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Tackling Open Source Software Vulnerabilities: From Culture, to Practices, to Tooling

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Introduction

It is almost essential for open source code to be present when developing any modern project. There are countless interconnected pieces of open source tooling and packages needed to build and maintain software, both for solo developers, teams, and companies. For example, free/libre Open Source Software or OSS saves the European economy roughly €114 billion per year directly, and up to €399 billion per year overall [1]. The prevalence and scale of OSS naturally means that any flaws manifest as vulnerabilities in the software and thereby the software that uses it. This is a highly relevant issue: countless household names have failed consumers and loss significant revenue due to OSS vulnerabilitiy exploitation. This was readily seen in the Equifax data leak in 2017, due to their deployed web application using a version of Apache Struts with a known vulnerability [2]. This could have been easily addressed, seeing as the vulnerability was known months before the leak occurred, and the fallout is still being dealt with by Americans today. Stories like these are present across all industries and are the reason for OSS vulnerabilities being a key focus of the security industry. WhiteSource's 2021 report found that 62.8% of 38,333 open source products that customers manage with their software have security vulnerabilities, even though 87% of them have known fixes. What makes OSS powerful and practical is also what makes it dangerous. The scale of use, high visibility, and openness to contribution means that good actors can update the software, while bad actors can find and exploit vulnerabilities. Whether a project for friends or an enterprise project for the masses, these focus areas are the keys to both short-term and long-term protection against notable OSS vulnerabilities that can harm global enterprises, all the way down to the average person. Fortunately, expanded tooling by leading security companies, in-depth research, and education by leading organizations such as OWASP are key initiatives to promote safer OSS practices.

Culture

How OSS is approached is key to reducing the burden of OSS, as it is often a matter of tech debt. Optimistically, fixing issues at the source would be the best solution. However, such a dramatic change would require industry-wide endeavor, as the scale of OSS is immense, manpower isn't. The complexity of such projects makes it hard to bring more people on, and even if bugs are found (which is difficult itself), there are estimates indicating that it can often take 3-5 months to fix a bug due to a variety of factors [3]. These time constraints can cause a considerable number of issues, and ones that hold true for many software projects. Developers may take pull requests for granted or fail to do rigorous testing, especially when code changes are long and confusing, especially when building on top of previously obscure and/or complex code. This issue may from the vested interest of developers, stemming from time commitments to private development. Although developers employed by companies or working on projects of their own use open source software, they are not being paid or directly encouraged to improve the OSS they use despite it having vulnerabilities. Teams responsible for the maintenance of OSS, if not affiliated with a company, may be quite small. One interesting idea is that it may be in a company's best interests to divert excess resources to key OSS. This helps the company's security and perhaps image (to an extent), the community, and also upskills engineers. Anecdotally, companies have started to offer a few hours a week for long-term growth and learning, time which could be spent on open source contributions. This would help all parties involved!

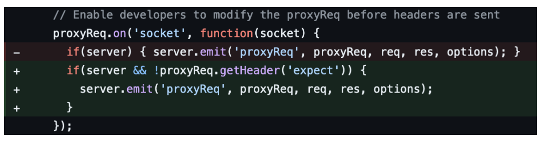
Looking deeper into culture, we can examine internal organizational culture and note that a healthy engineering mindset must be present and shared across teams and stakeholders for effective DevSecOps practices to be in place and to be practiced. Common practices for OSS vulnerabilities including upgrading software to safer versions and tracking usage, but it can be daunting to track so much information. Although tools for automation available, it takes time to set up systems that can live in DevOps infrastructure; this takes dedicated time, funding, and manpower that organizations must be willing to commit. No matter the research and tools present, there must be a vested interest in OSS best practices. Itweb puts this agreed sentiment best: "DevOps and DevSecOps empowered organizations generally are much more proactive in managing their open source component vulnerabilities".

Consistent and timely upkeep may be tedious, but continuous monitoring tooling is making it easier to identify upgrades retrieve a full report (Bill of Materials) of OSS [4]. This can be helpful for examining changes to dependency usage over time and examine what package(s) are the most problematic and thus cause the most risk, which would be the best to examine sooner in the case of an attack occurring. Having comprehensive information helps with upgrade plans, identification of alternatives, and preparedness to firefight. If attackers are successful, having a list to identify possible weaknesses is the key in systematically identify and removing the software that could've been exploited. Past security, there are great side effects, such as increased visibility into project structure for new developers and better documentation for legal purposes, such as compliance for OSS licensing [4]. This all factors into strong supply chain management, with standardized and systematic practices company wide [1].

Practical Examples

There are many tools that can directly analyze your code, dependency list, and public databases to combat OSS vulnerabilities. Automation here is the key, given the scale of dependencies and issue types. It is important to examine practical examples DOS attacks and SQL injections are common issues via OSS, which could found with static analysis tools integrated into a pipeline [3]. These tools may also include checks to examine if any installed OSS versions correspond with those in the National Vulnerability Database (NVD), a US government repository issued with CVE, the Common Vulnerabilities and Exposures program that tracks notable risks in the industry[2]. For example, Veracode's SCA tool uses publicly-known vulnerability information from National Vulnerability Database, as well as its own resources that it maintains and aggregates. In contrast to a more manual database approach, Veracode staffs security researchers that find vulnerabilities with a variety of ways, such as through the application of natural language processing and ML models to identify vulnerability-related commits and bug reports.[3].

Other DevSecOps tools include code analysis/scanning tools that are helpful for such deeper inspection; automation of identification of issues such as logic flaws and insecure legacy code can be integrated with monitoring and management systems, container vulnerability scanners, and code review tools. Such flaw identification can be seen with http-proxy, which has over 14 million weekly downloads via npm. http-proxy had a vulnerability fixed in mid-2020 to avoid Denial of Service attacks. For example, an HTTP request with a long body triggered the unhandled exception *ERR_HTTP_HEADERS_SENT* that crashes the proxy server when the proxy server sets headers in a given request using the proxyReq.setHeader function. Part of the fix relating to proxyReq is shown below:



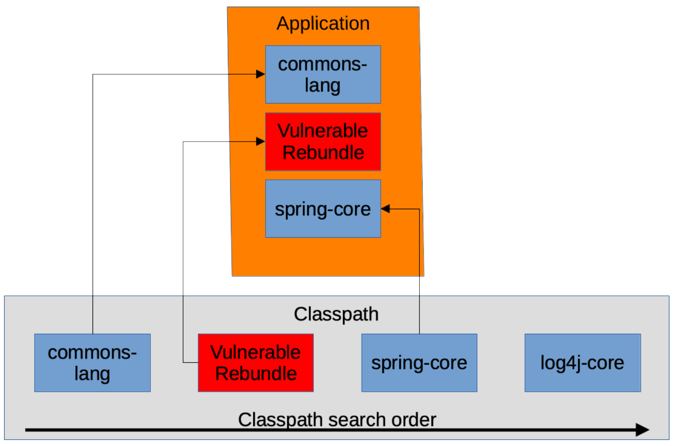
```
    // Enable developers to modify the proxyReq before headers are sent
    proxyReq.on('socket', function(socket) {
-     if(server) { server.emit('proxyReq', proxyReq, req, res, options); }
+     if(server && !proxyReq.getHeader('expect')) {
+       server.emit('proxyReq', proxyReq, req, res, options);
+     }
    });
```

This fix was merged May 17, 2020, 3 days after a GitHub issue was raised related to the npm audit that triggered the warning about the vulnerability [5] [6]. Even though we see a healthy amount of discussion about immediate resolutions and a long-term fix, the latter was only present after two days, which presented a window of opportunity for malicious users. GitHub, for example, has solutions to tackle questions of what to resolve. They have dependency insights to give advice for prioritization, offering a notion of low to critical risk based on the dependencies being used. The http-proxy issue above likely would have been on the higher end! With a healthy developer community that either reports directly on GitHub or shares reports from external organizations, GitHub and its tools offer one of many ways to take advantage of shared knowledge about OSS flagged as vulnerable. From this, we can learn that DevSecOps should also include continuous auditing to flag the most up to date issues.

Dynamic Challenges

A strong code foundation, including a clean code base, tracked dependencies, and static analysis for dependencies and tooling can create a clean and clear environment to do dynamic testing, which is the last area of focus and perhaps the most complex. Fortunately, tools such as Veracode Dynamic Analysis, a Dynamic Application Security Testing (DAST) solution for web applications are available. Of particular interest is how Veracode can crawl an application to find vulnerabilities that stem from dependencies [3]. More information about licenses, known vulnerabilities, versioning help with lessening risk and reducing security and legal issues, in addition to providing better visibility into their software projects [3].

Other tools such as Eclipse Steady can examine compiled Java code and report vulnerabilities by examining "fix-commits," as analyzing construct changes (ones impacting the AST) is less expensive and still efficient [7]. One study compared Steady with the OWASP Dependency Check (OWASP DC), scanning 300 large enterprise applications under development with 8165 dependencies and found all resulting code errors to be true positives, while only using OWASP DC with a differing code-centric approach led to 88.8% false positives [7]. Although we should be wary of greater bloat, multiple tools and strategies are helpful to tackle vulnerabilities due to less obvious minute details such as code bundling and dynamic loading, as seen in the following diagram:



Example of re-bundle in a Java program via SAP [8]

As seen, Java still has many risks despite its popularity. A common enterprise language, the programming language's dynamic nature means attackers have ways to exploit it. Since Java applications are able to change their behavior by loading new code at runtime, this poses new risks. Especially since this is being more commonly used in modern applications, potential attackers can attack dynamic platforms by loading in code dynamically. Attackers can the progress by stealing data, downloading malware, adding in ransomware, and more [8]. As SAP puts it, "re-bundles are a juicy attack vectors: the more popular a library is, the more probable it is that someone re-bundles vulnerable code that can be used by digital criminal to attack the application". Scanning with a code-based approach is a further step that may need to be taken, but keeping in mind the study with OWASP DC, more research needs to be done on how this can implemented effectively. Of course, this is the reason why OSS is on the forefront of the security industry's mind.

Ultimately, this is indicative of how complex OSS vulnerabilities can be, which is all the most reason that organizations need to invest in the tooling available to automatically scan software. Again, we should also minimize risk, considering newer practices such as debloating, in which we remove as much extra code and dependencies from our own software and from OSS as possible in a manner that does not change its functionality, thereby reducing available "attack surface" [8].

Final Thoughts

The bank industry is well-known for a slower pace due to bureaucracy and regulation. With more time, developers could be more conscious about OSS for auditing and security purposes. For example, in a notable American bulge bracket, external software had to be submitted to a security team for analysis, naturally creating documentation from the submissions and more careful usage of tooling. Although the manual review process did cause frustration, OSS was less of a concern since there were already standardized procedures. For example, remediation for Log4J was initially much quicker with comprehensive information about which dependencies also had Log4J as a dependency. Auditing OSS, both regular and suprise, as well as internal and external, were also made it easier [1]. This is a great example of how culture, practices, and tooling can have a clear and direct impact on OSS, but they must come together to be effective. It must be ingrained in the culture, and stakeholders need to care. While in this case there is a higher level of care due to the nature of the regulatory concerns of the industry, it is at least a good baseline for an industry that has much of our most sensitive private information stored.

As mentioned above, a more recent and infamous example of OSS is the Log4J vulnerability, in which Java-based logging utility tool allowed malicious users to execute remote code (a flaw now known as CVE-2021-44228) due to how the library processed data. As is true for most well-known vulnerabilities, it had an impact on organizations of all kinds worldwide, such as government agencies, financial institutions, and of course, tech companies. Although an emergency patch was quickly developed by the Log4J development team, there was still immense panic worldwide to the significant threat imposed on corporate security. This example is brough up to reemphasize the impact of OSS, and to reiterate how important it is the culture, practices, and tooling are integrated at an institutional level and hopefully at a broader level, with technology as a whole.

In some ways, it is ironic that DevOps tooling itself is prominently driven OSS, meaning the very foundation of valuable infrastructure that can help us better address the risks we are discussing also likely have them as well. Ultimately, the reality is that OSS vulnerabilities are deeply rooted in all of software engineering, with potential massive scale and impact for any given exploit. Despite this, there are luckily many practices that exist to reduce risk if time and investment is put into the right security mindset where automation augments OSS tracking and active remediate. Furthermore, folks technology and security are highly motivated to create improvements. These practices, augmented by cultural changes and upgraded tooling, are continually being discussed, monitored, and updated as we speak.

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