KubeCon | CloudNativeCon

China 2018

Turtles all the way down: securely managing Kubernetes secrets with secrets

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Turtles all the way down

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Protecting secrets

What's a secret?

Credentials, configurations, API keys, and other small bits of information needed by applications at build or run time

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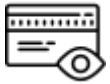
Why protect secrets?

- Attractive target
  - Controls access or use of sensitive resources
- Common attack vector
  - Checked into Github
  - Accessible by users who shouldn’t have access, e.g., CEO
  - Stored in public storage buckets

Secret management requirements

Identity

Require strong identities and least privilege



Auditing

Verify the use of individual secrets

Encryption

Always encrypt before writing to disk

Rotation

Change a secret regularly in case of compromise

Isolation

Separate where secrets are used vs managed

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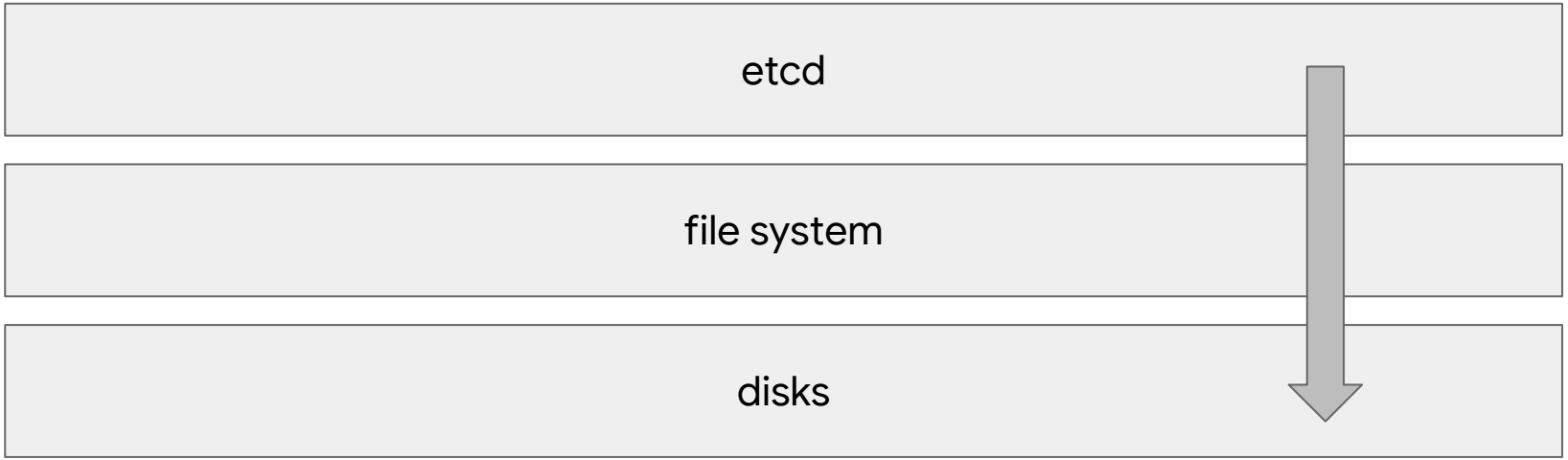
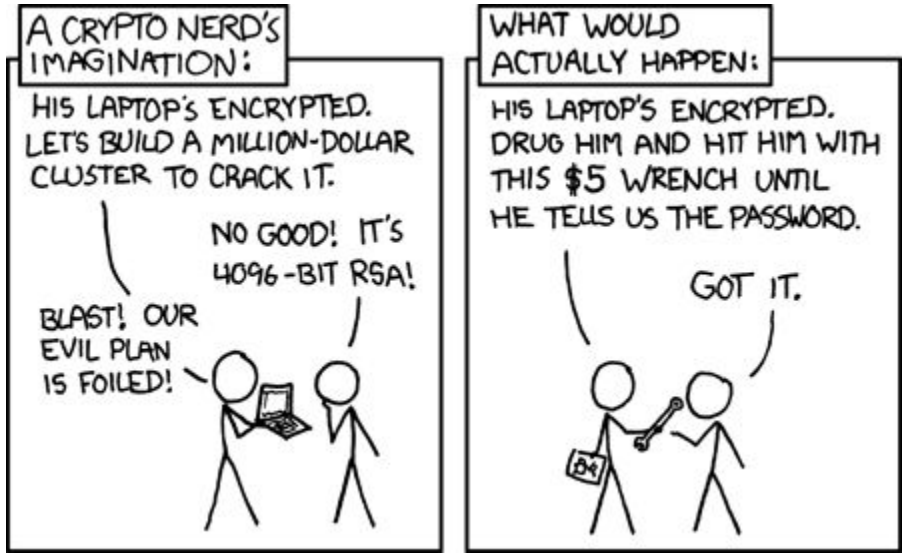
Encryption at different layers (or turtles)



Recommendation: Use two-layers of encryption, e.g., full-disk & application-layer

… then tries to decrypt it



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https://xkcd.com/538/, https://xkcd.com/license.html

Key rotation

“Keys are analogous to the combination of a safe. If a safe combination is known to an adversary, the strongest safe provides no security against penetration. Similarly, poor key management may easily compromise strong algorithms.”

NIST SP 800-57, Recommendation for Key Management


Keys get old

Key rotation

- **Key rotation** is meant to limit the
  - ‘Blast radius’ if a single key is compromised
  - Time available for attempts to penetrate physical, procedural, and logical access
  - Time available for computationally intensive cryptanalytic attacks
- A **cryptoperiod** is the time during which a key is used to encrypt data

Key rotation: cryptoperiod

There are lots of factors that influence the choice of cryptoperiod

From NIST SP 800-57:

- Strength of cryptographic algorithms used
- Implementation
- Operating environment
- Volume of data
- Re-keying method
- Number of key copies
- Personnel turnover
- Threat model
- New and disruptive technologies, e.g., quantum computers

Key rotation: compliance

PCI DSS v3.2.1

3.5 Document and implement procedures to protect keys used to secure stored cardholder data against disclosure and misuse.

3.6 Fully document and implement all key-management processes and procedures for cryptographic keys used for encryption of cardholder data, including the following:

> 3.6.4 Cryptographic key changes for keys that have reached the end of their cryptoperiod (for example, after a defined period of time has passed and/or after a certain amount of cipher-text has been produced by a given key)

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https://www.pcisecuritystandards.org/documents/Prioritized-Approach-for-PCI-DSS-v3_2_1.pdf


Re-encrypting
data is hard

Envelope encryption

Envelope encryption

Data

Envelope encryption

Data

Data encryption key (DEK)

Envelope encryption

Data

Data encryption key (DEK)

Key encryption key (KEK)

Envelope encryption: benefits

Easier to manage

Envelope encryption: best practices

Managing DEKs:

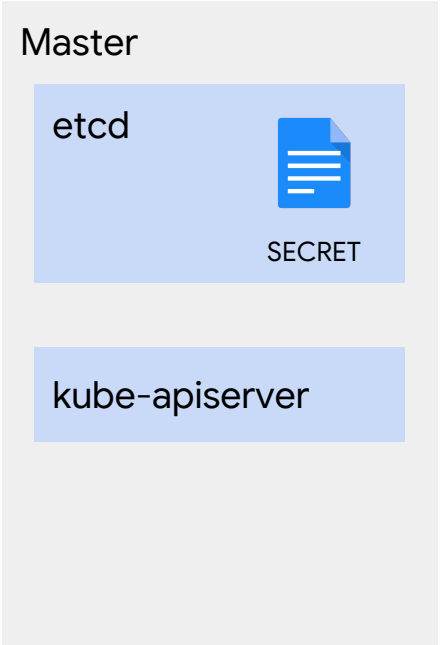
- Generate DEKs locally
- Use a strong cryptographic algorithm
- For easy access, store the DEK near the data that it encrypts
- Ensure DEKs are encrypted at rest
- Don’t use the same DEK to encrypt data from two different apps/users
- Generate a new DEK every time you write the data. This means you don't need to rotate the DEKs

Managing KEKs:

- Store KEKs centrally
- Set the granularity of the DEKs encrypted based on use case
- Rotate keys regularly, and also after a suspected incident

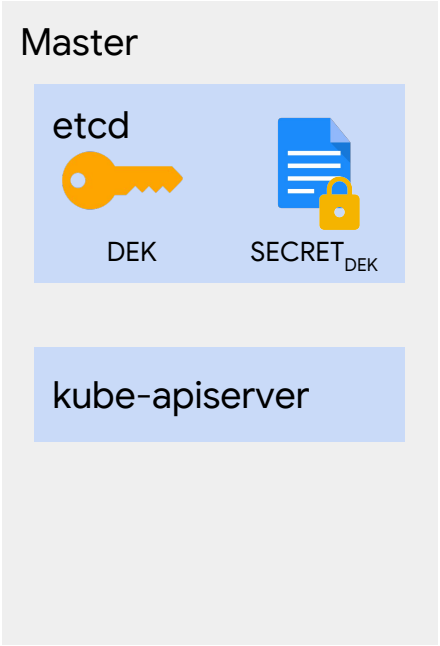
Kubernetes secrets

Kubernetes secrets



- Secrets are stored in etcd
  - base64 encoded
- A pod can access secrets via the filesystem, as an environment variable, or via Kubernetes API call
- Operations with secrets are audit logged

Kubernetes secrets: 1.7 EncryptionConfig



- Encrypt secrets with a locally managed key
- EncryptionConfig for secrets
- Multiple provider options
  - aesgcm
  - aescbc
  - secretbox

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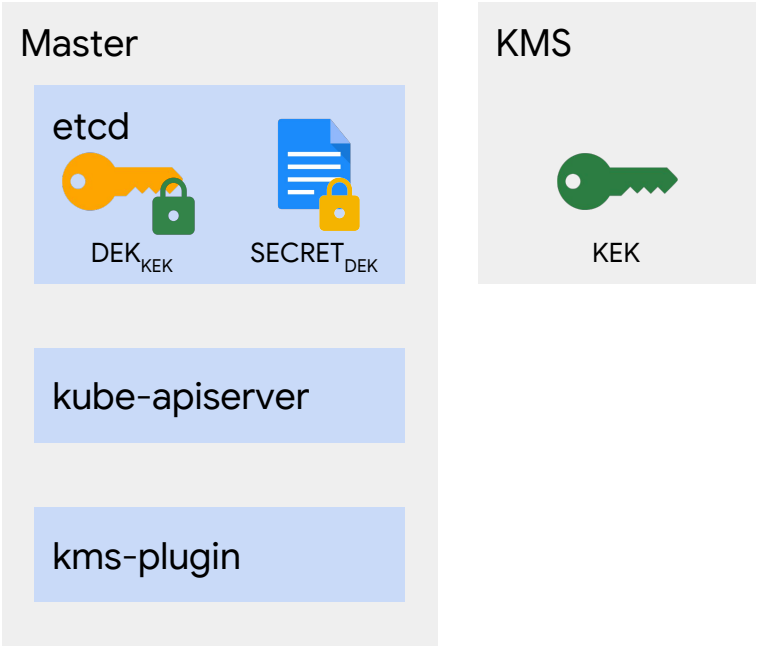
Kubernetes secrets: 1.7 EncryptionConfig

```
kind: EncryptionConfig
apiVersion: v1
resources:
  - resources:
    - secrets
    providers:
    - identity: {}
    - aesgcm:
        keys:
        - name: key1
          secret: c2VjcmV0IGlzIHNlY3VyZQ==
    - aescbc: {}
    - secretbox: {}
```

Kubernetes secrets: 1.10 KMS plugins



- Encrypt secrets with a locally managed key, which is then encrypted with a centrally managed key
- EncryptionConfig uses aescbc with a KMS provider
- Sidecar pod for the KMS plugin

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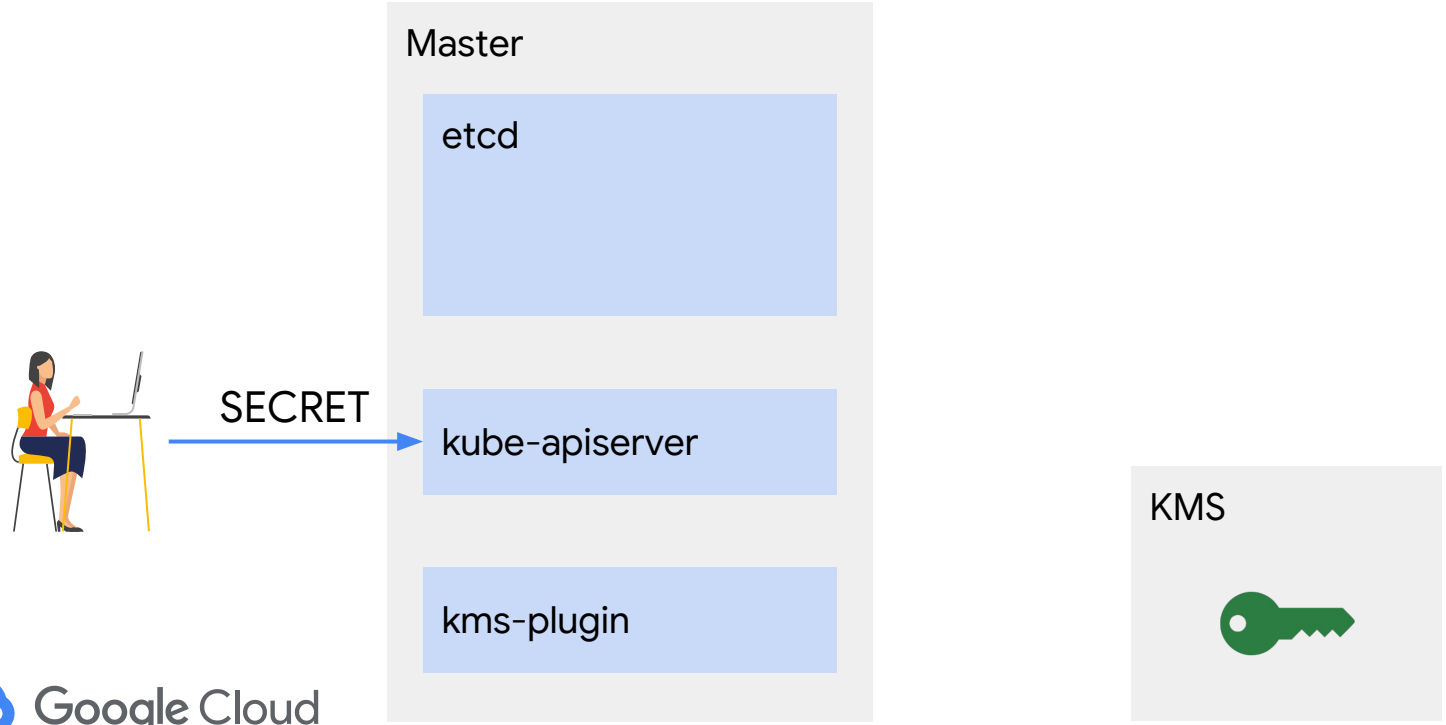
Terminology and Notation

DEK	Data encryption key
KEK	Key encryption key
$\{SECRET\}_{DEK}$	Secret is encrypted with DEK
$\{DEK\}_{KEK}$	DEK is encrypted with KEK
$\{SECRET\}_{DEK} + \{DEK\}_{KEK}$	Envelope

Source for crypto notation:
https://en.wikipedia.org/wiki/Security_protocol_notation

1.10 Envelope Encryption Sequence



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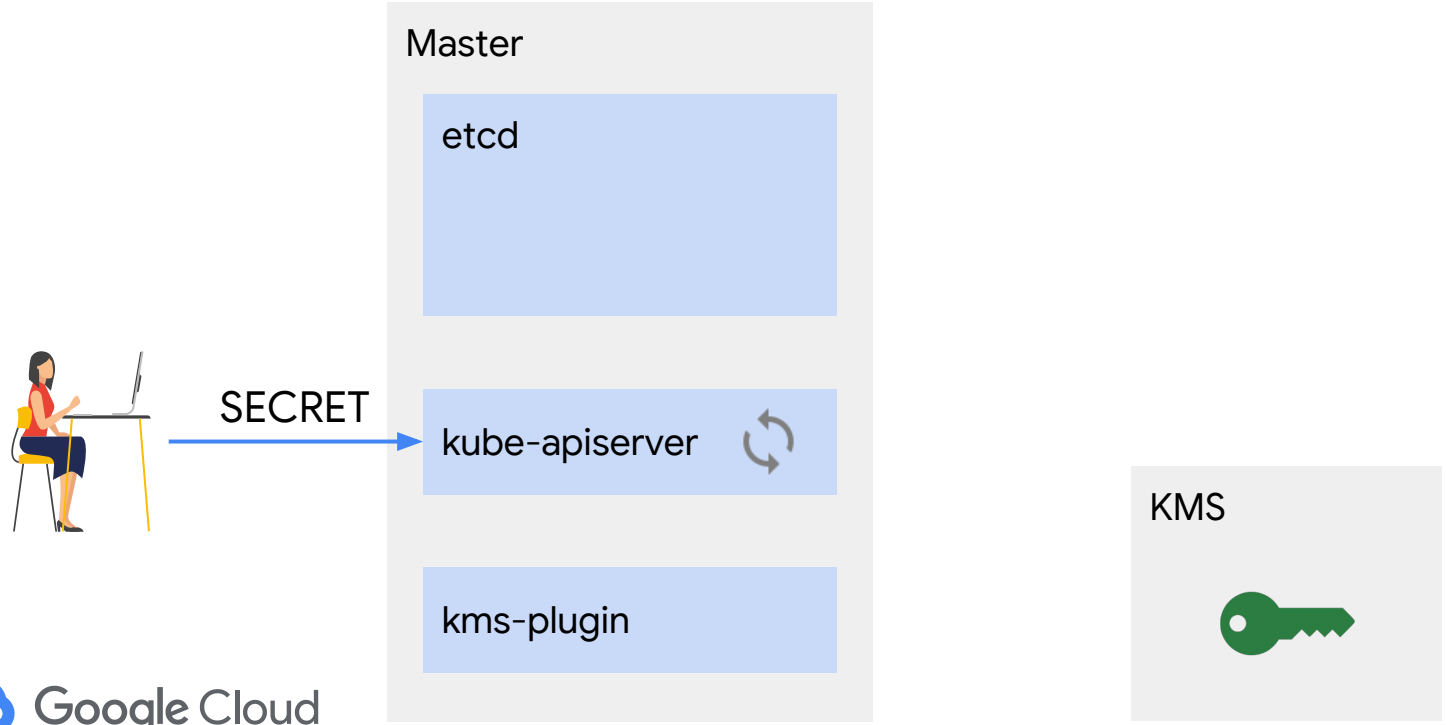
1.10 Kube-ApiServer Generates a DEK



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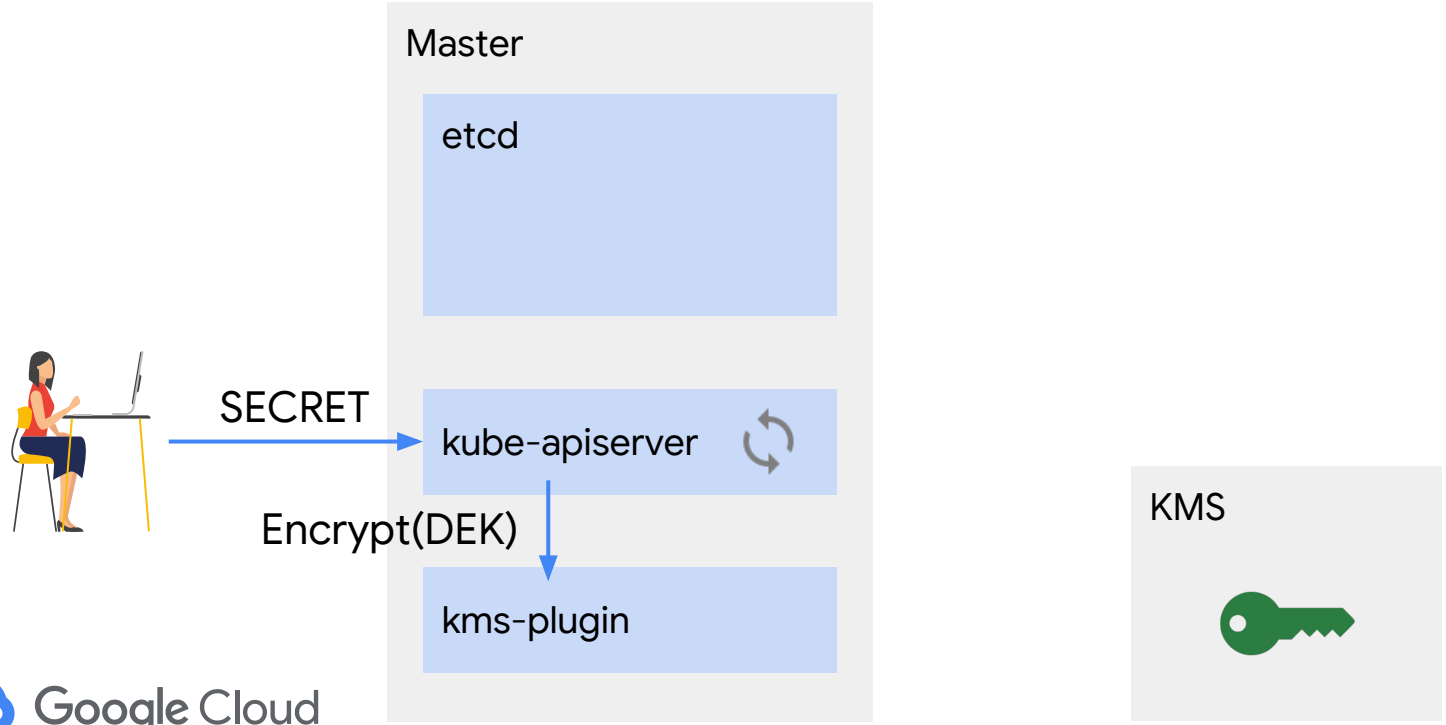
1.10 Kube-ApiServer Sends DEK to Plugin



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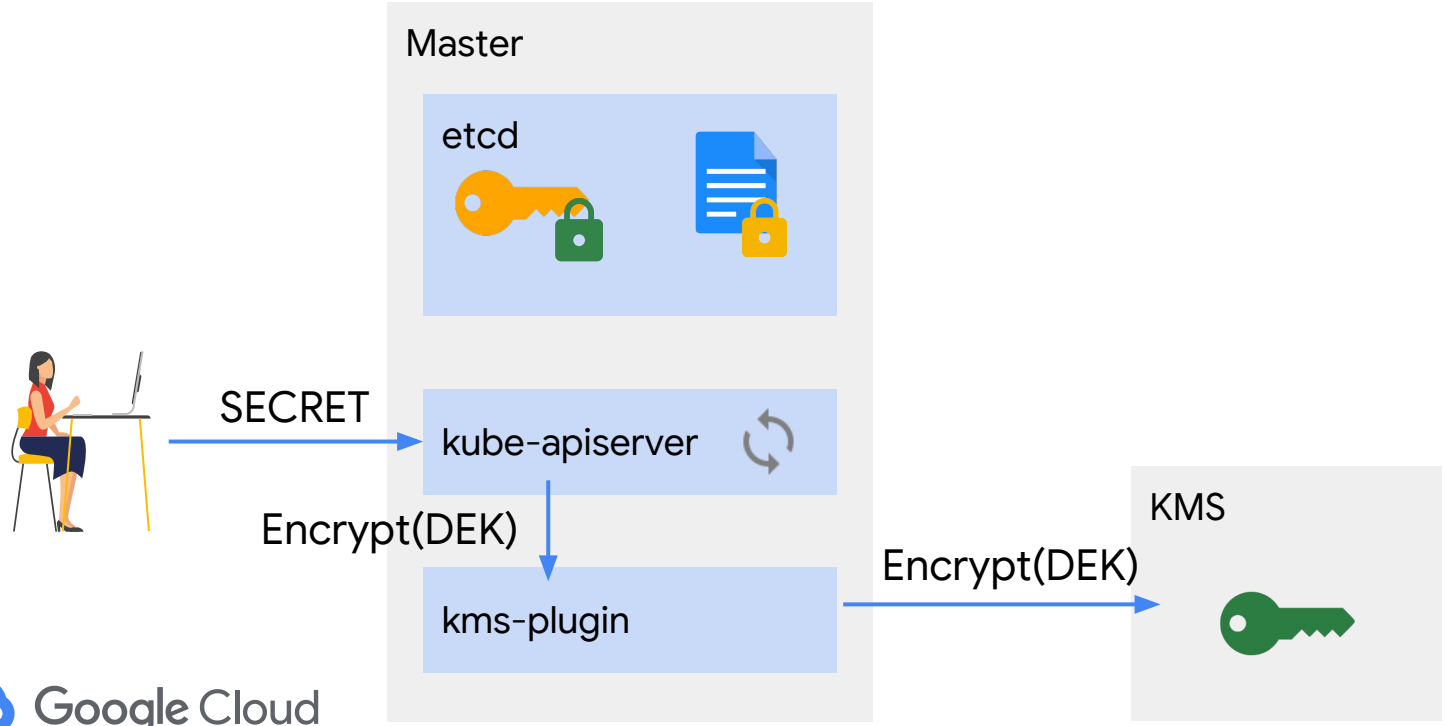
1.10 Plugin Forwards to KMS



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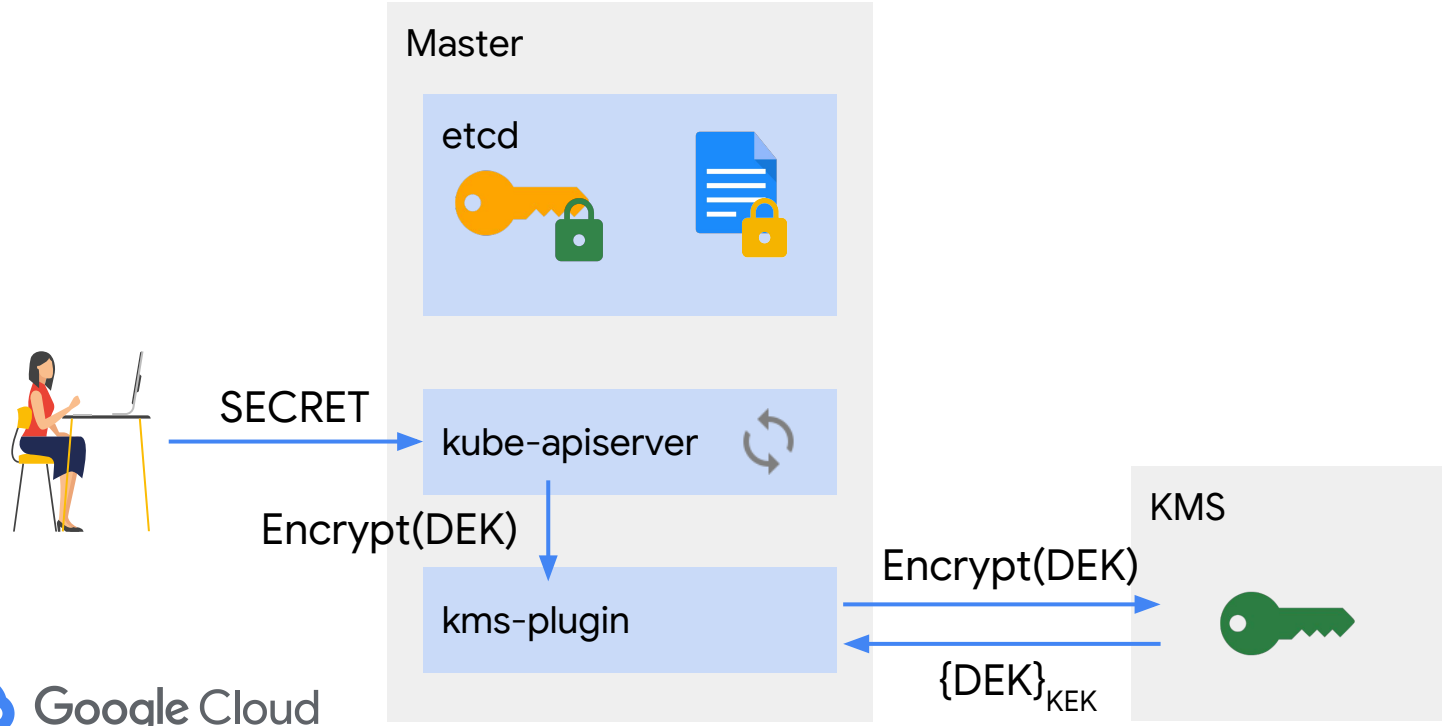
1.10 KMS Encrypts a DEK



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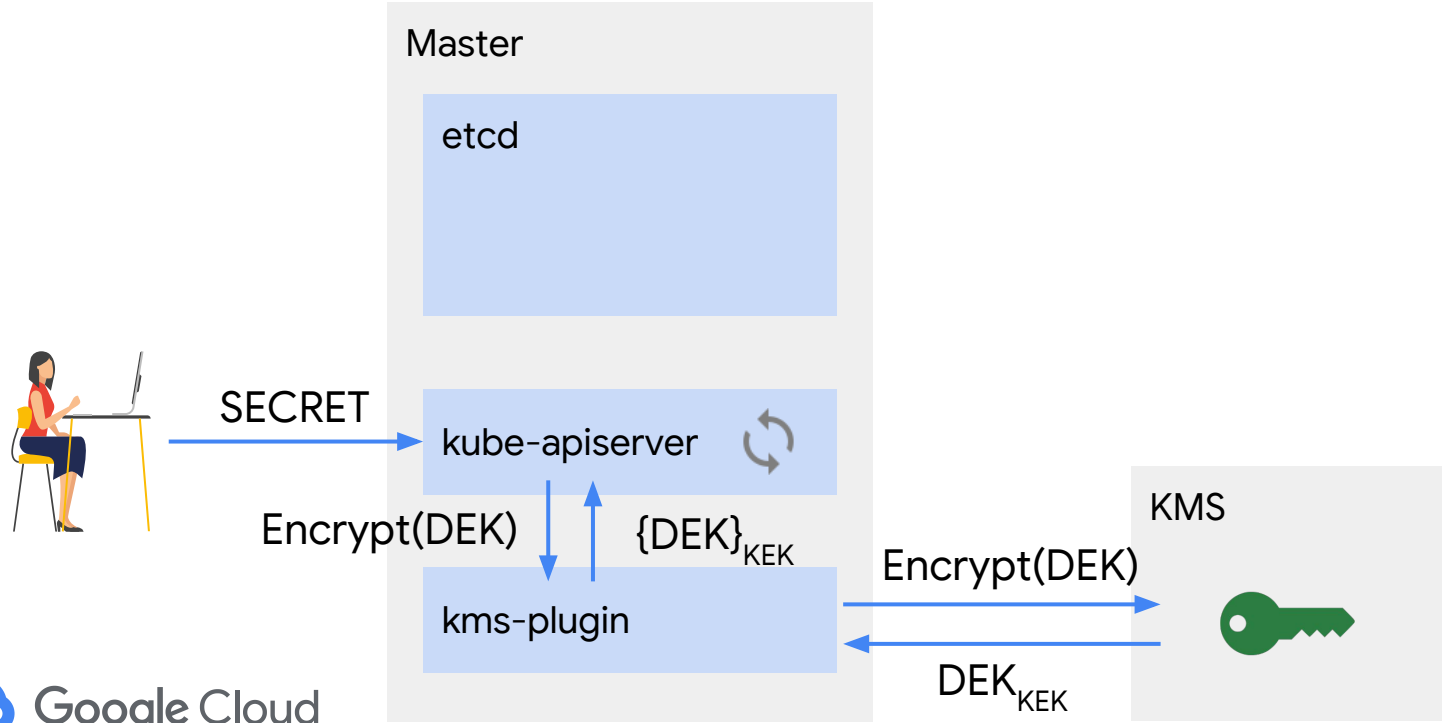
1.10 Kube-ApiServer Constructs an Envelope



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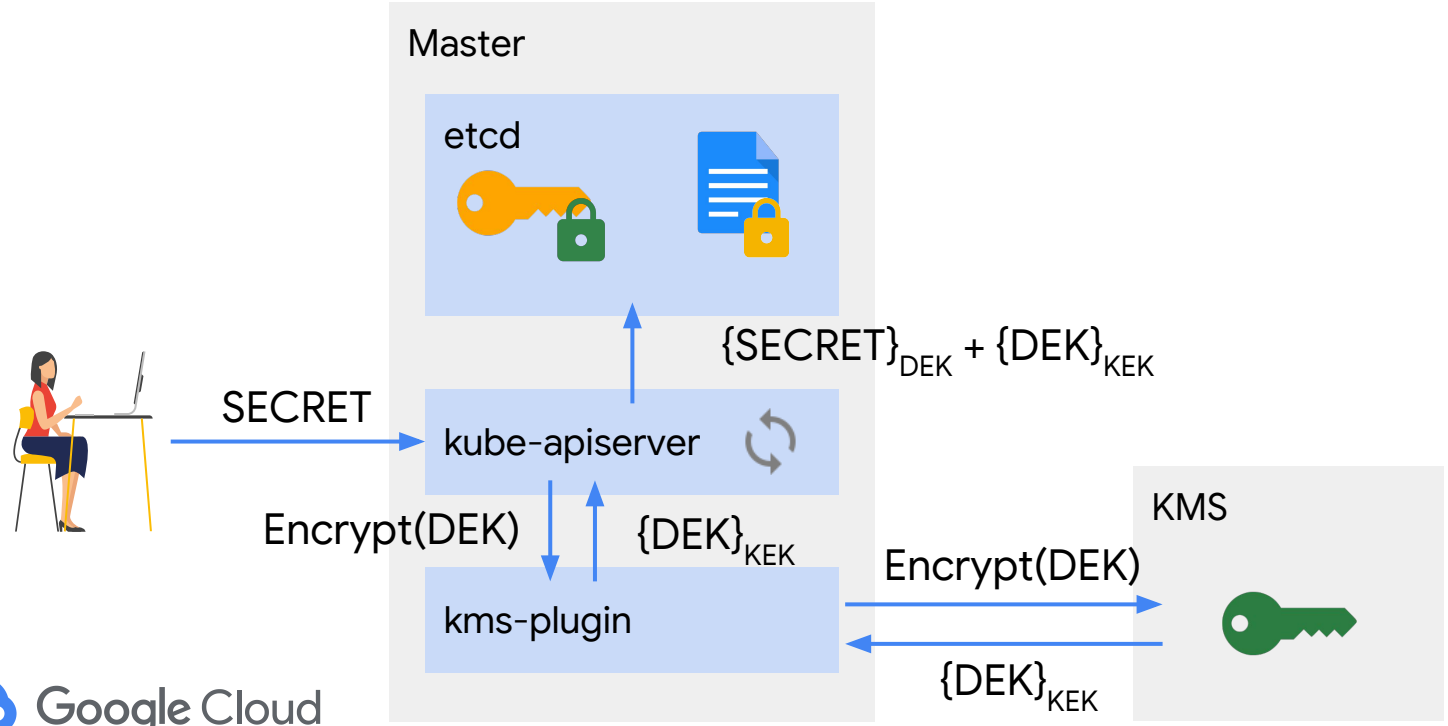
1.10 Enveloped Secret is saved to ETCD



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1.10 KMS plugin version management

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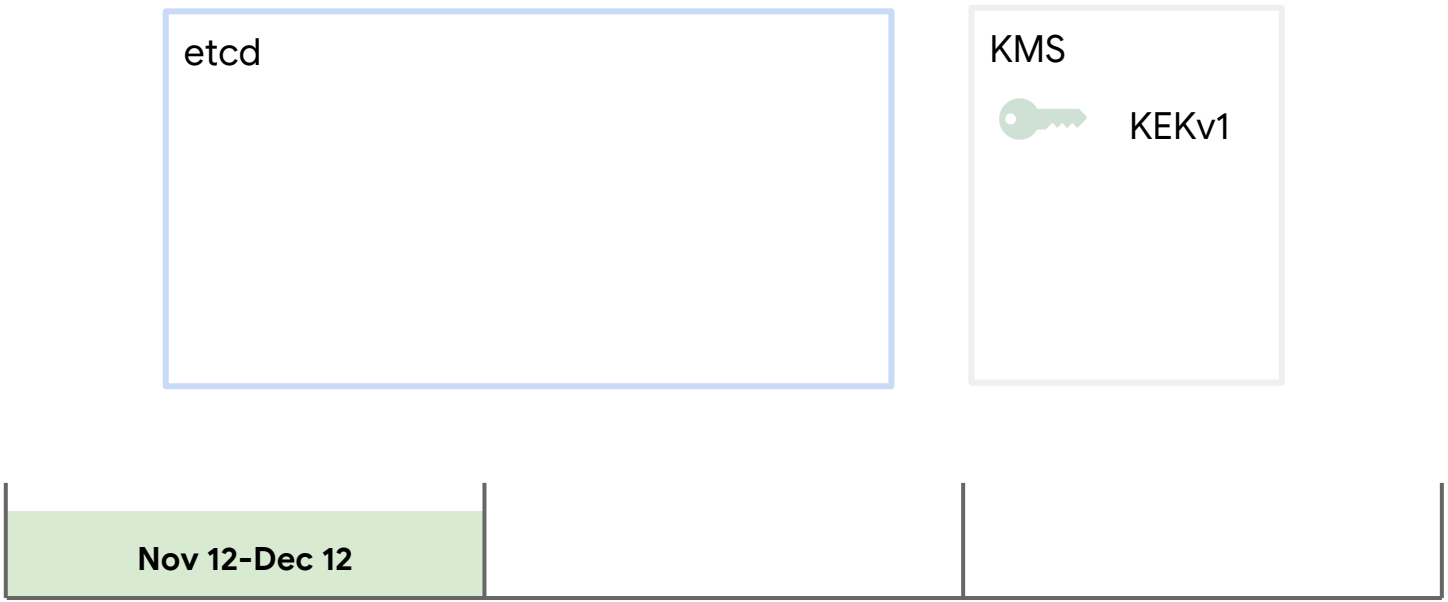
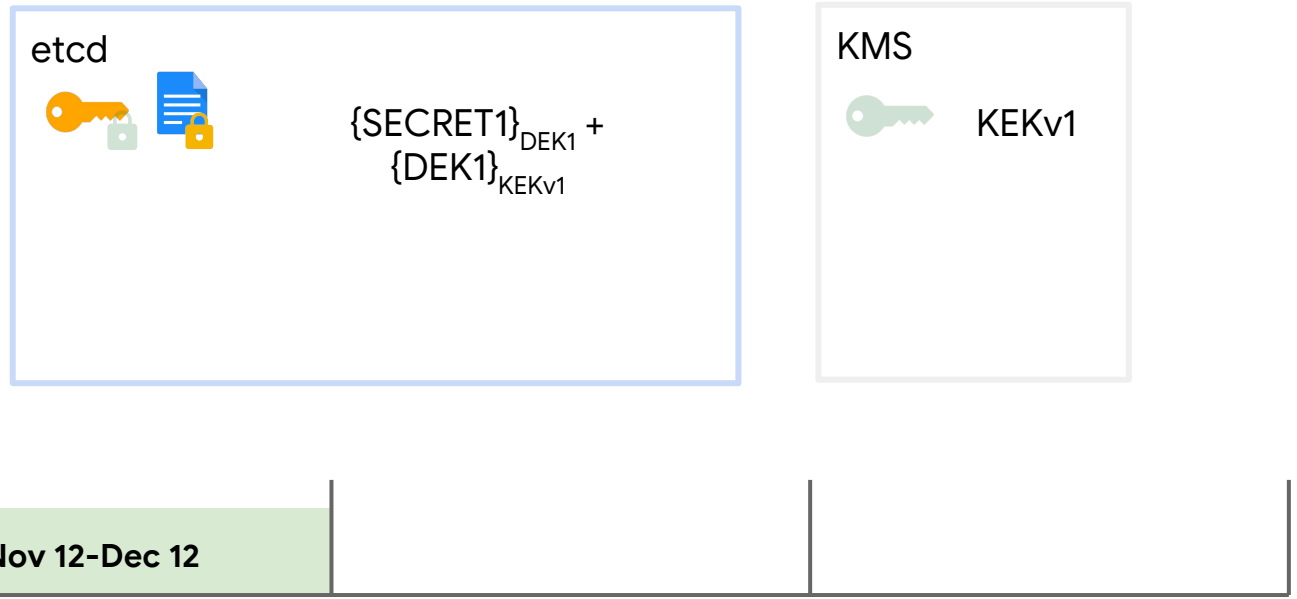
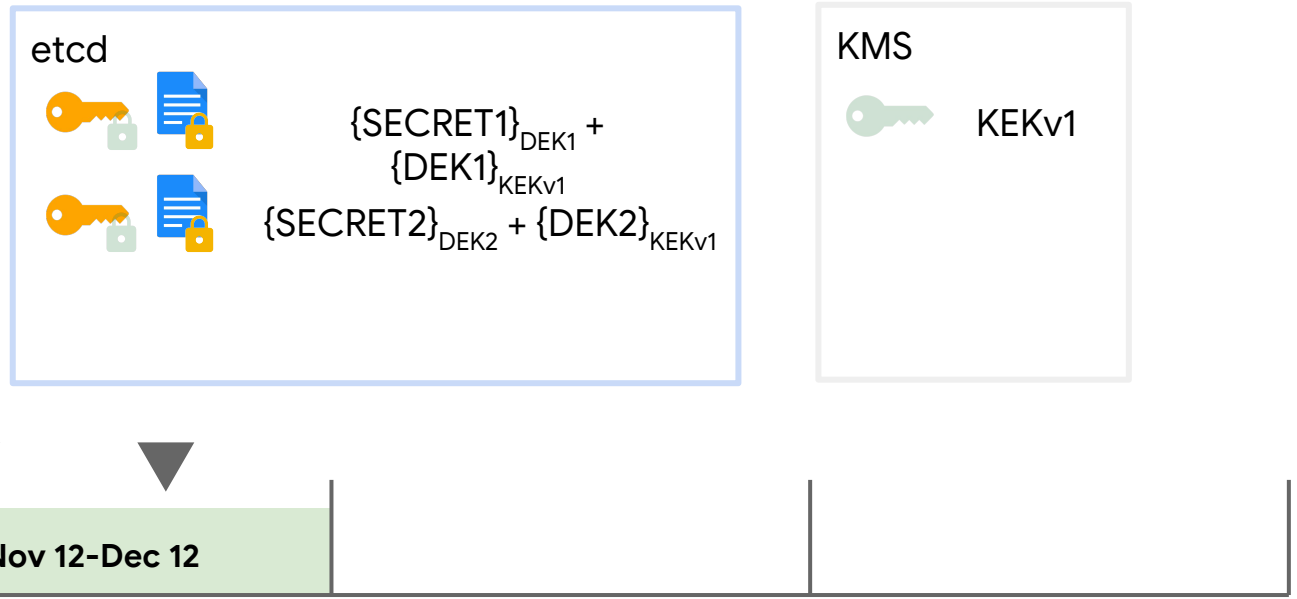


1.10 KMS plugin version management



1.10 KMS plugin version management



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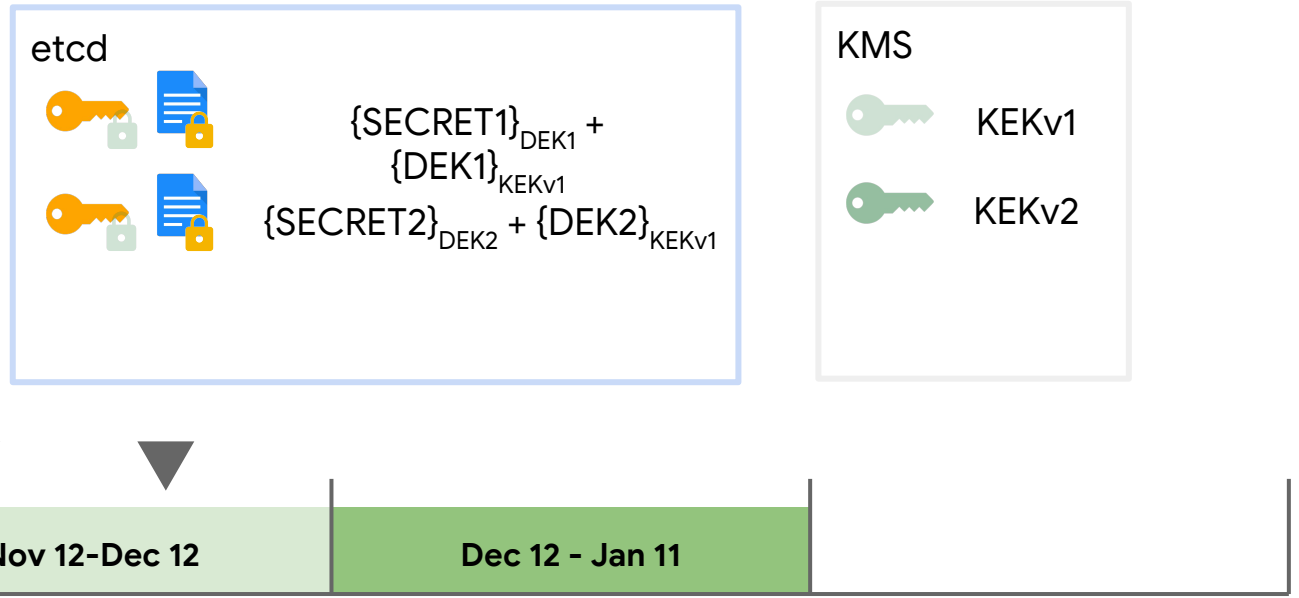
1.10 KMS plugin version management



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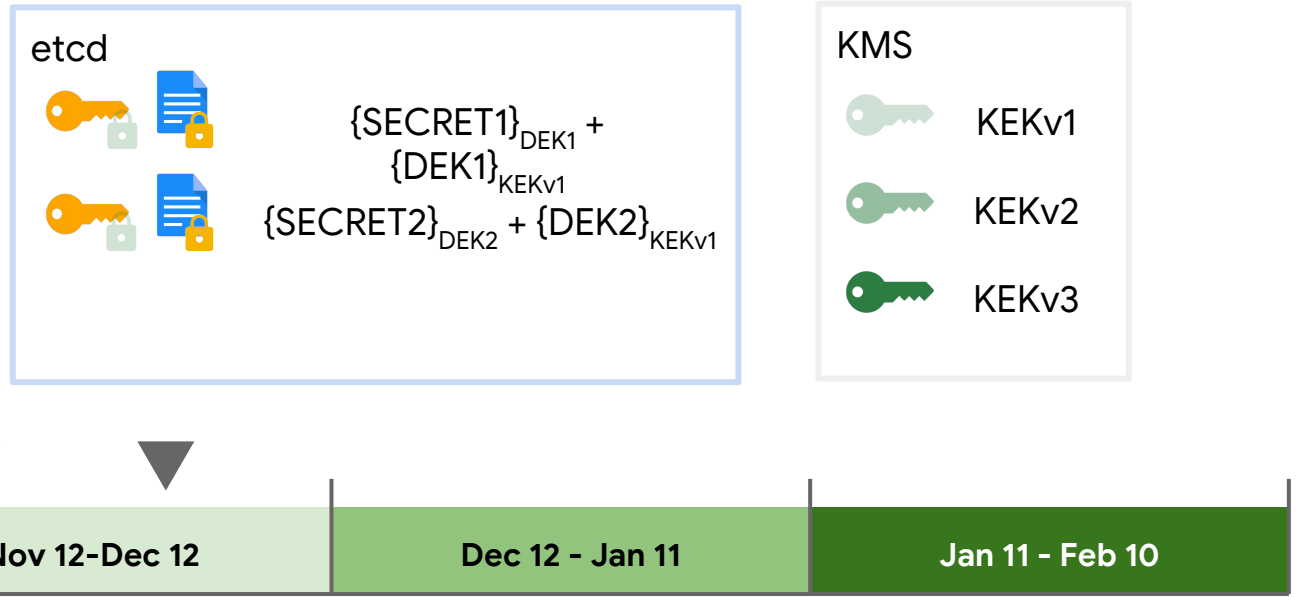
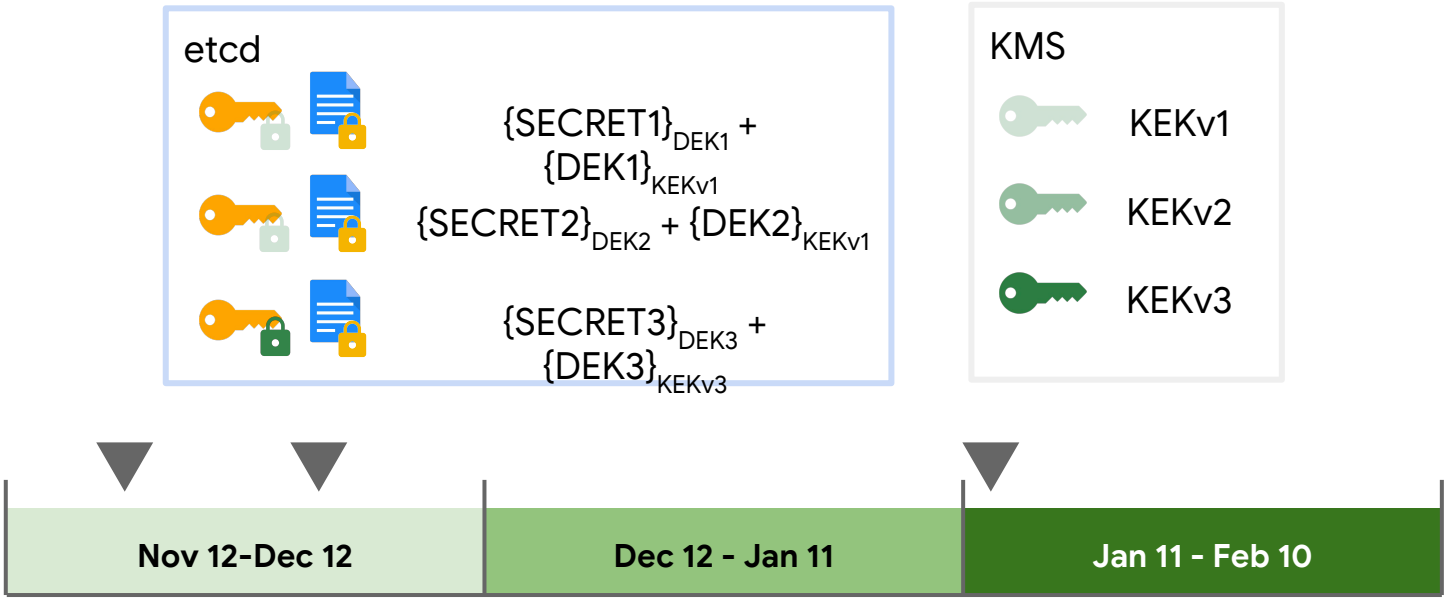
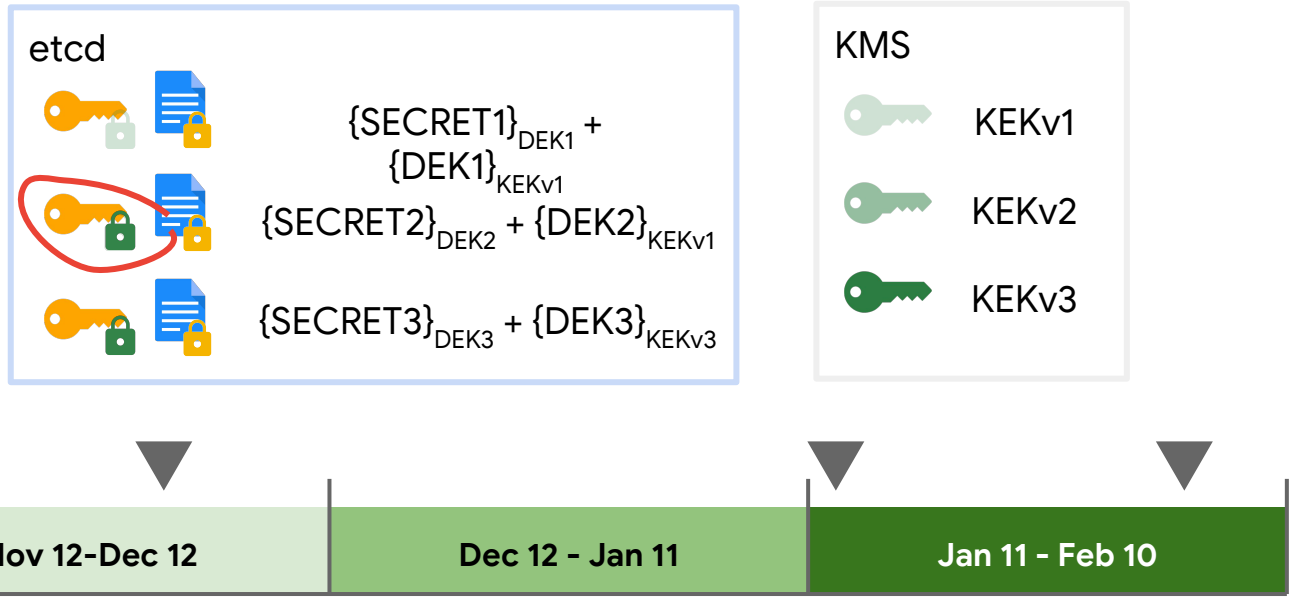
1.10 KMS plugin version management



1.10 KMS plugin version management



1.10 KMS plugin version management

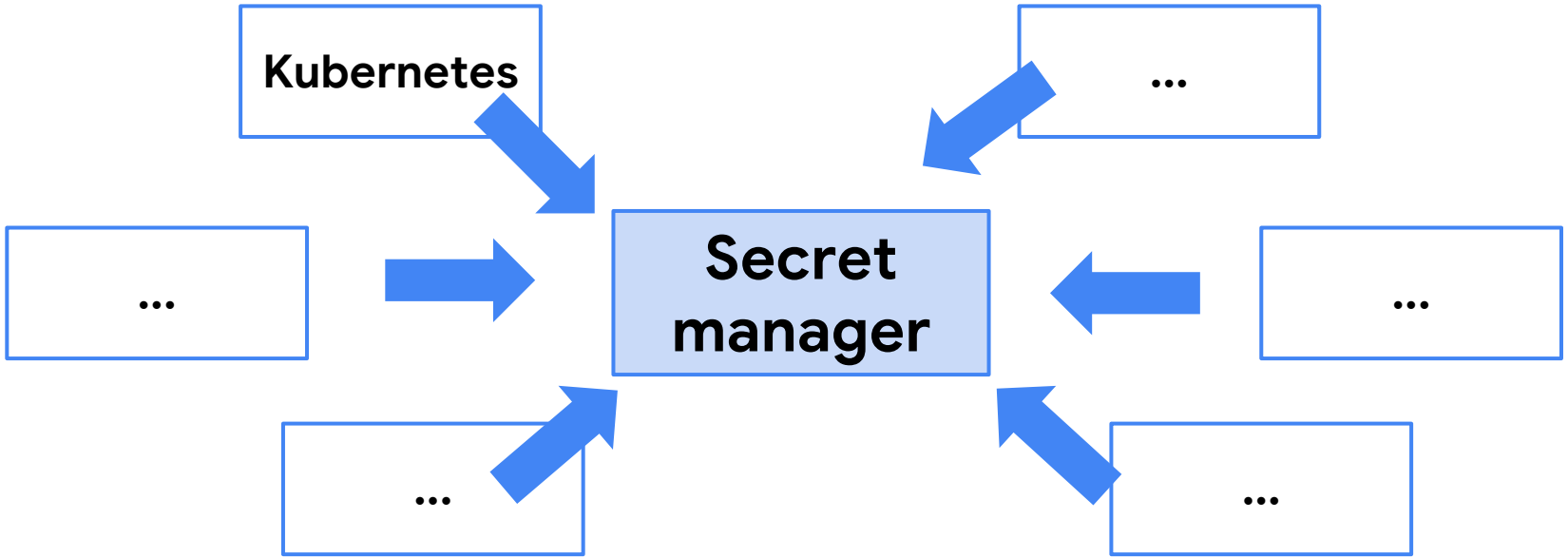


KMS plugin: threat model and concerns

- KMS server is compromised
- KMS plugin is compromised
- Auth token for KMS - offline attack against K8S with plugin

Demo

Kubernetes secrets: external secrets



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Kubernetes secrets: HashiCorp Vault

HashiCorp Vault KMS plugin for Kubernetes

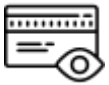
- Secrets are in etcd, with root of trust in Vault

Kubernetes auth backend for HashiCorp Vault

- Authenticate to Vault using a K8s service account

Watch: https://www.youtube.com/watch?v=B16YTeSs1hI

Kubernetes secrets: requirements

	 Identity	 Auditing	 Encryption	 Rotation	 Isolation
Kubernetes default	Node authorizer	K8s audit logging			In etcd, not in applications
1.7 EncryptionConfig	✓	✓	aescbc, aesgcm, or secretbox		✓
1.10 KMS plugin	✓	Additional KMS logs	aescbc	KEK only, depending on KMS	✓
External secrets provider	May be more tightly scoped	Additional secret manager logs	Depending on secret manager	Depending on secret manager	In external secret store

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Kubernetes secrets: summary

- **Use encryption based on your threat model**, e.g., two layers, like full-disk + application-layer
- **Rotate keys regularly** to limit the impact of a potential key compromise
- **Use envelope encryption** to separate key management from secret management, and maintain a root of trust
- **In Kubernetes, protect secrets using either the KMS plugin or if you already have one, use an external secret store**

Learn more

Kubernetes secrets: https://kubernetes.io/docs/concepts/configuration/secret/

- Secret encryption: https://kubernetes.io/docs/tasks/administer-cluster/encrypt-data/
- Using a KMS provider: https://kubernetes.io/docs/tasks/administer-cluster/kms-provider/

KMS plugins:

- Google Cloud KMS: https://github.com/GoogleCloudPlatform/k8s-cloudkms-plugin/
- Microsoft Azure Key Vault: https://github.com/Azure/kubernetes-kms
- AWS KMS: https://github.com/kubernetes-sigs/aws-encryption-provider
- HashiCorp Vault: https://github.com/oracle/kubernetes-vault-kms-plugin

Container security overview: https://cloud.google.com/containers/security/

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Q&A