SECOMlint: A linter for Security Commit Messages

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Abstract—Transparent and efficient vulnerability and patch disclosure are still a challenge in the security community, essentially because of the poor-quality documentation stemming from the lack of standards. SECOM is a recently-proposed standard convention for security commit messages that enables the writing of well-structured and complete commit messages for security patches. The convention prescribes different bits of security-related information essential for a better understanding of vulnerabilities by humans and tools. SECOMlint is an automated and configurable solution to help security and maintenance teams infer compliance against the SECOM standard when submitting patches to security vulnerabilities in their source version control systems. The tool leverages the natural language processing technique Named-Entity Recognition (NER) to extract security-related information from commit messages and uses it to match the compliance standards designed. We provide a demonstration of SECOMlint at https://youtu.be/-1hzpMN_uFI; and documentation and its source code at https://tqrg.github.io/secomlint/.

Index Terms—standard, compliance, best practices, security

I. INTRODUCTION

Only 9% of known security vulnerabilities reported on websites such as the Open-Source Vulnerability (OSV) database and the National Vulnerability database (NVD) reference the fixes, i.e., the code sample (or diff) that patched the problem. Maintenance and security teams revisit many of these vulnerabilities in yearly security reports or even when new exploits are found (in case of an incomplete fix). In addition, researchers often use the history of vulnerabilities to learn more about their scope [1] and as a baseline to validate new approaches in the security field [2], [3].

Transparent and efficient vulnerability and patch disclosure is still a challenge in the security community, essentially because of poor quality documentation [4] which is the result of the lack of standards and poor (or non) application of existent best practices. In the security field, many times, the documentation is poor on purpose to avoid potential threats that may arise from providing detailed information on vulnerabilities and respective patches. However, this violates transparent disclosure and encumbers the life of many maintenance and security teams. SECOM is a recently-proposed standard convention for security commit messages that enables the writing of well-structured and complete commit messages for security patches [5]. The convention includes security-related information that is crucial for a better understanding of vulnerabilities and respective patches for both humans and tools.

Motivation. Known vulnerabilities are reported on websites such as the National Vulnerability Database (NVD) and the Open-Source Vulnerability (OSV) Database. One example of a known vulnerability is CVE-2022-35928. A security commit is any commit involved in the patch of a known security vulnerability, such as CVE-2022-35928. For instance, if you look at the section “References to Advisories, Solutions, and Tools” of the CVE-2022-35928 report, you will find a GitHub reference to a GitHub commit (6876185) which is the commit responsible for the patch. A security commit message is typically used to document the security commit used to patch the vulnerability. Figure 1 shows the commit message used to document the patch for CVE-2022-35928. This commit message only provides a very brief description of the patch. It does not describe the vulnerability, its importance, and the patch in detail. It also does not provide the CVE identifier, the type of weakness, the severity of the vulnerability, who reviewed and authored the patch, and other bits of information that are crucial for understanding and maintaining the vulnerability and the patch.

Fig. 1. Example of the commit message used to patch the CVE-2022-35928 (screenshot taken on August 10th)

Security and Maintenance Teams. Providing well-structured documentation and context on the patches of these vulnerabilities in security commit messages is highly important for maintenance teams when vulnerabilities are exploited again or revisited in yearly reports.

SECOMlint is a linter or compliance checker that automates the verification of security commit messages against the SECOM convention. The linter applies rules on different text features and calculates the degree of compliance of a message with the standard. An output report is provided to assist security engineers to produce better security commit messages.

This paper describes SECOMlint and how one can use it to produce better, more informative, security commit messages.

II. SECOM CONVENTION

SECOM is a convention for security commit messages [5]. The convention was created based on a well-known group of sources [6]–[9] on writing good commit messages to facilitate the adoption in practice. The structure and set of fields included in the convention were inferred from 1) an empirical analysis of security-related commit messages collected from vulnerability databases such as NVD and OSV and 2) feedback collected alongside Open Source Security Foundation (OpenSSF). SECOM was considered one of the best practices for bulk generation of pull requests to scale vulnerability patching [10].

The convention (Figure 1) consists of five main sections: header, includes the type vuln-fix, a simple description of the vulnerability and its identifier (when available); body, describes the vulnerability (what), its impact (why) and the patch to fix the vulnerability (how); metadata, such as type of weakness (CWE-ID), severity, CVSS, detection methods, report link, and version of the software where the vulnerability was introduced; contacts, the names and e-mail contacts of the reporters and reviewers; and, finally, references to bug trackers. The different sections should be separated with a new line.

Listing 1. SECOM Convention

```xml
<type>: <header/subject> (<Vuln-ID>)
<body>
# (what) describe the vulnerability
# (why) describe its impact
# (how) describe the fix

Weakness: <Weakness Name/CWE-ID>
Severity: <Low, Medium, High, Critical>
CVSS: <Severity numerical representation>
Detection: <Method, Tool>
Report: <Report Link>
Introduced in: <Commit Hash>
Reported-by: <Name> (<E-mail>)
Signed-off-by: <Name> (<E-mail>)
Bug-tracker: <Bug-tracker Link>
OR
Resolves: <Issue/PR No.>
See also: <Issue/PR No.>
```

III. CHECKING SECURITY COMMIT MESSAGE COMPLIANCE WITH SECOMlint

SECOMlint is written in Python and requires at least Python 3.8 to run. It can be run as a standalone command-line application, and it is released under the MIT open-source license.

A. SECOMlint’s Components

Figure 2 shows the different components of SECOMlint and the information flow for one run of it. The tool takes as input a commit message which is parsed and divided into different sections: header, body, metadata, contact and bug-tracker references.

For each of those sections, we apply our Named Entity Recognition (NER) extractor. NER (or entity chunking) is a technique used in the natural language processing field to
**TABLE I**  
ENTITIES DESCRIPTION AND RATIONALE.

<table>
<thead>
<tr>
<th>entity</th>
<th>rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTION</td>
<td>A commit usually implies an action: adding some features, fixing a problem, refactoring code, and more.</td>
</tr>
<tr>
<td>FLAW</td>
<td>Fixing a security vulnerability usually implies fixing a flaw (e.g., problem, defect, issue, weakness, flaw, bug, error, etc.).</td>
</tr>
<tr>
<td>VUNLID</td>
<td>Known vulnerability ids: CVE, GHSA, DSV, etc.</td>
</tr>
<tr>
<td>CWEID</td>
<td>Vulnerability type (CWE-ID/Weakness name).</td>
</tr>
<tr>
<td>ISSUE</td>
<td>The GitHub issue number or pull request sometimes is referenced in commit messages.</td>
</tr>
<tr>
<td>EMAIL</td>
<td>Contact e-mails of reviewers and authors usually appear after tags such as 'Reported-by'.</td>
</tr>
<tr>
<td>URL</td>
<td>Vulnerability reports or blog posts; and bug-tracking references.</td>
</tr>
<tr>
<td>SHA</td>
<td>Sometimes commit hashes are mentioned to reference where the vulnerability was introduced.</td>
</tr>
<tr>
<td>VERSION</td>
<td>Software versions are sometimes important to find mentions of malicious software.</td>
</tr>
<tr>
<td>SEVERITY</td>
<td>Vulnerability severity: low, medium, high, critical.</td>
</tr>
<tr>
<td>DETECTION</td>
<td>Vulnerabilities are detected manually or using specific tools (such as codeql, coverity, oss-fuzz, libfuzzer, and more).</td>
</tr>
<tr>
<td>SECWORD</td>
<td>Words or group of words that were identified as security-relevant in previous work [11], [12].</td>
</tr>
</tbody>
</table>

identify and extract key information, also known as entities, in the text. Entities may be organizations, people’s names, company names, and more. Spacy provides language processing pipelines that take the text and perform several different pre-processing steps such as tokenization (segment text into tokens), tagger (assign part-of-speech tags), parser (assign dependency labels between tokens), and NER (detect and label named entities). The different steps can be enabled, disabled, or replaced by new rule-based models, i.e., steps such as NER can be replaced by new rule-based models to extract new types of entities. From a large empirical analysis of security commit messages, we noticed some groups of keywords that could represent different entities, such as vulnerability IDs, weakness IDs, severity, security-related words, and more. These groups of keywords or patterns can be translated into rules and used by the NER step in the spacy pipeline to extract the set of entities designed. Table [1] shows the different types of entities we end up designing. Some of the entities are not security specific but important since they are patterns that come from applying generic commit messages best practices, e.g., references to issues (#NUMBER).

The extractor uses a pre-trained model provided by spacy to parse and extract important features of the text. Some of these features, such as the part-of-speech tags, are used in the NER rules to improve precision. For instance, an action implies a verb; therefore, we only extract keywords like “fix”, “patch”, “prevent”, etc, when the speech tag is a verb. After extracting the different entities per section, we apply the different sets of section rules. Rules are explained in more detail here: [https://tqrg.github.io/secomlint/#/secomlint-rules](https://tqrg.github.io/secomlint/#/secomlint-rules)  
For some rules, the compliance checker takes into account the types of entities that are expected to obtain. For instance, for the rule header-ends-with-vuln-id, it is expected that the header line (first line of the message) ends with an entity type of VUNLID.

We also use the NER extractor to help the security engineer to make the body section security informative, i.e., the tool provides the option --is-body-informative which checks if the body includes any security-related words. If not, it should be improved to be more clear. The body section is especially important because it's where security engineers explain the problem, its importance, and fix.

B. Using SECOMlint

SECOMlint can be executed by checking out its source code or—more conveniently—be installed from the Python Package Index via the pip utility tool. The tool is meant to be used as a command-line application to ease its integration in the software development lifecycle. This section aims to provide an overview of the tool’s functionalities. One can get an overview of all command-line arguments by using the --help option after installing SECOMlint.

```
$ secomlint --help
```

Please note that to run SECOMlint successfully, the spacy English large model (python -m spacy download en_core_web_lg) has to be downloaded since it is responsible for extracting text features, such as the part-of-speech tags that are later used by the rule matcher. SECOMlint without any argument expects a text input. One way to provide it is by collecting the raw commit message with git: git log -1 --pretty=%B. But if you want to run it on a simple string, you can also do it by using echo.

```
$ git log -1 --pretty=%B | secomlint
```

```
$ echo "<message>" | secomlint
```

SECOMlint will output a report with the compliance of the message against each of the rules and a summary of it “found X problem(s), Y warning(s)”. Problems are compliance violations that, in our view, need to be fixed, while warnings are smaller problems that should be fixed.

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4[https://spacy.io](https://spacy.io)
5[PyPi: https://pypi.org/](https://pypi.org/)
The importance of the different checkers can be customized with an YAML file. The \(--\text{config}\) argument should be used to pass the new configuration. By default, rules are all active. Therefore, if one wants to disable a rule, it will have to set the rule \texttt{active} tag to false. Problems are set as \texttt{type} equal to 1 and warnings as \texttt{type} equal to 0. Therefore, one can change the importance type to 1 if one wants to make a rule mandatory to comply with. The value checked for some rules can be customized with a value or regular expression. One example is the rule \texttt{header_starts\_with\_type}, the value for the type at the beginning of the header can be changed.

<table>
<thead>
<tr>
<th>header_starts_with_type:</th>
</tr>
</thead>
<tbody>
<tr>
<td>type: 1</td>
</tr>
<tr>
<td>value: ‘fix’</td>
</tr>
<tr>
<td>metadata_has_detection:</td>
</tr>
<tr>
<td>active: false</td>
</tr>
</tbody>
</table>

\[
\text{git log } -l --pretty=%B | \text{secomlint } \quad --\text{config=config.yml}
\]

Since the list of results may be a little bit extensive for some viewers, we added the argument \texttt{--no-compliance}, which will only show the result of the rules that do not comply with the convention, i.e., warnings and problems. In addition, to measure the compliance of his security commit message against the SECOM convention, one can use the argument \texttt{--score}. This argument will add the percentage of compliance to the summary (Figure 2). The score is calculated as a simple probability, i.e., the number of rules satisfied by the security commit message divided by the total number of rules that should be satisfied.

\[
\text{git log } -l --pretty=%B | \text{secomlint } \quad --\text{no-compliance} \quad --\text{score}
\]

As mentioned before, the message’s body is very important because it summarizes the problem, its importance, and the patch. This information will help maintainers and researchers make better understanding of the vulnerabilities and respective solutions. In our empirical analysis, we observed several cases where we couldn’t understand how the commit was related to security because the vocabulary was not security-related enough. Therefore, we provide an extra feature that runs the entity extraction on the body’s message and checks if it can extract any security-related word. If not, then the writer should improve the body’s message.

\[
\text{git log } -l --pretty=%B | \text{secomlint } \quad --\text{is\_body\_informative}
\]

The tool can also be applied to a .csv file containing a column for messages by passing the file’s name with the \texttt{--from\_file} argument.

## IV. Evaluation

We evaluated \texttt{SECOMlint} in two different distributions: 1) \texttt{pre\_secom}, a subset of 500 random security commit messages collect from NVD and OSV reports (excluding the automated ones); 2) \texttt{after\_secom}, a subset of 500 random security commit messages collected from an experiment performed by a security engineer where several security vulnerability fixes used the SECOM convention to document the patch [10]. The mean compliance score for the \texttt{before\_secom} sample was 76.01%. The extractor extracted all types of entities from commit messages, but only a total of 2675 entities—an average of 5 entities per security commit message. The mean compliance score for the \texttt{after\_secom} sample was 86.61%. The tool extracted 10 out of 12 types of entities from commit messages, a total of 9911 different entities—an average of 20 entities per security commit message. It seems that by applying the SECOM convention, we can extract more information from security commit messages.

## V. Conclusions

In this work, we have summarized the inner workings and features of \texttt{SECOMlint}. This tool was designed to be quickly introduced into the software development life cycle and support the appliance of the SECOM convention to security-related commit messages. By providing \texttt{SECOMlint} as open-source, we hope to foster the development of well-structured and more informative security commit messages. Further information on \texttt{SECOMlint}, its documentation, and source code are available through \url{https://targ.github.io/secomlint/}. A tool demonstration can be observed on YouTube: \url{https://youtu.be/1hzpMN_uFl}. In the future, we plan to make the tool more customizable, extensible, and able to generate suggestions for the writer or even potential automated refactoring.

## References


