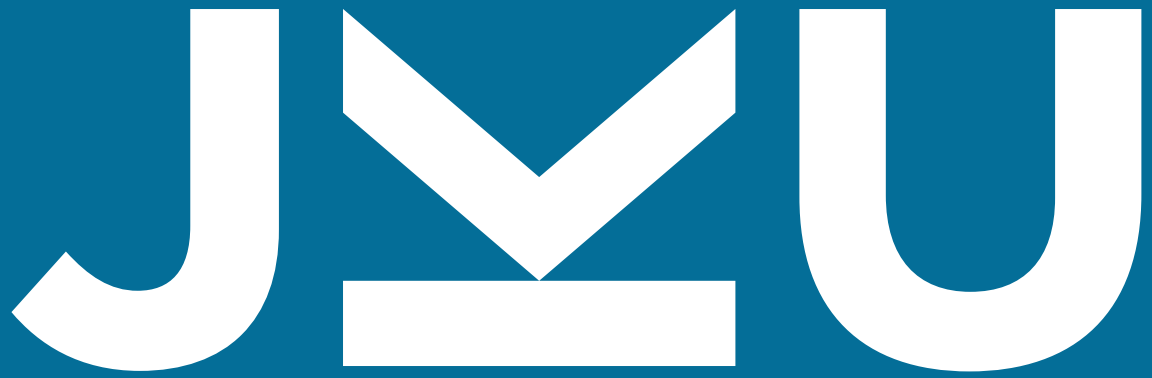
OpenTelemetry	Collect
Collect, transport and store: **Traces** Metrics Logs	**Instrumentation** At **Compile-Time** on **Kotlin IR** (AST) Using a **Multiplatform OTEL Trace API / SDK port**

Take Aways

OpenTelemetry	Collect	Transport
Collect, transport and store: **Traces** Metrics Logs	**Instrumentation** At **Compile-Time** on **Kotlin IR** (AST) Using a **Multiplatform OTEL Trace API / SDK port**	Using a **custom multiplatform exporter** **HTTP + JSON** in combination with a **batch processor**

Take Aways

OpenTelemetry	Collect	Transport	Future Work
Collect, transport and store: **Traces** Metrics Logs	**Instrumentation** At **Compile-Time** on **Kotlin IR** (AST) Using a **Multiplatform OTEL Trace API / SDK port**	Using a **custom multiplatform exporter** **HTTP + JSON** in combination with a **batch processor**	**Target-specific performance impact analysis** **Multi-Threading** **Adaptive Tracing** **Compiler-in-Compiler**



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UNIVERSITÄT LINZ