Assignment 4 – Detecting CVE's with Semgrep

Assigned CVE: **CVE-2024-23731**

Step 1 - Analysis:

What package/library does the CVE affect? What version was it introduced in, and which version was it patched in?
Package: **embedchain**
Affected versions: **< 0.1.57**
Patched version: **0.1.57**

Briefly describe the advisory's details about the vulnerability.
Embedchain is an Open-Source (RAG) Framework for personalizing LLM responses. It makes it easy to create and deploy personalized AI apps.
The **OpenAPI** loader in **Embedchain** before 0.1.57 allows attackers to **execute arbitrary code** due to insecure usage of **yaml.load** in the **load_data** function of **openapi.py**.
An attacker can execute arbitrary code by supplying a **crafted YAML file** that exploits the function's lack of safe loading.

Locate and analyze the patch for this CVE. Provide the link to the patch and identify which function is affected by the patch.

CWE – 88 (https://cwe.mitre.org/data/definitions/88.html)
Improper Neutralization of Argument Delimiters in a Command ('Argument Injection')
CWE – 94 (https://cwe.mitre.org/data/definitions/94.html)
Improper Control of Generation of Code ('Code Injection')

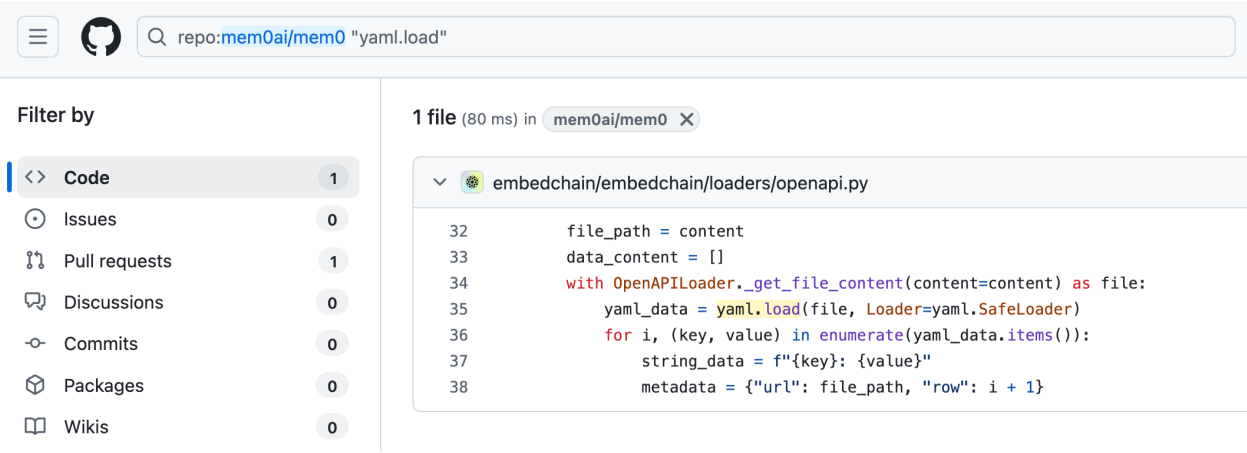
Patch - mem0ai:
PR: https://github.com/mem0ai/mem0/pull/1122
Fixed Code:
https://github.com/mem0ai/mem0/blob/main/embedchain/embedchain/loaders/openapi.py

Briefly describe the patch. Note: Analyzing the entire library is not necessary; describe the patch's purpose based on its code.

yaml_data = yaml.load(file, Loader=yaml.Loader)
yaml_data = yaml.load(file, Loader=yaml.SafeLoader)

The patch updates the YAML loading method to use **SafeLoader** instead of **Loader** for preventing the execution of arbitrary code during deserialization.

Once you identify the affected function from the patch (Q3), trace the function to find its callers. Note: The function may not have a parent/caller. If not, describe what steps you took.



The affected function from the patch is the **load_data** method in the **OpenAPILoader** class. As this is the only location where **yaml.load** is used with the unsafe Loader, there are no further callers to trace. The patch fixes this vulnerability by updating the yaml.load call to use the **yaml.SafeLoader**.

For the affected function(s)/class/component, review the library documentation and include examples of how they are meant to be used or called.
The **load_data** function is designed to load and process OpenAPI YAML files, converting each key-value pair into a document with metadata.
Usage:
yaml_data = yaml.load(file, Loader=yaml.Loader) **# Vulnerable**
yaml_data = yaml.load(file, Loader=yaml.SafeLoader) **# Recommended**

SafeLoader is a safer alternative to Loader, restricting YAML constructs to simple Python objects like str, list, and dict.

Example via original source code and ChatGPT:

Example Use in `OpenAPILoader`:

```python
with OpenAPILoader._get_file_content(content=content) as file:
    yaml_data = yaml.load(file, Loader=yaml.SafeLoader)  # Safely parse YAML
```

Intended Usage:

- **Input**: URL or file path pointing to an OpenAPI YAML document.
- **Output**: A structured dictionary representing the YAML content, broken down into individual "documents" for further processing, with metadata.

Example Flow:

1. Pass a URL or file path to `load_data`.
2. YAML content is parsed securely using `SafeLoader`.
3. Each key-value pair in the YAML is extracted and stored with associated metadata (e.g., source URL, line number).
4. A unique document ID is generated using `hashlib`.

This method ensures safe parsing while maintaining the integrity and usability of OpenAPI specifications.

Cross-reference other sources and summarize the information provided regarding questions 1 to 4. Note: Not all sources may provide complete information. Document whatever is available.

CVE-2024-23731 affects the Embedchain package (versions < 0.1.57) due to insecure usage of yaml.load in the load_data function of the OpenAPILoader class, which could allow attackers to execute arbitrary code by providing malicious YAML files. The issue was patched in version 0.1.57 by replacing yaml.Loader with yaml.SafeLoader to prevent unsafe deserialization. Users are advised to upgrade to version 0.1.57 or later and ensure strict input validation when processing YAML files. Safe alternatives like yaml.safe_load should be used to mitigate such risks.

PoC (via ChatGPT):

```
import yaml

# Insecure use of yaml.load with yaml.Loader
def load_data(file_path):
    with open(file_path, 'r') as file:
        yaml_data = yaml.load(file, Loader=yaml.Loader)
        return yaml_data

# Calling the vulnerable function
load_data('malicious.yaml')
```

Copy code

2. **Malicious YAML File** (`malicious.yaml`):

```
!!python/object/apply:os.system
- "echo 'Malicious code executed!'"
```

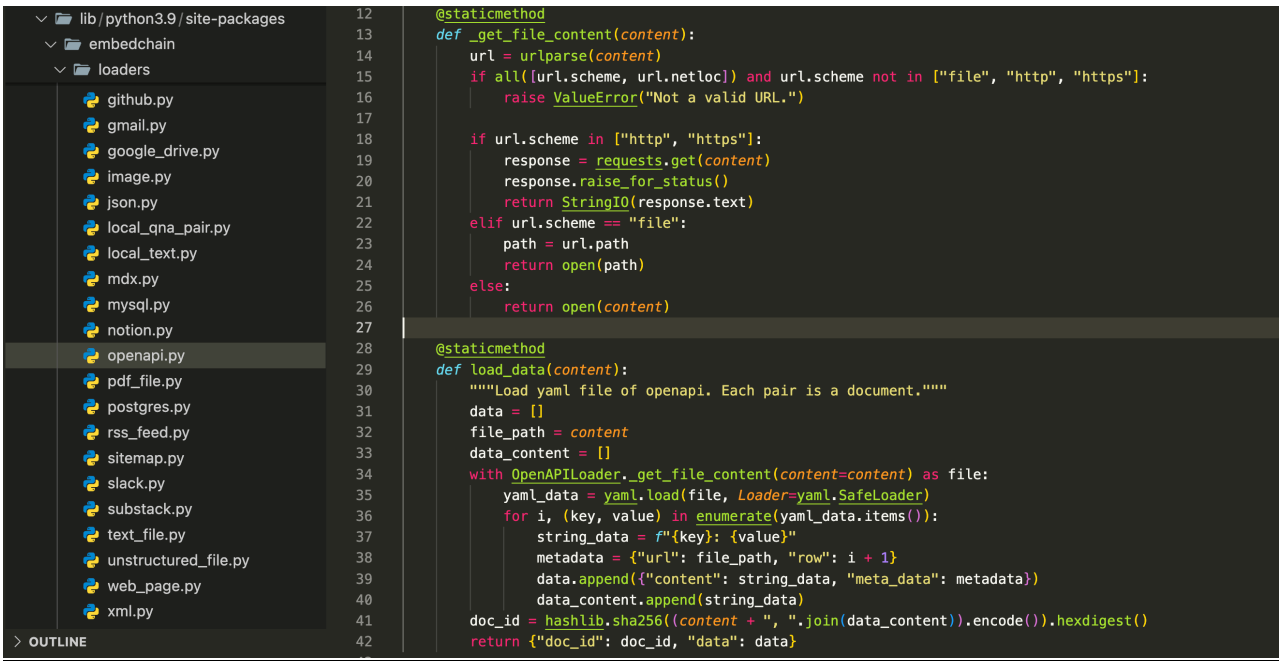
yaml

Copy code

Explanation:

- **Malicious YAML**: The YAML file uses the `!!python/object/apply` tag, which allows for the execution of arbitrary Python code. In this case, it is calling `os.system("echo 'Malicious code executed!'")` to execute a shell command that prints a message.
- **Loader**: `yaml.Loader` allows this malicious tag to be interpreted and executed, leading to the execution of the shell command when the YAML file is loaded.

How it works:



When we "**pip install embedchain**"
We can access the openapi loader, the OpenAPILoader class, and the load_data method, which calls **yaml.load** with the previously vulnerable **yaml.Loader**.

Based on the findings, users of the embedchain library who invoke the load_data method from the OpenAPILoader class could indirectly trigger the vulnerable yaml.load function with yaml.Loader. This means the CVE (CVE-2024-23731) has a tangible impact on both:

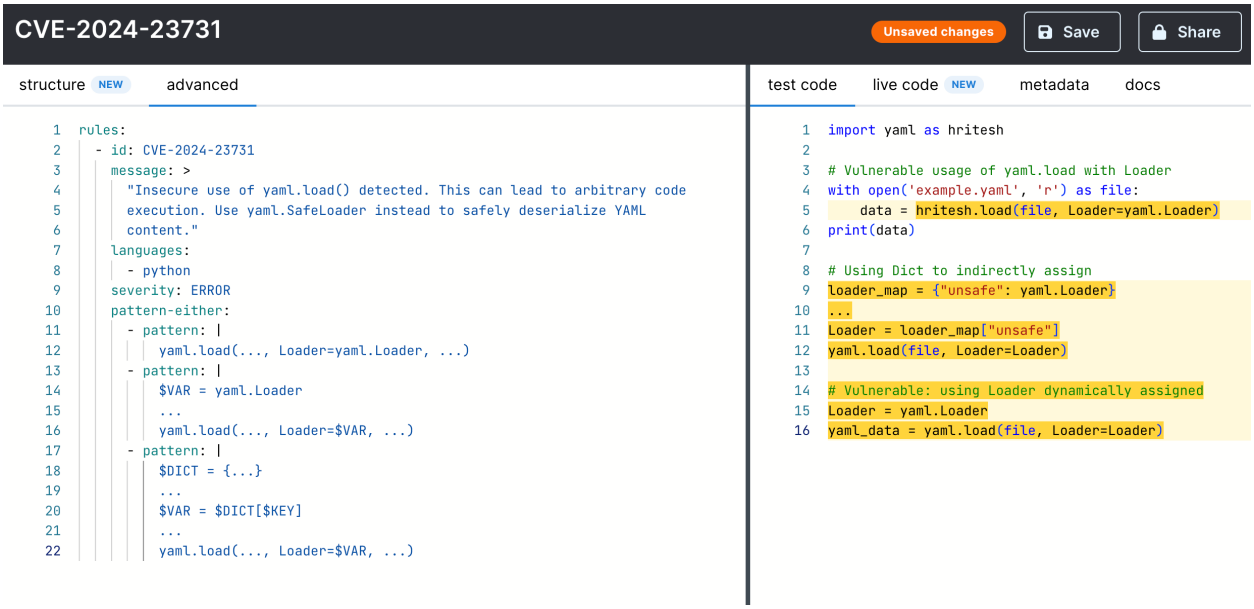
1. **Library Developers**: They must ensure internal code is secure by updating the load_data method to use yaml.SafeLoader instead of yaml.Loader. (**Fixed with the patch**, commit given above.)
2. **End Users**: They are affected because the vulnerable yaml.load is exposed through the OpenAPILoader class's public API. **(**Just Upgrade embedchain to version **0.1.57** or higher.**)**

Fix?

- Upgrade embedchain to version **0.1.57** or higher.
  We can do this by running ***pip install --update embedchain***.
- Input Validation: Ensure that the **YAML parser** in your OpenAPI loader **strictly validates** incoming data to avoid processing untrusted inputs.
- Safer methods: Utilize safer alternatives to ***yaml.load***, such as ***yaml.safe_load***, which is designed to resist arbitrary code execution.
- https://pyyaml.org/wiki/PyYAMLDocumentation

Step 2 – Writing Semgrep Rule:

```
pattern-either:
    - pattern: |
      yaml.load(..., Loader=yaml.Loader, ...)
    - pattern: |
      $VAR = yaml.Loader
      ...
      yaml.load(..., Loader=$VAR, ...)
    - pattern: |
      $DICT = {...}
      ...
      $VAR = $DICT[$KEY]
      ...
      yaml.load(..., Loader=$VAR, ...)
```



Step 3 – Testing the Rule:

```
submissions/
  ├── rules/
  │     └── CVE-2024-23731.yaml
  └── test-CVE-2024-23731/
        ├── test1.py
        ├── test2.py
        ├── test3.py
        ├── test4.py
        └── test5.py
```

Run:
semgrep --config path/to/CVE-2024-23731.yaml path/to/test/directory

Note: I'm encountering a false positive in *test3.py*. I'm not sure why it's detecting matches twice. If I remove the second pattern and keep the third, I end up losing a match, haha. Maybe I'll revisit this next week.

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References:

- https://github.com/advisories?query=2024-23731
- https://github.com/advisories/GHSA-rhhj-5436-95vf
- https://nvd.nist.gov/vuln/detail/CVE-2024-23731
- https://security.snyk.io/vuln/SNYK-PYTHON-EMBEDCHAIN-6183296
- https://ogma.in/cve-2024-23731-understanding-and-mitigating-vulnerabilities-in-embedchain-openapi-loader
- https://feedly.com/cve/CVE-2024-23731
- https://vuldb.com/?id.251693
- https://www.cve.org/CVERecord?id=CVE-2024-23731
- https://avd.aquasec.com/nvd/2024/cve-2024-23731
- https://pypi.org/project/embedchain
- https://docs.embedchain.ai/get-started/quickstart

Thank you!