

# An Empirical Study of Kotlin-Java Interactions

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## ABSTRACT

**Background:** Since Google introduced Kotlin as an official programming language for developing Android apps in 2017, Kotlin has gained widespread adoption in Android development. The interoperability of Java and Kotlin’s design nature allows them to coexist and interact with each other smoothly within a project. **Aims:** However, there is limited research on how Java and Kotlin interact with each other in real-world projects and what challenges are faced during these interactions. The answers to these questions are key to understanding these kinds of cross-language software systems. **Methods:** In this paper, we implemented a tool named *DependExtractor*, which can extract 11 kinds of Kotlin-Java dependencies, and conducted an empirical study of 23 Kotlin-Java real-world projects with 3,227 Java and 8,630 Kotlin source files. **Results:** Our findings revealed that Java and Kotlin frequently interact with each other in these cross-language projects, with access and call dependency types being the most dominant. Compared to files interacting with other files in the same language, Java/Kotlin source files, which participate in the cross-language interactions, undergo more commits. Additionally, among all Kotlin-Java problematic interactions, we identified seven common mistakes, along with their fixing strategies. **Conclusions:** The findings of this study can help developers understand and address the challenges in Kotlin-Java projects.

## KEYWORDS

Kotlin, Java, Code Dependency, Cross Language

## 1 INTRODUCTION

Since Google introduced Kotlin as an official programming language for developing Android apps in 2017, Kotlin has gained widespread adoption in Android development. According to recent studies, a significant of Android apps have been continuously migrated from Java to Kotlin [7, 20]. The interoperability of Java and Kotlin’s design nature allows them to coexist and evolve smoothly in a single project. Meanwhile, understanding the dependencies among software entities is fundamental to various aspects of software analysis, such as architecture recovery, code smell detection, and software quality evaluation [10, 22, 27]. Extracting and understanding the dependency interactions between Java and Kotlin code is essential for conducting software analysis in such cross-language software systems. Despite the increasing popularity of Kotlin and its interoperability with Java, there is limited research on how Java and Kotlin interact with and depend on each other in real-world projects. Furthermore, recent studies [17] have shown that a large percentage of bug fixes in deep learning frameworks implemented in Python and C++ involve modifying source code in both programming languages. Moreover, the complexity of code changes for such bug fixes is significantly higher than that of fixes in single-programming-language scenarios [18]. Similarly, many Android

applications are developed using both Java and Kotlin, mirroring the dual-language nature of deep learning frameworks which commonly employ Python and C++. Unlike the interactions between Python and C++, which rely on their compiled public APIs, Java and Kotlin, both being based on the Java Virtual Machine (JVM), can extensively depend on each other at the source code level. This raises the question of whether Kotlin-Java software systems also incur higher maintenance costs and are prone to cross-language bugs, similar to other multi-language systems like Python-C++. In other words, what challenges do developers face in the implementation and maintenance of Kotlin-Java systems? Understanding these challenges can assist researchers and practitioners in designing solutions and tools to navigate these issues and ensure the development of high-quality Kotlin-Java software systems.

Although Google Android have provided documentation to guide developers on integrating Kotlin and Java [3], the challenges faced in real-world projects remain largely unknown. In this paper, we propose to investigate into the dependency relations between Kotlin and Java in real-world projects to better understand the challenges associated with their interactions. To this end, we conducted an empirical study of 23 open-source projects, comprising 3,227 Java and 8,630 Kotlin source files. We developed a static code analysis tool to extract 11 kinds of dependency relations between Kotlin and Java code entities within these projects. Our findings indicate that Java and Kotlin frequently interact in these cross-language projects, with access and call dependency types being the most prevalent.

Compared to files interacting solely within the same language, Java/Kotlin source files that act as the interface for cross-language interactions have undergone more commits, but not necessarily contain a higher volume of lines of code (LOC). Furthermore, we identified seven common mistakes in Kotlin-Java problematic interactions, which deserve special attention from developers. To the best of our knowledge, this work is the first to explore Kotlin-Java dependency relations and to expose common problems in these interactions within real-world projects. The dependency analysis tool that we have implemented and the recurring patterns in Kotlin-Java problematic interactions can assist developers in comprehending and uncovering potential pitfalls in such cross-language systems.

To summarize, our **contributions** in this paper are as follows:

- We implemented a static code analysis tool named *DependExtractor* to extract dependencies between Java and Kotlin, addressing a gap that existing static code analysis tools cannot resolve regarding such dependencies.
- We demonstrated that the source files involved in Kotlin-Java interactions require undergoing more commits and changes than those only involved in a single language. It proves that the Kotlin-Java interface is not stable and actively changing.

- We identified seven common mistakes which cause bugs and maintenance effort in Kotlin-Java problematic interactions. These common mistakes can serve as a taxonomy and deserve developers' special attention.

## 2 APPROACH

In this section, we describe our approach to extract Kotlin-Java dependencies and to identify recurring patterns in Kotlin-Java problematic interactions which incur maintenance cost.

### 2.1 Kotlin-Java Dependency Extraction

We implemented a tool called *DependExtractor* to extract dependencies between Kotlin and Java code entities. *DependExtractor* first utilized the Kotlin compiler to resolve Kotlin and Java source files into PSI (Program Structure Interface, similar to Abstract Syntax Tree) elements, including their types, reference types, and locations. Subsequently, it extracted dependency relations between pairs of PSI elements. Finally, these dependencies into a graph containing all PSI elements are aggregated and can be exported in JSON format, with each node representing a Kotlin or Java source file and each edge representing the dependencies between two source files. Following the definitions of dependency relations from related works [1, 5, 13], *DependExtractor* is capable of extracting 9 types of Java-Java dependencies, 14 types of Kotlin-Kotlin dependencies, and 11 types of Kotlin-Java dependencies. As this paper focuses mainly on Kotlin-Java interactions, we list the 11 types of Kotlin-Java dependencies and their descriptions in Table 1.

**Table 1: Kotlin-Java Dependency Types Extracted by *DependExtractor***

DepType	Description
Access	an expression accesses a field or property (kotlin side)
Call	an expression calls a method
Create	an expression creates an object
Extend	a class extends a parent class
Extension	a Kotlin method or property extension
Local Variable Typed (LVT)	a local variable uses a class as its type
Property Typed (PT)	a Kotlin property uses a Java class as its type
Implement	a class implements an interface
Import	a statement imports a type
Parameter	a method uses a class as its parameter
Return	a method returns a class type

As observed from Table 1, Access signifies that an expression in one source file accesses a field or property of a class in another source file, while Call indicates that an expression in one source file calls a method of a class in another source file. Note that we not only record the dependency type between two source files, but also resolve dependency relations at a fine-grained granularity, capturing details such as the expression statement, locations, and type information for each specific dependency. This fine-grained approach can be valuable for future refactoring research, including but not limited to null safety addressing, exception handling, etc.

### 2.2 Common Mistake Identification in Kotlin-Java Interaction

To detect recurring patterns associated with Kotlin-Java problematic interactions, we initially mined code repositories to narrow the problematic commit scope for manual inspection. Subsequently, we conducted a thorough manual inspection of code changes to identify and classify code patterns related to Kotlin-Java problematic interactions.

**2.2.1 Locate Commits to Address Kotlin-Java Problems.** We conducted the following filtering process to narrow the scope of potential commits to address Kotlin-Java issues.

- f1) A commit's comment must contain the words 'fix,' 'bug,' 'issue,' or 'exception', and the modified files in a commit must contain file paths with extensions either .java or .kt. All commits that satisfy condition f1 will be added to a collection C1 and proceed to the next filter.
- f2) The modified Java or Kotlin source files in a commit must be involved in Kotlin-Java interactions. For each project, we can obtain the dependency graph of its latest release using the approach outlined in Section 2.1 and identify the files in Kotlin-Java dependency edges. If a commit contains modified files on Kotlin-Java dependency edges, we add it to collection C2 and proceed to the process of manual inspection.

**2.2.2 Identify Common Mistakes of Kotlin-Java Problems through Manual Inspection.** We establish a protocol for this manual inspection process. First, we located the code changes in Kotlin or Java source file. Then we checked whether the code changes are related with Kotlin-Java interactions. We did this by tracing the code changes down to its reference type. For instance, if a line of code in a Kotlin file is deleted, we get the variables and methods in this line and track the variables down to check whether it is a type of Java class, method, etc. Subsequently, we check whether any new code snippets are added in the Kotlin file near the location of the deleted code line. If present, we compared the differences between the added line and the deleted line. Last, we check the commit comments and discussed what problems developers are trying to address and why developers made such changes.

This step required the dedicated efforts of 2 students with 4 years of Java and 3 years of Kotlin development experience, and one senior researcher with 14 years of Java and 3 years of Kotlin development experience. We followed the practice described in [9], allowing the senior researcher to establish the procedure for identifying code changes and training the students with examples. Then, the two students collaborated to identify code changes and categorize the changes' reasons. If disagreements occurred, the senior researcher would review the specific cases and discuss them with the two students until a consensus was reached.

## 3 STUDY DESIGN

### 3.1 Subjects

The objective of our study is to investigate the interactions between Kotlin and Java code within real-world projects, and we need to mine open source projects with both Kotlin and Java code. To

**Table 2: Demographic Information of Kotlin-Java Projects in Our Study**

ProjectName	#Stars	Kotlin(%)	Java(%)	Domain	Repository Link
bilimiao2	1300	73.5	24.7	Android	<a href="https://github.com/10miaomiao/bilimiao2">https://github.com/10miaomiao/bilimiao2</a>
DataStats	32	81.8	17.9	Android	<a href="https://github.com/takke/DataStats">https://github.com/takke/DataStats</a>
dgs-framework	3000	82.2	16	Library	<a href="https://github.com/Netflix/dgs-framework">https://github.com/Netflix/dgs-framework</a>
FDPClient	353	65.4	34	Minecraft	<a href="https://github.com/SkidderMC/FDPClient">https://github.com/SkidderMC/FDPClient</a>
Flap	286	52.4	47.6	Android	<a href="https://github.com/AlanCheen/Flap">https://github.com/AlanCheen/Flap</a>
grpc-kotlin	1100	84.3	7.1	Library	<a href="https://github.com/grpc/grpc-kotlin">https://github.com/grpc/grpc-kotlin</a>
husi	192	74.2	14.2	Android	<a href="https://github.com/xchacha20-poly1305/husi">https://github.com/xchacha20-poly1305/husi</a>
intellij-powershell	67	73.1	6.4	IDEA Plugin	<a href="https://github.com/ant-druha/intellij-powershell">https://github.com/ant-druha/intellij-powershell</a>
java-stellar-anchor-sdk	34	62.2	37.7	Server backend	<a href="https://github.com/stellar/java-stellar-anchor-sdk">https://github.com/stellar/java-stellar-anchor-sdk</a>
java1in	7200	89	10.6	Library	<a href="https://github.com/java1in/java1in">https://github.com/java1in/java1in</a>
jetbrains	36	74.8	24.4	IDEA Plugin	<a href="https://github.com/sourcegraph/jetbrains">https://github.com/sourcegraph/jetbrains</a>
karibu-testing	104	78.6	6	Library	<a href="https://github.com/mvysny/karibu-testing">https://github.com/mvysny/karibu-testing</a>
legado	23848	77.6	14.3	Android	<a href="https://github.com/gedoor/legado">https://github.com/gedoor/legado</a>
LiquidBounce	1227	81.5	9.9	Minecraft	<a href="https://github.com/CCBlueX/LiquidBounce">https://github.com/CCBlueX/LiquidBounce</a>
MyExpenses	712	64.8	34.5	Android	<a href="https://github.com/mtotschnig/MyExpenses">https://github.com/mtotschnig/MyExpenses</a>
NightX-Client	103	61.3	38.4	Minecraft	<a href="https://github.com/Aspw-w/NightX-Client">https://github.com/Aspw-w/NightX-Client</a>
RootEncoder	738	55.8	42.1	Android	<a href="https://github.com/pedroSG94/RootEncoder">https://github.com/pedroSG94/RootEncoder</a>
SeriesGuide	1910	68.4	31.6	Android	<a href="https://github.com/UweTrottmann/SeriesGuide">https://github.com/UweTrottmann/SeriesGuide</a>
simbrain	87	60.7	38	Desktop App	<a href="https://github.com/simbrain/simbrain">https://github.com/simbrain/simbrain</a>
SkyHanni	172	84.2	15.7	Minecraft	<a href="https://github.com/hannibal002/SkyHanni">https://github.com/hannibal002/SkyHanni</a>
SkytilsMod	956	90.1	9.7	Minecraft	<a href="https://github.com/Skytils/SkytilsMod">https://github.com/Skytils/SkytilsMod</a>
tasks	3275	92.4	7.5	Android	<a href="https://github.com/tasks/tasks">https://github.com/tasks/tasks</a>
wire	4172	62.1	29.4	Library	<a href="https://github.com/square/wire">https://github.com/square/wire</a>

achieve this, we first applied GitHub API to search repositories with Kotlin code through the GitHub link<sup>1</sup>. We further filtered those Kotlin repositories according to the following criteria:

- 1) The repository must contain Java code alongside Kotlin, with Java code constituting more than 3% of the total code;
- 2) The repository should have a star count of no less than 20;
- 3) The repository must have been updated within the last 48 hours relative to our data collection time, which is 12:00 PM on Jan 15, 2024.

Since GitHub does not support searching repositories by multiple languages, we clicked and manually inspected each repository to assess the ratio of programming languages and to fulfill Criterion 1). We established a minimum threshold of 3% for Java code to ensure its active participation in the projects' functionalities. Criteria 2) and 3) focus on selecting repositories that are actively maintained, which are essential for identifying relevant challenges. By applying these criteria, we identified 23 projects, and their demographic information is presented in Table 2.

These 23 projects span various domains, with 9 focused on Android app development, 5 on Minecraft games, 2 on IntelliJ IDEA Plugins, and 7 encompassing other areas. The percentage of Java code ranges from 6% in the karibu-testing project to 47.6% in the Flap project. In contrast, the percentage of Kotlin code varies from 52.4% in the Flap project to 92.4% in the tasks project. The wide and diverse range of Java and Kotlin code present in these projects enables us to gain a deeper understanding of Kotlin-Java interactions.

<sup>1</sup><https://github.com/search?q=language%3AKotlin+&type=repositories>

### 3.2 Research Questions

We investigated the following Research Questions (RQs) to gain insight into Kotlin-Java interactions and challenges associated with their interactions.

**RQ1.** *How do dependencies among code entities look like in Kotlin-Java projects?* Kotlin is designed to be fully interoperable with Java, allowing code entities to be seamlessly accessed across both languages. Ideally, dependencies between Kotlin and Java should exhibit the same characteristics as those within homogeneous Kotlin or Java codebases. The answer to this question can enhance our understanding of such cross-language software systems and form the basis for further software analysis in Kotlin-Java projects.

**RQ2.** *Is the maintenance cost in files involved in Kotlin-Java interactions significantly higher than in files without Kotlin-Java interactions?* Recent studies on multi-language systems, such as those involving Python and C++, have shown that to address bugs occurring in the interface of two languages, developers need to modify code in both languages, resulting in a higher number of lines of code (LOCs) [18]. This observation raises the question of whether Kotlin-Java software systems are also prone to such cross-language maintenance costs. The answer to this question could pinpoint maintenance hotspots within these Kotlin-Java systems.

**RQ3.** *Are there common mistakes in Kotlin-Java interactions?* Previous research proposed various techniques for detecting code smells or anti-patterns within a single-language codebase. More recent studies have found that bugs and security problems in multiple language systems [17]. For instance, a recent study has uncovered security issues arising from interactions between Java and C++

code [16]. By investigating whether there exist common mistakes in Kotlin-Java interactions, we aim to evaluate the problems associated with Kotlin-Java interactions and pinpoint the scenarios that may require closer attention when handling such interactions.

## 4 RESULTS

### 4.1 Dependencies in Kotlin-Java Projects

Using the approach detailed in Section 2.1, we developed a tool capable of extracting dependencies within Kotlin-Java projects. We utilized this tool on the most recent versions of our 23 selected projects, and the results are presented in Table 3. This table includes columns labeled #J and #K, which denote the counts of Java and Kotlin source files, respectively. The J-J and K-K columns represent the number of dependencies between pairs of Java source files and pairs of Kotlin source files, respectively. Additionally, the K-J column indicates the number of dependencies from a Kotlin source file to a Java source file. It is interesting that in these 23 projects we did not observe any Java-Kotlin dependencies (*DependExtractor* was tested thoroughly). This may be due to our subject selection criteria, and the primary language of these projects is Kotlin, in which developers tend to use Kotlin to depend on Java for functionalities. All dependencies in this table are counted without weights. The last column shows the ratio of Kotlin-Java dependencies to the minimum of Java-Java and Kotlin-Kotlin dependencies. Since source files with fewer numbers can determine dependency intensity, we compare Kotlin-Java dependencies with the minimum dependencies in a single language to check the prevalence of their interactions.

**Table 3: Dependency Statistics in Kotlin-Java Projects**

ProjName	#J	#K	J-J	K-K	K-J	$\frac{K-J}{\min(J-J, K-K)} \%$
bilimiao2	88	489	222	5979	122	55.0
DataStats	9	10	2	24	46	2300.0
dgs-fw	108	305	93	1648	567	609.7
FDPClient	242	621	320	8886	1291	403.4
Flap	20	104	19	636	19	100.0
grpc-k	8	83	2	285	8	400.0
husi	29	175	81	1913	494	609.9
intellij-p	7	162	6	929	11	183.3
java...sdk	548	260	1381	810	4796	592.1
java1in	57	260	46	2600	635	1380.4
jetbrains	95	300	94	2104	204	217.0
karibu-t	7	112	6	171	3	50.0
legado	87	746	269	12057	89	33.1
LiquidBounce	84	575	11	9114	11	100.0
MyExpenses	325	703	678	9756	2842	419.2
NightX-Client	184	253	286	3223	1244	435.0
RootEncoder	136	334	340	3209	395	116.2
SeriesGuide	176	391	216	4483	1468	679.6
simbrain	325	481	756	8140	1434	189.7
SkyHanni	302	697	301	14271	1898	630.6
SkytilsMod	89	302	8	3639	107	1337.5
tasks	83	639	63	9028	1245	1976.2
wire	218	628	168	9935	60	35.7
Average						528.6

As shown in Table 3, Kotlin and Java source files frequently interact. For instance, in the bilimiao2 project, there are 122 Kotlin-Java dependencies within 88 Java and 489 Kotlin files. If we divide 122 Kotlin-Java dependencies by the minimum of Java-Java and Kotlin-Kotlin dependencies, we obtain 55.0%. This significant ratio indicates that Kotlin-Java dependencies are prevalent in this project. Similar results are observed in other projects. In the DataStats project, for example, there are 46 Kotlin-Java dependencies within 9 Java and 10 Kotlin files, outnumbering 2 Java-Java and 24 Kotlin-Kotlin dependencies. The resulting ratio of 2300.0% underscores the dominance of Kotlin-Java dependencies in this project. Overall, the last column of this table reveals that the ratio of Kotlin-Java dependencies ranges from 33.1% in the legado project to 2300.0% in the DataStats project, with an average of 528.6%. This average indicates that, on average, Kotlin-Java interactions are five times more prevalent than the minority of single-language interactions.

Figure 1 depicts the circular layout of dependencies in three projects. The nodes on the circle’s edge represent source files. The blue, red, and purple curved lines connecting two nodes represent Kotlin-Kotlin, Java-Java, and Kotlin-Java dependencies, respectively. It is evident that Kotlin-Java dependencies are not confined to a specific area; instead, they are spread across the entire systems, proving Kotlin-Java interoperability in real-world software projects.

Table 4 presents the statistics of Kotlin-Java dependency types in each project. As observed in this table, certain dependency types are present in some projects but not in others. For instance, the “Extension” dependency type is found in 9 projects, while the remaining 14 projects do not exhibit this type. We suspect this discrepancy is due to the distinct characteristics of the projects. However, all 11 defined types of Kotlin-Java dependencies can be observed across all projects. The top two most frequent dependency types among Kotlin-Java interactions are “Access” and “Call”.

**To answer RQ1, the dependency extraction from 23 open-source Kotlin-Java projects spanning various domains reveals that Kotlin-Java dependencies and interactions are widespread.** Kotlin-Java dependencies can occur more frequently than minor single-language interactions, with “Access” and “Call” being the top two most frequent dependency types. Furthermore, Kotlin-Java dependencies are distributed across the entire system rather than confined to a local area, thus validating the interoperability between Kotlin and Java.

### 4.2 Maintenance Cost in Kotlin-Java Projects

Recent studies on multi-language systems have revealed that the interface between two languages is vulnerable and susceptible to bugs, often resulting in increased maintenance costs for fixing these issues [16–18]. This raises the question of whether the interface between Kotlin and Java faces similar challenges. We investigated this question to gain a better understanding of Kotlin-Java interactions and the associated challenges.

For each project, utilizing the dependency information got in RQ1 (see Section 4.1), we extracted the paths of Kotlin or Java source files involved in Kotlin-Java dependencies, denoted as *Paths(kt/java)*. Subsequently, we traversed each project’s git commits and matched each modified file path of a commit with *Paths(kt/java)*. If a match was found, we incremented *#commit(aFile)* by 1 and added the



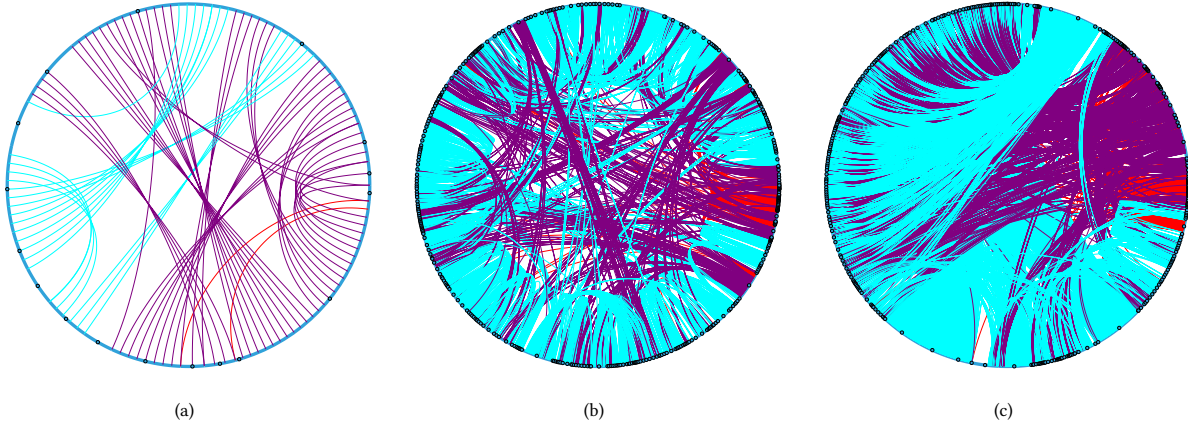


Figure 1: Circular Layout of Dependencies in (a) DataStats, (b) dgs-framework, and (c) NightX-Client

Table 4: Dependency Types in Kotlin-Java Interactions

ProjName	Access	Call	Create	Extend	Extension	LVT	PT	Implement	Import	Parameter	Return
bilimiao2	8	43	3	1	1	25	41	3	39	15	9
DataStats	163	89	0	0	0	29	13	0	9	0	0
dgs-framework	153	112	953	8	0	66	14	4	187	50	6
FDPCClient	5919	729	31	54	0	846	99	0	276	12	16
Flap	14	3	3	0	0	7	4	0	3	0	1
grpc-kotlin	89	3	1	0	0	0	6	0	0	1	0
husi	1523	81	120	14	64	167	4	0	111	40	64
intellij-powershell	8	3	1	0	0	1	0	0	3	0	1
java-stellar-anchor-sdk	5382	5115	2126	20	1	3462	882	3	1843	100	2752
javalin	204	1315	29	0	2	157	69	4	307	90	745
jetbrains	90	68	26	4	0	55	35	1	69	15	25
karibu-testing	1	0	1	0	0	0	0	0	0	1	0
legado	5	51	32	0	0	21	14	4	24	18	8
LiquidBounce	8	9	0	0	0	0	13	0	3	0	0
MyExpenses	3623	1365	124	63	5	1420	1086	40	2646	243	737
NightX-Client	4002	1277	141	40	0	443	141	0	333	3	23
RootEncoder	243	399	65	6	0	46	33	9	134	47	6
SeriesGuide	1142	581	700	94	4	488	346	23	506	147	43
simbrain	522	711	321	36	14	402	286	14	411	110	124
SkyHanni	2042	24	16	98	21	519	887	1	280	71	294
SkytilsMod	83	20	0	0	0	19	7	0	49	1	1
tasks	378	874	520	4	1	398	354	8	460	87	77
wire	45	76	18	4	0	50	7	0	24	0	4
Total	25647	12948	5231	446	113	8621	4341	114	7717	1051	4936

added and deleted lines of code (LOC) to  $\#LOC(aFile)$ . Similarly, we calculated  $\#commit$  and  $\#LOC$  for Java or Kotlin source files participating only in Java-Java or Kotlin-Kotlin interactions.

Table 5 presents the average LOC and commits for different types of files in each project. The first two columns denote the average commit counts and LOC for Kotlin source files that only interact with other Kotlin source files. The middle two columns denote the average commit counts and LOC for Java source files that only interact with other Java source files. The last two columns denote the average commit counts and LOC for Kotlin source files that interact with Java source files.

Comparing the first column with the second-to-last column, we observe that in 17 out of 23 projects (highlighted in blue), the average number of commits for Kotlin source files participating in Kotlin-Java interactions is significantly larger than for Kotlin source files not participating in Kotlin-Java interactions. The number in the parentheses denotes the ratio of these two commit counts. For example, in the husi project, the average number of commits (23.7) for Kotlin source files participating in Kotlin-Java interactions is 6.1 times of that (3.9) for Kotlin source files not participating in Kotlin-Java interactions. On average across all 23 projects, Kotlin source files participating in Kotlin-Java interactions have 2.5 times more

**Table 5: Maintenance Cost of Kotlin/Java Source Files in Kotlin-Kotlin, Java-Java, and Kotlin-Java**

ProjectName	Kotlin Files in Kotlin-Kotlin		Java Files in Java-Java		Kotlin Files in Kotlin-Java	
	#Avg_Cmt_K	Avg_LOC_K	#Avg_Cmt_J	Avg_LOC_J	#Avg_Cmt_Kj	Avg_LOC_Kj
bilimiao2	17	116.5	1.5	5.7	2.8	49.7
DataStats	4.6	22.0	4.5	47.0	20.5(4.5x)	27.2
dgs-framework	10.8	97.0	3.3	22.0	6.3	81.1
FDPCClient	11.1	60.6	14.8	110.1	37.5(3.4x)	53.9
Flap	13.3	102.1	12	58.6	27.9(2.1x)	61.8
grpc-kotlin	6.5	30.0	5	14	11(1.7x)	32.3
husi	3.9	24.0	3.5	34.8	23.7(6.1x)	20.8
intellij-powershell	11.5	53.7	11.3	90.3	38.3(3.3x)	26.3
java-stellar-anchor-sdk	7.3	113.9	7.3	52.9	14.9(2.0x)	102.3
java-lin	13.9	78.3	5.6	23.4	8.6	62.5
jetbrains	13.2	78.2	10.3	76.9	36.7(2.8x)	44.6
karibu-testing	10.5	99.5	8.4	62.6	3.4	121.7
legado	41.9	825.3	2.8	8.5	3.7	170.3
LiquidBounce	9	62.5	24	182	49(5.4x)	47.8
MyExpenses	18	102.6	42.7	228.1	103.3(5.7x)	84.7
NightX-Client	6.4	34.2	7	46.3	23.1(3.6x)	33.2
RootEncoder	15.6	90.5	14.9	87.0	26.8(1.7x)	46.0
SeriesGuide	7.3	41.6	7.4	37.7	17.5(2.4x)	40.0
simbrain	10.9	86.3	8.5	59.6	31.4(2.9x)	57.7
SkyHanni	21.9	117.1	6.5	42.1	17.2	90.3
SkytilsMod	17.9	102.9	10.3	194.5	31.2(1.7x)	35.6
tasks	11.7	65.4	11.1	66.1	35.6(3.0x)	49.1
wire	1.6	8.5	1.7	9.3	3.8(2.4x)	39.4

commits than Kotlin source files not participating in Kotlin-Java interactions.

However, as observed from Table 5, the LOC for Kotlin source files participating in Kotlin-Java interactions show no significant difference from Kotlin source files not participating in Kotlin-Java interactions. Only in these four projects (highlighted in blue in the last column) Kotlin source files participating in Kotlin-Java interactions have more LOCs on average. Furthermore, we conducted a t-test for these columns, and the t-test results between column #Avg\_Cmt\_K and #Avg\_Cmt\_Kj indicate a statistically significant difference at a 95% confidence level ( $df = 22$ ,  $p\text{-value} = 0.016$ ). Such results support the alternative hypothesis that #Avg\_Cmt\_Kj is significantly greater than #Avg\_Cmt\_K. However, the t-test results indicate no statistically significant difference between #Avg\_LOC\_K and #Avg\_LOC\_Kj ( $df = 22$ ,  $p\text{-value} = 0.125$ ). We conjecture this is because Kotlin source files participating in the interactions are often committed to modify only a small amount of code related to the facade, such as method calls, field access, parameter changes, etc.

To answer RQ2, the average number of commits and LOC for 23 open-source Kotlin-Java projects indicate that Kotlin source files participating in Kotlin-Java interactions tend to have more commits but not more LOCs. On average across all 23 projects, Kotlin source files involved in Kotlin-Java interactions have 2.5 times more commits compared to Kotlin source files that do not participate in Kotlin-Java interactions.

### 4.3 Common Mistakes in Kotlin-Java Interactions

The results of RQ2 reveal that source files participating in Kotlin-Java interactions undergo more commits and are prone to changes. To answer RQ3, we delve into the details of why certain Kotlin-Java interactions are problematic. Following the approach described in Section 2.2, we identified common mistakes in Kotlin-Java problematic interactions.

**Table 6: Locate Problematic Kotlin-Java Commits**

All commits	83792
f1: A commit's comment contains words 'fix', 'bug', 'issue' or 'exception'	5137
f2: A commit's modified files are participated in Kotlin-Java interactions	1314
Manual Inspection: confirmed commits to fix problematic Kotlin-Java interactions	103

Table 6 presents the data in the process of locating commits involving problematic Kotlin-Java interactions. Initially, there were 83,792 commits among these projects. After filtering commits with comments containing the words 'fix', 'bug', 'issue' or 'exception', there were 5,137 remaining commits. These 5,137 commits were compared with the dependency graphs of the latest version, resulting in 1,314 commits with modified files participating in Kotlin-Java interactions. Finally, we manually inspected these 1,314 commits

and confirmed 103 commits containing fixes for problematic Kotlin-Java interactions. After discussion among three developers, we classified 98 of these 103 problematic Kotlin-Java interactions into 7 categories according to the issue and fixing strategies. Table 7 lists these categories and their occurrences. In the following, we provide an example for each of these 7 categories.

**Table 7: Common Mistakes in Kotlin-Java Interactions**

Common Mistake Category	Occurrence
Java Return Value NPE	47
Java Invoke NPE	21
Kotlin Wrong Not Null Assertion	12
Call Chain NPE	9
Kotlin Inherit Java Nullability Inconsistency	5
Immutable Collection Conversion	3
Overuse Java Optional in Kotlin code	1
Other	5
Total	103

#### 4.3.1 Java Return Value NPE (NullPointerException): fix by adding Null-safe Operator for returned values from Java.

This is the most common mistake we observed among the 103 problematic interactions. When Kotlin code calls a Java method, the Kotlin compiler will not be able to determine the nullability of the return value if the Java method does not indicate the nullability of the return value with annotations such as `@NotNull` or `@Nullable`. If Kotlin code accesses a variable whose nullability is unknown, a `NullPointerException` (NPE) may get triggered.

```

74 74
75 75      val Class<*>.shPackageName
76 76      get() =
77 - canonicalName.substringBeforeLast('.')
77 + canonicalName?.substringBeforeLast('.')
78 78
79 79      fun Class<*>.getModContainer(): ModContainer? {
80 80      return packageLookup[shPackageName]
```

**Figure 2: Kotlin Add Null-Safe Operator to Fix NPE**

Figure 2 shows an example of this mistake in commit 2cd4ca1<sup>2</sup> in the SkyHanni project. The code marked in red attempts to call the method `getCanonicalName()` in the Java class 'Class' and assumes that the returned value from this method is not NULL. However, at runtime this method returns a NULL and the red line throws a NPE. As stated in the commit comment, the commit aims to “fix an NPE in `ReflectionUtils.shPackageName`”. It added the Null-Safe Operator `?` to the returned value of the `getCanonicalName()` method. In this way, the Null-Safe Operator `?` performs a NULL check on the returned value shown in the lime color. If it is NULL, it stops the process without proceeding to the next call.

<sup>2</sup><https://github.com/hannibal002/SkyHanni/commit/2cd4ca1>

#### 4.3.2 Java Invoke NPE: fix by clarifying Nullability on Java code.

This issue is similar to the previous one but differs in the error location and fixing strategy. When developing a Kotlin-Java system, adding appropriate nullable or non-nullable annotations (`@NotNull` or `@Nullable`) to Java’s public API will enable modern IDEs to alert developers its nullability at the time of invocation and provide stricter code checking during compilation. Without annotations on parameters of Java’s public API, Kotlin code is unable to determine the required nullability of parameters and an inappropriate API call will result in a NPE.

Figure 3 shows commit f240ed6<sup>3</sup> from the `intellij-powershell` project, which is a good example of the importance of Java nullability annotation when interacting with Kotlin. To “fix exception thrown when plugin is enabled but no powershell is found in the path” as stated in the commit comment, `@NotNull` annotation was added to the `powerShellExecPath` Java method (shown in lime color) and Kotlin code which invoked this method was also changed accordingly.

```

6 ...om/intellij/plugin/powershell/lang/lsp/ide/settings/PowerShellExecutableChooserPanel.java
@@ -48,7 +48,7 @@ public void validateSelectedFiles(VirtualFile @NotNull [] files) throws Exce
48     });
49 }
50
51 - private void updatePowerShellVersionLabel(String powerShellExePath) {
51 + private void updatePowerShellVersionLabel(@NotNull String powerShellExePath) {
52     CancellablePromise<String> versionPromise =
53         PSLanguageHostUtils.INSTANCE.getPowerShellVersion(powerShellExePath);
53     versionPromise.onError(throwable -> {
54         LOG.warn("Exception when getting PowerShell version: ", throwable);
@@ -60,8 +60,8 @@ public String getExecutablePath() {
60     return psExecutablePathTextFieldChooser.getText().trim();
61 }
```

**Figure 3: Java API Add Annotation to Fix NPE**

#### 4.3.3 Kotlin Wrong Not Null Assertion: fix by modifying non null assertion operator.

When a developer is confident that the returned value of a method or a property is non-null at all times, they apply a NOT NULL assertion `!!` operator in Kotlin code to emphasize its non-null nature. Such assertions offer significant convenience in subsequent code writing, eliminating the need for NULL checks and enhancing logical flow. However, not-null assertions also pose risks. If applied to a value whose nullability is not entirely determinable, an NPE may still occur at runtime if the value turns out to be null, potentially affecting a substantial portion of the subsequent code.

```

40 40      val map: Map<ProtoMember, Any?>
41 - get() = entries!!.toMap()
41 + get() = entries?.toMap() ?: emptyMap()
```

**Figure 4: Kotlin Not Null Assertion throws NPE**

Figure 4 depicts commit 83dc35e<sup>4</sup> from the `wire` project. A NOT NULL assertion `!!` operator was placed on the `entries` variable. However, this code throws a NPE at runtime because it fails to fully consider the nullability of the `entries` variable. The commit message

<sup>3</sup><https://github.com/ant-druha/intellij-powershell/commit/f240ed6>

<sup>4</sup><https://github.com/square/wire/commit/83dc35e>

“fix: options entries can be null for files imported from external jars” verified this observation and the NOT NULL assertion !! operator was changed to the null-safe Operator ? in this commit.

**4.3.4 Call Chain NPE: fix by adding null safe operation or add annotation on method signature.** In interactions between Kotlin and Java, we frequently observe that Kotlin code performs method chain calls on Java methods. If a method in the sequence returns a null value and the subsequent method call relies on this result without checking, it can lead to an NPE. The commit 79c9792<sup>5</sup> in the IntelliJ-Powershell project demonstrates an example of this case.

```
1 /* SyntheticPowerShellCodeBlock.kt */
2 import com.intellij.lang.ASTNode
3 import com.intellij.psi.formatter.java.LeafBlock
4
5 private fun isRParenth(block: Block?): Boolean {
6     return block is LeafBlock &&
7         block.node.elementType ===
8             PowerShellTypes.RP
9 }
```

In this example, a method in the SyntheticPowerShellCodeBlock Kotlin Class is importing and depending on Java classes ASTNode and LeafBlock. The code in Line 6 shows a calling chain to LeafBlock and ASTNode through `block.node.elementType` in this method. If the node attribute is not initiated in block object, the subsequent call `.elementType` will throw a NPE. In this commit, developers patched this bug by modifying it to `block.node?.elementType`. The null safe operator ? in `block.node?` performs a NULL check on the node object and allow for a safe call. If it is a null, `block.node?.elementType` will return a null without calling `.elementType`.

There are two ways to fix this issue. One is to use NULL SAFE operator just like in this example to allow the returned value being nullable. The other is to specify the return value of each method nullable by adding annotation along with the method's signature and let IDEs handle it at the compilation.

**4.3.5 Kotlin Inherit Java Nullability Inconsistency: fix by ensuring parent-child API consistent.** This scenario happens when a Kotlin class inherits a Java class and overrides the parent methods, the nullability of parameters in the overridden methods is inconsistent between the parent and child class. This is not a problem in Kotlin-Kotlin or Java-Java interactions as the type consistency is manually enforced in modern IDEs. However, the nullability consistency is not enforced for Kotlin-Java interactions by modern IDEs so developers need to manually check it. The commit da56686<sup>6</sup> in the grpc-kotlin project shows an example and how developers were addressing it.

As we can see from the following code, DeclarationSubject class is written in Kotlin and it extends the Subject Java class. The second parameter Declarations in the child Kotlin class is not null while the parent Java class Subject specify the second parameter *actual* as @Nullable. There exists an inconsistency between these two constructor methods, though this does not cause any problems before version 1.1.3 as the callers of these constructors in

the Factory interface does not specify @Nullable in its parameter too.

```
1 /** Subject.java */
2 protected Subject(FailureMetadata metadata,
3     @Nullable Object actual) {
4     this(metadata, actual, /*
5         typeDescriptionOverride= */ null);
6 }
7
8 /** DeclarationsSubject.kt */
9 class DeclarationsSubject(failureMetadata:
10     FailureMetadata, private val actual:
11     Declarations): Subject(failureMetadata,
12     actual) {...}
13
14 // This calls the Factory interface in Subject.
15 val declarationsSubjectFactory:
16     Subject.Factory<DeclarationsSubject,
17     Declarations> =
18     Subject.Factory(::DeclarationsSubject)
```

However, in Version 1.1.5, the Factory interface in Subject class added @Nullable annotations to its parameter ActualT as shown below. When the grpc-kotlin project upgraded the Subject's package – com.google.truth:truth–, from Version 1.1.3 to 1.1.5, the Factory interface requires a nullable type for *createSubject*'s second parameter specifically while DeclarationSubject is not. This results in a compilation error.

```
1 /** Factory in Subject.java in version 1.1.3. */
2 public interface Factory<SubjectT extends
3     Subject, ActualT> {
4     /** Creates a new {@link Subject}. */
5     SubjectT createSubject(FailureMetadata
6         metadata, ActualT actual);
7 }
8
9 /** Factory in Subject.java in version 1.1.5. */
10 public interface Factory<SubjectT extends
11     Subject, ActualT> {
12     /** Creates a new {@link Subject}. */
13     SubjectT createSubject(FailureMetadata
14         metadata, @Nullable ActualT actual);
15 }
```

To fix this error, developers added the NULL SAFE operator ? in the child Kotlin class DeclarationSubject, allowing the second parameter to be nullable. From this example, we can conclude that, although the inconsistency would not result in compilation errors within the DeclarationSubject class itself, it can arise potential issues from a third class' calling. It is necessary to make sure that Kotlin-Java parent-child overridden methods strictly follow the same nullability type. Furthermore, this is also a violation of Liskov Substitution Principle, which requires a subtype should be substitutable for its supertype.

**4.3.6 Immutable Collection Conversion: fix by creating a defensive copy of Java collections.** In Kotlin, collections can be categorized as modifiable, such as MutableList or MutableSet, and unmodifiable types, such as List or Set. If Java code calls collections from Kotlin code, modern IDEs ensure that proper methods

<sup>5</sup><https://github.com/ant-druha/intellij-powershell/commit/79c9792>

<sup>6</sup><https://github.com/grpc/grpc-kotlin/commit/da56686>



```

- val map = getFromBuilder(builder) as MutableMap<Any, Any>
- map.putAll(value as Map<Any, Any>)
+ when (val map = getFromBuilder(builder)) {
+     is MutableMap<*, *> -> map.putAll(value as Map<Nothing, Nothing>)
+     is Map<*, *> -> {
+         val mutableMap = map.toMutableMap()
+         mutableMap.putAll(value as Map<out Any?, Any?>)
+         set(builder, mutableMap)
+     }
+     else -> {
+         val type = map?.let { it::class.java }
+         throw ClassCastException("Expected a map type, got $type.")
+     }
+ }

```

Figure 5: Immutable Collection Conversion

of collections are invoked, meaning that mutation methods like *add()* or *remove()* in Java cannot be applied to an unmodifiable Kotlin collection.

However, if Kotlin code is accessing collections from Java code, the mutability of the collections is unknown to the Kotlin side. This is because unmodifiable collections in Java act as a wrapper around existing modifiable collections. Therefore, public methods such as *add*, *remove*, and *update* in Java modifiable collections can also be called on Java unmodifiable collections. This presents a challenge on the Kotlin side because the mutability of collections returned from Java is not known.

Figure 5 illustrates an example of this issue in the commit a8cf6eb<sup>7</sup> of the wire project. The *getFromBuilder* method utilizes Java’s reflection mechanism and returns an object with a *java.util.Map* type. Prior to this commit, this *Map* object was mistakenly treated as a Kotlin *MutableMap*. Since the mutability of Java’s collections is not inherently recognized in Kotlin, developers introduced a check for this *Map* object in this commit. If the object is confirmed to be a *MutableMap*, records are added to it directly. If it is not a *MutableMap*, a defensive copy of the map is created first, and then the records are put into the copied map. If the object cannot be cast to either a *MutableMap* or a *Map*, an exception is thrown. Although this approach solves the problem, we do not recommend using *obj is MutableMap* in JVM to check its mutability. The good practice is to assume that all collections of unknown mutability are immutable and create a defensive copy [6].

**4.3.7 Overuse Java Optional in Kotlin code: fix by leveraging safe check mechanism in Kotlin.** One key feature of Kotlin is to eliminate the danger of null references by leveraging nullable types and non-nullable type. Compared to Kotlin, Java does not have such feature and thus it needs other techniques such as *Optional* to check whether a value is null or not. *Optional* is a container class introduced in Java 8 and provides a way to represent optional values without using null references, thereby helping to avoid common programming pitfalls associated with null values. The *Optional* class includes methods like *isPresent()*, *get()*, *ifPresent()*, and *orElse()*, which enable developers to check value presence and absence and to handle cases where a value might be missing.

```

- var queryComplexity: Optional<Int> = Optional.empty()
- var operation: Optional<String> = Optional.empty()
- var operationName: Optional<String> = Optional.empty()
- var querySignature: Optional<QuerySignatureRepository.QuerySignature> = Optional.empty()
+ var queryComplexity: Int? = null
+ var operation: Operation? = null
+ var operationName: String? = null
+ var querySignature: QuerySignatureRepository.QuerySignature? = null

@Internal
fun tags(): Iterable<Tag> {
    val tags = mutableListOf<Tag>()
    tags += Tag.of(
        GqlTag.QUERY_COMPLEXITY.key,
        queryComplexity.map { it.toString() }.orElse(TagUtils.TAG_VALUE_NONE)
+       queryComplexity?.toString() ?: TagUtils.TAG_VALUE_NONE
    )
    tags += Tag.of(
        GqlTag.OPERATION.key,
        operation.map { it.uppercase() }.orElse(TagUtils.TAG_VALUE_NONE)
+       operation?.name ?: TagUtils.TAG_VALUE_NONE
    )

    tags += LimitedTagMetricResolver.tags(
        GqlTag.OPERATION_NAME.key,
        operationName.orElse(TagUtils.TAG_VALUE_ANONYMOUS)
+       operationName ?: TagUtils.TAG_VALUE_ANONYMOUS
    )

    tags += LimitedTagMetricResolver.tags(
        GqlTag.QUERY_SIG_HASH.key,
        querySignature.map { it.hash }.orElse(TagUtils.TAG_VALUE_NONE)
+       querySignature?.hash ?: TagUtils.TAG_VALUE_NONE
    )
}

```

Figure 6: Overuse Java Optional in Kotlin Code

We observed a case that Kotlin code overuse Java *Optional*, instead of leveraging Kotlin’s own typing system. The commit b9853c6<sup>8</sup> in the *dgs-framework* demonstrates an example, with its commit comment “*eliminate some unnecessary usage of Optional*”.

Figure 6 illustrates a portion of the code modifications made to the *DgsGraphQLMetricsInstrumentation* Kotlin file. Previously, the *Optional* class was extensively utilized to encapsulate four attributes: *queryComplexity*, *operation*, *operationName*, and *querySignature*. Within the *tags* method, the *map()* and *orElse()* methods from the *Optional* class were used to check the nullability of the wrapped objects. However, in this commit, developers opted to removed all this *Optional* wrapping and leveraged Kotlin’s null mechanisms. For instance, as shown in the last two lines of Figure 6, the null safe operator *?* was appended to *querySignature* to verify its nullability, thereby replacing the need for the *map()* method from the *Optional* class. Overuse of the *Optional* class not only consumes additional memory and can negatively affect system performance, but it may also complicate code comprehension. We strongly suggest practitioners to examine the overuse of *Optional* in Kotlin code.

To answer RQ3, we conducted a manual inspection of 103 cases involving Kotlin-Java interactions, which had already led to system errors or incurred maintenance costs. Through these inspections, we identified 7 categories of common mistakes along with corresponding fixing strategies. We believe that these categorized cases can serve as a taxonomy and assist developers in correctly handling Kotlin-Java interactions.

## 5 DISCUSSIONS

### 5.1 Analysis of Results

The findings of RQ1 have demonstrated the interoperability between Kotlin and Java. Unlike other cross-language systems that

<sup>7</sup><https://github.com/square/wire/commit/a8cf6eb>

<sup>8</sup><https://github.com/Netflix/dgs-framework/commit/b9853c6>

rely on compiled code, the dependencies between Kotlin and Java code are more direct and span across entire systems. Consequently, this leads to more cross-language interfaces and presents greater challenges for Kotlin-Java interactions. The results of **RQ2** indicate that source files involved in Kotlin-Java interactions undergo more commits than those exclusively involved in a single language. It demonstrates that Kotlin-Java interfaces are inherently more active, just like other cross-language interfaces, even though Kotlin and Java can coexist within the same IDEs and their interaction mechanism is different from other cross-language systems.

The manual inspections of 103 cases in **RQ3** reveal specific 7 categories of mistakes within Kotlin-Java interactions. In contrast to Python-C interfaces, which are known to suffer from vulnerabilities [16], 89 out of 103 problematic interactions between Kotlin and Java are related to `NullPointerExceptions` (NPEs). Despite Kotlin being known for its better null safety mechanism compared to Java, the interface between Kotlin and Java still experiences NPEs. Other mistakes, such as “Immutable Collection Conversion” and “Overuse of Java Optional in Kotlin”, result from unfamiliarity with Kotlin documentation. It is also surprising that we did not find any exception handling mistakes in the Kotlin-Java interactions, despite Java and Kotlin having different exception catching rules. This can be attributed to modern IDEs’s checking in the compilation process.

## 5.2 Implications

**To Software Practitioner:** Although Kotlin and Java can interact smoothly at the code level, common interaction mistakes still exist that may not be captured by modern IDEs. The identified categories of interaction mistakes and their fixing strategies can serve as a valuable reference, complementing the Kotlin-Java interoperability guide from Android [3].

**To Researchers:** Different cross-language interactions may suffer from various problems. Conducting empirical studies to identify problematic interactions with associated errors and maintenance costs is key to pinpointing them accurately. For Kotlin-Java interactions, there is a high demand for research and tools that can automatically detect and fix these issues.

## 5.3 Threats to Validity

One threat is the accuracy of our dependency extraction tool. *DependExtractor* is based on the Kotlin compiler and dependency types are defined according to previous research. Though we added test cases and manually validate the tool in several small projects, we cannot guarantee that it is 100% accurate for extracted dependencies. We plan to conduct more tests and validations of the tool in the future work.

Another threat is that we only investigated 23 real-world projects with Kotlin as the primary languages. It is possible that additional categories of problematic Kotlin-Java or Java-Kotlin interactions may be discovered in other projects. Exploring this possibility remains part of our future work.

## 6 RELATED WORK

In this section, we discuss related research to our work from two perspectives: empirical studies on Kotlin-Java projects and code dependency extraction in cross-language systems.

### 6.1 Empirical Studies on Kotlin-Java Projects

Since the introduction of Kotlin, various empirical studies have been conducted to understand Kotlin-Java projects. Martinez and Mateus investigated why developers migrate Android applications from Java to Kotlin [19]. They also examined the adoption, usage, and evolution of Kotlin features in Android development [20]. Nakamura *et al.* conducted a performance study of Kotlin and Java programs using bytecode analysis [24]. Ardito *et al.* compared the effectiveness of Kotlin versus Java in Android app development tasks [7]. Flauzino *et al.* compared code smells between Java and Kotlin [12]. Bose *et al.* compared Java versus Kotlin in terms of null safety, exception handling, and other aspects [8].

While previous studies have compared various characteristics of Java with Kotlin, our study offers an empirical investigation into how Kotlin actually interacts with Java code. Despite the availability of documentation from Google and Android guiding Kotlin-Java interaction, to our knowledge, our study is the first to examine Kotlin-Java interactions in real-world projects. Our findings reveal that while Kotlin and Java demonstrate great interoperability and interact with each other extensively across systems, challenges and issues persist in such interactions. The recurring patterns identified in problematic Kotlin-Java interactions in this paper deserve special attention from developers, especially Kotlin developers.

### 6.2 Code Dependencies Extraction

The dependency relations among entities in the source code form the foundations of software analysis [10, 22, 27]. Existing techniques often rely on static code analysis to capture and model extract dependency relations from source code such as Java, Python and C/C++ [11, 14, 23, 25]. Various tools such as Structure 101 [4], Understand [5], and DV8 [2] have been developed to support the extraction of dependency relations among entities in large-scale software projects.

While techniques and tools for extracting dependencies among code entities within single programming language are relatively mature, the extraction of dependencies among multiple programming languages remains largely unexplored. With advancements in modern platforms, it has become common to utilize multiple programming languages within the same system to achieve enhanced performance and scalability [21, 26]. However, this also increases the complexity of systems, posing challenges for extracting dependencies in such heterogeneous language environments. A recent systematic review reveals that traditional code analysis tools face challenges in these cross-language systems [15]. A study also highlights high-risk vulnerabilities between Python and C interfaces, proposing symbolic dependence analysis to detect such vulnerabilities [16]. As a complement to the above studies, our study proposed to extract code dependencies between Java and Kotlin code and further detect problems in Kotlin and Java interactions.

## 7 CONCLUSIONS

In this paper, we conducted an empirical study of Kotlin-Java interactions in 23 real-world projects. Our results demonstrate that Kotlin and Java interact frequently across the entire systems,

confirming the extensive interoperability of Kotlin and Java. However, our study also reveals that source files involved in such cross-language systems have more commits compared to source files involved in only a single language.

Furthermore, we identified seven common mistakes in Kotlin-Java interactions, along with their corresponding fixing strategies. Unlike code smells, which are detected by rules and often have high false positives, these mistakes were extracted from commits in Git repositories and have been shown to require more maintenance effort. We believe that recognizing these identified mistakes in Kotlin-Java interactions can assist developers in effectively improving such cross-language interactions.

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