

Institute of Software Technology

University of Stuttgart  
Universitätsstraße 38  
D–70569 Stuttgart

Bachelor Thesis

# **How Are Different Asynchronous Programming Constructs in JavaScript Related to Software Quality? A Repository Mining Study on GitHub**

Gamze Şevik

**Course of Study:** Software Engineering

**Examiner:** Prof. Dr. Stefan Wagner

**Supervisor:** Dr. Justus Bogner

**Commenced:** May 30, 2022

**Completed:** September 30, 2022



## Abstract

Since its introduction for small client-side tasks in the browser in 1995, JavaScript has become the lingua franca of web development. It was voted the most popular language and was the most used language on GitHub until the last quarter of 2021. However, understanding JavaScript applications involves challenges for developers. There are potential factors of JavaScript, such as its dynamic, asynchronous and event-driven nature, the dynamic interplay between JavaScript and the Document Object Model, and the asynchronous communication between client and server, which may hinder comprehension.

Because JavaScript is single-threaded, callback, `async/await`, and promise functions are frequently used to simulate concurrency. Nested, anonymous and asynchronous callback scheduling is used regularly to provide capabilities such as non-blocking I/O and concurrent request handling. Non-trivial callback-oriented programming tends to result in nested hierarchies of callback functions, which makes following the program flow hard - a problem described as "callback hell". Long term maintenance of large applications may be severely impacted due to tight coupling of callbacks and structural fragility. Handling errors and coordinating asynchronous tasks can quickly get messy if programming discipline is not enforced and proper patterns are not followed. Furthermore, a "callback hell" program comes with increased risk of introducing security vulnerabilities. However, there is still a lack of empirical evidence how different asynchronous programming constructs in JavaScript impact software quality.



# Contents

<b>1</b>	<b>Introduction</b>	<b>13</b>
1.1	Motivation . . . . .	13
1.2	Research Questions . . . . .	13
1.3	Thesis structure . . . . .	14
<b>2</b>	<b>Background and Fundamentals</b>	<b>15</b>
2.1	JavaScript . . . . .	15
2.2	Asynchronous Programming . . . . .	15
2.3	Software Quality . . . . .	15
<b>3</b>	<b>Related Work</b>	<b>17</b>
<b>4</b>	<b>Methodology</b>	<b>19</b>
4.1	Study Objects . . . . .	19
4.2	Data Collection . . . . .	19
4.3	Hypotheses . . . . .	19
4.4	Categorizing Bugs . . . . .	19
4.5	Metrics . . . . .	19
4.6	Static Analysis . . . . .	19
<b>5</b>	<b>Analysis and Results</b>	<b>21</b>
5.1	RQ1 (callbacks) . . . . .	21
5.2	RQ2 (async/await) . . . . .	21
5.3	RQ3 (promises) . . . . .	21
<b>6</b>	<b>Discussion</b>	<b>23</b>
6.1	RQ4 (something general) . . . . .	23
6.2	Threats to Validity . . . . .	23
<b>7</b>	<b>Conclusion</b>	<b>25</b>
7.1	Summary . . . . .	25
7.2	Future Work ? . . . . .	25



## List of Figures





## List of Tables



## List of Listings



# **1 Introduction**

## **1.1 Motivation**

## **1.2 Research Questions**

## **1.3 Thesis structure**

The structure of the thesis will be presented as follows:

**Chapter 2 (Background and Fundamentals) ....**

## **2 Background and Fundamentals**

### **2.1 JavaScript**

### **2.2 Asynchronous Programming**

#### **2.2.1 Asynchronous Callbacks**

#### **2.2.2 ES6: Generator Functions**

#### **2.2.3 ES7: Async/Await**

#### **2.2.4 Promises**

### **2.3 Software Quality**





## **3 Related Work**



## **4 Methodology**

### **4.1 Study Objects**

#### **4.1.1 Selection of the Mining Platform**

#### **4.1.2 Requirements**

#### **4.1.3 Sampling**

### **4.2 Data Collection**

### **4.3 Hypotheses**

### **4.4 Categorizing Bugs**

### **4.5 Metrics**

### **4.6 Statical Analysis**



## **5 Analysis and Results**

### **5.1 RQ1 (callbacks)**

### **5.2 RQ2 (async/await)**

### **5.3 RQ3 (promises)**



## **6 Discussion**

### **6.1 RQ4 (something general)**

### **6.2 Threats to Validity**





# **7 Conclusion**

This chapter summarizes the thesis and suggests possible directions for future work.

## **7.1 Summary**

## **7.2 Future Work ?**

All links were last followed on October 30, 2022.



### **Declaration**

I hereby declare that the work presented in this thesis is entirely my own and that I did not use any other sources and references than the listed ones. I have marked all direct or indirect statements from other sources contained therein as quotations. Neither this work nor significant parts of it were part of another examination procedure. I have not published this work in whole or in part before. The electronic copy is consistent with all submitted copies.

---

place, date, signature