VoltDB Kubernetes Administrator's Guide

Abstract

This book explains how to create and manage VoltDB database clusters using Kubernetes.

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VoltDB Kubernetes Administrator's Guide

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Preface

This book describes using Kubernetes and associated products to create and manage VoltDB databases and the clusters that host them. It is intended for database administrators and operators responsible for the ongoing management and maintenance of database infrastructure in a containerized environment.

This book is *not* a tutorial on Kubernetes or VoltDB. Please see "Related Documents" below for documents that can help you familiarize yourself with these topics.

1. Structure of This Book

This book is divided into 9 chapters and 1 appendix:

- Chapter 1, *Introduction*
- Chapter 2, *Configuring the VoltDB Database Cluster*
- Chapter 3, *Starting and Stopping the Database*
- Chapter 4, *Managing VoltDB Databases in Kubernetes*
- Chapter 5, *Updates and Upgrades*
- Chapter 6, *Monitoring VoltDB Databases in Kubernetes*
- Chapter 7, *Configuring Security in Kubernetes*
- Chapter 8, *Cross Datacenter Replication in Kubernetes*
- Chapter 9, *Managing XDCR Clusters in Kubernetes*
- Appendix B, *VoltDB Helm Properties*

2. Related Documents

This book assumes a working knowledge of Kubernetes, VoltDB, and the other technologies used in a containerized environment (specifically Docker and Helm). For information on developing and managing VoltDB databases, please see the manuals *Using VoltDB* and *VoltDB Administrator's Guide*. For new users, see the *VoltDB Tutorial*. For introductory information on the other products, please see their respective websites for appropriate documentation:

- Docker
- Helm
- Kubernetes

Finally, this book and all other documentation associated with VoltDB can be found on the web at http://docs.voltactivedata.com/.

Chapter 1. Introduction

Kubernetes is an environment for hosting virtualized applications and services run in containers. It is designed to automate the management of distributed applications, with a particular focus on microservices. VoltDB is not a microservice — there is coordination between the nodes of a VoltDB cluster that requires additional attention. So although it is possible to spin up a generic set of Kubernetes "pods" to run a VoltDB database, additional infrastructure is necessary to realize the full potential of Kubernetes and VoltDB working together.

VoltDB Enterprise Edition provides additional services to simplify, automate, and unlock the power of running VoltDB within Kubernetes environments. There are six key components to the VoltDB Kubernetes offering, three available as open-source applications for establishing the necessary hosting environment and three provided by VoltDB to Enterprise customers. The three open-source products required to run VoltDB in a Kubernetes environment are:

- **Kubernetes** itself
- **Docker**, for managing the container images
- **Helm**, for automating the creation and administration of VoltDB in Kubernetes

In addition to these base requirements, VoltDB provides the following three custom components:

- **Pre-packaged docker image** for running VoltDB cluster nodes
- **The VoltDB Operator**, a separate utility (and docker image) for orchestrating the startup and management of VoltDB clusters in Kubernetes
- **Helm charts** for initializing and communicating with Kubernetes, the VoltDB Operator and its associated VoltDB cluster

The remainder of this chapter provides an overview of how these components work together to support running virtualized VoltDB clusters in a Kubernetes environment, the requirements for the host and client systems, and instructions for preparing the host environment prior to running VoltDB. Subsequent chapters provide details on configuring and starting your VoltDB cluster as well as common administrative tasks such as:

- Managing the running database with Helm and kubectl
- Updating the database schema, configuration, or the VoltDB software
- Configuring and managing security options for the database and auxiliary services
- Configuring and starting multiple clusters using cross datacenter replication (XDCR)

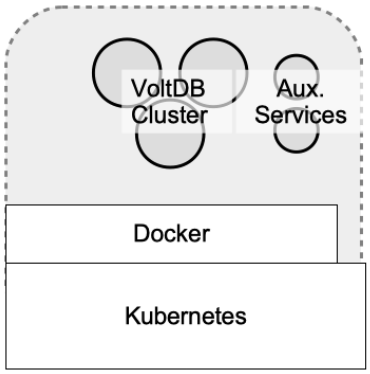
Finally, an appendix provides a full list of the Helm properties for configuring and controlling your VoltDB clusters.

1.1. Overview: Running VoltDB in Kubernetes

Kubernetes lets you create clusters of virtual machines, on which you run "pods". Each pod acts as a separate virtualized system or container. The containers are pre-defined collections of system and application components needed to run an application or service. Kubernetes provides the virtual machines, Docker

defines the containers, and Kubernetes takes responsibility for starting and stopping the appropriate number of pods that your application needs.

So the basic architecture for running VoltDB is a VoltDB database running on multiple instances of a Docker container inside a Kubernetes cluster. VoltDB also starts one or more auxiliary services as separate pods, such as the Volt Management Center.

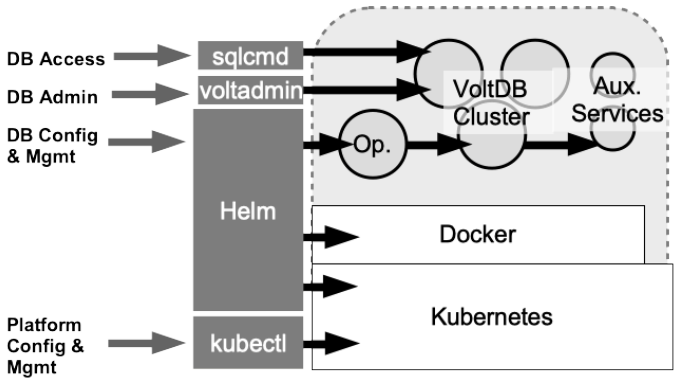


However, out of the box, VoltDB and Kubernetes do not "talk together" and so there is no agreement on when pods are started and stopped and whether a VoltDB node is active or not. To solve this problem, VoltDB provides an additional service, the VoltDB Operator that manages the interactions between the VoltDB cluster, its auxiliary services, and the Kubernetes infrastructure. The Operator takes responsibility for initializing and starting the VoltDB server instances as appropriate, monitoring their health, and coordinating changes to the configuration.

To further simplify the process, VoltDB uses the open-source management product Helm to integrate Kubernetes, Docker, and VoltDB under a single interface. Helm uses "charts" to define complex management operations, such as configuring and starting the Kubernetes pods with the appropriate Docker images and then initializing and starting VoltDB on those pods. Simply by "installing" the appropriate Helm chart you can instantiate and run a VoltDB database cluster within Kubernetes using a single command.

Once the database is running, you can use standard VoltDB command line utilities to interact with and manage the database contents, such as modifying the schema or initiating manual snapshots. However, you will continue to use Helm to manage the server process and cluster on which the database runs, for activities such as stopping and starting the database. Figure 1.1, “Kubernetes/VoltDB Architecture” shows the overall architecture of using VoltDB, the VoltDB Operator, and Helm to automate running a VoltDB database within Kubernetes.

Figure 1.1. Kubernetes/VoltDB Architecture



1.2. Setting Up Your Kubernetes Environment

Before you can run VoltDB in a containerized environment, you must be sure your host systems and client are configured with the right software and permissions to support VoltDB. The following sections outline:

- What products are required on both the host environment and the local client you use to control Kubernetes and VoltDB
- How to configure the host environment and user accounts to run the VoltDB components
- How to configure your local client to control Kubernetes and the Helm charts
- How to set permissions in Kubernetes and Docker to allow access to the VoltDB components

1.2.1. Product Requirements

Before you start, you must make sure you have the correct software products and versions installed on both the host system and your local client. The host environment is the set of servers where Kubernetes is installed, whether they are systems you set up yourself or hosted by a third-party cloud service, such as the Google Cloud Platform or Microsoft Azure. The local client environment is the system, such as a desktop or laptop, you use to access the services.

The following are the software requirements for running VoltDB in Kubernetes.

Host Environment

- Kubernetes V1.23.x through V1.27.x

VoltDB on Kubernetes has been validated for the following cloud service providers:

- AWS
- Azure
- Google Cloud
- OpenShift
- Tanzu

Client Environment

- Kubectl V1.22 or later[1]
- Helm V3.6.x or later

Optionally, you may want to install VoltDB on the client so you can use the **voltadmin** and **sqlcmd** command utilities to access the database remotely. If not, you can still use **kubectl** to create an interactive shell process on one of the server instances and run the utilities directly on the Kubernetes pods.

1.2.2. Configuring the Host Environment and Accounts

Once you have the necessary software installed, you must prepare the host environment to run VoltDB. This includes adding the appropriate Docker and chart repositories to Helm and configuring your host account with the permissions necessary to access those repositories.

[1]Kubectl on the client must be within one minor version of Kubernetes in the host environment. For example, if Kubernetes is at version 1.23, Kubectl can be 1.22, 1.23, or 1.24. See the Kubernetes version skew documentation for further information.

First, you need accounts on the Kubernetes host environment and on the docker repository where the VoltDB images are stored, https://docker.io. To run the VoltDB Helm charts, your accounts must be set up with the following permissions:

- **Your Kubernetes host account** must have sufficient permissions to allocate persistent volumes and claims and create and manage pods.
- **Your Docker repository account** must have permission to access the VoltDB docker images. Access to the VoltDB docker images is assigned to VoltDB Enterprise customers on a per account basis. Contact VoltDB support for more information.

1.2.3. Configuring the Client

Next you must configure your client environment so you can communicate with and control Kubernetes and the Helm charts. First, install the Kubernetes and Helm command line interfaces, **kubectl** and **helm**. Next, configure the services to access the appropriate remote accounts and repositories.

The primary setup task for kubectl is creating the appropriate context for accessing the Kubernetes host you will be using. This is usually done as part of the installation or with a Kubconfig file and the **kubectl config** command. Once you have a context defined, you can use the **kubectl cluster-info** command to verify that your client is configured correctly.

For helm, you must add a link to the VoltDB docker repository, using the **helm repo add** command:

```
$ helm repo add voltdb \
     https://voltdb-kubernetes-charts.storage.googleapis.com
```

The first argument to the command ("voltdb") is a short name for referencing the repository in future commands. You can specify whatever name you like. The second argument is the location of the repository itself and must be entered as shown above.

Note

Helm first looks in local folders for charts you specify, then in the repositories. So if the short name you use matches a local directory, they can conflict and cause errors. In that case, you may want to choose a different name, such as "voltkube", to avoid any ambiguity. Then the chart locations you use in Helm commands would be "voltkube/voltdb" rather than "voltdb/voltdb" as shown in the examples.

1.2.4. Granting Kubernetes Access to the Docker Repository

Finally, you need to tell Kubernetes to access the Docker repository using the credentials for your Docker account. There are several ways to do this. You can specify your credentials on the helm command line each time you install a new VoltDB cluster. You can save the credentials in a YAML file with other parameters you pass to helm. Or you can set the credentials in a Kuerbernetes secret using kubectl.

The advantage of using a secret to store the credentials is that you only need to define them once and they are not easily discovered by others, since they are encrypted. To create a Kubernetes secret you use the **kubectl create secret** command, specifying the type of secret (*docker-registry*) and the name of the secret (which must be *dockerio-registry*), plus the individual credential elements as arguments:

```
$ kubectl create secret docker-registry dockerio-registry \
   --docker-username=johndoe          \
   --docker-password='ThisIsASecret'  \
```

```
--docker-email="jdoe@anybody.org
```

Once you add the secret, you do not need to specify them again. If, on the other hand, you prefer to specify the credentials when you issue the helm commands to initialize the VoltDB cluster, you can supply them as the following helm properties using the methods described in Chapter 2, *Configuring the VoltDB Database Cluster*:

- `global.image.credentials.username`
- `global.image.credentials.password`

Chapter 2. Configuring the VoltDB Database Cluster

The two major differences between creating a VoltDB database cluster in Kubernetes and starting a cluster using traditional servers are:

- In Kubernetes, there is a single Helm command (install) that performs both the initialization and the startup of the database.
- You specify the database configuration with properties rather than as an XML file, environment variables, or command line arguments.

In fact, all of the configuration — including the configuration of the virtual servers (or pods), the server processes, and the database — is accomplished using Helm properties. Helm simplifies the process by coordinating all the different components involved, including Kubernetes, Docker, and VoltDB. By using the provided Helm charts, it is possible to start a default VoltDB cluster with a single command:

```
$ helm install mydb voltdb/voltdb \
   --set-file cluster.config.licenseXMLFile=license.xml
```

The name *mydb* specifies a name for the release you create, *voltdb/voltdb* specifies the Helm chart to install, and the `--set-file` argument specifies a new value for a property to customize the installation. In this case, `--set-file` specifies the location of the VoltDB license needed to start the database. The license is the only property you must specify; all other properties have default values that are used if not explicitly changed.

However, a default cluster of three nodes and no schema or configuration is not particularly useful. So VoltDB provides Helm properties to let you customize every aspect of the database and cluster configuration, including:

- Cluster configuration, including size of the cluster, available resources, and so on
- Network configuration, including the assignment of ports and external mappings
- Database initialization options, including administration username and password, schema, and class files
- Database configuration, including the settings normally found in the XML configuration file on non-Kubernetes installations

The following sections explain how to specify Helm properties in a properties file or on the command line, as well how to use those properties to make some of the most common customizations to your database. Later chapters explain how to configure specific features (such as security and XDCR). Appendix B, *VoltDB Helm Properties* provides a full list of the properties, including a brief description and the default value for each.

2.1. Using Helm Properties to Configure Your Database

First, it is useful to understand the different ways you can specify properties on the Helm command line. The following discussion is not intended as a complete description of Helm; only a summary to give you an idea of what they do and when to use them.

Helm offers three different ways to specify properties:

--set

The `--set` flag lets you specify individual property values on the command line. You can use `--set` multiple times or separate multiple property/value pairs with commas. For example, the following two commands are equivalent:

```
$ helm install mydb voltdb/voltdb \
   --set cluster.serviceSpec.clientPort=22222 \
   --set cluster.serviceSpec.adminPort=33333
$ helm install mydb voltdb/voltdb \
   --set cluster.serviceSpec.clientPort=22222,\
cluster.serviceSpec.adminPort=33333
```

The --set flag is useful for setting a few parameters that change frequently or for overriding parameters set earlier in the command line (such as in a YAML file).

--set-file

The `--set-file` flag lets you specify the contents of a file as the value for a property. For example, the following command sets the contents of the file `license.xml` as the license for starting the VoltDB cluster:

```
$ helm install mydb voltdb/voltdb \
   --set-file cluster.config.licenseXMLFile=license.xml
```

As with --set, You can use `--set-file` multiple times or separate multiple property/file pairs with commas. The `--set-file` flag is useful for setting parameters where the value is too complicated to set directly on the command line. For example, the contents of the VoltDB license file.

--values, -f

The --values flag lets you specify a file that contains multiple property definitions in YAML format. Whereas properties set on the command line with `--set` use dot notation to separate the property hierarchy, YAML puts each level of the hierarchy on a separate line, with indentation and followed by a colon. For example, the following YAML file (and `--values` flag set the same two properties show in the `--set` example above:

```
$ cat ports.yaml
cluster:
   serviceSpec:
      clientPort: 22222
      adminPort: 33333
$ helm install mydb voltdb/voltdb \
   --values ports.yaml
```

YAML files are extremely useful for setting multiple properties with values that do not change frequently. You can also use them to group properties (such as port settings or security) that work together to configure aspects of the database environment.

You can use any of the preceding techniques for specifying properties for the VoltDB Helm charts. In fact, you can use each method multiple times on the command line and mixed in any order. For example, the following example uses `--values` to set the database configuration and ports, `--set-file` to identify the license, and `--set` to specify the number of nodes requested:

```
$ helm install mydb voltdb/voltdb                    \
```

```
--values dbconf.yaml,dbports.yaml                    \
--set-file cluster.config.licenseXMLFile=license.xml \
--set cluster.clusterSpec.replicas=5
```

2.2. Configuring the Cluster

Many of the configuration options that are performed through hardware configuration, system commands or environment variables on traditional server platforms are now available through Helm properties. Most of these settings are listed in Section B.3, “Kubernetes Cluster Startup Options”.

Hardware Settings

Hardware settings, such as the number of processors and memory size, are defined as Kubernetes image resources through the Helm `cluster.clusterSpec.resources` property. Under `resources`, you can specify any of the YAML properties Kubernetes expects when configuring pods within a container. For example:

```
cluster:
  clusterSpec:
    resources:
      requests:
        cpu: 500m
        memory: 1000Mi
      limits:
        cpu: 500m
        memory: 1000Mi
```

System Settings

System settings that control process limits that are normally defined through environment variables can be set with the `cluster.clusterSpec.env` properties. For example, the following YAML increases the Java maximum heap size and disables the collection of JVM statistics:

```
cluster:
  clusterSpec:
    env:
      VOLTDB_HEAPMAX: 3072
      VOLTDB_OPTS: -XX:+PerfDisableSharedMem
```

One system setting that is *not* configurable through Kubernetes or Helm is whether the base platform has Transparent Huge Pages (THP) enabled or not. This is dependent of the memory management settings on the actual base hardware on which Kubernetes is hosted. Having THP enabled can cause problems with memory-intensive applications like VoltDB and it is strongly recommended that THP be disabled before starting your cluster. (See the section on Transparent Huge Pages in the *VoltDB Administrator's Guide* for an explanation of why this is an issue.)

If you are not managing the Kubernetes environment yourself or cannot get your provider to modify their environment, you will need to override VoltDB's warning about THP on startup by setting the cluster.clusterSpec.additionalArgs property to include the VoltDB start argument to disable the check for THP. For example:

```
cluster:
  clusterSpec:
    additionalStartArgs:
      - "--ignore=thp"
```

2.3. Configuring the Database

In addition to configuring the environment VoltDB runs in, there are many different characteristics of the database itself you can control. These include mapping network interfaces and ports, selecting and configuring database features, and identifying the database schema, class files, and security settings.

The network settings are defined through the `cluster.serviceSpec` properties, where you can choose the individual ports and choose whether to expose them through the networking service. For example, the following YAML file disables exposure of the admin port and assigns the externalized client port to 31313:

```
cluster:
  serviceSpec:
    type: NodePort
      adminPortEnabled: false
      clientPortEnabled: true
      clientNodePort: 31313
```

The majority of the database configuration options for VoltDB are traditionally defined in an XML configuration file. When using Kubernetes, these options are declared using YAML and Helm properties. The Helm properties follow the same structure as the XML configuration, beginning with "cluster.config". So, for example, where the number of sites per host is defined in XML as:

```
<deployment>
   <cluster sitesperhost="{n}"/>
</deployment>
```

It is defined in Kubernetes as:

```
cluster:
  config:
    deployment:
      cluster:
        sitesperhost: {n}
```

The following sections give examples of defining common database configurations options using YAML. See Section B.6, “VoltDB Database Configuration Options” for a complete list of the Helm properties available for configuring the database.

2.3.1. Configuring High Availability (K-Safety and Placement Groups)

Volt Active Data provides high availability through *K-safety*, where copies of each partition are distributed to different nodes in the database cluster. If a node fails, the database can continue to operate because there are still copies of every partition within the cluster. The amount of durability depends on the K factor. So a K factor of one means that the cluster is guaranteed to survive one node (or pod) failing, a factor of two guarantees two nodes, and so on. (See the chapter on Availability in the *Using VoltDB* manual for more information on how K-safety works.)

You set the K-safety factor using the `cluster.config.deployment.cluster.kfactor` property when configuring your database. For example, the following YAML sets the K-safety factor to two:

```
cluster:
```

```
clusterSpec:
  replicas: 6
config:
  deployment:
    cluster:
      sitesperhost: 8
      kfactor: 2
```

Note that the number of replicas must be at least as large as the K factor plus one (K+1) and K-safety is most effective if the number of replicas times the number of sites per host is a multiple of K+1.

The combination of K-safety and Kubernetes provides an automated, self-healing system where K-safety ensures the cluster survives individual nodes failing and Kubernetes manages the automated recreation of the pods when they fail so the database can be restored to a full complement of nodes as soon as possible. However, to take full advantage of this capability you need to ensure the Kubernetes infrastructure is configured correctly to distribute the Volt servers evenly and that Volt uses information about the configuration to manage the distribution of partitions within the database. The following sections explain how to use Kubernetes configuration options, such as affinity and spread constraints, and Volt placement groups to achieve maximum availability.

2.3.1.1. Configuring Kubernetes Clusters for High Availability (Spread Constraints and Affinity)

K-safety ensures the database cluster can survive at least a certain number of node failures. However, to reduce the risk of larger scale outages, you need to make sure that the Volt servers are distributed in such a way to minimize the impact of external outages. In particular, you want to ensure that each Volt server pod runs on a separate Kubernetes node (so that a Kubernetes node failure cannot impact multiple pods) and that the pods are, as much as possible, evenly distributed among the availability zones in use.

By default, the Volt Operator establishes Kubernetes affinity and anti-affinity rules such that no two Volt server pods can run on the same Kubernetes node. So, normally, you do not need to take any actions to make this happen. However, if you are overriding the Operator's default configurations, you will need to make sure your custom Kubernetes configuration includes this behavior.

When using multiple availability zones, you should also adjust the Kubernetes configuration — specifically the spread constraints — so that the Volt server pods are evenly distributed among the zones. This makes it possible to avoid the database failing due to the loss of any one zone that contains an unbalanced and excessive number of Volt server processes. You can define the distribution of server pods within your Helm configuration using the `cluster.clusterSpec.topologySpreadConstraints` property. The following example demonstrates how to do this, using the label selector to identify the Volt server processes.

```
cluster:
  clusterSpec:
    topologySpreadConstraints:
    - topologyKey: topology.kubernetes.io/zone
      whenUnsatisfiable: DoNotSchedule
      maxSkew: 1
      labelSelector:
        matchLabels:
          name: voltdb-cluster
```

If you are running multiple databases within a single namespace, you should consider replacing the last line of the configuration, "name: voltdb-cluster", with an identifier that is specific to the cluster being

configured. For example, if the cluster release name is *mydb*, the last line of the configuration should read "voltdb-cluster-name: mydb-voltdb-cluster".

2.3.1.2. Cloud Native Placement Groups

K-safety guarantees the minimum number of nodes that can fail without stopping the database. Configuring Kubernetes affinity and spread constraints to evenly distribute the database server pods reduces the overall threat of external failures taking down the database. However, to fully maximize the availability, Volt needs to use knowledge about the Kubernetes configuration to intelligently distribute the individual copies of the partitions among those servers.

The cluster may survive more failures than just the minimum guaranteed by K-safety depending on how the partitions are distributed and which nodes fail. *Placement groups* are a mechanism for providing more context concerning the hardware environment to improve the likelihood of the cluster surviving multiple failures. For example, if you tell Volt certain nodes are in the same region and zone (i.e. in the same placement group), it avoids placing all copies of any partition on those nodes, so if the zone fails, the database can survive.

Because you do not control exactly where each pod is created in Kubernetes, Volt can use its knowledge of the Kubernetes availability zones and regions[1] to automate the placement groups and minimize the potential of an infrastructure failure taking the database down with it. You enable cloud native placement groups in Kubernetes by setting the property `cluster.clusterSpec.useCloudNativePlacementGroup` to "true". For cloud native placement groups to be effective, the cluster configuration must meet the following requirements:

- The cluster must be distributed over three or more regions or availability zones.
- The number of nodes (or *replicas*) must be a multiple of the number of availability zones.
- The number of availability zones must be a multiple of K+1.

For example, the following configuration assumes the cluster is distributed across four availability zones:

```
cluster:
  clusterSpec:
    replicas: 8
    useCloudNativePlacementGroup: true
  config:
    deployment:
      cluster:
        sitesperhost: 8
        kfactor: 1
```

Once the database is running, you can use the @Statistics system procedure with the HOST selector to determine where each node is running and what partitions are running on that node. In addition, if one or more nodes go down, the "SAFETOSTOP" column lets you know which of the remaining nodes could safely be stopped without endangering the cluster as a whole.

```
$ sqlcmd
1> execute @Statistics HOST;
TIMESTAMP     HOST_ID HOSTNAME              PARTITIONS              LEADERS     PL
------------- ------- --------------------- ----------------------- ----------- --
```

[1]Placement groups depend on the Kubernetes labels topology.kubernetes.io/region and topology.kubernetes.io/zone, which are defined automatically by most commercial cloud providers. If you are using a custom cloud deployment, you will need to make sure these labels are declared appropriately before enabling cloud native placement groups.

```
1677777171869       0 mydb-voltdb-cluster-0 24,25,26,27,28,29,30,31 25,27,29,31 ea
1677777171870       1 mydb-voltdb-cluster-1 8,9,10,11,12,13,14,15   8,10,12,14  ea
1677777171870       2 mydb-voltdb-cluster-2 8,9,10,11,12,13,14,15   9,11,13,15  ea
1677777171870       3 mydb-voltdb-cluster-3 16,17,18,19,20,21,22,23 16,18,20,22 ea
1677777171870       4 mydb-voltdb-cluster-4 16,17,18,19,20,21,22,23 17,19,21,23 ea
1677777171870       5 mydb-voltdb-cluster-5 24,25,26,27,28,29,30,31 24,26,28,30 ea
1677777171870       6 mydb-voltdb-cluster-6 0,1,2,3,4,5,6,7         0,2,4,6     ea
1677777171870       7 mydb-voltdb-cluster-7 0,1,2,3,4,5,6,7         1,3,5,7     ea
(Returned 8 rows in 0.01s)
TIMESTAMP     PLACEMENTGROUP SAFETOSTOP
------------- -------------- ----------
1677777171882 east--zone3    true
1677777171882 east--zone2    true
1677777171882 east--zone1    true
1677777171882 east--zone4    true
```

2.3.2. Configuring Command Logging

Command logging provides durability of the database content across failures. You can control the level of durability as well as the length of time required to recover the database by configuring the type of command logging and size of the logs themselves. In Kubernetes this is done with the `cluster.config.deployment.commandlog` properties. The following example enables synchronous command logging and sets the log size to 3,072 megabytes and the frequency to 1,000 transactions:

```
cluster:
  config:
    deployment:
      commandlog:
        enabled: true
        synchronous: true
        logsize: 3072
        frequency:
          transactions 1000
```

2.3.3. Configuring Export

Export simplifies the integration of the VoltDB database with external databases and systems. You use the export configuration to define external "targets" the database can write to. In Kubernetes you define export targets using the `cluster.config.deployment.export.configurations` property. Note that the `configurations` property can accept multiple configuration definitions. In YAML, you specify a list by prefixing each list element with a hyphen, even if there is only one element. The following example defines one export target, *eventlog*, using the file export connector:

```
cluster:
  config:
    deployment:
      export:
        configurations:
           - target: eventlog
             type: file
             properties:
                type: csv
                nonce: eventlog
```

2.4. Configuring Logging

VoltDB uses Log4J for logging messages while the database is running. The chapter on '"Logging and Analyzing Activity in a VoltDB Database" in the *VoltDB Administrator's Guide* describes some of the ways you can customize the logging to meet your needs, including changing the logging level or adding appenders. Logging is also available in the Kubernetes environment and is configured using a Log4J XML configuration file. However, the default configuration and how you set the configuration when starting or updating the database in Kubernetes is different than as described in the *Administrator's Guide*.

Before you attempt to customize the logging, you should familiarize yourself with the default settings. The easiest way to do this is to extract a copy of the default configuration from the Docker image you will be using. The following commands create a docker container without actually starting the image, extract the configuration file to a local file (`k8s-log4j.xml` in the example), then delete the container.

```
$ ID=$(docker create voltdb/voltdb-enterprise)
$ docker cp ${ID}:/opt/voltdb/tools/kubernetes/server-log4j.xml k8s-log4j.xml
$ docker rm $ID
```

Once you extract the default configuration and made the changes you want, you are ready to specify your new configuration on the Helm command to start the database. You do this by setting the `cluster.config.log4jcfgFile` property. For example:

```
$ helm install mydb voltdb/voltdb                        \
   --values myconfig.yaml                                \
   --set cluster.clusterSpec.replicas=5                   \
   --set-file cluster.config.licenseXMLFile=license.xml \
   --set-file cluster.config.log4jcfgFile=my-log4j.xml
```

Similarly, you can update the logging configuration on a running cluster by using the `--set-file` argument on the Helm upgrade command:

```
$ helm upgrade mydb voltdb/voltdb --reuse-values        \
   --set-file cluster.config.log4jcfgFile=my-log4j.xml
```

Chapter 3. Starting and Stopping the Database

The key to managing VoltDB clusters in Kubernetes is to let the Helm charts do the work for you. You can use **helm** commands to perform all basic activities for running a database. This chapter explains how to use helm commands to:

- Start the cluster for the first time
- Stop and restart the cluster
- Resize the cluster
- Pause and resume
- Start multiple clusters within one Kubernetes namespace

Subsequent chapters explain how to manage the database once it is running, how to modify the database and cluster configuration, and how to upgrade the VoltDB software itself.

3.1. Starting the Cluster for the First Time

As described in Chapter 2, *Configuring the VoltDB Database Cluster* you can customize every aspect of the database and the cluster using Helm properties and the configuration can be as simple or as complex as you choose. But once you have determined the configuration options you want to use, actually initializing and starting the database cluster is a single command, **helm install**. For example:

```
$ helm install mydb voltdb/voltdb                          \
   --values myconfig.yaml                                  \
   --set-file cluster.config.licenseXMLFile=license.xml    \
   --set cluster.clusterSpec.replicas=5
```

3.2. Stopping and Restarting the Cluster

Once the cluster is running (what Helm calls a "release"), you can adjust the cluster to stop it, restart it, or resize it, by "upgrading" the release chart, specifying the new value for the number of nodes you want. You upgrade the release using much the same command as you do to start it, except rather than repeating the configuration, you can use the `--reuse-values` flag. So, for example, to stop the cluster, you simply set the number of replicas to zero, reusing all other parameters:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.clusterSpec.replicas=0
```

To restart the cluster after you stop it, you reset the replica count to five, or whatever you set it to when you initially defined and started it:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.clusterSpec.replicas=5
```

3.3. Resizing the Cluster with Elastic Scaling

To resize the cluster by adding nodes you simply upgrade the release specifying the new number of nodes you want. Of course, the new value must meet the requirements for elastically expanding the cluster, as set out in the discussion of adding nodes to the cluster in the *VoltDB Administrator's Guide*. So, for example, to increase the cluster size by two nodes, you can set the replica count to seven:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.clusterSpec.replicas=7
```

3.4. Pausing and Resuming the Cluster

To pause the database — that is stop client activity through the client port when performing certain administrative functions — you set the property cluster.clusterSpec.maintenanceMode to true. For example, the following commands pause and then resume the database associated with release *mydb*:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.clusterSpec.maintenanceMode=true

$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.clusterSpec.maintenanceMode=false
```

3.5. Starting More than One Cluster Within a Namespace

By default, the Volt Helm charts assume there is only one cluster in each Kubernetes namespace. It is possible to run more than one Volt cluster within a namespace; however, to do so you need to start and stop the clusters and the operator separately. You do this by performing separate **helm install** operations for the operator and each cluster, using separate release names for each operation and setting the `cluster.enabled` and `operator.enabled` properties appropriately in each step.

For example, let's assume we want to start two clusters, *rome* and *venice*, in a single namespace, The steps for starting multiple Volt clusters in a single Kubernetes namespace are as follows:

1. **Start the operator separately**

   Issue the helm install command setting the `operator.enabled` property to true and the `cluster.enabled` to false. Then wait for the operator to reach the ready state:

   ```
   $ helm install voltoperator voltdb/voltdb  \
      --values opconfig.yaml                  \
      --set operator.enabled=true             \
      --set cluster.enabled=false
   ```

   Note that you can provide additional operator properties, separately or as a YAML file, as part of the install operation. See Section B.7, “Operator Configuration Options” for a list of available operator properties.

2. **Start the first cluster**

Once the operator is ready, you can start the first cluster, reversing the values for `operator.enabled` and `cluster.enabled` and providing whatever cluster-specific configuration you need:

```
$ helm install rome voltdb/voltdb         \
   --values romeconfig.yaml               \
   --set cluster.clusterSpec.replicas=3   \
   --set operator.enabled=false           \
   --set cluster.enabled=true
```

Again, wait for the pods of the cluster to reach the ready state before moving on to the next step.

3. **Start subsequent clusters**

   Repeat step #2 for any other clusters you want to run in the namespace waiting after each install command for the pods to reach their ready state. In our example, we only have one other cluster:

```
$ helm install venice voltdb/voltdb       \
   --values veniceconfig.yaml             \
   --set cluster.clusterSpec.replicas=3   \
   --set operator.enabled=false           \
   --set cluster.enabled=true
```

The key point when running multiple clusters within a single namespace is that there is only one Volt Operator and the operator executes one operation at a time. So be sure to wait for each Helm command to complete before issuing a new command. Because of the constraint to sequential processing in the Operator, we recommend limiting the number of simultaneous Volt clusters within any single namespace to three.

3.6. Stopping, Restarting, and Shutting Down Multiple Clusters Within a Namespace

Once you have multiple clusters running in the same namespace, you can stop and start the databases independently, the same way you would a single database, by setting the property `cluster.clusterSpec.replicas` to zero to stop the database and the correct number of nodes to restart it. For example, the following command stops the *rome* cluster without affecting the operator or other clusters in the namespace:

```
$ helm upgrade rome voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.clusterSpec.replicas=0
```

If you want to shutdown and remove the clusters and operator entirely, you must first shutdown and delete the clusters, then delete the operator. The key point is that you cannot delete the Helm release for the operator until all of the releases it manages have been removed. Therefore, the process is:

4. Shutdown and delete the individual clusters

```
$ helm upgrade rome voltdb/voltdb --reuse-values   \
   --set cluster.clusterSpec.replicas=0
$ helm upgrade venice voltdb/voltdb --reuse-values \
   --set cluster.clusterSpec.replicas=0
$ helm delete rome
$ helm delete venice
```

5. Delete the operator

```
$      # Make sure all pods have been deleted
$ kubectl get pods
$      # Once all pods are gone, remove the Operator
$ helm delete voltoperator
```

Chapter 4. Managing VoltDB Databases in Kubernetes

When running VoltDB in Kubernetes, you are implicitly managing two separate technologies: the database cluster — that consists of "nodes" and the server processes that run on them — and the collection of Kubernetes "pods" the database cluster runs on. There is a one-to-one relationship between VoltDB nodes and Kubernetes pods and it is important that these two technologies stay in sync.

The good news is that the VoltDB Operator and Helm manage the orchestration of Kubernetes and the VoltDB servers. If a database server goes down, Kubernetes recognizes that the corresponding pod is not "live" and spins up a replacement. On the other hand, if you *intentionally* stop the database without telling the Operator or Kubernetes, Kubernetes insists on trying to recreate it.

Therefore, whereas on traditional servers you use **voltadmin** and **sqlcmd** to manage both the cluster and the database content, it is important in a Kubernetes environment that you use the correct utilities for the separate functions:

- Use **kubectl** and **helm** to manage the cluster and the database configuration
- Use **voltadmin** and **sqlcmd** to manage the database contents.

The following sections explain how to access and use each of these utilities. Subsequent chapters explain how to perform common cluster and database management functions using these techniques.

4.1. Managing the Cluster Using kubectl and helm

The key advantage to using Kubernetes is that it automates common administrative tasks, such as making sure the cluster keeps running. This is because the VoltDB Operator and Helm charts manage the synchronization of VoltDB and Kubernetes for you. But it does mean you must use **helm** or **kubectl**, and *not* the equivalent **voltadmin** commands, to perform operations that affect Kubernetes, such as starting and stopping the database, resizing the cluster, changing the configuration, and so on.

When you start the database for the first time, you specify the VoltDB Helm chart and a set of properties that define how the cluster and database are configured. The result is a set of Kubernetes pods and VoltDB server processes known as a Helm "release".

To manage the cluster and database configuration you use the **helm upgrade** command to update the release and change the properties associated with the feature you want to control. For example, to change the frequency of periodic snapshots in the *mydb* release to 30 minutes, you specify the new value for the `cluster.config.deployment.snapshot.frequency` property, like so:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.config.deployment.snapshot.frequency=30m
```

Note

It is also possible to use the **kubectl patch** command to change release properties, specifying the new property value and action to take as a JSON string. However, the examples in this book use the **helm upgrade** equivalent wherever possible as the helm command tends to be easier to read and remember.

One caveat to using the **helm upgrade** command is that it not only upgrades the release, it checks to see if there is a new version of the original chart (in this example, *voltdb/voltdb*) and upgrades that too. Problems could occur if there are changes to the original chart between when you first start the cluster and when you need to stop or resize it.

The public charts are not changed very frequently. But if your database is in production for an extended period of time it could be an issue. Fortunately, there is a solution. To avoid any unexpected changes, you can tell Helm to use a specific version of the chart — the version you started with.

First, use the **helm list** command to list all of the releases (that is, database instances) you have installed. In the listing it will include both the name and version of the chart in use. For example:

```
$ helm list
NAME  NAMESPACE  REVISION  UPDATED                 STATUS    CHART          APP VERSION
mydb  default    1         2020-08-12 12:45:30     deployed  voltdb-1.0.0   10.0.0
```

You can then specify the specific chart version when your upgrade the release, thereby avoiding any unexpected side effects:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.clusterSpec.replicas=7 \
   --version=1.0.0
```

4.2. Managing the Database Using voltadmin and sqlcmd

You manage the database using the VoltDB command line utilities **voltadmin** and **sqlcmd**, the same way you would in a traditional server environment. The one difference is that before you can issue VoltDB commands, you need to decide how to access the database cluster itself. There are two types of access available to you:

- Interactive access for issuing **sqlcmd** or **voltadmin** commands to manage the database
- Programmatic access, through the client or admin port, for invoking stored procedures

4.2.1. Accessing the Database Interactively

Kubernetes provides several ways to access the pods running your services. You can run commands on individual pods interactively through the **kubectl exec** command. You can use the same command to access the command shell for the pod by running bash. Or you can use port forwarding to open ports from the pods to your current environment.

In all three cases, you need to know the name of the pod you wish to access. When you start a VoltDB cluster with Helm, the pods are created with templated names based on the Helm release name and a sequential number. So if you named your three node cluster *mydb*, the pods would be called mydb-voltdb-cluster-0, mydb-voltdb-cluster-1, and mydb-voltdb-cluster-2. There are also separate pods for any auxiliary services, such as the Volt Management Center (VMC). If you are not sure of the names, you can use the **kubectl get pods** command to see a list:

```
$ kubectl get pods
NAME                                READY   STATUS    RESTARTS   AGE
mydb-voltdb-cluster-0               1/1     Running   0          26m
```

```
mydb-voltdb-cluster-1                   1/1     Running   0          26m
mydb-voltdb-operator-6bbb96b575-8z75x   1/1     Running   0          26m
mydb-voltdb-vmc-86c8d7b688-pnmlg        1/1     Running   0          26m
```

Having chosen a pod to use, running VoltDB commands interactively with **kubectl exec** is useful for issuing individual commands. After the command executes, **kubectl** returns you to your local shell. For example, you can check the status of the cluster using the **voltadmin status** command:

```
$ kubectl exec -it mydb-voltdb-cluster-0 -- voltadmin status
Cluster 0, version 10.0, hostcount 2, kfactor 0
 2 live host, 0 missing host, 0 live client, uptime 0 days 00:41:34.293
-----------------------------------------------
  HostId       Host Name
       0mydb-voltdb-cluster-0
       1mydb-voltdb-cluster-1
```

You can even use **kubectl exec** to start an interactive **sqlcmd** session, which stays active until you exit **sqlcmd**:

```
$ kubectl exec -it mydb-voltdb-cluster-0 -- sqlcmd
SQL Command :: localhost:21212
1> exit
$
```

Or you can pipe a file of SQL statements to **sqlcmd** as part of the command:

```
$ kubectl exec -it mydb-voltdb-cluster-0 -- sqlcmd < myschema.sql
```

However, **kubectl exec** commands execute in the context of the pod. So you cannot do things like load JAR files that are in your local directory. If you need to load schema and stored procedures, it is easier to use port forwarding, where ports on the pod are forwarded to the equivalent ports on localhost for your local machine, so you can run applications and utilities (such as **sqlcmd**, **voltdb**, and **voltadmin**) locally.

The **kubectl port-forward** command initiates port forwarding, which is active until you stop the command process. So you need a second process to utilize the linked ports. In the following example the user runs the voter sample application locally on a database in a Kubernetes cluster. To do this, one session enables port forwarding on the client port and the second session loads the stored procedures, schema, and then runs the client application:

Session #1

```
$ kubectl port-forward mydb-voltdb-cluster-0 21212
```

Session #2

```
$ cd ~/voltdb/examples/voter
$ sqlcmd
SQL Command :: localhost:21212
1> load classes voter-procs.jar;
2> file ddl.sql;
3> exit
$ ./run.sh client
```

Port forwarding is useful for ad hoc activities such as loading schema and stored procedures to a running database and quick test runs of client applications. Port forwarding is *not* good for running production applications or any ongoing activities, due to its inherent lack of security or robustness as a network solution.

You can also use port forwarding to monitor the cluster using the web-based Volt Management Center (VMC) by forwarding port 8080 from the VMC service, using the service name. The following example also adds the `--address` argument so it is available to others on the local area network. (Otherwise it is only accessible as localhost:8080 from the system on which the port forward command is issued.)

```
$ kubectl port-forward svc/mydb-voltdb-vmc 8080 --address=0.0.0.0
```

Note that there is only one instance of VMC for the entire cluster. By forwarding the port from the VMC service you can access all nodes of the cluster by using the **servers** menu on the DB Monitor tab.

4.2.2. Accessing the Database Programmatically

The approaches for connecting to the database interactively do not work for access by applications, because interactive access focuses on connecting to one node of the database. Applications are encouraged to create connections to *all* nodes of the database to distribute the workload and avoid bottle necks. In fact, the Java client for VoltDB has special settings to automatically connect to all available nodes (topology awareness) and direct partitioned procedures to the appropriate host (client affinity).

Kubernetes provides a number of services to make pods accessible beyond the Kubernetes cluster they run in; services such as cluster IPs, node ports, and load balancers. These services usually change the address and/or port number seen outside the cluster. And there are still other layers of networking and firewalls to traverse before these open ports are accessible outside of Kubernetes itself. This complexity, plus the fact that these services result in port numbers and external network addresses that do not match what the database itself thinks it is running on, make accessing the database from external applications impractical.

The recommended way to access a VoltDB database running in Kubernetes programmatically is to run your application as its own service within the same Kubernetes cluster as the database. This way you can take advantage of the existing VoltDB service names, such as *mydb-voltdb-cluster-client*, to connect to the database. You can then enable topology awareness in the Java cient and let the client make the appropriate connections to the current VoltDB host IPs.

For example, if your database Helm release is called *mydb* and is running in the namespace *mydata*, the Java application code to initiate access to the database might look like the following:

```
org.voltdb.client.Client client = null;

ClientConfig config = new ClientConfig("","");
config.setTopologyChangeAware(true);

client = ClientFactory.createClient(config);
client.createConnection("mydb-voltdb-cluster-client.mydata.svc.cluster.local");
```

Chapter 5. Updates and Upgrades

Once the database is up and running, Kubernetes works to keep it running in the configuration you specified. However, you may need to change that configuration as your database requirements evolve. Changes may be as simple as adding, deleting, or modifying database tables or procedures. Or you may want to modify the configuration of the database, adding new users, or even expanding the cluster by adding nodes.

The following sections describe some common update scenarios and how to perform them in a Kubernetes environment, including:

- Modifying the database schema
- Modifying the database or cluster configuration
- Upgrading the VoltDB software and Helm charts

5.1. Updating the Database Schema

Once the VoltDB database starts, you are ready to manage the database contents. Using Kubernetes does not change *how* you manage the database content. However, it does require a few extra steps to ensure you have access to the database, as described in Section 4.2.1, “Accessing the Database Interactively”.

First you need to identify the pods using the **kubectl get pods** command. You can then access the pods, individually, using the **kubectl exec** command, specifying the pod you want to access and the command you want to run. For example, to run sqlcmd on the first pod, use the following command:

```
$ kubectl exec -it mydb-voltdb-cluster-0 -- sqlcmd
SQL Command :: localhost:21212
1>
```

You can execute a local batch file of sqlcmd commands remotely by piping the file into the utility. For example:

```
$ cat schema.sql
 CREATE TABLE HELLOWORLD (
    HELLO VARCHAR(15), WORLD VARCHAR(15),
    DIALECT VARCHAR(15) NOT NULL
 );
 PARTITION TABLE HELLOWORLD ON COLUMN DIALECT;
$ kubectl exec -it mydb-voltdb-cluster-0 -- sqlcmd < schema.sql
Command succeeded.
Command succeeded.
$
```

Changing the database schema does not require synchronization with Helm or Kubernetes necessarily. However, if you specified the schema and/or procedure classes when you initially created the Helm release, it may be a good idea to keep those properties updated in case you need to re-initialize the database. (For example, when re-establishing a XDCR connection that was broken due to conflicts.) This can be done by updating the `cluster.config.schemas` and/or `cluster.config.classes` properties and their unique subproperties. For example:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
```

```
--set-file cluster.config.schemas.mysql=schema.sql \
--set-file cluster.config.classes.myjar=procs.jar
```

Note that for the schema and classes you must specify a unique subproperty of your choosing for each file (In the previous example *mysql* and *myjar*). This way you can include multiple schema or class files by specifying each with a separate `--set-file` flag and a separate unique subproperty name (such as sql1, sql2, and so on).

5.2. Updating the Database Configuration

You can also change the configuration options for the database or the cluster while the database is running. In Kubernetes, you do this by updating the release properties rather than with the **voltadmin update** command.

How you update the configuration properties is the same for all properties: you use the **helm upgrade** command to update the individual properties. However, what actions result from the update depend on the type of properties you want to modify:

- Dynamic database configuration properties that can be modified "on the fly" without restarting the database
- Static database configuration properties that require the database be restarted before they are applied
- Cluster configuration properties that alter the operation of the cluster and associated Kubernetes pods

The following sections describe these three circumstances in detail.

5.2.1. Changing Database Properties on the Running Database

There are a number of database configuration options that can be changed while the database is running. Those options include:

- Security settings, including user accounts

  ```
  cluster.config.deployment.security.enabled
  cluster.config.deployment.users
  ```

- Import and export settings

  ```
  cluster.config.deployment.export.configurations
  cluster.config.deployment.import.configurations
  ```

- Database replication settings (except the DR cluster ID)

  ```
  cluster.config.deployment.dr.role
  cluster.config.deployment.dr.connection
  ```

- Automated snapshots

  ```
  cluster.config.deployment.snapshot.*
  ```

- System settings:

  ```
  cluster.config.deployment.heartbeat.timeout
  ```

```
cluster.config.deployment.systemsettings.query.timeout
cluster.config.deployment.systemsettings.resourcemonitor.*
```

For example, the following helm upgrade command changes the heartbeat timeout to 30 seconds:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.config.deployment.heartbeat.timeout=30
```

When dynamic configuration properties are modified, the VoltDB Operator updates the running database configuration as soon as it is notified of the change.

5.2.2. Changing Database Properties That Require a Restart

Many database configuration properties are static — they cannot be changed without restarting the database. Normally, this requires manually performing a **voltadmin shutdown --save**, reinitializing and restarting the database cluster, then restoring the final snapshot. For example, command logging cannot be turned on or off while the database is running; similarly, the number of sites per host cannot be altered on the fly.

However, you *can* change these properties using the **helm upgrade** command and the VoltDB Operator will make the changes, but *not* while the database is running. Instead, the Operator recognizes the changes to the configuration, marks the database as requiring a restart, and then schedules a shutdown snapshot, reinitialization, and restart of the database for later.

For example, you cannot change the number of sites per host while the database is running. But the Operator does let you change the property in Kubernetes:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.config.deployment.siteperhost=12
```

No action is taken immediately, since the change will require a restart and is likely to interrupt ongoing transactions. Instead, the Operator waits until you are ready to restart the cluster, which you signify by changing another property, `cluster.clusterSpec.allowRestartDuringUpdate`, to true:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
   --set cluster.clusterSpec.allowRestartDuringUpdate=true
```

If you are sure you are ready to restart the cluster when you change the configuration property, you can set the two properties at the same time so that the change takes immediate effect:

```
$ helm upgrade mydb voltdb/voltdb                 \
   --reuse-values                                 \
   --set cluster.config.deployment.siteperhost=12  \
   --set cluster.clusterSpec.allowRestartDuringUpdate=true
```

Once `allowRestartDuringUpdate` is set to true, the Operator initiates the restart process, saving, shutting down, reinitializing, restarting and restoring the database automatically. Note that once the database is restarted, it is a good idea to reset `allowRestartDuringUpdate` to false to avoid future configuration changes triggering immediate restarts:

```
$ helm upgrade mydb voltdb/voltdb       \
   --reuse-values                       \
```

```
--set cluster.clusterSpec.allowRestartDuringUpdate=false
```

Warning

There are certain database configuration changes that cannot be made either on the fly or with a restart. In particular, do *not* attempt to change properties associated with directory paths or SSL configuration. Changing any of these properties will leave your database in an unstable state.

5.2.3. Changing Cluster Properties

There are properties associated with the environment that the VoltDB database runs on that you can also modify with the **helm upgrade** command. Most notably, you can increase the size of the cluster, using elastic scaling, by changing the `cluster.clusterSpec.replicas` property, as described in Section 3.3, “Resizing the Cluster with Elastic Scaling”.

Some properties affect the computing environment, such as environment variables and number of nodes. Others control the network ports assigned or features specific to Kubernetes, such as liveness and readiness. All these properties can be modified. However, they each have separate scopes that affect when the changes will go into affect.

Of particular note, pod-specific properties will not take affect until each pod restarts. If this is not a high availability cluster (that is, K=0), the Operator will wait until you to change the property `cluster.clusterSpec.allowRestartDuringUpdate` to true before restarting the cluster and applying the changes. The same applies for any cluster-wide properties.

However, for a K-safe cluster, the Operator can apply pod-specific changes without any downtime by performing a *rolling upgrade*. That is, stopping and replacing each pod in sequence. So for high availability clusters, the Operator will start applying pod-specific changes automatically via a rolling restart regardless of the `cluster.clusterSpec.allowRestartDuringUpdate` setting.

5.3. Upgrading the VoltDB Software and Helm Charts

When new versions of the VoltDB software are released they are accompanied by new versions of the Helm charts that support them. By default when you "install" a "release" of VoltDB with Helm, you get the latest version of the VoltDB software at that time. Your release will stay on its initial version of VoltDB as long as you don't update the charts and VoltDB Operator in use.

You can upgrade an existing database instance to a recent version using a combination of **kubectl** and **helm** commands to update the charts, the operator, and the VoltDB software. The steps to upgrade the VoltDB software in Kubernetes are:

1. Update your copy of the VoltDB repository.

2. Update the custom resource definition (CRD) for the VoltDB Operator.

3. Upgrade the VoltDB Operator and software.

The following sections explain how to perform each step of this process, including a full example of the entire process in Example 5.1, “Process for Upgrading the VoltDB Software” However, when upgrading an XDCR cluster, there is an additional step required to ensure the cluster's schema is maintained during the upgrade process. Section 5.3.4, “Updating VoltDB for XDCR Clusters” explains the extra step necessary for XDCR clusters.

Note

To use the **helm upgrade** command to upgrade the VoltDB software, the starting version of VoltDB must be 10.1 or higher. See the *VoltDB Release Notes* for instructions when using Helm to upgrade earlier versions of VoltDB.

5.3.1. Updating Your Helm Repository

The first step when upgrading VoltDB is to make sure your local copy of the VoltDB Helm repository is up to date. You do this using the **helm repo update** command:

```
$ helm repo update
```

Once you update your local copy of the charts, you can determine which version — of both the charts and the software — you want to use by listing all available versions. You do this with the **helm search repo** command.

```
helm search repo voltdb/voltdb --versions
NAME           CHART VERSION  APP VERSION  DESCRIPTION
voltdb/voltdb  2.1.1          12.3.1       The Helm chart for VoltDB
voltdb/voltdb  2.1.0          12.3.0       The Helm chart for VoltDB
voltdb/voltdb  2.0.2          12.2.2       The Helm chart for VoltDB
voltdb/voltdb  2.0.1          12.2.1       The Helm chart for VoltDB
voltdb/voltdb  2.0.0          12.2.0       The Helm chart for VoltDB
voltdb/voltdb  1.10.1         12.1.1       The Helm chart for VoltDB
voltdb/voltdb  1.10.0         12.1.0       The Helm chart for VoltDB
voltdb/voltdb  1.9.0          12.0.0       The Helm chart for VoltDB
voltdb/voltdb  1.8.8          11.4.10      The Helm chart for VoltDB
voltdb/voltdb  1.8.7          11.4.9       The Helm chart for VoltDB
      . . .
```

The display shows the available versions, including for each release a version number for the chart and one for the VoltDB software (app version). Make a note of the pair of version numbers who want to use because you will need them both to complete the following steps of the process. All of the examples in this document use the chart version *2.1.1* and the software version *12.3.1* for the purposes of demonstration.

5.3.2. Updating the Custom Resource Definition (CRD)

The second step is to update the custom resource definition (CRD) for the VoltDB Operator. This allows the Operator to be upgraded to the latest version.

To update the CRD, you must first save a copy of the latest chart, then extract the CRD from the resulting tar file. The **helm pull** command saves the chart as a gzipped tar file and the **tar** command lets you extract the CRD. For example:

```
$ helm pull voltdb/voltdb --version 2.1.1
$ tar --strip-components=2 -xzf voltdb-2.1.1.tgz  \
     voltdb/crds/voltdb.com_voltdbclusters_crd.yaml
```

Note that the file name of the resulting tar file includes the chart version number. Once you have extracted the CRD as a YAML file, you can use it to replace the CRD in Kubernetes:

```
$ kubectl replace -f voltdb.com_voltdbclusters_crd.yaml
```

5.3.3. Upgrading the VoltDB Operator and Software

Once you update the CRD, you are ready to upgrade VoltDB, including both the Operator and the server software. You do this using the **helm upgrade** command and specifying the version numbers for both items on the command line. As soon as you make this change, the Operator will pause the database, take a final snapshot, shutdown the database and then restart with the new version, restoring the snapshot in the process. For example:

```
$ helm upgrade mydb voltdb/voltdb --reuse-values \
   --set operator.image.tag=2.1.1 \
   --set cluster.clusterSpec.image.tag=12.3.1
```

Example 5.1, "Process for Upgrading the VoltDB Software" summarizes all of the commands needed to update a database release to VoltDB version *12.3.1*.

Example 5.1. Process for Upgrading the VoltDB Software

```
$    # Update the local copy of the charts
$ helm repo update
$ helm search repo voltdb/voltdb --versions
NAME           CHART VERSION  APP VERSION  DESCRIPTION
voltdb/voltdb  2.1.1          12.3.1       The Helm chart for VoltDB
voltdb/voltdb  2.1.0          12.3.0       The Helm chart for VoltDB
voltdb/voltdb  2.0.2          12.2.2       The Helm chart for VoltDB
voltdb/voltdb  2.0.1          12.2.1       The Helm chart for VoltDB
voltdb/voltdb  2.0.0          12.2.0       The Helm chart for VoltDB
    [ . . . ]
$
$    # Extract and replace the CRD
$ helm pull voltdb/voltdb --version 2.1.1
$ tar --strip-components=2 -xzf voltdb-2.1.1.tgz  \
     voltdb/crds/voltdb.com_voltdbclusters_crd.yaml
$ kubectl replace -f voltdb.com_voltdbclusters_crd.yaml
$
$    # Upgrade the Operator and VoltDB software
$ helm upgrade mydb voltdb/voltdb --reuse-values \
   --set operator.image.tag=2.1.1 \
   --set cluster.clusterSpec.image.tag=12.3.1
```

5.3.4. Updating VoltDB for XDCR Clusters

When upgrading an XDCR cluster, there is one extra step you must pay attention to. Normally, during the upgrade, VoltDB saves and restores a snapshot between versions and so all data and schema information is maintained. When upgrading an XDCR cluster, the data and schema is deleted, since the cluster will need to reload the data from another cluster in the XDCR relationship once the upgrade is complete.

Loading the data is automatic. But loading the schema depends on the schema being stored properly before the upgrade begins.

If the schema was loaded through the YAML properties `cluster.config.schemas` and `cluster.config.classes` originally and has not changed, the schema and classes will be restored automatically. However, if the schema was loaded manually or has been changed since it was originally loaded, you must make sure a current copy of the schema and classes is available after the upgrade. There are two ways to do this.

For both methods, the first step is to save a copy of the schema and the classes. You can do this using the **voltdb get schema** and **voltdb get classes** commands. For example, using Kubernetes port forwarding you can save a copy of the schema and class JAR file to your local working directory:

```
$ kubectl port-forward mydb-voltdb-cluster-0 21212 &
$ voltdb get schema -o myschema.sql
$ voltdb get classes -o myclasses.jar
```

Once you have copies of the current schema and class files, you can either set them as the default schema and classes for your database release before you upgrade the software or you can set them in the same command as you upgrade the software. For example, the following commands set the default schema and classes first, then upgrade the Operator and server software. Alternately, you could put the two `--set-file` and two `--set` arguments in a single command.

```
$ helm upgrade mydb voltdb/voltdb --reuse-values \
   --set-file cluster.config.schemas.mysql=myschema.sql  \
   --set-file cluster.config.classes.myjar=myclasses.jar
$ helm upgrade mydb voltdb/voltdb --reuse-values \
   --set operator.image.tag=2.1.1 \
   --set cluster.clusterSpec.image.tag=12.3.1
```

Chapter 6. Monitoring VoltDB Databases in Kubernetes

Once the database is running, you need to monitor the system to ensure reliable uptime and performance. Variations in usage, workload, or the operational environment can affect the dynamics of the data application, which may need corresponding adjustments to the schema, procedures, or hardware configuration. VoltDB provides system procedures (such as @Statistics) and the web-based Volt Management Center to help monitor current performance. But to provide persistent, historical intelligence concerning application performance it is best to use a dedicated metrics data store, such as Prometheus.

Prometheus is a metrics monitoring and alerting system that provides ongoing data collection and persistent storage for applications and other resources. By providing an open source industry standard for collecting and storing metrics, Prometheus allows you to:

- Offload monitoring from the database platform itself
- Combine metrics from VoltDB with other applications within your business ecosystem
- Query and visualize historical information about your database activity and performance (through tools such as Grafana)

Section 6.1, "Using Prometheus to Monitor VoltDB" explains how to configure your VoltDB database so the information you need is gathered and made available through Prometheus and compatible graphic consoles such as Grafana.

6.1. Using Prometheus to Monitor VoltDB

To monitor VoltDB with Prometheus on Kubernetes, you enable per pod metrics where each node of the cluster reports its own set of server-specific information. The servers make this data available in Prometheus format through an HTTP endpoint (/metrics) on the metrics port (which defaults to 11781). You can control the port number and other characteristics of the metrics system through Helm properties.

To enable Prometheus metrics, set the `cluster.config.deployment.metrics.enabled` property to *true*. You can also set the `cluster.serviceSpec.perpod.metrics.enabled` property to *true*, which creates a Kubernetes metrics service for each pod. Prometheus uses these metrics services to identify the Volt pods as targets for scraping. For example, the following command enables per pod metrics with default settings while initializing the *mydb* database cluster. It also sets the service type to *ClusterIP*:

```
$ helm install mydb voltdb/voltdb                                  \
   --set-file cluster.config.licenseXMLFile=license.xml            \
   --set cluster.clusterSpec.replicas=5                            \
   --set cluster.config.deployment.metrics.enabled=true            \
   --set cluster.serviceSpec.perpod.metrics.enabled=true           \
   --set cluster.serviceSpec.service.metrics.type=ClusterIP
```

Once metrics are enabled, each Volt server reports its own information through the Prometheus endpoint on the metrics port. If you enable the per pod service, connection to the Prometheus server is handled automatically. If the service is not enabled or Prometheus is not configured to auto-detect targets, you will need to edit the Prometheus configuration to add the cluster nodes to the list of scraping targets.

Finally, if the database has security enabled, you will also need to configure Prometheus with the appropriate authentication information based on the truststore and password for the cluster. See the Prometheus documentation for more information.

Chapter 7. Configuring Security in Kubernetes

There are two aspects to security with Volt Active Data — security within the database with is managed through user accounts and roles and network security between the database nodes, between the cluster and client applications, and between clusters in the case of cross datacenter replication (XDCR). For internal security, you define user accounts as part of the database configuration and assign them to roles that are defined as part of the schema. For network security, Volt recommends encryption and authentication certificates using the TLS/SSL protocol. The following sections explain how to configure both types of security within Kubernetes.

7.1. Configuring User Accounts and Roles Within The Database

User accounts allow you to control who has access to specific functions and procedures within the database. Security is enabled in the configuration with the `cluster.config.deployment.security.enabled` property. You must also use the properties to define the actual user names, passwords, and assigned roles. The `users` property expects a list of sub-elements so you must prefix each set of properties with a hyphen.

If you enable basic security, you must also tell the VoltDB operator which account to use when accessing the database. To do that, you define the `cluster.config.auth` properties, as shown below, which must specify an account with the built-in *administrator* role. The following example enables basic security, defines two accounts, and assigns the *admin* account for use by the VoltDB Operator:

```
cluster:
  config:
    deployment:
      security:
        enabled: true
      users:
        - name: admin
          password: superman
          roles: administrator
        - name: mitty
          password: thurber
          roles: user
    auth:
      username: admin
      password: superman
```

Once you have defined your account names, password and roles, as an additional level of privacy you can hash the contents of the YAML file so the passwords are not in plain text. With the **helm voltadmin** plugin (described in Appendix A, *Helm voltadmin Plugin*) you can use the **mask** command to hash the passwords. If you only specify an input file, the passwords are hashed in place and the input file overwritten. If you include a second file specification, the masked YAML file is written to that file instead.

The following example uses the **voltadmin mask** command to process the file `myaccounts.yaml` and write the YAML including hashed passwords to the file `hashedaccounts.yaml`.

```
$ helm voltadmin mask myaccounts.yaml hashedaccounts.yaml
```

You can then use the hashed file when starting the database:

```
$ helm install mydb voltdb/voltdb  \
   --values myconfig.yaml          \
   --values hashedaccounts.yaml
```

7.2. Configuring TLS/SSL

Another important aspect of security is securing and authenticating the ports used to access the database. The most common way to do this is by enabling TLS/SSL to encrypt data and authenticate the servers using user-created certificates. The process for creating the private keystore and truststore in Java is described in the section on "Configuring TLS/SSL on the VoltDB Server" in the *Using VoltDB* guide. This process is the same whether you are running the cluster directly on servers or in Kubernetes.

The one difference when enabling TLS/SSL for the cluster in Kubernetes is that if you want the Operator to verify the authenticity of the cluster's certificate, you must also configure the operator with an appropriate truststore, in PEM format. If not, you must set the `cluster.clusterSpec.ssl.insecure` property to *true*.

The easiest way to allow verification with a PEM format truststore is to configure the operator using the same truststore and password you use for the cluster itself. First, you will need to convert the truststore to PEM format using the Java **keytool**:

```
keytool -export          \
    -alias my.key -rfc   \
    -file mycert.pem     \
    -keystore mykey.jks  \
    -storepass topsecret \
    -keypass topsecret
```

Once you have your keystore, truststore, and truststore in PEM format, you can configure the cluster and operator with the appropriate SSL properties, using one of three methods:

- Configuring TLS/SSL with YAML properties
- Using Kubernetes secrets to store and reuse TLS/SSL information
- Using cert-manager to create and manage TLS/SSL information for you

The following sections describe the three methods for configuring encryption. In addition, TLS/SSL certificates have an expiration date. It is important you replace the certificate before it expires. If not, the operator will lose the ability to communicate with the cluster pods. See Section 7.3, “Updating TLS/SSL Security Certificates” for instructions on updating the TLS/SSL certificates in Kubernetes.

7.2.1. Configuring TLS/SSL With YAML Properties

The following example uses YAML properties to enable TLS/SSL security and specify the truststore and keystore passwords. First you must enable TLS/SSL encryption, using the `cluster.config.deployment.ssl.enabled` property. Then you choose which ports will use SSL encryption (in this example, the internal and external ports, but not DR). Finally, you specify the passwords for the keystore and truststore. The YAML does *not* include the actual content of the truststore and keystore files, since they are in a binary format.

```
cluster:
```

```
config:
  deployment:
    ssl:
      enabled: true
      external: true
      internal: true
      keystore:
        password: topsecret
      truststore:
        password: topsecret
clusterSpec:
  ssl:
    insecure: false
```

Using the preceding YAML file (calling it `ssl.yaml`), we can complete the SSL configuration by specifying the truststore and keystore files on the **helm** command line with the `--set-file` argument:

```
helm install mydb voltdb/voltdb                                          \
  --values myconfig.yaml                                                 \
  --values ssl.yaml                                                      \
  --set-file cluster.config.deployment.ssl.keystore.file=mykey.jks       \
  --set-file cluster.config.deployment.ssl.truststore.file=mytrust.jks   \
  --set-file cluster.clusterSpec.ssl.certificateFile=mycert.pem
```

Three important notes concerning TLS/SSL configuration:

- If you enable SSL for the cluster's external interface and ports and you enable metrics, you must provide the appropriate SSL information in the Prometheus configuration so it can access the metrics port.
- If you do not require validation of the TLS certificate by the operator, you can avoid setting the truststore PEM for the operator and, instead, set the `cluster.clusterSpec.ssl.insecure` property to *true*.
- If you enable SSL for the cluster, you must repeat the specification of the truststore and keystore files every time you update the configuration. Using the `--reuse-values` argument on the `helm upgrade` command is *not* sufficient.

7.2.2. Using Kubernetes Secrets to Store and Reuse TLS/SSL Information

An alternative method is to store the key and trust stores and passwords in a Kubernetes secret. Secrets are a standard feature of Kubernetes that allow you to store sensitive information as key value pairs in a protected space. Three advantages of using a secret are:

- You do not have to enter sensitive TLS/SSL information in plain text when configuring or updating your database.
- The secret is used automatically for subsequent updates; you do not have to repeatedly specify the TLS/SSL files when updating the database configuration.
- You can reuse the same secret for multiple database instances and services.

To use a Kubernetes secret to store the TLS/SSL information for your database, you must first create the necessary files as described in Section 7.2, “Configuring TLS/SSL”. Next you create your Kubernetes

secret using the **kubectl create secret** command, specifying the key names and corresponding artifacts as arguments. For example:

```
$ kubectl create secret generic my-ssl-creds     \
    --from-file=keystore_data=mykey.jks          \
    --from-file=truststore_data=mytrust.jks      \
    --from-file=certificate=mycert.pem           \
    --from-literal=keystore_password=topsecret   \
    --from-literal=truststore_password=topsecret
```

It is critical you use the key names *keystore_data*, *truststore_data*, *keystore_password*, *truststore_password*, and *certificate* for the keystore, truststore, corresponding passwords, and PEM file, respectively. If not, the Volt Operator will not be able to find them. Also, the secret must be the the same Kubenetes namespace as the Helm release you are configuring.

Once you create the secret you can use it to configure your database by *not* setting any of standard SSL properties such as the `cluster.config.deployment.ssl...` properties or `cluster.clusterSpec.ssl.certificateFile`. Instead, set the property `cluster.config.deployment.ssl.sslSecret.certSecretName`. Using the secret created in the preceding example, the configuration of your database will look something like this:

```
cluster:
  config:
    deployment:
      ssl:
        sslSecret:
          certSecretName: my-ssl-creds
```

7.2.3. Using Kubernetes cert-manager to Store TLS/SSL Certificates

Another alternative for maintaining the TLS/SSL information is to use the Kubernetes cert-manager (cert-manager.io). The *cert-manager* is an add-on for Kubernetes that helps you create and maintain certificates and other private information in Kubernetes. If you wish to use cert-manager for self-signed certificates, you not only use it to store the certificate and truststore, you create them with cert-manager as well. (For more detailed information concerning cert-manager, see the cert-manager documentation.)

The basic steps for storing self-signed TLS/SSL credentials in cert-manager are:

1. Create a Kubernetes secret with the TLS password you wish to use.
2. Create an *issuer* resource in Kubernetes that will generate and authenticate the certificate. You only need to do this once for the namespace and multiple certificate requests can use the same issuer.
3. Create a *request* for the issuer to generate the actual TLS/SSL certificate and store it in a Kubernetes secret.
4. Specify the resulting certificate secret in the VoltDB configuration and start your cluster.

You create the Kubernetes secret containing the password using the **kubectl create secret** command. For example, The following command creates a secret (*my-ssl-password*) with the password "topsecret". The password must be assigned to the label *password*:

```
$ kubectl create secret generic my-ssl-password     \
```

```
    --from-literal=password=topsecret
```

You create the cert-manager issuer and the certificate request using YAML properties. The easiest way to do this is by typing the property declarations into a YAML file. For example, the following two YAML files create a cert-manager issuer service and request a certificate.

create-issuer.yaml

```
apiVersion: cert-manager.io/v1
kind: Issuer
metadata:
   name: selfsigned-issuer
   namespace: mydb
spec:
   selfSigned: {}
```

request-cert.yaml

```
apiVersion: cert-manager.io/v1
kind: Certificate
metadata:
  name: my-ssl-certificate
  namespace: mydb
spec:
  commonName: voltdb.com
  duration: 8766h
  secretName: my-ssl-creds
  keystores:
    jks:
      create: true
      passwordSecretRef:
        name: my-ssl-password
        key: password
  issuerRef:
    name: selfsigned-issuer
    kind: Issuer
  privateKey:
    algorithm: RSA
    encoding: PKCS1
    size: 2048
  usages:
    - server auth
```

Four key points to note about the certificate request are:

- The issuer must be in the same namespace as the database that uses the certificate.
- The certificate request references the secret you created containing the password (*my-ssl-password* in the example).
- As mentioned before, the key in the password secret must be "password".
- You specify the duration of the certificate in hours. In this example, 8766 hours, or one year.

Once you create the YAML files, you can create the issuer and request the certificate:

```
$ kubectl apply -f create-issuer.yaml    # Do only once
$ kubectl apply -f request-cert.yaml
```

Finally, in your database configuration, you point to the two secrets containing the password and created by the certificate request (in this case, *my-ssl-password* and *my-ssl-creds*) the same way you would for a manually created secret:

```
cluster:
  config:
    deployment:
      ssl:
        sslSecret:
          passwordSecretName: my-ssl-password
          certSecretName: my-ssl-creds
```

7.3. Updating TLS/SSL Security Certificates

TLS certificates have an expiration date. If you are using TLS/SSL to encrypt data (either internally, externally, or both), you will need to update those certificates *before* they expire to ensure minimal disruption to normal operation.

One of the advantages of using cert-manager to create and manage your certificates is that it automatically updates the certificates before they expire. If you are not using cert-manager — that is, you are either creating your own secret to contain the keystore and truststore or defining them manually with helm properties — you will need to update the certificates yourself. Either way, shortly after the certificates are updated in Kubernetes, the operator takes responsibility for applying the new credentials to the cluster, the Operator, and the auxiliary services as appropriate.

To update the TLS keystores, truststores, and credentials when using a self-defined secret, you must:

1. Create a new version of the truststore and keystore using a certificate with a new expiration date.

2. Delete the current Kubernetes secret.

3. Create a new version of the same secret using the new files.

You create the new truststore and keystore using the same **keytool** commands used to create the original files, as described in Section 7.2, “Configuring TLS/SSL”. You then update the secret by deleting and recreating the secret using the **kubectl create secret** command from earlier, making sure you use the same name for the secret but the new SSL files. For example:

```
$ kubectl delete secret/my-ssl-creds
$ kubectl create secret generic my-ssl-creds      \
    --from-file=keystore_data=newkey.jks          \
    --from-file=truststore_data=newtrust.jks      \
    --from-file=certificate=newcert.pem           \
    --from-literal=keystore_password=topsecret    \
    --from-literal=truststore_password=topsecret
```

If you defined the TLS/SSL credentials manually using Helm properties, you will need to reapply the new truststore and keystore files using a **helm upgrade** command and the --set-file flag.

Chapter 8. Cross Datacenter Replication in Kubernetes

Previous chapters describe how to run a single VoltDB cluster within Kubernetes. Of course, you can run multiple independent VoltDB databases in Kubernetes. You do this by starting each cluster in separate regions, under different namespaces within the same Kubernetes cluster, or running a single instance of the VoltDB Operator managing multiple clusters in the same namespace. However, some business applications require the same database running in multiple locations — whether for data redundancy, disaster recovery, or geographic distribution. In VoltDB this is done through *Cross Datacenter Replication*, or XDCR.

Important

Please note that in addition to the guidance specific to Kubernetes provided in this chapter, the following rules apply to XDCR in *any* operating environment:

- **You must have command logging enabled** for three or more clusters.
- **You can only join (or rejoin) one cluster at a time** to the XDCR environment.

Command logging is always recommended when using XDCR to ensure durability. Using XDCR without command logging on two clusters, it is possible for transactions processed on one cluster to be lost if the cluster crashes before the binary log is sent to the other cluster. However, for three or more clusters, command logging is *required*. Without command logging, not only can XDCR transactions be lost, but *it is likely the databases will diverge without warning*, if a cluster crashes after sending a binary log to one cooperating cluster but not to the other.

8.1. Requirements for XDCR in Kubernetes

Once established, XDCR in Kubernetes works the same way it does in any other network environment, as described in the chapter on Database Replication in the *Using VoltDB* guide. The key difference when using XDCR in Kubernetes is how you establish the initial connection between the clusters. Unlike traditional servers with known IP addresses, in Kubernetes network addresses are assigned on the fly and are not normally accessible outside individual namespaces or regions. Therefore, you must do additional work to create the appropriate network relationships. Specifically, you must:

- **Establish a network mesh** between the Kubernetes clusters containing the VoltDB databases so that the nodes of each VoltDB cluster can identify and resolve the IP addresses and ports of all the nodes from the other VoltDB clusters.
- **Configure the VoltDB clusters**, including properties that identify the type of mesh involved and mesh-specific annotations that determine what network addresses and ports to use.

The following sections describe the different approaches to establishing a network mesh and how to configure the clusters in each case.

8.2. Choosing How to Establish a Network Mesh

For XDCR to work, each cluster must be able to identify and connect to the nodes of the other cluster. Establishing the XDCR relationship occurs in two distinct phases:

1. **Network Discovery** — First, the clusters connect over the replication port (port 5555, by default). The initial connection confirms that the configurations are compatible, that the schema of the two clusters match for all DR tables, and that there is data in only one of the clusters.

2. **Replication** — Once the clusters agree on the schema, each cluster sends a list of node IP addresses and ports to the other cluster and multiple connections are made, node-to-node, between the two clusters. If there is existing data, a synchronization snapshot is sent between the clusters and then replication begins.

For the network discovery phase, each cluster must have a clearly identifiable network address that the other cluster can specify as part of its XDCR configuration. For the replication phase, each cluster must have externally reachable network addresses for each node in the cluster that it can advertise during the discovery phase and that the other cluster uses to make the necessary connections for replication.

Since, by default, the ports on a Kubernetes pod are not externally accessible, you must use additional services to make the VoltDB nodes accessible. Three such options are:

- **Kubernetes Load Balancers** — One way to establish a network mesh is to use the built-in load balancer service within Kubernetes. Load balancers provide a defined, persistent external interface for internal pods. The advantage of using load balancers is that they are a native component of Kubernetes and are easy to configure. The disadvantage is that if you are running your VoltDB clusters in a hosted environment, load balancers tend to be far more expensive than regular pods and creating a separate load balancer for each node in the cluster to handle the replication phase can be prohibitively expensive unless you are managing your own infrastructure.

- **Kubernetes Node Ports** — An alternative to load balancers is using node ports. Node ports, like load balancers, are native services of Kubernetes and provide an externally accessible interface for the internal pods. However, unlike load balancers where the addresses are persistent over time, node ports take on the addresses of the underlying Kubernetes nodes and therefore can change as Kubernetes nodes are recycled. Therefore node ports are not appropriate for the Network Discovery phase. On the other hand, they can be a cheaper alternative to load balancers for the replication phase, since the cluster can advertise the current set of node port addresses as pods come and go.

- **Network Mesh Services** — These additional services, such as Consul, create a network mesh between Kubernetes clusters and regions. They essentially act as a virtual private network (VPN) within Kubernetes so the VoltDB clusters can interoperate as if they were local to each other. The advantage of using network mesh services is that configuring the VoltDB clusters is simpler, since all of the network topology is handled separately. The deficit is that this requires yet another service to set up. And the configuration of these services can be quite complex, requiring a deep understanding of — and access to — the networking layer in Kubernetes.

Which networking solution you use is up to you. You can even mix and match the alternatives — using, for example, a single load balancer per cluster for the Network Discovery phase and individual node ports for each VoltDB cluster node during the replication phase.

You define the type of network mesh to use and how to connect using YAML properties when you configure your clusters. In general, the Helm properties starting with `cluster.config.deployment.dr`, such as `id` and `role`, are generic properties common to all XDCR implementations. Helm properties starting with `cluster.serviceSpec` define the type of network mesh to use and annotations specific to the network type.

The following sections explain how to configure XDCR using Helm properties, with individual sections discussing the differences necessary for various networking options, including:

- Common XDCR Properties

- Configuring XDCR in Local Namespaces

- Configuring XDCR Using Load Balancers
- Configuring XDCR Using Node Ports for Replication
- Configuring XDCR Using Network Services

8.3. Common XDCR Properties

No matter what approach you choose for establishing the network mesh, you must first configure the clusters as members of the XDCR quorum the same way you do on bare metal. That is, you must assign:

- A unique DR ID for each cluster between 0 and 127
- The cluster role (XDCR)
- At least one node from the other cluster as the point of connection for the Network Discovery phase

On traditional servers these properties are defined in an XML configuration file. On Kubernetes, you specify the configuration using YAML properties starting. The following table configures XDCR using DR ID 1 with a connection to the cluster with a release name of *brooklyn*.

```
cluster:
  config:
    deployment:
      dr:
        id: 1
        role: xdcr
        connection:
          enabled: true
          source: \
  "brooklyn-voltdb-cluster-dr:5555"
```

8.4. Configuring XDCR in Local Namespaces

The easiest way to configure XDCR clusters is when the VoltDB clusters are within the same Kubernetes namespace or cluster. In this case, the cluster IP addresses are all locally visible and so do not need any additional network setup. The first step is to enable the DR service using the `cluster.serviceSpec.dr.enabled` property:

```
cluster:
  serviceSpec:
    dr:
      enabled: true
```

Next, you must provide the address of a replication port from one node of the remote cluster as the `source` property.

In Kubernetes the cluster nodes are assigned unique host names based on the initial Helm release name (that is, the name you assigned the cluster when you installed it). The VoltDB Operator also creates services that abstract the individual server addresses and provide a single entry point for specific ports on the database cluster. The two services of interest are DR and client, which will direct traffic to the corresponding port (5555 or 21212 by default) on an arbitrary node of the cluster. If the two database instances are within the same Kubernetes cluster, you can use the DR service to make the initial connection between the database systems, as shown in the following YAML configuration file.

If the databases are running in different namespaces, you will need to specify the fully qualified service name as the connection source in the configuration, which includes the namespace. So, for example, if the *manhattan* database is in namespace *ny1* and *brooklyn* is in *ny2*, the YAML configuration files related to XDCR for the two clusters would be the following.

Manhattan Cluster

```
cluster:
  config:
    deployment:
      dr:
        id: 1
        role: xdcr
        connection:
          enabled: true
          source: "brooklyn-voltdb-cluster-dr.ny2.svc.cluster.local:5555"
```

Brooklyn Cluster

```
cluster:
  config:
    deployment:
      dr:
        id: 2
        role: xdcr
        connection:
          enabled: true
          source: "manhattan-voltdb-cluster-dr.ny1.svc.cluster.local:5555"
```

8.5. Configuring XDCR Using Load Balancers

Kubernetes load balancers are an alternative for making VoltDB clusters accessible outside the Kubernetes cluster or region they are in. In this case you are not using load balancers for their traditional role, balancing the load between multiple pods. Instead, the load balancers are solely used to provide externally accessible IP addresses.

There are two approaches to using load balancers. The first approach is to assign a load balancer for each node of the cluster. Since the nodes are externally reachable through persistent IP addresses on their corresponding load balancer, the load balancers can be used for both the network discovery and replication phases. The second approach is to use only one load balancer for the entire cluster to provide network discovery, and use virtual network peering, available from your hosting provider, for replication.

Many hosting platforms, such as Google Cloud or AWS, provide proprietary mechanisms for performing network peering between regions or data centers. Each of these solutions has its own unique set up and configuration, separate from the configuration of VoltDB and the VoltDB Operator . As a result, using a network peering service is not as simple as the use of load balancers for replication. However, they can be significantly more cost effective when paired with a single load balancer for network discovery.

There is also the choice of assigning the IP addresses for the load balancers dynamically, or having them selected from a range of static addresses. Dynamic assignment is simpler, since you do not need to arrange with your hosting provider for pre-assigned IPs or hostnames. However, dynamic addresses also mean you do not know what the addresses are *until the cluster starts*. This means the remote XDCR cluster cannot assign the `source` property until after the cluster starts with its associated load balancers and you can determine the IP addresses assigned to them.

8.5.1. Separate Load Balancers For Each Node (cluster.serviceSpec.perpod)

First you must assign the DR `id` and `role` as Helm properties. If the remote cluster is using static addresses, you can specify one of its nodes as the `source`, as in the following example. If you are using dynamic load balancers, leave the `source` property blank and use the **helm upgrade --set** command once the clusters are running to assign a resulting node address for the remote cluster.

```
cluster:
  config:
    deployment:
      dr:
        id: 1
        role: xdcr
        connection:
          enabled: true
          source: "chicago-dc-2"  # Remote cluster
```

Then in the `cluster.serviceSpec` section, you enable `perpod` by setting its `type` to *LoadBalancer*. You will also want to set the `dr.enabled` property to *true* so the per pod load balancers are used for network discovery as well as replication.

For dynamically assigned addresses, set the `publicIPFromService` to *true*:

```
cluster:
  serviceSpec:
    perpod:
      type: LoadBalancer
      publicIPFromService: true
      dr:
        enabled: true
```

For static IP addresses, use the `staticIPs` property to specify the addresses to assign when creating the load balancers and, again, set `dr.enabled` to true.

```
cluster:
  serviceSpec:
    perpod:
      type: LoadBalancer
      staticIPs:
      - 12.34.56.78
      - 12.34.56.79
      - 12.34.56.80
      dr:
        enabled: true
```

8.5.2. Single Load Balancer For Discovery with Virtual Networking Peering (cluster.serviceSpec.dr)

To reduce the number of resources needed to connect XDCR clusters in different regions, you can use a single load balancer for network discovery and use virtual network peering services from your hosting provider for connecting the two clusters during replication. How you set up and configure your network peering is specific to each provider. See your provider's documentation for additional information. This

section describes how to set up a single Kubernetes load balancer for network discovery once you have your network peering established.

First you must assign the DR `id` and `role` as Helm properties and, if known in advance, the `source` for the remote cluster:

```
cluster:
  config:
    deployment:
      dr:
        id: 1
        role: xdcr
        connection:
          enabled: true
          source: "chicago-dc-2"  # Remote cluster
```

Then in the `cluster.serviceSpec` section, you enable the `dr` service (rather than `perpod`) and set its `type` to *LoadBalancer*. You may also need to provide additional annotations that help configure the service. These annotations are specific to the host environment you are using. So, for example, the following configuration provides annotations for AWS and the Google Cloud:

```
cluster:
  serviceSpec:
    dr:
      enabled: true
      type: LoadBalancer
      annotations:
        # Google Cloud
        networking.gke.io/load-balancer-type: "Internal"
        networking.gke.io/internal-load-balancer-allow-global-access: "true"

        # AWS
        service.beta.kubernetes.io/aws-load-balancer-internal: "true"
        service.beta.kubernetes.io/aws-load-balancer-type: "nlb"
```

8.6. Configuring XDCR Using Node Ports for Replication

Kubernetes node ports are another option for providing external access to the VoltDB cluster for replication. Node ports are similar to load balancers in that they provide an externally accessible network address for individual ports. Node ports are different in that the addresses are transitory — the address and/or port number will change as pods come and go. So node ports are less practical for the Network Discovery phase. However, they can be a cheap alternative for providing external access during the replication phase, since the cluster can advertise the new addresses as its topology changes.

It is also possible to mix and match solutions. So a single load balancer can be used to provide the Network Discovery service for a cluster, while node ports provide per pod network addresses for the replication phase, as described next.

Again, you start by assigning the DR `id` and `role` as Helm properties and, if known in advance, the `source` for the remote cluster:

```
cluster:
  config:
```

```
    deployment:
      dr:
        id: 1
        role: xdcr
        connection:
          enabled: true
          source: "chicago-dc-2"  # Remote cluster
```

You then define the load balancer for Network Discovery by setting the values of the `cluster.serviceSpec.dr` properties `enabled` to *true* and `type` to *LoadBalancer*.

```
cluster:
  serviceSpec:
    dr:
      enabled: true
      type: LoadBalancer
```

Finally, define the replication phase as using node ports by configuring `cluster.serviceSpec.perpod` properties `type` to *NodePort* and `dr.enabled` to *true*. You can also use the `dr.startReplicationNodePort` property to specify the starting port number for the externally accessible ports assigned to the node ports.

```
cluster:
  serviceSpec:
    perpod:
      type: NodePort
      dr:
        enabled: true
        startReplicationNodePort: 33111
```

8.7. Configuring XDCR Using Network Services

The goal of network services, such as Consul, is to make Kubernetes pods in different clusters or regions appear as if they were local to each other. This makes configuring XDCR within VoltDB itself easier; in most cases it is almost identical to how you configure clusters within local namespaces. However, how you configure the network service itself is very dependent on which service you are using and the hosting environment in which you are operating.

Using Consul as an example, Consul provides a "sidecar" — an additional process running in the same pod as the VoltDB process — that makes remote pods and clusters appear to be local to the pod itself. So rather than providing a remote IP address and port as the source for XDCR Network Discovery, you specify a local port. For example:

```
cluster:
  config:
    deployment:
      dr:
        id: 1
        role: xdcr
        connection:
          enabled: true
          source: "localhost:4444"
```

What port you specify and how you configure and start Consul and the Consul sidecar, is specific to the Consul product and your implementation of it. The same is true when using other third-party networking

services. You may also need to provide additional annotations within the Helm configuration to complete the network setup, depending upon which network service you use. For example:

```
cluster:
  clusterSpec:
    additionalAnnotations:
      "consul.hashicorp.com/connect-service": "chicago-voltdb-cluster"
      "consul.hashicorp.com/connect-service-upstreams": "chicago-voltdb-cluster:55
```

See the product documentation for the specific service for further information.

Chapter 9. Managing XDCR Clusters in Kubernetes

Once you have configured your XDCR clusters and your network environment, you are ready to start the clusters. You begin by starting two of the clusters. (Remember, only one of the clusters can have data in the DR tables before the XDCR communication begins.) Once the schema of the DR tables in two databases match, synchronization starts. After the initial two databases are synchronized, you can start additional XDCR clusters, one at a time.

There are several management procedures that help keep the clusters in sync, especially when shutting down or removing clusters from the XDCR environment. In other environments, these procedures use **voltadmin** commands, such as **shutdown**, **dr drop** and **dr reset**. In Kubernetes, you execute these procedures through the VoltDB Operator using Helm properties. Activities include:

- Removing a cluster temporarily
- Removing a cluster permanently
- Resetting XDCR when a cluster is lost
- Rejoining a cluster that was removed

9.1. Removing a Cluster Temporarily

If you want to remove a cluster from the XDCR environment temporarily, you simply shutdown the cluster normally, by setting the number of replicas to zero. This way, when the cluster restarts, the command logs will take care of recovering all of the data and re-establishing the XDCR "conversations" with the other clusters:

```
--set cluster.clusterSpec.replicas=0
```

9.2. Removing a Cluster Permanently

If you want to remove a cluster from the XDCR environment permanently, you want to make sure it sends all of its completed transactions to the other clusters before it shuts down. You do this by setting the DR role to "none" to perform an orderly shutdown:

```
--set cluster.config.deployment.dr.role="none"
--set cluster.clusterSpec.replicas=0
```

Of course, you do not have to shut the cluster down. You can simply remove it from the XDCR environment. Note that if you do so, the data in the current cluster will diverge from those clusters still participating in XDCR. So only do this if you are sure you want to maintain a detached copy of the data:

```
--set cluster.config.deployment.dr.role="none"
```

Finally, if you cannot perform an orderly removal from XDCR — for example, if one of the other clusters is offline or if sending the outstanding transactions will take too long and you are willing to lose that data — you can set the property `cluster.clusterSpec.dr.forceDrop` to "TRUE" to force the cluster to drop out of the XDCR mesh without finalizing its XDCR transfers. Once the cluster has been removed, it is advisable to reset this property to "FALSE" so future procedures revert to the orderly approach of flushing the queues.

```
--set cluster.clusterSpec.dr.forceDrop=TRUE
--set cluster.config.deployment.dr.role="none"
--set cluster.clusterSpec.replicas=0
 . . .
--set cluster.clusterSpec.dr.forceDrop=FALSE
```

9.3. Resetting XDCR When a Cluster Leaves Unexpectedly

Normally, when a cluster is removed from XDCR in an orderly fashion, the other clusters are notified that the cluster has left the mesh. However, if a cluster leaves unexpectedly — for example, if it crashes or is shutdown and deleted without setting its role to "none" to notify the other clusters — the XDCR network still thinks the cluster is a member and may return. As a result, the remaining clusters continue to save DR logs for the missing member, using up unnecessary processing cycles and disk space. You need to reset the XDCR network mesh to correct this situation.

To reset the mesh you notify the remaining clusters that the missing cluster is no longer a member. You do this be adding the DR ID of the missing cluster to the `cluster.clusterSpec.dr.excludeClusters` property. The property value is an array of DR IDs. For example, if the DR ID (`cluster.config.deployment.dr.id`) of the lost cluster is "3", you set the property to "{3}":

```
--set cluster.clusterSpec.dr.excludeClusters='{3}'
```

You must set this property for *all* of the clusters remaining in the XDCR environment. If later, you want to add the missing cluster (or another cluster with the same DR ID) back into the XDCR mesh, you will need to reset this property. For example:

```
--set cluster.clusterSpec.dr.excludeClusters=null
```

9.4. Rejoining an XDCR Cluster That Was Previously Removed

If a cluster is removed from the XDCR cluster permanently, by resetting the DR role, or through exclusion by the other clusters, it is still possible to rejoin that cluster to the XDCR network. To do that you must reinitialize the cluster and, if it was forcibly excluded, remove the exclusion from the current members of the network. (Note, the following procedure is *not* necessary if the cluster was removed temporarily by setting the number of replicas to zero.)

First, if the cluster was forcibly removed by exclusion, you must remove the exclusion from the current members of the XDCR network by clearing the `cluster.clusterSpec.dr.excludeClusters` property (removing the missing cluster's ID from the array):

```
--set cluster.clusterSpec.dr.excludeClusters=null
```

Then you must restart the cluster you want to rejoin, reinitializing the cluster's contents with the `cluster.clusterSpec.initForce` property and setting the appropriate properties (such as the DR role and connection properties):

```
--set cluster.clusterSpec.initForce=TRUE
--set cluster.config.deployment.dr.role="xdcr"
--set cluster.clusterSpec.replicas=3
```

Once the cluster rejoins the XDCR network and synchronizes with the current members, be sure to reset the `cluster.clusterSpec.initForce` property to false.

Appendix A. Helm voltadmin Plugin

You can control and administer the VoltDB cluster by adjusting properties through the **kubectl** and **helm** command line tools. However, a number of common administrative actions require several steps and adjustment of multiple properties in the right order to perform correctly. To simplify these activities, the helm plugin *voltadmin* automates these steps and simplifies the management process by providing a consistent interface across both bare metal and Kubernetes environments.

To use the **helm** plugin, you must first install the plugin software and its dependencies. To install the plugin:

1. **Install Dependencies** — The plugin requires the same versions of Python, Helm, and Kubernetes as the Volt software; plus an additional Python module, *click* (version 8.0.1 or later). The easiest way to install the *click* module is using **pip**:

   ```
   $ python3 -m pip install click
   ```

   If you do not already have **pip** installed, you may need to install it first. And if you do not want to install *click* for all users, you can use a virtual environment with **virtualenv**.

2. **Install the Plugin** — Do a directory of the repository for Volt Active Data charts and plugins (https://storage.googleapis.com/voltdb-kubernetes-charts/) and search for "voltadmin". Select the most recent version and install it using the **helm plugin install** command, specifying the URL of the plugin you want. For example, the following command installs version 1.4.3:

   ```
   $ helm plugin install \
   https://storage.googleapis.com/voltdb-kubernetes-charts/voltadmin-1.4.3.tgz
   ```

3. **Test the Plugin** — Once installed, you can use the **voltadmin** command directly on the helm command line. Use the `--help` flag to get a list of the commands and arguments you can use. For example:

   ```
   $ helm voltadmin --help
   ```

The following reference page describes the management commands that the voltadmin plugin supports.

helm voltadmin

helm voltadmin — Performs administrative functions on a VoltDB database in Kubernetes.

Syntax

```
helm voltadmin --release={release-name} collect

helm voltadmin --release={release-name} dr drop

helm voltadmin --release={release-name} dr reset [--cluster={cluster-id}]

helm voltadmin mask {config-file} [output-file]

helm voltadmin --release={release-name} pause

helm voltadmin --release={release-name} resume

helm voltadmin --release={release-name} shutdown

global qualifiers:
        --chart={chart-name}
        --context={context-name}
        --help
        --namespace={namespace-name}
        --verbose
```

Description

The **helm voltadmin** command allows you to perform administrative tasks on a VoltDB database. You specify the Helm release name and the action to take. There are global arguments to disambiguate the context (such as the chart name, Kubernetes context, and namespace) which can also precede the command keyword. Individual commands may have they own unique arguments as well.

Arguments

The following global arguments are available for all **helm voltadmin** commands and must precede the command name.

- -help

    Displays a list of available commands and qualifiers. To see help for a specific command and its options, put the **--help** qualifier *after* the command name. For example:

    ```
    $ helm voltadmin collect --help
    ```

--chart={*helm-chart-name*}

    Specifies the Helm chart the database is using.

--context={*context-name*}

    Specifies the Kubernetes context where the database is running.

--namespace={*namespace-name*}

Specifies the Kubernetes namespace where the database is running.

--verbose

Displays additional information about the specific commands being executed.

Commands

The following are the administrative functions that you can invoke using voltadmin.

collect

Collects logs, error files, stack dumps and other information needed for debugging any problems with database operation.

dr drop

Removes the current cluster from an XDCR environment. Performing a drop breaks existing DR connections, deletes pending binary logs and stops the queuing of DR data on the current cluster. It also tells all other clusters in the XDCR relationship to drop their connection to the current cluster and remove any associated binary logs for that cluster.

The **helm voltadmin dr drop** command lets you effectively remove a single cluster — the cluster on which the the command is executed — from a multi-cluster XDCR environment in a single command.

dr reset

Resets the database replication (XDCR) connection(s) for the database. Performing a reset breaks existing XDCR connections, deletes pending binary logs and stops the queuing of DR data on the current cluster.

If there are two clusters in an XDCR environment, you can use **helm voltadmin dr reset** from one cluster to drop the connection to the other cluster. If you are using multiple XDCR clusters, the **helm voltadmin dr drop** command is the recommended way to remove a running cluster from the environment.

In a multi-cluster XDCR environment you can use the **--cluster** qualifier to drop the connection to just one cluster. Specify the ID of the remote cluster you wish to drop as an argument to the **--cluster** option. For example, if one cluster has stopped and you want to remove it from the XDCR environment, you can reset the connections to that cluster by issuing the **helm voltadmin dr reset --cluster=*{id}*** command on all the remaining clusters.

mask *{configuration-file} [output-file}]*

Reads a YAML configuration file containing user and password declarations and hashes the passwords so they are not readable in plain text, but still usable for configuring the database. If you do not specify an output file, the command overwrites the input file.

pause

Pauses the database, stopping any additional activity on the client port.

resume

Resumes normal database operation after a pause.

shutdown

Shuts down the database process on all nodes of the cluster. The **shutdown** command performs an orderly shutdown, pausing the database, completing all pending transactions and writing any queued export, import, or DR data to disk before shutting down the database.

Examples

The following example pauses the database cluster associated with the *mydb* release.

```
$ helm voltadmin --release=mydb pause
```

The next example shuts down the database.

```
$ helm voltadmin --release=mydb shutdown
```

The last example uses the mask command to encrypt the passwords in the configuration file *myusers.yaml* and writes out the masked entries as a new YAML file, *maskedusers.yaml*.

```
$ helm voltadmin mask myusers.yaml maskedusers.yaml
```

Appendix B. VoltDB Helm Properties

You communicate with the VoltDB Operator, and Kubernetes itself, through the Helm charts that VoltDB provides. You can also specify additional Helm properties that customize what the Helm charts do. The properties are hierarchical in nature and can be specified on the Helm command line either as one or more YAML files or as individual arguments. For example, you can specify multiple properties in a YAML file then reference the file as part of your command using the `--values` or `-f` argument, like so:

```
$ helm install mydb voltdb/voltdb --values myoptions.yaml
```

Or you can specify the properties individually in dot notation on the command line using the --set flag, like so:

```
$ helm install mydb voltdb/voltdb \
     --set cluster.clusterSpec.replicas=5 \
     --set cluster.config.deployment.cluster.kfactor=2 \
     --set cluster.config.deployment.cluster.sitesperhost=12
```

For arrays and lists, you can specify the values in dot notation by enclosing the list in braces and then quoting the command as required by the shell you are using. For example:

```
$ helm upgrade mydb voltdb/voltdb -reuse-values
     --set cluster.clusterSpec.excludeClusters='{1,3}'
```

In YAML, you specify each element of the property on a separate line, following each parent element with a colon, indenting each level appropriately, and following the last element with the value of the property . On the command line you specify the property with the elements separated by periods and the value following an equals sign. So in the preceding `install` example, the matching YAML file for the command line properties would look like this:

```
cluster:
  clusterSpec:
     replicas: 5
  config:
     deployment:
        cluster:
           kfactor: 2
           sitesperhost: 12
```

Many of the properties have default values; the following tables specify the default values where applicable. You do not need to specify values for all of the properties. In fact, you can start a generic VoltDB database specifying only the license file. Otherwise, you need only specify those properties you want to customize.

Finally, the properties are processed in order and can be overridden. So if you specify different values for the same property in two YAML files and as a command line argument, the latter YAML file setting overrides the first and the command line option overrides them both.

B.1. How to Use the Properties

The following sections detail all of the pertinent Helm properties that you can specify when creating or modifying the VoltDB Operator and its associated cluster. The properties are divided into categories and each category identified by the root elements common to all properties in that category:

- Top-Level Kubernetes Options

- Kubernetes Cluster Startup Options
- Network Options
- VoltDB Database Startup Options
- VoltDB Database Configuration Options

For the sake of brevity and readability, the properties in the tables are listed by only the unique elements of the property after the root. However, when specifying a property in YAML or on the command line, you must specify all elements of the full property name, including both the root and the unique elements.

B.2. Top-Level Kubernetes Options

The following properties affect how Helm interacts with the Kubernetes infrastructure.

Table B.1. Top-Level Options

Parameter	Description	Default
cluster.enabled	Create VoltDB Cluster	true
cluster.serviceAccount.create	If true, create & use service account for VoltDB cluster node containers	true
cluster.serviceAccount.name	If not set and create is true, a name is generated using the fullname template	""

B.3. Kubernetes Cluster Startup Options

The following properties affect the size and structure of the Kubernetes cluster that gets started, as well as the startup attributes of the VoltDB cluster running on those pods.

Table B.2. Options Starting with cluster.clusterSpec...

Parameter	Description	Default
.replicas	Pod (VoltDB Node) replica count, scaling to 0 will shutdown the cluster gracefully	3
.maxPodUnavailable	Maximum pods unavailable in Pod Disruption Budget	kfactor
.maintenanceMode	VoltDB Cluster maintenance mode (pause all nodes)	false
.takeSnapshotOnShutdown	Takes a snapshot when cluster is shut down by scaling to 0. One of: NoCommandLogging (default), Always, Never. NoCommandLogging means 'snapshot only if command logging is disabled'.	""
.enableInServiceUpgrade	WARNING: Use this switch only when you know that version you are upgrading to is compat-	false

Parameter	Description	Default
	ible with current version, check Release Notes. Enable or disable in service upgrade. When this is enabled upon image change operator will not do full restart with new image. It does a RollingUpdate to upgrade individual pods image/software.	
.initForce	Always init --force on VoltDB node start/restart. WARNING: This will destroy VoltDB data on PVCs except snapshots.	false
.deletePVC	Delete and cleanup generated PVCs when VoltDBCluster is deleted, requires finalizers to be enabled (on by default)	false
.allowRestartDuringUpdate	Allow VoltDB cluster restarts if necessary to apply user-requested configuration changes. May include automatic save and restore of database.	false
.stoppedNodes	User-specified list of stopped nodes based on StatefulSet	[ ]
.forceStopNode	Enable or disable force stop node	false'
.persistentVolume.size	Persistent Volume size per Pod (VoltDB Node)	32Gi
.persistentVolume .storageClassName	Storage Class name to use, otherwise use default	""
.persistentVolume.hostpath .enabled	Use HostPath volume for local storage of VoltDB. This node storage is often ephemeral and will not use PVC storage classes if enabled.	false
.persistentVolume.hostpath.path	HostPath mount point, defaults to /data/voltdb/ if not specified.	""
.ssl.certificateFile	PEM encoded certificate chain used by the VoltDB operator when TLS/SSL is enabled	""
.ssl.insecure	If true, skip certificate verification by the VoltDB operator when TLS/SSL is enabled	false
.storageConfigs	Optional storage configs for provisioning additional persistent volume claims automatically	[ ]
.additionalVolumes	Additional list of volumes that can be mounted by node containers	[ ]

Parameter	Description	Default
.additionalVolumeMounts	Pod volumes to mount into the container's filesystem, cannot be modified once set	[ ]
.image.registry	Image registry	docker.io
.image.repository	Image repository	voltdb/voltdb-enterprise
.image.tag	Image tag	10.0.0
.image.pullPolicy	Image pull policy	Always
.additionalStartArgs	Additional VoltDB start command args for the pod container	[ ]
.priorityClassName	Pod priority defined by an existing PriorityClass	""
.additionalAnnotations	Additional custom Pod annotations	{ }
.additionalLabels	Additional custom Pod labels	{ }
.resources	CPU/Memory resource requests/limits	{ }
.nodeSelector	Node labels for pod assignment	{ }
.tolerations	Pod tolerations for Node assignment	[ ]
.affinity	Node affinity	{ }
.topologySpreadConstraints	describes how a group of pods ought to spread across topology	[ ]
.useCloudNativePlacementGroup	Enable or disable cloud native placement group in VoltDB	false'
.podSecurityContext	Pod security context	{"runAsNonRoot":true, "runAsUser":1001, "fsGroup":1001}
.securityContext	Container security context. WARNING: Changing user or group ID may prevent VoltDB from operating.	{"privileged":false, "runAsNonRoot":true, "runAsUser":1001, "runAsGroup":1001, "readOnlyRootFilesystem":true}
.clusterInit.initSecretRefName	Name of pre-created Kubernetes secret containing init configuration (deployment.xml, license.xml and log4j.xml), ignores init configuration if set	""
.clusterInit .schemaConfigMapRefName	Name of pre-created Kubernetes configmap containing schema configuration	""
.clusterInit .classesConfigMapRefName	Name of pre-created Kubernetes configmap containing schema configuration	""

Parameter	Description	Default
.podTerminationGracePeriodSeconds	Duration in seconds the Pod needs to terminate gracefully. Defaults to 30 seconds if not specified.	30
.livenessProbe.enabled	Enable/disable livenessProbe	true
.livenessProbe .initialDelaySeconds	Delay before liveness probe is initiated	20
.livenessProbe.periodSeconds	How often to perform the probe	10
.livenessProbe.timeoutSeconds	When the probe times out	1
.livenessProbe.failureThreshold	Minimum consecutive failures for the probe	10
.livenessProbe.successThreshold	Minimum consecutive successes for the probe	1
.readinessProbe.enabled	Enable/disable readinessProbe	true
.readinessProbe .initialDelaySeconds	Delay before readiness probe is initiated	30
.readinessProbe.periodSeconds	How often to perform the probe	17
.readinessProbe.timeoutSeconds	When the probe times out	2
.readinessProbe.failureThreshold	Minimum consecutive failures for the probe	6
.readinessProbe .successThreshold	Minimum consecutive successes for the probe	1
.startupProbe.enabled	Enable/disable startupProbe, feature flag must also be enabled at a cluster level (enabled by default in 1.18)	true
.startupProbe .initialDelaySeconds	Delay before startup probe is initiated	45
.startupProbe.periodSeconds	How often to perform the probe	10
.startupProbe.timeoutSeconds	When the probe times out	1
.startupProbe.failureThreshold	Minimum consecutive failures for the probe	18
.startupProbe.successThreshold	Minimum consecutive successes for the probe	1
.env.VOLTDB_OPTS	VoltDB cluster additional java runtime options (VOLTDB_OPTS)	""
.env.VOLTDB_GC_OPTS	VoltDB cluster java runtime garbage collector options (VOLTDB_GC_OPTS)	""
.env.VOLTDB_HEAPMAX	VoltDB cluster heap size, integer number of megabytes (VOLTDB_HEAPMAX)	""

Parameter	Description	Default
.env.VOLTDB_HEAPCOMMIT	Commit VoltDB cluster heap at startup, true/false (VOLTDB_HEAPCOMMIT)	""
.env .VOLTDB_K8S_LOG_CONFIG	VoltDB log4jcfg file path	""
.env .VOLTDB_REGION_LABEL_NAME	Override for region label on node	""
.env .VOLTDB_ZONE_LABEL_NAME	Override for zone label on node	""
.customEnv	Key-value map of additional envvars to set in all VoltDB node containers	{ }
.dr.forceDrop	Indicate if you want to drop cluster from XDCR without producer drain.	false
.dr.excludeClusters	User-specified list of clusters not part of XDCR	[ ]

B.4. Network Options

The following properties specify what ports to use and the port-mapping protocol.

Table B.3. Options Starting with cluster.serviceSpec...

Parameter	Description	Default
.type	VoltDB service type (options ClusterIP, NodePort, and LoadBalancer)	ClusterIP
.externalTrafficPolicy	VoltDB service external traffic policy (options Cluster, Local)	Cluster
.vmcPort	Volt Management Center web interface Service port	8080
.vmcNodePort	Port to expose Volt Management Center service on each node, type NodePort only	31080
.vmcSecurePort	Volt Management Center secure web interface Service port	8443
.vmcSecureNodePort	Port to expose Volt Management Center secure service on each node, type NodePort only	31443
.adminPortEnabled	Enable exposing admin port with the VoltDB Service	true
.adminPort	VoltDB Admin exposed Service port	21211

Parameter	Description	Default
.adminNodePort	Port to expose VoltDB Admin service on each node, type NodePort only	31211
.clientPortEnabled	Enable exposing client port with the VoltDB Service	true
.clientPort	VoltDB Client exposed service port	21212
.clientNodePort	Port to expose VoltDB Client service on each node, type NodePort only	31212
.loadBalancerIP	VoltDB Load Balancer IP	""
.loadBalancerSourceRanges	VoltDB Load Balancer Source Ranges	[ ]
.externalIPs	List of IP addresses at which the VoltDB service is available	[ ]
.http.sessionAffinity	SessionAffinity override for the HTTP service	ClientIP
.http.sessionAffinityConfig .clientIP.timeoutSeconds	Timeout override for http.sessionAffinity=ClientIP	10800
.dr.type	VoltDB DR service type, valid options are ClusterIP (default), LoadBalancer, or NodePort	""
.dr.annotations	Additional custom Service annotations	{ }
.dr.availableIPs[ ]	(OBSOLETE as of 1.6.0)	[ ]
.dr.staticIP	Single static IP for DR service use when creating LoadBalancers single DR service	``
.dr.enabled	Create single DR service for DR	false
.dr.externalTrafficPolicy	VoltDB DR service external traffic policy	""
.dr.replicationPort	Kubernetes service ports[ ].port for the VoltDB DR replication service	5555
.dr.replicationNodePort	Kubernetes service ports[ ].nodePort for VoltDB replication service on each node, only type NodePort. If -1 is specified, kubernetes will select a random unused port	31555
.dr.servicePerPod	(OBSOLETE as of 1.6.0)	false
.dr.publicIPFromService	Operator will wait to get the public IP address from the service status set by Kubernetes	false

Parameter	Description	Default
.dr.override	Allows per-pod-service overrides of serviceSpec	[ ]
.dr.override[ ].podIndex	(OBSOLETE as of 1.6.0)	""
.dr.override[ ].annotations	(OBSOLETE as of 1.6.0)	""
.dr.override[ ].publicIP	(OBSOLETE as of 1.6.0)	""
.dr.override[ ].spec	(OBSOLETE as of 1.6.0)	{ }
.dr.override[ ].spec.type	(OBSOLETE as of 1.6.0)	""
.dr.override[ ].spec.loadBalancerIP	(OBSOLETE as of 1.6.0)	""
.dr.override[ ].spec.externalIPs	(OBSOLETE as of 1.6.0)	[ ]
.perpod.type	VoltDB service type, valid options are ClusterIP (default), LoadBalancer, or NodePort	""
.perpod.publicIPFromService	Operator will wait to get the public IP address from the service status set by Kubernetes	false
.perpod.staticIPs[ ]	Available IPs and IP-ranges to use when creating LoadBalancers on a per-pod basis	[ ]
.perpod.dr.enabled	Enable DR services on a per-pod basis	false
.perpod.dr.replicationPort	Kubernetes service ports[ ].port for the perpod VoltDB DR replication services	5555
.perpod.dr .startReplicationNodePort	Starting Kubernetes service ports[ ].noodePort for poerpod VoltDB replication service, type NodePort only. Start port indicates starting port and each pod gets subsequent number. If -1 is specified, kubernetes will select a random unused port	32555
.perpod.dr.externalTrafficPolicy	VoltDB DR service external traffic policy for per pod DR services.	""
.perpod.metrics.enabled	Enables metrics k8s service for each pod	false
.service.metrics.type	Sets service type	ClusterIP

B.5. VoltDB Database Startup Options

The following properties affect how Helm interacts with the VoltDB cluster and specific initialization options, such as the initial schema and procedure classes.

Table B.4. Options Starting with cluster.config...

Parameter	Description	Default
.auth.username	Operator admin user name used to access VoltDB. Required. Superseded by credSecretName when provided	voltdb-operator
.auth.password	Operator admin password used to access VoltDB if security is enabled. Required. Superseded by credSecretName when provided.	""
.auth.credSecretName	Name of the premade secret containing Operator admin username and password. This overrides auth.username and auth.password values and avoids including the password in yaml.	""
.schemas	Map of optional schema files containing data definition statements	{ }
.classes	Map of optional jar files container stored procedures	{ }
.licenseXMLFile	VoltDB Enterprise license.xml	{ }
.log4jcfgFile	Custom Log4j configuration file	{ }

B.6. VoltDB Database Configuration Options

The following properties define the VoltDB database configuration.

Table B.5. Options Starting with cluster.config.deployment...

Parameter	Description	Default
.cluster.kfactor	K-factor to use for database durability and data safety replication	1
.cluster.sitesperhost	SitesPerHost for VoltDB Cluster	8
.heartbeat.timeout	Internal VoltDB cluster verification of presence of other nodes (seconds)	90
.partitiondetection.enabled	Controls detection of network partitioning	true
.commandlog.enabled	Command logging for database durability (recommended)	true
.commandlog.logsize	Command logging allocated disk space (MB)	1024
.commandlog.synchronous	Transactions do not complete until logged to disk	false
.commandlog.frequency.time	How often the command log is written, by time (milliseconds)	200

Parameter	Description	Default
.commandlog.frequency .transactions	How often the command log is written, by transaction command	2147483647
.dr.id	Unique cluster id, 0-127	0
.dr.role	Role for this cluster, currently the only accepted value is 'xdcr'	xdcr
.dr.conflictretention	Automatic pruning of xdcr conflict logs; value is integer followed by one of m/h/d, for minutes/hours/days	""
.dr.connection.enabled	Specifies whether disaster recovery is enabled	false
.dr.connection.source	If role is replica or xdcr: list of host names or IP addresses of remote node(s)	""
.dr.connection.preferredSource	Cluster ID of preferred source	""
.dr.connection.ssl	(OBSOLETE as of 2.0.0 as a setting in its own right; use the 3 following settings)	{ }
.dr.connection.ssl.truststore.file	Optional truststore file used to verify the identity of the remote VoltDB cluster; defaults to truststore of this cluster, unless sslSecret is set	""
.dr.connection.ssl.truststore .password	Password for truststore file specified above	""
.dr.connection.ssl.sslSecret .certSecretName	Optional pre-made secret containing truststore data, including password if needed	""
.dr.consumerlimit.maxsize	Enable DR consumer flow control either maxsize or maxbuffers must be specified maxsize can be specified as 50m, 1g or just number for bytes	""
.dr.consumerlimit.maxbuffers	Enable DR consumer flow control either maxsize or maxbuffers must be specified	""
.dr.schemachange.enabled	Enable DR consumer to continue while compatible schema changes are being made	"false"
.dr.schemachange.truncate	Enable values to be truncated if a VARCHAR column is wider on another cluster while schema changes are being made	"false"
.export.configurations	List of export configurations	[ ]
.import.configurations	List of import configurations	[ ]

Parameter	Description	Default
.avro.namespace	Avro namespace	""
.avro.registry	Avro registry URL	""
.avro.prefix	Avro configuration prefix	""
.avro.properties	Avro configuration properties	{ }
.topics.threadpool	Kafka topics threadpool to use	``
.topics.enabled	Kafka topics enabled or not	true
.topics.broker	Kafka topics broker configuration	``
.topics.broker.properties	Kafka topics broker configuration properties	[ ]
.topics.topic	List of topics	[ ]
.topics.topic.name	topic name	``
.topics.topic.procedure	Procedure to invoke upon getting message	``
.topics.topic.format	Format of topic message	``
.topics.topic.retention	Topic retention policy	``
.topics.topic.opaque	Is this an opaque topic	false
.topics.topic.allow	List of roles allowed to access the topic	``
.topics.topic.priority	Priority for topics requests (if priority scheduling is enabled)	4
.topics.topic.properties	Topic configuration properties	[ ]
.httpd.enabled	Determines if HTTP API daemon is enabled	false
.httpd.jsonapi.enabled	Determines if jSON over HTTP API is enabled	false
.httpd.port	Specifies port for HTTP	8080 or 8443
.paths.commandlog.path	Directory path for command log	/pvc/voltdb/voltdbroot/command_log
.paths.commandlogsnapshot.path	Directory path for command log snapshot	/pvc/voltdb/voltdbroot/command_log_snapshot
.paths.droverflow.path	Directory path for disaster recovery overflow	/pvc/voltdb/voltdbroot/dr_overflow
.paths.exportcursor.path	Directory path for export cursors	/pvc/voltdb/voltdbroot/export_cursor
.paths.exportoverflow.path	Directory path for export overflow	/pvc/voltdb/voltdbroot/export_overflow
.paths.largequeryswap.path	Directory path for large query swapping	/pvc/voltdb/voltdbroot/large_query_swap
.paths.snapshots.path	Directory path for snapshots. Must not be located in a read-only root directory of mounted storage (as init --force will rename exist-	/pvc/voltdb/voltdbroot/snapshots

Parameter	Description	Default
	ing snapshot folder). Use a subdirectory.	
.security.enabled	Controls whether user-based authentication and authorization are used	false
.security.provider	Sets authentication provider as 'hash' (local) or 'ldap' (using a customer-specified LDAP/LDAP server)	hash
.security.ldap.server	URL for LDAP server, required; as 'ldap://server:port', or 'ldaps://server:port', port optional	""
.security.ldap.user	Username used by VoltDB for read-only access on LDAP server, required	""
.security.ldap.password	Password corresponding to LDAP server username, required	""
.security.ldap.rootdn	Distinguished Name of the root of the LDAP schema that defines users and groups, required	""
.security.ldap.userclass	Name of the LDAP schema's objectClass containing user information	"inetOrgPerson"
.security.ldap.useruid	Name of the LDAP attribute in the userObjectClass that should contain the username provided by the VoltDB client	"uid"
.security.ldap.groupclass	Name of the LDAP schema's objectClass defining a group of users	"groupOfUniqueNames"
.security.ldap.groupmemberid	Name of the LDAP schema's objectClass defining a group of users	"uniqueMember"
.security.ldap.timeout	Timeout, in seconds, for requests to the LDAP server	10
.security.ldap.group	List of LDAP groups and their mapping to VoltDB roles	[ ]
.security.ldap.ssl.truststore.file	Truststore file used to validate LDAPS server certificate (Java KeyStore format)	""
.security.ldap.ssl.truststore .password	Password for LDAP truststore file	""
.snapshot.enabled	Enable/disable periodic automatic snapshots	true
.snapshot.frequency	Frequency of automatic snapshots (in s,m,h)	24h
.snapshot.prefix	Unique prefix for snapshot files	AUTOSNAP

Parameter	Description	Default
.snapshot.retain	Number of snapshots to retain	2
.snmp.enabled	Enables or disables use of SNMP	false
.snmp.target	Host name or IP address, and optional port (default 162), for SNMP server	""
.snmp.authkey	SNMPv3 authentication key if protocol is not NoAuth	voltdbauthkey
.snmp.authprotocol	SNMPv3 authentication protocol. One of: SHA, MD5, NoAuth	SHA
.snmp.community	Name of SNMP community	public
.snmp.privacykey	SNMPv3 privacy key if protocol is not NoPriv	voltdbprivacykey
.snmp.privacyprotocol	SNMPv3 privacy protocol. One of: AES, DES, 3DES, AES192, AES256, NoPriv	AES
.snmp.username	Username for SNMPv3 authentication; else SNMPv2c is used	""
.ssl.enabled	Enable or disable configuration of TLS/SSL on the cluster. Other properties control activation of TLS/SSL for specific ports and features	false
.ssl.external	Extends TLS/SSL security to all external ports (default admin 21211, client 21212). Only active if cluster.config.deployment .ssl.enabled is also "true".	false
.ssl.internal	Extends TLS/SSL security to the internal port (default 3021). Only active if cluster.config.deployment.ssl.enabled is also "true".	false
.ssl.dr	Extends TLS/SSL security to the DR port (5555). Only active if cluster.config.deployment .ssl.enabled is also "true".	false
.ssl.keystore.file	Keystore file to mount at the keystore path (unless sslSecret is set)	""
.ssl.keystore.password	Password for VoltDB keystore file	""
.ssl.truststore.file	Truststore file to mount at the truststore path (unless sslSecret is set)	""
.ssl.truststore.password	Password for VoltDB truststore file	""

Parameter	Description	Default
.ssl.sslSecret.certSecretName	Pre-made secret containing keystore and truststore data, optionally including passwords	""
.ssl.sslSecret .passwordSecretName	Pre-made secret containing password for keystore/truststore, if password is not in the secret named by certSecretName	""
.systemsettings.elastic.duration	Target value for the length of time each rebalance transaction will take (milliseconds)	50
.systemsettings.elastic.throughput	Target value for rate of data processing by rebalance transactions (MB)	2
.systemsettings.compaction .interval	Interval to indicate how often memory compaction should run (seconds)	60
.systemsettings.compaction .maxcount	Set a target block count compaction should try and achieve if there is memory fragmentation	1
.systemsettings.flushinterval .minimum	Interval between checking for need to flush (milliseconds)	1000
.systemsettings.flushinterval.dr .interval	Interval for flushing DR data (milliseconds)	1000
.systemsettings.flushinterval .export.interval	Interval for flushing export data (milliseconds)	4000
.systemsettings.procedure .copyparameters	if set, mutable array parameters should be copied before processing	true
.systemsettings.procedure.loginfo	Threshold for long-running task detection (milliseconds)	10000
.systemsettings.query.timeout	Timeout on SQL queries (milliseconds)	10000
.systemsettings.priorities.enabled	Enables priority scheduling of requests by VoltDB cluster (true/false)	false
.systemsettings.priorities .maxwait	Modifies priority scheduling by setting a limit on time waiting while higher priority requests execute (millisecs)	1000
.systemsettings.priorities.batch	Modifies priority scheduling algorithm to execute multiple requests before rescheduling	25
.systemsettings.priorities.dr .priority	Priority for DR requests (1-8, 1 is highest priority)	5
.systemsettings.priorities .snapshot.priority	Priority for snapshot requests (1-8, 1 is highest priority)	6

Parameter	Description	Default
.systemsettings.resourcemonitor .frequency	Resource Monitor interval between resource checks (seconds)	60
.systemsettings.resourcemonitor .memorylimit.size	Limit on memory use (in GB or as percentage)	80%
.systemsettings.resourcemonitor .memorylimit.alert	Alert level for memory use (in GB or as percentage)	70%
.systemsettings.resourcemonitor .disklimit.commandlog.size	Resource Monitor disk limit on disk use (in GB or percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.commandlog.alert	Resource Monitor alert level for disk use (in GB or as percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.commandlogsnapshot .size	Resource Monitor disk limit on disk use (in GB or percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.commandlogsnapshot .alert	Resource Monitor alert level for disk use (in GB or as percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.droverflow.size	Resource Monitor disk limit on disk use (in GB or percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.droverflow.alert	Resource Monitor alert level for disk use (in GB or as percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.exportoverflow.size	Resource Monitor disk limit on disk use (in GB or percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.exportoverflow.alert	Resource Monitor alert level for disk use (in GB or as percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.snapshots.size	Resource Monitor disk limit on disk use (in GB or percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.snapshots.alert	Resource Monitor alert level for disk use (in GB or as percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.topicsdata.size	Resource Monitor disk limit on disk use (in GB or percentage, empty is unlimited)	""
.systemsettings.resourcemonitor .disklimit.topicsdata.alert	Resource Monitor alert level for disk use (in GB or as percentage, empty is unlimited)	""
.systemsettings.snapshot.priority	Priority for snapshot work (really a delay factor; see under systemsettings for scheduling priority)	6

Parameter	Description	Default
.systemsettings.temptables .maxsize	Limit the size of temporary database tables (MB)	100
.systemsettings.clockskew .interval	Interval of the scheduled clock skew collection (minutes). 0 is allowed and it disables collection. Interval cannot be less than 0 and if set below such value it will be reset to default.	60
.users	Define a list of VoltDB users to be added to the deployment	[ ]
.metrics.enabled	Enables cloud native metrics system on each VoltDB pod. It is an alternative to using Prometheus Agent.	false
.metrics.interval	Controls how often metrics system prepares metrics slice to be sourced by external system like prometheus.	60seconds
.metrics.maxbuffersize	Controls how much memory, at maximum, metric system will use for internal metric buffering. But at least system will retain one metrics slice in the buffer.	16
.metrics.retain	Controls how many metrics slices retain in the buffer.	1

B.7. Operator Configuration Options

The following properties configure the Volt Operator, which is in turn responsible for managing the startup and operation of all other Volt components.

Table B.6. Options Starting with operator...

Parameter	Description	Default
.enabled	Create VoltDB Operator to manage clusters	true
.image.registry	Image registry	docker.io
.image.repository	Image repository	voltdb/voltdb-operator
.image.tag	Image tag	v0.1.0
.image.pullPolicy	Image pull policy	Always
.replicas	Pod replica count	1
.debug.enabled	Debug level logging	false
.logformat	Log encoding format for the operator (console or json)	json

Parameter	Description	Default
.serviceAccount.create	If true, create & use service account for VoltDB operator containers	true
.serviceAccount.name	If not set and create is true, a name is generated using the fullname template	""
.cleanupCustomResource	Attempt to cleanup CRDs before installing the Helm chart (Helm 2 only)	false
.cleanupNamespaceClusters	Delete ALL VoltDB clusters in the namespace when the operator Helm chart is deleted	false
.podLabels	Additional custom Pod labels	{ }
.podAnnotations	Additional custom Pod annotations	{ }
.resources	CPU/Memory resource requests/limits	{ }
.nodeSelector	Node labels for pod assignment	{ }
.tolerations	Pod tolerations for Node assignment	[ ]
.affinity	Node affinity	{ }
.securityContext	Container security context	{"privileged":false, "runAsNonRoot":true,"runA

B.8. Metrics Configuration Options

Properties starting with `metrics...` were used to configure the standalone VoltDB Prometheus agent. However, the Prometheus agent has been deprecated in favor of per pod metrics. See Section 6.1, “Using Prometheus to Monitor VoltDB” for more information on using the current metrics system.

B.9. Volt Management Center (VMC) Configuration Options

The following properties start and configure the web-based Volt Management Center auxiliary service.

Table B.7. Options Starting with cluster.serviceSpec...

Parameter	Description	Default
.perpod.metrics.enabled	Allocates a metrics service per VoltDB cluster pod.	false
.service.metrics.type	Metrics port service type (options ClusterIP, NodePort, and LoadBalancer)	ClusterIP