



EDB

Postgres® for the AI Generation

CloudNativePG 101

Gabriele Quaresima,
PGDay Austria,
09/04/2025





EDB

Postgres® for the AI Generation



Gabriele Quaresima

Staff SDE @ EDB

<3 OSS

<3 Coding

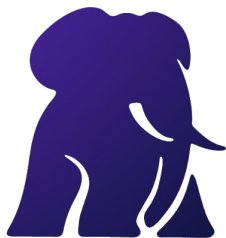
🎵 Playing sax

<3 Paola and Maria

Survey

CloudNativePG

- **CloudNativePG** is a CNCF Sandbox project. It is an open-source operator designed to manage **PostgreSQL** workloads on any supported **Kubernetes** cluster
- It defines a new K8s resource called **Cluster**, representing a PostgreSQL cluster made up of a single primary and an optional number of replicas



CloudNativePG



Kubernetes (K8s)

Kubernetes

- **Orchestrator** (runs and manages containerized applications on a cluster)
- Higher-level abstractions of workloads
- **Declarative** over imperative.

Via controller pattern, Kubernetes aligns the current state (of any applied resource) to the desired one

Kubernetes - Sample object

```

    apiVersion: apps/v1
    kind: Deployment
    metadata:
      name: nginx-deployment
    spec:
      selector:
        matchLabels:
          app: nginx
      replicas: 2 # tells deployment to run 2 pods matching the template
      template:
        metadata:
          labels:
            app: nginx
        spec:
          containers:
            - name: nginx
              image: nginx:1.14.2
              ports:
                - containerPort: 80

```

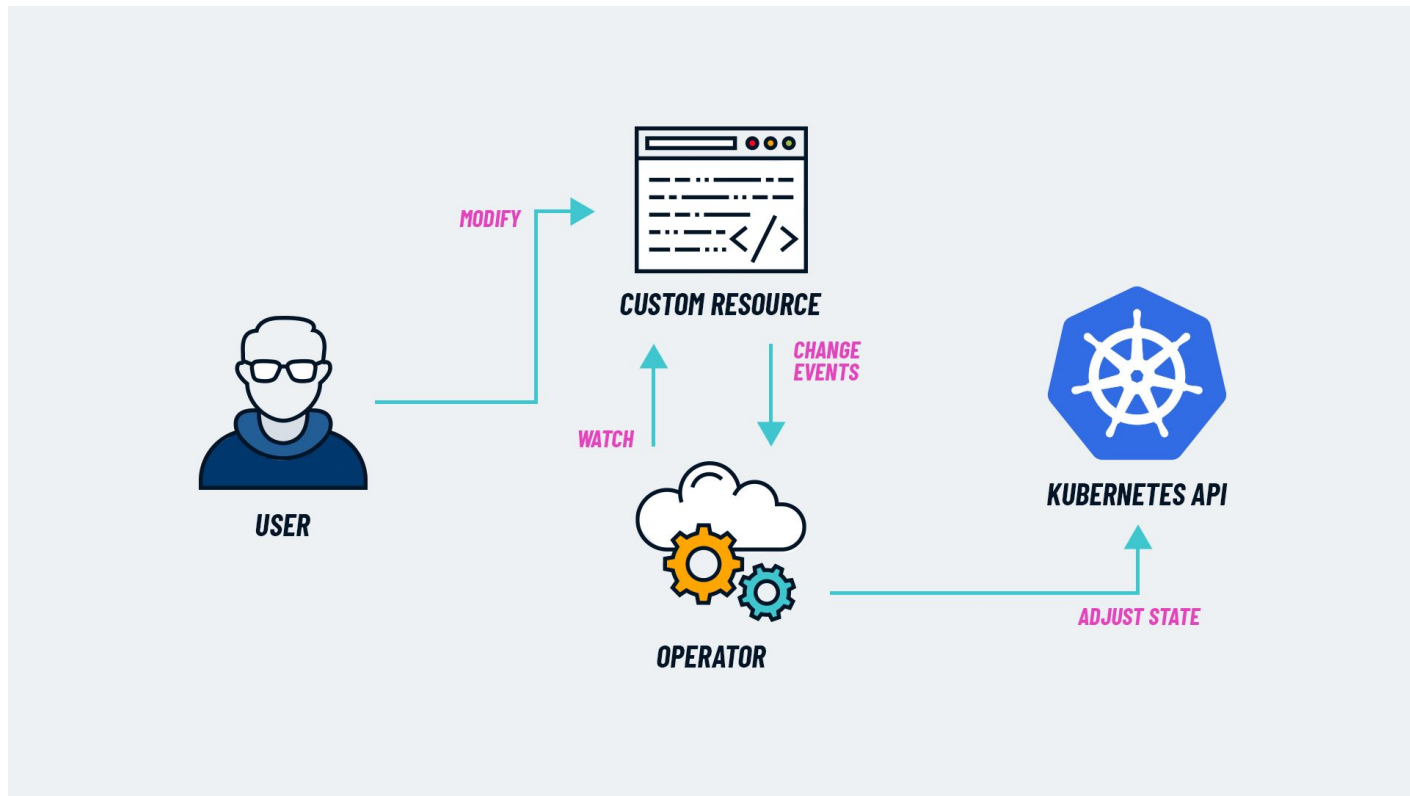
Cloud Native Applications

- Small loosely coupled services (microservices)
- Introduce a set of principles and a culture shift paradigm for **devops** and **CI/CD** approach



Kubernetes operators

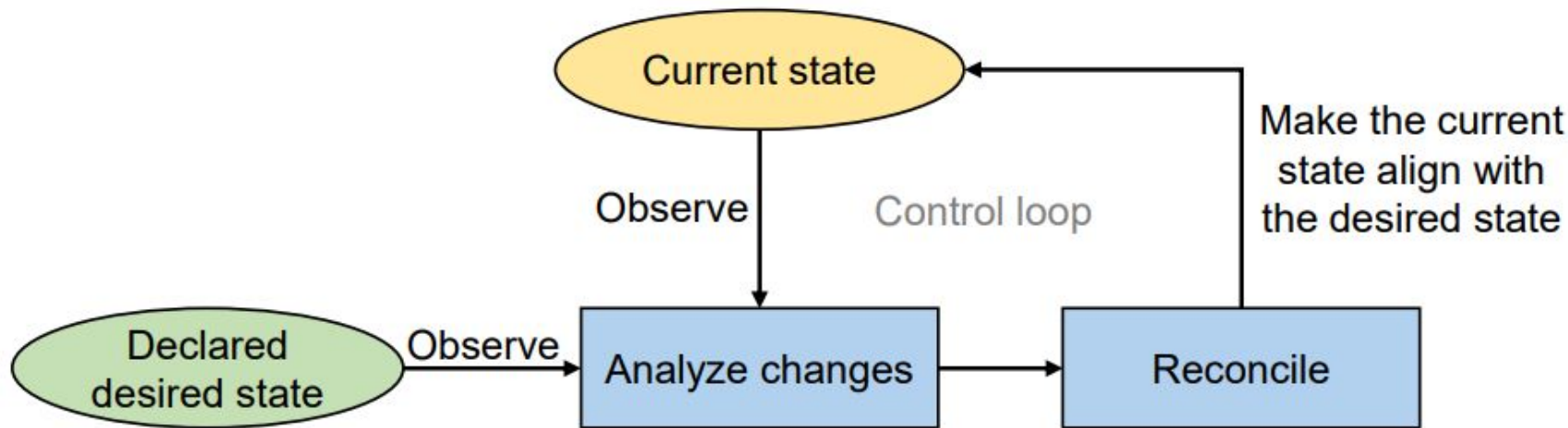
Kubernetes Operator



Kubernetes Operator - In a nutshell

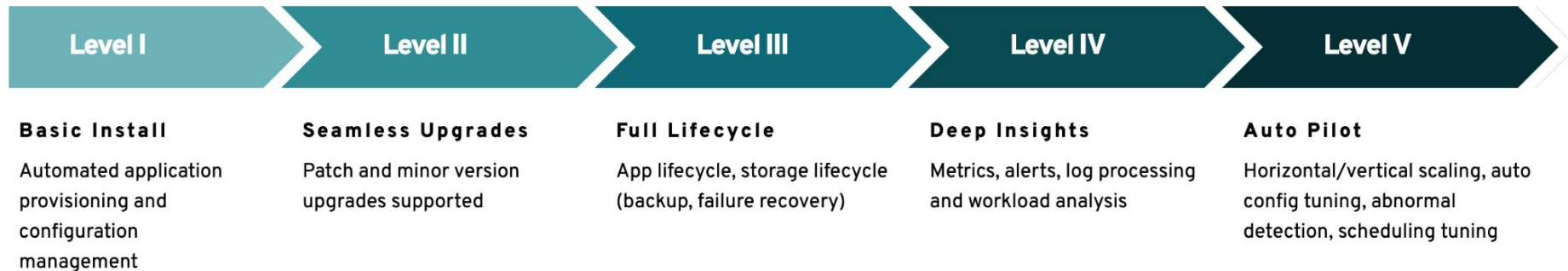
- Software extensions to Kubernetes
- Use of **custom resources** to manage applications and their components
- Operators follow Kubernetes principles, notably the control loop
- Operators implement and automate common Day-1 (installation, configuration, etc) and Day-2 (re-configuration, update, backup, failover, restore, etc.) activities
- Via operators, you can stop treating an application as a collection of primitives like Pods, Deployments, Services or ConfigMaps, but instead as a single object that only exposes the knobs that make sense for the application

Kubernetes Operator - Control loop



Picture from "[An Empirical Study on Kubernetes Operator Bugs](#)" by Gu - Xiao -Wei

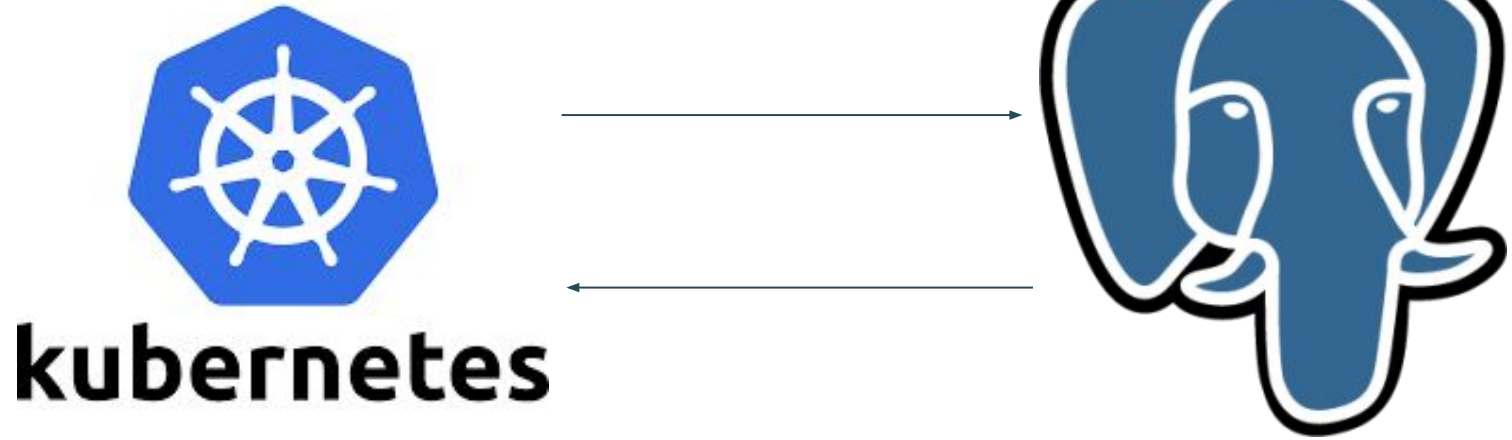
Kubernetes Operator - Capability levels



Kubernetes Operator - Write your own one

- **SDK** for the major languages
- Custom kubernetes **controllers**
- Design declarative **APIs** for operators
- Usually interact/control a custom object (Custom Resource Definitions (**CRD**))

Bring Kubernetes to Postgres, bring Postgres to Kubernetes!



Deep into CloudNativePG

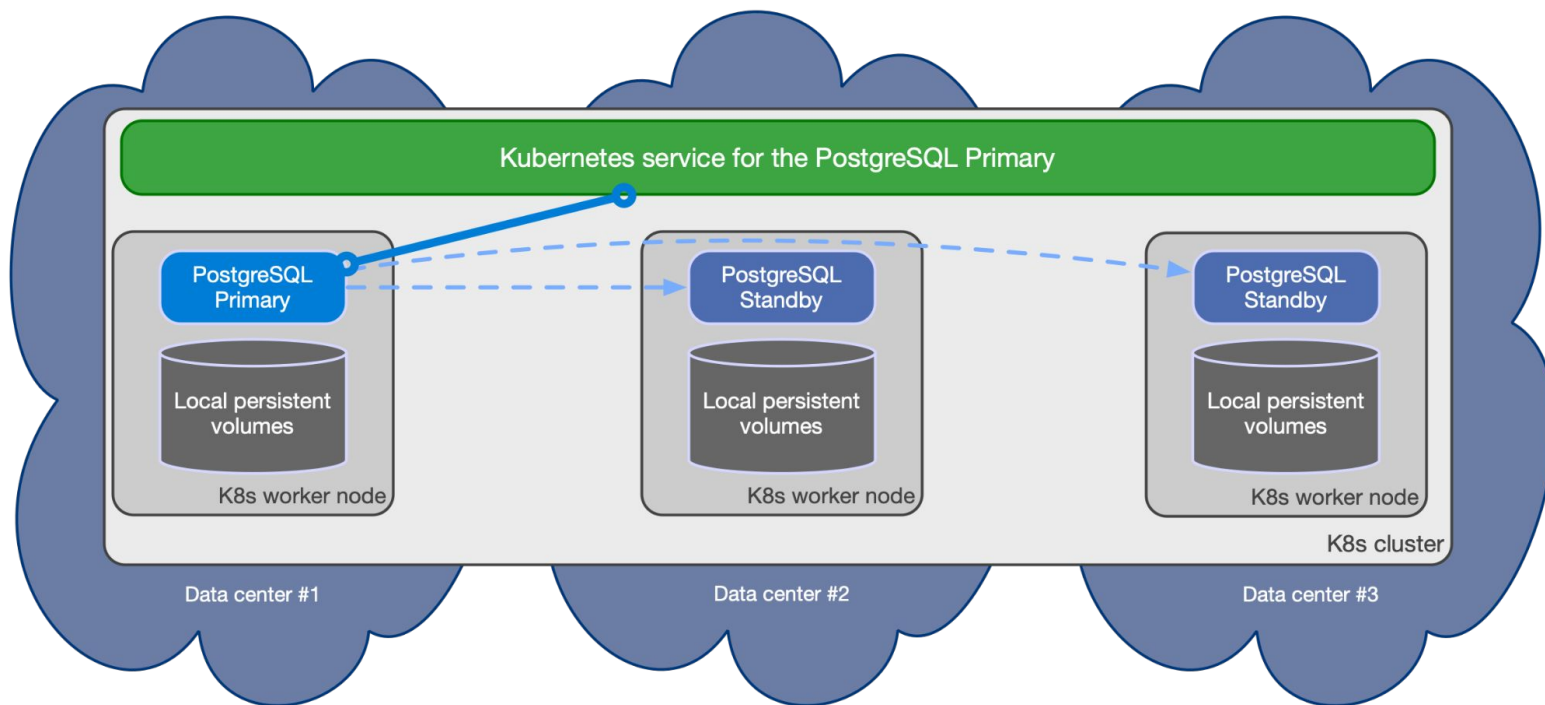
CloudNativePG - Cluster CRD example

```
> batcat cloudnative-pg/docs/src/samples/cluster-example.yaml
```

```
File: cloudnative-pg/docs/src/samples/cluster-example.yaml
```

```
1  apiVersion: postgresql.cnpg.io/v1
2  kind: Cluster
3  metadata:
4    name: cluster-example
5  spec:
6    instances: 3
7
8    storage:
9      size: 1Gi
```

CloudNativePG - Suggested architecture



CloudNativePG - PVC management

- **No Statefulsets**
- **The operator manages directly PersistentVolumeClaims:**
 - It creates a PVC for each PostgreSQL instance, with the goal of storing the PGDATA
 - It then mounts it into each pod
- **CSI** for PVCs allows
 - **Volume Snapshot** backup and restore
 - Online resize
 - PVC cloning

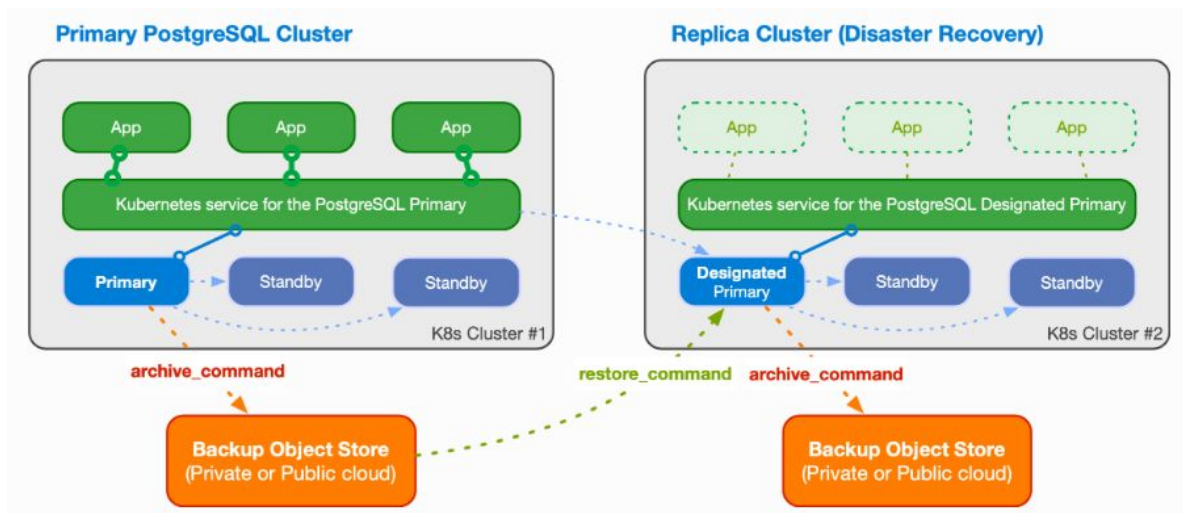
CloudNativePG - Main features

- Direct integration with K8s Api Server for self healing
- High Availability capability
- Planned switchover
- Scale up/down capabilities
- Definition of an arbitrary number of instances, rw and ro services
- Declarative management of PostgreSQL configuration
- Support for local PV with PVC templates
- Backup on VolumeSnapshot and object stores
- Major PG upgrade
- kubectl plugin for cluster management
- Declarative tablespaces, databases, publications and subscriptions
- CNPG-I: define your own plugin!

CloudNativePG - Deployment across Kubernetes clusters

Distributed PostgreSQL topology with **replica clusters** enables multi-cluster deployments in private, public, hybrid, and multi-cloud contexts.

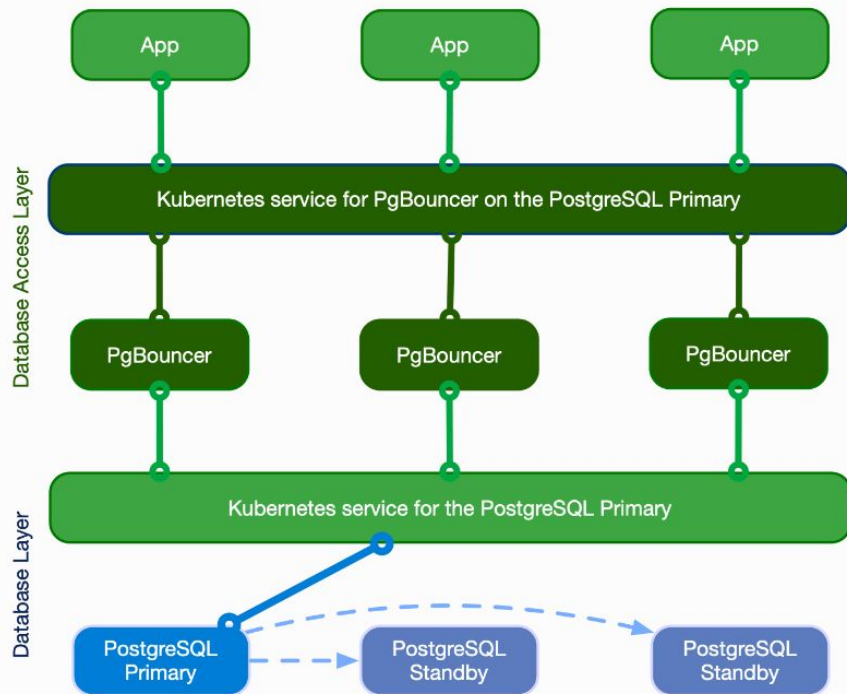
A replica cluster is a separate **Cluster** resource that is in continuous recovery, replicating from another source, either via WAL or streaming replication.



CloudNativePG - Connection pooling

CloudNativePG provides native support for connection pooling with PGBouncer, through the **Pooler** CRD.

A pooler is a deployment of PgBouncer pods that sits between your application and a PostgreSQL service. It creates a separate, scalable, configurable, and highly available database access layer.



CloudNativePG - Installation



```
kubectl apply --server-side -f \  
https://raw.githubusercontent.com/cloudnative-pg/cloudnative-pg/main/releases/cnpg-1.24.1.yaml
```

Refer to the CloudNativePG documentation for Helm Chart and Operator Lifecycle Manager (OLM), directly from OperatorHub.io

CloudNativePG - Operand images

- The PostgreSQL operand **container images** are available for all PGDG supported versions of PostgreSQL, across multiple architectures, directly from the postgres-containers project's GitHub Container Registry.
- Daily jobs ensure that CVEs in the entire stack are promptly addressed
- Additionally, the community provides images for the PostGIS extension
- Check this blog article, if you want create your own **custom** container image.

CloudNativePG - Observability

- CloudnativePG exposes native **Prometheus** exporters. Some are already defined, but you can extend them and add new ones
- All logs are in stdout and in **JSON** format
- CNPG plugin **status** command



CloudNativePG - Kubectl Plugin

CloudnativePG provides a **plugin** for kubectl to manage a cluster in Kubernetes

```
> ./kubectl-cnpg --help
A plugin to manage your CloudNativePG clusters

Usage:
  kubectl cnpg [command]

Operator-level administration
  install      CloudNativePG installation-related commands

Troubleshooting
  logs         Logging utilities
  report       Report on the operator or a cluster for troubleshooting

Cluster administration
  destroy      Destroy the instance named [cluster]-[node] or [node] with the associated PVC
  fencing      Fencing related commands
  hibernate    Hibernate related commands
  maintenance  Sets or removes maintenance mode from clusters
  promote      Promote the pod named [cluster]-[node] or [node] to primary
  reload       Reload a cluster
  restart      Restart a cluster or a single instance in a cluster

Database administration
  backup       Request an on-demand backup for a PostgreSQL Cluster
  certificate   Create a client certificate to connect to PostgreSQL using TLS and Certificate authentication
  publication   Logical publication management commands
  snapshot     DEPRECATED (use 'backup -m volumeSnapshot' instead)
  status       Get the status of a PostgreSQL cluster
  subscription Logical subscription management commands

Miscellaneous
  fio          Creates a fio deployment, pvc and configmap
  pgadmin4     Creates a pgAdmin deployment
  pgbench      Creates a pgbench job
  psql         Start a psql session targeting a CloudNativePG cluster

Additional Commands:
  completion   Generate the autocompletion script for the specified shell
  help         Help about any command
  version      Prints version, commit sha and date of the build
```

CloudNativePG - What I personally love

- Massive suite of e2e running in CI/CD pipelines
- Exhaustive documentation
- CNPG team members
- Community enthusiasm

The picture shows some of the maintainers running a demo at the Project Pavillion of KubeCon Eu London 2025



CloudNativePG - Product

- CloudNativePG is **production ready!**
- CloudNativePG became the de facto standard to deploy **PostgreSQL in Kubernetes**
- Community is very active inside the [Slack workspace](#)
- CloudNativePG has been accepted into the **CNCF Sandbox**

CloudNativePG - License

CloudNativePG has been originally created **EDB**

CloudNativePG is 100% **open source** and community-driven

All components are available under the [Apache 2 license](#) on Github

CloudNativePG - Adopters

- **Google Cloud**

<https://cloud.google.com/kubernetes-engine/docs/tutorials/stateful-workloads/cloudnativepg>

- **Microsoft Azure**

<https://learn.microsoft.com/en-us/azure/aks/postgresql-ha-overview>

- **IBM**

- **EDB**

EDB CloudNativePG Cluster, EDB CloudNativePG Global Cluster, EDB Postgres AI Cloud Service (DBaaS)

Full list [here](#)

CloudNativePG - End users

- **EDB**
- **Hitachi**
- **Akamai Technologies**
- **Tembo**
- **CNDI**

Full list at https://cloudnative-pg.io/end_users

CloudNativePG - Beyond the operator

CloudNativePG project contains a plenty of interesting repositories:

- Helm charts
- CNPG-I
- Grafana dashboards
- PostGIS Containers
- Ciclops

CloudNativePG - Useful links

Website: <https://cloudnative-pg.io/>

CloudNativePG is on LinkedIn, GitHub, cncf.io/sandbox-projects/ , but also on

- **Slack** <https://cloud-native.slack.com/archives/C08MAUJ7NPM>
- **Twitter** <https://twitter.com/CloudNativePg>
- **Mastodon** <https://mastodon.social/@CloudNativePG>
- **Bluesky** <https://bsky.app/profile/cloudnativepg.bsky.social>

CloudNativePG - Resources

- CloudNativePG [website](#) and [GitHub](#) project
- CloudNativePG Recipes on Gabriele Bartolini's [blog](#)
- CloudNativePG maintainers and contributors are active on [Data On Kubernetes](#) community
- Latest KubeCon talks mentions CloudNativePG, eg.
 - [“We tested and compared 6 Database Operators. The results are in!”](#)
 - [“Kubernetes on Multisites - A Story About Stateful App, Hybrid Clouds and High Availability”](#)
- CNCF blog article [“Cloud Neutral Postgres Databases with Kubernetes and CloudNativePG”](#)



**Join the
Community**





Demo

- Describe the demo environment
- Apply and analyze Cluster CRD
- Hands into PostgreSQL
- CNPG plugin usage
- Failover
- Declarative Database CRD

If we have time:

- Metrics
- Major PG offline upgrade

If we run out of time and you are interested,
let's chat in the hallway!

Thanks!

Get in touch with me on

- [#cloudnativepg-dev](#) on CNCF Slack
- [LinkedIn](#)
- gabriele.quaresima@enterprisedb.com