PERCONA

Operator for PostgreSQL 2.8.1

(December 16, 2025)

Documentation

Table of Contents

- Home
- Discover the Operator
  - Comparison with other solutions
  - Design and architecture
- Get help from Percona
- Quickstart guide
  - Overview
  - System requirements
  - 1 Quick install
    - With kubectl
    - With Helm
  - 2 Connect to PostgreSQL
  - 3 Insert data
  - 4 Make a backup
  - 5 Monitor the database with PMM
  - What's next
- Installation
  - Install on Minikube
  - Install with Everest
  - Install on Google Kubernetes Engine (GKE)
  - Install on Amazon Elastic Kubernetes Service (AWS EKS)
  - Install on Microsoft Azure Kubernetes Service (AKS)
  - Install on OpenShift
  - Generic Kubernetes installation
- Configuration
  - Application and system users
  - Exposing the cluster
  - Changing PostgreSQL options
  - Anti-affinity and tolerations

- Labels and annotations
- Transport encryption (TLS/SSL)
- Telemetry
- Configure concurrency for a cluster reconciliation

Management

- Back up and restore
  - About backups
  - Configure storage for backups
  - Make scheduled backups
  - Make on-demand backup
  - Restore from a backup
  - Backup encryption
  - Speed up backups
  - Backup retention
  - Delete the unneeded backup
  - Disable backups
- Deploy a standby cluster for Disaster Recovery
  - Introduction
  - Deploy standby cluster based on backups
  - Deploy standby cluster based on streaming replication
  - Failover
- Scale your cluster
- High-availability
- Huge pages
- Add sidecar containers
- Restart or pause the cluster
- Monitor the database with PMM

Upgrade

- About upgrades
- Upgrade the Operator
- Upgrade the database
- Upgrade PostgreSQL extensions
- Upgrade on Percona Operator for PostgreSQL on OpenShift

- Upgrade from version 1 to version 2
  - Using data volumes
  - Using backup and restore
  - Using standby

How-to

- Install the database with customized parameters
- Run Initialization SQL commands at cluster creation time
- Change PostgreSQL primary instance
- How to use private registry
- Manage PostgreSQL extensions
- Provide Percona Operator for PostgreSQL single-namespace and multi-namespace deployment
- Use PostgreSQL tablespaces with Percona Operator for PostgreSQL
- Monitor Kubernetes
- Use PostGIS extension
- Delete the Operator
- Retrieve Percona certified images

Troubleshooting

- Troubleshoot Operator installation issues
- Initial troubleshooting
- Check storage
- Exec into the container
- Check the logs
- Manage a database manually
- Reinitialize replicas

Reference

- Custom Resource options
- Backup resource options
- Restore options
- Secrets options
- Percona certified images
- Versions compatibility
- Copyright and licensing information
- Trademark policy

- Release Notes
  - Release notes index
  - Percona Operator for PostgreSQL 2.8.1 (2025-12-16)
  - Percona Operator for PostgreSQL 2.8.0 (2025-11-13)
  - Percona Operator for PostgreSQL 2.7.0 (2025-07-18)
  - Percona Operator for PostgreSQL 2.6.0 (2025-03-17)
  - Percona Operator for PostgreSQL 2.5.1 (2025-03-03)
  - Percona Operator for PostgreSQL 2.5.0 (2024-10-08)
  - Percona Operator for PostgreSQL 2.4.1 (2024-08-06)
  - Percona Operator for PostgreSQL 2.4.0 (2024-06-24)
  - Percona Operator for PostgreSQL 2.3.1 (2024-01-23)
  - Percona Operator for PostgreSQL 2.3.0 (2023-12-21)
  - Percona Operator for PostgreSQL 2.2.0 (2023-06-30)
  - Percona Operator for PostgreSQL 2.1.0 Tech preview (2023-05-04)
  - Percona Operator for PostgreSQL 2.0.0 Tech preview (2022-12-30)
- Home
- Discover the Operator
  - Comparison with other solutions
  - Design and architecture
- Get help from Percona
- Quickstart guide
  - Overview
  - System requirements
  - 1 Quick install
    - With kubectl
    - With Helm
  - 2 Connect to PostgreSQL
  - 3 Insert data
  - 4 Make a backup
  - 5 Monitor the database with PMM
  - What's next

- Installation
  - Install on Minikube
  - Install with Everest
  - Install on Google Kubernetes Engine (GKE)
  - Install on Amazon Elastic Kubernetes Service (AWS EKS)
  - Install on Microsoft Azure Kubernetes Service (AKS)
  - Install on OpenShift
  - Generic Kubernetes installation
- Configuration
  - Application and system users
  - Exposing the cluster
  - Changing PostgreSQL options
  - Anti-affinity and tolerations
  - Labels and annotations
  - Transport encryption (TLS/SSL)
  - Telemetry
  - Configure concurrency for a cluster reconciliation
- Management
  - Back up and restore
    - About backups
    - Configure storage for backups
    - Make scheduled backups
    - Make on-demand backup
    - Restore from a backup
    - Backup encryption
    - Speed up backups
    - Backup retention
    - Delete the unneeded backup
    - Disable backups
  - Deploy a standby cluster for Disaster Recovery
    - Introduction
    - Deploy standby cluster based on backups
    - Deploy standby cluster based on streaming replication

- Failover
- Scale your cluster
- High-availability
- Huge pages
- Add sidecar containers
- Restart or pause the cluster
- Monitor the database with PMM

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- About upgrades
- Upgrade the Operator
- Upgrade the database
- Upgrade PostgreSQL extensions
- Upgrade on Percona Operator for PostgreSQL on OpenShift
- Upgrade from version 1 to version 2
  - Using data volumes
  - Using backup and restore
  - Using standby

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- Use PostgreSQL tablespaces with Percona Operator for PostgreSQL
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- Check storage

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- Check the logs
- Manage a database manually
- Reinitialize replicas

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- Percona Operator for PostgreSQL 2.8.0 (2025-11-13)
- Percona Operator for PostgreSQL 2.7.0 (2025-07-18)
- Percona Operator for PostgreSQL 2.6.0 (2025-03-17)
- Percona Operator for PostgreSQL 2.5.1 (2025-03-03)
- Percona Operator for PostgreSQL 2.5.0 (2024-10-08)
- Percona Operator for PostgreSQL 2.4.1 (2024-08-06)
- Percona Operator for PostgreSQL 2.4.0 (2024-06-24)
- Percona Operator for PostgreSQL 2.3.1 (2024-01-23)
- Percona Operator for PostgreSQL 2.3.0 (2023-12-21)
- Percona Operator for PostgreSQL 2.2.0 (2023-06-30)
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Percona Operator for PostgreSQL documentation

The Percona Operator for PostgreSQL automates the creation, modification, or deletion of items in your Percona Distribution for PostgreSQL environment. The Operator contains the necessary Kubernetes settings to maintain a consistent PostgreSQL cluster.

Percona Kubernetes Operator is based on best practices for configuration and setup of a Percona Distribution for PostgreSQL cluster. The benefits of the Operator are many, but saving time and delivering a consistent and vetted environment is key.

This is the documentation for the latest release, **2.8.1** (Release Notes).

Starting with Percona Kubernetes Operator is easy. Follow our documentation guides, and you'll be set up in a minute.

Installation guides

Want to see it for yourself? Get started quickly with our step-by-step installation instructions.

Quickstart guides →

Security and encryption

Rest assured! Learn more about our security features designed to protect your valuable data.

Security measures →

Backup management

Learn what you can do to maintain regular backups of your PostgreSQL cluster.

Backup management →

Troubleshooting

Our comprehensive resources will help you overcome challenges, from everyday issues to specific doubts.

Diagnostics →

Discover the Operator

Compare various solutions to deploy PostgreSQL in Kubernetes

There are multiple ways to deploy and manage PostgreSQL in Kubernetes. Here we will focus on comparing the following open source solutions:

- Crunchy Data PostgreSQL Operator (PGO)
- CloudNative PG from Enterprise DB
- Stackgres from OnGres
- Zalando Postgres Operator
- Percona Operator for PostgreSQL

Generic

Feature/Product	Percona Operator for PostgreSQL	Stackgres	CrunchyData	CloudNativePG (EDB)	Zalando
Open-source license	Apache 2.0	AGPL 3	Apache 2.0, but images are under Developer Program	Apache 2.0	MIT
PostgreSQL versions	12 - 16	14 - 16	13 - 16	12 - 16	11 - 15
Kubernetes conformance	Various versions are tested	Various versions are tested	Various versions are tested	Various versions are tested	AWS EKS
Web-based GUI	Percona Everest	Admin UI	⛔	⛔	Postgres Operator UI

Maintenance

Feature/Product	Percona Operator for PostgreSQL	Stackgres	CrunchyData	CloudNativePG (EDB)	Zalando
Operator upgrade	✅	✅	✅	✅	✅
Database upgrade	Automated and safe	Automated and safe	Manual	Manual	Manual
Compute scaling	Horizontal and vertical	Horizontal and vertical	Horizontal and vertical	Horizontal and vertical	Horizontal and vertical
Storage scaling	Manual	Manual	Manual	Manual	Manual, automated for AWS EBS

PostgreSQL topologies

Feature/Product	Percona Operator for PostgreSQL	Stackgres	CrunchyData	CloudNativePG (EDB)	Zalando
Warm standby	✅	✅	✅	✅	✅
Hot standby	✅	✅	✅	✅	✅
Connection pooling	✅	✅	✅	✅	✅
Delayed replica	🚫	🚫	🚫	🚫	🚫

Backups

Feature/Product	Percona Operator for PostgreSQL	Stackgres	CrunchyData	CloudNativePG (EDB)	Zalando

Scheduled backups	✅	✅	✅	✅	✅
WAL archiving	✅	✅	✅	✅	✅
PITR	✅	✅	✅	✅	✅
GCS	✅	✅	✅	✅	✅
S3	✅	✅	✅	✅	✅
Azure	✅	✅	✅	✅	✅

Monitoring

Feature/Product	Percona Operator for PostgreSQL	Stackgres	CrunchyData	CloudNativePG (EDB)	Zalando
Solution	Percona Monitoring and Management and sidecars	Exposing metrics in Prometheus format	Prometheus stack and pgMonitor	Exposing metrics in Prometheus format	Sidecars

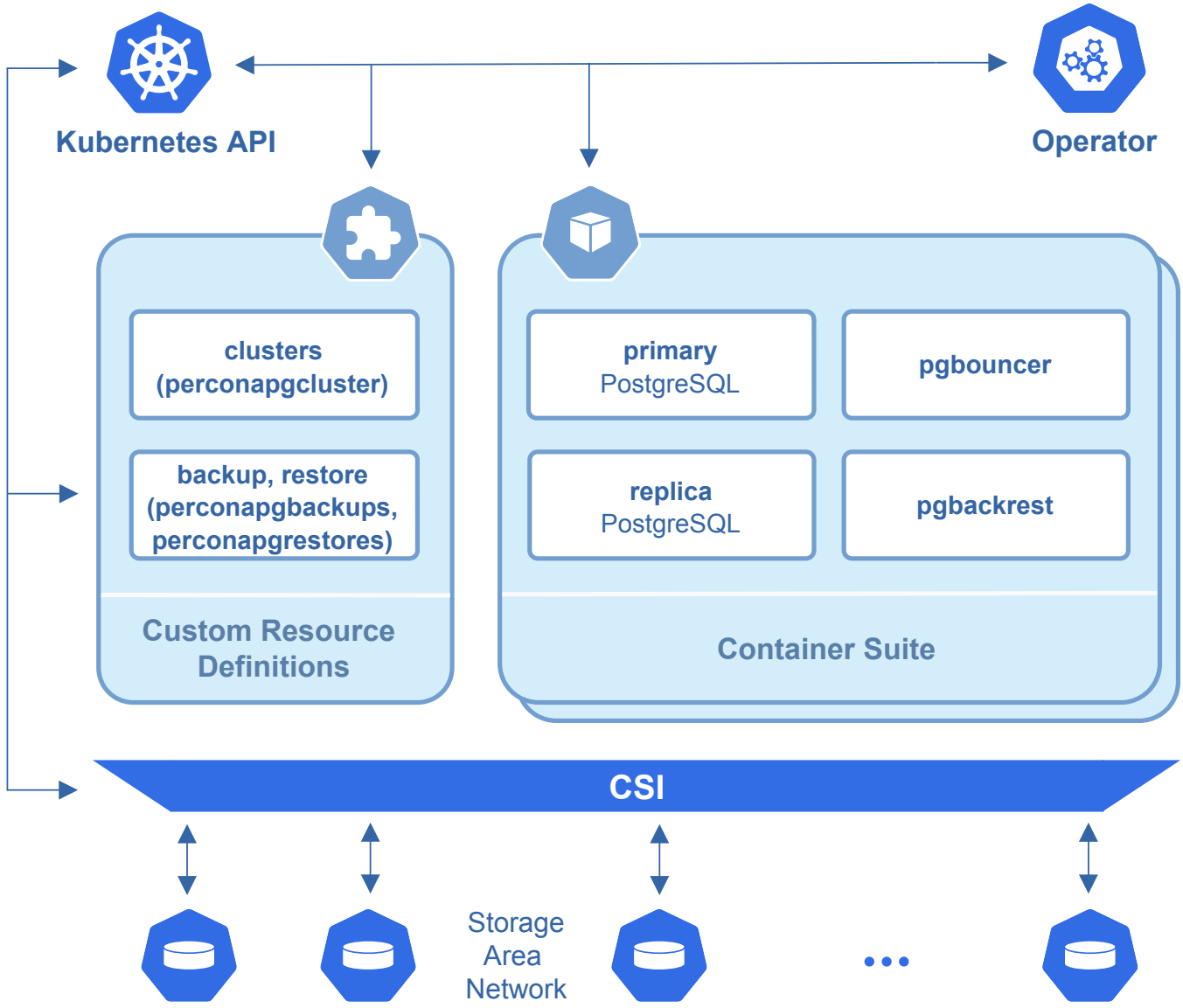
Miscellaneous

Feature/Product	Percona Operator for PostgreSQL	Stackgres	CrunchyData	CloudNativePG (EDB)	Zalando
Customize PostgreSQL configuration	✅	✅	✅	✅	✅
Sidecar containers for customization	✅	🚫	✅	🚫	✅

Helm	✅	✅	✅	✅	✅
Transport encryption	✅	✅	✅	✅	✅
Data-at-rest encryption	Through storage class	Through storage class	Through storage class	Through storage class	Through storage class
Create users/roles	✅	✅	✅	✅	limited

Design overview

The Percona Operator for PostgreSQL automates and simplifies deploying and managing open source PostgreSQL clusters on Kubernetes. The Operator is based on CrunchyData's PostgreSQL Operator.



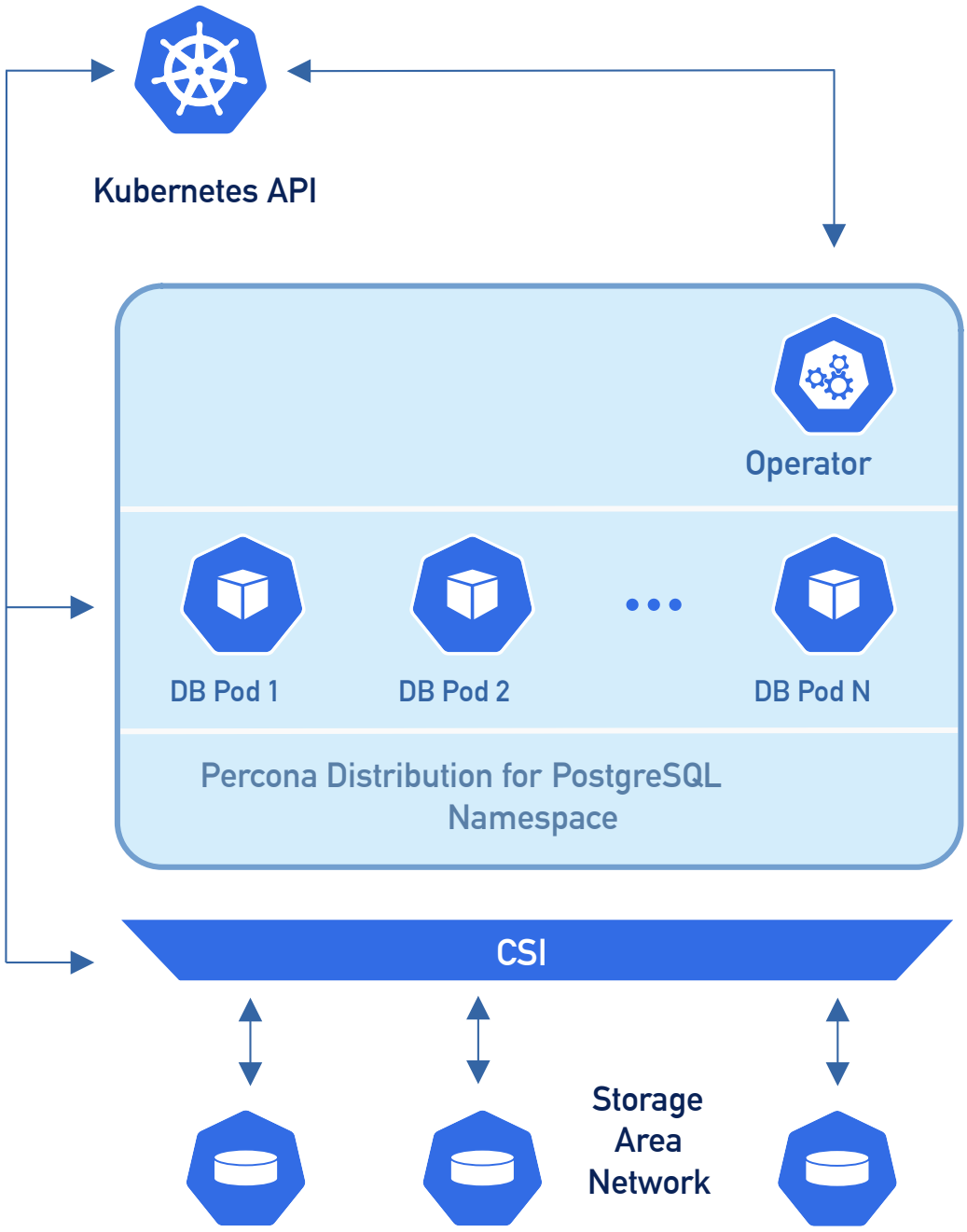
PostgreSQL containers deployed with the Operator include the following components:

- The PostgreSQL database management system, including:
  - PostgreSQL Additional Supplied Modules,
  - pgAudit PostgreSQL auditing extension,
  - PostgreSQL set_user Extension Module,
  - wal2json output plugin,

- The pgBackRest Backup & Restore utility,
- The pgBouncer connection pooler for PostgreSQL,
- The PostgreSQL high-availability implementation based on the Patroni template,
- the pg_stat_monitor PostgreSQL Query Performance Monitoring utility,
- LLVM (for JIT compilation).

Each PostgreSQL cluster includes one member available for read/write transactions (PostgreSQL primary instance, or leader in terms of Patroni) and a number of replicas which can serve read requests only (standby members of the cluster).

To provide high availability from the Kubernetes side the Operator involves node affinity to run PostgreSQL Cluster instances on separate worker nodes if possible. If some node fails, the Pod with it is automatically re-created on another node.



To provide data storage for stateful applications, Kubernetes uses Persistent Volumes. A *PersistentVolumeClaim* (PVC) is used to implement the automatic storage provisioning to pods. If a failure occurs, the Container Storage Interface (CSI) should be able to re-mount storage on a different node.

The Operator functionality extends the Kubernetes API with Custom Resources Definitions. These CRDs provide extensions to the Kubernetes API, and, in the case of the Operator, allow you to perform actions such as creating a PostgreSQL Cluster, updating PostgreSQL Cluster resource allocations, adding additional utilities to a PostgreSQL cluster, e.g. pgBouncer for connection pooling and more.

When a new Custom Resource is created or an existing one undergoes some changes or deletion, the Operator automatically creates/changes/deletes all needed Kubernetes objects with the appropriate settings to provide a proper Percona PostgreSQL Cluster operation.

Following CRDs are created while the Operator installation:

- `perconapgclusters` stores information required to manage a PostgreSQL cluster. This includes things like the cluster name, what storage and resource classes to use, which version of PostgreSQL to run, information about how to maintain a high-availability cluster, etc.
- `perconapgbackups` and `perconapgrestores` are in charge for making backups and restore them.

Get help from Percona

Our documentation guides are packed with information, but they can't cover everything you need to know about Percona Operator for PostgreSQL. They also won't cover every scenario you might come across. Don't be afraid to try things out and ask questions when you get stuck.

Percona's Community Forum

Be a part of a space where you can tap into a wealth of knowledge from other database enthusiasts and experts who work with Percona's software every day. While our service is entirely free, keep in mind that response times can vary depending on the complexity of the question. You are engaging with people who genuinely love solving database challenges.

We recommend visiting our Community Forum. It's an excellent place for discussions, technical insights, and support around Percona database software. If you're new and feeling a bit unsure, our FAQ and Guide for New Users ease you in.

If you have thoughts, feedback, or ideas, the community team would like to hear from you at Any ideas on how to make the forum better?. We're always excited to connect and improve everyone's experience.

Percona experts

Percona experts bring years of experience in tackling tough database performance issues and design challenges.

Talk to a Percona Expert

We understand your challenges when managing complex database environments. That's why we offer various services to help you simplify your operations and achieve your goals.

Service	Description
24/7 Expert Support	Our dedicated team of database experts is available 24/7 to assist you with any database issues. We provide flexible support plans tailored to your specific needs.
Hands-On Database Management	Our managed services team can take over the day-to-day management of your database infrastructure, freeing up your time to focus on other priorities.

Expert Consulting	Our experienced consultants provide guidance on database topics like architecture design, migration planning, performance optimization, and security best practices.
Comprehensive Training	Our training programs help your team develop skills to manage databases effectively, offering virtual and in-person courses.

We’re here to help you every step of the way. Whether you need a quick fix or a long-term partnership, we’re ready to provide your expertise and support.

Quickstart guide

Overview

Ready to get started with the Percona Operator for PostgreSQL? In this section, you will learn some basic operations, such as:

- Install and deploy an Operator
- Connect to PostgreSQL
- Insert sample data to the database
- Set up and make a manual backup
- Monitor the database health with PMM

Next steps

Install the Operator →

System requirements

The Operator is validated for deployment on Kubernetes, GKE and EKS clusters. The Operator is cloud native and storage agnostic, working with a wide variety of storage classes, hostPath, and NFS.

Supported versions

The Operator 2.8.1 is developed, tested and based on:

- PostgreSQL 18.1-1, 17.7-1, 16.11-1, 15.15-1, 14.20-1, 13.23-1 as the database. Other versions may also work but have not been tested.
- pgBouncer 1.25.0-1 for connection pooling
- Patroni version 4.1.0 for high-availability
- PMM Client 3.5.0
- PostGIS:
    - version 3.5.4 for PostgreSQL 18,
    - version 3.3.8 for PostgreSQL 17, 16, 15, 14, and 13

Supported platforms

The following platforms were tested and are officially supported by the Operator 2.8.1:

- Google Kubernetes Engine (GKE) 1.31 - 1.33
- Amazon Elastic Kubernetes Service (EKS) 1.31 - 1.34
- Azure Kubernetes Service (AKS) 1.32 - 1.34
- OpenShift 4.16 - 4.20
- Minikube 1.37.0 with Kubernetes v1.34.0

Other Kubernetes platforms may also work but have not been tested.

Huge pages

We strongly recommend enabling huge pages on worker nodes for better stability and performance.

Installation guidelines

Choose how you wish to install Percona Operator for PostgreSQL:

- with Helm
- with `kubectl`
- on Minikube
- on Google Kubernetes Engine (GKE)
- on Amazon Elastic Kubernetes Service (AWS EKS)
- on Azure Kubernetes Service (AKS)
- in a general Kubernetes-based environment

1 Quick install

Install Percona Distribution for PostgreSQL using kubectl

A Kubernetes Operator is a special type of controller introduced to simplify complex deployments. The Operator extends the Kubernetes API with custom resources.

The Percona Operator for PostgreSQL is based on best practices for configuration and setup of a Percona Distribution for PostgreSQL cluster in a Kubernetes-based environment on-premises or in the cloud.

We recommend installing the Operator with the kubectl command line utility. It is the universal way to interact with Kubernetes. Alternatively, you can install it using the Helm package manager.

Install with kubectl ↓ | Install with Helm →

Prerequisites

To install Percona Distribution for PostgreSQL, you need the following:

1. The **kubectl** tool to manage and deploy applications on Kubernetes, included in most Kubernetes distributions. Install not already installed, follow its official installation instructions.
2. A Kubernetes environment. You can deploy it on Minikube for testing purposes or using any cloud provider of your choice. Check the list of our officially supported platforms.

See also

- Set up Minikube
- Create and configure the GKE cluster
- Set up Amazon Elastic Kubernetes Service
- Create and configure the AKS cluster

Procedure

Here's a sequence of steps to follow:

1. Create the Kubernetes namespace for your cluster. It is a good practice to isolate workloads in Kubernetes by installing the Operator in a custom namespace. For example, let's name it `postgres-operator`:

```
kubectl create namespace postgres-operator
```

Expected output

```
namespace/postgres-operator was created
```

We will use this namespace further on in this document. If you used another name, make sure to replace it in the following commands.

2. Deploy the Operator using the following command:

```
kubectl apply --server-side -f
https://raw.githubusercontent.com/percona/percona-postgresql-
operator/v2.8.1/deploy/bundle.yaml -n postgres-operator
```

Expected output

```
customresourcedefinition.apiextensions.k8s.io/crunchybridgeclusters.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgbackups.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgclusters.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgrestores.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgupgrades.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/pgadmins.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/pgupgrades.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/postgresclusters.postgres-
operator.crunchydata.com serverside-applied
serviceaccount/percona-postgresql-operator serverside-applied
role.rbac.authorization.k8s.io/percona-postgresql-operator serverside-applied
rolebinding.rbac.authorization.k8s.io/service-account-percona-postgresql-operator
serverside-applied
deployment.apps/percona-postgresql-operator serverside-applied
```

At this point, the Operator Pod is up and running.

3. Deploy Percona Distribution for PostgreSQL cluster:

```
kubectl apply -f https://raw.githubusercontent.com/percona/percona-postgresql-operator/v2.8.1/deploy/cr.yaml -n postgres-operator
```

Expected output

```
perconapgcluster.pgv2.percona.com/cluster1 created
```

4. Check the Operator and replica set Pods status.

```
kubectl get pg -n postgres-operator
```

The creation process may take some time. When the process is over your cluster obtains the ready status.

Expected output

```
NAME       ENDPOINT                                  STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.postgres-operator.svc   ready    3          3           143m
```

You have successfully installed and deployed the Operator with default parameters. You can check them in the Custom Resource options reference.

Next steps

Connect to PostgreSQL →

Install Percona Distribution for PostgreSQL using Helm

Helm is the package manager for Kubernetes. A Helm chart is a package that contains all the necessary resources to deploy an application to a Kubernetes cluster.

You can find Percona Helm charts in percona/percona-helm-charts repository in Github.

Prerequisites

To install and deploy the Operator, you need the following:

1. Helm v3.
2. kubectl command line utility.
3. A Kubernetes environment. You can deploy it locally on Minikube for testing purposes or using any cloud provider of your choice. Check the list of our officially supported platforms.

See also

- Set up Minikube
- Create and configure the GKE cluster
- Set up Amazon Elastic Kubernetes Service

Installation

Here's a sequence of steps to follow:

1. Add the Percona's Helm charts repository and make your Helm client up to date with it:

```
helm repo add percona https://percona.github.io/percona-helm-charts/
helm repo update
```

2. It is a good practice to isolate workloads in Kubernetes via namespaces. Create a namespace:

```
kubectl create namespace <my-namespace>
```

3. Install the Percona Operator for PostgreSQL:

```
helm install my-operator percona/pg-operator --namespace <my-namespace>
```

The `my-namespace` is the name of your namespace. The `my-operator` parameter is the name of a new release object which is created for the Operator when you install its Helm chart (use any name you like).

4. Install Percona Distribution for PostgreSQL:

```
helm install cluster1 percona/pg-db -n <my-namespace>
```

The `cluster1` parameter is the name of a new release object which is created for the Percona Distribution for PostgreSQL when you install its Helm chart (use any name you like).

5. Check the Operator and replica set Pods status.

```
kubectl get pg -n <my-namespace>
```

The creation process is over when both the Operator and replica set Pods report the `ready` status:

Expected output

```
NAME       ENDPOINT                                 STATUS   POSTGRES   PGBOUNCER
AGE
cluster1   cluster1-pgbouncer.postgres-operator.svc   ready    3          3
143m
```

You have successfully installed and deployed the Operator with default parameters. You can check them in the Custom Resource options reference.

You can find in the documentation for the charts which Operator and database parameters can be customized during installation.

Next steps

Connect to PostgreSQL →

2 Connect to the PostgreSQL cluster

When the installation is done, we can connect to the cluster.

The `pgBouncer` component of Percona Distribution for PostgreSQL provides the point of entry to the PostgreSQL cluster. We will use the `pgBouncer` URI to connect.

The `pgBouncer` URI is stored in the Secret object, which the Operator generates during the installation.

To connect to PostgreSQL, do the following:

1. List the Secrets objects

   ```
   kubectl get secrets -n <namespace>
   ```

   The Secrets object we target is named as `<cluster_name>-pguser-<cluster_name>`. The `<cluster_name>` value is the name of your Percona Distribution for PostgreSQL Cluster. The default variant is:

   via kubectl

   `cluster1-pguser-cluster1`

   via Helm

   `cluster1-pg-db-pguser-cluster1-pg-db`

2. Retrieve the pgBouncer URI from your secret, decode and pass it as the `PGBOUNCER_URI` environment variable. Replace the `<secret>`, `<namespace>` placeholders with your Secret object and namespace accordingly:

   ```
   PGBOUNCER_URI=$(kubectl get secret <secret> --namespace <namespace> -o
   jsonpath='{.data.pgbouncer-uri}' | base64 --decode)
   ```

   The following example shows how to pass the pgBouncer URI from the default Secret object `cluster1-pguser-cluster1`:

   ```
   PGBOUNCER_URI=$(kubectl get secret cluster1-pguser-cluster1 --namespace
   <namespace> -o jsonpath='{.data.pgbouncer-uri}' | base64 --decode)
   ```

3. Create a Pod where you start a container with Percona Distribution for PostgreSQL and connect to the database. The following command does it, naming the Pod `pg-client` and connects you to the `cluster1` database:

```
kubectl run -i --rm --tty pg-client --image=perconalab/percona-
distribution-postgresql:16 --restart=Never -- psql $PGBOUNCER_URI
```

It may take some time to create the Pod and connect to the database. As the result, you should see the following sample output:

Expected output

```
psql (17.7-1)
SSL connection (protocol: TLSv1.3, cipher: TLS_AES_256_GCM_SHA384, bits: 256,
compression: off)
Type "help" for help.
cluster1=>
```

Congratulations! You have connected to your PostgreSQL cluster.

Next steps

Insert testing data →

3 Insert sample data

The next step after connecting to the cluster is to insert some sample data to PostgreSQL.

When you start a PostgreSQL container and connect to the database, a user is created with the username that matches the name of your cluster. Also, a database and a schema named after the name of this user are created so that you can create a table right away.

Create a schema (for Operator version earlier than 2.6.0)

In Operator versions earlier than 2.6.0, you must create a new schema to insert the data. This is because your user cannot access the default schema called `public` due to PostgreSQL restrictions (instroduced starting with PostgreSQL 15).

A schema stores database objects like tables, views, indexes and allows organizing them into logical groups.

Use the following statement to create a schema

```
CREATE SCHEMA demo;
```

Create a table

After you created a schema, all tables you create end up in this schema if not specified otherwise.

At this step, we will create a sample table `Library` as follows:

```
CREATE TABLE LIBRARY(
   ID INTEGER NOT NULL,
   NAME TEXT,
   SHORT_DESCRIPTION TEXT,
   AUTHOR TEXT,
   DESCRIPTION TEXT,
   CONTENT TEXT,
   LAST_UPDATED DATE,
   CREATED DATE
);
```

Tip

If the schema has not been automatically set to the one you created, set it manually using the following SQL statement:

```
SET schema 'demo';
```

Replace the `demo` schema name with your value if you used another name.

Insert the data

PostgreSQL does not have the built-in support to generate random data. However, it provides the `random()` function which generates random numbers and `generate_series()` function which generates the series of rows and populates them with the numbers incremented by 1 (by default).

Combine these functions with a couple of others to populate the table with the data:

```
INSERT INTO LIBRARY(id, name, short_description, author,
                            description,content, last_updated, created)
SELECT id, 'name', md5(random()::text), 'name2'
      ,md5(random()::text),md5(random()::text)
      ,NOW() - '1 day'::INTERVAL * (RANDOM()::int * 100)
      ,NOW() - '1 day'::INTERVAL * (RANDOM()::int * 100 + 100)
FROM generate_series(1,100) id;
```

This command does the following:

- Fills in the columns `id`, `name`, `author` with the values `id`, `name` and `name2` respectively;
- generates the random md5 hash sum as the values for the columns `short_description`, `description` and `content`;
- generates the random number of dates from the current date and time within the last 100 days, and
- inserts 100 rows of this data

Now your cluster has some data in it.

Next steps

Make a backup

4 Make a backup

Now your database contains some data, so it's a good time to learn how to manually make a full backup of your data with the Operator.

> **Note**
>
> If you are interested to learn more about backups, their types and retention policy, see the Backups section.

Considerations and prerequisites

- In this tutorial we use the AWS S3 as the backup storage. You need the following S3-related information:
  - The name of S3 bucket;
  - The endpoint - the URL to access the bucket
  - The region - the location of the bucket
  - S3 credentials such as S3 key and secret to access the storage.

  If you don't have access to AWS, you can use any S3-compatible storage like MinIO. Check the list of supported storages. Find the storage configuration instructions for each
- The Operator uses the `pgBackRest` tool to make backups. `pgBackRest` stores the backups and archives WAL segments in repositories. The Operator has up to four `pgBackRest` repositories named `repo1`, `repo2`, `repo3` and `repo4`. In this tutorial we use `repo2` for backups.
- Also, we will use some files from the Operator repository for setting up backups. So, clone the percona-postgresql-operator repository:

  ```
  git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
  cd percona-postgresql-operator
  ```

  > **Note**
  >
  > It is important to specify the right branch with `-b` option while cloning the code on this step. Please be careful.

Configure backup storage

1. Encode the S3 credentials and the pgBackRest repository name (`repo2` in our setup).

   Linux

   ```
   cat <<EOF | base64 --wrap=0
   [global]
   repo2-s3-key=<YOUR_AWS_S3_KEY>
   repo2-s3-key-secret=<YOUR_AWS_S3_KEY_SECRET>
   EOF
   ```

   macOS

   ```
   cat <<EOF | base64
   [global]
   repo2-s3-key=<YOUR_AWS_S3_KEY>
   repo2-s3-key-secret=<YOUR_AWS_S3_KEY_SECRET>
   EOF
   ```

2. Create the Secret configuration file and specify the base64-encoded string from the previous step. The following is the example of the `cluster1-pgbackrest-secrets.yaml` Secret file:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: cluster1-pgbackrest-secrets
   type: Opaque
   data:
     s3.conf: <base64-encoded-configuration-contents>
   ```

3. Create the Secrets object from this yaml file. Specify your namespace instead of the `<namespace>` placeholder:

   ```
   kubectl apply -f cluster1-pgbackrest-secrets.yaml -n <namespace>
   ```

4. Update your `deploy/cr.yaml` configuration. Specify the Secret file you created in the `backups.pgbackrest.configuration` subsection, and put all other S3 related information in the `backups.pgbackrest.repos` subsection under the repository name that you intend to use for backups. This name must match the name you used when you encoded S3 credentials on step 1.

For example, the S3 storage for the `repo2` repository looks as follows:

```
...
backups:
  pgbackrest:
    ...
    configuration:
      - secret:
          name: cluster1-pgbackrest-secrets
    ...
    repos:
    - name: repo2
      s3:
        bucket: "<YOUR_AWS_S3_BUCKET_NAME>"
        endpoint: "<YOUR_AWS_S3_ENDPOINT>"
        region: "<YOUR_AWS_S3_REGION>"
```

5. Create or update the cluster. Specify your namespace instead of the `<namespace>` placeholder:

```
kubectl apply -f deploy/cr.yaml
```

Make a backup

For manual backups, you need a backup configuration file.

1. Edit the example backup configuration file [deploy/backup.yaml](https://raw.githubusercontent.com/percona/percona-postgresql-operator/v2.8.1/deploy/backup.yaml). Specify your cluster name and the `repo` name.

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGBackup
metadata:
  name: backup1
spec:
  pgCluster: cluster2
  repoName: repo1
#  options:
#  - --type=full
```

2. Apply the configuration. This instructs the Operator to start a backup.

```
kubectl apply -f deploy/backup.yaml -n <namespace>
```

3. To make a backup takes a while. Track the backup progress:

```
kubectl get pg-backup -n <namespace>
```

Expected output

```
NAME      CLUSTER    REPO    DESTINATION    STATUS      TYPE    COMPLETED    AGE
backup1                     cluster1    repo2    s3://pg-operator-testing
Succeeded    full    3m14s       4m46s
```

Congratulations! You have made the first backup manually. Want to learn more about backups? See the Backup and restore section for details like types, retention and how to automatically make backups according to the schedule.

Next steps

Monitor the database →

5 Monitor the database

Finally, when we are done with backup, it's time for one more step. In this section you will learn how to monitor the health of Percona Distribution for PostgreSQL with Percona Monitoring and Management (PMM).

The Operator supports both PMM version 2 and PMM version 3.

It determines which PMM server version you are using based on the authentication method you provide. For PMM 2, the Operator uses API keys for authentication. For PMM 3, it uses service account tokens.

We recommend to use the latest PMM 3.

PMM is a client/server application. It includes the PMM Server and the number of PMM Clients running on each node with the database you wish to monitor.

A PMM Client collects needed metrics and sends gathered data to the PMM Server. As a user, you connect to the PMM Server to see database metrics on a number of dashboards. PMM Server and PMM Client are installed separately.

Considerations

1. If you are using PMM server version 2, use a PMM client image compatible with PMM 2. If you are using PMM server version 3, use a PMM client image compatible with PMM 3. Check Percona certified images for the right one.
2. If you specified both authentication methods for PMM server configuration and they have non-empty values, priority goes to PMM 3.
3. For migration from PMM2 to PMM3, see PMM upgrade documentation. Also check the Automatic migration of API keys page.

Install PMM Server

You must have PMM server up and running. You can run PMM Server as a *Docker image*, a *virtual appliance*, or in Kubernetes. Please refer to the official PMM documentation for the installation instructions.

Install PMM Client

PMM Client is installed as a side-car container in the database Pods in your Kubernetes-based environment. To install PMM Client, do the following:

Configure authentication

PMM3

PMM3 uses Grafana service accounts to control access to PMM server components and resources. To authenticate in PMM server, you need a service account token. Generate a service account and token. Specify the Admin role for the service account.

Warning

When you create a service account token, you can select its lifetime: it can be either a permanent token that never expires or the one with the expiration date. PMM server cannot rotate service account tokens after they expire. So you must take care of reconfiguring PMM Client in this case.

PMM2

Get the PMM API key from PMM Server. The API key must have the role “Admin”. You need this key to authorize PMM Client within PMM Server.

From PMM UI

Generate the PMM API key

From command line

You can query your PMM Server installation for the API Key using `curl` and `jq` utilities. Replace `<login>:<password>@<server_host>` placeholders with your real PMM Server login, password, and hostname in the following command:

```
API_KEY=$(curl --insecure -X POST -H "Content-Type: application/json" -d
'{"name":"operator", "role": "Admin"}' "https://<login>:
<password>@<server_host>/graph/api/auth/keys" | jq .key)
```

Warning

The API key is not rotated.

Create a secret

Now you must pass the credentials to the Operator. To do so, create a Secret object.

1. Create a Secret configuration file. You can use the deploy/secrets.yaml secrets file.

   PMM 3

   Specify the service account token as the `PMM_SERVER_TOKEN` value in the secrets file:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: cluster1-pmm-secret
   type: Opaque
   stringData:
     PMM_SERVER_TOKEN: ""
   ```

   PMM 2

   Specify the API key as the `PMM_SERVER_KEY` value in the secrets file:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: cluster1-pmm-secret
   type: Opaque
   stringData:
     PMM_SERVER_KEY: ""
   ```

2. Create the Secrets object using the `deploy/secrets.yaml` file.

   ```
   kubectl apply -f deploy/secrets.yaml -n postgres-operator
   ```

   Expected output

   ```
   secret/cluster1-pmm-secret created
   ```

Deploy a PMM Client

1. Update the `pmm` section in the deploy/cr.yaml file.
   - Set `pmm.enabled` = `true`.
   - Specify your PMM Server hostname / an IP address for the `pmm.serverHost` option. The PMM Server IP address should be resolvable and reachable from within your cluster.
   - Specify the name of the Secret object that you created earlier

   ```
     pmm:
       enabled: true
       image: percona/pmm-client:3.5.0
   #    imagePullPolicy: IfNotPresent
       secret: cluster1-pmm-secret
       serverHost: monitoring-service
   ```

2. Update the cluster

   ```
   kubectl apply -f deploy/cr.yaml -n postgres-operator
   ```

3. Check that corresponding Pods are not in a cycle of stopping and restarting. This cycle occurs if there are errors on the previous steps:

   ```
   kubectl get pods -n postgres-operator
   kubectl logs <pod_name> -c pmm-client
   ```

Update the secrets file

The `deploy/secrets.yaml` file contains all values for each key/value pair in a convenient plain text format. But the resulting Secrets Objects contains passwords stored as base64-encoded strings. If you want to *update* the password field, you need to encode the new password into the base64 format and pass it to the Secrets Object.

To encode a password or any other parameter, run the following command:

Linux

```
echo -n "password" | base64 --wrap=0
```

macOS

```
echo -n "password" | base64
```

For example, to set the new service account token in the `my-cluster-name-secrets` object, do the following:

Linux

```
kubectl patch secret/cluster1-pmm-secret -p '{"data":{"PMM_SERVER_TOKEN":
'$(echo -n <new-token> | base64 --wrap=0)'}}'
```

macOS

```
kubectl patch secret/cluster1-pmm-secret -p '{"data":{"PMM_SERVER_TOKEN":
'$(echo -n <new-token> | base64)'}}'
```

Check the metrics

Let's see how the collected data is visualized in PMM.

1. Log in to PMM server.
2. Click **PostgreSQL** from the left-hand navigation menu. You land on the **Instances Overview** page.
3. Click **PostgreSQL** → **Other dashboards** to see the list of available dashboards that allow you to drill down to the metrics you are interested in.

Next steps

What's next →

What's next?

Congratulations! You have completed all the steps in the Get started guide.

You have the following options to move forward with the Operator:

- Deepen your monitoring insights by setting up Kubernetes monitoring with PMM
- Control Pods assignment on specific Kubernetes Nodes by setting up affinity / anti-affinity
- Ready to adopt the Operator for production use and need to delete the testing deployment? Use this guide to do it
- You can also try operating the Operator and database clusters via the web interface with Percona Everest - an open-source web-based database provisioning tool based on Percona Operators. See Get started with Percona Everest on how to start using it

Installation

Install Percona Distribution for PostgreSQL on Minikube

Installing the Percona Operator for PostgreSQL on Minikube is the easiest way to try it locally without a cloud provider.

Minikube runs Kubernetes on GNU/Linux, Windows, or macOS system using a system-wide hypervisor, such as VirtualBox, KVM/QEMU, VMware Fusion or Hyper-V. Using it is a popular way to test Kubernetes application locally prior to deploying it on a cloud.

This document describes how to deploy the Operator and Percona Distribution for PostgreSQL on Minikube.

Set up Minikube

1. Install Minikube, using a way recommended for your system. This includes the installation of the following three components:

    1. kubectl tool,
    2. a hypervisor, if it is not already installed,
    3. actual minikube package

2. After the installation, initialize and start the Kubernetes cluster. The parameters we pass for the following command increase the virtual machine limits for the CPU cores, memory, and disk, to ensure stable work of the Operator:

    ```
    minikube start --memory=5120 --cpus=4 --disk-size=30g
    ```

    This command downloads needed virtualized images, then initializes and runs the cluster.

3. After Minikube is successfully started, you can optionally run the Kubernetes dashboard, which visually represents the state of your cluster. Executing `minikube dashboard` starts the dashboard and opens it in your default web browser.

Deploy the Percona Operator for PostgreSQL

1. Create the Kubernetes namespace for your cluster. It is a good practice to isolate workloads in Kubernetes by installing the Operator in a custom namespace. For example, let's name it `postgres-operator`:

   ```
   kubectl create namespace postgres-operator
   ```

   Expected output

   ```
   namespace/postgres-operator was created
   ```

   We will use this namespace further on in this document. If you used another name, make sure to replace it in the following commands.

2. Deploy the Operator using the following command:

   ```
   kubectl apply --server-side -f
   https://raw.githubusercontent.com/percona/percona-postgresql-
   operator/v2.8.1/deploy/bundle.yaml -n postgres-operator
   ```

Expected output

```
customresourcedefinition.apiextensions.k8s.io/crunchybridgeclusters.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgbackups.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgclusters.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgrestores.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgupgrades.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/pgadmins.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/pgupgrades.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/postgresclusters.postgres-
operator.crunchydata.com serverside-applied
serviceaccount/percona-postgresql-operator serverside-applied
role.rbac.authorization.k8s.io/percona-postgresql-operator serverside-applied
rolebinding.rbac.authorization.k8s.io/service-account-percona-postgresql-operator
serverside-applied
deployment.apps/percona-postgresql-operator serverside-applied
```

As the result you have the Operator Pod up and running.

3. Deploy Percona Distribution for PostgreSQL:

```
kubectl apply -f https://raw.githubusercontent.com/percona/percona-
postgresql-operator/v2.8.1/deploy/cr.yaml -n postgres-operator
```

Expected output

```
perconapgcluster.pgv2.percona.com/cluster1 created
```

Note

This deploys the default Percona Distribution for PostgreSQL configuration. Please see deploy/cr.yaml and Custom Resource Options for the configuration options. You can clone the repository with all manifests and source code by executing the following command:

```
git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
```

After editing the needed options, apply your modified `deploy/cr.yaml` file as follows:

```
kubectl apply -f deploy/cr.yaml  -n postgres-operator
```

4. The creation process may take some time. When the process is over your cluster will obtain the `ready` status. You can check it with the following command:

```
kubectl get pg -n postgres-operator
```

Expected output

```
NAME       ENDPOINT                          STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.default.svc    ready    3          3           30m
```

Verify the Percona Distribution for PostgreSQL cluster operation

When creation process is over, the output of the `kubectl get pg` command shows the cluster status as `ready`. You can try to connect to the cluster.

During the installation, the Operator has generated several secrets, including the one with password for default PostgreSQL user. This default user has the same login name as the cluster name.

1. Use `kubectl get secrets` command to see the list of Secrets objects. The Secrets object you are interested in is named as `<cluster_name>-pguser-<cluster_name>` (substitute `<cluster_name>` with the name of your Percona Distribution for PostgreSQL Cluster). The default variant will be `cluster1-pguser-cluster1`.

2. Use the following command to get the password of this user. Replace the `<cluster_name>` and `<namespace>` placeholders with your values:

```
kubectl get secret <cluster_name>-<user_name>-<cluster_name> -n
<namespace> --template='{{.data.password | base64decode}}{{"\n"}}'
```

3. Create a pod and start Percona Distribution for PostgreSQL inside. The following command will do this, naming the new Pod `pg-client`:

```
kubectl run -i --rm --tty pg-client --image=perconalab/percona-
distribution-postgresql:17.7-1 --restart=Never -- bash -il
```

Executing it may require some time to deploy the corresponding Pod.

4. Run a container with `psql` tool and connect its console output to your terminal. The following command will connect you as a `cluster1` user to a `cluster1` database via the PostgreSQL interactive terminal.

```
[postgres@pg-client /]$ PGPASSWORD='pguser_password' psql -h cluster1-
pgbouncer.postgres-operator.svc -p 5432 -U cluster1 cluster1
```

Sample output

```
psql (17.7-1)
SSL connection (protocol: TLSv1.3, cipher: TLS_AES_256_GCM_SHA384, bits: 256,
compression: off)
Type "help" for help.
pgdb=>
```

Delete the cluster

If you need to delete the Operator and PostgreSQL cluster (for example, to clean up the testing deployment before adopting it for production use), check this HowTo.

If you no longer need the Kubernetes cluster in Minikube, the following are the steps to remove it.

1. Stop the Minikube cluster:

```
minikube stop
```

2. Delete the cluster

```
minikube delete
```

This command deletes the virtual machines, and removes all associated files.

Install Percona Distribution for PostgreSQL cluster using Everest

Percona Everest is an open source cloud-native database platform that helps developers deploy code faster, scale deployments rapidly, and reduce database administration overhead while regaining control over their data, database configuration, and DBaaS costs.

It automates day-one and day-two database operations for open source databases on Kubernetes clusters. Percona Everest provides API and Web GUI to launch databases with just a few clicks and scale them, do routine maintenance tasks, such as software updates, patch management, backups, and monitoring.

You can try it in action by Installing Percona Everest and managing your first cluster.

Install Percona Distribution for PostgreSQL on Google Kubernetes Engine (GKE)

Following steps help you install the Operator and use it to manage Percona Distribution for PostgreSQL with the Google Kubernetes Engine. The document assumes some experience with Google Kubernetes Engine (GKE). For more information on GKE, see the Kubernetes Engine Quickstart.

Prerequisites

All commands from this installation guide can be run either in the **Google Cloud shell** or in **your local shell**.

To use *Google Cloud shell*, you need nothing but a modern web browser.

If you would like to use *your local shell*, install the following:

1. gcloud. This tool is part of the Google Cloud SDK. To install it, select your operating system on the official Google Cloud SDK documentation page and then follow the instructions.
2. kubectl. This is the Kubernetes command-line tool you will use to manage and deploy applications. To install the tool, run the following command:

   ```
   gcloud auth login
   gcloud components install kubectl
   ```

Create and configure the GKE cluster

You can configure the settings using the `gcloud` tool. You can run it either in the Cloud Shell or in your local shell (if you have installed Google Cloud SDK locally on the previous step). The following command creates a cluster named `cluster-1`:

```
gcloud container clusters create cluster-1 --project <project ID> --zone us-
central1-a --cluster-version 1.33 --machine-type n1-standard-4 --num-nodes=3
```

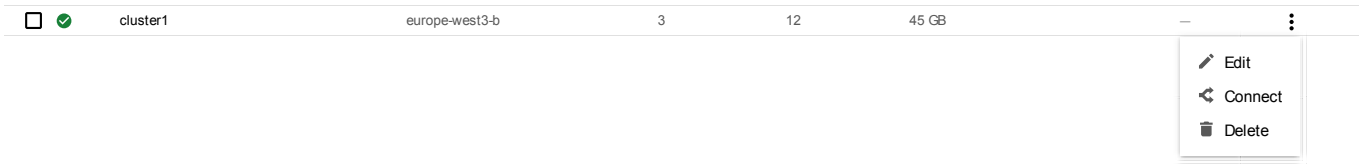
Note

You must edit the above command and other command-line statements to replace the `<project ID>` placeholder with your project ID (see available projects with `gcloud projects list` command). You may also be required to edit the *zone location*, which is set to `us-central1` in the above example. Other parameters specify that we are creating a cluster with 3 nodes and with machine type of 4 vCPUs.

You may wait a few minutes for the cluster to be generated.

When the process is over, you can see it listed in the Google Cloud console

Select *Kubernetes Engine* → *Clusters* in the left menu panel:



Now you should configure the command-line access to your newly created cluster to make `kubectl` be able to use it.

In the Google Cloud Console, select your cluster and then click the *Connect* shown on the above image. You will see the connect statement which configures the command-line access. After you have edited the statement, you may run the command in your local shell:

```
gcloud container clusters get-credentials cluster-1 --zone us-central1-a --
project <project name>
```

Finally, use your Cloud Identity and Access Management (Cloud IAM) to control access to the cluster. The following command will give you the ability to create Roles and RoleBindings:

```
kubectl create clusterrolebinding cluster-admin-binding --clusterrole
cluster-admin --user $(gcloud config get-value core/account)
```

Expected output

```
clusterrolebinding.rbac.authorization.k8s.io/cluster-admin-binding created
```

Install the Operator and deploy your PostgreSQL cluster

1. First of all, use the following `git clone` command to download the correct branch of the percona-postgresql-operator repository:

```
git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
cd percona-postgresql-operator
```

2. Create the Kubernetes namespace for your cluster if needed (for example, let's name it `postgres-operator`):

```
kubectl create namespace postgres-operator
```

Expected output

```
namespace/postgres-operator was created
```

Note

To use different namespace, specify other name instead of `postgres-operator` in the above command, and modify the `-n postgres-operator` parameter with it in the following steps. You can also omit this parameter completely to deploy everything in the `default` namespace.

3. Deploy the Operator using the following command:

```
kubectl apply --server-side -f deploy/bundle.yaml -n postgres-operator
```

Expected output

```
customresourcedefinition.apiextensions.k8s.io/crunchybridgeclusters.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgbackups.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgclusters.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgrestores.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgupgrades.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/pgadmins.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/pgupgrades.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/postgresclusters.postgres-
operator.crunchydata.com serverside-applied
serviceaccount/percona-postgresql-operator serverside-applied
role.rbac.authorization.k8s.io/percona-postgresql-operator serverside-applied
rolebinding.rbac.authorization.k8s.io/service-account-percona-postgresql-operator
serverside-applied
deployment.apps/percona-postgresql-operator serverside-applied
```

As the result you will have the Operator Pod up and running.

4. Deploy Percona Distribution for PostgreSQL:

```
kubectl apply -f deploy/cr.yaml -n postgres-operator
```

Expected output

```
perconapgcluster.pgv2.percona.com/cluster1 created
```

The creation process may take some time. When the process is over your cluster will obtain the `ready` status. You can check it with the following command:

```
kubectl get pg -n postgres-operator
```

Expected output

```
NAME       ENDPOINT                            STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.default.svc      ready    3          3           30m
```

You can also track the creation process in Google Cloud console via the Object Browser

When the creation process is finished, it will look as follows:

Name	Status	Type	Pods	Namespace	Cluster
cluster1-backup-7hsq	OK	Job	0/1	pg-opertor	cluster1
cluster1-instance1-mntz	OK	Stateful Set	1/1	pg-opertor	cluster1
cluster1-pgbouncer	OK	Deployment	1/1	pg-opertor	cluster1
cluster1-repo-host	OK	Stateful Set	1/1	pg-opertor	cluster1
cluster1-repo1-full	OK	Cron Job	0/0	pg-opertor	cluster1
percona-postgresql-operator	OK	Deployment	1/1	pg-opertor	cluster1

Verifying the cluster operation

When creation process is over, `kubectl get pg -n <namespace>` command will show you the cluster status as `ready`, and you can try to connect to the cluster.

During the installation, the Operator has generated several secrets, including the one with password for default PostgreSQL user. This default user has the same login name as the cluster name.

1. Use `kubectl get secrets` command to see the list of Secrets objects. The Secrets object you are interested in is named as `<cluster_name>-pguser-<cluster_name>` (substitute `<cluster_name>` with the name of your Percona Distribution for PostgreSQL Cluster). The default variant will be `cluster1-pguser-cluster1`.

2. Use the following command to get the password of this user. Replace the `<cluster_name>` and `<namespace>` placeholders with your values:

```
kubectl get secret <cluster_name>-<user_name>-<cluster_name> -n
<namespace> --template='{{.data.password | base64decode}}{{"\n"}}'
```

3. Create a pod and start Percona Distribution for PostgreSQL inside. The following command will do this, naming the new Pod `pg-client`:

```
kubectl run -i --rm --tty pg-client --image=perconalab/percona-
distribution-postgresql:17.7-1 --restart=Never -- bash -il
```

Executing it may require some time to deploy the corresponding Pod.

4. Run a container with `psql` tool and connect its console output to your terminal. The following command will connect you as a `cluster1` user to a `cluster1` database via the PostgreSQL interactive terminal.

```
[postgres@pg-client /]$ PGPASSWORD='pguser_password' psql -h cluster1-
pgbouncer.postgres-operator.svc -p 5432 -U cluster1 cluster1
```

Sample output

```
psql (17.7-1)
SSL connection (protocol: TLSv1.3, cipher: TLS_AES_256_GCM_SHA384, bits: 256,
compression: off)
Type "help" for help.
pgdb=>
```

Removing the cluster

If you need to delete the Operator and PostgreSQL cluster (for example, to clean up the testing deployment before adopting it for production use), check this HowTo.

Also, there are several ways that you can delete your Kubernetes cluster in GKE.

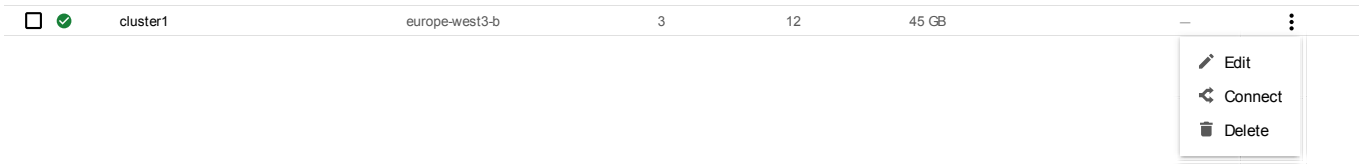
You can clean up the cluster with the `gcloud` command as follows:

```
gcloud container clusters delete <cluster name> --zone us-central1-a --
project <project ID>
```

The return statement requests your confirmation of the deletion. Type `y` to confirm.

Also, you can delete your cluster via the Google Cloud console

Just click the `Delete` popup menu item in the clusters list:



The cluster deletion may take time.

Warning

After deleting the cluster, all data stored in it will be lost!

Install Percona Distribution for PostgreSQL on Amazon Elastic Kubernetes Service (EKS)

This guide shows you how to deploy Percona Operator for PostgreSQL on Amazon Elastic Kubernetes Service (EKS). The document assumes some experience with the platform. For more information on the EKS, see the Amazon EKS official documentation.

Prerequisites

Software installation

The following tools are used in this guide and therefore should be preinstalled:

1. **AWS Command Line Interface (AWS CLI)** for interacting with the different parts of AWS. You can install it following the official installation instructions for your system.
2. **eksctl** to simplify cluster creation on EKS. It can be installed along its installation notes on GitHub.
3. **kubectl** to manage and deploy applications on Kubernetes. Install it following the official installation instructions.

Also, you need to configure AWS CLI with your credentials according to the official guide.

Creating the EKS cluster

1. To create your cluster, you will need the following data:
   - name of your EKS cluster,
   - AWS region in which you wish to deploy your cluster,
   - the amount of nodes you would like tho have,
   - the desired ratio between on-demand and spot instances in the total number of nodes.

> **Note**
>
> spot instances are not recommended for production environment, but may be useful e.g. for testing purposes.

After you have settled all the needed details, create your EKS cluster following the official cluster creation instructions.

2. After you have created the EKS cluster, you also need to install the Amazon EBS CSI driver on your cluster. See the official documentation on adding it as an Amazon EKS add-on.

> **Note**
>
> CSI driver is needed for the Operator to work properly, and is not included by default starting from the Amazon EKS version 1.22. Therefore servers with existing EKS cluster based on the version 1.22 or earlier need to install CSI driver before updating the EKS cluster to 1.23 or above.

Install the Operator and Percona Distribution for PostgreSQL

The following steps are needed to deploy the Operator and Percona Distribution for PostgreSQL in your Kubernetes environment:

1. Create the Kubernetes namespace for your cluster if needed (for example, let's name it `postgres-operator`):

```
kubectl create namespace postgres-operator
```

> **Expected output**
>
> ```
> namespace/postgres-operator was created
> ```

Note

To use different namespace, specify other name instead of `postgres-operator` in the above command, and modify the `-n postgres-operator` parameter with it in the following two steps. You can also omit this parameter completely to deploy everything in the `default` namespace.

2. Deploy the Operator using the following command:

```
kubectl apply --server-side -f
https://raw.githubusercontent.com/percona/percona-postgresql-
operator/v2.8.1/deploy/bundle.yaml -n postgres-operator
```

Expected output

```
customresourcedefinition.apiextensions.k8s.io/crunchybridgeclusters.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgbackups.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgclusters.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgrestores.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgupgrades.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/pgadmins.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/pgupgrades.postgres-
operator.crunchydata.com serverside-applied
customresourcedefinition.apiextensions.k8s.io/postgresclusters.postgres-
operator.crunchydata.com serverside-applied
serviceaccount/percona-postgresql-operator serverside-applied
role.rbac.authorization.k8s.io/percona-postgresql-operator serverside-applied
rolebinding.rbac.authorization.k8s.io/service-account-percona-postgresql-operator
serverside-applied
deployment.apps/percona-postgresql-operator serverside-applied
```

As the result you will have the Operator Pod up and running.

3. The operator has been started, and you can deploy your Percona Distribution for PostgreSQL cluster:

```
kubectl apply -f https://raw.githubusercontent.com/percona/percona-
postgresql-operator/v2.8.1/deploy/cr.yaml -n postgres-operator
```

Expected output

```
perconapgcluster.pgv2.percona.com/cluster1 created
```

Note

This deploys default Percona Distribution for PostgreSQL configuration. Please see deploy/cr.yaml and Custom Resource Options for the configuration options. You can clone the repository with all manifests and source code by executing the following command:

```
git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
```

After editing the needed options, apply your modified `deploy/cr.yaml` file as follows:

```
kubectl apply -f deploy/cr.yaml -n postgres-operator
```

The creation process may take some time. When the process is over your cluster will obtain the `ready` status. You can check it with the following command:

```
kubectl get pg
```

Expected output

```
NAME       ENDPOINT                          STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.default.svc    ready    3          3           30m
```

Verifying the cluster operation

When creation process is over, `kubectl get pg` command will show you the cluster status as `ready`, and you can try to connect to the cluster.

During the installation, the Operator has generated several secrets, including the one with password for default PostgreSQL user. This default user has the same login name as the cluster name.

1. Use `kubectl get secrets` command to see the list of Secrets objects. The Secrets object you are interested in is named as `<cluster_name>-pguser-<cluster_name>` (substitute `<cluster_name>` with the name of your Percona Distribution for PostgreSQL Cluster). The default variant will be `cluster1-pguser-cluster1`.

2. Use the following command to get the password of this user. Replace the `<cluster_name>` and `<namespace>` placeholders with your values:

   ```
   kubectl get secret <cluster_name>-<user_name>-<cluster_name> -n
   <namespace> --template='{{.data.password | base64decode}}{{"\n"}}'
   ```

3. Create a pod and start Percona Distribution for PostgreSQL inside. The following command will do this, naming the new Pod `pg-client`:

   ```
   kubectl run -i --rm --tty pg-client --image=perconalab/percona-
   distribution-postgresql:17.7-1 --restart=Never -- bash -il
   ```

   Executing it may require some time to deploy the corresponding Pod.

4. Run a container with `psql` tool and connect its console output to your terminal. The following command will connect you as a `cluster1` user to a `cluster1` database via the PostgreSQL interactive terminal.

   ```
   [postgres@pg-client /]$ PGPASSWORD='pguser_password' psql -h cluster1-
   pgbouncer.postgres-operator.svc -p 5432 -U cluster1 cluster1
   ```

   Sample output

   ```
   psql (17.7-1)
   SSL connection (protocol: TLSv1.3, cipher: TLS_AES_256_GCM_SHA384, bits: 256,
   compression: off)
   Type "help" for help.
   pgdb=>
   ```

Removing the cluster

If you need to delete the Operator and PostgreSQL cluster (for example, to clean up the testing deployment before adopting it for production use), check this HowTo.

To delete your Kubernetes cluster in EKS, you will need the following data:

- name of your EKS cluster,
- AWS region in which you have deployed your cluster.

You can clean up the cluster with the `eksctl` command as follows (with real names instead of `<region>` and `<cluster name>` placeholders):

```
eksctl delete cluster --region=<region> --name="<cluster name>"
```

The cluster deletion may take time.

Warning

After deleting the cluster, all data stored in it will be lost!

Install Install Percona Distribution for PostgreSQL on Azure Kubernetes Service (AKS)

This guide shows you how to deploy Percona Operator for PostgreSQL on Microsoft Azure Kubernetes Service (AKS). The document assumes some experience with the platform. For more information on the AKS, see the Microsoft AKS official documentation.

Prerequisites

The following tools are used in this guide and therefore should be preinstalled:

1. **Azure Command Line Interface (Azure CLI)** for interacting with the different parts of AKS. You can install it following the official installation instructions for your system.
2. **kubectl** to manage and deploy applications on Kubernetes. Install it following the official installation instructions.

Also, you need to sign in with Azure CLI using your credentials according to the official guide.

Create and configure the AKS cluster

To create your Kubernetes cluster, you will need the following data:

- name of your AKS cluster,
- an Azure resource group, in which resources of your cluster will be deployed and managed.
- the amount of nodes you would like tho have.

You can create your cluster via command line using `az aks create` command. The following command will create a 3-node cluster named `cluster1` within some already existing resource group named `my-resource-group`:

```
az aks create --resource-group my-resource-group --name  cluster1 --enable-
managed-identity --node-count 3 --node-vm-size Standard_B4ms --node-osdisk-
size 30 --network-plugin kubenet  --generate-ssh-keys --outbound-type
loadbalancer
```

Other parameters in the above example specify that we are creating a cluster with machine type of Standard_B4ms and OS disk size reduced to 30 GiB. You can see detailed information about cluster creation options in the AKS official documentation.

You may wait a few minutes for the cluster to be generated.

Now you should configure the command-line access to your newly created cluster to make `kubectl` be able to use it.

```
az aks get-credentials --resource-group my-resource-group --name  cluster1
```

Install the Operator and deploy your PostgreSQL cluster

1. Create the Kubernetes namespace for your cluster. It is a good practice to isolate workloads in Kubernetes by installing the Operator in a custom namespace. For example, let's name it `postgres-operator`:

   ```
   kubectl create namespace postgres-operator
   ```

   Expected output

   ```
   namespace/postgres-operator was created
   ```

   We will use this namespace further on in this document. If you used another name, make sure to replace it in the following commands.

2. Deploy the Operatorusing the following command:

   ```
   kubectl apply --server-side -f
   https://raw.githubusercontent.com/percona/percona-postgresql-
   operator/v2.8.1/deploy/bundle.yaml -n postgres-operator
   ```

Expected output

```
customresourcedefinition.apiextensions.k8s.io/perconapgbackups.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgclusters.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/perconapgrestores.pgv2.percona.com
serverside-applied
customresourcedefinition.apiextensions.k8s.io/postgresclusters.postgres-
operator.crunchydata.com serverside-applied
serviceaccount/percona-postgresql-operator serverside-applied
role.rbac.authorization.k8s.io/percona-postgresql-operator serverside-applied
rolebinding.rbac.authorization.k8s.io/service-account-percona-postgresql-operator
serverside-applied
deployment.apps/percona-postgresql-operator serverside-applied
```

At this point, the Operator Pod is up and running.

3. The operator has been started, and you can deploy Percona Distribution for PostgreSQL:

```
kubectl apply -f https://raw.githubusercontent.com/percona/percona-
postgresql-operator/v2.8.1/deploy/cr.yaml -n postgres-operator
```

Expected output

```
perconapgcluster.pgv2.percona.com/cluster1 created
```

Note

This deploys default Percona Distribution for PostgreSQL configuration. Please see deploy/cr.yaml and Custom Resource Options for the configuration options. You can clone the repository with all manifests and source code by executing the following command:

```
git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
```

After editing the needed options, apply your modified `deploy/cr.yaml` file as follows:

```
kubectl apply -f deploy/cr.yaml -n postgres-operator
```

The creation process may take some time. When the process is over your cluster will obtain the `ready` status. You can check it with the following command:

```
kubectl get pg
```

Expected output

```
NAME       ENDPOINT                          STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.default.svc    ready    3          3           30m
```

Verifying the cluster operation

It may take ten minutes to get the cluster started. When `kubectl get pg` command finally shows you the cluster status as `ready`, you can try to connect to the cluster.

During the installation, the Operator has generated several secrets, including the one with password for default PostgreSQL user. This default user has the same login name as the cluster name.

1. Use `kubectl get secrets` command to see the list of Secrets objects. The Secrets object you are interested in is named as `<cluster_name>-pguser-<cluster_name>` (substitute `<cluster_name>` with the name of your Percona Distribution for PostgreSQL Cluster). The default variant will be `cluster1-pguser-cluster1`.

2. Use the following command to get the password of this user. Replace the `<cluster_name>` and `<namespace>` placeholders with your values:

   ```
   kubectl get secret <cluster_name>-<user_name>-<cluster_name> -n
   <namespace> --template='{{.data.password | base64decode}}{{"\n"}}'
   ```

3. Create a pod and start Percona Distribution for PostgreSQL inside. The following command will do this, naming the new Pod `pg-client`:

   ```
   kubectl run -i --rm --tty pg-client --image=perconalab/percona-
   distribution-postgresql:17.7-1 --restart=Never -- bash -il
   ```

   Executing it may require some time to deploy the corresponding Pod.

4. Run a container with `psql` tool and connect its console output to your terminal. The following command will connect you as a `cluster1` user to a `cluster1` database via the PostgreSQL interactive terminal.

```
[postgres@pg-client /]$ PGPASSWORD='pguser_password' psql -h cluster1-
pgbouncer.postgres-operator.svc -p 5432 -U cluster1 cluster1
```

Sample output

```
psql (17.7-1)
SSL connection (protocol: TLSv1.3, cipher: TLS_AES_256_GCM_SHA384, bits: 256,
compression: off)
Type "help" for help.
pgdb=>
```

Removing the AKS cluster

To delete your cluster, you will need the following data:

- name of your AKS cluster,
- AWS region in which you have deployed your cluster.

You can clean up the cluster with the `az aks delete` command as follows (with real names instead of `<resource group>` and `<cluster name>` placeholders):

```
az aks delete --name <cluster name> --resource-group <resource group> --yes -
-no-wait
```

It may take ten minutes to get the cluster actually deleted after executing this command.

Warning

After deleting the cluster, all data stored in it will be lost!

Install Percona Distribution for PostgreSQL on OpenShift

Percona Operator for PostgreSQL is a Red Hat Certified Operator. This means that Percona Operator is portable across hybrid clouds and fully supports the Red Hat OpenShift lifecycle.

Installing Percona Distribution for PostgreSQL on OpenShift includes two steps:

- Installing the Percona Operator for PostgreSQL,
- Install Percona Distribution for PostgreSQL using the Operator.

Install the Operator

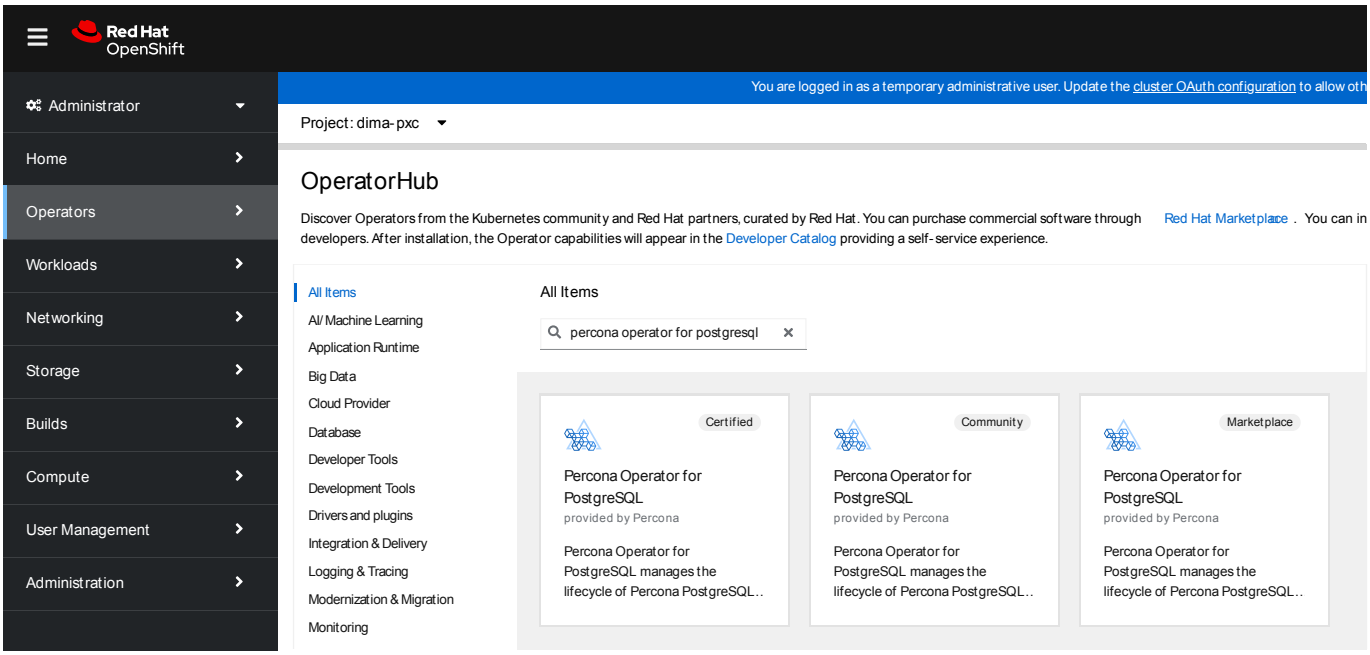
You can install Percona Operator for PostgreSQL on OpenShift using the web interface (the Operator Lifecycle Manager), or using the command line interface.

Install the Operator via the Operator Lifecycle Manager (OLM)

Operator Lifecycle Manager (OLM) is a part of the Operator Framework that allows you to install, update, and manage the Operators lifecycle on the OpenShift platform.

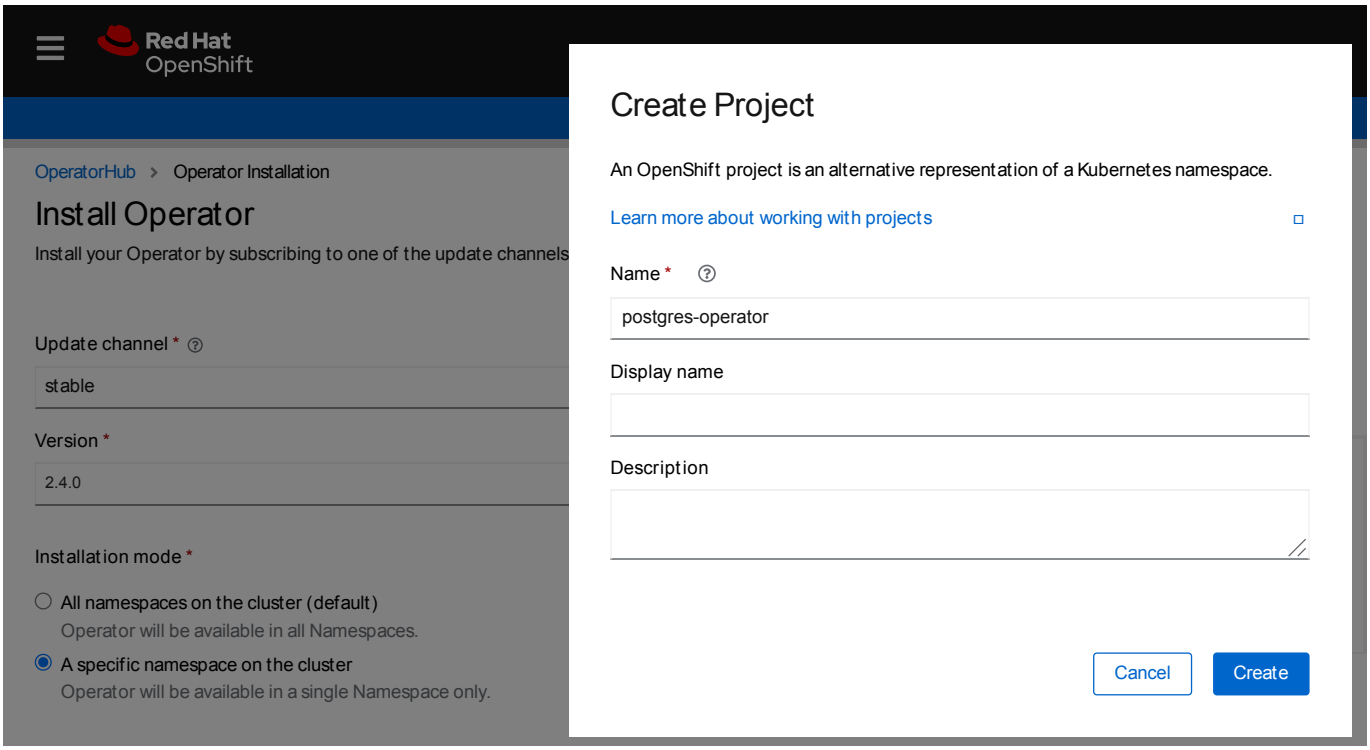
Following steps will allow you to deploy the Operator and PostgreSQL cluster on your OLM installation:

1. Login to the OLM and click the needed Operator on the OperatorHub page:



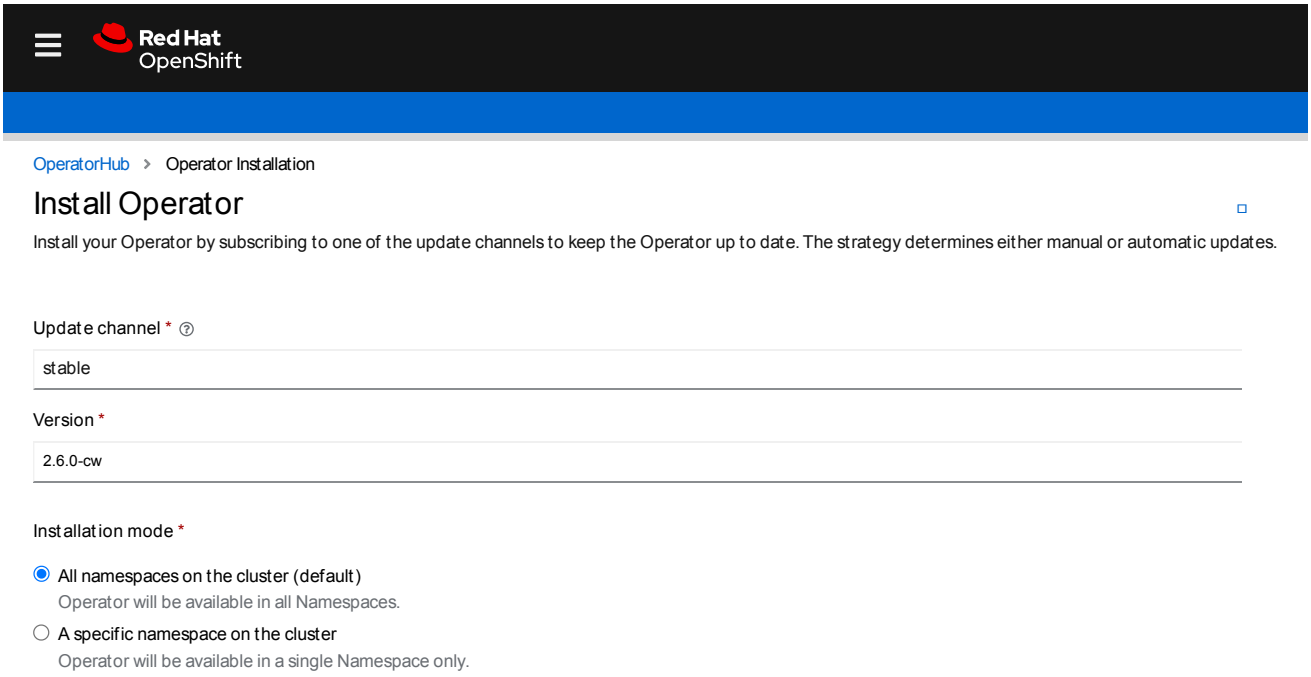
Then click “Continue”, and “Install”.

2. A new page will allow you to choose the Operator version and the Namespace / OpenShift project you would like to install the Operator into.



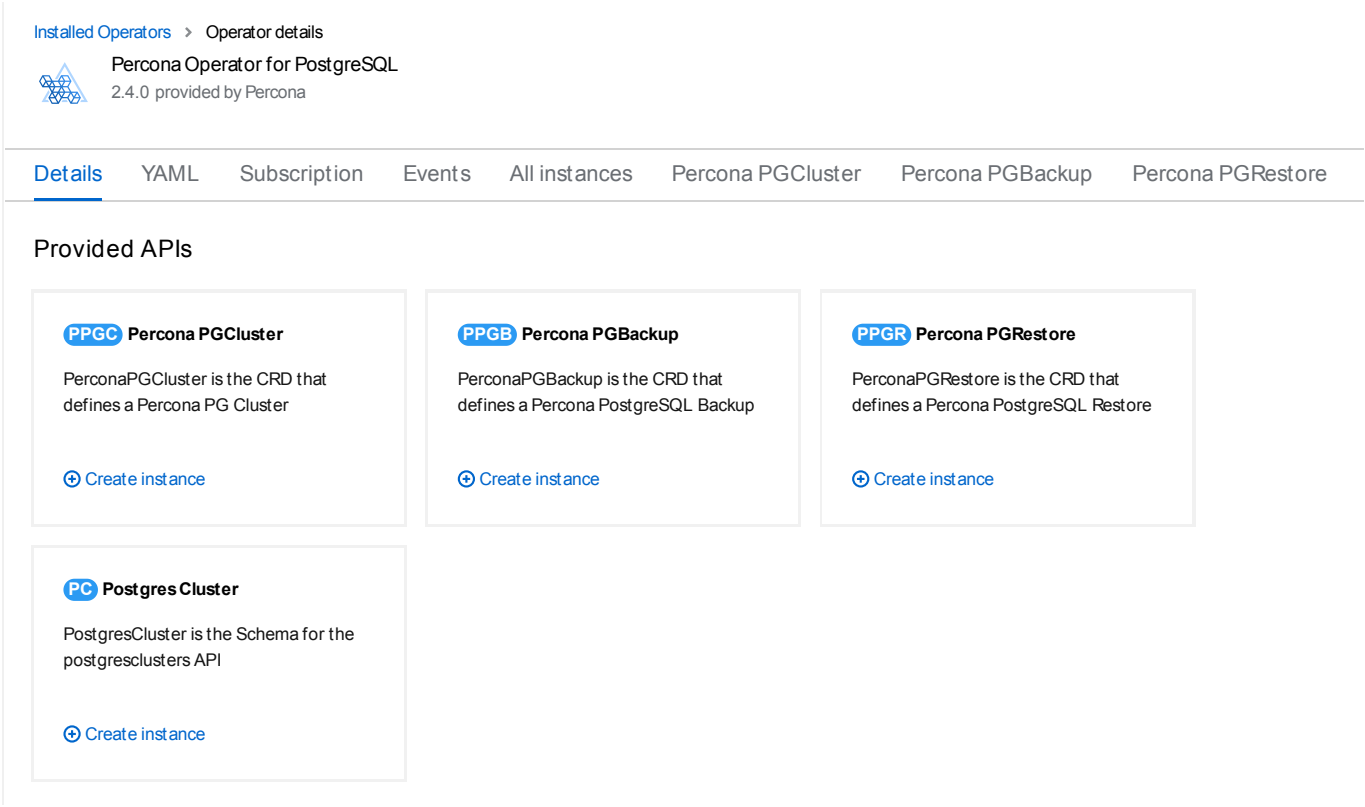
Note

If you are going to install the Operator in multi-namespace (cluster-wide) mode, please choose values with `-cw` suffix for the update channel and version, and select the “All namespaces on the cluster” radio button for the installation mode instead of choosing a specific Namespace:



Click “Install” button to actually install the Operator.

3. When the installation finishes, you can deploy PostgreSQL cluster. In the “Operator Details” you will see Provided APIs (Custom Resources, available for installation). Click “Create instance” for the `PerconaPGCluster` Custom Resource.



You will be able to edit manifest to set needed Custom Resource options, and then click “Create” button to deploy your database cluster.

Install the Operator via the command-line interface

1. First of all, clone the percona-postgresql-operator repository:

```
git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
cd percona-postgresql-operator
```

> **Note**
>
> It is crucial to specify the right branch with `-b` option while cloning the code on this step. Please be careful.

2. The Custom Resource Definition for Percona Distribution for PostgreSQL should be created from the `deploy/crd.yaml` file. Custom Resource Definition extends the standard set of resources which OpenShift “knows” about with the new items (in our case ones which are the core of the Operator). Apply it as follows:

```
oc apply --server-side -f deploy/crd.yaml
```

This step should be done only once; it does not need to be repeated with any other Operator deployments.

3. Create the OpenShift namespace for your cluster if needed (for example, let's name it `postgres-operator`):

```
oc create namespace postgres-operator
```

> **Note**
>
> To use different namespace, specify other name instead of `postgres-operator` in the above command, and modify the `-n postgres-operator` parameter with it in the following two steps. You can also omit this parameter completely to deploy everything in the `default` namespace.

4. The role-based access control (RBAC) for Percona Distribution for PostgreSQL is configured with the `deploy/rbac.yaml` file. Role-based access is based on defined roles and the available actions which correspond to each role. The role and actions are defined for Kubernetes resources in the yaml file. Further details about users and roles can be found in specific OpenShift documentation)

```
oc apply -f deploy/rbac.yaml -n postgres-operator
```

> **Note**
>
> Setting RBAC requires your user to have cluster-admin role privileges. For example, those using Google OpenShift Engine can grant user needed privileges with the following command:
>
> ```
> $ oc create clusterrolebinding cluster-admin-binding --clusterrole=cluster-admin --
> user=$(gcloud config get-value core/account)
> ```

5. If you are going to use the operator with anyuid security context constraint please execute the following command:

```
sed -i '/disable_auto_failover: "false"/a \ \ \ \ disable_fsgroup:
"false"' deploy/operator.yaml
```

6. Start the Operator within OpenShift:

```
oc apply -f deploy/operator.yaml -n postgres-operator
```

Optionally, you can add PostgreSQL Users secrets and TLS certificates to OpenShift. If you don't, the Operator will create the needed users and certificates automatically, when you create the database cluster. You can see documentation on Users and TLS certificates if still want to create them yourself.

Note

You can simplify the Operator installation by applying a single `deploy/bundle.yaml` file instead of running commands from the steps 2 and 4:

```
oc apply -f deploy/bundle.yaml
```

This will automatically create Custom Resource Definition, set up role-based access control and install the Operator as one single action.

7. After the Operator is started Percona Distribution for PostgreSQL cluster can be created at any time with the following command:

```
oc apply -f deploy/cr.yaml -n postgres-operator
```

Creation process will take some time. The process is over when both Operator and replica set Pods have reached their Running status:

```
oc get pg -n postgres-operator
```

Expected output

```
NAME       ENDPOINT                                 STATUS   POSTGRES   PGBOUNCER
AGE
cluster1   cluster1-pgbouncer.postgres-operator.svc   ready    3          3
143m
```

Verifying the cluster operation

When creation process is over, `oc get pg` command will show you the cluster status as `ready`, and you can try to connect to the cluster.

During the installation, the Operator has generated several secrets, including the one with password for default PostgreSQL user. This default user has the same login name as the cluster name.

1. Use `oc get secrets` command to see the list of Secrets objects. The Secrets object you are interested in is named as `<cluster_name>-pguser-<cluster_name>` (substitute `<cluster_name>` with the name of your Percona Distribution for PostgreSQL Cluster). The default variant will be `cluster1-pguser-cluster1`.

2. Use the following command to get the password of this user. Replace the `<cluster_name>` and `<namespace>` placeholders with your values:

   ```
   oc get secret <cluster_name>-<user_name>-<cluster_name> -n <namespace> --
   template='{{.data.password | base64decode}}{{"\n"}}'
   ```

3. Create a pod and start Percona Distribution for PostgreSQL inside. The following command will do this, naming the new Pod `pg-client`:

   ```
   oc run -i --rm --tty pg-client --image=perconalab/percona-distribution-
   postgresql:17.7-1 --restart=Never -- bash -il
   ```

   Executing it may require some time to deploy the corresponding Pod.

4. Run a container with `psql` tool and connect its console output to your terminal. The following command will connect you as a `cluster1` user to a `cluster1` database via the PostgreSQL interactive terminal.

   ```
   [postgres@pg-client /]$ PGPASSWORD='pguser_password' psql -h cluster1-
   pgbouncer.postgres-operator.svc -p 5432 -U cluster1 cluster1
   ```

   Sample output

   ```
   psql (17.7-1)
   SSL connection (protocol: TLSv1.3, cipher: TLS_AES_256_GCM_SHA384, bits: 256,
   compression: off)
   Type "help" for help.
   pgdb=>
   ```

Install Percona Distribution for PostgreSQL on Kubernetes

Following steps will allow you to install the Operator and use it to manage Percona Distribution for PostgreSQL in a Kubernetes-based environment.

1. First of all, clone the percona-postgresql-operator repository:

```
git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
cd percona-postgresql-operator
```

> **Note**
>
> It is crucial to specify the right branch with `-b` option while cloning the code on this step. Please be careful.

2. The Custom Resource Definition for Percona Distribution for PostgreSQL should be created from the `deploy/crd.yaml` file. Custom Resource Definition extends the standard set of resources which Kubernetes "knows" about with the new items (in our case ones which are the core of the Operator). Apply it as follows:

```
kubectl apply --server-side -f deploy/crd.yaml
```

This step should be done only once; it does not need to be repeated with any other Operator deployments.

3. Create the Kubernetes namespace for your cluster if needed (for example, let's name it `postgres-operator`):

```
kubectl create namespace postgres-operator
```

> **Note**
>
> To use a different namespace, specify another name instead of `postgres-operator` in the above command, and modify the `-n postgres-operator` parameter with it in the following two steps. You can also omit this parameter completely to deploy everything in the `default` namespace.

4. The role-based access control (RBAC) for Percona Distribution for PostgreSQL is configured with the `deploy/rbac.yaml` file. Role-based access is based on defined roles and the available actions which correspond to each role. The role and actions are defined for Kubernetes resources in the yaml file. Further details about users and roles can be found in Kubernetes documentation.

```
kubectl apply -f deploy/rbac.yaml -n postgres-operator
```

> **Note**
>
> Setting RBAC requires your user to have cluster-admin role privileges. For example, those using Google Kubernetes Engine can grant user needed privileges with the following command:
>
> ```
> $ kubectl create clusterrolebinding cluster-admin-binding --clusterrole=cluster-admin --user=$(gcloud config get-value core/account)
> ```

5. Start the Operator within Kubernetes:

```
kubectl apply -f deploy/operator.yaml -n postgres-operator
```

Optionally, you can add PostgreSQL Users secrets and TLS certificates to Kubernetes. If you don't, the Operator will create the needed users and certificates automatically, when you create the database cluster. You can see documentation on Users and TLS certificates if still want to create them yourself.

6. After the Operator is started Percona Distribution for PostgreSQL cluster can be created at any time with the following command:

```
kubectl apply -f deploy/cr.yaml -n postgres-operator
```

The creation process may take some time. When the process is over your cluster will obtain the `ready` status. You can check it with the following command:

```
kubectl get pg -n postgres-operator
```

Expected output

```
NAME       ENDPOINT                          STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.default.svc    ready    3          3           30m
```

Verifying the cluster operation

When creation process is over, the output of the `kubectl get pg` command shows the cluster status as `ready`. You can now try to connect to the cluster.

During the installation, the Operator has generated several secrets, including the one with password for default PostgreSQL user. This default user has the same login name as the cluster name.

1. Use `kubectl get secrets` command to see the list of Secrets objects. The Secrets object you are interested in is named as `<cluster_name>-pguser-<cluster_name>` (substitute `<cluster_name>` with the name of your Percona Distribution for PostgreSQL Cluster). The default variant will be `cluster1-pguser-cluster1`.

2. Use the following command to get the password of this user. Replace the `<cluster_name>` and `<namespace>` placeholders with your values:

   ```
   kubectl get secret <cluster_name>-<user_name>-<cluster_name> -n
   <namespace> --template='{{.data.password | base64decode}}{{"\n"}}'
   ```

3. Create a pod and start Percona Distribution for PostgreSQL inside. The following command will do this, naming the new Pod `pg-client`:

   ```
   kubectl run -i --rm --tty pg-client --image=perconalab/percona-
   distribution-postgresql:17.7-1 --restart=Never -- bash -il
   ```

   Executing it may require some time to deploy the corresponding Pod.

4. Run a container with `psql` tool and connect its console output to your terminal. The following command will connect you as a `cluster1` user to a `cluster1` database via the PostgreSQL interactive terminal.

```
[postgres@pg-client /]$ PGPASSWORD='pguser_password' psql -h cluster1-
pgbouncer.postgres-operator.svc -p 5432 -U cluster1 cluster1
```

Sample output

```
psql (17.7-1)
SSL connection (protocol: TLSv1.3, cipher: TLS_AES_256_GCM_SHA384, bits: 256,
compression: off)
Type "help" for help.
pgdb=>
```

Deleting the cluster

If you need to delete the cluster (for example, to clean up the testing deployment before adopting it for production use), check this HowTo.

Configuration

Users

The Percona Operator for PostgreSQL includes built-in functionality to simplify management of users and databases within your PostgreSQL cluster. By default, the Operator creates a single unprivileged user and the database that matches the cluster name.

However, many production workloads require more granular user access, separate databases for different applications, or restricted privileges for security and compliance. With the Operator, you can define custom users and manage their access to your database cluster resources:

This document explains how you can customize user and database management for your specific use case.

Understanding default user management

When you create a PostgreSQL cluster with the Operator and do not specify any additional users or databases, the Operator does the following:

1. Creates a database that matches the name of your PostgreSQL cluster.
2. Creates a schema for that database that matches the name of your PostgreSQL cluster.
3. Creates an unprivileged PostgreSQL user with the name of the cluster. This user has access to the database created in the previous step.
4. Creates a Secret with the login credentials and connection details for the PostgreSQL user from the previous step which is in relation to the database. The Secret is named `<clusterName>-pguser-<userName>` and contains the following information:
    - `user`: The name of the user account.
    - `password`: The password for the user account.
    - `dbname`: The name of the database that the user has access to by default.
    - `host`: The name of the host of the database. This references the Service of the primary PostgreSQL instance.
    - `port`: The port that the database is listening on.
    - `uri`: A PostgreSQL connection URI that provides all the information for logging into the PostgreSQL database via pgBouncer
    - `jdbc-uri`: A PostgreSQL JDBC connection URI that provides all the information for logging into the PostgreSQL database via the JDBC driver.

As an example, with the default PostgreSQL cluster name `cluster1`, the Operator creates the following:

- A database named `cluster1`.
- A schema named `cluster1` for the database `cluster1`
- A PostgreSQL user named `cluster1`.
- A Secret named `cluster1-pguser-cluster1` that contains the user credentials and connection information.

Custom users and databases

You can add and manage custom users and databases using the `spec.users` section in the Custom Resource. You can do this:

- at the cluster creation time
- at runtime.

Considerations

Here's what you need to know:

Adding custom users and databases:

- If you define custom users in `spec.users` during cluster creation, the Operator does **not** create any default users or databases (except for the `postgres` database). If you want additional databases, you must specify them explicitly.
- For each user added in `spec.users`, the Operator creates a Secret named `<clusterName>-pguser-<userName>` with that user's credentials. You can override this Secret name using the `spec.users.secretName` option.
  - If you do **not** specify any databases for a custom user, the resulting Secret will **not** include `dbname` or `uri` fields. This means the user will not have access to any database until one is assigned later.
  - If you include at least one database in `spec.users.databases` for the user, the Secret will include connection credentials for the **first** database in the list (`dbname` and `uri`).
- You can add a special `postgres` user as one of the custom users. This user is granted access to the `postgres` database, but its privileges cannot be changed.
- By default, the top-level `autoCreateUserSchema` option is set to `true`. This means each user

will have automatically-created schemas in all databases listed for this user under `users.databases`.

- By default, users without superuser privileges do not have access to the `public` schema. To allow a non-superuser to create and update tables in the `public` schema, set the `grantPublicSchemaAccess` option to `true`. This gives the user permission to create and update tables in the `public` schema of every database they own.
- Your custom superusers automatically have access to the `public` schema for their assigned databases.
- If multiple users are granted access to the `public` schema in the same database, each can only access tables they themselves have created. If you want one user to access tables created by another user, the table owner must explicitly grant privileges via PostgreSQL.

Behavior when removing or modifying users and databases:

- The Operator does **not** automatically drop users if you remove them from the Custom Resource, to prevent accidental data loss.
- Similarly, the Operator does **not** automatically drop databases when you remove them from the Custom Resource. (See how to actually drop a database here.)
- Role attributes (such as SUPERUSER) are not automatically removed if you delete them from the Custom Resource. You must specify the opposite attribute (e.g., `NOSUPERUSER`) to explicitly revoke privileges.

Creating a new user

Change `PerconaPGCluster` Custom Resource by editing your YAML manifest in the `deploy/cr.yaml` configuration file:

```
...
spec:
  users:
    - name: perconapg
```

After you apply such changes with the usual `kubectl apply -f deploy/cr.yaml` command, the Operator will create the new user as follows:

- The credentials of this user are populated in the `<clusterName>-pguser-perconapg` secret. There are no connection credentials.
- The user is unprivileged.

The following example shows how to create a new `pgtest` database and let `perconapg` user access it. The appropriate Custom Resource fragment will look as follows:

```
...
spec:
  users:
    - name: perconapg
      databases:
        - pgtest
```

If you inspect the `<clusterName>-pguser-perconapg` Secret after applying the changes, you will see `dbname` and `uri` options populated there, and the database `pgtest` is created in PostgreSQL as well.

Managing user passwords

Operator-generated passwords

The Operator generates a random password for each PostgreSQL user it creates. PostgreSQL allows almost any character in its passwords and the Operator generates passwords in ASCII format by default.

Your application may have stricter requirements to password creation. For example, if you need passwords without special characters, set the `spec.users.password.type` field for that user to `AlphaNumeric`.

To have the Operator generate a new password, remove the existing `password` field from the user Secret.

For example, to generate a new password for the user `cluster1` in the PostgreSQL cluster `cluster1` running in the `postgres-operator` namespace, use the following `kubectl patch` command:

```
kubectl patch secret -n postgres-operator cluster1-pguser-cluster1 -p
'{"data":{"password":""}}'
```

Replace the namespace and the secret name with your values to reuse this command.

Custom passwords

You may want a complete control over user passwords by setting a specific password for a PostgreSQL user instead of letting Percona Operator for PostgreSQL generate one for you. To do that, create a user Secret and specify the password within.

When you create a user Secret, the way you name it is important:

- If you specify a Secret name using the default naming convention that the Operator expects (`<clusterName>-pguser-<userName>`), the Operator will detect and use it automatically.
- If you use a custom name for your Secret, you must explicitly reference that Secret in the Custom Resource to let the Operator know about it.

The Operator looks for two fields in the Secret:

- `password`: the plaintext password.
- `verifier`: a hashed representation of the password using `SCRAM-SHA-256`.

When the `verifier` changes, the Operator updates the password inside the PostgreSQL cluster. This approach ensures the password is securely passed into the database.

You can set a custom password in these ways:

- You can provide a plaintext password in the `password` field and omit the verifier. The Operator will detect this and automatically generate a SCRAM verifier for your password.
- You can supply both the `password` and the `verifier` yourself. If both are present, the Operator will use them as-is and skip the generation step. Once the Secret contains both values, the Operator will make sure the credentials are correctly applied to PostgreSQL.

Here's how to set a custom password within a Secret with a custom name:

1. Export your namespace as an environment variable

   ```
   export NAMESPACE=postgres-operator
   ```

2. Create a Secrets object. For example, `cat-credentials`:

```
kubectl apply -n $NAMESPACE -f - <<EOF
apiVersion: v1
kind: Secret
metadata:
  name: cat-credentials
type: Opaque
data:
  password: $(echo -n 'mySuperStr0ngp@ssword' | base64)
EOF
```

Sample output

```
secret/cat-credentials created
```

3. Add a user and reference the Secret for them in the Custom Resource:

via cr.yaml

```
users:
 - name: cat
   databases:
     - zoo
   secretName: "cat-credentials"
   grantPublicSchemaAccess: true
```

Apply the configuration:

```
kubectl apply -f deploy/cr.yaml -n $NAMESPACE
```

via kubectl patch

To update a running cluster, use the `kubectl patch` command:

```
kubectl patch pg cluster1 -n $NAMESPACE --type=merge --patch '{
"spec": {
  "users": [
    {
      "name": "cat",
      "databases": ["zoo"],
      "secretName": "cat-credentials",
      "grantPublicSchemaAccess": true
     }
    ]
  }
}'
```

4. After you update the cluster, the Operator updates the Secret with the login credentials and connection information. View the Secret object to verify this with this command:

```
kubectl get secret cat-credentials -o yaml -n $NAMESPACE
```

5. Verify that the user is created by connecting to the database as your custom user.

Password rotation

If you want to rotate a user's password, just remove the old password in the corresponding Secret: the Operator will immediately generate a new password and save it to the appropriate Secret. You can remove the old password with the `kubectl patch secret` command:

```
kubectl patch secret <clusterName>-pguser-<userName> -p '{"data":
{"password":""}}'
```

In the same way you can update a password with your custom one for the user. Do it as follows:

```
kubectl patch secret <clusterName>-pguser-<userName> -p '{"stringData":
{"password":"<custom_password>", "verifier":""}}'
```

Adjusting privileges

You can set role privileges by using the standard role attributes that PostgreSQL provides and adding them to the `spec.users.options` subsection in the Custom Resource.

Grant privileges

The following example will make the `perconapg` a superuser. You can add the following to the spec in your `deploy/cr.yaml`:

```
...
spec:
  users:
    - name: perconapg
      databases:
        - pgtest
      options: "SUPERUSER"
```

Apply changes with the usual `kubectl apply -f deploy/cr.yaml` command.

If you want to add multiple privileges, you can use a space-separated list as follows:

```
...
spec:
  users:
    - name: perconapg
      databases:
        - pgtest
      options: "CREATEDB CREATEROLE"
```

Revoke privileges

To revoke the superuser privilege afterwards, apply the following configuration:

```
...
spec:
  users:
    - name: perconapg
      databases:
        - pgtest
      options: "NOSUPERUSER"
```

`postgres` User

By default, the Operator does not create the `postgres` user. You can create it by applying the following change to your Custom Resource:

```
...
spec:
  users:
    - name: postgres
```

This will create a Secret named `<clusterName>-pguser-postgres` that contains the credentials of the `postgres` user. The Operator creates a user `postgres` who can access the `postgres` database.

Deleting users and databases

The Operator does not delete users and databases automatically. After you remove the user from the Custom Resource, it will continue to exist in your cluster. To remove a user and all of its objects, as a superuser you will need to run `DROP OWNED` in each database the user has objects in, and `DROP ROLE` in your PostgreSQL cluster.

```
DROP OWNED BY perconapg;
DROP ROLE perconapg;
```

For databases, you should run the `DROP DATABASE` command as a superuser:

```
DROP DATABASE pgtest;
```

Superuser and pgBouncer

For security reasons we do not allow superusers to connect to cluster through pgBouncer by default. As a superuser, you can connect through the `primary` service. Read more about this service in exposure documentation.

Otherwise you can use the proxy.pgBouncer.exposeSuperusers Custom Resource option to enable superusers connection via pgBouncer.

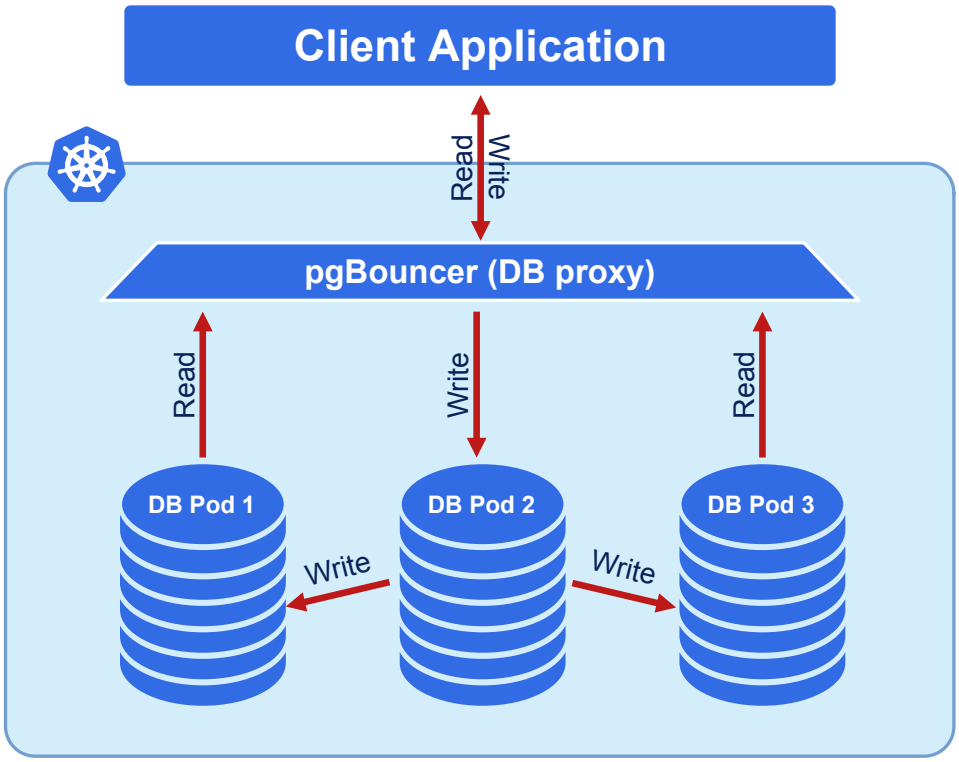
Exposing cluster

The Operator provides entry points for accessing the database by client applications. The database cluster is exposed with regular Kubernetes Service objects configured by the Operator.

This document describes the usage of Custom Resource manifest options to expose the clusters deployed with the Operator.

PgBouncer

We recommend exposing the cluster through PgBouncer, which is enabled by default.



You can disable pgBouncer by setting `proxy.pgBouncer.replicas` to 0.

The following example deploys two pgBouncer nodes exposed through a LoadBalancer Service object:

```
proxy:
  pgBouncer:
    replicas: 2
    image: docker.io/percona/percona-pgbouncer:1.25.0-1
    expose:
      type: LoadBalancer
```

The Service will be called `<clusterName>-pgbouncer`:

```
kubectl get service
```

Expected output

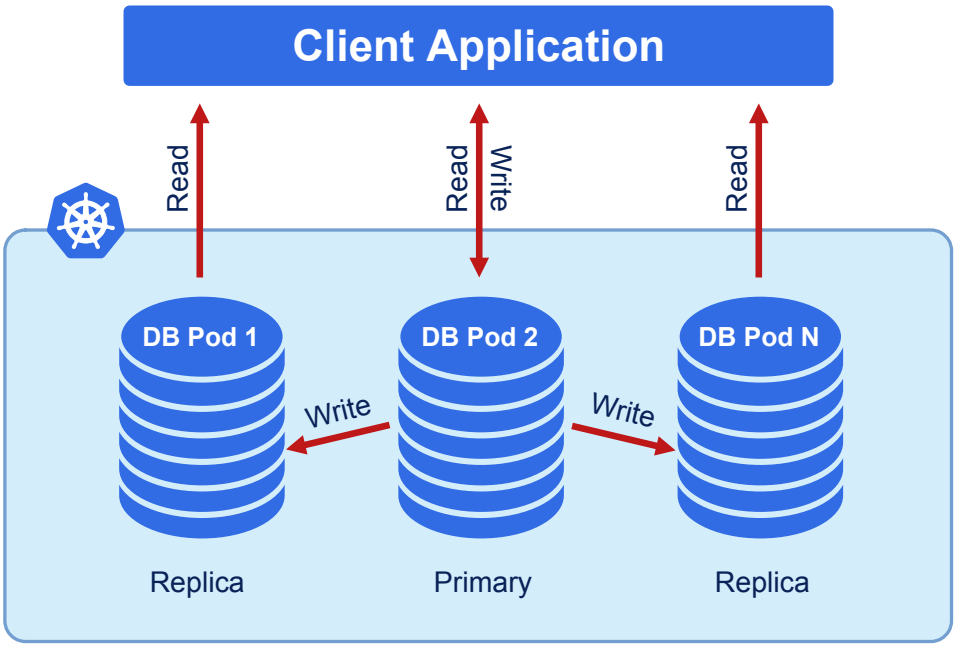
```
NAME                TYPE           CLUSTER-IP     EXTERNAL-IP      PORT(S)          AGE
...
cluster1-pgbouncer  LoadBalancer   10.88.8.48     34.133.38.186    5432:30601/TCP   20m
...
```

You can connect to the database using the External IP of the load balancer and port `5432`.

If your application runs inside the Kubernetes cluster as well, you might want to use the Cluster IP Service type in `proxy.pgBouncer.expose.type`, which is the default. In this case to connect to the database use the internal domain name - `cluster1-pgbouncer.<namespace>.svc.cluster.local`.

Exposing the cluster without `pgBouncer`

You can connect to the cluster without a proxy.



For that use `<clusterName>-ha` Service object:

```
kubectl get service
```

Expected output

```
NAME                TYPE        CLUSTER-IP    EXTERNAL-IP   PORT(S)    AGE
...
cluster1-ha         ClusterIP   10.88.8.121   <none>        5432/TCP   115s
...
cluster1-replicas   ClusterIP   10.88.8.115   <none>        5432/TCP   2m16s
```

The `cluster1-ha` service points to the active primary. In case of failover to the replica node, will change the endpoint automatically. Also, you can use `cluster1-replicas` service to make read requests to PostgreSQL replica instances.

To change the Service type, use `expose.type` in the Custom Resource manifest. For example, the following manifest will expose this service through a load balancer:

```
spec:
...
  expose:
    type: LoadBalancer
```

Changing PostgreSQL options

Despite the Operator's ability to configure PostgreSQL and the large number of Custom Resource options, there may be situations where you need to pass specific options directly to your cluster's PostgreSQL instances. For this purpose, you can use the PostgreSQL dynamic configuration method provided by Patroni. You can pass PostgreSQL options to Patroni through the Operator Custom Resource, updating it with `deploy/cr.yaml` configuration file).

Custom PostgreSQL configuration options should be included into the `patroni.dynamicConfiguration.postgresql.parameters` subsection as follows:

```
...
patroni:
  dynamicConfiguration:
    postgresql:
      parameters:
        max_parallel_workers: 2
        max_worker_processes: 2
        shared_buffers: 1GB
        work_mem: 2MB
```

Please note that configuration changes will be automatically applied to the running instances as soon as you apply Custom Resource changes in a usual way, running the `kubectl apply -f deploy/cr.yaml` command.

You can apply custom configuration in this way for both new and existing clusters.

Normally, options should be applied to PostgreSQL instances dynamically without restart, except the options with the postmaster context. Changing options which have `context=postmaster` will cause Patroni to initiate restart of all PostgreSQL instances, one by one. You can check the context of a specific option using the `SELECT name, context FROM pg_settings;` query to to see if the change should cause a restart or not.

Note

The Operator passes options to Patroni without validation, so there is a theoretical possibility of the cluster malfunction caused by wrongly configured PostgreSQL instances. Also, this configuration method is used for PostgreSQL options only and cannot be applied to change other Patroni dynamic configuration options. It means that options in the `parameters` subsection under `patroni.dynamicConfiguration.postgresql` will be applied, and everything else in `patroni.dynamicConfiguration.postgresql` will be ignored.

Using host-based authentication (pg_hba)

PostgreSQL Host-Based Authentication (pg_hba) allows controlling access to the PostgreSQL database based on the IP address or the host name of the connecting host. You can configure `pg_hba` through the Custom Resource `patroni.dynamicConfiguration.postgresql.pg_hba` subsection as follows:

```
...
patroni:
  dynamicConfiguration:
    postgresql:
      pg_hba:
      - host    all all 0.0.0.0/0 md5
```

As you may guess, this example allows all hosts to connect to any database with MD5 password-based authentication.

Obviously, you can connect both `dynamicConfiguration.postgresql.parameters` and `dynamicConfiguration.postgresql.pg_hba` subsections:

```
...
patroni:
  dynamicConfiguration:
    postgresql:
      parameters:
        max_parallel_workers: 2
        max_worker_processes: 2
        shared_buffers: 1GB
        work_mem: 2MB
      pg_hba:
      - local   all all trust
      - host    all all 0.0.0.0/0 md5
      - host    all all ::1/128   md5
      - host    all mytest 123.123.123.123/32 reject
```

The changes will be applied after you update Custom Resource in a usual way:

```
kubectl apply -f deploy/cr.yaml
```

Binding Percona Distribution for PostgreSQL components to specific Kubernetes/OpenShift Nodes

The operator does good job automatically assigning new Pods to nodes with sufficient resources to achieve balanced distribution across the cluster. Still there are situations when it is worth to ensure that pods will land on specific nodes: for example, to get speed advantages of the SSD equipped machine, or to reduce network costs choosing nodes in a same availability zone.

Appropriate sections of the deploy/cr.yaml file (such as `proxy.pgBouncer`) contain keys which can be used to do this, depending on what is the best for a particular situation.

Affinity and anti-affinity

Affinity makes Pod eligible (or not eligible - so called “anti-affinity”) to be scheduled on the node which already has Pods with specific labels, or has specific labels itself (so called “Node affinity”). Particularly, Pod anti-affinity is good to reduce costs making sure several Pods with intensive data exchange will occupy the same availability zone or even the same node - or, on the contrary, to make them land on different nodes or even different availability zones for the high availability and balancing purposes. Node affinity is useful to assign PostgreSQL instances to specific Kubernetes Nodes (ones with specific hardware, zone, etc.).

Pod anti-affinity is controlled by the `affinity.podAntiAffinity` subsection, which can be put into `proxy.pgBouncer` and `backups.pgbackrest.repoHost` sections of the `deploy/cr.yaml` configuration file.

`podAntiAffinity` allows you to use standard Kubernetes affinity constraints of any complexity:

```
affinity:
  podAntiAffinity:
    preferredDuringSchedulingIgnoredDuringExecution:
    - weight: 1
      podAffinityTerm:
        labelSelector:
          matchLabels:
            postgres-operator.crunchydata.com/cluster: keycloakdb
            postgres-operator.crunchydata.com/role: pgbouncer
        topologyKey: kubernetes.io/hostname
```

You can see the explanation of these affinity options in Kubernetes documentation.

Topology Spread Constraints

Topology Spread Constraints allow you to control how Pods are distributed across the cluster based on regions, zones, nodes, and other topology specifics. This can be useful for both high availability and resource efficiency.

Pod topology spread constraints are controlled by the `topologySpreadConstraints` subsection, which can be put into `proxy.pgBouncer` and `backups.pgbackrest.repoHost` sections of the `deploy/cr.yaml` configuration file as follows:

```
topologySpreadConstraints:
  - maxSkew: 1
    topologyKey: my-node-label
    whenUnsatisfiable: DoNotSchedule
    labelSelector:
      matchLabels:
        postgres-operator.crunchydata.com/instance-set: instance1
```

You can see the explanation of these affinity options in Kubernetes documentation.

Tolerations

Tolerations allow Pods having them to be able to land onto nodes with matching *taints*. Toleration is expressed as a `key` with and `operator`, which is either `exists` or `equal` (the latter variant also requires a `value` the key is equal to). Moreover, toleration should have a specified `effect`, which may be a self-explanatory `NoSchedule`, less strict `PreferNoSchedule`, or `NoExecute`. The last variant means that if a *taint* with `NoExecute` is assigned to node, then any Pod not tolerating this *taint* will be removed from the node, immediately or after the `tolerationSeconds` interval, like in the following example.

You can use `instances.tolerations` and `backups.pgbackrest.jobs.tolerations` subsections in the `deploy/cr.yaml` configuration file as follows:

```
tolerations:
- effect: NoSchedule
  key: role
  operator: Equal
  value: connection-poolers
```

The Kubernetes Taints and Tolerations contains more examples on this topic.

Labels and annotations

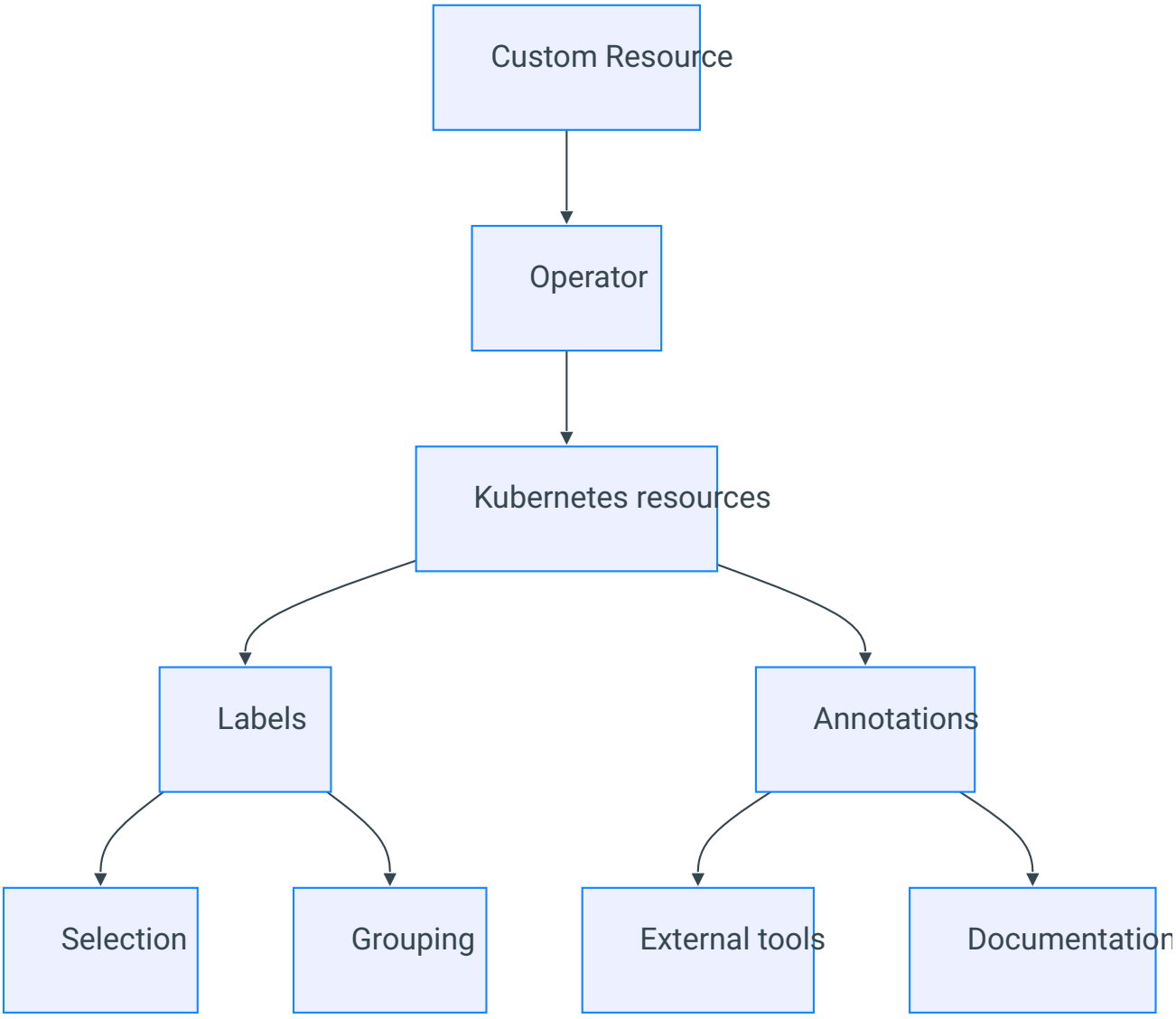
Labels and annotations are used to attach additional metadata information to Kubernetes resources.

Labels and annotations are rather similar but differ in purpose.

Labels are used by Kubernetes to identify and select objects. They enable filtering and grouping, allowing users to apply selectors for operations like deployments or scaling.

Annotations are assigning additional *non-identifying* information that doesn't affect how Kubernetes processes resources. They store descriptive information like deployment history, monitoring configurations or external integrations.

The following diagram illustrates this difference:



Both Labels and Annotations are assigned to the following objects managed by Percona Operator for PostgreSQL:

- Custom Resource Definitions
- Custom Resources
- Deployments
- Services
- StatefulSets
- PVCs
- Pods
- ConfigMaps and Secrets

When to use labels and annotations

Use **Labels** when:

- The information is used for object selection
- The data is used for grouping or filtering
- The information is used by Kubernetes controllers
- The data is used for operational purposes

Use **Annotations** when:

- The information is for external tools
- The information is used for debugging
- The data is used for monitoring configuration

Labels and annotations used by Percona Operator for PostgreSQL

Labels

Name	Objects	Description	Example values

`pgv2.percona.com/version`	CustomResourceDefinition	Specifies the version of the Percona Operator for PostgreSQL.	2.8.1
`app.kubernetes.io/instance`	Services, StatefulSets, Deployments	Identifies a specific instance of the application	cluster1
`app.kubernetes.io/managed-by`	Services, StatefulSets	Indicates the controller managing the object	percona-postgresql-operator
`app.kubernetes.io/component`	Services, StatefulSets	Specifies the component within the application	postgres, pgbouncer, pgbackrest
`app.kubernetes.io/part-of`	Services, StatefulSets	Indicates the higher-level application the object belongs to	percona-postgresql
`app.kubernetes.io/name`	Services, StatefulSets, Deployments, etc.	Specifies the name of the application	percona-postgresql
`postgres-operator.crunchydata.com/cluster`	StatefulSets, Deployments, Services, PVCs	Specifies the name of the application	cluster1
`postgres-operator.crunchydata.com/instance`	Services, StatefulSets, Deployments	Identifies a specific instance of the application	cluster1
`postgres-operator.crunchydata.com/instance-set`	Pods, StatefulSets	Describes the set of instances (such as a group of pods) within the PostgreSQL cluster.	
`postgres-operator.crunchydata.com/name`	pgBackRest resources (Jobs, CronJobs, Deployments, PVCs, etc.)	Used to specify the name of a pgBackRest repository.	
`postgres-operator.crunchydata.com/patroni`	Pods, StatefulSets	Indicates Patroni-related resources.	
`postgres-`	Pods, PVCs, Services	The role that Patroni sets on	

`operator.crunchydata.com/role`		the Pod that is currently the leader	
`postgres-operator.crunchydata.com/cluster-certificate`	Secrets	Identifies a secret containing a cluster certificate	postgres-tls
`postgres-operator.crunchydata.com/data`	Pods, PVCs	Identifies Pods and Volumes that store Postgres data	
`postgres-operator.crunchydata.com/move-job`	Jobs	Identifies a directory move Job.	
`postgres-operator.crunchydata.com/move-pgbackrest-repo-dir`	Jobs	Identifies a Job moving a pgBackRest repo directory.	
`postgres-operator.crunchydata.com/move-pgdata-dir`	Jobs	Identifies a Job moving a pgData directory.	
`postgres-operator.crunchydata.com/move-pgwal-dir`	Jobs	Identifies a Job moving a pg_wal directory.	
`postgres-operator.crunchydata.com/pgbackrest`	pgBackRest resources	Indicates a resource that is for pgBackRest.	
`postgres-operator.crunchydata.com/pgbackrest-backup`	Backup Jobs	Indicates a resource that is for a pgBackRest backup.	
`postgres-operator.crunchydata.com/pgbackrest-config`	ConfigMaps, Secrets	Indicates a ConfigMap/Secret for pgBackRest.	
`postgres-`	ConfigMaps	Indicates a ConfigMap that	

`operator.crunchydata.com/pgbackrest-dedicated`		is for a dedicated pgBackRest repo host.	
`postgres-operator.crunchydata.com/pgbackrest-repo`	Deployments, Pods	Indicates a Deployment or a Pod for a pgBackRest repo.	The name of the repository you define in CR
`postgres-operator.crunchydata.com/pgbackrest-volume`	PVCs	Indicates a PVC for a pgBackRest repo volume.	
`postgres-operator.crunchydata.com/pgbackrest-cronjob`	CronJobs	Indicates a resource is a pgBackRest CronJob.	
`postgres-operator.crunchydata.com/pgbackrest-restore`	Jobs, Pods	Indicates a Job/Pod for a pgBackRest restore.	
`postgres-operator.crunchydata.com/pgbackrest-restore-config`	ConfigMaps, Secrets	Indicates a configuration resource (e.g. a ConfigMap or Secret) for pgBackRest restore.	
`postgres-operator.crunchydata.com/crunchy-postgres-exporter`	Pods	Added to Pods running the exporter container for Prometheus discovery.	
`postgres-operator.crunchydata.com/pguser`	Secrets, Users	Identifies the PostgreSQL user an object is for/about.	Username
`postgres-operator.crunchydata.com/startup-instance`	Pods, Jobs	Indicates the startup instance associated with a resource.	

`postgres-operator.crunchydata.com/cbc-pgrole`	Secrets	Identifies a CBC PostgreSQL role secret.
`postgres-operator.crunchydata.com/pgadmin`	pgAdmin resources	Indicates a resource for a standalone pgAdmin instance.

Annotations

Name	Objects	Description	Example Values
`postgres-operator.crunchydata.com/trigger-switchover`	Custom Resource	Initiates a failover, switchover	
`postgres-operator.crunchydata.com/pgbackrest-backup-job-completion`	Restore, PVC	Added to restore jobs, pvcs, and VolumeSnapshots that are involved in the volume snapshot creation process. The annotation holds a RFC3339 formatted timestamp that corresponds to the completion time of the associated backup job.	timestamp
`postgres-operator.crunchydata.com/pgbackrest-hash`	Custom Resource	Specifies the hash value associated with a repo configuration as needed to detect configuration changes that invalidate running Jobs (and therefore must be recreated)	
`postgres-operator.crunchydata.com/pgbackrest-`	Custom Resource	Indicates whether to use an IPv6 wildcard address for the pgBackRest “tls-server-address”. Set the value “IPv6” to use an IPv6 addresses. If the annotation is not present of has a value other than IPv6, it defaults to IPv4 (0.0.0.0).	0.0.0.0

`ip-version`			
`postgres-operator.crunchydata.com/postgres-exporter-collectors`	Pods	Specifies which collectors to enable for the exporter. The value “None” disables all postgres_exporter defaults. Disabling the defaults may cause errors in dashboards.	`database,table`
`postgres-operator.crunchydata.com/adopt-bridge-cluster`	CrunchyBridgeCluster Custom Resource	Allows users to “adopt” or take control over an existing Bridge Cluster with a CrunchyBridgeCluster Custom Resource. Essentially, if a CrunchyBridgeCluster Custom Resource does not have a status.ID, but the name matches the name of an existing bridge cluster, the user must add this annotation to the Custom Resource to allow it to take control of the Bridge Cluster. The Value assigned to the annotation must be the ID of existing cluster.	existing cluster ID
`postgres-operator.crunchydata.com/autoCreateUserSchema`	Custom Resource	Controls if the Operator should create schemas for the users defined in `spec.users` for all of the databases listed for that user	`true`
`postgres-operator.crunchydata.com/authorizeBackupRemoval`	Custom Resource	Allows removal of PVC-based backups when changing from a cluster with backups to a cluster without backups. Backups stored on the cloud storage are intact	`true`
`postgres-operator.crunchydata.com/override-config`	ConfigMaps	Used to override default configuration from a ConfigMap.	`custom-config`

`pgv2.percona.com/monitor-user-secret-hash`	Custom Resource	Hash of the monitor user secret, used to detect changes and trigger updates.	`b6e1a2c3...`
`pgv2.percona.com/backup-in-progress`	Custom Resource	Indicates a backup that is currently running for the cluster.	`true`
`pgv2.percona.com/cluster-bootstrap-restore`	Custom Resource	Marks that the cluster was bootstrapped from a restore.	`2024-07-01T12:34:56Z`
`pgv2.percona.com/patroni-version`	Pods, StatefulSets	The Patroni version running in the Pod or StatefulSet.	`4.1.0`
`pgv2.percona.com/custom-patroni-version`	Pods, StatefulSets	Custom Patroni version specified by the user. Deprecated and ignored starting with version 2.8.0	`3.3.0-percona`
`kubectl.kubernetes.io/default-container`	Pods	Defines a default container used when the `-c` flag is not passed when executing to a Pod.	

Setting labels and annotations in the Custom Resource

You can define both Labels and Annotations as `key-value` pairs in the metadata section of a YAML manifest for a specific resource.

Set labels and annotations for Pods

For PostgreSQL, pgBouncer and pgBackRest Pods, use `instances.metadata.annotations` / `instances.metadata.labels`, `proxy.pgbouncer.metadata.annotations` / `proxy.pgbouncer.metadata.labels`, or `backups.pgbackrest.metadata.annotations` / `backups.pgbackrest.metadata.labels` keys as follows:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGCluster
...
spec:
...
  instances:
   - name: instance1
     replicas: 3
     metadata:
      annotations:
        my-annotation: value1
      labels:
        my-label: value2
    ...
```

Set labels and annotations for Services

For PostgreSQL and pgBouncer Services, use `expose.annotations` / `expose.labels` or `proxy.pgbouncer.expose.annotations` / `proxy.pgbouncer.expose.labels` keys as follows:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGCluster
...
spec:
  ...
  expose:
    annotations:
      my-annotation: value1
    labels:
      my-label: value2
    ...
```

Set global labels and annotations

You can also use the top-level spec `metadata.annotations` and `metadata.labels` options to set annotations and labels at a global level, for all resources created by the Operator:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGCluster
...
spec:
  ...
  metadata:
    annotations:
      my-global-annotation: value1
    labels:
      my-global-label: value2
  ...
```

Settings labels and annotations for the Operator Pod

You can assign labels and/or annotations to the Operator itself by editing the deploy/operator.yaml configuration file before applying it during the installation. This way you add labels and annotations to the Pod where the Operator is running

```
apiVersion: apps/v1
kind: Deployment
...
spec:
...
  template:
    metadata:
      labels:
        app.kubernetes.io/component: operator
        app.kubernetes.io/instance: percona-postgresql-operator
        app.kubernetes.io/name: percona-postgresql-operator
        app.kubernetes.io/part-of: percona-postgresql-operator
        pgv2.percona.com/control-plane: postgres-operator
        ...
```

Querying labels and annotations

To check which **labels** are attached to a specific object, use the additional `--show-labels` option of the `kubectl get` command.

For example, to see the Operator version associated with a Custom Resource Definition, use the following command:

```
kubectl get crd perconapgclusters.pgv2.percona.com --show-labels
```

Sample output

```{.text .no-copy} NAME CREATED AT LABELS

perconapgclusters.pgv2.percona.com 2025-07-01T13:13:36Z pgv2.percona.com/version=v2.8.1 ```

To check **annotations** associated with an object, use the following command:

```
kubectl get <resource> <resource-name> -o jsonpath='{.metadata.annotations}'
```

For example, this command lists annotations assigned to a `cluster1-pgbouncer` Service:

```
kubectl get service cluster1-instance1-xvbt-0 -o
jsonpath='{.metadata.annotations}'
```

Sample output

```
{
  "cloud.google.com/neg": "{\"ingress\":true}"
}
```

Special annotations

Metadata can be used as an additional way to influence the Operator behavior by setting special annotations.

Customizing Patroni version (for the Operator version 2.6.0 - 2.7.0)

Note

This behavior is deprecated and the annotation is ignored starting with version 2.8.0.
```

Starting from the Operator 2.6.0, Percona distribution for PostgreSQL comes with Patroni 4.x, which introduces breaking changes compared to previously used 3.x versions. To maintain backward compatibility, the Operator needs to detect the Patroni version used in the image. For this, it runs a temporary Pod named `cluster_name-patroni-version-check` with the following default resources:

```
Resources:
   Requests:
     memory: 32Mi
     cpu: 50m
   Limits:
     memory: 64Mi
     cpu: 100m
```

You can disable this auto-detection feature by manually setting the Patroni version via the following annotation in the metadata part of the Custom Resource (it should contain “4” for Patroni 4.x or “3” for Patroni 3.x):

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGCluster
metadata:
  name: cluster1
  annotations:
    pgv2.percona.com/custom-patroni-version: "4"
  ...
```

Transport layer security (TLS)

The Percona Operator for PostgreSQL uses Transport Layer Security (TLS) cryptographic protocol for the following types of communication:

- Internal - communication between PostgreSQL instances in the cluster
- External - communication between the client application and the cluster

The internal certificate is also used as an authorization method for PostgreSQL Replica instances.

TLS security can be configured in following ways:

- the Operator can generate long-term certificates automatically at cluster creation time,
- you can generate certificates manually.

> **Note**
>
> Additionally, you can *force* your database cluster to use only encrypted channels for both internal and external communications. This effect is achieved by setting the `tlsOnly` Custom Resource option to `true`.

Allow the Operator to generate certificates automatically

The Operator is able to generate long-term certificates automatically and turn on encryption at cluster creation time, if there are no certificate secrets available. Just deploy your cluster as usual, with the `kubectl apply -f deploy/cr.yaml` command, and certificates will be generated.

> **Note**
>
> Starting from 2.5.0, the Operator creates root CA on per-cluster basis. In Operator versions before 2.5.0, autogenerated certificates for all database clusters were based on the same generated root CA.

Check connectivity to the cluster

You can check TLS communication using `psql`, the standard interactive terminal-based frontend to PostgreSQL.

For this purpose, we will create a `pg-client` Deployment, which includes the necessary tools. We will use the existing Secret object with the TLS certificates, generated by the Operator.

Follow these steps:

1. Export the namespace as the environment variable to simplify further configuration:

   ```
   export NAMESPACE=<postgres-operator>
   ```

2. List the Secret objects:

   ```
   kubectl get secrets -n $NAMESPACE
   ```

   Expected output

   ```
   cluster1-cluster-ca-cert        Opaque   2      37m
   cluster1-cluster-cert           Opaque   3      37m
   cluster1-instance1-5nlp-certs   Opaque   6      37m
   cluster1-instance1-8rks-certs   Opaque   6      37m
   cluster1-instance1-z5tz-certs   Opaque   6      37m
   cluster1-pgbackrest             Opaque   5      37m
   cluster1-pgbouncer              Opaque   6      37m
   cluster1-pguser-cluster1        Opaque   12     37m
   cluster1-replication-cert       Opaque   3      37m
   ```

   The secret with TLS certificates is `<cluster-name>-cluster-ca-cert` (`cluster1-cluster-ca-cert` by default).

3. Create a deployment. Replace the placeholders in the following command with your values:

   - Replace the `<cluster-name>` placeholder with your actual cluster name
   - Specify the Secret object with the TLS certificate from step 1
   - Specify the CA certificate file for the `volumeMounts.name` and `volumes.name` options. This file is used to mount the root CA certificate into the container so that client tools like `psql` can verify the server's certificate. To view the file name, run `kubectl get secret <cluster-name>-cluster-ca-cert -o yaml -n $NAMESPACE` command.

```
cat <<EOF | kubectl apply -n $NAMESPACE -f -
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pg-client
spec:
  replicas: 1
  selector:
    matchLabels:
      name: pg-client
  template:
    metadata:
      labels:
        name: pg-client
    spec:
      containers:
        - name: pg-client
          image: percona/percona-distribution-postgresql:17.7-1
          imagePullPolicy: Always
          command:
          - sleep
          args:
          - "100500"
          volumeMounts:
            - name: root
              mountPath: "/tmp/tls"
      volumes:
      - name: root
        secret:
          secretName: <cluster_name>-cluster-ca-cert
          items:
          - key: root.crt
            path: root.crt
            mode: 0777
EOF
```

4. Retrieve the `pgBouncer` URI to connect to PostgreSQL. It is stored in the Secret object with user credentials: `<cluster-name>-pguser-<db-name>`. The default value is `cluster1-pguser-cluster1`. Run the following command and replace the `cluster1-pguser-cluster1` Secret name with your value:

```
kubectl get secret cluster1-pguser-cluster1 -o jsonpath='{.data.pgbouncer-uri}' -n $NAMESPACE | base64 --decode
```

Sample output

```text postgresql://cluster1:@cluster1-pgbouncer.default.svc:5432/cluster1
```

5. Now get shell access to the newly created container:

```
kubectl exec -it deployment/pg-client -- bash -il
```

Expected output

```
[postgres@pg-client-54b449898f-ztlrh /]$
```

6. Launch the `psql` interactive terminal to check connectivity over the encrypted channel. Make sure to use your cluster name, the pgBouncer URL you retrieved at the previous step, and the CA certificate you provided when you created the `pg-client` deployment:

```
PGSSLMODE=verify-ca PGSSLROOTCERT=/tmp/tls/root.crt psql
'postgresql://cluster1:<password>@cluster1-
pgbouncer.default.svc:5432/cluster1'
```

Now you should see the prompt of PostgreSQL interactive terminal:

```
psql (17.7-1)
Type "help" for help.
cluster1=>
```

Generate certificates manually

You can customize TLS for the Operator by providing your own TLS certificates. To do this, you must create two Kubernetes Secret objects *before* deploying your cluster:

- One for external communication, later referenced by the `spec.customTLSSecret` field in the `deploy/cr.yaml`
- One for internal communication (used for replication authentication), referenced by the `spec.customReplicationTLSSecret` field in the `deploy/cr.yaml`.

Each Secret must contain the following fields:

- `tls.crt` (the TLS certificate)
- `tls.key` (the TLS private key)
- `ca.crt` (the Certificate Authority certificate)

Note that you cannot use only one custom set of certificates. If you provide a custom TLS Secret, you **must** also provide a custom replication TLS Secret, and both must contain the same `ca.crt`.

Provide pre-existing custom certificates

For example, you have files named `ca.crt`, `my_tls.key`, and `my_tls.crt`. Run the following command to create a custom TLS Secret named `cluster1-tls`:

```
kubectl create secret generic -n postgres-operator cluster1-tls \
  --from-file=ca.crt=ca.crt \
  --from-file=tls.key=my_tls.key \
  --from-file=tls.crt=my_tls.crt
```

In the same way, create the custom TLS replication Secret, for example `replication1-tls`.

Next, reference your Secrets in the `deploy/cr.yaml` Custom Resource manifest as follows:

- add a Secret created for the external use to the `secrets.customTLSSecret.name` field
- add a Secret created for internal communications to the `secrets.customReplicationTLSSecret.name` field

Here's the sample configuration:

```
spec:
  ...
  secrets:
    customTLSSecret:
      name: cluster1-tls
    customReplicationTLSSecret:
      name: replication1-tls
  ...
```

Now you can create a cluster with your custom certificates:

```
kubectl apply -f deploy/cr.yaml
```

Provide a pre-existing custom root CA certificate to the Operator

You can also provide a custom root CA certificate to the Operator. In this case the Operator will not generate one itself, but will use the user-provided CA certificate. This can be useful if you would like to have several database clusters with certificates generated by the Operator based on the same root CA.

To make the Operator use a custom root certificate, create a separate secret with this certificate and specify this secret in the Custom Resource options **before** you deploy a cluster.

For example, if you have files named `my_tls.key` and `my_tls.crt` stored on your local machine, you could run the following command to create a Secret named `cluster1-ca-cert` in the `postgres-operator` namespace:

```
kubectl create secret generic -n postgres-operator cluster1-ca-cert \
  --from-file=tls.crt=my_tls.crt \
  --from-file=tls.key=my_tls.key
```

You also need to specify details about this secret in your `deploy/cr.yaml` manifest:

```
...
secrets:
  customRootCATLSSecret:
    name: cluster1-ca-cert
    items:
      - key: "tls.crt"
        path: "root.crt"
      - key: "tls.key"
        path: "root.key"
```

Now, you can create the cluster with the `kubectl apply -f deploy/cr.yaml` command. The Operator should use the root CA certificate you had provided.

Warning

This approach allows using root CA certificate auto-generated by the Operator for some other clusters, but it needs caution. If the cluster with auto-generated certificate has `delete-ssl` finalizer enabled, the certificate will be deleted at the cluster deletion event even if it was manually provided to some other cluster.

Generate custom certificates for the Operator yourself

Understand certificate requirements

To find out the certificates specifics needed for the Operator, view the certificates generated by the Operator automatically. For example, if you have a cluster deployed in some staging environment.

Here's how to do it:

1. Check the secrets created by the Operator:

   ```
   kubectl get secrets
   ```

   Expected output

   ```
   cluster1-cluster-ca-cert        Opaque   2      143m
   cluster1-cluster-cert           Opaque   3      143m
   cluster1-instance1-frdm-certs   Opaque   6      143m
   cluster1-instance1-qcqk-certs   Opaque   6      143m
   cluster1-instance1-wq55-certs   Opaque   6      143m
   cluster1-pgbackrest             Opaque   5      143m
   cluster1-pgbouncer              Opaque   6      143m
   cluster1-pguser-cluster1        Opaque   12     143m
   cluster1-replication-cert       Opaque   3      143m
   ```

   The Secrets of interest are `cluster1-cluster-cert` for external communication and `cluster1-replication-cert` for internal communication.

2. You can examine the auto-generated CA certificate (`ca.crt`) as follows:

   ```
   kubectl get secret/cluster1-cluster-cert -o jsonpath='{.data.ca\.crt}' |
   base64 --decode | openssl x509 -text -noout
   ```

Expected output

```
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            ec:f3:d6:f5:35:5c:97:0c:66:cc:90:ed:e6:4b:0a:07
        Signature Algorithm: ecdsa-with-SHA384
        Issuer: CN = postgres-operator-ca
        Validity
            Not Before: Dec 24 13:58:21 2023 GMT
            Not After : Dec 21 14:58:21 2033 GMT
        Subject: CN = postgres-operator-ca
        Subject Public Key Info:
        ...
    ...
```

3. You can check the auto-generated TLS certificate (`tls.crt`) in a similar way:

External communication

```
kubectl get secret/cluster1-cluster-cert -o jsonpath='{.data.tls\.crt}' |
base64 --decode | openssl x509 -text -noout
```

Expected output

```
Certificate:
    Data:
       Version: 3 (0x2)
       Serial Number:
           43:ac:81:65:4e:c6:1b:15:db:ca:36:c4:16:96:79:1b
       Signature Algorithm: ecdsa-with-SHA384
       Issuer: CN=postgres-operator-ca
       Validity
           Not Before: Jul 22 08:15:42 2025 GMT
           Not After : Jul 22 09:15:42 2026 GMT
       Subject: CN=cluster1-primary.default.svc.cluster.local.
       Subject Public Key Info:
           Public Key Algorithm: id-ecPublicKey
               Public-Key: (256 bit)
               pub:
                   04:cd:06:b5:27:67:64:2b:a3:9e:84:e6:31:81:7f:
                   3f:a9:ae:c9:da:bd:b8:76:3e:f0:09:bd:b8:eb:03:
                   88:c2:d3:4b:2a:1f:e9:5b:97:cf:4e:7b:b3:12:2b:
                   47:ee:a6:24:fb:29:ae:01:74:e2:4c:5c:3e:f9:8d:
                   cb:ff:0a:62:8d
               ASN1 OID: prime256v1
               NIST CURVE: P-256
       X509v3 extensions:
           X509v3 Key Usage: critical
               Digital Signature, Key Encipherment
           X509v3 Basic Constraints: critical
               CA:FALSE
           X509v3 Authority Key Identifier:
               59:98:FE:88:1B:54:A0:7D:DD:20:A0:F6:29:08:05:C7:18:38:7C:92
           X509v3 Subject Alternative Name:
               DNS:cluster1-primary.default.svc.cluster.local., DNS:cluster1-
primary.default.svc, DNS:cluster1-primary.default, DNS:cluster1-primary,
DNS:cluster1-replicas.default.svc.cluster.local., DNS:cluster1-
replicas.default.svc, DNS:cluster1-replicas.default, DNS:cluster1-replicas
    Signature Algorithm: ecdsa-with-SHA384
    ...
```

Internal communication

```
kubectl get secret/cluster1-replication-cert -o
jsonpath='{.data.tls\.crt}' | base64 --decode | openssl x509 -text -noout
```

Expected output

```
Certificate:
     Data:
          Version: 3 (0x2)
          Serial Number:
              31:1b:1e:ca:06:e6:98:4d:7e:de:6d:1b:68:d8:53:0e
          Signature Algorithm: ecdsa-with-SHA384
          Issuer: CN=postgres-operator-ca
          Validity
              Not Before: Jul 22 08:15:42 2025 GMT
              Not After : Jul 22 09:15:42 2026 GMT
          Subject: CN=_crunchyrepl
          Subject Public Key Info:
              Public Key Algorithm: id-ecPublicKey
                  Public-Key: (256 bit)
                  pub:
                      04:b1:f7:9d:cd:33:0d:a5:19:a3:f2:fd:f6:b3:cd:
                      e1:a5:e4:19:11:ec:18:db:fe:9c:a8:7e:eb:d2:27:
                      59:d1:ef:3b:09:24:58:21:6a:54:60:30:1c:be:b0:
                      7a:39:c5:91:6f:01:ee:d1:0b:23:86:0c:16:cf:fc:
                      7d:7e:39:cb:0e
                  ASN1 OID: prime256v1
                  NIST CURVE: P-256
          X509v3 extensions:
              X509v3 Key Usage: critical
                  Digital Signature, Key Encipherment
              X509v3 Basic Constraints: critical
                  CA:FALSE
              X509v3 Authority Key Identifier:
                  59:98:FE:88:1B:54:A0:7D:DD:20:A0:F6:29:08:05:C7:18:38:7C:92
              X509v3 Subject Alternative Name:
                  DNS:_crunchyrepl
     Signature Algorithm: ecdsa-with-SHA384
     ...
```

Both secrets share the same `ca.crt` certificate but have different `tls.crt` certificates. The `tls.crt` in the Secret for external communications should have a Common Name (CN) setting that matches the primary Service name (`CN = cluster1-primary.default.svc.cluster.local.` in the above example). Similarly, the `tls.crt` in the Secret for internal communications should have a Common Name (CN) setting that matches the preset replication user: `CN=_crunchyrepl`.

Generate certificates

One of the options to create certificates yourself is to use CloudFlare PKI and TLS toolkit.

You must generate certificates twice: one set is for external communications, and another set is for internal ones!

Let's say that your cluster name is `cluster1` and the desired namespace is `postgres-operator`. The commands to generate certificates may look as follows:

1. Set cluster context

```
export CLUSTER_NAME=cluster1
export NAMESPACE=postgres-operator
```

2. Generate the root CA certificate:

```
cat <<EOF | cfssl gencert -initca - | cfssljson -bare ca
  {
    "CN": "*",
    "key": {
      "algo": "ecdsa",
      "size": 384
    }
  }
  EOF
```

Expected output

```
2025/07/22 18:44:00 [INFO] generating a new CA key and certificate from CSR
2025/07/22 18:44:00 [INFO] generate received request
2025/07/22 18:44:00 [INFO] received CSR
2025/07/22 18:44:00 [INFO] generating key: ecdsa-384
2025/07/22 18:44:00 [INFO] encoded CSR
2025/07/22 18:44:00 [INFO] signed certificate with serial number
558041563526770695468617559855840603242491856749
```

You should have the following files:

- ca-key.pem – CA private key
- ca.pem – CA certificate

3. Define the CA signing policy for certificates signed by the CA.

```
cat <<EOF > ca-config.json
  {
     "signing": {
       "default": {
          "expiry": "87600h",
          "usages": ["digital signature", "key encipherment", "content
commitment"]
        }
     }
  }
  EOF
```

Explanation of the values:

- `expiry` - sets the lifetime for the certificates
- `usages` specifies what the certificate is valid for:
  - `digital signature`: for signing data
  - `key encipherment`: for secure key exchange
  - `content commitment`: ensures data integrity
- Generate the custom TLS certificates for external communication and sign them using the previously created CA certificate. These certificates have the Common Name (CN) `cluster1-primary.postgres-operator.svc.cluster.local`

```
cat <<EOF | cfssl gencert -ca=ca.pem  -ca-key=ca-key.pem -config=./ca-
config.json - | cfssljson -bare server
  {
     "hosts": [
       "localhost",
       "${CLUSTER_NAME}-primary",
       "${CLUSTER_NAME}-primary.${NAMESPACE}",
       "${CLUSTER_NAME}-primary.${NAMESPACE}.svc.cluster.local",
       "${CLUSTER_NAME}-primary.${NAMESPACE}.svc",
       "${CLUSTER_NAME}-replicas.${NAMESPACE}.svc.cluster.local",
       "${CLUSTER_NAME}-replicas.${NAMESPACE}.svc",
       "${CLUSTER_NAME}-replicas.${NAMESPACE}",
       "${CLUSTER_NAME}-tls-replicas"
     ],
     "CN": "${CLUSTER_NAME}-primary.${NAMESPACE}.svc.cluster.local",
     "key": {
       "algo": "ecdsa",
       "size": 384
     }
  }
EOF
```

You should have the following files as defined by the `-bare server` part of the command:

- `server.pem` - the signed certificate
- `server-key.pem` - the private key

- Generate the custom TLS certificates for internal communication and sign them using the previously created CA certificate. These certificates have the Common Name (CN) `_crunchyrepl`.

```
cat <<EOF | cfssl gencert -ca=ca.pem -ca-key=ca-key.pem -config=./ca-
config.json - | cfssljson -bare replication
  {
    "CN": "_crunchyrepl",
    "key": {
      "algo": "ecdsa",
      "size": 384
    }
  }
  EOF
```

You should have the following files as defined by the `-bare server` part of the command:

- `replication.pem` - the signed certificate
- `replication-key.pem` - the private key

You can find more on generating certificates this way in official Kubernetes documentation.

Refer to the Provide pre-existing custom certificates section for the steps to create Secrets and configure the Operator. Replace the values with your files.

Check your certificates for expiration

```
kubectl get secrets
```

1. First, check the necessary secrets names (`cluster1-cluster-cert` and `cluster1-replication-cert` by default):

   You will have the following response:

   ```
   NAME                              TYPE     DATA   AGE
   cluster1-cluster-cert             Opaque   3      11m
   ...
   cluster1-replication-cert         Opaque   3      11m
   ...
   ```

2. Now use the following command to find out the certificates validity dates, substituting Secrets names if necessary:

   ```
   {
     kubectl get secret/cluster1-replication-cert -o
   jsonpath='{.data.tls\.crt}' | base64 --decode | openssl x509 -noout -dates
     kubectl get secret/cluster1-cluster-cert -o jsonpath='{.data.ca\.crt}' |
   base64 --decode | openssl x509 -noout -dates
     }
   ```

   The resulting output will be self-explanatory:

   ```
   notBefore=Jun 28 10:20:19 2023 GMT
   notAfter=Jun 27 11:20:19 2024 GMT
   notBefore=Jun 28 10:20:18 2023 GMT
   notAfter=Jun 25 11:20:18 2033 GMT
   ```

Update certificates

The Operator automatically updates the automatically-generated certificates to ensure your applications continue operation without communication issues. However, the Operator doesn't update custom certificates. It is your responsibility to timely update them.

Update custom certificates

You can update only custom certificates for external and / or internal communication and keep the same root CA certificate.

You can update the contents of your existing Secrets referenced in the `spec.customTLSSecret` and/or `spec.customReplicationTLSSecret` fields in `deploy/cr.yaml` without changing their names. In this case, the Operator detects the updated certificate data and applies the changes to the running cluster without restarting it. Such update is called hot reload.

This example shows how you can do it. Let's say you have the following certificates and Secrets:

- `server.pem` / `server-key.pem` and the `cluster1-cert` Secret for external communication,
- `replica.pem` / `replica-key.pem` and `cluster1-replication-cert` Secret for internal communication
- `ca.pem` / `ca-key.pem` is the existing CA root certificate that you keep

Your cluster is deployed in the `postgres-operator` namespace.

1. Set the context for the cluster:

   ```
   export NAMESPACE=postgres-operator
   ```

2. Create a YAML manifest for the `cluster1-cert` Secret. Run the following command to generate a YAML manifest (adjust file paths if needed):

   ```
   kubectl create secret generic cluster1-cert \
      --from-file=tls.crt=server.pem \
      --from-file=tls.key=server-key.pem \
      --from-file=ca.crt=ca.pem \
      -n "$NAMESPACE" \
      --dry-run=client -o yaml > cluster1-cert.yaml
   ```

3. Create a YAML manifest for the `cluster1-replication-cert` Secret. Run the following command to generate a YAML manifest (adjust file paths if needed):

```
kubectl create secret generic cluster1-replication-cert \
   --from-file=tls.crt=replica.pem \
   --from-file=tls.key=replica-key.pem \
   --from-file=ca.crt=ca.pem \
   -n "$NAMESPACE" \
   --dry-run=client -o yaml > cluster1-replication-cert.yaml
```

4. Apply the manifests to update the Secrets:

```
kubectl apply -f cluster1-cert.yaml -f cluster1-replication-cert.yaml -n
"$NAMESPACE"
```

If you create new Secrets with new names and values, update the `spec.customTLSSecret` and `spec.customReplicationTLSSecret` fields in the `deploy/cr.yaml`. When you apply the new configuration,this causes the Operator to restart the cluster.

Update a custom root CA certificate

Here's what you need to know if you wish to update a custom root CA certificate:

- If you change a root CA certificate, you must also change your custom TLS certificates for external and internal communications as these must be signed with the same root CA.
- The new root CA and associated certs must be stored in new Secrets (not overwriting existing ones). This ensures rollback capability in case of misconfiguration or validation issues.
- You must pause the cluster before applying changes. This prevents the Operator from restarting or reconfiguring Pods mid-update.

To update a custom root CA certificate, do the following:

1. Generate a new root CA certificate and key. For example, you have them in files named `new-ca.pem` and `new-ca-key.pem`.
2. Generate all dependent certificates for external and internal communication and sign them using the new root CA certificate. Check the Generate certificates manually section for the steps. For example, you end up with the following certificates:
   - `server.pem` and `server-key.pem` for external communication
   - `replication.pem` and `replication-key.pem` for internal communication
3. Create a new Secret object for the new root CA certificate and define the new CA certificate and key within. Let's name it `cluster1-ca-cert-new`.

```
kubectl create secret generic -n postgres-operator cluster1-ca-cert-new \
  --from-file=ca.crt=new-ca.pem \
  --from-file=ca.key=new-ca-key.pem
```

4. Create new Secrets for external and internal communications, named `cluster1-tls` and `cluster1-replication-tls` respectively

```
kubectl create secret generic -n postgres-operator cluster1-tls \
  --from-file=ca.crt=ca.pem \
  --from-file=tls.key=server-key.pem \
  --from-file=tls.crt=server.pem
```

```
kubectl create secret generic -n postgres-operator cluster1-replication-
tls \
  --from-file=ca.crt=ca.pem \
  --from-file=tls.key=replication-key.pem \
  --from-file=tls.crt=replication.pem
```

5. Pause the cluster to prevent the Operator to restart the Pods mid-update.

```
kubectl patch pg cluster1 \
  --type merge \
  --patch '{"spec": {"pause": true}}' \
  --namespace postgres-operator
```

6. Specify details about new custom certificates in the `deploy/cr.yaml`. Since this is a provisioned cluster, apply the patch as follows:

```
kubectl patch pg cluster1 \
    --type merge \
    --patch '{
        "spec": {
            "secrets": {
                "customRootCATLSSecret": {
                    "name": "cluster1-ca-cert-new",
                    "items": [
                        {
                            "key": "ca.crt",
                            "path": "root.crt"
                        },
                        {
                            "key": "ca.key",
                            "path": "root.key"
                        }
                    ]
                },
                "customTLSSecret": {
                    "name": "cluster1-tls"
                },
                "customReplicationTLSSecret": {
                    "name": "cluster1-replication-tls"
                }
            }
        }
    }' \
    --namespace postgres-operator
```

7. Unpause the cluster to resume the Operator control:

```
kubectl patch pg cluster1 \
  --type merge \
  --patch '{"spec": {"pause": false}}' \
  --namespace postgres-operator
```

Keep certificates after deleting the cluster

In case of cluster deletion, objects, created for SSL (Secret, certificate, and issuer) are not deleted by default.

If the user wants the cleanup of objects created for SSL, there is a finalizers.percona.com/delete-ssl Custom Resource option, which can be set in `deploy/cr.yaml`: if this finalizer is set, the Operator will delete Secret, certificate and issuer after the cluster deletion event.

Telemetry

The Telemetry function enables the Operator gathering and sending basic anonymous data to Percona, which helps us to determine where to focus the development and what is the uptake for each release of Operator.

The following information is gathered:

- ID of the Custom Resource (the `metadata.uid` field)
- Kubernetes version
- Platform (is it Kubernetes or Openshift)
- Is PMM enabled, and the PMM Version
- Operator version
- PostgreSQL version
- PgBackRest version
- Was the Operator deployed with Helm
- Are sidecar containers used
- Are backups used

We do not gather anything that identify a system, but the following thing should be mentioned: Custom Resource ID is a unique ID generated by Kubernetes for each Custom Resource.

Telemetry is enabled by default and is sent to the Version Service server when the Operator connects to it at scheduled times to obtain fresh information about version numbers and valid image paths needed for the upgrade.

The landing page for this service, check.percona.com, explains what this service is.

You can disable telemetry with a special option when installing the Operator:

- if you install the Operator with helm, use the following installation command:

```
helm install my-db percona/pg-db --version 2.8.1 --namespace my-namespace --
set disable_telemetry="true"
```

- if you don't use helm for installation, you have to edit the `operator.yaml` before applying it with the `kubectl apply -f deploy/operator.yaml` command. Open the `operator.yaml` file with your text editor, find the `DISABLE_TELEMETRY` environment variable and set it to `"true"`

```
...
- name: DISABLE_TELEMETRY
  value: "true"
...
```

Configure concurrency for a cluster reconciliation

Reconciliation is the process by which the Operator continuously compares the desired state with the actual state of the cluster. The desired state is defined in a Kubernetes custom resource, like PostgresCluster.

If the actual state does not match the desired state, the Operator takes actions to bring the system into alignment—such as creating, updating, or deleting Kubernetes resources (Pods, Services, ConfigMaps, etc.) or performing database-specific operations like scaling, backups, or failover.

Reconciliation is triggered by a variety of events, including:

- Changes to the cluster configuration
- Changes to the cluster state
- Changes to the cluster resources

By default, the Operator has one reconciliation worker. This means that if you deploy or update 2 clusters at the same time, the Operator will reconcile them sequentially.

The `PGO_WORKERS` environment variable in the `percona-postgresql-operator` deployment controls the number of concurrent workers that can reconcile resources in PostgresSQL clusters in parallel.

Thus, to extend the previous example, if you set the number of reconciliation workers to `2`, the Operator will reconcile both clusters in parallel. This also helps you with benchmarking the Operator performance.

The general recommendation is to set the number of concurrent workers equal to the number of PostgreSQL clusters. When the number of workers is greater, the excessive workers will remain idle.

Set the number of reconciliation workers

1. Check the index of the `PGO_WORKERS` environment variable using the following command:

```
kubectl get deployment percona-postgresql-operator -o
jsonpath='{.spec.template.spec.containers[0].env[?
(@.name=="PGO_WORKERS")].value}'
```

Sample output


```
[
  {
    "name": "WATCH_NAMESPACE",
    "valueFrom": {
      "fieldRef": {
        "apiVersion": "v1",
        "fieldPath": "metadata.namespace"
      }
    }
  },
  {
    "name": "PGO_NAMESPACE",
    "valueFrom": {
      "fieldRef": {
        "apiVersion": "v1",
        "fieldPath": "metadata.namespace"
      }
    }
  },
  {
    "name": "LOG_STRUCTURED",
    "value": "false"
  },
  {
    "name": "LOG_LEVEL",
    "value": "INFO"
  },
  {
    "name": "DISABLE_TELEMETRY",
    "value": "false"
  },
  {
    "name": "PGO_WORKERS",
    "value": "2"
  }
]
```


The index is zero-based, thus `PGO_WORKERS` has index 5.

2. List deployments to find the right one:

```
kubectl get deployment
```

Sample output

```
NAME                           READY   UP-TO-DATE   AVAILABLE   AGE
cluster1-pgbouncer             3/3     3            3           3h49m
percona-postgresql-operator    0/1     1            0           3h50m
```

3. To set a new value, run the following command to patch the deployment:

```
kubectl patch deployment percona-postgresql-operator \
  --type='json' \
  -p='[{"op": "replace", "path": "/spec/template/spec/containers/0/env/5",
"value": {"name": "PGO_WORKERS", "value": "2"}}]'
```

The command does the following:

- Patches the deployment to update the `PGO_WORKERS` environment variable
- Sets the value to `2`

The value can be set to any number greater than 0.

Verify the change

To verify that the change has been applied, run the following command:

```
kubectl get deployment percona-postgresql-operator -o
jsonpath='{.spec.template.spec.containers[0].env[?
(@.name=="PGO_WORKERS")].value}'
```

The output should be `2`.

Management

Back up and restore

About backups

In this section you will learn how to set up and manage backups of your data using the Operator.

You can make backups in two ways:

- *On-demand*. You can do them manually at any moment.
- *Schedule backups*. Configure backups and their schedule in the deploy/cr.yaml file. The Operator makes them automatically according to the schedule.

What you need to know

Backup repositories

To make backups, the Operator uses the open source pgBackRest backup and restore utility.

When the Operator creates a new PostgreSQL cluster, it also creates a special *pgBackRest repository* to facilitate the usage of the pgBackRest features. You can notice an additional `repo-host` Pod after the cluster creation.

A pgBackRest repository consists of the following Kubernetes objects:

- A Deployment,
- A Secret that contains information specific to the PostgreSQL cluster (e.g. SSH keys, AWS S3 keys, etc.),
- A Pod with a number of supporting scripts,
- A Service.

In the `/deploy/cr.yml` file, pgBackRest repositories are listed in the `backups.pgbackrest.repos` subsection. You can have up to 4 repositories as `repo1`, `repo2`, `repo3`, and `repo4`.

Backup types

You can make the following types of backups:

- `full`: A full backup of all the contents of the PostgreSQL cluster,
- `differential`: A backup of only the files that have changed since the last full backup,
- `incremental`: Default. A backup of only the files that have changed since the last full or

differential backup.

Backup storage

You have the following options to store PostgreSQL backups:

- Cloud storage:
  - Amazon S3, or any S3-compatible storage,
  - Google Cloud Storage,
  - Azure Blob Storage
- A Persistent Volume attached to the pgBackRest Pod.

Next steps

Ready to move forward? Configure backup storage

Configure backup storage

Configure backup storage for your backup repositories in the `backups.pgbackrest.repos` section of the `deploy/cr.yaml` configuration file.

Follow the instructions relevant to the cloud storage or Persistent Volume you are using for backups.

S3-compatible backup storage

To use Amazon S3 or any S3-compatible storage for backups, you need to have the following S3-related information:

- The name of S3 bucket;
- The region - the location of the bucket
- S3 credentials such as S3 key and secret to access the storage. These are stored in an encoded form in Kubernetes Secrets along with other sensitive information.
- For S3-compatible storage other than native Amazon S3, you will also need to specify the endpoint - the actual URI to access the bucket - and the URI style (see below).

Note

The pgBackRest tool does backups based on write-ahead logs (WAL) archiving. If you are using an S3 storage in a region located far away from the region of your PostgreSQL cluster deployment, it could lead to the delay and impossibility to create a new replica/join delayed replica if the primary restarts. A new WAL file is archived in 60 seconds at the backup start by default, causing both full and incremental backups fail in case of long delay.

To prevent issues with PostgreSQL archiving and have faster restores, it's recommended to use the same S3 region for both the Operator and backup options. Additionally, you can replicate the S3 bucket to another region with tools like Amazon S3 Cross Region Replication.

Configuration steps

1. Encode the S3 credentials and the pgBackRest repository name that you will use for backups. In this example, we use AWS S3 key and S3 key secret and `repo2`.

Linux

```
cat <<EOF | base64 --wrap=0
[global]
repo2-s3-key=<YOUR_AWS_S3_KEY>
repo2-s3-key-secret=<YOUR_AWS_S3_KEY_SECRET>
EOF
```

macOS

```
cat <<EOF | base64
[global]
repo2-s3-key=<YOUR_AWS_S3_KEY>
repo2-s3-key-secret=<YOUR_AWS_S3_KEY_SECRET>
EOF
```

2. Create the Secret configuration file and specify the base64-encoded string from the previous step. The following is the example of the `cluster1-pgbackrest-secrets.yaml` Secret file:

```
apiVersion: v1
kind: Secret
metadata:
  name: cluster1-pgbackrest-secrets
type: Opaque
data:
  s3.conf: <base64-encoded-configuration-contents>
```

Note

This Secret can store credentials for several repositories presented as separate data keys.

3. Create the Secrets object from this YAML file. Replace the `<namespace>` placeholder with your value:

```
kubectl apply -f cluster1-pgbackrest-secrets.yaml -n <namespace>
```

4. Update your `deploy/cr.yaml` configuration. Specify the Secret file you created in the `backups.pgbackrest.configuration` subsection, and put all other S3 related information in the `backups.pgbackrest.repos` subsection under the repository name that you intend to use for backups. This name must match the name you used when you encoded S3 credentials on step 1.

Provide pgBackRest the directory path for backup on the storage. You can pass it in the backups.pgbackrest.global subsection via the pgBackRest `path` option (prefix it's name with the repository name, for example `repo1-path`). Also, if your S3-compatible storage requires additional repository options for the pgBackRest tool, you can specify these parameters in the same `backups.pgbackrest.global` subsection with standard pgBackRest option names, also prefixed with the repository name.

aws Amazon S3 storage

For example, the S3 storage for the `repo2` repository looks as follows:

```
...
backups:
  pgbackrest:
    ...
    configuration:
      - secret:
          name: cluster1-pgbackrest-secrets
    ...
    global:
      repo2-path: /pgbackrest/postgres-operator/cluster1/repo2
    ...
    repos:
    - name: repo2
      s3:
        bucket: "<YOUR_AWS_S3_BUCKET_NAME>"
        region: "<YOUR_AWS_S3_REGION>"
```

Using AWS EC2 instances for backups makes it possible to automate access to AWS S3 buckets based on IAM roles for Service Accounts with no need to specify the S3 credentials explicitly.

To use this feature, add annotation to the spec part of the Custom Resource and also add pgBackRest custom configuration option to the backups subsection as follows:

```
spec:
  crVersion: 2.8.1
  metadata:
    annotations:
      eks.amazonaws.com/role-arn: arn:aws:iam::1191:role/role-pgbackrest-access-s3-
bucket
  ...
  backups:
    pgbackrest:
      image: percona/percona-postgresql-operator:2.8.1-ppg16-pgbackrest
      global:
        repo2-s3-key-type: web-id
```

S3-compatible storage

For example, the S3-compatible storage for the `repo2` repository looks as follows:

```
...
backups:
  pgbackrest:
    ...
    configuration:
      - secret:
          name: cluster1-pgbackrest-secrets
    ...
    global:
      repo2-path: /pgbackrest/postgres-operator/cluster1/repo2
      repo2-storage-verify-tls=y
      repo2-s3-uri-style: path
    ...
    repos:
    - name: repo2
      s3:
        bucket: "<YOUR_AWS_S3_BUCKET_NAME>"
        endpoint: "<YOUR_AWS_S3_ENDPOINT>"
        region: "<YOUR_AWS_S3_REGION>"
```

The `repo2-storage-verify-tls` option in the above example enables TLS verification for pgBackRest (when set to `y` or simply omitted) or disables it, when set to `n`.

The `repo2-s3-uri-style` option should be set to `path` if you use S3-compatible storage (otherwise you might see “host not found error” in your backup job logs), and is not needed for Amazon S3.

5. Create or update the cluster. Replace the `<namespace>` placeholder with your value:

```
kubectl apply -f deploy/cr.yaml -n <namespace>
```

Google Cloud Storage

To use Google Cloud Storage (GCS) as an object store for backups, you need the following information:

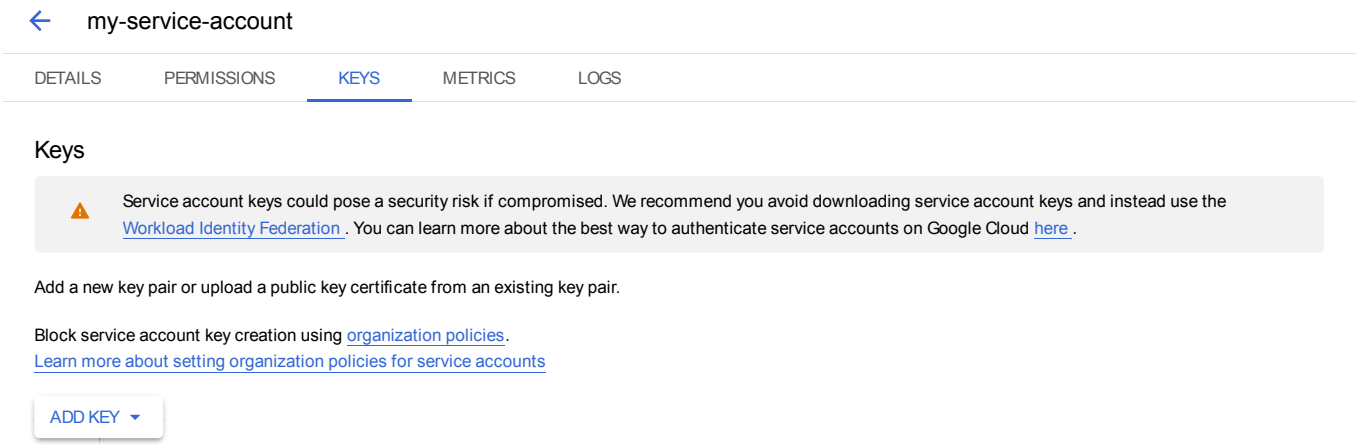
- a proper GCS bucket name. Pass the bucket name to `pgBackRest` via the `gcs.bucket` key in the `backups.pgbackrest.repos` subsection of `deploy/cr.yaml`.
- your service account key for the Operator to access the storage.

Configuration steps

1. Create your service account key following the official Google Cloud instructions.

2. Export this key from your Google Cloud account.

   You can find your key in the Google Cloud console (select *IAM & Admin* → *Service Accounts* in the left menu panel, then click your account and open the *KEYS* tab):



   Click the *ADD KEY* button, choose *Create new key* and choose *JSON* as a key type. These actions will result in downloading a file in JSON format with your new private key and related information (for example, `gcs-key.json`).

3. Create the Kubernetes Secret. The Secret consists of base64-encoded versions of two files: the `gcs-key.json` file with the Google service account key you have just downloaded, and the special `gcs.conf` configuration file.

   - Create the `gcs.conf` configuration file. The file contents depends on the repository name for backups in the `deploy/cr.yaml` file. In case of the `repo3` repository, it looks as follows:

     ```
     [global]
     repo3-gcs-key=/etc/pgbackrest/conf.d/gcs-key.json
     ```

   - Encode both `gcs-key.json` and `gcs.conf` files.

     Linux

     ```
     base64 --wrap=0 <filename>
     ```

     MacOS

     ```
     base64 -i <filename>
     ```

   - Create the Kubernetes Secret configuration file and specify your cluster name and the base64-encoded contents of the files from previous steps. The following is the example of the `cluster1-pgbackrest-secrets.yaml` Secret file:

     ```
     apiVersion: v1
     kind: Secret
     metadata:
       name: cluster1-pgbackrest-secrets
     type: Opaque
     data:
       gcs-key.json: <base64-encoded-json-file-contents>
       gcs.conf: <base64-encoded-conf-file-contents>
     ```

   Info This Secret can store credentials for several repositories presented as separate data keys.

4. Create the Secrets object from the Secret configuration file. Replace the `<namespace>` placeholder with your value:

```
kubectl apply -f cluster1-pgbackrest-secrets.yaml -n <namespace>
```

5. Update your `deploy/cr.yaml` configuration. Specify your GCS credentials Secret in the `backups.pgbackrest.configuration` subsection, and put GCS bucket name into the `bucket` option in the `backups.pgbackrest.repos` subsection. The repository name must be the same as the name you specified when you created the `gcs.conf` file.

   Also, provide pgBackRest the directory path for backup on the storage. You can pass it in the backups.pgbackrest.global subsection via the pgBackRest `path` option (prefix it's name with the repository name, for example `repo3-path`).

   For example, GCS storage configuration for the `repo3` repository would look as follows:

```
...
backups:
  pgbackrest:
    ...
    configuration:
      - secret:
          name: cluster1-pgbackrest-secrets
    ...
    global:
      repo3-path: /pgbackrest/postgres-operator/cluster1/repo3
    ...
    repos:
    - name: repo3
      gcs:
        bucket: "<YOUR_GCS_BUCKET_NAME>"
```

6. Create or update the cluster. Replace the `<namespace>` placeholder with your value:

```
kubectl apply -f deploy/cr.yaml -n <namespace>
```

Azure Blob Storage (tech preview)

To use Microsoft Azure Blob Storage for storing backups, you need the following:

- a proper Azure container name.

- Azure Storage credentials. These are stored in an encoded form in the Kubernetes Secret.

Configuration steps

1. Encode the Azure Storage credentials and the pgBackRest repo name that you will use for backups with base64. In this example, we are using `repo4`.

   Linux

   ```
   cat <<EOF | base64 --wrap=0
   [global]
   repo4-azure-account=<AZURE_STORAGE_ACCOUNT_NAME>
   repo4-azure-key=<AZURE_STORAGE_ACCOUNT_KEY>
   EOF
   ```

   macOS

   ```
   cat <<EOF | base64
   [global]
   repo4-azure-account=<AZURE_STORAGE_ACCOUNT_NAME>
   repo4-azure-key=<AZURE_STORAGE_ACCOUNT_KEY>
   EOF
   ```

2. Create the Secret configuration file and specify the base64-encoded string from the previous step. The following is the example of the `cluster1-pgbackrest-secrets.yaml` Secret file:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: cluster1-pgbackrest-secrets
   type: Opaque
   data:
     azure.conf: <base64-encoded-configuration-contents>
   ```

   Note

   This Secret can store credentials for several repositories presented as separate data keys.

3. Create the Secrets object from this yaml file. Replace the `<namespace>` placeholder with your value:

```
kubectl apply -f cluster1-pgbackrest-secrets.yaml -n <namespace>
```

4. Update your deploy/cr.yaml configuration. Specify the Secret file you have created in the previous step in the `backups.pgbackrest.configuration` subsection. Put Azure container name in the `backups.pgbackrest.repos` subsection under the repository name that you intend to use for backups. This name must match the name you used when you encoded Azure credentials on step 1.

   Also, provide pgBackRest the directory path for backup on the storage. You can pass it in the backups.pgbackrest.global subsection via the pgBackRest `path` option (prefix it's name with the repository name, for example `repo4-path`).

   For example, the Azure storage for the `repo4` repository looks as follows.

```
...
backups:
  pgbackrest:
    ...
    configuration:
      - secret:
          name: cluster1-pgbackrest-secrets
    ...
    global:
      repo4-path: /pgbackrest/postgres-operator/cluster1/repo4
    ...
    repos:
    - name: repo4
      azure:
        container: "<YOUR_AZURE_CONTAINER>"
```

5. Create or update the cluster. Replace the `<namespace>` placeholder with your value:

```
kubectl apply -f deploy/cr.yaml -n <namespace>
```

Persistent Volume

Percona Operator for PostgreSQL uses Kubernetes Persistent Volumes to store Postgres data. You can also use them to store backups. A Persistent volume is created at the same time when the Operator creates PostgreSQL cluster for you. You can find the Persistent Volume configuration in the `backups.pgbackrest.repos` section of the `cr.yaml` file under the `repo1` name:

```
        ...
backups:
  pgbackrest:
    ...
    global:
      repo1-path: /pgbackrest/postgres-operator/cluster1/repo1
    ...
    repos:
    - name: repo1
        volume:
          volumeClaimSpec:
            accessModes:
            - ReadWriteOnce
            resources:
              requests:
                storage: 1Gi
```

This configuration is sufficient to make a backup.

Next steps

- Make an on-demand backup
- Make a scheduled backup

Make scheduled backups

Backups schedule is defined on the per-repository basis in the `backups.pgbackrest.repos` subsection of the `deploy/cr.yaml` file.

You can supply each repository with a `schedules.<backup type>` key equal to an actual schedule that you specify in crontab format.

1. Before you start, make sure you have configured a backup storage.
2. Configure backup schedule in the `deploy/cr.yaml` file. The schedule is specified in crontab format as explained in Custom Resource options. The repository name must be the same as the one you defined in the backup storage configuration. The following example shows the schedule for `repo1` repository:

```
...
backups:
  pgbackrest:
  ...
        repos:
        - name: repo1
          schedules:
            full: "0 0 * * 6"
            differential: "0 1 * * 1-6"
          ...
```

1. Update the cluster:

```
kubectl apply -f deploy/cr.yaml
```

Next steps

Restore from a backup

Useful links

Backup retention

Making on-demand backups

To make an on-demand backup manually, you need a backup configuration file. You can use the example of the backup configuration file deploy/backup.yaml:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGBackup
metadata:
  name: backup1
spec:
  pgCluster: cluster1
  repoName: repo1
#  options:
#  - --type=full
```

Here's a sequence of steps to follow:

1. Before you start, make sure you have configured a backup storage.
2. In the `deploy/backup.yaml` configuration file, specify the cluster name and the repository name to be used for backups. The repository name must be the same as the one you defined in the backup storage configuration. It must also match the repository name specified in the `backups.pgbackrest.manual` subsection of the `deploy/cr.yaml` file.
3. If needed, you can add any pgBackRest command line options.
4. Make a backup with the following command (modify the `-n postgres-operator` parameter if your database cluster resides in a different namespace):

   ```
   kubectl apply -f deploy/backup.yaml -n postgres-operator
   ```

   Expected output

   ```
   perconapgbackup.pgv2.percona.com/backup1 created
   ```

5. Making a backup takes time. Use the `kubectl get pg-backup` command to track the backup progress. When finished, backup should obtain the `Succeeded` status:

   ```
   kubectl get pg-backup backup1 -n postgres-operator
   ```

Expected output

```
NAME      CLUSTER    REPO    DESTINATION    STATUS       TYPE   COMPLETED   AGE
backup1   cluster1   repo1                  Succeeded    incr   3m38s       3m53s
```

Tip

To list available backups, run:

```
kubectl get pg-backup -n postgres-operator
```

Next steps

Restore from a backup

Useful links

Backup retention

Restore the cluster from a previously saved backup

The Operator supports the ability to perform a full restore on a PostgreSQL cluster as well as a point-in-time-recovery. There are two ways to restore a cluster:

- restore to a new cluster using the dataSource.postgresCluster subsection,
- restore in-place to an existing cluster (note that this is destructive).

Restore to a new PostgreSQL cluster

Restoring to a new PostgreSQL cluster allows you to take a backup and create a new PostgreSQL cluster that can run alongside an existing one. There are several scenarios where using this technique is helpful:

- Creating a copy of a PostgreSQL cluster that can be used for other purposes. Another way of putting this is *creating a clone*.
- Restore to a point-in-time and inspect the state of the data without affecting the current cluster.

To create a new PostgreSQL cluster from either an active one, or a former cluster whose pgBackRest repository still exists, edit the dataSource.postgresCluster subsection options in the Custom Resource manifest of the *new cluster* (the one you are going to create). The content of this subsection should copy the `backups` keys of the original cluster - ones needed to carry on the restore:

- `dataSource.postgresCluster.clusterName` should contain the source cluster name,
- `dataSource.postgresCluster.clusterNamespace` should contain the namespace of the source cluster (it is needed if the new cluster will be created in a different namespace, and **you will need the Operator deployed in multi-namespace/cluster-wide mode to make such cross-namespace restore**),
- `dataSource.postgresCluster.options` allow you to set the needed pgBackRest command line options,
- `dataSource.postgresCluster.repoName` should contain the name of the pgBackRest repository, while the actual storage configuration keys for this repository should be placed into `dataSource.pgbackrest.repo` subsection,
- `dataSource.pgbackrest.configuration.secret.name` should contain the name of a

Kubernetes Secret with credentials needed to access cloud storage, if any.

The following example bootstraps a new cluster from a backup, which was made on the `cluster1` cluster deployed in `percona-db-1` namespace. For simplicity, this backup uses `repo1` repository from the Persistent Volume backup storage example, which needs no cloud credentials. The resulting `deploy/cr.yaml` manifest for the *new* cluster should contain the following lines:

```
...
dataSource:
  postgresCluster:
    clusterName: cluster1
    repoName: repo1
    clusterNamespace: percona-db-1
...
```

Creating the new cluster in its namespace (for example, `percona-db-2`) with such a manifest will initiate the restoration process:

```
kubectl apply -f deploy/cr.yaml -n percona-db-2
```

Restore to an existing PostgreSQL cluster

To restore the previously saved backup, use a *backup restore* configuration file. The example of the backup configuration file is deploy/restore.yaml:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGRestore
metadata:
  name: restore1
spec:
  pgCluster: cluster1
  repoName: repo1
  options:
  - --type=time
  - --target="2022-11-30 15:12:11+03"
```

The following keys are the most important ones:

- `pgCluster` specifies the name of your cluster,
- `repoName` specifies the name of one of the 4 pgBackRest repositories, already configured in the `backups.pgbackrest.repos` subsection,

- `options` passes through any pgBackRest command line options.

To start the restoration process, run the following command (modify the `-n postgres-operator` parameter if your database cluster resides in a different namespace):

```
kubectl apply -f deploy/restore.yaml -n postgres-operator
```

Specifying which backup to restore

When there are multiple backups, the Operator will restore the latest full backup by default.

if you want to restore to some previous backup, not the last one, follow these steps:

1. Find the label of the backup you want to restore. For this, you can list available backups with `kubectl get pg-backup` command, and then get detailed information about the backup of your interest with `kubectl describe pg-backup <BACKUP NAME>`. The output should look as follows:

   ```
   Name:         cluster1-backup-c55w-f858g
   Namespace:    default
   Labels:       <none>
   Annotations:  pgv2.percona.com/pgbackrest-backup-job-name: cluster1-
   backup-c55w
                 pgv2.percona.com/pgbackrest-backup-job-type: replica-create
   API Version:  pgv2.percona.com/v2
   Kind:         PerconaPGBackup
   Metadata:
     Creation Timestamp:  2024-06-28T07:44:08Z
     Generate Name:       cluster1-backup-c55w-
     Generation:          1
     Resource Version:    1199
     UID:                 92a8193c-6cbd-4cdf-82e5-a4623bf7f2d9
   Spec:
     Pg Cluster:  cluster1
     Repo Name:   repo1
   Status:
     Backup Name:  20240628-074416F
     Backup Type:  full
   ...
   ```

   The “Backup Name” status field will contain needed backup label.

2. Now use a *backup restore* configuration file with additional `--set=<backup_label>` pgBackRest option. For example, the following yaml file will result in restoring to a backup labeled `20240628-074416F`:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGRestore
metadata:
  name: restore1
spec:
  pgCluster: cluster1
  repoName: repo1
  options:
  - --type=immediate
  - --set=20240628-074416F
```

3. Start the restoration process, as usual:

```
kubectl apply -f deploy/restore.yaml -n postgres-operator
```

Restore the cluster with point-in-time recovery

Point-in-time recovery functionality allows users to revert the database back to a state before an unwanted change had occurred.

> **Note**
>
> For this feature to work, the Operator initiates a full backup immediately after the cluster creation, to use it as a basis for point-in-time recovery when needed (this backup is not listed in the output of the `kubectl get pg-backup` command).

You can set up a point-in-time recovery using the normal restore command of pgBackRest with few additional `spec.options` fields in `deploy/restore.yaml`:

- set `--type` option to `time`,
- set `--target` to a specific time you would like to restore to. You can use the typical string formatted as `<YYYY-MM-DD HH:MM:DD>`, optionally followed by a timezone offset: `"2021-04-16 15:13:32+00"` (`+00` in the above example means UTC),

- optional `--set` argument followed with a pgBackRest backup ID allows you to choose the backup which will be the starting point for point-in-time recovery. This option must be specified if the target is one or more backups away from the current moment. You can look through the available backups with the pgBackRest info command to find out the proper backup ID.

pgBackRest backup ID example

After obtaining the Pod name with `kubectl get pods` command, you can run `pgbackrest --stanza=db info` command on the appropriate Pod as follows:

```
kubectl -n postgres-operator exec -it cluster1-instance1-hcgr-0 -c database --
pgbackrest --stanza=db info
```

Then find ID of the needed backup in the output:

```
stanza: db
    status: ok
    cipher: none

    db (prior)
        wal archive min/max (16): 0000000F000000000000001C/0000002000000036000000C5

        full backup: 20240401-173403F
            timestamp start/stop: 2024-04-01 17:34:03+00 / 2024-04-01 17:36:57+00
            wal start/stop: 0000001200000000000000022 / 0000001200000000000000024
            database size: 31MB, database backup size: 31MB
            repo1: backup set size: 4.1MB, backup size: 4.1MB

        incr backup: 20240401-173403F_20240415-201250I
            timestamp start/stop: 2024-04-15 20:12:50+00 / 2024-04-15 20:14:19+00
            wal start/stop: 000000190000000000000005C / 000000190000000000000005D
            database size: 46.0MB, database backup size: 25.7MB
            repo1: backup set size: 6.1MB, backup size: 3.8MB
            backup reference list: 20240401-173403F

        incr backup: 20240401-173403F_20240415-201430I
...
```

Now you can put this backup ID to the *backup restore* configuration file as follows:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGRestore
metadata:
  name: restore1
spec:
  pgCluster: cluster1
  repoName: repo1
  options:
  - --set="20240401-173403F"
```

The example may look as follows:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGRestore
metadata:
  name: restore1
spec:
  pgCluster: cluster1
  repoName: repo1
  options:
  - --type=time
  - --target="2022-11-30 15:12:11+03"
```

Note

Latest succeeded backup available with the `kubectl get pg-backup` command has a “Latest restorable time” information field handy when selecting a backup to restore. Tracking latest restorable time is turned on by default, and you can easily query the backup for this information as follows:

```
kubectl get pg-backup <backup_name> -n postgres-operator -o
jsonpath='{.status.latestRestorableTime}'
```

After setting these options in the *backup restore* configuration file, start the restoration process:

```
kubectl apply -f deploy/restore.yaml -n postgres-operator
```

Note

Make sure you have a backup that is older than your desired point in time. You obviously can’t restore from a time where you do not have a backup. All relevant write-ahead log files must be successfully pushed before you make the restore.

Providing pgBackRest with a custom restore command

There may be cases where it is needed to control what files are restored from the backup and apply fine-grained filtering to them. For such scenarios there is a possibility to overwrite the restore_command used in PosgreSQL archive recovery. You can do it in the `patroni.dynamicConfiguration` subsection of the Custom Resource as follows:

```
patroni:
  dynamicConfiguration:
    postgresql:
      parameters:
        restore_command: "pgbackrest --stanza=db archive-get %f \"%p\""
```

The `%f` template in the above example is replaced by the name of the file to retrieve from the archive, and `%p` is replaced by the copy destination path name on the server. See PostgreSQL official documentation for more low-level details about this feature.

Fix the cluster if the restore fails

The restore process changes database files, and therefore restoring wrong information or causing restore fail by misconfiguring can put the database cluster in non-operational state.

For example, adding wrong pgBackRest arguments to `PerconaGPRestore` custom resource breaks existing database installation while the restore hangs.

In this case it's possible to remove the *restore annotation* from the Custom Resource correspondent to your cluster. Supposing that your cluster `cluster1` was deployed in `postgres-operator` namespace, you can do it with the following command:

```
kubectl annotate -n postgres-operator pg cluster1 postgres-
operator.crunchydata.com/pgbackrest-restore-
```

Alternatively, you can temporarily delete the database cluster by removing the Custom Resource (check the `finalizers.percona.com/delete-pvc` finalizer is not turned on, otherwise you will not retain your data!), and recreate the cluster back by running `kubectl apply -f deploy/cr.yaml -n postgres-operator` command you have used to deploy the it previously.

One more reason of failed restore to consider is the possibility of a corrupted backup repository or missing files. In this case, you may need to delete the database cluster by removing the Custom Resource, find the startup PVC to delete it and recreate again.

Configure backup encryption

Backup encryption is a security best practice that helps protect your organization's confidential information and prevents unauthorized access.

The pgBackRest tool used by the Operator allows encrypting backups using AES-256 encryption. The approach is **repository-based**: pgBackRest encrypts the whole repository where it stores backups. Encryption is enabled if a user-supplied encryption key was passed to pgBackRest with the `-repo-cypher-pass` option *when configuring the backup storage*.

⚠ **Limitation:** You cannot change encryption settings after the backups are established. You must create a new repository to enable encryption or change the encryption key.

This document describes how to configure backup encryption.

Generate the encryption key

You should use a long, random encryption key. You can generate it using OpenSSL as follows:

```
openssl rand -base64 48
```

Configure backup storage

Follow the general backup storage configuration instruction relevant to the backup storage you are using. The only difference is in encoding your cloud credentials and the pgBackRest repository name to be used for backups: you also add the encryption key to the configuration file as the `repo-cipher-pass` option. The repo name within the option must match the pgBackRest repo name.

The following example shows the configuration for S3-compatible storage and the pgBackRest repo name `repo2` (other cloud storages are configured similarly).

1. Encode the storage configuration file.

Linux

```
cat <<EOF | base64 --wrap=0
[global]
repo2-s3-key=<YOUR_AWS_S3_KEY>
repo2-s3-key-secret=<YOUR_AWS_S3_KEY_SECRET>
repo2-cipher-pass=<YOUR_ENCRYPTION_KEY>
EOF
```

macOS

```
cat <<EOF | base64
[global]
repo2-s3-key=<YOUR_AWS_S3_KEY>
repo2-s3-key-secret=<YOUR_AWS_S3_KEY_SECRET>
repo2-cipher-pass=<YOUR_ENCRYPTION_KEY>
EOF
```

2. Create the Secrets configuration file and the Secrets object as described in steps 2-3 of the S3-compatible backup storage configuration. Follow the instructions relevant to the backup storage you are using.
3. Update the `deploy/cr.yaml` configuration. Specify the following information:
   - The Secret name you created in the `backups.pgbackrest.configuration` subsection
   - All storage-related information in the `backups.pgbackrest.repos` subsection under the repository name that you intend to use for backups. This name must match the name you used when you encoded S3 credentials on step 1.
   - The cipher type in the `pgbackrest.global` subsection

   The following example shows the configuration for the S3-compatible storage and the pgBackRest repo name `repo2`:

```
backups:
  pgbackrest:
    ...
    configuration:
      - secret:
          name: cluster1-pgbackrest-secrets
    ...
    repos:
    - name: repo2
      s3:
        bucket: "<YOUR_AWS_S3_BUCKET_NAME>"
        endpoint: "<YOUR_AWS_S3_ENDPOINT>"
        region: "<YOUR_AWS_S3_REGION>"
    global:
      cipher-type: aes-256-cbc
```

4. Apply the changes. Replace the `<namespace>` placeholder with your value.

```
kubectl apply -f deploy/cr.yaml -n <namespace>
```

Make a backup

Make an on-demand backup | Make a scheduled backup

Speed-up backups with pgBackRest asynchronous archiving

Backing up a database with high write-ahead logs (WAL) generation can be rather slow, because PostgreSQL archiving process is sequential, without any parallelism or batching. In extreme cases backup can be even considered unsuccessful by the Operator because of the timeout.

The pgBackRest tool used by the Operator can, if necessary, solve this problem by using the WAL asynchronous archiving feature.

You can set up asynchronous archiving in your storage configuration file for pgBackRest. Turn on the additional `archive-async` flag, and set the `process-max` value for `archive-push` and `archive-get` commands. Your storage configuration file may look as follows:

s3.conf

```
[global]
repo2-s3-key=REPLACE-WITH-AWS-ACCESS-KEY
repo2-s3-key-secret=REPLACE-WITH-AWS-SECRET-KEY
repo2-storage-verify-tls=n
repo2-s3-uri-style=path
archive-async=y
spool-path=/pgdata

[global:archive-get]
process-max=2

[global:archive-push]
process-max=4
```

No modifications are needed aside of setting these additional parameters. You can find more information about WAL asynchronous archiving in gpBackRest official documentation and in this blog post.

Backup retention

The Operator supports setting pgBackRest retention policies for full and differential backups. When a full backup expires according to the retention policy, pgBackRest cleans up all the files related to this backup and to the write-ahead log. Thus, the expiration of a full backup with some incremental backups based on it results in expiring of all these incremental backups.

You can control backup retention by the following `pgBackRest` options:

- `--<repo name>-retention-full` number of full backups to retain,
- `--<repo name>-retention-diff` number of differential backups to retain.

You can also specify retention type for full backups as `<repo name>-retention-full-type`, setting it to either `count` (the number of full backups to keep) or `time` (the number of days to keep a backup for).

You can set both backup type and retention policy for each of 4 repositories as follows.

```
backups:
    pgbackrest:
...
      global:
        repo1-retention-full: "14"
        repo1-retention-full-type: time
        ...
```

Differential retention can be set in a similar way:

```
backups:
    pgbackrest:
...
      global:
        repo1-retention-diff: "3"
        ...
```

Delete the unneeded backup

The maximum amount of stored backups is controlled by the retention policies. Older backups are automatically deleted.

Manual deleting of a previously saved backup requires not more than the backup name. This name can be taken from the list of available backups returned by the following command:

```
kubectl get pg-backup
```

When the name is known, backup can be deleted as follows:

```
kubectl delete pg-backup/<backup-name>
```

Delete backups on cluster deletion

You can enable `percona.com/delete-backups` finalizer in the Custom Resource (turned off by default) to ensure that all backups are removed when the cluster is deleted. If the finalizer is enabled, the Operator will delete all the backups from all the configured repos on cluster deletion. Besides removing all the physical backup files, finalizer will also delete all `pg-backup` objects.

Warning

This `percona.com/delete-backups` finalizer is in tech preview state, and it is not yet recommended for production environments.

Disable backups

The recommended approach to deploy and run the database is with the disaster recovery strategy in mind. Therefore, the Operator is designed and running with the backups enabled by default.

There are some specific use cases when you may wish to run a database without enabled backups. Disabling backups should be a conscious decision based on your data's value and recoverability. These are example use cases where it is considered acceptable are when the data is fully disposable:

- Ephemeral development/testing environments: For clusters that are frequently torn down and rebuilt from application code or test data scripts.
- CI/CD pipeline jobs: For automated pipeline runs where the cluster's entire lifecycle is temporary and tied to a single job.

Key considerations before disabling backups

Before you proceed with disabling backups, here's what you need to know and carefully assess:

1. Without backups you have no way to restore data. If by mistake you drop a table, that data is lost as you have no option to recover it.
2. You cannot clone a cluster when you deploy a standby cluster for disaster recovery. This is because cloning is based on restoring a backup on a new cluster.
3. When you run a cluster without backups, `pgBackRest` metrics are unavailable.

Start a new cluster with disabled backups

To deploy a new cluster without backups, do the following:

1. Clone the Operator repository to be able to edit resource manifests.

   ```
   git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
   ```

2. Edit the `deploy/cr.yaml` Custom Resource and set the `backups.enabled` option to `false`

```
spec:
  backups:
    enabled: false
```

3. Apply the Custom Resource to start the cluster creation.

```
kubectl apply -f deploy/cr.yaml -n <namespace>
```

Disable backups for a running cluster

Before you start, read the considerations carefully.

To disable backups for a running cluster, update the `deploy/cr.yaml` Custom Resource manifest with the following configuration:

- Set the `backups.enabled` option to `false`
- Add the annotation `pgv2.percona.com/authorizeBackupRemoval:"true"`

Since it is a running cluster, we will use the `kubectl patch` command to update its configuration:

```
kubectl patch pg cluster1 --type merge \
  -p '{
    "metadata": {
      "annotations": {
        "pgv2.percona.com/authorizeBackupRemoval": "true"
      }
    },
    "spec": {
      "backups": {
        "enabled": false
      }
    }
  }' -n <namespace>
```

Warning

After you apply this configuration and disable backups, the Operator deletes the `repo-host` PVC. Thus, all data that was stored in that PVC will be deleted too. The backups stored on the cloud backup storage remain.

Re-enable backups

To re-enable backups for a running cluster, do the following:

1. Remove the annotation `pgv2.percona.com/authorizeBackupRemoval:"true"`

   ```
   kubectl annotate pg cluster1 pgv2.percona.com/authorizeBackupRemoval-
   ```

2. Apply the patch to your running cluster and enable backups:

   ```
   kubectl patch pg cluster1 --type merge \
     -p '{
       "spec": {
         "backups": {
           "enabled": true
         }
       }
     }'
   ```

Deploy a standby cluster for Disaster Recovery

How to deploy a standby cluster for Disaster Recovery

Disaster recovery is not optional for businesses operating in the digital age. With the ever-increasing reliance on data, system outages or data loss can be catastrophic, causing significant business disruptions and financial losses.

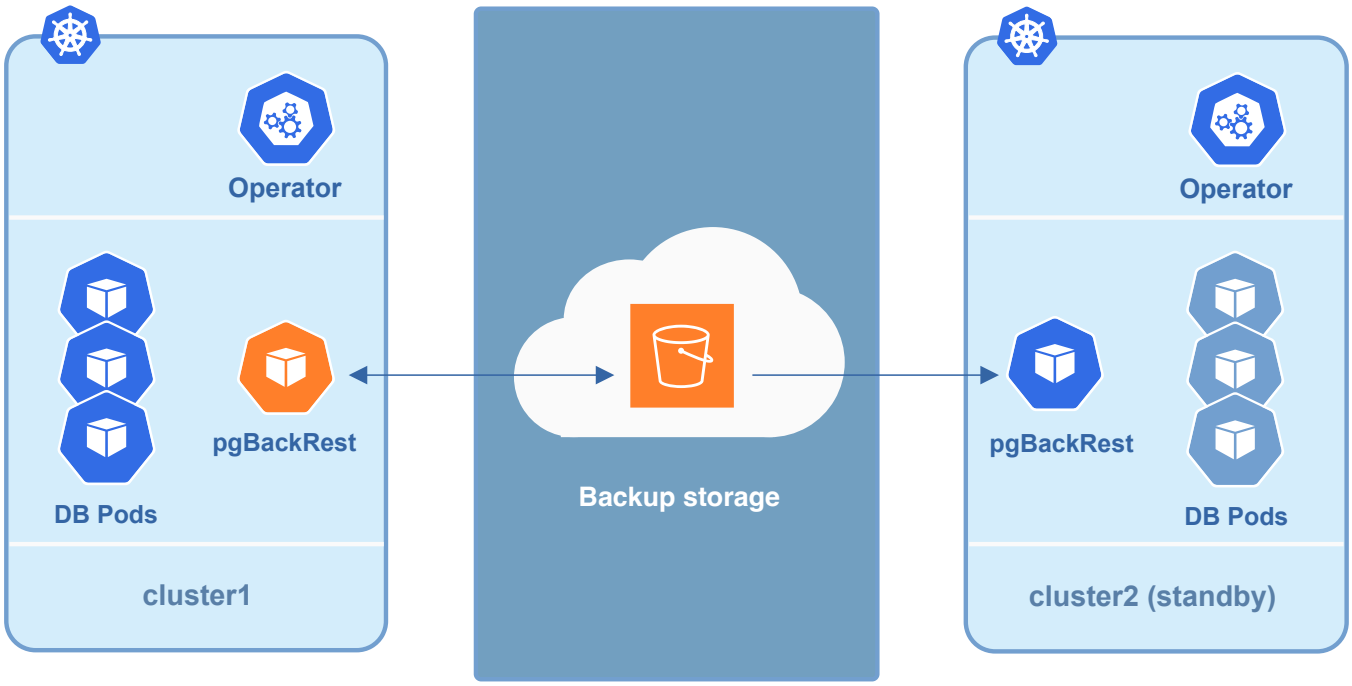
With multi-cloud or multi-regional PostgreSQL deployments, the complexity of managing disaster recovery only increases. This is where the Percona Operators come in, providing a solution to streamline disaster recovery for PostgreSQL clusters running on Kubernetes. With the Percona Operators, businesses can manage multi-cloud or hybrid-cloud PostgreSQL deployments with ease, ensuring that critical data is always available and secure, no matter what happens.

Operators automate routine tasks and remove toil. For standby, the Percona Operator for PostgreSQL version 2 provides the following options:

1. pgBackrest repo based standby. The standby cluster will be connected to a pgBackRest cloud repo, so it will receive WAL files from the repo and apply them to the database.
2. Streaming replication. The standby cluster will use an authenticated network connection to the primary cluster to receive WAL records directly.
3. Combination of (1) and (2). The standby cluster is configured for both repo-based standby and streaming replicaton. It bootstraps from the pgBackRest repo and continues to receive WAL files as they are pushed to the repo, and can also directly receive them from primary. Using this approach ensures the cluster will still be up to date with the pgBackRest repo if streaming falls behind.

Standby cluster deployment based on pgBackRest

The pgBackRest repo-based standby is the simplest one. The following is the architecture diagram:



pgBackrest repo based standby

1. This solution describes two Kubernetes clusters in different regions, clouds or running in hybrid mode (on-premises and cloud). One cluster is Main and the other is Disaster Recovery (DR)
2. Each cluster includes the following components:
    a. Percona Operator
    b. PostgreSQL cluster
    c. pgBackrest
    d. pgBouncer
3. pgBackrest on the Main site streams backups and Write Ahead Logs (WALs) to the object storage
4. pgBackrest on the DR site takes these backups and streams them to the standby cluster

Deploy disaster recovery for PostgreSQL on Kubernetes

Configure Main site

1. Deploy the Operator using your favorite method. Once installed, configure the Custom Resource manifest, so that pgBackrest starts using the Object Storage of your choice. Skip this step if you already have it configured.
2. Configure the `backups.pgbackrest.repos` section by adding the necessary configuration. The below example is for Google Cloud Storage (GCS):

   ```
   spec:
     backups:
       configuration:
         - secret:
             name: main-pgbackrest-secrets
       pgbackrest:
         repos:
         - name: repo1
           gcs:
             bucket: MY-BUCKET
   ```

   The `main-pgbackrest-secrets` value contains the keys for GCS. Read more about the configuration in the backup and restore tutorial.
3. Once configured, apply the custom resource:

   ```
   kubectl apply -f deploy/cr.yaml
   ```

   Expected output

   ```
   perconapgcluster.pg.percona.com/standby created
   ```

   The backups should appear in the object storage. By default pgBackrest puts them into the pgbackrest folder.

Configure DR site

The configuration of the disaster recovery site is similar to that of the Main site, with the only difference in standby settings.

The following manifest has `standby.enabled` set to `true` and points to the `repoName` where backups are (GCS in our case):

```
metadata:
  name: standby
spec:
...
  backups:
    configuration:
      - secret:
          name: standby-pgbackrest-secrets
    pgbackrest:
      repos:
      - name: repo1
        gcs:
          bucket: MY-BUCKET
  standby:
    enabled: true
    repoName: repo1
```

Deploy the standby cluster by applying the manifest:

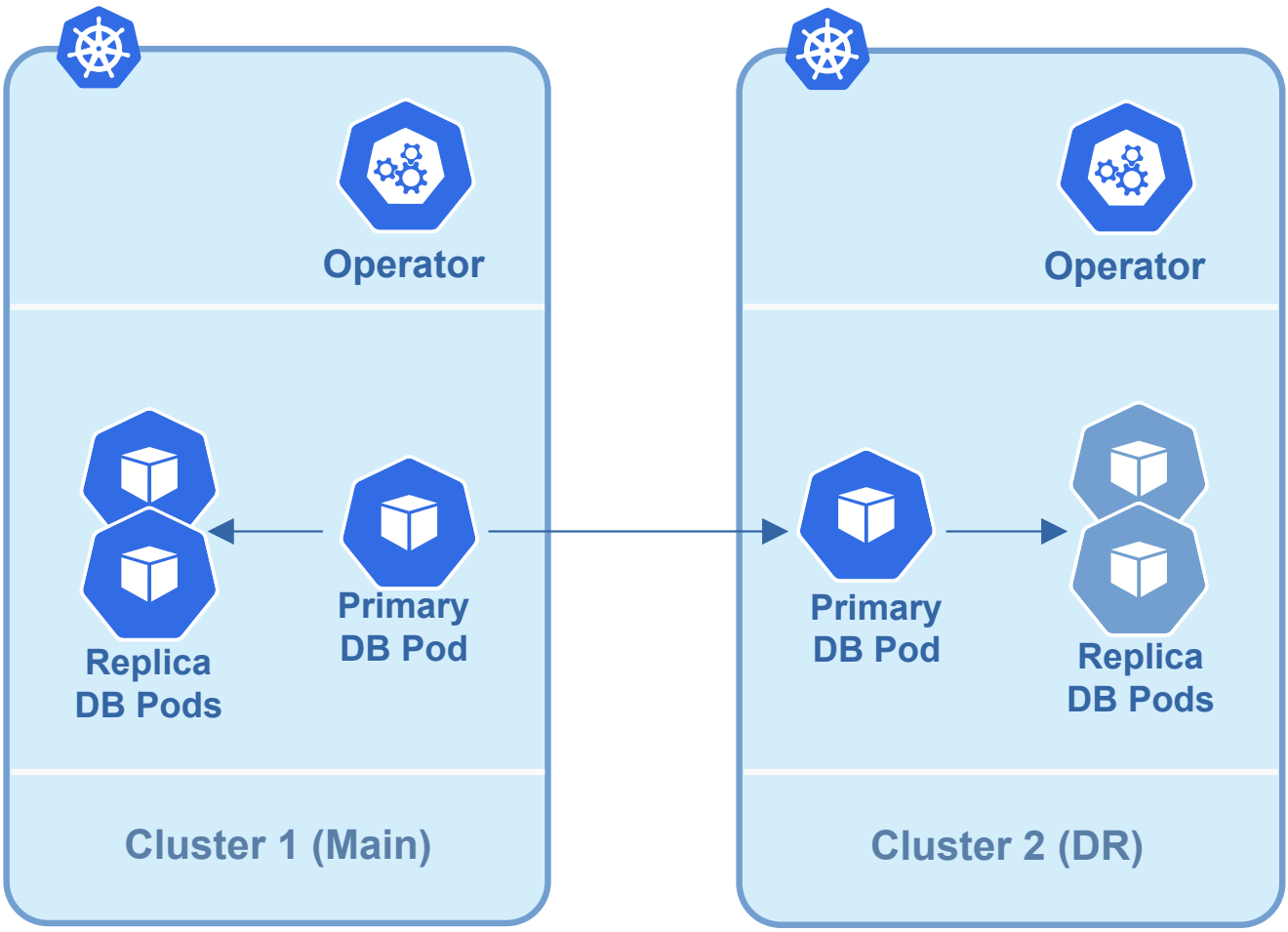
```
kubectl apply -f deploy/cr.yaml
```

Expected output

```
perconapgcluster.pg.percona.com/standby created
```

Standby cluster deployment based on streaming replication

The following diagram explains how the standby based on streaming replication works:



1. This solution describes two Kubernetes clusters in different regions, clouds, data centers or even two namespaces, or running in hybrid mode (on-premises and cloud). One cluster is Main site, and the other is Disaster Recovery site (DR)
2. Each site supposedly includes Percona Operator and for sure includes PostgreSQL cluster.
3. In the DR site the cluster is in Standby mode
4. We set up streaming replication between these two clusters

Deploy disaster recovery for PostgreSQL on Kubernetes

Configure Main site

1. Deploy the Operator using your favorite method.
2. The Main cluster needs to expose it, so that standby can connect to the primary PostgreSQL instance. To expose the primary PostgreSQL instance, use the `spec.expose` section:

   ```
   spec:
     ...
     expose:
       type: ClusterIP
   ```

   Use here a Service type of your choice. For example, `ClusterIP` is sufficient for two clusters in different Kubernetes namespaces.
3. Once configured, apply the custom resource:

   ```
   kubectl apply -f deploy/cr.yaml -n main-pg
   ```

   Expected output

   ```
   perconapgcluster.pg.percona.com/standby created
   ```

   The service that you should use for connecting to standby is called -ha (main-ha in my case):

   ```
   main-ha          ClusterIP   10.118.227.214   <none>        5432/TCP
   163m
   ```

Configure DR site

To get the replication working, the Standby cluster would need to authenticate with the Main one. To get there, both clusters must have certificates signed by the same certificate authority (CA). Default replication user `_crunchyrepl` will be used.

In the simplest case you can copy the certificates from the Main cluster. You need to look out for two files:

- main-cluster-cert
- main-replication-cert

Copy them to the namespace where DR cluster is going to be running and reference under `spec.secrets` (in the following example they were renamed, replacing “main” with “dr”):

```
spec:
  secrets:
    customTLSSecret:
      name: dr-cluster-cert
    customReplicationTLSSecret:
      name: dr-replication-cert
```

If you are generating your own certificates, just remember the following rules:

1. Certificates for both Main and Standby clusters must be signed by the same CA
2. `customReplicationTLSSecret` must have a Common Name (CN) setting that matches `_crunchyrepl`, which is a default replication user.

You can find more about certificates in the TLS doc.

Apart from setting certificates correctly, you should also set standby configuration.

```
  standby:
    enabled: true
    host: main-ha.main-pg.svc
```

- `standby.enabled` controls if it is a standby cluster or not
- `standby.host` must point to the primary node of a Main cluster. In this example it is a `main-ha` Service in another namespace.

Deploy the standby cluster by applying the manifest:

```
kubectl apply -f dr-cr.yaml -n dr-pg
```

Expected output

```
perconapgcluster.pg.percona.com/standby created
```

Once both clusters are up, you can verify that replication is working.

1. Insert some data into Main cluster
2. Connect to the DR cluster

To connect to the DR cluster, use the credentials that you used to connect to Main. This also verifies that the connection is working. You should see whatever data you have in the Main cluster in the Disaster Recovery.

Failover

In case of the Main site failure or in other cases, you can promote the standby cluster. The promotion effectively allows writing to the cluster. This creates a net effect of pushing Write Ahead Logs (WALs) to the pgBackrest repository. It might create a split-brain situation where two primary instances attempt to write to the same repository. To avoid this, make sure the primary cluster is either deleted or shut down before trying to promote the standby cluster.

Once the primary is down or inactive, promote the standby through changing the corresponding section:

```
spec:
  standby:
    enabled: false
```

Now you can start writing to the cluster.

Split brain

There might be a case, where your old primary comes up and starts writing to the repository. To recover from this situation, do the following:

1. Keep only one primary with the latest data running
2. Stop the writes on the other one
3. Take the new full backup from the primary and upload it to the repo

Automate the failover

Automated failover consists of multiple steps and is outside of the Operator's scope. There are a few steps that you can take to reduce the Recovery Time Objective (RTO). To detect the failover we recommend having the 3rd site to monitor both DR and Main sites. In this case you can be sure that Main really failed and it is not a network split situation.

Another aspect of automation is to switch the traffic for the application from Main to Standby after promotion. It can be done through various Kubernetes configurations and heavily depends on how your networking and application are designed. The following options are quite common:

1. Global Load Balancer - various clouds and vendors provide their solutions

2. Multi Cluster Services or MCS - available on most of the public clouds
3. Federation or other multi-cluster solutions

Scale Percona Distribution for PostgreSQL on Kubernetes

One of the great advantages brought by Kubernetes is the ease of an application scaling. Scaling an application results in adding resources or Pods and scheduling them to available Kubernetes nodes.

Scaling can be vertical and horizontal. Vertical scaling adds more compute or storage resources to PostgreSQL nodes; horizontal scaling is about adding more nodes to the cluster. High availability looks technically similar, because it also involves additional nodes, but the reason is maintaining liveness of the system in case of server or network failures.

This document focuses on vertical scaling. For deploying high-availability, see High-availability guide.

Vertical scaling

Scale compute

There are multiple components that the Operator deploys and manages: PostgreSQL instances, pgBouncer connection pooler, pgBackRest and others (See Architecture for the full list of components.)

You can manage compute resources for a specific component using the corresponding section in the Custom Resource manifest. We follow the structure for requests and limits that Kubernetes provides.

The most common resources to specify are CPU and memory (RAM).

You can specify a **request** for CPU or memory for a component's Pod. In this case, the Kubernetes scheduler uses these values to decide on which Kubernetes node to place the Pod, ensuring the node has at least the requested resources available. The Pod will only be scheduled on a node that can satisfy all its resource requests.

If you specify a **limit** for the resources, this is the maximum amount of CPU or memory the container is allowed to use. If the container tries to use more than the limit, it may be throttled (for CPU) or terminated (for memory).

You can set both `requests` and `limits` in the `resources` section of your Custom Resource. For example:

```
spec:
...
  instances:
  - name: instance1
    replicas: 3
    resources:
      requests:
        cpu: 1.0
        memory: 2Gi
      limits:
        cpu: 2.0
        memory: 4Gi
```

If you only set `limits` and omit `requests`, Kubernetes will default the request to the limit value.

Use our reference documentation for the Custom Resource options for more details about other components.

Scale storage

Kubernetes manages storage with a PersistentVolume (PV), a segment of storage supplied by the administrator, and a PersistentVolumeClaim (PVC), a request for storage from a user. In Kubernetes v1.11 the feature was added to allow a user to increase the size of an existing PVC object (considered stable since Kubernetes v1.24). The user cannot shrink the size of an existing PVC object.

Scaling with Volume Expansion capability

Certain volume types support PVCs expansion (exact details about PVCs and the supported volume types can be found in Kubernetes documentation).

You can run the following command to check if your storage supports the expansion capability:

```
kubectl describe sc <storage class name> | grep AllowVolumeExpansion
```

Expected output

```
AllowVolumeExpansion: true
```

The Operator versions 2.5.0 and higher will automatically expand such storage for you when you change the appropriate options in the Custom Resource.

For example, you can do it by editing and applying the `deploy/cr.yaml` file:

```
spec:
  ...
  instances:
    ...
    dataVolumeClaimSpec:
      resources:
        requests:
          storage: <NEW STORAGE SIZE>
```

Apply changes as usual:

```
kubectl apply -f cr.yaml
```

Automated scaling with auto-growable disk

The Operator 2.5.0 and newer is able to detect if the storage usage on the PVC reaches a certain threshold, and trigger the PVC resize. Such autoscaling needs the upstream “auto-growable disk” feature turned on when deploying the Operator. This is done via the `PGO_FEATURE_GATES` environment variable set in the `deploy/operator.yaml` manifest (or in the appropriate part of `deploy/bundle.yaml`):

```
...
subjects:
- kind: ServiceAccount
  name: percona-postgresql-operator
  namespace: pg-operator
...
spec:
  containers:
  - env:
    - name: PGO_FEATURE_GATES
      value: "AutoGrowVolumes=true"
...
```

When the support for auto-growable disks is turned on, the auto grow will be working automatically if the maximum value available for the Operator to scale up is set in the `spec.instances[].dataVolumeClaimSpec.resources.limits.storage` Custom Resource option:

```
spec:
  ...
  instances:
    ...
    dataVolumeClaimSpec:
      resources:
        requests:
          storage: 1Gi
        limits:
          storage: 5Gi
```

High availability

High availability (HA) ensures that your PostgreSQL database remains accessible even in the event of node or pod failures. With the Percona Operator for PostgreSQL, high availability is achieved by running multiple PostgreSQL nodes in a cluster, using the Patroni framework for automated failover and PostgreSQL streaming replication for data consistency.

A PostgreSQL cluster consists of the following members:

- A Primary node handles all write operations. The Primary continuously streams changes to its Standby nodes.
- Read-only (Standby in PostgreSQL terminology) replicas that continuously receive and replay changes from the Primary node. If the Primary fails, one of the Standbys can be automatically promoted to become the new Primary.

Data replication

Percona Operator leverages PostgreSQL streaming replication to keep Standby nodes up-to-date.

By default, **asynchronous replication** is used: the Primary sends changes to Standbys, but does not wait for confirmation before committing transactions. This offers better performance but presents a risk of minimal data loss (transactions not yet copied to a Standby could be lost in a failure).

Synchronous replication is also supported. In this replication type the Primary waits for at least one Standby to acknowledge receipt of data before marking a transaction as committed. This minimizes the risk of data loss, but can be slightly slower since each transaction must wait for a confirmation.

Minimum and recommended number of nodes for high availability:

The absolute minimum that can technically work for high availability is **2 nodes**. But this does not provide full high availability or protection against split-brain scenarios since the loss of either node can impact availability and data safety.

The recommended number of nodes for high availability setups is **3 or more PostgreSQL nodes**.

Adding nodes to a cluster

There are two ways how to control the number replicas in your HA cluster:

1. Through changing `spec.instances.replicas` value

2. By adding new entry into `spec.instances`

Using `spec.instances.replicas`

For example, you have the following Custom Resource manifest:

```
spec:
...
  instances:
    - name: instance1
      replicas: 2
```

This will provision a cluster with two nodes - one Primary and one Replica. Add the node by changing the manifest…

```
spec:
...
  instances:
    - name: instance1
      replicas: 3
```

…and applying the Custom Resource:

```
kubectl apply -f deploy/cr.yaml
```

The Operator will provision a new replica node. It will be ready and available once data is synchronized from Primary.

Using `spec.instances`

Each instance's entry has its own set of parameters, like resources, storage configuration, sidecars, etc. When you add a new entry into instances, this creates replica PostgreSQL nodes, but with a new set of parameters. This can be useful in various cases:

- Test or migrate to new hardware
- Blue-green deployment of a new configuration
- Try out new versions of your sidecar containers

For example, you have the following Custom Resource manifest:

```
spec:
...
  instances:
    - name: instance1
      replicas: 2
      dataVolumeClaimSpec:
        storageClassName: old-ssd
        accessModes:
        - ReadWriteOnce
        resources:
          requests:
            storage: 100Gi
```

Now you have a goal to migrate to new disks, which are coming with the `new-ssd` storage class. You can create a new instance entry. This will instruct the Operator to create additional nodes with the new configuration keeping your existing nodes intact.

```
spec:
...
  instances:
    - name: instance1
      replicas: 2
      dataVolumeClaimSpec:
        storageClassName: old-ssd
        accessModes:
        - ReadWriteOnce
        resources:
          requests:
            storage: 100Gi
    - name: instance2
      replicas: 2
      dataVolumeClaimSpec:
        storageClassName: new-ssd
        accessModes:
        - ReadWriteOnce
        resources:
          requests:
            storage: 100Gi
```

Using Synchronous replication

Synchronous replication offers the ability to confirm that all changes made by a transaction have been transferred to one or more synchronous standby servers. When requesting synchronous replication, each commit of a write transaction will wait until confirmation is received that the commit has been written to the write-ahead log on disk of both the primary and standby server. The drawbacks of synchronous replication are increased latency and reduced throughput on writes.

You can turn on synchronous replication by customizing the `patroni.dynamicConfiguration` Custom Resource option.

- Enable synchronous replication by setting `synchronous_mode` option to `on`.
- Use `synchronous_node_count` option to set the number of replicas (PostgreSQL standby servers) which should operate in syncrhonous mode (the default value is `1`).

The result in your `deploy/cr.yaml` manifest may look as follows:

```
...
  patroni:
    dynamicConfiguration:
      synchronous_mode: "on"
      synchronous_node_count: 2
      ...
```

You will have the desired amount of replicas switched to synchronous replication after applying changes as usual, with `kubectl apply -f deploy/cr.yaml` command.

Find more options useful to tune how your database cluster should operate in synchronous mode in the official Patroni documentation.

Using huge pages with Percona Operator for PostgreSQL

Overview

Huge Pages (also called large or super pages) are bigger memory blocks that help reduce CPU overhead. Normally, memory is managed in 4kB chunks, also called “pages”, but when your PostgreSQL workload grows, the CPU has to juggle a lot of these small pages. By switching to larger pages like 2MiB or 1GiB, you reduce the number of pages the CPU needs to track, which can improve efficiency and performance.

For PostgreSQL clusters managed by Percona Operator for PostgreSQL, enabling huge pages is a recommended optimization, especially for memory-intensive workloads.

Why to use huge pages in PostgreSQL

PostgreSQL uses shared memory extensively for:

- Shared buffer pool
- WAL buffers
- Dynamic shared memory segments

When huge pages are enabled:

- PostgreSQL can access memory more efficiently.
- The system spends less time managing memory.
- Performance improves, especially under heavy load.

Configure huge pages for Percona Operator for PostgreSQL

Enable huge pages in your Kubernetes environment

Before configuring your cluster, make sure huge pages are enabled and available on the Kubernetes nodes. This setup is done outside the Operator and depends on your Kubernetes environment, whether you use a cloud-based Kubernetes like GKE, EKS, etc or use a bare-metal one.

Consult the Kubernetes environment's official documentation for how to enable huge pages there.

For the further setup, you need to keep in mind the following:

- What page sizes are available (e.g., 2MiB vs 1GiB)
- How many pages are preallocated
- Will other workloads compete for these pages
- Do all nodes that will run PostgreSQL pods have huge pages available
- When adding more nodes to your cluster, will they have huge pages available

Request huge pages in your cluster Custom Resource

Once your Kubernetes nodes are ready, you can configure your PostgreSQL cluster to use huge pages.

1. Set the huge pages resource limits in your `deploy/cr.yaml` Custom Resource.

   This example configuration tells Kubernetes to allocate 16Mi worth of 2MiB huge pages for this instance. If you're using 1GiB pages, change the key to `hugepages-1Gi`.

   ```
   spec:
     instances:
       - name: instance1
         resources:
           limits:
             hugepages-2Mi: 16Mi
             memory: 4Gi
   ```

   Important

   Kubernetes requires that `requests` and `limits` for huge pages match. If you only specify `limits`, Kubernetes will assume the same value for `requests`.

2. Apply the configuration

   ```
   kubectl apply -f deploy/cr.yaml -n <namespace>
   ```

Verify huge pages are reserved

After deploying your cluster with huge pages configured, you can verify that they're being used by checking inside the database container:

```
cat /proc/meminfo | grep HugePages
```

You should see values for `HugePages_Total`, `HugePages_Free`, and `HugePages_Rsvd`, confirming that huge pages are reserved and in use.

A note on default behavior

To avoid unexpected startup failures, Percona Operator disables huge pages by default (`huge_pages = off`). This prevents PostgreSQL from trying to use huge pages when none were requested. Once you explicitly configure huge pages in your spec, the Operator sets `huge_pages = try`, allowing PostgreSQL to use them if available.

If huge pages are enabled on your nodes but not requested by your pods, PostgreSQL might fall back to minimal memory settings. To avoid this, either:

- Enable huge pages properly in your pod spec.
- Schedule pods on nodes without huge pages.
- Or manually set `shared_buffers` to a reasonable value:

```
spec:
  config:
    parameters:
      shared_buffers: 128MB
```

Using sidecar containers

Sidecar containers are extra containers that run alongside the main container in a Pod. They are often used for logging, proxying, or monitoring.

The Operator uses a set of “predefined” sidecar containers to manage the cluster operation:

- `replica-cert-copy` - is responsible for copying TLS certificates needed for replication between PostgreSQL instances
- `pgbouncer-config` - handles configuration management for `pgBouncer`
- `pgbackrest` - runs the main backup/restore agent
- `pgbackrest-config` - handles configuration management for `pgBackRest`

The Operator allows you to deploy your own sidecar containers to the Pod. You can use this feature to run debugging tools, some specific monitoring solutions, etc.

Note

Custom sidecar containers can easily access other components of your cluster. Therefore use them with caution, only when you are sure what you are doing.

Adding a custom sidecar container

You can add sidecar containers to these Pods:

- a PostgreSQL instance Pod
- a pgBouncer Pod

To add a sidecar container, use the `instances.sidecars` or `proxy.pgBouncer.sidecars` subsection in the `deploy/cr.yaml` configuration file. Specify this minimum required information in this subsection:

- the container name
- the container image
- a command to run

Note that you cannot reuse the name of the predefined containers. For example, PostgreSQL instance Pods cannot have custom sidecar containers named as `database`, `pgbackrest`, `pgbackrest-config`, and `replica-cert-copy`.

Use the `kubectl describe pod` command to check which names are already in use.

Here is the sample configuration of a sidecar container for a PostgreSQL instance Pod:

```
spec:
  instances:
  - name: instance1
    ....
    sidecars:
    - image: busybox:latest
      command: ["sleep", "30d"]
      args: ["-c", "while true; do echo echo $(date -u) 'test' >> /dev/null;
sleep 5; done"]
      name: my-sidecar-1
    ....
```

Find additional options suitable for the `sidecars` subsection in the Custom Resource options reference and the Kubernetes Workload API reference

Apply your modifications as usual:

```
kubectl apply -f deploy/cr.yaml
```

Running `kubectl describe` command for the appropriate Pod can bring you the information about the newly created container:

```
kubectl describe pod cluster1-instance1
```

Expected output

```
Name:           cluster1-instance1-n8v4-0
....
Containers:
....
testcontainer:
Container ID:
containerd://c2a9dc1057ba30ac25d73e1856d99c04e49fd0942a03501405904510bc15cf5b
Image:         nginx:latest
Image ID:
docker.io/library/nginx@sha256:dc53c8f25a10f9109190ed5b59bda2d707a3bde0e45857ce9e1efaa32
ff9cbc1
Port:          <none>
Host Port:     <none>
Command:
  sleep
  30d
State:          Running
  Started:      Thu, 26 Jun 2025 18:13:05 +0200
Ready:          True
Restart Count:  0
Environment:    <none>
Mounts:
  /tmp from tmp (rw)
  /var/run/secrets/kubernetes.io/serviceaccount from kube-api-access-5l57g (ro)
....
```

Getting shell access to a sidecar container

You can login to your sidecar container as follows:

```
kubectl exec -it cluster1-instance1n8v4-0 -c testcontainer -- sh
/ #
```

Pause/resume and standby mode for a PostgreSQL cluster

Pause and resume

Sometimes you may need to temporarily shut down (pause) your cluster and restart it later, such as during maintenance.

The `deploy/cr.yaml` file contains a special `spec.pause` key for this. Setting it to `true` gracefully stops the cluster:

```
spec:
  .......
  pause: true
```

To start the cluster after it was paused, revert the `spec.pause` key to `false`.

Troubleshooting tip

If you're pausing the cluster when there is a running backup, the Operator won't pause it for you. It will print a warning about running backups. In this case delete a running backup job and retry.

Put in standby mode

You can also put the cluster into a standby (read-only) mode instead of completely shutting it down. This is done by a special `spec.standby` key. Set it to `true` for read-only state. To resume the normal cluster operation, set it to `false`.

```
spec:
  .......
  standby: false
```

Monitor with Percona Monitoring and Management (PMM)

In this section you will learn how to monitor the health of Percona Distribution for PostgreSQL with Percona Monitoring and Management (PMM).

The Operator supports both PMM version 2 and PMM version 3.

It determines which PMM server version you are using based on the authentication method you provide. For PMM 2, the Operator uses API keys for authentication. For PMM 3, it uses service account tokens.

We recommend to use the latest PMM 3.

PMM is a client/server application. It includes the PMM Server and the number of PMM Clients running on each node with the database you wish to monitor.

A PMM Client collects needed metrics and sends gathered data to the PMM Server. As a user, you connect to the PMM Server to see database metrics on a number of dashboards. PMM Server and PMM Client are installed separately.

Considerations

1. If you are using PMM server version 2, use a PMM client image compatible with PMM 2. If you are using PMM server version 3, use a PMM client image compatible with PMM 3. Check Percona certified images for the right one.
2. If you specified both authentication methods for PMM server configuration and they have non-empty values, priority goes to PMM 3.
3. For migration from PMM2 to PMM3, see PMM upgrade documentation. Also check the Automatic migration of API keys page.

Install PMM Server

You must have PMM server up and running. You can run PMM Server as a *Docker image*, a *virtual appliance*, or in Kubernetes. Please refer to the official PMM documentation for the installation instructions.

Install PMM Client

PMM Client is installed as a side-car container in the database Pods in your Kubernetes-based environment. To install PMM Client, do the following:

Configure authentication

PMM3

PMM3 uses Grafana service accounts to control access to PMM server components and resources. To authenticate in PMM server, you need a service account token. Generate a service account and token. Specify the Admin role for the service account.

Warning

When you create a service account token, you can select its lifetime: it can be either a permanent token that never expires or the one with the expiration date. PMM server cannot rotate service account tokens after they expire. So you must take care of reconfiguring PMM Client in this case.

PMM2

Get the PMM API key from PMM Server. The API key must have the role “Admin”. You need this key to authorize PMM Client within PMM Server.

From PMM UI

Generate the PMM API key

From command line

You can query your PMM Server installation for the API Key using `curl` and `jq` utilities. Replace `<login>:<password>@<server_host>` placeholders with your real PMM Server login, password, and hostname in the following command:

```
API_KEY=$(curl --insecure -X POST -H "Content-Type: application/json" -d
'{"name":"operator", "role": "Admin"}' "https://<login>:
<password>@<server_host>/graph/api/auth/keys" | jq .key)
```

Warning

The API key is not rotated.

Create a secret

Now you must pass the credentials to the Operator. To do so, create a Secret object.

1. Create a Secret configuration file. You can use the deploy/secrets.yaml secrets file.

   PMM 3

   Specify the service account token as the `PMM_SERVER_TOKEN` value in the secrets file:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: cluster1-pmm-secret
   type: Opaque
   stringData:
     PMM_SERVER_TOKEN: ""
   ```

   PMM 2

   Specify the API key as the `PMM_SERVER_KEY` value in the secrets file:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: cluster1-pmm-secret
   type: Opaque
   stringData:
     PMM_SERVER_KEY: ""
   ```

2. Create the Secrets object using the `deploy/secrets.yaml` file.

   ```
   kubectl apply -f deploy/secrets.yaml -n postgres-operator
   ```

   Expected output

   ```
   secret/cluster1-pmm-secret created
   ```

Deploy a PMM Client

1. Update the `pmm` section in the deploy/cr.yaml file.

   - Set `pmm.enabled` = `true`.
   - Specify your PMM Server hostname / an IP address for the `pmm.serverHost` option. The PMM Server IP address should be resolvable and reachable from within your cluster.
   - Specify the name of the Secret object that you created earlier

   ```
     pmm:
       enabled: true
       image: percona/pmm-client:3.5.0
   #    imagePullPolicy: IfNotPresent
       secret: cluster1-pmm-secret
       serverHost: monitoring-service
   ```

2. Update the cluster

   ```
   kubectl apply -f deploy/cr.yaml -n postgres-operator
   ```

3. Check that corresponding Pods are not in a cycle of stopping and restarting. This cycle occurs if there are errors on the previous steps:

   ```
   kubectl get pods -n postgres-operator
   kubectl logs <pod_name> -c pmm-client
   ```

Update the secrets file

The `deploy/secrets.yaml` file contains all values for each key/value pair in a convenient plain text format. But the resulting Secrets Objects contains passwords stored as base64-encoded strings. If you want to *update* the password field, you need to encode the new password into the base64 format and pass it to the Secrets Object.

To encode a password or any other parameter, run the following command:

Linux

```
echo -n "password" | base64 --wrap=0
```

macOS

```
echo -n "password" | base64
```

For example, to set the new service account token in the `my-cluster-name-secrets` object, do the following:

Linux

```
kubectl patch secret/cluster1-pmm-secret -p '{"data":{"PMM_SERVER_TOKEN":
'$(echo -n <new-token> | base64 --wrap=0)'}}'
```

macOS

```
kubectl patch secret/cluster1-pmm-secret -p '{"data":{"PMM_SERVER_TOKEN":
'$(echo -n <new-token> | base64)'}}'
```

Check the metrics

Let's see how the collected data is visualized in PMM.

1. Log in to PMM server.
2. Click **PostgreSQL** from the left-hand navigation menu. You land on the **Instances Overview** page.
3. Click **PostgreSQL** → **Other dashboards** to see the list of available dashboards that allow you to drill down to the metrics you are interested in.

Upgrade

Upgrade Percona Operator for PostgreSQL

Starting from the version 2.2.0, you can upgrade Percona Operator for PostgreSQL to newer 2.x versions.

The upgrade process consists of these steps:

- Upgrade the Custom Resource Definition (CRD)
- Upgrade the Operator deployment
- Upgrade the database (Percona Distribution for PostgreSQL)

Update scenarios

You can either upgrade both the Operator and the database, or you can upgrade only the database. To decide which scenario to choose, read on.

Full upgrade (CRD, Operator, and the database)

When to use this scenario:

- The new Operator version has changes that are required for new features of the database to work
- The Operator has new features or fixes that enhance automation and management.
- Compatibility improvements between the Operator and the database require synchronized updates.

When going on with this scenario, make sure to test it in a staging or testing environment first. Upgrading the Operator may cause performance degradation.

Upgrade only the database

When to use this scenario:

- The new version of the database has new features or fixes that are not related to the Operator or other components of your infrastructure
- You have updated the Operator earlier and now want to proceed with the database update.

When choosing this scenario, consider the following:

- Check that the current Operator version supports the new database version.
- Some features may require an Operator upgrade later for full functionality.

Upgrade from the Operator version 1.x to version 2.x

Upgrades from the Operator version 1.x to 2.x are completely different from the upgrades within 2.x versions due to substantial changes in the architecture.

There are several ways to do such version 1.x to version 2.x upgrade. Choose the method based on your downtime preference and roll back strategy:

	Pros	Cons
Data Volumes migration - re-use the volumes that were created by the Operator version 1.x	The simplest method	- Requires downtime - Impossible to roll back
Backup and restore - take the backup with the Operator version 1.x and restore it to the cluster deployed by the Operator version 2.x	Allows you to quickly test version 2.x	Provides significant downtime in case of migration
Replication - replicate the data from the Operator version 1.x cluster to the standby cluster deployed by the Operator version 2.x	- Quick test of v2 cluster - Minimal downtime during upgrade	Requires significant computing resources to run two clusters in parallel

Upgrading the Operator and CRD

Upgrading Percona Operator for PostgreSQL and its associated Custom Resource Definitions (CRDs) is essential to take advantage of new features, bug fixes, and compatibility with your evolving Kubernetes environment. Before performing any upgrade, review the following considerations to ensure a smooth and reliable process.

Considerations

Considerations for Kubernetes Cluster versions and upgrades

1. Before upgrading the Kubernetes cluster, have a disaster recovery plan in place. Ensure that a backup is taken prior to the upgrade.
2. Plan your Kubernetes cluster or Operator upgrades with version compatibility in mind.

   The Operator is supported and tested on specific Kubernetes versions. Always refer to the Operator's release notes to verify the supported Kubernetes platforms.

   Note that while the Operator might run on unsupported or untested Kubernetes versions, this is not recommended. Doing so can cause various issues, and in some cases, the Operator may fail if deprecated API versions have been removed.
3. During a Kubernetes cluster upgrade, you must also upgrade the `kubelet`. It is advisable to drain the nodes hosting the database Pods during the upgrade process.
4. During the `kubelet` upgrade, nodes transition between `Ready` and `NotReady` states. Also, in some scenarios, older nodes may be replaced entirely with new nodes. Ensure that nodes hosting database or proxy pods are functioning correctly and remain in a stable state after the upgrade.
5. Regardless of the upgrade approach, pods will be rescheduled or recycled. Plan your Kubernetes cluster upgrade accordingly to minimize downtime and service disruption.

Considerations for the Operator upgrades

1. The Operator version has three digits separated by a dot (`.`) in the format `major.minor.patch`. Here's how you can understand the version `2.6.0`:
   - `2` - major version
   - `6` - minor version

- `0` - patch version

  You can upgrade the Operator only to the nearest `major.minor.patch` version. For example, if the next version is 2.7.1, you can go directly from 2.6.0 to 2.7.1 without any intermediate steps.

  To upgrade to a newer version, which differs from the current `minor.major` version by more than one, you need to make several incremental upgrades sequentially.

  For example, to upgrade the CRD and Operator from the version 2.4. 0 to 2.6.0, first upgrade it from 2.4.0 to 2.5.1, and then from 2. 5.1 to 2.6.0.

2. CRD supports **the last 3 minor versions of the Operator**. This means it is compatible with the newest Operator version and the two previous minor versions. If the Operator is older than the CRD by no more than two versions, you should be able to continue using the old Operator version. But updating the CRD and Operator is the recommended path.
3. Using newer CRD with older Operator is useful to upgrade multiple single-namespace Operator deployments in one Kubernetes cluster, where each Operator controls a database cluster in its own namespace. In this case upgrading Operator deployments will look as follows:
   - upgrade the CRD (not 3 minor versions far from the oldest Operator installation in the Kubernetes cluster) first
   - upgrade the Operators in each namespace incrementally to the nearest minor version (e.g. first 2.4.0 to 2.5.1, then 2.5.1 to 2.6.0)

Upgrade guides

Choose the upgrade instructions below based on how you originally deployed the Operator:

Manual upgrade **Upgrade via Helm** Upgrade on OpenShift(.md-button)

Manual upgrade

You can upgrade the Operator and CRD as follows, considering the Operator uses `postgres-operator` namespace, and you are upgrading it to the version 2.8.1.

1. Update the CRD for the Operator and the Role-based access control. You must use the server-side flag when you update the CRD. Otherwise you can encounter a number of errors caused by applying the CRD client-side: the command may fail, the built-in PostgreSQL extensions can be lost during such upgrade, etc.

Take the latest versions of the CRD and Role-based access control manifest from the official repository on GitHub with the following commands:

```
kubectl apply --server-side -f
https://raw.githubusercontent.com/percona/percona-postgresql-
operator/v2.8.1/deploy/crd.yaml
kubectl apply --server-side -f
https://raw.githubusercontent.com/percona/percona-postgresql-
operator/v2.8.1/deploy/rbac.yaml -n postgres-operator
```

Note

In case of cluster-wide installation, use `deploy/cw-rbac.yaml` instead of `deploy/rbac.yaml`.

2. Next, update the Percona Distribution for PostgreSQL Operator Deployment in Kubernetes by changing the container image of the Operator Pod to the latest version. Find the image name for the current Operator release in the list of certified images. Use the following command to update the Operator to the `2.8.1` version:

```
kubectl -n postgres-operator patch deployment percona-postgresql-operator
\
-p'{"spec":{"template":{"spec":{"containers":
[{"name":"operator","image":"docker.io/percona/percona-postgresql-
operator:2.8.1"}]}}}}'
```

3. The deployment rollout will be automatically triggered by the applied patch. You can track the rollout process in real time with the `kubectl rollout status` command with the name of your cluster:

```
kubectl rollout status deployments percona-postgresql-operator -n
postgres-operator
```

Expected output

```
deployment "percona-postgresql-operator" successfully rolled out
```

Upgrade via Helm

If you have installed the Operator using Helm, you can upgrade the Operator deployment with the `helm upgrade` command.

The `helm upgrade` command updates only the Operator deployment. The update flow for the database management system (Percona Distribution for PostgreSQL) is the same for all installation methods, whether it was installed via Helm or `kubectl`.

1. You must have the compatible version of the Custom Resource Definition (CRD) in all namespaces that the Operator manages. Starting with version 2.7.0, you can check it using the following command:

   ```
   kubectl get crd perconapgclusters.pgv2.percona.com --show-labels
   ```

2. Update the Custom Resource Definition for the Operator, taking it from the official repository on GitHub.

   Refer to the compatibility between CRD and the Operator and how you can update the CRD if it is too old. Use the following command and replace the version to the required one until you are safe to update to the latest CRD version.

   ```
   kubectl apply --server-side --force-conflicts -f
   https://raw.githubusercontent.com/percona/percona-postgresql-
   operator/v2.8.1/deploy/crd.yaml
   ```

   If you already have the latest CRD version in one of namespaces, don't re-run intermediate upgrades for it.

3. Upgrade the Operator deployment

With default parameters

To upgrade the Operator installed with default parameters, use the following command:

```
helm upgrade my-operator percona/pg-operator --version 2.8.1
```

The `my-operator` parameter in the above example is the name of a release object which you have chosen for the Operator when installing its Helm chart.

With customized parameters

If you installed the Operator with some customized parameters, list these options in the upgrade command.

a. Get the list of used options in YAML format :

```
helm get values my-operator -a > my-values.yaml
```

b. Pass these options to the upgrade command as follows:

```
helm upgrade my-operator percona/pg-operator --version 2.8.1 -f my-values.yaml
```

During the upgrade, you may see a warning to manually apply the CRD if it has the outdated version. In this case, refer to step 2 to upgrade the CRD and then step 3 to upgrade the deployment.

Next steps

Upgrade the database

Upgrade Percona Distribution for PostgreSQL

Considerations

1. Starting from the Operator 2.4.0 you can do a *minor* upgrade (for example, from 15.5 to 15.7, or from 16.1 to 16.3) and a *major* upgrade (for example, upgrade from PostgreSQL 15.5 to PostgreSQL 16.3) of Percona Distribution for PostgreSQL. Before the Operator version 2.4.0, you could only do a minor upgrade of Percona Distribution for PostgreSQL.
2. Starting with the Operator 2.6.0, PostgreSQL images are based on Red Hat Universal Base Image (UBI) 9 instead of UBI 8. UBI 9 has a different version of collation library `glibc` and this introduces a collation mismatch in PostgreSQL. Collation defines how text is sorted and compared based on language-specific rules such as case sensitivity, character order and the like. PostgreSQL stores the collation version used at database creation. When the collation version changes, this may result in corruption of database objects that use it like text-based indexes. Therefore, you need to identify and reindex objects affected by the collation mismatch.
3. Upgrading a PostgreSQL cluster may result in downtime, as well as failover caused by updating the primary instance.

Before you start

1. We recommend to update PMM Server **before** upgrading PMM Client.
2. If you are using PMM server version 2, use a PMM client image compatible with PMM 2. If you are using PMM server version 3, use a PMM client image compatible with PMM 3. See PMM upgrade documentation for how to migrate from version 2 to version 3.

Minor version upgrade

To make a minor upgrade of Percona Distribution for PostgreSQL (for example, from 17.5.2 to 17.6.1) , do the following:

1. Check the version of the Operator you have in your Kubernetes environment. If you need to update it, refer to the Operator upgrade guide

2. Check the current version of the Custom Resource and what versions of the database and cluster components are compatible with it. Replace the Operator version with your value in the following command:

```
curl https://check.percona.com/versions/v1/pg-operator/2.6.0 |jq -r
'.versions[].matrix'
```

You can also find this information in the Versions compatibility matrix.

3. Update the database, the backup and PMM Client image names with a newer version tag. Find the image names in the list of certified images.

We recommend to update the PMM Server **before** the upgrade of PMM Client. If you haven't done it yet, exclude PMM Client from the list of images to update.

Since this is a working cluster, the way to update the Custom Resource is to apply a patch with the `kubectl patch pg` command.

This example command updates the cluster with the name `cluster1` in the namespace `postgres-operator` to the `2.8.1` version:

With PMM Client

```
kubectl -n postgres-operator patch pg cluster1 --type=merge --patch '{
   "spec": {
      "crVersion":"2.8.1",
      "image": "docker.io/percona/percona-distribution-postgresql:17.7-1,
      "proxy": { "pgBouncer": { "image": "docker.io/percona/percona-
pgbouncer:1.25.0-1" } },
      "backups": { "pgbackrest":  { "image": "docker.io/percona/percona-
pgbackrest:2.57.0-1" } },
      "pmm": { "image": "docker.io/percona/pmm-client:3.5.0" }
   }}'
```

The following image names in the above example were taken from the list of certified images:

- `docker.io/percona/percona-distribution-postgresql:17.7-1`,
- `docker.io/percona/percona-pgbouncer:1.25.0-1`,
- `docker.io/percona/percona-pgbackrest:2.57.0-1`,
- `docker.io/percona/pmm-client:3.5.0`.

Without PMM Client

```
kubectl patch pg cluster1 -n postgres-operator --type=merge --patch '{
   "spec": {
      "crVersion":"2.8.1",
      "image": "docker.io/percona/percona-distribution-postgresql:17.7-1",
      "proxy": { "pgBouncer": { "image": "docker.io/percona/percona-
pgbouncer:1.25.0-1" } },
      "backups": { "pgbackrest":  { "image": "docker.io/percona/percona-
pgbackrest:2.57.0-1" } }
   }}'
```

The following image names in the above example were taken from the list of certified images:

- `docker.io/percona/percona-distribution-postgresql:17.7-1`,
- `docker.io/percona/percona-pgbouncer:1.25.0-1`,
- `docker.io/percona/percona-pgbackrest:2.57.0-1`,

4. After you applied the patch, the deployment rollout will be triggered automatically. The update process is successfully finished when all Pods have been restarted.

Expected output

```
NAME                                       READY   STATUS      RESTARTS   AGE
cluster1-backup-4vwt-p5d9j                 0/1     Completed   0          97m
cluster1-instance1-b5mr-0                  4/4     Running     0          99m
cluster1-instance1-b8p7-0                  4/4     Running     0          99m
cluster1-instance1-w7q2-0                  4/4     Running     0          99m
cluster1-pgbouncer-79bbf55c45-62xlk        2/2     Running     0          99m
cluster1-pgbouncer-79bbf55c45-9g4cb        2/2     Running     0          99m
cluster1-pgbouncer-79bbf55c45-9nrmd        2/2     Running     0          99m
cluster1-repo-host-0                       2/2     Running     0          99m
percona-postgresql-operator-79cd8586f5-2qzcs   1/1     Running     0          120m
```

5. Scan for indexes that rely on collations other than `C` or `POSIX` and whose collations were provided by the operating system (`c`) or dynamic libraries (`d`). Connect to PostgreSQL and run the following query:

```
SELECT DISTINCT
    indrelid::regclass::text,
    indexrelid::regclass::text,
    collname,
    pg_get_indexdef(indexrelid)
FROM (
    SELECT
        indexrelid,
        indrelid,
        indcollation[i] coll
    FROM
        pg_index,
        generate_subscripts(indcollation, 1) g(i)
) s
JOIN pg_collation c ON coll = c.oid
WHERE
    collprovider IN ('d', 'c')
    AND collname NOT IN ('C', 'POSIX');
```

6. If you see the list of affected images, find the database names where indexes use a different collation version:

```
SELECT * FROM pg_database;
```

Sample output

```{.text .no-copy} oid | datname | datdba | encoding | datlocprovider | datistemplate | datallowconn | datconnlimit | datfrozenxid | datminmxid | dattablespace | datcollate | datctype | daticulocale | daticurules | datcollversion | datacl

-------+----------+-------+---------+--------------+--------------+-------------+-------------+-----------+--------------+------------
+------------+------------+-----------+--------------+-----------------------------------------------------

5 | postgres | 10 | 6 | c | f | t | -1 | 722 | 1 | 1663 | en_US.utf-8 | en_US.utf-8 | | | 2.28 | 1 | template1 | 10 | 6 | c | t | t | -1 | 722 | 1 | 1663 | en_US.utf-8 | en_US.utf-8 | | | 2.28 | {=c/postgres,postgres=CTc/postgres} 4 | template0 | 10 | 6 | c | t | f | -1 | 722 | 1 | 1663 | en_US.utf-8 | en_US.utf-8 | | | | {=c/postgres,postgres=CTc/postgres} 16466 | cluster1 | 10 | 6 | c | f | t | -1 | 722 | 1 | 1663 | en_US.utf-8 | en_US.utf-8 | | | 2.28 | {=Tc/postgres,postgres=CTc/postgres,cluster1=CTc/postgres} (4 rows)
```

7. Refresh collection metadata and rebuild affected indexes. This command requires the privileges of a superuser or a database owner:

```
ALTER DATABASE cluster1 REFRESH COLLATION VERSION;
```

Major version upgrade

Major version upgrade allows you to jump from one database major version to another (for example, upgrade from PostgreSQL 15.x to PostgreSQL 16.x).

Major version upgrades feature is currently a **tech preview**, and it is **not recommended for production environments.**

The upgrade is triggered by applying the YAML file which refers to the special *Operator upgrade image* and contains the information about the existing and desired major versions. An example of this file is present in `deploy/upgrade.yaml`:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGUpgrade
metadata:
  name: cluster1-15-to-16
spec:
  postgresClusterName: cluster1
  image: docker.io/percona/percona-postgresql-operator:2.8.1-upgrade
  fromPostgresVersion: 15
  toPostgresVersion: 16
  toPostgresImage: docker.io/percona/percona-distribution-postgresql:16.11-1
  toPgBouncerImage: docker.io/percona/percona-pgbouncer:1.25.0-1
  toPgBackRestImage: docker.io/percona/percona-pgbackrest:2.57.0-1
```

As you can see, the manifest includes image names for the database cluster components (PostgreSQL, pgBouncer, and pgBackRest). You can find them in the list of certified images for the current Operator release. For older versions, please refer to the old releases documentation archive).

After you apply the YAML manifest as usual (by running `kubectl apply -f deploy/upgrade.yaml` command), the actual upgrade takes place:

1. The Operator pauses the cluster, so the cluster will be unavailable for the duration of the upgrade,
2. The cluster is specially annotated with `pgv2.percona.com/allow-upgrade`: `<PerconaPGUpgrade.Name>` annotation,
3. Jobs are created to migrate the data,
4. The cluster starts up after the upgrade finishes.
5. Scan for indexes that rely on collations other than `C` or `POSIX` and whose collations were provided by the operating system (`c`) or dynamic libraries (`d`). Connect to PostgreSQL and run the following query:

```
SELECT DISTINCT
    indrelid::regclass::text,
    indexrelid::regclass::text,
    collname,
    pg_get_indexdef(indexrelid)
FROM (
    SELECT
        indexrelid,
        indrelid,
        indcollation[i] coll
    FROM
        pg_index,
        generate_subscripts(indcollation, 1) g(i)
) s
JOIN pg_collation c ON coll = c.oid
WHERE
    collprovider IN ('d', 'c')
    AND collname NOT IN ('C', 'POSIX');
```

6. If you see the list of affected images, find the database names where indexes use a different collation version:

```
SELECT * FROM pg_database;
```

Sample output

```{.text .no-copy} oid | datname | datdba | encoding | datlocprovider | datistemplate | datallowconn | datconnlimit | datfrozenxid | datminmxid | dattablespace | datcollate | datctype | daticulocale | daticurules | datcollversion | datacl

------+----------+-------+---------+--------------+---------------+--------------+--------------+--------------+----------+--------------+------------+------------+--------------+-------------+----------------+-----------

5 | postgres | 10 | 6 | c | f | t | -1 | 722 | 1 | 1663 | en_US.utf-8 | en_US.utf-8 | | | 2.28 | 1 | template1 | 10 | 6 | c | t | t | -1 | 722 | 1 | 1663 | en_US.utf-8 | en_US.utf-8 | | | 2.28 | {=c/postgres,postgres=CTc/postgres} 4 | template0 | 10 | 6 | c | t | f | -1 | 722 | 1 | 1663 | en_US.utf-8 | en_US.utf-8 | | | | {=c/postgres,postgres=CTc/postgres} 16466 | cluster1 | 10 | 6 | c | f | t | -1 | 722 | 1 | 1663 | en_US.utf-8 | en_US.utf-8 | | | 2.28 | {=Tc/postgres,postgres=CTc/postgres,cluster1=CTc/postgres} (4 rows)
```

7. Refresh collection metadata and rebuild affected indexes. This command requires the privileges of a superuser or a database owner:

```
ALTER DATABASE cluster1 REFRESH COLLATION VERSION;
```

Note

If the upgrade fails for some reason, the cluster will stay in paused mode. Resume the cluster manually to check what went wrong with upgrade (it will start with the old version). You can check the PerconaPGUpgrade resource with `kubectl get perconapgupgrade -o yaml` command, and check the logs of the upgraded Pods to debug the issue.

During the upgrade data are duplicated in the same PVC for each major upgrade, and old version data are not deleted automatically. Make sure your PVC has enough free space to store data. You can remove data at your discretion by executing into containers and running the following commands (example for PostgreSQL 15):

```
rm -rf /pgdata/pg15
rm -rf /pgdata/pg15_wal
```

You can also delete the `PerconaPGUpgrade` resource (this will clean up the jobs and Pods created during the upgrade):

```
kubectl delete perconapgupgrade cluster1-15-to-16
```

Upgrade PostgreSQL extensions

Upgrade `pg_stat_monitor` (for Operator earlier than 2.6.0)

`pg_stat_monitor` is the built-in extension, which is used to provide query analytics for Percona Monitoring and Management (PMM). If you enabled it in the Custom Resource (`deploy/cr.yaml` manifest), you need to manually update it *after the database upgrade* (this manual step is not required for the Operator versions 2.6.0 and newer):

1. Find the primary instance of your PostgreSQL cluster. You can do this using Kubernetes Labels as follows (replace the `<namespace>` placeholder with your value):

   ```
   kubectl get pods -n <namespace> -l postgres-
   operator.crunchydata.com/cluster=cluster1 \
       -L postgres-operator.crunchydata.com/instance \
       -L postgres-operator.crunchydata.com/role | grep instance1
   ```

   Sample output

   ```
   cluster1-instance1-bmdp-0             4/4     Running   0          2m23s
   cluster1-instance1-bmdp   replica
   cluster1-instance1-fm7w-0             4/4     Running   0          2m22s
   cluster1-instance1-fm7w   replica
   cluster1-instance1-ttm9-0             4/4     Running   0          2m22s
   cluster1-instance1-ttm9   master
   ```

   PostgreSQL primary is labeled as `master`, while other PostgreSQL instances are labeled as `replica`.

2. Log in to a primary instance (`cluster1-instance1-ttm9-0` in the above example) as an administrative user:

   ```
   kubectl exec  -n <namespace> -ti cluster1-instance1-ttm9-0 -c database --
   psql postgres
   ```

3. Execute the following SQL statement:

   ```
   postgres=# alter extension pg_stat_monitor update;
   ```

Upgrade custom PostgreSQL extensions

If you have installed custom PostgreSQL extensions, you need to build and package each custom extension for the new PostgreSQL major version. During the upgrade, the Operator will install extensions into the upgrade container.

Refer to the Update custom extensions section for step-by-step instructions.

Upgrade the Operator and the database on OpenShift

Upgrade the Operator via Operator Lifecycle Manager (OLM)

You can upgrade the Operator for PostgreSQL that was installed on the OpenShift platform using OLM directly through the Operator Lifecycle Manager.

Before you start

You must manually update the `initContainer.image` Custom Resource option for each PostgreSQL cluster managed by the Operator. Without this, clusters may enter an error state after the Operator upgrade.

Follow these steps to upgrade the `initContainer.image`:

1. Export the namespace as environment variable

   ```
   export NAMESPACE=postgres-operator
   ```

2. Retrieve the current Operator installation image used for `initContainer` by running:

   ```
   kubectl get deploy percona-postgresql-operator -n $NAMESPACE -o
   jsonpath='{.spec.template.spec.containers[*].image}'
   ```

   Find the `image` value in the relevant section of the output, for example:

   ```
   registry.connect.redhat.com/percona/percona-postgresql-
   operator@sha256:986941a8c5f5d00a0c9cc7bd12acc9f78aa51fdcc98c7d0acddff05392
   d4b9a0
   ```

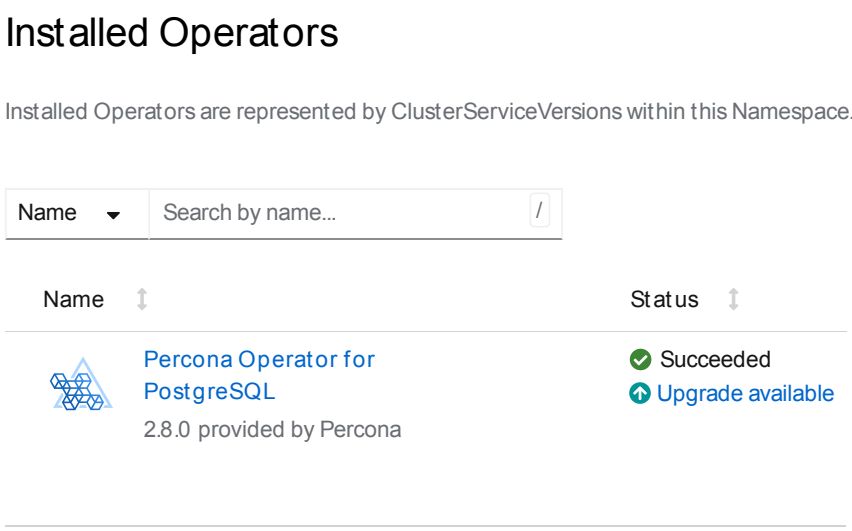
3. Update your PostgreSQL cluster's Custom Resource with the image you found above, replacing `cluster1` with your cluster name:

```
kubectl patch pg cluster1 -n $NAMESPACE --type=merge --patch '{
    "spec": {
      "initContainer": { "image": "<IMAGE_FROM_STEP_2>" }
    }}'
```

Repeat this command for each cluster managed by the Operator.

Upgrade the Operator

1. Log in to the OpenShift web console and check the list of installed Operators in your namespace to see if upgrades are available.



2. Click the “Upgrade available” link to review details, click “Preview InstallPlan,” and then click “Approve” to upgrade the Operator.

Upgrade Percona Distribution for PostgreSQL

Before you start

1. We recommend to update PMM Server **before** upgrading PMM Client.
2. If you are using PMM server version 2, use a PMM client image compatible with PMM 2. If you are using PMM server version 3, use a PMM client image compatible with PMM 3. See PMM upgrade documentation for how to migrate from version 2 to version 3.

Upgrade steps

1. Find the **new** initial Operator installation image name (it had changed during the Operator upgrade) and other image names for the components of your cluster with the `kubectl get deploy` command:

   ```
   kubectl get deploy percona-postgresql-operator -n $NAMESPACE -o yaml
   ```

   Expected output

   ```
   {
     "initContainer": {
       "image": "registry.connect.redhat.com/percona/percona-postgresql-
   operator@sha256:ae9b319eaf3367f73d135fdda4ce69f58bcb9a2b05eea71903b7d631bd8b56c2"
     },
     "image": "registry.connect.redhat.com/percona/percona-postgresql-operator-
   containers@sha256:2092b8badac196100a70e708e18ef6c70f9f398c99431f3905e8394b9cadd91a"
   ,
     ...
     "proxy": {
       "pgBouncer": {
         "image": "registry.connect.redhat.com/percona/percona-postgresql-operator-
   containers@sha256:73916031a5b9a033efdf86597b9df58837336ae208a8743d4c70874d459daeda"
       }
     },
     ...
     "backups": {
       "pgbackrest": {
         "image": "registry.connect.redhat.com/percona/percona-postgresql-operator-
   containers@sha256:5937c9778be5c94acb4be81d979b6e5503f85dea1196f20f435b19467e56d1d0"
       }
     },
     ....
     "pmm": {
       "enabled": false,
       "image": "registry.connect.redhat.com/percona/percona-postgresql-operator-
   containers@sha256:05dc00f69ed0fae48453476ace93bd43c046bf07a511cdca16e2fcad29c53805"
     }
   }
   ```

2. Apply a patch to update your cluster's Custom Resource. Set the `crVersion` field to match the Operator version and update the images as needed.

Depending if you already updated the PMM client, include its image in the list of images to update in your patch command. Otherwise, exclude the PMM client image from the patch.

If your cluster is named `cluster1`, use the following command as an example:

=== “With PMM Client”

```
   ```bash
   kubectl patch pg cluster1 -n $NAMESPACE --type=merge --patch '{
   "spec": {
   "crVersion":"2.8.1",
   "initContainer": { "image": "registry.connect.redhat.com/percona/percona-
postgresql-
operator@sha256:ae9b319eaf3367f73d135fdda4ce69f58bcb9a2b05eea71903b7d631bd8b5
6c2" },
   "image": "registry.connect.redhat.com/percona/percona-postgresql-operator-
containers@sha256:2092b8badac196100a70e708e18ef6c70f9f398c99431f3905e8394b9ca
dd91a",
   "proxy": { "pgBouncer": { "image":
"registry.connect.redhat.com/percona/percona-postgresql-operator-
containers@sha256:73916031a5b9a033efdf86597b9df58837336ae208a8743d4c70874d459
daeda" } },
   "backups": { "pgbackrest": { "image":
"registry.connect.redhat.com/percona/percona-postgresql-operator-
containers@sha256:5937c9778be5c94acb4be81d979b6e5503f85dea1196f20f435b19467e5
6d1d0" } },
   "pmm": { "image": "registry.connect.redhat.com/percona/percona-postgresql-
operator-
containers@sha256:05dc00f69ed0fae48453476ace93bd43c046bf07a511cdca16e2fcad29c
53805" }
   }}'
   ```

=== "Without PMM Client"

   ```bash
   kubectl patch pg cluster1 -n $NAMESPACE --type=merge --patch '{
   "spec": {
   "crVersion":"2.8.1",
   "initContainer": { "image": "registry.connect.redhat.com/percona/percona-
postgresql-
operator@sha256:ae9b319eaf3367f73d135fdda4ce69f58bcb9a2b05eea71903b7d631bd8b5
6c2" },
   "image": "registry.connect.redhat.com/percona/percona-postgresql-operator-
containers@sha256:2092b8badac196100a70e708e18ef6c70f9f398c99431f3905e8394b9ca
dd91a",
   "proxy": { "pgBouncer": { "image":
"registry.connect.redhat.com/percona/percona-postgresql-operator-
containers@sha256:73916031a5b9a033efdf86597b9df58837336ae208a8743d4c70874d459
daeda" } },
   "backups": { "pgbackrest": { "image":
"registry.connect.redhat.com/percona/percona-postgresql-operator-
containers@sha256:5937c9778be5c94acb4be81d979b6e5503f85dea1196f20f435b19467e5
```
```

```
6d1d0" } }
   }}'
   ```
```

1. The deployment rollout will be automatically triggered by the applied patch. You can track the rollout process in real time with the `kubectl rollout status` command with the name of your cluster:

   ```
   kubectl rollout status deployments percona-postgresql-operator -n
   postgres-operator
   ```

   Expected output

   ```
   deployment "percona-postgresql-operator" successfully rolled out
   ```
   ```

Upgrade from version 1 to version 2

Upgrade using data volumes

Prerequisites:

The following conditions should be met for the Volumes-based migration:

- You have a version 1.x cluster with `spec.keepData: true` in the Custom Resource
- You have both Operators deployed and allow them to control resources in the same namespace
- Old and new clusters must be of the same PostgreSQL major version

This migration method has two limitations. First of all, this migration method introduces a downtime. Also, you can only reverse such migration by restoring the old cluster from the backup. See other migration methods if you need lower downtime and a roll back plan.

Prepare version 1.x cluster for the migration

1. Remove all Replicas from the cluster, keeping only primary running. It is required to assure that Volume of the primary PVC does not change. The `deploy/cr.yaml` configuration file should have it as follows:

```
...
pgReplicas:
    hotStandby:
      size: 0
```

2. Apply the Custom Resource in a usual way:

```
kubectl apply -f deploy/cr.yaml
```

3. When all Replicas are gone, proceed with removing the cluster. Double check that `spec.keepData` is in place, otherwise the Operator will delete the volumes!

```
kubectl delete perconapgcluster cluster1
```

4. Find PVC for the Primary and `pgBackRest`:

```
kubectl get pvc --selector=pg-cluster=cluster1 -n pgo
```

Expected output

```
NAME                  STATUS   VOLUME                                     CAPACITY
ACCESS MODES   STORAGECLASS   AGE
cluster1              Bound    pvc-940cdc23-cd4c-4f62-ac3a-dc69850042b0   1Gi
RWO            standard-rwo   57m
cluster1-pgbr-repo    Bound    pvc-afb00490-5a45-45cb-a1cb-10af8e48bb13   1Gi
RWO            standard-rwo   57m
```

A third PVC used to store write-ahead logs (WAL) may also be present if external WAL volumes were enabled for the cluster.

5. Permissions for `pgBackRest` repo folders are managed differently in version 1 and version 2. We need to change the ownership of the `backrest` folder on the Persistent Volume to avoid errors during migration. Running a `chown` command within a container fixes this problem. You can use the following manifest to execute it:

chown-pod.yaml

```
apiVersion: v1
kind: Pod
metadata:
  name: chown-pod
spec:
  volumes:
    - name: backrestrepo
      persistentVolumeClaim:
        claimName: cluster1-pgbr-repo
  containers:
    - name: task-pv-container
      image: ubuntu
      command:
      - chown
      - -R
      - 26:26
      - /backrestrepo/cluster1-backrest-shared-repo
      volumeMounts:
        - mountPath: "/backrestrepo"
          name: backrestrepo
```

Apply it as follows:

```
kubectl apply -f chown-pod.yaml -n pgo
```

Execute the migration to version 2.x

The old cluster is shut down, and Volumes are ready to be used to provision the new cluster managed by the Operator version 2.x.

1. **Install the Operator version 2** (if not done yet). Pick your favorite method from our documentation.

2. Run the following command to show the names of PVC belonging to the old cluster:

```
kubectl get pvc --selector=pg-cluster=cluster1 -n pgo
```

Expected output

```
NAME                  STATUS   VOLUME                                     CAPACITY
ACCESS MODES   STORAGECLASS   AGE
cluster1              Bound    pvc-db9bf618-04d5-4807-948d-e32e81098575   1Gi
RWO            standard-rwo   87m
cluster1-pgbr-repo    Bound    pvc-37d93aa9-bf02-4295-bbbc-c1f834ed6045   1Gi
RWO            standard-rwo   87m
```

3. Now edit the Custom Resource manifest (`deploy/cr.yaml` configuration file) of the version 2.x cluster: add fields to the `dataSource.volumes` subsection, pointing to the PVCs of the version 1.x cluster:

```
...
dataSource:
  volumes:
      pgDataVolume:
        pvcName: cluster1
        directory: cluster1
      pgBackRestVolume:
        pvcName: cluster1-pgbr-repo
        directory: cluster1-backrest-shared-repo
```

4. Do not forget to set the proper PostgreSQL major version. It must be the same version that was used in version 1 cluster. You can set the version in the corresponding `image` sections and `postgresVersion`. The following example sets version 14:

```
spec:
  image: percona/percona-postgresql-operator:2.8.1-ppg14-postgres
  postgresVersion: 14
  proxy:
    pgBouncer:
      image: percona/percona-postgresql-operator:2.8.1-ppg14-pgbouncer
  backups:
    pgbackrest:
      image: percona/percona-postgresql-operator:2.8.1-ppg14-pgbackrest
```

5. Apply the manifest:

```
kubectl apply -f deploy/cr.yaml
```

The new cluster will be provisioned shortly using the volume of the version 1.x cluster. You should remove the `spec.datasource.volumes` section from your manifest.

Upgrade using backup and restore

This method allows you to migrate from the version 1.x to version 2.x cluster by restoring (actually creating) a new version 2.x PostgreSQL cluster using a backup from the version 1.x cluster.

Note

To make sure that all transactions are captured in the backup, you need to stop the old cluster. This brings downtime to the application.

Prepare the backup

1. Create the backup on the version 1.x cluster, following the official guide for manual (on-demand) backups. This involves preparing the manifest in YAML and applying it in the usual way:

   ```
   kubectl apply -f deploy/backup/backup.yaml
   ```

2. Pause or delete the version 1.x cluster to ensure that you have the latest data.

   Warning

   Before deleting the cluster, make sure that the spec.keepBackups Custom Resource option is set to `true`. When it's set, local backups will be kept after the cluster deletion, so you can proceed with deleting your cluster as follows:

   ```
   kubectl delete perconapgcluster cluster1
   ```

Restore the backup as a version 2.x cluster

Restore from S3 / Google Cloud Storage for backups repository

1. To restore from the S3 or Google Cloud Storage for backups (GCS) repository, you should first configure the `spec.backups.pgbackrest.repos` subsection in your version 2.x cluster Custom Resource to point to the backup storage system. Just follow the repository documentation instruction for S3 or GCS. For example, for GCS you can define the repository similar to the following:

```
spec:
  backups:
    pgbackrest:
      repos:
      - name: repo1
        gcs:
          bucket: MY-BUCKET
          region: us-central1
```

2. Create and configure any required Secrets or desired custom pgBackrest configuration as described in the backup documentation for te Operator version 2.x.

3. Set the repository path in the `backups.pgbackrest.global` subsection. By default it is `/backrestrepo/<clusterName>-backrest-shared-repo`:

```
  spec:
  backups:
    pgbackrest:
      global:
        repo1: /backrestrepo/cluster1-backrest-shared-repo
```

4. Set the `spec.dataSource` option to create the version 2.x cluster from the specific repository:

```
spec:
  dataSource:
    postgresCluster:
      repoName: repo1
```

   You can also provide other pgBackRest restore options, e.g. if you wish to restore to a specific point-in-time (PITR).

5. Create the version 2.x cluster:

```
kubectl apply -f cr.yaml
```

Migrate using Standby

This method allows you to migrate from version 1.x to version 2.x by creating a new version 2.x PostgreSQL cluster in a “standby” mode, mirroring the version 1.x cluster to it continuously. This method can provide minimal downtime, but requires additional computing resources to run two clusters in parallel.

This method only works if the version 1.x cluster uses Amazon S3 or S3-compatible storage, or Google Cloud storage (GCS) for backups. For more information on standby clusters, please refer to this article.

Migrate to version 2

There is no need to perform any additional configuration on version 1.x cluster, you will only need to configure the version 2.x one.

1. Configure `spec.backups.pgbackrest.repos` Custom Resource option to point to the backup storage system. For example, for GCS, the repository would be defined similar to the following:

```
spec:
  backups:
    pgbackrest:
      repos:
      - name: repo1
        gcs:
          bucket: MY-BUCKET
          region: us-central1
```

2. Create and configure any required secrets or desired custom pgBackrest configuration as described in the backup documentation for the version 2.x.

3. Set the repository path in `backups.pgbackrest.global` section of the Custom Resource configuration file. By default it will be `/backrestrepo/<clusterName>-backrest-shared-repo`:

```
      spec:
      backups:
        pgbackrest:
          global:
            repo1: /backrestrepo/cluster1-backrest-shared-repo
```

4. Enable the standby mode in `spec.standby` and point to the repository:

```
spec:
  standby:
    enabled: true
    repoName: repo1
```

5. Create the version 2.x cluster:

```
kubectl apply -f deploy/cr.yaml
```

Promote version 2.x cluster

Once the standby cluster is up and running, you can promote it.

1. Delete version 1.x cluster, but ensure that `spec.keepBackups` is set to `true`.

```
kubectl delete perconapgcluster cluster1
```

2. Promote version 2.x cluster by disabling the standby mode:

```
spec:
  standby:
    enabled: false
```

You can use version 2.x cluster now. Also the 2.x version is now managing the object storage with backups, so you should not start your old cluster.

Create the replication user

Right after disabling standby, run the following SQL commands as a PostgreSQL superuser. For example, you can login as the `postgres` user, or exec into the Pod and use `psql`:

- add the managed replication user

```
CREATE ROLE _crunchyrepl WITH LOGIN REPLICATION;
```

- allow for the replication user to execute the functions required as part of “rewinding”

```
GRANT EXECUTE ON function pg_catalog.pg_ls_dir(text, boolean, boolean) TO
_crunchyrepl;
GRANT EXECUTE ON function pg_catalog.pg_stat_file(text, boolean) TO
_crunchyrepl;
GRANT EXECUTE ON function pg_catalog.pg_read_binary_file(text) TO
_crunchyrepl;
GRANT EXECUTE ON function pg_catalog.pg_read_binary_file(text, bigint,
bigint, boolean) TO _crunchyrepl;
```

The above step will be automated in upcoming releases.

How-to

Install Percona Distribution for PostgreSQL with customized parameters

You can customize the configuration of Percona Distribution for PostgreSQL and install it with customized parameters.

To check available configuration options, see deploy/cr.yaml and Custom Resource Options.

kubectl

To customize the configuration when installing with `kubectl`, do the following:

1. Clone the repository with all manifests and source code by executing the following command:

   ```
   git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
   ```

2. Edit the required options and apply your modified `deploy/cr.yaml` file as follows:

   ```
   kubectl apply -f deploy/cr.yaml -n postgres-operator
   ```

Helm

To install Percona Distribution for PostgreSQL with custom parameters using Helm, use the following command:

```
helm install --set key=value
```

You can pass any of the Operator's Custom Resource options as a `--set key=value[,key=value]` argument.

The following example deploys a PostgreSQL 17.7-1 based cluster in the `my-namespace` namespace, with enabled Percona Monitoring and Management (PMM):

```
helm install my-db percona/pg-db --version 2.8.1 --namespace my-namespace \
  --set postgresVersion=17.7-1 \
  --set pmm.enabled=true
```

How to run initialization SQL commands at cluster creation time

The Operator can execute a custom sequence of PostgreSQL commands when creating the database cluster. This sequence can include both SQL commands and meta-commands of the PostgreSQL interactive shell (psql). This feature may be useful to push any customizations to the cluster: modify user roles, change error handling, set and use variables, etc.

psql interactive terminal will execute these initialization statements when the cluster is created, after creating custom users and databases specified in the Custom Resource.

To set SQL initialization sequence you need creating a special ConfigMap with it, and reference this ConfigMap in the `databaseInitSQL` subsection of your Custom Resource options.

The following example uses initialization SQL command to add a new role to a PostgreSQL database cluster:

1. Create YAML manifest for the ConfigMap as follows:

   my_init.yaml

   ```
   apiVersion: v1
   kind: ConfigMap
   metadata:
     name: cluster1-init-sql
     namespace: postgres-operator
   data:
     init.sql: CREATE ROLE someonenew WITH createdb superuser login password
   'someonenew';
   ```

   The `namespace` field should point to the namespace of your database cluster, and the `init.sql` key contains the sequence of commands, which will be passed to the psql.

   Create the ConfigMap by applying your manifest:

   ```
   kubectl apply -f my_init.yaml
   ```

2. Update the `databaseInitSQL` part of the `deploy/cr.yaml` Custom Resource manifest as follows:

```
...
databaseInitSQL:
  key: init.sql
  name: cluster1-init-sql
...
```

Now, SQL commands will be executed when you create the cluster by apply the manifest:

```
kubectl apply -f deploy/cr.yaml -n postgres-operator
```

The psql command is executed the standard input and the file flag (`psql -f -`). If the command returns `0` exit code, SQL will not be run again. When psql returns with an error exit code, the Operator will continue attempting to execute it as part of its reconcile loop until success. You can fix errors in the SQL sequence, for example by interactive `kubectl edit configmap cluster1-init-sql -n postgres-namespace` command.

Note

You can use following psql meta-command to make sure that any SQL errors would make psql to return the error code:

```
\set ON_ERROR_STOP
\echo Any error will lead to exit code 3
```

Change the PostgreSQL primary instance

The Operator uses PostgreSQL high-availability implementation based on the Patroni template. This means that each PostgreSQL cluster includes one member available for read/write transactions (PostgreSQL primary instance, or leader in terms of Patroni) and a number of replicas which can serve read requests only (standby members of the cluster).

You may wish to manually change the primary instance in your PostgreSQL cluster to achieve more control and meet specific requirements in various scenarios like planned maintenance, testing failover procedures, load balancing and performance optimization activities. Primary instance is re-elected during the automatic failover (Patroni's "leader race" mechanism), but still there are use cases to control this process manually.

In Percona Operator, the primary instance election can be controlled by the `patroni.switchover` section of the Custom Resource manifest. It allows you to enable switchover targeting a specific PostgreSQL instance as the new primary, or just running a failover if PostgreSQL cluster has entered a bad state.

This document provides instructions how to change the primary instance manually.

For the following steps, we assume that you have the PostgreSQL cluster up and running. The cluster name is `cluster1`.

1. Check the information about the cluster instances. Cluster instances are defined in the `spec.instances` Custom Resource section. By default you have one cluster instance named `instance1` with 3 PostgreSQL instances in it. You can check which cluster instances you have. Do this using Kubernetes Labels as follows (replace the `<namespace>` placeholder with your value):

   ```
   kubectl get pods -n <namespace> -l postgres-
   operator.crunchydata.com/cluster=cluster1 \
       -L postgres-operator.crunchydata.com/instance \
       -L postgres-operator.crunchydata.com/role | grep instance1
   ```

Sample output

```
cluster1-instance1-bmdp-0             4/4     Running   0          2m23s
cluster1-instance1-bmdp   replica
cluster1-instance1-fm7w-0             4/4     Running   0          2m22s
cluster1-instance1-fm7w   replica
cluster1-instance1-ttm9-0             4/4     Running   0          2m22s
cluster1-instance1-ttm9   master
```

PostgreSQL primary is labeled as `master`, while other PostgreSQL instances are labeled as `replica`.

2. Now update the following options in the `patroni.switchover` subsection of the Custom Resource:

```
patroni:
  switchover:
    enabled: true
    targetInstance: <instance-name>
```

You can do it with `kubectl patch` command, specifying the name of the instance that you want to be the new primary. For example, let's set the `cluster1-instance1-bmdp` as a new PostgreSQL primary:

```
kubectl -n <namespace> patch pg cluster1 --type=merge --patch '{
  "spec": {
    "patroni": {
      "switchover": {
        "enabled": true,
        "targetInstance": "cluster1-instance1-bmdp"
      }
    }
  }
}'
```

3. Trigger the switchover by adding the annotation to your Custom Resource. The recommended way is to set the annotation with the timestamp, so you know when switchover took place. Replace the `<namespace>` placeholder with your value:

```
kubectl annotate --overwrite -n <namespace> pg cluster1 postgres-
operator.crunchydata.com/trigger-switchover="$(date)"
```

The `--overwrite` flag in the above command allows you to overwrite the annotation if it already exists (useful if that's not the first switchover you do).

4. Verify that the cluster was annotated (replace the `<namespace>` placeholder with your value, as usual):

```
kubectl get pg cluster1 -o yaml -n <namespace>
```

Sample output

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGCluster
metadata:
  annotations:
    kubectl.kubernetes.io/last-applied-configuration: |
      {....
      "patroni":{"switchover":{"enabled":true,"targetInstance":"cluster1-instance1-
bmdp"}},}
```

5. Now, check instances of your cluster once again to make sure the switchover took place:

```
kubectl get pods -n <namespace> -l postgres-
operator.crunchydata.com/cluster=cluster1 \
    -L postgres-operator.crunchydata.com/instance \
    -L postgres-operator.crunchydata.com/role | grep instance1
```

Sample output

```
cluster1-instance1-bmdp-0             4/4     Running     0          24m
cluster1-instance1-bmdp   master
cluster1-instance1-fm7w-0             4/4     Running     0          24m
cluster1-instance1-fm7w   replica
cluster1-instance1-ttm9-0             4/4     Running     0          23m
cluster1-instance1-ttm9   replica
```

6. Set `patroni.switchover.enabled` Custom Resource option to `false` once the switchover is done:

```
kubectl -n <namespace> patch pg cluster1 --type=merge --patch '{
  "spec": {
    "patroni": {
      "switchover": {
        "enabled": false
      }
    }
  }
}'
```

Use Docker images from a private registry

Using images from a private Docker registry may be required for privacy, security or other reasons. In these cases, Percona Operator for PostgreSQL allows the use of a custom registry. The following example illustrates how this can be done by the example of the Operator deployed in the OpenShift environment.

Prerequisites

1. First of all login to the OpenShift and create project.

   ```
   oc login
   Authentication required for https://192.168.1.100:8443 (openshift)
   Username: admin
   Password:
   Login successful.
   oc new-project pg
   Now using project "pg" on server "https://192.168.1.100:8443".
   ```

2. There are two things you will need to configure your custom registry access:

   - the token for your user,
   - your registry IP address.

   The token can be found with the following command:

   ```
   oc whoami -t
   ADO8CqCDappWR4hxjfDqwijEHei31yXAvWg61Jg210s
   ```

   And the following one tells you the registry IP address:

   ```
   kubectl get services/docker-registry -n default
   NAME              TYPE        CLUSTER-IP       EXTERNAL-IP   PORT(S)
   AGE
   docker-registry   ClusterIP   172.30.162.173   <none>        5000/TCP   1d
   ```

3. Use the user token and the registry IP address to login to the registry:

   ```
   docker login -u admin -p ADO8CqCDappWR4hxjfDqwijEHei31yXAvWg61Jg210s
   172.30.162.173:5000
   ```

Expected output

```
Login Succeeded
```

4. Use the Docker commands to pull the needed image by its SHA digest:

```
docker pull docker.io/perconalab/percona-postgresql-
operator@sha256:991d6049059e5eb1a74981290d829a5fb4ab0554993748fde1e67b2f46
f26bf0
```

Expected output

```
Trying to pull repository docker.io/perconalab/percona-postgresql-operator ...
sha256:991d6049059e5eb1a74981290d829a5fb4ab0554993748fde1e67b2f46f26bf0: Pulling
from docker.io/perconalab/percona-server-mongodb
Digest: sha256:991d6049059e5eb1a74981290d829a5fb4ab0554993748fde1e67b2f46f26bf0
Status: Image is up to date for docker.io/perconalab/percona-postgresql-
operator@sha256:991d6049059e5eb1a74981290d829a5fb4ab0554993748fde1e67b2f46f26bf0
```

You can find correct names and SHA digests in the current list of the Operator-related images officially certified by Percona.

5. The following method can push an image to the custom registry for the example OpenShift `pg` project:

```
docker tag \
    docker.io/perconalab/percona-postgresql-
operator@sha256:991d6049059e5eb1a74981290d829a5fb4ab0554993748fde1e67b2f46
f26bf0 \
    172.30.162.173:5000/psmdb/percona-postgresql-operator:17.7-1
docker push 172.30.162.173:5000/pg/percona-postgresql-operator:17.7-1
```

6. Verify the image is available in the OpenShift registry with the following command:

```
oc get is
```

Expected output

```
NAME                                DOCKER REPO
TAGS            UPDATED
percona-postgresql-operator         docker-registry.default.svc:5000/pg/percona-
postgresql-operator  17.7-1  2 hours ago
```

7. When the custom registry image is available, edit the the `image:` option in `deploy/operator.yaml` configuration file with a Docker Repo + Tag string (it should look like `docker-registry.default.svc:5000/pg/percona-postgresql-operator:17.7-1`)

Note

If the registry requires authentication, you can specify the `imagePullSecrets` option for all images.

8. Repeat steps 3-5 for other images, and update corresponding options in the `deploy/cr.yaml` file.
9. Now follow the standard Percona Operator for PostgreSQL installation instruction.

Manage PostgreSQL extensions

One of the specific PostgreSQL features is the ability to provide it with additional functionality via Extensions. Percona Distribution for PostgreSQL comes with a number of extensions. These extensions are available for the database cluster managed by the Operator as well.

Built-in extensions

You can enable or disable built-in extensions in the `extensions.builtin` section of your `deploy/cr.yaml` file. Set an option to `true` to enable an extension, or to `false` to disable it. To see which extensions are enabled by default, check the deploy/cr.yaml Custom Resource manifest.

```
extensions:
  ...
  builtin:
    pg_stat_monitor: true
    pg_audit: true
    pgvector: false
    pg_repack: false
```

Apply changes after editing with `kubectl apply -f deploy/cr.yaml` command. This causes the Operator to restart the Pods of your cluster.

Add custom extensions

The needed extension may not be in the list of extensions supplied with Percona Distribution for PostgreSQL, or it's a custom extension developed by the end-user. To add such a custom extension is not straightforward in a containerized database in a Kubernetes environment. It requires building a custom PostgreSQL image.

Starting with version 2.3, the Operator provides an alternative way to extend Percona Distribution for PostgreSQL by downloading pre-packaged extensions from and external storage on the fly.

Advanced configuration

Custom extensions configuration is an advanced feature that requires careful consideration. Adding custom extensions may violate the immutability of Pod images, which can lead to unexpected behavior and maintenance challenges. Use this feature only if you are certain what you are doing and understand the implications. Or reach out to our experts for assistance with adding custom extensions into your infrastructure.

Here's how it works:

1. You build and package a custom extension. The package must have a strict structure. See Packaging requirements for details.
2. You upload the extension to a cloud storage.
3. In the `extensions` section of the Custom Resource, specify the storage configuration and the extension information.
4. The Operator downloads the extension and installs it.
5. In PostgreSQL, you create the extension for every database where you want to use it.

Understanding which files are required for a given extension may not be easy. To figure this out, you can spin up a Docker container or a virtual machine, install Percona Distribution for PostgreSQL and developer tools there, then build and install the extension from source. Then copy all the installed files to the archive.

Check the Example configuration for the steps that can help you in building and adding your own custom extension.

Packaging requirements

Custom extensions require specific packaging for the Operator to use them. The package must be a `.tar.gz` archive that follows this naming format:

`${EXTENSION}-pg${PG_MAJOR}-${EXTENSION_VERSION}`

The archive must be created with `usr` at the root and must include all the required files in the correct directory structure:

1. The control file and any shared library must be in the `LIBDIR` directory
2. All required SQL script files must be in the `SHAREDIR/extension` directory. At least one SQL script is required.

The `SHAREDIR` corresponds to `/usr/pgsql-${PG_MAJOR}/share` and `LIBDIR` to `/usr/pgsql-${PG_MAJOR}/lib`.

For example, the directory for `pg_cron` extension should look as follows:

```
tree ~/pg_cron-1.6.7/
/home/user/pg_cron-1.6.7/
└── usr
    └── pgsql-17
        ├── lib
        │   └── pg_cron.so
        └── share
            └── extension
                ├── pg_cron--1.0--1.1.sql
                ├── pg_cron--1.0.sql
                ├── pg_cron--1.1--1.2.sql
                ├── pg_cron--1.2--1.3.sql
                ├── pg_cron--1.3--1.4.sql
                ├── pg_cron--1.4--1.4-1.sql
                ├── pg_cron--1.4-1--1.5.sql
                ├── pg_cron--1.5--1.6.sql
                └── pg_cron.control
```

The resulting `.tar` archive has the name `pg_cron-pg17-1.6.7.tar.gz`.

Example configuration

The following is an **example workflow** showing how to build and package the `pg_cron` extension. This example is intended to illustrate the general process and give you an idea of the required steps. However, the exact workflow and specifics may differ for your custom extension. Always review your extension's build and packaging requirements and adapt accordingly.

Considerations

1. You must build your extension on a host **with the same operating system and architecture** as the one used for Percona Distribution for PostgreSQL images to prevent library incompatibility. Otherwise, your extension may not load or may not function correctly.

   To check the operating system, do the following:

   a. Connect to one of the database Pods:

   ```
   kubectl exec -it cluster1-instance1-xrcf-0 -n <namespace> -c database -- bash
   ```

b. List the installed packages:

```
rpm -qa|grep percona
```

Sample output

```
percona-release-1.0-32.noarch
percona-postgresql17-libs-17.6-1.el9.x86_64
percona-postgresql17-17.6-1.el9.x86_64
percona-postgresql-client-common-280-1.el9.noarch
percona-telemetry-agent-1.0.5-1.el9.x86_64
percona-pg-telemetry17-1.1.3-1.el9.x86_64
percona-postgresql17-server-17.6-1.el9.x86_64
percona-pgbackrest-2.56.0-1.el9.x86_64
percona-pg_stat_monitor17-2.2.0-1.el9.x86_64
percona-pgaudit17-17.1-1.el9.x86_64
percona-pgvector_17-0.8.0-3.el9.x86_64
percona-wal2json17-2.6-1.el9.x86_64
percona-postgresql17-contrib-17.6-1.el9.x86_64
percona-postgresql-common-280-1.el9.noarch
percona-pg_repack17-1.5.2-2.el9.x86_64
percona-pgaudit17_set_user-4.1.0-3.el9.x86_64
percona-patroni-4.0.6-1.el9.x86_64
```

c. Check the operating system version:

```
cat /etc/redhat-release
```

Sample output

```
Red Hat Enterprise Linux release 9.6 (Plow)
```

2. Your extension must be compatible with PostgreSQL version you are running. To check the version, run the following command:

```
kubectl -n <namespace> get pg cluster1 -o go-template='{{.spec.image}}'
```

Sample output

```
docker.io/perconalab/percona-postgresql-operator:main-ppg17-postgres
```

3. In this example configuration, we use a Docker container to build the `pg_cron` extension. However, you can use any environment that matches the distribution's operating system, such as a virtual machine or a Kubernetes Pod, not just Docker.
4. We assume you have deployed a Percona Distribution for PostgreSQL cluster in Kubernetes. If not, use the Quickstart guide to deploy it.

Prepare your build environment

Run the following commands as the root user or with `sudo` privileges.

1. Start a Docker container and establish a shell session inside. In this example we use a Red Hat Universal Base Image 9 on `x86_64` architecture.

```
docker run -it --name pg redhat/ubi9:latest /bin/bash
```

2. Install basic tools:

```
dnf install git make 'dnf-command(config-manager)'
```

3. Install additional PostgreSQL packages:
   - Add the Extra Packages for Enterprise Linux by installing the `epel-release` package:

```
dnf install -y https://dl.fedoraproject.org/pub/epel/epel-release-latest-
9.noarch.rpm
```

   - Add the codeready builder repository that contains additional packages for use by developers:

```
dnf config-manager --add-repo
https://dl.rockylinux.org/pub/rocky/9/CRB/x86_64/os/
```

   - Import GPG keys

```
rpm --import https://dl.rockylinux.org/pub/rocky/RPM-GPG-KEY-Rocky-9
```

   - Install `perl-IPC-Run` to run and interact with child processes:

```
dnf install perl-IPC-Run -y
```

4. Install build tools:

```
dnf groupinstall "Development tools"
```

Troubleshooting tip: If development tools fail to install, add BaseOS and AppStream repos:

```
dnf config-manager --add-repo
https://dl.rockylinux.org/pub/rocky/9/BaseOS/x86_64/os/
dnf config-manager --add-repo
https://dl.rockylinux.org/pub/rocky/9/AppStream/x86_64/os/
dnf clean all && dnf makecache
```

Then retry the installation.

5. Install PostgreSQL developer packages from Percona repositories:
   - Install `percona-release` repository management tool:

```
dnf install https://repo.percona.com/yum/percona-release-latest.noarch.rpm
```

   - Enable PostgreSQL repository:

```
percona-release setup ppg17
```

   - Disable the `potsgresql` module supplied with the operating system:

```
dnf -qy module disable postgresql
```

   - Install PostgreSQL developer packages:

```
dnf install percona-postgresql17-devel percona-postgresql17-libs percona-
postgresql17
```

Build the extension

1. Download the extension source:

```
git clone https://github.com/citusdata/pg_cron.git
```

2. Navigate to the cloned extension and switch to the desired version. In this example we use version `1.6.7`:

```
cd pg_cron
git checkout v1.6.7
```

3. Ensure `pg_config` is in your path:

```
export PATH=/usr/pgsql-17/bin:$PATH
```

4. Build and install the extension

```
make && sudo PATH=$PATH make install
```

As the result you should see the binaries in the following paths: `/usr/pgsql-17/share/extension/pg_cron` and `/usr/pgsql-17/lib/`.

Package the extension

1. Create a `.tar` archive of the extension:

```
tar -czvf pg_cron-pg17-1.6.7.tar.gz \
  /usr/pgsql-17/lib/pg_cron.so \
  /usr/pgsql-17/share/extension/pg_cron*
```

2. Check that the package structure follows the requirements.
3. Copy the archive to the local machine. Run this command on the local machine:

```
docker cp pg:/pg_cron-pg17-1.6.7.tar.gz ./
```

Upload a custom extension to the cloud storage

After packaging the extension, upload it to a cloud storage. In our example we use AWS S3 storage. You can upload the extension via the Amazon web interface or using the `aws` command line tool as shown below:

1. Export the AWS S3 access credentials as the environment variables:

```
export AWS_ACCESS_KEY_ID=<your-access-key-id-here>
export AWS_SECRET_ACCESS_KEY=<your-secret-key-here>
```

2. Upload the extension to your storage. Use your value for the bucket and specify your path to the archive:

```
aws s3 cp path/to/pg_cron-pg17-1.6.7.tar.gz s3://my-bucket
```

Create a Secret with the storage credentials

After the upload is complete, place the access credentials for the cloud storage in a Secret.

1. Create a Secrets file with the credentials that the Operator needs to access extensions stored on Amazon S3:
   - The `metadata.name` key is the name you will use to refer to your Kubernetes Secret.
   - The `data.AWS_ACCESS_KEY_ID` and `data.AWS_SECRET_ACCESS_KEY` keys contain base64-encoded credentials used to access the storage.

     To encode credentials, use this command:

     in Linux

     For GNU/Linux:

     ```
     echo -n 'plain-text-string' | base64 --wrap=0
     ```

     in macOS

     For Apple macOS:

     ```
     echo -n 'plain-text-string' | base64
     ```

   Here's the example Secrets file `extensions-secret.yaml`:

   extensions-secret.yaml

```
apiVersion: v1
kind: Secret
metadata:
  name: cluster1-extensions-secret
type: Opaque
data:
  AWS_ACCESS_KEY_ID: <base64 encoded secret>
  AWS_SECRET_ACCESS_KEY: <base64 encoded secret>
```

2. Create the Secrets object from this file:

```
kubectl apply -f extensions-secret.yaml -n <namespace>
```

Configure the Operator to load and install the custom extension

Specify both the storage and extension details in the Custom Resource so the Operator can download and install it.

1. In the `extensions.storage` subsection of the Custom Resource, specify the following information:
   - storage details such as the bucket where your extension resides, region and endpoint to access the storage
   - the Secret name with the storage credentials that you created before.

```
extensions:
  ...
  storage:
    type: s3
    bucket: pg-extensions
    region: eu-central-1
    endpoint: s3.eu-central-1.amazonaws.com
    secret:
      name: cluster1-extensions-secret
```

2. In the `extensions.custom` subsection, specify the extension name and version:

```
extensions:
  ...
  custom:
  - name: pg_cron
    version: 1.6.1
```

3. Some extensions (such as `pg_cron` in our example) may require additional shared memory. If this is the case, you need to configure PostgreSQL to preload it at startup:

   ```yaml … patroni: dynamicConfiguration: postgresql: parameters: shared_preload_libraries: pg_cron …

4. Apply the configuration:

   ```
   kubectl apply -f deploy/cr.yaml -n <namespace>
   ```

   This causes the Operator to restart the Pods of your cluster.

#### Enable custom extension in PostgreSQL

The installed extension is not enabled by default. You need to explicitly enable it in PostgreSQL for all databases where you want to use it.

Here's how to do it:

1. Connect to the primary Pod:

   ```
   kubectl exec -it cluster1-instance1-69r8-0 -c database -n <namespace> -- bash
   ```

2. Connect to the required database in PostgreSQL and create the extension for this database using the `CREATE EXTENSION` statement:

   ```
   CREATE EXTENSION pg_cron;
   ```

Update custom extensions

To update your custom extension inside the Operator, do the following:

1. Prepare the `*.tar` archive of the extension's new version. See the Packaging requirements section for the archive's structure and naming format
2. Reference the new version of the extension in the Custom Resource. For example, you update `pg_cron` extension to version 1.6.8. Then your configuration looks like this:
   ```

```
extensions:
  ...
  custom:
  - name: pg_cron
    version: 1.6.8
```

3. Apply the configuration for the changes to come into place:

```
kubectl apply -f deploy/cr.yaml -n <namespace>
```

Percona Operator for PostgreSQL single-namespace and multi-namespace deployment

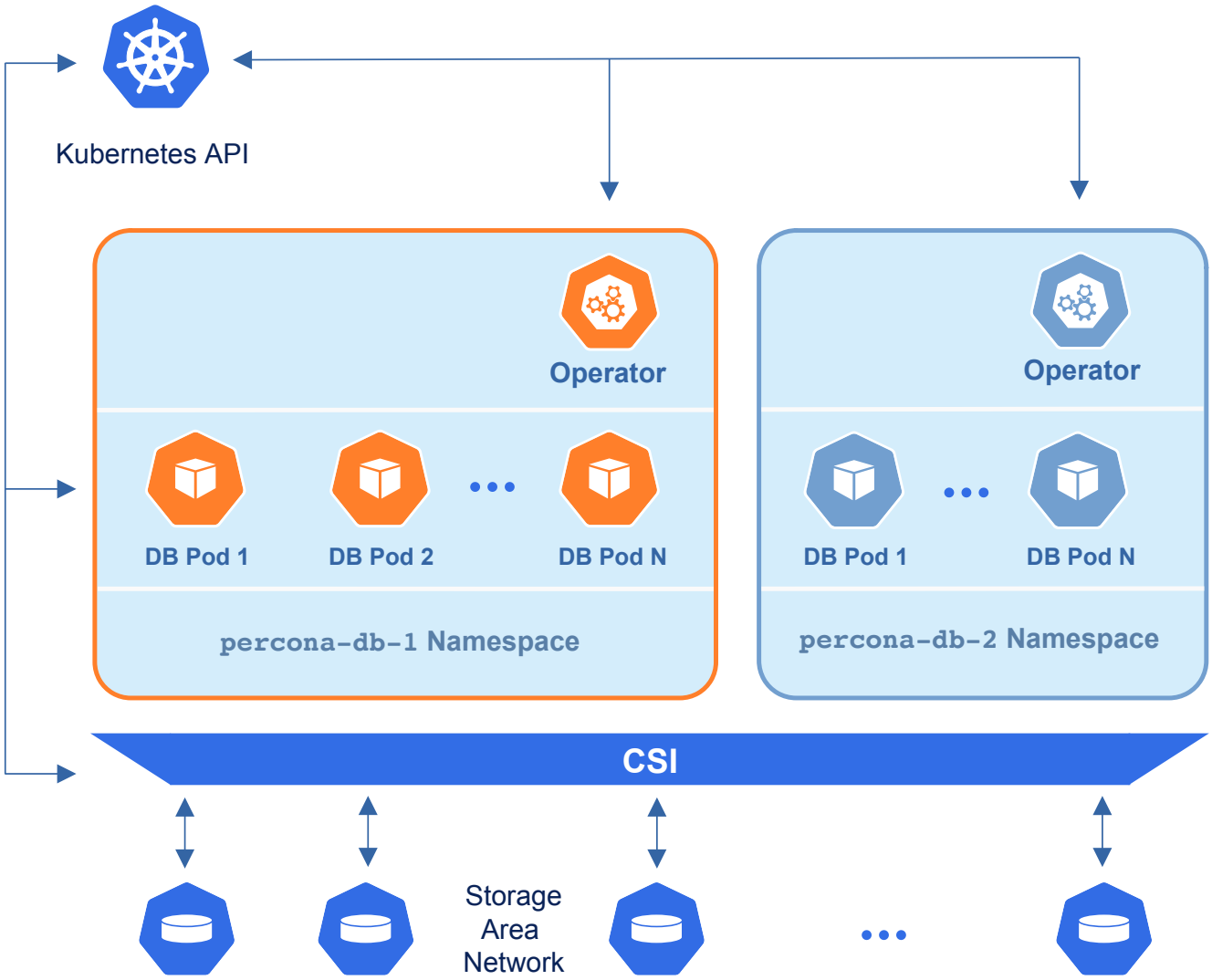
There are two design patterns that you can choose from when deploying Percona Operator for PostgreSQL and PostgreSQL clusters in Kubernetes:

- Namespace-scope - one Operator per Kubernetes namespace,
- Cluster-wide - one Operator can manage clusters in multiple namespaces.

This how-to explains how to configure Percona Operator for PostgreSQL for each scenario.

Namespace-scope

By default, Percona Operator for PostgreSQL functions in a specific Kubernetes namespace. You can create one during the installation (like it is shown in the installation instructions) or just use the default namespace. This approach allows several Operators to co-exist in one Kubernetes-based environment, being separated in different namespaces:



Normally this is a recommended approach, as isolation minimizes impact in case of various failure scenarios. This is the default configuration of our Operator.

Let's say you will use a Kubernetes Namespace called `percona-db-1`.

1. Clone `percona-postgresql-operator` repository:

   ```
   git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
   cd percona-postgresql-operator
   ```

2. Create your `percona-db-1` Namespace (if it doesn't yet exist) as follows:

   ```
   kubectl create namespace percona-db-1
   ```

3. Deploy the Operator using the following command:

```
kubectl apply --server-side -f deploy/bundle.yaml -n percona-db-1
```

4. Once Operator is up and running, deploy the database cluster itself:

```
kubectl apply -f deploy/cr.yaml -n percona-db-1
```

You can deploy multiple clusters in this namespace.

Add more namespaces

What if there is a need to deploy clusters in another namespace? The solution for namespace-scope deployment is to have more than one Operator. We will use the `percona-db-2` namespace as an example.

1. Create your `percona-db-2` namespace (if it doesn't yet exist) as follows:

```
kubectl create namespace percona-db-2
```

2. Deploy the Operator:

```
kubectl apply --server-side -f deploy/bundle.yaml -n percona-db-2
```

3. Once Operator is up and running deploy the database cluster itself:

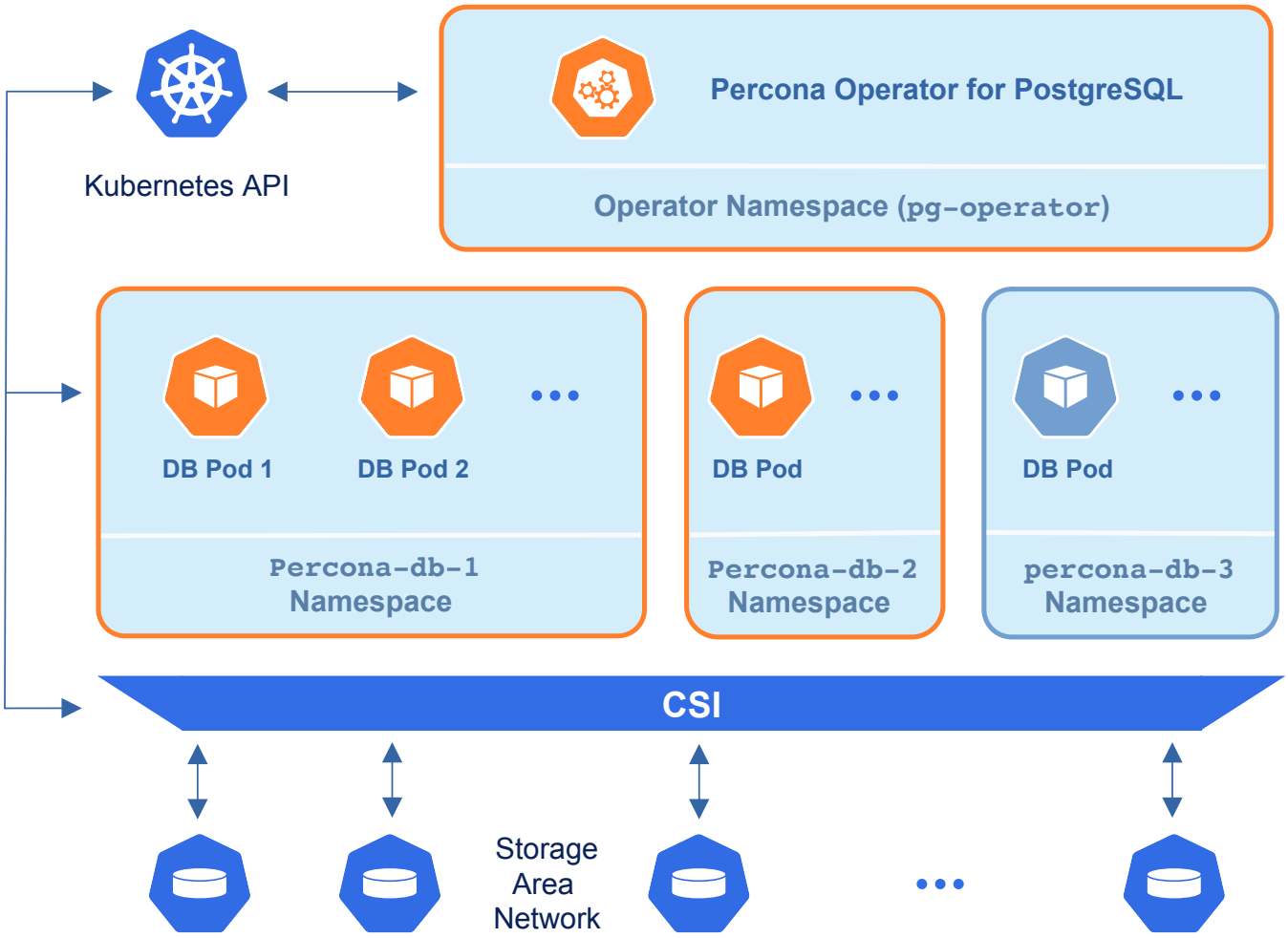
```
kubectl apply -f deploy/cr.yaml -n percona-db-2
```

> **Note**
>
> Cluster names may be the same in different namespaces.

Install the Operator cluster-wide

Sometimes it is more convenient to have one Operator watching for Percona Distribution for PostgreSQL custom resources in several namespaces.

We recommend running Percona Operator for PostgreSQL in a traditional way, limited to a specific namespace, to limit the blast radius. But it is possible to run it in so-called *cluster-wide* mode, one Operator watching several namespaces, if needed:



To use the Operator in such cluster-wide mode, you should install it with a different set of configuration YAML files, which are available in the deploy folder and have filenames with a special `cw-` prefix: e.g. `deploy/cw-bundle.yaml`.

While using this cluster-wide versions of configuration files, you should set the following information there:

- `subjects.namespace` option should contain the namespace which will host the Operator,
- `WATCH_NAMESPACE` key-value pair in the `env` section should have `value` equal to a comma-separated list of the namespaces to be watched by the Operator, *and* the namespace in which the Operator resides. If this key is set to a blank string, the Operator will watch **only the namespace it runs in**, which would be the same as single-namespace deployment.

Note

Installing the Operator cluster-wide on OpenShift via the the Operator Lifecycle Manager (OLM) requires making different selections in the OLM web-based UI instead of patching YAML files.

The following simple example shows how to install Operator cluster-wide on Kubernetes.

1. Clone `percona-postgresql-operator` repository:

   ```
   git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
   cd percona-postgresql-operator
   ```

2. Let's say you will use `pg-operator` namespace for the Operator, and `percona-db-1` namespace for the cluster. Create these namespaces, if needed:

   ```
   kubectl create namespace pg-operator
   kubectl create namespace percona-db-1
   ```

3. Edit the `deploy/cw-bundle.yaml` configuration file to make sure it contains proper namespace name for the Operator:

   ```
   ...
   subjects:
   - kind: ServiceAccount
     name: percona-postgresql-operator
     namespace: pg-operator
   ...
   spec:
     containers:
     - env:
       - name: WATCH_NAMESPACE
         value: "pg-operator,percona-db-1"
   ...
   ```

4. Apply the `deploy/cw-bundle.yaml` file with the following command:

   ```
   kubectl apply --server-side -f deploy/cw-bundle.yaml -n pg-operator
   ```

   Right now the operator deployed in cluster-wide mode will monitor all namespaces in the cluster, either already existing or newly created ones.

5. Deploy the cluster in the namespace of your choice:

```
kubectl apply -f deploy/cr.yaml -n percona-db-1
```

Verifying the cluster operation

When creation process is over, you can try to connect to the cluster.

During the installation, the Operator has generated several secrets, including the one with password for default PostgreSQL user. This default user has the same login name as the cluster name.

1. Use `kubectl get secrets` command to see the list of Secrets objects. The Secrets object you are interested in is named as `<cluster_name>-pguser-<cluster_name>` (substitute `<cluster_name>` with the name of your Percona Distribution for PostgreSQL Cluster). The default variant will be `cluster1-pguser-cluster1`.

2. Use the following command to get the password of this user. Replace the `<cluster_name>` and `<namespace>` placeholders with your values:

   ```
   kubectl get secret <cluster_name>-<user_name>-<cluster_name> -n
   <namespace> --template='{{.data.password | base64decode}}{{"\n"}}'
   ```

3. Create a pod and start Percona Distribution for PostgreSQL inside. The following command will do this, naming the new Pod `pg-client`:

   ```
   kubectl run -i --rm --tty pg-client --image=perconalab/percona-
   distribution-postgresql:17.7-1 --restart=Never -- bash -il
   ```

   Executing it may require some time to deploy the corresponding Pod.

4. Run a container with `psql` tool and connect its console output to your terminal. The following command will connect you as a `cluster1` user to a `cluster1` database via the PostgreSQL interactive terminal.

   ```
   [postgres@pg-client /]$ PGPASSWORD='pguser_password' psql -h cluster1-
   pgbouncer.postgres-operator.svc -p 5432 -U cluster1 cluster1
   ```

Sample output

```
psql (17.7-1)
SSL connection (protocol: TLSv1.3, cipher: TLS_AES_256_GCM_SHA384, bits: 256,
compression: off)
Type "help" for help.
pgdb=>
```

Using PostgreSQL tablespaces with Percona Operator for PostgreSQL

Tablespaces allow DBAs to store a database on multiple file systems within the same server and to control where (on which file systems) specific parts of the database are stored. You can think about it as if you were giving names to your disk mounts and then using those names as additional parameters when creating database objects.

PostgreSQL supports this feature, allowing you to *store data outside of the primary data directory*, and Percona Operator for PostgreSQL is a good option to bring this to your Kubernetes environment when needed.

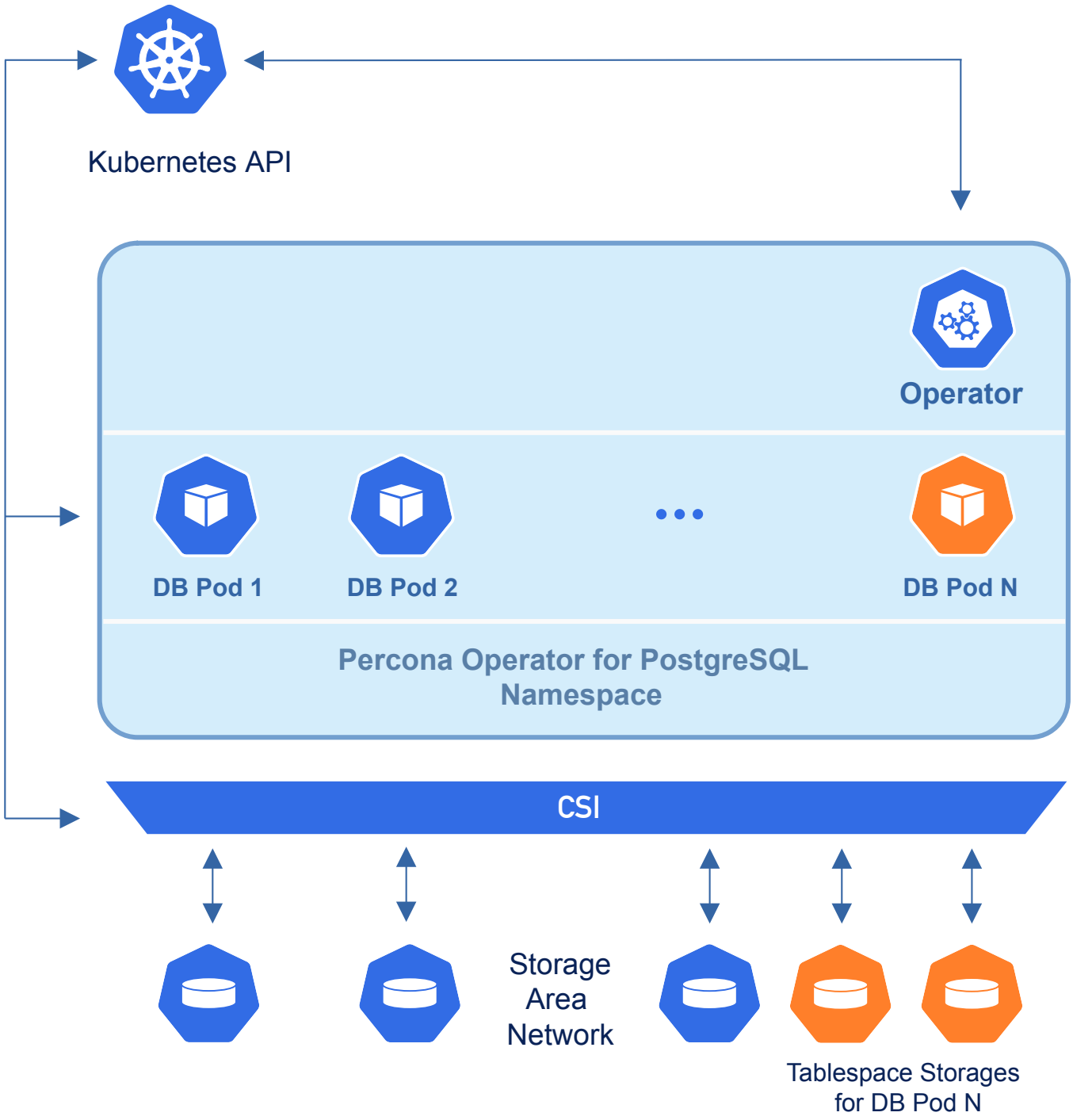
Possible use cases

The most obvious use case for tablespaces is performance optimization. You place appropriate parts of the database on fast but expensive storage and engage slower but cheaper storage for lesser-used database objects. The classic example would be using an SSD for heavily-used indexes and using a large slow HDD for archive data.

Of course, the Operator already provides you with traditional Kubernetes approaches to achieve this on a per-Pod basis (Tolerations, etc.). But if you would like to go deeper and make such differentiation at the level of your database objects (tables and indexes), tablespaces are exactly what you would need for that.

Another well-known use case for tablespaces is quickly adding a new partition to the database cluster when you run out of space on the initially used one and cannot extend it (which may look less typical for cloud storage). Finally, you may need tablespaces when migrating your existing architecture to the cloud.

Each tablespace created by Percona Operator for PostgreSQL corresponds to a separate Persistent Volume, mounted in a container to the `/tablespaces` directory.



Creating a new tablespace

Providing a new tablespace for your database in Kubernetes involves two parts:

1. Configure the new tablespace storage with the Operator,
2. Create database objects in this tablespace with PostgreSQL.

The first part is done in the traditional way of Percona Operators, by modifying Custom Resource via the `deploy/cr.yaml` configuration file. It has a special spec.tablespaceStorages section for tablespaces.

The example already present in `deploy/cr.yaml` shows how to create tablespace storage 1Gb in size (you can see official Kubernetes documentation on Persistent Volumes for details):

```
spec:
  instances:
    ...
    tablespaceVolumes:
      - name: user
        dataVolumeClaimSpec:
          accessModes:
            - 'ReadWriteOnce'
          resources:
            requests:
              storage: 1Gi
```

After you apply this by running the `kubectl apply -f deploy/cr.yaml` command, the new `/tablespaces/user/` mountpoint will appear for your database. Please take into account that if you add your new tablespace to the already existing PostgreSQL cluster, it may take time for the Operator to create Persistent Volume Claims and get Persistent Volumes actually mounted.

Now you should actually create your tablespace on this volume with the `CREATE TABLESPACE <tablespace name> LOCATION <mount point>` command, and then create objects in it (of course, your user should have appropriate `CREATE` privileges to make it possible):

```
CREATE TABLESPACE user121
LOCATION '/tablespaces/user/data';
```

Now when the tablespace is created you can append `TABLESPACE <tablespace_name>` to your `CREATE` SQL statements to implicitly create tables, indexes, or even entire databases in specific tablespace.

Let's create an example table in the already mentioned `user121` tablespace:

```
CREATE TABLE products (
    product_sku character(10),
    quantity int,
    manufactured_date timestamptz)
TABLESPACE user121;
```

It is also possible to set a default tablespace with the `SET default_tablespace = <tablespace_name>;` statement. It will affect all further `CREATE TABLE` and `CREATE INDEX` commands without an explicit tablespace specifier, until you unset it with an empty string.

As you can see, Percona Operator for PostgreSQL simplifies tablespace creation by carrying on all necessary modifications with Persistent Volumes and Pods. The same would not be true for the deletion of an already existing tablespace, which is not automated, neither by the Operator nor by PostgreSQL.

Deleting an existing tablespace

Deleting an existing tablespace from your database in Kubernetes also involves two parts:

- Delete related database objects and tablespace with PostgreSQL,
- Delete tablespace storage in Kubernetes.

To make tablespace deletion with PostgreSQL possible, you should make this tablespace empty (it is impossible to drop a tablespace until *all objects in all databases using this tablespace* have been removed). Tablespaces are listed in the `pg_tablespace` table, and you can use it to find out which objects are stored in a specific tablespace. The example command for the `lake` tablespace will look as follows:

```
SELECT relname FROM pg_class WHERE reltablespace=(SELECT oid FROM
pg_tablespace WHERE spcname='user121');
```

When your tablespace is empty, you can log in to the *PostgreSQL Primary instance* as a *superuser*, and then execute the `DROP TABLESPACE <tablespace_name>;` command.

Now, when the PostgreSQL part is finished, you can remove the tablespace entry from the `tablespaceStorages` section (don't forget to run the `kubectl apply -f deploy/cr.yaml` command to apply changes).

Monitor Kubernetes

Monitoring the state of the database is crucial to timely identify and react to performance issues. Percona Monitoring and Management (PMM) solution enables you to do just that.

However, the database state also depends on the state of the Kubernetes cluster itself. Hence it's important to have metrics that can depict the state of the Kubernetes cluster.

This document describes how to set up monitoring of the Kubernetes cluster health. This setup has been tested with the PMM Server as the centralized data storage and the Victoria Metrics Kubernetes monitoring stack as the metrics collector. These steps may also apply if you use another Prometheus-compatible storage.

Pre-requisites

To set up monitoring of Kubernetes, you need the following:

1. PMM Server up and running. You can run PMM Server as a Docker image, a virtual appliance, or on an AWS instance. Please refer to the official PMM documentation for the installation instructions.
2. Helm v3.
3. kubectl.
4. The PMM Server API key. The key must have the role "Admin".

   Get the PMM API key:

From PMM UI

Generate the PMM API key

From command line

You can query your PMM Server installation for the API Key using `curl` and `jq` utilities. Replace `<login>:<password>@<server_host>` placeholders with your real PMM Server login, password, and hostname in the following command:

```
API_KEY=$(curl --insecure -X POST -H "Content-Type: application/json" -d
{"name":"operator", "role": "Admin"}' "https://<login>:
<password>@<server_host>/graph/api/auth/keys" | jq .key)
```

Note

The API key is not rotated.

Install the Victoria Metrics Kubernetes monitoring stack

Quick install

1. To install the Victoria Metrics Kubernetes monitoring stack with the default parameters, use the quick install command. Replace the following placeholders with your values:
   - `API-KEY` - The API key of your PMM Server
   - `PMM-SERVER-URL` - The URL to access the PMM Server
   - `UNIQUE-K8s-CLUSTER-IDENTIFIER` - Identifier for the Kubernetes cluster. It can be the name you defined during the cluster creation.

   You should use a unique identifier for each Kubernetes cluster. The use of the same identifier for more than one Kubernetes cluster will result in the conflicts during the metrics collection.

   - `NAMESPACE` - The namespace where the Victoria metrics Kubernetes stack will be installed. If you haven't created the namespace before, it will be created during the command execution.

   We recommend to use a separate namespace like `monitoring-system`.

```
curl -fsL  https://raw.githubusercontent.com/Percona-Lab/k8s-monitoring/refs/tags/v0.1.1/vm-operator-k8s-stack/quick-install.sh | bash -s -- --api-key <API-KEY> --pmm-server-url <PMM-SERVER-URL> --k8s-cluster-id <UNIQUE-K8s-CLUSTER-IDENTIFIER> --namespace <NAMESPACE>
```

Note

The Prometheus node exporter is not installed by default since it requires privileged containers with the access to the host file system. If you need the metrics for Nodes, add the `--node-exporter-enabled` flag as follows:

```
curl -fsL  https://raw.githubusercontent.com/Percona-Lab/k8s-monitoring/refs/tags/v0.1.1/vm-operator-k8s-stack/quick-install.sh | bash -s -- --api-key <API-KEY> --pmm-server-url <PMM-SERVER-URL> --k8s-cluster-id <UNIQUE-K8s-CLUSTER-IDENTIFIER> --namespace <NAMESPACE> --node-exporter-enabled
```

Install manually

You may need to customize the default parameters of the Victoria metrics Kubernetes stack.

- Since we use the PMM Server for monitoring, there is no need to store the data in Victoria Metrics Operator. Therefore, the Victoria Metrics Helm chart is installed with the `vmsingle.enabled` and `vmcluster.enabled` parameters set to `false` in this setup.
- Check all the role-based access control (RBAC) rules of the `victoria-metrics-k8s-stack` chart and the dependencies chart, and modify them based on your requirements.

Configure authentication in PMM

To access the PMM Server resources and perform actions on the server, configure authentication.

1. Encode the PMM Server API key with base64.

   Linux

   ```
   $ echo -n <API-key> | base64 --wrap=0
   ```

   macOS

   ```
   echo -n <API-key> | base64
   ```

2. Create the Namespace where you want to set up monitoring. The following command creates the Namespace `monitoring-system`. You can specify a different name. In the latter steps, specify your namespace instead of the `<namespace>` placeholder.

   ```
   kubectl create namespace monitoring-system
   ```

3. Create the YAML file for the Kubernetes Secrets and specify the base64-encoded API key value within. Let's name this file `pmm-api-vmoperator.yaml`.

   pmm-api-vmoperator.yaml

   ```
   apiVersion: v1
   data:
     api_key: <base-64-encoded-API-key>
   kind: Secret
   metadata:
     name: pmm-token-vmoperator
     #namespace: default
   type: Opaque
   ```

4. Create the Secrets object using the YAML file you created previously. Replace the `<filename>` placeholder with your value.

   ```
   kubectl apply -f pmm-api-vmoperator.yaml -n <namespace>
   ```

5. Check that the secret is created. The following command checks the secret for the resource named `pmm-token-vmoperator` (as defined in the `metadata.name` option in the secrets file). If you defined another resource name, specify your value.

```
kubectl get secret pmm-token-vmoperator -n <namespace>
```

Create a ConfigMap to mount for `kube-state-metrics`

The `kube-state-metrics` (KSM) is a simple service that listens to the Kubernetes API server and generates metrics about the state of various objects - Pods, Deployments, Services and Custom Resources.

To define what metrics the `kube-state-metrics` should capture, create the ConfigMap and mount it to a container.

Use the example `configmap.yaml` configuration file to create the ConfigMap.

```
kubectl apply -f https://raw.githubusercontent.com/Percona-Lab/k8s-
monitoring/refs/tags/v0.1.1/vm-operator-k8s-stack/ksm-configmap.yaml -n
<namespace>
```

As a result, you have the `customresource-config-ksm` ConfigMap created.

Install the Victoria Metrics Kubernetes monitoring stack

1. Add the dependency repositories of victoria-metrics-k8s-stack chart.

   ```
   helm repo add grafana https://grafana.github.io/helm-charts
   helm repo add prometheus-community https://prometheus-
   community.github.io/helm-charts
   ```

2. Add the Victoria Metrics Kubernetes monitoring stack repository.

   ```
   helm repo add vm https://victoriametrics.github.io/helm-charts/
   ```

3. Update the repositories.

   ```
   helm repo update
   ```

4. Install the Victoria Metrics Kubernetes monitoring stack Helm chart. You need to specify the following configuration:

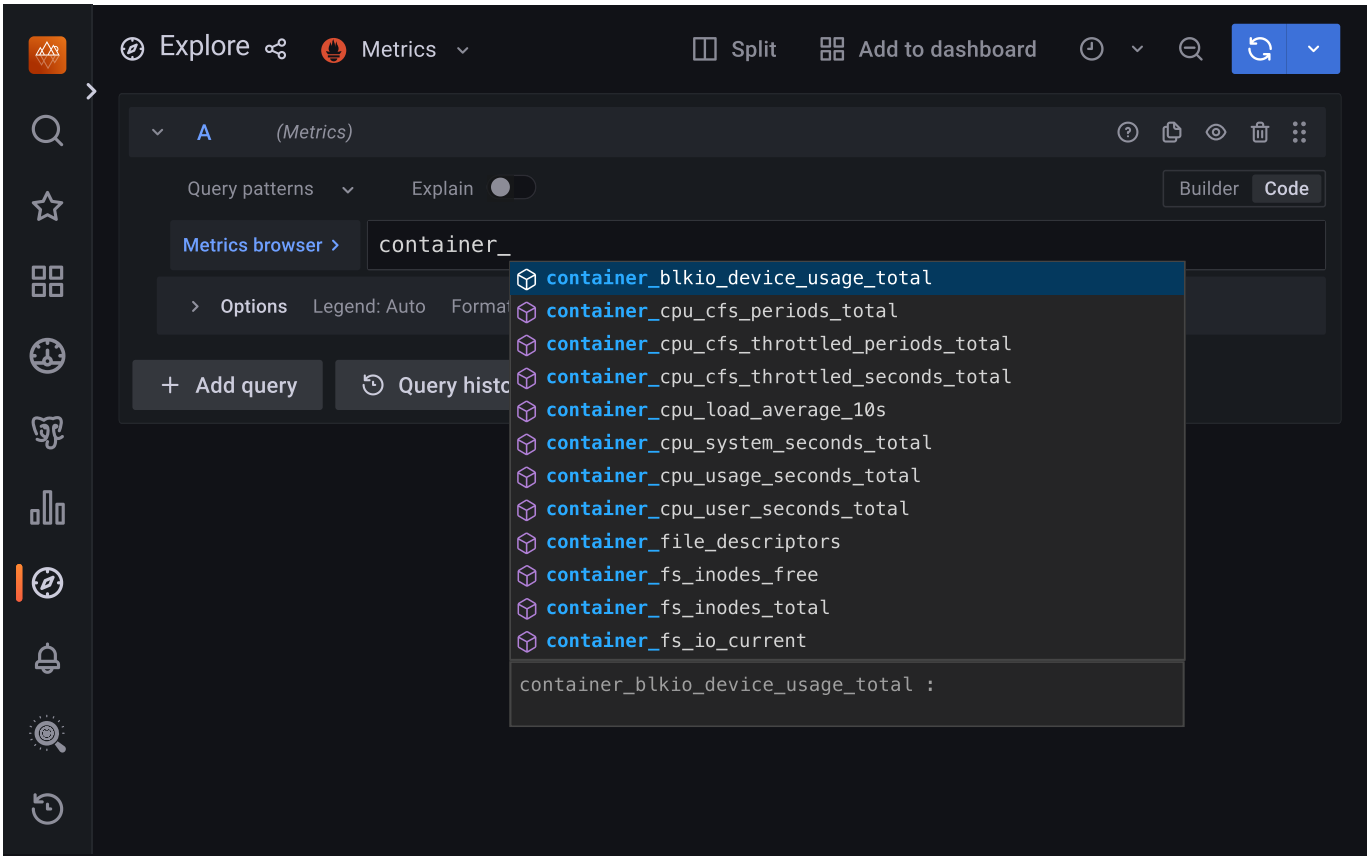
   - the URL to access the PMM server in the `externalVM.write.url` option in the format `<PMM-SERVER-URL>/victoriametrics/api/v1/write`. The URL can contain either the IP address or the hostname of the PMM server.
   - the unique name or an ID of the Kubernetes cluster in the `vmagent.spec.externalLabels.k8s_cluster_id` option. Ensure to set different values if you are sending metrics from multiple Kubernetes clusters to the same PMM Server.
   - the `<namespace>` placeholder with your value. The Namespace must be the same as the Namespace for the Secret and ConfigMap

```
bash
    helm install vm-k8s vm/victoria-metrics-k8s-stack \
     -f https://raw.githubusercontent.com/Percona-Lab/k8s-monitoring/refs/tags/v0.1.1/vm-operator-k8s-stack/values.yaml \
     --set externalVM.write.url=<PMM-SERVER-URL>/victoriametrics/api/v1/write \
     --set vmagent.spec.externalLabels.k8s_cluster_id=<UNIQUE-CLUSTER-IDENTIFIER/NAME> \
     -n <namespace>
```

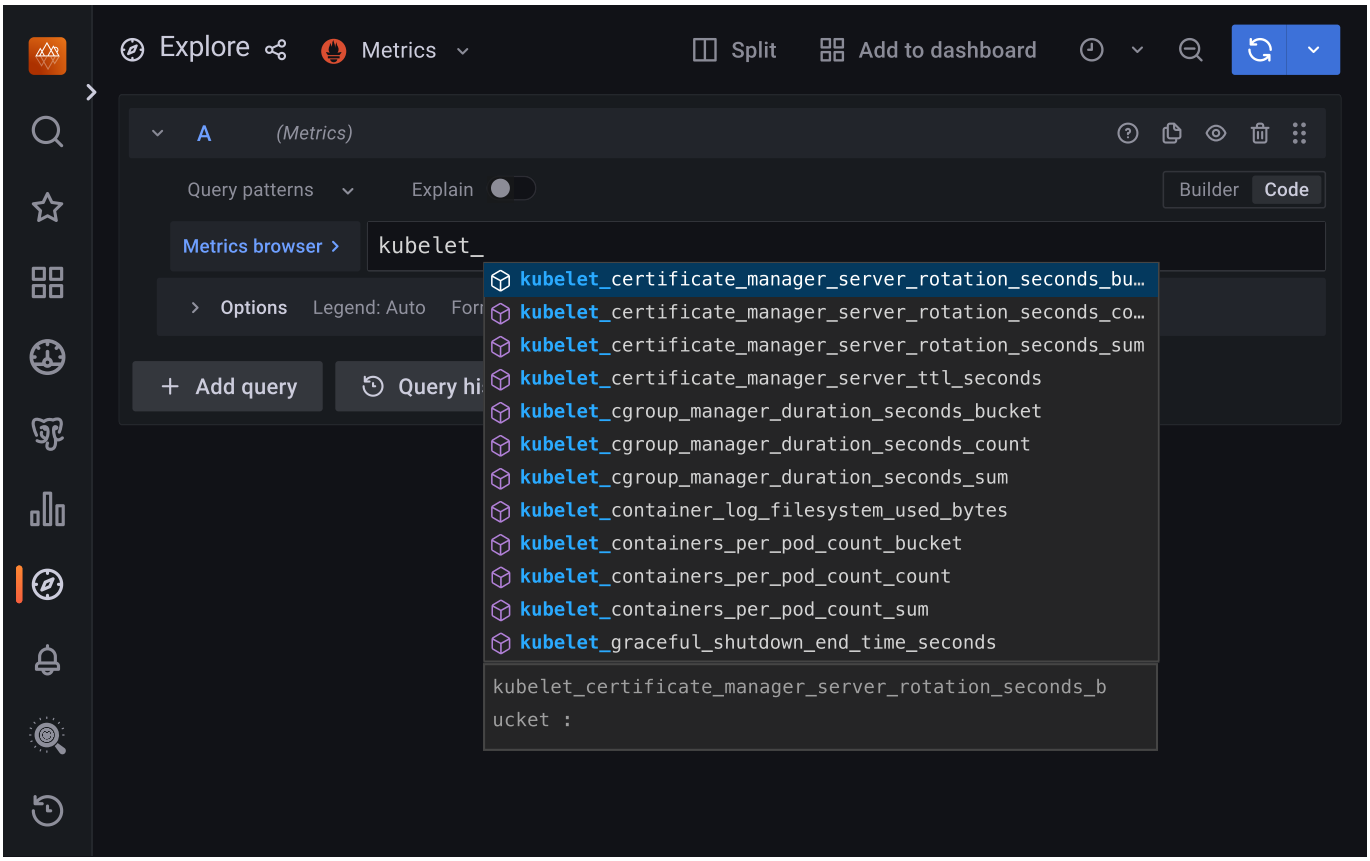
To illustrate, say your PMM Server URL is `https://pmm-example.com`, the cluster ID is `test-cluster` and the Namespace is `monitoring-system`. Then the command would look like this:

```{.bash .no-copy } $ helm install vm-k8s vm/victoria-metrics-k8s-stack \ -f https://raw.githubusercontent.com/Percona-Lab/k8s-monitoring/refs/tags/v0.1.1/vm-operator-k8s-stack/values.yaml \ –set externalVM.write.url=https://pmm-example.com/victoriametrics/api/v1/write \ –set vmagent.spec.externalLabels.k8s_cluster_id=test-cluster \ -n monitoring-system

## Validate the successful installation

```
kubectl get pods -n <namespace>
```

**Sample output**

```
vm-k8s-stack-kube-state-metrics-d9d85978d-9pzbs                    1/1     Running   0
28m
vm-k8s-stack-victoria-metrics-operator-844d558455-gvg4n            1/1     Running   0
28m
vmagent-vm-k8s-stack-victoria-metrics-k8s-stack-55fd8fc4fbcxwhx   2/2     Running   0
28m
```

What Pods are running depends on the configuration chosen in values used while installing `victoria-metrics-k8s-stack` chart.

Verify metrics capture

1. Connect to the PMM server.
```

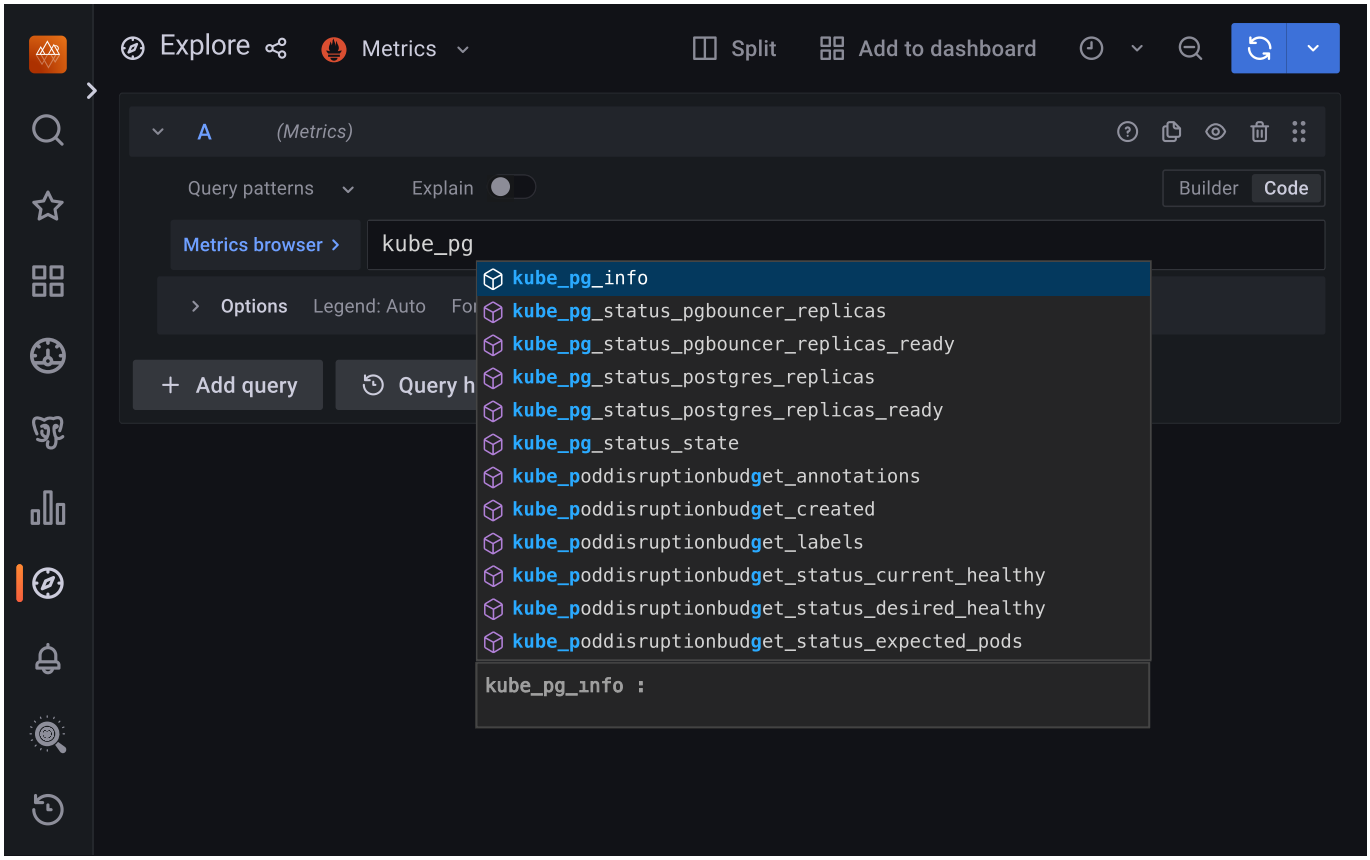
2. Click **Explore** and switch to the **Code** mode.
3. Check that the required metrics are captured, type the following in the Metrics browser dropdown:
   - cadvisor:



   - kubelet:



- [kube-state-metrics](#) metrics that also include Custom resource metrics for the Operator and database deployed in your Kubernetes cluster:



Uninstall Victoria metrics Kubernetes stack

To remove Victoria metrics Kubernetes stack used for Kubernetes cluster monitoring, use the cleanup script. By default, the script removes all the Custom Resource Definitions(CRD) and Secrets associated with the Victoria metrics Kubernetes stack. To keep the CRDs, run the script with the `--keep-crd` flag.

Remove CRDs

Replace the `<NAMESPACE>` placeholder with the namespace you specified during the Victoria metrics Kubernetes stack installation:

```
bash <(curl -fsL https://raw.githubusercontent.com/Percona-Lab/k8s-monitoring/refs/tags/v0.1.1/vm-operator-k8s-stack/cleanup.sh) --namespace <NAMESPACE>
```

Keep CRDs

Replace the `<NAMESPACE>` placeholder with the namespace you specified during the Victoria metrics Kubernetes stack installation:

```
bash <(curl -fsL https://raw.githubusercontent.com/Percona-Lab/k8s-monitoring/refs/tags/v0.1.1/vm-operator-k8s-stack/cleanup.sh) --namespace <NAMESPACE> --keep-crd
```

Check that the Victoria metrics Kubernetes stack is deleted:

```
helm list -n <namespace>
```

The output should provide the empty list.

If you face any issues with the removal, uninstall the stack manually:

```
helm uninstall vm-k8s-stack -n < namespace>
```

Use PostGIS extension with Percona Distribution for PostgreSQL

PostGIS is a PostgreSQL extension that adds GIS capabilities to this database.

Starting from the Operator version 2.3.0 it became possible to deploy and manage PostGIS-enabled PostgreSQL.

Due to the large size and domain specifics of this extension, Percona provides separate PostgreSQL Distribution images with it.

Deploy the Operator with PostGIS-enabled database cluster

Following steps will allow you to deploy PostgreSQL cluster with these images.

1. Clone the percona-postgresql-operator repository:

   ```
   git clone -b v2.8.1 https://github.com/percona/percona-postgresql-operator
   cd percona-postgresql-operator
   ```

   Note

   It is crucial to specify the right branch with `-b` option while cloning the code on this step. Please be careful.

2. The Custom Resource Definition for Percona Distribution for PostgreSQL should be created from the `deploy/crd.yaml` file. Custom Resource Definition extends the standard set of resources which Kubernetes "knows" about with the new items (in our case ones which are the core of the Operator). Apply it as follows:

   ```
   kubectl apply --server-side -f deploy/crd.yaml
   ```

3. Create the Kubernetes namespace for your cluster if needed (for example, let's name it `postgres-operator`):

   ```
   kubectl create namespace postgres-operator
   ```

4. The role-based access control (RBAC) for Percona Distribution for PostgreSQL is configured with the `deploy/rbac.yaml` file. Role-based access is based on defined roles and the available actions which correspond to each role. The role and actions are defined for Kubernetes resources in the yaml file. Further details about users and roles can be found in Kubernetes documentation.

   ```
   kubectl apply -f deploy/rbac.yaml -n postgres-operator
   ```

   Note

   Setting RBAC requires your user to have cluster-admin role privileges. For example, those using Google Kubernetes Engine can grant user needed privileges with the following command:

   ```
   $ kubectl create clusterrolebinding cluster-admin-binding --clusterrole=cluster-admin --user=$(gcloud config get-value core/account)
   ```

5. Start the Operator within Kubernetes:

   ```
   kubectl apply -f deploy/operator.yaml -n postgres-operator
   ```

6. After the Operator is started, modify the `deploy/cr.yaml` configuration file with PostGIS-enabled image - use `docker.io/percona/percona-postgresql-operator:2.8.1-ppg17.7-postgres-gis3.3.8` instead of `docker.io/percona/percona-postgresql-operator:2.8.1-ppg17.7-postgres`

   ```
   apiVersion: pgv2.percona.com/v2
   kind: PerconaPGCluster
   metadata:
     name: cluster1
   spec:
     ...
     image: docker.io/percona/percona-postgresql-operator:2.8.1-ppg17.7-postgres-gis3.3.8
     ...
   ```

   When done, Percona Distribution for PostgreSQL cluster can be created at any time with the following command:

   ```
   kubectl apply -f deploy/cr.yaml -n postgres-operator
   ```

The creation process may take some time. When the process is over your cluster will obtain the `ready` status. You can check it with the following command:

```
kubectl get pg -n postgres-operator
```

Expected output

```
NAME       ENDPOINT                          STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.default.svc    ready    3          3           30m
```

Check PostGIS extension

To use PostGIS extension you should enable it for a specific database.

For example, you can create the new database named `mygisdata` with the `psql` tool as follows:

```
CREATE database mygisdata;
\c mygisdata;
CREATE SCHEMA gis;
```

Next, enable the `postgis` extension. Make sure you are connected to the database you created earlier and run the following command:

```
CREATE EXTENSION postgis;
```

Finally, check that the extension is enabled:

```
SELECT postgis_full_version();
```

The output should resemble the following:

```
postgis_full_version
    ----------------------------------------------------------------------------
----------------------------------------------------------------------------
-----------
 POSTGIS="3.3.3" [EXTENSION] PGSQL="140" GEOS="3.10.2-CAPI-1.16.0"
PROJ="8.2.1" LIBXML="2.9.13" LIBJSON="0.15" LIBPROTOBUF="1.3.3" WAGYU="0.5.0
(Internal)"
```

You can find more about using PostGIS in the official Percona Distribution for PostgreSQL documentation, as well as in this blogpost.

Delete Percona Operator for PostgreSQL

When cleaning up your Kubernetes environment (e.g., moving from a trial deployment to a production one, or testing experimental configurations), you may need to remove some (or all) of the following objects:

- Percona Distribution for PosgreSQL cluster managed by the Operator
- Percona Operator for PostgreSQL itself
- Custom Resource Definition deployed with the Operator
- Resources like PVCs and Secrets

Delete a database cluster

You can delete the Percona Distribution for PosgreSQL cluster managed by the Operator by deleting the appropriate Custom Resource.

Note

There are two finalizers defined in the Custom Resource, which define whether TLS-related objects and data volumes should be deleted or preserved when the cluster is deleted.

- `finalizers.percona.com/delete-ssl`: if present, deletes objects, created for SSL (Secret, certificate, and issuer) when the cluster deletion occurs.
- `finalizers.percona.com/delete-pvc`: if present, deletes Persistent Volume Claims for the database cluster Pods and user Secrets when the cluster deletion occurs.

Both finalizers are off by default in the `deploy/cr.yaml` configuration file, and this allows you to recreate the cluster without losing data, credentials for the system users, etc.

Here's a sequence of steps to follow:

1. List Custom Resources, replacing the `<namespace>` placeholder with your namespace.

```
kubectl get pg -n <namespace>
```

Sample output

```
NAME       ENDPOINT                          STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.default.svc    ready    3          3           30m
```

2. Delete the Custom Resource with the name of your cluster (for example, let's use the default `cluster1` name).

```
kubectl delete pg cluster1 -n <namespace>
```

Sample output

```
perconapgcluster.pgv2.percona.com "cluster1" deleted
```

3. Check that the cluster is deleted by listing the available Custom Resources once again.

```
kubectl get pg -n <namespace>
```

Sample output

```
No resources found in <namespace> namespace.
```

Delete the Operator

You can uninstall the Operator by deleting the Deployments related to it.

1. List the deployments. Replace the `<namespace>` placeholder with your namespace.

```
kubectl get deploy -n <namespace>
```

Sample output

```
NAME                          READY   UP-TO-DATE   AVAILABLE   AGE
percona-postgresql-operator   1/1     1            1           13m
```

2. Delete the `percona-*` deployment

```
kubectl delete deploy percona-postgresql-operator -n <namespace>
```

3. Check that the Operator is deleted by listing the Pods. As a result you should have no Pods related to it.

```
kubectl get pods -n <namespace>
```

Sample output

```
No resources found in <namespace> namespace.
```

Delete Custom Resource Definition

If you are not just deleting the Operator and PostgreSQL cluster from a specific namespace, but want to clean up your entire Kubernetes environment, you can also delete the CustomResourceDefinitions (CRDs).

Warning

CRDs in Kubernetes are non-namespaced but are available to the whole environment. This means that you shouldn't delete CRD if you still have the Operator and database cluster in some namespace.

You can delete CRD as follows:

1. List the CRDs:

```
kubectl get crd
```

Sample output

```
allowlistedv2workloads.auto.gke.io                    2023-09-07T14:15:30Z
allowlistedworkloads.auto.gke.io                      2023-09-07T14:15:29Z
audits.warden.gke.io                                  2023-09-07T14:15:32Z
backendconfigs.cloud.google.com                       2023-09-07T14:15:41Z
capacityrequests.internal.autoscaling.gke.io          2023-09-07T14:15:25Z
frontendconfigs.networking.gke.io                     2023-09-07T14:15:41Z
managedcertificates.networking.gke.io                 2023-09-07T14:15:41Z
memberships.hub.gke.io                                2023-09-07T14:15:30Z
perconapgbackups.pgv2.percona.com                     2023-09-07T14:28:59Z
perconapgclusters.pgv2.percona.com                    2023-09-07T14:29:02Z
perconapgrestores.pgv2.percona.com                    2023-09-07T14:29:03Z
postgresclusters.postgres-operator.crunchydata.com    2023-09-07T14:29:06Z
serviceattachments.networking.gke.io                  2023-09-07T14:15:44Z
servicenetworkendpointgroups.networking.gke.io        2023-09-07T14:15:43Z
storagestates.migration.k8s.io                        2023-09-07T14:15:53Z
storageversionmigrations.migration.k8s.io             2023-09-07T14:15:53Z
updateinfos.nodemanagement.gke.io                     2023-09-07T14:15:55Z
volumesnapshotclasses.snapshot.storage.k8s.io         2023-09-07T14:15:52Z
volumesnapshotcontents.snapshot.storage.k8s.io        2023-09-07T14:15:52Z
volumesnapshots.snapshot.storage.k8s.io               2023-09-07T14:15:52Z
```

2. Now delete the `percona*.pgv2.percona.com` CRDs:

```
kubectl delete crd perconapgbackups.pgv2.percona.com
perconapgclusters.pgv2.percona.com perconapgrestores.pgv2.percona.com
```

Sample output

```
customresourcedefinition.apiextensions.k8s.io "perconapgbackups.pgv2.percona.com"
deleted
customresourcedefinition.apiextensions.k8s.io "perconapgclusters.pgv2.percona.com"
deleted
customresourcedefinition.apiextensions.k8s.io "perconapgrestores.pgv2.percona.com"
deleted
```

Clean up resources

By default, TLS-related objects and data volumes remain in Kubernetes environment after you delete the cluster to allow you to recreate it without losing the data.

You can automate resource cleanup by turning on `percona.com/delete-pvc` and/or `percona.com/delete-ssl` finalizers). You can also delete TLS-related objects and PVCs manually.

To manually clean up resources, do the following:

1. Delete Persistent Volume Claims.

    1. List PVCs. Replace the `<namespace>` placeholder with your namespace:

        ```
        kubectl get pvc -n <namespace>
        ```

        Sample output

        ```
        NAME                                STATUS   VOLUME
        CAPACITY   ACCESS MODES   STORAGECLASS   VOLUMEATTRIBUTESCLASS   AGE
        cluster1-instance1-mkwh-pgdata   Bound    pvc-c22220e9-c5e9-40b8-91b5-
        3d437b40bdec   1Gi        RWO            standard-rwo   <unset>
        4m17s
        cluster1-instance1-nvh4-pgdata   Bound    pvc-61a64aca-5165-4d25-b055-
        efc455d545b8   1Gi        RWO            standard-rwo   <unset>
        4m17s
        cluster1-instance1-qknb-pgdata   Bound    pvc-87bc6549-ee49-47f5-9f5e-
        83a315f78fd9   1Gi        RWO            standard-rwo   <unset>
        4m18s
        cluster1-repo1                   Bound    pvc-380e1100-b679-4716-ae8f-
        78372448b5f0   1Gi        RWO            standard-rwo   <unset>
        4m15s
        ```

    2. Delete PVCs related to your cluster. The following command deletes PVCs for the `cluster1` cluster:

        ```
        kubectl delete pvc cluster1-instance1-mkwh-pgdata cluster1-instance1-
        nvh4-pgdata cluster1-instance1-qknb-pgdata cluster1-repo1 -n
        <namespace>
        ```

        Sample output

        ```
        persistentvolumeclaim "cluster1-instance1-mkwh-pgdata" deleted
        persistentvolumeclaim "cluster1-instance1-nvh4-pgdata" deleted
        persistentvolumeclaim "cluster1-instance1-qknb-pgdata" deleted
        persistentvolumeclaim "cluster1-repo1" deleted
        ```

Note that if your Custom Resource manifest includes the `percona.com/delete-pvc` finalizer, all user Secrets will be automatically deleted when you delete the PVCs. To prevent this from happening, disable the finalizer.

3. Delete the Secrets

    1. List Secrets:

    ```
    kubectl get secrets -n <namespace>
    ```

    2. Delete the Secret:

    ```
    kubectl delete secret <secret_name> -n <namespace>
    ```

Retrieve Percona certified images

When preparing for the upgrade, you must have the list of compatible images for a specific Operator version and the database version you wish to update to. You can either manually find the images in the list of certified images or you can get this list by querying the **Version Service** server.

What is the Version Service?

The **Version Service** is a centralized repository that the Percona Operator for PostgreSQL connects to at scheduled times to get the latest information on compatible versions and valid image paths. This service is a crucial part of the automatic upgrade process, and it is enabled by default. Its landing page, `check.percona.com`, provides more details about the service itself.

How to query the Version Service

You can manually query the Version Service using the `curl` command. The basic syntax is:

```
curl https://check.percona.com/versions/v1/pg-operator/<operator-
version>/<pg-version> | jq -r '.versions[].matrix'
```

where:

- `<operator-version>` is the version of the Percona Operator for PostgreSQL you are using.
- `<pg-version>` is the version of PostgreSQL you want to get images for. This part is optional and helps filter the results. It can be a specific PostgreSQL version (e.g.16.3), a recommended version (e.g. 16-recommended), or the latest available version (e.g. 16-latest).

For example, to retrieve the list of images for Operator version `2.4.0` for PostgreSQL version `16.3`, use the following command:

```
curl https://check.percona.com/versions/v1/pg-operator/2.4.0/16.3 | jq -r
'.versions[].matrix'
```

Sample output


```
{
"pmm": {
    "2.42.0": {
        "imagePath": "percona/pmm-client:2.42.0",
        "imageHash": "14cb96de47e3bc239bf285f22ec6f170b4a1181301b19100f5b7dc22c210bf8c",
```

```
        "imageHashArm64": "",
        "status": "recommended",
        "critical": false
    }
},
"operator": {
    "2.4.0": {
        "imagePath": "percona/percona-postgresql-operator:2.4.0",
        "imageHash": "3012437bcfe793eaf34258aa44bb3bc404e7702711aefe4183324ee2d6928240",
        "imageHashArm64": "",
        "status": "recommended",
        "critical": false
    }
},
"postgresql": {
    "16.3": {
        "imagePath": "percona/percona-postgresql-operator:2.4.0-ppg16.3-postgres",
        "imageHash": "8248b290a88b881f1871fbca0de7da1acace31f94f795d1990e3ca3ca5dd3636",
        "imageHashArm64": "",
        "status": "recommended",
        "critical": false
    }
},
"pgbackrest": {
    "16.3": {
        "imagePath": "percona/percona-postgresql-operator:2.4.0-ppg16.3-pgbackrest2.51-
1",
        "imageHash": "3e59b19b619e5580292c4fa8f9efedea3e9d05b79af8e186643490b13a6f83a5",
        "imageHashArm64": "",
        "status": "recommended",
        "critical": false
    }
},
"pgbackrestRepo": {},
"pgbadger": {},
"pgbouncer": {
    "16.3": {
        "imagePath": "percona/percona-postgresql-operator:2.4.0-ppg16.3-
pgbouncer1.22.1",
        "imageHash": "37f466cea2330939f16c890a327b1d88b16cd85063ce45aff8255b8108accb08",
        "imageHashArm64": "",
        "status": "recommended",
        "critical": false
    }
},
"postgis": {
    "16.3": {
        "imagePath": "percona/percona-postgresql-operator:2.4.0-ppg16.3-postgres-
gis3.3.6",
        "imageHash": "7ca3172329ade3be97b9bd837a3315fcb87179357e420f76662a9d0e9a4a74d3",
        "imageHashArm64": "",
        "status": "recommended",
        "critical": false
    }
}
}
```

To narrow down the results to the recommended version of PostgreSQL 16, you can use:

```
curl https://check.percona.com/versions/v1/pg-operator/2.4.0/16-recommended |
jq -r '.versions[].matrix'
```

This command helps you retrieve the PostgreSQL images available for a specific Operator version (`2.4.0` in the following example):

```
curl -s https://check.percona.com/versions/v1/pg-operator/2.4.0 | jq -r
'.versions[0].matrix.postgresql | to_entries[] | "\(.key)\t\
(.value.imagePath)\t\(.value.status)"'
```

Sample output

```
12.19   percona/percona-postgresql-operator:2.4.0-ppg12.19-postgres recommended
13.15   percona/percona-postgresql-operator:2.4.0-ppg13.15-postgres recommended
14.12   percona/percona-postgresql-operator:2.4.0-ppg14.12-postgres recommended
15.7    percona/percona-postgresql-operator:2.4.0-ppg15.7-postgres  recommended
16.3    percona/percona-postgresql-operator:2.4.0-ppg16.3-postgres  recommended
```

Troubleshooting

Percona Operator troubleshooting

This section provides information on how to troubleshoot issues when you install Percona Operator for PostgreSQL.

Make sure you have CLI tool `kubectl` installed to interact with Kubernetes API.

Check connection to Kubernetes cluster

It may happen that `kubectl` you installed locally is not connected to your Kubernetes cluster.

To check connectivity to your Kubernetes API, run the following command:

```
kubectl cluster-info
```

If you see the output similar to the following, it means that `kubectl` is connected to your Kubernetes cluster:

Sample output

```
Kubernetes control plane is running at https://<control-plane-ip>:49475
CoreDNS is running at https://<control-plane-ip>:49475/api/v1/namespaces/kube-system/services/kube-dns:dns/proxy
```

If multiple Kubernetes configurations are present in `kubeconfig`,check if you have set the correct context. If the context is wrong, switch it. Here's how:

1. Check the current context:

   ```
   kubectl config current-context # Get the current Context
   ```

2. Switch the context :

   ```
   kubectl config use-context <Context-To-Be-Used>
   ```

3. Run the `kubectl cluster-info` command again to verify that `kubectl` is connected to your Kubernetes cluster.

If you are still running into issues, check with your Kubernetes cluster administrator to resolve the connectivity or configuration issues.

Troubleshoot Operator installation issues

1. Check the Operator logs

   ```
   kubectl logs deploy/<operator-deployment-name>
   ```

2. Installing the Operator requires specific privileges, such as the ability to create custom resource definitions and other Kubernetes objects.

   To verify that you have the necessary privileges, run the following script:

   ```
   bash <(curl -s
   https://gist.githubusercontent.com/cshiv/6048bdd0174275b48f633549c69d0844/
   raw/fd547b783a30b827362ee9f9ec03436f9bc79524/check_priviliges.sh)
   ```

   Sample output

   ```
   Checking privileges to install Percona Operators in kubernetes cluster...
   Warning: Unable to check the privileges for resource 'issuers', check if the
   resource 'issuers' is present in the cluster
   Warning: Unable to check the privileges for resource 'certificates', check if the
   resource 'certificates' is present in the cluster

   Warning: Some resources are not found in the kubernetes cluster.Check the Warning
   messages before you proceed
   ---------------------------------------------------------------------------------
   -------
   GOOD TO INSTALL: Percona Operator for PostgreSQL
   https://docs.percona.com/percona-operator-for-postgresql/index.html
   ---------------------------------------------------------------------------------
   -------
   GOOD TO INSTALL: Percona Operator for MySQL based on Percona XtraDB Cluster
   https://docs.percona.com/percona-operator-for-postgresql/index.html
   ---------------------------------------------------------------------------------
   -------
   GOOD TO INSTALL: Percona Operator for MongoDB
   https://docs.percona.com/percona-operator-for-mongodb/index.html
   ```

   If you have insufficient permissions, the script will show you which ones are missing for installing a particular Operator. In this case, contact the Kubernetes cluster administrator.

3. If you have the necessary privileges but the installation is still failing, review the Kubernetes Events for more details. Keep in mind that Kubernetes Events are retained for only 60 minutes.

   ```
   kubectl get events --sort-by=".lastTimestamp"
   ```

   Events provide good information about affinity issues, resource issues etc.

Troubleshooting database cluster issues

1. The Operator deployment must be in the `Running` state for the database cluster to function properly. Check the Operator Pod for restarts to identify potential issues.

   ```
   kubectl get pod <operator-pod-name>
   ```

2. Check the status of the database cluster

   ```
   kubectl get pg <database-cluster-name>
   ```

   The cluster should typically be in the `Running` state. It may briefly enter the `initializing` state while reconciling changes. If the cluster remains in the `initializing` state for an extended period, investigate further to identify any underlying issues.

   Additionally, you can describe the database cluster and search for the information in the `State` and `State Description` fields:

   ```
   kubectl describe pg <database-cluster-name>
   ```

3. Check the Operator logs

   ```
   kubectl logs deploy/<operator-deployment-name>
   ```

4. Check the events

   ```
   kubectl get events --sort-by=".lastTimestamp"
   ```

   Events can provide information like storage class issues, PVC binding issues etc

5. Check for the PVC, PV. Both of them should be in `Bound` status

```
kubectl get pvc
```

```
kubectl get pv
```

6. Check for logs of database pods / Proxy pods

   ```
   kubectl logs <database-pod-name>
   ```

   ```
   kubectl logs <proxy-pod-name>
   ```

   To check logs of `init` containers or other sidecar containers, use the option `-c` with the container name:

   ```
   kubectl logs <proxy-pod-name> -c postgres-startup
   ```

7. Check for error details. Run the `kubectl describe` command:

   ```
   kubectl describe <database-pod-name>
   ```

   ```
   kubectl describe <proxy-pod-name>
   ```

   Check the information in the `Status` section. The `State` and `State Description` fields explain why the Pod reports errors.

8. To run commands inside a container, use the `kubectl exec` command:

   ```
   kubectl exec <pod-name> -- <command>
   ```

   If you need an interactive shell to run multiple commands, use the `-it` flag for an interactive terminal:

   ```
   kubectl exec -it <pod-name> -- sh
   ```

9. If the pods are not running, it may not be possible to execute commands or open an interactive shell. In such cases, consider using a `sleep-forever` script to prevent the containers from restarting repeatedly.

See the Disable health check probes for maintenance section for steps.

Initial troubleshooting

Percona Operator for PostgreSQL uses Custom Resources to manage options for the various components of the cluster.

- `PerconaPGCluster` Custom Resource with Percona PostgreSQL Cluster options (it has handy `pg` shortname also),
- `PerconaPGBackup` and `PerconaPGRestore` Custom Resources contain options for pgBackRest used to backup PostgreSQL Cluster and to restore it from backups (`pg-backup` and `pg-restore` shortnames are available for them).

The first thing you can check for the Custom Resource is to query it with `kubectl get` command:

```
kubectl get pg
```

Expected output

```
NAME       ENDPOINT                          STATUS   POSTGRES   PGBOUNCER   AGE
cluster1   cluster1-pgbouncer.default.svc    ready    3          3           30m
```

The Custom Resource should have `Ready` status.

Note

You can check which Percona's Custom Resources are present and get some information about them as follows:

```
kubectl api-resources | grep -i percona
```

Expected output

```
perconapgbackups          pg-backup    pgv2.percona.com/v2           true
PerconaPGBackup
perconapgclusters         pg           pgv2.percona.com/v2           true
PerconaPGCluster
perconapgrestores         pg-restore   pgv2.percona.com/v2           true
PerconaPGRestore
```

Check the Pods

If Custom Resource is not getting `Ready` status, it makes sense to check individual Pods. You can do it as follows:

```
kubectl get pods
```

Expected output

```
NAME                                              READY   STATUS      RESTARTS   AGE
cluster1-backup-4vwt-p5d9j                        0/1     Completed   0          97m
cluster1-instance1-b5mr-0                         4/4     Running     0          99m
cluster1-instance1-b8p7-0                         4/4     Running     0          99m
cluster1-instance1-w7q2-0                         4/4     Running     0          99m
cluster1-pgbouncer-79bbf55c45-62xlk               2/2     Running     0          99m
cluster1-pgbouncer-79bbf55c45-9g4cb               2/2     Running     0          99m
cluster1-pgbouncer-79bbf55c45-9nrmd               2/2     Running     0          99m
cluster1-repo-host-0                              2/2     Running     0          99m
percona-postgresql-operator-79cd8586f5-2qzcs      1/1     Running     0          120m
```

The above command provides the following insights:

- `READY` indicates how many containers in the Pod are ready to serve the traffic. In the above example, `cluster1-repo-host-0` container has all two containers ready (2/2). For an application to work properly, all containers of the Pod should be ready.
- `STATUS` indicates the current status of the Pod. The Pod should be in a `Running` state to confirm that the application is working as expected. You can find out other possible states in the official Kubernetes documentation.
- `RESTARTS` indicates how many times containers of Pod were restarted. This is impacted by the Container Restart Policy. In an ideal world, the restart count would be zero, meaning no issues from the beginning. If the restart count exceeds zero, it may be reasonable to check why it happens.
- `AGE`: Indicates how long the Pod is running. Any abnormality in this value needs to be checked.

You can find more details about a specific Pod using the `kubectl describe pods <pod-name>` command.

```
kubectl describe pods cluster1-instance1-b5mr-0
```

Expected output

```
...
Name:         cluster1-instance1-b5mr-0
Namespace:    default
...
Controlled By:  StatefulSet/cluster1-instance1-b5mr
Init Containers:
 postgres-startup:
...
Containers:
 database:
...
 pgbackrest:
...
   Restart Count:  0
   Liveness:   http-get https://:8008/liveness delay=3s timeout=5s period=10s #success=1
#failure=3
   Readiness:  http-get https://:8008/readiness delay=3s timeout=5s period=10s
#success=1 #failure=3
   Environment:
...
   Mounts:
...
Volumes:
...
Events:
...
```

This gives a lot of information about containers, resources, container status and also events. So, describe output should be checked to see any abnormalities.

Check Storage-related objects

Storage-related objects worth to check in case of problems are the following ones:

- Persistent Volume Claims (PVC) and Persistent Volumes (PV), which are playing a key role in stateful applications.
- Storage Class, which automates the creation of Persistent Volumes and the underlying storage.

It is important to remember that PVC is namespace-scoped, but PV and Storage Class are cluster-scoped.

Check the PVC

You can check all the PVC with the following command (use different namespace name instead of `postgres-operator`, if needed):

```
kubectl get pvc -n postgres-operator
```

Expected output

```
NAME                              STATUS   VOLUME
CAPACITY   ACCESS MODES   STORAGECLASS   AGE
cluster1-instance1-4xkv-pgdata   Bound    pvc-2d20abb7-5350-4810-a098-fbdfbffda041   1Gi
RWO            standard       11h
cluster1-instance1-njt9-pgdata   Bound    pvc-f2e9a722-fd30-435b-ade4-9edf20b2104b   1Gi
RWO            standard       11h
cluster1-instance1-qhh6-pgdata   Bound    pvc-7228300b-81de-4a60-a615-8ca935c95139   1Gi
RWO            standard       11h
cluster1-repo1                   Bound    pvc-b2e0bac3-993d-499e-b311-3aa7b9851bc2   1Gi
RWO            standard       11h
```

- **STATUS**: shows the state of the PVC:
  - For normal working of an application, the status should be `Bound`.
  - If the status is not `Bound`, further investigation is required.
- **VOLUME**: is the name of the Persistent Volume with which PVC is Bound to. Obviously, this field will be occupied only when a PVC is Bound.
- **CAPACITY**: it is the size of the volume claimed.

- **STORAGECLASS**: it indicates the Kubernetes storage class used for dynamic provisioning of Volume.
- **ACCESS MODES**: Access mode indicates how Volume is used with the Pods. Access modes should have write permission if the application needs to write data, which is obviously true in case of databases.

Now you can check a specific PVC for more details using its name as follows:

```
kubectl get pvc cluster1-instance1-4xkv-pgdata -n postgres-operator -oyaml #
output stripped for brevity, name of PVC may vary
```

Expected output

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  ...
  name: cluster1-instance1-4xkv-pgdata
  namespace: postgres-operator
  ...
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1G
  storageClassName: standard
  volumeMode: Filesystem
  volumeName: pvc-2d20abb7-5350-4810-a098-fbdfbffda041
status:
  accessModes:
  - ReadWriteOnce
  capacity:
    storage: 24Gi
  phase: Bound
```

You can use a number of Custom Resource options to tweaking PVC for the components of your cluster:

- options under `instances.walVolumeClaimSpec` allow you to set access modes and requested storage size for PostgreSQL Write-ahead Log storage,
- options under `instances.dataVolumeClaimSpec` allow you to set access modes and also requests and limits for PostgreSQL database storage,
- options under `instances.tablespaceVolumes.dataVolumeClaimSpec` allow you to set access

modes and requested storage size for PostgreSQL tablespace volumes,

- options under `backups.pgbackrest.repos.volume.volumeClaimSpec` allow you to set access modes and requested storage size for the pgBackRest storage.

Check the PV

It is important to remember that PV is a cluster-scoped Object. If you see any issues with attaching a Volume to a Pod, PV and PVC might be looked upon.

Check all the PV present in the Kubernetes cluster as follows:

```
kubectl get pv
```

Expected output

```
NAME                                       CAPACITY   ACCESS MODES   RECLAIM POLICY
STATUS   CLAIM                                                 STORAGECLASS   REASON   AGE
pvc-2d20abb7-5350-4810-a098-fbdfbffda041   1Gi        RWO            Delete
Bound    postgres-operator/cluster1-instance1-4xkv-pgdata   standard                11h
pvc-7228300b-81de-4a60-a615-8ca935c95139   1Gi        RWO            Delete
Bound    postgres-operator/cluster1-instance1-qhh6-pgdata   standard                11h
pvc-b2e0bac3-993d-499e-b311-3aa7b9851bc2   1Gi        RWO            Delete
Bound    postgres-operator/cluster1-repo1                   standard                11h
pvc-f2e9a722-fd30-435b-ade4-9edf20b2104b   1Gi        RWO            Delete
Bound    postgres-operator/cluster1-instance1-njt9-pgdata   standard                11h
```

Now you can check a specific PV for more details using its name as follows:

```
kubectl get pv pvc-2d20abb7-5350-4810-a098-fbdfbffda041 -oyaml
```

Expected output

```
apiVersion: v1
kind: PersistentVolume
metadata:
  ...
  name: pvc-f3e7097f-accd-4f5d-9c9d-6f29b54a368b
  ...
spec:
  accessModes:
  - ReadWriteOnce
  capacity:
    storage: 1Gi
  claimRef:
    apiVersion: v1
    kind: PersistentVolumeClaim
    name: cluster1-instance1-4xkv-pgdata
    namespace: postgres-operator
    resourceVersion: "912868"
    uid: f3e7097f-accd-4f5d-9c9d-6f29b54a368b
 gcePersistentDisk:
    fsType: ext4
    pdName: pvc-f3e7097f-accd-4f5d-9c9d-6f29b54a368b
 nodeAffinity:
    required:
      nodeSelectorTerms:
      - matchExpressions:
        - key: topology.kubernetes.io/zone
          operator: In
          values:
          - us-central1-a
        - key: topology.kubernetes.io/region
          operator: In
          values:
          - us-central1
  persistentVolumeReclaimPolicy: Delete
  storageClassName: standard
  volumeMode: Filesystem
status:
  phase: Bound
```

Fields to check if there are any issues in binding with PVC, are the `claimRef` and `nodeAffinity`.

The `claimRef` one indicates to which PVC this volume is bound to. This means that if by any chance PVC is deleted (e.g. by the appropriate finalizer), this section needs to be modified so that it can bind to a new PVC.

The `spec.nodeAffinity` field may influence the PV availability as well: for example, it can make Volume accessed in one availability zone only.

Check the StorageClass

StorageClass is also a cluster-scoped object, and it indicates what type of underlying storage is used for the Volumes.

You can set StorageClass in `instances.dataVolumeClaimSpec.storageClassName`, `instances.walVolumeClaimSpec.storageClassName`, and `backups.pgbackrest.repos.volume.volumeClaimSpec.storageClassName` Custom Resource options.

The following command checks all the storage class present in the Kubernetes cluster, and allows to see which storage class is the default one:

```
kubectl get sc
```

Expected output

```
NAME                 PROVISIONER             RECLAIMPOLICY   VOLUMEBINDINGMODE
ALLOWVOLUMEEXPANSION   AGE
premium-rwo          pd.csi.storage.gke.io   Delete          WaitForFirstConsumer   true
44d
standard (default)   kubernetes.io/gce-pd    Delete          Immediate              true
44d
standard-rwo         pd.csi.storage.gke.io   Delete          WaitForFirstConsumer   true
44d
```

If some PVC does not refer any storage class explicitly, it means that the default storage class is used. Ensure there is only one default Storage class.

You can check a specific storage class as follows:

```
kubectl get sc standard -oyaml
```

Expected output

```
allowVolumeExpansion: true
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
 annotations:
   storageclass.kubernetes.io/is-default-class: "true"
 creationTimestamp: "2022-10-09T06:28:03Z"
 labels:
   addonmanager.kubernetes.io/mode: EnsureExists
 name: standard
 resourceVersion: "906"
 uid: 933d37db-990b-4b2d-bf3a-dd091d0b00ae
parameters:
 type: pd-standard
provisioner: kubernetes.io/gce-pd
reclaimPolicy: Delete
volumeBindingMode: Immediate
```

Important things to observe here are the following ones:

- Check if the provisioner and parameters are indicating the type of storage you intend to provision.
- Check the volumeBindingMode especially if the storage cannot be accessed across availability zones. “WaitForFirstConsumer” volumeBindingMode ensures volume is provisioned only after a Pod requesting the Volume is created.
- If you are going to rely on the Operator storage scaling functionality, ensure the storage class supports PVC expansion (it should have `allowVolumeExpansion: true` in the output of the above command).

You can set PVC storage class with the following Custom Resource options:

- `instances.walVolumeClaimSpec.storageClassName` allows you to set storage class for PostgreSQL Write-ahead Log storage,
- `instances.dataVolumeClaimSpec.storageClassName` allows you to set storage class for PostgreSQL database storage,
- `instances.tablespaceVolumes.dataVolumeClaimSpec.storageClassName` allows you to set storage class for PostgreSQL tablespace volumes,
- `backups.pgbackrest.repos.volume.volumeClaimSpec.storageClassName` allows you to set storage class for the pgBackRest storage.

Exec into the containers

If you want to examine the contents of a container “in place” using remote access to it, you can use the `kubectl exec` command. It allows you to run any command or just open an interactive shell session in the container. Of course, you can have shell access to the container only if container supports it and has a “Running” state.

In the following examples we will access the container `database` of the `cluster1-instance1-b5mr-0` Pod.

- Run `date` command:

  ```
  kubectl exec -ti cluster1-instance1-b5mr-0 -c database -- date
  ```

  Expected output

  ```
  Wed Jun 14 11:18:47 UTC 2023
  ```

  You will see an error if the command is not present in a container. For example, trying to run the `time` command, which is not present in the container, by executing `kubectl exec -ti cluster1-instance1-b5mr-0 -c database -- time` would show the following result:

  ```
  OCI runtime exec failed: exec failed: unable to start container process:
  exec: "time": executable file not found in $PATH: unknown command
  terminated with exit code 126
  ```

- Print log files to a terminal:

  ```
  kubectl exec -ti cluster1-instance1-b5mr-0 -c database -- cat
  /pgdata/pg16/log/postgresql-*.log
  ```

- Similarly, opening an Interactive terminal, executing a pair of commands in the container, and exiting it may look as follows:

```
kubectl exec -ti cluster1-instance1-b5mr-0 -c database -- bash
bash-4.4$ hostname
cluster1-pxc-0
bash-4.4$ ls /pgdata/pg16/log/
postgresql-Wed.log
bash-4.4$ exit
exit
$
```

Check the logs

Logs provide valuable information. It makes sense to check the logs of the database Pods and the Operator Pod. Following flags are helpful for checking the logs with the `kubectl logs` command:

Flag	Description
`-c`, `--container=<container-name>`	Print log of a specific container in case of multiple containers in a Pod
`-f`, `--follow`	Follows the logs for a live output
`--since=<time>`	Print logs newer than the specified time, for example: `--since="10s"`
`--timestamps`	Print timestamp in the logs (timezone is taken from the container)
`-p`, `--previous`	Print previous instantiation of a container. This is extremely useful in case of container restart, where there is a need to check the logs on why the container restarted. Logs of previous instantiation might not be available in all the cases.

In the following examples we will access containers of the `cluster1-instance1-b5mr-0` Pod.

- Check logs of the `database` container:

```
kubectl logs cluster1-instance1-b5mr-0 --container database
```

- Check logs of the `pgbackrest` container:

```
kubectl logs cluster1-instance1-b5mr-0 --container pgbackrest
```

- Filter logs of the `database` container which are not older than 600 seconds:

```
kubectl logs cluster1-instance1-b5mr-0 --container database --since=600s
```

- Check logs of a previous instantiation of the `database` container, if any:

```
kubectl logs cluster1-instance1-b5mr-0 --container database --previous
```

Increase pgBackRest log verbosity

The pgBackRest tool used for backups supports different log verbosity levels. By default, it logs warnings and errors, but sometimes fixing backup/restore issues can be simpler when you get more debugging information from it.

Log verbosity is controlled by pgBackRest –log-level-stderr option.

You can add it to the `deploy/backup.yaml` file to use it with on-demand backups as follows:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGBackup
metadata:
  name: backup1
spec:
  pgCluster: cluster1
  repoName: repo1
  options:
  - --log-level-stderr=debug
```

Manual management of database clusters deployed with Percona Operator for PostgreSQL

The purpose of the Operator is to automate database management tasks for you. However, you may need to manage the database cluster manually. For example, to troubleshoot issues or for maintenance.

The following sections explain how you can manage your cluster manually.

Disable health check probes for maintenance

Probes are tasks Kubernetes runs to gather information about the health and status of containers running within Pods. They serve as a mechanism to ensure the system is running smoothly by periodically checking the state of applications and services.

Kubernetes has various types of probes:

- Startup probe verifies whether the application within a container is started
- Liveness probe determines when to restart a Pod
- Readiness probe checks that the container is ready to start accepting traffic

Sometimes it's necessary to take a manual control over the `postgres` process for maintenance. This means you need to disable a Kubernetes liveness probe so that it doesn't restart the database container during the maintenance period.

Here's what you need to do:

1. Create a `sleep-forever` file in the data directory with the following command:

   ```
   kubectl exec cluster1-instance1-24b8-0 -- touch /pgdata/sleep-forever
   ```

2. Delete the Pod:

   ```
   kubectl delete pod cluster1-instance1-24b8-0
   ```

3. After the Pod restarts, it won't start PostgreSQL. You can check it with the following command:

```
kubectl logs cluster1-instance1-24b8-0 database
```

Expected output

```
The pgdata/sleep-forever file is detected, node entered an infinite sleep
If you want to exit from the infinite sleep, remove the pgdata/sleep-forever file
```

4. Now you can start PostgreSQL manually:

```
kubectl exec cluster1-instance1-24b8-0 -- pg_ctl -D /pgdata/pg17 start
```

Expected output

```
2025-04-01 16:27:41.850 UTC [1434] LOG:  pgaudit extension initialized
2025-04-01 16:27:42.075 UTC [1434] LOG:  redirecting log output to logging
collector process
2025-04-01 16:27:42.075 UTC [1434] HINT:  Future log output will appear in
directory "log".
 done
server started
```

5. When you are done with the maintenance, remove the `sleep-forever` file to re-enable the liveness probe.

```
kubectl exec cluster1-instance1-24b8-0 -- rm /pgdata/sleep-forever
```

Stop reconciliation by putting a cluster into an unmanaged mode

The Operator reconciles the database cluster to ensure its current state doesn't differ from the state defined in the configuration. It can automatically install, update, or repair the cluster when needed.

By doing this, the Operator might interfere with your operations during the maintenance. Therefore, you can put a cluster in an unmanaged mode to stop the Operator from reconciling the cluster at all.

Edit the `deploy/cr.yaml` Custom Resource manifest and set the `spec.unmanaged` option to `true`:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGCluster
metadata:
  name: cluster1
spec:
  unmanaged: true
  ...
```

Apply the changes:

```
kubectl apply -f deploy/cr.yaml -n <namespace>
```

Warning

Putting a cluster in an unmanaged mode doesn't disable any of the health check probes already configured for containers. The Operator is only responsible for configuring the probes, not for running them. Refer to the Disabling health check probes for maintenance section for the steps.

Override Patroni configuration

For a whole cluster

The Operator creates a ConfigMap called `<cluster-name>-config` to store a Patroni cluster configuration. If you just edit the ConfigMap contents, the Operator will immediately rewrite and remove your changes. To override anything in this ConfigMap and keep the changes, you need to annotate it using a special annotation `pgv2.percona.com/override-config`.

Here is the example command for the cluster named `cluster1`:

```
kubectl annotate cm cluster1-config pgv2.percona.com/override-config=true
```

Expected output

```
configmap/cluster1-config annotated
```

As long as the ConfigMap has this `pgv2.percona.com/override-config` annotation, the Operator doesn't rewrite your changes. You can edit the ConfigMap's contents however you want.

Warning

The Operator does not validate your configuration changes.

Before applying any changes, consult the Patroni documentation to ensure your configuration is correct. This will help you avoid issues caused by invalid settings.

It takes some time for your changes of ConfigMap to propagate to running containers. You can verify if changes are propagated by checking the mounted file in containers. For example:

```
kubectl exec -it cluster1-instance1-24b8-0 -- cat /etc/patroni/~postgres-operator_cluster.yaml
```

Operator doesn't apply a new configuration for Patroni automatically. You must run `patronictl reload <cluster_name> <pod-name>` to apply it after your changes are propagated to the container.

Warning

Don't forget to remove this annotation once you've finished. It's not recommended to use this feature to permanently override Patroni configuration. As long as this annotation exists, the Operator won't touch the ConfigMap and you might have problems with your cluster.

To remove the annotation, use the following command:

```
kubectl annotate cm cluster1-config pgv2.percona.com/override-config-
```

For an individual Pod

Operator creates a ConfigMap called `<pod-name>-config` to store Patroni instance configuration for each Pod. If you just edit the ConfigMap contents, the Operator will immediately rewrite and remove your changes. To override anything in these ConfigMaps and keep the changes, you need to annotate them using a special annotation:

```
kubectl annotate cm cluster1-instance1-24b8-config pgv2.percona.com/override-config=true
```

Expected output

```
configmap/cluster1-instance1-24b8-config annotated
```

As long as the ConfigMap has the `pgv2.percona.com/override-config` annotation, the Operator doesn't rewrite your changes. You can edit the ConfigMap's contents however you want.

Warning

The Operator does not validate your configuration changes.

Before applying any changes, consult the Patroni documentation to ensure your configuration is correct. This will help you avoid problems caused by invalid settings.

It takes some time for your changes of ConfigMap to propagate to running containers. You can verify if changes are propagated by checking the mounted file in containers for a Pod. For example:

```
kubectl exec -it cluster1-instance1-24b8-0 -- cat /etc/patroni/~postgres-operator_cluster.yaml
```

Operator doesn't apply a new configuration automatically. You must run `patronictl reload <cluster_name> <pod_name>` to apply it after your changes are propagated to the container.

To find the cluster name, run:

```
kubectl exec -it cluster1-instance1-24b8-0 -- patronictl list
```

Expected output

```
Cluster: cluster1-ha (7523193408153182293) -------------------------+---------+---------
--+----+-----------+
| Member                   | Host                                     | Role    | State
| TL | Lag in MB |
+--------------------------+------------------------------------------+---------+-------
----+----+-----------+
| cluster1-instance1-24b8-0 | cluster1-instance1-bw58-0.cluster1-pods | Replica |
streaming |  3 |         0 |
| cluster1-instance1-tmqj-0 | cluster1-instance1-tmqj-0.cluster1-pods | Leader  |
running   |  3 |           |
| cluster1-instance1-xf85-0 | cluster1-instance1-xf85-0.cluster1-pods | Replica |
streaming |  3 |         0 |
+--------------------------+------------------------------------------+---------+-------
----+----+-----------+
```

Warning

Don't forget to remove this annotation once you've finished. It's not recommended to use this feature to permanently override Patroni configuration. As long as this annotation exists, the Operator won't touch the ConfigMap and you might have problems with your cluster.

To remove the annotation, use the following command:

```
kubectl annotate cm cluster1-instance1-24b8-0 pgv2.percona.com/override-config-
```

Override PostgreSQL parameters

Use the `patronictl show-config` command to print PostgreSQL parameters used in the cluster. For example:

```
kubectl exec cluster1-instance1-24b8-0 -- patronictl show-config
```

Expected output

```
loop_wait: 10
postgresql:
  parameters:
    archive_command: 'pgbackrest --stanza=db archive-push "%p" && timestamp=$(pg_waldump
"%p" | grep -oP "COMMIT \K[^;]+" | sed -E "s/([0-9]{4}-[0-9]{2}-[0-9]{2}) ([0-9]{2}:[0-
9]{2}:[0-9]{2}\.[0-9]{6}) (UTC|[\\+\\-][0-9]{2})/\1T\2\3/" | sed "s/UTC/Z/" | tail -n 1
| grep -E "^[0-9]{4}-[0-9]{2}-[0-9]{2}T[0-9]{2}:[0-9]{2}:[0-9]{2}\.[0-9]{6}(Z|[\+\-][0-
9]{2})$"); if [ ! -z ${timestamp} ]; then echo ${timestamp} >
/pgdata/latest_commit_timestamp.txt; fi'
    archive_mode: 'on'
    archive_timeout: 60s
    huge_pages: 'off'
    jit: 'off'
    password_encryption: scram-sha-256
    restore_command: pgbackrest --stanza=db archive-get %f "%p"
    ssl: 'on'
    ssl_ca_file: /pgconf/tls/ca.crt
    ssl_cert_file: /pgconf/tls/tls.crt
    ssl_key_file: /pgconf/tls/tls.key
    track_commit_timestamp: 'true'
    unix_socket_directories: /tmp/postgres
    wal_level: logical
  pg_hba:
  - local all "postgres" peer
  - hostssl replication "_crunchyrepl" all cert
  - hostssl "postgres" "_crunchyrepl" all cert
  - host all "_crunchyrepl" all reject
  - host all "monitor" "127.0.0.0/8" scram-sha-256
  - host all "monitor" "::1/128" scram-sha-256
  - host all "monitor" all reject
  - hostssl all "_crunchypgbouncer" all scram-sha-256
  - host all "_crunchypgbouncer" all reject
  - hostssl all all all md5
  use_pg_rewind: true
  use_slots: false
ttl: 30
```

Use the `patronictl edit-config` command to change any PostgreSQL parameter.

For example, run the following command to change the `restore_command` parameter:

```
kubectl exec -it cluster1-instance1-24b8-0 -- patronictl edit-config --pg
restore_command=/bin/true
```

Expected output

```
---
+++
@@ -9,7 +9,7 @@
     huge_pages: 'off'
     jit: 'off'
     password_encryption: scram-sha-256
-    restore_command: pgbackrest --stanza=db archive-get %f "%p"
+    restore_command: /bin/true
     ssl: 'on'
     ssl_ca_file: /pgconf/tls/ca.crt
     ssl_cert_file: /pgconf/tls/tls.crt

Apply these changes? [y/N]:
```

This command changes the `shared_preload_libraries` parameter:

```
kubectl exec -it cluster1-instance1-24b8-0 -- patronictl edit-config --pg
shared_preload_libraries=""
```

Expected output

```
---
+++
@@ -11,7 +11,6 @@
     password_encryption: scram-sha-256
     pg_stat_monitor.pgsm_query_max_len: '2048'
     restore_command: pgbackrest --stanza=db archive-get %f "%p"
-    shared_preload_libraries: pg_stat_monitor
     ssl: 'on'
     ssl_ca_file: /pgconf/tls/ca.crt
     ssl_cert_file: /pgconf/tls/tls.crt

Apply these changes? [y/N]:
```

Warning

If you update any object controlled by the Operator, it'll reconcile the cluster and your configuration changes will be reverted. You can put the cluster in an unmanaged mode to prevent this.

Override `pg_hba` entries

You may want to append entries to `pg_hba`. You can use the `spec.patroni.postgresl.pg_hba` field to add your rules.

```
  patroni:
    dynamicConfiguration:
      postgresql:
        pg_hba:
        - local all all trust
        - reject all all all
```

The order of parameters matters in `pg_hba.conf`, so consider overriding the list completely. For this, you can use the `patronictl edit-config` command:

```
kubectl exec -it cluster1-instance1-24b8-0 -- patronictl edit-config --set
postgresql.pg_hba='[
  "local all all trust",
  "reject all all all"
]'
```

Warning

If you update any object controlled by the Operator, it'll reconcile the cluster and your configuration changes will be reverted. You can put the cluster in an unmanaged mode to prevent this.

Reinitialize replicas

When you create a new Percona PostgreSQL cluster, the Operator uses the `basebackup` method to create replicas for it. After the database instances are ready, the Operator automatically creates a full backup. Once this backup finishes successfully, the Operator updates the Patroni configuration and **prepends** (puts as the first method) `pgBackRest` in the `create_replica_methods` list so that new replicas are created using it.

Warning

The Operator doesn't run `patronictl reload` in old replicas even if Patroni instance configurations are updated to put `pgBackRest` as the first method in the `create_replica_methods` list. For this configuration to run into force, you need to either restart the Pods or manually run `patronictl reload <cluster_name>` on all old replicas.

You may need to reinitialize cluster replicas. For example, if the data on the replica becomes corrupted or inconsistent with the primary node. Reinitialization ensures the replica is rebuilt with the correct data. Or, if the replica falls significantly behind the primary or encounters issues that prevent successful synchronization, reinitialization can reset the replica to match the current state of the primary.

This document provides the ways how to do it.

Reinitialize by deleting replica Pod and its PersistentVolumeClaim

You can force reinitialization by deleting the Pod and its PersistentVolumeClaim:

```
kubectl delete pvc/cluster1-instance1-24b8-pgdata pod/cluster1-instance1-
24b8-0
```

Expected output

```
persistentvolumeclaim "cluster1-instance1-24b8-pgdata" deleted
pod "cluster1-instance1-24b8-0" deleted
```

The Operator will reinitialize a replica using the method configured in this instance's Patroni configuration. This configuration is stored within the ConfigMap for the instance. Use the following command to find it:

```
kubectl get cm cluster1-instance1-24b8-config
```

Expected output

```
NAME                              DATA   AGE
cluster1-instance1-24b8-config    1      95m
```

Reinitialize with `patronictl reinit`

You can reinitialize a replica using the `patronictl reinit` command. Note that configuration in ConfigMap might not have been applied to a running Patroni instance. The recommended approach is to first run `patronictl reload <cluster_name>` and then run `patronictl reinit`.

For example:

1. List and verify Patroni configuration:

   ```
   kubectl exec -it cluster1-instance1-24b8-0 -- cat /etc/patroni/~postgres-operator_instance.yaml
   ```

2. Find the cluster name:

   ```
   kubectl exec -it cluster1-instance1-24b8-0 -- patronictl list
   ```

Expected output

```
Cluster: cluster1-ha (7523193408153182293) ------------------------+---------+----
-------+----+-----------+
| Member                     | Host                                     | Role    |
State     | TL | Lag in MB |
+----------------------------+------------------------------------------+---------+--
---------+----+-----------+
| cluster1-instance1-24b8-0 | cluster1-instance1-bw58-0.cluster1-pods | Replica |
streaming |  3 |         0 |
| cluster1-instance1-84xm-0 | cluster1-instance1-tmqj-0.cluster1-pods | Leader  |
running   |  3 |           |
| cluster1-instance1-nv28-0 | cluster1-instance1-xf85-0.cluster1-pods | Replica |
streaming |  3 |         0 |
+----------------------------+------------------------------------------+---------+--
---------+----+-----------+
```

3. Reload the configuration:

```
kubectl exec -it cluster1-instance1-24b8-0 -- patronictl reload cluster1-
ha cluster1-instance1-24b8-0
```

Expected output

```
+ Cluster: cluster1-ha (7487948770079264836) ------------------------+---------+--
---------+----+-----------+
| Member                     | Host                                     | Role    |
State     | TL | Lag in MB |
+----------------------------+------------------------------------------+---------+--
---------+----+-----------+
| cluster1-instance1-24b8-0 | cluster1-instance1-24b8-0.cluster1-pods | Replica |
streaming |  1 |         0 |
| cluster1-instance1-84xm-0 | cluster1-instance1-84xm-0.cluster1-pods | Leader  |
running   |  1 |           |
| cluster1-instance1-nv28-0 | cluster1-instance1-nv28-0.cluster1-pods | Replica |
streaming |  1 |         0 |
+----------------------------+------------------------------------------+---------+--
---------+----+-----------+
Are you sure you want to reload members cluster1-instance1-24b8-0? [y/N]: y
Reload request received for member cluster1-instance1-24b8-0 and will be processed
within 10 seconds
```

4. Reinitialize the replica:

```
kubectl exec -it cluster1-instance1-24b8-0 -- patronictl reinit cluster1-
ha cluster1-instance1-24b8-0
```

Expected output

```
+ Cluster: cluster1-ha (7487948770079264836) ------------------------+---
------+-----------+----+-----------+
| Member                     | Host                                      |
Role    | State     | TL | Lag in MB |
+--------------------------+-------------------------------------------+---
------+-----------+----+-----------+
| cluster1-instance1-24b8-0 | cluster1-instance1-24b8-0.cluster1-pods |
Replica | streaming |  1 |         0 |
| cluster1-instance1-84xm-0 | cluster1-instance1-84xm-0.cluster1-pods |
Leader  | running   |  1 |           |
| cluster1-instance1-nv28-0 | cluster1-instance1-nv28-0.cluster1-pods |
Replica | streaming |  1 |         0 |
+--------------------------+-------------------------------------------+---
------+-----------+----+-----------+
Are you sure you want to reinitialize members cluster1-instance1-24b8-0?
[y/N]: y
Success: reinitialize for member cluster1-instance1-24b8-0
```

Configure `create_replica_methods`

The Operator uses `basebackup` and `pgBackRest` methods to create replicas by default. These methods are defined within the `create_replica_methods` configuration block of a Patroni instance.

If you want to change `create_replica_methods` list for any reason, you can use the `spec.patroni.create_replica_methods` option in the `deploy/cr.yaml` Custom Resource manifest:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGCluster
metadata:
  name: cluster1
spec:
  patroni:
    createReplicaMethods:
    - basebackup
    - pgbackrest
  ...
```

Apply this configuration:

```
kubectl apply -f deploy/cr.yaml
```

The Operator updates Patroni instances' ConfigMaps. You can check their configuration with this command:

```
kubectl get configmap cluster1-instance1-24b8-config -o yaml
```

Expected output

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster1-instance1-24b8-config
data:
  patroni.yaml: |
    # Generated by postgres-operator. DO NOT EDIT UNLESS YOU KNOW WHAT YOU'RE DOING.
    # If you want to override the config, annotate this ConfigMap with
pgv2.percona.com/override-config=true
    kubernetes: {}
    postgresql:
      basebackup:
      - waldir=/pgdata/pg17_wal
      create_replica_methods:
      - basebackup
      - pgbackrest
      pgbackrest:
        command: '''bash'' ''-ceu'' ''--'' ''install --directory --mode=0700
"${PGDATA?}"
          && exec "$@"'' ''-'' ''pgbackrest'' ''restore'' ''--delta'' ''--stanza=db''
          ''--repo=1'' ''--link-map=pg_wal=/pgdata/pg17_wal'' ''--type=standby'''
        keep_data: true
        no_leader: true
        no_params: true
      pgpass: /tmp/.pgpass
      use_unix_socket: true
    restapi: {}
    tags: {}
```

After the ConfigMap is updated, it takes some time for changes to appear in mounted files in containers. You can verify the updates by manually checking the file:

```
kubectl exec -it cluster1-instance1-24b8-0 -- cat /etc/patroni/~postgres-
operator_instance.yaml
```

Expected output

```
# Generated by postgres-operator. DO NOT EDIT UNLESS YOU KNOW WHAT YOU'RE DOING.
# If you want to override the config, annotate this ConfigMap with
pgv2.percona.com/override-config=true
kubernetes: {}
postgresql:
  basebackup:
  - waldir=/pgdata/pg17_wal
  create_replica_methods:
  - basebackup
  - pgbackrest
  pgbackrest:
    command: '''bash'' ''-ceu'' ''--'' ''install --directory --mode=0700 "${PGDATA?}"
      && exec "$@"'' ''-'' ''pgbackrest'' ''restore'' ''--delta'' ''--stanza=db''
      ''--repo=1'' ''--link-map=pg_wal=/pgdata/pg17_wal'' ''--type=standby'''
    keep_data: true
    no_leader: true
    no_params: true
  pgpass: /tmp/.pgpass
  use_unix_socket: true
restapi: {}
tags: {}
```

Though the Operator updates the ConfigMaps, it doesn't automatically apply the new configuration for Patroni. To make Patroni aware of the changes, reload its configuration on every instance with the `patronictl reload <cluster_name> <pod-name>` command.

Reference

Custom Resource options

The Cluster is configured via the deploy/cr.yaml file.

`metadata`

The metadata part of this file contains the following keys:

- `name` (`cluster1` by default) sets the name of your Percona Distribution for PostgreSQL Cluster; it should include only URL-compatible characters, not exceed 22 characters, start with an alphabetic character, and end with an alphanumeric character;
- `annotations.pgv2.percona.com/custom-patroni-version` Kubernetes annotation which allows turning off automatic Patroni version detection by the Operator. You can use this annotation to set the version manually ("3" for Patroni 3.x, "4" for Patroni 4.x).
- `finalizers.percona.com/delete-ssl` if present, activates the Finalizer which deletes objects, created for SSL (Secret, certificate, and issuer) after the cluster deletion event (off by default).
- `finalizers.percona.com/delete-pvc` if present, activates the Finalizer which deletes Persistent Volume Claims for the database cluster Pods and user Secrets after the deletion event (off by default).
- `finalizers.percona.com/delete-backups` if present, activates the Finalizer which deletes all the backups of the database cluster from all configured repos on cluster deletion event (off by default). **`delete-backups` finalizer is in tech preview state, and it is not yet recommended for production environments.**

Top level `spec` elements

The spec part of the deploy/cr.yaml file contains the following:

`crVersion`

Version of the Operator the Custom Resource belongs to.

Value type	Example

string	`2.8.1`

`metadata.annotations`

The Kubernetes annotations metadata to be set at a global level for all resources created by the Operator.

Value type	Example
label	`example-annotation: value`

`metadata.labels`

The Kubernetes labels metadata to be set at a global level for all resources created by the Operator.

Value type	Example
label	`example-label: value`

`tlsOnly`

Enforce the Operator to use only Transport Layer Security (TLS) for both internal and external communications.

Value type	Example
boolean	`false`

`standby.enabled`

Enables or disables running the cluster in a standby mode (read-only copy of an existing cluster, useful for disaster recovery, etc).

Value type	Example

boolean	`false`

`standby.host`

Host address of the primary cluster this standby cluster connects to.

Value type	Example
string	`"<primary-ip>"`

`standby.port`

Port number used by a standby copy to connect to the primary cluster.

Value type	Example
string	`"<primary-port>"`

`openshift`

Set to `true` if the cluster is being deployed on OpenShift, set to `false` otherwise, or unset it for auto-detection.

Value type	Example
boolean	`true`

`autoCreateUserSchema`

If set to `true`, the cluster will have automatically created schemas for the custom user defined in the `spec.users` subsection for all of the databases listed for this specific user.

Value type	Example
boolean	`true`

`standby.repoName`

Name of the pgBackRest repository in the primary cluster this standby cluster connects to.

Value type	Example
string	`repo1`

`secrets.customRootCATLSSecret.name`

Name of the secret with the custom root CA certificate and key for secure connections to the PostgreSQL server, see Transport Layer Security (TLS) for details.

Value type	Example
string	`cluster1-ca-cert`

`secrets.customRootCATLSSecret.items`

Key-value pairs of the `key` (a key from the `secrets.customRootCATLSSecret.name` secret) and the `path` (name on the file system) for the custom root certificate and key. See Transport Layer Security (TLS) for details.

Value type	Example

subdoc	`- key: “tls.crt”`
	`  path: “root.crt”`
	`- key: “tls.key”`
	`  path: “root.key”`

`secrets.customTLSSecret.name`

A secret with TLS certificate generated for *external* communications, see Transport Layer Security (TLS) for details.

Value type	Example
string	`cluster1-cert`

`secrets.customReplicationTLSSecret.name`

A secret with TLS certificate generated for *internal* communications, see Transport Layer Security (TLS) for details.

Value type	Example
S string	`replication1-cert`

`users.name`

The name of the PostgreSQL user.

Value type	Example
S string	`rhino`

`users.databases`

Databases accessible by a specific PostgreSQL user with rights to create objects in them (the option is ignored for `postgres` user; also, modifying it can't be used to revoke the already given access).

Value type	Example
S string	`zoo`

`users.password.type`

The set of characters used for password generation: can be either `ASCII` (default) or `AlphaNumeric`.

Value type	Example
S string	`ASCII`

`users.options`

The `ALTER ROLE` options other than password (the option is ignored for `postgres` user).

Value type	Example
S string	`"SUPERUSER"`

`users.secretName`

The custom name of the user's Secret; if not specified, the default `<clusterName>-pguser-<userName>` variant will be used.

Value type	Example
S string	`"rhino-credentials"`

`users.grantPublicSchemaAccess`

Grants access to the `public` schema to the user for all databases associated with this user.

Value type	Example
S string	`false`

`databaseInitSQL.key`

Data key for the Custom configuration options ConfigMap with the init SQL file, which will be executed at cluster creation time.

Value type	Example
S string	`init.sql`

`databaseInitSQL.name`

Name of the ConfigMap with the init SQL file, which will be executed at cluster creation time.

Value type	Example
S string	`cluster1-init-sql`

`pause`

Setting it to `true` gracefully stops the cluster, scaling workloads to zero and suspending CronJobs; setting it to `false` after shut down starts the cluster back.

Value type	Example
S string	`false`

`unmanaged`

Setting it to `true` stops the Operator's activity including the rollout and reconciliation of changes made in the Custom Resource; setting it to `false` starts the Operator's activity back.

Value type	Example
S string	`false`

`dataSource.postgresCluster.clusterName`

Name of an existing cluster to use as the data source when restoring backup to a new cluster.

Value type	Example
S string	`cluster1`

`dataSource.postgresCluster.clusterNamespace`

Namespace of an existing cluster used as a data source (is needed if the new cluster will be created in a different namespace; needs the Operator deployed in multi-namespace/cluster-wide mode).

Value type	Example
S string	`cluster1-namespace`

`dataSource.postgresCluster.repoName`

Name of the pgBackRest repository in the source cluster that contains the backup to be restored to a new cluster.

Value type	Example
S string	`repo1`

`dataSource.postgresCluster.options`

The pgBackRest command-line options for the pgBackRest restore command.

Value type	Example
S string	

`dataSource.postgresCluster.tolerations.effect`

The Kubernetes Pod tolerations effect for data migration.

Value type	Example
S string	`NoSchedule`

`dataSource.postgresCluster.tolerations.key`

The Kubernetes Pod tolerations key for data migration.

Value type	Example
S string	`role`

`dataSource.postgresCluster.tolerations.operator`

The Kubernetes Pod tolerations operator for data migration.

Value type	Example
S string	`Equal`

`dataSource.postgresCluster.tolerations.value`

The Kubernetes Pod tolerations value for data migration.

Value type	Example
S string	`connection-poolers`

`dataSource.pgbackrest.stanza`

Name of the pgBackRest stanza to use as the data source when restoring backup to a new cluster.

Value type	Example
S string	`db`

`dataSource.pgbackrest.configuration.secret.name`

Name of the Kubernetes Secret object with custom pgBackRest configuration, which will be added to the pgBackRest configuration generated by the Operator.

Value type	Example

string	`pgo-s3-creds`

`dataSource.pgbackrest.global`

Settings, which are to be included in the `global` section of the pgBackRest configuration generated by the Operator.

Value type	Example
subdoc	`/pgbackrest/postgres-operator/hippo/repo1`

`dataSource.pgbackrest.repo.name`

Name of the pgBackRest repository.

Value type	Example
string	`repo1`

`dataSource.pgbackrest.repo.s3.bucket`

The Amazon S3 bucket or Google Cloud Storage bucket name used for backups. Bucket name should follow Amazon naming rules or Google naming rules, and additionally, it can't contain dots.

Value type	Example
string	`"my-bucket"`

`dataSource.pgbackrest.repo.s3.endpoint`

The endpoint URL of the S3-compatible storage to be used for backups (not needed for the original Amazon S3 cloud).

Value type	Example

string	`"s3.ca-central-1.amazonaws.com"`

`dataSource.pgbackrest.repo.s3.region`

The AWS region to use for Amazon and all S3-compatible storages.

Value type	Example
boolean	`"ca-central-1"`

`dataSource.pgbackrest.tolerations.effect`

The Kubernetes Pod tolerations effect for pgBackRest at data migration.

Value type	Example
string	`NoSchedule`

`dataSource.pgbackrest.tolerations.key`

The Kubernetes Pod tolerations key for pgBackRest at data migration.

Value type	Example
string	`role`

`dataSource.pgbackrest.tolerations.operator`

The Kubernetes Pod tolerations operator for pgBackRest at data migration.

Value type	Example
string	`Equal`

`dataSource.pgbackrest.tolerations.value`

The Kubernetes Pod tolerations value for pgBackRest at data migration.

Value type	Example
S string	`connection-poolers`

`dataSource.volumes.pgDataVolume.pvcName`

The PostgreSQL data volume name for the Persistent Volume Claim used for data migration.

Value type	Example
S string	`cluster1`

`dataSource.volumes.pgDataVolume.directory`

The mount point for PostgreSQL data volume used for data migration.

Value type	Example
S string	`cluster1`

`dataSource.volumes.pgDataVolume.tolerations.effect`

The Kubernetes Pod tolerations effect for PostgreSQL data volume used for data migration.

Value type	Example
S string	`NoSchedule`

`dataSource.volumes.pgDataVolume.tolerations.key`

The Kubernetes Pod tolerations key for PostgreSQL data volume used for data migration.

Value type	Example
string	`role`

`dataSource.volumes.pgDataVolume.tolerations.operator`

The Kubernetes Pod tolerations operator for PostgreSQL data volume used for data migration.

Value type	Example
string	`Equal`

`dataSource.volumes.pgDataVolume.tolerations.value`

The Kubernetes Pod tolerations value for PostgreSQL data volume used for data migration.

Value type	Example
string	`connection-poolers`

`dataSource.volumes.pgDataVolume.annotations`

The Kubernetes annotations metadata for PostgreSQL data volume used for data migration.

Value type	Example
label	`test-annotation: value`

`dataSource.volumes.pgDataVolume.labels`

The Kubernetes labels for PostgreSQL data volume used for data migration.

Value type	Example
label	`test-label: value`

`dataSource.volumes.pgWALVolume.pvcName`

The PostgreSQL write-ahead logs volume name for the Persistent Volume Claim used for data migration.

Value type	Example
S string	`cluster1`

`dataSource.volumes.pgWALVolume.directory`

The mount point for PostgreSQL write-ahead logs volume used for data migration.

Value type	Example
S string	`cluster1`

`dataSource.volumes.pgWALVolume.tolerations.effect`

The Kubernetes Pod tolerations effect for PostgreSQL write-ahead logs volume used for data migration.

Value type	Example
S string	`NoSchedule`

`dataSource.volumes.pgWALVolume.tolerations.key`

The Kubernetes Pod tolerations key for PostgreSQL write-ahead logs volume used for data migration.

Value type	Example
S string	`role`

`dataSource.volumes.pgWALVolume.tolerations.operator`

The Kubernetes Pod tolerations operator for PostgreSQL write-ahead logs volume used for data migration.

Value type	Example
string	`Equal`

`dataSource.volumes.pgWALVolume.tolerations.value`

The Kubernetes Pod tolerations value for PostgreSQL write-ahead logs volume used for data migration.

Value type	Example
string	`connection-poolers`

`dataSource.volumes.pgWALVolume.annotations`

The Kubernetes annotations metadata for PostgreSQL write-ahead logs volume used for data migration.

Value type	Example
label	`test-annotation: value`

`dataSource.volumes.pgWALVolume.labels`

The Kubernetes labels for PostgreSQL write-ahead logs volume used for data migration.

Value type	Example
label	`test-label: value`

`dataSource.volumes.pgBackRestVolume.pvcName`

The pgBackRest volume name for the Persistent Volume Claim used for data migration.

Value type	Example
S string	`cluster1`

`dataSource.volumes.pgBackRestVolume.directory`

The mount point for pgBackRest volume used for data migration.

Value type	Example
S string	`cluster1`

`dataSource.volumes.pgBackRestVolume.tolerations.effect`

The Kubernetes Pod tolerations effect pgBackRest volume used for data migration.

Value type	Example
S string	`NoSchedule`

`dataSource.volumes.pgBackRestVolume.tolerations.key`

The Kubernetes Pod tolerations key for pgBackRest volume used for data migration.

Value type	Example
S string	`role`

`dataSource.volumes.pgBackRestVolume.tolerations.operator`

The Kubernetes Pod tolerations operator for pgBackRest volume used for data migration.

Value type	Example
string	`Equal`

`dataSource.volumes.pgBackRestVolume.tolerations.value`

The Kubernetes Pod tolerations value for pgBackRest volume used for data migration.

Value type	Example
string	`connection-poolers`

`dataSource.volumes.pgBackRestVolume.annotations`

The Kubernetes annotations metadata for pgBackRest volume used for data migration.

Value type	Example
label	`test-annotation: value`

`dataSource.volumes.pgBackRestVolume.labels`

The Kubernetes labels for pgBackRest volume used for data migration.

Value type	Example
label	`test-label: value`

`image`

The PostgreSQL Docker image to use.

Value type	Example
string	`perconalab/percona-postgresql-operator:2.8.1-ppg17.7-1-postgres`

`imagePullPolicy`

This option is used to set the policy for updating PostgreSQL images.

Value type	Example
string	`Always`

`postgresVersion`

The major version of PostgreSQL to use.

Value type	Example
int	`16`

`port`

The port number for PostgreSQL.

Value type	Example
int	`5432`

`expose.annotations`

The Kubernetes annotations metadata for PostgreSQL primary.

Value type	Example
label	`my-annotation: value1`

`expose.labels`

Set labels for the PostgreSQL primary.

Value type	Example
label	`my-label: value2`

`expose.type`

Specifies the type of Kubernetes Service for PostgreSQL primary.

Value type	Example
string	`LoadBalancer`

`expose.loadBalancerClass`

Define the implementation of the load balancer you want to use. This setting enables you to select a custom or specific load balancer class instead of the default one provided by the cloud provider.

Value type	Example
string	`eks.amazonaws.com/nlb`

`expose.loadBalancerSourceRanges`

The range of client IP addresses from which the load balancer should be reachable (if not set, there is no limitations).

Value type	Example
string	`"10.0.0.0/8"`

`exposeReplicas.annotations`

The Kubernetes annotations metadata for PostgreSQL replicas.

Value type	Example

label	`my-annotation: value1`

`exposeReplicas.labels`

Set labels for the PostgreSQL replicas.

Value type	Example
label	`my-label: value2`

`exposeReplicas.type`

Specifies the type of Kubernetes Service for PostgreSQL replicas.

Value type	Example
string	`LoadBalancer`

`exposeReplicas.loadBalancerClass`

Define the implementation of the load balancer you want to use. This setting enables you to select a custom or specific load balancer class instead of the default one provided by the cloud provider.

Value type	Example
string	`eks.amazonaws.com/nlb`

`exposeReplicas.loadBalancerSourceRanges`

The range of client IP addresses from which the load balancer should be reachable (if not set, there is no limitations).

Value type	Example
string	`"10.0.0.0/8"`

Instances section

The `instances` section in the deploy/cr.yaml file contains configuration options for PostgreSQL instances. This section contains at least one *cluster instance* with a number of *PostgreSQL instances* in it (cluster instances are groups of PostgreSQL instances used for fine-grained resources assignment).

`instances.metadata.labels`

Set labels for PostgreSQL Pods.

Value type	Example
label	`pg-cluster-label: cluster1`

`instances.name`

The name of the PostgreSQL instance.

Value type	Example
string	`rs 0`

`instances.replicas`

The number of Replicas to create for the PostgreSQL instance.

Value type	Example
int	`3`

`instances.env.name`

Name of an environment variable for PostgreSQL Pods. Read more about defining environment variables in Kubernetes documentation.

Value type	Example
S string	`MY_ENV`

`instances.env.value`

The value for an environment variable.

Value type	Example
S string	`1000`

`instances.envFrom.secretRefName`

Name of a Secret or a ConfigMap, key/values of which are used as environment variables for PostgreSQL Pods.

Value type	Example
S string	`instance-env-secret`

`instances.initContainer.image`

Defines an image for an init container to run before the main container in the Pod. The init container is typically used for setup tasks such as initializing filesystems, setting permissions, or preparing configuration.

Value type	Example
S string	`perconalab/percona-postgresql-operator:2.8.1`

`instances.initContainer.resources.limits.cpu`

Kubernetes CPU limits for an init container.

Value type	Example

string	`2.0`

`instances.initContainer.resources.limits.memory`

The Kubernetes memory limits for an init container.

Value type	Example
string	`4Gi`

`instances.initContainer.securityContext`

Security settings for the init container. These settings control privileges, user/group IDs, and other security-related options. For more details, see the Kubernetes documentation on SecurityContext

Value type	Example

subdoc	`runAsUser: 1001`
	`runAsGroup: 1001`
	`runAsNonRoot: true`
	`privileged: false`
	`allowPrivilegeEscalation: false`
	`readOnlyRootFilesystem: true`

`instances.resources.requests.cpu`

Kubernetes CPU requests for a PostgreSQL instance. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
string	`1.0`

`instances.resources.requests.memory`

Kubernetes memory requests for a PostgreSQL instance. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`3Gi`

`instances.resources.limits.cpu`

Kubernetes CPU limits for a PostgreSQL instance.

Value type	Example
S string	`2.0`

`instances.resources.limits.memory`

The Kubernetes memory limits for a PostgreSQL instance.

Value type	Example
S string	`4Gi`

`instances.containers.replicaCertCopy.resources.requests.cpu`

Kubernetes CPU requests for a `replica-cert-copy` sidecar container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`100m`

`instances.containers.replicaCertCopy.resources.requests.memory`

Kubernetes memory requests for a `replica-cert-copy` sidecar container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`120Mi`

`instances.containers.replicaCertCopy.resources.limits.cpu`

Kubernetes CPU limits for `replica-cert-copy` sidecar container.

Value type	Example
S string	`200m`

`instances.containers.replicaCertCopy.resources.limits.memory`

The Kubernetes memory limits for `replica-cert-copy` sidecar container.

Value type	Example
S string	`128Mi`

`instances.topologySpreadConstraints.maxSkew`

The degree to which Pods may be unevenly distributed under the Kubernetes Pod Topology Spread Constraints.

Value type	Example
1 int	`1`

`instances.topologySpreadConstraints.topologyKey`

The key of node labels for the Kubernetes Pod Topology Spread Constraints.

Value type	Example
string	`my-node-label`

`instances.topologySpreadConstraints.whenUnsatisfiable`

What to do with a Pod if it doesn't satisfy the Kubernetes Pod Topology Spread Constraints.

Value type	Example
string	`DoNotSchedule`

`instances.topologySpreadConstraints.labelSelector.matchLabels`

The Label selector for the Kubernetes Pod Topology Spread Constraints.

Value type	Example
label	`postgres-operator.crunchydata.com/instance-set: instance1`

`instances.tolerations.effect`

The Kubernetes Pod tolerations effect for the PostgreSQL instance.

Value type	Example
string	`NoSchedule`

`instances.tolerations.key`

The Kubernetes Pod tolerations key for the PostgreSQL instance.

Value type	Example
S string	`role`

`instances.tolerations.operator`

The Kubernetes Pod tolerations operator for the PostgreSQL instance.

Value type	Example
S string	`Equal`

`instances.tolerations.value`

The Kubernetes Pod tolerations value for the PostgreSQL instance.

Value type	Example
S string	`connection-poolers`

`instances.priorityClassName`

The Kubernetes Pod priority class for PostgreSQL instance Pods.

Value type	Example
S string	`high-priority`

`instances.securityContext`

A custom Kubernetes Security Context for a Pod to be used instead of the default one.

Value type	Example
≡ subdoc	

```
fsGroup: 1001
runAsUser: 1001
runAsNonRoot: true
fsGroupChangePolicy: “OnRootMismatch”
runAsGroup: 1001
seLinuxOptions:
  type: spc_t
  level: s0:c123,c456
seccompProfile:
  type: Localhost
  localhostProfile: localhost/profile.json
supplementalGroups:
- 1001
sysctls:
- name: net.ipv4.tcp_keepalive_time
  value: “600”
- name: net.ipv4.tcp_keepalive_intvl
  value: “60”
```

`instances.walVolumeClaimSpec.accessModes`

The Kubernetes PersistentVolumeClaim access modes for the PostgreSQL Write-ahead Log storage.

Value type	Example
S string	`ReadWriteOnce`

`instances.walVolumeClaimSpec.storageClassName`

Set the Kubernetes storage class to use with the PostgreSQL Write-ahead Log storage PersistentVolumeClaim.

Value type	Example
S string	`standard`

`instances.walVolumeClaimSpec.resources.requests.storage`

The Kubernetes storage requests for the storage the PostgreSQL instance will use.

Value type	Example
S string	`1Gi`

`instances.dataVolumeClaimSpec.accessModes`

The Kubernetes PersistentVolumeClaim access modes for the PostgreSQL storage.

Value type	Example
S string	`ReadWriteOnce`

`instances.dataVolumeClaimSpec.storageClassName`

Set the Kubernetes storage class to use with PostgreSQL Cluster PersistentVolumeClaim for the PostgreSQL storage.

Value type	Example
S string	`standard`

`instances.dataVolumeClaimSpec.resources.requests.storage`

The Kubernetes storage requests for the storage the PostgreSQL instance will use.

Value type	Example
S string	`1Gi`

`instances.dataVolumeClaimSpec.resources.limits.storage`

The Kubernetes storage limits for the storage the PostgreSQL instance will use.

Value type	Example
S string	`5Gi`

`instances.tablespaceVolumes.name`

Name for the custom tablespace volume.

Value type	Example
S string	`user`

`instances.tablespaceVolumes.dataVolumeClaimSpec.accessModes`

The Kubernetes PersistentVolumeClaim access modes for the tablespace volume.

Value type	Example
S string	`ReadWriteOnce`

`instances.tablespaceVolumes.dataVolumeClaimSpec.resources.requests.storage`

The Kubernetes storage requests for the tablespace volume.

Value type	Example
S string	`1Gi`

`instances.sidecars` subsection

The `instances.sidecars` subsection in the deploy/cr.yaml file contains configuration options for custom sidecar containers which can be added to PostgreSQL Pods.

`instances.sidecars.image`

Image for the custom sidecar container for PostgreSQL Pods.

Value type	Example
string	`busybox:latest`

`instances.sidecars.name`

Name of the custom sidecar container for PostgreSQL Pods.

Value type	Example
string	`testcontainer`

`instances.sidecars.imagePullPolicy`

This option is used to set the policy for the PostgreSQL Pod sidecar container.

Value type	Example
string	`Always`

`instances.sidecars.env`

The environment variables set as key-value pairs for the custom sidecar container for PostgreSQL Pods.

Value type	Example
subdoc	

`instances.sidecars.envFrom`

The environment variables set as key-value pairs in ConfigMaps for the custom sidecar container for PostgreSQL Pods.

Value type	Example

subdoc

`instances.sidecars.command`

Command for the custom sidecar container for PostgreSQL Pods.

Value type	Example
array	`["/bin/sh"]`

`instances.sidecars.args`

Command arguments for the custom sidecar container for PostgreSQL Pods.

Value type	Example
array	`["-c", "while true; do trap 'exit 0' SIGINT SIGTERM SIGQUIT SIGKILL; done;"]`

Backup section

The `backup` section in the deploy/cr.yaml file contains the following configuration options for the regular Percona Distribution for PostgreSQL backups.

`backups.enabled`

Enables to turn on/off backups for the cluster. Use this option with caution. Read more in Disable backups.

Value type	Example
string	`true`

`backups.trackLatestRestorableTime`

Enables or disables tracking the latest restorable time for latest successful backup (on by default). It can be turned off to reduced S3 API usage.

Value type	Example
boolean	`true`

`backups.pgbackrest.metadata.labels`

Set labels for pgBackRest Pods.

Value type	Example
label	`pg-cluster-label: cluster1`

`backups.pgbackrest.image`

The Docker image for pgBackRest.

Value type	Example
string	`docker.io/percona/percona-pgbackrest:2.57.0-1`

`backups.pgbackrest.env.name`

Name of an environment variable for pgBackRest Pods. Read more about defining environment variables in Kubernetes documentation.

Value type	Example
string	`MY_ENV`

`backups.pgbackrest.env.value`

The value for an environment variable.

Value type	Example
S string	`1000`

`backups.pgbackrest.envFrom.secretRefName`

Name of a Secret or a ConfigMap, key/values of which are used as environment variables for pgBouncer Pods.

Value type	Example
S string	`repo-host-env-secret`

`backups.pgbackrest.containers.pgbackrest.resources.requests.cpu`

Kubernetes CPU requests for a `pgBackRest` container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`150m`

`backups.pgbackrest.containers.pgbackrest.resources.requests.memory`

Kubernetes memory requests for a `pgBackRest` container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`120Mi`

`backups.pgbackrest.containers.pgbackrest.resources.limits.cpu`

Kubernetes CPU limits for a pgBackRest container.

Value type	Example
S string	`1.0`

`backups.pgbackrest.containers.pgbackrest.resources.limits.memory`

The Kubernetes memory limits for a pgBackRest container.

Value type	Example
S string	`1Gi`

`backups.pgbackrest.containers.pgbackrestConfig.resources.limits.cpu`

Kubernetes CPU limits for `pgbackrest-config` sidecar container.

Value type	Example
S string	`1.0`

`backups.pgbackrest.containers.pgbackrestConfig.resources.limits.memory`

The Kubernetes memory limits for `pgbackrest-config` sidecar container.

Value type	Example
S string	`1Gi`

`backups.pgbackrest.containers.pgbackrestConfig.resources.requests.cpu`

Kubernetes CPU requests for a `pgbackrest-config` sidecar container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`150m`

`backups.pgbackrest.containers.pgbackrestConfig.resources.requests.memory`

Kubernetes memory requests for a `pgbackrest-config` sidecar container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`120Mi`

`backups.pgbackrest.configuration.secret.name`

Name of the Kubernetes Secret object with custom pgBackRest configuration, which will be added to the pgBackRest configuration generated by the Operator.

Value type	Example
S string	`cluster1-pgbackrest-secrets`

`backups.pgbackrest.jobs.backoffLimit`

The number of retries to make a backup with incremental pauses of 10 seconds, 20 seconds, etc. between retries. By default it's `0`, which means that pgBackRest job Pod fails after first unsuccessful attempt (causing creation of a new Pod on failure).

Value type	Example
1 int	`2`

`backups.pgbackrest.jobs.restartPolicy`

The Kubernetes Pod restart policy for pgBackRest jobs.

Value type	Example
S string	`OnFailure`

`backups.pgbackrest.jobs.priorityClassName`

The Kubernetes Pod priority class for pgBackRest jobs.

Value type	Example
S string	`high-priority`

`backups.pgbackrest.jobs.resources.limits.cpu`

Kubernetes CPU limits for a pgBackRest job.

Value type	Example
1 int	`200`

`backups.pgbackrest.jobs.resources.limits.memory`

The Kubernetes memory limits for a pgBackRest job.

Value type	Example
S string	`128Mi`

`backups.pgbackrest.jobs.resources.requests.cpu`

Kubernetes CPU requests for a pgBackRest job. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`150m`

`backups.pgbackrest.jobs.resources.requests.memory`

Kubernetes memory requests for pgBackRest job. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`120Mi`

`backups.pgbackrest.jobs.tolerations.effect`

The Kubernetes Pod tolerations effect for a backup job.

Value type	Example
S string	`NoSchedule`

`backups.pgbackrest.jobs.tolerations.key`

The Kubernetes Pod tolerations key for a backup job.

Value type	Example

string	`role`

`backups.pgbackrest.jobs.tolerations.operator`

The Kubernetes Pod tolerations operator for a backup job.

Value type	Example
string	`Equal`

`backups.pgbackrest.jobs.tolerations.value`

The Kubernetes Pod tolerations value for a backup job.

Value type	Example
string	`connection-poolers`

`backups.pgbackrest.jobs.securityContext`

A custom Kubernetes Security Context for a Pod to be used instead of the default one.

Value type	Example
subdoc	

```
fsGroup: 1001
runAsUser: 1001
runAsNonRoot: true
fsGroupChangePolicy: “OnRootMismatch”
runAsGroup: 1001
seLinuxOptions:
  type: spc_t
  level: s0:c123,c456
seccompProfile:
  type: Localhost
  localhostProfile: localhost/profile.json
supplementalGroups:
- 1001
sysctls:
- name: net.ipv4.tcp_keepalive_time
  value: “600”
- name: net.ipv4.tcp_keepalive_intvl
  value: “60”
```

`backups.pgbackrest.global`

Settings, which are to be included in the `global` section of the pgBackRest configuration generated by the Operator.

Value type	Example

subdoc	`repo1-retention-full: “14”`
	`repo1-retention-full-type: time`
	`repo1-path: /pgbackrest/postgres-operator/cluster1/repo1`
	`repo1-cipher-type: aes-256-cbc`
	`repo1-s3-uri-style: path`
	`repo2-path: /pgbackrest/postgres-operator/cluster1-multi-repo/repo2`
	`repo3-path: /pgbackrest/postgres-operator/cluster1-multi-repo/repo3`
	`repo4-path: /pgbackrest/postgres-operator/cluster1-multi-repo/repo4`

`backups.pgbackrest.repoHost.sidecars.name`

The name of a custom sidecar container for pgBackRest Pods.

Value type	Example
S string	`testcontainer`

`backups.pgbackrest.repoHost.sidecars.image`

The image used to deploy a custom sidecar container for pgBackRest Pods.

Value type	Example
S string	`busybox:latest`

`backups.pgbackrest.repoHost.sidecars.command`

The command to use inside a custom sidecar container for pgBackRest Pods

Value type	Example
S string	`["sleep", "30d"]`

`backups.pgbackrest.repoHost.sidecars.securityContext`

Security settings for the sifecar container. These settings control privileges, user/group IDs, and other security-related options. For more details, see the Kubernetes documentation on SecurityContext

Value type	Example
S string	`{}`

`backups.pgbackrest.repoHost.resources.requests.cpu`

Kubernetes CPU requests for a pgBackRest repo. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`150m`

`backups.pgbackrest.repoHost.resources.requests.memory`

Kubernetes memory requests for pgBackRest repo. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`120Mi`

`backups.pgbackrest.repoHost.resources.limits.cpu`

Kubernetes CPU limits for a pgBackRest repo.

Value type	Example
1 int	`200`

`backups.pgbackrest.repoHost.resources.limits.memory`

The Kubernetes memory limits for a pgBackRest repo.

Value type	Example
S string	`128Mi`

`backups.pgbackrest.repoHost.priorityClassName`

The Kubernetes Pod priority class for pgBackRest repo.

Value type	Example
S string	`high-priority`

`backups.pgbackrest.repoHost.topologySpreadConstraints.maxSkew`

The degree to which Pods may be unevenly distributed under the Kubernetes Pod Topology Spread Constraints.

Value type	Example
1 int	`1`

`backups.pgbackrest.repoHost.topologySpreadConstraints.topologyKey`

The key of node labels for the Kubernetes Pod Topology Spread Constraints.

Value type	Example
S string	`my-node-label`

`backups.pgbackrest.repoHost.topologySpreadConstraints.whenUnsatisfiable`

What to do with a Pod if it doesn't satisfy the Kubernetes Pod Topology Spread Constraints.

Value type	Example
S string	`ScheduleAnyway`

`backups.pgbackrest.repoHost.topologySpreadConstraints.labelSelector.matchLabels`

The Label selector for the Kubernetes Pod Topology Spread Constraints.

Value type	Example
label	`postgres-operator.crunchydata.com/pgbackrest: ""`

`backups.pgbackrest.repoHost.affinity.podAntiAffinity`

Pod anti-affinity, allows setting the standard Kubernetes affinity constraints of any complexity.

Value type	Example
subdoc	

`backups.pgbackrest.repoHost.tolerations.effect`

The Kubernetes Pod tolerations effect for pgBackRest repo.

Value type	Example
string	`NoSchedule`

`backups.pgbackrest.repoHost.tolerations.key`

The Kubernetes Pod tolerations key for pgBackRest repo.

Value type	Example
string	`role`

`backups.pgbackrest.repoHost.tolerations.operator`

The Kubernetes Pod tolerations operator for pgBackRest repo.

Value type	Example
string	`Equal`

`backups.pgbackrest.repoHost.tolerations.value`

The Kubernetes Pod tolerations value for pgBackRest repo.

Value type	Example

string	`connection-poolers`

‘backups.pgbackrest.repoHost.securityContext’

A custom Kubernetes Security Context for a Pod to be used instead of the default one.

Value type	Example

subdoc	`fsGroup: 1001`
	`runAsUser: 1001`
	`runAsNonRoot: true`
	`fsGroupChangePolicy: “OnRootMismatch”`
	`runAsGroup: 1001`
	`seLinuxOptions:`
	`  type: spc_t`
	`  level: s0:c123,c456`
	`seccompProfile:`
	`  type: Localhost`
	`  localhostProfile: localhost/profile.json`
	`supplementalGroups:`
	`- 1001`
	`sysctls:`
	`- name: net.ipv4.tcp_keepalive_time`
	`  value: “600”`
	`- name: net.ipv4.tcp_keepalive_intvl`
	`  value: “60”`

`backups.pgbackrest.manual.repoName`

Name of the pgBackRest repository for on-demand backups.

Value type	Example
string	`repo1`

`backups.pgbackrest.manual.options`

The on-demand backup command-line options which will be passed to pgBackRest for on-demand backups.

Value type	Example

S string	`--type=full`

`backups.pgbackrest.manual.initialDelaySeconds`

The time to delay a backup start after the backup Pod is scheduled. The backup process wait for the defined time before it connectsto the API server to start a backup.

Value type	Example
1 int	`120`

`backups.pgbackrest.repos.name`

Name of the pgBackRest repository for backups.

Value type	Example
S string	`repo1`

`backups.pgbackrest.repos.schedules.full`

Scheduled time to make a full backup specified in the crontab format.

Value type	Example
S string	`0 0 \* \* 6`

`backups.pgbackrest.repos.schedules.differential`

Scheduled time to make a differential backup specified in the crontab format.

Value type	Example
S string	`0 0 \* \* 6`

`backups.pgbackrest.repos.volume.volumeClaimSpec.accessModes`

The Kubernetes PersistentVolumeClaim access modes for the pgBackRest Storage.

Value type	Example
S string	`ReadWriteOnce`

`backups.pgbackrest.repos.volume.volumeClaimSpec.storageClassName`

Set the Kubernetes Storage Class to use with the Percona Operator for PostgreSQL backups stored on Persistent Volume.

Value type	Example
S string	`standard`

`backups.pgbackrest.repos.volume.volumeClaimSpec.resources.requests.storage`

The Kubernetes storage requests for the pgBackRest storage.

Value type	Example
S string	`1Gi`

`backups.pgbackrest.repos.s3.bucket`

The Amazon S3 bucket name used for backups

Value type	Example
S string	`"my-bucket"`
.	

`backups.pgbackrest.repos.s3.endpoint`

The endpoint URL of the S3-compatible storage to be used for backups (not needed for the original Amazon S3 cloud).

Value type	Example
S string	`"s3.ca-central-1.amazonaws.com"`

`backups.pgbackrest.repos.s3.region`

The AWS region to use for Amazon and all S3-compatible storages.

Value type	Example
S string	`"ca-central-1"`

`backups.pgbackrest.repos.gcs.bucket`

The Google Cloud Storage bucket name used for backups.

Value type	Example
S string	`"my-bucket"`

`backups.pgbackrest.repos.azure.container`

Name of the Azure Blob Storage container for backups.

Value type	Example
S string	`my-container`

`backups.restore.tolerations.effect`

The Kubernetes Pod tolerations effect for the backup restore job.

Value type	Example
S string	`NoSchedule`

`backups.restore.tolerations.key`

The Kubernetes Pod tolerations key for the backup restore job.

Value type	Example
S string	`role`

`backups.restore.tolerations.operator`

The Kubernetes Pod tolerations operator for the backup restore job.

Value type	Example
S string	`Equal`

`backups.restore.tolerations.value`

The Kubernetes Pod tolerations value for the backup restore job.

Value type	Example
S string	`connection-poolers`

PMM section

The `pmm` section in the deploy/cr.yaml file contains configuration options for Percona Monitoring and Management.

`pmm.enabled`

Enables or disables monitoring Percona Distribution for PostgreSQL cluster with PMM.

Value type	Example
boolean	`false`

`pmm.image`

Percona Monitoring and Management (PMM) Client Docker image.

Value type	Example
string	`percona/pmm-client:3.5.0`

`pmm.imagePullPolicy`

This option is used to set the policy for updating PMM Client images.

Value type	Example
string	`IfNotPresent`

`pmm.secret`

Name of the Kubernetes Secret object for the PMM Server password.

Value type	Example
string	`cluster1-pmm-secret`

`pmm.serverHost`

Address of the PMM Server to collect data from the cluster.

Value type	Example

string	`monitoring-service`

pmm.customClusterName

A custom name to define for a cluster. PMM Server uses this name to properly parse the metrics and display them on dashboards. Using a custom name is useful for clusters deployed in different data centers - PMM Server connects them and monitors them as one deployment. Another use case is for clusters deployed with the same name in different namespaces - PMM treats each cluster separately.

Value type	Example
string	`postgresql-cluster`

`pmm.resources.requests.cpu`

Kubernetes CPU requests for a PMM Client container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
string	`150m`

`pmm.resources.requests.memory`

Kubernetes memory requests for PMM Client container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
string	`120Mi`

`pmm.resources.limits.cpu`

Kubernetes CPU limits for a PMM Client container.

Value type	Example
1 int	`200`

`pmm.resources.limits.memory`

The Kubernetes memory limits for a PMM Client container.

Value type	Example
S string	`128Mi`

`pmm.querySource`

Query source to track PostgreSQL statistics. Either pg_stat_monitor (`pgstatmonitor`, the default value) or pg_stat_statements (`pgstatstatements`) can be used.

Value type	Example
S string	`pgstatmonitor`

`pmm.postgresParams`

Additional parameters which will be passed to the `pmm-admin add postgresql` command for PostgreSQL Pods.

Value type	Example
S string	

Proxy section

The `proxy` section in the deploy/cr.yaml file contains configuration options for the pgBouncer connection pooler for PostgreSQL.

`proxy.pgBouncer.metadata.labels`

Set labels for pgBouncer Pods.

Value type	Example
label	`pg-cluster-label: cluster1`

`proxy.pgBouncer.replicas`

The number of the pgBouncer Pods to provide connection pooling.

Value type	Example
1 int	`3`

`proxy.pgBouncer.image`

Docker image for the pgBouncer connection pooler.

Value type	Example
S string	`docker.io/percona/percona-pgbouncer:1.25.0-1`

`proxy.pgBouncer.env.name`

Name of an environment variable for pgBouncer Pods. Read more about defining environment variables in Kubernetes documentation.

Value type	Example
S string	`MY_ENV`

`proxy.pgBouncer.env.value`

The value for an environment variable.

Value type	Example
S string	`1000`

`proxy.pgBouncer.envFrom.secretRefName`

Name of a Secret or a ConfigMap, key/values of which are used as environment variables for pgBouncer Pods.

Value type	Example
S string	`pgbouncer-env-secret`

`proxy.pgBouncer.exposeSuperusers`

Enables or disables exposing superuser user through pgBouncer.

Value type	Example
boolean	`false`

`proxy.pgBouncer.resources.requests.cpu`

Kubernetes CPU requests for a pgBouncer container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`150m`

`proxy.pgBouncer.resources.requests.memory`

Kubernetes memory requests for a pgBouncer container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`120Mi`

`proxy.pgBouncer.resources.limits.cpu`

Kubernetes CPU limits for a pgBouncer container.

Value type	Example
S string	`200m`

`proxy.pgBouncer.resources.limits.memory`

The Kubernetes memory limits for a pgBouncer container.

Value type	Example
S string	`128Mi`

`proxy.pgBouncer.containers.pgbouncerConfig.resources.limits.cpu`

Kubernetes CPU limits for `pgbouncer-config` sidecar container.

Value type	Example
S string	`1.0`

`proxy.pgBouncer.containers.pgbouncerConfig.resources.limits.memory`

The Kubernetes memory limits for `pgbouncer-config` sidecar container.

Value type	Example
S string	`1Gi`

`proxy.pgBouncer.containers.pgbouncerConfig.resources.requests.cpu`

Kubernetes CPU requests for a `pgbouncer-config` sidecar container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`150m`

`proxy.pgBouncer.containers.pgbouncerConfig.resources.requests.memory`

Kubernetes memory requests for a `pgbouncer-config` sidecar container. It must not exceed the limit.

If you specify a limit and don't specify a request, Kubernetes uses the specified limit as the requested value for a resource.

Value type	Example
S string	`120Mi`

`proxy.pgBouncer.expose.type`

Specifies the type of Kubernetes Service for pgBouncer.

Value type	Example

string	`ClusterIP`

`proxy.pgBouncer.expose.annotations`

The Kubernetes annotations metadata for pgBouncer.

Value type	Example
label	`my-annotation: value1`

`proxy.pgBouncer.expose.labels`

Set labels for the pgBouncer Service.

Value type	Example
label	`pg-cluster-label: cluster1`

`proxy.pgBouncer.expose.loadBalancerClass`

Define the implementation of the load balancer you want to use. This setting enables you to select a custom or specific load balancer class instead of the default one provided by the cloud provider.

Value type	Example
string	`eks.amazonaws.com/nlb`

`proxy.pgBouncer.expose.loadBalancerSourceRanges`

The range of client IP addresses from which the load balancer should be reachable (if not set, there is no limitations).

Value type	Example
string	`"10.0.0.0/8"`

`proxy.pgBouncer.affinity.podAntiAffinity`

Pod anti-affinity, allows setting the standard Kubernetes affinity constraints of any complexity.

Value type	Example
subdoc	

‘proxy.pgBouncer.securityContext’

A custom Kubernetes Security Context for a Pod to be used instead of the default one.

Value type	Example

subdoc	`fsGroup: 1001`
	`runAsUser: 1001`
	`runAsNonRoot: true`
	`fsGroupChangePolicy: “OnRootMismatch”`
	`runAsGroup: 1001`
	`seLinuxOptions:`
	`  type: spc_t`
	`  level: s0:c123,c456`
	`seccompProfile:`
	`  type: Localhost`
	`  localhostProfile: localhost/profile.json`
	`supplementalGroups:`
	`- 1001`
	`sysctls:`
	`- name: net.ipv4.tcp_keepalive_time`
	`  value: “600”`
	`- name: net.ipv4.tcp_keepalive_intvl`
	`  value: “60”`

`proxy.pgBouncer.config`

Custom configuration options for pgBouncer. Please note that configuration changes are automatically applied to the running instances without validation, so having an invalid config can make the cluster unavailable.

Value type	Example
subdoc	`global:` `pool_mode: transaction`

proxy.pgBouncer.sidecars subsection

The `proxy.pgBouncer.sidecars` subsection in the deploy/cr.yaml file contains configuration options for custom sidecar containers which can be added to pgBouncer Pods.

`proxy.pgBouncer.sidecars.image`

Image for the custom sidecar container for pgBouncer Pods.

Value type	Example
S string	`mycontainer1:latest`

`proxy.pgBouncer.sidecars.name`

Name of the custom sidecar container for pgBouncer Pods.

Value type	Example
S string	`testcontainer`

`proxy.pgBouncer.sidecars.imagePullPolicy`

This option is used to set the policy for the pgBouncer Pod sidecar container.

Value type	Example
S string	`Always`

`proxy.pgBouncer.sidecars.env`

The environment variables set as key-value pairs for the custom sidecar container for pgBouncer Pods.

Value type	Example
subdoc	

`proxy.pgBouncer.sidecars.envFrom`

The environment variables set as key-value pairs in ConfigMaps for the custom sidecar container for pgBouncer Pods.

Value type	Example
subdoc	

`proxy.pgBouncer.sidecars.command`

Command for the custom sidecar container for pgBouncer Pods.

Value type	Example
array	`["/bin/sh"]`

`proxy.pgBouncer.sidecars.args`

Command arguments for the custom sidecar container for pgBouncer Pods.

Value type	Example
array	`["-c", "while true; do trap 'exit 0' SIGINT SIGTERM SIGQUIT SIGKILL; done;"]`

Patroni Section

The `patroni` section in the deploy/cr.yaml file contains configuration options to customize the PostgreSQL high-availability implementation based on Patroni.

Value type	Example

1 int	3

patroni.syncPeriodSeconds

How often to perform liveness/readiness probes for the patroni container (in seconds).

Value type	Example
1 int	3

patroni.leaderLeaseDurationSeconds

Initial delay for liveness/readiness probes for the patroni container (in seconds).

patroni.dynamicConfiguration

Custom PostgreSQL configuration options. Please note that configuration changes are automatically applied to the running instances without validation, so having an invalid config can make the cluster unavailable.

Value type	Example

subdoc	`postgresql:`
	`  parameters:`
	`  max_parallel_workers: 2`
	`  max_worker_processes: 2`
	`  shared_buffers: 1GB`
	`  work_mem: 2MB`

patroni.switchover.enabled

Enables or disables manual change of the cluster primary instance.

Value type	Example
S string	`true`

`patroni.switchover.targetInstance`

The name of the Pod that should be set as the new primary. When not specified, the new primary will be selected randomly.

Value type	Example
S string	

`patroni.createReplicaMethods`

Defines available replica creation methods and the order of executing them during a cluster start or reinitialisation. Patroni will stop on the first one that returns 0.

By default, `pg_basebackup` is used to create replicas during a new cluster deployment. After the Operator makes an initial backup, it updates the Patroni ConfigMap assign the `pgBackRest` as the first item in the list. This configuration is not propagated to Patroni itself until you restart the database instance Pods or manually reload Patroni configuration.

In the same way, after you define the replica set methods and apply the configuration, the Operator updates the Patroni ConfigMap. You must manually reload Patroni configuration of every database instance to make Patroni aware of the changes. Read more about setting replica methods in the Configure create_replica_methods section.

Value type	Example
S string	- pgbackrest - basebackup

Custom extensions Section

The `extensions` section in the deploy/cr.yaml file contains configuration options to manage PostgreSQL extensions.

`extensions.image`

Image for the custom PostgreSQL extension loader sidecar container.

Value type	Example
S string	`docker.io/percona/percona-postgresql-operator:2.8.1`

`extensions.imagePullPolicy`

Policy for the custom extension sidecar container.

Value type	Example
S string	`Always`

`extensions.storage.type`

The cloud storage type used for backups. Only `s3` type is currently supported.

Value type	Example
S string	`s3`

`extensions.storage.bucket`

The Amazon S3 bucket name for prepackaged PostgreSQL custom extensions.

Value type	Example
S string	`pg-extensions`

`extensions.storage.region`

The AWS region to use.

Value type	Example
S string	`eu-central-1`

`extensions.storage.endpoint`

The S3 endpoint to use.

Value type	Example
string	`s3.eu-central-1.amazonaws.com`

`extensions.storage.forcePathStyle`

When set to `true`, enforces path-style access method of constructing S3 URLs, where the bucket name appears in the path portion of the URL. Default `false` value means the Operator uses the virtual-hosted-style for accessing S3 storage, where the bucket name is part of the domain name.

Value type	Example
boolean	`false`

`extensions.storage.disableSSL`

When set to `true`, instructs the Operator to skip TLS verification when accessing the storage. Can be used if your storage endpoint uses self-signed certificates or doesn't support TLS to allow successful downloads.

Value type	Example
boolean	`false`

`extensions.storage.secret.name`

The Kubernetes secret for the custom extensions storage. It should contain `AWS_ACCESS_KEY_ID` and `AWS_SECRET_ACCESS_KEY` keys.

Value type	Example
string	`cluster1-extensions-secret`

`extensions.builtin.pg_stat_monitor`

Enable or disable pg_stat_monitor PostgreSQL extension.

Value type	Example
boolean	`true`

`extensions.builtin.pg_stat_statements`

Enable or disable pg_stat_statements PostgreSQL extension.

Value type	Example
boolean	`false`

`extensions.builtin.pg_audit`

Enable or disable PGAudit PostgreSQL extension.

Value type	Example
boolean	`true`

`extensions.builtin.pgvector`

Enable or disable pgvector PostgreSQL extension. **This extension is not compatible with PostgreSQL 12!**

Value type	Example
boolean	`false`

`extensions.builtin.pg_repack`

Enable or disable pg_repack PostgreSQL extension.

Value type	Example
boolean	`false`

`extensions.custom.name`

Name of the PostgreSQL custom extension.

Value type	Example
string	`pg_cron`

`extensions.custom.version`

Version of the PostgreSQL custom extension.

Value type	Example
string	`1.6.1`

Backup Resource Options

A Backup resource is a Kubernetes object that tells the Operator how to create and manage your database backups. The `deploy/backup.yaml` file is a template for creating backup resources when you make an on-demand backup. It defines the `PerconaPGBackup` resource.

This document describes all available options that you can use to customize your backups.

`apiVersion`

Specifies the API version of the Custom Resource. `pgv2.percona.com` indicates the group, and `v2` is the version of the API.

`kind`

Defines the type of resource being created: `PerconaPGBackup`.

`metadata`

The metadata part of the `deploy/backup.yaml` contains metadata about the resource, such as its name and other attributes. It includes the following keys:

- `name` - The name of the backup resource used to identify it in your deployment. You also use the backup name for the restore operation.

`spec`

This subsection includes the configuration of a backup resource.

`pgCluster`

Specifies the name of the PostgreSQL cluster to back up.

Value type	Example
S string	`cluster1`

`repoName`

Specifies the name of the `pgBackRest` repository where to save a backup. It must match the name you specified in the `spec.backups.pgBackRest.repos` subsection of the `deploy/cr.yaml` file.

Value type	Example
S string	`repo1`

`options`

You can customize the backup by specifying different command line options supported by pgBackRest :octicons-external-link-16:.

Value type	Example
S string	`--type=full`

Restore Resource Options

A Restore resource is a Kubernetes object that tells the Operator how to restore your database from a specific backup. The `deploy/restore.yaml` file is a template for creating restore resources. It defines the `PerconaPGRestore` resource.

This document describes all available options that you can use to customize a restore.

`apiVersion`

Specifies the API version of the Custom Resource. `pgv2.percona.com` indicates the group, and `v2` is the version of the API.

`kind`

Defines the type of resource being created: `PerconaPGRestore`.

`metadata`

The metadata part of the `deploy/restore.yaml` contains metadata about the resource, such as its name and other attributes. It includes the following keys:

- `name` - The name of the restore resource used to identify it in your deployment. You use this name to track the restore operation status and view information about it.

`spec`

This subsection includes the configuration of a restore resource.

`pgCluster`

Specifies the name of the PostgreSQL cluster to restore.

Value type	Example
S string	`restore1`

`repoName`

Specifies the name of one of the 4 pgBackRest repositories, already configured in the `backups.pgbackrest.repos` subsection of the `deploy/cr.yaml` file.

Value type	Example
S string	`repo1`

`options`

Specify the command line options supported by pgBackRest :octicons-external-link-16:. For example, to make a point-in-time restore.

Value type	Example
S string	`--type=time` `--target=YYYY-MM-DD HH:MM:DD +00`

Secrets Resource options

A Kubernetes Secret is an object used to store sensitive data, such as passwords, tokens, or keys in a secure and manageable way. Unlike ConfigMaps, Secrets are specifically designed to hold confidential information and can be mounted as volumes or injected into environment variables within Pods.

`apiVersion`

Specifies the API version of the Custom Resource.

`kind`

Defines the type of resource being created: `Secret`.

`metadata.name`

Contains the metadata about the resource, such as its name.

`type`

Defines the type of data stored within the Secret resource. `Opaque` type signals to Kubernetes and to the Operator that the content of the secret is custom and unstructured.

`stringData`

The data that you pass to the Operator within the Secret.

Value type	Example
S string	`PMM_SERVER_TOKEN`

Percona certified images

This page lists Percona's certified Docker images that you can use with Percona Operator for PostgreSQL 2.8.1.

To find images for a specific Operator version, see Retrieve Percona certified images

Images released with the Operator version 2.8.1:

Image	Digest
percona/percona-postgresql-operator:2.8.1 (x86_64)	018b0063352fff83d7850d732c80ba6a938c425ac2d9ac7e9a0a270361ff3fc0
percona/percona-postgresql-operator:2.8.1 (ARM64)	ce7e6f612d4cef4ef86f06521549f3e3c4e1fe8ecf794feff6f3205667863792
percona/percona-distribution-postgresql:18.1-1	23522ee9c1abda0b9cbb40c4b414328dafc10596506731954a5754e8b6994e76
percona/percona-distribution-postgresql:17.7-1	c4eec3a4fc8a5d7ba6a631a19f7387f5e34ca9ddcc8ba34bdc6709159be2c3ac
percona/percona-distribution-postgresql:16.11-1	4cd7092284bf323893c75349a5f6c0f4948d8e602fa213210e3efca28cfc2f1d
percona/percona-distribution-postgresql:15.15-1	9ace25f15a319ec741ab32502d4818874a981c38dbb22625e8f2f67bf42bb558
percona/percona-distribution-postgresql:14.20-1	e926d10167ba73da8e2c75218256cd99c68ca9072fd1b9b1ed4b00822a165ab0
percona/percona-distribution-postgresql:13.23-1	03d8d76d844495d07d1eae3fe5767a1c8130fba0a29c6c1353e872601380f9da

percona/percona-postgresql-operator:2.8.1-ppg18.1-postgres-gis3.5.4	706c0aa7c45692d108fbb172cbcd6bf990ee95ff5a77c5e5f79638e45dccd0a9
percona/percona-postgresql-operator:2.8.1-ppg17.7-postgres-gis3.3.8	6ceb2c24a279ddc6914ec762cf96f4b89cbd4869aa8a875c4a55fc82685cb3e7
percona/percona-postgresql-operator:2.8.1-ppg16.11-postgres-gis3.3.8	dca87ac8ddf79ed600f8b7243d7a351ec058a0a65aedbd360ac77fcb061e441c
percona/percona-postgresql-operator:2.8.1-ppg15.15-postgres-gis3.3.8	c82dc9203cbe24b5dbf3cc540d5c13484c543be8b225ad9fdec92fc4c8b6f2ff
percona/percona-postgresql-operator:2.8.1-ppg14.20-postgres-gis3.3.8	14ec320d529d7c941b23da58d4d0da6249e6eba3b6d10b5d11b36e4d2aaeb929
percona/percona-postgresql-operator:2.8.1-ppg13.23-postgres-gis3.3.8	9df1dd41a1369d672b6f8a9653dd358f2cf85f363ceff1ca3389641094494b07
percona/percona-pgbouncer:1.25.0-1 (x86_64)	bf2f325cc733b96dc360c2386c8931ed9e3513f55cb425e59033e1e56737134f
percona/percona-pgbouncer:1.25.0-1 (ARM64)	902feac78cf98fbd6a7aece1761371dd1a43faaed88b63be0e0d54dd524b8286
percona/percona-pgbackrest:2.57.0-1 (x86_64)	2bf7265f84210671bc5c0928cc772202c0e6054d426eb6ecf86279d69e831b96
percona/percona-pgbackrest:2.57.0-1	59245b25fd5d0c1a2540b465e846b69f4c91b6cd183c3bfd96aa856d3e7ffbf3

(ARM64)	
percona/pmm-client:2.44.1-1	52a8fb5e8f912eef1ff8a117ea323c401e278908ce29928dafc23fac1db4f1e3
percona/pmm-client:3.5.0 (x86_64)	352aee74f25b3c1c4cd9dff1f378a0c3940b315e551d170c09953bf168531e4a
percona/pmm-client:3.5.0 (ARM64)	cbbb074d51d90a5f2d6f1d98a05024f6de2ffdcb5acab632324cea4349a820bd

For older versions, please refer to the old releases documentation archive).

Versions compatibility

Versions of the cluster components and platforms tested with different Operator releases are shown below. Other version combinations may also work but have not been tested.

Cluster components:

Operator	PostgreSQL	pgBackRest	pgBouncer
2.8.1	13 - 18	2.57.0	1.25.0
2.8.0	13 - 17	2.56.0	1.24.1
2.7.0	13 - 17	2.55.0	1.24.1
2.6.0	13 - 17	2.54.2 for PostgreSQL 13-16 and 17.4, 2.54.0 for PostgreSQL 17.2	1.24.0 for PostgreSQL 13-16 and 17.2, 1.23.1 for PostgreSQL 17
2.5.1	12 - 16	2.54.2	1.24.0
2.5.0	12 - 16	2.53-1	1.23.1
2.4.1	12 - 16	2.51	1.22.1
2.4.0	12 - 16	2.51	1.22.1
2.3.1	12 - 16	2.48	1.18.0
2.3.0	12 - 16	2.48	1.18.0
2.2.0	12 - 15	2.43	1.18.0
2.1.0	12 - 15	2.43	1.18.0
2.0.0	12 - 14	2.41	1.17.0
1.6.0	12 - 14	2.50	1.22.0
1.5.1	12 - 14	2.47	1.20.0

1.5.0	12 - 14	2.47		1.20.0
1.4.0	12 - 14	2.43		1.18.0
1.3.0	12 - 14	2.38		1.17.0
1.2.0	12 - 14	2.37		1.16.1
1.1.0	12 - 14	2.34		1.16.0 for PostgreSQL 12, 1.16.1 for other versions
1.0.0	12 - 13	2.33		1.13.0

Platforms:

Operator	GKE	EKS	Openshift	Azure Kubernetes Service (AKS)	Minikube
2.8.1	1.31 - 1.33	1.31 - 1.34	4.16 - 4.20	1.32 - 1.34	1.37.0
2.8.0	1.31 - 1.33	1.31 - 1.34	4.16 - 4.20	1.32 - 1.34	1.37.0
2.7.0	1.30 - 1.32	1.30 - 1.33	4.15 - 4.19	1.30 - 1.33	1.36.0
2.6.0	1.29 - 1.31	1.29 - 1.32	4.14 - 4.18	1.29 - 1.31	1.35.0
2.5.1	1.28 - 1.30	1.28 - 1.30	4.13.46 - 4.16.7	1.28 - 1.30	1.33.1
2.5.0	1.28 - 1.30	1.28 - 1.30	4.13.46 - 4.16.7	1.28 - 1.30	1.33.1
2.4.1	1.27 - 1.29	1.27 - 1.30	4.12.59 - 4.15.18	-	1.33.1
2.4.0	1.27 - 1.29	1.27 - 1.30	4.12.59 - 4.15.18	-	1.33.1
2.3.1	1.24 - 1.28	1.24 - 1.28	4.11.55 - 4.14.6	-	1.32

2.3.0	1.24 - 1.28	1.24 - 1.28	4.11.55 - 4.14.6	-	1.32
2.2.0	1.23 - 1.26	1.23 - 1.27	-	-	1.30.1
2.1.0	1.23 - 1.25	1.23 - 1.25	-	-	-
2.0.0	1.22 - 1.25	-	-	-	-
1.6.0	1.26 - 1.29	1.26 - 1.29	4.12.57 - 4.15.13	-	1.33
1.5.1	1.24 - 1.28	1.24 - 1.28	4.11 - 4.14	-	1.32
1.5.0	1.24 - 1.28	1.24 - 1.28	4.11 - 4.14	-	1.32
1.4.0	1.22 - 1.25	1.22 - 1.25	4.10 - 4.12	-	1.28
1.3.0	1.21 - 1.24	1.20 - 1.22	4.7 - 4.10	-	-
1.2.0	1.19 - 1.22	1.19 - 1.21	4.7 - 4.10	-	-
1.1.0	1.19 - 1.22	1.18 - 1.21	4.7 - 4.9	-	-
1.0.0	1.17 - 1.21	1.21	4.6 - 4.8	-	-

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Release Notes

Percona Operator for PostgreSQL Release Notes

- Percona Operator for PostgreSQL 2.8.1 (2025-12-16)
- Percona Operator for PostgreSQL 2.8.0 (2025-11-13)
- Percona Operator for PostgreSQL 2.7.0 (2025-07-18)
- Percona Operator for PostgreSQL 2.6.0 (2025-03-17)
- Percona Operator for PostgreSQL 2.5.1 (2024-03-03)
- Percona Operator for PostgreSQL 2.5.0 (2024-10-08)
- Percona Operator for PostgreSQL 2.4.1 (2024-08-06)
- Percona Operator for PostgreSQL 2.4.0 (2024-06-24)
- Percona Operator for PostgreSQL 2.3.1 (2024-01-23)
- Percona Operator for PostgreSQL 2.3.0 (2023-12-21)
- Percona Operator for PostgreSQL 2.2.0 (2023-06-30)
- Percona Operator for PostgreSQL 2.1.0 Tech preview (2023-05-04)
- Percona Operator for PostgreSQL 2.0.0 Tech preview (2022-12-30)

Percona Operator for PostgreSQL 2.8.1 (2025-12-16)

Get started with the Operator →

Release Highlights

This release provides the following features and improvements:

PostgreSQL 18 support

You can now deploy PostgreSQL 18 on Kubernetes with the Operator. This latest major version of PostgreSQL delivers major improvements in performance, usability, and security, empowering you to make large-scale, mission-critical deployments more reliable and efficient.

Key improvements of PostgreSQL 18 are:

- Asynchronous I/O (AIO) boosts throughput and reduces latency for sequential scans, vacuums, and other heavy operations. This means faster queries and smoother performance under load.
- Queries can now use multicolumn B-tree indexes more effectively. Users benefit from faster lookups without needing redundant indexes.
- Upgrades made via `pg_upgrade` no longer discard optimizer statistics. This reduces downtime and ensures consistent query performance after migrations.
- You can now enforce PRIMARY KEY, UNIQUE, and FOREIGN KEY constraints over ranges of time. This is especially valuable for applications managing time-series or historical data.
- Generated columns are now computed at read time by default. This reduces storage overhead and makes schema design more flexible.

Read more about PostgreSQL 18 in:

- Percona Blog: Planning Ahead for PostgreSQL 18: What Matters for Your Organization
- PostgreSQL 18.1 release notes

Find PostgreSQL 18 images in the list of Percona-certified images.

Supported software

The Operator 2.8.1 is developed, tested and based on:

- PostgreSQL 18.1-1, 17.7-1, 16.11-1, 15.15-1, 14.20-1, 13.23-1 as the database. Other versions may also work but have not been tested.
- pgBouncer 1.25.0-1 for connection pooling
- Patroni version 4.1.0 for high-availability
- PMM Client 3.5.0
- PostGIS:
  - version 3.5.4 for PostgreSQL 18,
  - version 3.3.8 for PostgreSQL 17, 16, 15, 14, and 13

Supported platforms

Percona Operators are designed for compatibility with all CNCF-certified Kubernetes distributions.

Our release process includes targeted testing and validation on major cloud provider platforms and OpenShift, as detailed below for Operator version 2.8.1:

- Google Kubernetes Engine (GKE) 1.31 - 1.33
- Amazon Elastic Kubernetes Service (EKS) 1.31 - 1.34
- Azure Kubernetes Service (AKS) 1.32 - 1.34
- OpenShift 4.16 - 4.20
- Minikube 1.37.0 with Kubernetes v1.34.0

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona certified images

Find Percona's certified Docker images that you can use with the Percona Operator for PostgreSQL in the following table.

Image	Digest

percona/percona-postgresql-operator:2.8.1 (x86_64)	018b0063352fff83d7850d732c80ba6a938c425ac2d9ac7e9a0a270361ff3fc0
percona/percona-postgresql-operator:2.8.1 (ARM64)	ce7e6f612d4cef4ef86f06521549f3e3c4e1fe8ecf794feff6f3205667863792
percona/percona-distribution-postgresql:18.1-1	23522ee9c1abda0b9cbb40c4b414328dafc10596506731954a5754e8b6994e76
percona/percona-distribution-postgresql:17.7-1	c4eec3a4fc8a5d7ba6a631a19f7387f5e34ca9ddcc8ba34bdc6709159be2c3ac
percona/percona-distribution-postgresql:16.11-1	4cd7092284bf323893c75349a5f6c0f4948d8e602fa213210e3efca28cfc2f1d
percona/percona-distribution-postgresql:15.15-1	9ace25f15a319ec741ab32502d4818874a981c38dbb22625e8f2f67bf42bb558
percona/percona-distribution-postgresql:14.20-1	e926d10167ba73da8e2c75218256cd99c68ca9072fd1b9b1ed4b00822a165ab0
percona/percona-distribution-postgresql:13.23-1	03d8d76d844495d07d1eae3fe5767a1c8130fba0a29c6c1353e872601380f9da
percona/percona-postgresql-operator:2.8.1-ppg18.1-postgres-gis3.5.4	706c0aa7c45692d108fbb172cbcd6bf990ee95ff5a77c5e5f79638e45dccd0a9
percona/percona-postgresql-operator:2.8.1-ppg17.7-postgres-gis3.3.8	6ceb2c24a279ddc6914ec762cf96f4b89cbd4869aa8a875c4a55fc82685cb3e7
percona/percona-	dca87ac8ddf79ed600f8b7243d7a351ec058a0a65aedbd360ac77fcb061e441c

postgresql-operator:2.8.1-ppg16.11-postgres-gis3.3.8	
percona/percona-postgresql-operator:2.8.1-ppg15.15-postgres-gis3.3.8	c82dc9203cbe24b5dbf3cc540d5c13484c543be8b225ad9fdec92fc4c8b6f2ff
percona/percona-postgresql-operator:2.8.1-ppg14.20-postgres-gis3.3.8	14ec320d529d7c941b23da58d4d0da6249e6eba3b6d10b5d11b36e4d2aaeb929
percona/percona-postgresql-operator:2.8.1-ppg13.23-postgres-gis3.3.8	9df1dd41a1369d672b6f8a9653dd358f2cf85f363ceff1ca3389641094494b07
percona/percona-pgbouncer:1.25.0-1 (x86_64)	bf2f325cc733b96dc360c2386c8931ed9e3513f55cb425e59033e1e56737134f
percona/percona-pgbouncer:1.25.0-1 (ARM64)	902feac78cf98fbd6a7aece1761371dd1a43faaed88b63be0e0d54dd524b8286
percona/percona-pgbackrest:2.57.0-1 (x86_64)	2bf7265f84210671bc5c0928cc772202c0e6054d426eb6ecf86279d69e831b96
percona/percona-pgbackrest:2.57.0-1 (ARM64)	59245b25fd5d0c1a2540b465e846b69f4c91b6cd183c3bfd96aa856d3e7ffbf3
percona/pmm-client:2.44.1-1	52a8fb5e8f912eef1ff8a117ea323c401e278908ce29928dafc23fac1db4f1e3
percona/pmm-client:3.5.0 (x86_64)	352aee74f25b3c1c4cd9dff1f378a0c3940b315e551d170c09953bf168531e4a
percona/pmm-client:3.5.0 (ARM64)	cbbb074d51d90a5f2d6f1d98a05024f6de2ffdcb5acab632324cea4349a820bd

Percona Operator for PostgreSQL 2.8.0 (2025-11-13)

Get started with the Operator →

Release Highlights

This release provides the following features and improvements:

Custom PostgreSQL user credentials are now fully respected by the Operator

You no longer have to define full login and connection information within a Secret to have the Operator use it. Now you can set only the password. The Operator generates the missing details that it needs automatically using the values from the Custom Resource. Also, if you name your Secret in the format that the Operator expects such as `<clusterName>-pguser-<userName>` — the Operator will automatically detect and use it without needing an explicit reference in the Custom Resource.

However, if you choose a custom name for the Secret, you must still reference it explicitly in the Custom Resource under the `users[].secretName` field. This ensures the Operator can locate and apply it correctly.

Read more about managing user passwords in the documentation.

This enhancement makes the management of user credentials more straightforward.

Ability to use huge pages

PostgreSQL can now use huge pages if they are enabled for your Kubernetes cluster. Instruct the Operator to use huge pages when deploying a PostgreSQL cluster with this configuration:

```
spec:
  instances:
    - name: instance1
      resources:
        limits:
          hugepages-2Mi: 16Mi
          memory: 4Gi
```

This improvement leads to a more efficient memory utilization and improved performance. Learn more about huge pages and their use in the Huge pages chapter.

Expanded S3 compatibility for custom extensions

Some S3-compatible services (like MinIO or Ceph) require path-style access instead of virtual-hosted style. Or they may use self-signed certificates or not support TLS.

To address these issues, you can now fine-tune the Operator with these new options:

- `forcePathStyle` enforces path-style access instead of virtual-hosted style
- `disableSSL` disables SSL verification to allow successful downloads.

```
extensions:
    image: docker.io/perconalab/percona-postgresql-operator:main
    storage:
      .....
      forcePathStyle: false
      disableSSL: false
```

This improvement enables you to use a wider range of S3-compatible storage services with the Operator for storing custom extensions.

Changed Patroni version management

The Operator no longer runs a temporary Pod `cluster_name-patroni-version-check` to identify the Patroni version during cluster initialization.

Instead, it uses the `patronictl` CLI tool to connect to a database Pod and detect the Patroni version. The detected version is recorded in the `pgv2.percona.com/patroni-version` annotation on the cluster resource and is added to the resource status.

The Operator standardizes on Patroni 4 as the only supported version and no longer honors Patroni version overrides via the `pgv2.percona.com/custom-patroni-version` annotation.

However, if your Custom Resource is still at version 2.7.0, the Operator 2.8.0 will continue to run a temporary Pod to check Patroni version and use Patroni 3 if specified via the annotation for backward compatibility. But after you upgrade the Custom Resource to version 2.8.0, the `pgv2.percona.com/custom-patroni-version` annotation is ignored, and Patroni 4 is always used.

This change eliminates ambiguity and ensures your cluster is deployed with a modern high-availability implementation.

Official Docker image for PostgreSQL images

The Operator now uses the official Percona Docker images for Percona Distribution for PostgreSQL, with the image path `percona/percona-distribution-postgresql:<postgresql-version>`.

Because of this transition, the Operator is compatible with and supports only the following specific PostgreSQL versions:

- Percona Distribution for PostgreSQL 17.6
- Percona Distribution for PostgreSQL 16.10
- Percona Distribution for PostgreSQL 15.14
- Percona Distribution for PostgreSQL 14.19
- Percona Distribution for PostgreSQL 13.22

Attempting to use the Operator with other PostgreSQL versions or custom images is not supported.

Changelog

New features

- K8SPG-730 - Added the `status.observedGeneration` field to the Custom Resource Definition to improve observability and ensure the controller successfully reconciled the latest changes to the cluster.
- K8SPG-752 - Allowed setting loadBalancerClass service type and use a custom implementation of a load balancer rather than the cloud provider default one.
- K8SPG-768 Introduced a mechanism to prevent excessive logging caused by continuous pod annotation updates for suggested volume sizing. The Operator now skips updating the Pod annotation with the suggested volume size unless the auto-growable disk feature is explicitly configured. This significantly reduces redundant logs and unnecessary load on both the Kubernetes API and the logging pipeline.
- K8SPG-832 - Users can now specify custom sidecar containers for the `repo-host` Pod, enabling seamless integration with external tools, storage systems, or observability agents. This enhances flexibility in backup workflows without modifying the Operator's core logic.

- K8SPG-833 - Added the ability to define custom environment variables across all components. This enables tighter integration with external systems, secrets, or runtime configurations.

Improvements

- K8SPG-460 - The Operator now correctly enables and used Huge pages functionality if they are enabled on the OS level.
- K8SPG-570 - The Operator now correctly respects custom user passwords defined in secrets when creating new users, and automatically adds any missing credentials.
- K8SPG-611 - The operator now uses official Percona PostgreSQL docker images, which are compatible only with specific latest PostgreSQL versions.
- K8SPG-624, K8SPG-728 - Added the ability to configure the Operator to use path-style access to S3 storage or skip TLS verification to ensure broader compatibility with S3 storage services.
- K8SPG-718 - Improved Patroni observability by sending Patroni metrics to PMM.
- K8SPG-748 - The PerconaPGCluster status now provides more comprehensive details, including persistent volume resizing and pgBackRest backup conditions.
- K8SPG-757: The Percona PostgreSQL Operator now successfully deploys in environments where `readOnlyRootFilesystem` is enforced.
- K8SPG-874- Improved logging to no longer contain backup-related information when backups are disabled.
- K8SPG-882 - The operator no longer deploys a temporary Patroni version check pod, as it now detects the version directly from running database instances.

Fixed bugs

- K8SPG-724 - Fixed the issue with upgrading custom extension versions. The Operator now correctly uninstalls old versions and installs new ones automatically.
- K8SPG-777 - Custom Resource `crVersion` is now automatically assigned if not explicitly defined.
- K8SPG-778 - Backup restores no longer fail due to empty repository name errors during the finalization process.
- K8SPG-781- Error messages for primary pod issues now reveal the specific underlying problem instead of a generic message.
- K8SPG-803 - Outdated backups are now correctly cleaned up, even when pgBackRest debug logging is enabled.

- K8SPG-826 - Fixed the issue with cluster monitoring on OpenShift by using the correct folder for PMM3 .
- K8SPG-835 - Improved affinity behavior for `patroni-version-check` pod
- K8SPG-844 - Fixed the issue with the Operator overriding user configuration with archive commands when the latest restorable time tracking disabled by fully respecting user configuration.
- K8SPG-869 - A backup repository is no longer required when configuring a cluster with disabled backups.
- K8SPG-872 - Updated DNS records used in certificates to no longer include a trailing period to comply with updated validation standards.
- K8SPG-876: Fixed an issue where PostgreSQL clusters remained in an “Initialized” state after restoring a backup from S3 storage.
- K8SPG-879 - Clusters can now be created successfully on Kubernetes version 1.34.
- K8SPG-883: Patroni version information is now displayed in the `status.patroni.version` field instead of `status.patroniVersion`.
- K8SPG-884 - Clusters deployed with PostgreSQL 13 now correctly support the `pg_stat_statements` extension.

Documentation improvements

- Refined the Upgrade guide structure, moving instructions for updating built-in extensions under the Database upgrade section for better clarity.
- Improved documentation for generating custom TLS certificates used by your cluster and added steps how to safely renew or replace your certificate authorities and secrets.
- Enhanced the Adding custom extensions documentation by including a sample configuration for a custom extension, illustrating the overall workflow as a practical reference.
- Improved the Upgrade document with the steps to change collation version is there is a collation mismatch.
- PostGIS image documentation now accurately reflects the available versions.

Deprecation, Change, Rename and Removal

- New repository for `postgresql` image.

Now the Operator uses the official Percona Docker images for PosgreSQL. Pay attention to the new image path when you upgrade the Operator and the database. Check the Percona certified images for exact image names.

- The `patroni.patroniVersion` field in Custom Resource Definition is deprecated and will be removed in future releases. Starting with version 2.8.0, the Operator uses the `patroni.version` field in Custom Resource Definition to populate Patroni version.

```
patroni:
  status:
    systemIdentifier: "7569216022115639385"
  version: 4.0.6
```

Adjust your applications or scripts accordingly to this change if they rely on Patroni version information.

- New fields in the Custom Resource Definition:
- `status.observedGeneration` to track whether the controller has successfully applied the latest changes to the custom resource
- `patroni` subsection contains these fields for Patroni state:
  - `patroni.version`
  - `patroni.systemIdentifier`
  - `patroni.switchover`
  - `patroni.switchoverTimeline`
- `pgBackRest` subsection contains these fields to track the status of backup repository and backup jobs:
  - `pgBackRest.manualBackup`
  - `pgBackRest.repoHost`
  - `pgBackRest.repos`

Supported software

The Operator 2.8.1 is developed, tested and based on:

- PostgreSQL 13.22-1, 14.19-1, 15.14-1, 16.10-1,17.6-1 as the database. Other versions may also work but have not been tested.

- pgBouncer 1.24.1-1 for connection pooling
- Patroni version 4.0.6 for high-availability
- PostGIS version 3.3.8

Supported platforms

Percona Operators are designed for compatibility with all CNCF-certified Kubernetes distributions.

Our release process includes targeted testing and validation on major cloud provider platforms and OpenShift, as detailed below for Operator version 2.8.1:

- Google Kubernetes Engine (GKE) 1.31 - 1.33
- Amazon Elastic Container Service for Kubernetes (EKS) 1.31 - 1.34
- OpenShift 4.16 - 4.20
- Azure Kubernetes Service (AKS) 1.32 - 1.34
- Minikube 1.37.0 with Kubernetes v1.34.0

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Percona certified images

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Image	Digest
percona/percona-postgresql-operator:2.8.0 (x86_64)	e34a185e1b295ff627facd3cfbdfc31f32bab714eac550de5e6da00abd9053e2
percona/percona-postgresql-operator:2.8.0 (ARM64)	18445bd761ac3f77901f0e9eddd79b295d28b779779a29bb2d69eb51c32e3815
percona/percona-distribution-	ce91a339a511d91d9f1946708d7ca326572796b642d2a022a1d52a2adff8a08b

postgresql:17.6-1	
percona/percona-distribution-postgresql:16.10-1	ba1aede456a938f85c9614bb70c50ce264ec68b659917a3a0847112e42bc9259
percona/percona-distribution-postgresql:15.14-1	8280ba2410235e8266761004a2f180fe3999203e69772eb822959cf1849bd967
percona/percona-distribution-postgresql:14.19-1	052e7fd765b790ad2321675e8f2b273fe705512afda5004c4d2a4da78489bfb0
percona/percona-distribution-postgresql:13.22-1	2989dcc4919c8381dc970b2286dadec45c8a53067b48f2bcfff7c7c042b3a654
percona/percona-postgresql-operator:2.8.0-ppg17.6-postgres-gis3.3.8	3322136e6e54214255601586be8f610677fe51a494d3a002cabfacd233258fab
percona/percona-postgresql-operator:2.8.0-ppg16.10-postgres-gis3.3.8	2d5f9ac5a84129e81b9ab8df25abce712223c358847afed3637fb7063a3e4a8f
percona/percona-postgresql-operator:2.8.0-ppg15.14-postgres-gis3.3.8	e7f5fda3cf7d2fab028b3fb70636c9b3b11fe6b89a9f31970d2792bd8f48d8ca
percona/percona-postgresql-operator:2.8.0-ppg14.19-postgres-gis3.3.8	3f69534a0df0b608d68808df04618222e4a20c1d1567462e4482f07b86349806
percona/percona-postgresql-operator:2.8.0-ppg13.22-postgres-gis3.3.8	cd5a2a1057708fac5dda28d0ce47006cdbf865e6ffef1ac2df74065b95258fd3
percona/percona-	39bd093ec83ca4eaeb93b43b286d39daae4cc4b3b32956d627d242d30a5ad6f5

pgbouncer:1.24.1-1 (x86_64)	
percona/percona-pgbouncer:1.24.1-1 (ARM64)	84d34843180d852182790ce6175f1407a0438b3a415a21741212701706808ac0
percona/percona-pgbackrest:2.56.0-1 (x86_64)	387469090be8e009e17cc07903aa28aa1c748ce1cc385bd69e88de3762657877
percona/percona-pgbackrest:2.56.0-1 (ARM64)	29290808bdeb17a49c90f2ce3ccc75f3bfab43e96e160320baf16cb557d165ee
percona/pmm-client:2.44.1-1	52a8fb5e8f912eef1ff8a117ea323c401e278908ce29928dafc23fac1db4f1e3
percona/pmm-client:3.4.1 (x86_64)	1c59d7188f8404e0294f4bfb3d2c3600107f808a023668a170a6b8036c56619b
percona/pmm-client:3.4.1 (ARM64)	2d23ba3e6f0ae88201be15272c5038d7c38f382ad8222cd93f094b5a20b854a5

Percona Operator for PostgreSQL 2.7.0 (2025-07-18)

Get started with the Operator →

Release Highlights

This release provides the following features and improvements:

PMM3 support

The Operator is natively integrated with PMM 3, enabling you to monitor the health and performance of your Percona Distribution for PostgreSQL deployment and at the same time enjoy enhanced performance, new features, and improved security that PMM 3 provides.

Note that the Operator supports both PMM2 and PMM3. The decision on what PMM version is used depends on the authentication method you provide in the Operator configuration: PMM2 uses API keys while PMM3 uses service account token. If the Operator configuration contains both authentication methods with non-empty values, PMM3 takes the priority.

To use PMM, ensure that the PMM client image is compatible with the PMM Server version. Check Percona certified images for the correct client image.

For how to configure monitoring with PMM see the documentation.

Improved monitoring for clusters in multi-region or multi-namespace deployments in PMM

Now you can define a custom name for your clusters deployed in different data centers. This name helps Percona Management and Monitoring (PMM) Server to correctly recognize clusters as connected and monitor them as one deployment. Similarly, PMM Server identifies clusters deployed with the same names in different namespaces as separate ones and correctly displays performance metrics for you on dashboards.

To assign a custom name, define this configuration in the Custom Resource manifest for your cluster:

```
spec:
  pmm:
    customClusterName: postgresql-cluster
```

Added labels to identify the version of the Operator

Custom Resource Definition (CRD) is compatible with the last three Operator versions. To know which Operator version is attached to it, we've added labels to all Custom Resource Definitions. The labels help you identify the current Operator version and decide if you need to update the CRD. To view the labels, run: `kubectl get crd perconapgclusters.pgv2.percona.com --show-labels`.

Grant users access to a public schema

Starting with PostgreSQL 15, a non-database owner cannot access the default `public` schema and cannot create tables in it. We have improved this behavior so that the Operator creates a user and a schema with the name matching the username for all databases listed for this user. This custom schema is set by default enabling you to work in the database right away.

You can explicitly grant access to a `public` schema for a non-superuser setting the `grantPublicSchemaAccess` option to `true`. This grants the user permission to create tables and update in the `public` schema of every database they own. If multiple users are granted access to the `public` schema in the same database, each user can only access the tables they have created themselves. If you want one user to access tables created by another user in the `public` schema, the owner of those tables must connect to PostgreSQL and explicitly grant the necessary privileges to the other user.

Superusers have access to the `public` schema for their databases by default.

Improved troubleshooting with the ability to override Patroni configuration

You can now override Patroni configuration for the whole cluster as well as for an individual Pod. This gives you more control over the database and simplifies troubleshooting.

Also, you can redefine what method the Operator will use when it creates replica instances in your PostgreSQL cluster. For example, to force the Operator to use `pgbasebackup`, edit the `deploy/cr.yaml` manifest:

```
patroni:
  createReplicaMethods:
    - basebackup
    - pgbackrest
```

Note that after you apply this configuration, the Operator updates the Patroni ConfigMap, but it doesn't apply this configuration to Patroni. You must manually reload the Patroni configuration of every database instance for it to come into force.

Read more about these troubleshooting methods in the documentation.

Changelog

New features

- K8SPG-615 - Introduced a custom delay on the entrypoint of the backup pod. The backup process waits the defined time before connecting to the API server
- K8SPG-708, K8SPG-663 - Added the sleep-forever feature to keep a database container running.
- K8SPG-712 - Added the ability to control every parameter supported by Patroni configuration.
- K8SPG-725 - Added the ability to configure resources for the repo-host container
- K8SPG-719 - Added support for PMM v3

Improvements

- K8SPG-571 - Added the ability to access to a public schema for a non-superuser custom user for every database listed for them.
- K8SPG-612 - Updated the `pgBouncer` image to use the official `percona-pgbouncer` Docker image
- K8SPG-613 - Updated the `pgBackRest` image to use the official `percona-pgbackrest` Docker image
- K8SPG-654 - Added the ability to add custom parameters in the Custom Resource and pass them to PMM.
- K8SPG-675 - Added the ability to define resource requests for CPU and memory
- K8SPG-704 - Added the ability to configure `create_replica_methods` for Patroni
- K8SPG-710 - Added the ability to disable backups

- K8SPG-715 - Improved custom-extensions e2e test by adding `pgvector`
- K8SPG-726 - Added ability to define security context for all sidecar containers
- K8SPG-729 - Added Labels for Custom Resource Definitions (CRD) to identify the Operator version attached to them
- K8SPG-732 - Enhanced readability of `pgbackrest debug logs` by printing log messages on separate lines
- K8SPG-738 - Added startup log to the Operator Pod to print commit hash, branch and build time
- K8SPG-743 - Disabled client-side rate limiting in the Kubernetes Go client to avoid throttling errors when managing multiple clusters with a single operator. This change leverages Kubernetes' server-side Priority and Fairness mechanisms introduced in v1.20 and later. (Thank you Joshua Sierles for contributing to this issue)
- K8SPG-744 - Improved Contributing guide with the steps how to build the Operator for development purposes
- K8SPG-717, K8SPG-750 - Added the ability to define a custom cluster name for PMM for filtering
- K8SPG-753 - Added the ability to enable `pg_stat_statements` instead of `pg_stat_monitor`
- K8SPG-761 - Added the ability to add concurrent reconciliation workers
- K8SPG-828 - Added registry name to images due to Openshift 4.19 changes

Bugs Fixed

- K8SPG-532 - Improved log visibility to include logs about missing data source to INFO logs
- K8SPG-574 - Added `pg_repack` to the list of built-in extensions in the Custom Resource
- K8SPG-661 - Added documentation about replica reinitialization in the Operator
- K8SPG-677 - Made the `imagePullPolicy` in `pg-db` Helm chart configurable
- K8SPG-680 - Prevent scheduled backups to start until the volume expansion is completed with success.
- K8SPG-698 - Fixed the issue with `pgbackrest` service account not being created and reconciliation failing by creating the StatefulSet for this service account first
- K8SPG-703 - Fixed the issue with the backup Pod being stuck in a running state due to running jobs being deleted because of the TTL expiration by adding an internal finalizer to keep the job running until it finishes
- K8SPG-722 - Documented the replica reinitialization behavior.

- K8SPG-772 - Fixed the issue with WAL watcher panicking if some backups have no `CompletedAt` status field by using `CreationTimestamp` as fallback.
- K8SPG-782 - Fixed the issue with crashing WALWatcher by assigning Patroni version to status when Patroni label is configured through the Custom resource option
- K8SPG-785 - Fixed PMM template in Helm chart (Thank you user Nik for reporting this issue)
- K8SPG-792 - Add the ability to configure and use images defined in environment variables when starting a cluster (Thank you Jakub Jaruszewski for reporting this issue)
- K8SPG-799 - Fixed the issue with the cluster being blocked due to inability to pull the image fot the Patroni Version Detector Pod if imagePullSecrets in configured. The issue is fixed by respecting the configuration for the patroni version check pod. (Thank you Baptiste Balmon for reporting this issue)
- K8SPG-804 - Fixed an issue where outdated cluster state could cause a duplicate backup job to be created, blocking new backups. The issue was fixed by ensuring `reconcileManualBackup` fetches the latest postgrescluster state.
- K8SPG-812 - Fixed image in PerconaPGUpgrade example

Deprecation, Change, Rename and Removal

- New repositories for `pgBouncer` and `pgBackRest`

  Now the Operator uses the official Percona Docker images for `pgBouncer` and `pgBackRest` components. Pay attention to the new image repositories when you upgrade the Operator and the database. Check the Percona certified images for exact image names.

- Changes in image pulling on OpenShift

  Starting with OpenShift version 4.19, the way Operator images are pulled has changed. Now the registry name must be specified for image paths to ensure the images are pulled successfully from DockerHub.

  All Custom Resource manifests now include the registry name in image paths. This enables you to successfully install the Operator using the default manifests from Git repositories. If you upgrade the Operator and the database cluster via the command line interface, add the `docker.io` registry name to image paths for all components in the format:

  ```
  "docker.io/percona/percona-postgresql-operator:2.8.1-ppg17.7-1-postgres"
  ```

  Follow our upgrade documentation for update guidelines.

Supported software

The Operator 2.8.1 is developed, tested and based on:

- PostgreSQL 13.21, 14.18, 15.13, 16.9, 17.5.2 as the database. Other versions may also work but have not been tested.
- pgBouncer 1.24.1 for connection pooling
- Patroni version 4.0.5 for high-availability
- PostGIS version 3.3.8

Supported platforms

Percona Operators are designed for compatibility with all CNCF-certified Kubernetes distributions.

Our release process includes targeted testing and validation on major cloud provider platforms and OpenShift, as detailed below for Operator version 2.8.1:

- Google Kubernetes Engine (GKE) 1.30 - 1.32
- Amazon Elastic Container Service for Kubernetes (EKS) 1.30 - 1.33
- OpenShift 4.15 - 4.19
- Azure Kubernetes Service (AKS) 1.30 - 1.33
- Minikube 1.36.0 with Kubernetes v1.33.1

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona certified images

Find Percona's certified Docker images that you can use with the Percona Operator for PostgreSQL in the following table.

Image	Digest
percona/percona-postgresql-operator:2.7.0 (x86_64)	96e4e3d7e4bcbd4880adebc5ccb958c0f4385298f0becdef2eb14b81fab407e5

percona/percona-postgresql-operator:2.7.0 (ARM64)	055da3233a7765f22b318c97223909c20ecbbc9f34c6a8f7845d04ade51364ca
percona/percona-postgresql-operator:2.7.0-ppg17.5.2-postgres	cfb99ebeec00ab6efb4fca4a8da2b8c3b489dd792bd2f907848197ba09bc9553
percona/percona-postgresql-operator:2.7.0-ppg16.9-postgres	0787088575b4e4fec368acbcf4dd7aea49620ec4524451e3b44ed424fb0eeebb
percona/percona-postgresql-operator:2.7.0-ppg15.13-postgres	c93f52ea1d6ec955a368c4539b843a9c57ee4a5acc907f0dfb59ae3018560d1b
percona/percona-postgresql-operator:2.7.0-ppg14.18-postgres	a24059edd9864f7dc9607c3e2964844f417718a5b9f471ceb98c0a0d774a4bca
percona/percona-postgresql-operator:2.7.0-ppg13.21-postgres	2c9a05399b34cfe79698bdaab66db8fdaece0db7b1fa34441124cccdbe375255
percona/percona-postgresql-operator:2.7.0-ppg17.5.2-postgres-gis3.3.8	860ccc180c1ac6be3c34c354d6ba9148b00330e183ba5913954e34d49c95d22f
percona/percona-postgresql-operator:2.7.0-ppg16.9-postgres-gis3.3.8	ca50f560bc7b3e18ec3360dc1a6b8c860e0346472af051cb0d2aec2a7a45d8b3
percona/percona-postgresql-operator:2.7.0-ppg15.13-postgres-gis3.3.8	bb6707fd12ea430708e2eb22f6c7dadf3ab4258fcfd31e86f1f78c66ba211742
percona/percona-postgresql-operator:2.7.0-ppg14.18-postgres-gis3.3.8	c3b55d1394d8f0a476cea29340442313c9c08dcd8c83f31ccfc66afdbde42488

percona/percona-postgresql-operator:2.7.0-ppg13.21-postgres-gis3.3.8	3df44c1089563b42198ef929e27b9797ef2b04d92736293952163fa7541c0068
percona/percona-pgbouncer:1.24.1	451431afa3cd288ecda92b6446bec8833fbf376fbd1b7c7e314fc42f3355255f
percona/percona-pgbouncer:1.24.1 (ARM64)	479aa893e55c5afe8b97852c90d7551dc55d3fc526773a5a7d992876bbf54cb0
percona/percona-pgbackrest:2.55.0	b0d2defbc7a07cf395b1fa6c6e13d9d3267c3a2d3c52362ac440db26ea4a4bad
percona/percona-pgbackrest:2.55.0 (ARM64)	bc15d058e7820499bf67ccec2fe51c583fe67a6e3ed55ec28adf3e252828924a
percona/pmm-client:2.44.1	8b2eaddffd626f02a2d5318ffebc0c277fe8457da6083b8cfcada9b6e6168616
percona/pmm-client:2.44.1 (ARM64)	337fecd4afdb3f6daf2caa2b341b9fe41d0418a0e4ec76980c7f29be9d08b5ea
percona/pmm-client:3.3.0	0f4ef6a814946f83ef1ed26cf3526ff606fc7815007f84995492d3e4eaa15a0e
percona/pmm-client:3.3.0 (ARM64)	c03aa678d26faf783c3598b3a139a8f3154e5bf1bc9f5a3c9abf0533922f79d6

Percona Operator for PostgreSQL 2.6.0 (2025-03-17)

Installation

Release Highlights

This release provides the following features and improvements:

Backup improvements

This release implemented several improvements to the backup/restore process:

- A new delete-backups finalizer was implemented to automatically remove all backups when deleting the cluster. This finalizer is off by default. It's experimental and, therefore, is not recommended for production environments.
- Backup logic was improved and now allows retrying a failed backup in the same backup Pod for a specified number of times before deleting this Pod and creating a new one. This should be beneficial in case of short connectivity issues or timeouts. This behavior is controlled by the new backups.pgbackrest.jobs.backoffLimit and backups.pgbackrest.jobs.restartPolicy Custom Resource options.
- You can now overwrite the default restore command for `pgBackRest` via the patroni.dynamicConfiguration Custom Resource option. Particularly, this allows to control and filter files restored to `pg_wal` directory without editing these files in the backup repository storage.

PostgreSQL 17 support

PostgreSQL 17 is now supported by the Operator in addition to versions 13 - 16. The appropriate images are now included in the list of Percona-certified images. See these blogposts for details about the latest PostgreSQL 17 features with the added security and functionality improvements:

- Encrypt PostgreSQL Data at Rest on Kubernetes by Ege Gunes
- The Powerful Features Released in PostgreSQL 17 Beta 2 by Shivam Dhapatkar
- PostgreSQL 17: Two Small Improvements That Will Have a Major Impact by David Stokes.

PostgreSQL 17 is currently not recommended for production environments due to the known limitation.

Update from April 1, 2025: We have added PostgreSQL 17.4 image and database cluster components based on this image. It is now production ready and we recommend updating the database cluster from PostgreSQL 17.2 to 17.4. Check the upgrade instructions for steps

`pgvector` is added to the PostgreSQL image

To support you with your AI journey, we've added the `pgvector` extension to the PostgreSQL images shipped with our Operator. Now, you can easily use Percona Distribution for PostgreSQL as a vector database by simply enabling it in your Custom Resource options. No more custom extension installations needed.

New features

- K8SPG-628: The custom `restore_command` can be now passed to pgBackRest via the patroni.dynamicConfiguration Custom Resource option
- K8SPG-619: New `backups.pgbackrest.jobs.backoffLimit` and `backups.pgbackrest.jobs.restartPolicy` Custom Resource options allow to retry backup in the backup Pod for a specified number of times before abandoning the Pod and creating the new one
- K8SPG-648: PostgreSQL 17 is now supported by the Operator

Improvements

- K8SPG-487: New `spec.metadata.labels` and `spec.metadata.annotations` Custom Resource options allow setting labels and annotation globally for all Kubernetes objects created by the Operator
- K8SPG-554: New `tlsOnly` Custom Resource option allows the user to enforce TLS connections for the database cluster
- K8SPG-586: The new experimental `finalizers.delete-backups` finalizer (off by default) removes all backups of the cluster at cluster deletion event
- K8SPG-634: The new `autoCreateUserSchema` Custom Resource option enhances the declarative user management by automatically creating per-user schemas
- K8SPG-652: Improve security and meet compliance requirements by using PostgreSQL images

built based on Red Hat Universal Base Image (UBI) 9 instead of UBI 8

- K8SPG-692: Patroni versions 4.x are now supported by the Operator in addition to versions 3.x
- K8SPG-699: The `pgvector` extension is now included within the PostgreSQL image used by the Operator
- K8SPG-701: The `extensions.image` Custom Resource option is now optional, and can be omitted for builtin PostgreSQL extensions
- K8SPG-702: A retry logic was implemented to fix intermittent Pod exec failures caused by timeouts (Thanks to dcaputo-harmoni for contribution)
- K8SPG-711: The new README.md explains how to build your own images for the PostgreSQL cluster components used by the Operator

Bugs Fixed

- K8SPG-594: Fix a bug where extension was still appearing in pg_extension table after being removed from Custom Resource and physically deleted by the Operator
- K8SPG-637: Fix a bug where restore was failing with “waiting for another restore to finish” if the pg-restore object of a previous unfinished restore was manually deleted
- K8SPG-638: Fix a bug that caused flooding the logs with no completed backups found error at cluster initialization.
- K8SPG-645: Fix a bug where creating sidecar containers for pgBouncer did not work
- K8SPG-681: Fixed a bug where the “Last Recoverable Time” information field was missing from the output of the `kubectl get pg-backup` command due to misdetection cases
- K8SPG-713: Fix a bug where The cluster not found errors were appearing in the Operator logs on cluster deletion

Deprecation, Change, Rename and Removal

- The new versions of Percona distribution for PostgreSQL used by the Operator come with Patroni 4.x, which introduces breaking changes compared to previously used 3.x versions.

  To maintain backward compatibility, the Operator detects the Patroni version used in the image. It is also possible to disable this auto-detection feature by manually setting the Patroni version via the [following annotation set in the metadata part](../annotations.md#customizing-patroni-version-for-the-operator-version-260—270 of the Custom Resource:

```
pgv2.percona.com/custom-patroni-version: "4"
```

- PostgreSQL 12 is no longer supported by the Operator 2.6.0 and newer versions.

Known limitations

- PostgreSQL 17.2 image and images for other database cluster components based on PostgreSQL 17 contain the known CVE-2025-1094 - a vulnerability in the libpq PostgreSQL client library, which makes images used by the Operator vulnerable to SQL injection within the PostgreSQL interactive terminal due to the lack of neutralizing quoting. Images for PostgreSQL 17 will be available soon, while images for other PosgreSQL versions have already been fixed.
- PostgreSQL 17.4 image includes the fix for CVE-2025-1094, which closed a vulnerability in the `libpq` PostgreSQL client library but introduced a regression related to string handling for non-null terminated strings. The error would be visible based on how a PostgreSQL client implemented this behavior.

Supported platforms

The Operator 2.8.1 is developed, tested and based on:

- PostgreSQL 13.20, 14.17, 15.12, 16.8, 17.2 and 17.4 as the database. Other versions may also work but have not been tested.
- pgBouncer for connection pooling:
  - version 1.23.1 - for PostgreSQL 17.2
  - version 1.24.0 - for PostgreSQL 13.20, 14.17, 15.12, 16.8, 17.4
- Patroni for high-availability:
  - version 4.0.5 - for PostgreSQL 17.4
  - version 4.0.3 - for PostgreSQL 17.2
  - version 4.0.4 - for PostgreSQL 13.20, 14.17, 15.12, 16.8

Percona Operators are designed for compatibility with all CNCF-certified Kubernetes distributions.

Our release process includes targeted testing and validation on major cloud provider platforms and OpenShift, as detailed below for Operator version 2.8.1:

- Google Kubernetes Engine (GKE) 1.29 - 1.31
- Amazon Elastic Container Service for Kubernetes (EKS) 1.29 - 1.32
- OpenShift 4.14 - 4.18
- Azure Kubernetes Service (AKS) 1.29 - 1.31
- Minikube 1.35.0 with Kubernetes 1.32.0

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.5.1

- **Date**

  March 03, 2025

- **Installation**

  Installing Percona Operator for PostgreSQL

Release highlights

This release fixes the CVE-2025-1094, vulnerability in the libpq PostgreSQL client library, which made images used by the Operator vulnerable to SQL injection within the PostgreSQL interactive terminal due to the lack of neutralizing quoting. For now, the fix includes the image of PostgreSQL 16.8 and other database cluster images based on PostgreSQL 16.8. Fixed images for other PostgreSQL versions are to follow in the upcoming days.

Update from March 04, 2025: images of PostgreSQL 15.12 and other database cluster components based on PostgreSQL 15.12 were added.

Update from March 06, 2025: images of PostgreSQL 14.17 and other database cluster components based on PostgreSQL 14.17 were added.

Update from March 07, 2025: images of PostgreSQL 13.20 and other database cluster components based on PostgreSQL 13.20 were added.

Supported platforms

The Operator was developed and tested with PostgreSQL versions 12.20, 13.20, 14.17, 15.12, and 16.8. Other options may also work but have not been tested. The Operator 2.5.1 provides connection pooling based on pgBouncer 1.24.0 and high-availability implementation based on Patroni 3.3.2.

The following platforms were tested and are officially supported by the Operator 2.5.1:

- Google Kubernetes Engine (GKE) 1.28 - 1.30
- Amazon Elastic Container Service for Kubernetes (EKS) 1.28 - 1.30
- OpenShift 4.13.46 - 4.16.7
- Azure Kubernetes Service (AKS) 1.28 - 1.30

- Minikube 1.34.0 with Kubernetes 1.31.0

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.5.0

- **Date**

  October 08, 2024

- **Installation**

  Installing Percona Operator for PostgreSQL

Release Highlights

Automated storage scaling

Starting from this release, the Operator is able to detect if the storage usage on the PVC reaches a certain threshold, and trigger the PVC resize. Such autoscaling needs the upstream auto-growable disk feature turned on when deploying the Operator. This is done via the `PGO_FEATURE_GATES` environment variable set in the `deploy/operator.yaml` manifest (or in the appropriate part of `deploy/bundle.yaml`):

```
- name: PGO_FEATURE_GATES
  value: "AutoGrowVolumes=true"
```

When the support for auto-growable disks is turned on, the `spec.instances[].dataVolumeClaimSpec.resources.limits.storage` Custom Resource option sets the maximum value available for the Operator to scale up.

See official documentation for more details and limitations of the feature.

Major versions upgrade improvements

Major version upgrade, introduced in the Operator version 2.4.0 as a tech preview, had undergone some improvements. Now it is possible to upgrade from one PostgreSQL major version to another with custom images for the database cluster components (PostgreSQL, pgBouncer, and pgBackRest). The upgrade is still triggered by applying the YAML manifest with the information about the existing and desired major versions, which now includes image names. The resulting manifest may look as follows:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGUpgrade
metadata:
  name: cluster1-15-to-16
spec:
  postgresClusterName: cluster1
  image: percona/percona-postgresql-operator:2.4.1-upgrade
  fromPostgresVersion: 15
  toPostgresVersion: 16
  toPostgresImage: percona/percona-postgresql-operator:2.5.0-ppg16.4-postgres
  toPgBouncerImage: percona/percona-postgresql-operator:2.5.0-ppg16.4-
pgbouncer1.23.1
  toPgBackRestImage: percona/percona-postgresql-operator:2.5.0-ppg16.4-
pgbackrest2.53-1
```

Azure Kubernetes Service and Azure Blob Storage support

Azure Kubernetes Service (AKS) is now officially supported platform, so developers and vendors of the solutions based on the Azure platform can take advantage of the official support from Percona or just use officially certified Percona Operator for PostgreSQL images; also, Azure Blob Storage can now be used for backups.

New features

- K8SPG-227 and K8SPG-157: Add support for the Azure Kubernetes Service (AKS) platform and allow using Azure Blob Storage for backups
- K8SPG-244: Automated storage scaling is now supported

Improvements

- K8SPG-630: A new `backups.trackLatestRestorableTime` Custom Resource option allows to disable latest restorable time tracking for users who need reducing S3 API calls usage
- K8SPG-605 and K8SPG-593: Documentation now includes information about upgrading the Operator via Helm and using databaseInitSQL commands
- K8SPG-598: Database major version upgrade now supports custom images
- K8SPG-560: A `pg-restore` Custom Resource is now automatically created at bootstrapping a new cluster from an existing backup
- K8SPG-555: The Operator now creates separate Secret with CA certificate for each cluster

- K8SPG-553: Users can provide the Operator with their own root CA certificate
- K8SPG-454: Cluster status obtained with `kubectl get pg` command is now “ready” not only when all Pods are ready, but also takes into account if all StatefulSets are up to date
- K8SPG-577: A new `pmm.querySource` Custom Resource option allows to set PMM query source

Bugs Fixed

- K8SPG-629: Fix a bug where the Operator was not deleting backup Pods when cleaning outdated backups according to the retention policy
- K8SPG-499: Fix a bug where cluster was getting stuck in the init state if pgBackRest secret didn’t exist
- K8SPG-588: Fix a bug where the Operator didn’t stop WAL watcher if the namespace and/or cluster were deleted
- K8SPG-644: Fix a bug in the `pg-db` Helm chart which prevented from setting more than one Toleration

Deprecation, Change, Rename and Removal

With the Operator versions prior to 2.5.0, autogenerated TLS certificates for all database clusters were based on the same generated root CA. Starting from 2.5.0, the Operator creates root CA on a per-cluster basis.

Supported platforms

The Operator was developed and tested with PostgreSQL versions 12.20, 13.16, 14.13, 15.8, and 16.4. Other options may also work but have not been tested. The Operator 2.5.0 provides connection pooling based on pgBouncer 1.23.1 and high-availability implementation based on Patroni 3.3.2.

The following platforms were tested and are officially supported by the Operator 2.5.0:

- Google Kubernetes Engine (GKE) 1.28 - 1.30
- Amazon Elastic Container Service for Kubernetes (EKS) 1.28 - 1.30
- OpenShift 4.13.46 - 4.16.7
- Azure Kubernetes Service (AKS) 1.28 - 1.30
- Minikube 1.34.0 with Kubernetes 1.31.0

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.4.1

- **Date**

  August 6, 2024

- **Installation**

  Installing Percona Operator for PostgreSQL

Bugs Fixed

- K8SPG-616: Fix a bug where it was not possible to create a new cluster after deleting the previous one with the `kubectl delete pg` command

Supported platforms

The Operator was developed and tested with PostgreSQL versions 12.19, 13.15, 14.12, 15.7, and 16.3. Other options may also work but have not been tested. The Operator 2.4.1 provides connection pooling based on pgBouncer 1.22.1 and high-availability implementation based on Patroni 3.3.0.

The following platforms were tested and are officially supported by the Operator 2.4.1:

- Google Kubernetes Engine (GKE) 1.27 - 1.29
- Amazon Elastic Container Service for Kubernetes (EKS) 1.27 - 1.30
- OpenShift 4.12.59 - 4.15.18
- Minikube 1.33.1

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.4.0

- **Date**

  June 26, 2024

- **Installation**

  Installing Percona Operator for PostgreSQL

Release Highlights

Major versions upgrade (tech preview)

Starting from this release Operator users can automatically upgrade from one PostgreSQL major version to another. Upgrade is triggered by applying the yaml file with the information about the existing and desired major versions, with an example present in `deploy/upgrade.yaml`:

```
apiVersion: pgv2.percona.com/v2
kind: PerconaPGUpgrade
metadata:
  name: cluster1-15-to-16
spec:
  postgresClusterName: cluster1
  image: perconalab/percona-postgresql-operator:main-upgrade
  fromPostgresVersion: 15
  toPostgresVersion: 16
```

After applying it as usual, by running `kubectl apply -f deploy/upgrade.yaml` command, the actual upgrade takes place as follows:

1. The cluster is paused for a while,
2. The cluster is specially annotated with `pgv2.percona.com/allow-upgrade`: `<PerconaPGUpgrade.Name>` annotation,
3. Jobs are created to migrate the data,
4. The cluster starts up after the upgrade finishes.

Check official documentation for more details, including ones about tracking the upgrade process and side effects for users with custom extensions.

Supporting PostgreSQL tablespaces

Tablespaces allow DBAs to store a database on multiple file systems within the same server and to control where (on which file systems) specific parts of the database are stored. You can think about it as if you were giving names to your disk mounts and then using those names as additional parameters when creating database objects.

PostgreSQL supports this feature, allowing you to store data outside of the primary data directory. Tablespaces support was present in Percona Operator for PostgreSQL 1.x, and starting from this version, Percona Operator for PostgreSQL 2.x can also bring this feature to your Kubernetes environment, when needed.

Using cloud roles to authenticate on the object storage for backups

Percona Operator for PostgreSQL has introduced a new feature that allows users to authenticate to AWS S3 buckets via IAM roles. Now Operator This enhancement significantly improves security by eliminating the need to manage S3 access keys directly, while also streamlining the configuration process for easier backup and restore operations.

To use this feature, add annotation to the `spec` part of the Custom Resource and also add pgBackRest custom configuration option to the `backups` subsection:

```
spec:
  crVersion: 2.4.0
  metadata:
    annotations:
      eks.amazonaws.com/role-arn: arn:aws:iam::1191:role/role-pgbackrest-
access-s3-bucket
  ...
  backups:
    pgbackrest:
      image: percona/percona-postgresql-operator:2.4.0-ppg16-pgbackrest
      global:
        repo1-s3-key-type: web-id
        ...
```

New features

- K8SPG-138: Users are now able to use AWS IAM role to provide access to the S3 bucket used

for backups

- K8SPG-254: Now the Operator automates upgrading PostgreSQL major versions
- K8SPG-459: PostgreSQL tablespaces are now supported by the Operator
- K8SPG-479 and K8SPG-492: It is now possible to specify tolerations for the backup restore jobs as well as for the data move jobs created when the Operator 1.x is upgraded to 2.x; this is useful in environments with dedicated Kubernetes worker nodes protected by taints
- K8SPG-503 and K8SPG-513: It is now possible to specify resources for the sidecar containers of database instance Pods

Improvements

- K8SPG-259: Users can now change the default level for log messages for pgBackRest to simplify fixing backup and restore issues
- K8SPG-542: Documentation now includes HowTo on creating a disaster recovery cluster using streaming replication
- K8SPG-506: The `pg-backup` objects now have a new `backupName` status field, which allows users to obtain the backup name for restore simpler
- K8SPG-514: The new `securityContext` Custom Resource subsections allow to configure securityContext for PostgreSQL instances, pgBouncer, and pgBackRest Pods
- K8SPG-518: The `kubectl get pg-backup` command now shows the latest restorable time to make it easier to pick a point-in-time recovery target
- K8SPG-519: The new `extensions.storage.endpoint` Custom Resource option allows specifying a custom S3 object storage endpoint for installing custom extensions
- K8SPG-549: It is now possible to expose replica nodes through a separate Service, useful if you want to balance the load and separate reads and writes traffic
- K8SPG-550: The default size for `/tmp` mount point in PMM container was increased from 1.5G to 2G
- K8SPG-585: The namespace field was added to the Operator and database Helm chart templates

Bugs Fixed

- K8SPG-462: Fixed a bug where backups could not start if a previous backup had the same name
- K8SPG-470: Liveness and Readiness probes timeouts are now configurable through Custom

Resource

- K8SPG-559: Fix a bug where the first full backup was incorrectly marked as incremental in the status field
- K8SPG-490: Fixed broken replication that occurred after the network loss of the primary Pod with PostgreSQL 14 and older versions
- K8SPG-502: Fix a bug where backup jobs were not cleaned up after completion
- K8SPG-510: Fix a bug where pausing the cluster immediately set its state to “paused” instead of “stopping” while Pods were still running
- K8SPG-531: Fix a bug where scheduled backups did not work for a second database with the same name in cluster-wide mode
- K8SPG-535: Fix a bug where the Operator crashed when attempting to run a backup with a non-existent repository
- K8SPG-540: Fix a bug in the pg-db Helm chart readme where the key to set the backup secret was incorrectly specified (Thanks to Abhay Tiwari for contribution)
- K8SPG-543: Fix a bug where applying a cr.yaml file with an empty `spec.proxy` field caused the Operator to crash
- K8SPG-547: Fix dependency issue that made pgbackrest-repo container incompatible with pgBackRest 2.50, resulting in the older 2.48 version being used instead

Deprecation and removal

- The `plpythonu` extension was removed from the list of built-in PostgreSQL extensions; users who still need it can enable it for their databases via custom extensions functionality

Supported platforms

The Operator was developed and tested with PostgreSQL versions 12.19, 13.15, 14.12, 15.7, and 16.3. Other options may also work but have not been tested. The Operator 2.4.0 provides connection pooling based on pgBouncer 1.22.1 and high-availability implementation based on Patroni 3.3.0.

The following platforms were tested and are officially supported by the Operator 2.4.0:

- Google Kubernetes Engine (GKE) 1.27 - 1.29
- Amazon Elastic Container Service for Kubernetes (EKS) 1.27 - 1.30
- OpenShift 4.12.59 - 4.15.18

- Minikube 1.33.1

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.3.1

- **Date**

  January 23, 2024

- **Installation**

  Installing Percona Operator for PostgreSQL

Release Highlights

This release provides a number of bug fixes, including fixes for the following vulnerabilities in PostgreSQL, pgBackRest, and pgBouncer images used by the Operator:

- OpenSSH could cause remote code execution by ssh-agent if a user establishes an SSH connection to a compromised or malicious SSH server and has agent forwarding enabled (CVE-2023-38408). This vulnerability affects pgBackRest and PostgreSQL images.
- The c-ares library could cause a Denial of Service with 0-byte UDP payload (CVE-2023-32067). This vulnerability affects pgBouncer image.

Both Operator 1.x (including version 1.5.0) and Operator 2.x (including version 2.3.0) are affected. The 2.x versions upgrade to 2.3.1 is recommended to resolve these issues.

Bugs Fixed

- K8SPG-493: Fix a regression due to which the Operator could run scheduled backup only one time
- K8SPG-494: Fix vulnerabilities in PostgreSQL, pgBackRest, and pgBouncer images
- K8SPG-496: Fix the bug where setting the `pause` Custom Resource option to `true` for the cluster with a backup running would not take effect even after the backup completed

Supported platforms

The Operator was developed and tested with PostgreSQL versions 12.17, 13.13, 14.10, 15.5, and 16.1. Other options may also work but have not been tested. The Operator 2.3.1 provides connection pooling based on pgBouncer 1.21.0 and high-availability implementation based on Patroni 3.1.0.

The following platforms were tested and are officially supported by the Operator 2.3.1:

- Google Kubernetes Engine (GKE) 1.24 - 1.28
- Amazon Elastic Container Service for Kubernetes (EKS) 1.24 - 1.28
- OpenShift 4.11.55 - 4.14.6
- Minikube 1.32

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.3.0

- **Date**

  December 21, 2023

- **Installation**

  Installing Percona Operator for PostgreSQL

Release Highlights

PostGIS support

Modern businesses heavily rely on location-based data to gain valuable insights and make data-driven decisions. However, integrating geospatial functionality into the existing database systems has often posed a challenge for enterprises. PostGIS, an open-source software extension for PostgreSQL, addresses this difficulty by equipping users with extensive geospatial operations for handling geographic data efficiently. Percona Operator now supports PostGIS, available through a separate container image. You can read more about PostGIS and how to use it with the Operator in our documentation.

OpenShift and PostgreSQL 16 support

The Operator is now compatible with the OpenShift platform empowering enterprise customers with seamless on-premise or cloud deployments on the platform of their choice. Also, PostgreSQL 16 was added to the range of supported database versions and is used by default starting with this release.

Experimental support for custom PostgreSQL extensions

One of great features of PostgreSQL is support for Extensions, which allow adding new functionality to the database on a plugin basis. Starting from this release, users can add custom PostgreSQL extensions dynamically, without the need to rebuild the container image (see this HowTo on how to create and connect yours).

New features

- K8SPG-311 and K8SPG-389: A new `loadBalancerSourceRanges` Custom Resource option allows to customize the range of IP addresses from which the load balancer should be reachable
- K8SPG-375: Experimental support for custom PostgreSQL extensions was added to the Operator
- K8SPG-391: The Operator is now compatible with the OpenShift platform
- K8SPG-434: The Operator now supports Percona Distribution for PostgreSQL version 16 and uses it as default database version

Improvements

- K8SPG-413: The Operator documentation now includes a comptibility matrix for each Operator version, specifying exact versions of all core components as well as supported versions of the database and platforms
- K8SPG-332: Creating backups and pausing the cluster do not interfere with each other: the Operator either postpones the pausing until the active backup ends, or postpones the scheduled backup on the paused cluster
- K8SPG-370: Logging management is now aligned with other Percona Operators, allowing to use structured logging and to control log level
- K8SPG-372: The multi-namespace (cluster-wide) mode of the Operator was improved, making it possible to customize the list of Kubernetes namespaces under the Operator's control
- K8SPG-400: The documentation now explains how to allow application users to connect to a database cluster without TLS (for example, for testing or demonstration purposes)
- K8SPG-410: Scheduled backups now create `pg-backup` object to simplify backup management and tracking
- K8SPG-416: PostgreSQL custom configuration is now supported in the Helm chart
- K8SPG-422 and K8SPG-447: The user can now see backup type and status in the output of `kubectl get pg-backup` and `kubectl get pg-restore` commands
- K8SPG-458: Affinity configuration examples were added to the `default/cr.yaml` configuration file

Bugs Fixed

- K8SPG-435: Fix a bug with insufficient size of /tmp filesystem which caused PostgreSQL Pods to be recreated every few days due to running out of free space on it
- K8SPG-453: Bug in `pg_stat_monitor` PostgreSQL extensions could hang PostgreSQL

- K8SPG-279: Fix regression which made the Operator to crash after creating a backup if there was no backups.pgbackrest.manual section in the Custom Resource
- K8SPG-310: Documentation didn't explain how to apply pgBackRest `verifyTLS` option which can be used to explicitly enable or disable TLS verification for it
- K8SPG-432: Fix a bug due to which backup jobs and Pods were not deleted on deleting the backup object
- K8SPG-442: The Operator didn't allow to append custom items to the PostgreSQL `shared_preload_libraries` option
- K8SPG-443: Fix a bug due to which only English locale was installed in the PostgreSQL image, missing other languages support
- K8SPG-450: Fix a bug which prevented PostgreSQL to initialize the database on Kubernetes working nodes with enabled huge memory pages if Pod resource limits didn't allow using them
- K8SPG-401: Fix a bug which caused Operator crash if deployed with no `pmm` section in the `deploy/cr.yaml` configuration file

Supported platforms

The Operator was developed and tested with PostgreSQL versions 12.17, 13.13, 14.10, 15.5, and 16.1. Other options may also work but have not been tested. The Operator 2.3.0 provides connection pooling based on pgBouncer 1.21.0 and high-availability implementation based on Patroni 3.1.0.

The following platforms were tested and are officially supported by the Operator 2.3.0:

- Google Kubernetes Engine (GKE) 1.24 - 1.28
- Amazon Elastic Container Service for Kubernetes (EKS) 1.24 - 1.28
- OpenShift 4.11.55 - 4.14.6
- Minikube 1.32

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.2.0

- **Date**

  June 30, 2023

- **Installation**

  Installing Percona Operator for PostgreSQL

Percona announces the general availability of Percona Operator for PostgreSQL 2.2.0.

Starting with this release, Percona Operator for PostgreSQL version 2 is out of technical preview and can be used in production with all the improvements it brings over the version 1 in terms of architecture, backup and recovery features, and overall flexibility.

We prepared a detailed migration guide which allows existing Operator 1.x users to move their PostgreSQL clusters to the Operator 2.x. Also, see this blog post to find out more about the Operator 2.x features and benefits.

Improvements

- K8SPG-378: A new `crVersion` Custom Resource option was added to indicate the API version this Custom Resource corresponds to
- K8SPG-359: The new `users.secretName` option allows to define a custom Secret name for the users defined in the Custom Resource (thanks to Vishal Anarase for contributing)
- K8SPG-301: Amazon Elastic Container Service for Kubernetes (EKS) was added to the list of officially supported platforms
- K8SPG-302: Minikube is now officially supported by the Operator to enable ease of testing and developing
- K8SPG-326: Both the Operator and database can be now installed with the Helm package manager
- K8SPG-342: There is now no need in manual restart of PostgreSQL Pods after the monitor user password changed in Secrets
- K8SPG-345: The new `proxy.pgBouncer.exposeSuperusers` Custom Resource option makes it possible for administrative users to connect to PostgreSQL through PgBouncer

- K8SPG-355: The Operator can now be deployed in multi-namespace (“cluster-wide”) mode to track Custom Resources and manage database clusters in several namespaces

Bugs Fixed

- K8SPG-373: Fix the bug due to which the Operator did not not create Secrets for the `pguser` user if PMM was enabled in the Custom Resource
- K8SPG-362: It was impossible to install Custom Resource Definitions for both 1.x and 2.x Operators in one environment, preventing the migration of a cluster to the newer Operator version
- K8SPG-360: Fix a bug due to which manual password changing or resetting via Secret didn’t work

Known limitations

- Query analytics (QAN) will not be available in Percona Monitoring and Management (PMM) due to bugs PMM-12024 and PMM-11938. The fixes are included in the upcoming PMM 2.38, so QAN can be used as soon as it is released and both PMM Client and PMM Server are upgraded.

Supported platforms

The Operator was developed and tested with PostgreSQL versions 12.14, 13.10, 14.7, and 15.2. Other options may also work but have not been tested. The Operator 2.2.0 provides connection pooling based on pgBouncer 1.18.0 and high-availability implementation based on Patroni 3.0.1.

The following platforms were tested and are officially supported by the Operator 2.2.0:

- Google Kubernetes Engine (GKE) 1.23 - 1.26
- Amazon Elastic Container Service for Kubernetes (EKS) 1.23 - 1.27
- Minikube 1.30.1 (based on Kubernetes 1.27)

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.1.0 (Tech preview)

- **Date**

  May 4, 2023

- **Installation**

  Installing Percona Operator for PostgreSQL

The Percona Operator built with best practices of configuration and setup of Percona Distribution for PostgreSQL on Kubernetes.

Percona Operator for PostgreSQL helps create and manage highly available, enterprise-ready PostgreSQL clusters on Kubernetes. It is 100% open source, free from vendor lock-in, usage restrictions and expensive contracts, and includes enterprise-ready features: backup/restore, high availability, replication, logging, and more.

The benefits of using Percona Operator for PostgreSQL include saving time on database operations via automation of Day-1 and Day-2 operations and deployment of consistent and vetted environment on Kubernetes.

Note

Version 2.1.0 of the Percona Operator for PostgreSQL is a **tech preview release** and it is **not recommended for production environments.** As of today, we recommend using Percona Operator for PostgreSQL 1.x, which is production-ready and contains everything you need to quickly and consistently deploy and scale PostgreSQL clusters in a Kubernetes-based environment, on-premises or in the cloud.

Release Highlights

- PostgreSQL 15 is now officially supported by the Operator with the new exciting features it brings to developers
- UX improvements related to Custom Resource have been added in this release, including the handy `pg`, `pg-backup`, and `pg-restore` short names useful to quickly query the cluster state with the `kubectl get` command and additional information in the status fields, which now show `name`, `endpoint`, `status`, and `age`

New Features

- K8SPG-328: The new `delete-pvc` finalizer allows to either delete or preserve Persistent Volumes at Custom Resource deletion
- K8SPG-330: The new `delete-ssl` finalizer can now be used to automatically delete objects created for SSL (Secret, certificate, and issuer) in case of cluster deletion
- K8SPG-331: Starting from now, the Operator adds short names to its Custom Resources: `pg`, `pg-backup`, and `pg-restore`
- K8SPG-282: PostgreSQL 15 is now officially supported by the Operator

Improvements

- K8SPG-262: The Operator now does not attempt to start Percona Monitoring and Management (PMM) client if the corresponding secret does not contain the `pmmserver` or `pmmserverkey` key
- K8SPG-285: To improve the Operator we capture anonymous telemetry and usage data. In this release we add more data points to it
- K8SPG-295: Additional information was added to the status of the Operator Custom Resource, which now shows `name`, `endpoint`, `status`, and `age` fields
- K8SPG-304: The Operator stops using trust authentication method in `pg_hba.conf` for better security
- K8SPG-325: Custom Resource options previously named `paused` and `shutdown` were renamed to `unmanaged` and `pause` for better alignment with other Percona Operators

Bugs Fixed

- K8SPG-272: Fix a bug due to which PMM agent related to the Pod wasn't deleted from the PMM Server inventory on Pod termination
- K8SPG-279: Fix a bug which made the Operator to crash after creating a backup if there was no `backups.pgbackrest.manual` section in the Custom Resource
- K8SPG-298: Fix a bug due to which the `shutdown` Custom Resource option didn't work making it impossible to pause the cluster
- K8SPG-334: Fix a bug which made it possible for the monitoring user to have special characters in the autogenerated password, making it incompatible with the PMM Client

Supported platforms

The following platforms were tested and are officially supported by the Operator 2.1.0:

- Google Kubernetes Engine (GKE) 1.23 - 1.25
- Amazon Elastic Container Service for Kubernetes (EKS) 1.23 - 1.25

This list only includes the platforms that the Percona Operators are specifically tested on as part of the release process. Other Kubernetes flavors and versions depend on the backward compatibility offered by Kubernetes itself.

Percona Operator for PostgreSQL 2.0.0 (Tech preview)

- **Date**

  December 30, 2022

- **Installation**

  Installing Percona Operator for PostgreSQL

The Percona Operator is based on best practices for configuration and setup of a Percona Distribution for PostgreSQL on Kubernetes. The benefits of the Operator are many, but saving time and delivering a consistent and vetted environment is key.

> **Note**
>
> Version 2.0.0 of the Percona Operator for PostgreSQL is a **tech preview release** and it is **not recommended for production environments.** As of today, we recommend using Percona Operator for PostgreSQL 1.x, which is production-ready and contains everything you need to quickly and consistently deploy and scale PostgreSQL clusters in a Kubernetes-based environment, on-premises or in the cloud.

The *Percona Operator for PostgreSQL 2.x* is based on the 5.x branch of the Postgres Operator developed by Crunchy Data. Please see the main changes in this version below.

Architecture

Operator SDK is now used to build and package the Operator. It simplifies the development and brings more contribution friendliness to the code, resulting in better potential for growing the community. Users now have full control over Custom Resource Definitions that Operator relies on, which simplifies the deployment and management of the operator.

In version 1.x we relied on Deployment resources to run PostgreSQL clusters, whereas in 2.0 Statefulsets are used, which are the de-facto standard for running stateful workloads in Kubernetes. This change improves stability of the clusters and removes a lot of complexity from the Operator.

Backups

One of the biggest challenges in version 1.x is backups and restores. There are two main problems that our user faced:

- Not possible to change backup configuration for the existing cluster
- Restoration from backup to the newly deployed cluster required workarounds

In this version both these issues are fixed. In addition to that:

- Run up to 4 pgBackrest repositories
- Bootstrap the cluster from the existing backup through Custom Resource
- Azure Blob Storage support

Operations

Deploying complex topologies in Kubernetes is not possible without affinity and anti-affinity rules. In version 1.x there were various limitations and issues, whereas this version comes with substantial improvements that enables users to craft the topology of their choice.

Within the same cluster users can deploy multiple instances. These instances are going to have the same data, but can have different configuration and resources. This can be useful if you plan to migrate to new hardware or need to test the new topology.

Each postgreSQL node can have sidecar containers now to provide integration with your existing tools or expand the capabilities of the cluster.

Try it out now

Excited with what you read above?

- We encourage you to install the Operator following our documentation.
- Feel free to share feedback with us on the forum or raise a bug or feature request in JIRA.
- See the source code in our Github repository.