



# Hashicorp Certified: Vault Associate Certification Crash Course

*Vault 1.12.1 Edition*



# About the trainer



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# Certification Exam

Objectives, Curriculum, Prerequisites, Learning  
Resources

# Exam Objectives

*“Basic understanding of concepts and skills associated with open source HashiCorp Vault.”*



**The certification program allows users to demonstrate their competence in a multiple choice test.**

<https://www.hashicorp.com/certification/vault-associate>



# The Curriculum

<b>1</b>	<b>Compare authentication methods</b>
1a	Describe authentication methods
1b	Choose an authentication method based on use case
1c	Differentiate human vs. system auth methods

<b>2</b>	<b>Create Vault policies</b>
2a	Illustrate the value of Vault policy
2b	Describe Vault policy syntax: path
2c	Describe Vault policy syntax: capabilities
2d	Craft a Vault policy based on requirements

<b>3</b>	<b>Assess Vault tokens</b>
3a	Describe Vault token
3b	Differentiate between service and batch tokens. Choose one based on use-case
3c	Describe root token uses and lifecycle
3d	Define token accessors
3e	Explain time-to-live
3f	Explain orphaned tokens
3g	Create tokens based on need

<b>4</b>	<b>Manage Vault leases</b>
4a	Explain the purpose of a lease ID
4b	Renew leases
4c	Revoke leases



# The Curriculum

<b>5</b>	<b>Compare and configure Vault secrets engines</b>
5a	Choose a secret method based on use case
5b	Contrast dynamic secrets vs. static secrets and their use cases
5c	Define transit engine
5d	Define secrets engines

<b>7</b>	<b>Utilize Vault UI</b>
7a	Authenticate to Vault
7b	Configure authentication methods
7c	Configure Vault policies
7d	Access Vault secrets
7e	Enable Secret engines

<b>6</b>	<b>Utilize Vault CLI</b>
6a	Authenticate to Vault
6b	Configure authentication methods
6c	Configure Vault policies
6d	Access Vault secrets
6e	Enable Secret engines
6f	Configure environment variables

<b>8</b>	<b>Be aware of the Vault API</b>
8a	Authenticate to Vault via Curl
8b	Access Vault secrets via Curl



# The Curriculum

9	<b>Explain Vault architecture</b>
9a	Describe the encryption of data stored by Vault
9b	Describe cluster strategy
9c	Describe storage backends
9d	Describe the Vault agent
9e	Describe secrets caching
9f	Be aware of identities and groups
9g	Describe Shamir secret sharing and unsealing
9h	Be aware of replication
9i	Describe seal/unseal
9j	Explain response wrapping
9k	Explain the value of short-lived, dynamically generated secrets

10	<b>Explain encryption as a service</b>
10a	Configure transit secret engine
10b	Encrypt and decrypt secrets
10c	Rotate the encryption key



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# Candidate Prerequisites



Basic terminal skills



Basic understanding of on premises and cloud architecture



Basic level of security understanding



# Preparing for the Exam

*Documentation is not allowed during the test*

- Study Guide:

<https://developer.hashicorp.com/vault/tutorials/associate-cert/associate-study>

- Exam Review:

<https://developer.hashicorp.com/vault/tutorials/associate-cert/associate-review>

- Sample Questions:

<https://developer.hashicorp.com/vault/tutorials/associate-cert/associate-questions>



# Interacting with Vault

Introduction, Installation, Vault UI & API



# What is Vault?

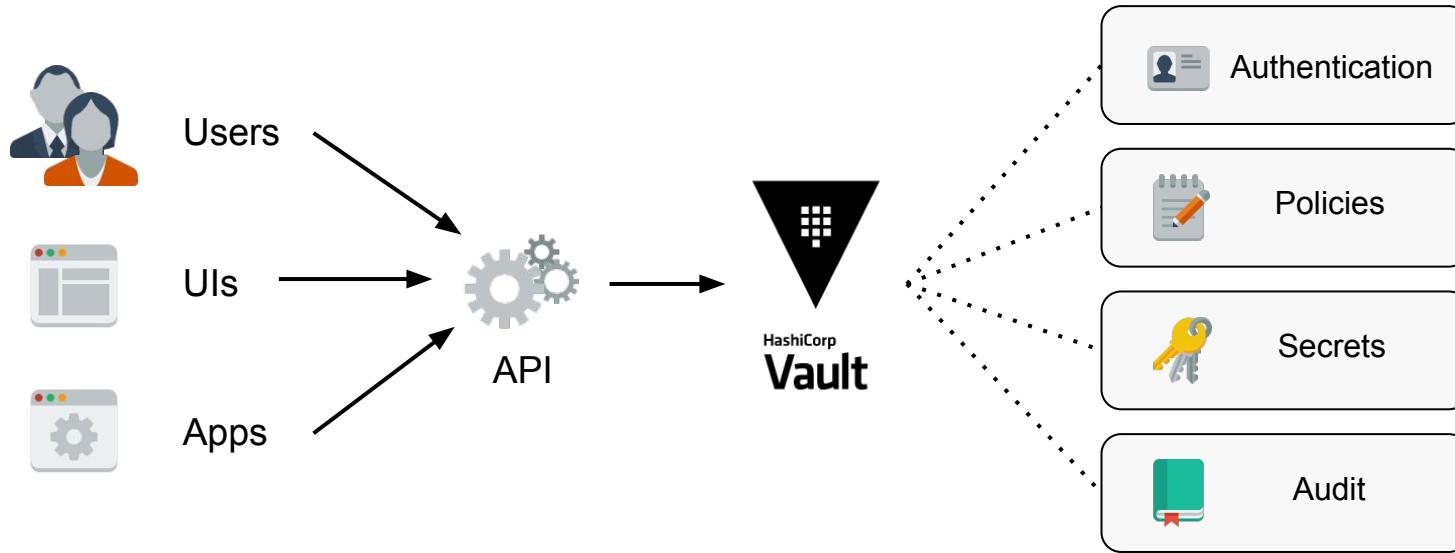
*Centralized secrets manager with a client and server component*

- Manages static (a hard-coded value) and dynamic secrets (generated on-the-fly)
- A secret could be an API key, a password, or a SSN
- Exists as open source solution or in the cloud as a commercial offering ([Vault Cloud](#))
- You can interact with Vault with the CLI, the UI, or directly with the API



# High-Level Vault Architecture

*Common entry point for all communication is the API*



# Installing Vault



*Easy to install on all operating systems*

- Manual installation
  - Download ZIP file containing the pre-compiled binary
  - Add binary to PATH environment variable
- Using a package manager
  - Available via Homebrew, Chocolatey, and apt-get
  - Takes care of adding binary to terminal



# Verifying and Using Vault

*The vault executable is the main entry point*

```
$ vault version  
Vault v1.12.1 ...
```

```
$ vault -help  
Usage: vault <command> [args]  
  
Common commands:  
  read      Read data and retrieves secrets  
  write     Write data, configuration, and secrets  
  delete    Delete secrets and configuration  
  list      List data or secrets  
  login     Authenticate locally  
  agent     Start a Vault agent  
  server    Start a Vault server  
  status    Print seal and HA status  
  unwrap   Unwrap a wrapped secret
```

...



# Using Development Mode

*Server can be run on local machine for dev purposes*

- Runs on localhost without SSL (only allows HTTP access)
- The user interface is enabled by default
- Runs a key-value secrets store in memory (loses data upon restart)
- Starts unsealed with a single unseal key (allows access to decrypted data by clients)



# Starting Developing Server

*Start up and use root token to log in*

```
$ vault server -dev
...
Unseal Key: 6WYdi1rhIv+FsfvoV7fL2grz0wwk1ChAfGXWjguC2Fk=
Root Token: hvs.kVrw0a8LT4MzDj9xxrFmDhPN

$ addr='http://127.0.0.1:8200'
$ token=hvs.kVrw0a8LT4MzDj9xxrFmDhPN

$ vault login -address=$addr $token
```



# Vault Environment Variables

*Evaluated automatically by `vault` command*

```
$ export VAULT_ADDR='http://127.0.0.1:8200'  
$ export VAULT_TOKEN=hvs.kVrw0a8LT4MzDj9xxrFmDhPN
```



Just two of the standard Vault  
[environment variables](#)



# Interacting with the UI

*Accessing via Vault address + the /ui context path*



# Interacting with the API

*The UI and CLI use the RESTful API*

```
$ curl -H "X-Vault-Token: $VAULT_TOKEN" -X GET ← Get host information  
$VAULT_ADDR/v1/sys/host-info
```

```
$ curl -H "X-Vault-Token: $VAULT_TOKEN" -X LIST ← List all secrets  
$VAULT_ADDR/v1/secret
```

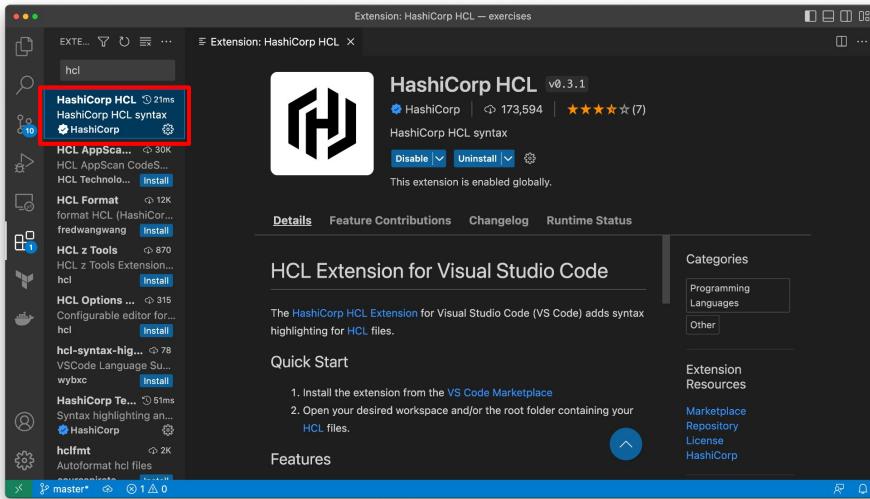
```
$ curl -H "X-Vault-Token: $VAULT_TOKEN" -X GET ← Get information  
$VAULT_ADDR/v1/secret/foo about a specific secret
```



# IDE Integration with VSCode



*Search for “HashiCorp HCL” in the Extensions*



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# EXERCISE

Installing Vault and  
Interacting with it



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# Q & A



# Managing Authentication Methods

Use Cases, Configuration, Human vs. System  
Authentication Methods

# What are Authentication Methods?

*Verifies identity when interacting with the Vault API*

- Different methods are allowed and can be referenced from internal (Vault native) or external sources (e.g. AWS IAM, LDAP).
- Authentication methods are provided by plug-ins.
- The end goal is to retrieve a *token*.
- Calls to the Vault API use the token to authenticate.



# Choosing a Suitable Method

*Ask yourself the following question to determine fitting method*

- **Who** is going to access Vault? Is it a internal or external human user? Are you planning to use Vault from a machine?
- **How** does the authentication process look like? Interactive or by providing a value.
- **What** kinds of authentication method has been established in the past? LDAP vs. username/password vs. cloud provider



# Vault Native Methods

*Built into Vault and doesn't require reaching out to external source*

- **Userpass:** Meant for human users as a way to enter username/password credentials interactively.
- **AppRole:** Meant for applications that provide credentials programmatically. Consists of RoleID and SecretID.
- **Token:** Can be used by human or program. A single key sent with API request in header.



# Listing Methods from CLI

*By default, only the token auth method is enabled*

\$ vault auth list				
Path	Type	Accessor	Description	Version
token/	token	auth_token_c635dfe4	token based credentials	n/a



# Listing Methods from UI

Access > *Auth Methods*

The screenshot shows the HashiCorp Vault web interface. At the top, there's a navigation bar with tabs: Secrets, Access (which is highlighted with a red box), Policies, and Tools. To the right of the tabs are Status, a search icon, and user account icons. Below the navigation is a sidebar titled "ACCESS" with options: Auth Methods (highlighted with a red box), Multi-factor authentication, Entities, Groups, Leases, and OIDC Provider. The main content area is titled "Authentication Methods". It displays a table with one row, showing a "token/" method with a "auth\_token\_c635dfe4" value. There are "Enable new method +", "...", and "..." buttons. At the bottom of the page, there's a footer with copyright information: "© 2022 HashiCorp Vault 1.12.1 Upgrade to Vault Enterprise Documentation".



# Enabling a Method

*Providing a custom path is optional (see [docs](#))*

```
$ vault auth enable userpass
```

```
Success! Enabled userpass auth method at: userpass/
```

```
$ vault auth enable -path=service approle
```

```
Success! Enabled approle auth method at: service/
```

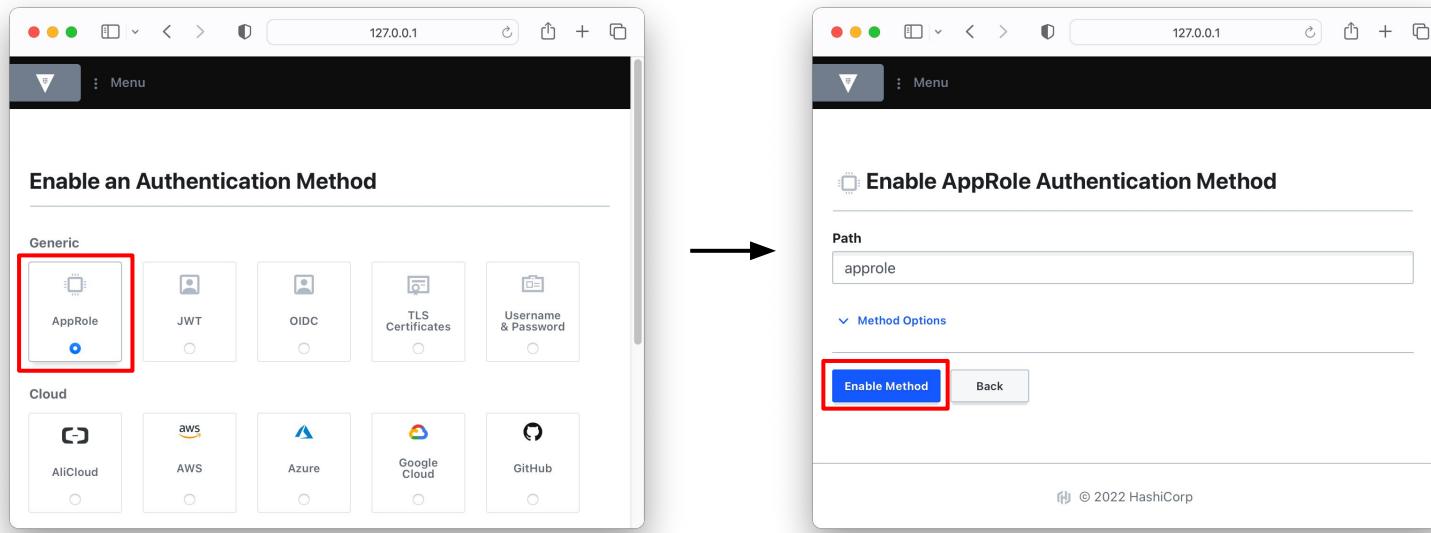
← Derives path from  
method type

↑  
Uses the custom path provided



# Enabling a Method from UI

*Access > Auth Methods > Enable new method*



# Tuning a Method from CLI

*Changes the settings of an existing method*

```
$ vault auth tune -description="Service application" service/  
Success! Tuned the auth method at: service/
```

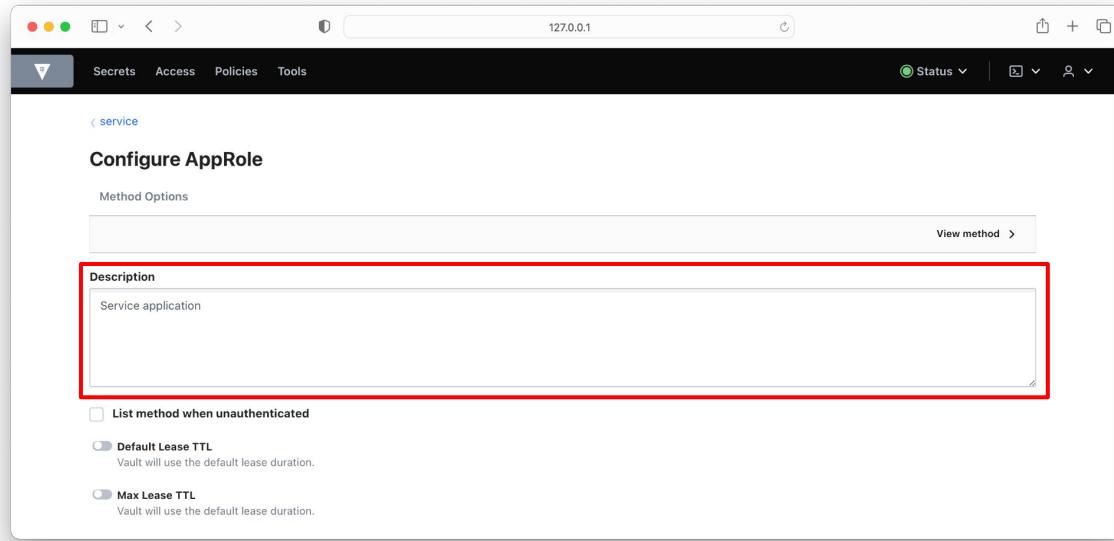


Sets the description



# Tuning a Method from UI

*Access > Auth Methods > View configuration > Configure*



# Getting Path Information from CLI

*Renders supported paths for a backend*

```
$ vault path-help auth/userpass ←  
...  
^login/(?P<username>\w(([\w-.]+)?\w)?)$  
    Log in with a username and password.  
  
^users/(?P<username>\w(([\w-.]+)?\w)?)$  
    Manage users allowed to authenticate.  
  
^users/(?P<username>\w(([\w-.]+)?\w)?) /password$  
    Reset user's password.  
  
^users/(?P<username>\w(([\w-.]+)?\w)?) /policies$  
    Update the policies associated with the username.  
  
^users/?$  
    Manage users allowed to authenticate.
```

Requires the type of path, in this case auth



# Creating a User from CLI

*Add username to path & provide password with param*

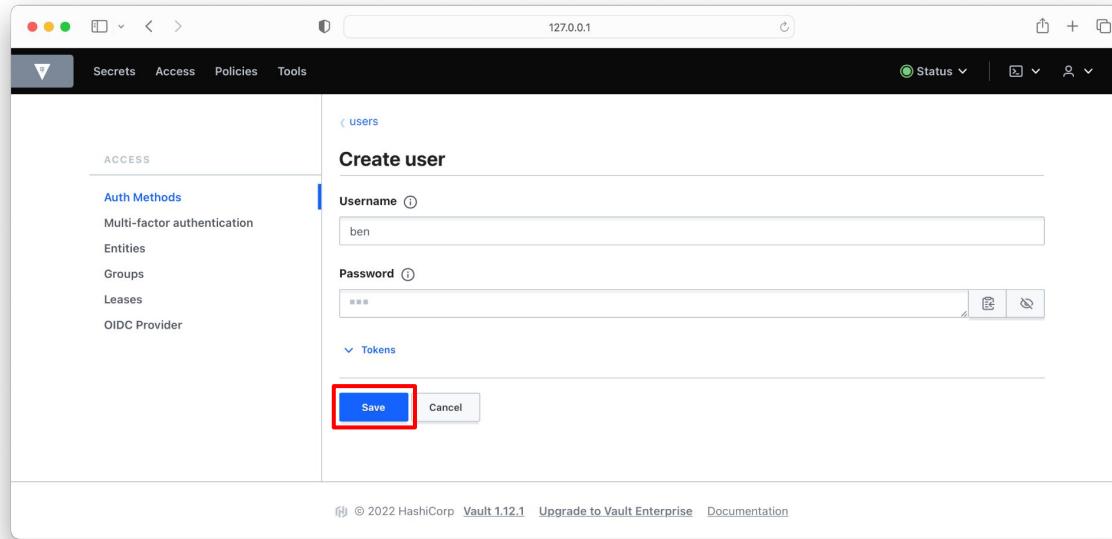
```
$ vault write auth/userpass/users/ben password=123  
Success! Data written to: auth/userpass/users/ben
```

>Password is provided  
as key-value pair



# Creating a User from UI

*Access > Auth Methods > Users > Create user*



# Creating an AppRole from CLI

*Provide the role name as parameter*

```
$ vault write auth/approle/role/batch role_name="batch"
Success! Data written to: auth/approle/role/batch

$ vault list auth/approle/role
Keys
-----
batch
```

From the Vault UI:

The Vault UI only supports configuration for this authentication method. For management, the [API or CLI](#) should be used.



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# EXERCISE

Managing  
Authentication  
Methods



# Using a User from CLI

*Use the `login` command and provide `username` param*

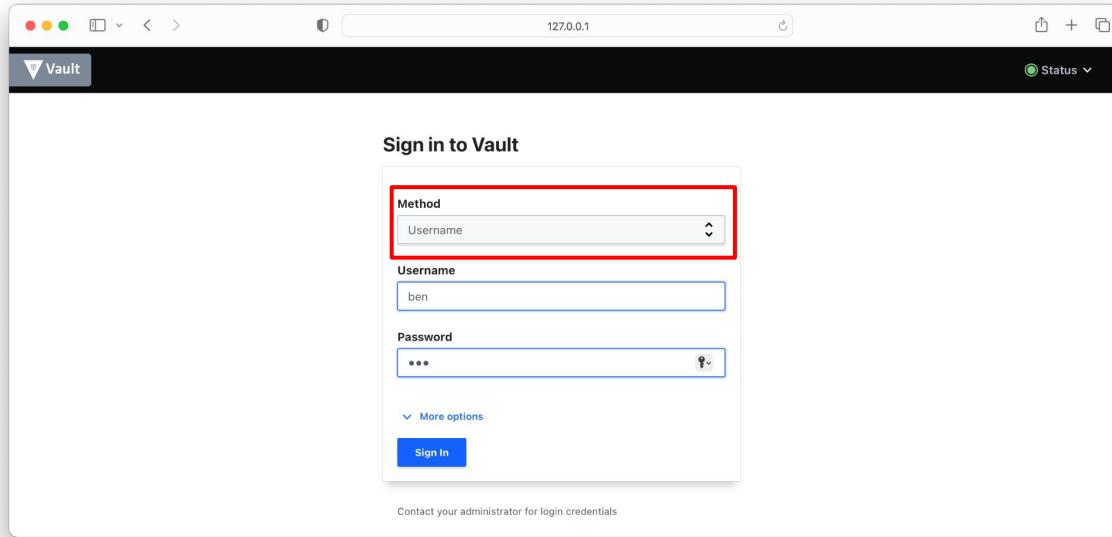
```
$ vault login -method=userpass username=ben
Password (will be hidden):
...
Key          Value
---          -----
token        hvs.CAESIIZ_1g...
token_accessor
M2SX78GxvpijWpulzXEPXNdM
token_duration    768h
token_renewable   true
token_policies   ["default"]
identity_policies []
policies        ["default"]
token_meta_username ben
```

You can use the token for  
API calls going forward



# Using a User from UI

*Log out of dashboard and sign back in with username method*



# Using an AppRole from CLI

*Read RoleID, generate SecretID, and write information*

```
$ vault read auth/approle/role/batch/role-id
Key          Value
---          -----
role_id      0a437428-f796-f336-8013-2a248f91da7b

$ vault write -force auth/approle/role/batch/secret-id
Key          Value
---          -----
secret_id    9962a7fc-391b-a509-6741-0fd5f3c0096d

$ vault write auth/approle/login role_id=0a437428-f796-f336-8013-2a248f91da7b
  secret_id=9962a7fc-391b-a509-6741-0fd5f3c0096d
Key          Value
---          -----
token        hvs.CAESILOTjUkA...
```

Read the role identifier

Generate a secret identifier

You can use the token for API calls going forward



# Disabling a Method from CLI

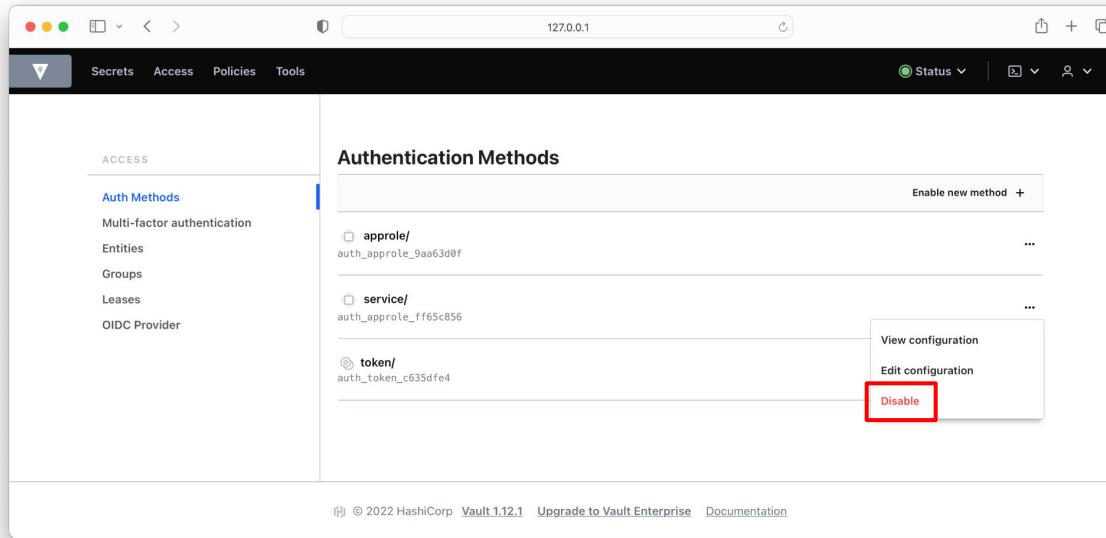
*Identified by path, removes authentication method*

```
$ vault auth disable service/  
Success! Disabled the auth method (if it existed) at: service/
```



# Disabling a Method from UI

*Access > Auth Methods > Disable*



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# EXERCISE

Using an  
Authentication  
Method



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# Q & A



# Managing Policies

Overview, Policy Syntax and Management,  
Assignment to Authentication Method

# What are Policies?

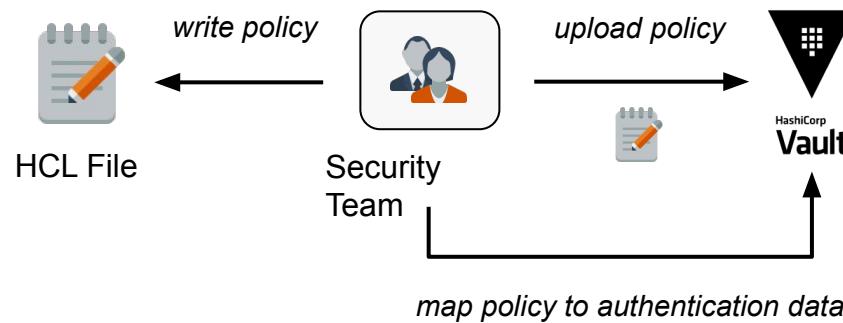
*Define permissions in Vault, also called ACL Policies*

- Specifies “What operations am I allowed/denied to perform as the authenticated user or identity?”.
- Built-in policies (default and root) exist to establish standard permissions.
- Deny by default, so an empty policy grants no permission in the system.



# Policy Management Process

*Security team is responsible for writing and uploading policies*



# Policy Syntax

*The most common syntax is HCL, consists of two components*

- **Path:** Defines the URL context path for a functionality to assign the permissions to.
- **Capability:** The operations are allowed for the path.

```
path "secret/foo" {  
    capabilities = ["read"]  
}
```



Read permissions for  
the path `secret/foo`



# Path Definition

*Explicit, fully-spelled out path or path containing a glob*

```
path "secret/foo" { ... } ← Only this path, no path segment below
```

```
path "secret/bar/*" { ... } ← Any segment path below this path
```

secret/bar/web

secret/bar/some/other

```
path "secret/+/team" { ... }
```



This path with a *single* path segment (any number of characters)

secret/web/team

secret/other/team



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# Available Capabilities

*Permitted or denied operations (see [docs](#))*

- **Basic (mapped to HTTP verbs):** create, read, update, patch, delete, list
- **Vault-Specific (not mapped to HTTP verbs):** sudo (access to paths that are root-protected), deny (disallow access)



# Capability HTTP Verbs

*Verbs to be used when making a call to*

Capability	Associated HTTP verbs
create	POST/PUT
read	GET
update	POST/PUT
delete	DELETE
list	LIST
patch	PATCH
sudo	-
deny	-



# Path Precedence

*Rules can defines more fine-grained capabilities*

```
path "secret/*" {  
    capabilities = ["create", "read", "update", "patch", "list"]  
}  
  
path "secret/bar" {  
    capabilities = ["deny"]  
}
```



Deny capability takes precedence over more generalized rule for this specific path



# Formatting Policies from CLI

*Automatically aligns contents based on style conventions*

```
$ vault policy fmt admin-policy.hcl  
Success! Formatted policy: secrets-list.hcl
```

```
path "secret/bar"  
{  
    capabilities = ["deny"]  
}
```



```
path "secret/bar" {  
    capabilities = ["deny"]  
}
```



---

# Policy Assignment

*Explicit or automatic assignment to authentication method*

- Explicitly assigned when token is created.
- Automatic assignment to an authentication method when its token is created. The association between policy and authentication method needs to be defined beforehand.
- Assigned to an entity in the identity secrets engine.



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# Built-In Policies

*Come with Vault and define standard permissions*

- **Default Policy:** Attached to all tokens upon creation. Can be modified but not deleted.
- **Root Policy:** A policy that is allowed to perform any operation on any path. Assigned to root token and acts as initial superuser. Cannot be modified or deleted. Exists in a brand new Vault installation but should be revoked in the production environments.



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# Listing Policies from CLI

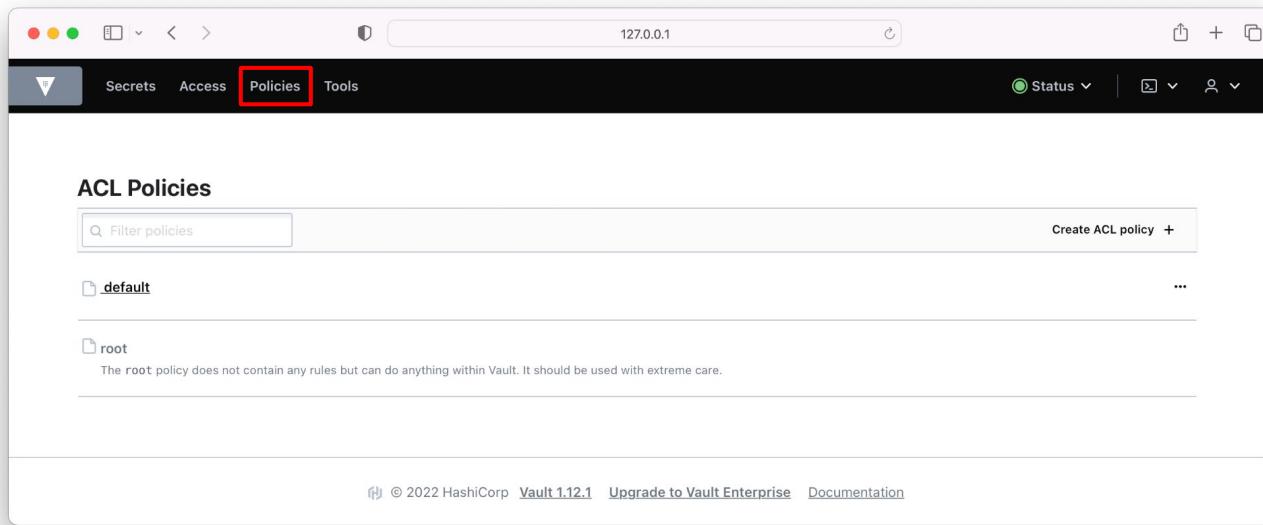
*Built-in policies will always be rendered*

```
$ vault policy list
default
root
```



# Listing Policies from UI

*Policies menu option*



# Creating a Policy from CLI

*Point to the HCL policy file*

```
$ vault policy write admin admin-policy.hcl  
Success! Uploaded policy: admin
```

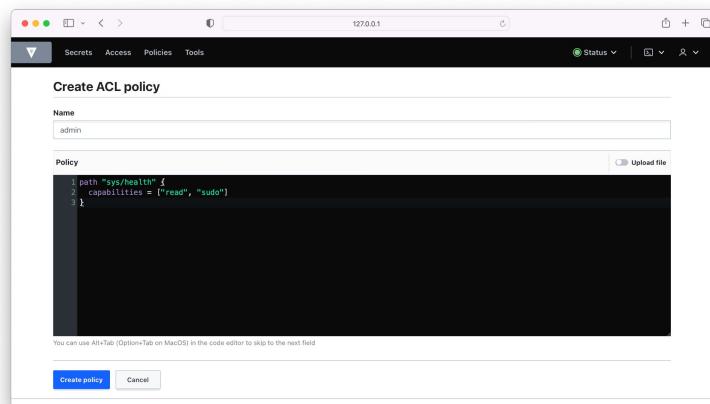


```
path "sys/health" {  
    capabilities = ["read", "sudo"]  
}
```



# Creating a Policy from UI

*Policies > Create ACL policy*



# Reading a Policy from CLI

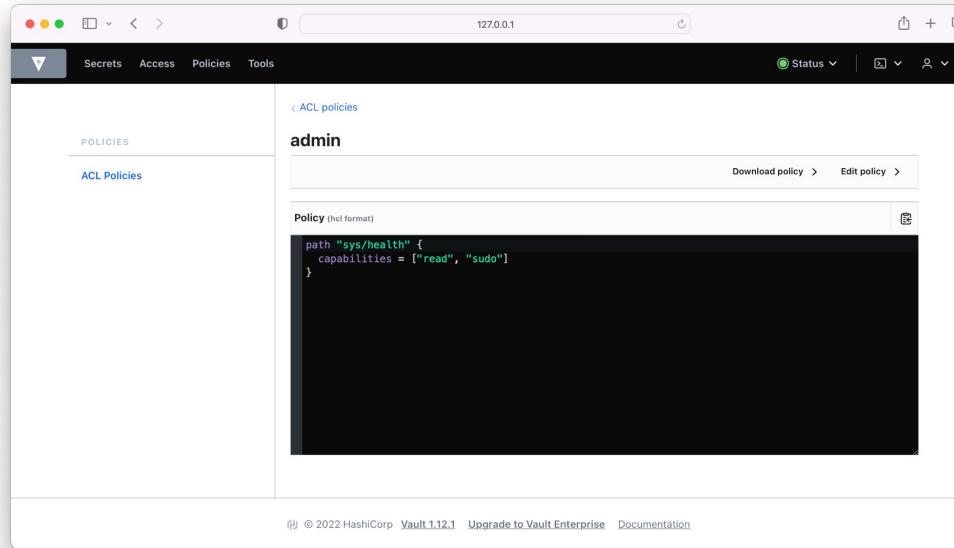
*Renders the contents of uploaded policy file*

```
$ vault policy read admin
path "sys/health" {
    capabilities = ["read", "sudo"]
}
```



# Reading a Policy from UI

*Policies > Select policy*



# Updating a Policy from CLI

*Change contents of policy file and upload again*

```
$ vault policy write admin admin-policy.hcl  
Success! Uploaded policy: admin
```

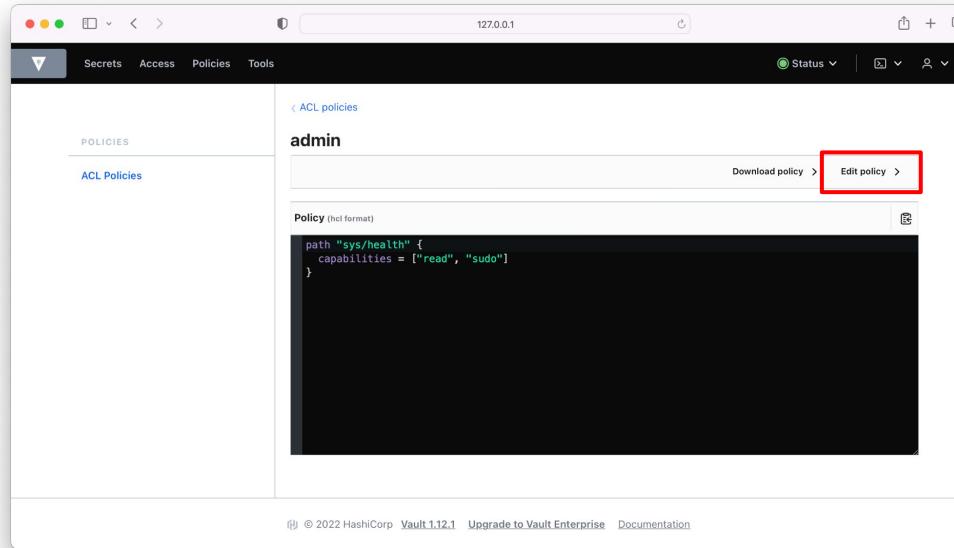


Change file contents and  
run the same command  
used for creation



# Updating a Policy from UI

*Policies > Select policy > Edit policy*



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# EXERCISE

## Managing Policies



# Assigning a Policy from CLI

*Assignment to token, userpass, or identity*

```
$ vault token create -policy="admin"  
$ vault write auth/userpass/users/ben token_policies="admin"  
$ vault write identity/entity/name/ben policies="admin"
```

Assignment to an  
identity in secrets  
engine

Assignment to an  
authentication  
method

Assignment  
to a token



# Policy Effects from CLI

*Enforces denied operations*

```
$ curl -H "X-Vault-Token: $token" -X GET $VAULT_ADDR/v1/sys/audit
{"errors": ["1 error occurred:\n\t* permission denied\n\n"]}
```

```
$ curl -H "X-Vault-Token: $token" -X GET $VAULT_ADDR/v1/sys/health
{"initialized": true, "sealed": false, "standby": false, "performance_standby": false, "replication_performance_mode": "disabled", "replication_dr_mode": "disabled", "server_time_utc": 1668210669, "version": "1.12.1", "cluster_name": "vault-cluster-f910f67d", "cluster_id": "d6d79d2e-9ced-21dd-66ec-3c094b051a79"}
```



---

# Deleting a Policy from CLI

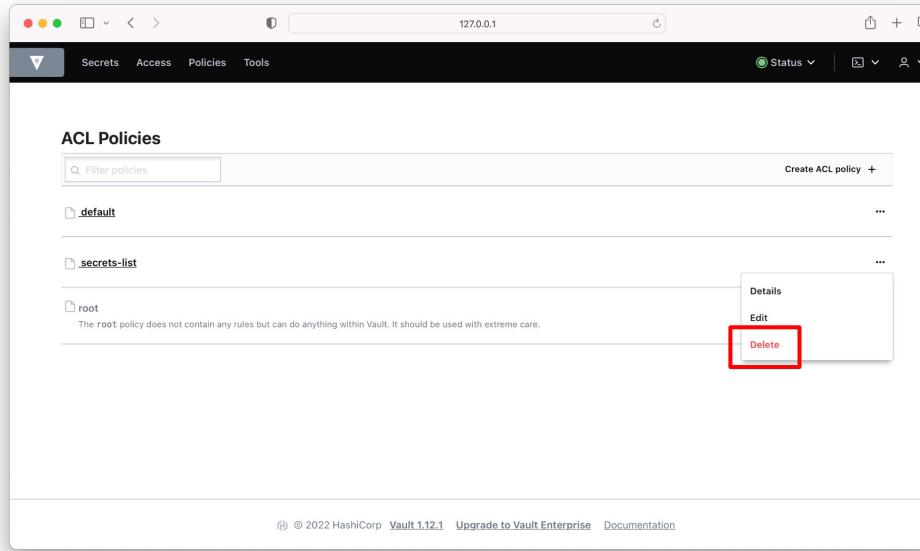
*Detaches policy from assigned authentication data*

```
$ vault policy delete admin  
Success! Deleted policy: admin
```



# Deleting a Policy from UI

*Policies > Select policy > Delete*



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# EXERCISE

Assigning a Policy  
to an Authentication  
Method



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# Q & A



# Using Tokens

Overview, Use Cases, Token Types, Token Lifecycle, TTL

# What are Tokens?

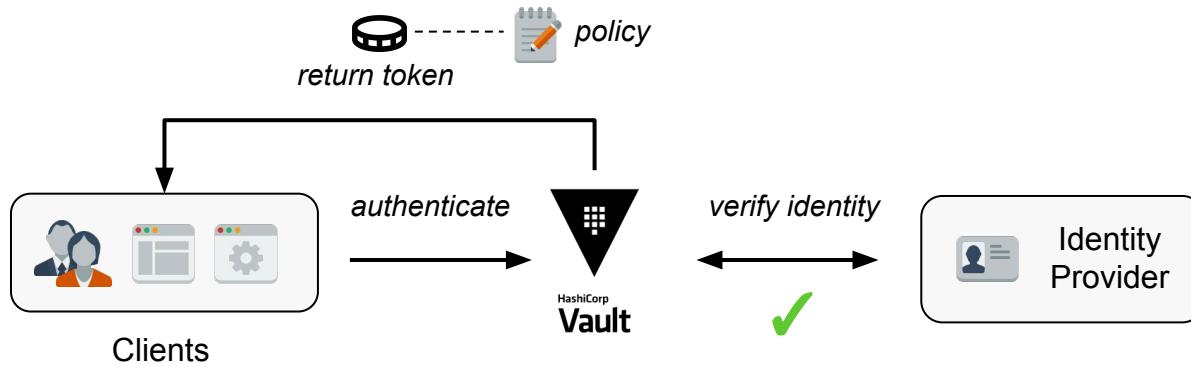
*Core method for authentication within Vault (see [docs](#))*

- Can be provided directly when making a call to the API. For example, you can use the initial root token to initialize your system.
- You can generate a token from an authentication method. For example, for an Userpass authentication method, you can generate a corresponding token.
- A token maps to a set of policies that define what the token holder is allowed to do.



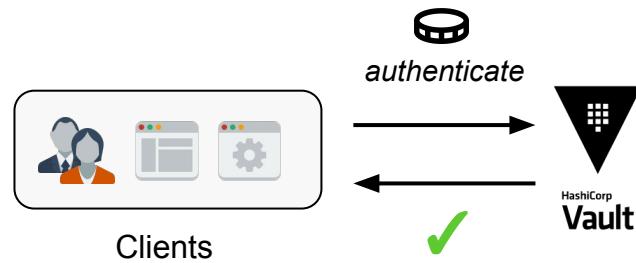
# Token Generation

*Vault generates token upon successful authentication*



# Token Usage

*Subsequent calls to API provide the token*



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# Root Token

*A token with all available permissions*

- Vault starts with a root token used to initialize setup.
- Does not expire.
- Should be revoked as soon as possible after setup procedure.
- A root token can create other root tokens. Those tokens should only be used in emergency situations.



# Token Properties

*Every token has specific characteristics*

- **ID:** Value used for logging in or making a call to the API.
- **Accessor:** Value to look up a token without using it.
- **Type:** Is it a service or a batch token?
- **Policies:** Assigned when issued and evaluated when used.
- **TTL:** When does the token expire?
- **Orphaned:** Does the token have a parent token?



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# What's the Role of the Accessor?

*Reference to a token with limited actions (see [docs](#))*

- Created and returned when token is generated. Some token types do not provide an accessor.
- It can only view token properties but not the ID.
- It can view capabilities for a path.
- It can be used to renew or revoke a token.



# Token Types

Select the type based on use case (see [feature comparison](#))

- **Service Token**
  - Has all features and is persisted in storage backend.
  - Can be renewed or revoked before reaching their time-to-live (TTL) value.
  - Default if not explicitly set to batch type.
- **Batch Token**
  - Lightweight, scalable, and not written to storage backend.
  - Cannot be listed or manually revoked.
  - Use to reduce the stress of managing a large number of tokens in parallel for performance reasons.



# Token Prefixes

*The ID of the token indicates token type*

Token Type	Prefix
Service token	hvs.
Batch token	hvb.
Recovery token	hvr.



# Creating a Service Token from CLI

*Renders the contents of uploaded policy file*

```
$ vault token create -policy=default -ttl=24h
Key          Value
---          -----
token        hvs.CAESIDPJkS-bHn...
token_accessor
YV7q0uqcYqivx0vJ2pfoyFys
token_duration    24h
token_renewable   true
token_policies    ["default"]
identity_policies []
policies         ["default"]
```

This is the ID of the token

This is the accessor of the token



# Service Token Info with ID from CLI

*Uses the ID and renders full information*

```
$ vault token lookup hvs.CAESIDPJks-bHn...
Key          Value
---          -----
accessor     YV7q0uqcYqivx0vJ2pfoyFys
creation_time 1668629257
creation_ttl 24h
display_name token
entity_id    n/a
expire_time  2022-11-17T13:07:37.251426-07:00
explicit_max_ttl 0s
id          hvs.CAESIDPJks-bHn...
issue_time   2022-11-16T13:07:37.251432-07:00
meta         <nil>
num_uses     0
orphan       false
path         auth/token/create
policies     [default]
renewable    true
ttl          23h51m24s
type        service
```

Type `service` is the default



# Token Info with Access. from CLI

*Uses the accessor and renders limited information*

```
$ vault token lookup -accessor YV7q0uqcYqivx0vJ2pfoyFys
Key          Value
---          ---
accessor     YV7q0uqcYqivx0vJ2pfoyFys
creation_time 1668629257
creation_ttl 24h
display_name token
entity_id    n/a
expire_time  2022-11-17T13:07:37.251426-07:00
explicit_max_ttl 0s
id           n/a ←
issue_time   2022-11-16T13:07:37.251432-07:00
meta         <nil>
num_uses    0
orphan       false
path         auth/token/create
policies    [default]
renewable    true
ttl          23h50m37s
type        service
```

Token ID cannot be viewed



# Creating a Batch Token from CLI

*Renders the contents of uploaded policy file*

```
$ vault token create -type=batch -policy=default -ttl=10m
Key          Value
---          -----
token        hvb.AAAAAQJz7U...
token_accessor  n/a
token_duration  10m
token_renewable false
token_policies  ["default"]
identity_policies []
policies      ["default"]
```



# Batch Token Info with ID from CLI

*Uses the ID and renders full information*

```
$ vault token lookup hvb.AAAAQJz7U...
Key          Value
---          -----
accessor     n/a
creation_time 1669162941
creation_ttl 10m
display_name token
entity_id    n/a
expire_time  2022-11-22T17:32:21-07:00
explicit_max_ttl 0s
id           hvb.AAAAQJz7U...
issue_time   2022-11-22T17:22:21-07:00
meta         <nil>
num_uses    0
orphan       false
path         auth/token/create
policies    [default]
renewable    false
ttl          5m57s
type        batch
```

Doesn't have an accessor

Cannot be renewed



# TTL Details

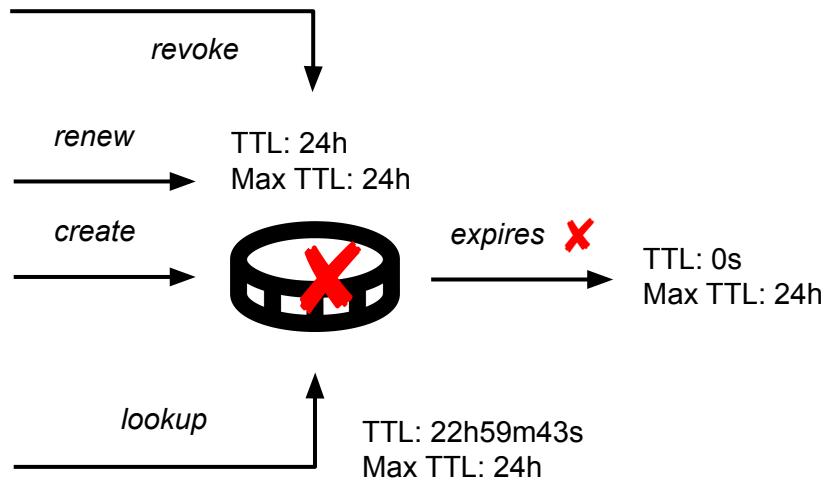
*Creation time, elapsed time, and maximum expiration time*

TTL Attribute	Description
<code>creation_time</code>	The token creation timestamp in Unix format.
<code>creation_ttl</code>	TTL set when token was created.
<code>expire_time</code>	Projected time when token will expire.
<code>expire_max_ttl</code>	Maximum TTL that cannot be exceeded.
<code>issue_time</code>	Token creation timestamp in human-readable format.
<code>ttl</code>	Computed time left until token expires.



# Token Life Cycle

*The lifespan of a token can be controlled*



# Renewing a Token from CLI

*Extend TTL by given increment or up to max TTL*

```
$ vault token renew -increment=120m hvs.CAESIDPJkS-bHn...
Key          Value
---
token        hvs.CAESIDPJkS-bHn...
token_accessor YV7q0uqcYqivx0vJ2pfoyFys
token_duration 2h ←
token_renewable true
token_policies ["default"]
identity_policies []
policies      ["default"]
```



Provided increment



# Revoking a Token from CLI

*Uses the accessor and renders limited information*

```
$ vault token revoke -accessor YV7q0uqcYqivx0vJ2pf0yFys  
Success! Revoked token (if it existed)
```



For security reasons, the effective outcome of the operation is not revealed



---

# EXERCISE

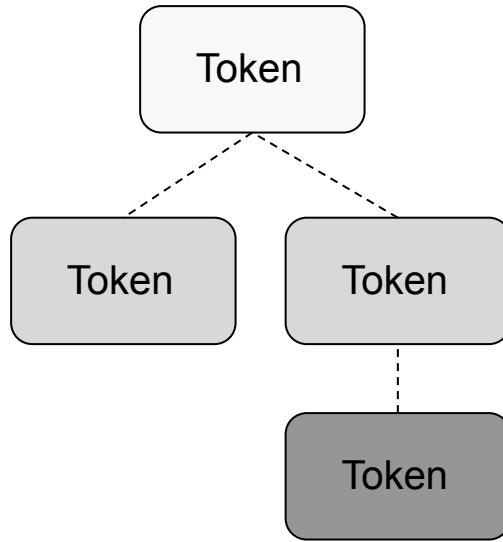
Creating and Using  
a Service and Batch  
Token



---

# Token Hierarchies

*A token can create child tokens, usually cascade revokes children*



---

# Orphaned Tokens

*Token without a parent token*

- Can be defined up creation with `-orphan` option.
- Tokens created by authentication methods will be orphaned by default.
- Revoking a parent token can explicitly make its children orphans.



# Creating Orphan Token from CLI

*A token without a parent*

```
$ vault token create -orphan
Key          Value
---          -----
token        hvs.7fM8ne4k08Vq6BbYKKSSMff4
token_accessor AhG5TfkiEtfY4gp2lzBtf5nQ
token_duration   ∞
token_renewable    false
token_policies      ["root"]
identity_policies []
policies           ["root"]
```



---

# Q & A



# Comparing and Configuring Secrets Engines

Overview, Dynamic vs. Static, Managing Engines

# What are Secrets Engines?

*Plugins in Vault for managing secret data (see [docs](#))*

- Can store, generate, or encrypt data depending on the engine type.
  - **Store:** Data is stored outside of Vault but we want to give access to it through Vault.
  - **Generate:** Interacts with external service that Vault generates information for.
  - **Encrypt:** Vault provides encryption for data that lives outside of the system.
- Accessible through the path `/sys/mounts` and provide functions like read, write, and delete.



# Examples for Secrets Engines

*Wide range of options are available*

- **Vault-Internal:** Identity, Key-value store, Transit
- **Cloud:** AWS, Azure, Google Cloud
- **Identity:** LDAP, Active Directory
- **Databases:** MongoDB, Redis, PostgreSQL, MySQL
- **Others:** Kubernetes, Terraform Cloud, RabbitMQ



# Default Dev Secrets Engines

*The dev server starts with some initial secret engine paths*

- **/identity**: Keeps track of authenticated clients to Vault. Cannot be disabled.
- **/cubbyhole**: Stores arbitrary secrets within the configured physical storage for Vault namespaced to a token. Cannot be disabled.
- **/secret**: A key-value store used to store arbitrary secrets. Can be disabled. This secrets engine is meant as a playground for starters when using the development server.



# Listing Secrets Engines from CLI

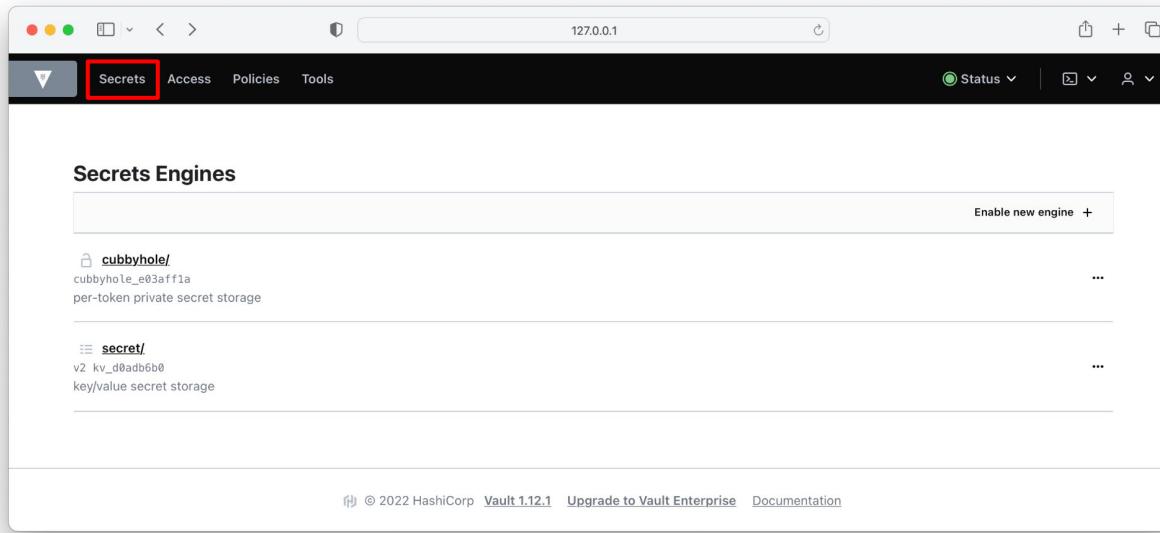
*Description field describes the type of secret engine*

\$ vault secrets list			
Path	Type	Accessor	Description
---	---	-----	-----
cubbyhole/	cubbyhole	cubbyhole_e03aff1a	per-token private
secret storage			
identity/	identity	identity_3b6c23eb	identity store
secret/	kv	kv_d0adb6b0	key/value secret
storage			
sys/	system	system_47c5e1dd	system endpoints used
for control, policy and debugging			



# Listing Secrets Engines from UI

*Secrets menu option*



---

# Static vs. Dynamic Secrets Engines

*As an end user, you will primarily interact with dynamic ones*

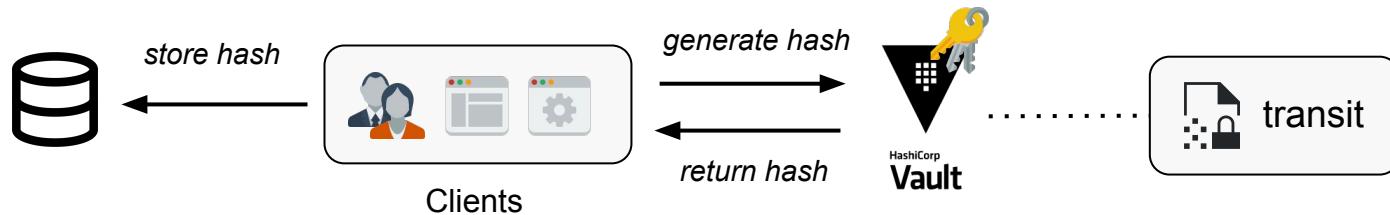
- **Static:** Manual management of secrets in Vault. An example of this is the key-value secret engine.
- **Dynamic:** Generates data upon request. Every secret has a lease which automatically expires the secret after specific time frame. Most secret engines in Vault are dynamic, e.g. the database secret engines.



# Transit Engine

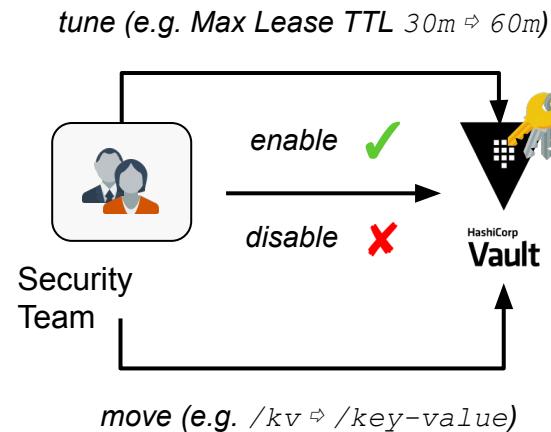
*Doesn't store data, but provides cryptographic functions (see [docs](#))*

- **Primary use case:** Encrypt data from applications while still storing that encrypted data in some primary data store.
- **Functions:** Sign and verify data; generate hashes and [HMACs](#) of data; and act as a source of random bytes.



# Secrets Engine Lifecycle

*Security team is responsible for writing and uploading policies*



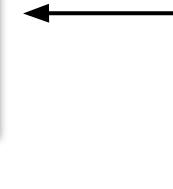
# Enabling a Secrets Engine from CLI

*Enables engine by path*

```
$ vault secrets enable -path=kv kv-v1  
Success! Enabled the kv secrets engine at: kv-v1/
```

```
$ vault secrets enable -path=kv-v2 -version=2 kv-v2  
Success! Enabled the kv-v2 secrets engine at: kv-v2/
```

Engine type is  
“key-value” with version  
1



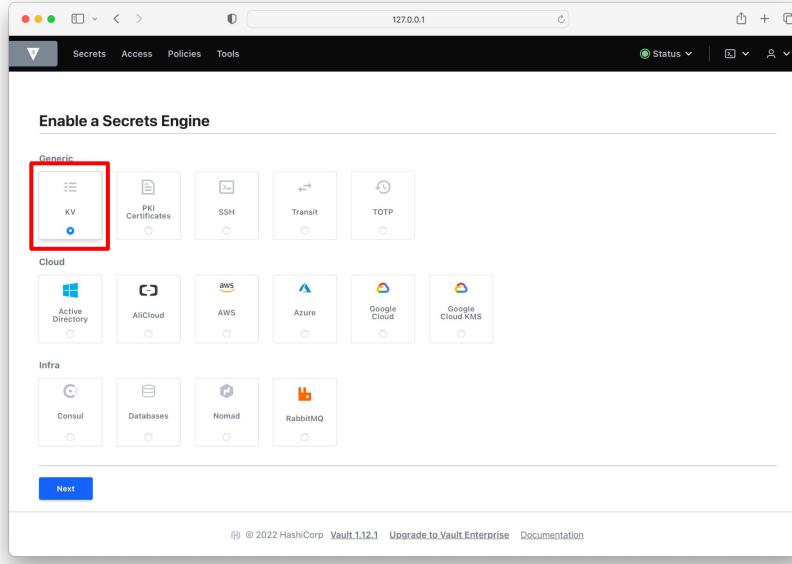
Engine type is  
“key-value” with version  
2

Comparison between kv engine versions



# Enabling a Secrets Engine from UI

*Secrets > Enable new engine*



# Tuning a Secrets Engine from CLI

*Tweaks configuration of existing engine (see [docs](#))*

```
$ vault secrets tune -default-lease-ttl=72h  
-description="My key-value secret" kv  
Success! Tuned the secrets engine at: kv/
```

← Updates TTL and description

```
$ vault write kv/config max_versions=5  
Success! Data written to: kv/config
```

← Updates # of versions to keep in history

Cannot be changed from the UI!



---

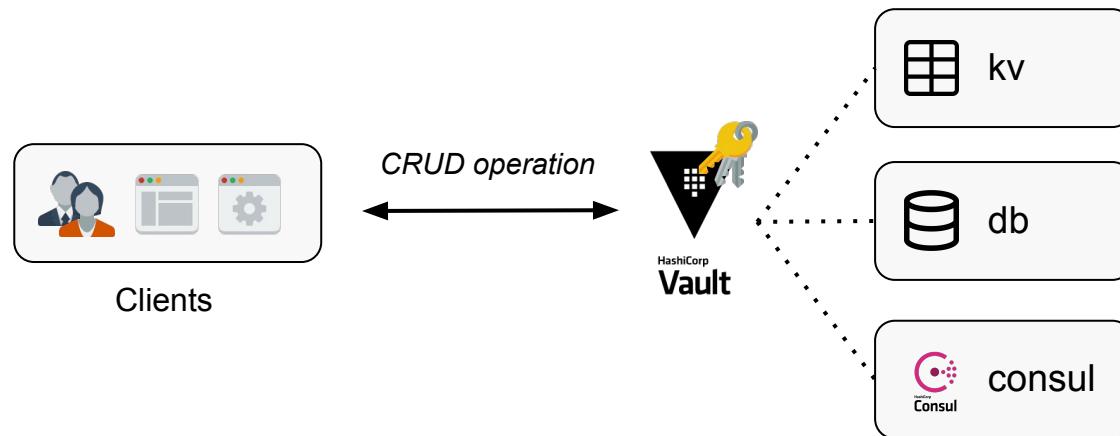
# EXERCISE

Enabling and  
Configuring a  
Secrets Engine



# Secrets Usage

*Standard operations are available through CLI, API, and UI*



# KV Command Interaction from CLI

*Only applies to kv secrets engine (see [docs](#))*

```
$ vault kv put business-app/db name=therium
```

```
...
```

```
$ vault kv list business-app
```

```
Keys
```

```
----
```

```
db
```

```
$ vault kv get -field=name business-app/db  
therium
```

Creates a new version of entries in kv secrets engine

Get all keys

Get the value of a specific key



# Secret Interaction from CLI

*Use the read and write command*

```
$ vault read business-app/data/db
Key          Value
---          -----
data         map[password:test123 username:ben]
metadata     map[created_time:2022-12-02T20:07:23.356605Z
custom_metadata:<nil> deletion_time: destroyed:false version:3]
```



# Secret Interaction from API

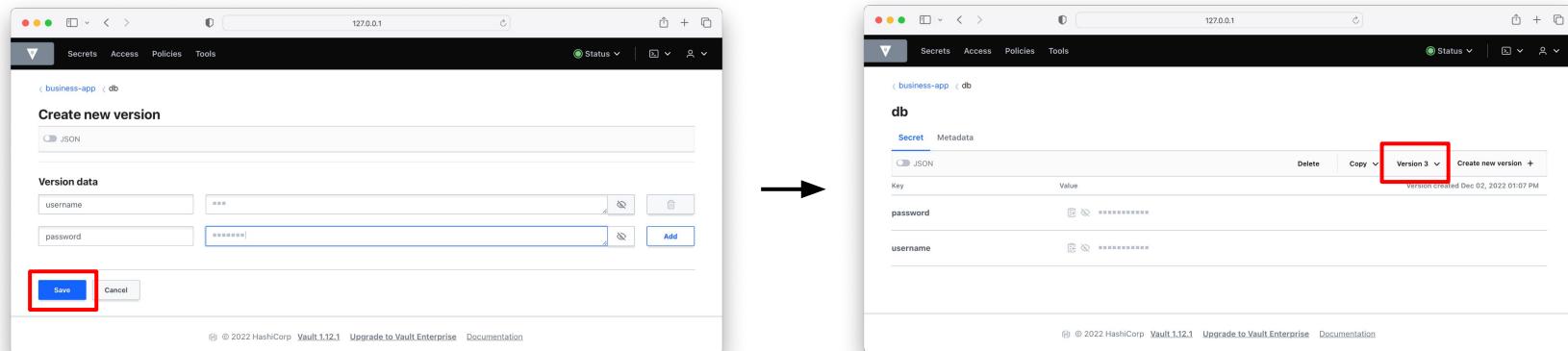
*Get the latest or a specific version (see [docs](#))*

```
$ curl -H "X-Vault-Token: hvs.1dx0yCjCNZFQQOfUljLyRukq"  
$VAULT_ADDR/v1/business-app/data/db\?version=3  
{"request_id": "4096fcec-d6e5-8d75-a18b-e29373474cd8", "lease_id": "",  
 "renewable": false, "lease_duration": 0, "data": {"data": {"password": "test123", "username": "ben"}, "metadata": {"created_time": "2022-12-02T20:07:23.356605Z", "custom_metadata": null, "deletion_time": "", "destroyed": false, "version": 3}}, "wrap_info": null, "warnings": null, "auth": null}
```



# KV Interaction from UI

*Secrets > Select Engine*



---

# EXERCISE

Interacting with a  
Secrets Engine



---

# Q & A



# Managing Leases

Overview, Life Cycle, Operations

# What are Leases?

*Control life cycle of a dynamic secret or a service token (see [docs](#))*

- A lease is effectively metadata that determine the duration the data will be valid for available at path /sys/leases.
- When a lease expires, Vault will automatically invalidate the data and prevents further renewal.
- A client can renew a lease to extend the time span of a secret, or request a replacement secret.



---

# Lease Properties

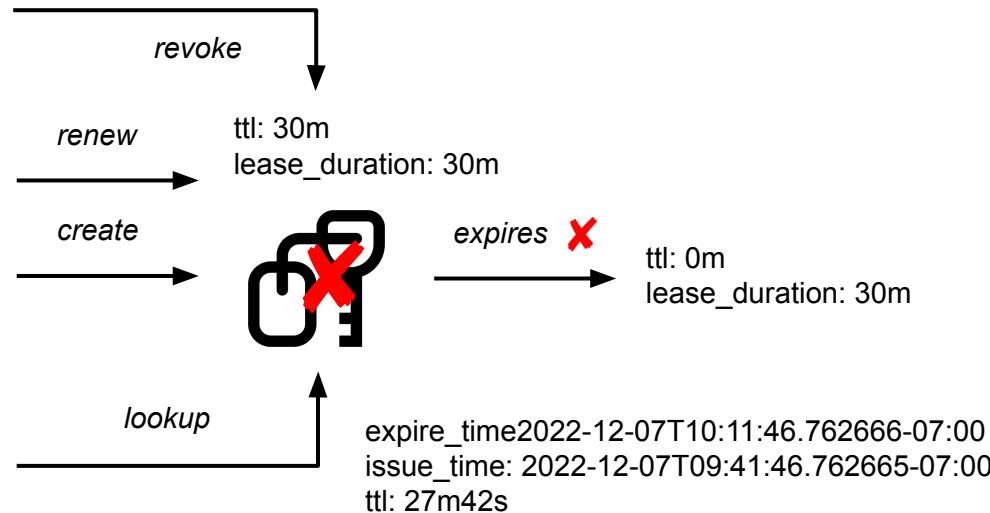
*Similar to token properties*

- `lease_id`: The unique identifier attached to a lease.
- `lease_duration`: The amount of time left until the lease expires.
- `lease_renewable`: A boolean value that tells you if the lease can be renewed.



# Lease Life Cycle

*Very similar to token life cycle but with different terminology*



# **Listing Active Leases from CLI**

*Access only available through path*

```
$ vault list sys/leases/lookup
Keys
-----
auth/

$ vault list sys/leases/lookup/auth/userpass/login/jill
Keys
-----
h39b78c1c71e0bca8c130c4dfd811837db0f5c006a9760487ad4ab7b79b7fae3a
h432e5a575b0e40f188e795c0a2980b767afdcf0717ce4363bbfbf6d3a7487f63
```



# Lease Details from CLI

*Renders TTL information*

```
$ vault lease lookup auth/userpass/login/jill/h39b78c1c71e0b...
Key          Value
---          -----
expire_time  2022-12-07T10:11:46.762666-07:00
id           auth/userpass/login/jill/h39b78c1c71e0b...
issue_time   2022-12-07T09:41:46.762665-07:00
last_renewal <nil>
renewable    true
ttl          27m42s
```



# Renewing a Lease from CLI

*Resets the TTL and adjusts*

```
$ vault lease renew database/creds/readonly/27e1b9a1-27b8-...
Key          Value
---          -----
lease_id    database/creds/readonly/27e1b9a1-27b8-...
lease_duration 5m
lease_renewable true
```

Command only works  
for a dynamic secret,  
not for a token



# Revoking a Lease from CLI

*Deletes the lease*

```
$ vault lease revoke auth/userpass/login/jill/h39b78c1c71e0b... ←  
All revocation operations queued successfully!
```

```
$ vault list sys/leases/lookup/auth/userpass/login/jill  
Keys  
----
```

```
h432e5a575b0e40f188e795c0a2980b767afdcf0717ce4363bbfbf6d3a7487f63
```

```
$ vault lease revoke -prefix auth/userpass/login/jill ←  
All revocation operations queued successfully!
```

```
$ vault list sys/leases/lookup/auth/userpass/login/jill  
No value found at sys/leases/lookup/auth/userpass/login/jill
```

Revokes a single lease by ID

Revokes all leases by path



---

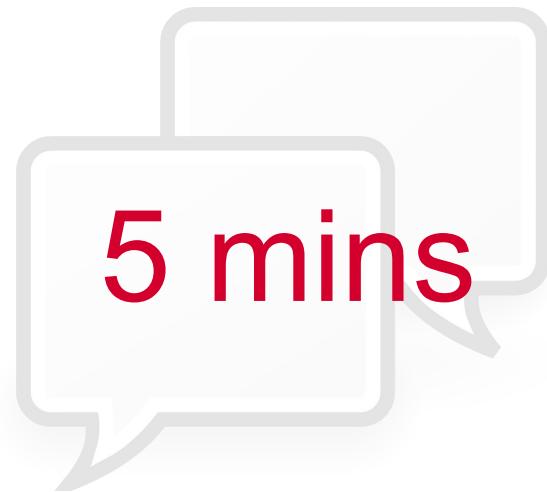
# EXERCISE

Working With  
Leases



---

# Q & A

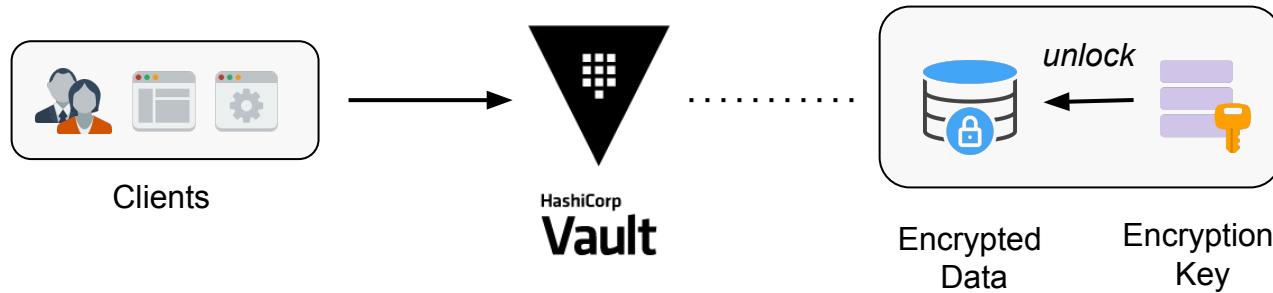


# Understanding the Vault Architecture

Data Encryption, Storage Backends, High Availability, Identity Management, Vault Agent, Response Wrapping

# Encryption of Data in Vault

*Data stored in Vault is encrypted with encryption key*



---

# Seal and Unseal

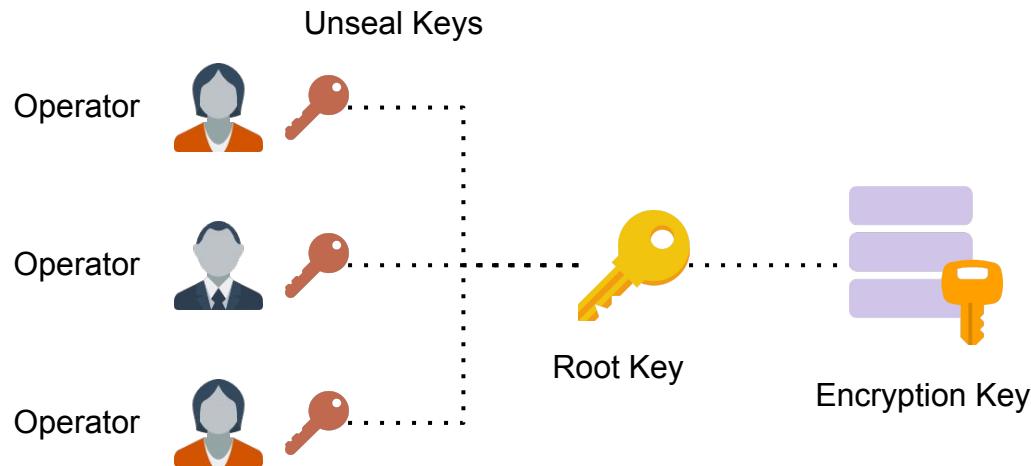
*Only unsealed servers allow access to decrypted data (see [docs](#))*

- Vault data is encrypted using the encryption key in the keyring; the keyring is encrypted by the root key; and the root key is encrypted by the unseal key.
- A server starts in *sealed* mode. It knows where and how to access the physical storage, but doesn't know how to decrypt any of it. Almost no operations are possible with Vault.
- *Unsealing* is the process of obtaining the plaintext root key necessary to read the decryption key to decrypt the data.



# Shamir Seal

Algorithm that distributes unseal keys used to reconstruct root key



---

# Configuring Vault Server

*Meant for production environments*

- Runtime parameters can be set with the help of a HCL or JSON file.
- Supports runtime aspects like storage backend, telemetry, and high availability.
- Every initialized Vault server starts in the sealed state. You need to unseal it before data can be accessed.



# Server Configuration File

*File name can be chosen freely (see [docs](#))*

```
storage "raft" {  
    path      = "./vault/data"  
    node_id   = "node1"  
}  
  
listener "tcp" {  
    address    = "127.0.0.1:8200"  
    tls_disable = "true"  
}  
  
api_addr = "http://127.0.0.1:8200"  
cluster_addr = "https://127.0.0.1:8201"  
ui = true
```

Storage backend configuration

How Vault server listens for incoming requests from clients

General configuration  
e.g. if the UI is enabled



# Starting the Vault Server

*Use server command and point to HCL config file*

```
$ mkdir -p ./vault/data  
$ vault server -config=config.hcl  
...  
==> Vault server configuration:  
...  
==> Vault server started! Log data will stream in  
below:  
...
```

Storage directory  
needs to exist before  
starting the Vault  
server

Section that renders  
server configuration

Section that  
renders log stream



# Initializing the Vault

*Generates encryption keys, unseal keys, and the initial root token*

```
$ vault operator init  
Unseal Key 1:  
XNLxjqdc/rB03GzZBjVIHS5JiYv6IbGLU9qR0RmLLbSa  
Unseal Key 2:  
BminmjWWV73O+qLvNwKVkPRC7WTBq2dVO8YTjdWNgzh0  
Unseal Key 3:  
aNBF0p91DZCsCjJPb+Usw0kbJZGWTwvuGH/wcGdG032  
Unseal Key 4:  
SwGrPcLyVHXiB7rGcxUOaHqhhnX8QKyBZRxVZ8NCM6mn  
Unseal Key 5:  
IKrOA7DT/j5AR4CHoDFILJUm7zeTPMT0CKoMzClFFji
```

Initial Root Token: hvs.ZdvMiI70dPVw4UDqe4haES6V

Store unseal keys and root token in safe location. They cannot be retrieved anymore.



# Unsealing the Vault

*Repeat process until “unseal threshold” has been reached*

```
$ vault operator unseal
Unseal Key (will be hidden): <enter unseal key>
Key          Value
---          -----
Seal Type    shamir
Initialized   true
Sealed       true
Total Shares 5
Threshold    3
Unseal Progress 1/3
UnsealNonce  93c5d490-4dde-9cel-be62-2af1fe778a9d
Version      1.12.1
Build Date   2022-10-27T12:32:05Z
Storage Type  raft
HA Enabled   true
```

Enter one of the  
unseal keys here

The amount of times you have  
to repeat the process for



---

# EXERCISE

Initializing and  
Unsealing a Vault  
Server



# Storage Backend

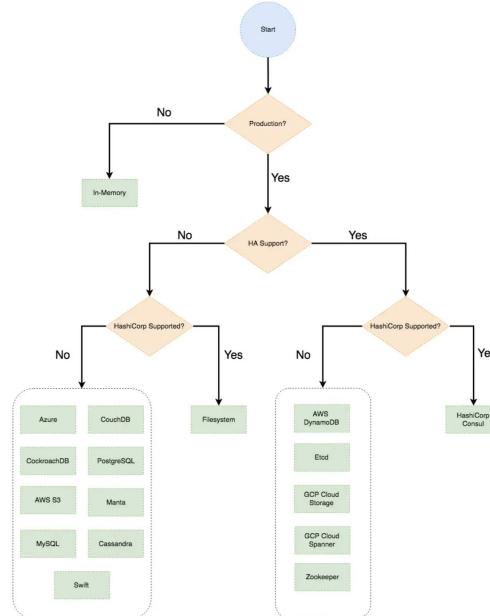
*Persists encrypted data in external or integrated location (see [docs](#))*

- Supports *external* solutions like Azure, Consul, and S3, each of which have their own pros, cons, advantages, and trade-offs.
- *Integrated* storage, e.g. Raft, to support HA concerns by replicating the data across multiple nodes.
- HashiCorp recommends using an integrated storage over external storage for easy of management and support for non-functional requirements.



# Deciding on a Storage Backend

*Factors like High Availability, support, and production-readiness*



<https://www.ahead.com/resources/hashicorp-vault-storage-backend-decision-tree>



# Configuring a Storage Backend

Use the *storage stanza* (see [docs](#))

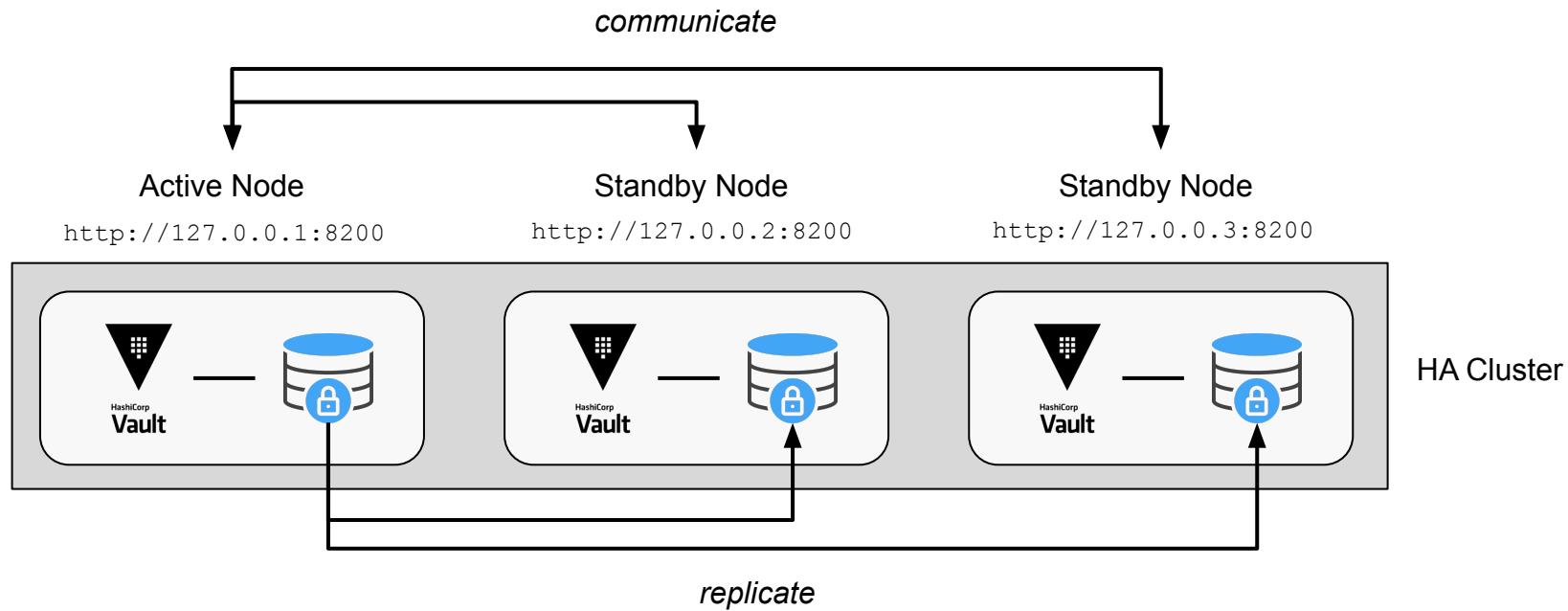
```
storage "raft" {
    path      = "./vault/raft"
    node_id  = "node_2"

    retry_join {
        leader_api_addr = "http://127.0.0.2:8200"
    }
}
```



# High Availability Cluster Architecture

*Involves node machines, networking, and storage*



# High Availability Cluster Aspects

*Protects against outages by running multiple Vault servers*

- The active node puts a lock on the storage, all other nodes become standby nodes.
- Standby nodes forward or redirect requests to the active node if they receive requests.
- HA in Vault is not about scalability. The bottleneck is access to storage.



---

# Enterprise Data Replication

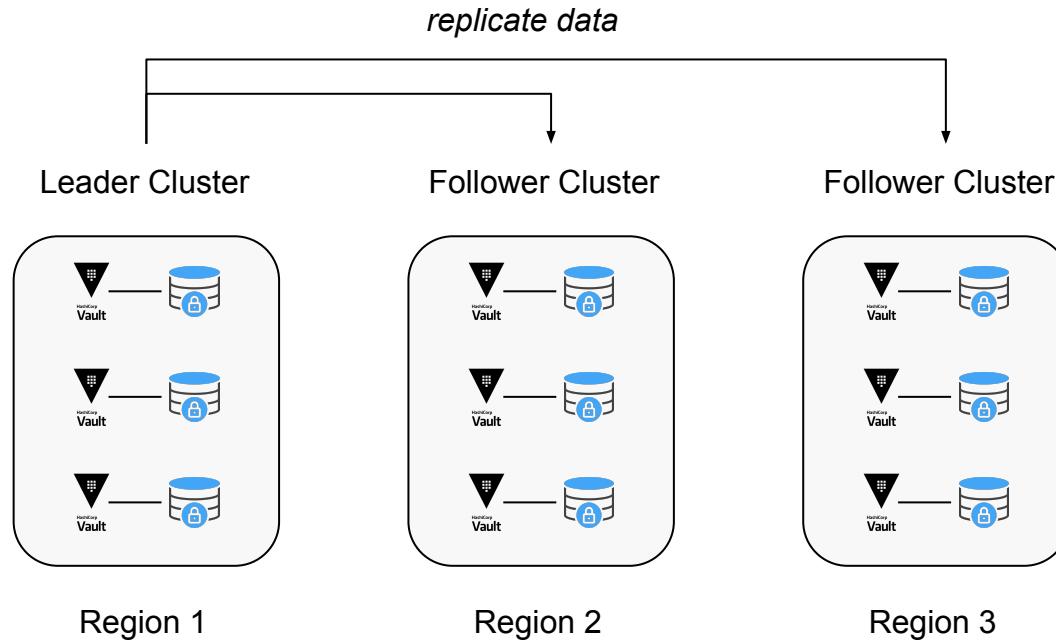
*Works across Vault clusters in different regions or data centers (see [docs](#))*

- Feature is only supported by Vault Enterprise, the commercial product of Vault.
- Operates on a leader/follower model, and works asynchronously.
- Requires a storage backend that supports transactional updates, such as Integrated Storage or Raft or Consul.



# Multi-Cluster HA Architecture

*Supports aspects like disaster recovery and performance*



# What is the Identity Engine?

*Maintains the clients who are recognized by Vault (see [docs](#))*

- Mounted by default. Cannot be disabled or moved.
- Policies can be set on the entities which adds capabilities to the tokens that are tied to entity identifiers.
- Introduces and manages identity objects like *Entity*, *Alias*, and *Group*.



# Identity Terms

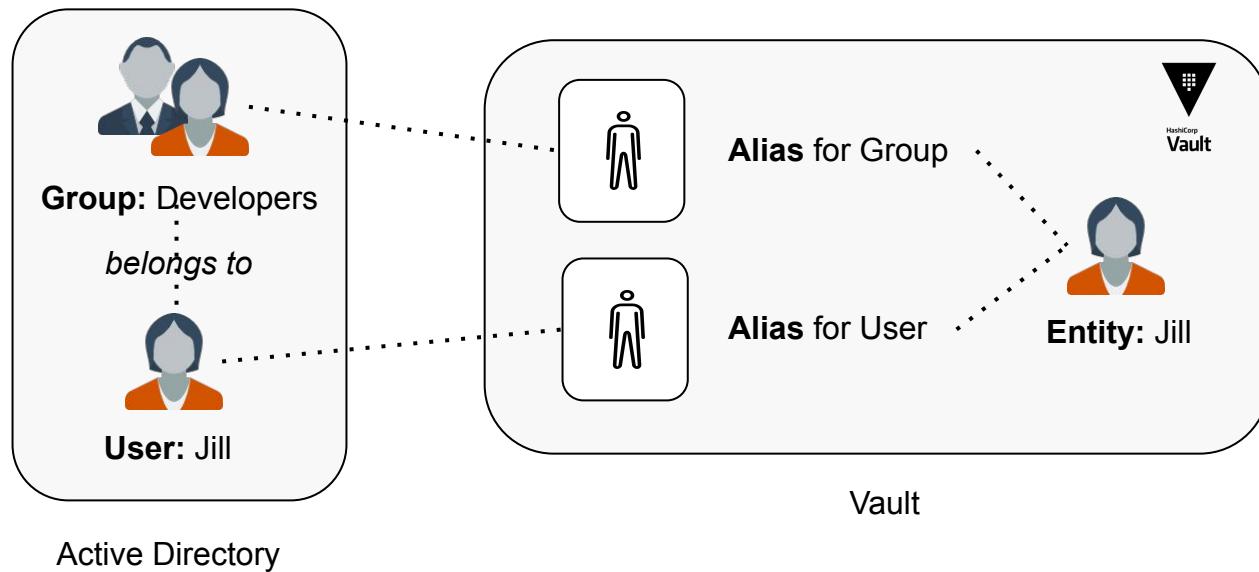
*Terms used by identity engine*

- **Entity:** Represents a client, e.g. the `vault` CLI tool, a HTTPS call made via the `curl` command, or a human user, associated with a token.
- **Alias:** Represents an authentication method and is linked to an entity.
- **Group:** Managed internal or externally. Internal groups can contain entities and other groups.



# Example: Mapping Entity and Alias

*Users and Groups in Active Directory*



# What is the Vault Agent?

*Simplifies integration of an application with Vault (see [docs](#))*

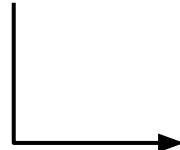
- The agent needs to be started as a process and usually runs in the background. The application interacts with the agent instead of the Vault server directly.
- The agent provides the following features:
  - Auto-authentication and token renewal.
  - Secrets caching and renewal.
  - Template for writing a secret to a file for consumption by the application.



# Running the Vault Agent

*Configuration lives in HCL file (see [docs](#))*

```
$ vault agent -config=/etc/vault/agent-config.hcl
```



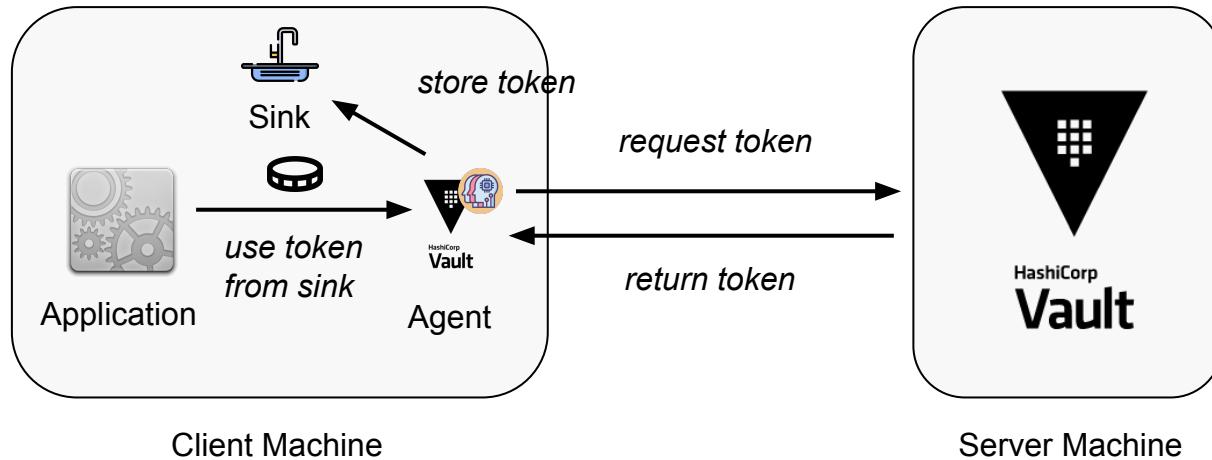
```
vault {
    address = "https://vault-fqdn:8200"
    retry {
        num_retries = 5
    }
}

...
```



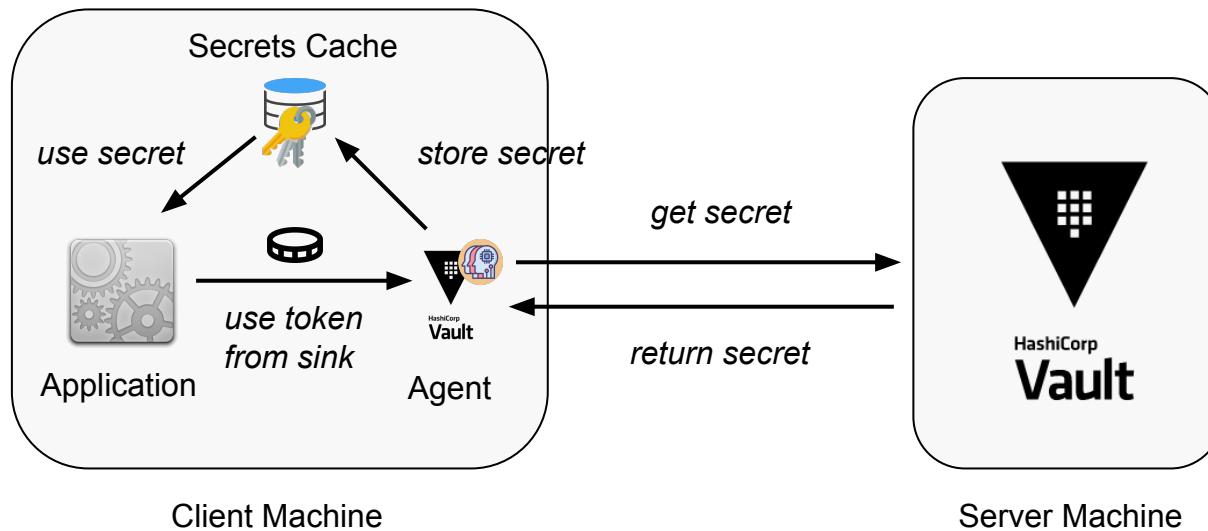
# Auto-Authentication Workflow

*Abstracts authentication procedure and provides token to application*



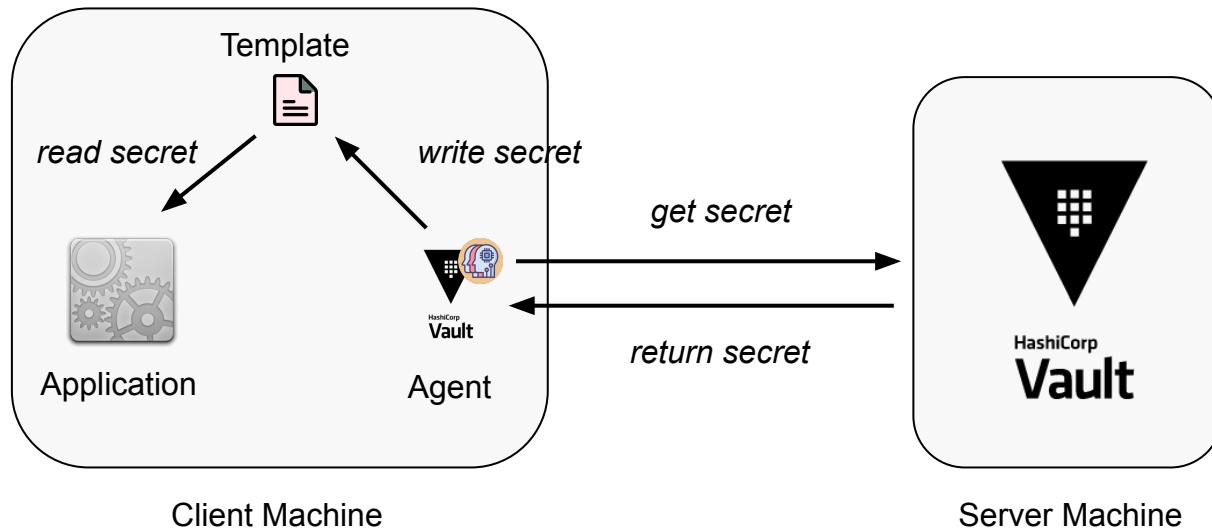
# Secrets Caching Workflow

*Stores secrets locally and reuses them for subsequent calls*



# Template Workflow

*Application reads plain-text secret from file, doesn't interact with agent*



---

# What is the Response Wrapping?

*Using a single-use token to access secret (see [docs](#))*

- Under certain conditions, it's easier to provide a client with a token instead of the secret directly. This is especially true if the process would involve multiple clients/machines, or if intermediary machines are need to transfer the secret.
- Instead you can provide the dedicated, single-use token to clients. Clients would then be able to retrieve the secret themselves. The token cannot be renewed and will be invalidated after use.



# Response Wrapping Commands

*To wrap use `-wrap-ttl` option, to unwrap use `unwrap cmd`*

```
$ vault kv get -wrap-ttl=1m secret/dev
Key           Value
---          -----
wrapping_token:  hvs.CAESIGu9UlC0Uhmqa...
```

```
...
...
```

```
$ vault unwrap hvs.CAESIGu9UlC0Uhmqa...
Key           Value
---          -----
data          map[password:my-long-password
username:webapp]
...
...
```

Creates wrapping token with a TTL

Unwraps secret with wrapping token



---

# EXERCISE

Wrapping and  
Unwrapping a  
Secret



---

# Q & A



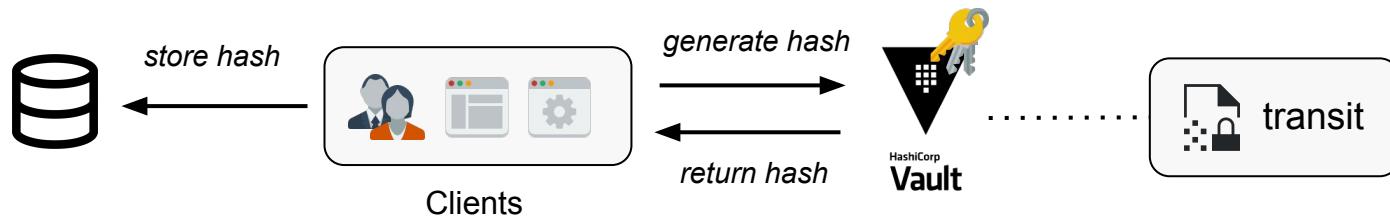
# Explain Encryption as a Service

Overview, Transit Engine, Encryption, Decryption,  
Encryption Key Rotation

# What is the Transit Engine?

*Provides encryption as a service (see [docs](#))*

- Consumer submits unencrypted data, engine return encrypted data.
- Engine doesn't store the data.
- Manages cryptographic keys.



# Encryption Keys

Select a key type by use case (see [docs](#))

- AES, ChaCha20, Ed25519, ECDSA, RSA, HMAC with different versions.
- Key type determines supported actions, e.g. AES supports encryption/decryption, ECDSA supports signing and signature verification.
- Periodic rotation of the encryption keys is recommended.



# Versioning of Keys

*Not all versions are kept in memory for performance reasons*

- The transit engine support versioning of keys. If you rotate a key, it will be added to the *working set* available in memory.
- Versions earlier than `min_decryption_version` or `min_encryption_version` get archived in the *archive set* residing in the Vault storage backend.
- Keys can be deleted permanently by trimming them. The config operation takes care of configuring them.



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# Enabling the Transit Engine from CLI

*Enable by type transit*

```
$ vault secrets enable transit  
Success! Enabled the transit secrets engine at: transit/
```



# Creating Encryption Key from CLI

*Interact with key using operations like list, read, write*

```
$ vault write -f transit/keys/my-key
```

```
Success! Data written to: transit/keys/my-key
```

```
$ vault write -f transit/keys/my-key type=ecdsa-p256
```

```
Success! Data written to: transit/keys/my-key
```

```
$ vault read transit/keys/my-key
```

Key	Value
---	-----

...

latest_version	1
----------------	---

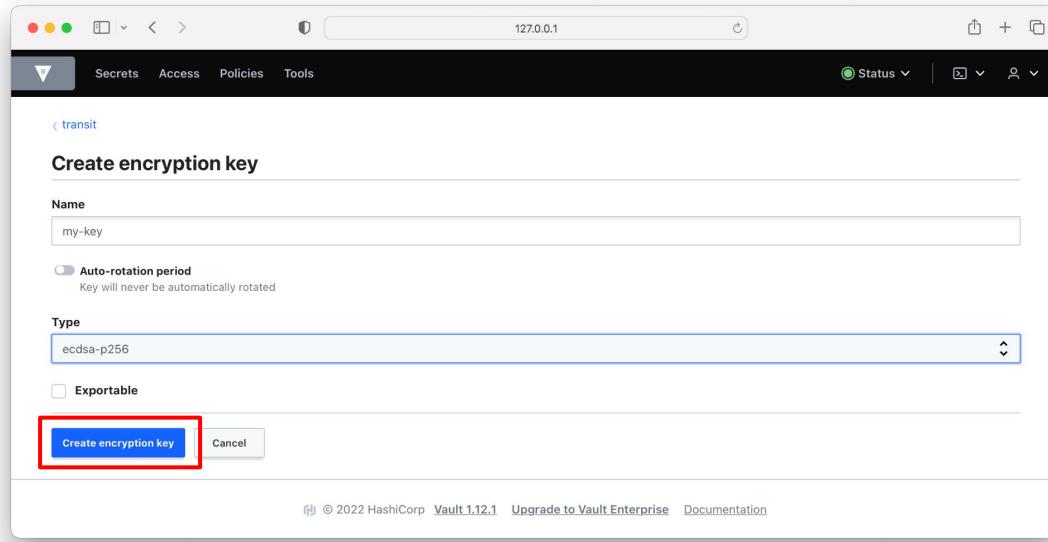
Default is  
aes256-gcm96

Provides path with  
type parameter



# Creating Encryption Key from UI

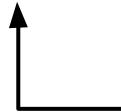
*Secrets > Select transit engine > Create encryption key*



# Rotating Encryption Key from CLI

*Determine time when key should be rotated based on formula*

```
$ vault write -f transit/keys/my-key/rotate  
Success! Data written to: transit/keys/my-key/rotate  
  
$ vault read transit/keys/my-key  
Key          Value  
---          -----  
...  
latest_version    2
```

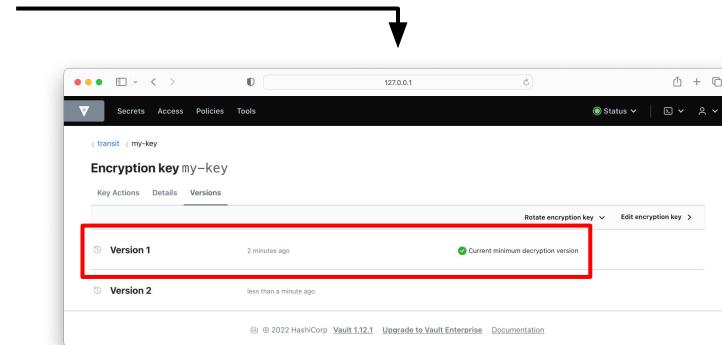
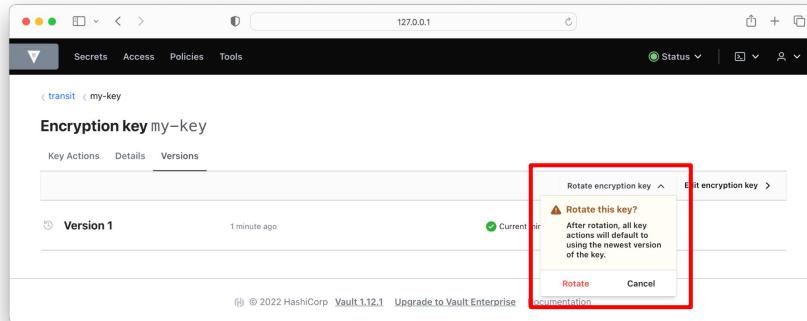


Key version is  
bumped up



# Rotating Encryption Key from UI

*Secrets > Select transit engine > Select key > Versions > Rotate*



# Configuring Encryption Key from CLI

*Configures properties of encryption key*

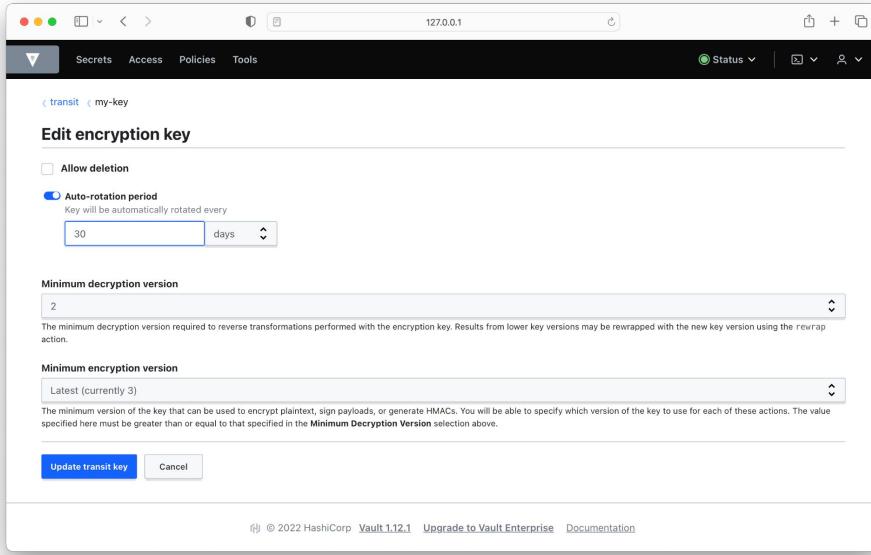
```
$ vault write transit/keys/my-key/config min_decryption_version=2
Success! Data written to: transit/keys/my-key/config
```

```
$ vault read transit/keys/my-key
Key          Value
---          -----
...
min_decryption_version    2
```



# Configuring Encryption Key from UI

*Secrets > Select transit engine > Select key > Versions > Edit*

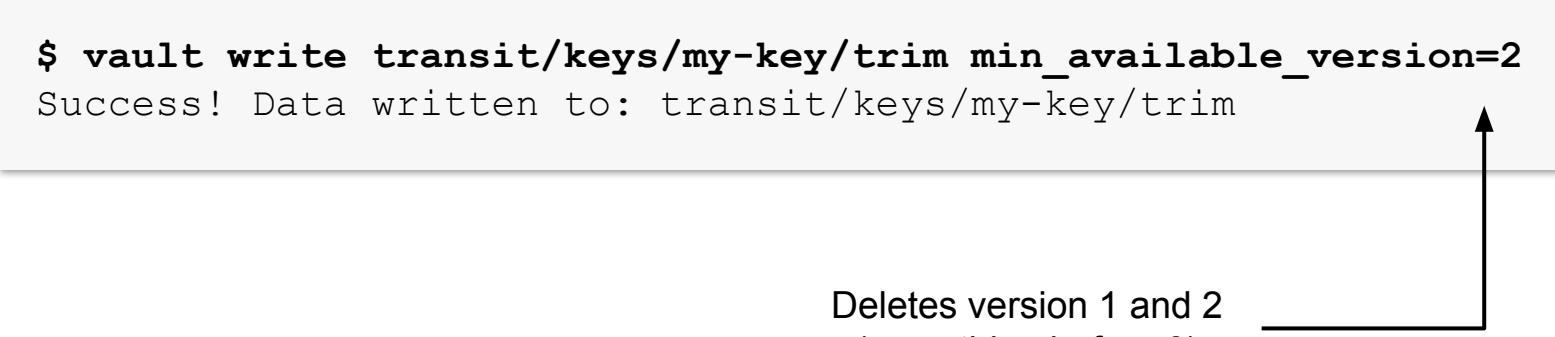


# Trimming Encryption Key from CLI

*Deleted key versions cannot be revived*

```
$ vault write transit/keys/my-key/trim min_available_version=2  
Success! Data written to: transit/keys/my-key/trim
```

Deletes version 1 and 2  
(everything before 3)



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# Encrypting & Decrypting Data

*Operations only available to key type that supports them*

- **Encryption:** Submitted value has to be base64-encoded. You will receive encrypted value and metadata in response.
- **Decryption:** Returned value is base64-encoded and needs to be decoded. Version of the key is included as metadata. You will need to use exact key version to decrypt value.



# Encrypting Data from CLI

*Base64-encode value and pass it in with encryption call*

```
$ echo "mypassword" | base64  
bXlwYXNzd29yZAo=  
  
$ vault write transit/encrypt/my-key plaintext=bXlwYXNzd29yZAo=  
Key          Value  
---          -----  
ciphertext   vault:v3:6QeNuLGvLWnsND...  
key_version  3
```



# Decrypting Data from CLI

*Use ciphertext to decrypted, Base64-decode for plain-text value*

```
$ vault write transit/decrypt/my-key ciphertext=6QeNuLGvLWnsND...
Key          Value
---          -----
plaintext    bXlwYXNzd29yZAo=
$ echo "bXlwYXNzd29yZAo=" | base64 -d
mypassword
```



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# EXERCISE

Using the Transit  
Engine for  
Cryptographic  
Operations



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# Q & A



# Summary & Wrap Up

Last words of advice...



Thank you

