KubeBlocks - A domain-driven design operator for stateful workloads

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Part 1

Status Quo of stateful workloads on k8s

Stateful workloads on k8s

94% of organizations surveyed deploy services and applications on Kubernetes

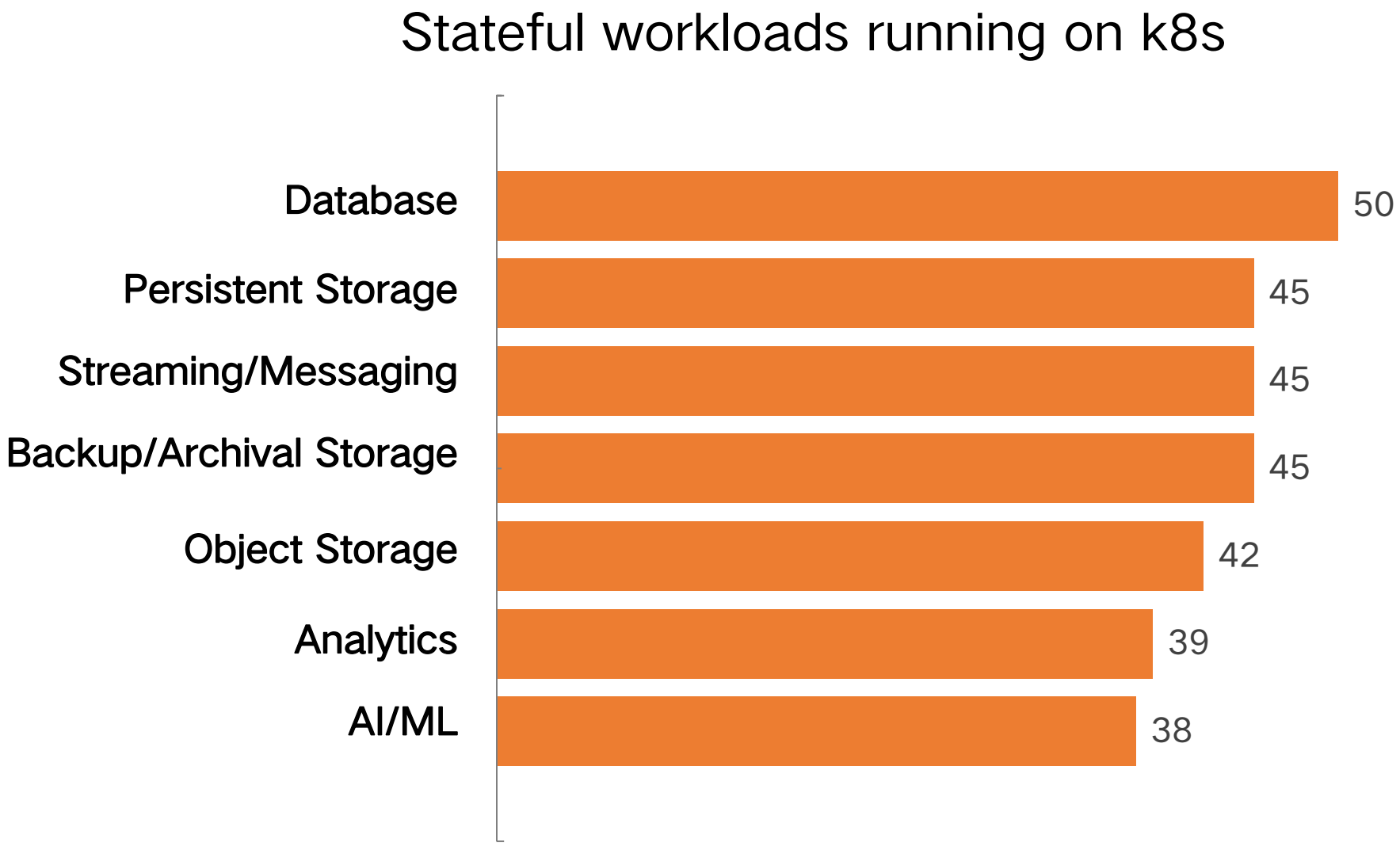
90% of surveyed companies believe Kubernetes is ready for stateful workloads

a large majority (70%) of them are running them in production

Databases take the top spot with persistent storage, streaming, messaging, backup archival storage all tying for the second spot here

From DoKC - Data on Kubernetes Community 2021 Report

Stateful workloads on k8s



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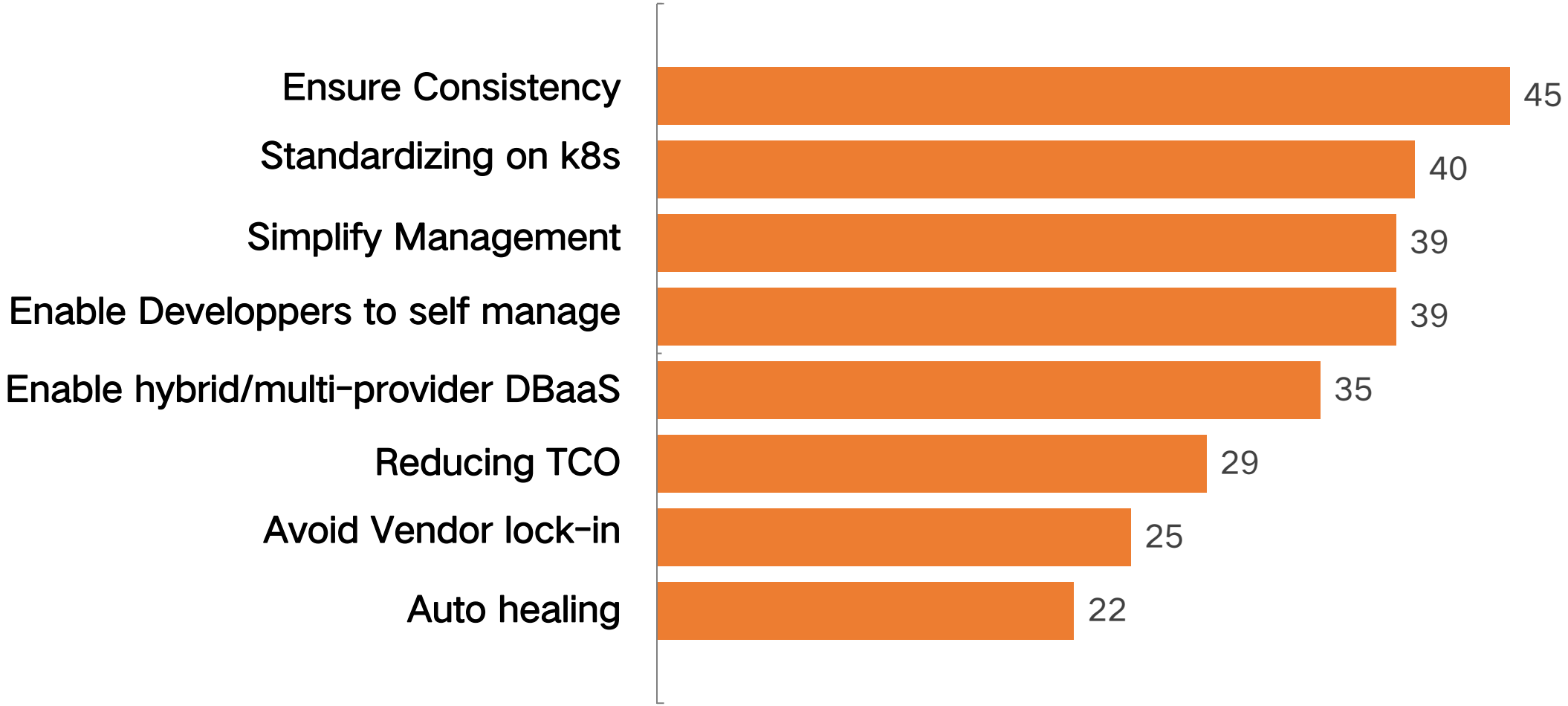
Stateful workloads on k8s

Most important factors affecting the decision to run stateful workloads on k8s



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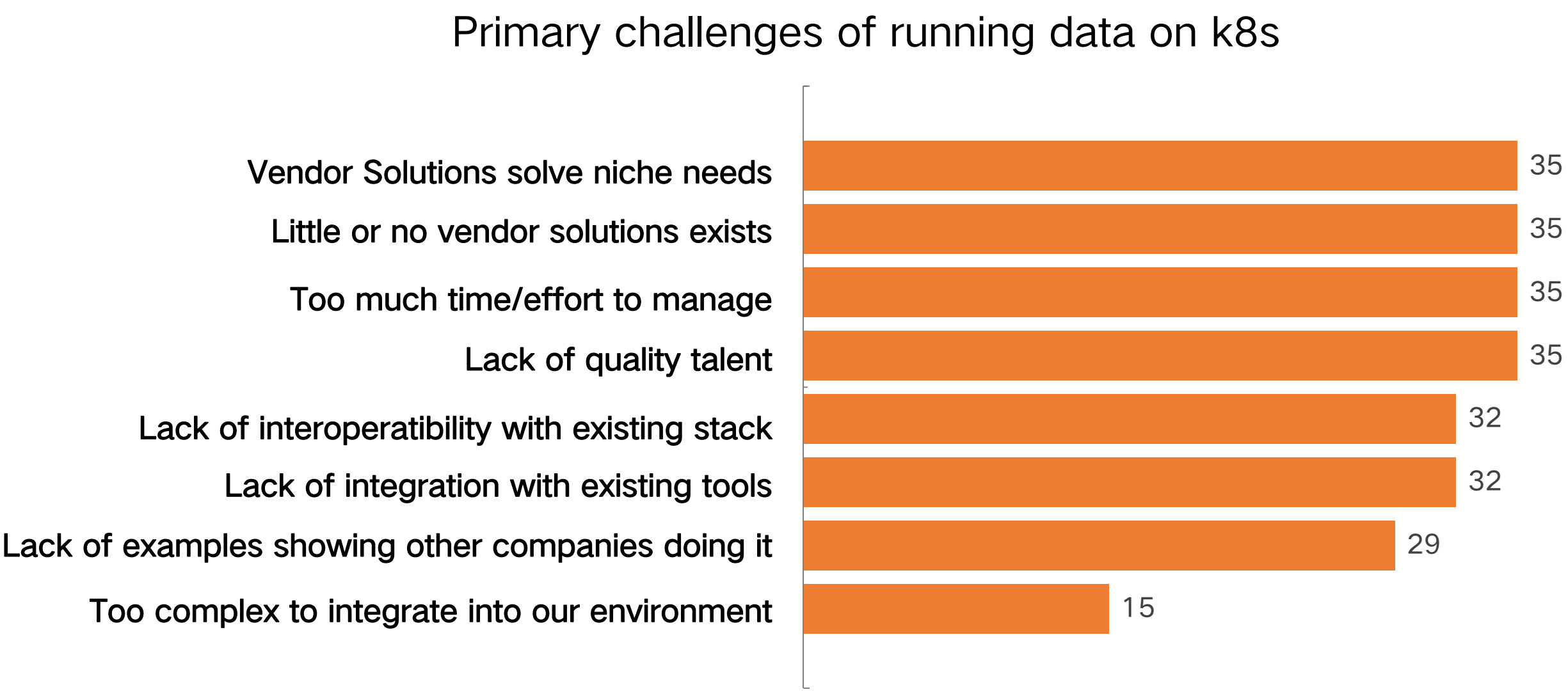

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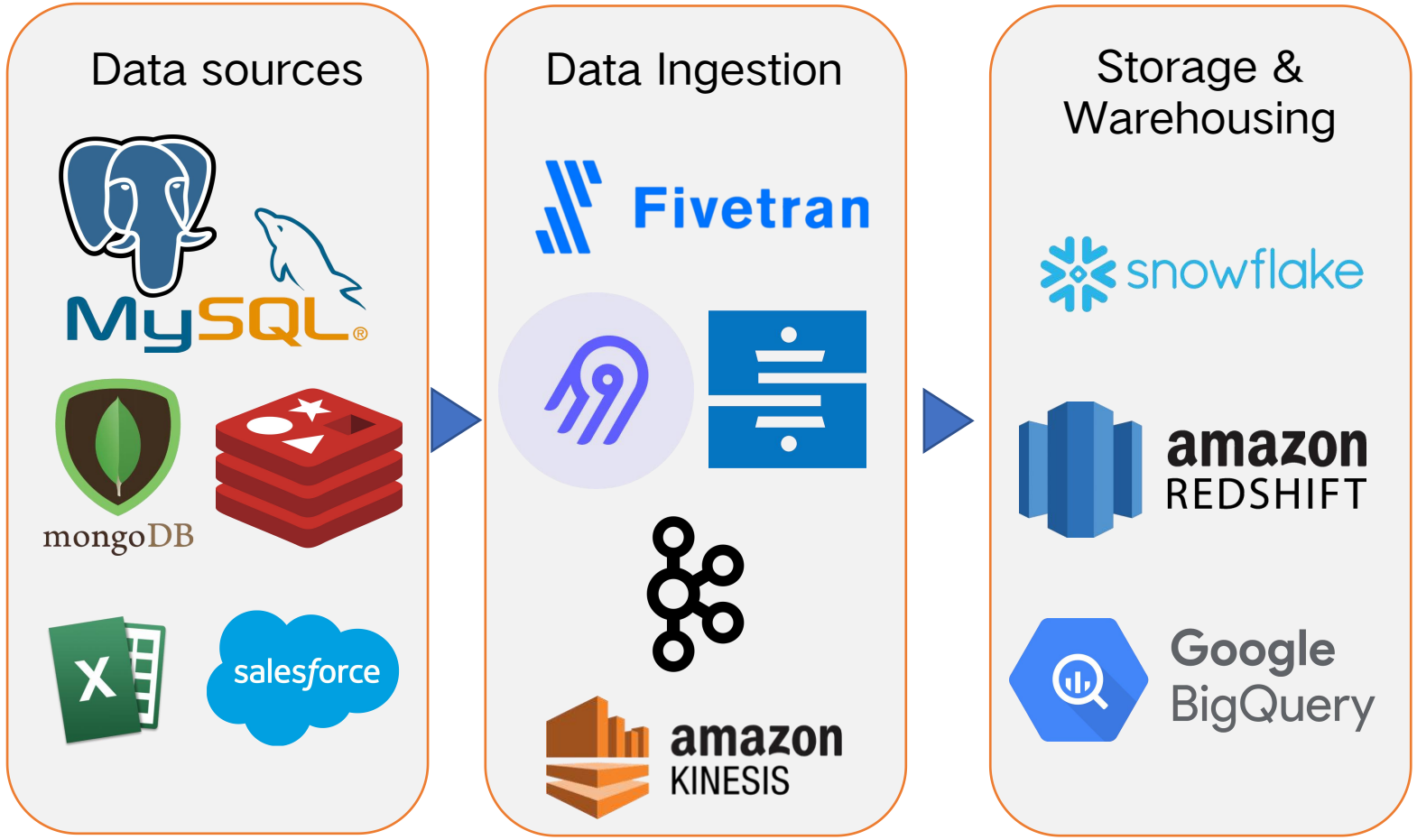
Part 2

What are the real challenges?

Multiple databases with Multiple operators

Multiple operators for provisioning a modern data stack



A modern business data flow is composed of:

- OLTP database for transaction
- NoSQL database for caching & k-v retrieving
- Steaming database for ETL
- Warehouse database for data mining

Existing database operators on k8s

Database	Operator	LifeCycle	Scaling	Backup/Restore	Monitoring	HA
MySQL	Oracle MySQL	Create/Update/Destroy	Scale up	Snapshot	Exporter & Grafana	Group Replication
MySQL	Percona	Create/Update/Destroy	Scale up	xtrabackup	Exporter & Grafana	XtraDB
PostgreSQL	Zalando	Create/Update/Destroy	Scale up	pg_backbackup	Exporter & Grafana	Patroni
Redis	redis-operator	Create/Update/Destroy	Scale up & out	x	Exporter & Grafana	Sentinel
MongoDB	MongoDB Community	Create/Update/Destroy	Scale up	x	Exporter & Grafana	MongoDB
...	...	...	...	...	...	...

Operators explosion

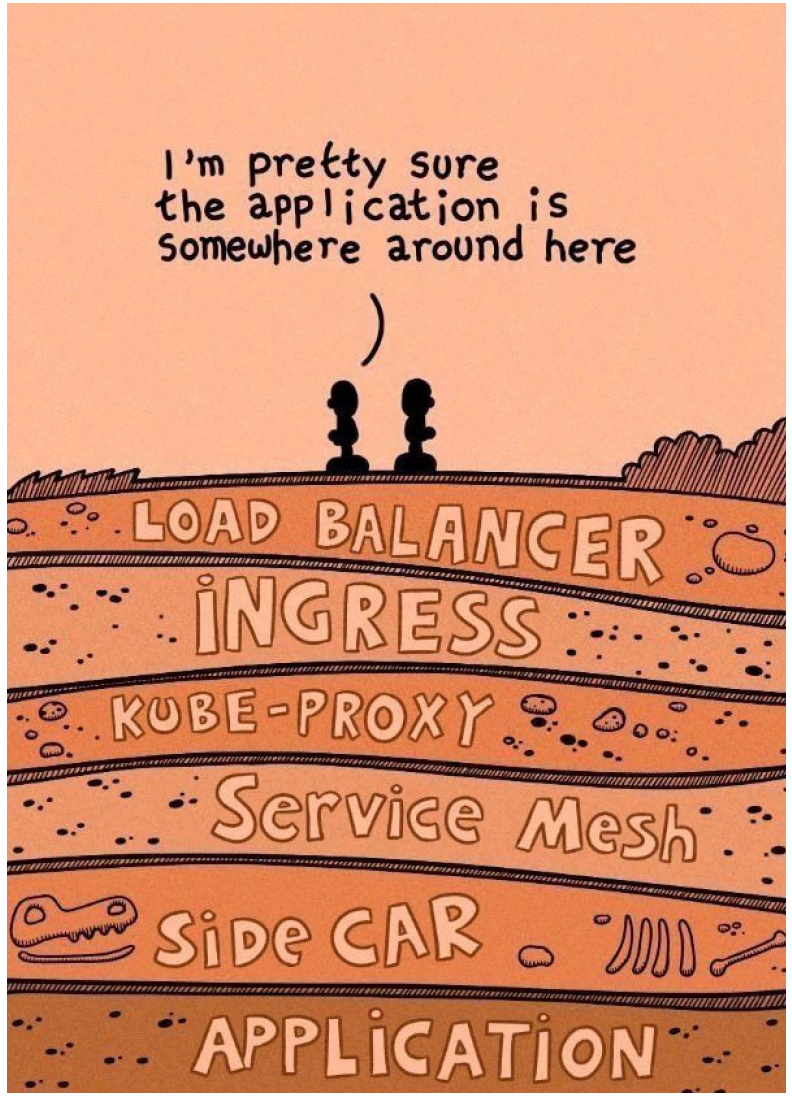
All what you need is database, not operators

K8s is lack of standard for stateful workloads

Multiple operators comes with operators explosion:

- **Inconsistent experience**
  - . different UI & APIs
  - . features are disaligned
- **Learning a bunch of operators**
  - . keep you busy from the real business
- **Maintainence burden**
  - . upgrading becomes disaster
  - . what if an operator stops evolving

Profound k8s stack



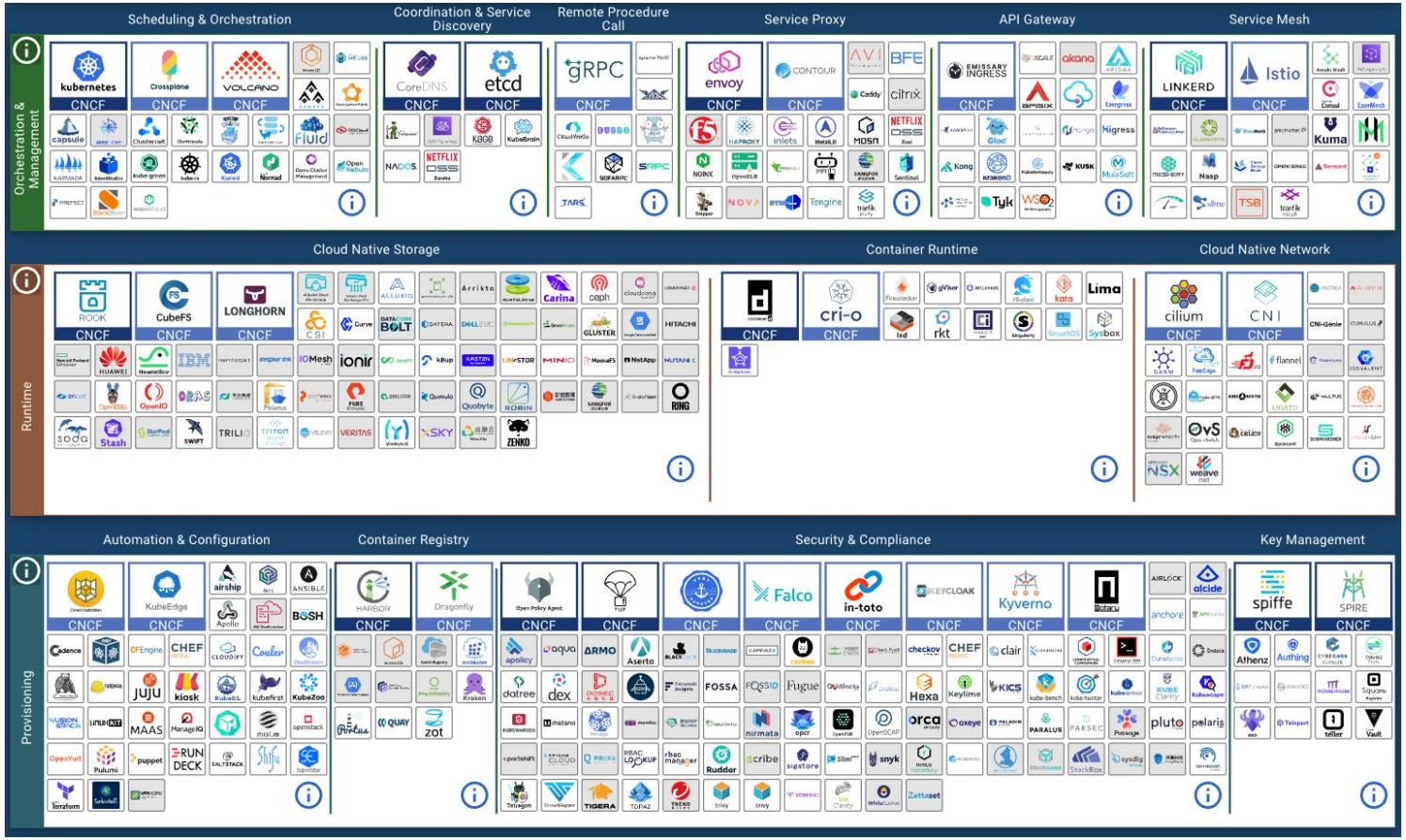
Trouble shooting is getting harder

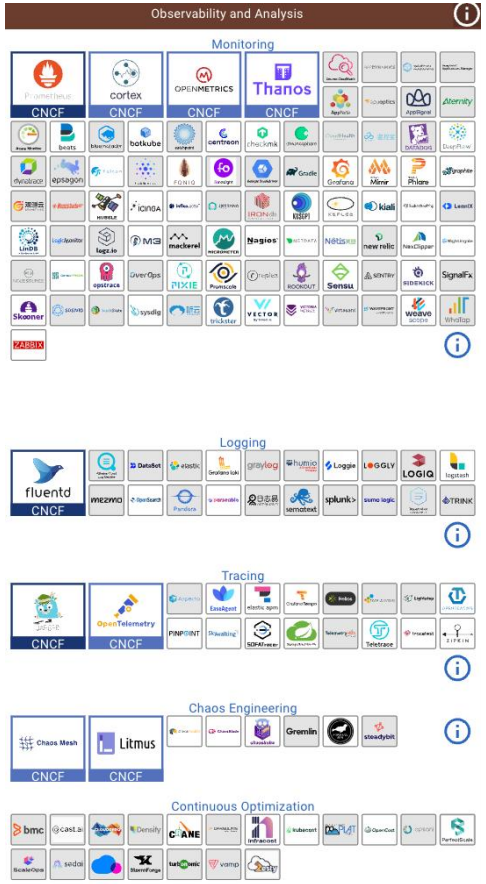
In order to troubleshoot an outage, you need to be:

- at least, a profound CKA
  . or a helm install chokes you
- undoubted, a sophisticated Network Expert
  . as traffic is magic
- for better, a qualified System Engineer
  . log is everywhere and nowhere
- at last, a professional DBA
  . app hangs at web, boss hangs on phone, and you hangs...

Good at orchestration, but lack of integration

K8s landscape is awesome,
but what you need is a necklace, not pearls on beach.





When you fight with database on k8s

Part 3

A domain-driven design for stateful workloads operators

Standard is always the first thing

As operators have similar features such as lifecycle management, backup, monitoring, upgrade, etc...

Is it possible to build a general purpose CRD and Controller for all stateful workloads ?

Insights from existing database operators

Let's dive into stateful workloads and popular database operators, we can see the facts:

1, Major part of the operators is handling with Lifecycle(create/destroy/update),while lack of day-2 operations

2, The stateful workload has more than one roles/components in an instance, such as primary, secondary, leader, follower and learner, etc.

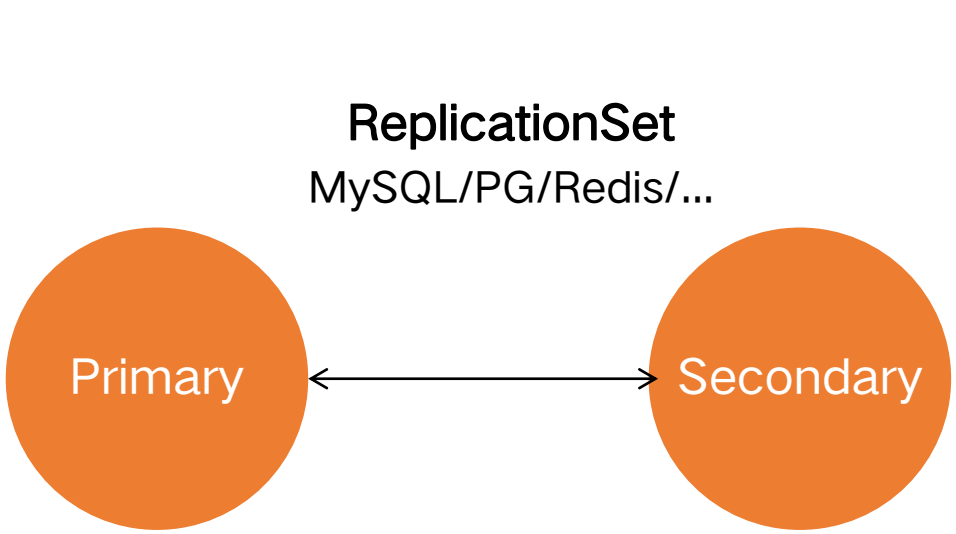
3, Lifecycle is about processing the topology and traits of an instance, the topology is relations & dependencies among roles/components, while the traits are runtime metas can be mainly described by podSpec

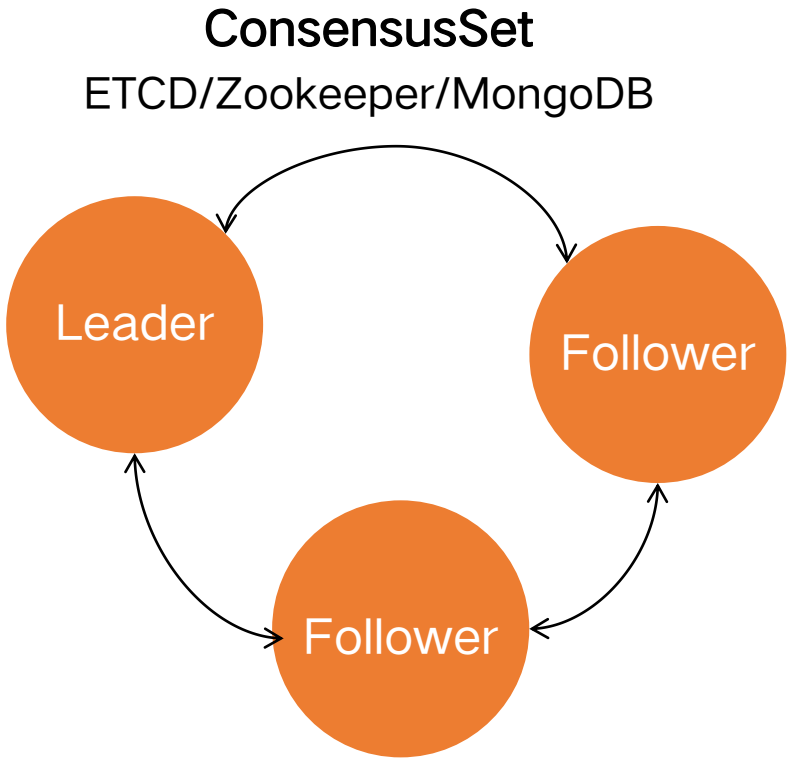
4, A stateful workload has many versions against same topology

5, The data dependencies between components can be concluded as primary-secondary for calssic hot standby cluster, leader-follower for distributed clusters based on PAXOS or RAFT

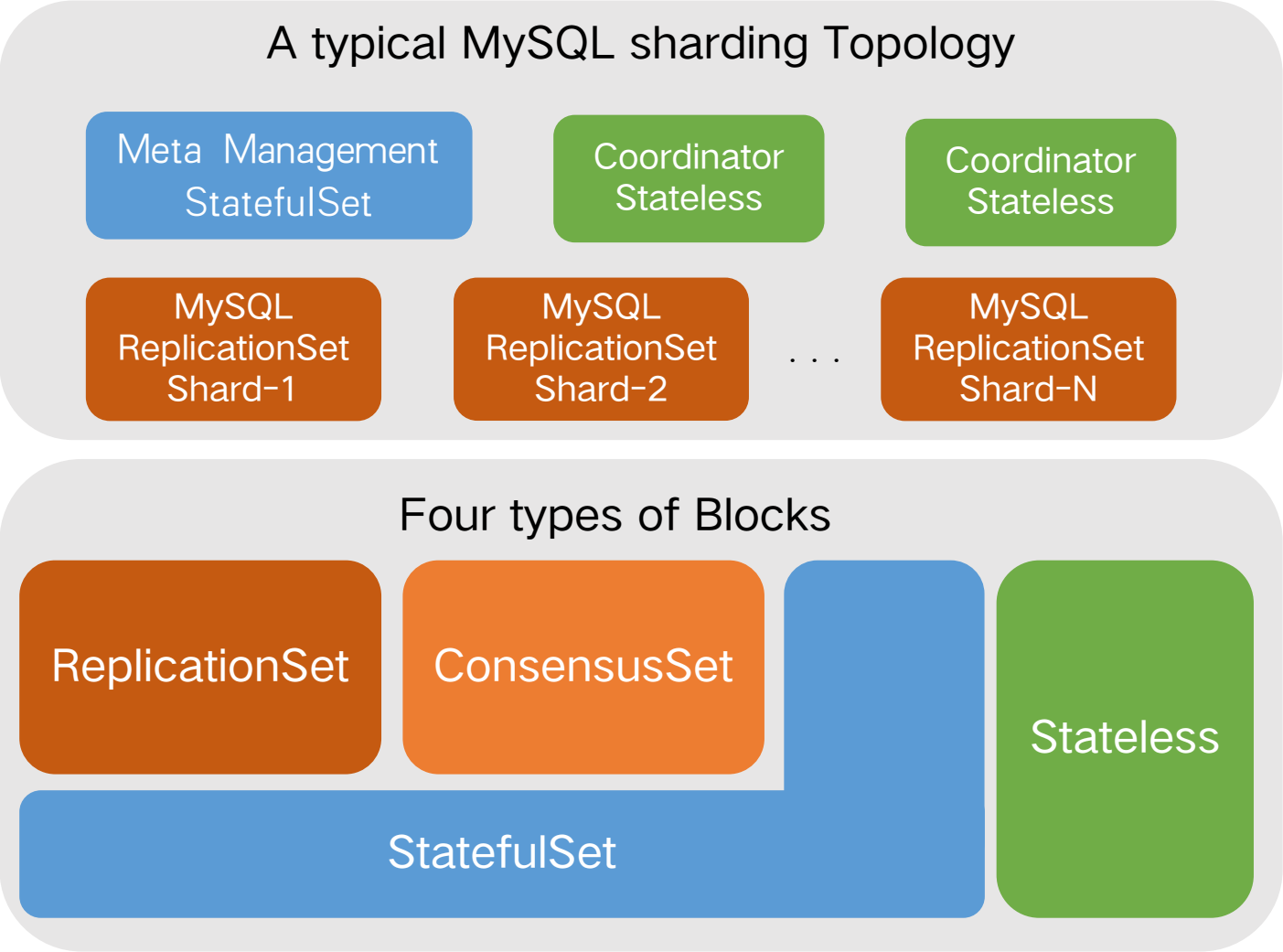
ReplicationSet & ConsensusSet

A primary-secondary group is so cohesive that we can treat them as a basic set named ReplicationSet, while we call the leader-follower group as ConsensusSet. ReplicationSet & ConsensusSet are basic blocks to build larger stateful clusters. That's also why we got the name KubeBlocks.





Basic blocks of KubeBlocks



- **Stateless Block** is native k8s stateless deployment, used for proxy, control plane process
- **Statefulset Block** is native k8s statefulset, used for process holding persistent data and providing service alone
- **ReplicationSet Block** is built on StatefulSet, used for classical hot standby cluster
- **ConsensusSet Block** is built on StatefulSet, used for Paxos or RAFT group

CRDs in KubeBlocks

ClusterDefinition

— Specification for topology and default runtime metas

```
kind:ClusterDefinition
metadata:
spec:
  componentDefs:
  - characterType: postgresql
    workloadType: Replication
    configSpecs:
    logConfigs:
    monitor:
    name: postgresql
    podSpec:
      containers:
```

```
kind:ClusterVersion
metadata:
spec:
  clusterDefinitionRef: postgresql
  componentVersions:
  -  componentDefRef: postgresql
     versionContext:
       containers:
         - image: spilo:12.14.1
       initContainers:
         - image: spilo:12.14.1
```

ClusterVersion

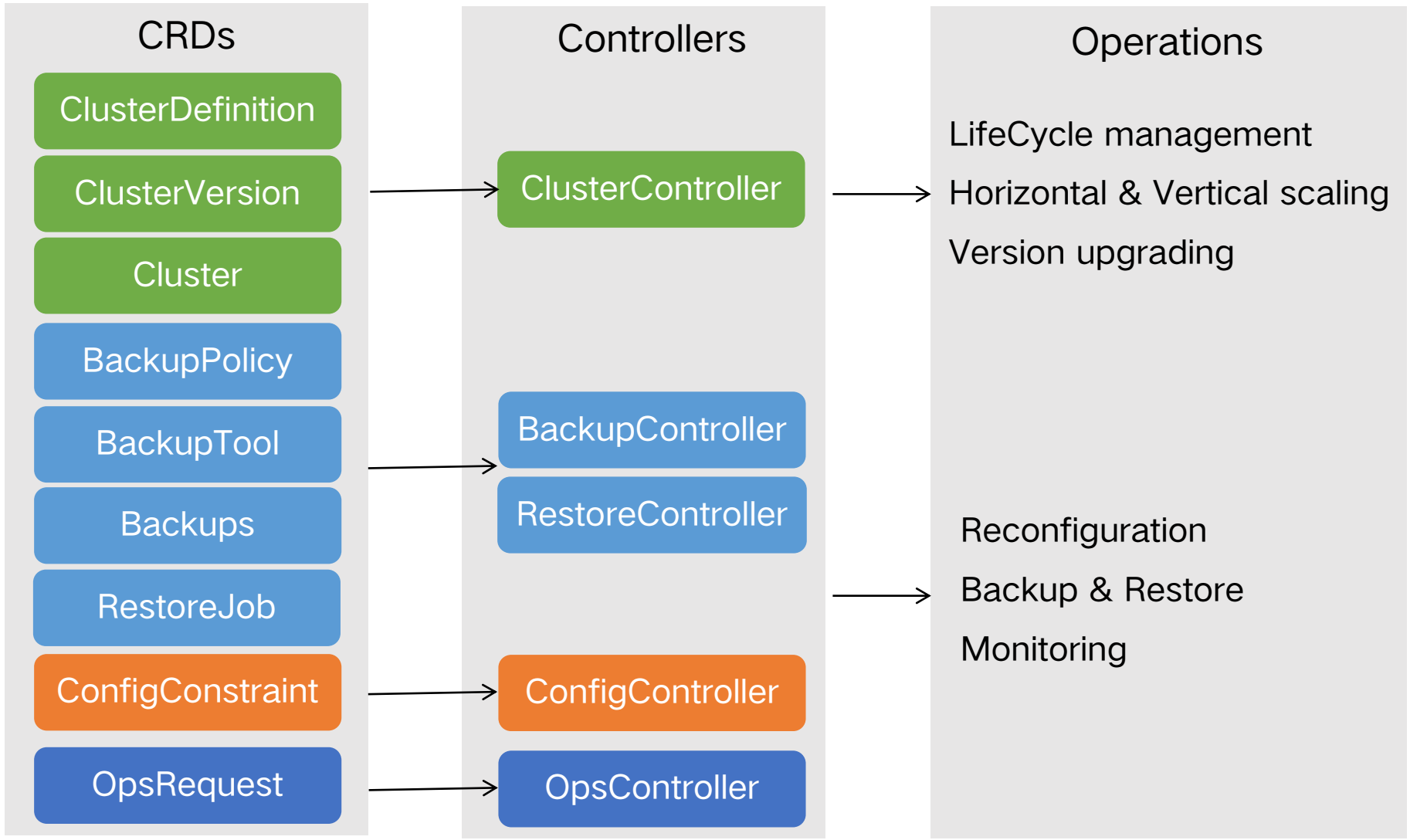
- Specification for image version
- Override the default images in ClusterDefintion

Cluster

- Specification for a concrete cluster
- Override the default runtime settings of monitoring, logs, resources, affinity, VCTs...

```
kind:Cluster
metadata:
spec:
  clusterDefinitionRef: postgresql
  clusterVersionRef: postgresql-12.14.1
  componentSpecs:
  - componentDefRef: postgresql
    replicas: 2
    volumeClaimTemplates:
```

Controllers in KubeBlocks



Part 4

A rich set of day-2 operations is must to have

Operator capability levels

Basic Install

Automated application provisioning and configuration management

Seamless Upgrades

Patch and minor version upgrades supported

Full Lifecycle

App lifecycle, storage lifecycle (backup, failure recovery)

Deep Insights

Metrics, alerts, log processing and workload analysis

Auto Pilot

Horizontal/vertical scaling, auto config tuning, abnormal detection, scheduling tuning

Reconfiguration

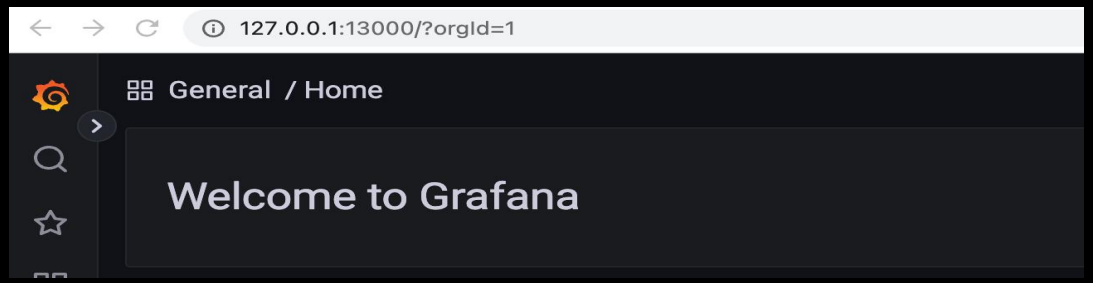
```
# 'rose35' is name of a primary-secondary postgresql
# describe the config of cluster rose35
$ kbcli cluster describe-config rose35

# edit the postgresql.conf like kubectl edit
$ kbcli cluster edit-config rose35

# explain the config parameters
#  kbcli cluster  explain-config rose35

# set max connections to 500
 kbcli cluster  configure rose35 --set max_connections=500
```

Backup & Restore

```
 # create a backup
kbcli cluster backup rose35

# create a snapshot backup, make sure the CSI support it
kbcli cluster backup rose35 --type snapshot

# create a backup with specified backup policy
kbcli cluster backup rose35 --backup-policy <backup-policy-name>

# restore a new cluster from a backup
kbcli cluster restore new-cluster-name --backup backup-name

# restore a new cluster from point in time
kbcli cluster restore new-cluster-name --restore-to-time "Apr 13,2023 18:40:35
UTC+0800" --source-cluster rose35
```

Monitoring

```
# dashboard of grafana, prometheus and alertmanager
$ kbcli dashboard list
NAME                                  NAMESPACE   PORT    CREATED-TIME
kubeblocks-grafana                    kb-system   13000   May 31,2023 16:45 UTC+0800
kubeblocks-prometheus-alertmanager    kb-system   19093   May 31,2023 16:45 UTC+0800
kubeblocks-prometheus-server          kb-system   19090   May 31,2023 16:45 UTC+0800

# open grafana in browser
$ kbcli dasharboard open kubeblocks-grafana
```



Monitoring

Horizontal & vertical scaling

```
# horizontal scaling of rose35, add a replica for cluster
$ kbcli cluster hscale rose35 --replicas=3

OpsRequest rose35-horizontalscaling-ldlwk created successfully, you can view
the progress:
-- kbcli cluster describe-ops rose35-horizontalscaling-ldlwk -n default

# vertical scaling of cpu and memory
$ kbcli cluster vscale rose35 --components=postgresql --cpu=500m --
memory=500Mi
```

Horizontal & vertical scaling

```
slc@slcmac kubeblocks % kbcli cluster describe-ops rose35-horizontalscaling-ldlwk -n default
Spec:
  Name: rose35-horizontalscaling-ldlwk  NameSpace: default      Cluster: rose35 Type: HorizontalScaling

Command:
  kbcli cluster hscale rose35 --components=postgresql --replicas=3 --namespace=default

Last Configuration:
COMPONENT    REPLICAS
postgresql          2

Status:
  Start Time:         Jun 06,2023 12:48 UTC+0800
  Completion Time:    Jun 06,2023 12:49 UTC+0800
  Duration:           50s
  Status:             Succeed
  Progress:           1/1
                      OBJECT-KEY               STATUS    DURATION   MESSAGE
                      Pod/rose35-postgresql-2   Succeed   36s        Successfully created pod: Pod/rose35-postgresql-2 in Component: postgresql

Conditions:
LAST-TRANSITION-TIME         TYPE               REASON                           STATUS   MESSAGE
Jun 06,2023 12:48 UTC+0800   Progressing        OpsRequestProgressingStarted     True     Start to process the OpsRequest: rose35-horizontalscaling-ldlwk in Cluster: rose35
Jun 06,2023 12:48 UTC+0800   Validated          ValidateOpsRequestPassed         True     OpsRequest: rose35-horizontalscaling-ldlwk is validated
Jun 06,2023 12:48 UTC+0800   HorizontalScaling  HorizontalScalingStarted         True     Start to horizontal scale replicas in Cluster: rose35
Jun 06,2023 12:49 UTC+0800   Succeed            OpsRequestProcessedSuccessfully  True     Successfully processed the OpsRequest: rose35-horizontalscaling-ldlwk in Cluster: rose35
```

Version upgrading

```
 # Attention : the major version upragde may cause a failure due to
incompatible data format, so we suggest that the minor version upgrade
through the 'upgrade' subcommand, the major version upragde through a
data migration
# upgrade the cluster to the target version
  kbcli cluster upgrade rose35 --cluster-version=postgresql-14.7.2

OpsRequest rose35-upgrade-6bwct created successfully, you can view the
progress:
            kbcli cluster describe-ops rose35-upgrade-6bwct -n default
```

Migration

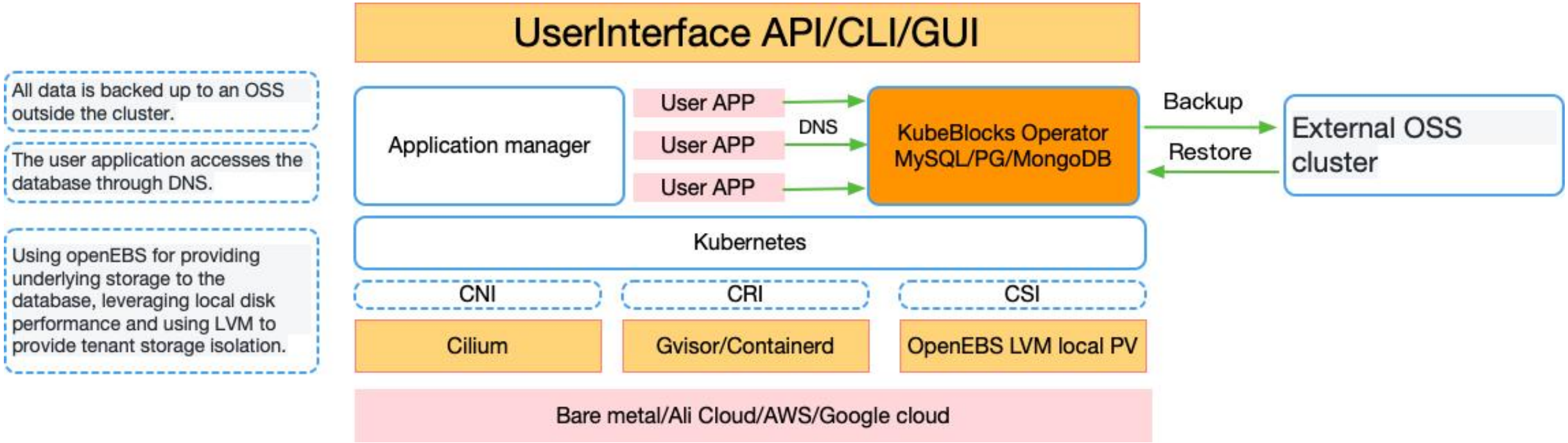
```
# Attention : only a subset versions of databases are supported
# Create a migration task to migrate the entire database under mysql: mydb1
and mytable1 under database: mydb2 to the
target mysql
  kbcli migration create mytask --template apecloud-mysql2mysql
  --source user:123456@127.0.0.1:3306
  --sink user:123456@127.0.0.1:3305
  --migration-object '"mydb1","mydb2.mytable1"'
```

Part 5

Solution for cloud-native applications

Sealos with KubeBlocks

SealOS is a Cloud Operating System designed for managing cloud-native applications,
leveraging KubeBlocks for privision of database workloads.
They can be deployed in on-premises & multi-cloud environments.



What about us

All great things start from scratches.

All great minds have a percentage of madness.

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