Running PostgreSQL in a Kubernetes Cluster: CloudNativePG

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Before joining EnterpriseDB in 2022, Nick had been working at IBM Canada for more than 10 years as a database and cloud application architect. He has experience with database design, performance tuning, HA&DR implementation, migration on multiple database platforms, including Postgres, Db2, SQL Server, Oracle, MySQL, and others.

He's based in Toronto, Canada.

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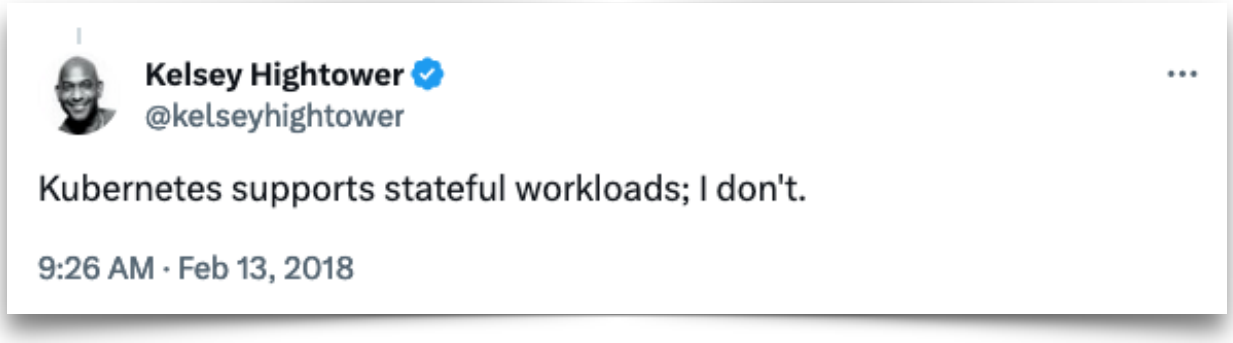
Can you run databases on K8s?



CloudNativePG

Documentation Blog Support End Users

Star 2,212

Run PostgreSQL.

The Kubernetes way.

CloudNativePG is the Kubernetes operator that covers the full lifecycle of a highly available PostgreSQL database cluster with a primary/standby architecture, using native streaming replication.

View on GitHub

Why operator is needed

- K8s built-in controllers only handle built-in resources
  - ReplicaSet - no PVC templates
  - StatefulSet - doable, but too complex to configure
- CNPG controller incorporates Postgres knowledge
  - Manages custom resources

What you need

- A Kubernetes cluster
  - `kind` works just fine
- `kubectl`
- `cnpg` plugin

Postgres CRD

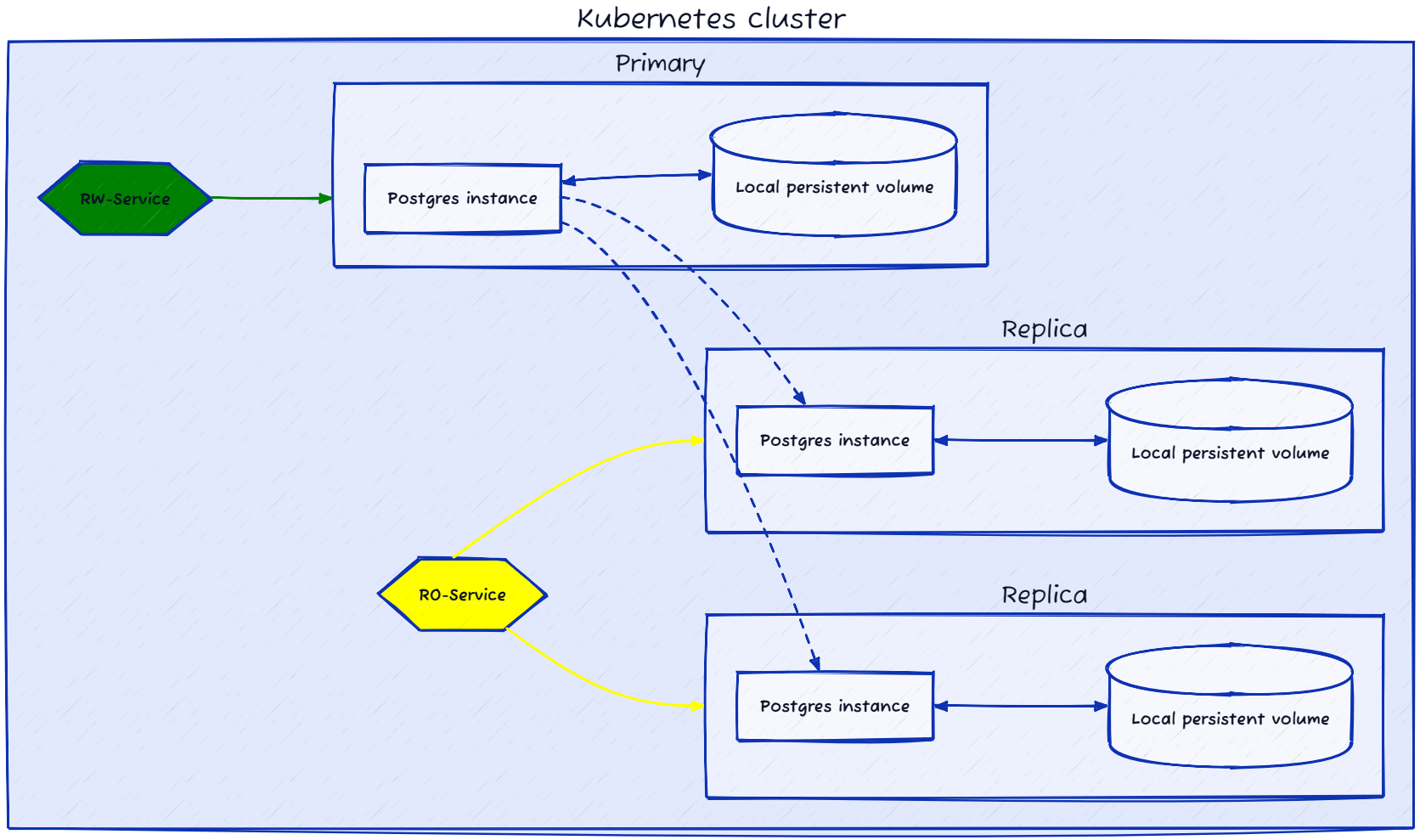
```yaml
apiVersion: postgresql.cnpg.io/v1
kind: Cluster
metadata:
  name: pg15
spec:
  instances: 3
  primaryUpdateStrategy: unsupervised
  storage:
    size: 1Gi
```

- All you need to create a three-node cluster
- Uses all defaults
- Demo

What's created

- Postgres pods as requested by the manifest
- Persistent volumes
- Three services
  - `<cluster name>-rw` — for the primary node
  - `<cluster name>-ro` — for the standby nodes
  - `<cluster name>-r` — for all nodes
- Secrets
  - Authentication credentials for database users
  - TLS certificates

What's created



Replication

- Physical replication streaming WAL records
- All databases in the instance
- Replicas are read-only
- Asynchronous or synchronous
- Automatic management of replication slots

Cluster initialisation methods

- New (`initdb`)
- From a backup (Barman Cloud)
- From another Postgres instance (`pg_basebackup`)
- Using import (`pg_dump` & `pg_restore`)
- Demo

High Availability and Failure Modes

- Highly reliable streaming replication
- No external failover managers
  - Postgres Instance Manager + K8s
- PVs reused if possible to start new pods
  - Backup of a primary otherwise
- Demo

Scheduling and resources

- Use dedicated worker nodes if possible
  - `nodeSelector` and `tolerations`
- Anti-affinity by default
- Scheduling is based on the resource `requests`
  - It is counterproductive to set `limits` much higher
- Use `Guaranteed` QOS

Maintenance: Rolling Updates

- Triggered automatically
- Unsupervised update is fully automatic
- Supervised update requires intervention prior to the final switchover
- Only minor version upgrade possible (currently)

Maintenance: Backup & Recovery

- Hot only, on-demand or scheduled, plus WAL archiving
- Optional compression & encryption
- Uses Barman Cloud
  - Any S3-compatible service
  - MinIO Gateway option offers many alternatives
- Recovery — instantiate a new cluster from backup

Maintenance: Volume Snapshots

- Alternative backup & recovery method
- Hot or cold
- Allows incremental and delta backup
  - If supported by the storage class
- Better choice for large databases

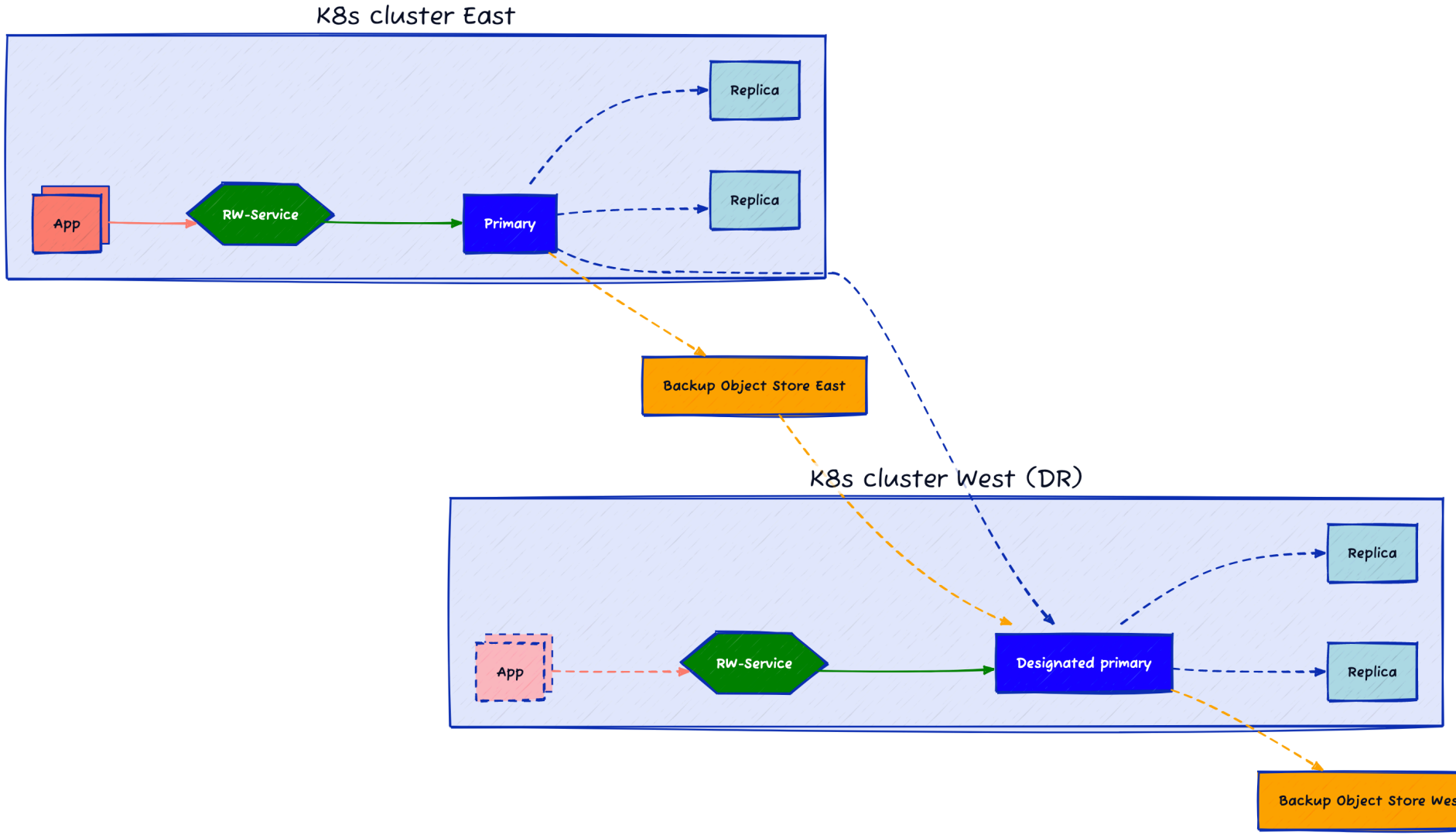
Maintenance: More

- Fencing nodes
- Hibernation
- TLS certificate management

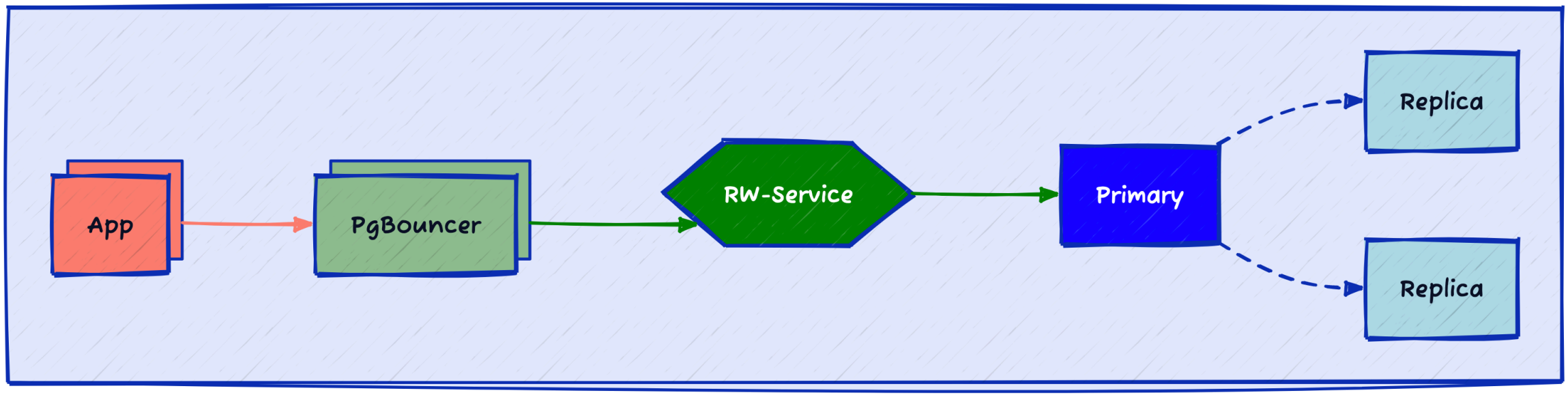
Cluster Monitoring

- Prometheus — “default” on K8s
- Exporters are set up upon deployment
- Create PodMonitor resources using the cluster spec

DR with Replica Clusters



Application Connection Pooling

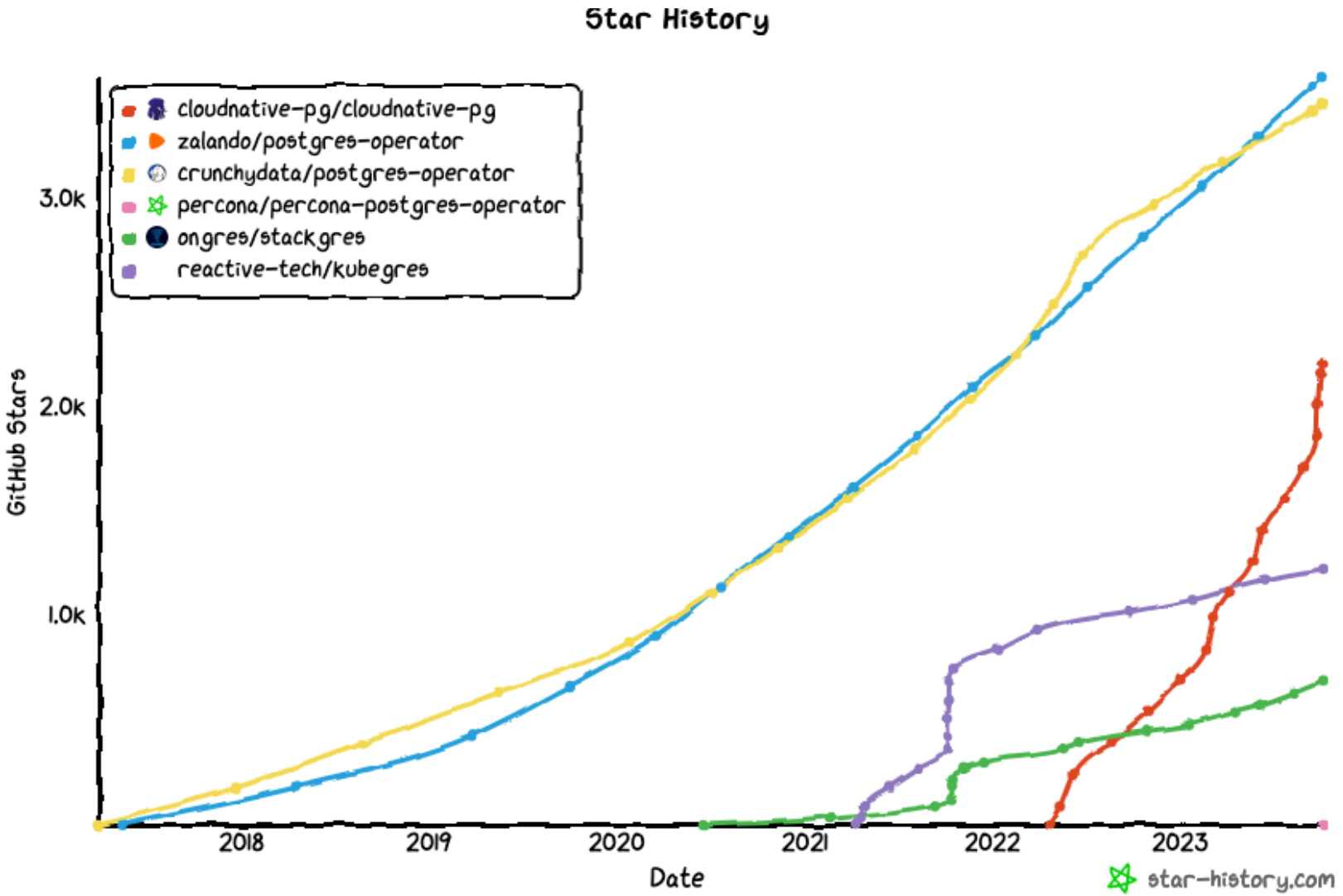


Final words

Operator capability levels

Source: https://sdk.operatorframework.io/docs/overview/operator-capabilities/

K8s Operators for Postgres



Links

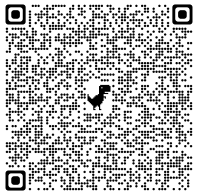
CloudNative Pg project home

Recommended architectures for PostgreSQL in Kubernetes

Cloud Native Disaster Recovery Whitepaper

More links

Github star history



`kind` - tool for running K8s clusters using Docker

Session evaluation

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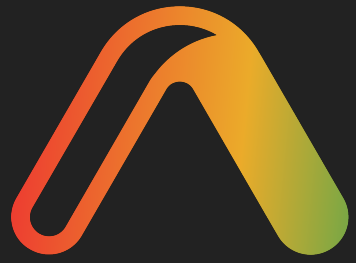

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Thank you

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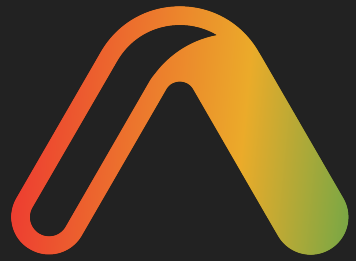
https://github.com/nick-ivanov-edb



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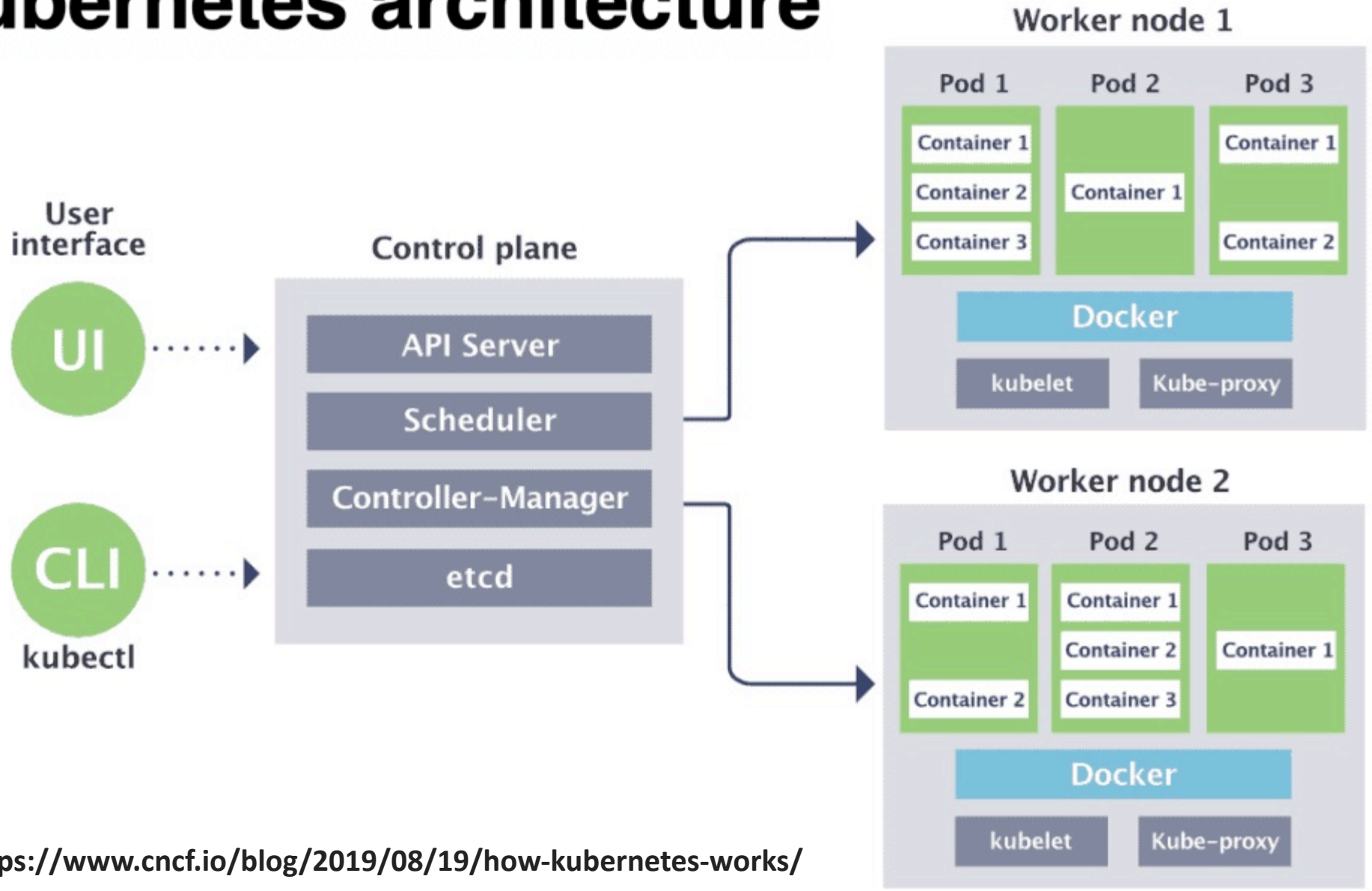
Backup slides

Kubernetes architecture



Source: https://www.cncf.io/blog/2019/08/19/how-kubernetes-works/