Viewing Note

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Simplifying Kotlin Compile-Time Code Instrumentation

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Markus Weninger, Institute for System Software

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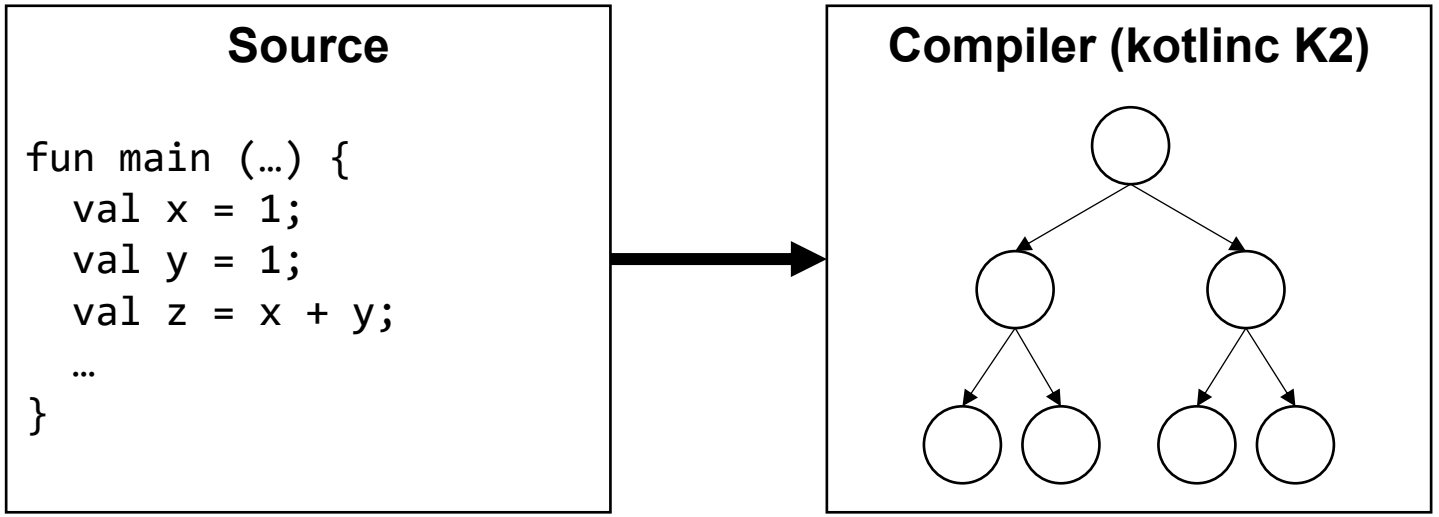
Altenberger Straße 69
4040 Linz, Österreich
jku.at

Introduction

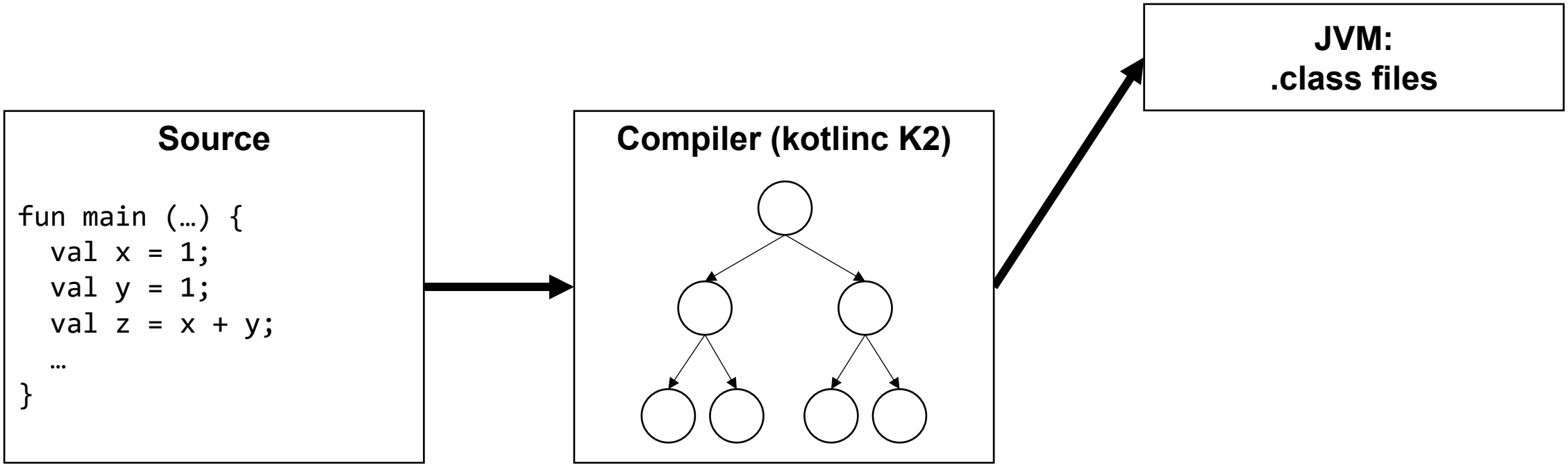
Source

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

Introduction



Introduction



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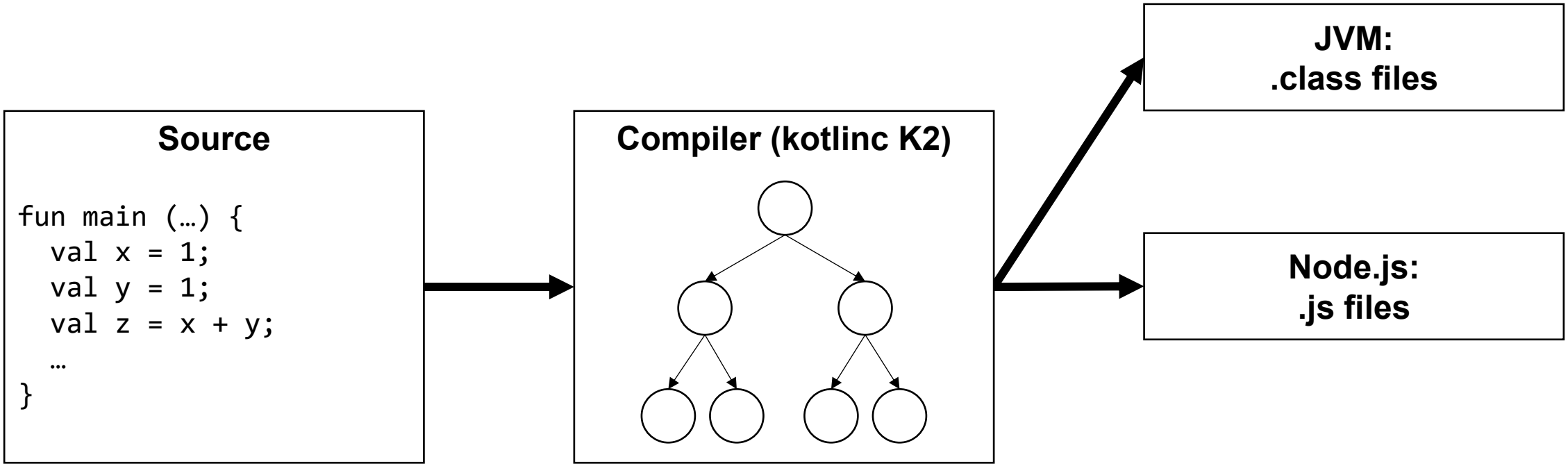

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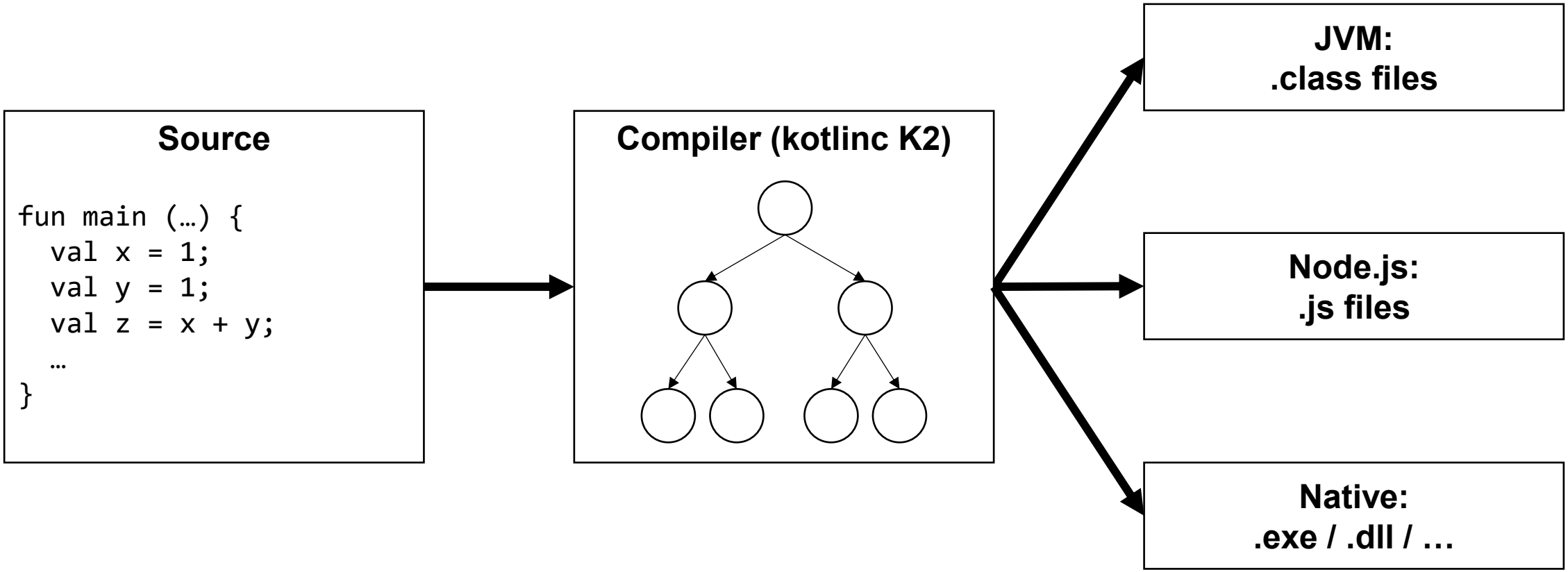

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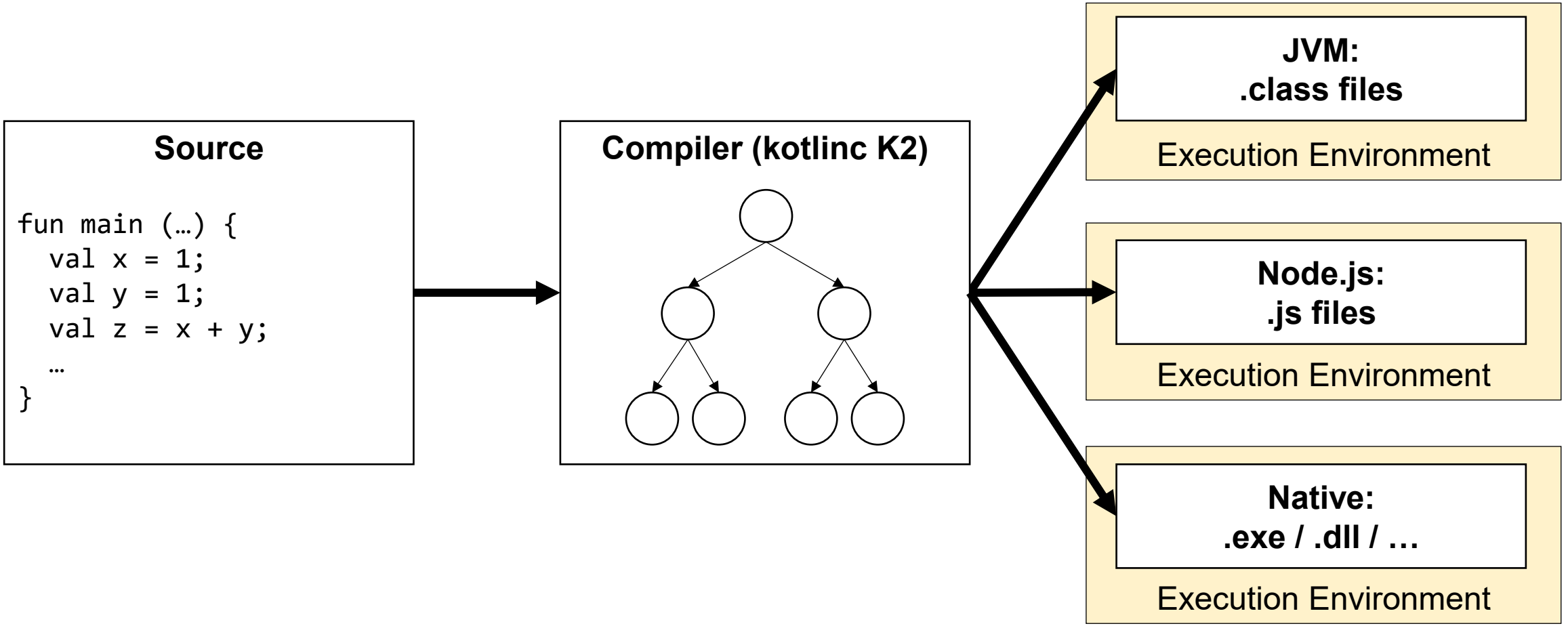
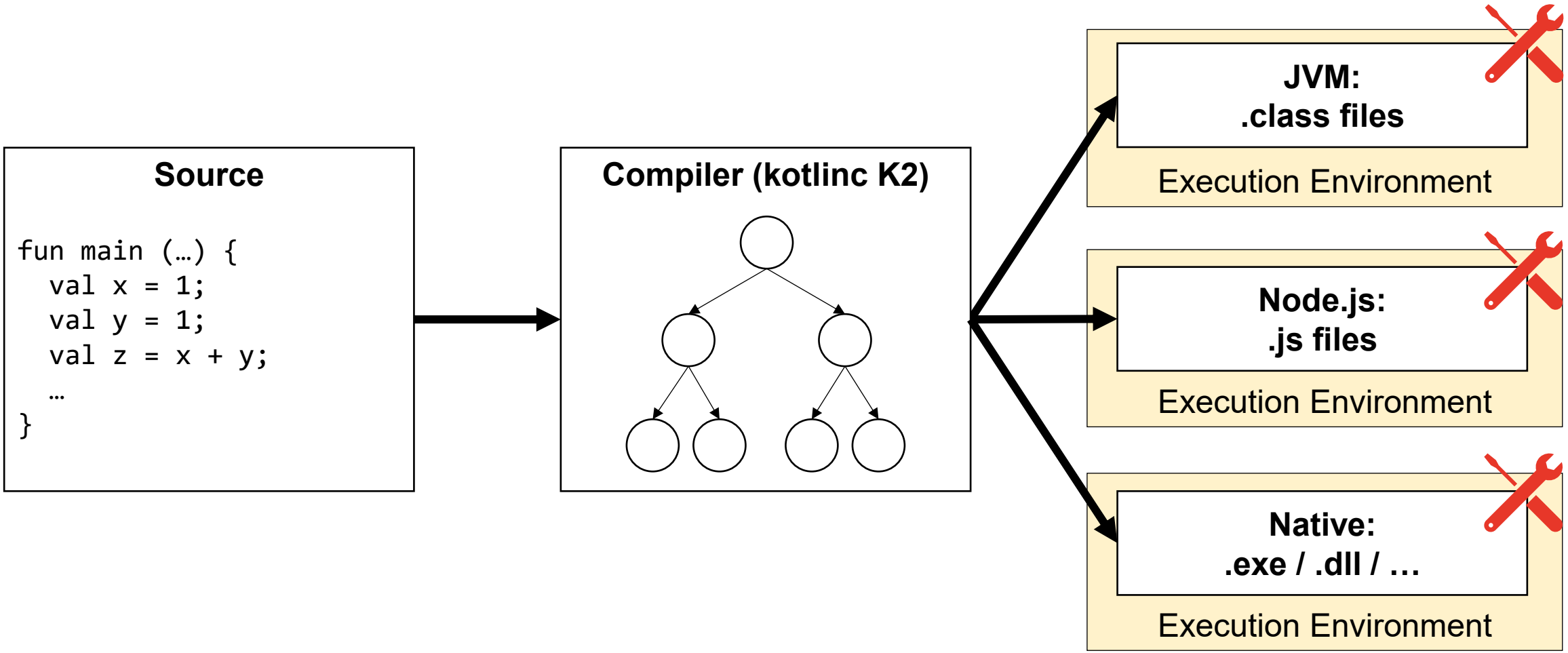


Introduction

(3) Code Instrumentation



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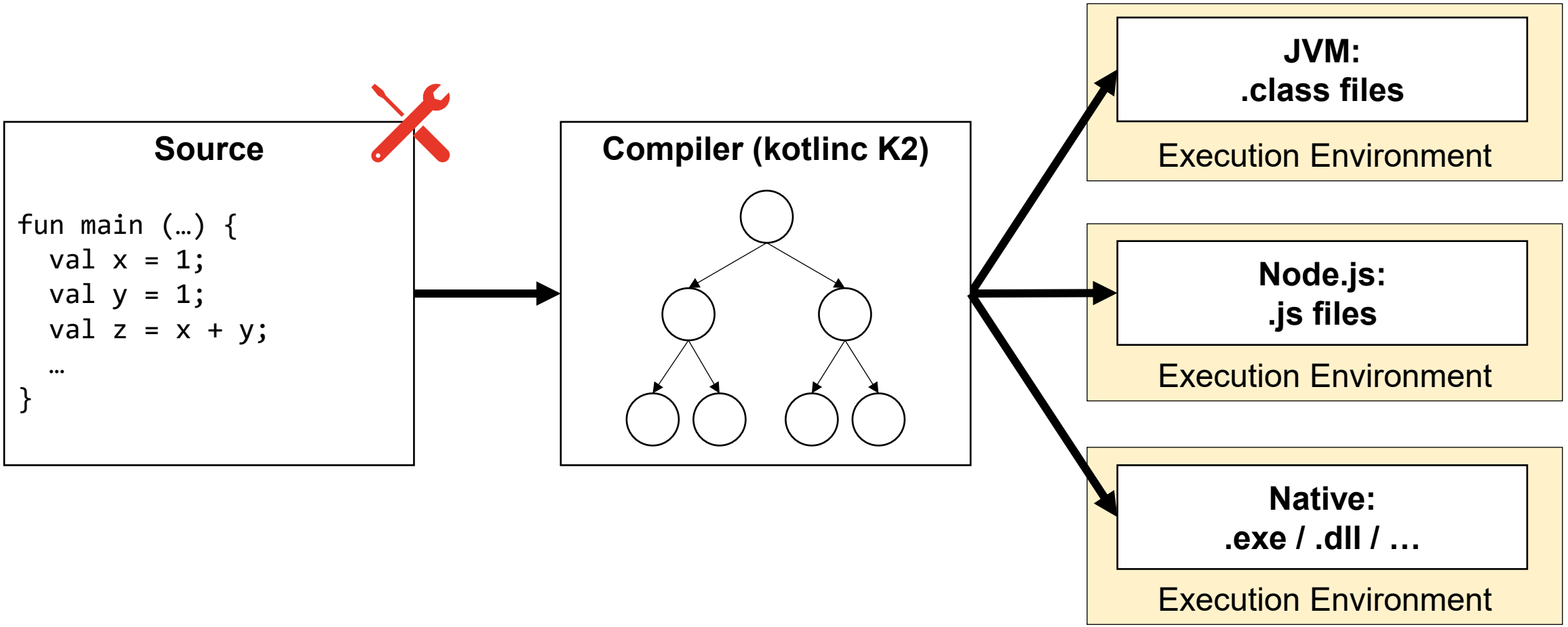

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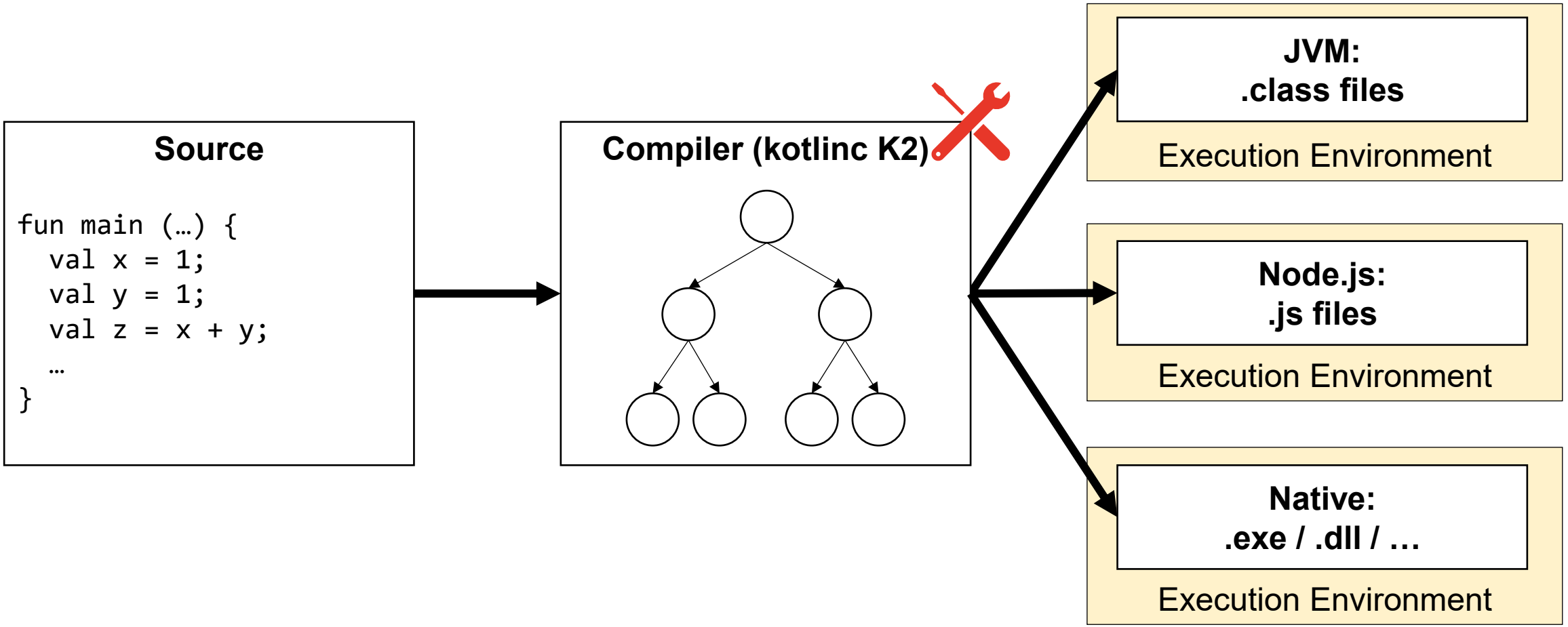

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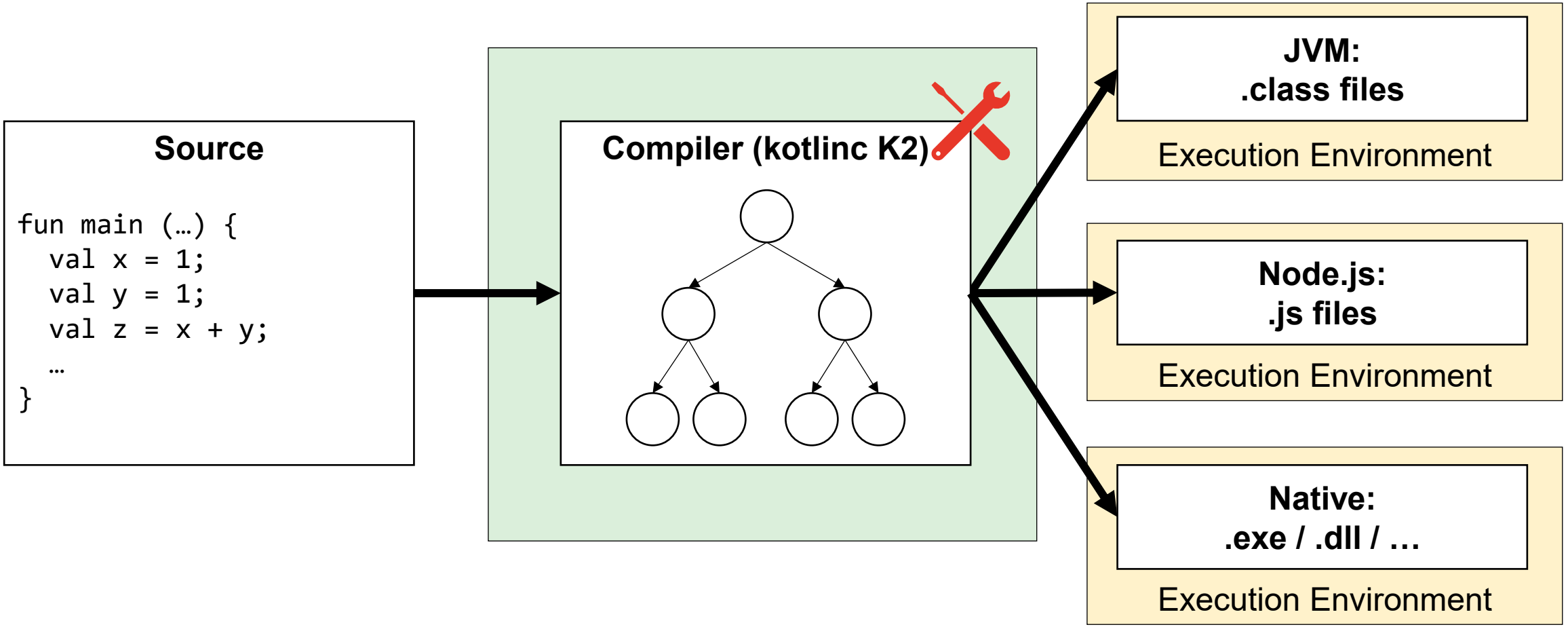

Introduction

Code Instrumentation ?

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Compiler (k

JVM:
ass files

ecution Environment

Node.js:
.js files

Execution Environment

Native:
.exe / .dll / …

Execution Environment

Tracing Performance Metrics in Kotlin Multiplatform Projects via Compile-Time Code Instrumentation

Markus Weninger
markus.weninger@jku.at
Institute for System Software, Johannes Kepler University Linz, Austria

Introduction

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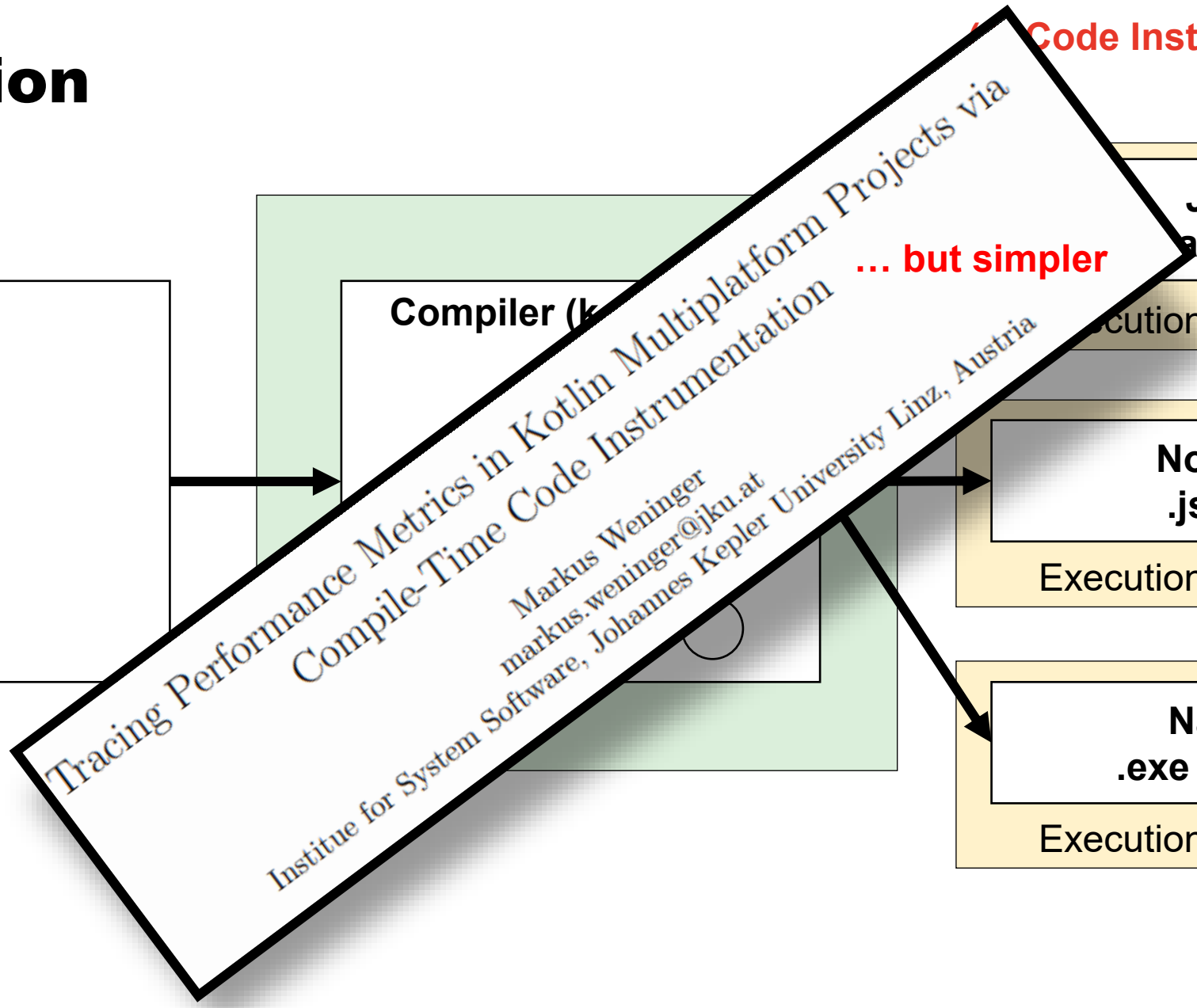
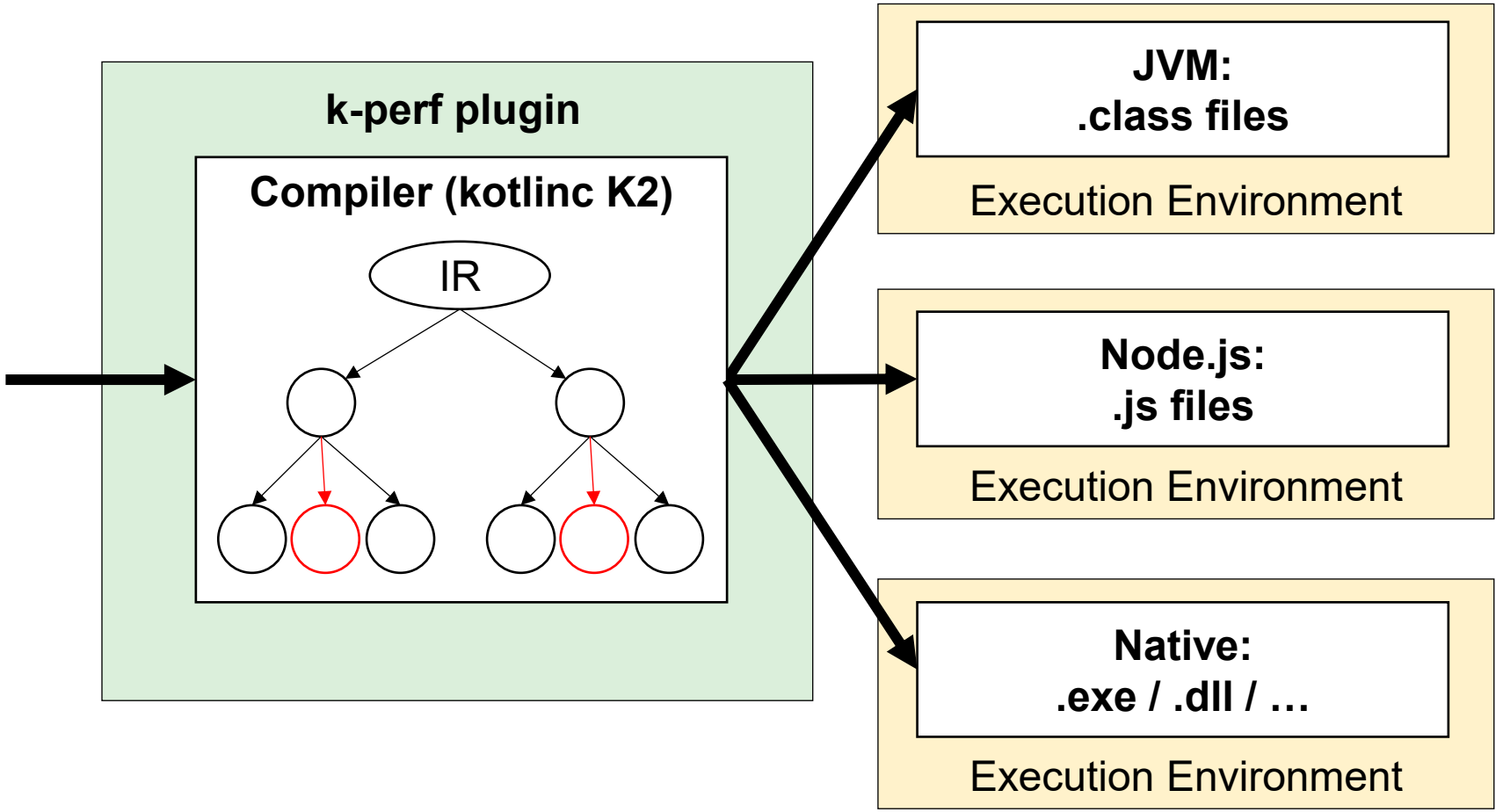


… but simpler

K-perf Plugin

Source

```
fun main () {
  val start = _enter(1)
  try {
    val x = 1
    val y = 1
    val z = x + y
  } finally {
    _exit(start)
  }
}
```



K-perf Plugin

Added to all methods

Source

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fun main () {
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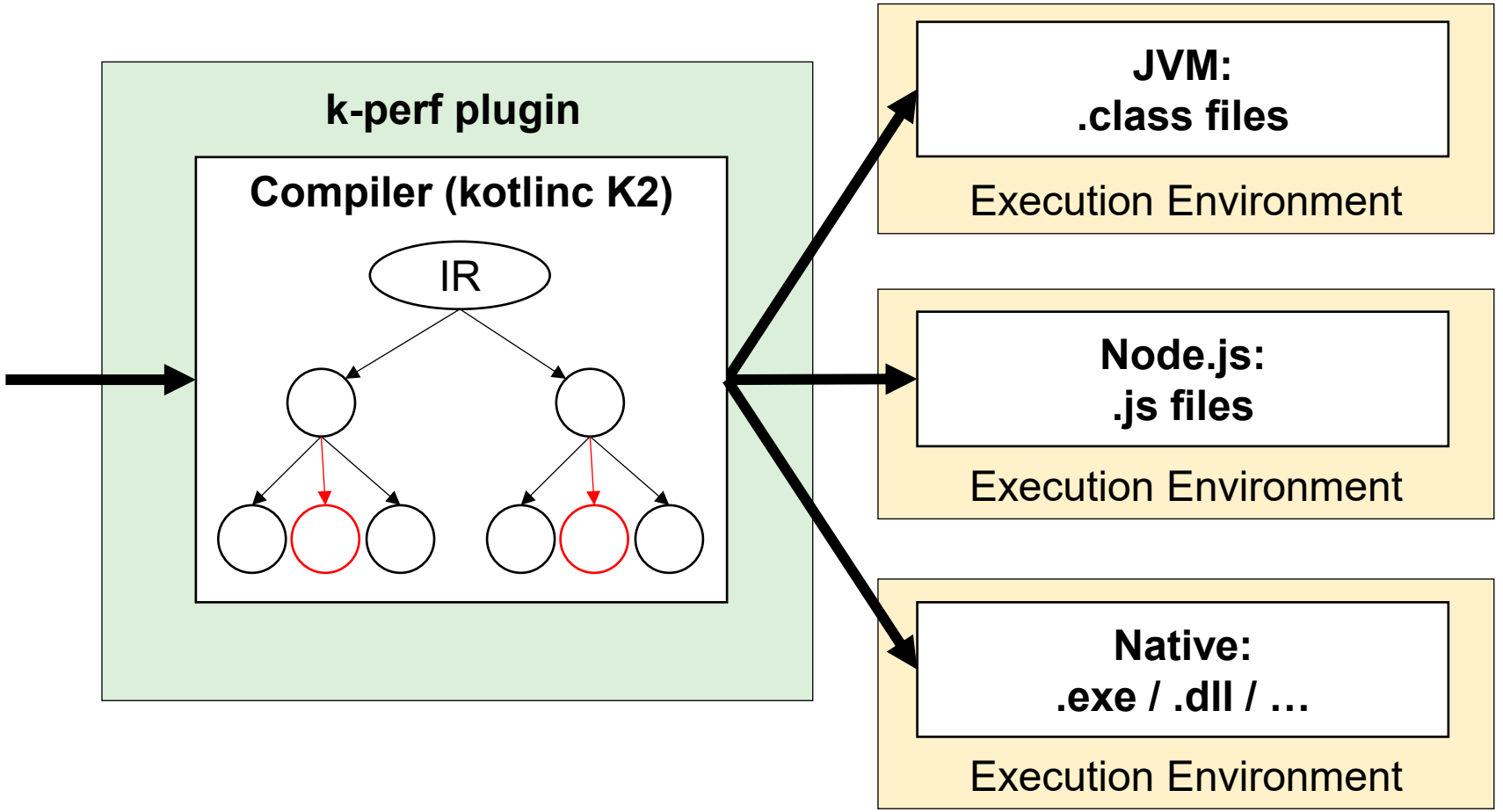

K-perf Plugin

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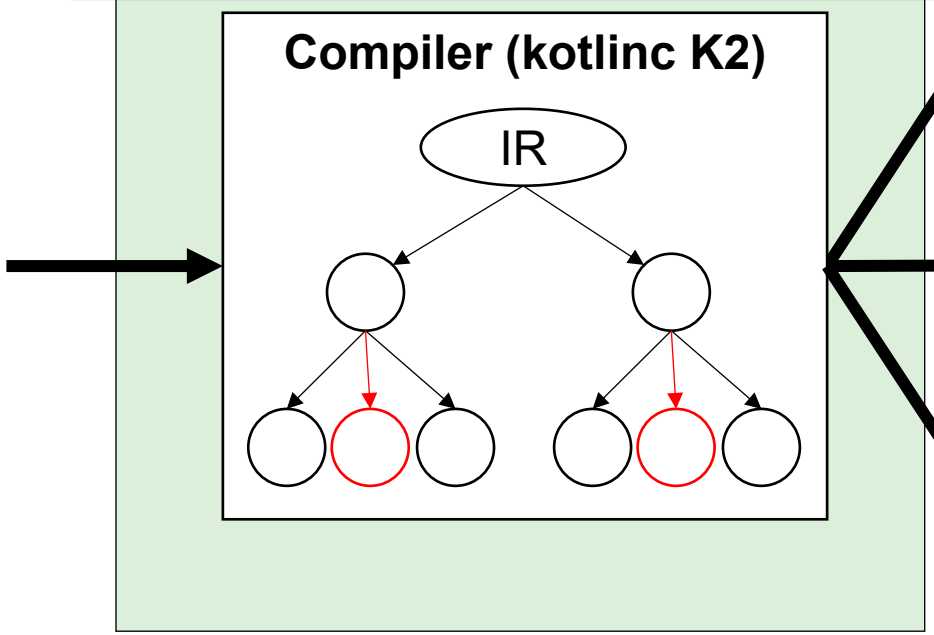
  }
}
```

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



JVM:
.class files

Execution Environment

Node.js:
.js files

Execution Environment

Native:
.exe / .dll / …

Execution Environment

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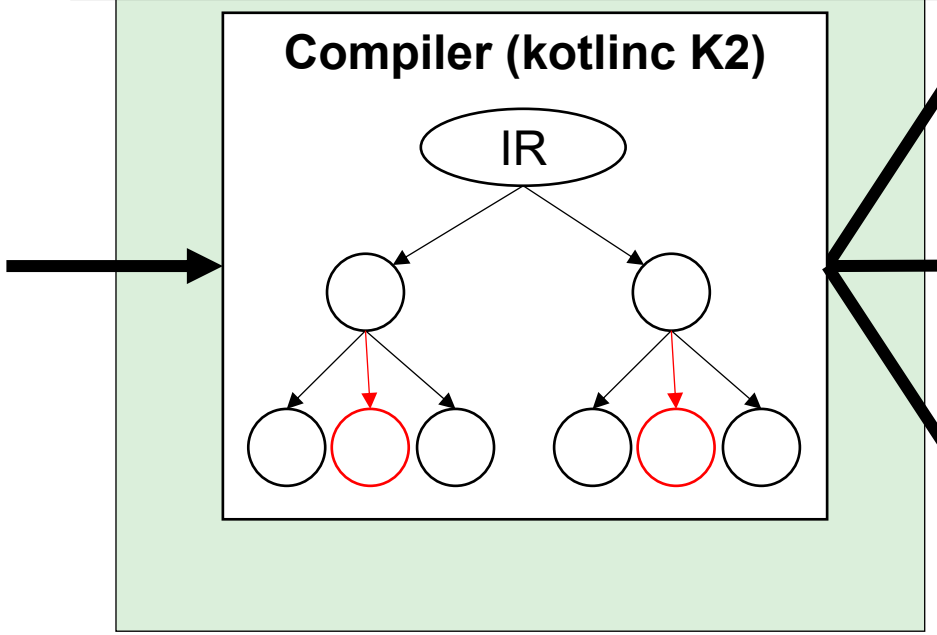

JVM:
.class files

Execution Environment

Node.js:
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Execution Environment

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.exe / .dll / …

Execution Environment

We want to simplify the generation of those additional IR nodes

K-perf Plugin

K-perf Plugin

```
val bufferedTraceFileSink : Sink =
  fs.sink(Path(traceName)).buffered()
```

K-perf Plugin

Sink ~ File

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K-perf Plugin

Sink ~ File

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val bufferedTraceFileSink : Sink =
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```
val bufferedTraceFileSink = pluginContext.irFactory.buildField {
    name = Name.identifier("bufferedTraceFileSink")
    type = rawSinkClass.defaultType
    isFinal = false
    isStatic = true
}.apply {
    initializer = DeclarationIrBuilder(pluginContext, firstFile.symbol).run {
        irExprBody(irCall(bufferedFunc).apply {
            extensionReceiver = irCall(sinkFunc).apply {
                dispatchReceiver = irCall(systemFileSystem.owner.getter!!)
                putValueArgument(
                    0,
                    irCall(pathConstructionFunc).apply {
                        putValueArgument(0, irGetField(null, bufferedTraceFileName))
                    })
            }
        })
    }
}
```

K-perf Plugin

Sink ~ File

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            }
        })
    }
}
```

K-perf Plugin

Sink ~ File

```
val bufferedTraceFileSink : Sink =
  fs.sink(Path(traceName)).buffered()
```

```
val bufferedFunc = pluginContext.referenceFunctions(
   CallableId(
      FqName("kotlinx.io"),
      Name.identifier("buffered")
   )
).single { it.owner.extensionReceiverParameter!!.type
== sinkFunc.owner.returnType }
```

```
val rawSinkClass = …
```

```
val sinkFunc = …
```

```
val systemFileSystem = …
```

```
val pathConstructionFunc = …
```

```
val bufferedTraceFileSink = pluginContext.irFactory.buildField {
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      })
   }
}
```

K-perf Plugin

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               })
}
```

We first have to manually look up all classes, functions, properties, … we need in the generation process

K-perf Plugin

Sink ~ File

```
val bufferedTraceFileSink : Sink =
  fs.sink(Path(traceName)).buffer
```

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val bufferedFunc = pluginContext.referenc
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```

```
val rawSinkClass = ...
```

```
val sinkFunc = ...
```

```
val systemFileSystem = ...
```

```
val pathConstructionFunc = ...
```

Future Work

```
redTraceFileSink = pluginContext.irFactory.buildField {
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```

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```

```
val sinkFunc = ...
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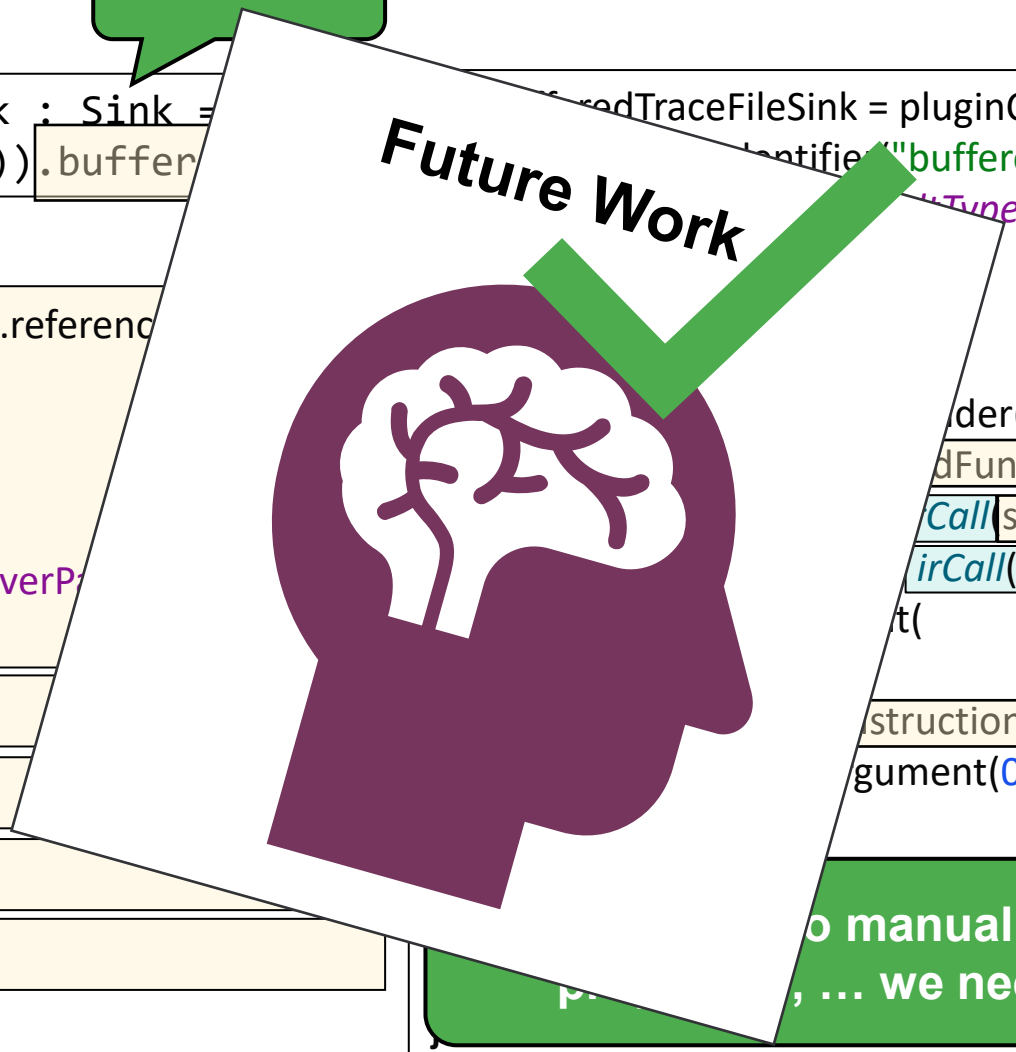
```
val systemFileSystem = ...
```

```
val pathConstructionFunc = ...
```

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Goal of the KIRHelperKit

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            }
        })
    }
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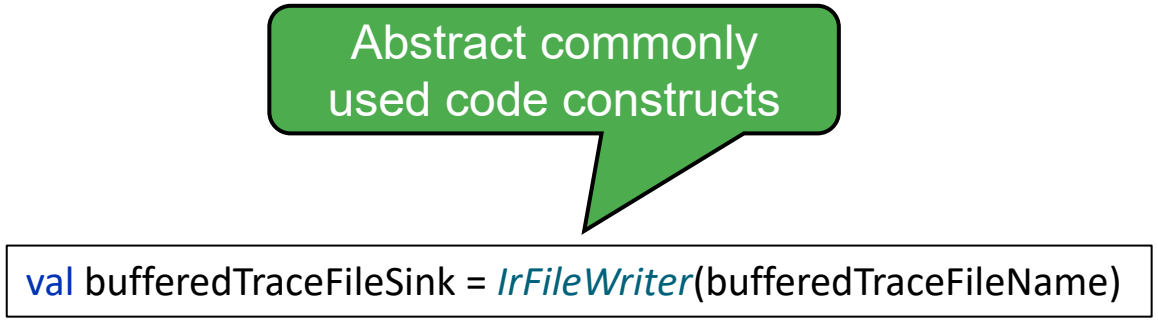
```

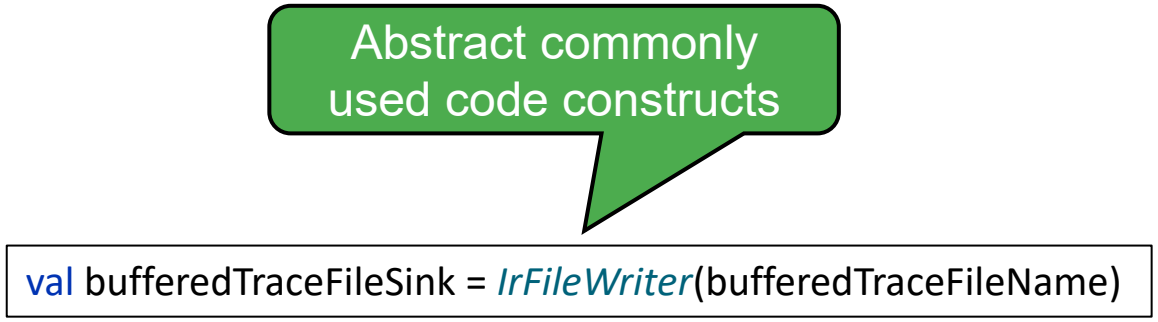
Goal of the KIRHelperKit

```
val bufferedTraceFileSink = IrFileWriter(bufferedTraceFileName)
```

Goal of the KIRHelperKit



Goal of the KIRHelperKit



Streamline lookup operations

Goal of the KIRHelperKit

Abstract commonly used code constructs

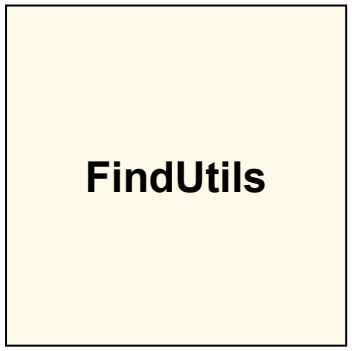
```
val bufferedTraceFileSink = IrFileWriter(bufferedTraceFileName)
```

Streamline lookup operations

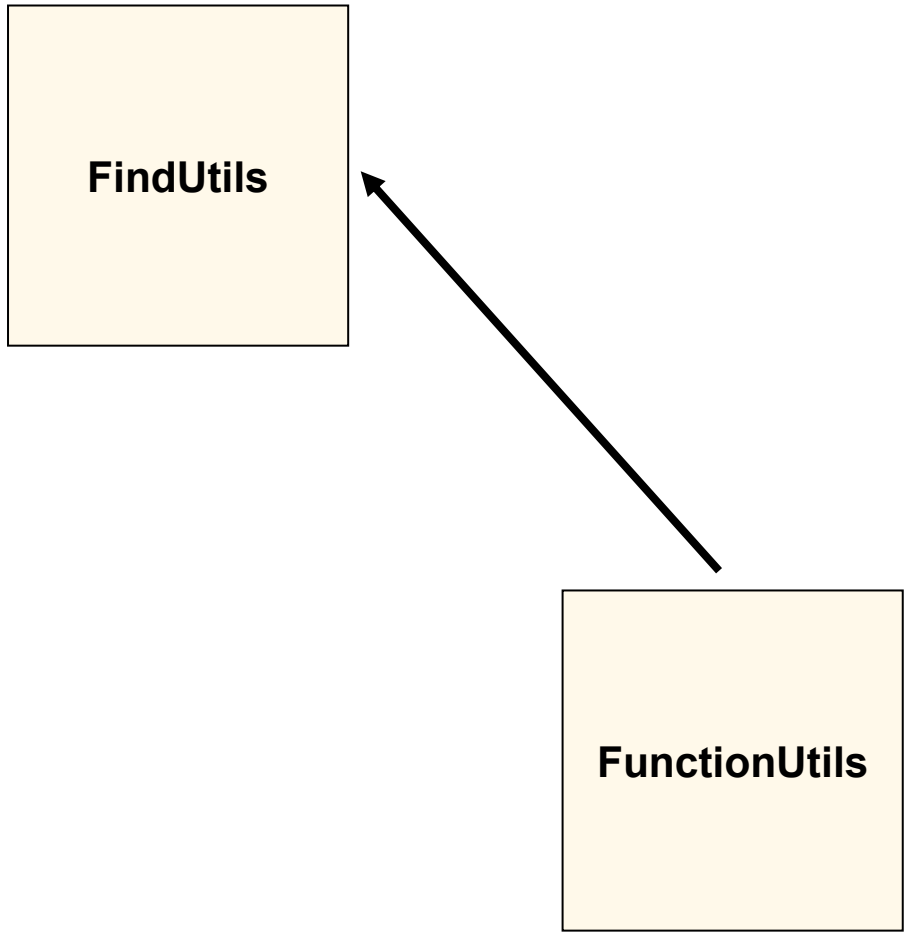
Reduce complexity of function call generation

KIRHelperKit

KIRHelperKit



KIRHelperKit



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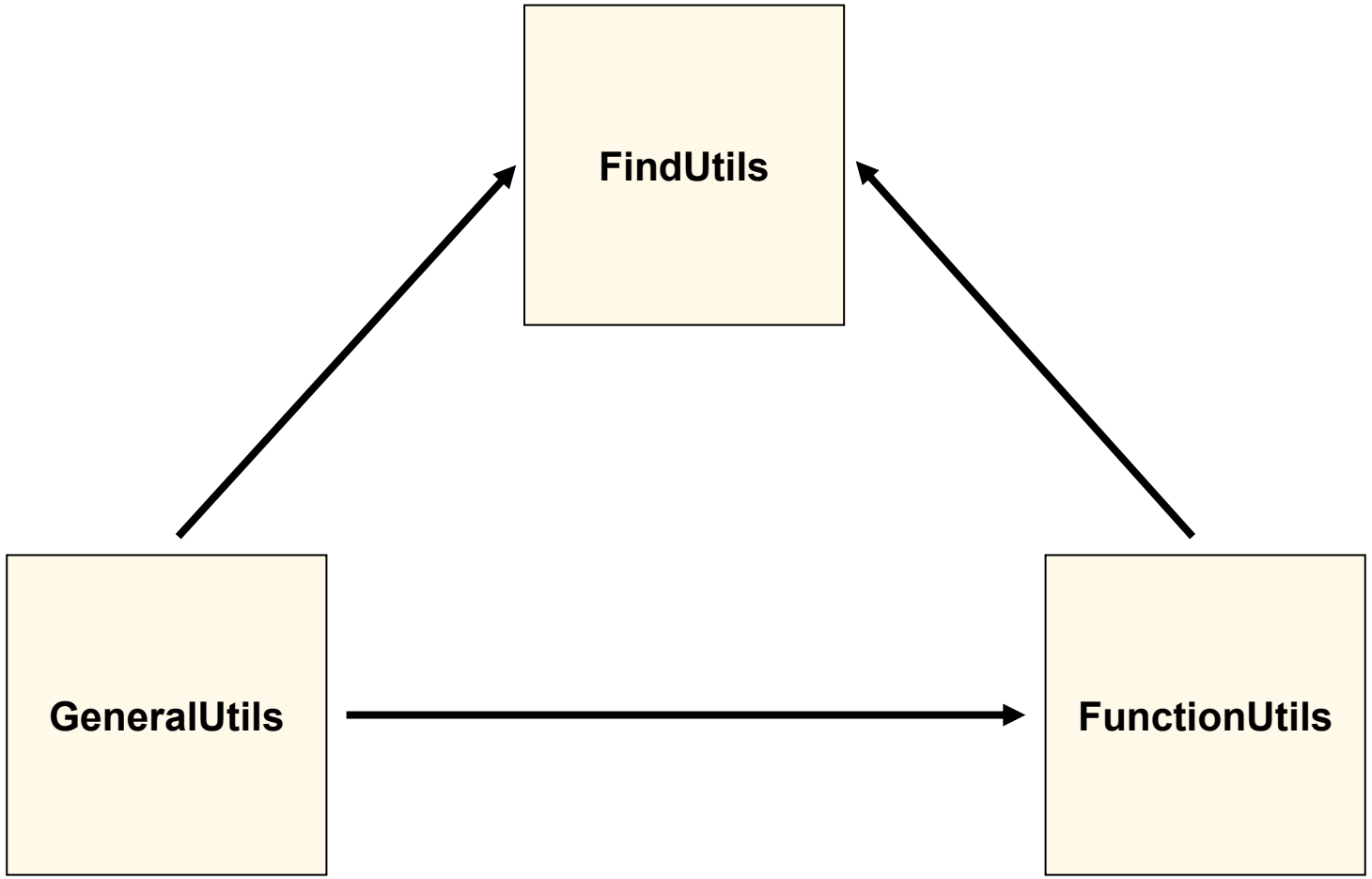

KIRHelperKit

FindUtils

KIRHelperKit

FindUtils

AtomicInteger.*getAndAdd*(Int)

KIRHelperKit

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AtomicInteger.*getAndAdd*(Int)

Goal: find this function

KIRHelperKit

FindUtils

AtomicInteger.*getAndAdd*(Int)

Goal: find this function

```
val addFn =
pluginContext.referenceFunctions(CallableId(
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KIRHelperKit

FindUtils

AtomicInteger.*getAndAdd*(Int)

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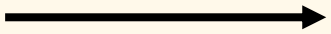

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Search based on simple String

KIRHelperKit

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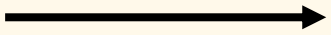

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val addFn = pluginContext.findFunction(
    "java/util/concurrent/atomic/
    AtomicInteger.getAndAdd(int)"
)
```

Search based on simple String

KIRHelperKit

FindUtils

AtomicInteger.*getAndAdd*(Int)

Goal: find this function

```
val addFn =
pluginContext.referenceFunctions(CallableId(
    FqName("java.util.concurrent.atomic"),
    FqName("AtomicInteger"),
    Name.identifier("getAndAdd")
)).single { func ->
    func.valueParameters.size == 1 &&
    func.valueParameters[0].type ==
        pluginContext.irBuiltIns.intType
}
```

```
val addFn = pluginContext.findFunction(
    "java/util/concurrent/atomic/
    AtomicInteger.getAndAdd(int)"
)
```

Search based on simple String

KIRHelperKit

FindUtils

Global Lookup

KIRHelperKit

FindUtils

Global Lookup

```
pluginContext.findClass("package/class")
```

KIRHelperKit

FindUtils

Global Lookup

```
pluginContext.findClass("package/class")
```

```
pluginContext.findConstructor("package/class(p)")
```

KIRHelperKit

FindUtils

Global Lookup

```
pluginContext.findClass("package/class")
```

```
pluginContext.findConstructor("package/class(p)")
```

```
pluginContext.findFunction("package/class.fun(p)")
```

KIRHelperKit

FindUtils

Global Lookup

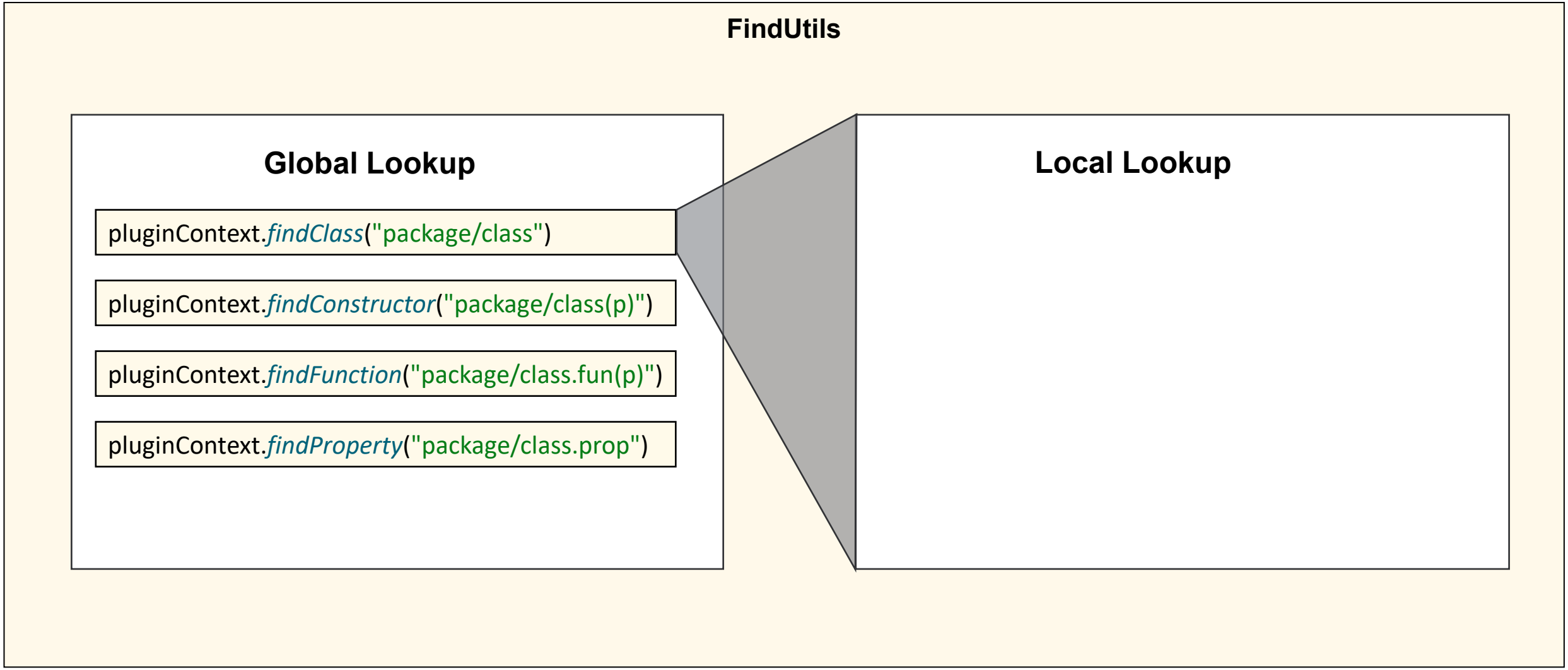
```
pluginContext.findClass("package/class")
```

```
pluginContext.findConstructor("package/class(p)")
```

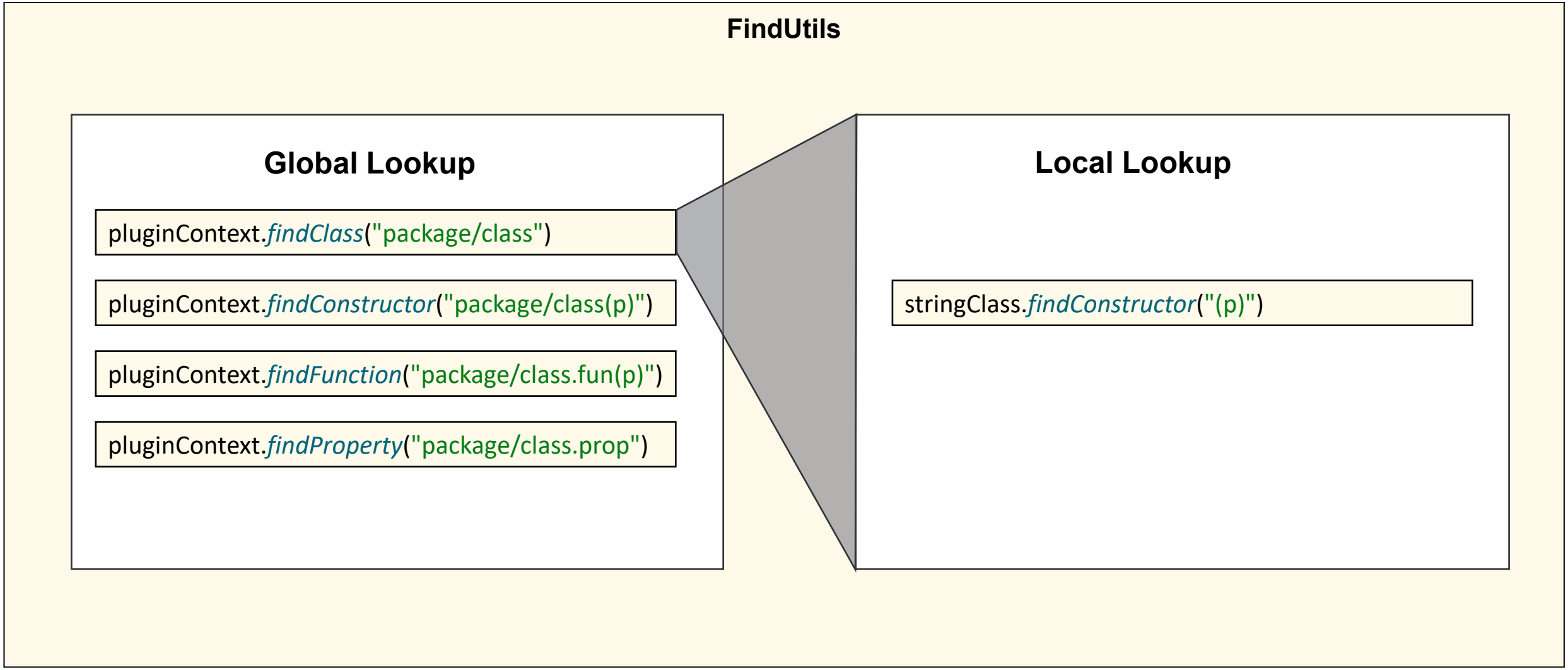
```
pluginContext.findFunction("package/class.fun(p)")
```

```
pluginContext.findProperty("package/class.prop")
```

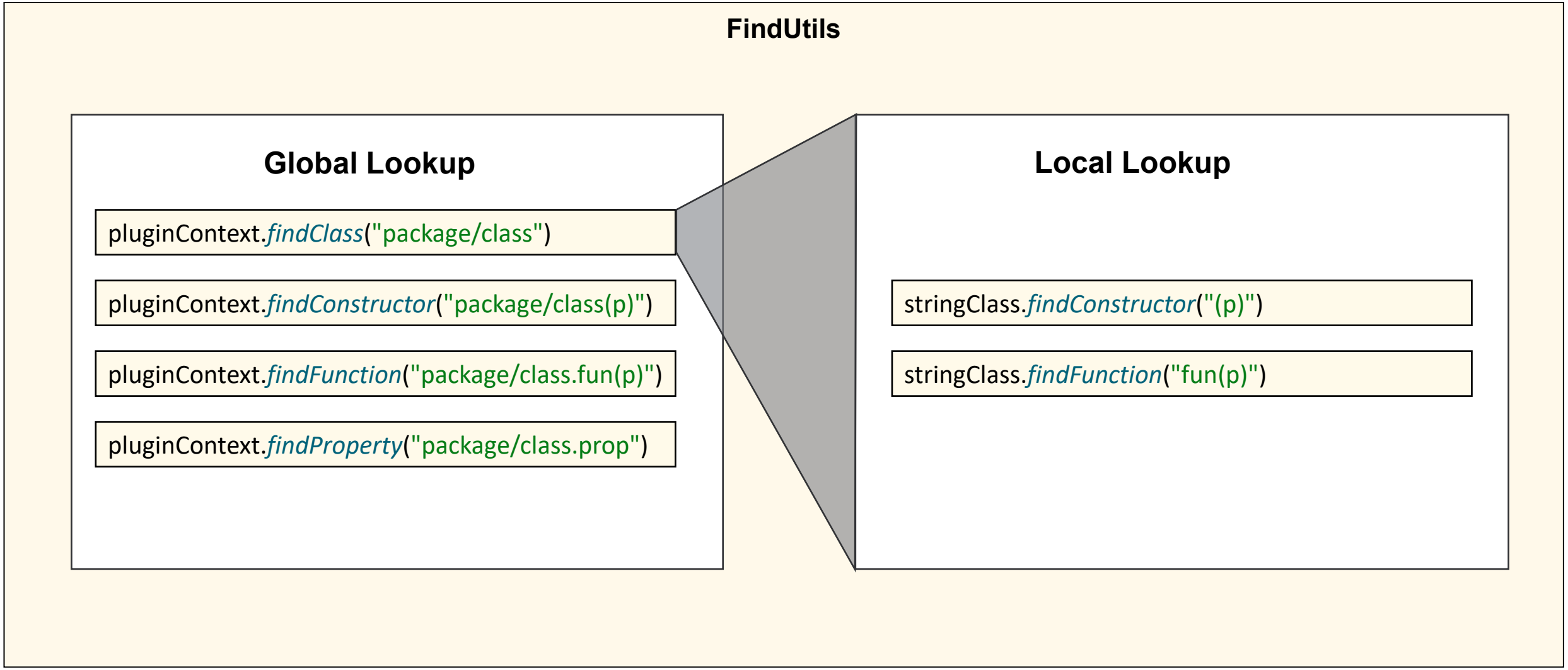
KIRHelperKit



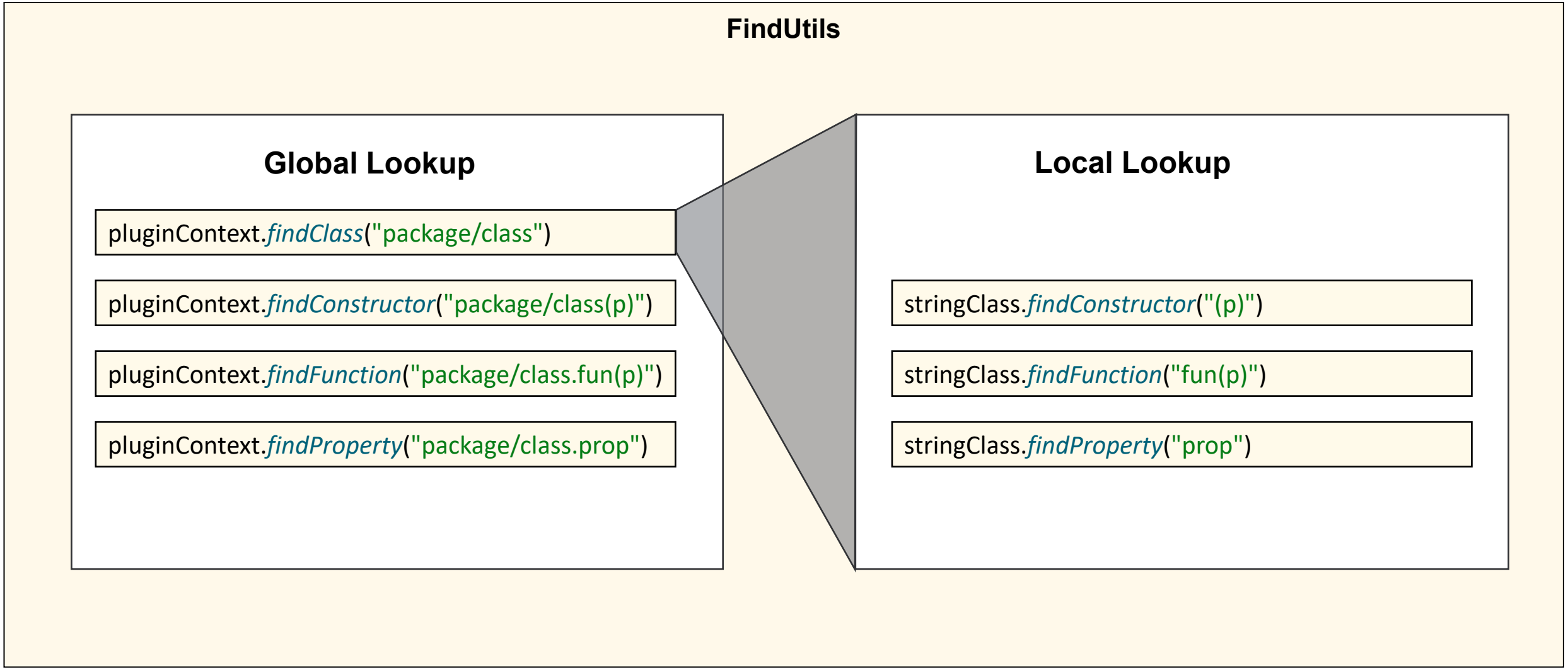
KIRHelperKit



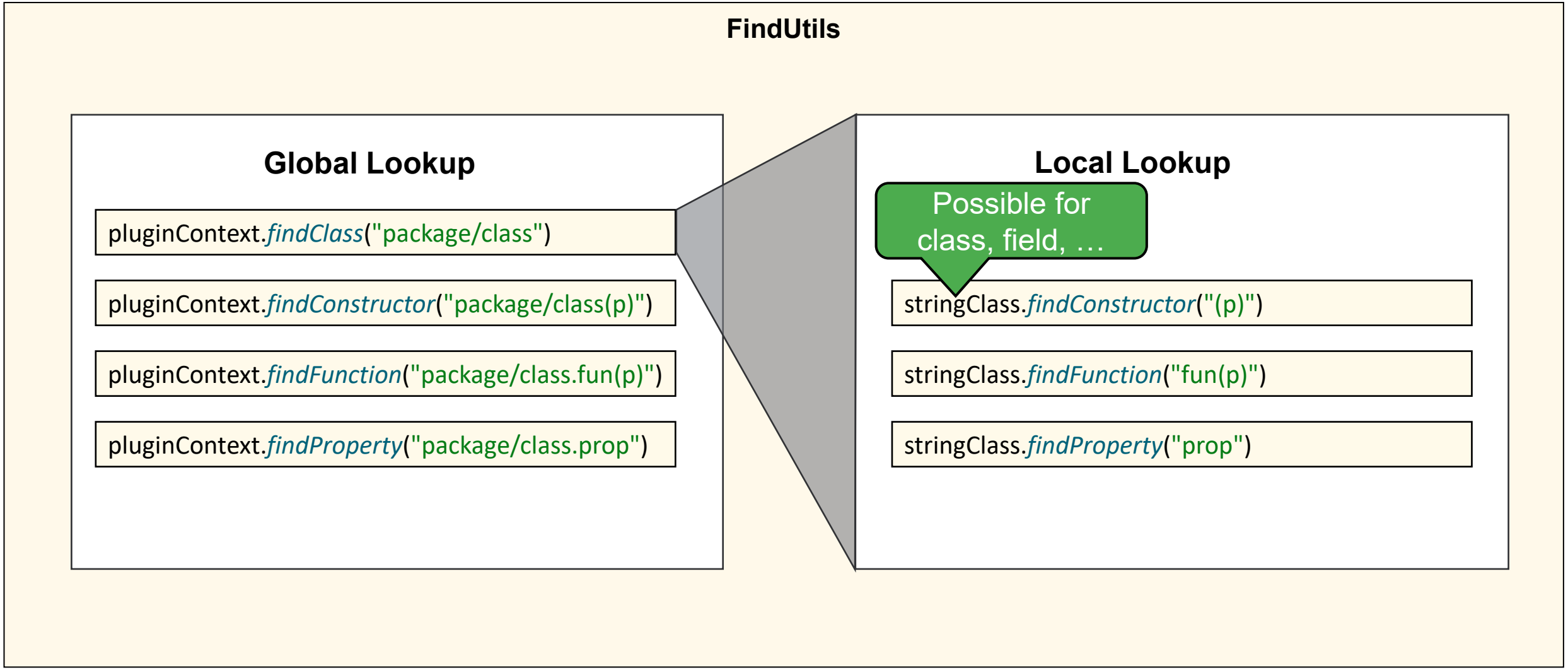
KIRHelperKit



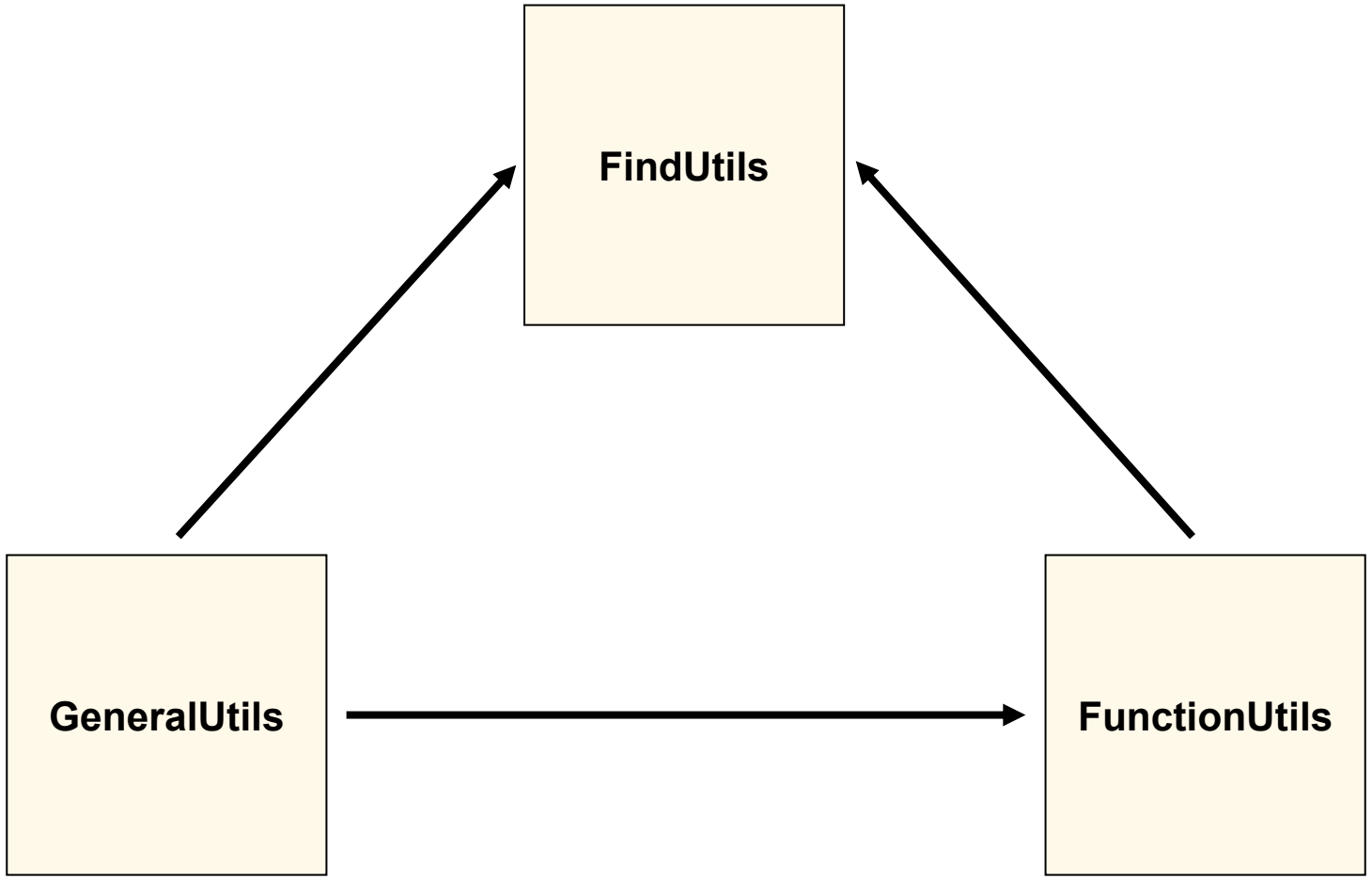
KIRHelperKit



KIRHelperKit



KIRHelperKit



KIRHelperKit

FunctionUtils

KIRHelperKit

FunctionUtils

```
val couter = AtomicInteger()
counter.getAndAdd(2).toString()
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KIRHelperKit

FunctionUtils

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Goal: generate these function calls

KIRHelperKit

FunctionUtils

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```
val toStringFn = ...
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        putValueArgument(0, irInt(2))
    }
}
```

KIRHelperKit

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Recursive structure

KIRHelperKit

FunctionUtils

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Recursive structure

KIRHelperKit

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KIRHelperKit

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}
```

Recursive structure

→

```
val toStringCall = counter.call("getAndAdd(int)", 2).call("toString()")
```

KIRHelperKit

FunctionUtils

```
val couter = AtomicInteger()
counter.getAndAdd(2).toString()
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Goal: generate these function calls

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val toStringFn = ...
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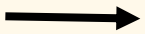
Recursive structure



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KIRHelperKit

FunctionUtils

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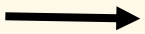
}
```

Recursive structure



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KIRHelperKit

FunctionUtils

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}
```

Recursive structure

→

```
val toStringCall = counter.call("getAndAdd(int)", 2).call("toString()")
```

Automatic conversion of parameters

KIRHelperKit

FunctionUtils

```
val couter = AtomicInteger()
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```
val toStringFn = ...
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        dispatchReceiver = irGetField(null, counter)
        putValueArgument(0, irInt(2))
    }
}
```

Recursive structure

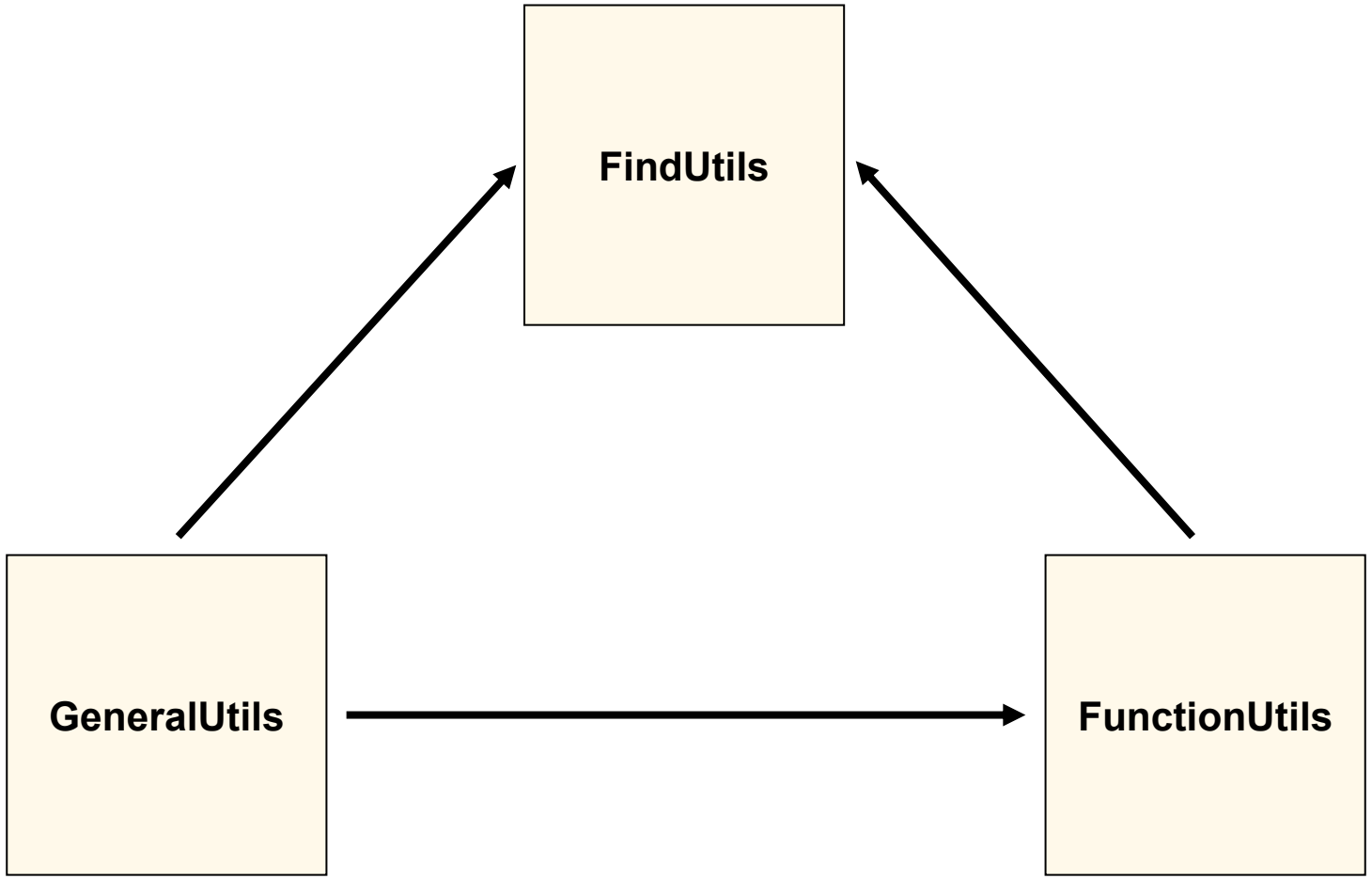
→

```
val toStringCall = counter.call("getAndAdd(int)", 2).call("toString()")
```

No more need for manual lookup

Automatic conversion of parameters

KIRHelperKit



KIRHelperKit

GeneralUtils

KIRHelperKit

GeneralUtils

```
IrPluginContext.generateField ("fieldName", init)
```

KIRHelperKit

GeneralUtils

```
IrPluginContext.generateField ("fieldName", init)
```

```
IrStringBuilder()
```

KIRHelperKit

GeneralUtils

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IrPluginContext.generateField ("fieldName", init)
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```
IrStringBuilder()
```

```
IrFileReader("fileName")
```

KIRHelperKit

GeneralUtils

```
IrPluginContext.generateField ("fieldName", init)
```

```
IrStringBuilder()
```

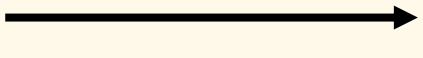
```
IrFileReader("fileName")
```

```
IrFileWriter("fileName")
```

KIRHelperKit

GeneralUtils

IrPluginContext.*generateField* ("fieldName", init)



```
val field = pluginContext.generateField("field") {
    //... initializer
}
```

IrStringBuilder()

IrFileReader("fileName")

IrFileWriter("fileName")

KIRHelperKit

GeneralUtils

IrPluginContext.*generateFie*

IrStringBuilder()

IrFileReader("fileName")

IrFileWriter("fileName")

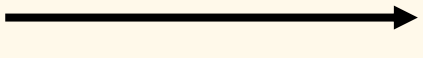
```
val output = pluginContext.irFactory.buildField {
    name = Name.identifier("output")
    type = rawSinkClass.defaultType
    isFinal = false
    isStatic = true
}.apply {
    initializer = DeclarationIrBuilder(pluginContext, firstFile.symbol).run {
        irExprBody(irCall(bufferedFunc).apply {
            extensionReceiver = irCall(sinkFunc).apply {
                dispatchReceiver = irCall(systemFileSystem.owner.getter!!)
                putValueArgument(
                    0,
                    irCall(pathConstructionFunc).apply {
                        putValueArgument(0, irGetField(null, bufferedTraceFileName))
                    })
            }
        })
    }
}
```

rateField("field") {

KIRHelperKit

GeneralUtils

IrPluginContext.*generateField* ("fieldName", init)



```
val field = pluginContext.generateField("field") {
    //... initializer
}
```

IrStringBuilder()

IrFileReader("fileName")

IrFileWriter("fileName")

KIRHelperKit

GeneralUtils

IrPluginContext.*generateField* ("fieldName", init)

```
val field = pluginContext.generateField("field") {
    //... initializer
}
```

IrStringBuilder()

IrFileReader("fileName")

IrFileWriter("fileName")

```
val output = IrFileWriter("fileName")
output.writeData ("Hello World!")
```

KIRHelperKit

GeneralUtils

IrPluginContext.*generateField* ("fieldName", init)

```
val field = pluginContext.generateField("field") {
   //... initializer
}
```

IrStringBuilder()

IrFileReader("fileName")

IrFileWriter("fileName")

Generate file source field

```
val output = IrFileWriter("fileName")
output.writeData ("Hello World!")
```

KIRHelperKit

GeneralUtils

IrPluginContext.*generateField* ("fieldName", init)

```
val field = pluginContext.generateField("field") {
   //... initializer
}
```

IrStringBuilder()

IrFileReader("fileName")

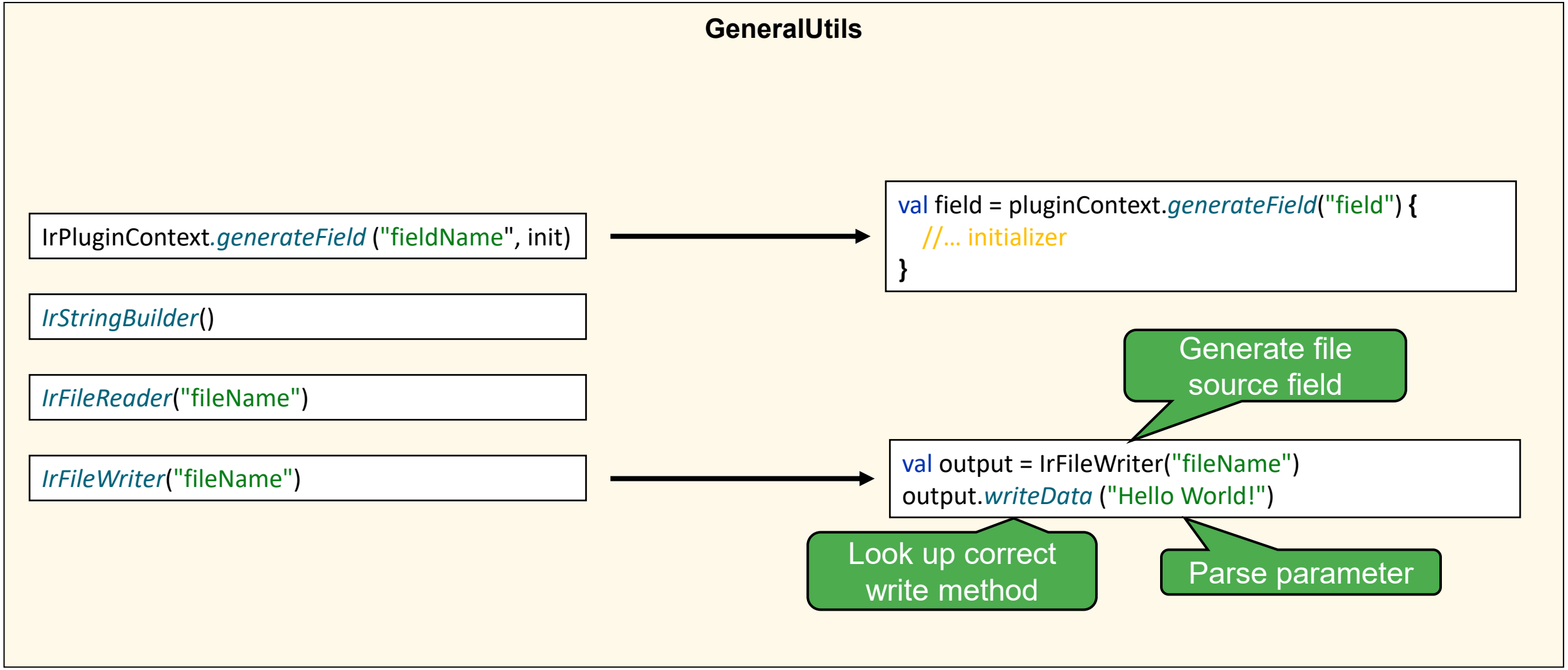
IrFileWriter("fileName")

```
val output = IrFileWriter("fileName")
output.writeData ("Hello World!")
```

Generate file source field

Look up correct write method

KIRHelperKit



Results: Code Reduction

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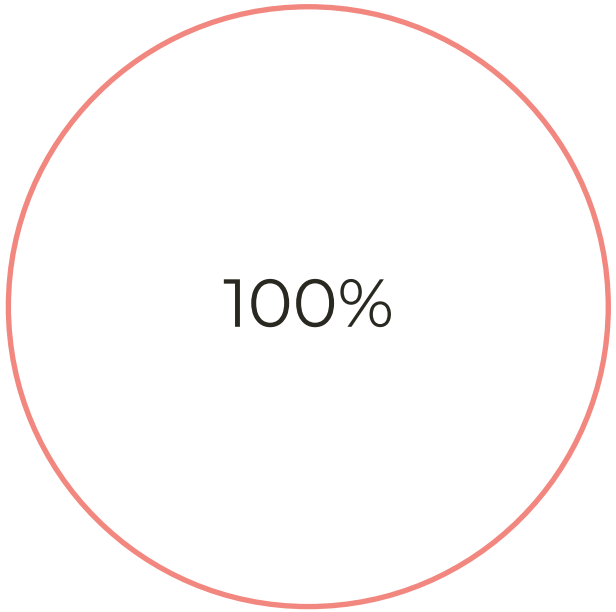
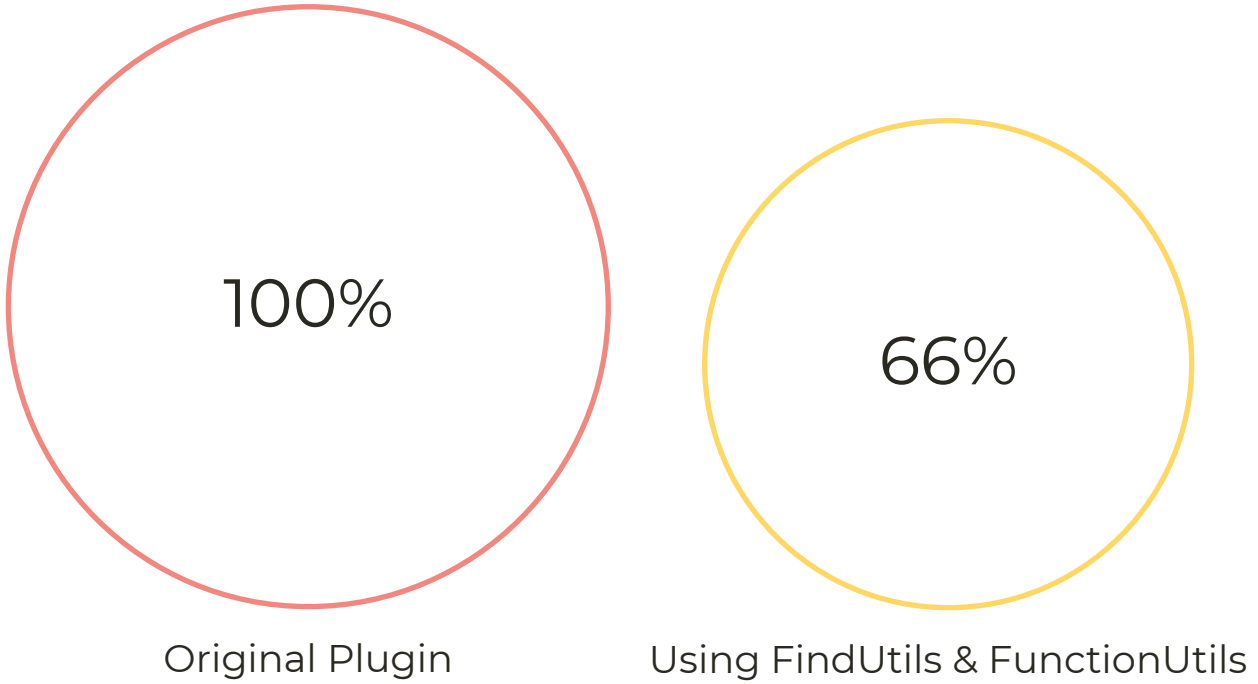


Original Plugin

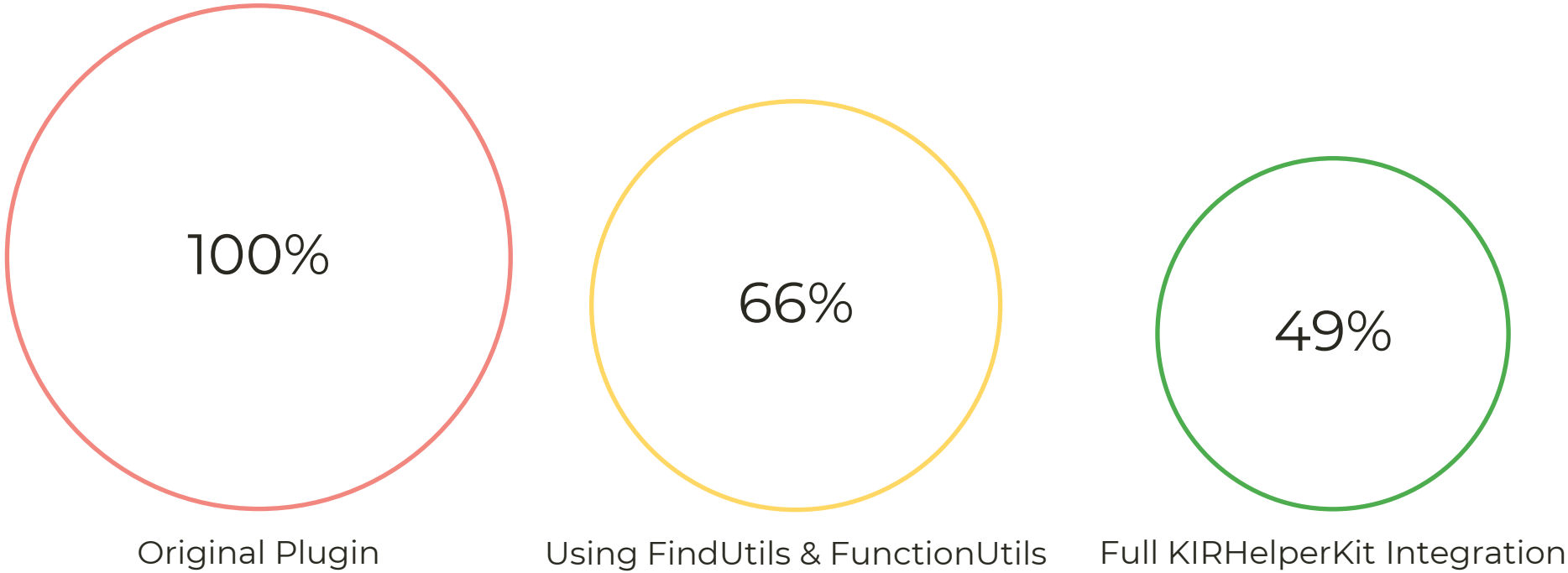
Results: Code Reduction



Original Plugin

Using FindUtils & FunctionUtils

Results: Code Reduction

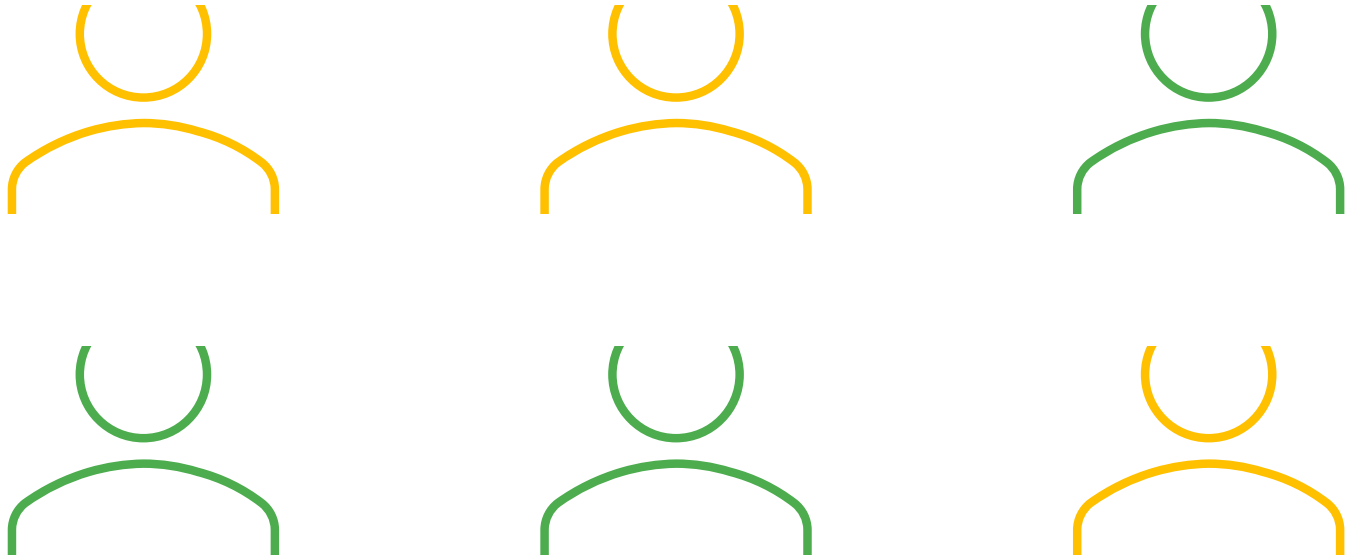


Original Plugin

Using FindUtils & FunctionUtils

Full KIRHelperKit Integration

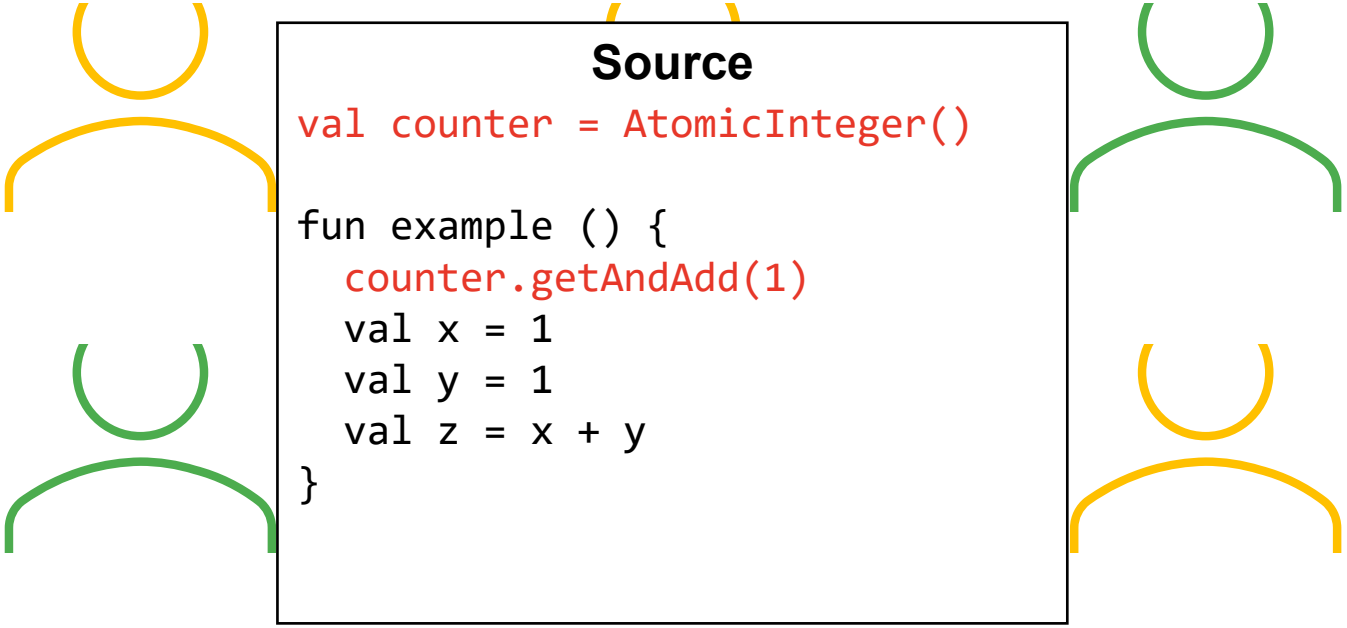
Results: User Study



With IR Experience

Without IR Experience

Results: User Study



With IR Experience

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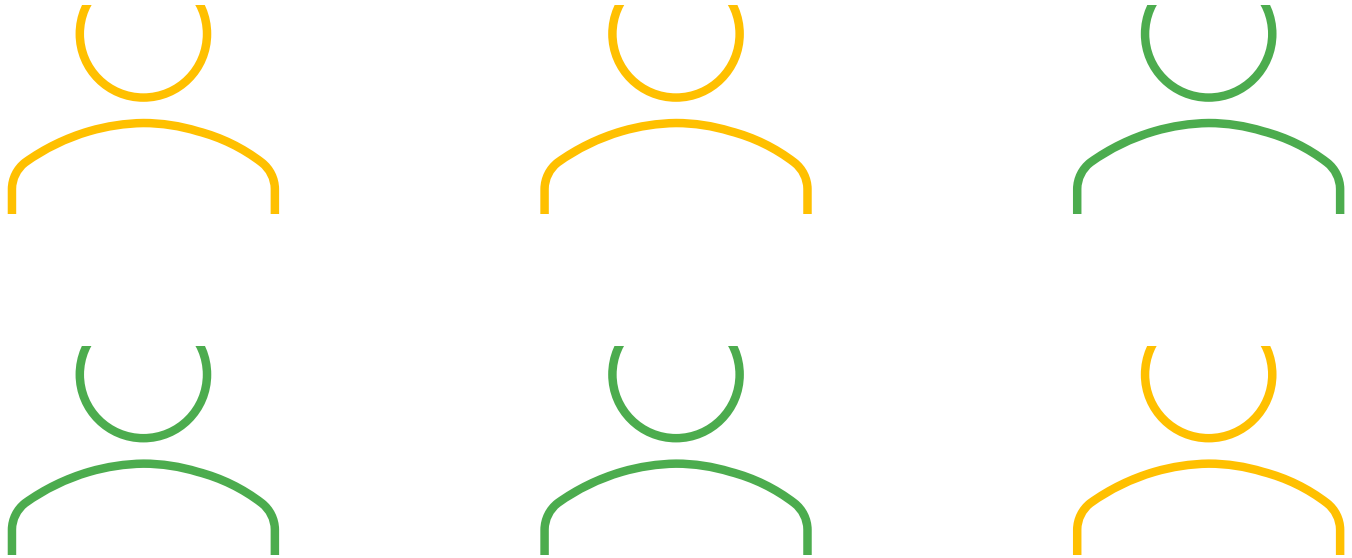

With IR Experience

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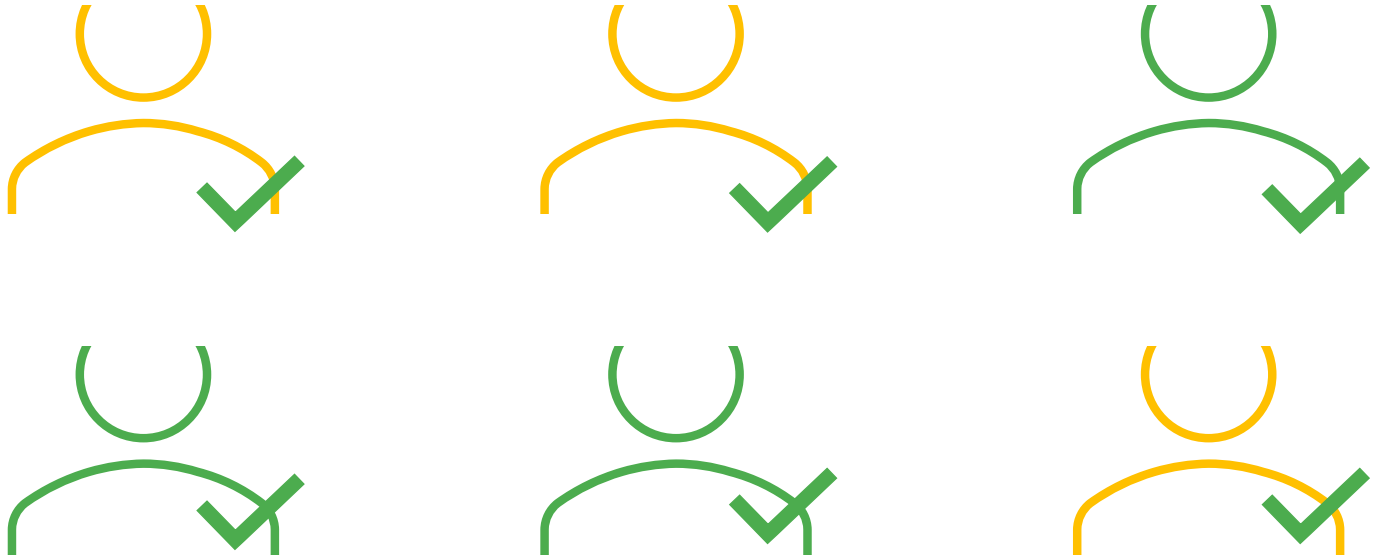
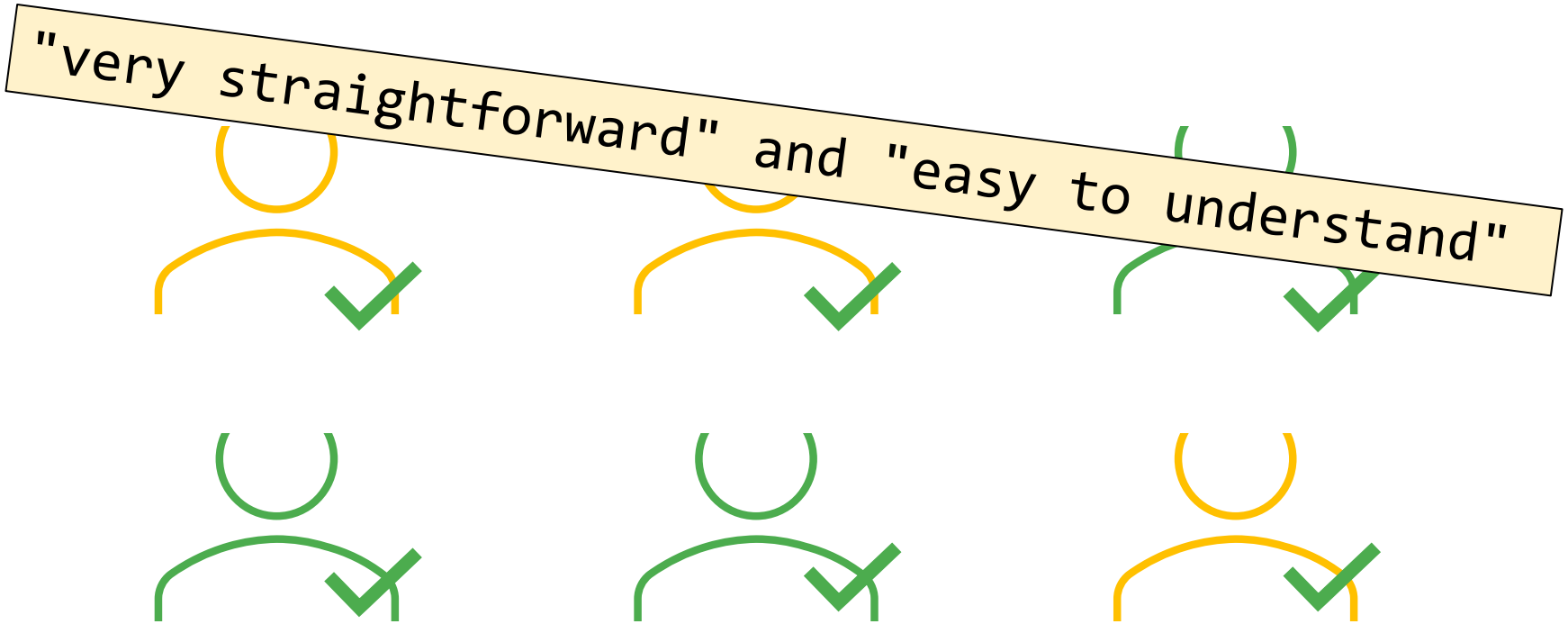


2:17 - 10:30 minutes

With IR Experience

Without IR Experience

Results: User Study



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With IR Experience

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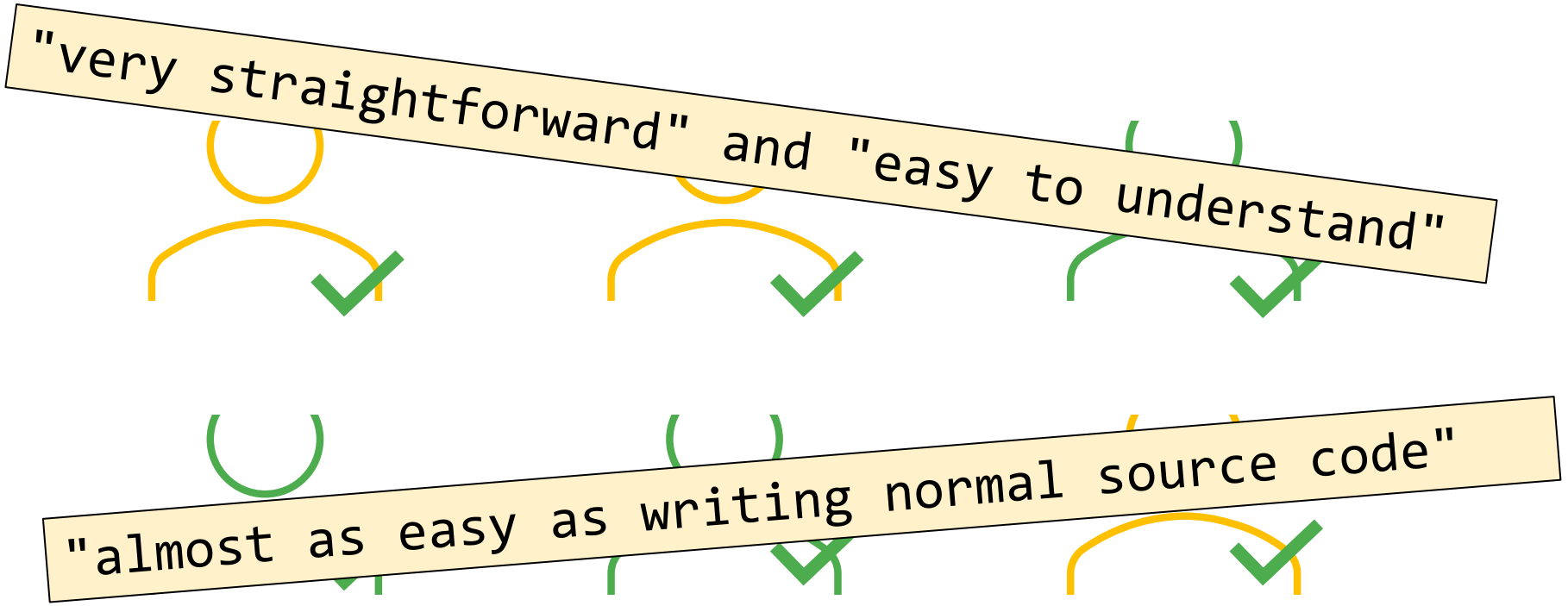

2:17 - 10:30 minutes

With IR Experience

Without IR Experience

User Study / Future Work

User Study / Future Work

Aspect-oriented plugin design

User Study / Future Work

- Aspect-oriented plugin design
- More features for the general utilities

User Study / Future Work

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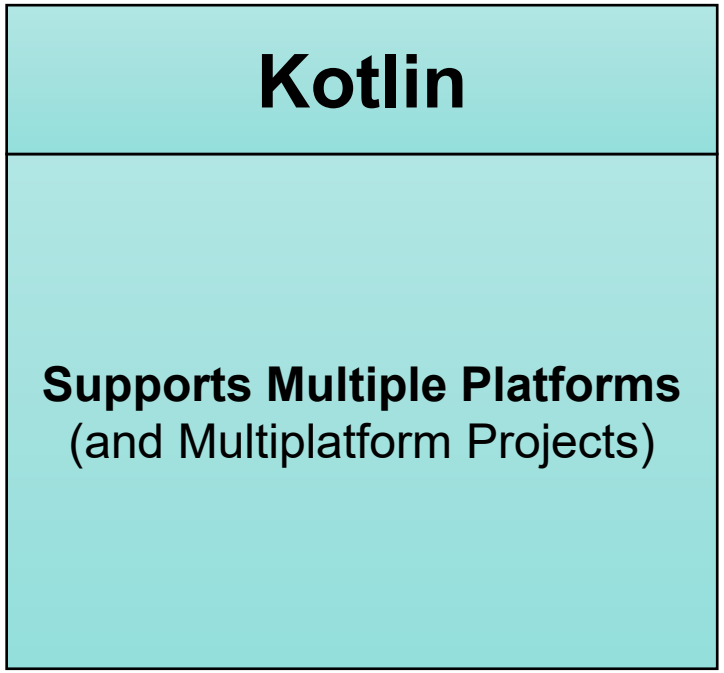
- More features for the general utilities
- Analyze other compiler plugins

User Study / Future Work

- Aspect-oriented plugin design
- More features for the general utilities
- Analyze other compiler plugins
- Student / developer feedback

Summary

Summary


Kotlin
Supports Multiple Platforms
(and Multiplatform Projects)

Summary

Kotlin	Kotlin Plugins
Supports Multiple Platforms (and Multiplatform Projects)	Extremly Versatile (but sadly badly documented) **Common Instrumentation for Multiple Targets using a Single Plugin**

Summary

Kotlin	Kotlin Plugins	KIRHelperKit
Supports Multiple Platforms (and Multiplatform Projects)	Extremly Versatile (but sadly badly documented) **Common Instrumentation for Multiple Targets using a Single Plugin**	Simplifies IR Plugin Development **Unified Search API** **Function Call DSL** **Utility Functions**

Summary

Kotlin

Supports Multiple Platforms
(and Multiplatform Projects)

Kotlin Plugins

Extremly Versatile (but sadly badly documented)

Common Instrumentation for Multiple Targets using a Single Plugin

KIRHelperKit

Simplifies IR Plugin Development

Unified Search API
Function Call DSL
Utility Functions

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