Attacking and Defending GitHub Actions

Is it safe now?

By Simon Gerst

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GitHub Actions

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- Automate workflows
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Why attack?

- Can modify source code: supply chain attacks
- Give access to secrets, such as API keys: escalate privileges

Workflow files

- YAML files [a]
- Must be stored in `.github/workflows`
- Can be triggered by events
- Can be triggered manually
- Can be triggered by other workflows

[a] ruudvanasseldonk.com/2023/01/11/the-yaml-document-from-hell

Example workflow

```yaml
name: hello-world
on: [push]

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> `name`: name of the workflow

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> `on`: trigger for the workflow

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> `jobs`: jobs to run

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`hello_world_job`: name of the job

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> `runs-on`: OS to run the job on

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> `steps`: steps to run

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`name: Hello World`: name of the step

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> `run`: a shell command step

Example triggers

Events

- Push to a branch: `on: push`
- Pull request: `on: pull_request`

```yaml
name: Build and Test
on: [push, pull_request]
jobs:
  build:
    runs-on: ubuntu-latest
    steps:
      - name: Checkout code
        uses: actions/checkout@v2
      - name: Install dependencies
        run: npm install
      - name: Build project
        run: npm run build
      - name: Run tests
        run: npm test
```

Example triggers

Events

- Push to a branch: `on: push`
- Pull request: `on: pull_request`
- Issue comment: `on: issue_comment`

```yaml
name: Comment Notification
on:
  issue_comment:
    types: [created]
jobs:
  notify:
    runs-on: ubuntu-latest
    steps:
      - name: Send notification
        uses: peter-evans/slack-action@v3
        with:
          slack_secret: ${{ secrets.SLACK_WEBHOOK_URL }}
          text: "New comment by ${{
github.event.comment.user.login }}"
```

Example triggers

Events

- Push to a branch: `on: push`
- Pull request: `on: pull_request`
- Issue comment: `on: issue_comment`
- Cron: `on: schedule`

```yaml
name: Stale Issues
on:
  schedule:
    - cron: '20 16 * * *' # every day at 16:20 UTC
jobs:
  stale:
    runs-on: ubuntu-latest
    steps:
      - name: Close Stale Issues
        uses: actions/stale@v3.0.5
        with:
          repo-token: ${{ secrets.GITHUB_TOKEN }}
          days-before-stale: 30
```

Example triggers

Events

- Push to a branch: `on: push`
- Pull request: `on: pull_request`
- Issue comment: `on: issue_comment`
- Cron: `on: schedule`
- Manual (workflow dispatch): `on: workflow_dispatch`

```yaml
on:
  workflow_dispatch:
    inputs:
      V8_VERSION:
        description: "V8_VERSION"
        required: false
        type: string
        default: ""
      V8_BUILD_MODE:
        default: "release-fuzz"
        required: true
        type: choice
        options:
          - release-fuzz
          - debug-no-fuzz
```

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- `issue_comment`, `issues`, `push`, and `workflow_run` give base permissions and secret access

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- For pull requests from forks: reduce all permissions to a maximum of read access, and no secrets are available
- `issue_comment`, `issues`, `push`, and `workflow_run` give base permissions and secret access
- `pull_request_target` gives base permissions and secret access even for forks
- Only `pull_request` is restricted for forks

User-controlled input

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the root of all evil

Templating in workflows

```
${{ ... }}
```

- Inserted as-is into the workflow file before execution
- Predefined variables: `github`, `env`, `secrets`, ...
- Predefined functions: `fromJson`, `startsWith`, `endsWith`, `contains`, ...

Example workflow: unsafe templating

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How to fix this?

- Don't mix code and data
- Instead, store data in environment variables
- The shell will not interpret the environment variable as code
- No code injection

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- `on: pull_request` is safe
- Doesn't give access to secrets and write access

Example workflow: unsafe cloning

```yaml
on:
  pull_request_target
jobs:
  build:
    name: Build and test
    runs-on: ubuntu-latest
    steps:
      - uses: actions/checkout@v2
        with:
          ref: ${{ github.event.pull_request.head.sha }}
      - uses: actions/setup-node@v1
      - run: |
          npm install
          npm build
      - run: gh pr comment ${{ github.event.pull_request.number }} -b "Build successful"
```

- `${{ github.event.pull_request.head.sha }}` is user-controlled and cloned
- `npm install` and `npm build` can execute user-controlled code

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- Save results as artifacts

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- Save results as artifacts
- Privileged workflow: fetch artifacts and work with them

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`pull_request`: unprivileged, executes untrusted code

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`workflow_run`: privileged, doesn't execute untrusted code

```yaml
on:
  workflow_run:
    workflows:
      - name-of-previous-workflow
    types:
      - completed
    status:
      - success
jobs:
  comment:
    name: Build and test
    runs-on: ubuntu-latest
    steps:
      - run: gh pr comment ${{
github.event.workflow_run.pull_requests[0].number }} -b
"Build successful"
```

How to (mostly) fix this? Safer checkout defaults

What changed?

- `actions/checkout@v7` refuses common pwn requests by default

What is not fixed?

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The common checkout-based pwn request is heavily mitigated now 🎉

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Workflow splitting and new problems

```
on:
  pull_request
jobs:
  build:
    # ...
    # upload PR number as artifact
    - run: echo ${{ github.event.pull_request.number }}
> pr_number
    - uses: actions/upload-artifact@v2
      with:
        name: pr_number
        path: pr_number
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```
on:
  workflow_run:
jobs:
  comment:
    # ...
    - uses: actions/download-artifact@v2
      with:
        name: pr_number
    - run: |
        echo "PR_NUMBER=$(cat pr_number)" >> $GITHUB_ENV
    - run: gh pr comment $PR_NUMBER -b "Build
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- We completely control the value of `pr_number`!

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    - uses: actions/download-artifact@v2
      with:
        name: pr_number
    - run: |
        echo "PR_NUMBER=$(cat pr_number)" >> $GITHUB_ENV
    - run: gh pr comment $PR_NUMBER -b "Build
successful"
```

- We completely control the value of `pr_number`!
- `$GITHUB_ENV` is a special file used for setting environment variables

Workflow splitting and new problems

```
on:
  pull_request
jobs:
  build:
    # ...
    # upload PR number as artifact
    - run: echo ${{ github.event.pull_request.number }}
> pr_number
    - uses: actions/upload-artifact@v2
      with:
        name: pr_number
        path: pr_number
```

```
on:
  workflow_run:
jobs:
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    # ...
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- We completely control the value of `pr_number`!
- `$GITHUB_ENV` is a special file used for setting environment variables
- We can inject a newline in `pr_number`, letting us set arbitrary environment variables

How to fix this?

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Be very careful when working with untrusted data.

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Be very careful when working with untrusted data.

- Verify that the types are correct
- Verify that the data is sanitized
- Verify that the data is escaped, ...

Bonus problems with `pull_request_target`

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- ~~Just exploit another, still vulnerable branch~~
- **Workflows now always use the default branch of the repository**

[a] github.blog/changelog/2025-11-07-actions-pull_request_target-and-environment-branch-protections-changes/

My workflow has (almost) no permissions and no secrets

- Scenario: `pull_request_target` workflow, only permissions for comments

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Cache poisoning: Actions cache

- Poison the cache

[a] github.com/AdnaneKhan/Cacheract

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- Ready-made tool:
- Cacheract can find, predict, and poison cache entries [a]
- Self-replicating worm

Cache poisoning: `tempo/tempo-xyz`

Why?

- Tempo uses `Depot` runners for CI and releases

How?

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Those entries are visible to the release workflow.

`tempo/tempo-xyz`: predicting sccache keys

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- Release builds use `Mozilla-Actions/sccache-action`

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- Future keys can be computed and poisoned

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Impact

- Poisoned object code will be linked into the final build output

How to fix this?

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- Not just for first-time contributors


Reality is often disappointing

`tempo/tempo-xyz`: reality check

What we expected

- Depot Cache is shared between branches

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Sometimes you run into undocumented behavior.

Keeping you safe(r) — I

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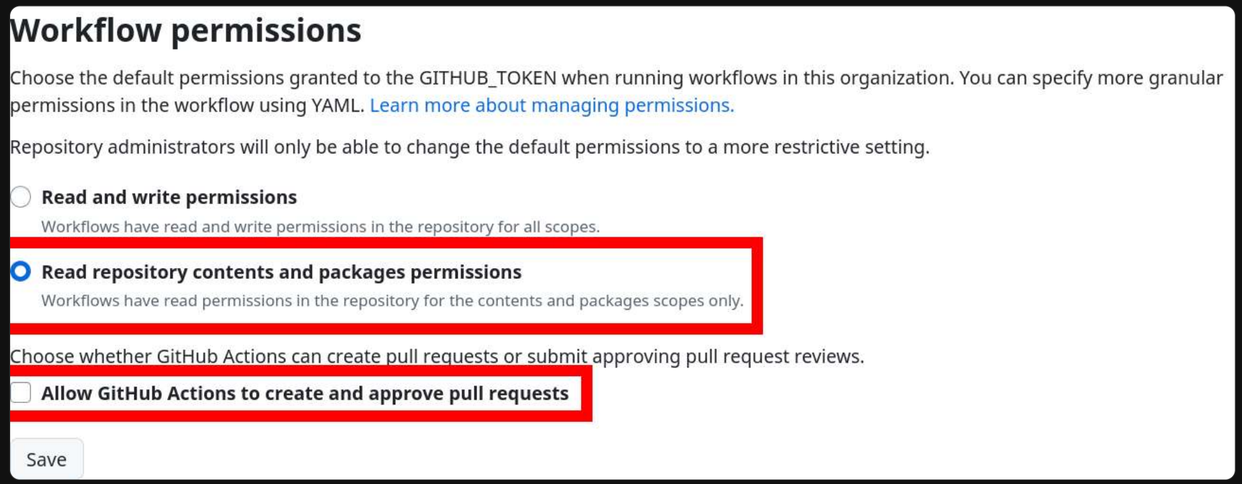

Keeping you safe(r) — II

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- Enable CodeQL analysis for GitHub Actions:

github.blog/security/application-security/how-to-secure-your-github-actions-workflows-with-codeql/

Keeping you safe(r) — III

Planned cache hardening

- GitHub is exploring `cache-mode` for workflows and jobs [a]

Why it matters

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Reduce cache-poisoning risk without changing existing workflows by default.

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Keeping you safe(r) — IV

Workflow execution protections

- Public preview for enterprises, organizations, and repositories [a]

What can you block?

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Central policy beats reasoning about security one YAML file at a time.

[a] github.blog/changelog/2026-06-18-control-who-and-what-triggers-github-actions-workflows/

Resources

- docs.github.com/en/actions/reference/workflows-and-actions/workflow-syntax
- docs.github.com/en/actions/reference/workflows-and-actions/events-that-trigger-workflows
- docs.github.com/en/actions/reference/security/secure-use
- docs.github.com/en/actions/reference/workflows-and-actions/dependency-caching
- ruudvanasseldonk.com/2023/01/11/the-yaml-document-from-hell
- securitylab.github.com/research/github-actions-preventing-pwn-requests/
- securitylab.github.com/research/github-actions-untrusted-input/
- securitylab.github.com/research/github-actions-building-blocks/
- securitylab.github.com/resources/github-actions-new-patterns-and-mitigations/
- github.blog/2023-08-09-four-tips-to-keep-your-github-actions-workflows-secure/
- github.blog/security/application-security/how-to-secure-your-github-actions-workflows-with-codeql/
- github.blog/changelog/2025-11-07-actions-pull_request_target-and-environment-branch-protections-changes/
- github.blog/changelog/2026-06-18-safer-pull_request_target-defaults-for-github-actions-checkout/
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Thank you!

Questions? Concerns? Comments?