CLOUDFLARE®

Managing server secrets at scale
with a vaultless password manager

Ignat Korchagin

@secumod

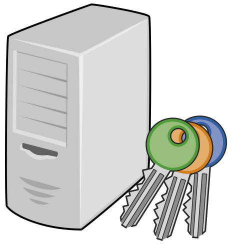
$ whoami

- Platform engineer at Cloudflare
- Passionate about security and crypto
- Enjoy low level programming

CLOUDFLARE

Disclaimer

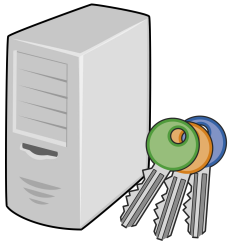
So you have a server



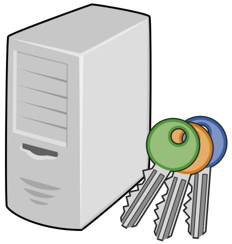
So you have a server

You need:

- server SSH key



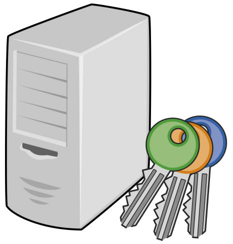
So you have a server



You need:

- server SSH key
- configuration management key

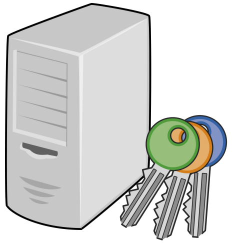
So you have a server



You need:

- server SSH key
- configuration management key
- disk encryption key

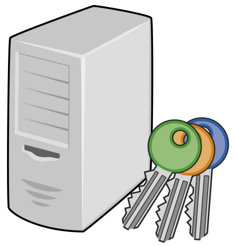
So you have a server



You need:

- server SSH key
- configuration management key
- disk encryption key
- some server credentials

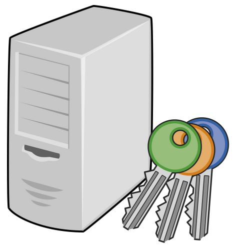
So you have a server



You need:

- server SSH key
- configuration management key
- disk encryption key
- some server credentials
- probably more...

So you have a server

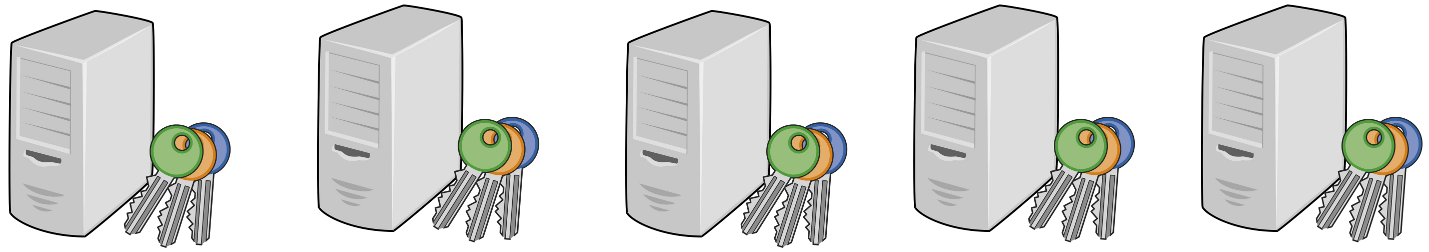


You need:

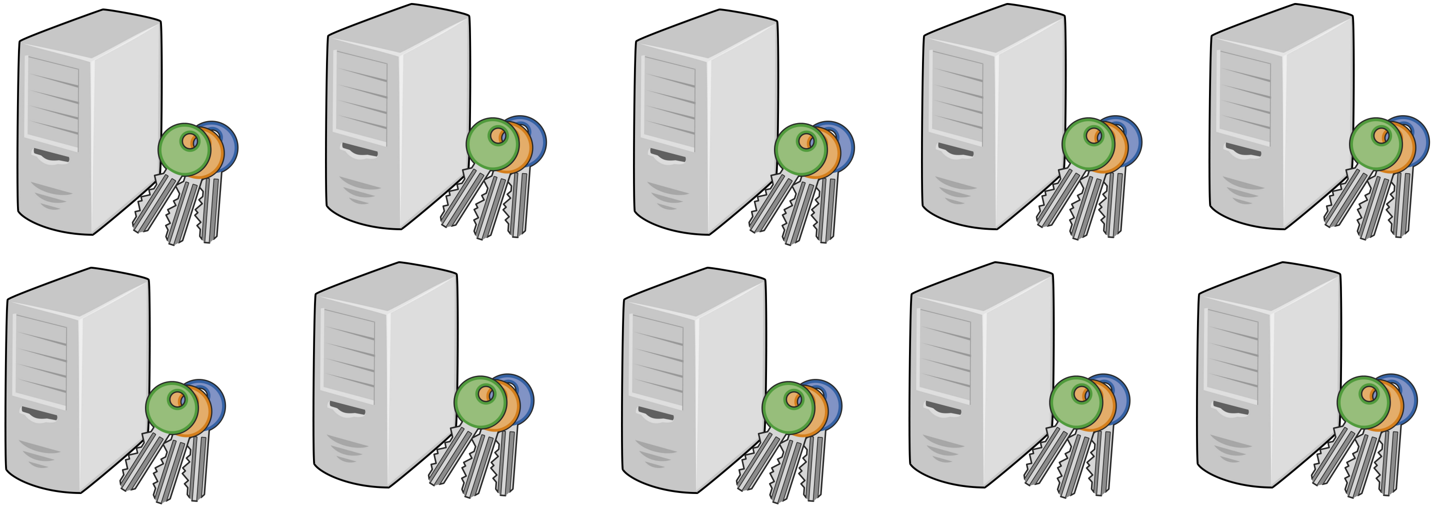
- server SSH key
- configuration management key
- disk encryption key
- some server credentials
- probably more…

… so at least 5 keys… and that’s per server

So you have a datacentre

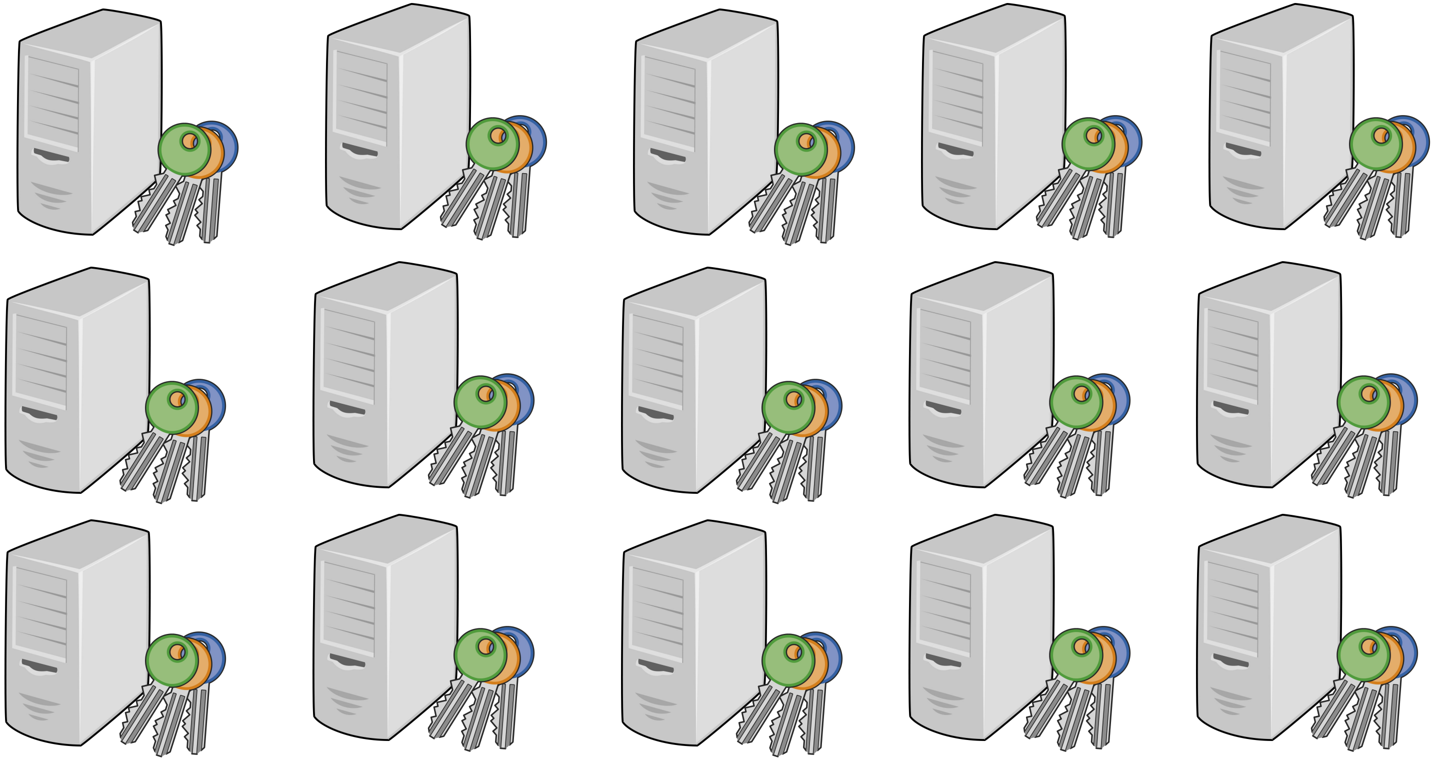


So you have a datacentre**(s)**

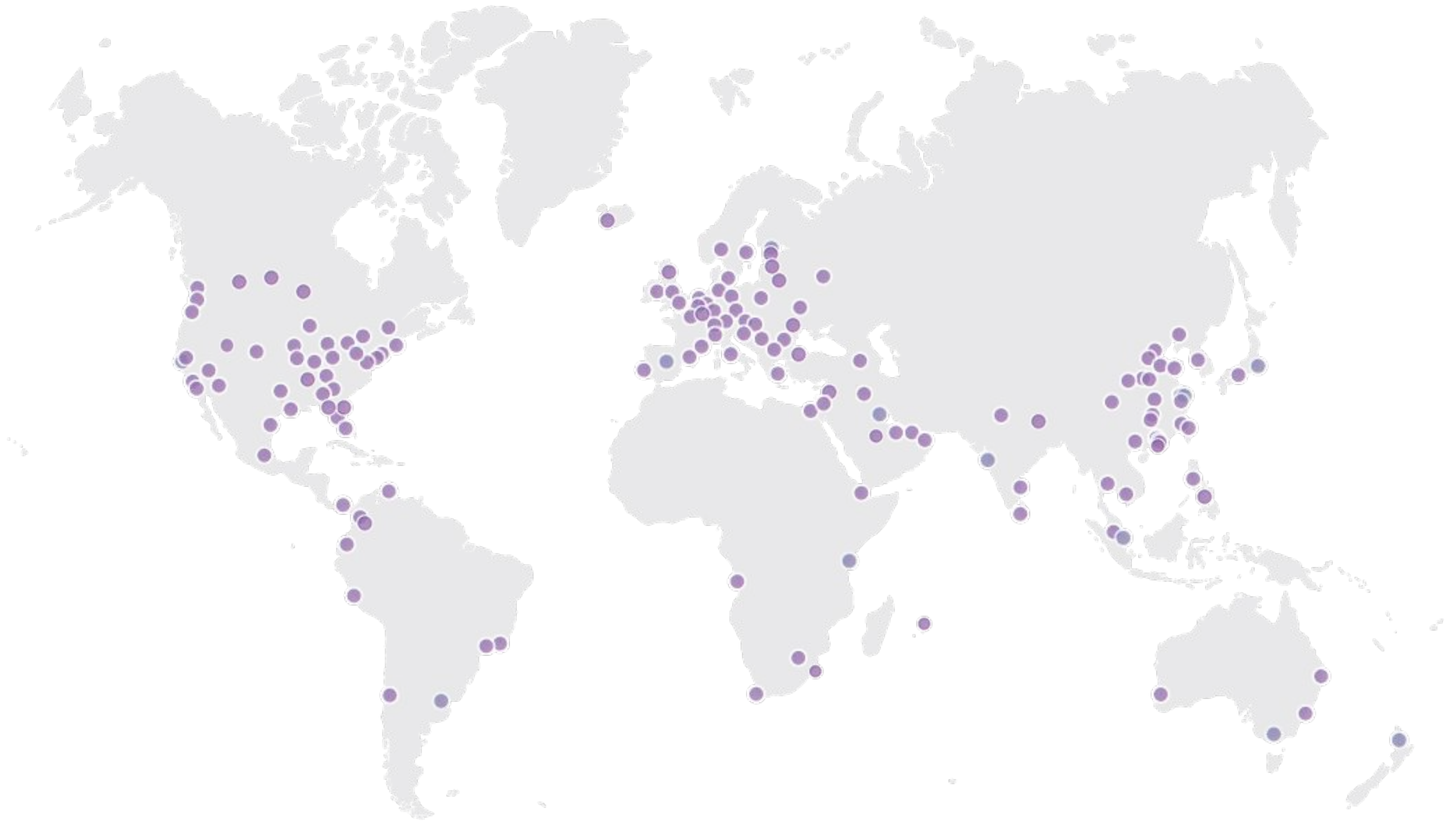


CLOUDFLARE

So you have a datacentre**(s)**



Cloudflare network today



CLOUDFLARE

So you have a datacentre**(s)**

Where do keys live?

Where do keys live?

Where do keys live?

Keys in configuration management

```
#!yaml|gpg

root-password: |
    -----BEGIN PGP MESSAGE-----
    Version: GnuPG v1

    hQIMA221uplZYlMdARAA583Z4o3xZawWzK8yUYJKBEkMQD/i+RRn7A0+h8SEmsov
    QkrxgeaCWfIZ5pRpCpVOK1SWZGi0dzWkWe1DeNisawv5X/VUG3d5ej1xtAD4kBTy
    AzcnFft7QfIsV8C+jguHYGITU++pFVAgEdGrb09mf6SEDaAGJhOq01BmHccw0Pat
    rBH/+gvD155F7sxM/BBQwL25ZjtC+8jUsp1bUcTQVofsy6kTVRNSS4hO4UNtMuMQ
    hYf6UAPaJv3PhFXKYYu0tEp2THZVTlUtTjyKAZrNiKyRpC/0exbJjJMqkYmmUG9r
    yP1CvubJnmHda2u42981dK3pz5TlLEO4MrBry6vynN0TJfXwn1nt7YMVatiViQb9
    UK5NDbjVKBBE6KkN28kSJtsTkCOM7+RztjLdf+7ZWzwxFV5EkM+2SLPIhQFCMjRG
    ...
```

Keys in configuration management

Keys in configuration management

- Bootstrap configuration management

Keys in configuration management

- Bootstrap configuration management
- Does not scale for unique keys

Keys in configuration management

- Bootstrap configuration management
- Does not scale for unique keys

```
#!yaml|gpg

root-password: |
{% if grains['hostname'] == 'baredog' %}
  -----BEGIN PGP MESSAGE-----
  ...
{% elif grains['hostname'] == 'cheesyonion' %}
  -----BEGIN PGP MESSAGE-----
  ...
{% elif grains['hostname'] == … %}
```

Keys on local disk

Keys on local disk

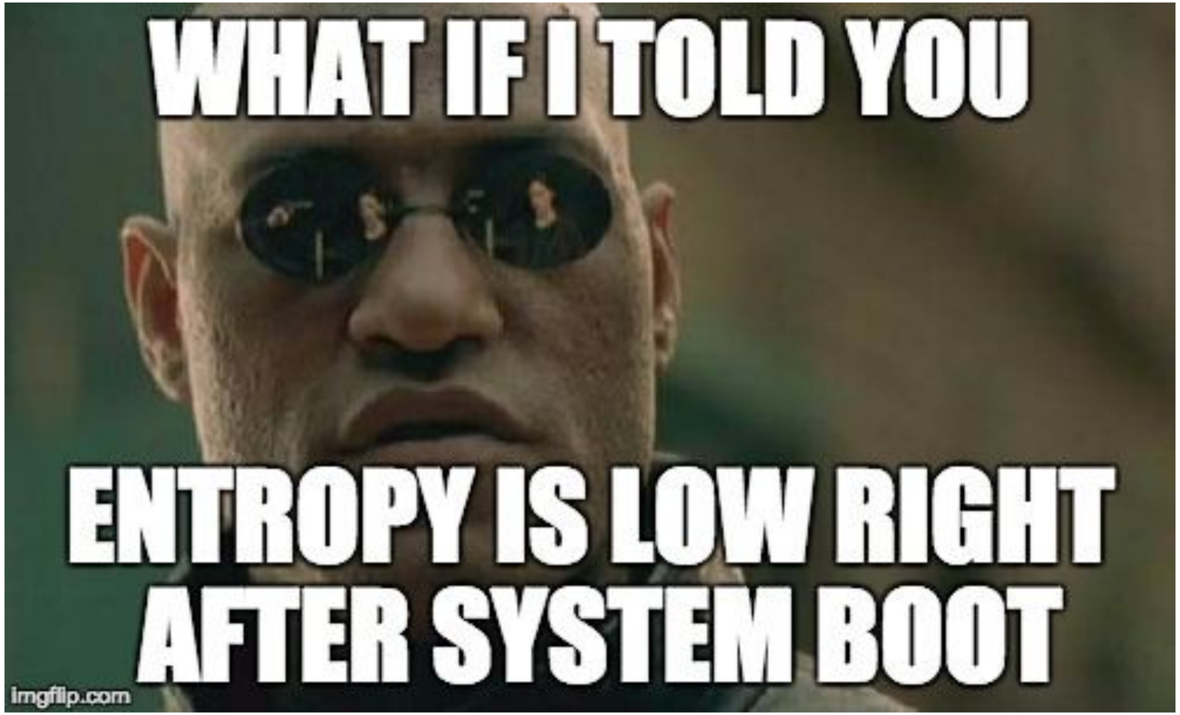
- Usually generated by startup scripts

```
#!/bin/bash

# super nitty startup script, fully automated !!!
if [ ! -f /etc/server_key ]; then
  dd if=/dev/urandom of=/etc/server_key bs=1 count=32
fi

# don't forget SSH
if [ ! -f /etc/ssh/id_rsa ]; then
  ssh-keygen -f /etc/ssh/id_rsa
fi
```

Entropy


WHAT IF I TOLD YOU
ENTROPY IS LOW RIGHT AFTER SYSTEM BOOT
imgflip.com

Keys on local disk

Keys on local disk

- Not suitable for some key types

Keys on local disk

- Not suitable for some key types
    - root passwords

CLOUDFLARE

Keys on local disk

- Not suitable for some key types
    - root passwords
- Does not play well with disk encryption

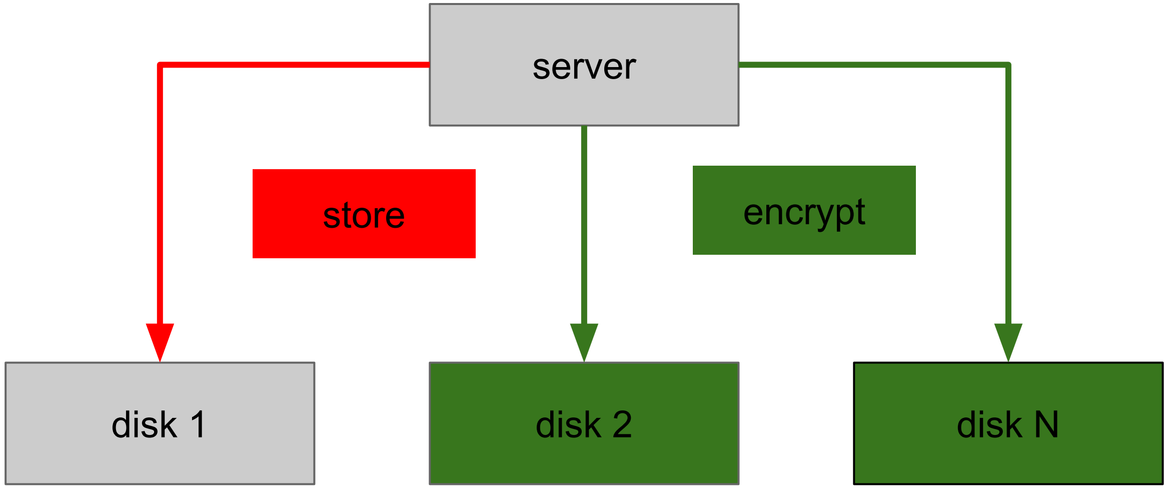
Keys on local disk

- Not suitable for some key types
  - root passwords
- Does not play well with disk encryption
  - decrypt configuration management key

Keys on local disk

- Not suitable for some key types
  - root passwords
- Does not play well with disk encryption
  - decrypt configuration management key
- What about diskless/stateless systems?

Encrypted disks



Unified Extensible Firmware Interface

Unified Extensible Firmware Interface

- Aka BIOS 2.0

Unified Extensible Firmware Interface

- Aka BIOS 2.0
- Standard pre-OS environment

Unified Extensible Firmware Interface

- Aka BIOS 2.0
- Standard pre-OS environment
- Extensible (you can write your own apps)

Unified Extensible Firmware Interface

- Aka BIOS 2.0
- Standard pre-OS environment
- Extensible (you can write your own apps)
- Supported by most major OSes

Unified Extensible Firmware Interface

- Aka BIOS 2.0
- Standard pre-OS environment
- Extensible (you can write your own apps)
- Supported by most major OSes
- Provides many advanced features

Unified Extensible Firmware Interface

- Aka BIOS 2.0
- Standard pre-OS environment
- Extensible (you can write your own apps)
- Supported by most major OSes
- Provides many advanced features
    - UEFI variables

CLOUDFLARE

UEFI variables

- Backed by flash memory on platform firmware chip

UEFI variables

- Backed by flash memory on platform firmware chip
- Can store standard and custom (OEM/user) data

UEFI variables

- Backed by flash memory on platform firmware chip
- Can store standard and custom (OEM/user) data
- Can be accessed after OS kernel booted

UEFI variables

- Backed by flash memory on platform firmware chip
- Can store standard and custom (OEM/user) data
- Can be accessed after OS kernel booted
- Have built-in support in Linux

CLOUDFLARE

UEFI variables in Linux

```
# not needed for systemd-based Linux distributions
mount -t efivarfs efivarfs /sys/firmware/efi/efivars


# need to prepend data with 4 byte attr and put an “owner” GUID
cat <(printf "\x07\x00\x00\x00") <(cat mydata.bin) > \
/sys/firmware/efi/efivars/mydata-<some GUID>
```

UEFI variables in Linux

```
# not needed for systemd-based Linux distributions
mount -t efivarfs efivarfs /sys/firmware/efi/efivars

# need to prepend data with 4 byte attr and put an “owner” GUID
cat <(printf "\x07\x00\x00\x00") <(cat mydata.bin) > \
/sys/firmware/efi/efivars/mydata-<some GUID>
```

- always available

UEFI variables in Linux

```
# not needed for systemd-based Linux distributions
mount -t efivarfs efivarfs /sys/firmware/efi/efivars


# need to prepend data with 4 byte attr and put an “owner” GUID
cat <(printf "\x07\x00\x00\x00") <(cat mydata.bin) > \
/sys/firmware/efi/efivars/mydata-<some GUID>
```

- always available
- can be accessed in early boot stages

CLOUDFLARE

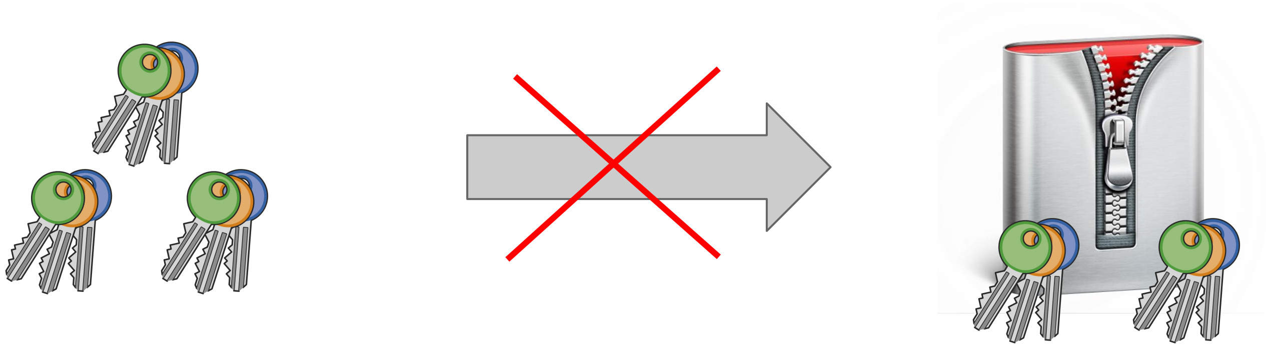
UEFI variables in Linux

```
# not needed for systemd-based Linux distributions
mount -t efivarfs efivarfs /sys/firmware/efi/efivars


# need to prepend data with 4 byte attr and put an “owner” GUID
cat <(printf "\x07\x00\x00\x00") <(cat mydata.bin) > \
/sys/firmware/efi/efivars/mydata-<some GUID>
```

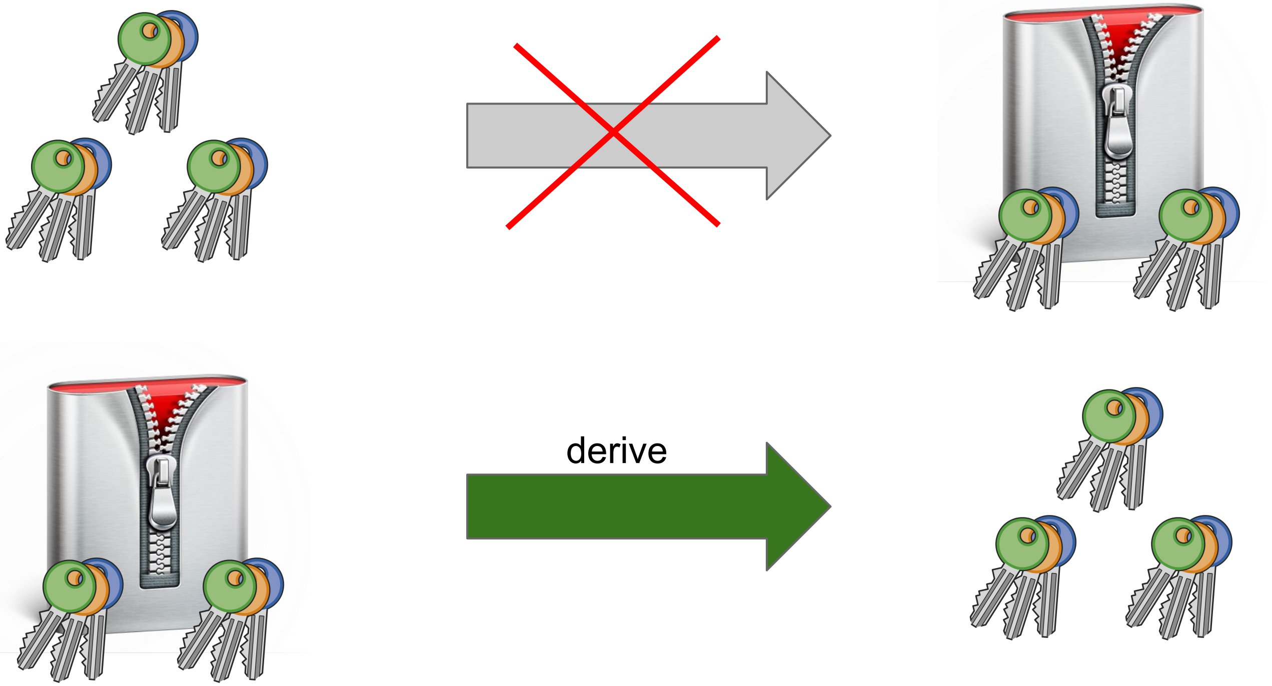
- always available
- can be accessed in early boot stages
- however, may have limited storage

Keys in cryptography

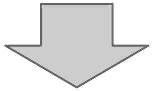


CLOUDFLARE

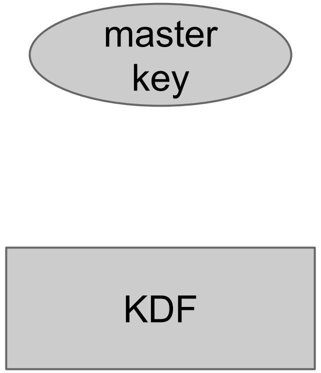
Keys in cryptography



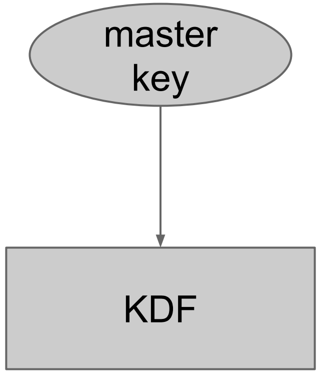
Keys in cryptography



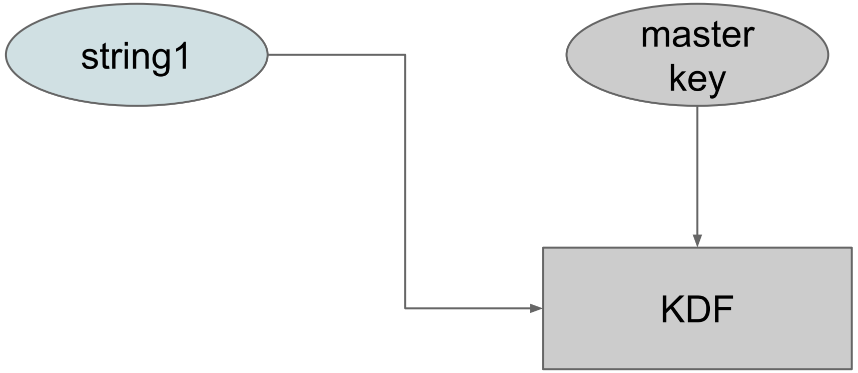
Key derivation functions



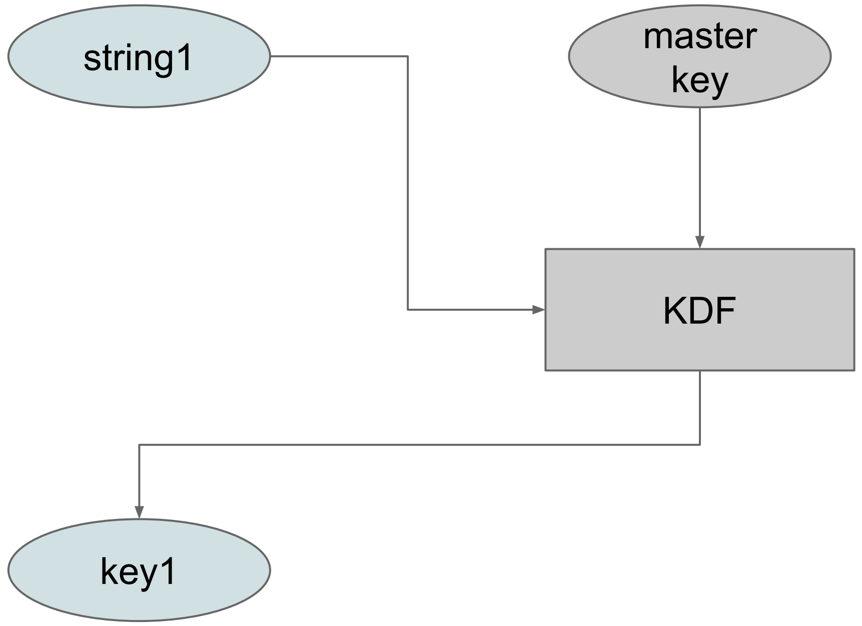
Key derivation functions



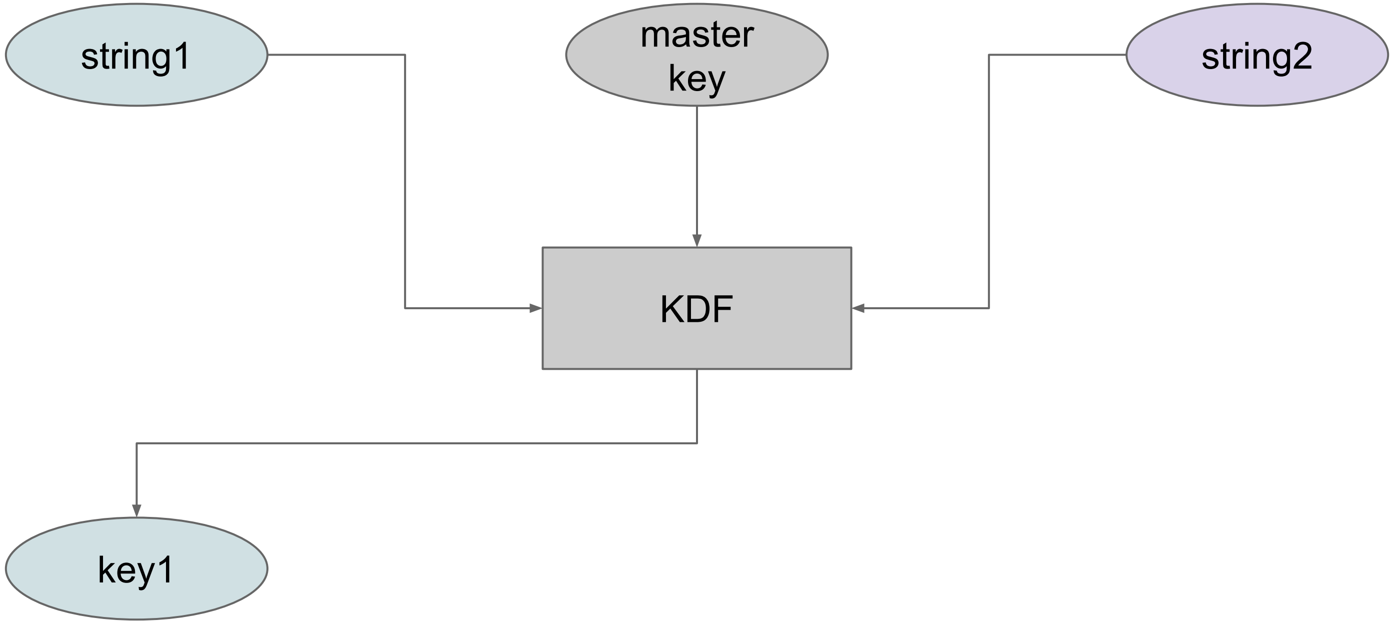
Key derivation functions



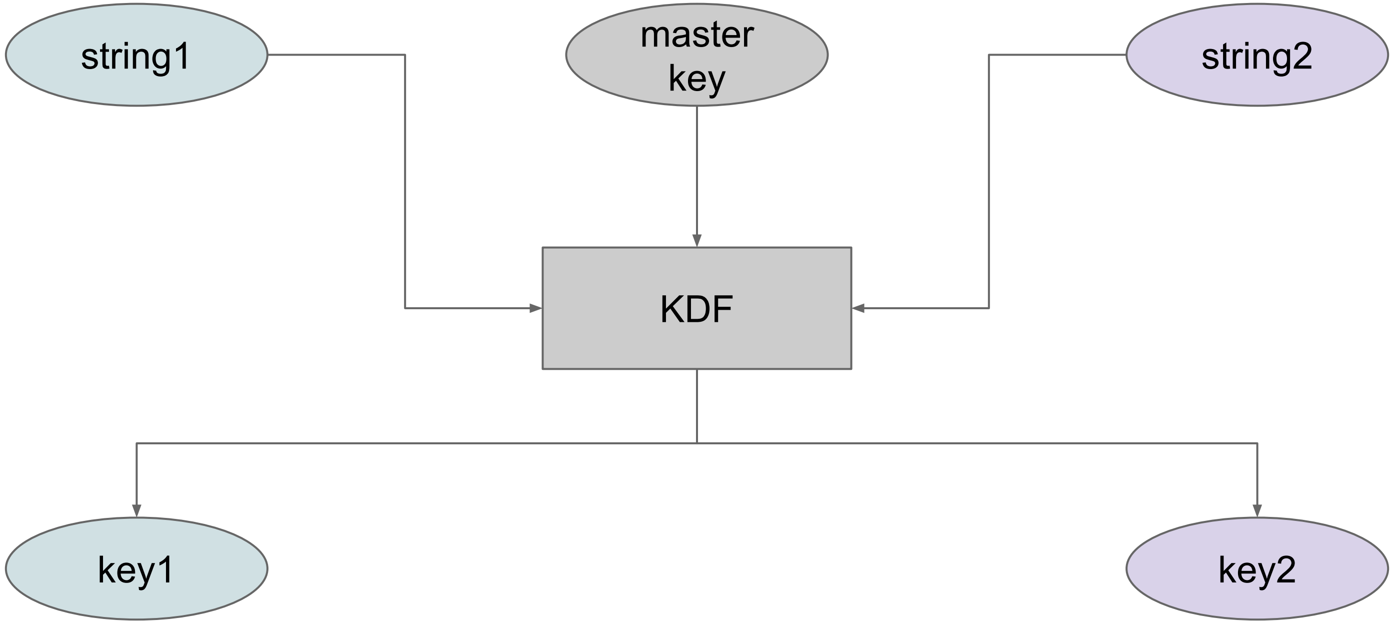
Key derivation functions



Key derivation functions



Key derivation functions

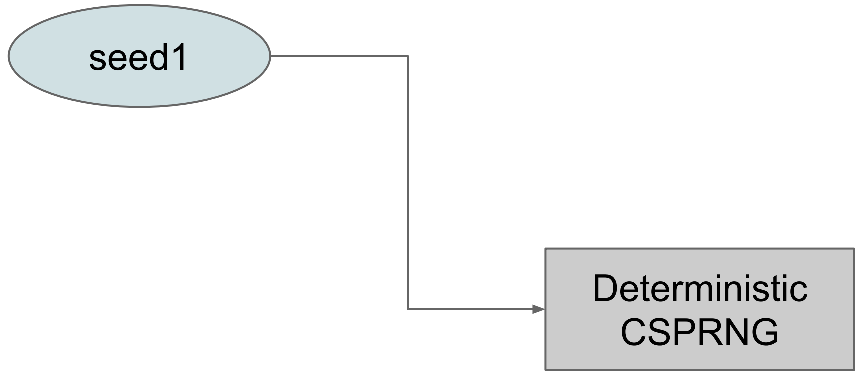


CLOUDFLARE

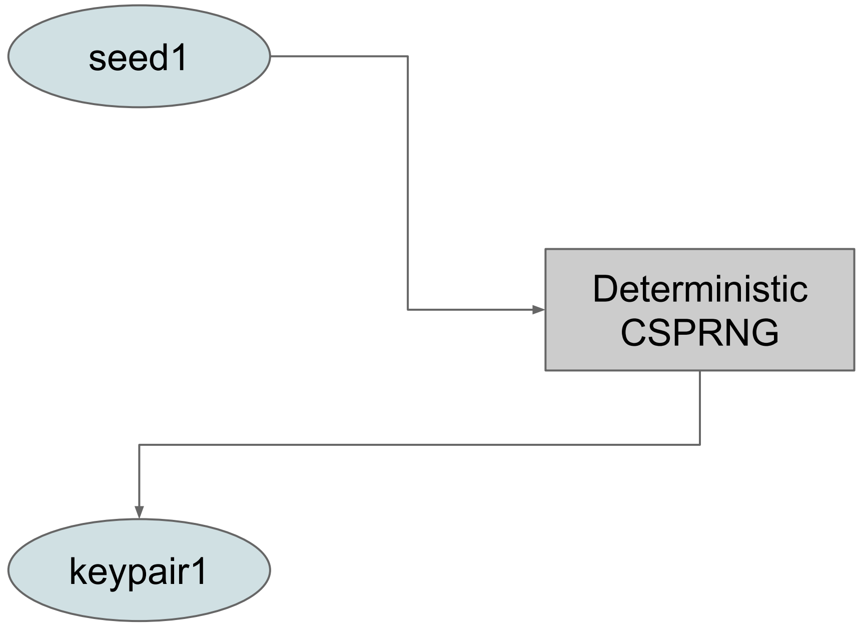
Generating key pairs

Deterministic CSPRNG

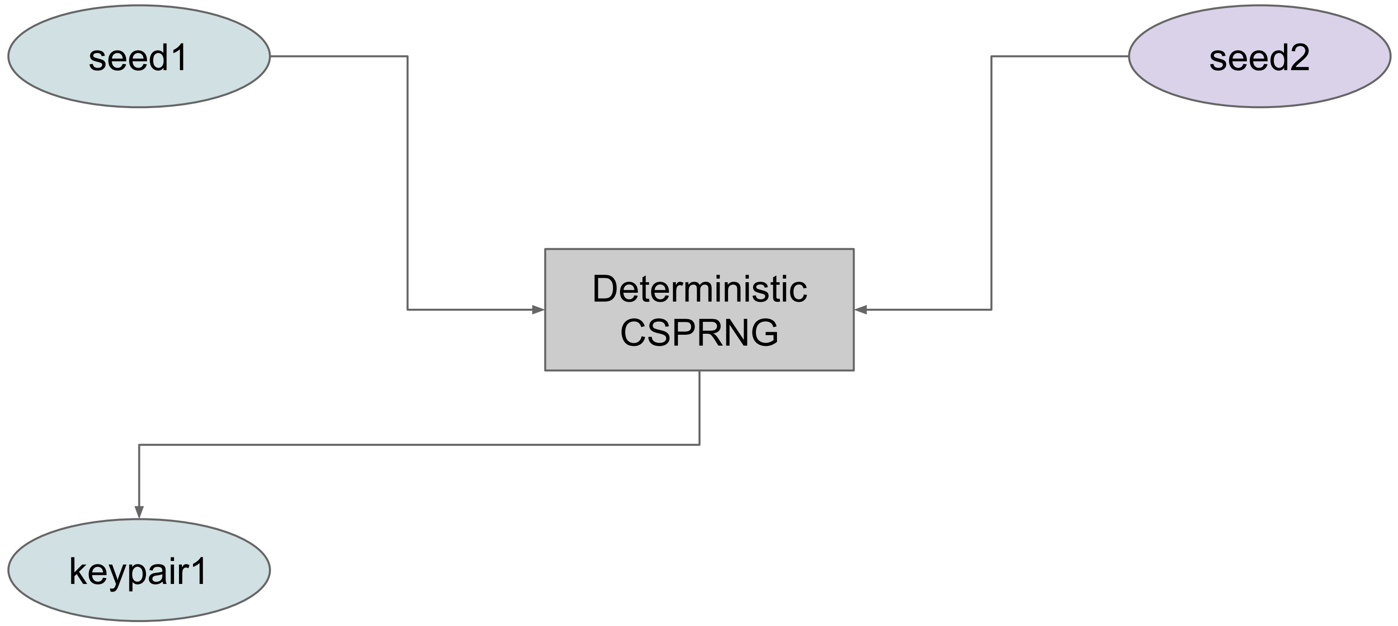
Generating key pairs



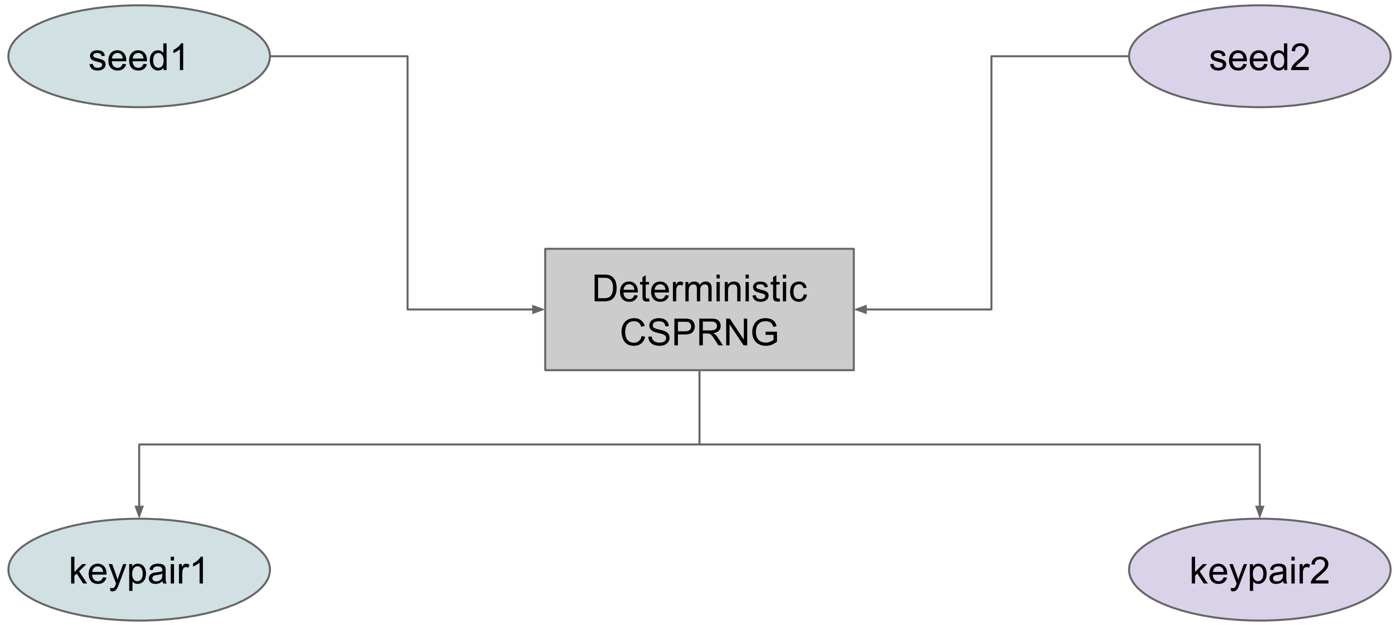
Generating key pairs



Generating key pairs



Generating key pairs

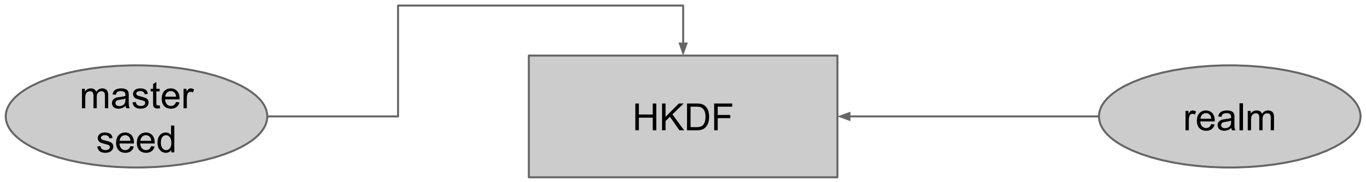


Introducing gokey tool

master seed
realm

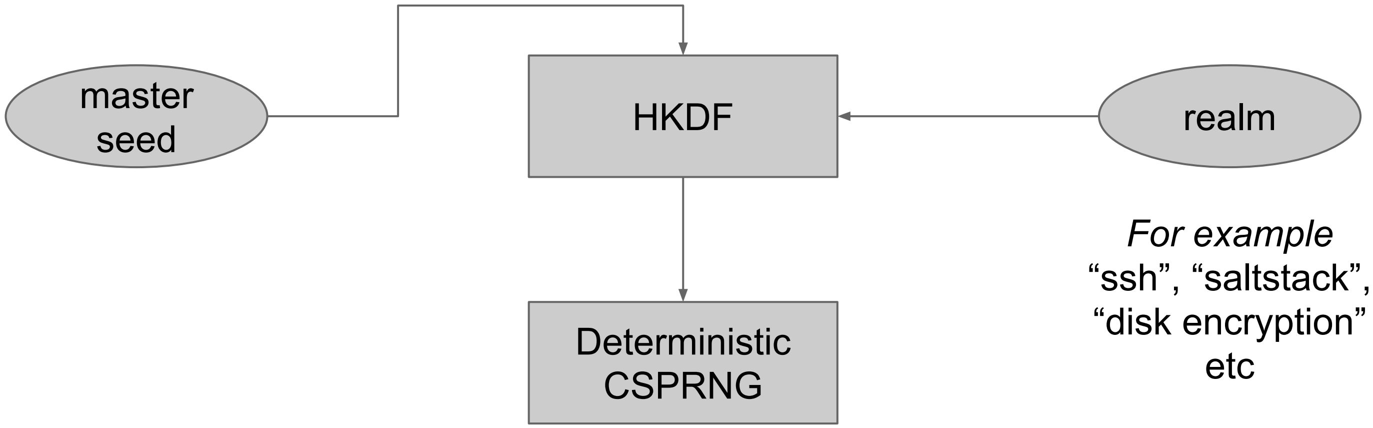
For example
“ssh”, “saltstack”,
“disk encryption”
etc

Introducing gokey tool



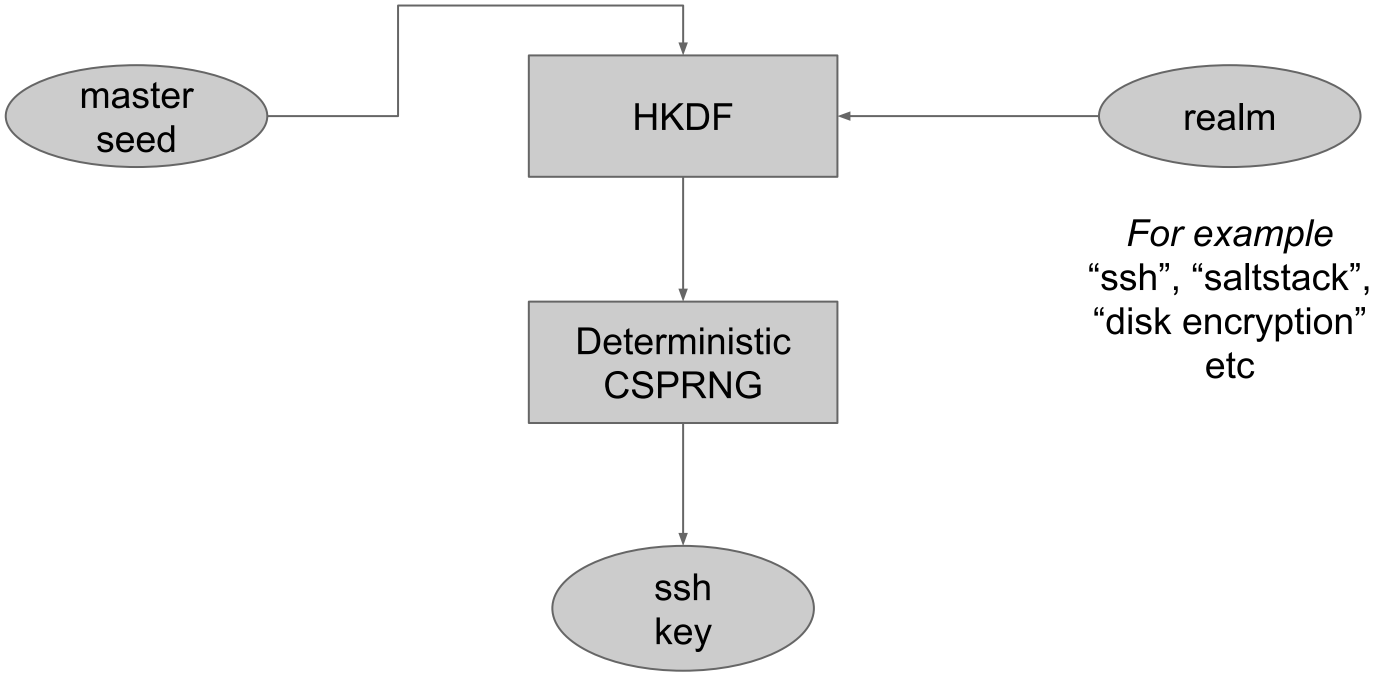
For example
“ssh”, “saltstack”,
“disk encryption”
etc

Introducing gokey tool



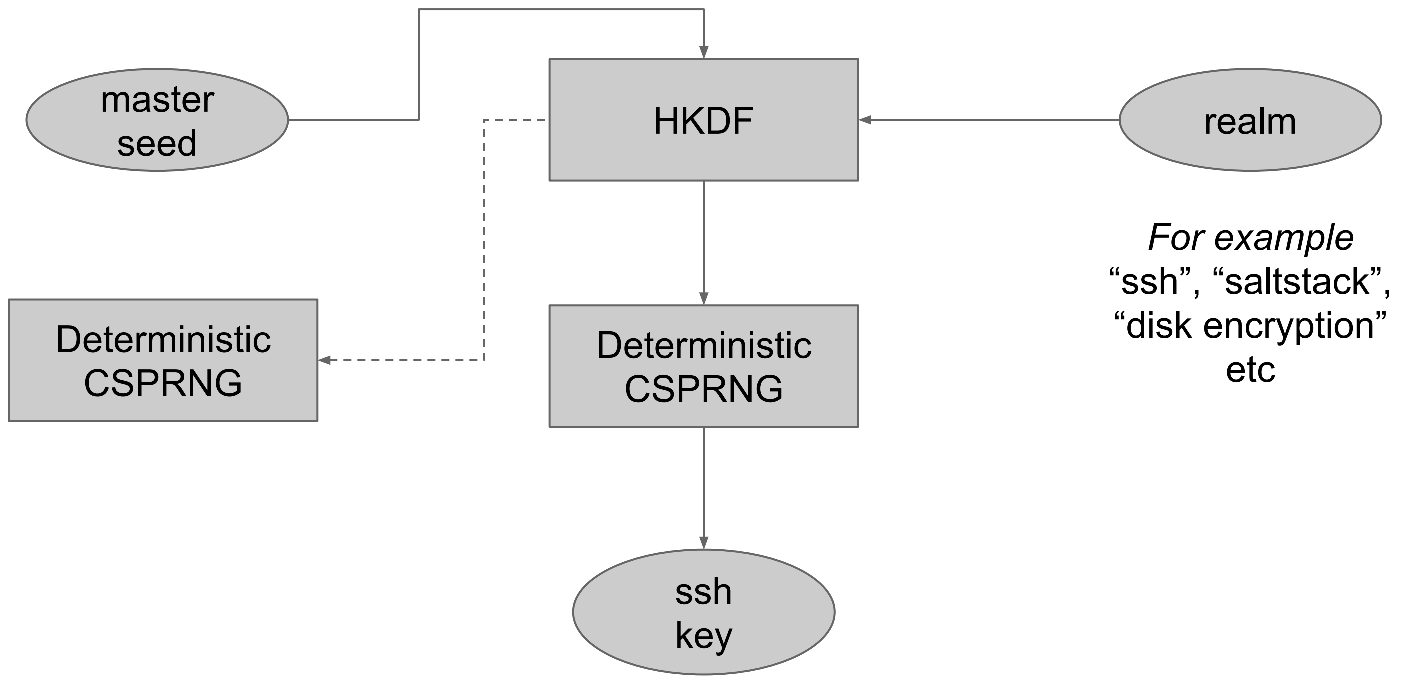
For example
“ssh”, “saltstack”,
“disk encryption”
etc

Introducing gokey tool



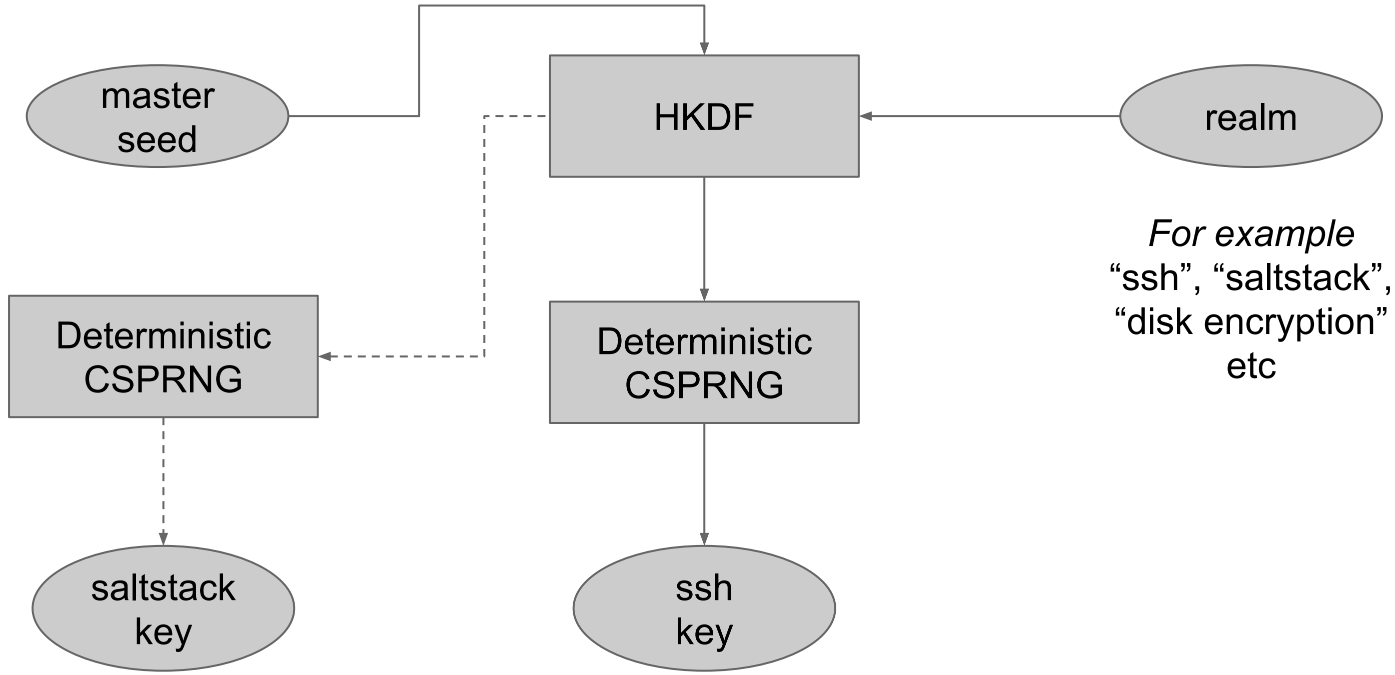
For example
“ssh”, “saltstack”,
“disk encryption”
etc

Introducing gokey tool



For example
“ssh”, “saltstack”,
“disk encryption”
etc

Introducing gokey tool



For example
“ssh”, “saltstack”,
“disk encryption”
etc

Key management

- Provisioning process ensures a master seed is generated and stored in UEFI on first boot

CLOUDFLARE

Key management

- Provisioning process ensures a master seed is generated and stored in UEFI on first boot
- Startup scripts “recover” (derive from master seed) configuration management credential (key)

Key management

- Provisioning process ensures a master seed is generated and stored in UEFI on first boot
- Startup scripts “recover” (derive from master seed) configuration management credential (key)
- Configuration management “recovers” all other keys

Key management

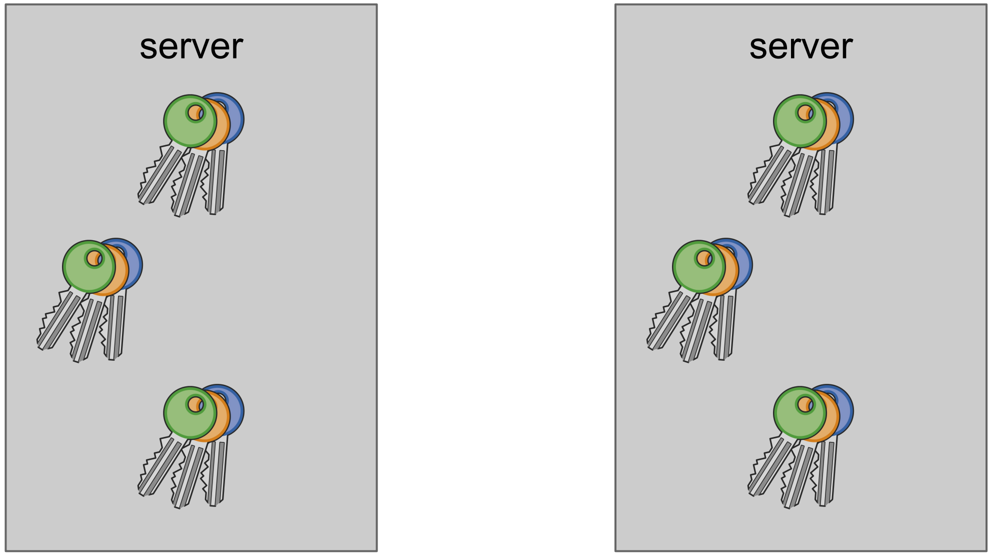
```
root-password: |
{% if grains['hostname'] == 'baredog' %}
  -----BEGIN PGP MESSAGE-----
  ...
{% elif grains['hostname'] == 'cheesyonion' %}
  -----BEGIN PGP MESSAGE-----
```

Key management

```
root-password: |
{% if grains['hostname'] == 'baredog' %}
  -----BEGIN PGP MESSAGE-----
  ...
{% elif grains['hostname'] == 'cheesyonion' %}
  -----BEGIN PGP MESSAGE-----
```

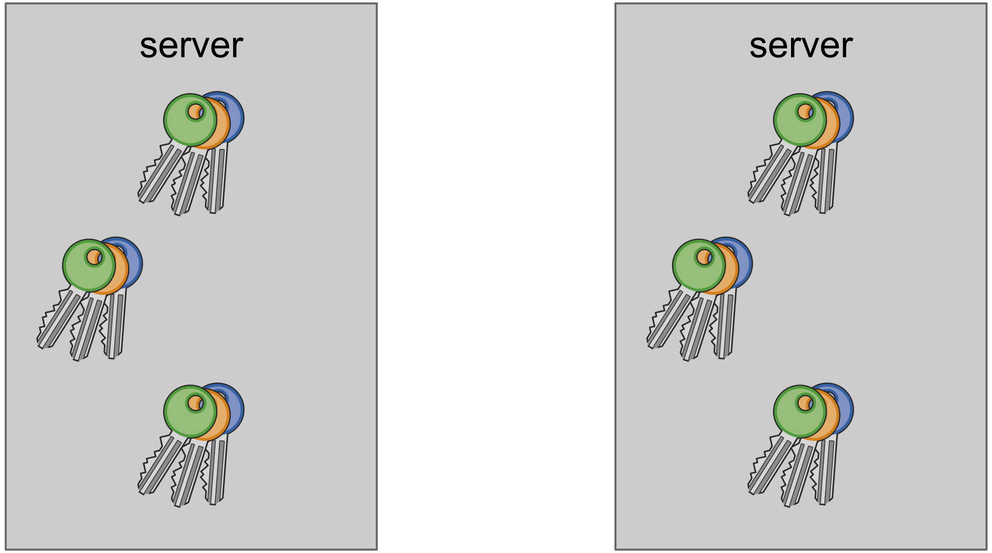
```
root-password: {% gokey('root-password') %}
ssh-key: {% gokey('ssh') %}
```

Adding a service key



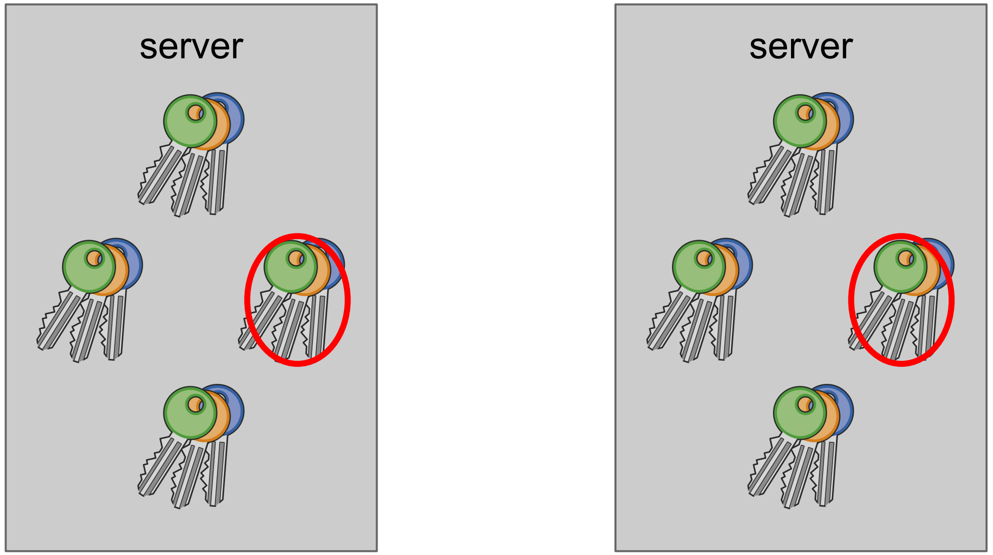
CLOUDFLARE

Adding a service key



```
my-service-key: {% gokey('my-service-key') %}
```

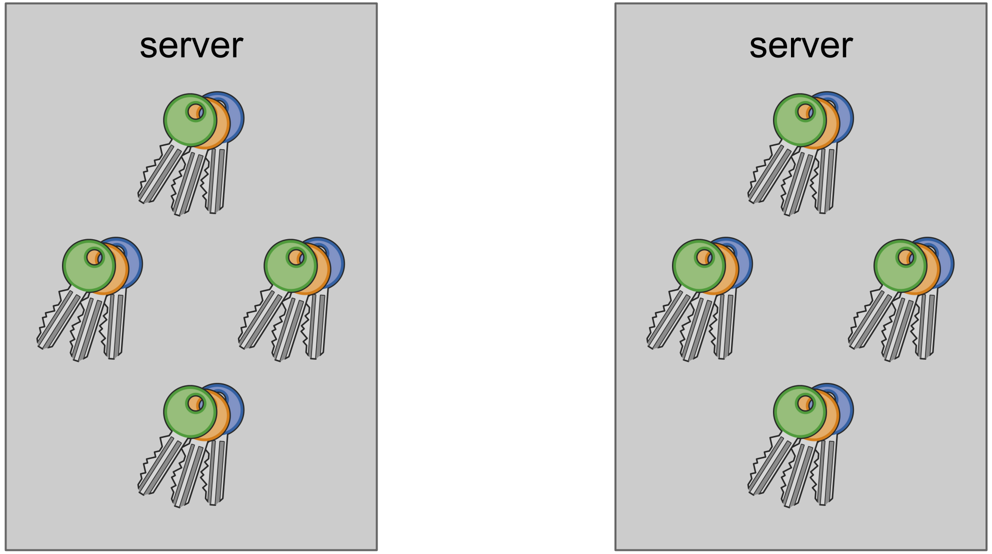
Adding a service key



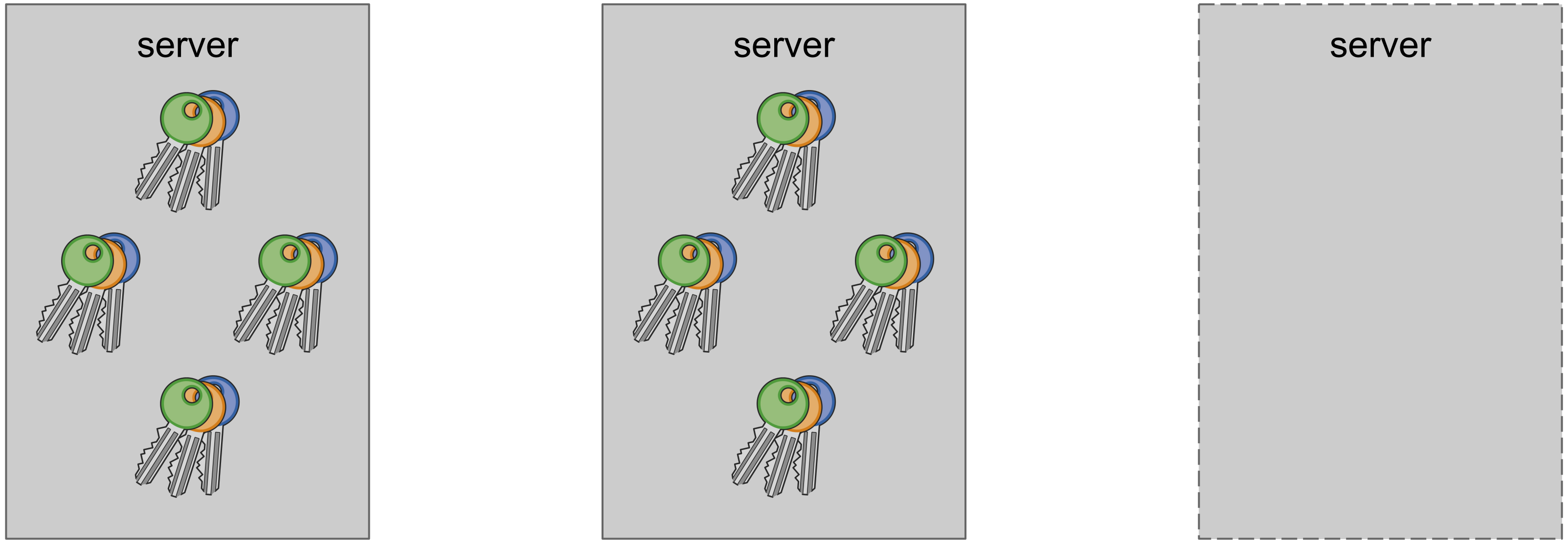
```
my-service-key: {% gokey('my-service-key') %}
```

CLOUDFLARE

Adding a server

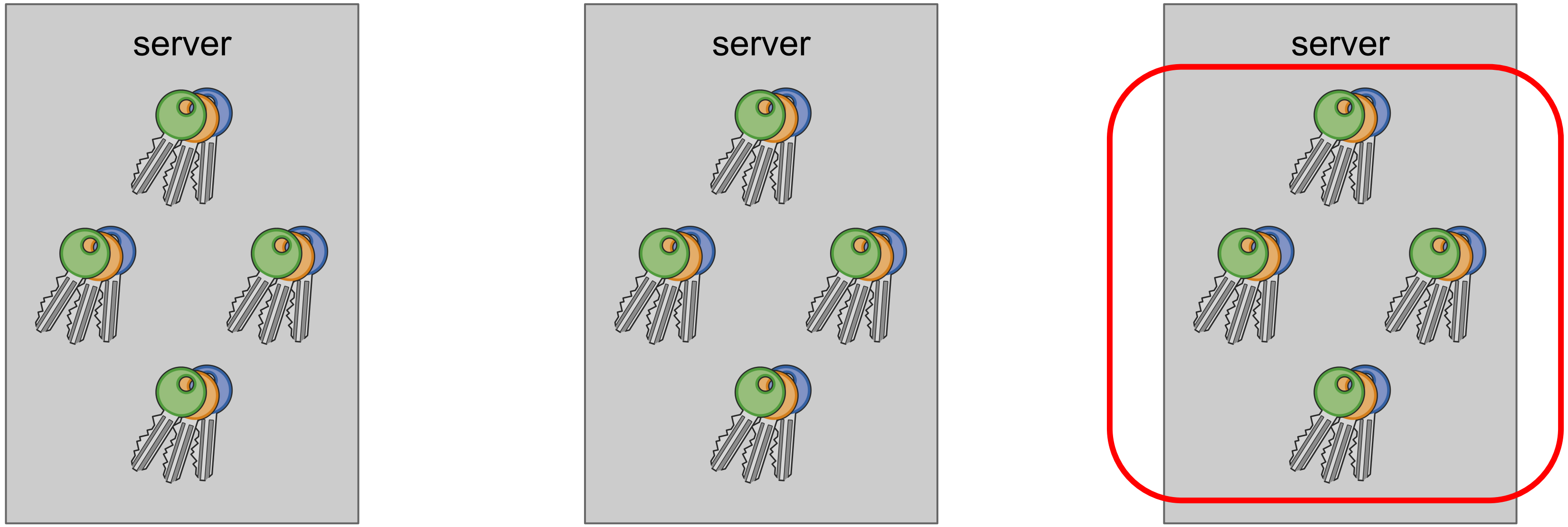


Adding a server

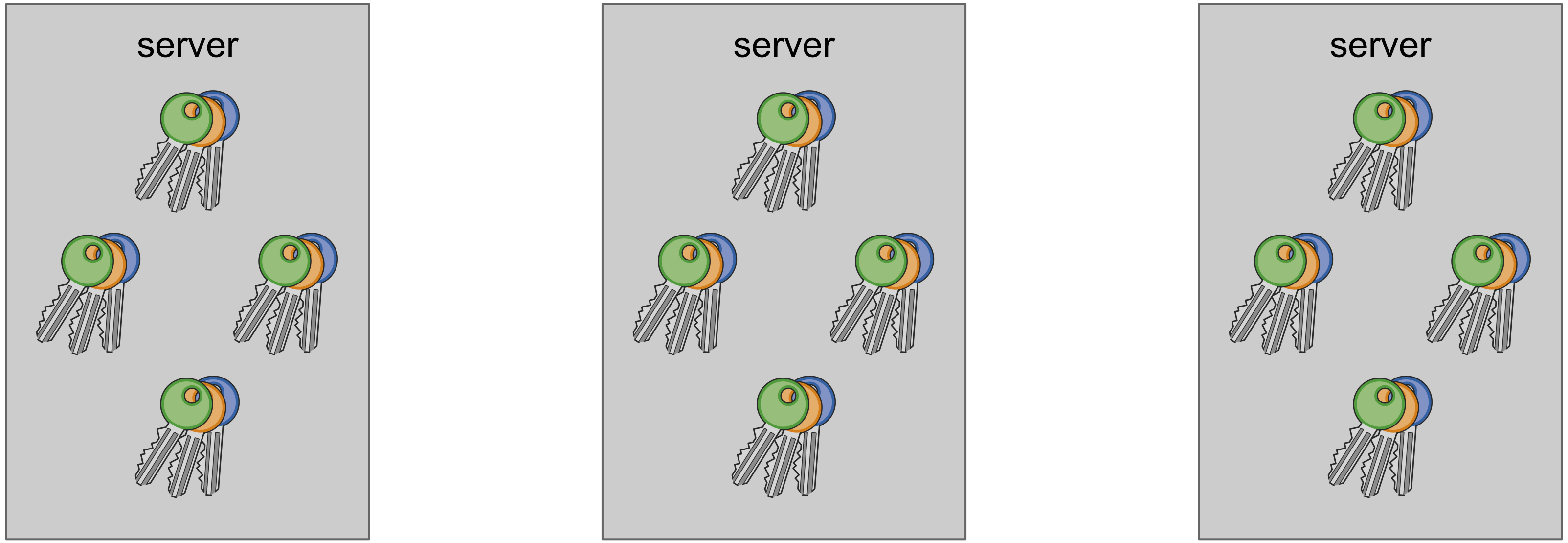


CLOUDFLARE

Adding a server

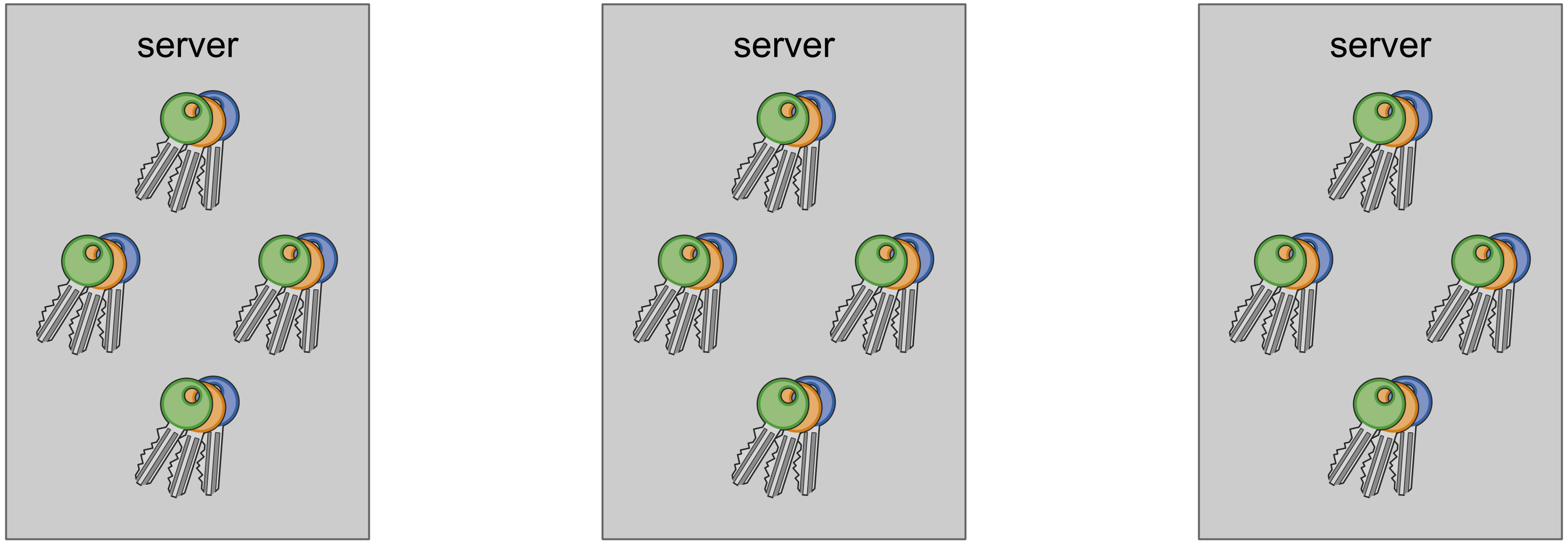


Rotate a specific service key



CLOUDFLARE

Rotate a specific service key

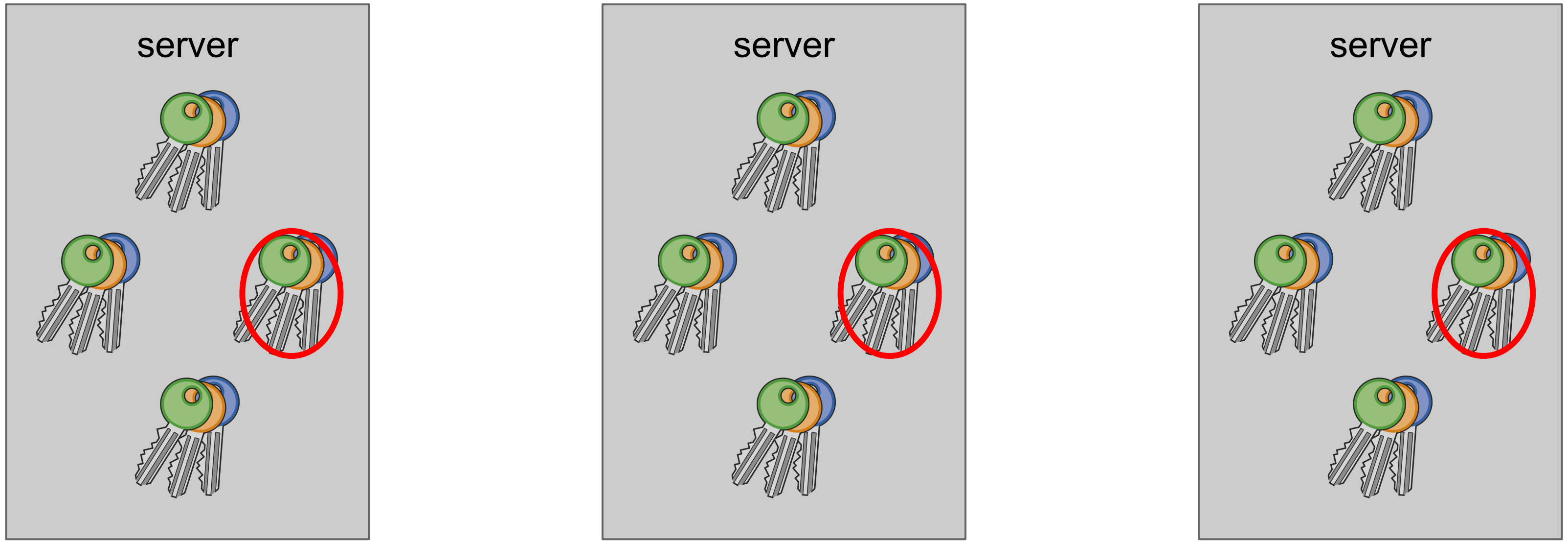


```
ssh-key: {% gokey('ssh') %}
```

```
ssh-key: {% gokey('ssh-v2') %}
```

CLOUDFLARE

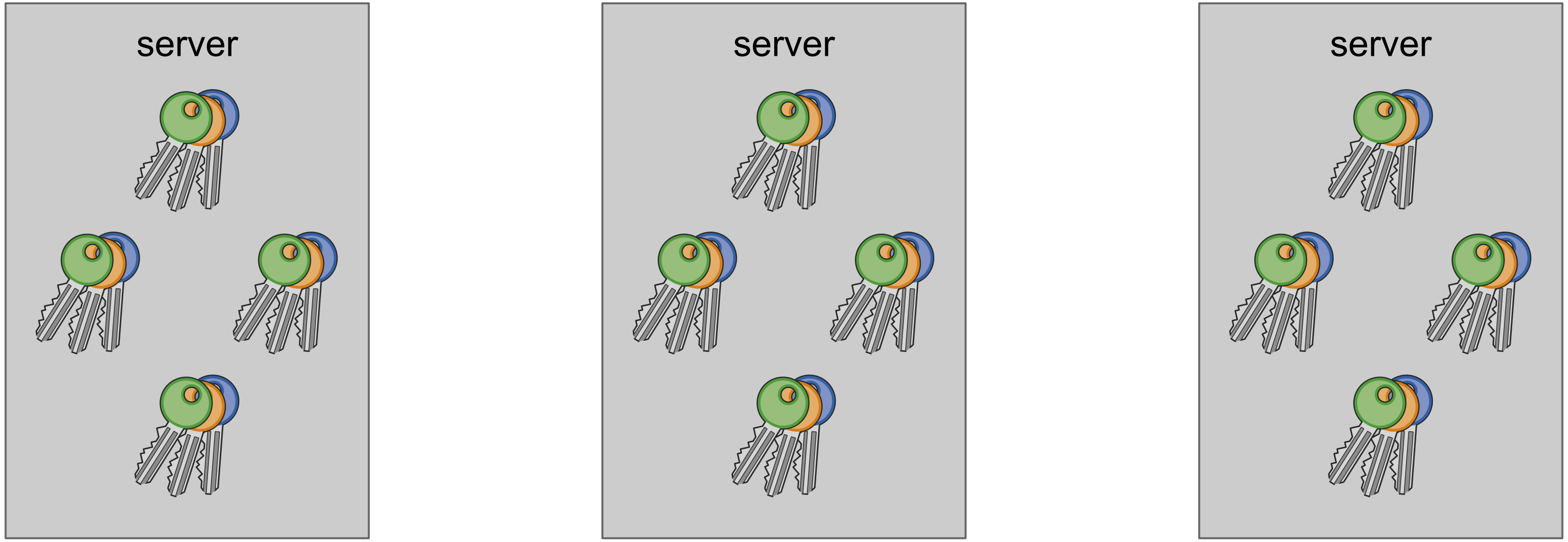
Rotate a specific service key



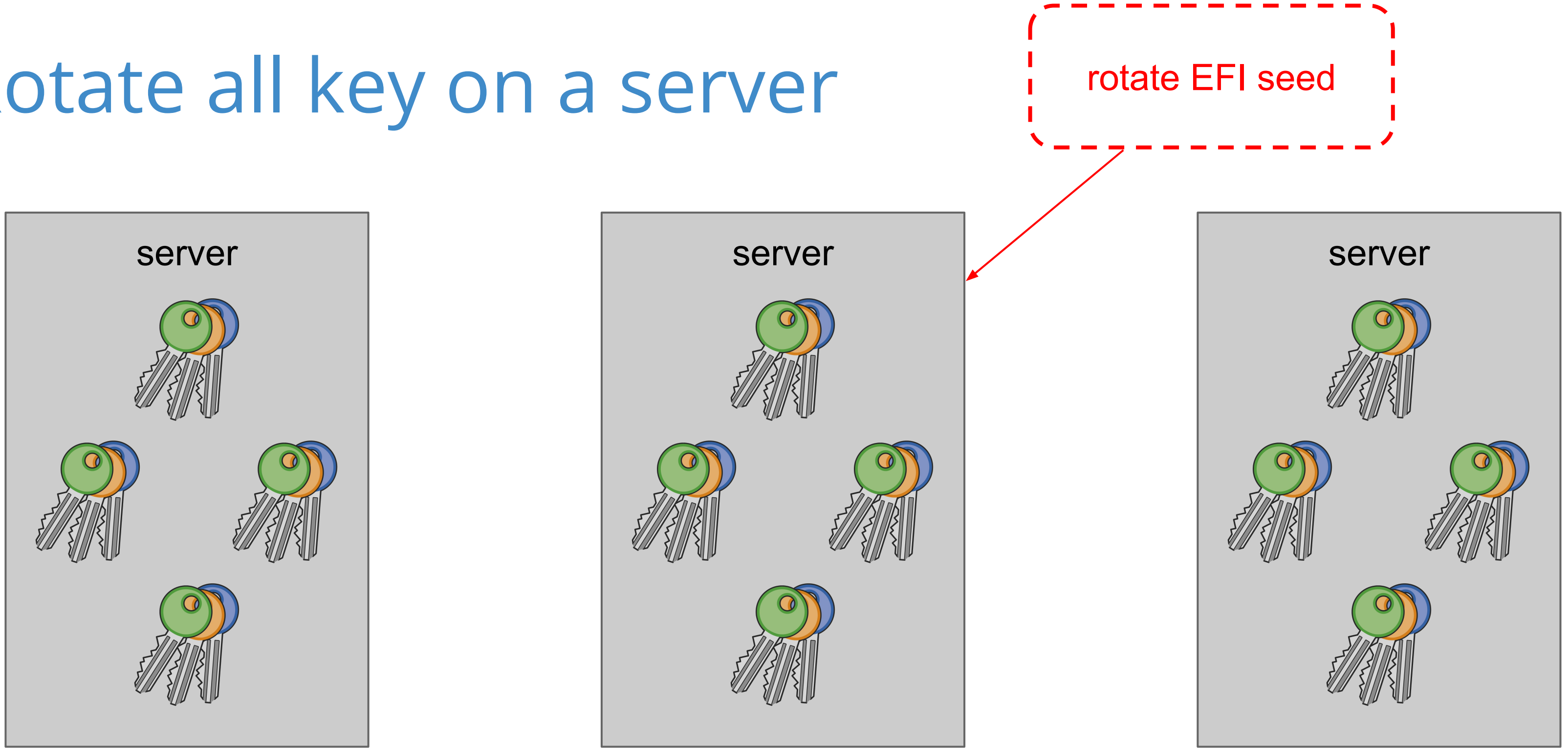
```
ssh-key: {% gokey('ssh') %}
```

```
ssh-key: {% gokey('ssh-v2') %}
```

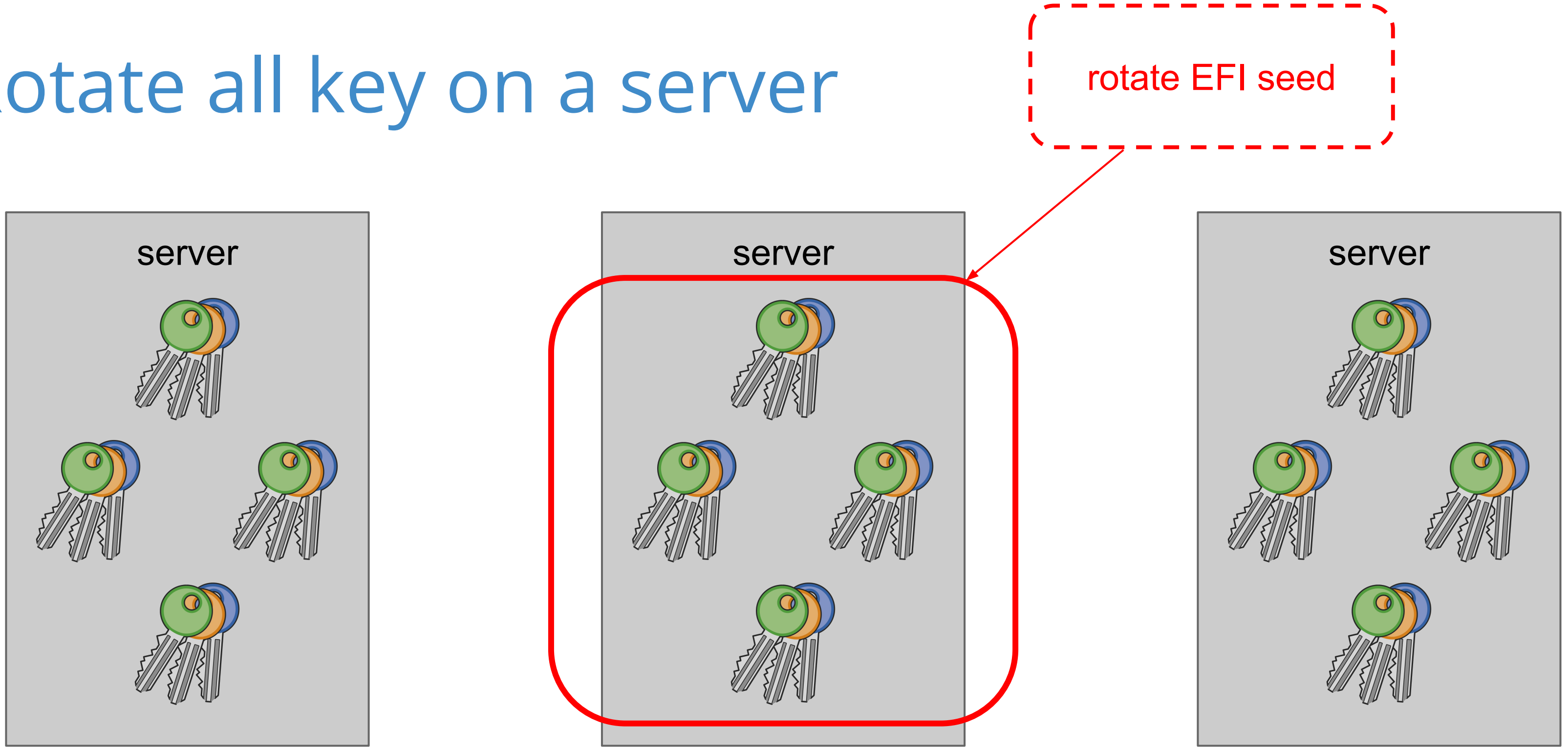
Rotate all key on a server



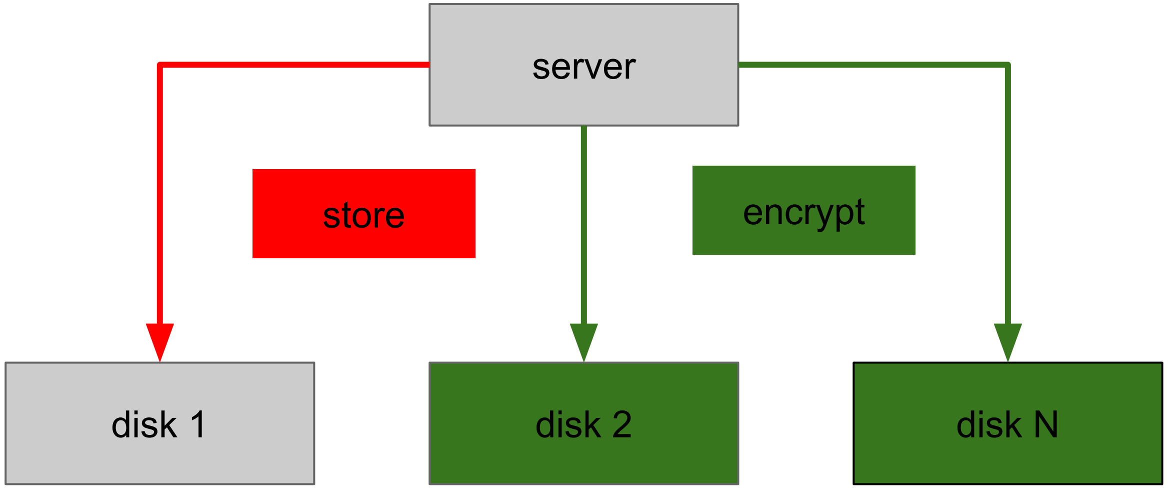
Rotate all key on a server



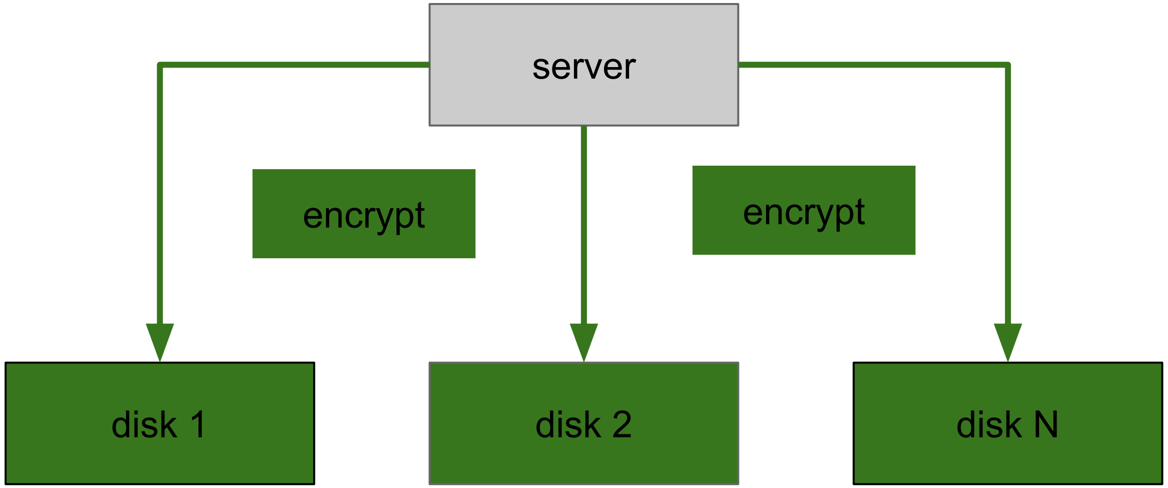
Rotate all key on a server



Encrypted disks (previously)



Encrypted disks



Conclusions

Conclusions

- Decouple key storage from regular storage

Conclusions

- Decouple key storage from regular storage
- Decouple key contents from key management

CLOUDFLARE

Conclusions

- Decouple key storage from regular storage
- Decouple key contents from key management
- Easy to add new or rotate existing keys

Conclusions

- Decouple key storage from regular storage
- Decouple key contents from key management
- Easy to add new or rotate existing keys
- Better security guarantees

Conclusions

- Decouple key storage from regular storage
- Decouple key contents from key management
- Easy to add new or rotate existing keys
- Better security guarantees

https://github.com/cloudflare/gokey

CLOUDFLARE®

Thank you