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Multi-Language Software: Incidence and Support

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Cross-Language Links (XLLs)

via Cross-Language Identifiers (XLIs)

...established by frameworks, libraries, and runtimes

Importance of XLLs - from a **developer** perspective



Contents

Part I

Empirical Evidence (incidence, developer opinions, taxonomy)

Part II

Tool Support (MLSD IDE, other options)

Part I: Empirical Data

MLSA Incidence

Study* via data mining of 1150 GitHub projects selected for diversity



size and commits

... are correlated to language count

age and committers

...are not

web languages

... use 2-3 languages more than the reference (Java,

* **Philip Mayer** and Alexander Bauer. <u>An Empirical Analysis of the Utilization of Multiple Programming Languages in Open Source Projects</u>. In Proceedings of the 19th International Conference on Evaluation and Assessment in Software Engineering (EASE), pages 1-10, Nanjing, China. April 27-29, 2015.



* Philip Mayer and Alexander Bauer. <u>An Empirical Analysis of the Utilization of Multiple Programming Languages in Open Source Projects</u>. In Proceedings of the 19th International Conference on Evaluation and Assessment in Software Engineering (EASE), pages 1-10, Nanjing, China. April 27-29, 2015.

Professional Developers Survey

Study* via survey of 139 professional software developers

mean number of languages:

3

link pairs per project; 152 total distinct pairs

- Java -> XML/SQL/HTML/.properties
- JavaScript->HTML

benefits for

- developer motivation
- translation of requirements

problems in

- understandability
- changeability

over 92% of participants

have reported XLL-related problems

tool support

is requested - in particular error detection

* **Philip Mayer**, Michael Kirsch, and Minh Anh Le <u>On multi-language software development</u>, cross-language links and accompanying tools: a survey of professional software developers. In Journal of Software Engineering Research and Development (2017), doi:10.1186/s40411-017-0035-z, published online 19 April 2017.

Taxonomy of linking mechanisms

Study* via taxonomy development of 22 OSS frameworks which use XLLs



* Philip Mayer. <u>A taxonomy of cross-language linking mechanisms in open source frameworks</u>. In Computing (2017), July 2017, Volume 99, Issue 7, pp 701-724, doi:10.1007/s00607-016-0528-3, published online 20 December, 2016

Summary Empirical Evidence

MLSD is common in both OSS and industrial projects - 5 to 7 languages reported

Problems exist

as reported by professional developers

- program understanding
- changeability

The design space

is large; many different options exist

- taxonomy allows better categorization
- ...but choice of frameworks matters

Part II: Tool Support

Tool Support



Features, Prototype, and Evaluation^{1,2} for an MLSD-aware IDE



¹ **Philip Mayer** and Andreas Schroeder. <u>Automated Multi-Language Artifact Binding and Rename Refactoring between Java and DSLs used by Java Frameworks</u>. In Proceedings of the European Conference on Object-Oriented Programming (ECOOP), July 28-August 1, 2014, Uppsala, Sweden. R. Jones (Ed.): ECOOP 2014, LNCS 8586, pages 437-462. Springer, Heidelberg (2014)

² **Philip Mayer** and Andreas Schroeder: <u>Towards Automated Cross-Language Refactorings between Java and DSLs used by Java Frameworks</u>. In Proceedings of the 6th ACM Workshop on Refactoring Tools (WRT), 2013 ACM SIGPLAN conference on Systems, Programming, Languages, and Applications: Software for Humanity (SPLASH), pages 5-8, October 26-31 2013, Indianapolis, USA.



Features

Highlighting of linked identifiers Navigation between linked identifiers Error marking of problematic identifiers Refactoring across language borders



Listing 5.1: Hibernate Queries (HQL)

Links between 5 languages

	<pre>public class HibernateJtracDao { public int bulkUpdateStatusToOpen(Space sp, int st) { int c = bulkUpdate("update Item i set i.status=? where i</pre>
	Listing 5.2: Hibernate Mapping (HBM)
	<pre>1 <hibernate-mapping package="info.jtrac.domain"> 2 <class name="Item" table="items"> 3 <property column="status" name="status"></property> </class> 4 5 <class name="History" table="history"> 6 <property column="status" name="status"></property> </class> 7 8 </hibernate-mapping></pre>
	Listing 5.3: Java Getters and Setters
	<pre>public abstract class AbstractItem { public Integer getStatus() { return status; } public void setStatus(Integer status) { this.status = status; } } </pre>
	Listing 5.4: Wicket Property & Definition (Wicket/API)
	<pre>private class ItemViewForm extends Form { public ItemViewForm() { History h = new History(); setModel(new BoundCompoundPropertyModel(h)); add(new IndicatingDropDownChoice("status", states, renderer)); } } </pre>
	Listing 5.5: Wicket Page Fragment (Wicket/HTML)
a 1.1.1	<pre>1 <form wicket:id="form"> 2 <select wicket:id="status"></select></form></pre>

eclipse

Prototype (2/3)

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🖸 Config.java 🛿 🗖	🗎 jtrac.hbm.xml 🕱 🗖 🗖
<pre>/** * Simple name value pair to hold configuration parameters * in the database for JTrac, e.g. SMTP e-mail server, etc. * TODO better validation, type-safety, masking of mail server password */ public class Config implements Serializable { private String param; // someone reported that "key" is a reserved word in MyS private String value; private static final Set<string> PARAMS; // set up a static set of valid config key names static { PARAMS = new LinkedHashSet<string>(); PARAMS.add("mail.server.host"); PARAMS.add("mail.server.port"); PARAMS.add("mail.server.port"); PARAMS.add("mail.server.starttls.enable"); PARAMS.add("mail.subject.prefix"); PARAMS.add("mail.session.jndiname"); PARAMS.add("incl.edefault"); PARAMS.add("iccle.default"); PARAMS.add("attachment.maxsize"); } mublic static SetoString> oetParams() { mublic static SetoString> oetParams() { // set up static SetoString> oetParams() { // set up a static SetoString> oetParams() { // set up a static set of valid config key names // set up a static set of valid config key names static { PARAMS.add("mail.server.host"); PARAMS.add("mail.server.port"); PARAMS.add("mail.server.port"); PARAMS.add("mail.server.port"); PARAMS.add("mail.server.starttls.enable"); PARAMS.add("mail.server.starttls.enable"); PARAMS.add("incl.setosion.indiname"); PARAMS.add("incl.edefault"); PARAMS.add("incl.edefault"); PARAMS.add("attachment.maxsize"); } } } </string></string></pre>	<pre><class name="Metadata" table="metadata"></class></pre>
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👒 XLL Report Artifacts 👒 XLL Report Links 👒 XLL Report Closures 🕱

#	Start Artifact	Affected Languages	#Artif	#Link:	#Lang	#Edits	Time (Warn?	No Changes	Java	НВМ	HQL	SpringIOC	WicketHTML	WicketJava
, 12	columnitedanig.interentena.values	Java mekegava	•	•	2		N//N	NO		14/7	14/74	14/74	1 MAY	14/74	14/14
▶ 73	ColumnHeading.visible	Java WicketJava	3	2	2	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
▶ 74	columnName	WicketHTML WicketJava	2	1	2	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
▶ 75	columns	WicketHTML WicketJava	2	1	2	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Þ 76	columns	WicketHTML WicketJava	2	1	2	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
▶ 77	comment	HBM Java WicketHTML Wicke	6	6	4	N/A	N/A	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Þ 78	comment	Java WicketHTML WicketJava	4	3	3	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Þ 79	comment	Java WicketHTML WicketJava	4	3	3	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Þ 80	comment	WicketHTML WicketJava	2	1	2	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Þ 81	commits	WicketHTML WicketJava	2	1	2	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
▶ 82	Config	HBM Java	2	1	2	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
▶ <mark>8</mark> 3	ConfigFormPage	WicketHTML WicketJava	2	1	2	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Open Source Software, <u>www.xllsrc.net</u>

eclipse

Prototype (3/3)

27.03.2018



Implementation of highlighting, navigation, error marking, and rename refactorings

tested on **open source projects**

languages implemented

frameworks

between all languages

- Spring (Java + sXML)
- Hibernate (Java + hXML + HQL) -
- Wicket (Java + W/API + HTML)

Refactoring evaluation





...across all 7 case studies:



for unresolved artifacts: Warn Fail Warn OK

■ OK

Problems Finding Identifiers

bulkUpdate("update Item item set item." +
 field.getName() + " = null");

- Leads to:
 - Unresolved artifacts artifacts without a name
 - **Orphaned** artifacts artifacts without context



Other tool options?



1 Estelle Perez: A Heuristic Approach to Detecting Cross-Language Links. Bachelor's Thesis, Ludwig-Maximilians-Universität München, Supervised by **Philip Mayer** and Martin Wirsing, April 2014, Munich, Germany.

2 Philip Mayer, Andreas Schroeder. Cross-Language Program Analysis and Refactoring. In Proceedings of 12th IEEE International Working Conference on Source Code Analysis and Manipulation (SCAM) 2012, pp 94-103, Riva del Garda, Italy, September 23-24, 2012.

3 Philip Mayer, Andreas Schroeder: Patterns of Cross-Language Links in Java Frameworks. In 21st IEEE International Conference on Program Comprehension (ICPC), pages 113-122, May 20-21 2013, San Francisco, USA.

4 Philip Mayer, Anna Biebl, Andreas Schroeder, and Joschka Rinke. History-Based Detection and Tracking of Cross-Language Identifiers. Technical Report LMU-20160600, Institute for Informatics, Ludwig-Maximilians-Universität München, Oettingenstr 67, 80538 München, Germany, June 2016.

Summary & Next Steps

Summary

Part I

Empirical Evidence (incidence, developer opinions, taxonomy)

Part II

Tool Support (MLSD IDE, other options)



More empirical data!

analyze industrial software; talk to OSS devs; identify good/bad language interactivity; ...

Let's talk MLSD to students

raise awareness for XLLs and MLSD-related issues

Lang/Lib/Tool Devs

get people to think about interoperability as soon as possible





Thank You!

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