

# Searching for Answers: An Exploratory Study of the Formation, Use, and Impact of Queries During Debugging

find where what copies performed involve scp org.apache.tools.IntrospectionHelper.IntrospectionHelper failonerror classes is org.apache.tools.AntClassLoader.nextResource used are org.apache.tools.ProjectHelper.configureProject recursive calls

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## Introduction

We performed an exploratory study investigating how developers form and use queries during a debugging task as well as the impact of the queries. The results of this study provide additional evidence regarding the impact of query-based debuggers. The insights gained from this study can inform efforts that are focused on developing and improving query-based debuggers.

## Study Design

We had eight subjects perform two debugging tasks for an open source Java system, ANT. The subjects were asked to correct the following two bugs collected from the ANT bug tracking system.

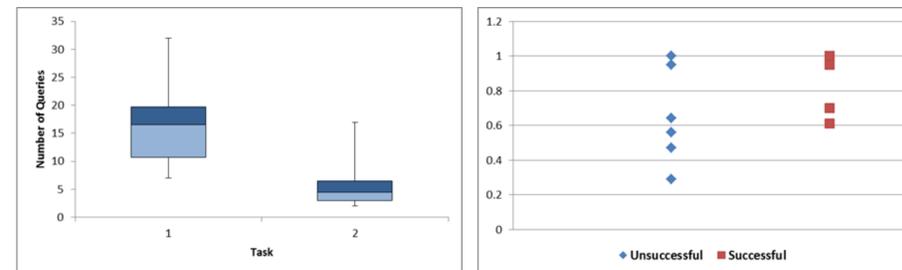
Bug ID	Description
38175	The failonerror="no" doesn't work for locked files. When we try to perform a recursive copy in a directory that contains a locked file, the copy fails before the end of the whole copy, even if I have the attribute failonerror set to "no".
38082	SCP Task password with special characters. The scp task does not handle password with special characters like "@"

All the Subjects were recorded using screen capture. We observed the 8 recordings and collected observations into a set of data collection forms. The data was transferred to a spreadsheet for analysis.

Participant #:  
Task #:  
Was task successfully completed (y/n)?  
Query #:  
Query Description:  
Describe Context of Query:  
Describe Events Leading to Query:  
Was this query satisfied (y/n)?  
Was this query expressed (y/n)?  
Did existing tool support help answer the query (y/n)?

## Results of Query Impact

### RQ1: Do queries significantly impact debugging?



Not all subjects worked on both tasks. Some subjects did not complete task 1 and never attempted task 2. There were 6 subjects who worked on both tasks and all subjects worked on task 1.

Task	Subjects Attempted	Min	Mean	Max	Std. Dev
1	8	7	16.75	32	7.96
2	6	2	5.67	16	5.24

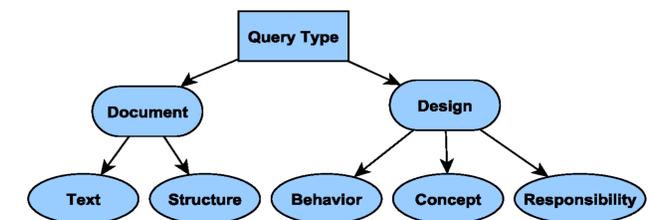
We computed the query satisfaction rates for each subject on both tasks by dividing the satisfied queries by the total number of queries. The results of these calculations were then compared. In most cases, the rates for successful tasks are higher than the rates for unsuccessful tasks. We performed a one-tailed Wilcoxon rank sum test to determine if this difference was significant. With  $p < .05$ , we confirmed the rates are significantly higher for successful tasks.

## Discussion of Query Impact

Each of the eight subjects formed multiple queries for each task attempted, which helps confirm that developers form queries during software maintenance tasks. Additionally, we observed that successfully completed tasks correlated positively with a higher query satisfaction rate. We believe queries that were not satisfied took time away from completing the task.

## Results of Query Types

### RQ2: What types of queries are used by developers?



Using a grounded theory approach, we analyzed the type of information each query was seeking. From this analysis, we identified two major categories of queries. Document queries focus on locating portions of the source. Design queries seek to better understand the system by examining design-oriented aspects.

Query Type	Identified	Description
Text	67	Locate text in source code
Structure	29	Locate a portion of the source code based on a structural link
Behavior	27	Ascertain behavior at runtime
Concept	17	Identify elements related to concept
Responsibility	29	Identify purpose of a source element

## Discussion of Query Types

Of the five query types identified, the type that occurred most was the text query. This query type occurred more than the next two most numerous query types combined. Our observations revealed that text queries were commonly sub-queries to another query type. With proper tool support, the number of text queries should decrease.