Sniffing for Codebase Secret Leaks with Known Production Secrets in Industry

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ABSTRACT
Leaked secrets, such as passwords and API keys, in codebases were responsible for numerous security breaches. Existing heuristic techniques, such as pattern matching, entropy analysis, and machine learning, exist to detect and alert developers of such leaks. Heuristics, however, naturally exhibit false positives, which require triaging and can lead to developer frustration. We propose to use known production secrets as a source of ground truth for sniffing secret leaks in codebases. We develop techniques for using known secrets to sniff whole codebases and continuously sniff differential code revisions. We uncover different performance and security needs when sniffing for known secrets in these two situations in an industrial environment.

CCS CONCEPTS
• Security and privacy → Software security engineering; • Software and its engineering → Software maintenance tools;

KEYWORDS
application security, continuous testing, experience paper, hardcoded secrets, leak detection, production secrets, secret management, secure coding, static analysis

1 INTRODUCTION
Code repositories may accidentally leak secrets, such as private keys, API tokens, or passwords. Such leaks facilitated numerous past security exploits [4, 7, 13]. Existing tools for detecting leaked secrets often use heuristic techniques such as regex patterns [1, 2, 8–10, 12], entropy analysis [1, 3, 8, 12], and machine learning [5, 6]. Heuristic techniques, however, can be prone to false positives, thus requiring manual triaging of analysis output. Moreover, a blocking mechanism to prevent developers from ever uploading secrets into codebases requires a very low false-positive rate; otherwise, developers will become frustrated and lose confidence [11].

We propose a method for detecting secret leaks in codebases that aims to minimize false positives. We use known production secrets as a source of ground truth for detecting the presence of secrets. We extract known production secrets from our secret managers—tools that centrally manage storage of and access to secrets. Although sniffing for known secrets cannot detect leaks of secrets not stored in a secret manager, we expect very few false positives with our technique of sniffing with known secrets.

2 APPROACH

2.1 Whole Codebase Sniffer
We sniff for secret leaks in whole codebases by pattern matching against raw production secrets. The Whole Codebase Sniffer pulls production secrets from secret managers, constructs regex patterns for each secret, and attempts to find matches for these instructions in our codebase.

When constructing a regex pattern for a secret, we consider the possibility that a hard-coded secret might be interrupted by whitespace or string concatenations. We thus match any whitespace and up to 5 non-whitespace characters between each character in the secret.

Since our codebase is gigabytes in size, our Whole Codebase Sniffer needs to be reasonably performant on such large inputs.

2.2 Continuous Differential Revision Sniffer
Unlike the scenario of sniffing whole codebases, sniffing differential code revisions—such as git commits—does not require sifting through gigabytes of source code. However, our Continuous Differential Revision Sniffer needs to cope with a high velocity of uploaded code revisions during times of busy development.

We found the Whole Codebase Sniffer’s step of pulling all production secrets from our secret managers per every invocation to be excessively slow for continuous sniffing. An alternative is to maintain a cache of raw production secrets for our continuous sniffer. Caching our production secrets, however, increases our attack surface and requires strict access control to the system hosting the continuous sniffer.
To satisfy the performance needs of continuously sniffing a high velocity of code revisions while managing risks to the confidentiality of our production secrets, we use a hashing-based approach to detect leaks of known secrets. Figure 1 visualizes the process of sniffing for leaked secrets in a differential code revision. The continuous sniffer maintains a cache of hashed secrets derived from the raw secrets in our secret managers. When a developer uploads a differential code revision for code review, the continuous sniffer tokenizes the differential code revision. The sniffer then hashes the revision’s tokens and compares the set of hashed tokens to the set of hashed production secrets. If the intersection of the two sets is nonzero, then the code revision leaks secrets.

If the Continuous Differential Revision Sniffer detects the leak of known secrets in a developer’s code revision, the most secure next step is to block the developer from pushing the leaky code revision onto the remote codebase. A developer-blocking solution, however, brings stricter requirements for reliability and security of the sniffing tool and its supporting infrastructure. Failures in a developer-blocking secret sniffer, whether due to logic bugs or infrastructure failure, can—in the worst case—hinder every single software developer in the company from pushing code. Such failures can induce developers to lose trust and confidence in the company’s security team. Such distrust can lead to an unwillingness to adopt developer-facing security tools in the future. Moreover, a developer-blocking sniffer would open a potential attack vector to brute force production secrets. Remedies to close this attack vector, such as rate limiting, are also subject to the same stringent reliability requirements of a developer-blocking sniffer. As an interim solution, the sniffer alerts security incident responders, rather than block the developer, in the event of a detected secret leak.

3 CONCLUSION AND FUTURE WORK

We propose using known production secrets as a source of ground truth for sniffing secret leaks with few false positives. We intend to use known secrets to sniff both whole codebases and continuously sniff differential code revisions in our industrial software engineering environment.

We intend to evaluate our sniffers on our internal codebases, and compare their performance to existing heuristics-based secret detection tools.

We observe that a substantial portion of our secrets reside in structured formats (e.g., JSON, XML) alongside non-secret information. An example is a JSON credentials file containing a non-secret username and a secret password. We may develop techniques to decompose such structured secrets in future work.

Since secret leaks are not exclusive to codebases, we are also considering extending our sniffers to inspect emails, chat systems, and databases.

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Figure 1: Continuous Differential Revision Sniffer