Trust No One: Secure Storage for Confidential Containers

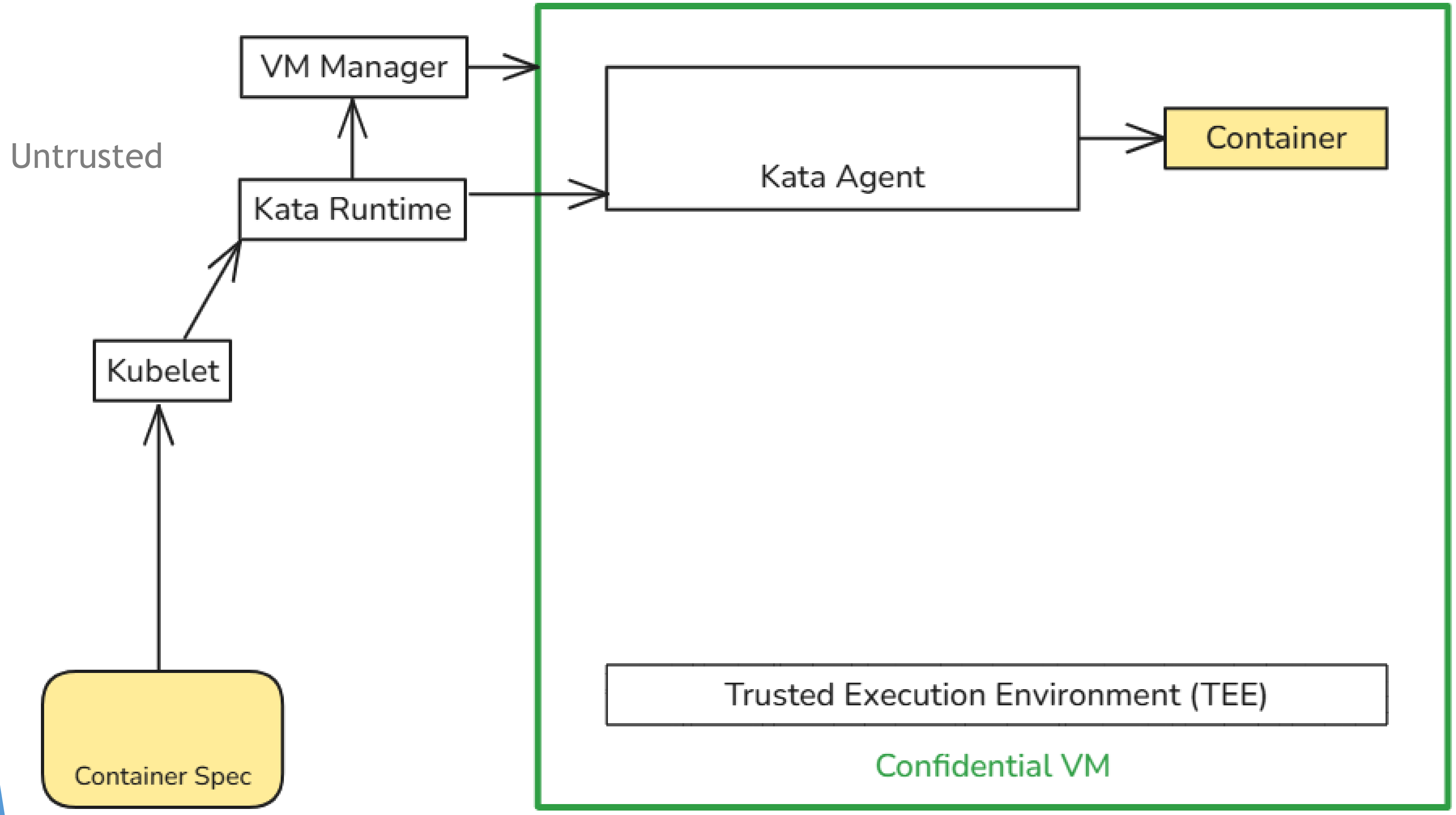
Aurélien Bombo

Confidential Containers | Kata Containers | Microsoft

What is a confidential container?

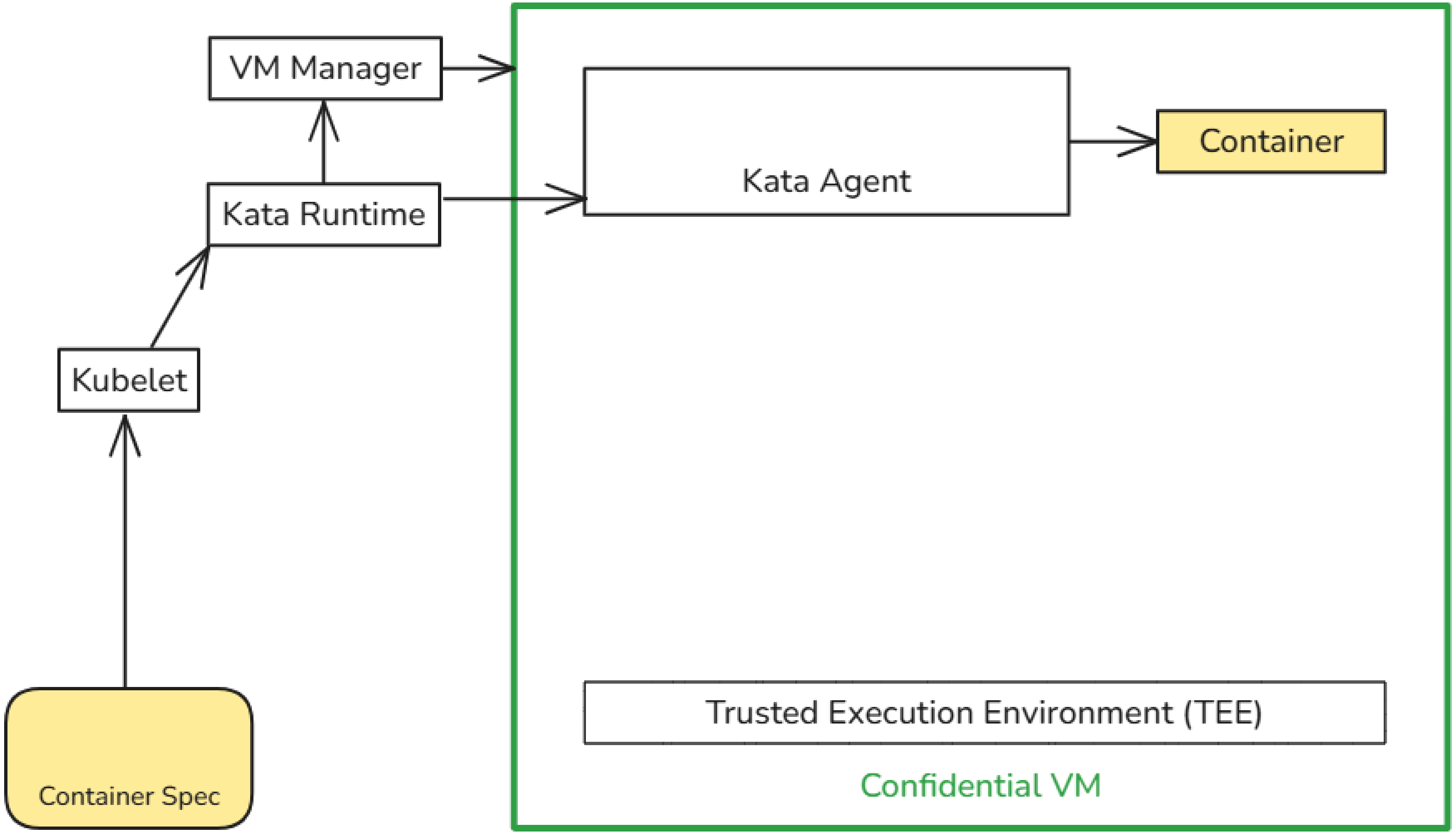
- runC containers
  - Shared kernel
- Kata Containers
  - Virtualization
- **Confidential Containers (CoCo)**
  - Builds on top of Kata Containers
  - Trusted Execution Environment (TEE)
  - Remote Attestation
  - Security Policy

- **Kubernetes**
  - Container Orchestrator
  - Storage


Untrusted
VM Manager
Kata Runtime
Kubelet
Container Spec
Kata Agent
Container
Trusted Execution Environment (TEE)
Confidential VM

Ephemeral storage

- Data is short-lived, but does not fit in memory
    - Sharing between containers inside VM
- Goals
    - Confidentiality
    - Kubernetes integration
- Design
    - Create block device on host and pass to VM
    - Encrypt & format device inside VM
- Challenge
    - Secure VM boundary: security policy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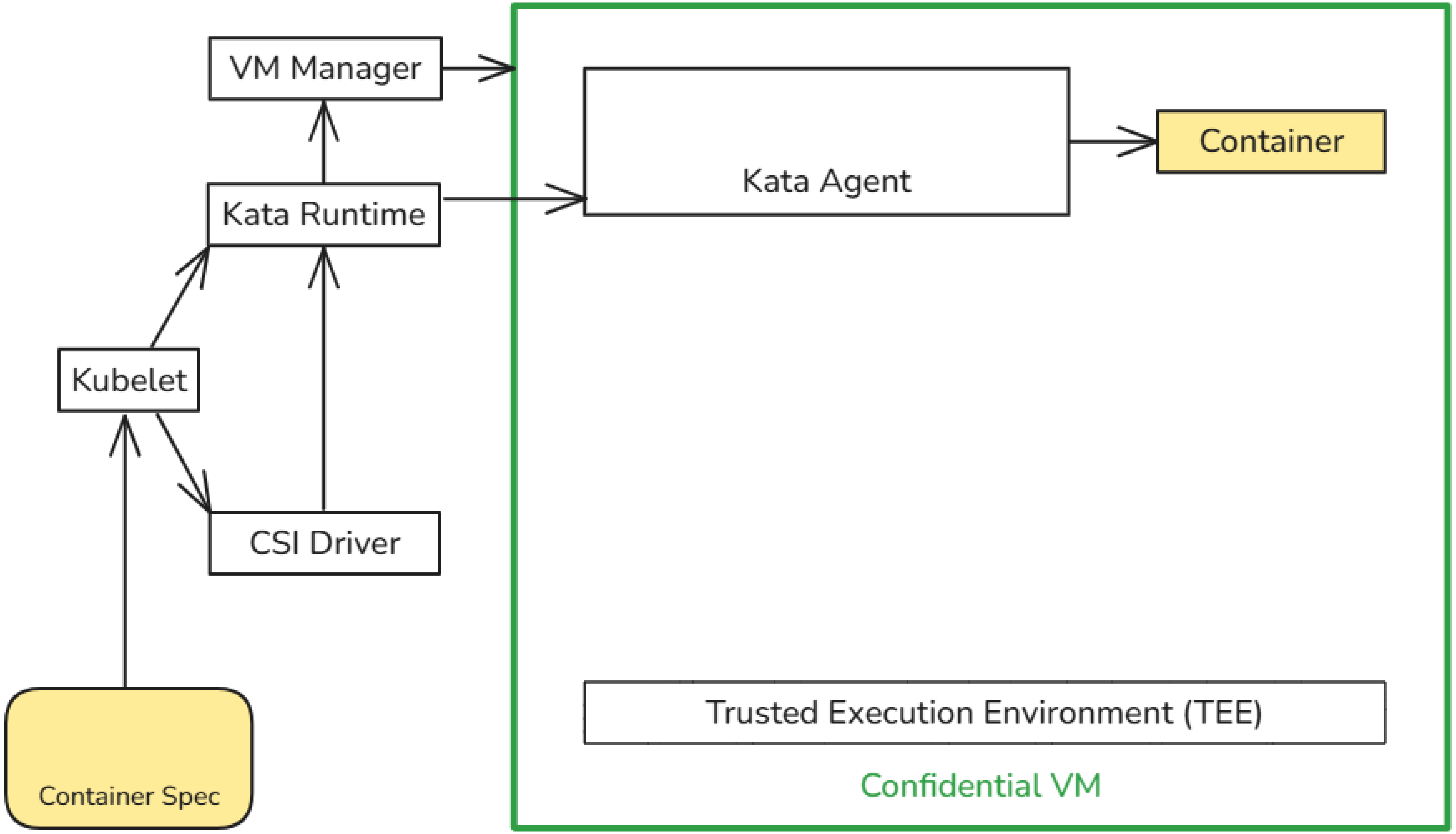
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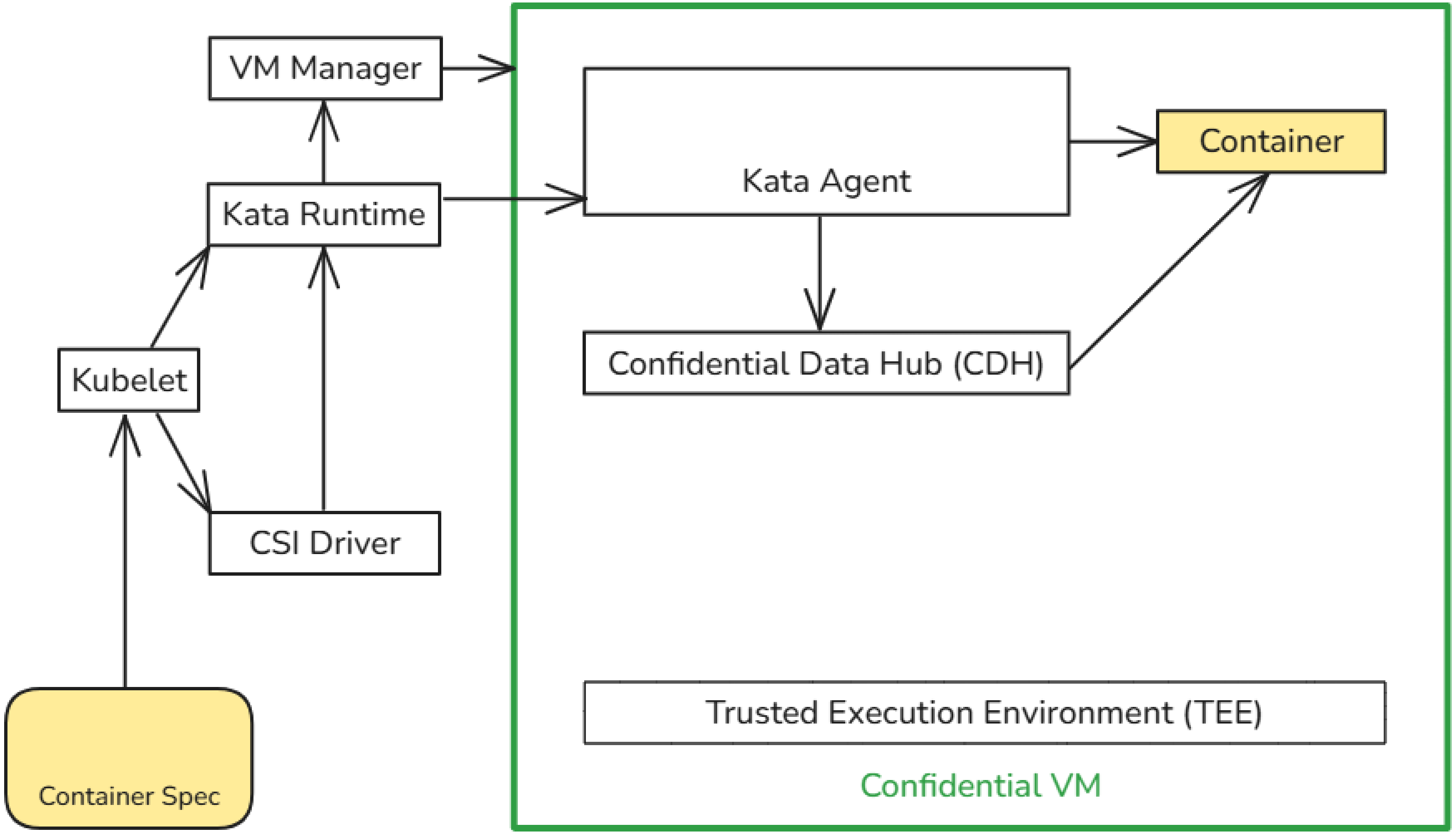
virto-blk



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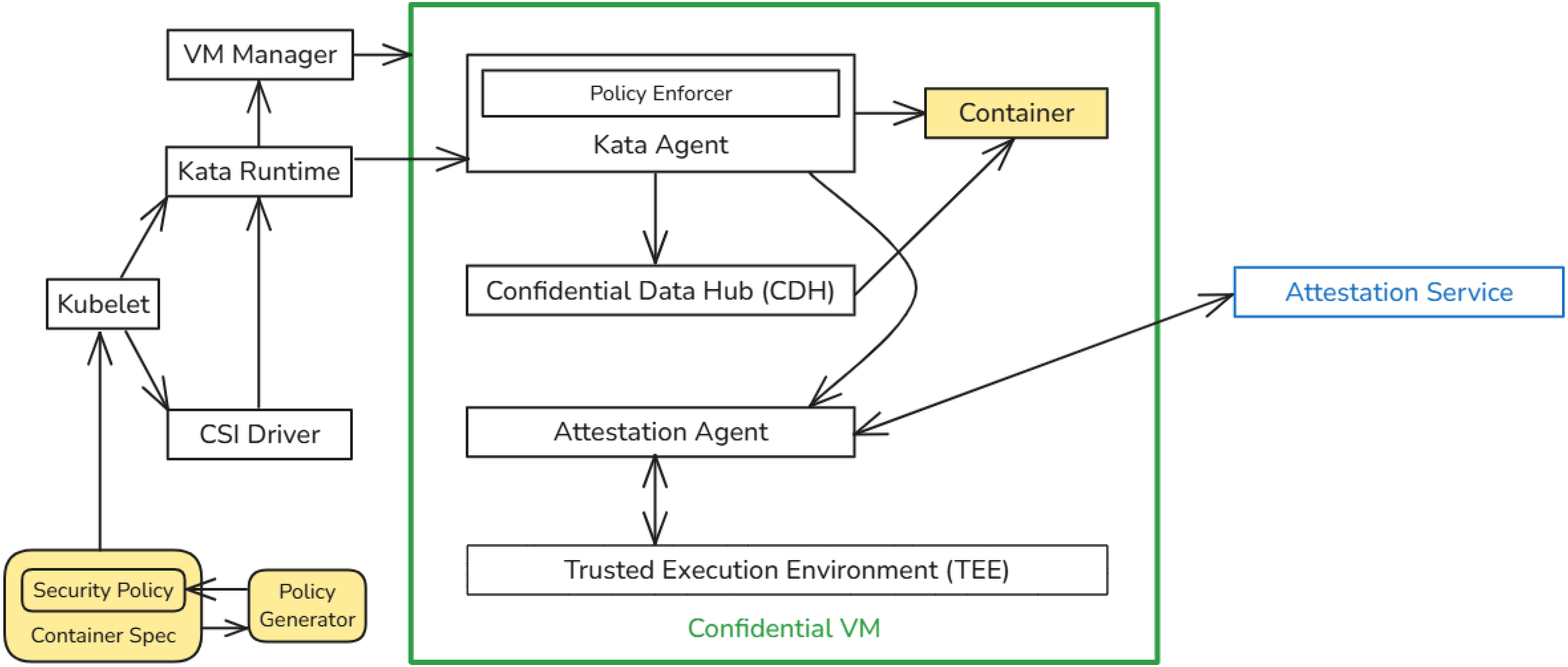
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```
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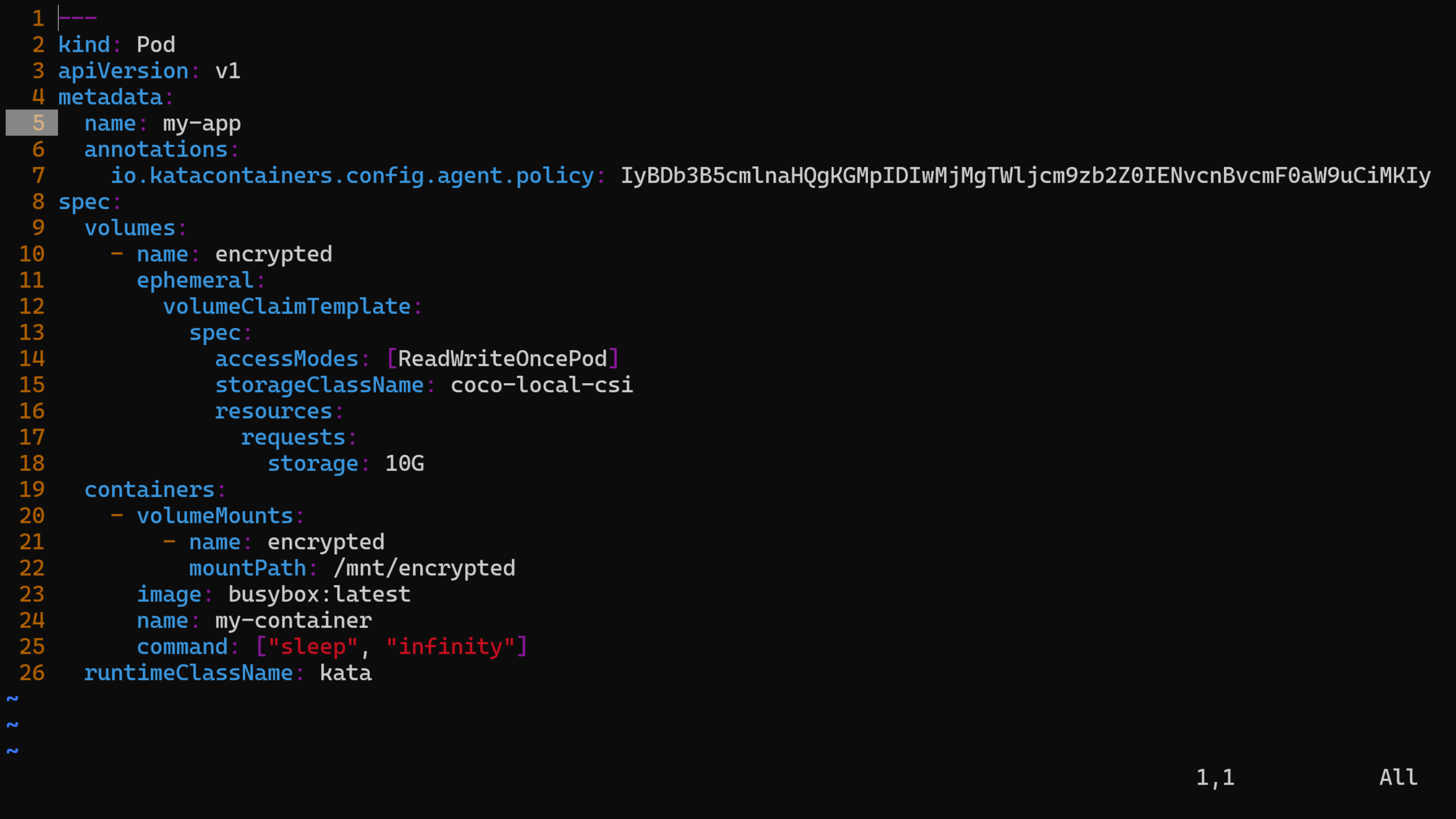

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kind: Pod
apiVersion: v1
metadata:
  name: my-app
  annotations:
    io.katacontainers.config.agent.policy: IyBDb3B5cmlnaHQgKGMpIDIwMjMgTWljcm9zb2Z0IENvcnBvcmF0aW9uCiMKIy
spec:
  volumes:
    - name: encrypted
      ephemeral:
        volumeClaimTemplate:
          spec:
            accessModes: [ReadWriteOncePod]
            storageClassName: coco-local-csi
            resources:
              requests:
                storage: 10G
  containers:
    - volumeMounts:
        - name: encrypted
          mountPath: /mnt/encrypted
      image: busybox:latest
      name: my-container
      command: ["sleep", "infinity"]
  runtimeClassName: kata
```
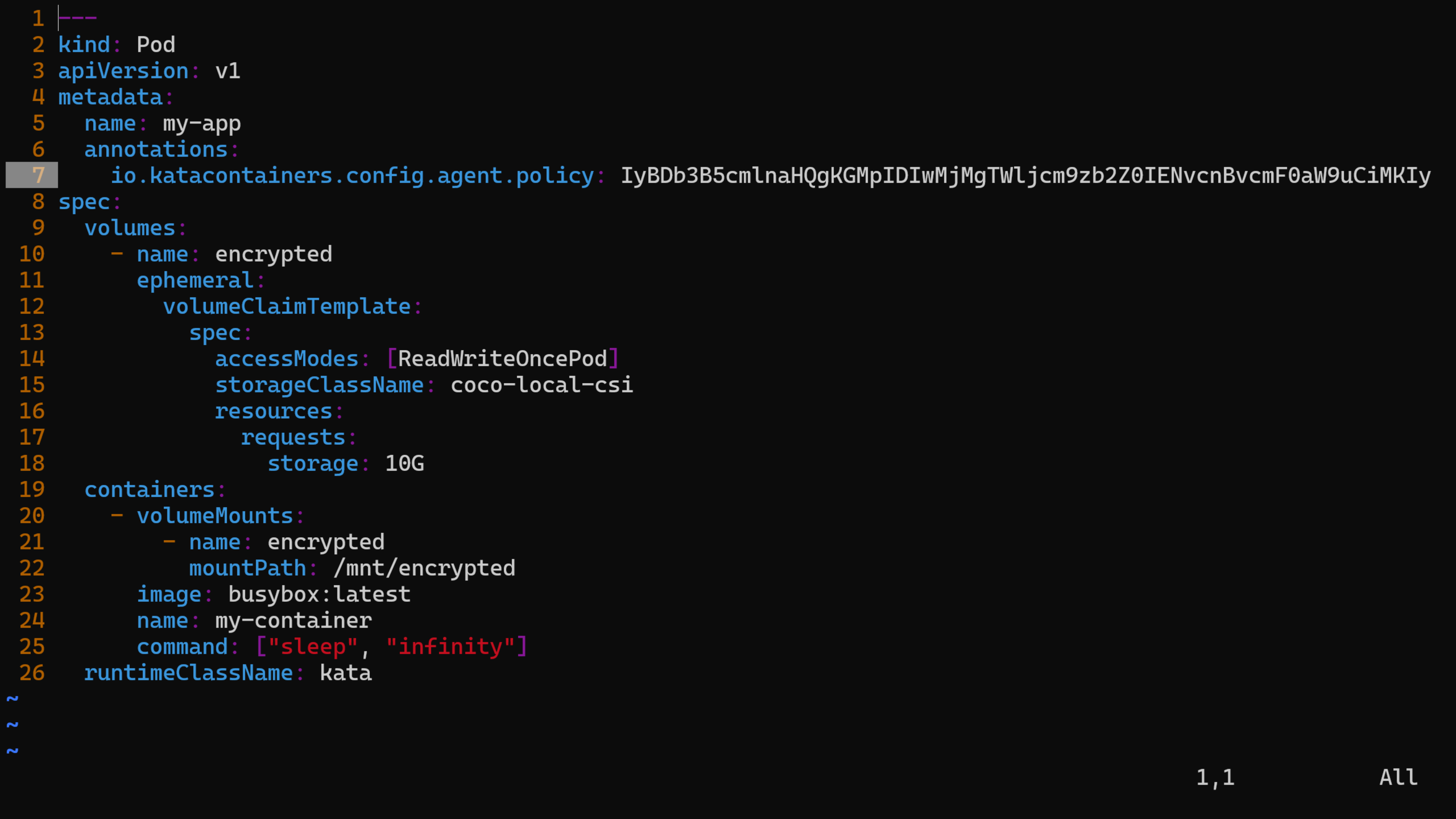

1,1   All



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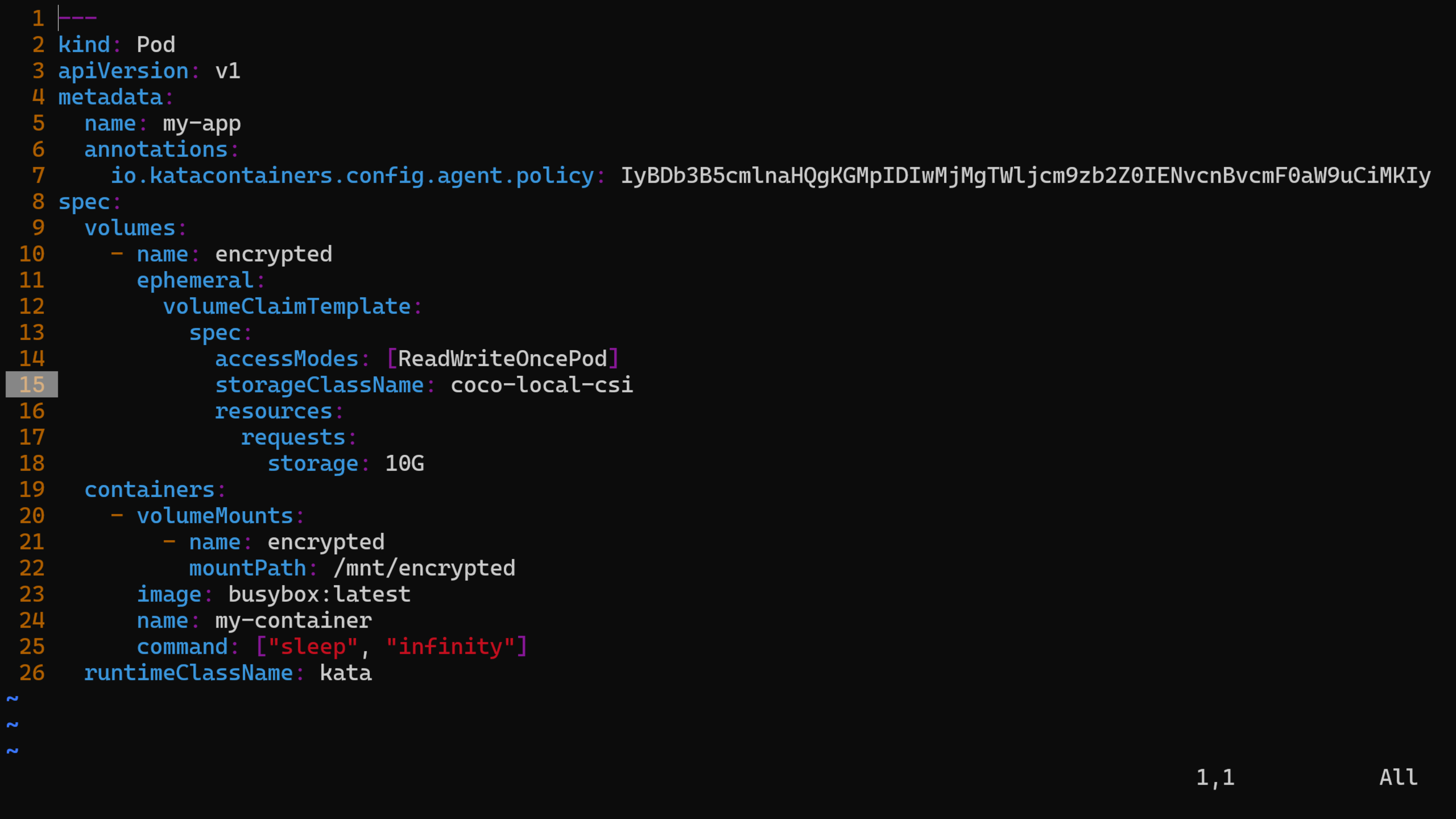

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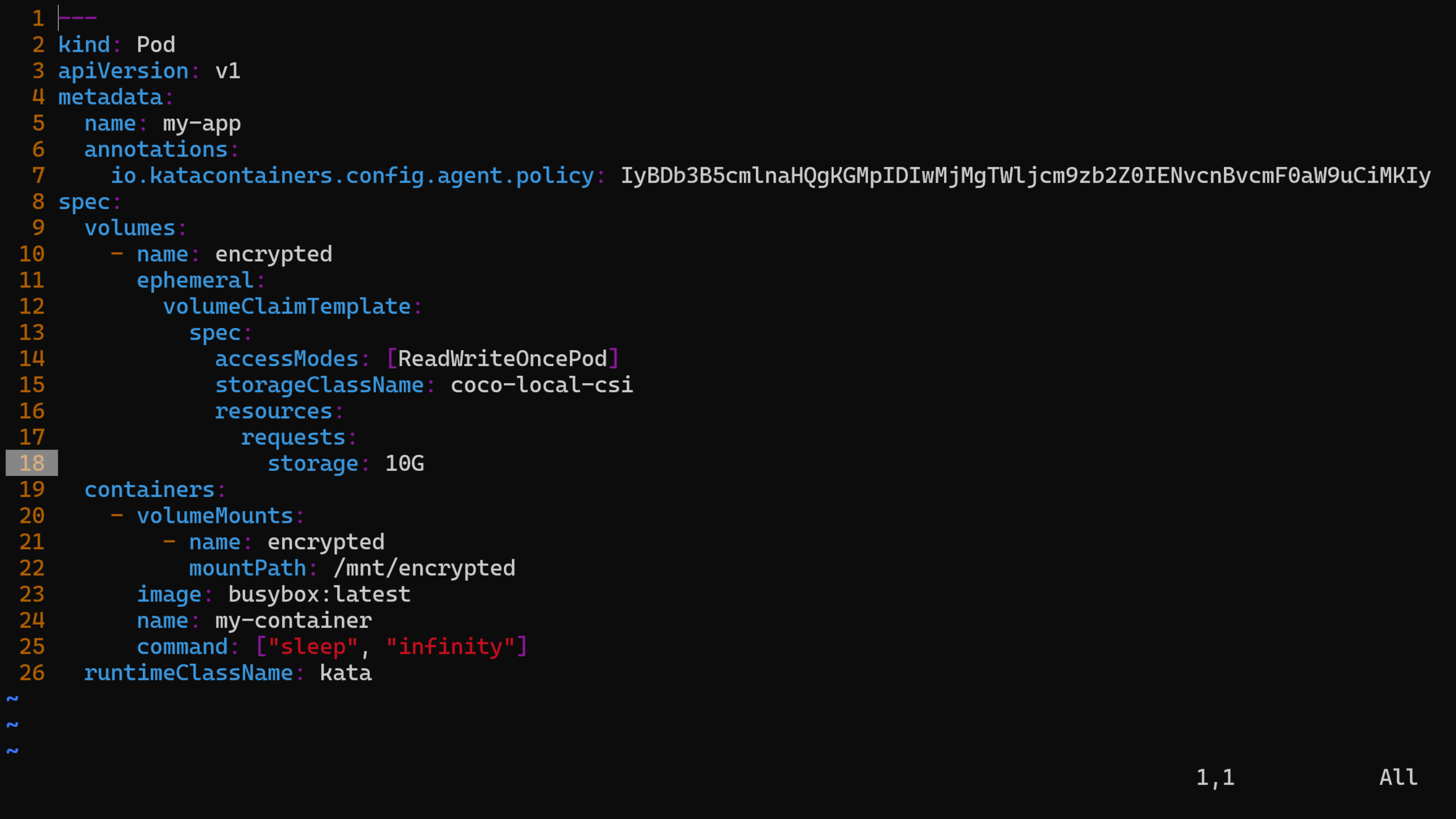

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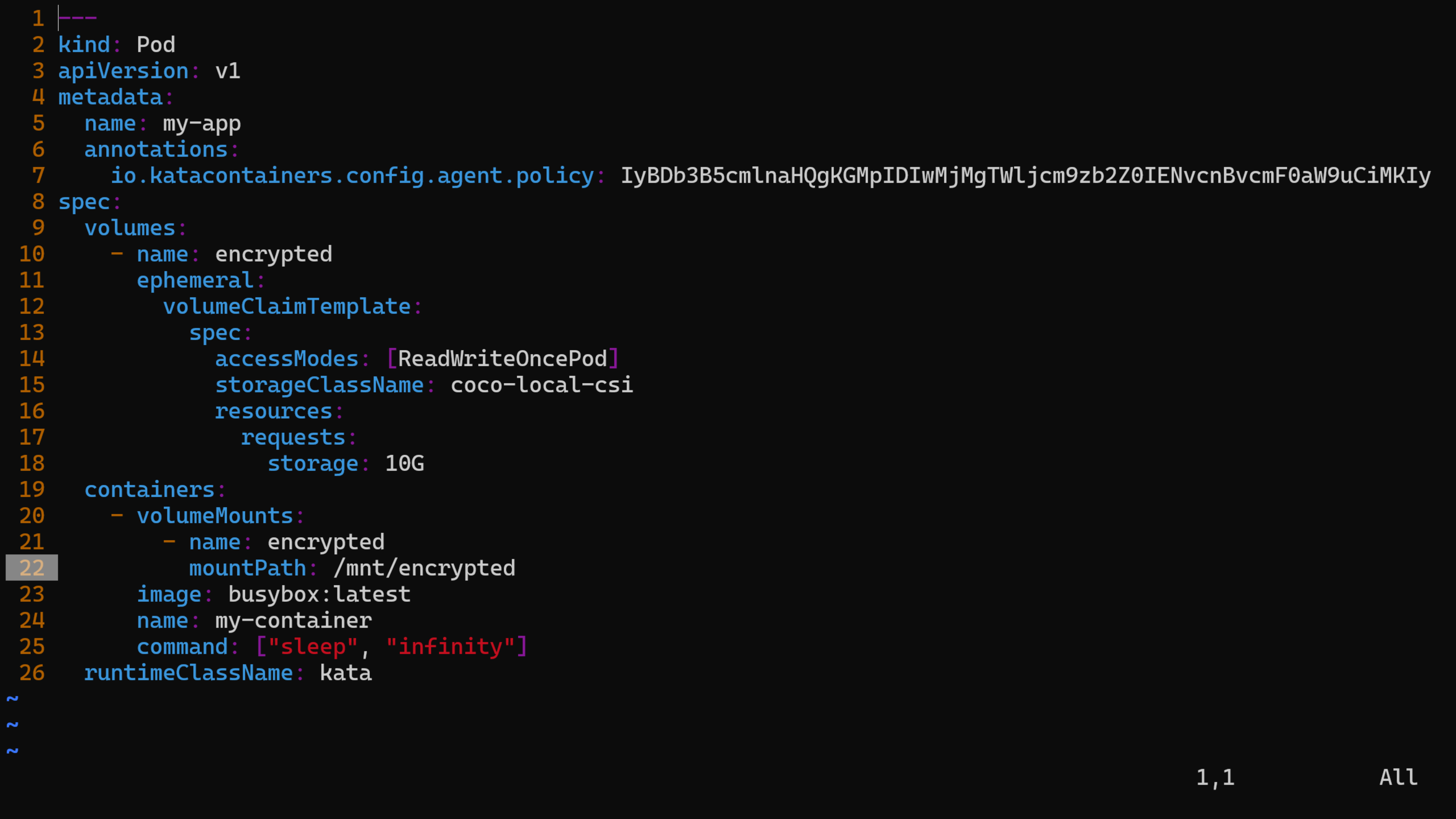

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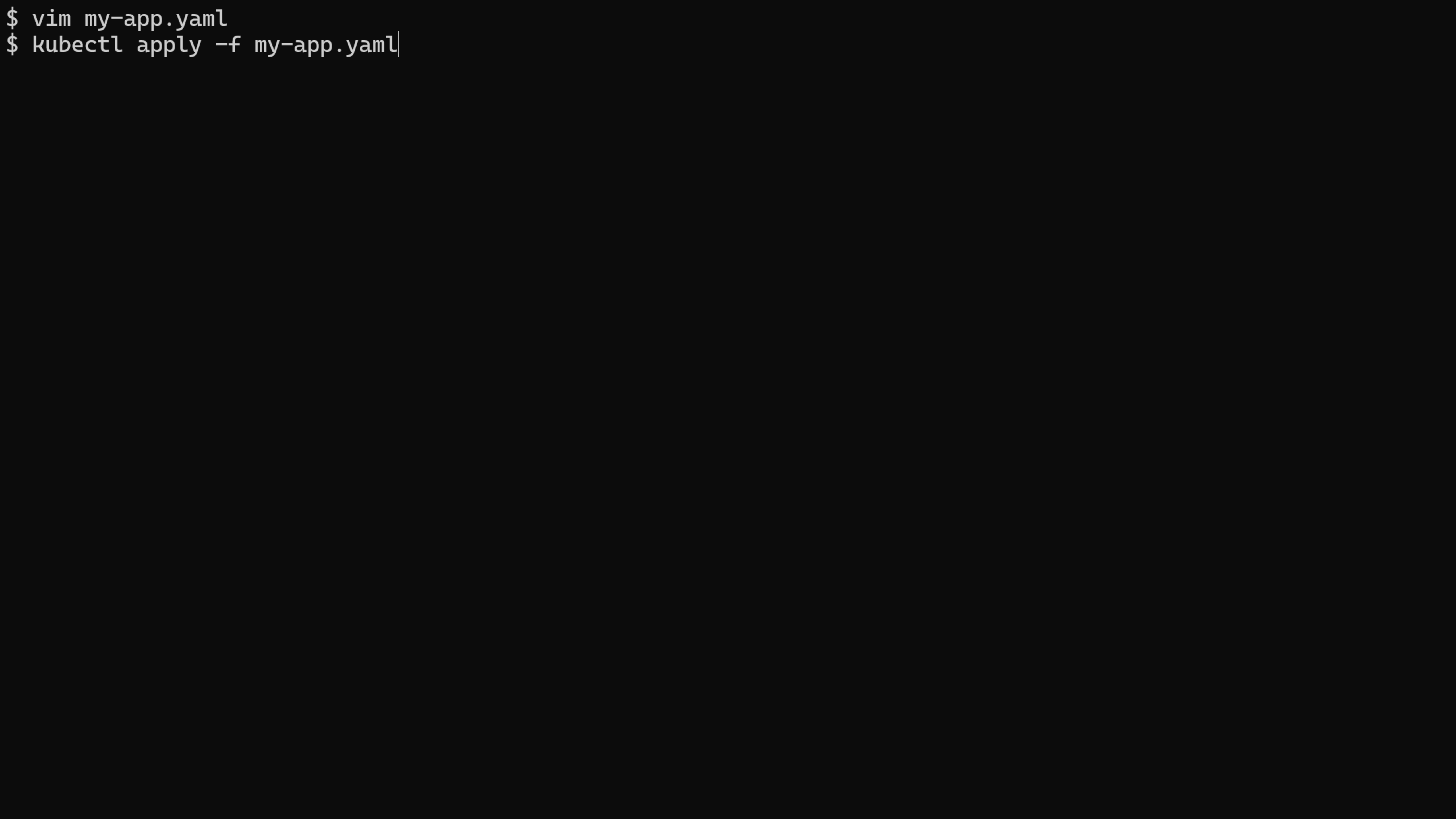

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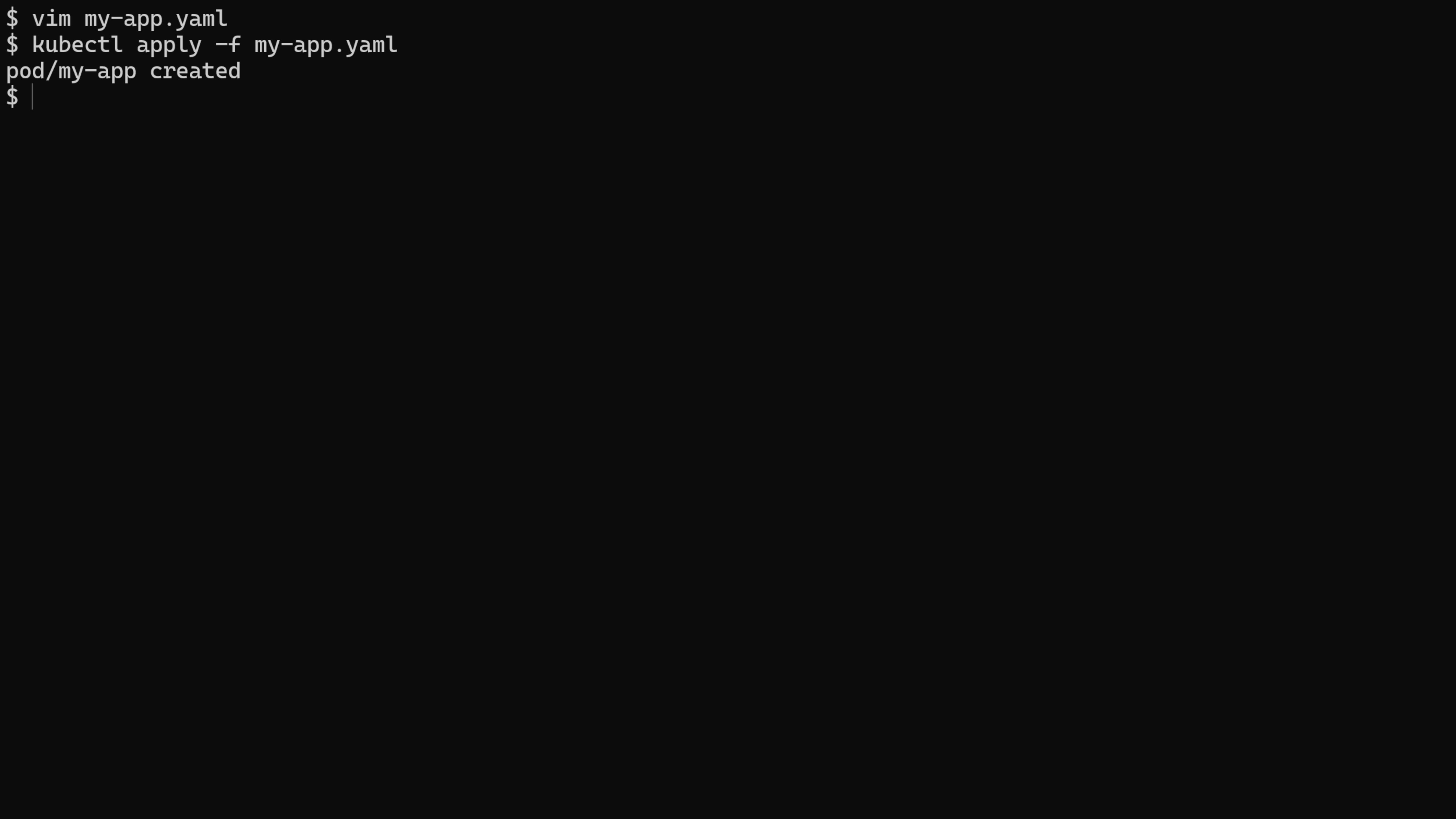

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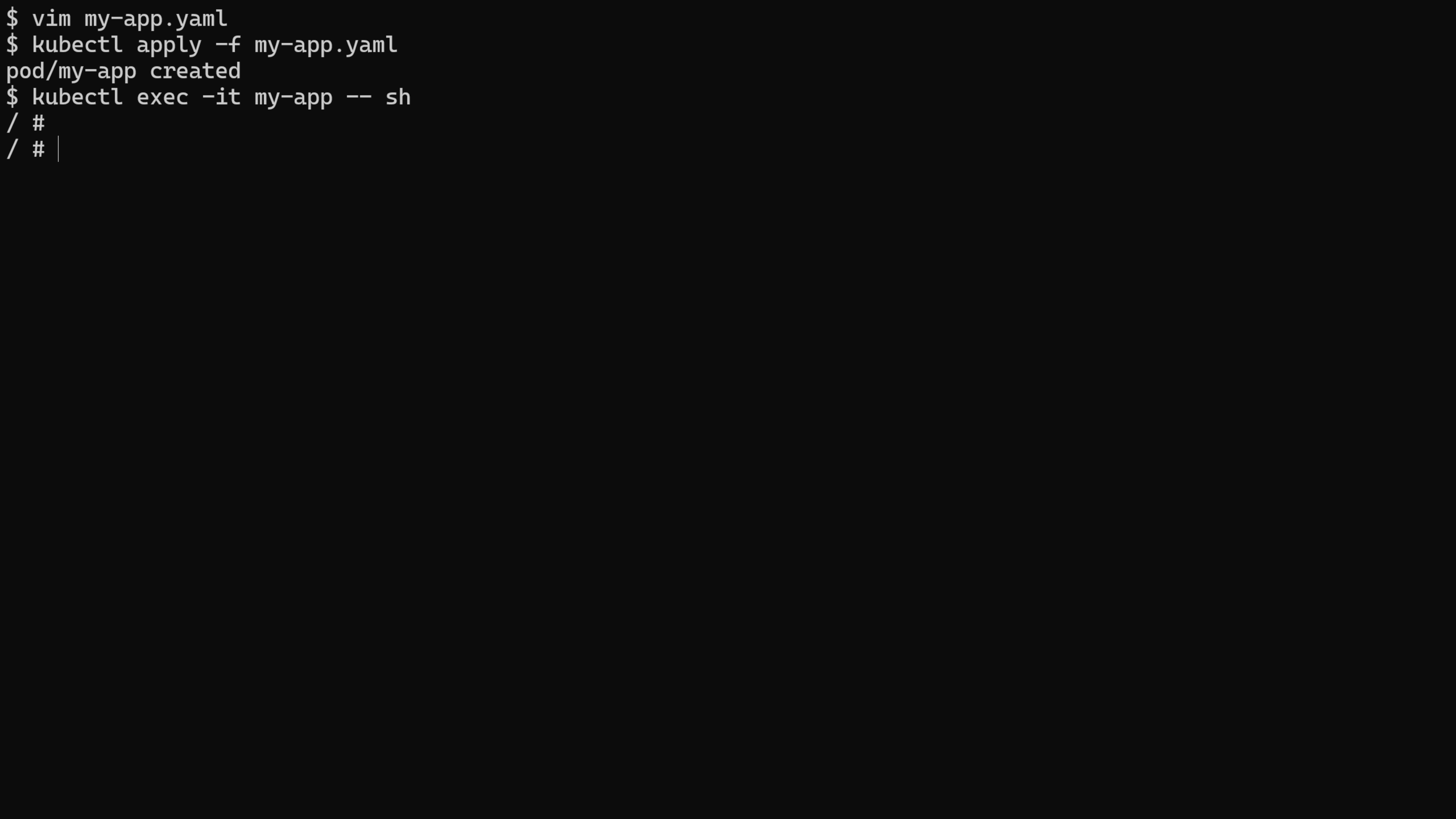

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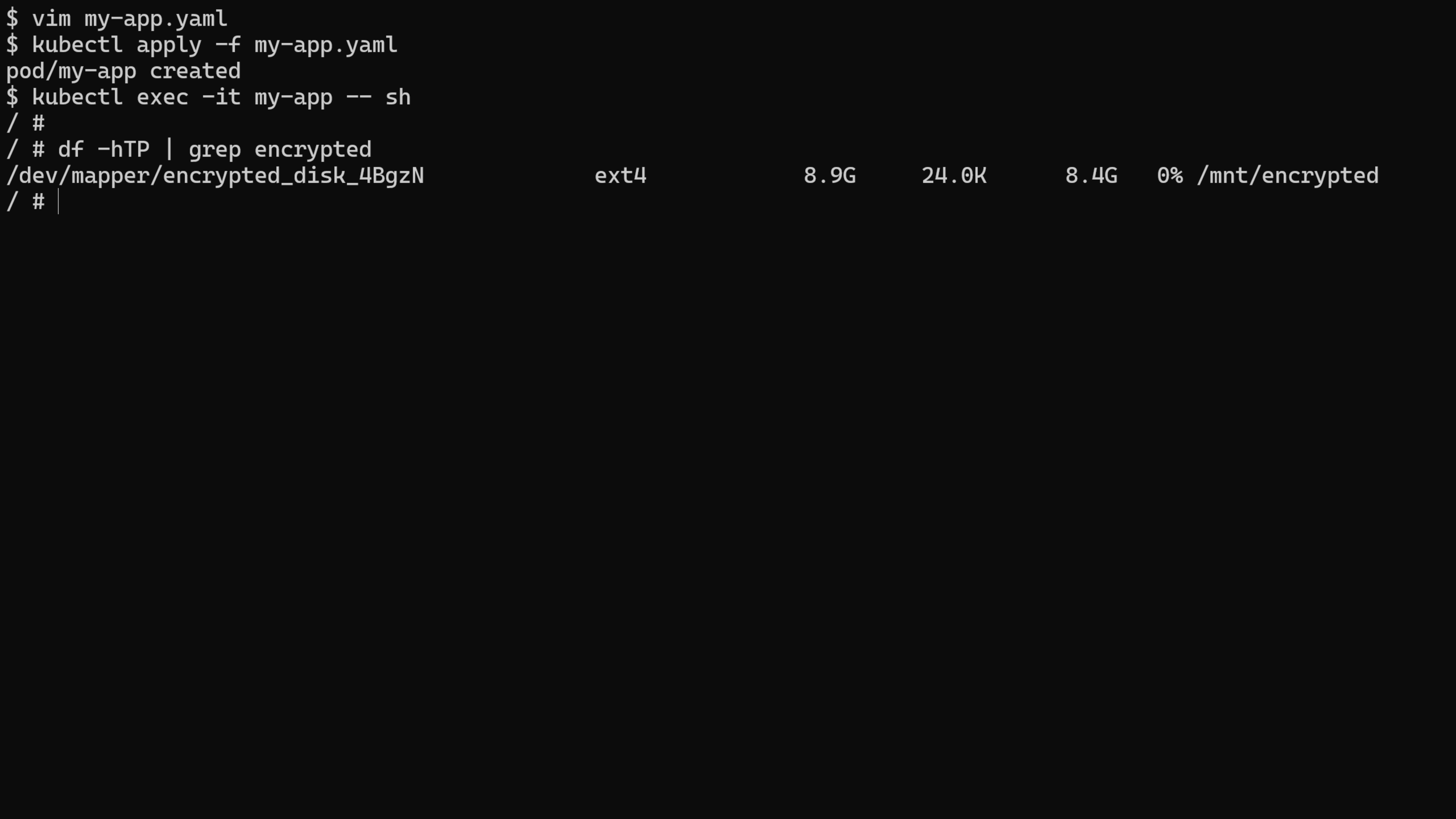

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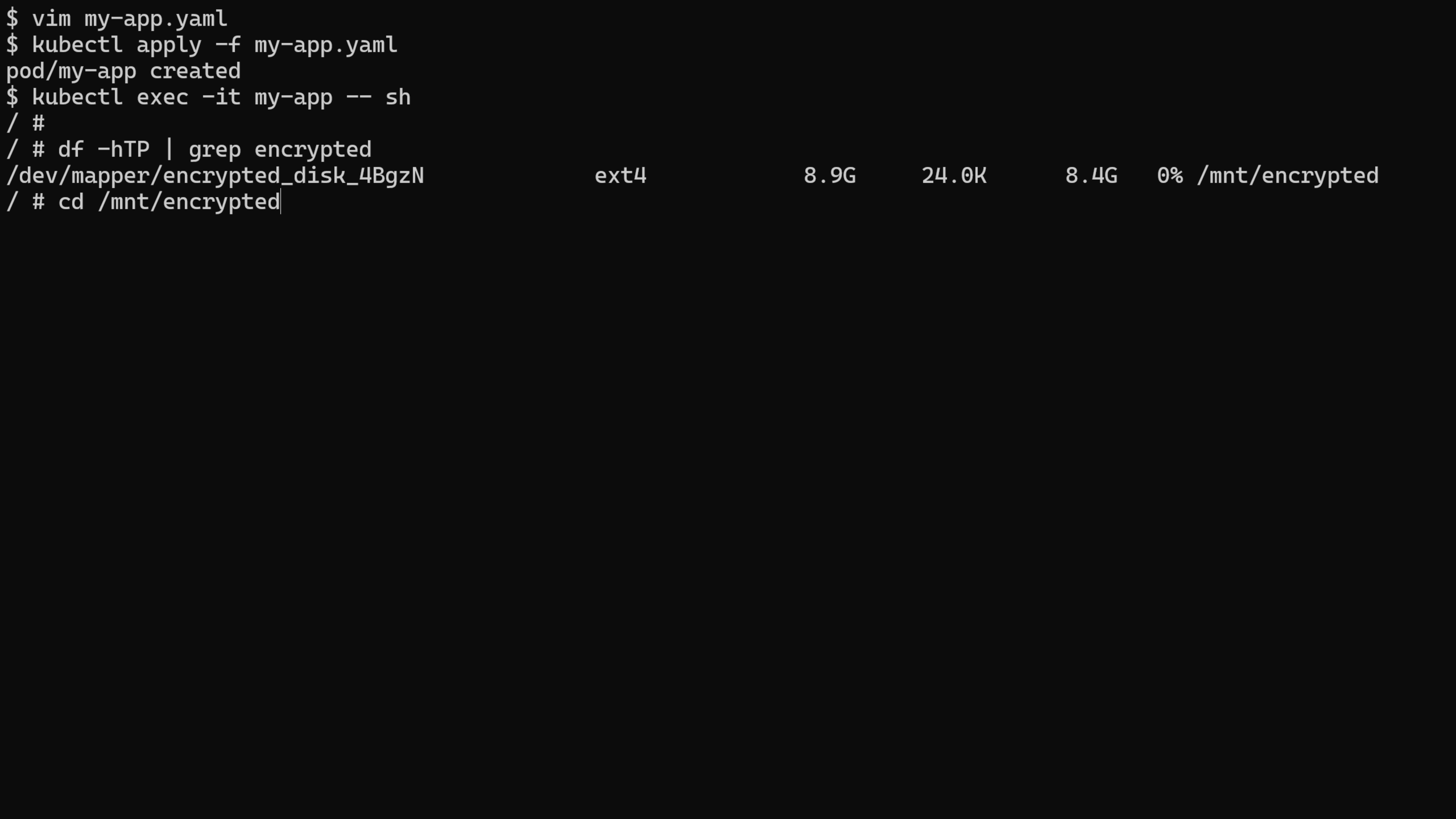

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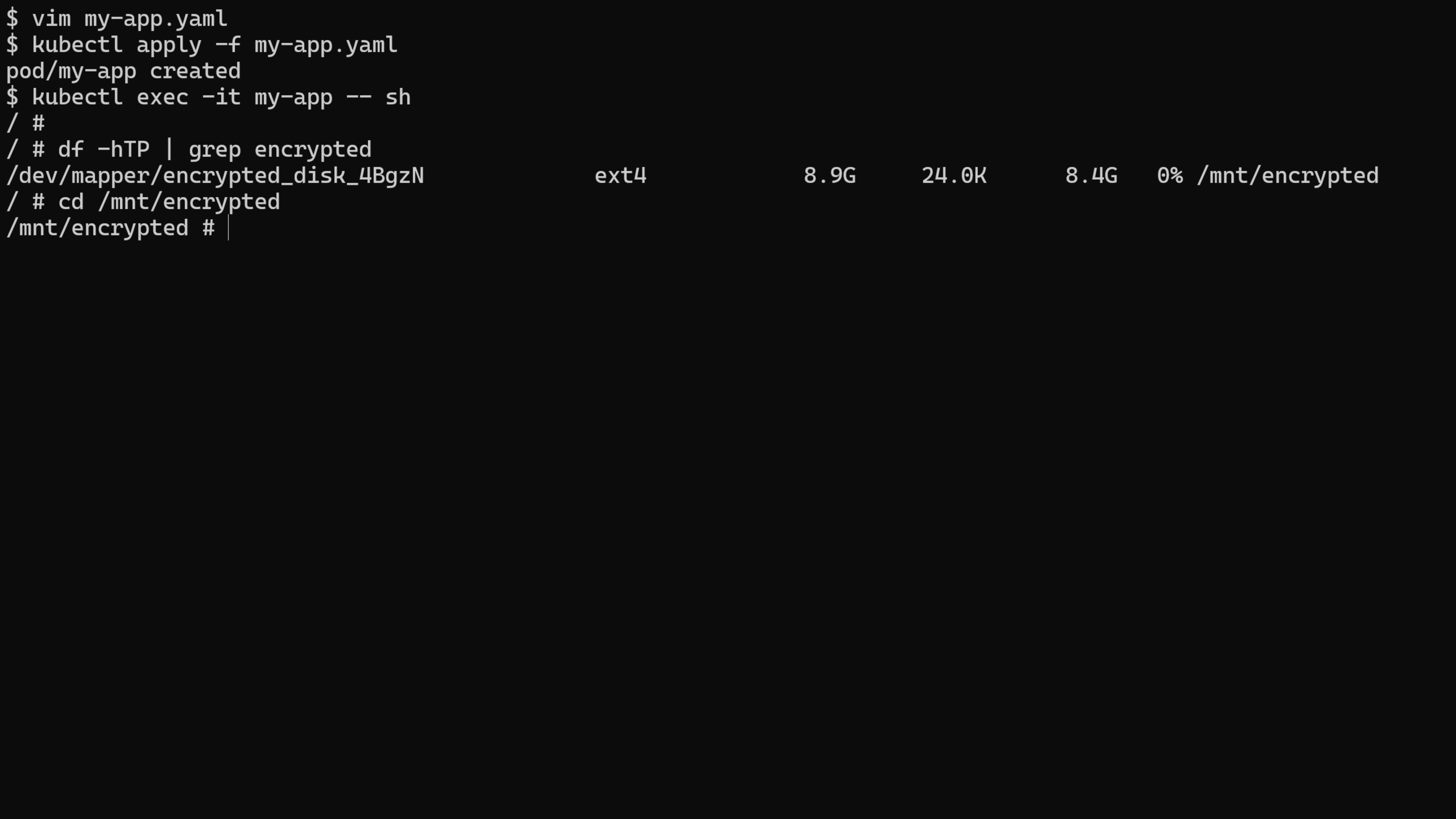

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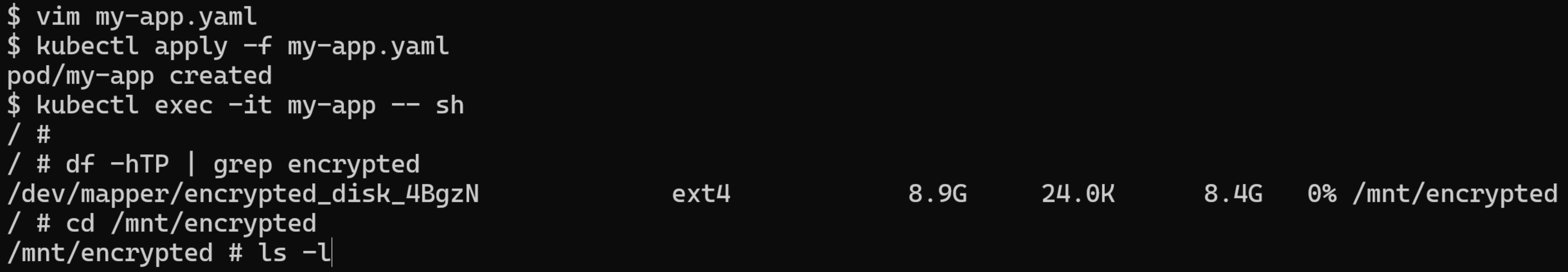

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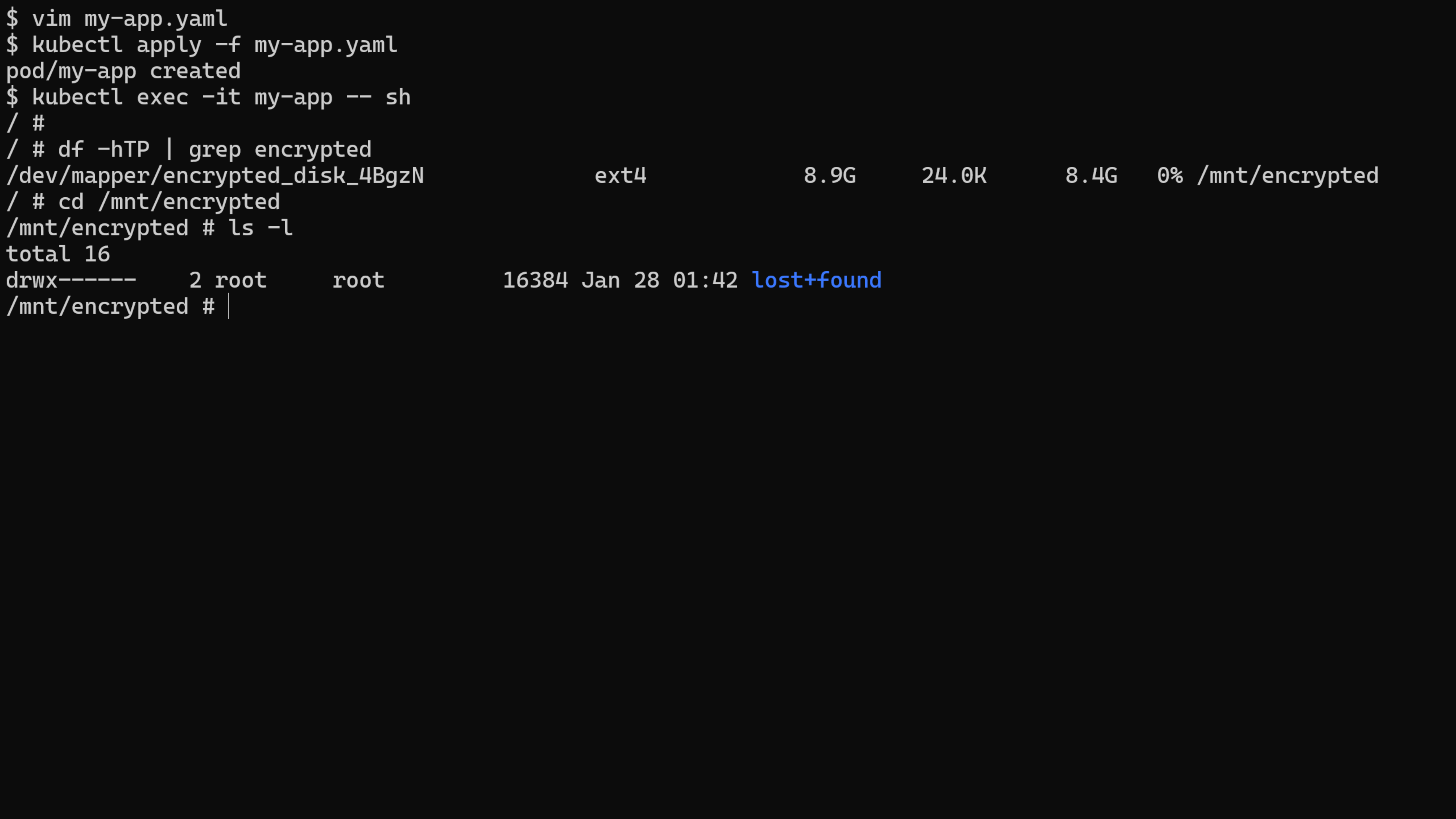

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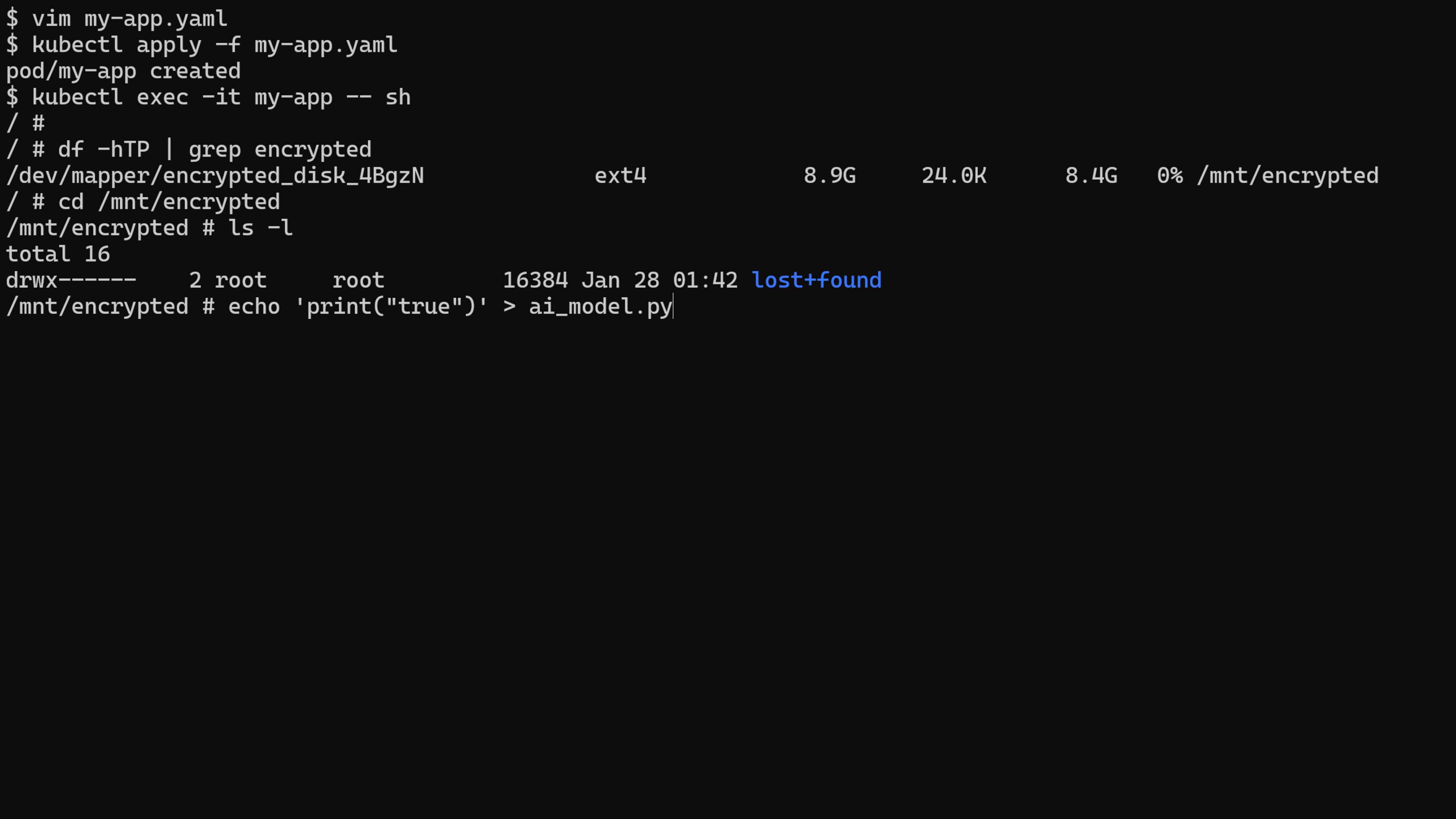

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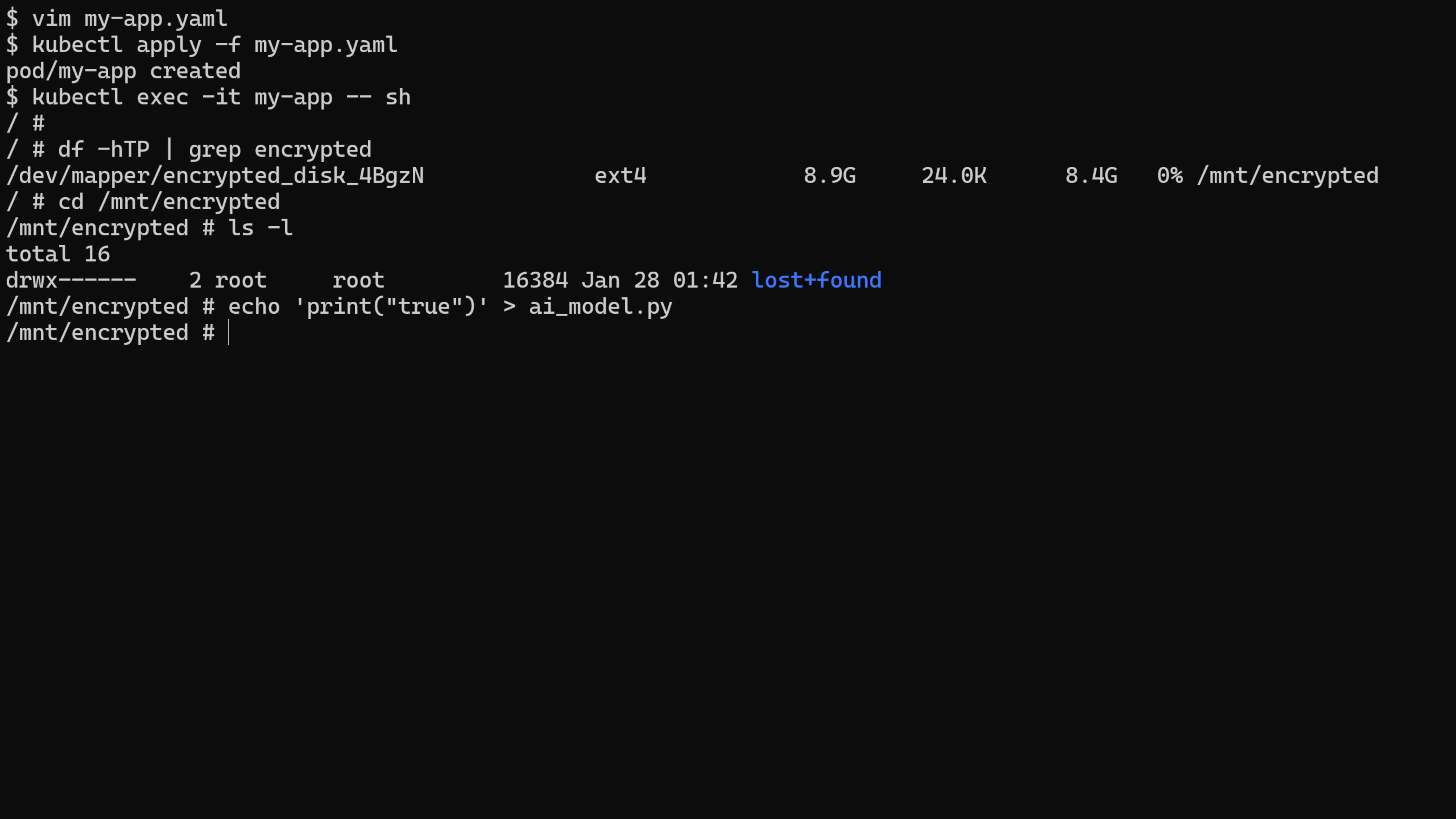

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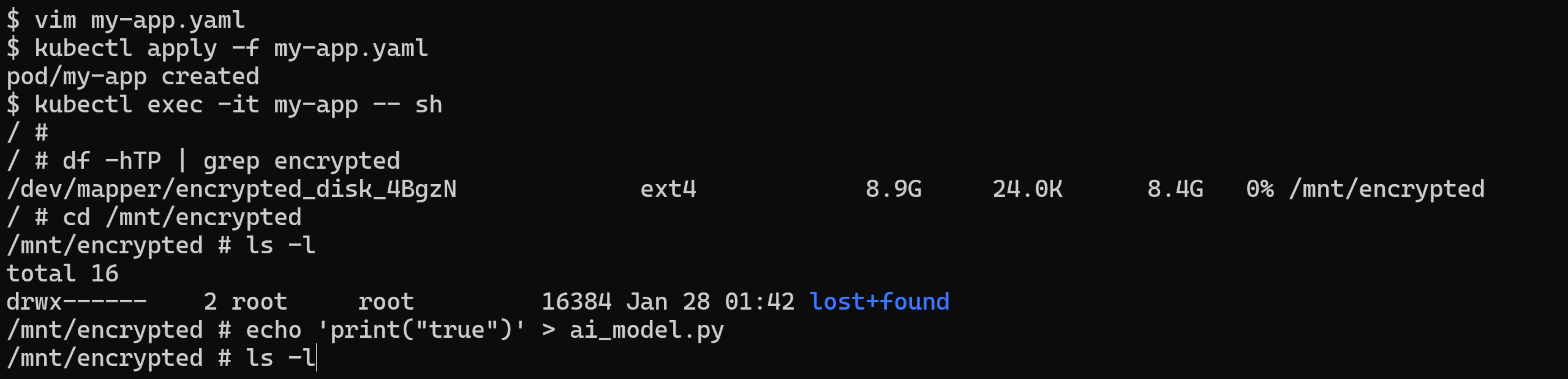

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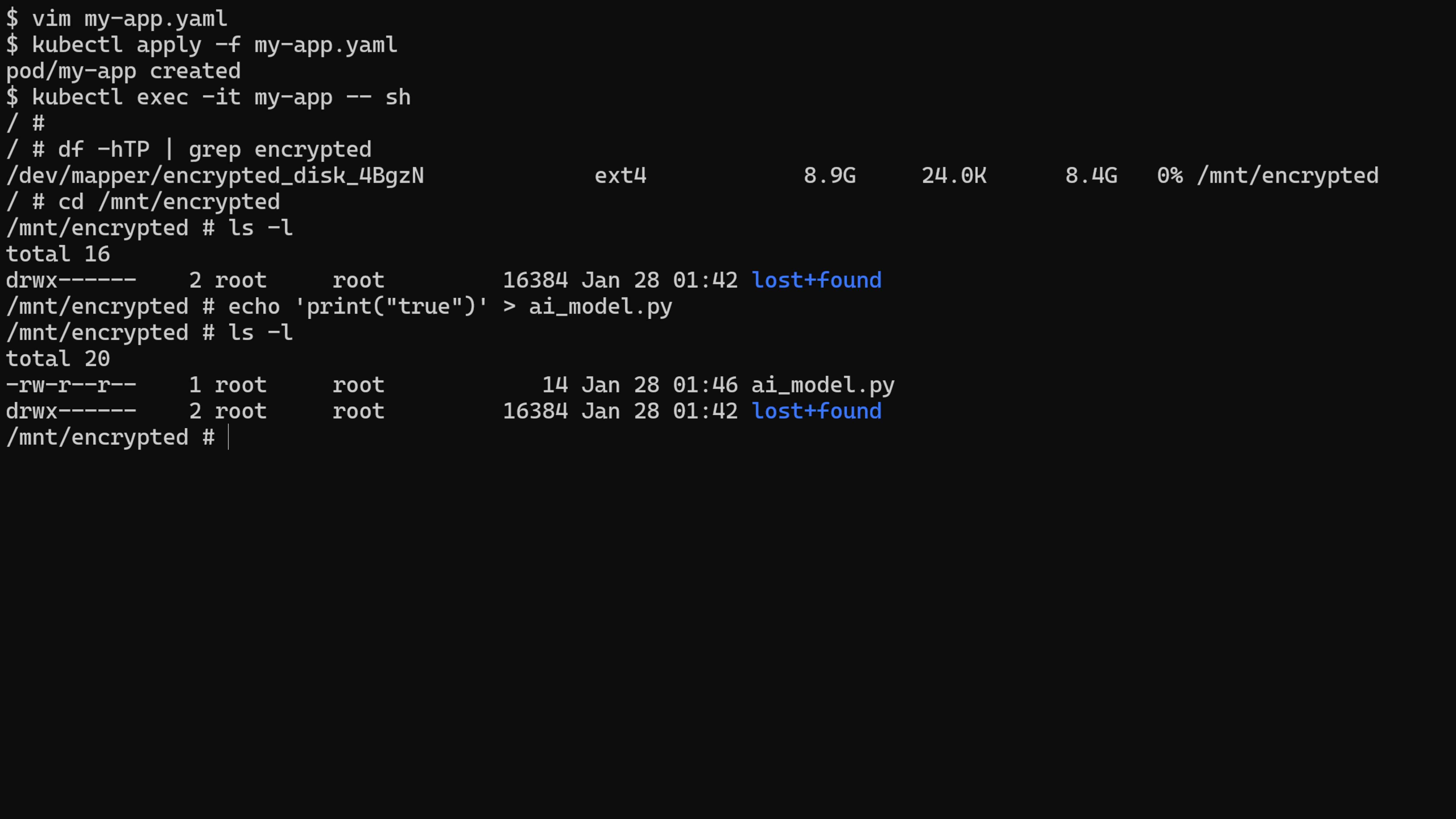

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-rw-r--r--    1 root     root            14 Jan 28 01:46 ai_model.py
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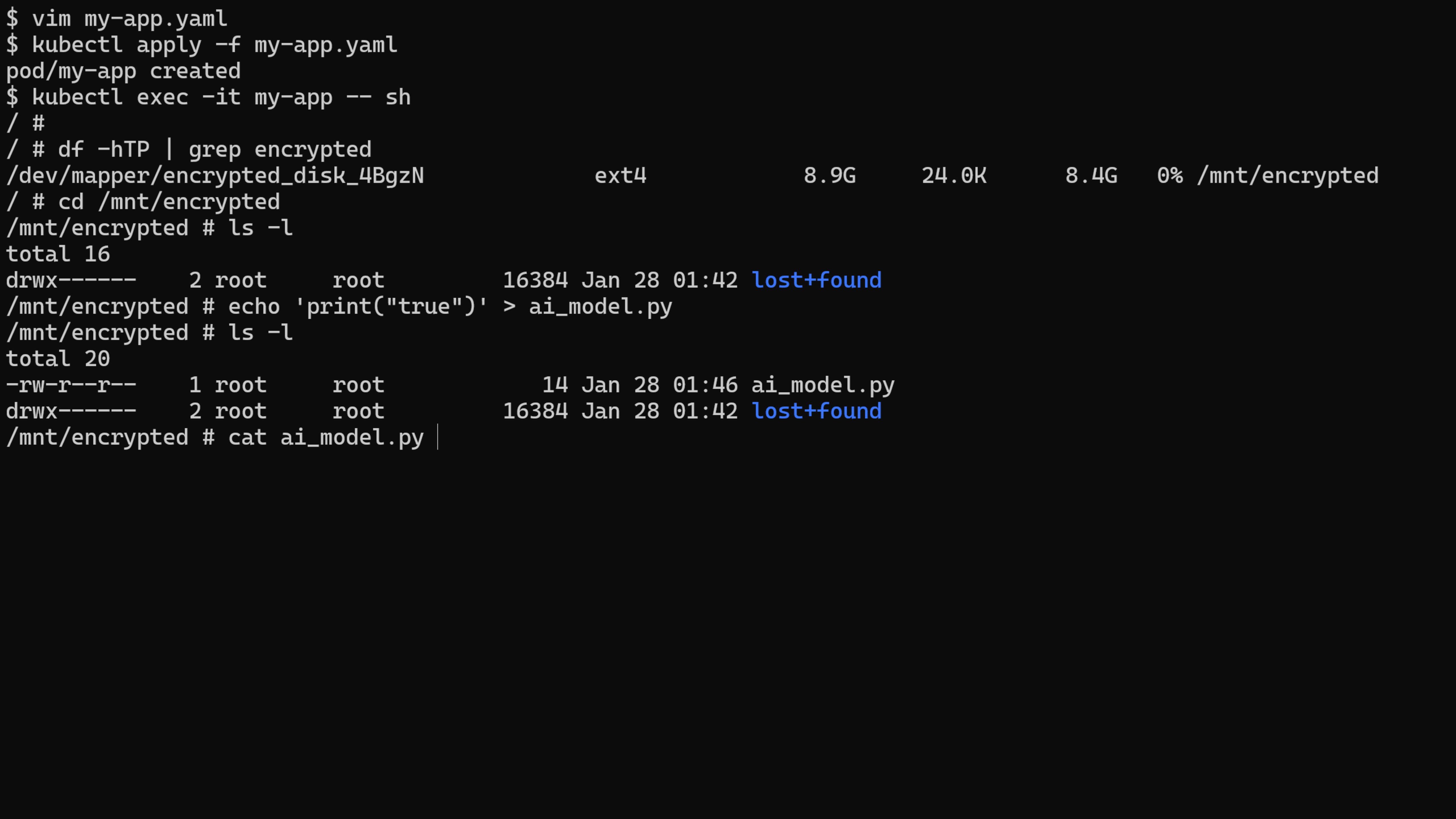

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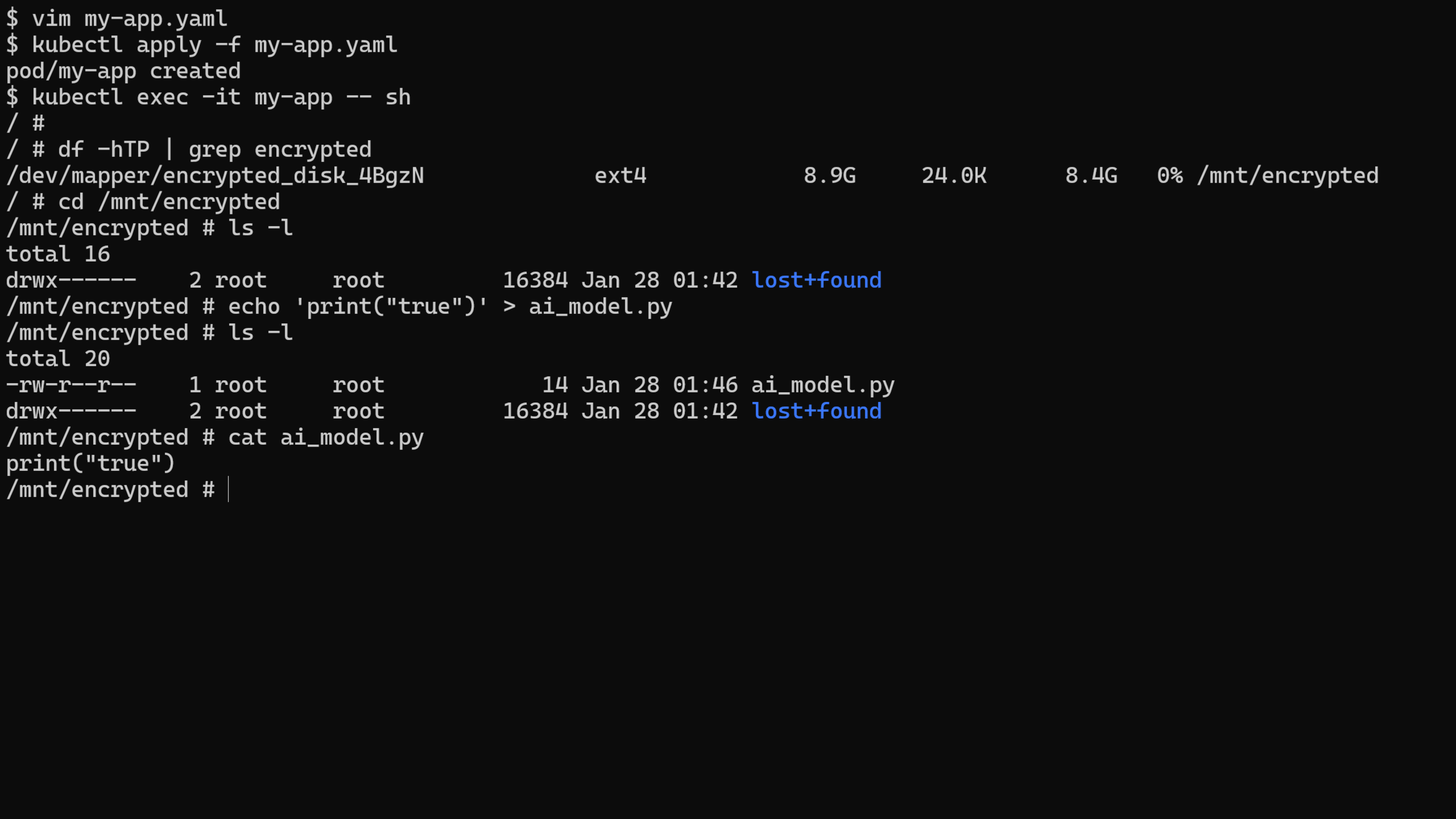

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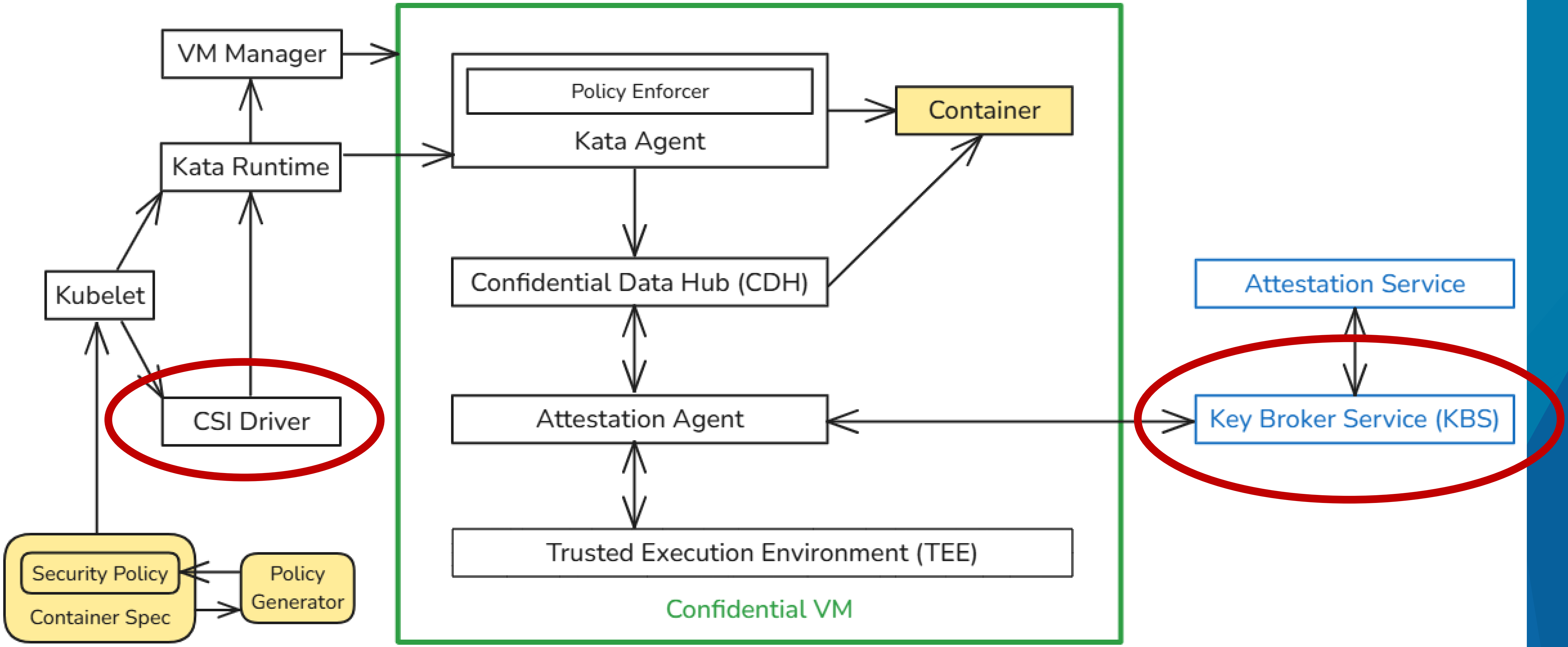
Persistent storage

- Final design TBD
- Builds on ephemeral storage
- Key differences
    - CSI driver
    - Key Broker Service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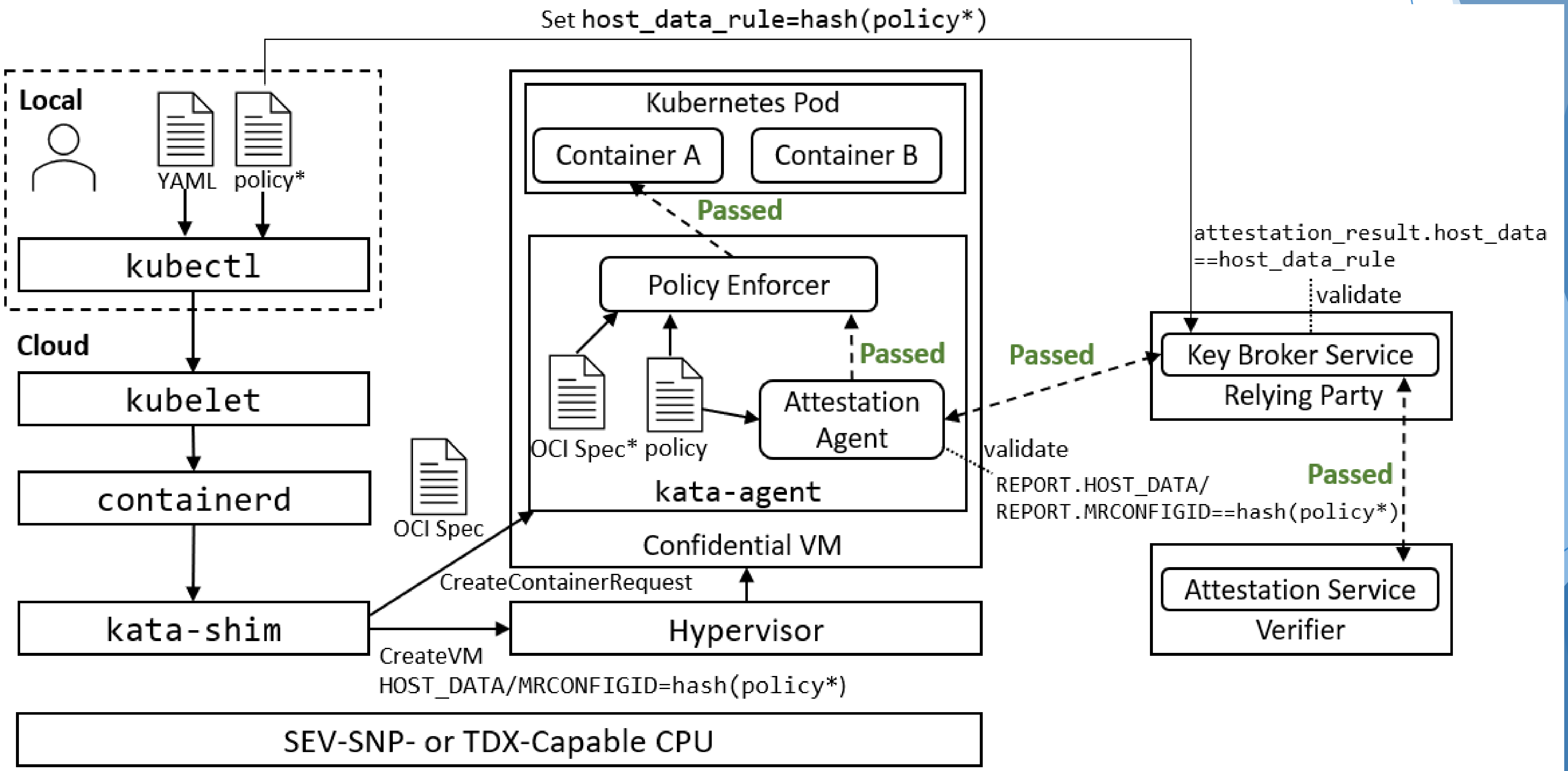
Attestation Service
Key Broker Service (KBS)

Questions?

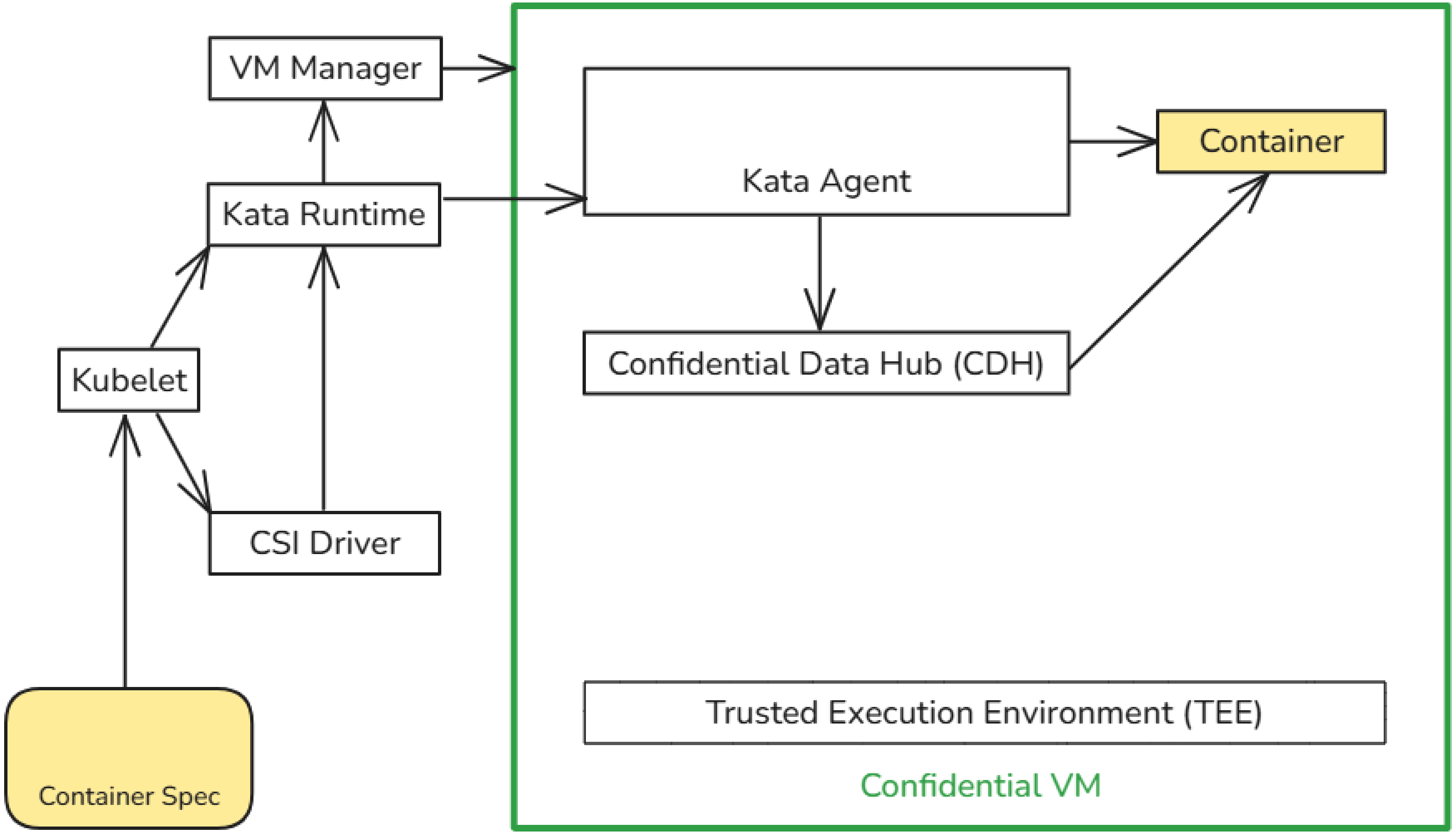
Links

- PR (& proposal) to implement confidential ephemeral storage
  - github.com/**kata-containers/kata-containers**/pull/**10559**
- Confidential Containers website
  - confidentialcontainers.org
- Confidential Containers code
  - github.com/**kata-containers/kata-containers**
  - github.com/**confidential-containers/guest-components**

Policy validation



[RFC] Proposal for Container Metadata Validation · Issue #126 · confidential-containers/confidential-containers



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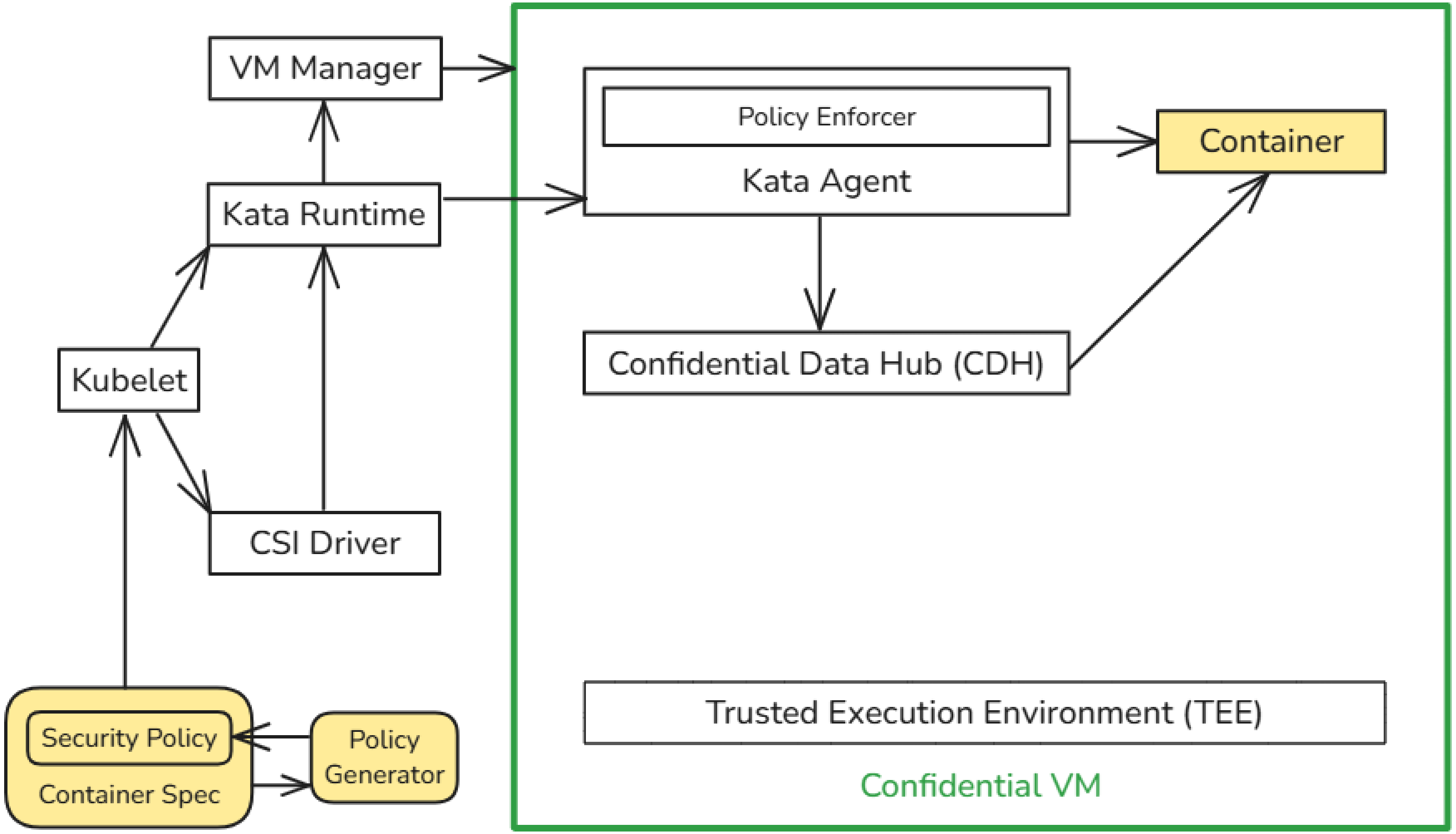
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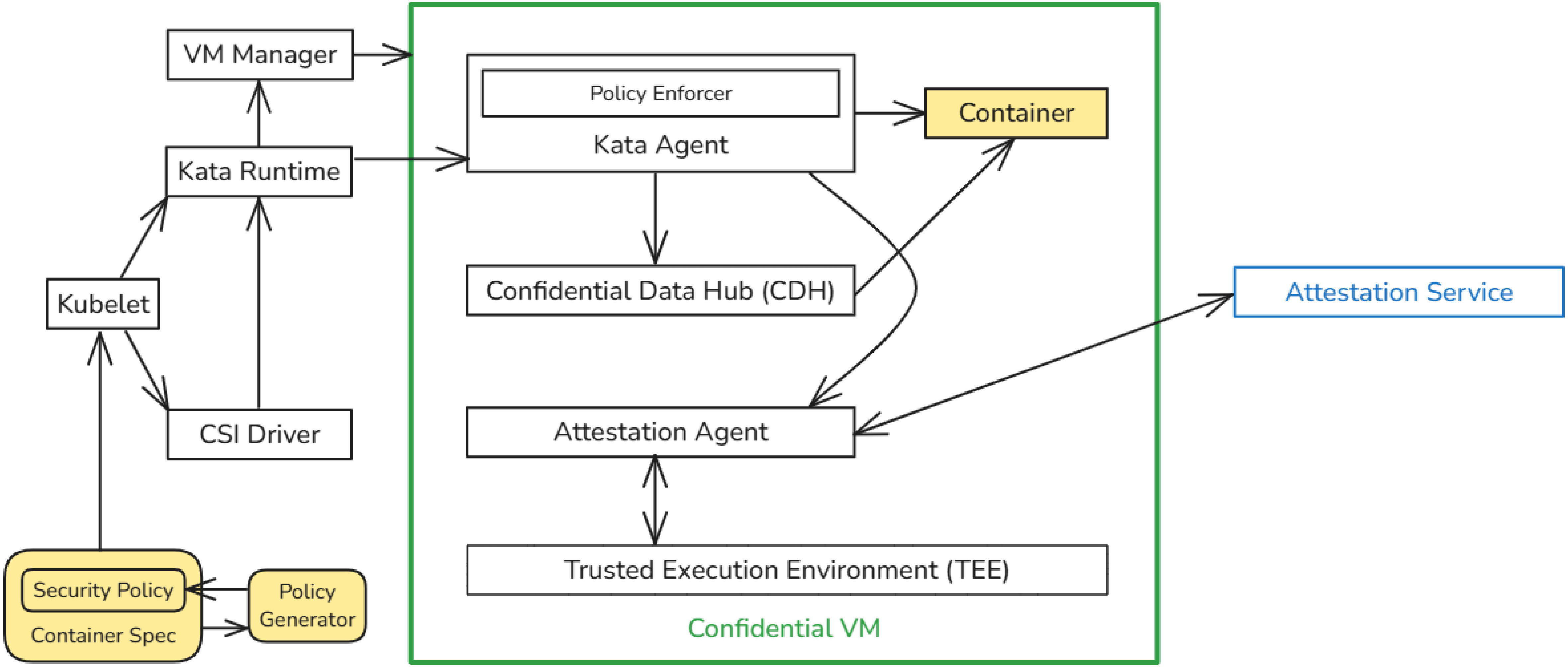
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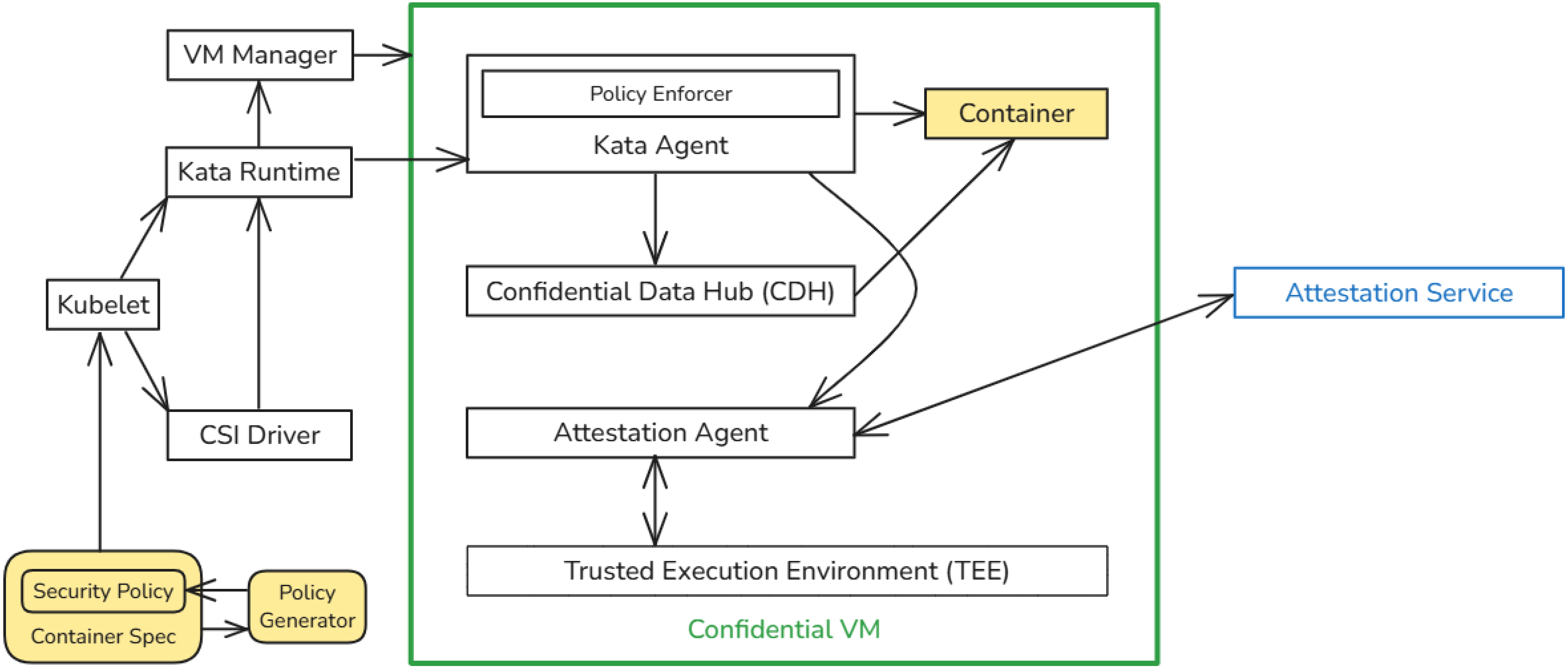
Ephemeral models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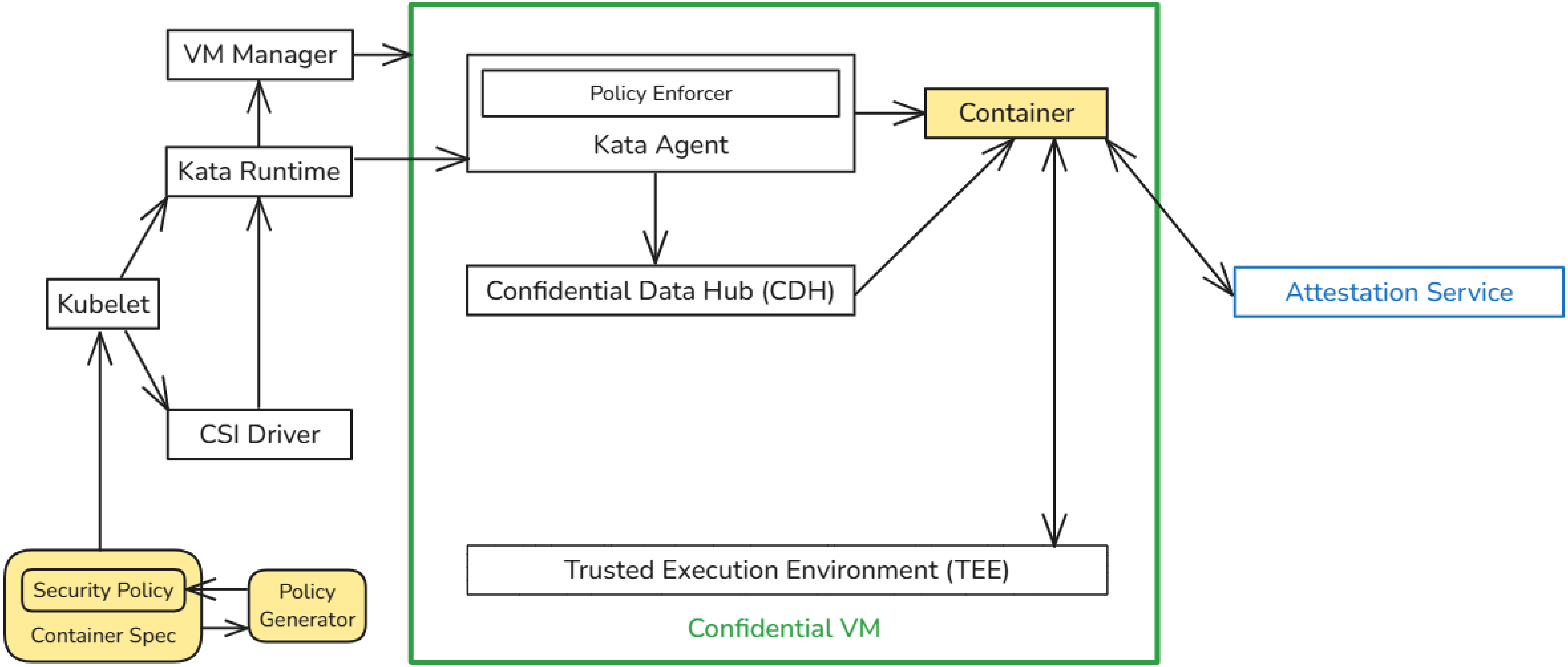
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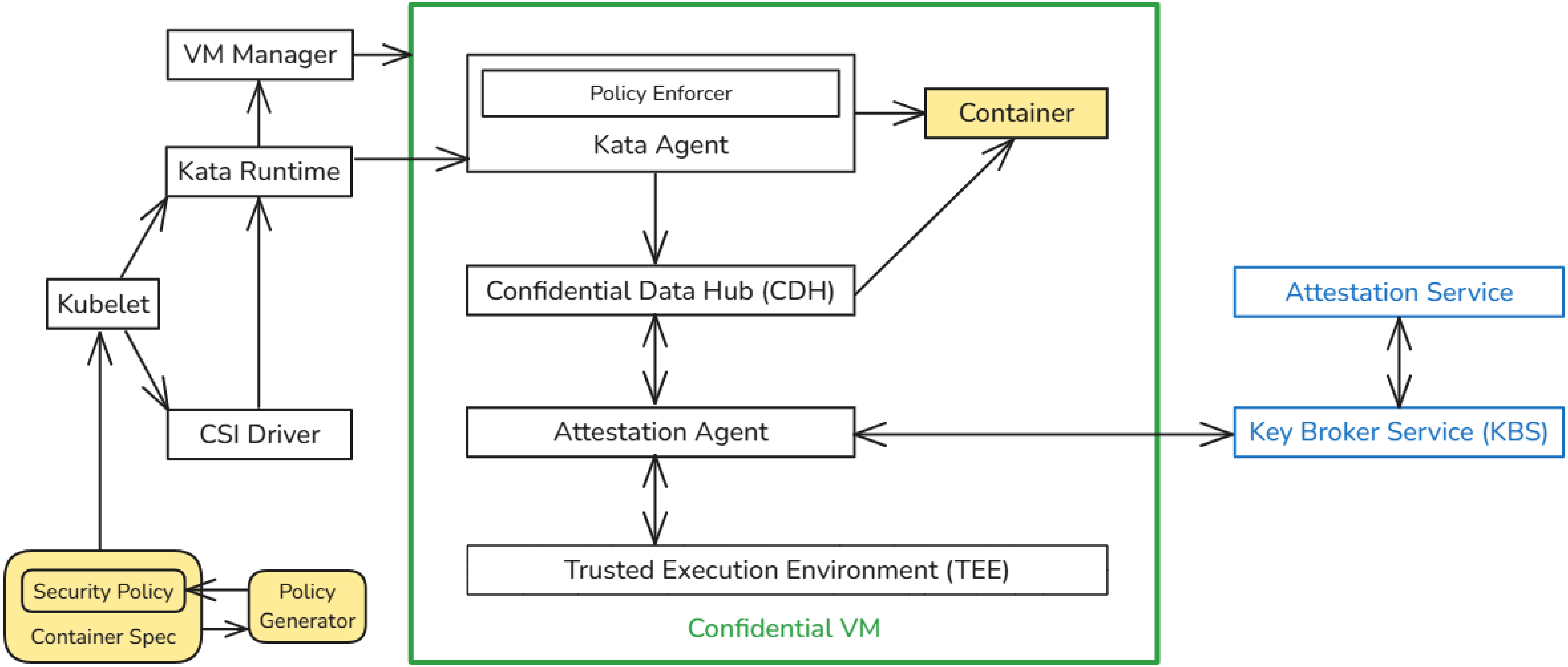
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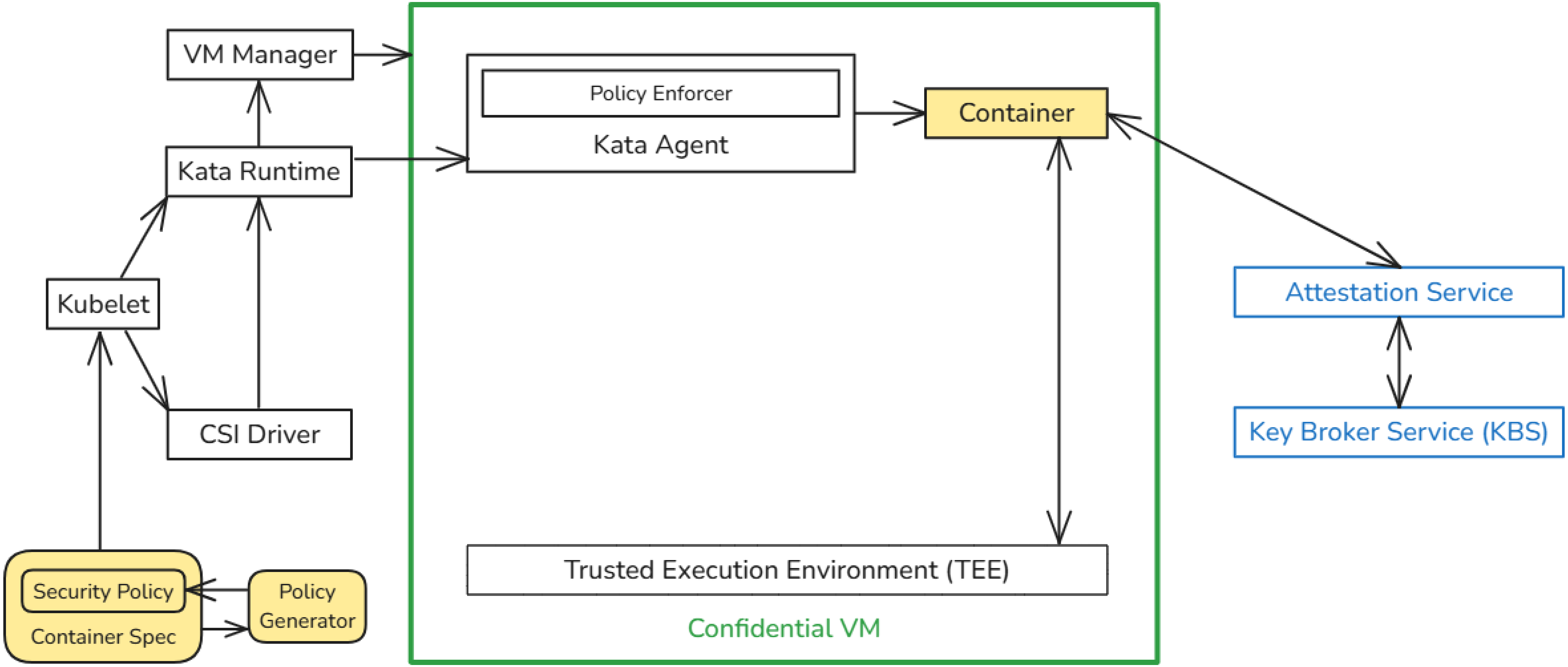
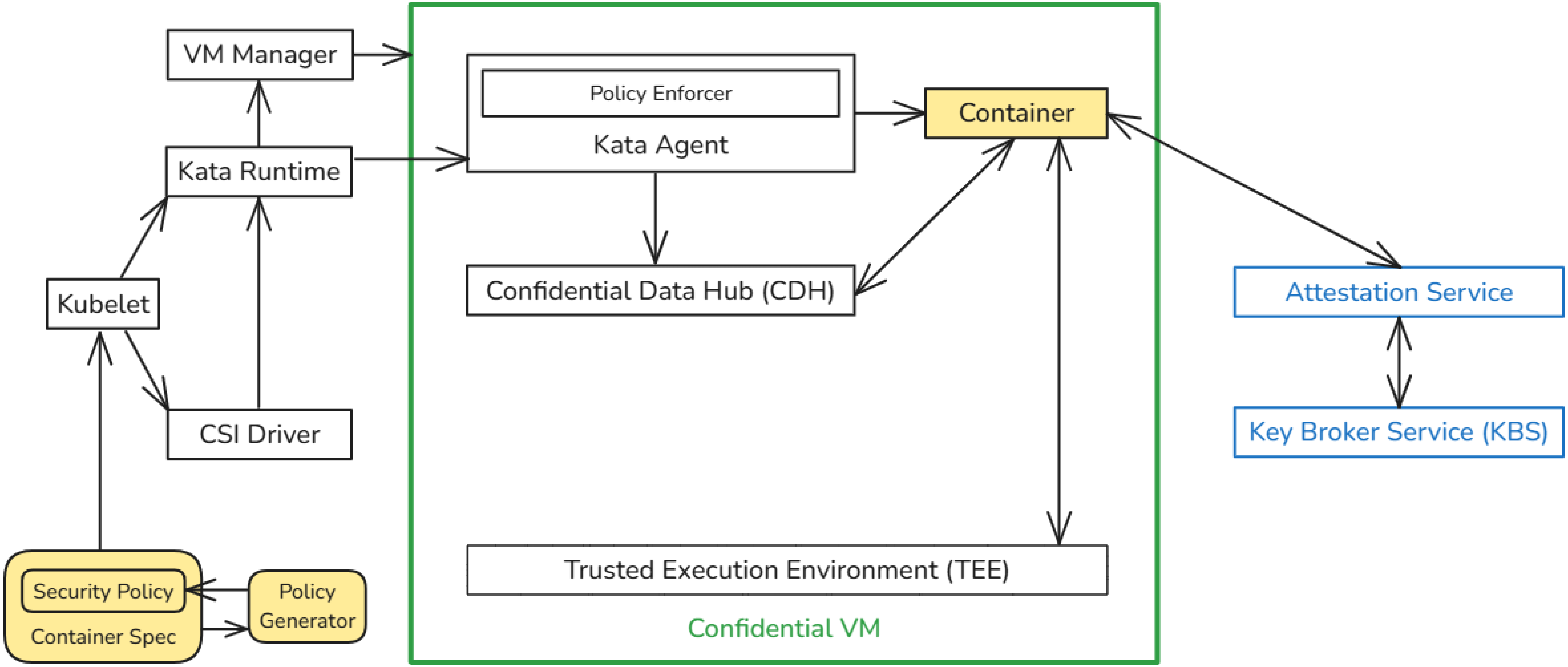
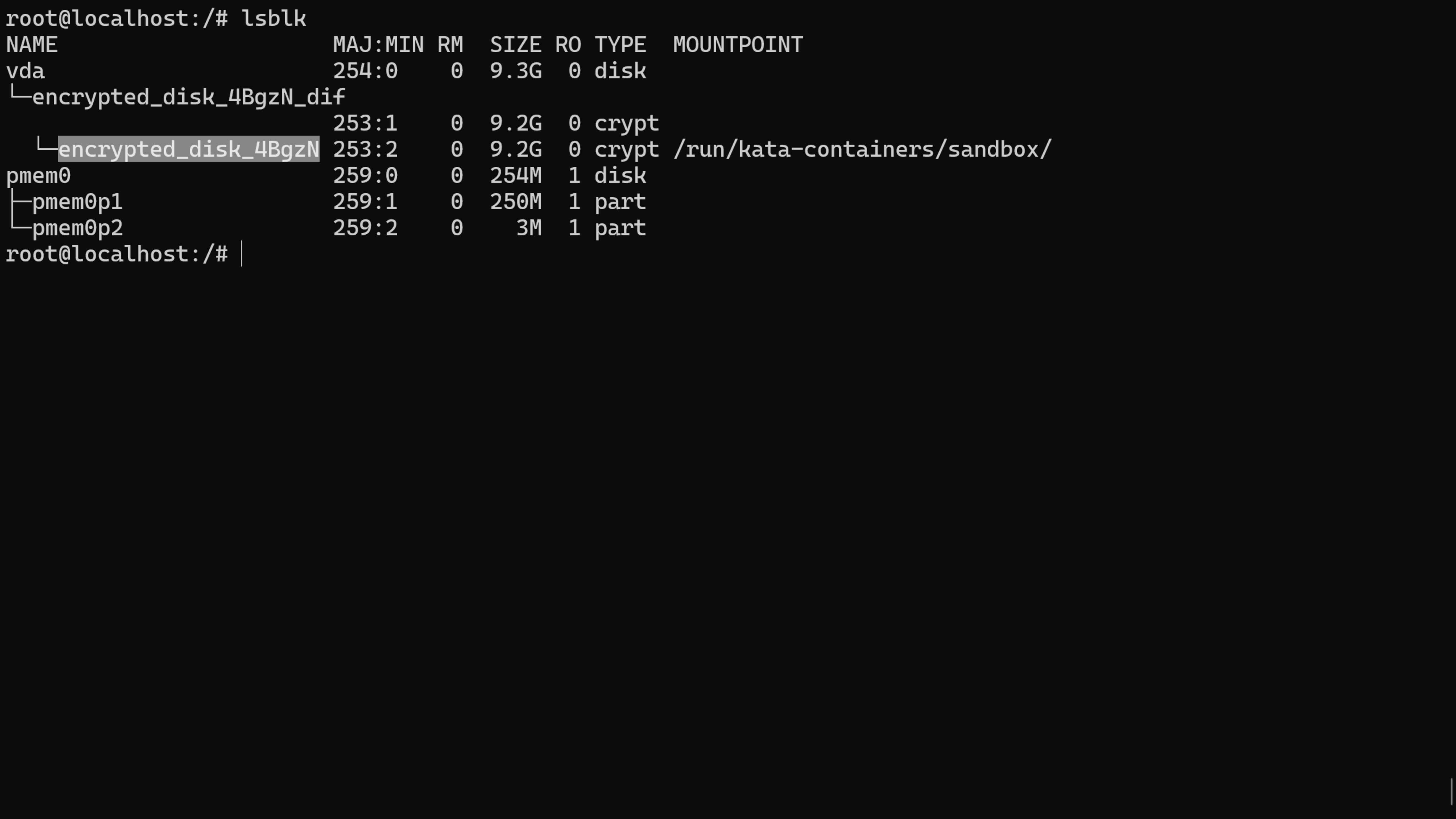
Key Broker Service (KBS)


VM Manager
Policy Enforcer
Kata Agent
Container
Kata Runtime
Kubelet
CSI Driver
Attestation Service
Key Broker Service (KBS)
Security Policy
Container Spec
Policy Generator
Trusted Execution Environment (TEE)
Confidential VM

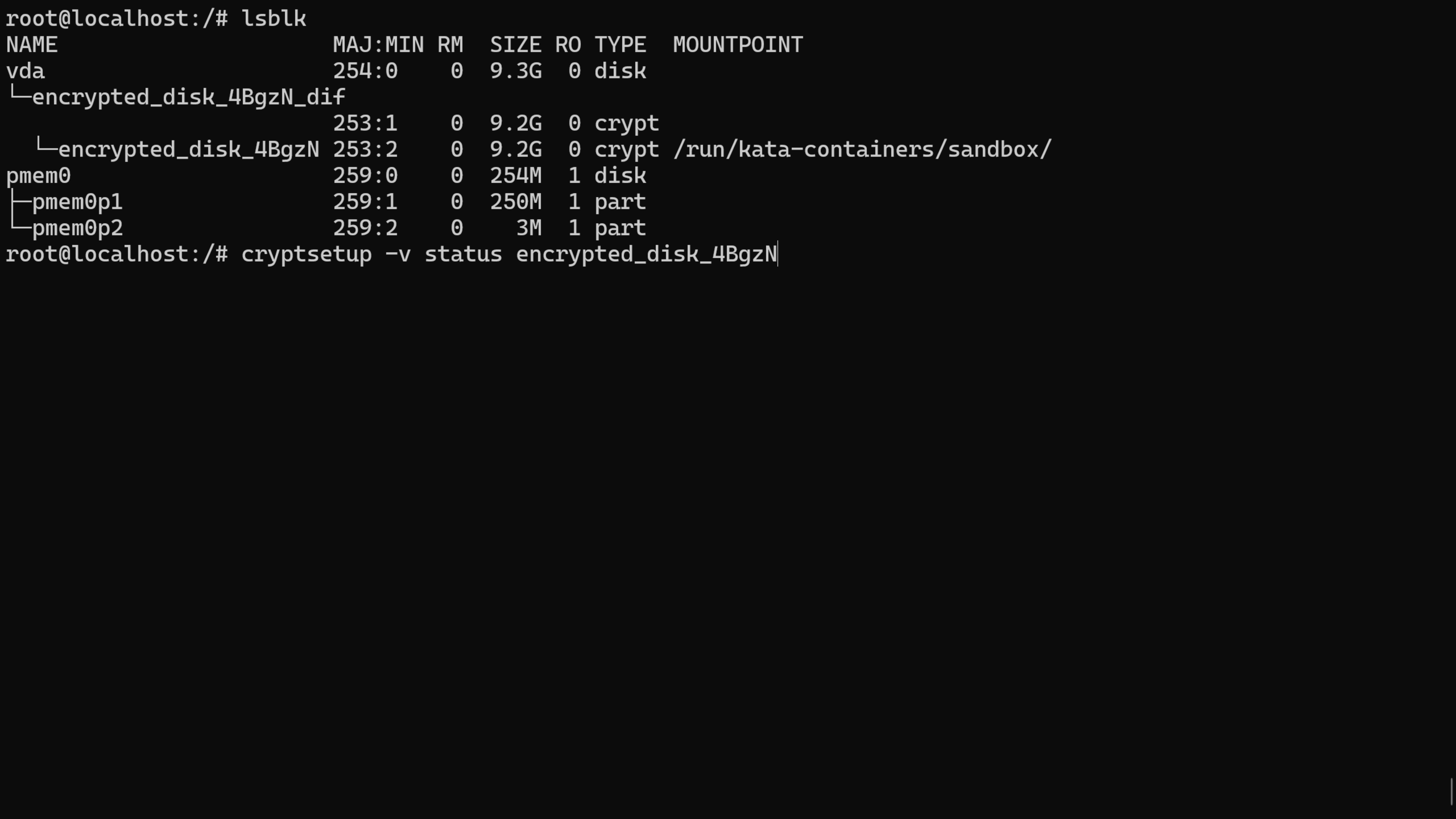

VM Manager
Kata Runtime
Kubelet
CSI Driver
Security Policy
Container Spec
Policy Generator
Policy Enforcer
Kata Agent
Container
Confidential Data Hub (CDH)
Trusted Execution Environment (TEE)
Confidential VM
Attestation Service
Key Broker Service (KBS)

Verifying encryption settings

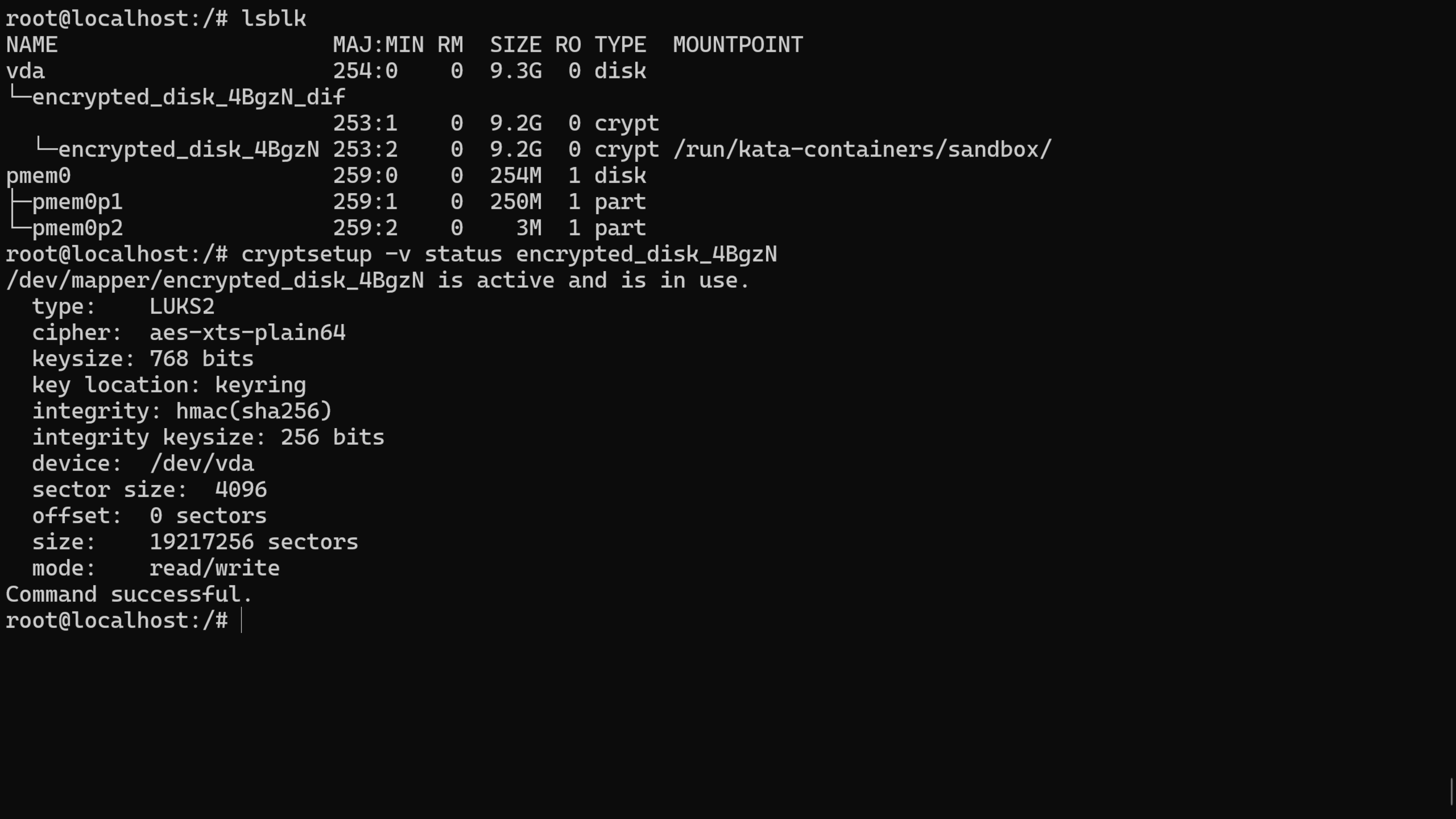
```
root@localhost:/#
```



```
root@localhost:/# lsblk
NAME                      MAJ:MIN RM  SIZE RO TYPE  MOUNTPOINT
vda                       254:0    0  9.3G  0 disk
└─encrypted_disk_4BgzN_dif
                          253:1    0  9.2G  0 crypt
  └─encrypted_disk_4BgzN 253:2    0  9.2G  0 crypt /run/kata-containers/sandbox/
pmem0                     259:0    0  254M  1 disk
├─pmem0p1                 259:1    0  250M  1 part
└─pmem0p2                 259:2    0    3M  1 part
root@localhost:/# 
```



```
root@localhost:/# lsblk
NAME                       MAJ:MIN RM  SIZE RO TYPE  MOUNTPOINT
vda                        254:0    0  9.3G  0 disk
└─encrypted_disk_4BgzN_dif
                           253:1    0  9.2G  0 crypt
  └─encrypted_disk_4BgzN 253:2    0  9.2G  0 crypt /run/kata-containers/sandbox/
pmem0                      259:0    0  254M  1 disk
├─pmem0p1                  259:1    0  250M  1 part
└─pmem0p2                  259:2    0    3M  1 part
root@localhost:/# cryptsetup -v status encrypted_disk_4BgzN
```

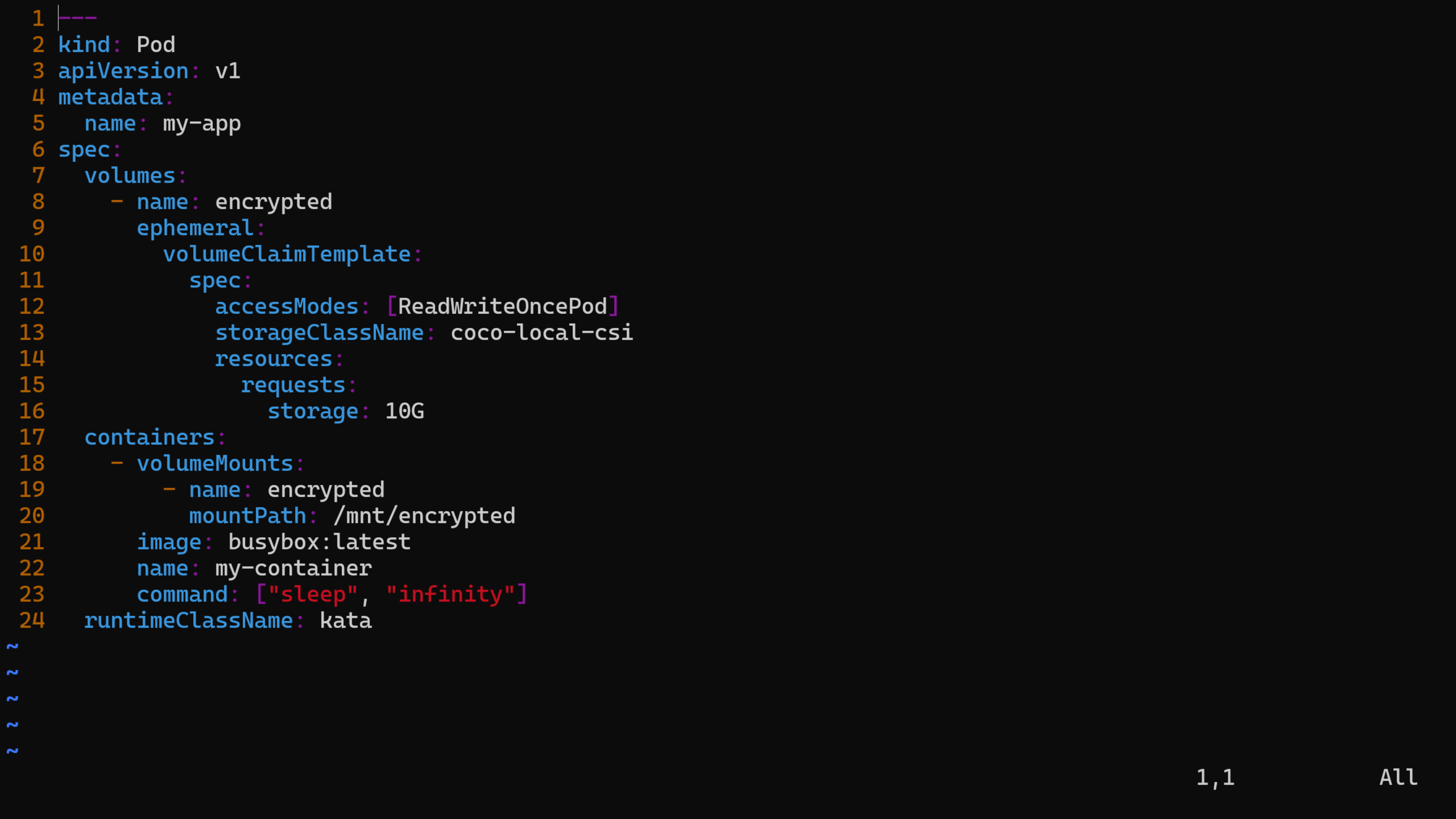


```
root@localhost:/# lsblk
NAME                      MAJ:MIN RM  SIZE RO TYPE  MOUNTPOINT
vda                       254:0    0  9.3G  0 disk
└─encrypted_disk_4BgzN_dif
                          253:1    0  9.2G  0 crypt
  └─encrypted_disk_4BgzN 253:2    0  9.2G  0 crypt /run/kata-containers/sandbox/
pmem0                     259:0    0  254M  1 disk
├─pmem0p1                 259:1    0  250M  1 part
└─pmem0p2                 259:2    0    3M  1 part
root@localhost:/# cryptsetup -v status encrypted_disk_4BgzN
/dev/mapper/encrypted_disk_4BgzN is active and is in use.
  type:    LUKS2
  cipher:  aes-xts-plain64
  keysize: 768 bits
  key location: keyring
  integrity: hmac(sha256)
  integrity keysize: 256 bits
  device:  /dev/vda
  sector size:  4096
  offset:  0 sectors
  size:    19217256 sectors
  mode:    read/write
Command successful.
root@localhost:/# 
```

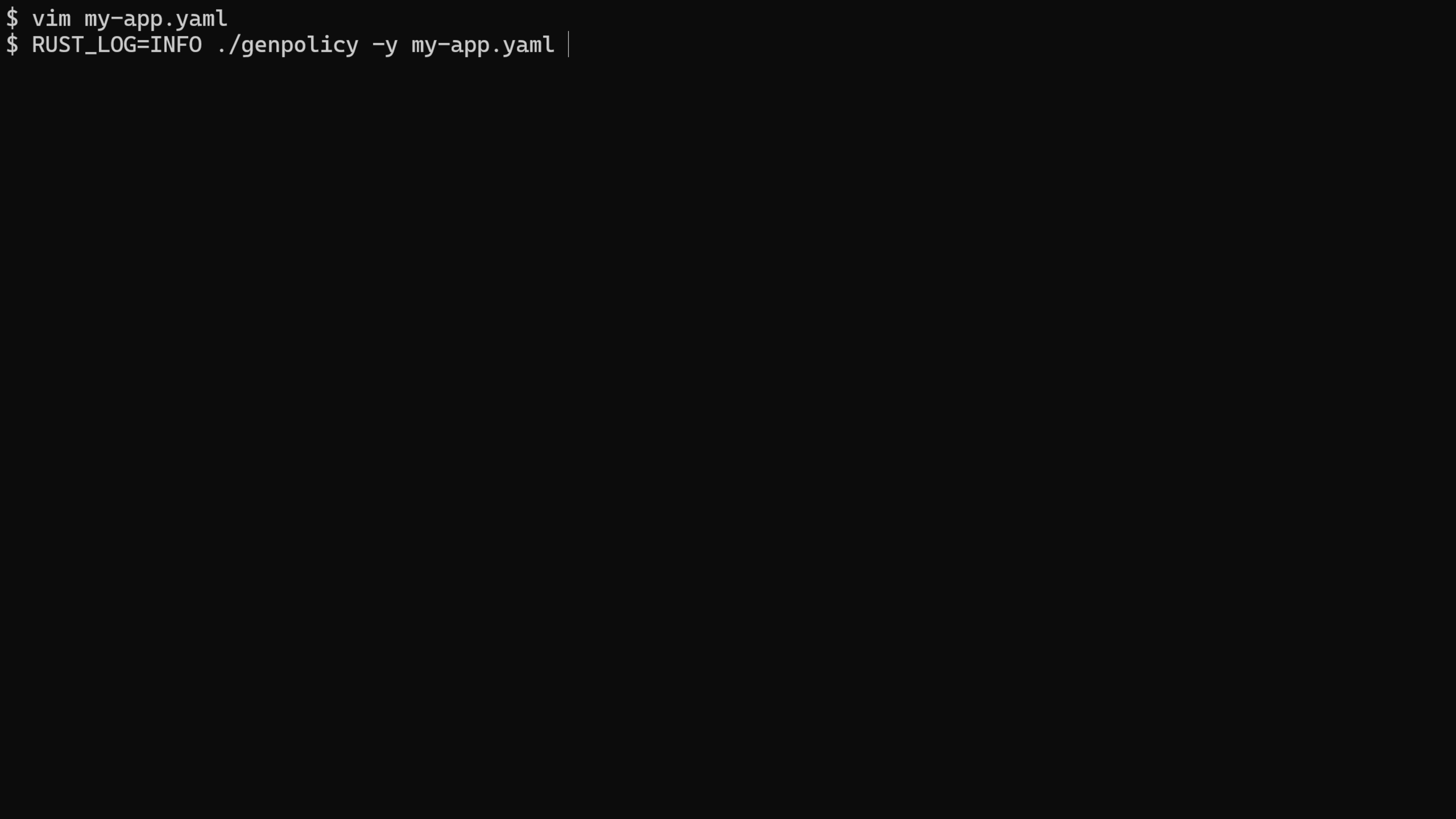
Generating security policy

```
$
```

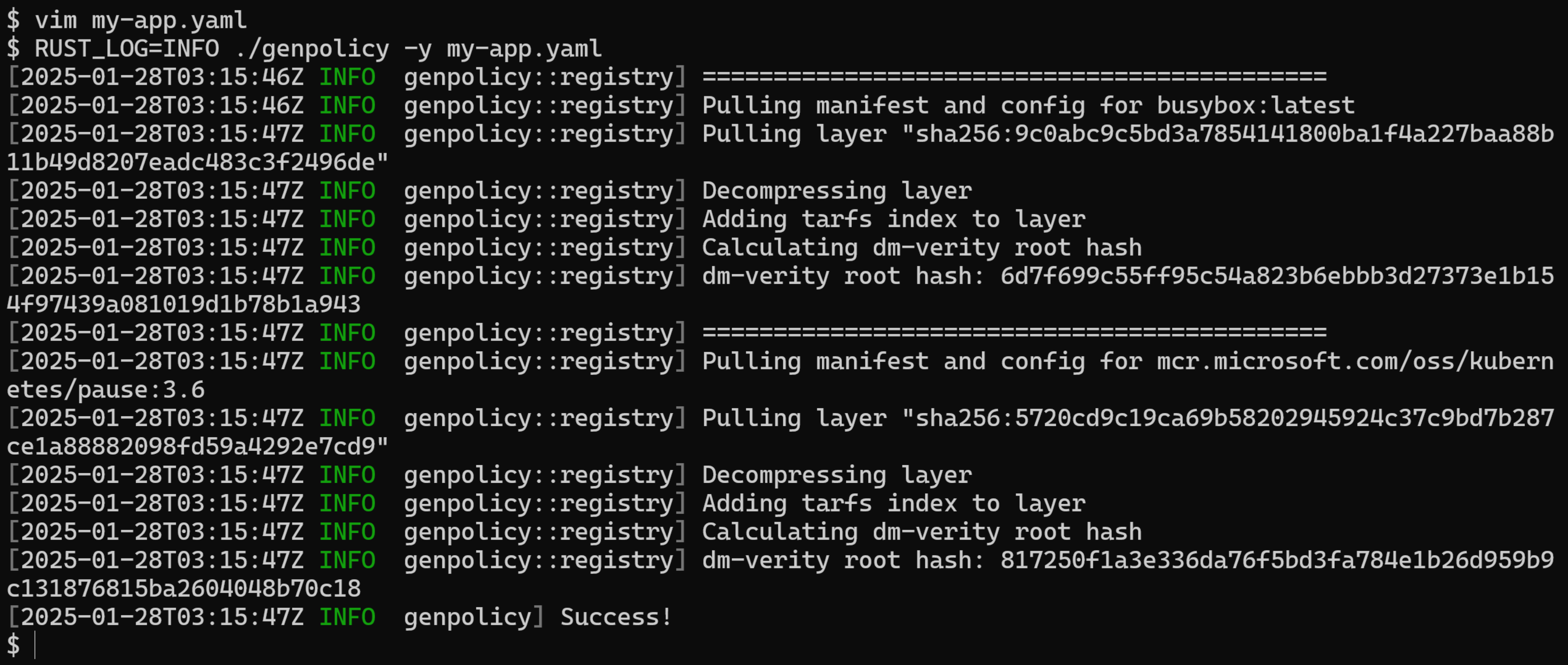
```
$ vim my-app.yaml
```



```yaml
---
kind: Pod
apiVersion: v1
metadata:
  name: my-app
spec:
  volumes:
    - name: encrypted
      ephemeral:
        volumeClaimTemplate:
          spec:
            accessModes: [ReadWriteOncePod]
            storageClassName: coco-local-csi
            resources:
              requests:
                storage: 10G
  containers:
    - volumeMounts:
        - name: encrypted
          mountPath: /mnt/encrypted
      image: busybox:latest
      name: my-container
      command: ["sleep", "infinity"]
  runtimeClassName: kata
```

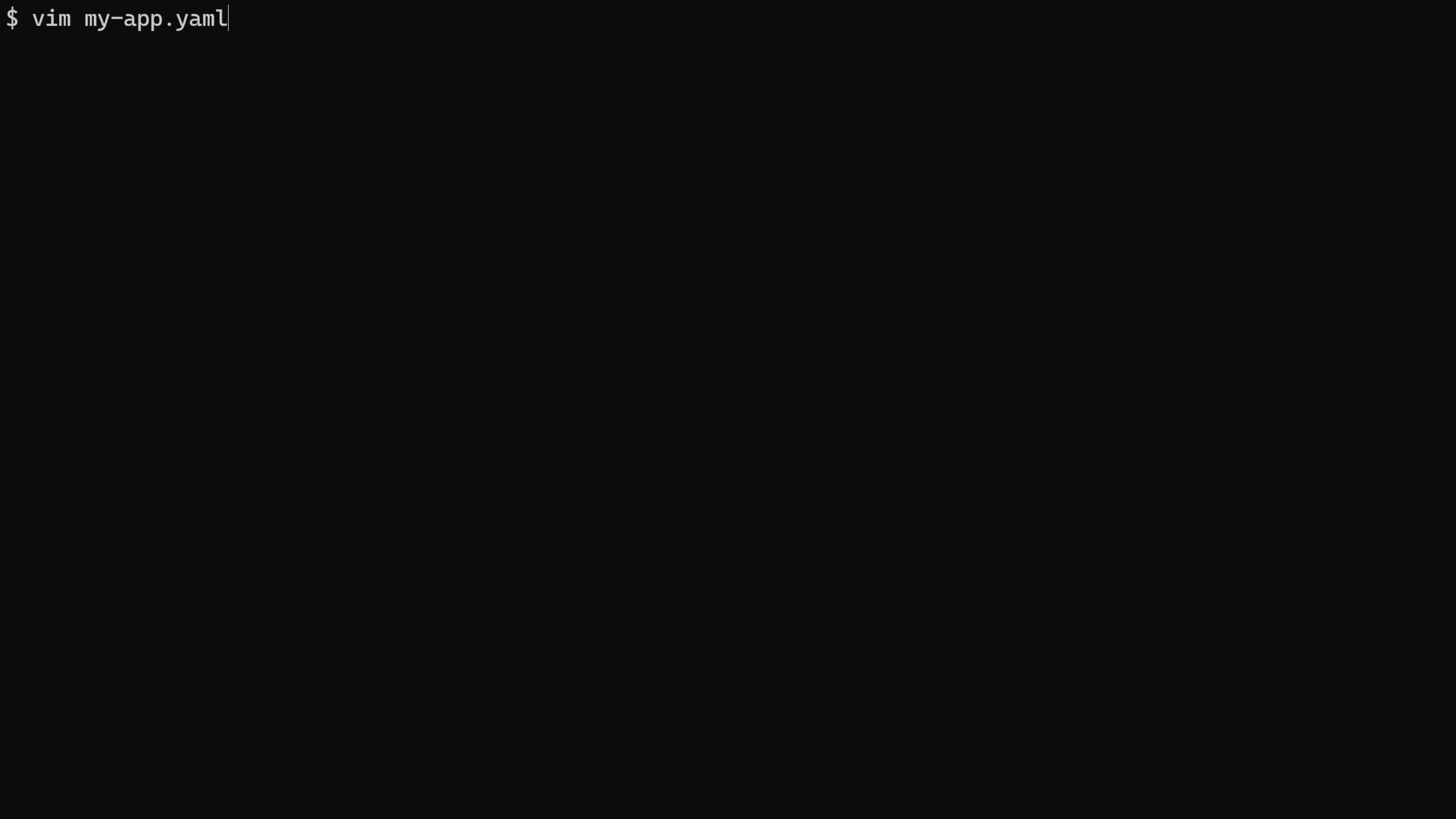


```
$ vim my-app.yaml
$ RUST_LOG=INFO ./genpolicy -y my-app.yaml
```

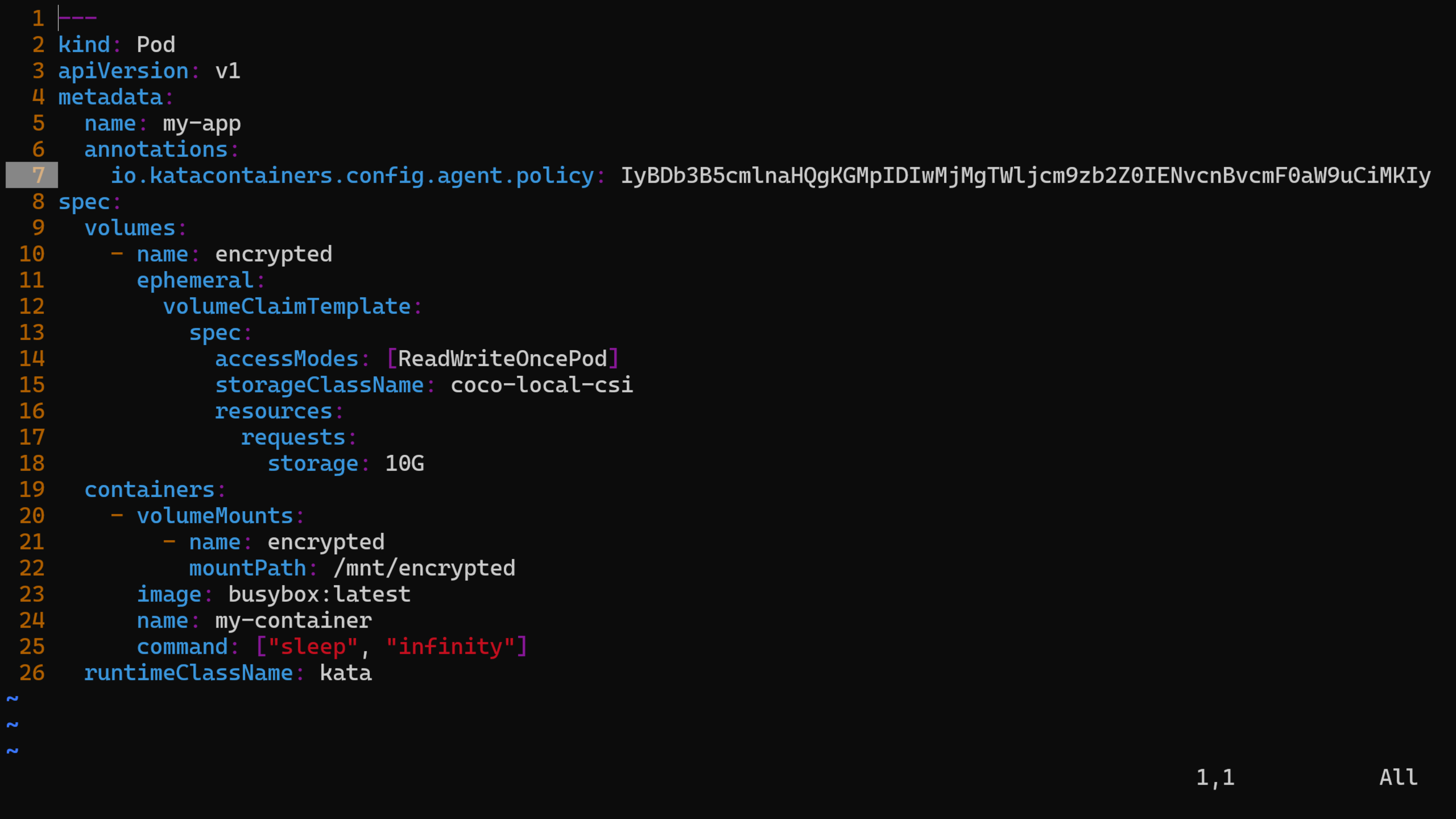


```
$ vim my-app.yaml
$ RUST_LOG=INFO ./genpolicy -y my-app.yaml
[2025-01-28T03:15:46Z INFO  genpolicy::registry] =============================================
[2025-01-28T03:15:46Z INFO  genpolicy::registry] Pulling manifest and config for busybox:latest
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Pulling layer "sha256:9c0abc9c5bd3a7854141800ba1f4a227baa88b
11b49d8207eadc483c3f2496de"
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Decompressing layer
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Adding tarfs index to layer
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Calculating dm-verity root hash
[2025-01-28T03:15:47Z INFO  genpolicy::registry] dm-verity root hash: 6d7f699c55ff95c54a823b6ebbb3d27373e1b15
4f97439a081019d1b78b1a943
[2025-01-28T03:15:47Z INFO  genpolicy::registry] =============================================
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Pulling manifest and config for mcr.microsoft.com/oss/kubern
etes/pause:3.6
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Pulling layer "sha256:5720cd9c19ca69b58202945924c37c9bd7b287
ce1a88882098fd59a4292e7cd9"
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Decompressing layer
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Adding tarfs index to layer
[2025-01-28T03:15:47Z INFO  genpolicy::registry] Calculating dm-verity root hash
[2025-01-28T03:15:47Z INFO  genpolicy::registry] dm-verity root hash: 817250f1a3e336da76f5bd3fa784e1b26d959b9
c131876815ba2604048b70c18
[2025-01-28T03:15:47Z INFO  genpolicy] Success!
$ 
```

```
$
```



```
$ vim my-app.yaml
```



```yaml
---
kind: Pod
apiVersion: v1
metadata:
  name: my-app
  annotations:
    io.katacontainers.config.agent.policy: IyBDb3B5cmlnaHQgKGMpIDIwMjMgTWljcm9zb2Z0IENvcnBvcmF0aW9uCiMKIy
spec:
  volumes:
    - name: encrypted
      ephemeral:
        volumeClaimTemplate:
          spec:
            accessModes: [ReadWriteOncePod]
            storageClassName: coco-local-csi
            resources:
              requests:
                storage: 10G
  containers:
    - volumeMounts:
        - name: encrypted
          mountPath: /mnt/encrypted
      image: busybox:latest
      name: my-container
      command: ["sleep", "infinity"]
  runtimeClassName: kata
```