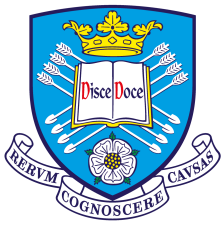

The University Of Sheffield.

Finding Security Issues in (Open Source) Software Repositories

Zer Jun Eng

supervised by

Dr. Achim Brucker

This report is submitted in partial fulfilment of the requirement for the degree of MEng Software Enginnering by Zer Jun Eng

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Declaration

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Name : Zer Jun Eng

Date : 1st October 2018

Contents

Chapter 1

Introduction

1.1 Background

Free/Libre and Open Source Software (**FLOSS**) is a type of software which its license allows the users to inspect, use, modify and redistribute the software's source code [3]. Since the introduction of Git, and later the Git repositories hosting site such as GitHub, many users have started to make their softwares open source by storing them as public repositories on GitHub. As a result, the participation of global communities into **FLOSS** projects has started to grow and different contributions were made to improve the softwares quality, which included fixing the software vulnerabilities [4].

Building a secure software is expensive, difficult, and time-consuming. In **FLOSS** projects, it is necessary to know when and how a security vulnerability is fixed. Therefore, having a list of changelogs or informative git commit messages that record the fixed security vulnerabilities is helpful. However, Arora and Telang [1] stated that some open source developers believe that public disclosure of security vulnerabilities patch is dangerous, and thus vulnerability fixing commits are not commonly identified in some open source software repositories to prevent malicious exploits. Hence, a repository mining tool that investigate vulnerability patterns and identify vulnerable software components can be developed to reduce the time and cost required to mitigate the vulnerabilities.

1.2 Objectives

- Identify the security patterns of the most popular security issues in OWASP Top Ten Project. The patterns should be expressed using regular expressions.
- Develop a repository mining tool to search through the commit history of a repository and find a list of commit messages that match the patterns.
- Extend the mining tool which checks the code difference in the commits found to obtain the actual commits fixing the security vulnerabilities.

1.3 Challenges

- **Data**: There are a large numbers of open source repositories available on GitHub. However, it is challenging to find a set of sample repositories that can produce accurate and consistent results.
- **Evaluation**: After mining a list of commit messages that contain the identified patterns, the evaluation process might not correctly locate the lines of code that addressed the security vulnerability.
- **Time**: Large repository such as Linux which has more than 780,000 commits in total [8] could be extremely time-consuming for the repository mining tool to complete the search and evaluation process.

1.4 Report Structure

Chapter 2 reviews a range of academic articles, theories and previous studies that is related to this project, as well as investigating the techniques and tools to be used.

Chapter 3 is a list of detailed requirements and a thorough analysis for design, implementation and testing stage.

Chapter 4 is a comparison between different design concepts, where the

advantages and disadvantages of difference approach are stated. The chosen design is justified with suitable diagrams provided including wireframes and UML.

Chapter 5 describes the implementation process by highlighting novel aspects to the algorithms used. Testing are performed by following a suitable model to evaluate the implementation.

Chapter 6 presents all the results along with critical discussions about the main findings, and outlines the possible improvements that could be made in the future work.

Chapter 7 summarises the main points of previous chapters and emphasise the results found.

1.5 Relationship to Degree Programme

This project will be focused on researching real-world software security problem by deploying a repository mining tool to open source software repositories with the purpose of studying the patterns of different security vulnerabilities patch. This relates to the 'Software Engineering' degree as it requires a good understanding in version control system and it aims to improve softwares quality by reducing the time and effort needed to locate and fix security vulnerabilities in the source code.

Chapter 2

Analysis

The purpose of this chapter is to discuss the problems to be solved and consider some of the core decisions to be made before starting the implementation.

2.1 Problems

As mentioned in **Section 1.2**, the repository mining tool must be able to detect commits that contain distinct patterns such as *fix*, *patch*, *vulnerability* etc. After extracting a possible list of commits, it should perform an evaluation process to identify the actual commits that fixed security vulnerability. This could be hard because not all open source software repositories are using the same programming language. Hence, it might be difficult to determine the actual lines of code that addressed the vulnerabilities.

2.2 Proposed Method

Build a command-line interface program that is able to run two separate process: the mining process and the evaluation process. The **mining** process takes a Git repository as input, searches through the commit log, and return the list of commits that might potentially contain a patch as a log file (JSON,

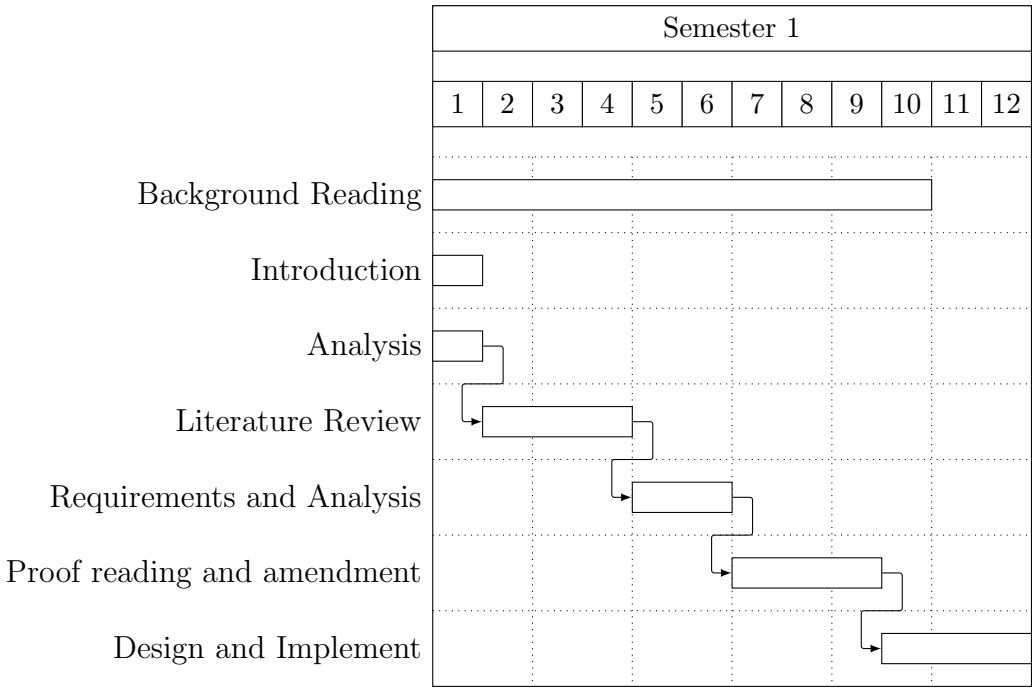
HTML, etc.). The **evaluation** process takes a log file as input, and check the code difference of every commit in the log file to identify the real patches.

2.3 Tools

- PyGithub is a Python library build to access the GitHub API [7].
- GitPython is a Python library build to interact with Git repositories using a combination of python and git command implementation [5].
- Secbench Mining Tool is a repository mining tool build by The Quasar Research Group to mine vulnerability patterns from GitHub repositories [15].

2.4 Plan of Action

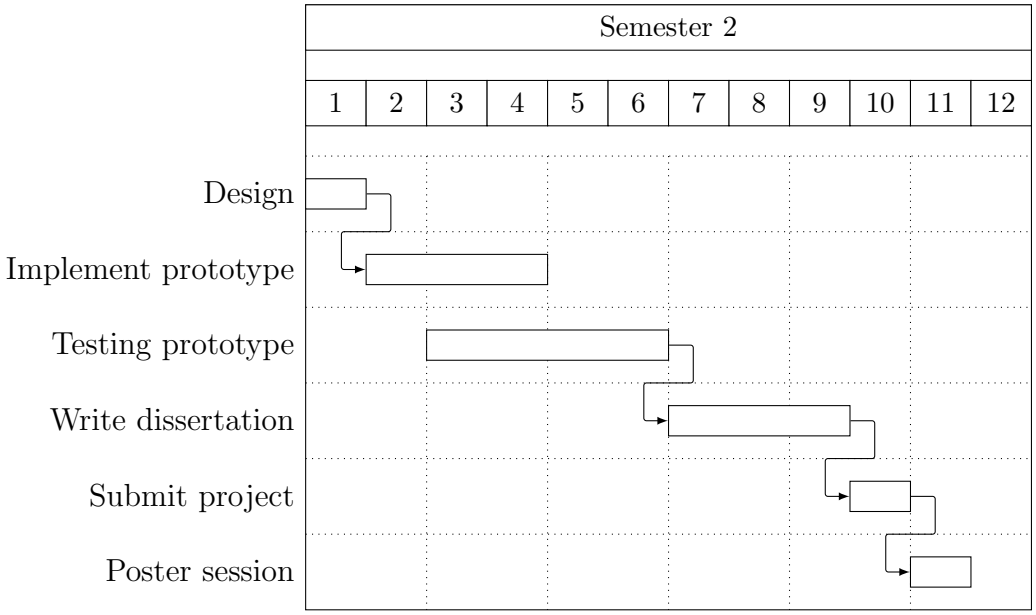
2.4.1 Semester 1



- **Week 7**: Starting from this week, discuss with the supervisor weekly about the document, also it is best to start the design stage early, and

show the prototype to the supervisor.

2.4.2 Semester 2



- **Week 1**: Finished the design and started implementation during holiday.
- **Week 2**: The implementing and testing stage is a repetitive process. It is very likely that the program will run into errors in the testing and had to spend more time fixing it.

Chapter 3

Literature Review

This chapter will start with the background contents of the project, and then focus on discussing the security aspect of open source softwares. Lastly, previous and existing relevant work are reviewed and a critical analysis is provided for the comparison of these resources and this project.

3.1 Open Source Security

There are currently two approaches to the license distribution of software: open source and closed source. The users of closed source software are limited to accept the level of security provided by their chosen vendor. In contrast, open source softwares provide more flexibility and freedom over the security option to their users [12], where the users can decide to wait for a patch from the vendor or collaborate with the community to develop their own.

Hoepman and Jacobs [6] suggested that open source softwares will have better security and reliability than closed source softwares through the power of open data and crowdsourcing. Conversely, Schryen [14] has shown that open source and closed source softwares do not have significant difference in terms of security vulnerabilities in his experiment and concluded that the policy of the developers is the main factor that determines the security. Wheeler [16] agrees with Schryen's view, but he also pointed out that open source systems are more resistant to attacks based on his researches.

While both statements might be true, Cowan [2] indicates that there are many factors determining the security of a software, and the source availability model is not the primary factor. Othmane et al. [9] have classified the main factors that affects the time required to fix a vulnerability into different categories, and one of them that is related to this project is the vulnerabilities characteristics. Vulnerabilities characteristics is the categorisation of security attacks into different types, which will be discussed in the next section.

3.2 Security Issues in Open Source Softwares

The Open Web Application Security Project (**OWASP**) is a worldwide non-profit organization committed to improve the software security of the open source community [10]. The project members of **OWASP** have worked together to produce a list of the most critical web application security risks based on the community feedback and comprehensive data contributed by different organizations. The list consists of ten categories of security attacks which are considered to be the most dangerous and popular in the recent years. The list published by **OWASP** in 2017 [11] will be analysed and the security risks listed in older versions of the top ten project will covered in this section too.

3.2.1 Injection

An injection attack is the exploitation of a software vulnerability where the attacker injects malicious code into the software and perform harmful executions. The most common types of injection attacks are Structured Query Language (**SQL**) injection, cross-site scripting (**XSS**), and command injection [13]. Injection flaws are very widespread and easy to discover when attackers have access to the source code, where they could use a code scanner tool to find all possible ways of the injection attacks.

3.2.2 Broken Authentication

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