Software Cloned Vulnerabilities: A Growing Threat to Software Security

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Abstract: Code is copied and pasted from one software project to another, a practise known as software cloning. Although it can be a convenient approach to save time and effort, doing so may also result in security flaws. Any vulnerabilities present in the original code are copied into the cloned code when it is duplicated. This implies that if an attack can be made against the original code, it can also be made against the copied code. Cloned vulnerabilities have become more prevalent in recent years. This is partly a result of the growing acceptance of open-source software, which is frequently copied and reused by other programmers. Software security may be seriously threatened by cloned vulnerabilities. They have occasionally been employed to carry out effective attacks on software systems. Overviews of cloned vulnerabilities, their effects, and available mitigation strategies are provided in this paper. It also explores the difficulties in identifying and avoiding copied vulnerabilities.

Keywords: cloned vulnerabilities, software security, code cloning, open-source software

Introduction: Software cloning is the practise of copying sections of code between software projects or inside a single software system. Code clones are sections of code that are very similar, either identically or architecturally [5]. Code clones typically fall into one of four categories: Type 1 clones: Exact replicas of code snippets that pop up across the software. Code snippets of type 2 clones share a similar syntax but may differ in the use of whitespace, variable names, or literals. Code fragments of type 3 clones are comparable in terms of functionality, but they may also include additional alterations or modifications in addition to syntactic changes. Code copies of type 4 share semantic similarities but are written in distinct syntax [5].

Cloning is often used because it enables developers to take use of already-written, well-tested code, which reduces development time, encourages code reuse, and makes maintenance easier [6]. However, dealing with cloned vulnerabilities poses additional difficulties and hazards due to software cloning. Widespread security hazards may result from the cloning of a code fragment that contains security holes, defects, or other vulnerabilities across the programme codebase [1]. Cloned vulnerabilities must be found and fixed in order to keep software secure and maintain the integrity of the codebase [6]. Due to the fact that attackers can use the same security flaws in other system components, the existence of such vulnerabilities increases the effect of possible assaults [1]. As a result, the copied code is likewise attackable if the original code is susceptible [1]. Cloned vulnerabilities have become more prevalent recently [2]. This is partly attributable to the growing use of open-source software, which is frequently copied and reused by other programmers [2].

It needs specialised tools and approaches that can precisely identify weak code portions to find replicated vulnerabilities [7]. Particularly for big codebases, manual examination may be time-consuming and error-prone [2]. Because of this, automated code clone detection techniques are essential for finding clones and assisting developers in efficiently resolving the problems [7]. These tools employ a variety of methods, including AST matching, text-based matching, token-based matching, and metric-based approaches [7]. Effective methods and scalable strategies are needed to find copied vulnerabilities in big codebases [2]. In order to expedite the identification process, several automated clone detection applications use indexing structures and optimisation methods [2]. These improvements make it possible for programmers to quickly analyse huge source repositories, making it easier to find and fix copied vulnerabilities [2].

Developers must follow recommended practises in code management and security to reduce the dangers brought on by copied vulnerabilities. Cloned vulnerabilities may be found and fixed early in the development process with the aid of regular code reviews and adherence to security principles and standards. The potential dangers of code copying and the significance of vulnerability identification may also be raised by encouraging a security-conscious culture inside development teams. Utilising automated vulnerability scanning techniques can help in effectively identifying copied issues inside huge codebases. Developers may reduce the effect of copied vulnerabilities and produce more robust and secure software systems by putting proactive procedures in place and continually checking the codebase for them.

Causes of Cloned Vulnerabilities: Cloned vulnerabilities can happen for a variety of reasons. Among the most frequent causes are:

- Unintentional copying: Cloned vulnerabilities are most frequently caused by accidental copying. It happens when developers unintentionally copy vulnerable code from one project to another [9].
- bad intent: In certain instances, bad actors purposefully introduce copied vulnerabilities. This can be done to steal private information or to take advantage of holes in software systems [9].
- Lack of knowledge: A lot of developers are not aware of the dangers of code copying. As a result, their software projects may unintentionally contain vulnerabilities [9].

Impact of Cloned Vulnerabilities: Cloned vulnerabilities can significantly affect the safety of software. They have occasionally been employed to carry out effective assaults on software systems. For instance, code cloning led to the introduction of the Heartbleed bug, a serious vulnerability in the OpenSSL cryptographic library [10]. This vulnerability affects several sorts of systems, including web servers, websites, software applications, and operating system releases. The Common Vulnerabilities and Exposures number for this issue is CVE-2014-0160 [47]. Since Heartbleed is a two-way vulnerability, both the server and the client are at risk. 2014 saw the discovery of this vulnerability by a Google security engineering team. All of this began with the Heartbeat TLS (Transport Layer Security) extension's debut in 2012 as a stage of development for OpenSSL standards. Heartbeat messages are continually delivered to the server as seen in the image below in order to maintain session life and connectivity. When a packet is received, the server will reply by retrieving the specified number of bytes from its own memory and sending it to the client. As a result, a vulnerability enables attackers to access memory of a system that houses sensitive data, such as user login passwords and secret keys protected by a weak version of OpenSSL. Due to a little error in the implementation of the OpenSSL Heartbeat extension, a vulnerability exists since there is no bound check on the size of the packet that needs to be acknowledged to the client or server.

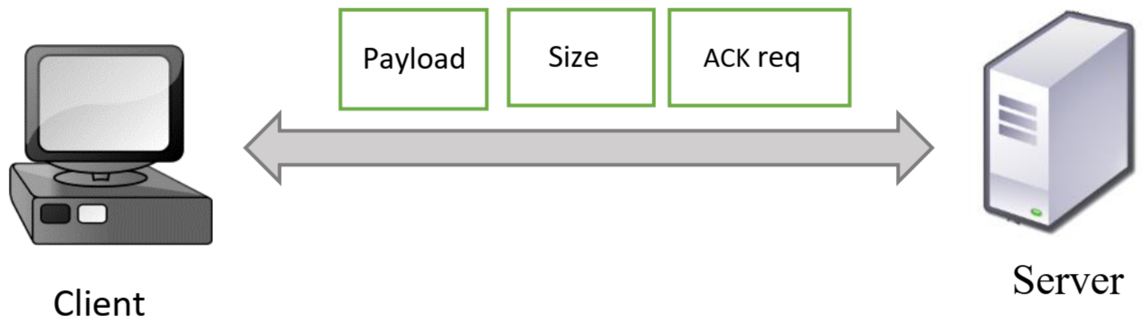

Figure 1: Heartbeat Message structure

This bug allowed attackers to read arbitrary memory from the server, which could be used to steal sensitive information such as passwords and credit card numbers.

Challenges of Detecting and Preventing Cloned Vulnerabilities: The software development community has very difficult hurdles in identifying and avoiding replicated vulnerabilities. These difficulties result from the difficulty in spotting patterns in code, comprehending the origins of vulnerabilities, and putting sensible mitigation measures in place [11]. Here are a few of the main difficulties:

- **Code Variability:** Software projects frequently include codebases with a high degree of unpredictability. Different developers or teams may write code using different programming languages, frameworks, and coding styles. since of these variances, it can be difficult to identify cloned vulnerabilities since same code parts may seem differently as a result of syntactic variations.
- **False Positives and False Negatives:** Automated clone detection methods have the potential to create both false positives (which mistake non-cloned code for clones) and false negatives (which fail to detect true clones). It's important to strike the correct mix between recall and precision. False negatives can prevent vulnerabilities from being found while high false positives might overload developers.
- **Partial Clones:** The code that is vulnerable may only be partially shared by cloned vulnerabilities, rather than being an identical duplicate. More advanced methods are required to detect partial clones since they may go undetected by traditional clone detection methods.

- **Code Evolution:** Throughout its existence, software is constantly updated, changed, and has bugs fixed. Cloned vulnerabilities can be added, removed, or changed while a programme is being developed, making it difficult to manage and keep up with a complete database of vulnerabilities.
- **Detection Scalability:** Large codebases can have millions of lines of code, especially in enterprise-level systems. Scalable techniques and available computing power are necessary for effectively scanning large repositories for replicated vulnerabilities.
- **Legacy Code:** It may be difficult to locate enough documentation or expertise about the code in older projects or legacy systems since the code may have been produced decades ago. It might be difficult to find replicated vulnerabilities in vintage systems because they may use antiquated coding techniques and security precautions.
- **Mitigation Strategies:** Developers must effectively patch any discovered copied vulnerabilities. Multiple software product vulnerability fixes can be difficult, time-consuming, and error-prone. A crucial problem is carrying out the necessary repairs without creating new vulnerabilities.
- **Third-Party Dependencies:** Software frequently uses libraries and parts from other companies. If these dependencies have security flaws, they may be copied across several projects, posing serious security threats. For total software security, third-party vulnerability management and identification are crucial.
- **Developer Awareness:** Because developers are unaware of or have a limited grasp of safe coding practises, developers may unintentionally add copied vulnerabilities. Such problems can be resolved by increasing knowledge of the dangers of code repetition and by offering safe coding training.
- **Open-Source Software:** The use of open-source software has substantially increased, presenting both many benefits and threats. Cloned flaws in well-known open-source projects may have an effect on a variety of applications.

Combining automated code clone detection techniques, developer training, safe coding procedures, and ongoing security audits is necessary to address these issues. Collaboration between security researchers, developers, and the larger software community is essential to keep ahead of any possible security dangers caused by copied vulnerabilities as the threat landscape changes.

Conclusion:

The software development community has significant obstacles when it comes to identifying and avoiding copied vulnerabilities. Effectively discovering and fixing these vulnerabilities is severely hampered by the variety of code, false positives and false negatives in detection, and the ongoing evolution of software. The landscape of software security is further complicated by legacy code, third-party dependencies, and the presence of open-source software. Throughout the entire software development lifecycle, developers must take preventative actions to lessen the harm posed by replicated vulnerabilities. This entails following secure coding guidelines, using specialised tools and methodologies for automatic code clone detection, and conducting thorough security audits [8]. Additionally, it is critical to raise developer knowledge of the dangers of code reuse and the value of secure development.It is crucial for security researchers, developers, and the larger software community to work together in order to exchange knowledge, best practises, and details regarding vulnerabilities that have been found. Industry-wide initiatives to address the problems posed by cloned vulnerabilities may result in the creation of more effective tools and methods for vulnerability early detection and remediation. Vigilance against copied vulnerabilities must remain a high focus as the software ecosystem develops. The resilience of applications and systems in the face of evolving threats will ultimately be determined by the community's commitment to software security. The software industry can make the user experience safer and more secure by taking on the threat of copied vulnerabilities head-on and securing sensitive data and crucial infrastructures from criminal actors.

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