Code-based Vulnerability Detection in Node.js Applications: How far are we?

Bodin Chinthanet  
Nara Institute of Science and Technology, Japan  
bodin.chinthanet.ay1@is.naist.jp

Serena Elisa Ponta, Henrik Plate, Antonino Sabetta  
SAP Security Research, France  
serena.ponta@sap.com  
henrik.plate@sap.com  
antonino.sabetta@sap.com

Raula Gaikovina Kula, Takashi Ishio, Kenichi Matsumoto  
Nara Institute of Science and Technology, Japan  
raula-k@is.naist.jp  
ishio@is.naist.jp  
matsumoto@is.naist.jp

ABSTRACT

With one of the largest available collection of reusable packages, the JavaScript runtime environment Node.js is one of the most popular programming application. With recent work showing evidence that known vulnerabilities are prevalent in both open source and industrial software, we propose and implement a viable code-based vulnerability detection tool for Node.js applications. Our case study lists the challenges encountered while implementing our Node.js vulnerable code detector.

ACM Reference Format:
Bodin Chinthanet, Serena Elisa Ponta, Henrik Plate, Antonino Sabetta, and Raula Gaikovina Kula, Takashi Ishio, Kenichi Matsumoto. 2020. Code-based Vulnerability Detection in Node.js Applications: How far are we?. In Proceedings of The 35th IEEE/ACM International Conference on Automated Software Engineering (ASE 2020). ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/nnnnnn.nnnnnn

1 INTRODUCTION

As of 2020, the Node.js package manager (i.e., npm) is reported to serve over 1.3 million packages to roughly 12 million developers, who download such packages 75 billion times a month, and all at a growing rate [19]. Furthermore, as evidence of its influence, the industry giant Microsoft’s GitHub had completed its acquisition of npm earlier in April, 2020. Recent studies have shown evidence that known vulnerabilities can affect both open source and industrial applications alike [24].

Most detection methods for vulnerabilities has been at metadata [7, 17]. Meta-detection capabilities rely on the assumption that the metadata associated to Open Source Software (OSS) libraries (e.g., name, version), and to vulnerability descriptions (e.g., technical details, list of affected components) are always available and accurate. The metadata, which are used to map each library onto a list of known vulnerabilities that affect it, are often incomplete, inconsistent, or missing altogether. Existing works show that such approaches are unreliable and suffer from false positives [28].

Ponta et al. [21, 22] proposed Eclipse-Steady, a code-centric and usage-based approach to detect open source vulnerabilities. The Eclipse-Steady project [6] is able to identify, assess and mitigate open source dependencies with known vulnerabilities for Java and Python industry grade applications. It supports software development organizations in regard to the secure use of open source components during application development. A code-centric approach reduces the number of false positives and false negatives as it accounts for the actual presence of vulnerable constructs (i.e., constructs that are modified by the patch), no matter where they occur [21, 22]. Having identified the vulnerable constructs, it is then possible to establish whether they are reachable in the context of an application thereby assessing the potential impact of the vulnerability.

Although most studies use meta-detection (i.e., checking the package.json configuration file) for mapping npm vulnerabilities to the packages, there is yet to be a code-centric approach designed for JavaScript Node.js applications [4, 5, 10, 29]. Lauinger et al. [11] provides evidence that JavaScript issues are prevalent in most web applications, strengthening the argument for a Node.js code-centric solution. Due to the dynamic event-based nature of JavaScript code, the performance of a code-centric approach is unknown.

To address this gap, in this paper we present an experience report on a code-centric approach to detect open source vulnerabilities using bill of materials to determine whether vulnerable code is repackaged within Node.js applications. First, we discuss the challenges associated with the construction of bill of materials of Node.js applications. We then propose our solution to counter these challenges. To evaluate our approach, we perform a case study on 65 Node.js applications under development at SAP. Preliminary results show that our method is viable, with vulnerable code from five vulnerabilities being detected in 18 applications under development. The study highlights three lessons learned and the challenges that require attention by both researchers and practitioners dealing with Node.js applications and JavaScript in general.

2 PERILS OF JAVASCRIPT NODE.JS ANALYSIS

Analysis of JavaScript code is not trivial, as server-side Node.js applications (including npm packages) involve sockets, streams, and files performed in an asynchronous manner, where the execution of listeners is triggered by events [13]. The challenge for such dynamic code is the proper identification of a function call, which has been the issue for static analysis tools [3, 23]. Moreover, JavaScript allows...
anonymous functions, i.e., functions without a name [25]. To avoid this complexity of the reachability analysis, our approach is based on the detection of vulnerable code.

We reuse the approach proposed by Ponta et al. [21, 22], where a vulnerability is detected whenever an application dependency contains program constructs (such as methods) that were modified, added, or deleted to fix that vulnerability. We extend Eclipse-Steady to support the analysis of JavaScript code [14]. In particular, we add the ability to construct the list of program constructs modified to fix JavaScript vulnerabilities, as well as the list of program constructs which are part of a JavaScript application and dependencies (its bill of materials).

3 BILL OF MATERIALS FOR NODE.JS
When compared to the classical model (i.e., Java or C++), JavaScript does not provide a true class implementation. Instead, it has only the object construct with its private property (i.e., prototype) to imitate the constructs from the classical model [27]. A program construct is defined as a set of structural elements with a language, a type, and a unique fully-qualified name identifier as defined in Ponta et al. [21, 22].

3.1 Constructs for a Node.js application

Listing 1: Example of a class of util_b.js

```javascript
class Car {
    constructor(name, age) { ... }
    drive(distance, direction) { ... }
}
var item_list = { ... }
function buy(item) { ... }
```

Figure 1 illustrates a hierarchical structure of a Node.js project, which will be used as our running example. Complementary, Listing 1 shows a code snippet from the JavaScript file util_b.js of Figure 1. We use these running examples to explain our proposed approach to building the list of program constructs (i.e., NODE.js).

Table 1: Defined List of Constructs in hierarchical chain for Node.js Applications. This is based on Figure 1 and Listing 1

| Construct Type | Description | Fully Qualified Name |
|---------------|-------------|----------------------|
| Package (PACK)| Package and Directory name | ProjectA             |
| Module (MODU) | File name   | ProjectA.utils.util_b |
| Function (FUNC)| Function name with arguments | ProjectA.utils.util_b.buy(item) |
| Class (CLAS)  | Class name with extended class | ProjectA.utils.util_b.Car() |
| Method (METH) | Method name with arguments | ProjectA.utils.util_b.Car().drive(distance,direction) |
| Constructor (CONS) | Constructor name with arguments | ProjectA.utils.util_b.Car().constructor(name,age) |
| Object (OBJT) | Object name | ProjectA.utils.util_b.item_list |

Table 2: Defined List of Constructs in hierarchical chain for Node.js Applications. This is based on Figure 1 and Listing 1

3.2 Dependency Constructs and their Features

The program constructs defined in Section 3 are also used to obtain the bill of materials of the third-party dependencies that are contained within the application (i.e., npm package). Following our running example in Figure 1, we use the package.json configuration file and the node_modules directory. In our example, the vulnerable construct is in the debug package at the OBJT level (i.e., debug.src.node.exports.formatters.o(v)).

Listing 2: Dependency snippet from package.json

```json
...,
"dependencies": {
  "moment": "2.25.3"
},
"devDependencies": {
  "debug": "3.0.0"
}
...
```

Figure 1: Running example of the Node.js project with its hierarchical structure.
The first is related to whether or not the dependency will be used in production. There are two types of dependencies. Runtime dependencies (i.e., moment package) are those intended to be used in production. Test dependencies (i.e., debug package) are intended as development-only packages, unneeded in production.

![Dependency tree of ProjectA](image)

Listing 3: Dependency tree of ProjectA

The second feature is the dependency tree depth. Listing 3 shows the dependency tree that depicts the relationships among the packages debug, moment and ms. There are two types of dependencies: direct and transitive. Direct dependencies are directly required by the application. As shown in the example, the packages debug and moment are direct dependencies and are listed in the package . json file. Transitive dependencies are not directly required by the application but are required by its dependencies. As shown in Listing 3, the ms package is a transitive package required by debug.

4 CASE STUDY OF NODE.JS APPLICATIONS

To evaluate our proposed constructs, we conducted an assessment of vulnerable code from under-development projects at SAP.

4.1 Experiment Design

The experiment consisted of the detection of a set of known open source vulnerabilities against a set of industrial applications. Note that our experiment was conducted in September, 2019.

Bill of materials extraction. We create a bill of materials (BOM) which consists of construct lists of the application and its dependencies (i.e., both direct and transitive). To do this, we use ANTLR-v4 with a JavaScript grammar [1] to model and extract the Node.js application source code. This grammar is able to partially extract JavaScript with ES6 features at the beginning of our development (July 24, 2019).

To obtain the BOM from an application, we first download the application dependencies by using npm install. We then explore and build the dependency tree by looking at the package-lock.json file. After that, we use ANTLR-v4 to extract the list of constructs from the JavaScript files of the application. Next, we traverse the dependency tree depth-first to extract the list of constructs from each dependency.

Table 2: Experimental Dataset

| OSS npm package vulnerabilities |  |
|-------------------------------|--|
| number of vulnerabilities     | 60 |
| number of vulnerable package  | 24 |
| number of valid vulnerabilities| 32 |
| number of valid vulnerable package | 15 |

| Industrial Node.js applications |  |
|----------------------------------|--|
| number of applications           | 65 |
| number of valid application      | 42 |

Vulnerability knowledge base. We build our own Node.js vulnerability dataset which includes the vulnerability information and its fix for Eclipse-Steady. We first retrieve the list of Node.js vulnerabilities and their information from the National Vulnerability Database (NVD) [2]. We selected only vulnerabilities that have fixes and affect the top-100 most depended npm packages [18]. We then manually annotate the set of commits that correspond to the vulnerability fix. The set of commits has to be confirmed as it appeared on the master branch of the library git repository. Given the fix commit(s) for a vulnerability, we use our extension of Eclipse-Steady to determine the changes that were applied to the code by the fix commit. As shown in Table 2, we end up with 60 vulnerabilities in our study.

SAP Node.js Applications. We used SAP GitHub enterprise to identify Node.js applications suitable for our case study. We considered only applications under development having the package . json file in their root directory. We selected a sample of 65 applications, as shown in Table 2.

Table 3: Dependency Type information.

| Dependencies | Median | Min | Max | Q1 | Q3 | SD  |
|--------------|--------|-----|-----|----|----|-----|
| # All Dep.    | 464.5  | 3   | 1,226| 229.75 | 748.5 | 339.55 |
| # Runtime Dep.| 108.5  | 0   | 586 | 40.75 | 193 | 146.18 |
| # Test Dep.   | 257    | 0   | 1,067 | 117.25 | 561.5 | 335.31 |

Table 3 shows the distribution of dependencies, showing more than a hundred dependencies in each application by median (i.e. 464.5 dependencies) with some applications having up to a thousand dependencies (i.e., 1,226 dependencies). We observe that the number of test dependencies is bigger than the one of runtime dependencies by two times (i.e., 257 > 108.5).

4.2 Results

We present our results in terms of: (i) detected vulnerabilities, and (ii) dependency constructs.

Detected Vulnerabilities. Our prototype was able to detect five vulnerabilities that affected the lodash and debug npm packages. Lodash [12] is "A modern JavaScript utility library delivering modularity, performance, and extras". According to the npmjs website [16], lodash is a very popular package, with over 27,500,000 weekly downloads and 114,917 other packages that are dependent on this package. Debug [26] is "A tiny JavaScript debugging utility modelled after Node.js core’s debugging technique". According to the npmjs website [15], debug is also considered a popular package, with over 66,800,000 weekly downloads and 34,494 dependents.

Dependency Constructs and features. In our case study, our extension to Eclipse-Steady could analyze 42 out of 65 applications.

Table 4 shows the distribution of the BOM extracted from the applications. Our prototype was able to extract more than a hundred constructs from an application and its dependencies (i.e., 164.5 constructs). In more detail, the number of application constructs is bigger than the one of dependency constructs by three times (i.e., 75 > 26).
Table 4: Summary of Construct Information from the experiment.

| # Constructs | Median | Min | Max | Q1 | Q3 | SD |
|--------------|--------|-----|-----|----|----|----|
| # App Consts. | 75     | 0   | 3,083 | 28.25 | 167.5 | 573.99 |
| # Dep Consts. | 26     | 0   | 9,549 | 1.25 | 114.25 | 2,144.69 |
| # App + Dep Consts. | 164.5 | 1   | 9,671 | 83.25 | 609.75 | 2,224.14 |

Table 5: Frequency count of Dependent Construct Changes per vulnerability

| CVE            | Construct Change Type | Added | Modified | Removed |
|----------------|-----------------------|-------|----------|---------|
| CVE-2017-16137 | FUNC:1 MODU:1 FUNC:1 |       |          |         |
| CVE-2018-3721  | FUNC:2 OBJT:1 MODU:2 FUNC:2 |       |          |         |
| CVE-2018-16487 | OBJT:4 MODU:2 FUNC:4 |       |          |         |
| CVE-2019-10744 | FUNC:1 OBJT:3 MODU:2 FUNC:2 |       |          |         |
| CVE-2019-1010266 | FUNC:1 MODU:2 FUNC:3 |       |          |         |

Table 6: Frequency distribution of Dependency Constructs based on the dependency features.

| Vulnerability | Runtime (26) | Test (31) |
|---------------|--------------|-----------|
|               | Direct | Trans. | Direct | Trans. |          |          |
| CVE-2017-16137 | 0      | 1      | 0      | 11     |          |          |
| CVE-2018-3721  | 0      | 6      | 1      | 2      |          |          |
| CVE-2018-16487 | 0      | 6      | 1      | 3      |          |          |
| CVE-2019-10744 | 0      | 7      | 1      | 8      |          |          |
| CVE-2019-1010266 | 0      | 6      | 1      | 3      |          |          |
|               | 0      | 26     | 4      | 27     |          |          |

Potential future avenues are two-fold. First, we would like to consider all the ways in which objects can be created in JavaScript. Second, we intend to evaluate the detection capabilities of our approach at different levels of the construct hierarchy (i.e., MODU vs. FUNC vs. OBJT).

5.2 Node.js application reliance on the npm ecosystem

The applications in our case study rely on npm packages, and as such, are potentially prone to attacks targeting popular packages, like the lodash and debug packages. Since the npm ecosystem is considered one of the biggest and most popular, it does also suffer the most in terms of known vulnerabilities, with the GitHub Advisory Database reporting npm as having the highest number of vulnerabilities (i.e., 681) when compared to six other ecosystems [8].

With the GitHub acquisition of npm, we envisage that Node.js applications will need to be aware of changes within the npm ecosystem. The creation and evaluation of such reporting mechanisms are seen a future work.

5.3 Faster Technology Adoption

Officially known as ECMAScript, the JavaScript language has been in constant evolution with its technology, with new specifications released every year. In response, Node.js keeps up to date [9]. Since industrial projects struggle with migration due to various migration or compatibility issue, it is a struggle for applications to keep up with the Node.js technology. For example, practitioners would like to control or specify the supported platform of the language. As mentioned in Section 5.2, the usage of npm packages requires industrial applications to keep up with the npm ecosystem evolution. Like most tools, we find that JavaScript static tools (such as ANTLRv4) struggle to keep up to date.

Potential future avenues for both researchers and practitioners should include strategies that help application developers to properly manage backward compatibility or guidelines to keep up with the ever-evolving technology.

6 CONCLUSION

In this paper, we present an experience report on the implementation of a code-centric vulnerability detection tool for open source dependencies of Node.js applications. Using extracted constructs, we show that a code-centric detection tool is viable, although there are challenges related to the JavaScript language and the complexity of the application dependencies.

Future work would be to tackle the challenges of JavaScript analysis, or extending the tool to analyze the reachability of vulnerable constructs using static and dynamic analysis techniques. We believe that our results and experience is not only useful for the Eclipse-Steady project, but also in regards to the overall analysis of Node.js applications and their npm packages.

ACKNOWLEDGEMENT

This work is supported by Japanese Society for the Promotion of Science (JSPS) KAKENHI Grant Numbers 18H04094, 18H03221, 18KT0013, and 20K19774.

5 EXPERIENCE REPORT

Our results indicate that a Node.js vulnerable code detector is viable. We now report three lessons learned and their potential future roadmap.

5.1 Mapping JavaScript Object to Constructs

In our approach, we defined a more classical inheritance of constructs (like Java and C++) on top of the JavaScript prototypical inheritance model. With this choice, one of the main issues is to ensure that we capture all the different ways to create objects and their constructs. For instance, there are at least six way to declare a function in JavaScript [20]. Furthermore, it is still an open question whether the implementation efforts required to extract the finer-level constructs (e.g., OBJT) are worth. As shown in Table 5, in most of the cases the MODU constructs were sufficient for the detection of the vulnerabilities.

Table 5 and Table 6 show the affected dependency constructs and their construct type. Table 5 shows that the construct changes were detected at the OBJT, MODU and FUNC level. We observe that the majority of the vulnerable dependencies are transitive (28 runtime dependencies and 27 test dependencies), i.e., usually out of the control of the application developer. We also observe that most of the vulnerable constructs are detected in test dependencies.

5 EXPERIENCE REPORT

Our results indicate that a Node.js vulnerable code detector is viable. We now report three lessons learned and their potential future roadmap.

5.1 Mapping JavaScript Object to Constructs

In our approach, we defined a more classical inheritance of constructs (like Java and C++) on top of the JavaScript prototypical inheritance model. With this choice, one of the main issues is to ensure that we capture all the different ways to create objects and their constructs. For instance, there are at least six way to declare a function in JavaScript [20]. Furthermore, it is still an open question whether the implementation efforts required to extract the finer-level constructs (e.g., OBJT) are worth. As shown in Table 5, in most of the cases the MODU constructs were sufficient for the detection of the vulnerabilities.

5 EXPERIENCE REPORT

Our results indicate that a Node.js vulnerable code detector is viable. We now report three lessons learned and their potential future roadmap.

5.1 Mapping JavaScript Object to Constructs

In our approach, we defined a more classical inheritance of constructs (like Java and C++) on top of the JavaScript prototypical inheritance model. With this choice, one of the main issues is to ensure that we capture all the different ways to create objects and their constructs. For instance, there are at least six way to declare a function in JavaScript [20]. Furthermore, it is still an open question whether the implementation efforts required to extract the finer-level constructs (e.g., OBJT) are worth. As shown in Table 5, in most of the cases the MODU constructs were sufficient for the detection of the vulnerabilities.
REFERENCES

[1] ANTLR. 2017. grammars-v4/javascript at master · antlr/grammars-v4. https://github.com/antlr/grammars-v4/tree/master/javascript. (Accessed on 08/11/2020).

[2] National Vulnerability Database. 2007. NVD - Home. https://nvd.nist.gov/. (Accessed on 08/11/2020).

[3] James Davis, Arun Thekumparampil, and Dongyoung Lee. 2017. Node.Fz: Fuzzing the Server-Side Event-Driven Architecture. In Proceedings of the 12th European Conference on Computer Systems (EuroSys). 145–160.

[4] Alexandre Decan, Tom Mens, and Eleni Constantinou. 2018. On the Evolution of Technical Lag in the npm Package Dependency Network. In the 34th International Conference on Software Maintenance and Evolution (ICSM). 404–414.

[5] Alexandre Decan, Tom Mens, and Eleni Constantinou. 2018. On the impact of security vulnerabilities in the npm package dependency network. In Proceedings of the 15th International Conference on Mining Software Repositories (MSR) 181–191.

[6] Eclipse. 2018. Eclipse Steady 3.11.11 (Incubator Project). https://eclipse.github.io/steady/. (Accessed on 08/11/2020).

[7] GitHub. 2017. About security alerts for vulnerable dependencies. https://help.github.com/articles/about-security-alerts-for-vulnerable-dependencies/. (Accessed on 08/11/2020).

[8] GitHub. 2019. GitHub Advisory Database. https://github.com/advisories. (Accessed on 08/11/2020).

[9] William Kapke. 2016. Node.js ES2015/ES6, ES2016 and ES2017 support. https://node.green/. (Accessed on 08/11/2020).

[10] Ruvo Kikas, Georgios Gounios, Marlon Dumas, and Dietmar Pfahl. 2017. Structure and Evolution of Package Dependency Networks. In Proceedings of the 14th International Conference on Mining Software Repositories (MSR) 102–112.

[11] Tobias Lautner, Abdelberrh Chaabane, Sagad Arshad, William Robertson, Christo Wilson, and Engin Kirda. 2017. Thou Shalt Not Depend on Me: Analysing the Use of Outdated JavaScript Libraries on the Web. In Proceedings of the 24th Network and Distributed System Security Symposium (NDSS).

[12] Lodash. 2012. lodash/lodash: A modern JavaScript utility library delivering modularity, performance, & extras. https://github.com/lodash/lodash. (Accessed on 08/11/2020).

[13] Magnus Madsen, Frank Tip, and Ondřej Lhoták. 2015. Static Analysis of Event-Driven Node.Js JavaScript Applications. In Proceedings of the International Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA). 505–519.

[14] NAIST-SE. 2020. NAIST-SE/steady: Analyses your Java and Python applications for open-source dependencies with known vulnerabilities, using both static analysis and testing to determine code context and usage for greater accuracy. https://github.com/NAIST-SE/steady. (Accessed on 08/11/2020).

[15] npm. 2011. debug - npm. https://www.npmjs.com/package/debug. (Accessed on 08/11/2020).

[16] npm. 2012. debug - npm. https://www.npmjs.com/package/debug. (Accessed on 08/11/2020).

[17] npm. 2018. npm - most dependend upon. https://www.npmjs.com/browse/dependencies. (Accessed on 08/11/2020).

[18] npm blog. 2020. npm blog: Next Phase Montage. https://blog.npmjs.org/post/612764668880078800/next-phase-montage. (Accessed on 05/20/2020).

[19] Dmitri Pavlutin. 2016. 6 Ways to Declare JavaScript Functions. https://dmitripavlutin.com/6-ways-to-declare-javascript-functions/. (Accessed on 08/11/2020).

[20] Rodrigo Elizalde Zapata, Raula Gaikovina Kula, Bodin Chinthanet, Takashi Ishio, Kenichi Matsumoto, and Akinori Ihara. 2018. Towards Smoother Library Migrations: A Look at Vulnerable Dependency Migrations at Function Level for npm JavaScript Packages. In Proceedings of the 34th International Conference on Software Maintenance and Evolution (ICSM). 559–563.

[21] Ahmed Zerouali, Eleni Constantinou, Tom Mens, Gregorio Robles, and Jesus Gonzalez-Barahona. 2018. An Empirical Analysis of Technical Lag in npm Package Dependencies. In Proceedings of the 17th International Conference on Software Reuse (ICSR). 93–102.

[22] MDN web docs. 2020. Inheritance and the prototype chain - JavaScript | MDN. https://developer.mozilla.org/en-US/docs/Web/JavaScript/Inheritance_and_the_prototype_chain. (Accessed on 08/11/2020).

[23] MDN. https://developer.mozilla.org/en-US/docs/Web/JavaScript/Inheritance_and_the_prototype_chain.

[24] Synopsys. 2020. 2020 Open Source Security and Risk Analysis (OSSRA) Report | Synopsys. https://www.synopsys.com/software-integrity/resources/analyst-reports/2020-open-source-security-risk-analysis.html. (Accessed on 05/27/2020).

[25] JavaScript Tutorial. 2020. JavaScript Anonymous Functions. https://www.javascripttutorial.net/javascript-anonymous-functions/. (Accessed on 08/11/2020).

[26] Visionmedia. 2011. visionmedia/debug: A tiny JavaScript debugging utility modelled after Node.js core's debugging technique. Works in Node.js and web browsers. https://github.com/visionmedia/debug. (Accessed on 08/11/2020).

[27] MDN web docs. 2020. Inheritance and the prototype chain - JavaScript | MDN. https://developer.mozilla.org/en-US/docs/Web/JavaScript/Inheritance_and_the_prototype_chain. (Accessed on 08/11/2020).

[28] Rodrigo Elizalde Zapata, Raula Gaikovina Kula, Bodin Chinthanet, Takashi Ishio, Kenichi Matsumoto, and Akinori Ihara. 2018. Towards Smoother Library Migrations: A Look at Vulnerable Dependency Migrations at Function Level for npm JavaScript Packages. In Proceedings of the 34th International Conference on Software Maintenance and Evolution (ICSM). 559–563.

[29] Ahmed Zerouali, Eleni Constantinou, Tom Mens, Gregorio Robles, and Jesus Gonzalez-Barahona. 2018. An Empirical Analysis of Technical Lag in npm Package Dependencies. In Proceedings of the 17th International Conference on Software Reuse (ICSR). 93–102.