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Percona Kubernetes Operator for Percona XtraDB Cluster

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CONTENTS

Kubernetes and the OpenShift platform, based on Kubernetes, have added a way to manage containerized systems, including database clusters. This management is achieved by controllers, declared in configuration files. These controllers provide automation with the ability to create objects, such as a container or a group of containers called pods, to listen for an specific event and then perform a task.

This automation adds a level of complexity to the container-based architecture and stateful applications, such as a database. A Kubernetes Operator is a special type of controller introduced to simplify complex deployments. The Operator extends the Kubernetes API with custom resources.

Part I

Requirements

CHAPTER

ONE

SYSTEM REQUIREMENTS

The Operator supports Percona XtraDB Cluster (PXC) 5.7 and 8.0.

The new `caching_sha2_password` authentication plugin which is default in 8.0 is not supported for the ProxySQL compatibility reasons. Therefore both PXC 5.7 and 8.0 are configured with `default_authentication_plugin = mysql_native_password`.

1.1 Officially supported platforms

The following platforms are supported:

- OpenShift 3.11
- OpenShift 4.2
- Google Kubernetes Engine (GKE) 1.13
- GKE 1.15
- Amazon Elastic Kubernetes Service (EKS) 1.15
- Minikube 1.16

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

1.2 Resource Limits

A cluster running an officially supported platform contains at least three Nodes, with the following resources:

- 2GB of RAM,
- 2 CPU threads per Node for Pods provisioning,
- at least 60GB of available storage for Persistent Volumes provisioning.

1.3 Platform-specific limitations

The Operator is subsequent to specific platform limitations.

- Minikube doesn't support multi-node cluster configurations because of its local nature, which is in collision with the default affinity requirements of the Operator. To arrange this, the *Install Percona XtraDB Cluster on Minikube* instruction includes an additional step which turns off the requirement of having not less than three Nodes.

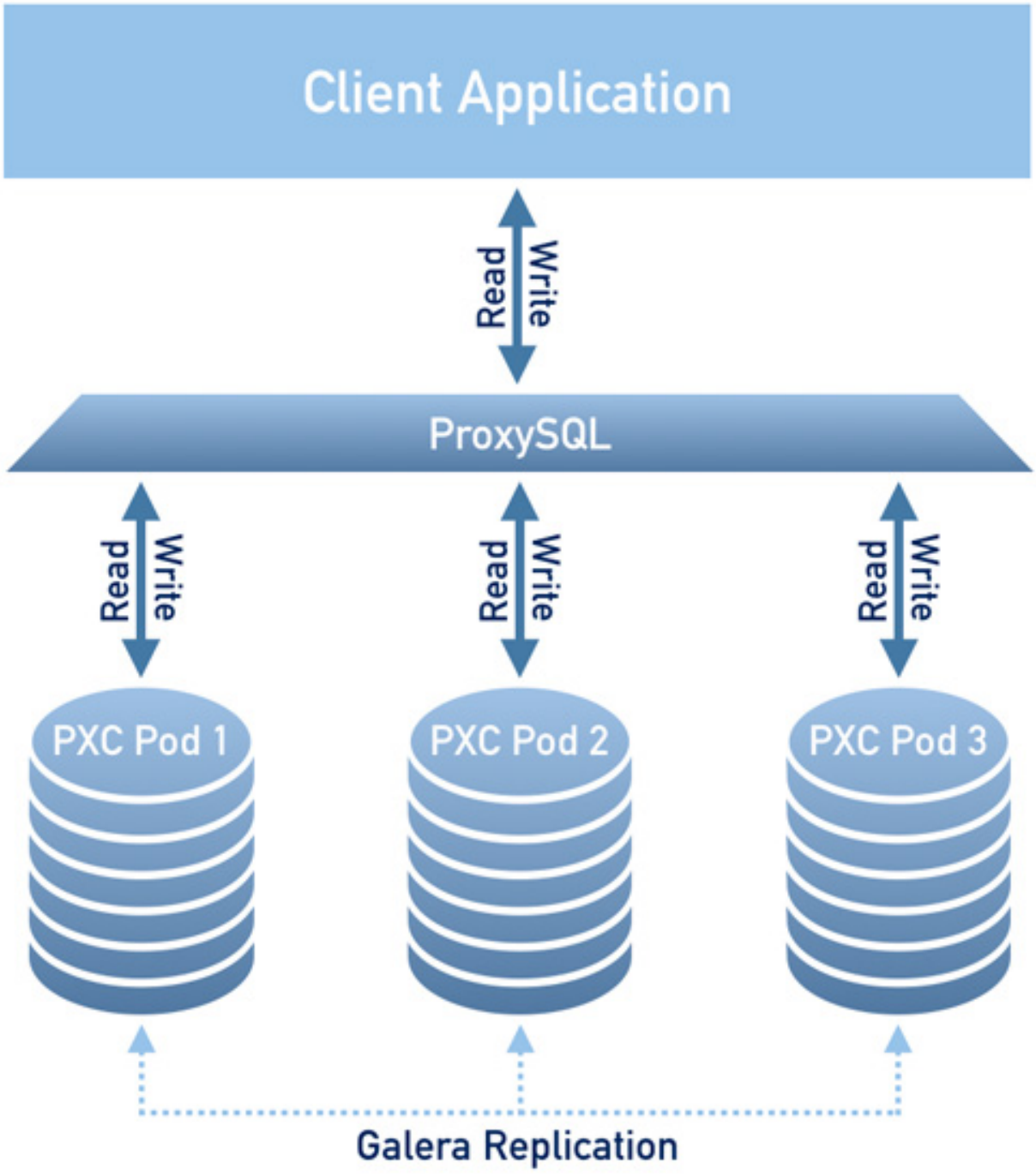
CHAPTER

TWO

DESIGN OVERVIEW

Percona XtraDB Cluster integrates *Percona Server for MySQL* running with the XtraDB storage engine, and *Percona XtraBackup* with the *Galera library* to enable synchronous multi-primary replication.

The design of the operator is highly bound to the Percona XtraDB Cluster high availability implementation, which in its turn can be briefly described with the following diagram.

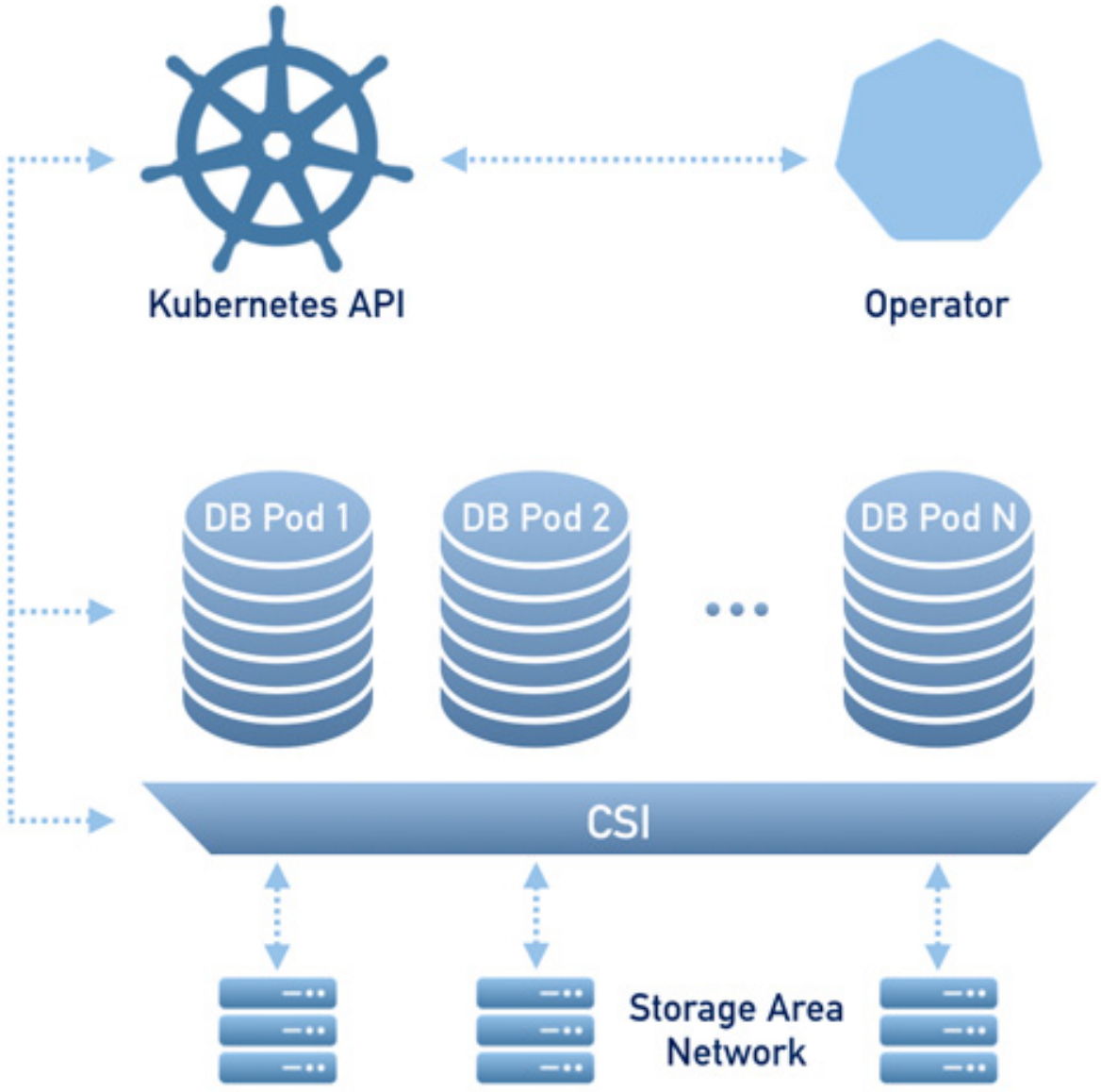


Being a regular MySQL Server instance, each node contains the same set of data synchronized accross nodes. The recommended configuration is to have at least 3 nodes. In a basic setup with this amount of nodes, Percona XtraDB Cluster provides high availability, continuing to function if you take any of the nodes down. Additionally load balancing can be achieved with the ProxySQL daemon, which accepts incoming traffic from MySQL clients and forwards it to backend MySQL servers.

Note: Using ProxySQL results in more efficient database workload management in comparison with other load balancers which are not SQL-aware, including built-in ones of the cloud providers, or the Kubernetes NGINX Ingress

Controller.

To provide high availability operator uses node affinity to run PXC 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 PVC StorageClass must support this feature (Kubernetes and OpenShift support this in versions 1.9 and 3.9 respectively).

The Operator functionality extends the Kubernetes API with *PerconaXtraDBCluster* object, and it is implemented as a golang application. Each *PerconaXtraDBCluster* object maps to one separate PXC setup. The Operator listens to all events on the created objects. When a new PerconaXtraDBCluster object 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 properly PXC operating.

Part II

Quickstart guides

CHAPTER

THREE

INSTALL PERCONA XTRADB CLUSTER ON MINIKUBE

Installing the PXC Operator 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 the Kubernetes application locally prior to deploying it on a cloud.

The following steps are needed to run PXC Operator on Minikube:

0. Install Minikube, using a way recommended for your system. This includes the installation of the following three components: #. kubectl tool, #. a hypervisor, if it is not already installed, #. actual Minikube package

   After the installation, run `minikube start --memory=4096 --cpus=3` (parameters increase the virtual machine limits for the CPU cores and memory, to ensure stable work of the Operator). Being executed, this command will download needed virtualized images, then initialize and run the cluster. After Minikube is successfully started, you can optionally run the Kubernetes dashboard, which visually represents the state of your cluster. Executing `minikube dashboard` will start the dashboard and open it in your default web browser.

1. Clone the percona-xtradb-cluster-operator repository:

   ```
   git clone -b v1.5.0 https://github.com/percona/percona-xtradb-cluster-operator
   cd percona-xtradb-cluster-operator
   ```

2. Deploy the operator with the following command:

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

3. Because minikube runs locally, the default `deploy/cr.yaml` file should be edited to adapt the Operator for the the local installation with limited resources. Change the following keys in `pxc` and `proxysql` sections:

   1. comment `resources.requests.memory` and `resources.requests.cpu` keys (this will fit the Operator in minikube default limitations)
   2. set `affinity.antiAffinityTopologyKey` key to `"none"` (the Operator will be unable to spread the cluster on several nodes)

   Also, switch `allowUnsafeConfigurations` key to `true` (this option turns off the Operator's control over the cluster configuration, making it possible to deploy Percona XtraDB Cluster as a one-node cluster).

4. Now apply the `deploy/cr.yaml` file with the following command:

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

5. During previous steps, the Operator has generated several secrets, including the password for the `root` user, which you will definitely need to access the cluster. Use `kubectl get secrets` to see the list of Secrets objects (by default Secrets object you are interested in has `my-cluster-secrets` name). Then `kubectl get secret my-cluster-secrets -o yaml` will return the YAML file with generated secrets, including the root password which should look as follows:

```
...
data:
  ...
  root: cm9vdF9wYXNzd29yZA==
```

Here the actual password is base64-encoded, and `echo 'cm9vdF9wYXNzd29yZA==' | base64 --decode` will bring it back to a human-readable form.

6. Check connectivity to a newly created cluster.

   First of all, run percona-client and connect its console output to your terminal (running it may require some time to deploy the correspondent Pod):

```
kubectl run -i --rm --tty percona-client --image=percona:5.7 --restart=Never --␣
↪bash -il
```

   Now run `mysql` tool in the percona-client command shell using the password obtained from the secret:

```
mysql -h cluster1-proxysql -uroot -proot_password
```

CHAPTER

FOUR

INSTALL PERCONA XTRADB CLUSTER ON GOOGLE KUBERNETES ENGINE (GKE)

This quickstart shows you how to configure a Percona XtraDB cluster operator with the Google Kubernetes Engine. The document assumes some experience with Google Kubernetes Engine (GKE). For more information on the GKE, see the Kubernetes Engine Quickstart.

4.1 Prerequisites

All commands from this quickstart 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. It 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
```

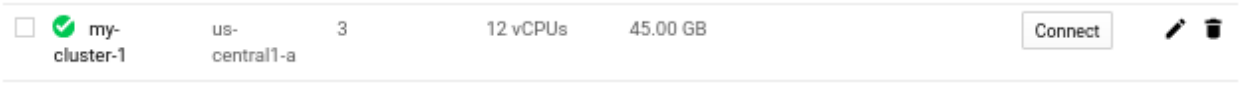
4.2 Configuring default settings for the cluster

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 will create a cluster named `my-cluster-1`:

```
$ gcloud container clusters create my-cluster-1 --project <project name> --zone us-
↪central1-a --cluster-version 1.15 --machine-type n1-standard-4 --num-nodes=3
```

Note: You must edit the following command and other command-line statements to replace the `<project name>` placeholder with your project name. 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 and 45 GB memory.

You may wait a few minutes for the cluster to be generated, and then you will 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 configures command-line access. After you have edited the statement, you may run the command in your local shell:

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

4.3 Installing the Operator

1. First of all, 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)
   ```

   The return statement confirms the creation:

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

2. Create a namespace and set the context for the namespace. The resource names must be unique within the namespace and provide a way to divide cluster resources between users spread across multiple projects.

   So, create the namespace and save it in the namespace context for subsequent commands as follows (replace the `<namespace name>` placeholder with some descriptive name):

   ```
   $ kubectl create namespace <namespace name>
   $ kubectl config set-context $(kubectl config current-context) --namespace=
   ↪<namespace name>
   ```

   At success, you will see the message that namespace/<namespace name> was created, and the context (gke_<project name>_<zone location>_<cluster name>) was modified.

3. Use the following `git clone` command to download the correct branch of the percona-xtradb-cluster-operator repository:

   ```
   git clone -b v1.5.0 https://github.com/percona/percona-xtradb-cluster-operator
   ```

   After the repository is downloaded, change the directory to run the rest of the commands in this document:

   ```
   cd percona-xtradb-cluster-operator
   ```

4. Deploy the Operator with the following command:

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

   The following confirmation is returned:

```
customresourcedefinition.apiextensions.k8s.io/perconaxtradbclusters.pxc.percona.
↪com created
customresourcedefinition.apiextensions.k8s.io/perconaxtradbclusterbackups.pxc.
↪percona.com created
customresourcedefinition.apiextensions.k8s.io/perconaxtradbclusterrestores.pxc.
↪percona.com created
customresourcedefinition.apiextensions.k8s.io/perconaxtradbbackups.pxc.percona.
↪com created
role.rbac.authorization.k8s.io/percona-xtradb-cluster-operator created
serviceaccount/percona-xtradb-cluster-operator created
rolebinding.rbac.authorization.k8s.io/service-account-percona-xtradb-cluster-
↪operator created
deployment.apps/percona-xtradb-cluster-operator created
```

5. The operator has been started, and you can create the Percona XtraDB cluster:

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

   The process could take some time. The return statement confirms the creation:

   ```
   perconaxtradbcluster.pxc.percona.com/cluster1 created
   ```

6. During previous steps, the Operator has generated several secrets, including the password for the `root` user, which you will need to access the cluster.

   Use `kubectl get secrets` command to see the list of Secrets objects (by default Secrets object you are interested in has `my-cluster-secrets` name). Then `kubectl get secret my-cluster-secrets -o yaml` will return the YAML file with generated secrets, including the root password which should look as follows:

   ```
   ...
   data:
     ...
     root: cm9vdF9wYXNzd29yZA==
   ```

   Here the actual password is base64-encoded, and `echo 'cm9vdF9wYXNzd29yZA==' | base64 --decode` will bring it back to a human-readable form.

4.4 Verifying the cluster operator

It may take ten minutes to get the cluster started. You can verify its creation with the `kubectl get pods` command:

```
$ kubectl get pods
NAME                                               READY     STATUS    RESTARTS   AGE
cluster1-proxysql-0                                3/3       Running   0          102s
cluster1-proxysql-1                                3/3       Running   0          77s
cluster1-proxysql-2                                3/3       Running   0          42s
cluster1-pxc-0                                     1/1       Running   0          103s
cluster1-pxc-1                                     0/1       Running   0          56s
percona-xtradb-cluster-operator-7455888c9d-wpn9j   1/1       Running   0          4m3s
```

Also, you can see the same information when browsing Pods of your cluster in Google Cloud console via the *Object Browser*:

Name	Status	Type	Cluster
core		API Group	
Pod		Kind	
cluster1-proxysql-0	Running	Pod	my-cluster-1
cluster1-proxysql-1	Running	Pod	my-cluster-1
cluster1-proxysql-2	Running	Pod	my-cluster-1
cluster1-pxc-0	Running	Pod	my-cluster-1
cluster1-pxc-1	Running	Pod	my-cluster-1
cluster1-pxc-2	Running	Pod	my-cluster-1

If all nodes are up and running, you can try to connect to the cluster with the following command:

```
$ kubectl run -i --rm --tty percona-client --image=percona:5.7 --restart=Never --␣
↪bash -il
```

Executing this command will open a `bash` command prompt:

```
If you don't see a command prompt, try pressing enter.
$
```

Now run `mysql` tool in the percona-client command shell using the password obtained from the secret:

```
mysql -h cluster1-proxysql -uroot -proot_password
```

This command will connect you to the MySQL monitor.

```
mysql: [Warning] Using a password on the command line interface can be insecure.
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 111
Server version: 5.5.30 (ProxySQL)

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affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.
```

The following example will use the MySQL prompt to check the `max_connections` variable:

```
mysql> SHOW VARIABLES LIKE "max_connections";
```

The return statement displays the current max_connections.

```
+-----------------+-------+
| Variable_name   | Value |
+-----------------+-------+
| max_connections | 79    |
+-----------------+-------+
1 row in set (0.02 sec)
```

4.5 Troubleshooting

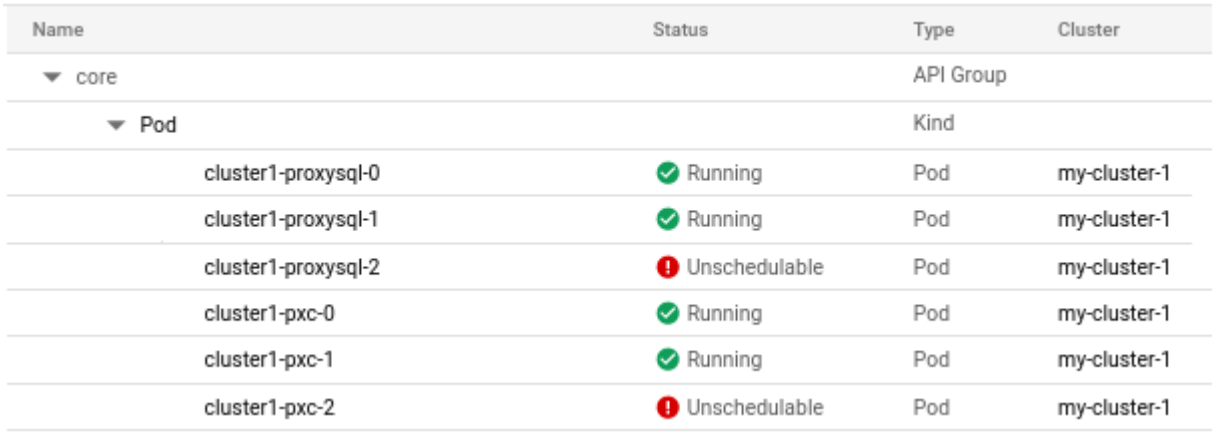
If `kubectl get pods` command had shown some errors, you can examine the problematic Pod with the `kubectl describe <pod name>` command. For example, this command returns information for the selected Pod:

```
kubectl describe pod cluster1-proxysql-2
```

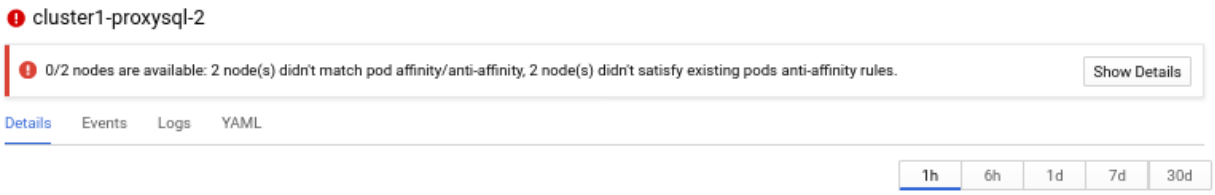
Review the detailed information for `Warning` statements and then correct the configuration. An example of a warning is as follows:

> *Warning FailedScheduling 68s (x4 over 2m22s) default-scheduler 0/1 nodes are available: 1 node(s) didn't match pod affinity/anti-affinity, 1 node(s) didn't satisfy existing pods anti-affinity rules.*

Alternatively, you can examine your Pods via the *object browser*. Errors will look as follows:



Clicking the problematic Pod will bring you to the details page with the same warning:



4.6 Removing the GKE cluster

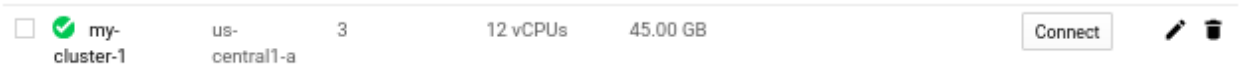
There are several ways that you can delete the cluster.

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

```
gcloud container clusters delete <cluster name>
```

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

Also, you can delete your cluster via the GKE console. Just click the appropriate trashcan icon in the clusters list:



The cluster deletion may take time.

CHAPTER

FIVE

INSTALL PERCONA XTRADB CLUSTER ON AMAZON ELASTIC KUBERNETES SERVICE (EKS)

This quickstart shows you how to deploy Percona XtraDB cluster operator on Amazon Elastic Kubernetes Service (EKS). The document assumes some experience with Amazon EKS. For more information on the EKS, see the Amazon EKS official documentation.

5.1 Prerequisites

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.

5.2 Create the EKS cluster

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 amount of on-demand and spot instances to use.

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

The most easy and visually clear way is to describe the desired cluster in YAML and to pass this configuration to the `eksctl` command.

The following example configures a EKS cluster with one managed node group:

```
apiVersion: eksctl.io/v1alpha5
kind: ClusterConfig

metadata:
    name: test-cluster
    region: eu-west-2

nodeGroups:
    - name: ng-1
      minSize: 3
      maxSize: 5
      instancesDistribution:
        maxPrice: 0.15
        instanceTypes: ["m5.xlarge", "m5.2xlarge"] # At least two instance types␣
↪should be specified
        onDemandBaseCapacity: 0
        onDemandPercentageAboveBaseCapacity: 50
        spotInstancePools: 2
      tags:
        'iit-billing-tag': 'cloud'
      preBootstrapCommands:
          - "echo 'OPTIONS=\"--default-ulimit nofile=1048576:1048576\"' >> /etc/
↪sysconfig/docker"
          - "systemctl restart docker"
```

Note: `preBootstrapCommands` section is used in the above example to increase the limits for the amount of opened files: this is important and shouldn't be omitted, taking into account the default EKS soft limit of 65536 files.

When the cluster configuration file is ready, you can actually create your cluster by the following command:

```
$ eksctl create cluster -f ~/cluster.yaml
```

5.3 Install the Operator

1. Create a namespace and set the context for the namespace. The resource names must be unique within the namespace and provide a way to divide cluster resources between users spread across multiple projects.

   So, create the namespace and save it in the namespace context for subsequent commands as follows (replace the `<namespace name>` placeholder with some descriptive name):

   ```
   $ kubectl create namespace <namespace name>
   $ kubectl config set-context $(kubectl config current-context) --namespace=
   ↪<namespace name>
   ```

   At success, you will see the message that namespace/<namespace name> was created, and the context was modified.

2. Use the following `git clone` command to download the correct branch of the percona-xtradb-cluster-operator repository:

   ```
   git clone -b v1.5.0 https://github.com/percona/percona-xtradb-cluster-operator
   ```

   After the repository is downloaded, change the directory to run the rest of the commands in this document:

```
cd percona-xtradb-cluster-operator
```

3. Deploy the Operator with the following command:

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

The following confirmation is returned:

```
customresourcedefinition.apiextensions.k8s.io/perconaxtradbclusters.pxc.percona.
↪com created
customresourcedefinition.apiextensions.k8s.io/perconaxtradbclusterbackups.pxc.
↪percona.com created
customresourcedefinition.apiextensions.k8s.io/perconaxtradbclusterrestores.pxc.
↪percona.com created
customresourcedefinition.apiextensions.k8s.io/perconaxtradbbackups.pxc.percona.
↪com created
role.rbac.authorization.k8s.io/percona-xtradb-cluster-operator created
serviceaccount/percona-xtradb-cluster-operator created
rolebinding.rbac.authorization.k8s.io/service-account-percona-xtradb-cluster-
↪operator created
deployment.apps/percona-xtradb-cluster-operator created
```

4. The operator has been started, and you can create the Percona XtraDB cluster:

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

The process could take some time. The return statement confirms the creation:

```
perconaxtradbcluster.pxc.percona.com/cluster1 created
```

5. During previous steps, the Operator has generated several secrets, including the password for the `root` user, which you will need to access the cluster.

Use `kubectl get secrets` command to see the list of Secrets objects (by default Secrets object you are interested in has `my-cluster-secrets` name). Then `kubectl get secret my-cluster-secrets -o yaml` will return the YAML file with generated secrets, including the root password which should look as follows:

```
...
data:
  ...
  root: cm9vdF9wYXNzd29yZA==
```

Here the actual password is base64-encoded, and `echo 'cm9vdF9wYXNzd29yZA==' | base64 --decode` will bring it back to a human-readable form (in this example it will be a `root_password` string).

6. Now you can check wether you are able to connect to MySQL from the outside with the help of the `kubectl port-forward` command as follows:

```
kubectl port-forward svc/example-proxysql 3306:3306 &
mysql -h 127.0.0.1 -P 3306 -uroot -proot_password
```

Part III

Advanced Installation Guides

CHAPTER

SIX

INSTALL PERCONA XTRADB CLUSTER ON KUBERNETES

0. First of all, clone the percona-xtradb-cluster-operator repository:

```
git clone -b v1.5.0 https://github.com/percona/percona-xtradb-cluster-operator
cd percona-xtradb-cluster-operator
```

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

1. Now Custom Resource Definition for PXC 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).

   This step should be done only once; it does not need to be repeated with the next Operator deployments, etc.

```
$ kubectl apply -f deploy/crd.yaml
```

2. The next thing to do is to add the `pxc` namespace to Kubernetes, not forgetting to set the correspondent context for further steps:

```
$ kubectl create namespace pxc
$ kubectl config set-context $(kubectl config current-context) --namespace=pxc
```

3. Now RBAC (role-based access control) for PXC should be set up from the `deploy/rbac.yaml` file. Briefly speaking, role-based access is based on specifically defined roles and actions corresponding to them, allowed to be done on specific Kubernetes resources (details about users and roles can be found in Kubernetes documentation).

```
$ kubectl apply -f deploy/rbac.yaml
```

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)`

Finally it's time to start the operator within Kubernetes:

```
$ kubectl apply -f deploy/operator.yaml
```

4. Now that's time to add the PXC Users secrets to Kubernetes. They should be placed in the data section of the `deploy/secrets.yaml` file as logins and base64-encoded passwords for the user accounts (see Kubernetes documentation for details).

   Note: the following command can be used to get base64-encoded password from a plain text string: `$ echo -n 'plain-text-password' | base64`

   After editing is finished, users secrets should be created (or updated with the new passwords) using the following command:

   ```
   $ kubectl apply -f deploy/secrets.yaml
   ```

   More details about secrets can be found in *Users*.

5. Now certificates should be generated. By default, the Operator generates certificates automatically, and no actions are required at this step. Still, you can generate and apply your own certificates as secrets according to the *TLS instructions*.

6. After the operator is started and user secrets are added, Percona XtraDB Cluster can be created at any time with the following command:

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

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

   ```
   $ kubectl get pods
   NAME                                               READY   STATUS    RESTARTS   AGE
   cluster1-pxc-0                                     1/1     Running   0          5m
   cluster1-pxc-1                                     1/1     Running   0          4m
   cluster1-pxc-2                                     1/1     Running   0          2m
   cluster1-proxysql-0                                1/1     Running   0          5m
   percona-xtradb-cluster-operator-dc67778fd-qtspz    1/1     Running   0          6m
   ```

7. Check connectivity to newly created cluster

   ```
   $ kubectl run -i --rm --tty percona-client --image=percona:5.7 --restart=Never --␣
   ↪bash -il
   percona-client:/$ mysql -h cluster1-proxysql -uroot -proot_password
   ```

CHAPTER

SEVEN

INSTALL PERCONA XTRADB CLUSTER ON OPENSHIFT

0. First of all, clone the percona-xtradb-cluster-operator repository:

```
git clone -b v1.5.0 https://github.com/percona/percona-xtradb-cluster-operator
cd percona-xtradb-cluster-operator
```

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

1. Now Custom Resource Definition for PXC 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).

   This step should be done only once; it does not need to be repeated with the next Operator deployments, etc.

```
$ oc apply -f deploy/crd.yaml
```

Note: Setting Custom Resource Definition requires your user to have cluster-admin role privileges.

   If you want to manage your PXC cluster with a non-privileged user, necessary permissions can be granted by applying the next clusterrole:

```
$ oc create clusterrole pxc-admin --verb="*" --resource=perconaxtradbclusters.pxc.
↪percona.com,perconaxtradbclusters.pxc.percona.com/status,
↪perconaxtradbclusterbackups.pxc.percona.com,perconaxtradbclusterbackups.pxc.
↪percona.com/status,perconaxtradbclusterrestores.pxc.percona.com,
↪perconaxtradbclusterrestores.pxc.percona.com/status
$ oc adm policy add-cluster-role-to-user pxc-admin <some-user>
```

   If you have a cert-manager installed, then you have to execute two more commands to be able to manage certificates with a non-privileged user:

```
$ oc create clusterrole cert-admin --verb="*" --resource=issuers.certmanager.k8s.
↪io,certificates.certmanager.k8s.io
$ oc adm policy add-cluster-role-to-user cert-admin <some-user>
```

2. The next thing to do is to create a new `pxc` project:

```
$ oc new-project pxc
```

3. Now RBAC (role-based access control) for PXC should be set up from the `deploy/rbac.yaml` file. Briefly speaking, role-based access is based on specifically defined roles and actions corresponding to them, allowed to

be done on specific Kubernetes resources (details about users and roles can be found in OpenShift documentation).

```
$ oc apply -f deploy/rbac.yaml
```

Finally, it's time to start the operator within OpenShift:

```
$ oc apply -f deploy/operator.yaml
```

4. Now that's time to add the PXC Users secrets to OpenShift. They should be placed in the data section of the `deploy/secrets.yaml` file as logins and base64-encoded passwords for the user accounts (see Kubernetes documentation for details).

   Note: The following command can be used to get base64-encoded password from a plain text string: `$ echo -n 'plain-text-password' | base64`

   After editing is finished, users secrets should be created (or updated with the new passwords) using the following command:

   ```
   $ oc apply -f deploy/secrets.yaml
   ```

   More details about secrets can be found in *Users*.

5. Now certificates should be generated. By default, the Operator generates certificates automatically, and no actions are required at this step. Still, you can generate and apply your own certificates as secrets according to the *TLS instructions*.

6. After the operator is started and user secrets are added, Percona XtraDB Cluster can be created at any time with the following command:

   ```
   $ oc apply -f deploy/cr.yaml
   ```

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

   ```
   $ oc get pods
   NAME                                               READY   STATUS    RESTARTS   AGE
   cluster1-pxc-0                                     1/1     Running   0          5m
   cluster1-pxc-1                                     1/1     Running   0          4m
   cluster1-pxc-2                                     1/1     Running   0          2m
   cluster1-proxysql-0                                1/1     Running   0          5m
   percona-xtradb-cluster-operator-dc67778fd-qtspz    1/1     Running   0          6m
   ```

7. Check connectivity to newly created cluster

   ```
   $ oc run -i --rm --tty percona-client --image=percona:5.7 --restart=Never -- bash␣
   ↪-il
   percona-client:/$ mysql -h cluster1-proxysql -uroot -proot_password
   ```

CHAPTER

EIGHT

USE DOCKER IMAGES FROM A CUSTOM REGISTRY

Using images from a private Docker registry may be useful in different situations: it may be related to storing images inside of a company, for privacy and security reasons, etc. In such cases, Percona XtraDB Cluster Operator allows to use a custom registry, and the following instruction illustrates how this can be done by the example of the Operator deployed in the OpenShift environment.

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 pxc
Now using project "pxc" 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 find out 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. Now you can use the obtained token and address to login to the registry:

```
$ docker login -u admin -p ADO8CqCDappWR4hxjfDqwijEHei31yXAvWg61Jg210s 172.30.162.
↪173:5000
Login Succeeded
```

4. Pull the needed image by its SHA digest:

```
$ docker pull docker.io/perconalab/percona-xtradb-cluster-
↪operator@sha256:841c07eef30605080bfe80e549f9332ab6b9755fcbc42aacbf86e4ac9ef0e444
Trying to pull repository docker.io/perconalab/percona-xtradb-cluster-operator ...
sha256:841c07eef30605080bfe80e549f9332ab6b9755fcbc42aacbf86e4ac9ef0e444: Pulling␣
↪from docker.io/perconalab/percona-xtradb-cluster-operator
```

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```
Digest: sha256:841c07eef30605080bfe80e549f9332ab6b9755fcbc42aacbf86e4ac9ef0e444
Status: Image is up to date for docker.io/perconalab/percona-xtradb-cluster-
↪operator@sha256:841c07eef30605080bfe80e549f9332ab6b9755fcbc42aacbf86e4ac9ef0e444
```

5. The following way is used to push an image to the custom registry (into the OpenShift pxc project):

```
$ docker tag \
    docker.io/perconalab/percona-xtradb-cluster-
↪operator@sha256:841c07eef30605080bfe80e549f9332ab6b9755fcbc42aacbf86e4ac9ef0e444␣
↪\
    172.30.162.173:5000/pxc/percona-xtradb-cluster-operator:1.2.0
$ docker push 172.30.162.173:5000/pxc/percona-xtradb-cluster-operator:1.2.0
```

6. Check the image in the OpenShift registry with the following command:

```
$ oc get is
NAME                                DOCKER REPO                                    ␣
↪                           TAGS      UPDATED
percona-xtradb-cluster-operator   docker-registry.default.svc:5000/pxc/percona-
↪xtradb-cluster-operator   1.5.0     2 hours ago
```

7. When the custom registry image is Ok, put a Docker Repo + Tag string (it should look like `docker-registry.default.svc:5000/pxc/percona-xtradb-cluster-operator:1.5.0`) into the `image:` option in `deploy/operator.yaml` configuration file.

   Please note it is possible to specify `imagePullSecrets` option for all images, if the registry requires authentication.

8. Repeat steps 3-5 for other images, and update corresponding options in the `deploy/cr.yaml` file.

9. Now follow the standard Percona XtraDB Cluster Operator installation instruction.

8.1 Percona certified images

Following table presents Percona's certified images to be used with the Percona XtraDB Cluster Operator:

Image	Digest
percona/percona-xtradb-cluster-operator:1.4.0	277d62967e94dc4e7d0569656413967e6a8597842753da05f083543e68c9b719
percona/percona-xtradb-cluster-operator:1.4.0-proxysql	1ee8b9c291dac955dd98441187476fe8c3b5a4930e9e4dc39b9534376d0cc4f2
percona/percona-xtradb-cluster-operator:1.4.0-pxc8.0	58296417cc97378b906e12855cb1f4f2420f06168d2096acc08a93c8afa793f6
percona/percona-xtradb-cluster-operator:1.4.0-pxc8.0-backup	566ea1f6cf9387a06898d5f7af15189ed577d3af771d5954b2e869593b80cb6b
percona/percona-xtradb-cluster-operator:1.4.0-pxc5.7	4ff39dab7872a4b45250ca170604f6bce1fcc52510407f6cbd93cd81f5a32d8f
percona/percona-xtradb-cluster-operator:1.4.0-pxc5.7-backup	ca8e3fd49d3a2ac15c0b9c44f8ea4e0f8240789de274859a91ec9cd8d8e80763
percona/percona-xtradb-cluster-operator:1.4.0-pmm	28bbb6693689a15c407c85053755334cd25d864e632ef7fed890bc85726cfb68
percona/percona-xtradb-cluster-operator:1.3.0	85cfaf78394e21b722be92015912c39e483f7ae5de1aab114293520a3825eb99
percona/percona-xtradb-cluster-operator:1.3.0-proxysql	8e40dec83008894aaa438f31233acb90f29969ad660cce26b700075eeaf9d34b
percona/percona-xtradb-cluster-operator:1.3.0-pxc	a7d04c0a343fd0b7f08a306bb9f00b6df2f398bb7163990ba787f037c294853e
percona/percona-xtradb-cluster-operator:1.3.0-backup	f786d92d96c5036df1785647d323081235c06fad56653ca93ae44af85c2d19e8
percona/percona-xtradb-cluster-operator:1.3.0-pmm	28bbb6693689a15c407c85053755334cd25d864e632ef7fed890bc85726cfb68
percona/percona-xtradb-cluster-operator:1.2.0	841c07eef30605080bfe80e549f9332ab6b9755fcbc42aacbf86e4ac9ef0e444
percona/percona-xtradb-cluster-operator:1.2.0-pxc	d38482fcbe0d0f169e41eefd889404e967e8abc65a6890cbab4dd1f3ea2229df
percona/percona-xtradb-cluster-operator:1.2.0-proxysql	1385b77d3498cebc201426821fda620e0884e8fdaba6756240c9821948864af3
percona/percona-xtradb-cluster-operator:1.2.0-backup	bd45486507321de67ff8ad2fa40c4f55fc20bd15db6369b61c73a5db11bb57cd
percona/percona-xtradb-cluster-operator:1.2.0-broker	c0903f41539767fcfe49da815e1c3bfefe4e48a36912b64fb5350b09b51cab32
percona/percona-xtradb-cluster-operator:1.2.0-pmm	28bbb6693689a15c407c85053755334cd25d864e632ef7fed890bc85726cfb68
percona/percona-xtradb-cluster-operator:1.1.0	fbfc2fc5c3afc80f18dddc5a1c3439fab89950081cf86c3439a226d4c97198eb
percona/percona-xtradb-cluster-operator:1.1.0-pxc	a66a9212760e823af3c666a78e4b480cc7cc0d8be5cfa29c8141319c0036706e
percona/percona-xtradb-cluster-operator:1.1.0-proxysql	ac952afb3721eafe86431155da7c3f7f90c4e800491c400a4222b650fd393357
percona/percona-xtradb-cluster-operator:1.1.0-backup	4852da039dd2a1d3ae9243ec634c14fd9f9e5af18a1fc6c7c9d25d4287dd6941
percona/percona-xtradb-cluster-operator:1.0.0	b9e97c66a69f448898f8d43b92dd0314aaf53997b70824056dd3d0aec62488eb
percona/percona-xtradb-cluster-operator:1.0.0-pxc	6797c8492cff8092b39cdce75d7d85b9c2d4d08c4f6e0ba7b05c21562a54f168
percona/percona-xtradb-cluster-operator:1.0.0-proxysql	b9360f1a8dc1e57e5ae7442373df02869ddc4da69ef9190190edde70b465235e
percona/percona-xtradb-cluster-operator:1.0.0-backup	652be455c8faf2d610de15e3568ff57fe8630fa353b6d97ff1c6b91d44741f8b

CHAPTER

NINE

DEPLOY PERCONA XTRADB CLUSTER WITH SERVICE BROKER

Percona Service Broker provides the Open Service Broker object to facilitate the operator deployment within high-level visual tools. Following steps are needed to use it while installing the Percona XtraDB Cluster on the OpenShift platform:

1. The Percona Service Broker is to be deployed based on the `percona-broker.yaml` file. To use it you should first enable the Service Catalog, which can be done with the following command:

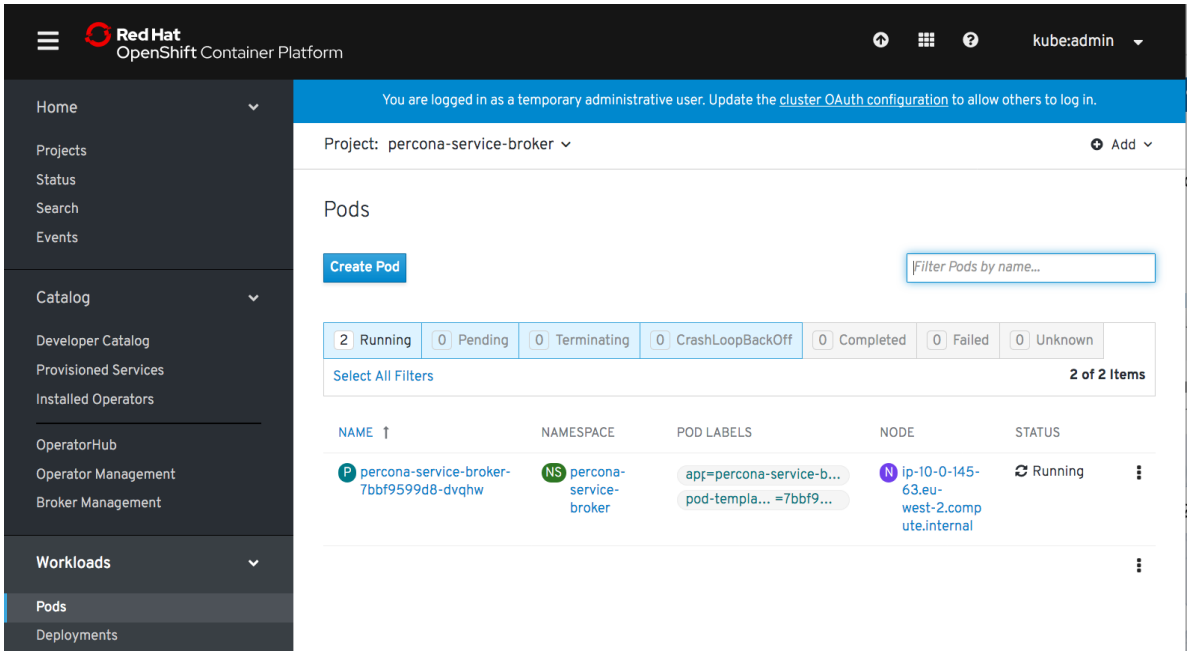
   ```
   $ oc patch servicecatalogapiservers cluster --patch '{"spec":{"managementState":
   ↪"Managed"}}' --type=merge
   $ oc patch servicecatalogcontrollermanagers cluster --patch '{"spec":{
   ↪"managementState":"Managed"}}' --type=merge
   ```

   When Service Catalog is enabled, download and install the Percona Service Broker in a typical OpenShift way:

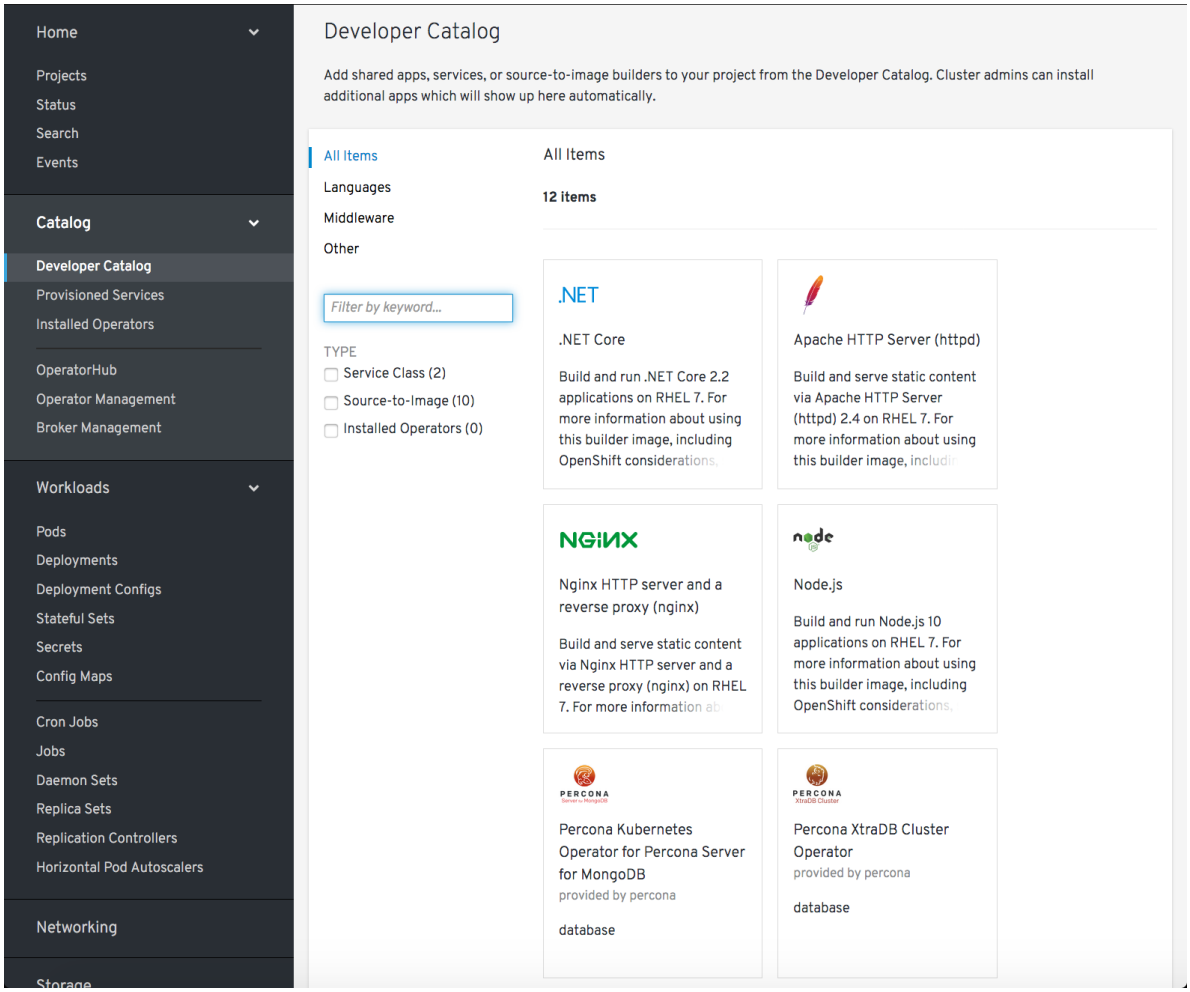
   ```
   $ oc apply -f https://raw.githubusercontent.com/Percona-Lab/percona-dbaas-cli/
   ↪broker/deploy/percona-broker.yaml
   ```

   Note: This step should be done only once; the step does not need to be repeated with any other Operator deployments. It will automatically create and setup the needed service and projects catalog with all necessary objects.

2. Now login to your OpenShift Console Web UI and switch to the percona-service-broker project. You can check its Pod running on a correspondent page:

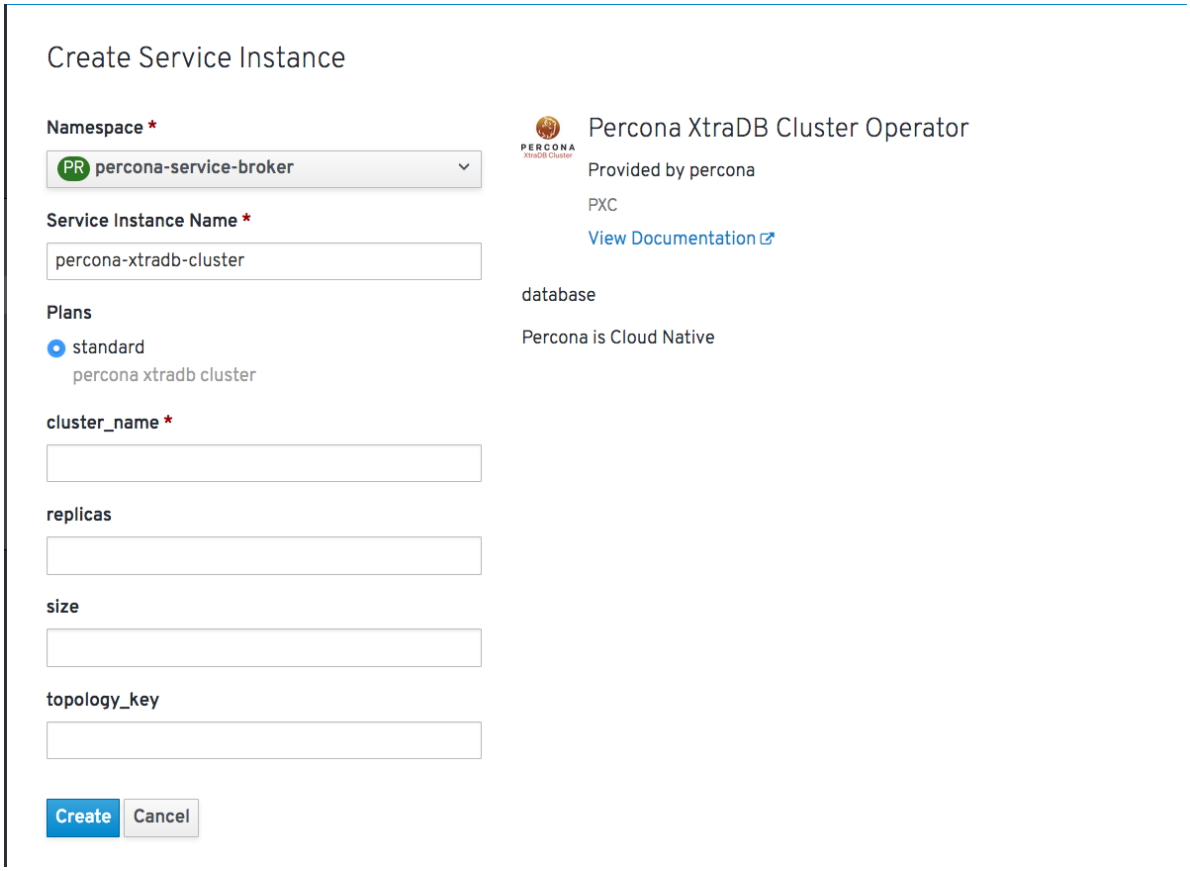


Now switch to the Developer Catalog and select Percona XtraDB Cluster Operator:



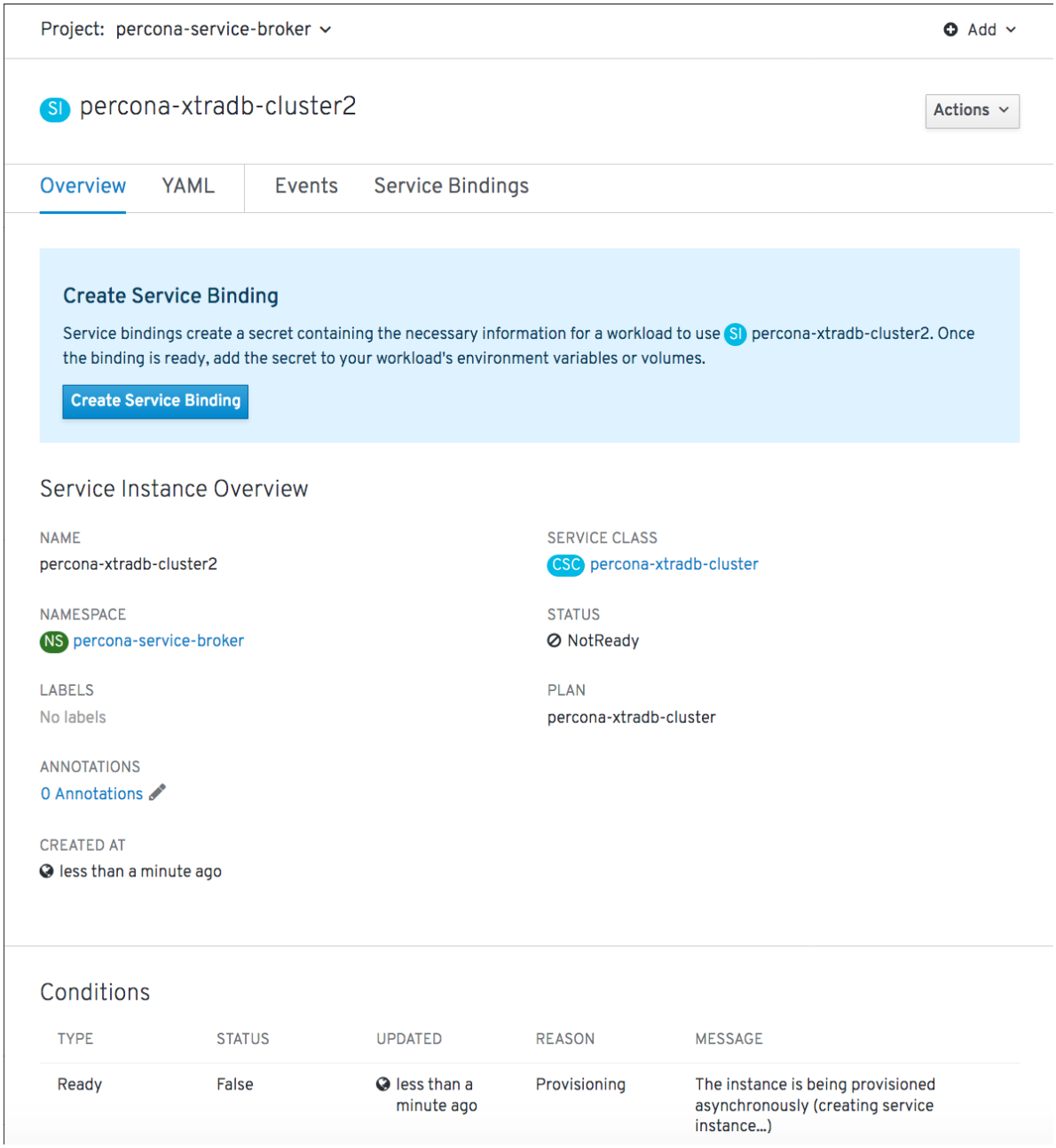
Choose `Percona XtraDB Cluster Operator` item. This will lead you to the Operator page with the *Create Service Instance* button.

3. Clicking the *Create Service Instance* button guides you to the next page:



The two necessary fields are *Service Instance Name* and *Cluster Name*, which should be unique for your project.

4. Clicking the *Create* button gets you to the *Overview* page, which reflects the process of the cluster creation process:



You can also track Pods to see when they are deployed and track any errors.

Part IV

Configuration

CHAPTER

TEN

USERS

MySQL user accounts within the Cluster can be divided into two different groups:

- *application-level users*: the unprivileged user accounts,
- *system-level users*: the accounts needed to automate the cluster deployment and management tasks, such as PXC Health checks or ProxySQL integration.

As these two groups of user accounts serve different purposes, they are considered separately in the following sections.

10.1 Unprivileged users

There are no unprivileged (general purpose) user accounts created by default. If you need general purpose users, please run commands below:

```
$ kubectl run -it --rm percona-client --image=percona:5.7 --restart=Never -- mysql -
↪hcluster1-pxc -uroot -proot_password
mysql> GRANT ALL PRIVILEGES ON database1.* TO 'user1'@'%' IDENTIFIED BY 'password1';
```

Note: MySQL password here should not exceed 32 characters due to the replication-specific limit introduced in MySQL 5.7.5.

Verify that the user was created successfully. If successful, the following command will let you successfully login to MySQL shell via ProxySQL:

```
$ kubectl run -it --rm percona-client --image=percona:5.7 --restart=Never -- bash -il
percona-client:/$ mysql -h cluster1-proxysql -uuser1 -ppassword1
mysql> SELECT * FROM database1.table1 LIMIT 1;
```

You may also try executing any simple SQL statement to ensure the permissions have been successfully granted.

10.2 System Users

To automate the deployment and management of the cluster components, the Operator requires system-level PXC users.

Credentials for these users are stored as a Kubernetes Secrets object. The Operator requires to be deployed before the PXC Cluster is started. The name of the required secrets (`my-cluster-secrets` by default) should be set in in the `spec.secretsName` option of the `deploy/cr.yaml` configuration file.

The following table shows system users' names and purposes.

Warning: These users should not be used to run an application.

User Purpose	Username	Password Secret Key	Description
Admin	root	root	Database administrative user, can be used by the application if needed
ProxySQLAdmin	proxyadmin	proxyadmin	ProxySQL administrative user, can be used to add general-purpose ProxySQL users
Backup	xtrabackup	xtrabackup	User to run backups
Cluster Check	clustercheck	clustercheck	User for liveness checks and readiness checks
Monitoring	monitor	monitor	User for internal monitoring purposes and PMM agent
PMM Server Password	should be set through the operator options	pmmserver	Password used to access PMM Server
Operator Admin	operator	operator	Database administrative user, should be used only by the Operator

10.2.1 YAML Object Format

The default name of the Secrets object for these users is `my-cluster-secrets` and can be set in the CR for your cluster in `spec.secretName` to something different. When you create the object yourself, it should match the following simple format:

```
apiVersion: v1
kind: Secret
metadata:
  name: my-cluster-secrets
type: Opaque
data:
  root: cm9vdF9wYXNzd29yZA==
  xtrabackup: YmFja3VwX3Bhc3N3b3Jk
  monitor: bW9uaXRvcg==
  clustercheck: Y2x1c3RlcmNoZWNrcGFzc3dvcmQ=
  proxyadmin: YWRtaW5fcGFzc3dvcmQ=
  pmmserver: c3VwYXxefHBheno=
  operator: b3BlcmF0b3JhZG1pbg==
```

The example above matches *what is shipped in deploy/secrets.yaml* which contains default passwords. You should NOT use these in production, but they are present to assist in automated testing or simple use in a development environment.

As you can see, because we use the `data` type in the Secrets object, all values for each key/value pair must be encoded in base64. To do this you can simply run `echo -n "password" | base64` in your local shell to get valid values.

10.2.2 Password Rotation Policies and Timing

When there is a change in user secrets, the Operator creates the necessary transaction to change passwords. This rotation happens almost instantly (the delay can be up to a few seconds), and it's not needed to take any action beyond changing the password.

Note: Please don't change `secretName` option in CR, make changes inside the secrets object itself.

10.2.3 Marking System Users In MySQL

Starting with MySQL 8.0.16, a new feature called Account Categories has been implemented, which allows us to mark our system users as such. See the official documentation on this feature for more details.

10.3 Development Mode

To make development and testing easier, `deploy/secrets.yaml` secrets file contains default passwords for PXC system users.

These development mode credentials from `deploy/secrets.yaml` are:

Secret Key	Secret Value
root	`root_password`
xtrabackup	`backup_password`
monitor	`monitor`
clustercheck	`clustercheckpassword`
proxyuser	`s3cret`
proxyadmin	`admin_password`
pmmserver	`supa|^|pazz`
operator	`operatoradmin`

Warning: Do not use the default PXC user passwords in production!

CHAPTER

ELEVEN

LOCAL STORAGE SUPPORT FOR THE PERCONA XTRADB CLUSTER OPERATOR

Among the wide rage of volume types, supported by Kubernetes, there are two which allow Pod containers to access part of the local filesystem on the node. Two such options are *emptyDir* and *hostPath* volumes.

11.1 emptyDir

The name of this option is self-explanatory. When Pod having an emptyDir volume is assigned to a Node, a directory with the specified name is created on this node and exists until this Pod is removed from the node. When the Pod have been deleted, the directory is deleted too with all its content. All containers in the Pod which have mounted this volume will gain read and write access to the correspondent directory.

The `emptyDir` options in the deploy/cr.yaml file can be used to turn the emptyDir volume on by setting the directory name.

11.2 hostPath

A hostPath volume mounts some existing file or directory from the node's filesystem into the Pod.

The `volumeSpec.hostPath` subsection in the deploy/cr.yaml file may include `path` and `type` keys to set the node's filesystem object path and to specify whether it is a file, a directory, or something else (e.g. a socket):

```
volumeSpec:
  hostPath:
    path: /data
    type: Directory
```

Please note, that hostPath directory is not created automatically! Is should be created manually and should have following correct attributives: 1. access permissions 2. ownership 3. SELinux security context

`hostPath` is useful when you are able to perform manual actions during the first run and have strong need in improved disk performance. Also, please consider using tolerations to avoid cluster migration to different hardware in case of a reboot or a hardware failure.

More details can be found in the official hostPath Kubernetes documentation.

CHAPTER

TWELVE

BINDING PERCONA XTRADB CLUSTER COMPONENTS TO SPECIFIC KUBERNETES/OPENSHIFT NODES

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

Both `pxc` and `proxysql` sections of the deploy/cr.yaml file contain keys which can be used to do this, depending on what is the best for a particular situation.

12.1 Node selector

`nodeSelector` contains one or more key-value pairs. If the node is not labeled with each key-value pair from the Pod's `nodeSelector`, the Pod will not be able to land on it.

The following example binds the Pod to any node having a self-explanatory `disktype: ssd` label:

```
nodeSelector:
  disktype: ssd
```

12.2 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. Particularly this approach is good to 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.

Percona XtraDB Cluster Operator provides two approaches for doing this:

- simple way to set anti-affinity for Pods, built-in into the Operator,
- more advanced approach based on using standard Kubernetes constraints.

12.2.1 Simple approach - use topologyKey of the Percona XtraDB Cluster Operator

Percona XtraDB Cluster Operator provides a `topologyKey` option, which may have one of the following values:

- `kubernetes.io/hostname` - Pods will avoid residing within the same host,
- `failure-domain.beta.kubernetes.io/zone` - Pods will avoid residing within the same zone,
- `failure-domain.beta.kubernetes.io/region` - Pods will avoid residing within the same region,
- `none` - no constraints are applied.

The following example forces Percona XtraDB Cluster Pods to avoid occupying the same node:

```
affinity:
  topologyKey: "kubernetes.io/hostname"
```

12.2.2 Advanced approach - use standard Kubernetes constraints

Previous way can be used with no special knowledge of the Kubernetes way of assigning Pods to specific nodes. Still in some cases more complex tuning may be needed. In this case `advanced` option placed in the deploy/cr.yaml file turns off the effect of the `topologyKey` and allows to use standard Kubernetes affinity constraints of any complexity:

```
affinity:
   advanced:
     podAffinity:
       requiredDuringSchedulingIgnoredDuringExecution:
       - labelSelector:
           matchExpressions:
           - key: security
             operator: In
             values:
             - S1
         topologyKey: failure-domain.beta.kubernetes.io/zone
     podAntiAffinity:
       preferredDuringSchedulingIgnoredDuringExecution:
       - weight: 100
         podAffinityTerm:
           labelSelector:
             matchExpressions:
             - key: security
               operator: In
               values:
               - S2
           topologyKey: kubernetes.io/hostname
     nodeAffinity:
       requiredDuringSchedulingIgnoredDuringExecution:
         nodeSelectorTerms:
         - matchExpressions:
           - key: kubernetes.io/e2e-az-name
             operator: In
             values:
             - e2e-az1
             - e2e-az2
       preferredDuringSchedulingIgnoredDuringExecution:
       - weight: 1
         preference:
           matchExpressions:
```

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```
            - key: another-node-label-key
              operator: In
              values:
              - another-node-label-value
```

See explanation of the advanced affinity options in Kubernetes documentation.

12.3 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:

```
tolerations:
- key: "node.alpha.kubernetes.io/unreachable"
  operator: "Exists"
  effect: "NoExecute"
  tolerationSeconds: 6000
```

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

12.4 Priority Classes

Pods may belong to some *priority classes*. This allows scheduler to distinguish more and less important Pods to resolve the situation when some higher priority Pod cannot be scheduled without evicting a lower priority one. This can be done adding one or more PriorityClasses in your Kubernetes cluster, and specifying the `PriorityClassName` in the deploy/cr.yaml file:

```
priorityClassName: high-priority
```

See the Kubernetes Pods Priority and Preemption documentation to find out how to define and use priority classes in your cluster.

12.5 Pod Disruption Budgets

Creating the *Pod Disruption Budget* is the Kubernetes style to limits the number of Pods of an application that can go down simultaneously due to such *voluntary disruptions* as cluster administrator's actions during the update of deployments or nodes, etc. By such a way Distribution Budgets allow large applications to retain their high availability while maintenance and other administrative activities.

We recommend to apply Pod Disruption Budgets manually to avoid situation when Kubernetes stopped all your database Pods. See the official Kubernetes documentation for details.

CHAPTER

THIRTEEN

CHANGING MYSQL OPTIONS

You may require a configuration change for your application. MySQL allows the option to configure the database with a configuration file. You can pass the MySQL options from the my.cnf configuration file to the cluster in one of the following ways:

- Edit the CR.yaml file
- Use a ConfigMap

13.1 Edit the CR.yaml

You can add options from the my.cnf by editing the configuration section of the deploy/cr.yaml.

```
spec:
  secretsName: my-cluster-secrets
  pxc:
    ...
      configuration: |
        [mysqld]
        wsrep_debug=ON
        [sst]
        wsrep_debug=ON
```

See the Custom Resource options, PXC section for more details

13.2 Use a ConfigMap

You can use a configmap and the cluster restart to reset configuration options. A configmap allows Kubernetes to pass or update configuration data inside a containerized application.

Use the `kubectl` command to create the configmap from external resources, for more information see Configure a Pod to use a ConfigMap.

For example, let's suppose that your application requires more connections. To increase your `max_connections` setting in MySQL, you define a `my.cnf` configuration file with the following setting:

```
[mysqld]
...
max_connections=250
```

You can create a configmap from the `my.cnf` file with the `kubectl create configmap` command.

You should use the combination of the cluster name with the `-pxc` suffix as the naming convention for the configmap. To find the cluster name, you can use the following command:

```
kubectl get pxc
```

The syntax for `kubectl create configmap` command is:

```
kubectl create configmap <cluster-name>-pxc <resource-type=resource-name>
```

The following example defines cluster1-pxc as the configmap name and the my-cnf file as the data source:

```
kubectl create configmap cluster1-pxc --from-file=my.cnf
```

To view the created configmap, use the following command:

```
kubectl describe configmaps cluster1-pxc
```

13.3 Make changed options visible to the Percona XtraDB Cluster

Do not forget to restart Percona XtraDB Cluster to ensure the cluster has updated the configuration (see details on how to connect in the Install Percona XtraDB Cluster on Kubernetes page).

13.4 Auto-tuning MySQL options

Few configuration options for MySQL can be calculated and set by the Operator automatically based on the available Pod resources (memory and CPU) **if these options are not specified by user** (either in CR.yaml or in ConfigMap).

Options which can be set automatically are the following ones:

- `innodb_buffer_pool_size`
- `max_connections`

If PXC Pod limits are defined, then limits values are used to calculate these options. If PXC Pod limits are not defined, Operator looks for PXC Pod requests as the basis for calculations. if neither PXC Pod limits nor PXC Pod requests are defined, auto-tuning is not done.

CHAPTER

FOURTEEN

CONFIGURING LOAD BALANCING WITH HAPROXY

Percona XtraDB Cluster Operator provides a choice of two cluster components to provide load balancing and proxy service: you can use either HAProxy or ProxySQL. You can control which one to use, if any, by enabling or disabling via the `haproxy.enabled` and `proxysql.enabled` options in the `deploy/cr.yaml` configuration file.

Use the following command to enable HAProxy:

```
kubectl patch pxc cluster1 --type=merge --patch '{
  "spec": {
     "haproxy": {
        "enabled": true,
        "size": 3,
        "image": "percona/percona-xtradb-cluster-operator:1.5.0-haproxy" },
     "proxysql": { "enabled": false }
  }}'
```

Note: For obvious reasons the Operator will not allow the simultaneous enabling of both HAProxy and ProxySQL.

The resulting HAPproxy setup will contain two services:

- `cluster1-haproxy` service listening on ports 3306 (MySQL) and 3309 (the proxy protocol). This service is pointing to the number zero PXC member (`cluster1-pxc-0`) by default when this member is available. If a zero member is not available, members are selected in descending order of their numbers (e.g. `cluster1-pxc-2`, then `cluster1-pxc-1`, etc.). This service can be used for both read and write load, or it can also be used just for write load (single writer mode) in setups with split write and read loads.
- `cluster1-haproxy-replicas` listening on port 3306 (MySQL). This service selects PXC members to serve queries following the Round Robin load balancing algorithm.

When the cluster with HAProxy is upgraded, the following steps take place. First, reader members are upgraded one by one: the Operator waits until the upgraded PXC member becomes synced, and then proceeds to upgrade the next member. When the upgrade is finished for all the readers, then the writer PXC member is finally upgraded.

14.1 Passing custom configuration options to HAProxy

You can pass custom configuration to HAProxy using the `haproxy.configuration` key in the `deploy/cr.yaml` file.

Note: If you specify a custom HAProxy configuration in this way, the Operator doesn't provide its own HAProxy configuration file. That's why you should specify either a full set of configuration options or nothing.

Here is an example of HAProxy configuration passed through `deploy/cr.yaml`:

```
...
haproxy:
    enabled: true
    size: 3
    image: percona/percona-xtradb-cluster-operator:1.5.0-haproxy
    configuration: |
      global
        maxconn 2048
        external-check
        stats socket /var/run/haproxy.sock mode 600 expose-fd listeners level user
      defaults
        log global
        mode tcp
        retries 10
        timeout client 10000
        timeout connect 100500
        timeout server 10000
      frontend galera-in
        bind *:3309 accept-proxy
        bind *:3306
        mode tcp
        option clitcpka
        default_backend galera-nodes
      frontend galera-replica-in
        bind *:3309 accept-proxy
        bind *:3307
        mode tcp
        option clitcpka
        default_backend galera-replica-nodes
 ...
```

CHAPTER

FIFTEEN

CONFIGURING LOAD BALANCING WITH PROXYSQL

Percona XtraDB Cluster Operator provides a choice of two cluster components to provide load balancing and proxy service: you can use either HAProxy or ProxySQL. You can control which one to use, if any, by enabling or disabling via the `haproxy.enabled` and `proxysql.enabled` options in the `deploy/cr.yaml` configuration file.

Use the following command to enable ProxySQL:

```
kubectl patch pxc cluster1 --type=merge --patch '{
  "spec": {
     "proxysql": {
        "enabled": true,
        "size": 3,
        "image": "percona/percona-xtradb-cluster-operator:1.5.0-proxysql" },
     "haproxy": { "enabled": false }
  }}'
```

Note: For obvious reasons the Operator will not allow the simultaneous enabling of both HAProxy and ProxySQL.

The resulting setup will use the number zero PXC member (`cluster1-pxc-0` by default) as writer.

When a cluster with ProxySQL is upgraded, the following steps take place. First, reader members are upgraded one by one: the Operator waits until the upgraded member shows up in ProxySQL with online status, and then proceeds to upgrade the next member. When the upgrade is finished for all the readers, then the writer PXC member is finally upgraded.

Note: when both ProxySQL and PXC are upgraded, they are upgraded in parallel.

15.1 Accessing the ProxySQL Admin Interface

You can use ProxySQL admin interface to configure its settings.

Configuring ProxySQL in this way means connecting to it using the MySQL protocol, and two things are needed to do it:

- the ProxySQL Pod name
- the ProxySQL admin password

You can find out ProxySQL Pod name with the `kubectl get pods` command, which will have the following output:

```
$ kubectl get pods
NAME                                               READY   STATUS    RESTARTS   AGE
cluster1-pxc-node-0                                1/1     Running   0          5m
cluster1-pxc-node-1                                1/1     Running   0          4m
cluster1-pxc-node-2                                1/1     Running   0          2m
cluster1-proxysql-0                                1/1     Running   0          5m
percona-xtradb-cluster-operator-dc67778fd-qtspz    1/1     Running   0          6m
```

The next command will print you the needed admin password:

```
kubectl get secrets $(kubectl get pxc -o jsonpath='{.items[].spec.secretsName}') -o␣
↪template='{{ .data.proxyadmin | base64decode }}'
```

When both Pod name and admin password are known, connect to the ProxySQL as follows, substituting `cluster1-proxysql-0` with the actual Pod name and `admin_password` with the actual password:

```
kubectl exec -it cluster1-proxysql-0 -- mysql -h127.0.0.1 -P6032 -uproxyadmin -padmin_
↪password
```

.

CHAPTER

SIXTEEN

TRANSPORT LAYER SECURITY (TLS)

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

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

The internal certificate is also used as an authorization method.

TLS security can be configured in several ways. By default, the Operator generates certificates automatically if there are no certificate secrets available. Other options are the following ones:

- The Operator can use a specifically installed *cert-manager* for the automatic certificates generation,
- Certificates can be generated manually.

You can also use pre-generated certificates available in the `deploy/ssl-secrets.yaml` file for test purposes, but we strongly recommend

avoiding their usage on any production system!

The following subsections explain how to configure TLS security with the Operator yourself, as well as how to temporarily disable it if needed.

16.1 Install and use the *cert-manager*

16.1.1 About the *cert-manager*

A *cert-manager* is a Kubernetes certificate management controller which widely used to automate the management and issuance of TLS certificates. It is community-driven, and open source.

When you have already installed *cert-manager* and deploy the operator, the operator requests a certificate from the *cert-manager*. The *cert-manager* acts as a self-signed issuer and generates certificates. The Percona Operator self-

signed issuer is local to the operator namespace. This self-signed issuer is created because PXC requires all certificates are issued by the same CA.

The creation of the self-signed issuer allows you to deploy and use the Percona Operator without creating a clusterissuer separately.

16.1.2 Installation of the *cert-manager*

The steps to install the *cert-manager* are the following:

- Create a namespace
- Disable resource validations on the cert-manager namespace
- Install the cert-manager.

The following commands perform all the needed actions:

```
kubectl create namespace cert-manager
kubectl label namespace cert-manager certmanager.k8s.io/disable-validation=true
kubectl apply -f https://raw.githubusercontent.com/jetstack/cert-manager/release-0.7/
↪deploy/manifests/cert-manager.yaml
```

After the installation, you can verify the *cert-manager* by running the following command:

```
kubectl get pods -n cert-manager
```

The result should display the *cert-manager* and webhook active and running.

16.2 Generate certificates manually

To generate certificates manually, follow these steps:

1. Provision a Certificate Authority (CA) to generate TLS certificates
2. Generate a CA key and certificate file with the server details
3. Create the server TLS certificates using the CA keys, certs, and server details

The set of commands generate certificates with the following attributes:

- `Server-pem` - Certificate
- `Server-key.pem` - the private key
- `ca.pem` - Certificate Authority

You should generate certificates twice: one set is for external communications, and another set is for internal ones. A secret created for the external use must be added to `cr.yaml/spec/secretsName`. A certificate generated for internal communications must be added to the `cr.yaml/spec/sslInternalSecretName`.

```
cat <<EOF | cfssl gencert -initca - | cfssljson -bare ca
{
  "CN": "Root CA",
  "key": {
    "algo": "rsa",
    "size": 2048
  }
}
```

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```
EOF

cat <<EOF | cfssl gencert -ca=ca.pem  -ca-key=ca-key.pem - | cfssljson -bare server
{
  "hosts": [
    "${CLUSTER_NAME}-proxysql",
    "*.${CLUSTER_NAME}-proxysql-unready",
    "*.${CLUSTER_NAME}-pxc"
  ],
  "CN": "${CLUSTER_NAME}-pxc",
  "key": {
    "algo": "rsa",
    "size": 2048
  }
}
EOF

kubectl create secret generic my-cluster-ssl --from-file=tls.crt=server.pem --
from-file=tls.key=server-key.pem --from-file=ca.crt=ca.pem --
type=kubernetes.io/tls
```

16.3 Run PXC without TLS

Omitting TLS is also possible, but we recommend that you run your cluster with the TLS protocol enabled.

To disable TLS protocol (e.g. for demonstration purposes) edit the `cr.yaml/spec/allowUnstafeConfigurations` setting to `true` and make sure that there are no certificate secrets available.

CHAPTER

SEVENTEEN

DATA-AT-REST ENCRYPTION

Full data-at-rest encryption in Percona XtraDB Cluster is supported by the Operator since version 1.4.0.

Note: Data at rest means inactive data stored as files, database records, etc.

To implement these features, the Operator uses `keyring_vault` plugin, which ships with Percona XtraDB Cluster, and utilizes HashiCorp Vault storage for encryption keys.

17.1 Installing Vault

The following steps will deploy Vault on Kubernetes with the Helm 3 package manager. Other Vault installation methods should also work, so the instruction placed here is not obligatory and is for illustration purposes.

1. Clone the official HashiCorp Vault Helm chart from GitHub:

```
$ git clone -b v0.4.0 https://github.com/hashicorp/vault-helm.git
$ cd vault-helm
```

2. Now use Helm to do the installation:

```
$ helm install vault-service ./
```

3. After the installation, Vauld should be first initialized and then unsealed. Initializing Vault is done with the following commands:

```
$ kubectl exec -it pod/vault-service-0 -- vault operator init -key-shares=1 -key-
↪threshold=1 -format=json > /tmp/vault-init
$ unsealKey=$(jq -r ".unseal_keys_b64[]" < /tmp/vault-init)
```

   To unseal Vault, execute the following command **for each Pod** of Vault running:

```
$ kubectl exec -it pod/vault-service-0 -- vault operator unseal "$unsealKey"
```

17.2 Configuring Vault

1. First, you should enable secrets within Vault. Get the Vault root token:

```
$ cat /tmp/vault-init | jq -r ".root_token"
```

The output will be like follows:

```
s.VgQvaXl8xGFO1RUxAPbPbsfN
```

Now login to Vault with this token and enable the "pxc-secret" secrets path:

```
$ kubectl exec -it vault-service-0 -- /bin/sh
$ vault login s.VgQvaXl8xGFO1RUxAPbPbsfN
$ vault secrets enable --version=1 -path=pxc-secret kv
```

Note: You can also enable audit, which is not mandatory, but useful:

```
$ vault audit enable file file_path=/vault/vault-audit.log
```

---

2. To enable Vault secret within Kubernetes, create and apply the YAML file, as described further.

2.1. To access the Vault server via HTTP, follow the next YAML file example:

```
apiVersion: v1
kind: Secret
metadata:
  name: some-name-vault
type: Opaque
stringData:
  keyring_vault.conf: |-
     token = s.VgQvaXl8xGFO1RUxAPbPbsfN
     vault_url = vault-service.vault-service.svc.cluster.local
     secret_mount_point = pxc-secret
```

Note: the `name` key in the above file should be equal to the `spec.vaultSecretName` key from the `deploy/cr.yaml` configuration file.

2.2. To turn on TLS and access the Vault server via HTTPS, you should do two more things:

- add one more item to the secret: the contents of the `ca.cert` file with your certificate,
- store the path to this file in the `vault_ca` key.

```
apiVersion: v1
kind: Secret
metadata:
  name: some-name-vault
type: Opaque
stringData:
  keyring_vault.conf: |-
    token = = s.VgQvaXl8xGFO1RUxAPbPbsfN
    vault_url = https://vault-service.vault-service.svc.cluster.local
    secret_mount_point = pxc-secret
```

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```
    vault_ca = /etc/mysql/vault-keyring-secret/ca.cert
  ca.cert: |-
    -----BEGIN CERTIFICATE-----
    MIIEczCCA1ugAwIBAgIBADANBgkqhkiG9w0BAQQFAD..AkGA1UEBhMCR0Ix
    EzARBgNVBAgTClNvbWUtU3RhdGUxFDASBgNVBAoTC0..0EgTHRkMTcwNQYD
    7vQMfXdGsRrXNGRGnX+vWDZ3/zWI0joDtCkNnqEpVn..HoX
    -----END CERTIFICATE-----
```

Note: the `name` key in the above file should be equal to the `spec.vaultSecretName` key from the `deploy/cr.yaml` configuration file.

Note: For techincal reasons the `vault_ca` key should either exist or not exist in the YAML file; commented option like `#vault_ca = ...` is not acceptable.

More details on how to install and configure Vault can be found in the official documentation.

17.3 Using the encryption

If using *Percona XtraDB Cluster* 5.7, you should turn encryption on explicitly when you create a table or a tablespace. This can be done by adding the `ENCRYPTION='Y'` part to your SQL statement, like in the following example:

```
CREATE TABLE t1 (c1 INT, PRIMARY KEY pk(c1)) ENCRYPTION='Y';
CREATE TABLESPACE foo ADD DATAFILE 'foo.ibd' ENCRYPTION='Y';
```

Note: See more details on encryption in Percona XtraDB Cluster 5.7 here.

If using *Percona XtraDB Cluster* 8.0, the encryption is turned on by default. The following table presents the default values of the correspondent my.cnf configuration options:

Option	Default value
early-plugin-load	keyring_vault.so
keyring_vault_config	/etc/mysql/vault-keyring-secret/keyring_vault.conf
default_table_encryption	ON
table_encryption_privilege_check	ON
innodb_undo_log_encrypt	ON
innodb_redo_log_encrypt	ON
binlog_encryption	ON
binlog_rotate_encryption_master_key_at_startup	ON
innodb_temp_tablespace_encrypt	ON
innodb_parallel_dblwr_encrypt	ON
innodb_encrypt_online_alter_logs	ON
encrypt_tmp_files	ON

Part V

Management

CHAPTER

EIGHTEEN

PROVIDING BACKUPS

Percona XtraDB Cluster Operator allows doing cluster backup in two ways. *Scheduled backups* are configured in the deploy/cr.yaml file to be executed automatically in proper time. *On-demand backups* can be done manually at any moment.

Backup files are usually stored on Amazon S3 or S3-compatible storage, but storing backups on Persistent Volumes is also possible.

18.1 Making scheduled backups

Since backups are stored separately on the Amazon S3, a secret with `AWS_ACCESS_KEY_ID` and `AWS_SECRET_ACCESS_KEY` should be present on the Kubernetes cluster. The secrets file with these keys should be created: for example `deploy/backup-s3.yaml` file with the following contents:

```
apiVersion: v1
kind: Secret
metadata:
  name: my-cluster-name-backup-s3
type: Opaque
data:
  AWS_ACCESS_KEY_ID: UkVQTEFDRS1XSVRILUFXUy1BQ0NFU1MtS0VZ
  AWS_SECRET_ACCESS_KEY: UkVQTEFDRS1XSVRILUFXUy1TRUNSRVQtS0VZ
```

The `name` value is the Kubernetes secret name which will be used further, and `AWS_ACCESS_KEY_ID` and `AWS_SECRET_ACCESS_KEY` are the keys to access S3 storage (and obviously they should contain proper values to make this access possible). To have effect secrets file should be applied with the appropriate command to create the secret object, e.g. `kubectl apply -f deploy/backup-s3.yaml` (for Kubernetes).

Backups schedule is defined in the `backup` section of the deploy/cr.yaml file. This section contains following subsections:

- `storages` subsection contains data needed to access the S3-compatible cloud to store backups.
- `schedule` subsection allows to actually schedule backups (the schedule is specified in crontab format).

Here is an example of deploy/cr.yaml which uses Amazon S3 storage for backups:

```
...
backup:
  enabled: true
  ...
  storages:
    s3-us-west:
      type: s3
      s3:
        bucket: S3-BACKUP-BUCKET-NAME-HERE
        region: us-west-2
        credentialsSecret: my-cluster-name-backup-s3
  ...
  schedule:
   - name: "sat-night-backup"
     schedule: "0 0 * * 6"
     keep: 3
     storageName: s3-us-west
  ...
```

if you use some S3-compatible storage instead of the original Amazon S3, the endpointURL is needed in the *s3* subsection which points to the actual cloud used for backups and is specific to the cloud provider. For example, using Google Cloud involves the following endpointUrl:

```
endpointUrl: https://storage.googleapis.com
```

The options within these three subsections are further explained in the *Custom Resource options*.

One option which should be mentioned separately is `credentialsSecret` which is a Kubernetes secret for backups. Value of this key should be the same as the name used to create the secret object (`my-cluster-name-backup-s3` in the last example).

The schedule is specified in crontab format as explained in *Custom Resource options*.

18.2 Making on-demand backup

To make an on-demand backup, the user should first configure the backup storage in the `backup.storages` subsection of the `deploy/cr.yaml` configuration file in a same way it was done for scheduled backups. When the `deploy/cr.yaml` file contains correctly configured storage and is applied with `kubectl` command, use *a special backup configuration YAML file* with the following contents:

- **backup name** in the `metadata.name` key,
- **PXC Cluster name** in the `spec.pxcCluster` key,
- **storage name** from `deploy/cr.yaml` in the `spec.storageName` key.

The example of the backup configuration file is deploy/backup/backup.yaml.

When the backup destination is configured and applied with *kubectl apply -f deploy/cr.yaml* command, the actual backup command is executed:

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

Note: Storing backup settings in a separate file can be replaced by passing its content to the `kubectl apply` command as follows:

```
cat <<EOF | kubectl apply -f-
apiVersion: pxc.percona.com/v1
kind: PerconaXtraDBClusterBackup
metadata:
  name: backup1
spec:
  pxcCluster: cluster1
  storageName: s3-us-west
EOF
```

18.3 Storing backup on a private volume

Here is an example of the `deploy/cr.yaml` backup section fragment, which configures a private volume for filesystem-type storage:

```
...
backup:
  ...
  storages:
    fs-pvc:
      type: filesystem
      volume:
        persistentVolumeClaim:
          accessModes: [ "ReadWriteOnce" ]
          resources:
            requests:
              storage: 6Gi
  ...
```

Note: Please take into account that 6Gi storage size specified in this example may be insufficient for the real-life setups; consider using tens or hundreds of gigabytes. Also, you can edit this option later, and changes will take effect after applying the updated `deploy/cr.yaml` file with `kubectl`.

18.4 Enabling compression for backups

There is a possibility to enable LZ4 compression for backups.

Note: This feature is available only with PXC 8.0 and not PXC 5.7.

To enable compression, use pxc-configuration key in the `deploy/cr.yaml` configuration file to supply Percona XtraDB Cluster nodes with two additional `my.cnf` options under its `[sst]` and `[xtrabackup]` sections as follows:

```
pxc:
  image: percona/percona-xtradb-cluster-operator:1.5.0-pxc8.0
  configuration: |
    ...
    [sst]
    xbstream-opts=--decompress
    [xtrabackup]
    compress=lz4
    ...
```

When enabled, compression will be used for both backups and SST.

18.5 Restore the cluster from a previously saved backup

Following steps are needed to restore a previously saved backup:

1. First of all make sure that the cluster is running.
2. Now find out correct names for the **backup** and the **cluster**. Available backups can be listed with the following command:

   ```
   kubectl get pxc-backup
   ```

   And the following command will list available clusters:

   ```
   kubectl get pxc
   ```

3. When both correct names are known, it is needed to fix `spec.pxcCluster` and `spec. backupName` fields in `deploy/backup/restore.yaml` file. After that, the actual restoration process can be started as follows:

   ```
   kubectl apply -f deploy/backup/restore.yaml
   ```

Note: Storing backup settings in a separate file can be replaced by passing its content to the `kubectl apply` command as follows:

```
cat <<EOF | kubectl apply -f-
apiVersion: "pxc.percona.com/v1"
kind: "PerconaXtraDBClusterRestore"
metadata:
  name: "restore1"
spec:
  pxcCluster: "cluster1"
  backupName: "backup1"
EOF
```

18.6 Delete the unneeded backup

Deleting 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 pxc-backup
```

When the name is known, backup can be deleted as follows:

```
kubectl delete pxc-backup/<backup-name>
```

18.7 Copy backup to a local machine

Make a local copy 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 pxc-backup
```

When the name is known, backup can be downloaded to the local machine as follows:

```
./deploy/backup/copy-backup.sh <backup-name> path/to/dir
```

For example, this downloaded backup can be restored to the local installation of Percona Server:

```
service mysqld stop
rm -rf /var/lib/mysql/*
cat xtrabackup.stream | xbstream -x -C /var/lib/mysql
xtrabackup --prepare --target-dir=/var/lib/mysql
chown -R mysql:mysql /var/lib/mysql
service mysqld start
```

CHAPTER

NINETEEN

PAUSE/RESUME PERCONA XTRADB CLUSTER

There may be external situations when it is needed to shutdown the PXC cluster for a while and then start it back up (some works related to the maintenance of the enterprise infrastructure, etc.).

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 shut down just revert the `spec.pause` key to `false`.

CHAPTER

TWENTY

UPGRADE PERCONA XTRADB CLUSTER

Starting from version 1.1.0, Percona Kubernetes Operator for Percona XtraDB Cluster allows upgrades to newer versions. This includes upgrades of the Operator itself, and upgrades of the Percona XtraDB Cluster.

20.1 Upgrading the Operator

This upgrade can be done either in semi-automatic or in manual mode.

Note: The manual update mode is the recomended way for a production cluster.

20.1.1 Semi-automatic upgrade

Note: Only the incremental update to a nearest minor version of the Operator is supported (for example, update from 1.2.0 to 1.3.0). To update to a newer version, which differs from the current version by more than one, make several incremental updates sequentially.

1. Update the Custom Resource Definition file for the Operator, taking it from the official repository on Github, and do the same for the Role-based access control:

```
kubectl apply -f https://raw.githubusercontent.com/percona/percona-xtradb-cluster-
↪operator/v1.5.0/deploy/crd.yaml
kubectl apply -f https://raw.githubusercontent.com/percona/percona-xtradb-cluster-
↪operator/v1.5.0/deploy/rbac.yaml
```

2. Edit the `deploy/cr.yaml` file, setting `updateStrategy` key to `RollingUpdate`.
3. Now you should apply a patch to your deployment, supplying necessary image names with a newer version tag. This is done with the `kubectl patch deployment` command. For example, updating to the `1.5.0` version should look as follows, depending on whether you are using Percona XtraDB Cluster 5.7 or 8.0.

A. For Percona XtraDB Cluster 5.7 run the following:

```
kubectl patch deployment percona-xtradb-cluster-operator \
   -p'{"spec":{"template":{"spec":{"containers":[{"name":"percona-xtradb-
↪cluster-operator","image":"percona/percona-xtradb-cluster-operator:1.5.0"}]}
↪}}}'

kubectl patch pxc cluster1 --type=merge --patch '{
   "metadata": {"annotations":{ "kubectl.kubernetes.io/last-applied-
↪configuration": "{\"apiVersion\":\"pxc.percona.com/v1-5-0\"}" }},
   "spec": {"pxc":{ "image": "percona/percona-xtradb-cluster-operator:1.5.0-
↪pxc5.7" },
       "proxysql": { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
↪proxysql" },
       "backup":   { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
↪pxc5.7-backup" },
       "pmm":      { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
↪pmm" }
   }}'
```

B. For Percona XtraDB Cluster 8.0 run the following:

```
kubectl patch deployment percona-xtradb-cluster-operator \
   -p'{"spec":{"template":{"spec":{"containers":[{"name":"percona-xtradb-
↪cluster-operator","image":"percona/percona-xtradb-cluster-operator:1.5.0"}]}
↪}}}'

kubectl patch pxc cluster1 --type=merge --patch '{
   "metadata": {"annotations":{ "kubectl.kubernetes.io/last-applied-
↪configuration": "{\"apiVersion\":\"pxc.percona.com/v1-5-0\"}" }},
   "spec": {"pxc":{ "image": "percona/percona-xtradb-cluster-operator:1.5.0-
↪pxc8.0" },
       "proxysql": { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
↪proxysql" },
       "backup":   { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
↪pxc8.0-backup" },
       "pmm":      { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
↪pmm" }
   }}'
```

4. 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 sts cluster1-pxc
```

20.1.2 Manual update

Note: Only the incremental update to a nearest minor version of the Operator is supported (for example, update from 1.2.0 to 1.3.0). To update to a newer version, which differs from the current version by more than one, make several incremental updates sequentially.

1. Update the Custom Resource Definition file for the Operator, taking it from the official repository on Github, and do the same for the Role-based access control:

```
kubectl apply -f https://raw.githubusercontent.com/percona/percona-xtradb-cluster-
↪operator/v1.5.0/deploy/crd.yaml
kubectl apply -f https://raw.githubusercontent.com/percona/percona-xtradb-cluster-
↪operator/v1.5.0/deploy/rbac.yaml
```

2. Edit the `deploy/cr.yaml` file, setting `updateStrategy` key to `OnDelete`.

3. Now you should apply a patch to your deployment, supplying necessary image names with a newer version tag. This is done with the `kubectl patch deployment` command. For example, updating to the `1.5.0` version should look as follows, depending on whether you are using Percona XtraDB Cluster 5.7 or 8.0.

   A. For Percona XtraDB Cluster 5.7 run the following:

   ```
   kubectl patch deployment percona-xtradb-cluster-operator \
      -p'{"spec":{"template":{"spec":{"containers":[{"name":"percona-xtradb-
   ↪cluster-operator","image":"percona/percona-xtradb-cluster-operator:1.5.0"}]}
   ↪}}}'

   kubectl patch pxc cluster1 --type=merge --patch '{
      "metadata": {"annotations":{ "kubectl.kubernetes.io/last-applied-
   ↪configuration": "{\"apiVersion\":\"pxc.percona.com/v1-5-0\"}" }},
      "spec": {"pxc":{ "image": "percona/percona-xtradb-cluster-operator:1.5.0-
   ↪pxc5.7" },
            "proxysql": { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
   ↪proxysql" },
            "backup":   { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
   ↪pxc5.7-backup" },
            "pmm":      { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
   ↪pmm" }
      }}'
   ```

   B. For Percona XtraDB Cluster 8.0 run the following:

   ```
   kubectl patch deployment percona-xtradb-cluster-operator \
      -p'{"spec":{"template":{"spec":{"containers":[{"name":"percona-xtradb-
   ↪cluster-operator","image":"percona/percona-xtradb-cluster-operator:1.5.0"}]}
   ↪}}}'

   kubectl patch pxc cluster1 --type=merge --patch '{
      "metadata": {"annotations":{ "kubectl.kubernetes.io/last-applied-
   ↪configuration": "{\"apiVersion\":\"pxc.percona.com/v1-5-0\"}" }},
      "spec": {"pxc":{ "image": "percona/percona-xtradb-cluster-operator:1.5.0-
   ↪pxc8.0" },
            "proxysql": { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
   ↪proxysql" },
            "backup":   { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
   ↪pxc8.0-backup" },
            "pmm":      { "image": "percona/percona-xtradb-cluster-operator:1.5.0-
   ↪pmm" }
      }}'
   ```

4. The Pod with the newer Percona XtraDB Cluster image will start after you delete it. Delete targeted Pods manually one by one to make them restart in desired order:

   1. Delete the Pod using its name with the command like the following one:

   ```
   kubectl delete pod cluster1-pxc-2
   ```

   2. Wait until Pod becomes ready:

```
kubectl get pod cluster1-pxc-2
```

The output should be like this:

```
NAME              READY   STATUS    RESTARTS   AGE
cluster1-pxc-2    1/1     Running   0          3m33s
```

5. The update process is successfully finished when all Pods have been restarted.

20.2 Upgrading Percona XtraDB Cluster

Starting from version 1.5.0, the Operator can do fully automatic upgrades to the newer versions of Percona XtraDB Cluster within the method named *Smart Updates*.

To have this upgrade method enabled, make sure that the `updateStrategy` key in the `deploy/cr.yaml` configuration file is set to `SmartUpdate`.

When automatic updates are enabled, the Operator will carry on upgrades according to the following algorithm. It will query a special *Version Service* server at scheduled times to obtain fresh information about version numbers and valid image paths needed for the upgrade. If the current version should be upgraded, the Operator updates the CR to reflect the new image paths and carries on sequential Pods deletion in a safe order, allowing StatefulSet to redeploy the cluster Pods with the new image.

The upgrade details are set in the `upgradeOptions` section of the `deploy/cr.yaml` configuration file. Make the following edits to configure updates:

1. Set the `apply` option to one of the following values:

   - `Recommended` - automatic upgrades will choose the most recent version of software flagged as Recommended (for clusters created from scratch, the PXC 8.0 version will be selected instead of the PCX 5.7 one regardless of the image path; for already existing clusters, the 8.0 vs. 5.7 branch choice will be preserved),
   - `Latest` - automatic upgrades will choose the most recent version of the software available (for clusters created from scratch, the PXC 8.0 version will be selected instead of the PCX 5.7 one regardless of the image path; for already existing clusters, the 8.0 vs. 5.7 branch choice will be preserved),
   - *specific version number* - will apply an upgrade if the running PXC version doesn't match the explicit version number with no future upgrades (version numbers are specified as `5.7.26-31.37`, `5.7.27-31.39`, `5.7.28-31.41.2`, `5.7.29-31.43`, etc.),
   - `Never` or `Disabled` - disable automatic upgrades

   Note: When automatic upgrades are disabled by the `apply` option, Smart Update functionality will continue working for changes triggered by other events, such as updating a ConfigMap, rotating a password, or changing resource values.

2. Make sure the `versionServiceEndpoint` key is set to a valid Version Server URL (otherwise Smart Updates will not occur).

   A. You can use the URL of the official Percona's Version Service (default). Set `versionServiceEndpoint` to `https://check.percona.com/versions`.

   B. Alternatively, you can run Version Service inside your cluster. This can be done with the `kubectl` command as follows:

```
kubectl run version-service --image=perconalab/version-service --env="SERVE_
↪HTTP=true" --port 11000 --expose
```

Note: Version Service is never checked if automatic updates are disabled. If automatic updates are enabled, but Version Service URL can not be reached, upgrades will not occur.

3. Use the `schedule` option to specify the update checks time in CRON format.

The following example sets the midnight update checks with the official Percona's Version Service:

```
spec:
  updateStrategy: SmartUpdate
  upgradeOptions:
    apply: Recommended
    versionServiceEndpoint: https://check.percona.com/versions
    schedule: "0 0 * * *"
...
```

CHAPTER

TWENTYONE

SCALE PERCONA XTRADB CLUSTER ON KUBERNETES AND OPENSHIFT

One of the great advantages brought by Kubernetes and the OpenShift platform is the ease of an application scaling. Scaling a Deployment up or down ensures new Pods are created and set to available Kubernetes nodes.

Size of the cluster is controlled by a *size key* in the *Custom Resource options* configuration. That's why scaling the cluster needs nothing more but changing this option and applying the updated configuration file. This may be done in a specifically saved config, or on the fly, using the following command:

```
$ kubectl patch pxc cluster1 --type='json' -p='[{"op": "replace", "path": "/spec/pxc/
↪size", "value": 5 }]'
```

In this example we have changed the size of the Percona XtraDB Cluster to `5` nodes.

Warning: Using `kubectl scale StatefulSet_name` command to rescale Percona XtraDB Cluster is not recommended, as it makes `size` configuration option out of sync, and the next config change may result in reverting the previous number of nodes.

21.1 Increase the Persistent Volume Claim size

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. The user cannot shrink the size of an existing PVC object. Certain volume types support, be default, expanding PVCs (details about PVCs and the supported volume types can be found in Kubernetes documentation)

The following are the steps to increase the size:

0. Extract and backup the yaml file for the cluster

   ```
   kubectl get pxc cluster1 -o yaml --export > CR_backup.yaml
   ```

1. Delete the cluster

   ```
   kubectl delete -f CR_backup.yaml
   ```

2. For each node, edit the yaml to resize the PVC object.

   ```
   kubectl edit pvc datadir-cluster1-pxc-0
   ```

   In the yaml, edit the spec.resources.requests.storage value.

```
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 6Gi
```

Perform the same operation on the other nodes.

```
kubectl edit pvc datadir-cluster1-pxc-1
kubectl edit pvc datadir-cluster1-pxc-2
```

3. In the CR configuration file, use vim or another text editor to edit the PVC size.

```
vim CR_backup.yaml
```

4. Apply the updated configuration to the cluster.

```
kubectl apply -f CR_backup.yaml
```

CHAPTER

TWENTYTWO

CRASH RECOVERY

22.1 What does the full cluster crash mean?

A full cluster crash is a situation when all database instances where shut down in random order. Being rebooted after such situation, Pod is continuously restarting, and generates the following errors in the log:

```
It may not be safe to bootstrap the cluster from this node. It was not the last one␣
↪to leave the cluster and may not contain all the updates.
To force cluster bootstrap with this node, edit the grastate.dat file manually and␣
↪set safe_to_bootstrap to 1
```

Note: To avoid this, shutdown your cluster correctly as it is written in *Pause/resume Percona XtraDB Cluster*.

The Percona Operator for Percona XtraDB Cluster provides two ways of recovery after a full cluster crash.

- The automated *Bootstrap Crash Recovery method* is the simplest one, but it may cause loss of several recent transactions.
- The manual *Object Surgery Crash Recovery method* includes a lot of operations, but it allows to restore all the data.

22.2 Bootstrap Crash Recovery method

In this case recovery is done automatically. The recovery is triggered by the `pxc.forceUnsafeBootstrap` option set to `true` in the `deploy/cr.yaml` file:

```
pxc:
  ...
  forceUnsafeBootstrap: true
```

Applying this option forces the cluster to start. However, there may exist data inconsistency in the cluster, and several last transactions may be lost. If such data loss is undesirable, experienced users may choose the more advanced manual method described in the next chapter.

22.3 Object Surgery Crash Recovery method

Warning: This method is intended for advanced users only!

This method involves the following steps: * swap the original PXC image with the *debug image*, which

does not reboot after the crash, and force all Pods to run it,

- find the Pod with the most recent PXC data, run recovery on it, start `mysqld`, and allow the cluster to be restarted,
- revert all temporary substitutions.

Let's assume that a full crash did occur for the cluster named `cluster1`, which is based on three PXC Pods.

Note: The following commands are written for PXC 8.0. The same steps are also for PXC 5.7 unless specifically indicated otherwise.

1. Change the normal PXC image inside the cluster object to the debug image:

```
$ kubectl patch pxc cluster1 --type="merge" -p '{"spec":{"pxc":{"image":"percona/
↪percona-xtradb-cluster-operator:1.5.0-pxc8.0-debug"}}}'
```

Note: For PXC 5.7 this command should be as follows:

```
$ kubectl patch pxc cluster1 --type="merge" -p '{"spec":{"pxc":{"image":"percona/
↪percona-xtradb-cluster-operator:1.5.0-pxc5.7-debug"}}}'
```

2. Restart all Pods:

```
$ $ for i in $(seq 0 $(($(kubectl get pxc cluster1 -o jsonpath='{.spec.pxc.
↪size}')-1))); do kubectl delete pod cluster1-pxc-$i --force --grace-
↪period=0; done
```

3. Wait until the Pod `0` is ready, and execute the following code (it is required for the Pod liveness check):

```
$ for i in $(seq 0 $(($(kubectl get pxc cluster1 -o jsonpath='{.spec.pxc.size}')-
↪1))); do until [[ $(kubectl get pod cluster1-pxc-$i -o jsonpath='{.status.phase}
↪') == 'Running' ]]; do sleep 10; done; kubectl exec cluster1-pxc-$i -- touch /
↪var/lib/mysql/sst_in_progress; done
```

4. Wait for all PXC Pods to start, then find the PXC instance with the most recent data - i.e. the one with the highest sequence number (seqno):

```
$ for i in $(seq 0 $(($(kubectl get pxc cluster1 -o jsonpath='{.spec.pxc.size}')-
↪1))); do echo "###############cluster1-pxc-$i###############"; kubectl exec␣
↪cluster1-pxc-$i -- cat /var/lib/mysql/grastate.dat; done
```

The output of this command should be similar to the following one:

```
###############cluster1-pxc-0##############
# GALERA saved state
```

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```
version: 2.1
uuid:    7e037079-6517-11ea-a558-8e77af893c93
seqno:   18
safe_to_bootstrap: 0
###############cluster1-pxc-1#############
# GALERA saved state
version: 2.1
uuid:    7e037079-6517-11ea-a558-8e77af893c93
seqno:   18
safe_to_bootstrap: 0
###############cluster1-pxc-2#############
# GALERA saved state
version: 2.1
uuid:    7e037079-6517-11ea-a558-8e77af893c93
seqno:   19
safe_to_bootstrap: 0
```

Now find the Pod with the largest `seqno` (it is `cluster1-pxc-2` in the above example).

5. Now execute the following commands *in a separate shell* to start this instance:

```
$ kubectl exec cluster1-pxc-2 -- mysqld --wsrep_recover
$ kubectl exec cluster1-pxc-2 -- sed -i 's/safe_to_bootstrap: 0/safe_to_
↪bootstrap: 1/g' /var/lib/mysql/grastate.dat
$ kubectl exec cluster1-pxc-2 -- sed -i 's/wsrep_cluster_address=.*/wsrep_cluster_
↪address=gcomm:\/\//g' /etc/mysql/node.cnf
$ kubectl exec cluster1-pxc-2 -- mysqld
```

The `mysqld` process will initialize the database once again, and it will be available for the incoming connections.

6. Go back *to the previous shell* and return the original PXC image because the debug image is no longer needed:

```
$ kubectl patch pxc cluster1 --type="merge" -p '{"spec":{"pxc":{"image":"percona/
↪percona-xtradb-cluster-operator:1.5.0-pxc8.0"}}}'
```

Note: For PXC 5.7 this command should be as follows:

```
$ kubectl patch pxc cluster1 --type="merge" -p '{"spec":{"pxc":{"image":"percona/
↪percona-xtradb-cluster-operator:1.5.0-pxc5.7"}}}'
```

---

7. Restart all Pods besides the `cluster1-pxc-2` Pod (the recovery donor).

```
$ for i in $(seq 0 $(($(kubectl get pxc cluster1 -o jsonpath='{.spec.pxc.size}')-
↪1))); do until [[ $(kubectl get pod cluster1-pxc-$i -o jsonpath='{.status.phase}
↪') == 'Running' ]]; do sleep 10; done; kubectl exec cluster1-pxc-$i -- rm /var/
↪lib/mysql/sst_in_progress; done
$ kubectl delete pods --force --grace-period=0 cluster1-pxc-0 cluster1-pxc-1
```

8. Wait for the successful startup of the Pods which were deleted during the previous step, and finally remove the `cluster1-pxc-2` Pod:

```
$ kubectl delete pods --force --grace-period=0 cluster1-pxc-2
```

9. After the Pod startup, the cluster is fully recovered.

CHAPTER

TWENTYTHREE

DEBUG

For the cases when Pods are failing for some reason or just show abnormal behavior, the Operator can be used with a special *debug image* of the Percona XtraDB Cluster, which has the following specifics:

- it avoids restarting on fail,
- it contains additional tools useful for debugging (sudo, telnet, gdb, etc.),
- it has debug mode enabled for the logs.

Particularly, using this image is useful if the container entry point fails (`mysqld` crashes). In such a situation, Pod is continuously restarting. Continuous restarts prevent to get console access to the container, and so a special approach is needed to make fixes.

To use the debug image instead of the normal one, set the following image name for the `pxc.image` key in the `deploy/cr.yaml` configuration file:

- `percona/percona-xtradb-cluster-operator:1.5.0-pxc8.0-debug` for PXC 8.0,
- `percona/percona-xtradb-cluster-operator:1.5.0-pxc5.7-debug` for PXC 5.7.

The Pod should be restarted to get the new image.

Note: When the Pod is continuously restarting, you may have to delete it to apply image changes.

Part VI

Reference

CHAPTER

TWENTYFOUR

CUSTOM RESOURCE OPTIONS

The operator is configured via the spec section of the deploy/cr.yaml file. This file contains the following spec sections to configure three main subsystems of the cluster:

Key	Value type	Default	Description
upgradeOptions	subdoc		Percona XtraDB Cluster upgrade options section
pxc	subdoc		Percona XtraDB Cluster general section
proxysql	subdoc		ProxySQL section
pmm	subdoc		Percona Monitoring and Management section
backup	subdoc		Percona XtraDB Cluster backups section
allowUnsafeConfigurations	boolean	`false`	Prevents users from configuring a cluster with unsafe parameters such as starting the cluster with less than 3 nodes or starting the cluster without TLS/SSL certificates
secretsName	string	`my-cluster-secrets`	A name for *users secrets*
vaultSecretName	string	`keyring-secret-vault`	A secret for the HashiCorp Vault to carry on *Data-at-Rest Encryption*
sslSecretName	string	`my-cluster-ssl`	A secret with TLS certificate generated for *external* communications, see *Transport Layer Security (TLS)* for details
sslInternalSecretName	string	`my-cluster-ssl-internal`	A secret with TLS certificate generated for *internal* communications, see *Transport Layer Security (TLS)* for details
updateStrategy	string	`SmartUpdate`	A strategy the Operator uses for upgrades

24.1 Upgrade Options Section

The `upgradeOptions` section in the deploy/cr.yaml file contains various configuration options to control Percona XtraDB Cluster upgrades.

Key	upgradeOptions.versionServiceEndpoint
Value	string
Example	`https://check.percona.com/versions`
Description	The Version Service URL used to check versions compatibility for upgrade
Key	upgradeOptions.apply
Value	string
Example	`Disabled`
Description	Specifies how *updates are processed* by the Operator. `Never` or `Disabled` will completely disable automatic upgrades, otherwise it can be set to `Latest` or `Recommended` or to a specific version string of PXC (e.g. `8.0.19-10.1`) that is wished to be version-locked (so that the user can control the version running, but use automatic upgrades to move between them).
Key	upgradeOptions.schedule
Value	string
Example	`0 2 * * *`
Description	Scheduled time to check for updates, specified in the crontab format

24.2 PXC Section

The `pxc` section in the deploy/cr.yaml file contains general configuration options for the Percona XtraDB Cluster.

Key	pxc.size
Value	int
Example	`3`
Description	The size of the Percona XtraDB cluster must be >= 3 for High Availability
Key	pxc.image
Value	string
Example	`percona/percona-xtradb-cluster-operator:1.5.0-pxc`
Description	The Docker image of the Percona cluster used
Key	pxc.readinessDelaySec
Value	int
Example	`15`
Description	Adds a delay before a run check to verify the application is ready to process traffic
Key	pxc.livenessDelaySec
Value	int
Example	`300`
Description	Adds a delay before the run check ensures the application is healthy and capable of processing requests

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Table 1 – continued from previous page

Key	pxc.forceUnsafeBootstrap
Value	boolean
Example	`false`
Description	The setting can be reset in case of a sudden crash when all nodes may be considered unsafe to bootstrap from. The setting lets a node be selected and set to `safe_to_bootstrap` and provides data recovery
Key	pxc.configuration
Value	string

Example	`|`
	`[mysqld]`
	`wsrep_debug=ON`
	`wsrep-provider_options=gcache.size=1G;gcache.recover=yes`

Description	The `my.cnf` file options to be passed to Percona XtraDB cluster nodes
Key	pxc.imagePullSecrets.name
Value	string
Example	`private-registry-credentials`
Description	The Kubernetes ImagePullSecret
Key	pxc.priorityClassName
Value	string
Example	`high-priority`
Description	The Kubernetes Pod priority class
Key	pxc.schedulerName
Value	string
Example	`default-scheduler`
Description	The Kubernetes Scheduler
Key	pxc.annotations
Value	label
Example	`iam.amazonaws.com/role: role-arn`
Description	The Kubernetes annotations
Key	pxc.labels
Value	label
Example	`rack: rack-22`
Description	Labels are key-value pairs attached to objects
Key	pxc.resources.requests.memory
Value	string
Example	`1G`
Description	The Kubernetes memory requests for a PXC container
Key	pxc.resources.requests.cpu
Value	string
Example	`600m`
Description	Kubernetes CPU requests for a PXC container

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Table 1 – continued from previous page

Key	pxc.resources.limits.memory
Value	string
Example	`1G`
Description	Kubernetes memory limits for a PXC container
Key	pxc.nodeSelector
Value	label
Example	`disktype: ssd`
Description	Kubernetes nodeSelector
Key	pxc.affinity.topologyKey
Value	string
Example	`kubernetes.io/hostname`
Description	The Operator topology key node anti-affinity constraint
Key	pxc.affinity.advanced
Value	subdoc
Example	
Description	In cases where the Pods require complex tuning the *advanced* option turns off the `topologyKey` effect. This setting allows the standard Kubernetes affinity constraints of any complexity to be used
Key	pxc.tolerations
Value	subdoc
Example	`node.alpha.kubernetes.io/unreachable`
Description	Kubernetes Pod tolerations
Key	pxc.podDisruptionBudget.maxUnavailable
Value	int
Example	`1`
Description	The Kubernetes podDisruptionBudget specifies the number of Pods from the set unavailable after the eviction
Key	pxc.podDisruptionBudget.minAvailable
Value	int
Example	`0`
Description	The Kubernetes podDisruptionBudget Pods that must be available after an eviction
Key	pxc.volumeSpec.emptyDir
Value	string
Example	`{}`
Description	The Kubernetes emptyDir volume The directory created on a node and accessible to the PXC Pod containers
Key	pxc.volumeSpec.hostPath.path
Value	string
Example	`/data`
Description	Kubernetes hostPath The volume that mounts a directory from the host node's filesystem into your Pod. The path property is required

continues on next page

Table 1 – continued from previous page

Key	pxc.volumeSpec.hostPath.type
Value	string
Example	`Directory`
Description	The Kubernetes hostPath. An optional property for the hostPath
Key	pxc.volumeSpec.persistentVolumeClaim.storageClassName
Value	string
Example	`standard`
Description	Set the Kubernetes storage class to use with the PXC PersistentVolumeClaim
Key	pxc.volumeSpec.persistentVolumeClaim.accessModes
Value	array
Example	`[ReadWriteOnce]`
Description	The Kubernetes PersistentVolumeClaim access modes for the Percona XtraDB cluster
Key	pxc.volumeSpec.resources.requests.storage
Value	string
Example	`6Gi`
Description	The Kubernetes PersistentVolumeClaim size for the Percona XtraDB cluster
Key	pxc.gracePeriod
Value	int
Example	`600`
Description	The Kubernetes grace period when terminating a Pod
Key	pxc.containerSecurityContext
Value	subdoc
Example	`privileged: true`
Description	A custom Kubernetes Security Context for a Container to be used instead of the default one
Key	pxc.podSecurityContext
Value	subdoc
Example	`fsGroup: 1001` `supplementalGroups: [1001, 1002, 1003]`
Description	A custom Kubernetes Security Context for a Pod to be used instead of the default one

24.3 HAProxy Section

The `haproxy` section in the deploy/cr.yaml file contains configuration options for the HAProxy service.

Key	haproxy.enabled
Value	boolean
Example	`true`
Description	Enables or disables load balancing with HAProxy Services
Key	haproxy.size
Value	int

continues on next page

Table 2 – continued from previous page

Example	`3`
Description	The number of the HAProxy Pods to provide load balancing
Key	haproxy.image
Value	string
Example	`percona/percona-xtradb-cluster-operator:1.5.0-haproxy`
Description	HAProxy Docker image to use
Key	haproxy.imagePullSecrets.name
Value	string
Example	`private-registry-credentials`
Description	The Kubernetes imagePullSecrets for the HAProxy image
Key	haproxy.configuration
Value	string
Example	
Description	The custom HAProxy configuration file contents
Key	haproxy.annotations
Value	label
Example	`iam.amazonaws.com/role: role-arn`
Description	The Kubernetes annotations metadata
Key	haproxy.labels
Value	label
Example	`rack: rack-22`
Description	Labels are key-value pairs attached to objects
Key	haproxy.servicetype
Value	string
Example	`ClusterIP`
Description	Specifies the type of Kubernetes Service to be used
Key	haproxy.resources.requests.memory
Value	string
Example	`1G`
Description	The Kubernetes memory requests for the main HAProxy container
Key	haproxy.resources.requests.cpu
Value	string
Example	`600m`
Description	Kubernetes CPU requests for the main HAProxy container
Key	haproxy.resources.limits.memory
Value	string
Example	`1G`
Description	Kubernetes memory limits for the main HAProxy container
Key	haproxy.resources.limits.cpu
Value	string

continues on next page

Table 2 – continued from previous page

Example	`700m`
Description	Kubernetes CPU limits for the main HAProxy container
Key	haproxy.sidecarResources.requests.memory
Value	string
Example	`1G`
Description	The Kubernetes memory requests for the sidecar HAProxy containers
Key	haproxy.sidecarResources.requests.cpu
Value	string
Example	`500m`
Description	Kubernetes CPU requests for the sidecar HAProxy containers
Key	haproxy.sidecarResources.limits.memory
Value	string
Example	`2G`
Description	Kubernetes memory limits for the sidecar HAProxy containers
Key	haproxy.sidecarResources.limits.cpu
Value	string
Example	`600m`
Description	Kubernetes CPU limits for the sidecar HAProxy containers
Key	haproxy.priorityClassName
Value	string
Example	`high-priority`
Description	The Kubernetes Pod Priority class for HAProxy
Key	haproxy.schedulerName
Value	string
Example	`default-scheduler`
Description	The Kubernetes Scheduler
Key	haproxy.nodeSelector
Value	label
Example	`disktype: ssd`
Description	Kubernetes nodeSelector
Key	haproxy.affinity.topologyKey
Value	string
Example	`kubernetes.io/hostname`
Description	The Operator topology key node anti-affinity constraint
Key	haproxy.affinity.advanced
Value	subdoc
Example	
Description	If available it makes a topologyKey node affinity constraint to be ignored
Key	haproxy.tolerations
Value	subdoc

continues on next page

Table 2 – continued from previous page

Example	`node.alpha.kubernetes.io/unreachable`
Description	Kubernetes Pod tolerations
Key	haproxy.podDisruptionBudget.maxUnavailable
Value	int
Example	`1`
Description	The Kubernetes podDisruptionBudget specifies the number of Pods from the set unavailable after the eviction
Key	haproxy.podDisruptionBudget.minAvailable
Value	int
Example	`0`
Description	The Kubernetes podDisruptionBudget Pods that must be available after an eviction
Key	haproxy.gracePeriod
Value	int
Example	`30`
Description	The Kubernetes grace period when terminating a Pod
Key	haproxy.loadBalancerSourceRanges
Value	string
Example	`10.0.0.0/8`
Description	The range of client IP addresses from which the load balancer should be reachable (if not set, there is no limitations)
Key	haproxy.serviceAnnotations
Value	string
Example	`service.beta.kubernetes.io/aws-load-balancer-backend-protocol: http`
Description	The Kubernetes annotations metadata for the load balancer Service
Key	haproxy.serviceAccountName
Value	string
Example	`percona-xtradb-cluster-operator-workload`
Description	The Kubernetes Service Account for the HAProxy Pod

24.4 ProxySQL Section

The `proxysql` section in the deploy/cr.yaml file contains configuration options for the ProxySQL daemon.

Key	proxysql.enabled
Value	boolean
Example	`false`
Description	Enables or disables load balancing with ProxySQL Services
Key	proxysql.size
Value	int
Example	`1`

continues on next page

Table 3 – continued from previous page

Description	The number of the ProxySQL daemons to provide load balancing must be = 1 in current release
Key	proxysql.image
Value	string
Example	`percona/percona-xtradb-cluster-operator:1.5.0-proxysql`
Description	ProxySQL Docker image to use
Key	proxysql.imagePullSecrets.name
Value	string
Example	`private-registry-credentials`
Description	The Kubernetes imagePullSecrets for the ProxySQL image
Key	proxysql.annotations
Value	label
Example	`iam.amazonaws.com/role: role-arn`
Description	The Kubernetes annotations metadata
Key	proxysql.labels
Value	label
Example	`rack: rack-22`
Description	Labels are key-value pairs attached to objects
Key	proxysql.servicetype
Value	string
Example	`ClusterIP`
Description	Specifies the type of Kubernetes Service to be used
Key	proxysql.resources.requests.memory
Value	string
Example	`1G`
Description	The Kubernetes memory requests for the main ProxySQL container
Key	proxysql.resources.requests.cpu
Value	string
Example	`600m`
Description	Kubernetes CPU requests for the main ProxySQL container
Key	proxysql.resources.limits.memory
Value	string
Example	`1G`
Description	Kubernetes memory limits for the main ProxySQL container
Key	proxysql.resources.limits.cpu
Value	string
Example	`700m`
Description	Kubernetes CPU limits for the main ProxySQL container
Key	proxysql.sidecarResources.requests.memory
Value	string
Example	`1G`

continues on next page

Table 3 – continued from previous page

Description	The Kubernetes memory requests for the sidecar ProxySQL containers
Key	proxysql.sidecarResources.requests.cpu
Value	string
Example	`500m`
Description	Kubernetes CPU requests for the sidecar ProxySQL containers
Key	proxysql.sidecarResources.limits.memory
Value	string
Example	`2G`
Description	Kubernetes memory limits for the sidecar ProxySQL containers
Key	proxysql.sidecarResources.limits.cpu
Value	string
Example	`600m`
Description	Kubernetes CPU limits for the sidecar ProxySQL containers
Key	proxysql.priorityClassName
Value	string
Example	`high-priority`
Description	The Kubernetes Pod Priority class for ProxySQL
Key	proxysql.schedulerName
Value	string
Example	`default-scheduler`
Description	The Kubernetes Scheduler
Key	proxysql.nodeSelector
Value	label
Example	`disktype: ssd`
Description	Kubernetes nodeSelector
Key	proxysql.affinity.topologyKey
Value	string
Example	`kubernetes.io/hostname`
Description	The Operator topology key node anti-affinity constraint
Key	proxysql.affinity.advanced
Value	subdoc
Example	
Description	If available it makes a topologyKey node affinity constraint to be ignored
Key	proxysql.tolerations
Value	subdoc
Example	`node.alpha.kubernetes.io/unreachable`
Description	Kubernetes Pod tolerations
Key	proxysql.volumeSpec.emptyDir
Value	string
Example	`{}`

continues on next page

Table 3 – continued from previous page

Description	The Kubernetes emptyDir volume The directory created on a node and accessible to the PXC Pod containers
Key	proxysql.volumeSpec.hostPath.path
Value	string
Example	`/data`
Description	Kubernetes hostPath The volume that mounts a directory from the host node's filesystem into your Pod. The path property is required
Key	proxysql.volumeSpec.hostPath.type
Value	string
Example	`Directory`
Description	The Kubernetes hostPath. An optional property for the hostPath
Key	proxysql.volumeSpec.persistentVolumeClaim.storageClassName
Value	string
Example	`standard`
Description	Set the Kubernetes storage class to use with the PXC PersistentVolumeClaim
Key	proxysql.volumeSpec.persistentVolumeClaim.accessModes
Value	array
Example	`[ReadWriteOnce]`
Description	The Kubernetes PersistentVolumeClaim access modes for the Percona XtraDB cluster
Key	proxysql.volumeSpec.resources.requests.storage
Value	string
Example	`6Gi`
Description	The Kubernetes PersistentVolumeClaim size for the Percona XtraDB cluster
Key	proxysql.podDisruptionBudget.maxUnavailable
Value	int
Example	`1`
Description	The Kubernetes podDisruptionBudget specifies the number of Pods from the set unavailable after the eviction
Key	proxysql.podDisruptionBudget.minAvailable
Value	int
Example	`0`
Description	The Kubernetes podDisruptionBudget Pods that must be available after an eviction
Key	proxysql.gracePeriod
Value	int
Example	`30`
Description	The Kubernetes grace period when terminating a Pod
Key	proxysql.loadBalancerSourceRanges
Value	string
Example	`10.0.0.0/8`
Description	The range of client IP addresses from which the load balancer should be reachable (if not set, there is no limitations)

continues on next page

Table 3 – continued from previous page

Key	proxysql.serviceAnnotations
Value	string
Example	`service.beta.kubernetes.io/aws-load-balancer-backend-protocol: http`
Description	The Kubernetes annotations metadata for the load balancer Service
Key	proxysql.serviceAccountName
Value	string
Example	`percona-xtradb-cluster-operator-workload`
Description	The Kubernetes Service Account for the ProxySQL Pod

24.5 PMM Section

The `pmm` section in the deploy/cr.yaml file contains configuration options for Percona Monitoring and Management.

Key	pmm.enabled
Value	boolean
Example	`false`
Description	Enables or disables monitoring Percona XtraDB cluster with PMM
Key	pmm.image
Value	string
Example	`perconalab/pmm-client:1.17.1`
Description	PMM client Docker image to use
Key	pmm.serverHost
Value	string
Example	`monitoring-service`
Description	Address of the PMM Server to collect data from the cluster
Key	pmm.serverUser
Value	string
Example	`pmm`
Description	The PMM Serve_User. The PMM Server password should be configured using Secrets
Key	pmm.resources.requests.memory
Value	string
Example	`200M`
Description	The Kubernetes memory requests for a PMM container
Key	pmm.resources.requests.cpu
Value	string
Example	`500m`
Description	Kubernetes CPU requests for a PMM container

24.6 Backup Section

The `backup` section in the deploy/cr.yaml file contains the following configuration options for the regular Percona XtraDB Cluster backups.

Key	backup.image
Value	string
Example	`percona/percona-xtradb-cluster-operator:1.5.0-backup`
Description	The Percona XtraDB cluster Docker image to use for the backup
Key	backup.imagePullSecrets.name
Value	string
Example	`private-registry-credentials`
Description	The Kubernetes imagePullSecrets for the specified image
Key	backup.storages.<storage-name>.type
Value	string
Example	`s3`
Description	The cloud storage type used for backups. Only `s3` and `filesystem` types are supported
Key	backup.storages.<storage-name>.s3.credentialsSecret
Value	string
Example	`my-cluster-name-backup-s3`
Description	The Kubernetes secret for backups. It should contain `AWS_ACCESS_KEY_ID` and `AWS_SECRET_ACCESS_KEY` keys.
Key	backup.storages.<storage-name>.s3.bucket
Value	string
Example	
Description	The Amazon S3 bucket name for backups
Key	backup.storages.s3.<storage-name>.region
Value	string
Example	`us-east-1`
Description	The AWS region to use. Please note **this option is mandatory** for Amazon and all S3-compatible storages
Key	backup.storages.s3.<storage-name>.endpointUrl
Value	string
Example	
Description	The endpoint URL of the S3-compatible storage to be used (not needed for the original Amazon S3 cloud)
Key	backup.storages.<storage-name>.persistentVolumeClaim.type
Value	string
Example	`filesystem`
Description	The persistent volume claim storage type
Key	backup.storages.<storage-name>.persistentVolumeClaim.storageClassName
Value	string
Example	`standard`

continues on next page

Table 4 – continued from previous page

Description	Set the Kubernetes Storage Class to use with the PXC backups PersistentVolumeClaims for the `filesystem` storage type
Key	backup.storages.<storage-name>.persistentVolumeClaim.accessModes
Value	array
Example	`[ReadWriteOne]`
Description	The Kubernetes PersistentVolume access modes
Key	backup.storages.<storage-name>.persistentVolumeClaim.storage
Value	string
Example	`6Gi`
Description	Storage size for the PersistentVolume
Key	backup.storages.<storage-name>.annotations
Value	label
Example	`iam.amazonaws.com/role: role-arn`
Description	The Kubernetes annotations
Key	backup.storages.<storage-name>.labels
Value	label
Example	`rack: rack-22`
Description	Labels are key-value pairs attached to objects
Key	backup.storages.<storage-name>.resources.requests.memory
Value	string
Example	`1G`
Description	The Kubernetes memory requests for a PXC container
Key	backup.storages.<storage-name>.resources.requests.cpu
Value	string
Example	`600m`
Description	Kubernetes CPU requests for a PXC container
Key	backup.storages.<storage-name>.resources.limits.memory
Value	string
Example	`1G`
Description	Kubernetes memory limits for a PXC container
Key	backup.storages.<storage-name>.nodeSelector
Value	label
Example	`disktype: ssd`
Description	Kubernetes nodeSelector
Key	backup.storages.<storage-name>.affinity.nodeAffinity
Value	subdoc
Example	
Description	The Operator node affinity constraint
Key	backup.storages.<storage-name>.tolerations
Value	subdoc

continues on next page

Table 4 – continued from previous page

Example	`backupWorker`
Description	Kubernetes Pod tolerations
Key	backup.storages.<storage-name>.priorityClassName
Value	string
Example	`high-priority`
Description	The Kubernetes Pod priority class
Key	backup.storages.<storage-name>.schedulerName
Value	string
Example	`default-scheduler`
Description	The Kubernetes Scheduler
Key	backup.storages.<storage-name>.containerSecurityContext
Value	subdoc
Example	`privileged: true`
Description	A custom Kubernetes Security Context for a Container to be used instead of the default one
Key	backup.storages.<storage-name>.podSecurityContext
Value	subdoc
Example	`fsGroup: 1001` `supplementalGroups: [1001, 1002, 1003]`
Description	A custom Kubernetes Security Context for a Pod to be used instead of the default one
Key	backup.schedule.name
Value	string
Example	`sat-night-backup`
Description	The backup name
Key	backup.schedule.schedule
Value	string
Example	`0 0 * * 6`
Description	Scheduled time to make a backup specified in the crontab format
Key	backup.schedule.keep
Value	int
Example	`3`
Description	Number of stored backups
Key	backup.schedule.storageName
Value	string
Example	`s3-us-west`
Description	The name of the storage for the backups configured in the `storages` or `fs-pvc` subsection

CHAPTER

TWENTYFIVE

PERCONA KUBERNETES OPERATOR FOR PERCONA XTRADB CLUSTER 1.5.0 RELEASE NOTES

25.1 *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.5.0

Date July 21, 2020

Installation Installing Percona Kubernetes Operator for Percona XtraDB Cluster

25.1.1 New Features

- K8SPXC-298: Automatic synchronization of MySQL users with ProxySQL
- K8SPXC-294: HAProxy Support
- K8SPXC-284: Fully automated minor version updates (Smart Update)
- K8SPXC-257: Update Reader members before Writer member at cluster upgrades
- K8SPXC-256: Support multiple PXC minor versions by the Operator

25.1.2 Improvements

- K8SPXC-290: Extend usable backup schedule syntax to include lists of values
- K8SPXC-309: Quickstart Guide on Google Kubernetes Engine (GKE) - link
- K8SPXC-288: Quickstart Guide on Amazon Elastic Kubernetes Service (EKS) - link
- K8SPXC-280: Support XtraBackup compression
- K8SPXC-279: Use SYSTEM_USER privilege for system users on PXC 8.0
- K8SPXC-277: Install GDB in PXC images
- K8SPXC-276: Pod-0 should be selected as Writer if possible
- K8SPXC-252: Automatically manage system users for MySQL and ProxySQL on password rotation via Secret
- K8SPXC-242: Improve internal backup implementation for better stability with PXC 8.0
- CLOUD-404: Support of loadBalancerSourceRanges for LoadBalancer Services
- CLOUD-556: Kubernetes 1.17 added to the list of supported platforms

25.1.3 Bugs Fixed

- K8SPXC-327: CrashloopBackOff if PXC 8.0 Pod restarts in the middle of SST
- K8SPXC-291: PXC Restore failure with "The node was low on resource: ephemeral-storage" error (Thanks to user rjeka for reporting this issue)
- K8SPXC-270: Restore job wiping data from the original backup's cluster when restoring to another cluster in the same namespace
- K8SPXC-352: Backup cronjob not scheduled in some Kubernetes environments (Thanks to user msavchenko for reporting this issue)
- K8SPXC-275: Outdated documentation on the Operator updates (Thanks to user martin.atroo for reporting this issue)
- K8SPXC-347: XtraBackup failure after uploading a backup, causing the backup process restart in some cases (Thanks to user connde for reporting this issue)
- K8SPXC-373: Pod not cleaning up the SST tmp dir on start
- K8SPXC-326: Changes in TLS Secrets not triggering PXC restart if AllowUnsafeConfig enabled
- K8SPXC-323: Missing `tar` utility in the PXC node docker image
- CLOUD-531: Wrong usage of `strings.TrimLeft` when processing apiVersion
- CLOUD-474: Cluster creation not failing if wrong resources are set

25.2 *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.4.0

Date April 29, 2020

Installation Installing Percona Kubernetes Operator for Percona XtraDB Cluster

25.2.1 New Features

- K8SPXC-172: Full data-at-rest encryption available in PXC 8.0 is now supported by the Operator. This feature is implemented with the help of the `keyring_vault` plugin which ships with PXC 8.0. By utilizing Vault we enable our customers to follow best practices with encryption in their environment.
- K8SPXC-125: Percona XtraDB Cluster 8.0 is now supported
- K8SPXC-95: Amazon Elastic Container Service for Kubernetes (EKS) was added to the list of the officially supported platforms
- The OpenShift Container Platform 4.3 is now supported

25.2.2 Improvements

- K8SPXC-262: The Operator allows setting ephemeral-storage requests and limits on all Pods
- K8SPXC-221: The Operator now updates observedGeneration status message to allow better monitoring of the cluster rollout or backup/restore process
- K8SPXC-213: A special *PXC debug image* is now available. It avoids restarting on fail and contains additional tools useful for debugging
- K8SPXC-100: The Operator now implements the crash tolerance on the one member crash. The implementation is based on starting Pods with `mysqld --wsrep_recover` command if there was no graceful shutdown

25.2.3 Bugs Fixed

- K8SPXC-153: S3 protocol credentials were not masked in logs during the PXC backup & restore process
- K8SPXC-222: The Operator got caught in reconciliation error in case of the erroneous/absent API version in the `deploy/cr.yaml` file
- K8SPXC-261: ProxySQL logs were showing the root password
- K8SPXC-220: The inability to update or delete existing CRD was possible because of too large records in etcd, resulting in "request is too large" errors. Only 20 last status changes are now stored in etcd to avoid this problem.
- K8SPXC-52: The Operator produced an unclear error message in case of fail caused by the absent or malformed pxc section in the `deploy/cr.yaml` file
- K8SPXC-269: The `copy-backup.sh` script didn's work correctly in case of an existing secret with the AWS_ACCESS_KEY_ID/AWS_SECRET_ACCESS_KEY credentials and prevented users from copying backups (e.g. to a local machine)
- K8SPXC-263: The `kubectl get pxc` command was unable to show the correct ProxySQL external endpoint
- K8SPXC-219: PXC Helm charts were incompatible with the version 3 of the Helm package manager
- K8SPXC-40: The cluster was unable to reach "ready" status in case if `ProxySQL.Enabled` field was set to `false`
- K8SPXC-34: Change of the `proxysql.servicetype` filed was not detected by the Operator and thus had no effect

25.3 *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.3.0

Percona announces the *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.3.0 release on January 6, 2020. This release is now the current GA release in the 1.3 series. Install the Kubernetes Operator for Percona XtraDB Cluster by following the instructions.

The Percona Kubernetes Operator for Percona XtraDB Cluster automates the lifecycle and provides a consistent Percona XtraDB Cluster instance. The Operator can be used to create a Percona XtraDB Cluster, or scale an existing Cluster and contains the necessary Kubernetes settings.

The Operator simplifies the deployment and management of the Percona XtraDB Cluster in Kubernetes-based environments. It extends the Kubernetes API with a new custom resource for deploying, configuring and managing the application through the whole life cycle.

The Operator source code is available in our Github repository. All of Percona's software is open-source and free.

New features and improvements:

- CLOUD-412: Auto-Tuning of the MySQL Parameters based on Pod memory resources was implemented in the case of Percona XtraDB Cluster Pod limits (or at least Pod requests) specified in the cr.yaml file.
- CLOUD-411: Now the user can adjust securityContext, replacing the automatically generated securityContext with the customized one.
- CLOUD-394: The Percona XtraDB Cluster, ProxySQL, and backup images size decrease by 40-60% was achieved by removing unnecessary dependencies and modules to reduce the cluster deployment time.
- CLOUD-390: Helm chart for Percona Monitoring and Management (PMM) 2.0 has been provided.
- CLOUD-383: Affinity constraints and tolerations were added to the backup Pod
- CLOUD-430: Image URL in the CronJob Pod template is automatically updated when the Operator detects changed backup image URL

Fixed bugs:

- CLOUD-462: Resource requests/limits were set not for all containers in a ProxySQL Pod
- CLOUD-437: Percona Monitoring and Management Client was taking resources definition from the Percona XtraDB Cluster despite having much lower need in resources, particularly lower memory footprint.
- CLOUD-434: Restoring Percona XtraDB Cluster was failing on the OpenShift platform with customized security settings
- CLOUD-399: The iputils package was added to the backup docker image to provide backup jobs with the ping command for a better network connection handling
- CLOUD-393: The Operator generated various StatefulSets in the first reconciliation cycle and in all subsequent reconciliation cycles, causing Kubernetes to trigger an unnecessary ProxySQL restart once during the cluster creation.
- CLOUD-376: A long-running SST caused the liveness probe check to fail it's grace period timeout, resulting in an unrecoverable failure
- CLOUD-243: Using *MYSQL_ROOT_PASSWORD* with special characters in a ProxySQL docker image was breaking the entrypoint initialization process

Percona XtraDB Cluster is an open source, cost-effective and robust clustering solution for businesses. It integrates Percona Server for MySQL with the Galera replication library to produce a highly-available and scalable MySQL® cluster complete with synchronous multi-primary replication, zero data loss and automatic node provisioning using Percona XtraBackup.

Help us improve our software quality by reporting any bugs you encounter using our bug tracking system.

25.4 *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.2.0

Percona announces the *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.2.0 release on September 20, 2019. This release is now the current GA release in the 1.2 series. Install the Kubernetes Operator for Percona XtraDB Cluster by following the instructions.

The Percona Kubernetes Operator for Percona XtraDB Cluster automates the lifecycle and provides a consistent Percona XtraDB Cluster instance. The Operator can be used to create a Percona XtraDB Cluster, or scale an existing Cluster and contains the necessary Kubernetes settings.

The Operator simplifies the deployment and management of the Percona XtraDB Cluster in Kubernetes-based environments. It extends the Kubernetes API with a new custom resource for deploying, configuring and managing the application through the whole life cycle.

The Operator source code is available in our Github repository. All of Percona's software is open-source and free.

New features and improvements:

- A Service Broker was implemented for the Operator, allowing a user to deploy Percona XtraDB Cluster on the OpenShift Platform, configuring it with a standard GUI, following the Open Service Broker API.
- Now the Operator supports Percona Monitoring and Management 2, which means being able to detect and register to PMM Server of both 1.x and 2.0 versions.
- A `NodeSelector` constraint is now supported for the backups, which allows using backup storage accessible to a limited set of nodes only (contributed by Chen Min).
- The resource constraint values were refined for all containers to eliminate the possibility of an out of memory error.
- Now it is possible to set the `schedulerName` option in the operator parameters. This allows using storage which depends on a custom scheduler, or a cloud provider which optimizes scheduling to run workloads in a cost-effective way (contributed by Smaine Kahlouch).
- A bug was fixed, which made cluster status oscillate between "initializing" and "ready" after an update.
- A 90 second startup delay which took place on freshly deployed Percona XtraDB Cluster was eliminated.

Percona XtraDB Cluster is an open source, cost-effective and robust clustering solution for businesses. It integrates Percona Server for MySQL with the Galera replication library to produce a highly-available and scalable MySQL® cluster complete with synchronous multi-primary replication, zero data loss and automatic node provisioning using Percona XtraBackup.

Help us improve our software quality by reporting any bugs you encounter using our bug tracking system.

25.5 *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.1.0

Percona announces the general availability of *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.1.0 on July 15, 2019. This release is now the current GA release in the 1.1 series. Install the Kubernetes Operator for Percona XtraDB Cluster by following the instructions.

The Percona Kubernetes Operator for Percona XtraDB Cluster automates the lifecycle and provides a consistent Percona XtraDB Cluster instance. The Operator can be used to create a Percona XtraDB Cluster, or scale an existing Cluster and contains the necessary Kubernetes settings.

The Operator simplifies the deployment and management of the Percona XtraDB Cluster in Kubernetes-based environments. It extends the Kubernetes API with a new custom resource for deploying, configuring and managing the application through the whole life cycle.

The Operator source code is available in our Github repository. All of Percona's software is open-source and free.

New features and improvements:

- Now the Percona Kubernetes Operator allows upgrading Percona XtraDB Cluster to newer versions, either in semi-automatic or in manual mode.
- Also, two modes are implemented for updating the Percona XtraDB Cluster `my.cnf` configuration file: in *automatic configuration update* mode Percona XtraDB Cluster Pods are immediately re-created to populate changed options from the Operator YAML file, while in *manual mode* changes are held until Percona XtraDB Cluster Pods are re-created manually.
- A separate service account is now used by the Operator's containers which need special privileges, and all other Pods run on default service account with limited permissions.

- User secrets are now generated automatically if don't exist: this feature especially helps reduce work in repeated development environment testing and reduces the chance of accidentally pushing predefined development passwords to production environments.
- The Operator is now able to generate TLS certificates itself which removes the need in manual certificate generation.
- The list of officially supported platforms now includes Minikube, which provides an easy way to test the Operator locally on your own machine before deploying it on a cloud.
- Also, Google Kubernetes Engine 1.14 and OpenShift Platform 4.1 are now supported.

Percona XtraDB Cluster is an open source, cost-effective and robust clustering solution for businesses. It integrates Percona Server for MySQL with the Galera replication library to produce a highly-available and scalable MySQL® cluster complete with synchronous multi-primary replication, zero data loss and automatic node provisioning using Percona XtraBackup.

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25.6 *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.0.0

Percona announces the general availability of *Percona Kubernetes Operator for Percona XtraDB Cluster* 1.0.0 on May 29, 2019. This release is now the current GA release in the 1.0 series. Install the Kubernetes Operator for Percona XtraDB Cluster by following the instructions. Please see the GA release announcement. All of Percona's software is open-source and free.

The Percona Kubernetes Operator for Percona XtraDB Cluster automates the lifecycle and provides a consistent Percona XtraDB Cluster instance. The Operator can be used to create a Percona XtraDB Cluster, or scale an existing Cluster and contains the necessary Kubernetes settings.

The Percona Kubernetes Operators are based on best practices for configuration and setup of the Percona XtraDB Cluster. The Operator provides a consistent way to package, deploy, manage, and perform a backup and a restore for a Kubernetes application. Operators deliver automation advantages in cloud-native applications.

The advantages are the following:

- Deploy a Percona XtraDB Cluster environment with no single point of failure and environment can span multiple availability zones (AZs).
- Deployment takes about six minutes with the default configuration.
- Modify the Percona XtraDB Cluster size parameter to add or remove Percona XtraDB Cluster members
- Integrate with Percona Monitoring and Management (PMM) to seamlessly monitor your Percona XtraDB Cluster
- Automate backups or perform on-demand backups as needed with support for performing an automatic restore
- Supports using Cloud storage with S3-compatible APIs for backups
- Automate the recovery from failure of a single Percona XtraDB Cluster node
- TLS is enabled by default for replication and client traffic using Cert-Manager
- Access private registries to enhance security
- Supports advanced Kubernetes features such as pod disruption budgets, node selector, constraints, tolerations, priority classes, and affinity/anti-affinity
- You can use either PersistentVolumeClaims or local storage with hostPath to store your database

- Customize your MySQL configuration using ConfigMap.

25.6.1 Installation

Installation is performed by following the documentation installation instructions for Kubernetes and OpenShift.