Characterizing and understanding security risks through Fuzzing Secure-Aware Mutation Testing of RESTFul-API services

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Overview

1. Research Proposal
2. Literature Review
   - Next tasks
   - Challenges
3. Work plan

Research Proposal

Problem

1. API-RESTFul is an architectural style for designing web services
2. RESTFul APIs exchange sensitive information and private date
3. Top 10 vulnerabilities Application Security Project (OWASP) https://owasp.org/www-project-api-security/
4. Coverage of the security tests: penetration and policies
5. Opportunity for mutation testing

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Research question

¿How to design fuzzed secure-aware mutation operators in the coverage of the vulnerabilities in the configuration of security policies in RESTFul APis?

Objectives

Develop a collection of security-aware mutation operators designed for safeguarding the configuration of security policies within RESTFul API services.

Specific

Specific objective	Expected result
1. Identification of the elements of the security policies in API-RESTFul services	Characteristics of the security policies in API-Restful services
2. Describe a set of fuzzed security-aware mutation operators for testing of security policies in API-RESTFul services	Description of the mutation operators according to the elements of security policies in API-Restful services
3. Develop the set of security-aware mutation operators for testing in Django Rest and Flask Frameworks in Python	Source code of the secure-aware mutation operators
4. Evaluate the proposed security-aware mutation operators in RESTFul API services	Report about the performance of the created operators against tools from the literature.

Table 1: Specific objectives and expected results

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Literature Review

Strategy

1. Questions about the current state of art in the configuration security policies of RESTFul APIs.
2. Window of time from 2000 to 2024. https://doi.org/10.1515/itit-2013-1035
3. Emphasis in the last 5 years. https://doi.org/10.1145/3617175, https://journal.ijresm.com/index.php/ijresm/article/view/970 the rise of the RESTFul APIs.

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Research questions

1. RQ1: What are the elements of the security configuration policies in the RESTFul API Services?
2. RQ2: What are the current challenges about the security policies of RESTFul API Services?
3. RQ3: What are the most common configuration security mistakes of the developers in the building of RESTFul API Services?
4. RQ4: What are the current testing techniques and tools for the testing of configuration policies of RESTFul API Services based on Python?
5. RQ5: What experiences have been reported in the literature about the use of mutation testing for the security testing of RESTFul API Services?

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RQ1: Elements of security configuration policies

1. Authentication: Methods for the identification of the user.
2. Authorization: Methods for the access control.
3. Encryption: Protocol SSL/TLS.
4. Data masking: Hide sensitive data in logs and responses.
5. Input validation and sanitization: Prevent injection attacks (SQL, XSS).
6. Thottling: Number of requests per time.
7. API Keys: Each user with their own key.
8. Login level: Detailed and security monitoring.

RQ1: References I

Kellezi, D., Boegelund, C., & Meng, W. (2019). Towards secure open banking architecture: An evaluation with owasp. In *Lecture notes in computer science* (pp. 185–198). Springer International Publishing. https://doi.org/10.1007/978-3-030-36938-5_11

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RQ2: Current challenges

1. Keep the data integrity in RESTFul API Services is a challenge that changes every day.
2. Several recent studies have identified security gaps in many of them.
3. One of the most problems about software vulnerabilities is the configuration security policies of RESTFul APIs
4. Testing methods and tools are not enough to cover all the vulnerabilities.

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RQ2: References I

Bakhtin, A., Al Maruf, A., Cerny, T., & Taibi, D. (2022). Survey on tools and techniques detecting microservice api patterns. *2022 IEEE International Conference on Services Computing (SCC)*. https://doi.org/10.1109/scc55611.2022.00018

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RQ3: Common configuration mistakes

1. Lack of input validation.
2. Insecure deserialization.
3. Lack of proper authentication and authorization.
4. Insecure direct object references.
5. Lack of proper logging and monitoring.
6. Insecure communication with untrusted components.

RQ3: References I

Hussain, F., Hussain, R., Noye, B., & Sharieh, S. (2020). Enterprise api security and gdpr compliance: Design and implementation perspective. *IT Professional*, *22*(5), 81–89. https://doi.org/10.1109/mitp.2020.2973852

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RQ3: References II

Votipka, D., Fulton, K. R., Parker, J., Hou, M., Mazurek, M. L., & Hicks, M. (2020). Understanding security mistakes developers make: Qualitative analysis from build it, break it, fix it. *29th USENIX Security Symposium (USENIX Security 20)*, 109–126. https://www.usenix.org/conference/usenixsecurity20/presentation/votipka-understanding

RQ4: Testing techniques and tools

Penetration testing, vulnerability assessment, and network scanning.

1. OWASP ZAP: Penetration testing.
2. Postman: API testing.
3. Burp Suite: Penetration testing.
4. Nessus: Vulnerability assessment.
5. Nmap: Network scanning.
6. Metasploit: Penetration testing.

Techniques: Fuzzing, black box, statistical.

RQ4: References I

Corradini, D., Zampieri, A., Pasqua, M., Viglianisi, E., Dallago, M., & Ceccato, M. (2022). Automated black-box testing of nominal and error scenarios in restful apis. *Software Testing, Verification and Reliability*, *32*(5). https://doi.org/10.1002/stvr.1808

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RQ4: References II

Tsai, C.-H., Tsai, S.-C., & Huang, S.-K. (2021). Rest api fuzzing by coverage level guided blackbox testing. *2021 IEEE 21st International Conference on Software Quality, Reliability and Security (QRS)*, 291–300. https://doi.org/10.1109/QRS54544.2021.00040

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RQ5: Mutation testing in security of RESTFul API Services

1. Mutation testing has proven to be a strategy for evaluating the security of applications.
2. The literature suggests an emphasis in data integrity.
3. Different strategies for the mutation testing: using artificial intelligence, black box testing, penetration testing, validation of data integrity and statistical methods.

RQ5: References I

Ahmed, S., & Hamdy, A. (2023). Artificial bee colony for automated black-box testing of restful api. In *Smart innovation, systems and technologies* (pp. 1–17). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-6706-3_1

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RQ5: References II

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Ehsan, A., Abuhaliqa, M. A. M. E., Catal, C., & Mishra, D. (2022). Restful api testing methodologies: Rationale, challenges, and solution directions. *Applied Sciences*, *12*(9), 4369. https://doi.org/10.3390/app12094369

Felício, D., Simão, J., & Datia, N. (2023). Rapitest: Continuous black-box testing of restful web apis. *Procedia Computer Science*, *219*, 537–545. https://doi.org/10.1016/j.procs.2023.01.322

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RQ5: References III

Lyu, C., Xu, J., Ji, S., Zhang, X., Wang, Q., Zhao, B., Pan, G., Cao, W., & Beyah, R. (2023). Miner: A hybrid data-driven approach for rest api fuzzing. https://doi.org/10.48550/ARXIV.2303.02545

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Yandrapally, R., & Mesbah, A. (2021). Mutation analysis for assessing end-to-end web tests. *2021 IEEE International Conference on Software Maintenance and Evolution (ICSME)*, 183–194. https://doi.org/10.1109/ICSME52107.2021.00023

Tasks

1. Finish the literature review: Categories and subcategories. Article of the review of the state of the art.
2. Adjust the proposal according to this guidelines.
3. Defense of the proposal.

Challenges

1. RESTFul APIs handle sensitive information that needs to be protected, software testing evaluates how they are handled, but because vulnerabilities are constantly being discovered, there is an opportunity for improvement in this area.
2. Mutation testing has proven to be a strategy for evaluating the security of applications, there has been a lot of work done related to specific applications in languages such as Java and Python, there is an opportunity to contribute to the development of RESTFul API.
3. Security is a challenge for software development today, and several recent studies have identified security gaps in many of them, which could be studied to provide a framework for the development of tools to assess data security and generate recommendations for improvement.

Work plan

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Contribution selection

Working plan: Following the snowball methodology

- Review of vulnerabilities in RESTFul APIs: Survey in the interception between mutation testing and security evaluation in Restful-API.
- Description of the mutation operators
- Prototype implementation and testing

Total: 3 years.

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