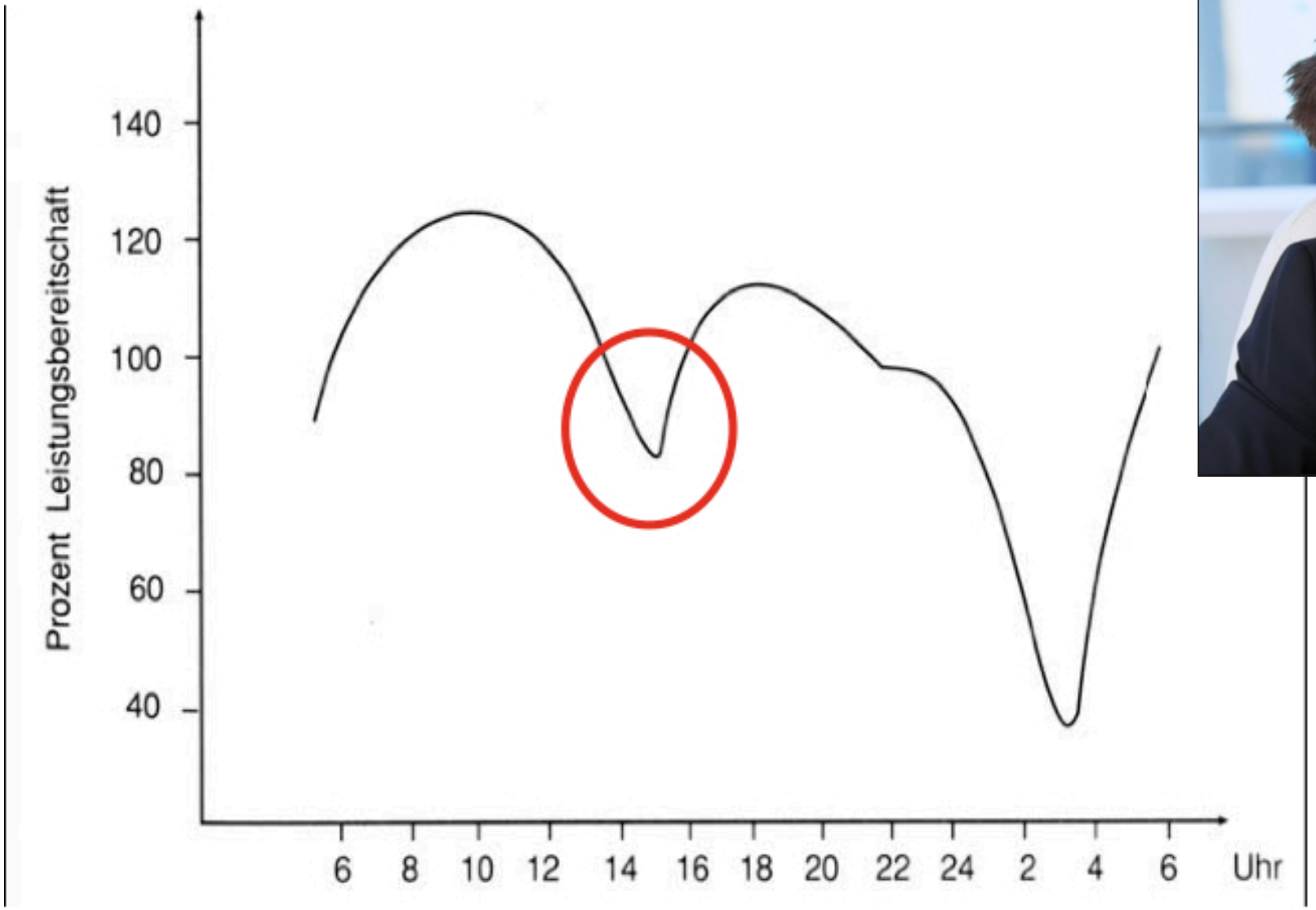
Secret Management with Hashicorp's Vault

Daniel Bornkessel

INNOQ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SPACE STATION
DEVFEST
NANTES 2018
TOUR BRETAGNE
14H00 19 OCTOBER
MANAGEMENT WITH HASHICORP'S VAULT
FUN
I LEARNED A LOT
GREAT SPEAKER
TOO TECHNICAL
VERY INTERESTING
TOO THEORETICAL
NEED MORE DEMO
NOT ENOUGH DEMO
TOO COMPLEX

Secret Management with Hashicorp's Vault

Daniel Bornkessel

INNOQ

Focus of this talk

- what is secret management
- why do you need it
- what is Vault and how can it help you with secret management
- some Vault internals

Goal of this talk

- think about best practices with secrets that your company could improve on
- go and play with Vault

Why focus on Vault

- unmatched (afaik) feature set
- not vendor or framework specific
- open source (mostly ... some closed sourced enterprise features)

Other solutions*

- KeyWiz from Square: not as many features, no dynamic secrets, HSM in open source version
- Cloud Foundry CredHub: tailored and specific to Cloud Foundry
- AWS Secrets Manager: AWS specific, promising, dynamic'esque secrets for certain AWS services, automatic rotation (for supported services + extendable via Lambda functions)
- self made: a lot of complexity and work

* I have not personally used those solutions

Secret Managemant

Secrets

- sensitive data != secrets ... but: secrets == sensitive data
- tokens
- passwords
- certificates
- API keys
- etc.

Secret Management

- part of your security concept
- one focus: on internal threads like
  - rogue employees
  - unauthorized access to secrets
  - long living secrets
- audit log: who requested credentials for which system at what point of time
- high automation for changing / revoking / rolling secrets
- high entropy passwords

todo: extreme example

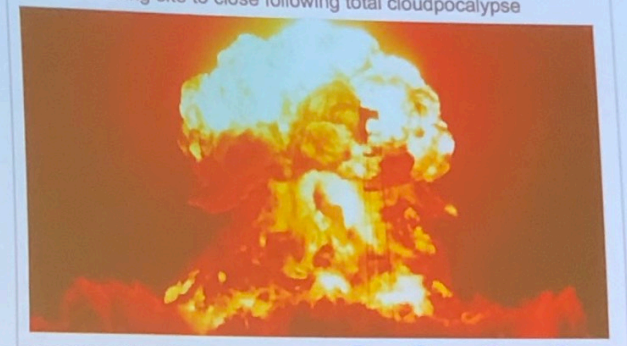
re Development Conference
erlin, October 29 - November 2, 2018
of Workshops // Three Days of Conference

CODESPACES R.I.P.

Data Center ▸ Cloud

Code Spaces goes titsup FOREVER after attacker NUKES its Amazon-hosted data

Source-sharing site to close following total cloudpocalypse



18 Jun 2014 at 20:54, Neil McAllister 547

http://www.theregister.co.uk/2014/06/18/code_spaces_destroyed/

goto; berlin

@gotober

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Secret Management: current situation

- best practices are widely known
- is usually seen as (very) important
- implementation is hard
- solutions are rare
- apps and frameworks not ready for modern secret management
- high automation still an exception (as opposed to external thread mitigation measures)
- often neglected in favour of business critical features

Question

Who here has production credentials on their laptop at this very moment (e.g. AWS credentials file, DB credentials, passwordless ssh private keys to access machines or git repos, API-keys, etc.)?

Who thinks this is a good idea?

Why am I talking about secret management

About me

Daniel Bornkessel / @kesselborn

- Senior Consultant at INNOQ (part time)
- Focus on DevOps & Continuous Delivery

INNOQ

- Consulting, reviews and development
- https://www.innoq.com/de/culture/working-at-innoq/

Typical project

- Monolith -> Micro Services / Self Contained Systems
- Language: set (mostly Java)
- Framework: set (often Spring Boot)
- Data center: set (mostly AWS or on premise)
- Container Management: set (mostly Kubernetes)
- CI: set (whatever they used before ...please for god's sake: use Gitlab CI)
- Logging / Monitoring: set (ELK & prometheus)
- Secret Management: sure ... eh ... wat?

Typical project: Secret Management

- we pass secrets in via env vars
- we read the values from Kubernetes secrets
- we have role based access control all figured out
- changing and updating passwords is a manual process for now
- yeah: audit log is something we are looking into
- no, we can not confidently say who has the password for DB xy
- no, we do not change all passwords if an employee leaves the company
- revoking credentials is not something we currently support

Introducing Vault

Vault — executive summary

Vault — executive summary

"A Tool for Managing Secrets"

Vault — executive summary

- not comparable to password managers like 1Password, LastPass, etc.
  - Vault is designed for the system side of things — password managers "just" encrypt your static secrets and provide a nice way use them

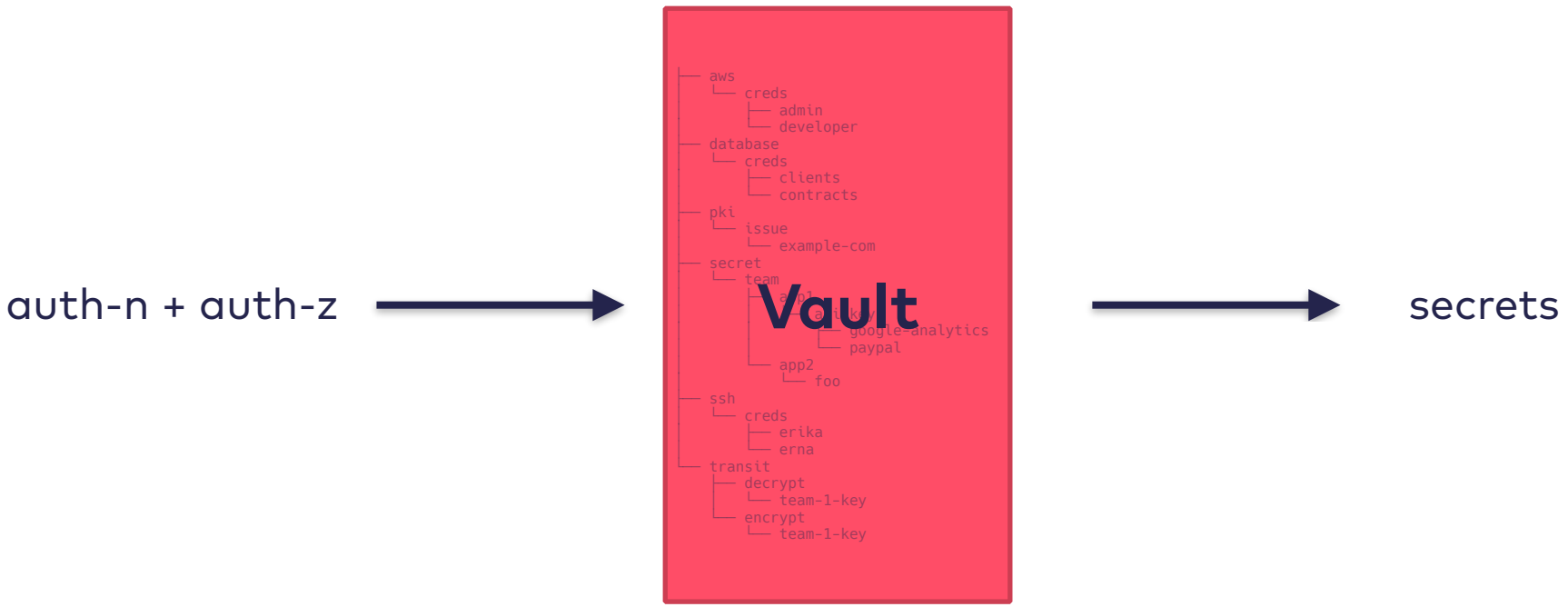
Vault — executive summary

- secures, stores and tightly controls
  - tokens
  - passwords
  - certificates
  - API keys
  - and other secrets

Vault — executive summary

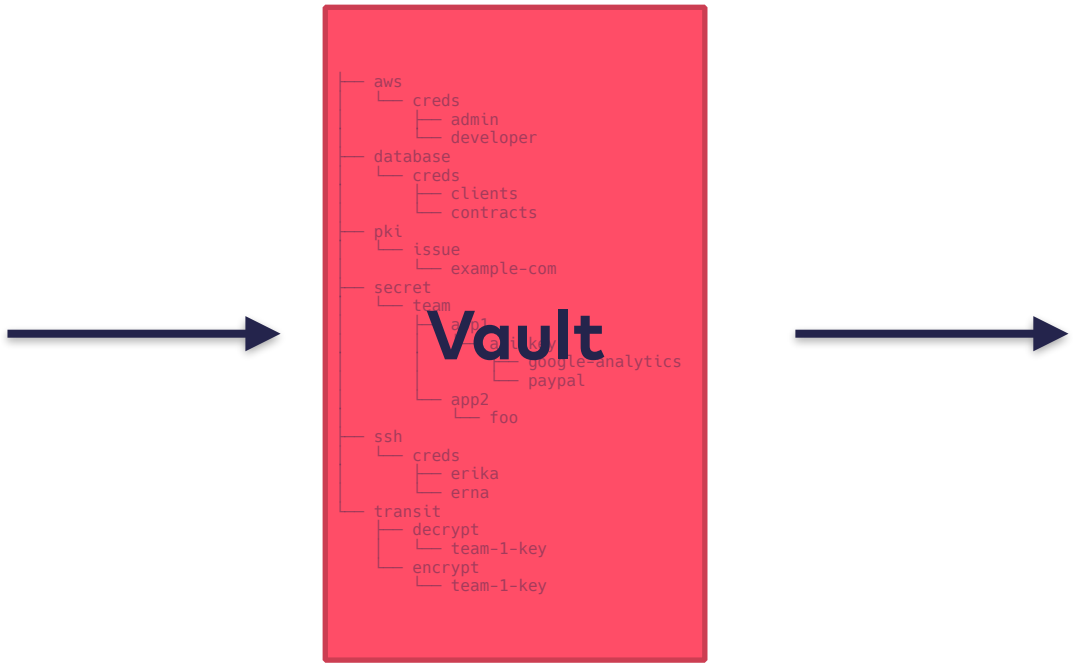
- handles
  - leasing
  - key revocation
  - key rolling
  - auditing
- provides an API for all operations
- is not meant as a service or token provider which gets embedded in your request / response cycle

Vault


auth-n + auth-z
Vault
secrets
aws
creds
admin
developer
database
creds
clients
contracts
pki
issue
example-com
secret
team
google-analytics
paypal
app2
foo
ssh
creds
erika
erna
transit
decrypt
team-1-key
encrypt
team-1-key

Vault auth backends

- **Tokens**
- **LDAP**
- **AWS**
- **Kubernetes**
- **Google Cloud**
- **Username & Password**
- **AppRole**
- **GitHub**
- **MFA**
- **Okta**
- **RADIUS**
- **TLS Certificates**



- AWS
- Consul
- Cubbyhole
- Databases
- Identity
- Static secrets (Key /Value)
- Nomad
- PKI (Certificates)
- RabbitMQ
- SSH
- TOTP
- Transit

Vault secret backends

- Tokens
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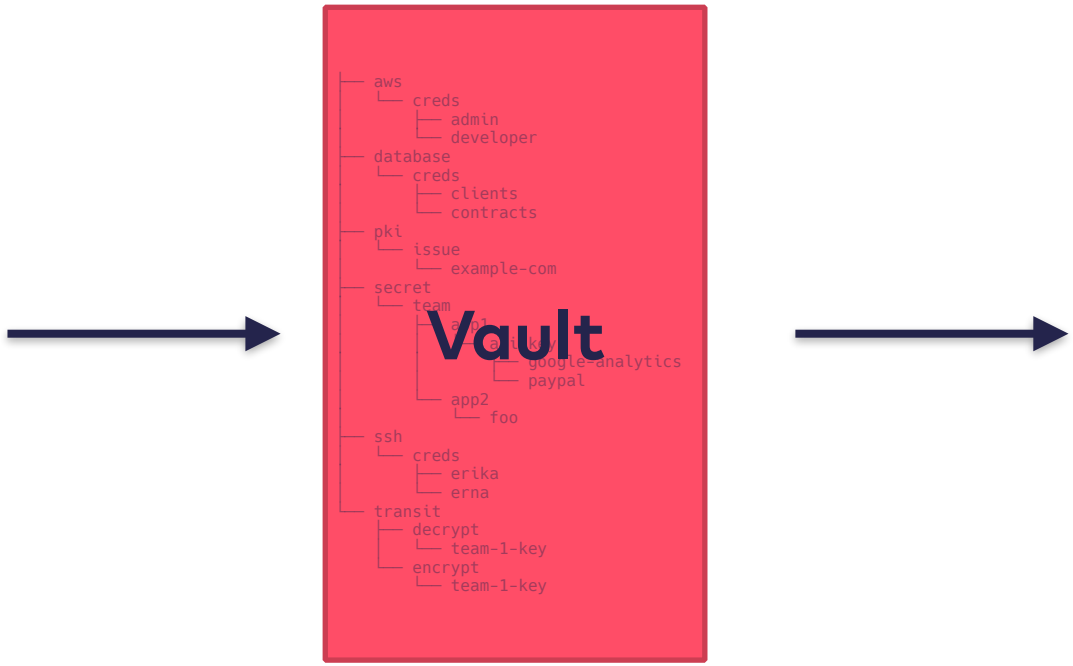

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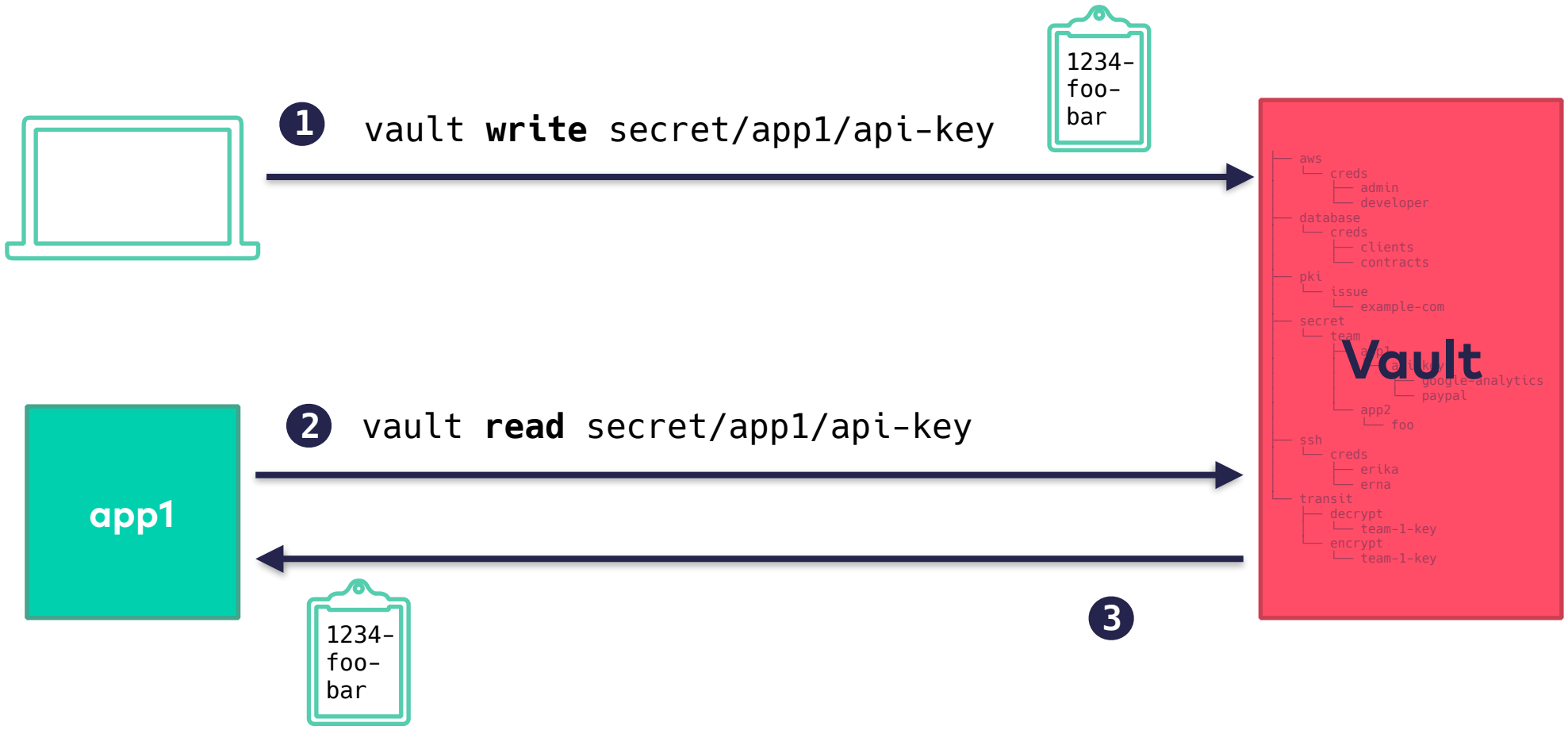
Vault — secret backends

Vault secret backends — static secrets

Vault secret backends — static secrets



Vault secret backends — dynamic secrets

Vault secret backends — dynamic secrets

What they are

- on-the-fly created credentials (hence dynamic) for each instance of an app / user who wants a secret
- usually short to medium long ttl
- fully audited

Vault secret backends — dynamic secrets

How they work (in a Nutshell)

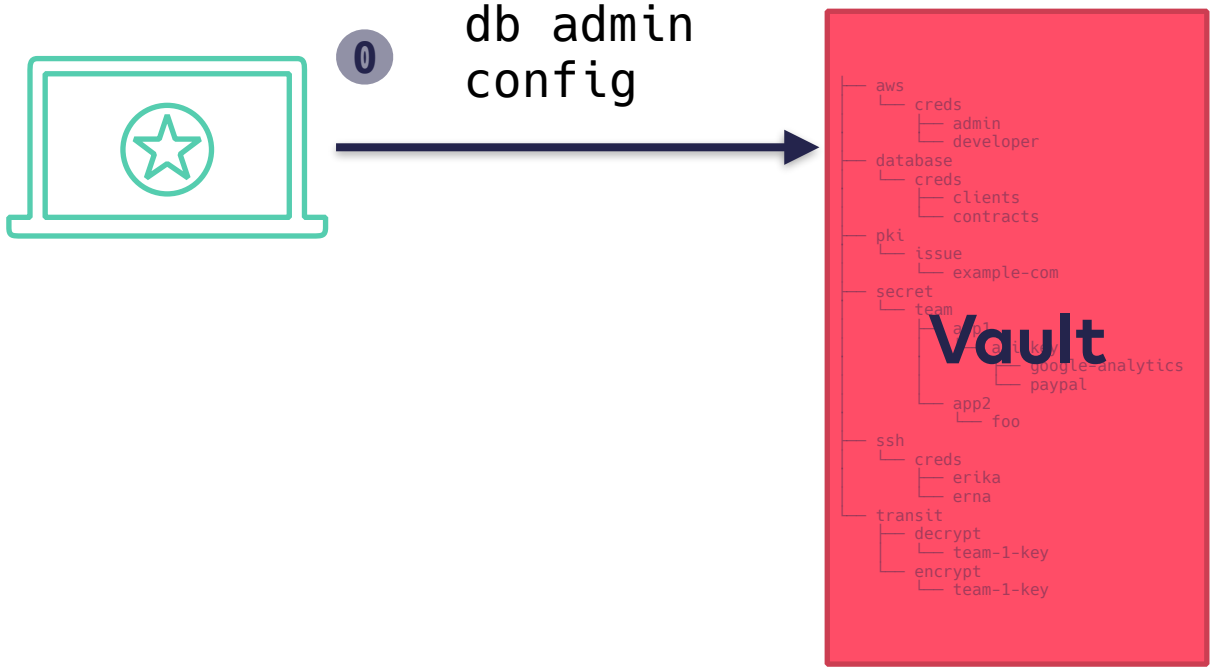
1. provide Vault credentials for a user that has rights to create users or tokens in a remote system (e.g. db)
2. configure Vault with settings on how to create credentials
3. configure Vault with settings on how to invalidate credentials in the remote system

Vault secret backends — Databases

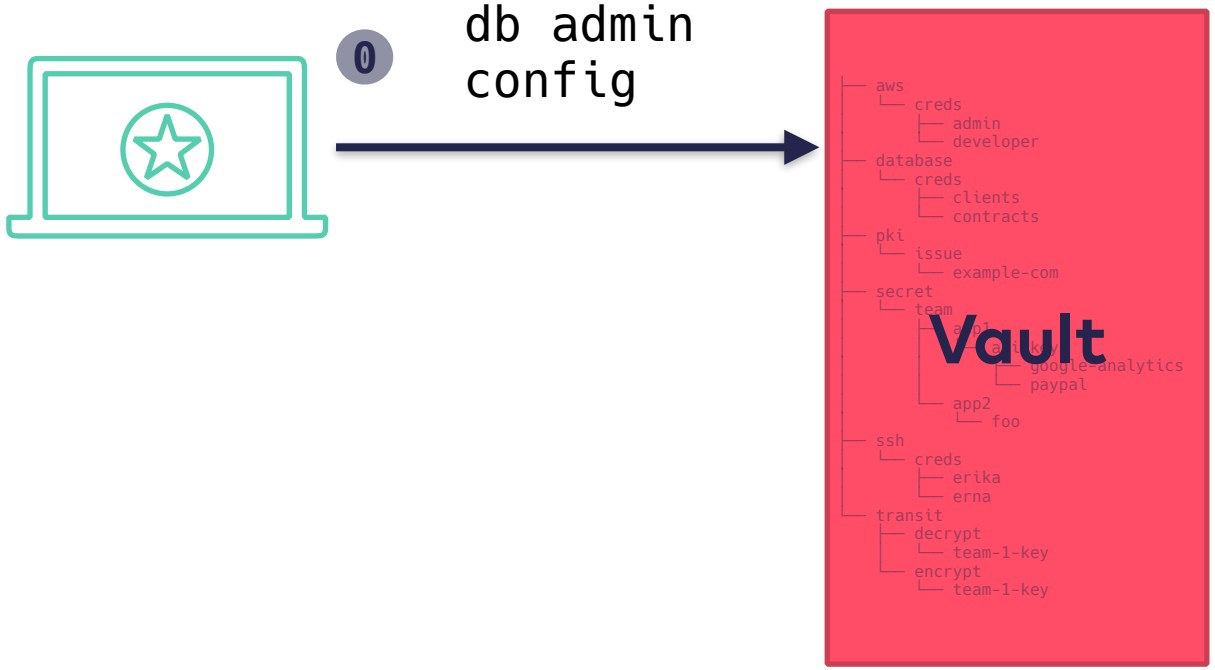
Vault secret backends — Databases

- Idea: get access to databases
- Vault gets configured with credentials for a database user that has necessary permissions on the database
- Vault gets a policy that maps users and roles to users with configured permissions in the database
- when user requests credentials, Vault creates a new database user on the fly
- when configured (usually the case), all created users have a ttl assigned — when the ttl is reached, Vault deletes the user from the database

Vault secret backends — Databases



Vault secret backends — Databases

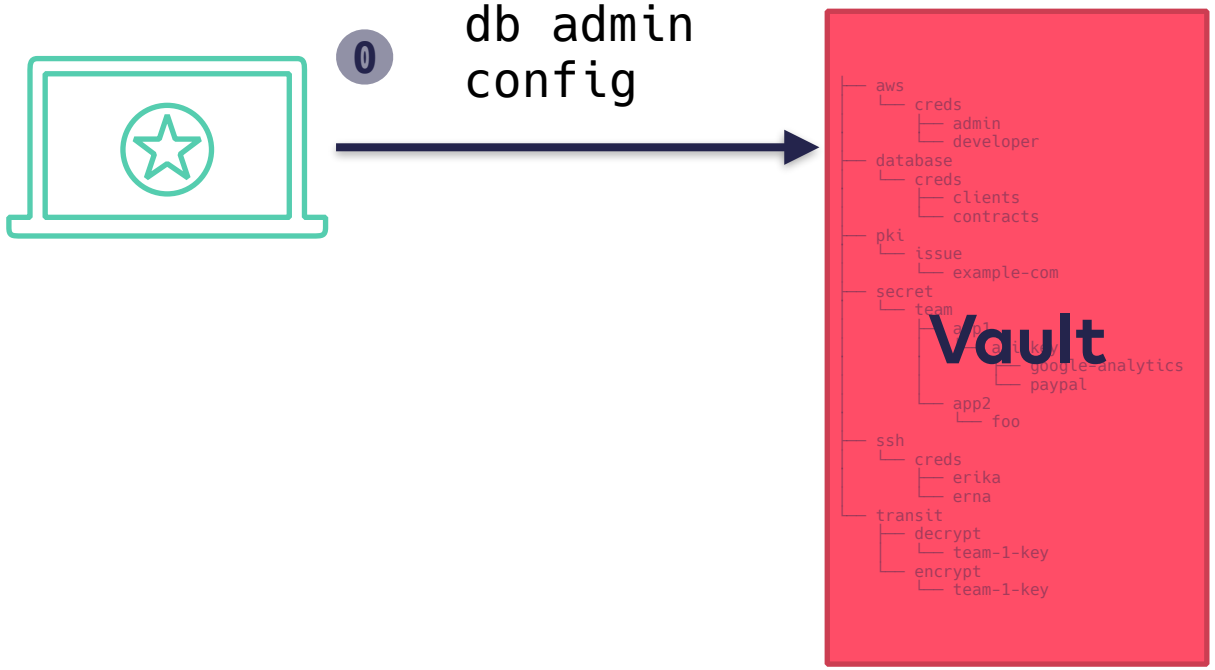



```
vault secrets enable -path=db database

vault write db/config/clients \
  plugin_name=mysql-database-plugin \
  connection_url="admin:pw@tcp(db.example.com)/" \
  allowed_roles="clients-ro,clients-rw"

vault write database/roles/clients-ro \
  db_name=clients \
  creation_statements="\
    CREATE USER '{{name}}'@'%' IDENTIFIED BY \
    '{{password}}'; \
    GRANT SELECT ON clients.* TO '{{name}}'@'%';" \
  default_ttl="1h" \
  max_ttl="240h"
```

Vault secret backends — Databases

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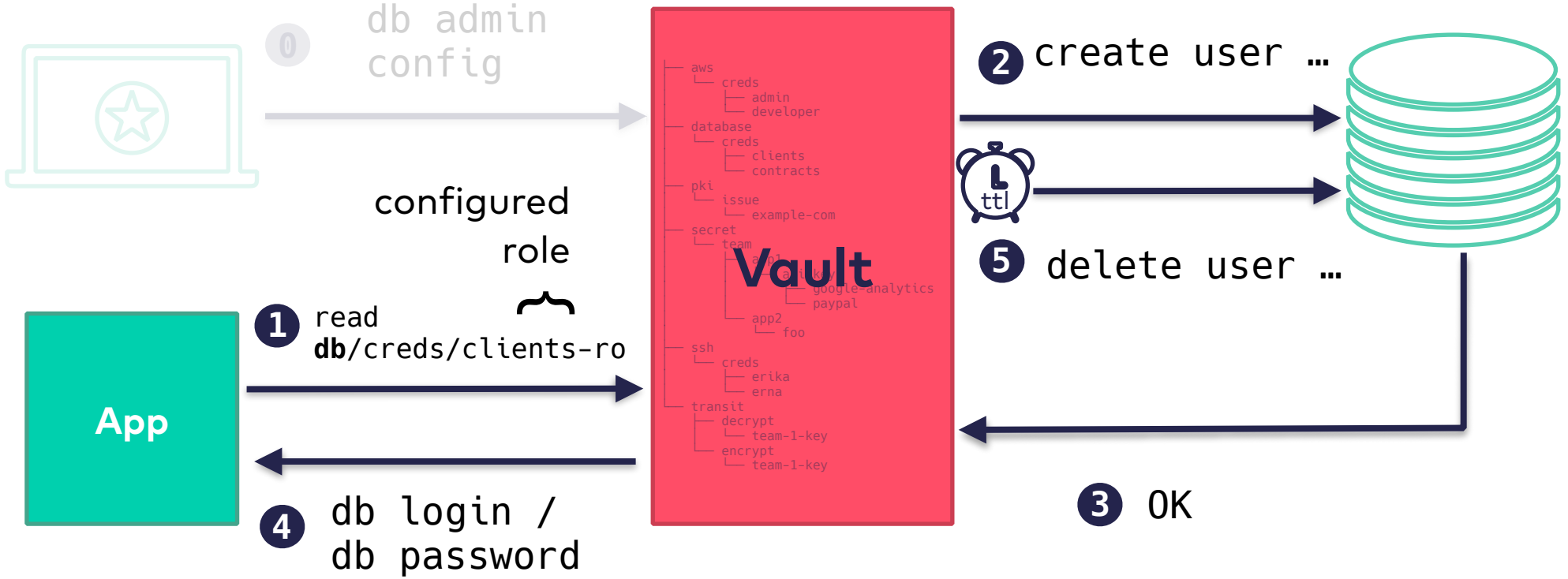
Vault secret backends — Databases



Vault secret backends — Databases

Available Plugins:

- Cassandra
- HanaDB
- MongoDB
- MSSQL
- MySQL/MariaDB
- PostgreSQL
- Oracle

Vault secret backends — Google Cloud

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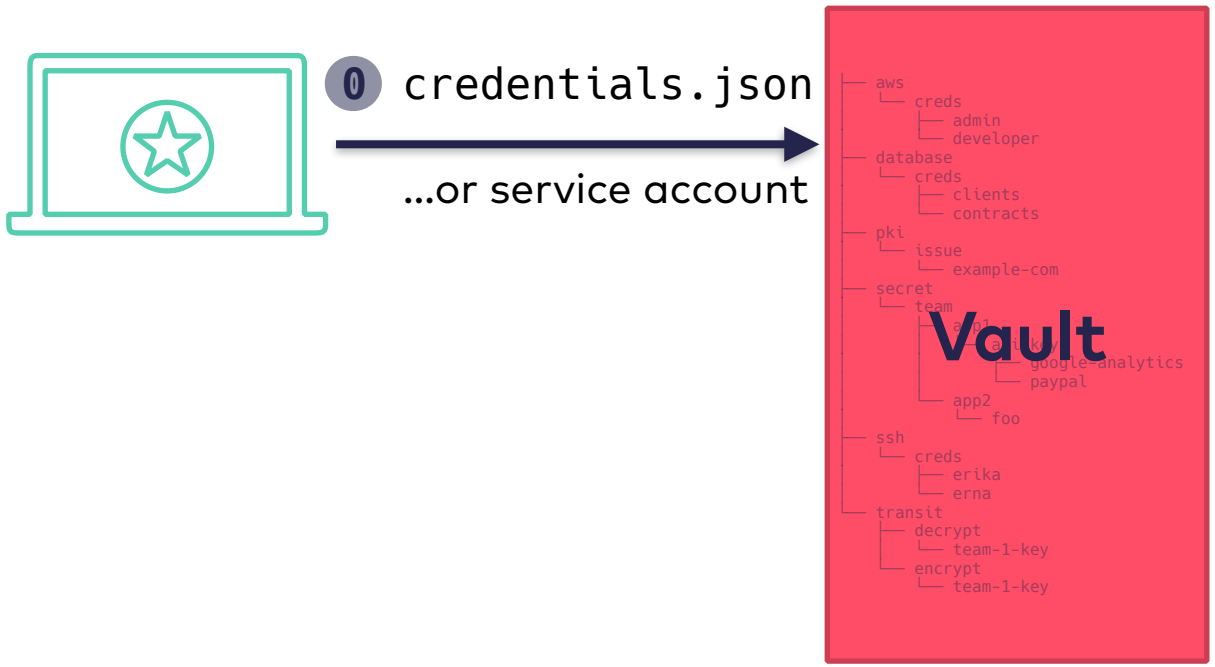
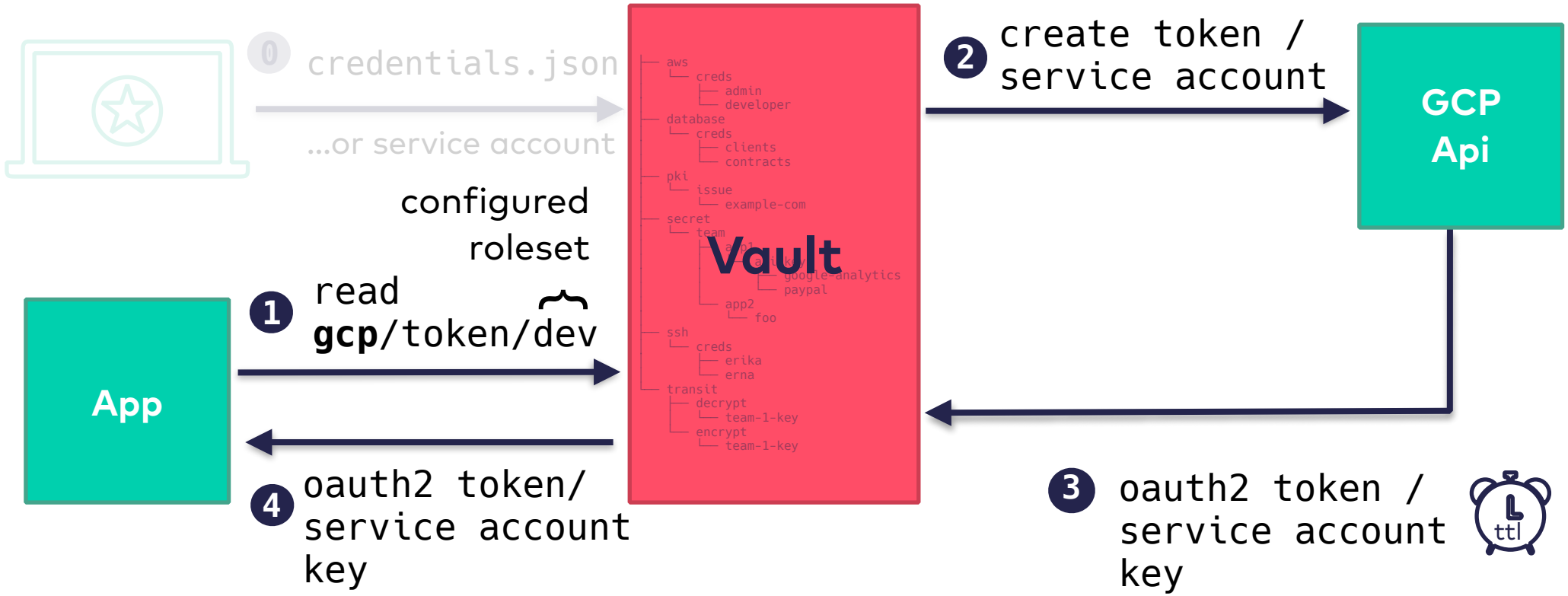


define rolesets to generate oauth2 access tokens (preferred) or Service Accounts

Vault secret backends — Google Cloud

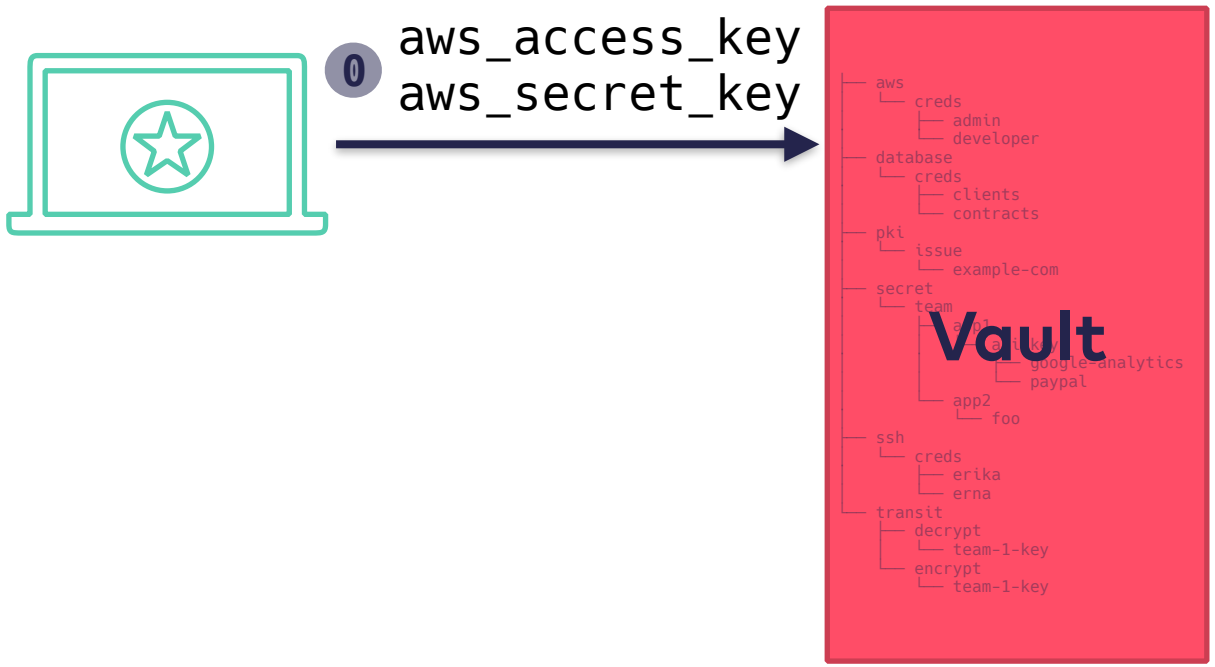


Vault secret backends — AWS

Vault secret backends — AWS

- Idea: get access to AWS resources
- Vault gets configured with an AWS user that has necessary permissions
- Vault gets a policy that maps users or roles to AWS roles
- when user requests credentials, Vault creates STS tokens, assume role tokens or dynamic IAM users
- when configured (usually the case), all created secrets have a ttl assigned

Vault secret backends — AWS



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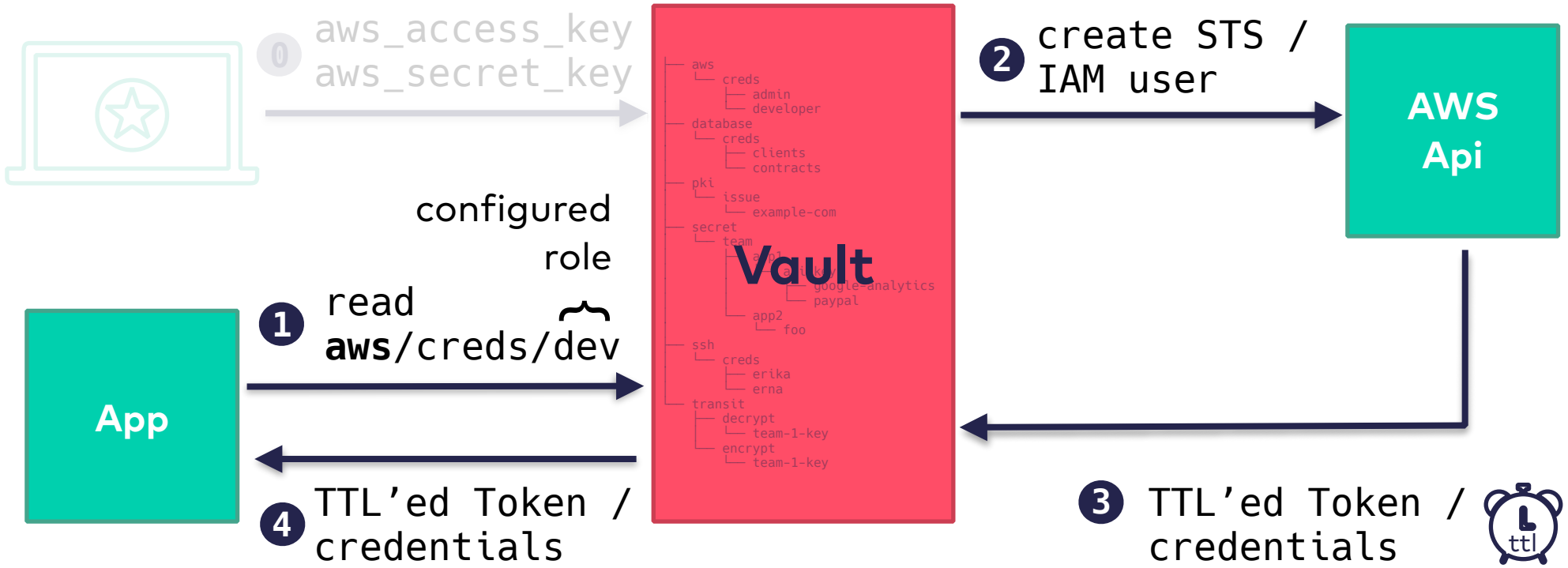
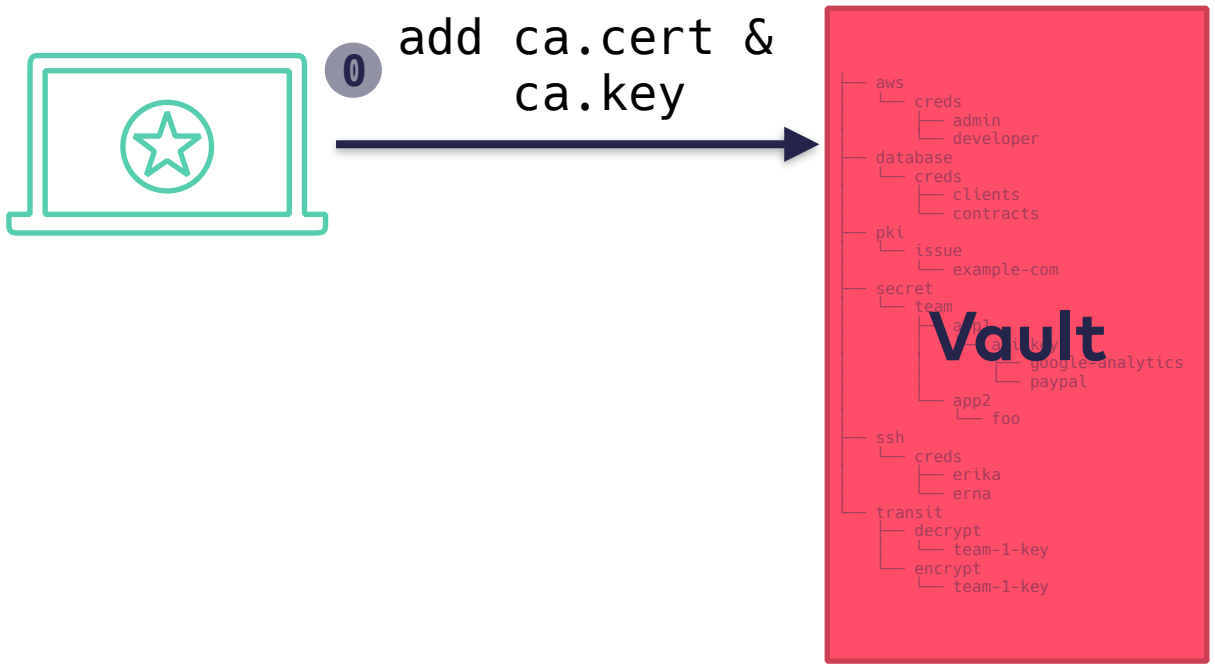


Vault secret backends — PKI

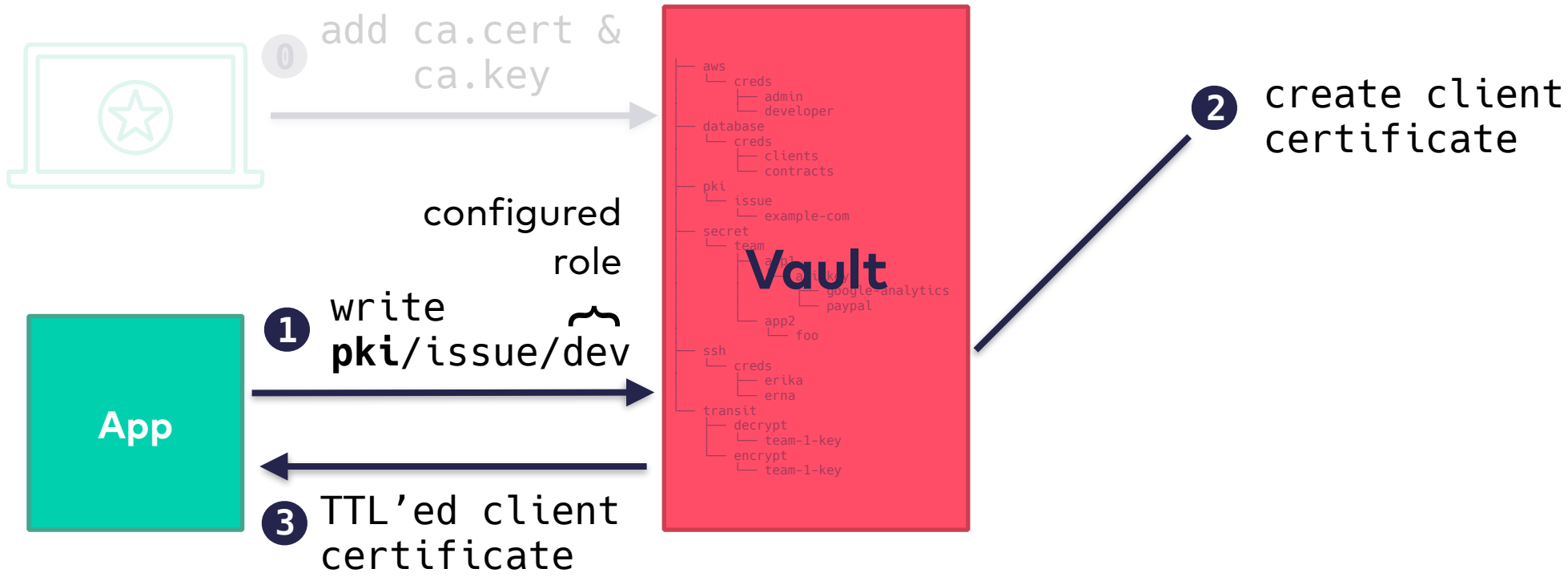
Vault secret backends — PKI

- Idea: issue client certificates on the fly
- Vault gets configured a CA Certificate and a private key
- Vault gets a configuration about how certificates for this CA should be issues (ttl, subject, etc.)
- when user requests credentials, Vault issues a certificate on the fly
- when configured (usually the case), all created certificates have a ttl assigned

Vault secret backends — PKI



Vault secret backends — PKI



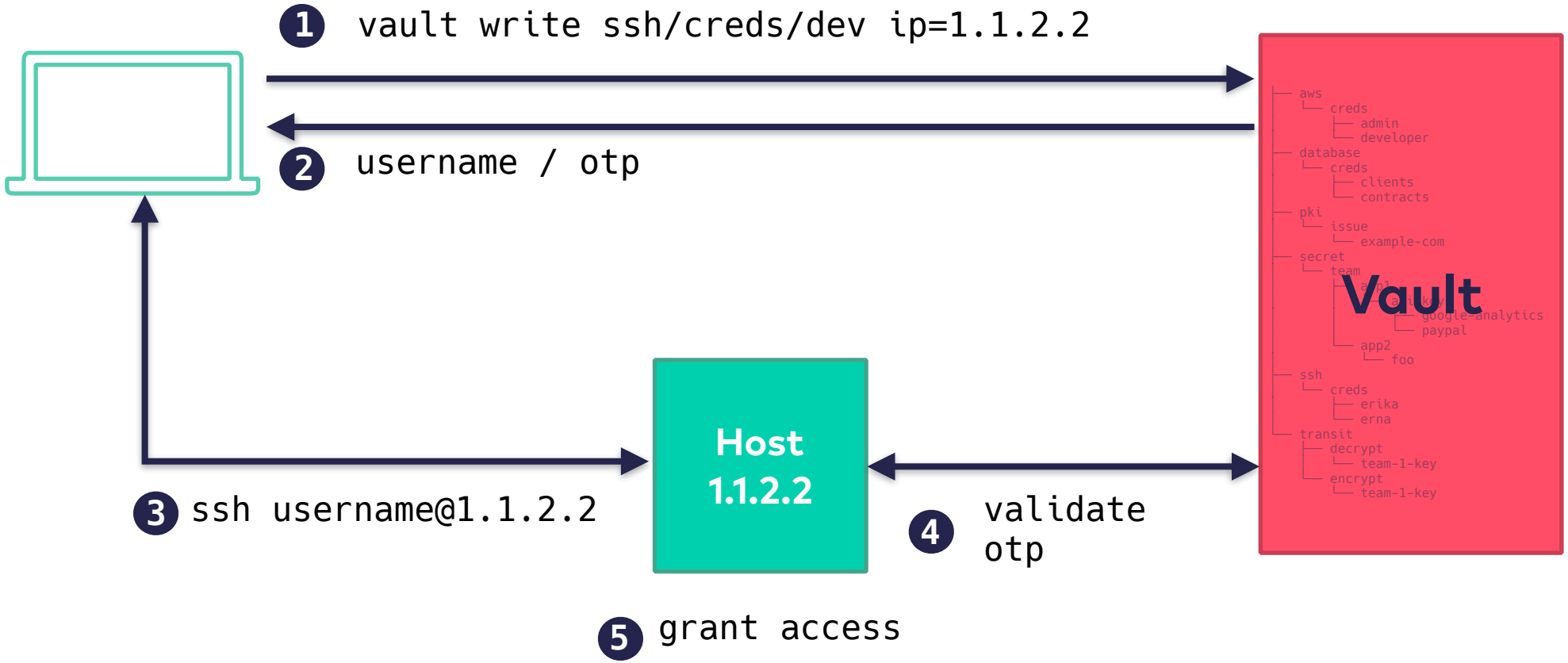
Vault secret backends — SSH

Vault dynamic secret backends — ssh

One-Time SSH Passwords

- Idea: get ssh access to machines
- every host in the system has a small Vault-helper process running
- user fetches a one time password from Vault
- when authenticating via ssh, the Vault-helper checks, whether the one time password is valid and deletes it

Vault secret backends — SSH



Vault dynamic secret backends — ssh

Signed SSH Certificates

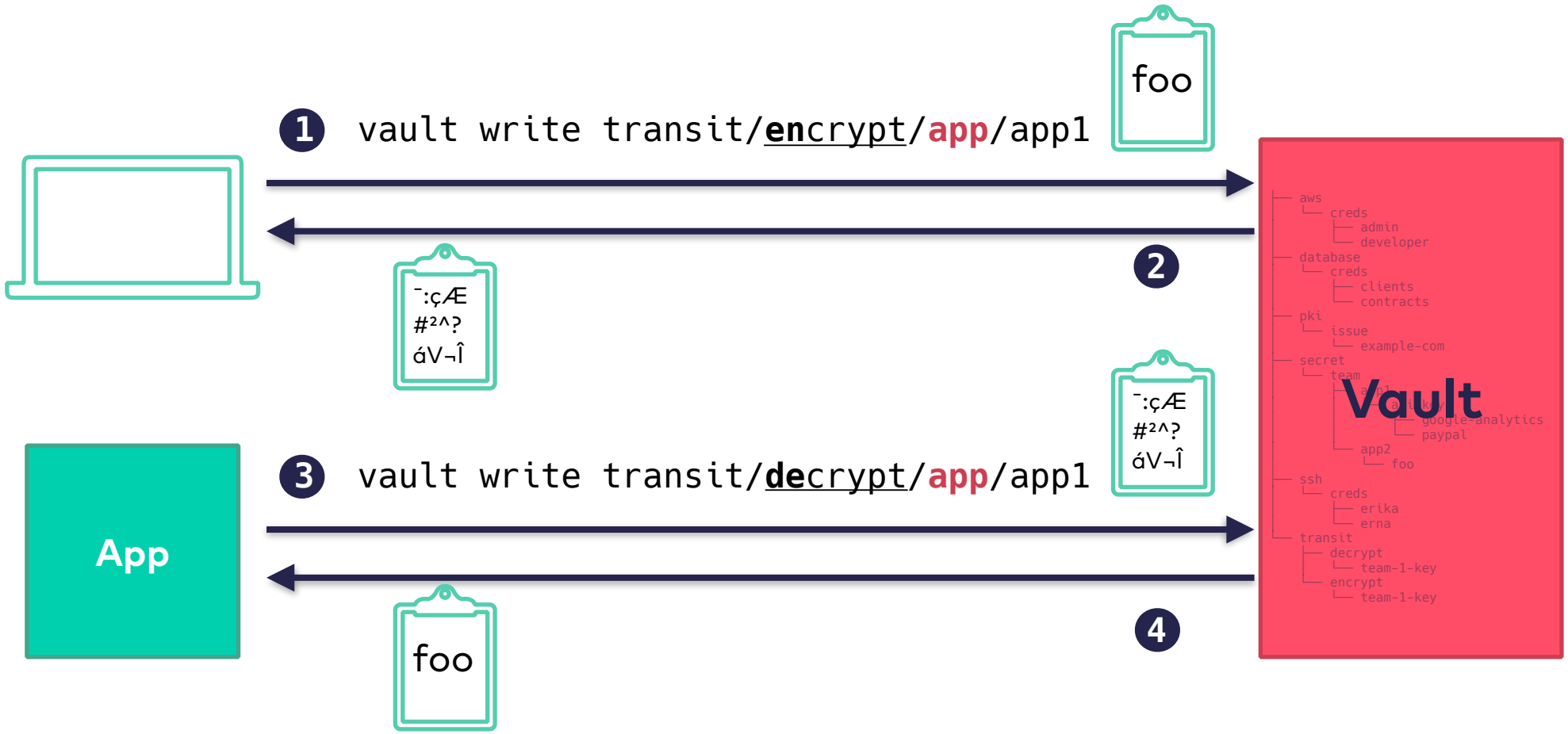
- Idea: get ssh access to machines
- user configures Vault-ssh with a CA, a private and a public key
- the public key gets distributed to all system hosts
- the user asks Vault to sign one of his public ssh keys with the provided CA and gets a new, signed public key as a response
- the user can use this new, signed key to login to machines

Vault dynamic secret backends — Transit

Vault dynamic secret backends — Transit

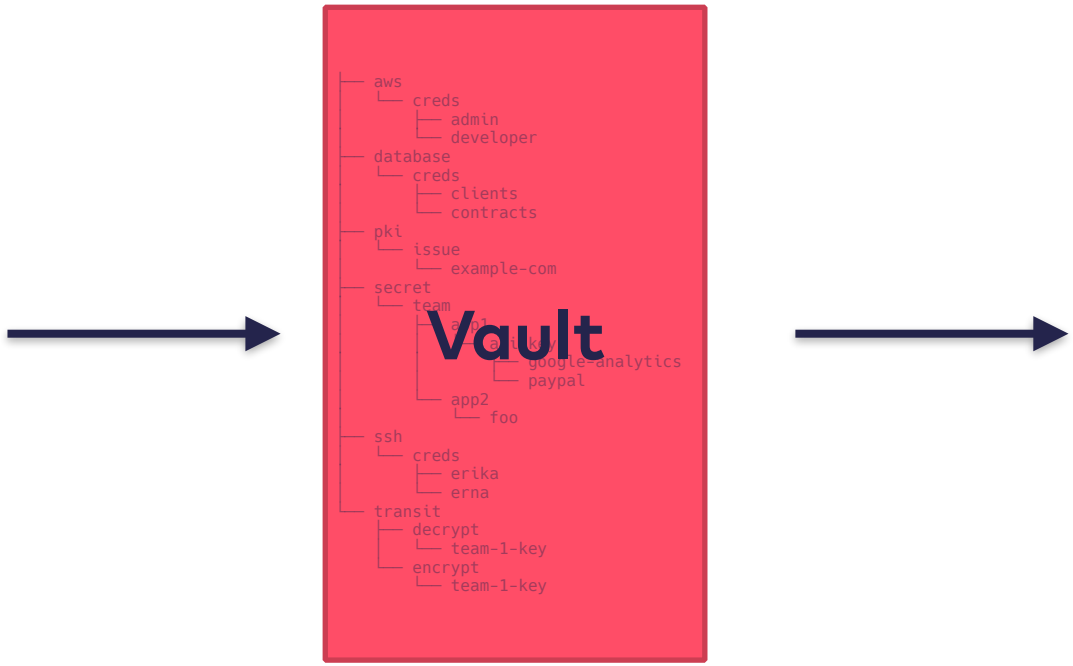
- **Idea: de- and encrypt data without handling private keys**
- **User creates a new transit path in Vault**
- **Users can encrypt data by writing the data to this transit path (e.g.** `transit/encrypt/my-keys/foo`**)**
- **Users with sufficient permissions can decrypt data by writing to the respective transit path (e.g.** `transit/decrypt/my-keys/foo`**)**
- **the private key never leaves Vault**
- **the data is not stored on Vault (hence the name transit)**

Vault secret backends — Transit



Vault secret backends

- Tokens
- LDAP
- AWS
- Kubernetes
- Google Cloud
- Username & Password
- AppRole
- GitHub
- MFA
- Okta
- RADIUS
- TLS Certificates



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Vault — auth backends

Vault auth backends

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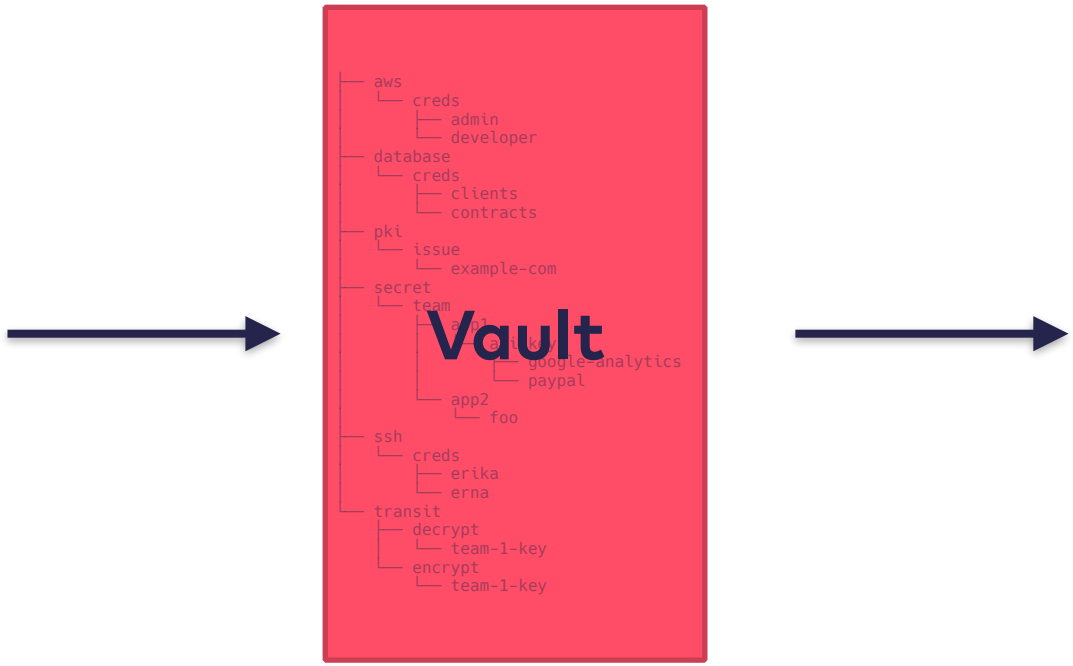

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Vault auth backends — tokens

token auth

- created by Vault
- only way to authorize (auth-z) against Vault
- returned when authenticated (auth-n) successfully
- comparable to a session-id on a website
- has permissions / policies assigned to it

token auth

```
$ vault token create -ttl=5m -policy=admin

Key                  Value
---                  -----
token                d9640590-63c8-b3a6-50ac-1403c8180948
token_accessor       5a362982-f34c-3706-143a-26ada278b6cf
token_duration       5m
token_renewable      true
token_policies       [admin default]
```

Vault auth backends — userpass

userpass auth

- **statically created by users and stored in Vault**

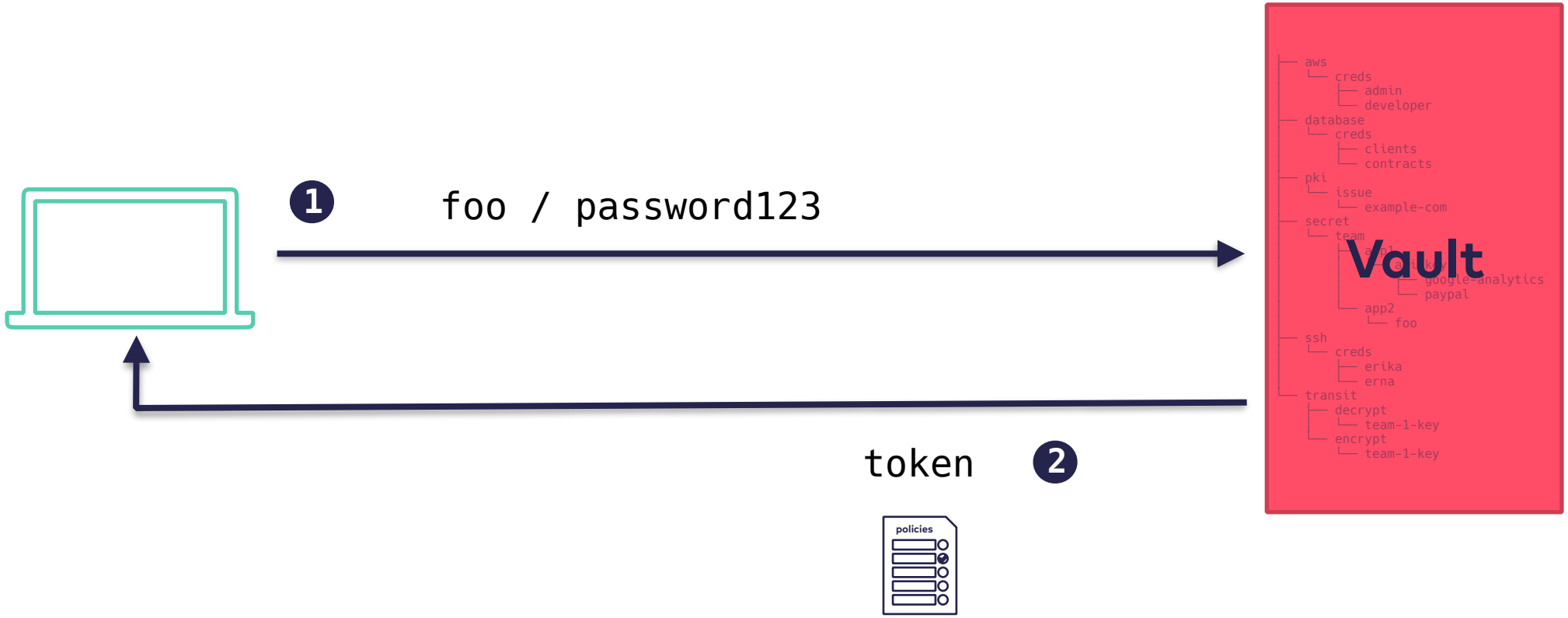
```
$ vault auth enable userpass

$ vault write auth/userpass/users/kesselborn \
    password=foo policies=admin

$ vault login -method=userpass username=kesselborn

Key                  Value
---                  -----
token                d9640590-63c8-b3a6-50ac-1403c8180948
. . .
token_duration       5m
token_policies       [admin default]
```

Vault auth backends — userpass

- setup username / password

Vault auth backends — userpass

- authenticate with a username & password



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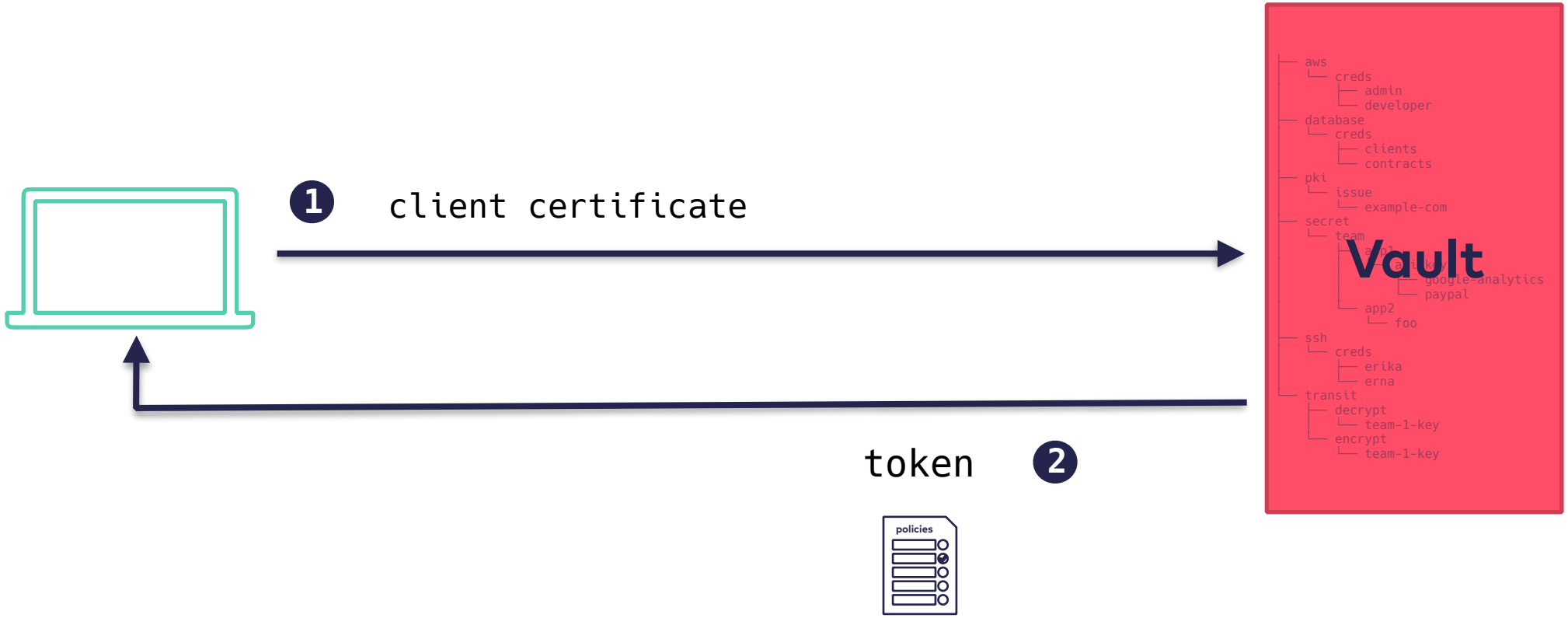
Vault auth backends — TLS certificates

Vault auth backends — TLS certificates

- setup TLS certificate authentication

Vault auth backends — TLS certificates

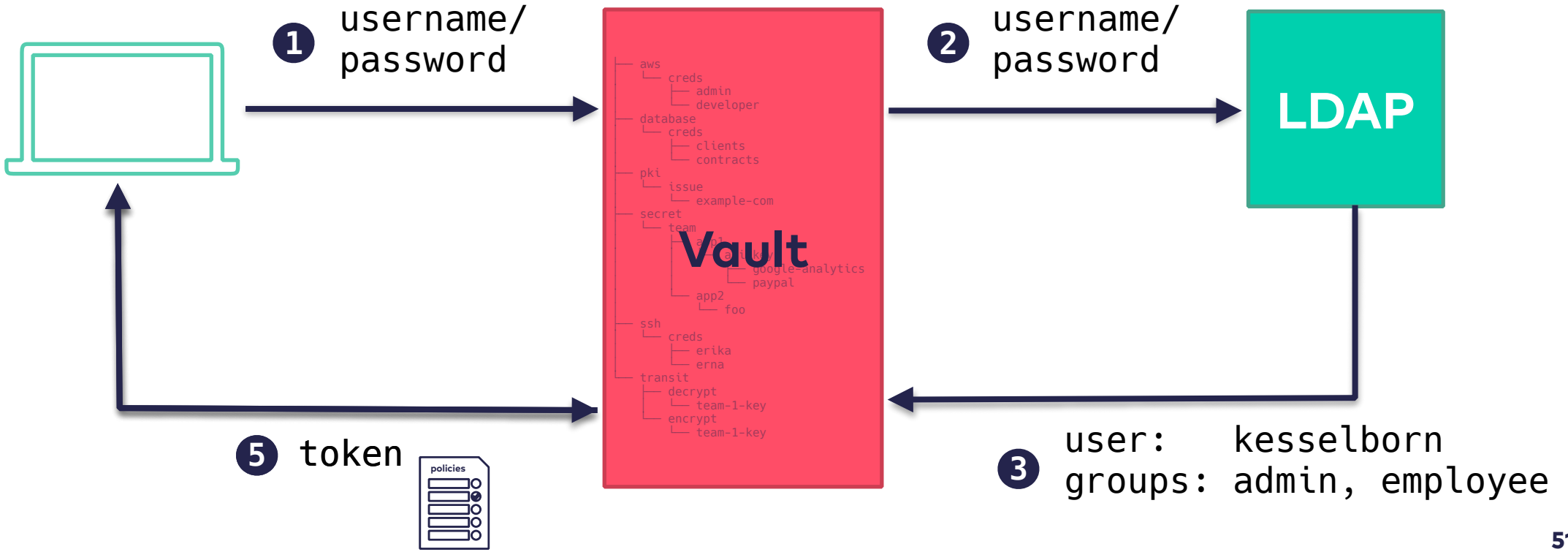
- authenticate with a TLS client certificate



Vault auth backends — external identity providers

Vault auth backends — LDAP / Radius / Okta auth

- $SERVICE is used as an identity provider (using LDAP here)

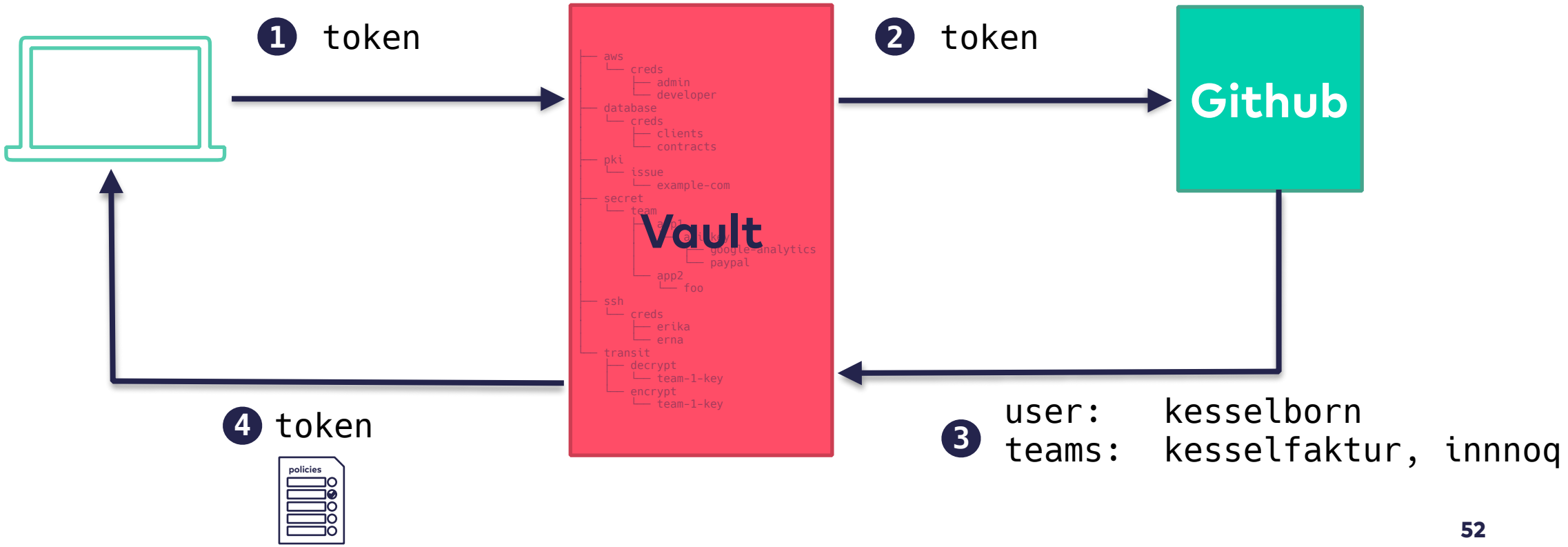


LDAP auth

```
$ vault write auth/ldap/config \
    url="ldaps://ldap.example.com" \
    userattr="uid" \
    userdn="ou=People,dc=innoq,dc=com" \
    binddn="cn=vaultuser,dc=example,dc=com" \
    bindpass="3cK{hrh7hi/Hj" \
    groupdn="ou=Group,dc=example,dc=com" \
    starttls=true

$ vault write auth/ldap/groups/employee policies=employee

$ vault write auth/ldap/users/kesselborn policies=admin
```

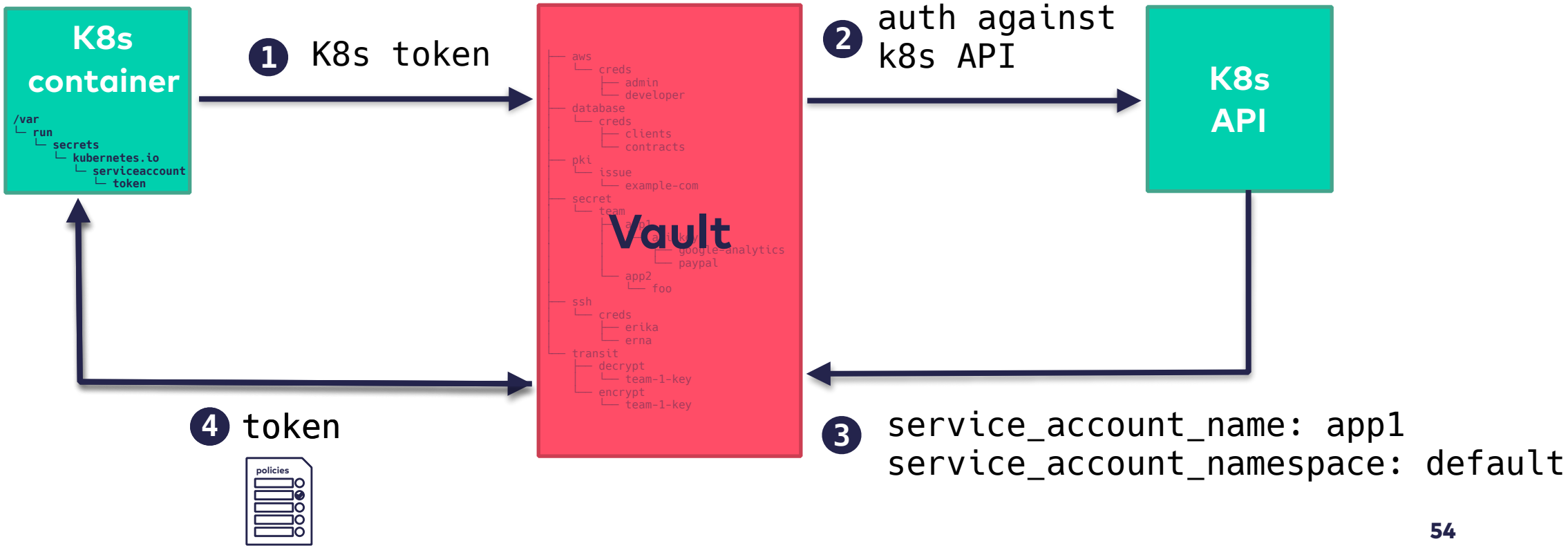
Github auth

- Github is used as an identity provider

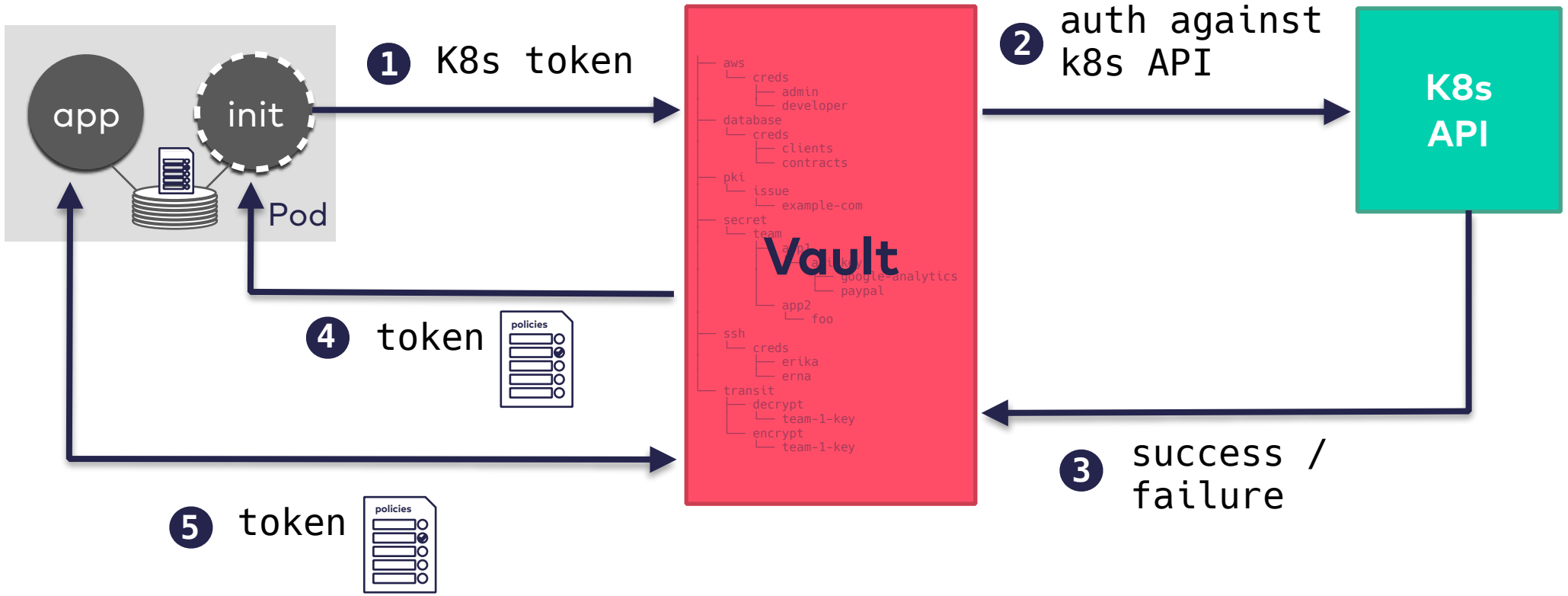


Vault auth backends — Kubernetes auth

Vault auth backends — Kubernetes auth



Vault auth backends — Kubernetes auth

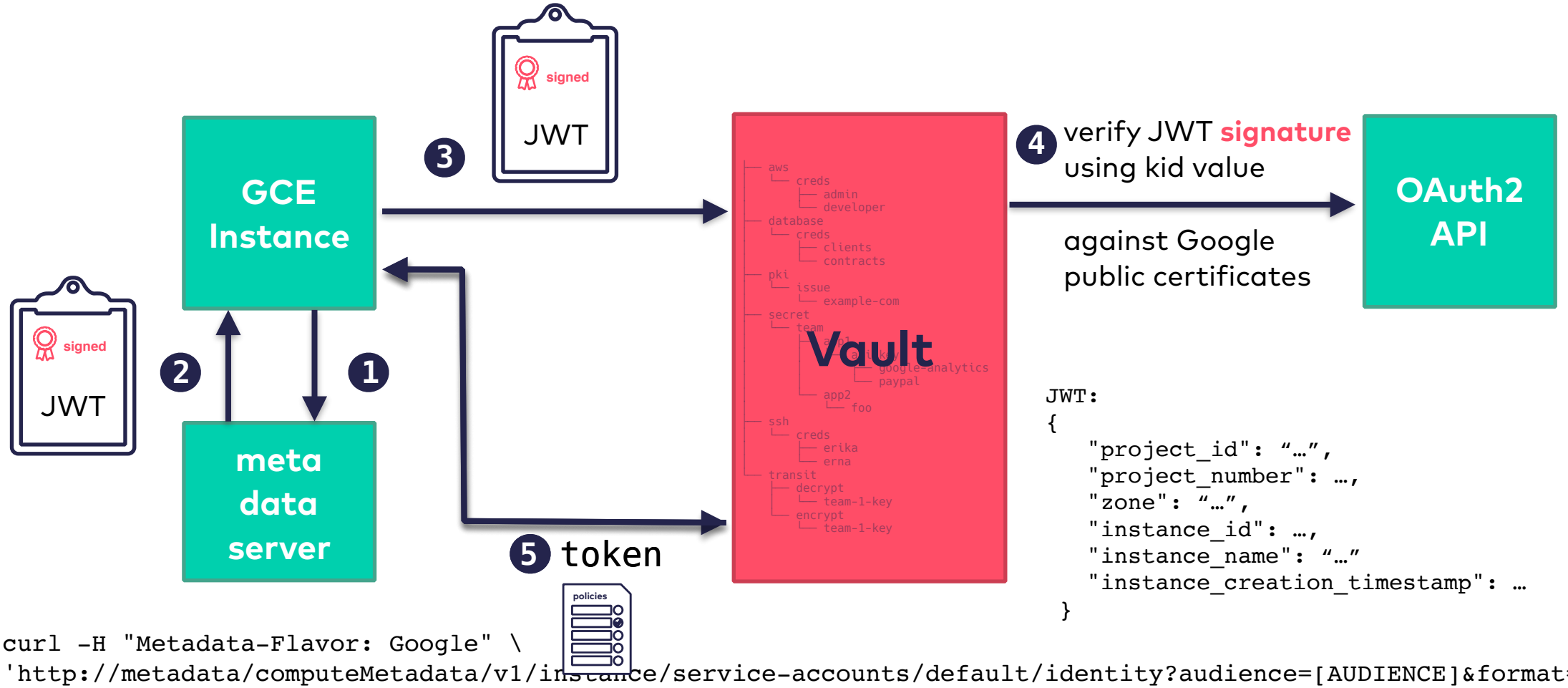


Vault auth backends — Kubernetes auth

```
$ vault auth enable kubernetes

$ vault write auth/kubernetes/config \
  kubernetes_host=“https://api.k8s.example.com" \
  kubernetes_ca_cert=“@ca.crt"

$ vault write auth/kubernetes/role/demo \
    bound_service_account_names=vault-auth \
    bound_service_account_namespaces=default \
    policies=default \
    ttl=1h
```

Vault auth backends — GCE auth

Vault auth backends — GCE auth




```
JWT:
{
   "project_id": "…",
   "project_number": …,
   "zone": "…",
   "instance_id": …,
   "instance_name": "…"
   "instance_creation_timestamp": …
 }
```

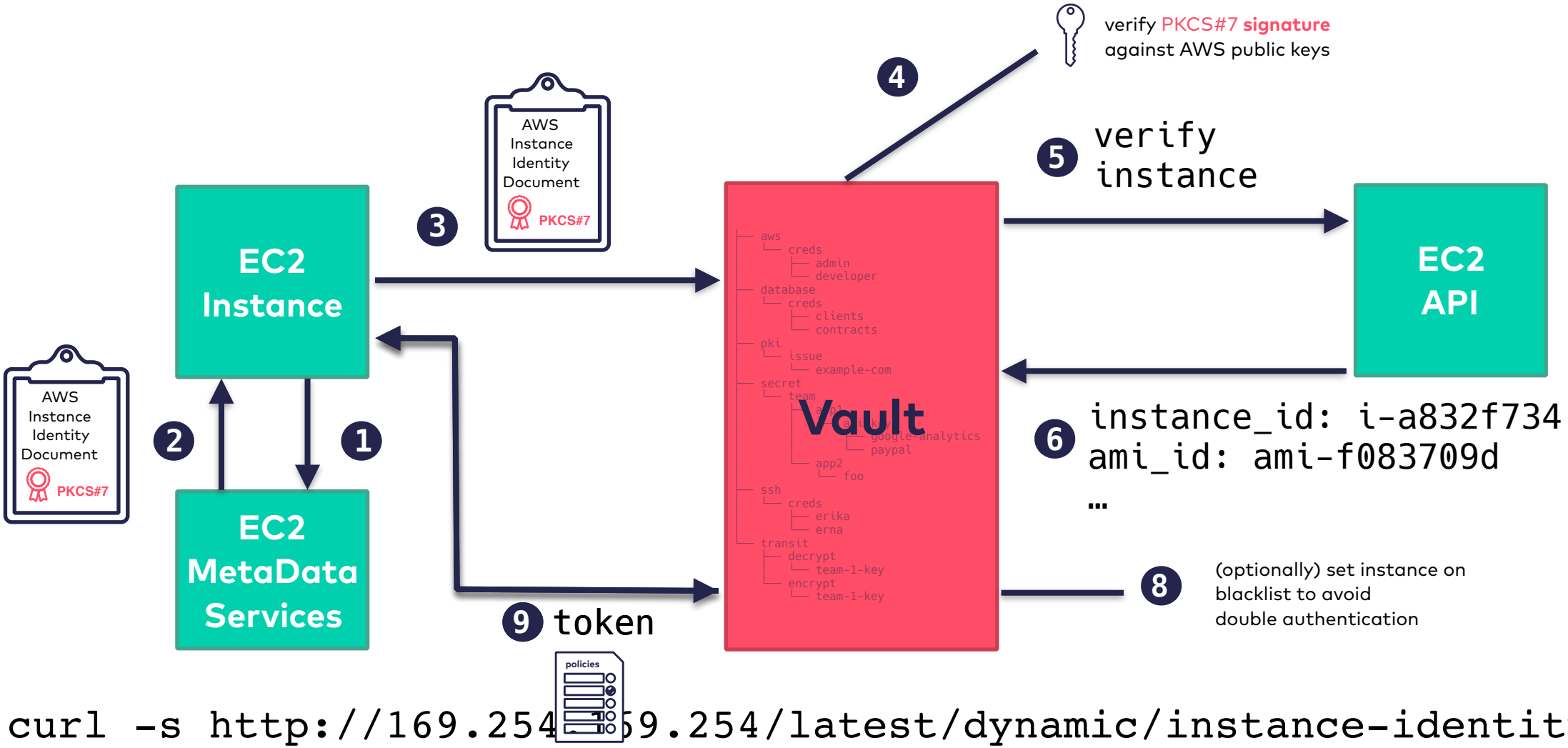
```
curl -H "Metadata-Flavor: Google" \
'http://metadata/computeMetadata/v1/instance/service-accounts/default/identity?audience=[AUDIENCE]&format=[FORMAT]'
```

Vault auth backends — AWS auth

Vault auth backends — AWS auth

- Vault checks passed in data was encrypted with a AWS private key
- can be limited to instances which have a specific instance role applied
- can be limited (and usually is) to allow one authentication per ec2 instance only
- after authentication, roles and policies are mapped as usual

Vault auth backends — AWS auth




```
curl -s http://169.254.169.254/latest/dynamic/instance-identity/pkcs7
```

Vault auth backends — AWS auth

```
$ vault write auth/aws/role/dev-role \
        auth_type=ec2 \
        bound_ami_id=ami-fce3c696 \
        policies=prod,dev max_ttl=500h

$ vault write auth/aws/role/dev-role-iam \
        auth_type=iam \
        bound_iam_instance_profile_arn=… \
        policies=prod,dev max_ttl=500h
```

Vault auth backends — AWS auth

- alternatively: IAM auth method
- client signs a GetCallerIdentity query using the AWS Signature v4 algorithm and submits 4 pieces of information to the Vault server to recreate a valid signed request
- https://www.vaultproject.io/docs/auth/aws.html#iam-auth-method

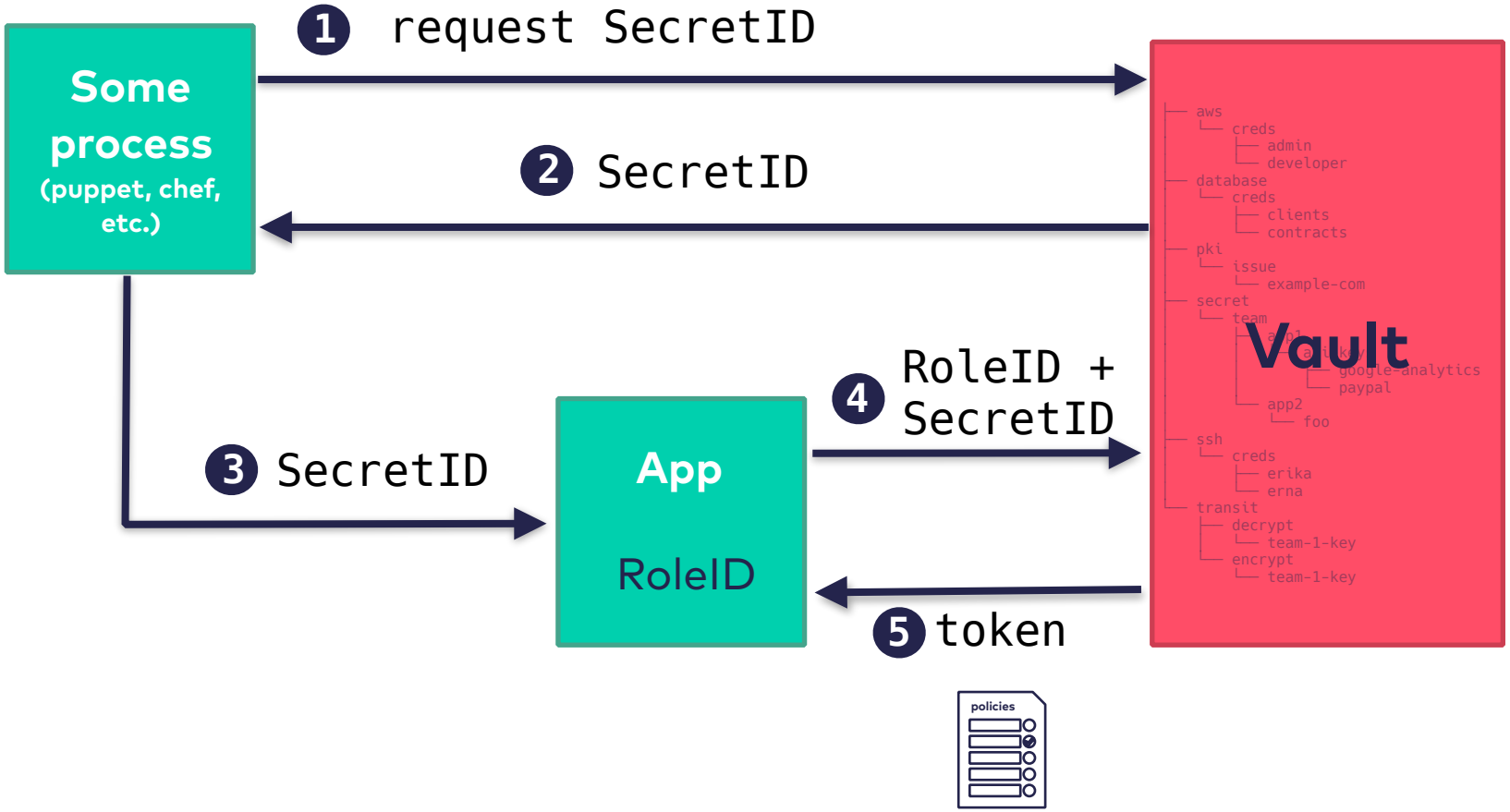
Vault auth backends — AppRole

Vault auth backends — AppRole

- a generic approach to authenticate machines or applications
- an AppRole can be created for a particular machine, a particular user on that machine, or a service spread across machines
- for authenticating, two values are needed
  - RoleID: static, can live with an app or on a machine)
  - SecretID: gets created on the fly before authenticating

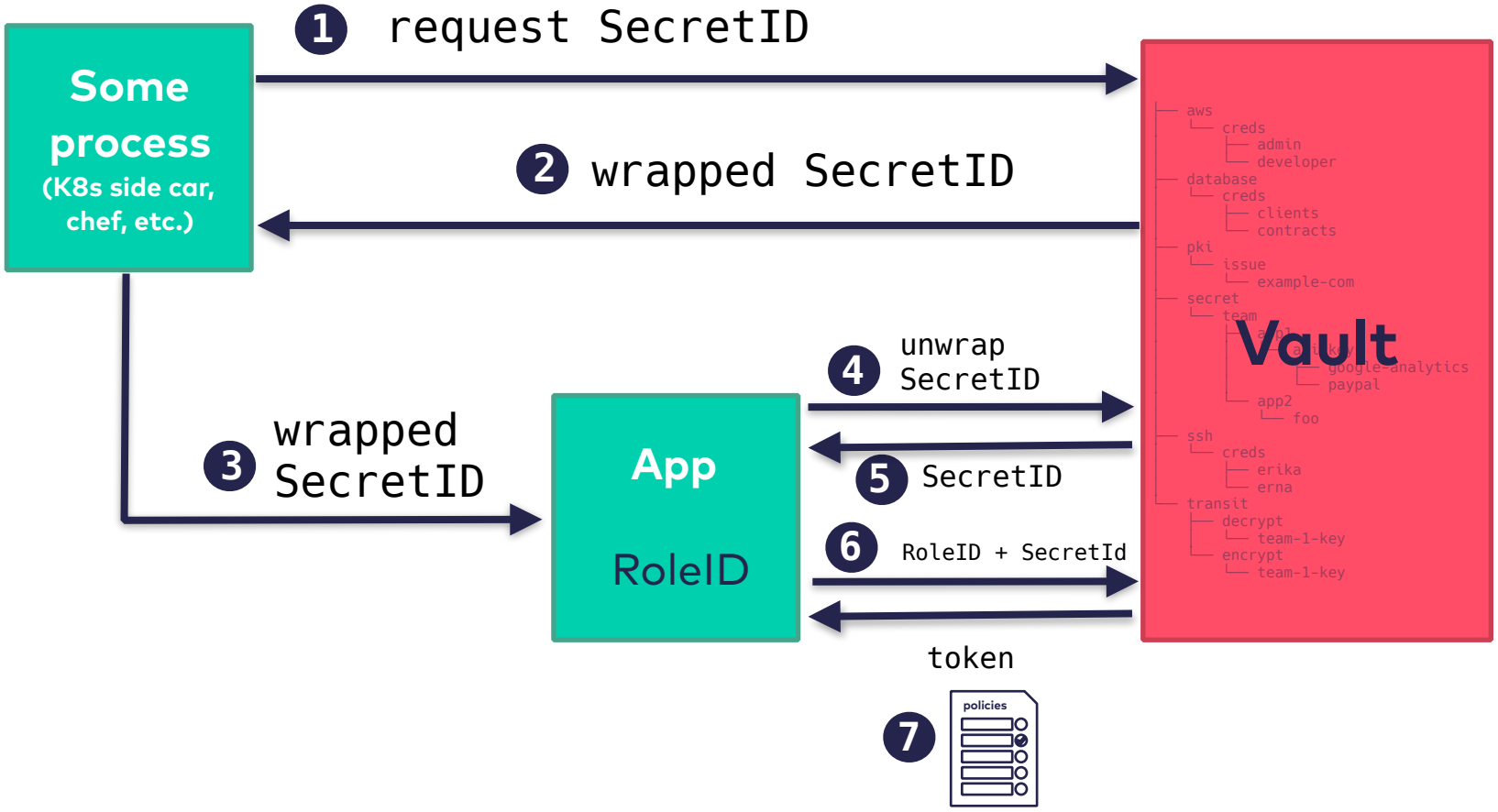
Vault auth backends — AppRole

- mainly used for machines or apps to authenticate against Vault



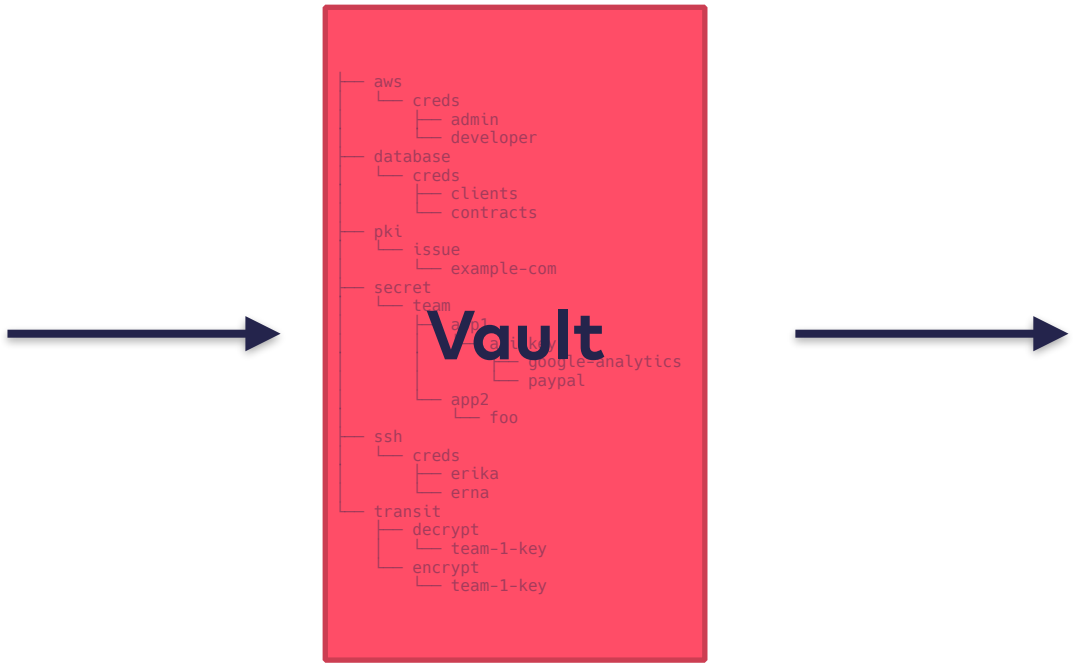
Vault auth backends — AppRole

- mainly used for machines or apps to authenticate against Vault



Vault auth backends

- **Tokens**
- **LDAP**
- **AWS**
- **Kubernetes**
- **Google Cloud**
- **Username & Password**
- **AppRole**
- **GitHub**
- **MFA**
- **Okta**
- **RADIUS**
- **TLS Certificates**

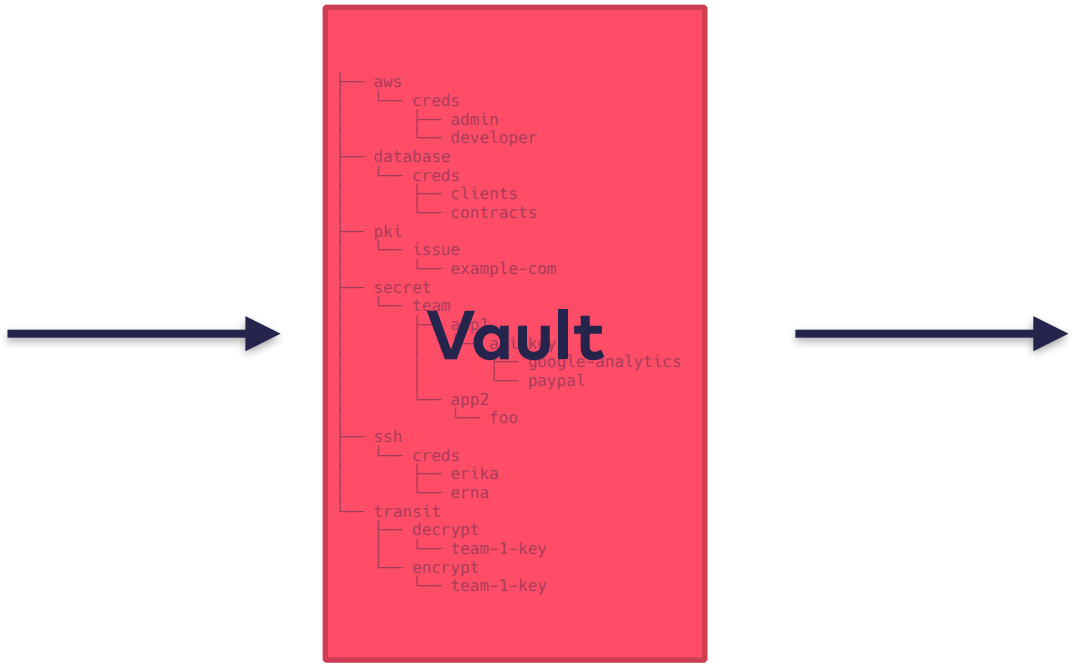


- AWS
- Consul
- Cubbyhole
- Databases
- Identity
- Static secrets (Key /Value)
- Nomad
- PKI (Certificates)
- RabbitMQ
- SSH
- TOTP
- Transit

Use whatever the auth you want

Vault

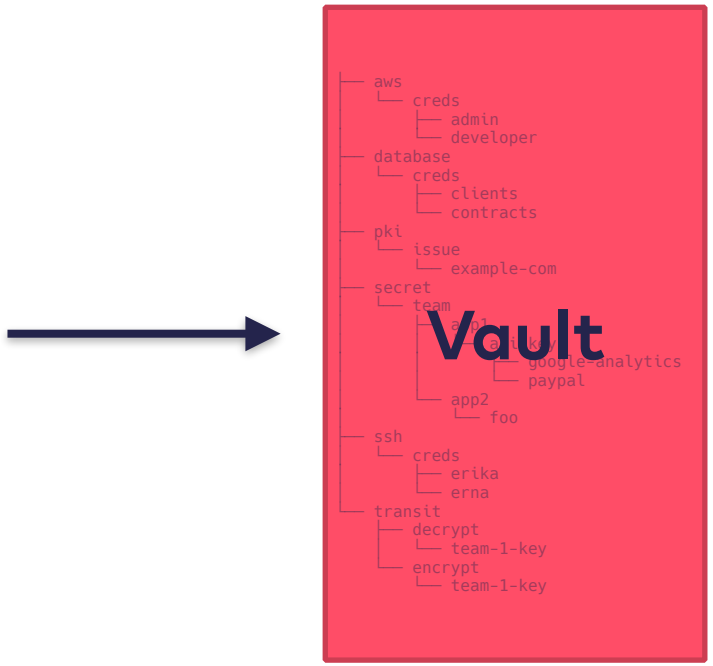
- Tokens
- **LDAP**
- AWS
- Kubernetes
- Google Cloud
- Username & Password
- AppRole
- GitHub
- MFA
- Okta
- RADIUS
- TLS Certificates



- **AWS**
- Consul
- Cubbyhole
- **Databases**
- Identity
- Static secrets (Key /Value)
- Nomad
- **PKI -> Kubernetes access**
- RabbitMQ
- **SSH**
- TOTP
- Transit

Vault

- Tokens
- LDAP
- AWS
- **Kubernetes**
- Google Cloud
- Username & Password
- AppRole
- GitHub
- MFA
- Okta
- RADIUS
- TLS Certificates

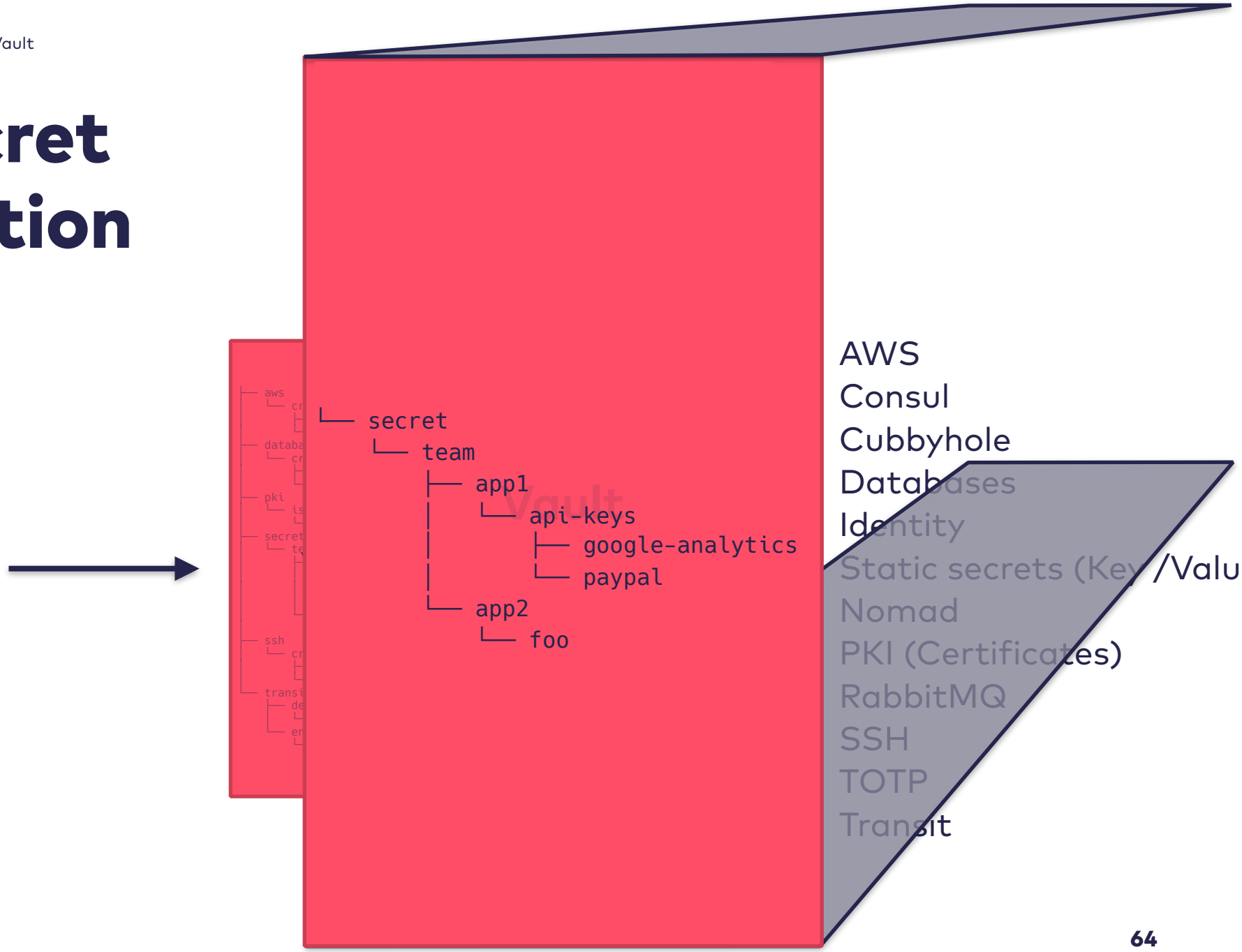


- AWS
- Consul
- Cubbyhole
- **Databases**
- Identity
- **Static secrets (Key /Value)**
- Nomad
- **PKI (Certificates)**
- RabbitMQ
- SSH
- TOTP
- **Transit**

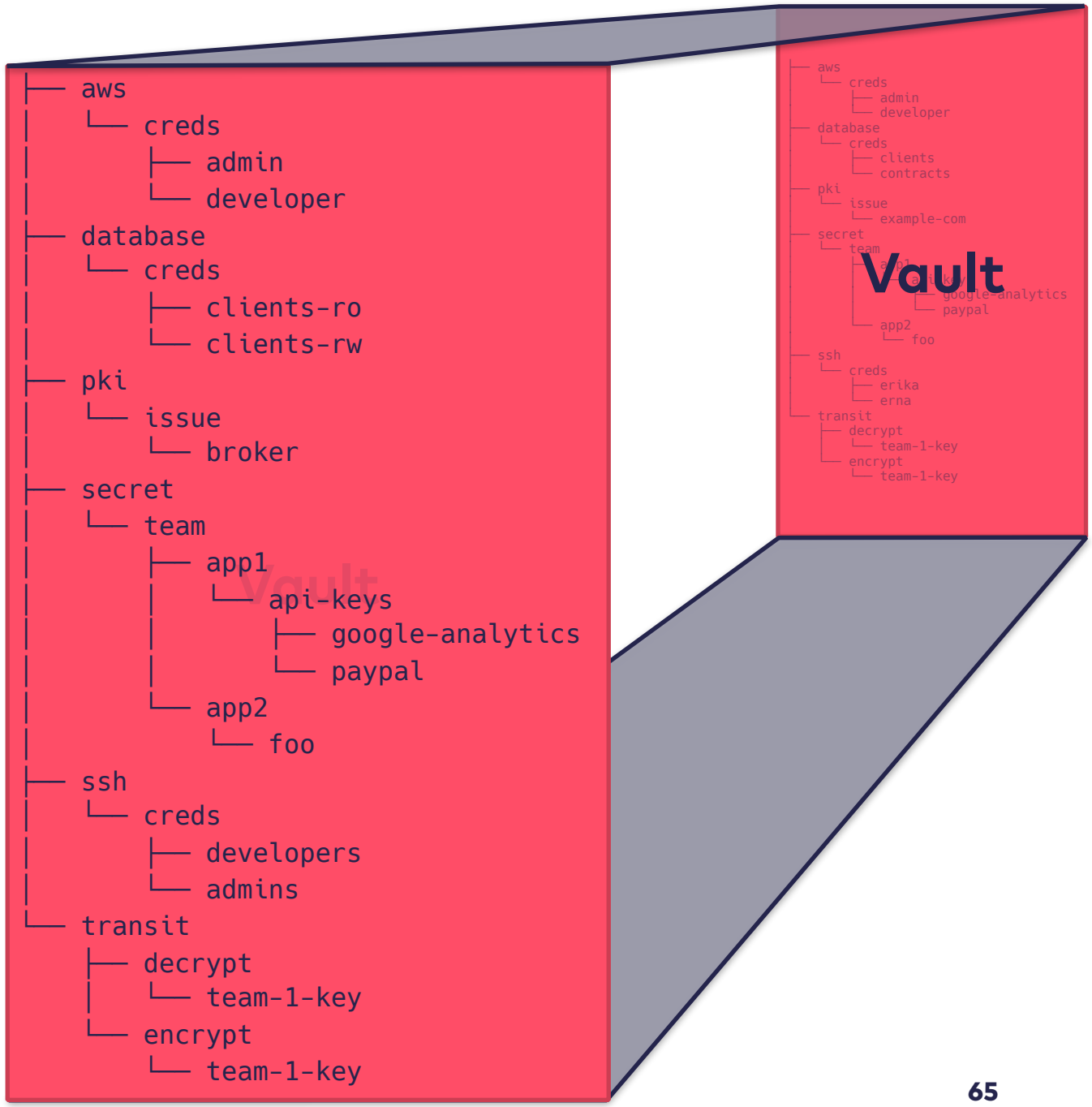
Vault — policies

Vault — secret representation

- Tokens
- LDAP
- AWS
- Kubernetes
- Google Cloud
- Username & Password
- AppRole
- GitHub
- MFA
- Okta
- RADIUS
- TLS Certificates

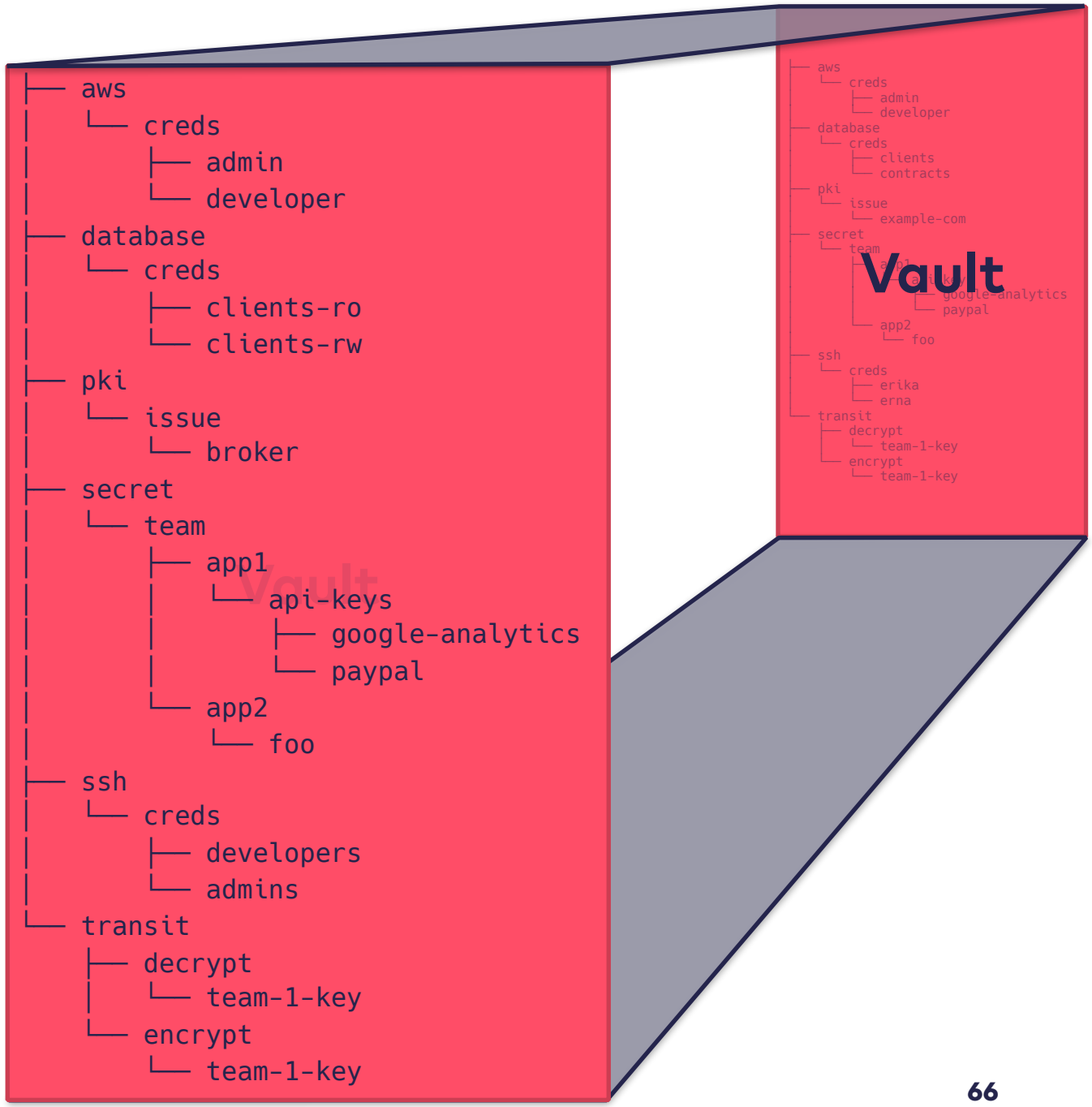


Vault — secret representation



Vault — policies

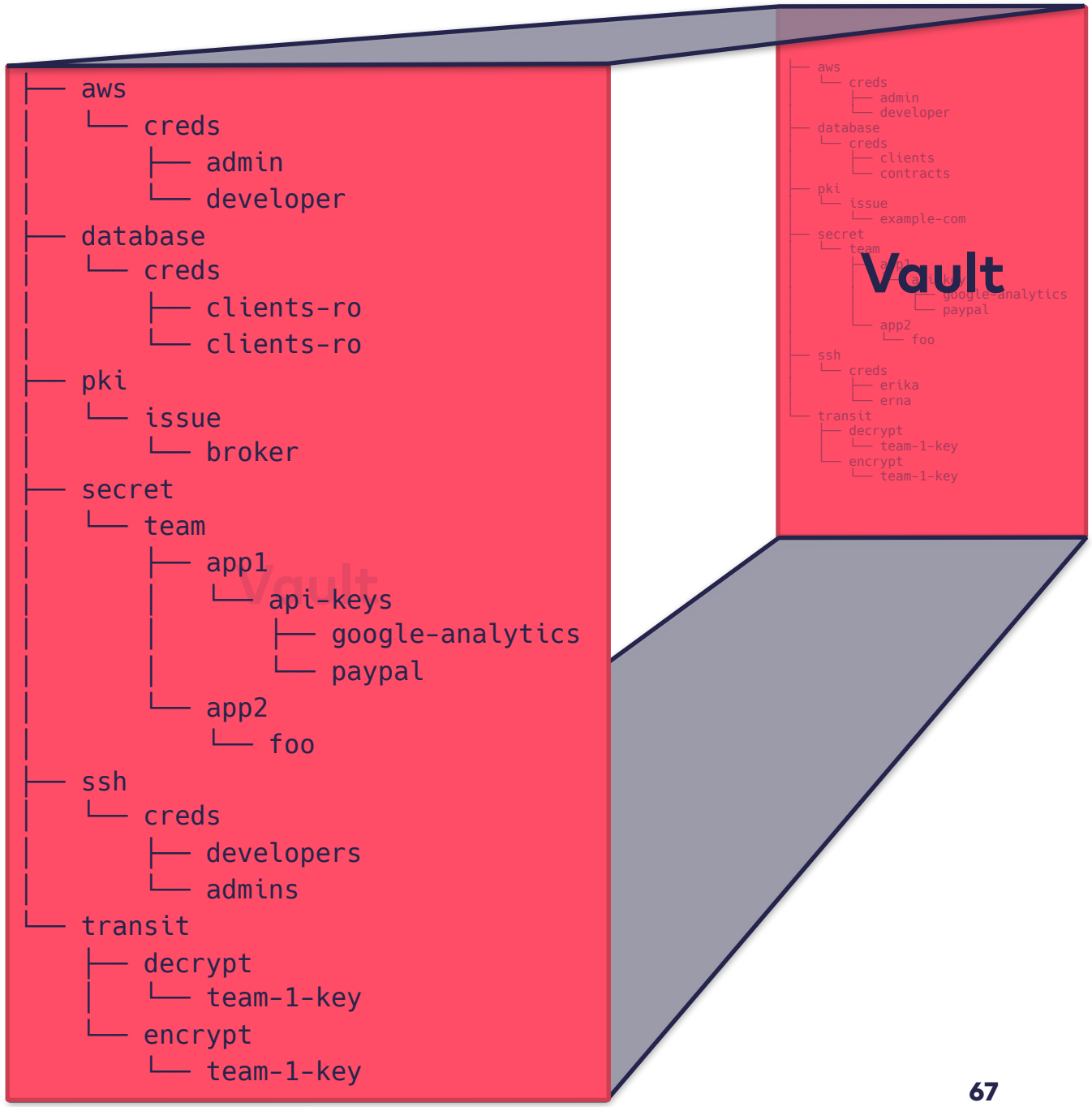
- applied to “files” or “directories”
- support filesystem wildcards
- control what a user can access
- get assigned after authentication
- policies of a token can’t be changed



Vault — policies

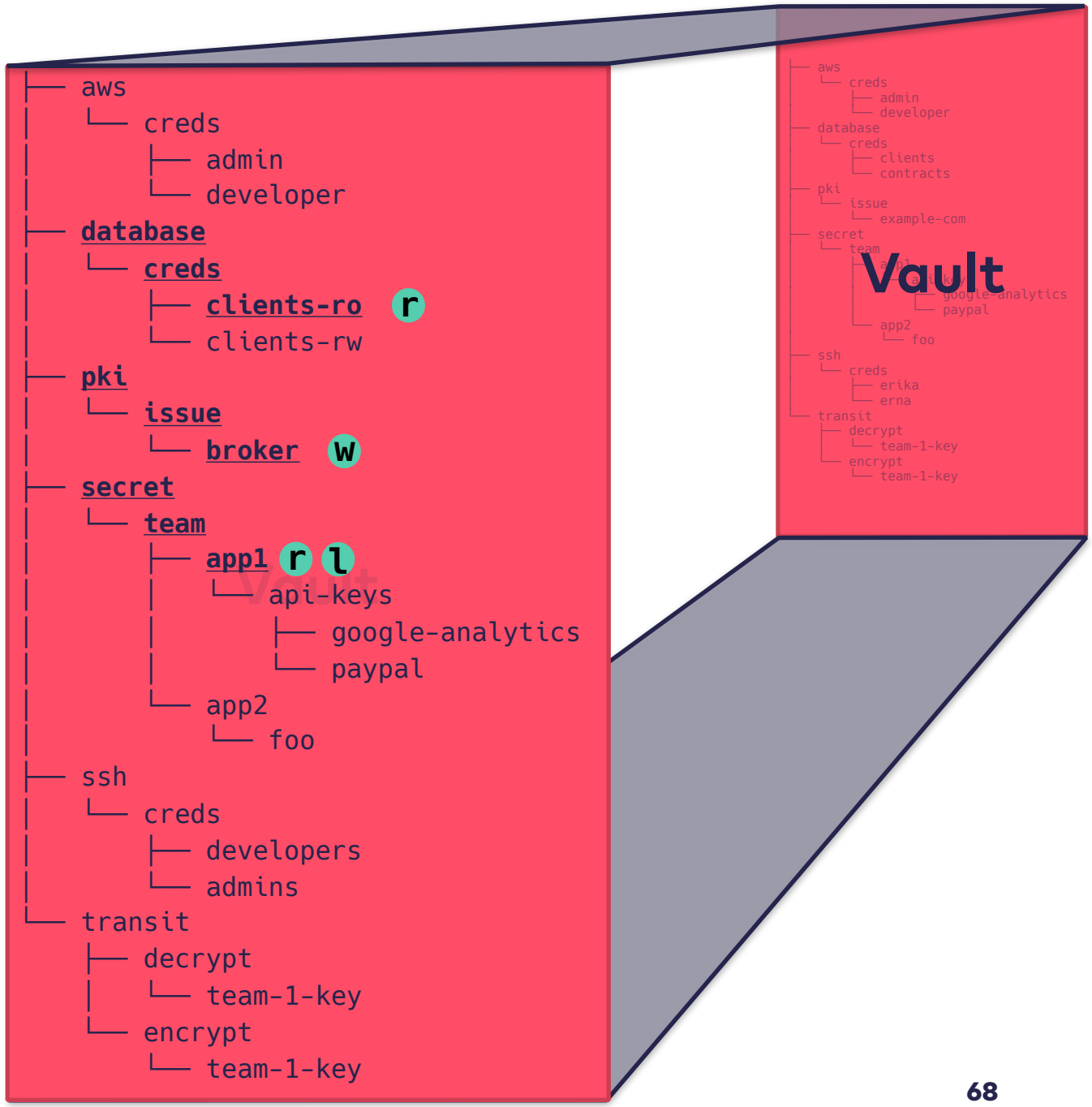
- `create` c
- `read` r
- `update` u
- `delete` d
- `list` l
- `deny` d

- `sudo` s



Vault — policies

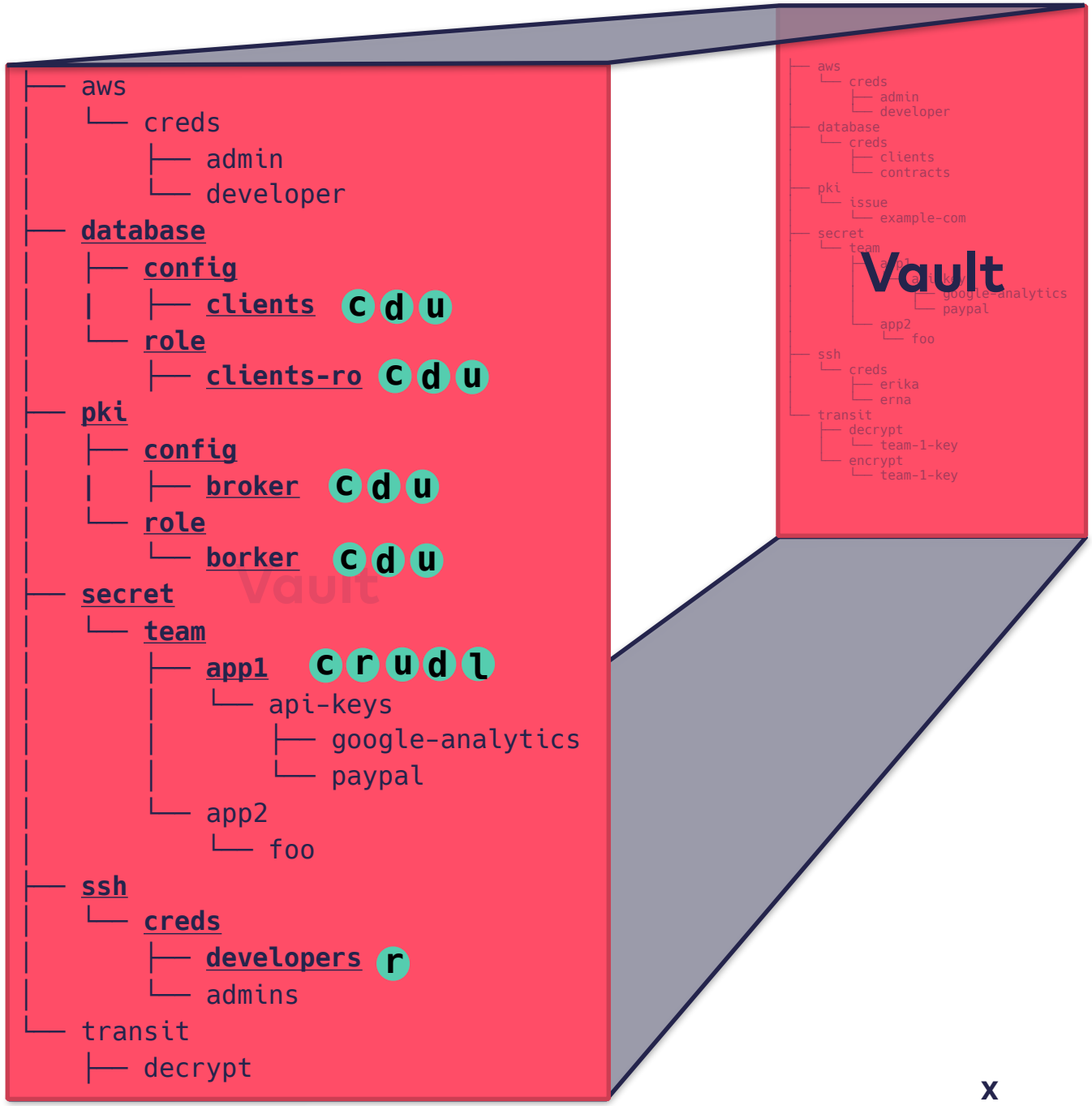
```
$ cat app1-policy.hcl

path “secret/team/app1/*“ {
  capabilities = [“read”, “list”]
}

path “pki/issue/broker” {
  capabilities = [“write”]
}

path “database/creds/clients-ro“ {
  capabilities = [“read”]
}
```



Vault — policies

```
$ cat app1-erna-policy.hcl
```

```
path “secret/team/app1/*“ {
  capabilities = [“read”, “list”, “create”,
                  “update”, “delete”]
}

path “pki/role/*” {
  capabilities = [“create”, “update”, “delete”]
}

path “pki/config/*” {
  capabilities = [“create”, “update”, “delete”]
}

path “database/config/clients“ {
  capabilities = [“create”, “update”, “delete”]
}

path “database/role/clients-ro“ {
  capabilities = [“create”, “update”, “delete”]
}

path “ssh/creds/developers“ {
  capabilities = [“read”]
}
```



Vault — Audit log

Vault internals — Audit log

- off by default
- supported backend
  - file
  - syslog
  - socket
- if audit log can not be written, Vault does not reply to requests

Vault internals — Audit log

- every operation creates a log entry with
  - what was done
  - when was it executed
  - by who was it requested
  - request payload
  - response payload
- sensitive data is hashed with a salt using HMAC-SHA256

Vault internals — Audit log

- {"time":"2018-10-10T10:59:53.557231528Z","type":"response","auth":{"client_token":"hmac-sha256:41f2474f04f6277eb43cc8eae700dbc8534c5369d9185991eed4c4f70b1a5840","accessor":"hmac-sha256:27e400da69c94fce2378f5738cbf950531d7a9513215274abfbbdaa4927e00ba","display_name":"ldap-daniel.bornkessel@innoq.com","policies":["default"],"token_policies":["default"],"metadata":{"username":"daniel.bornkessel@innoq.com"},"entity_id":"8950f5f7-fad8-3ecb-4e62-e5841815df60"},"request":{"id":"9f2b6dfa-5c18-af6a-1f66-2c78b25a875f","operation":"list","client_token":"hmac-sha256:41f2474f04f6277eb43cc8eae700dbc8534c5369d9185991eed4c4f70b1a5840","client_token_accessor":"hmac-sha256:27e400da69c94fce2378f5738cbf950531d7a9513215274abfbbdaa4927e00ba","path":"secret/","data":null,"policy_override":false,"remote_address":"100.96.0.76","wrap_ttl":0,"headers":{}},"response":{"data":{"error":"hmac-sha256:d9d7a78363fd091f1b4c12629b7c9b5d7a7ffbf904ef5d29d002d5265d5bbf33"}},"error":"1 error occurred:\n\n* permission denied"}

Vault

policies

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- Google Cloud
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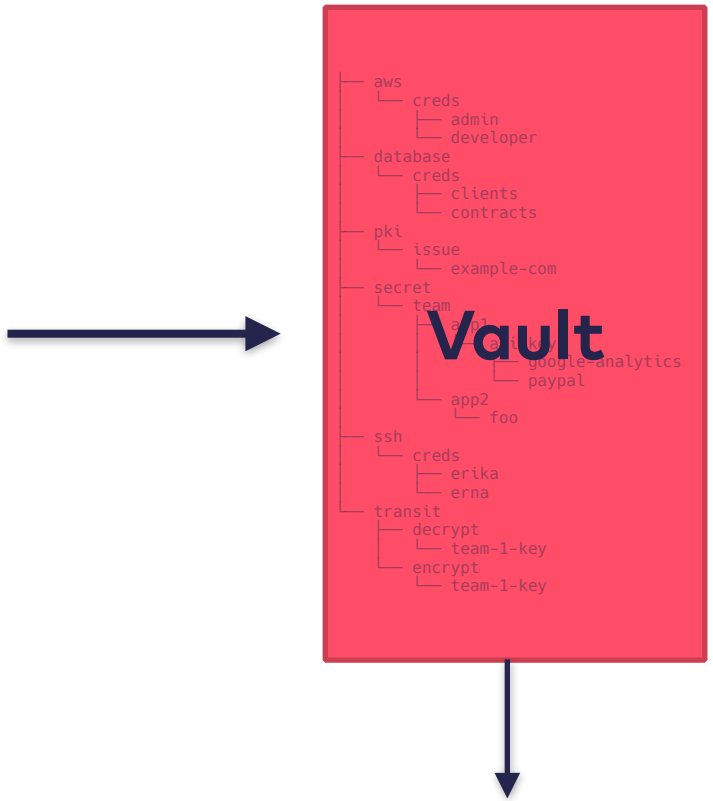

audit logs

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Vault internals

Vault internals — storage

Vault internals — storage

- several storage backends available: Consul, Etcd, Azure, Cassandra, CockroachDB, CouchDB, DynamoDB, Filesystem, FoundationDB, Google Cloud Spanner, Google Cloud Storage, In-Memory, Manta, MySQL, PostgreSQL, S3, Swift, Zookeeper
- data encrypted at rest with a symmetric key
- symmetric key is encrypted by “master key” and stored on storage backend
- master key is encrypted with “Shamir’s Secret Sharing”

Vault internals — storage

Shamir's Secret Sharing

- 1 ... N keys are needed in order to decrypt the data
- you can provide the decryption keys in any order
- N ... N+M keys can be created and distributed to different parties

Vault internals — storage

Shamir's Secret Sharing

- by default, Vault creates 5 keys on initialization (which is a once per storage backend operation)
- 3 of the 5 keys are needed in order to unseal a Vault instance
- this is configurable (e.g. 10/8, 15/5, etc.)

Vault internals — storage

Shamir's Secret Sharing

- HA of key holders
- one key alone is worthless
- key holder != admins: designers, ops, devs, etc.
- new unsealing keys can be created when provided enough unsealing keys (e.g. when employees leave the company)
- every time a Vault **instance** is started, the master key has to be decrypted

Vault internals — HA

Vault internals — HA

- some backends support Vault HA mode (currently: Consul, Etcd, DynamoDB, Foundation DB, Google Cloud Spanner, Google Cloud Storage, MySQL, Zookeeper)
- Active-Passive mode:
  - only the active Vault instance replies to requests
  - all other Vault instances reply with a HTTP 302 to the active Vault instance (i.e. LB in front of HA Vaults does not make sense)
  - leader election done in storage backend

Vault usage

Vault usage — integration

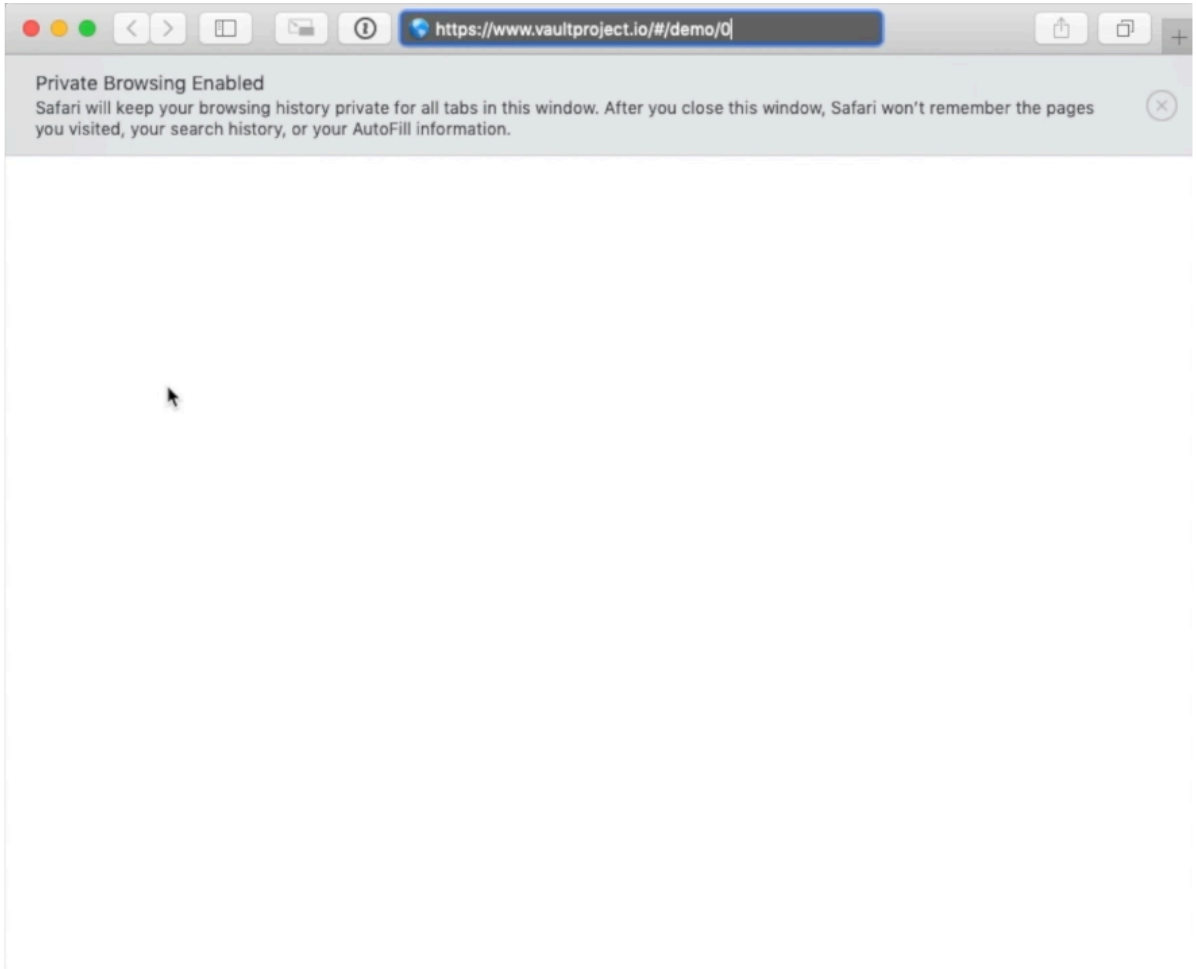
Vault usage — integration

- some frameworks have integration for Vault
- when home made solution
  - create config files with a helper app to avoid development pain
  - prepare your app for ttl'ed credentials: react accordingly if the (e.g.) DB password is not valid anymore:
    - re-read config file with new credentials
    - make sure, helper app gets new credentials in time
    - re-try DB request
    - when in a container managed system, exit if appropriate

Vault usage — getting started

Vault — getting started (1 minute invest)

https://www.vaultproject.io/#/demo/0



Vault — getting started

- interactive tutorial
- download it locally and start it with '`--dev`' parameter (investment: 20 min - a few hours)
- there is a steep learning curve
  - different backends use the same words with different meanings (ttl, tokens, etc.)
  - hard to quickly test something as you need the backend systems in place: AWS auth to get MySQL passwords?
  - most tutorials only run in dev mode

Vault — recap

You authenticate somehow, get a token with some policy attached to it, which again allows you to read some secrets.

Thank you and auf Wiedersehen

We are hiring in Hamburg, Berlin, Munich, Frankfurt, Monheim (between Düsseldorf and Cologne), and remote

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